NXT GEN HIGHTECH

Systems Engineering framework and learning lines
The case study of the systems architect

4th Feb 2025

Who are we

Pascal Etman

- MSc, PhD in Mechanical Engineering
- Research in systems modeling, design and optimization
- Associate professor at TU/e – CST group
- Contact at: l.f.p.etman@tue.nl

Sapfo Tsoutsou

- MSc in Mechanical Engineering
- EngD in Automotive Systems Design
- Engineering industry experience of 8 years
- Program manager Systems Engineering at TU/e, CST
- Contact at: s.tsoutsou@tue.nl

NXT GEN HIGHTECH

Agenda

- Introduction to NextGen Systems Engineering project
- Systems Engineering Roles
- Job Functions – vacancy analysis
- Design process of the SE development line (with example)
- Assignment regarding Systems Architect competencies

Introduction to NextGen Systems Engineering

Goal

Strengthening the innovative power of the high-tech equipment industry in the Netherlands by increasing the quality and supply of Systems Engineers, in a way that appeals to the international imagination.

How

By designing, developing and realizing:

- The **Dutch Approach of Systems Engineering** (DASE Framework)
- A **Continuous Development Line on Systems Engineering**

Definition of SE roles

Customer Interface
Coordinates with the customer

Concept Creator
Holistically explores the problem or opportunity space and develops the overarching vision for a system(s) that can address this space.

Requirements Owner
Translating customer requirements to system or sub-system requirements

System Designer / System Architect / Chief Engineer
Designing the architectures of the system (functional, physical)

Detailed Designer
Provides technical designs that match the system architecture; for any part of the design for the overall system.

Support Engineer / Logistics - Ops Engineer
Performs the 'back end' of the systems lifecycle, who may operate the system, provide support during operation, provide guidance on maintenance, or help with disposal.

Validation/ Verification Eng.
Verification and validation activities such as testing, demonstration, and simulation.

System Integrator
The 'technical conscience' or 'seeker of issues that fall in the cracks' – particularly, someone who is concerned with interfaces.

System Analyst / performance modeler
Modeling or analysis support to system development activities, ensuring that the system as designed meets he specification.

Program/Project Manager
Works closely with technical experts and other systems engineers while maintaining overall project cost and schedule.

Organizational/ Functional Manager
Personnel management of systems engineers or other technical personnel in a business setting.

Coordinator
Brings together and to agreement a broad set of individuals or groups who help to resolve systems related issues.

Process Engineer
Defines and maintains the systems engineering processes

Information Manager
Responsible for the flow of information during system development activities.

Technical Manager
Controls cost, schedule, and resources for the technical aspects of a system.

Instructor/Teacher
Provides or oversees critical instruction on the systems engineering discipline, practices, processes, etc.

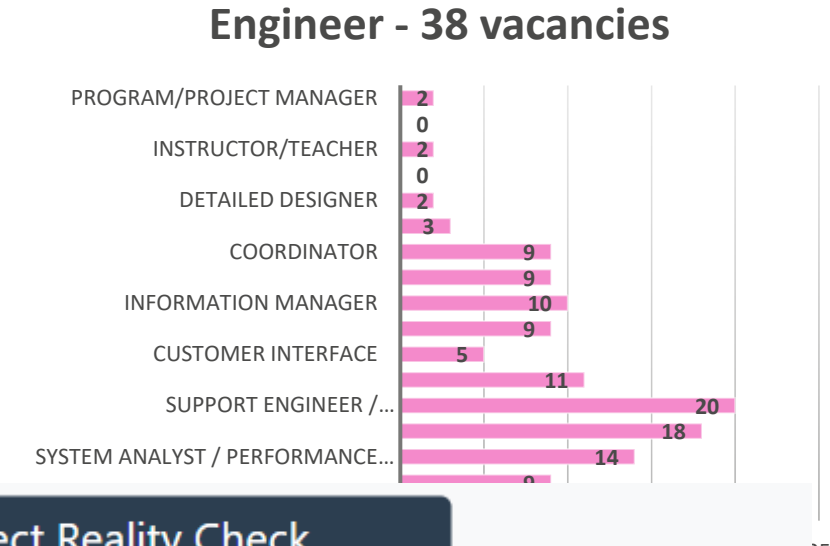
Systems Engineering Champion
Promotes the value of systems engineering outside of the SE community

