EWAWS

Product Overview

RTDynamics

EWAWS Overview

RTDynamics

- EWAWS is a real-time simulation library for **sensor**, **electronic** **warfare** and **weapon** simulation
- EWAWS is available as a standalone C++ library and a VR-Forces plug-in.
- Ready to use and reconfigurable models for various weapons and EW equipment
- EWAWS models are physics based and allow for higher quality training
- Multithreaded architecture for high performance

Model Library

RTDynamics

Radar simulation

- Radar Model
- Chaff
- Radar Warning Receiver
- Radar Cross Section Model
- Noise Jammer Model
- Towed Decoy

IR simulation

- IR Sensor Model
- IR Emission Model
- Directed Infrared Countermeasure
- Flare

Laser Sensor and Designator Simulation

- Laser Designator Model
- Laser Sensor Model
- Laser Reflection model

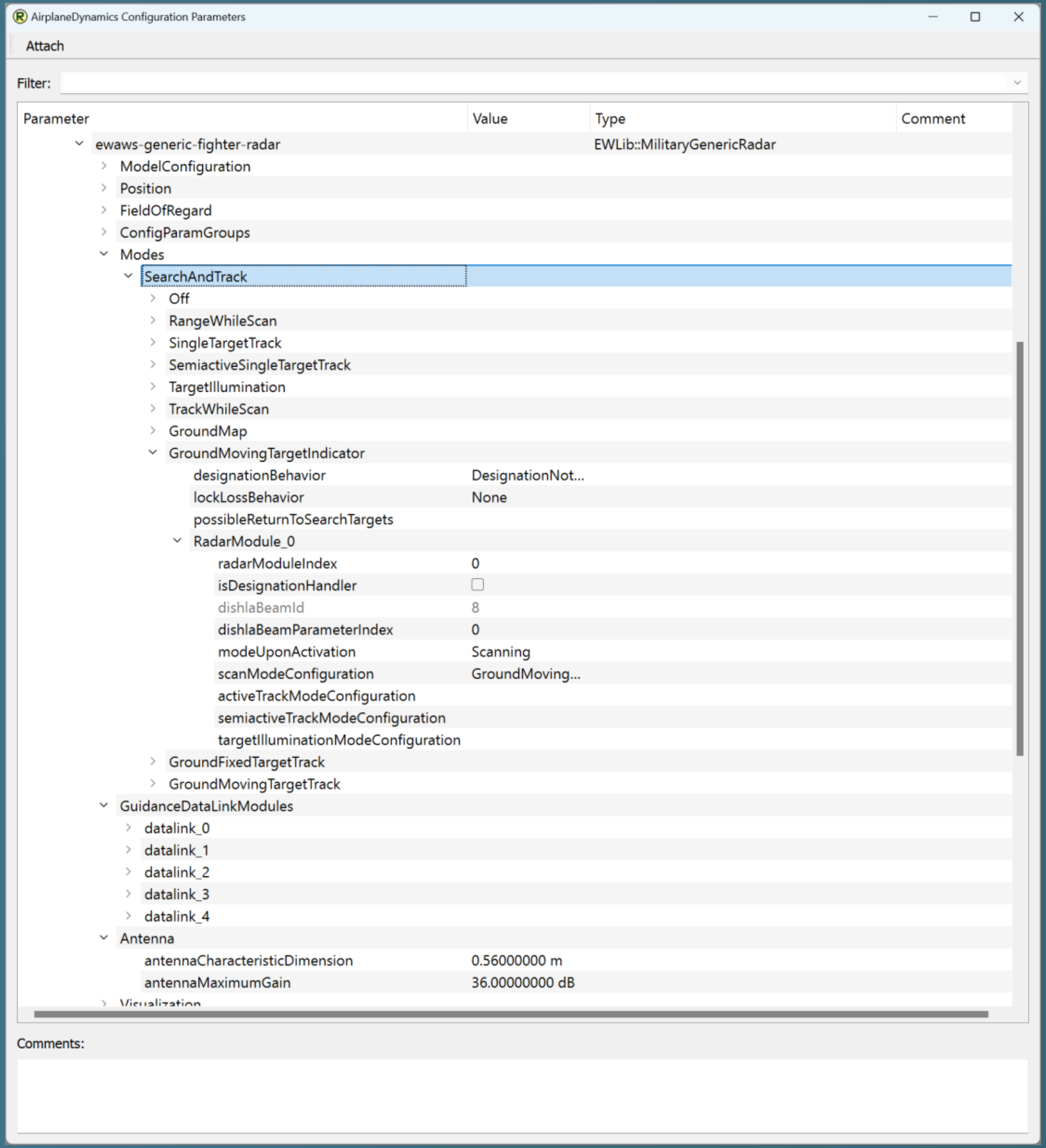
Weapon Systems Simulation

- Missile Dynamics Model
- Propulsion Model
- Warhead and Pkill Model (in VRF, VRF's own Warhead model is used)
- Fuse Model
- Guidance Controller Model

Other

- Missile Approach Warning Sensor

RADAR Parameters in RIME



Example Systems

RTDynamics

By using the available EWAWS models various systems can be modeled and simulated.

