Temasek Defence Systems Institute

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# Enhancing Mission Engineering Route Selection Through Digital Twin Decision Support

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## Objective of thesis

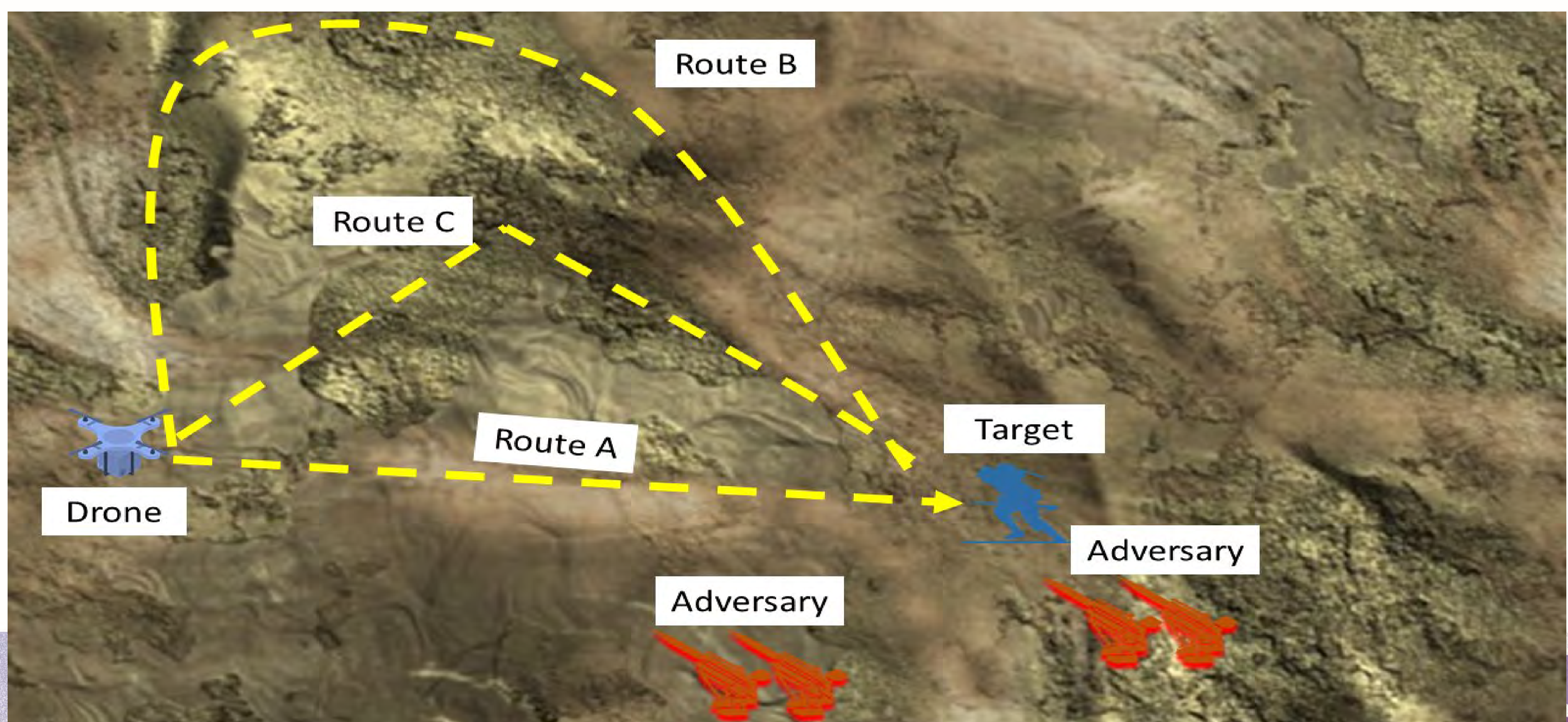
This thesis presents a Model-Based Systems Engineering (MBSE) methodology for the development of a Unmanned Aerial System (UAS) Digital Twin (DT) with the ability to demonstrate route selection capability with a mission engineering focus.

## Methodology

| Steps | Details |
|---|---|
| S1: Define stakeholder Needs | • Define system physical design<br>• Define goal of the operations analysis |
| S2: Create functional model or digital twin of the system | • Develop system via MBSE software using Systems Modeling Language (SysML) |
| S3: Develop parametric equations | • Define system quantitative characteristics<br>• Parameters can be derived from other subsystem parameters and mathematical expressions can be defined in the model |
| S4: Integrate digital twin with Operations Analysis software | • Integrate model with statistical analysis tools for operations analysis i.e. route optimization |
| S5: Define Risk attitude weightage | • Risk attitude towards the mission affects the weightage given to each route selection criteria |
| S6: Perform Operations Analysis | |

## Case Study

**Mission**: To deliver supplies to a forward deployed soldier. Routes entail exposure to adversary action. The DT decision support module shall recommend the most optimal route which is based on the operator's risk-attitude.




