Wits Transnet Centre of Systems Engineering: TCSE

Presentation to SA INCOSE Western Cape Branch

27 February 2014

Rudolph Louw

FACULTY OF ENGINEERING & THE BUILT ENVIRONMENT

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

TCSE
WITS TRANSNET CENTRE OF SYSTEMS ENGINEERING

Wits Transnet Centre of Systems Engineering: TCSE

Systems Engineering training and education in context of a major South African SoC: Transnet and its *LTPF and* Market Demand Strategy (MDS)

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Structure of Presentation

Actually not – let's have a discussion around SE and its deserved role in SA application, training and education… Agreed?

A Little Bit of Marketing….

Origin of the TCSE

The Wits Transnet Centre of Systems Engineering (TCSE) – also encompassing a named Chair of Systems Engineering - was contracted by Transnet (as founder sponsor) in 2012 to play a positive role in contributing to and empowering the vision of Transnet and that of the country in pursuit of its Long-Term Planning Framework (LTPF) as embodied in the Market Demand Strategy (MDS) and/or successor strategies.

Transnet Long Term Planning Framework

TRANSNET

delivering freight reliably

Business address and registered office
Transnet SOC Ltd
Carlton Centre
150 Commissioner Street
Johannesburg
2001

PO Box 72501
Parkview
2122
South Africa

Company registration
1990/000900/06

TRANSNET

delivering freight reliably

LTPF : Macro-Economic Freight Demand Forecast

TRANSNET

delivering freight reliably

Long-term Planning Framework (LTPF) 2012

Executive Overview

Transnet's Long-term Planning Framework (LTPF) defines Transnet's long-term port, rail and pipeline infrastructural investment based on a macro-economic freight demand forecast.

This 2012 edition of the LTPF is the most recent version of a process that began with the Port and Rail Corridor Development Plans of 2006, and evolved annually through the Port and Rail Development Plans (2007), the National Infrastructure Plan (2008), and the 2009 and 2011 Transnet Infrastructure Plans.

LTPF 2012 features closer alignment with the National Development Plan of the National Planning Commission and with Transnet's Corporate Plan, further integration of planning demand, development of sustainability planning principles, enhancement of the unconstrained 30-year capital plan, and development of the corresponding strategic infrastructural investment projects.

Future enhancements will include the evolution from a plan that focuses primarily on infrastructural investment into a plan that provides insight into other dimensions of stable long-term business sustainability such as energy and workforce plans, and strategic environmental assessments.

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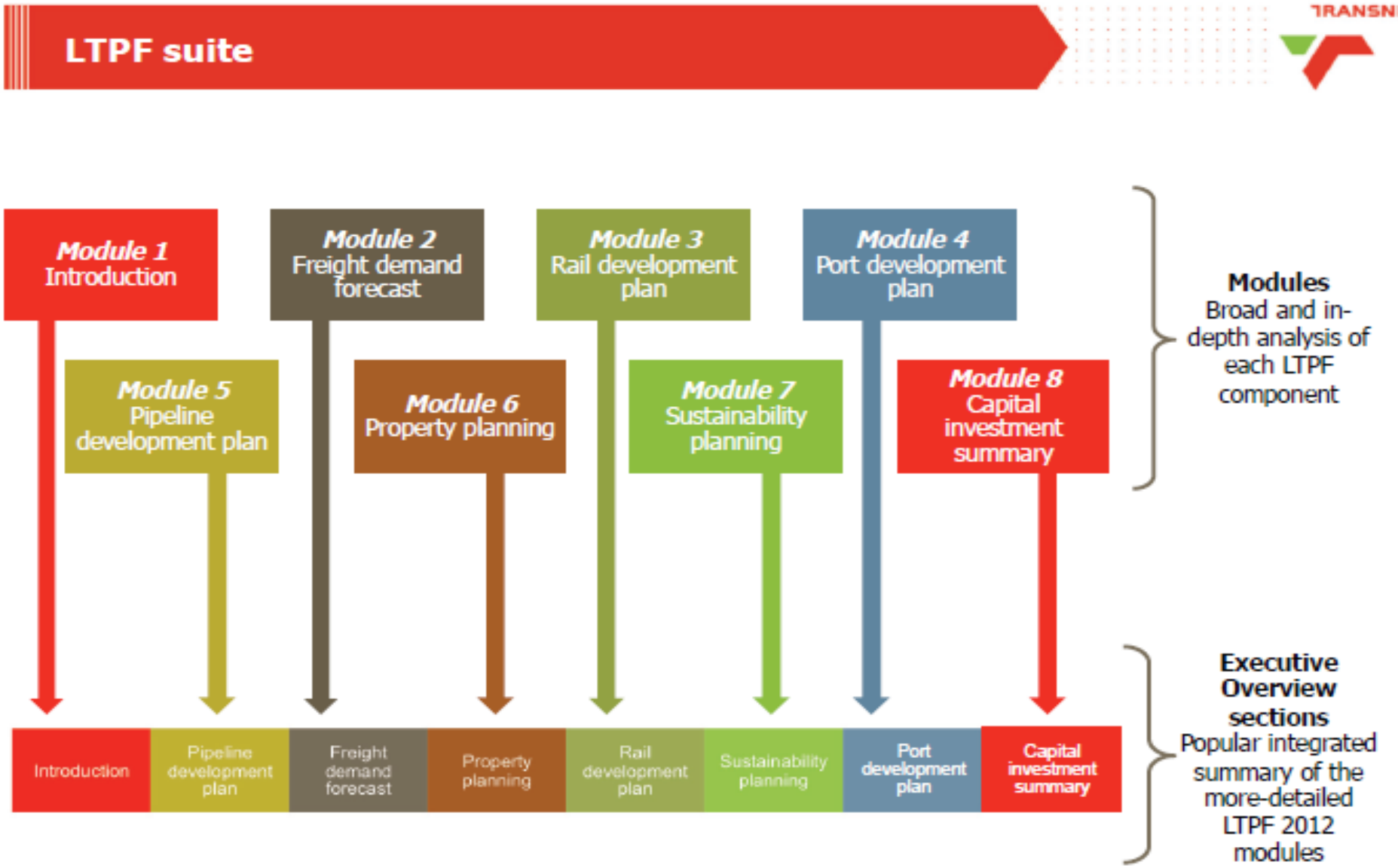
LTPF Suite


LTPF suite
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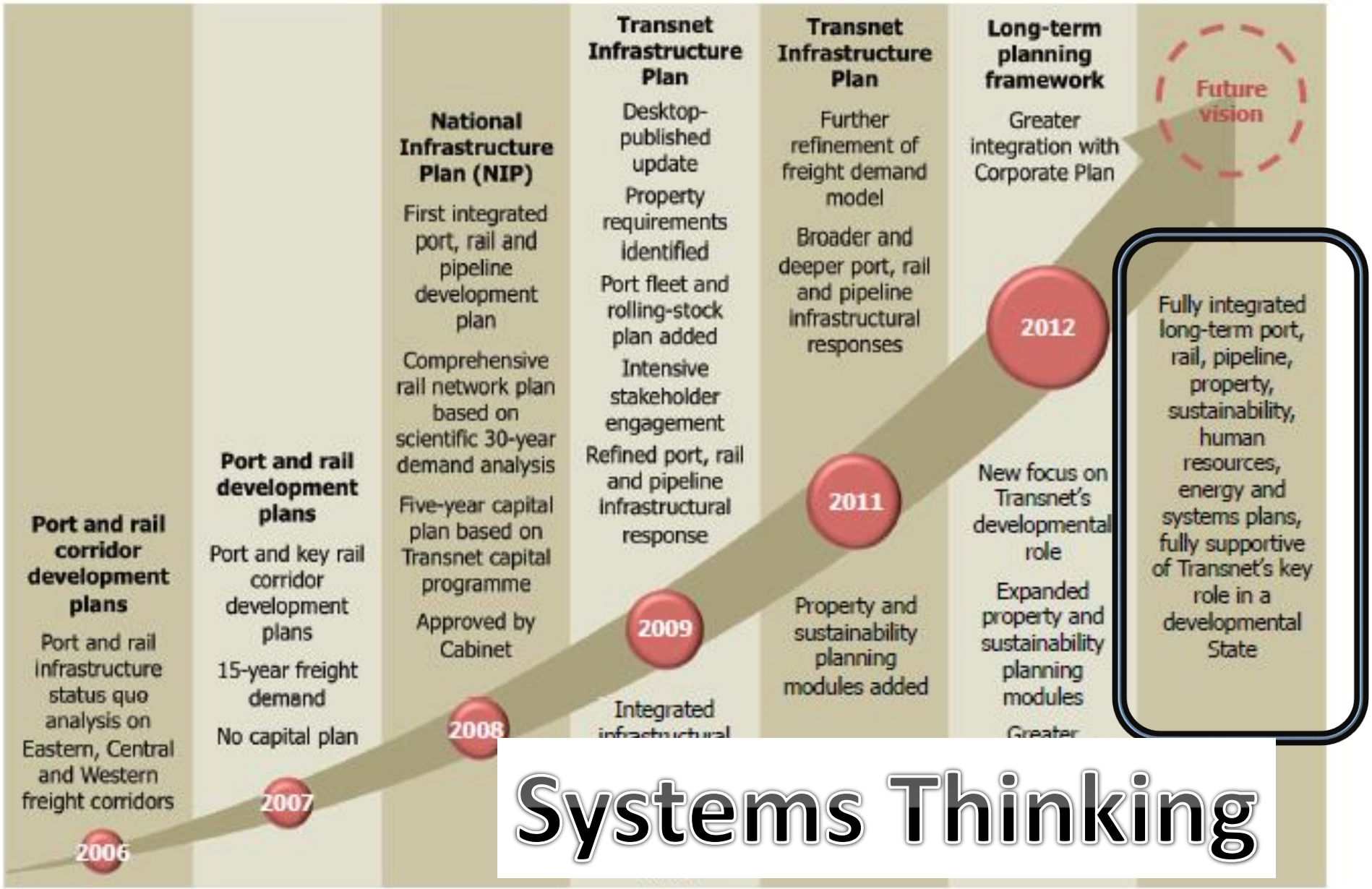
Module 1 Introduction
Module 2 Freight demand forecast
Module 3 Rail development plan
Module 4 Port development plan
Module 5 Pipeline development plan
Module 6 Property planning
Module 7 Sustainability planning
Module 8 Capital investment summary
Modules
Broad and in-depth analysis of each LTPF component
Introduction
Pipeline development plan
Freight demand forecast
Property planning
Rail development plan
Sustainability planning
Port development plan
Capital investment summary
Executive Overview sections
Popular integrated summary of the more-detailed LTPF 2012 modules

