International Council on Systems Engineering
A better world through a systems approach

The Art of Systems Thinking

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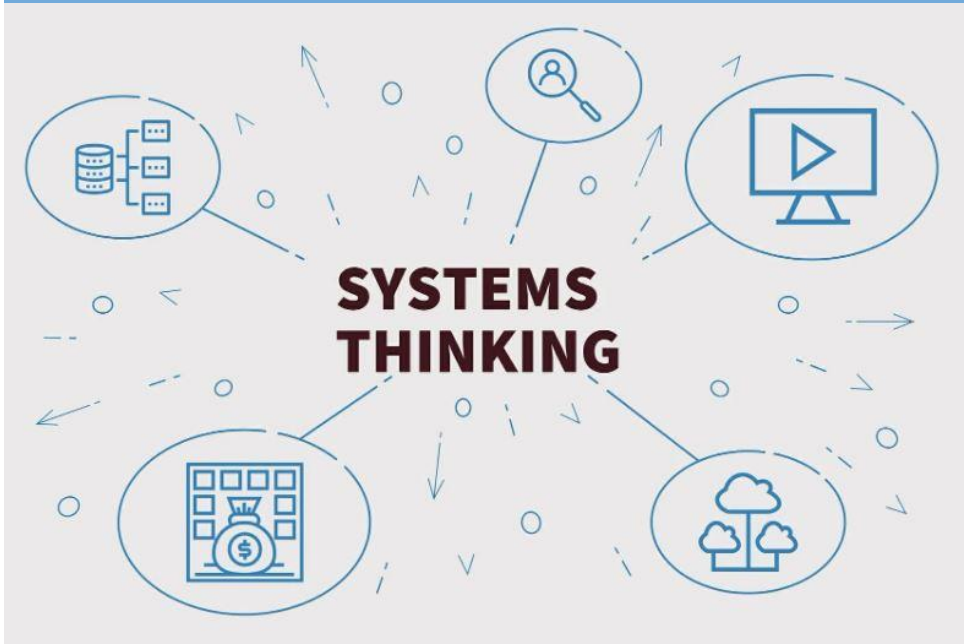
Systems Thinking

Systems thinking is a way of understanding complex problems by looking at how different parts interact within a larger system.

Rather than looking at events or problems in isolation, systems thinking helps us identify underlying causes and connections with other events.



Exploring Systems Thinking

Systems Thinking can be regarded as a diagnostic tool, enabling us to look at problems from multiple angles and help us ask better questions.

"No problem ever exists in complete isolation. Every problem interacts with every other problem and is therefore part of a set of interrelated problem, a system of problems."

Russell Ackoff

Who Applies Systems Thinking?

Ideally, everyone engineering systems should be applying some level of systems thinking.

For some, systems thinking is an intuitive process….

- A natural ability to see related patterns
- An understanding of how parts of a system are connected
- An ability to predict behaviors based on observed interactions

For others, this is a learned skill using methodical analysis.

In this SE Fundamental presentation skills are shared to highlight how systems thinking can be approached by anyone involved in engineering of complex systems (not just the systems engineers…)

INCOSE Competency Area: Systems Thinking

Per the INCOSE SE Competency Framework, Systems Thinking is a key competency to implement Systems Engineering processes:

	Technical Processes														Technical Management Processes							Agreement Processes		Organizational Project-Enabling Processes					
	Business or mission analysis	Stakeholder needs and requirements definition	System requirements definition	Architecture definition	Design definition	System analysis	Implementation	Integration	Verification	Transition	Validation	Operation	Maintenance	Disposal	Project planning	Project assessment and control	Decision management	Risk management	Configuration management	Information management	Measurement	Quality assurance	Acquisition	Supply	Life cycle model management	Infrastructure management	Portfolio management	Human resource management	Quality management	Knowledge management
Systems Thinking	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓	✓	✓✓✓	✓✓✓	✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓	✓	✓		✓	✓	✓			✓✓✓	✓	✓	✓	✓	✓

INCOSE Competency Area: Systems Thinking

Systems thinking is involved in every SE technical process area as well.