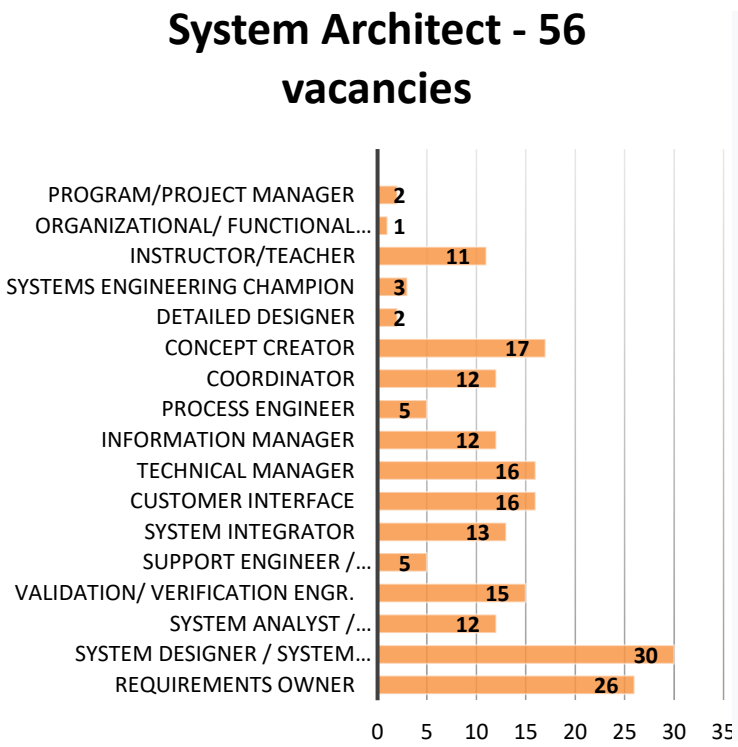
Based on: S. Sheard "Twelve Systems Engineering Roles" and INCOSE International "The Roles of Systems Engineers Revisited"

