SHIBAURA MOT DISCUSSION PAPER

芝浦工業大学大学院工学マネジメント研究科

ディスカッションペーパー

2010 IFSR Conversation Report: Towards Integrative Systems Engineering for Movement of People, Goods and Information

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Abstract

This report explains the year-round Systems Design Conversation process of Team 4 of the 2010 IFSR – Towards Integrative Systems Engineering for Movement of People, Goods and Information. The paper explores a hypothetical urban transportation problem as a basis for developing a more "systems rich" form of a systems engineering approach. Urban transportation is an ideal context to consider a more systemic form of systems engineering. Movement of people, goods and information should be viewed as one system. The paper identifies the considerations that would be reflected in the key phases of a typical systems engineering design process. We call this enhanced process "Integrative Systems Engineering".

要旨

本報告書は，国際システム・デザイン・カンバセーションにおける「ヒト，モノ，情報の移動についての統合的なシステム・エンジニアリング」チームの，準備段階からブレーンストーミングを経て結論にいたる過程とその結果の報告書である。本報告書では，仮想の都市交通問題を理想的なコンテキストとして，従来よりも一層システム思考を強めたシステム・エンジニアリング・アプローチを考える。本報告書は，そのようなデザイン過程で反映させるべき事柄を明らかにして「統合システム・エンジニアリング」と名づけた。

Keywords : Integrative systems engineering; movement of people, goods and information; conversation

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1. Introduction

This report explains the year-round Systems Design Conversation process of Team 4 of the 2010 IFSR (International Federation of Systems Research) Design Conversation (hereafter DC). DC is a year-round brainstorming process of a team, before, during, and after the on-site six-day-long Conversation in Pernegg, Austria. During the pre-DC phase, the team was formulated, decided on the topic to work on, and exchanged input papers. The six-day on-site Conversation, began with an intensive brainstorm on the topic. After DC, the team continued working on the topic and produced a final report. This paper summarizes the whole year-round DC.

We explored a hypothetical urban transportation problem as a basis for developing a more "systems rich" systems engineering approach. We believe that our chosen method of consideration of urban transportation represents a more systemic approach to a complex case study. Our brainstorm soon got us to realize that valuable distinction was to be gained by incorporating movement of information as part of the transport system as compared to the traditional view where information is used as a means to improve the transport of people and goods. In this sense, the systems boundary was extended and information was viewed both as a logistic which facilitates movement of goods and people, and information as a substitute for the movement of goods and people (like phone, fax, email). A classic commercial example is internet banking where the movement of cash is replaced by an information exchange. Another realization was how ICT (Information and Communication Technology) acts as a counterintuitive lever of change potentially increasing traffic flows – e.g., news of real-time powder snow falls invites more people to ski fields.

Frequently emphasis is given to a design methodology which brings "requisite variety" (Ashby[(1)]) through user-designers being involved in all aspects of the design of the exemplar improved urban transport system. The paper identifies the additional considerations that would be reflected in the key phases of a typical systems engineering design process. We call this enhanced process "Integrative Systems Engineering" (ISE).

2. 2010 IFSR Systems Design Conversation

Bela H. Banathy and others organized the first design conversation in 1982 in Fuschl-am-see in Austria, and 2010 DC is its continuation. (Banathy [(2)]) Banathy describes the reasons for initiating a week-long Fuschl Conversation, as an alternative to an academic conference that mainly consists of presentations and Q&As: "Arranged into groups, we asked the question: How can we use the insights gained from systems science for the improvement of the human conditions?" (Ibid., p. 219) "(D)ialogue is not aimed to pursue a specific task, such as the design of a new system. It aims to create a common frame of reference, a shared worldview among the parties of the dialogue." (Ibid., p. 214) "So what is the purpose of design conversation? Does design conversation aim at discovering attributes/manifestations of the group's shared view of the world? Or should it create a practical, action-oriented plan? ... (I)n a design-oriented design conversation instead of an either/or choice, both aims should be chosen." (Ibid., p. 221)

3. Phase 1: Pre-Conversation: Topic-Formulation

During the pre-conversation team formation stage Yoshihide Horiuchi (YH) had suggested that the systems

engineering domain be explored in the context of "a new urban, personal door-to-door transportation system: a demand articulation for city dwellers", in that this would provide a focus as well as investigating a key problem affecting many nations. However, the input papers from the group members strongly emphasized the need to consider and develop a method of applying systems thinking to similar problems. The intent was to cover both the general and specific issues surrounding the introduction of creative new technology including ICT, and the issue of matching demand to supply with the aim of allowing consumers to have a greater say in the introduction of new technology. Essential points of the input papers are shown below. For the references in the input papers, consult Dyer et al. [9].

