26th annual INCOSE international symposium

Edinburgh, UK

July 18 - 21, 2016

Product System Families at Rolls-Royce: A Case Study in Enterprise Transformation

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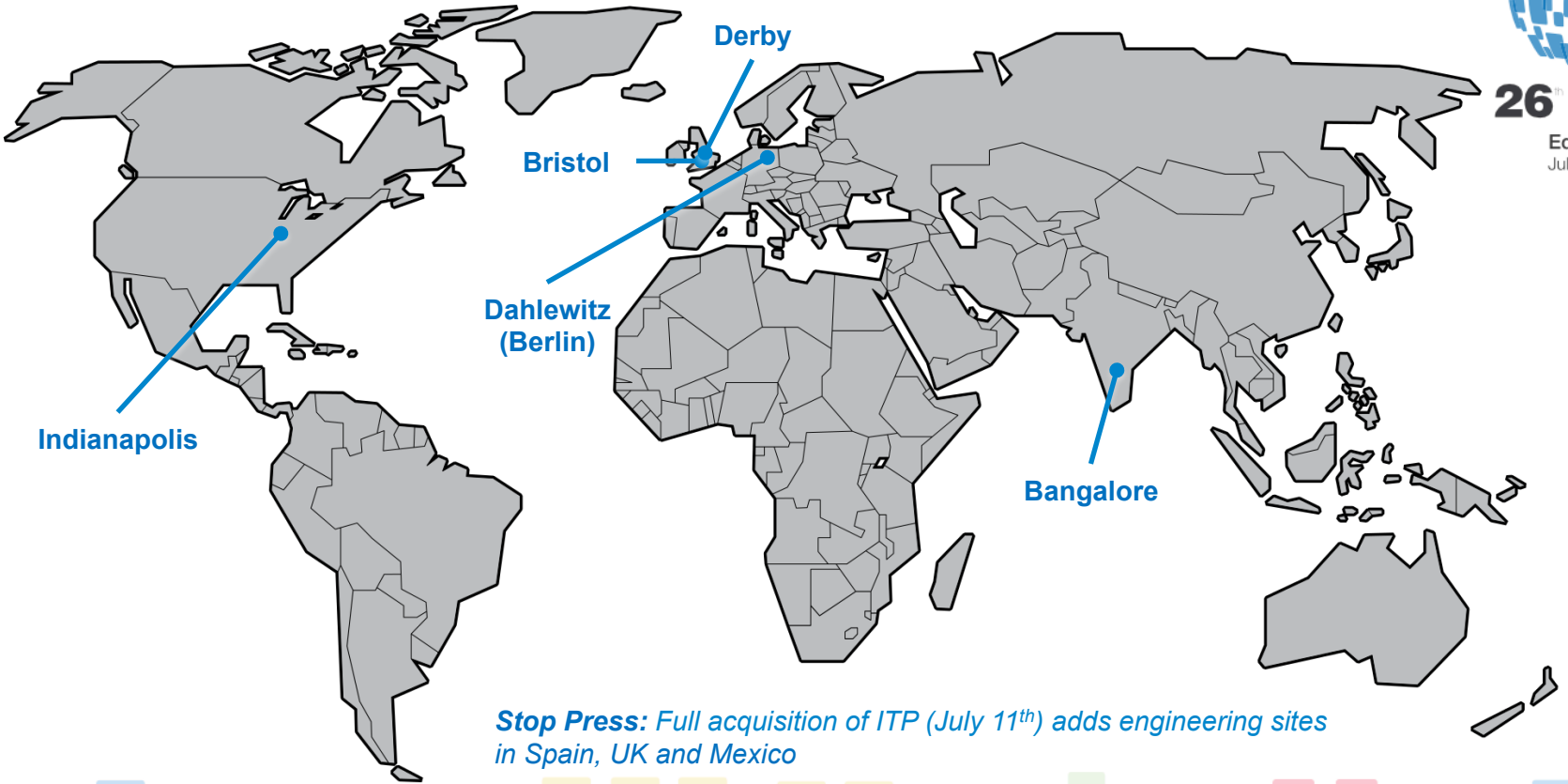
Presenter: Jonathan Holt


SIR DAVID ATTENBOROUGH

Aerospace Engineering Locations



Stop Press: *Full acquisition of ITP (July 11th) adds engineering sites in Spain, UK and Mexico*

Success Brings Challenges!

