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Implementing Product Line Engineering for Railway Rolling Stock

Where the big bucks (will) come from

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CEO Acuity Solutions



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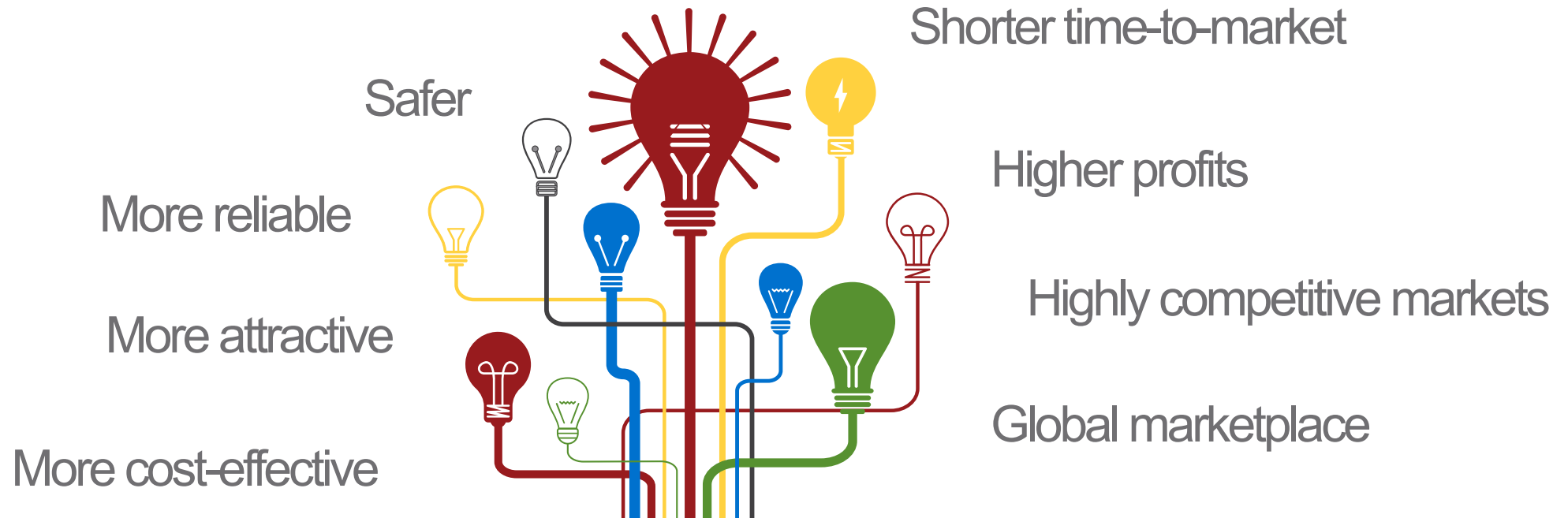
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A too familiar picture



An example: railway rolling stock industry



- Significant changes over the past few years
 - New players – operators and rolling stock providers
 - Market growth spread world-wide
 - European railway operations market now formally open to competition



- Key factor: delivering the appropriate product with ever shorter times-to-market and at competitive costs

How to face this challenge?

Push products  to the market?

Leverage previously developed assets for their reuse into a new product?



About reuse

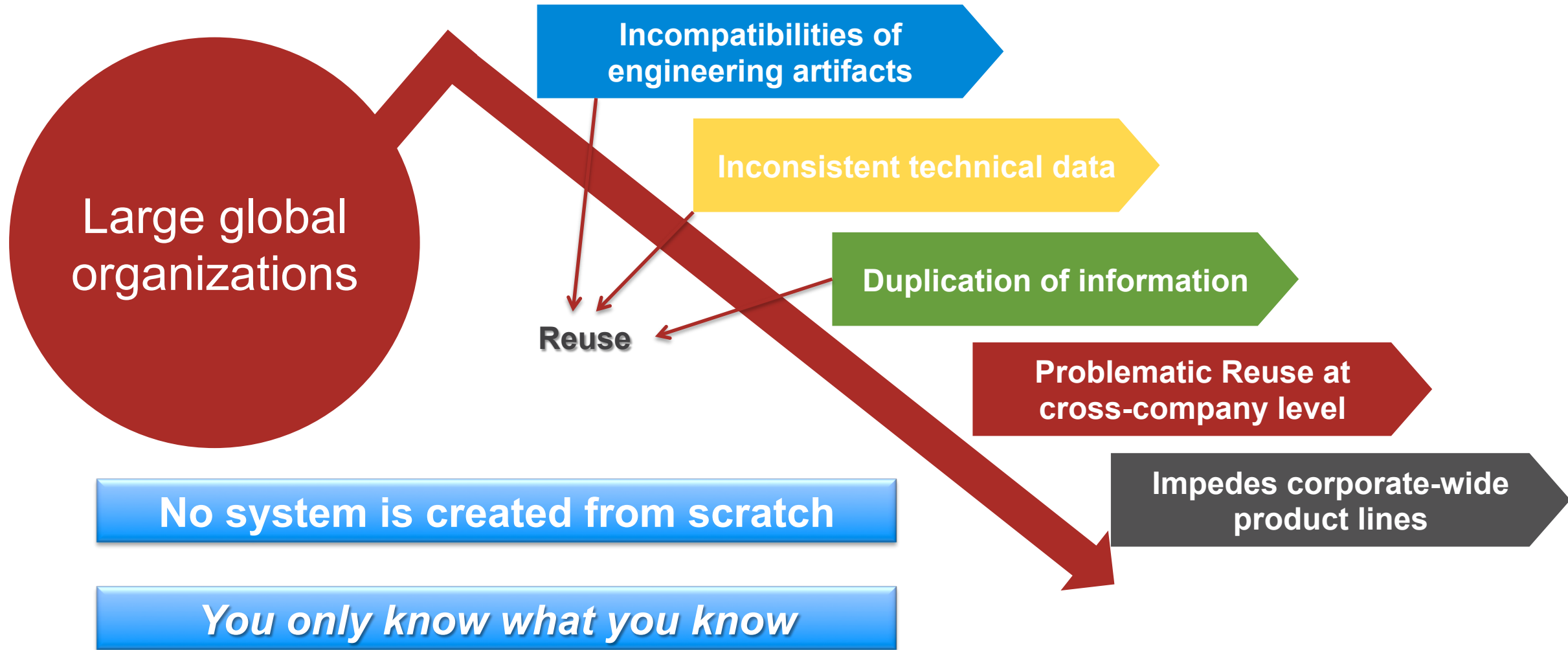
- A known concept – *Use again what you have done before to produce the same thing or something similar*
- But an unclear understanding of its ***purpose*** – *Produce the same thing or something similar... only faster and better*

