# Modelling of Command and Control Agility

**R Oosthuizen & L Pretorius**

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UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

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# Content outline

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- Modelling of Command and Control
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  - System Dynamics
  - Design Science Research
- Case Study – South African Border Safeguarding
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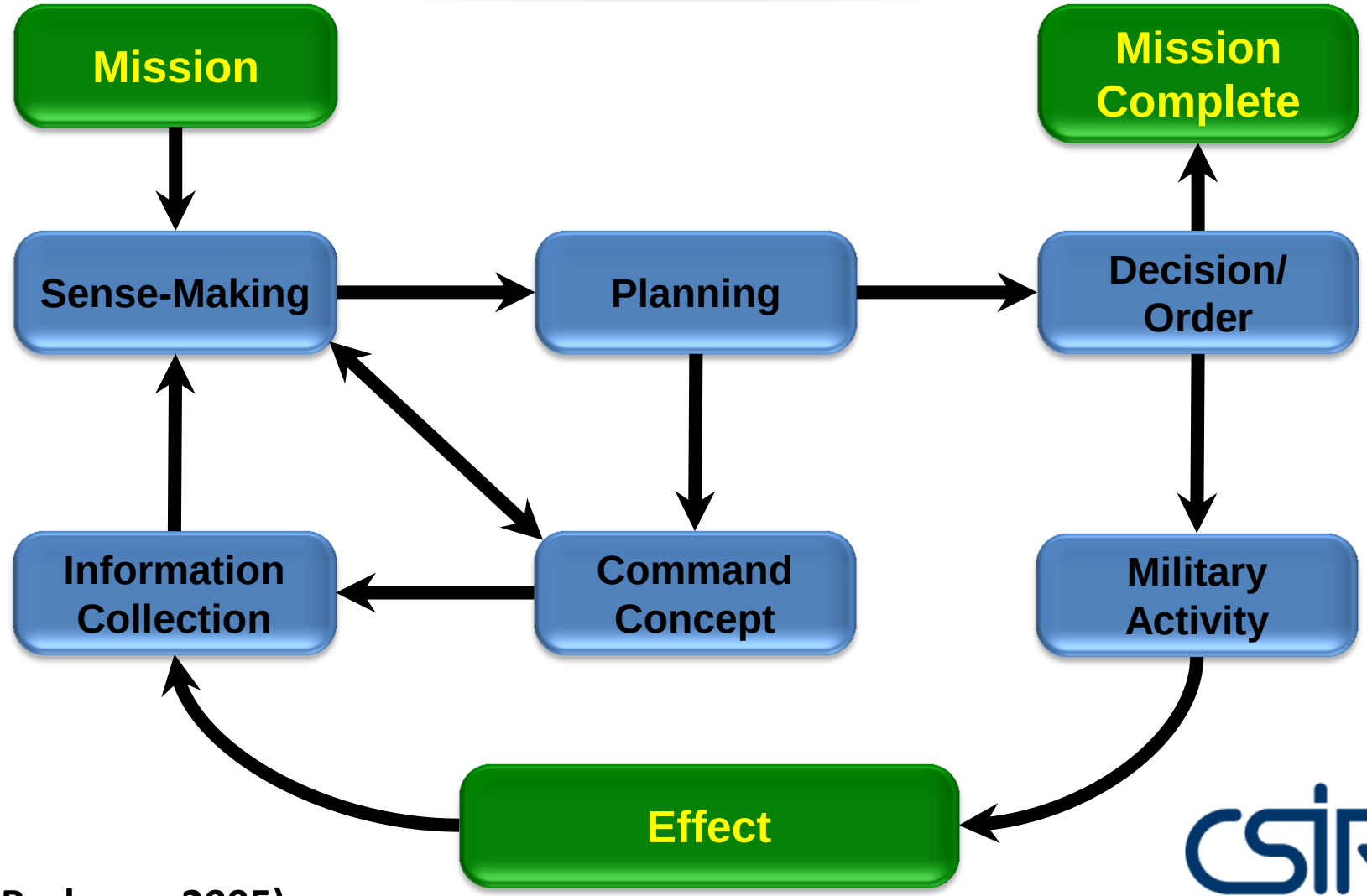
# Introduction

- C2 is a complex sociotechnical system
- C2 systems often developed through integrating of new technology into existing systems
- System development require modelling
- Modelling must address human role and dynamic interaction

# Command and Control System

- Commanders face complexity, uncertainty and novelty
- War is complex environment
  - Chance
  - Contextual complexity
  - Nonlinear interaction
  - Collective dynamics
  - Adaptation
- The purpose of C2 is to bring all available information and assets to bear on an objective to ensure the desired effects
- C2 is a complex dynamic system
  - Time pressure, risks and delays in the cyclic C2 process