- Rolls-Royce's Civil Aerospace business has grown from a small player in 1990 to market leader in engines for wide-bodied aircraft engines
- Shortening of product lifecycles

- Both trends mean separately mean increase in draw on engineering resources.
- This paper is about an approach to address this:

Product System Families

The Product System Families Transformation

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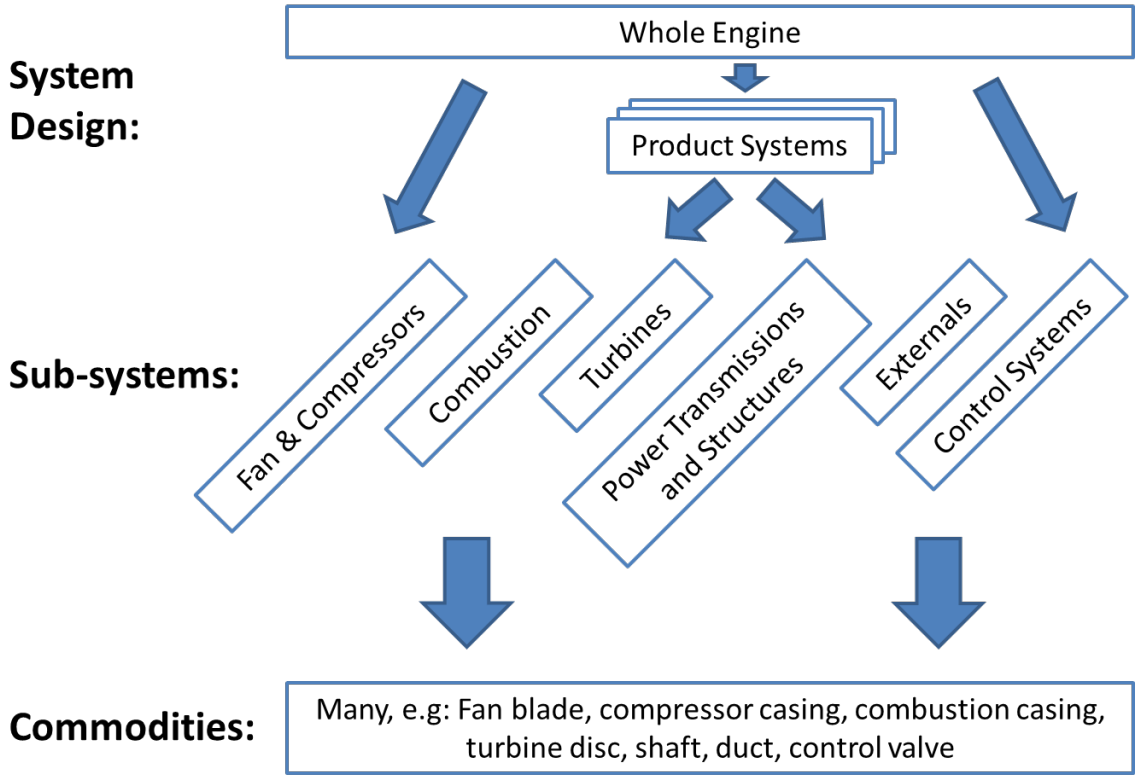
- Systems designed fresh for each Project
- Some informal reuse
- Small number of large simultaneous Projects
- Small central functional team