LTPF evolution



Systems Thinking

LTPF Planning Principles & Outputs

Planning principles and outputs

Planning principles

- Create capacity ahead of demand
- Ensure long-term sustainability
- Integrate port, rail and pipeline planning
- Align with national road and electricity planning
- Operational efficiency precedes infrastructural investment
- Provide safe, reliable and cost-effective freight-handling infrastructure
- Benchmark internationally
- Reduce total cost of South African freight transport and logistics
- Promote regional integration
- Provide responsive infrastructure

Planning outputs

- Status quo assessment of port, rail and pipeline freight network
- 30-year integrated freight demand forecast
- Description of planning methodology
- Assessment of future port, rail and pipeline capacity requirements
- Assessment of related property requirements
- Assessment of Transnet's long-term key business sustainability requirements
- Long-term port, rail and pipeline development plans
- Summary of Transnet's 7-year and 30-year infrastructural capital investment requirements

A Systems Approach

Planning principle number 1 –
Create capacity ahead of demand

→ **What demand to plan for?**

1: Freight Demand Model

- Macro-economic and market intelligence
- All freight modes
- 66 commodity classes
- Supply and demand – 365 districts
- Annual update

→

2: Transportation Model

- Routing and flow
- Origins to destinations
- Port demand output
- All freight modes
- Mineral exports replaced
- Ongoing updates

→

3: Market Share Model

- Freight by mode
- Road/Rail/Pipeline
- Suitability of freight
  - Determines potential
  - Market share targets
- Annual update

Demand planning involves using a set of three models – to determine the demand for the transportation of all types of freight in Southern Africa and predicting how this demand will change over the following 30 years.

WHAT IS THE MDS?

Transnet's Market Demand Strategy (MDS), will expand and modernise the country's ports, rail and pipelines infrastructure over a period of seven years to promote economic growth in South Africa.

The main pillar of the MDS is the R300bn investment programme.

The MDS will make Transnet one of the biggest rail freight companies in the the world.

Rail volumes will increase from around 200 million tons to 350 million tons.

Transnet plays a pivotal role in supporting government's drive for infrastructure-investment-led economic growth. The MDS will enable us to transport goods in a reliable, efficient and cost-effective fashion.

288 000
The total number of jobs we will create within the South African economy

16%
The percentage of revenue growth we expect per annum over the next seven years

R7.7bn
THE AMOUNT WE WILL SPEND ON TRAINING, SKILLS DEVELOPMENT, BURSARIES AND GRANTS BY 2018/19

25%
The headcount increase over the next seven years

71.2%
The percentage by which we will grow container capacity by 2019

A switch from road to rail will reduce costs, congestion and carbon emissions.

OUR PLAN

1. Address capacity constraints.
2. Improve the performance of the regional rail system.
3. Switch from road to rail transport.
4. Decrease congestion on the country's roads.
5. Promote skills development.
6. Improve global and regional maritime connectivity.
7. Develop supplier industries for all modes of transport.
8. Provide world-class infrastructure and technology.
9. Create an infrastructure that meets the demands of the growing economy.
10. Improve the competitiveness of the nation's freight system.

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WHY DO WE NEED THE MDS?

INVESTMENT in infrastructure and growth of the economy are central to the South African government's New Growth Path. By expanding our rail, ports and pipelines infrastructure, and facilitating the shift from road to rail transport, the MDS will have a marked impact on the cost of doing business in South Africa.

JOBS

The MDS investment programme will create and sustain hundreds of thousands of direct and indirect jobs, every year for the next seven years.

COMPANY GROWTH

We will increase our headcount by 25% over the seven-year period to support the growth of the business.

SKILLS DEVELOPMENT

We will prioritise skills development to promote a high performance culture.

SUSTAINABLE VALUE

The MDS will deliver lasting economic, social and environmental value to South Africa.

"The successful implementation of the MDS will position Transnet as a top-tier logistics and transport provider."

BRIAN MOLEFE
GROUP CHIEF EXECUTIVE

TRANSNET

HOW WILL THE MDS BENEFIT SOUTH AFRICA?

Our infrastructure development programme will **reduce** the overall cost of doing business in South Africa.

The switch from road transport to rail will **reduce costs** and carbon emissions of transport and doing business in the region.

Upgrades and expansions will **improve efficiency**.

We will address capacity constraints in many sectors of the economy – most significantly in mining.

Addressing the underdeveloped freight system will enable South Africa to become **competitive**.

Improved infrastructure can lower supply-chain costs of businesses in South Africa.

Transnet National Ports Authority will optimise operational efficiencies to **reduce** the costs of trade.

The capacity of the Port of Ngqura will be increased from handling 800 000 containers a year in 2012 to **two million** in 2019, making it a key transshipment hub between the East and the West.

The upgrade of ports will enhance business, and be beneficial to South Africa's **trade relationships**.

Foreign investors are keen to invest in the programme.

Over the next seven years, Transnet's R300-billion infrastructure spending plan will significantly reduce the cost of doing business in South Africa and the rest of Africa.

BRIAN MOLEFE
GROUP CHIEF EXECUTIVE

THE IMPACT OF THE MDS ON SA

THE SUCCESSFUL EXECUTION OF THE MDS WILL ENABLE SOUTH AFRICA TO:

- Expand its mining and resource processing industries.
- Become an important thermal coal supplier for India and China.
- Maintain its position as a credible supplier of iron ore to both the domestic and export markets.
- Capture its rightful place as a leading manganese exporter globally.
- Become the regional container transshipment hub for sub-Saharan Africa.
- Create a reputation of world-class operational efficiencies.
- Position South Africa as the leading logistics hub in the region.

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DID YOU KNOW THAT

BETWEEN NOW AND 2019 TRANSNET WILL...

...spend R80k every minute over the next seven years.

...hire 6 people every day (not including turnover).

...be the fourth largest supplier of coal to China.

We need to take charge of our destinies, to put our dreams into practical purpose to ensure that they come to fruition. This means making sure that programmes like our MDS work.

BRIAN MOLEFE
GROUP CHIEF EXECUTIVE

2013 – 2019 .....

...have its ports among the top 20 of the busiest ports in the world.

...load/unload 6.3 additional containers every minute.

...deliver 57 more tons of both coal and iron ore every minute.

...put 2.7 new locomotives in service every week.

...create 223 new jobs in South Africa every day.

...earn R4 059 in additional revenue every second.

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TCSE Vision

The Wits TCSE is a significant, value-adding and trusted partner;

- **continuously successfully addressing and resolving significant challenges,**
- **across techno-disciplinary and organizational boundaries in a harmonized, integrated fashion to provide solutions,**
- **as well as developing a feeder stream of highly qualified and contributing engineers and related staff,**
- **towards empowering significant South African corporates to pursue and succeed in their strategic goals of economic growth, sustainability and upliftment of the country in general.**

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WITS TRANSNET CENTRE OF SYSTEMS ENGINEERING

TCSE Primary Activities

- Co-operating and work-s… …ership to offer synergistic, universit… …ue new directions and perspective…
- Identifying … …ing fundamental and applied researc…
- Fo… …ate … …and … other di… …ontact point … …e transfer of kno… …d … overseas channels w… …ations;
- …veloping an integrated knowled… …eeds of Transnet over a wide range of p…
- Developing technology advancem… …e.