## Case Study (Continue)

**Route Selection Criteria:**

1) Time To Target

Straight-line distance divided by the speed of the UAS

2) Probability of Hit

$$P_h = P_{Weapon} \times P_{Command} \times P_{Threat}$$

3) Remaining Battery Life

$$E_{demand} = P_M \times P_I \times t$$

$$E_{supply} = V_{batt} \times C_{batt} \times 3600$$

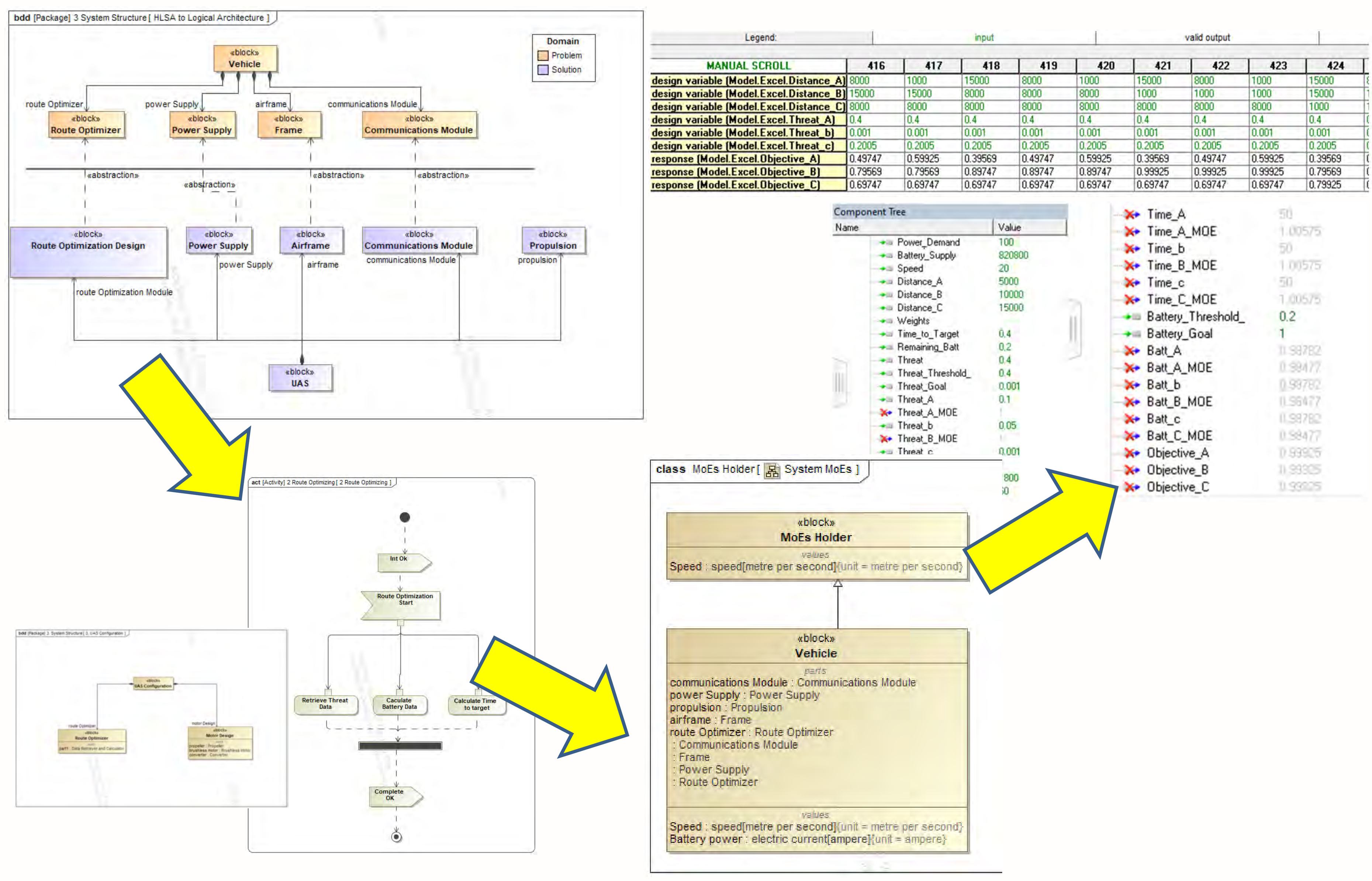
$$B_R = \frac{E_{demand} - E_{supply}}{E_{supply}}$$

**Value Function using Multi-Attribute Utility Theory:**

$$v_{missionlead} = w_1 TimetoTarget_{score} + w_2 ProbabilityofHit_{score} + w_3 RemainingBattlife_{score}$$

## Results

**UAS Digital Twin Model and Operations Analysis**



The UAS model developed via Cameo Enterprise Architecture was integrated with the ModelCenter analysis software. A total of 720 runs are simulated based on a 6-factorial design-of-experiments of the variables. The results validate that the most optimal route with the highest objective value is selected.

## Key Observations

- Defining risk-attitude weightage prior to operations, enhance the quality of decision-making by making them more consistent and traceable
- Quality of data is fundamental to the success of decision support algorithms

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