Implementing Systems Engineering:
A Step-By-Step Guide

Fifth European Systems Engineering Conference
18-20 September 2006

Bram de Landtsheer, *Mpire change awareness, Utrecht, the Netherlands*
Louis Aartman, *NLR, Amsterdam, the Netherlands*
Jac Jamar, *TNO Science and Industry, Eindhoven, the Netherlands*
Jan de Liefde, *Siemens department of engineering, the Hague, the Netherlands*
Niels Malotaux, *N R Malotaux Consultancy, Bilthoven, the Netherlands*
Hennie Reinhoudt, *Philips Semiconductors BV, Nijmegen, the Netherlands*
Paul Schreinemakers, *SEPIAdvies, Utrecht, the Netherlands*

ABSTRACT

Implementing a new method, another way of working in an organisation is not easy. It involves new attitudes, another way of thinking. It cannot be done by just snapping your fingers. It takes time; it takes several steps.
This step-by-step plan provides motivation and guidance to implementing Systems Engineering. Systematically, in 8 steps, the actions, the decisions and the pitfalls on the road to SE are described. These steps are not a guarantee for success. They need tailoring to your specific situation. However, one way or another, these steps are to be taken, if you ever want your organisation to progress in SE. This is the heartfelt experience of the Special interest group Systems Engineering implementation of the Dutch chapter of INCOSE from which this paper originated.
Moreover, the preliminary results of a pilot project at Siemens Netherlands show positive effects using this step-by-step plan.

INTRODUCTION

SCOPE

This document describes a step-by-step guide to implementing Systems Engineering processes, as described in the Systems Engineering Handbook (INCOSE, 2004). The steps can be regarded as part or a generic implementation strategy, as devised during the monthly meetings of the SIG-SEI, the 'Special interest group Systems Engineering implementation' of INCOSE Netherlands.

It is intended for those organizations or parts of organizations where processes are largely characterized by a multidisciplinary nature.

A large number of the activities in these organizations is executed in projects. An analysis of the results of these projects has indicated the need of improvement of the way of working.

Furthermore, it is assumed that the organization where SE is to be implemented, already explicitly made the choice that SE is a solution for their problems.

This step-by-step guide does not explain WHAT should be implemented. (The Handbook covers the WHAT extensively.) Moreover, this depends heavily on the specific circumstances in the organization. The guide rather deals with the HOW, using what techniques, and in what order activities should be executed, in order to achieve an optimal result of a change based on SE.

GOAL

In this step-by-step guide we have accumulated many years of experience in implementing SE processes. Thus, the members of this taskforce try and help professionals in the field in recognizing and avoiding pitfalls as many as possible. Executing the steps in the right order will increase the probability of a successful SE implementation.

It is very important that organizations using this guide are aware of their own particular needs. The step-by-step plan can and should be tailored to the specific and detailed situation. Moreover, a rigid execution of this plan may obstruct the desired result: an improvement of one or more processes.

N.B. tailoring is not about SE processes, but about the step-by-step plan itself.

TARGET AUDIENCE

The audience of this guide consists of professionals in (a department of) multidisciplinary organizations, who are responsible for implementing SE or who are in any other way committed to SE. For instance: systems engineers, project leaders, program managers and system architects.

SE methods are applied traditionally in technically oriented organizations involved in the development of complex systems. However, these methods can be found more and more in other branches dealing with complex problems. This universal, but adaptable step-by-step plan can be applied there as well.

Additionally, we assumed that every user of this plan is, or soon will be familiar with current quality models, especially the Handbook of Systems Engineering.

A MOTIVE: DO YOU RECOGNIZE THIS?

You are presently employed in an organization where product quality is a hot issue. This is indeed the fact for which the organization is renowned.

Lately, the management has noticed that the competition has not been sleeping. Some contracts, which were at first easy money, are no longer granted to your organization. Of course, you want to know the reason. The argument is always the same. Your projects are overdue, products are delivered far beyond the set delivery date, and sometimes it takes twice or even three times the contracted duration.

The project starting at this moment is a project where the mere existence of the whole organization is at risk. The project has already been accepted, the delivery date is already set, but actually, nobody in the whole organization is convinced that, with the current way of working, this project will be finished in time and with the approved level of quality.

Also some other things have changed in the organization. A number of your most experienced staff, upon whom the organization heavily depended during unexpected situations, have speeded up their careers and have gone elsewhere.

The organization still has staff at her disposal with the essential knowledge, but their number is very limited. Therefore, the use of their skills has to be very efficient. Moreover, a large number of contractors will have to perform the majority of the work.

Subcontracting a large part of the project is under serious consideration, but it is not at all clear which part could be subcontracted. Subcontracting a part of the project demands the requirements to be very clear and unambiguous. Every change within the internal activities will have to be assessed on consequences and impact on the external part. This has been done before, but never without time-consuming (and therefore costly) problems.

