System Engineering Management Plan (SEMP)
DOES ONE SIZE FIT ALL?

Moderator: *Dr. A. Zonnenshain, RAFAEL*
Panelists: *N. Malotaux, N.R. Malotaux - Consultancy*
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Abstract:

One of the managerial and professional tools of the systems engineers in a project is the Systems Engineering Management Plan (SEMP). According to the INCOSE Systems Engineering Handbook, the SEMP is the top-level plan for managing the Systems Engineering effort. The SEMP defines how the project will be organized, structured, and conducted and how the total engineering process will be controlled to provide a system that meets stakeholder requirements. The Handbook guides projects to tailor the SEMP to fit project, customer, or company standards.
There are several procedures and templates for the SEMP. But in many organizations, companies and projects we find SEMPs that are not tailored for the project needs and goals and are not presenting specific and effective SE efforts to cope with the real project risks. It appears that many organizations believe that one SEMP size fits all projects, and work effectively from that belief.
This panel will discuss the application and tailoring of the SEMP to different domains; how to make it effective. In particular, the panel will consider the following questions and dilemmas:

- How is the SEMP different than the actual planning?
- What are the special characteristics of a SEMP for developing:
  - Complex Systems?
  - Systems with high Technology Uncertainty?
  - Systems with high Novelty and Innovation?
  - Systems at a fast pace, or for Agile development?
- How to integrate effectively the SEMP into the project and system development planning and execution?
- How to integrate effectively the SEMP into evolutionary processes?
- How to deal with the most important requirement-time?

Can an effective SEMP contribute to the success of the project?

Biographies:

Moderator:

Dr. A Zonnenshain is currently the Senior Associate Researcher at RAFAEL Advanced Defense Systems Ltd., Israel. Dr. Zonnenshain has a Ph.D. in Systems Engineering from the University of Arizona, Tuscon. Formerly, Dr. Zonnenshain held several major positions in the quality and systems engineering area:

- Director for Quality & Productivity at RAFAEL
- Director of the Quality of Excellence Center, in the Prime Minister's Office
- Director of Quality & Certification Department, in the Standardization Institute of Israel
- The first President of the World Quality Council (WQC)
- Director of Systems Department
- Deputy for Operations, Ordnance Systems at RAFAEL
- President of INCOSE_IL

Dr. Zonnenshain is an active member of the Israel Society for Quality (ISQ). He is the leader of the assessment team for the National Quality Award for Industry. He is also the Chairman of the Standardization Committee for Management & Quality. Dr. Zonnenshain is active in the community as the Chairman of the Steering Committee of RAFAEL for Social Responsibility. Dr. Zonnenshain is an Associate Professor at the TechnioñIsrael Institute of Technology. He guides students studying for advanced degrees in Quality, Management and Systems Engineering.

Panelists:

Niels Malotaux is an independent Project Coach specializing in optimizing project performance. He has over 30 years experience in designing electronic hardware and software systems, at Delft University, in the Dutch Army, at Philips Electronics and 20 years leading his own systems design company. Since 1998 he devotes his expertise to helping projects to deliver Quality On Time: delivering what the customer needs, when he needs it, to enable customer success. To this effect, Niels developed an approach for effectively teaching Evolutionary Project Management (Evo) Methods, Requirements Engineering, and Review and Inspection techniques. Since 2001, he taught and coached some 100 projects in 25+ organizations in the Netherlands, Belgium, Germany, India, Ireland, Israel, Japan, Romania, South Africa and the US, which led to a wealth of experience in which approaches work better and which work less in practice.

Mr. Eric Honour, CSEMP has been in international leadership of the engineering of systems for a dozen years, part of a 39-year career of complex systems development and operation. His energetic and informative presentation style actively involves participants. He was the founding Chair of the INCOSE (International Council on Systems Engineering) Technical Board in 1994, was elected to INCOSE President for 1997, and served as Director of the Systems Engineering Center of Excellence (SECOE). He was selected in 2000 for Who's Who in Science and Technology and in 2004 as an INCOSE Founder. He is on the editorial board for *Systems Engineering*. He has been a systems engineer, engineering manager, and program manager at Harris Information Systems, E-Systems Melpar, and Singer Link, preceded by nine years as a US Naval Officer flying P-3 aircraft. He has led or contributed to the development of 17 major systems, including the Air Combat Maneuvering Instrumentation systems, the Battle Group Passive Horizon Extension System, the National Crime Information Center 2000, and the DDC1200 Digital Zone Control system for heating and air conditioning. Mr. Honour now heads Honourcode, Inc., a consulting firm offering effective methods in the development of system products. Mr. Honour has a BSSE (Systems Engineering) from the US Naval Academy, MSEE from the Naval Postgraduate School, and is a doctoral candidate at the University of South Australia.

