18ª Semana de Tecnologia Metroferroviária

Integrando Sistemas:

O caso de projetos de Sistema Metroferroviário

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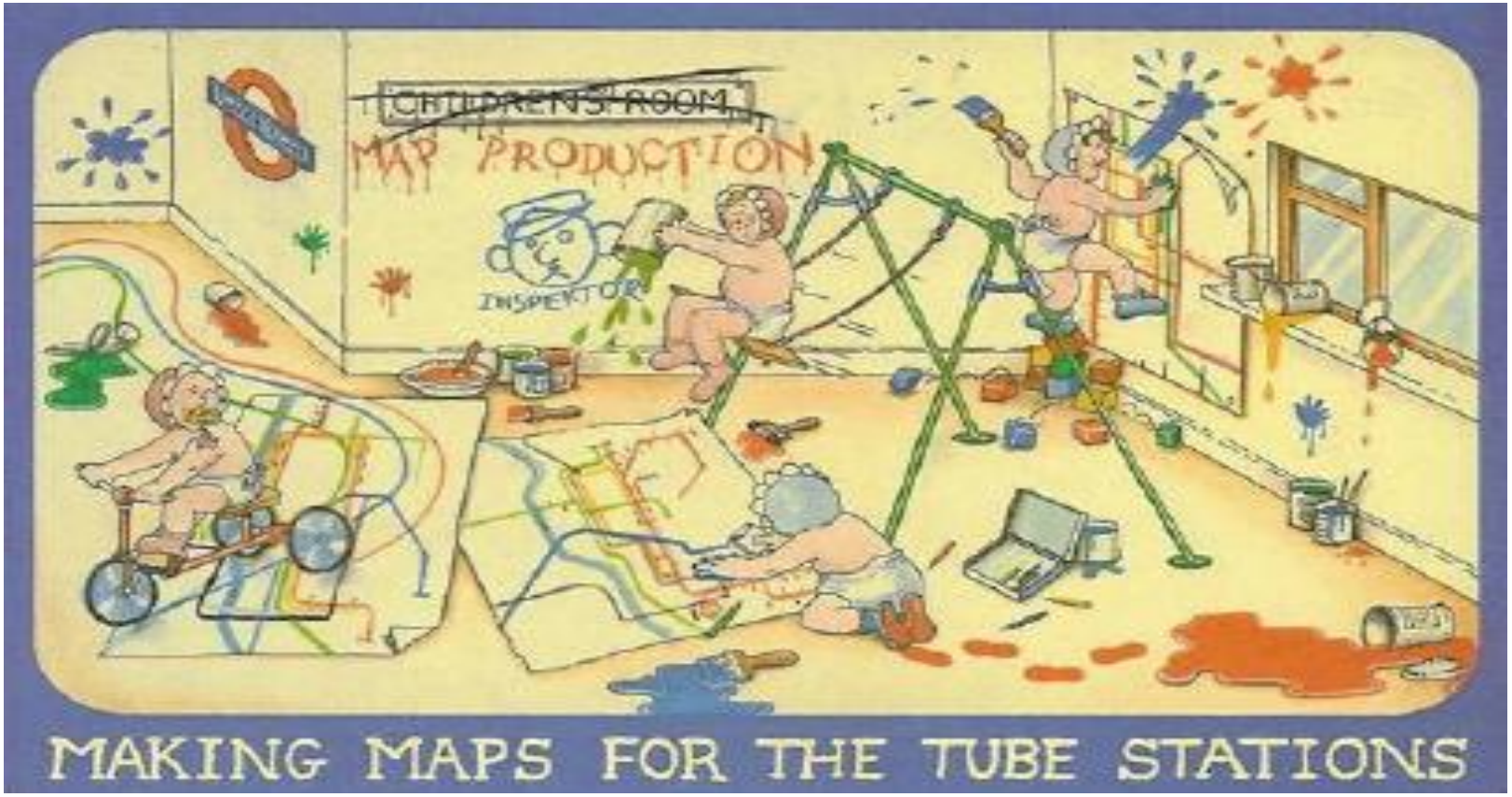
13 Setembro 2012

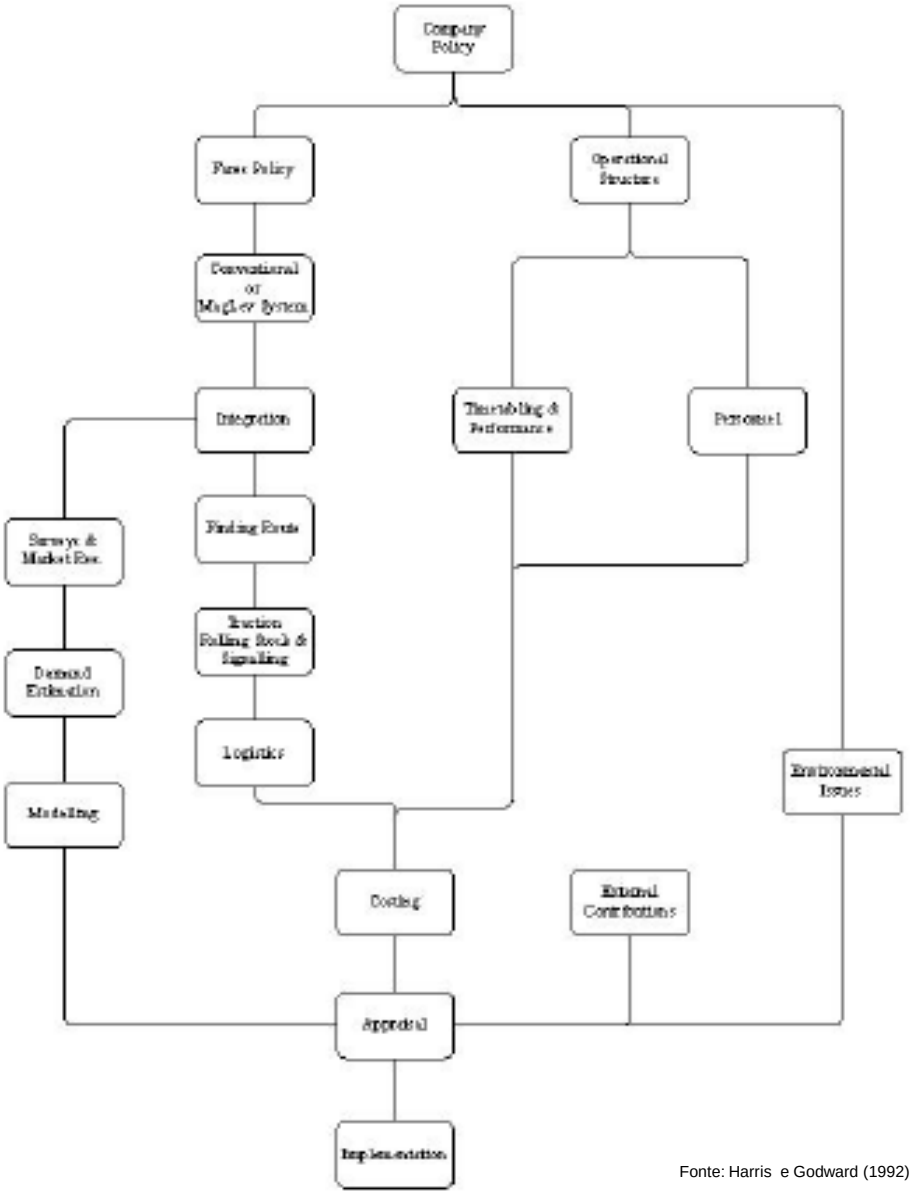
Engenharia de Sistemas

- 2009 - 2012 – MBA em Excelência Gerencial do Metro, Fundação Instituto de Administração – FIA, FEA/USP.
- 2007 - 2008 – Mestre em Railway System Engineering and Integration, University of Birmingham (UoB), UK.
- 1994 - 1999 – Engenheiro Eletricista, Faculdade Engenharia Industrial (FEI), SBC.
- 1994 - 1999 – Técnico em Eletrotécnica, Escola Técnica Federal de São Paulo (ETFSP).

Planejamento . . . Não desta forma . . .

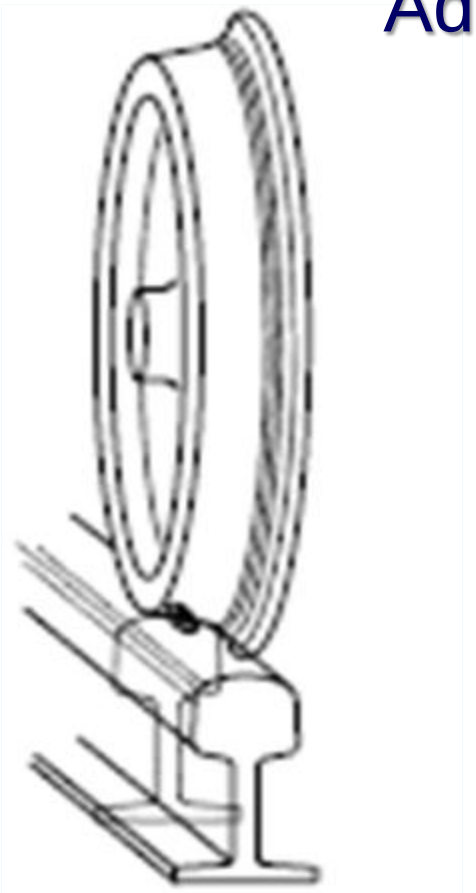


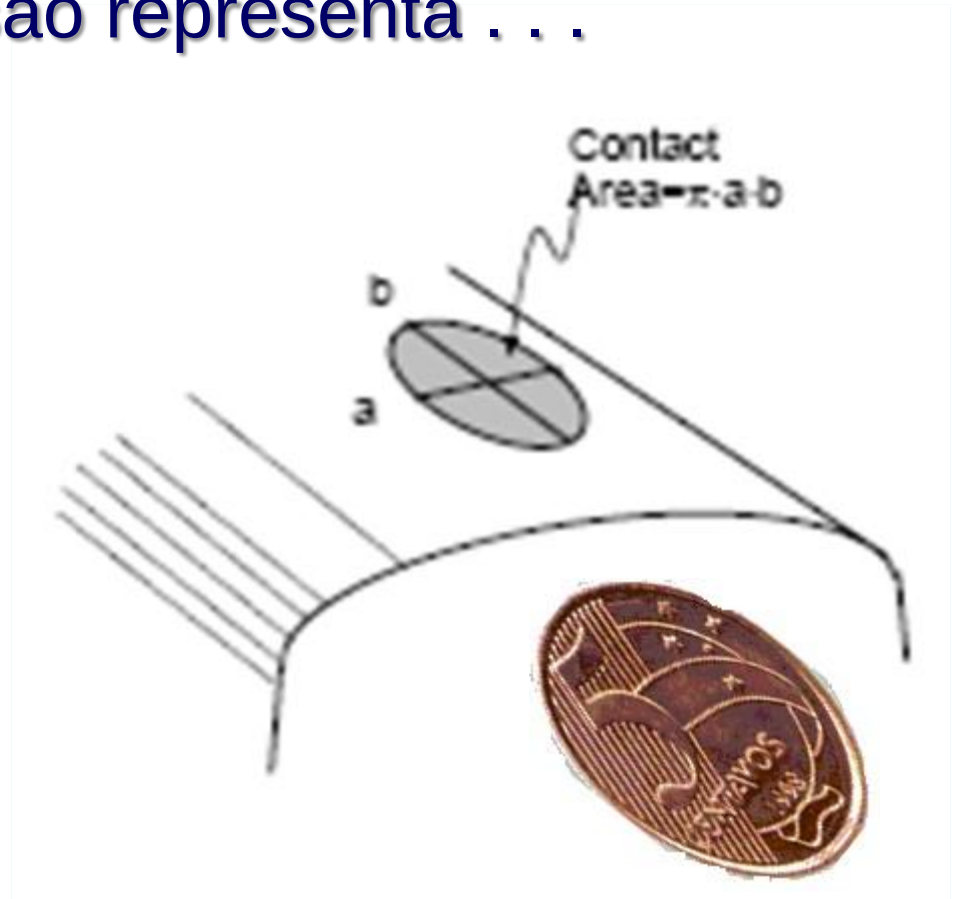
… mas desta forma,
muito melhor!!!



Fonte: Harris e Godward (1992)

Adesão representa . . .





Permitam-me descrever algumas definições...

Sistema Ferroviário é um conjunto **integrado** de pessoas, ativos fixos e móveis que estão **organizados** de certa maneira para transportar pessoas e produtos de um ponto A até um ponto B de forma **segura**, **confiável**, **temporal**, e **energeticamente eficiente**.

Gerenciar um Sistema Ferroviário com sucesso, significa **controlar** todas as **interfaces** entre subsistemas de uma maneira efetiva enquanto garante que **fatores humanos** estão sendo apropriadamente considerados e que as necessidades do **meio ambiente** estão sendo respeitadas a todo o momento.

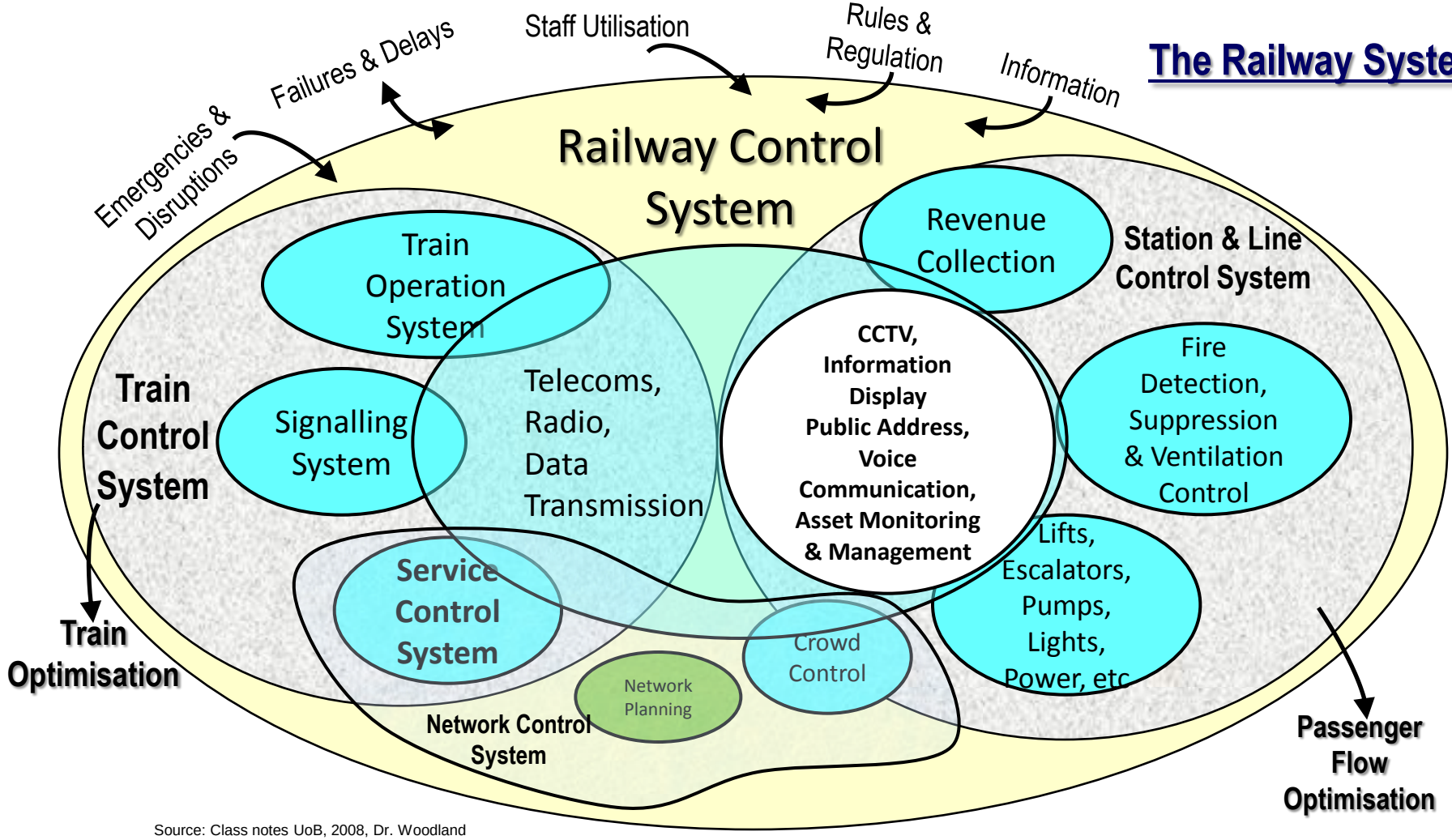
Sistema de Transporte sobre Trilhos possui alta complexidade e deve ser composto pelo estado da arte com os seguintes componentes:

- Infra-estrutura
- Estações
- Material Rodante
- Operação
- Sistemas de Sinalização e Controle
- Marketing
- Manutenção
- Financeiro
- Gerenciamento
- Aspectos Legais

Contexto do Sistema sobre Trilhos

Operação do Trem	Condução	Parada do Trem	Fechamento de Portas	Operação em Caso de Incidente	Exemplos
Manual (GoA – 1)	Condutor	Condutor	Condutor	Condutor	Bruxelas Barcelona Hamburgo
STO - Semi – Automática (GoA – 2)	Automático	Automático	Condutor	Condutor	Metrô SP L1,2,3 Hong Kong Singapura
DTO Driverless (GoA – 3)	Automático	Automático	Agente no Trem	Agente no Trem	Docklands Osaka Ankara
UTO Unattended (GoA – 4)	Automático	Automático	Automático	Automático	Metrô SP - L4 Metrô Paris - L14 Toulouse People Movers

The Railway System



Source: Class notes UoB, 2008, Dr. Woodland

CONFIANÇA

- DISPONIBILIDADE — Capacidade de o sistema disponibilizar serviços quando necessário
- CONFIABILIDADE — Capacidade de o sistema disponibilizar serviços conforme necessário
- SEGURANÇA — Capacidade de o sistema operar sem falhas catastróficas
- PROTEÇÃO — Capacidade de o sistema se proteger contra invasão acidental ou deliberada

System Engineering

Falhas em Projetos

Por quê é importante controlar melhor um Sistema?

- Requisitos incompletos - 13,1%
- Não envolve os usuários - 12,4%
- Recursos insuficientes/cronograma - 10,6%
- Expectativas irrealistas - 9,9%
- Falta de apoio da gestão - 9,3%
- Alteração de Requisitos - de 8,7%
- Falha de planejamento - 8,1%
- Não mais necessário - 7,4%

Fonte: www.standishgroup.com

História do *System Engineering*

2000

1980

1970

1960

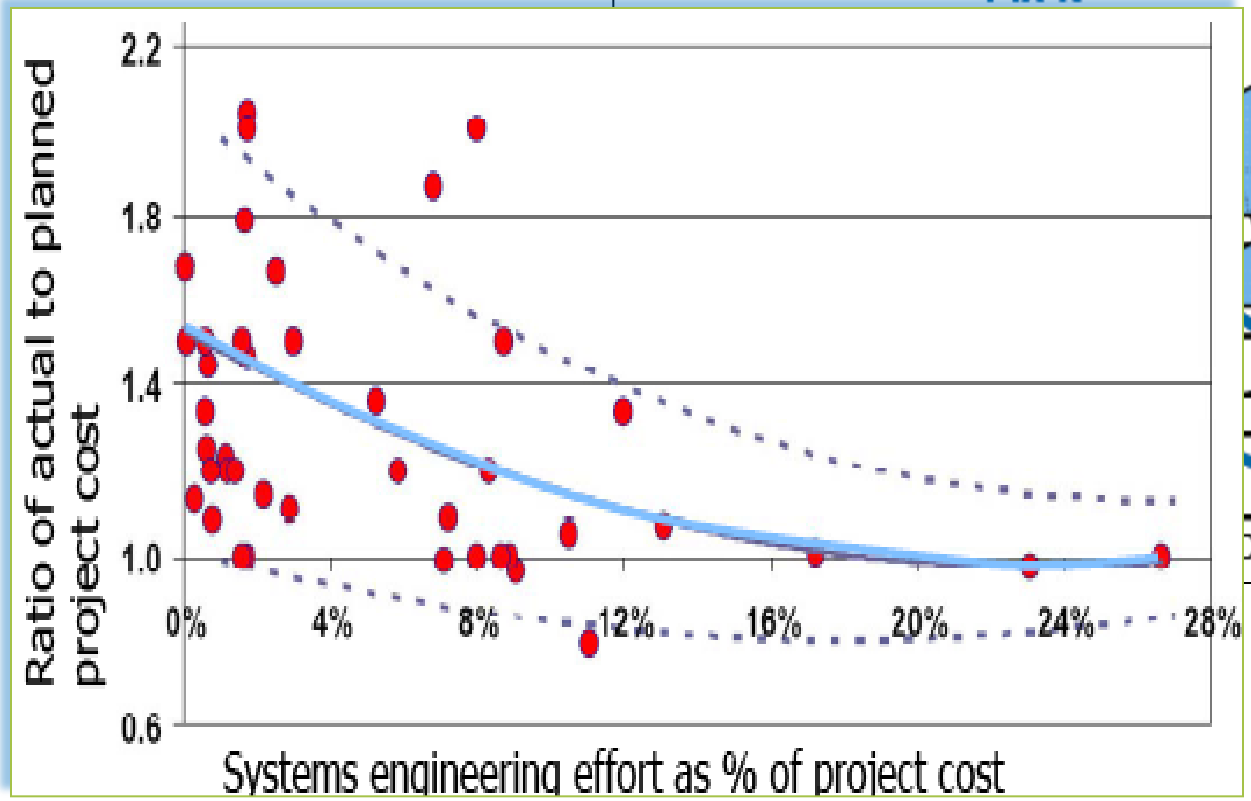
1950

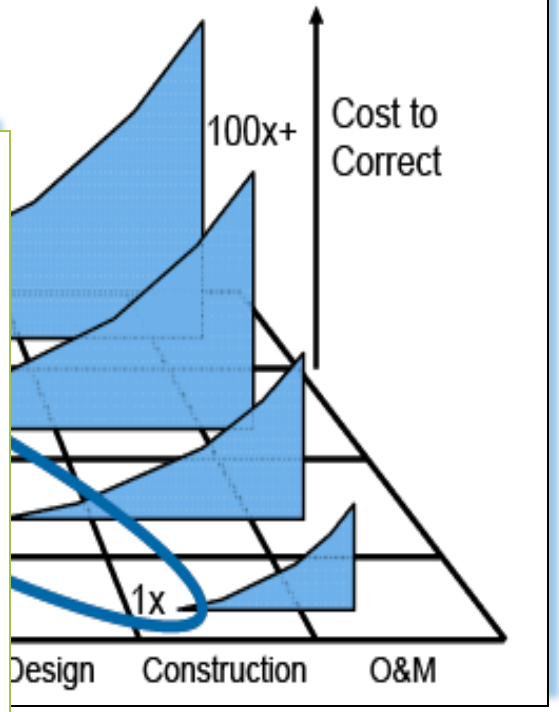
Produtos

Software

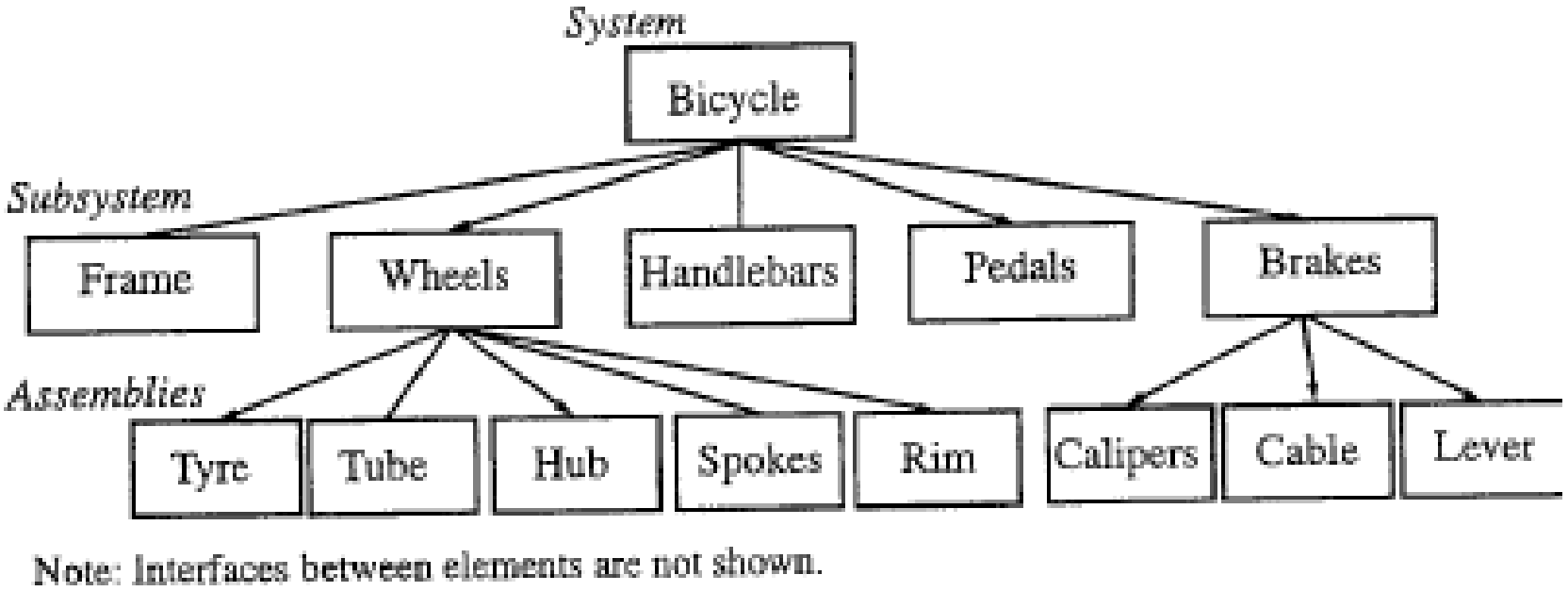
Projetos

Fix It



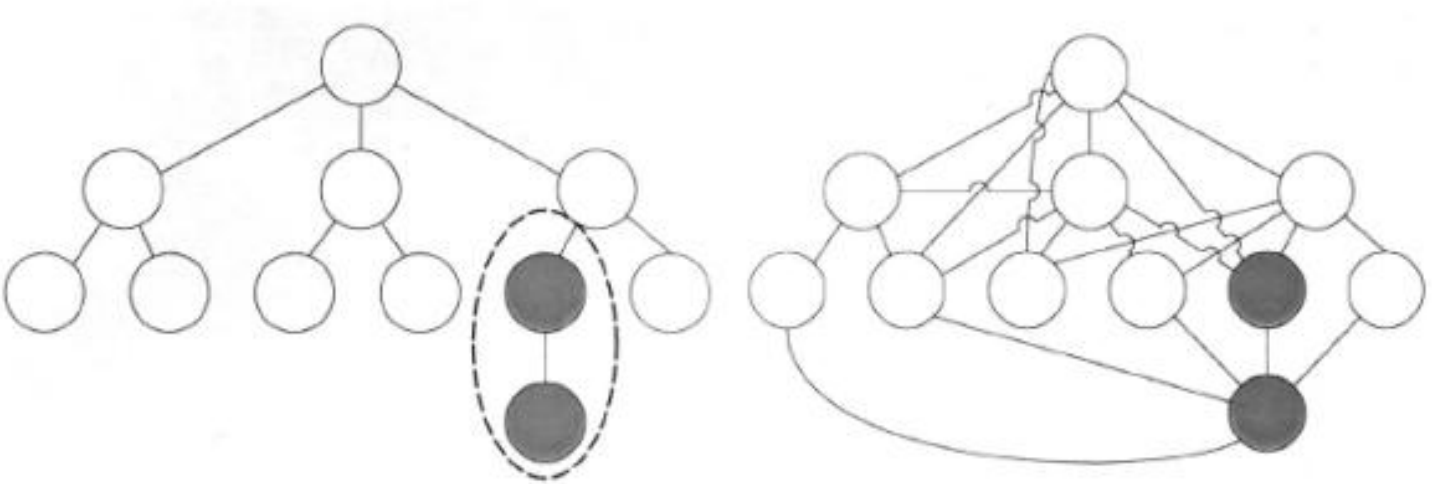


Fonte: Adaptado a partir de Steve McConnell, *Code Complete)* e INCOSE

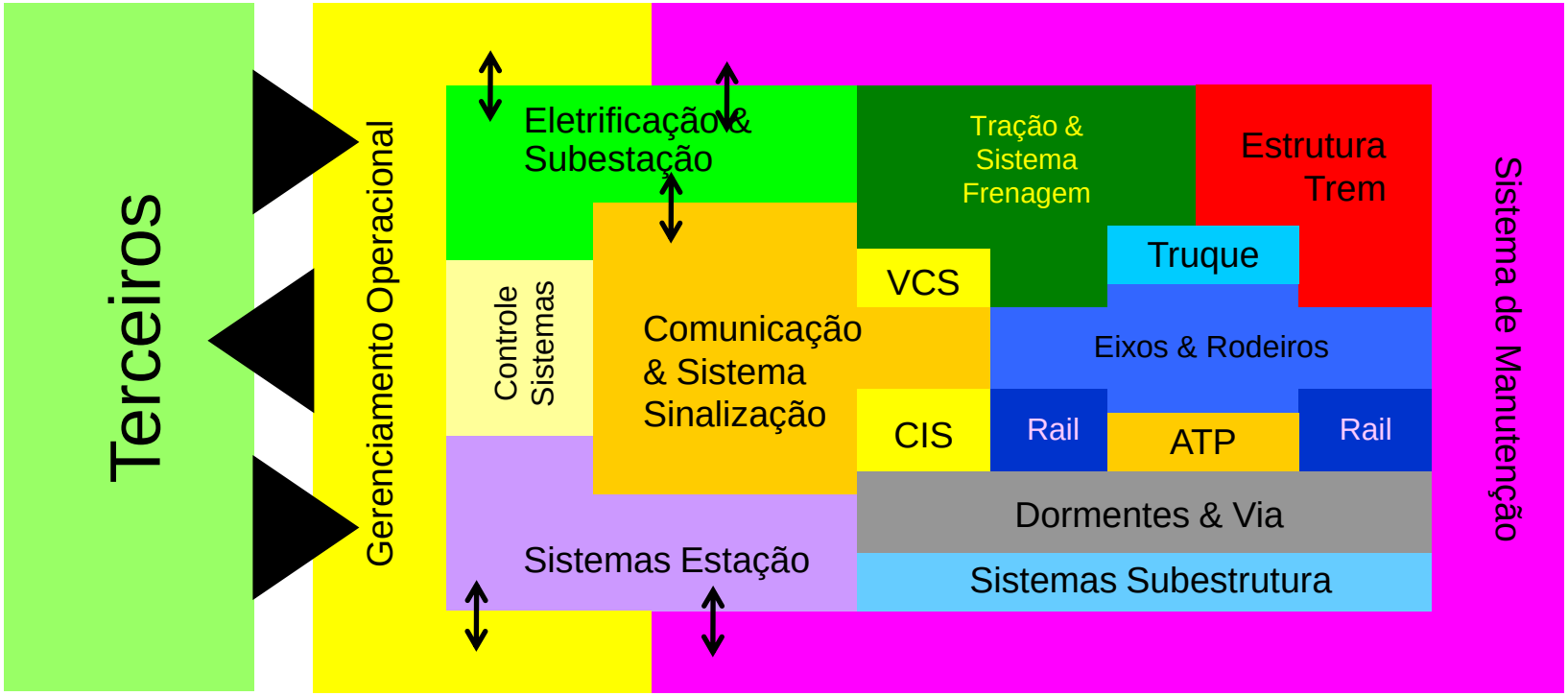


Note: Interfaces between elements are not shown.