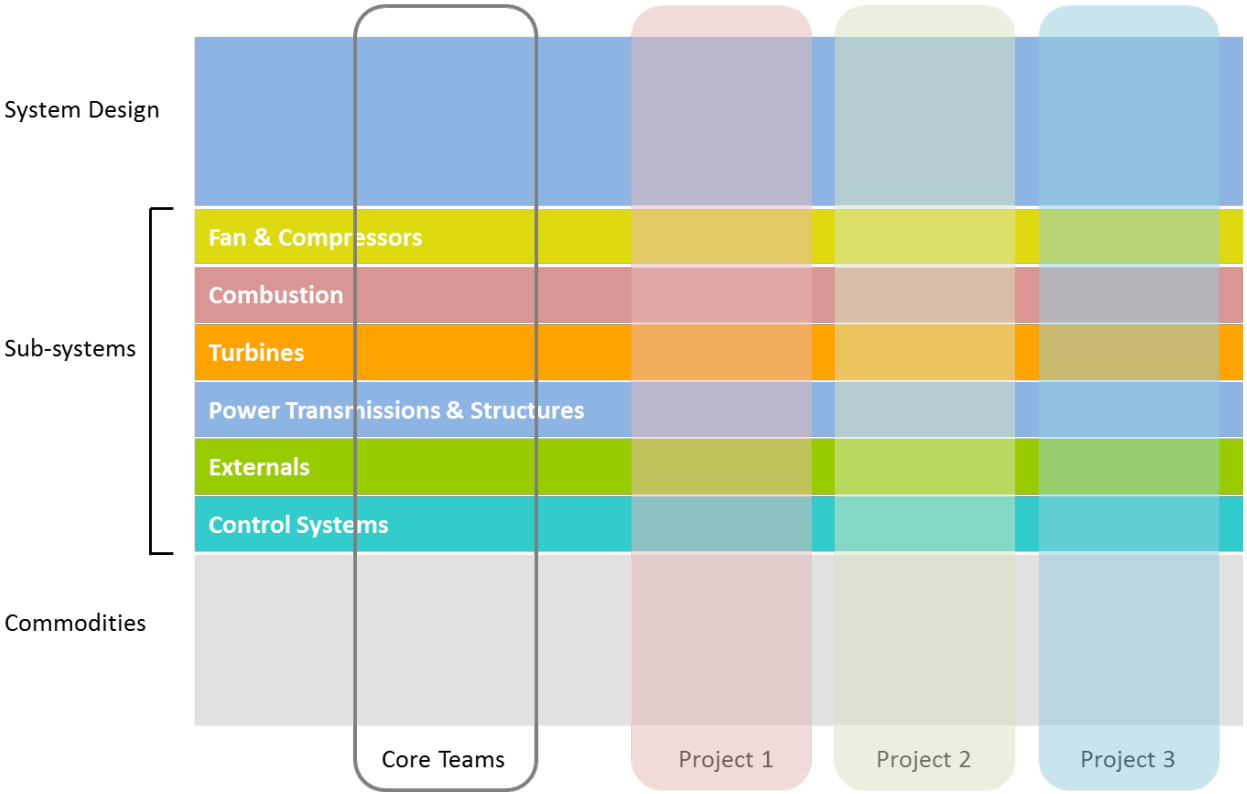
- Generic system designed off-Project
- Intentional, controlled re-use
- Larger number of small simultaneous Projects
- Larger central functional team

