



30th Annual **INCOSY**
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Addressing Cognitive Bias in Engineering Teams



What is a System?

A **System** is an arrangement of parts or elements that together exhibit **behavior** or **meaning** that the individual constituents do not.

A *physical* system exhibits **behavior**
A *conceptual* system exhibits **meaning**

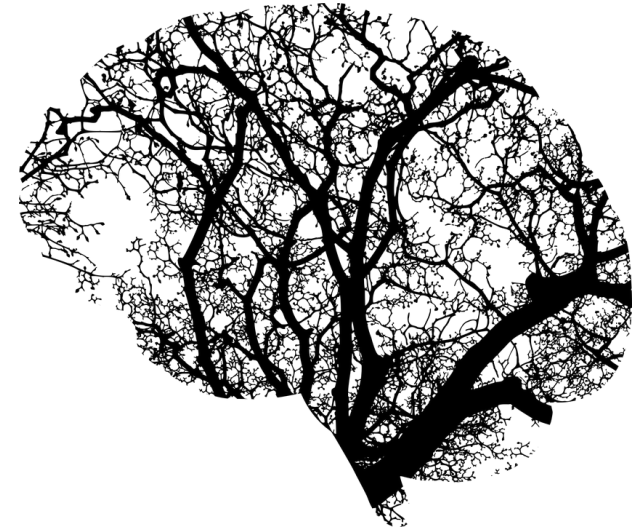
International Council on Systems Engineering
INCOSE Definitions Report (2019)

<https://www.incose.org/about-systems-engineering/system-and-se-definitions>



What is Thinking?

- **Conscious** versus **unconscious** thought: Are the contents of consciousness *thoughts* or the *product of thoughts*?
- **Sub-vocal** talking versus **non-verbal** thoughts
- **Emotional** versus **rational** thought
- Physiological correlates of thought: *Is the brain activity that can be measured during thought the thought itself?*



Systems and critical thinking includes all the conscious and unconscious, verbal and non-verbal, emotional, and rational thoughts about systems.

What is Cognition?

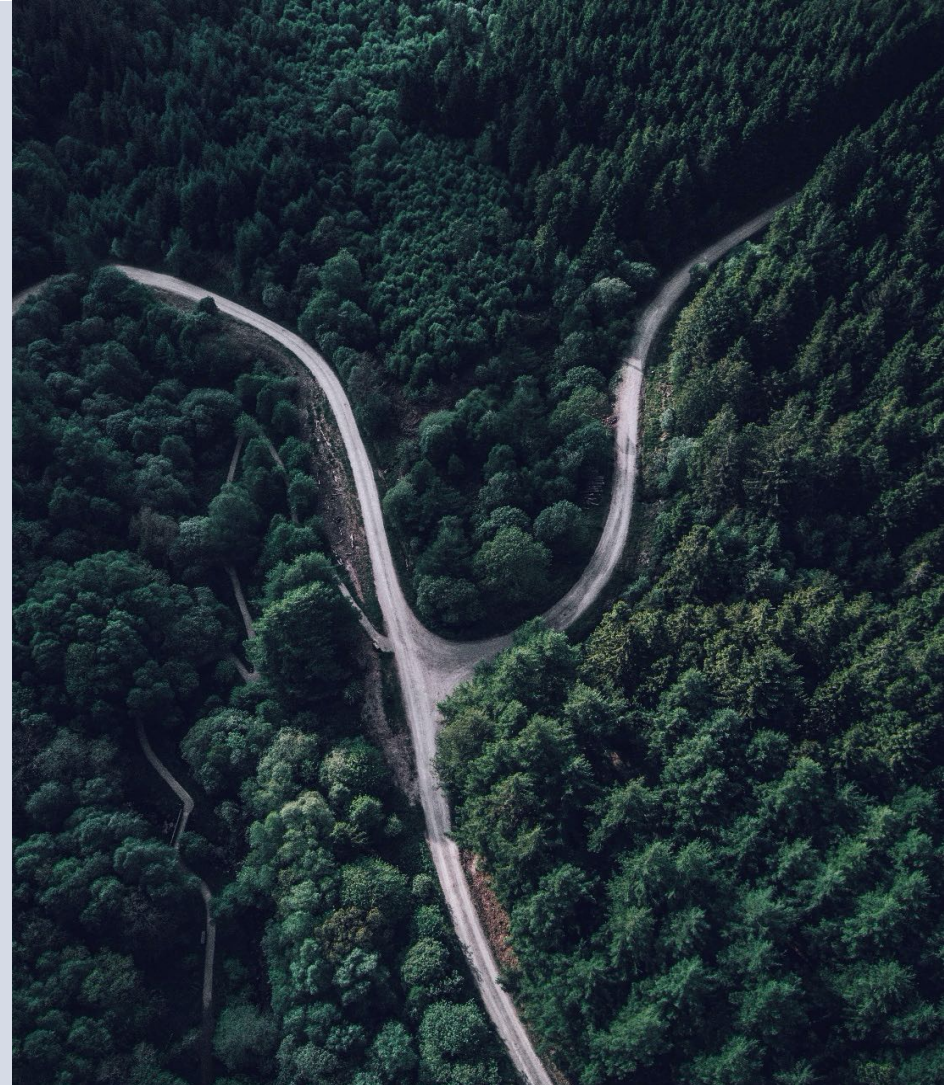
- **Cognition** is the information-processing activity associated with thought. It involves processing of data from the senses, storing and retrieving information to and from memory, transforming information, and preparing responses.
 - *Various information processing models and metaphors, often driven by the most recent information processing technology of an era.*
- Information processed in cognition can be represented in various ways, such as verbal, spatial, visual, auditory, relational, etc.