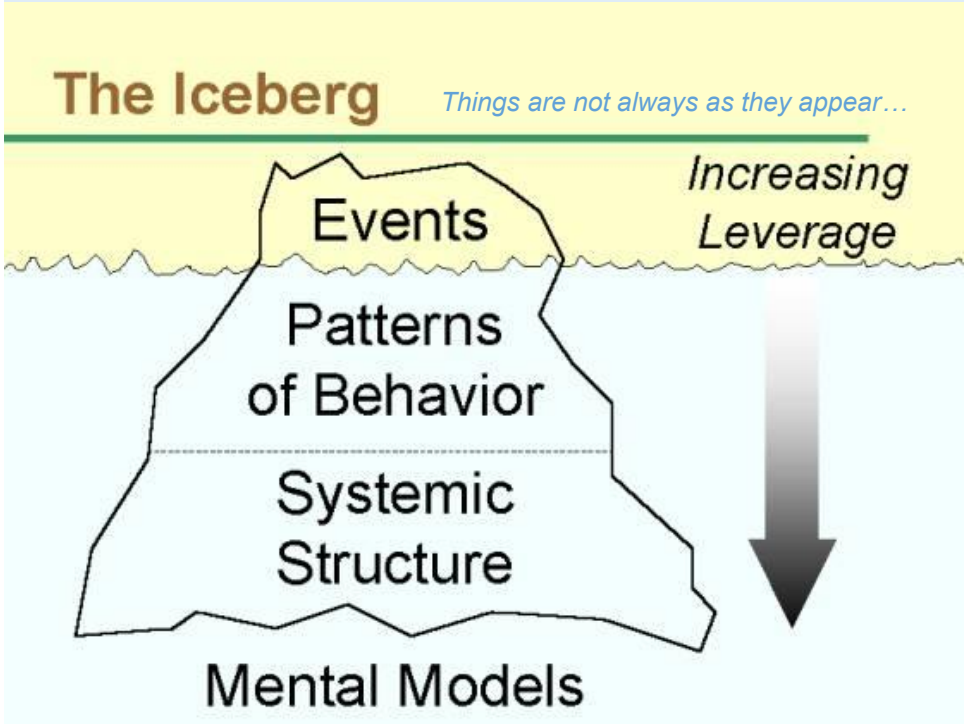
SEP PROGRAM TECHNICAL AREAS	Systems Thinking
Requirements Engineering	✓✓✓
Systems and Decision Analysis	✓✓✓
Architecture/Design Development	✓✓✓
Systems Integration	✓
Verification and Validation	✓
System Operation and Maintenance	✓
Technical Planning	✓✓✓
Technical Monitoring and Control	✓✓✓
Acquisition and Supply	✓
Information and Configuration Management	✓
Risk and Opportunity Management	✓✓✓
Lifecycle Process Definition and Management	✓
Specialty Engineering	✓✓✓
Organizational Project Enabling Activities	✓✓✓

The Iceberg Model

Systems thinking addresses the ability to look beyond the obvious and see the underlying structure and behaviors.

This can be demonstrated by the “iceberg model,” which is a metaphor for the hidden interactions that create events.

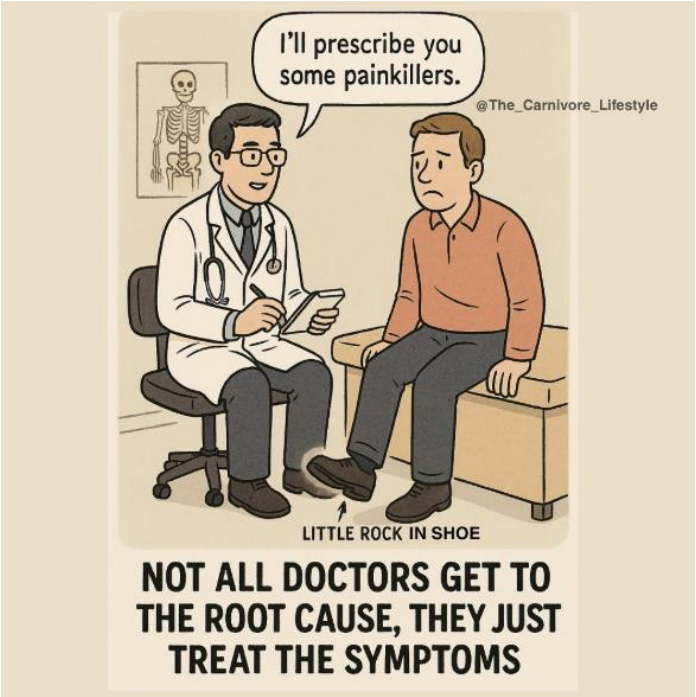
Each level down the iceberg offers a deeper understanding of the system being examined as well as increased leverage for changing it.



https://agsystemsthinking.net/2017/11/13/iceberg/

Problem Solving Without Using Systems Thinking

- Without systems thinking, there is a tendency to address the observed event without digging deeper.
- Solving a symptom addresses only the surface-level or immediate issues that are visible, rather than identifying and resolving the root cause of the problem.
- This is “Band-aiding” the issue instead of solving it!



