Coping with Complexity in Command and Control

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Introduction

- Effective Command and Control (C2) is key to operations
- C2 has to operate in a increasingly complex environment:
  - War amongst the people.
  - Fog of war.
  - Communication technology.
- C2 system support human to solve “Wicked and Messy” problems:
  - Improve sense-making through effective HMI.
  - HMI need to support cognitive and social capabilities of humans.
- Cognitive System Engineering address cognitive and social aspects:
  - Cognitive Work Analysis.
  - Cynefin Framework.

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SCOPE

- Command and Control Defined
- Complexity Defined
- Command and Control as a Complex System
- Cognitive system Engineering
- Coping with Complexity in Command and Control
- Conclusion

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War

Modern War

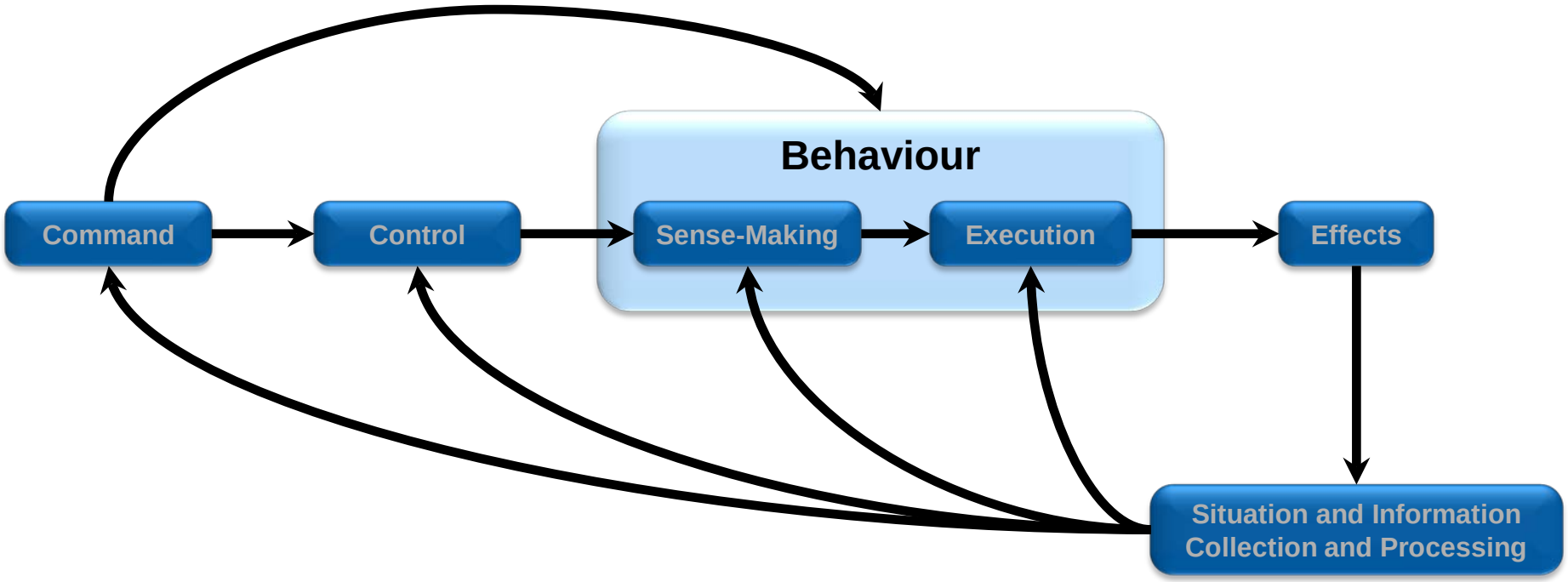
Command and Control

- Definition:
  - Problem solving within a military context to provide focus and convergence of effort.
  - Assess environment and decide on course of action.

- Purpose
  - Bring all available information and all available assets to bear on an objective

- Requirements
  - Vision of outcome
  - Understand high level intent and priorities
  - Assessment of environment
  - (Re-) Evaluation of situation

Command and Control Model



(Alberts 2006)

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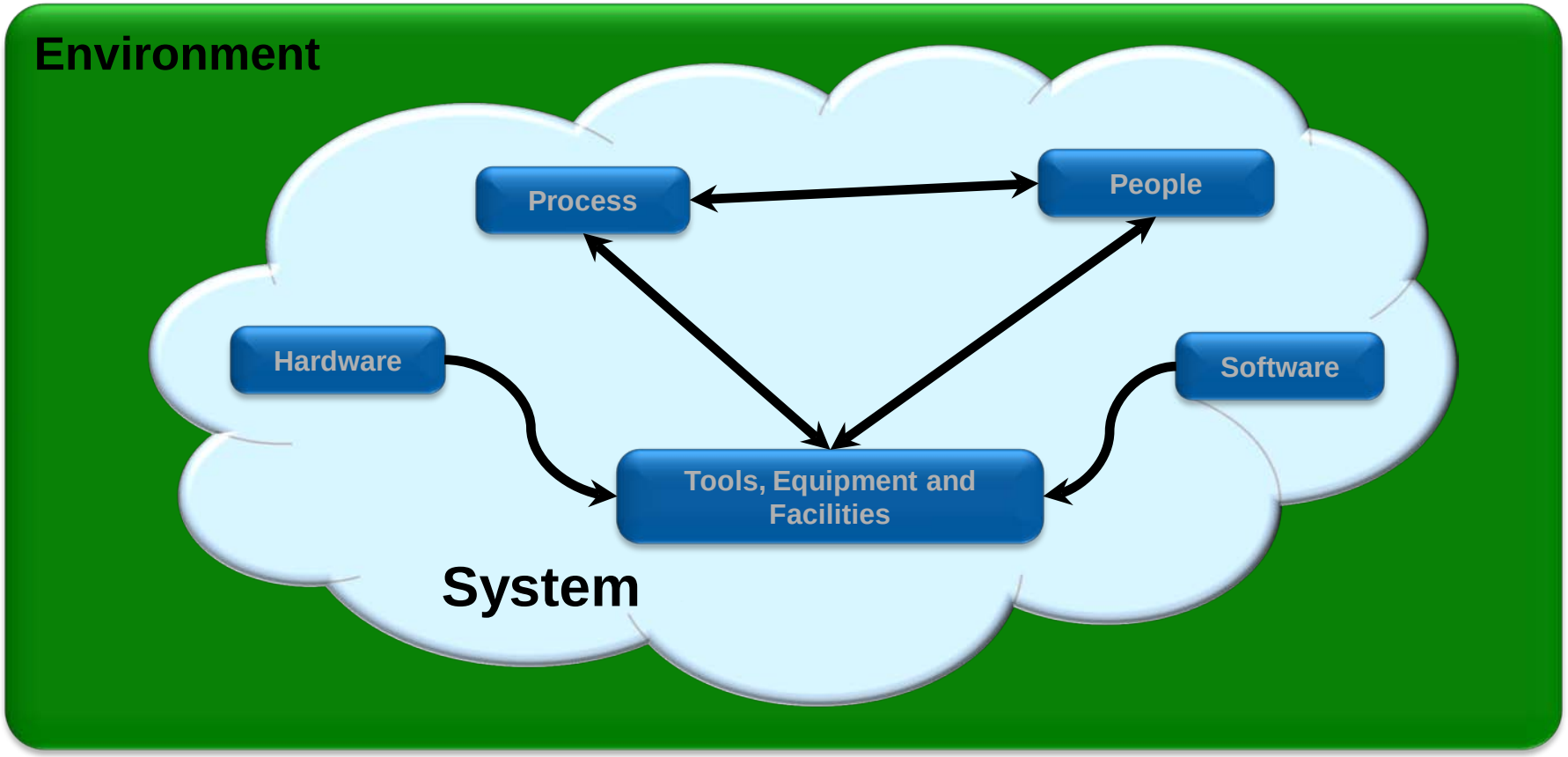
Socio-technical System



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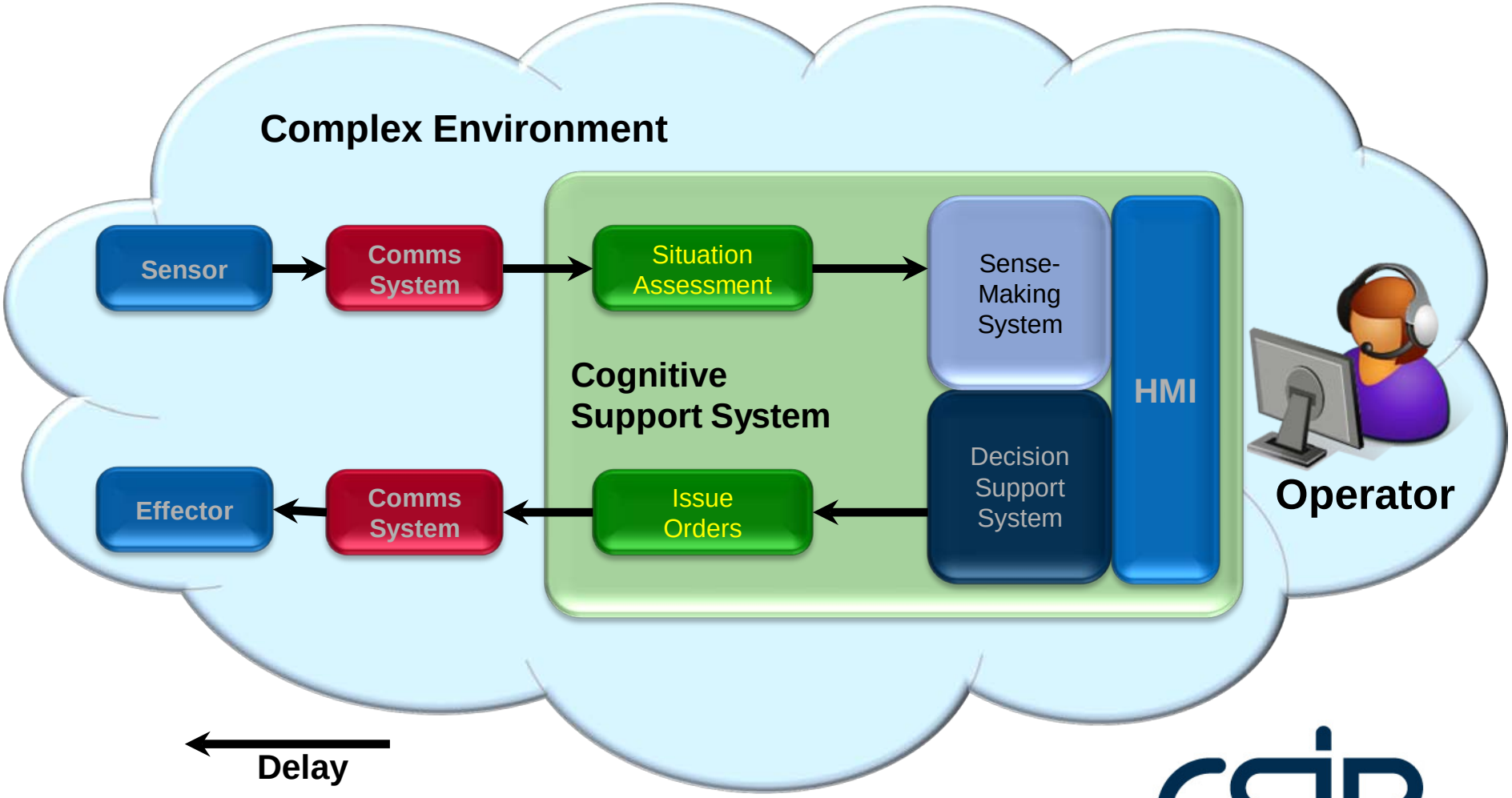
C2 System