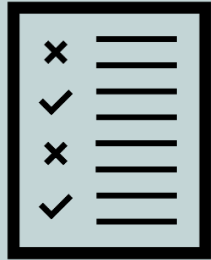
What is Decision Making?

- ***Decision making*** is the generation of alternatives and the selection of one of those alternatives, which is then used to prepare the response.
- ***Decision making*** is the cognitive process by which a response is selected from among two or more identified alternatives
- These cognitive processes **do not tend to follow formal rules of logic** or other formal descriptions.





Conceptual Approaches to Decision Making



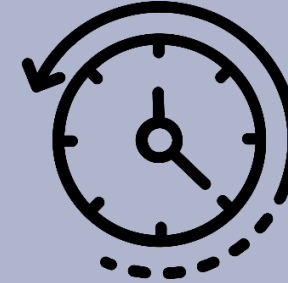
Rational Man

Decisions (should be) made rationally, by due consideration of all relevant factors, weighing probabilities, assigning values to possible outcomes, and selecting the best overall alternative given the available data and effort



“Satisficing” Decisions

Decisions are made by progressively considering possible actions and estimating the likely outcome, until a satisfactory outcome is identified



Recognition- Primed Decisions

Decisions are made based on outcomes experienced in similar situations in the past

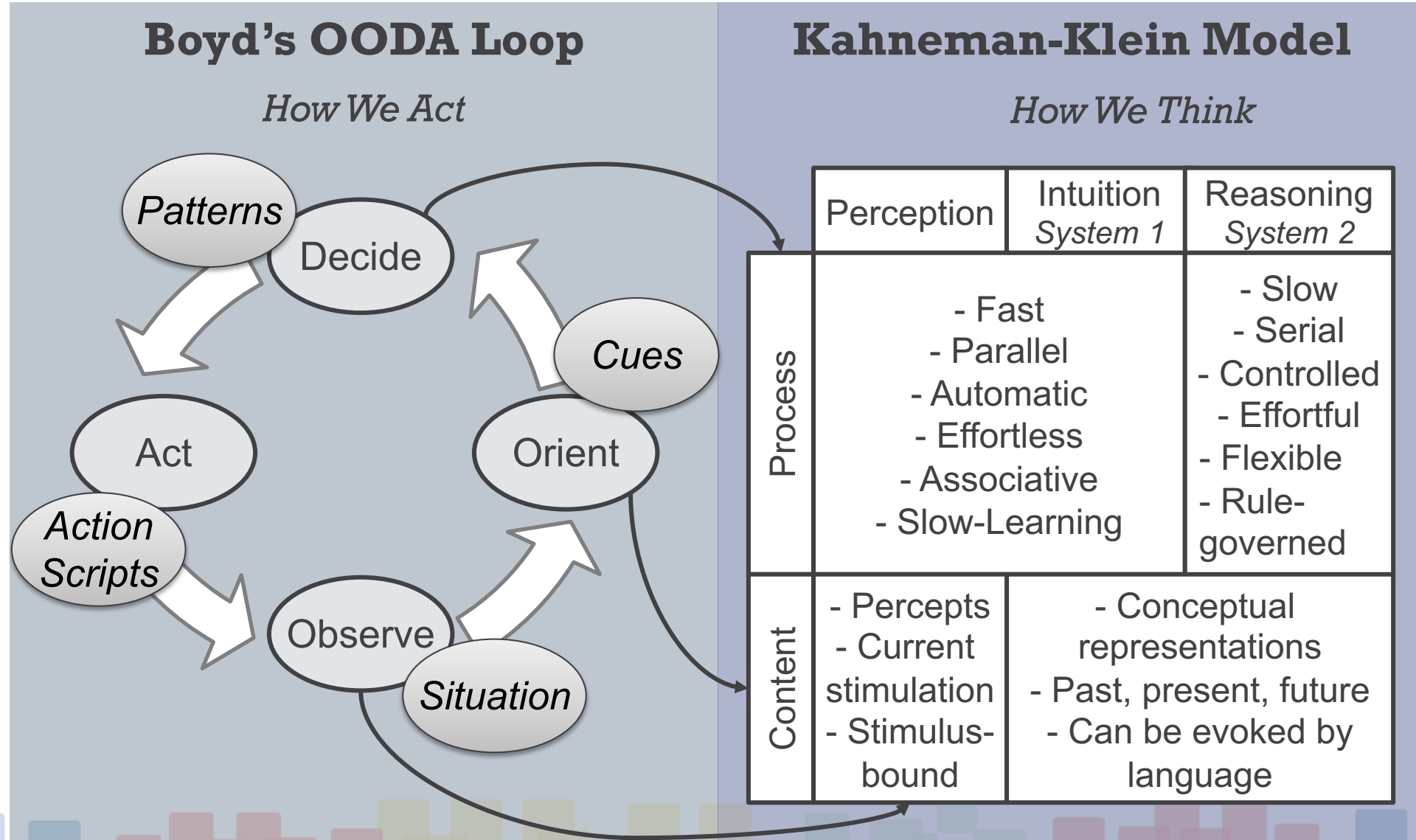


Thinking Fast and Slow

System 1	System 2