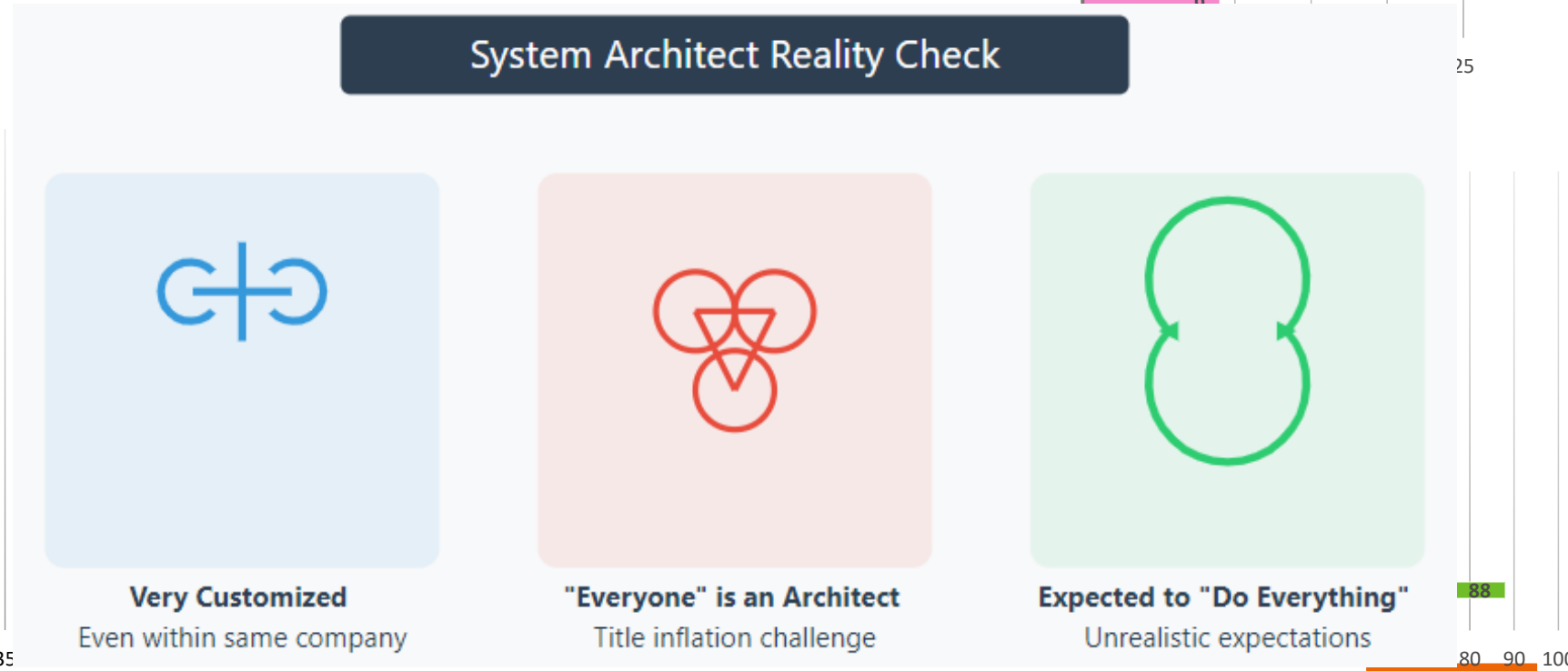
Job functions – vacancy analysis

Brainport vacancy portal.

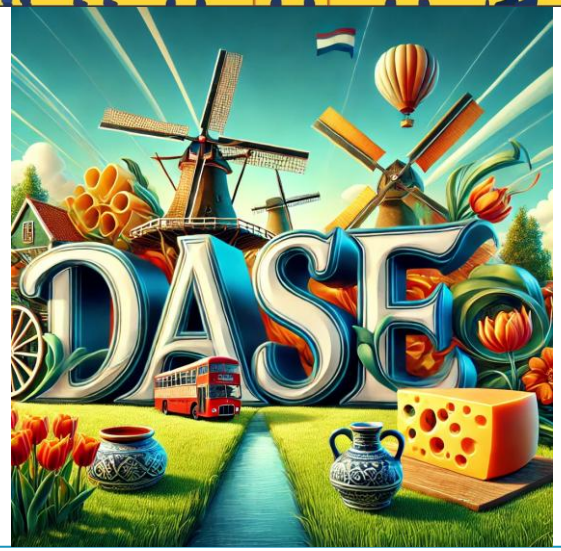
Started with ~1800 vacancies and ended with 308.





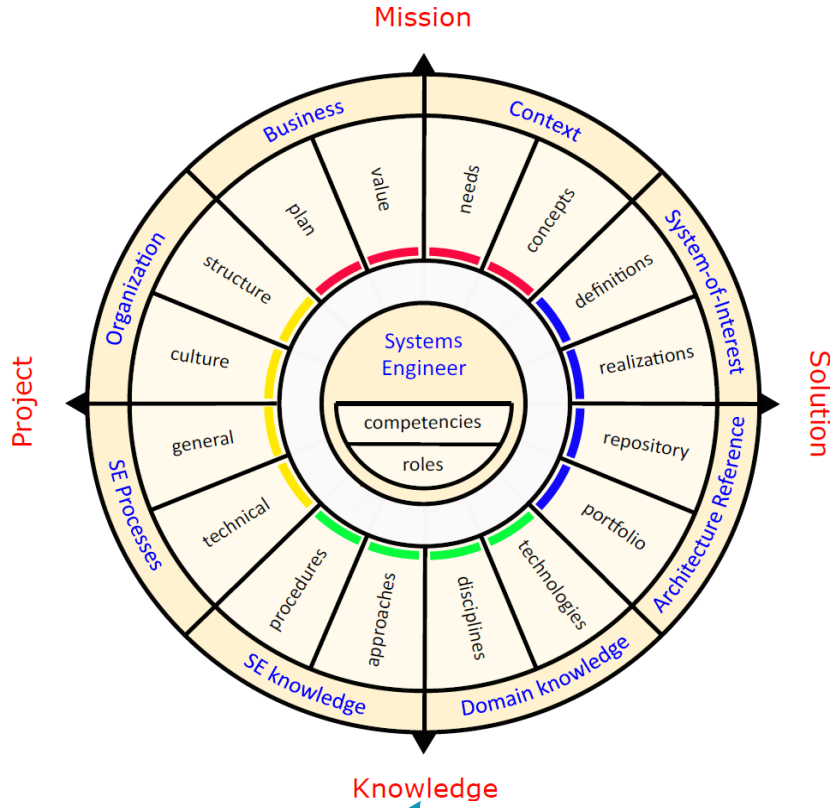


Design process of the SE development line



INCOSE Systems Engineering HANDBOOK

Added value: Customized SE education according to the needs of the Dutch Industry



NXT GEN HIGHTECH

INCOSE competencies

Core competencies:
Covers core principles which underpin engineering as well as systems engineering.