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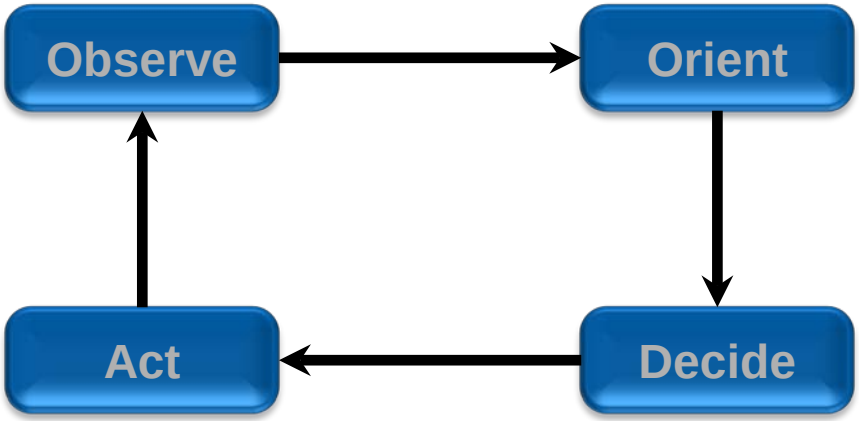
The Famous OODA Loop



(Boyd, 1987)

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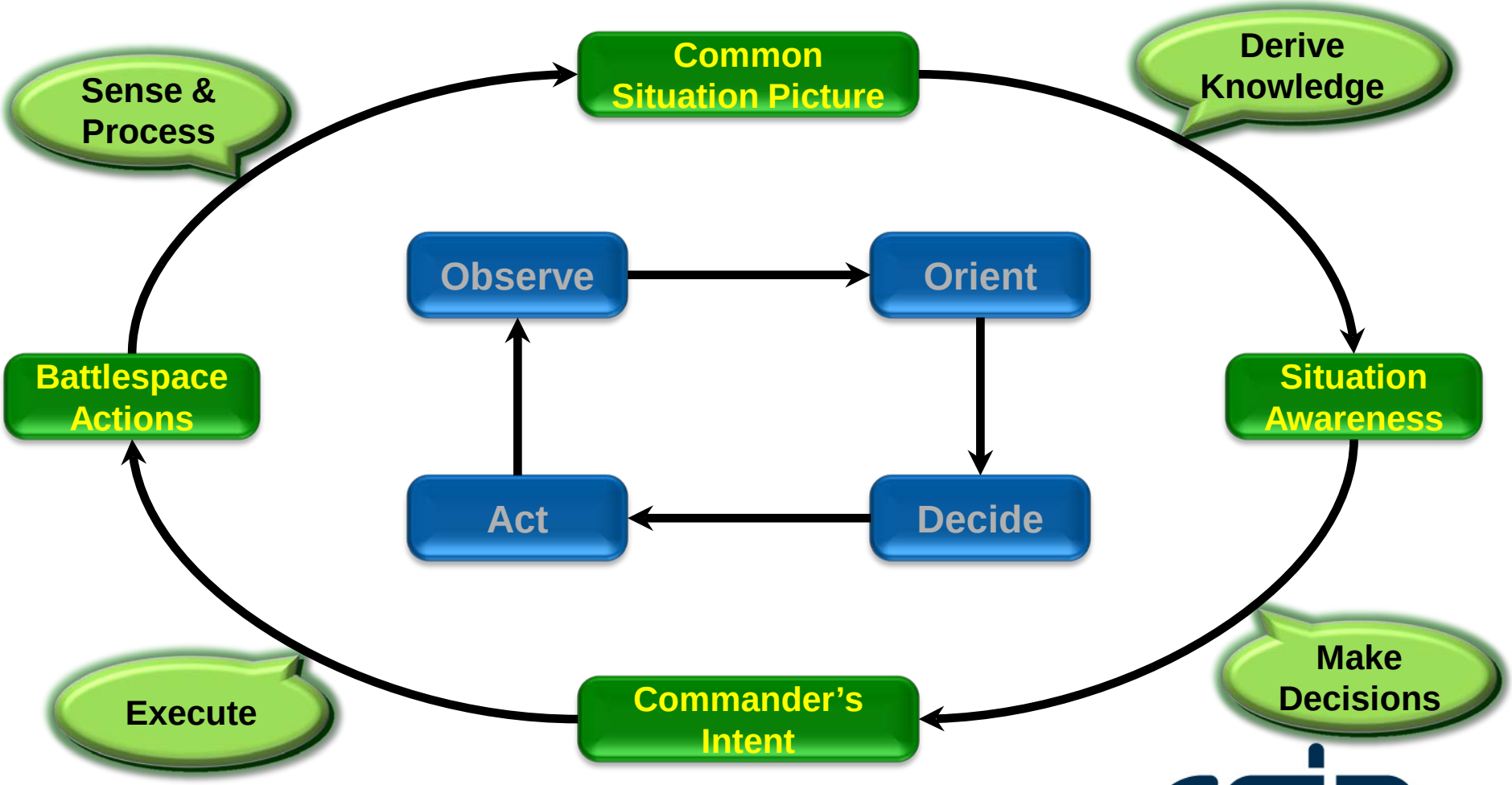

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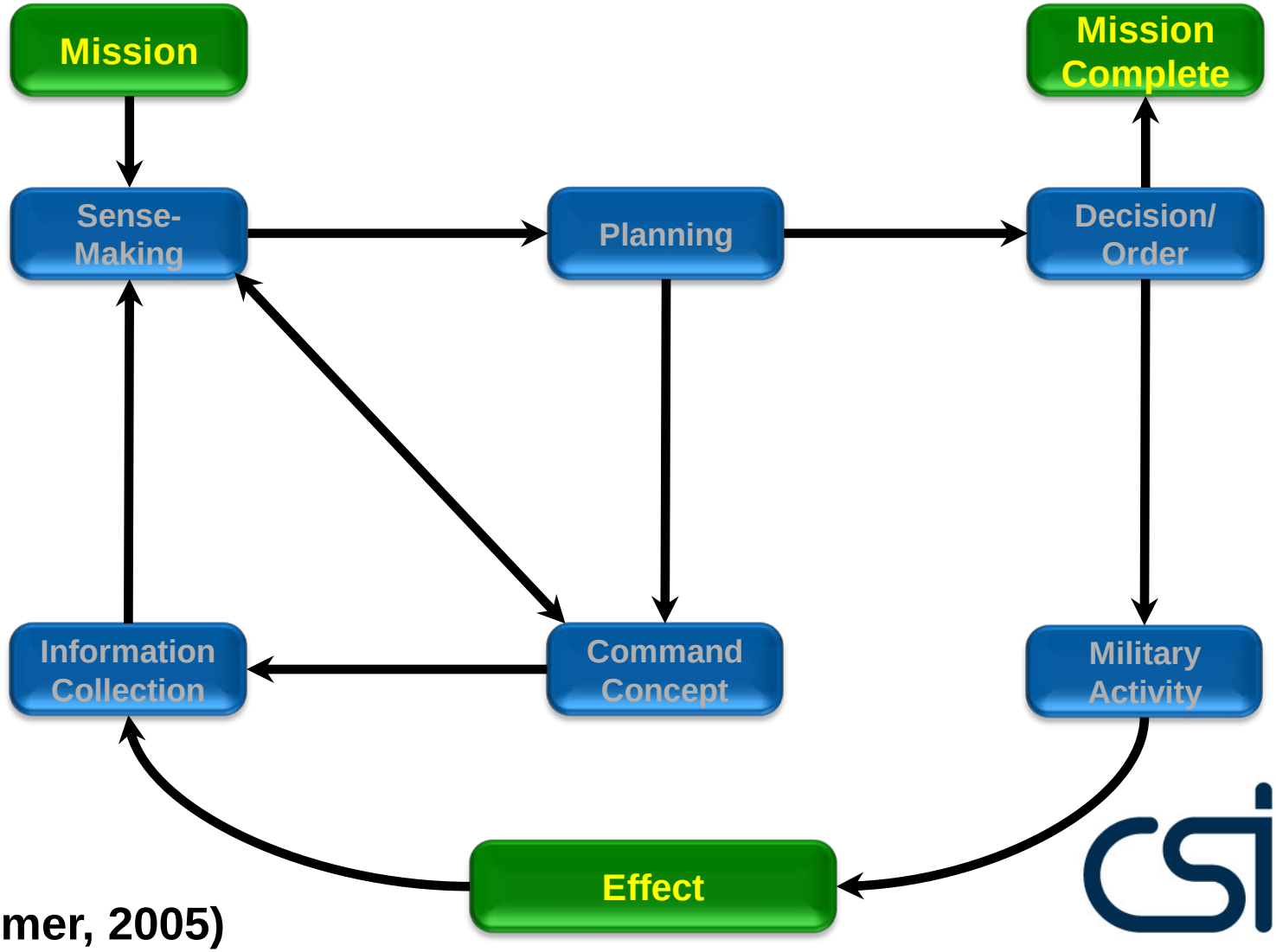
Dynamic OODA Loop