What the problems are exactly is still not clear. Every time one does evaluations, a large number of the people who participated in the project under evaluation is not available, due to – in their own opinion - more important activities at that moment. The reason? Well, new projects demand their attention and history proves that most projects will be finished in the end, even without their active involvement. And despite all the problems, the organization still exists.

Besides that, it is common practice that all sorts of people, particularly marketing and sales representatives, members of the board, top management and other people with customer relations, driven by growing insights, overload the project till the very end with questions and new, forgotten or changed requirements. It is even common use that customers themselves have direct access to engineers within the project. The engineers obviously try very hard to please the customer and implement their latest wishes as soon as possible in the products.

This bears consequences for other parts of the project. Especially those parts out of immediate sight, and in particular the planning, have been overlooked more than once. The adjustments are very small most of the time; one should not make a problem of that. In addition, after all, the customer is the one who pays the bill! The fact that the customer is not aware of the consequences of those "minor adjustments", in terms of time and money, often turns out to be a source of heavy frustration. Moreover, obviously the project manager has to update his or her schedule and budget claims.

Another effect is that the original concept of the project, due to the many "minor adjustments" only exists in general terms. That way, until the last moment, it is not clear, what the exact results of the project will be. This in turn results in a severe delay in testing, for which last minute test cases and other items have to be invented to assure the approved quality level. In short: testing starts too late, because it is unknown what should be tested, integration testing is not possible until everything is finished and hardly ever all test cases that were scheduled, are performed. Delivery is due and time is running out.

By now, your management has heard from colleagues in other organizations who work with Systems Engineering that this results in much more predictable performance of projects, on the quality level of both products and schedules.

After wise consideration, your management has decided to implement Systems Engineering.

Now it is up to you to perform this beautiful and challenging task: how will the organization adopt SE, starting with this one project, so vital for the organization.

You will get full cooperation of the whole management, even though they do not know what it means. You will have to prove the method works, within this project, with duration of three years. Besides that, there are of course some restrictions: resources are not unlimited (there are more tasks, equally important, which also have to be done) and this project will have to be both on time and profitable. Delivery on time is of the utmost importance, since overdue delivery will result in fines, which may well threaten the very existence of the organization.

THE STEP-BY-STEP PLAN

Following the next 8 steps, you should be able to implement SE in your organisation. In appendix 2 the products are presented resulting from each step.
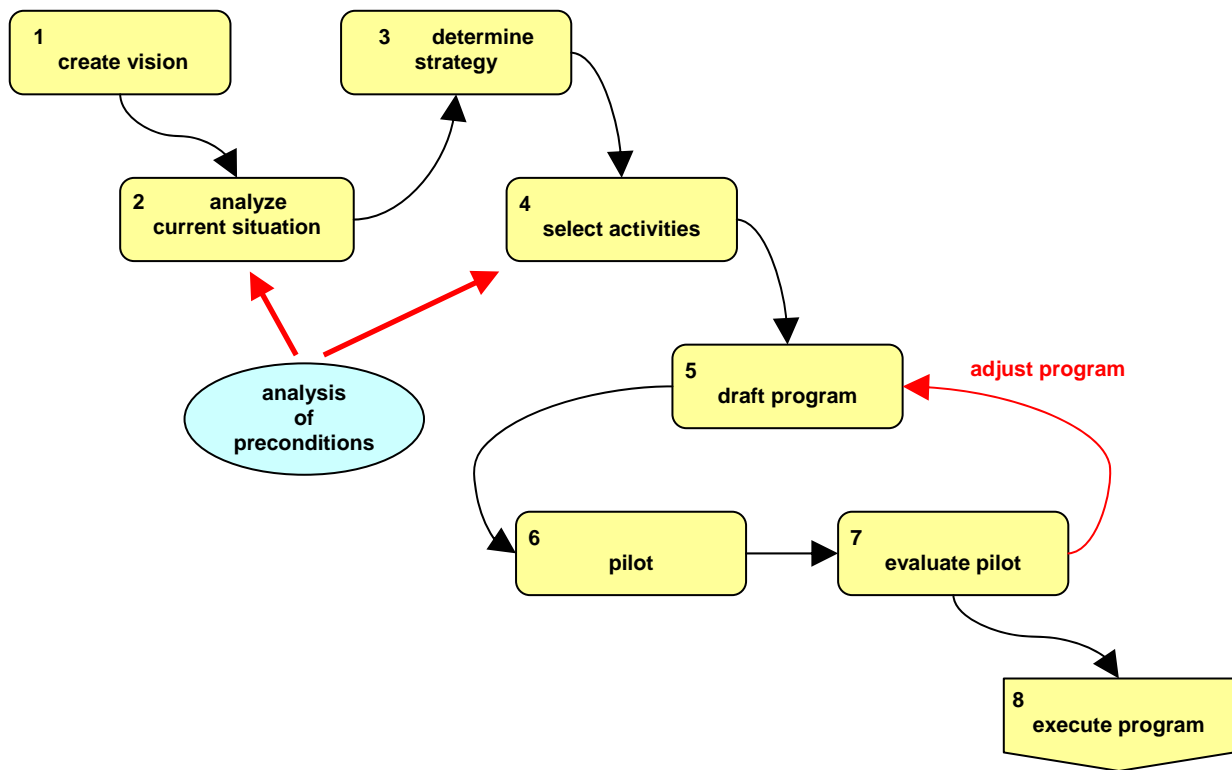
STEP 1: VISION MAKING: WHAT DO WE WANT TO ACHIEVE?

