Dimensions of Understanding of Systems Engineering

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Abstract. This paper continues work begun by Hitchins with the development of the 5-layer model of systems engineering. Hitchins' work was later extended to form the Hitchins-Kasser-Massie representation of systems engineering, HKM Framework, which adds a time dimension related to the stages of a project. The HKM Framework describes the layers of concern and the stages and types of projects at which they are dominant interests. In this paper we introduce a solid space concept to the HKM Framework based on Maslow's Hierarchy of Needs and Palmer's Modes of Being. The additional dimensions are useful to guide thinking about the purpose of the product system which is the focus of the project and the kind of existence which it has at the various stages of development. These additional dimensions are expected to be useful in the development of a framework for developing processes to guide the development through an appropriate path to achieve the desired outcome.

Introduction

Hitchins (2000) has described a 5-layer model of systems engineering for the purpose of assisting awareness of the range of kinds of concern that may be addressed through systems engineering. This was later extended into a two dimensional description of systems engineering in the Hitchins-Kasser-Massie, HKM, framework (Kasser 2007). The second dimension adds time, in the form of project phase, to the model. The HKM framework is useful in providing understanding of the emphases in projects at the various phases of the project lifecycle because, in particular phases, there will be a weight of attention given to the issues and concerns raised by particular layers in the 5-layer model.

In this paper we explore the addition of three further dimensions to the description of systems engineering. The additional dimensions are one built on Maslow's hierarchy of human needs (Maslow 1943). The second is a dimension developed out of Palmer's (2009) presentation of the hierarchy of modes of being. We also add a dimension of historical time. Where the project phase time dimension is concerned with time as an intra-project phenomenon the second time dimension is concerned with time as an inter-project phenomenon. The details of the three new dimensions will be discussed later in the paper, but here we introduce the rationale for each.

The dimension based on Maslow's hierarchy is useful because it draws attention to the range of kind of need for which systems engineering projects may be developed. The project teams must be aware of the fundamental purpose of the project, because the range of acceptable solutions is closely linked to the underlying, probably unstated, purpose. The purpose of projects is normally to achieve an outcome quite distinct from the product system and its direct functionality, with these things all being means to a purpose which often include intangible elements.

The dimension based on Palmer's hierarchy of kinds of being is the most abstract of the dimensions. This dimension is important because it assists us in understanding the nature of the existence of the project at various stages in the lifecycle, during which it is transformed from a dream of something which may possibly exist, with all the fluidity that is present in dreams through various stages of bonding to reality until it become a fully realised tangible entity which has particular shape. And then in use the product system is perceived as more than just the material of which it is composed because it also has the quality of being perceived as equipment which enables actions and achievement of goals.

The inter-project historic time dimension contributes the changes in perspective about what should be produced which develop through time. Over the historical time scale our consciousness of how to enhance human life and the effect of the environmental impacts of our activities changes, resulting in different issues being addressed by different projects. In more conventional language, the capabilities demanded of systems change through time.

Purpose – Maslow's Hierarchy of Human Needs

We now discuss the introduction of a third dimension, introducing Maslow's Hierarchy of Needs to the HKM model. This dimension was presented in (Peng and Hsu 2009). Maslow's hierarchy was a description of the kinds of human needs that exist, and is shown in Figure 1. Figure 1 shows Maslow's hierarchy of need types in the middle column group and our classification grouping the layers into functional and super-functional groups, according to their life context, in the third column.

Layer	Need Type	Life context
5	Self actualization	Image and projection of oneself
4	Esteem	
3	Love/belonging	
2	Safety	Function and quality matter – need for sustainment of self
1	Physiological	

Figure 1. Maslow's hierarchy of human needs (Maslow 1943).

At the lowest level people must address their basic physiological needs. These include the elemental matters which address the various needs required to sustain physical life, such as food, drink, and functional clothing and shelter. At the next level is the need for safety, which is concerned with protection from untoward events. However, safety only begins to matter when people have a reasonable level of sustenance. Safety has little meaning to a person who is concerned about their elementary sustenance. This is expressed in the idiom "nothing to lose".