Product Line: “A family of similar products with variations in features and functions”

Product Line Engineering: “The engineering of a product line using a shared set of engineering assets and an efficient means of production, taking advantage of the commonality shared across the family, while efficiently and systematically managing the variation among the products”



About real life





Problem statement

How can a large, global organization transition from a widespread, careless practice on reuse to an **effective** and **profitable** implementation of PLE?

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Where to start?



Reuse: a well documented practice in SW and manufacturing

01

References for a reuse *practice* for engineering complex systems is scarce and relatively new



02

04



Let common sense be the guide: Apply a little systems thinking & start with your own needs

Understand where you are (identify current practices) & Decide where you want to go (how would we like to go about your business)

03



What are the barriers?

Enterprise transformation

- Acceptance and application of PLE principles: difficult in areas where reuse is performed “unintentionally”
- PLE calls for a more rigorous formalization: It is seen as burdensome, rigid & process-oriented
 - “I don’t have time to do this!”*
- PLE requires upfront investment and forethought
 - “... and you also want me to pay **and** think?!”*



Keywords: Step-by-step & Flexibility

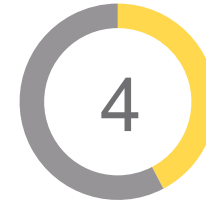
→ Best approach: a balance between your problem and your maturity



The top challenges



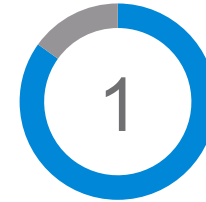
3 *“Reuse concerns only final tangible products”*



4 Careless reuse
(Copy-paste **is not** engineering)



2 *“I want my product line, too!”*



1 *“Not with my money, you won’t!”*
(Power to the Projects...
a.k.a. Quick wins, long-term losses)



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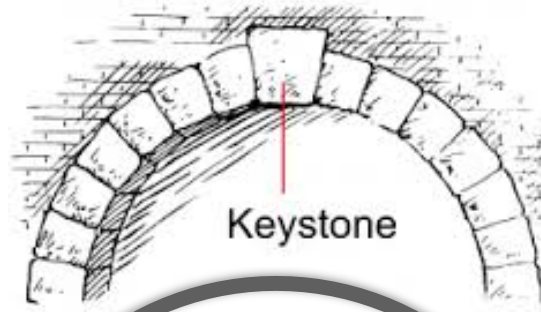


