Improvement Opportunities for Systems Engineering Practice in Brazil and in the World

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Systems Engineering Day
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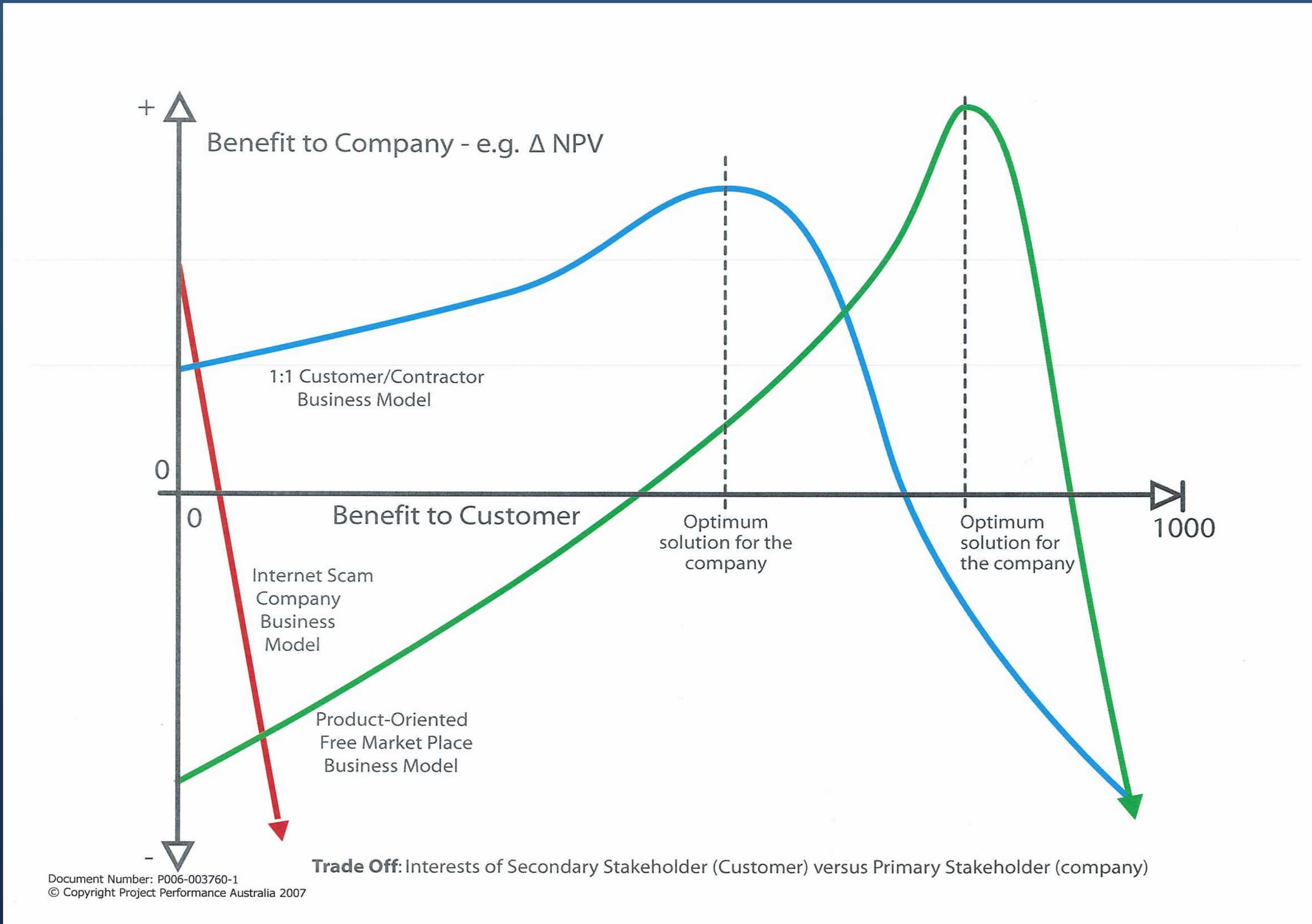
- Current INCOSE Ambassador

What We'll Discuss

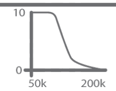
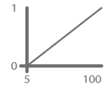
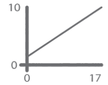
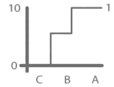
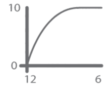
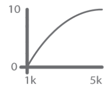
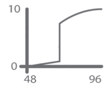
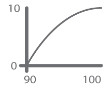
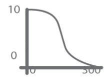
- Success of systems engineering! What is it, and how do we measure it?
- The state of engineering practice
- Comparison of SE in Brasil and worldwide
- Is systems engineering helping?
- Problem areas in SE, and solutions
- New challenges.