During the panel presentation, Mr, Honour intends to present the following thoughts in a provocative way that leaves room for significant discussion by the panel and the audience.

Joseph Kasser has been a practicing systems engineer for 35+ years and an academic for about 10 years. He is an INCOSE Fellow, the author of "A Framework for Understanding Systems Engineering" and "Applying Total Quality Management to Systems Engineering" and many INCOSE symposia papers. He is a recipient of NASA's Manned Space Flight Awareness Award (Silver Snoopy) for quality and technical excellence for performing and directing systems engineering and other awards. He holds a Doctor of Science in Engineering Management from The George Washington University, and is a Certified Manager.
He has also served as President of INCOSE Australia and Region VI Representative to the INCOSE Member Board. He gave up his positions as a Deputy Director and DSTO Associate Research Professor at the Systems Engineering and Evaluation Centre at the University of South Australia in early 2007 to move back to the UK to develop the world's first immersion course in systems engineering as a Leverhulme Visiting Professor at Cranfield University. He is currently a principal at the Right Requirement Ltd. and a Visiting Associate Professor at the National University of Singapore.

Uzi Orion is the Deputy Manager of the R&D division and Chief Systems Engineer at ELBIT SYSTEMS Electro-Optics - ELOP, located in Ness Ziona, Israel. ELOP is a leading manufacturer of military Electro-optics equipment.

Mr. Orion holds a B.Sc.EE degree (summa cum laude) from Ben Gurion University in Be'er-Sheva, Israel**.**
Mr. Orion has a vast experience in many engineering fields, including video processing & communication for the Israeli Air Force, development of advanced military communication instruments for Motorola Israel. He has held a variety of functions at ELOP, including establishment and development of a world class level technical specialty groups, leading of professional groups, management of military Electro-Optics projects including Laser systems, fire-control systems for tanks,

advanced displays, and space systems, as well as managing the East European marketing desk and many other positions.
Mr. Orion is the President of the Israeli Society of Systems Engineers INCOSE_IL.
Mr. Uzi Orion intends to talk and discuss how to increase the effectivity of the SEMP Document.

Mrs. Michal Shabaty is working in Rafael Advanced Defense Systems as a planning and control manager in a manufacturing plant. She is responsible for integration analysis of the plant work plans and monitors large scale projects. She has developed and implemented policies and procedures concerning projects control and change management.

Mrs. Shabtay has a B.Sc. in Economics and Management from the Technion, and she is studying at the Technion for M.Sc. in Industrial Engineering. Working under the guidance of Dr. Avigdor Zonnenshain, she is conducting research on "Assessment of Projects Success in an Adaptive Project Management Approach" based on projects in Rafael. As a part of her research, Michal has worked along with numerous project managers on tailoring project management and the project's SE management plan (SEMP) according to the project's dimensions.

Mrs. Michal Shabtay intends to propose and discuss an approach of tailoring the SEMP plan based on the strategic goals and the dimensions of the systems design including novelty, complexity, technology uncertainty and pace.

Position Paper # 1 – by Niels Malotaux

The SEMP and how to meet the most important requirement

The SE Management Plan (SEMP) is to support the successful execution of the SE role in a project and it should contain whatever necessary to serve that purpose.

The SEMP should, however, be kept concise. If it's a large document, it probably won't be used. The plan shouldn't contain the execution details, nor elements if they are documented elsewhere, like Project Management Plan, Risk Management Plan, Configuration Management Plan, Requirements or Business Case. It should however reference these documents and add appropriate detail as necessary.

The SEMP captures in general:

1. Why we should be doing certain SE activities (SE activity "Business Case")
2. Which SE activities should be performed on which inputs, with which results and why (SE activity Requirements)
3. How these activities could be performed (possible solutions - process design)
4. Assumptions
5. Questions and unclears, with solutions
6. Which method has been chosen to perform each activity with the reasoning why (implementation)
7. Once we find out that any element of the SEMP should better be improved: loop back to the appropriate item of this list (continuous improvement)

At the start of any project, the initial SEMP will probably be more or less be incorrect, incomplete, overcomplete or irrelevant. That's not a problem, as long as we keep the SEMP as a living document during the whole project, continuously improving it along the way to more and more reflect what we really are (and should be) doing, hence the loop at item 7. This way it records the lessons learnt not for the next project, but rather immediately for the current project. After all, the SEMP is not a goal on it's own, but merely a support for the successful execution of the SE activities in the project. Using an Evolutionary Project approach (see Gilb-1988, 2005) and Malotaux-2004, 2006, 2007), frequent and rapid Plan-Do-Check-Act (PDCA- or Deming[1]) cycles will provide the mechanism for keeping the SEMP up-to-date and continuously improving.