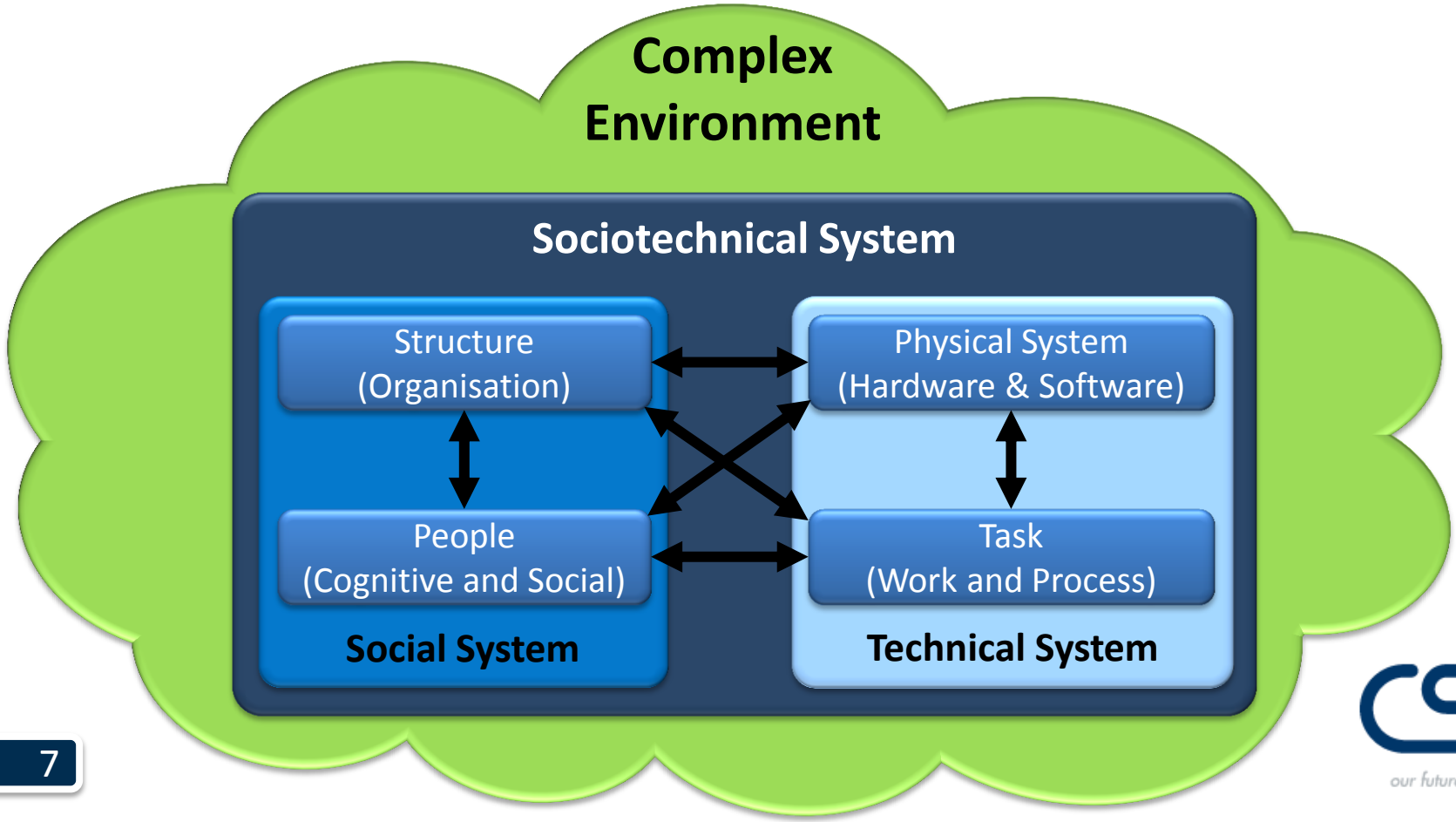
# Command and Control Model




(Brehmer, 2005)

# Command and Control as Complex Sociotechnical System

- C2 is a sociotechnical system
  - Equipment and people organised in a structure to execute tasks



# Command and Control as Complex Sociotechnical System

- Complex System
  - Whole made up of interrelated parts
  - Intricately intertwined with non-linear interactions
  - Behaviour can be emergent, non-deterministic and unpredictable
  - Characteristic of the artefact technology or its situated use
- Combat is a complex system
  - Opposing forces influence successful execution of plans
  - Environment with uncertainty, risk and time pressure
- Law of Requisite Variety
  - Variety of states within C2 must be similar to the combat it control
  - C2 must be a complex system

# Systems Engineering

- Solve problems through the application of Systems Thinking
- Systems Engineering of complex STS
  - Integration of new technology into a complex STS
  - Require modelling, assessment and experimentation
- Modelling
  - Describes system structure and behaviour
  - Abstract reality, simplify complexity, consider constraints and synthesize results
  - Experiment with knowledge on the problem

# Command and Control Modelling

- Require a methodology to model and analyse structure and dynamic behaviour of C2 system

- Cognitive Work Analysis
  - Capture system information and analyse human work

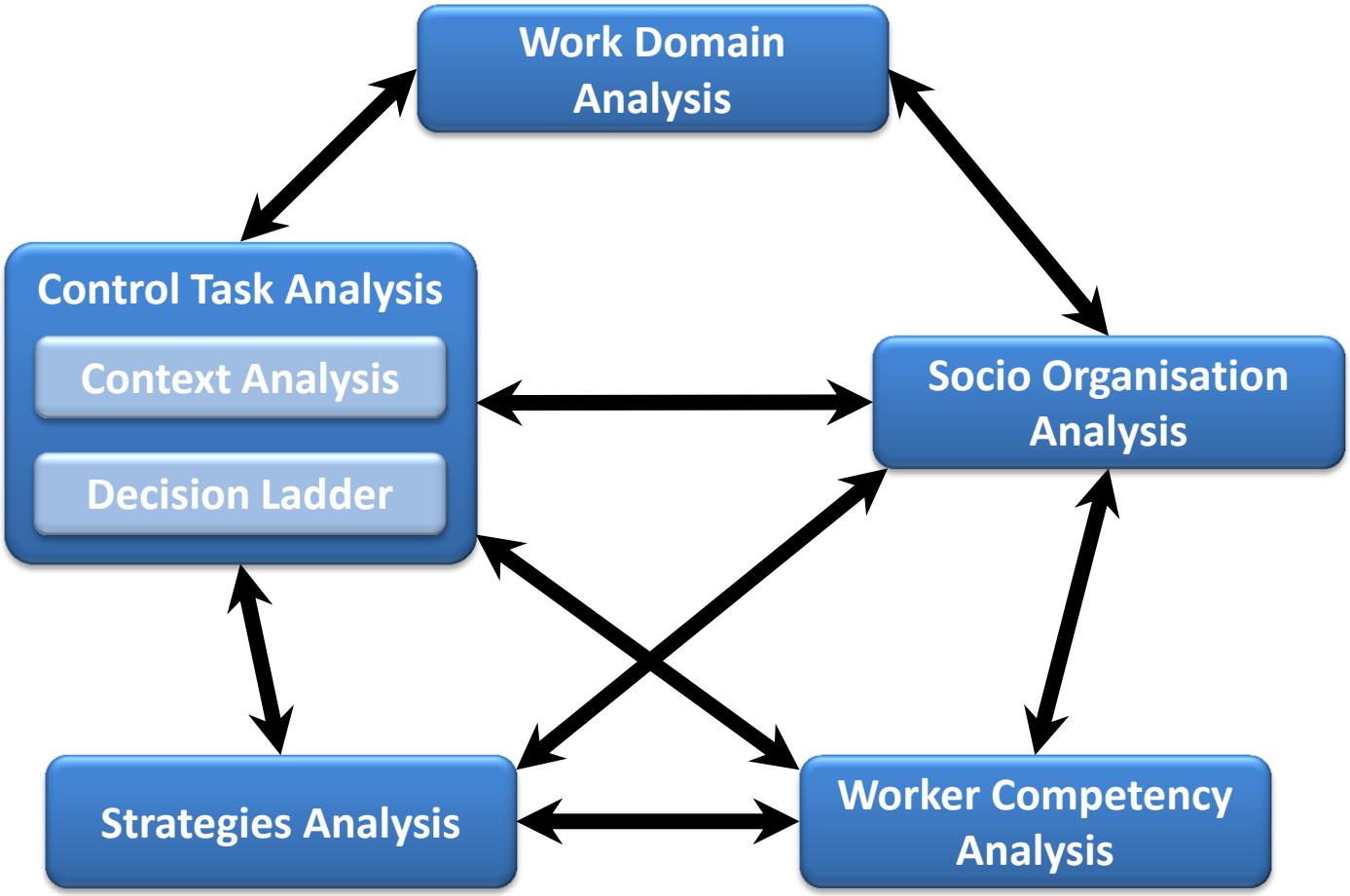
- System Dynamics
  - Investigate the dynamic effect of feedbacks and delays in the system on decision making

