System Engineering Processes

Lessons Learnt 11.10.21

Tim Stevenson and Phil Crosby

Aims

As part of the process to update the SEMP:

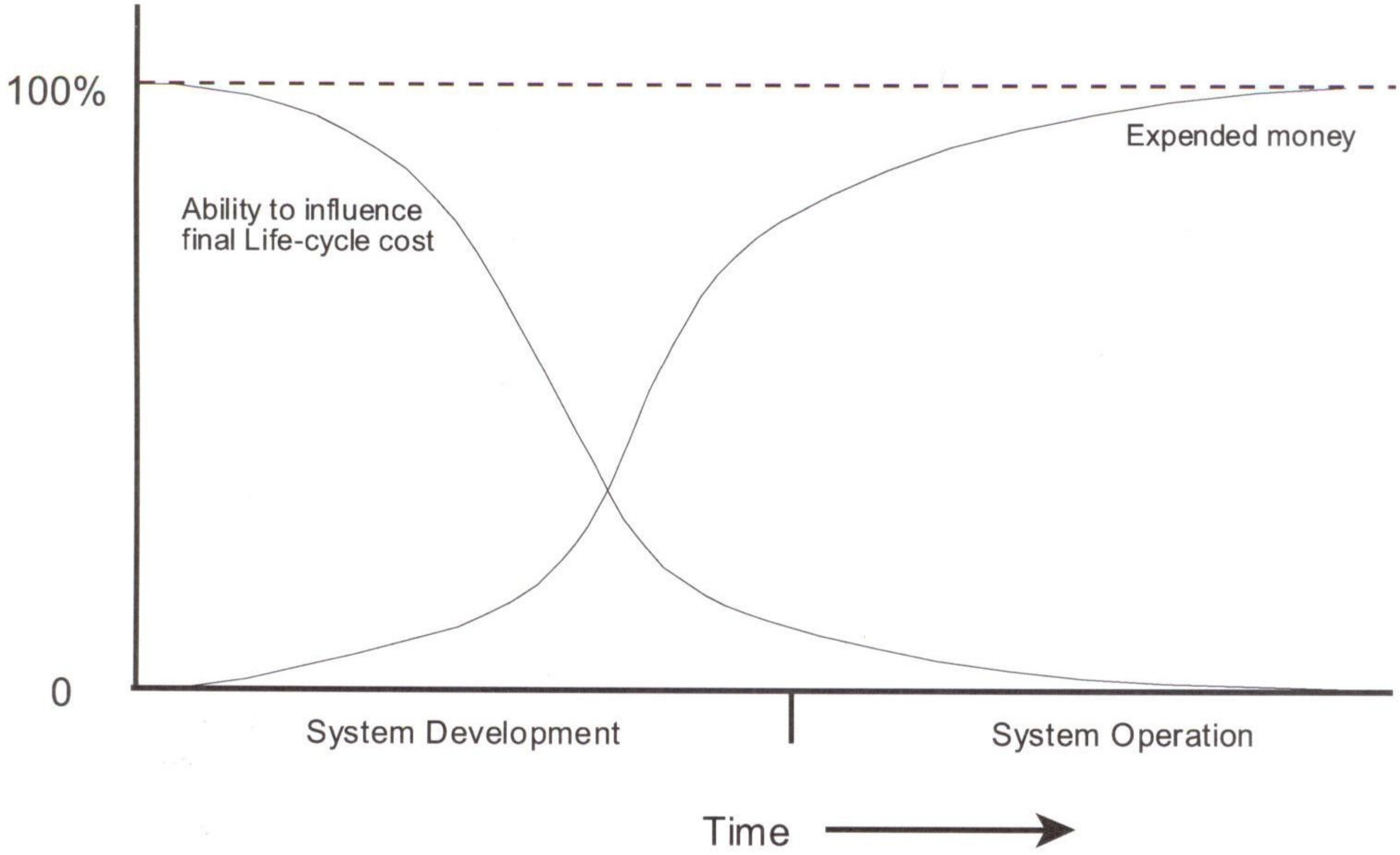
- Place SE in the PM context
- Consider experience from relevant projects in specific areas
- To increase stakeholding and consensus in the various SE processes
- To expose sensitivities to compromise on classical SE
  - The ‘Pragma’ vs ‘Dogma’ debate

Introduction

Topics

- Conduct of Reviews
- Requirements and Design Baselining
- Standards & standardisation
- Modelling of Requirements
- Interface Management
- Verification Management
- System Engineering risk
- Quality and Mission/Product Assurance