Systems Thinking
Lifecycles
Capability Engineering
General Engineering
Critical Thinking
Systems Modelling and Analysis

Professional competencies:
Covers behavioral competencies which are all well established within the Human Resources (HR) domain.

Communications
Ethics and Professionalism
Technical Leadership
Negotiation
Team Dynamics
Facilitation
Emotional Intelligence
Coaching and Mentoring

Management competencies:
Covers the competencies needed to perform tasks associated with controlling and managing systems engineering work.

Planning
Monitoring and Control
Decision Management
Concurrent Engineering
Business and Enterprise Integration
Acquisition and Supply
Information Management
Configuration Management
Risk and Opportunity Mng

Technical competencies:
Covers the competencies needed to perform a series of tasks associated with the Technical Processes identified in the INCOSE SE Handbook 4th Edition.

Requirements Definition
System Architecting
Design for…
Integration
Interfaces
Verification
Validation
Transition
Operation and Support

Integrating competencies:
Covers the systems engineering competencies required to understand and integrate the viewpoints and perspectives of others into the overall picture.

Project Management
Finance
Logistics
Quality

NXT GEN HIGHTECH

DASE compass

Value statement and plan by enterprise about the system-of-interest developed in the project.

Problem statement and characterization of the solution space for the desired system.

Network of people developing, producing, and supporting the SoI, using a structure and culture.

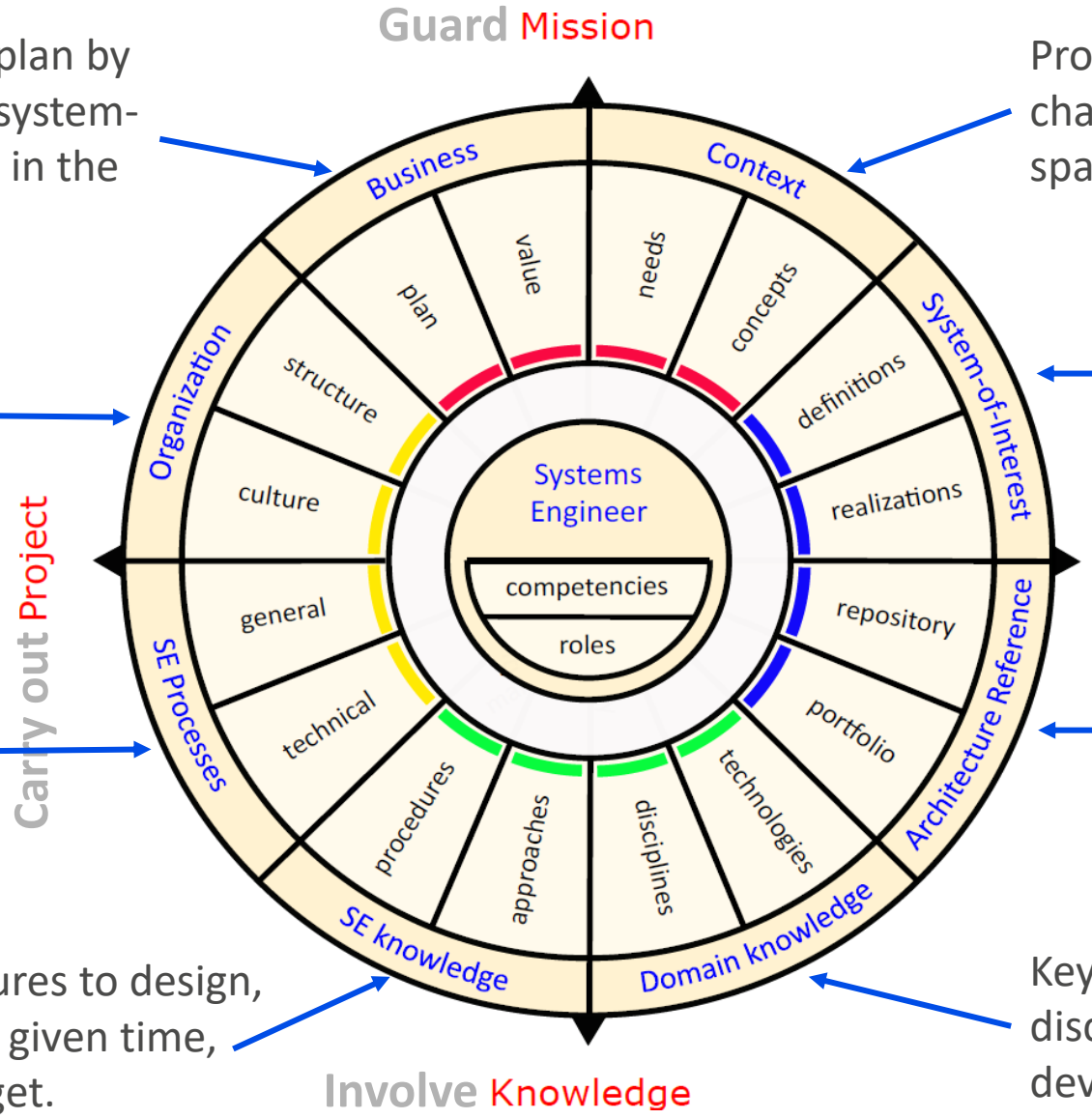
System to be created, in terms of its design definitions and physical realizations.