- Design Science Research
  - Framework to integrate modelling approaches and enable learning

# Cognitive Work Analysis

- Based on Systems Thinking, Adaptive Control Systems and Ecological Psychology
- Formative analysis
  - People adapt to changes in the environment to solve unexpected problems
  - Order and represent information in constructs
- Define cognitive system information requirements and application context

# Cognitive Work Analysis



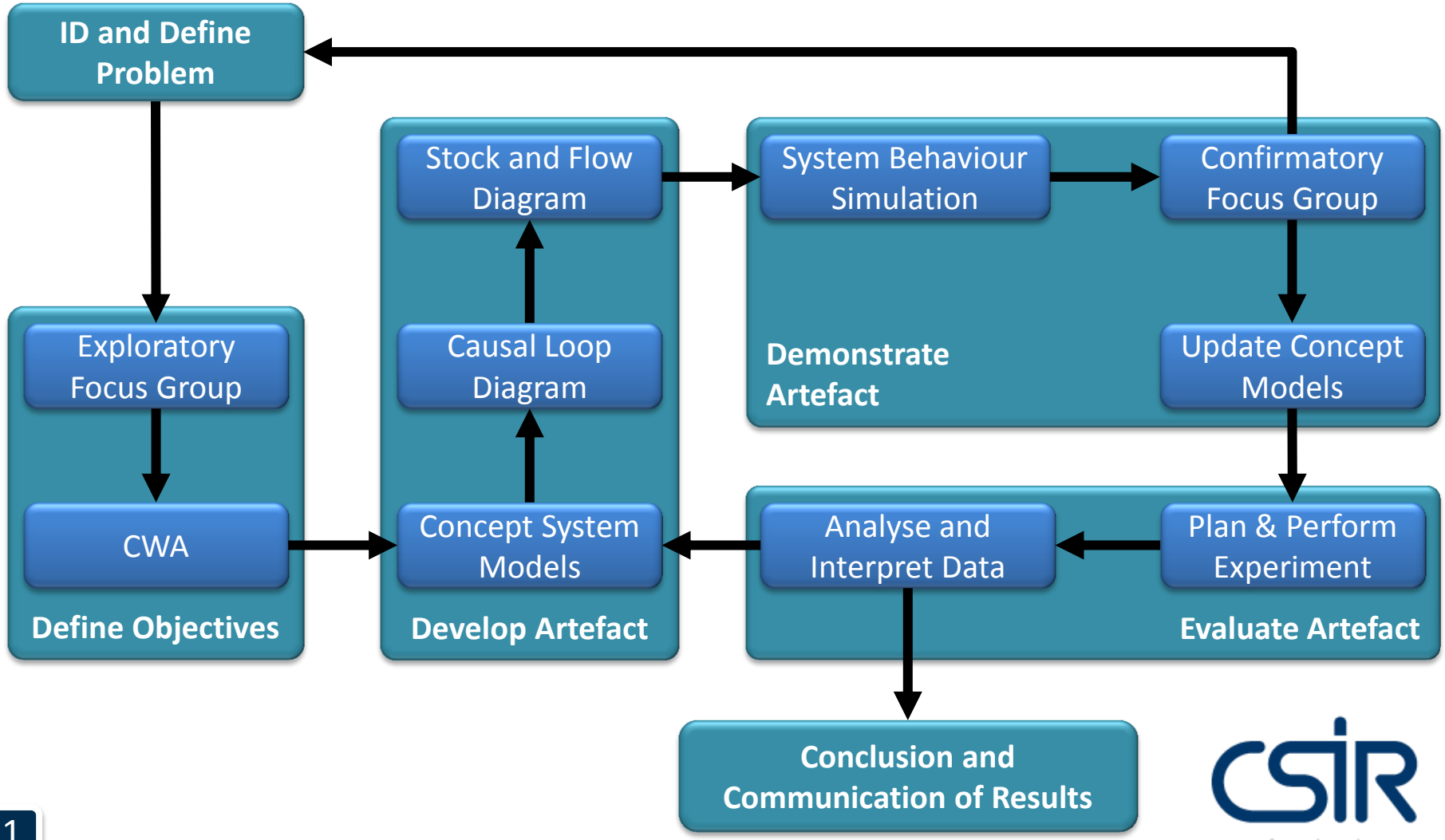
# Work Domain Analysis

- Support understanding of the functional and physical structure of the system
  - Assess affect of environmental constraints
- Abstraction Decomposition Space
  - Organise and present information and knowledge about a system
  - Provide constructs and reasoning space
  - Identify and model event independent goals and purposes of system
  - Integrates top-down view (purposes) with the bottom-up view of physical resources
  - Support the means-to-ends analysis required for C2