Addressing the Symptom

Tire is flat

- Replace the Tire

One year later, new tire is flat

Starting to Apply Systems Thinking

Tire is flat

- Assess Road Conditions (no obvious hazards)
- Assess Tire
- Find wear in the tire

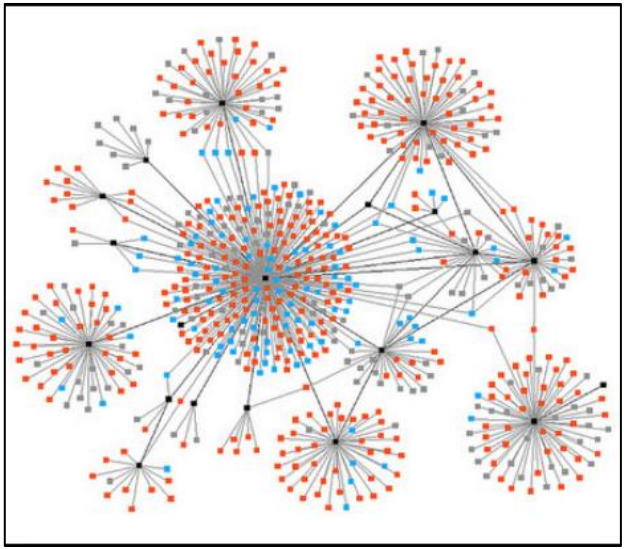
Why is there wear in the tire?

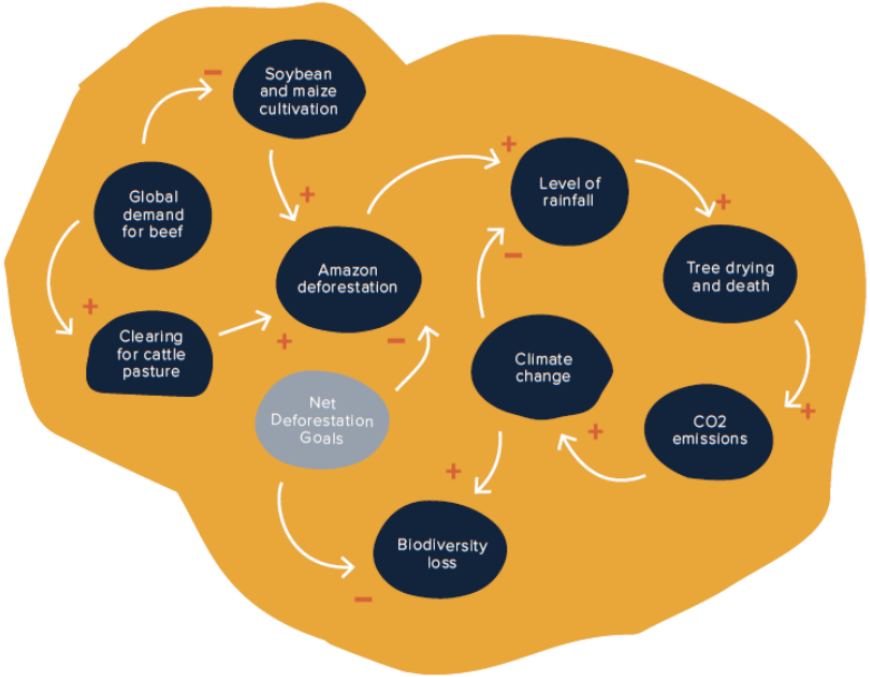
- Assess driver ability (careful driver)
- Assess vehicle alignment (tire is part of a system)
- Find vehicle is misaligned (root cause to degrade tire)

Fix vehicle alignment and replace tire

Systems Are Dynamic

- Systems can demonstrate emergence, meaning that the whole system can have properties or behaviors that aren't just the sum of its individual components.
- A key concept in systems thinking is feedback loops, where changes in one part of a system influence other parts, creating cycles that reinforce or balance the system.
- The Iceberg Model alone does not help visualize this set of interactions.