Workflows of general and technical SE activities, and their interactions, to carry out the project.

Document, digital and physical reference sources to derive SoI architecture from.

Methods and procedures to design, realize, use, retire SoI given time, quality, and cost budget.

Key technologies and disciplines needed for the development of the SoI.



NXT GEN HIGHTECH

Design process of the SE development line

Educational Goals

Job Functions

Industry workshops

Related processes

INCOSE Related competencies

Required Competencies

INCOSE processes

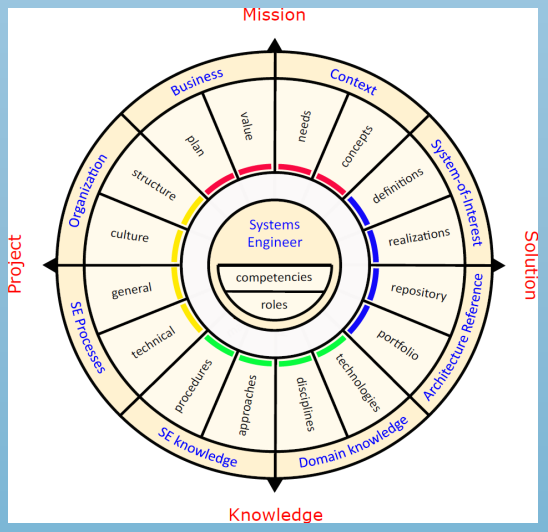
Sarah Sheard / INCOSE

Roles

INCOSE Related professional competencies

Required Prof. Competencies

Related elements & knowledge



Responsibilities in terms of the compass

NXT GEN HIGHTECH

System Designer/ SA / Chief Engineer Role

Key Responsibilities

- Develops high-level system architecture and design
- Evaluates and selects major components
- Analyzes building options against requirements
- Defines detailed specifications for subsystems
- Focuses on integration and verification
- Works closely with Requirements Owner
- Emphasizes architecture over low-level development

NXT GEN HIGHTECH

System Designer/ SA / Chief Engineer Role

Strong / High

- Technical Leadership
- Negotiation
- Team Dynamics
- Coaching and Mentoring
- Systems Thinking
- General Engineering
- Critical Thinking
- Systems Modelling and Analysis

Medium / Somehow

- Communications
- Facilitation
- Emotional Intelligence
- Lifecycles
- Capability engineering
- Requirements Definition
- Integration

