Product Line Thinking

-

Applying System Thinking to Product Lines

Alain Le Put – MALP Conseil

Product Line Thinking

❖ **Context**
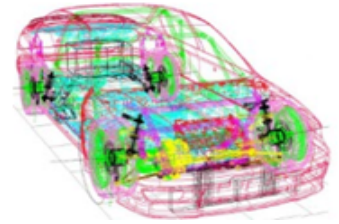
❖ **System Thinking for the implementation of Product Line**

❖ **System Thinking when developing in a Product Line**

❖ **Product Line Thinking for VSME**

❖ **Product Line Thinking**

System Product Line

A Product Line is a set of products and/or services:

❖ **sharing explicitly defined and managed common features**

❖ **and variable features to meet the variable needs of specific markets**

❖ **It is also a global development strategy able to bring significant benefits for the Customer(s) and the Enterprise.**
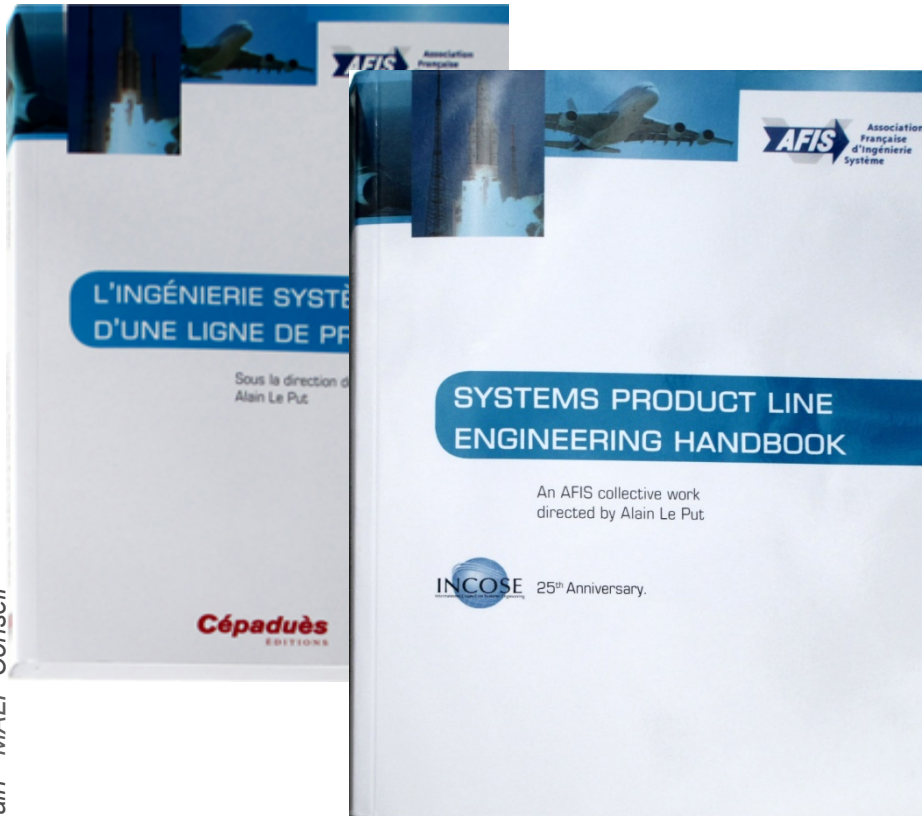
The Systems Engineering Product Line Handbook

❖ **Written in 2012, the Handbook is a Reference Document describes:**

 ❑ *the main concepts,*

 ❑ *the possible strategy to set up or to improve a Product Line Organization*

❖ **This Handbook is mainly built on Return of Experience :**

 ❑ *captured during 4 years in France,*

 ❑ *From about 20 Industrial representatives from AFIS:*

 ◆ *Automotive, defense, satellite, nuclear power…*

 ◆ *Research, Universities…*

 ◆ *Software solution editors…*

Return of Experience from industry.

The Systems Engineering Product Line Handbook

❖ **Translated in English, the Handbook received the 2015 INCOSE award for Product of the Year.**

> *"The Systems Product Line Engineering Handbook now enables both French & English speaking people around the world to easily learn and quickly benefit from this important best practice."*

Systems Engineering Product Line
What's new ?

A lot of experiences gathered since 2012 all around the world.

The International ICOSE Working Group organized about two to three meetings or events a year since its creation in January 2013 in Jacksonville.

And new returns of experience …

Systems Engineering Product Line
What's new in France ?

In France, training courses has been organized with ENSTA ParisTech to deploy Product Lines:

❖A "standard" 3 days training course,

❖And a comprehensive set of training courses dedicated to VSME :

❑ *an informative session to catch attention on Product Lines,*

❑ *a high level short training session to bring the VSME managers to make decision,*

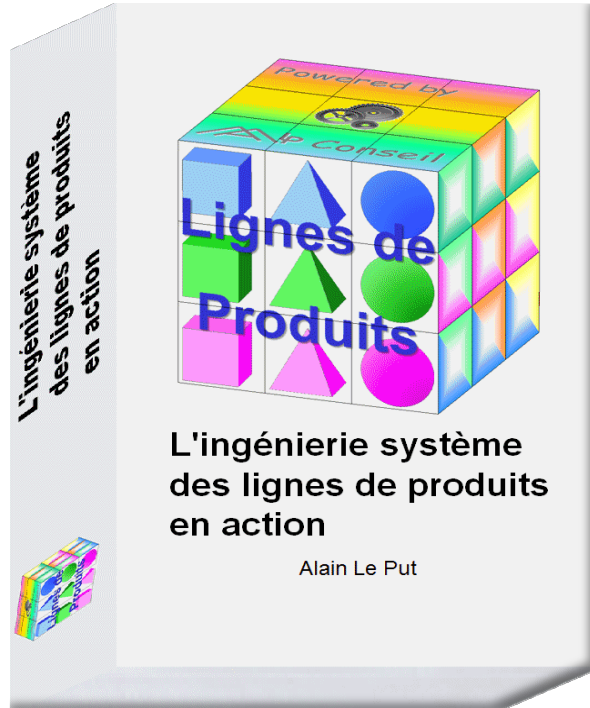❑ *an exhaustive training session to give the knowledge necessary for an immediate implementation.*