But not in isolation – working with all of you…

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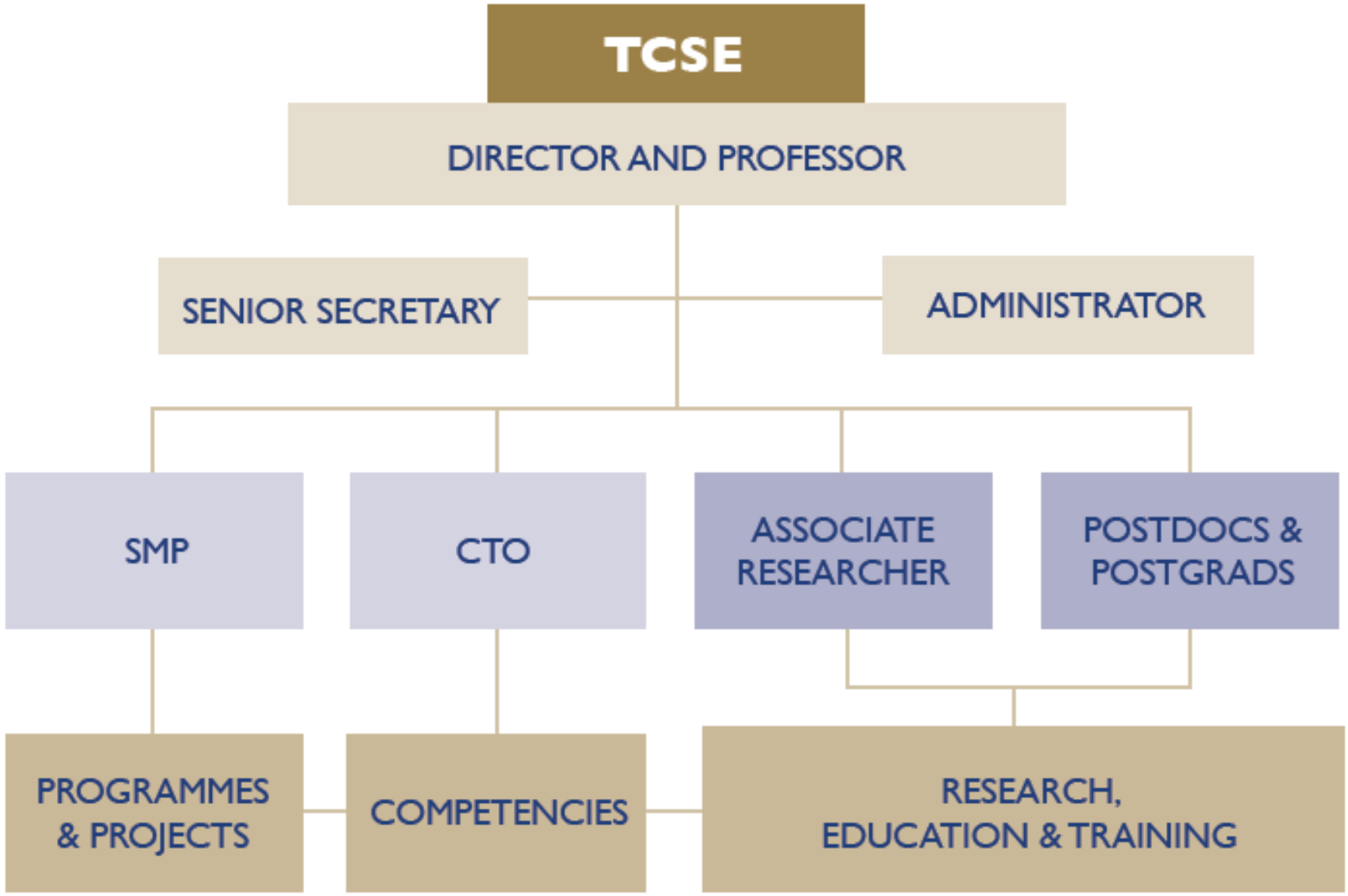
WITS TRANSNET CENTRE OF SYSTEMS ENGINEERING

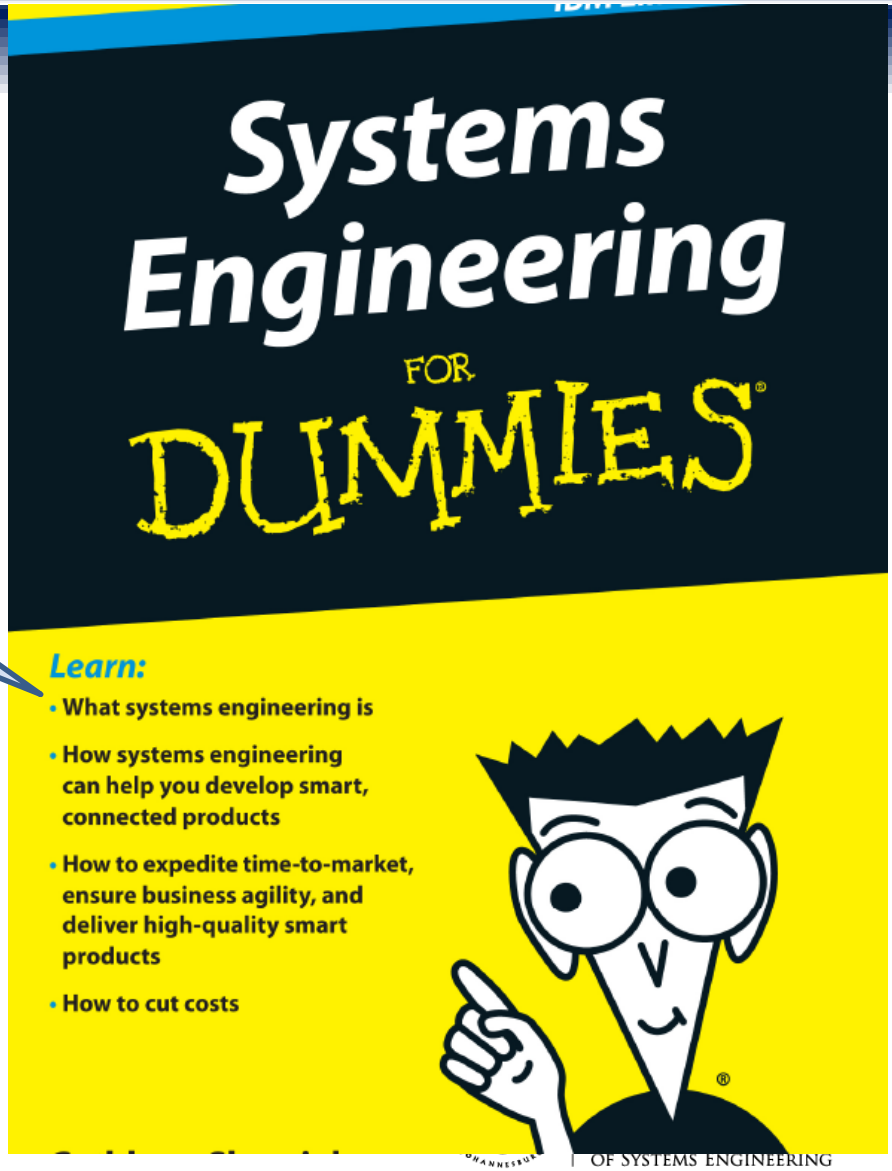
FACULTY OF ENGINEERING
& THE BUILT ENVIRONMENT



What is Systems Engineering /Systems Thinking?

We can see that SE is a well-recognised discipline....

Bell telephone laboratories 1940's



Further Confirmation of SE as a Recognised Discipline

The globally recognised source of all knowledge nowadays…….

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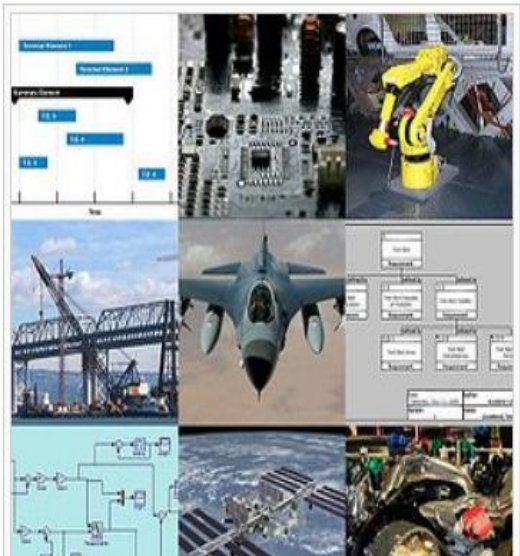
Systems engineering

From Wikipedia, the free encyclopedia

Systems engineering is an interdisciplinary field of engineering that focuses on how to design and manage complex engineering projects over their life cycles. Issues such as reliability, logistics, coordination of different teams (requirements management), evaluation measurements, and other disciplines become more difficult when dealing with large, complex projects. Systems engineering deals with work-processes, optimization methods, and risk management tools in such projects. It overlaps technical and human-centered disciplines such as control engineering, industrial engineering, organizational studies, and project management. Systems Engineering ensures that all likely aspects of a project or system are considered, and integrated into a whole.