3.1 Input Paper by Gordon Dyer, December, 2009

As I interpret our remit, it centers on considering how new technology can be developed "systemically" in that:

(1) It is more appropriately matched to the needs that the consumer society collectively define - in contrast to a current process where the producer/supplier introduces new technology as soon as they can, based often on their drive for profit and limited consumer needs research. .

(2) Significant new technology should always be subject to impact assessment.

(3) Impact assessment should also cover the likely social impact on the consumers.

3.2 Input Paper by Yoshihide Horiuchi, Sadeharu Ishida, and Mitsutoshi Kawasaki, January, 2010.

(1) Research on Transportation and Vehicle Research and Development in Japan

Most of them are about hardware. There is hardly any R&D in the field of social systems including transportation. The research category of social systems design with transportation does not exist. Nor is anybody submitting a R&D proposal in that field.

(2) New Research Field of How to Shrink Cities for Positive Results. : Cities are getting smaller worldwide, with only a few exceptions such as Minneapolis and Chicago. We should stop expansionism for cities. Instead we need to think how to shrink a city and benefit its dwellers. Boston and San Francisco are good examples of successfully shrinking cities.

Conclusion from these two points above

When we design a new transportation system for a city.

(1) We need to find out successful examples of administration and universities conducting R&D of a social system including transportation rather than just transportation hardware.

(2) Combining points 1 and 2 above, our can discuss a new social systems design including transportation for shrinking cities, which is a new R&D topic.

3.3 Input Paper by Gerhard Chroust, February, 2010

What Can Systems Thinking Contribute?

There are several areas where system thinking can have a beneficial effect on the engineering of a system:

• Requirements definition (what to *expect or wish* from the system),

• Specification (what should the system *provide from a user's point of view)*

• Design (how should the system be *technically architectured*),

• Implementation (how is the system *built in detail*),

• Operation (how does the system *behave* when actually used – especially in the very early stages) (Requirement and

Design) some basic architectural decisions must be made) which are very difficult to be reverted later.

• Who will be the users - what different interests do they have (business man, house wives with children, handicapped, city administration, green groups, taxi drivers, ...)

• identify conflicts by applying SSM (Checkland [3])

• solving conflicts by WIN-WIN

"Systemic thinking will be helpful in guiding technical development to be socially and environmentally compatible and to encourage their sustainability." It can also at the same time help to solve some of our societal problems.

3.4 Input Paper by Jed Jones, March, 2010

As YH has stated, we are not transportation engineers or specialists. Rather, we are systems designers. To that end, our goal should not be to design a personal transportation system per se. Instead, we should think about, dialogue about, and design the: structure and environment; team formation requirements and process; and, design process. Therefore, I propose the following triggering questions for our team:

1. Which types of people should be included in the new design team?
2. How would we describe idealized system design to them? Note, that without properly being able to describe the goals, methods and processes of Idealized Systems Design, would-be participants would likely mistake the project as a mere planning or engineering project.
3. What would be the ideal design environment for this new team? Which types of design processes should be put in place to facilitate the design process?
4. Which conditions can the design team use to determine whether their effort was a success or a failure?

3.5 Input Paper by Leonie Solomons, March, 2010

On the specific, the very scope of the vision itself opens the question to: (1) Whether transport is of the entire physical body of a person (or object) or whether a facet of the physical body will suffice. Here I refer to voice and data communication. (2) The obsolescence factor of the current transport avenues and/or the relationship balance between the existing and the new transport vision.

On the general, what enamors me is how system thinking can enable me to contribute valuably to this conversation, particularly if the rest of the team is similarly non-technically and/or generalist orientated? This opens our conversation to consider *process* as distinct from focusing on *content of applicat*ion, albeit that both are interrelated. There are different types of large group intervention processes so that a diversity of people can come into conversation to discuss from a diversity of perspectives, experience and expertise. Modeling and simulation' which would be relevant when seeking to evaluate different innovative ideas.

4. Phase 2: On-Site Conversation: Initial Exploration

Our initial exploration of the topic was focused on scoping the area, with particular concern on purpose and boundary. We also discussed the process of our conversation and the output we desired. We decided to capture our initial thoughts on a flipchart laid horizontally on the table so as not to ascribe any apparent authority to the person standing at the chart. All members were invited to write notes on the flip chart.

