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ABSTRACT

This Dissertation presents a comprehensive Process Map for innovation [the Map], based on a comparison and synthesis of the reported steps for creating in many disciplines, including Engineering Design and Buddhist Meditation. The Map is presented in three stages and seven detailed steps, following a review of the status quo of innovation in Engineering Design from literature and Industry surveys, and can be said to provide the first natural and common language for innovation. The application of Buddhist Methods is a key feature in the development of the Map, introducing a consistency and hierarchy, as well as co-evolutionary and eco-systemic aspect to academic understanding of innovation and its management, which has been lacking in models proposed in literature and Tools such as TRIZ in the past. Presentation of the Map theory and Map itself is followed by reports of its testing and proof of concept with an Industry Collaborator from 2006–10, including: [i] benchmarking of ‘Systematic Innovation’ [ii] an Industry Pilot Test comparing teaching of TRIZ with the Innovation Map and [iii] results of four nine-month periods of application in training, coaching, workshops, Games and GameDays. The Map is shown to improve high-end technical innovation in corporate environments, by streamlining the way questions are asked, and answers found and evaluated. It is directly responsible for unprecedented solutions achieved by Engineering Design teams addressing long-standing problems in very short time frames. Facilitated sessions using the Map achieve an ROI up to 2847% in each session and are estimated to have contributed billions of Euros value to the Industry Collaborator over four years of testing. In comparison with other options, the Map provides cheaper, simpler and more elegant innovation incorporating Tools, process and potential culture for any kind of User – Company, Consultant, Innovation Manager or Academic.
ABBREVIATIONS

TRIZ ‘The Theory of Inventive Problem–Solving’ and all associated Innovation Tools. developed by Altshuller, his TRIZ Masters and international TRIZ consultants.

SIT ‘Systematic Inventive Thinking’, developed by Filkovsky et al. A derivative of TRIZ.

ASIT ‘Advanced Systematic Inventive Thinking’, developed by Horowitz. A derivative of TRIZ.

USIT ‘Unified Structured Inventive Thinking’, developed by Sikafus and Ford Motor Company. A derivative of TRIZ.

PRIZM ‘The Theory of Inventive Problem–Solving, Modernised’. An Innovation Map and Game developed by Pahl. An extension of TRIZ.

IFR ‘The Ideal Final Result’ – a concept used in TRIZ and re-applied in PRIZM and Buddhist Technologies.

Tools ‘Thinking Tools’, ‘Creativity Tools’ or ‘Innovation Tools’. All non–IT aids for creativity and innovation, including rigorously applicable checklists, matrices, repeatable processes and methods as well as more vague methodologies including TRIZ, but not theoretical models.

ROI ‘Return on Investment’, a standard performance measure, calculated here as [gain from investment – costs of investment] /cost of investment x 100 %

HCI ‘Human–Computer Interaction’

ICT ‘Information Communication and Technology’

AI ‘Artificial Intelligence’
Chapter 1  INTRODUCTION: The Context, Quest and Ideal Final Result

The Main Hypothesis for the Research described in this Dissertation is:

There is a fundamental nature to creation, and, by association, a fundamental pattern of innovation, that underlies all human thought processes and, consequently, all product development. This pattern is expected to define a map of creating and/or an Innovation Map. This pattern can be discovered by comparison and synthesis of all the ‘steps of creating’ that have been reported in the scientific and humanities literature of different disciplines. These steps can also be better understood by reference to: [i] the mechanisms of TRIZ, the Russian ‘Theory of Inventive Problem-solving’ [one the best-known Innovation Tools for Engineers] and in particular its process of resolving technical contradiction; and [ii] the methods of certain Buddhist Meditations, which structure the process of creating, sharing and transforming conceptual spaces. Based on these elements, a Map can be outlined that defines the skeleton process of modern product innovation with seven steps and three stages, which enable its user to integrate conceptual contradiction and transform the coincident Design space. Such a Map can be applied cheaply, easily and elegantly, with repeated benefits for Engineering Design.

This Chapter presents the background to the above hypothesis as follows; It outlines the need for an Innovation Map and better rules defining innovation [in section 1.2.1]; It defines the worldview that limits the current context of innovation and the worldview of this research [1.2.2 and 1.2.3]; It explains the reasons for a multidisciplinary approach and emphasis on Buddhist methods in this research [section 1.2.4]; It briefly presents the Innovation Map and its associated Tools and sketches out why this artefact is the basis of the Dissertation [1.2.5] and how it is initially relevant to Engineering Design [see 1.2.6]. Finally the research methods [section 1.3.0] and entire Dissertation structure are presented [1.4.0], followed by a summary of claims for contributions to scientific knowledge made in this Dissertation [1.5.0].

1.1.0 THE BACKGROUND OF THE DISSERTATION

In the 20th Century, physicists were obsessed with finding a fundamental pattern to unify the different forces of physical interaction in a so-called ‘Theory of Everything [TOE]’ [Ellis, 1986, 2002; Barrow, 1990; Weinberg, 1993; Hawking 2002]. Biologists, likewise, hoped to integrate their observations of competing natural phenomena in a ‘Theory of Consilience’ [Thagard, 1978; Wilson, 1998], as they assumed a unifying explanation of universal behaviour should include not just the quarks and gravity waves studied by physicists, but all objects inhabiting the rest of the cosmos. In other words, proof of the fundamental universal order should be everywhere. The author of this Dissertation also believed there was an ultimately fundamental order underlying the creation of the universe – her quest to define the nature of this pattern spanned eighteen years and three disciplines in the ‘hard Sciences’, originally resulting in an unsubmitted first PhD on the TOE, where she did, in fact, define a single generic pattern that unified all the forces of creation. However, a sudden and general lack of academic faith in the TOE caused her to shelve attempts to find new supervisors and collaborators and define ‘hard Scientific proof’ for the TOE in mid–1999, and change her focus to an area with potentially more immediate benefit for polite society. Her move to research ‘creativity’ and ‘innovation’ coincided with a global academic move toward treating these as intersecting domains of complex knowledge, rather than chance or genius. At the same time, she met Western Buddhist teachers who showed her rigorous methods for universal creation and dissolution and was introduced to a new field which prized social usefulness above all – Engineering. She started to integrate these domains and methods to formulate a ‘common language’ that seemed to be lacking in innovation at that point. The initial combination of these fields led to surprising but promising support for a fundamental and generic pattern of creation yet again, albeit in ‘soft Science’. This was turned into an Innovation
Map and Game for 13-year olds, called PRIZM [in 2005], whose basic theory was defined in an invited paper in the Journal of Design Research in 2007. The practical benefits of the Innovation Map and Game were tested for short- and medium-term projects in Engineering Design, and are described in detail in this Dissertation. It is the Map and the benefits of its use [with and without its derivatives and associate Tools], which are this author’s key claim to advancing the scientific knowledge of innovation in general, and fulfil the requirements for submitting this PhD.

1.2.0 WHY THIS DISSERTATION IS IMPORTANT

1.2.1 The Need for an Innovation Map or At Least Better Rules

The rapid commercialization of new products through ‘Innovation Management’ has been a hot topic in all industries and countries for nearly 15 years, the more so, since the financial crisis started in early 2009. In spite of this, understanding of the nature of the innovation process which is supposed to be managed, is still mostly based on trial and error [Tidd, 2010]. The practise of innovation does not yet include a rigorous ‘front–end’ prior to having a good idea – most businesses expect only that innovation refers to the ‘back–end’ of taking a priori good ideas to market, using a linear ‘innovation funnel’ or ‘pipeline’ model [eg. see Harkema, 1994; DeSai, 1999 and Figure 4.1 in this Dissertation]. Between such a front– and back–end, there also seems to be much confusion and opinionated debate about how or when to implement well–known Tools or popular methods or methodologies, since the use of localised props can seem at odds with the necessity of encouraging a pervasive innovative mindset or ‘culture’ in an organization. Given that there are, indeed, so many different views and academically differentiated aspects of innovation and its management – variously identified as Tools, methods, processes, people, culture, measurement, collaboration structures, and so on, it could be said that there is is an absence of a standard definition and ‘common language’ [this author’s term for a framework, standard, set of principles, grammar or rules based on identifiable and verifiable commonalities] around the whole process of innovation.

When the research for this project started in 2006, over 110 commercial ‘Thinking Tools’ [this author’s term for all non–IT aids for creativity and innovation – hereafter also simply called Tools or Innovation Tools, and assumed to include rigorously applicable checklists, matrices, repeatable processes and methods as well as more vague methodologies] and many additional theoretical models existed for creativity and innovation, and were identified in an exhaustive literature review [Chapter 2]. Despite this, none of them completely described the process of innovation itself. As Chapter 2 will explain, most Tools were created in a bespoke fashion, in isolation from each other, and fit only a certain type of personality, industry or commercial purpose. Some serious clustering of Tools had been attempted [eg. the Model of 42 Models by Tabor Greene, 2001; the taxonomy of Cross and Sivaloganathan, 2005] but no comprehensive taxonomy of Tools or the steps of innovative or creative behaviours existed. Likewise, long literary explanations regarding the psychology and nurture of creation or innovation were available, but these were difficult to apply to corporate situations. Even models that professed to have cracked a part of the code of nurturing innovation, by making it systematic [eg. the so–called ‘Theory of Inventive Problem–solving’ or Teoriya Reshenija Izobretatel’skikh Zadatch, better know by its Russian Acronym, TRIZ; Altshuller & Shapiro, 1956; Altshuller, 1984, 1999; discussed in depth in Chapter 4] were not widely accessible. It is asserted that these factors contribute to the variable results achieved by companies attempting to systematise their innovation initiatives and that without a simple and coherent process map that puts Tools, people and environments into one understandable context, consistent progress cannot be expected. In short, a comprehensive map has been missing, for inventors and Innovation Managers to build upon.

The research presented in this Dissertation points to the missing Innovation Map [hereafter also called the Process Map, the Innovation Process Map, the PRIZM Innovation Map, Innovation Map and simply The Map] via a summary of thousands of examples of the process–steps for creating and innovating analysed in the literature and practise of many disciplines [summarised in Tables 2., 2.2, 2.3 and 5.1]. The abstraction and synthesis of their common steps defines a fundamental or generic pattern for creation of any Design [Pahl, 2005; Pahl, Newnes and McMahon, 2007], which is arguably the simplest and most comprehensive model for innovation currently available. Simply put, these are the mental steps that human beings always follow, in order to make, create or produce any kind of ‘stuff’ and they are the basis for the Process Map for innovation.
presented in Chapter 5. The process of innovation thus uncovered appears to be fractal [as explained in Chapter 3], so the same steps are relevant at the level of the individual [allowing genius and chance to still play a part in the process of so-called ‘Innovation 1.0’ level; Rae, 2006], the team [where systematisation and repeatability are more important, as per ‘Innovation 2.0’; Rae, 2006, Carpenter 2010] and the society or Company or world [where management and a sustainable culture are arguably the most important factors in ‘Innovation 3.0’: Johnson 2007, Hafkesbrink and Schroll, 2010; Hafkesbrink and Evers, 2010]. Evidence will be presented that supports this assertion, however the main focus of the Dissertation is on the presentation and testing of the Innovation Map at the level of the individual and teams, so relatively little will be said about Innovation Management and innovation culture.

Adjunct to elucidation of the Innovation Process Map, four very simple but important rules and indicators of innovation emerge. The most important of these is based on the Latin term ‘Inne Novare’. Properly translated, this means ‘in something new’ or ‘something new inside’. Such an act is not one of mere creation [bringing something ‘completely new’ into being], neither is it renovation [which restores something old to an ‘as–new’ state]. Instead, the Latin implies it is a recasting and transformation of old, potentially previously irrelevant or even harmful information in a new space – or vice versa, like the evolution of a pearl from a grain of sand. This is a kind of analogic action which requires, for instance, Mechanical Engineers to re–use information about electrical systems or vice versa, as happens in TRIZ [Altshuller, 1984, 1997 and Chapter 2]. It is also an action that allows information from biological systems to inform Engineering Design and opens up the field of biomimetics [Vincent, 2002 and Chapter 4]. While analogic transfer of knowledge is a well–known creativity method [see sections 2.4.0 and 2.6.0], it has been little used in formal Engineering contexts, beyond the nascent field of biomimetics and isolated individual studies such as Maiden et al. [2004]. In many cases, as the Engineers surveyed in this Dissertation suggest, analogy is considered no more than random imagination or a childish Tool. Yet the very hallmark of innovation is a conscious ‘change of context’ that moves creation in a known space into an unknown one, synthesizing both conceptual spaces [Csikszentmihalyi and Getzels, 1988; Csikszentmihalyi, 1990a; Boden, 2005]. Certainly, it is this shift from unconscious and potentially vague analogic insight to conscious and more rigorous analogic pattern–matching that can be expected to give innovation a chance of being repeatable, thus taking it from the realm of chance or genius into the realm of Science. At the same time, this new kind of innovation that consciously matches two previously unmatched patterns, from two potentially unrelated disciplines, must then effectively co-evolve and transform the two disciplines or ‘worlds’ [this term from Gero and Kannengiesser, 2004, and intended to be a frame of reference which is inclusive of all necessary physical, social, mental/psychological and ‘conceptual’ spaces of Boden 1994 a, b, c] it involves, feeding new information back to each – an added benefit to the original insight. By definition, ‘putting something new inside an old space’ must engage people or information from radically different areas of expertise, and can therefore be expected to provoke the much sought after ‘disruptive’ events of technological breakthrough, as well as eco–systemic cultural change [ie. Innovation 3.0 as defined above]. For this reason, it is what this author calls the definitive ‘Rule of Innovation’ or ‘I–Rule’ [see also 3.2.0 and 3.3.1].

What this also means, is that the innovation community of the future needs more than a ‘single–track map’ through a single, known, world [see section 3.2.1]. It needs a map in which two or more different worlds can be mutually explored and beneficially combined. As will be explained shortly, no new world can be found with an old map. Thus a ‘worldview’ [this term intended as the map or view from inside the frame of one of Gero and Kannengiesser’s 2004 worlds, outlined above] is required at the outset, which transcends each of the worlds that are to be included in the ideal and final result.

1.2.2 Establishing a Worldview that Transcends the Worlds to be Mapped

When a breakthrough has been made, it is always easy to retrospectively wonder: why had no one previously looked in that direction, for that particular ideal result before? Why, for instance, had no one postulated there could be a fundamental or generic pattern of innovation? Why had no one even taken the first step to place all competing theories on these topics together, side by side, to see if there was a commonality or not?

The reason relevant to this Dissertation is rooted in Aristotelian culture. Western Science and business thinking inescapably based on this model demands an ‘either–or’ scenario of dualistic decision–making, forcing data that does not immediately fit a preconceived and often simplistic worldview to be thrown out, as is evident in every straight line drawn through miscellaneous
points on a graph [Figure 1.1]. Yet, Einstein apparently stated many times [and was re-quoted by the physicists Penrose and Feynmann] that ‘the thinking that created a problem cannot be used to solve it’ [eg. Infinite Innovations, 1997]. In other words, an integrated map for innovation cannot exist and cannot be found when sought from a worldview that demands irreconcilable separation of parts – just as a curve cannot exist and cannot be found on a map allowing only straight lines, and a Theory of All Things in the Universe cannot be formulated in a mathematical system that decrees only separate parts and reference frames exist. To suggest otherwise is to side with the proverbial man searching for his keys under a streetlamp: he can never find them, no matter how much light shines on the area, because he lost them elsewhere. Thus this author proposes that a complete picture of innovation can only be achieved from a worldview, which declares the opposite of Aristotle from the outset. An integrated map for innovation can only be achieved from a worldview that assumes all parts really do exist in one single reference frame, and that a fundamental pattern coincidentally also exists, which supports the existence or emergence of all these apparently conflicting, dualistic technical parts or social points of view. This worldview is explained more fully in section 1.3.0.

Since no such transcendent reference frame exists in Western literature for apparently mismatched data or, indeed, mismatched views of the same data, the template for it must be either invented or found elsewhere. This author did not wish to invent a template but rather turned to known and proven, if somewhat unorthodox, alternative sources, comparing Eastern methods and Tools for thinking and creating in complex environments with those in the West. She sought to integrate what was common and strengthen what was weak in the existing Western worldview and models for innovation in the process. Here, two methodologies stood out as candidates to help understand the process of complex and conflict-ridden technical innovation better – one from Russia; the thinking system called TRIZ [Altshuller & Shapiro, 1956; Altshuller, 1984, 1999 and explored at length in Chapter 4], and one from Tibet: Buddhist Meditation [after Gampopa, 1999; Nydahl, 2000 and elucidated in Chapter 3]. Both of them are grounded in frameworks, which declare that a fundamental pattern exists, wherein conflicting or dualistic behaviours, technical contradictions or socially mismatched points of view can be integrated. The underlying axioms of both methodologies are similar and therefore compatible, which helps greatly to create a robust, integrated worldview for innovation – though of the two, the Tibetan is the more comprehensive and useful, in that it also explains discrepancies in the Russian system, as outlined further below and in Chapters 4 and 5.

The Innovation Map proposed in this Dissertation integrates the worlds, worldviews and maps of Innovation-in-general and TRIZ-in-particular with Buddhist Meditation, and tests their applicability in yet another space; Engineering Design. The fact that this is possible is due to this author starting from a worldview that transcends all of the worlds in question. Yet of course, this should not remain her own personal worldview – rather it should be transferrable to the task of improving the worldview of innovators and Innovation Managers. And inevitably, even if one’s worldview may be assumed to arbitrarily ‘include everything’, its verbal and artistic description must be rather more limited. Thus, some decisions are necessary on ‘what to include’ and ‘what to leave out’, of the maps of the worlds to be integrated. And thus it is also necessary to take responsibility for what is observed – ie. from the multitude of possibilities, exactly which points one will place on the map that is to define the journey of innovation. This is not only true for the author of this Dissertation – it is also a necessary discussion for innovators at the outset of each innovation project, as covered in the next two sections [and in more detail in Chapters 4 and 5].

1.2.3 The Worldview of this Dissertation

For the research presented in this Dissertation, the author based all exploration and explanation on the following points, mainly inspired by physicists such as Einstein and Penrose, Buddhist Meditators, and the creativity experts Margaret Boden and Mihalyi Csikzentmihalyi [further explored in Chapters 2, 3 and 5]. This worldview can be considered either a ‘meta-map’ ie. the worldview described by it integrates or transcends the worldview from which it is taken, as well as the one in which it is subsequently used [as required from the previous section], or, conversely, the second-level hypothesis of the research. In the latter case, it is part of the process of discovering the Innovation Map, and not the thesis to be proved:

* There exists a fundamental, unifying pattern for all natural creations and creative behaviours, including human endeavour. This fundamental pattern should be obvious in all theories, processes, observations and steps reported by humanity for making, creating or
producing any kind of physical stuff. The fundamental pattern of creation can be simply explained.

• In its most elementary form, the fundamental pattern of creation encompasses the following concept:
  ▪ The Diamond of Diverging and Converging Thought

• In a more comprehensive form, the fundamental pattern of creation can be observed in Western theories, processes, observations and reported steps for creation and innovation. It is also usefully elucidated by the structure and mechanisms of Vajrayana ie. ‘Diamond Way’ Buddhist Meditation. Such Meditation is a more elegant starting point for understanding and explaining the fundamental pattern of creative or innovative behaviour, than any other currently available pattern, method or tool for creativity and innovation in Western Science or business as it provides a set of simple methods for unifying, integrating or resolving opposing viewpoints, conflicts and conceptual contradictions. While such resolution is recognised as being intrinsic to creativity and innovation by Western scientists [see sections 1.2.4 and 3.3.1], there have been no rigorous Western methods available to achieve it in the past. The use of Buddhist Meditation thus provides additional insights into innovation regarding:
  ▪ The [opposing] ‘Arrows’ of Creation and Innovation
  ▪ Pattern–matching of a problem and its solution

• Elucidating the fundamental pattern of creation can help to enhance human creativity and innovation. The PRIZM Innovation Map and Game is the first practical example of using this fundamental pattern for innovation, team–building and Engineering Design. It provides the first common language and hence the first Western standard and process map for the entire innovation process, which is fractal, co–evolving and emergent.

1.2.4 Taking Responsibility for Deciding the Points on the Map

Prior to this research, the structure and mechanisms of practise of any kind of Buddhist Meditation had not been considered useful to investigate for insight into creativity, innovation or Engineering Design. In fact, the possibility that Meditation might be useful for these fields is potentially emotionally loaded, since it is tradition to keep religion and Science separate, lest the presumed belief of one impinge on the presumed non–belief of the other [cf. Kuhn 1963, 1996]. At the outset of this Dissertation, this author challenged herself many times on whether she had a right to trespass these psychological spaces. Did she have a right to question the fundamental axioms of Science and Engineering, in a bid to free innovation from its current limits? And did she have a right to systemically integrate Science with the previously secret Buddhist Methods?

Those questions of the ‘rights’ and ‘right way’ for both science and religious practise have meant that this Dissertation uses and explains Buddhist practise in a manner not previously attempted, proposing that Buddhism is more Science than religion and can be a complement to Western Science. The revision of Buddhism as a Science is especially relevant in the context of creation and innovation, since psychologists agree a hallmark of creative behaviour is the ability to integrate contradicting or dualistic variables and opinions [eg. Mednick and Mednick’s 1967 RAT; and Goldratt’s 2004 ‘Theory of Constraints’ are examples]. Yet Western Science has no long–term research or widely–accepted methods that enable inventors to master this subject, while Buddhism has 2500 years of research and can provide widely–accepted methods whereby all conflicting and dualistic concepts of physical, social and conceptual spaces are overcome. As will be shown in Chapters 3 and 5, the Mahayana or Great Way and Vajrayana or Diamond Way Buddhist Meditation are able to elucidate a pattern for creation and innovation in such a way that it enables users to creatively overcome dualistic worldviews and observations. This pattern also serendipitously appears, in retrospect, to have been ‘hidden’ in Western Tools and theories all along.

Regarding the points on the map; that they are biassed according to the journey taken is unavoidable. And yet, the efficacy of a map is not endangered if it is a meta–map, as defined above. That is assumed to be the case in using Buddhism as Science in this research. Simply; this author considers both Western Science and Buddhism proceed in the same manner. They:
(1) aim at a goal for the benefit of humanity,

(2) define their starting axioms [even though the nature of the starting axioms and nature of the goal of the Eastern and Western Sciences differ],

(3) encourage practitioners to make hypotheses about reality,

(4) give repeatable methods for testing whether the hypotheses and experience of reality match. When these do not match, Buddhist practitioners change their assumptions about reality just as Western scientists do, rather than insist that things must be a certain way – the historical Buddha and the H.H Dalai Lama both encouraged followers and colleagues to do so, many times during the course of their life [Tattvasamgraha 3588; Dighanikaya ii ; Visuddhimagga VII].

Certainly, it is in the context of treating Buddhism as a Science, not as an adjunct to, or a foreign discipline to Science, that this author was given permission from Buddhist lineage holders to explore formal Meditation in the context of Engineering, Science and business. That means the use of Buddhist teachings in this Dissertation is not about religion or its practise or the transmission of lineage information. Instead, it is limited to exploring and recasting the conceptual structure of the formal Meditations, which are widely available without undertaking initiations. Thus, rather than deal with the intricacy of meaning or ‘realisation’ layered in religious texts and practise, this author dealt directly with the geometric pattern of the formal practises explicitly laid out in the texts.

To be very exact, this means there are three roles that Buddhist Meditation has played in developing a greater scientific understanding of innovation for this author, as also discussed in this Dissertation;

i. as a source of design inspiration for the Map artefact itself. This means that the basis for describing seven steps to be fundamental to the innovation process, as explained briefly in the following section, and at length in Chapter 5, is that the geometry and steps of the Diamond Way Buddhist ‘Refuge’ and ‘16th Karmapa Guru Yoga’ Meditations describe seven fundamental parts or steps to creation of the ideal physical and/or conceptual world.

ii. as a source of design inspiration for a Game experience based on the Map artefact – in particular a ‘serious game’ ie. ‘a game which has an explicit and carefully thought out educational [or similar] purpose and [is] not intended to be ... primarily for amusement ... [but] which [also] does not mean [it is] not, or should not be, entertaining’ [Abt, 1970, additions in parentheses by this author]. This means that the basis for defining the Innovation Map to [a] provide rules and a structure, which deliver the stability of a common, repeatable language and rules for achieving [innovative] outcomes, and simultaneously [b] introduce provocation and novelty of unusual and changeable information from unknown, multidisciplinary, multinational or otherwise ‘foreign’ people and materials, and also [c] demand extraordinary conscious effort and joyful participation of players, each of which start from a different point of view and yet aim to reach a shared goal in very short timeframes, is that daily work at Diamond Way Buddhist [live-in] Centres and [international] events is defined by these three points, and these, in turn, are the basis for any game-like experience [as explained further in sections 2.4.3, 2.6.2 and 2.6.3] as well as the ‘Innovation Rules’ defined in this Dissertation [eg. sections 2.4.2, 3.1.2 and 3.2.1] . For example, this author observed that the formal structures of Buddhist Meditation provide a common yet unspoken language and coincident worldview, which allow individuals and teams from many countries to sustainably self-organize themselves and their environment so as to create socially-beneficial products, services and processes in unprecedented timeframes – and, moreover, to do this in a way that promotes [self-reported] profound personal growth and joy in all participants. Indeed, one of the intended effects of formal Diamond Way Buddhist Meditation is to improve a practitioner’s creativity and happiness in daily life, to a point where the end-result of practise appears to have the same characteristics as the ‘flow’ observed and reported by Professor Mihalyi Csikzentmihalyi [1990, 1997, 1998; see 2.4.0 and 3.3.1] in any other context. As Csikzentmihalyi [ibid] observed, the end-result of any intensive endeavour to learn and repeatedly apply given rules or processes in changing contexts, the latter of which also requires and enables creative novelty and freedom of response, and is characterised by enhanced awareness and potentially a kind of ‘peak experience’ [latter term from Maslow, 1964]. It also often includes game-like elements Csikzentmihalyi [1990]. That all said, it was not intended that using the Innovation Map would replicate the experience of practising
Meditation per se and it should not be assumed by the users of the Map [or readers of this Dissertation] that the Map or Game ‘delivers Meditation’ to its users. That the effect of using the Innovation Map in teams is strangely similar to the effect of repeated Meditation in individuals is probably unavoidable, since the structure of both Map and Meditation are the same – in the same way that a Hollywood screenplay may repeat and abstract –thereby making obvious – the acts of someone’s life-story. Furthermore, the structure of both Map and Meditation, as suggested in 1.2.3 and 5.1.0, may owe their existence to a more fundamental pattern, or intrinsic nature, of creation and innovation that is evident in most or all acts of creation. As is explained in sections 3.1.0, 3.1.1 and 3.1.2, the only reason that Buddhist sources have been used for inspiration by this author at this point in the history of understanding the mechanisms and process of innovation, is that Buddhist teachers apparently identified and described a kind of fundamental pattern for creation and innovation by another name, which Western Science had not previously described, and which can now be applied to clarify and enhance innovative flow for individuals and teams in Western business and Engineering contexts. Massive multiplayer video-gamers are, perhaps, not far behind in producing similarly innovative flow in both individuals and teams, according to Jane McGonigal in ‘Reality is Broken’ [2011], and would make another topic worthy of exploration. However to discuss the mechanisms of modern gaming as well as the mechanisms of Buddhist practise in respect to the nature of innovative behaviour is beyond the scope of the current Dissertation.

iii. as a source of design inspiration or metaphor for developing a larger-scale programme of innovation around the Map and Game artefacts, that is experienced as a journey toward mastery. This means the basis for using the Innovation Map to structure not just a two-hour game nor merely a two-day process, but also a two–year or longer Innovation Programme, wherein each participant may enter at their own speed and capacity, and yet join with others and traverse common territories in order to achieve common goals, is that Diamond Way Buddhist practise is also fractal in the same way. This fractality, in turn, means that the steps of Meditation are also built into, and visible as, the steps of a larger journey. In short, formal Meditation to overcome theoretical or conceptual obstacles on a personal or local scale is not considered enough to reach mastery in Buddhism. Everyone is expected to aim at a heroic, world–changing goal that overcomes ‘real’ obstacles on the larger scale of society or world, and not remain sitting on a cushion. Thus the structure of Buddhist practise includes a ‘Hero’s Journey’ similar to that identified by Joseph Campbell [1949], and in each individual Meditation, as well as in the larger journey, a student combines Tools, Team and Teacher in a template of seven steps moving back and forth between two worlds, as well as transcending them. This journey is briefly discussed in section 3.5.2, and again later in 6.6.1.

In any case, in ordinary creativity and innovation as well as Buddhist practise, the use of archetypal or non–verbal patterns allow participants of an exercise to cut through the psychological baggage that accompanies over–familiar terms and excessive words. Buddhist methods may have been intentionally designed this way, in order to liberate users from the ‘fixation’ associated with verbal concepts [this term is from Eckert & Stacey, 2001, 2003] and enable a continuously fresh view and experience of one’s world. This author therefore considers the Diamond Way Meditation structure to be comparable to the structure of Western Innovation Tools, as well as the strategy of games and gamification [see Chapter 2], and calls the simplification and integration of Buddhist Methods with Western Scientific language ‘Buddhist Technologies’, for want of a better term.

Buddhist Technologies thus provide the basis for use of the Innovation Process Map explained at length in Chapter 5. When this Map is integrated with some elements of basic TRIZ theory [as defined in section 4.3.0], it produces the PRIZM Game, as a happy by–product. The use of the Innovation Map also lifts the TRIZ Tools and their worldview out of their Russian context and helps them become relevant to the West – in other words, simplifying the use of TRIZ is one of the first benefits of using Buddhist Technologies in Engineering Design, as outlined in section 1.2.6.

1.2.5 The Innovation Map, Inspiration Cards and PRIZM Game

A thorough explanation of the Innovation Map and PRIZM Game are given in Chapter 5. In this section, the Innovation Map, Inspiration Cards and PRIZM Game are briefly introduced as artefacts, which pre–date this Dissertation, but which can explain, and, conversely, be better explained, through reviewing the existing knowledge and literature about innovation and
Buddhism [in Chapters 2, 3 and 4] and through the applied research, which is presented briefly in the next section and in detail in Chapters 6 and 7.

The Innovation Map

The Innovation Map, which is fully explained in Chapter 5 of this Dissertation, was created by Anja-Karina Pahl of The PRIZM Game Company Ltd in June 2005. It was originally developed for teenagers studying innovation and problem-solving in design, in the Key Stage 3 Design and Technology Curriculum at UK high schools.

The Map outlines seven steps and three stages of creation and innovation over the figure of a diamond, as shown in Figure 1.1. In this way, the Map intends to represent the minimum number of issues to be addressed during the phases of ‘divergent’, ‘convergent’ and ‘inspirational’ human thinking that takes advantage of multidisciplinary information [see section 2.4.3 for details]. It is generally printed on a 1.5m² vinyl canvas that is laid on a table to aid team discussion during design of products and processes. Five team members can fit around a single Map, in addition to a facilitator, coach or teacher. As questions are asked and answered by the team, the Map is populated with Post-it notes [Figure 1.2].

The divergent thinking phase outlined on the left hand side of the Innovation Map is not a phase of brainstorming, as is generally expected in lay ‘creativity’ [see 1.2.1, 2.4.3 and 2.5.0], but three steps for problem-finding. In other words, the first three columns require participants in the process to unpack very precise details of the problem they believe they face. They are asked to define their issue in terms of the three most fundamental divisions of the material universe; [i] required materials or structures, [ii] actions, functions or behaviours, as well as [iii] space and time [see sections 5.1.0 and 5.2.0 for details].

Figure 1.1. The PRIZM Innovation Map has the form of a diamond in the background, to outline the three stages of human thinking during problem-finding and problem-solving; divergent on the left, convergent on the right and inspirational or transformational in the centre. The Innovation Map that existed at the outset of this Dissertation, as shown above did not have exact instructions for the second–last step [column] of the process. This was modified after 12 months to include titles and instructions for that step [cf. Fig 5.1 and see sections 5.2.7 and 7.3.0].
The central part of the Map [ie. the rainbow-coloured column in Figure 1.1] represents a single idea-generation step. This step is further discussed below, in terms of the Game.

Then, on the right hand side of the Map, the phase of convergent thinking is represented in three more steps. These provide details for evaluating the ideas which have been generated in the previous phases of work, and for synthesizing combinations of the strongest ideas. The end result of the process is a set of three ‘business cases’ or technical prototypes.

Used as an aid for early stages of Design, the Map is intended to exhaust the user’s possibilities for asking questions and capturing discussion around the issue in question and provide better quality knowledge-capture, as well as better quality idea-generation and faster idea-evaluation. The facilitator of the session must take care that for each variation on the original problem, and each diversion of these variations into other technical or social domains that the discussion [questions and answers] is captured on a separate Map, and not mixed into the first Map. To be lax on this front can undo the reason for having the Innovation Map in the first place, since the only reason for its existence is to clarify a process or journey that seems initially confused.

The Map can be used as a Game when it is combined with other Thinking Tools that enhance its capability to draw out problems or ideas from participants at any given step [cf. section 2.6.1]. In particular, the Map is usually combined with the Inspiration Cards outlined in the next part of this section [and in more detail in Chapter 5].

When the Map and Inspiration Cards combine in a Game, play is very fast – some steps take as little as three minutes and the whole process takes a maximum of 90 minutes. Better yet, when the Game format is used, a facilitator is not limited to coaching 5 participants intensively over a single Innovation Map. Many tables can be set up with Maps and run concurrently – in the PRIZM Game Company, Games have been run at youth events with up to 200 concurrent players.

The Inspiration Cards

As just mentioned above, the Inspiration Cards are the mechanism that allow the Map to be turned into a Game for technical product development, on top of its use as a pedagogical and coaching or training framework.

![Figure 1.2. One of the [black set of] PRIZM Inspiration Cards, front and back.](image)

The PRIZM Inspiration Cards exhibit photographs on the front, plus a written instruction and associated graphical icon or ‘quasi-chemical’ equation on the back [Figure 1.2]. Each card is psychologically coordinated so that the photograph and icon support the written instruction; which is itself a very short, simple form of one of the 40 Inventive Principles from TRIZ [explained more fully in Chapter 4]. In this way, the cards appeal to four different learning styles; visual, verbal, mathematical and tactile. It is worthwhile noting, however, that the Inspiration Cards are not the only way in which elements of TRIZ are, or can be, integrated within the more generic process of the Innovation Map, even if they are the most obvious one.
There are 65 cards in total, arranged in nine colours, according to the nine kinds of problem, which can be set up in the divergent thinking phase of the Innovation Map. This means, for example, that red cards match up to what is called a ‘material–material’ problem, and black cards match up to ‘environment–environment’ problems [see sections 4.4.0 and 5.2.0] and are considered at the end of an arrow on the Map, where this kind of problem has been very clearly defined in the two previous steps. Sometimes identical instructions are repeated as ‘answers’ on different coloured cards [eg. the instruction ‘make things move and adjust’ appears several times in different places in the whole set of Inspiration Cards], however they do not mean the same thing to players in each case – each instruction should mean something different every time it is considered according to the context [or colour] of the problem that is being answered. As a result, when the Inspiration Cards are used in the idea-generation phase of the Innovation Map, the combination of Map and Inspiration Cards provides inestimably more exact and higher value answers for participants in the process, than would be possible by brainstorming alone [see sections 6.1.0 and 6.2.0].

The use of the Inspiration Cards plus Innovation Map in a Game is shown in a series of three figures below [Figure 1.3. a, b, c].

Figure 1.3 [a]. Participants define the details of their problem [in nine categories] and populate the left-hand side of the Innovation Map with post-it notes. The Inspiration Cards wait, colour-coordinated according to their problem-type, in the central step.

Figure 1.3 [b]. The problem is defined in nine categories and the left-hand side of the Innovation Map is populated with post-it notes. Participants are now discussing the Inspiration Cards in the central step of the PRIZM Game.
Why the Innovation Map is the basis for this Dissertation

That the Innovation Map and PRIZM Game pre-date this Dissertation is due to fact that the author of this Dissertation possessed just enough knowledge of unified theories, Buddhism and TRIZ, thanks to her previous employment and personal interests, that she could intuit the synthesis of a Map artefact and Game process from these fields, and expect that it would be useful for young people learning innovation at school [as stated in the background of the report at the very outset of this Dissertation and section 1.2.3]. While the artefact did indeed appear useful in this context, the justification for its existence was both unproven in an academic context and untested in a commercial sense. Obviously, in order to make a useful contribution to scientific knowledge and prove the Hypothesis stated at the outset of this Dissertation, both of these gaps would need to be filled.

Several things would be necessary – for example; [i] to review the literature of all possible fields of human endeavour, which had been recorded elsewhere, to determine whether or not the Innovation Map did indeed cover all relevant steps of creation or innovation; [ii] to make explicit the previously secret Buddhist teachings, which had informed the intuitive development of the Map; [iii] to test the actual process of using the Map with real-world and real-time technical Design rather than youth, both on its own and against competitors – and then, assuming it worked well in that context, improve and streamline the process of applying it [see also section 1.3.0]. Thus, while the Innovation Map pre-dates this Dissertation, the academic proof for a generic process of innovation and a streamlined and improved technique for applying that generic process to benefit Engineering Design have necessarily evolved during the course of this research.

1.2.6 Applying the Innovation Map to Engineering Design

One of the first benefits of applying Buddhist Technologies to Engineering via the Innovation Map is its effect of simplifying TRIZ. 

Due to the strength of its research on Engineering patents, TRIZ has, from around 1990 until recently, been considered the best methodology for innovation in Engineering in the West. However, as evidence from Chapter 4 indicates, the way in which it is currently taught and used in English–speaking countries, is complex and unstandardized. All consultants teaching the system have different approaches and explanations for different parts of the system. There are presumably two main reasons for this:

First; even though it has a basis in rigorous research of patents, TRIZ has no basis in rigorous research of the innovation process. This is because Genrich Altshuller, the originator of the system, looked only at Engineering patents. In these, he abstracted a list of 1521 problems and 40 solutions, presenting this in a Matrix [of contradictions], which could be used to shortcut the
process of finding one's own answers to a problem. It was an admirable and useful exercise, yet patents are the end-result of a long process of thinking and say nothing about the process of thinking itself. There are no published papers which show Altshuller did any research into the thinking process of Engineers, nor of the thinking process of creators in any other industry. The author of this Dissertation thus challenges his claim to have synthesized a true theory for inventive problem-solving.

As there is no recognisable repeatable and hence teachable theory to speak of in TRIZ, each consultant training Engineering Companies in TRIZ must present his own version of the technique. And, as benchmarking studies in Chapter 4 [section 4.3.1] indicate, the teaching and application of TRIZ philosophy and methodology thus takes anywhere from five days to five weeks. Furthermore, the benchmarking undertaken for the Dissertation indicates that real-world, post–training application of TRIZ in most industries is generally under 3% of people trained. Few individuals appear to immediately understand the methodology and can apply it under their own steam to produce great financial benefits for their company. Instead, it is more usual that the return on investment on training a whole segment of a company with ‘basic' and ‘advanced' TRIZ [as defined in Chapter 4] is low and can create a strain on the financial resources for developing a sustainable innovation culture [Pahl and Newnes, 2007].

Second; Russian Masters translating TRIZ for use in the West never clarified that TRIZ has an implicitly Marxist background. Marxism is a philosophy and proto–non–dualistic view of the world, which Westerners do not learn at school and have little practise understanding. As a result it seems that Westerners also do not easily understand ‘contradiction’ and its resolution – one of the main principles of Marxism [which is in turn based on Hegelianism; see sections 1.2.2, 2.4.2 and 4.2.2], and in turn a primary principle on which TRIZ is based. It is an ‘industry in-joke’, albeit said with reverence, that the Russian 'Masters' of TRIZ seem like magicians, due to their implicit understanding of the use and resolution of contradiction in technical problems. It is a premise of the author of this Dissertation, related to the question about worldview above, and explored at length in Chapter 4, that without a non–dualistic cultural background and related starting axioms, the set of TRIZ Tools will inevitably seem incoherent to Western newcomers. This may be one reason that, for all its strength and in spite of great initial enthusiasm by new Western users, not even the most simple and important tool in the kit – the Contradiction Matrix– is widely applied after training [Pahl and Newnes, 2007].

As Chapters 5 and 6 will show in detail, Buddhist Technologies integrated in the Innovation Map can help provide the non–dualistic worldview, which is required for Engineers to get more from TRIZ, in a way that can be hidden in the process, and is thus more elegant and simple than learning about Marxism. Simply put, the Innovation Map and associated Game outlined in Chapter 5 reduce teaching of the components of the Contradiction Matrix and other so-called ‘classic' and ‘basic' TRIZ Tools [defined in 4.3.2] to under 90 minutes. This is possible because the Innovation Map fills the two significant gaps [outlined above] which were left by the originator of TRIZ and the Western community of consultants. In addition, they can be immediately applied on one’s daily work, without examples, saving significant time from the training budget.

In the course of this research, as is introduced in section 2.5.0 and section 4.3.0 and then covered in detail in Chapter 6, the PRIZM Innovation Map and Game were tested in an internationally–leading Engineering Industry with Design, R&D, assessment/test and Manufacturing hubs in several countries [hereafter also called The Collaborator, The Industry Collaborator, The Company or The Engineering Company – the name and sector are withheld for reasons of industry confidentiality], in direct competition with TRIZ Tools. The PRIZM Innovation Map proved itself not only in benefiting TRIZ users, but also on its own. Over four years of testing, the post–training use of TRIZ, when it was taught with the PRIZM Innovation Map varied from 10% to 30% of initial course participants [significantly higher than the 3% industry standard identified in benchmarking in Chapter 4, for post–training use of TRIZ on its own]. The use of the PRIZM Innovation Map also appears to significantly increase innovative output of individuals and teams in early stages of Engineering Design and product development, compared with using other Innovation Tools, or no Innovation Tools. And most importantly; the use of the PRIZM Innovation Map on its own, applied in workshops or training sessions [of only two days duration] lead to highly significant technical and financial results in 37 of the first 40 user–groups, including:
implementable business solutions,
• technical patent submissions
• lead-time savings.

Finally, the method tested in this Dissertation remedies additional issues which are currently recognized as pitfalls in TRIZ training as well as in Innovation Management and development of an innovation culture. Namely:

• how to engage teams and capture and streamline their unstructured ideas, information or knowledge,
• how to rapidly transform multidisciplinary information or stakeholders in new, integrated ways of thinking or working,
• how to take Engineering Designers from a worldview of problem-solving to a worldview of solution-finding – preferably one in which the solution is already inherent in the system resources.

In short, the research findings presented in Chapters 6 and 7 of this Dissertation aims to provide definitive confirmation that use of Buddhist Technologies is of benefit to Engineering Design in the form of the Innovation Process Map, on the three levels of; cost, simplicity and excellence.

1.3.0 THE RESEARCH PLAN OF THIS DISSERTATION

The first step in this research took place after conception and preliminary commercialization of the PRIZM Innovation Map and Game. This step was to elucidate the fundamental pattern of creation. The project involved two six–month literature reviews revisiting previous data [from this author’s first unsubmitted PhD in Australia] and compiling summaries that matched formal Buddhist Meditation and TRIZ thinking with knowledge of the processes of creating, creativity and innovation in Western Science and business. It also involved a one–month survey of the state–of–the–art of Innovation tool use in the Industry Collaborator in 2006. Two invited papers resulted; in the Journal of Design Research [Pahl, Newnes and McMahon, 2007] and in the Insite Journal [Pahl and Newnes, 2007].

The second step of research was a nine–month Pilot Test in Engineering Design in Europe with The Industry Collaborator, exploring the use of the Innovation Map as a benchmark for designing company–wide training in TRIZ, and as a framework for a Systematic Innovation programme. As a consequence of this success, the PRIZM Innovation Map and Game was also tested as an Innovation Tool in its own right, in direct competition with a training and coaching programme with its now nearest competitor, TRIZ. A total or 130 Engineers were involved at this pilot stage. At the end of this time, a go–ahead decision on wider use of the Innovation Map and Game was made by the Industry Collaborator.

The third step of research was two nine–month projects implementing and validating the PRIZM Game and Innovation Map in various Engineering Design projects involving a number of The Collaborator’s Design and manufacturing sites. This involved running training sessions on Tools for up to 25 participants, as well as real–time team workshops and real–time individual coaching on issues that needed a resolution in timeframes of less than three months. In total, this part of the evolving Systematic Innovation programme involved 440 people [mainly male] of varying age and experience, and was carried out over many stages of product development from early–Design phase to manufacturing. While continuing to grow the network while writing this Dissertation in 2009–2010, an additional 440 people joined the programme, to total over 1000 Engineers.

1.4.0 OUTLINE OF CHAPTERS IN THIS DISSERTATION

This Dissertation is presented in the format of the steps of the actual Innovation Map, whose existence is its main subject. It thus has seven Chapters – one for each step defined in the Map. Headings of each Chapter are described with the exact same words as are used on the Innovation Map. The content of the Dissertation is presented in the same manner that an innovative problem would be discussed while using the Map.
The background and intentions of the Dissertation are presented here in Chapter 1, followed by this outline and a summary of the hypothesis and ‘Ideal Final Result’ of creating the Innovation Map and Game, which are the subject of the Dissertation. The research methods are presented and the claim for PhD is also made at the conclusion of this Chapter.

Chapter 2 outlines the major Western Tools for creativity and innovation. First, creativity and innovation are defined for the purpose of this Dissertation. Then there is a general introduction to the topic in Engineering Design, followed by a summary of relevant research on creativity from the humanities [with an emphasis on psychology]. The steps of the processes of creation reported in these contexts are tabulated. This tabulation assists in visualisation of the overlaps and correspondences between different disciplines, and hints at the underlying pattern of creation and innovation, which is described more fully in subsequent Chapters. The Collaborator’s view of Innovation Tools is presented and finally, some of the best-known commercial Tools are placed into their strongest position in the process of creation – a new taxonomy of Innovation Tools for Engineers is thus presented. The Chapter concludes with a discussion of the measurement of innovative outcomes of the PRIZM Innovation Map and Game and suggests that even this small change can create a step change for Innovation in Design.

Chapter 3 introduces the concept of ‘Buddhist Technologies’ – being the use of methods of Diamond Way Buddhist Meditation as an adjunct to, and potential reference frame for, understanding creativity and innovation in Western Science, Engineering and business. The key points covered in this Chapter deal with the creation [or also ‘emanation’] of an ideal world, inclusive of a hierarchy of three main principles and five ways of interacting with conceptual and physical spaces. The points covered from 2500–year–old [and previously mainly orally transmitted] Buddhist teachings are first reframed in a modern way and then re–contextualized as they are integrated with Western research on creativity and innovation.

In Chapter 4, the fundamental concepts of TRIZ are reframed and simplified. Misunderstandings are addressed, which have occurred as TRIZ moved from Russia to America to Europe. The fundamental concepts of TRIZ are not different to the fundamental patterns proposed by Buddhist Technologies and the Innovation Map, and both sources are built upon, to suggest improvements to existing Innovation Tools, processes and culture. Evidence from a Pilot Test in the Engineering Company is provided as an example of the status quo of TRIZ training. Then all the Tools of basic TRIZ are put in a context which is a prelude to the Innovation Map of the next Chapter.

The Process Map for innovation is fully explained in Chapter 5. This map synthesises all the theories and Tools discussed in previous Chapters, in a simple three–stage, seven–step model. In a highly visual form, the Map makes obvious how the crucial problem–definition phase [also hereafter called problem–identification, and problem–finding, after Getzels & Csikszentmihalyi, 1975; Csikzentmihalyi and Getzels, 1988] of innovation can be simplified. Research shows that a problem can be described simply and systematically using the ‘natural language’ [this author’s term for a grammar, vocabulary or other mode of communication that is both common and simple to communicators] of Engineers in three steps; identifying a cause–and–effect relationship of two parameters [one wanted, one unwanted], and pattern–matching the so–defined problem to a pre–existing solution. The problem is almost automatically ‘transformed’ into a solution, not as the result of chance or genius and not only as the insight of the originator of TRIZ, but through the mechanisms adopted from Meditation, which explain how mental concepts are concretised from, and re–dissolved into, an ideal conceptual space. The act of taking new information into an old space transforms two worlds – symbolized by ‘Arrows of Innovation’ borrowed from the process of emanation in Chapter 3. The interrelation of a conceptual space [i.e. mind] and physical space [i.e. space] described in Buddhism explains the cyclic nature and complexities of co–evolution of the Design Space in Engineering.

Applications of the PRIZM Innovation Map and Game during its first four years in Engineering Design are outlined in Chapter 6. The finer details of problems solved and results achieved are confidential, but the general schema of how the Innovation Map and Game work in different contexts is discussed. A summary of the key results from workshops involving 1000 participants on eight sites is provided, along with real–time returns in terms of Engineering solutions implemented, patents submitted and lead time saved on projects. The Innovation Map and Game also provide the framework for an innovation deployment programme, which is potentially self–sustaining and integrable into existing company work processes though bottom–up growth. This is due to the unexpected benefits of improving team communication in multidisciplinary teams,
facilitating transparency of problem situations, and providing a common language for communication, which in turn leads to greater confidence and joy in innovative behaviour.

Chapter 7 concludes that the results achieved by using the PRIZM Innovation Map and Game are ‘cheap’ to make and sustain in terms of employee time and direct financial costs. The Map is relatively ‘simple’ for the End-User to grasp and also makes simple improvements to previously complex or misplaced creativity and Innovation Tools, including TRIZ. It provides a simple benchmark for ‘Systematic Innovation’ [the consulting industry term for innovation related to or derived from TRIZ]. Finally, the experience of using the Innovation Map in the PRIZM Game achieves the kind of elegance and excellence result wished for by Innovation Managers and as intended by the Buddhist method on which it is based. It liberates fixation, enhances personal joy and confidence, elevates the team spirit and communication and makes the discipline of following a structure easy to adhere to; resulting in streamlined results and improved productivity. The Systematic Innovation Programme for bottom-up Innovation, which was developed for the one specific Engineering Industry described in this Dissertation, based on the PRIZM Innovation Map is transferrable to any kind of Engineering project and any level of expertise. In addition, it can be used in other industries and was already successful in preliminary tests in education, banking, advertising, food technology and customer service. However this is only a first step in application of the Map and Game, so the chapter includes an overview of the limitations, weaknesses and lessons learned as well as potential further applications and improvements before proposing that the Innovation Map does indeed fulfil its claims of contributing to the knowledge and practise of Innovation in Engineering Design.

1.5.0 THE INNOVATION PROCESS MAP CLAIMS

For her Doctorate, the author claims that:

1. The PRIZM Innovation Map and Game is the first map of a fundamental pattern of creation and innovation. It is also the first practical process for using the fundamental pattern of creation and innovation to improve innovation and team communication in Engineering Design. The Map and Game are also the first application of Buddhist Meditative structure in Engineering Design. Together, the Map and Game provide the first common language and hence the first Western standard and process map for the entire process of innovation, in a way that is fractal, co-evolving and emergent. The Map proves that Buddhist Meditation [aka ‘Buddhist Technologies’] can provide useful insights for the Engineering Design process.