# System Dynamics

- Learn about the dynamic nature of a system
  - Behaviour is a result of system structure
  - Behaviour as result of function over time
- Feedback in the system causes most of the complexity
  - In simple systems interaction may be complex
  - Delays in decisions and feedback increase complexity
- SD Modelling
  - Causal loop diagrams – Feedback structure
  - Stock and flow diagrams – Physical process of resource accumulation
- SD Simulation
  - Develop mental models through understanding the system

# Command and Control Modelling and Assessment



# Border Safeguarding Case Study


- Priorities
  - Cross-border crime such as rustling of livestock
  - Firearms & Drug smuggling
  - Smuggling of stolen and untaxed goods, often part of organised crime
  - Illegal immigration
  - Human trafficking

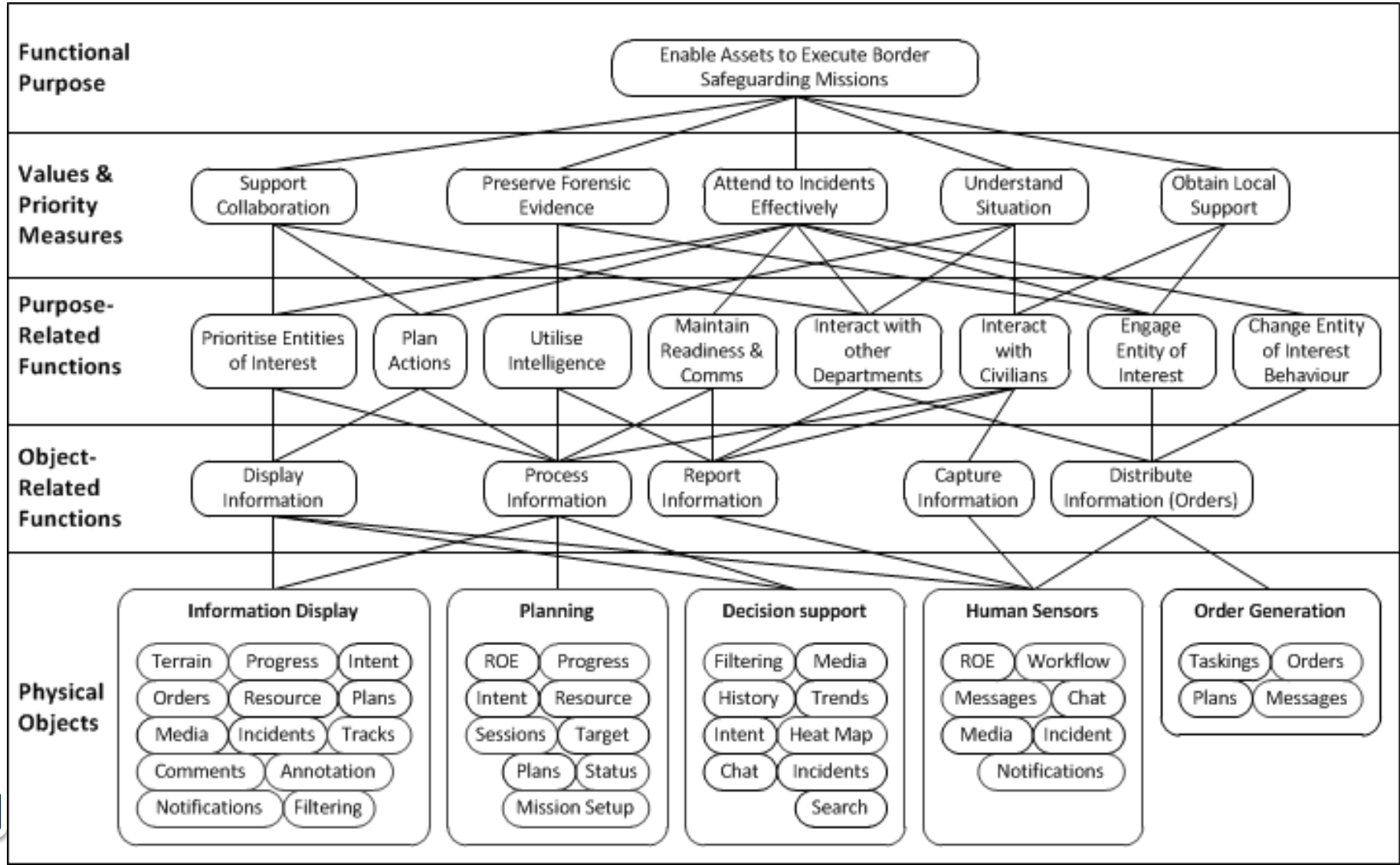
- Tasks and activities
  - Deployment of sensors and barriers
  - Patrols on the border as well as in depth
  - The arrest, transport and guarding of suspects
  - The search of areas or buildings looking for illegal immigrants or contraband
  - The recording of evidence for prosecution
  - The seizure of illegal goods

