WITS UNIVERSITY | TCSE
WITS TRANSNET CENTRE OF SYSTEMS ENGINEERING

Partnering for Systems Solutions

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Wits TCSE Vision

The TCSE supports the Wits Vision 2022 Strategic Framework by becoming the leading Systems Centre in Africa to address the complex needs of our transforming society.

Wits TCSE Mission

Our mission is to develop capability in Systems through education, research and engagement through projects with industry.

We partner for systems solutions through lifecycle to address significant challenges and opportunities across socio-technical and economic environments.

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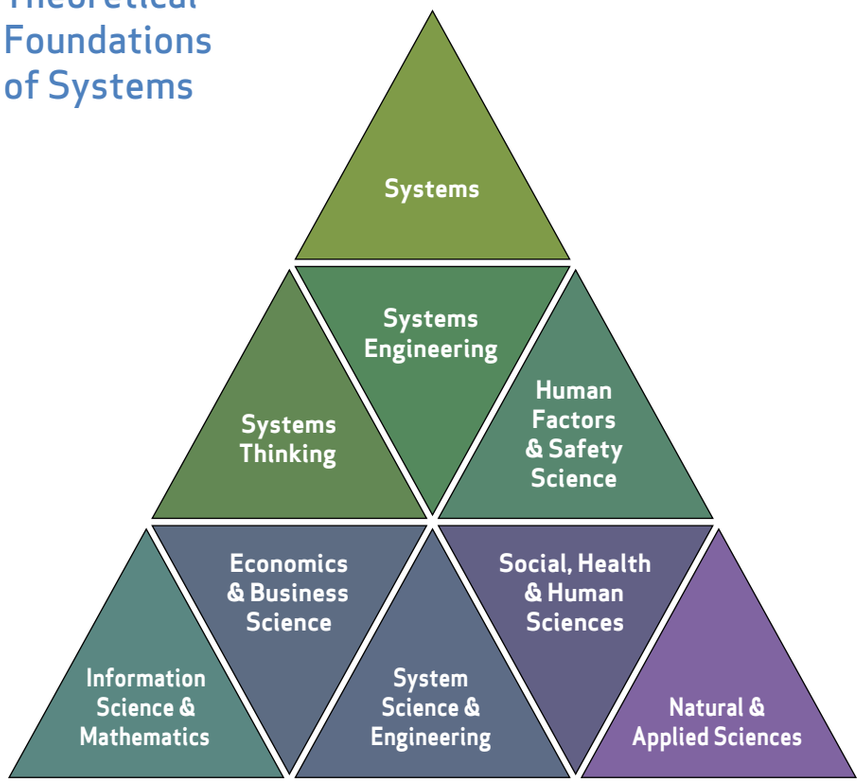
Theoretical Foundations of Systems



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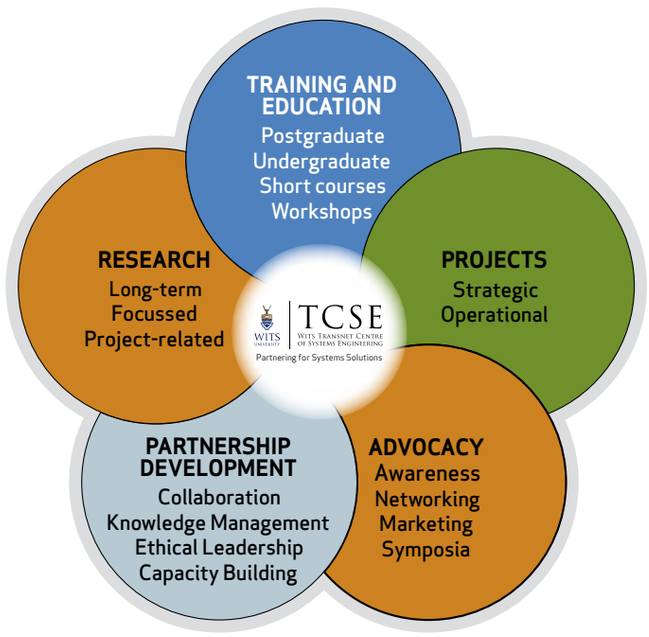
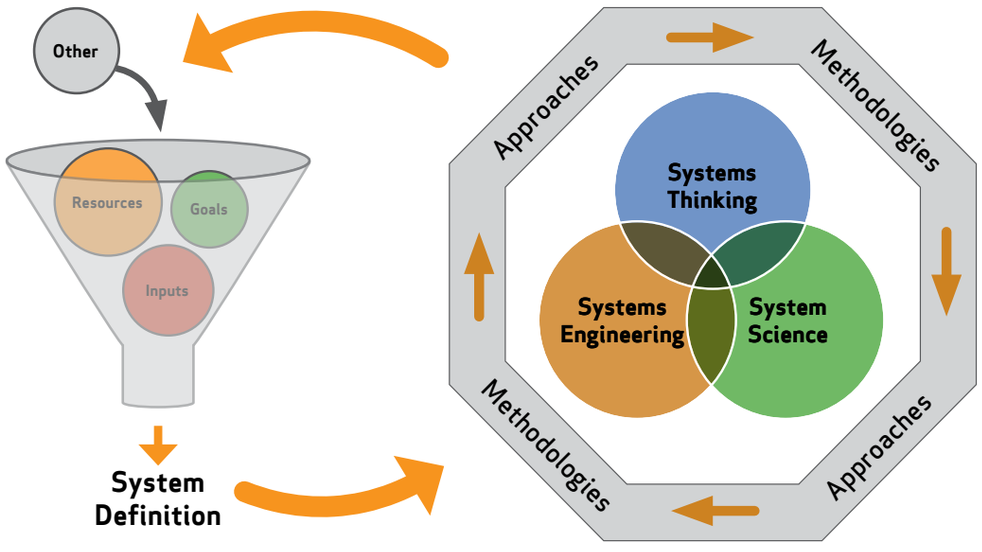
TCSE Main Streams of Activity