Every organization changes, whether you like it or not. You can leave it at that, but then you don't know where you are going. You'd better be aware of what you're doing. In short, you act according to a vision. In our case, the vision is: "we want to implement SE". For most (if not all) organizations (people) this vision is too general, too vague. Moreover, this vision should fit in the overall vision of the organization concerned.
A good vision shows how an organization will operate in 2 to 4 years time, in relation to customers, suppliers, employees, society, and shareholders. The wording of this vision results in a slogan everybody will understand. In the light of this vision, every employee will be able to recognize his or her place in the organization. We refer to the six aspects of a good vision according to Kotter (1996).
Good leadership ensures the development of a vision the entire organization will support and promote. However, this means that every member of the organization should be involved or represented in the making of the vision. The contributions of everybody, top manager and first hand alike, are all as valuable. The only difference between top and bottom in this case is that the management facilitates the making of the vision. In other words, it is a simultaneous bottom-up and top-down approach.

Execute the next steps to achieve a good vision on implementing SE:
- Select people everywhere in the organization
- Ensure that everybody around them knows who are the representatives of their group
- Call a meeting
    o everybody tells his/her vision on SE in relation to the current situation
    o another person summarizes what the speaker has told them
    o Look for similarities together
    o Are there mutual issues to be identified (on a more abstract level)?
    o Are there any opposite opinions and where and how do they fit in the common visions?
    o Make a survey (again) of the common visions that remain
    o How do these visions relate to the definition of SE (SE handbook, etc.)?
    o What are the priorities, do they fit in the SE approach, and how does this lead to concrete results?

- o All common results are documented
- Ensure that the results of this meeting are presented to the organization; maybe not in full detail, but be sure to explain the process of cooperation and the making of ideas
- Repeat and detail these steps (when needed)
- Communicate, communicate, communicate ……………………….

STEP 2: ANALYSIS OF CURRENT SITUATION AND IDENTIFICATION OF BUSINESS CASE: WHAT PROBLEM DO WE WANT TO SOLVE?

Next, we determine our current situation and decide what to do and where to go. To this end, we begin by asking:
- What problems exist:
    - o What problems do people talk about?
    - o What do people perceive as problems?
    - o What are the differences between perception and reality?
    - o Is it a unique incident, or is it something structural?
- Business objectives
    - o What does the organization focus on, what is the goal? (markets, products, growth)
    - o What is the most important strategic target (in relation to product development)? (lead time, customer satisfaction, quality, costs of development, life cycle cost)
- Current procedures
    - o Are (uniform) (engineering) processes used?
    - o Are the (uniform) (engineering) processes documented?
    - o If so, are the documented processes known to the employees?
    - o Are the actual processes performed according to the documented processes?
    - o Are the processes deduced from a (standard) method?
    - o Can the processes be mapped on SE; do SE elements already exist (albeit in another terminology)?
    - o Do the processes contribute to the business objectives?
- Determine the extent and the quality of the communication and the contact between the various parties concerned / professions / departments
    - o How strong are those contacts?
    - o How effective is the communication?
    - o Are these contacts very dependent on the person involved or are these contacts on a regular basis?
    - o Do people speak the same language (both spoken language and jargon do matter)?
    - o Can and will people share experiences, both good and bad?

Identification of business case

- What improvements fit in the vision (step 1) and are they in line with the results of the analyses of the current situation?
- Determine improvement potential. What can or must be improved and what part of SE is useful?
- The planned improvements have to coincide with the strategic targets of the entire business: faster, cheaper, and/or better?
- Estimate roughly the effort needed to realize (a part of) the improvements.
- Assess critically the feasibility of various improvements in the light of this rough estimation. Than draft an advice for business cases which stand the best chance for success.

Analysis of preconditions

This analysis is meant to get a clear view on four aspects critical for success:
1. Willingness to change or sense of urgency or, contrarily, resistance against change.
2. External conditions.
3. What and how many resources are available, or can be made available.
4. Available expertise (in the field of SE and change management)

This analysis is carried out at the end of step 2. For each aspect a number of issues is shown in appendix 1.