Stakeholders and Value



Modelling Value

Value (System Effectiveness) Model

MOEs	Worst	Best	Pri	Pts	Weight %	UF
Cost, $k's per unit	200	50	1	100	25	
Reliability, %	95	100	1	100	25	
Interoperability	0	17	7	14	4	
Size(A/B/C)	C	A	8	3	1	
Schedule (MonthS)	12	6	3	40	10	
Visible Optical Range	1000	5000	5	30	7	
Duration of Transmission, hr	48	96	6	27	6	
Readiness, %	90	100	4	39	10	
OS & D Cost, $k pu/10 years	300	10	2	50	12	
				403	100	

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Indicators of Effective SE for a Business:

- On, under or close to budget
- On, ahead of or close to schedule
- High Return on Sales
- Market leadership
- Low warranty costs
- Repeat business is the norm
- High staff satisfaction and retention

Indicators of Effective SE for the Public Sector:

- On, under or close to budget
- On, ahead of or close to schedule
- High degree of stakeholder satisfaction, immediate and ultimate (in a democracy, the public)
- Efficient use of national resources
- High value delivered/taxation collection ratio
- High staff satisfaction and retention
- Employer of choice

The Engineering of Systems – Overall Assessment of State of the Practice

Typical MOEs	State of SE Practice
Satisfaction of end-user needs	Variable, but averaging only fair. Some outstanding successes (e.g. the iPhone), but many more disappointments. Developing the wrong thing remains the norm.
Cost	Cost overrun is the norm.
Schedule	Schedule slippage is the norm.

Systems Engineering - Oopa, got that wrong!

And not just in Kabul!

A Specific Process Example – Requirements Analysis

Knowledge Area	Brasil	Rest of World
Knowledge of the history of projects and the pivotal role of requirements in project outcomes	Medium to low	Medium to low
Knowledge of the parameters which define any problem	Low	Low
General understanding of risk	Low	Low
Deep knowledge of the principles and methods of requirements analysis	Very low	Very low
Knowledge of how to measure requirements quality	Very low	Very low
At least basic familiarity with the application domain for the item which is to be the subject of the requirements analysis.	Usually OK	Usually OK

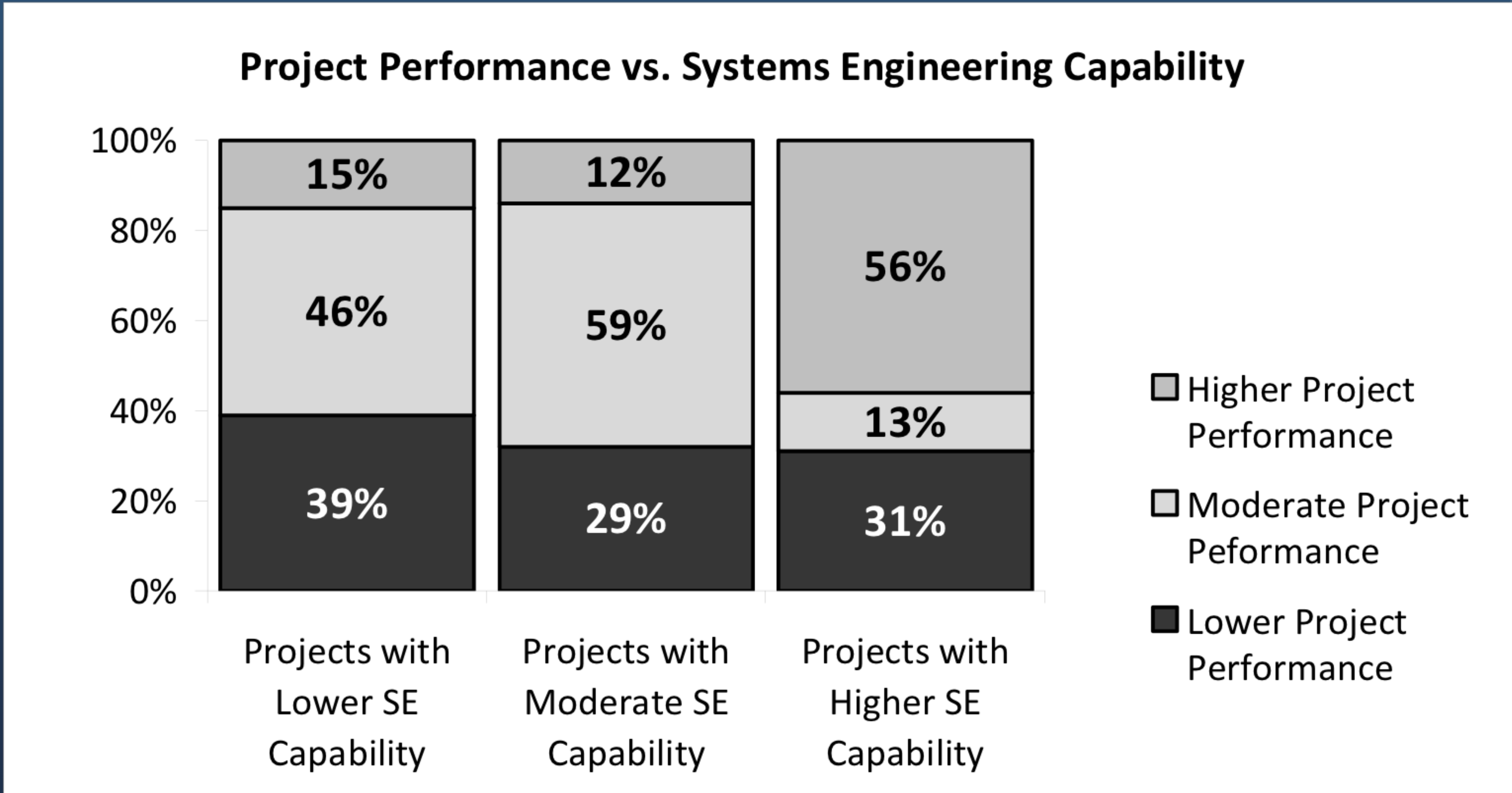
A Specific Process Example – Requirements Analysis

