An Initiative to Strengthen Guidance on the Systems Engineering of Systems which are Already in Service: First Progress Report

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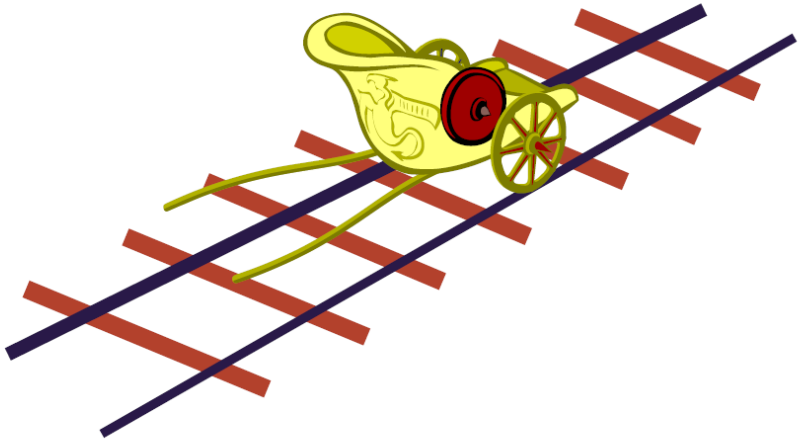
Contents

Did Julius Caesar write this?

- Technical specification for interoperability relating to the infrastructure subsystem of the trans-European high-speed rail system (2002/732/EC)

  "Track gauge

  the distance between the rails (gauge) shall be set at the reference standard value of 1435 mm"

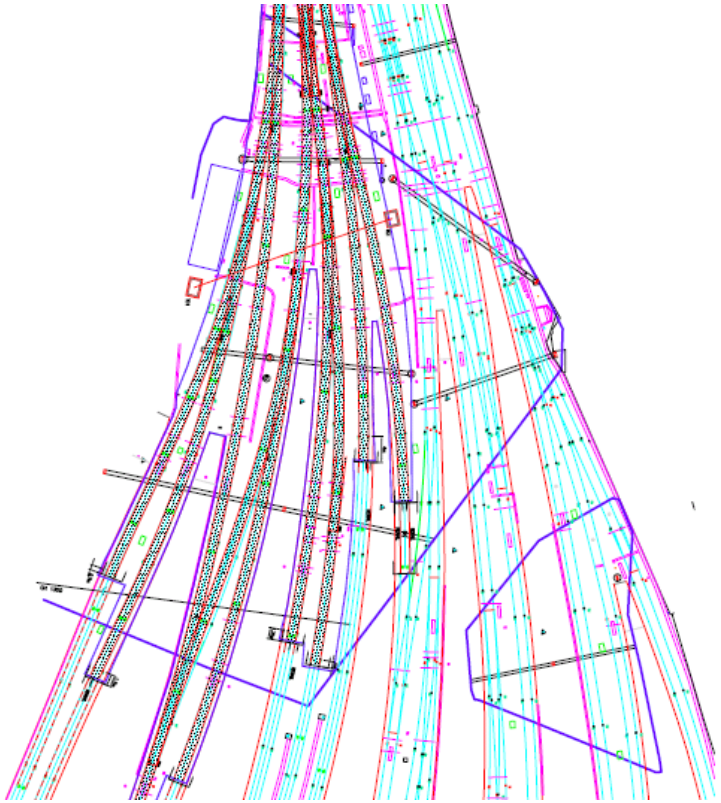


Case Study: Rail Upgrade 1/2

- Replace all switches and crossing within an area marked on a plan
  - to current standards
  - unless otherwise agreed
- All work to be completed within 54 hours
- A a lot of cables threaded through plastic pipes under the tracks
  - in contravention of current standards.

- This is a systems problem!

