FFI Norwegian Defence Research Establishment

A method for analysing status and operational effectiveness of armed forces – support to strategic decision making

NATO OR&A conference 2023, Johns Hopkins Univ., USA

Stein Malerud & Lars Musland

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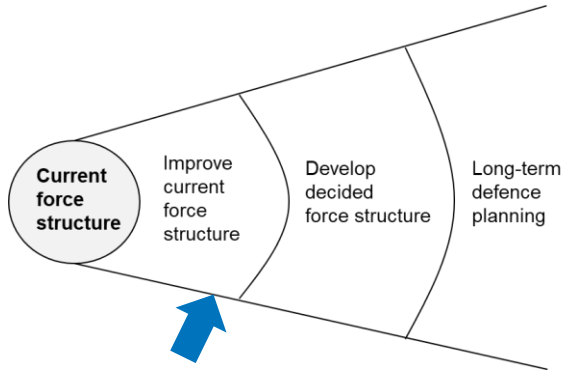
Introduction

- Aim: Provide decision support to help identify and prioritize measures to improve operational effectiveness of the armed forces

- However, first we need to understand weaknesses and shortcomings in the current force structure affecting system performance and operational effectiveness

- Recurring challenges:
  - Lack of quantitative analytical methods to relate the status of system elements to operational effectiveness
    - Previously: mainly qualitative assessments
  - Availability of reliable data and information



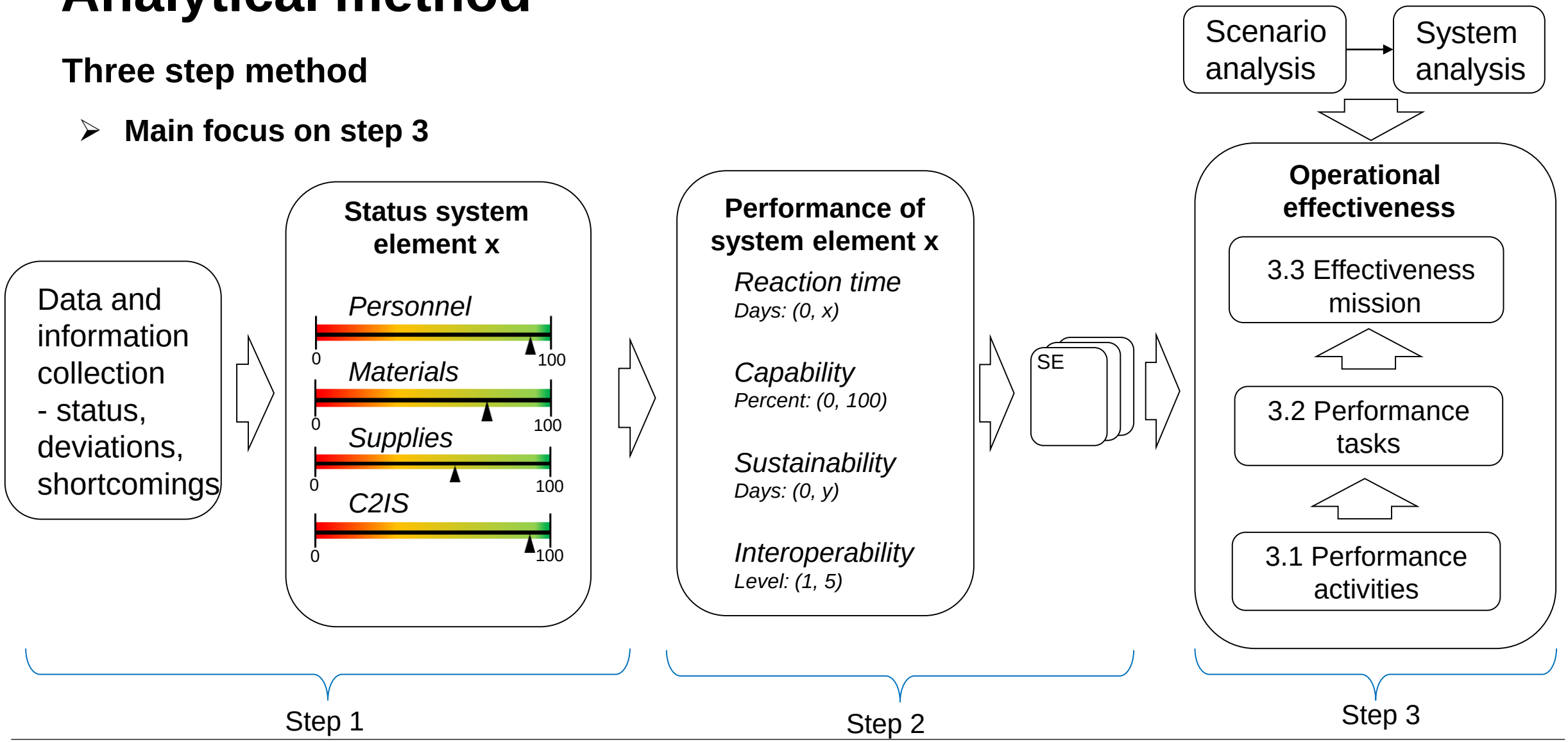
- We propose a quantitative method that:
  - Estimates the current status of system elements in the force structure, and further
  - Relates the status to consequences for operational effectiveness

