Connecting Simulations of Various Architectures in a Central Simulation Framework with Networking Capability to Support Wargaming for the Swedish Armed Forces

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Presentation overview

- Objectives
- Simulation system
- Models
- Simulation example
- Networking
- Data processing and evaluation
- Conclusion

Objectives

Provide simulation data to support adjudication in the Swedish Armed Forces defence planning wargaming activities

Re-use models and simulations of relevant systems

Adapt models and provide simulation support for the focus areas defined by the Swedish Armed Forces

Current focus area: Air-to-Air (BVR) scenario

Overview Air-to-Air focus area

Acquire and process simulation data to improve adjudication of air defence scenarios

Starting with simple scenarios

- Air-to-Air (BVR)
- Small units, typically one to four aircraft

Cooperation with FOI, the Swedish Defence Research Agency

Central Simulation Framework

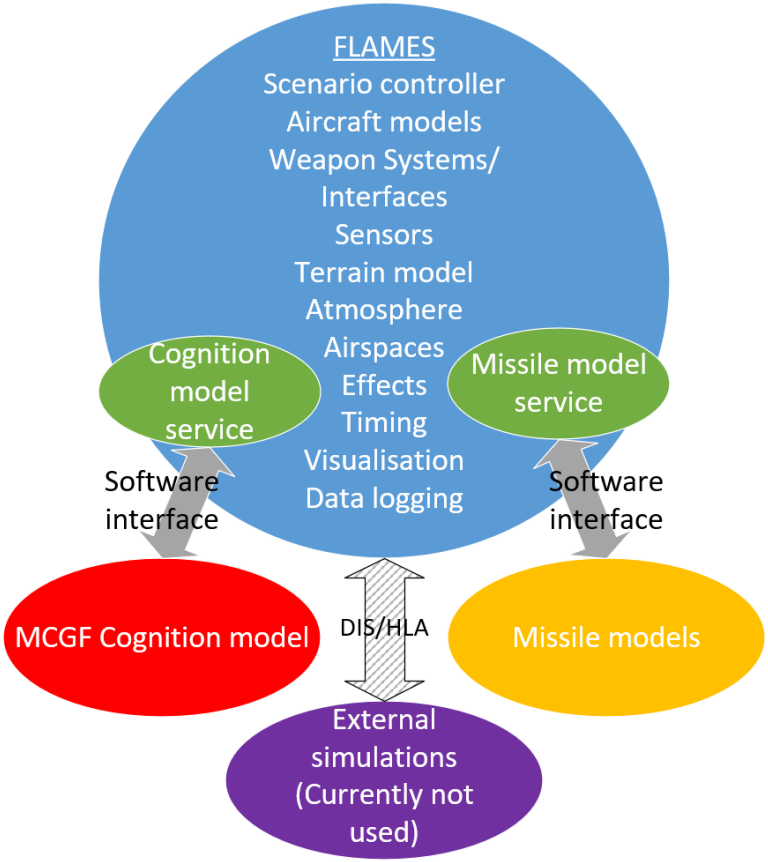
FLAMES, by Ternion Corporation, Huntsville, Alabama, USA
Provides for example

- Setup, control and execution of scenarios
- Visualization in map view and perspective view
- Data logging
- Comes with “Bundled models”, full source code for Microsoft Visual Studio 2010, 2013 and 2017

Simulation System Overview

Some models and general housekeeping in FLAMES (blue area)

Re-used models, often more advanced, run externally



Models

High model fidelity

- Aircraft
- Pilots
- Missiles

Low model fidelity

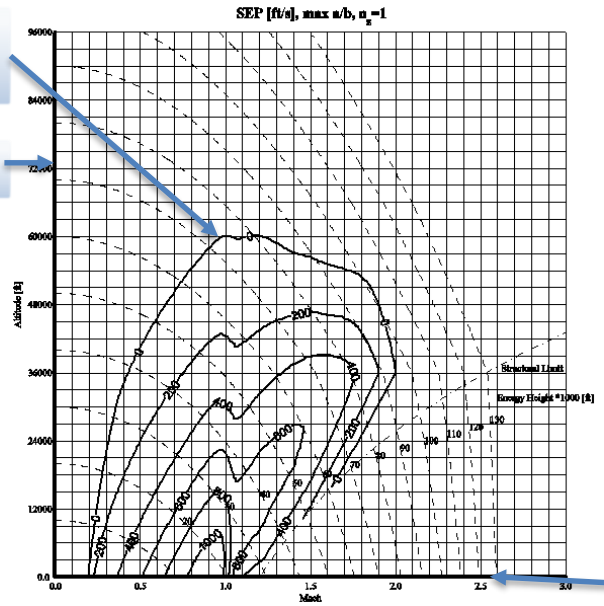
- Sensors
- Countermeasures/EW
- Physical environment

Aircraft Models

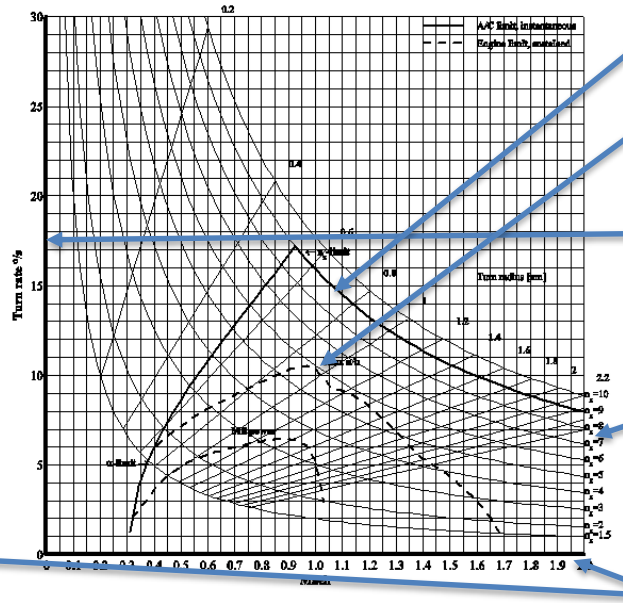
- Based on FLAMES “bundled model” fixed wing aircraft
- Aerodynamics and engine data from FMV Technical Intelligence Department (FMV TeknUnd)