2. The PRIZM Innovation Map and Game has three integrated functions no other Thinking Tool has been proven to have. Namely, it:

- Streamlines the way Designers ask questions so that they find ‘the right problem’ to solve. This is a key indicator of historically significant innovation.
- Provokes ‘focussed idea generation’, at a rate of 100’s of ideas per hour, by introducing previously successful databases of solutions which are ‘pattern-matched’ to selected problems only. This hugely shortens the time needed to find new and useful solutions.
- Provides a rapid, consistent method for evaluating, combining and strengthening the generated ideas, which enables teams to produce an average of 10 commercially useful results concluding each application of the Map in less than one day real-time work.

3. Significant benefits are achieved by understanding and applying the fundamental pattern of creation and innovative behaviour to daily work. In particular, the use of the PRIZM Innovation Map and Game dramatically improves:

- Material product development and productivity of internationally competitive solutions in high-end technical industries, ie. efficient or ‘Cheaper Innovation’ [cost benefit to maker]

- The didactics, teaching and application of commercial creativity and Innovation Tools [including but not limited to the Russian TRIZ system] and the academic understanding of problem-solving, creativity and innovation ie. ‘Simpler Innovation’ [use benefit for user].

- Multi-disciplinary team communication, better decision-making and personal joy. The experience of transparency, equality and ‘freedom from idea fixation’ is increased by providing a common language to individuals and teams, which is repeatable at several scales and encourages a self-sustaining ecosystem of innovation. ie. ‘Beautiful Innovation’ [excellence benefit for society].
Chapter 2  WESTERN TOOLS, METHODS & MODELS FOR CREATIVITY & INNOVATION: Where We Are Now

Chapter 2 outlines the major Western Tools for creativity and innovation. First, creativity and innovation are defined for the purpose of this Dissertation. Then there is a general introduction to the topic in Engineering Design, followed by a summary of relevant research on creativity from the humanities [with an emphasis on the psychology]. The steps of the processes of creation reported in these contexts are tabulated. This tabulation assists in visualisation of the overlaps and correspondences between different disciplines, and hints at the underlying pattern of creation and innovation, which is described more fully in subsequent Chapters. The Collaborator’s view of Innovation Tools is presented and finally, some of the best–known commercial Tools are placed into their strongest position in the process of creation – a new taxonomy of Innovation Tools for Engineers is thus presented. The Chapter concludes with a discussion of the measurement of innovative outcomes of the PRIZM Innovation Map and Game and suggests that even this small change this can create a step change in Innovation in Design.

2.1.0 DEFINITIONS OF CREATIVITY AND INNOVATION

‘Innovation’, in business today, is largely thought of as the process of commercializing a new and useful idea, intended to be distinct from a process of ‘creativity’ or creation, which does not always have this end in mind [Plsek, 1997; and Gryskiewicz, 2000 for instance define innovation as ‘the implementation of creative solutions’ and see below]. More accurately however, according to its Latin root, innovation is not necessarily about a ‘back–end’ of creation, but about making something new [L. novare] inside [L. inne] a presumably older state. As already introduced relatively extensively in section 1.2.1 [and as will be revisited in 3.1.2, 3.2.1 and 3.3.1 as well as sections 4.4.0 and 4.5.0 and sections 5.2.5, 5.2.5 and 5.4.0], the definition of innovation which is emphasized in this Dissertation is not only distinct from ‘creation’, which about making something new, and ‘renovation’, which means to restore something old to an ‘as–new’ state. As implied by its Latin root, the main definition of innovation in this Dissertation is about the transformation of the two kinds of information or indeed worlds involved, which can be said to be the distinguishing mechanism of innovation.

‘Creativity’, is tautologically defined in many dictionaries and in popular use, as the generation of novelty, even when this does not coincide with usefulness. On the other hand, academic researchers such as Boden [1990] distinguish historically significant or ‘H–creativity’ that has socially obvious success and usefulness of some measure, from creativity which is novel and significant only to the person generating it ie. personal or ‘P–creativity’. Sternberg & Lubart [1995] and Amabile [1997] similarly define creativity and ‘business creativity’, respectively, as the production of novel and appropriate solutions to organisational problems [cf. Plsek 1997 and above]. The other major contributors to modern definitions of creativity are treated in more depth in section 2.3.0 below.

Suffice to say here that, given the terms ‘innovation’ and ‘creativity’ are etymologically unrelated, it is perhaps little wonder that the concepts are also notoriously ill–defined and separated in the historical literature of all domains [Taylor, 1988 cites 60 references], for as Csikzentmihalyi [1990] points out, ‘...each researcher looks only from the perspective of his discipline. Therefore, in economics and business, creative processes are called ‘entrepreneurship’, in sociology [they are] ‘innovation’, in history and literature [they are known by] a variety of terms, and in psychology and education [as] creativity’. However, for this Dissertation the author refers to creativity and innovation as interchangeable – firstly because allowing a new thing to grow inside an older one [‘Inne Novare’] can still be considered an act of creation, and secondly because when the ideal innovative act implied is mathematically defined, it is recursive and potentially fractal, creating ‘something new within something just a little older’, over and over again [cf. the hallmark of creativity mentioned in section 1.2.1]. This definition and associated
The interchangeable use of the terms creativity and innovation makes it easier to determine the overlaps and correspondences between the ‘steps of creating’ and innovating in different disciplines. Indeed, these suggest there is an underlying or fundamental pattern of creation and innovation – introduced in Tables 2.2, 2.3a and 2.3b of this Chapter and ultimately presented in Chapter 5. The interchangeability of creativity and innovation also makes it easier to assess the best-known commercial Tools according to their main function. Together, this enables a short taxonomy of Innovation Tools to be produced for Engineers at the conclusion of this Chapter.

2.2.0 THE ENGINEERING DESIGN COMMUNITY – A GENERAL OVERVIEW

As the survey of Engineers in this Chapter [section 2.5.0] indicates, the professional Engineering community seem greatly divided on the question of how best to use formal creativity or Innovation Tools to assist product Design. This is perhaps not surprising given that over 110 commercial and popular approaches, methods, models, Tools and techniques, processes and checklists for enhancing creativity and innovation in different areas of business, education and Science were identified in the literature review of this Dissertation.

It appears from the lack of theoretical background and cross-referencing in historical data, that many of these Tools were created in a bespoke fashion, in isolation from each other. Typically, Tools seem to have been ‘made to fit’ the circumstances and language of only a certain type of industry, mindset or commercial purpose and their subsequent popularity grew through word-of-mouth transfer to similar industries, rather than through objective validation of the theory or structure. The author of this Dissertation proposes that due to the historic genesis and application of Tools in specific contexts, they have been applied in new contexts, without proper training on the techniques of application from the originator of the Tool and thus in an ad hoc way. This may explain the variable effectiveness and unclear benefits for highly technical industries, and it may explain why Innovation Tools seem to have been disregarded in early phases of Engineering Design, as the survey in the Industrial Collaborator indicates [section 2.5.0].

The author of this Dissertation proposes that some confusion as to the use and benefits of these Tools can be clarified in also clarifying the process of innovation, in the same way that baking is clarified in the process of following a recipe. It is crucially important to know not only in which order to add various ingredients, but also in which order to use the various baking tools. In the same way, it is probable that existing Innovation Tools would also work better, if they could be placed in the context of a ‘recipe for innovation’. And, since not one of the currently available Tools completely describes such a process of innovation nor provides a context or reference frame for the rest, this leaves a gap for a generic Tool or map to provide a foundation or umbrella for all Tools. Without a benchmark such as this, it is difficult for researchers and practitioners to undertake an objective analysis of Innovation Tools, to improve one or other of them in particular, and create a taxonomy that improves innovation in general. In other words, Engineers are missing both a taxonomy of Tools and a standard or common knowledge of the steps of the process of innovation itself – as LaFleur [1992] states, ‘a generic representation for Design problems is needed’.

Apparently it is also not only Engineers who suffer from this fate – psychologists likewise appear to have no commonly agreed view of the steps of the innovation process, as explored more fully in section 2.4.0 below. It would seem that prior to this study, there has been no multi-disciplinary comparison or integration on the thinking steps followed during creation or innovation – even, or especially, when it is undertaken without supporting Tools. Such comparison and integration is the ideal result of the Dissertation.

In order to address this issue, three phases of preliminary research were intended to ascertain the state-of-the-art, identify what Engineers require and define where gaps exist in the domain, that would need to be filled. These are as follows;
Phase 1. A review of the academic literature in the domains of Engineering and Humanities and Business [sections 2.3.0 and 2.4.0 of this Chapter]

Phase 2. An evaluation of Tools currently being used, primarily through a survey of 49 middle management Engineers within the Collaborating Company to ascertain their understanding of innovation and use of Innovation Tools [section 2.5.0]

Phase 3. Definition of the shortcoming of Tools and what needs to be achieved to make a step-change within the Engineering Design community [section 2.6.0]

2.3.0 THE STATUS QUO OF INNOVATION IN ENGINEERING DESIGN

A comprehensive literature review of Tools in Engineering Design was originally done by Rickards [1980], Cross [1990] and recently in computing by Kicinger et al [2005]. Table 2.1 is a distillation of the important activities and perceptions of Designers from these papers and an additional rough survey by this author of 500 more papers [pre–2005] carried out in 2005. It does not include information on any HCI [Human–Computer Interaction] and ICT [Information Communication and Technology] Tools, even though some researchers hope or intend them to codify the knowledge underlying Design activities [David and Foray, 1995] or clarify the creative steps which transform the Designer’s purpose into the behaviour and structure of an artefact [Gero, 1996; Lui, 2000]. At the time of this review, the author of this Dissertation believed Engineering software solutions perpetuate an intellectual laziness on the part of users, which appears to feed into the coincident lack of feedback to designers of these systems. This assertion is somewhat supported by results from a Pilot Test with the Collaborating Industry, testing the use of Software instruments in competition with the use of Thinking Tools for Systematic Innovation, the results of which are published in a company report [Pahl and Newnes, 2007] but not further discussed in this Dissertation. The author’s survey of Design literature in this section was therefore intended only to uncover how Engineers currently use Thinking Tools to support innovation and/or Design. During that process, the first notable observation made was that the extent of Tool use in different Design steps or phases cannot be easily mapped from the literature since there is no consistency or recognition of common steps of innovation cited in the reports. Engineers do not report their Tool use linked to specific phases of Design, in spite of the fact that the steps of Engineering Design are necessarily and consciously taught in University [and subsequently continue to be intuitively used by all professional Engineers] and in spite of the fact that there have been attempts to define the innovation process in Engineering contexts in the absence of Tools, coincident with a developing a ‘Theory of Design Science’; eg. Cross, 1993). The use of Tools reported in the literature is very unstructured and ad hoc, presumed by this author to be due to a lack of understanding of both the context of the Tools [as intimated in section 2.2.0] and the structure or nature of the innovation process, in which the Tools are being applied. The layout of Table 2.1 reflects this arbitrary nature of reportage, in that it is difficult for this author to represent the main ways in which the Tools are applied in a time sequence, as well as to define groups of similar Tools used over all the literature surveyed. This literature survey makes it apparent that there was no previous research that attempts to link the use of creativity and Innovation Tools to a certain part of the process of Design in Engineering.

This author proposes that there are three more reasons why attempts to define the innovation process in Engineering Design seems to have languished in the last decades.

First; the Engineering community has historically been rather reticent to consider that creative Design may be a systematic, scientific process rather than an art – as pointed out by Dixon and Finger [1989]. That is proven, on the one hand, by the enormous number of case–studies published in the last ten years, which comment on innovation or creativity or ‘novelty in Design’ and the use of Tools as outlined above. And it is proven in converse, by the very few reports of rigorous experiments on the actual process followed or involved, and a great absence of any useful information on innovation being referenced or transferred from other disciplines. In particular, Engineers have not drawn upon the fields of psychology, education and business, even though these other researchers have somewhat more experience in the identification of socially useful creativity and innovation, as outlined in section 2.4.0 of this Chapter.

Next; there is little cross–fertilization between or integration of the concepts or theories which have been proposed by Engineering researchers in different countries [eg those of Suh, 1984;
Hubka and Eder, 1988; Yoshikawa, 1981; Checkland and Scholes, 1990; Hatchuel, 2002, Hatchuel and Weil 2003; Gero and Kannengiesser, 2002, 2004]. This means there is little external consistency between the best-known models for innovative Engineering Design, which is not helped by the fact that all these models are initially highly complex in themselves.

TABLE 2.1: Tools and processes reported in use by Engineers in respect to a search on 'creativity and innovation in Design', in over 500 papers in journals including: Design Studies, The International Journal for Human–Computer Studies, The Journal of Product Innovation–Management, Creativity and Innovation Management, and Knowledge-Based Systems, among others. Please note that there is no sequence to the arrangement of activities under a particular column heading in the table, nor any correlation between activities located on a particular row.

<table>
<thead>
<tr>
<th>Formal Engineering Evaluation Processes including risk analysis matrices and production models</th>
<th>CAD/CAM/ICT/HCI Tools and software</th>
<th>Maths models</th>
<th>Sketching or Visualization or Analogues</th>
<th>Action research or other social, participatory or descriptive techniques</th>
<th>Tools for idea-generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysis of legislative repts and regulatory standards</td>
<td>Interface standards</td>
<td>Design as information processing</td>
<td>Drawing as discovery, through the different phases of solution</td>
<td>Interviews with Designers</td>
<td>Brainstorming</td>
</tr>
<tr>
<td>Review of commercial competition</td>
<td>Virtual workbench</td>
<td>Maps as conversational Tools e.g. Conversation-makers (not decision-makers)</td>
<td>Observations and case studies</td>
<td>Exploration of possibilities– gap-finding</td>
<td></td>
</tr>
<tr>
<td>Technical literature reviews</td>
<td>Sketches in comparison with geometric standards</td>
<td>Emergent visual and verbal language relating to map system/strategic knowledge</td>
<td>Protocol studies</td>
<td>Collection of loose possibilities</td>
<td></td>
</tr>
<tr>
<td>Life-cycle Design Strategy</td>
<td>Map as a group memory</td>
<td>Simulation trials</td>
<td>Scenarios and consequences</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product-orientation</td>
<td>Use of visual Metaphors</td>
<td>Review of relevant past projects</td>
<td>Identification of barriers</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>'Side-on' views</td>
<td>Review on general themes</td>
<td>Stripping down to fundamental functionality</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Morphological charts</td>
<td>Reflection and theorizing</td>
<td>TRIZ and patent searches</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Annotation [esp in architecture]</td>
<td>Face-to-face conversation</td>
<td>Systematic re-use of recent innovations</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reading books and browsing images, looking at art/ocean</td>
<td>Relationship to expertise</td>
<td>Concept-mapping or mind-mapping</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-linear idea generation</td>
<td></td>
<td>Playing with toys</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Environmental support – making above resources available</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Finally; Engineers in organizations as large as the Engineering Industry collaborating in this Dissertation, face particularly complex and paradoxical problems at the initial stages of a project for which they may not be fully equipped. Design issues are rarely purely technical – they equally include multi-disciplinary communication barriers and many separate conflicting views on a situation. Each variation of a situation can include different stakeholders in the process of sensemaking [Snowden 1998a & c, 2000, 2002; Kurz and Snowden 2002], and, as Gero [1990], Qian and Gero [1993, 1996], Suwa, Gero, and Purcell [2000], Dorst and Cross [2001] and Gero and Kannengiesser [2004] imply, a model for innovation in Engineering Design should ideally and continually reframe or reformulate the perception of the problem, at the same time as it concretises a solution. This is a pre-requisite hardly addressed in existing Tools and such a process of creative Design may be at first difficult to conceive, but would undoubtedly also be easier to understand, if Engineers had a map that could include and transcend all required conceptual spaces in the fields concerned.
Since Engineers are apparently missing information on the innovation process, and this information does not seem to be forthcoming from their own field, it makes sense to consider other domains, in order to start piecing together the map of the process. The next section of the Chapter therefore considers the humanities and business.

2.4.0 THE STATUS QUO OF INNOVATION IN HUMANITIES AND BUSINESS

The survey of literature carried out by this author, of previous research on creativity in various disciplines of the humanities, shows enormous variability in the focus of the topic over the last fifty years – starting with a predominately psychological focus on the 'nature', and 'qualities' visible in the personality and cognition of prominent individuals and children during the 1950's–70's [ie. focus on the individual] This was followed in the broadest sense, by a greater interest and awareness of the 'nurture' of the activity of creativity – including the spatial environments and the social contexts, education and business of teams [ie. focus on the activity – see for example reviews by Yeomans, 1996; Dust, 1999; Rhyammar and Brolin, 1999; Beattie 2000; Craft, 2000]. Most recently, creativity has been considered as a universal rather than merely human activity, including Artificial Intelligence [AI] or simply focussed on the larger process [eg. Boden, 1990; Gero and Maher, 1993; Saunders and Gero, 2001; Gero and Kulinski, 2002]. All three foci are considered important in defining the Innovation Map for this Dissertation, and will be briefly addressed in the following sections, in turn.

2.4.1 The Individual

Craft [2000], Sternberg [1999] and Sternberg and Lubart [1999] summarised the typical characteristics of creative individuals, which are said include, among other things: openness, playfulness, experimentation or willingness to take risks plus the expertise and ability to meet the given challenges and access to one or more [new] knowledge sets, which can be accessed in unexpected ways. These are traits which are being assigned renewed importance and highly emphasized in techniques and technologies focussing on the overt use of 'challenges' or 'gameful' [term from McGonigal, 2010] competitions to enhance idea-generation for innovation in corporations, or indeed to outsource corporate idea-generation to an external crowd. They are also being employed to win profitable massive–multiplayer engagement in videogames, and even to covertly engage participants in learning, leadership and other skilful activities through 'serious games' [McGonigal, 2010 and the Game of this Dissertation]. At the same time Kahn, Zimmerman, Csikzentmihalyi and Getzels [1986] and Csikzentmihalyi and Getzels, [1988] showed that the characteristics of overtly creative people more or less cover the 3 classical dimensions of psychological functioning described by Hilgard [1980] and are a kind of trilogy of mental concerns. These are emphasized differently in different domains and over time, depending on whether acts of creating receive favourable feedback, leading to Boden's [1990] ‘H–creativity' or not. Hilgard's [1980] three traits are ably recast by Csikzentmihalyi [1990] as: [1] the personal value system, which enables decision–making [2] the ability to discover and formulate new problems in a given domain of expertise, and [3] the intention to contribute, despite obstacles from the field of peers and circumstances. What is important about these traits for the purpose of this Dissertation is that they appear to be coincident with the Buddhist contexts and environments in which an individual must act and categories into which space must differentiate, when it concretises conceptual form, which in turn informs our understanding of how innovation must be coincident in individual and context. This will be explored more fully in sections 3.3.1. and 5.2.5. The traits or contexts also appear to be coincident with the measurement system whereby innovation is historically judged – even by those who claim not to use an overt measurement system, but use only internal or implicit [sensory] judgements, as will be briefly explored in section 2.4.3.

2.4.2 His Activity

Since the objective of this Dissertation is to synthesize a simple, useful and yet comprehensive model from as many conflicting theories on creativity and innovation as possible, it is important that the elements of the act, action or activity in which one is creatively involved, can also be grouped simply. The somewhat dated but unsurpassed observations of Arthur Koestler [1964]
on the function and structure of the elements of creative activities, have recently been revitalised by computational Designers [Gero and Kannengiesser, 2002, 2004]. The point made is that there are three crucially important elements of all provocative art, science or humour. Most importantly, whereas two elements may be simply identified as two different and separated worlds or worldviews, the third element is partly hidden, in that it exists only in ‘bisociation’ – the connection of two previously unconnected worlds within the [third] view or world of the observer, where the connection is perceived as existing simultaneously in both places, which are habitually incompatible [Koestler, ibid]. This element, which was introduced as the resolution of dualism in Chapter 1 [see 1.2.2, Gampopa 1998; Tenga Rinpoche 1999; and cf. Hegel 1807 or Kant 1787] and is identified as mathematical and philosophical ‘perspective’ and ‘contradiction’ or the ‘non-dualistic perspective’ of Buddhism, in the latter part of this Dissertation [see Chapters 4 and 5], also leads to important physiological experiences in the moment of bisociation. Apparently, the moment which resolves the tension of viewing two separated worlds, by bringing them into a single frame, also brings about a release that is usually accompanied by a feeling of shock or joy, causing, for example, laughter at a joke.

The main relevant difference between Hegel’s dialectic and Koestler’s bisociation [the latter being more akin to the Buddhist principles of non-dualism, which imply co-existing and co-emerging worlds], is that alternating steps of ‘thesis–antithesis–synthesis’ in a zig-zag fashion never really leads to a satisfying resolution. This type of behaviour is proposed to be typical of the nature of problem-solving in the West, and leads, in the opinion of this author, to an potentially eternal ‘string’ of problem and resolution in a world that cannot transform, because it there is nowhere else to go [see section 5.3.0]. This is the exact form which ‘CPS’, the ‘Creative–Problem–Solving’ of Osborne and Parnes [1976] takes [see section 2.6.1], and in direct contrast with the the nature of innovation proposed in this thesis, which is, according to the desirable outcome of achieving a ‘disruptive’ innovation or technology [as per the term coined by Christensen, 2003] and the definitions earlier in this Chapter, always supposed to open up an entirely new worldview – and can do so, because it includes more than one world in the first place.

It is possible that the action of bisociating or resolving the dualistic discrepancy between two worlds may also be a continual one, not merely in a single joke-like event. For instance, there is always a balancing act between refining one’s apparent skills to match the increasing challenges one faces in a creative task. If these can be resolved in a continuous flow rather than a single event, the author proposes the result is a state of ‘flow’, such as that reported by Csikszentmihalyi [1991; 1997], regarding the experiences of factory workers and musicians, among others. His research shows that when individuals felt they were achieving a personal best in their discipline, they lost a sense of having boundaries between the world with rules they needed to keep to achieve external targets, and the world where they needed to break rules to reach new internal targets. This is further discussed throughout Chapter 3, since it is beyond the scope of the literature review of this Chapter. For now, the next section outlines some relevant basic models available for defining [the rules of] creation in Western psychology as they are generally represented today, even if the creative actions themselves are not considered bisociative or innovative, in the way they have been defined above.

### 2.4.3 The Wider Process of Creativity

Table 2.2 illustrates the commonalities of ‘thinking steps’ recognisable during the creative process, as described in fundamental historical models in the humanities – i.e. Wallas [1926], Rossman [1931] and Osborn [1953]. Psychologists have consistently observed and intuited roughly the same sequence of [between four and seven] steps in all processes of creating something new, and include also two stages – a period of ‘convergent’ thinking after a period of ‘divergent’ thinking [Guildford, 1950]. Observing the commonalities here, the fallacy that innovation starts with idea-generation and goes to market is laid to rest immediately – there is no process of creation that begins with idea-generation. All modern empirical research studies back this up. It is not limitless ‘brainstorming’ [as originally defined in the most popular part of Osborn and Parnes ‘Creative Problem–Solving’ Technique and first described in Osborn, 1950] or random idea-generation that defines creativity [Lonergan et al. 2004]. On the contrary, a creative act must absolutely include acts of identification and pre-selection, as well as post–idea–
Designers today generally accept that the steps of the creative process do not fall into strict linear order. However, the extent of non-linearity is not yet fully known. Vinacke [1953] was the first to argue that the order of stages is not set, and pre-empted a recursive behaviour or cycles of evolution in creation, though he did not explain this diagrammatically. It was Paul Plsek, an Engineering Manager at Bell Laboratories who made the cyclic nature of the process visual rather than verbal [Plsek, 1997 and see Figure 2.1], into which he mapped some of the common elements of what is, for the remainder of this Dissertation, called 'the process of creating', as was partly outlined in Table 2.2. He defined four stages of creative activity including ‘preparation’, ‘imagination’, ‘development’ and ‘action’, also including the concerns of Quality Management. The process of creating that he identified follows the sequence of all creationary or evolutionary processes in nature – namely iterative variation, selection and transmission [Campbell, 1960; 1974].

The circular representation of the process of creating is visually arresting and brings home the point that there is a cyclic nature or potential ebb and flow of creation and innovation. One could argue in retrospect that the cyclic ebb was always implicit in the recognition of a need for a period of ‘reflection’ [in the sense of contemplation or ‘rumination’ eg. Osborn 1953] or incubation in the process of creating. This same fact is also exploited in 'Action Research' as a method of enquiry into Engineering Design [eg. Visser, 1994; Valkenburg and Dorst, 1998; Lauche, 2001; cf. Wadsworth 1998 and see 3.1.1]. The cycles of creation are increasingly addressed in AI [though not Software instruments for innovation], where they are considered to account for co-evolutionary or emergent patterns transforming the space of both problem-finding and problem-solving [eg. Gero and Kazakov, 1998; Gero and Kannengiesser, 2004 and further addressed in section 3.3.1]. However even though there are cyclic or recursive phases of the whole innovation process as well as of parts of the process of innovation, this author argues that a circle is not the most useful representation for the process. For the purpose of creating an appropriately detailed and common language or map for innovation in the first instance, a tabular format allows an easier comparison of the steps of creating in different disciplines –this being a crucial exercise to carry out [see 5.1.1]. A Tabular format also lends itself to elucidation

<table>
<thead>
<tr>
<th>Commonalities</th>
<th>Wallas 1926</th>
<th>Rossman 1931</th>
<th>Osborn 1953</th>
<th>Plsek 1997</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Problem or situation definition</td>
<td>Preparation</td>
<td>Observation</td>
<td>Orientation</td>
<td>Prepartion</td>
</tr>
<tr>
<td>2</td>
<td>Analysis of need</td>
<td>Preparation</td>
<td>Observation</td>
<td>Analysis</td>
</tr>
<tr>
<td>3</td>
<td>Incubation</td>
<td>Formation of object solution</td>
<td>Ideation [alternatives or choices]</td>
<td>Imagination</td>
</tr>
<tr>
<td>4</td>
<td>Idea generation</td>
<td>Critical analysis of solution</td>
<td>Development</td>
<td>Enhancement</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td>Evaluation</td>
</tr>
<tr>
<td>6 Solution generation</td>
<td>Illumination</td>
<td>Birth of an idea / invention</td>
<td>Synthesis</td>
<td>Action</td>
</tr>
<tr>
<td>[including problem situation recapitulation]</td>
<td>Verification</td>
<td>Experimentation to determine best embodiment</td>
<td>Evaluation</td>
<td>Living with it</td>
</tr>
</tbody>
</table>

TABLE 2.2. Commonalities between historical observations on the 'steps of creating' defined in psychological literature. The column showing numbers is carried through to subsequent tables in this Dissertation, where the assignment of steps and relation of creative, innovative or Design activities will become clearer.
of the divergent and convergent phases of thinking and reflective action of more than one thinker at a time, as is outlined in Process Map for innovation [Chapter 5].

The ideas outlined in this section are those which this author considers the most useful historical contributions to understanding the persons, field and domain of creativity. They are important not just in their own right, but because there is a historical flow of ideas from Koestler [1964] to Boden [1990, 2001, 2004], who was influenced by Koestler, and from Csikzentmihalyi [all] to Gero [2002], who was influenced in his systems model by Csikzentmihalyi [ibid]. If one summarizes and combines all the influences of these people with a new definition of creativity proposed by this author’s colleagues, Warr and O’Neill [2004], one can now produce a comprehensive definition of creativity, that will also pre-empt the ‘Four Rules of Innovation’ proposed in Chapter 3.0, as follows [with additions in parentheses by this author];

‘Creativity [or ‘Innovation’ refers to the process of] … generation of ideas [or products] which are a combination of two or more matrices of thought … considered unusual or new to the mind in which the ideas arose, and [which] are appropriate to the [technical and social demands of peers and experts who contribute to define the] characteristics of a desired solution [and evolve through continual co-evolution or re-definition of problem and solution, especially] during the problem-definition and preparation stage of the process [of creating or innovating].

![Figure 2.1 The ‘Directed Creativity’ model (Plsek, 1997). Starting from the 0900 position, the four phases of creative activity are carried out in a cyclic fashion, including I. Preparation II. Imagination III. Development, and IV. [Physical] Action.]

2.5.0 OVERVIEW OF INDUSTRIAL COLLABORATOR’S OPINION OF INNOVATION TOOLS

The survey of Innovation Tool use in Engineering Design outlined in this section, as well as the practical tests of the PRIZM Innovation Map and Game [section 4.3.0 and Chapters 6 and 7] were carried out in an internationally-leading Engineering Industry [also called the Collaborator, The Industry Collaborator, The Company or The Engineering Company in this Dissertation]. The aim of this survey, made at the request of the Collaborator as well as for the purposes of this research, was to develop a internal benchmark for the understanding of innovation and use of Innovation Tools at the Middle Management Level.

Due to confidentiality agreements, this author is unable to provide the name and sector of the industry involved, and is able only to describe the nature of the Collaborator’s large, complex and long-life Engineering products in general terms. These products contain thousands of sub-systems, with the majority involving multinational and multidisciplinary teams in Design, Research, Development, Assessment/Test and Manufacturing hubs in several countries. Teams and projects can also not be identified in detail –thus the eight sites on which research was conducted are labelled A1, A2, B1, B2, C1, C2, C3, D [this labelling format is continued in Chapter 6]. In any case, a precise description of each product and team involved in the Research would be beyond the scope of this Dissertation even were it not subject to confidentiality agreements, since the key contribution to knowledge provided by this research is about the nature of the process of innovation, and improvements to its facilitation, not the technical results of the products being innovated.
As must be true in most leading industries today, the Collaborator is not necessarily concerned about the creativity of its staff in general, but with improving and streamlining the initiatives for idea-generation and innovation that have in its past been localized and largely self-directed by the most motivated individuals on given projects, and without Top-Management support. The key and consistent challenges facing all individuals and teams inside the Industry Collaborator also involve common Engineering issues – there are expectations around customer satisfaction, ease of manufacture and operation, environmental-friendliness and cost-saving. For example, all Engineers in the Company would agree that their future products will be required to be more fuel-efficient, as well as cheaper to manufacture and operate.

The above are apparently constant problems, to which innovative solutions are found on a continuous basis. From an Innovation Management perspective however, the Industry Collaborator believed it would be helpful if some of the ‘unknowns’ in terms of Tools, people and culture could be made known. In particular, the request for an analysis of the status quo of innovation in the Company was catalysed when the Collaborator was approached by a large software developer, whose main Tool is in the arena of Systematic Innovation. This software company was pressuring internal departments, with seductive options that promised to deliver grand results at a very high cost per user licence, and the Collaborator wished to know whether; [i] the TRIZ theory and/or Thinking Tools on which the software was based, were of any use on their own, and if so [ii] could or should the theory, Thinking Tools or related software be implemented on a company-wide basis [leading to the benchmarking and Pilot Test described in sections 4.3.1 and 4.3.2]. Suffice to say, that when a company considers whether to implement a large-scale deployment of Innovation Tools or seed an innovation culture potentially costing millions of Euros, it needs to be thorough in making its choice of supplier and Tools.

The initial survey of 49 Engineers at Middle Management levels in the Industry Collaborator provided a starting point for understanding the status quo of innovation in the Company – and in the personal experience of the author [who is able to obtain personally communicated information from Innovation Managers in other industries, for instance] also seems to be a fair representation of the status quo in other Engineering companies around the world.

Interviews were carried out with 27 Team leaders and some 22 more team members, on 5 sites [A1, B1, B2, C2, C3], from May 16 to June 22, 2006, with initial participants selected and invited by the Head of Knowledge Management in the Industry Collaborator, due to their professed interest in the topic of innovation in previous years. Further participants were invited by word-of-mouth from team leaders or recommendations of previous interviewees. Each interviewee initially set aside one hour with the author [though this was occasionally extended]. Participants were informed that their responses would be used to help make decisions about the implementation of TRIZ or other Systematic Innovation Tools in the Company, but that details would remain completely confidential and they would not be identified by name on any internal report. The notes and quotes taken during the interviews were transcribed and remain the property of the Collaborating Company.

At the outset of the survey, each Team leader or team, if present, received a 35-minute presentation on Systematic Innovation, which was created solely as an introduction for the survey and intended Pilot Test for Systematic Innovation. It was designed to give survey participants enough information about the relevant Tools to interest them in joining the intended Pilot Test. After the presentation, feedback was solicited in two forms; [i] where the interviewee had a pre-existing interest and knowledge in innovation, a formal questionnaire was used. This contained 30 general questions about the innovation process, 80 detailed questions about the innovation process and 85 [yes/no] questions specific to the use of the Thinking Tools which are identified in section 2.6.0 and Tables 2.3a and 2.3b, below. The questionnaire was based on the literature review already carried out and described above, as well as pre-existing research which had produced the seven-step PRIZM Innovation Map, and which is described in Chapters 4 and 5. The aim was to indicate not only which Tools were being used, but which of the seven steps were being exploited and which were being neglected in different areas of the company [ii] where the interviewee had no pre-existing interest or knowledge in innovation.
they were encouraged to speak freely about their ‘innovation experience’ in the Company – where there was no impulse to do so, the following questions were used to stimulate responses:

- What do you already know about innovation?
- What do you know about TRIZ?
- What Tools & methods do you already use?
- What don’t you do & what do you want?

The results were eye-opening, the more so, for what was not discussed. Despite their initial enthusiasm and self-professed interest in, or knowledge about, innovation, in this survey, 95% of individual Engineers used nothing more than brainstorming or mindmapping [after Buzan and Buzan, 1993] in team meetings, or on their own Design briefs [Pahl and Newnes, 2007]. In many cases, it was apparent that creativity was considered as a kind of ‘genius’, that potentially opposed logic and especially ‘Engineering logic’, and that in some cases, there was even a kind of outdated stigma attached to ‘being creative’. The very few survey participants who had tried out other Tools were considered outliers [term after Gladwell, 2008b], who had tested up to 30% of the available techniques on the questionnaire and used them to invent new products, or even, in the case of one individual, to develop his own taxonomy for use with his team, which he incidentally then ‘had to keep secret’, since there was no company interest in developing this further.

If given the option of choosing new Tools to learn at no cost to themselves ie. provided with free training, such as might have been available through the Collaborator’s Knowledge Management Programme, as well as the intended Systematic Innovation Pilot Test, Engineers favoured logical Thinking Tools, such as ‘fault–tree analysis’ or functional–cost analysis’ or TRIZ, about which they had heard good reports [and which are discussed further in the section following], even when they did not know the specifics of the Tool. Another eye-opening response was that the Engineer’s preference was usually expressed in the following sentence construction; ‘I wouldn’t mind trying [eg. visualization and imagery techniques or 6 Thinking Hats] but ...’. In short, the ‘but’ was followed by an excuse that indicated Engineers were highly sceptical that apparently ‘creative’ Tools would be truly helpful in their technical innovation issues.

2.6.0 A TAXONOMY OF TOOLS

2.6.1 What Tools Do Not Do

The literature reviewed in this Dissertation indicates that pre 2006–7, over 110 Tools already existed for enhancing creativity and innovation during organizational change, Design and manufacture, in different countries, and in different areas of industry, education and Science, and possibly up to 250 Tools, depending on how the variations [of Tools] are counted and their provenance established. By 2010–11, the issue of differentiating how many and what kind of Tools exist has been compounded, thanks to a rapid escalation of interest in creating better Innovation Tools, more game-like innovation processes, or indeed compounding these as ‘Innovation Games’ [as, for example, defined by Hohmann, 2006] as the topic of innovation hots up in industry. For instance, individuals from backgrounds with an emphasis on ‘Visual Thinking’ [e.g. Xplane in USA] have recast existing Tools such as SWOT, HIT and Value Analysis [defined below], not to mention brainstorming, among others, in a new, more ‘gameful’ [this term after McGonigal, 2010] light, giving them a completely different name and more appealing appearance, but arguably identical function to the original Tool [eg. Gray et al., 2010]. In this section, only what appear to be the ‘original’ Tools will be discussed further.

Of the original Tools, as mentioned in section 2.5.0 above, the Engineers in the Industry Collaborator indicate their most well-known and used Tools are for idea-generation or ideation, during ad hoc team discussion – especially brainstorming [Osborn, 1950], the ‘Six Thinking Hats’, ‘Lateral Thinking’ or ‘Random Word’ techniques of De Bono [respectively 1999a, 1999b, 2005, although De Bono did not originate the latter type of analogic force–fit method – rather, Gordon and Prince are the originators, in their Synetics approach, as further discussed in this section, below] and the mindmapping method of Buzan and Buzan [1993], which is sometimes, incidentally, also used by the Collaborator to represent the problem–space not merely the idea-
space [i.e. the former being the physico-conceptual space of Boden, 1994a, b, c; and see Chapters 3 and 5 of this Dissertation] that exists before ideas are generated.

Tools, which fulfil a similar ideational function, but are less well known by the Collaborator or indeed laypeople, include: Provocation or Po [i.e. a deliberately unreasonable idea proposed to provoke others, as defined in De Bono’s 2005 Lateral Thinking Kit]; SCAMPER or SCAMMPERR [an acronym for ‘substitute, combine, adapt, modify or magnify, put it elsewhere, eliminate, reverse or rearrange’ by Eberle eg. 1997]; and the collaborative derivative of brainstorming i.e. Brainwriting 6–3–5 [Rohrbach, 1969]; not to mention those Tools officially demanding or providing some kind of rules for ‘sensory overload’, ‘saturation’, ‘jokes’, music or other unexpected stimuli or information, ‘dream diaries’ or ‘wishing’, ‘excursions to other worlds’, ‘alternative scenarios’, ‘imagining oneself in other people’s shoes’, ‘crazy ideas’, ‘breaking the rules’ or ‘relaxation’, story–boards, collective notebooks, ‘group mandalas’, ‘Art Gallery’, ‘Walt Disney’ or ‘Da Vinci’ technique [the latter defined in Michalko, 1991], controlled imagery, ‘borrowed genius’ [as per Wenger, 2001], analogy, metaphor, affinities, relational words, free association, visualizing, ‘rolestorming’ or ‘superheroes’ [the latter described by Mycoted, 2005]. Needless to say, whilst these Tools can facilitate the stereotypical ‘out of the box’ thinking that is considered the beginner’s milestone of personal creativity, they lack the kind of structural depth required for capture, analysis or synthesis of complex, potentially contradictory expertise or technical data that might pre–exist the more desirable and historically significant idea–generation or emerge during it, which has been identified as the true hallmark of the creative process [see section 2.4.0 and especially 2.4.2]. In technical problem–solving, the view of this author confirms the opinion of the Collaborator’s Engineers reported in the section above – such Tools used on their own are of little use to push the envelope of innovative Design in a multinational Engineering Company. In many cases, they add no more than a simple brainstorming session would add, and they concern only one [albeit central] step of the three necessary stages of innovation that are identified as generic and outlined by the Innovation Map that is the subject of this Dissertation. Conversely, all the Tools listed in this paragraph can be included or integrated, singly or together, obviously or unobtrusively, by a good facilitator familiar with the entire innovation process, in any innovation workshop that is based on the seven steps of the Innovation Map.

Assisting at either other end of the innovation process, there are then a handful of relatively specialist, rigorous and popular Tools used by Engineers such as: Taguchi methods [Phadke, 1989]; failure mode and effect analysis or FMEA [of military origin]; Quality–Function Deployment or QFD [Mizuno and Akao, 1994; Akao, 1994], which outline the questions that need to be asked to define a problem, as well as assess the quality of the output.

At the same time, many other apparently good Tools that might help lay problem–definition [i.e. at the beginning of the innovation process defined in this Dissertation], are relatively ordinary, everyday techniques for defining problems in Engineering environments, which makes them unlikely to be included on an Engineer’s ‘Top–10 favourite Innovation Tools’ list, in the absence of a facilitator. These include: ‘backward–forward planning’ and 5W&H [immortalised after Rudyard Kipling’s poem in 1902] – both a type of cause and effect chain; boundary examination and simple ‘bug listing’, ‘attribute listing’, component detailing or heuristic ideation or HIT [the latter attributed to Edward Tauber, described in VanGundy, 1988]; so–called ‘mess–finding’ [first identified in Osborne and Parnes’ CPS model and to be further discussed below], ‘Cherry–split’ or ‘fractionation’ [Michalko, 2005]; and finally a panel of experts, focus groups, dialectic and CATWOE [Checkland, 1981] or stakeholder analysis.

Likewise, the popular lay Tools for evaluation of ideas, post–ideation phase, such as: a plain and simple list of ‘pros and cons’, laddering, prioritizing, ‘plus–minus–interactions’ [PMI] or force–field analysis [the latter attributed to Lewin, 1922 and popular in social psychology]; or clustering, categorization and ‘consensus mapping’ – with or without rigorous marketing or technical criteria – and with or without additional formatting tools for the clustering, such as gap analysis, SWOT analysis, Delphi criteria [RAND group, 1950]; or Fault–tree analysis or FTA [created as an evaluation mechanism for the Minuteman I Intercontinental Ballistic Missile launch Control System eg. Ludwig, 1975, Clifton, 1999], Functional Cost Analysis, Value Analysis or Value Engineering [attributed to another Russian, Sobolev, 1948, with a notably high usage of the terms ‘subsystem’ and ‘supersystem’ in parallel to their usage in TRIZ], critical path
diagrams [DuPont Engineering and Remington Brand via Kelly and Walker, 1959, 1989] and Kepner & Tregoe’s [1960] variation on root cause analysis method from RAND – with or without additional project management, technology road-mapping or requirements analysis Tools, do not demand a different kind of thinking to that already required in ordinary, everyday techniques for evaluating the strength of proposed solutions in Engineering environments – so, again, these Tools are unlikely to rate a mention from Engineers as a special kind of Innovation Tool. In short, while these Tools each, individually, cover one of the three necessary phases of creative action known to exist [as just discussed in section 2.4.3] and only one of the seven necessary steps outlined in the Innovation Map of this Dissertation, and while they should therefore be used in combination with [ie. after] ideation Tools, this author agrees with the Collaborator’s Engineers that they have limited use in systematically streamlining innovation in a multinational Engineering Company on their own. Each of these Tools is missing the elucidation of a greater process, into which their function fits, and which would allow them to stack or comfortably coincide with each other. On the other hand, the Innovation Map to be introduced in detail in Chapter 5 subtly integrates some of these Tools in its steps, and can bluntly add other problem categorization and evaluation functions of a large proportion of these Tools, in a way that simplifies and enhances their value and experience for a team of users.

One of the main components of the research in this Dissertation, the Russian ‘Theory of Inventive Problem–solving’, TRIZ [eg. Altshuller, 1984, 1999], takes a step further than most other Tools, in that it attempts to address the issue of formulating a precise problem–definition, and then proceeds to match the problem thus defined with scientifically derived and analogically provocative choices for novel solutions from areas outside the users’ personal expertise. However, like most other Tools, it provides only incomplete instructions to help users formulate a problem, not to mention that is does not help users find what this author calls ‘the right problem’ [see 4.2.3] to solve in the first place. Nor does it help users evaluate their creative solutions by providing any kind of filter, sorting or ranking criteria to determine which ideas could be socially or historically useful, after they are generated. In short, TRIZ fails to cover or even consciously acknowledge the existence of the steps of the process of innovation that can be identified from previous knowledge of the creative process and the literature review described in this Chapter, and which is fully described in the process Map of Chapter 5.

In the entire marketplace, there are only two Tools, which attempt to lead users through a complete process for creation or innovation, and which also include more than a couple of the steps or stages identified in the generic process of creating [Tables 2.2 and 5.1 as well as Figures 5.6, 5.7, 5.8] and the Innovation Map of this Dissertation – these are Synectics eg. Gordon 1961, 1976; Prince, 1970, both from Arthur D. Little] and Creative Problem Solving or ‘CPS’ [Osborne and Parnes, 1950]. Both these systems have widely differing foci from the other, and neither system was known to this author prior to creation of the Innovation Map and PRIZM Game, yet both kinds of view are included in the Innovation Map and the process of playing the PRIZM Game for innovation, simply because they are intrinsic to the creative problem–solving process that is revealed as a natural process of all creators, in the generic process of this Dissertation.

Of the two Tools, Synectics is perhaps the more interesting, nowadays including many additional Thinking Tools under the auspices of three interacting spheres – defined as ‘climate’, ‘thinking’ and ‘action’. These spheres are identified in sections 2.4.0 to 2.4.3 and 3.3.1 of this Dissertation, and also included in the sixth column of the Innovation Map, albeit by different names, as the three communities which fundamentally co–exist in every community or company on the planet, and which must therefore all be simultaneously satisfied with the experience and outcomes of the innovation process. They essentially cover the trilogy of concerns of the modern Innovation Manager. In addition, the three main assumptions of Synectics are also the main assumptions of TRIZ and PRIZM – that: the creative process can be described and taught; invention in the arts and sciences [or, in the case of TRIZ, different engineering disciplines; and, in the case of this author, even creation of nature itself] are analogous and driven by the same kinds of processes; and individual and group creativity are analogous. The overt appeal of Synectics does seem to be the emphasis on metaphor and analogy, which involves participants more deeply than simple brainstorming and seems to encourage more rigorous problem analysis, as well as allowing new and surprising solutions to emerge. In fact, the ‘triggers’ for brainstorming in Synectics are very similar to many TRIZ principles. Yet at the same time, the
deep driver of the technique was the founders’ great concern that participants in discussion and brainstorming do not just focus on the outcome of idea generation, but also deeply listen to each other, and pay greater attention to the experience and interpretation of others. This is built into Synectics as the core principle, and makes the process as useful and popular for team discussion and conflict resolution [emphasized by Prince, 1970] as it is for invention [emphasized by Gordon, after the two partners business split in 1960]. These same concerns about discussion and attention are part of the model for playing the PRIZM Game in innovation workshops, and indeed are one of the key though perhaps surprising outcomes of playing the game [see section], since they are unspoken at the outset, and merely built into the process. Easy and joyful discussion and conflict resolution are a natural consequence of requiring the steps of the Innovation Map to be followed exactly, with particular timing and defined periods of individual and group work.

This all said, Synectics is a somewhat messy system allowing individuals and teams many different starting points and paths to achieve the desired result, while the Parnes–Osborne model heavily emphasizes structure. The Parnes–Osborne model is a continuously repeating and complementing cycle of diverging and converging thought, through the following steps: mess-finding; fact-finding; problem-finding; idea-finding; solution-finding; action-finding. Some of the facilitators trained in the method at Osborne’s Creative Education Foundation [CEF] in Buffalo, New York represent these steps as a string of diamonds that looks similar to Figure 5.7 of this Dissertation. At a very basic level, there are great similarities between CPS and the Innovation Map in this Dissertation – the order of steps is the same, and actually the only additional step in the PRIZM process is that two types of mess are explored – first, the vagueness of the desired ideal final result, and then the complexity of the status quo, at opposite ends of the process. However, beyond these basic similarities, the PRIZM Innovation Map offers far more structure to achieve the desired end as well as far more information about the interactive nature of the process that must occur, to link the structure of the problem and allow its solution to appear from an unrelated conceptual space, than CPS can hope to provide. At first glance therefore, the PRIZM Innovation Map could be said to combine the best elements of both Synectics and CPS, merely because these elements are inbuilt into the generic process [defined in this Dissertation] that all human beings appear to use, when they create or innovate.

Incidentally, CPS and the ‘cycling worlds’ of modern Synectics also seem to have influenced the visualization of the ‘gamestorming’ process proposed by Gray et al. [2010], in the latter’s very brief illustration and explanation of the problem-solving process as a diamond-shaped game, that first ‘opens’ and then ‘closes a world’. On the other hand, as mentioned above, the author of this Dissertation was not familiar with the process of Synectics and CPS [which are both taught in a licence model and requires upfront payment to earn the rights to the details] nor gamestorming [which was published in the last few months of writing this Dissertation], when she developed the Innovation Map and PRIZM Game, and while these methods plainly all work very well as approximate systems for non-experts [and the more so for their trained and experienced facilitators], they are of little help in formally yet simply elucidating the nature and details of the innovative process in the first instance, which is the aim of this Dissertation and indeed the pressing necessity for developing a common view of, and improvement on, innovative behaviour and practise in either Engineering Companies or the non-expert world.

Lastly, to compound the shortcomings of existing Tools, it is also a concern for Innovation Management, that it is not, at any stage, general practise to use Knowledge Management Tools to systematically capture and manage the spoken concerns and valuable conversations of participants in Innovation workshops. Knowledge capture is notoriously sparse even for the insights that emerge during small-scale brainstorming sessions, and Engineers in the Industry Collaborator routinely report that notes made during meetings ‘disappear’ and cannot be re-used even after a short period of time, not to mention that systematic reports about any long-term, large-scale, multi-disciplinary and/or multinational process of innovation are virtually non-existent. While new, online ‘idea-management’ tools are being implemented in many companies in a hope to remedy this lack at least for that central step of the innovation process, and it is also possible that an existing Tool for Knowledge Management could be modified for this purpose, such as the Sensemaking Tool and Cynefin Organizational Complexity model; Snowden, 2002; Kurz and Snowden, 2002], so far, a commercial Tool does not exist, which can capture activity in just one Innovation Workshop in a meaningful way. Likewise, there is no Tool
that allows the discussions and outputs from one Workshop, to be compared and integrated with the discussions and outputs from other workshops in a given company or industry. The Innovation Map may be a crude capturing system, however it does begin to address this lack.

To reiterate, as already argued in section 2.1.0 above, it seems fairly certain from the lack of information on their genesis and underlying theory, and indeed, the recent upswing in recasting pre-existing Tools in a new light, that most Tools for provoking creativity and innovation were developed by trial and error to appeal to a certain user and cope with a certain environment. This author proposes that assertion can be confirmed by comparing the main function of each individual Tool with the steps of the creative process defined by psychologists and summarised in Table 2.2. In this comparison, it becomes clear that only a few Tools cover more than one or two steps of the basic process of creation and innovation which is uncovered in this Dissertation – and rarely more. Cross and Sivaloganathan’s [2005] recent overview of some 100 of these Tools also shows this to be true, by plotting Tool function in relation to idealized ‘Design process stages’. As will be more fully described in Chapter 5, there are no Tools that fully and deliberately cover every step of the process of innovation as said process is unclearly defined or not systematically repeatable when defined by the academic community, innovation consultants or Engineering Companies in the literature and practise of innovation thus far.

2.6.2 A Taxonomy of Creativity Tools

Cross and Sivaloganathan’s [2005] representation is the first true, if rough, taxonomy of Tools available in public domain. Despite previous attempts to define a taxonomy, that actually only clustered Tools in categories [eg. Greene, 2001; Hopkins, 2004; Wenger, 2005], this was the first list to present its elements in an ordered way, so as to indicate natural relationships and/or laws between the categories, as required for a true taxonomy or reference system.

That said, for the purpose of this Dissertation, Cross and Sivaloganathan’s [2005] taxonomy was used only as a reference point and not built upon, due to the comparison of the steps of creating, which was already underway to include other disciplines in addition to Engineering, and which was expected to provide the more comprehensive foundation for the process of innovation [see 5.1.2] whereby to sort Tools into a taxonomy.