"Partnering for Systems Solutions"



Through applied Systems approaches and methodologies



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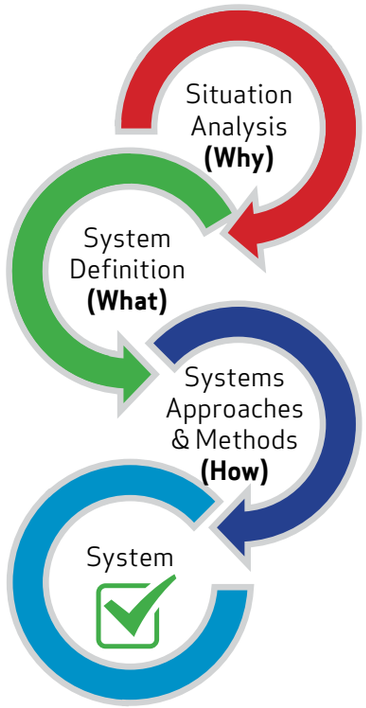
What is a System?

"A 'system' is a construct or collection of different elements that together produce results not obtainable by the elements alone.

The elements, or parts, can include people, hardware, software, facilities, policies, and documents; that is, all things required to produce system-level results."

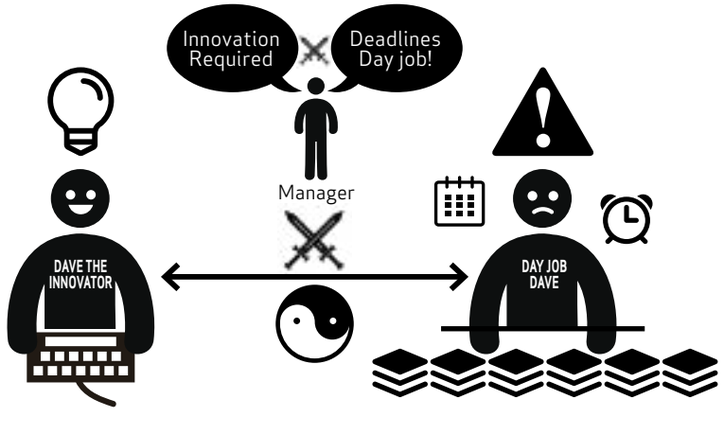
Rechtin, E. (1999), Systems Architecting of Organizations: Why Eagles Can't Swim



Systems Approaches and Methodologies

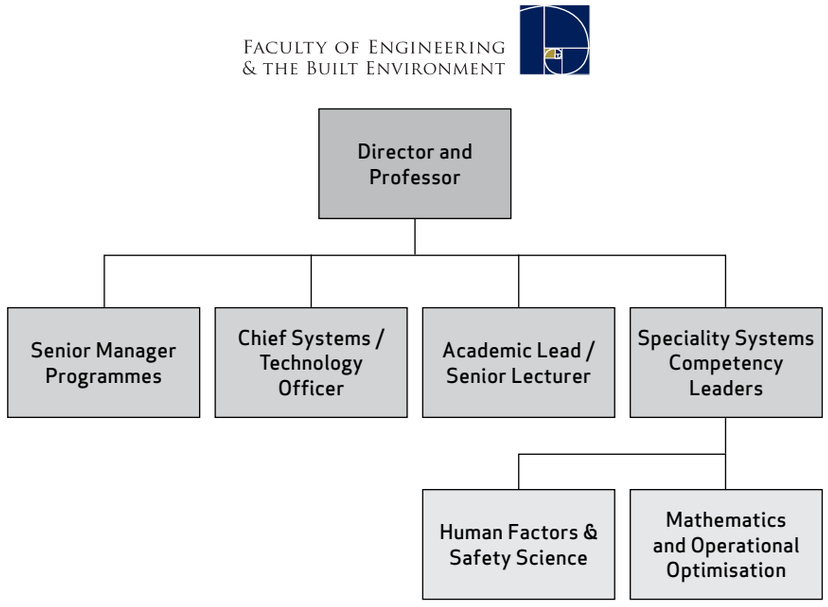
Systems encourages the adoption, combination and adaptation of approaches and methodologies to comprehend and manage complexity; e.g.

- System definition
- Viewpoint analysis
- Requirements management
- Concept of Operations
- Systems V-diagram
- Soft Systems methodology
  (including Rich Pictures and CATWOE)



TCSE Structure

Housed within the Faculty of Engineering and the Built Environment (FEBE), the TCSE aims to develop sufficient academic capacity in Systems and feed adequate and capable learners into the demand stream to capacitate Transnet and other major SA enterprises.