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2.1 Origins and traditional scope

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Definitions of SE – our Preference….

- **Definition from Rechtin, *Systems Architecting of Organizations: Why Eagles Can't Swim:***
  - "Systems engineering is a methodical, disciplined approach for the design, realization, technical management, operations, and retirement of 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."

Where Does SE fit into an Organisation?

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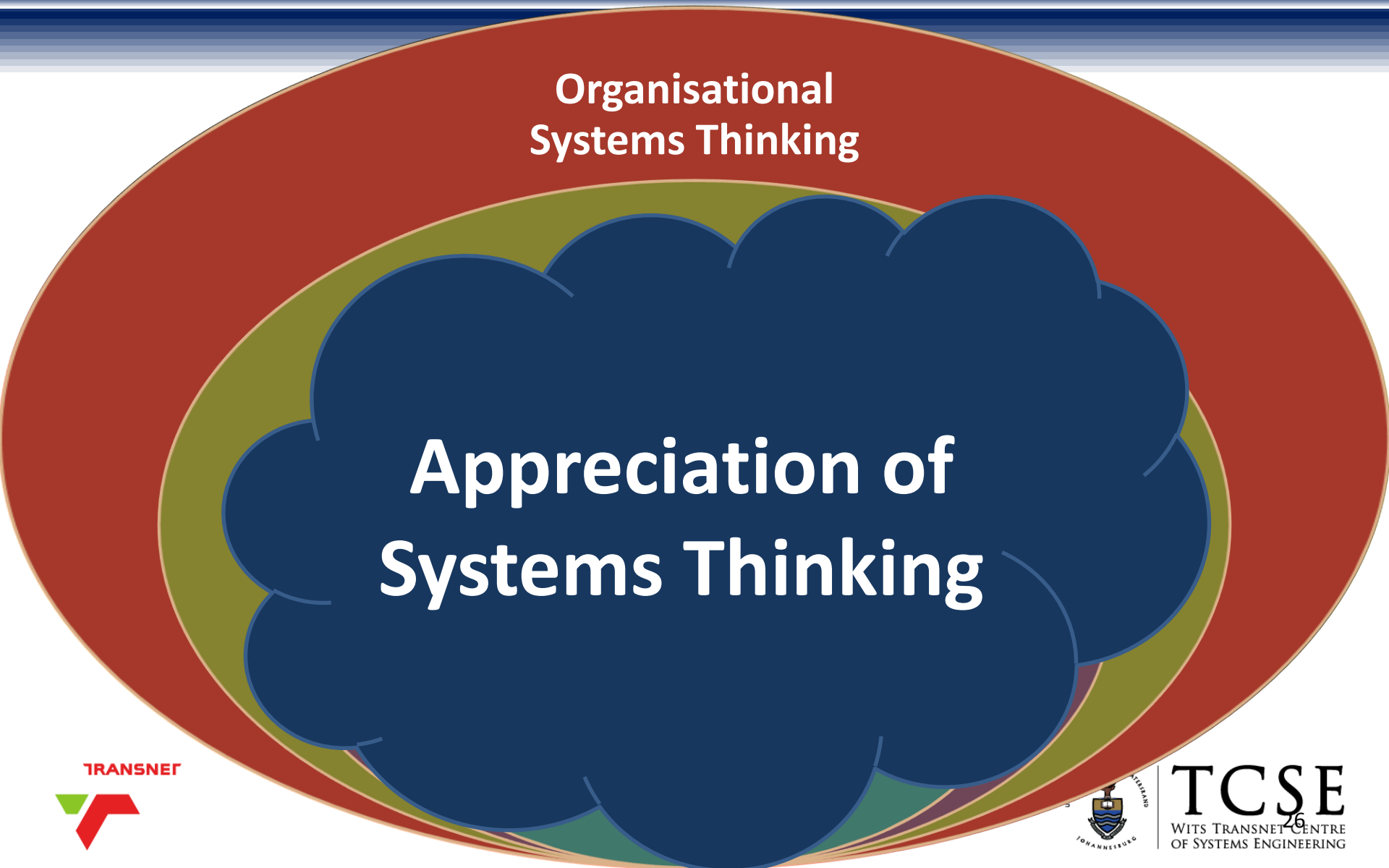
Where Does SE fit into an Organisation?



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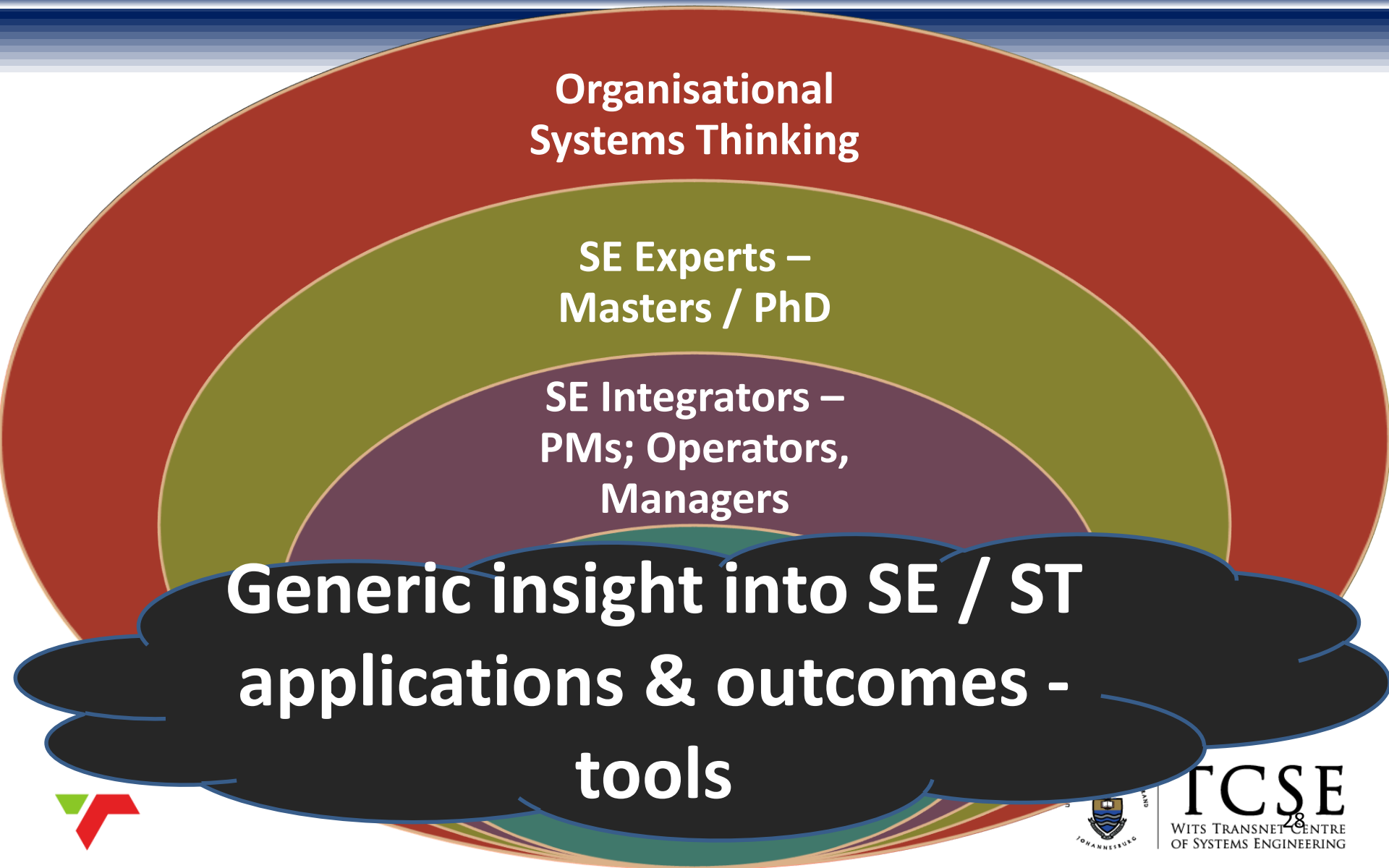