- The proposed method helps to identify the most severe weaknesses and shortcomings that impact system performance and operational effectiveness, and thus should be prioritized and mitigated

Analytical method

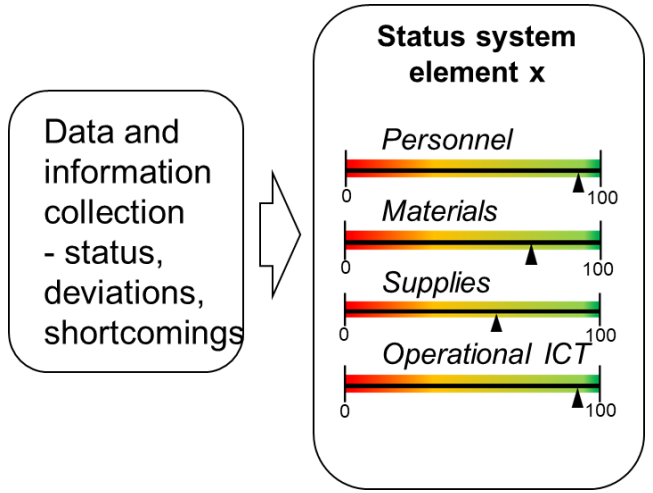
Three step method

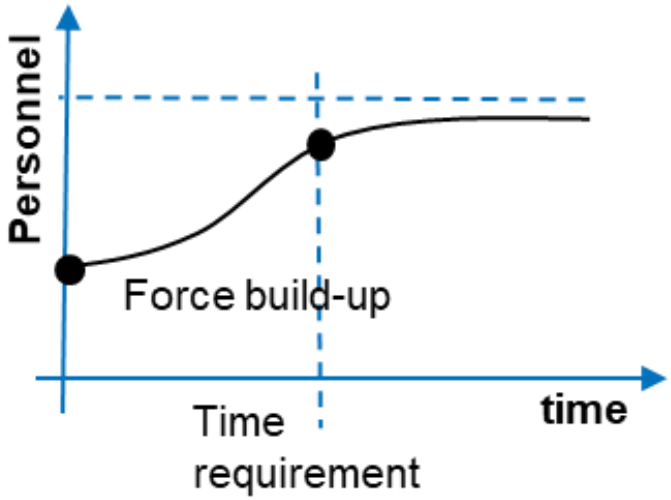
- **Main focus on step 3**



Step 1: Information collection and status of system elements

- What is the current status of relevant force system elements?
- Input:
  - Reports and documents produced by the defence forces (status, weaknesses and shortcomings)
  - Expert judgements
  - Mainly qualitative information
  - Substantial uncertainties
- The SE status is estimated by combining information from available sources using four state parameters (range 0-100 %):
  - Personnel (P)
  - Material (M)
  - Supplies (S)
  - Command, control and information systems (C2IS)
- Status assessed at two points:
  - “Observed” current status (t = 0)
  - Predicted status under force build-up at t = reaction time requirement





Step 2: Impact on system element performance

- Given SE status – what is the impact on SE performance?