Interfaces Simples - Complexa



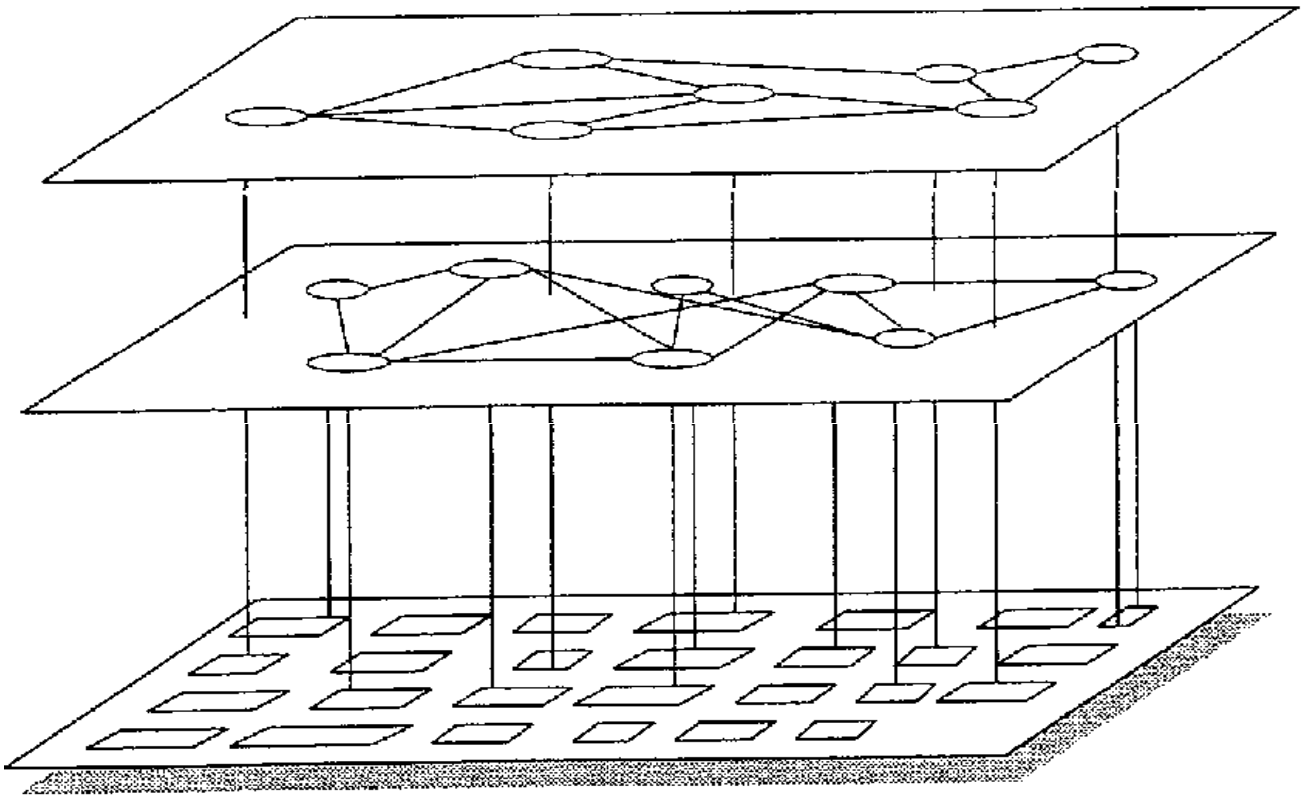
Diversos Subsistemas e Interfaces



CIS:Sistema de Informação ao Usuário / VCS: Sistema de Controle do Trem

Fonte: Notas de Aulas University of Birmingam Schmid (2008)

Conectividades

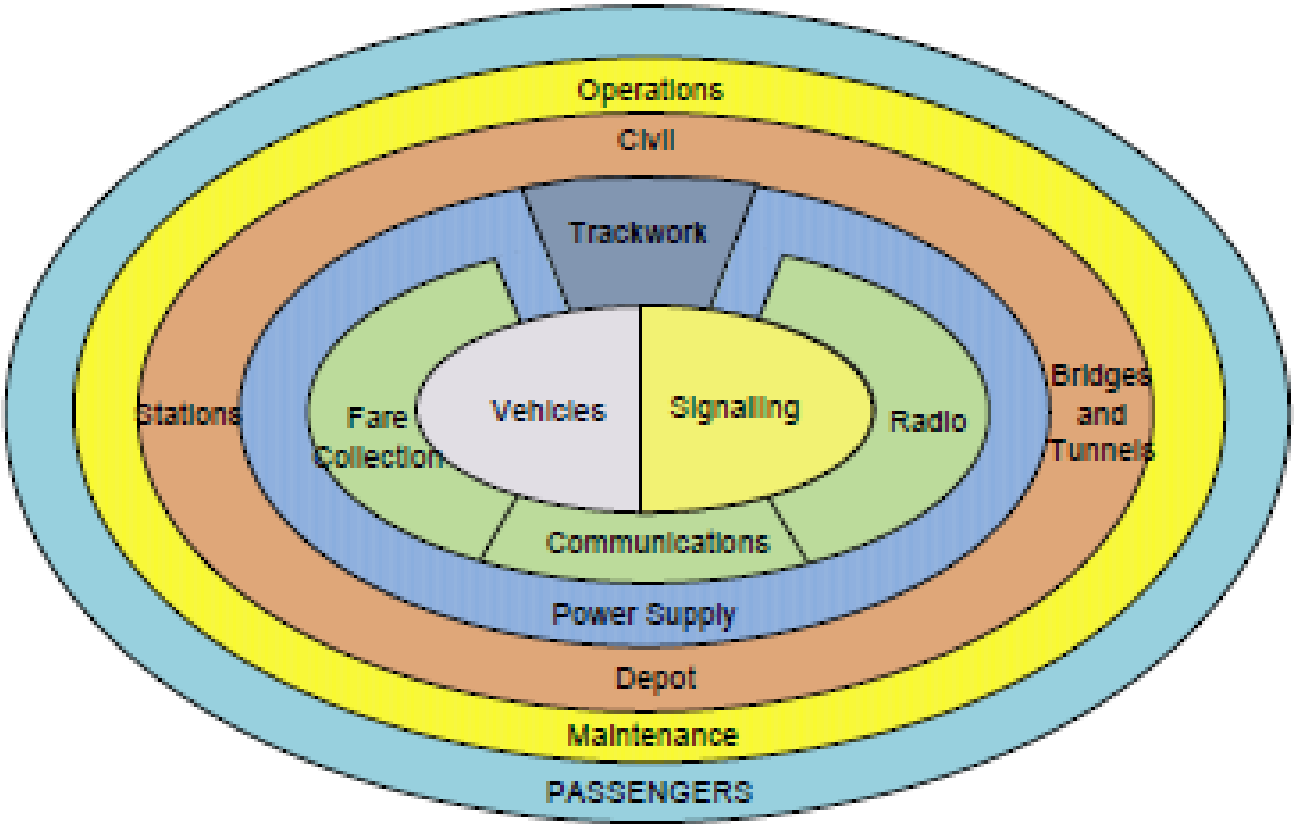


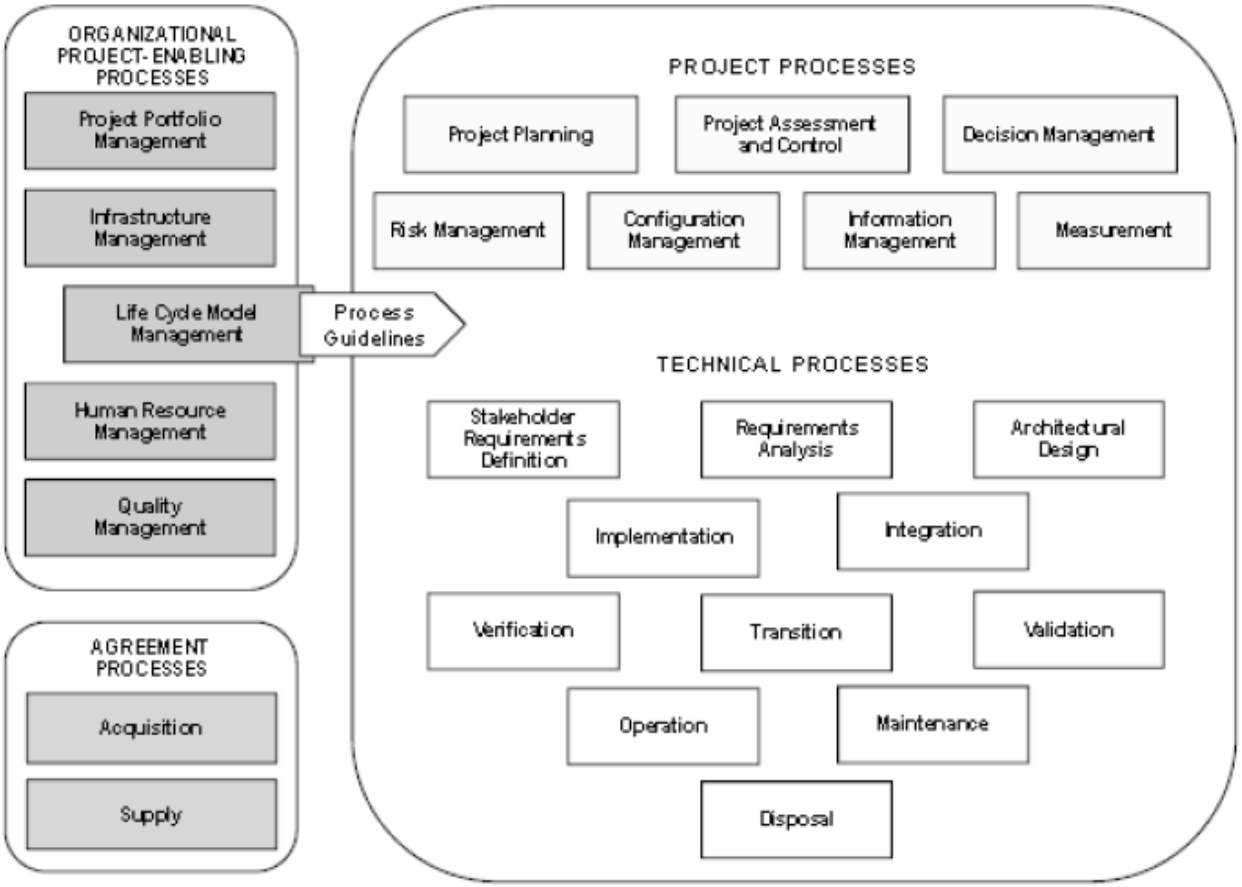
Conectividade:

- Através de funções do projeto;
- Cenários existentes;
- Interoperabilidade;