The layers above safety concern nurture for the mental aspect of the person. The first of these layers is love and belonging, in which people have a need to feel included in a community, and not to be left alone. Above this is esteem, in which the person seeks to receive the messages of being considered an important member of their society. This need can be satisfied through the presentation of various kinds of recognitions for a good contribution, which go beyond the mere payment which enables satisfaction of the lower layers of needs. The highest level in Maslow's hierarchy is self actualization, which has to do with the individual's sense of inner satisfaction of their inmost being through the situation in which they participate in life.

Maslow's hierarchy was developed as a description of the kinds of needs that motivate people to action, with particular attention to why there comes a time when certain types of motivation cease to stimulate a particular person in their circumstances. This effect arises because their most acutely felt need is something other than is addressed by the motivator. Thus attempts to motivate using motivators pitched at needs above or below the individual's most acutely felt need will be ineffective because they fail to address a suitably tender area.

The psychological construct is also useful for understanding the interest that people may have at a certain time for a particular kind of product. People in straightened circumstances may desire every product that they have to provide absolutely the best possible value for money, defined in terms of functional performance per unit of expenditure. At this level they are seeking satisfaction of the lower needs, such as the physiological needs. As their circumstances improve their interest may shift towards safety of the products that they obtain.

At these levels the primary focus of the buyer is on the functional performance of the products. The emphasis is on whether the product provides useful functionality in a safe manner, but without concern for the issues of convenience and style of finish and other refinements.

People in more comfortable circumstance seek the products that they use to satisfy further levels of need in Maslow's hierarchy. Thus, many kinds of product are subject to fashion with a perceived need to have a particular brand or model or product because it provides one with a sense of belonging with the group of people who are able to use that product. Having and using the product enables one to identify with others who have and use it, and so the possession enables a sense of belonging. At a higher level there is a sense that having or using certain products distinguishes one as above the crowd, and so addresses the need for esteem that one may pursue if one has already satisfied the need for a sense of belonging.

It is normally not possible for possession of things to satisfy a need for self actualization, and it is not unusual to hear accounts of the discontent of the rich and famous who tried to provide self-actualization through possession of things.

These concepts are expressed in the right column in Figure 1, in which the lower two levels of Maslow's hierarchy are associated with functionality and quality, defined at its elementary level of reliably providing correct and safe function. The higher levels are concerned with one's image of oneself and projection of that image into the community.

This is important in systems engineering because in the satisfaction of the lower levels of Maslow's hierarchy the engineer is concerned with the bare functional achievement of the necessary function and performance standard. In the satisfaction of the higher levels of Maslow's hierarchy the engineer must be concerned to add to the function and performance refinements which make the product system desirable as a product to have and use and which make being known to have or to use the product a desirable social good. That is, to satisfy the higher levels of Maslow's hierarchy the engineered product must offer both the reality and the perception of refinement.

Essentially products are procured to do one of two things:

1. Provide a functional service; or

2. Impress the neighbors.

All this presents a challenge of specification. For product systems of the functional kind the traditional approaches to defining a technical specification that describes the required functionality and performance is effective. A more subtle approach to specification is required when one is seeking to address the higher levels in Maslow's hierarchy, where the issues of desirability, projected image of the self, and refinement are important to the definition of success.

Hitchins' 5-Layer Model

Hitchins (2000) presented the 5-layer model of systems engineering, reproduced in Figure 2. This model was presented to show the logical relations of the layers and the kinds of systems associated with them:

> The 5 layers form a "nesting" model, i.e. many products make a project, many projects make a business, many businesses make an industry and many industries make a socio-economic system. Clearly, these statements are only approximate. A socio-economic system has more in it than just industries. A business has more in it than just projects, and so on. Nonetheless, the 5-layer model provides a useful basis for illustrating how each level "lives within", and contributes to, the one above. For that reason, each layer will be presented in turn, starting at the bottom – Layer 1 (Hitchins 2000).