# Identify and Define the Problem

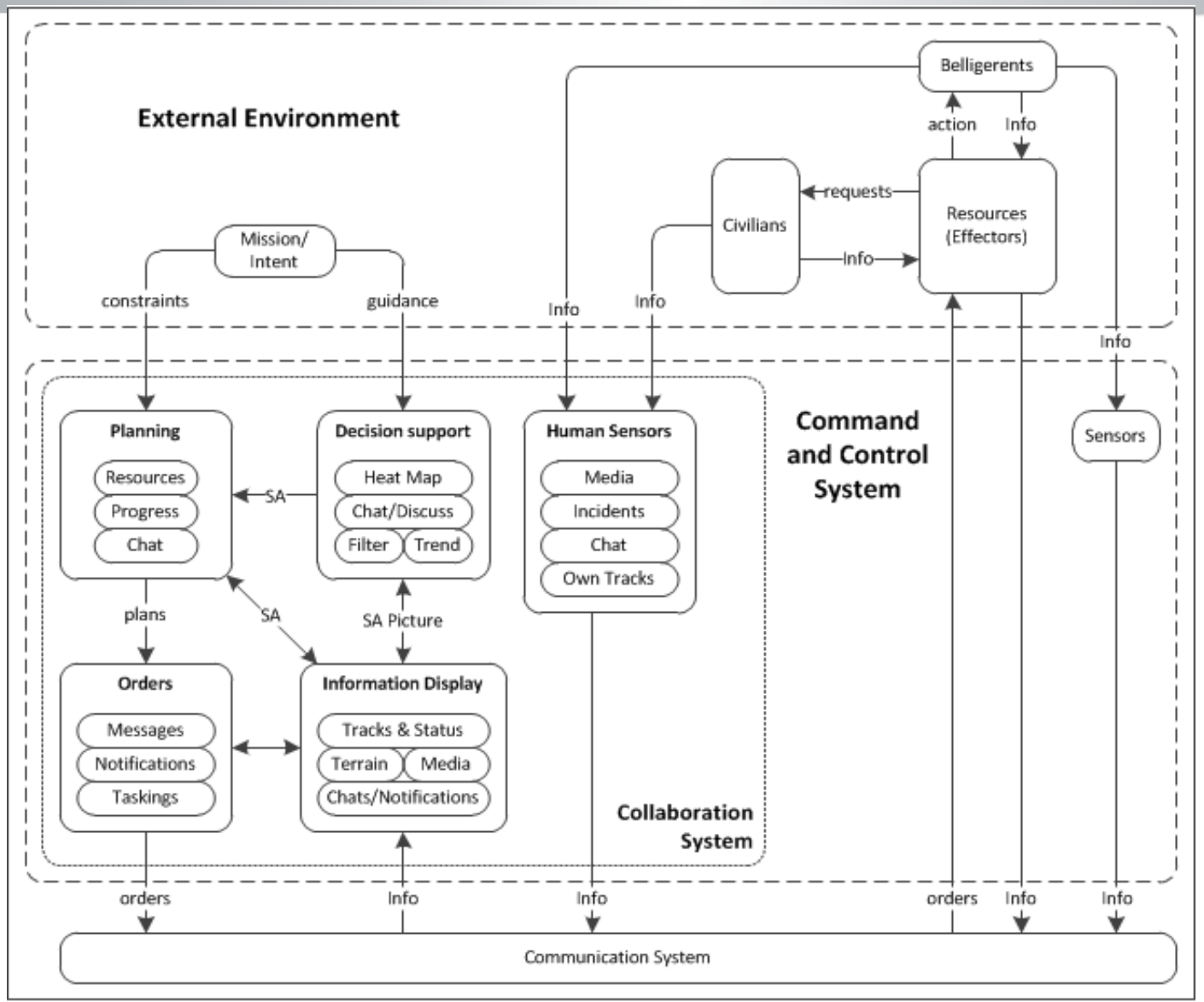
- New collaboration technology
  - Smart phones and web services
  - Communication and situation awareness display

- Case study assess effect of new technology on a C2 system for border safeguarding
  - Gather information for intelligence from sensors or interaction with the local communities
  - Planning courses of action for prioritised tasks
  - Take action and control
  - Liaise with other departments
  - Preserve forensic artefacts for prosecution

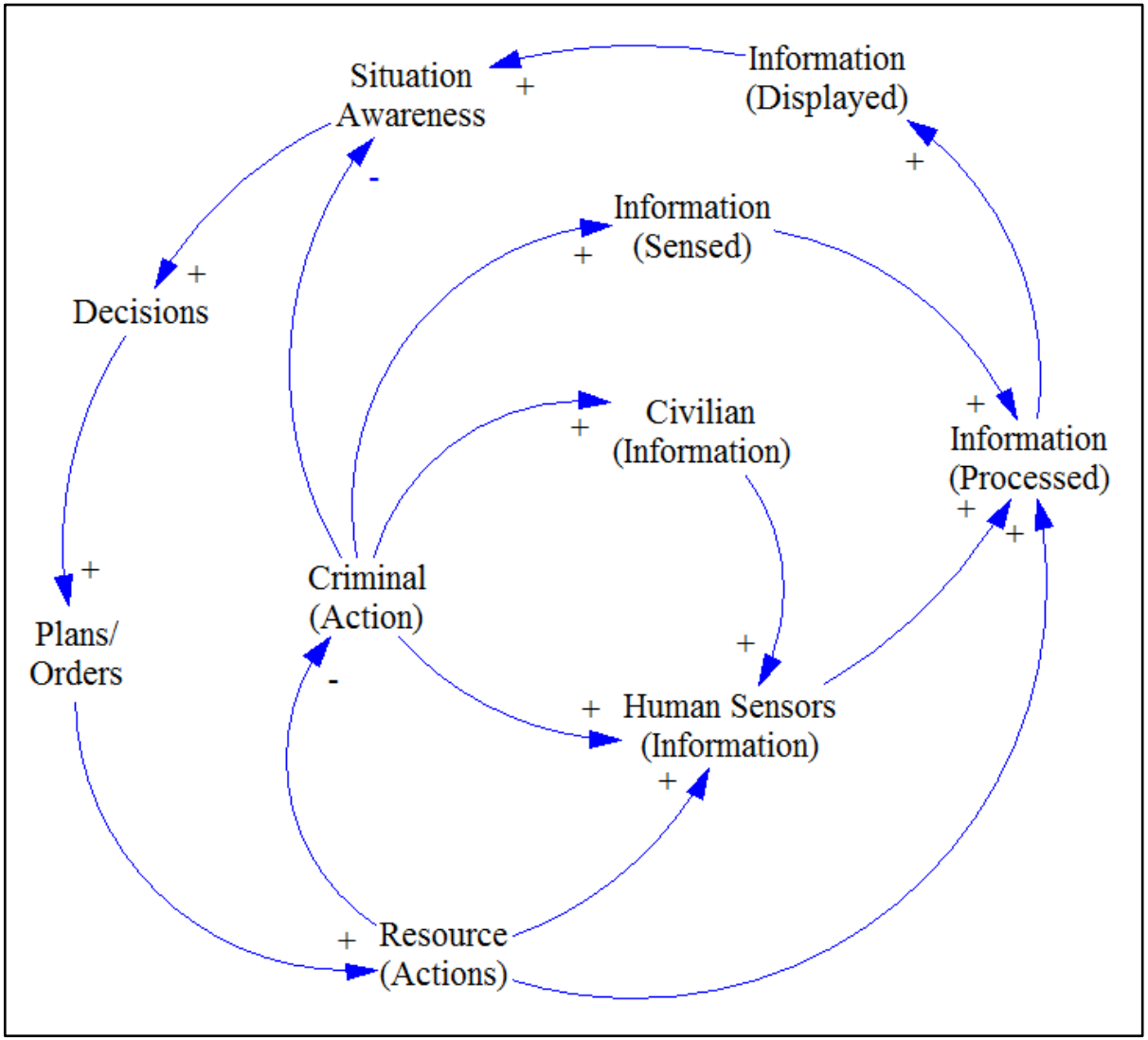
# Define Objective and Contribution of the Solution Artefact



