Tactical Technologies Inc.

"Modeling and Simulation based analytical tools in countermeasures development & support".

- November 2008

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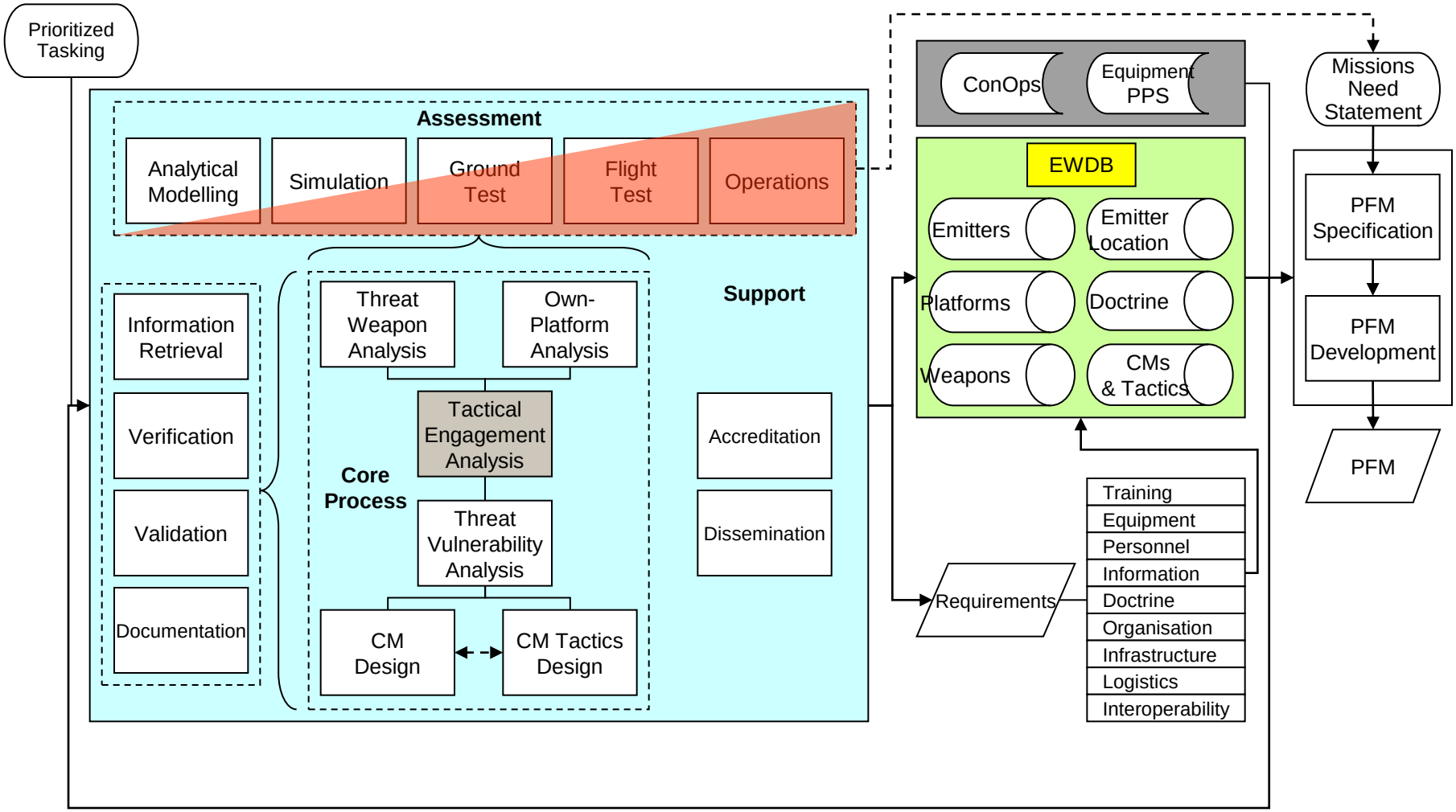
Presentation Objectives

- Identify the contribution modeling and simulation based analysis & tools provide to effect based countermeasure development and support
  - » Basic research & development in techniques and tactics
  - » Threat system analysis
  - » ECM & ECCM effectiveness test & evaluation,
  - » Hardware-in-the-loop T&E
  - » Real time operator training (radar, EW & pilots)
  - » Operational doctrine development ,
  - » And associated requirements
- common modeling and simulation infrastructure can support these requirements

Countermeasure Development Process



c/o David Tuffnell - MASS Consultants Limited, Lincoln, UK

CM Readiness Level / Maturity Model

CRL 9	Actual CM Tactics qualified e.g. through reliability demonstration in operations	Test, qualification and operation
CRL 8	Actual CM Tactics completed and qualified through operational test and evaluation	
CRL 7	Actual CM (Tactics) prototype demonstrated in an operationally relevant environment	Demonstration, equipment checks
CRL 6	Actual CM validation in laboratory environment	
CRL 5	Actual CM (Tactics) prototype demonstrated in a laboratory environment	
CRL 4	Generic CM validation in laboratory environment	Research to prove feasibility
CRL 3	Analytical & experimental CM critical function and characteristic proof-of-concept	
CRL 2	CM concept and application formulated	
CRL 1	Basic CM principles observed & reported	Basic research