Rolls-Royce Aerospace Engineering Organization



Slightly modified from version in paper due to organisational changes

Team Deployment



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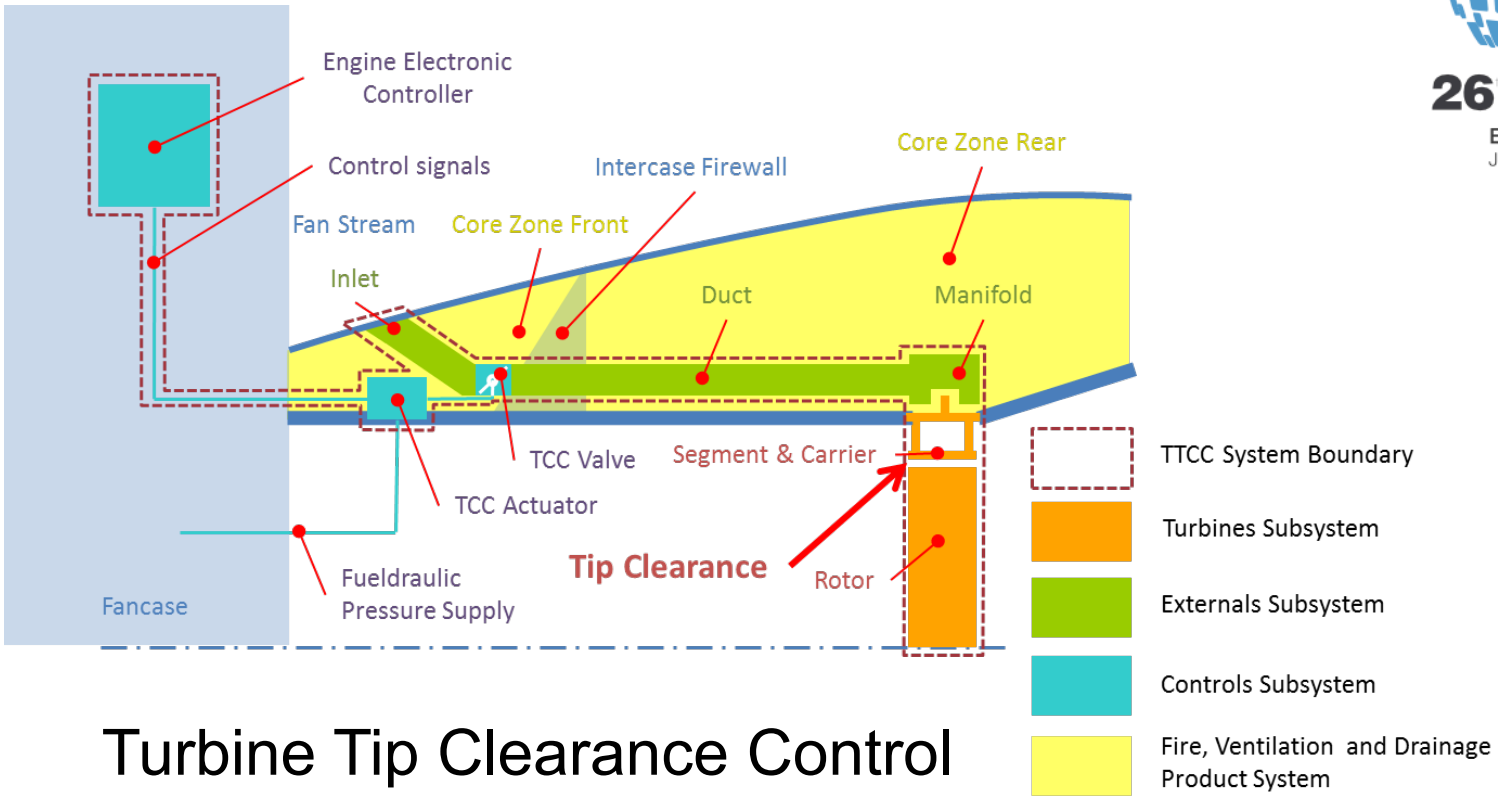
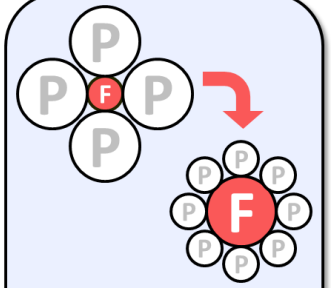
Product System Example



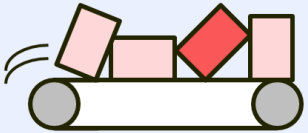
Turbine Tip Clearance Control

Benefits of the Product System Family Approach



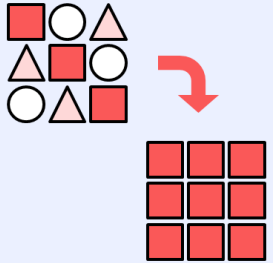
Ability to deliver more Projects (**P**) with the same levels of resource by doing more (pre-)work in central Function (**F**)

Materials Costs
Unit Costs
Design Costs
Verification Costs



Supply Chain Stability
Customer Confidence
Quality Products
Risk Benefits

Design Time
Maturity Time
Verification Time



Consistent products will increase volumes driving economies of scale

Product System Family Development Process

Operational Initiation
- Project Charter
- Network of Activities
- WBS and RACI

Boundary, Context & Functional Analysis
- Boundary Diagram
- Context Diagram
- Functional Flow Diagram
- FFMEA & FHA

Requirements Capture
- Product System Requirements Document

Requirements Review

Architecture Generation, Selection and Justification
- Brainstorming
- Functional Means Analysis
- Selection – Pugh Matrix

Concept Support
- Capability Acquisition Strategy
- IP & Competitor Analysis
- Lifecycle Cost Info Doc
- System Verification Strategy

Concept Documentation
- Product System Definition Document
- Applicability

Concept Review

Requirements and Functional Phase

Physical Architecture Phase

Issue

Pugh Matrix Enhancements – sensitivity analysis

Attribute	Weighting	Baseline Concept	Concept 1	Concept 2	Concept 3
Unit Cost	40%	0	-1	3	1
Weight	10%	0	3	-3	0
Technical Risk	30%	0	-3	-1	-3
Non-recurring Cost	5%	0	-1	-3	-3
In-service Reliability	15%	0	-1	1	-1
Weighted Totals:		**0**	**-1.2**	**0.6**	**-0.8**