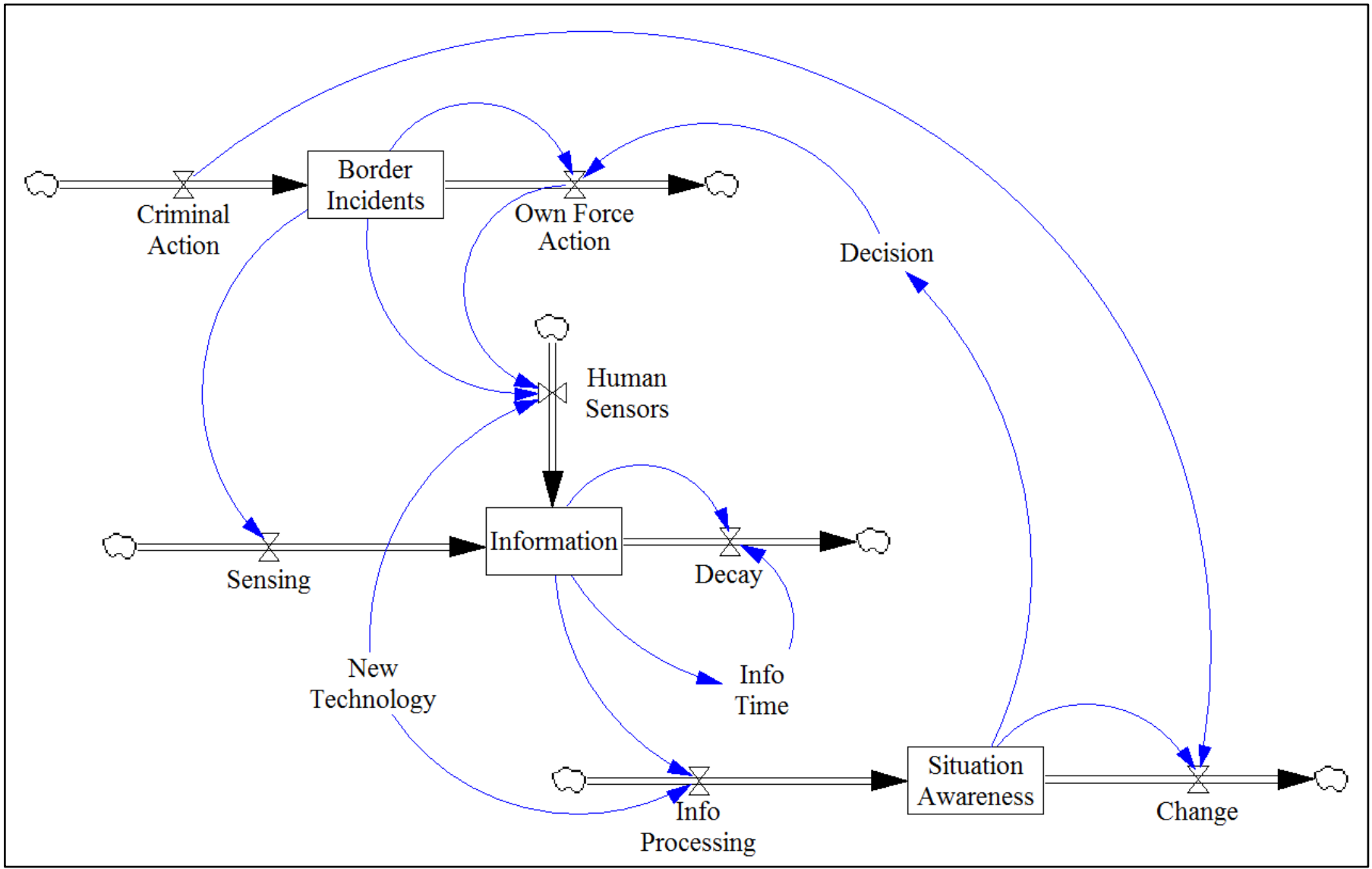
# Design and Develop Artefact - System Model