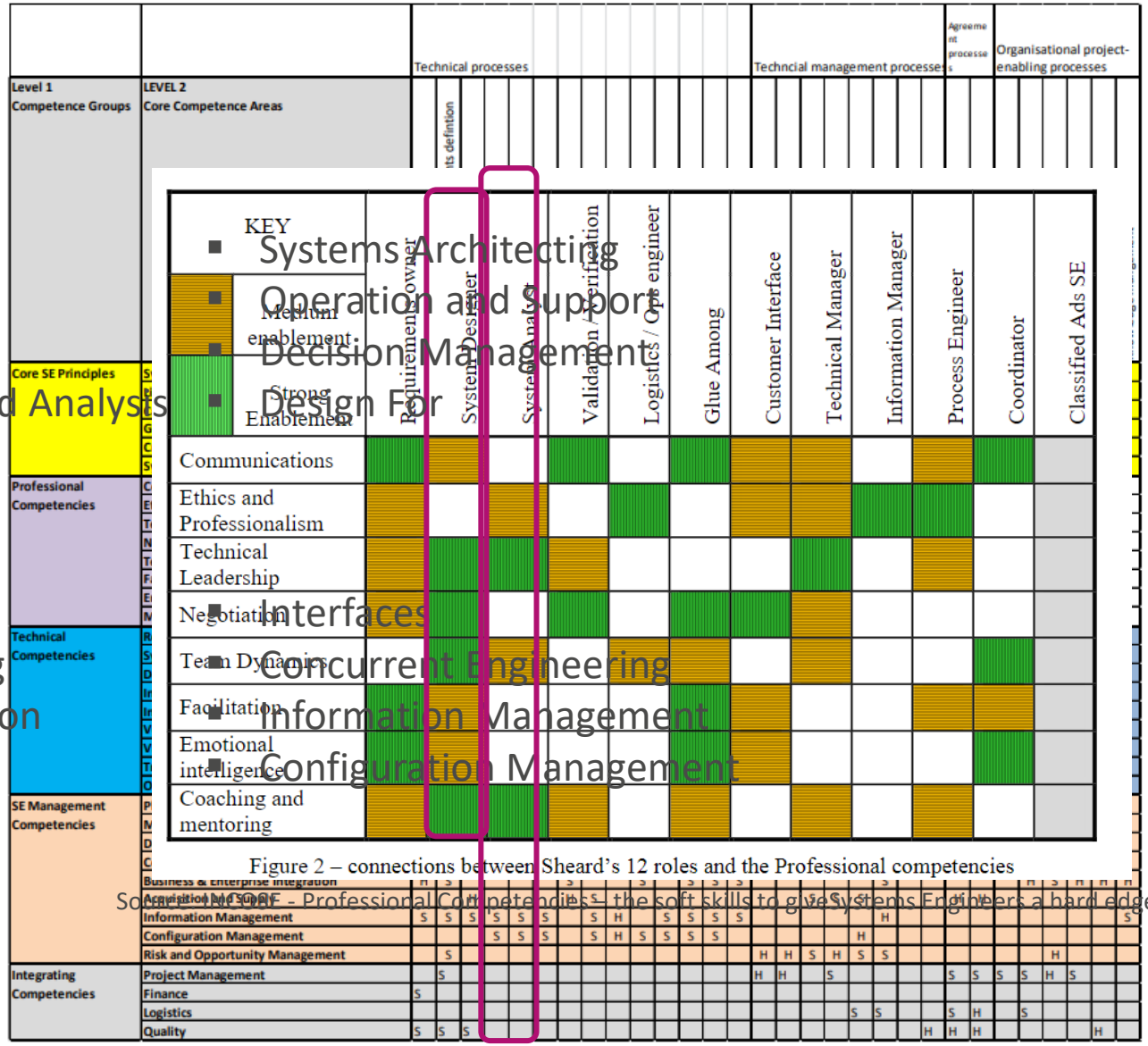


Figure 2 – connections between Sheard's 12 roles and the Professional competencies

Source: INCOSE - Professional Competencies – the soft skills to give Systems Engineers a hard edge

- Systems Architecting
- Operation and Support
- Decision Management
- Design For
- Interfaces
- Concurrent Engineering
- Information Management
- Configuration Management