Flight Test

Ground Test

Modeling & Simulation

c/o David Tuffnell - MASS Consultants Limited, Lincoln, UK

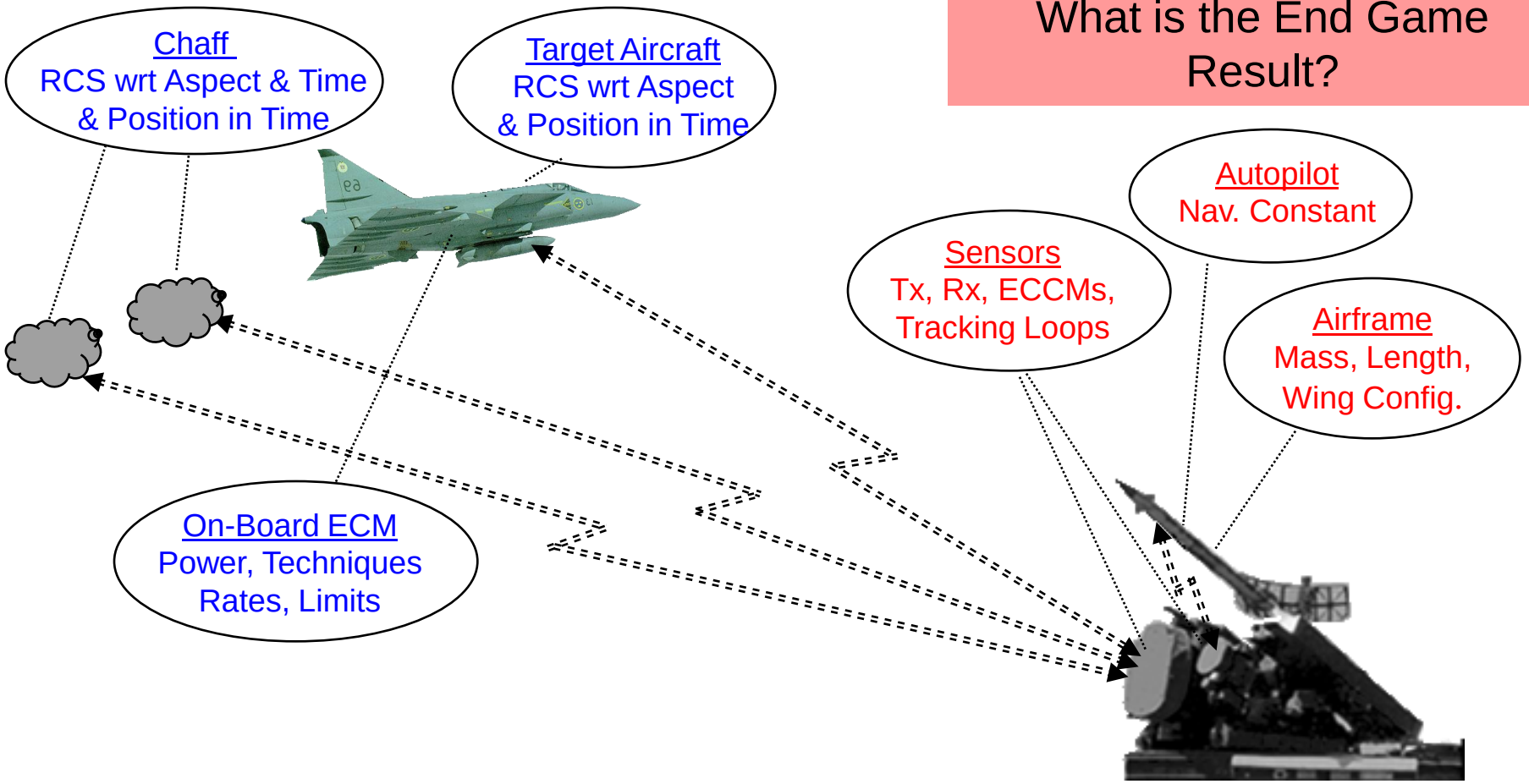
General M&S Requirements

- Countermeasure Effectiveness
  - is measured in miss distance and probability of kill at end-game
  - this requires the computation of a complete closed-loop dynamic engagement &
  - use of high fidelity weapon system models
  - with dynamic & non-linear system elements
  - Batch run and Monte Carlo analysis
- Real time HWIL test & evaluation - closed-loop
  - simulate engagements with T&E hardware & system under test
  - provide comparative analysis between the virtual and hardware loops for verification
- Built in test report & audit tools
- Real time interactive operator training
- Ideally the same system models and software supports all these applications

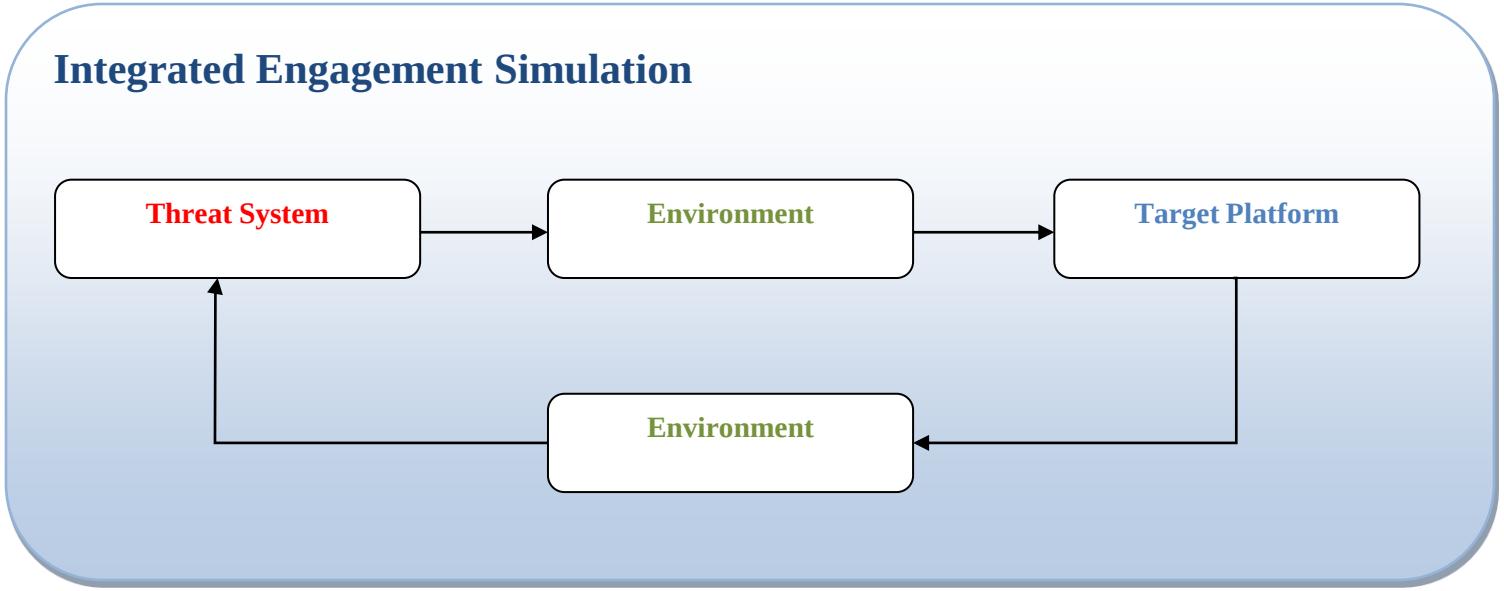
Pragmatic Requirements

- Integrated engagement simulation = turn-key engagement
- Standard PC's with Windows®
- MATLAB® and Simulink® infrastructure
  - Advanced system modeling & simulation language
    - » Open, Hierarchical Structure
    - » Easy To Program, Validate and Modify…
- Source Code & Source Code Software Description Documents - standard options
- Classified data is entered by the user
- Users can easily modify system models to add capabilities
- Totally open, modular, extensible and supported
- COTS Product – support & continues to evolve
- Will evolve with your requirements

The Engagement Problem



Integrated Engagement Simulation (IES)



•Threat System = Sensor, Target Tracking, Guidance, Auto-Pilot, Airframe etc…
•Target Platform = Signature, Maneuvers & Self Protection capabilities
•Environment Systems = effects caused between the threat & target related to engagement geometry, signal propagation, background noise, multipath, clutter etc.