(Brehmer, 2005)

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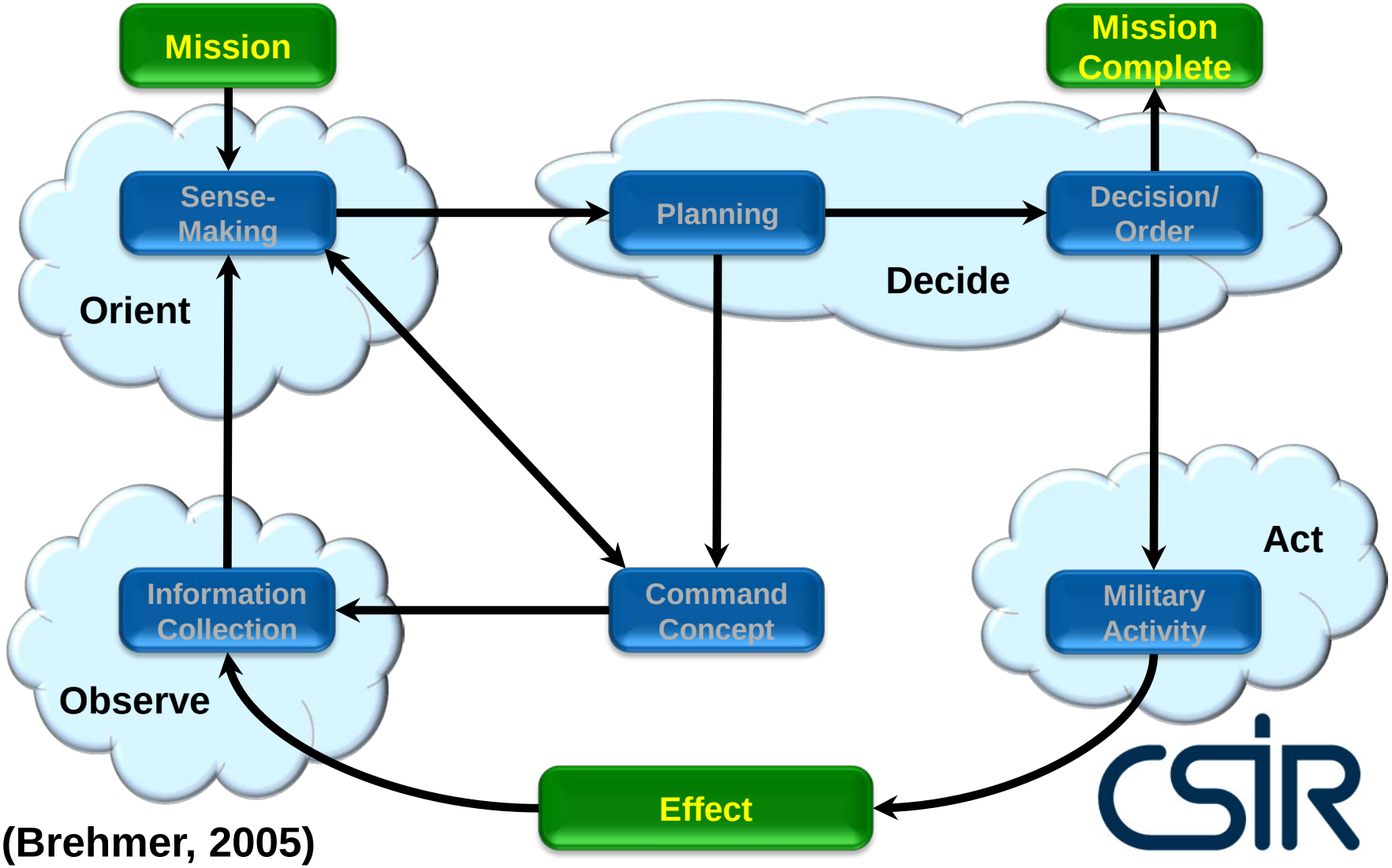
Dynamic OODA Loop



(Brehmer, 2005)

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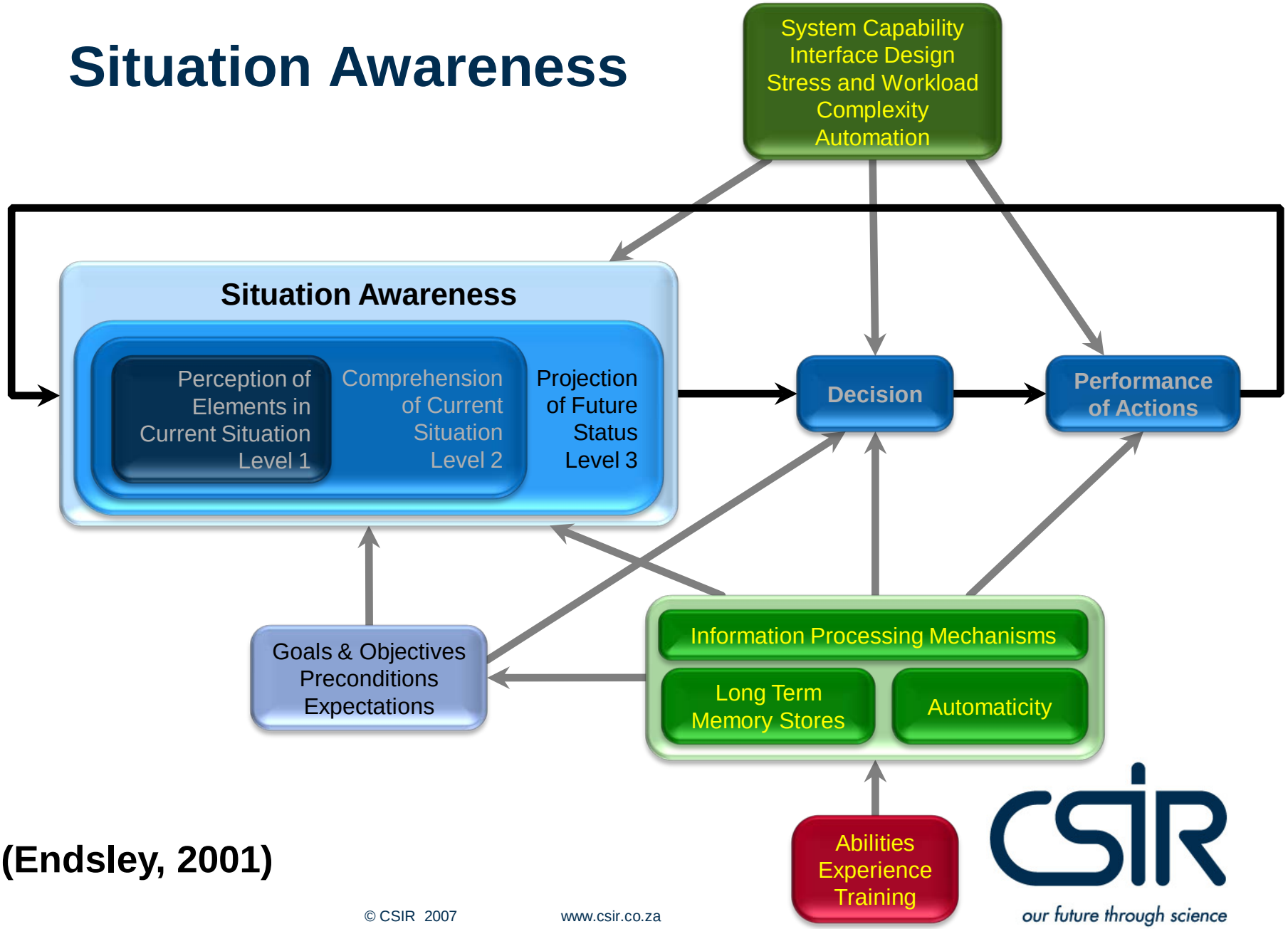
Situation Awareness

- “Perception of elements in the environment within a volume of time and space, comprehension of their meaning and projection of their status into the near future” – Endsley.
- Situation Awareness exist in the mind of the operator.
- HMI is the interface between the operator and C2 system.
- Prerequisite for Decision Making.
- Require a careful analysis on what is required for Decision Making.

Situation Awareness



(Endsley, 2001)