Sowing the seeds of PLE

Anchor PLE as or in the
strategy of the Organization

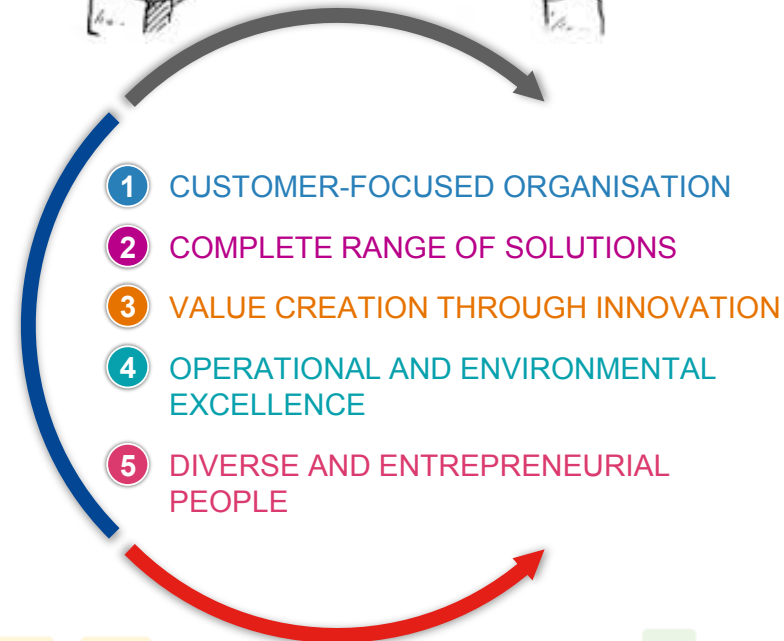
PLE must be understood
correctly

Required investments
Expected benefits

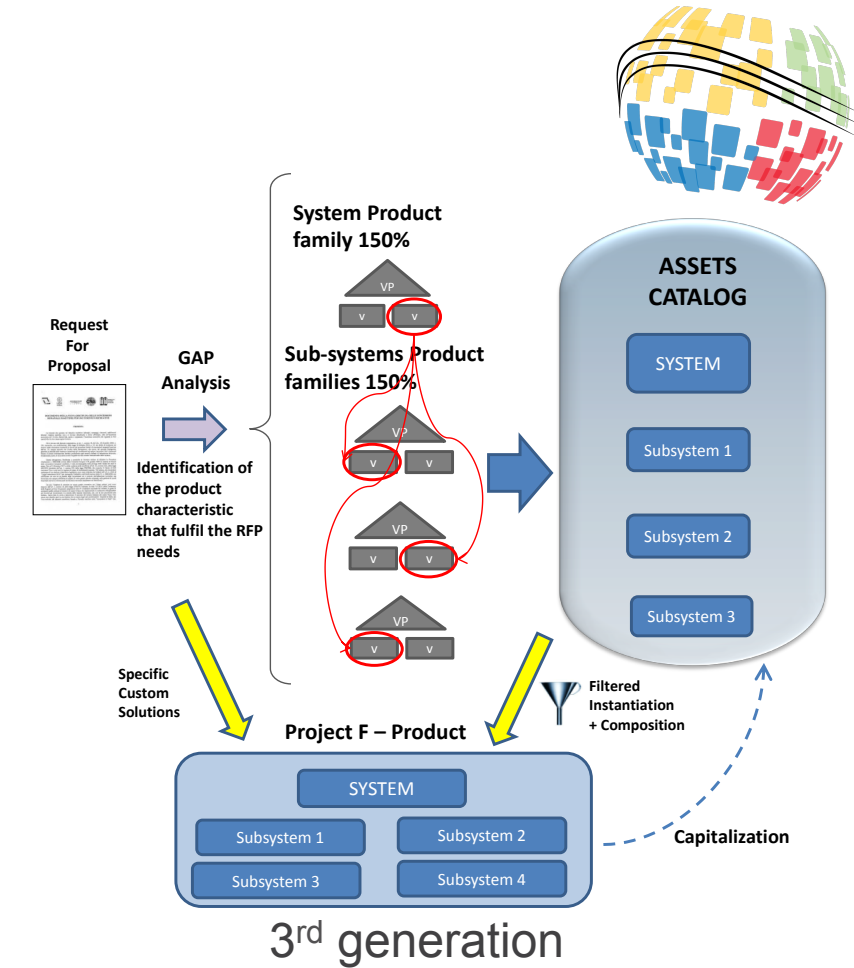
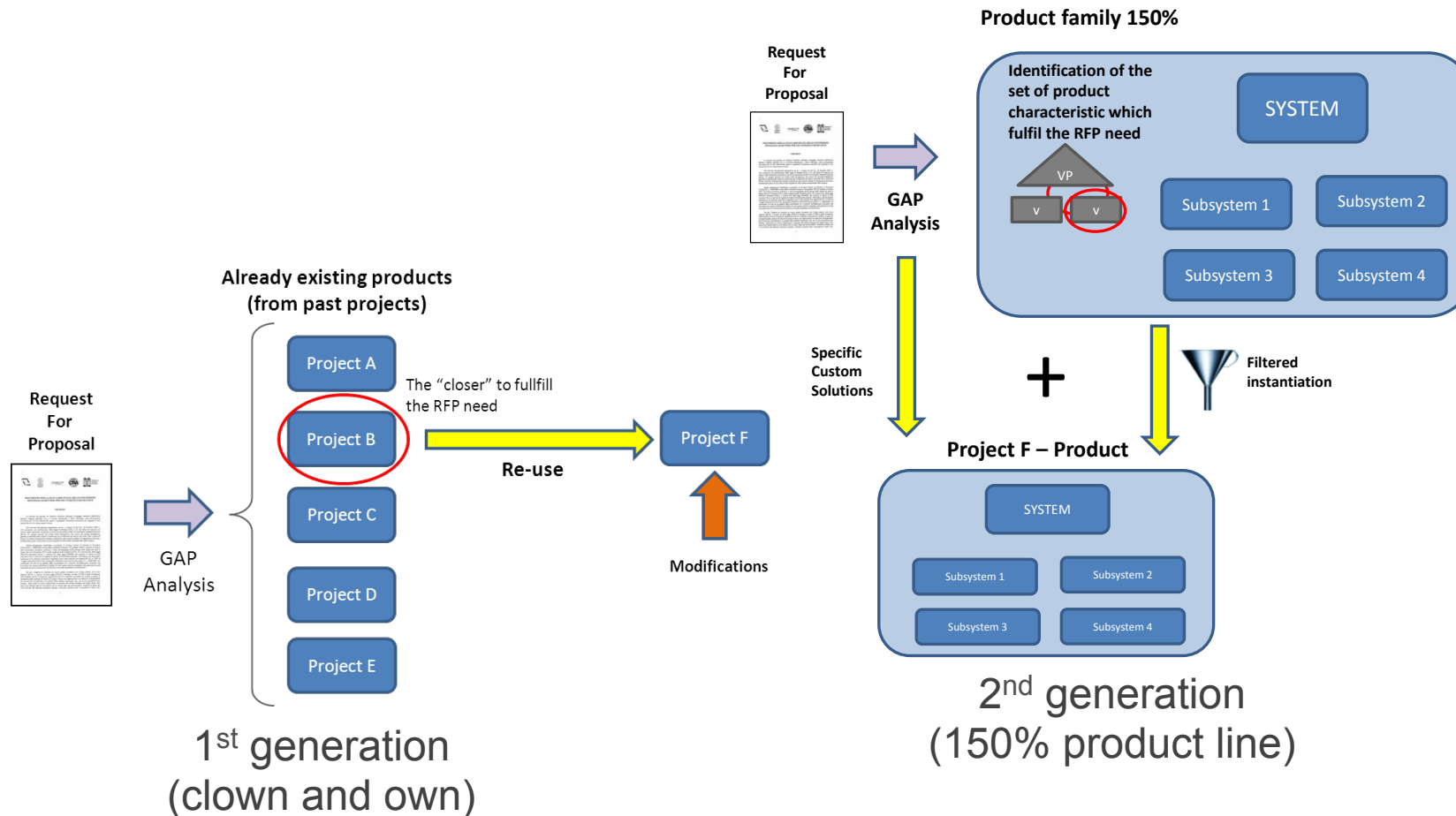