= an integrated engagement simulation system-of-systems

from Detection/Launch-to-End Game

Common Infrastructure

Training in countermeasure concepts & physics

Training Radar & EW with operators-in-the-loop

TESS

Developing & evaluating countermeasures

System test & evaluation using hardware-in-the-loop

Standard COTS TESS

Is a family of integrated engagement simulation (IES) based analytical tools covering various weapon system classes

It supports IR & radar guided weapons in surface-to-air, air-to-air , anti-ship, and anti-tank engagements

Self-contained, turn-key COTS products include all the primary systems involved in a tactical engagement

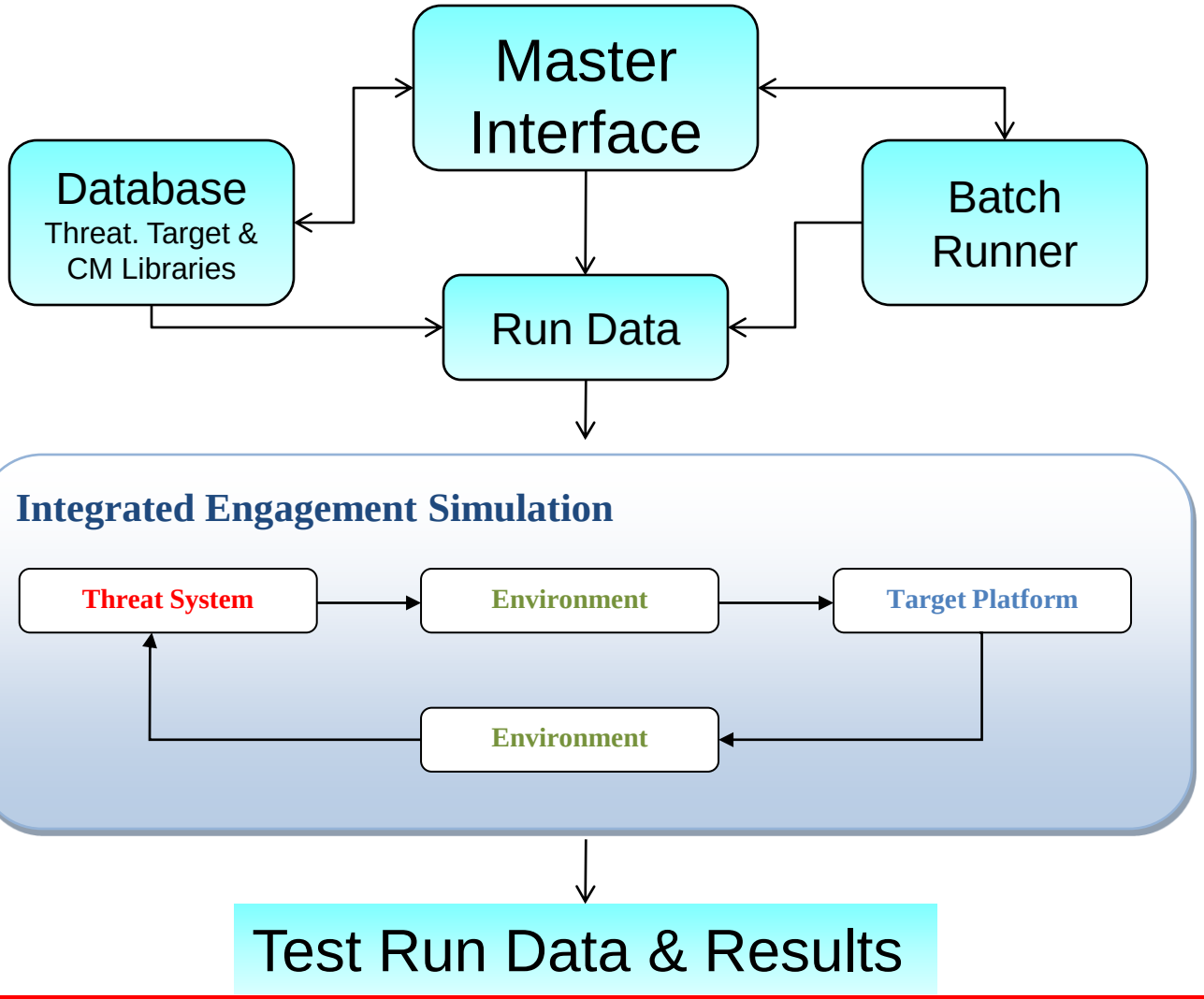
Analytical features built-in:

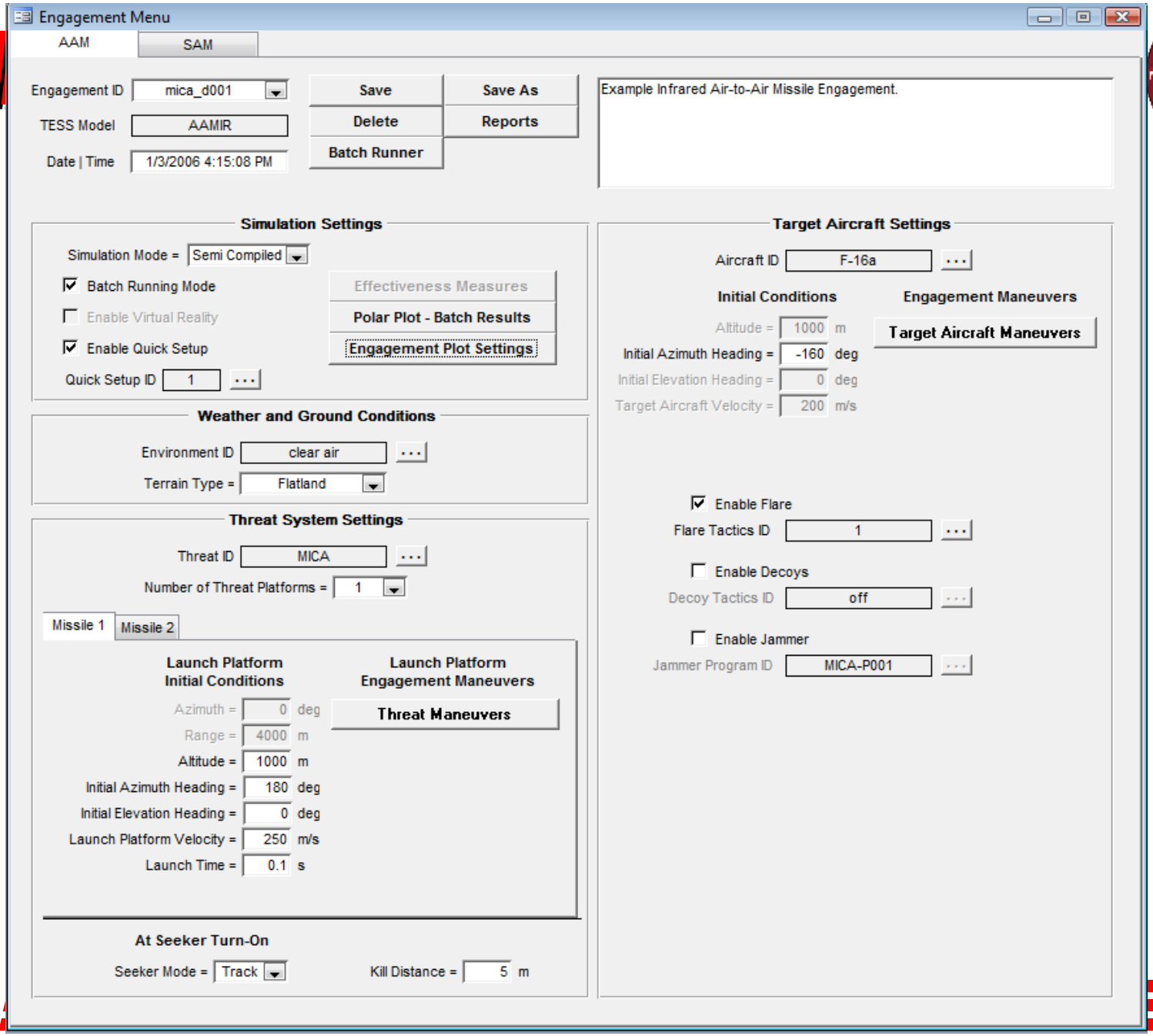
- measures of effectiveness
- threat/target/ECM library database
- system scopes
- test reports and
- support for deterministic and Monte Carlo analysis (batch runner)