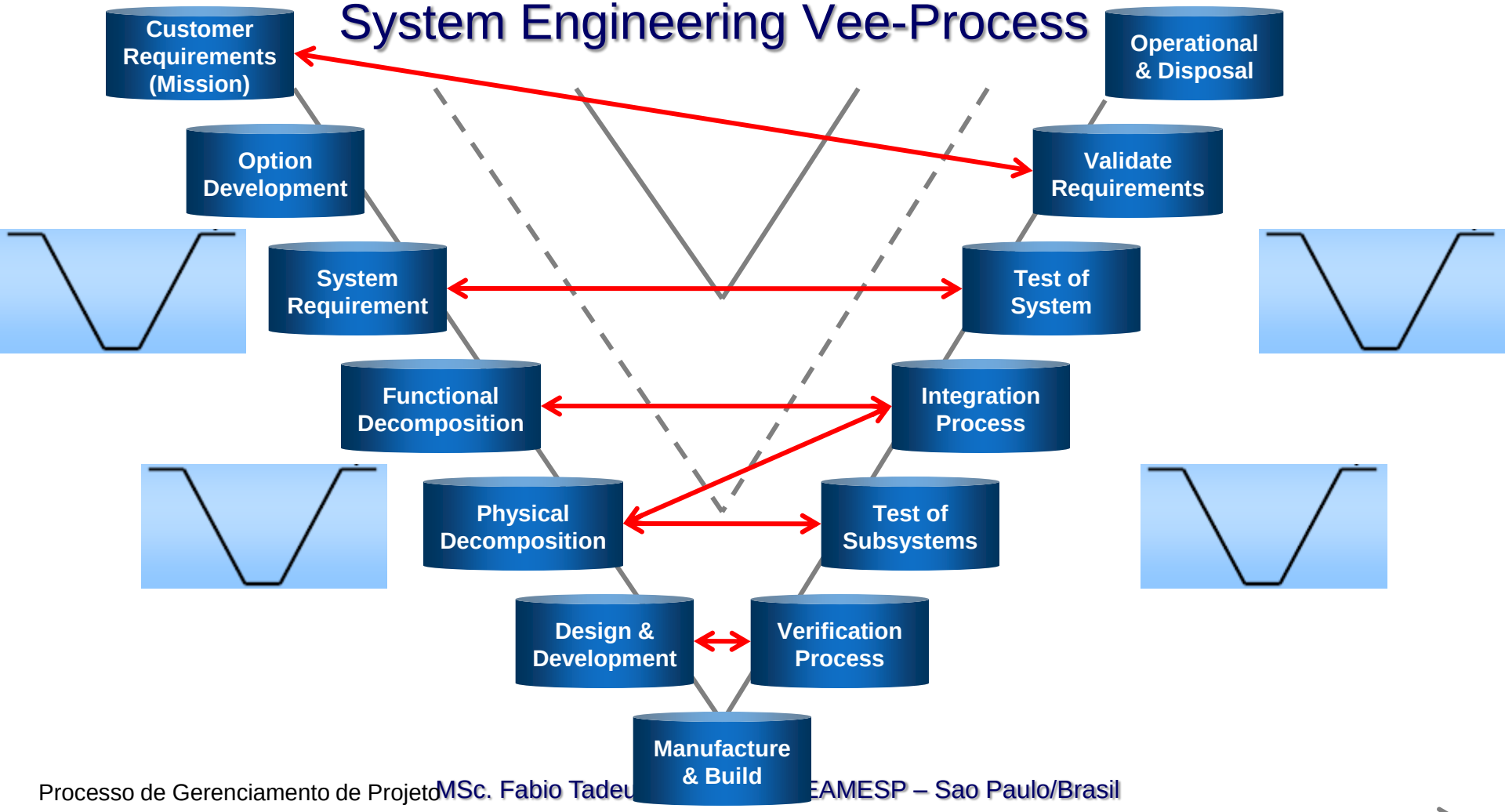
Fonte: Keith Robinson

Sistema de Transporte de Passageiros

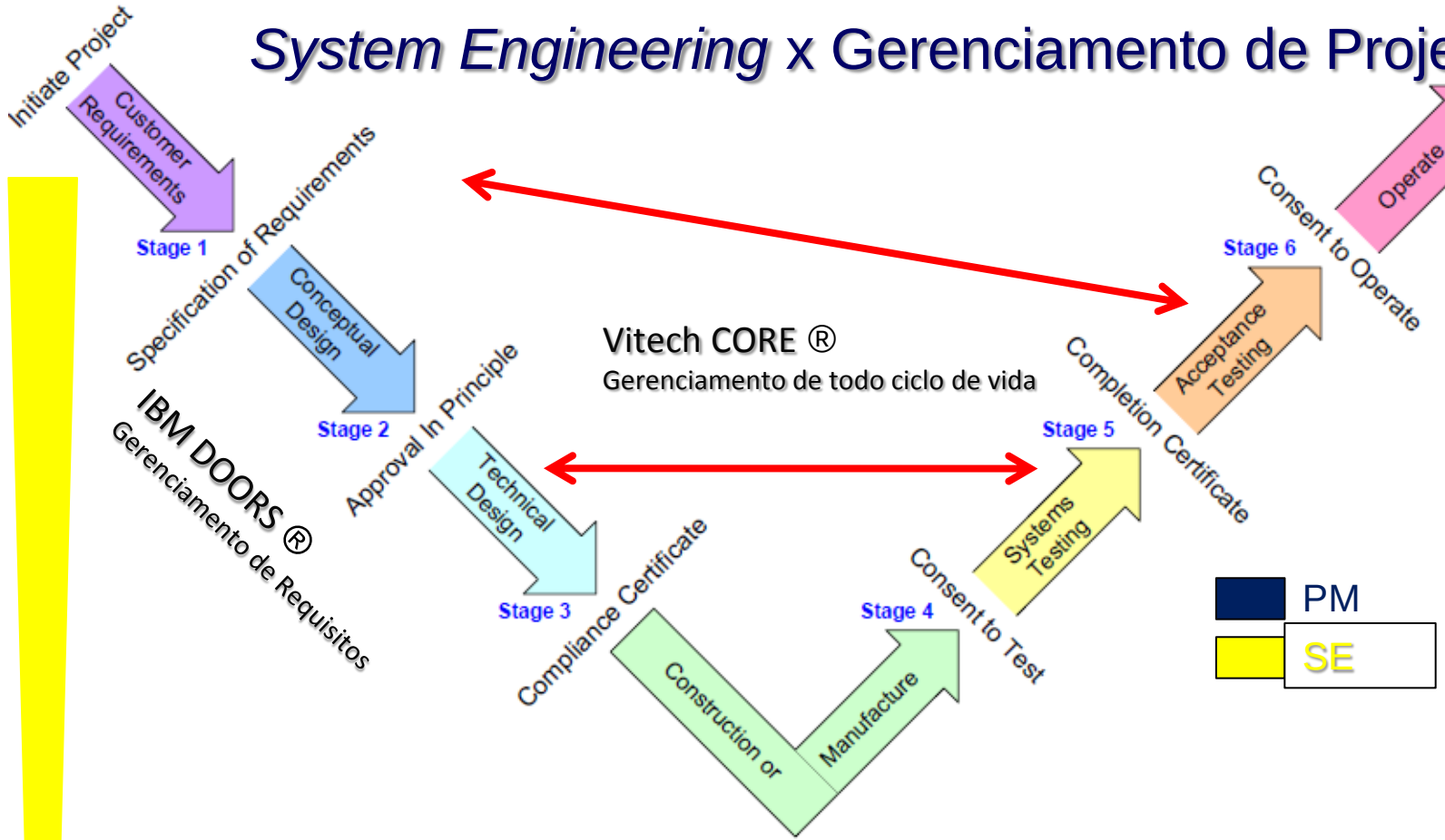




Gerenciamento do Projeto: System Engineering Vee-Process

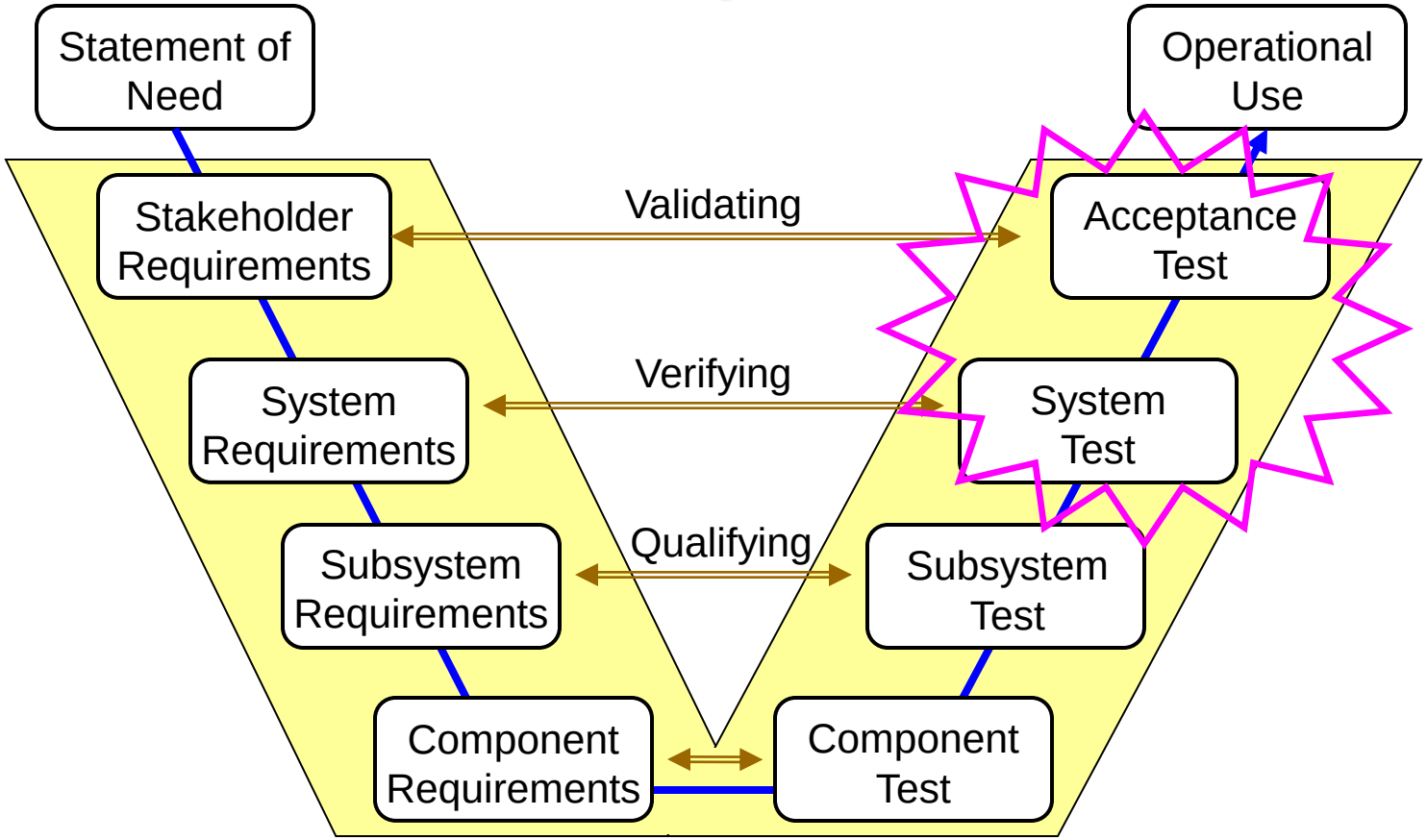


System Engineering x Gerenciamento de Projetos

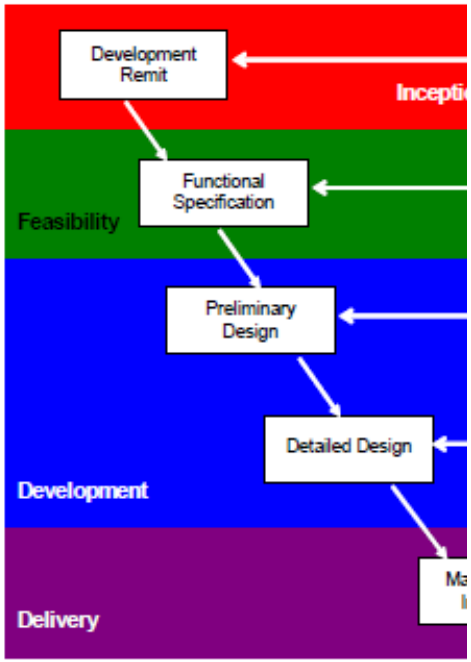


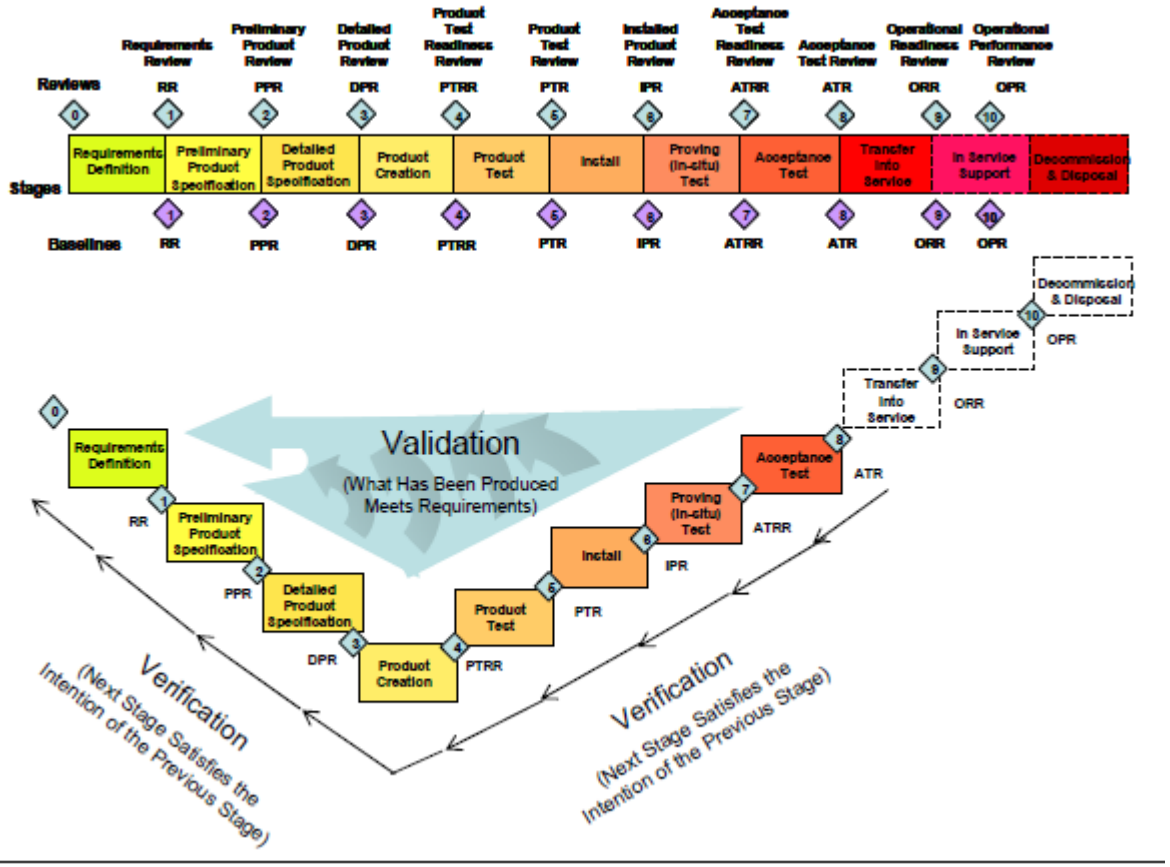
Introduction

❿ TEMP on the 'Vee' Cycle

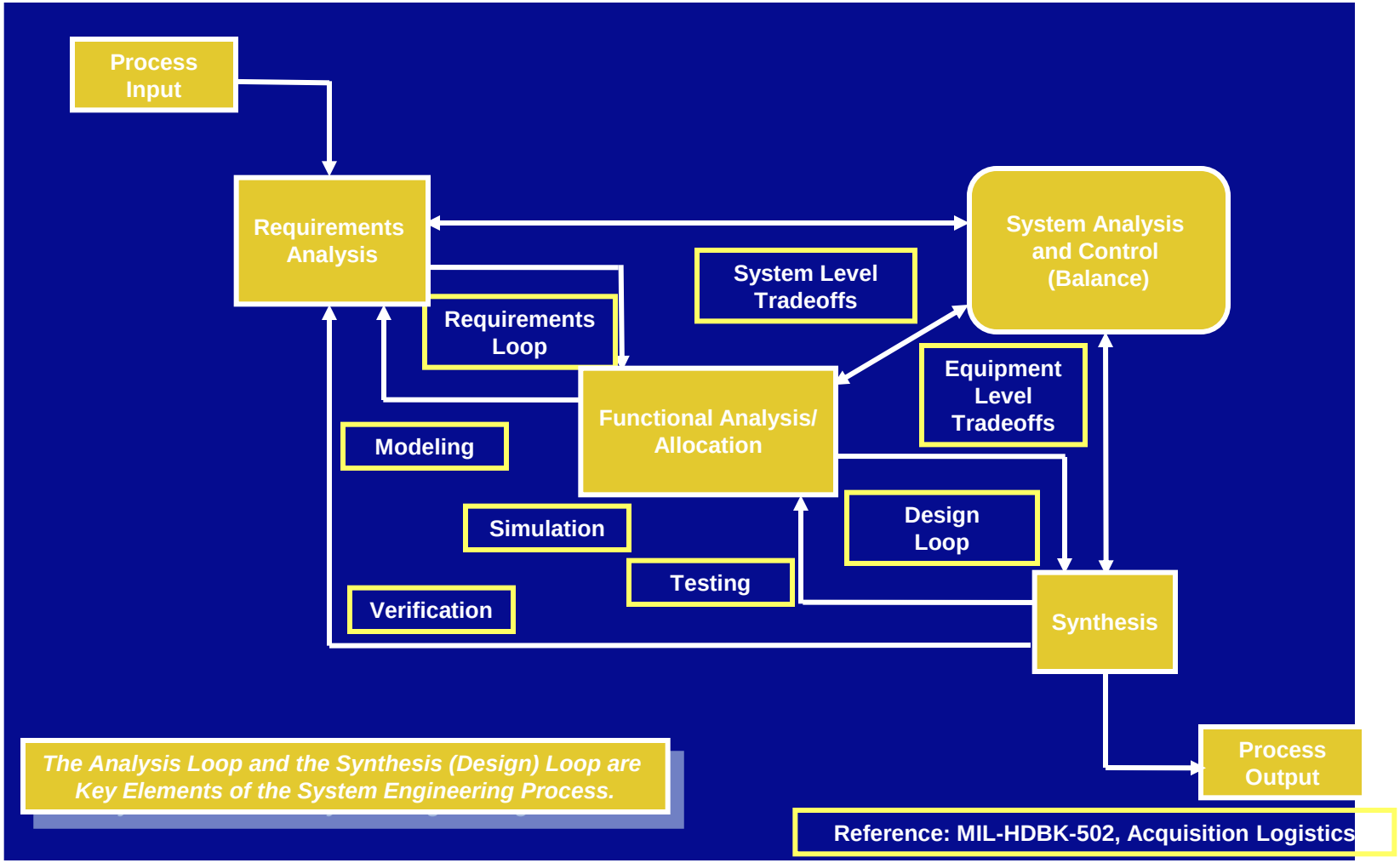


LuL – East London Lin Poject (ELLP)