Using the “System Mapping” approach from System Dynamics is another way to apply systems thinking to understand system interactions.

https://marcabraham.com/2022/01/16/my-product-management-toolkit-48-systems-thinking/

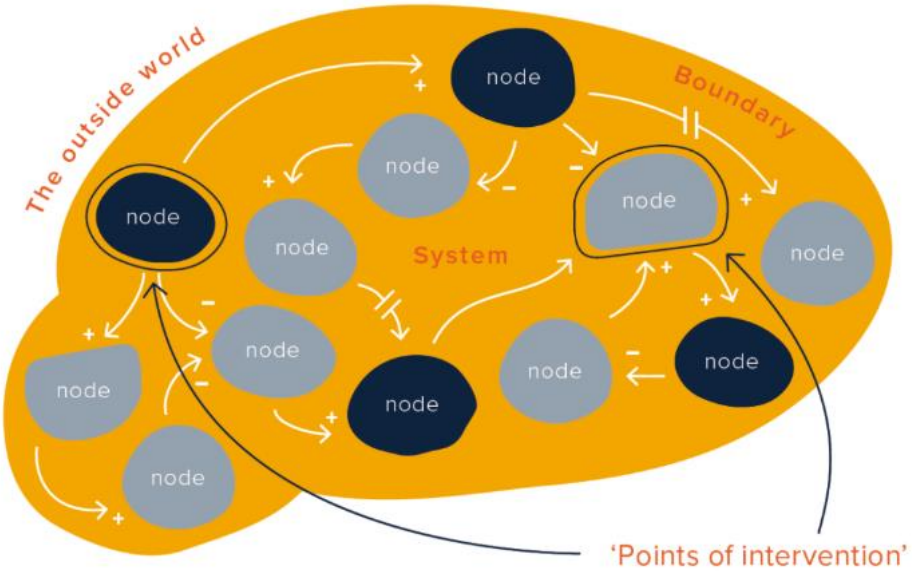


Image Credit: Xynteo

The point of these maps is to spend time identifying and understanding the different components of a system and the problems they might cause or amplify.

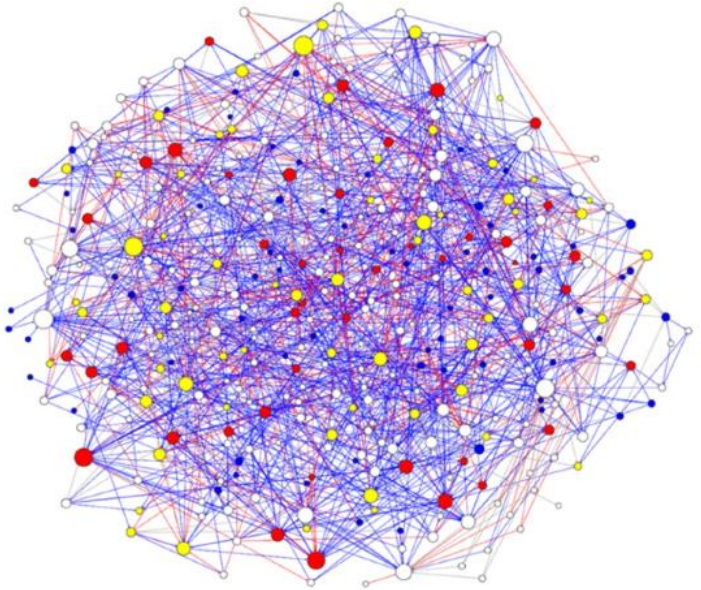
The next step is to think about 'interventions'; areas where taking action would have a desired effect through the system.

https://marcabraham.com/2022/01/16/my-product-management-toolkit-48-systems-thinking/

Case Study: Reforming agricultural policy design

Using systems thinking to deliver large-scale, rapid change in agricultural policy design and evaluation

- The UK Department for Environment, Food and Rural affairs underwent a systems mapping exercise to understand the agricultural system.
- They held workshops to develop the process maps, then integrated within modeling software applications.
- The outcome of using systems thinking on this project was a holistic approach for addressing complex, interrelated policy problems as well as a reduction of silos within their organization.