Guided Missiles

- Air-to-air
- Air-to-ground
- Surface-to-air
- Cruise (incl. terrain following flight capability)

Bombs

- Smart bombs
- Free fall bombs

Sensor Systems

- Airborne Radars
- Ground Radars
- Radar Warning Receiver
- IR Search & Track

Missile Seekers

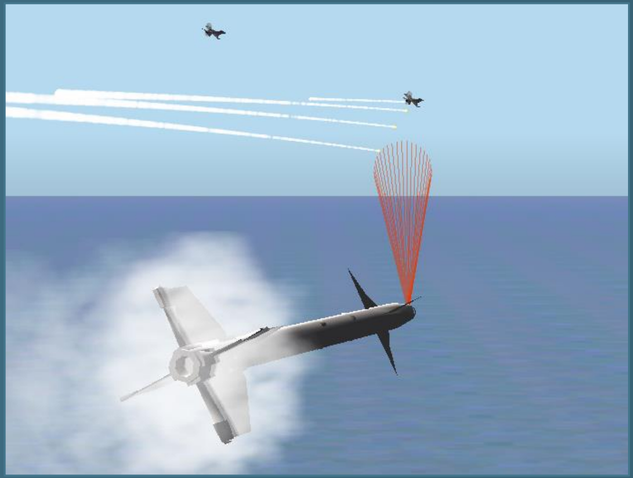
- IR
- Laser
- Radar

Countermeasures

- Jammer
- Chaff / Flare
- DIRCM
- Towed Decoy

Examples

RTDynamics



Semi-active Radar Guided Missile.

Target illuminated by aircraft radar. Missile radar passive.

Screenshot from C++ example

IR missile locked on to IR emission originating from flares.

Red cone indicates IR seeker FOV.

Screenshot from C++ example

Modeling Specific Weapons & EW Equipment

RTDynamics

EWAWS models can be configured to model real world EW equipment and weapons

Fuse		
fuseSafetyTime	1.00000000 sec	
fuseActivationDistanceToTarget	30.00000000 m	
SelfDestruct		
selfDestructTimeWithoutContact	8.00000000 sec	
selfDestructSpeedIAS	200.00000000 Kts	
Warhead		
warheadKillProbabilityDistanceFactorR2	20.00000000 m	
warheadKillProbabilityDistanceFactorR1	5.00000000 m	
warheadKillProbabilityDistanceFactorPwarheadmax	0.90000000	
warheadPkillGivenHitFactorDirectionFunc		
SensorSimulationComponents		
RadarReflectionModel		EWLib::RadarCrosssectionModel
IREmissionModel		EWLib::GenericIREmissionModel
Position		
referenceXYZ		
referenceHPR		
Signature		
outputFactor	1.00000000	
spectralRadiantIntensityDistribution		
minimumFrequency	24981 GHz	
maximumFrequency	99931 GHz	
totalRadiantIntensity	20 Watt/Sr	
directionFactorTable		
IRSeeker		EWLib::GenericIRSensorModel
TrimSolver		
StabilityCriteria		