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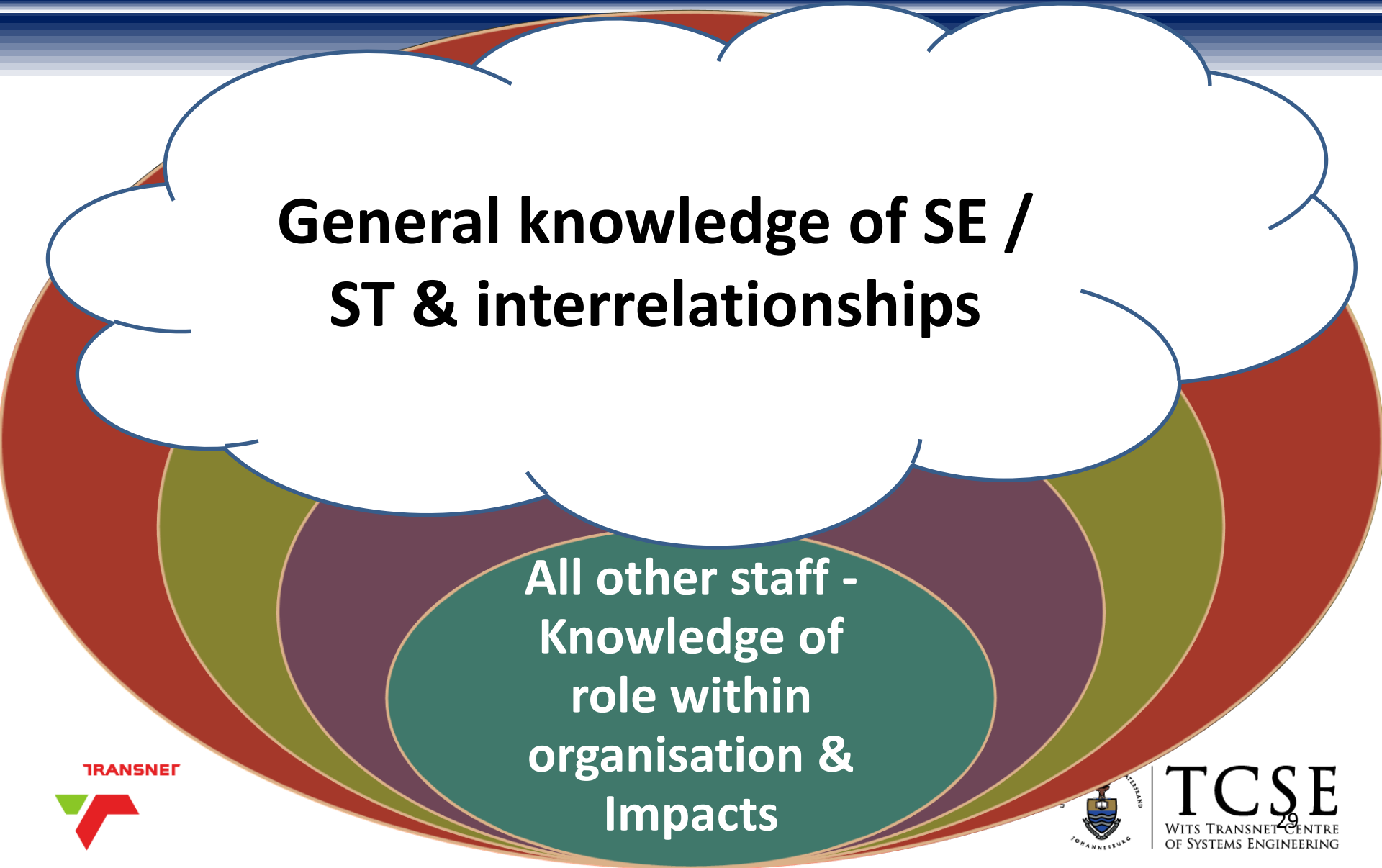
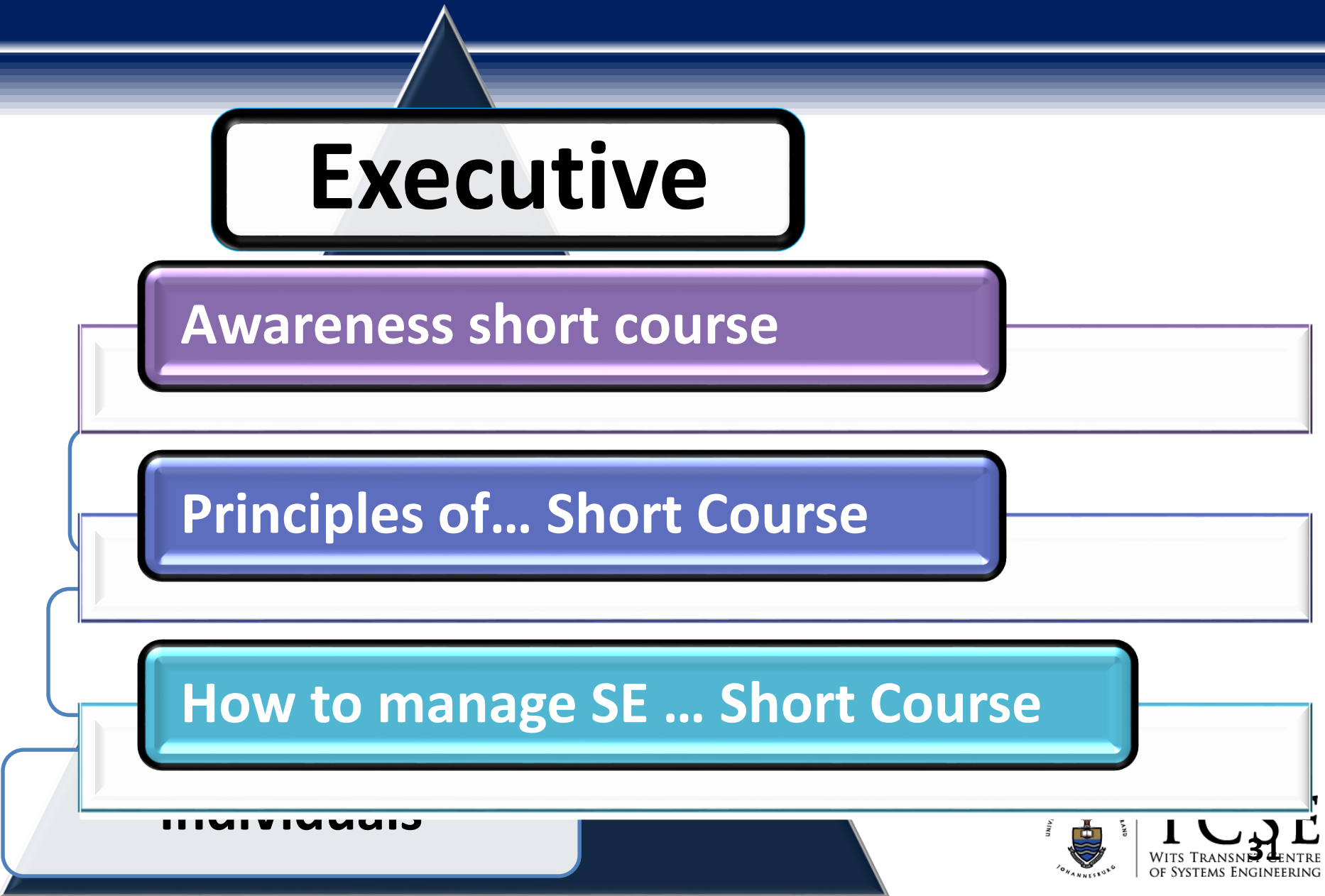
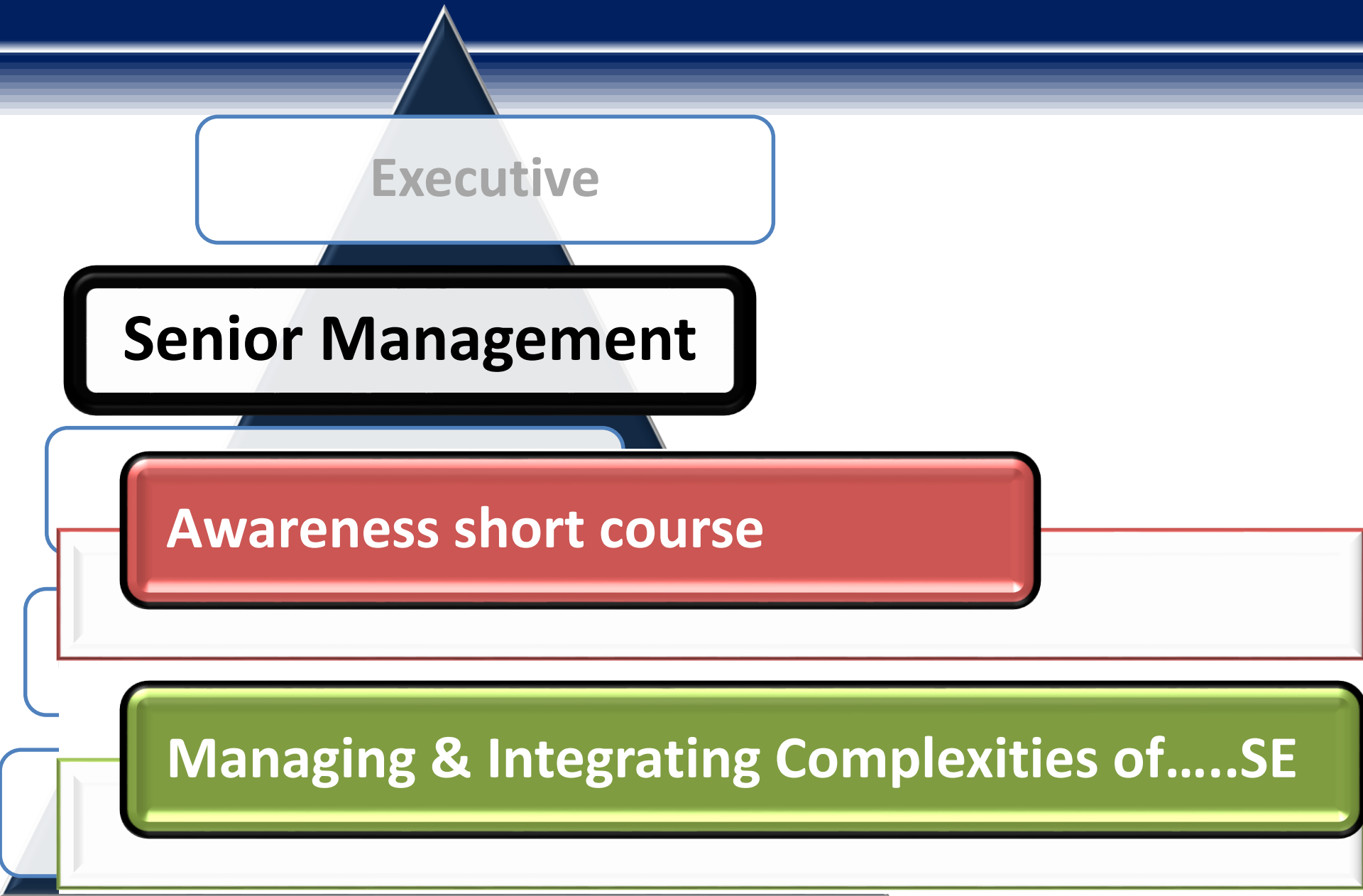