At this point of the research, the steps of creation which had been defined in Table 2.2 were taken as the starting point, and in addition, each Tool was assessed in relation to its function on this scale, asking the following questions: ‘what does one really want to do with this Tool [matrix, list, analysis etc.] in the instant that it is used?’ and ‘what kind of operation is this Tool carrying out on the ideas?’ These two questions were intended to draw together the various technical, economical, organizational and social concerns. The resulting taxonomy was not intended to be an ultimate one, but a starting point to gain insight about the steps of creation, that would [conversely] inform the investigation of the steps of creating in other disciplines [even while it was partially informed by these emerging], and at the same time, would provide additional insight to the previously published version.

Thus an independent taxonomy was created, including 105 Tools [a comparable number to Cross and Sivaloganathan, ibid], most of which have been briefly discussed in relation to each other, in section 2.6.1 above. The prior sources of these Tools are well summarized by Michalko [1991], Mycoted [2005] and Leith [2005].

Tables 2.3a and 2.3b, show steps numbered in the extreme left column according to the steps of creating identified by psychologists and summarised in Table 2.2 of this Chapter. This is supplemented in column two, by the steps of Engineering Design as identified by German Engineers [Pahl and Beitz, 1977] and taught in UK Universities.
TABLE 2.3a [divergence]: A taxonomy showing best use of commercial creativity and Innovation Tools with reference to the generic process from psychology [Table 2.2], a generic Engineering Design process distilled from accepted Engineering Design process and the ‘generic process of creating’ from Pahl [2005a, b].

<table>
<thead>
<tr>
<th>GENERIC PROCESS OF CREATING (Pahl 2005a, b)</th>
<th>Specific Growth of ideas and How to choose the right tool</th>
<th>IDEAL Commercial Creativity methods, models, tools and techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning</td>
<td>Situation is: vague, abstracted, generalized and simplified</td>
<td>Backward-forward planning, backwards mapping, boundary examination</td>
</tr>
<tr>
<td>Problem as point [Step 1 in Table 2.2]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problem as field [Step 2 in Table 2.2]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conceptual design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Idea generation [divergent thinking] [Step 3 in Table 2.2]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ideas come:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ideas link to: original problem</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ideas relate to: form or behaviour or environment</td>
<td>Brainstorming, lateral thinking, provocation/ brainstorming, random words [brute force], free association, brainstorming, random words [brute force], free association, brainstorming</td>
<td></td>
</tr>
<tr>
<td>Ideas link to: ideal requirements or ideal final result</td>
<td>Sensory overload, satiation, jokes, music unrelated to problem, brainstorming, inversion, brainstorming, brainstorming, brainstorming</td>
<td></td>
</tr>
<tr>
<td>Ideas relate to: form or behaviour or environment</td>
<td>40 TRIZ principles, TRIZ contradiction matrix, contrived problem, brainstorming, brainstorming, brainstorming, brainstorming, brainstorming</td>
<td></td>
</tr>
<tr>
<td>Ideas are sourced from:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Random, similar or dissociated datasets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ideas are sourced from:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Associated, similar or matched datasets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ideas are sourced from:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ideas link to: original problem</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ideas relate to: form or behaviour or environment</td>
<td>Art Gallery, Gallery technique, Da Vinci thinking, controlled imagination, borrowed genius, morphological forced connections and circle of opportunity</td>
<td></td>
</tr>
<tr>
<td>Idea link to: ideal requirements or ideal final result</td>
<td>Analogy, metaphor, affinities, relational words, free association, random words [brute force], be the problem, TRIZ smart little people</td>
<td></td>
</tr>
<tr>
<td>Ideas relate to: form or behaviour or environment</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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The column headed ‘specific growth of ideas and how to choose the right Tool’ is the result of enquiring about the nature of the process according to the questions defined above, and is an assumption as to how a person potentially mentally processes information at each step in the process of creation or Design. This set of questions also led to a most important realization that there are hidden, and hence hitherto unrecognized ‘leaps’ built into the process of innovation and even ordinary Design – most notably in idea generation [divergent thinking], where the concern moves from being about the problem in the first stage, to being about the solution. In other words, it appears even in this small comparison that the idea generation stage does not exist only in the problem-space. Ideas are introduced into the problem domain from outside the original problem-space [or domain of knowledge], thus the idea-generation phase...
the co-emergence or co-evolution of problem and solution, and intimates the recursive behaviour of innovation on all scales, as will be further discussed in Chapter 5 [5.3.0 and 5.4.0].

In the final column, Tools are forced–to–fit in one category of use only, in contrast to former authors, even though they can be useful in more than one step of the process of creation. The force–to–fit is for convenience of representation and teaching with the generic process for innovation to be defined in Chapter 5.

Placing a Tool in its potentially most useful position in a process or recipe for innovation is expected to enhance its effect, in comparison with the effect that can be achieved in ad hoc application –but naturally this is still no guarantee of its effectiveness in producing real innovation outcomes. Even were it guaranteed, the next issue that needs to be addressed in defining the status quo of innovation in Engineering is to discuss what that guarantee would mean in each different case; what exactly would be put through or out, for how much input and how often? In other words, the next issue to be covered is that of measuring the outcomes.

2.6.3 The Measurement of Innovative Outcomes

Measurement of the effectiveness of Tools or other innovation initiatives is yet another area in which no taxonomy and little agreement exists in the literature. This section summarizes the main points relevant to the use and the assessment of the PRIZM Innovation Map as a Tool for innovation.

Currently, there is no direct measure for ‘creativity’. In a comprehensive literature review, Beattie [2000] offers detailed suggestions for the format of assessment tasks and the criteria required for judgements in a review of over 200 instruments developed for this purpose. However, as Sternberg and Lubart [1999] also realized, none of these are really able to measure the concept adequately.

Likewise, as mentioned in the sections above, no Innovation Tool exists that sets a standard benchmark for other Tools and no international standard has been proposed for the process of innovation in general. If either existed, they would define the kinds of inputs, throughputs, outcomes and measurements that should be undertaken at various points, to prove that something significant had indeed been achieved. The Oslo Manual [2005] is perhaps closest to a comprehensive attempt to measure innovation at a national level, and its suggested measures are implemented in various European Community Innovation Surveys [ECIS]. These cover many and varied inputs, throughputs and outputs, including; input such as ‘Innovation Intensity’ and output such as ‘Market Share’ or throughput such as ‘Patents Awarded’ and ‘Collaboration’ results to prove the concept. However, significantly, even such apparently comprehensive metrics are domain–specific and variable, relying on decisions of key stakeholders regarding the relative significance of measures to be implemented. Part of the problem with measurement of innovation in general, which is borne out in the case of the Industry Collaborator in this Dissertation, seems to be that decisions on new products need to be made long before significant results on any of the metric scales are known for certain [Dew et al, 2010]. In the meantime, the process of keeping track of all results in an initiative, which involves hundreds of Engineers and takes a year or more to bear fruit, is overwhelming and thus frequently not completed. This means proof of the ultimate effectiveness of any Innovation Tool or new incentive is notoriously difficult to define.

In this Dissertation, the main innovation activities affected by using the Innovation Map and Game include [i] the time taken to learn this Tool in comparison with others [ii] the type of learning users feel they have gained [iii] the amount of learning retained post–training, [iv] the level or frequency of Tool applied post–training and [v] the actual results achieved with learning and post–training Tool implementation, including new, useful, elegant and successful Engineering Designs or business concepts, patents and time savings on Design or manufacturing. The PRIZM Innovation Map and Game are benchmarked in a Pilot Test against the nearest competitor, TRIZ, and also iteratively measured against their own previous performance, or where appropriate, against a team’s previous performance with/without other Tools [section 4.3.2 and Chapter 6]. In all cases, questionnaires and feedback forms provided qualitative as well as quantitative data.
In addition to formal questionnaires post-Tool use, there is an immediate and additional measurement of innovative outcomes built into the use of the Innovation Map itself, which allows participants to judge [screen and rank] and cluster their own ideas, pre-selecting what is most cost-effective, most useful and most elegant, and what can therefore be immediately implemented or important for focussing further research and development. As Chapter 3 [3.2.2 and 3.3.1] and Chapter 5 [5.2.7] describe, there are three categories defined in the last played step of the Innovation Map that cover the three communities or Gatekeepers whose needs must be addressed if an innovation is to be historically significant [based on the research of Csikzentmihalyi; see 3.2.3 and the concretisation of an ideal world defined in Buddhist Methods see section 3.3.1]. The criteria relevant to each community is broadly defined in terms of [a] ‘cheap to make and run’, [b] ‘simple to use’ and [c] ‘beautiful, elegant or excellent’.

These are the same three categories that, according to Dew et al. [2010], are a virtually ‘intuitive’ measure, which allow even individuals [ie. Managers] with no expert knowledge of a system to assess its ‘innovativeness’ [term from Dew et al. ibid], regardless of the field in which the measure must be applied. These authors take the measure from Plsek [1997], who asserts that ‘all innovations have these [criteria] in common’, and then extend it as shown in Table 2.4. to ten levels of detail [or sub-scales]. Of the three types of scoring possible in Table 2.4, ‘first’ in Dew et al.’s [ibid] table corresponds to ‘beautiful’ in the Innovation Map of Chapter 5 [and also ‘new’, in this author’s terminology for the ‘TRIZ plus PRIZM Excel Table’ of section 6.1.0 and Appendix 4.0]. Similarly, ‘useful’ corresponds to ‘simple’ in the Innovation Map [and also ‘useful’ in the TRIZ plus PRIZM Excel Table] while ‘successful’ is taken to mean successfully implementable and corresponds to ‘cheap’ in the Innovation Map [and also ‘fast’]. Just as was indicated by the research of Csikzentmihalyi; see section 3.2.3] and is the case in the last two steps of the Innovation Map of this Dissertation [leading to the ‘Ideal Final Result’ of the Map after Altshuller’s TRIZ –see Chapter 4; and also used interchangeably with the terms ‘IFR’, ‘ideal result’ and ‘ideal’, for the remainder of this Dissertation], Dew et al. [ibid] confirm that Managers can [and should] combine all three types of scores in the Innovation Scoring Table to determine an overall level of innovativeness for any product or process being assessed.

Table 2.4: Innovation Scoring Table from Dew et al. [2010]

<table>
<thead>
<tr>
<th>Score</th>
<th>First</th>
<th>Useful</th>
<th>Successful</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>World first patentable</td>
<td>Completely reversible</td>
<td>Works for a new problem</td>
</tr>
<tr>
<td>9</td>
<td>World first non-patentable</td>
<td>Minimal switching costs</td>
<td>Works in a different context</td>
</tr>
<tr>
<td>8</td>
<td>Unprecedented nationally</td>
<td>Innovation fits context</td>
<td>Works reliably &amp; repeatedly</td>
</tr>
<tr>
<td>7</td>
<td>Unprecedented in industry</td>
<td>Specific benefits</td>
<td>Performs most of the time</td>
</tr>
<tr>
<td>6</td>
<td>Large firm initial adoption</td>
<td>General benefits</td>
<td>Achieves initial creator vision</td>
</tr>
<tr>
<td>5</td>
<td>Large firm division adoption</td>
<td>Potential benefits</td>
<td>Exceeds promised results</td>
</tr>
<tr>
<td>4</td>
<td>Medium firm adoption</td>
<td>Minimal effort required</td>
<td>Delivers promised results</td>
</tr>
<tr>
<td>3</td>
<td>Other firm level adoption</td>
<td>Significant effort needed</td>
<td>Materially substantial solution</td>
</tr>
<tr>
<td>2</td>
<td>Individual first (no experience)</td>
<td>Understand relevance</td>
<td>Some promising results</td>
</tr>
<tr>
<td>1</td>
<td>Individual first (some skills)</td>
<td>Understand purpose</td>
<td>Increased understanding</td>
</tr>
</tbody>
</table>

No other heuristics have yet been proven to be quasi–universal or ‘intuitive’ to individuals who must make an assessment of innovativeness of a product or concept in the absence of expert knowledge or complete data. Thus it is assumed by this author that for the purposes of this Dissertation it is appropriate to use the similar measures which are intrinsic to the Innovation Map. Please note that the research of Dew et al. [ibid] was not available when the Innovation Map was created, and thus innovative results assessed by participants in this research was not made in the same detail as proposed by those authors. In future, it is planned that the ten levels of details for each type of innovative assessment will be added to the explanation for the Innovation Map.
2.6.4 The Need for a Step Change in Design

In conclusion, the literature reviewed in this Chapter shows that a large amount of research has been done on different aspects of creativity, and much trial and error has been involved in generating successful creativity Tools, yet none of this solves the need to describe a generic process of creativity and innovation, that would apply to all fields of human endeavour. Neither Engineers nor psychologists have looked beyond the boundaries of their own field, to make a comparison of the processes or rules of creating in other fields. Nor have previous researchers integrated the three main contexts of creating –including the view or role of the individual creator, the view or role of the society which nurtures or accepts the creation, and the rules of the process of creating, to create a single comprehensive model for the process of innovation. Without a model or map that does these things, innovation in Engineering Design will remain locked in a worldview of ad hoc invention by ‘genius’ individuals, who may or may not even use Tools to improve their own performance in the so-called stage of Innovation 1.0 [Rae, 2006], that is only the first of many stages of innovation a company or society can experience. Without the common language that a generic map for innovation can provide, Design cannot become systematic nor allow multiple disciplines to engage with each other in the stage of Innovation 2.0. It is only the wide-scale engagement of participants, improving their respective individual views in a greater, innovating society that will bring about the step change that is required, for each discipline to operate at the higher, more effective level of Innovation 3.0 [Johnson, 2007; Hakfesbrink and Schroll, 2010; Hakkesbrink and Evers, 2010]. And it is only a simple, integrative and common language that will bring about this engagement. That map and that common language is the proposed contribution of this Dissertation.
Chapter 3  BUDDHIST TECHNOLOGIES AS A NEW FRAME FOR INNOVATION: What We Want to Keep and Improve

Chapter 3 introduces the concept of ‘Buddhist Technologies’ – being the use of methods of Diamond Way Buddhism as an adjunct to, and potential reference frame for, understanding creativity and innovation in Western Science, Engineering and business. The key points covered under this heading deal with the creation or ‘emanation’ of an ideal world, inclusive of a hierarchy of three main principles and five ways of interacting with conceptual and physical spaces. Throughout, the points covered from 2500-year-old [and previously mainly orally transmitted] Buddhist teachings are first reframed in a modern way and then recontextualized as they are integrated with Western research on creativity and innovation.

3.1.0 INTRODUCTION AND GENERAL OVERVIEW

This Chapter introduces the main elements of Buddhist Meditation, with reference to Engineering Design, the creativity Tools and psychology of creativity and innovation introduced in Chapter 2, and of course the Innovation Map. The intention here is not to delve deeply into complex philosophy and logic, rather to examine the structural and symbolic elements of Meditation practise, upon which the philosophy is arguably based. In short, we are concerned only with those Buddhist maps for exploring conceptual spaces, which might be useful to better understand individual and team creativity in Engineering Design. We, know, after all [from Chapters 1 and 2], that Engineers and innovators lack a common map for sharing the conceptual space of Design and innovation. This Chapter therefore borrows the Buddhist representations of conceptual spaces. It explores whether these can indeed help define the world [term from Gero and Kannengiesser, 2004, now also intended to be inclusive of all physical, social and mental/psychological/conceptual spaces of Boden 1994a, b, c] of Engineering Design. It is emphasized that this Chapter is not about any religious implications. The way in which the Meditation is defined as a precise geometric map in this Chapter therefore, is not standard in Buddhist teaching, but a quasi-translation and interpretation of Meditation geared to Engineering sensibilities. The geometry hidden in Meditations in Buddhist practise is not ever mathematically precise, and rarely a written explanation. And while it may become obvious to long-time Meditators post hoc, that a strict geometry is embedded in all explanations of Meditation, to the beginner, Meditation is set out only as a simple symbolic field [the advantage of doing so is that each user can evolve her own picture, words and understanding for the Meditation elements and their relationships in the map].

It is important to distinguish what is necessary for map–making and map–reading. In order to use a map well, the supposed reality [ie. the physical existence of the object] it represents is not questioned, nor indeed relevant to its representation. This Chapter intends to show that is just as useful to behave in this way with maps of invisible conceptual spaces, as with physical ones. There are indeed two extremes of interacting with the world represented on a map, which are not mutually exclusive. These are that the world is; [i] externally independent and thus ‘pre–given’ [in the sense of Schutz referred to in Wagner, 1974], which can thus be consensually experienced or shared, and [ii] internally experienced and thus not ‘pre–given’ [but determined ipso facto by the experience or observer, in the sense of Schroedinger’s cat; Schroedinger, 1935; Gribbin, 1984], which is generally non–shareable. The practical advantage of allowing a map to represent either or both of these realities [and not really mind which is true], is that one does not require the map to be perfect and is not incapacitated by its imagined failings, or the hearsay of others before making a start on the journey, of using it. In fact, it is fully expected one will explore and discover the truth of any map in the using of it. For example, given a map of Paris when visiting the city for the first time, one would not question whether the map was ‘true’ or ‘real’. One would simply go out into the street, assume it was adequate, and experiment till one had proved to oneself to what degree it was a figment of another’s imagination. In Buddhist Meditation the same principle holds. One begins by assuming the reality it represents exists and is shareable, just as the streets of Paris exist and are shareable. At the same time, one does not
lose touch of one’s own internally [or previously] experienced reality with its own implicit map, but superposes the two maps. This is just as simple as for two people who live different lives in Paris who have totally different experiential and initially non-shareable maps of the streets. All experiential maps superposed on maps of physical spaces are nonetheless equally valid and true, and can indeed at some point become part of a map that is shareable with others. Suffice to say that the point of Meditation practise is not to introduce multiple new worlds and see them as separate from each other, but to superpose the map and experience of an ideal and ‘Divine’ world [in the sense of Beyer, below] with the map and experience of the ordinary pre–given one, so that a transformation of both occurs. This will be explained more fully in subsequent sections of this Chapter. In short, the as–yet-unexperienced map of the ideal should be mistaken for a shareable reality at the outset – this is also exactly what we want to do for the conceptual Design space of Engineers.

3.1.1 Preliminary Thoughts

Engineering Design has traditionally focussed on immediate action and product generation, with little regard for short- or long-term reflection or feedback on the consequences of that action or product generation. However psychologists since Osborn [1953] have known that ‘reflection’ [in the sense of contemplation or ‘rumination’] is intrinsic to the process of creating. Simply put, one cannot improve one’s creative abilities without thinking about one’s creation or reflecting upon its progress and modifying and improving it, as one goes along.

There exist very few methods, which can help facilitate reflection or introduce early stage feedback in Engineering Design, and indeed Engineers themselves are loath to use these Tools in the absence of an experienced facilitator. The soft Science of ‘Action Research’ [Schoen, 1983, 1987; McTaggart, 1996; Wadsworth, 1998: Reason, 2002; Heron & Reason, 1995] is perhaps the only validated method currently available, that facilitates ‘cycles of action and reflection’ in teams and may be said to nod to the process of resolving conflict via Hegelian dialectic [see section 2.4.2 and Chapter 4]. However while it has been used to facilitate research and data collection on the Engineering Design process [eg. Visser, 1994; Valbenberg and Dorst, 1998; Lauche, 2001], as a whole, the method is neither detailed nor systematic enough to define a map for Engineering Design, especially when there is apparently irreconcilable technical conflict.

The formal structure of Buddhist methods [of which the main example used in this Dissertation is from Nydahl 2000a, and described in section 3.5.1 below], can help fill this gap. In order to use Buddhist methods for inspiration in Design, this section briefly explores ‘Meditation’. Traditionally in Buddhism, there are two senses of the term and the practise; one is as a formal structure or map used by individual practitioners, which provides the capacity for reflection on one’s own actions and purpose, in the objective way that a mirror also does [this will be Designated in the remainder of this Dissertation with a capital ‘M’]. The other sense is that meditation is a subjective and complete experience, which encompasses [i] the initiating formal action and [ii] subsequent reflection on that action, as well as a third element [iii] an awareness of the co–existence of these two. In the latter sense, it means for example, that one’s own experiential map of the Parisian streets is superposed on a complete pre–existing map of all possible streets and at the same time, one always remains aware that both maps are interactive. The insider Buddhist definition of meditation as an ‘effortless resting in the way things really are’ [Seegers, 2007a] refers to this awareness or experience of the co–existence of the two maps and worlds. This is designated for the remainder of the Dissertation with a small ‘m’.

In addition, in both the objective and subjective cases, the capacity to reflect on one’s action in any conceptual space requires clarity on one’s motivation for being there in the first place. One can only reflect on progress, with a benchmark – ie. a starting point and/or finishing point, from which one can measure how far one has moved. In a conceptual space, there are no physical markers for measurement and one must rely on confirming the starting point of one’s original motivation for moving at all and at the same time confirm the imagined finishing point of the ideal state, so that one can reflect upon [and triangulate from] both. One’s ‘motivation’ is a ‘layer’ of choice in both physical and conceptual reality. For instance, if someone wishes to go to the Louvre from a hotel, they need to decide which, of a variety of roads, best leads to that goal. It means that to just have the goal of getting to the Louvre is not enough. There are additional elements in the world and therefore additional criteria, which define whether and how one moves. To go fast, roadblocks should be avoided. On the other hand, to see tourist attractions, one can choose a roundabout route. In either case, additional layers of maps for roadblocks and attractions can be laid on top of the first map, and so on.
In the same way, the preparation for Meditation [or Design] requires the practitioner to contemplate the starting situation, and why she might want to be somewhere else, as well confirming she has the correct map for the general way in which she wants to move and that it is detailed or long-sighted enough to include the specific Ideal Final Result she is aiming at. There are two ways in which this preparation can be done. They are effectively a ‘top–down’ and ‘bottom–up’ scenario, as follows:

- Buddha’s first teachings captured in the Theravada system, known as The Four Noble Truths, for instance, are ordered in a way Westerners would recognize as coming from a problem-oriented viewpoint. This is a bottom-up scenario; working one’s way out of a problem from a starting point that seems familiar. In short, this map acknowledges [i] one experiences anguish about one’s world [ii] the cause for this suffering is that one likes things to be some particular way, which seems not to be in their nature [iii] there is a solution to the distress, in allowing things to be as they naturally are [iv] there are methods to reach this peaceful way of experiencing the world, and one should use them.

- The same set of pithy truths can be explained starting from the viewpoint of the solution-space and exact, mirror-image of the problem-space [defined in section 1.6.1], in the Vajrayana or Diamond Way system. In this case, motivation is established top-down, by acknowledging that: [i] one has great opportunities to help others in one’s world; [ii] nothing, including problems, lasts forever; [iii] one is responsible for changing one’s thinking to anticipate solutions in every apparent problem; [iv] one can learn from those who already know how to see all solutions.

These simple thoughts summarise lengthy Buddhist teachings on impermanence, karma, interdependent origination and emptiness. They are incidentally identical with the considerations reported by Engineers and young people at early stages of determining their problem–space and goal of innovation [Pahl, 2006b; Pahl and Newnes, 2007]. They also make up the first four steps of the complete Process Map for innovation to be described in Chapter 5.

3.1.2 Why use Meditation in Engineering Design?

The literature review in Chapter 2 indicates that Engineering Designers need maps and make them when none are previously available. The reason for this is that a map provides the framework for a pre-given, shareable reality and then allows each user to make her own adventure of it, by making choices regarding which path to take and which to forsake. Even more so, it provides landmarks around which there can be discussion and improvement of the shareable map. This is true even if the map is for a conceptual space rather than a material one.

Maps for Engineering Design do already exist, in that there are accepted sequences in which Design is taught and talked about. Pahl and Beitz’s [1984] system is perhaps the most widely accepted standard in the UK, which outlines a set of simple steps, moving from problem to solution. For the purpose of this Dissertation, such a map is a ‘single-track-map’ [discussed further in section 3.2.1 below]. Furthermore, Designers have always made ad hoc personal maps, to capture their thinking and Design decisions, and the most popular became the models outlined in Chapter 2. But currently, no single-track-map for consensual Design, nor any single personal, non-shareable map appears to suffice as a template for the complexity of the whole innovation space and its stakeholders. Engineering Design would therefore presumably benefit from a map that enables systematic links to be made between all the different worlds that co-exist and co-evolve between stakeholders. In other words, it would be useful to have a map relating the inner and outer organization of all spaces Engineers perceive and act in.

Paraphrasing the comments already made above, Buddhist maps were created to allow such links to take place. In order to deal with an invisible conceptual world, Buddhist maps of these spaces also first assume that users are predisposed to understand their world through physical objects and spaces [this is developed further in 5.3.0]. Second, the map assumes that intellectual concepts can be made into ‘objects’, if none are physically available to aid understanding of a given situation. This last point introduces a paradox; the maps provided in Meditation are supposed to provide structure for the mind, but at the same time also liberate the mind from fixation on objects. It may seem impossible – to provide a structure and yet be simultaneously free of structure. Yet on closer inspection, this is the very same question Engineering Designers face for, ideally, innovation will produce a result which is close enough to a standard set of rules to be recognisable and useful, and yet far enough away from the standard, to be exciting or profitable. This ‘Rule of Innovation’ [#1] is implicit in the judgement and
acceptance of products, even by lay people [as determined by Dew et al., 2010; and see section 2.6.3], and even without an official international standard [ISO] for measurement of innovation, and paraphrases the work of Csikszentmihalyi [1990, 1997, 1998, to be further discussed in section 3.3.1 below].

To achieve a freedom which is inclusive of structure, formal Meditations therefore focus the mind on a world, which is stripped of any but the most fundamental pre-given rules. Such a world is liberated from the confusion or anarchy that would result from not having any kind of reference at all, to then test through experience ‘how things really are’. But it is precisely because it is only a rudimentary template that it works. It allows room for change. It provides no predictable events or decisions that pre-populate the adventure of moving through the field of the map, nor therefore a need to meet [one’s own or any other] pre-given expectations of that adventure. Formal Meditation thus offers something similar to what Schutz would have called ‘the life world’ – a world, which is pre-structured for the individual who actually wants to construct ‘his own world’ but who cannot do so in isolation from the building blocks and methods offered to him by others [as cited in Wagner, 1974].

Meditations have an additional crucial function, which is exploited for the purpose of this Dissertation. Not only do they offer a map of an ordinary-looking pre-given world in which confusion does not exist. They also present a microcosm of its creation and ‘un-creation’. There is no comparable, coherent Western model, as the literature review in Chapter 2 indicated – there is no currently accepted universal coincidence of the steps of creation or innovation described in any academically or commercially available model for creativity or innovation. This suggests that Meditation could be used as a reference frame to compare other processes of creating in Western Science, Engineering and business – as was initiated in Chapter 2 [2.4.0 and 2.6.3], and is completed in Chapter 5 [section 5.1.1]. The research first described in Pahl [2005] and Pahl et al. [2007] does indeed indicate that all Western models fit into the model of creation described in Meditation, and that this could become the basis for a generic process of creation. To reiterate once more: Meditation is thus not about an imagined religious world, but about the creation of one’s own world and the process of changing one’s present situation of perceiving problems, into a situation of perceiving solutions and manifesting an Ideal Final Result.

3.2.0 EMANATION OF A DIVINE WORLD

3.2.1 The Single-Track-Map

If one wishes to build a comprehensive Innovation Map, Meditation can provide inspiration both for the artefact of the Map, and for the application of the Map in a journey or Game [as previously described in section 1.2.4]. In order to do, Meditation can be described in three levels of complexity. The first level describes a single-track map which places the map-user at some distance opposite his ideal final result [IFR]. This is shown, drawing on Beyer’s [1973, see p67 and 103] explanations, in Figure 3.1. Such a map can be used in two ways.

In the first case, the map-user is solely responsible for reaching the Ideal Final Result, and the model works much like Western Scientific problem-solving. The map–user starts from a pre-given reality, and realizes she has problems in it. She then is given a formal map of an ideal world and uses this to construct a model of the ideal as best she can, given her limited experience, in which her problems nevertheless disappear. The construction of this ideal world is essentially done ‘bottom-up’, within the pre-given shareable world, as well as in the personal non-shareable world of her experience, partly already described above. There are no elements of the ideal world, which are required to truly exist outside of the experience or mind of the map–user. Instead, imagined elements are manifested or made real within her pre-existing world as the map–user continuously adjusts these two points or maps according to her experience of the journey: [i] the pre-given world or problem–space, which evolves or at least looks different as she moves; and [ii] the ideal or solution–space, her perception of which also evolves as she moves closer. The act of observing both spaces is not one–sided, but rather involves a kind of ‘co-evolution’ of the problem– and solution–spaces, just like that identified to operate in Design [Reyman et al., 2007; Smulders et al., 2007; Mayer and Poon, 2008], which will be further discussed in Chapter 5. It is probably seen as the ‘logical’ route to creation.

In the second case, where the map–user is not solely responsible for reaching the Ideal Final Result, the model differs from Western Scientific problem–solving, and indeed, co-evolutionary
Design as it is currently accepted. Therefore this is where one can learn the most. Here, the ideal result is not constructed ‘bottom-up’ by the power of one’s own mind. Rather the elements of the ideal are assumed, or indeed required, to truly exist in their own world with their own pre-given rules, outside the experience or mind of the map-user. These are then experienced coincidentally by the map–user as ‘top–down’ inspiration delivered directly from an ideal world. Yet this is not like the Divine inspiration often thanked for creativity in the West – the Divine here is very methodical and moves towards the map–user in increments, the more fully she becomes aware of the nature of the problems in her pre–given world. And when the map–user meets the Divine face–to–face, her own pre–given world is not ‘added to’, as it is in the above case. Nor are the gaps in her understanding merely ‘filled’ with new information. Rather, her knowledge of both her own pre–given world and the pre–given ideal one are fully integrated and thereby both are transformed. This, it is proposed, is the next ‘Rule of Innovation’ [#2]; innovation is distinct from an act of ‘creation’, which requires the creator to work in only one direction. Rather, innovation requires work or mindfulness in two directions simultaneously. It requires ‘pattern-matching’ of the problem with the solution, by integrating opposites and similarities, both in how it is achieved and how it is judged.

Figure 3.1. There are two directions of action, which constitute the ritual and experience of Meditation. One is from the pre–given world [inclusive of a subset of a non–shareable personal map of that world], the other is from an ideal Divine world.

The process of creating the ideal in this case still involves an apparently co–evolutionary adjustment between two worlds, and potentially many iterations of this, just as it does above. However the big difference with the above case [and the normal model for Scientific problem–solving and creation in the West], is that the map–user is not adjusting between a pre–given world and her experiential one, but between two pre–given worlds, which at first appear to her to be irreconcilable. More importantly; not only do these two worlds exist of their own accord – illogically, in the moment of epiphany, they become one. This fact is hugely important for this Dissertation, in that innovation of this ilk was pre–empted by Csikszentmihalyi [see 3.3.1 below] and Genrich Althsuller [as further discussed in Chapters 4 and 5]. Simply put, all world–changing inventions have historically involved the discovery and integration of information from two fields of endeavour which had previously been considered separate. To be succinct, this suggests another ‘Rule of Innovation’ [#3] in that it, by definition, requires old information to be put in a new space, or vice versa. This holds true for the breakthroughs defined by Altshuller’s 40 Inventive Principles of Engineering Design [as introduced in the I–Rule of section 1.2.4], and because, as already mentioned in Chapter 1, the term ‘Inne Novare’ [Lat.] is assumed to refer to the act of making something apparently ‘new within itself’.

In terms of Engineering Design, the Divine fulfils the same function as one’s peers and friends. The Divine and one’s peers both provide reflection, increase one’s knowledge and are empowering. All enable positive feedback to be introduced into the map–user’s own otherwise non–shareable world, and improve her understanding of ‘the way things really are’, in the shareable world.
3.2.2 The Hierarchical Map of Meditation

As outlined above and also by Leidy and Thurmann [1999, in their appendices], a true meditation experience is bi-directional or co-evolutionary even along a single-track-map, whether the map-user [i] achieves some knowledge of the ideal and gathers her own power to manifest it in her world or [ii] achieves some knowledge of the ideal and calls the ideal to meet her and help transform her world. As also mentioned above, the first case is the apparently logical and easily acceptable attitude to problem-solving and creation already known in the West.

This section will now follow the thread of creation from the Divine point of view i.e. moving from the IFR back towards the problem-space. Far from being merely co-evolutionary [or merely bi-directional on a single track] as suggested above for innovative Design, the act of manifesting the Buddhist ideal and transforming a pre-given world, actually takes place via a hierarchical series of steps. They are the object of this section. For ease of reading, the terms Divine and Ideal Final Result can be replaced by: ‘any colleague or set of information that exists outside the original problem and can provoke a solution for the map-user with the problem’.

In the first movement of the IFR, back towards the problem-space, Mahayana Buddhism suggests three divisions of space occur. These are said to ‘emanate’, in that they are not fully concrete or material, but yet can be experienced as existing by an observer in an ordinary, pre-given and material world. These three divisions of space define the simplest structure and most important components that can be recognised and understood by a map-user in the pre-given world. Grouped together as The Three Jewels [which are more fully discussed in section 3.2.3 below], the three parts are said to signify [i] a Being or Actor, [ii] his actions and [iii] the field in which he appears and acts. In short, they are called [i] Buddha – a Pali and Sanskrit term interpreted as ‘awakened one’, and often standing for the historical Buddha Shakyamuni, [ii] Dharma [Pali/Sanskrit] – generally considered to be the ‘law’ or teachings given by the historical Buddha and [iii] Sangha [Pali/Sanskrit] – always interpreted as ‘community of practitioners’. Interestingly, these three divisions of space are intrinsic to the structure of every [ancient and] modern organisation on earth, as well as to the structure of the English sentence [see also 4.4.0 and 5.2.3]. Even without formal evidence to back up this proposal in this Dissertation, a thought-experiment on organizations around the planet should hopefully illustrate this point here;

The Buddha can be considered the founder of a village or inventor of a product. He may no longer be alive, but he started it all. People make posters of him, like a movie star, venerate and strive to imitate him. He gave the rules or Dharma, to help people work or advised on the operating instructions for an object’s proper functioning. These may be written or unwritten, verbal or implicit laws. The Dharma becomes a common pattern or language and shareable knowledge. The Sangha, villagers or End-Users of inventions are also indispensable. In small societies and large production companies, individuals would achieve little without colleagues to share the load and help overcome difficulties on the way. Sangha iron out the quirks in each other’s understanding and practise of the operating instructions for their product or life, and strengthen each other’s resolve to continue using the rules to achieve their agreed ultimate goal. Rules can be tweaked and added to, by this community, as they get used to the way things are. A community continues to exist as long as all members strive for the same ideal or idealise the same person [and conversely, those who meet and find they share goals or have rules in common quite naturally create communities to help each other on the way]. A transient fourth element of space, called the Lama, is also a useful variation on the Buddha. That is so, because founders die or reach retirement and yet a need for leadership remains. Consequently, a new Mayor or CEO is elected. He’s the one who knows the newest trade routes and market conditions, and has experience in all aspects of the business. Usually, he has worked his way to the top of the ladder from the bottom. He knows what it takes to play by the rules or break them, while he also consistently builds towards the original founder’s vision for the villagers or the inventor’s intentions for stakeholders in the business.

These divisions of space can be described not only as concepts but as Beings, as they are many religions, including early Pali texts where they are called The Three Protectors. These particular texts shed additional light on the way in which the elements of the trinity have a temporal relationship – there is a sequence of emanation of conceptual principles from space, which is exceedingly important for this Dissertation and the construction of a map for creating or
Designing any world, i.e., an Innovation Map [a fact not obvious from assignation of space and mind in The Three Jewels, where the elements merely co-exist].

It happens as follows: Two of the three divisions of space are 'offshoots' of the first, which is an original absolute and final ideal. The first also reappears at the 'lower level' of emanation with a different name [thus incidentally producing the fourth element described as the Lama, in the paragraph above]. In particular, the Mahavagga of the Vinaya [Mv 1, 5] and Majjhima–Nikaya [Mj] and also the old Javanese Buddhist canon Sang Hyang Kamahyanikan [SHK], all quoted in Long & Burnama [2005], describe the process of emanation of the ideal in a pre–given world, as starting when a primordial Divine emanates two additional variations of himself; '... a deity comes forth from the right side of the body ... called Lokeshvara. A deity comes forth from the left side ... called Bajrapani. [Together with the original deity ...] These three are Buddha, Dharma, Sangha'.

The ancient sources [Long & Burnama, ibid] then say that these two emanated versions of the original, each split into two more forms, in a next step; '... Lokeshvara divides himself into two, so that ... Aksobhya and Ratnasambhava come into existence ... Bajrapani divides himself, so that ... Amitabha and Amoghasiddhi come into existence. These five are termed The Five Tathagatas [Buddhas] ... ' [the Five Buddhas are introduced fully in The Mandala of the Five Buddha Families, in section 3.3.2 below].

Unfortunately, no ancient texts nor any oral teaching currently available in English clearly state that it is Lokeshvara who is the equivalent of the Dharma, while Bajrapani would represent the Sangha. And indeed, as often happens in ancient Buddhist texts, which were not always penned by the original 'realised Master' but often by colleagues and students who had heard his oral teaching, and often many years after the event, the indisputable fact of which deity results from which previous deity is contradicted even within this one long text [i.e. the SHK, ibid]. That means it is not entirely clear whether it is Lokeshvara who emanates Aksobhya and Ratnasambhava, or whether it is Vajrapani who does this.

For the purpose of this Dissertation, a correlation is made, based on the fact that in standard modern Buddhist teachings, Lokeshvara is responsible for 'compassionate action', which is usually assumed to indicate he compassionately passes on Buddhist teachings, methods or laws. At the same time, Bajrapani, or Vajrapani [as he is usually called, and will be called for the remainder of this Dissertation, when not quoting sources], is responsible for 'power', which can be interpreted as multiplying or applying the teachings in a larger context – for example with more people.

The potential mis-assignments of these deities and their qualities means there is an additional layer of possible discrepancy to consider in the re-use of Meditation for innovation and Engineering Design in section 3.4.0 and steps 6 and 7 of the Innovation Map presented in Chapter 5. It is important to think clearly about the assignments or correlations made, since each of The Five Buddhas has a particular attributes associated with them, which will look different if placed in a different context. In other words; in all Buddhist teachings, Aksobhya and Ratnasambhava represent the ability to see all Beings as Buddhas – with the distinction that Aksobhya refers to oneself as a Buddha, while Ratnasambhava is about others. Amitabha and Amoghasiddhi represents the use of energy – with the distinction that Amitabha is concerned about oneself, while Amoghasiddhi concerns all things. Finally the central Buddha, who has different names in different schools, represents the integration of the other four. It can be said that the two pairs of emanations are each a set of 'one and many' solutions around the same principle [see 3.3.2]. But it will make some difference to Figure 3.2[b] and the Diamond Model proposed at the conclusion of this Chapter, whether the solution set around 'seeing Buddhas' is relevant to 'law' and whether the solution set around 'using energy' is relevant to 'people', or vice versa. The issue will therefore be covered in more detail in Chapter 5.

For the purpose this section, it will suffice to summarise that the principle of Dharma or 'law' makes two variations of himself, and the principle of Sangha or 'people' also makes two further variations of himself – so in the end, the IFR has emanated or become five functions or interacting 'solution–principles' with different views and behaviours that comprise 'A Complete System' [this term is from Beer; eg. 1984, 1985, 1989 and explained more fully in section 3.3.3]. The division of Buddhist conceptual space into these categories is illustrated in this way, in Figure 3.2[a] and rephrased for an Engineering Company in Figure 3.2[b]. In Figure 3.2[b], the division of an Engineering Project is seen therefore to ideally involve three kinds of people [called the 'Gatekeepers of Innovation' in 5.2.7] with different skills that represent the complete
information of the company or system and fill the functions of The Three Jewels – a Technical Expert or Engineering Designer, an End–User and finally a Manager, Researcher or Facilitator, who is the go–between and integrates the concerns of the other two. Together, they fulfill five essential functions; the Designer and End–User can each comment on their respective fields of expertise in terms of the theory or ‘one’ system, plus any variations of it; ie. ‘many’ systems. The Technical Expert can provide the structure and methods for Design, while the End–User would reflect and provide feedback on applications of the proposed methods and Design. The Manager/Researcher/Facilitator would facilitate execution of a project by integrating exchanges between, and insights from, the two opposing camps. He does not need absolute knowledge of the final result at the outset of a project since his knowledge co–evolves as details and conversations between parties evolve. His main role is only to ask questions of the other two participants in the discussion. This is a crucial point in the co–emergence of problem and solution that was indicated by Csikzentmihalyi [1988a] and Csikzentmihalyi and Getzels [1988], as being the indicator of historically significant invention or inventors [further explored in 3.3.1 below]. These roles are also explored more fully in The Mandala of the Five Buddha Families [section 3.3.2] and also in The Viable System [section 3.3.3], below.

Figure 3.2 [a]. Unfolding or Emanation of Conceptual or Actual Space in three steps; starting from a place of Absolute and Indescribable Knowledge or Reality [ie. the Divine or Ideal Final Result] moving through The Three Jewels and ending with The Five Buddha Families.

Figure 3.2 [b]. Unfolding or Emanation of Conceptual or Actual Space after Figure 3.2[a], rephrased for an Engineering Company; starting from a place with complete information about the system, moving through a top–level with three representatives of the system, and ending with a description of their five functions.
3.2.3 The Three Jewels in 3D

As introduced in section 3.2.2 above, The Three Jewels stand for an intrinsic structure and interrelated qualities of a conceptual ideal, that can first be seen as the latter emanates and eventually concretises in an ordinary, pre–given world from an ideal Divine state. Because the term ‘qualities’ is quite abstract, the qualities are imagined as a sentence–like trio of Actors, action and/or the environment in which the Actor appears, or alternately, of three co–evolving Actors. In this section, a visual elaboration will be made regarding Meditation geometry comprising these elements, in order to better assign roles and functions to the three main Actors required for innovation in an Engineering Company, and pre–empt an explanation of how co–evolution might occur in the Design Space [which is to be discussed further in sections 5.3.1, 5.3.4 and 5.3.5]. In other words, the Meditation will be presented as a 3D map, as if the conceptual elements were to completely define a pre–given physical world.

The basis of a modern Mahayana Meditation on The Three Jewels is illustrated in Figure 3.3. The oral instructions for this Meditation are as follows:

1. the Buddha is called to mind as the historical Shakyamuni, sitting in front and a little to the left of oneself
2. the Dharma is visualized as books or a library directly in front and a little ahead of oneself
3. the Sangha is visualized as a compassionate being, in front and a little to the right.

The Three Jewels therefore occupy entire visual field of the practitioner. The straight black arrows and lines signify the limits of the practitioner’s field of vision, assuming the elements were physical objects situated at an imagined horizon at each side and at a vanishing point in the distance. A square is then created by joining The Three Jewels with the practitioner as if they really were sitting together in physical space.

Formal Meditation takes place by attending to these elements clockwise in turn, confirming their relevance to one’s life. In Mahayana practise, attention is moved from the Buddha to the Dharma and then the Sangha in order [the blue circular arrows represent the cycle of attention in the field of view]. This is repeated as many times as one likes.

The Three Jewels are extended in Vajrayana [Diamond Way] practise, by introducing the Lama as the fourth element [as mentioned in section 3.2.2]. This completes the geometry of Figure 3.3 i.e. :

4. the Lama is added as a teacher, as close as comfortable and directly in front of oneself

[Nydhall, 2000b]. Please note that if the preceding elements are visualized as sitting in the plane of the practitioner’s point of view, the Lama might obscure the library behind him.

In Vajrayana Meditation practise, the Lama is considered to unify the other three qualities of mind, and the geometry of the square is completed with him, rather than with the practitioner. In fact, the practitioner remains invisible outside the square [discussed further in Figure 3.4 below]. In Vajrayana practise, one therefore starts by focussing attention on the Lama, then follows in turn with the Buddha, the Dharma and finally completes the cycle with the Sangha.

There are two important results of mapping the three parts of an ideal conceptual space in this way, which are made use of, in the PRIZM Innovation Map described in Chapter 5. In summary these are;

- As a result of the simplicity of its geometry and elements, and the scientifically repeatable nature of the cycle of attention [by oneself and by all others who use the same map], Meditation on The Three Jewels forms a basic and implicit, non–verbal/symbolic and common language. This language can be understood by all who wish to deal with the same conceptual space. It can even be understood by those who do not use the same map [ie. practise Meditation], as long as the pattern of the idealised world makes common sense in the pre–given one.

- The method of cyclic attention is Designed not only to help arrange one’s own internal space of experience, nor only to develop a common language. It is also intended to enable literal manifestation of three different parts of the ideal in the ordinary pre–given world. In other words, Vajrayana Buddhist practise assumes not only that one imagines a
teacher, rules and a team to exist, but that these actually and truly exist in the pre-given, shareable reality. The map is absolutely expected to be the territory and vice versa.

To complete the explanation of Meditation geometry [for The Three Jewels or any other Meditation], it is also important to note that there would be four major planes of mirror reflection and lines of rotation, were different directions of the conceptual compass not assigned different qualities of space or mind. The fact that there are, however, such differences, means that the only plane of geometric reflection which truly exists, lies between the imagined or revealed Meditation elements and the Meditator’s inner world. This means that it is the Meditator who creates the 3D world that apparently now exists in front of him, by his very contemplation of it, whether he knows it or not. This relationship of Meditator and ‘meditated-upon’ can be better understood by imagining the Meditator looking at a framed painting of his Meditation elements on a wall, as shown in Figure 3.4. In short, all Meditation must be considered to be an interactive 3D world, which includes and repeatedly involves the practitioner, even when it is apparently only a conceptual world.

Figure 3.3. The Geometry of a Mahayana Meditation on The Three Jewels of Buddhism, seen from the point and in the plane of view of the practitioner. The central element is a Vajrayana addition.

Figure 3.4: View of the Meditation of Figure 3.3 as if it were a framed Artwork hung vertically on a wall.
3.3.0 THE DIVINE IN MANY WORLDS

3.3.1 The Three Contexts of Creating

All these points about Meditation are important because, in Western Science also, researchers recognize there are a great number of potential contexts for Designing or creating a newly common world – at the very least, as many as there are stakeholder worlds from which to start [ref]. This could well be one of the reasons for confusion about the framework for innovation. However recent research indicates that the many variables can be meaningfully understood when portrayed in just three groups [Csikzentmihalyi, 1988a, 1997]. These groups cover the elements of the three classical dimensions of psychological functioning [eg. Hilgard, 1980] and are identical with the three elements of Buddhist Meditation explored in this Chapter so far.

Summarizing and paraphrasing the work and terminology of Csikzentmihalyi [1990, 1997], Koestler [1964] and Boden [1994b, 2005] among others, and integrating it with The Three Jewels described above, the generic process of innovation and/or Innovation Map requires that there are ‘Three Contexts of Creating’ in which all innovation should ideally take place [Pahl et al., 2007]. All three contexts are coincident with each other and historically significant innovations make the constituent communities and/or Gatekeepers of each context ‘happy’. Whatever the criteria are, which define the three communities/contexts/Gatekeepers, innovations which fail to address all of them simultaneously, do not seem to become historically significant [Csikzentmihalyi, 1988a, 1997].

In detail, The Three Contexts are as follows:

1. **The Person** [term from Csikzentmihalyi, 1990, 1997 and equivalent to the Buddha in The Three Jewels]. This is the element that activates creation or produces variation. Among many necessary skills and qualities, Kahn et al. [1986] determined the key factor regarding a person’s contribution to society was their inner motivation. It is the person who evaluates and produces variation or transformation of any information [Csikzentmihalyi, 1997] or conceptual space [Boden, 1994b], as well as self-transformation [Boden, 1994b, 2005]. The motivation of the person is in this Dissertation considered equivalent to an ‘organizational mission statement’ or core value – it is when actions are evaluated according to feedback that is intrinsically, rather than extrinsically sourced. Furthermore, it is only in the context of the Actor, that knowledge of the domain [as defined below] and skilled action in the field [defined below] can be explored in the first place, before it is even combined or transformed in the second. It is only through the Actor that the inner and outer worlds of motivation or intention and ‘conditions’ are coincidentally experienced and their match must be reflected and acted upon. A writer’s motivation, for example, is always to establish a symbolic ‘mirror’ of the literary hero’s complex internal or conceptual wishes and intentions in the structure of his external physical world [achieving this kind of reflection between inner and outer worlds is also the hallmark of profound meditation; Gampopa, 1998; Kalu Rinpoche, 1995a,b, 2002]. It is the failure to achieve such harmony that threatens an Actor’s world with chaos and propels him to its resolution. The ability to make choices in order to achieve this harmony, is what Koestler [1964] calls ‘developing a strategy’, to cope with changes in the field from one day to the next, whilst still always fulfilling the requirements of our given domain.

   • Note on conflict and resolution: The desire to overcome conflict is arguably intrinsic to any strong motivation to contribute to a domain. If there is no tension, why seek to resolve anything? Creators must see gaps in knowledge, or tension and inconsistencies between the proponents of leading arguments and wish to fill them in. Arguably, the conflict must be general and the resolution must be highly personal, since as both Boden [1990] and Csikzentmihalyi [1990] point out, highly driven creators answer [internally generated] questions that do not even exist for other practitioners in the field, until they appear to be spelt out coincidentally with their answers being found. The most spectacular cases of invention do this via paradigm shifts, changing the ground rules by integrating knowledge from different disciplines. For instance, the first powered aircraft was preceded only very slightly by the invention of ground-based transport with internal
combustion engines, and the Wright brothers combined this idea with domain-specific information on aerodynamics. Such solutions can be readily recognized even by non-experts as being creative when ‘...they could not have been predicted from knowledge of previous work in their constituent domains – they were solutions to discovered problems’ [Boden, ibid ; Csikzentmihalyi, ibid].

2. The Domain [term from Csikzentmihalyi, 1990, 1997 and equivalent to the Dharma in The Three Jewels]. This is the element, which preserves a [collective] map of all creations for the benefit of the field, that existing results might be reproduced, used or further developed i.e. for the purpose of transmission. It is the body of knowledge, the expounded principles or innate laws which provide questions and transmit information to a person. They are the elements, which Koestler [1964] also called a ‘fixed code of rules’ – they are Gero and Kannengiesser’s [2002; 2004] structure of an object, as well as a writer’s classical story structure or ‘map of terrain’, which defines where a hero can but must not necessarily go. The domain includes every educational discipline and university subject, every practise of movement of objects or thoughts invented, described or known to man.

- Note on Multidisciplinarity: Traditionally, domains of Science and art have been well bounded. However, in the last fifteen years, it has become evident that insight leading to high levels of acceptable novelty in products and processes is often instigated by provocation and synthesis of information from outside a habitual environment. As a result, there is increased interest in cross-, inter-, and multidisciplinary collaboration and information transfer. This has led to the creation of entirely new fields of research such as ‘Biomimetics’ and ‘Astrobiology’ for example. But it also raises entirely new sets of problems, since the rules for the [as yet non–existent] domain are outside of both previous constituent domains.