Layer	**Title of layer**
5	Socio-economic
4	Industrial systems engineering / supply chain
3	Business systems
2	Project / system level
1	Product level

Figure 2. Hitchins' 5-Layer model of systems engineering.

The 5-layer model of the systems engineering environment is also useful in alerting the systems engineer to the context in which their work on a particular project or system, the most common loci of systems engineering work, belongs within the context of the overall effort to identify and address the need. This is useful because, whilst systems engineering is the engineering discipline which seeks to look outwards at the need, the purpose and the context of the development, in order to develop the most suitable solution, it is still easy for the systems engineer's attention to focus on the matters within the sphere of control and for which the individual is accountable. A misdirected focus is liable to result in product systems which do not achieve the intended outcomes. Hitchin's 5-layer model seeks to direct attention at the appropriate context of the work in order to lead to the right outcomes.

The Hitchin's 5-layer model provides a useful frame for the systems engineer to appreciate the importance of the range of processes in ISO/IEC 15288 (2002). The processes identified in the standard address a range of issues ranging from the detail technical matters that are described in Layer-1 through to the high level contextual matters described in Layers-3 and -4 in Hitchins' model.

Hitchins' 5-Layer model is useful for providing the insightful conceptualization that all systems engineering work involves hierarchical interfaces both upwards and downwards, to ensure that the parts and sub-systems designed or selected are suitable in the context of their anticipated situation of application

Project Lifecycle Phase

The Hitchins 5-layer model describes the range of systems which exist in terms of their scale and magnitude in a hierarchy of scale. This is a view which has a static quality, the systems at the various layers are taken as existing, but there is a lack of interplay of the layers with any other dimension. Kasser and Massie (2001; Kasser 2007) proposed a second dimension, the project lifecycle stages, Figure 3, which adds the strength of enabling us to review the emphases of the various stages of the project with respect to the layers of Hitchins' model. This is interesting because at the various phases in the project the emphasis shifts between the product level and the higher levels in the 5-layer model. The emphasis is on the higher layers in the early phases of the project, in which specification of the intended product system to suit the context of its planned deployment is important, and also in the later phases where the product system is being integrated into the whole system and into its context of deployment. In the operations and maintenance, upgrading and disposal phases a major part of the focus is on the fit of the product system in its context of deployment.

Layer	**Life-cycle phase**
1	Need identification
2	Requirements
3	Design
4	Construction
5	Unit testing
6	Integration and testing
7	Operations and maintenance, upgrading
8	Disposal

Figure 3. The lifecycle phase dimension added to Hitchins' 5-Layer model of systems engineering by Kasser and Massie (2001).

In a similar way, the processes described in ISO/IEC 15288 map to both the lifecycle and to the layers of the Hitchins model. The technical processes are largely concerned with the product and the project or system layer. The project processes are concerned with the project and system layer. The enterprise processes are concerned mainly with the business system, or enterprise layer and a little with the supply chain layer. The agreement processes are concerned primarily with the supply chain layer. In addition to this mapping of the processes in ISO/IEC 15288 to Hitchins' layers, the processes are also concerned primarily with certain phases of the project lifecycle, as described above in the general explanation of the value of the value of the second dimension which establishes the HKM model.

Existential – Palmer's Hierarchy of Modes of Being

Palmer (2009) has presented a hierarchy of modes of being[1] built on the work of Heidegger (1973) and Merleau-Ponty (1968). This hierarchy of modes of being is described in Figure 4.

Layer	Mode of Being	Explanation
5	Ultra-being	Distorted or separated – need to think more about this
4	Wild-being	Meta-field of overlapping fields – need to think more about this
3	Hyper-being	The realm of possibility, that which can be made
2	Process-being	Dynamic, changing, becoming
1	Static/pure-being	Present - existent

Figure 4. Palmer's hierarchy of modes of being (Goertzel 1999).