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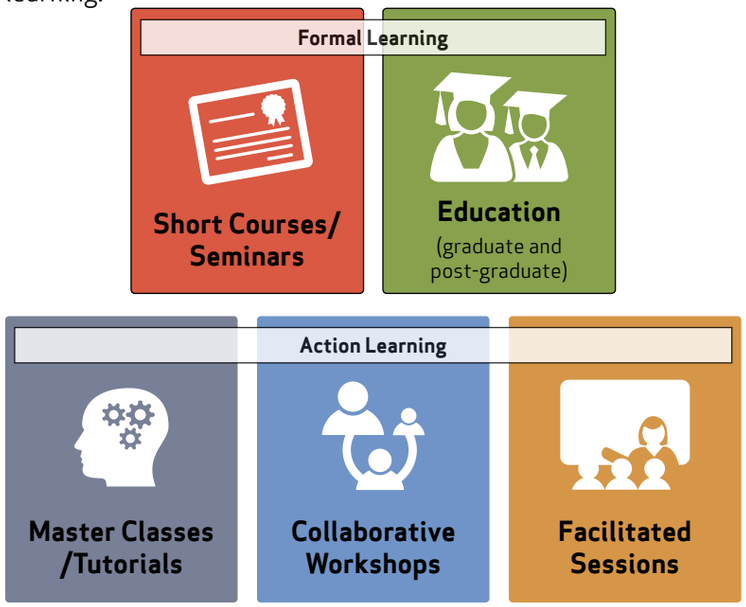
Education and Training

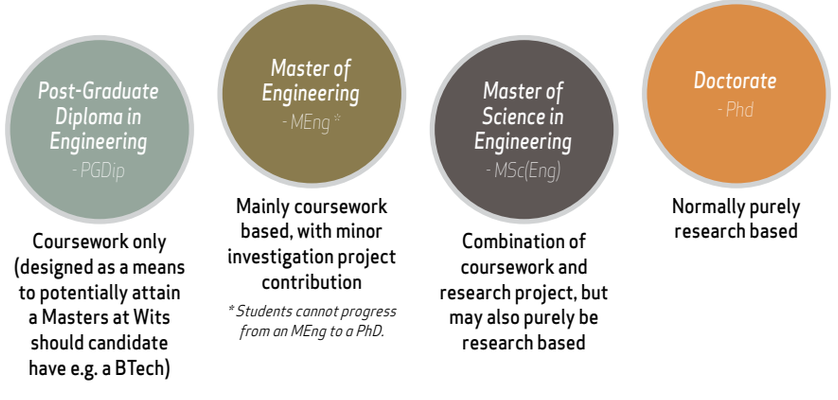
Education and Training activities are primarily focused on the development of knowledge and skills through formal and action learning.



Formal Learning

The TCSE supports the following formal learning initiatives in compliance with Wits University Rules:

- Undergraduate lecturing in Systems
- Post-Graduate supervision and mentorship in Systems
- Training – Short courses/seminars/workshops
- Systems Post-Graduate studies as "Occasional Students"
- Wits MSc (Eng.) in Systems Engineering



Wits MSc (Eng.) in Systems Engineering

Course Structure:

- 4 Courses (20 credits each)
  - Systems Engineering compulsory course
  - At least 2 Systems Engineering elective courses
  - Maximum of 1 course from MSc in Industrial Engineering or MSc in Electrical Engineering electives
- Research methods course (10 credits)
- Research report (90 credits)

Systems Engineering Compulsory Course	
Systems Engineering: Hard Systems Methodologies	**MECN7058**

Systems Engineering Elective Courses	
Systems Engineering Management	**MECN7053**
Systems Engineering: Soft Systems Methodologies	**MECN7054**
Requirements Analysis in Systems Engineering	**MECN7055**
Systems Engineering: Architecture	**MECN7056**
Systems Engineering: An Overview	**MECN7062**
Systems Engineering – Modelling and Simulation: Principles and Approaches	**MECN7063**
Systems Engineering: Integration, Verification and Validation	**MECN7064**

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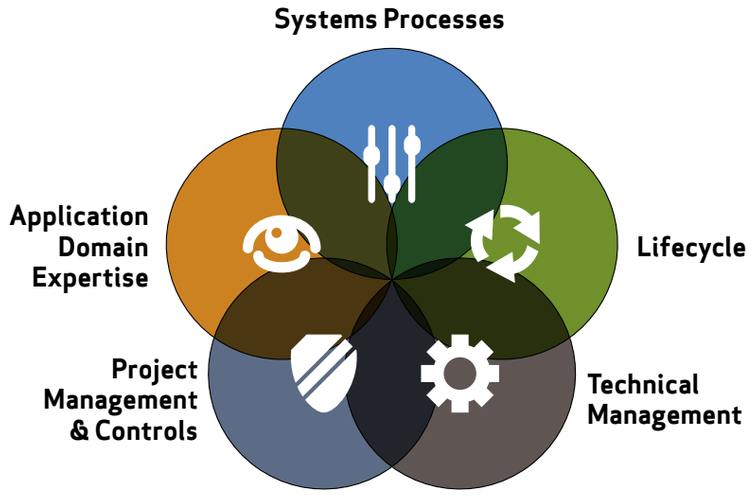
Action Learning

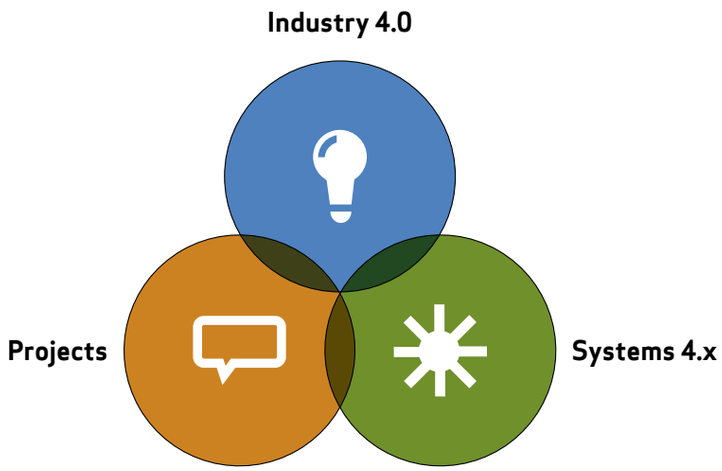
The application of Systems principles, making use of industry experience, that actively involves a small group working on real issues, taking action, and learning together as individuals, as a team, and as an organisation. The project control and management remains with the identified industry person.



