



# Design logic in practice: A method to extract design criteria for future C2 systems

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# Disposition

- Purpose – to present a method to find requirements and elicit design criteria from scenario-based exercises using a design logical framework.
- Context – the development of future C2 capability within the Swedish Armed Forces (SwAF).
- Theoretical foundations – C2 theory and design logic.
- Method – three scenario-based exercises with subject matter experts (SMEs).
- Results – 109 requirements that could be used for eliciting design criteria.
- Conclusion – the combination of scenario-based exercises and design logic could be useful for the purpose of eliciting design criteria.

# Future C2 capability in SwAF

- This study has been conducted within a larger scope – the development of future C2 capability for the SwAF to be implemented during the 2025-2035 period.



# A theoretic framework for C2 (1)

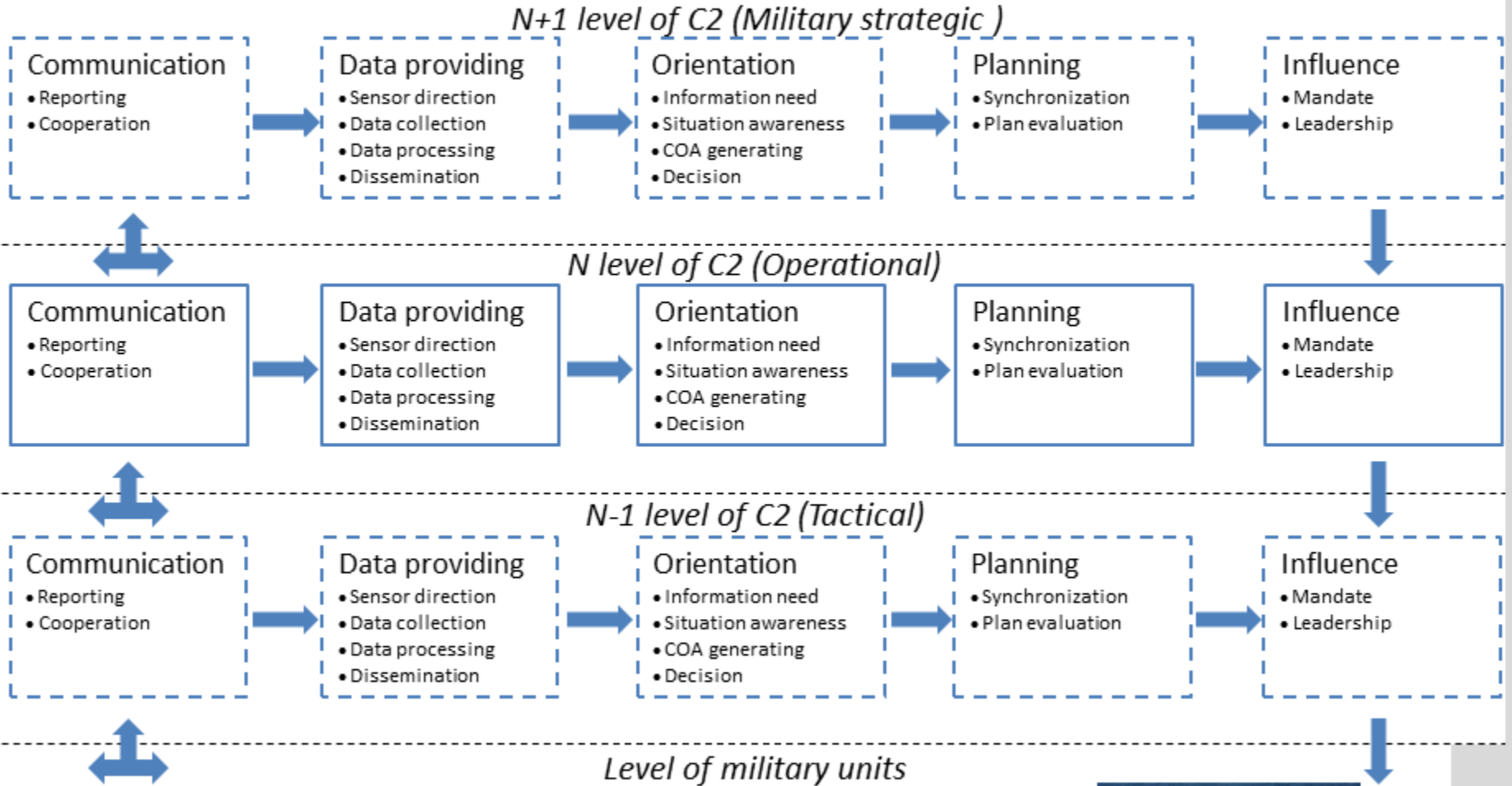
- The five necessary and sufficient functions needed to provide direction and coordination:
- Data providing
  - Collection, processing and dissemination of data from the operational environment – produces e.g., common operational pictures (COPs).
- Orientation
  - Problem solving, decision making, information needs – produces action-oriented understanding (e.g., commanders intent, course of action).
- Planning
  - Synchronization of resources in time and space and evaluation of the plan – produces a developed plan.

[1] (Brehmer, 2013).

# A theoretic framework for C2 (2)

- Influence
  - Ensures that the plan is effectuated (by the military mandate to command), provides leadership aspects – produces the actual order.
- Communication
  - Produces communication both within the C2 system and between the C2 system and the execution system (military units).