3. The Field [term from Csikzentmihalyi, 1990, 1997 and equivalent to the Sangha in The Three Jewels]. This is the sphere of action and interaction, where the creation is widely applied and where Csikzentmihalyi’s [ibid] ‘Gatekeepers’ of peers select or reject variations [made by individuals surpassing a standard] and pass them back to the domain. It is thus also the place where an individual has an obvious effect. One can consider the field to be a flexible matrix, as it were, of collective skills [cf. Koestler, 1964], dependent on feedback, where knowledge irreversibly affects environments. In classic literature, the field is both the writer’s plot and the hero’s actual journey – together one of many paths imposed on the domain, which is allowed to, and invariably does, change as one goes along. It is also what is in this Chapter referred to as the personal, experiential [and often non-shareable] map of a pre–given world.

- Note on Collaboration: Whether it is intended and sought out, during early phases of the process of Design, or enforced during the later stages of business development and patenting, creators must work with others, in order to ensure acceptance of their contribution into the domain. New explorations, combinations and transformations must be evaluated – by a creator, his peers or society in general, as being both novel [Boden, 2001] and useful [Csikzentmihalyi, 1997]. For this, a variation of ‘Rule [#1] of Innovation’ is proposed; in that the product must stick to the norm [standards] and simultaneously deviate from it, or in other words, it must keep the rules and break them, at the same time and in the right degree. For, if the new version of a thing is too far from the known, it will not be recognized in the first place – yet if it is too close, it will not be seen as exciting. Further; Holding to a standard promotes stability, whilst novelty promotes growth – having both creates sustainability. Thus the last ‘Rule of Innovation’ [#4] might state that only when these two criteria are fulfilled synchronously, can a product be perceived as a valuable and powerful contribution to society [and indeed herald what is called a step-change]. This rule is proposed to be the point where all other rules come together and speak to the experience of the innovator who is innovating, not just about the innovated effect. The paradox is one of fulfilling all criteria simultaneously and having left nothing important out enables a kind of ‘sustainable novelty’ – itself
a contradiction in terms. It is a potentially fulfilling experience akin to the bisociation of Koestler [see 2.3.2] or Csikzentmihalyi’s [1990, 1997, 1998] state of ‘flow’, a state of advanced meditation, or what athletes call ‘being in the zone’. As will become obvious in Chapters 5 and 6, this rule is kept and this point is reached when the experience of pattern-matching of problem and solution, or questioning–End-User with answering–Designer, really works, and there is no separation between the creator and the created.

Table 3.1: Comparison of the Field, Domain and Person in the Act of Creation; over the Three Contexts of Creating, The Three Jewels, The Three Pillars and the Diamond Model for Design [see section 3.4.0].

<table>
<thead>
<tr>
<th>The Contexts of Creating</th>
<th>The Three Pillars of Buddhism</th>
<th>The Three Jewels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field</td>
<td>End–User [User]</td>
<td>Action or Behaviour</td>
</tr>
<tr>
<td>Domain</td>
<td>Designer [Designer]</td>
<td>Contemplation or Meditation</td>
</tr>
<tr>
<td>Person</td>
<td>Manager [Researcher/Facilitator]</td>
<td>Learning</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>The Diamond Model of Design</th>
<th>The Three Jewels</th>
</tr>
</thead>
<tbody>
<tr>
<td>This Chapter [and Pahl &amp; Newnes, 2007]</td>
<td>Holding the View (applying the methods symbolically in a pre-given social world)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Meditation (use of technical methods for reflection)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[integrating methods and their application]</td>
<td></td>
</tr>
</tbody>
</table>

One additional contribution from Buddhism is important to confirm the relationship implied above, between the people and environments required for innovation; If The Three Jewels or The Three Protectors represent Actors who display certain ideal qualities or styles of behaviour, there is also an appropriate or ideal environment, which supports and enhances the emergence of the ideal Actor and actions. These environments are in Buddhism called The Three Pillars. They are defined in modern terms by Seegers [2007b] and by Nydahl [1996], as environments of [i] action, where one ‘holds the view’ or general structure of the ideal in daily life but does not always apply rigorous rules for this [ii] contemplation, where one uses exact technical methods for reflection on the ideal, and [iii] learning, where one integrates and potentially transforms the direct and indirect experience of the ideal. Individuals are required to explore all environments to achieve the Ideal Final Result –in the case of Buddhism this is to reach a comprehensive understanding of ‘the way things really are’ [Nydahl, 1996]. For easy reference, Table 3.1 shows how the terminology of the Three Contexts of Creating, The Three Jewels and The Three Pillars are related to the world of Engineering Design [called the Diamond Model of Design in section 3.4.2], which is the object of their application in this Chapter.

3.3.2 The Mandala of The Five Buddha Families

In order to develop the most comprehensive model of ideal space possible to enhance understanding of the process of innovative Engineering Design, in this section the concept Meditation geometry is extended. For just as the The Three Jewels appear in 3D, so also The Five Buddha Families appear in a visual ‘Mandala’ where each element interacts with the map–user in her pre–given world. The Mandala is essentially the pattern of intersection of the Divine with the pre–given world.

Buddhist Mandalas are Meditation practises, which originated over 1500 years ago in India and were brought to Tibet in the mid–7th century. The Sanskrit term Mandala, which predates Buddhism, is mostly translated as ‘circle’, for this is also the best–known geometry of the visualised Divine [in Figure 3.3 above this represents ‘the cycle of attention’]. However the Tibetan term kyil khor, which means ‘centre circle’, captures more accurately not just the periphery of the form but also the importance of the point at the centre of the Mandala, from...
whence the Divine being is said to emanate, and this allows for forms to be many other shapes and not just circular – regardless of its shape, every point of every geometric figure can be considered to radiate from a central point.

There are many different and complex ways in which the Divine ‘divides itself’ as it emanates or moves towards the pre-given world and becomes visible and interactive with Meditators – in Vajrayana Buddhism, each division or ‘emanation’ is considered to [quasi-holographically] represent the whole, even while it is a recognisably different ‘Buddha Aspect’. Aspects with similar functions or qualities are said to belong to one ‘Family’ [eg. Beer, 2003, p234–236; and Snellgrove, 2004, p191–213 provide details] and yet each Buddha Aspect has his/her own Mandala. The instructions for the creation of all the hundreds of different Mandala forms are thus also very specific – there is not much room for spontaneous [‘creative’] individual expression on the part of a map-maker [see for instance, Leidy and Thurmann, 1998; McArthur, 2002, p175]. Indeed, the form of a Mandala should definitively not be freely created – rather a Meditator should use the pre-given form to more freely create his own life. Use of the Mandala is intended to transform both the individually experienced and socially pre-given worlds in which the map-user feels he exists, from being an experience of confusion, problems and suffering into one of wisdom and bliss [among other things], as already discussed in the sections of this Chapter above.

In this Chapter, it was already suggested that it is simple and liberating for a map-user to consider three elements of the ideal as people or objects rather than abstract qualities [in The Three Jewels]. In the same way, the five functions which these elements carry out while coming closer to the pre-given world are also represented as forms – specifically as five Buddhas – and their families, in a Mandala.

Figure 3.5 presents a template of this Mandala, stylised for this Dissertation [more beautiful versions are available in traditional Buddhist thangkas in Art Galleries, Museums or Buddhist centres in many countries]. Each of the four compass directions is assigned [or considered to inherently possess] one aspect of a completely informed and fully functioning space [this term is used comparably with Stafford Beer’s ‘Viable System’ description, to be explained below]. The fifth and central position is given to the fully integrated, completely functioning space – which is seen as the Divine mind.

Further useful links are made in Buddhist Meditation, which enable the map-user to find his way to meet the ideal, or potentially bring it into his pre-given world on his own terms; For instance, the five ways in which the Divine interacts with the pre-given ordinary or human world are said to correspond to the five human senses. In Vajrayana Buddhist thinking, full experience of one’s five senses in a pre-given reality should naturally lead one’s mind to the next highest level of perception, organisation and experience – that embodying The Three Jewels. Thus the Mandala of The Five Buddha Families idealises the five senses and their five associated emotions or mental states. It makes ‘a perfection’ of an imperfect state, as follows:

Traditionally, the five possibly disturbing and non-ideal mental states associated with different kinds of ‘sense fixation’ are: anger, pride, desire, jealousy and ignorance. Liberating oneself from these mental fixations means to gradually transform the gross state of behaviour into a subtler and supposedly ‘wise’ one – the latter are more abstract than concrete, more ideal than real, more energy and light than physico-mechanical. It is important for this Dissertation to emphasize that such refinement is not an obscure religious concept but rather seems to be a natural trend of evolution. The liberation of mental fixation and gross states of physical behaviour for instance, is the IFR of Engineering innovation and the evolution of entire classes of Engineered products [Altshuller, 1984].

In the Mandala of the Five Buddha Families, the five wise, liberated mental states emerge as follows:

1. Akshobya [in the East] deals with seeing the highest potential of oneself – specifically overcoming the anger associated with feeling separated from, or violently different to, an ideal [Buddha]. To realise that one that is neither separated nor different, but indeed also has the potential to be ideal, is called realising the ‘mirror-like quality [or capacity]’ of mind.

2. Ratnasambhava deals with seeing the highest potential of others. Almost the opposite of the above, one overcomes the false pride of feeling special and realises that one is not
3. Amitabha [sitting opposite Akshobya], deals with one’s own energy – specifically with directing or controlling it appropriately, rather than just letting loose. To focus on achieving and holding the ideal, without deviation, in one’s internal world, leads to a ‘discriminating quality’ of mind.

4. Amoghasiddhi deals with energy in relationship to others. When energy is not jealously constrained by oneself, but all-encompassing and interactive in a field, this leads to an ‘all-accomplishing’ capacity of mind.

5. Finally Vairocana [in the centre] represents integration of the above – overcoming separation from the ideal in oneself and others, and enabling an ideal flow of energy in internal and external space. He thus represents ‘awareness of the absolute reality itself’ [Scherer, 2005 p171–173 and p204–205 and also Vessantara, 1993].

As intimated earlier in this Chapter and is hopefully clear from this explanation, the functions of the five Buddhas are related, such that the first two are concerned with the ideal form [of self/one and other/many], while the latter two are concerned with the ideal ‘formless’ flow [for self/one and other/many]. This will become even more relevant to Engineering Design, in step six of the Innovation Process Map in Chapter 5.

![Figure 3.5. The Mandala of The Five Buddha Families stylized for this Dissertation.](image)

3.3 The Viable System

There are many parallels of the Buddhist view of the world with the organisational worldview of Stafford Beer, who was called ‘the father of managerial cybernetics’ by Norbert Wiener [himself ‘the father of cybernetics’]. Exploring these and integrating them with the Buddhist models for conceptual space which have already been explored in this Chapter, is the object of this section.

Beer created a model for organizational behaviour which was quite revolutionary in the early 1970s and into the 1990’s. Beginning with personal observations made as a Psychologist in the Army, and in several decades of Management in the steel industry, he intuited that man’s biological structure and mechanisms of perception are intrinsically linked to his social behaviour. In order to model this, he combined a set-theoretical model of the brain with what was then understood about the central nervous system and general brain structure. And, in a series of hefty books such as ‘The Brain of the Firm’ [Beer, 1972] and ‘The Heart of Enterprise’ [Beer, 1979, and see also Beer 1984; 1985; 1989], he postulated that a well-functioning, independent organization would follow the same patterns as an individual. He identified five distinct, necessary and sufficient types of behaviours which made up a complete well-functioning system and proposed their integration as sub-systems in a ‘Viable System Model’ or VSM. In his books, Beer [ibid] describes how functional decentralization coupled with the inherent cohesion of a
five-sub-system model allows autonomous Design, adaptability and flexibility. In decades of his own testing and adjustment, which included some major clients [eg. President Allende prior to the Chilean coup], it seems that the theory works – organizations built on his principles are apparently better able to balance both external and internal perspectives, and long- and short-term thinking, than others who do not use them [Leonard, 1997].

In spite of his insistence and personal proofs that five behaviours and sub-systems must exist in an organization, Beer never actually provided an ordered list of their manifestation or evolution. His rationale for not doing so [as he explained many years later, in response to others trying to create such a list], was that there could be no stepwise order to it; ‘the five sub-systems work recursively and cannot be isolated from each other, so attempts … to identify them separately with managerial names are ill-conceived’ [Beer, 2000]. For the purpose of this Dissertation however, this gap must be filled since it can be considered a given from the Buddhist view, that behaviours are interdependently arising and recursive. Thus a summary of the stages, qualities and functions, which VSM sub-systems exhibit, is here distilled from many different parts of Beer’s [ibid] work:

1. the physical structure or elements and/or the initial direction in which growth occurs;
2. the system, which coordinates flow of information and basic relationships between elements in [1];
3. the autonomic command centre, which controls or operates the functions of [1] and [2];
4. the system that strategically plans and integrates [1] and [2] and [3] with the outside world;
5. the overall command centre, which balances all above functions with an original purpose and external demands – the apparent ‘heart’ of the firm.

A more succinct summary of the VSM, whose stages are nevertheless comparable to those just outlined, has been also proposed by Leonard [1997], who worked with Beer for 25 years [this will is useful in Table 3.2 of this section]:

- Implementation [System1]
- Coordination [System2]
- Control [System3]
- Intelligence [System4]
- Policy [System5]

In order to describe the interrelation of sub-systems, Beer [eg. 1972, p143] tended to think of them in a complex geometry approximating a kind of ‘Mandala’, which is not illustrated here [but can be found in Pahl and Newnes, 2005]. His point in doing so was to clarify the coupling he believed occurs between human biological organization in the nervous system, and the elements of man-made organisations, societies or companies. For, as mentioned above, Beer [1972, p. 182] was certain that the [externally] pre-given world mirrors the [internally] perceived and experienced world. He fully believed that one’s internal perception depends on the way in which external movement and experiences are wired into the brain, and vice versa. Beer, of course, was also not the only one to make observations and inferences like these – the phenomenologist Merleau-Ponty [1962, 1964, 1965] was convinced that the experience of the outer world and the organization of the inner world are linked and his work is continued even today in University Departments of Philosophy in the movement called ‘Interactive Mind’ and ‘Extended Mind [Clark and Chalmers, 1998; Clark, 2005; Rupert, 2009; Menary, 2010].

Further discussion of these correspondences is beyond the scope and not the object of this Dissertation. What is relevant here is that the VSM can therefore be better interpreted by adding a summary of the Five Buddhist Skandhas [standing for five kinds of sensory awareness] and The Mandala of The Five Buddha Families, as shown in Table 3.2, using Leonard’s 1997 terms for the sub-systems. All three systems make similar conclusions about the way in which human perception and behaviour are associated and organized. All three systems assume that the physiological functions of the brain and nervous system underpin our actions and external interactions with the pre-given world. As introduced in Chapter 1 [1.3.0] it is also a central axiom of this Dissertation that human brains are part of the pattern of creation of the greater
cosmos, and may have inbuilt tendencies to follow roughly the same steps in creating other things in turn, no matter what, or in which field, they create. In other words, humans may build Sciences, Engineering products, systems, and structures in the same manner or according to the same pattern whereby they build relationships and organizations, whether they know it or not. This seems to be borne out by the generic process for creating proved by Pahl et al., [2007], which will be elucidated in Chapter 5.

In Beer’s VSM and both Buddhist models, each of sub–systems one to four supports the function of the others in a recursive, co–evolving relationship, and is subservient only to sub–system five and the whole. This means that sub–systems one to four are ‘open’, in the mathematical sense. Only the fifth sub–system of a complete system enables the whole to ‘close in on itself’ [Beer, 1989], and this is what makes the system ‘viable’. Mathematical closure is relatively easy to achieve. In practise however, Beer reported that organizations find psychological and philosophical closure difficult and hence viability impossible to achieve. He noted that teams were often flustered when asked to define the crucial fifth sub–system in their organization, even though they could easily decide upon the components of the sub–systems one to four. Often, everyone gave a different answer and there was no agreement on what ought to have been the central question, or ‘heart’ of their organization [Beer, ibid].

Reflecting on why this should be difficult, Beer realized [particularly during his work with President Allende in Chile] that people projected their expectations for their own particular sub–system, and thus pre–given world, onto the whole. Since a large organization has generally grown together in a bottom–up way with different stakeholders and from different directions, there is not always a coincident view of how growth of the whole should take place – and this is also the exact situation a product Designer and its End–User face, when trying to integrate their worldviews. At that point of insight, many years after first establishing his model, Beer realized that it was the fifth sub–system needed to set, and affirm if necessary, some original intention as to what kind of organizational growth all sub–systems should undergo. This is the part of a complete system which is therefore defined by ‘Integrity’ in step 6 on the PRIZM Innovation Map. The integration of Beer’s model with the Mandala of the Five Buddha Families also overcomes some of this problem in the next section and in Chapter 5.

Table 3.2 The Mandala of The Five Buddha Families, The Five Buddhist Skandhas and the Viable System Model of Stafford Beer all propose that an ideal system [including the ideal human organization] is composed of five similar sub–systems.

<table>
<thead>
<tr>
<th>System describing organization of an ideal</th>
<th>Function of the sub–systems of an ideal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandala of The Five Buddha Families</td>
<td>Identification of a single Ideal form</td>
</tr>
<tr>
<td></td>
<td>Identification of Diverse Ideal forms</td>
</tr>
<tr>
<td></td>
<td>Discriminate use of energy</td>
</tr>
<tr>
<td></td>
<td>All–inclusive use of energy</td>
</tr>
<tr>
<td></td>
<td>Centralised integration</td>
</tr>
<tr>
<td>The Five Skandhas [awareness of …]</td>
<td>Form, structure, body, sense objects</td>
</tr>
<tr>
<td></td>
<td>Perceptual stimulus, feeling, sensation</td>
</tr>
<tr>
<td></td>
<td>Cognition, mental processing of sensory stimuli</td>
</tr>
<tr>
<td></td>
<td>Ideas, associations, volition</td>
</tr>
<tr>
<td></td>
<td>Interrrelationship of self, others and world</td>
</tr>
<tr>
<td>Viable System Model</td>
<td>Implementation, structure</td>
</tr>
<tr>
<td></td>
<td>Coordination, information</td>
</tr>
<tr>
<td></td>
<td>Internal control</td>
</tr>
<tr>
<td></td>
<td>Externalized intelligence</td>
</tr>
<tr>
<td></td>
<td>Intention, Policy, overall command</td>
</tr>
</tbody>
</table>
3.4.0 EMANATION OF Engineering Design

3.4.1 Living in Two Worlds

Iterated Meditation, as intimated previously in this Chapter, should lead the map-user to ever more refined thought and behaviour. In other words, when Meditation is used to achieve an ideal result from the bottom-up, the five gross modes of sense-related behaviour prevalent in the user’s pre-given world [and mirrored in the map of The Five Buddha Families] should morph into three subtler modes of perception and behaviour such as those exemplified in the map of The Three Jewels. Conversely the ideal world can also be constructed from the top-down, with the three interrelated components or principles of ideal space first showing up as The Three Jewels or Three Protectors, which can be essentially paraphrased as a sentence involving the Actor, Action and Acted Upon/In. These, in turn, concretise five principles of interaction with physical space, which can be paraphrased as functions carried out by the three Actors, which affect both individuals and groups and both material objects and energy.

The crucial step of transformation in Meditation matches the maps representing the world from each worldview ie. from the bottom-up and from the top-down, and then dissolves the gap. In this section, we will explore the exact steps as to how this co-emergent or co-evolutionary transformation from ‘real to ideal’ happens both in terms of Buddhist Mediation and in the terms of Engineering Design.

As a complement to the ideal world represented by The Five Buddha Families, another map is now introduced; the so-called Mandala of The Five Kings, which represents the highest possible symmetry of the pre-given world and mirrors every element of The Five Buddha Families. These Five Kings are not ideal, meaning they are not liberated from fixation on objects. Yet they are said to act in a manner similar to the Five Buddhas [see for eg. McArthur, 2002, p71] since they have reached the pinnacle of achievement in their respective fields. In terms of Engineering Design, their achievements would be exemplified by striving for perfection in material objects and perfection in the control and flow of energy in all things for which one is responsible. Apart from benefiting others, such actions reduce chaos and lead to streamlined, refined and evolved behaviours to achieve any goal.

In Vajrayana Buddhism, the two kinds of world [of the Kings and of the Buddhas], relate to each other not just by reflection, but by being integrated in the perception and experience of someone sitting in the middle of both. As already mentioned already in Chapter 1 [the I-Rule or Rule #1 of innovation], integration is the very essence of innovation; it is not enough to have or introduce new information, nor even to match it to a problem. New information it must be integrated into an old space, in order to make effect true transformation. In the case of the Kings and the Buddhas, integration is possible because both the pre-given world of the Kings and the ideal world of the Buddhas are represented by a conceptual map. The one who sees both worlds and integrates them, thereby overcoming all duality and discrepancies between them, is called The [or a] Buddha.

In Figure 3.6 [a] is shown how a Buddha can perceive two worlds, while seated in the centre of a third world [this figure is based on the view of the Meditator introduced in Figure 3.4]. He may or may not believe himself to be looking at a non-conceptual map [of the pre-given world] as well as at a conceptual map [of the ideal one], while drawing his conclusions in his own non-conceptual [experiential] world. An external observer looking at a theoretical Buddha [outside the plane of the page on which the diagram of the event is drawn], however, would definitely see him seated in the centre of two conceptual worlds and only one non-conceptual one. In strict geometric terms, the only non-conceptual world is the one in which the Buddha is actually seated, meditating [eg. on the riverbank]. Of the conceptual worlds, one is a pre-given Divine world, to which he can journey with his mental body, and whereupon he becomes its central figure [the world of The Five Buddha Families]. The other is a pre-given human world, in which he ordinarily acts with his physical body [when he is not sitting on the bank of a river] and where he has also reached the pinnacle of achievement and become the central figure [the world of The Five Kings]. This is why Long & Burnama [2005] point out from ancient Mahayana texts, it is probable that ‘... the mental body of the [earthly King Shakyanumi who was A Buddha-to-be] ... proceeded to the Divine world, even as his [physical] body remained seated on the bank of the ... River’.
In the next step, the very same situation is integrated into more cohesive geometry [Figure 3.6 [b]], which is technically speaking an octagon, but can be loosely called a diamond. It illustrates how the action, reflection and integrated understanding of the Divine [first described in Figure 3.1], would look in 3D. At this point, the theoretical Buddha of this Chapter will definitely appear to an external observer to be coincidentally King, Meditator and Buddha. The three positions of true centre and the two central end points are also completely equivalent since a Buddha acts in [and indeed creates or co-evolves] all these worlds simultaneously. And, as the theoretical Buddha makes all his worlds coincident, to our external eye, this not only integrates but inverts the geometry of the preceding part of this figure.

Figure 3.6 [a]. An external observer looking at a theoretical Buddha would see him seated in the centre of two conceptual worlds.

Figure 3.6 [b]. The theoretical Buddha may also make both his worlds coincident and co-evolving. This integrates [and inverts] the geometry of the preceding figure.

If one now tries to directly relate the situation of the Buddha in the previous diagrams to Engineering Design, one immediately encounters a block [Figure 3.7]. Plainly put, while the Buddha is one person, but three people are required to carry out the roles at the end points and centre, much as the roles of Engineering Designer, End-User and Manager/Researcher/Facilitator were assigned to the three functions of The Three Jewels, earlier in this Chapter. Each of these people has their own view or part of a pre-given world which is constructed in isolation from other possible parts or views of a pre-given world. Each projects or perceives the important elements of his world around him in the geometry introduced in Figure 3.4, ie. a half-diamond. Putting together two such people, each with their own geometric projection, to join up the two half-diamonds up in a single diamond, as shown in Figure 3.7 is impossible, because there is a mismatch in the position of the elements of the respective worldviews. It is possible, if one does not look too closely, that one might propose the worlds mirror each other, but truthfully, they do
not. The Mandalas on either side of the central plane are simply opposites. Of course, that is precisely what happens when one looks in a mirror every morning while brushing one’s teeth in the Western pre-given world. The image that greets oneself on the other side of a mirror does not actually part its hair on the same side.

This mismatch on either side of a mirror is unavoidable because, as Plato pointed out in his book Timaeus [quoted and extended in Plitcha, 1998, p108], two mirrors must be placed at right angles to each other, giving four-fold quadrant symmetry [assuming the mirror extends behind the intersection one looks], with infinite space in each direction, in order to get the correct image reflected back from the central join. Actually, as Plitcha [ibid] tested it, such a four-fold mirror ‘…shows me as if I were standing in front of myself and thus in reverse. In addition there are two normal reflections, one on the left and one on the right’ . Plitcha proposes that a ‘space of concepts’ can also be said to have or require a quadruple structure because it would only be completely knowable by arranging two plane conceptual mirrors in this way [Plitcha, ibid, p105].

Plitcha’s exercise thus establishes a Mandala of four sides, and five Actors or elements, which can be considered a mathematical corollary for Buddhist Meditation. In other words, a five-element system seems to be the best way to model a complete conceptual space in the plane of the perceiver, just as the Mandala of The Five Buddha Families suggests. In addition to the perceiver of a world within the central space of the [four-sided] geometry in the mirror, there is a similar world outside it, just as is the case for the Buddha in Figure 3.6[a] and [b]. The existence of one or more perceivers [both inside and outside] the perceived five-element system confirms that as the 2D map translates into 3D or even 4D, it reveals two more hidden elements for completely describing a world – thus totalling seven. This is important for the seven steps exemplified in the generic process of creation [Pahl et al., 2007], further discussed in the next section and Chapter 5.

Figure 3.7. The worldview of two teams oppose each other. Even though both have independently evolved similar Mandalas of thought and behaviour, they do not naturally match over the central mirror plane.

To make life simple for Engineers, one could disregard the situation of mismatched worlds and force the elements of the two worlds of Designers and End-Users to coincide, just like they do for a theoretical Buddha, on either side of a central mirror plane. With no other option, this would achieve a relative simplicity in discussion between the two opposing teams [see Appendix in Pahl and Newnes 2005, for ‘Structuring Designer–User conversations with the 3D Diamond Model’] and a kind of prototype model. But fortunately, ‘forcing the world to fit’ one’s fixations is not necessary. There is a way to resolve all discrepancies and dualism as if by magic, so that everything fits perfectly. This is possible because there is a second way for a Buddha to create a perfectly integrated world, utilizing the structure that can be recognized by yet another external observer, as will be elaborated in the next section.

3.4.2 A Diamond Model of Design

The resolution for the mismatch of the two five-element Mandalas for Engineering Design, which are experienced and projected by Designers and End–Users respectively is in ‘The Hierarchical Map of Meditation’ presented in section 3.2.2 of this Chapter. This is now applied as follows:
Assuming that Designers and End–Users are part of a single co–evolving system, they act as two of The Three Jewels – the first inventing or providing methods and/or structure, the second applying the methods and/or structure in context and supplying feedback. In other words, the Designers and End–Users respectively ‘emanate’ from the central research point or management point. At the practical level, each of them is responsible for answering only two questions: how does this look in the original system, and how does it look when there are many variations. In other words, of the five qualities or functions that make up, or must be addressed in, a complete Mandala or complete, Viable System [whether organization or technical product], the Engineering Designer is responsible for only two. The End–User must also provide similar feedback on two more considerations, while the Manager/Researcher/Facilitator is responsible for only one. A well–functioning company or Complete System [of integrated information or knowledge] is shown in Figure 3.8 [a], with arrows indicating responsibilities for the questions which must be covered – a three–person team and their functions form a diamond [ie. the impartial Manager/ Researcher/Facilitator is invisible in the middle].

Figure 3.8 [a]. The complete and ideal system. The purpose and viewpoint of the Designer and End–User form end–points of discussion, comparable to two of The Three Jewels. The two functions or questions of each person add to the other in a central plane, to create an integrated whole.

Figure 3.8 [b]. The final Diamond Model for Designer–User interaction. There is no set starting point for asking questions or combining answers to form a whole. Each question and its feedback should inform others, to co–emerge or co–evolve a complete and ideal system; hence the continual circle of blue arrows.

The kind of feedback which must be offered by the End–Users from their experience of similar situations are for example; [i] what kind of hull do we really need for ferry–pilots on the leisurely Sunday morning route between Manly and Sydney [ii] how will this hull hold up after 10 years service, doing x, y, z on that route etc. The more complex the original product or map being
produced or explored, the more important it is, to have additional information from the world of the End-User, so that the expectation or ideal can be matched up in each direction.

At the very simplest level, the two kinds of questions which must be asked by Designers, for instance in creating a new Ferry hull, are of the ilk: [i] what are the minimal elements this hull must have to work? [ii] what additions or modifications must the hull have to work well in different systems and environments – car ferries crossing the English Channel compared with Sydney Harbour etc.

It is also, therefore completely irrelevant, which of the worlds of the Designer or End-User is considered to be ideal. Either of them can be considered a pre-given world – and suffice to say that an unknown world is always an ideal world to someone who has not yet experienced it, as was already discussed in the case of the map and experience of Paris, in the introduction to this Chapter. As intimated in section 3.3.1; when both the standard and its deviations come together and continually co-evolve to improve the other, the result is likely to be not only relevant to both the original worlds, but transformational for other worlds that intersect them too. Thus in Figure 3.8 [b], the generic process for creating, making or producing anything from nothing, by integrating two worlds to make a difference in, or even transform, a third, is presented as a Diamond Model for Designer–User interaction. This summarizes all Buddhist Teachings covered in this Chapter in a non-standard and modern way, and is the conceptual basis for understanding co-evolution in the Innovation Process Map presented in Chapter 5.

3.5.0 THE MAP OF ALL WORLDS

3.5.1 Meditation as Design

There are many different types of Meditation in different Buddhist traditions. They have different goals, and use different sets of images, sounds or body movements. In the West, non-Buddhists have usually heard there are two different types – meditations which focus on calming the body and breath and seem to induce relaxation, and meditations which mostly focus on using the brain and involve analysis or insight. Ideally, however, both these types or mechanisms of practise are integrated in a single path, the underlying structure of which, as was explained in sections 3.1.1 and 3.2.0 above, starts with the motivation of the practitioner and ends with her creation of the world. This is certainly true in the Vajrayana or Diamond Way tradition of Tibetan Buddhism, from which the Meditative Tool that forms the basis of the comparison of processes of creating in Chapter 5 is derived [Nydahl 2000a].

In most Diamond Way Meditations, there are seven distinct steps of the process of formal Meditation, which usually take about two pages to explain [see Appendix 1.0 for full explanation]. Since they are alluded to in all sections of this Chapter, and will be again referred to in explanations of the Innovation Map [Chapter 5], this sections aims to show how creation of the Divine or ideal world in Meditation and creation of the Ideal final result of the Designer are related in a little more detail.

The seven steps of Meditation that call the world of the Divine into being are:

1. Motivation [four thoughts]
2. Refuge
3. Building up
4. Blessing
   • Body
   • Speech
   • Mind
5. Completion [melting or dissolution]
6. Activation
7. Dedication

This author [Pahl, 2005] previously ‘translated’ these steps of Meditation into terms used in studies on organizational complexity [Snowden, 2002; Kurz and Snowden, 2003], and indeed the Engineering Design process according to Pahl and Beitz’s [1984] form and function model, among others in this way:
A. One defines the current situation [point of origin] and coincident motivation for moving, transforming or changing something. That means one determines the needs and/or tasks. In Western psychology, motivation is usually established by focussing on the pathology of being stuck in the current situation ie. the problem. In contrast, the Meditative Tool used here focuses on the ultimate goal or most positive motivation and outcome of moving from the current situation.

B. One develops or is given [and accepts] specifications for a template of the desired goal [point of solution]. This goal does not exist arbitrarily, as some philosophical point. It is a high level of function or functioning, which has a high level of internal structure – both geometric and psycho-social, with which one can identify.

C. In the first cycle of action, one creates a conceptual Design, by setting up the gross template of the solution as a mirror opposite our existing situation. The goal is not arbitrarily fixed in some space one cannot see and does not know how to find. Its internal structure, as well as the structure one forms in relation to it, both create a map for transforming the user’s current situation or ‘the space where we are’ into the ideal ‘space where we want to be’. The map outline is very simple – one mentally diverges from the starting point and converges on the desired finishing point, just like the eye does, when it looks at objects apparently located behind a physical mirror, in a diamond shape.

D. In the next cycle of action, the user maps the details from the template onto the existing situation. That means she carries out iterations of convergence and divergence for all subsystems of the overall form – material, communication and information systems. In terms of Pahl and Beitz [1984], she selects building blocks or combinations of solution principles to fulfil the overall function.

E. The user overlays the complete template of the solution on the existing structure, in its current context, trying to ‘melt’ or ‘dissolve’ the boundaries between them. This is the stage of detailed Design, concept variants, or form variant or embodiment Design. In Meditation, this is the point at which one does or does not achieve transparency of the point of origin on the goal.

F. One gives up trying to create the perfect fit and just allows a best fit of the template in the current context to appear, however it best fits. The final layout or prototype is fully formed.

G. Finally, one imagines a general application or manufacture of the template for all other systems, which are similar to the pre-existing world in which one started, and might therefore benefit from using the same map to create another world.

3.5.2 The Hero of Innovation

Meditation, as described above, is however not just a process that happens on the scale of the individual [where it is called Theravada practise], but a process that happens on the scale of society [where it is called Mahayana practise], and indeed the cosmos at the highest level [where it is Vajrayana practise]. At the highest level, one’s practise necessarily includes the two previous levels also, since the individual cannot be separated from the social or cosmic environments, in which he acts [see also 5.2.3]. This means that the steps of Meditation as described in the previous section, which are applicable to Engineering Design and innovation at the individual level can, or indeed must, become applicable to innovation at the social level also.

Buddhist teachers like to say; ‘If something is true, it is always true – at all scales and in all directions’ [Nydahl, 2004]. In other words, if the geometry of space and mind proposed by Buddhist methods points to a fundamental, fractal principle of creation in the cosmos, then the space in the outer world should include, or be included in, the space in the inner world of the practitioner or vice versa [Nydahl, ibid]. Thus Buddhist teachings are designed in a fractal way [see also 5.3.5 and 5.4.0], so that a deep and wide understanding of the nature of creative space can emerge through experiencing it at different levels. And thus the geometry of Meditation that an individual practises in her own mind while sitting on the banks of a river is the same geometry that an individual could practise while interacting with others around a table, walking around a kingdom or an Industry. This means, the experience of Meditation can be lived out, over long time scales, moving through each step in turn, as if it were an adventure.

The Innovation Map that is the focus of this Dissertation is intended to be applied and experienced in a similar way. In the GameDay format [see 6.1.1], when it is used twice in quick
succession, experience shows that participants move toward their own personal ‘highest level of innovative behaviour’, by first mastering innovation at the levels of the individual and the society, in turn. This means that in the first Game, participants are invariably fixed on personal liberation, concentrating on learning the rules and understanding the process for themselves. In the second game, participants are no longer overly concerned about their own performance and keeping to the rules, and thus find that team interaction improves exponentially, as do the results of discussion. At that point this author likes to say that ‘true innovation’ starts, since it involves at least two parties with conflicting starting points [as described in all sections above] and must be inherently social. Following this experience of ‘social innovation’, participants in workshops of the Collaborator often ask if they can repeat the process with friends or at home with their children, which takes them beyond using the Innovation Map as a map for innovation for Engineering Design, into an experience of relatively ‘global transformation’.

Practising the Meditative process over long time scales in daily life – ie living the adventure of practise with the motivation to transcend all difficulties in daily life, transcende them and then help others to transcend their own difficulties in the same way is called the Bodhisattva path [Gampopa, 1998], literally meaning ‘The Path of the Hero of Enlightenment’. In plain english, this level of practise of Meditation is A Hero’s Journey, which is vaguely similar to the hero’s journey of classical fairytale [as elucidated by Campbell, 1949] and Hollywood screenplays, whereby one moves toward an Ideal Final Result, via a series of adventures, misadventures and great personal growth. Similarly, when used over a longer time-span in industry and in preliminary tests with educational bodies and youth, it appears that the Innovation Map can also lead participants to experience a kind of journey of innovation. In other words, the Innovation Map can become ‘The Map for the Journey of A Hero of Innovation’. Setting up this kind of journey is indeed part of the strategy of the PRIZM Game Company for youth programmes and would also work well as both/ either an implicit or explicit framework for corporate innovation programmes. The steps of the Hero’s journey, which may also be experienced by participants encountering and repeatedly using the Innovation Map, are as follows:

i. Great Joy – meeting an Expert and understanding that one’s ideal goal really does exist, and that it can be reached by following the footsteps of those who have a map to get there. This step is characterised by a feeling of personal abundance. This is the step of seeing the Ideal Final Result : B, from section 3.5.1 above, and simultaneously ‘the call to adventure’ and ‘supernatural aid’ of Campbell’s [1949] Hero’s journey that is exemplified in all fairytales.

ii. Stainless – applying the methods/map [that are set out in order that students might reach the goal] to one’s own situation. This step requires practise and is characterised by personal discipline. This is the step of requiring positive motivation in challenging circumstances : A, from the section above and where the fairytale Hero ‘crosses the threshold’, leaving the known world.

iii. Radiant – applying the methods/map for the benefit of others who are also in the same situation as oneself. This step requires a different kind of practise that is characterised by patience. This is the step of applying the map in general : C, from 3.5.1 above.

iv. Luminous – withdrawing from society [one’s original world] to reflect intensively on the methods and how they work. This step is characterised by perserverance in applying the methods – especially because they probably seem by now not to work. This is the step of applying the map in particular : D, from section 3.5.1 and where the fairytale Hero finds himself in ‘the Belly of the Whale’ or falls on other hard times.

v. Very Difficult to ‘Train’ – striving to integrate all one has learned in retreat and in the world, and overcoming great obstacles from others [who do not believe the goal can be reached or that the method/map works, or who do not work toward the same goal]. This step is characterised by concentration. This is the step of dissolving boundaries between the particular and the general world : E, from section 3.5.1 and the ‘Road of Trials’ in fairytales and movies, where the Hero meets all the tests and tasks that will lead to his transformation.

vi. Obviously transcendent – the point of reaching, then transcending one’s original goals inside one’s original world, and then finding there are yet more worlds and yet another point of integration that can be reached. This step is characterised by the kind of wisdom that arises from the experience of flow [after Csikzentmihalyi, 1990] with all things in one’s original world. This is the step of accepting the best fit and getting on with things : F, from section 3.5.1 above and ‘Meeting with the Goddess’ in fairytales, where the Hero begins to see himself and his world in a transcendental, non-dualistic way.
Gone Afar – the methods and lessons learnt so far are now applied at another scale, or in another world, where they are adjusted and perfected. This step is characterised by the development of ‘skilful means’. This is the step of reproducing the map and its results in all other possible situations: G, from section 3.5.1, whereby the previous step turns out to be a kind of ‘false climax’ or ‘Meeting with the Temptress’ in fairytales and movies, which must include [or be followed by] a further three steps including ‘Meeting the Father’ and ‘Apotheosis’, before finally achieving ‘the Boon’ and ‘crossing the return threshold’ to help others with it, thereby becoming the ‘Master of Two Worlds’ [cf. section 3.4.1 above]. And while Campbell [1949] delineates more than ten steps in total, the final three steps of the Boddhisattva journey still perfectly match Campbell’s [ibid] understanding of the Heroic Journey in that: at the 8th step the returning/far-going Hero trains to directly understand the actions of all fellow beings while he perfects his wishes, characteristically becoming ‘immovable’ in his understanding of how to apply his wisdom and able to include knowledge from other contexts in his own context ie. achieve the Boon and return to his original world; at the 9th step, the returning/far-going Hero trains to directly understand the mind or languages of the highest gods, while increasing his own good wishes for fellow beings and increasing his strength in achieving the Boon ie. Meet the Father and undergo Apotheosis; and at the 10th step the Hero is beyond formal training, able to understand all things both in and out of context, directly from space, attaining omniscience in all Worlds ie. Master of Two Worlds.

These steps can also be correlated with Figures 3.8 [a] and [b], which begs discussion of the way in which a whole ‘Innovation 3.0 ecosystem or culture’ might evolve beyond the Map and Game, as introduced in 1.2.1. This will be addressed again in Sections 5.2.0 and briefly in 6.6.1, although an extensive, detailed consideration is beyond the scope of Dissertation. The next Chapter will therefore bring the focus of the Dissertation back to the level of Innovation 2.0 – ie. to systematising innovation. This requires laying bare the rules of TRIZ, to determine how to integrate them with the mechanisms of Buddhist Methods. For, as the Rules of Innovation and Hero’s Journey uncovered in this Chapter have indicated, it is only after the rules are known, that they can be bent or transcended.
Chapter 4 A PROTO THEORY OF PROBLEM-SOLVING: Finding the Problem behind the Problem

In this Chapter, the fundamental concepts of TRIZ are reframed and simplified. Misunderstandings are addressed, which have occurred as TRIZ moved from Russia to America to Europe. The fundamental concepts of TRIZ are not different to the fundamental patterns proposed by Buddhist Technologies and both sources are built upon, to suggest improvements to existing Innovation Tools, processes and culture. Evidence from a Pilot Test in the Engineering Company is provided as example of the status quo of TRIZ training. Then all the Tools of basic TRIZ are put in a context which is a prelude to the Innovation Map of the next Chapter.

4.1.0 THE THEORY OF INVENTIVE PROBLEM-SOLVING [TRIZ]: ITS ORIGIN AND TRANSMISSION

Teoriya Resheniya Izobretatelskikh Zadatch, the ‘Theory of Inventive Problem-solving’ or TRIZ, as it is better known, was developed by Soviet Engineer and Inventor Genrich Altshuller, and extended by his colleagues, in the second half of C20th. As a problem-solving system, it is variously called a theory, methodology, or knowledge-base for generating ideas to solve problems.

4.1.1 Thanks to Stalin: The Work of Altshuller

In the early-mid 1940’s, Altshuller was a patent officer in the Russian Navy. Much like Einstein, he had the opportunity to casually, as well as officially, analyse patents that passed over his desk, and investigate what inventors had done, to come up with noteworthy ideas. There is no biography available on his life, but it is known that as an inventor himself, he was dedicated to simplifying the process of inventing. Legend has it that, after only a little time, he intuited there was a pattern in the patents, that could be systematised and thus potentially benefit inventors in all of Russia [Ikovenko, 2003]. He wrote to Stalin, proposing that his fledgling system could be extended to rebuild Russia after WWII, but due to his apparently politically incorrect approach, was arrested and sent to a Gulag for 25-years of hard labour. Altshuller met colleagues while in incarceration, with whom he tested and extended his ideas, and together they are said to have investigated 200,000 patents, from which they abstracted and classified a limited number of [1521] problems and [40] solutions or ‘Inventive Principles’, used by all Engineering inventors who had made significant historical changes in their discipline; especially when they had re-used previously proposed ideas in a new way. On his release in 1953, Altshuller published a paper with the outline of a ‘Theory of Inventing’ with colleague Rafael Shapiro, in the Russian Journal, Questions on Psychology, called ‘On the Psychology of Inventive Creation’. Through the 1960’s and 70’s, Altshuller was joined by many others, who extended his original work into a greater understanding of Engineering and invention and indeed a kind of ‘movement’ in primary and secondary schools in those states where support existed, as well as starting an ‘Institute for Inventive Creation’, which evolved into today’s TRIZ Association, headquartered in St. Petersburg.

4.1.2 Moving Marx to Massachusetts: Russian Genius in America

In the first 30 years of its use and propagation in the Soviet Union, TRIZ was taught in the same way as Buddhist teachings are passed on – first in secret, and always by oral instruction among friends and believers, with very little written information available. This is relevant to the problems it encounters in being used in Europe, as will be outlined in section 4.2.0 below, regarding ‘The Problem with Finding Problems’.

Following the end of the Cold War, Altshuller and his friends and students, now ‘TRIZ-Masters’, emigrated from the former Soviet Union and brought TRIZ to other countries, especially the US,
Israel and France. The movement continued to grow, with many ‘Fortune-500’ Companies impressed by the capabilities of Russian Geniuses, some of whom had memorised the entire set of [roughly] 6084 correspondences of inventive problem-solving in the famous ‘Contradiction Matrix’ [discussed below]. Among other things, the Russian TRIZ Masters could diagnose almost any problem with any technical instrument with impressive speed, and American Companies wanted to learn their secrets. This was easier said than done, for reasons which will be explored in the next sections, so, to encourage wider use in corporates, simpler ‘TRIZ-derivatives’ such as SIT [Systematic Inventive Thinking; Filkovsky et al., 1975], ASIT [Advanced Systematic Inventive Thinking; Horowitz, 1980] and USIT [Unified Structured Inventive Thinking; Sikafus and Ford Motor Company, 1995], were developed. As computing and search-engine power increased from the year 2000, software was also developed to shortcut the whole process of thinking [eg. by Invention Machine and other companies started by Altshuller’s colleagues].

Altshuller died in 1998, and in spite of his wish for the work to continue in public domain and in spite of the great strength of having categorised existing Engineering solutions into general principles which could be used to solve all known and unknown problems, and in spite of the clustering of a large suite of Tools which could be applied to every possible part of a problem to provoke a radically different yet simple solution, TRIZ remains an elite subject. Especially in Europe and UK, it has not inspired the new generation of Engineers and inventors that many hoped – a great pity. Why this is so, is discussed in the following sections, while suggestions for improvement are proposed.

4.2.0 THE PROBLEM WITH FINDING PROBLEMS: RE-TRANSLATING TRIZ FOR THE ENGLISH MIND

4.2.1 About Theorising

It should be clarified that the term ‘theory’ in the title of the ‘Theory of Inventive Problem-Solving’ must be meant in its widest philosophical sense, as a kind of informed speculation or contemplation of how inventors create. Altshuller must have assumed it was obvious, even while implicit, that TRIZ is not a rigorous theory in any scientific sense, in that it does not propose an explanation or hypothesis of the phenomenon of thinking in general. This must be so, since neither Altshuller nor his original colleagues examined areas outside their Engineering expertise, to substantiate their use of the very generic title.

In other words, while Altshuller looked at hundreds of thousands of patents, these are merely the end result of the inventive thinking of one type of human – Engineers. Patents say nothing about the mechanism of thinking itself. As far as anyone in the TRIZ consulting industry knows, Altshuller and friends did not research; [i] psychological, neurological or medical literature on the mechanism of thinking itself, nor [ii] the mechanisms of creating and inventing in any other discipline outside Engineering. They were thus unable to delineate any steps or stages of human thought during creating and inventing in general and link this to their proposed system. It is only a universal view that can define a universal theory of inventive thinking – and this can only be achieved by multidisciplinary research that goes beyond Engineering, such as was done in this Dissertation, and which has resulted in the Process Map for innovation outlined in Chapter 5.

The problem with a vague and inconsistent theory, and the coincident implications for teaching TRIZ, have been ignored in the past. And it is not mere academic theory that has been affected. The confusion has led to UK consultants ‘mashing–up’ their own Engineering expertise and wishful thinking with the Tools and genius of Altshuller, unwittingly passing off the combination as a panacea for all things Engineering. Notwithstanding the power of its one rigorously repeatable and successful Tool [the Contradiction Matrix], which is arguably TRIZ’ main claim to fame, as Engineers at Site A1 of the Industry Collaborator pointed out, most of TRIZ seems to rely on faith rather than a repeatable process, and so has little chance of success in the cynical and analytically–minded business communities of the English world [Pahl and Newnes 2007 report on the Industry Pilot Test, outlined in section 2.5.0 and in section 4.3.2 below]. In other words, the difficulty of passing on complex information without a rigorous theory means that TRIZ has been seen as inaccessible, except through consultants as ‘high priests of understanding’, in a way reminiscent of religion [pers. comm]. This has not only alienated
potential business clients, but presumably prevented the spread of TRIZ in European and UK education.

4.2.2 Dialectic and Dualism

In addition to the above, there are further issues with the ‘translation’ of TRIZ concepts in Europe and UK, which can be presumed to have been implicit in Altshuller’s teachings to his friends. Chief among these is an understanding of dialectic. Soviets, who grew up with the philosophical teachings of Marx, were imbued with knowledge of the topic since childhood. That their view of the world was coloured by this, should go without saying. In the UK on the other hand, the concept of dialectic is virtually unknown, except to University-level students of Hegelian Philosophy, Socratic dialogue, Hinduism, Talmud or Buddhism.

Dialectic is the chief ingredient required for understanding the concept of ‘contradiction’, which in turn is central to TRIZ [explained below]. It requires that the world be considered in a proto-non-dualistic way; that is to say one does not need to make an ‘either-or’ decision about data, but instead allows a gentle, mental zig-zagging ‘to-and-fro’ between conflicting parameters, on the path to their unification or resolution. Dialectic is slightly distinct from the Buddhist concept of ‘non-dualism’, in that in Buddhism, there is no implied conceptual to-and-fro, but simply a continuous co-existence of all data; a co-emergence and co-evolution of apparently contradicting and complex parameters in mind or space, which are, albeit, already in the process or state of unification, whether one knows it or not. This worldview is also one of the fundamental tenets of ‘systems thinking’ or ‘Systems Science’, and is popular in many fields [after biologist von Bertalanffy’s 1950 ‘General Systems Theory’ or GST, and see Boulding, 1956 and von Bertalanffy, 1972].

That said, while it has become trendy to talk about ‘both-and’ solutions in disciplines and businesses which are influenced by ‘systems thinking’, Buddhist or TRIZ thought, this is currently still the exception. Generally the English-speaking Scientific and business worlds still presume, thanks to Aristotle, that the cosmos is composed of separate and separable parts, and that unwanted information can therefore be easily screened and distinctly removed. In fact as already suggested in Chapter 1, Westerners have been specifically taught to remove data which does not fit the expected [straight] line, in order to simplify explanations of how things work. Basic Western mathematics removes problems by removing unwanted data; ignoring the fact that the so-called problem is always irrevocably attached to the thing one wants to keep [or an experiencer would indeed simply remove it] – a coincidence which Hegel and Altshuller did not call a problem at all, but a ‘contradiction’ [see below]. Without a background in systems thinking, dialectic theory or a non-dualistic view of the world, people educated in an English system do not have the cultural or intellectual matrix to understand the most central point of the TRIZ Contradiction Matrix. This is presumably another of the most important reasons why TRIZ has been so difficult to teach and promote.

4.2.3 The Real or Right Problem

With the background outlined above, and with the addition of huge time pressure in their daily work, Engineers are not very good at recognizing the true nature of a problem; this is a self-proclaimed truism of most Engineers on Site A of the Collaborating Company. They prefer to ‘jump straight to the solution’ and spend very little time figuring out whether the problem they appear to face is, indeed ‘real’ or ‘the right problem’ to solve [Pahl and Newnes 2007].