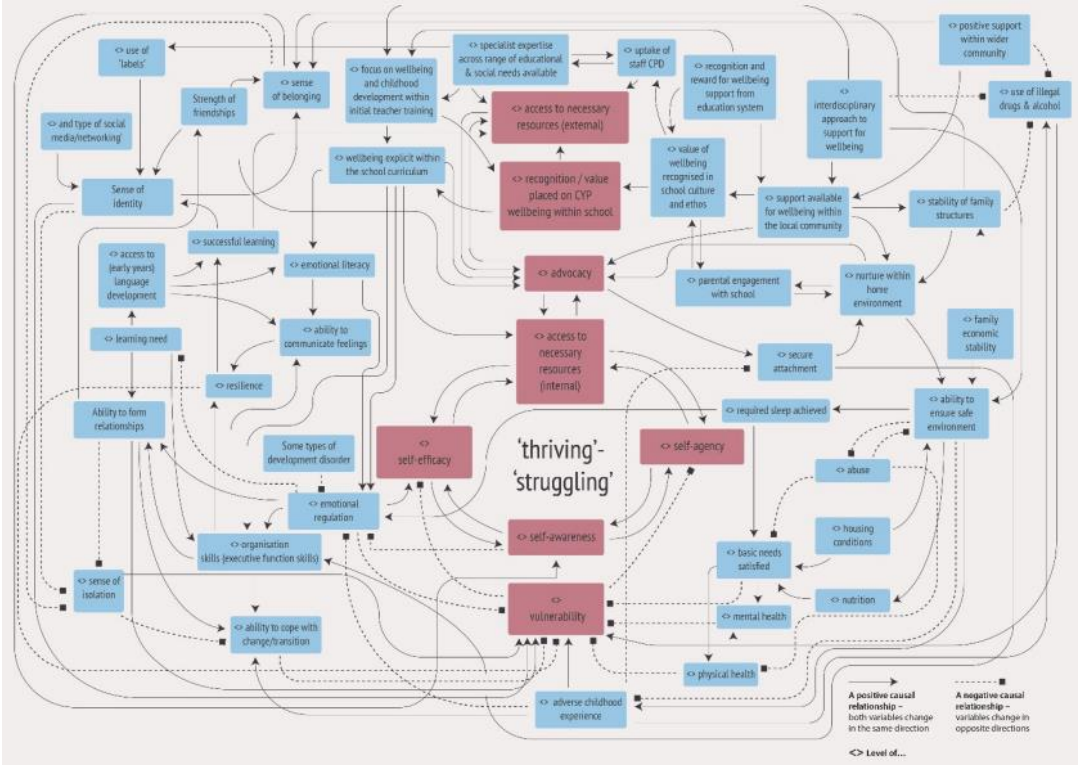


https://www.gov.uk/government/publications/systems-thinking-for-civil-servants/case-studies#case-study-2

Case Study: Child and Young People (CYP) Wellbeing

Using systems thinking to identify the influences on the wellbeing of young people.

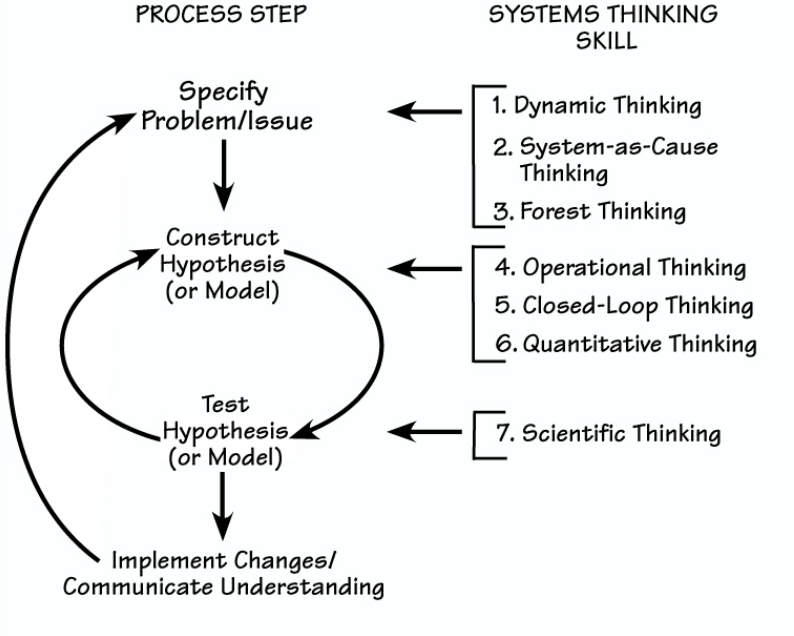
- The UK Department for Education performed system mapping as a way of capturing interdependencies and interrelationships which influence the wellbeing of the youth in their community.
- The resultant system map helped them identify various factors which resulted in improved wellbeing, this guided an approach to educate school personnel to help realize these results.