5. Phase 3. On-Site Conversation: Steps towards Our Focus of Inquiry

The questions tabled related to the scope were:

(1) Should we explore the introduction of new technology as a general problem, or focus on urban transport as an exemplar? The view was that the latter would provide markers for the general area.

(2) Should we consider urban transportation in a developed or developing country, or should it be a specific city? We were inclined to consider a city in a generic term, with Vienna and its Mayor often mentioned only as an example and as a possible focus of discussion of a Problem champion, and Stakeholders of a city.

(3) What should be the timeframe of consideration?

(4) Was our initial trigger the correct starting point?

(5) What to transport? We decided to take a new, broader approach, by considering People, Goods *and Information*.

6. Phase 4. Development of a Systems Design for a "Problem Champion" in a Transportation Context: ICT and Its Potential Impacts on Traffic Loads

ICT was a potential vital lever for change. It obviously eliminates the need for some travelling, especially for acquiring information somewhere. There is, however, also a danger that ICT and telecommuting could well result in the generation of more travel than it eliminates. Experience from Tokyo suggested that the current transportation network was not, in any case, used to best efficiency. We believe that relatively little data on the purposes of travelers is known and such data could be beneficial for modeling and determining the effects of potential changes.

To see whether these issues could be examined through a light application of a Soft Systems Methodology (SSM) (Checkland[3]), we drew some simple systems maps, seeing whether there was a feasible or desirable system for change, or a root definition of a relevant system.

6.1 Entry Point for Further Discussion

Solomons suggested that in order to provide an entry point for discussion each team member should write down what for them was a key question they wanted the answer to. The points that arose were:

- How to change attitude and culture towards public transport?
- How to improve the effectiveness of public transport to overcome the convenience of the car?
- How to deal with relationships between boundaries e.g. city/town planning and health management systems?
- What role can ICT and information movement play in reducing movement of people and goods?
- What is the nature of the movement of information in the broader sense?

Leverage points in general were agreed as key considerations – the key questions are what to change, and why, and what are the criteria for choice? We then constructed a systems influence diagram to cover these points (see diagram in Fig. 1 below). As we continued our discussion we found ourselves taking a hypothetical position of submitting a proposal for the re-design of movement of people, goods and information to the Mayor of Vienna, as the problem champion. Hence, our focus at that point was 2010 with the current and emerging

7. Phase 5 Emergence of a New Perspective of Integrative Systems Engineering

At this point we were better placed to design a systems-based toolkit to help a problem champion deal with their specific case/context, and formulated the following draft statement to the full Pernegg conversation group: *We*

seek to Design a system of inquiry for How to design a system which will help a problem champion reduce/solve/ameliorate/improve the movement of people, goods, and information.

8. Phase 6: Development of a Systems Inquiry Design for a" Problem Champion"

8.1 Reflections Relating to an Initial Dialogue with the Problem Champion

As a precursor to designing a "design system" we discussed how to approach a typical problem champion and how to open the dialogue both in the context of process to be adopted and the content/boundary of the investigation. We felt that three areas were particularly important:

- The need to ascertain whether the "consultancy" design, would be primarily "content" based ("what"), or "process" based ("how"); and which of these will predominate.
- The need to include diversity of opinion into the stakeholder group.
- The need to evaluate any methodology process.

8.2 Diversity of Stakeholder Group

The stakeholder group should include all the normal representation that would be expected in an engineering project, e.g. technical specialists, political and financial experts. But it must also include "end-users" i.e., those who use the current system, those affected by the system, and those excluded or otherwise disadvantaged, by the current system. The project champion might have his/her own views or have been given views by an internal advisor. Thus it would be important to stress the value of involving the "user-designer" in terms of several dimensions:

Ethical and Philosophical level – it is unethical to design for someone else. The designers of a system should include those who use the system or who are affected by the system (Banathy, 1996).

Usability level – there is no point in designing a system which no one uses.

Political level – involving local citizens in decisions on a key project could be a vote winner.

The crucial point will be the clarification of the initial boundary for stakeholders.

- both in the sense of "law of diminishing returns" and group management. Chroust proposed that this be restated as "law of diminishing contribution", and that when this point is reached we have "closure" (in a logical sense) around the stakeholder core discussion group. Additionally, opinion-seeking surveys might be useful for specific types of questions. Diagram below (IEMA, 2002) provides helpful ideas on participation levels and selection of techniques. In view of today's possibilities of ICT it should be augmented by electronic conferencing systems.