This author maintains that some kind of solution can always be found for any problem – the creativity of Engineers is rarely in question. But there is little point in finding a solution, if it answers the wrong question. Currently there are no sobering statistics on the amount of time and money which is wasted in UK and European industry due to hasty ‘patch-up’ solutions for ‘the wrong problem’. There are likewise no statistics on the time that teams spend brainstorming solutions – i.e. generating ideas [Site A, B and C Engineers call this the ‘fun part’ of finding solutions] which may not always be technically or commercially implementable, compared with the time they spend on analysing issues in the actual system to find what really should be improved [the apparently less fun or ‘hard part’]. However anecdotal evidence from Innovation
Managers in 'Fortune-500' companies suggests that the entire English-speaking world is tarred by the same brush [Conley and Adunka, 2007]; the vast majority of people ignore problem-finding in favour of solution-finding, and in the opinion of this author, this amounts to untold 'lost-opportunity' in real innovation, were the right problem found before solutions were generated.

How TRIZ is presented in the UK is of little help in problem-finding. The best-known Tool of TRIZ, the Contradiction Matrix, can be applied only once the problem is already well-known. And since systemic analysis of problems are avoided for reasons outlined at the beginning of this section, finding the 'problem behind the problem', or potentially even the problem behind that, is even harder. This must be remedied, for Csikzentmihalyi’s work [paraphrased in ‘The Three Contexts of Creating’ in Chapter 3, section 3.3.1], indicates that one of the traits of renowned inventors as well as one of the indicators of historically significant invention is that the problem seems to appear at the same time as the answer. In other words, only Engineers with the patience to delve deeply into the root cause of an issue, which appears benign or simple on the surface, will co-emergently find out what the problem that should be answered really is, while in the process of answering it – and only such people will seed inventions that change the world. This is consistent with the wry observation of physicists [Einstein, quoted in 1997] that a problem cannot be fixed with the same thinking [or view of the world] that created it, but requires a shift in perspective.

In aid of setting up a situation where the real problem can be fully known and the Contradiction Matrix can be properly used, this author suggests that the TRIZ community can benefit from clarifying that [i] TRIZ is not a theory but a set of Tools [ii] all TRIZ Tools operate in a presumed dialectic, non-dualistic, karmic or 'systems-oriented' world, and [iii] a benchmarking, problem-finding step must always precede problem-definition and indeed must precede the statement of a ‘contradiction’ and use of the Contradiction Matrix; a point made obvious in the Innovation Process Map of the next Chapter. This in turn must precede the ‘solution-finding’ step, for the fact that ‘ideas are cheap’ is becoming a new catchphrase of modern businesses [Gladwell, 2008, Hardagon, 2008]. This implies that, despite the continued prevalence of Innovation Funnel thinking uncovered in Chapter 1 [section 1.1.0] and shown in Figure 4.1, that proposes to begin innovation with idea-generation and end with a product on the market, UK businesses are realising that solution-finding is not sufficient and may not be the real starting point of innovation. Finding the right problem is the real beginning of Innovation. It may also help the TRIZ community to make this obvious.

For the last point, a pre-requisite analysis of the problem could easily use standard Engineering Tools such as Root Cause Analysis or Cause-And-Effect Chains, as well as Functional Analysis [or

Figure 4.1. Innovation is often depicted in a funnel, starting with a process of idea-generation and ending with a product on the market. While such a diagram may well define the simplest kind of innovation, it also ignores the stage of problem-finding that Csikzentmihalyi and Getzels [1988] implied accompanies the generation of history's most important inventions, and which is obvious in the Innovation Process Map of Chapter 5.
also ‘System Analysis’, which is a kind of extended Functional Analysis invented by the author of this Dissertation] and the TRIZ ‘9-boxes’ Tool [explained below]. When Engineers are unsure of the problem they face, the research findings of the later projects in this Dissertation show that these props help identify the salient point. It is even more effective when this can be done visually and collaboratively, through hand-drawn pictures or Software instruments, since it quickly becomes obvious, which parts of a system affect which other parts, and which potentially support or alternately contradict the others.

4.3.0 TRIZ IN MODULES

4.3.1 Benchmarking Systematic Innovation

As was pointed out in Chapter 2, there is no international standard [eg. ISO] against which Innovation Tools, the innovation process or Innovation Management must measure up. Given that [as sections 2.3.0 and 2.6.3 indicated] all these are notoriously unsystematic across disciplines and indeed countries and organizations, it is no wonder that Engineers and innovation consultants alike hope TRIZ can provide a preliminary starting point for the missing standard. Yet to summarise the sections above, TRIZ can provide at best half a standard; this is true not only because its focus and results are on Engineering in particular rather than creativity and innovation. To reiterate points made elsewhere in this Dissertation; it is also true because within the TRIZ industry, the quality of teaching required to make a success of the Tools and methodology are so variable that often only the TRIZ Masters qualified by Altshuller himself are able to make them work.

The main points made in the sections above are borne out by a benchmarking of possible options for TRIZ training that was carried out for, and at the request of the Collaborator in 2006 [Pahl and Newnes, 2007], and became the first phase of the research proper, for this Dissertation. The Collaborator was interested in TRIZ since it was under pressure to implement TRIZ training or Tools after overseas competitors in its field had done so, and software companies were pressuring internal departments with seductive options that promised to deliver grand results at a very high cost. At the time of carrying out this initial benchmarking, this author was a full-time researcher with the University of Bath, with no interest in using the PRIZM Innovation Map or Game as a corporate Innovation Tool – the latter had been made for teenagers and were not expected to be useful to high-end technical Design. While supervisors at the University of Bath hoped that PRIZM could be tested and proven as a useful Innovation Tool, this author expected only that the Innovation Map would be useful as a reference frame for structuring and evaluating the Collaborator’s intended TRIZ-based Systematic Innovation Programme and conducted her initial phone conversations benchmarking the status quo of the TRIZ Industry in Europe on this basis.

Following phone conversations with all European suppliers for TRIZ and associated methods and Tools, it became clear that the state–of–the–art of TRIZ in Europe was still young, compared with the Soviet. Suppliers did not agree on ‘what TRIZ actually is’ or what it ‘should become’, and consequently had differing foci for the training they offered. It was also apparent that there were no TRIZ Masters in Western Europe, and so consulting and training experience and competence, and the coincident cost of potentially disseminating TRIZ widely in a 70,000–person corporation, as was the pertinent question in the Collaborator at that time, would vary widely. Possible suppliers in Western Europe ranged from:

a. Universities and Research Institutes; the University of Bath, UK, the University of Strasbourg, France and The Fraunhofer Institute of Production Technology in Aachen, Germany. Corporate consulting was offered on a short–term basis, or research projects within their consortiums. Strasbourg offered only a long–term MSc training programme in TRIZ and other problem–solving Tools.
b. Micro–consultancies. Oxford Creativity, with 3 people in UK, were the largest and most active. In 2006, after 7–years experience, they offered basic and advanced training, including an overview of most of what were called the classic Tools of TRIZ [the distinctions of basic, advanced and classic TRIZ are outlined in section 4.3.2 below] with class examples taken from different sources using TRIZ in other Engineering companies. Their 2–day public sessions on TRIZ cost...
2000GBP [3040 Euro] per person. SIT [Systematic Inventive Thinking], originally created by Roni Horowitz and based in Israel also had a German office. They did not provide classic Tools but a derivative for product development, which simplified Altshuller’s 40 inventive principles [in the Contradiction Matrix explained below] to only 5 variations, screening out most of the systematic power. This cost 1750 Euro per day. Ratio Strategy and Innovation, run by the head of TRIZ Zentrum Oesterreich and his team, offered a 2–day ‘TRIZ for Beginners’ coaching after teams had already defined their problem. Their training focussed on the Contradiction Matrix [see below] and ‘Trends’, while also offering most classic Tools, at a rate of 1200 Euro per consultant per day for a small group or 4800 Euro per day for training up to 15 people.

c. Software companies such as CREAX in Belgium did not offer classic training in the TRIZ Thinking Tools but only ‘Software-specific training’, based on a simplification and/or extension of TRIZ. This cost 1600 Euro per participant [including a one year floating software licence]. In addition, they offered research combining their expertise and software [6wks–3mths work] at 40–70K Euro depending on complexity. Invention Machine Corp., with its head office in the US and representatives in many European countries, grew from Altshuller himself but no longer offered classic TRIZ training, merely what was relevant to sales of their software. Their ‘Goldfire’ package came in two versions: one which reintroduced the complete complexity of millions of online patents, after Altshuller had abstracted and removed them to produce the Contradiction Matrix [below], and another which offered ‘Functional Analysis’ and ‘Root Cause Analysis’ Tools [ie. problem-definition]. The cost per named-user licence was 12–14K per year. This did not include the cost of a trainer coming for a week to teach clients to use the Tool, at 1875 Euro per day plus costs. They were, in fact the very software company whose Tools had promoted the Collaborator’s original question on the efficacy of investment in TRIZ or Systematic Innovation and related Thinking Tools as a whole.

Suffice to say that none of the interviewed Universities, Institutes or Micro-consultancies would commit to teach, nor guarantee their participants would learn, the Contradiction Matrix [ie. the most powerful and necessary Tool of TRIZ], in less than one day. However it was already clear from this author’s own research, that she could teach all the main components of TRIZ in under 2 hours, and that participants could learn to work with the Contradiction Matrix in less than 20 minutes, when taught with her Process Map for Innovation.

Suffice also to say that when a corporation considers whether to implement a large-scale deployment of Innovation Tools or seed an innovation culture potentially costing millions of Euros, it needs to avoid the problems outlined earlier in this Chapter and be thorough in making its choice of supplier and Tools, so that according to ‘Six-Sigma style’ criteria, they are: [i] best quality [ii] most cost–effective [iii] useful for the broadest range of programme participants.

In order to assess which suppliers could best fit the criteria defined by the Collaborator for its intended programme, and lacking any other standard for Systematic Innovation, a checklist was devised by this author for what TRIZ trainers in Europe should be able to offer. This was from the very outset based on; [i] the requirements quoted by Company Engineers in personal interviews on innovation [as outlined in 2.5.0] and [ii] the fact that the Process Map for innovation which had been previously developed by the author of this Dissertation [Pahl, 2005; Pahl, Newnes and McMahon 2007 and see Chapter 5], covered and explained most elements of basic TRIZ in a very short time frame. In particular, with the help of the Innovation Map, the TRIZ Contradiction Matrix could be explained, understood and applied in less than 30 minutes.

The benchmark created for the original Pilot Test of TRIZ therefore required trainers to deliver on the following key points, each of which is addressed by the Innovation Process Map [Chapter 5] and PRIZM Game:

• Is TRIZ presented in the context of a wider innovation picture
• Can TRIZ be passed on in small modules, as a Toolkit, rather than a theory
• Will training cover all classic Tools of TRIZ, rather than derivatives
• Can the TRIZ Contradiction Matrix be taught in less than two hours
• Will participants leave a basic course knowing how to use the Contradiction Matrix without further help
• Will participants leave a basic course knowing how to use other TRIZ Tools without further help
• Can training be flexible and bespoke for each situation

4.3.2 The Industry Pilot Test [2006]

The initial training programme implemented by the Collaborator after this benchmarking then tested two things interactively: [i] the power of TRIZ as a thinking system or set of Tools in itself, and [ii] the efficacy of its mode of presentation, by running in ‘modules’ rather a continuous two–day ‘stream of consciousness’. The latter was usual for basic TRIZ training in the industry at that time and informal benchmarks [success and failure stories] for such training were already widely known. The choice to train TRIZ in modules was, in summary, partly because feedback from the company team leaders during the initial interviews on innovation requirements [see 2.5.0] indicated that no team members would be allowed to leave their daily work for more than three hours training – thus necessitating a modular approach. And it was also, of course, due to the use of the PRIZM Innovation Map as the preliminary benchmark for structuring a simple and sustainable programme, since the seven steps and three stages in the Map easily lend themselves to modularising the presentation of TRIZ Tools as well as any other Innovation Tools [see section 2.6.0 and Chapters 6 and 7].

The Collaborator’s aim in the Pilot Test was to get a clear understanding about the quantitative and qualitative benefits of using TRIZ and PRIZM in the Engineering Company. The key questions to be answered, were: ‘To what extent can the Thinking Tools of TRIZ and PRIZM improve’:
- Problem–definition and system clarification
- Prediction of consequences
- Quality and rate of idea generation
- Systematisation of the process of innovation
- Greater ‘idea to product’ conversion rate
- Faster access to patents and comparable technology sources
- Submission rate of patents

Four modules were defined; titled ‘Divergence’, ‘Contradiction’, ‘Convergence’ and ‘Map and Method’, based on research by Pahl [2005] and Pahl, Newnes and McMahon [2007], which indicated that all creative thinking naturally happens in three stages and a wider context [fully explained in Chapter 5]. When the main TRIZ Tools are fit into this natural pattern of thinking, they should be even more powerful than presented in a vague order on their own. Altogether, the four modules were envisaged to give a complete basic training of TRIZ – meaning that at the end, participants should have a thorough understanding and basic competence in using the most important and so-called classic TRIZ Tools: The 9–boxes, Smart little people, The Contradiction Matrix [including its 39 parameters and 40 Principles], Ideality, The Ideal Final Result and Resource Checklist, Size–time–cost Tool, S–curves and the Trends of Technical Evolution. The consultants who were subcontracted and managed by this author, to provide the bulk of TRIZ training for the initial Pilot Test were asked to modify their usual format of two–day basic training into these modules and include an overview of a wider innovation context.

Each of the modules was to include as many [unspecified] Tools from the classic TRIZ set [outlined above] as were relevant, and each was supposed to be immediately applicable to the daily work of the Engineering participants. The modules were to build on each other, and could be taken in any order, or indeed some modules left out altogether, without affecting the integrity of the lessons learned. Participants could choose to come to one or all, according to their personal interest and available time. It was anticipated that over time, as team members came to different modules, there would be a gradual and sustainable build–up of knowledge about TRIZ and the innovation process in the team as a whole. It meant work time was taken into account, personal differences were catered for, and no individual was forced to do something they did not like; yet at the same time, the result for the team and eventually the company could be layered and ‘rich’.
An ‘intensive’ training module was also designed, in which there should be more depth and detail; more real-life examples and more time to discuss the application of TRIZ Tools [with potential extras that were less well known], and using problems and innovation issues specific to the Industry Collaborator as the class examples.

In all, 11 teams with over 80 people from 13 departments took part in the Industry Collaborator’s Pilot Test in 2006, testing the TRIZ training in modules over nine months. There were ultimately 12 workshops over four sites.

Independent TRIZ consultants [hereafter called The Consultants or The Subcontractor] were hired as the original Subcontractor to provide all the modules. However, since the requirements demanded for TRIZ training [as outlined above, according to the Collaborators interviews and benchmarking previously outlined in section 2.5.0] were such a radical departure from what had been done in the TRIZ consulting industry before, ongoing changes to the programme were necessary after each module provided by The Consultants. Misunderstandings about the content that should be provided were rife, and it seemed difficult for The Consultants to rearrange their usual presentation of the theory of TRIZ [over 5 days], to convey the Tools simply and clearly in such short time frames [of 2 hours to 2 days], without losing their meaning. Because the situation was not improved by the third training session delivered, the Head of Knowledge Management eventually decided that this author would provide all training on site A, using the PRIZM Game and Innovation Map as an obvious framework and additional Tool, to contrast with the training modules provided by The Subcontractor. This late-stage adjustment to the original Pilot Test schedule was to provide extra information at no extra cost to the Collaborator. Thus in the second part of the Pilot Test, the delivery of TRIZ Tools on their own was compared with delivery of TRIZ Tools in the framework and wider context of the Innovation Map [called ‘TRIZ plus PRIZM’, or ‘Systematic Innovation training’ in the remainder of this Dissertation], in both cases still delivered in modules.

After each training session, multiple choice questionnaires were given to all participants, based on the key questions defined by the Collaborator [in this section, above], as well as on the basis of this author’s previous professional experience of what each Tool could or should do. The questions were intended to test the range of effects, which both TRIZ and PRIZM could have on innovation and problem-solving, including participant-perceived learning [especially in respect to the ability to identify the essential problems or functions to be improved, generate solutions and predict future consequences] the time taken to apply a given Tool and the results after application. All responses were tabulated in an Excel spreadsheet, arranged by workshop [Pahl and Newnes, 2007].

Overall, the Pilot Test showed that the Tools would benefit Company participants in several ways. In summary, the feedback proved that:

- Ultimately, participants prefer to engage a complete two days of learning TRIZ Tools ie. although the original request was to modularise TRIZ – and the ‘Theory’ was duly modularised into Tools by this author, participants ultimately saw the benefit in learning all the modules together.
- TRIZ was considered of value and even potentially exciting for problem-definition, system clarification and for idea generation. However, participants did not see TRIZ on its own as a defined process for problem-solving, which is its main claim to fame. In contrast, the addition of the Innovation Map [in TRIZ plus PRIZM training] was considered a useful process for problem-solving by 100% of participants.
- Basic TRIZ training from The Subcontractor resulted in 25% of participants confident to apply the Tools on their own, with little further support following the training. In comparison, basic and intensive TRIZ plus PRIZM training by this author, using the Innovation Map as a framework, resulted in 50% of participants able to apply the Tools on their own, with little further support after training.
- Advanced TRIZ training in the style of The Subcontractor took participants away from their daily work. In contrast, advanced TRIZ plus PRIZM training by this author using the
Innovation Map allowed participants to use their daily work as a case study – ie. the training did not take time out from daily work, but enhanced it.

- Participants self-assessed that both TRIZ on its own, and TRIZ plus PRIZM training provided Tools that would help them with problem-definition and predicting consequences of problems, although when TRIZ was presented with the Innovation Map (in TRIZ plus PRIZM training) the efficacy of TRIZ Tools was rated higher than when TRIZ Tools were presented alone.

- Teams who trained in TRIZ plus PRIZM continued to work with the TRIZ Tools and the Innovation Map in their own case-studies after training. This was not the case where participants were trained in TRIZ alone by the Subcontractor.

Data on improvements of the ‘idea-to-product conversion rate’ and submission rate of patents, as were requested by the Collaborator [see above], could not be self-assessed in participant questionnaires at the conclusion of training. These results could only be collected a significant time after the initial training, and are provided in Chapter 6, where they represent not only this Pilot Test but also data from the contracts carried out by the author of this Dissertation with the Collaborator, in the four years following the Pilot Test.

That said, there were also two cases which followed immediately from TRIZ plus PRIZM training in the Pilot Test, which resulted in ‘quick wins’ in idea-to-product conversion as well as submission of patents, which centre around the Innovation Map and Game. These are:

- **Blue Sky Design Project**: The PRIZM Game and Innovation Map were applied with the TRIZ Tools, for a problem in ‘Blue Sky Design’ on Site A, during the intensive training phase in October 2006. While the issue in question was still in the concept phase of Design, it was nevertheless a real issue, that was expected to lead to patentable advances for the technology in question. The Team had already been brainstorming the problem for three months and were close to the project deadline, when they were taught and immediately applied the Tools. Their use of the Innovation Map and Game immediately added two new, potentially significant and implementable ideas to their existing total of ideas within two hours. As a result, the team were inspired to recruit further team members and continue using the Innovation Map to structure investigation and evaluation in four extra days work on their own time. They worked on their own, with only one hour extra supervision by this author. The outcome was a thorough analysis of the virtues of each potential Design [including the solutions they had proposed previously], which was presented to their Line Managers. They were able a quick and final decision on the Blue Sky Design which would be implemented in the new product, which was to be released in coming years. Two patents were submitted and accepted as a result of this work with the Innovation Map.

- **Functional Requirements Team**: The TRIZ Contradiction Matrix was taught to this team of 8 people on Site C, using the three step, 20-minute approach of the PRIZM Innovation Map in July 2006. This enabled one team member to produce a framework for a generic document to track Concurrent Engineering in Design. Using the Contradiction Matrix and Altshuller’s parameters [see 4.4.2, below] as the common language and framework enabled the functional breakdown documents of five teams to be integrated into a single document –thus for the first time listing all potential problems and potential innovative foci around the issue in one place. In the end, a single team member completed work on this document on his own with only one hour extra supervision by this author. It was hoped to integrate all these documents into one generic document in 2007, a project for which 12 weeks had been allocated for 33 people [660 man–days work]. Only 10 days were used to create the initial integration, a far smaller sum than otherwise expected.

When the Industry Pilot Test finished after nine months, another round of interviews was undertaken, to summarize opinions on the programme –especially in regard to use of the modular teaching format and the Innovation Map, and gather requirements for continuing the training in future. Some 20 people were interviewed on all sites. What they said about the Pilot Test testifies to the early quick wins possible in using the PRIZM Innovation Map to structure the
teaching of TRIZ [in TRIZ plus PRIZM training] as well as to structure the entire Systematic Innovation Programme, as well as to use it as a Tool in its own right:

- The modules for the teams worked well ... I am confident we can train everyone on our shopfloor in the Contradiction Matrix.
- [Because we already bought the TRIZ-related software and use this sometimes] we haven’t really used the TRIZ [Thinking] Tools. But what we have used quite a few times is the PRIZM process, to characterize our problem.
- We would keep using the [TRIZ] Thinking Tools, but perhaps not in the form they were taught. We would take out the bits which are useful for us.
- Everyone who came out of our team project [using TRIZ plus PRIZM] said ‘that’s really great’ ... but not one of them would have done it on their own. The team learning process is really key to keeping going.
- Even though we started [TRIZ] on our own before the training, the modular programme really expanded our knowledge and we are ready to inject the methodology in our next operation. It enlarges our scope for adding value.
- Engineers like drawings rather than words – PRIZM goes some way toward this [but the] language of TRIZ is just not realistic. PRIZM is a good way to teach how Engineers should be thinking ... though in the Company, Engineers should already be thinking like this!

In addition to the quick wins, the Pilot Test also presented as many questions as it answered. For instance; if the Subcontractor originally employed was indeed representative of the industry, and if therefore, the same difficulties in modularisation of previously extensive TRIZ teaching would have been encountered with other European consultants offering classic training, then the use of the PRIZM Innovation Map may be said to be the only defining factor in the success of the TRIZ plus PRIZM training, over the success of TRIZ alone. However if this is not the case, there are many human factors, which must equally as important as the use of the PRIZM Innovation Map, in determining the success of the Pilot Test. Of these, the presenter’s expertise in the subject of Systematic Innovation or ‘experience in presenting, training or coaching’ is ruled out in determining the success of TRIZ plus PRIZM over the success of TRIZ Tools alone, since the author of this Dissertation [who presented TRIZ plus PRIZM] had no experience in providing training and coaching, whereas the Subcontractor was deemed to be an expert [with over seven years experience in the field of training]. Further, once the Innovation Map had been presented to participants by this author, it was immediately successfully applied by people with even less experience in the subject of innovation or experience in presenting, training coaching others.

Three factors which thus seem especially pertinent to the success of the Pilot Test likely rest not just on the strength of the Tools provided, nor on the quality of the trainer of particular modules but on the following three factors:

- engagement of participants on the basis of real need [through interviews], as well as a focus on ‘fun’ [through simplification of the subject] and personal interest [through involvement of the daily work], and not through any forced initiative from Management
- a continuously high amount of engagement via personal contact maintained with participants throughout the nine–month programme, by its coordinator [ie. this author]
- flexibility in delivering the training, which was thereby positively perceived by participants, as being accessible [even if imperfect] and thus able to grow with direct user–feedback.

These factors pertain more to what is traditionally seen as Innovation Management, rather than innovation per se. It is certainly a topic for further discussion [in Chapters 6 & 7] around the issue of turning innovation from a piecemeal, chance driven, individual or Tool–based approach, nicknamed Innovation 1.0 [Rae, 2006] into a more comprehensive and repeatable system lately called Innovation 2.0 [Rae, 2006; Carpenter, 2007]. In addition, the mere fact of having a repeatable system that removes chance is not enough to inspire an innovation culture or encourage people to remain involved beyond using a given set of Tools ie. seed Innovation 3.0 [Johnson, 2007; Hafkesbrink and Schroll, 2010; Hafkesbrink and Evers, 2010]. The Industry Pilot Test indicated that any potential success that TRIZ might have, in a far–reaching innovation programme, could only be nurtured and sustained by allowing it to emerge largely as a natural system ie. by bottom–up growth initiatives and engagement, rather than top–down ones. Certainly, the Head of Knowledge Management in the Industry Collaborator considered that after this Pilot Test, if TRIZ could not be delivered in a flexible and bespoke
manner, to grow with its users, it would fail both in terms of individual use and as a culture or ‘movement’ in the Company.

It was decided [together with the then Head of Knowledge Management in the Industry Collaborator], that the future of Systematic Innovation in the Engineering Company should include a broad range of offers and flexible engagement options, ideally including implementation of TRIZ Tools with the PRIZM Innovation Map and the PRIZM Game via the following mechanisms, in succession or together:


2. Deep and intensive training and mentoring of local ‘focal points’ in each country and different departments, who would be defined by hierarchy or earlier interest, and who would use the methods daily and become the local specialists. They would work as internal consultants providing operational support in problem–solving or innovation to teams, but without giving training in Tool Use to others.

3. Customized and flexible training and application of TRIZ plus PRIZM for each department and key individuals, based on on going interviews and discussion of existing Engineering processes in that area

4. Official Software to support the training in the Thinking Tools.

5. A network of Innovation/TRIZ practitioners for regular exchange and support.


7. Training all of the top 50 Designers in the Company on TRIZ plus PRIZM.

In short, the Pilot Test indicated that the PRIZM Innovation Map provides two important supports when compared to the standard TRIZ training offered by all European trainers – [i] a larger context for innovation, into which the TRIZ Tools fit in a logical order; and [ii] a shortcut or fast–track to accessing the power of Altshuller’s Contradition Matrix, even if participants do not fully realise they are using it. Thus, the approach to the next two years of TRIZ training was streamlined as TRIZ plus PRIZM training, on the basis of the Innovation Map and the PRIZM Game. Further, as will be explained in the following section, this author was invited to continue implementing the Systematic Innovation Programme as well as presenting the training as an independent subcontractor with her own company, rather than as a University researcher.

4.4.0 TRIZ AS A SET OF TOOLS WITH JUST ONE OBJECTIVE

4.4.1 The Objective of All Tools

Given the above results, it seemed that dissemination of TRIZ Tools, as part of a wider innovation culture in all of the UK and Europe may happen more easily if TRIZ were to promote itself without a vague theory, and instead proposed itself to include; [i] ‘A Set of Tools’ with [ii] ‘A Common Worldview’ [ie. of dialectic, karmic or systems–thinking] and with [iii] ‘A Common Objective’ in respect of problem–definition, as will be clarified in this section. Making a common objective clear, for instance, would set the scene for the use of TRIZ with an emergent common language of innovation – as per the Process Map in Chapter 5.

In respect to the objective of TRIZ; the premise under which this author ran training and workshops in the Industry Collaborator in the years subsequent to the Pilot Test outlined above, is [as already outlined in section 1.3.0 on the Worldview of the Dissertation], that there really is a fundamental pattern of creation, and thus the same rules of creation hold for the cosmos where Altshuller made his observations of Engineers, as in the one where we apply his insights. There is nothing significant Altshuller can have known about Engineering materials, human or material behaviour or the space and time in which these operate, that can be different from what everyone else knows and experiences. More importantly, as will be explained in detail in the next Chapter in terms of ‘The Universal Sentence’ [section 5.2.3], the cosmos itself has only a finite number of categories in which it can be observed, described and understood – simply; [i] material objects, [ii] their actions and [iii] the environment/ space/ time in which they exist and
move. The categories are most easily understood and irrefutable in this author’s own even more simple statement of the fact; ‘Things do things somewhere’ [see Vincent et al. 2006]. This means that any analysis carried out and any Tool used to give information about any Engineering system has to deal in one or more of these three categories. TRIZ is no exception. In short, the objective of using TRIZ Tools should be not just to make our life easier in some vague way, but to do this by clarifying the nature of the Engineering system very exactly, in terms of [i] its material attributes or structure, [ii] its behaviours or function and [iii] its relation to, and effect on, a complex environment of other objects and behaviours which are in turn embedded in space/time itself.

Whether or not Altshuller had this as his own stated objective, the premise can be considered implicit in his Tools and worldview. And explaining the TRIZ Tools according to this premise can simplify their presentation. Certainly, apart from Altshuller’s ‘Smart Little People’ Tool and what can be informally called ‘The Resource Checklist’, it should be retrospectively undeniable that all his Tools do clarify the interrelationship of materials, behaviours, space and time and lean towards Csikzentmihalyi [1990] and Csikzentmihalyi and Geztel’s [1988] observation that the problem and solution are ideally and utterly interrelated and co-emergent. For instance:

- The ‘System-Operator’, or 9-Boxes, has two axes which are delineated as ‘space’ and ‘time’, respectively. The axis of space allows for three levels of observation – a system, and what is above [super–] and below [sub–] the system, while the axis of time allows for observations of past, present and future. The field of boxes filling space and time is populated with material or structural variables of the system.
- Su-Field or Substance-Field Analysis pictorially delineates the interaction [behaviour] of one or more substances [ie. materials] in a field [ie. environment].
- Even the Size-time-cost Tool uses the concept of alternately ‘exploding’ and ‘minimising’ space, time and quality of substance [material], in order to provoke the user to take a new look at the elements of a problem or its potential solution.

Indeed, this author believes it is almost crucially important to the End-User, to emphasize that the single most important contribution of all TRIZ Tools is not just to vaguely make Engineers’ lives easier, but to completely describe the material, behaviour and environment of all elements in a system. This is even more important if one wants to simplify the most systematic Tool in the kit, the Contradiction Matrix, as will be done in the next section.

4.4.2 The Matrix of Materials, Behaviours and Environments

The existing Contradiction Matrix [See Appendix 2.0] is the best-known Tool of TRIZ and, arguably, the reason for TRIZ’ amazing reputation. In summary, it contains three key pieces of information:

1. There are only 40 simple principles, which have ever been used as inventive solutions in Engineering patents, by the world’s top 5% of inventors [according to Altshuller’s original classification of patents in five ‘levels of inventing’]. These answers can and should be re-used.
2. There are only 39 parameters of interest to an Engineer, when he describes his problem. For the sake of simplicity, only these parameters should be used to formulate the problem statement.
3. The problem statement is a contradiction between two parameters – one parameter that one wants to improve, and a second, which worsens as a result of the other’s improvement.

The Matrix looks reasonably simple, if comprehensive; it can fit on a single A4 sheet of paper, with 39 problem-defining parameters along one axis and 39 along the other, together creating approximately 1521 contradictions and a maximum of 6084 problem-solution combinations as explained in the following simple instructions for using the Matrix [Figure 4.2]:

i. Define the parameter which is wanted and should be improved along one axis.
ii. Define the parameter which is not wanted or worsens along the other axis
iii. Find the solutions to the contradiction at the intersection of these parameters – there are a maximum of 4 inventive principles that solve the problem in each case.

Having said that using the Contradiction Matrix is simple, that is only true if the problem is understood well enough that two contradicting parameters can be defined. The Matrix cannot be
used, if a contradiction cannot be defined and defining one’s problem simply is certainly not necessarily a simple process.

One of the ways in which the process of problem-finding and the definition of contradicting parameters can be simplified for Engineers, is not to force them to translate their usual language into an artificial language of 39 parameters. Instead, the Contradiction Matrix can be rearranged to fit their natural language via The Universal Sentence [see 4.4.1 above and 5.2.3] since it is simple enough for 13-year-olds to understand. This is indeed what was done for the PRIZM Innovation Map. The method and implications of said ‘translation’ will be outlined in the remainder of this Chapter.

**Figure 4.2: How to use Altshuller’s Contradiction Matrix, in three steps [from Pahl 2007; Systematic Innovation for Engineers, HKM Training, German Catalogue, Industry Collaborator.]**

Acknowledging, as already mentioned above [and 1.3.0], that Altshuller lived and observed in the same cosmos as everyone else, it is necessary to demand that each of the 39 parameters of his Contradiction Matrix fit into one or other of the same three categories that define all other natural systems. In other words, the Matrix can be radically simplified, by fitting all parameters into one of the three categories of The Universal Sentence; ‘material’, ‘function’ or ‘environment’ [see sections 3.2.2 and 5.2.3]. For instance, the parameter called ‘weight of moving object’ can be re-classified as a ‘material’ parameter, while ‘productivity’ can be re-classified as an ‘environmental’ parameter.

When all parameters are re-classified in these terms, all parameters [on both axes] should be rearranged so that similar ones sit next to each other, as shown for material parameters in Figure 4.3. At the same time, the inventive solutions that correspond to the contradicting parameters should also be moved to retain their correct place [removing only repetitions/redundancies of solutions in merged boxes] so that the Matrix remains fully functional. On the Innovation Map and in the PRIZM Game, the solutions at the intersection of ‘material–material’ contradictions are assigned the colour red.

This means that, ultimately, there can be nine [and only nine] types of contradiction ie. ‘problem–types’ [sets of improving–worsening features or of wanted–unwanted parameters]. These are; material–material, material–function, material–environment, function–material, function–function, function–environment, environment–material, environment–function and environment–environment. When all parameters [with their solutions] are arranged together, the result is a 3x3 Matrix rather than a 39x39 Matrix. Each of the nine contradictions is coloured differently, as summarised in Figure 4.4; which makes the system highly visual [Pahl, 2005].
The classification system for the Innovation Map was preempted in research in which this author collaborated at the Centre for Biomimetics and Natural Technology at the University of Bath from 2002–2004 [Vincent et al., 2006], prior to setting up the PRIZM Game Company. This project compared the inventive solutions used by Engineers with the solutions used by biological systems in nature. At the conclusion of that project, six types of parameters had been defined for each axis of a new TRIZ–style Contradiction Matrix, based on simple parameters used by all natural systems; substance, structure, space, time, energy, information [Table 1 in Vincent et al., ibid]. Thus 36 types of contradiction [cf. the nine simpler types of the PRIZM system] were defined in that project.

![Contradiction Matrix](image)

Figure 4.3: Each parameter in Altshuller’s original Technical Contradiction Matrix must fit into one of the main three categories of natural systems; material, function or environment. When the parameters are evaluated in this way and rearranged so that all material parameters sit next to each other, the inventive solutions at the intersection of contradicting parameters move to retain their correct place. In this case, the solutions to ‘material–material contradictions’ are coloured red [from Pahl 2007; Systematic Innovation for Engineers, HKM Training, German Catalogue, Industry Collaborator].

In addition to reclassifying the Contradiction Matrix into a 3x3 system of natural language, the PRIZM Game takes one further step beyond both the TRIZ Contradiction Matrix and the work of Vincent et al., [ibid]. It acknowledges biological systems do not work in the same way as Engineer’s minds, and uses primarily those inventive solutions that are common to both.

As can be seen in Vincent et al.’s [ibid] Table 2, the inventive solutions favoured by natural systems solving evolutionary problems, yields a population of significantly different solutions [from an analysis of 2500 organisms from cellular to eco–system level] from those that Engineers would use to solve these same problems. In Vincent et al., [ibid]’s paper, the coincidence of biological and Engineering solutions for the six problem–types quoted in their Tables 1 and 2 [p477] is said to be only 0.12 [where complete coincidence is 1.0]. However, this figure is possibly misleading. When Vincent et al. [ibid]’s Table 1 and Table 2 are manually compared, as was done by Pahl [2005], counting ‘substance’ and ‘structure’ in the ‘material’ category defined above; ‘energy’ and ‘information’ in the ‘function’ category; and ‘space’ and ‘time’ in the ‘environment’ category, the overlap of inventive principles used by natural systems and Engineers ranges from 25% to 62.5% in common in each of the three categories of The Universal Sentence. It is a strength of the PRIZM Innovation Map and Game that exactly and only the inventive solutions which are common to both Engineering and nature are included.

That said, even without the addition of biological information, rearranging the Contradiction Matrix according to The Universal Sentence means that Engineers can communicate using a more natural language. They can continue to describe their system and problem in terms of only three
parameters; materials, behaviours and environments, as they would naturally do in their native speech, rather than being forced to fit the 39 parameters of TRIZ or the six parameters of Vincent et al. [ibid]. Ultimately, as will be shown in sections 5.2.4 and 5.2.5, it means that complex problems can be defined and solved with all the power of the Contradiction Matrix [essentially both teaching 'Contradiction' and applying the Matrix in less than 30 minutes] but without using a Matrix as all.

Figure 4.4. When all 39 parameters in the original TRIZ Contradiction Matrix are evaluated in terms of a natural system and rearranged so that material parameters sit together, while behavioural [function] parameters sit together and environmental parameters sit together, the result is 3x3 Matrix, rather than a 39x39 Matrix. The solutions at the intersection of each set of the nine possible contradiction types remain as they did in the original TRIZ Matrix, with only redundancies removed. A different colour is used for the solutions to each different problem-type [from Pahl 2007; Systematic Innovation for Engineers, HKM Training, German Catalogue, Industry Collaborator].
Chapter 5 THE PROCESS MAP: Transformation of the Known and Unknown

The Process Map for innovation is finally explained in detail here. This map synthesises all theories and tools discussed in previous chapters, in a simple three-stage, seven-step model. In a highly visual form, the map makes obvious how the crucial problem-definition phase of innovation can be simplified. Research shows that a problem can be described simply and systematically using the natural language of engineers in three steps: identifying a cause-and-effect relationship of two parameters [one wanted, one unwanted], and pattern-matching the so-defined problem to a pre-existing solution. The problem is almost automatically ‘transformed’ into a solution, not as the result of chance or genius and not only as the insight of the originator of TRIZ, but through the mechanisms adopted from meditation, which explain how mental concepts are concretised from, and re-dissolved into, an ideal conceptual space. The act of taking new information into an old space transforms two worlds – symbolized by ‘Arrows of Innovation’ borrowed from the process of emanation in chapter 3. The interrelation of conceptual space [mind] and physical space [space] described in Buddhism can thus explain the cyclic nature and complexities of co-evolution of the design space in engineering.

5.1.0 THE PRIZM GAME; INTRODUCTION AND OVERVIEW

In 2005, following the conclusion of the project with Vincent et al. [2006], which had compared the TRIZ contradiction matrix with all the principles in natural systems [outlined in chapter 4], the author of this dissertation formulated a game called The PRIZM Game, using the Russian acronym her colleagues had made for her; Pravila Reshenija Izobretatelskih Zadach Modernizirovanny – meaning ‘The Rules of Inventive Problem-solving, Modernized’. As mentioned in the previous chapter, she summarised and extended the initial results of the Biomimetics project, as well as integrating it with what she had understood of the fundamental pattern of creation from Buddhist teachers and her first [unsubmitted] PhD on the TOE in Australia [Pahl, 1994, 1996a, 1996b, 1999, 2000, Pahl and Deardorff, 2005]. This Game was intended to give teenagers a shortcut for science and innovation through the use of the innovation map, and it inadvertently made TRIZ simple enough for 13-year-olds in the UK. In 2005, commercial development of The PRIZM Game was funded by a UK business award and it was first printed in the US in the same year, winning a design award there. The game and Innovation Map were tested in 10 schools and colleges in the SW UK area, with ASDAN and with the Irish Science Teacher’s Association, as well as at the University of Bath, undergoing small improvements in this time.

In 2006, the author was the primary researcher on a literature review at the innovative design and manufacturing research centre [IDMRC] at the university of Bath, which formed the basis of an invited paper for the journal of design research [Pahl, Newnes and McMahon, 2007]. The first part of this has been described in chapter 2 [sections 2.2.0, 2.3.0, 2.4.0 and 2.6.0]. The second part of this review, which is described in the following section, suggests that a fundamental set of [seven] steps for creation is pervasively embedded in human thinking. These steps are elucidated in a thorough explanation of the Innovation Process Map in the subsequent sections. Then, in the final sections of this chapter, the author will simplify and integrate the information from Buddhist Technologies [outlined in chapter 3], and TRIZ [outlined in chapter 4] with current knowledge on innovation [extending what was presented in chapter 2], in order to explain the experience of co-evolutionary innovation as an intrinsic effect of using the Innovation Map and PRIZM game. Please note again that the content of this entire dissertation is laid out, according to the steps to be defined in this chapter.

5.1.1 The Seven Steps of Innovation: A Synthesis of the Literature on Creating

After the preliminary literature review outlined in chapter 2, the logical next step decided upon by this author, was to expand the view of creativity from the historical psychological definitions. This led to her capturing and comparing the steps of every ‘process of creating’ that had been reported in every possible field or domain of human endeavour. In an ironic twist of fate, it is the change of focus to the study of concrete ‘stuff’, rather than the study of mind, person and social inputs to creativity, that shows the nature of the creating human mind most clearly.
The original comparison built on the stages of creativity and innovation derived from psychological literature, and included the rules from well-accepted and arguably dominating theories of process in Engineering Design [eg. Pahl and Beitz, 1977; Archer 1971, Pugh, 1991], knitting fashion [eg. Gerst et al., 2001; Eckert and Stacey, 2001, 2003], sociological action research [eg. Heron and Reason 1995, Wadsworth, 1998; Reason 2002;], organizational development [Snowden 1998a & c, 2000, 2002, 2005; Kurz and Snowden 2002], theories of colour and perspective in renaissance art and architecture [Blunt, 1940; Gombrich, 1960, 1966, 1972; Kemp, 1990, 2001], the form of baroque and early classical music [in the works of Bach, Handel, Haydn, Mozart], the classic dramatic structures of literature [eg. Freytag 1863, based on Aristotle] and modern screenwriting [McKee, 1997] as well as the practise of Buddhist meditation [Kalu Rinpoche 1995a, b; 2002; Padmasambhava, 1996, 1997; Nydahl, 1996, 1998, 2004]. Some of these processes are summarized in 'a snapshot of comparison' in Table 5.1a and 5.1b [presented in two halves due to space limitations, with repetition of the column showing the commonalities from humanities literature and also Pahl and Beitz’s 1977 Engineering Design process]. Mindmapping [Buzan and Buzan, 1993], is also included for interest, since it incidentally is one of the few Tools to lead users through more than four of the generic stages of the creative process defined by psychologists.

By laying the processes of creating from different disciplines side-by-side, it reveals some common, standard fundamental or underlying principles, which can be said to be merely ‘translated’ somewhat differently in different contexts and domains. The ‘generic process of creating’ presented at the left hand side of Table 5.1b [after Table 2.1 in Chapter 2 and modified from Pahl, 2005a] is the most concise means of including all the steps detailed in all processes which were examined, while at the same time abstracting their essence and simplifying their language. The steps outlined in this process can be considered generic. They form the basis of a generic model for creativity and innovation in Engineering Design that is here called the Innovation Map.

There are seven main steps defined. While other decisions regarding the step number could have been made, this decision is, in the final analysis, most influenced by the fact that Buddhist Meditation has seven distinct steps which define the process of creating. Moreover, it is because the seven steps in Buddhist Technologies are not seen, developed or experienced by the user as a linear progression, but at least as bi-directional [see 3.2.1] and hinting at a kind of co-evolutionary process, which includes and integrates information from two different worlds or spaces, that Meditation was considered by this author to have the greatest potential for providing the basis for the steps of the ultimate Innovation Map. The three stages of diverging, converging and inspiring thought are not separate from the seven steps and can be thought of, as a separate layer, on top. While they are only implicit in Table 5.1, the three stages again become visually obvious in the representation of the Innovation Map in succeeding sections.
Table 5.1[a] Part 1 of 2. A simple comparison of steps in some universally accepted systems, together with a single generic ‘process of creating’, which includes and simplifies all other steps.

<table>
<thead>
<tr>
<th>Commonalities in humanities literature</th>
<th>Action Research method</th>
<th>Engineering Design PROCESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Problem or situation definition</td>
<td>Problem-aimed research</td>
<td>Generic</td>
</tr>
<tr>
<td></td>
<td>Problem-Definition</td>
<td>Archer 1971</td>
</tr>
<tr>
<td></td>
<td>Market Need</td>
<td>Pahl &amp; Beitz 1977</td>
</tr>
<tr>
<td></td>
<td>Strategic planning</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Establish strategic objectives</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Create outlines for innovation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Identify essential problem, need or task</td>
<td></td>
</tr>
<tr>
<td>2 Data collection</td>
<td>Planning</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Research</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Identify an area of need</td>
<td></td>
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<tr>
<td></td>
<td>Establish state of the art</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Outline performance specification</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Create specifications for solution</td>
<td></td>
</tr>
<tr>
<td>3 Incubation</td>
<td>Cyclic action and critical reflection</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Physical principle</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Working principle</td>
<td></td>
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<td></td>
<td>Feasibility Study</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Resolve critical problems in principle</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Search for working principles</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prepare sketch of solution</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Combine principles into concept variants</td>
<td></td>
</tr>
<tr>
<td>4 Idea evaluation</td>
<td>Preliminary description of solution</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Design</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Expand and quantify performance specifications</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Concept preliminary layouts</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Develop detailed Design</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Test with respect to solution principles</td>
<td></td>
</tr>
<tr>
<td>5 Incubation</td>
<td>Cyclic action and critical reflection</td>
<td></td>
</tr>
<tr>
<td>6 Solution generation including problem situation recapitulation</td>
<td>Second description of emergent solution</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Layout, validation and pre-production</td>
<td></td>
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<tr>
<td></td>
<td>Prototype Development</td>
<td></td>
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<tr>
<td></td>
<td>Construct mock-up</td>
<td></td>
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<tr>
<td></td>
<td>Form variants of assemblies</td>
<td></td>
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<tr>
<td></td>
<td>Conduct bench experiments</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Optimize Design</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Detailed Design</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Evaluate performance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Conduct user trials</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Evaluate user performance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reappraise market in light of trials</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Finalize production documents</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Revise performance specs</td>
<td></td>
</tr>
<tr>
<td>7 Third description of emergent solution</td>
<td>Full description and production</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Production Development</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manufacturing and marketing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Develop documents for production</td>
<td></td>
</tr>
</tbody>
</table>
Table 5.1[b] Part 2 of 2. A simple comparison of steps in some universally accepted systems, together with a single generic ‘process of creating’, which includes and simplifies all other steps.

<table>
<thead>
<tr>
<th>GENERIC PROCESS OF CREATING</th>
<th>Commonalities in humanities literature</th>
<th>Engineering Design PROCESS</th>
<th>CREATIVITY METHODS, MODELS, TOOLS and TECHNIQUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pahl 2005</td>
<td>Mindmapping</td>
<td>LYNEFIN MODEL for COMPLEXITY</td>
<td>Narrativa/Literature</td>
</tr>
<tr>
<td>Problem as point</td>
<td>Problem definition</td>
<td>Identify essential problem, need or task</td>
<td>Buzan and Buzan 1993</td>
</tr>
<tr>
<td>Problem as field</td>
<td>Establish function structures</td>
<td>First burst of associative ideas around the goal (brainstorming)</td>
<td>Establish parameters of Knowable domain</td>
</tr>
<tr>
<td>Idea generation</td>
<td>Search for working principles</td>
<td>First reconstruction and revision</td>
<td>Establish conflicts</td>
</tr>
<tr>
<td>Idea transformation</td>
<td>Concept preliminary layouts</td>
<td>Second reconstruction and revision, analysis and decision-making</td>
<td>Establish detailed structure of solution template in iterations addressing material, information and communication systems</td>
</tr>
<tr>
<td>Solution as field</td>
<td>Incubation</td>
<td>Test embodiment with respect to solution principles</td>
<td>Establish detailed structure of solution template in iterations addressing material, information and communication systems</td>
</tr>
<tr>
<td>Solution as point</td>
<td>Optimization</td>
<td>Finalize production documents</td>
<td>Establish second known situation</td>
</tr>
</tbody>
</table>

5.1.2 The Three Stages of Innovation: Divergence, Convergence and Inspiration

As a Tool, the Game is highly visual, highly tactile and highly collaborative. It consists of a 1.5m² map – the Innovation Map – laid on a table, with the steps and stages of creation and innovation clearly labelled over the figure of a diamond [Figure 5.1]. ‘Quest Cards’ give players a problem to solve, if they do not have their own. And ‘Inspiration Cards’ and post–it notes complete the necessary physical parts. Up to 5 players can sit around each Innovation Map and more than 200 people can play at once. The number of relevant results which are achieved by playing the Game on a given ‘Quest’ [problem] is multiplied, the more people are involved. A minimum of 10 highly–focussed, new and useful results is guaranteed in each GameDay [as discussed further in
Chapters 6 and 7], when evaluated from 100’s of ideas generated by each team in less than half an hour during play. Inside The Engineering Company, PRIZM is generally played as a 90-minute Game and used as Framework for teaching TRIZ over two days. It can also be used in many other teaching models; from one-hour coaching with individuals, to three-day events involving hundreds of young people. And in addition, it is modular in itself, so that the Map and cards can be used separately or together, and both can be combined with other Thinking Tools if required.

The left hand side of this Innovation Map outlines the divergent phase of human thinking [as already discussed in Chapter 2], which is not a phase of uncontrolled brainstorming, as is often expected of creativity Tools [see 1.2.1 and 2.5.0], but three steps for problem-finding.

The central part of the map provides the idea-generation step, in the form of a set of ‘Inspiration Cards’. These have photographs on the front, plus a written instruction and associated ‘chemical equation’ on the back. Each card is psychologically coordinated so that the photograph and equation support the written instruction; which is itself a very short and simple form of one of Altshuller’s 40 Inventive Principles. This allows the same information to be accessible to young people with different learning tendencies; visual, verbal, mathematical, as well as tactile. There are 65 cards in total, arranged over nine fields, since some instructions are repeated in different fields, where they come to mean completely different things, according to their new context. The nine fields are the nine possible problem-types [contradictions] from the previous Chapter, which will also be described more fully below. The sets of cards are colour-coordinated, so that red ones match up to ‘material–material’ problems, for example, and lie at the end of an arrow on the map, where the ‘material–material’ problem has already been very clearly defined in the two previous steps. In this step, both inspiration and transformation occur.

Figure 5.1. The current PRIZM Innovation Map has the form of a diamond in the background, to outline the three stages of human thinking during creation, innovation and problem-solving – divergent on the left, convergent on the right and inspirational or transformational in the centre. The instructions for the second last column, which did not exist at the outset of the study [see Fig 1.1], are now filled in [see section 5.2.7].

On the right hand side of the Map, the ‘convergent phase’ of human thinking is represented. This is divided into three steps for evaluating the ideas which have been generated by the Inspiration Cards, and for synthesizing combinations of the strongest ideas. This results in three
business cases or technical prototypes being proposed in the penultimate column of the Innovation Map [though this is actually the last step of Gameplay, as will be explained in detail below].

All boxes on the Map are populated by post-it notes, with answers written by each individual in the team of 5 young people who sit around each Map during play [Figure 5.2 and Appendix 3.0]. Play is very fast – some steps are as short as three minutes and the whole Game takes a maximum of 90 minutes. A little extra time is needed for each team’s presentation of results and ‘judging the winner’, when 2 or more teams play in competition against each other, around the same initial issue. In the PRIZM Game Company, Games have been run with up to 200 concurrent players at youth events.

Figure 5.2. The PRIZM Innovation Map populated with post-it notes, in an almost complete Game [pictured from top].