Skill Area	Brasil	Rest of World
Skills in applying the knowledge of the principles and methods of requirements analysis	Low	Low
Skills in identifying defects in requirements	Low	Low
Skills to distinguish between, and switch thinking between, problem domain and solution domain	Low	Low
Skills in measuring requirements quality	Very low	Very low
Skills in human communication	Medium	Medium
Skills in writing individual requirements, in applicable language(s)	Low	Low
Skills in the development of verification requirements.	Low	Low

A Specific Process Example – Requirements Analysis

Attitudes Area	Brasil	Rest of World
Respect for the right of the owners of requirements to decide what they require	Low-Medium	Low-Medium
Willingness to accept approximation and incompleteness in requirements, and related requirements analysis tasks – "adequacy" not "perfection"	OK	OK
Subject to the "adequacy" criterion, attention to detail.	Low	Low

CMU/NDIA Study Results



Source: "A Survey of Systems Engineering Effectiveness", CMU/SEI-2008-SR-034, December 2008

CMU/NDIA Study Results - 2

Supplier's Systems Engineering Capability[3]	**Relationship to Project Performance**	**Relationship (Gamma**[4]**)**	**Section Reference**
Project Planning	Weak positive relationship	+0.13	5.1.3.2
Project Monitoring and Control	Weak negative relationship	-0.13	5.1.3.3
Risk Management	Moderately strong positive relation-ship	+0.28	5.1.3.4
Requirements Development and Management	Moderately strong positive relation-ship	+0.33	5.1.3.5
Trade Studies	Moderately strong positive relation-ship	+0.37	5.1.3.6
Product Architecture	Moderately strong to strong positive relationship	+0.40	5.1.3.7
Technical Solution	Moderately strong positive relation-ship	+0.36	5.1.3.8
Product Integration	Weak positive relationship	+0.21	5.1.3.9
Verification	Moderately strong positive relation-ship	+0.25	5.1.3.10
Validation	Moderately strong positive relation-ship	+0.28	5.1.3.11
Configuration Management	Weak positive relationship	+0.13	5.1.3.12
IPT-Related Capability	Moderately strong positive relation-ship	+0.34	5.1.3.1

Source: "A Survey of Systems Engineering Effectiveness", CMU/SEI-2008-SR-034, December 2008

Do:

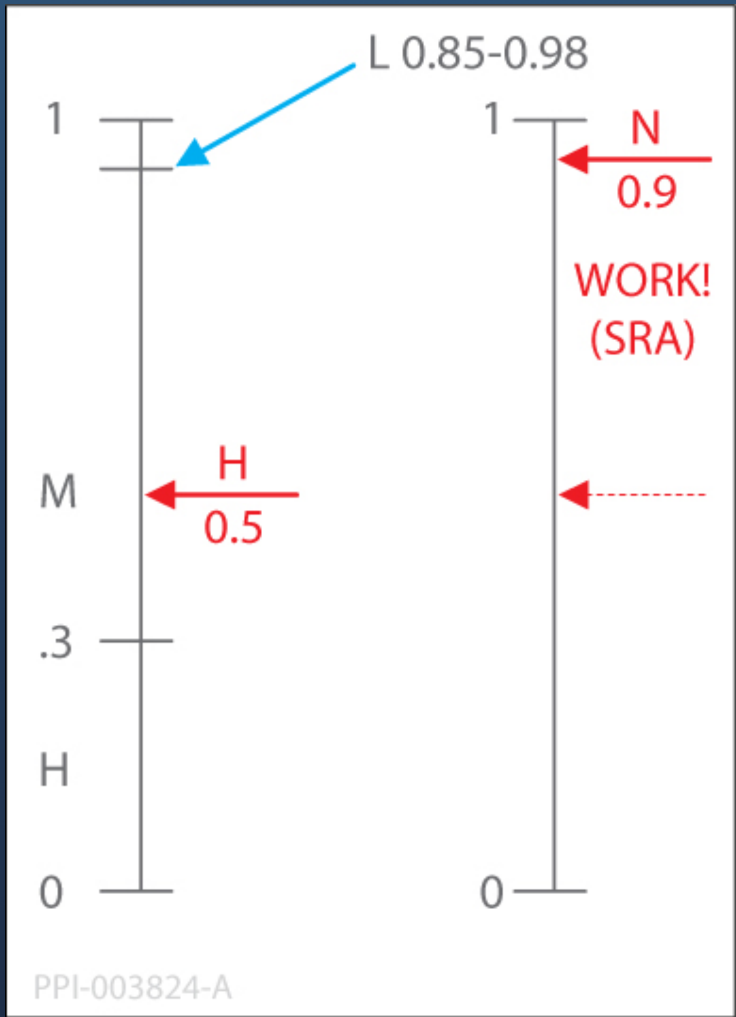
- Establish an objectively adequate problem definition before committing significant resources to design and development

Today?

