Dimensions of Understanding of Systems Engineering

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Outline

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Introduction to the subject matter

- This paper extends earlier work of Hitchins, Kasser and Massie and Peng and Hsu by adding three new dimensions to our understanding of the SE task
- Existing work included:
  - Hitchins 5-layer model of SE
  - Kasser and Massie's addition of project phases to Hitchins' model
  - Peng and Hsu's addition of Maslow's hierarchy on needs
- The new work presented:
  - An existential dimension based on Kent Palmer's work
  - An historical time dimension expressing inter-project changes

Purpose dimension

- Maslow's hierarchy concerns human needs which are important a certain stages of development
- SE concerns design of product systems to address needs
  - The target level of capability must be related to Maslow's hierarchy in order to specify a product which will satisfy the need for which it is developed

Purpose dimension

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

Purpose dimension

- Maslow's hierarchy is a psychological construct which influences perception of products according to the level in the hierarchy which they satisfy

Need type	Product emphasis
Self actualisation	Product provides complete refinement in all ways – desired by connoisseurs
Esteem	Product has 'luxury' status, provides status
Love/belonging	Product becomes a desired brand
Safety	Product function with reliability, safety, ergonomics etc.
Physiological	Product function (significant risk accepted)

Hitchins’ 5-layer model dimension

- Hitchins’ 5-layer model describes layers of scope of attention in systems engineering
- Entities at each layer contain multiple entities of the layer below
  - This model is useful to show the SE the context of their work

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

Project life cycle phase dimension

- Kasser and Massie extended Hitchins' 5-layer model by overlaying the phases of the project lifecycle on an orthogonal axis
  - This is useful because it can be used to show at which layer the emphasis of SE work is during each project phase
    - The relation of layers and project phases is instructive because it tends to follow a Vee

Project life cycle phase dimension

Layer	Title of layer
8	Disposal
7	Operations and maintenance, upgrading
6	Integration and testing
5	Unit testing
4	Construction
3	Design
2	Requirements
1	Need identification

Existential dimension

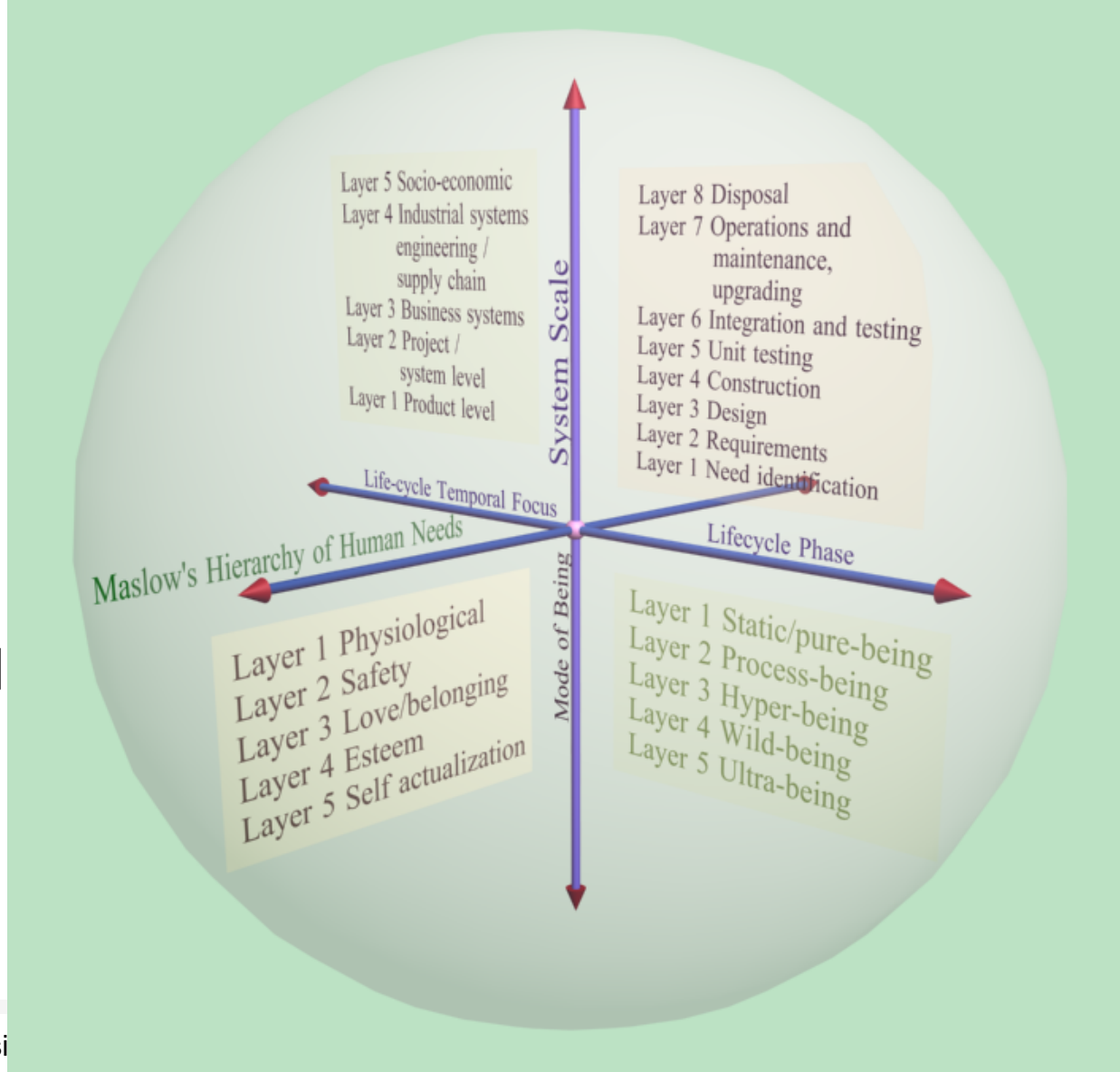
- This dimension relates to how we relate to what either exists or can be made or can be conceived