Formalize and share the
purpose of PLE

Keep focused
Reorient initiatives



Formalizing reuse practices





Pre-requisites & enabling factors



Implement configuration mechanisms

Chose applicable variants and instantiate asset repositories



Explicit dependencies

What engineering artifacts are affected and how



Describe product variability

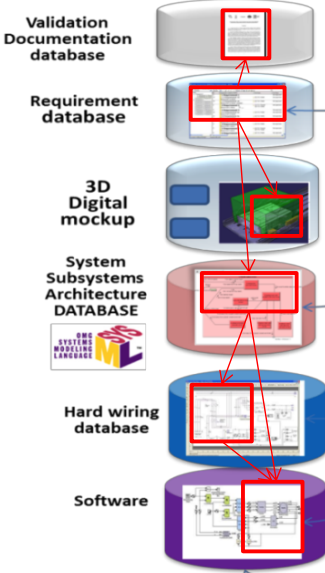
Issue: identifying **core** assets



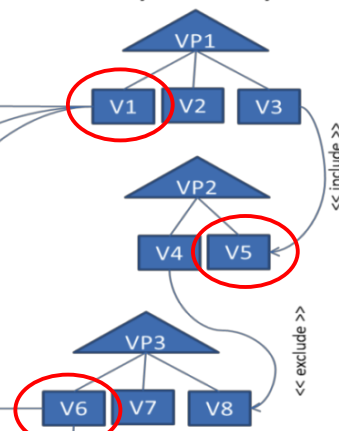
Stop gambling

1. Use Systems Engineering
2. Perform **good SE**