Research

TCSE Research centres on industry-led challenges and opportunities that supports the development, integration, testing and sustainability of systems, enterprises and services; specifically:

- Informing best practice application to projects and operations
- Providing a means to adopt, combine and adapt systems approaches and methodologies for successful design and development of systems
- Underpinning effective integration of people, process and technology through lifecycle.



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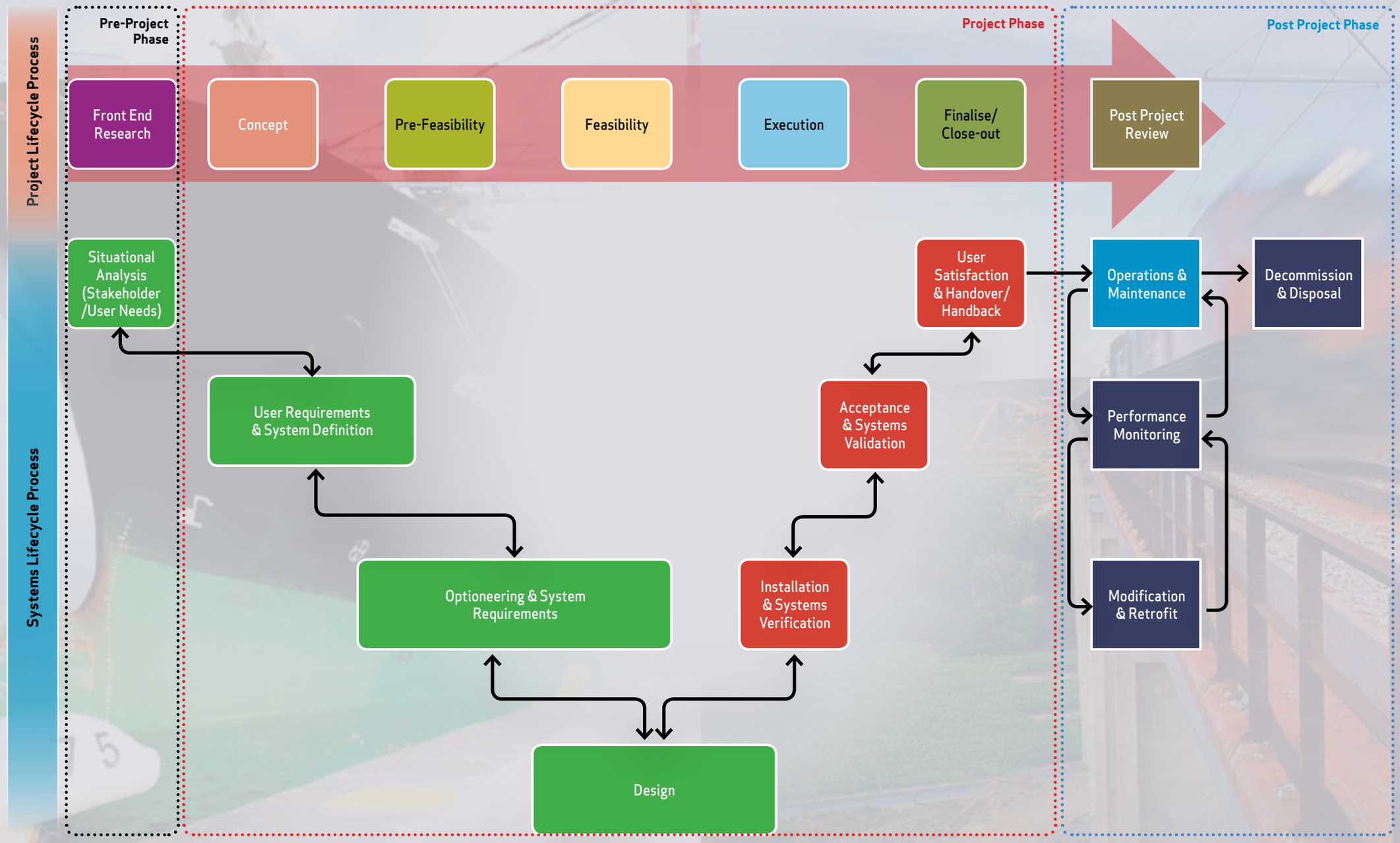
Systems Engineering Toolbox

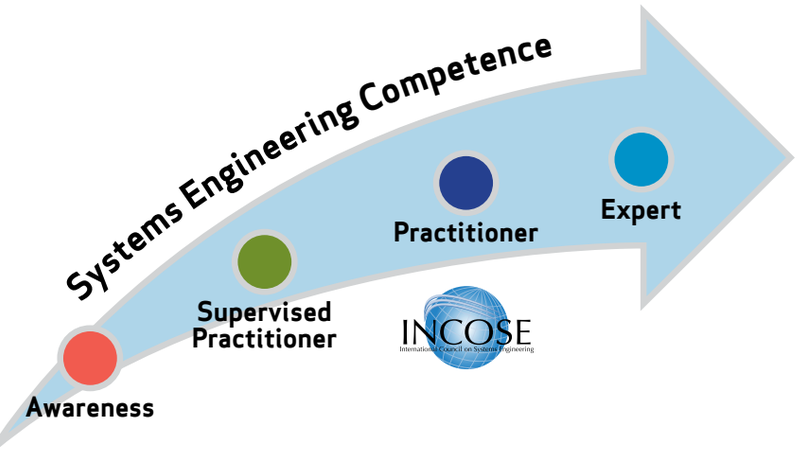
- Requirements Management
- Through Lifecycle Engineering
- Risk Management
- Verification & Validation
- Interface Management
- Functional Analysis
- Design Synthesis
- Integrity of Analyses
- Integrated Technical Management
- Configuration Management
- Trade Studies
- Speciality Competencies *(e.g. Human Factors & Safety Science)*