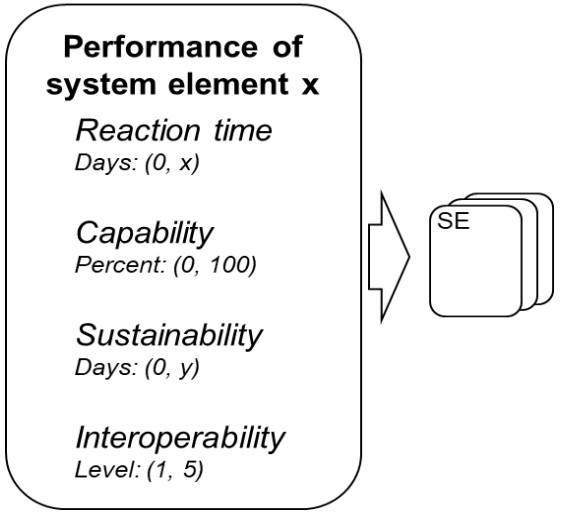
- Defined four measures of performance (MoP):
  - Reaction time – time to be ready for operations
  - Capability – ability to perform a certain activity or task
  - Sustainment – period the system element can sustain operations
  - Interoperability – ability to cooperate with other system elements in a operation

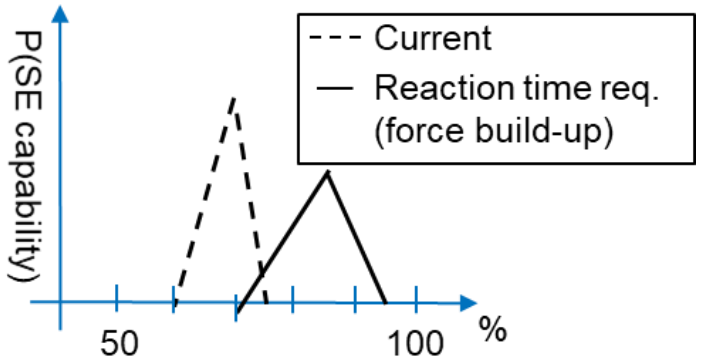
- Reaction time and capability are merged
  - Capability = *f*(time)
  - Evaluated at two points in time: t = 0, reaction time requirement

- Assessments are performed by SMEs and analysts

- For every performance parameter, we assess
  - The most likely level of performance (mode)
  - A minimum and maximum level to include uncertainties in the assessment

- Output: Triangular distributions for the performance parameters (minimum, mode, maximum)





Step 3: Scenario analysis

- Input: Selected scenario

- Scenario analysis to identify and derive requirements to
  - Mission {objectives, COA, tasks}
  - Tasks {activities}
  - Activities {capabilities and capacity, time (start, end), cooperation}

- Tasks and activities are derived using the Joint functions
  - command and control (C2)
  - intelligence (ISR)
  - engagement (fire and manoeuvre)
  - logistics
  - protection

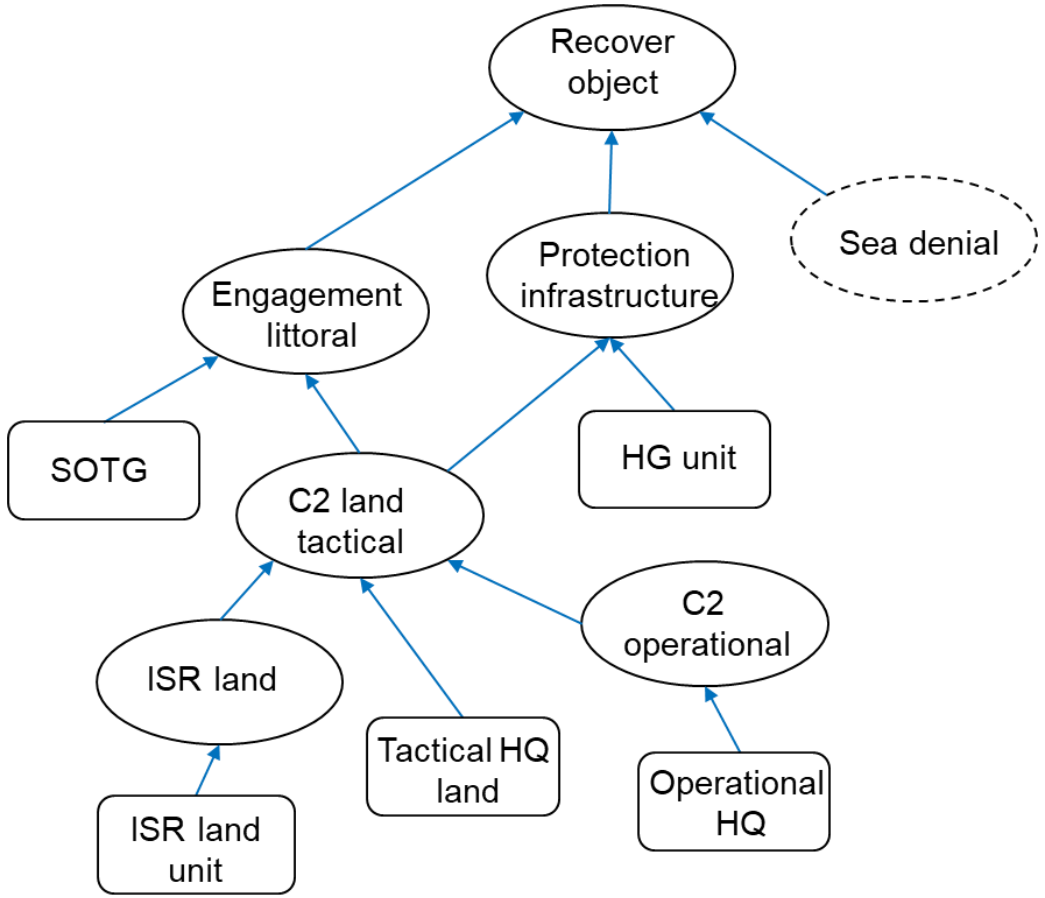
Case scenario:

- Raid against a littoral object
- The adversary is a state actor that aims to take control of the object (e.g. a harbour/sea port).
- Our objective: regain control of the object without escalating the situation any further

COA	Tasks	Activities	Capability and capacity	Cooperation	Start-end
Special operation task group (SOTG) to recover object. Sea forces and home guard (HG) to protect prioritized areas and objects	Engage adversary	Engagement littoral	SOTG	Operational, tactical HQ	10h-2d
	Protect prioritized infrastructure	Protection littoral objects	Protection littoral HG unit	Operational, tactical HQ	5h-2d
	C2 of operation	C2 land tactical	C2 land HQ	Operational HQ, tactical units	0-2d
	C2 of operation	C2 operational	C2 operational HQ	Tactical HQ	0-2d
	ISR land	ISR land activities	ISR land unit	Tactical HQ	0-2d

Step 3: System analysis

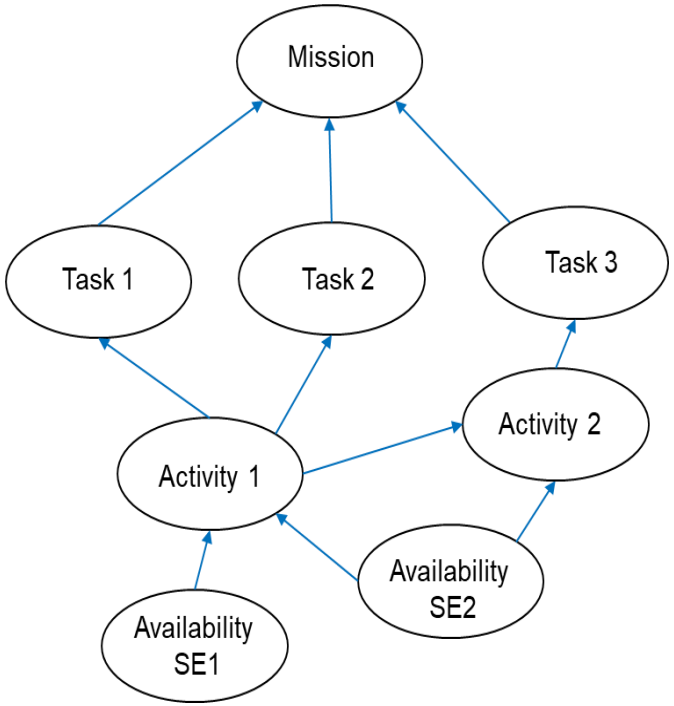
- Input: scenario analysis
- Identify SEs with relevant capabilities
- Identify dependencies and relations between
  - SEs and activities
  - activities and tasks
  - tasks and mission
- Develop system models based on the joint functions and scenario requirements



Method: Bayesian networks

- Bayesian network models:
  - Stochastic
  - Directed acyclic graph (DAG) comprising
    - Nodes: representing stochastic variables
    - Arcs: link dependent variables – causal or influential
    - Node probability tables (NPT)

- Every node in the network has an NPT containing information about conditional dependencies between variables
  - The probabilities of the NPTs must be specified