Product family – engineering models



Product family - variability model



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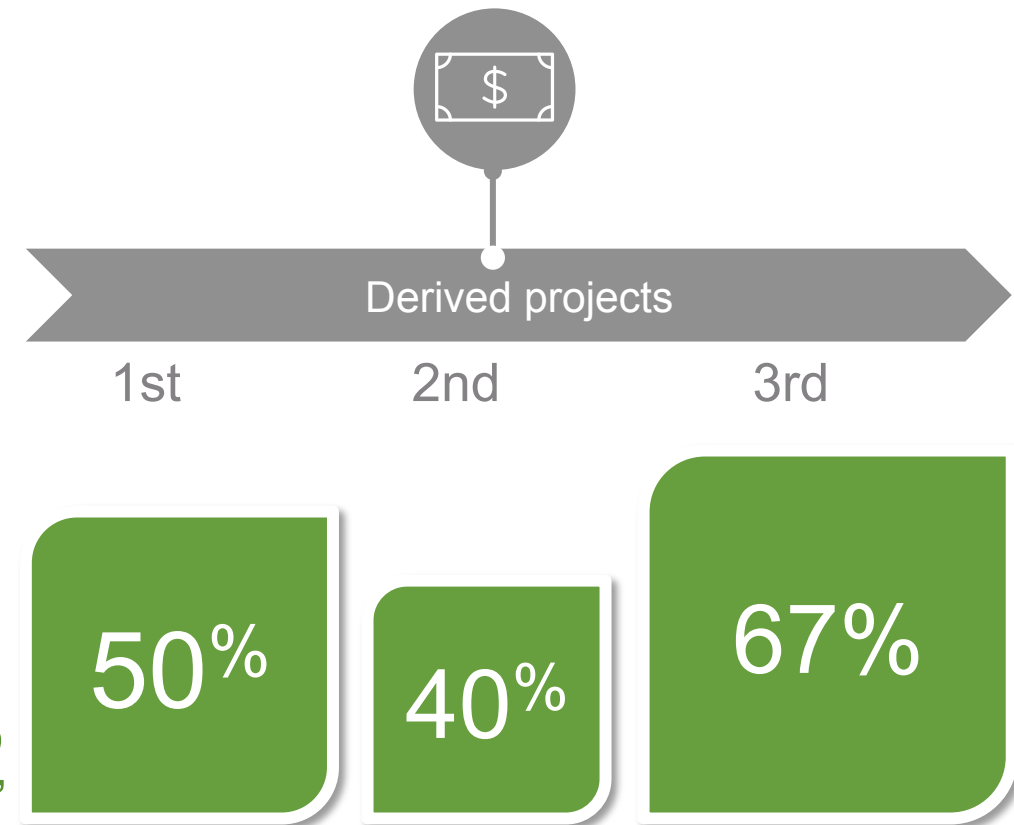
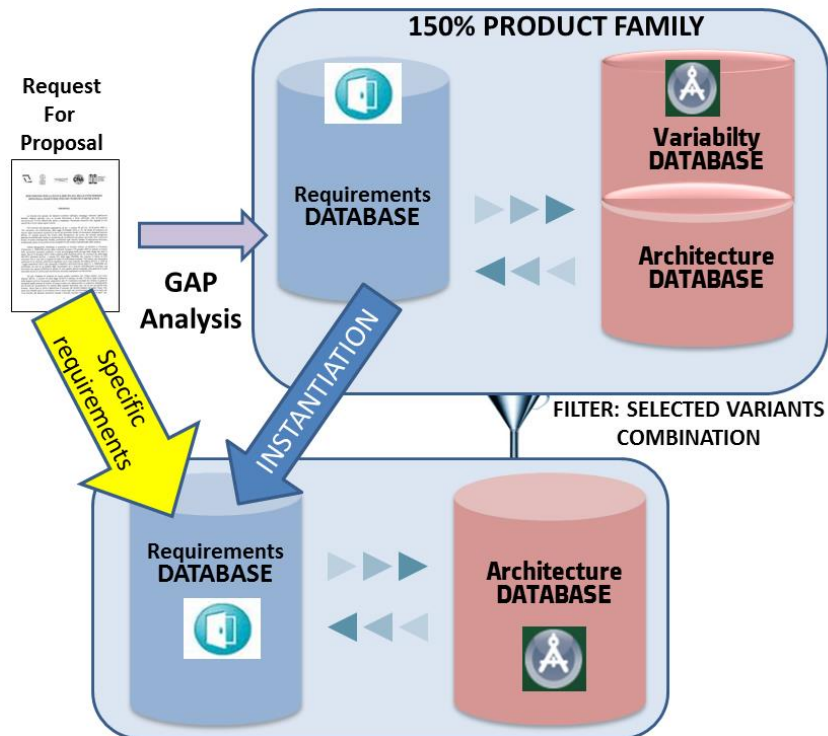
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Light at the End of the Tunnel

1st Initiative : Platform Concepts Anew

Gap analysis performed directly on the 150% Product Family database.



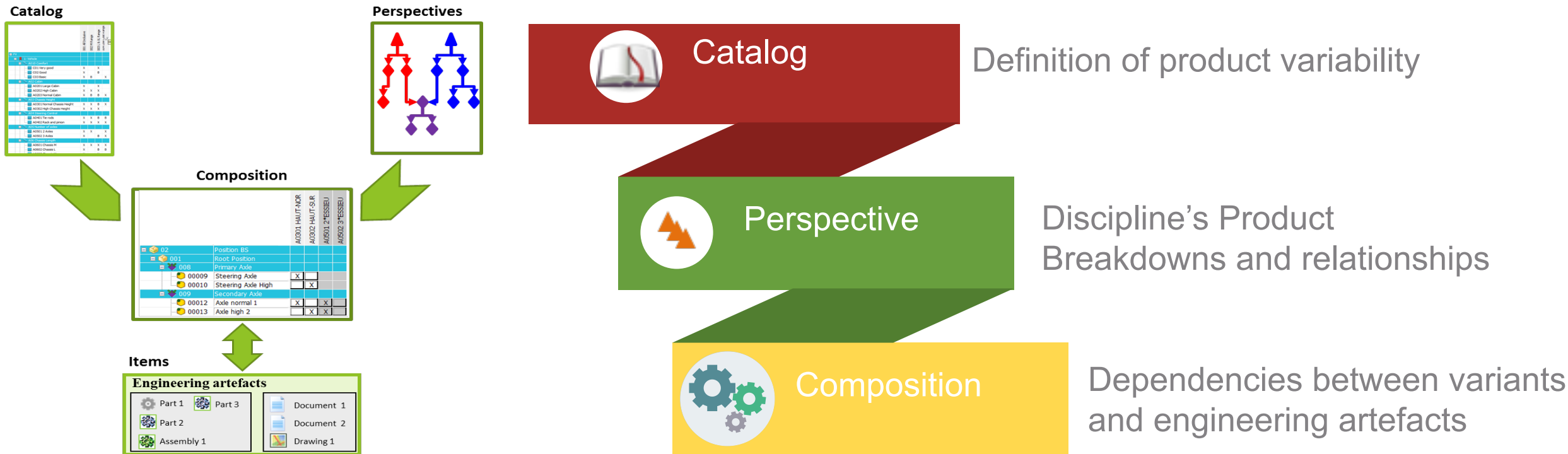
Reduction of fixed engineering costs in requirement development process compare to typical "White page"