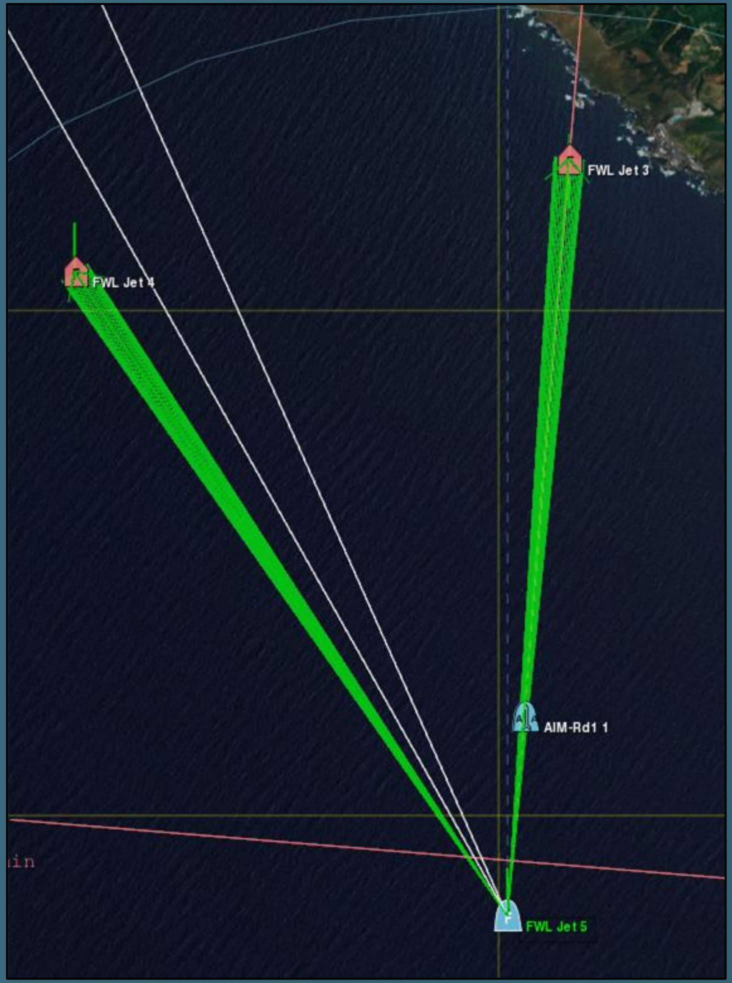
Models in detail

RADAR SIMULATION

Radar Model

RTDynamics

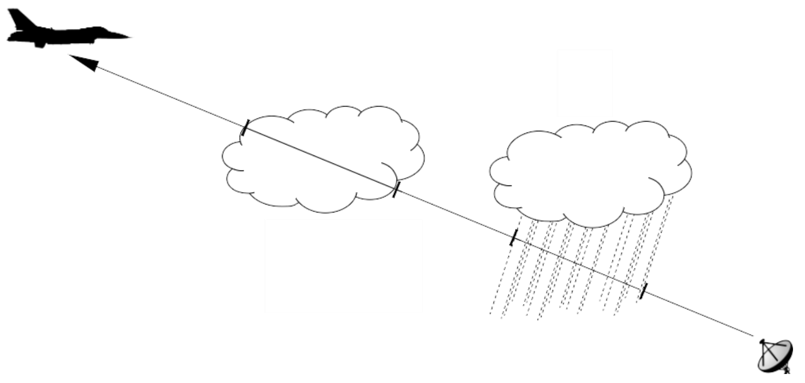
- Physics based, reconfigurable radar model
- GUI based configuration editor
- Doppler filtering (velocity gate)
- Frequency Hopping (Agile Radar) Support
- Antenna stabilization
- DIS/HLA data link beam
- Ground, air, naval surveillance radars
  - Circular and sector scan
- Airborne targeting radars
  - Air to Air Modes
    - Track While Scan, Range While Scan, Single Target Track,
  - Air to Ground Modes
    - Ground Map, Ground Moving Target Indication, Fixed Target Track, Ground Moving Target Track
  - Raster scan
- Missile seekers
  - Target tracking
  - Spiral scan for target reacquisition
- ECM support
  - Radar model takes ECM both in scanning and tracking modes into account.
  - Towed Decoy
  - Jammer
  - Chaff



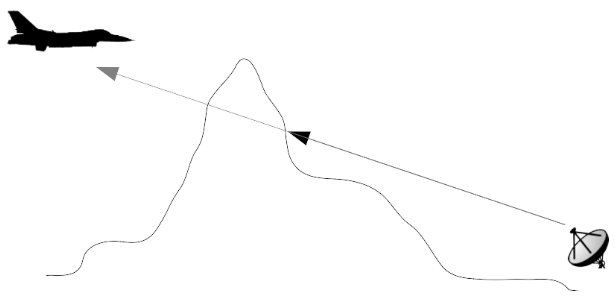
Radar Model – cont'd

RTDynamics

- **Radar equation** is used for computing signal levels.
  - Detection occurs if the received signal level exceeds the noise with a user provided S/N ratio.
- Antenna model automatically computes a realistic gain pattern with **side lobes and zero points**.
- Terrain obstruction taken into account
- Atmospheric Attenuation
  - Pressure, temperature, humidity,
  - Rain fall, cloud coverage, fog/haze
- *EWAWS RCS Model*
  - RCS depends on frequency, azimuth and elevation
  - RCS is given in tables in Rime



Atmospheric attenuation model takes weather conditions into account



Terrain obstruction

Radar Model – cont'd

World State :
Position and Configuration of the sensor and targets

Terrain

Environment :
atmospheric conditions, weather state

Radar Model

Inputs

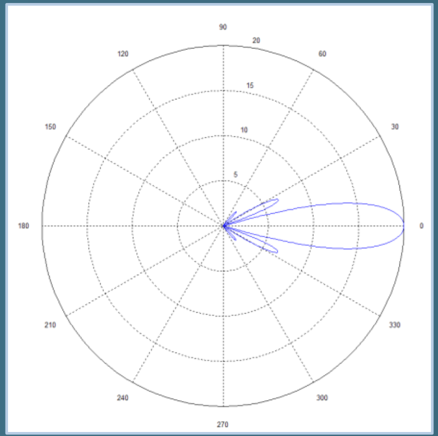
Outputs

Configuration

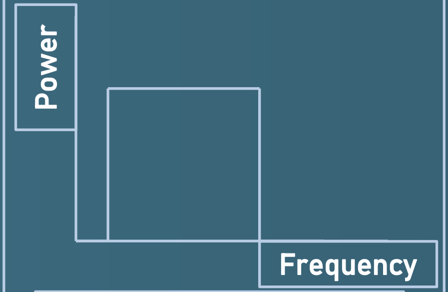
Tracking:
Target Distance
Antenna Direction
Closure Rate