An intuition-based decision-making system that makes decisions quickly, often in the context of emotional factors.	A slower, controlled cognitive process that can temporarily inhibit the responses selected by the System 1 activity
It operates in all decisions and generally has priority.	It sometimes leads to a different decision than System 1 produced.
<i>This is based on the body of work by Daniel Kahneman</i>	



Dynamic Model of Decision Making





Economy of Information Processing

- **Cognition**-Characteristic errors in decision making are thought to arise from biases in cognitive processes
- **Economy**- These biases may be rooted in unconscious strategies to economize expenditure of effort in processing information
- **Utility**- Many of these have been useful in avoiding physical danger



Typical Information Biases

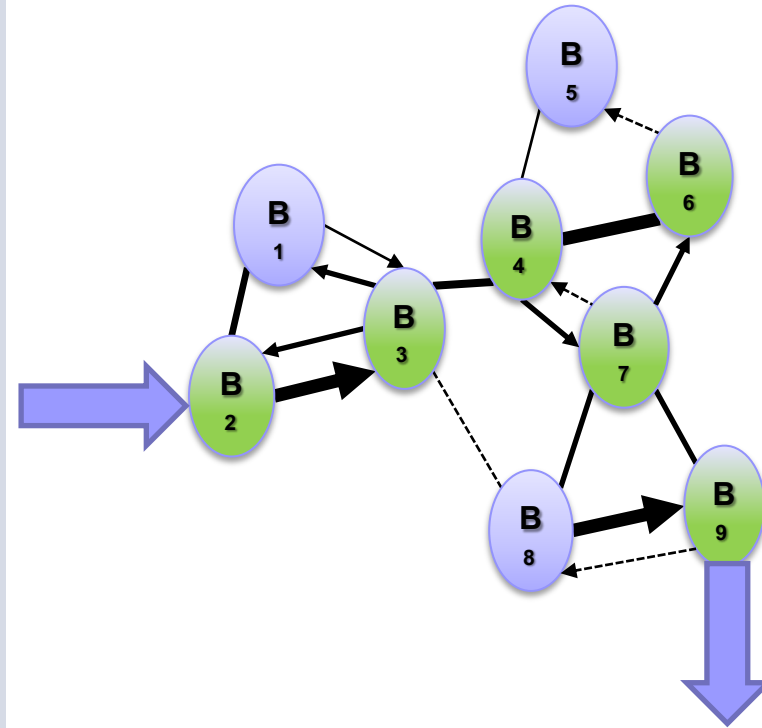
- Sensitivity to Information
 - Vividness (especially images, video, audio)
 - Authority (when visual information represents authority or trust)
 - Randomness (causal relationships assumed for similar events or visual info)
- Irrelevant Information
 - That has emotional appeal, is rare or unique
 - Volume of information often implies authority
 - Decisions often influenced by recent or well-known events