Light at the End of the Tunnel

2nd Initiative : Variability Management

On single point of truth for the variability of product lines and catalog of train subsystem





Light at the End of the Tunnel

2nd Initiative : Variability Management

00000 - Respect reliability and availability constraints (0/1)
TR070000 - Respect weight limitations (2/2)
TR080000 - Ensure safety (6/11)
TR090000 - Integrate the vehicle into the complete system railway (8/9)
TR040000 - Ensure aesthetic design (1/3)
SR020000 - Accelerate, maintain speed, brake and stop (13/15)
SR030000 - Provide access and loading (14/30)
SR040000 - Connect vehicles and consists (5/8)
SR050000 - Provide energy (17/26)
SR060000 - Provide sanitary services (6/13)
SR070000 - Provide train communication, monitoring and control (14/15)
SR080000 - Provide public address, passenger information, intercommunication and entertainment (5/18)
SR090000 - Provide surveillance (for passenger or load) (2/6)
SR010000 - Carry and protect passengers, train crew and payload (7/15)
SR020000 - Provide interior lighting (1/3)
SR030000 - Provide proper climate (5/7)
SR040000 - Respect product requirements (2/4)
SR050000 - Respect countries definitions and certifications (9/22)

4CD LIEU DE CIRCULATION
4CS SOUS LIEU CIRCULATION FRANCE
SCD CAPACITE
SCS CLASSE RAME
6CD VITESSE

4CD01 FRANCE (F)
4CD02 TRANSFRONTALIER SUISSE (S)
4CD03 TRANSFRONTALIER ALLEMAND (D)
4CD04 ALGERIE (A)
4CD05 TUNISIE (T)

0A03 CATEGORIE MATERIEL
0A48 PROFIL ROUE
0A50 FONCTIONNEL PORTE Allemagne
0A0300 SANS Matériel catégorie B suivant STI Tu...
0A4801 Roue au profil Allemand (silicon d'usure)
0A5000 SANS Fonctionnel porte spécifique pour l'Allemagne
0A0301 Matériel catégorie B suivant STI Tunnel
0A4802 Roue au profil Allemand (silicon d'usure)
0A5001 Fonctionnel porte spécifique pour l'Allemagne
0A0302 Matériel catégorie B suivant STI Tunnel - simplifié

0A52 FONCTIONNEL PORTE SUISSE
0A55 DIFFERENTIATION DESIGN REGIONAL / PERJURBAIN
0A73 TRAIN LABORATOIRE
0A5200 SANS Fonctionnel porte spécifique pour L...
0A5500 SANS OBJET
0A7300 SANS Train laboratoire
0A5201 Fonctionnel porte spécifique pour la Suisse
0A5501 SANS Différentiation design 1° CI Régionale et Pérurbain...
0A7301 Train laboratoire Roumanie
0A5502 Différentiation design 1° CI Régionale et Pérurbain confortable

0E113 POWERPACK TROPICALISE \$gnon utilise\$
0E1300 SANS Powerpack tropicalisé
0E1301 Fonctionnement spécifique France (section neutre...)
0E1302 Fonctionnement spécifique France (section neutre...)

Completeness & Consistency

Colères et Valeurs

OV_Synchro Synchro
OV_DoorDensity Doors density
OV_DoorDensity_HSD High (4 doors per face...
OV_DoorDensity_L000 Low
OV_DoorType Type of door
OV_DoorType_EXSL External Sliding
OV_DoorType_SPL Sliding Plug
OV_Shape Shape of side
OV_Shape_CURV Curved
OV_Shape_OED Dihedral
OV_Shape_FLAT Flat
OV_CSMat_CarbonFiber Material
OV_CSMat_ALUM Aluminum
OV_CSMat_STST Stainless Steel

Items

INSTALLATION CONFIGURATION PILLARS

0T00000477413-DOOR PILLARS - FLAT - ALU...
0T00000477413-DOOR PILLARS - DED - ALU...
0T00000477413-DOOR PILLARS - CURV - ALU...
0T00000477413-DOOR PILLARS - FLAT - STS...
0T00000477413-DOOR PILLARS - DED - STS...
0T00000477413-DOOR PILLARS - FLAT - STS...
0T00000477413-DOOR PILLARS - DED - STS...
0T00000477413-DOOR PILLARS - CURV - ALU...
0T00000477413-DOOR PILLARS - FLAT - STS...
0T00000477413-DOOR PILLARS - DED - STS...
0T00000477413-DOOR PILLARS - FLAT - ALU...
0T00000477413-DOOR PILLARS - DED - ALU...