What if:

Scoring Uncertainty

Weighting Uncertainty

Attribute	Weighting	Baseline Concept	Concept 1	Concept 2	Concept 3
Unit Cost	40%	0	-1	3	1
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Weighted Totals:		**0**	**-1.2**	**0.3**	**-0.8**

Outcome Unchanged

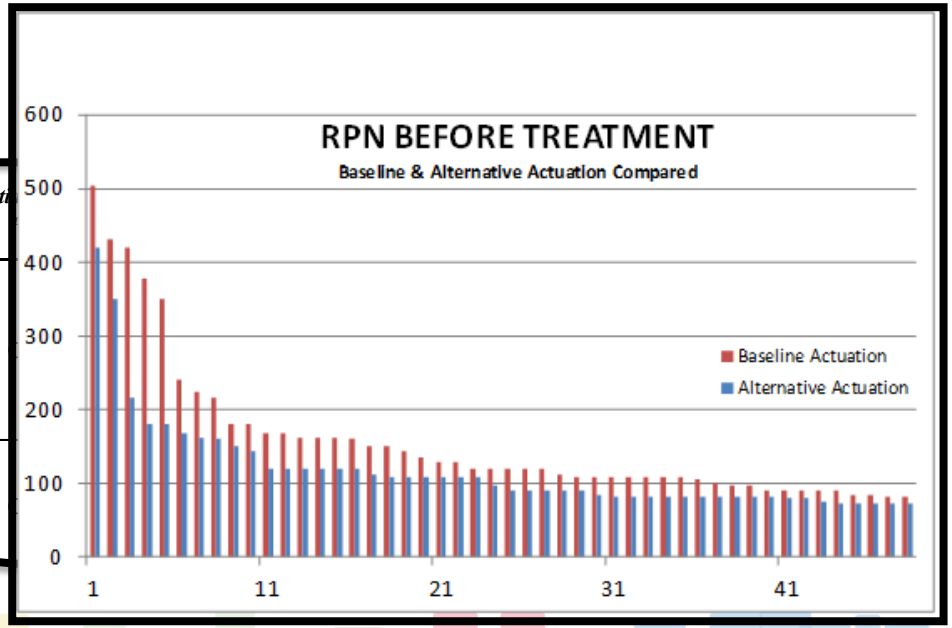
Attribute	Weighting	Baseline Concept	Concept 1	Concept 2	Concept 3
Unit Cost	20%	0	-1	3	1
Weight	20%	0	3	-3	0
Technical Risk	30%	0	-3	-1	-3
Non-recurring Cost	5%	0	-1	-3	-3
In-service Reliability	15%	0	-1	1	-1
Weighted Totals:		**0**	**-0.7**	**-0.3**	**-1**