A lot of returns of experience of a new type:

❖*Writing a strategic plan,*
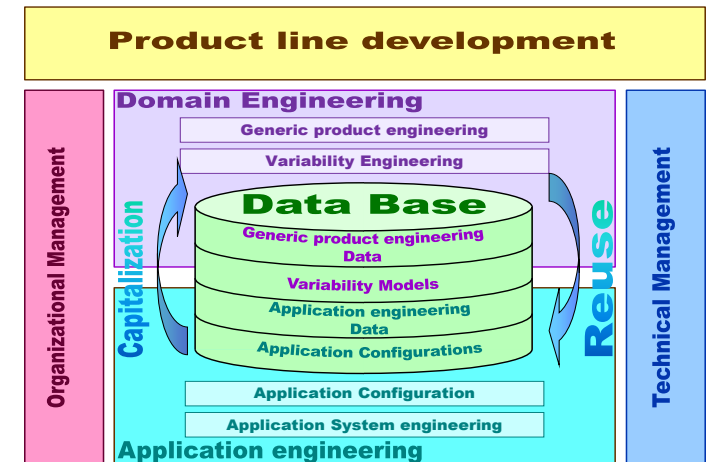
❖*Simulating return on Investment,*

❖*Modelling variability, …*

Systems Engineering Products Line in action

A new 600 pages version of the Product Line Handbook will be soon available in French.

L'ingénierie système des lignes de produits en action

Alain Le Put

1. Key Concepts
2. Product Line Development
3. Product Line System Engineering
4. Variability Definition and Engineering
5. Management
6. Success Factors

❖ A new consistent Meta Model,
❖ A new reuse capability model,
❖ A method to define and develop variability models, …

Systems Engineering Product Line - deployment

… but also some issues

❖ **People having:**
  - ❏ *to face with the Product Line inherent complexity,*
  - ❏ *to change their way of thinking,*

❖ **New targets (VSME)**

❖ **…**

System Thinking for System Engineering

The System Engineering set of processes and methods is not sufficient to develop and understand systems.

Even if well trained, beginner system engineers will not be able to develop complex systems, but senior system engineers will. In fact they perform the same processes! If we try to understand the fundamental difference between them which enable success, we need to focus on the way of thinking the System.

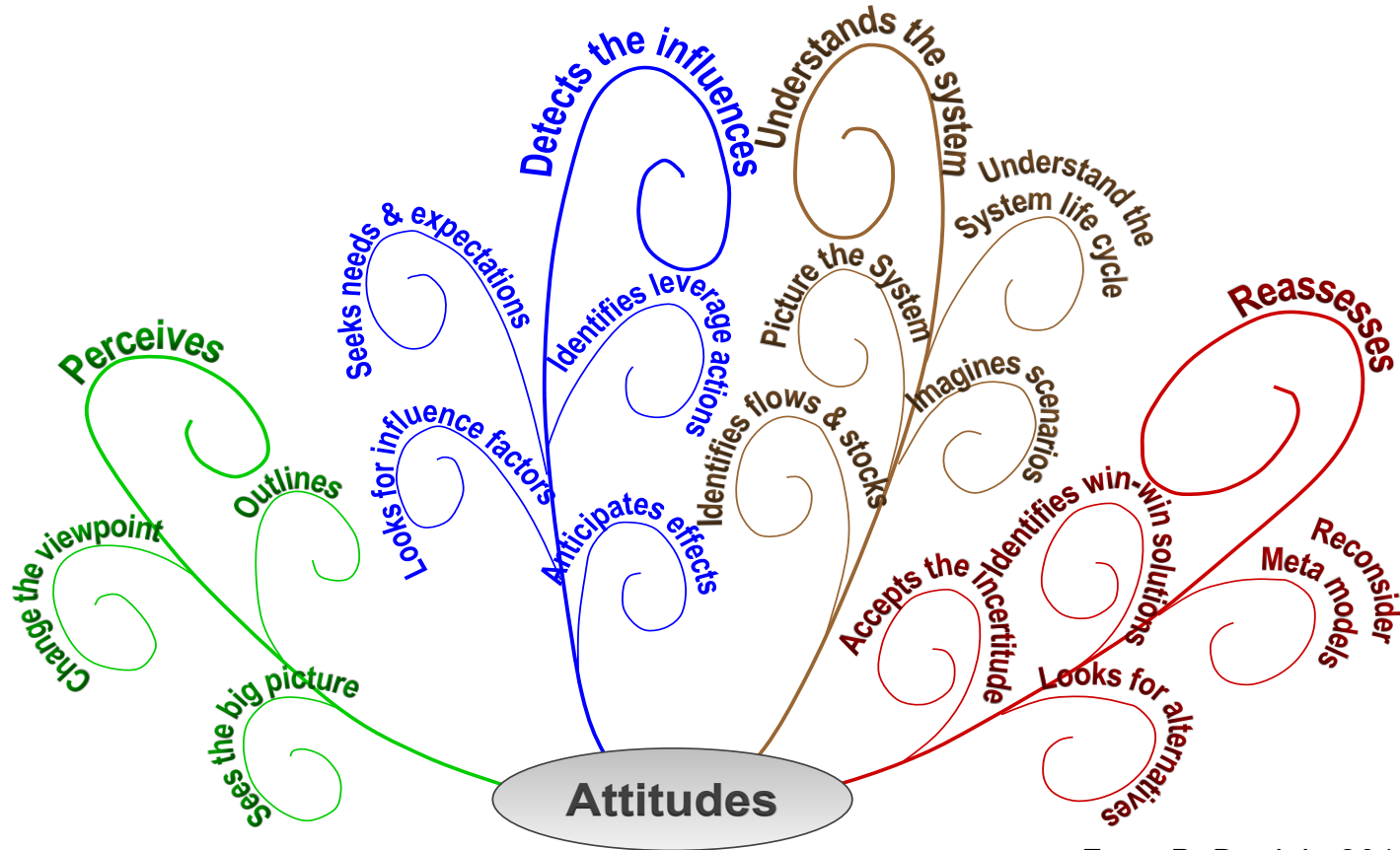*AFIS handbook, written in French in 2012*
by Mrs. Brigitte Daniel.