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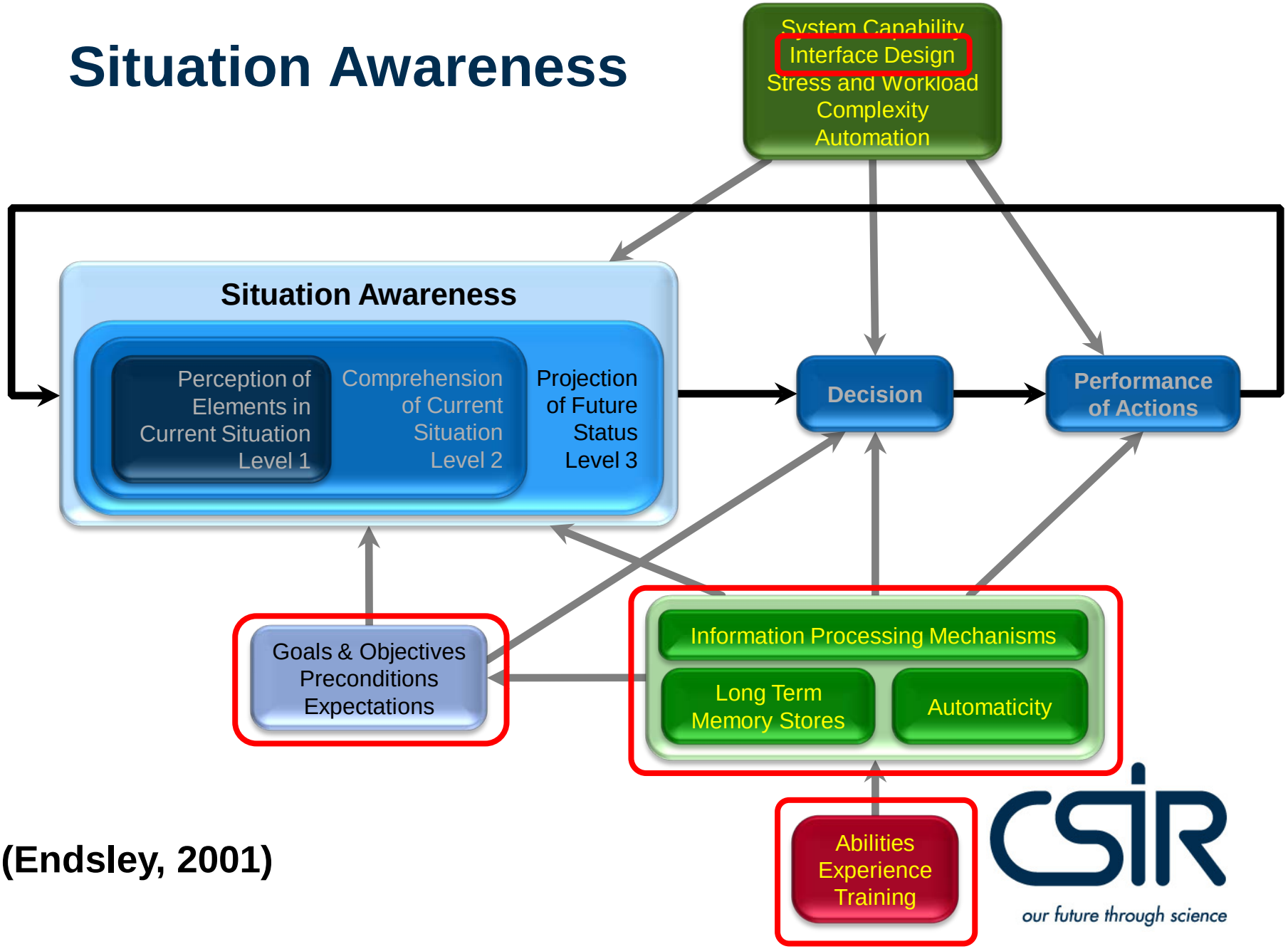
Situation Awareness



(Endsley, 2001)

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Sense Making & Decision Making

- C2 require decisions on adapting to changing environment.
- Complexity requires intuition and judgement from cognitive abilities and past experience.
- Align presentation of information with operator mental models.
- HMI of C2 system support sense-making.
- Identify when decisions are required.

Complexity

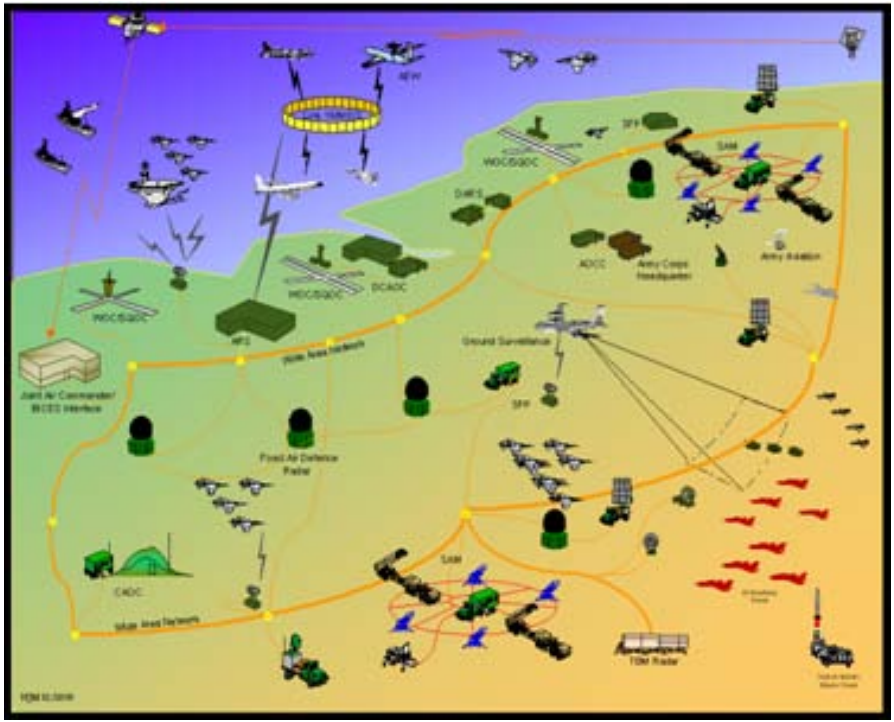
- Definition:
  - “a whole made up of complicated or interrelated parts”
  - “braided or entwined together”

- Complex System consist of many interconnected nonlinear elements that cause unpredictable behaviour.

- Behaviour is nondeterministic, despite apparent order.

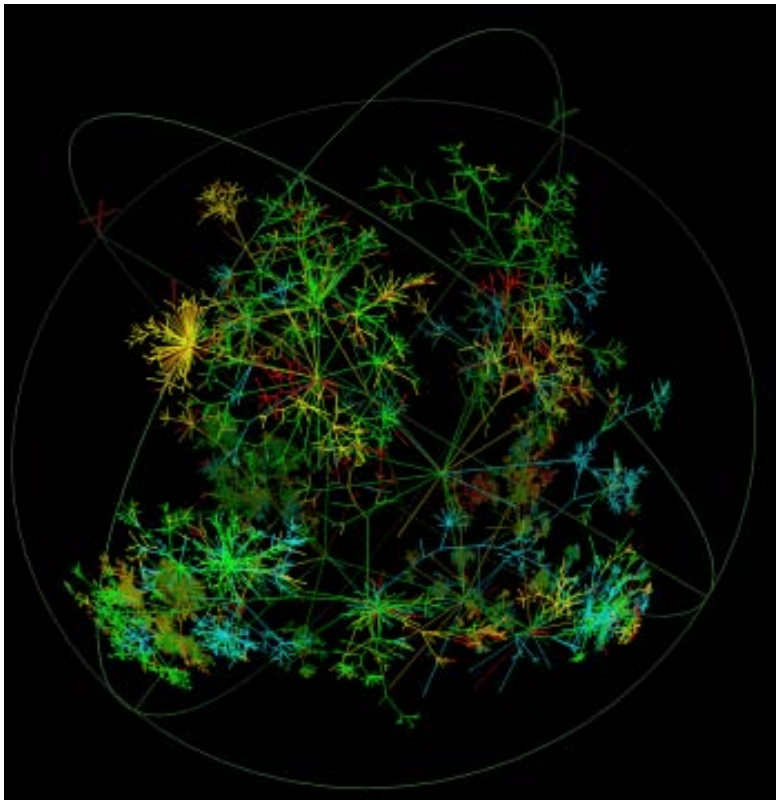
- Display emergent behaviour

- Modelling help to understand.

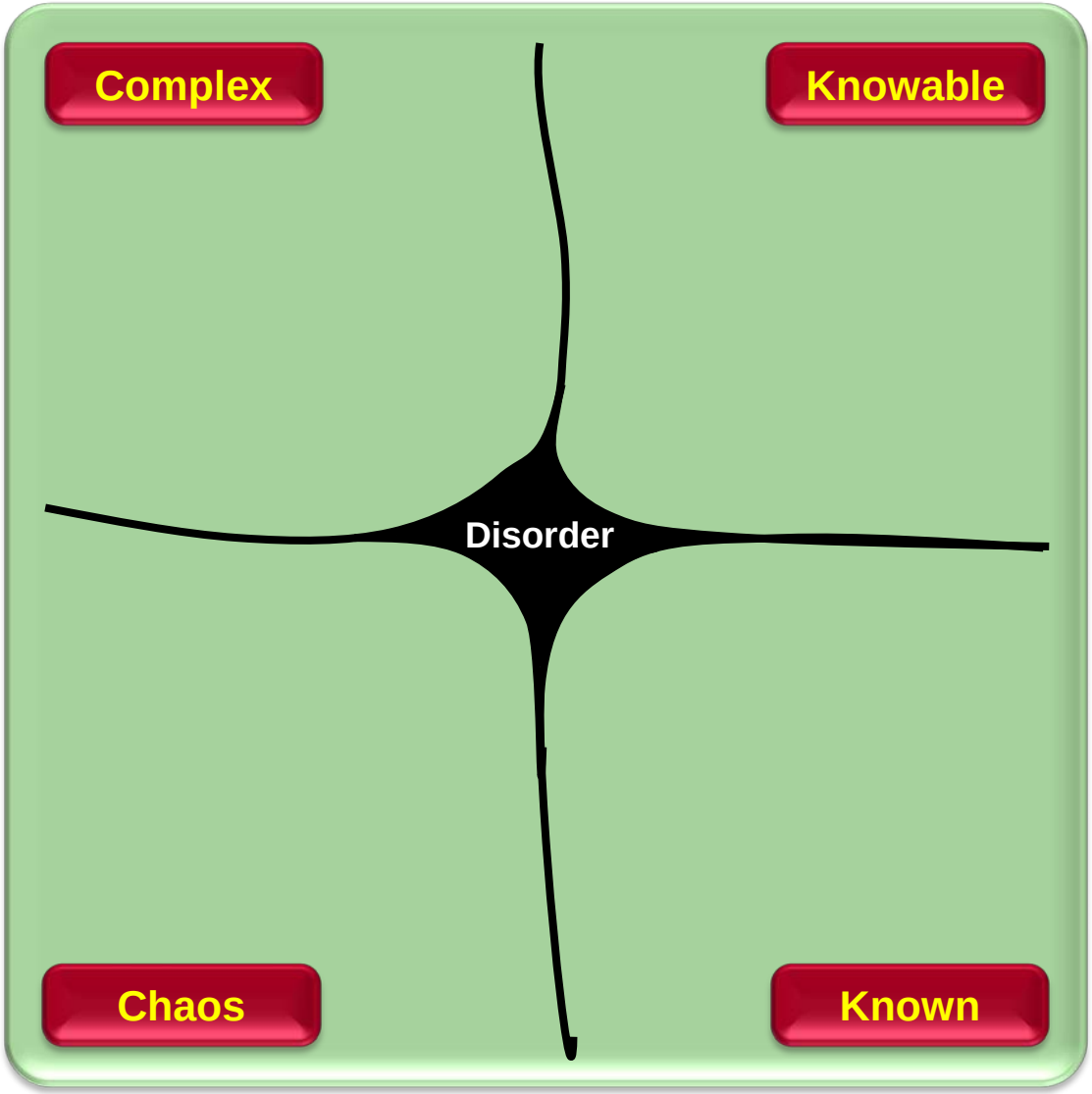


Complexity

- Systems where people play a major part tends to be complex.
- Cognitive work is dynamic and context dependant in sociotechnical system.
- Systems need to support assimilation of information in uncertainty.
- Complexity science provide tools and concepts.
- The Cynefin Framework (Snowden) assist in making sense of complex situations.