Specific excess power diagram

Altitude



Turn performance diagram, instantaneous and sustained



Turn rate

Nz

Mach

Example diagrams from open F-16 model

Aircraft Models, ”how to”

- Aerodynamics and engine data converted to AER format as published by Saab
- FLAMES 3DoF “Bundled Model” modified to use data tables
- Other changes to “Bundled Model”
  - Fuel consumption
  - External stores
  - Stall
  - Attitude angles
  - Large heading changes
  - Time constants
  - Limits

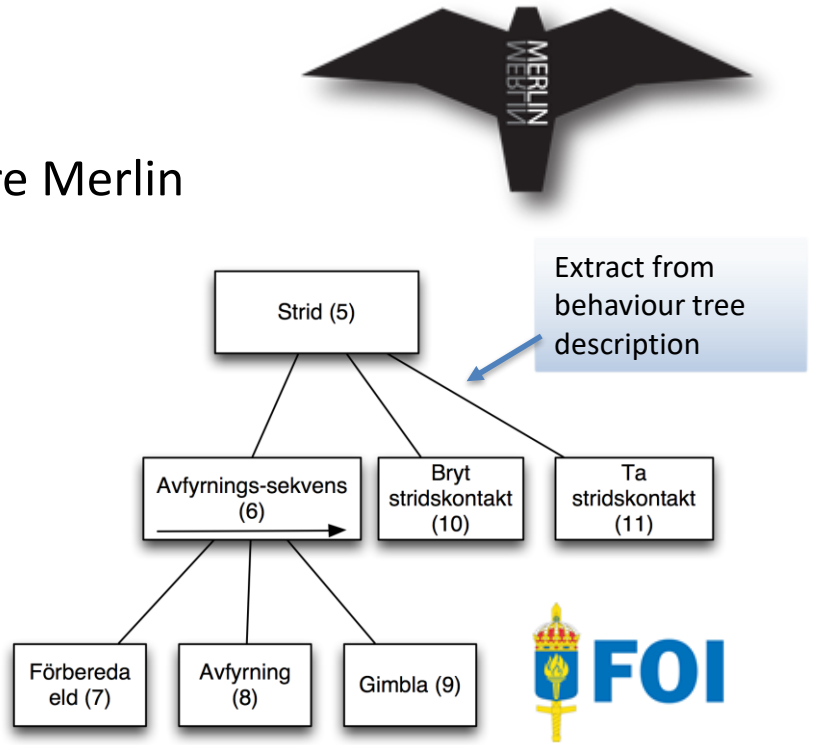
AER table example

```
CDICL2
CDi/CL^2 sfa Mach och CL:
140317
2
CL
MACH
0     0    0
0     0.7  0
0.1   0    0.1
0.1   0.7  0.15
0.1   1.   0.16
0.1   2.0  0.18
0.2   0    0.15
0.2   0.7  0.18
0.2   1.   0.19
0.2   2.0  0.12
0.5   0    0.15
0.5   0.7  0.18
0.5   1.0  0.10
0.5   1.5  0.09
1.0   0    0.12
1.0   0.7  0.15
1.0   1.0  0.16
```

Pilot Models

Pilot behaviour MCGF by FOI

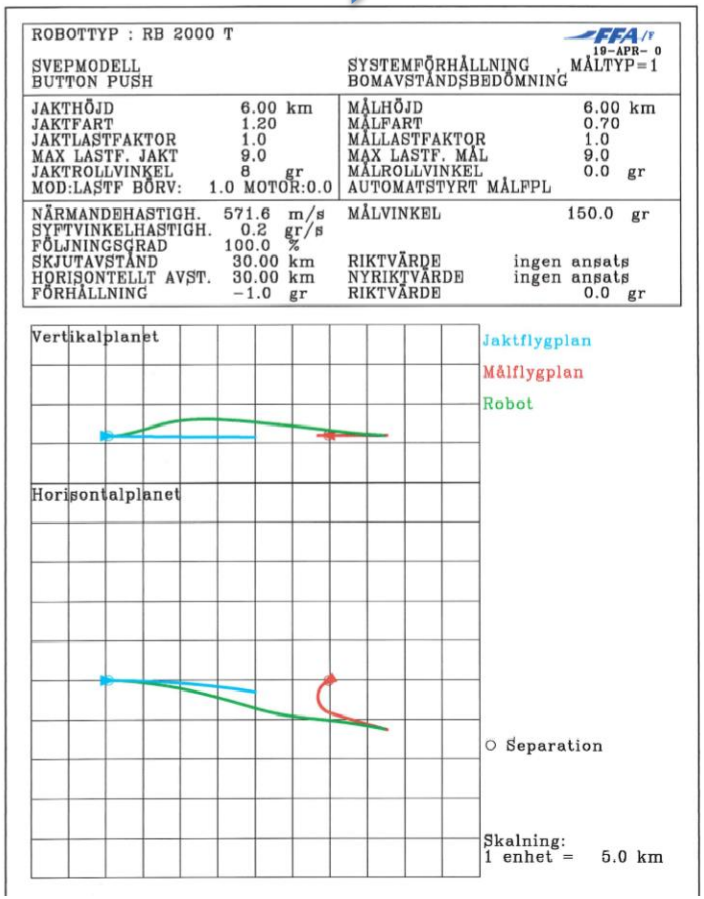
- FMV/FOI component based architecture Merlin
- Developed in collaboration with active fighter pilots
- Behaviour trees defined in XML
- “Leaves” defined in C++
- Integrated with FLAMES by FOI
- Driven by service in FLAMES
- Approximately 3 Hz update rate
- Controls aircraft and weapon system via FLAMES commands and queries