Networks of Beliefs Produce Bias

- **Cognitive Belief Network (CBN):** Individuals possess various related beliefs, many consistent, some contradictory
- **Three belief parameters:**
 - Veracity (strength)
 - Epsilon (malleability)
 - Defense (resistance)
- **Outputs reflect related beliefs**





Typical Belief Biases

- Belief driven
 - Confirmation – tendency to gather and interpret information that supports our experience or beliefs, and ignore other information
 - Sunk Cost – tendency to consider past (sunk) effort or cost in future decisions, even though they have no impact on the future
 - In-Out Group Bias – tendency to explain outcomes based on behavioral traits
 - Positive traits of in-group actors are viewed as resulting in good outcomes (hard work paid off), while external factors are associated with their bad outcomes (just had bad luck).
 - External factors are viewed as resulting in good outcomes (got lucky), while negative traits of are associated with their bad outcomes (got what they deserved).



Application to Systems Engineering

- Human perception and cognition (and errors) are key considerations in developing a concept for a new system and in understanding existing systems.
- Systems engineering is often portrayed as a logical sequence, with straightforward deductive reasoning leading from one level to the next.
- In practice, systems engineering is a human enterprise subject to the same biases and errors in decision making as any other human activity. Human information processing commonly leads to biased decisions, some of which are beneficial, but some are erroneous.
- Decisions are generally motivated by emotional or other irrational factors. This needs to be understood by systems engineers.

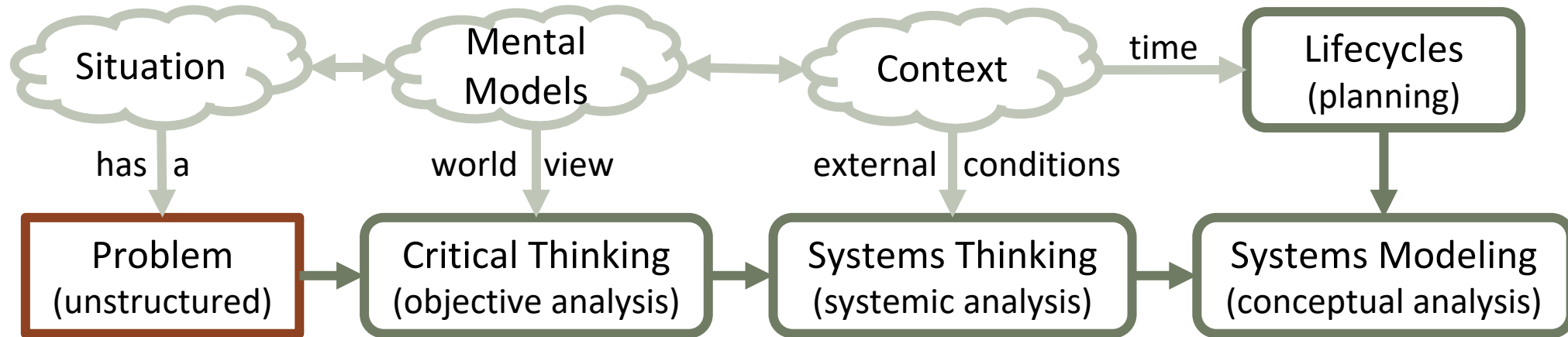


Application to Systems Engineering

- Confronting bias and characteristic error goes beyond basic facilitation and team leadership practices. It involves awareness of these common biases and the ability to council individuals when they are occurring.
- This is a very difficult aspect of systems engineering and team leadership, as denial of bias is another very human trait.
- In particular, fundamental attribution bias is difficult to overcome when groups are deeply divided.



Systems & Critical Thinking



- The process of systems and critical thinking helps to overcome bias by explicitly studying multiple human perspectives of a decision space



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