Conceptual Implementation in Organisations

Conceptual Implementation



Conceptual Implementation



Conceptual Implementation

- Awareness training
- Detailed “toolbox” training per preference
- Masters degree / PhD research
- Functional appointment of SE
- Daily involvement e.g. SEMP, Gate Reviews, etc.
- Readiness evaluations

Conceptual Implementation

- Awareness training
- Detailed “toolbox” across all functions
- Functional execution of SE
- Daily involvement e.g. SEMP, Gate Reviews, etc.
- Readiness evaluations
- CMMI application to measure

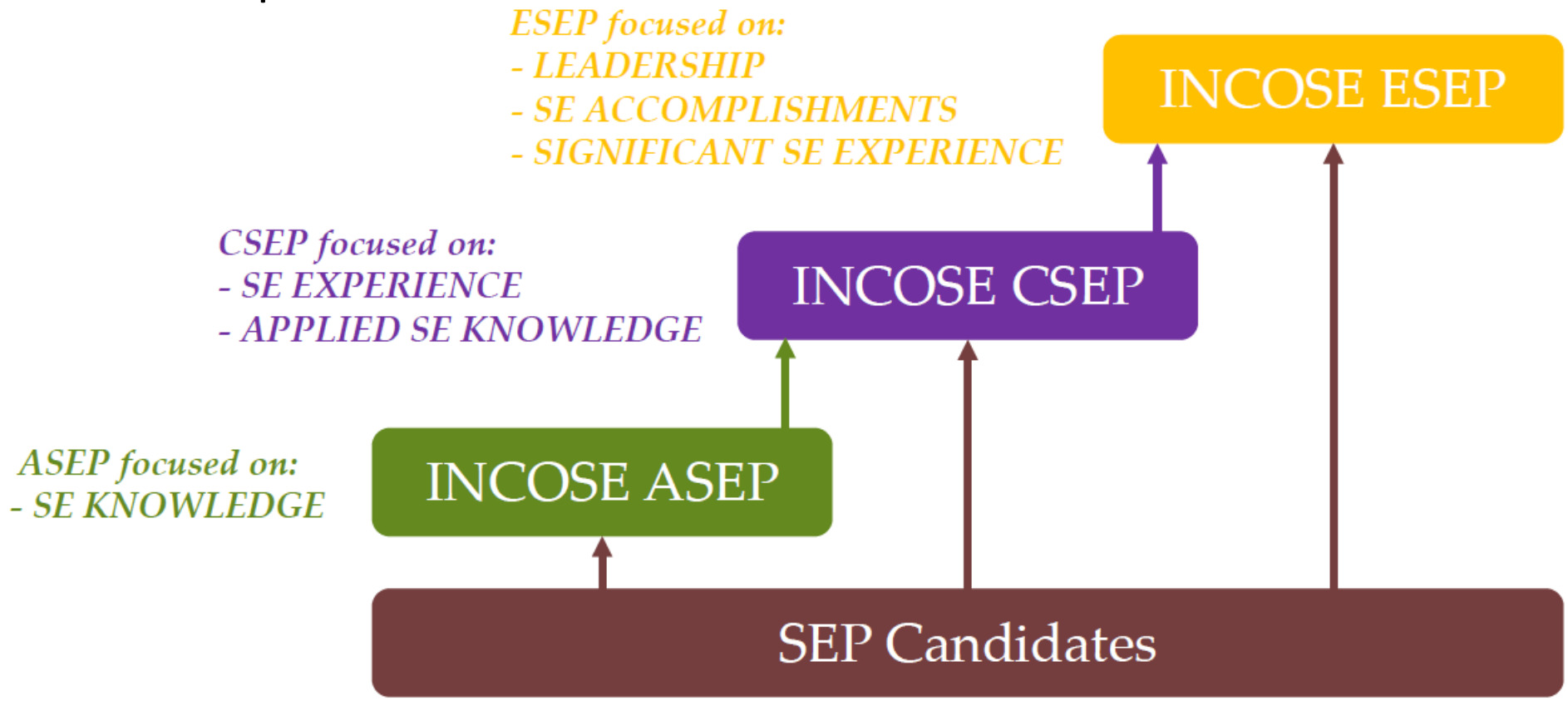
SE Tools and Methods

Systems engineering encourages the use of tools and methods to better comprehend and manage complexity in systems. Some examples of these tools can be seen here:

- System model, Modelling, and Simulation,
- Requirements analysis,
- System architecture,
- Optimization,
- System dynamics,
- System analysis,
- Statistical analysis,
- Reliability analysis, and
- Decision making.

INCOSE SE Qualifications

- SEBoK = Systems Engineering Body of Knowledge
- ASEP – Basic
- CSEP – Foundation
- ESEP - Expert



INCOSE SA SETWG

INCOSE International Council on Systems Engineering
South Africa

INCOSE SA, PO Box 67018, Highveld Park, 0169, South Africa

DOCUMENT TITLE: SYSTEMS ENGINEERING TRAINING WORKING GROUP CHARTER

DOCUMENT NUMBER: INCOSE SA 2011-01

DOCUMENT HISTORY

Revision	Approval date	Description	Author
1	29 May 2011	Original document	A G Smit
2	28 December 2011	Review comments included	A G Smit

1. PURPOSE

Systems Engineering (SE) training in South Africa is currently based on the initiative and perception of individual educational institutions and training providers. The real industry need for SE training and the requirements for such SE training are unknown.

The purpose of the INCOSE SA SE Training Working Group (WG) is to establish a consolidated SE training need for SA and to provide guidance on a SE reference curriculum.

2. GOALS

The goals of the INCOSE SA SE Training WG are to:

a. Establish the local need for SE training (from companies connected to the CHAPTER through corporate or individual membership).
b. Identify the current local offerings on SE training (from major academic institutions or service providers involved in SE training in South Africa).
c. Present a consolidated SE training need to local training providers.
d. Discuss the mapping of their respective offerings to the consolidated need with each academic institution or training provider individually.
e. With inputs from the BKCASE[1] project, provide guidelines on what a SE reference curriculum should include.
f. Establish a sustainable process for periodic review of SE training needs and guidelines.