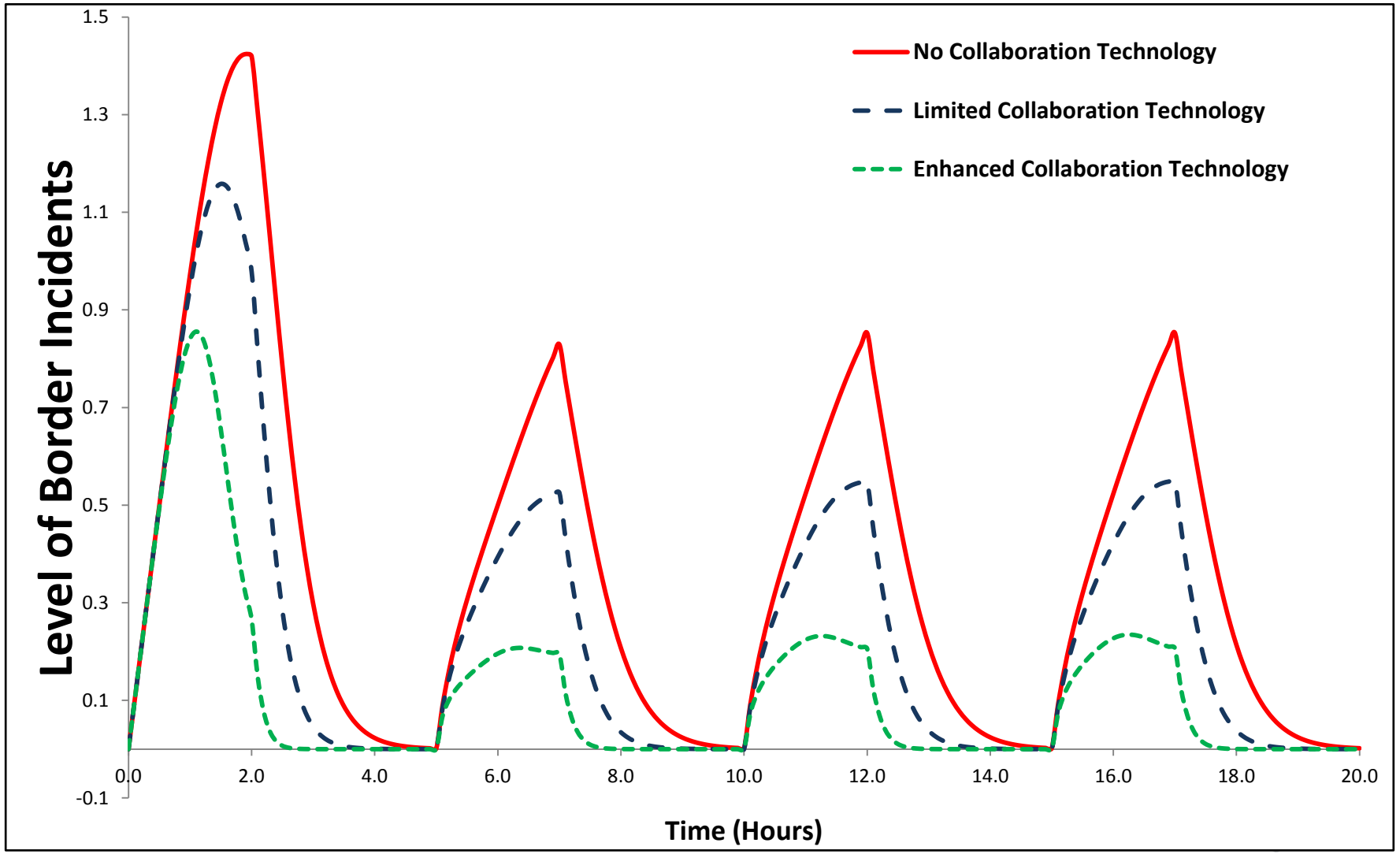
# Design and Develop Artefact - Causal Loop Diagram



# Design and Develop Artefact - Stock and Flow Diagram



# Demonstrate Artefact Ability in Context to Solve Problem



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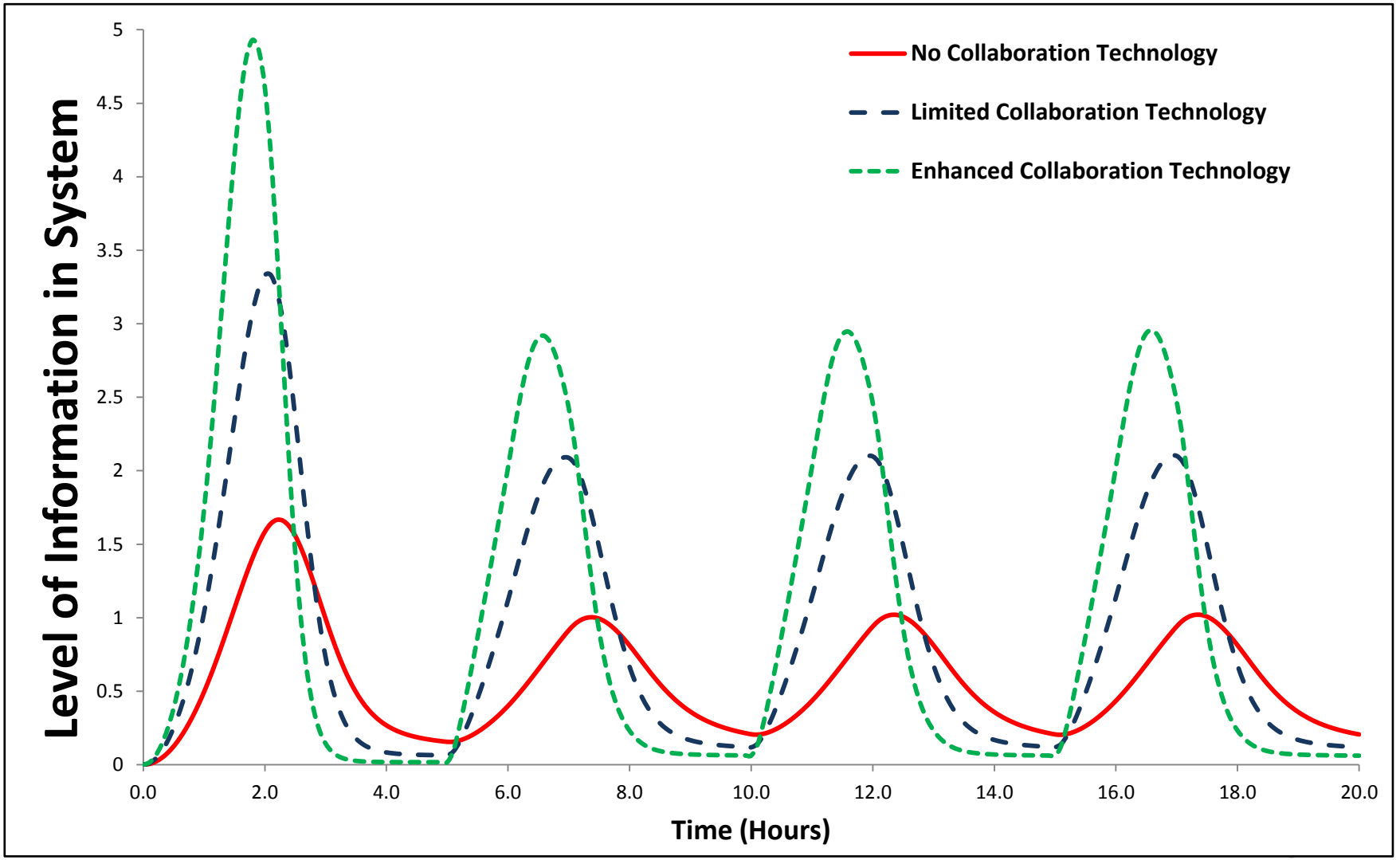

