Evaluating Unmanned Systems' Command and Control Technologies under Realistic Assumptions

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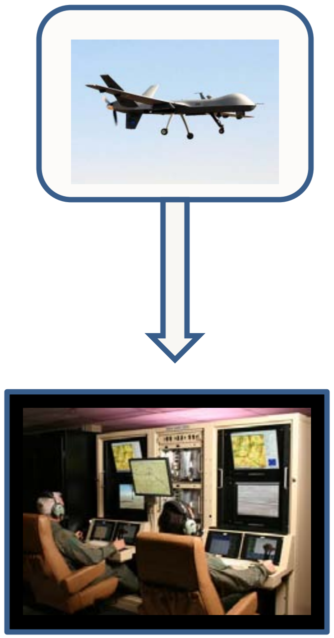
The Future of Unmanned Systems

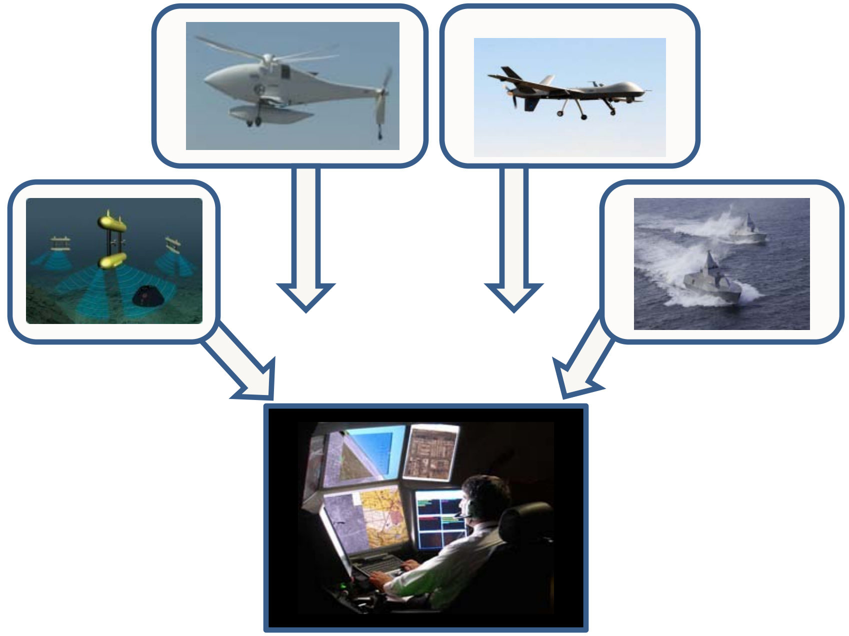
- The Department of Defense's future vision for Network Centric Operations (NCO) is intended to increase combat control by networking relevant entities across the battlefield [1].
  - ✓ In a future NCO scenario, one operator is going to supervise a team of heterogeneous Unmanned Vehicles (UVs) to work together towards a specific task.