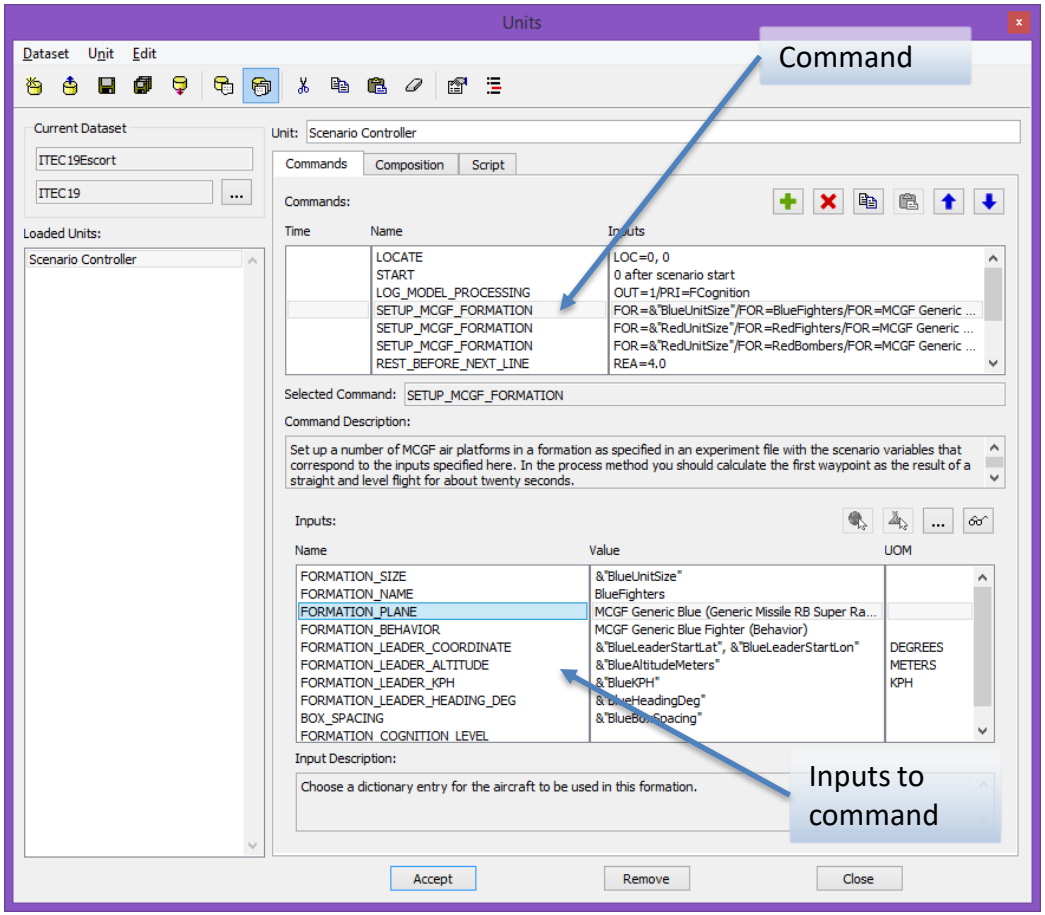
Missile Models, ”Refbib”

- Successfully integrated in various simulations since the 1990s
- Updated using data from FMV, FOI and industry
- Models defined entirely in FORTRAN, in Linux environment
- FORTRAN “wrapper”, called from C in FLAMES to input and extract data to/from missile simulation
- Driven by service in FLAMES
- 50 Hz update rate