The first two layers of this model were identified by Heidegger (1973), the English translation of the 1927 work, as the present-at-hand, *vorhanden*, and the ready-to-hand, *zuhanden*, modes of being. The idea of the present-at-hand mode is the static entity, the material and the form, with their static properties, such as mass and colour. This mode refers to the flat, inert existence of the entity. This is the material stuff which is fashioned in the production process in order to make the entity, and refers to the entity sitting, doing nothing. This mode is called pure-being, conveying the idea of the emphasis on the materiality of the entity. In engineering pure-being maps to the build phase, in which the entity is fashioned from parts and materials and the life-cycle support aspects of the use phase, in which one is concerned with maintaining the entity in a state, with the necessary supplies, in order to enable it to be and do what it is meant to be and do.

The second layer, the process-being, refers to Heidegger's ready-to-hand mode of being. In this mode the entity is useful for doing something, it is seen as equipment, which can be used for a purpose and therefore becomes means of effecting intent. Heidegger (1972) illustrated the nature of the static-being and process-being distinction by reference to a hammer. To a carpenter, who recognises the hammer as a tool for driving nails the hammer has process-being, meaning that it is a useful entity which can be used to support the carpenter's work, that is, it is equipment. To someone who does not recognise the hammer as a hammer it is merely an object made of certain materials and of a certain size, shape and mass. It is an inert object with no particular purpose or value, and thus is an entity with pure-being, but nothing higher, and not affording some emergent property. In progressing from pure-being to process-being the emergent property is that the entity becomes useful for a purpose through its becoming means to do something, rather than just an object or an ornament. The process-being mode maps, in the engineered system context, to the use phase of the entity, that is, the activities in which the entity is used to effect whatever it was acquired to effect.

The third layer is hyper-being, which concerns that which is possible (Palmer 2009). In particular

[1] The word "being" is used here because this is the word which has been established in the tradition of this work since Heidegger's *Sein und Zeit*, 1927. The issue we question is whether the nature of the entity changes with the mode or merely the relation of the observer to the entity. If the former, then the word "being" is appropriate, and if the latter, the concept of "relations" would be more appropriate. This matter is not investigated here, and does not make a material difference to the argument in this paper.

hyper Being pertains to the possibilities of the entities which can be organised through design to become particular things with particular attributes and capabilities. That is, in contrast to the lower levels of being described above, where pure-being concerns the stuff in and of itself, and process-being concerns the entity as equipment for effecting intent, hyper-being concerns the possibilities which could be designed and built into the entity which is in the hyper-being mode of existence. The hyper-being mode presents the possibilities which could be produced through particular design choices. In the hyper-being mode of being the capability afforded by the entity is not actual, but rather potential, because the entity itself does not have tangible existence, and therefore cannot be viewed as pure-being nor be used as process-being.

The fourth layer is wild-being, which contains propensity (Palmer 2009). That is, in the wild-being mode there is a set of possibilities afforded by the fundamental attributes of things and materials which enable the possibilities, which are more tangible, that are the subject matter of the hyper-being mode. The scientific knowledge which engineering uses in order to analyse design proposals is at the level of wild-being, because it makes possibilities of what could be developed or analysed and therefore contains the propensity that can be turned into design. It is clear to engineers that there is a profound difference between the activity of engineering and the science which it uses as a tool to its ends.

The fifth layer is ultra-being, which is the unrepresentable (Palmer 2009). In this mode of being the entity is neither tangible nor a representable set of capabilities. That is, in ultra-being we have an entity at the very front end of the systems engineering process, in which it exists only as a somewhat vague dream of what might exist or be achievable through an entity which could be made. This is the most nebulous idea of an entity which can exist, despite Heidegger's concern of the possibility of describing an infinite regress of progressively more tenuous modes of being (Palmer 2009).

The importance of this dimension is that it shows the differences in the qualities of entities at different stages of their development. It is commonly taught, and is one of the premises supporting systems engineering, that the major decisions affecting life-cycle cost are made at the beginning of project development (Fabrycky and Blanchard 1991; Blanchard and Fabrycky 2006). In the first instance the recognition of the modes of being described here outlines the nature of the problem, which is the use that we make of this dimension in this paper. Palmer's construct (2009) develops these concepts in order to create an approach to design which maps the pathway through the various levels of being which temporarily proceeds from the vague dream that prompts consideration through investigation of the propensities of things and materials which may be used, and the possibilities that could be implemented, which may exist in the form of models, and a transformation into an assembly of material things in order to create the entity which can be used as a tool to an end.