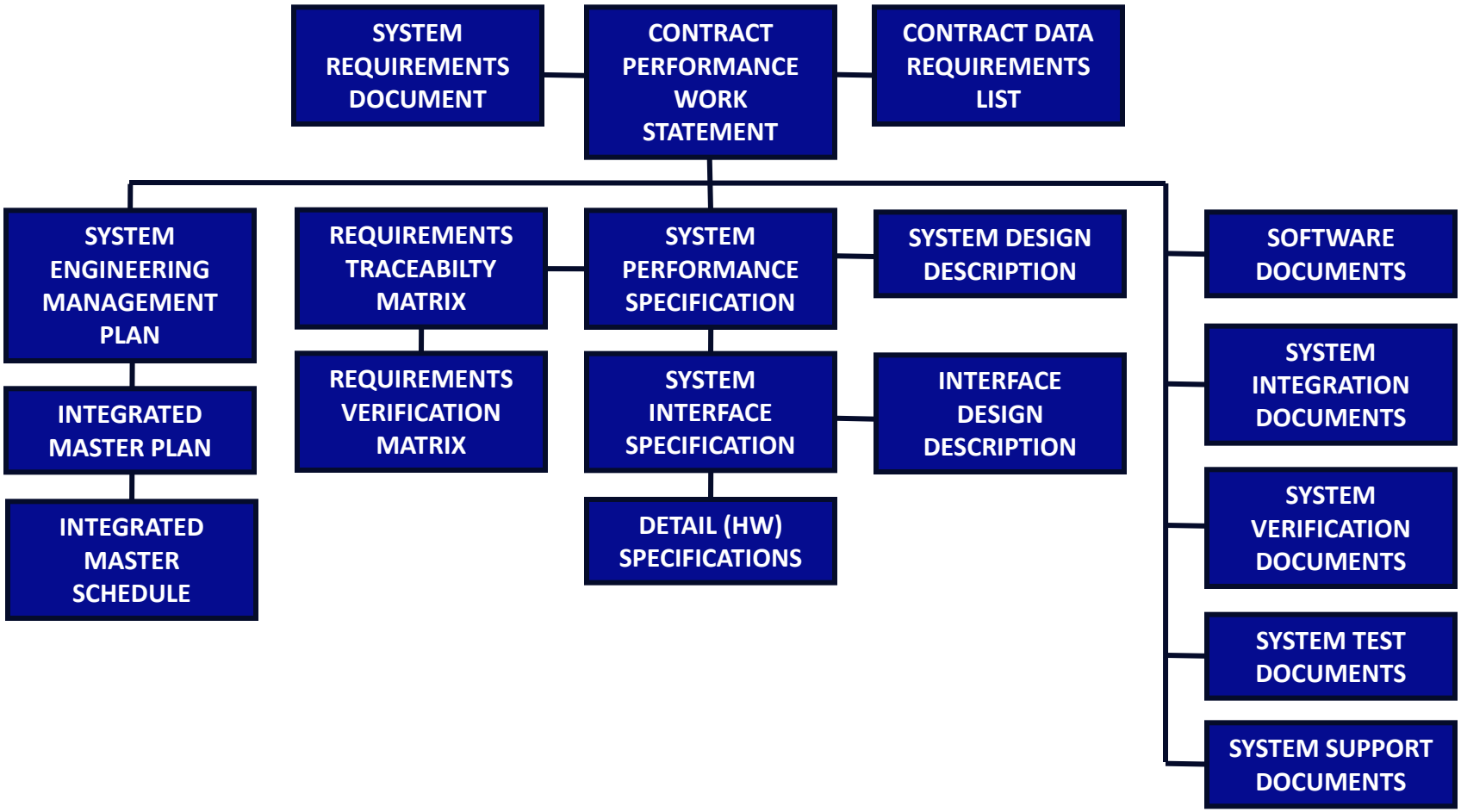




SYSTEM ENGINEERING PROCESS FLOW



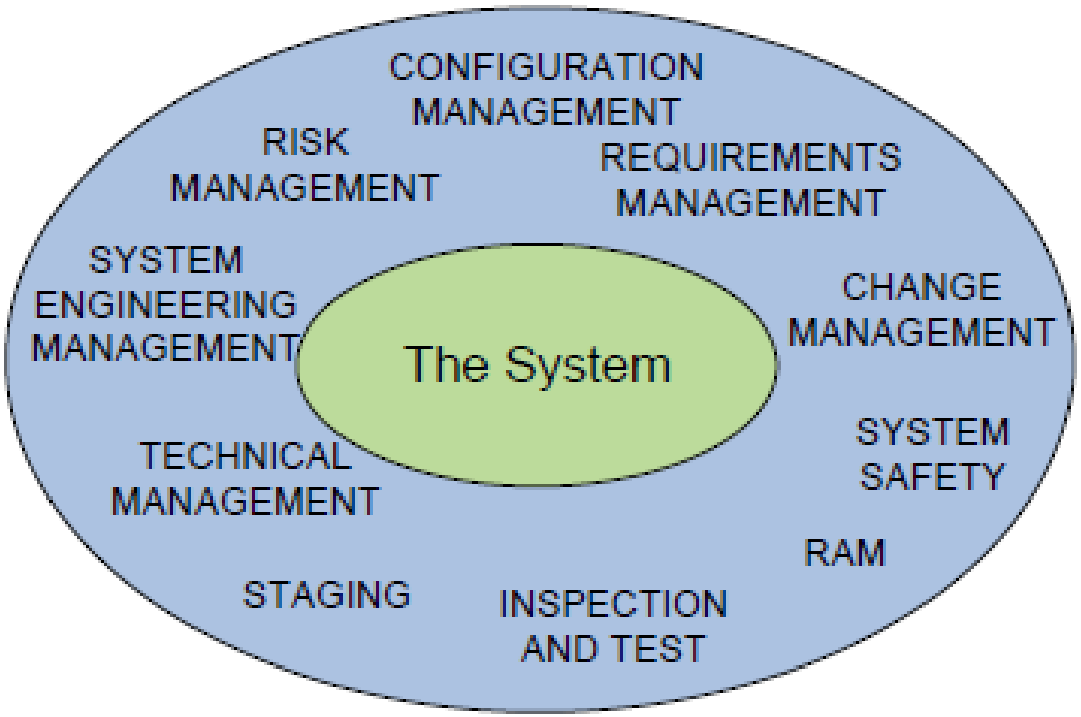
SYSTEM DOCUMENTATION TREE



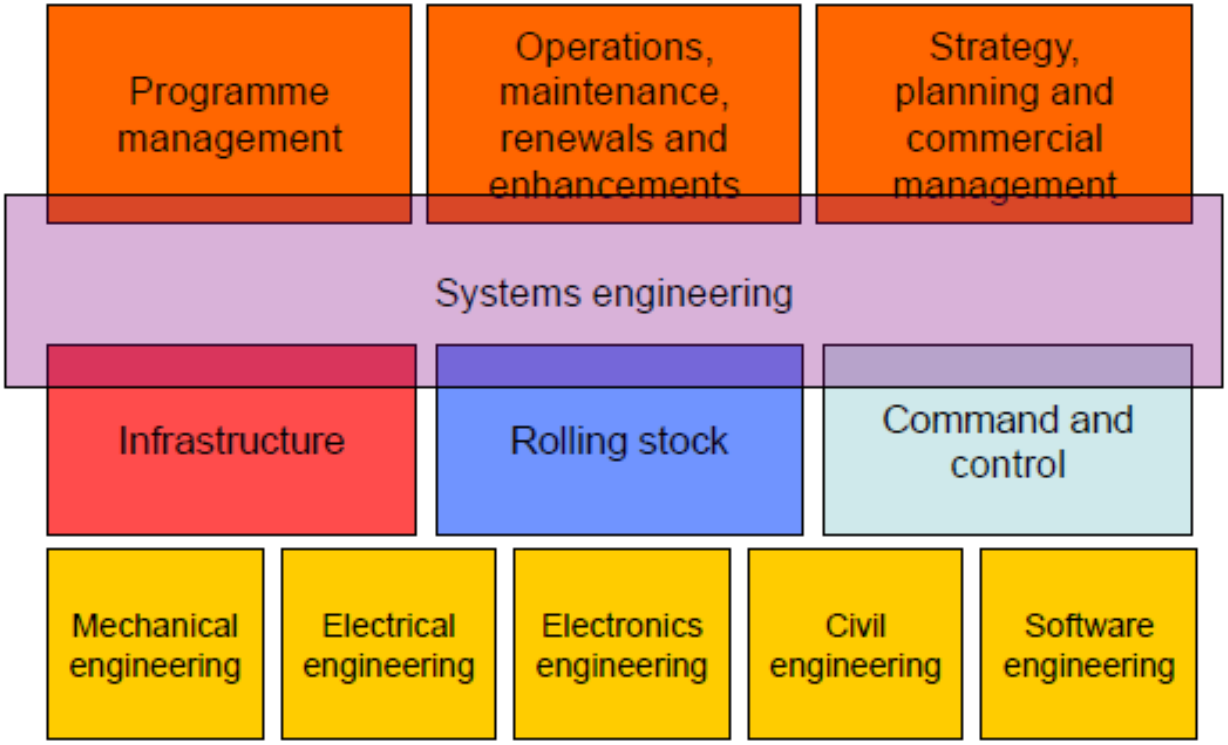
- The objective of this presentation is to review the purpose and scope of SE documents prepared on a program.
- SE documents that will be discussed include the following:

  - System Documentation Tree
  - System Engineering Management Plan (SEMP)
  - Integrated Master Plan (IMP)
  - Integrated Master Schedule (IMS)
  - System Performance Specification (PS)
  - System Design Description (SDD)
  - System Interface Specification (IS)
  - Interface Design Description (IDD)
  - Requirements Traceability Matrix (RTM)
  - Requirements Verification Matrix (RVM)
  - Detail Specifications (DS)
  - Software Documents
  - System Integration Documents
  - System Verification Documents
  - System Test Documents
  - System Support Documents

THE PROJECT


CONFIGURATION MANAGEMENT
RISK MANAGEMENT
REQUIREMENTS MANAGEMENT
SYSTEM ENGINEERING MANAGEMENT
The System
CHANGE MANAGEMENT
SYSTEM SAFETY
TECHNICAL MANAGEMENT
RAM
STAGING
INSPECTION AND TEST

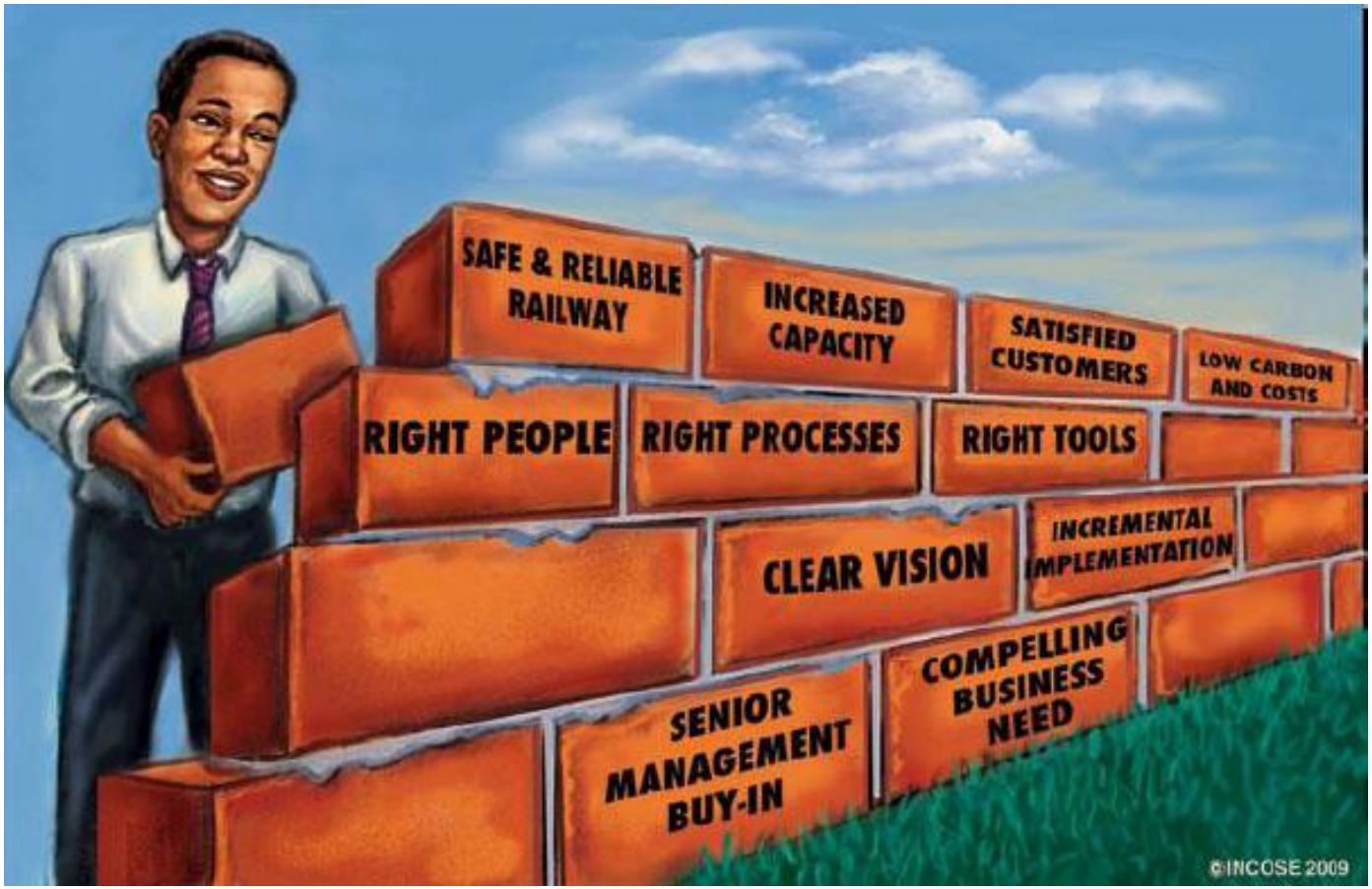
Desafios para a aplicação de um Sistema de Engenharia Metroferroviario



Desafios para a aplicação de um Sistema de Engenharia Metroferroviario

Whole life, whole systems approach
- Rail systems engineering people and competencies
- Integrating client and supply side systems engineering
- Innovation and technology management
- Programme systems integration
- Whole system reliability
- Systems engineering services, infrastructure and rolling stock
- Systems engineering the rail industry

Desafios para a aplicação de um Sistema de Engenharia Metroferroviario



Desafios para a aplicação de um Sistema de Engenharia Metroferroviario

- Deep competence for some –basic skill for all
- Skills and knowledge can be trained
- How do we get people with the right attributes
  - –Seeing issues from multiple perspectives
  - –… and at multiple levels
  - –Rapport building
  - –Knowing when to continuing to analyse – and when to stop
- Where do we get them
  - –From rail or other sectors
  - –In house or consultants

SysCon 2008 – IEEE International Systems Conference
Montreal, Canada, April 7-10, 2008

Master Plan for the Korean CBTC System Development Project

2008. 4. 9

Young-Hoon Lee

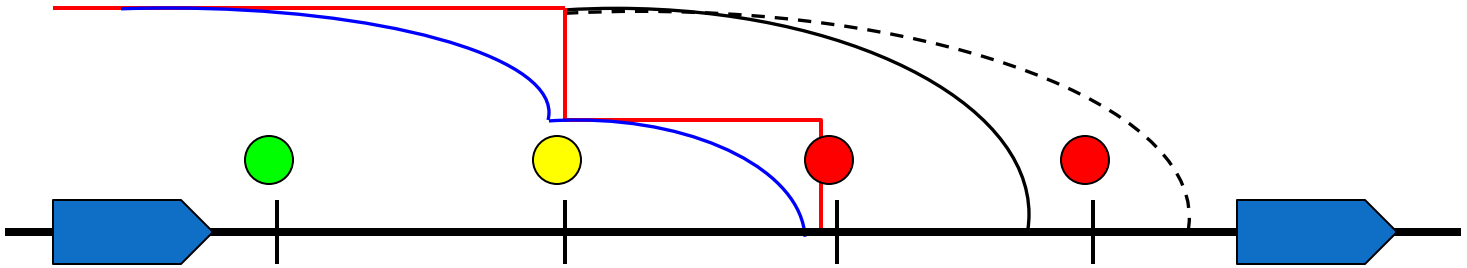
Byoung-Gil Lee, Jae-Chon Lee, Yong-Kyu Kim

Korea Railroad Research Institute
Ajou University

Introduction

❿ Traditional Railroad Signaling

- Safe distance between trains
  - Train position, speed, the direction, etc.