Baseline Now Preferred

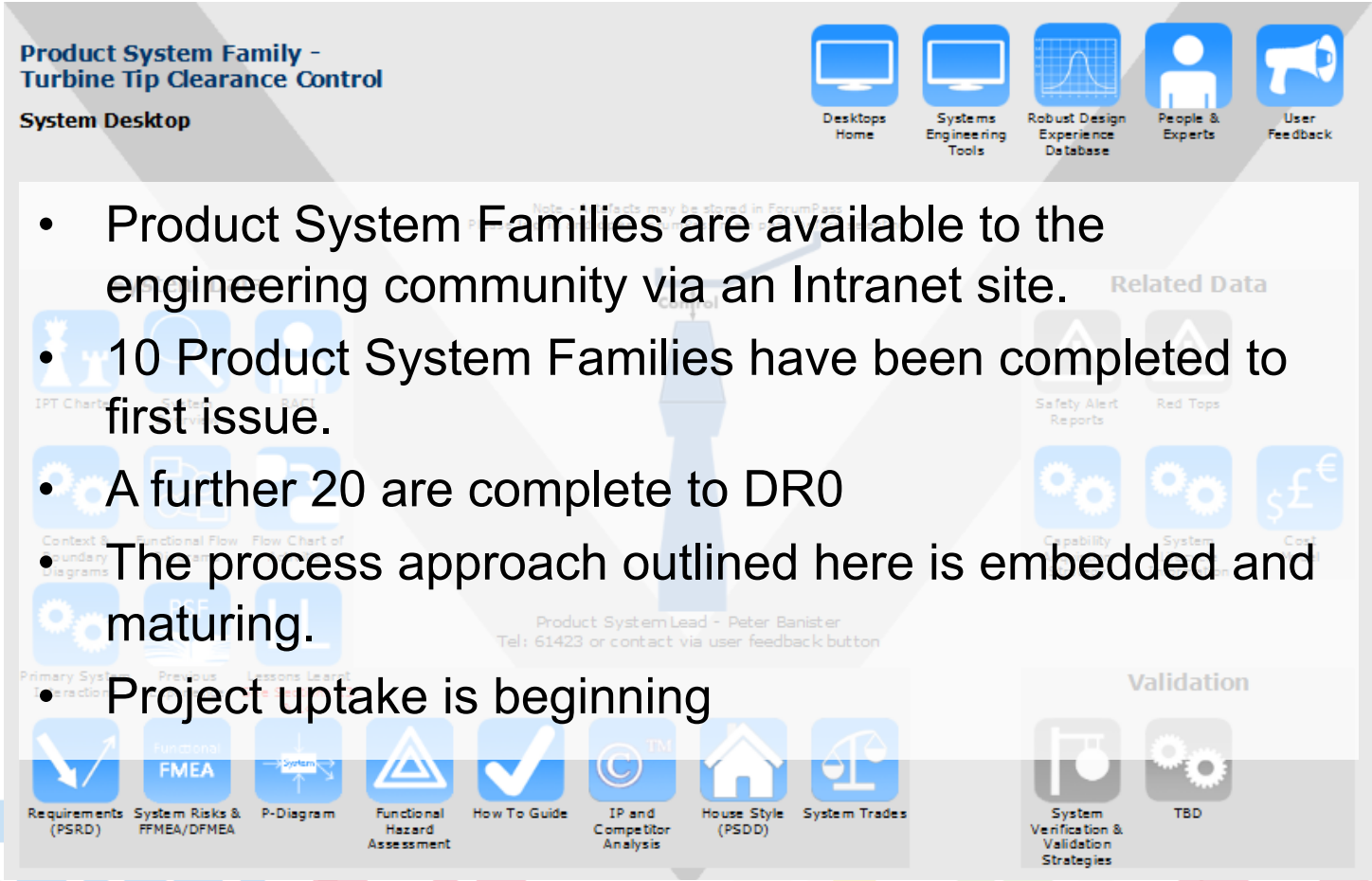
Pugh Matrix Enhancements – Comparative DFMEA

- If the top ranked option is novel, what if there are hidden risks? Is it really better or have we just not yet discovered the issues?
- Comparative DFMEA 'front-end'

Date risk raised	Part/Feature	Function	Potential Failure Mode	Potential Effect(s) of Failure	SEV	Potenti
19/06/12	Valve	Modulate Air flow	jams open	Fire Extinguising system ineffective, Over cools casing, leading to Tip Rubbing	9	Wear,
19/06/12	Valve	Modulate Air flow	jams closed	Overheating, TGT Increase and Loss of SFC	5	Wear,