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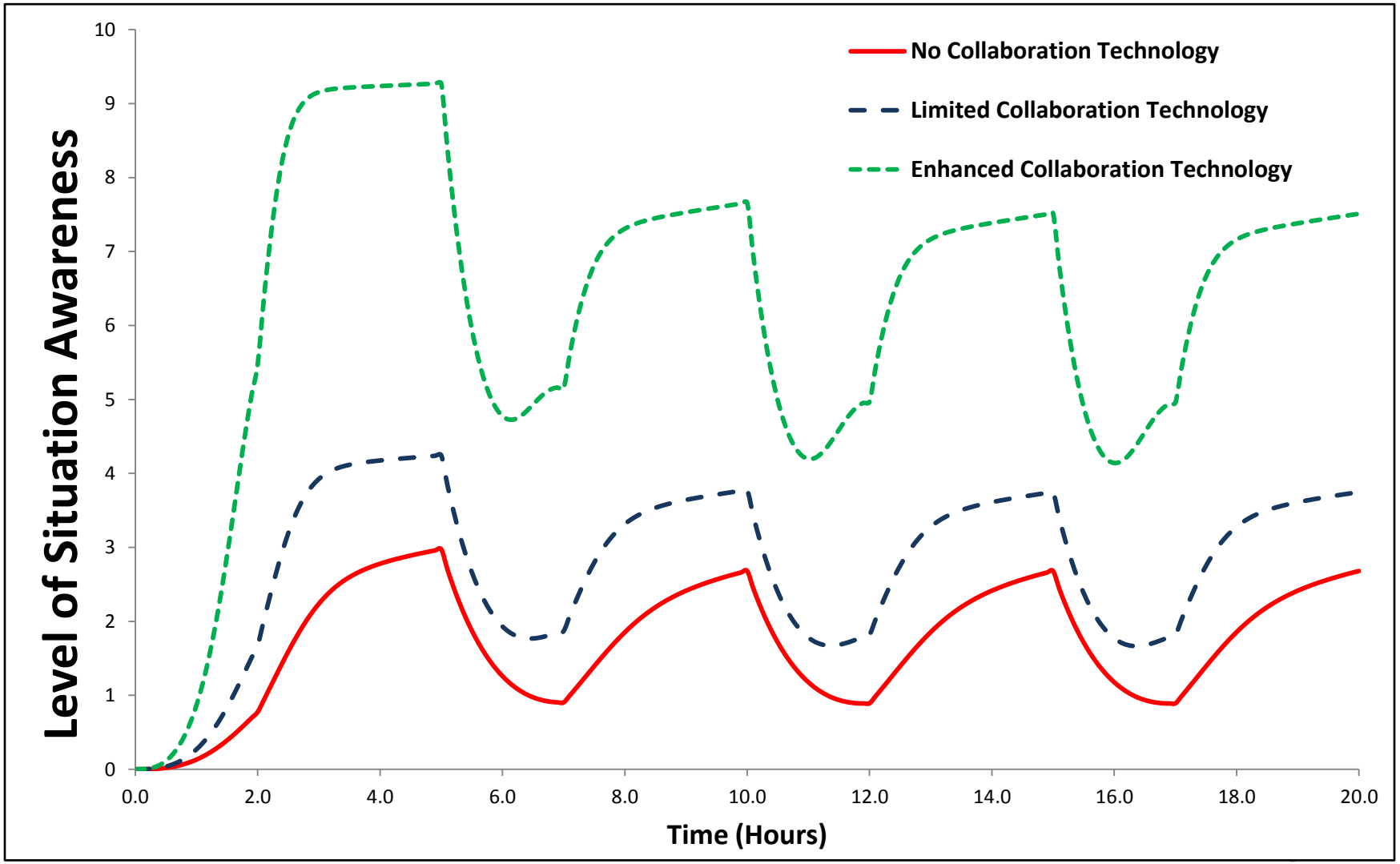

# Evaluation to Determine Ability of the Artefact Solve the Problem

- Modelling and simulation support field experiment planning
- Support knowledge on the problem to identify requirements for system development
- The cycle of learning also improve the models for further learning

# Conclusion

- Careful modelling and analysis are required to develop complex STS
- Modelling support experimentation to understand system requirements under diverse conditions
- Modelling of complex  Sociotechnical System
  - CWA provides models and constructs on human work
  - SD support assessment of dynamic behaviour
  - DSR framework to structure the methodology
- Knowledge from modelling and simulation support field experiments

# Thank you

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