An Experience Report at Thales Aerospace:

"The Lean Journey"

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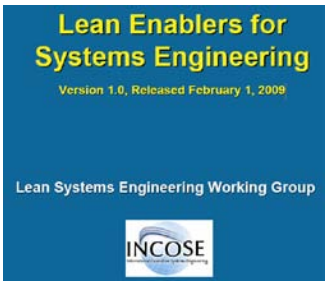
Abstract

This experience report illustrates the implementation of 'Value Streams' in Systems Engineering and Product Development at Thales Aerospace. It explains how non-added value elements are eliminated thanks to these value stream mappings.

This paper is based on one of our real experiences. Therefore, it could be considered as a concrete example of Lean Principle 2 of Lean Enablers for Systems Engineering developed by the INCOSE Lean Working Group:

- "have cross functional stakeholders work together to build the agreed value stream"
- "use formal value stream mapping methods to identify and eliminate Systems Engineering and Product Development waste, and to tailor and scale tasks".



This experience report describes an achieved example of value stream mapping and its positive impacts on Systems Engineering. It also offers an overview of this pragmatic methodology and the training courses for implementation. Current worldwide deployment status and achievements in terms of performances and customer satisfaction are also provided. Finally key success factors and upcoming steps are described to further improve the performance.

IMPLEMENT LEAN ENGINEERING IN THALES AEROSPACE

Introduction

This paper presents the process improvements that have been and that are currently leaded in a major Aerospace company. The first section explains the challenges and the context of this experience report. The second section gives a typical example of mapping the value stream of Systems Engineering as well as a detailed description of the methodology and dedicated training sessions. Then, the document describes Business impacts and current deployments. In the final section, this paper highlights upcoming steps and key success factors.

Context

Thales Aerospace belongs to the Thales Group.

Figure 1: "Thales Aerospace key figures for 2008"

THALES Aerospace is currently Position N°1 in Europe, N°3 worldwide with 13,000 employees in 11 countries. Key capabilities are civil & military equipment and functions (cockpit, cabin, electrical), combat systems (electronic warfare, airborne radars), mission and surveillance systems (UAV, Space and airborne systems).

Around one quarter of revenues is allocated for Research & Technology: a large portion for Systems Engineering. With new comers and open markets, customers are more and more demanding: they are often involved in the definition and validation phases, requirements are evolving rapidly and development cycle time have to be reduced. Competition and $ effect create challenges in term of cost (Recurring and Non–Recurring Costs) and cash flow. On another hand, systems are more and more complex and need multiple competencies at the same time and upfront. Engineering teams are located in several sites and system/product work sharing is international.

In this context, Thales Aerospace has launched in Mid 2007 an initiative to reduce wastes in Systems Engineering and Product development. This initiative is based on applying Lean Principle 2: "Map the Value Stream" in a concrete and pragmatic bottom-up approach. Expected feedbacks were mainly reduction of development cycle, process simplification, rework avoidance while insuring customer satisfaction through flexibility and reactivity. The next section presents a representative implementation of Thales Aerospace workshops.

"What is Lean?". A short answer by one of our expert:
"It is not a miraculous toolbox but a pragmatic approach allowing a company, a team or a person to look at its activities from a new vantage point. Lean stands on several pillars: 'obsession of the customer and satisfaction of its needs', 'attention on problems and elimination of wastes' and 'involvement and development of the employees by the resolution of the problems'."

IMPROVEMENT WORKSHOP IN SYSTEMS ENGINEERING

The following example presents a Lean process improvement workshop performed in Thales Aerospace in 2008. Extracted from our database of 'lessons learnt', it shall be considered as a concrete and fruitful testimony of the application of a major Lean Principle in Systems Engineering: "how to map the value stream and eliminate non added value elements?".

Experience report: "Lean for up-stream Systems Engineering"

In Thales Aerospace, we noticed a substantial increase of workload because of two key factors: new product developments and larger proportion of systems engineering in contracts. This paper explains the sequence and tools used to improve Systems Engineering maturity and process performances.