8.3 Evaluation

The interactive participation of many stakeholders is important, especially in the very early phases of the conceptualization of a system one needs wide discussion with potential stakeholders.

8.4 Search for Methodology

Following ISO 15288, a standard for developing technical software systems, the activities can be depicted as in Figure 3 below. The diagram only shows the logical order of the tasks, but does not imply a specific sequence in which parts of these tasks will be performed. The more innovative and conceptually creative a system is, the more important (and time and effort!) are the early phases, especially with respect to understanding what the system should be designed for. ISO 15288 distinguishes two 'start-up' phases: 'Stakeholder Requirements Definitions' where stakeholders set down wishes and, 'Requirements Analysis' where a single set of feasible and consistent

requirements is created. This is similar to Soft Systems Methodology, SSM, (Checkland [3]) where a 'rich picture' is drawn containing all available information, including non-technical issues like personal motivations, animosities, power plays etc.

Figure 3 also indicates the lessening influence of creativity with respect to the whole system in favor of more attention to technical details and the need for performing quality assurance activities in parallel. Initially the validation actions are concerned with the question "Is this the product we need?' Later verification activities will pose the question "Is the system built in the right way?" Various methods are available there. In our discussions only the very early phases of the design process were of focal interest. We approached the development of a systems design by pooling descriptions and ideas relating to different methodologies with which we were familiar. We concluded that no single systems methodology would provide the complete answer But many individual techniques exist, e.g. Rich Pictures (Checkland [3]).

It is important to stress the differences between our suggested Integrative Systems Engineering (ISE) and current SE-practice - refer Figure 4. The column on the left shows the real world that exists or is changed by development of new, or enhanced, practice or technology.

The right hand side takes us into the world of modeling when a change to the real world is considered by using any problem solving method.

The middle column shows a typical systems engineering methodology. The methodology is highly iterative. The right hand column show those aspects which are – in our opinion – key to a systemic approach and therefore justify the name "Integrated Systems Engineering" (ISE) because it considers systemic requirements over and above those simply involved in any classical design process (cf. ISO 15288). See below for more details.

As a first step modeling takes place either through observation and scientific measurements, or sampling of comment and opinions. Such gathering of data, such modeling, is inevitably only a partial reflection of the real world. The remaining stages of the methodology take place in the modeling world, until after a decision on the course of action to take, implementation and testing takes place in the real world. A review of the impact of the change in the real world, and measurement of the performance of the new technology, then follows, with an evaluation of the methodology process.

9. Phase 7: Integrated Systems Engineering (ISE) - Summary of Differences

Our first thoughts on emerging technology and projects related to an integrative transportation system. Though both approaches involve systems engineering, an urban transportation project is very different to developing a new fighter aircraft. This is because it is the public who regularly use the current system who are the experts in that they are likely to be best placed to comment on its shortfalls, be able to identify needs for information which could improve the system, and be able to assess how proposals for new technology may offer benefits and disadvantages. It is for these reasons that a widened stakeholder group is so important.

We believe that our consideration of urban transportation represents a more systemic approach to a complex case study. Another intention of ours is that rather than just considering the problem of transporting people and goods, we consider the movement /transporting of people, goods and information as one system. Traditionally information is used as means to improve the transport of people and goods, but not considered as item in its own rights, thus,

limiting the scope of the systems boundary.

9.1 Problem Formulation/Objectives and Criteria Phases

More attention to diversity of views and requisite variety:

• Extended boundary in both: (1) coverage of investigation to include needs for movement of information, and, (2) a widened boundary for consultation with various stakeholder groups.

• A major attempt to incorporate the user-designer concept, and participative "democracy" into the project process.

We would aim to achieve a "necessary and sufficient" level of diversity in the group until the "point of diminishing contribution" was evident and thus closure on participation could be agreed upon.

It would be our intention to exploit the potential of ICT in terms of the speed of communication and interaction between stakeholders as much as possible which will also be beneficial in addressing the issue of complexity.

9.2 Options Generation and Evaluation Phases

As a wider group of stakeholders is involved, the goals/objectives/criteria will have been set with the capability to understand repercussions of options considered across a wider boundary. While the same range of creativity techniques would be used, a major advantage is that ideas generated would be related to a wider boundary. The same advantage applies to the identification of constraints and the evaluation of options. LS commented that using meta-level criteria such as those suggested by Vester would be helpful in evaluating the process. These include to what extent double–loop learning will emerge as the design process develops, and whether a structure exists which could capitalize on the learning. Chroust commented that designing a new process/methodology is not enough; it has to be introduced to the stakeholders, often not an easy task. Once established one has to observe with what competence the processes are actually enacted. From the field of software engineering a wealth of evaluation methods for assessing the capability of an organization to perform a given predefined process. This is one of the indicators of an organization's capability to produce quality product (or solutions) in the future, in our case a reasonable, well balanced system. and thus acceptable to the users.