The SEMP should contain a TimeLine (Malotaux-2007) of when certain SE activities are required and how this TimeLine synchronizes with the overall project TimeLine.

The most important requirement

The most important requirement for most projects is *time*; that is *time for completion*. Projects are supposed to generate a considerable Return on Investment (RoI). Therefore the cost of one day delay is not only the cost of running the project one day longer, but also the cost of not being ready (cost of people/equipment waiting, missed revenue, etc) of that day, which is usually a lot more than the cost of the project itself. Project delay is usually very costly.

Still, most projects are late. Isn't it weird that projects apparently judge all other requirements more important than the requirement of time even if time is one of the most important requirements? Both Project Management (responsible for the project) and System Engineering (responsible for the product) are responsible for the consequences of ignoring this most important requirement.

How to meet the most important requirement

Once we see that we did something that took more time than we have available, we can (and should) learn from it, but the time is already gone and can never be regained. Because projects usually take more time than envisaged, we must start saving time from the very beginning. If we try to do something about it towards the end of the available time, we don't have much time and opportunity to gain time any more.

Fortunately, there are several ways to save time, *without negatively affecting the Result of the project (on the contrary!)*:

Improving the efficiency in *what* (*why, for whom)* we do: *doing only what is needed, not doing things that later prove to be not needed, preventing mistakes and preventing working on superfluous things.* Because people tend to do more than necessary, especially if the goals are not clear, there is ample opportunity for *not* doing what is *not* needed. We use the *Business Case* and continuous *Requirements Management* to control this process.

Improving the efficiency in *how* we do it: *doing things differently*.

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[1] Deming-1986, Malotaux-2006-chapter 6

This works in several dimensions:

The product

Choosing the proper and most efficient solution. The solution chosen determines both the performance and cost of the product, as well as the time and cost of the project. Because performance and project time are usually in competition, the solution should be an optimum compromise and not the first solution that comes to mind. We use *Architecture* and *Design* to control this process. We use *DeliveryCycles* to check the requirements and assumptions.

The project
We can probably do the same in less time if we don't immediately do it the way we always did, but first think of an alternative and more efficient way. We do not only design the product, we also continuously *design the project*. We use *Evolutionary Planning* to control this process.

Continuous improvement and prevention processes
Actively and constantly learning how to do things better and how to overcome bad tendencies. We use rapid and frequent *Plan-Do-Check-Act* (PDCA- or Deming) cycles to actively improve the product, the project and the processes. We use *Early Reviews* to recognize and tackle tendencies before they pollute our work products any further and we use a *Zero-Defect* attitude because it's the only way ever to approach Zero Defects.

Improving the efficiency of *when* we do it: *doing things at the right time, in the right order*. A lot of time is wasted by synchronization problems like waiting for each other, or redoing things that were done in the wrong order. Actively Synchronizing and *designing* the order of what we do saves time. We use *Evolutionary Planning* to control this process, with *TaskCycles* and *DeliveryCycles* to make sure we do the right things in the right order, and *TimeLine* to get and keep the whole project under control. Elements of these are *Just Enough Estimation, Dynamic Prioritizing* and *Calibration* techniques.
All of these elements are huge time savers. Of course we don't have to wait for the project getting into trouble. We can also apply these time savers if what we think we have to do easily fits in the available time, to produce results even faster.

TimeBoxing provides incentives to constantly apply these ways to save time, in order to stay within the TimeBox. For TimeBoxing to work properly, it is important to change from optimistic or pessimistic, to realistic estimation. If the TimeBox is too short, we cause stress with adverse effects. If the TimeBox is too long it doesn't work. In the experience of the author, people in projects can easily change into realistic estimators in a few weeks time, *if* we are serious about time. TimeBoxing is much more efficient than FeatureBoxing (= waiting until we're ready), because with FeatureBoxing we lack a deadline, causing Parkinson's Law[2] and the Student Syndrome[3] to kick in badly.
Note that this concept of saving time is similar to "eliminating waste" in Lean thinking, and already indicated by Henry Ford in his book "My Life and Work", back in 1922:" We eliminated a great number of wastes".

The **Evolutionary Project Management** (Evo) approach uses and constantly evolutionarily optimizes the elements of saving time as shown above: Plan-Do-Check-Act cycles, Zero-Defects attitude, Business Case techniques, Requirements Management techniques, Design techniques, Early Reviews, TaskCycles, DeliveryCycles and TimeLine. Projects starting to use the Evo approach almost immediately become 30% more productive. Background of the Evo approach can be found in Gilb (1988, 2005) and Malotaux (2004, 2006, 2007).