System Thinking for System Engineering

System Thinking is an approach to problem solving, by viewing "problems" as parts of an overall system, rather than reacting to specific part, outcomes or events and potentially contributing to further development of unintended consequences.

System Engineering

System

System Thinking

The System Thinking attitudes mind map

Detects the influences

Understands the system

Understand the System life cycle

Seeks needs & expectations

Perceives

Picture the System

Reassesses

Identifies leverage actions

Imagines scenarios

Looks for influence factors

Outlines

Identifies flows & stocks

Reconsider Meta models

Identifies win-win solutions

Change the viewpoint

Anticipates effects

Accepts the Incertitude

Looks for alternatives

Sees the big picture

Attitudes

From B. Daniel - 2012

STA1. Perceive

STA2. Detect the influences

STA3. Understand the system

STA4. Reassess
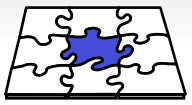
System Thinking for System Engineering

Systems thinking can be used as a set of habits or practices, something like a dictionary of system engineer attitudes for:

❖ **Envisioning a new system,**

❖ **Understanding an existing system.**

System Thinking is not sufficient to develop a System, but contributes to Knowledge Management and should help:

❖ **The beginners, to encourage them to identify and solve problems,**

❖ **The seniors, to remind them the ways to avoid problems.**

> *A highly efficient "tool" to solve problems …*
> *… Why not use it for Product Lines?*

Product Line Thinking

❖ **Context**

❖ **System Thinking for the implementation of Product Line**

❖ **System Thinking when developing in a Product Line**
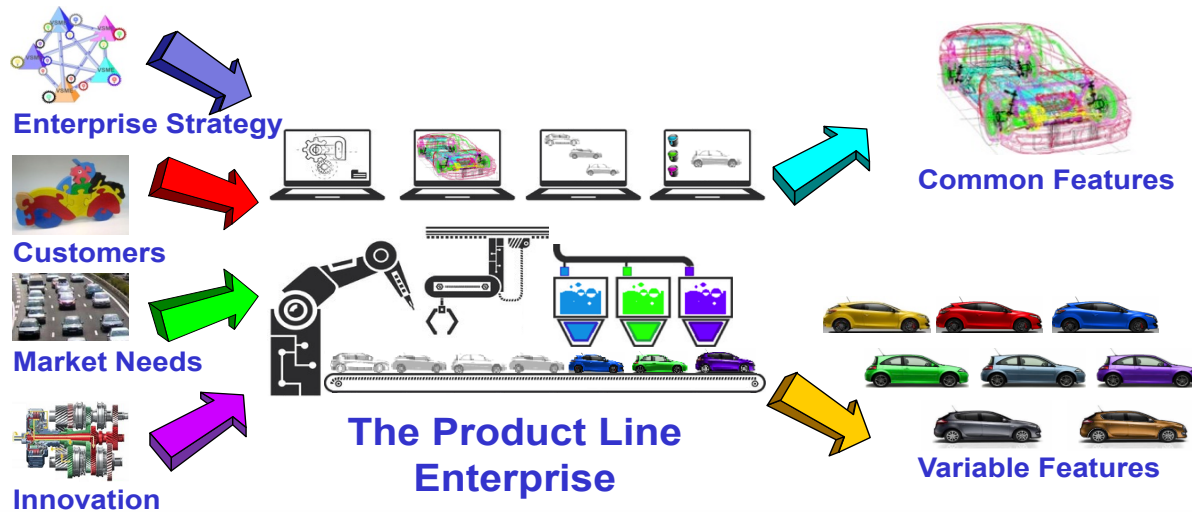
❖ **Product Line Thinking for VSME**