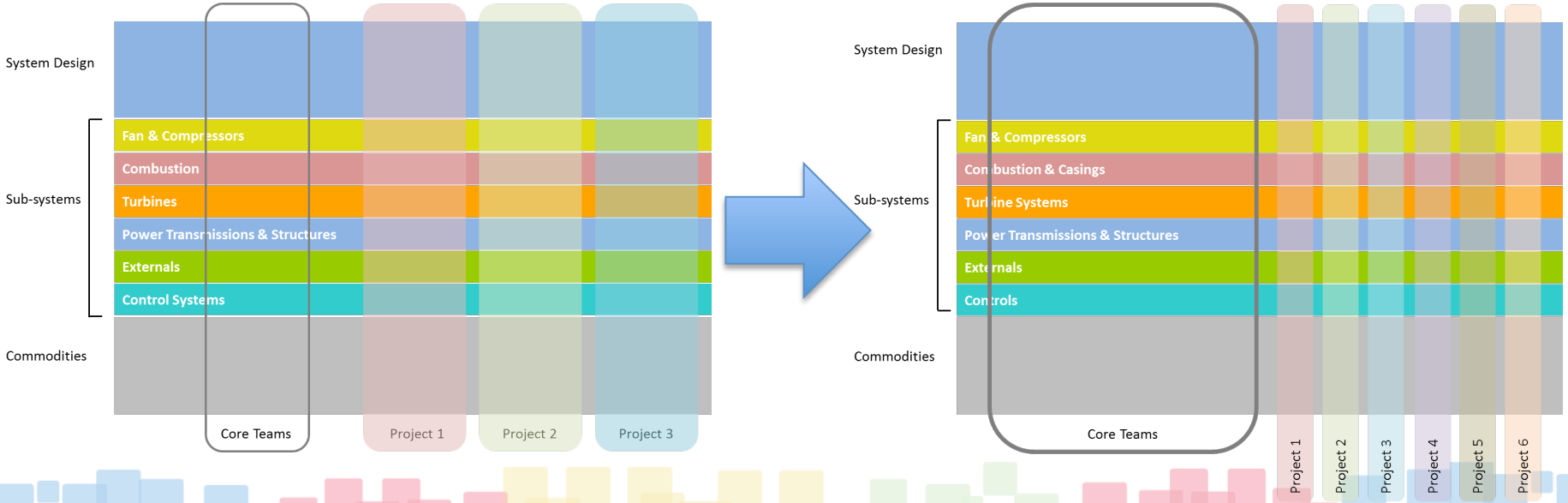
Current Status



- Product System Families are available to the engineering community via an Intranet site.
- 10 Product System Families have been completed to first issue.
- A further 20 are complete to DR0
- The process approach outlined here is embedded and maturing.
- Project uptake is beginning

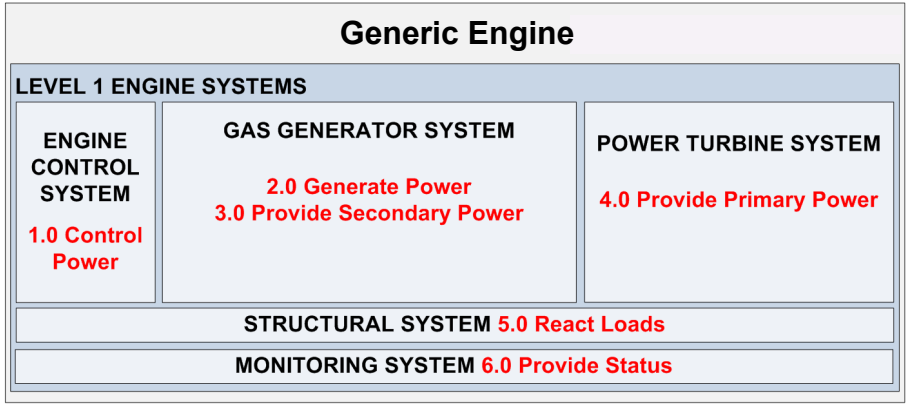
Future Plans - Organisation

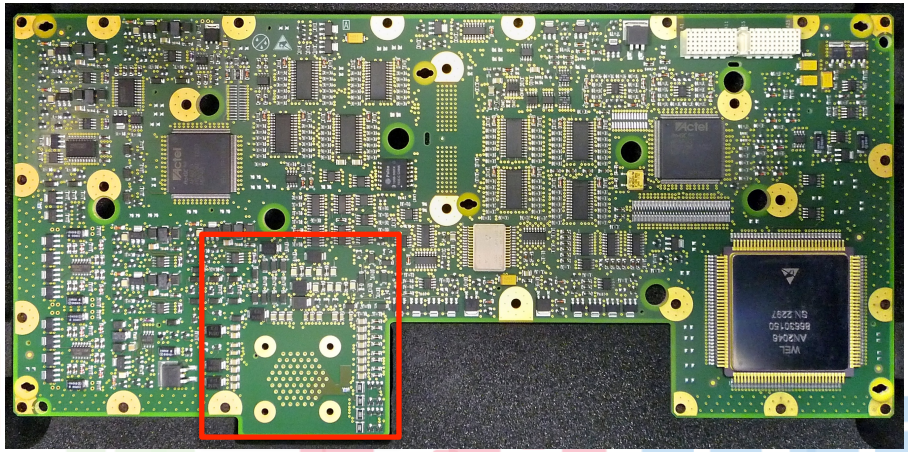
- The biggest inhibiter to Product Lines is known to be that *it requires fundamental change*.
- Supporting more simultaneous Projects.



Future Plans – Product Breakdown

- Systematic top-down Product- (and therefore Work-) Breakdown.
  - Functionally-based
  - Architectural principles (seeking minimum interactions between systems)
- Controlled Variation Points to optimise product value






Q&A