# The functional structure of the C2 system: possible subfunctions and systems approach.



[2] Adapted from (Spak, 2017).

# Design logic

- A tool for analyzing existing artefacts as well as for creating and developing new artifacts.
- The simplest version contains three levels:
  - The top level concerns the *purpose* of the artefact and answers to the question of *why* an artifact exists or why it should be created.
  - The second level concerns which *functions* are needed to achieve the purpose, i.e. *what* the artifact must produce to fulfill its purpose.
  - The third level concerns the actual form which describes *how* the functions are fulfilled.

[1] (Brehmer, 2013).

# Design criteria

- *Design criteria* are more specific or fine-grained requirements or constraints.
- Design criteria are a class of qualifiers that complements the three levels in design logic.
- Design criteria typically answer the question: *in what way?*
- In contrast to more general requirements, design criteria must be measurable and operationalized.



# The design logic hierarchy.

*Purpose (the "why?" of the C2 system): Direction and coordination*

*Design criteria ("in what way"?)*

*Function (the "what?" of the C2 system)*

## Communication

- Reporting
- Cooperation

## Data providing

- Sensor direction
- Data collection
- Data processing
- Dissemination

## Orientation

- Information need
- Situation awareness
- COA generating
- Decision

## Planning

- Coordination
- Wargaming

## Influence

- Mandate
- Leadership

*Form (the "how?" of the C2 system): Method, organization, personell, technology*



Existent solution



New solutions

# The scenario-based exercises (1)

- Methods relying on practitioners experiences could help developers to modify the current system, but not necessarily to find entirely new solutions.
- Instead we used three different scenarios that were portraying possible futures.

		Strategy	
		War-avoidance (Wa)	War-fighting (Wf)
Level of escalation	Offensive (O)	Wa + O (Scenario 1)	Wf + O (Scenario 3)
	Defensive (D)	-----	Wf + D (Scenario 2)

[3] (Edström & Josefsson, 2016).

# The scenario-based exercises (2)

- Text scenarios describing a global situation year 2027, threats and actions taken by an adversary towards Sweden, and planned or ongoing activities from the Swedish side.
- The scenarios also contained some examples of military units and equipment available to the Swedish side and also some of the adversary's resources.
- Participants: experienced officers that were specialists from the strategic, operational, and tactical (Army, Navy, and Air Force) command levels.

# The scenario-based exercises (3)

- Procedure:
  - The exercises took about one day to accomplish on three different occasions a month apart.
  - Participants were asked a set of questions: Who do you command? Where and when is C2 performed? What kind of decisions are needed? What are the prerequisites for decision making? What are your information needs?
  - Answers were recorded and the research team compiled a list of 109 C2 requirements\* for the development of a future C2 concept.

\* [4] See also (Andersson & Spak, 2016).

# Results (1)

- A two-step analysis was conducted:
  - First, each requirement was categorized in accordance with the five generic C2 functions.
  - Next, the requirements were scrutinized regarding possible design criteria contained within the more general requirements.
- One example of how design criteria could be extracted from the requirements is presented.
  - Requirement (scenario 3, Data providing and Orientation): *"The content of the operational picture should be adaptable to the level of conflict."*

## Results (2)

- This statement contains one general requirement: *"The content of the operational picture should be adaptable",*
- but also a more specific design criterion: *"to the level of conflict."*
- This criterion is measurable along a category scale (e.g., peace, elevated preparedness and war).
- Next step: *"In what way should the content of the operational picture be adaptable to a) a peace-time situation, b) a raised level of preparedness, and c) a war-time situation?"*

# Results (3)

- Next, we ask how these instances of an adaptable operational picture could fulfill the data providing function and the orientation function with its respective sub-functions (going up in the design logic hierarchy).
- This operation generates a total of 24 (3 levels of conflict X 2 functions X 4 sub-functions) new more specific questions to guide the design process – aiding the extraction of new design criteria.



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Existent solution

An "adaptable operational picture" (requirement) generates new solutions by the connection to generic C2 functions (and sub-functions) and more precise design criteria ("the level of conflict"). This design-process implies "going up and down" in the design logic hierarchy.



New solutions

Analysis of artefacts from form to purpose

Design process from purpose to form

Command and control system



# Conclusion

- The scenario driven exercises together with a design logical framework, were useful for identifying a multitude of requirements on a future C2 system.
- By displaying how the transformation of expressed requirements to design criteria could be done, this study contributes to the design process of adapting existent form elements, and also finding new form elements, for future C2 systems.

# References

- [1] Brehmer, B. (2013). *Insatsledning: Ledningsvetenskap hjälper dig att peka åt rätt håll*. Försvarshögskolan, Stockholm [in Swedish].
- [2] Spak, U. (2017, November). The common operational picture: A powerful enabler or a cause of severe misunderstanding. *Proceedings of the 22nd International Command and Control Research and Technology Symposium (ICCRTS)*, Los Angeles, CA.
- [3] Edström, H., & Josefsson, A. (2016) Vem kan leda operationer...och vem bör? *Kungl. Krigsvetenskapsakademiens Handlingar och tidskrift*, 1/2016, p.67-86 [in Swedish].
- [4] Andersson I., & Spak, U. (2016) *Krav och designkriterier gällande framtida ledningssystem*. Rapport till Försvarsmakten LED 151601S Huvudstudie Ledning. Försvarshögskolan, Stockholm [in Swedish].