Open… to be customized, reconfigured, integrated with other system models, HWIL and training systems, and

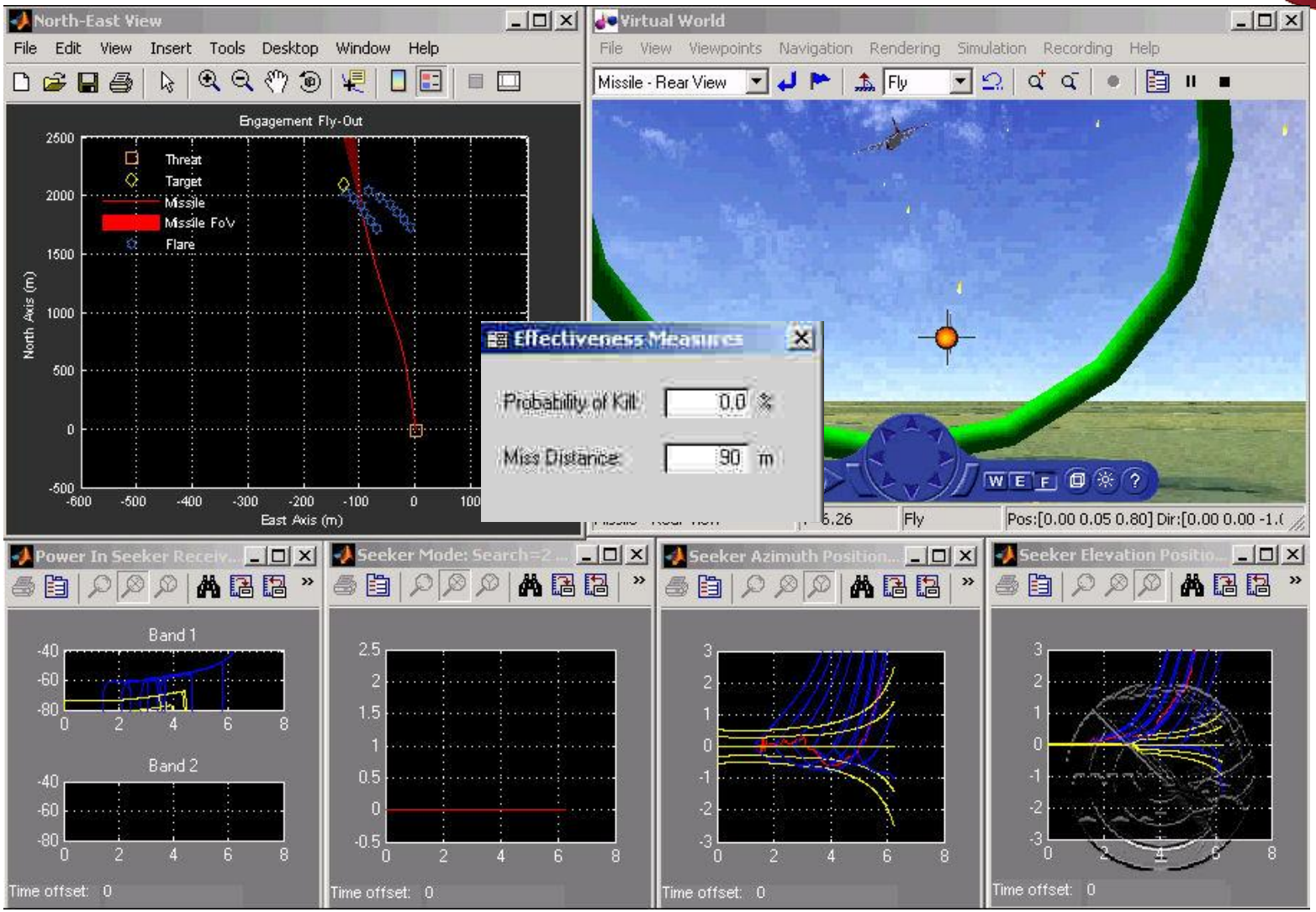
TESS can run slower, faster or in real-time.