SE Competency levels and career stages

- **Awareness** (level 1): able to explain (Bloom: remember - understand)
- **Super-vised practitioner** (level 2): able to assist (Bloom: understand - apply)
- **Practitioner** (level 3): able to practice (Bloom: apply – analyse)
- **Lead practitioner** (level 4): able to influence (Bloom: evaluate)
- **Expert** (level 5): able to provide vision (Bloom: create)

Junior	**Medior**	**Senior**
1 – 5 years of SE experience	6 – 15 years of SE experience	15+years of SE experience

NXT GEN HIGHTECH

COMPETENCY AREA - PROFESSIONAL: TECHNICAL LEADERSHIP

Description:

Systems Engineering technical leadership is the combination of the application of technical knowledge and experience in Systems Engineering with appropriate professional competencies. This encompasses an understanding of customer need, problem solving, creativity and innovation skills, communications, team building, relationship management, operational oversight and accountability skills coupled with core Systems Engineering competency and engineering instinct.

Why it matters:

The complexity of modern system designs, the severity of their constraints and the need to succeed in a high tempo, high-stakes environment where competitive advantage matters, demands the highest levels of technical excellence and integrity throughout the lifecycle. Systems Engineering technical leadership helps teams meet these challenges.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Explains the role of technical leadership within Systems Engineering. Defines "vision", "strategy" and "goal" terms and why each is important in leadership. Explains why understanding the strategy is central to Systems Engineering leadership. Explains why fostering collaboration is central to Systems Engineering. Explains why the art of communications is central to Systems Engineering. Explains why fostering collaboration is central to Systems Engineering leadership and how poor collaboration impacts on the quality of leadership provided. Describes technical analysis and problem techniques and established best practices which can be used improve the excellence of Systems Engineering solutions. Explains how creativity, ingenuity, experimentation and accidents or errors, often lead to technological and	Performs Systems Engineering activities with integrity, earning trust from others by applying both professional and technical competencies successfully. States the vision and describes how it impacts both the project and the wider enterprise. States team and project goals and works towards these, thinking strategically, holistically and systemically when performing own tasks. Accepts constructive criticism and uses this to self-improve, whilst remaining willing to challenge or offer constructive criticism to others on the team. Listens to viewpoints from others and takes these into account when developing solutions. Communicates ideas clearly and effectively to peers, selecting techniques and technical vocabulary. Applies creativity, innovation and problem solving techniques in own work. Identifies concepts and ideas in sciences, technologies and engineering	Leads Systems Engineering activities on their team with integrity, earning trust from others. Leads Systems Engineering activities on the team, combining appropriate competencies, with demonstrable success. Interprets vision for project team, influencing and integrating their viewpoints to gain acceptance. Strives for project goals, changing strategies as necessary, to ensure success. Accepts constructive criticism and uses this to self-improve, whilst remaining willing to challenge or offer constructive criticism to others. Leads Systems Engineering activities collaboratively. Enables and empowers team members to be successful, by supporting, facilitating, promoting, giving ownership and supporting them in their endeavors. Communicates ideas clearly and effectively to team, using appropriate techniques and technical vocabulary. Applies creativity, innovation and problem solving techniques to develop strategies or resolve team or project issues.	Recognized, within the enterprise, as a leader in Systems Engineering, contributing to best practice. Leads Systems Engineering activities across the enterprise with integrity, earning trust from others. Leads Systems Engineering activities across the enterprise, combining professional and technical competencies, with demonstrable success. Accepts criticism with professional demeanor using it to self-improve, whilst remaining open to challenging or offer constructive criticism to others within and beyond the enterprise. Fosters collaboration between stakeholders across the enterprise, sharing ideas and knowledge and establishing mutual trust. Enables and empowers others within the enterprise to be successful. Applies creativity, innovation and problem solving techniques to develop strategies or resolve complex project or enterprise issues. Maintains current technical expertise, through studying new and emerging best practice in own discipline and in sciences, technologies and engineering disciplines beyond their own.	Recognized, beyond the enterprise boundary, as a leader in Systems Engineering, Contributes to best practice in leadership in Systems Engineering. Influences key Systems Engineering stakeholders in leadership issues beyond the enterprise boundary with integrity, earning trust from others. Leads Systems Engineering activities beyond the enterprise, combining appropriate professional competencies with technical knowledge and experience. Leads activities collaboratively beyond the enterprise boundary, establishing mutual trust. Enables and empowers others beyond the enterprise boundary to be successful. Advises in complex or sensitive problem or issue resolution, applying creativity and innovation to ensure successful delivery. Fully utilizes their extended network and influencing skills to gain collaborative agreement with key stakeholders to progress project or enterprise needs. Champions the introduction of novel techniques and ideas in leadership,