Motivation: Rail Upgrade 2/2



- The requirements seem unsophisticated
  - But the only ambiguities about the defined end state are deliberate
  - The hard part is to define the start state
- SE handbooks and standards move on from requirements to architecture
  - But we are not creating a new architecture
- The transition from the old system to the new one is a first-class part of the problem

None of these issues is specific to rail systems

Pictures: www.boeing.com, www.operations.mod.uk

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- Phase 1: Analyzing the Problem
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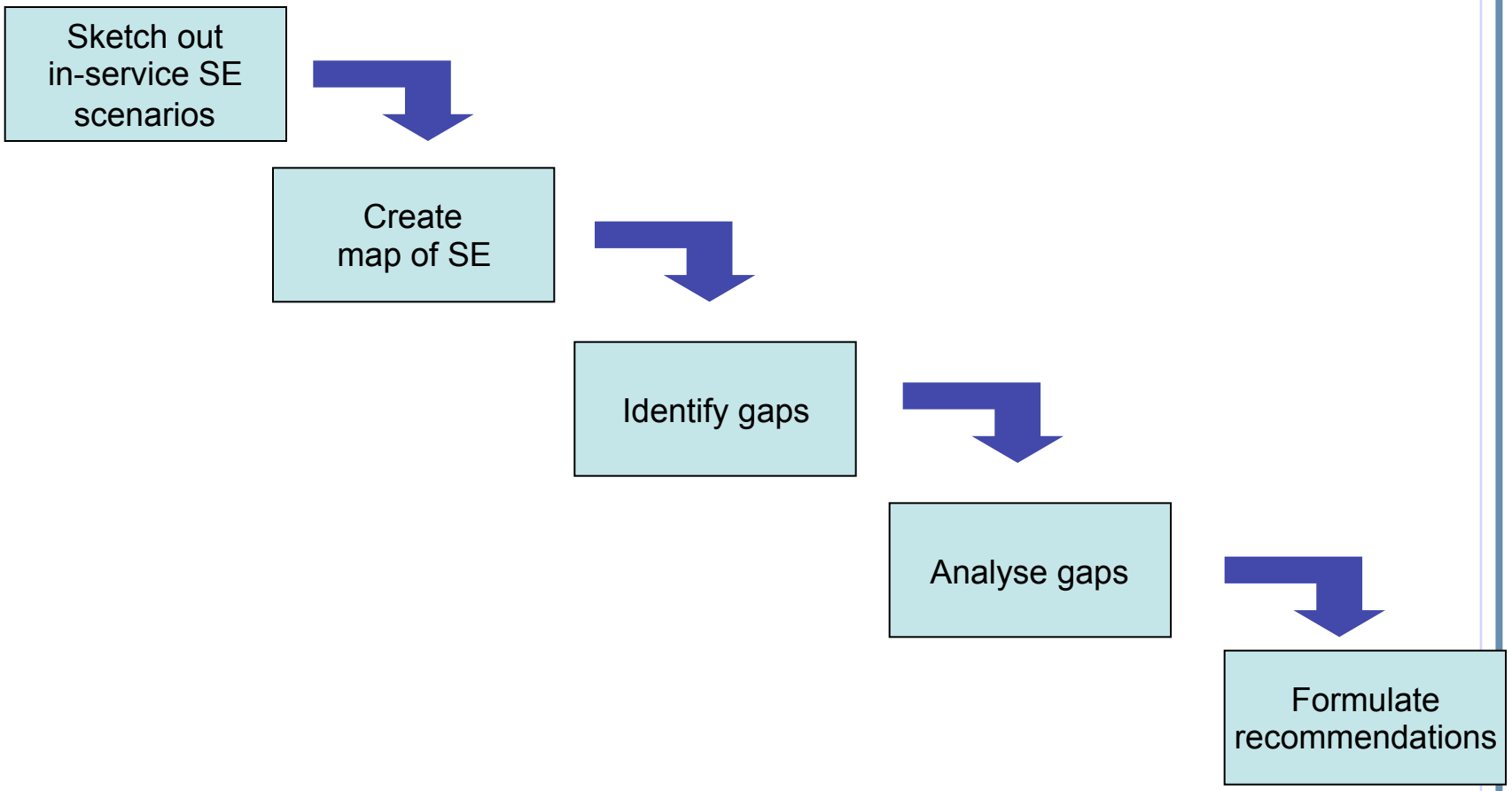
Phase 1: Analyzing the Problem