Historical Time Dimension Added to the Solid Space

The four dimensions described above include one time dimension, the project life-cycle phase dimension associated with the HKM model of systems engineering. The four dimensions of the systems engineering situation discussed in the preceding sections are illustrated in Figure 5. Figure 5 shows the space describing a single project. The life-cycle phase time dimension conveys the staging of the project through the time related phases of the project and product life-cycle. The time scale we introduce here is a much longer-term time scale that relates the entire four dimension construct described above to historical scale calendar time. By this we mean a view of time that progresses through historical scales of time, that is, years or multiples of years or generations of human life. This scale of time is significant in relation to the other dimensions described because over this scale of time the context of life and work changes and provides different imperatives.

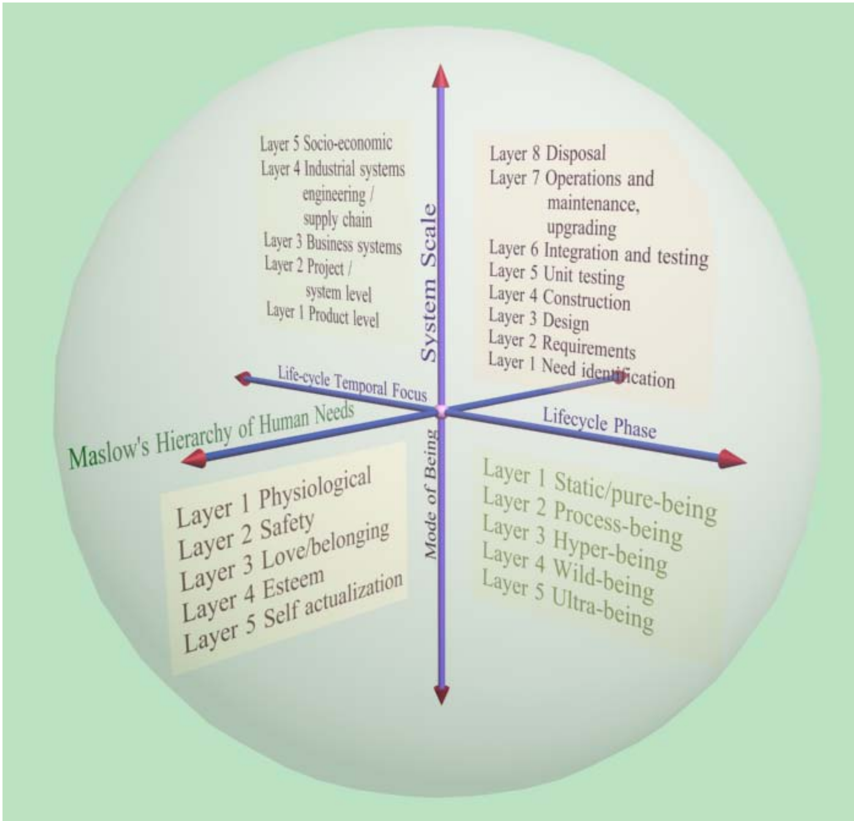

Figure 5. The four dimensions of systems engineering described in the ‘Solid Space’.

For example, the typical progress of economic development, which often occurs over a period of a generation or two, or even more, commences with people in a state of generalized poverty, in which a primary economic concern is sustenance of life, the concerns of survival. These occur at the lower end of Maslow’s hierarchy of human needs. Then as progress begins there is often a strong push for economic development, which emphasizes the functional concerns associated with satisfying survival needs. In this phase there is often significant consumption of resources and, unfortunately, often degradation of the physical and social environment. At some stage there is a sufficiently broadly based discontent with the amenity of life provided by this kind of economic development, and the kind of engineered products and infrastructure associated with it, along with sufficient wealth that people are willing to look beyond these basic needs, that the mood changes and a broad cross-section of people in society develop an interest in satisfying the higher layers of Maslow’s hierarchy of needs. When this happens there is a shift in the kinds of products consumers buy and the industrial conditions that workers and the community in general will tolerate.