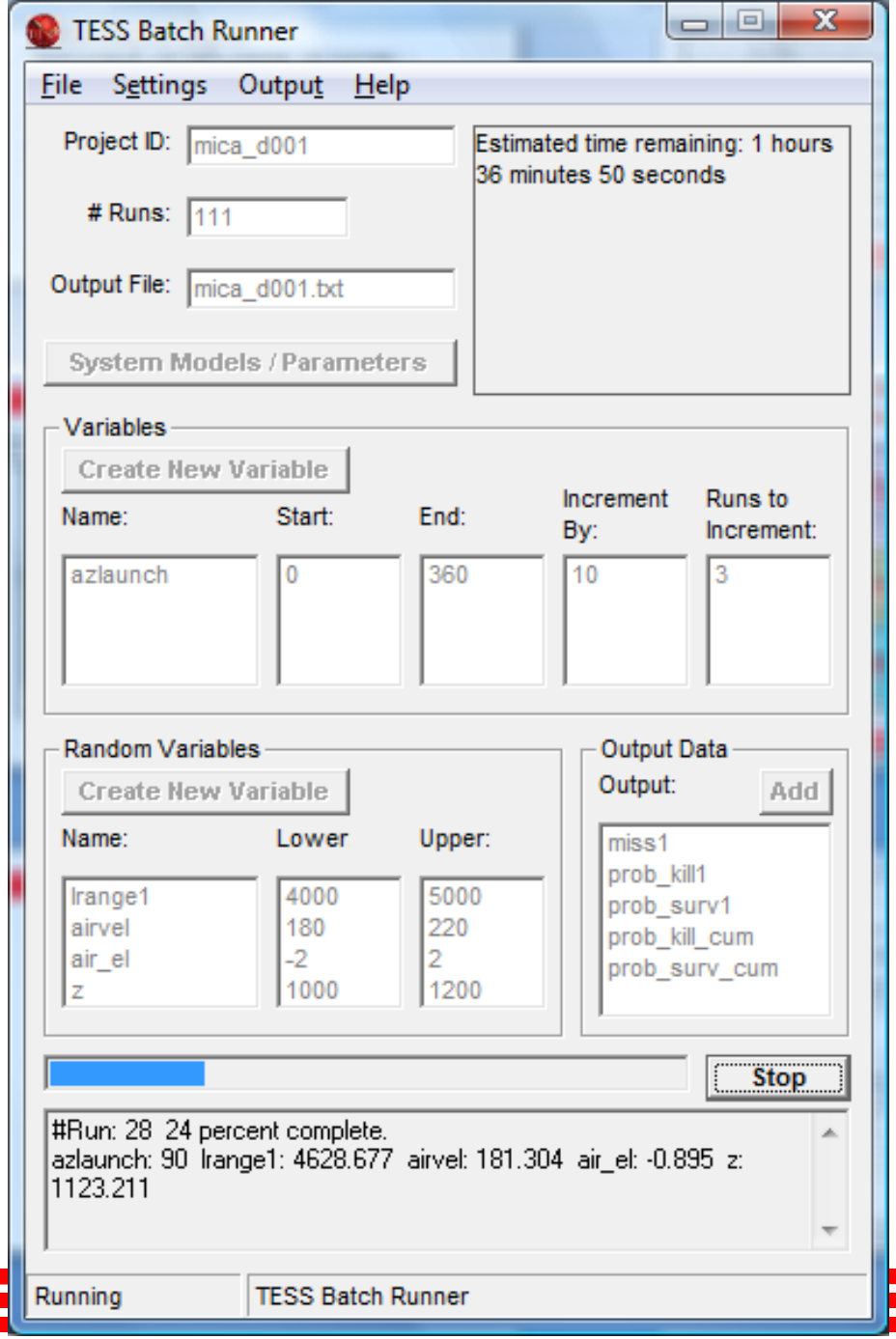
TESS IES Overview (scripted)



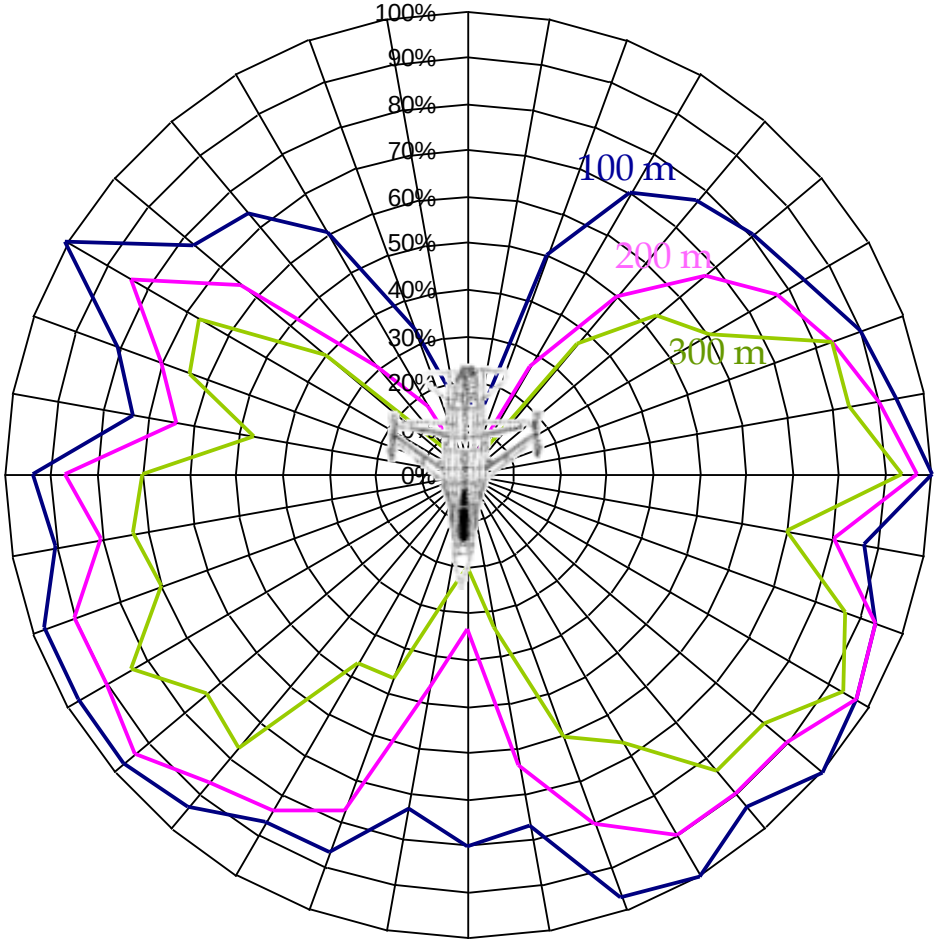


Miss Distance vs IR Flares





Polar Plot of the Probability Miss Exceeds Threshold



Fixed Parameters

A/C IR Rad Int
800 w/str

Flare IR Rad Int
4000 w/str

Flare Deployment
6 flares
0.5 sec spacing

Random Parameters
(Monte Carlo Selection)

Launch Distance
- 2000 to 4000 m

Missile Velocity
- 600 to 1000 m/s

Batch Run Data File

SIMULATION GENERAL INFO
// Matlab File Name
saamir.mdl
// Matlab Block: Background
// Parameters:
Spectral Radiance Weighting Factor [Band 1 Band 2]: [1 1]
// Matlab Block: DIRCM Environment
// Parameters:
Atmospheric Attenuation Weighting Factor [Band 1 Band 2]: [1 1]
// Matlab Block: Seeker 1 Environment
// Parameters:
Atmospheric Attenuation Weighting Factor [Band 1 Band 2]: [1 1]
// Matlab Block: Seeker 2 Environment
// Parameters:
Atmospheric Attenuation Weighting Factor [Band 1 Band 2]: [1 1]
// Matlab Block: Simulation Control
// Parameters:
Select Simulator:: Passive Infrared Air-To-Air Missile
Number of Threat Platforms:: 1