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SETWG

3. SCOPE

The scope of the INCOSE SA SE Training WG is to consolidate SE training requirements for South Africa and provide guidance to educational institutions and training providers operating in South Africa on a SE reference curriculum that will address the consolidated SE training requirements.

4. INPUT REQUIREMENTS

a. List of companies connected to the CHAPTER through corporate or individual membership (from Membership Officer).
b. List of major academic institutions or service providers involved in SE training in South Africa.
c. Cooperation will be required from companies connected to the CHAPTER through corporate or individual membership, for the establishment of a consolidated need.
d. Cooperation will be required from major academic institutions or service providers involved in SE training in South Africa for:
    i. The establishment of current offerings.
    ii. Individual discussions on mapping of current offerings to the consolidated need.
    iii. Individual discussions on how current offerings can be tailored to meet the consolidated need.
e. INCOSE SA financial support for visiting individual organisations.
f. Support from employers of participating WG members to allow time for visiting individual organisations.

5. MEMBERS, ROLES AND RESPONSIBILITIES

Lead:	Alwyn Smit
Responsibilities:	Status Reporting to INCOSE SA President
	Chair at WG Meetings
	Recruitment of Members
	Working Group member database
	Working Group web page on INCOSE SA website
	Owner of LinkedIn INCOSE SA SE Training Group
Co-Lead(s):	To be determined later
Members:	To be listed in member database

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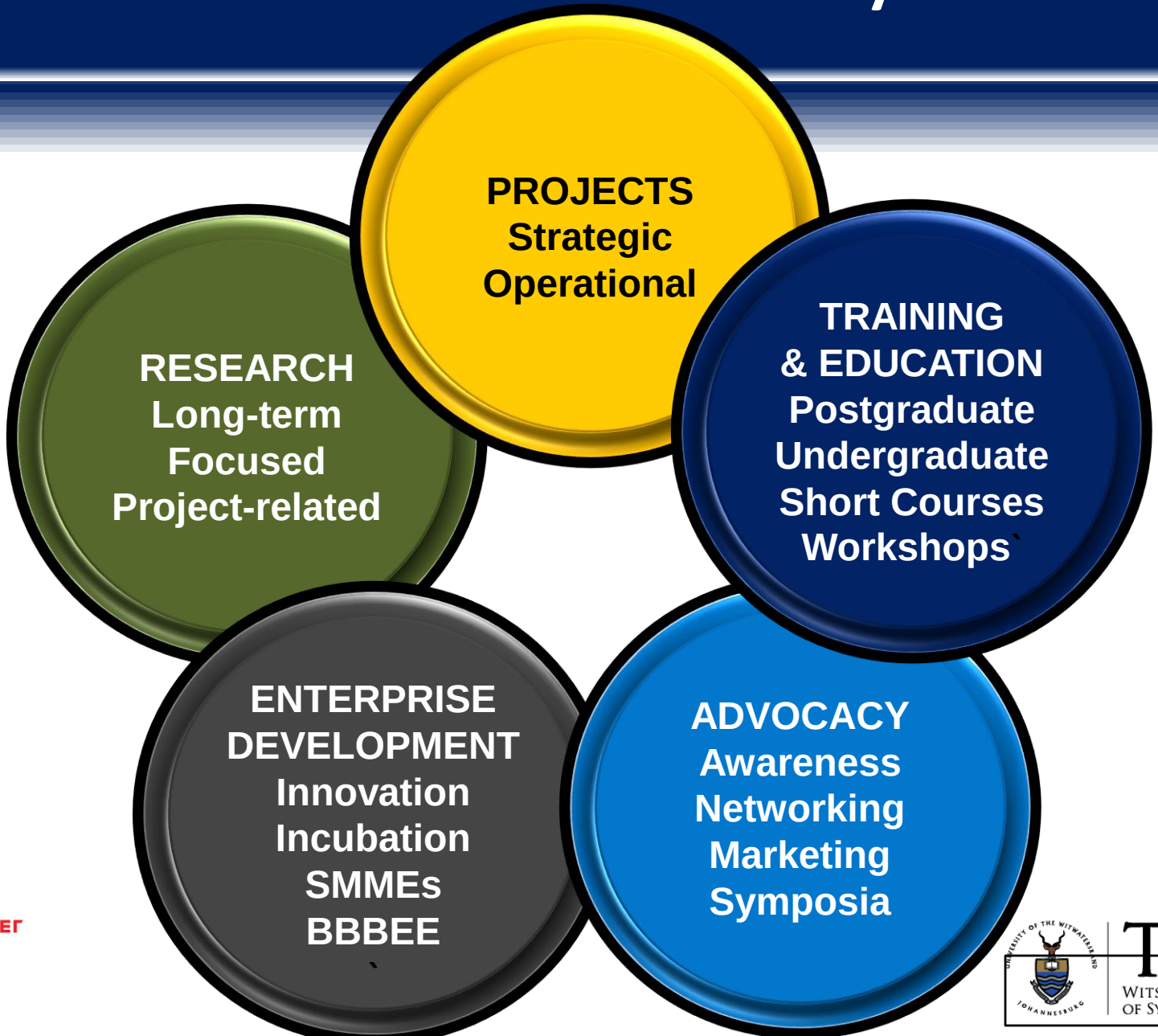
TCSE Five Main Streams of Activity



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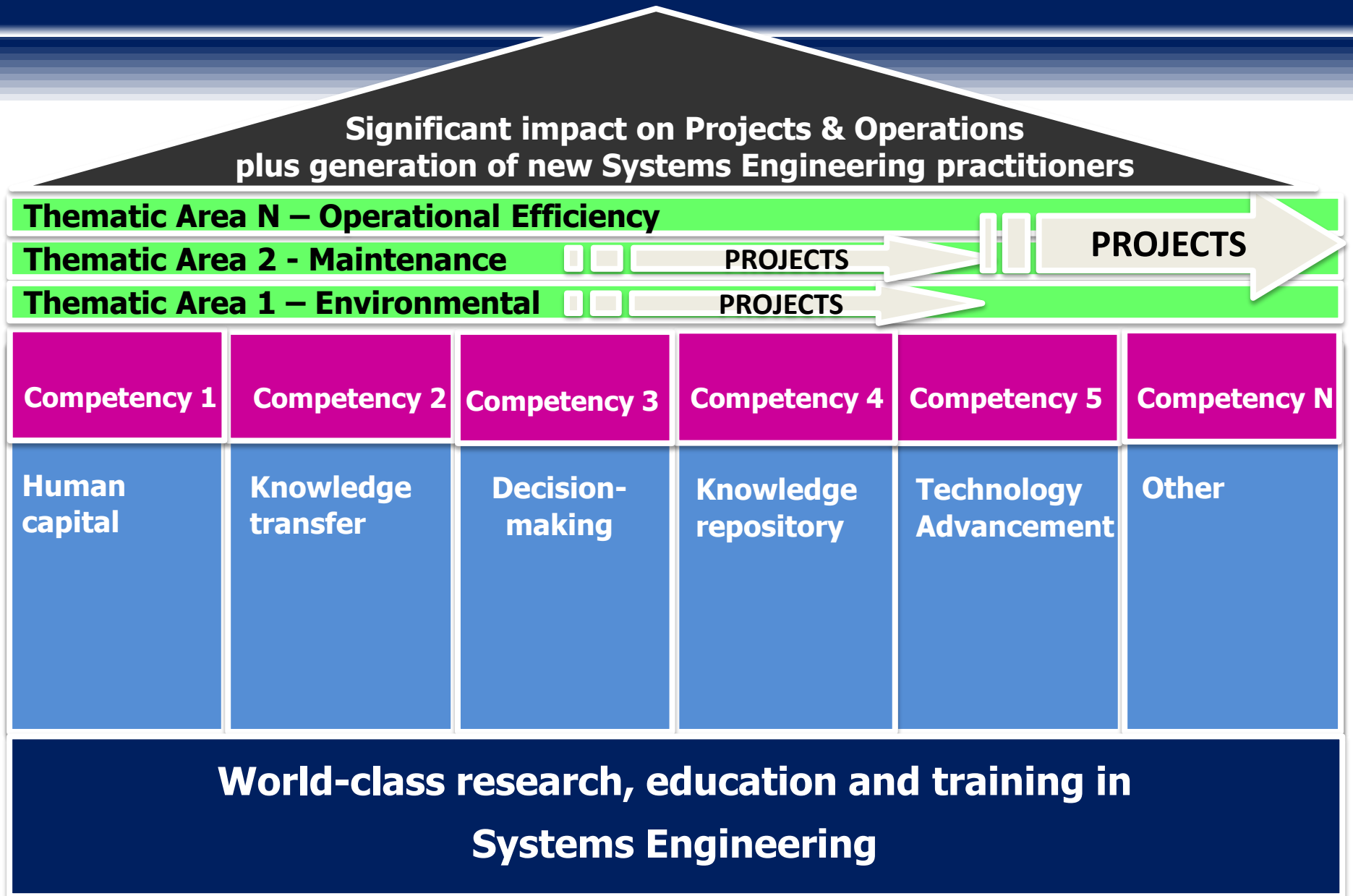
Thematic Areas, Competencies, Projects



Undergraduate SE Offerings to Consider

- **Strategy for undergraduate courses in various disciplines:**
  - make use of existing courses;
  - develop new appropriate courses;
  - perform project work where possible in SE;
  - move towards SE programmes as appropriate and possible.
- **CPD courses to also address other organisational levels.**
- **Investigating which other undergraduate courses, from other Institutions – SA and International - could conceivably be included in a comprehensive SE training curriculum, irrespective of source and/or institution of teaching.**
- **Joint degrees?**

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Undergraduate SE

- Ongoing discussions ongoing to implement appropriate SE content into undergraduate curricula at different institutions.
- ECSA broadening course requirement – an opportunity?
- E.g. @ Wits Three System Dynamics courses taught to 1st and 2nd year Biomedical Engineering students in Electrical and Information Engineering (EIE).
- E.g. @ UCT: MEC4103F – Product Design, a pre-requisite for MEC4108S – System Design. Both courses employ the well-tested V-model for the Systems Engineering process.