Because the time saving actions don't come easy (otherwise this would be practiced already everywhere), it's advisable to document in the SEMP how the SE plans to optimize the time saving process and how the SE function works together and synchronizes adequately with Project Management. We suggest studying the Evolutionary approach and using it to the advantage of the project success.

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2 Parkinson's Law: "Work expands so as to fill the time available for its completion".
Parkinson (1955) observed: "Granted that work (and especially paperwork) is elastic in its demands on time, it is manifest that there need be little or no relationship between the work to be done and the size of the staff to which it may be assigned."

3 Starting as late as possible, only when the pressure of the FatalDate is really felt. Term attributed to E. Goldratt (1997).

Position Paper # 2 – by Eric Honour

How is the Systems Engineering Management Plan (SEMP) Different than the Actual Planning?

In any development, the first task performed is always scope definition – "What are we going to do?" The second task is always planning – "How are we going to do it?" Even in a pragmatic laboratory environment, before the engineer jumps to create the first model, that engineer must pause for a moment to work out what to do and how to do it. In the Agile development paradigm, with very short development cycles, each cycle starts with defining what the cycle will achieve and how it will achieve it. So planning is an inherent task in any development effort.

In system development, the planning task requires more rigor. This rigor is necessary so that the myriad of participants know what tasks to perform at what times. After agreeing on scope, system development efforts start with a proposal during which the developer defines and estimates the tasks, their cost, and their duration. This proposal often creates a project baseline that lasts for the duration of the project. Whether for an amortized system product or a government contracted system, this project baseline is often an extensive set of materials – technical proposal, Work Breakdown Structure (WBS), master schedule, work package descriptions, budgets, and more.

So where does the Systems Engineering Management Plan (SEMP) fit in? How is it different than all this other planning?

In some ways, the SEMP overlaps this other planning. SEMP content, according to the INCOSE Systems Engineering Handbook, includes the WBS and the Systems Engineering Master Schedule (SEMS). It defines how the project will be organized, structured and conducted. This content could easily be in the technical proposal or in a Project Management Plan, leaving a casual observer wondering why there is a document called SEMP?

The unique feature provided by the SEMP, however, is its focus on the engineering of the system. It is the top-level plan for managing the systems engineering effort, with the underlying understanding that the "systems engineering effort" is much more than just "systems engineering." The SEMP recognizes, as acknowledged by ISO-15288, that systems engineering is the discipline with overall responsibility for the technical quality and integration of the system product. This responsibility requires the systems engineering effort to encompass and integrate technical efforts throughout the project – design engineers (electronics, software, mechanical, etc.), specialty engineers (logistics, reliability, safety, human systems integration, etc.), technical documentation, production, integration, and test.

To meet this demand, the SEMP considers and includes the project task/cost/schedule planning, integrating that planning with the technical objectives, boundaries, assumptions, validation and verification. The SEMP integrates the technical efforts and defines the technical controls on them. It defines the technical trade studies to be performed and how to perform them. It defines the technical reviews, their content, and entry and exit criteria for each. In essence, the SEMP provides the reason-for-being for each technical work package and task in the project plan.

The format of the SEMP can be varied. In some formal projects, the SEMP is a highly-structured document subject to extensive review and control. In less formal projects, the SEMP is a notebook held and managed by the systems engineer. In Agile projects, the SEMP may be no more than a verbal agreement. But regardless of the format, the Systems Engineering Management Plan is an important set of information, agreed by the project participants, that provides the technical rationale for the project tasks.

Position Paper # 3 – By Joseph Kasser

The SEMP in the 21st century

Systems engineering is making a transition from a paper or document based paradigm to a database paradigm in which documents are views of the contents of databases. This discussion uses a conceptual object-oriented approach to link requirements, work, products, risks, schedules and costs together in a SEMP database in a manner suitable for many if not all types of projects including those being developed using agile techniques or facing high technological and program related risks.

The discussion integrates previously published work in system and software engineering to produce a SEMP that can be stored in a database and updated as work progresses, in a manner similar to the way an outline is converted to a document.

The database approach produces high visibility of progress and the lack thereof and the presentation concludes by speculating on how the incorporation of expert system technology could be added to the database to reduce the probability of project failures.

Position Paper # 4 – By Uzi Orion

The New SEMP

The SEMP is one of the most important documents of the project. So why don't we use it effectively?