❖ **Product Line Thinking**

Implementation of Product Line

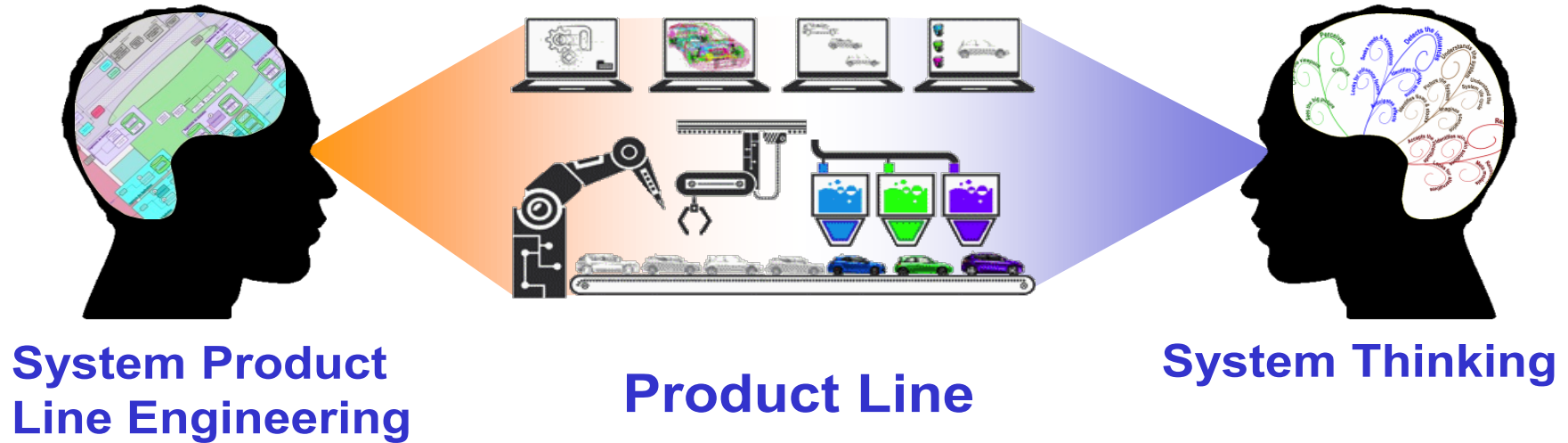**Let's consider a Product Line as a System to be developed, but:**
❖**Product Lines add the variability dimension, one concept to Systems Engineering, and thus to its inherent complexity,**
❖ **a lot of people are "new developers" for Product Lines, even if they are senior system engineers, …**

Enterprise Strategy

Customers

Market Needs

Innovation

The Product Line Enterprise

Common Features

Variable Features

> *The implementation strategy needs to be tailored to the industrial and market context.*

System Thinking
for the implementation of Product Line

**System Product
Line Engineering**

Product Line

System Thinking

What could be the suited attitudes to be taken by the "Product Line Architect"?

System Thinking attitudes for the implementation of Product Line

PLTA1. Perceive:

– **Outline, define the Product Line domain: common features and variability,**

– **See the big picture, address all the customers at once to get a global view of needs,**

– **Change his viewpoint, adopt both the Customer Change and the Supplier viewpoints.**

System Thinking attitudes
for the implementation of Product Line

PLTA2. Detect the influences:

– look for business breakthrough (technical and technological innovation).

– be aware of the market change and trends (what the customers really want to acquire).

– Anticipate effects, analyze carefully the cause-effects loops:
  - *the reuse and capitalize loop;*
  - *the Product Line organization and the needed investment, then the expected benefits.*

System Thinking attitudes
for the implementation of Product Line

PLTA3. Understand the system, envisioning a new Product Line, in order to choose the best Product Line architecture or organization:

- **Picture the Product Line organization,**

- **Identify flows & stocks: interfaces between processes, artefacts to capitalize**

- **Understand the Product Line life cycle:**
  - *Cyclic, to reassess the opportunities periodically,*
  - *Incremental, several steps to set up the expected organization,*
  - *and iterative, executed for each application;*

- **Imagine scenarios for: setting up the Product Line, developing the domain products and the applications in the Product Line, changing culture (training, incentive).**

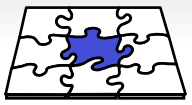# System Thinking attitudes for the implementation of Product Line

PLTA4. Reassess:

–Reconsider Meta models: more complex context outside and inside the enterprise, more customers, more stakeholders, explosion of the offer, more complex product,

–Accept the incertitude: the context to take into account must be extended to trends, emerging technologies, … as a result, the picture is necessarily more blurred.

–Look for alternatives: Product Line or single system engineering; many possible organizations for one Product Line.

–Identify win-win solutions: Try to find the best Product Line organization, not necessarily the more mature one, but the most efficient one.

Product Line Thinking
for the implementation of Product Line

The main challenges when implementing a new Product Line or improving an existing one is how to have a good view of the context and to choose the best organization of Product Lines; so the main attitudes are:

❖ PLTA2 "Detects the influences"

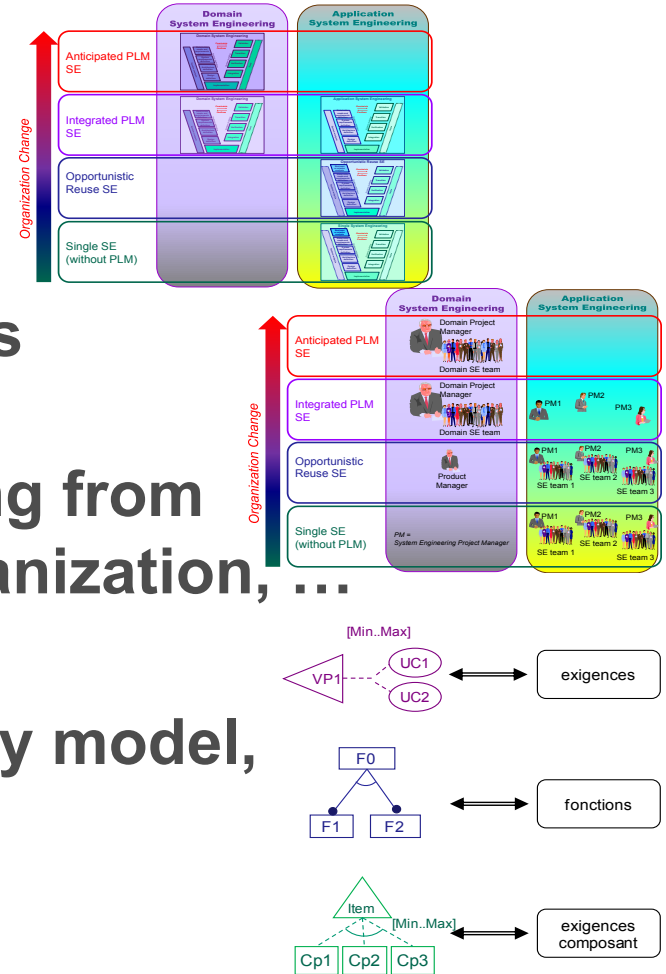❖ and PLTA3 "Understands the system".