- Issue explored at a UK workshop in 2007. Consensus that
  - the principles underpinning SE remain the same across the lifecycle, but that
  - the guidance for in-service systems engineering could be strengthened in some areas
- A UK working group with experience in defense, aerospace, air traffic control and rail was formed to advise on:
  - the difficulties encountered, in practice, in applying authoritative guidance on SE, including the INCOSE SE Handbook, to systems that are in service;
  - best current practice in adapting SE guidance to overcome these difficulties; and
  - additional work that might be initiate to assist its members further in overcoming these difficulties.
- Report delivered in 2008
  - Available from www.incoseonline.org.uk, follow links to In-Service Group

The Approach Taken



The W Lifecycle (adapted from ISO/IEC 15288)

Lifecycle Stage	
	Identify stakeholders' needs; Explore concepts; Propose viable solutions
DEVELOPMENT'	Refine system requirement; Create solution description; Build system; Verify and validate system
CONSTRUCTION'	Produce sub-systems
INTEGRATION'	Integrate sub-systems; Inspect and test [verify]
UTILIZATION/SUPPORT	Operate system to satisfy users' needs; Provide sustained system capability
CONCEPT''	Identify stakeholders' needs for change; Explore concepts; Propose viable solutions
DEVELOPMENT''	Refine change requirement; Create solution description; Build change; V&V change
CONSTRUCTION''	Produce changed sub-systems
INTEGRATION''	Integrate changed sub-systems
	Integrate change with in-service system; Inspect and test
RETIREMENT	Store, archive, or dispose of the system

SE Activities

- Stakeholder Req Definition
- Requirements Analysis
- Architectural Design
- Implementation
- Integration
- Verification
- Transition
- Validation
- Operation
- Maintenance
- Disposal

- **Cross-lifecycle activities**
- Project Planning
- Project Assessment
- Project Control
- Decision-Making
- Engineering Environment
- Risk and Opportunity Mgt
- Configuration Management
- Information Management
- Systems Analysis

Map of In Service SE

	STAGE										
Activity	**Devt'**	**Constr'**	**Int'**	**Concept'**	**Util/Supp**	**Concept''**	**Devt''**	**Constr''**	**Int''**	**Ins''**	**Ret**
Stakeholder Req Defn											
Requirements Analysis											
Architectural Design											
Implementation											
Integration											
Verification											
Transition											
Validation											
Operation											
Maintenance											
Disposal											
Project Planning											
Project Assessment											
Project Control											
Decision-Making											
Engineering Environment											
Risk & Opp Mgt											
Configuration Management											
Information Management											
Systems Analysis											

Identification of Gaps

	STAGE										
Activity	**Devt'**	**Constr'**	**Int'**	**Concept'**	**Util/Supp**	**Concept''**	**Devt''**	**Constr''**	**Int''**	**Ins''**	**Ret**
Stakeholder Req Defn											
Requirements Analysis											
Architectural Design											
Implementation											
Integration											
Verification											
Transition											
Validation					1						
Operation											
Maintenance											
Disposal											
Project Planning											
Project Assessment											
Project Control											
Decision-Making											
Engineering Environment											
Risk & Opp Mgt											
Configuration Management											
Information Management											
Systems Analysis											

Through-life validation:
Establishing whether the system and the user needs have drifted apart and some action (a new "V") is required