Over historical time, the driving interests of all stakeholders in relation to the orientation and emphasis of the core of the model described above changes. Over generations the typical emphasis of project purpose changes from addressing survival to satisfying aesthetic and self-actualisation motives. Of course, specific projects, at all times are likely to have a broad range of purpose. For example, in a wealthy society many infrastructure projects will emphasize functional achievement of the required objectives, subject to satisfying sufficiently low deleterious impacts. However, projects interfacing directly with end users are likely to have a shift of emphasis to seeking greater refinement to address the higher levels of Maslow's hierarchy because the market has moved in that direction. The range of project purposes at any time is considerable. However, as the general trend moves through the stages of development described in the paragraph above, the design objectives of even predominantly functional projects will include increased interest in the impact of the product in society or on the environment.

In relation to specific projects, these things are captured in the four dimensions of the solid space illustrated in Figure 5. However the historical trends result in changes in what is considered important in relation to the capabilities and desired impact of the projects addressed. This creates a further hierarchical dimension which specifically relates to the historical time dimension, presented in Figure 6, which advances the work described in Peng and Hsu (2009).

Layer	Values reflected in the capabilities sought and designs considered acceptable	Historical context that illustrates when this emphasis may exist
1	Human Benefit – Direct functional capability emphasized	The capability sought is newly achievable (first of a kind type projects) and modest economic resources
2	Human Impact – Emphasis on both positive benefits and limiting deleterious human impacts	There is reasonable understanding of and concern about the product class and reasonable wealth
3	Natural Environment Impact – Add emphasis on the whole lifecycle impact on the physical environment	Concern about the impact of human activity on the environment and significant wealth available to enable action
4	Aesthetics	All more basic needs are satisfied and considerable wealth is available to pursue refinement in quality

Figure 6. "Human, Nature, Aesthetics" – Bud of a blooming multi-value infrastructure.

The historical time scale results in changes in the emphasis of product system development projects over time, in response to changes in the context in which the projects are done. The context is fundamentally driven by the community-wide perception of what is desirable, and the demand through the political and legal processes to advance through the layers of the fundamental drive dimension of the human, natural and aesthetic concerns. The community-wide perception of what is important depends on the general state of the physical, social, political and economic environment in which the community lives, and so is different in different places and times. This is a significant contributor to the diversity of solutions found acceptable for addressing apparently similar needs, and why solutions provided from an ethnic culture often have significant similarities.

The discussion here, showing the growth in interest in bigger and broader issues following from the grander aspirations associated with increased wealth has an apparent parallel with the five layers of Hitchins original work in this area. However, in the usual interpretation of Hitchins 5-layer model, based on formulation of the space around projects or programs to deliver particular capabilities the higher layers are considered as providing a context in which the work is to be done. The higher layers are conceived as changing, but relatively slowly, and in ways that are not explicitly associated with radical changes in perspective about what should be built or done. The fifth dimension introduced here, historical time, is long enough that significant changes in project objectives and aspiration occur, and therefore significantly impact the kind of product system which would be seen as an appropriate solution for a need.

This historical scale time is illustrated in Figure 7, which shows the evolution of interests and concerns related to what is perceived to be desirable to either enhance human life or to sustain the environment.