Scanning:
Target Distances
Target Elevations
Target Azimuths
Closure Rates
Signal Strengths

Reference Position and Orientation
Internal Noise (dBm)
Min Signal/Noise Ratio
Field of regard
Maximum Unambiguous Range (m)
Range resolution (m)



Antenna Gain and Characteristic Dimension (Automatically computed gain pattern)

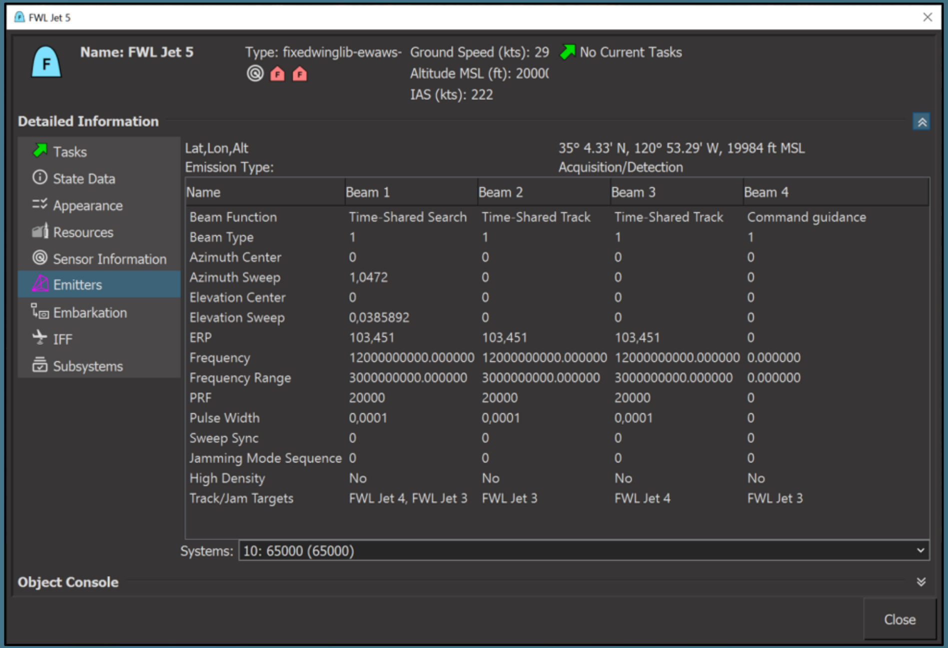


Emitter Power (Spectral Distribution , Watt)

Electronically Scanned Array RADAR Add-on

RTDynamics

- Mode interleaving
  - e.g. air and ground scan modes can be active at the same time.
- Time shared search/track
  - e.g. while a radar is searching targets it can maintain a dedicated beam on designated targets
- Multiple search beams within a mode
  - concurrent search beams with different frequency and PRF values



FWL Jet 5

Name: FWL Jet 5 | Type: fixedwinglib-ewaws- | Ground Speed (kts): 29 | No Current Tasks
Altitude MSL (ft): 2000(
IAS (kts): 222

Detailed Information

Tasks
State Data
Appearance
Resources
Sensor Information
Emitters
Embarkation
IFF
Subsystems