Existential dimension

Layer	Mode of Being	Explanation
5	Ultra-being	Distorted or separated – at this level the entity cannot be described as any particular set of capabilities. The entity exists only as a vague dream of a solution to ...
4	Wild-being	At this level there is the propensity – the possibilities offered by the properties of matter and the phenomena discovered by science. However, there is no tangible thing or representation of a tangible thing.
3	Hyper-being	The realm of possibility, that which can be made. This is the state of design ideas which have been proposed and are subject to analysis and developmental investigation
2	Process-being	The enablement provided by the product is in the foreground. Its material nature is not central
1	Static/pure being	The material is known as material with properties, but the behavior of the product is not in the foreground

Historical time dimension

- The four dimensions provide a method to understand the SE effort to address a particular need
- The above four dimensions tend to provide a static view of SE



Historical time dimension

- Between projects there are changes in:
  - What is needed
  - What is perceived as a suitable solution
  - The technical environment of deployment
  - The organizational or social environment of deployment
  - The economic capability of the acquirer
  - The expectation of stakeholders

Historical time dimension

- These changes between projects are small in projects commenced year to year
  - e.g. annual model updates for cars
- The changes are dramatic across generations
  - E.g. compare a 1950's car with today with respect to:
    - Performance; safety; reliability; style; technologies used; features and capabilities buyers value enough to pay for – even a classic 1950's car would obtain a small market if released as a new car today
- Recognizing this has led to the presentation of the idea of am 'historical time' dimension