5.2.0 THE SEVEN STEPS OF THE PROCESS MAP

In using the Innovation Map as an aid for early stages of Design, it should ideally exhaust the Engineer’s possibilities for asking questions and capturing discussion around the topic in question. Care must be taken that each variation on the original problem, and each diversion of these variations into other technical or social domains is played in a separate Game and captured on a separate Innovation Map.

The problem to be solved is called ‘The Quest’, using the terminology of the Hero’s Journey in literature. The Quest must be stated before play commences and include as much information as possible about the constraints of the issue. It must be formulated in a precise [and ideally short] sentence and each participant in the process must agree that this sentence defines the situation. As play commences and in the first two steps of the Game, each team will produce the own variation of the Quest, since their view of it will be influenced by their collective expertise, which differs from that of other teams, if multiple disciplines are involved. When the Quest is defined, play can start.

Each view or variation of the Quest leads to a different outcome and ultimately, all variations of the original Quest and their outcomes can be combined into one view.

5.2.1 Step 1 – The Ideal Final Result

As already summarised in the context of Meditation in section 3.5.2, the Hero of a fairytale or Hollywood screenplay is incited to action, through a ‘call to action’ or so-called ‘inciting incident’ [respectively Campbell, 1949; McKee, 1997]. The same is true of the Hero on the
Buddhist path; generally people are inspired to practise by realising their current circumstances are not perfect and meeting a live teacher who can show them a way to apparent perfection – in this case, the inciting incident is also the incidence of ‘finding supernatural aid’ [term from Campbell, 1949]. In any case, the inciting incident offers an insight into an ideal, final result – the first sight of which often provides the reason for someone to move from the status-quo in the direction that leads to the ideal. As outlined in Chapter 3, this step of the journey is generally characterised by great joy, as a result of knowing that there can be an end to one’s problems.

The Ideal Final Result [IFR] is a term used by Altshuller, for the final state of technological evolution, which is supposed to lead to the same general conclusion that Buddhism and other religions lead, in regards to the ideal state of spiritual evolution. In summary, the IFR of technical evolution expects that the following major things [and eight minor ones, which will not be discussed here] occur.

1. Provides the required function but does not necessarily take up material space ie. minimises parts and functions
2. Removes all limitations and barriers
3. Uses the resources inherent in the system, requiring little or nothing to be added and at no cost
4. Carries out the required work automatically without human intervention when needed and effectively ‘disappears’ when not needed.
5. Provides all possible material benefits and least possible harmful or annoying effects in material, action or space and time
6. Is constituted of energy and light.

Altshuller discovered the IFR existed, on analysing groups of similar patents ie. products and systems made for the same purpose. This author calls these ‘classes’ of products, borrowing the term from biology. Altshuller found that all classes of products evolve according to simple rules. In particular, each product in a class has its own cycle of birth, maturation and death shaped as an ‘S-curve’, which is also well-known to describe the lifecycle of biological systems. Yet at the same time, a set of S-curves for all products in the class group around a more linear ‘trend’ eg. woodblocks, Gutenberg’s Printing Press, electric typewriters and computers group around the trend of ‘printing words’. A trend moves an entire class of products toward an IFR, which, according to the six very general rules stated above, seems impossible or even ‘godlike’ at the outset of the trend. Yet especially in the C21st, it is undeniably true: printing products really do carry out their function remotely, printing with invisible energy and light; appearing only when needed, with little cost and little action on our part, and leaving little evidence of their existence when not required. By the time that ‘printing’ happens with neurologically implanted microchips transmitting direct from brain to brain, the trend will be complete.

When relevant in TRIZ plus PRIZM training, this step is run as an extended session, making a special exercise of Altshuller’s observations of trends, which this author calls ‘King of the World’. Essentially it makes the six points above obvious, and calls for participants to address each one in turn, leading to a comprehensive formulation and team agreement of how the IFR looks. Agreeing on the endpoint is an oft neglected part of teamwork.

In terms of the PRIZM Innovation Map, the six apparent rules of Altshuller’s IFR are also stated in the instructions. However following the Buddhist principles, it is not so important the exact technical specifications of the IFR. What is important is that an ideal result is known or believed without doubt to exist and becomes the motivation for moving. This step incites individuals and teams to step out of their original problem–mindset immediately and imagine what the world would be like, if they achieved their desired result. In the Game, they are encouraged to think holistically in terms not only of the technical achievements, but also in terms of how it would feel, and what people [eg. adults, children, friends, media] would say if the result were achieved. This step sets the scene for new team members to get to know each other and express and share some of their innermost wishes; something that dealing with ‘pre-requisites’ is unlikely to do. It enables them to freely associate the qualities of a world in which the problem does not exist, and, having once been freed from how–things–must–be, this step, despite [or perhaps because of] its limited allocated time [three minutes in The PRIZM Game], consequently makes the following emotionally and intellectually intensive [and apparently more difficult] problem–solving steps a little easier. Each thought is written on a single post–it note and planted in the box at the end of the Map.
5.2.2 Step 2 – Where We Are Now

This step requires participants to face their status quo with brutal honesty. As noted previously [eg. 2.6.1 and 4.2.3], Engineers tend to avoid investigating the true nature of their problem situation, in favour of immediately proposing solutions ie. brainstorming, in the idea-generation phase of the process of innovation.

In Buddhism, as in story-telling, it is crucially important that the Hero re-assess his current life in light of the revelation just acquired through the inciting incident [eg. sections 3.1.1 and 3.5.2]. While this step of the journey may, in Western or Theravada terms, be seen as the problem situation, it is also coincidentally in Vajrayana terms rephrased as a ‘precious opportunity’. It is characterised by discipline – knowing that one can go nowhere without applying oneself to the insight one has just received; having experienced a taste of the IFR, one must make or find a map to move toward it.

Several hours can be spent on this step if TRIZ Tools such as the 9-Boxes are applied, or when Functional Analysis, Root Cause Analysis or Cause-And-Effect Chains are used, to tease out the exact situation of the apparent problem. In TRIZ plus PRIZM training in the Industry Collaborator, significant time is indeed spent on analysing the status-quo in this way, which is especially effective with pictorial provocation, as outlined in one of the case studies in Chapter 6.

In The PRIZM Game used on its own without extra Tools, it is not necessary or even possible to be exact, at this point of beginning the Hero’s Journey. This step is thus designed as a ‘brain-dumping’, lasting only a few minutes. In essence, it requires and achieves a benchmarking of everything that exists in the presumed problem-space including materials, behaviours, environmental effects. It requires participants look at problems not just as something ‘bad’ but as opportunities and also note what others have done in similar but not identical situations, that can define the status-quo. Just as in as the previous step, even without being a thorough analysis, this step still allows each individual in a team to to share some of their deeply held beliefs about the situation without a fear of being judged, not least because the time limit will not allow it. Each thought is written on a single post-it note and planted in the box at the beginning of the Map.

5.2.3 Step 3 – What We Want to Keep and Improve; The Universal Sentence

This step requires participants to decide on what will be permanent, of the ever-changing scenarios and possible routes in the journey they are contemplating. The question is; ‘What, of everything that they have defined in the previous step, and everything they want in their IFR [from Step 1], do they really have in front of them, to keep and improve?’.

In a Hollywood screenplay, this is where the action really takes off. It is where the Hero starts to consciously work on the Quest that faces him, and finds it is not as simple as he hoped. The Buddhist Meditation that formed the basis of The PRIZM Game counts this step as one of the ‘Four Basic Thoughts’ that are necessary to ready oneself for finding the great love, recognition and/or understanding that one has glimpsed in the IFR [section 3.1.1]. It requires a conscious acknowledgement that some of the things the Hero believed were permanent about life are patently not so. At the same time, the Hero tries to find what is –or should be– permanent and lasting, that will help him achieve his IFR. The step is characterised by establishing the details of one’s surroundings and taking into account the requirements of others [section 3.5.2] – it thus requires great patience.

In The PRIZM Game, this step allows only three possible parts to define the details of the Hero’s situation, which are all expected to hang together. They form what this author has called The Universal Sentence [preempted in 3.2.2, 4.4.1 and 4.4.2], since the three categories in which the universe can be described and understood involve the three parts of the English sentence structure – A Subject, A Verb, and An Object and/or Predicate. It is a strange but wonderful fact that everything in the known cosmos fits into one of the three categories of the English sentence. There is, in fact, no chance that an object merely ‘exists’, without acting in some way,
and without a space to act in. In other words, as this author maintains in Vincent et al., [2006]; ‘Things do things to other Things’ or ‘Things do Things Somewhere’; there is no simpler division of the cosmos. There is also no simpler way in which one can describe one’s apparent problem-space. What one can work with, in Meditation, on the Hero’s Journey or in product development, absolutely must have a material and coincident structure; there must be behaviours or functions associated with the material/structure; and there must be a space–time or environment in which, and reason or effect for which, the material and its behaviour exist.

This step and the next are partly coincident, in terms of their function in TRIZ training, for this is the first part of Altshuller’s contradiction, as illustrated in Figure 5.3. However, as partly explained in Chapter 4, section 4.4.2, The PRIZM Game enables participants to use their natural language and communication and not worry about understanding contradiction [or for that matter, the Buddhist concept of ‘impermanence’] at all. The easiest way to deal with a contradiction and figure out what is really happening in the problem or world, is to separate it into [i] the thing one wants to keep, which is Altshuller’s improving feature, and [ii] the associated thing that one doesn’t want – the worsening feature. The latter is dealt with, in the next step. Only the first part of the contradiction is addressed in this step of the Innovation Map.

The easiest way in which to describe the parameters which one wants to keep and improve is in a sentence covering all three parts of the known cosmos. In the Industry Collaborator, that sentence is called ‘The Functional Analysis Statement’. It asks ‘Who Does What To Whom?’. In other words; ‘Who’ is the question about the required materials or structure – the subject of the sentence; ‘Does What’ is the question about the actions, functions or behaviours of the subject – the verb; ‘To Whom’ is the question about where or in what context or environment the subject acts. In this step, therefore, post–it notes are placed in the three boxes of the Innovation Map corresponding to these parts, which outline each wanted parameter in a sentence. For example, if our Ideal Final Result is a house trained cat, one may be concerned with keeping and improving; the cat [material] sits [function] on the mat [environment]. If the Ideal Final Result involves a perfect breakfast, one may be concerned that Dr. Suess [material or subject] eats green eggs and ham [behaviour or act] in the local cafe [environment]. If the IFR is a new kind of engine for use in cold countries, one may say that the turbine [material] operates at 1 million rotations per minute [function] in icy conditions [environment]. A separate post–it note is used for each part of the sentence, and each member of the team shares as many sentences as possible, which in their opinion are relevant to their Quest and IFR, all arranged in order on the Map.

At the conclusion of the step, a team decision is made on the most important or fun sentence –ie the one that will potentially get the team to their IFR in the next 90 minutes.

5.2.4 Step 4 – What Stops Us; The Contradiction Self-imposed or Inherited

That things are impermanent in a physical cosmos [as acknowledged in the previous step] is actually half of the equation of ‘karma’ – the point addressed in this step. In a Hero’s Journey this step requires intense reflection on the rules and how everything works as a cause–and–effect relationship. This is, as mentioned in section 3.5.2, the ‘Belly of the Whale’, where one may feel swallowed up in the immensity of the task or problems one faces and believe there is no way out.

In Buddhism, karma is not about good intentions or, conversely, punishment for bad actions. It is a scientifically strict concept and exactly the same as Newton’s Third Law: for every action there is an equal and opposite reaction. It is this same coincidence of the desired action and the [undesired] effect that Altshuller called ‘contradiction’. The advantage of knowing this is that one understands in advance that there will indeed be an effect and even some effect is inescapable, one still has the opportunity to change change things. One has the opportunity to see or think ahead and escape potentially harmful effects. In other words, to paraphrase the sentiment of Einstein in the popular way; ‘If you do what you’ve always done, you’ll get what you always got’. Conversely, if former words, thoughts and actions led to into this situation that one now wants to improve, then one can change them, and the future. One can pre–empt what problems might occur, and circumvent problems that already exist. At the larger scale, this step of the Buddhist
Hero’s Journey is characterised by perseverance in applying the truths he has just learnt, to the tests that he faces.

In the PRIZM Game, two kinds of information are given for this step. The most important is that, as Altshuller also pointed out, a so-called problem does not exist in isolation. If it did, one could easily get rid of it and live in heaven on earth. The fact of human existence is that the ‘Things We Don’t Want’ are intimately and inescapably bound up with the ‘Things We [do] Want to Keep and Improve’ in an apparent dualism or contradiction. It means that for every part of The Universal Sentence which was defined in the previous step, that there are potentially damaging results of both staying put and moving ahead. There are ‘conditions that worsen’ [to use Altshuller’s words], or, alternatively, ‘conditions that seem to keep us from moving’ – and one can and really should try to see both of these before they get worse, so that one can also think ahead to a solution.

![Figure 5.3](image)

Figure 5.3. In the PRIZM Game, Altshuller’s Contradiction Matrix is completely replaced with three steps first using The Universal Sentence to identify the cause-and-effect relationship of the problem and then finding the solution. All the power of the Matrix is kept, but participants using the Innovation Map do not need to worry about understanding contradiction, dialectic or non-dualism to define 9 different variations of a problem. They are able to use their natural language to populate the fields.

The next information given is something Altshuller ignored, but which Buddhism clearly states – one can either take responsibility for a problem or blame someone else. In other words, the things perceived to be problems have a cause; in one’s own thinking or someone else’s thinking. Those problems, which seem not to be related to oneself, in that they appear to be ‘arbitrary conditions’ that already exist, and for which one might want to blame someone else, can be call ‘Inherited’. In order to circumvent these, one can ask the simple question; ‘What stops us achieving the Things We Want’. Those potential problems for which one can take responsibility can be called ‘Self-imposed’. In order to catch these before they happen, one only need ask the simple question; ‘What can get worse’ or ‘What potentially harmful effects will my desires bring?’.

In either case since one is still living in the same cosmos as in the previous step, the potentially harmful effects will also fall in the same three categories of the cosmos, as the previous step. It means that answers to this question are each written on a post-it note and planted in one of the boxes clearly linked with arrows to the previous step. Each part of the sentence in the previous step [ie. of the object one ‘Wants to Keep and Improve’] is treated individually and in turn, finding three potential problems associated with; [i] the cat [ii] sitting [iii] on the mat environment. Please note however, that while each part is treated individually, one does not
forget the other parts – it is like having three windows looking out on the same view. If one stands in the middle of a room and looks outside, one knows that the same garden lies behind each window-frame, and yet, the view through each individual frame is different and important in its own way [and this author believes the same reasoning holds true for the 9-Boxes [of space and time], as mentioned in 4.4.1].

Thus; If one focusses on apparently pre-existing or Inherited issues, which ‘keep us from having’ a perfect cat sitting on a mat inside the house, one might say that a potential material issue is that there is no cat flap and no litter tray. A functional issue is that a cat needs to relieve itself at least once in 12 hours. An environmental issue is that the cat was inherited from a friend only yesterday and there has not been time to house-train the cat before leaving for work this morning.

And, if one focusses only on the potential Self-Imposed problems related to the cat itself, one could say that a potential material issue is that the house [in which the cat sits on its mat] must be locked up. A behavioural problem might be that the cat cannot open a door by itself [to relieve itself in the garden]. An environmental or space–time issue might be that the house–owners–and–new–cat–owners are at work elsewhere from 7am in the morning till 7pm in the evening [and therefore cannot open a door for the cat to relieve itself in the garden].

The same procedure is repeated for the issue of [ii] sitting and [iii] the mat in the house environment, until all the 9-boxes in this column are filled with post–it notes and there are, as a result, 9 distinct contradictions [see 4.4.2] or problem–statements. Again, where there is more than one post–it per box in this column, a team decision is made on the most important or fun issue in each box –ie. the one that will potentially get the team to their IFR in the next 90 minutes.

Please note that If the purpose or goal of the team is changed as discussion continues, or new [and thus implicitly contradictory] information turns up and becomes more relevant, then one must start a new line of enquiry to go with it. In the process of using the Innovation Map, it is not necessary to draw a new superposed map for the new enquiry to put upon the first [as would need to be done by using a simple map such as one of the diamonds from Figure 5.7 below]. No new map needs to be drawn or superposed, since all lines of enquiry are included on post–it notes and captured and linked to the resulting discussion about the Design in their correct place [see Figure 5.2 above and Appendix 3.0].

Also, in contrast to Gero and Kannengiesser [ibid], one cannot transform questions about the function of an artefact, into a question about its structure. Each of the steps defined by these authors – for example the transition F→B or B→S [and all subsequent reformulations in the sequence of eight] is, in the Innovation Map, a single line of contradiction plus a single point of resolution [distinguished on the map by a single arrow linking the contradiction with the Inspiration Cards that point to the answer] and each question has a separate co-evolutionary process in the group discussion, in which the entire two worlds [of diamond–like thought] are implicitly traversed, even when they are not mapped.

5.2.5 Step 5 – Pattern–matching ; Inspiration and Transformation

This point of the Buddhist Hero’s Journey is characterised by concentration – specifically on how one’s usual world and worldview is to be matched up with the new, unusual or spiritual one. In individual Meditation, this step is a crucial acknowledgement that one’s usual world cannot provide fulfilment and that one absolutely wishes to reach the IFR and/or bring it into one’s own world [as introduced in section 2.5.0 and 3.5.2]. It is also the point at which one acknowledges that since one does still not really know the way to get to the IFR, one needs to learn from someone who does. One must have a Teacher to learn from or a Map to make the path explicit.

In screenwriting, this point is the beginning of the Road of trials, where problems come thick and fast, yet also miracles or magic happen. This road does not have to be unhappy –rather it can be exhilarating, because one sees very quick feedback and rewards for one’s actions. Yet of course the miracles do not happen without effort – they require the Hero or Meditator to do his part. As indicated in Chapter 3 [3.2.1 and 3.4.0], this is the point at which the Divine first meets
the pre-given earth-bound world, in a rudimentary form. It is therefore not just the point of inspiration, but the beginning of transformation.

In The PRIZM Game, as it is used for innovation in product development, this step involves Altshuller’s Inventive Principles. As outlined in Chapter 4, the entire Contradiction Matrix of potential problems and its associated solution set has been rearranged on the Innovation Map. Please note however that the Game uses only the Engineering solutions which are checked against biological solutions. Since nature does not actually use all the 40 Inventive Principles that Altshuller defined for Engineers, but only 34 of them [see previous Chapter section 4.4.2], only these 34 principles are all included in the Inspiration Cards in this step. They are arranged in their correct place and repeated where they are also repeated in the original Matrix.

The Inspiration Cards instruct Game participants in one potential solution per card. As Figure 4.4 in Chapter 4 shows, the red cards are pre-sorted solutions, which have all the potential solutions from the mundane world, which are associated with ‘material–material’ problem–types. The orange cards are pre-sorted, to provoke users to think of solutions to ‘material–function’ problem–types. The yellow cards are pre-sorted to address ‘material–environment’ problems ... and so on [see also 4.4.2].

In Gameplay, the team now takes up each card set in turn and considers the solutions proposed on the card in respect to the exact problem they have defined in the previous two steps. The relationship of each set of cards to each problem–type is clearly laid out with the arrows on the Map, so participants keep their focus on relating the potential solutions only to the relevant problems or questions.

Now a brainstorming takes place for idea–generation. Participants ask ‘How is this solution relevant to us’, or ‘How does this solution help answer the question we posed?’. They think of as many answers as possible, writing each answer on a separate post–it note and sticking this on the Inspiration Card which provokes the answers. While they are given only 30 minutes to complete this whole step, meaning they have less than 30 seconds for each card, teams regularly generate five or more potential solutions for each. At the end of the step, teams have therefore often generated five [or more] ideas on each of 65 cards ie. a minimum of 325 potential solutions for the nine specific problem–types outlined in the previous step.

5.2.6 Step 6 –The Complete System

At this point in the journey, the Buddhist Hero achieves wisdom, in the manner of Csikszentmihalyi’s [1990] ‘flow’. He realizes that the cosmos [in its Universal Sentence] really is composed of inseparable parts; whereby the Creator and the Act–of–Creating and The–Thing–Created–or–Affected are all co-dependently part of one whole. This kind of wisdom is a state–of–being which is viscerally experienced [or perhaps encountered as the Goddess of fairytales, mentioned in section 3.5.2], as well as intellectually known, and therefore characterised as being ‘beyond duality’, or obviously transcendent.

It is also, as Chapter 3 [3.2.2, 3.3.2 and 3.4.1] indicates, the point at which the Divine or ideal world is not just touched, but literally becomes manifest, for the first time, in its five distinct parts. Moreover, the wisdom attained is not just a mundane wisdom about the path already followed and left behind on the left–hand–side of the Map, nor about the pre–given world which was newly re–organized as a result of following the path. It is, in Design, the step that allows the first nascent appearance of the solution in the problem–space. For it is, in Guru Yoga Meditation [section 3.5.1], the so–called ‘melting’ of the Meditator with the IFR at the end of space–time [though please note this step looks slightly different in the Meditation on the 16th Karmapa, since the Five Buddhas are implicitly contained in the Three Lights or Three Jewels that first emanate in space, from the IFR coming toward the Meditator}. In short, on both the level of personal liberation through Meditation and the universal level of transformation through the Hero’s Journey, it is the step that pre–empted the coincidence of all worlds; the point at which the distinction between the Meditator, the Meditated–upon–World of the other half of the Map, and the Meditation itself dissolves.
In a screenplay, this is where things start to make sense, yet it is a ‘false climax’; the point at which both the Actor and the audience are supposed to think that everything has been achieved, while the truth is, creation of the new world is not yet complete, as becomes obvious in the next step.

In the PRIZM Game, this step makes use of the Complete System of the Viable System Model of organizational growth from Stafford Beer [see 3.3.3] to lay out all necessary parts of prototypes that should be made.

The author of this Dissertation generally paraphrases Beer’s model during facilitation of the Game, matching it up with the Five Buddha Families, so that two parts of a complete system are concerned with ‘materials’, as follows;
1. The first is a structural framework that provides the template for a material system – like the skeleton of a human body.
2. The second is an overlying or integrated framework, which coordinates how all material parts of the first system move within the whole – like the circulatory system or muscles of the body.

Two more parts of a complete system concern ‘non–materials’.
3. One of these is an internal management or control system, that determines not so much how, but ‘how much’ or indeed ‘whether’ the first two systems move at all – like the brain. Together with the two parts above, this makes an almost complete, or proto–complete–system.
4. The other is an external management system, that determines how much and whether the first three systems interact with a wholly different system or set of systems. In anthropomorphic terms, this is like a relationship of two people. This is the point where the ‘smartness’ or intelligence of any individual system first becomes obvious, since intelligence is a function of being able to appropriately adjust to external feedback and continually improve or refine internal control to this stimulus. After all, while a skeleton with muscles and a brain may be the most intelligent Being on the planet, this is not obvious to anyone, if the creature merely sits alone on a mountain–top. It is only in relation to others, that a system is able to really reflect on its own place in a greater system and adjust itself to feedback and whereby its ability to achieve control over itself and its environment is able to become complete.

The fifth and last system is yet more refined, and ‘neither material nor non–material’. It requires the original system to achieve a relationship not just with one or more other systems like itself, but with the entirety of all systems it could possibly be related to, in a kind of ‘meta–system’ of global application. This sub–system is both separate[d] and whole, in the same sense of the wisdom of the Buddhist Hero mentioned above. In human beings, this system might be thought of, as the value– or belief–system which affirms the value or purpose of an individual in the cosmos. It is also the point at which the value of a system becomes obvious not just to itself and those immediately around itself, but also in places where it had previously no reason to exist.

This can be understood in the examples, which are always given to participants in two forms: A technical example and an organisational one.

For example; if the complete system were a C20th clothes–peg, the five subsystems would be; [i] wood and wire material, [ii] coiling spring coordination system, [iii] stiffness of spring determining control, [iv] relationship with hand, clothes and clothesline, [v] intention to be the best holding–together–object that was ever created. Note that in achieving the stated intention, a number of added applications immediately become obvious – ie. the clothes–peg is good not only for holding clothes, but also for holding envelopes together and closing potato chip packets.

If the complete system in question were a company, the five sub–systems could be, in turn; [i] Manufacturing and Technical Design, [ii] Administration and other Coordination, [iii] Management, [iv] Business Development; internal and external, [v] Branding and Culture.
At this point of the Game, teams take up all the Inspiration Cards populated with Post-it notes from the previous step, and re-assess what kind of ideas they are. After only a little discussion, they place each idea in the appropriate box for its type – in either [i] materials and structure [ii] coordination [iii] control [iv] relationship [v] integrity and added applications. This step requires a lot of decision-making and agreement, but generally teams complete it very quickly [in the space of 10–15 minutes].

5.2.7 Step 7 –The Three Gatekeepers and Business Cases

On the Innovation Map, this is the second–last column, but when using the Innovation Map for product development in the PRIZM Game, this is the last step played. Here the Buddhist Hero comes to the Divine world in the purest form it can take, when it first emanates to reach toward the pre–given world. In a fairytale and most Hollywood movies, this is the ‘happily–ever–after’ end, where the Hero ‘goes afar’ [see section 3.5.2] without any explanation, for the initial story is complete in itself at this point. A few movies, and indeed the Buddhist Hero’s Journey, however, show exactly how the Hero can go further if he were to return to his original world and there tell his story and help others use his Map to find their own IFR – characteristically creating new and skilful means to help others. There would be further meetings with the ‘God of all Gods’ leading to atonement or Apotheosis and achieving ‘The Ultimate Boon’ and further trials in crossing the return threshold and becoming the ‘Master of Two Worlds’ [ie. there are overall 10 steps in the Buddhist Hero’s Journey and the composite fairytale of Campbell, 1949], albeit at a totally different scale to the trials encountered in the early part of the journey. This was briefly explained in section 3.5.2 and is partly addressed in The Diamond of Creation and The Arrows of Innovation [section 5.3.0] below, though a detailed explanation is beyond the scope of this Dissertation. Suffice to say here that the most important further steps of the returning fairytale Hero and Buddhist Hero are integrated in this final step of the Innovation Map, as the Hero comes to understand: [i] the actions of all fellow beings; [ii] the mind of the highest gods; [iii] all things simultaneously both in and out of context. Thus the three hidden steps the Hero must take within this last step also match up with the same three principles whereby the Divine world manifests from space to be visible to ordinary mortals, that were explored in sections 3.2.2. and 3.3.2 and 3.4.0 – meaning that: [i] the Hero’s fellow beings are the sangha or end–users; [ii] the rules of the divine are the dharma or managers of rules [iii] integrating ordinary and non–ordinary realities, while overcoming yet existing in both refers to the buddha, designer or technical experts.

These three hidden steps of the Hero’s journey within the final step of the Innovation Map are therefore also the three Gatekeepers and communities previously introduced in section 3.3.1, which a product Designer must appease if he is to make significant change in the world. To not address the needs of all three Gatekeepers means that a product or cause will have less wide appeal and a shorter life. Patently, each of the different Gatekeepers have different criteria for buying a given product. Therefore, in the PRIZM Game, three different scenarios are now considered to fulfil the criteria of each of these three communities. The scenarios can be technical prototypes or business cases for non–technical solutions, depending on the original problem that was to be solved by using the Innovation Map. The criteria for decisions made by each of the three Gatekeepers arose from conversations with the Head of Knowledge Management in the Industry Collaborator in 2007, regarding the natural language in which Engineers could make the requisite decisions on the suitability of each idea for each Gatekeeper. Obviously, the three Gatekeepers will have different significance for every type of Map–user and for Engineers who are Designers, the set of Gatekeepers are not those of Figure 3.2[b], which concern the Company instead. An Engineer’s Gatekeepers include the Expert [ie. other Innovators or Designers], the Rules he keeps or breaks [eg. of Science or Technology] and the Field in which he makes a difference [ie. for his internal End–User or Customer].

In short, the decisions that Engineers make at this point involve thinking about each idea from the previous step in these contexts:

- Rule–keepers in Engineering include Manufacturers, Risk–Analysis, Quality Assurance, Safety, Finance Experts etc. These and other rule–keepers are, not surprisingly concerned that one sticks a close as possible to the rules and does not break them [cf. the four Rules of Innovation in Chapter 3], and that any deviations made from the
standard are as small as possible – in other words, that prototypes fulfil a condition of efficiency. That means the prototypes this market segment wants to see and buy must be ‘cheap to make and run’.

- The End-Users of Engineering Manufacturing include, for instance, vehicle retailers and companies using vehicles as businesses, including train-drivers, bus-drivers or pilots, crew and passengers. They and other users are not concerned about the rules – in fact they often ask for the rules to be broken [see the four Rules of Innovation in Chapter 3], generating novelty at least indirectly if not directly in this way, in order that prototypes fulfil a condition of ease of use. In fact the only reason why this market segment will buy a new product is because it ‘makes their life simpler’.

- The Experts in a given field of Engineering are the Company Engineers, Architects, Designers and their competitors, as well as Engineers in other, related or interested disciplines. These are the people who not only can judge if a proposed solution is a good one, they can judge if the problem ought to have been solved in the first place. As Csikzentmihalyi said [see 3.3.1], it is this coincidence of previously-unknown problem and previously-unknown solution that makes history, it is only Experts that can know not only how to keep the rules and how to break them but when to do this and other Experts will wish they had done it first. The only reason this market segment will sign-off on a prototype is because it is elegant or ‘beautiful’ in all these respects.

To make the prototypes or business cases, participants playing the Game now assess each of the individual ideas screened into the five categories in the previous step, and rank them. ‘Ranking’ means that they take each set of cards from each of the five sub-systems in turn, and judge and rearrange the ideas on them one more time, according to the criteria of the Gatekeepers. To do this, they take the set of material solutions and ask; [i] which single idea, of all these possibilities is the very cheapest to make and run? [ii] which single idea, of all these possibilities is the simplest for the End-User [iii] which single idea, of all these possibilities is the most beautiful solution? Which one of every group will make the Gatekeepers happiest in each of the three categories?

They place only one idea from each set in each of the three prototype boxes, keeping the rest of ideas generated to the side. In the end, there are three complete prototypes or business cases containing five cards each i.e. the cheapest possible business case consisting of; with materials, coordination system, control system, relationship system and integrity. Likewise, they have the simplest possible business case consisting of these five parts, and the most beautiful or elegant possible business case consisting of these five parts.

The Game finishes with each team presenting their business cases to each other as stories in a competition. At the conclusion of any PRIZM workshop using the Innovation Map and Game, it has never failed that hundreds [or even thousands] of ideas have been generated by the team in less than 90 minutes and 10% of the solutions proposed [as individual ideas or complete prototypes] are immediately implementable in the business, or patentable.

5.3.0 THE DIAMOND OF CREATION AND THE ARROWS OF INNOVATION

5.3.1 Mapping a Process as a Physical Space

Over and above the individual steps of Design and innovation, which are laid out in the Innovation Map, and followed by participants in the PRIZM Game, there is another kind of flow between question-asking and answer-finding [i.e. problem-finding and solution-finding], which is layered into the diamond shape and use of the Innovation Map. This includes and goes beyond the information offered by psychologists that the process of creation and innovation starts with ‘divergent thinking’ and ends with ‘convergent thinking’ [see 2.4.3]. It is also intended to refer to the geometry of Buddhist Meditation introduced in Chapter 3. And it is also intended to help approach the process of problem-solving from first principles, mapping the ‘conceptual space’ of creative thought as if thoughts were physical objects in physical spaces – ie using the exact rules of ‘real external physical space’ to draw ‘the space one thinks one sees with one’s eyes’, during the process of pattern-matching problems with solutions.
It is acknowledged by many Designers surveyed in the Industry Collaborator [section 2.5.0 and Pahl and Newnes, 2007] that their thinking does not move easily ‘in a straight line’, or from a known problem ‘on the left hand side of a page’, to a known solution ‘on the right’. Rather, as Design discussion evolves, the direction of thinking of individuals and groups changes, ebbs and flows. Newell et al, [1962] and Getzels and Csikzentmihalyi [1975] suggest that it must the Designer’s thought process becomes at least bi-directional and inclusive of problem–finding at the same time as solution–finding and thus increasingly complex to map. Using a diamond on the Innovation Map to represent insights from TRIZ and Buddhist Technologies, the complexity of the innovative process in particular and indeed the Engineering Design process in general can start to be explained, without requiring 100–dimensional graphs, as will be done in the succeeding sections of this Chapter.

5.3.2 The Line of Contradiction

At some point in their Quest, Engineering Designers invariably face Altshuller’s [1956; 1984] ‘contradiction’. In simple terms, they have one thing they want, and another, which they don’t want – or two things which they want [or don’t want] equally much. It is relatively easy to map this concept. The simplest geometric form which can represent a contradiction, is a line with two end points representing the apparently irreconcilable and thus conflicting targets that must be integrated or addressed [Pahl & Bogatyreva, 2003]. The line of contradiction cannot include a point of resolution of the conflict [Figure 5.4].

Figure 5.4. The simplest description of contradiction is as a line of conflicting targets that does not include a point of resolution of the conflict.

5.3.3 The Triangle of Resolution

The point of resolution of a contradiction must lie outside this line. And, no matter where the solution is placed on a page, as it connects with the contradiction, the three points form a triangle, adding another dimension to the problem situation. For the sake of simplicity in this example, the relationship is shown in Figure 5.5 as an equilateral triangle, known in biology, cosmology and mathematics to be the simplest and strongest natural structure, apart from the circle. Importantly, the triangle can represent both an intermediate resolution or a final one. It can take the place of one entire half of the process of creating [i.e either divergent thinking or convergent thinking].

More importantly, this says something about how Designers must approach their problem. In the same way that railway tracks run parallel yet appear to converge at a vanishing point on the horizon, a problem is represented as conflicting targets spanning the point where the querent stands, while the resolution is a point on the horizon, joined via the two separate paths of imagined binary vision.
5.3.4 The Diamond of Co-evolution

As indicated in the survey of Engineers in the Engineering Company [sections 2.5.0 and 4.2.1], Engineers often hastily assume they completely understand their problem. But inevitably, the true cause or root of the present conflict is hidden so far in the past, it can be represented in relation to the present, as speck on the horizon. Thus, for an ill-defined problem situation, the Engineer effectively stands in the centre of her conceptual map, with space open around her, holding the above-defined contradiction as conflicting elements in each of her two hands. Then she must look behind her to find the original problem, following the same rules of mapping and visual perspective, as she did, when she looked to the future horizon, to find its resolution, as illustrated in Figure 5.6.

5.3.5 The Nature of Innovative Thought

At first glance, Figure 5.6 describes the same simple pattern of divergence and convergence of thought that is known to Designers and psychologists, and which was alluded to, in previous sections of this Dissertation. But in fact, it is not.

The direction of one’s thoughts is different, depending on one’s motivation, worldview and interpretation of events. Based on the evidence about a Buddha’s view of two worlds [section 3.4.1], and the Diamond Model of Design presented in Chapter 3, Figure 3.8[a] and [b], it is proposed that even when represented in 2D, the nature of thought motivated by innovation does not move in the same direction or manner as the nature of thinking, motivated by problem-solving.

Broadly speaking, to simplify the information about the creation of worlds in multidimensional space using Buddhist Methods, so that it is mapped in 2D, there are three possible views of any given diamond map, and three possible ways of describing the movement of thoughts.

The first scenario represents a Meditator and Designer building a world from bottom-up, as if all existence really were known to start at one exact point of problem-definition, and problems could be solved, by diverging and converging thoughts in a single sequence, to one exact, recognizable finishing point. This is the standard scenario of problem-solving used in the West, best represented as a ‘left to right’ direction of movement on a map. As Lui et al [2003] point out, problem-solving is however not a single event, but requires iterated cycles of divergence and convergence, turning the space–time representation of such a thinking process into a problem–resolution string. This view absolutely assumes that the original solution becomes the
new problem and the exercise is repeated until one tires of it or runs out of money to continue [Figure 5.7].

Figure 5.7. In problem-solving scenarios, the problem and solution are respectively assumed to be completely defined and definable at the beginning and at the end of the process. They do not emerge or evolve as time progresses. The original resolution thus generally becomes the new problem and results in a string of actions which cannot really produce any new insights, merely variations on the old ones.

For innovation however, it is not enough to solve a problem by moving once from left to right through a cycle of diverging and converging thought. It is not even enough to repeat the cycle several times over. For, while the exercise of diverging and converging around a problem may yield temporary solutions, this worldview does not address the Engineer’s involvement in perceiving the problem in the first place. It does not allow Engineers to identify contradictions, nor their cause-and-effect, nor does it allow them to transform their view of a problem, by reformulating their language and identifying the interacting but apparently conflicting elements. It therefore forces stake-holders to continue dealing with the same kind of conflicts and the same kind of solutions they have always had, in the mistaken belief that a larger transformation is taking place, merely because the context of the problem changes and looks a little different in each iteration. The truth is, however, that mere exploration and movement of the problem-solving space does not represent the transformative action of changing the existing space that defines an activity as being creative or innovative [see Boden, 1994 and section 5.4.0 below].

The second scenario, as already shown in Figure 5.6 above, acknowledges that the perception, position or view of the Designer is part of the problem. It allows her to reformulate and transform her view of the necessary but apparently irreconcilable elements of Design into manageable concepts which include conflict and its resolution. It allows her to identify potential causes and effects of the interacting elements, to find their interdependence and trace the net of existence back to an ultimate cause, while at the same time, also moving towards a resolution of her situation.

The final scenario of diamond-shaped evolution is the most interesting [Figure 5.8]. It requires the Designer to consider not only her own thoughts, but also those of others [see also 3.5.0]. This is a variation of the second scenario described above, iterated for all participants, all systems and all scales [to the point of ultimate transformation described in section 5.4.0]. This makes most sense in a real life situation, where the path of innovation [at least in the Industry Collaborator] involves the superposed thought-maps of many collaborating stake-holders and elements. This scenario can be represented most simply as two different kinds of situations which are variations of the ‘external’, ‘expected’ and ‘interpreted’ worlds of Gero and Kannengiesser [2004].

This suits this author’s argument perfectly. In drawing conceptual spaces as if they were physical objects and spaces, Gero and Kannengiesser’s [2004] external world, interpreted [external] world and consequently expected [external] worlds are linked in a feedback loop. In contrast to Gero and Kannengiesser [ibid] however, it is possible to distinguish two types of interpreted world, based on the various Designer’s concepts and perceptions. The one is based on a map of space[s] known and agreed through previous experience, which can continue to be called expected, whether it concerns physical or conceptual space or both – this is the ‘pre-given’ world of Chapter 3. The other is a world that includes the non-shareable experiences of all Designers and the possibility of a map where those experiences coincide, whose boundaries are not initially known and cannot be defined until the most important relationships between elements are linked. This is the ‘to-be-created’ world and space of Meditation defined in
Chapter 3. This latter world comes into being only through the act of refraining from expectation, because one cannot interpret what is there in the instant it appears, but only by making connections to other things ie. in retrospect [heralding the argument for analogy in section 5.4.0 of this Chapter]. As a result, in this world one cannot and does not map thoughts as converging to an expected horizon, but than opposite. In other words, standing at the starting point of a world with unknown elements, unknown contradictory relationships and an unknown finishing point, one can only ‘see’ and plot the evolution of that world as if it were a path emerging ahead of oneself; ie. as if it were the source of the light cone of original creation.

It is interesting that when they are considered on their own, the arrows of thought in maps of both these types of interpreted world move in opposite directions –ie. towards the horizon point of an expected world in the first, and out from the point source of the to-be-created world in the second. And yet both types of interpretation also include the possibility that the Designer looks in two directions from her starting position ie. forward and back.

Figure 5.8. The direction of movement of thought towards the horizon in the ‘expected’ world on the left, contrasts with direction of movement of thought from the [cone of light] source of creation in the ‘to-be-created’ world on the right. However both diagrams include the possibility of the Designer looking in two directions.

Figure 5.9. In the ‘to-be-created’ world, the Designer starts from a point situated at the middle ground between her contradictions or desires. Superposing the ‘expected’ world and ‘to-be-created’ world, she achieves a co-evolutionary world with high symmetry. The bold lines show that the act of idea creation are the same as those in Figure 5.8, so the direction of movement of thought remains obvious. Note that the direction of the divergent movement paths clearly show that the original ‘solution’ moves towards the original problem and vice versa. Note also that at the central point, the problem and solution are not only mirrored, they are co-existent, and that the Designer may also perceive herself as a result, to be standing
at either end of the picture, where there is yet another mirror, and that the complete map of innovation is therefore both fractally nested and repeated ad infinitum, as well as non-existent.

Next; because both worlds co-exist, one needs to combine the expected and to-be-created worlds. This issue covered here [in 2D drawings] is the same issue faced by the Buddha-to-be [and described in the 3D Figures in sections 3.4.0 and 3.5.1] and can be done in two ways.

One option is to halve each of them, and add the first act of the ‘to-be-created’ world to the second half of the ‘expected’ world. This is the situation which exactly represents problem-solving, as previously described in Figure 5.6.

The other option is to superpose them [Figure 5.9]. When one superposes these two maps of the expected and to-be-created world onto each other, a complete symmetry of behaviours is achieved. This would be equivalent to superposing Figures 3.6 [1] and [b] in Chapter 3. This author proposes that this illustrates how co-evolution is intrinsic to the simplest process of creating, whether it is actually wished for, and known about, or not. This particular type of map includes all the possible paths associated with a Quest and ensures a functional coincidence of the external and pre-given world in which a Designer acts, the expected world which she draws or maps, and the third, interpreted world[s] which is yet to-be-created and experienced [something that is not obviously the case in Gero and Kannengiesser, 2002].

As is expected to be the case in formal Meditation also, the superposed map proposed here represents a space that is simultaneously bounded and infinite, and where exploration and transformation of that space are reduced to a single process. This kind of coincidence defines the ultimate level of a creative system, according to Boden [2005]. This is practical since, as Figure 5.9 shows, such a map allows the solution to really move towards the problem and vice versa. In other words, the experience of finding the solution is a mirror image of ‘finding the source of the problem’, and the exploration of space in the direction of the problem can be treated as if it were also an experience of creation ie. the same questions can be asked of the problem one does not know one has, as are asked of the solution one does not [yet] have. This addresses several of the discrepancies which currently exist in respect to the demands of computational algorithms [eg. it is currently difficult for CAD-systems to find problems, without being set them, in the first place].

5.4.0 THE NON-EXISTENT MIRROR OF TRANSFORMATION

Achieving a final overlap of two kinds of worlds in an implicit third world brings out one final important attribute of the process of co-evolution between domains; the transformation that occurs as an end-result of ‘knowledge transfer’ between the co-evolving question and answer ie. the integration that occurs when all patterns are matched or mirrored, and the problem situation thereby turns into an ideal and final result.

The non-existent mirror can be considered to be located at the level of the central horizontal plane [not shown] in Figure 5.9. More obviously, it exists at step 5 on the Innovation Map, where the Inspiration Cards sit. This is where, if the Engineer knows the ‘pattern of the problem’ completely, the solution appears to come to meet him. It is, in other words, the point where, if one has split one’s problem apart correctly [with enough functional analysis and identification of contradictory elements], one not only knows the interdependent patterns of the problem completely, one sees the problem transform before one’s very eyes, as if it had never existed in the first place.

The moment when coincidence of problem and solutions is achieved and an ‘expected’ and unexpected [and previously unexperienced] world coincide in this way can seem magical and can be attributed to the Divine [cf. sections 3.2.1 and 3.4.1]. Even in the psychological literature outlined in Chapter 2 [2.4.0 and 2.6.2], this fifth step of creation or innovation has historically been considered the place of ‘inspiration’, whose mechanics are unknowable. But as Louis Pasteur, inventor of immunization, is supposed to have once said, and the Innovation Map of this Dissertation likewise suggests, ‘change favours the prepared mind’. Thus it seems likely that having knowledge of the mechanics of ‘two worlds colliding’, melting or being integrated, as described by the Buddhist Technologies in Chapter 3 and above, allows knowledge transfer to
be taken from the realm of magic in the realm of being systematic. It also means that in order to practise becoming expert at innovation, the process of pattern-matching of problem and solution must first be made completely conscious and obvious [ie. as if it were a real mirror in which reflection could be seen], before it can later become intuitive and effectively non-existent again.

It is possible that the level to which this experience of coincidence of problem and solution can be achieved intuitively, depends on the level to which analogical thinking is second nature. Great historical Inventors [eg. Georg De Mistral, the inventor of Velcro] have often been reported to have found solutions by matching the pattern of a completely-known problem in one world [eg. De Mistral was an Engineer interested in the world of Textile Design], with its mirror image in a world which was not and could not be known from their own expertise [eg. while walking in the woods, De Mistral observed small multi-sided burrs from a special kind of grass sticking to the dog's coat, and they were hard to remove, whereupon he realised he could use the same 'hook' and 'fur' technique to stick fabric pieces together without glue; see Freeman and Golden, 1997].

Without requiring skill or intuition in analogical thinking of participants in the Game, the Innovation Map provides pre-sorted, pattern-matched analogies to provoke the process of solution-finding. And at the same time there is also a deeper, more important level of analogy built into the Innovation Map, which this author asserts is responsible for the success of capturing and streamlining the teamwork of the diverse and multidisciplinary stakeholders involved in creating any given Design in the Industry Collaborator.

As Gero and Kulinski [2000] point out in the abstraction and transfer of knowledge [ie. pattern-matching, in their case in software for Engineers], there is categorically no single place where 'The Analogy' is 'situated'. This is confirmed in numerous reports in Engineering, AI, and the arts, where it is known that the description of a situation not only changes as the system searches for a matching or analogous pattern, but also that the 'perception of an analogue [solution] may be permanently influenced by having seen it in a particular [analogical] relation to something else' [Boden, 1994].

The fact is, that true analogy is not an abstraction or mere literary device – it is a mathematical process, defined by the ancient Greeks as involving three discrete steps [Lawlor, 1989; Pahl, 2001]. It is thus a behaviour or iterated process of comparison that achieves ever-finer precision of measured similarities and differences between objects, which at the same time ‘constructs the situation within which the analogy itself is constructed’ [Boden, 2005]. The process of integrating information from two fields, domains or worlds in a third world [as per section 3.4.1] is, in essence, the process of true analogy. At all points in the process of integrating the two kinds of information into the third world of the observer or creator, the process involves more than one scale. And, could the process continue indefinitely, the penultimate reference frame could include all scales. Thus the best ideas in Design are invariably also the most ‘richly linked’ [Simon, 1990; Goldschmidt and Tatsa, 2005].

This author asserts that transformation is both cumulative and the end stage of continued cycles of co-evolving Design. It happens especially at step 5 of the Innovation Map, but also at all stages of using the Map. That is because the analogic process of comparing one thing to another thing to yet a third thing, is like the process of looking in a mirror every time a comparison must be made ie. every time the question must be asked ‘does this fit [our aim]?’.

Since the iterated process of asking such questions and looking for the answers [from wherever they may come] is also the process of innovation, the process of transformation is hidden in every step of the Map. In other words, the process of innovation could be visualised in a sort of multidimensional, fractally-nested diamond ie. as a diamond inside another diamond inside yet more diamonds, perhaps as an extension of Figure 5.9, which is beyond this author’s artistic capabilities to draw], centred around the non-existent mirror as the point or plane of ultimate resolution and transformation. This is in contrast to considering the process as a one-dimensional [problem-resolution] string of diamonds [ie Figure 5.7 above]. There is no reason why such nesting should not be a self-organizing feature of the human thinking system, just as it seems to be in the growth of biological and physical systems.
This author thus proposes that co-evolution and continued co-emergence of the two worlds which are to be integrated in a new Engineering product innovation happens via a kind of hall-of-mirror effect, leading to ever-refined scales of reflection of the two worlds, until at some point the distinction between problem and solution can cease to exist. This author therefore also proposes that the so-called ‘creative leap’ or ‘ah-hah moment of insight’ that is often described in the creative or innovative process actually is not a leap at all, but its opposite – the moment when co-evolving and bisociative paths of thought are completely unified and there is a dissolution of opposites, dualism or separation of worldviews into ‘nothing’ [see 3.4.1 and 3.5.1]. In other words, the epiphanic moment of creation and innovation, when surprise or delight seem to be a universal response, is not about the act of finding something new, nor about an act of integrating something new with something a bit older [see 1.2.1 and 2.1.0], but counter-intuitively, in a kind of non-action of finding what had been there, all along.

In summary, the process of using the Innovation Map involves the super-nested, recursive and fractal structure of the true analogical process, and this is exactly what allows participants in the process to create something new within something just a little older, over and over again, so quickly. There is no single stage at which the process maps onto itself. Analogical resolution and diamond co-evolution occur for the process as a whole just as they also occur at every one of the seven steps outlined in the Innovation Map and each part of every activity of Tables 5.1[a] and [b] of this Chapter, as well as at each of Gero et al’s [ibid] eight stages of Design. This can explain why the ideal Design system, as originally pointed out by Hofstadter [1985], and quoted by Minsky [1986], always ‘makes variations on a theme ... [which are] the crux of creativity’. In other words, according to the definitions given at the outset of this Dissertation, the whole process of innovation is identical to the process of classical or true analogy.

The Innovation Map is visually and conceptually simple at the outer level of participant use, whilst also comprehensive at the deeper levels of understanding innovation required by a Facilitator or Consultant in Systematic Innovation. As Chapter 6 will outline, the Innovation Map can almost guarantee an innovative result every time it is applied, whether the Design involves a team of twenty or a team of one [cf. Goldschmidt,1995]. Thus the Innovation Map appears to be a generic model that is applicable to all steps, stages, phases and types of Innovation, and all stages, fields and domains of Engineering Design [for all contexts of Csikzentmihalyi explained in 3.3.1 and of Visser, 1992].
Chapter 6  USING THE PROCESS MAP IN THE ENGINEERING COMPANY: ‘Quick Wins’ in Five Areas

Some of the applications of the PRIZM Innovation Map and Game in its first four years in Engineering Design are outlined in this Chapter. The finer details of research questions asked, problems solved and results achieved are confidential, but the general schema of how the Innovation Map and Game work in different contexts is discussed. A summary of the key results from workshops involving 1000 participants on eight sites is provided, along with real-time returns in terms of Engineering solutions implemented, patents submitted and lead time saved on projects. The Innovation Map and Game also provide the framework for an innovation deployment programme, which is potentially self-sustaining and integrated into existing company work processes though bottom-up growth. This is due to the unexpected benefits of improving team communication in multidisciplinary teams, facilitating transparency of problem situations, and providing a common language for communication, which in turn leads to greater confidence and joy in innovative behaviour.

6.1.0 INTRODUCTION AND GENERAL OVERVIEW OF THE INNOVATION MAP IN THE ENGINEERING COMPANY from 2007–2010

Following the Pilot Test for TRIZ plus PRIZM outlined in Chapter 4, the PRIZM Innovation Map became the official standard for the Collaborator’s Systematic Innovation Programme. In the following years, four contracts were then undertaken to continue delivering TRIZ plus PRIZM [ie. the Innovation Map and PRIZM Game just described in Chapter 5], in various combinations, on all major sites of the company. In total, over 600 participants took part in the sessions in 2007–8. A further 400 participants took part in Systematic Innovation training and workshops in 2009–10. Overall, 60 training, coaching, workshop, Game or GameDay sessions using the Innovation Map were run by this author in the Engineering Company up to the end of 2010, at the same time as she was organizing and managing the network created with past-participants of the training.