Cynefin Framework



(Snowden)

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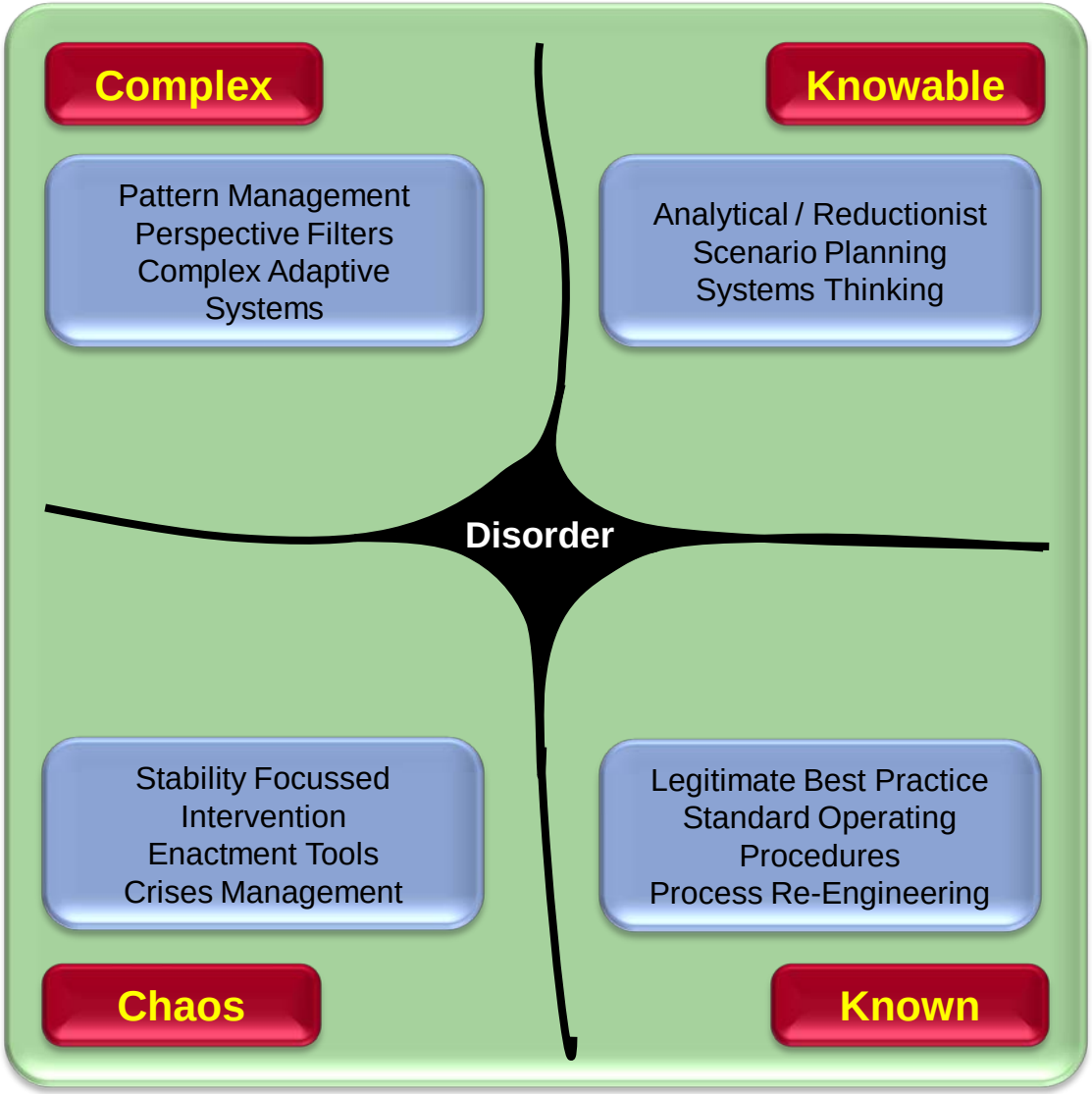
Cynefin Framework



(Snowden)

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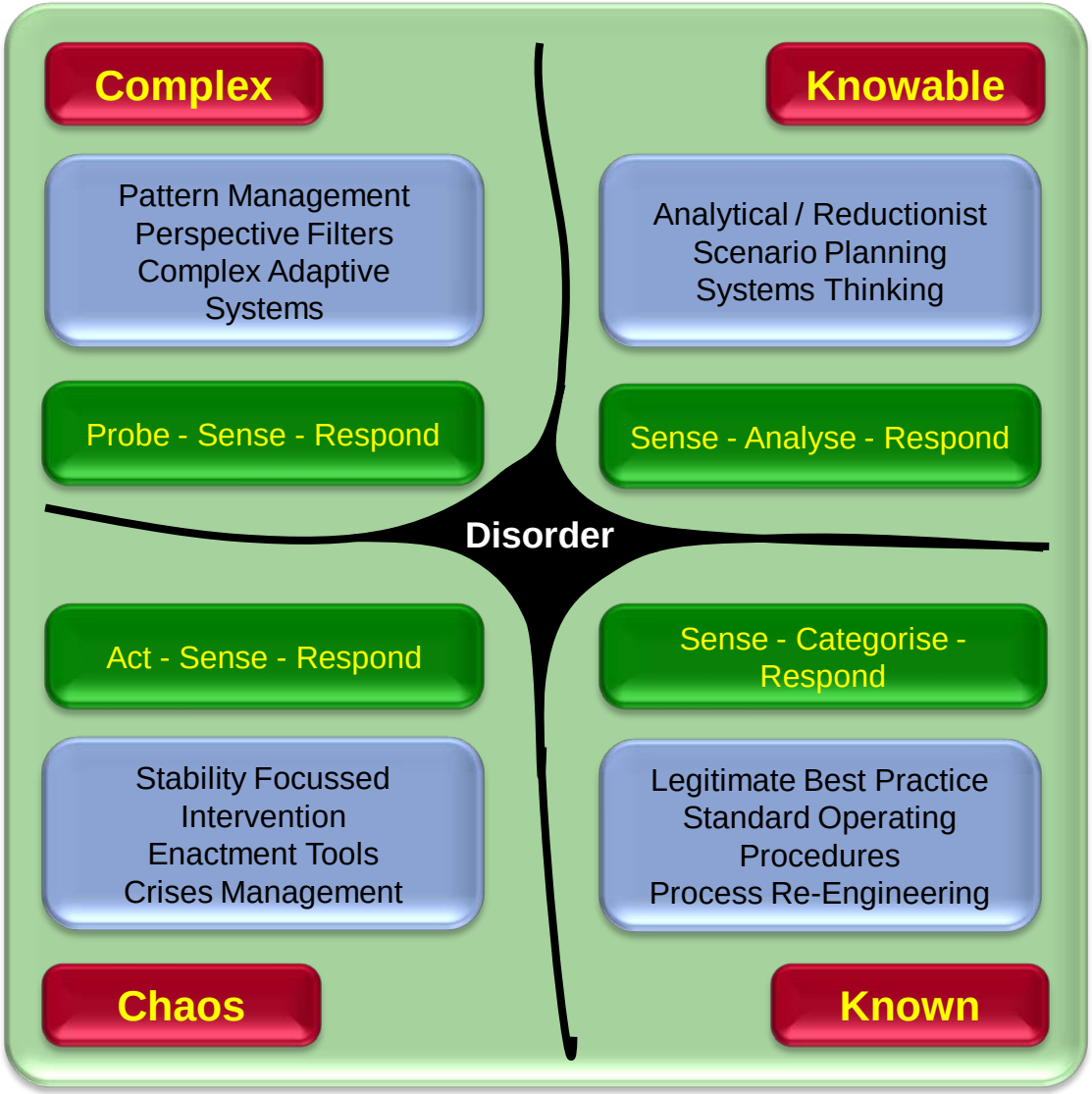
Cynefin Framework



(Snowden)

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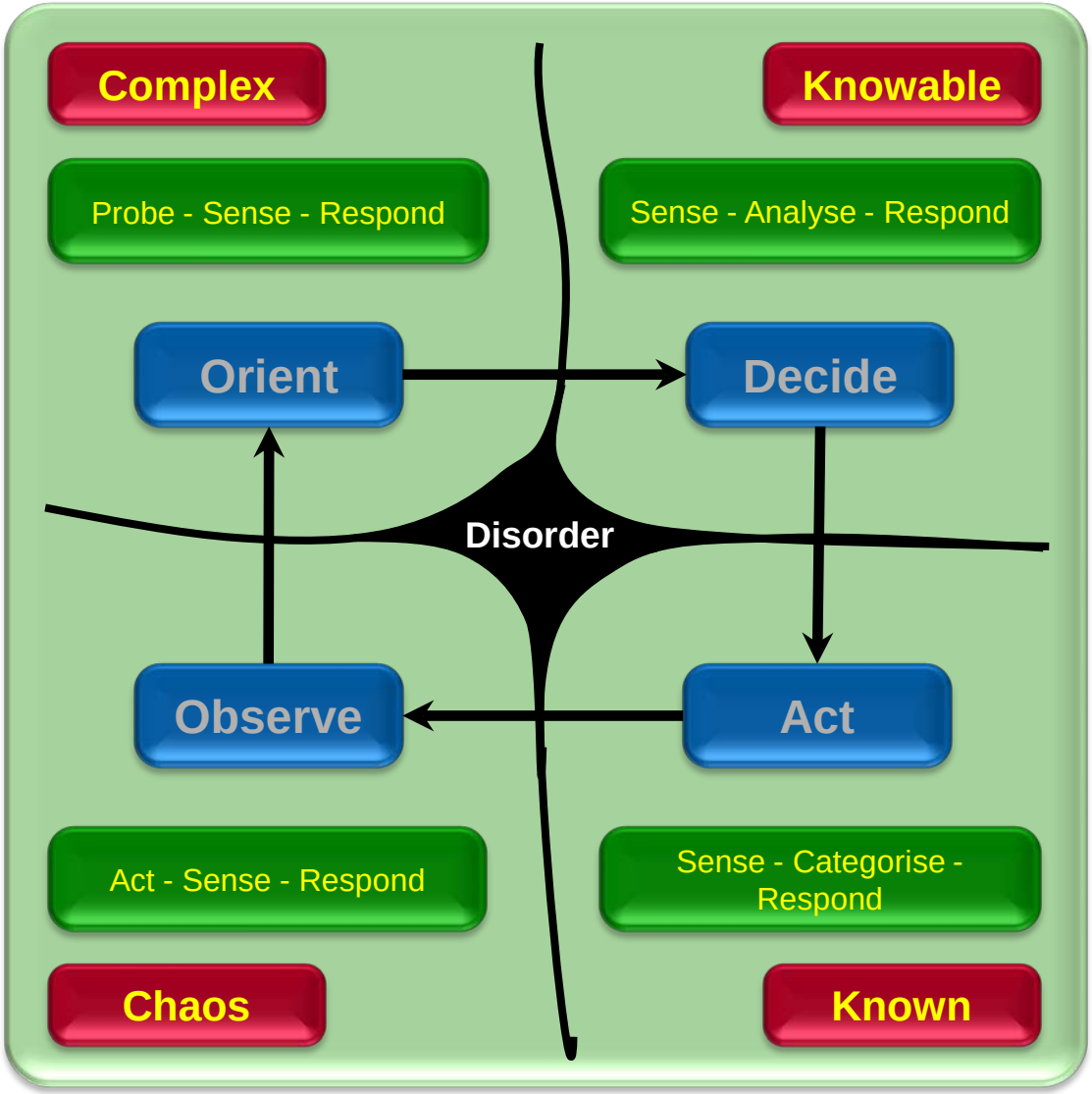
C2 as a Complex System