C2 Transition

Today:
Manually control of one UV

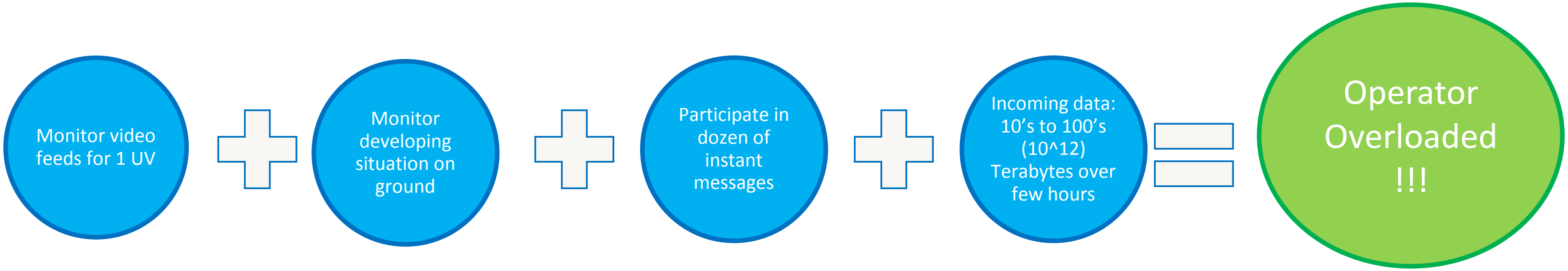


Future:
Supervisory control of a team of heterogeneous UVs

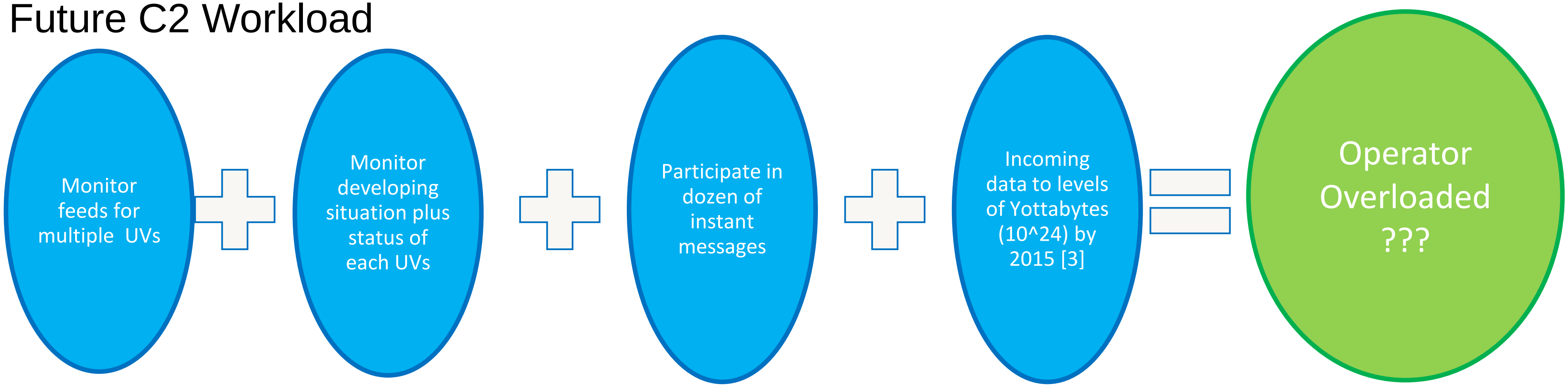


Workload Sources

Current C2 Workload



Future C2 Workload



Design Challenges

- Information overload
- Attention allocation
- Task switching and interruption
- Trust and effectiveness of the system to match mission requirements

Motivation

- To successfully develop Unmanned System's technology for NCO scenarios the following is required:
  - ✓ Rigorous mathematical methods and tools for predicting the behavior of newly developed C2 technologies and the operator under realistic assumptions.
  - ✓ Field testing approaches to identify potential problems and prove the capabilities and robustness of the new technologies.

Questions of Interest

1. With the current overloaded state of the information of most C2 technologies, how can we ensure an adequate ratio of UVs to an operator in NCO scenarios?

2. Are new C2 technologies being developed for NCO scenarios truly reducing information overload and increasing operator performance for a given set of mission requirements?

Research Goals

- Develop a decision-making tool that will serve to help decision makers:
  - ✓ Select an adequate C2 technology for a complex mission scenario.
  - ✓ Determine the limitations of the C2 technology in terms of mission requirements (i.e., team size, performance level).
  - ✓ Determine areas that require improved designs in order to modify them and increase operator performance.
  - ✓ Develop a better understanding of what enables operator capacity in this type of mission scenario.

Research Approach

- A decision-making tool was developed using a Decision Network (DN).
  - ✓ DN uses decision theory, which is a close cousin of probability theory, to:
    - o Specify the desirability of various outcomes and the cost of various actions that may be performed to affect the outcome.
    - o Find an action or plan that maximizes the expected utility minus the cost.

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Modeling Operator Capacity

- Simplified version [4]:
  - Only 1 UV

$$FO = \frac{NT + IT}{IT} = \frac{NT}{IT} + 1$$

- Modified Version [5]:
  - Multiple homogeneous UVs

$$FO = \frac{NT}{IT(WTI) + (WT)} + 1$$

How is the situation modeled?

- Model the situation [6]:
  - Discrete event simulation.
  - Heterogeneous UVs.
  - UT as workload measure.