6.1.1 The Research Questions and Evaluation of the Innovation Process Map

Over these four contracts, the use of the Innovation Map evolved at the same time as the research questions [and coincidentally desired outcomes] emphasized by the Industry Collaborator and this author also evolved, from a more technical and comparative beginning [ie. beginning with a comparison of the training styles and possibilities of TRIZ and PRIZM, as Chapter 4 has already shown, and continuing with measurement of the technical outcomes of using either or both techniques together, as this Chapter shows] to a more qualitative and participative end. This evolution of questions is, of course, to be expected in any long-term research situation as new information comes to light – the more so, when research concerns the refinement of a process involving many users and possibilities, rather than a product with non-changing parts. And it is also inevitable that any initial study that applies a complex new product or IP must be about testing and exploring in how many ways it can indeed be useful, following each new lead when it arises, rather than planning ahead to question or measure something which cannot be known to even exist at the outset of the study.

In short, this means that overarching and initial question posed for this study [especially by the Industry Collaborator] was; ‘What use is it at all’, and that the method of evaluating the benefits of the Innovation Map changed over time, as these uses were discovered and exploited. However, ultimately, there were four general questions of interest to the Industry Collaborator, in which the use of Process Map was investigated and evaluated by this author, which were relevant to the initial aims stated in the Hypothesis at the outset of this Dissertation ie. in order to explore to what extent the Innovation Map would be a cheap[er], simple[er] and [more] elegant solution for systematising innovation than other Tools on the market:

The first was the direct cost–benefit analysis of technical solutions attained, discussion of which is the object of section 6.2.0. This is perhaps the most obvious question that any Industry Collaborator asks and that a new Tool or Process must be able to answer well ie. Can the
Innovation Map provide solutions we would not otherwise get, and if so how many, and are they really worth something?

The second was a consideration of the additional benefits the Company accrues beyond technical solutions, which may or may not be easily valued in Euros. For example, while man–hours and professional development also have associated direct costs and opportunity costs, these are not easily quantified against the non–tangible and non–quantifiable increases in employee morale, information flow and solution quality, and this will be discussed in section 6.3.0.

The third was by comparison with solutions that could have been generated with other Thinking Tools eg. TRIZ in the same time or with the same effort. The results of this comparison affect not only the Company in which the research was carried out, but also academia and wider society. These were already addressed in section 4.3.2 and will be further discussed in sections 6.3.0 and 6.4.0.

Finally, there are wider applications and benefits from using the Innovation Map [eg. on the innovation culture], that could not have been generated or catalysed with other Thinking Tools, which will be discussed in sections 6.5.0 and 6.6.0.

6.1.2 The Method of Testing, Extending and Evolving the Innovation Process Map

The format of testing ie. technique of presenting or using the Map evolved over the four periods of study and was eventually standardised in the following five main modes [although they themselves, in turn, evolved], described as training, coaching, workshops, Games and GameDays:

Systematic Innovation Training – These were two–day sessions with up to 15 participants, presenting all the classic TRIZ Tools in the order of the three stages of the Innovation Process Map [as pre–determined by this author according to their function], as well as presenting The PRIZM Game as a Tool in its own right as a simplified TRIZ Contradiction Matrix [as Chapters 4 and 5 have previously clarified]. In 2007–8, training was not standardised –rather participants in each training worked on a different live problem from their daily work in order to learn each Tool and the Game [ie. the training was done in workshop–style]. This means that initial expectations were very high – in terms of a learning outcome, participants were expected to have learnt how to use all the 10 TRIZ Tools presented, by the completion of training on day two. In terms of a technical outcome, significant, potentially implementable results were expected on the live Design issues from all trainings, which participants could take back and use in their daily work – they were indeed achieved and are illustrated in Table 6.1. However it seemed that participants were not able to learn [and remember] the details of how to use the various Tools at the same time as they were solving problems with them.

A significant extension of the TRIZ Matrix was also invented and taught in these sessions, based on the PRIZM question format – as illustrated in the TRIZ plus PRIZM Excel Table in Appendix 4.0. This extension uses ‘Word Excel’ software to capture the decision–making process of participants in problem–finding and problem–solving during application of the TRIZ Contradiction Matrix taught with the short–cut of the natural language in the PRIZM Innovation Map. It enables all team decisions to be captured and re–used after the training, in terms of: [i] all potential problems ie. contradictions proposed with the Design issue in question [ii] the actual contradiction which was decided to address [iii] all inventive principles found which solved the contradiction [iv] all solutions proposed that were brainstormed from the principles found [v] all solutions that were judged ‘new’ to the international industry, as far as the expert participant/s was aware [vi] all solutions that were judged ‘useful’ to the Company and might therefore be implemented in the large products, as far as the expert participant/s was aware [vii] all solutions that might be patented. These results are also reflected in Table 6.1 and 6.2, and had the potential to significantly contribute to the Company output.

Since it was a very high expectation to levy on participants, that they should address and indeed solve a difficult Engineering Design issue, which would by all accounts usually take years to solve [see below], and which was unknown to all–but–one of the group at the outset, at the same time as they should learn 10 new and reasonably complex TRIZ Tools, in 2009–2010, the format of training was standardised, so that participants no longer addressed a live problem, during the Tool learning process. Rather, the issue of ‘Improving Entertainment’ was used as the single example whereby all Tools were illustrated and all exercises in the training carried out. The
change of focus from workshop-style training to a more standard ‘Tools–only’ training, which presented the TRIZ Tools in the order of steps in the Innovation Process Map [see Tables 2.3a & b and 5.1a & b], simplified the experience for participants, and feedback, which was always collected after each training, reflected an increased satisfaction in experience and self-assessed learning outcomes. This change in format was also accompanied by reducing the participant and management expectation of the learning outcomes from the outset – participants were expected to ‘take home’ only one ‘favourite’ Tool from the workshop and apply it in their daily work after the training was complete.

Systematic Innovation Coaching – A seven–week process with 5 to 15 participants, going through one step of the Innovation Process Map, together with the relevant TRIZ Tools, in a one–hour session once per week. This was intended to be a ‘learning–by–doing’ approach [Bernard, 2008], although in almost every session, the technical outcome, rather than the learning outcome, was unduly emphasized by participants. Further, while there were early successes, this format proved difficult to implement, due to difficulty in coordinating participant schedules, and few seven–week sessions were commissioned after 2007. Coaching continued in the form of one–hour sessions, using one Tool at a time, at the discretion of the facilitator [ie. this author].

The PRIZM Game – as described fully in the previous Chapter, this is a 90–minute process using the Innovation Map and Inspiration Cards together, run as a workshop on live, often deadline–critical Design issues. In addition, the session usually runs with an additional hour introduction and problem–definition phase, prior to beginning the Game. An hour is also added at the end, for teams to present their results to each other, and discuss and agree on further actions to be taken [so the total time for this workshop is 3.5 hours]. In the Collaborating Industry, sessions have been run with between 7 to 18 participants, divided into teams of 3, 4 or 5 people competing against each other, on the same topic or ‘Quest’. The competition inside a team facilitates the multiplication of new, useful and powerful technical and workflow solutions, since each team works on a variation of the same original issue. There is no intended learning outcome, only an intended technical outcome. However there is an improved understanding of the innovation process and the Systematic Innovation Tools, due to a so–called ‘learning–by–doing’ effect in applying the Game [Bernard, 2008].

PRIZM GameDay – this is a one–day workshop on live, often deadline–critical Design issues. Up to 15 participants take part at one time in the Collaborating Industry [though bigger sessions are run for youth elsewhere]. The PRIZM Game, ie. the 90–minute process using the Innovation Map and Inspiration Cards together, is played twice in a day, with front– and back–end, plus a lunch break between. In this case, the same problem–statement is addressed in both Games, albeit in two variations on the theme; generally the first pass of using the Game yields the deeper issues of the problem to be faced and the second pass of using the Game provides immediately implementable and internationally competitive solutions. It has never failed that hundred of ideas are generated in each team and approximately 10% of these are always completely new and potentially useful for Engineering Design.

Workshops – a two–day workshop with 8 to 30 participants, on live, often deadline–critical Design issues. The format of these was highly varied in each case, including different combinations of TRIZ Tools and PRIZM Inspiration Cards, the PRIZM Innovation Map, the PRIZM Game or GameDay format. In every case, they were set up as multidisciplinary events, involving participants from every possible country site and department that could contribute to the Design issues in question. In the case of one department, a series of 10 workshops was commissioned, which were intended as a learning–by–doing approach to the Tools applied, as well as providing a technical outcome. While these sessions generally started with this author’s suggestion that participants apply Tools in the order of steps determined by the Innovation Process Map, the depth of the problem and the unfolding of the solution could not be predicted and often the steps of the innovation process were not completed, before participants had either [i] run out of time [ii] found a solution or [iii] were happy with extent to which the original problem had been unravelled and further actions could be taken to come closer to a solution on returning to their daily work [where the problem was ‘in situ’], after the workshop.

In the case of the department workshop series and all other workshops outside this department, contradictions were never captured for re–use in the way that they were captured in the training – there is no Excel Table which documents the intensity of problem–finding nor the extent of the problem left behind. However all new, potentially useful and internationally competitive solutions
are always captured. In addition, all actions to be taken to research the proposed solutions were always captured and prioritised, and are counted on Table 6.1, 6.2 and 6.3 as providing benefits or outcomes in themselves, since they saved time from daily work on the issue addressed.

Demand from teams to use The PRIZM Game as a Tool for workshops, rather than TRIZ Tools, and indeed without TRIZ at all, increased over the years. This is presumably due to Systematic Innovation training participants being initially impressed with the Tool presented there and requesting it for their workshop and/or then passing on word of mouth information to others. In short, later demand seems to be due to the word-of-mouth success of the initial workshops.

The ‘Happy Meter’ was invented for these workshops, to [i] be certain of what participants actually expected to experience or resolve, and [ii] measure whether those expectations were met. This measure was thus a two-pronged and variable one – each participant expressed their own individual expectation of the workshop contents or outcome at its begin, and compared it with their opinion of how closely these expectations were met at the end. The expectations expressed by all team members generally are variations or combinations of the following two themes; [i] being exposed to a new Tool or way to improve their capacity for innovation, [ii] solving the technical issue at hand. The percentage figure listed in the Tables in the next section indicates to what extent their [variable] expectations were fulfilled.

6.2.0 MATERIAL AND TECHNICAL RESULTS

The results of using the Innovation Process Map to teach innovation on its own, or to structure workshops with TRIZ tools, which are known, calculable and/or have been verified are outlined in the Tables and Case Studies below.

6.2.1 Key Results Table for 2007

Table 6.1, at the end of this Chapter, shows the raw results of some key training, coaching and workshop sessions undertaken in 2007 [in the formats explained in section 6.1.2 above]. The columns reflect the columns of the ‘TRIZ plus PRIZM Excel Table [example in Appendix 4.0], which was invented by this author, based on the simplification of the TRIZ Matrix in the Innovation Map, and taught in the Systematic Innovation training. The key results of interest to the Industry Collaborator and indeed this author [and shown in Table 6.1] were:

I. Participant numbers

II. all potential problems identified by participants i.e. all potential contradictions proposed for the live Design issue in question

III. the actual problems or contradictions which Engineers finally decided to address [of the tens of hundred generated in the previous step]

IV. all inventive principles found, which solved the contradiction

V. all solutions that were brainstormed in response to the principles from the previous step – these being the total of ideas which participants felt might address the problem

VI. all solutions that were judged ‘new’ to the international industry, as far as the expert participants were aware i.e. the new ideas that were a subset of the above

VII. all solutions that were judged ‘useful’ to the Engineering Company and might therefore be implemented in the products, as far as the expert participants were aware i.e. as a subset of the total ideas

VIII. all solutions that might be patented, as far as the expert participants were aware.

All the above results had the potential to significantly contribute to the Engineering Company output – over and above the existing process of generating solutions for Design in daily work. The calculated cost significance is reported in section 6.2.5 below.

Please note that the workshop sessions on ‘Control’ [i.e. listed in Table 6.1] were carried out mainly with the Innovation Process Map and PRIZM Game [rather than with TRIZ Tools] and hence the Map and Game were responsible for generating the solutions. This particular workshop was a particular success, which is not calculable in section 6.2.5. It resulted in several models for a new configuration for one of the most significant products for the Collaborator, which was in
early Design phase at that time. Research on the configurations continued after this workshop, so that Engineers could determine which of the 18 patents and nine potential business solutions proposed during the workshop would bring the most benefit. The ultimate Design based on this initial work with the Innovation Map was finalised 2.5 years following the workshop facilitated by this author with the Innovation Map and PRIZM Game. An official media release from the Engineering Company has just been made to the European Press [October 2010], claiming that the design [ie. which was decided upon in the PRIZM Game workshop] is revolutionary in terms of eco-friendliness and customer comfort.

6.2.2 Key Results Table for 2008

Table 6.2, at the end of this Chapter, shows the raw results of the key training, coaching and workshop sessions undertaken in 2008. The format of all sessions is explained in section 6.1.2. The eight columns depicted in the Table represent the key results of interest to the Industry Collaborator and indeed this author, in the same manner as explained in the eight bullet points of section 6.2.1.

There is one small aberration in this Table compared with the previous year: three of the sessions [marked by ‘+’ in the Table] were delivered by another subcontractor, who was employed and trained by this author through the PRIZM Game Company, rather than by this author herself. The results for those sessions are also included here, to show that it is delivery of the PRIZM Game and use of the Innovation Map that is relevant to the fast-track of teaching of TRIZ, and not the trainer.

In the bottom half of the Table, some of the series of 10 workshops commissioned for the Flight Physics department are represented, one of which is described more fully in the case study below.

Most of the workshop delivered in this year included both TRIZ Tools and PRIZM, however workshops for Cabin increasingly demanded use of the PRIZM Game only [marked by ‘*’ in the Table].

Please note that the extreme right hand side of Table 6.2 now includes: figures on the actions to be taken as a result of solutions generated in the workshop, and: % happiness of participants measured in the Happy Meter [which was not populated in Table 6.1 for the previous year], as explained under the heading 'workshops', in section 6.1.2.

Please also note that many workshops were not actually carried out on technical issues, but on issues related to workflow. The Workflow Issue Feb 08 and Nov 08 workshops on site D shown in Table 6.2, for instance, required a re-organization of the process whereby mathematical calculations were moved from one department to the next, for the six or so departments involved. Two workshops were done on this issue, clarifying the workflow and resulting in a time saving of ‘one day per loop’ for 7 people at one point, and ‘10 days per loop’ for 7 people in another instance; the total would translate into a 630,000 Euro cost benefit, were it actualized. Similar issues were solved for the Calculation Workshops on sites A1 and B2, both in Nov 08, one of which is further discussed below.

6.2.3 Key Results Table for 2009–10

Table 6.3, at the end of this Chapter, shows the raw results of key training, coaching and workshop sessions carried out in 2009–10. The format of each session is explained in section 6.1.2. The eight columns depicted in the Table represent the key results of interest to the Industry Collaborator and indeed this author, in the same manner as explained in the eight bullet points of section 6.2.1.

Most of the workshops delivered in this year demanded use of the PRIZM Game only [as marked ‘*’ in the Table], or the use of the Game in the GameDay format. The right hand side of the Table includes: figures on the actions to be taken as a result of solutions generated in the workshop, and; % happiness of participants measured in the Happy Meter, as explained under the heading 'workshops' in section 6.2.1 above.

The Small Product workshop Oct 10 on site B1 is described more fully as a Case Study below.
Please note that the workshop on the Small Product Sept 09 on Site B1 involved not only participants from the Industry Collaborator, but also invited guests from Universities and sub-contracting technical companies who were already involved in that Design issue. It is a general feature of PRIZM-based workshops, that multidisciplinary teams are able to act together by using the common language of the Innovation Process Map to understand each other more easily and find the common ground around the problem-definition, which leads, in turn, to outstanding results in very short time frames.

6.2.4 Case Studies, as Examples of Material and Technical Results

Calculation Workshop [November 2008], Site A1

The last in a series of departmental ‘learning–by–doing’ workshops was organized at short notice, due to new requirements that participants had just received from Top Management in the Engineering Company. They had been asked to shave 18 months from their process of calculating data flow on one component of a large product, in order that a decision on the Design for the component could be made by the end of the year. There were three possible shapes for the component at this point, and they were supposed to definitely answer ‘which is the worst’ [ie. they would be required to eliminate the option most likely to fail and keep considering the other two options for the Design to ‘Prototype stage’]. On the day of the workshop, six weeks remained to make that deadline.

The crux of the issue was that the large product in question was only at the ‘Concept Design stage’, so no physical tests on data flow were possible. And for each proposed shape change of the large product, new mathematical models had to be invented for the process and then millions of calculations had to be redone [at a cost of millions of Euros], to determine the stress on each part of it. All the members of the team entered the workshop in a state of some shock. Because there was little or no representative information on how to produce data of sufficient quality to make the decision that would allow the ‘Specific Design stage’ to start, many assumptions had to be made for each shape change that was made in the large product. No one agreed where they might start to make the changes required to reduce the calculations that had, in every other case in their experience, been absolutely necessary to meet safety requirements. They feared it would be impossible to reduce the required work time.

For this workshop, this author started with the TRIZ 9–boxes Tool and asked participants to do a pictorial System Analysis, to tease out what they had to work with. These exercises took all morning and then in the afternoon the PRIZM Game was run. Participants were unresponsive and some were outright hostile through this process, since it seemed to them that this author did not fully grasp the seriousness of the issue. The situation in their mind was already hopeless. The whole day was spent trying to find a good starting point for the issue, which is actually not unusual in the problem–finding stage of innovation and thus this author did not believe the issue was indeed unsolvable. And, while the team ‘circled’ at least three possible points or ideas at the conclusion of each exercise that could be ‘plugged into’ the next Tools to refine their questions and to refine the direction they might look for solutions [this author’s usual way of working], everyone left the day despondent.

At the beginning of day two, this author re–used only the ‘circled’ data from day one, which had proved most promising to find the direction in which participants could look next to address their issue. Also, this author asked them to create in a process map showing which data should follow which [due to their being overwhelmed by all the data, which had just now been sifted out in this workshop, they had not previously created a map for this calculation process]. The entire dataflow was captured and timing for inputs–outputs was identified for the first time. At the conclusion of this step, a few more points were contributed by individuals responsible for specific calculations in the matrices, but which had been unknown to the bigger team. Yet there was still no glaringly obvious starting point for calculation and their mood did not improve so it was becoming apparent to this author the enormity of what Top Management had asked them to do. By lunchtime, this author took the Team Leader aside, admitting she now agreed the result might not be possible to achieve, and asked if the workshop should be cut short and report to Top Management that the issue was unsolvable.
The Team Leader on the other hand, had not had unrealistic expectations of the workshop from the outset. His ideal outcome was only ‘... to identify the process which could achieve a result including the factor for global stress, or at minimum to identify actions which would progress to process modifications [not necessarily to achieve the result itself]’. He was happy that his team were being pushed beyond their comfort zone. He was also happy with the progress being made during the 1.5 days of the workshop thus far; the comments contributed and data unearthed. In particular, he had liked the Game and wondered if it could be done again, without going through the whole seven steps. It was therefore decided to skip the step of creating a set of specific contradictions and use the Inspiration Cards on their own, starting from only the vague set of problems identified from previous exercises.

On reconvening in the afternoon, the team was prodded one last time, and given encouragement ‘to go a little crazy’ during the solution-finding session. The starting point for this exercise relied on the points identified in previous exercises, even though these seemed inadequate to the team. And while the issue was now deliberately presented to the Team as ‘indeed potentially unsolvable’, at the same time the Team were also asked to pretend it was solvable –ie. they were expected to act ‘as if’ and ask what if?’ The 12 people in the workshop were split into smaller teams, each with a set of Inspiration Cards, that they should fill with post-it notes full of ideas. After one hour, results would be shared and a final conclusion for the workshop drawn.

In direct contrast to the earlier situation, participants now found 21 new ideas which could potentially achieve the results they wanted. Of these, 12 seemed ‘really promising’, and three were so good, they could be acted on immediately. In total, 12 actions were agreed to carry out the necessary research to achieve the goal. Thus the answers had indeed been in front of them all along, and it seemed the period of discomfort sifting through the status quo of all the conflicting information was necessary, in order for this to become apparent. When some team members asked this author, why it had not been possible to achieve this result, without needing to go through the anguish of the previous 1.5 days, this author pointed out that it would have been possible, if they had been able to identify the contradictions for the final [Inspiration Card] exercise, as the starting point, at the outset of the first morning. The fact was, that they had not been able to provide this starting point when asked to provide it on the first day, without indeed going through all previous exercises. All exercises had been necessary in this case, in order to produce 17 vague problem statements to which a solution could be generated. At the conclusion of the workshop, the team leader judged his aims had been ‘achieved 110%’. The success was confirmed six months later; the team had indeed managed to reduce their own calculation time by 15 months, achieving a lead-time saving which would lead to the earlier product delivery that had been demanded by Top Management.

System Issue [January 2009], Site B2

The last of a series of Innovation Workshops for another department was organized at short notice, when one of the team attended a Systematic Innovation training and was impressed by the PRIZM Game. He asked this author to do a workshop with his team of 4 people. Their task was to integrate all exterior and interior supporting systems and components for a new multi-billion Euro large-scale product development – this contribution would save multi-millions on each sale in both manufacturing and running costs. They still had enough time to make their deadline in a year, and they had some ideas on how to do it, however they wanted to dramatically improve their present understanding of the situation and thus the quality of the potential solutions they would generate. Because they had been working on the issue for some months already, they had a good understanding of the status quo as a team, and the starting point for the workshop was agreed over the phone. It was intended to run one problem through the Game in two variations –ie using the GameDay format to get depth on each part of the issue.

On the day of the workshop, the situation had changed. Now there were 17 people crowded in the room, since the original team had gathered all their possibly relevant cohort from other parts of the company together, so that they would have the best chance to create something new and useful for the incredibly ambitious multidisciplinary task, without having to explain or ‘sell’ the results to others who had not been present afterwards. In addition, they had decided to do four variations on the Design theme, not two.
This development meant this author was completely unprepared. She had brought only one Game to the workshop, and its Innovation Map is just big enough to fit 5 people around it. This meant changes needed to be made to the usual process for using the Innovation Map as a Game—it needed to be split up and done virtually i.e. most of the work needed to be done on Flipcharts rather than on the Map. Furthermore, the starting points for the two new topics were not well-defined, which meant that extra time needed to be spent prior to starting, to make sure that everyone in the team agreed on the status quo, since it is impossible to get good results from the process, if the input is fuzzy. It is no small feat to get a proper problem-description for one complex topic, which has previously not been described in any simple terms, let alone four, but using the 9-Boxes [of space and time] it was possible, and the second part of the workshop began with four distinct and succinct problem-descriptions on the Concept Design they wanted to test and improve: variations 1A, 1B, 2A and 2B. In other words, they had defined four Quests, which meant that only one Game could be applied to each Quest, in order to finish in two days.

Due to being unable to use the Innovation Map in its usual Game format, the focus of the workshop was much more on the innovation process itself. The group was divided into three large teams for each issue to be solved, so that the Inspiration Cards could also be cleanly divided at the idea-generation step; one team would address only the material issues in the overall problem, the second team would look at the function issues and the third team would address the environmental issues. While the data were perhaps not captured as cleanly on the Flipcharts as they would have been on the PRIZM Innovation Map, at least they were not lost and the process could be carried through as it should. In spite of the logistical difficulties, the team were engaged throughout the day.

At the end of the day, after sifting through the hundreds of ideas that invariably are generated by each team in the idea-generation phase of the PRIZM process, the exercise had yielded a total of 16 completely new, useful and internationally competitive technical solutions, which they had not been able to create in the previous six months of brainstorming as a team. Most importantly, these were not simple ideas on individual Design features, but indeed integrated Design features—after all, their task was to integrate huge systems in a way that all of them could be built into the new development at once, rather than as individual systems. The Happy Meter of the team leaders was 100% and almost all participants asked if they could use the PRIZM Game by themselves in future work on the issue, to continue the growth spurt they had just started.

Small Product [October 2010] Site B1

The most recent workshop carried out for the Collaborator was commissioned by a previous participant in a Systematic Innovation training, who was impressed by the PRIZM Game. He asked this author to do a series of 4 workshops for his department. The first one of these was arranged to show a ‘quick win’ on two supposedly simple but very longstanding problems that had not been addressed in the Engineering Industry for 20 years.

It was agreed that for both cases, the process would be run in a GameDay format, going into depth on the issues, since the invited team would be multidisciplinary and not all of them would be familiar with the problem. The GameDay format would allow each participant to become comfortable with the nuances of each issue and make a real contribution to the solution. In all, 7 participants signed up for the workshop, which was voluntary and not deadline-critical. Thus, they were relaxed even while they were not convinced that anything could really be done to solve the issue, which had been annoying for so long. Nor were they convinced in particular, that a Game would be the Tool that could help them solve it.

The first issue involved small connecting wires of large-scale electrical systems with a set of related problems, including cleaning, moving and varnishing connections. There are untold numbers of connections throughout the system, since they are a safety requirement and are fitted at regular intervals on all cables. When something affects the connecting wire, this is not an immediate and large concern, but a Query has to be raised and addressed during routine maintenance. Each Query costs an average 10,000 Euro to address. There are always many Queries on this issue, in each individual set of systems. If a problem is not solved, or it is queried only after the system is installed, then the cost of fixing it is possibly exponentially higher [exact figure unknown by the team], even if it is spread out over regular checks.
The second issue was related to the first, involving a sleeve on the connecting wire. It seemed the thickness of the sleeve changes over time and places different pressure on the internal connection, which in turn changes the electric current connecting the wire with other tubes. Here the problem was also an apparently small one with big knock-on effects, and several solutions had been proposed over the last three years, of which none were satisfactory to the Company. The reason was that there is both an Engineering issue [the cost of redrawing Designs is 500,000 Euro for each new Design in one area] if a solution is proposed that is radically different to the existing Design. And on the other hand, there are safety issues [death of repairmen and failure in use leading to fire or partial system failure] if the Design is not changed.

The workshop ran smoothly and each step of the Innovation Process was addressed in turn, yielding a good starting point ie. problem-definition and ever-increasing understanding of the issue. The points ‘circled’ as most important potential starting points in a particular step were easily plugged into each new step of the process, to gain depth of problem-definition.

At the end of the workshop, the team had defined 18 new ideas to address their issues, of which 11 were judged new, useful and internationally competitive, as well as potentially patentable – the more so because this particular challenge was not just a Company issue but a problem that the whole Engineering Industry had not addressed or improved in 20 years [the team itself had not found answers in three years of brainstorming the issue]. In addition, three ideas were good enough to be built into prototypes to test and potentially implement as the final product in very short order.

6.2.5 Summary of Material and Technical Benefits

As outlined in Chapter 2 [section 2.6.3], the main innovation activities which have been affected in the Company [or could be affected elsewhere] by using the Innovation Map include;

(i) the time taken to learn this Tool in comparison with other Innovation Tools
(ii) the type of learning users feel they have gained in comparison with having no Tools
(iii) the amount of learning retained post–training
(iv) the level or frequency of Tool or knowledge applied post–training
(v) the actual results achieved with learning and post–training Tool implementation, including new, useful, elegant and successful Engineering Designs or business concepts, patents and time savings on Design or manufacturing.

All these activities have a cost associated with them, of man–hours and market–lead–time [i.e. Euros], and a cost which can be saved or made by improving them above the status quo, which can also be estimated or measured in man–hours and market–lead–time [i.e. Euros].

This author considers points [i]– [iv] above to be related to improvement in information and so, even while there are also cost benefits and these can be calculated, they will be treated in section 6.3.0 below.

For point [v], which has a direct bearing on the Engineering materials, the cost benefits are calculated here. This is done in two parts; confirmed and not confirmed, since for reasons outlined in Chapter 2 [section 2.6.3] and 6.2.1, exact numerical values were not confirmed by participants for man–hours or lead–time [i.e. Euros] for most of the cases in which the Innovation Map was applied. The exception are results from the case studies outlined above and in Tables 6.1, 6.2 and 6.3. Thus;

The six direct and confirmed material results from facilitated use of the Innovation Map –on its own, with TRIZ Tools, or with the PRIZM Game, during the first four years of its use in the Industry Collaborator are:

• On Site B1 in Oct 10, the savings made in two days, by finding an appropriate solution without having to unnecessarily redo two technical drawings is 1 million Euro. In addition, the cost conservatively saved by not raising two Queries per system for each of 150 systems sold in a year, is 3 million Euro. Please note the actual number of systems sold in some years can be more than four times that amount. And finally, each patent changing a 20 year old component could be worth more than 1 million Euro per
year to the company, if sold to, or used by a competitor ie. 11 patents could return 11 million Euro/year.

- On Site A1, Nov 08, the lead-time to final Design of a large multi-component product was shortened by 15 months, due to improvement in calculations made over two days work. This led to many months reduction in the lead-time on manufacture and the ability to take the product to market faster. The expected revenue stream from this large product is in the multiple billions over the next five years.

- On Site D, Nov 08, 630,000 Euro workflow time savings were made as a result of the changes to the Workflow Issues, over two workshops [ie. four days].

- On Site C3, Jun 08, a major, multi-billion–Euro contract that hinged largely on a small product, was renewed partly as a result of improvements made during the two-day workshop.

- On Site C3, in Sept, Nov and Dec 07, the position of major components was changed, leading to estimated 15% lower operating costs of a large product, due to improvements made in the Game afternoon and two [two–day] workshops on Control. The official media release made by the Engineering Company on the design, which resulted from this workshop, touted revolutionary eco–friendliness and customer comfort.

- On Site A1 in Sept 06, 2 patents were submitted as a result of the training and project with the Blue Sky Design case study [see 4.3.2]. These patents are estimated to be worth approximately one million Euro to the Company each year ie. total two million Euro/yr.

The three direct but unconfirmed beneficial material results from facilitated use of the Innovation Map – its own, with TRIZ Tools, or with the PRIZM Game, during the first four years of its use in the Industry Collaborator, as indicated in section 2.6.3 [point v of the metrics] are the following:

- The number of best or right innovative problems found, which can be addressed before a competitor thinks about them – and which therefore have a high opportunity value since they indicate a gap in the market that could be successfully exploited [as discussed in 3.3.1] are identified as contradictions. These are tabulated in each training and workshop run in 2007 [summarised in the key results of Tables 6.1], so that they can be re-used at any later date. In 2007, a total of 638 problems were identified, which could be worked on, which had not previously been addressed in the industry. Of these, 213 were considered and led to new and/or useful ideas being proposed on those issues in that year [see next points]. In 2008 and 2009–10, recording of contradictions during training and workshops was less fastidious, since the TRIZ plus PRIZM Excel Table was used less often due to the popularity of the Game format increasing, in which the contradictions were perceived by participants to be less important than the three prototypes that could be outlined by the conclusion of each workshop [although in years to come, the contradictions generated in the Game format will again be counted and captured]. Thus the total number of contradictions tallied in 2008 was 309, of which 122 problems were considered and led to new ideas and/or useful ideas being proposed on those issues in that year [see next points]. And in 2009–10, the total number of problems which were considered in one workshop alone was 36 and led to new ideas and/or useful ideas being proposed on those issues in that year [see next points].

- The total number of ideas generated. The total number of ideas is a good marker of effectiveness in brainstorming, since having more ideas can mean that one also has higher likelihood of finding a ‘good’ idea [according to Industry–specific criteria], this figure also has a high opportunity value to the Company. This opportunity potentially increases exponentially, if the ideas are answers to the right problem that was already previously found [see point above]. As Tables 6.1, 6.2 and 6.3 show, the key sessions generated a total of 375 ideas in 2007, 370 ideas in 2008, and 552 ideas in 2009–10.

- The total number of new ideas. This is important because the innovative value of a product increases dramatically if it is a ‘world–first’. All ideas were therefore also assessed
and graded by Industry experts, as to their likely ‘newness’, according to criteria built into the Innovation Map, which are confirmed by Dew et al., 2010 [see 2.6.3]. Thus every single idea counted as ‘new’ in a PRIZM session was new for the industry as a whole ie. scoring at level 7–9 on the Scoring Table of Dew et al. [ibid]. The total number of such new ideas generated in key sessions in 2007 was 119. The total number of new ideas generated in key sessions in 2008 was 186. The total number of new ideas generated in just four key workshops in 2009–10 was 88. If only half of the new ideas ever became implementable [after further research and prototyping by their creators], and if these very conservatively contributed 10,000 Euro each to the value of the total product Design, then the total contribution made to the Company by new ideas implemented as a result of working with the Innovation Map would be 1.96 million Euro.

- The total number of useful or implementable ideas. The innovative value of a product increases dramatically if it is considered useful, rather than just being a superficial cosmetic improvement. All ideas generated in a PRIZM session were therefore also assessed and graded by Industry experts, as to their likely ‘usefulness’ to the Company, according to criteria built into the Innovation Map and Dew et al. [ibid]. Thus every single idea counted as ‘useful’ in a PRIZM session ranged between levels 4–8 on the Scoring Table of Dew et al. [ibid]. The total number of such useful ideas generated in key sessions in 2007 was 186. The total number of useful ideas generated in key sessions in 2008 was 223. The total number of useful ideas generated in key sessions in 2009–10 in just four sessions was 27. If each idea that was useful was indeed implemented in the various Company products, and each idea conservatively saved or made 25,000 Euro just once [ie. not making additional savings over every year of the original product lifecycle, nor making additional revenue when implemented in other products, both of which are also possible], then the total saved or made from all useful ideas generated by using the Innovation Map in four years is over 10 million Euro.

- The total number of patents. The maximum innovative potential of a new product judged by Dew et al [ibid] is reached when it is patentable. In the four years 2006 to 2010, 41 patents were due to be written up as a result of only six two-day workshops using the Innovation Map. These can be conservatively estimated to be worth approximately 41 million Euro to the Company, when used by or sold to a competitor [at one million Euro each].

6.3.0 INFORMATION AND COORDINATION BENEFITS

The Innovation Process Map and/or the PRIZM Game involving the Innovation Map does three things simultaneously for Engineering Design and product innovation, which no other Thinking Tool has been proven to do. Two of these are relevant to this section – being that it;

- Generates hundreds of solutions per half hour, which are intrinsically matched to only nine variations of the original right problem being addressed. Thus even without a direct cost analysis and even before the final technical solution is achieved, working with the Innovation Map produces superior results in terms of ‘more focussed ideas’.
- Enables evaluation of the ideas to prototype or business case stage, such that an average of 10% of ideas generated are usually judged ‘internationally competitive’ and ‘immediately useful’ in terms of patents or implementable product solutions, when the session ends. Thus, even without a direct cost analysis and even before the final technical solution is achieved, working with the Innovation Map produces superior results in terms of a ‘better quality of ideas’.

6.3.1 PRIZM vs. brainstorming

These benefits can be most easily assessed in terms of comparisons with brainstorming and mindmapping, since, as discovered in the survey of Chapter 2 [see 2.5.0], Engineers are most likely to use brainstorming and mindmapping as their Tools of choice for idea–generation in team meetings around a Design issue in daily work. As a result, they generally operate on problems at the ‘back–end’ of innovation [ie. also the back end of the Innovation Map], completely ignoring the steps of problem–identification which make up the ‘front–end’ defined
In this Dissertation [Chapters 4 and 5] and FEI [2007], and have no rigorous way of matching problems with answers.

In each workshop, this author asked these two general questions at the outset of each workshop, to assess this potential benefit [and the results were captured on ‘voting notes’ from each participant]; ‘How long has the issue-at-stake been an issue?’ and ‘What Tools have you used to address it?’.

In the case of every single workshop carried out with PRIZM [ie. including a series of 10 departmental ‘learning-by-doing’ workshops, a series of four departmental Innovation Workshops and all other miscellaneous workshops run over four years], the individuals who participate admit to have been working on their Design issue for many months prior to the workshop. This is also true for all Design issues addressed in the Systematic Innovation training in 2007. In many cases, a team had been working on their Design issue, while not always exclusively, at least as part of a greater whole, for a period in excess of three years. In fact, some of the workshops this author ran were commissioned for the very reason that teams saw PRIZM as a ‘last resort’, which could be implemented at short notice, prior to a looming deadline on Design.

To be clear, the intelligence of Engineers does not change when they walk in the door of the PRIZM workshop. And yet, where three years of brainstorming and mindmapping has generally failed to yield any useful result on a given issue, two days of using the PRIZM Game or Innovation Map, with or without the application of TRIZ Tools as an added bonus, invariably yields high-class results that Designers never expected and could not, in their own words, have imagined achieving with their current modus operandi [some of which were summarised in the Tables and Case Studies above]. This means that PRIZM provides a very stark benchmark against the most popular Innovation Tools.

In addition, the benefits of using the Innovation Map or PRIZM Game can be assessed in terms of comparison with TRIZ as succeeding sections will show.

6.3.2 Simplified Basic TRIZ Training

The summary of benefits which were achieved in the Company [and which can presumably continue to be achieved] by using the PRIZM Innovation Map to explain and coordinate basic TRIZ training is that participants;

1. Learn all basic TRIZ Tools thoroughly and more quickly in the wider innovation context provided by the Map, than learning TRIZ Tools alone. In particular, the time spent training the Contradiction Matrix is greatly reduced. Using the Innovation Map to teach the Contradiction Matrix, it is generally understood in 30 minutes rather than five hours. This is 10 times faster than benchmarked European competitors using other methods of delivery [and even on this short timescale, can be said to have saved the Company 90 minutes per 1000 participants costed at 75 Euro per man–hour ie. saving 112,500 Euro].

2. Can apply one or more TRIZ Tools on their own after training. In particular, when the TRIZ Tools are presented in the context of the PRIZM Innovation Map, 100% of participants are able and willing to use one or more of the Tools presented during and after training. This compares with an industry standard for application of TRIZ Tools by participants post their initial training [as determined in the benchmarking survey of this Dissertation, section 4.3.1] of around 3%. Thus training TRIZ with PRIZM provides markedly higher returns on training time per employee.

3. Can get the same or better results using the Innovation Map and PRIZM Game as using basic TRIZ when facilitated by a recognized TRIZ expert [cf. benchmarked situation of TRIZ taught by other facilitators described in Chapter 4 [4.3.1]. This is the case because most basic TRIZ Tools are implicitly incorporated in the Map in natural language, so that even if TRIZ is not taught or used; participants using the Innovation Map cover the same ground as those using the entire basic TRIZ Toolkit. There are two benefits to this – firstly, in terms of learning, no one worries that something has been missed or not understood, which can happen when people feel uncomfortable not understanding one or more Tools of TRIZ. Thus participants using the Innovation Map feel more confident about their new skills and more willing to test them in their daily work, benefiting company morale as well as producing significant technical results [as discussed in sections above]. Secondly, the technical results achieved by participants using the Innovation Map in the Game format are achieved in less
In short, this research indicates the Innovation Map simplifies and accelerates the learning process for Systematic Innovation in individual sessions, including the problem-definition and problem-solving or creativity phases. The Innovation Map also simplifies and accelerates the actual innovation process. In the hands of an expert facilitator, the Innovation Map also produces equal or higher value output than every other Innovation Tool.

On the basis of this research it can be said that if a metric were to exist, which combined the issues of [i] learning the Tool [ii] applying the Tool without supervision [iii] getting higher value results with the Tool, then the Innovation Map would clearly outperform TRIZ, which has until recently been considered the most powerful Tool available for Engineering invention in the West. Using the Innovation Map to streamline innovation can be said to be akin to learning to drive in a day rather than a month, and arriving at the Ideal Final Result faster.

6.3.3 Enhanced Creativity: Tools on a Map

The Innovation Map can be easily coordinated with TRIZ Tools, as well as with the other commercial creativity and Innovation Tools for Engineering outlined in Table 2.3 [a] and [b]. Figure 6.1 shows where the TRIZ Tools sit, in terms of the seven steps and three stages of the Innovation Map — i.e. in a wider innovation context.

Figure 6.1 TRIZ on a Map. The Tools of TRIZ make more sense when presented in the wider innovation context. They can be used in participants own daily work, post-training, individually and in any order, once the step is identified, at which help is required. From left, column one contains the 9-boxes [of space and time] and System Analysis, columns two and three show how to set up a contradiction, column four shows the [40] Inventive Principles, column six shows S-curves, Trends and the Resource Checklist, column seven shows the Size–time–cost Tool and the Ideal Final Result.

This is the order in which TRIZ Tools are presented to participants in the Systematic Innovation Programme in the Industry Collaborator, and in which experience confirms them to make most sense to participants. The other creativity Tools of Table 2.3 are not shown on this Figure for the simple reason that there are too many to fit. Suffice to say that they would also be overlaid on the seven steps of the Map in the same way as the TRIZ Tools in Figure 6.1.

After the Map is understood on its own to represent its users’ Design process, and once users understand how different Tools fit on the Map, the Map need not be followed in any particular
order. Instead, users are able to identify the step at which they need support in their daily work, and are able to self-select Tools to help themselves, or ask for a facilitator to provide additional support.

6.4.0 MANAGEMENT BENEFITS

The Innovation Map has several applications for managing the inception and sustainability of innovation in a large, multinational Company, which is beyond the scope of this Dissertation to prove or discuss. It is mentioned here only briefly because this Dissertation follows the format of the Innovation Map itself [as introduced in Chapters 1 and 5], and thus it is important to point out that from the outset, the Systematic Innovation Programme set up for the Collaborating Industry was intended to become a Complete System with five benefits, in the same way a solution would emerge as a Complete System [albeit after a potentially challenging or chaotic period of inception], at Step 6 of the Innovation Map. The two main benefits of using the Innovation Map format for enhancing Innovation Management [IM] are presented briefly as follows.

6.4.1 Problem-Capture

As Csikzentmihalyi [1988, 1990, 1997] and Csikzentmihalyi and Getzels [1988] pointed out, and as was discussed in section 3.3.1], the invention that is most likely to become historically significant solves a problem that competitors could not even recognise as being important before it was solved [elsewhere in this Dissertation also called 'the right problem']. One has a greater potential to find that right problem, if one spends time investigating all the potential cause-and-effect relationships of all systems that are related to the apparent problem, and regards each as a potential starting point for innovation. Such investigation is exactly what the Innovation Map leads users to do, and in the case of the TRIZ plus PRIZM Excel Table already mentioned above [and see Appendix 4.0], the investigation is even more thorough – as well as being time efficient. Finally, it is of paramount importance not just to investigate but actually to capture the details of potential problems discussed. If this is not done, the discussion needs to be repeated each time a team wants to return to another part of its original issue, or each time the same problem is addressed in subsequent years, by others who were not part of the original brief. In using the Innovation Map or the TRIZ plus PRIZM Excel Table to define and capture problems in a standard format [see 5.5.0 below], this discussion does not need to be repeated, and problems which were identified but not acted upon [ie. the total contradictions identified in the TRIZ plus PRIZM Excel Table and summarised in the Key Results Tables of section 6.2.0] can be 'data-mined' and addressed by both the original team and others at a later date. This allows technical advances made in the field since the original discussion to inform the newer investigation of the problem and has the added benefit that departments which are not related to the original department can also potentially contribute to, as well as learn from and transfer knowledge from the first domain into their own, thus generating even more innovative behaviour for the Company [ie. the I–Rule in section 1.2.1]. As the Key Results Tables, Case Studies and discussion above indicate [section 6.2.0], the potential to gain a professional competitive advantage achieved by finding the right problem through capturing all problems, is highly increased for the Company, compared with not using these Tools.

6.4.2 Project Planning and Management

Every big company has their own in–house method for navigating through large–scale projects and programmes. The Innovation Map can be readily adapted to enhance and support these programmes. Such an intention was set by the Industry Collaborator, during the Systematic Innovation projects carried out by this author from 2007 onwards. As a result, a preliminary survey of the process maps for project planning and management of different Engineering Design and manufacturing processes has been carried out [the details of which are beyond the scope of this Dissertation]. Sufficient to say that, in order for a sustainable innovation culture to emerge, which would be the Ideal Final Result of implementing Innovation Tools and activities in the Company, that it is necessary to ‘translate’, embed and transform a new process [such as the Innovation Map] into existing processes. Assuming that the Innovation Map is indeed a common language for the creation or Design of any object, such as was indicated by the comparison and synthesis of steps reported in the processes for creating reported in several other disciplines [see section 5.1.1], it is conceivably easy to also compare and synthesize the Innovation Map with the detailed processes of Design in the Industry Collaborator or any other Company.
6.5.0 MULTIDISCIPLINARY BENEFITS

6.5.1 A Common Language for Design

Even without a direct cost analysis and regardless of the final technical solutions achieved, working with the Innovation Map produces three significant and beneficial effects beyond the original team involved, all of which stem from having a common language for innovation or Design in the Company. This is because the common language provided by the Map gives teams a standard, repeatable framework for discussion, like a grammar [see Chapter 5, section 5.2.3], which provides the structure and rules of engagement that are necessary for large-scale communication and at the same time, it allows enough flexibility to be re-used in untold ways, and thus for all individual stories to be told [see also ‘Rule of Innovation’ [#4], section 3.3.1, which requires rules to be broken and kept at the same time]. The biggest benefits of using the Innovation Map are indeed expected when the Map creates a common language not just for a single team, but for the Company as a whole.

Again, it is beyond the scope of this Dissertation to treat this topic in detail. However the three main benefits of having a common language, which occur roughly in the following order, are mentioned for the sake of completeness and can be summed up as enabling:

- transparency and capturing of each phase of problem-definition and idea-generation in Design, so that the right opportunity is found to be addressed and solved, leading to higher quality solutions immediately and in future [see also section 6.4.1 above]
- equality and consensus in discussion and decision-making around the Design in each team. This is important and useful for multidisciplinary teams in particular, and those with language differences, and leads in turn to self-sustaining communication between teams on multiple sites and in multiple countries and improved internal business development [see also section 6.4.2]
- personal joy and boosted company morale, due to having a repeatable, transferrable process to take beyond the team in which the Map is first used, leading to greater confidence in innovative behaviour and a proto-innovation culture [see 6.6.1 below].

6.6.0 CULTURAL AND INDUSTRY-WIDE BENEFITS

6.6.1 Innovation 3.0

Wayne Johnson, Vice President, University Relations Worldwide of the Hewlett-Packard Company believed that productive industry–academic collaborations in strategic ‘knowledge networks’ would define the future of worldwide innovation. It was his definition of ‘Innovation 3.0’ for government, academia, industry [and their consulting community], which suggested that the three should rally around a common purpose, to recreate a post-Sputnik-type success of scientific and technological renaissance in a new, networked world [Johnson, 2007]. He foresaw that leading and sustaining innovation required a kind of ecosystem platform, from which to steer investment and manage complexity, while solving problems at the right strategic levels.

For an ecosystem to evolve, one can imagine it is seeded using a simple, repeatable process whose effects are different at different scales or in different contexts of application, but whose DNA remains simple and the same [eg. so that a seed always becomes a plant, but an acorn grows into an oak tree while a vine shoot grows up a vine], regardless of context. An ecosystem must exist simultaneously on several levels [eg. as seed, tree and forest], using biofeedback to adjust to threats and symbiotic rather than parasitic relationships to evolve. Thus an ecosystem works through bottom-up, sustainable growth, allowing all parts to join at their own speed, in their own way, by inspiration and adaptation rather than force.

This is, as introduced in Chapter 3 [3.5.2] what Buddhist Technologies and the Map were designed to do. And it is, indeed, what the Innovation Map does when it provides the frame for an Innovation Deployment Programme. The Map can be seeded as Game, Tool, project, process,
programme, knowledge-capturing and social networking event, on timescales ranging from two hours to two years, which allows different entry levels. Each of these delivery modes is based on the same grammar; the seven-step, three-stage model that appears to be the natural process and common language or DNA of human innovation. At all levels, it emerges and is sustained by encouraging exchange and dissemination of information and joy through verbal feedback in interactive, multidisciplinary and open teamwork and knowledge networks, allowing all participants to join at their own speed [which is all the more true in the Industry Collaborator, as a result of not having Top–Management support]. In this sense the Innovation Map is not just a map but a kind of glue that can hold all required parts of an innovation ecosystem together, and which may currently be the only concept that spans Innovation 1.0, and 2.0 as well as the leading edge of Innovation 3.0 [and see also 3.5.2].

It is important to contemplate [albeit only briefly in this Dissertation], whether it is possible to establish culture without a fractal map and common language to guide evolution. In this author’s opinion, it is not ... a culture cannot be merely transplanted from one petri dish to another. For, while it makes sense, where innovation is a guiding value in one company’s inception and growth, to expect ecosystem–like elements to exist in their innovation culture, it makes no sense to expect this in other organizations where innovation was not a core value at their inception. ... consistent effort should be expected in making pervasive cultural change around this issue. In the same way, it does not make sense that exemplary innovative success can be achieved by merely transplanting overt symbols of an innovation culture from one company into another – and there are currently no industry or academic success stories that indicate it can be done. So while Google Inc. and other new technology firms are as famous among Innovation Consultants for allowing employees to rollerblade indoors, as for their respective products, it should not be expected that when a completely different and long-established organization suddenly encourages employees to rollerblade down the halls or play with toys, that it will grow an innovation culture that has deep roots or produces real fruit.

It is a premise of this Dissertation that it is easiest to seed a new [innovation] culture in, or let it emerge from, an old existing culture, when a fractal and self–evident pattern is used as the seed. In other words, this author assumes that matching the underlying pattern and common language of creation of all human beings with existing Engineering systems and processes is the easiest way to help Engineers do what they already do, better and faster. Thus while this author’s work with the Industry Collaborator is ongoing, it is assumed that using the Innovation Map as the framework for an Innovation Deployment Programme will eventually lead to the emergent, self–sustaining Ideal Final Result that Innovation Managers and Industry itself are striving for. Suffice to say that, as heralded by Johnson [ibid] and also by Rae [2006], Hafkesbrink and Schroll [2010] and Hafkesbrink and Evers [2010], a Systematic Innovation Programme based on the Innovation Map is intended to provide a self–sustaining ecosystem involving academic insights and entre– or intra–preneurial testing to set international government–level standards, in a way that does not require constant fertilization from external sources [at extra cost] but which produces consistent high quality results, regardless of the context in which it finds purchase and co–evolves with its participants into a true and unique innovation culture wherever it is embedded.

6.7.0 SUMMARY OF THREATS TO THE VALIDITY OF RESULTS

While every attempt has been made to accurately calculate the cost–benefits and indirect benefits of using the PRIZM Game and Innovation Map, readers should please note however, that the results achieved in workshops could not always be verified as having a definitive cost–benefit or return–on–investment [ROI], for several complex reasons:

First, Engineers were not asked in advance of their workshop to estimate the benefit that having a solution would bring [with the exception of the most recent phase of work in 2010], and when they were asked, they rarely volunteered the information willingly.