Project & Systems Lifecycle Processes



Systems Engineering Competency Development Programme

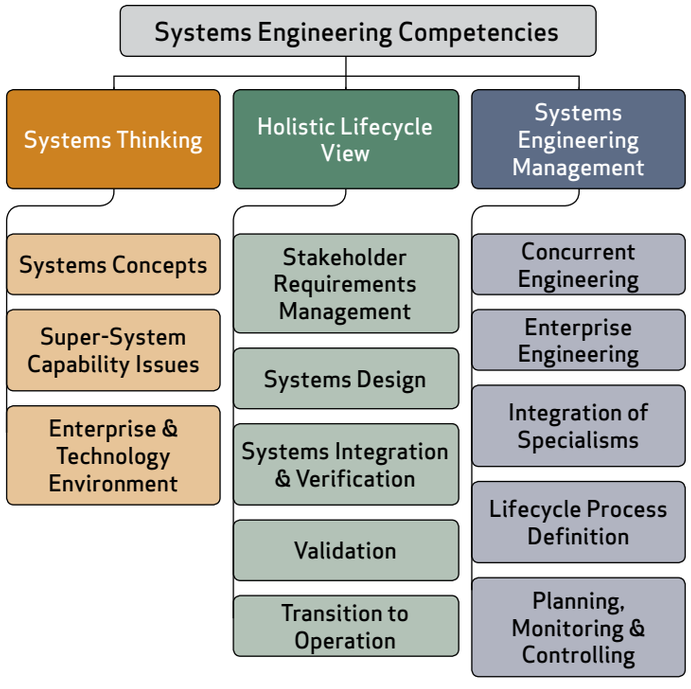
The Competency Development Programme is focussed at building knowledge and skills through formal learning and practical application through domain- and industry-specific application.



What is Systems Engineering?

"Systems Engineering is a methodical, disciplined approach for the design, realization, technical management, operations, and retirement of a system."

Rechtin, E. (1999), Systems Architecting of Organizations: Why Eagles Can't Swim



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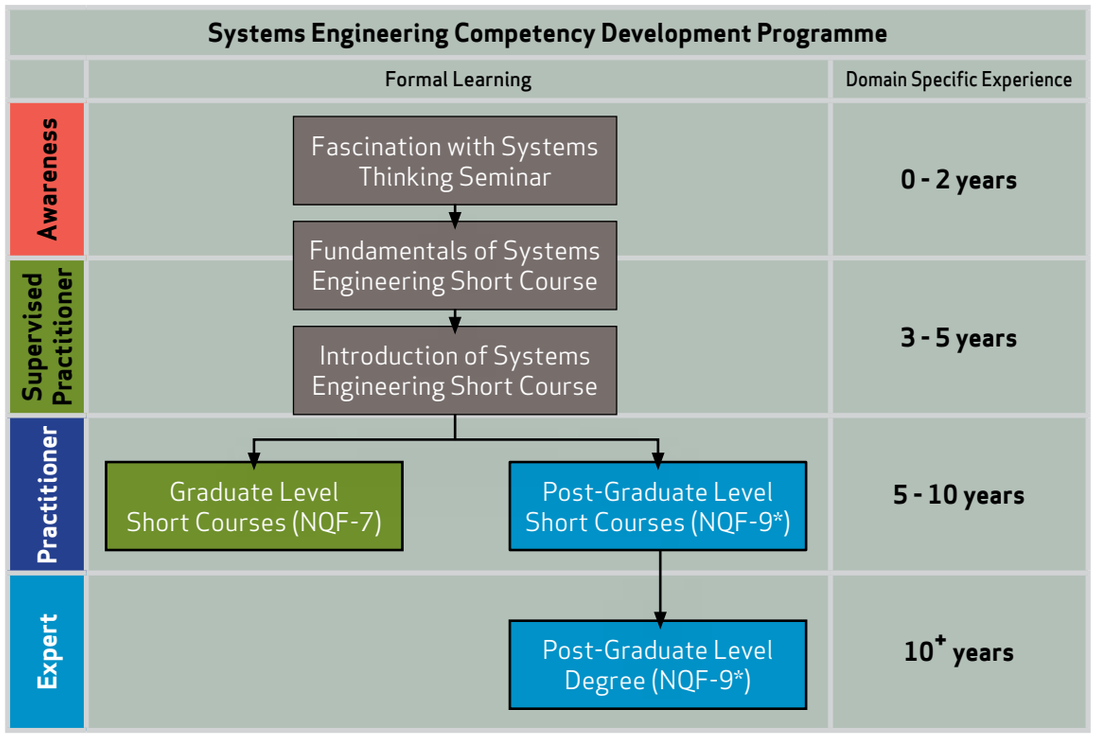


** NQF Level 9 Short Courses could be credited for Masters degree purposes, if the short course was done for a Certificate of Competence and achieved at an appropriate level.*

TCSE Short Courses

Graduate Level Short Courses (NQF -7)
Fundamentals of Systems Engineering
Introduction to Systems Engineering
Systems Engineering Practices
Advanced Systems Engineering
Integrated Logistics Support
Requirements Formulation
Engineering Economy
Earned Value Management
Inventory Management
Procurement Practices
Quality as a Strategic Weapon
Acquisition Management
Principles of Project Management
Project Lifecycle Management for Professionals
Fundamentals of Human Factors in Systems
Applied System Dynamics Workshop