1) Initialization & guidelines of the project:

The Lean process improvement workshop called "Up-Stream SE" was prepared and formalised during a single meeting (½ day):

- definition of the borders of this workshop (in & out of scope);
- selection of members who will work within a new project (the stakeholders preparing a new product and scheduling the 'future' project: the "customers" of this workshop);
- selection of members who have worked on previous projects (the stakeholders of former SE phases and PD tasks: the "suppliers" of this workshop with operational feedbacks, realistic data, etc);
- identification of the objectives for the team (achievements versus commitments).

The contract to deliver this new product was signed with several constraints: demanding performances and a very restrictive perimeter in terms of delays and cost variances. The success of the Lean workshop was vital for Thales Aerospace. At the end of the first meeting, executive managers validated it. Then the team was gathered and this workshop was launched during a dedicated kick-off meeting.

2) Description of the 'Current State':

The 'Current State' was mapped during two meetings (2 x ½ day):

- description of the existing value stream by the team of operational stakeholders (the real-life experience was challenged by frequent questions from the 'future' project) ➔ deliverable = current VSM (value stream mapping);
- collection of wastes and major dysfunctions by team members' feedbacks (collected as discussion goes along);
- confirmation of the 'Current State' through dedicated interviews of other active projects.

The data collection and the quantification of the 'Current State' were performed during a single meeting (½ day):

- addition of facts and real data over the current VSM (for example: days of reviews, duration of development phases, number of iterations of documents, etc);
- estimation of major steps in terms of delays, costs and real performances (10%, 50%, 90%) and estimation of dysfunctions (impacts and frequency);
- completion of 'Current State' (facts & data: faithful & accurate map of the current reality).

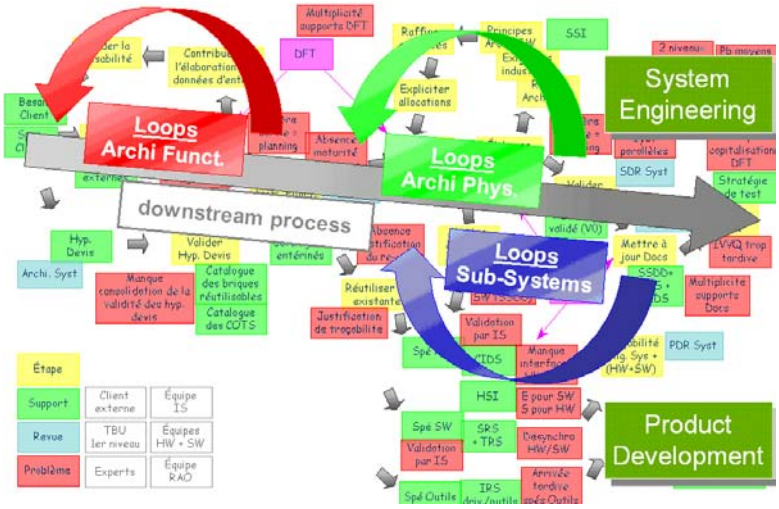


Figure 2: "Current VSM"

The value stream map covers the entire up-stream process (from the needs of the customer to the beginning of the integration/validation phase). Built with brown paper and post-it, the 'Current VSM' displays the SE and PD tasks: the operational stakeholders identify the Value-Added and Non-Value Added elements.

The visual deliverables of these meetings enabled the team to understand how necessary was the improvement of its organisation. By making imperfections visible to all, they also facilitate looking for solutions to improve the 'Current State'. Not only the organisation but also the skills and competencies of the staff involved in the 'future' project need to be improved. In fact, the future product has become more 'system' than any of our previous projects. The first dysfunction revealed by the Lean process improvement workshop was a 'downward process' without real parent-child relationships: the "SE to PD" activities were not synchronized to implement a successful incremental process. The second weakness was a push flow based on physical circuits and boards: the scheduling activities were not using functions required by the customer.

3) Analyse of inefficiencies :

The classification of wastes started as soon as the 'Current State' was built and agreed by the entire team: impact and probability of problems determined the priorities of the Lean workshop. The search of root-causes and the identification of possible solutions were performed during a single meeting (½ day):

- description of dysfunctions and inefficiencies (impact x probability = criticity);
- search for the root-cause(s) of all the identified problems;
- record of a 'Board of Weaknesses' ➔ non-technical risks for the 'future' project.

With a minimum effort, the team built a factual and structured analysis of potential risks for its future activities (reinforce by real-life feedbacks).