- Lack of understanding of the importance of the SEMP and its functions
- lack of time or knowledge to do it correctly, in the early stages of the project
- The natural wish to run and do the job…
- Fear from written mistakes
- Natural failing of engineers to document design considerations
- Prediction of many changes after the preparation of the SEMP and difficulties to foresee the final configuration of the system
- Many unknowns and missing technologies / know-how / infrastructure at the time of writing the SEMP

The Solution

To find the time, before the beginning of the development cycle, to formulate and document the systems engineering design considerations.

To prepare a concise document that is understood by the decision makers. This document should concentrate on aims, targets and plans.

The proposed SEMP has to express the selected SDLC model, including the rationale for the selection, as well as the main milestones for realization.

The document should express thoroughly also the known significant investments in money, time or human resources.

All known required disciplines, especially the odd ones should be referenced in the document.

This is the document that should summarize the identified risks and include a management plan to mitigate them.

It is also recommended to include the main identified proven reused parts in the program, technologies and suppliers, as well as the intentions to do new generic modules (beyond the aims of the specific project)

The proposed contents

- Scope of the systems engineering process in the project
- System development life cycle model and main milestones
- Significant investments issues
  - Time
  - Money
  - Human resources
- Main problematic issues
  - Specifications
  - Parts
  - Infrastructure
  - Intellectual property
  - Export / import legal limitations
  - Other sensitivities
- Specialty disciplines and their rolls in the project
- Reuse and generic issues
- Main Risks and their management plan

Remarks

- The document should be as short, concise and transparent as possible.
- The formalization of the document should be full and clear to a non SE reader.
- The document intends to summarize the ideas of the systems engineer prior to the development phase. The emphasis should be on main issues of the program as well as on selection of the SDLC model.
- The SEMP is passively vivid all over the development phase. It should be tracked all over the system realization process. In a case that a major change happens, the document should be revised for backwashes.
- The risks should be managed separately.
- To eliminate contradictions, the materials included with the SEMP should not repeat materials included in other project documents.

Position Paper # 5 – By Michal Shabtay

The Adaptive SEMP

Every systems engineer encounters challenges to plan and execute effective systems engineering activities during system design and development and throughout the project management. Most organizations provide standards, processes and procedures for applying systems engineering. One of the dangers of applying Systems Engineering (SE) in system and product development is applying the same planning and the same execution for each product development.

In our research, which is conducted in RAFAEL, following the research of Prof. A. Shenhar and Prof. D. Dvir on the "Diamond approach" for Project Management[4], we implement an adaptive approach for system engineering in which we tailor the system engineering planning and execution according to two main aspects:

- The System Development goals and success criteria.
- The System Development characteristics and dimensions in which we include crucial dimensions as novelty, complexity, technology uncertainty and pace.

Why do we need adaptive SEMP?

1. **<u>Adapt to the System Development goals</u>**
   - Efficiency goals should impact the efforts invested in design to cost (DTC), controlling the schedule and the development time line, managing the cost of quality, etc.
   - The customer needs should have an impact on the requirements, management, and design for RAMS (reliability, availability, maintainability and safety), considering to conduct quality function deployment (QFD) in order to fully understand the needs of the stakeholders.
   - The impact on the team should be reflected in the efforts invested in team building, skills developed, and in communication with the people involved. The business success should impact policy with time buffers and budget reserve levels.
   - The environmental considerations should influence technical solutions to meet the environmental requirements and to consider only "environmentally friendly processes".
   - The societal issues should lead to systems that meet societal requirements such as accessibility, diversity, and ethics.
   - The preparation for the future should impact the investment in new technology
2. **<u>Adapt to the System Development Dimensions:</u>**
   - <u>Novelty</u> affects the accuracy of market prediction, the ability to determine requirements, and the timing of requirements freeze.

[4] Shenhar, J.A., Dvir, D., *Reinventing Project Management*, Harvard Business School Press, 2007

- A higher Technology level requires increased design and development activities, more design cycles, later design freeze, improved communication among the designers, higher technical skills and more effective design reviews.
- Complexity affects the formality of the hierarchy and procedures.
- Pace requires increased attention to schedule, and the faster the pace, the greater the autonomy is needed for the designers.

In order to implement the adaptive approach effectively, it is recommended to:

- Train and mentor project managers and system engineers in applying the adaptive approach.
- Build the support of top management for the adaptive approach.
- Prepare organizational guidelines for the adaptive approach and implement the approach in the organizational procedures and practices.
- Periodically update the plans, based on the current situation and environment.
- Periodically (at least annually) learn the lessons from applying the adaptive model and modify the plans according to these lessons.

It is recommend that INCOSE consider adding to the SE Handbook the guidelines for implementing the adaptive approach for SE planning, management and execution.