TARGET INFO
// Matlab Block: **Target Platform/Aircraft**
// Parameters:
Initial Platform Position: Altitude (m): z
Initial Platform Heading and Velocity: Azimuth (deg): -160
Initial Platform Heading and Velocity: Elevation (deg): air_el
Initial Platform Heading and Velocity: Velocity (m/s): airvel
Platform Type: [Fixed Wing (1) or Rotary Wing (2)]: 1
Platform Dimensions: Radius (m): 3.5
Platform Dimensions: Length (m): 14
Platform Dimensions: Vulnearable Area (m^2): 50

// Matlab Block: **Target Platform/Flares**
// Parameters:
Number of Flares: 12
Ejected Mass (g): 350
Reference Area (m^2): 0.0013
Drag Coefficient: 1
Flare Type: [Standard (1) or Propelled (2)]: 1
Mass of Flammable Material (g): 350
Nozzle Area (m^2): 0.0006
Specific Impulse (s): 10

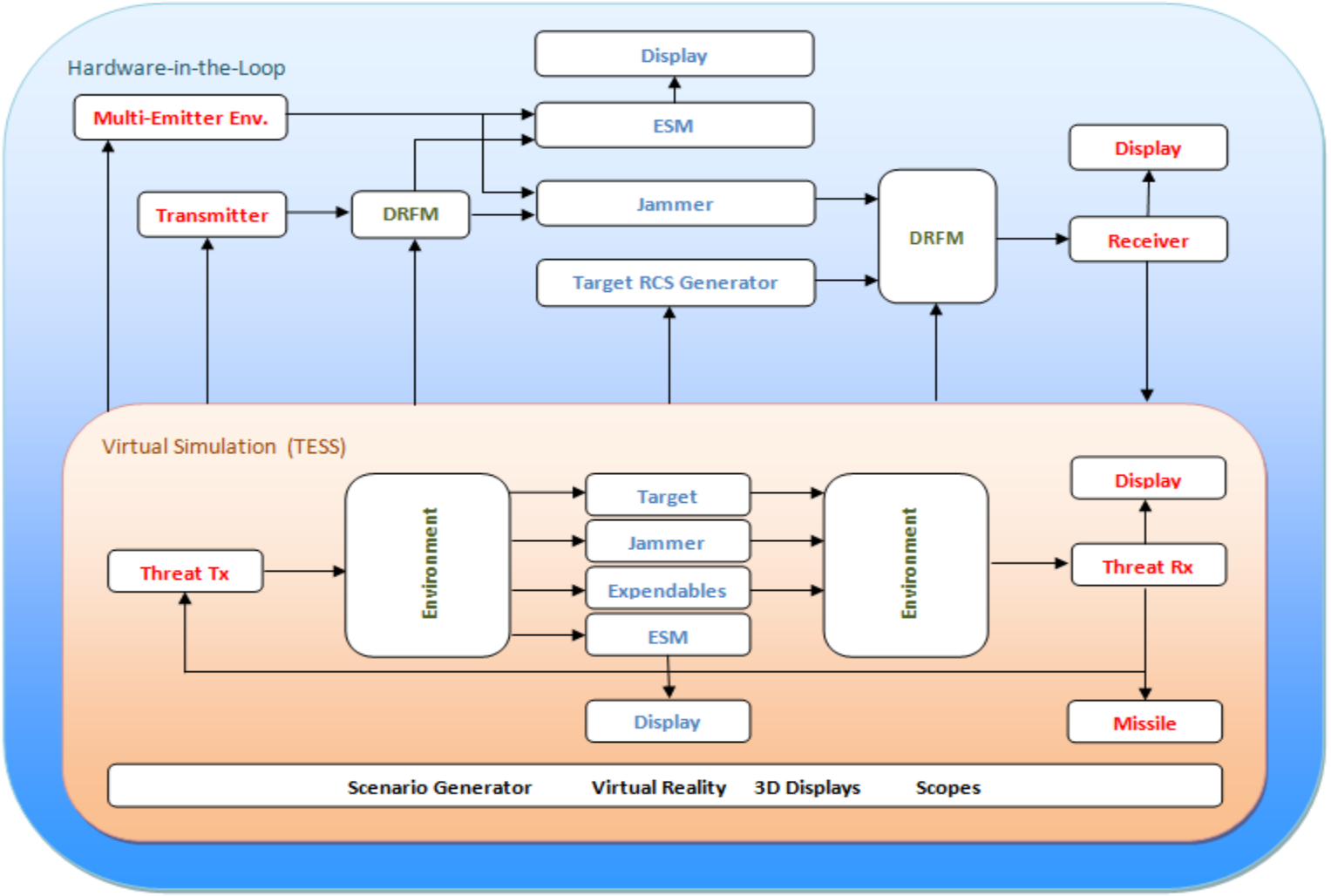
THREAT 1 INFO
// Matlab Block: **Threat System 1/Seeker Receiver**
// Parameters:
Select Parameters Type: Search Mode Parameters
Seeker Mode at Turn-On: Track
Gimbal Limits (deg): Azimuth, Elevation : [45 45]
Select Seeker Search Pattern : Helical Scan
Helical Scan Period (s): 2
Frequency of Rotating Optics (Hz): Element 1, Element 2: [15 29]
Sensor Aperture Area (cm^2), Fields Of View (deg): Instantaneous, Total: [7 1.5 15]
Detectivity (Hz^(1/2)/W): Band1, Band2: [1E+12 5E+11]
Select Number of Bands: 2

// Matlab Block: **Threat System 1/Airframe**
// Parameters:
Aiframe Modeling Approach:: Aerodynamic Coefficients
Subsystem Parameters:: Propulsion
Initial Missile Mass (kg): 64
Propellant Mass (kg): 25
Burn Time (s): 3