Searched values

1-Image
03-End Validity Date

HVAC-01 - Group main characteristics

2-Product number
4-Number of condenser
5-Number of evaporator
6-Number of condenser fan
7-Number of evaporator fan
8-Number of compressor
9-Type of compressor
10-Extractor fan
11-Number of filter (fresh, return, mix)

HVAC-02 - Performances

1-Group type
2-Refrigerant type
3-Steering interior temperature (°C)
4-Steering condition external temperature (°C)
5-Steering condition internal humidity (% RH)
6-Steering condition external humidity (% RH)
7-Fresh airflow (m³/h)
8-Acoustic power for internal faces (dB(A))
9-Acoustic power for external faces (dB(A))
10-Number of supply air areas (m²)
11-Integrated electrical cubicle (Yes) or (No)
12-Integrated CVSS (Yes) or (No)
13-Weight (kg)
14-Length (mm)
15-Height (mm)
16-Width (mm)
17-Panel (Yes/No)
18-Low voltage (V)
19-Frequency (Hz)

	P4	P8	P9
2-Product number	1	2	2
4-Number of condenser	1	2	2
5-Number of evaporator	2	2	2
6-Number of condenser fan	2	2	2
7-Number of evaporator fan	2	2	2
8-Number of compressor	2	2	2
9-Type of compressor	Horizontal scroll	Vertical scroll	Vertical scroll
10-Extractor fan	0	(2,0,2)	(2,0,1)
11-Number of filter (fresh, return, mix)	(1,1,0)	(2,0,2)	(2,0,1)
1-Group type	compact	Compact	Compact
2-Refrigerant type	R134a or R407c	R134a	R134a
3-Steering interior temperature (°C)	23	25	25
4-Steering condition external temperature (°C)	23	25	25
5-Steering condition internal humidity (% RH)	75	70	5
6-Steering condition external humidity (% RH)	32	50	32
7-Fresh airflow (m³/h)	900	900	900
8-Acoustic power for internal faces (dB(A))	4000	5000	5000
9-Acoustic power for external faces (dB(A))	73 dB(A) for supply / 62 dB(A) for return	812	
10-Number of supply air areas (m²)	1	2	1
11-Integrated electrical cubicle (Yes) or (No)	Yes	No	Yes
12-Integrated CVSS (Yes) or (No)	No	No	No
13-Weight (kg)	650	845	810
14-Length (mm)	3700	3444	3700
15-Height (mm)	350	540	540
16-Width (mm)	1730	2058	1730
17-Panel (Yes/No)	No	No	No
18-Low voltage (V)	110	110	110
19-Frequency (Hz)	50	50	50

Mechanisms to configure products :

- Guided route to valid configuration
- On Click generation of filtered views of assets