STEP 3: STRATEGY MAKING: WHAT FIELD OF SE CONTAINS THE SOLUTION?

Using the results of step 2 (starting point and targets) the vision (step 1) is detailed and moulded into a strategy. A logical set of targets is made constituting the vision. And a broad choice is made from the activities in the relevant field of SE.

This step resembles step 1, but is not executed in the same way. Commitment of all involved employees is again of great importance, but now more leadership of (especially appointed) managers is expected. They consult all sorts of advisors, both external and internal, preferably internal. Every employee may present valuable advice. Moreover, everything is more detailed. This is possible, because the broad choice (step 1) is already made and because much more knowledge (step 2) is available.

STEP 4: SELECTION OF SE-ACTIVITIES: WHAT SE-METHODS DO WE IMPLEMENT?

The resulting strategy (step 3) and the matching activities lead to a choice in SE-activities. These activities have to be translated into the terminology of the involved groups of people:

- Start with the most profitable field using the selected problems (step 2), elaborate on this field including the desired methods, techniques etc. Then pick the next most profitable field. Thus finish off all remaining issues which can be improved by using SE.
- Try to select a method for every issue, which either everybody or nobody knows, to avoid prevalence of a method of a specific profession. (It is better to have a mutual enemy).
- Construct entire business cases for selected changes (what is the problem, what are the costs at present, what procedure is needed and what should be the results, qualitatively and/or quantitatively, if the change is implemented).
- Determine the risks and the matching countermeasures to reduce or eliminate these risks. This results in a list of activities and possibly a decrease in number of business cases, because the risks at present are too big and cannot be reduced within the available budget.
- Determine the sequence of the execution of the business cases based on the expected revenue and risk analysis.
- Select a limited set of methods of implementation and instruct the relevant stakeholders in these methods, for example in workshops. If you are not willing and able to deliver the workshop yourself, hire somebody. Someone you trust in good cooperation. And tailor the information specifically to your own situation.
- Besides methods of implementation determine the way you will measure the results, both quantitatively and qualitatively. Especially the reliability of the quantitative measurements will increase as more activities are completed. Moreover, evaluations have to be carried out on a regular basis. Not everything will be reliable from the beginning or can be measured quantitatively. Use the expertise of experienced employees. Their opinion will turn out to be very valuable.
- Determine very specifically the organizational framework in which the activities are performed. This means the determination of the sort of people, the type of organization and the tasks, responsibilities and competences needed for a successful implementation.
- Choose and assign the right resources.

Some remarks to keep in mind during the selection process:

- Stimulate everybody in looking across the borders of their own profession; everybody should examine the processes from start to finish.
- Commence at the existing procedures and show the omissions clearly.
- Map the need for information of all stakeholders and submit the result to these stakeholders for acceptance. Not everybody needs to know everything in the same detail. Too much detail will even be contra productive.
- Assign the tasks, responsibilities, and competences to each stakeholder and make them sign for it. The most important stakeholders are the process owners in the organization (if they exist).
- Make sure that information and expertise in the field of the selected methods are available constantly (at least on a stand by basis), both internally and externally.
- In this phase, you should be reluctant in using automated tools. As soon as the effects of the processes and procedures are clear, the appropriate support of tools can be selected. If tools are implemented too soon, the insight in the processes (what might go wrong) is blurred. Moreover, it is very likely that you concede too soon to the limitations of the selected tool.

Analysis of preconditions

This analysis, at the end of step 4, is meant to check whether all issues are dealt with according the 4 categories of preconditions; these are critical to the success in the next steps (appendix 1).

They are the same 4 aspects as in the analyses of conditions at the end of step 2:
1. Willingness to change or sense of urgency or, contrarily, resistance against change.
2. External conditions.
3. What and how many resources are available or can be made available.
4. Available expertise (in the field of SE and change management)

... however, now the questions are tailored to the status at the end of step 4.

STEP 5: DRAFTING THE PROGRAM: HOW DO WE HANDLE THE IMPLEMENTATION?

Using the results of step 4 the strategy (step 3) can be detailed showing a comprehensive set of projects and sequence in decision making; the first issue of the program being the pilot. As always: "The proof of the pudding is in the eating". In every new project, all tasks should be inspected in order to see whether the situation has changed and, consequently, whether the program should be adapted.

STEP 6: SELECTING AND EXECUTING A PILOT PROJECT: WHO'LL BE THE GUINEA PIG?