- Combat is complex (Sun Tzu & Clausewitz).
- C2 is a complex system:
  - Large problem space.
  - Social interaction with heterogeneous perspectives.
  - Distributed cognition and decision making.
  - Mediated interaction and dynamic decision-making.
  - Hazards and disturbances.
- C2 have to make sense of complex situations and manage risks.
- C2 is a sociotechnical system.

C2 as a Complex System



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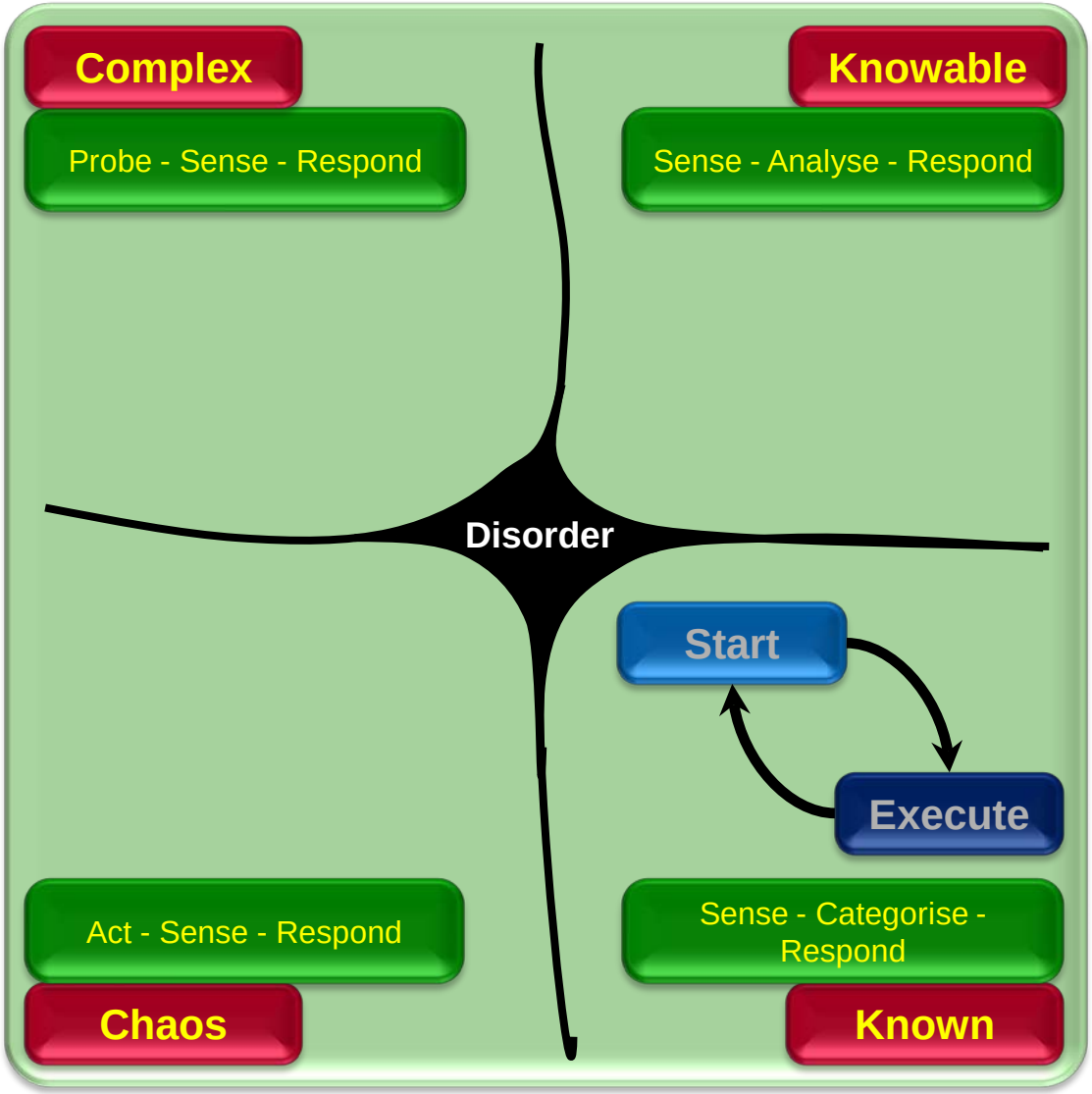
C2 as a Complex System



Up to WW I

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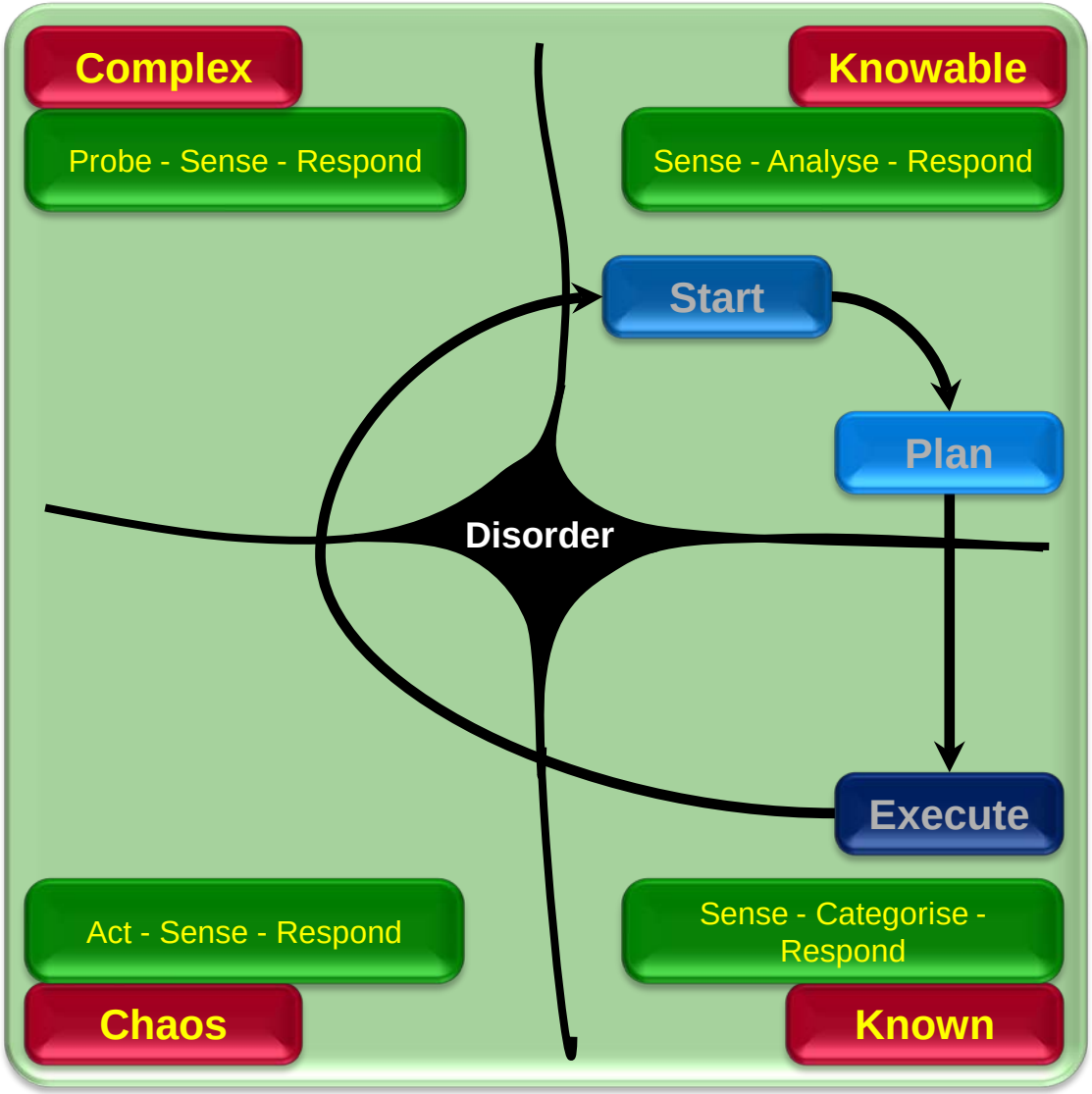
C2 as a Complex System