❖ **Context**

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❖ **Product Line Thinking**
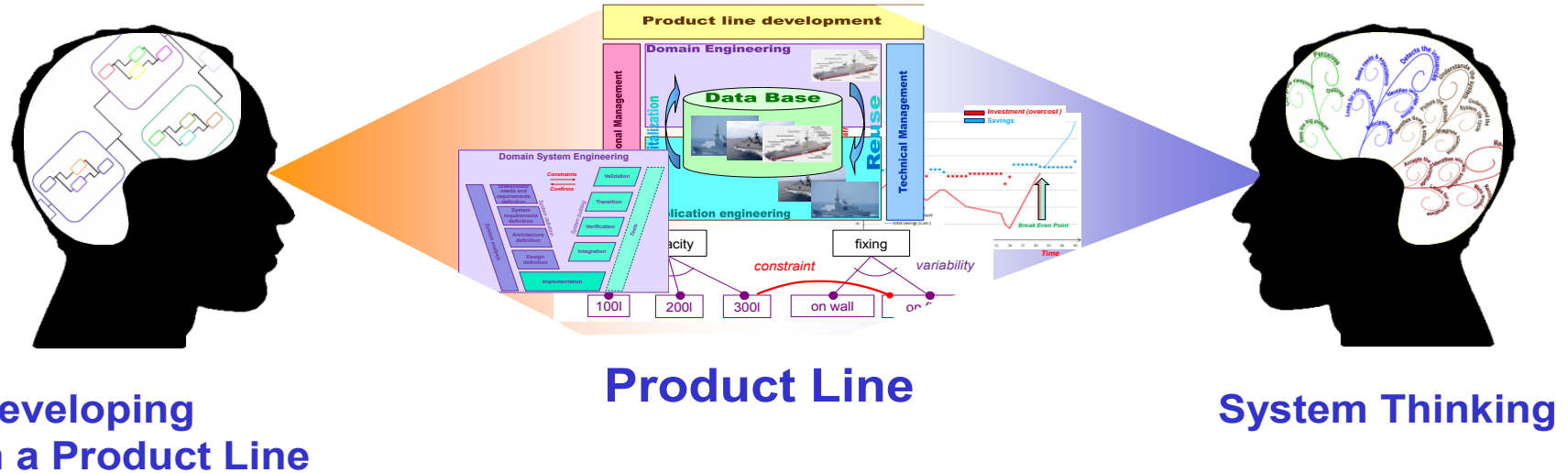
Developing in a Product Line

Setting up a Product Line induces many changes in the day-to-day way of engineering a system:

❖ **systems engineering processes are adapted to the reuse and capitalization strategy,**

❖ **systems engineering products concerns now the domain and the applications,**

❖ **organization itself is changing: migrating from multiple projects to a single platform organization, …**

and new processes, new artefacts arise:

❖ **variability engineering and the variability model,**

❖ **capitalization and reuse.**

System Thinking
when developing in a Product Line

**Developing
in a Product Line**

Product Line

System Thinking

It is important not to neglect the human obstacles to adopt a Product Lines, including:

❖**resistance to change,**

❖**resistance to the reuse of products created by others: the well-known "Not Invented Here" (NIH) syndrome,**

❖**participants' fear of losing leadership or expertise …**

System Thinking attitudes
when developing in a Product Line

PLWA1. Perceive:

– **Outline: understand the defined Product Line domain: common features and variability,**

– **See the big picture: work at the enterprise level, on a platform, not in a single project,**

– **Change their viewpoint:**
  - *understand the enterprise objective, not only the customer needs,*
  - *from a personal viewpoint to a collective one*

System Thinking attitudes
when developing in a Product Line

PLWA2. Detect the influences:

– **Look for influence factors: build a team spirit,**

– **Seek the Product Line needs & expectations,**

– **Anticipate effects: a context where everyone is enriched in contact with each other,**

– **Identify leverage actions: as training and coaching,**

System Thinking attitudes
when developing in a Product Line

PLWA3. Understand the system, envisioning a new Product Line, in order to choose the best Product Line architecture or organization:

– **acquire a functional view of the Product Line organization.**

– **understand the system engineering artefacts, the assets, the processes inputs & outputs;**

– **understand the Product Line life cycle in order to perform the right activity with the right product configuration.**

– **Imagine scenarios: understand the scenario when developing the domain products and the applications in the Product Line (as a sequence of tasks).**

System Thinking attitudes
when developing in a Product Line

PLWA4. Reassess:

–Reconsider Meta models:

- *Work on a platform (common to all applications), not in a project team dedicated to one contract execution;*
- *Work with more stakeholders, accept compromises;*
- *Avoid the NIH syndrome ("Not Invented Here");*
- *Work with more complex product: multiple, variable.*

–Accept the incertitude: the incertitude may be due to the continuous, almost permanent change, either of the process and/or the product,

–…

System Thinking attitudes when developing in a Product Line

PLWA4. Reassess:

–the added value is now in developing a reusable generic product (instead of making the best choice for a single application):

- *Choose the best set of variants (and rejecting to specific features);*
- *Design the best architecture for the variability model.*
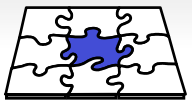
–the managers have to take into account the cultural aspects and have to find win-win solutions: new motivations as the Enterprise performance ensuring the durability of employment, new values as sharing, incentive objectives which do not disadvantage people who invest.