Second, where results were indeed outstanding and recognized as such at the conclusion of a workshop, either by the participants themselves, or by the supervisor [ie. generally the Team Leader or Line Manager] who had commissioned the workshop, supervisors of that team were reticent to jeopardize their Department by reporting the results: they feared that Financial Controllers or incompletely-informed-individuals-in-positions-of-power could suggest the newly–achieved results implied work was previously incorrectly done and/or that less people or
time might be required to address similar problems in future, which may not necessarily be the case [Bernard, 2008].

In addition, as has been previously suggested in section 4.3.2, the comparison of standard TRIZ training by other Subcontractors in direct competition with 'TRIZ plus PRIZM' training carried out by this author, also presents as many questions as it answers.

For instance; if all TRIZ trainers are like the Subcontractor employed in the pilot test, then all of them would encounter similar difficulties in modularising their extensive TRIZ teaching – thus the use of the PRIZM Innovation Map to modularize TRIZ can be definitively said to be the only defining factor in the success of the TRIZ plus PRIZM training, over the success of TRIZ alone. [Though it is conversely of note that in the time this author has been presenting her work at international TRIZ conferences, promoting the modularisation and simplification of TRIZ, other European consultants have also started talking about teaching ‘Tools’ of TRIZ ie. in a modularized way, rather than teaching the ‘Theory’ ie. in a non-modularised way].

However if this is not the case ie. if the success of using the Innovation Map to teach TRIZ [over and above the success of using ad hoc theory to teach TRIZ] is not due to the accompanying modularisation and simplification of TRIZ theory, then the only other explanation for the success of these trainings, workshops, games and GameDays is that some human factor plays a large part.

Of the potential human factors that may influence the success, or the interpretation of success of training or workshops, the presenter's expertise in the subject [of Engineering or of Systematic Innovation] and in presenting, training or coaching is ruled out. The plain fact is the author of this Dissertation [who presented the Innovation Map, Game and ‘TRIZ plus PRIZM’] is not an Engineer, was not an expert in TRIZ and had no experience in training and coaching. The Subcontractors, on the other hand, were Engineers and presented themselves as experts in TRIZ, also with over seven years experience in training. What is more; once it had been presented by this author, the Innovation Map could be, and was often, immediately successfully applied by Engineers with even less experience in TRIZ, systematic innovation, or experience in presenting to, training or coaching others.

There are other human factors, however, that are still pertinent to the success of using the Innovation Map as an addition to TRIZ, to enhance and simplify TRIZ training, and to the success of using the Innovation Map in a Game that replaces TRIZ, and indeed to the development of a Company–wide Innovation programme based on this root. These pertain to what is traditionally seen as Innovation Management, rather than innovation per se, and have been long identified in creativity circles as being intrinsic to success [see section 2.4.1, 2.4.2 and 2.4.3]. Without these factors, both this author and the Head of Knowledge Management in the Industry Collaborator agreed that short–term participation would be minimised and long–term sustainable uptake of the Innovation Map would also fail. They are:

- initial engagement of participants only on the basis of a real need [discovered through personal contact and interviews prior to taking part in any innovation session]
- promise of delivering direct benefits for the participants, in regards to their needs, in each session – usually through involvement of their daily work
- a continuously high amount of engagement maintained personally with participants throughout the programme of sessions [by the facilitator / this author], to check that their needs and questions were still being met, post–training
- flexibility in delivering the sessions, which was thereby positively perceived by participants as being accessible [even if imperfect] and was thus able to grow with direct user–feedback.
- nurture of the large, longer–term innovation network /programme. by bottom–up growth initiatives and engagement, rather than top–down ones. Were it not to emerge largely as a natural system, it would fail both in terms of individual use and as a culture or ‘movement’ in the Company.
While acknowledging these risks however, it cannot be said that they in any way threaten the validity of the results obtained so far. The measurements of the facilitated use of the Innovation Map and Game in comparison with use of TRIZ and brainstorming are true and fair comparisons – the mitigating factors which might appear to modify the success of the results for the Map apply just as much to TRIZ, where no official industry statistics exist on its use, measurement or successes, as to PRIZM. That is of course, not to say that there are no limitations on the use of the Map, nor that there were no significant improvements and lessons learnt in the course of applying it in this study. Those limitations and lessons are addressed in the next Chapter.

Table 6.1 Results of some key training, coaching and workshop sessions undertaken in 2007. From left to right, the columns indicate: [i] the site of the Industry Collaborator on which the session took place [ii] the kind of session carried out, as explained in section 1.0 above [iii] the number of participants [iii] the number of potential problems/contradictions which were proposed for the Design issue in question, [iv] the number of actual problems/contradictions which were addressed [v] the number of solutions which were proposed [vi] all solutions that were judged ‘new’ to the international industry, by expert participants [vii] all solutions that were judged ‘useful’ and might therefore be implemented in the products [viii] the number of solutions that might be patented [ix] the number of solutions that could be implemented in the business immediately [x] confirmed costs/time saved or revenue gained [xi] other actions generated for the team to follow up, which contributed to solving the problem [xii] Happy Meter – assessment on how close to the ideal result the participants had come [from zero] in the facilitated session.
Table 6.2 Results of some key training, coaching and workshop sessions undertaken in 2008. From left to right, the columns indicate: [i] the site of the Industry Collaborator on which the session took place [ii] the kind of session carried out, as explained in section 1.0 above [iii] the number of participants [iii] the number of potential problems/contradictions which were proposed for the Design issue in question, [iv] the number of actual problems/contradictions which were addressed [v] the number of solutions which were proposed [vi] all solutions that were judged ‘new’ to the international industry, by expert participants [vii] all solutions that were judged ‘useful’ and might therefore be implemented in the products [viii] the number of solutions that might be patented [ix] the number of solutions that could be implemented in the business immediately [x] confirmed costs/time saved or revenue gained [xi] other actions generated for the team to follow up, which contributed to solving the problem [xii] Happy Meter – assessment on how close to the ideal result the participants had come [from zero] in the facilitated session.

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Table 6.3 Results of some key training, coaching and workshop sessions undertaken in 2009–10. From left to right, the columns indicate: [i] the site of the Industry Collaborator on which the session took place [ii] the kind of session carried out, as explained in section 1.0 above [iii] the number of participants [iii] the number of potential problems/contradictions which were proposed for the Design issue in question, [iv] the number of actual problems/contradictions which were addressed [v] the number of solutions which were proposed [vi] all solutions that were judged ‘new’ to the international industry, by expert participants [vii] all solutions that were judged ‘useful’ and might therefore be implemented in the products [viii] the number of solutions that might be patented [ix] the number of solutions that could be implemented in the business immediately [x] confirmed costs/time saved or revenue gained [xi] other actions generated for the team to follow up, which contributed to solving the problem [xii] Happy Meter – assessment on how close to the ideal result the participants had come [from zero] in the facilitated session.

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*TRIZ plus PRIJV
**PRIJV Game

Happy Meter - assessment on how close to the ideal result the participants had come [from zero] in the facilitated session.
Chapter 7 CONCLUSION: Long-term Benefits for Three Communities

Chapter 7 concludes that the results achieved by using the PRIZM Innovation Map and Game are ‘cheap’ to make and sustain in terms of employee time and direct financial costs. The programme is relatively ‘simple’ for an End-user to grasp and also makes simple improvements to previously complex or misplaced creativity and Innovation Tools, including TRIZ. It provides a simple benchmark for Systematic Innovation. Finally, the experience of using the Innovation Map in the PRIZM Game achieves the kind of excellence or ‘beautiful’ result wished for by Innovation Managers and as intended by the Buddhist method on which it is based. It liberates fixation, enhances personal joy and confidence, elevates the team spirit and communication and makes the discipline of following a structure easy to adhere to; resulting in streamlined results and improved productivity. The Systematic Innovation Programme for bottom-up innovation, which was developed for the one specific Engineering Industry described in this Dissertation, based on the PRIZM Innovation Map, is transferrable to any kind of Engineering project and any level of expertise. In addition, it can be used in other industries and was already successful in preliminary tests in education, banking, advertising, food technology and customer service.

7.1.0 INTRODUCTION AND GENERAL OVERVIEW

This Chapter summarises and concludes that the facilitated use of the PRIZM Innovation Map and Game in the Industry Collaborator fulfil the criteria that make an invention historically significant [according to the exact Rules uncovered in the literature reviews and syntheses in this Dissertation eg. sections 2.6.3, 3.3.1 and 5.2.7] and also fulfil the claim, described in Chapter 1, for this Degree.

That is not to say that there are no limitations on the use of the Map, or that there were no important lessons learnt during the process of applying and improving it – these do exist and are presented in section 7.3.0. What it does mean, however, is that the Tool that is the object of this Dissertation does what the Divine [see 3.2.2, 3.3.1 and 5.2.7] and every product Designer wants to do. It makes significant change in a pre-given world, by allowing users to find a significant problem that no one else has identified, and simultaneously propose a solution – with five levels of application, which are relevant for three different communities.

As been suggested in Chapters 5 and 6, when an Engineer uses the Map, the three communities he can and should take account of, while determining his Design, are; Experts such as other Designers in his company as well as international competitors; Rulekeepers such as Manufacturers, Risk-Analysis, Quality Assurance, Safety and Financial Departments; and the End-Users to whom his product is sold – for example, Product Retailers and their downstream businesses, staff and customers.

On the other hand, when an Innovation Manager uses the Map, three different communities can and should be affected – the outcomes measured in the Engineering Company of this Dissertation are just one aspect of the effect that a new Innovation Map can, and should, have on innovation. For Innovation Managers, Engineers represent the Rulekeepers, not the Experts, while the two additional communities that are important in assessing the potential impact of the Map are: Academic Engineers and TRIZ Consultants who are the immediate, if not End–Users of TRIZ; and Innovation Managers and the wider communities using Innovation Tools. It is the latter who now signify ‘the Experts’ in the field of Innovation, using the ranking criteria of the Innovation Map itself [ie. as explained in section 5.2.7].

The potential benefits for Innovation Managers [rather than Engineers] using the Innovation Map are therefore now set out in this Chapter, in the same way that the Map itself is set out, as a summary of three business cases [including five subsystems each]. In other words, one case is made for each community that can potentially benefit from the research in this Dissertation. These cases are arranged in order, paraphrasing the criteria for innovativeness of Dew et al.
[2010 and see 2.6.3] in the natural language of the Innovation Map [and especially 5.2.7] to summarise the options relevant to the different communities.

In each case, for each of the three communities that can potentially benefit from knowing about the Innovation Map, the use of the Map is considered in respect to five functions. The Map [and Game] is considered as: i. a Tool on its own [which can help produce only Material and Technical benefits]; ii. a context for other Tools [which leads to Information and Coordination benefits]; iii. a context for other Engineering processes [potentially providing Management benefits]; iv. a context for innovation involving other disciplines [Multidisciplinary benefits]; and v. as a seed for wider social innovation [intuitively suggesting there may be Cultural benefits].

In each case, the benefits achieved for a given community have specific nuances, relevant only to that community. Thus, the benefits which may be expected to be thought important by an Engineering Company, who want quick, cost–effective results are those focussing on efficiency or being 'cheap to make and run'. The expected benefits for Academics and TRIZ Consultants are those that make learning easier for students at the same time as [the field of] Innovation becomes simpler to teach, research and understand. And finally, if the Map addresses a significant problem no one knew existed while simultaneously providing a solution no one else saw, it can be beneficial simply by being a more worthy, elegant or ‘beautiful’ manifestation of Innovation Tools [according to the requirements of section 5.2.7], already used by Innovation Managers and the wider community of users of Creativity Tools.

7.2.0 THE THREE COMMUNITIES THAT CAN BENEFIT FROM THIS DISSERTATION

7.2.1 The Case for The Company

i. Material and Technical benefits:

As has been fully described in Chapter 6, the results achieved by the Collaborating Industry during all modes of facilitated use of the Innovation Map [described in 6.1.1] are indeed ‘cheap’ to make and sustain in terms of employee–time and direct financial costs of running an Innovation Map session, compared with the results that were achieved. The results achieved during the course of this study are here summarised in three ways – as ‘confirmed results’, ‘other benefits’ and ROI, as follows.

The confirmed results achieved during facilitated use of the Innovation Map – on its own, with TRIZ Tools, or with the PRIZM Game, in some key two–day sessions in the Industry Collaborator between 2007–10 [see also 6.2.0] include;

- Reducing workflow cycles, leading to time savings [saving 630K Euro]
- Reducing lead–time to a final product design by 15 months, reducing 15 months work time for the entire workforce and shortening the time to an expected revenue stream of multiple billion Euros over the next 5 years.
- Reducing two safety issues per system for each of 150 systems [saving 3 mill Euro/ year].
- Improving a small product that was key in the renewal of a major, multi–billion–Euro contract with another Industry partner
- Improving major components, leading to an estimated 15% lower operating costs for the End–User /Buyer of the large products and making the new, more cost–effective product more attractive to more Buyers in the first place.
- Improving but not redoing two technical drawings [saving 1 mill Euro].
- Submitting 13 patents for small products [returning 13 mill Euro/year].

The total of all above confirmed cost–benefits to the Industry Collaborator, as a direct result of facilitated workshops carried out with the Innovation Map is therefore in the order of 16 million Euros made or saved per year for at least the next 3 years, on small products and safety, plus the potential to receive several billion Euros in client contracts up to 15 months earlier than originally planned.
Other benefits resulting from use of the Innovation Map in some key sessions in the Industry Collaborator between 2007–10 [see also 6.2.0] include:

• A total of 983 innovative problems found, which indicate a potential gap in the market that can now be exploited before a competitor does, and which therefore have a high opportunity value were captured in Excel Tables, to be re-used by any team at any later date.

• A total of 371 problems were considered, which led to a total of 1297 potential solutions to those issues being proposed.

• A total of 393 new ideas were generated, which were assessed as highly significant ie. at levels 7–9 of Dew et al., 2010 Scoring Table [Table 2.4 of this Dissertation] and if half became implementable and contributed 10K Euro each to the value of the total product, then their contribution to the Company would be 1.96 mill Euro.

• A total of 436 useful or implementable ideas were generated, assessed at medium to high significance ie. at levels 4–8 of Dew et al., 2010 Scoring Table [Table 2.4 of this Dissertation] and if each was implemented, saving or returning 25K Euro not inc. additional savings over the product lifecycle, nor additional revenue when implemented in other products, then their contribution would be 10 mill Euro+.

• A total of 41 patents ie. new and useful ideas assessed to have maximum innovative significance according to Dew et al. [2010] Scoring Table [Table 2.4 of this Dissertation], were due to be written up as a result of only six two-day workshops and could contribute 41 mill Euro to the Company.

Based on the above, a calculation can now be made for the potential return on investment for the Company using the Innovation Map in facilitated sessions during the initial phase of research between 2007–10:

• When a team of 15 Engineers spends two days using the Innovation Map, this costs 15 * 8 hours * 2days * 75 Euros/hour = 18,000 Euros. In addition, the day-rate for running a training, coaching, GameDay or other Workshop session in the Engineering Company during the research phase of testing the Innovation Map was costed at a special rate of 1500 Euro/day. Thus in total, the Company spent approximately 21,000 Euro/session.

• The conservative minimum result achieved in any workshop was 10 new and useful ideas, which are competitive in the international industry, and worth a minimum 10,000 Euro each, as described above ie. A facilitated session with the Innovation Map brings a conservative minimum return of 100,000 Euro per session to the Industry Collaborator, if the new ideas are acted upon. In addition, this benefit arises from addressing daily work issues directly in a concentrated [maximum] 2–day period, with no time taken away from daily work – whereas, in contrast, surveys and workshop reports [sections 2.3.0, 2.5.0, 4.3.0, 6.2.0, 6.3.0 and 6.40] prove that Engineers would have otherwise spent a conservative minimum of 3 months brainstorming their original issue to come up with a comparable result to that achieved in the facilitated [2–day] session with the Innovation Map. In other words, the time usually spent on achieving the result costs the company 15 Engineers * 8hours * 60days * 75 Euros/hour = 540,000Euro, so a facilitated session with the Innovation Map also saves a conservative minimum of 519,000 Euro per session in the Industry Collaborator. Please note where teams have spent or would spend 3 years brainstorming around their problem [as was reported by teams in question in several instances], the time saving in using the Innovation Map to address the issue is approximately 1.5 million Euro/yr * 3 = 4.5 million Euro – however this figure is not used in the following calculation.

• Thus the minimum estimated ROI for each session using the Innovation Map is:

  • (Gain – costs) /costs = ([$100,000 Euro in ideas +$519,000 Euro savings in brainstorming time] – 21,000 Euro cost of training time) /21,000 x 100 % = 2847 % the initial investment.
Thus also the minimum estimated total return the Company gained in 2007-10, from implementing facilitated sessions using the Innovation Map 60 times over this period, in comparison with doing nothing or using other Tools inefficiently is: 60 sessions * 619,000 Euro \[\text{ideas created} + \text{time saved}\] = 37.14 million Euro.

ii. Information and Coordination benefits

Sections 2.3.0, 2.5.0, 4.3.2 and all Chapter 6 indicate that use of the Innovation Map in the learning processes simplifies and accelerates understanding of Systematic Innovation and all other Tools for problem-definition, problem-solving or creativity [6.3.2]. As a result of improved understanding [and in addition to an expert facilitator], participants' application of Tools in the context of the Innovation Map also produces equal or higher value output than every other Innovation Tool. If a metric were to exist, which combined the issues of [i] learning the Tool [ii] applying the Tool without supervision [iii] getting higher value results with the Tool, then the Innovation Map would clearly outperform all other Tools, including TRIZ, which has until recently been considered the most powerful Tool available for Engineering invention in the West [6.3.2].

Three direct benefits exist for using the Innovation Map to coordinate the information from other Tools and processes for innovation – ie. in comparison with Tools in general, in comparison with TRIZ in particular and in comparison with Engineering Design processes in general, as summarised following [see also 6.3.0].

In comparison to applying brainstorming, mindmapping or other popular creativity and Innovation Tools to a problem in the Engineering Company, applying the Innovation Map as a Game;

- Produces 'more focussed ideas' than other Tools. This is because it generates hundreds of solutions per half hour, which are intrinsically matched to only nine variations of the one 'right problem' being addressed.
- Produces a 'better quality of ideas'. This is because it enables evaluation of the ideas to prototype or business case stage, such that an average of 10% of ideas generated are judged 'internationally competitive', new and immediately useful as implementable product solutions or patents.

In comparison with learning TRIZ Tools and similar complex problem-solving, creativity and Innovation Tools on their own, [section 6.3.2 indicates] learning TRIZ in the framework of the Innovation Map;

- is quicker. In particular, time spent training the Contradiction Matrix is 10 times faster than benchmarked European competitors using other methods of delivery and saves the Company 90 minutes compared with benchmarked competitors –see section 4.3.1. Costed at 75 Euro per man–hour this saves 112,500 Euro per 1000 participants.
- is simpler and thus provides markedly higher returns on training time per employee. In particular, it enables 100% participants to apply one or more TRIZ Tools on their own after training cf. industry standard of around 3% application of Tools post–training.
- is more elegant. In particular, when the actual TRIZ Tools are hidden in the Map, it achieves the same or better results as basic TRIZ facilitated by non–Master TRIZ consultants. As a result, participants do not worry that something has been missed or not understood [which can happen in learning TRIZ] and feel more confident about their new skills and more willing to test them in their daily work. This benefits company morale as well as producing significant technical results in less than half the time of similar results achieved using TRIZ Tools –this research indicates the Company can save a minimum 1 man–day of thinking time for each project using the Innovation Map, compared for each similar project using TRIZ.

In comparison to using any popular problem-solving, creativity and Innovation Tools in an ad hoc way, without knowledge of the process of innovation, this research indicates [6.3.3] that understanding the Map enables Engineers;
• To understand their own Design Process as a process of innovation. This lays the foundation for an innovation culture.

• To establish in which part of the Design Process they require additional input, and to self-select the right Innovation Tool for the job, or ask for support in problem-solving.

iii. Management benefits

This research indicates that the Innovation Map can benefit Management in general in three main ways [see sections 6.4.0 and 6.5.0], in that it enables unprecedented:

• Multidisciplinary and multi-national discussion in the natural language of Engineers, using the structure of the Map as a reference point

• Problem-capture, using the structure of the Map and the TRIZ plus PRIZM Excel Table to find ‘the right problem’ [being the one that is important and which competitors have not addressed see 4.2.3]. As part of the package, the Map enables capture of all potentially relevant problems and solutions and all discussion and decisions made between those points, so that innovative potential can be fully exploited and re-used

• Project Planning and Management, using the structure of the Map to compare, translate and integrate the innovation process more overtly into existing Engineering processes

iv. Multidisciplinary and Internal Business Development benefits

Feedback from Engineers in the Industry Collaborator indicates that common language provided by the Map has given multidisciplinary and multi-national teams their first structured, common language for communication [4.3.2, 6.2.0, 6.3.0, 6.4.0 and 6.5.0]. This is hypothesized by this author to be due to the fact that the Map gives a standard, repeatable framework or grammar for discussion. It provides the structure and rules of engagement necessary for large-scale communication while also allowing enough flexibility to be re-used in potentially infinite ways. This fulfils ‘Rule of Innovation’ [#4] of this Dissertation and provides the following three explicit benefits:

• transparency and capturing of each phase of problem-definition and idea-generation in Design, so that the right opportunity is found to be addressed and solved, leading to higher quality solutions immediately and in future.

• equality and consensus in discussion and decision-making around the Design in each team. This is important and useful for multidisciplinary teams in particular, and those with language differences, and leads in turn to self-sustaining communication between teams on multiple sites and in multiple countries. This leads to a higher rate of collaboration and higher rate of internal business development.

• personal joy and boosted company morale, due to having a repeatable, transferrable process to take beyond the team in which the Map is first used, leading to greater confidence in innovative behaviour and a proto-innovation culture.

v. Cultural and Industry-wide benefits

As pointed out in Chapters 3 and 6, this author assumes that it is easiest to seed a new [innovation] culture in, or let it emerge from, an old existing culture, when a coherent, useful, fractal and self-evident [or fundamental] pattern is used as the seed. This means that the easiest way to help Engineers do what they already do, better and faster, should be to match the underlying pattern and common language of creation outlined in section 5.1.1 with existing Engineering systems and processes.

The Map can be seeded as Game, Tool, project, process, programme, knowledge-capturing and social networking event, on timescales ranging from two hours to two years, which allows different entry levels, according to each participant’s needs or wishes. Each of these delivery modes is based on the same grammar; the seven-step, three-stage model that appears to be the natural process and common language or DNA [6.6.1] of human innovation. At all levels in the Industry Collaborator, during the four years of testing, sessions using the Map have emerged and are sustained by encouraging exchange and dissemination of information through reasonably joyful [!] verbal feedback in interactive, multidisciplinary and open teamwork and knowledge networks, allowing all participants to join at their own speed – which is all the more true for not having Top-Management support.
In other words, so far, the Innovation Map [applied in any of five modes of 6.1.1] is simple to use, and grows by word-of-mouth success stories, rather than costly marketing ie. it is also cheap to make and run. Plus, the four years of this research indicate that it has the potential to seed a self-sustaining ecosystem for innovation, when used as the framework for an Innovation Deployment Programme. Its growth should not require constant fertilization from external sources [including this author] at extra cost, but become embedded by self-selected users and promoters. Assuming that the self-selected users are also good facilitators, application of the Innovation Map should continue to produce consistent, high quality results, regardless of the context in which it finds purchase. In this way, an Innovation Programme based on the Innovation Map could be expected to co-evolve with its participants into a true and unique innovation culture. At this point, it would set the standard not just for the Industry Collaborator but for other Engineering Companies [or indeed completely other industries], who are also looking for a way to implement or encourage an enjoyable, sustainable, productive Innovation Programme, inside an existing culture. It is of benefit to any Company to set the standard for its Industry – this becomes part of the brand for which it is known. Thus, especially in today's economy, setting the standard for innovation may yet be a great financial and marketing asset to the Industry Collaborator, as well as a boon to the community of which it is a part.

7.2.2 The Case for Academics and TRIZ Consultants

i. Material and Technical benefits

The Innovation Map clearly outlines three technical components which are both industrially and pedagogically [or didactically] important, since they characterise the three levels [3.5.0] and three natural stages of the complete thinking process, during an act of creation or innovation [see 2.4.3]. The Map also outlines the seven coincident steps of creation and innovation, which are common to all reported processes for creating in the literature of many disciplines [see 2.3.3, 5.1.1 and 5.1.2]. Together, these provide a context for understanding innovation in general, and for understanding the best way in which Innovation Tools can be applied [see eg. 4.3.2 and 6.3.3].

While they have been recognized as important for creativity and innovation by others in the past [2.4.3], the following components have been, as a set, lacking in all other Innovation Tools [see 2.6.1 and 2.6.2]. These are provided in toto, in the Innovation Map:

- a two-step process for problem-finding [addressing the stage of divergent thinking], which is a means for Users to determine historically significant starting points for innovation before competitors do [see 3.3.1]. ie. the Map focusses Users on only ‘the right problem’, and not random or ‘assumed’ problems [see 4.2.3, 5.2.3 and 5.2.4].
- a profound set of pre-existing solutions to provoke idea-generation [addressing the stage of inspiration and transformational thinking], abstracted from a rigorously researched database combining Engineering and biological solutions. These solutions are pattern-matched in sets to only nine possible variations of the original ‘right problem’, so that only the statistically best solutions in Engineering and nature are considered by users [see 5.2.5].
- a two-step process of ranking and screening results [addressing the stage of convergent thinking] that produces internationally competitive results in the form of complete business cases or technical prototypes, which come close to an Ideal Final Result, every time the process is applied [see 5.2.6 and 5.2.7].

The elucidation of these process steps for innovation has the following benefits to Academic Engineers and innovation consultants in general, as well as TRIZ Consultants in particular:

- In comparison with brainstorming, mindmapping and other popular creativity and Innovation Tools such as those listed in Table 2.3[a] and [b], the Innovation Map provides a structure that is rigorously proven as well as easily understood and can therefore be quickly repeated by others, to achieve world-class results every time it is applied [see eg. 4.3.2].
- In comparison with basic TRIZ training, the Innovation Map covers the same ground, yet has a simpler physical and pedagogical presentation. This makes it simpler for consultants
in general and TRIZ Consultants in particular to apply, and simpler for their customers to achieve world-class results [see eg. 4.3.2 and 6.3.0].

- **In comparison with existing theories of innovation in Engineering Design**, which are uni-directional and generally limited to a worldview of creation or of problem-solving [see 1.2.1, 2.1.0 and 2.3.0 cf. 5.3.0 and 5.4.0], the Innovation Map provides a means of bi-directional and co-evolutionary discussion, which re-uses, integrates and transforms pre-existing information from other fields and disciplines in the manner of true and historically significant innovation [see 2.3.3 and 3.3.1]. It does this via its own structure [ie. in the Inspiration Cards – see 5.2.5], as well as in the arrangement of multidisciplinary participants solving a given issue around one Map [in variations of the Designer–User discussion –see 3.4.2, 5.3.4 and 5.3.5]. While it can be argued that the Innovation Map does not actually provide a simple explanation for innovation per se [ie. especially when all its levels and modes of application are taken into account], its fractal and symmetrical nature nevertheless offer a relatively simple explanation for what is a highly complex phenomenon, and one that is particularly simple in comparison to other more confused or incomplete alternatives.

ii. **Information and Coordination benefits**

For all Tools listed in Table 2.3[a] and [b], the Innovation Map provides a wider context in which these Tools, which may have been previously misplaced or misunderstood, can be better placed and understood. While it may be argued that the Innovation Map does not actually provide a very simple context for innovation [also see point above], it is yet still arguably simpler for Academics and TRIZ Consultants to build upon it by starting with ‘a context’ rather than ‘no context’. Thus the Innovation Map should benefit Academic and Consultant End–Users by providing a context for application, which can improve the efficiency and efficacy of application of other Tools. As a comprehensive and at least relatively simple framework for other Innovation Tools, ultimately including the Design process itself as a process of innovation, the Map could even be expected to enable greater Innovation Tool use of all descriptions, in Engineering Design and Academia.

In comparison with TRIZ, which is generally considered complex by customers of TRIZ Consultants [see 4.3.1], the Innovation Map provides a wider context in which the Tools can be placed and understood. In particular, it lends itself to modularising the presentation of TRIZ Tools and enables a quicker and simpler teaching model for the TRIZ Contradiction Matrix, the most important Tool of TRIZ [see 4.3.2 and 6.3.2]. This, in turn, leads to a greater self-assessed learning benefit post–training [4.3.2] and a greater post-training success rate in application of the learned material [4.3.2], all of which is of benefit to a University’s and TRIZ Consultant’s reputation.

iii. **Management benefits**

The Innovation Map and the ‘TRIZ plus PRIZM Excel Table’ should benefit Academics and TRIZ consultants because both these formats enable information and knowledge about Engineering Design to be captured, collated and managed more simply. That is because the Map and TRIZ plus PRIZM Excel Table capture all discussions and decisions made by Design teams during facilitated innovation sessions, in a standardised way; this includes all possible problems related to a given original issue including ‘the right problem’ [see 4.2.3], as well as all proposed solutions to these problems. Academia, in particular [compared with Industry], has the time and job-description to re–use information from elsewhere and could thus [with appropriate confidentiality agreements in place] explore or exploit all potentially relevant problems and solutions, which are left behind from each industry case in which the Innovation Map is applied. It could thus also greatly benefit Consultants and Academics to work together on these issues, so that the innovative potential of problems can be fully exploited [and it is indeed a strategy of the PRIZM Game Company to work with Academia in this way in future, albeit with cases from youth, rather than industry].

iv. **Multidisciplinary benefits**

The Innovation Map provides both a natural language [4.4.1 and 4.4.2] and a common language [2.4.0, 2.6.0, 5.1.1 and 5.1.2], which can be used as a simple yet international standard [2.6.3] for discussion around innovation in multiple disciplines, in a way that has previously not been possible [2.6.3 cf. 4.3.2, 6.2.5 and 6.5.1]. This is crucially important for Academia and its third party End–Users, since without a comprehensive yet relatively simple
starting point that can be debated and improved to create a true theoretical basis for understanding its mechanics, innovation and its management can never be taught in Universities with the same rigour as other subjects. The development of a rigorous innovation theory that spans many disciplines, based on the common steps and co-evolutionary nature indicated by the Innovation Map in this Dissertation will benefit students who go on to jobs in any Engineering Industry as well as, conversely, those who already come from industry for additional information on innovation, and to gain MBAs, MAs or MScs in their field.

In addition, TRIZ consultants are not currently in a position to promote multidisciplinary and multi-national discussion of innovative Design using Altshuller's Tools in any simple way, nor in a team or workshop format. On the other hand, using the Innovation Map does exactly this – it delivers a standard for multidisciplinary discussion in teamwork, which especially includes previously external participants and thus ‘outsourced’ information. The Innovation Map could thus set a new standard for basic TRIZ training or Systematic Innovation in workshop mode, and benefit Consultants by widening their potential network of participants.

v. Cultural and Industry-wide benefits

An interest in co-evolving systems and pattern–matched information is not limited to the topic of innovation nor to Engineering Design, and so this research could be of interest on a much wider scale. In particular, just as this research was informed by many fields and disciplines, it could now feedback to, and re–fertilise those fields, potentially leading to improvements in their understanding of relevant issues – Biomimetics and Buddhist Technologies being two cases in point. This would be an ideal academic outcome, for as the I–Rule of this Dissertation indicates [1.2.1 and 3.3.1], the fact that innovation moves in at least two directions is a necessary condition of its existence [1.2.2 and 3.4.0]. Using the Innovation Map to provide a framework to ask questions in multidisciplinary research could also potentially enable new fields of applied research to emerge. This should be true not just for the hard sciences and Engineering, but also for the soft sciences [eg. psychology] and humanities [eg. business] where an understanding of the co-evolutionary nature of social innovation could greatly benefit the development of new cultural models.

7.2.3 The Case for Innovation Managers and Society

The Innovation Map is an elegant solution to an issue that was previously not well identified ie. the possibility and indeed the necessity of simplifying the complex information of TRIZ and putting this together with an overarching model for innovation.

i. Material and Technical benefits

The Map is also an elegant solution to the problem of requiring one single Innovation Tool [rather than a combination of 10 or 110 others] for wide–scale application in a multi–national organization, since it:

• offers five different consulting formats with one Tool – including training, coaching, Games, GameDays and real–time, learning–by–doing workshops [see section 6.1.0].

• can be applied at all levels of Design [in part or whole] from shop–floor to Chief Designer [section 4.3.2 and 6.5.0].

• can be used by individuals or teams [section 4.3.2].

• will lead users to exhaustively address all potentially relevant Design issues, and capture these for future re–use [sections 6.2.0 and 6.4.1].

• is cheap to implement [6.2.0 and 7.2.1], simple for users to grasp [6.3.0] and provides internationally competitive results in record time, compared with using other Innovation Tools or no Tools [7.2.1/i]

ii. Information and Coordination benefits

Using the Innovation Map as a framework for an Innovation Programme is an elegant way of providing a context for Tools and consulting as an Innovation Manager, since it:
• arranges all other Innovation Tools in the context of an apparently intuitive and provable process of creation, that applies to innovation, product design and development, regardless of the field or discipline involved [2.3.3, 2.6.2, 5.1.1 and 5.1.2]

• simplifies teaching and improves the post–training application of other Tools [6.3.0]

iii. Management benefits

The Innovation Map provides a beautiful solution for embedding and streamlining innovation in other pre–existing product programmes in a multi–national company, since it works for:

• design processes at every level and scale
• manufacturing improvements
• workflow, supply chain and process improvements
• multi–disciplinary business development and internal platforms, teamwork and team–building

• Designer–End–User focus groups

iv. Multidisciplinary benefits

The Innovation Map and Game provide a common language, which is the most elegant way to enable massive multi–player engagement in innovation. This is because the Map provides the rules or grammar [5.2.3] necessary for large–scale communication and yet remains flexible enough for local variations [see 3.3.1]. The main benefits of this, for an Innovation Manager, are;

• transparency, equality and eventual consensus in discussion and decision–making around Design in each team using the Map as a reference point, which is especially useful for multidisciplinary and multi–national teams [4.3.2, 6.5.1], and internal business development [6.4.2]

• potentially self–sustaining communication between teams on multiple sites and in multiple countries when many teams use the Map as a reference point

• personal joy during use of the Tool, leading to greater confidence in innovative behaviour [6.3.2] and boosted company morale or indeed a proto–innovation–culture [see also next point].

v. Cultural, Societal and Industry–wide benefits

The Innovation Map appears to be the only system currently available for Innovation Managers, that can seed an innovation culture as an ecosystem [6.6.1], in an elegant way. This is because it;

• can be seeded as Game, GameDay, Tool, project, process, programme, knowledge–capturing and social networking event, on timescales ranging from two hours to two years
• uses a fractal, simple and self–evident natural and common language as the seed [5.1.1]. It thus neither requires huge upheaval of thinking processes nor of product development and management processes, but merely helps innovators streamline what they already do, becoming better and faster, and certainly enabling them to produce more, consistent high quality results, regardless of the context in which the Map finds purchase.

• grows ground–up, allowing all potential participants to find their own entry level and is therefore self–selecting and sustainable by word–of–mouth success stories [see 2.5.0 and 4.3.2], rather than requiring constant marketing from external sources at extra cost

• encourages ‘open innovation’ through interactive, multidisciplinary teamwork and knowledge networks wherever and however it is implemented, leading to better internal collaboration [6.2.4] and internal business development

• is self–teachable [4.3.2] and thus able to adapt and co–evolve with its participants and users. This is the main point that is expected to enable a true and unique innovation culture to emerge, wherever the Map is embedded and thus has the potential to set the standard for innovation in any Industry where it is first applied. Outside the Industry reported on, in this Dissertation, other tests with the Innovation Map already look promising on this count, in education, banking, advertising, food technology, medicine and customer service.
7.3.0 LIMITATIONS OF, AND LESSONS LEARNT WITH, THE INNOVATION MAP AND GAME

7.3.1 Limitations

The research presented in this Dissertation can be divided into two main parts: [i] elucidating the theory for The Innovation Map of the PRIZM Game Company, including presentation of evidence for a fundamental pattern of creation and/or innovation, plus recasting of relevant information from the modern Problem-Solving system known as TRIZ and from the ancient Eastern Science of Vajrayana Buddhism; and [ii] testing and evolving the application of the primary Map artefact in one of five modes as outlined in section 6.2.1.

The potential limitations of both parts of research will now be briefly addressed.

On the first count, regarding the proposed theory and fundamental pattern of innovation, this Dissertation provides only a bare bones starting point. This is due to the natural limit of research that can be undertaken by a lone doctoral candidate in a limited time span. It is, furthermore, also a natural limit due to the fact that a synthesis of any kind must cover a lot of ground, rather than focus on detail. Since this is the first time that a proposition has been made and such evidence presented in Western Science, that the fundamental pattern of creation exists at all, it was not, and could not be, the object of this single Dissertation to provide a complete and exhaustive proof of its existence or useful application in all disciplines of human endeavour. An exhaustive proof beyond the framework presented here could presumably necessitate several more doctoral Dissertations. Thus, as is always the case in research, it is now the job of the rest of the scientific community to either expand upon the argument, or prove it false.

Regarding the testing and evolution of the theory via the Innovation Map and Game, there are also some limitations, as follows:

First, the Map itself is not designed to do chemical equations nor mathematics. It can only deal with statements, sentences and discussion in a natural language about material objects, actions and environments. On the other hand, as was discovered in several workshops with the Industry Collaborator, the Map can help with the manipulation of mathematical matrices. What is necessary for this, is to treat the mathematical models as if they were objects and discuss these models as objects, rather than discuss the mathematics itself.

Second, as discussed in section 2.6.3, measurement of innovative outcomes is notoriously difficult in all circumstances, not just in regards to applying the Map in this study. The calculations carried out in section 7.2.1 are done to the best of this author’s ability, using industry standard values, and indeed the figure of the confirmed minimum cost–benefit to the Collaborator ie. saving/making 16 million Euro/year, and an ROI of 2847% on running Innovation Map workshops is not to be sneezed at. However, while the ROI figure holds over all sessions, it must be stressed that the confirmed outcomes represent only a small proportion of sessions actually run between 2007–10. The reason for this, as also stated in 7.2.1 and 2.6.3, is that not all outcomes of the innovation workshops are, or could be, measured and confirmed, since: [a] individual participants are sometimes loath to admit to having gained good outcomes, since they fear this will show a lack in their capabilities as Engineers [see section 6.7.0]; [b] 60 multinational teams, dispersed over 4 countries seem to make themselves intentionally difficult to keep track of, over the 1–2–3 year timeframes in which additional research and validation of the initial results from a workshop with the Innovation Map must be carried out; and [c] not all outcomes that could be implemented into the Collaborator’s business or technical products are actually implemented, so the figure of potential benefits calculated in 7.2.1 is a projection of what could be achieved if the company were to follow up on implementing the found solutions at market rates, not what was actually achieved. Of course it is a moot point [even for the Designers in the Collaborating Company] that what is ultimately implemented [of all possible good ideas they have ever proposed] has little to do with any Innovation Tool or workshop in general, not to mention the Innovation Map, nor even the participants in a given idea-generating session, and instead everything to do with internal project planning capabilities, Departmental budgets and Company politics or vision.

The third limitation in claiming the Innovation Map and Game to be a revolutionarily useful Innovation Tool is, as the Head of Knowledge Management in the Company pointed out, that the
results gained from these workshops may not be due primarily to the Tool, but to the ability of a good facilitator, who can find and define a clarity in the problem that participants in workshops do not themselves see. Since this author was the facilitator for all the Innovation Map sessions, this is a flattering proposition. However it is a limited argument. As pointed out in section 4.3.2, this author had no prior training in facilitation in general and no knowledge of TRIZ training or Engineering in particular. Were the knowledge and skills of the facilitator to unduly influence the outcome, then the facilitation of this author can only have made the outcomes worse, not better – a point that seems to be borne out in early feedback of the TRIZ plus PRIZM training [eg. 2007-08]. In this case, this author was running the training as workshop sessions ie. on live problems, not on ‘previously-worked’ or ‘known-to-work’ examples that were de rigueur in most other training offered by TRIZ consultants. As a result of this oversight and over-expectation of achievement on the part of this author, participants found the training style of this author confusing. That said, this author eventually [and somewhat painfully] acquired better facilitation skills over the course of the contracts carried out with the Collaborator and standardised the training [though not the workshops], whereupon participants feedback on her training style improved – of note is that feedback on the Tools remained consistent throughout. Besides, it is to be expected that the Innovation Map is best implemented in the hands of trained and skilled facilitator or coach and that, without such appropriate background skills and knowledge, it will be, like anything else would be in the wrong hands; a dead duck.

The last related limitation in using the Map and interpreting the results achieved in any of the five kinds of session listed in 6.2.1, also has to do with facilitation issues – however in this case, with all the human factors that detract from the matter at hand and take the eye of both the facilitator and the participants off the challenge, ‘quest’ or aim of running the workshop in the first place. These are serious limitations to applying the Innovation Map effectively, although given that this is not a Dissertation about facilitation skills, any further discussion is beyond the scope of this section. In short, such limitations to the effective application of the Innovation Map can be said to include:

- the facilitator’s ability to deal with any personality clashes [her own with participants, and participants with each other];
- participant objections or downright hostility towards the technique during the explanation phase, especially when they arrive at a training session, only because ‘their boss told them to’
- difficulties in language/culture and comprehension differences between the facilitator [presenting in english] and participants [used to german, french or spanish] and a related inability of participants to voice their concerns of understanding on this front, since they do not in that instance know, what they do not know;
- inadequate management of the expectations of participants regarding how the session will run, or what kind of results can be achieved, before the session starts. Over–expectation about what participants will learn or remember is counter–productive. At the same time, under–expectation is also counter–productive.

7.3.2 Lessons Learned

Having said, in the previous section, that this is not a Dissertation about facilitation skills, the biggest lessons learned about applying and improving the Innovation Map were indeed about how best to facilitate the process, and not about the Map itself. This is a direct result of this author being required to vary the format of presentation and facilitation for various audiences – quite often, quite quickly and fairly dramatically, to respond to the various Collaborator environments over the 4-year time span of testing.

Testing any product with 1500 volunteers is a significant undertaking [most tests for new face creams released to market do not involve so many volunteers before significant claims are made], and it is thanks to the sheer number of participants in this project that improvements were possible. While the Map itself was well–defined IP [belonging to the PRIZM Game Company], and the theory of innovation was reasonably understood by this author [as elucidated in Chapters 2, 3, 4 and 5], the delivery process of the Innovation Map was still immature when testing started, and this is the inescapable reason why many of the above–mentioned issues with facilitation were encountered. Happily, these difficulties served to streamline the delivery of the
Game and GameDay formats, and this author’s understanding of the innovation process as a whole – especially in conversation and feedback with the Head of Knowledge Management in the Industry Collaborator.

The main lessons learned about improving use of the Innovation Map are these:

1. **The use of a script for applying the Map as a Game is of paramount importance.** During the first two years of use, this author had the habit of giving somewhat lengthy, detailed explanations for the new and apparently unusual material of what was included and what should be done by participants at each step of the Map or Game. Those explanations confused and dismayed a large number of participants – and even continued to do so, when the explanation length/time was shortened. To some extent, the degree of individual participant’s understanding/misunderstanding seemed to average out over a team and did not hugely affect the positive outcome from the process [which was achieved in every session without fail], however it was uncomfortable for everyone involved, including the facilitator. By early 2008 therefore, a script evolved for presenting the Game, some of which was agreed with the Industry Collaborator to reduce the need for lengthy or detailed explanations.

   In particular, the Collaborator encouraged this author to stick to an exact script, no matter which questions were posed by participants. This meant that, instead of answering a given question in a different way, each time it was asked by different individuals working together on a single issue, that exactly the same words would be repeated, over and over, until participants simply decided to do the work [whether or not they understood the instruction] rather than ask for another explanation. This is a trick used successfully in early childhood education [eg. the structure of the ‘Blues Clues’ television show reported on by Gladwell, 2001] and in talent hotbeds for music, sport or literature, which encourage maximum repetition [such as those reported on by Coyle, 2010], which enables participants to ‘learn by doing’. The ‘learning by doing’ was also assumed to happen subconsciously in a large proportion of workshops commissioned by other departments in the Industry Collaborator [see 6.1.2], where it seems to have significantly less pedagogical effect than conscious repetition. This was not a formal issue measured during this study, but is an interesting area for future research. The number of participants who self-reported to have understood the process of innovation at the conclusion of workshops in which repetition was either not highlighted or included was significantly less than those who who reported understanding the process of innovation ‘at least a little bit’ after training or workshops where conscious repetition of instructions was included.

   The evolution of a script for streamlined facilitation of the process co-evolutionarily helped this author/facilitator understand the process/step details better. The key example of this is the story of how the criteria were defined for decision-making, in the last step played in the Game. This step requires participants to make a decision about their business cases/prototypes. The step was initially ill-defined, having a lengthy and detailed explanation that took several minutes, requiring the three potential business cases to be described with a series of synonyms. The plethora of synonyms for describing these business cases are the reason that the boxes [on the Map] in which answers should be posted for this step initially had no title [see Figure 5.1 cf Figure 5.1]. Participants thus found it difficult to make the decisions that would fill these boxes with appropriate answers. It was not until the Head of Knowledge Management in the Industry Collaborator picked the essential words from this facilitator’s script, that the penny dropped for everyone. Thus ‘cheap’, ‘simple’, ‘beautiful’ came to exist, as the defining criteria with which participants create their three prototypes in the final step of the Game.

2. **The inclusion of body actions to accompany verbal explanations of each step of the Map / Game is of paramount importance.** Again, at the request of Head of Knowledge Management in the Engineering Company, the script for delivering the Map as a gameful Innovation Process came to include the deliberate body actions for: picking up post-it notes; writing on them; and sticking them in the appropriate box on one of the physical Maps lying on participant tables. It seems participants needed to actually visually see the facilitator make the appropriate actions for each step and not just hear about what they needed to do – indeed, as actions mostly needed to be exaggerated or over-dramatised, with huge arm movements.

   Reducing the script, and adding actions to the instructions finely streamlined the process of this facilitator’s delivery and the participant’s response, to the point where in 2010, there were no more changes to be made. Indeed, while the number of words spoken by this
facilitator had reduced radically, the participant's understanding of the process and their consequent ability to carry out the innovation tasks at each step of the process increased dramatically.

3. Prior to any work with the Map / Game, it is of utmost importance for participants to define and agree on a starting point or problem-definition. If the problem or quest to be achieved is not reasonably defined and agreed upon, well before detailed work starts, chaos ensues. Significant million- or billion-Euro results simply cannot be achieved from using the Map in the short timeframe of a two-hour or two-day innovation workshop, if the starting points of all participants are not in alignment. It is absolutely the facilitator's responsibility to make sure the team applies all necessary effort to define such details.

This author found that sometimes, there needed to be a 'pre-workshop workshop' of one to two hours, or that this time needed to be budgeted for, in the existing workshop or coaching, before work with the Innovation Map could commence. Naturally, while there are many Tools that could be used to assist in this part of the overall innovation process, this author favoured applying the TRIZ Tools which were already built into the Systematic Innovation training, to such workshop situations. In every second of applying one's chosen Tools for problem-definition, the facilitator simply cannot let teams or individuals off lightly, since this threatens the ability to achieve a useful result from the day's work.

The same is true for every step of the process of using the Innovation Map /Game. Where teams suppose to have an 'impossible problem', and are therefore reticent to look at the details of it and put effort into the workshop exercises, one must learn to be hard-nosed and not take 'No' for an answer. The most supposedly intractable problem this author/facilitator faced was described in section 6.2.4 as the 'Calculation Workshop in November 2008 on Site A1'. This would have been infinitely easier to solve, had her facilitation skills been better and had she been better able to handle the objections and criticisms of participants before the final breakthrough. However it would have been truly impossible to solve, had she not developed a hard skin on the spot, and continued asking participants to apply all Tools and attend to all steps, in excruciating detail, at every step of work with the Innovation Map.
7.4.0 CONCLUSION

7.4.1 The Innovation Map fulfils Its Claim

The research described in this Dissertation, inclusive of the preliminary survey with the Industrial Collaborator [2006 and see 2.5.0], the Benchmarking of Systematic Innovation [2006 and see 4.3.1] and Industry Pilot Test [2006-7 and see 4.3.2], the four 9-month contracts with the Engineering Company [2007, 2008, 2009, 2010 and see 6.2.0, 6.3.0, 6.4.0, 6.5.0 and 6.6.0], thoroughly tested and evolved the Innovation Map from its theoretical basis [1.1.0, 1.2.0, 1.3.0, 2.3.3, 2.6.2, 3.2.0, 3.3.0, 3.4.0, 4.4.2, 5.1.0, 5.2.0, 5.3.0 and 5.4.0] to a proven concept, providing unprecedented results for high-end technical innovation in corporate environments.

Thus the research carried out for, and presented in, this Dissertation fulfils the claim made [1.6.0], that:

1. The PRIZM Innovation Map and Game is the first practical example of using the fundamental pattern of creation and innovative behaviour to improve innovation and team communication in Engineering Design. It provides the first common language and hence the first Western standard and process map for the entire process of innovation, which is both fractal and co-evolving or emergent. The successful use of the PRIZM Innovation Map and Game in Engineering proves the benefits of using Meditation as a template for the Engineering Design process.

2. The PRIZM Innovation Map and Game has three integrated functions no other Thinking Tool has been proven to have. Namely, it:

   • Streamlines the way Designers ask questions so that they find ‘the right problem’ to solve. This is a key indicator of historically significant innovation.
   • Provokes ‘focussed idea generation’, at a rate of 100's of ideas per hour, by introducing previously successful databases of solutions which are ‘pattern-matched’ to selected problems only. This hugely shortens the time Engineers and Designers need to find new and useful solutions.
   • Provides a rapid, consistent method for evaluating, combining and strengthening the generated ideas, which enables teams to produce an average of 10 commercially useful results at the conclusion of each application of the Game, Map and Method in less than one day of real-time work.

3. Significant benefits can be achieved by understanding and applying the fundamental pattern of creation and innovative behaviour to daily work. In particular, the use of the PRIZM Innovation Map and Game dramatically improves:

   • Material product development and productivity of internationally competitive solutions in high-end technical industries, leading to efficient and thus ‘Cheaper Innovation’ – a cost benefit to Manufacturers/Engineering Companies.
   • The didactics, teaching and application of commercial creativity and Innovation Tools [including but not limited to the Russian TRIZ system] and the academic understanding of problem-solving, creativity and innovation. This leads to ‘Simpler Innovation’ – a use benefit for Academics and Innovation Consultants.
   • Multi-disciplinary team communication, better decision-making and personal joy. The experience of transparency, equality and ‘freedom from idea fixation’ is increased by providing a common language to individuals and teams, which is repeatable at several scales and encourages a self-sustaining ecosystem of innovation. This leads to ‘Beautiful Innovation’ – an excellence benefit to Innovation Managers and Society.
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