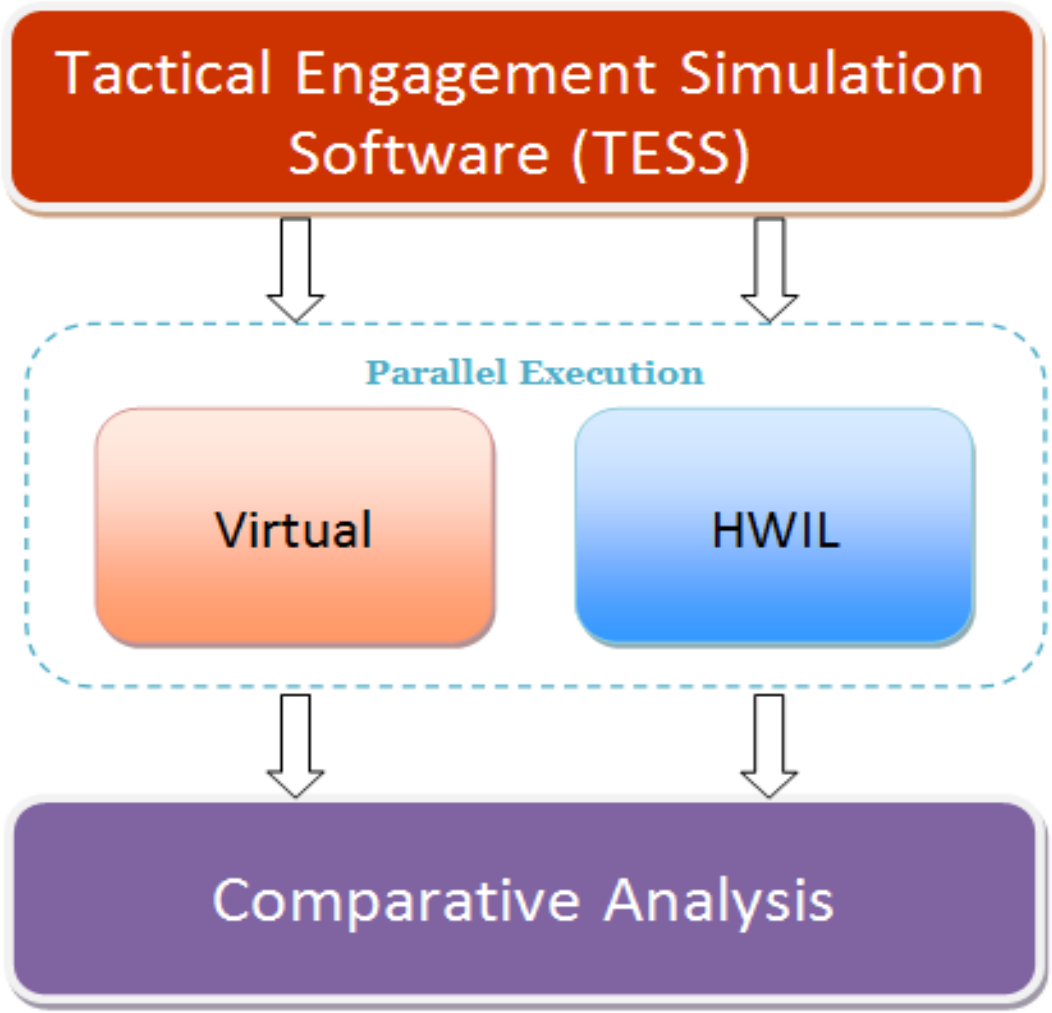
// Matlab Block: **Threat System 1/Threat Platform**
// Parameters:
Initial Position: [Azimuth (deg), Range (m), Altitude (m)]: [azlaunch lrange1 1000]
Velocity (m/s), Initial Orientation: [Azimuth (deg), Elevation (deg)]: [250 180 0]
Turn Times (s): 1, 2, 3, 4: [2 5 10 12]
Lateral Accelerations (+/- g): 1, 2, 3, 4: [3 3 -3 0]
Normal Accelerations (+/- g): 1, 2, 3, 4: [0 0 0 0]
Enable Missile: on
Missile Assignment: [Lead Angle (deg), Super Elevation (deg)]: [0 0]
Missile Launch Time (s): 0.1

// **Output Data** 111
Run
Number;azlaunch;lrange1;airvel;air_el;z;miss1;prob_kill1;prob_surv1;prob_kill_cum;prob_surv_cum;AOA1;AOA2;
1;0;4029.945;202.38;1.014;1052.212;90.5597664361346;0;100;0;100;160;160;
2;0;4801.886;193.624;-0.522;1157.117;94.0531625685274;0;100;0;100;160;160;
3;0;4741.312;197.426;0.377;1166.2;99.3212585436438;0;100;0;100;160;160;
4;10;4676.881;206.222;-1.581;1007.829;104.708869501736;0;100;0;100;170;170;
5;10;4190.03;215.865;-0.84;1001.622;79.0387019873123;0;100;0;100;170;170;
6;10;4536.357;215.058;0.176;1182.964;78.9514999945641;0;100;0;100;170;170;