4) Formalisation of recommendations:

The Lean workshop generated a list of actions: four major axis were defined to facilitate communication with the rest of the SE and PD departments. First of all, the team of the future project was gathered in a single area and initialized a common board for visual management. The recommendations were displayed on the wall to be visible by all the team members: their own suggestions structured the beginning of the new project.

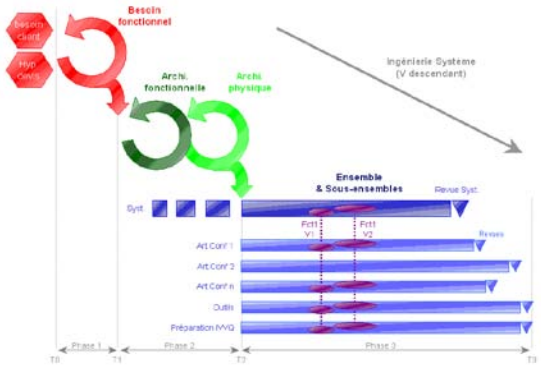
Figure 3: "Axis of actions"

In a common area, the project team displays its conclusion to the rest of the department. This clear communication plan provokes new proposals: immediate actions and participation of virtually everyone in the open space.

From this action plan, the two following paragraphs explain major opportunities to improve the 'Current State': identification of a target and definition of common rules.

Action1: « Identify an ideal engineering process »

Thanks to the 'Current VSM', the team proposed an ideal value stream by eliminating non-added value elements and by scheduling tasks for the future project. Interviews of central experts helped to define a consistent process. Exchanges with SE peers helped to reduce possible risks and to synchronize critical items.



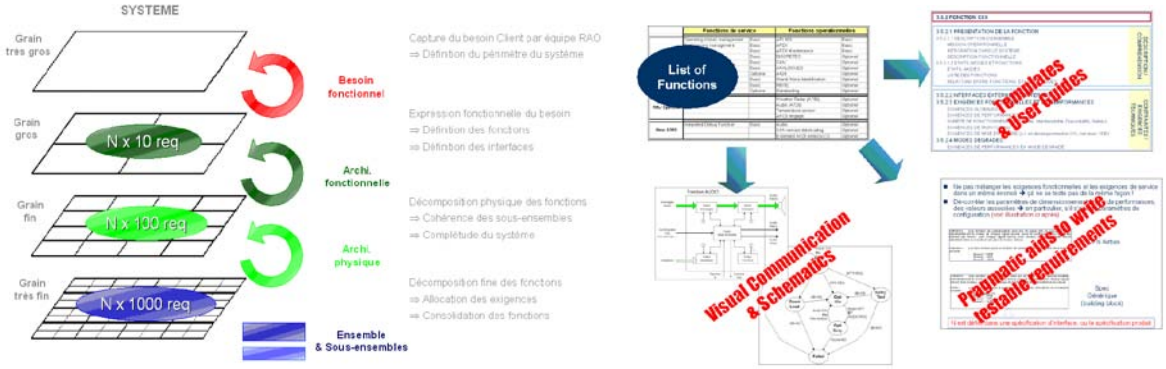
Figures 4 & 5: "Future State"

The team has defined an ideal value stream (the Future VSM) with the description of both SE and PD tasks. The mutual understanding across the value stream permits flexibility to absorb new customer requirements.

One month was enough to perform the mentioned meetings. With a minimum number of visual tools, the team of the new project took control of the SE value stream, involved PD tasks and shared knowledge among engineering professionals. The target was also approved by managers, validated by SE peers and compatible with the official approach stipulated by central experts.

Action2: « Define rules to manage requirements »

Thanks to the ideal value stream, the Lean workshop defined the ideal organisation for official documents. With the feedbacks of previous projects, the team of the new project established pragmatic rules to allocate requirements, promoted the way to integrate them in documents and most of all planed how to verify and validate them (preparation of the Integration/ Verification/ Validation/ Qualification phase, facilitation of traceability).