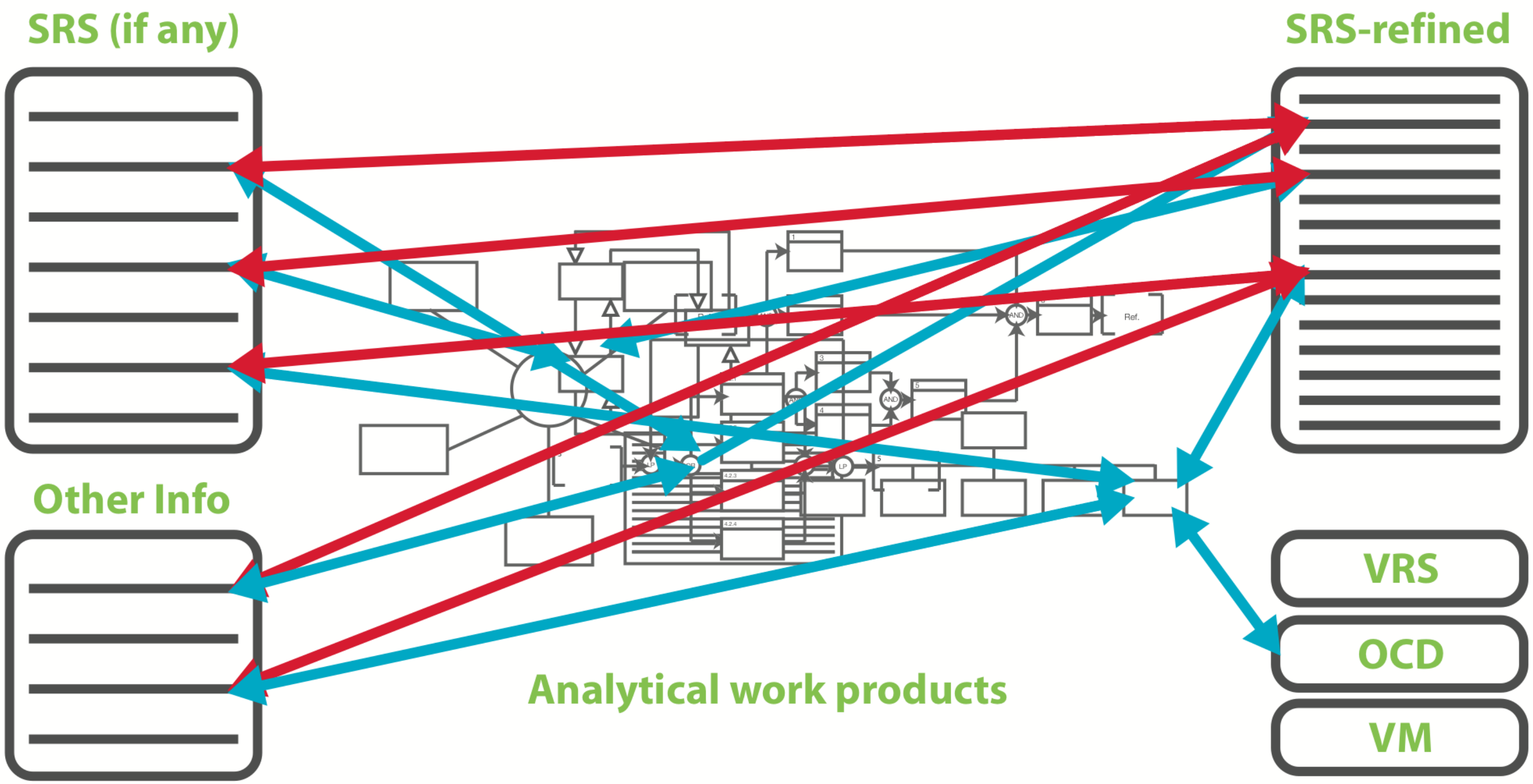
- Most graduate engineers are almost clueless when it comes to problem definition. So are most of the rest!