Integrating HWIL to TESS



Closing the Virtual & HW loops

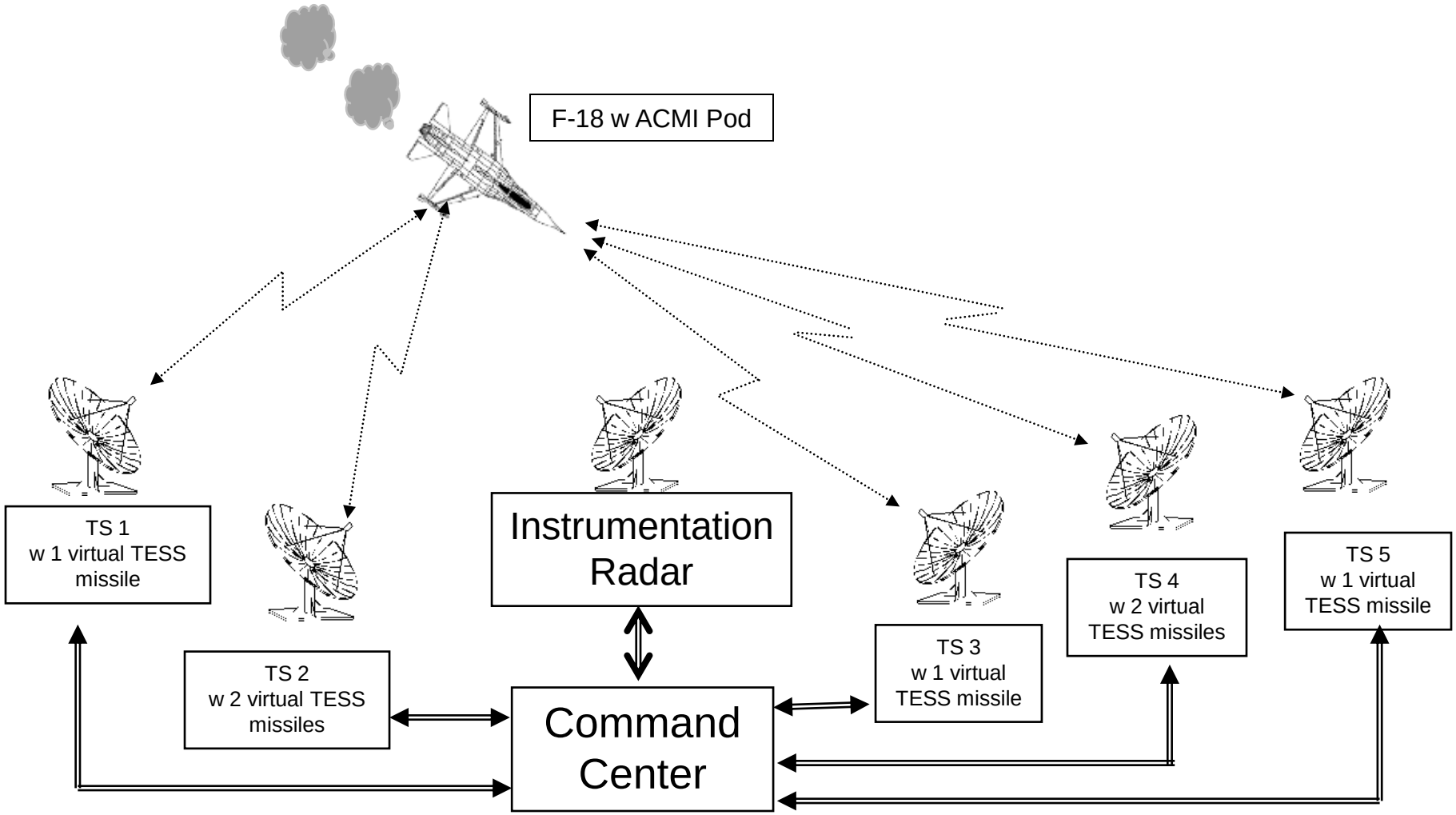


Surface Threat Electronic Warfare System (STEWS)

Used by many NATO aircraft for countermeasures training at CFB Cold Lake – Maple Flag

- 5 high power threat emitters emulate SAM & AAA radars
- Command and Control Center controls engagements
- Multiple aircraft can be handled on the range simultaneously
- Radar and ACMI pods provide position and event data
- TESS is integrated into the ground system to provide
  - Virtual SAM and AAA engagements (up to 7 from 5 sites)
  - Scoring of each engagement in real time with missile miss distance and probability of survival
  - Post mission reports and engagement playback capability for pilot debriefing

STEWS



STEWS Debriefing Reports

TWSS ENGAGEMENT EVALUATION REPORT

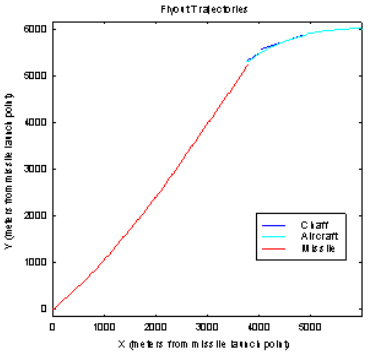
Mission: 3 Engagement: 99 Date: 02-Mar-99 Time: 00:00:01.200

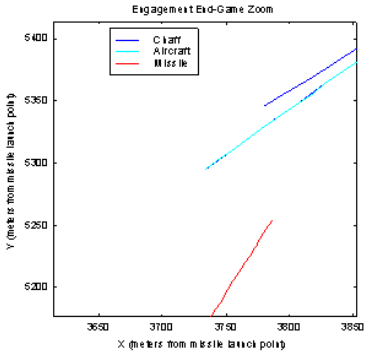
Pilot's Name: Clair Hess Call Sign: 0091 Aircraft Tail Number: 228296

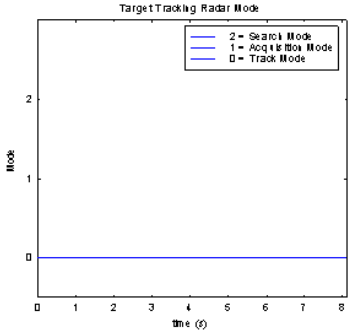
Engagement Duration: 7.5 seconds Remote Emitter Identifier: 4

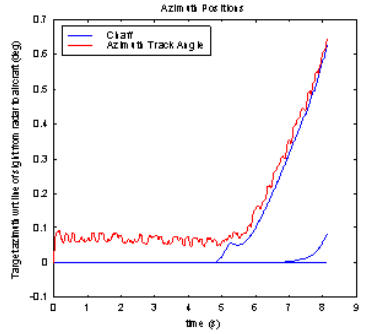
Chaff Deployed: ☑ Jammer On: ☑

Probability of Kill: 2 % Estimated Miss Distance: 69 meters









TWSS SCOPE EVALUATION REPORT

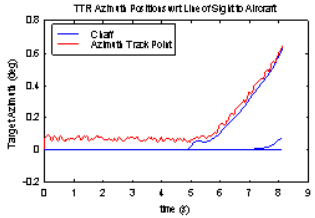
Mission: 3 Engagement: 99 Date: 02-Mar-99 Time: 00:00:01.200

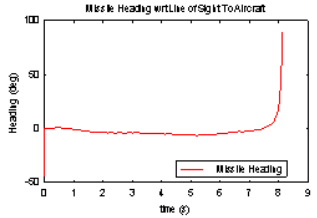
Pilot's Name: Clair Hess Call Sign: 0091 Aircraft Tail Number: 228296

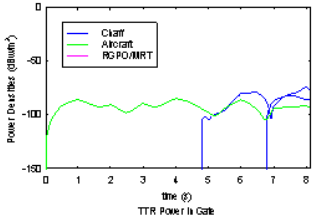
Engagement Duration: 7.5 seconds Remote Emitter Identifier: 4

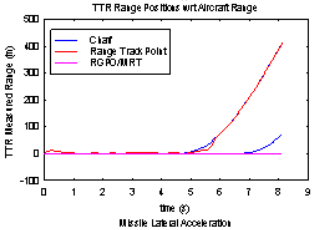
Chaff Deployed: ☑ Jammer On: ☑

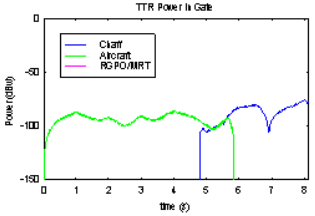
Probability of Kill: 1.9 % Estimated Miss Distance: 69 meters

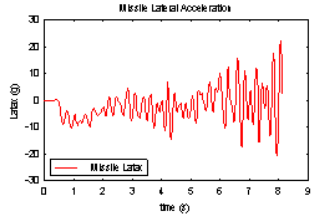












Summary

Modeling and simulation can make a substantial contribution to indigenous countermeasure knowledge and development capability

An infrastructure based on an integrated engagement simulation makes this easier to validate and evolve

A common open, modular and COTS modeling and simulation infrastructure should be considered to minimizes cost, lower risk, and leave your options open - an advanced baseline for evolving requirements with common models and same parameters

Requirements can range from slower-than-real-time, faster-than-real-time, or real-time simulations

- Virtual engagement simulations to support countermeasure analysis
- HWIL engagement simulations – comparative analysis
- Custom hard and soft kill engagement simulations
- Custom simulation development - building blocks
- Test range & other real-time operator/platform in the loop training
- Air, sea and land EW/ECM/ECCM