Postgraduate SE Offerings

- **Postgraduate (with Parallel CPD Courses) Education – Three Possible Programmes:**

Mainly coursework based, with minor research project contribution.

Combination of coursework and research project, but may be purely research based.

Normally purely research based (South Africa).

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Existing Postgraduate Systems Courses

- **Courses currently available at Masters level, each presented as a CPD course (or imminently so):**
  - Systems Engineering: an Overview
  - Systems Engineering: Architecture
  - Systems Engineering: Soft Systems Methodologies
  - Systems Engineering Management
  - Systems Engineering: Hard Systems Methodologies
  - Requirements analysis in Systems Engineering
  - Systems Engineering: Integration, Verification and Validation
  - Systems Engineering – Modelling and Simulation: Principles and Approaches
  - Enterprise Engineering

International Benchmarking

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SE Competencies Framework: Nov 2006 INCOSE UK

COMPETENCY AREA - Systems Thinking: *System Concepts*

Description:

The application of the fundamental concepts of systems thinking to systems engineering. These include understanding what a system is, its context within its environment, its boundaries and interfaces and that it has a lifecycle.

Why it matters:

Systems thinking is a way of dealing with increasing complexity. The fundamental concepts of systems thinking involves understanding how actions and decisions in one area affect another, and that the optimisation of a system within its environment does not necessarily come from optimising the individual system components.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	EXPERT
Is aware of systems concepts. Aware of the importance of; • system lifecycle • hierarchy of systems • system context • interfaces	Understands systems concepts. Understands the system lifecycle in which they are working. Understands system hierarchy and the principles of system partitioning in order to deal with complexity. Understands the concept of emergent properties. Can identify system boundaries and understands the need to define and manage the interfaces. Understands how humans and systems interact and how humans can be elements of systems.	Able to identify and manage complexity with appropriate techniques in order to reduce risk. Able to predict resultant system behaviour. Able to define system boundaries and external interfaces. Able to assess the interaction between humans and systems. Able to guide supervised practitioner.	Able to review and judge the suitability of systems solutions. Has coached new practitioners in this field. Has championed the introduction of novel techniques and ideas in this field which produced measurable improvements Has contributed to best practice.

BKCASE

Body of Knowledge and Curriculum to Advance Systems Engineering

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BKCASE Project Vision

This is the story of the BKCASE Project as envisioned by the core BKCASE team. This core team is comprised of six members; two members each from the lead project university, Stevens Institute of Technology, together with the Naval Postgraduate school, and the Department of Defense. We kicked off the BKCASE project in the Fall of 2009 with the vision that Systems Engineering competency models, certification programs, textbooks, graduate programs, and related workforce development initiatives around the world align with BKCASE – the Body of Knowledge and Curriculum to Advance Systems Engineering.

A D V O C A C Y

ACTIVITY LANDSCAPE OF THE WITS TCSE

RESEARCH OUTPUTS

PROJECTS OUTPUTS

ENTERPRISE DEVELOP-MENT OUTPUTS

TRAINING & EDUCATION OUTPUTS

CARRY OUT LONG-TERM, LARGELY PROJECT- RELATED RESEARCH

Optimization Methods; Human Factors; Fundamental Studies in Materials Handling; Energy; System Dynamics; Agent Based Modelling; Modelling of Medical Systems; etc.

DEFINE AND CARRY OUT STRATEGIC AND OPERATIONAL PROJECTS

Regenerative Braking; Simulators for Train Drivers; Carbon Footprint Application; Linear Wave generator; Handling Water-Sensitive Bulk; Pneumatic Off Loading of Sulphur; Weighing of Containers; etc.

CONCEPT 2: DEVELOP INNOVATION AND RESEARCH CENTRE

- Satellite facility for social, technological and business innovation.
- Transnet provides funding for R&D and related services.
- Transnet may source engineers from the School of Engineering to assist.
- Transnet will partner with existent structures such as CSIR/TIA.

MARKET and DELIVER UG and PG TECHNICAL & CPD COURSES

In the engineering disciplines: Mechanical; Electrical & Electronic; Civil; Mechatronics; Chemical; etc.

MARKET and DELIVER UG and PG SYSTEMS & CPD COURSES

Systems Thinking; Operations Research; Systems Engineering; System Dynamics; Enterprise Engineering; etc.

RESEARCH DEFINITION & FORMALIZATION

Formulated in terms of UG (vacation work, final year) or PG (MSc or PhD) research.

CARRY OUT COURSE & TRAINING DEVELOPMENTS & INCUBATION

Strategic Acquisition; Human Factors; Systems Engineering Course Development; Integrated Logistics; etc

CONCEPT 1: DEVELOP LOW-TECH SOLUTIONS TO HIGH-TECH CHALLENGES

1. Proof of market (< R 1 m)
2. Proof of concept (< R 3 m)
3. Development of prototype (< R 5 m)

MARKET and DELIVER BUSINESS DEVELOPMENT COURSES

Project Management; Group Dynamics; Principles of Economics; Operations Management, Accounting & Finance; Strategic Management; etc .

OTHER FORMS OF LEARNING

SHORT COURSES; WORKSHOPS; SELF-LEARNING; COLLABORATIVE LEARNING; TRAINING; MENTORING

STRATEGIC RESEARCH

May arise from promising proposals - accompanied by expertise - in longer term research, potentially of use to Transnet.. Unfunded research, by academic staff for example, may be allowed to be more distantly relevant to Transnet.

THEMATIC AREAS

OPERATIONAL EFFICIENCY; CAPITAL EXECUTION; MAINTENANCE; STRATEGY, PLANNING & EXECUTION; E-NABLEMENT; CLUSTERS OF EXCELLENCE; MARKET PENETRATION & RETENTION; KNOWLEDGE MANAGEMENT; ENVIRONMENTAL SUSTAINABILITY; TECHNOLOGY MANAGEMENT

+ Directed Supervision & Guidance

COMPETENCY DEVELOPMENT

SYSTEMS THINKING; INTER-PERSONAL; GROWTH ENABLING; NORMATIVE; ANTICIPATORY; STRATEGIC; BUSINESS UNIT SPECIFIC

Potential Roles of Partner HEIs in SE

- Direct inputs into projects and research in the context of thematic areas.
- Development of specialities in areas of relevance to Transnet or other SOCs, in which individual academics have competence. Could lead to performing a leadership role in such speciality.
- Supervision, mentorship and guidance of undergraduate bursary students.
- Supervision of postgraduate projects for degree purposes, pertaining to graduate engineers in Transnet.
- Development of undergraduate and postgraduate Systems Engineering (SE) courses, as required.
- Lecturing undergraduate and postgraduate SE courses, including contributions to Engineer in Training (EIT) programmes.

Potential Roles of Partner HEIs: Benefits

- Involvement can be on the basis of contracts, with commensurate financial support.
- Full funding (bursaries, etc) will be available for approved projects.
- Publishable research outputs have value in their own right.
- Opportunities exist to develop specialities that are valuable to Transnet and thus will have longer term relevance, support, persistence and sustainability.
- Joint postgraduate degree arrangements are possible between Wits University and the partnering HEIs.
- Additional postgraduate research students generally give impetus to research activities, with financial benefits (attributable income) accruing to the host institution.
- THRIP

TRANSNET

TCSE
WITS TRANSNET CENTRE OF SYSTEMS ENGINEERING

Thank You

Quo Vadis on SE training & education in SA …

Q&A - Discussion

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http://en.wikipedia.org/wiki/The_Wits_Transnet_Centre_of_Systems_Engineering_%E2%80%93_the_TCSE