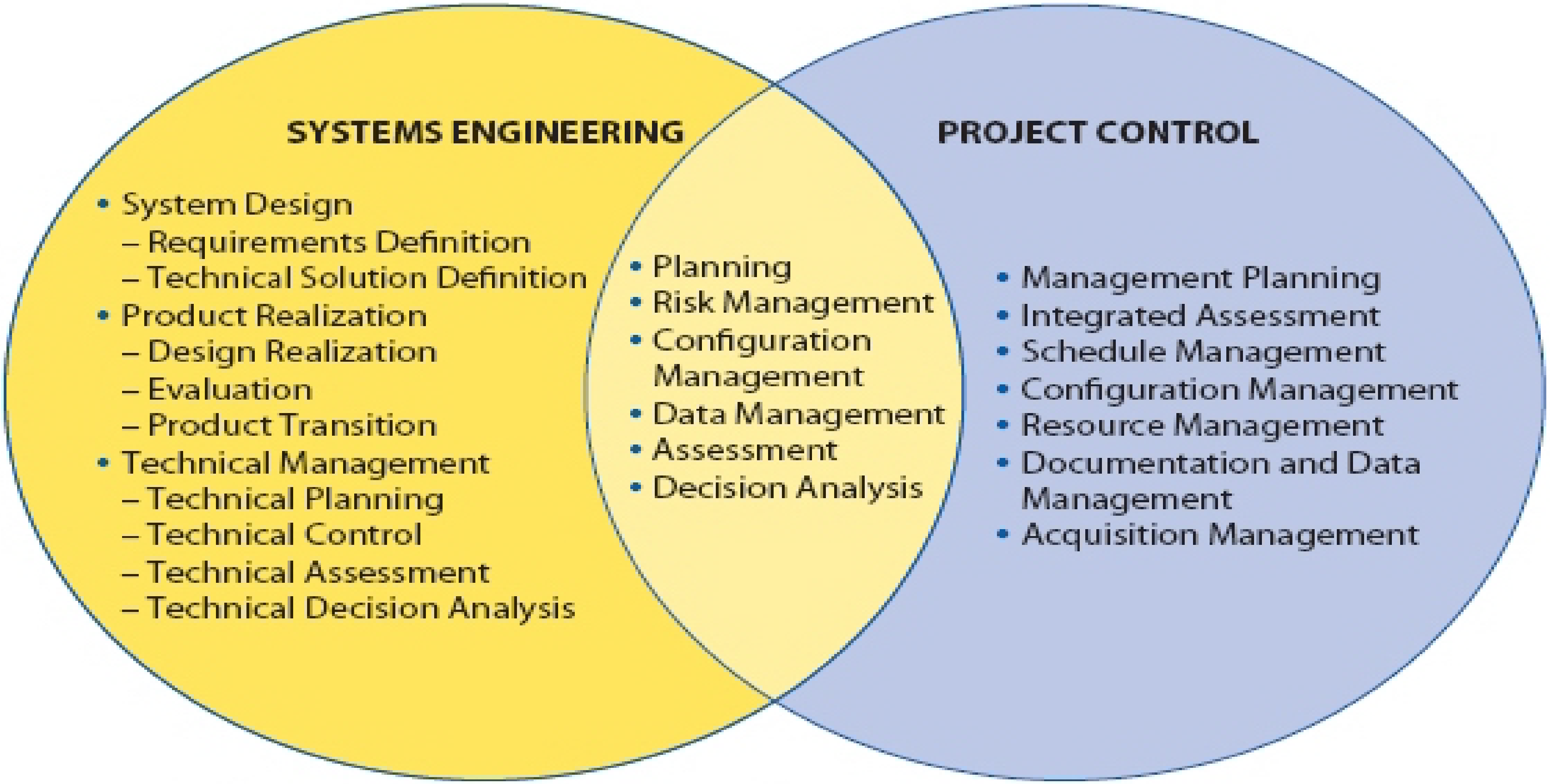
SE in Project Management



(Swart & Meiring, 2003 p169)

SE in Project Management

- The common areas between SE and Project Control



(NASA, 2007a p4)

Conduct of Reviews

Considerations

- Reviews examine project progress against expectations. They may have GO/NOGO power
- The material will have already been disseminated amongst project participants and thoroughly reviewed internally
- Reviews are conducted by independent Panels
- Reviews may also confirm a baseline

Conduct of Reviews

- Reviews as a whole contribute to effective life-cycle management (Smith, 2007; Anbari, 2008)

- E.g The major re-baselining review of the US National Ignition Facility Project (NIF). In tightening the project scope, the NIF management review clarified the project-completion criteria, and incorporated all changes in the project execution plan where they remained unchanged (NASA, 2011b).

- The BAE SYSTEMS Lifecycle Management Framework (LMF) material shows regular reviews to be **central** in technical project execution.

- To be effective SE tools, review outcomes require timely response – BAE SYSTEMS expects 60 days maximum.