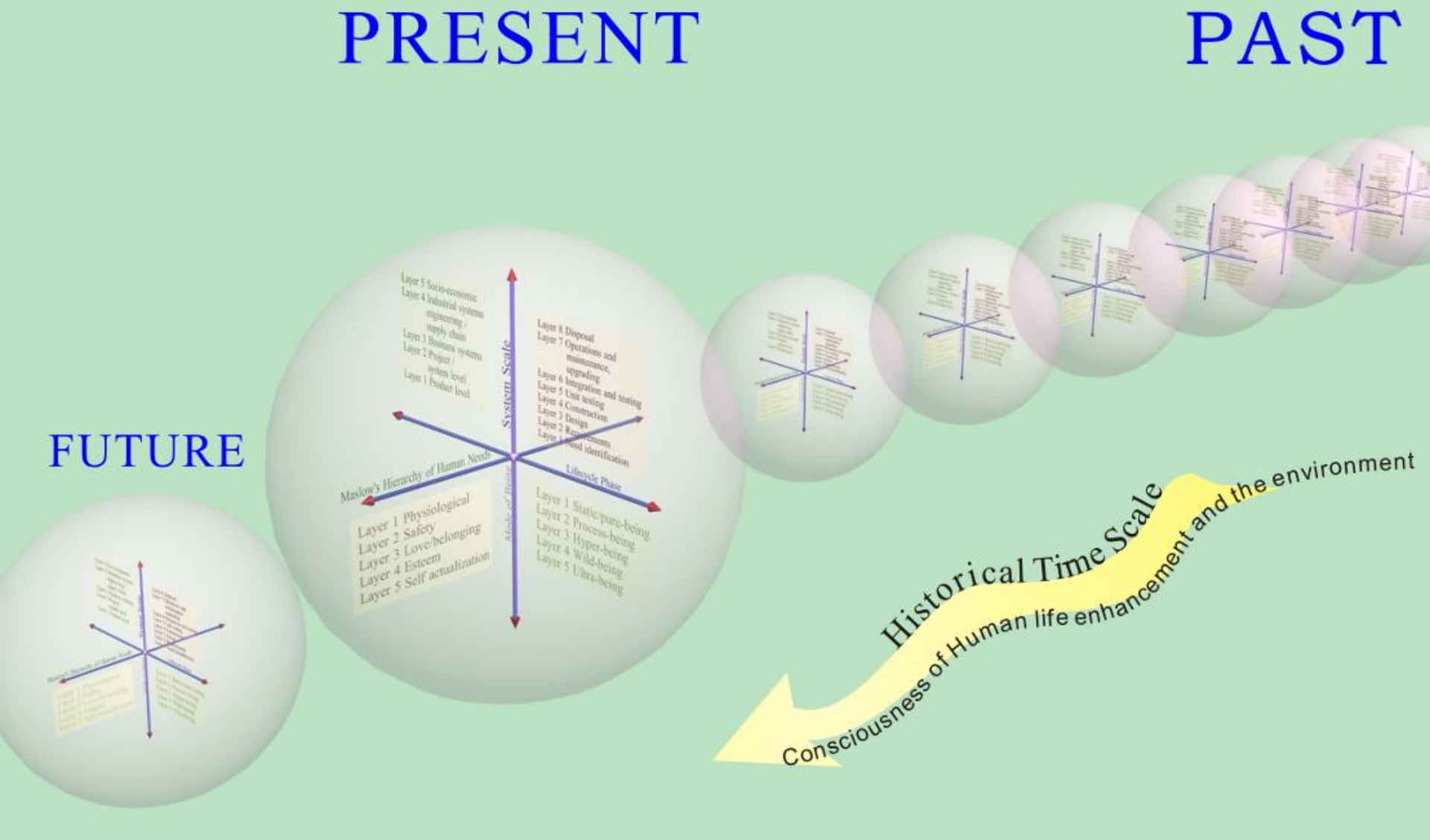
Historical time dimension

- In the historical time dimension there are many projects, each of which targets its specific need (defined relative to its temporal context)
- Result:
  - History spawns multiple ‘solid space balls’ – each representing different specific projects
  - The multiplicity of ‘solid space balls’ shows there is no eternal solution to a need because the need itself changes over time

Historical time dimension

Layer	Values reflected in expectations	Historical context
4	Aesthetics	All more basic needs are satisfied and considerable wealth is available to pursue refinement in quality
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
2	Human impact	Emphasis on benefits and deleterious effects. There is reasonable understanding of and concern about the product class and reasonable wealth
1	Human benefit	Functional capability emphasized. The capability sought is newly achievable and modest resources available

Historical time dimension



The relation of the dimensions

- The dimensions described in the paper are significantly different – orthogonal
- The dimensions draw attention to the range of interests and concerns of SE with respect to development of appropriate product systems
- Understanding of these dimensions can assist in identifying decisions based on attempts to satisfy unstated objectives
  - E.g. Checkland's analysis of the Concorde project as not primarily about building a fast plane – but rather a bout a political process of aligning the interests of England and France
  - Or recommendations for use of certain sub-systems which might bolster the image of the recommender
  - Etc.

The relation to enterprise architecture

- In most organizations the SE practiced is part of the whole scope of SE
  - This results from buyer/supplier boundaries; organizational purposes etc
- The dimensions can be used to understand the impact of the role of the organization on the practice of SE
- Understanding of the scope of work required within the organization is important for organizational design
  - Ensure the correct skills are available, and
  - Design appropriate workflows

Conclusion

- The five dimensional model provides understanding of SE as:
  - A means to design product systems which correctly identify the class of need they are to satisfy
  - A means to deal with matters at all scales of interest
  - A means to deal with the project activities related to developing the project through its various phases
  - A means to conceptualize the product in its various forms from dream to instantiation
  - A means to understand how the driving imperatives behind needs change over the time between projects
- The five dimensional framework provides a clear frame for understanding the nature and work of SE

Questions