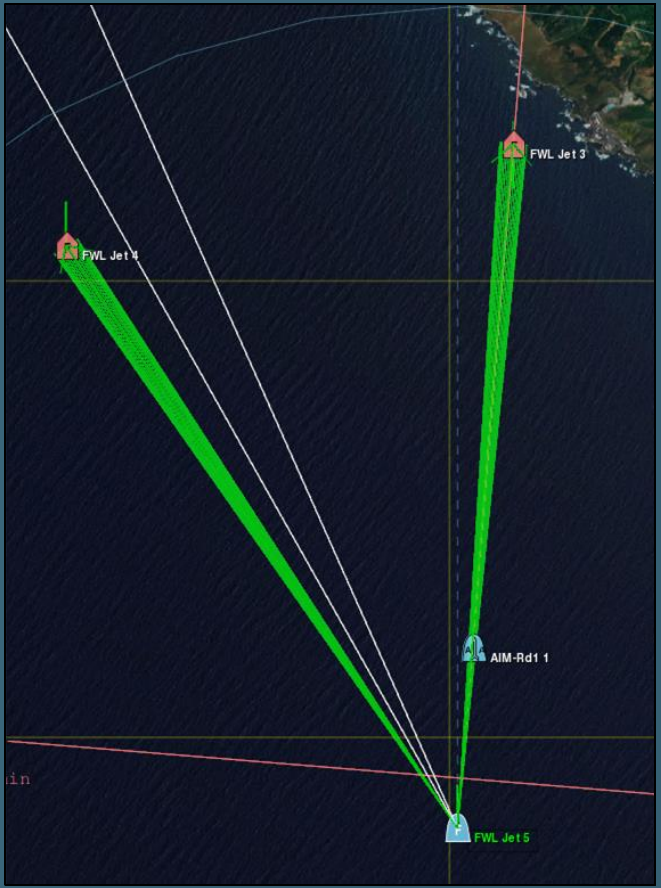
Lat,Lon,Alt: 35° 4.33' N, 120° 53.29' W, 19984 ft MSL
Emission Type: Acquisition/Detection

Name	Beam 1	Beam 2	Beam 3	Beam 4
Beam Function	Time-Shared Search	Time-Shared Track	Time-Shared Track	Command guidance
Beam Type	1	1	1	1
Azimuth Center	0	0	0	0
Azimuth Sweep	1,0472	0	0	0
Elevation Center	0	0	0	0
Elevation Sweep	0,0385892	0	0	0
ERP	103,451	103,451	103,451	0
Frequency	12000000000.000000	12000000000.000000	12000000000.000000	0.000000
Frequency Range	3000000000.000000	3000000000.000000	3000000000.000000	0.000000
PRF	20000	20000	20000	0
Pulse Width	0,0001	0,0001	0,0001	0
Sweep Sync	0	0	0	0
Jamming Mode Sequence	0	0	0	0
High Density	No	No	No	No
Track/Jam Targets	FWL Jet 4, FWL Jet 3	FWL Jet 3	FWL Jet 4	FWL Jet 3

Systems: 10: 65000 (65000)

Object Console

Close



A fighter performs raster scan and has two dedicated beams to designated targets

Radar Warning Receiver

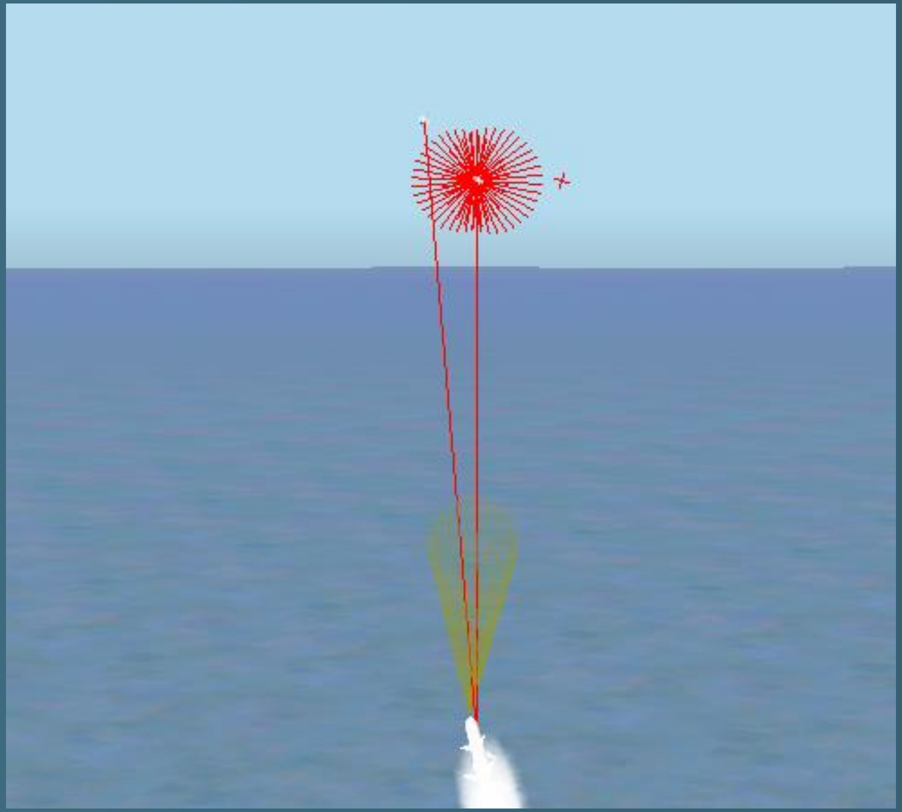
RTDynamics

- Similar to the radar model, the *radar equation* is used for computing signal levels.
  - Detection occurs if the received signal level exceeds the noise with a user provided S/N ratio.
- Detects the **radar mode and type**. This information is used by other modules.
  - For example: Countermeasure launcher system is interfaced with RWR. If RWR reports that a radar is in target illumination mode, chaff is launched automatically.
- Terrain obstruction taken into account
- Atmospheric Attenuation
  - Pressure, temperature, humidity,
  - Rain fall, cloud coverage, fog/haze