Simulation of single shot, generic missile



Scenario Controller

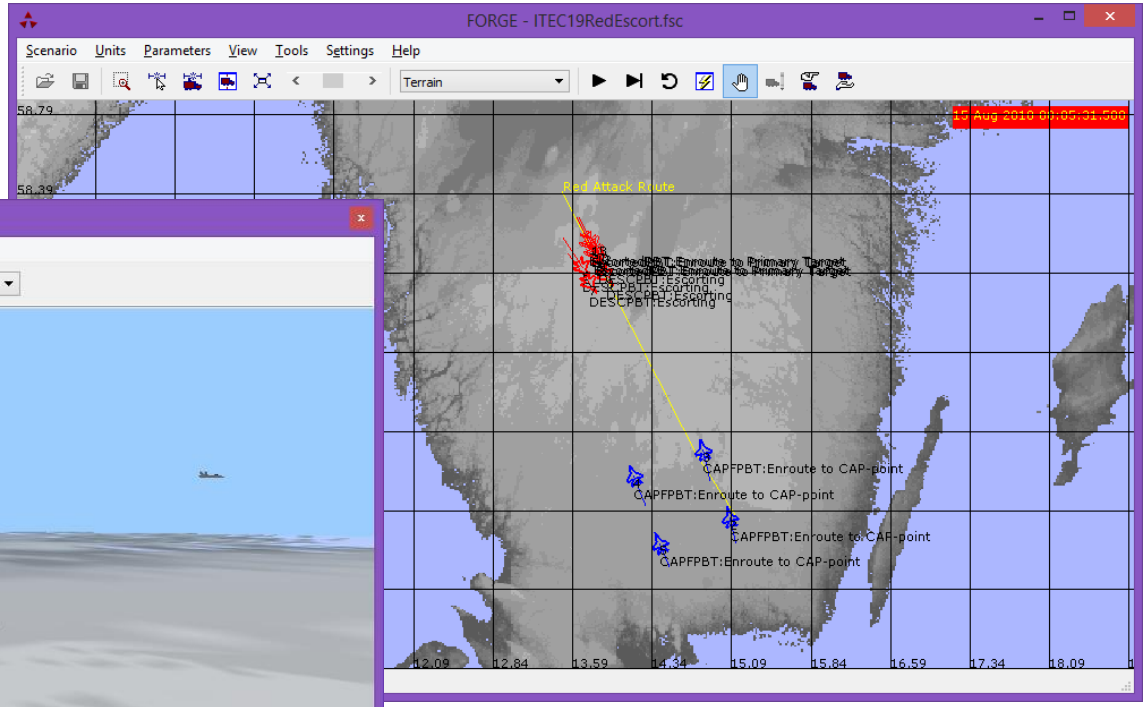


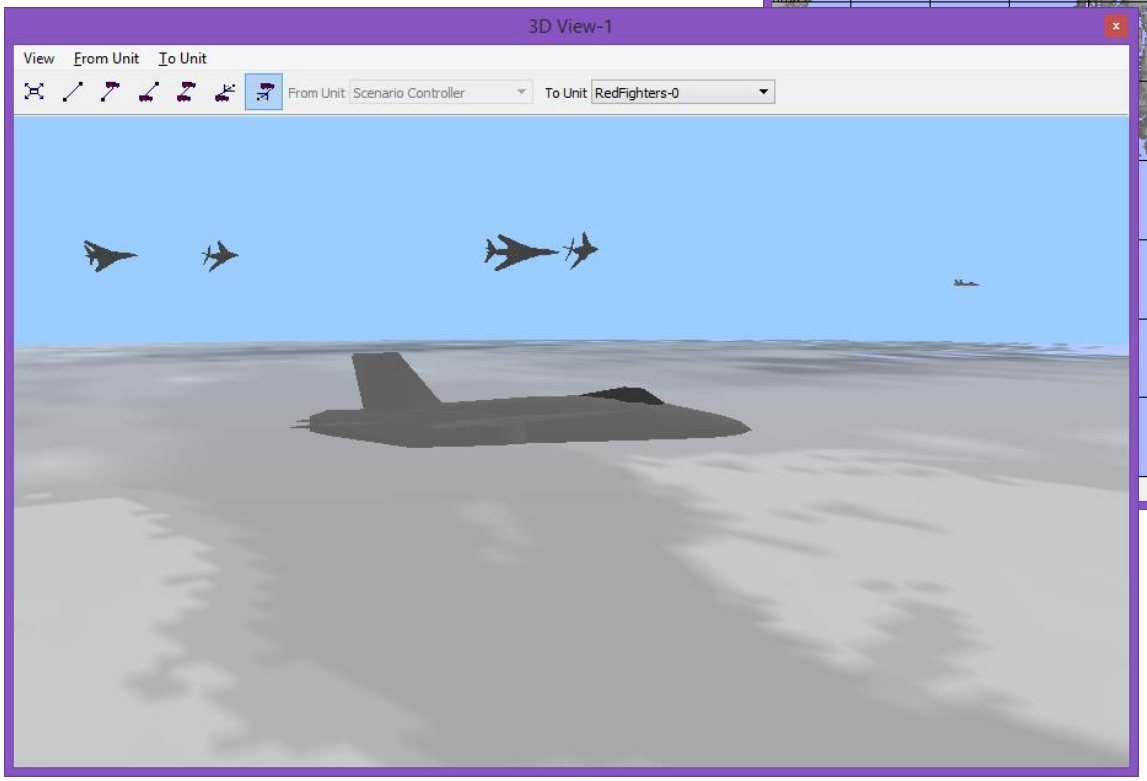
Configured in FLAMES ”Units” window

Using commands to set up formations, give them their tasks and launch them

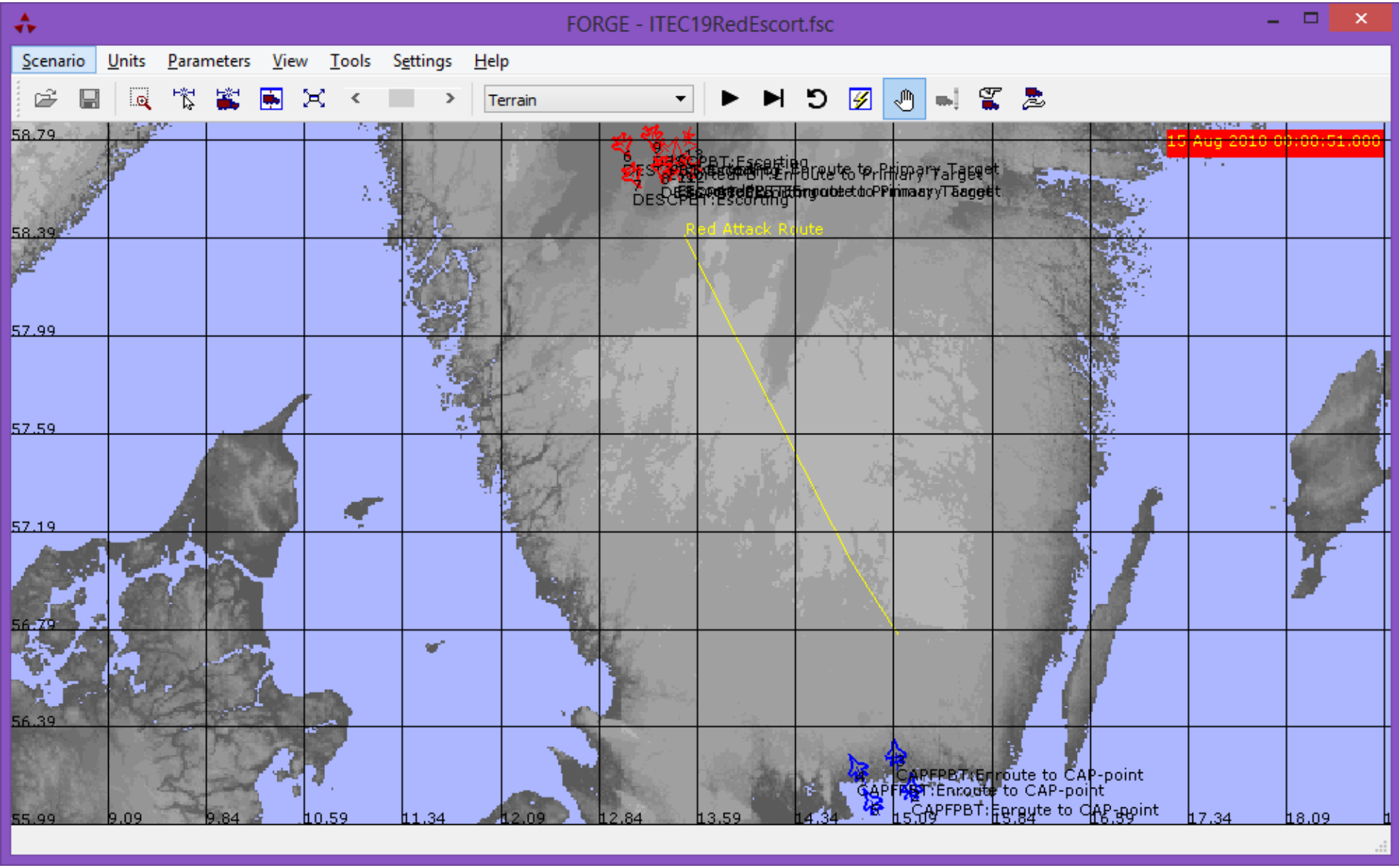
Inputs utilize ”Scenario Variables” than can be set in a number of ways