9.3 Thoughts on Emerging Technology

Largely due to lack of time, but also due to the Team's technical expertise, most of conversation was focused on systems thinking around the issue of urban transportation rather than the potential of any specific emerging technology. However, we noted that in some urban contexts like Vienna, the two-wheeled Segway, and its four-wheeled development (Segway Centaur [7]), could have a useful role.

10. Conclusions of Conversation: Our Journey Continues

Urban transportation is an ideal context to consider a more systemic form of systems engineering. Firstly, this is because movement of information, which is usually seen as means to improve the transport of people and goods (in the sense of "logistics"), is itself a significant matter to consider. Thus the movement of people, goods and information should be viewed as one system. Urban transportation is also an ideal context to begin to develop a systems engineering approach which is more systems rich, as it offers the chance to incorporate user-views and the underlying 'WHAT' in design change. These users, along with others affected by the system or excluded by the current system should be an important part of the stakeholder group, to provide crucial diversity and requisite variety. These characteristics, along with additional methods of process evaluation which we have suggested,

justified to the name of this enhanced approach: Integrative Systems Engineering (ISE).

11. Reflection on DC by Sadaharu Ishida, First Time DC Participant

As I work in a multinational company, I am used to multinational meetings, but not DC.

I focused on following the DC flow. So many opinions came up in the DC. In a company meeting I can anticipate who will say what. But not in DC. Hence, it needed efforts to follow DC. Unlike my company which is based on the American culture, in this group, a topic which I thought was already resolved came back again and again. This amazed me. As DC participants have quite diverse backgrounds and experiences, I enjoyed the whole six-day experience on and of DC. In the final meeting, I made a presentation on my first DC. Since I could not expect tacit, common framework among the DC participants unlike within my company, this presentation was an interesting, new experience. I would recommend people this DC for experiencing thoughts and conversation patterns of people with various backgrounds.

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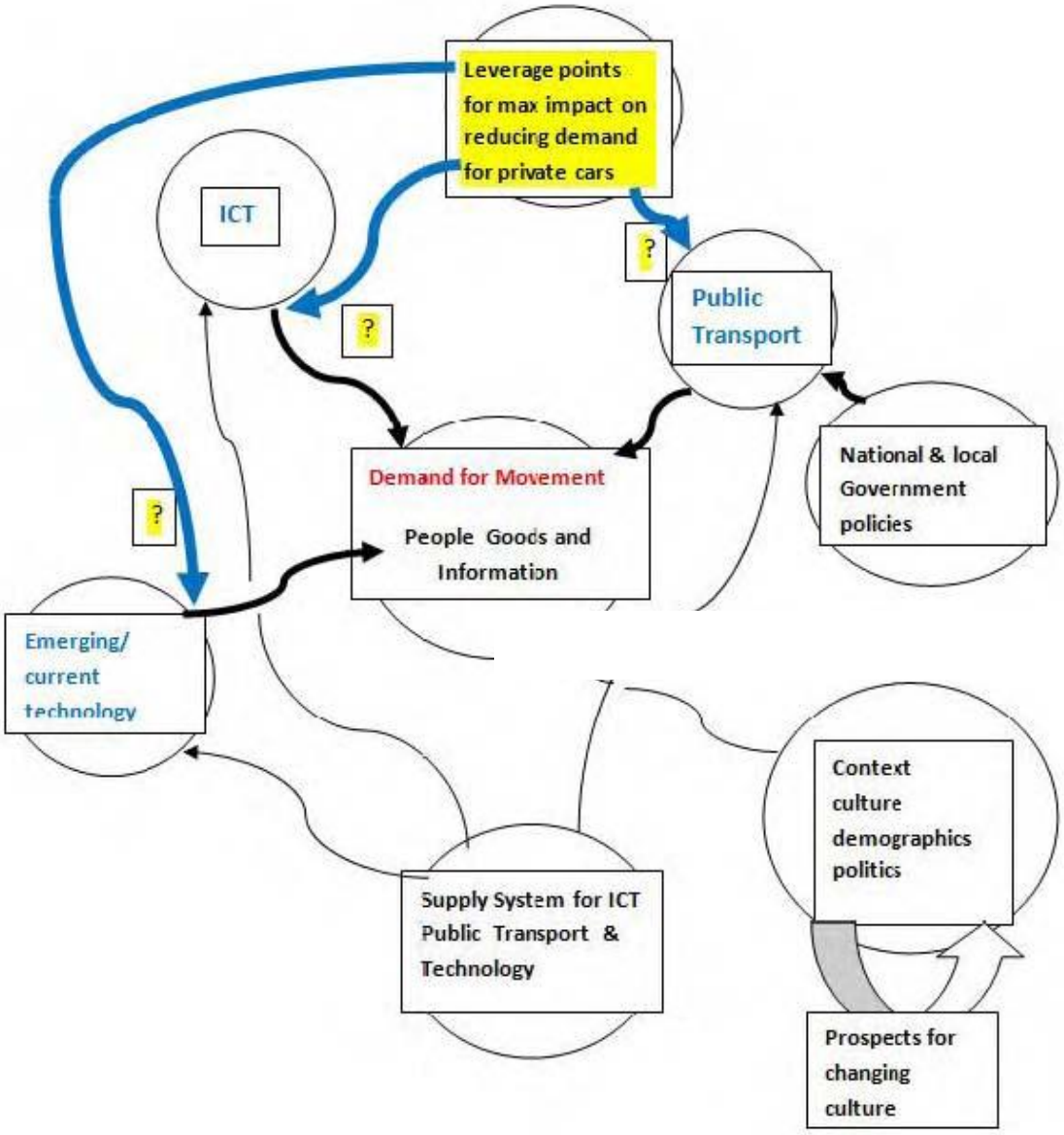