Product Line Thinking
when developing in a Product Line

The main challenges when adopting a new Product Line is to accept change; so the main attitude is:

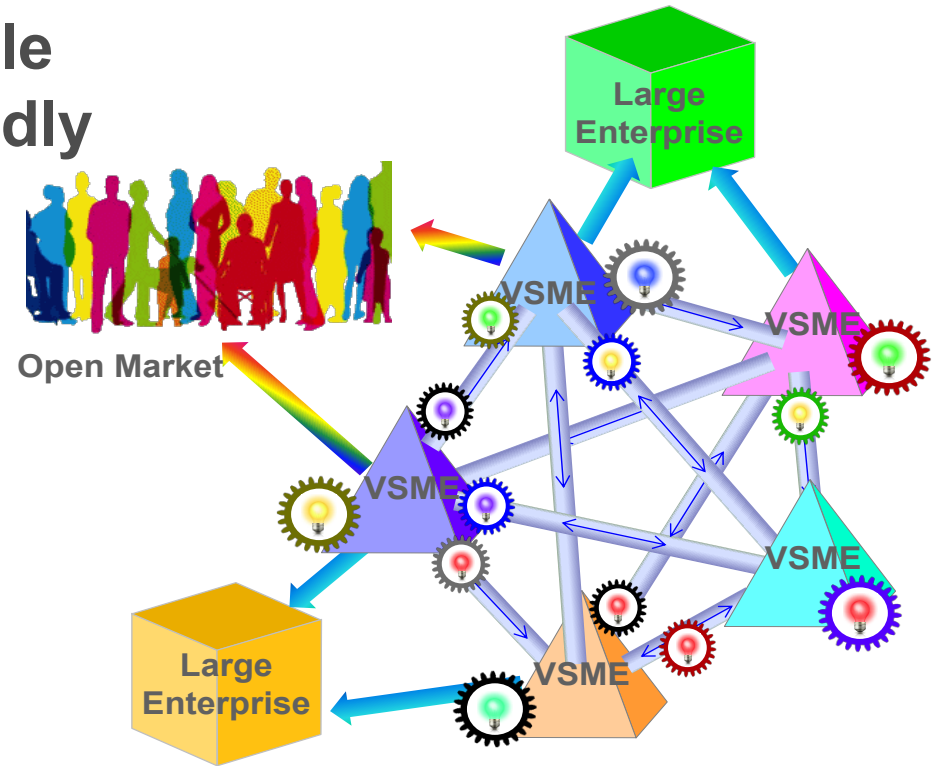❖ PLWA4 "Reassesses", in order to change the mental map of developers and various stakeholders.

Product Line Thinking

❖ **Context**

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❖ **Product Line Thinking for VSME**

❖ **Product Line Thinking**

Product Lines: a solution dedicated to VSME

❖ **When regarding the main challenges for VSME, we need to pay attention to their ecosystem made of other VSME, large enterprises, …**

❖ **Putting the product at the middle of that ecosystem we state rapidly that to evolve in a changing ecosystem, the product has to satisfy a wider number of various needs.**
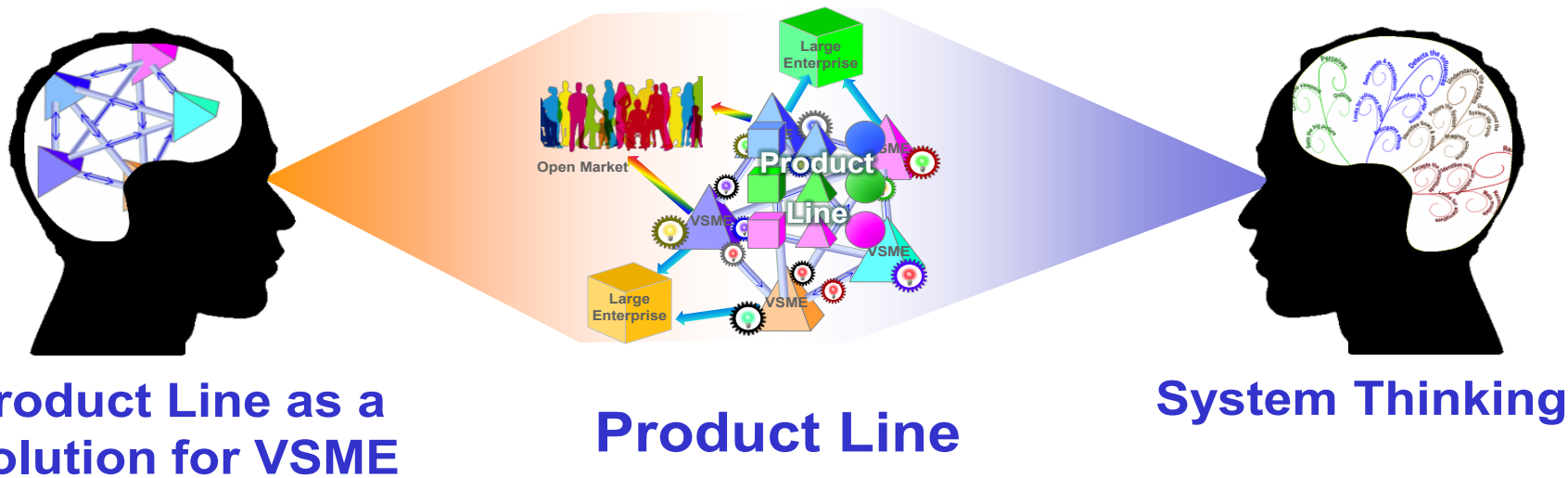
Product Lines: a solution dedicated to VSME

Thus variability (i.e. Product Lines) proves to be the right solution to:

❖ **tighten the links with purchasers (large enterprise),**

❖ **take the control of the product life cycle,**

❖ **open to other customers, to the market,**

❖ **create links with other VSME by sharing a common set of products,**

❖ **evolve on the range of product value.**

System Thinking
when implementing Product Line in VSME

We need to integrate the VSME ecosystem to the analysis, and consequently to adapt the "Product Line Architect" attitudes when implementing a Product Line in a VSME.