Identification of Gaps

	STAGE										
Activity	**Devt'**	**Constr'**	**Int'**	**Concept'**	**Util/Supp**	**Concept''**	**Devt''**	**Constr''**	**Int''**	**Ins''**	**Ret**
Stakeholder Req Defn											
Requirements Analysis						2					
Architectural Design											
Implementation											
Integration											
Verification											
Transition											
Validation											
Operation											
Maintenance											
Disposal											
Project Planning											
Project Assessm											
Project Control											
Decision-Making											
Engineering Environment											
Risk & Opp Mgt											
Configuration Management											
Information Management											
Systems Analysis											

Domain Knowledge:
Obtaining relevant facts about the environment of the system to be built is often the larger part of the problem but the guidance is focussed on Requirements

Identification of Gaps

	STAGE										
Activity	**Devt'**	**Constr'**	**Int'**	**Concept'**	**Util/Supp**	**Concept''**	**Devt''**	**Constr''**	**Int''**	**Ins''**	**Ret**
Stakeholder Req Defn											
Requirements Analysis											
Architectural Design						3	3				
Implementation											
Integration											
Verification											
Transition											
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Disposal											
Project Plan											
Project Ass											
Project Con											
Decision-Ma											
Engineering											
Risk & Opp Mgt											
Configuration Management											
Information Management											
Systems Analysis											

Architecture Design:
Little guidance on modifying architectures. How much should you change / re-evaluate? How to deal with architectures that are implicit in standards?

Identification of Gaps

	STAGE										
Activity	**Devt'**	**Constr'**	**Int'**	**Concept'**	**Util/Supp**	**Concept"**	**Devt"**	**Constr"**	**Int"**	**Ins"**	**Ret**
Stakeholder Req Defn											
Requirements Analysis											
Architectural Design											
Implementation											
Integration										4	
Verification											
Transition											
Validation											
Operation											
Maintenance											
Disposal											
Project Planning										4	
Project Assessment											
Project Control											
Decision-Making											
Engineering Environment											
Risk & Opp Mgt											
Configuration Management											
Information Management											
Systems Analysis											

Incremental Acquisition:
Planning out an incremental acquisition process that keeps the service going: backward compatibility; logistics

Identification of Gaps

	STAGE										
Activity	**Devt'**	**Constr'**	**Int'**	**Concept'**	**Util/Supp**	**Concept"**	**Devt"**	**Constr"**	**Int"**	**Ins"**	**Ret**
Stakeholder Req Defn											
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Project Planning											
Project Assessment											
Project Control											
Decision-Making											
Engineering Environment											
Risk & Opp Mgt											
Configuration Management										5	
Information Management											
Systems Analysis											

Integration of Project CM with System CM:
Delivery project CM information must be integrated into the CM system for the enclosing system

Identification of Gaps

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Activity	**Devt'**	**Constr'**	**Int'**	**Concept'**	**Util/Supp**	**Concept''**	**Devt''**	**Constr''**	**Int''**	**Ins''**	**Ret**
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Project Assessm											
Project Control											
Decision-Making											
Engineering Environment											
Risk & Opp Mgt											
Configuration Management											
Information Management					6						
Systems Analysis											

Information Management:
Maintaining accessibility and modification of information through life

Recommendations

- To initiate two parallel further threads for the next phase of work:
  - Phase 2: Thread 1: A UK-led working group to develop supplementary guidance to cover the gaps identified.
  - Phase 2: Thread 2: An international working group to improve and extend the work carried out by the UK working group, to achieve a broader consensus on the conclusions and to establish arrangements for integrating additional guidance into existing INCOSE products

