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

Gunnar Hovmark, ÅF

Fredrik Jonsson, Swedish Defence Materiel Administration



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 **pFOI**, 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)





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 0.7 0 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 1.0 0.10 0.5 0.5 1.5 0.09 1.0 0 0.12 1.0 0.7 0.15 1.0 0.16 1.0



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



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Simulation of single shot, generic missile

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



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Scenario Controller

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SETUP_MCGF_FORMATION FOR=&RedUnitSize*/FOR=RedBombers/FOR=MCGF_Gen	eric
REST_BEFORE_NEXT_LINE REA=4.0	×
Selected Command: SETUP_MCGF_FORMATION	
Command Description:	
Set up a number of MCGF air platforms in a formation as specified in an experiment file with the scenario variables t correspond to the inputs specified here. In the process method you should calculate the first waypoint as the result	hat 🏠
straight and level flight for about twenty seconds.	×
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FORMATION_BEHAVIOR MCGF Generic Blue Fighter (Behavior)	
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BOX SPACING & "BlueBourspacing"	
FORMATION COGNITION LEVEL	×
Input Description:	
Choose a dictionary entry for the aircraft to be used in this formation.	
command	
Accept Remove Close	

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





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Networking with DIS



Implemented PDUs (source code available):

Entity State

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Fire

Start/Resume

Stop/Freeze

Acknowledge





Networking with DIS

Encoding, indentifier to enumeration Decoding, enumeration to identifier

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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





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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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