Typical FLAMES Views





Generic scenario ”ITEC19RedEscort”



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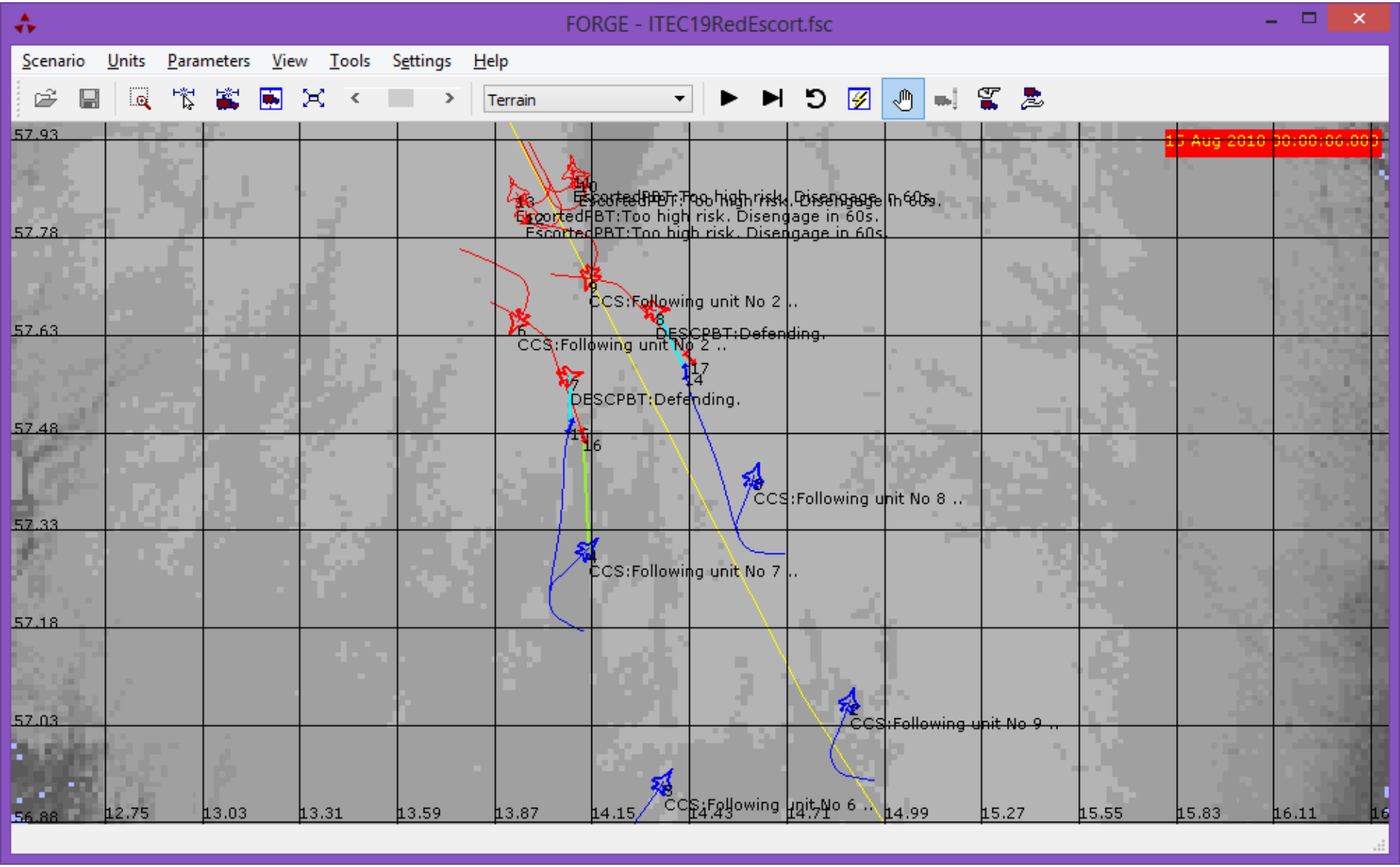