WW II

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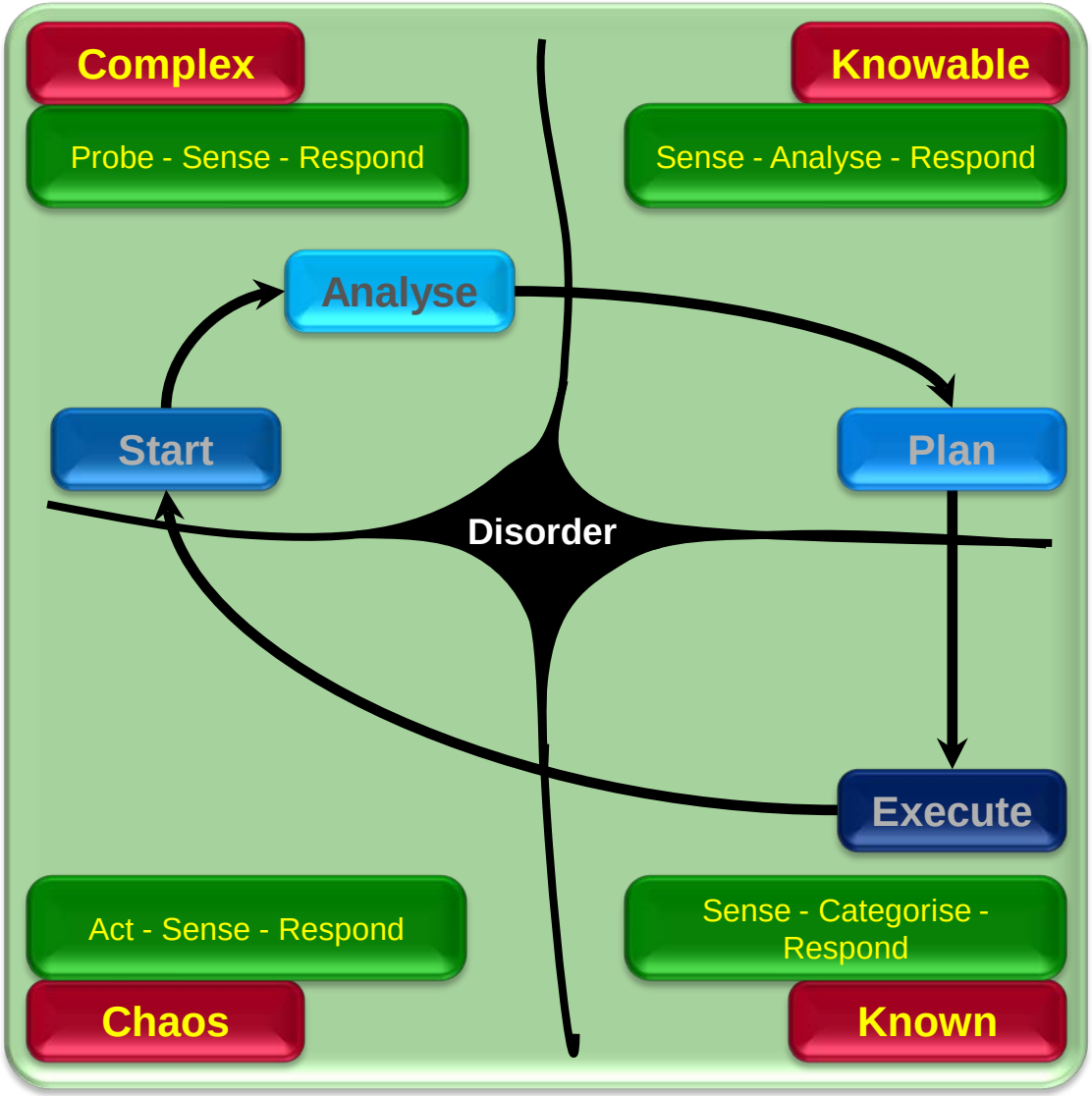
C2 as a Complex System



Modern War

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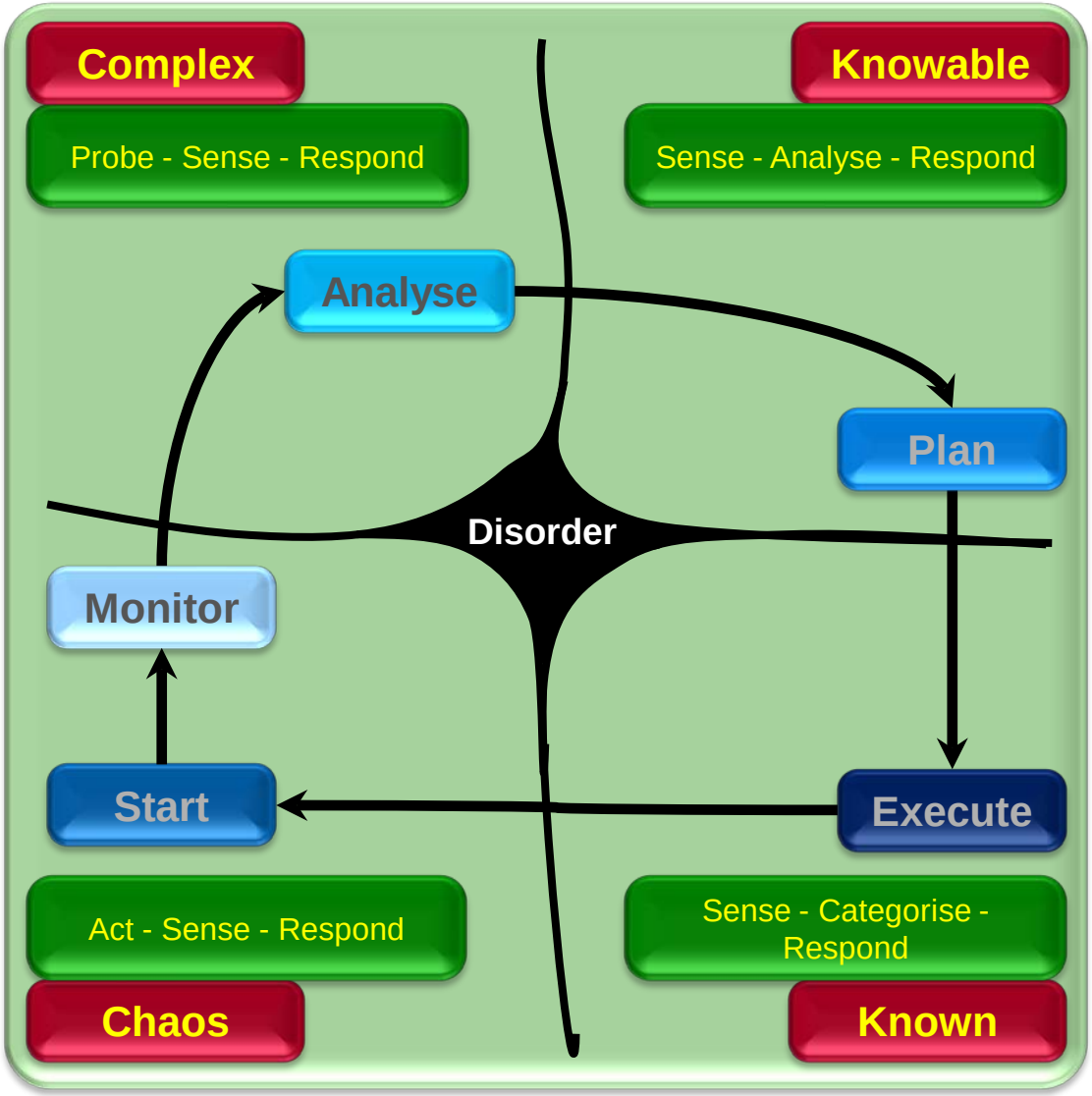
C2 as a Complex System



Modern War

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Cognitive System Engineering

- Classic System Engineering:
  - Focus more on technical aspect.
  - Automate to reduce human error.
  - Lead to failures in complex and unforeseen situations.

- Humans are central to complex systems.

- C2 requires Decision Support Systems to assist sense-making and problem solving:
  - Display information, not raw data.
  - Provide ease of control.
  - Complement cognitive capability.
  - Support operators to cope with and adapt to unfamiliar situations.
  - Indicate when decisions need to be taken.

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Cognitive System Engineering

- Apply Cognitive Work Analysis (CWA) to develop “cognitive affordances” to support sense-making and decision-making.
  - Support analysis, design and evaluation of complex sociotechnical systems.
  - Define required information and application context.
  - Define “ecological” HMI for effective man - machine operation.

- Support direct perception and manipulation.

- Support creativity and innovation in unanticipated events.

- Capture the knowledge and processes of experts to support novices though the system and HMI.