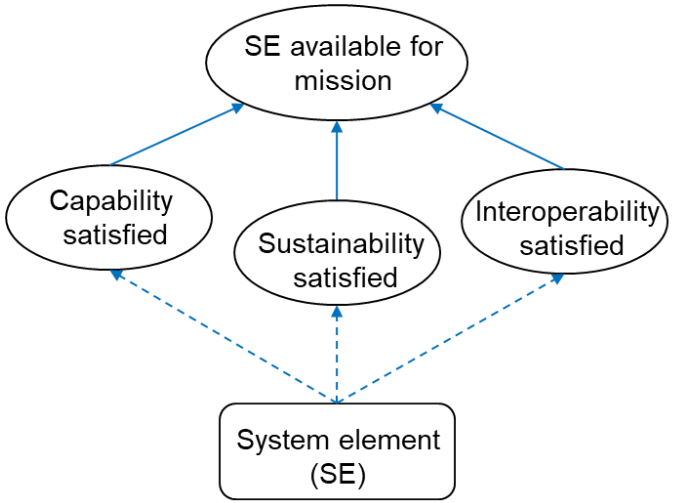
Step 3: transition step 2 => step 3

- Probability that a certain SE is available for operations (mission) according to scenario requirements
  - Capability & capacity
  - Sustainability
  - Interoperability

- Input: status and performance of relevant system elements from step 2

- Variables have two states: true (T) and false (F)

- Output: P(SE available for mission = T)



NPT for node “SE available for mission”

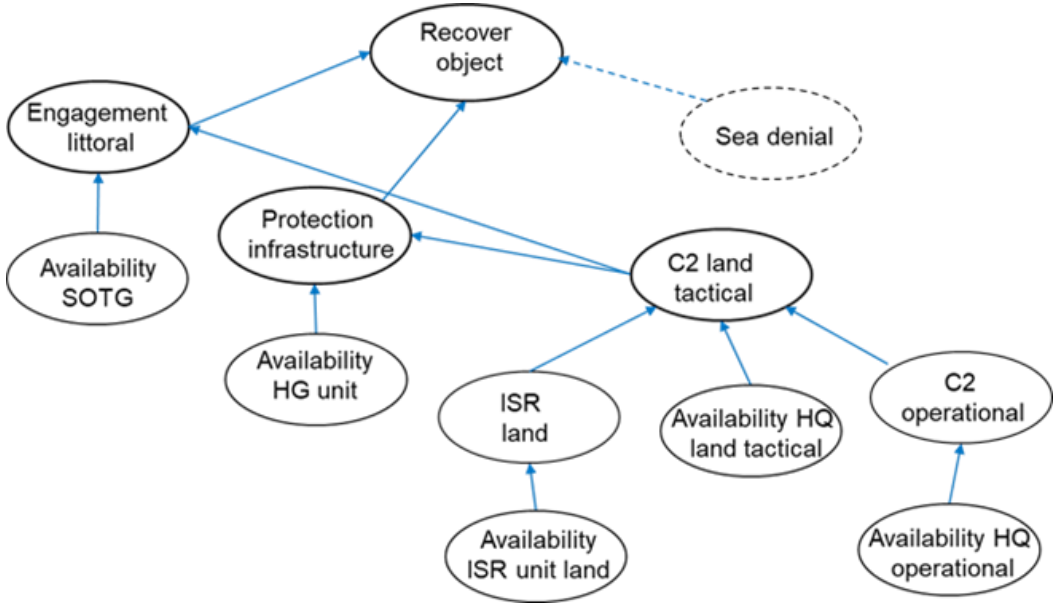
Capability	Sustain	Interoper	P(available = true)
T	T	T	1
T	T	F	0.8
T	F	T	0,9
T	F	F	0.7
F	T	T	0.4
F	F	T	0.3
F	T	F	0.1
F	F	F	0

Step 3: Models of activities, tasks and mission

- Input:
  - System models
  - Availability of system elements for mission
  - Scenario requirements

- Develop BN models:
  - DAG linking together activities, tasks and mission
  - NPTs comprising conditional probabilities

- Apply the model to calculate
  - Measure of performance (MoP):
    - measure the accomplishment of activities and tasks
  - Measure of effectiveness (MoE):
    - measures the state of a the system compared to goals and objectives