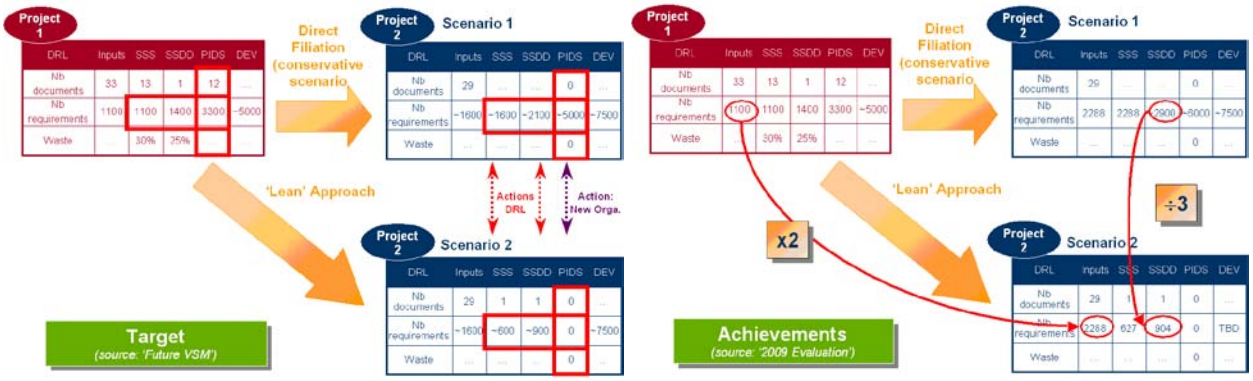
Figures 6 & 7: "Sharing of best practices"

Near the communication plan, the team displays examples of best practices for daily tasks (write requirements, allocate functions in documents, integrate new resources, etc). Less computer screens and more visual communication to build a new team spirit.

5) Control of the new process:

The Lean process improvement workshop covered the entire value stream from customer needs to the preparation of the integration/validation phase. The team defined two methods to control the 'Future State': measure the number of requirements for each level of the value stream (SE and PD activities) and estimate delays, costs and rework of each revision of official documents. Thanks to the capitalisation on previous project, the team was able to compare the target to the former situations: achievements became improvements!

Performance measures were confirmed by a post-project evaluation: the indicators display on the walls of the common room gave to all the team members the improvement gap. While the customer was doubling its requirements, the team has stabilized the size of its system: all PD requirements were directly managed by PD leaders (a common traceability tool insures the correct coverage of requirements).



Figures 8 & 9: "Initial estimation in 2008 and measured reality in 2009"

The Lean workshop has estimated a significative reduction of the total workload of the new project. After the evaluation, an audit has estimated the improvement: the number of requirements was divided by three while the number of customer demands was multiplied by two.

6) Conclusion:

With a minimum investment (a total of 10 meetings of ½ day with 5 to 8 people), the Lean process improvement workshop achieved several major changes in this R&T Unit:

- Use lessons learnt on previous projects for future programs;
- Develop a clear and agreed value stream for the next project;
- Deploy a visual management in open spaces to make progress visible;
- Use Lean tools to facilitate the flow of information and the commitment of team members;

In terms of return on investments (ROI including workload and materials), the Lean process improvement workshop offered a ratio around 6 while the scheduling was respected. The variability was reduced and the rework during IVVQ (Integration, Verification, Validation, Qualification) phase was strongly diminished. Traceability tools helped to collect data and to extract statistics for post-mortem analysis.

These performance improvements provoked new workshops in Systems Engineering processes.

The next session explains how we have defined our Lean methodology and how we have deployed numerous Lean workshops in SE and PD fields.

Lean Thinking has a long history in fields as diverse as manufacturing, offices, etc. But many examples of dramatic improvements in high-performance companies have demonstrated how Lean is not a magic formula and how Lean needs a solid approach to become successful in R&D domains (especially Systems Engineering). Hereafter is the recommended approach.

Step 1: "Make the Lean concept our own"

Seeing waste is the first activity to deploy Lean in a company. As many companies have started Lean in industrial areas, they use the usual seven wastes identified by Shigeo Shingo from Toyota [5]. Powerful in Lean Manufacturing, this list is useless in R&D domains if directly applied. Our way was to translate these terms into the "seven wastes in engineering" [7]. For example, "inventory" become "partially done work" because a partially done task ties up resources in investments (material and human) as storage does. Our way was also to adjust these wastes to fit our experiences in development areas. For example, "defects" are not described with a recurrent impact and a bad yield but are defined as a risk introduced in development processes: the latest the detection, the worst the impact (similar to Lean Manufacturing but with a Lean Development point of view).