Figure 1. Influence Diagram on Demand for Management

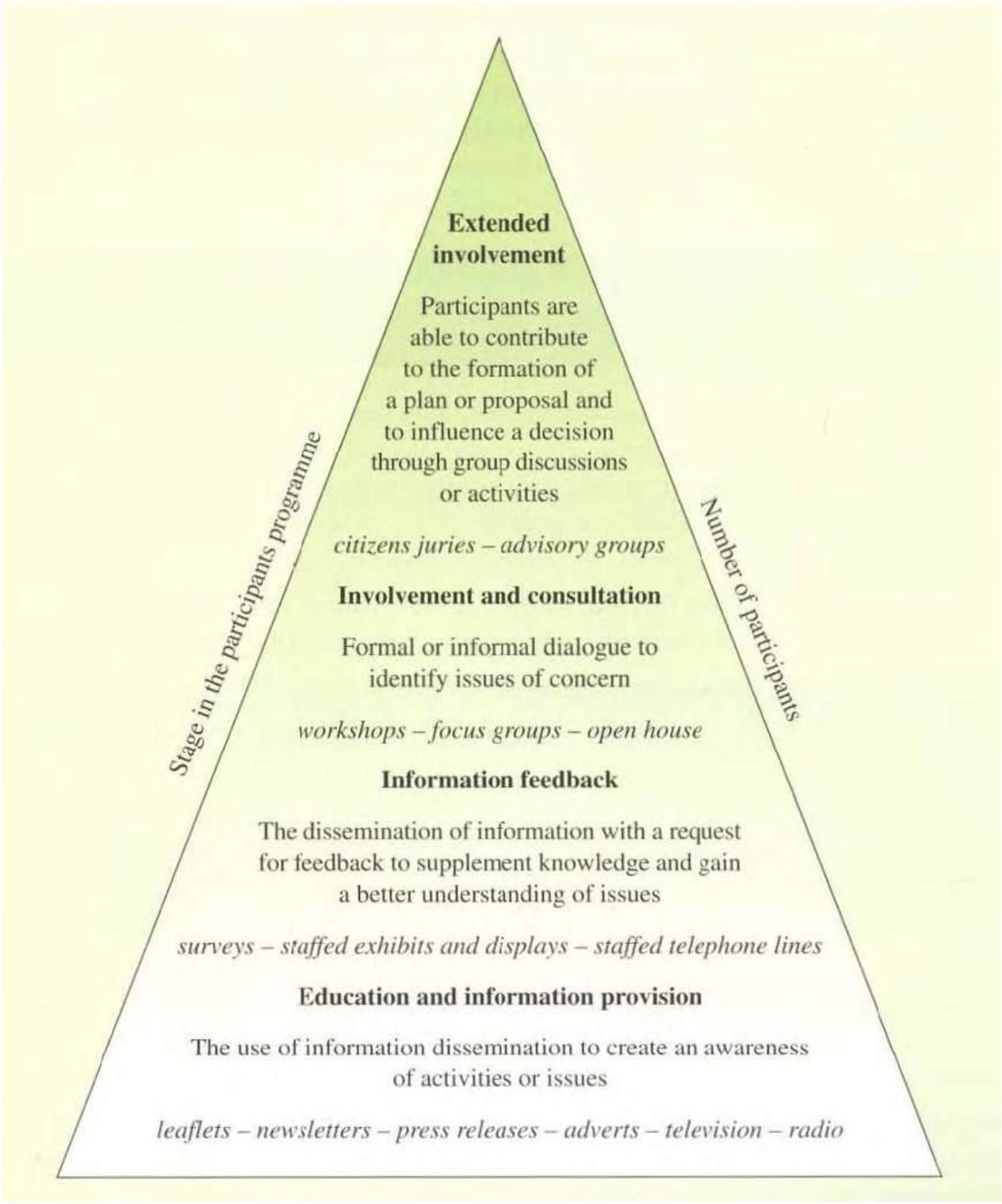

Figure 2. Levels of Participation, Technologies and Factors Influencing the Selection of Techniques