C2 land tactical

Tac HQ	Op HQ	ISR land	P()
T	T	T	1,0
T	T	F	0,6
T	F	T	0,8
T	F	F	0,4
F	T	T	0,5
F	F	T	0,2
F	T	F	0,3
F	F	F	0,1

Engagement littoral

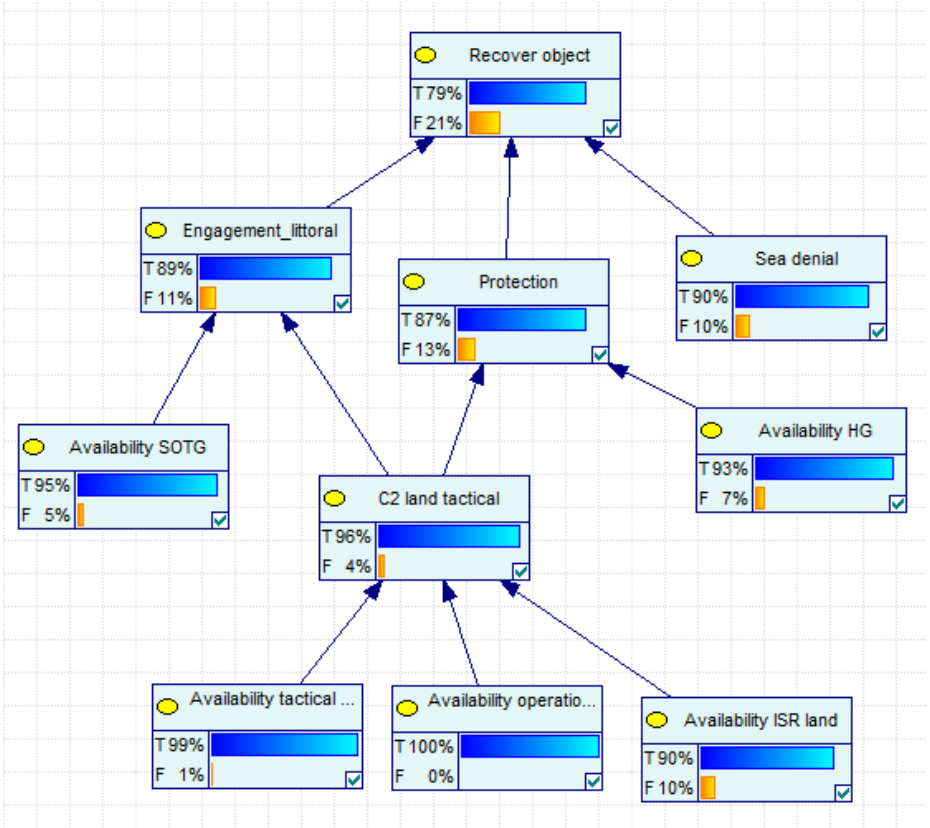
SOTG	C2 tac	P()
T	T	0,95
T	F	0,5
F	T	0,1
F	F	0,1

Protection infrastructure

HG-unit	C2 tac	P()
T	T	0,95
T	F	0,5
F	T	0,1
F	F	0,1

Impact on Operational Effectiveness

- The BN model is implemented applying the BN tool GeNie*
- Probability of successful recovery of object = 0.78 (high probability on an ordinal scale)



Recover object

Engage littoral	Protect	Sea denial	P()
T	T	T	0,9
T	T	F	0,7
T	F	T	0,8
T	F	F	0,6
F	T	T	0,2
F	F	T	0,1
F	T	F	0,1
F	F	F	0,01

*www.bayesfusion.com/genie

Conclusions

- The purpose of the proposed method is to provide an estimate of
  - the current status of system elements, and further
  - relate this status to consequences for operational effectiveness in different scenarios

- Aim: Inform decision makers about the effect of weaknesses and shortcomings in the force structure
  - ➢ Decision support to identify and prioritize measures to improve operational effectiveness

- The method and models are based on a previous, more qualitative approach, and are still under development

- We believe the improvements presented in this paper will enhance the quality of the method and models
  - Qualitative => quantitative models
  - A more structured, transparent and traceable approach
    - ➢ And thus, increase the confidence to the results

Way ahead

- Further develop step 1 and 2 of the method (garbage in => garbage out)
- Ensure models are sufficiently sensitive to changes in system element performance
- Validation of the system and BN models
- How to cope with larger models?
  - More variables and relations
  - Larger NPTs – more relations and states of the variables
- Operational risks

Questions?