Jammer Model

RTDynamics

- EWAWS Jammer appears as an external **noise source** to the radar model.
- Jamming noise drives the noise level in a radar receiver to higher levels, thereby reducing the S/N ratio and preventing detection.
- Jammer's antenna parameters, **frequency and power output** is taken into account during noise contribution computation.
- Jammer's position relative to the radar antenna is taken into account. If the jamming signals come through **side lobes**, they are much **less effective**.



Self-defensive noise jammer. In this image, jamming signals enter through the antenna main lobe and are hence very effective.

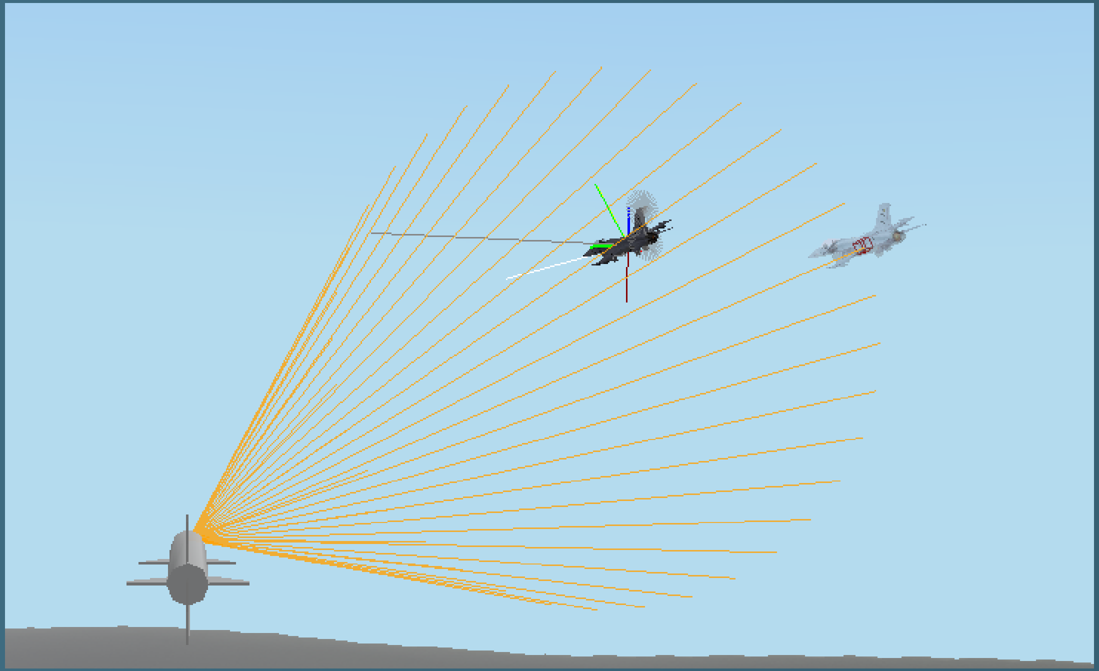
Chaff Model

RTDynamics

- Chaff model is implemented as a powerful reflector.
- Gravity and air drag affects the flight path
- Reflections from chaff confuse the tracking radar. Radar turns its antenna away from targets and towards the chaff.
- The radar cross-section of the chaff can change according to a predefined schedule (defined in configuration files).

Towed Decoy Model

- EWAWS Towed Decoy is implemented as a powerful reflector
- It creates an imaginary target with higher S/N ratio as the target and draws the seeker.
- Towed decoys can be destroyed:
  - Statistical fuse triggering model
  - Warhead and vulnerability model



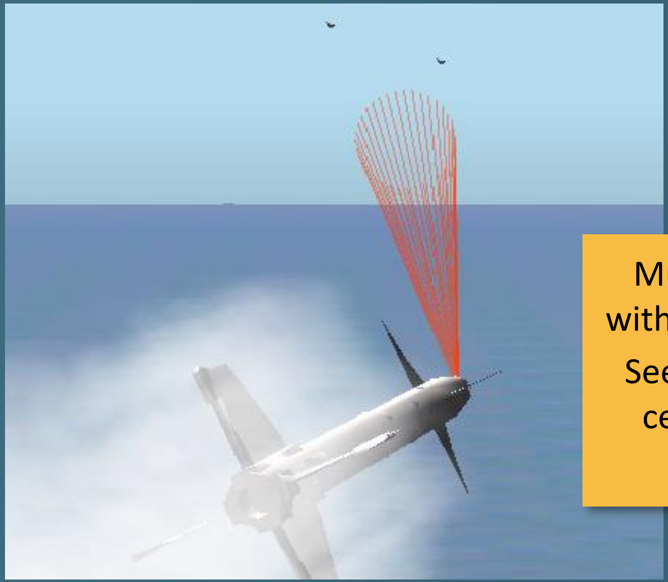
Towed decoy is represented as a transparent aircraft in this image