Postgraduate Level Short Courses (NQF -9)	
Systems Engineering: Hard Systems Methodologies	MECN7058
Systems Engineering Management	MECN7053
Systems Engineering: Soft Systems Methodologies	MECN7054
Requirements Analysis in Systems Engineering	MECN7055
Systems Engineering: Architecture	MECN7056
Systems Engineering: An Overview	MECN7062
Systems Engineering – Modelling and Simulation: Principles and Approaches	MECN7063
Systems Engineering: Integration, Verification and Validation	MECN7064

TCSE Speciality Systems Competencies

Human Factors and Safety Science

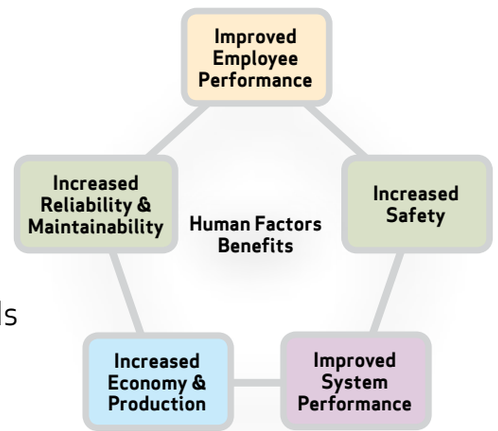
What is Human Factors?

The International Ergonomics Association (IEA) defines Human Factors as:

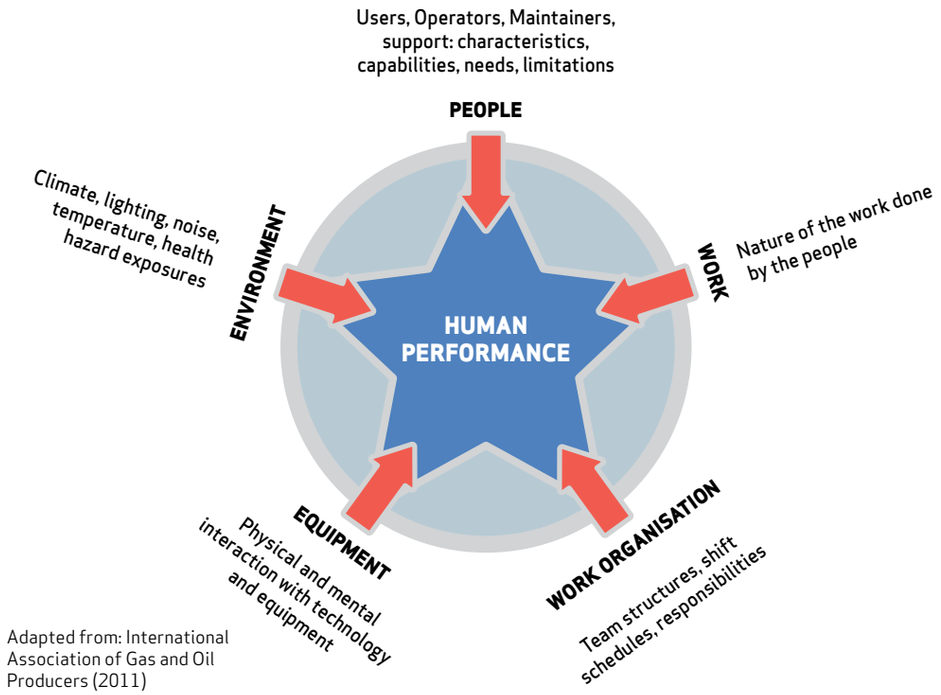
"The scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance."
(IEA, 2016)

Human Factors Methods:

- Education & training
- Ergonomic risk assessments
- Accident Investigations
- Mental workload assessments
- Fatigue management & shift work
- Alignment to Human Factors standards



Improving Human & System Performance

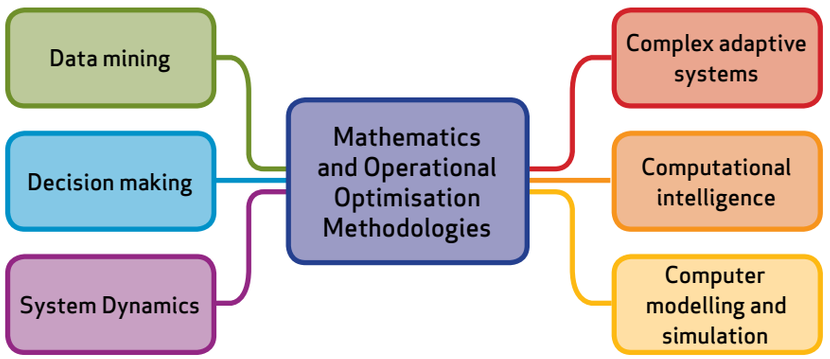


Adapted from: International Association of Gas and Oil Producers (2011)

Mathematical and Operational Optimisation (Modelling & Simulation)

Mathematics and information science drawing on General Systems Theory and Systems Science for mathematical and operational optimisation in strategy, planning and execution.