Points of attention when CHOOSING a pilot project:
- The project team members should accept and understand the principles of the methods to be introduced
- Especially the project manager should whole-heartedly support the methods and ideas to be introduced and understand the rationale for each method. After all, the project manager should conduct the pilot and must make sure it will be successful.
- Without a Sense of Urgency for improvement, and an understanding and acknowledgement that the methods to be introduced will bring this improvement, the pilot will fail.
- The Sense of Urgency can be induced by:
  o A project that is getting out of control, suggesting a sense that a different approach is needed.
  o An inner drive in the majority of the team members to improve on results
  o Absolute Fatal Dates, after which it is clear that continuation of the project is meaningless or obviously has large negative financial consequences.
  o Self imposed milestones, which people seriously commit to.
- Should the pilot be conducted on a new project or on an already running project?
  A completely new project adds two complicating factors:
  o The start-up ('fuzzy-front-end') of the project, with all its uncertainties
  o Acquiring a new way of working
  Therefore it is better to start with a running project, rather than with a new project.
- However, if the only project fit for a pilot is a starting project, then, in spite of the double complication, it is still better to start with this project, as long as you are sufficiently sure that it will bring clear improvement. Of course, you can decide to reduce the scope of the improvement activities.
- As just mentioned, we should anyway adjust the scope and complexity of newly introduced methods to match the ability of the project to absorb them. Forcing more than they can absorb will jeopardize the result. After all, until now, the organization survived even without the change. It is not necessary to improve everything at once.
- A pilot *has* to be successful. If it fails, the chances for another try are rare. So, plan for success. If success is not predictable, re-asses the options.
- Remember re-evaluating the top-five drivers for project success, according to the CHAOS-report (Standishgroup, 2001):
  1. Executive Support
  2. User Involvement
  3. Experienced Project Manager
  4. Clear Business Objectives
  5. Minimized Scope

STEP 7: EVALUATION: IS THIS WHAT WE EXPECTED?

When introducing new practices, evaluation is crucial. After all, we would not like the new approach to be worse than the approach replaced. Without evaluation we wouldn't even know. Pursuing an improperly implemented procedure harms any motivation and diminishes the chances for further steps. Therefore, it is crucial to measure the results of your changes and adapting according to your analysis, making sure that any change really is an improvement.

Therefore, evaluate:

- During the pilot, al least at every milestone, before starting a new phase.
- Adjust based on the results of the evaluations.
- Disseminate the knowledge gained from the evaluations, to inform similar projects, so they can adjust too, wasting less time. Make sure, however, that you have sufficient capacity to assist also those other projects.
- Do an overall evaluation at the end of the project. Re-evaluate the results of earlier partial evaluations.

The evaluation should be conducted in several sessions, with all stakeholders, to prevent the opinion of a minority of people leading to incorrect conclusions.

Issues for evaluation in every phase:

- What went well, what went not so good and especially: why?
- What was changed in the meantime, why, and what was the outcome?
- What can be copied immediately in other projects?
- What has to be changed and how, to make it useful for subsequent projects?
- What could even be improved in a subsequent project?
- Which SE elements are implemented in this project? Why these?
- Was the order of activities right? Why? Why not?
- Did some issues receive too little attention, with the risk of a relapse?
- Were roles, responsibilities and competences assigned to the right people and were they executed well?
- Were there organizational bottlenecks and how can these be solved?

STEP 8: EXECUTION OF THE PROGRAM: CONTINUE OR STOP?

How to continue, after steps 1-7 have been completed? Has the moment arrived the SE approach will be formally announced as THE approach, or will a process of continuous improvement be more appropriate? The latter is most probable. In our fast changing world, very limited space is left for functional strictly separated and strongly hierarchic organizations. It is very unlikely that all employees will be permanently convinced of the potential of SE.

By continuous improvement to the level of the individual employee, as documented in our targeted audience, we strive for an optimal tuning of the relationship between the organization, her customers, and the market as a whole. To stay tuned, organizations must be capable of improving on a continuous basis.

This can be done in a number of ways, assuming there have been positive results in following some form of this roadmap:

- Continuation of the roadmap.
  Repeat the evaluation after every part of the program in STEP 5 and adjust, when necessary the sequence, the means, the organization, the activities, and all other items that did not perform as expected. By adjusting all items that were not successful, you will motivate everyone to stay involved time and time again.
- Adaptation of a standard improvement model, possibly in the framework of an existing quality model in the organization.
  A recent example of this is the Capability Maturity Model Integrated (CMMI®, 2002), where process improvement in general and Systems Engineering in particular is defined in several ways. CMMI is based upon a number of different capability maturity models. CMMI identifies process areas in the domains engineering, project management and organization.

Adoption of a standard like CMMI, in most cases, touches all aspects of the organization. However, continuation of this roadmap may have a more local and limited character. There is a strong emphasis on expanding individual and team skills and competences. Certification is not pursued, avoiding the pitfall that the means becomes the goal.