https://assets.publishing.service.gov.uk/media/5f2bcb51e90e0732e16a7b3c/A_system_mapping_approach_to_understanding_child_and_adolescent_wellbeing.pdf

Applying System Thinking Skills

- Based on the system being developed and where it is in the lifecycle, different systems thinking skills may be applied to help ensure a successful system.



https://thesystemsthinker.com/the-thinking-in-systems-thinking-honing-your-skills/

System Thinking Skills

- Being able to utilize different thinking skills can enable problem solvers to innovate holistic approaches.
- System Thinking is an Art, not an exact science, often experience and context can help define what skills best apply to situations.

SYSTEMS THINKING SKILL	PRACTICING THE SKILL
Dynamic Thinking: Framing a problem in terms of a pattern of behavior over time.	Construct behavior over time graphs; think of events as interesting points in a variable's overall trajectory over time.
System-as-Cause Thinking: Seeing internal actors who manage the policies and "plumbing" of the system as responsible for a behavior.	Instead of blaming, ask "How could those within the system have been responsible?" or "What could those within the system have done to make it more resilient to external shocks?"
Forest Thinking: Seeing beyond the details to the context of relationships in which they're embedded.	Focus on similarities rather than differences.
Operational Thinking: Understanding how a behavior is actually generated.	Ask "What is the true nature of a process?" rather than "What are all the factors that influence the process?"
Closed-Loop Thinking: Viewing causality as an ongoing process, not a one-time event, with effects feeding back to influence causes, and causes affecting each other.	Take a "laundry list" and try to understand how the items on it might influence each other.
Quantitative Thinking: Knowing how to quantify, though you can't always measure.	Ask what key "soft" variables have been left out of analyses, and ruminate about the implications of including them in your model.
Scientific Thinking: Knowing how to define testable hypotheses.	"Shock" a computer model by drastically changing the values of certain variables, to see how the model holds up.

https://thesystemsthinker.com/the-thinking-in-systems-thinking-honing-your-skills/

INCOSE Competency Area: Systems Thinking

Systems thinking is a foundational competency for the practice of systems engineering!

COMPETENCY AREA - CORE: SYSTEMS THINKING

Description:

The application of the fundamental concepts of systems thinking to Systems Engineering. These concepts include understanding what a system is, its context within its environment, its boundaries and interfaces, and that it has a life cycle. System thinking applies to the definition, development and production of systems within an enterprise and technological environment and is a framework for curiosity about any system of interest.

Why it matters:

Systems thinking is a way of dealing with increasing complexity. The fundamental concepts of systems thinking involve understanding how actions and decisions in one area affect another, and that the optimization of a system within its environment does not necessarily come from optimizing the individual system components. Systems Thinking is conducted within an enterprise and technological context. These contexts impact the life cycle of the system and place requirements and constraints on the systems thinking being conducted. Failing to meet such constraints can have a serious effect on the enterprise and the value of the system.