7 wastes in Manufacturing	7 wastes in Development	Examples in Development
Inventory	Partially Done Work	Untested solutions/ unfinished documents
Overproduction	Extra Features	Unnecessary functions for customers
Extra Processing	Relearning	Re-invented solutions
Transportation	Handoffs	Complex validation process
Waiting	Delays	Waiting for decisions/ asynchronous tasks
Motion	Task Switching	"Stop & Go" tasks
Defects	Defects	Rework because of wrong requirements

Figure 10: "Similarities between Lean Manufacturing and Lean Engineering"

Our innovation was to define the Lean Thinking as a destination because of improvements but also as a journey because of the necessary apprenticeship.

Step 2: "Deploy the Lean philosophy from the start"

Lean in production areas started its deployment a long time ago (the term 'Lean' appeared in the 90's by J.Womack and D.Jones [2]) but its application in R&D domains is quite recent. Because of their knowledge in Lean Manufacturing, many companies have avoided the practicing phase of Lean deployment and have applied immediately industrial solutions or production tools without any restriction. Some have failed because of the fundamental differencies between engineering and production (recurrent and non recurrent processes, cultural aspects, physical or virtual jobs, etc). Our way was to go back to basics and observe where Lean comes from. Therefore, we focused our first activities on eliminating wastes: we deployed Kaizen events which are

improvement projects with a typical sequence coming from 6 Sigma methods [4]: DMAIC (Define, Measure, Analyse, Improve, Control). That is why we have chosen few but efficient tools to start our projects. VSM (Value Stream Mapping) was the first one we used. Once again, our way was to adjust it to fit our experiences in development areas. For example, VSM is not described as a process mapping to improve activities' balancing but VSM is described as a visual and collective tool to generate a map of a process or to secure a schedule as a PERT does.

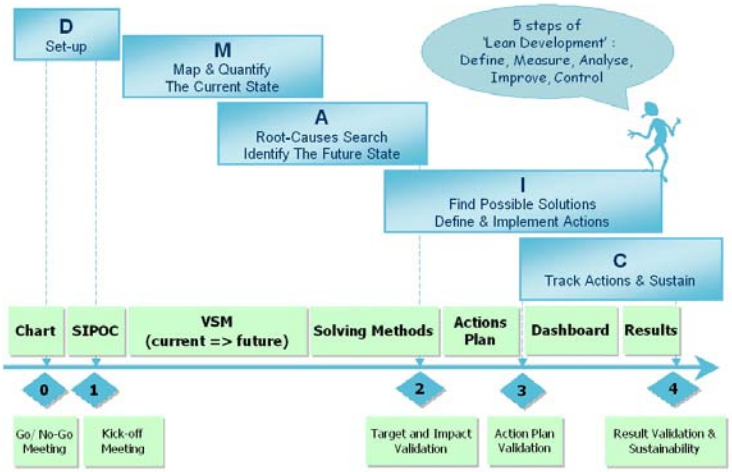


Figure 11: "typical sequence of a Lean workshop"

Our innovation was to accelerate the pace of the Lean journey rather than to short cut some steps of the apprenticeship.

Step 3: "Add value to the job"

Today's companies are facing the difficult implementation of successful improvement programs. As for CMMI, ISO, TQM, 6 Sigma and even Lean, a lot of organisations failed to change the behaviour of their staff. In most improvement programs, managers tell workers how to do their jobs: the change efforts are always for others! Our way was to focus workers on their own activities. With collaborative and visual tools, they come up with proposals to improve their own jobs (including the interfaces or interferences with other jobs). Our way was also to have those who made proposals to be responsible to implement them: they receive supports for immediate actions. The middle managers are directly involved in improvement projects not as know-how workers but as true leaders to facilitate changes [13].