Individual Assignment (15 minutes)

- Fill in the list for the role of System Architect

	Junior (1-5y SE experience)	Medior (6-15y SE experience)	Senior (15+y SE experience)
Technical Leadership	2	3	4
Negotiation			
Team Dynamics			
Coaching and Mentoring			
Systems Thinking			
General Engineering			
Critical Thinking			
Systems Modelling and Analysis			
System Architecting			
Operation and Support			
Decision Management			
Design for ….			
…			

1: awareness, 2: supervised practitioner, 3: practitioner, 4: lead practitioner, 5: expert

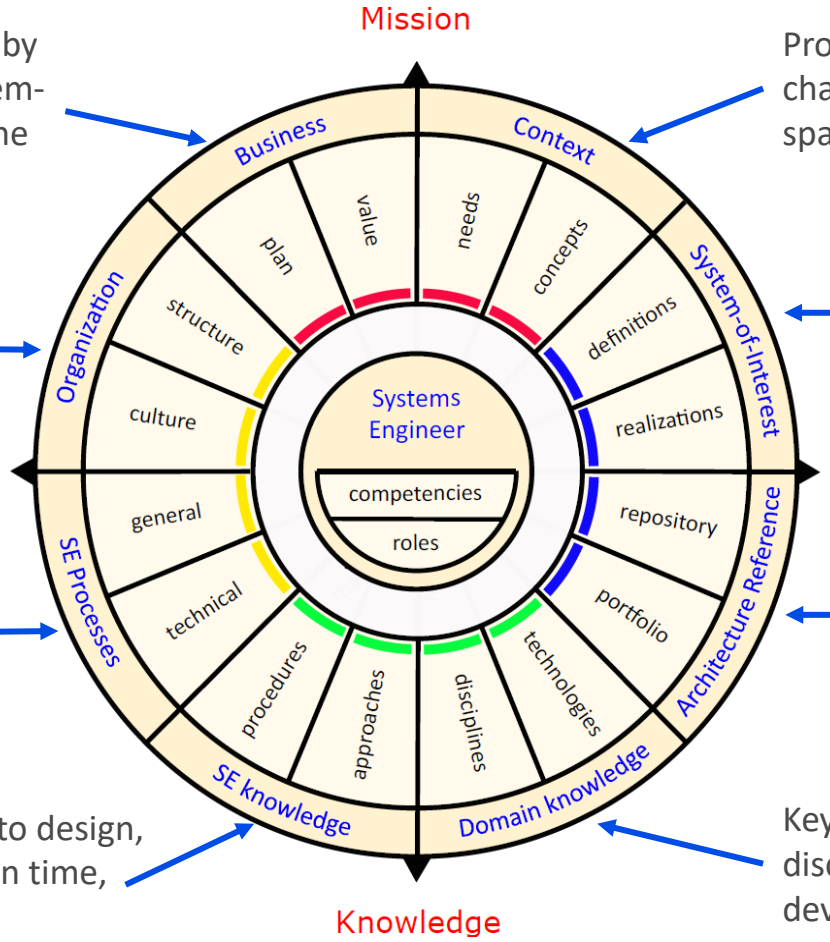
NXT GEN HIGHTECH

NXT GEN HIGHTECH

Tot ziens!

Discussion item

What characterizes your company regarding Systems Engineering? You can use the compass as a reference



Value statement and plan by enterprise about the system-of-interest developed in the project.

Problem statement and characterization of the solution space for the desired system.

Network of people developing, producing, and supporting the SoI, using a structure and culture.

System to be created, in terms of its design definitions and physical realizations.

Workflows of general and technical SE activities, and their interactions, to carry out the project.

Document, digital and physical reference sources to derive SoI architecture from.

Methods and procedures to design, realize, use, retire SoI given time, quality, and cost budget.

Key technologies and disciplines needed for the development of the SoI.