Product Line as a solution for VSME

Product Line

System Thinking

System Thinking attitudes
when implementing Product Line in VSME

PLVSME1. Perceive:

– **Outlines define the actual ecosystem and the expected change.**

– **See the big picture: address all the potential customers and partners of the ecosystem.**

– **Change one 's viewpoint:**

  • *Understand the actual and potential purchaser acquisition strategy;*

  • *Understand the expectations and the strategy of other VSME in the ecosystem.*

System Thinking attitudes when implementing Product Line in VSME

PLVSME2. Detect the influences:

–   **Look for influence factors: identify what new products may change needs.**

–   **Seek needs & expectations: make an inventory of the ecosystem enterprise needs.**

–   **Anticipates effect: understand the reciprocity and the complementary offer with other VSME.**

–   **Identify leverage actions: create a new cluster or enter in an existing VSME cluster.**

System Thinking attitudes when implementing Product Line in VSME

PLVSME3. Understand the system. Envision the ecosystem, in order to help defining how Product Lines can enable to adapt to the ecosystem change:

- **Picture the System: the near ecosystem and the large one.**

- **Identify flows & stocks: who needs what product in the ecosystem and who can provide products.**

- **Understand the System life cycle: identify changes in the ecosystem.**

- **Imagine scenarios: how to initialize and to support a strategy for sharing products in the ecosystem or for offering variable products to large enterprises and the open market.**

System Thinking attitudes when implementing Product Line in VSME

PLVSME4. Reassess:

–Reconsider Meta models:

- *take the responsibility of the product life cycle,*
- *turn to the market: moves from a single business-to-business model to wider business-to-market model.*

–Accept the incertitude: small partners may be unstable.

–Look for alternatives:

- *Plan how to collaborate with other VSME,*
- *Plan how to create a larger enterprise by integrating several one … instead of being a concurrent;*
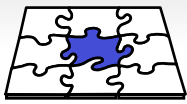- *Plan how to move on the product range of value.*

–Identify win-win solutions:

- *with acquirer s(large enterprise) and suppliers (VSME);*
- *with other VSME of the ecosystem.*

Product Line Thinking
when implementing Product Line in VSME

The main challenges when implementing a Product Line or improving an existing one in VSME is how to have a good view of the ecosystem and to choose the best products to share;

so the main attitude is:

❖ PLVSME1 "Perceives" in order to fit with the expected change of the ecosystem.

Product Line Thinking

❖ **Context**

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❖ **Product Line Thinking**

Conclusion: The Product Line Thinking

What can we learn from these three business cases ?

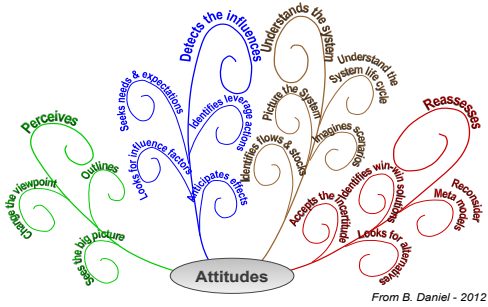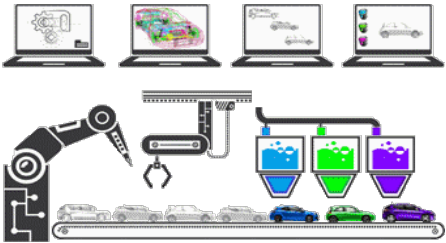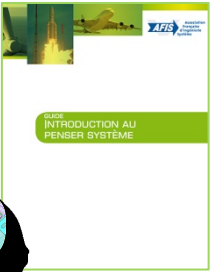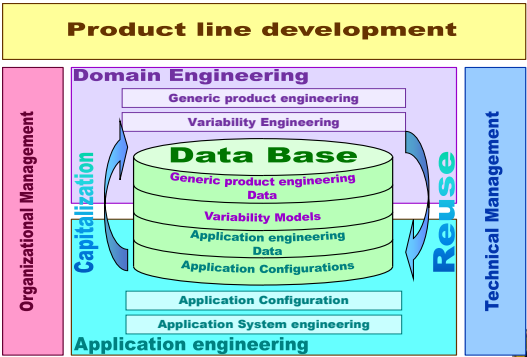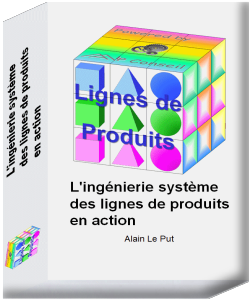| Product Line **business case**	**Challenge**	Main Product Line Thinking **attitude to adopt**
1) Implementation of a Product Line	Envisioning a new Product Line domain. Defining the best organization Product Line	Detect the influences & Understand the system
2) Developing in a Product Line	To change culture.	Reassess
3) Implementation of Product Line in VSME	To use Product Lines to evolve (or survive) in a changing ecosystem.	Perceive

Conclusion: The Product Line Thinking

The Product Line Thinking is an approach for understanding Product Line regarded as a System. Product Line Thinking can be used both for:

❖ **Envisioning a new Product Line, in order to get a good idea of the business and to define the best organization (Product Line Scoping).**

❖ **Understanding an existing Product Line, in order to adopt it and to work in its organization at best.**

The Product Line Thinking turns out to be really effective to manage the inherent Product Line complexity and uncertainty which does not lead to a single implementation