Mechanisms to check completeness and consistency

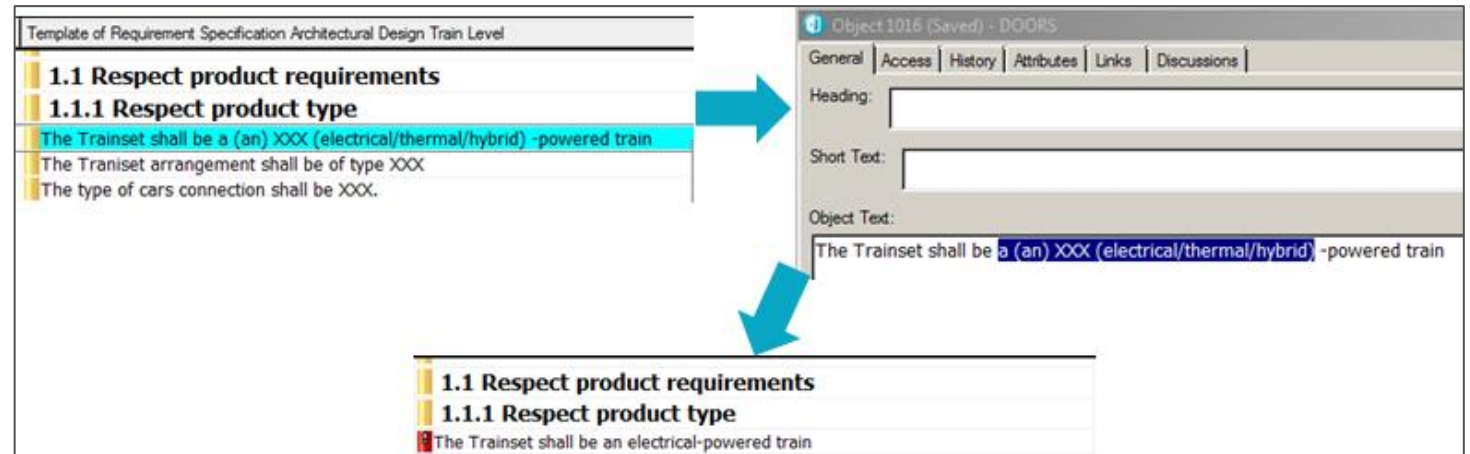
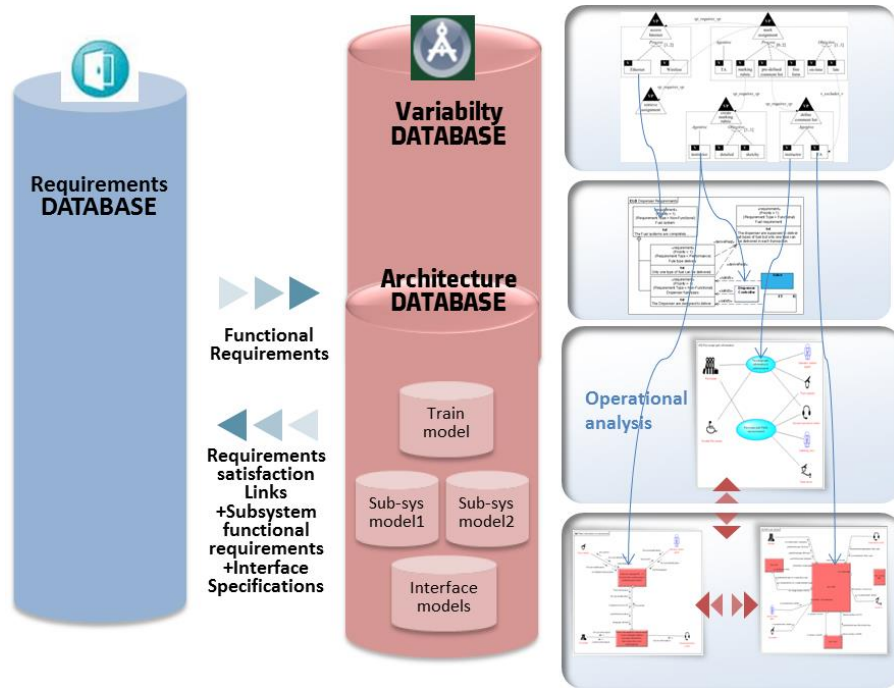
Eligible Solutions Comparison with respect to Subsystem Configuration

Implementation in PLEIADE® by Acuity Solutions of those concepts and use of its dedicated tools to master Diversity



Light at the End of the Tunnel

3rd Initiative : Configurable, Reusable Assets

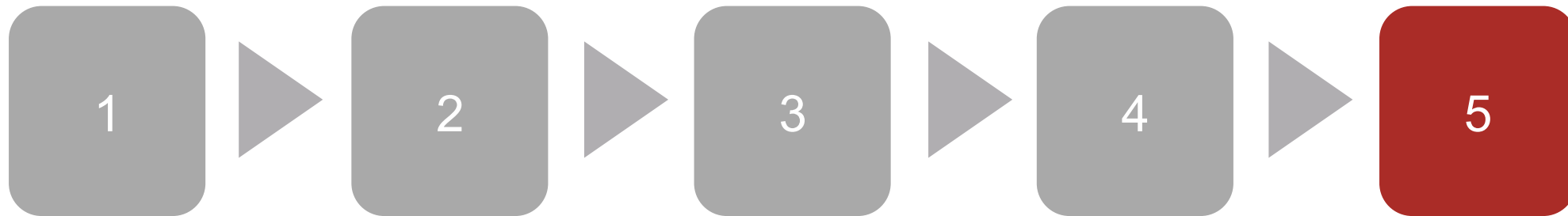


Example :

A generic requirements module is created following a standard structure and “pre-filled” requirements .

The generic module is configured and then made available for a particular project.

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Put on your



The work done

- Intermediate results are very encouraging, given the relatively small resources allocated to PLE initiatives
 - The duration of the requirements development process of successive instantiations from one product have gone from 12 to 6, then to 5 and 3 months
→ This could be brought down to **3 weeks**
- Other engineering activities could benefit from similar improvements enabled by PLE
 - Increased effectiveness, decrease of non-quality issues
→ Cost avoidance

Tremendous improvement potential in profitability

Put on your



Optimize Product Lines Scopes

Define more “inclusive” Product Lines without managing every single artifact as a reusable asset nor targeting a perfectly stable planning of variability

IT and tool interoperability

Get more information OUT of tools than what is put INTO tools



Pursue current efforts

- Create reusable assets repositories
- Promote the sharing of engineering assets across product families
- Extend variability management across disciplines/domains

Cultural change

- Put the company's money in the right place
- Define and achieve an organizational PLE transition strategy



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