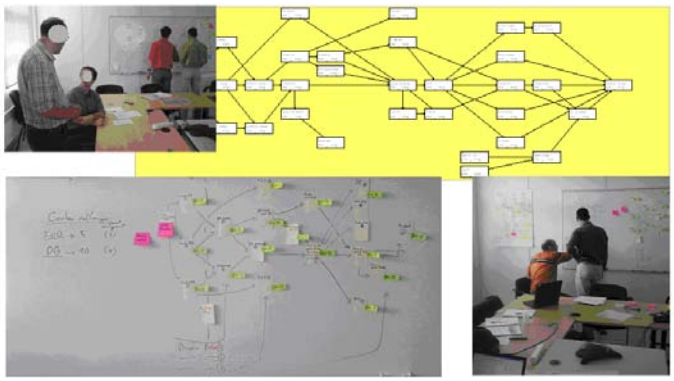


Figure 12: 'typical meetings during a Lean workshop'

Our innovation was to carefully choose leaders and teams to be sure that the project is worth doing it. Our success was to introduce a methodical approach to do a real activity and not to create a new job upon over-booked managers.

Step 4: "Pull the methodology by the customers"

Companies implementing improvement methodologies know how hard it is to involve teams in new approaches. Many trials to deploy Lean failed because of a "push" methodology: "here are the tools and the user guides, now use them and progress". Feedbacks of Systems Engineering and Product Development teams have demonstrated how different were the official speeches and the on-field reality. Our way was to avoid excessively complex tools and complicated concepts. Therefore, we started by defining different level of users:

- Beginner who is an inexperienced person in Lean Thinking;
- Team member who takes part in Lean Process Improvement Workshops;
- Leader who animates and dispenses the Lean Thinking.

Then we have designed a tailored Lean toolbox to respect these three levels. For example, the basic presentation to introduce Lean has been declined into three documents:

- Awareness for beginner (5 minutes to read);
- Training for team member (20 minutes to read);
- Coaching for leader (60 minutes to read).

As a consequence, we also tailored training courses with the same logic:

- A 2-hour session for beginners to acquire vocabulary, understand basic principles and discover examples of workshops.
- A 8-hour session for team members to learn the typical sequence (DMAIC), to understand the main tools and discover the Lean Thinking through testimonies and real-life feedbacks.
- A 24-hour session for leader to understand workshops, to practice Lean tools and to set-up the own workshops.

Our innovation was to create a modular toolbox with different levels to avoid enormous tools but to minimize the depth of knowledge. Our added value was to design a full methodology pulled by its customers: toolbox, training course, testimonies and capitalisation on previous workshops. All of these elements available on line in a dynamic database.

Step 5: "Stop theory, put into practice"

One of the fundamental Lean principles is the use of problem solving to learn and progress. In fact, every team should have time to find problems and solve them. The first rule of process improvement is not to try to do everything at once. Experience grows like a knowledge spiral: from small trials to wide iterations. Our way was to integrate problem solving into our training sessions: from a small exercise to prepare a workshop to a large case study to map a value stream. In doing so, we simulated possible workshops and facilitate new improvements.
On another hand, we considered games as a quick way to practice [12]. For example, we have created a Trivial Pursuit-style game to assess people's knowledge of Lean. Correct answers are rewarded with "Added-Value" points. Meanwhile, wrong answers generate "Waste" or "Non-Added Value" points. At the end of this game named "The Lean Journey", the highest Added Value / Non-Added Value score wins!

Figure 13: 'The Lean Journey: cover and box'

Our innovation was to implement our bottom-up approach into modular training courses by using exercises, case studies and games to have people practicing as much as possible.

Our Lean Thinking was on the way.

BUSINESS IMPACTS

Since 2008, more than an hundred of Lean workshops have been conducted. More than 500 people have been involved from executive managers to experts and technicians. Our Lean Journey has produced substantial results. Our database of 'Lessons Learnt' has generated significant statistics.

Improve performances and competitiveness:

First of all, technical teams have simplified development processes through a collective buy in, a reduction of mistakes and a decreasing rework. 'Quick wins' solutions have generated immediate implementations and tangible savings. With minimum resources (usually between 5 to 10 people) and short durations (typically from 1 to 3 months), Lean improvement workshops have achieved returns on investment of a factor of 5 (ROI). In aerospace business, that ratio means an average of a hundred k$ savings per Lean process improvement workshop through secured baselines, optional solutions and fewer iterations.

On another hand, most of the completed workshops have positive impacts to reduce product development cycle time and time to market. An improvement initiative on Integration/ Verification/ Validation phase quite simply enabled to reduce IVV cycle time by six months for an avionics display.