Baselining

Considerations

- A Baseline is a consistent, thoroughly understood & agreed set of assumptions (requirements, designs or plans)
- Baselines provide stability so that analysis, design, building or testing can take place without their invalidation by major change
- Baselines are threatened by change, but science facility development must be flexible and accept change
  - We need to analyse and approve baseline changes as quickly as possible
  - We need to set the timeframe of entity and sub-entities Reviews as short as possible

Baselining

Considerations

- A Baseline is a ... tood & agreed s... signs or pl...
- ... ign,
- ... facility
- ... as
- ... and sub-entities

"The project baseline, and the detailed schedules/plans that it supports, are a bundled set of dynamics incorporating stakeholder assumptions and constraints, and form the project 'touch-stone' on which success depends so much".
Elenbaas (2000)

Standards

Considerations

- Standards, where applied, obviate the need for detailed requirements
- Standards are established in the ‘real world’, where cost is usually a major factor
- Standards are followed by solutions (methods, technologies, products)
- Standards are already widely applied in even the most innovative development (fasteners, connectors)

Standardisation

Considerations

- Similar problems occur all over a system
- There are places where design choices are ‘near arbitrary’
- Opportunities exist for massive cost saving by common solutions, even when they are not always ‘best fit’
- System engineering does not emphasise the process of unifying solutions
- How to do?

Modelling Requirements

Considerations

- Requirements are often ‘soft’, or ‘make it as good as it can be’
  - Not just performance, but also functions – ‘wouldn’t it be cool if...’
- To conduct trade studies, we need to place value on performance and functionality
- We need agreed models of (scientific) value of (engineering) performance and function to trade against cost
- The cop out is to use Goals....

Interface Management

Considerations

- Architecture – where are the principal interfaces that require management?
  - Standards play a role here
  - Easy to neglect interfaces or aspects of interfaces
- On what timetable do those interfaces need to be frozen?
- Interfaces are a special case for change management
  - Convention dictates that a special effort is required for early definition and strict control

Verification Management

Considerations

- It is not a question of whether to verify, but how to verify
- Verification by analysis (rather than test) is only cheaper if done properly
- There must be a dedicated system level activity that ensures that verification is done at the lowest possible level of integration consistent with risk
  - AKA earliest possible time

Risk

- **Risk & Contingency**

- Big ‘high-tech’ projects have high risk –it’s what they do
- Standard tools (risk registers) – good as far as they go
- But offer no comfort against *unknown unknowns*
- It’s not a matter of *‘if’,* but *‘when’* an unexpected event will occur (q.v. ALMA gas energy supply, OPAL reactor leak, surface water effects at desert sites, Space shuttle foam debris)
- Risks to SE include: conflicting specifications, poor interface definition, & insufficient system testing
- ‘Unknowns’ doesn’t mean we should do nothing...
- We can apply calculated contingency (e.g. NASA, DoE tools)
- Or apply intelligent modelling borrowed from risk professionals (Zurich, 2010)

Risk

- **Risk & Contingency**

	Data exists	Data do not exist
Modeling possible	**Known knowns** • Dynamic system theory • Network analysis	**Unknown knowns** • Simulation • Monte Carlo exercises
Modeling not possible	**Known unknowns** • Statistical techniques	**Unknown unknowns** • Imagination • Scenario analysis

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Q & P Assurance

Considerations

- Strict adherence to SE principles go a long way towards Mission, Quality and Product Assurance
- Much of SKA will be supplied by the lowest bidder
  – Where conformity will be solely to requirements and some waivers may be required
- Expediency and other compromise will exist locally – A System level dedicated Assurance function is necessary to oversee variances wherever they may be

Mission Assurance

NASA defines the focus of Mission Assurance (NASA, 2010b p95) as:

the: *"established design criteria and standardized control design practices to ensure that the design is capable of:*

- ***Functioning properly during the required mission lifetime***
- ***Minimizing or eliminating potential sources of human-induced failures***
- ***Permitting ease of assembly, test, fault isolation, repair, servicing, and maintenance without compromising safety, reliability, quality, and performance***
- ***Allowing for access requirements that might arise during assembly, test, and prelaunch checkout, and***
- ***Utilizing such analytical techniques as Design Trade-off Analyses, Failure Modes Effect and Criticality Analyses (FMECA), Parts Stress Analyses, Probabilistic Risk Assessment (PRA), and Worst Case Analyses"***

Interestingly, despite the obvious benefits to system engineering and overall project success, there is no evidence (yet) of any large astronomy project defining or incorporating a 'mission-assurance' role into the program.

An opportunity to do something different!

Summary

Features of the SKA SE landscape

- Need for discipline
  - In project reviews, change control, and mission assurance
- Need for pragmatism
  - Where analyses resources are spent in support of change
- Need for definition and dissemination of a common purpose
  - Let's all be building the same thing, within a controlled system
- Large scale
  - Mostly dull stuff – no need to re-invent wheels
- Limited budget
  - No Buck Rogers, no bucks
    - If we can't demonstrate we can do spectacular science for the minimum money, we won't get any at all

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'Insanity is doing the same thing over and over again and expecting different results.'

Dr. Albert Einstein, Physicist 1879-1955

Offers?

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