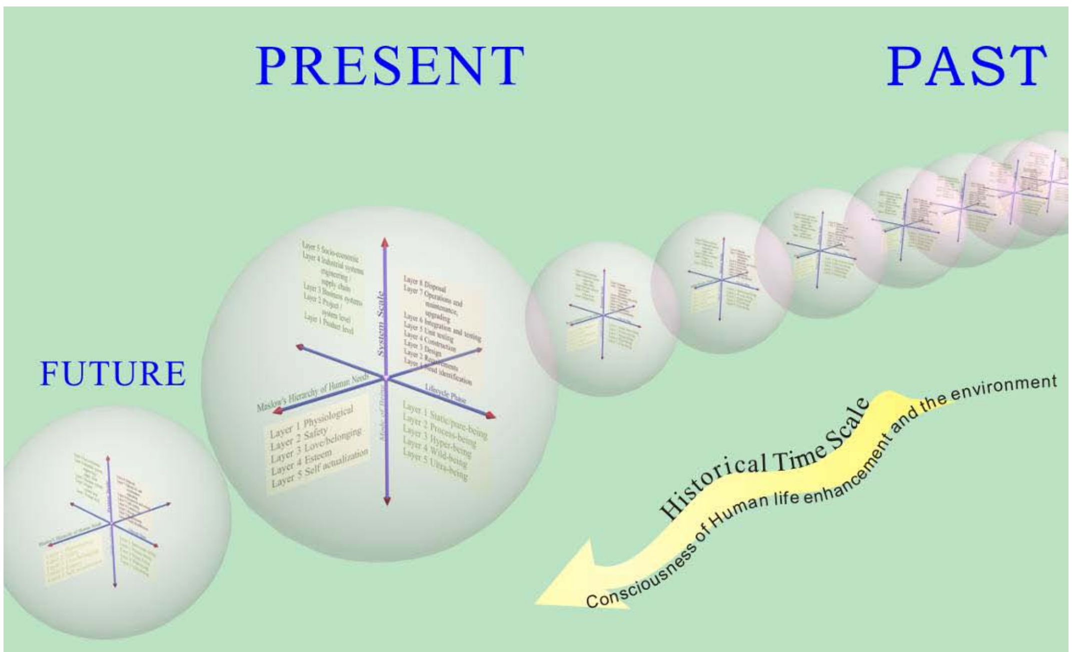

Figure 7. The repetitions of the 'Solid Space' of a single project that show the evolution of concerns impacting on different projects.

The Relation of the Dimensions

The dimensions described in this paper are quite different, describing significantly different aspects of the workspace of systems engineering. The scope dimension describes the scale of the matter of interest. This identifies whether the matter of interest is a small scale issue of how the product entity itself will be made while the large scale layers identify interest in the manner in which the product contributes to the broader context of either a system or some broader organizational or even national scale.

The life-cycle dimension identifies the life-cycle phases associated with particular kinds of systems engineering effort. This dimension is concerned with particular developments and projects, which pass through the lifecycle described.

The purpose dimension, built upon Maslow's hierarchy of human needs describes the intent of the project at the high level of what it is for, rather than the functional perspective of what it is meant to do. Understanding of the kind of human need which the product is intended to satisfy focuses the attention of the developers in an appropriate way to enable them to appropriately perceive what they are really trying to achieve. In contrast, focus on the functionality required results in attention being placed on the achievement of a technical challenge, implementing that functionality. The purpose dimension recognises the need for designers to understand the level of cultivation or refinement required in the deliverable to make it a desirable product, in contrast to the pure achievement of technical objectives. This dimension enables understanding of the distinction of product systems designed to perform functions as the sole or major objective, contrasted with products designed to enhance pleasure in life through refinement of the product that appeals to the connoisseurship of the owner or user or which may make the possession or use of the product a matter of status building.

The opposition, at the poles of this dimension, between things acquired to perform function, alone, and things acquired to enhance the higher order levels of interest to people indicates that part of the front end systems engineering work must involve discovery of the intention of the acquirer with respect to the effect of the thing for them.

The fourth, existential, dimension describes the kind of existence that the system has. The higher levels of the existential dimension describe the various kinds of unrealised existence that things have as we proceed from the initial dream that such-and-such would be a good idea through processes of seeking to define a possible entity which would instantiate that such-and-such and eventually through the engineering task of reducing it to pure-being material that can provide a service in the process-being mode which instantiates the original dream of the entity.

The dimensions are independent, referring to different aspects of the nature of engineered products, and their relation to the people who develop or acquire or use them. The two dimensions added to the HKM framework in this paper, the first based on Maslow's hierarchy which was introduced in Peng and Hsu (2009), and the second based on Palmer's recent work (2009) are significant enhancers of our understanding of systems engineering area of concern.