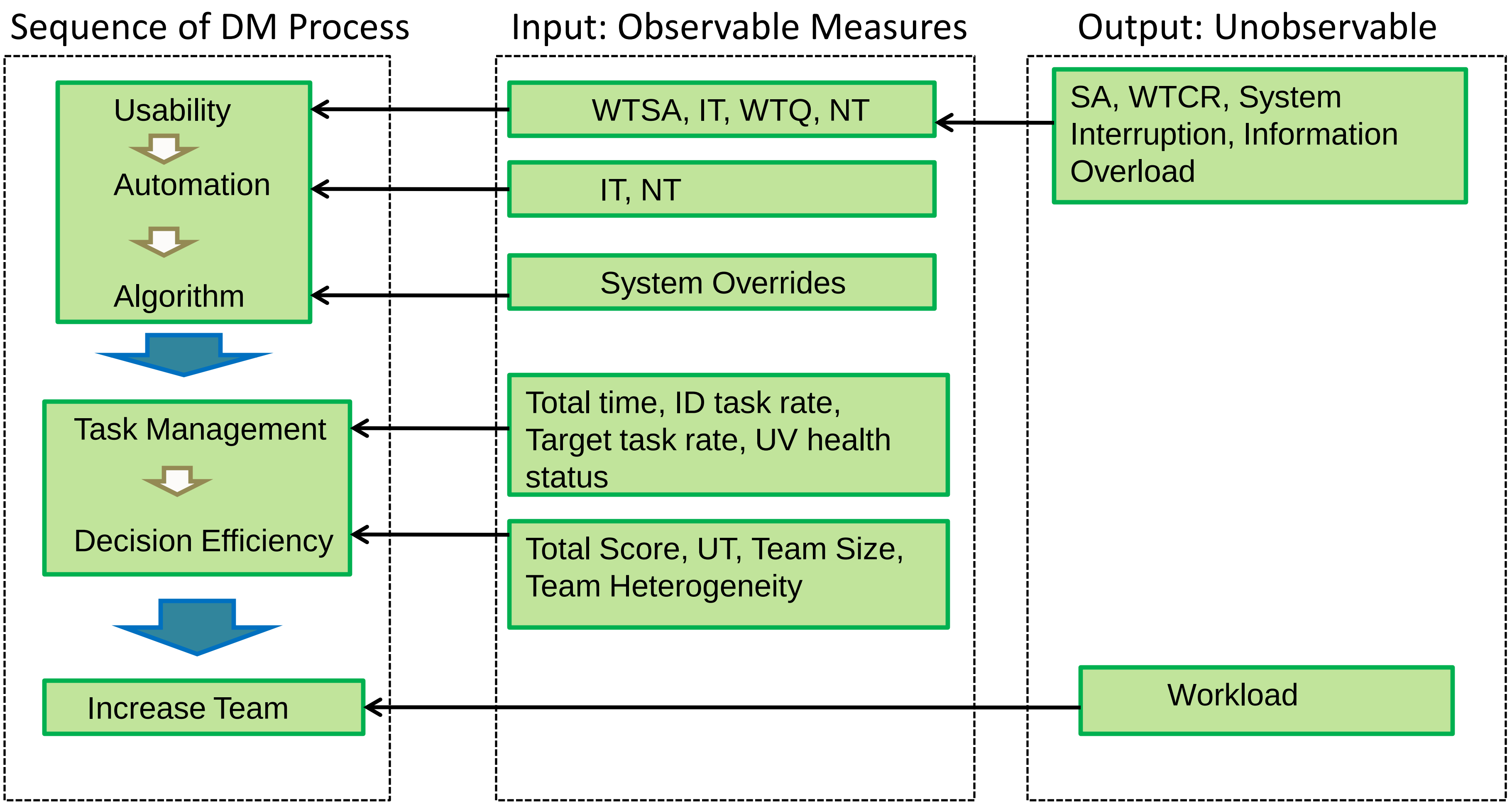
- Information Processing theories [7]:
  - What affects performance?

What affect the operator in complex tasks?