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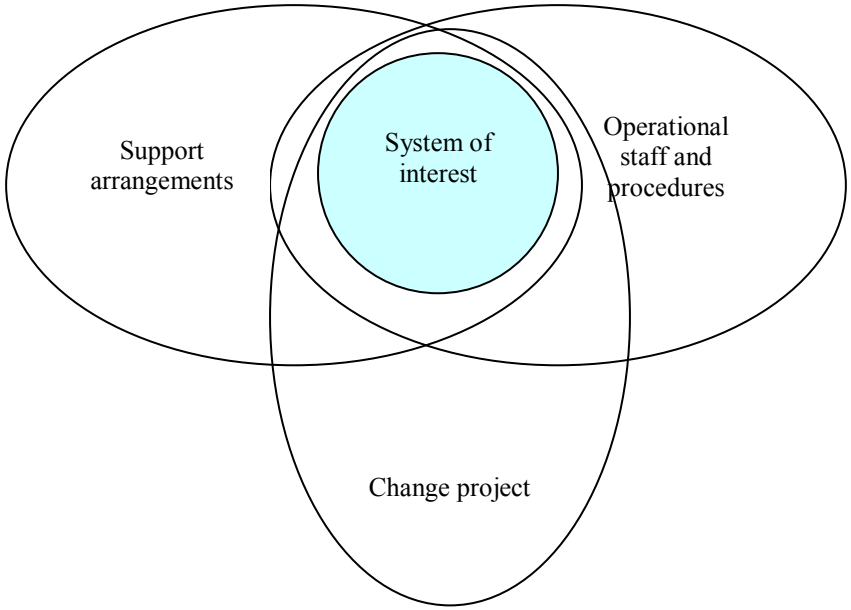
Phase 2: Thread 1 – Developing Guidance

- The UK Working Group was reconvened in April 2009
- Supplementary guidance was published in April 2010
  - Available from www.incoseonline.org.uk, follow links to In-Service Group

Four viewpoints and four systems

- Managing the System
  - Maintaining or improving system performance
- Changing the System
  - Updating or upgrading the system in response to changing needs and circumstances
- Delivering the Service
  - Using the system to deliver a provide a service that advances the business objectives of the organisation
- Optimising the Supply Chain
  - Designing the right supply network to deliver effective support to the system in question at an affordable cost



Four process groups

- Requirements, Validation and Verification
  - Gaps 1 and 2
- Architectural Design
  - Gap 3
- Implementation and Transition
  - Gap 4
- Information and Configuration Management
  - Gaps 5 and 6

Summary of Guidance

- If you are modifying the architecture of an existing system then, in additional to the traditional, 'forward' architecting suitable for the system. Deciding when to change the architecture and when to work within it is key to success.
- Systems architectural techniques are useful in documenting and optimising the supply chain.

you may need to spend significant effort establishing where you are starting from.

➢ Architectural Design

- If you are modifying the architecture of an existing system then, in additional to the traditional, 'forward' architecting suitable for the system. Deciding when to change the architecture and when to work within it is key to success.
- Systems architectural techniques are useful in documenting and optimising the supply chain.

whole new dimension to the design and planning problem

➢ Information and Configuration Manag

- Sustaining real systems too often requires dealing with incomplete and unreliable information.
  - It is not enough for the project and the system owner to follow good practice in configuration management, they also need to co-ordinate their activities.
- Do not neglect the information held in people's heads

a system while keeping it in design and planning problem

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- Phase 2: Thread 2 – Integrating Guidance
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Phase 2: Thread 2 – Integrating Guidance

- The international In-Service Systems Working Group was chartered
  - The international In-Service Systems Working Group was chartered and held its kick-off meeting on 21st October 2009.
- At the time of writing, it had 17 members from 4 countries
  - Three activities:
    - Considering the guidance produced by the INCOSE UK working group
    - Considering the current channels by which INCOSE publishes advice on good SE practice in order to make recommendations on how additional guidance on performing SE on in-service systems should be integrated into these publications
    - Making recommendations on how best to bring the guidance to the attention of practicing systems engineers who can benefit from it

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Guidance

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Conclusions

- The principles of SE seem to remain the same across the lifecycle
- But the application of some of these principles has to be
  - The principles of SE seem to remain the same across the lifecycle
  - But the application of some of these principles has to be adjusted for the in-service phase
- Existing guidance is stronger on the realization of new systems
  - Supplementary guidance exists to remedy this anomaly
- This is a step in a long process
  - Work is underway to refine this guidance and make

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