Palmer's work is clearly important in all traditional and potential future fields of application of systems engineering. This general applicability applies because Palmer's work was developed to provide a general understanding of the nature of design in systems engineering, and deliberately encompassed all the matters related to the project from the initial imagination through the conceptualization and the instantiation. These activities happen in any engineering development.

The work of Peng and Hsu is important in extending the conceptualization of systems engineering into the development of commercial products and product systems intended for direct deployment to consumers and society at large, as distinct from product systems that are intended for use in situations heavily emphasizing the functionality as have the traditional application domains of systems engineering, and even the extensions into domains such as infrastructure and transport. In these domains the product systems have a 'producer good' character, in which the function and performance take precedence over issues of refinement because systems are acquired as capital investments which deliver capability for action[2].

We summarize the view of systems engineering embedded in the theory about the systems engineering described by the dimensions we have discussed. Systems engineering transforms from the invisible idea of something through action to make something visible. The products of the systems engineering process simultaneously address all the characteristics of interest to produce product systems which satisfy the range of intentions for which they were developed. The range of important factors changes over time, and impacts the combinations of attributes needed in product systems.

Relation to Enterprise Architectures

Our discussion above has concerned systems engineering, which is the field motivating our work. Systems engineering is variously understood, in part as a result of the different perspectives of participants (Martin and Ferris 2008). The position presented by Martin and Ferris is that the type of responsibility that an individual has in the systems engineering field influences their understanding of the nature of systems and the role of systems engineering. In turn, this will influence the location of their work in the space described by the five dimensions. However, it is generally agreed that systems engineering should be used where the task is a project to develop a product system which incorporates a significant piece of technical development (Cook and Ferris 2007).

Organizations or enterprises are human intensive systems established for the purpose of providing some combination of goods and services. It is normal for the provision of the enterprise outputs to require the use of significant technological enabling products, which in turn need to be provided, most appropriately through project processes guided by sound systems engineering work.

By nature enterprises are intended to be enduring entities, for all the beneficial reasons that led to the development of the concept of the joint stock company during the early phase of the European trade with and colonisation of the world. The standard concerned with enterprise architectures, ISO 15704 (ISO/IEC 2005), identifies a range of concerns that must be addressed in the architecture of an enterprise, being: human; process; decision; economic; technology; mission-fulfilment; mission control; life-cycle; life history; stakeholder; viewpoint; model; model view; enterprise interoperation; verification and validation, orientations. These orientations reflect the broad range of concerns which must be addressed in the development of an appropriate enterprise architecture. The range of orientations describe specific concerns within the first four dimensions introduced above to describe systems engineering. The fifth dimension, related to historical time, is related to the adaptability of the enterprise that enables maintenance of the architecture to remain appropriate through time as the context changes, leading to changes in the nature of the concerns impacting on the situation.

While enterprise architecting is normally addressed by methods other than systems engineering the recognition that the concerns fall within the dimensions of systems engineering described in this paper is an indication of the likely completeness of the five dimensions, and that the five dimensions are not unreasonably narrowly applicable to systems engineering.

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[2] We acknowledge that even in these traditional application domains for systems engineering some acquisition decisions may be biased by individual desires to have certain kinds of equipment because that equipment fits the self-image that the acquiring decision maker wishes to bolster.

Conclusions

Our presentation of a five dimensional model of the systems engineering task and context provides a frame to understand the progression of the product system from the initial dream to instantiation, and situates it in a context of its social purpose in the life setting of the acquirer, along with its technical purpose and impact in that context and the life-cycle of the project and system. It also could provide the research and development team the foundational thinking underlying particular projects more fully that current traceability to needs methods and provide a tool for product development strategists to predict future directions with respect to innovation and green-technology.

This framework can be used as a the structure to guide all systems project work, by alerting the systems engineers and the managers who commission projects to the multiple dimensions of the impact of their work so that they develop solutions which are sound holistic solutions to the issues they address.

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