In fact, beyond financial implications and productivity, Lean is all about initiating behavioural changes and a culture of continuous improvement.

And today, our Lean Journey is getting bigger. We are applying this pragmatic approach to a wider scope, tackling systemic waste on cross-functional organisation. Some recent experimentations have already added new fields to our bottom-up approach. Programme reporting, problem backlogs, re-use, and document rework are several identified savings: potential of millions of non-productive hours by focusing engineering on added value. The first step of our journey laid the foundations, we are moving forward.

Customer satisfaction

Have teams focused on customer expectations is the basic Lean principle. Add value for the customer pulls all our activities and workshops. Improve visibility, pay attention to waste and develop collective behaviours are powerful methods to secure baselines, to react quickly to new request or customer change.

Finally, several Lean initiatives with customers enabled us to satisfy their needs, identify new opportunities and propose efficient products.

Lean is all about making things simple.

"Everything should be made as simple as possible
but not one bit simpler" Albert Einstein.

DEPLOYMENT

Mapping Systems Engineering and Product Development is currently implemented on all worldwide sites of Thales Aerospace. Countries such as the United-States, United-Kingdom, Canada, Germany and France are proactively involved.

More than 100 concrete Lean process improvement workshops have been completed since 2008. Between 50 to 100 new workshops are planned in 2010, including local and transverse value stream mapping.

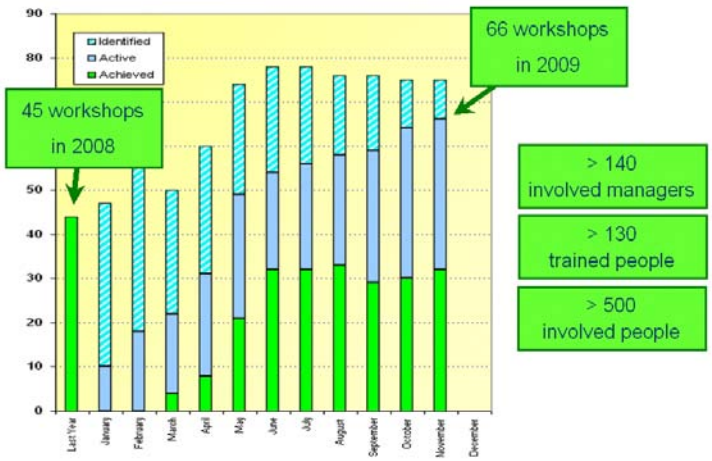


Figure 14: "Deployment of lean process improvement workshops since 2008"

Executive managers are involved in this implementation. They are setting Lean resources and projects priority. More than 50 Worldwide Executive Managers were attending a Lean awareness session in March 2009. According to our observations and supported by the statements of the interviewees, two major factors have contributed to this successful session:

- Executive management's commitment
  - Personal involvement
  - Strong enforcement
  - Lean Resource availability
- Visible support
  - Alignment with business objectives
  - Achievements and rewards on real projects
  - Long-term positive impact

Team Managers and their team who are mapping their own product are empowered and a team spirit is developed. More than 130 people were intensively trained how to map their own Systems Engineering and Product Development value streams. More than 50 people will be trained in 2010. There was noticeably less noise and confusion during workshops. Workload in this high intensity environment decreased despite the leaner staffing. Furthermore, those responsible for key decisions were able to expand their time horizon and think ahead instead of continually reacting to events.

In few cases, engineering suppliers were involved in Value Stream Mapping. Partners and preferred suppliers will be more involved in the near future. Our training sessions will be adjust to integrate external and internal teams from SE and PD fields.

Systems Engineering organization composed of middle managers or senior Design Authorities were attending a Lean awareness and sharing experiences seminar in May 2009. Priorities were defined and best practices shared.

Figure 15: "Lean & Systems Engineering Seminar"

A proactive network of Lean ambassadors is managing the Lean implementation as described in the next figure. On site coaches allow local presence and support. A Lean sharing knowledge team is meeting every month to share best practices, new events and to launch new initiatives. This Lean Team is international and takes benefit of multicultural values and international standards.