Solution: Education

Objective Criteria for Adequacy of Requirements



Use Analysis Followed by Resolution of Specific Issues as the Primary RA Strategy



SRS: system or software requirements specification
VRS: verification requirements specification
OCD: operational concept description
VM: value (or system/software) effectiveness model

Do:

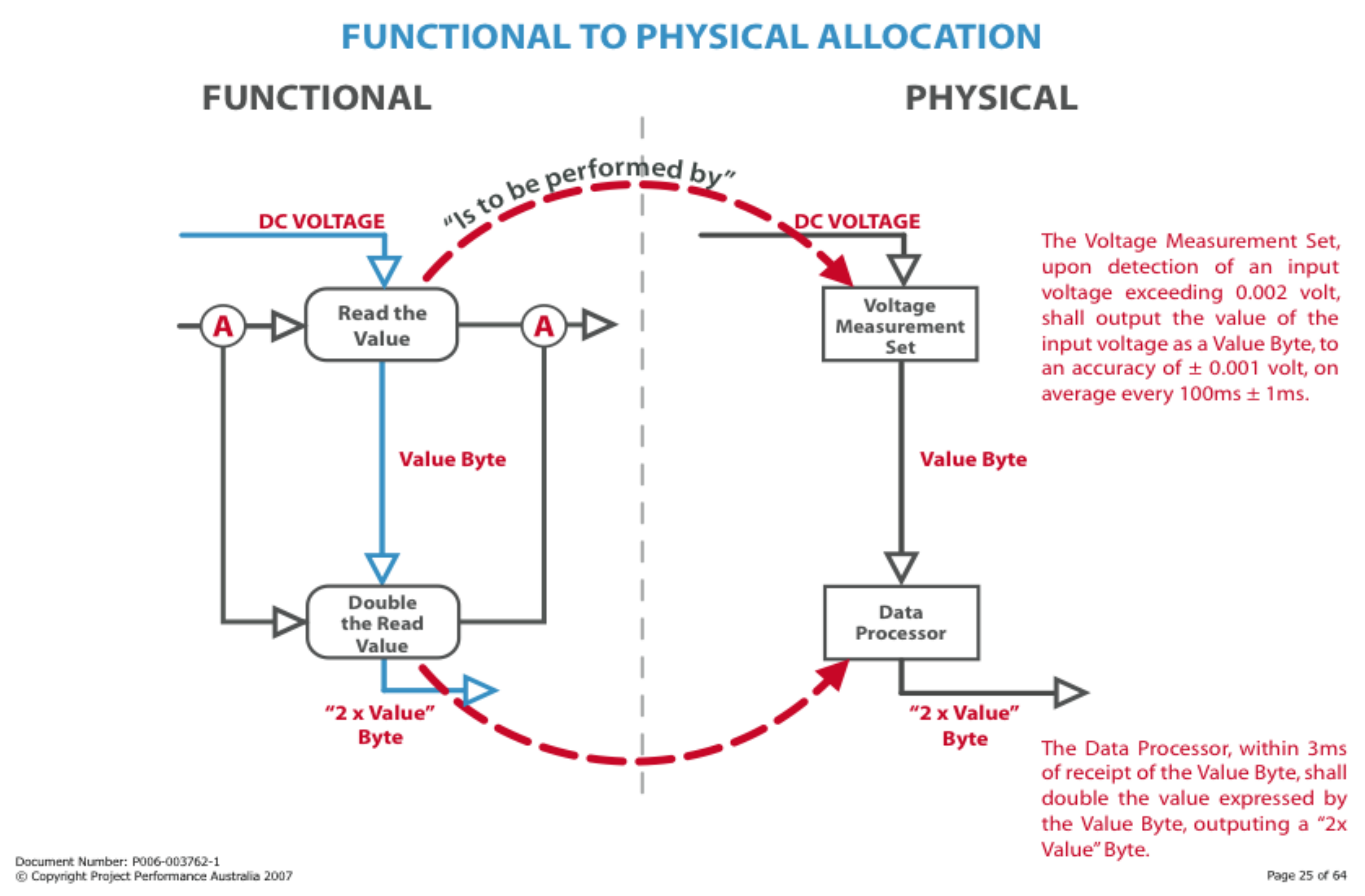
- Apply design skills and technology knowledge in *creating* requirements.

Today?

- Many people are tasked with “developing requirements” without appreciation that to do so effectively needs sound design processes.

The Solution: Education

Use Design Processes and Technology Knowledge to Create Requirements



Do:

- Maintain a distinction between the statement of the problem to be solved, and the description of the solution to that problem, for the system-of-interest, and for each element of the evolving solution.

Today?