EFFECTIVE INDICATORS OF KNOWLEDGE AND EXPERIENCE

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Explains what "systems thinking" is and explains why it is important. [CSTA01]	Defines the properties of a system. [CSTS01]	Identifies and manages complexity using appropriate techniques. [CSTP01]	Creates enterprise-level policies, procedures, guidance and best practice for systems thinking, including associated tools. [CSTL01]	Communicates own knowledge and experience in systems thinking in order to improve best practice beyond the enterprise boundary. [CSTE01]
Explains what "emergence" is, why it is important, and how it can be "positive" or negative" in its effect upon the system as a whole. [CSTA02]	Explains how system behavior produces emergent properties. [CSTS02]	Uses analysis of a system functions and parts to predict resultant system behavior. [CSTP02]	Judges the suitability of project-level systems thinking on behalf of the enterprise, to ensure its validity. [CSTL02]	Influences individuals and activities beyond the enterprise boundary to support the systems thinking approach of their own enterprise. [CSTE02]
Explains what a "system hierarchy" is and why it is important. [CSTA03]	Uses the principles of system partitioning within system hierarchy on a project. [CSTS03]	Identifies the context of a system from a range of viewpoints including system boundaries and external interfaces. [CSTP03]	Persuades key enterprise-level stakeholders across the enterprise to support and maintain the technical capability and strategy of the enterprise. [CSTL03]	Advises organizations beyond the enterprise boundary on the suitability of their approach to systems thinking. [CSTE03]
Explains what "system context" is for a given system of interest and describes why it is important. [CSTA04]	Defines system characteristics in order to improve understanding of need. [CSTS04]	Identifies the interaction between humans and systems, and systems and systems. [CSTP04]	Adapts existing systems thinking practices on behalf of the enterprise to accommodate novel, complex or difficult system situations or problems. [CSTL04]	Advises organizations beyond the enterprise boundary on complex or sensitive systems thinking issues. [CSTE04]
Explains why it is important to be able to identify and understand what interfaces are. [CSTA05]	Explains why the boundary of a system needs to be managed. [CSTS05]	Identifies enterprise and technology issues affecting the design of a system and addresses them using a systems thinking approach. [CSTP05]	Persuades project stakeholders across the enterprise to improve the suitability of project technical strategies in order to maintain their validity. [CSTL05]	Champions the introduction of novel techniques and ideas in systems thinking beyond the enterprise boundary, in order to develop the wider Systems Engineering community in this competency. [CSTE05]

INCOSE Competency Area: Systems Thinking

AWARENESS	SUPERVISED PRACTITIONER	PRACTITIONER	LEAD PRACTITIONER	EXPERT
Explains why it is important to recognize interactions amongst systems and their elements. [CSTA06]	Explains how humans and systems interact and how humans can be elements of systems. [CSTS06]	Uses appropriate systems thinking approaches to a range of situations, integrating the outcomes to get a full understanding of the whole. [CSTP06]	Persuades key stakeholders to address enterprise-level issues identified through systems thinking. [CSTL06]	Coaches individuals beyond the enterprise boundary in systems thinking techniques, in order to further develop their knowledge, abilities, skills or associated behaviors. [CSTE06]
Explains why it is important to understand purpose and functionality of a system of interest. [CSTA07]	Identifies the influence of wider enterprise on a project. [CSTS07]	Identifies potential enterprise improvements to enable system development. [CSTP07]	Coaches or mentors practitioners across the enterprise in Systems thinking in order to develop their knowledge, abilities, skills or associated behaviors. [CSTL07]	Maintains expertise in this competency area through specialist Continual Professional Development (CPD) activities. [CSTE07]
Explains how business, enterprise and technology can each influence the definition and development of the system and vice versa. [CSTA08]	Uses systems thinking to contribute to enterprise technology development activities. [CSTS08]	Guides team systems thinking activities in order to ensure current activities align to purpose. [CSTP08]	Promotes the introduction and use of novel techniques and ideas in systems thinking across the enterprise, to improve enterprise competence in this area. [CSTL08]	
Explains why it may be necessary to approach systems thinking in different ways, depending on the situation, and provides examples. [CSTA09]	Develops their own systems thinking insights to share thinking across the wider project (e.g. working groups and other teams). [CSTS09]	Develops existing case studies and examples of systems thinking to apply in new situations. [CSTP09]	Develops expertise in this competency area through specialist Continual Professional Development (CPD) activities. [CSTL09]	
	Develops own understanding of this competency area through Continual Professional Development (CPD). [CSTS10]	Guides new or supervised practitioners in System thinking techniques in order to develop their knowledge, abilities, skills or associated behaviors. [CSTP10]		
		Maintains and enhances own competence in this area through Continual Professional Development (CPD) activities. [CSTP11]		

Where to Learn More

- INCOSE SE Competency Framework v2 (2025), INCOSE Store.
- How Systems Thinking contributes to Systems Engineering, INCOSE UK. https://incoseuk.org/Documents/zGuides/Z7_Systems_Thinking_WEB.pdf
- What is Systems Thinking? SEBoK. https://sebokwiki.org/wiki/What_is_Systems_Thinking?
- Introduction to Systems Thinking. The Systems Thinker. https://thesystemsthinker.com/introduction-to-systems-thinking/
- The “Thinking” in Systems Thinking: Honing Your Skills. The Systems Thinker. https://thesystemsthinker.com/the-thinking-in-systems-thinking-honing-your-skills/
- Intro to Systems Mapping https://youtu.be/wrBDy91M7-0

Thank You!

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