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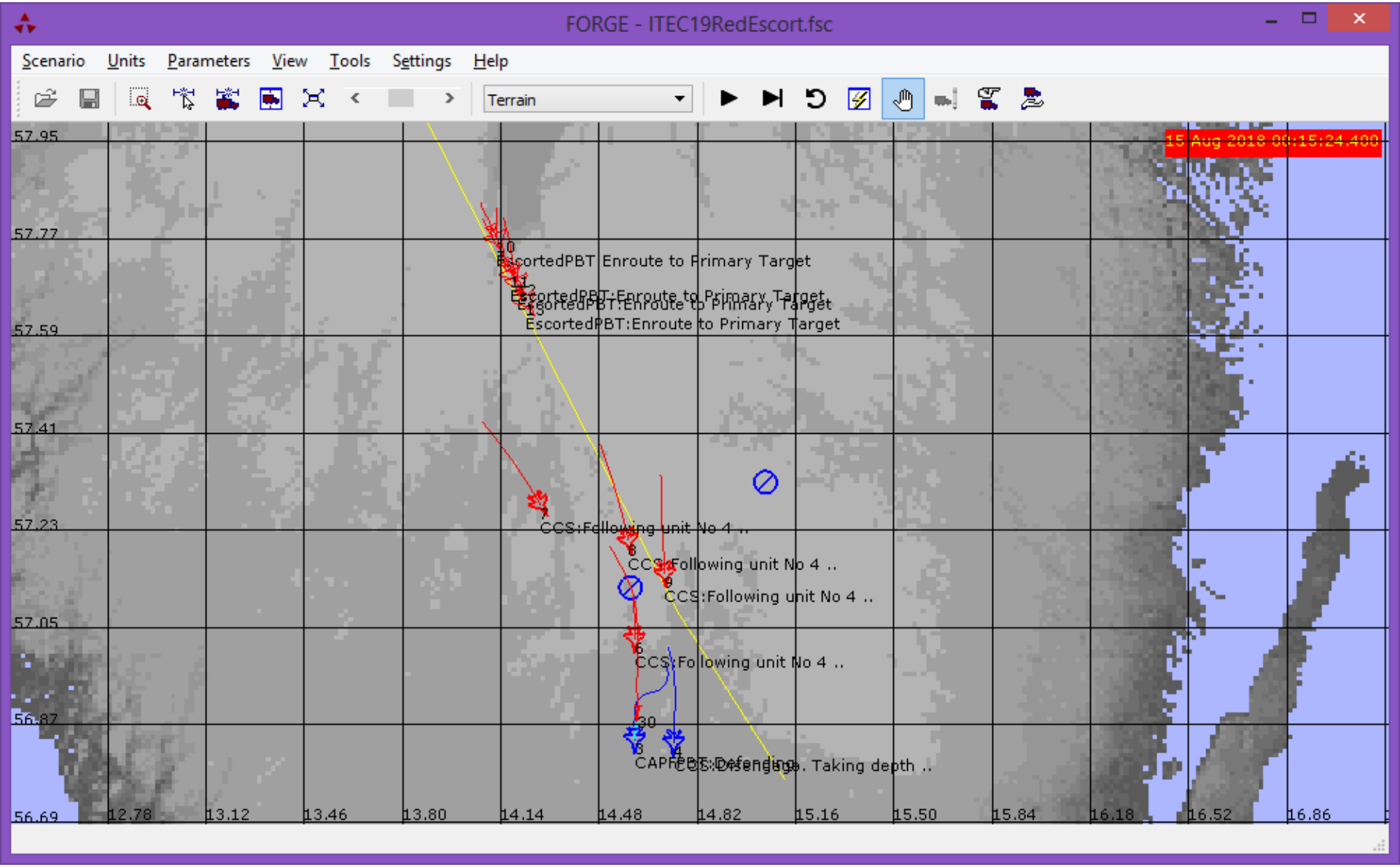

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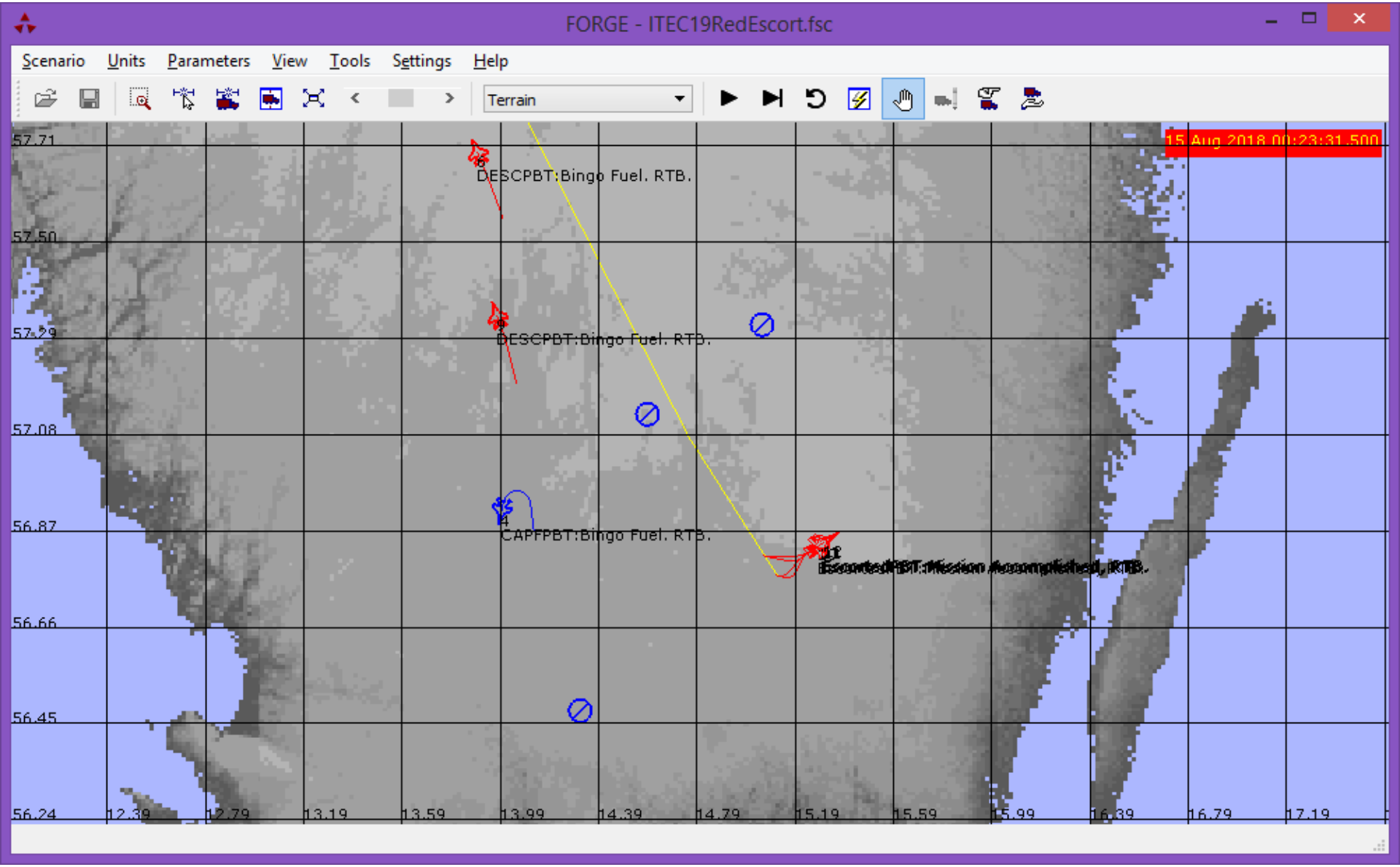
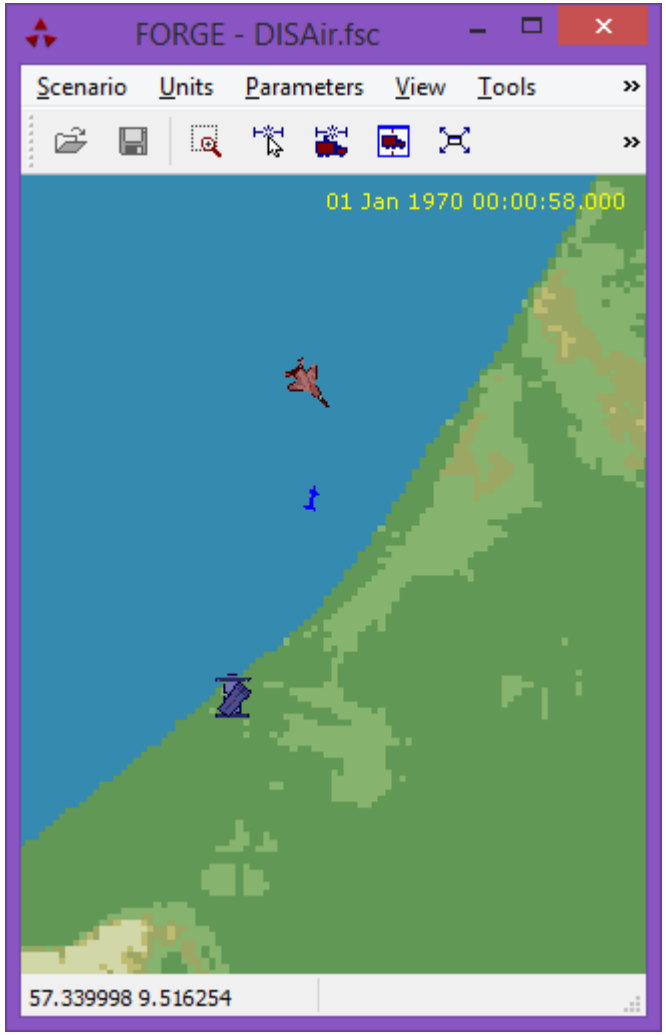