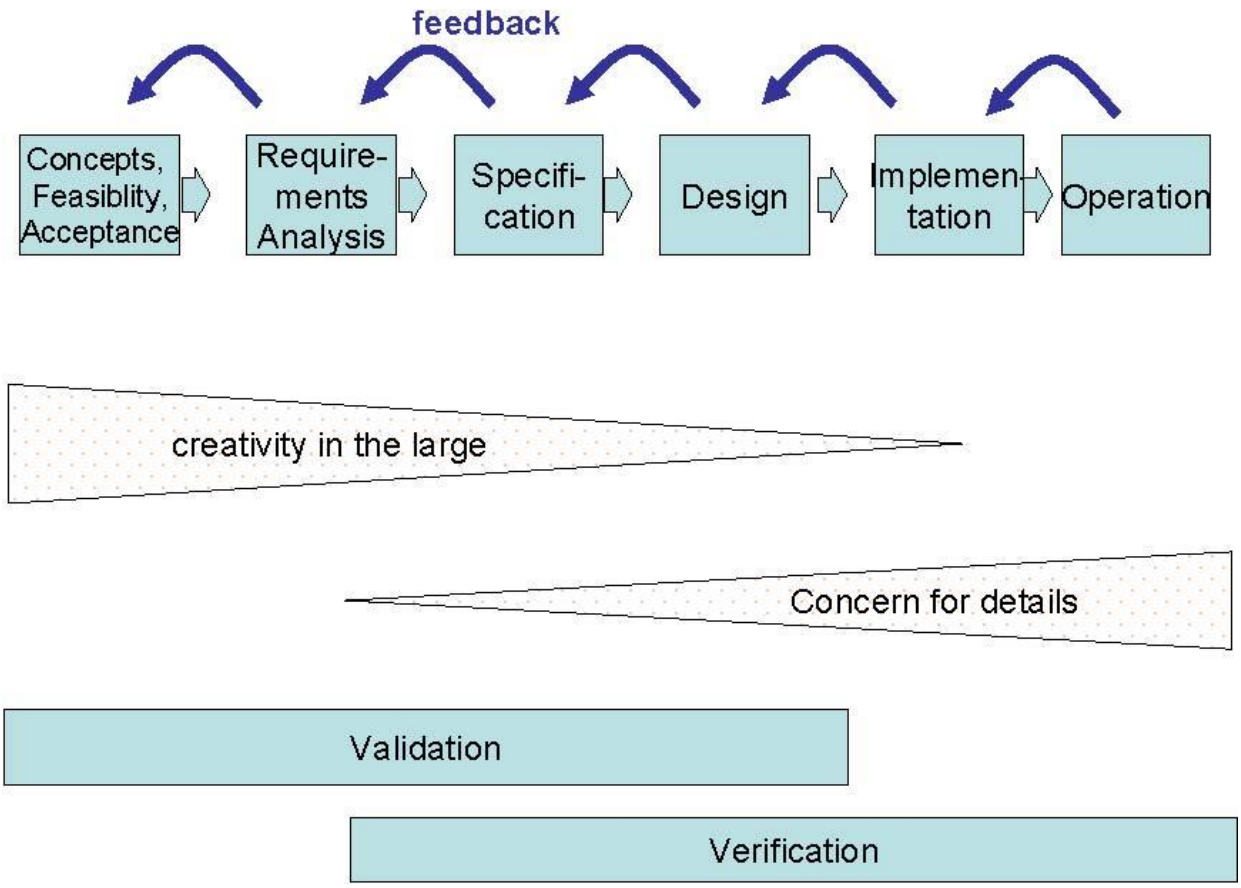

Figure 3. Basic Design Cycle