Essential for the motivation is a measurable success of the effort. Implementing SE should be visibly beneficial to the business. This is a strong plea to continue scheduled pilots, aimed at success within normal ongoing

activities. It offers opportunities for continuous learning, schooling of new staff, and continuous adaptation to the ever-changing external circumstances. Thus, the unique identity of the organization can be preserved.

THE STEP BY STEP GUIDE IN PRACTICE

INTRODUCTION

In early 2004 the awareness of SE started to grow at the Department of Engineering at Siemens in the Netherlands (DESN). At the end of 2004 this step-by-step plan became public within the INCOSE community in Holland. This relative synchronicity led to the start of a pilot project at DESN in spring 2005
First of all a core team of 6 people from various engineering disciplines (including senior management) was establish. This team tailored the step by step plan to the specific needs of DESN. On the one hand the changes were dealing with the organisation of the department and company. On the other hand the criteria were emphasised to pass from one step to the other. These criteria are about:
- Are resources still available for the next step?
- Are contracts still complying with legal constraints?
- Are experienced and committed people still staying on the job?
- Are there still no conflicts with other projects?

STEP 1: VISION MAKING

The Core Team provided presentations and courses and collected comments from the entire organization. Thus, the vision of DESN was formed in relation to SE. This vision reflects the traditional and new markets where DESN can make a difference using SE. To this purpose SE should be the normal way of working within DESN. The Core Team suggested the ESDN management to create the new (thus far non-existent) function of Systems Engineer. With this new function and the projects tasks belonging to this function two big advantages were gained:
- high potential engineers, fresh from university, would have attractive perspectives within the Siemens organization
- the bigger and complex projects would have a qualified Systems Engineer for the technical management
So one of the first products made in this phase was a Systems Engineer Profile for selecting the new Systems Engineers. Moreover, an assessment was developed and used in the selection process.

 STEP 2: ANALYSIS OF CURRENT SITUATION

In the Netherlands the customers in the field of Civil Infrastructural Systems (mainly government) are engaged in changing to SE themselves. This is the onset of making the application of SE mandatory for their suppliers. Within the scope of the business objectives (markets and growth) and the current way of working problem areas were identified. This was done in close collaboration with the sales force, because they consider SE a selling point bonus.
Past projects were evaluated and new prospects were considered. Although no accurate measurements were available, there was a clear indication of the benefits of using SE. Business cases were made for the following problem areas:
- Requirements management
- Configuration management
- Traceability
- Interface management
- Speciality Engineering

STEP 3: STRATEGY MAKING

Commitment both in management and in the workforce was divers over the various engineering fields. It turned out that commitment was best in infrastructural construction. This resulted in the strategic choice to concentrate the SE implementation on infrastructural projects. As indicated earlier, in the Netherlands the customers in this specific field are now applying SE themselves. Thus, reaching agreements and getting assignments is much more promising.

The targets were formulated in the fields of:
- Requirements management
- Configuration management
- Traceability
- Interfaces management
- Project organisation adapted to SE
- Speciality Engineering
- Trade-off Studies (evaluating alternatives).

STEP 4: SELECTION OF SE-ACTIVITIES

The selection is based on the analysis of current projects and the possibilities of using best practices from previous projects. The recurring activities are requirements management, configuration management and systems modelling. Combining this with traceability en interface management a quick result can expected. Moreover, considering STEP 3 the following SE-activities were the obvious choice:
- Requirements management
- Traceability
- Interface management
- Configuration management
- System modelling.

STEP 5: DRAFTING THE PROGRAM

Commitment in the selected domain (infra projects) was very strong both in the management and the project teams and, last but not least, in the sales organisation. Commitment outside this domain is still questionable. Resources, time and money were readily available. However, employees may be assigned to several projects. So SE-projects are still depending on the success of other projects. The delivered products within the introduction phase were:
- Presentations on SE
- Introduction Course SE for about 40 people
- SE Profile
- Pilot project
- A first evaluation.

STEP 6: SELECTING AND EXECUTING A PILOT PROJECT

Two projects were selected for piloting. One pilot project is in the bid phase where for 2 subsystems a conceptual design including trade-off studies have to be made. Within this project the processes Requirement Management, System Modelling, Trade-off studies for two subsystems and Traceability will be implemented. While writing this paper the process is halfway in progress. The SE tool CORE is used in design and documentation.
The other selected pilot project is about product development in intelligent traffic systems. This is a re-design of a product which was developed 15 years ago and is not up to date anymore. Within this project the relevant processes are:
- Requirement Engineering (Requirement Management and Requirement Developing)
- Risk Analysis
- Traceability
- Configuration Management.

STEP 7: EVALUATING THE PROJECT

A first evaluation was held in February 2006. This evaluation was performed by the SE Core Team. The first experiences with implementing SE were very positive.