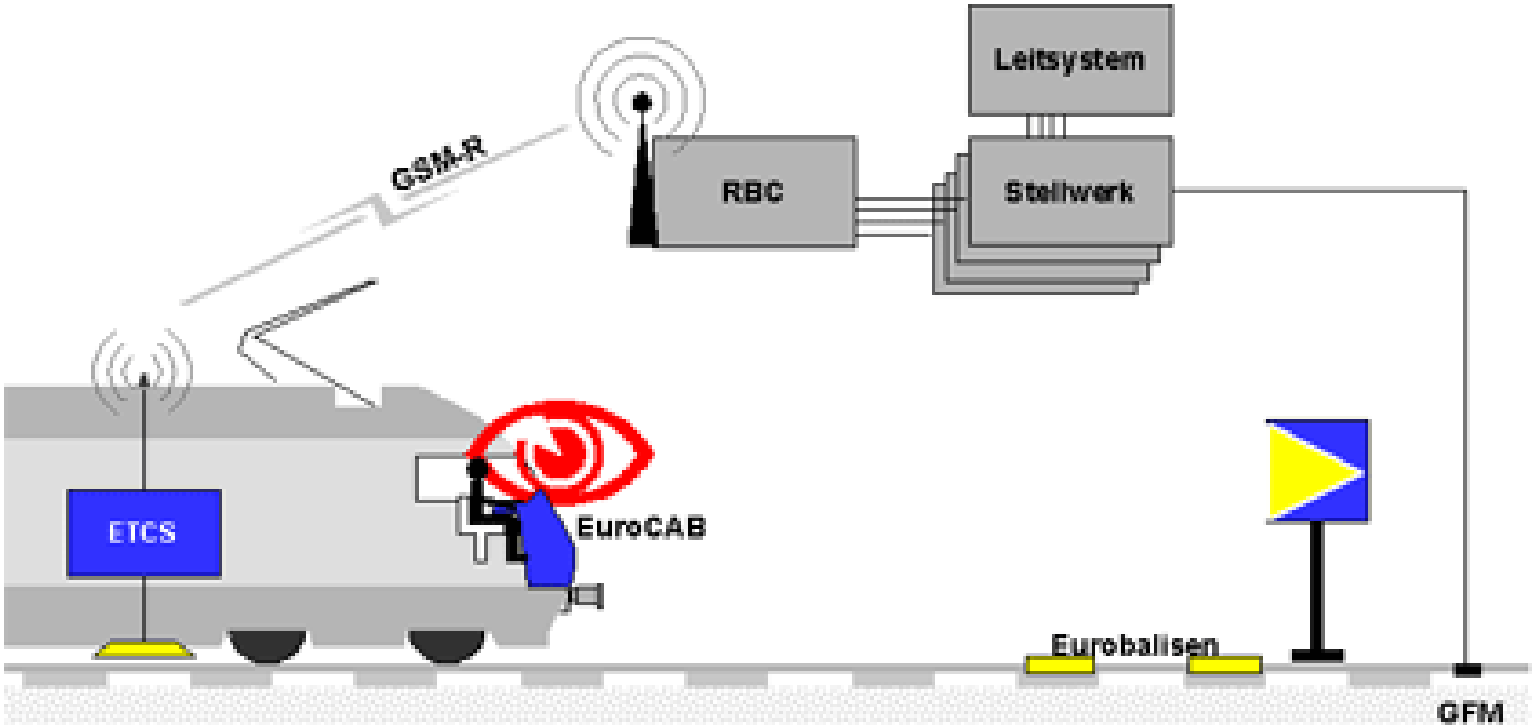


- Block sections to control the train speed safely
  - Position of moving train is continuously relayed

Examples of CBTC System

⑩ ERTMS/ETCS Level 2

- http://www.etcs.eu/en/funktionsprinzip/etcs_level_2.htm



Introduction

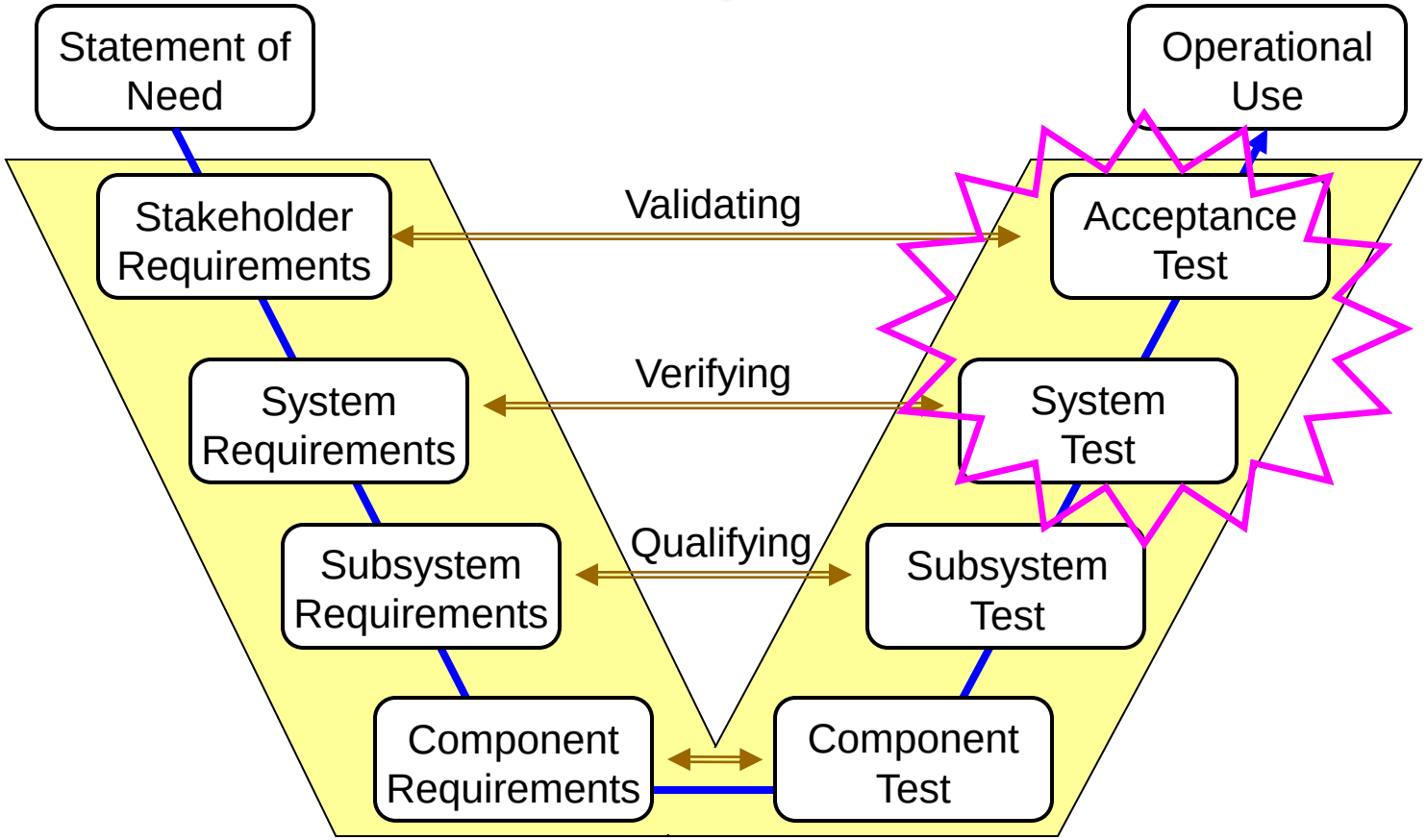
What is a TEMP?

- Test & Evaluation Master Plan
- Requirements for test & evaluation,
- Procedures for accomplishing testing,
- Resources required, associated planning information etc.

Why TEMP?

- High degree of confidence: performing as intended
- Evaluation & validation of the whole system to ensure that the requirements have been met
- Starting usually in the concept design phase

⑩ TEMP on the 'Vee' Cycle



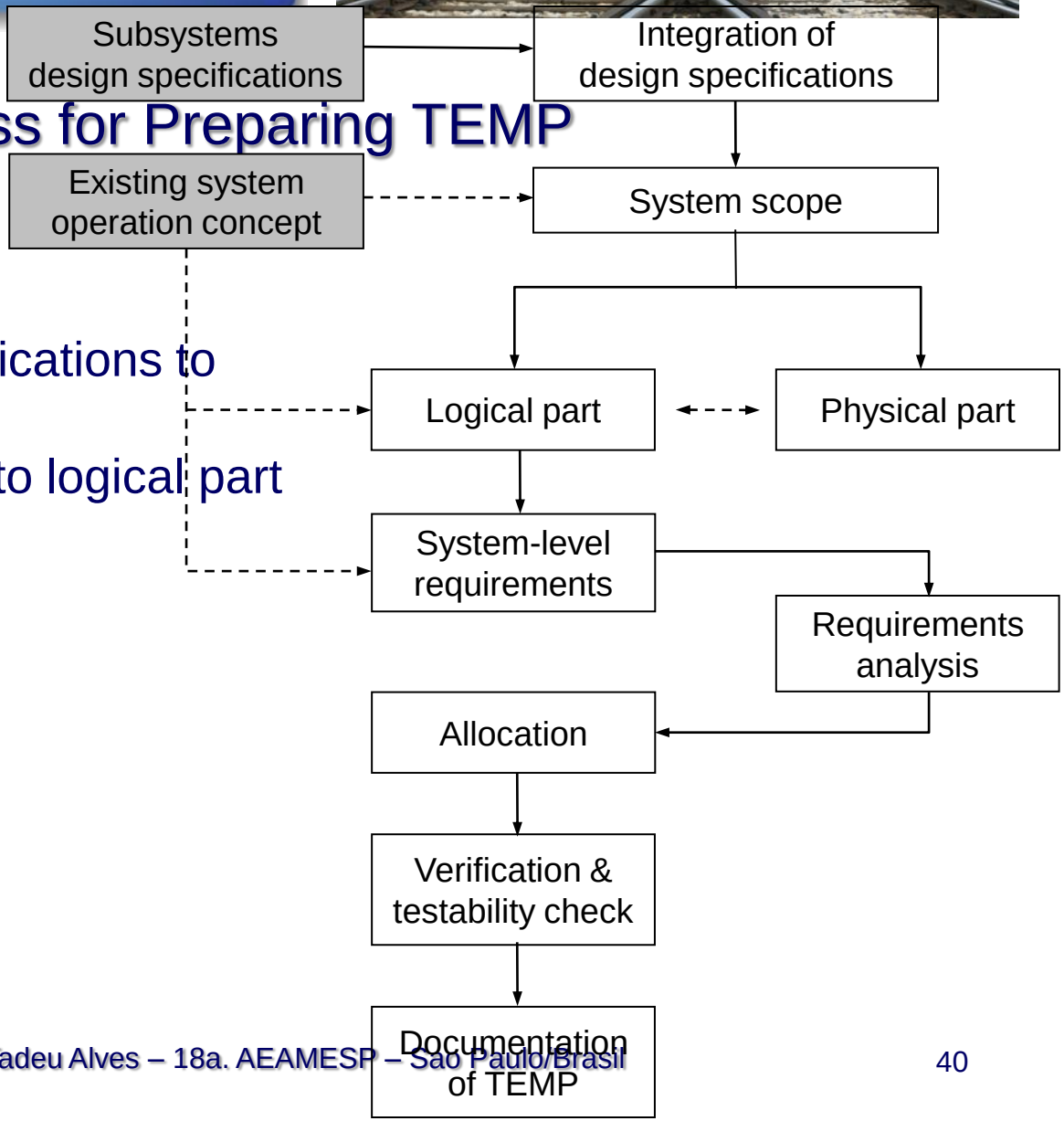
Process for Generating TEMP

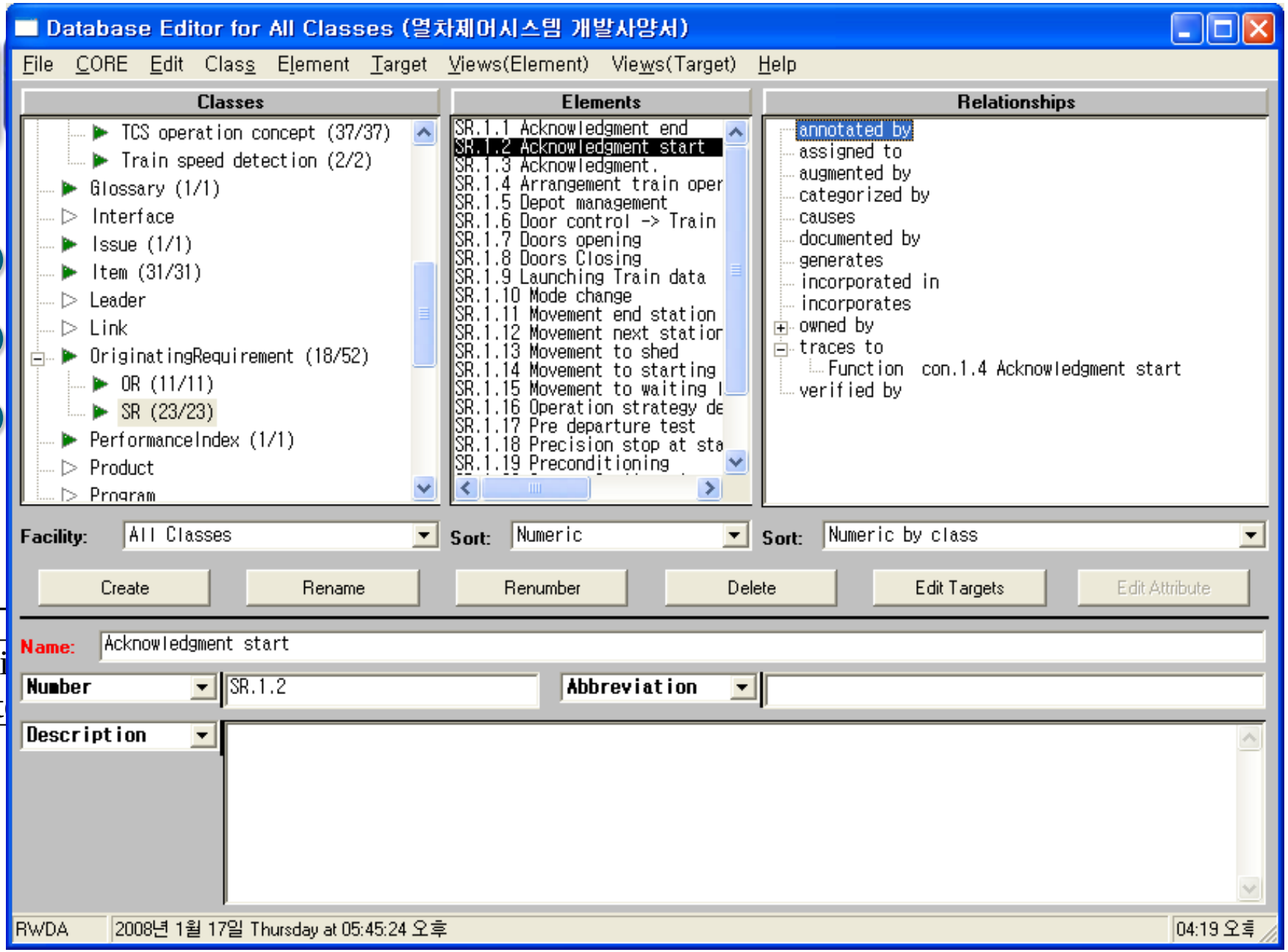
- Generating TEMP
  - Verification of the system to be integrated & built
  - Test & evaluation for the system validation
- We have:
  - Design specifications for 5 subsystems
    - ATS, ATP, ATO, RCN, EIE
  - Existing signaling systems
- We need:
  - System-level requirements