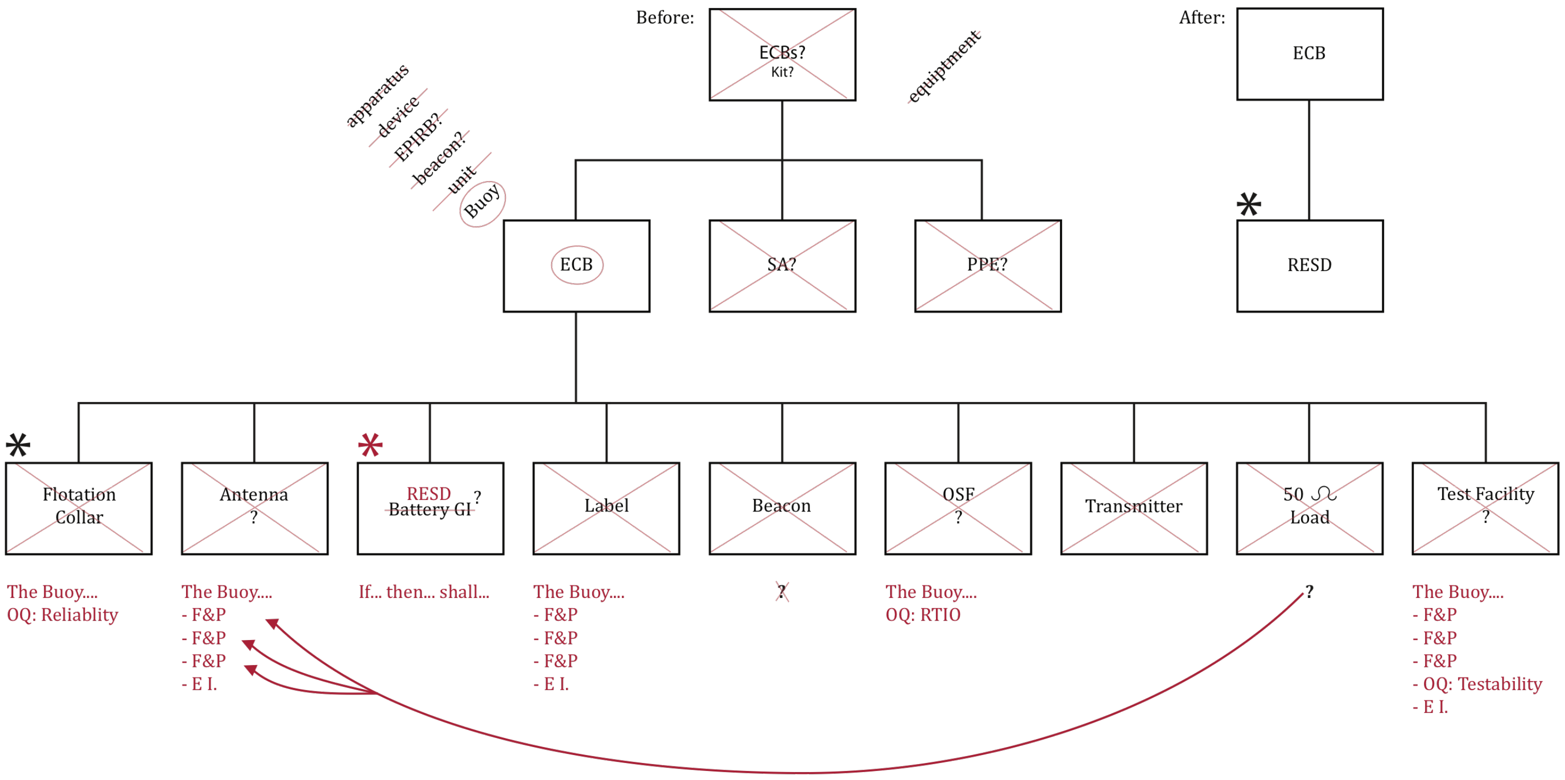
- Most graduate engineers have little or no ability to distinguish between problem and solution. Some engineers never acquire that ability!

The Solution: Education

Design Requirements Analysis

Buoy Design Requirements Analysis

Objectives:
1. Identify any existing, specified design requirements.
2. Validate these.



Legend:

ECB	Emergency Communication Buoy	RESD	Replacable Energy Storage Device
F&P	Functional & Performance	RTIO	Resistance to Inadvertent Operation
OQ	Other Quality	SA	Sleeve Adaptor
OSF	Operational Switching Facilities		

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Do:

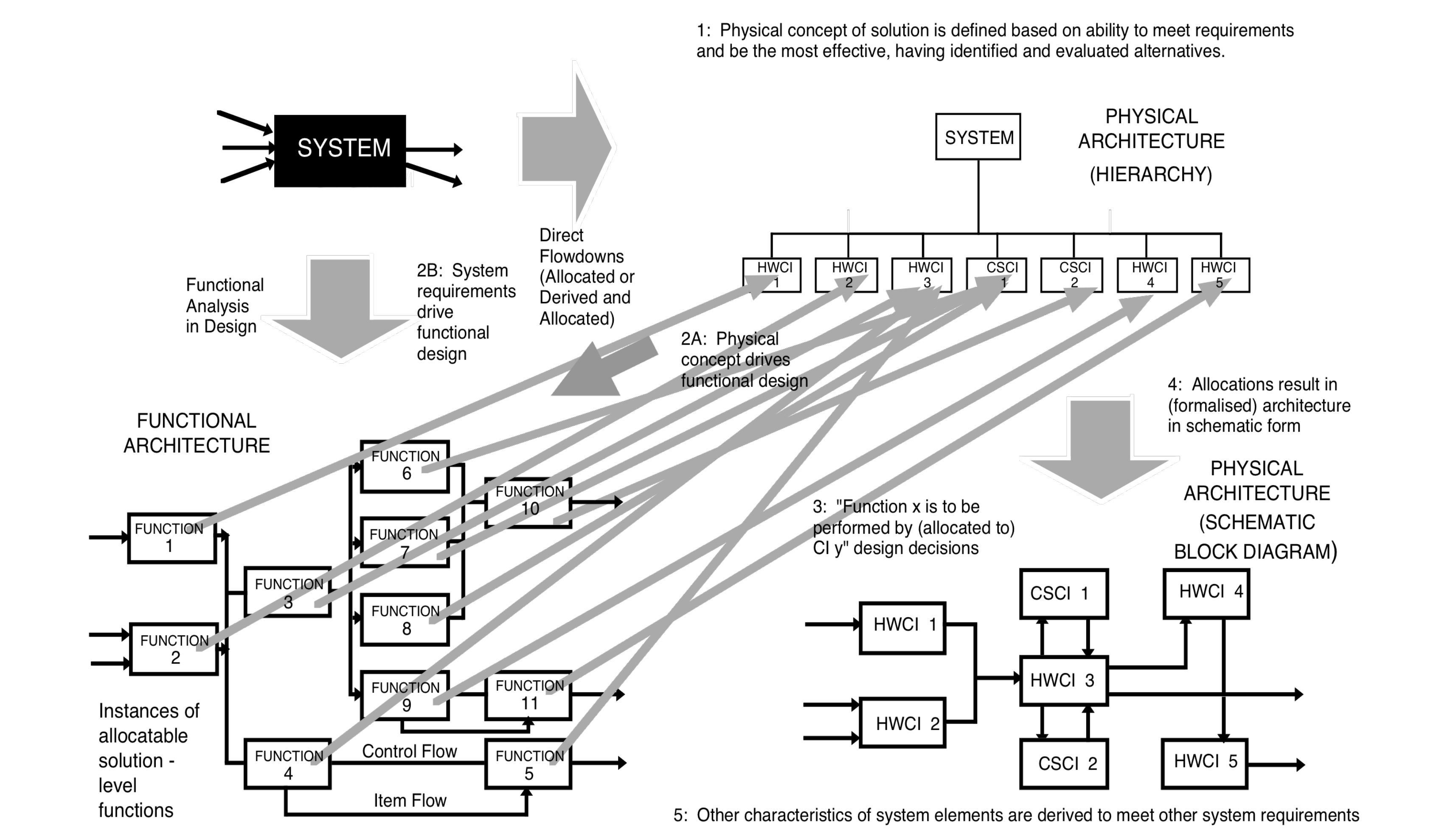
- Except for simple problems, develop logical solution descriptions (description of how the system is to meet its requirements) as a means of developing physical solution descriptions (description of how to build the system).

Today?

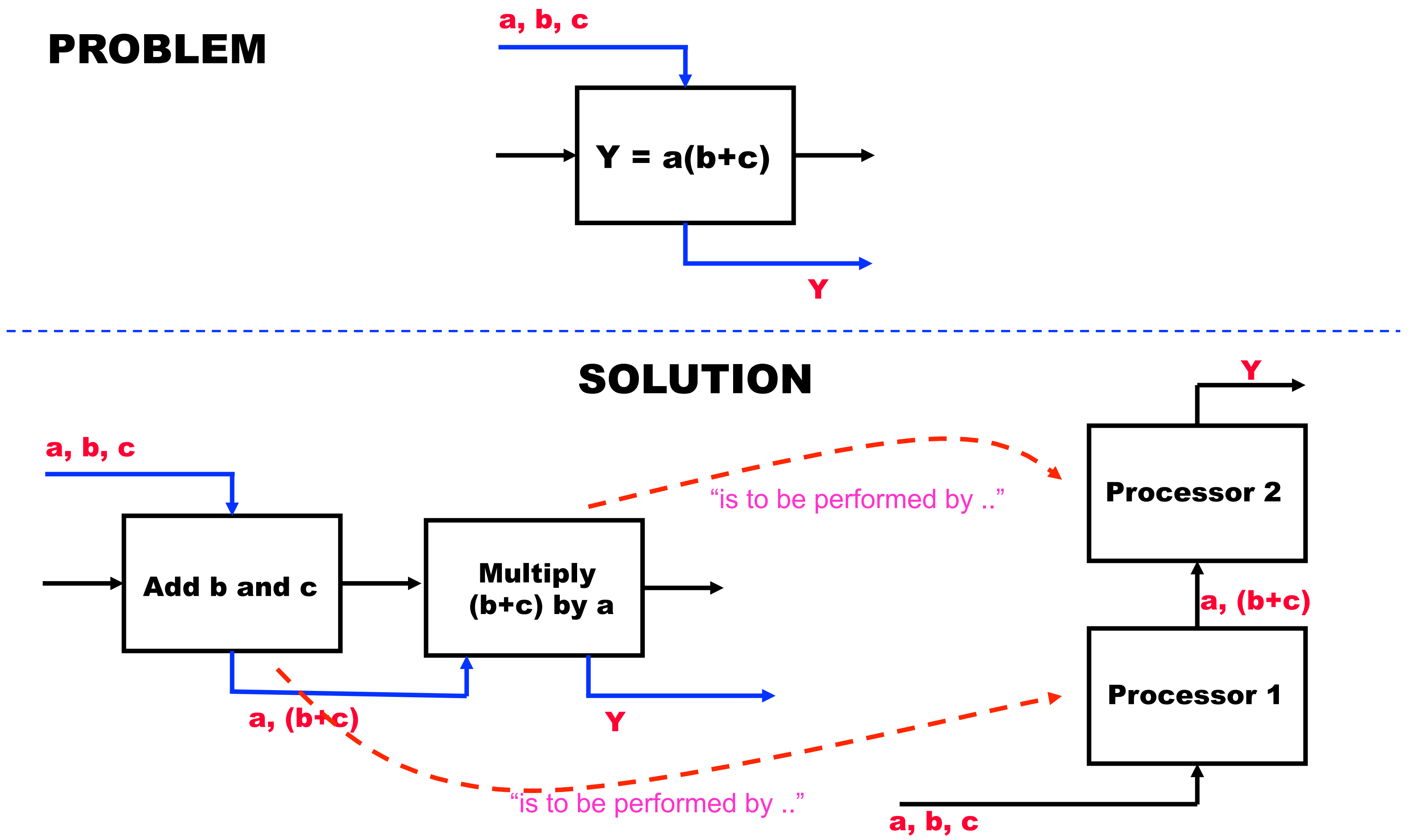
- Most engineers lack the basic concepts of logical design as related to physical design, lack the concepts of allocation of solution-level functions to system elements, and lack understanding of the distinction between control flow and item flow and its significance