> *The Product Line Thinking is to be integrated in the deployment tool set!*

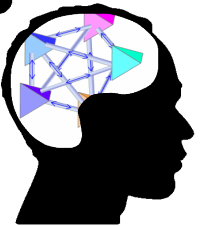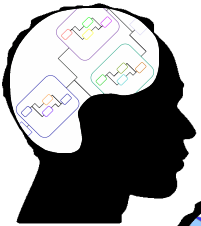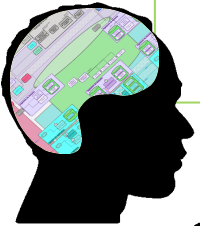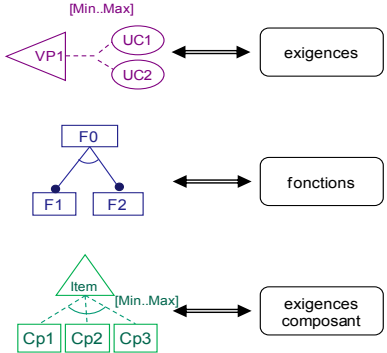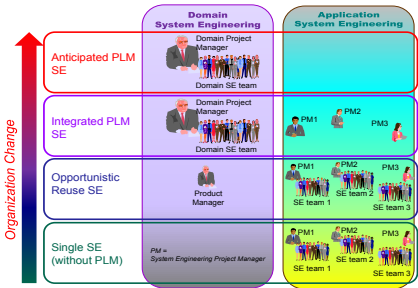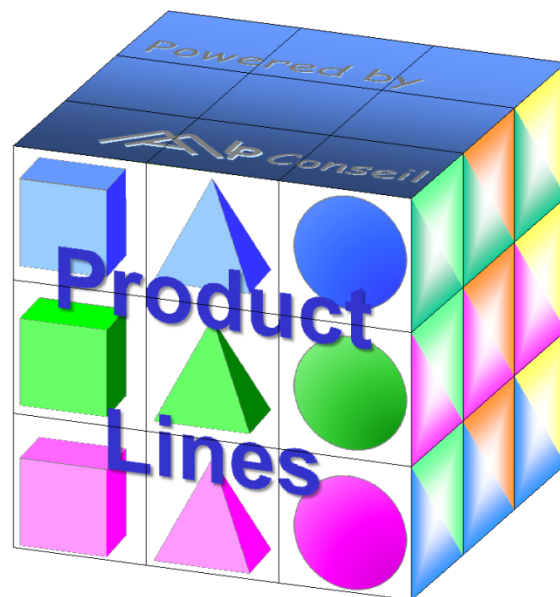# *Thank You*

SYSTEMS PRODUCT LINE ENGINEERING HANDBOOK

An AFIS collective work
directed by Alain Le Put

INCOSE 25th Anniversary

Lignes de Produits

L'ingénierie système des lignes de produits en action

Alain Le Put

GUIDE
INTRODUCTION AU PENSER SYSTÈME

Product line development

Domain Engineering

Generic product engineering

Variability Engineering

Data Base

Generic product engineering Data

Variability Models

Application engineering Data

Application Configurations

Application Configuration

Application System engineering

Application engineering

Organizational Management

Capitalization

Reuse

Technical Management

[Min..Max]

VP1 — UC1 / UC2 ⟷ exigences

F0 — F1 / F2 ⟷ fonctions

Item [Min..Max]
Cp1 Cp2 Cp3 ⟷ exigences composant

Perceives · Change the viewpoint · Outlines · Sees the big picture · Seeks needs & expectations · Looks for influence factors · Anticipates effects · Detects the influences · Identifies leverage points · Identifies flows & stocks · Understands the system · Picture the system · Imagines scenarios · Understand the System life cycle · Reassesses · Accepts the interactions · Identifies win-win solutions · Looks for synthesis · Reconsider · Meta models

Attitudes

From B. Daniel - 2012

	Domain System Engineering	**Application System Engineering**
Anticipated PLM SE	Domain Project Manager / Domain SE team	
Integrated PLM SE	Domain Project Manager / Domain SE team	PM1 PM2 PM3 SE team 2
Opportunistic Reuse SE	Product Manager	PM1 PM2 PM3 SE team 1 SE team 2 SE team 3
Single SE (without PLM)	PM = System Engineering Project Manager	PM1 PM2 PM3 SE team 1 SE team 2 SE team 3

Organization Change

Alain Le Put – MALP Conseil
Contact : alain.leput@orange.fr

Alain Le Put – MALP Conseil

Engineer degree from the high graduate school Ecole Centrale de Lyon (1973) France, retired, creator of the MALP Conseil (consultancy) in 2009.
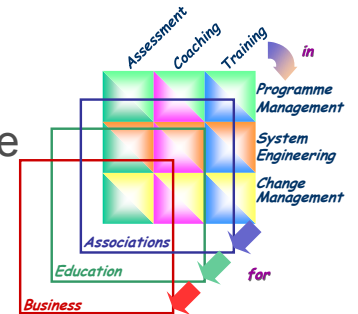
Alain Le Put spent most of his career in the Thales Group, where he worked as project manager for systems for the Navy.

Then he was responsible for process improvement, with the participation to more than 50 assessments including 30 evaluations as a Thales CMMI lead assessor. He taught Project management to some hundreds of Engineers.

Responsible for System Engineering trade of the Thales Group: he animates the Thales Systems Engineering community (7000 system engineers around the world), he evolved the Thales System Engineering Handbook, and he developed training courses.

He is involved in AFIS and INCOSE: he is the chairman of the Product Lines Working Group, and he participates in several other Working Groups

(Lean, Architecting and Systems of Systems, System Thinking).

He is involved in the Advanced Training in System Engineering of the high graduate school ENSTA ParisTech. He give lectures in several French Universities.

Author of the "System Product Line Engineering Handbook" published by Cépaduès.

As the creator of MALP Conseil, he acts also as a consultant in the Industry.