Networking with DIS



Implemented PDUs
(source code available):

Entity State

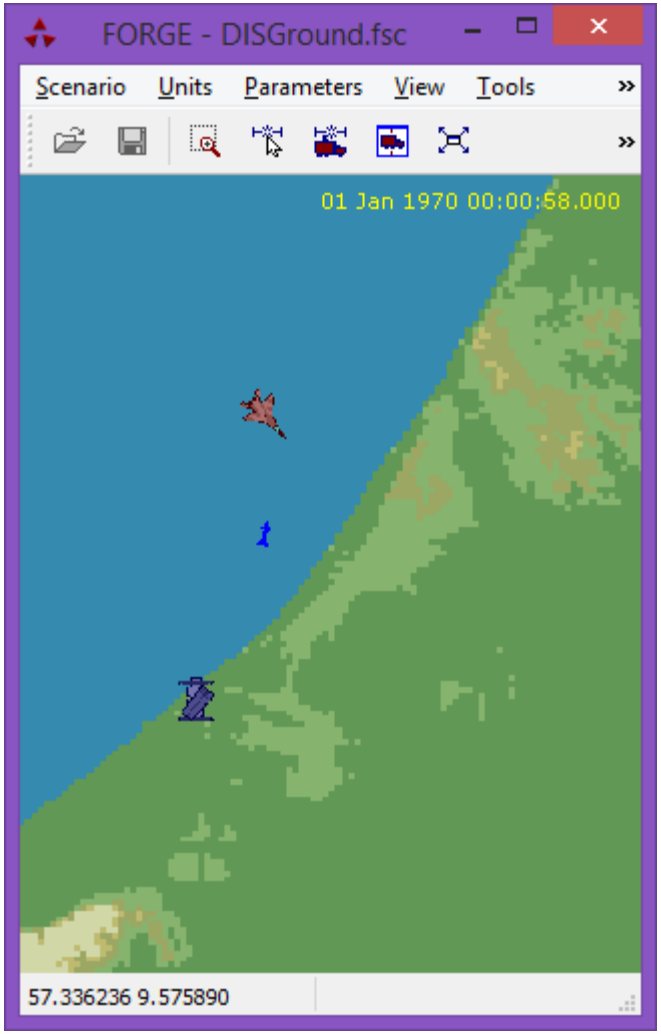
Detonation

Fire

Start/Resume

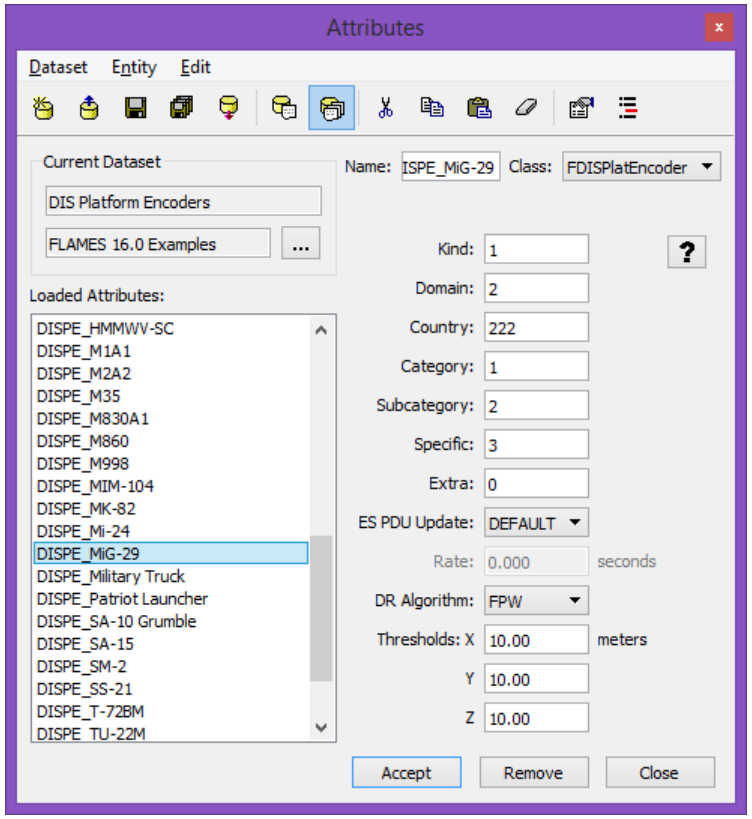
Stop/Freeze

Acknowledge

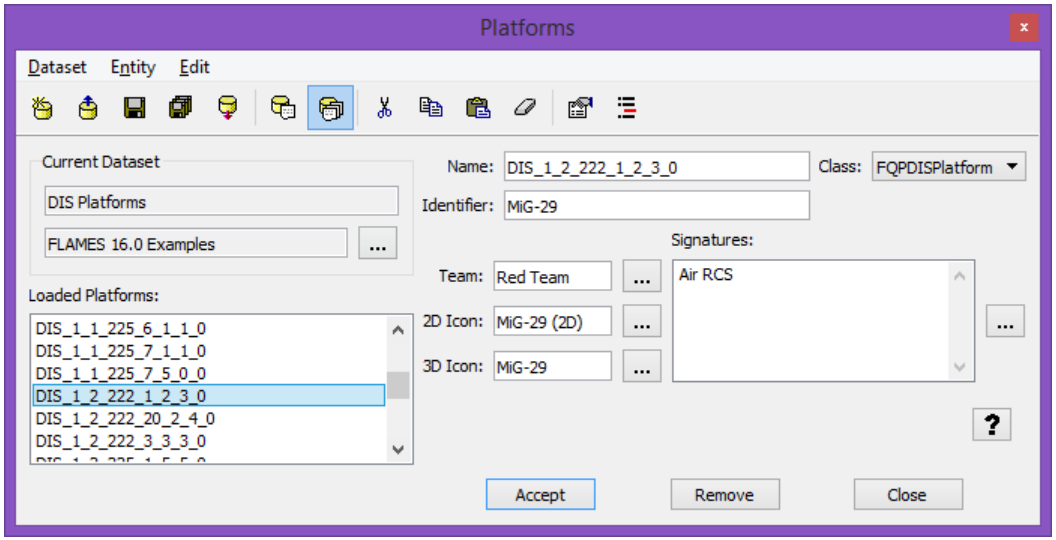


Networking with DIS

Encoding, indentifier to enumeration

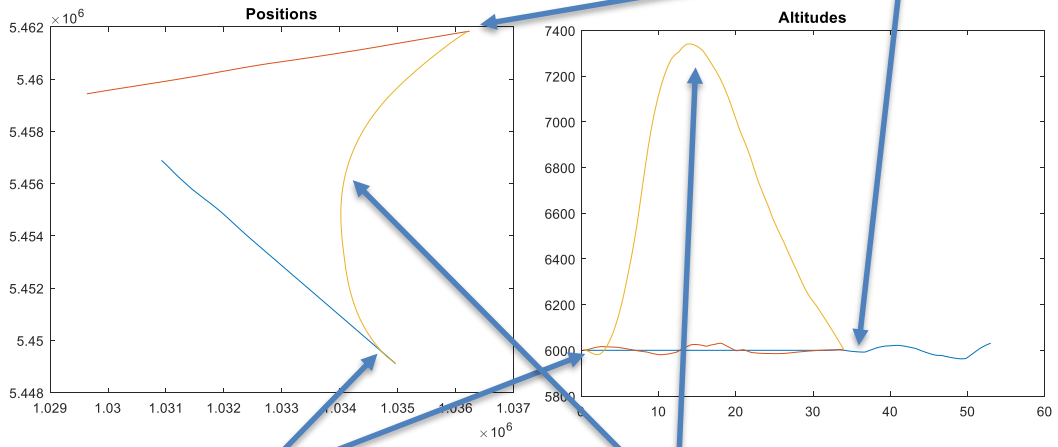


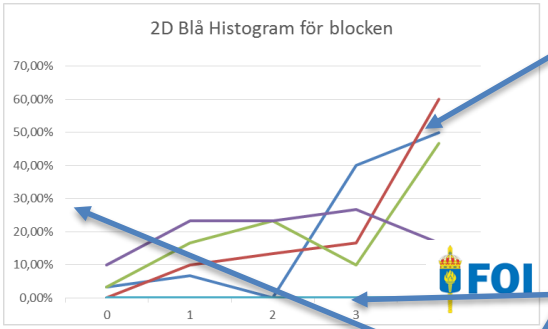
Decoding, enumeration to identifier

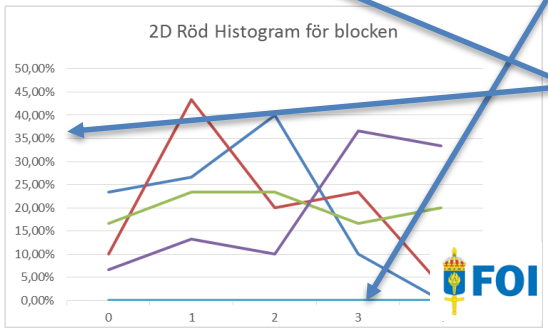


Simulation & Evaluation, FOI Work

- Experiment files, batch simulations
- “Randomness” created by shifting start positions
- Data recording in .csv files
- Data processing in Excel, MATLAB and/or PostgreSQL



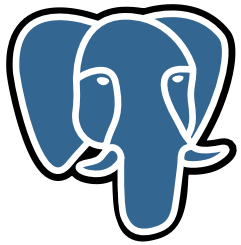




Data Processing in PostgreSQL

GUI in Java/Netbeans to run PostGreSQL queries, for example:

- Who detected who first?
- Who launched first?
- How many missiles were fired? Hit/missed?
- How many aircraft were destroyed on each side?



Extra, ground attack evaluation using PostGIS:

- How many air to ground munitions were launched?
- How much of the ground target was destroyed?

Current state and what to do next

Available now:

- A set of tools that can “easily” be extended to handle new models and scenarios
- A set of models
- Evaluation tools

Next:

- Refine extraction and presentation of simulation results
- Improve model fidelity

Lessons learned

- Modelling and simulation is excellent for improving understanding of dynamic situations
- Don’t code everything yourself, always look at the alternatives
- Re-use, old code works

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