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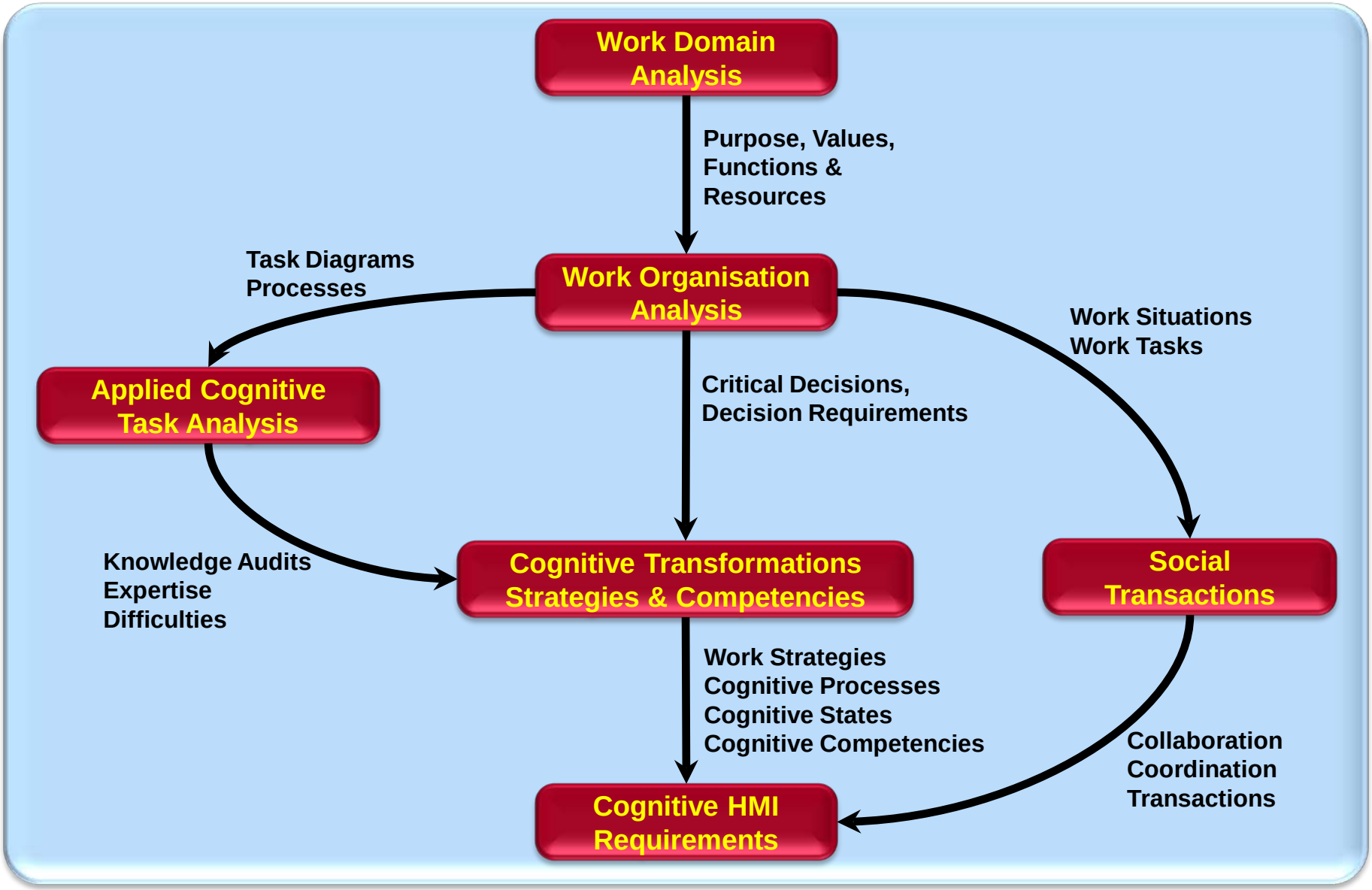
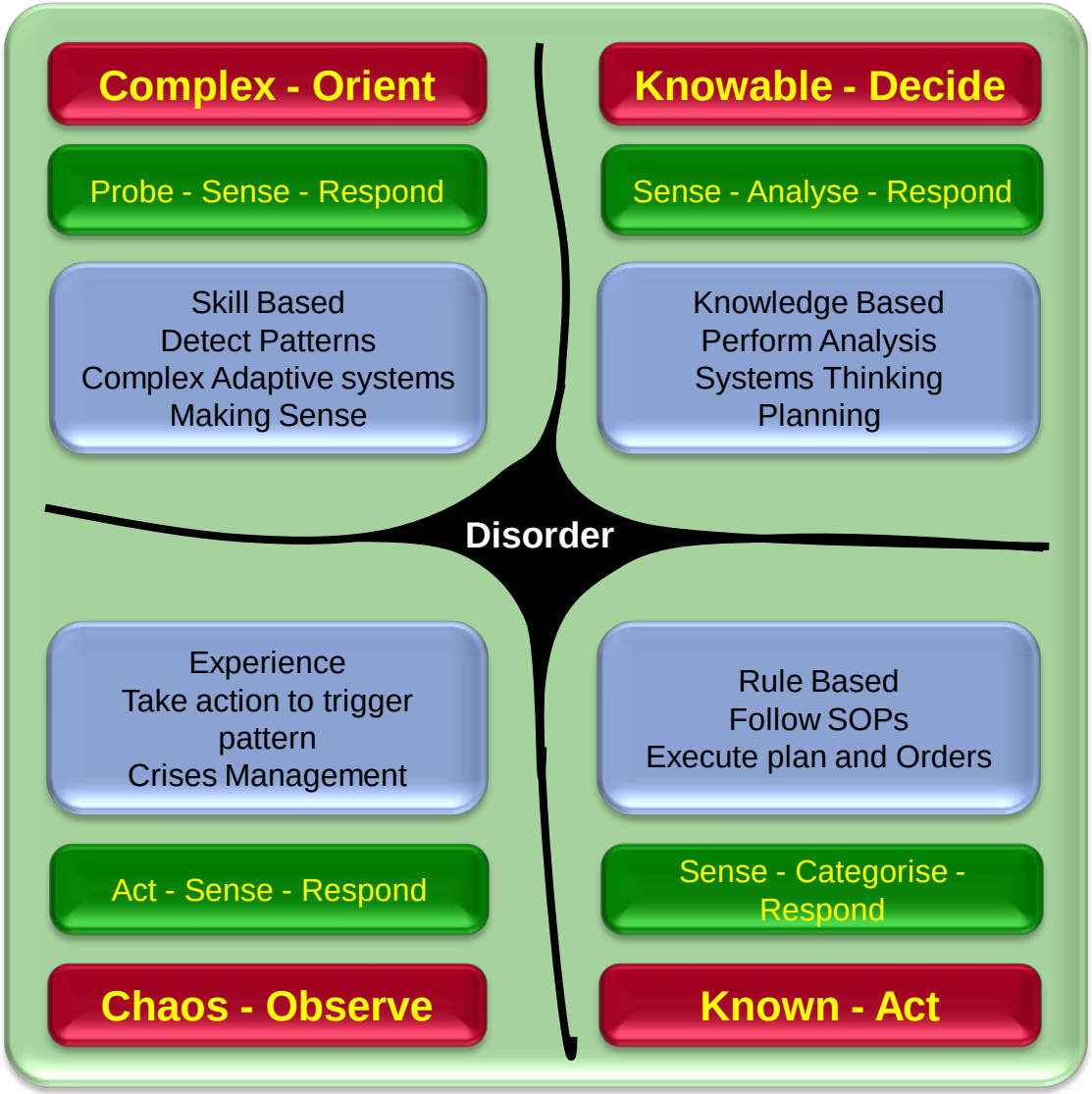
Cognitive System Engineering



Cognitive System Engineering



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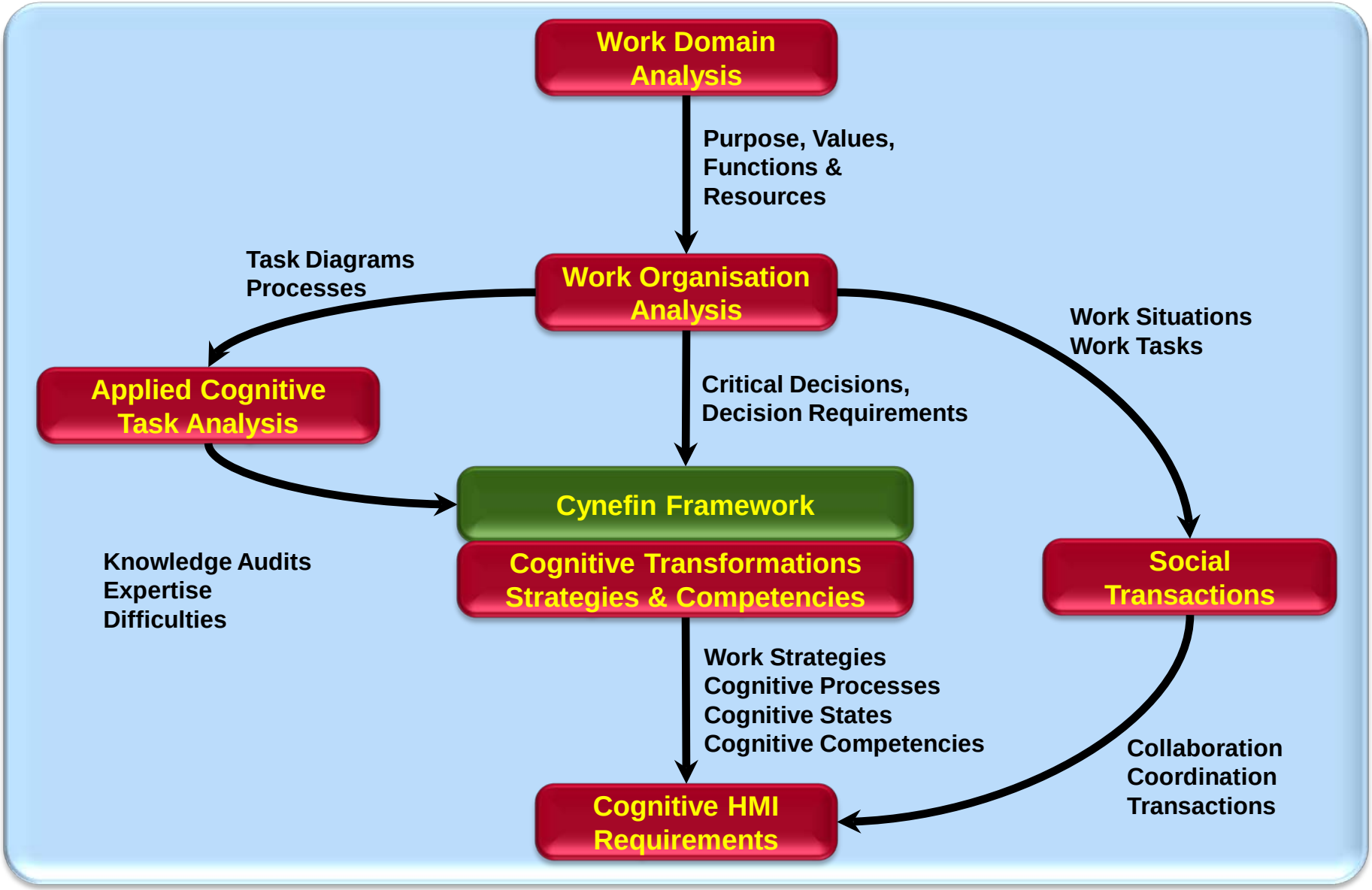
Cognitive System Engineering



Conclusion

- Conducting military operations in modern and complex environment is difficult.
- C2 systems need to support commanders solve increasingly complex and dynamic problems.
- Be flexible to adapt to changes in environment and context.
- Focus on Situation Awareness, Sense-making and Decision-making.
- Support human cognitive and social abilities in C2 system design (HMI).
- Apply CWA enhanced with Cynefin diagram to design, develop and evaluate C2 systems.