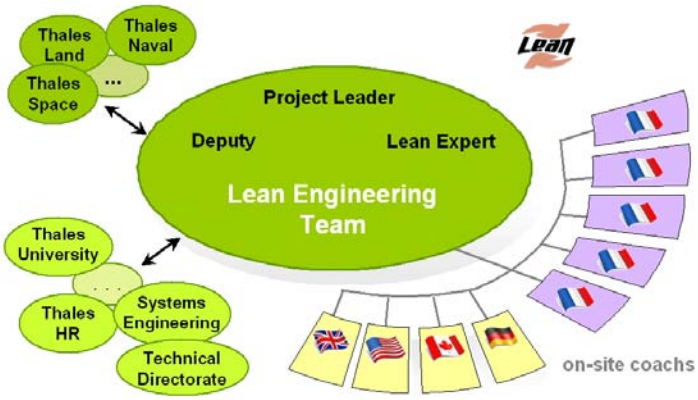


Figure 16. "On site resources for dissemination"

Sharing knowledge and practices was done since 2007 and will be developed in 2010 with the following organizations:

- Other Divisions of the Thales Group
- Other companies having different markets and domains
- Universities and engineering/business schools through training and testimony, internship or apprentices

CONCLUSION

This paper provides an experience report of concrete implementation of Value Stream Mapping for Systems Engineering.

Key factors of success of this methodology, ensuring its perennity, are:

- Focus on customer needs;
- Engineering teams buy in, through collective bottom-up workshops;
- Involvement of different levels of management, from Team Managers, Middle Managers to Executive Managers

Needs to manage cultural changes, even if people are more receptive to change

- Lean engineering is a structural transformation and a cultural change
- Improving company performances through Lean need a drastic cultural change to face problems at every level of the engineering organization
- Lean means evolving engineering skills and competencies, which need the visible involvement of the executive management on a long-term basis.

Lean is a continuous improvement; upcoming identified steps are listed below:

- 100% deployment across all Systems Engineering activities, including local and transversal ones, such as change request, technical problem reports, etc.
- Focus on the simplification of processes and organizations
- More involvement of customers and suppliers in Value Stream Mapping, focusing on definition and Verification/Validation phases
- Develop visual methods wherever possible to communicate schedule, workloads, changes to customer requirements (Lean enabler 2.13)

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BIOGRAPHY

Michel Baujard: Business Process Improvements, Lean Engineering Expert, Thales Aerospace

Industrial experiences
Michel Baujard has helped organizations in Aerospace & Defence measurably improve quality and productivity, coached more than 100 process improvement projects, save millions of dollars in costs of poor quality. His background is systems engineering and program development experiences, both in commercial and military environments. He has published various papers on improvement techniques, technical patents, and press releases. He is an active member of AFIS on Lean Engineering.
Teaching experiences
He is teaching graduate courses in Lean and change management and he is professor of Program Management in Engineering Schools.
Education
Engineer (Post grad degree), 1981, Supelec France
Armed forces Engineer degree, 1983
Awards: Platinium Change Leader in 2007, 1st prize Innovation in 2003

Harry Gilles: Black Belt Lean Sigma, CMMI Expert, at Thales Aerospace.

Industrial experiences
Harry Gilles is a Thales Black Belt Lean Sigma and CMMI expert for Aerospace & Defence. He has coached more than 30 process improvement projects for large organizations, with challenging business objectives. He has participated in many assessments for Thales group organizations to reach higher SEI maturity levels (EPG leader). His background is in system and software engineering, both in commercial and military environment.
Education
Engineer (Post grad degree), 1995, CESI France
Non-commissioned officer in French Air force.
Trained to CMMI$_{SM}$ and Lean Six Sigma approaches

Olivier Terrien: Lean Expert, Thales Aerospace.

Industrial experiences:
Olivier Terrien is a Thales Lean Expert and is the Thales Aerospace reference for Lean Engineering. He has implemented process improvement workshops based on Lean Manufacturing and/or Lean Engineering approaches (in systems engineering, software development and customer commitment). His background is in engineering processes (design of microwave components, development of electronic warfare receivers, integration of naval radar systems and airborne electronic warfare suites). He has published more than 150 article pages in the worldwide Press.
Education:
Engineer (post grad degree), 1997, ESEO, France
MBA, 2006, IAE Paris-La Sorbonne, France