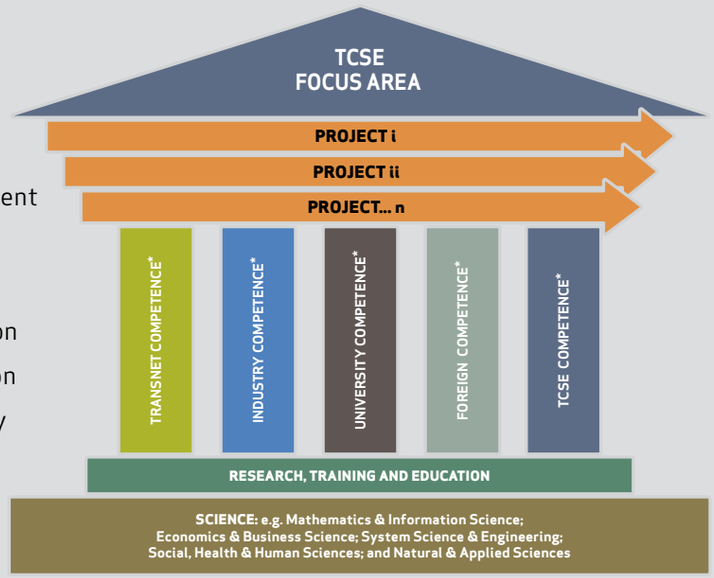
Typical Mathematical and Operational Optimisation Methodologies



Projects

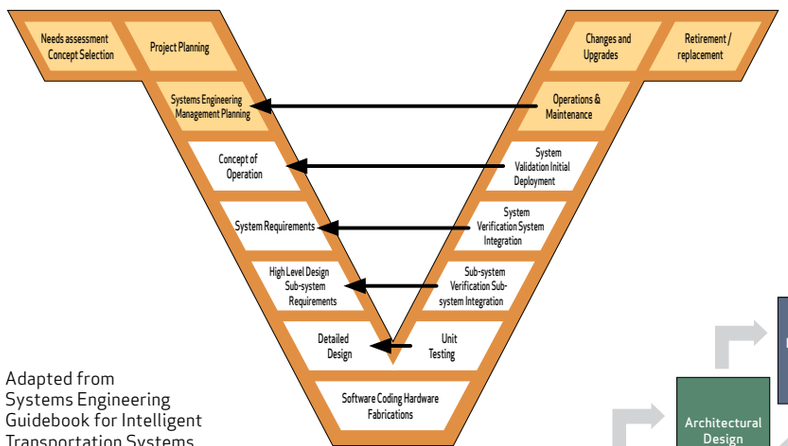
Building on the foundations of Research, Training and Education; the TCSE develops individual, team and organisational Systems competencies through the application of Systems approaches and methodologies on Projects.

- Research and Development
- Capacity Development
- Digitisation
- Operational Optimisation
- Modelling and Simulation
- Human Factors & Safety Science
- Support and Advisory

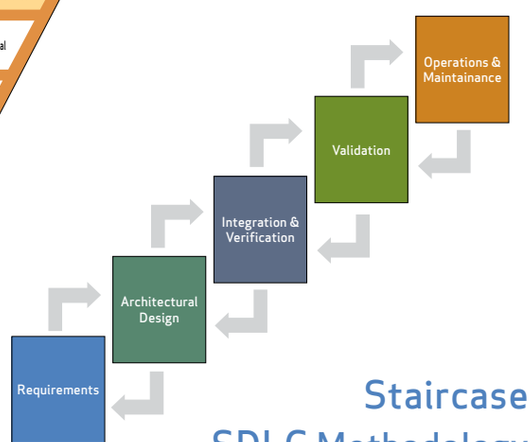


* Competencies to make reference to relevant legislation, regulations, standards, policies and processes

"Vee" Diagram



Adapted from
Systems Engineering
Guidebook for Intelligent
Transportation Systems



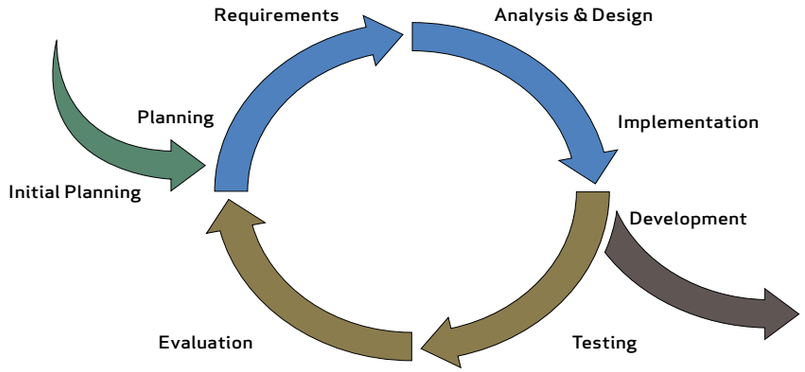
Staircase SDLC Methodology

Programme Management

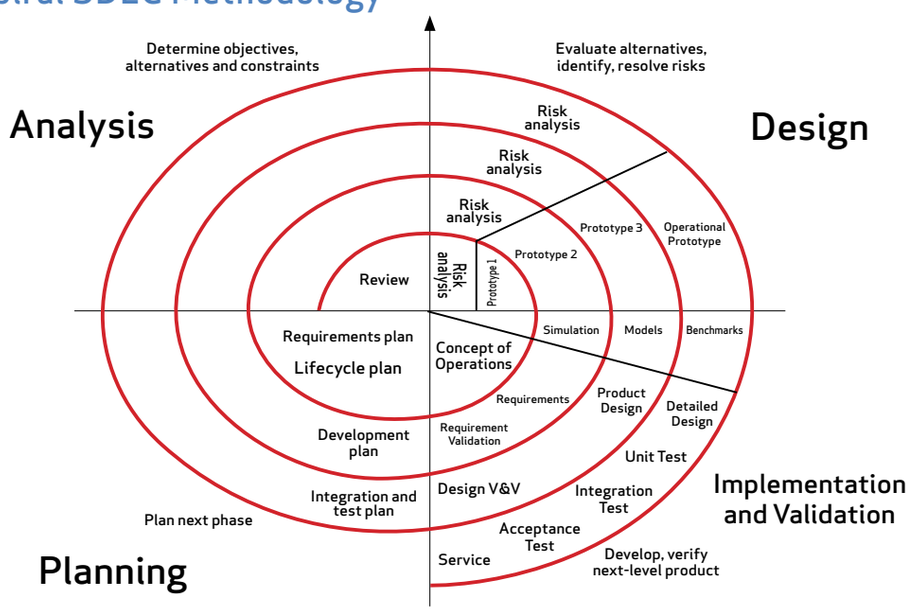
The appropriate System Development Lifecycle (SDLC) methodology is dependent on the type of project and the applicable technologies.