The observed penetration of SE in DESN was larger than expected. The best prove was the decision of the manager of DESN to analyze his department using SE processes. With functional analysis, requirements engineering and modelling it is possible to perform a trade-off study optimizing DESN processes.

Another evaluation was performed by one of the pilot projects itself. In this project first Requirements Analysis and Functional Analysis were performed. The customer, sales force and engineers were all surprised by the positive results of using SE processes in the bid phase of a project. In this phase DESN customers were shown some new insights in the functionality of the system they have to build by using processes as requirements analysis, architectural breakdown, functional breakdown, traceability.

Thus, finally the architecture and requirements allocation were different and better than expected. The sales force saw the opportunity to use the competence in SE as a selling point in DESN working domains. Moreover, customers considered the result of the SE approach in financial terms the better proposition in comparison to the competitors.

STEP 8: EXECUTING THE PROGRAM

In March 2006 it was decided to start the next phase of implementing SE at DESN. New goals for this phase were set and new products were defined such as:

- DESN SE Handbook for formalizing the SE processes
- SE Smart Cards: a quick reference of DESN processes including contact persons
- Master class SE for every potential Systems Engineer the relevant training
- SE Library with basic and standard architectures, patterns, SE books and SE info within DESN working domains.

CONCLUSION

At this moment the pilot teaches us a number of preliminary lessons:

- New ways of working need time and money. The starters need money and time. They are an investment.
- Implementing SE means changing management: the project engineer is split into a project manager (the politician) and the system engineer (the technician). This is a source of resistance.
- It is essential that the management and the workforce grow together into the new ways of working.
- Implementing SE needs a medium to long term planning.

Nevertheless, the central question remains: is it better, cheaper, more efficient, more effective to use SE? The evaluation of the pilot at Siemens shows positive results. But are the benefits quantifiable? Very hard! All kinds of metrics have been designed, but the bottom line is: you never execute the same project with and without SE.

So, the step-by-step plan seems to be working. You may wish to pass some steps in lesser detail, which may lead to an earlier success. Skipping steps, however, will most likely result in more delay in the end.

So, if you want success, allow yourself to be guided, but at all times: use your own experience and common sense.

The Special Interest Group SE Implementation would appreciate to be informed about your experiences in using the Step-by-Step plan. This would surely improve the model in time and be of better value for others in the INCOSE community, who want to implement SE in their organizations.

AKNOWLEDGEMENTS

REFERENCES

CMMI, 2002, technical report CMU/SEI-2002-TR-003, www.sei.cmu.edu

INCOSE, 2004, "Systems Engineering Handbook", version 2a, www.incose.org

Kotter, J.P., 1996, "Leading Change", Harvard Business School Press, Boston, Ma, USA

Standishgroup, 2001, "Extreme Chaos", wwww.standishgroup.com

BIOGRAPHY

Bram de Landtsheer is an independent consultant (Mpire.nl) helping people in companies that want to grow better. He gathered his knowledge and experience in the banking, automotive, IT and pharma industry. Bram holds a Ph.D. in astronomy (1984, University of Utrecht) and publishes periodically his views on how to improve organizations heavily depending on IT.

Louis Aartman is currently Business Manager Industry and European Research Programmes in the Aerospace Systems and Applications Division of the National Aerospace Laboratory NLR. As electronics engineer he has been at the NLR since 1981 and has been engaged in design and development of aircraft equipment and spacecraft systems. Starting in 1987 with introducing computer aided engineering methods and systems, he has been involved in the most recent years in the implementation of systems engineering in an R&D environment for aerospace systems.

Jac Jamar is currently working as a Systems Engineer in the Netherlands Organisation for Applied Scientific Research (TNO). In TNO's core area Science & Industry he is responsible for the Systems Engineering in multidisciplinary product development projects. Formerly, he was a senior development engineer for Philips Display Components, where he participated in technology development projects and product development projects for colour picture tubes. He holds a M.Sc. degree in Experimental Physics from the Catholic University of Nijmegen and a Ph.D. degree from the University of Utrecht for his thesis on a subject in human visual perception.

Jan de Liefde is currently working as a systems engineer for Infrastructural projects within Siemens Netherlands. In the Department of Engineering at Siemens Netherlands he is responsible for the implementation of Systems Engineering.

Niels Malotaux is an independent consultant and project coach specializing in optimizing project performance. He has over 30 years experience in designing hardware and software systems. Since 1998 he devotes his expertise to teaching and coaching projects how to deliver Quality On Time. Since 2001 he coached some 40 projects, in the Netherlands, Belgium, India, Ireland and the US, which led to a wealth of experience in which approaches work better and which work less.

Hennie Reinhoudt works at the moment as a quality-, risk-, and compliance manager at Philips Semi Conductors O & I department. She has 15 years of experience in process improvement, quality assurance and quality management in system- and software development departments of various companies.