Process for Preparing TEMP

❿ Proposed Process

- Integration of design specifications to system-level specification
- Partitioning specification into logical part and physical part
- Analysis of logical part
- Testability check
- Documentation to TEMP




Database Editor for All Classes (열차제어시스템 개발사양서)
File CORE Edit Class Element Target Views(Element) Views(Target) Help
Classes
TCS operation concept (37/37)
Train speed detection (2/2)
Glossary (1/1)
Interface
Issue (1/1)
Item (31/31)
Leader
Link
OriginatingRequirement (18/52)
OR (11/11)
SR (23/23)
PerformanceIndex (1/1)
Product
Program
Elements
SR.1.1 Acknowledgment end
SR.1.2 Acknowledgment start
SR.1.3 Acknowledgment.
SR.1.4 Arrangement train oper
SR.1.5 Depot management
SR.1.6 Door control -> Train
SR.1.7 Doors opening
SR.1.8 Doors Closing
SR.1.9 Launching Train data
SR.1.10 Mode change
SR.1.11 Movement end station
SR.1.12 Movement next statior
SR.1.13 Movement to shed
SR.1.14 Movement to starting
SR.1.15 Movement to waiting
SR.1.16 Operation strategy de
SR.1.17 Pre departure test
SR.1.18 Precision stop at sta
SR.1.19 Preconditioning
Relationships
annotated by
assigned to
augmented by
categorized by
causes
documented by
generates
incorporated in
incorporates
owned by
traces to
Function con.1.4 Acknowledgment start
verified by
Facility: All Classes
Sort: Numeric
Sort: Numeric by class
Create
Rename
Renumber
Delete
Edit Targets
Edit Attribute
Name: Acknowledgment start
Number SR.1.2
Abbreviation
Description
RWDA
2008년 1월 17일 Thursday at 05:45:24 오후
04:19 오후

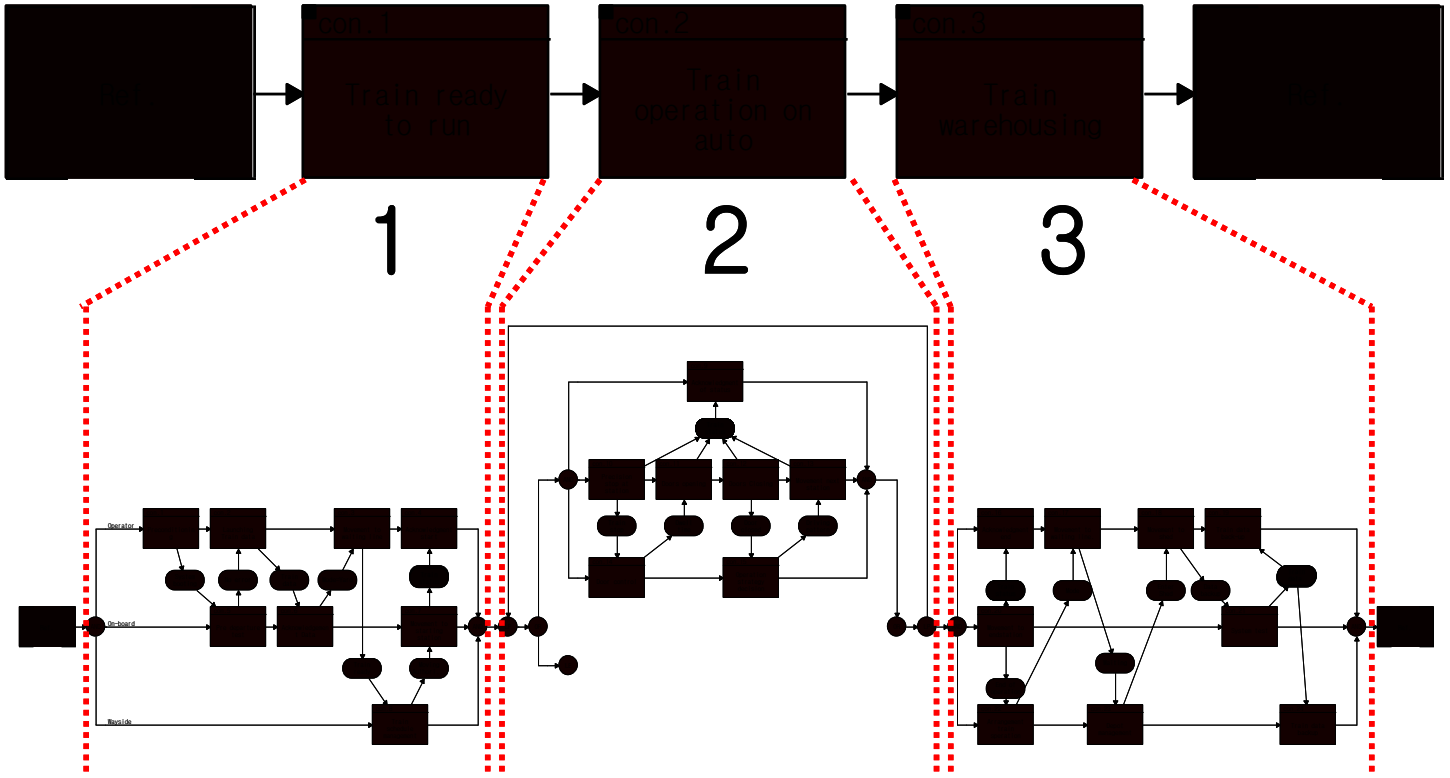
System-Level Specification

⑩ Logical Part

- Functional requirements of the system mostly
- Analysis based on signaling expert's knowledge with operation concept of existing system
  - System functions
  - Logical operation activities
- Logical operation scenario for the system mission
  - Reflection to system-level requirements
- Test items from the testability check

Logical Operation Scenario

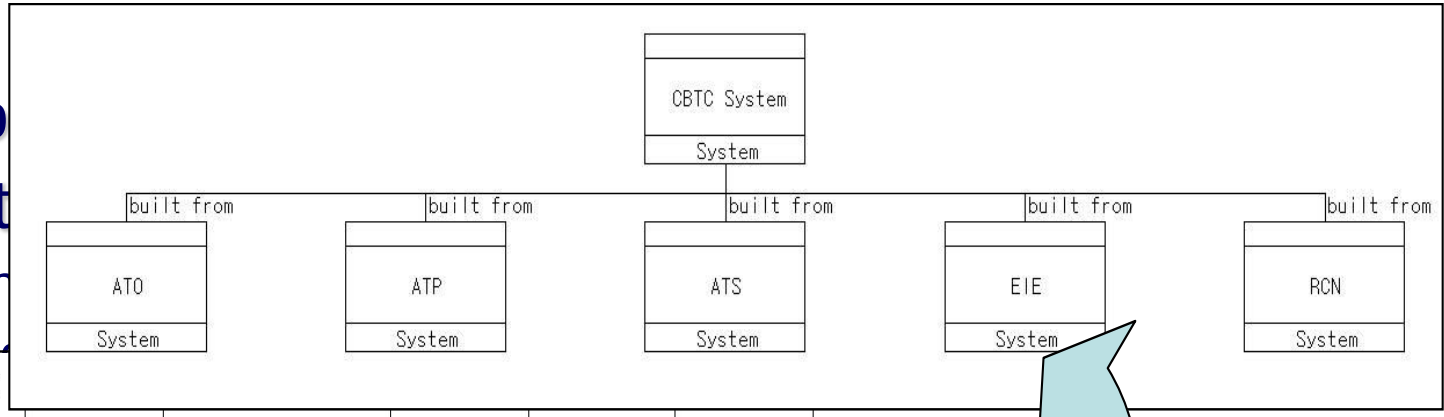
- Logical Operation Activities
- Setting for the system mission

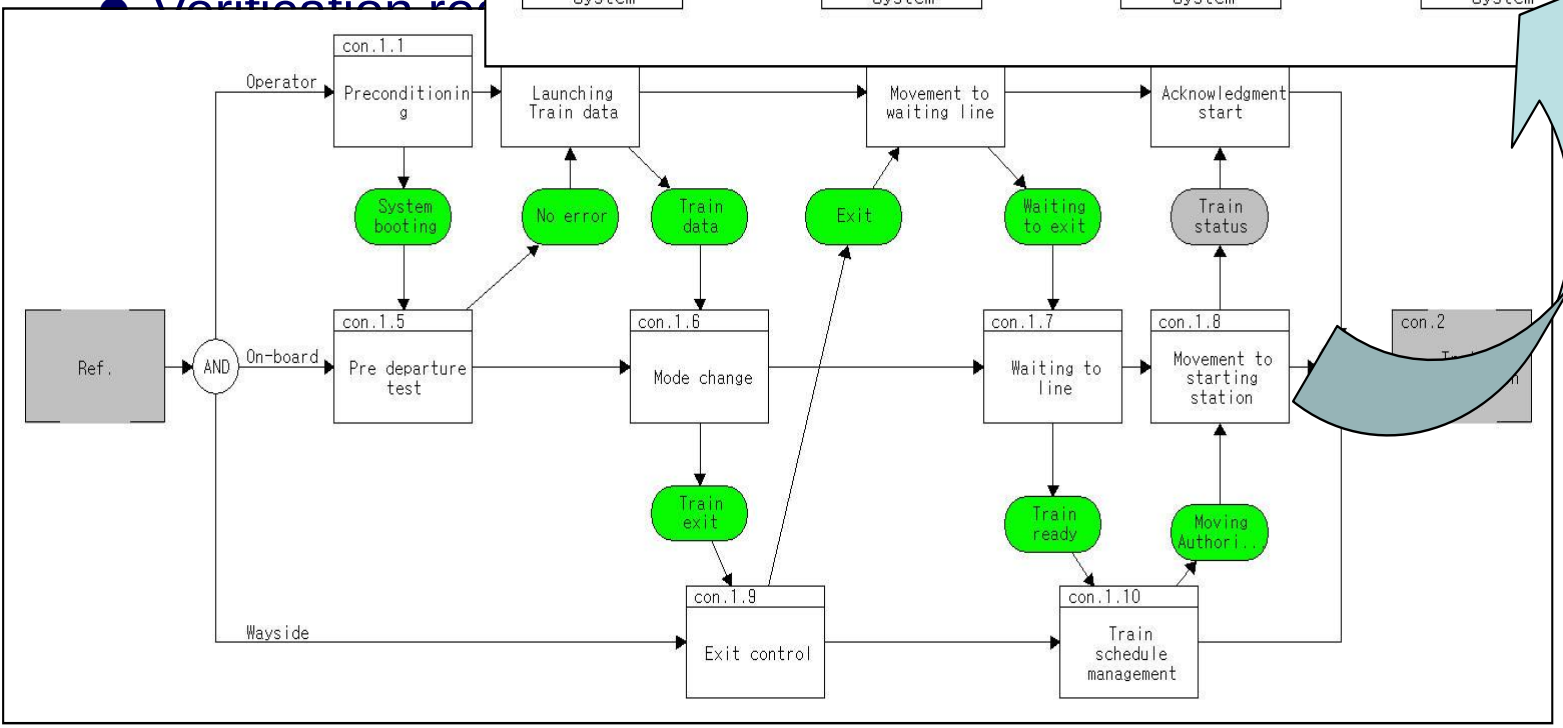


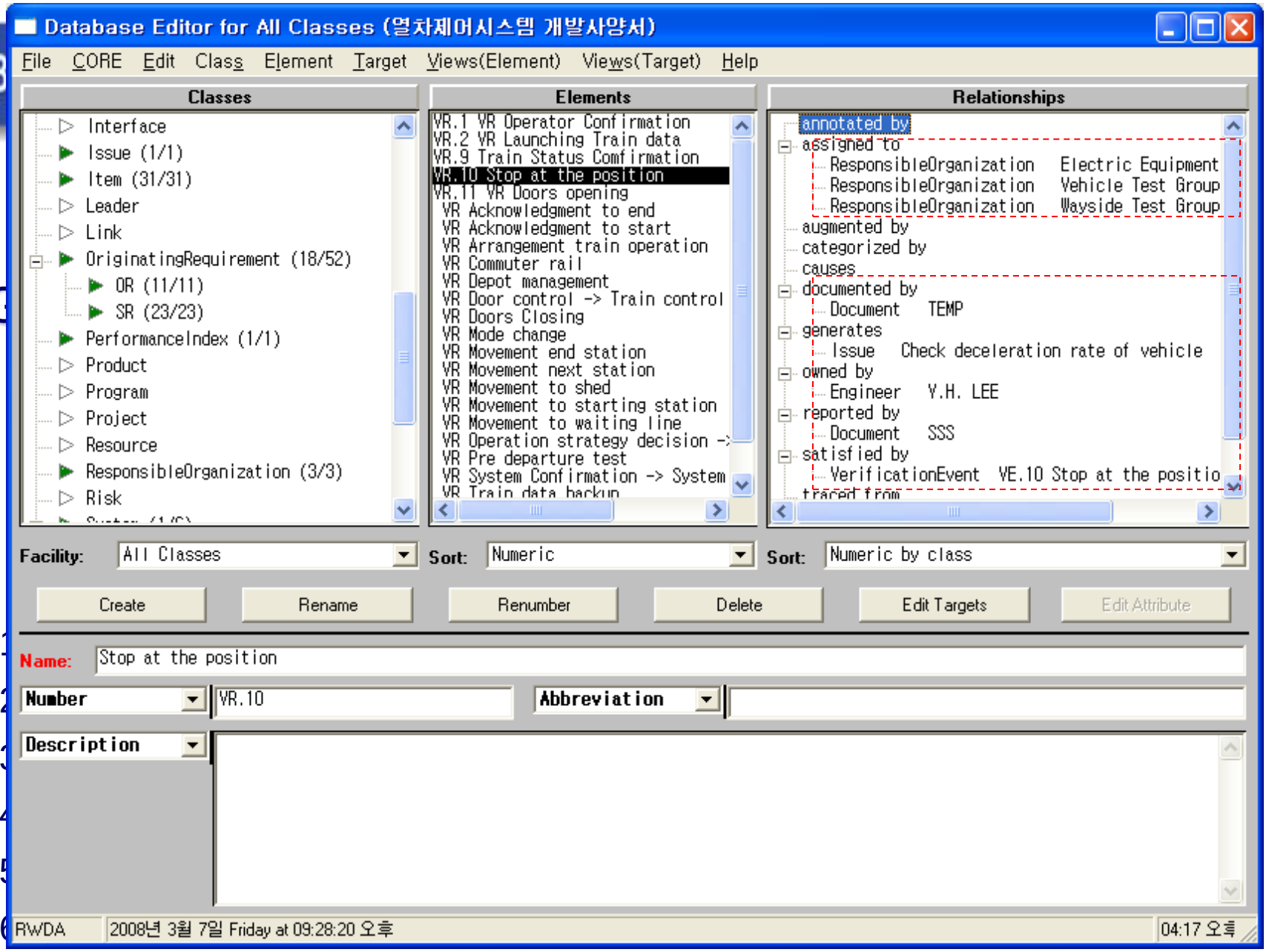
System-Level Requirements

- Physical part of system-level specification
  - Physical elements of the system
- Allocation of requirements to physical elements
  - Traceability with relationships
  - Verification requirements for test items
- System-level requirements
  - Base material in generating the TEMP
    - What the integrated system has to be met
    - Principal technical elements & risk
  - Technical performance measures for the test items