The Solution: Education

Allocation of Functions to Architectural Elements



Physical and Logical Design - Example



Do:

- Select between (feasible) design alternatives based on the evaluation of risk-adjusted expected benefit to applicable stakeholders, i.e., on expected overall effectiveness.

Today?

- The principles of sound decision making, and supporting methods, are very poorly understood throughout the project world.

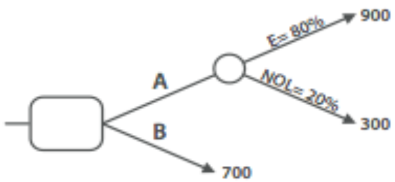
The Solution: Education

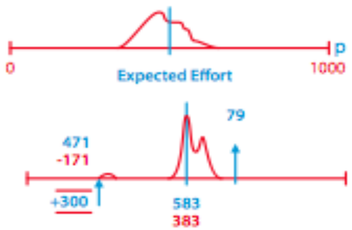
Trade Studies and Design Iteration

ARCH. A

Moes	Worst	Best	Pri	pts	%	UF	Value of MOE	RVC	AVC (RVC x wt)	
Cost, $K's p/u	200k	50k	1	100	25		~~55k~~ 57	10	250	
Reliability %	95	100	1	100	25		~~95.5%~~ 97	~~100~~ 5	~~25~~ 125	+100
Intercoperability	0	17	7	14	4		0	0	0	0
Size(A/B/C)	C	A	8	3	1		~~C~~ B	~~0~~ 5	~~0~~ 5	+5
Scheldule (Month)	12	6	3	40	10		~~7~~ 8	~~10~~ 9	~~100~~ 90	-10
Visible optical range	1000	5000	5	30	7		~~1200~~ 2500	~~2~~ 5	~~14~~ 35	+21
Duration of transmission, hr	48	96	6	27	6		50	0.5	3	
Readiness %	90	100	4	39	10		~~91~~ 95	~~[illegible]~~ 5	~~10~~ 50	+40
OS & d cost $K pu/10 years	300	10k	2	50	12		~~200k~~ 106	~~1.5~~ 8	~~18~~ 96	+74
				392	100			Σ	420	567

VM





Arising Issues:

- Engineering is a *discipline*. However, generational culture is moving in the direction of short, very short, periods of work activity, punctuated by texting, checking email, and the like. This culture is inconsistent with the deep thinking and attention to detail necessary to do engineering well. *Will the next ten years create a generation of engineers who cannot engineer?*

- Engineering remains poorly understood and valued in the community in most countries. It is no news that this cultural trait is unhelpful to attracting the best people to engineering. We do not have a solution! Fortunately, Brasil appears to be higher on the scale of valuing engineers than are many countries.

Pitfalls in Exploiting SE:

- seeing SE as something different to doing engineering well.
- seeing SE as a process per se, rather than as a set of principles, together with a set of process building blocks, used to construct an engineering system
- "silver bullet" mentality – that SE alone is sufficient
- influence of inappropriate resources (e.g. standards, handbooks)
- forcing new processes on unwilling participants – use evolution not than evolution
- only superficial training of engineers in SE

What Can an INCOSE Brazil Chapter Do?

- Define minimum SE competency standards for *all* engineers in Brasil , regardless of discipline and application domain.
- Broadcast these standards
- Work with government and academia to have these standards become mandatory
- Work with government and academia to have education to these standards become a part of every graduate engineering degree program at every university in Brasil
- Measure and broadcast the results from these initiatives

A Project Performance International parabeniza os membros do INCOSE Brazil e deseja todo o sucesso ao Capitulo

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