Models in detail

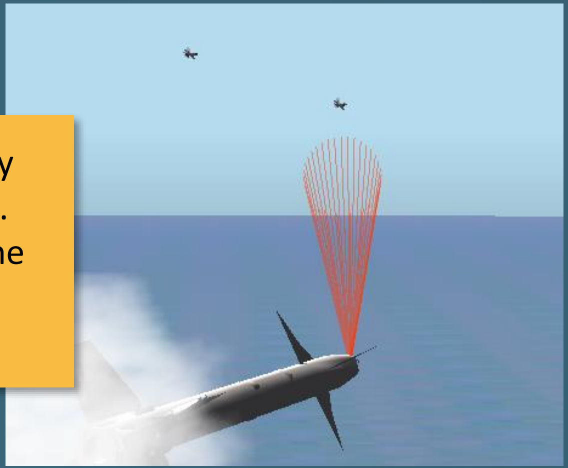
IR SIMULATION

IR Simulation

- IR sensor and emission models work together to create a physically based IR environment.
- IR emission model creates target IR signatures in the scene.
- IR sensor model can detect and track these signatures.
- IR sensor model can be used for IR search & track sensors and missile seekers.



Multiple targets within field of view.
Seeker tracks the centroid of the emissions.

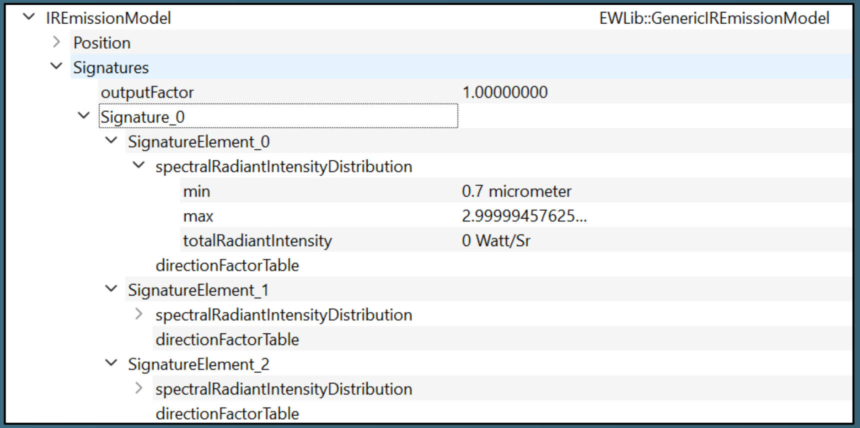


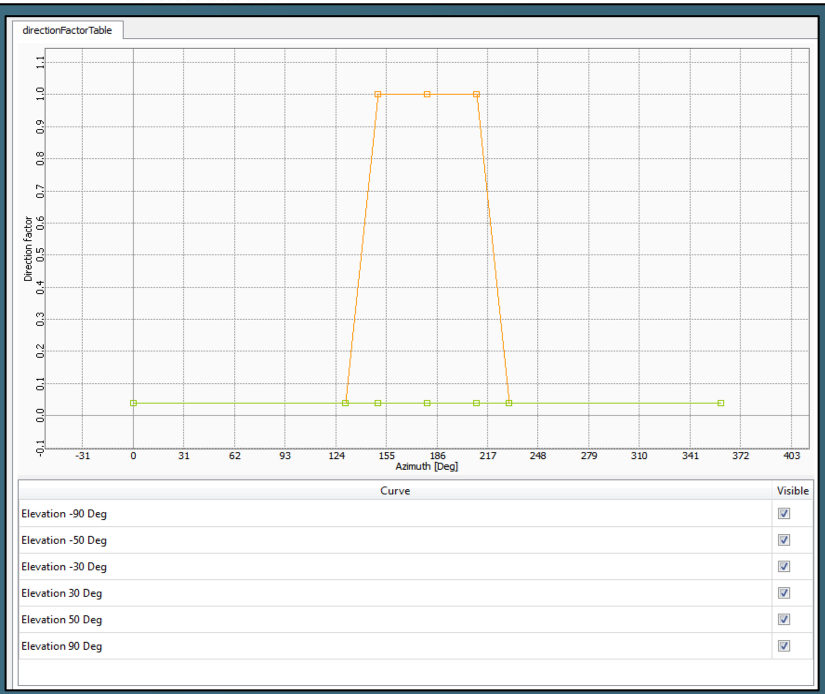
Missile is sufficiently close to the targets. Seeker locks on to the signature with highest intensity.