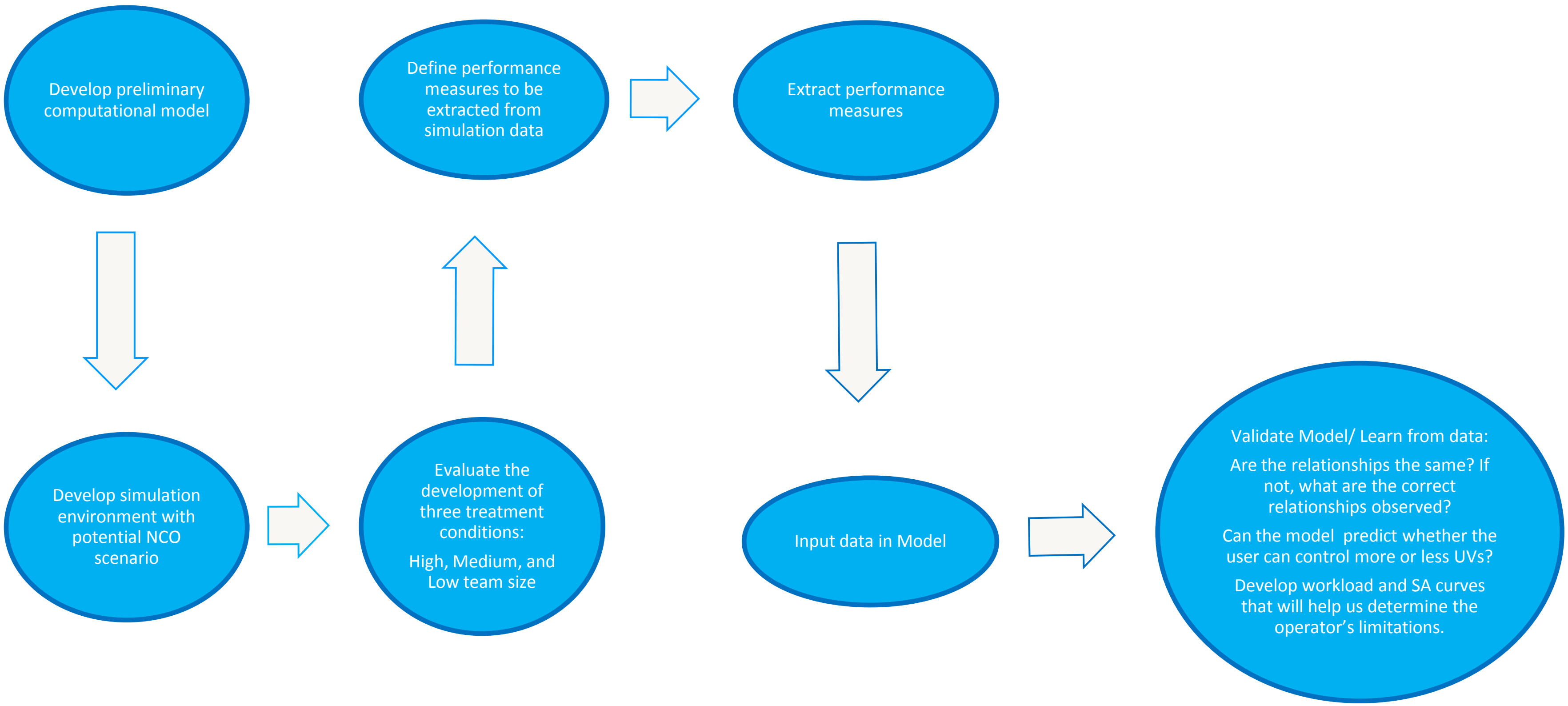
Complex Mission Task → **Operator Cognitive Capacity Model**

- NCO Scenario: multiple heterogeneous UVs, high workload, simultaneous tasks, multiple enemies, etc.

Model Details



Experimental Methodology



Experimental Trials

- Experimental trials are currently being conducted online at Naval Postgraduate School (NPS).
  - ✓ The online trial includes: a background and exit survey, a tutorial, a trial game, and one of a set of possible experimental conditions.
- The study design will be a between subjects with three conditions:
  - ✓ High team size (9 UVs), medium team size (7 UVs), and low team size (5 UVs).

Research Implications

- Better understanding of operator cognitive capacity in complex UV mission scenarios.
- Development of specific C2 design requirements for complex UV environments.
- Definition of the performance measures for this type of complex mission scenario.

Future Research

- Model Validation Phase 2:
  - ✓Validate the model with a different NCO technology.
  - ✓Incorporate workload and SA curves into the model to strength prediction.
  - ✓Start working on a decision tool package that will include model and program to extract input from any simulation.
- Investigate the development of a warning tool based on our decision net.

Questions?

References

[1] Department of Defense, “Network Centric Warfare: Department of Defense Report to Congress,” Office of the Secretary of Defense, Washington, DC, 2001.

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[4] Olsen, D.R. & Goodrich, M.A. (2003). Metric for Evaluating Human Robot Interactions. In Proc. NIST Performance Metrics for Intelligent Systems Workshop.

[5] Crandall, J.W. & Cummings, M.L. (2007). Developing Performance Metrics for the Supervisory Control of Multiple Robots. Human Robot Interaction Conference, Arlington, VA..

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[7]Speier, C., Valacich, J.S. & Vessey, I. (1999). The Influence of Task Interruptions on Individual Decision Making: An Information Overload Perspective. Decision Sciences, 30(2): 337-360.