- Logical & p
- Traceabilit
  - Links betwee
  - Verification re






Database Editor for All Classes (열차제어시스템 개발사양서)
File CORE Edit Class Element Target Views(Element) Views(Target) Help
Classes
Interface
Issue (1/1)
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Leader
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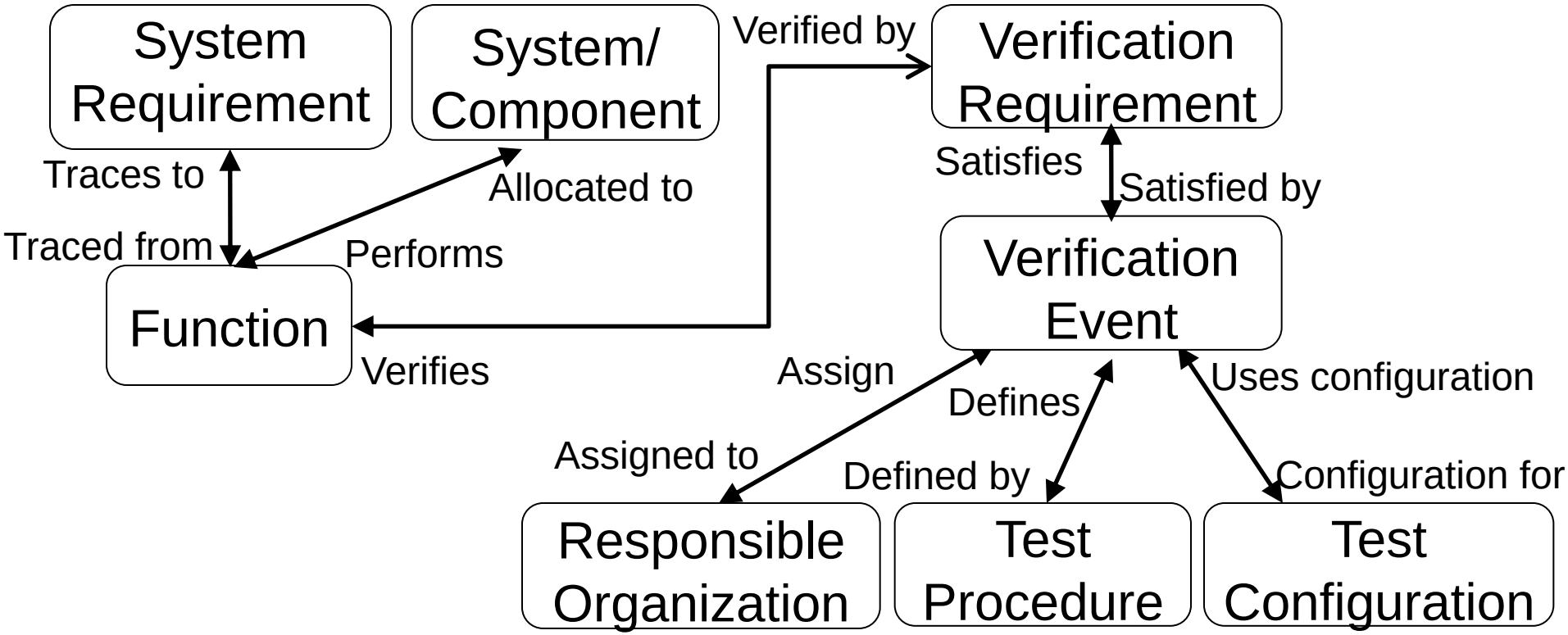
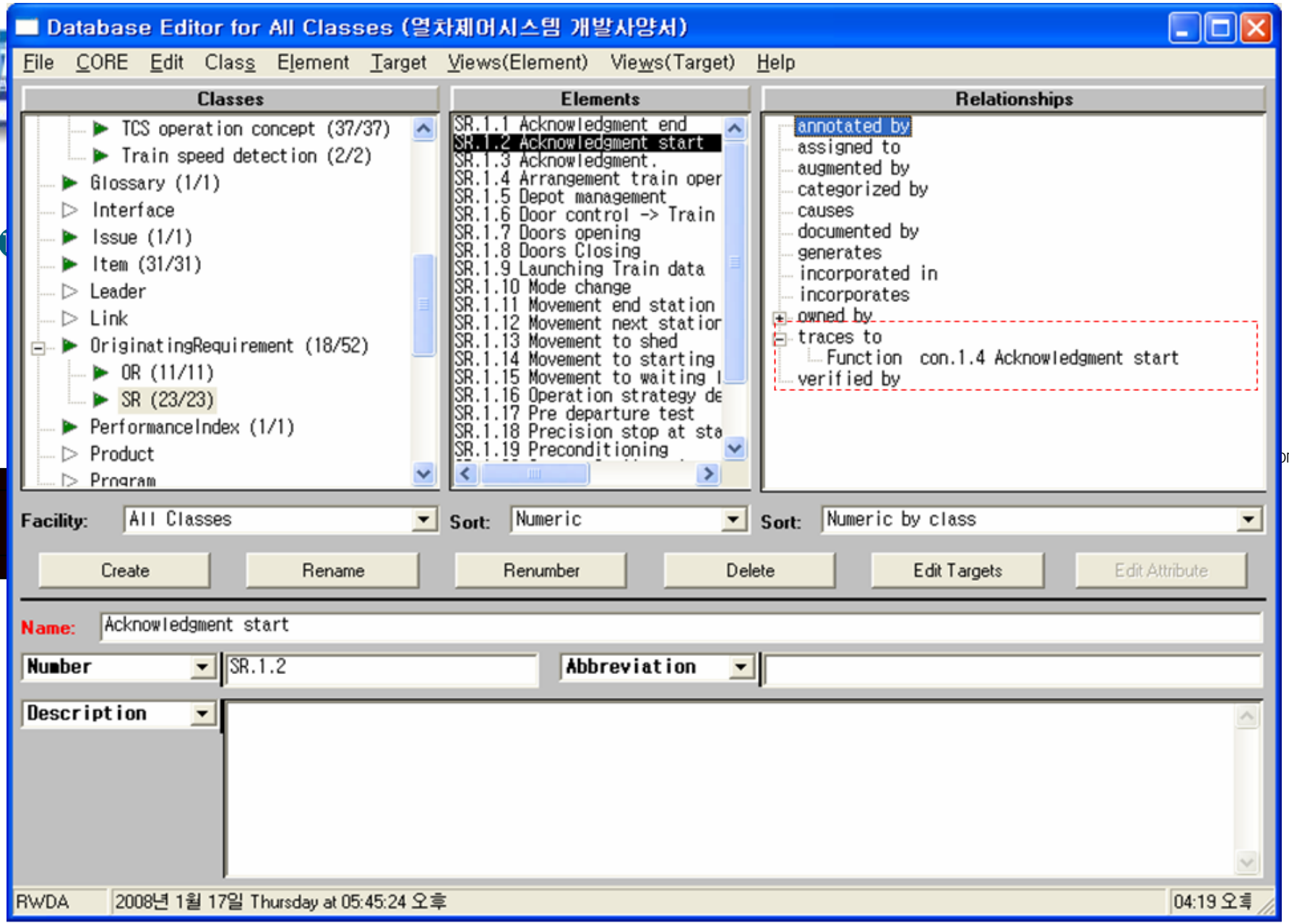
OR (11/11)
SR (23/23)
PerformanceIndex (1/1)
Product
Program
Project
Resource
ResponsibleOrganization (3/3)
Risk
Elements
VR.1 VR Operator Confirmation
VR.2 VR Launching Train data
VR.9 Train Status Comfirmation
VR.10 Stop at the position
VR.11 VR Doors opening
VR Acknowledgment to end
VR Acknowledgment to start
VR Arrangement train operation
VR Commuter rail
VR Depot management
VR Door control -> Train control
VR Doors Closing
VR Mode change
VR Movement end station
VR Movement next station
VR Movement to shed
VR Movement to starting station
VR Movement to waiting line
VR Operation strategy decision ->
VR Pre departure test
VR System Confirmation -> System
VR Train data backup
Relationships
annotated by
assigned to
ResponsibleOrganization Electric Equipment
ResponsibleOrganization Vehicle Test Group
ResponsibleOrganization Wayside Test Group
augmented by
categorized by
causes
documented by
Document TEMP
generates
Issue Check deceleration rate of vehicle
owned by
Engineer Y.H. LEE
reported by
Document SSS
satisfied by
VerificationEvent VE.10 Stop at the positio
traced from
Facility: All Classes
Sort: Numeric
Sort: Numeric by class
Create
Rename
Renumber
Delete
Edit Targets
Edit Attribute
Name: Stop at the position
Number VR.10
Abbreviation
Description
RWDA
2008년 3월 7일 Friday at 09:28:20 오후
04:17 오후

Implementation with CORE®

- Schema with the relationships between classes

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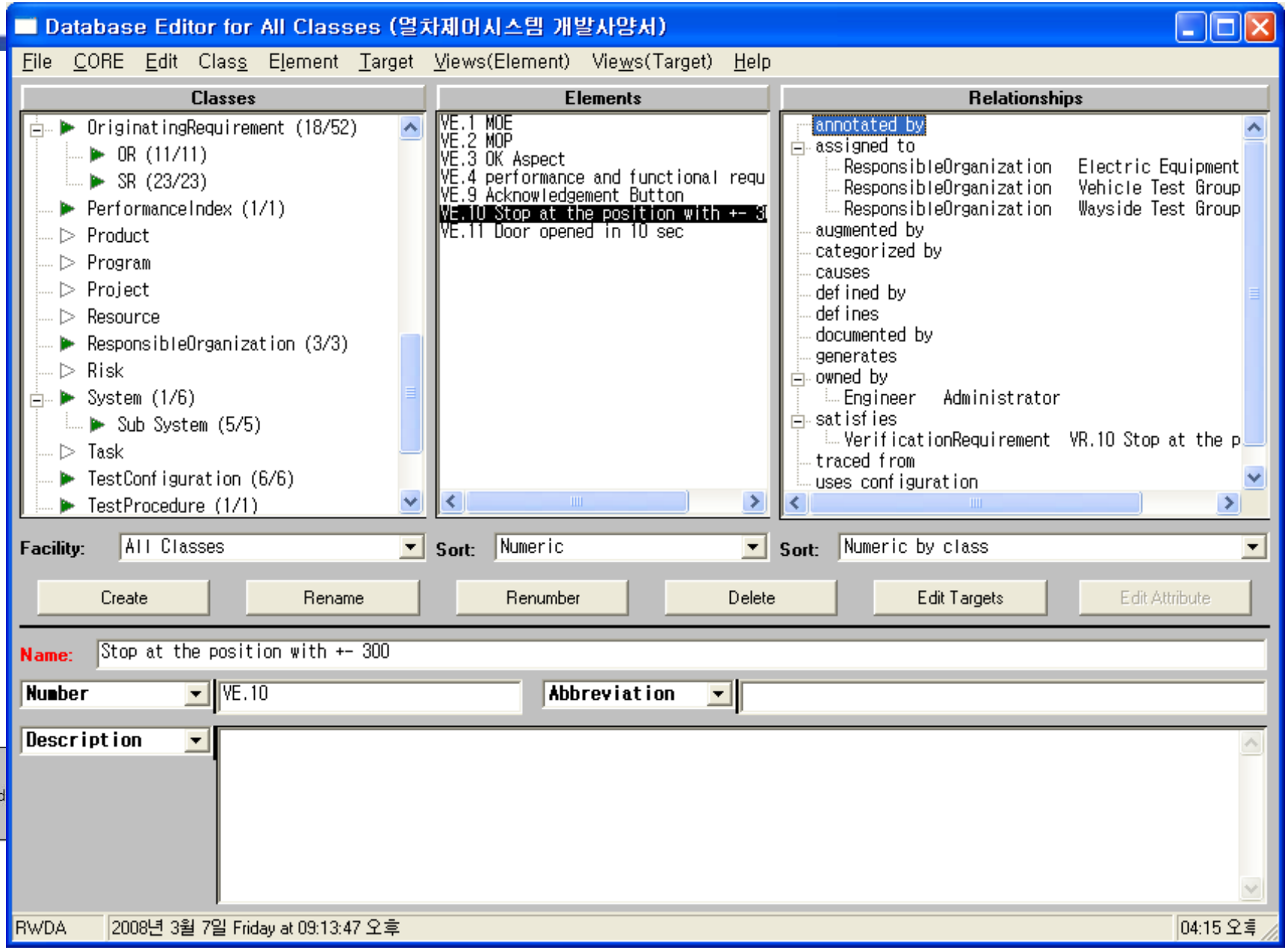
Interface
Issue (1/1)
Item (31/31)
Leader
Link
OriginatingRequirement (18/52)
OR (11/11)
SR (23/23)
PerformanceIndex (1/1)
Product
Program
Elements
SR.1.1 Acknowledgment end
SR.1.2 Acknowledgment start
SR.1.3 Acknowledgment.
SR.1.4 Arrangement train oper
SR.1.5 Depot management
SR.1.6 Door control -> Train
SR.1.7 Doors opening
SR.1.8 Doors Closing
SR.1.9 Launching Train data
SR.1.10 Mode change
SR.1.11 Movement end station
SR.1.12 Movement next statior
SR.1.13 Movement to shed
SR.1.14 Movement to starting
SR.1.15 Movement to waiting
SR.1.16 Operation strategy de
SR.1.17 Pre departure test
SR.1.18 Precision stop at sta
SR.1.19 Preconditioning
Relationships
annotated by
assigned to
augmented by
categorized by
causes
documented by
generates
incorporated in
incorporates
owned by
traces to
Function con.1.4 Acknowledgment start
verified by
Facility: All Classes
Sort: Numeric
Sort: Numeric by class
Create
Rename
Renumber
Delete
Edit Targets
Edit Attribute
Name: Acknowledgment start
Number SR.1.2
Abbreviation
Description
RWDA
2008년 1월 17일 Thursday at 05:45:24 오후
04:19 오후


Database Editor for All Classes (열차제어시스템 개발사양서)
File CORE Edit Class Element Target Views(Element) Views(Target) Help
Classes
OriginatingRequirement (18/52)
OR (11/11)
SR (23/23)
PerformanceIndex (1/1)
Product
Program
Project
Resource
ResponsibleOrganization (3/3)
Risk
System (1/6)
Sub System (5/5)
Task
TestConfiguration (6/6)
TestProcedure (1/1)
Elements
VE.1 MOE
VE.2 MOP
VE.3 OK Aspect
VE.4 performance and functional requ
VE.9 Acknowledgement Button
VE.10 Stop at the position with +- 3
VE.11 Door opened in 10 sec
Relationships
annotated by
assigned to
ResponsibleOrganization Electric Equipment
ResponsibleOrganization Vehicle Test Group
ResponsibleOrganization Wayside Test Group
augmented by
categorized by
causes
defined by
defines
documented by
generates
owned by
Engineer Administrator
satisfies
VerificationRequirement VR.10 Stop at the p
traced from
uses configuration
Facility: All Classes
Sort: Numeric
Sort: Numeric by class
Create
Rename
Renumber
Delete
Edit Targets
Edit Attribute
Name: Stop at the position with +- 300
Number VE.10
Abbreviation
Description
RWDA
2008년 3월 7일 Friday at 09:13:47 오후
04:15 오후

Lições Aprendidas em Aplicação em Sistemas Metroferroviario

- Utilizar as atividades abaixo:
  - Develop a Pilot Project or Prototype
  - Requirements Management
  - System Integration
  - System Staging
  - Schedule (Track Access)
  - Testing
  - System Operating Requirements
  - Evolution of Technology
  - Coordination with other Capital Programs
  - Procurement Approach
  - Consultants
  - SYSTEM ENGINEERING MUST BE TRULY TOP DOWN

... e finalmente, a maneira de tratar as coisas caso não de certo . . .

Muito Obrigado !

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+55 11 98232 3516