Typical approaches applied to projects are Staircase-, Spiral-, and/ or Concurrent-SDLC methodologies; as well as the Systems "Vee" Diagram.

Concurrent SDLC Methodology

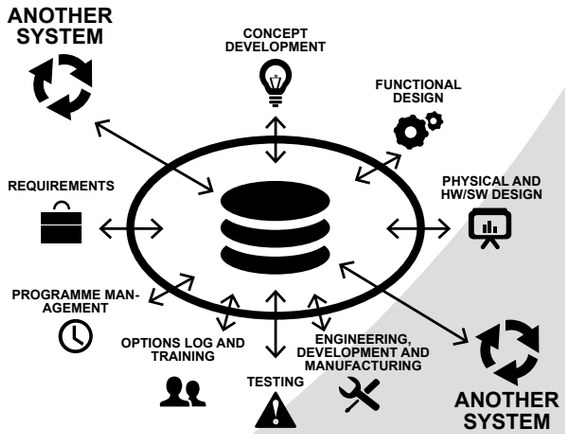


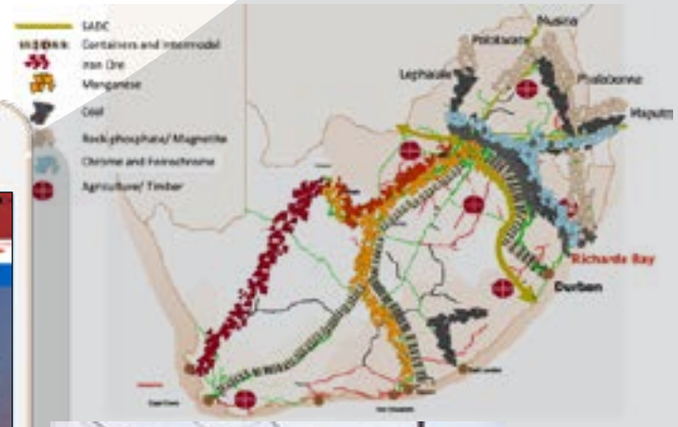
Spiral SDLC Methodology

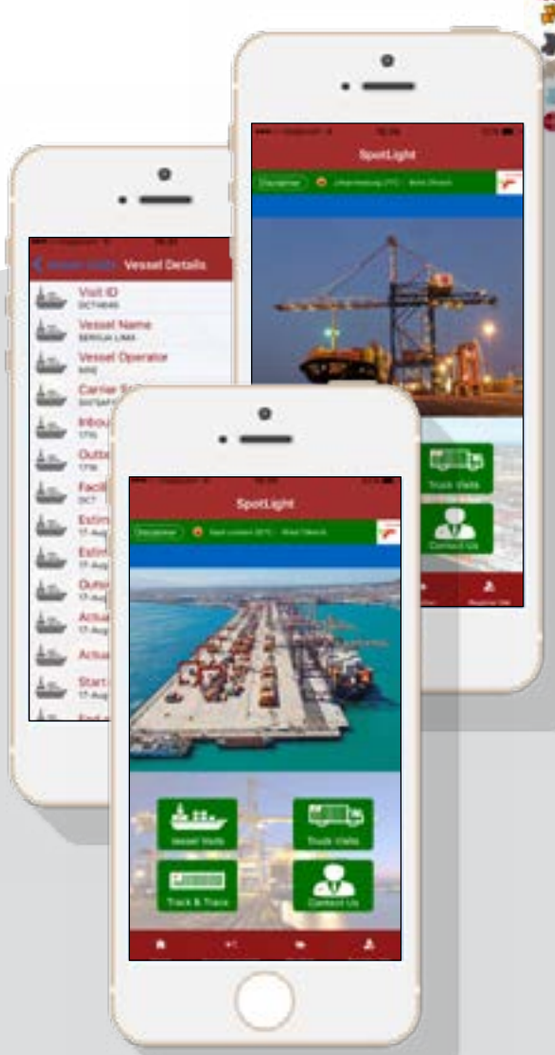


Project Execution

Projects delivery draws on the resources of the TCSE, Wits University, other local education and research institutions and foreign research and technology networks; e.g. Control Systems, Mobile Applications, e-Enablement, Materials Handling, Value Chain, Supply Chain, Logistic Corridors, Rail Technology, High Voltage Systems, Energy Optimisation, Renewable Energy Sources and Capital Planning.







Advocacy

The TCSE participates in and develops various events, networks, collaborations and outreach through various professional bodies and interest groups – often in collaboration with local and international universities. Examples include:

- International Council on Systems Engineering (INCOSE)
- INCOSE South Africa Chapter
- Ergonomics Society of South Africa (ESSA)
- Southern African System Dynamics (SASD) Chapter
- International Heavy Haul Association (IHHA)
- South African Heavy Haul Association (SAHHA)
- Southern African Systems Analysis Centre (SASAC)
- Transport Forum

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