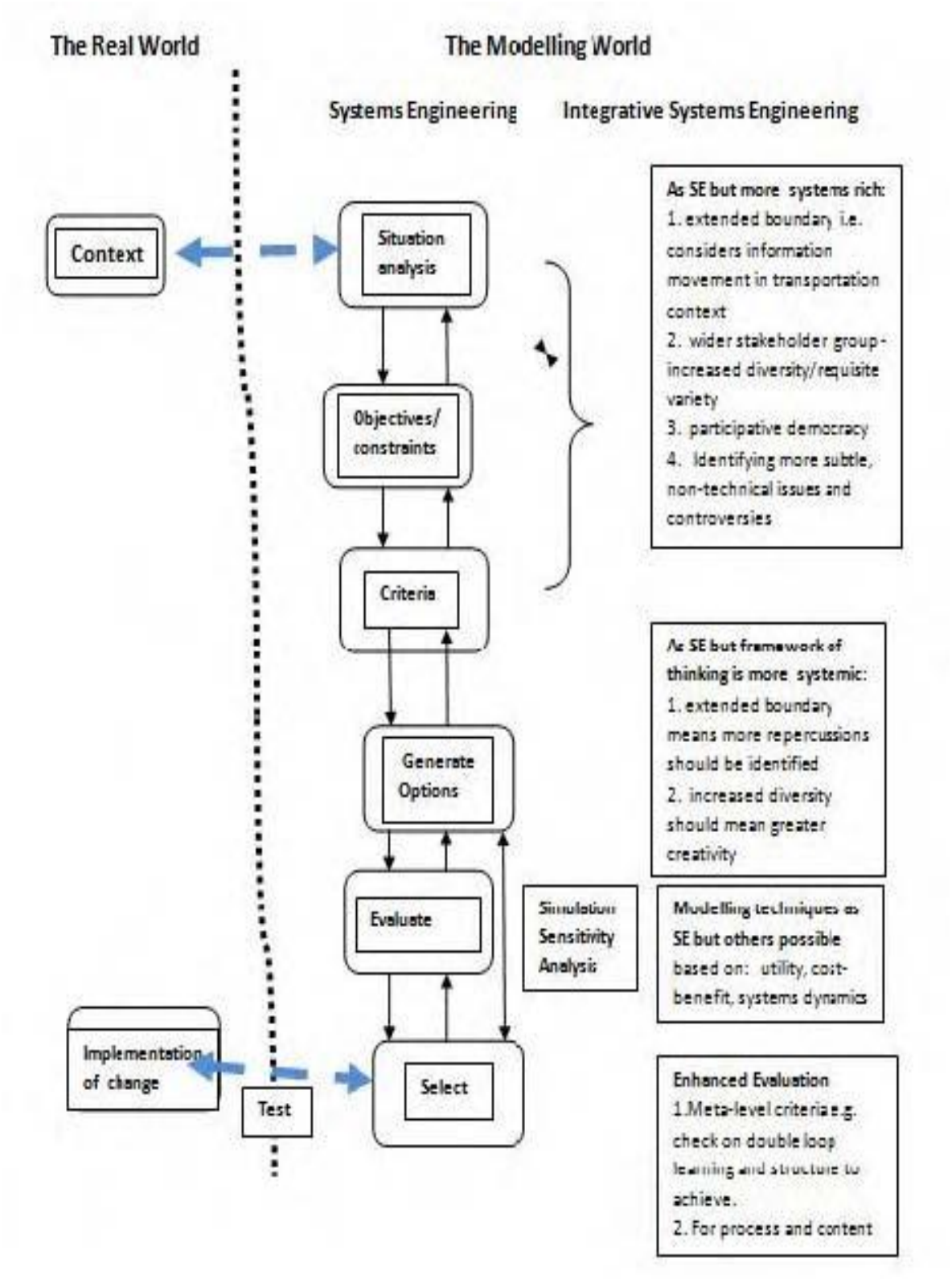

Figure 4. Systems Engineering and Integrated Systems Engineering