Paul Schreinemakers is an independent consultant (SEPIAdvies.nl) in implementing and applying Systems Engineering and Hardware CMMI. Paul has a University degree on Engineering Product Design and has over 16 years of experience, varying from Space and Military industries to the field of Train Transportation and Civil Construction. The projects he is involved with, generally, have a very international oriented character.

CONTACT INFORMATION

Bram de Landtsheer, *Mpire change awareness*,
Wittevrouwensingel 63,
3572 CC Utrecht,
the Netherlands
tel. +31 655 914 813
bdl@mpire.nl

Appendix 1: Attention points for Analysis of Preconditions in step 2 and step 4

Aspect:	Questions to ask in step 2 (analysis of current situation done) (at the transition from step 2 to step 3)	Questions to ask in step 4 (selection of activities for SE-implementation made). (at the transition from step 4 to step 5)
Willingness to change, sense of urgency, resistance against change	• Is the organisation both willing and able to adopt a more structured way of working? • The willingness to change can be high when a running project is in danger of failure. • Is there a REAL business objective that justifies the effort needed to improve the working processes? • Is there any reason to expect resistance to the changes? Why? From whom? • People from different disciplines talk the same language? Are there any organizational issues which: • contribute to, or even cause, the problem? • could obstruct implementing a new way of working? (E.g. conflicts between employees, emotional situations, financial or contractual issues, differences in corporate culture etc.) • How, and by whom, can/must these issues be solved? • Who can provide the 'drive', who can play the role of 'champion' of the new way of working (e.g. the project leader of a newly started project who is enthusiastic about SE).	• Do the selected activities really match with the chosen business case? • Do we have the right people, with the right expertise and attitude (enthusiasm), participating in the project? • Have the problem issues, found in step 2, been solved, or is it clear how they will be solved, or at least managed, during the SE implementation? • Or did we select the activities in such a way that these problems and risks will not affect the SE implementation? • Should we start with some 'team building' activities first?
External conditions	• Which existing norms or standards do we want to comply? • What are the requirements from our customers / principals / subcontractors / ....? • E.g. a new project where the customer explicitly requires certain SE activities.	• Do we need to order, or subscribe to, certain publications of norms and standards? • Will it be necessary to follow courses to become familiar with norms and standards? • Are such courses available at the right time, location, and in the right language? • Are external parties sufficiently involved in the selected activities (e.g. are customers or subcontractors participating?) • Have agreements with these external parties been made, and are they really committed?
Available resources	• How much time, from which employees, for how many months? • Budget (e.g. for courses, for purchasing software) • Tools that are already present/ available; however, beware of 'tool fetishism'!	• Are budgets approved? • Is time / capacity / commitment promised by all involved dept. managers etc.? • What is the delivery time for selected tools?
Available expertise (in the fields of SE and change management)	• Which expertise is available: • in the own organisation? • from external advisors? • from tool suppliers? However, remember that suppliers have their own interests and may have a limited view.	• Do we have all expertise available that is needed for the selected activities? If not, take actions to make expertise available, or adapt selection of activities.

Appendix 2: Step-by-step products

Step	Step	Product	Who (* responsible)	Contents
1	Vision making	Vision	• Management Team* • Representatives of various groups in the organization	• Vision on effective improvements using SE • expected completion date
2	Analysis of current situation and identification of business case	Analysis report	• Management* • Representatives	• Status of communication • List of bottlenecks • Overview of actual processes • Willingness to changes, Sense of Urgency
		Business Case	• Management*	• Business targets • Anticipated improvements • Potential for improvement • Required resources
3	Strategy making	Plan in general terms	• Management* • SE Project manager	• Detailing of the vision • Global description of activities to be executed

4	Selection of SE-activities	Layout of activities	• Management*
			• SE Project manager
				• List of most beneficial activities (see 2)
				• Generic and specific method for problem solving
				• Business case for every selected change including:
				  • Overview of risks
				  • Expected profit
				  • Method of implementation
				  • Conditions for success of change

		Analysis of conditions	• Management* • SE Project manager	• Willingness to change, Sense of urgency • How may and which resources are available • Available expertise (both SE and change management)
5	Drafting the program	Improvement plan	• Program Manager "Improvement" * • Improvement team (incl. Management)	• Project targets (do's and don'ts) • Pilot selection • Budgets (time, money, resources) • Success indicators • Go/No-Go milestones • Communication (within the team and with stakeholders)
6	Selecting and executing a pilot project	• Pilot plan • Pilot results	• Pilot project leader* • Pilot group members	• Planning, resources, schedules, targets, risk management • Finished products, changed procedures, documented way of working
7	Evaluation	Evaluation report	• PM Improvement * • Improvement team (incl. Management)	• Status success indicators • Lessons learned
8	Executing the Program	• Project plan • List of activities	• "Everybody"	• Detailed description of activities