IR Emission Model

RTDynamics

- The IR signature of each simulation entity can be specified in the configuration files.
  - Multiple emission wavelength ranges
  - For each range total radiant intensity (W/sr) and 2D directional distribution
- Configuration parameters can be modified at run-time via C++ interface.
  - For example, the directional distribution and total radiant intensity can be adjusted based on the **afterburner** state.

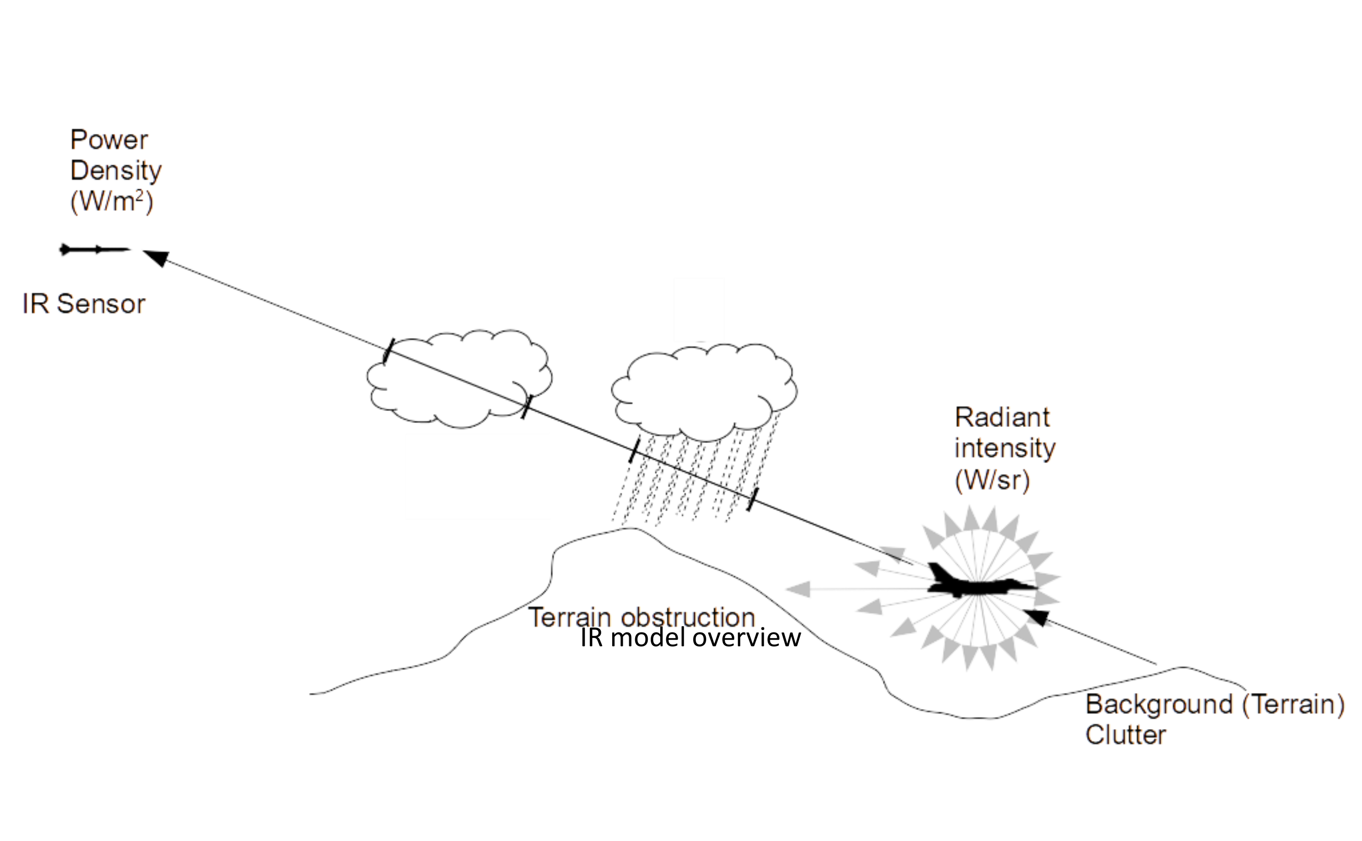




IR Sensor Model

RTDynamics

- The IR sensor model calculates the amount of IR energy reaching the sensor from an emission based on radiometric principles..
- A target is detected if its S/N ratio exceeds the user defined threshold.
- Terrain geometry is taken into account
  - Terrain obstruction
  - Background clutter
  - Clutter suppression
- Atmospheric Attenuation
  - Pressure, temperature, humidity,
  - Rain fall, cloud coverage, fog/haze

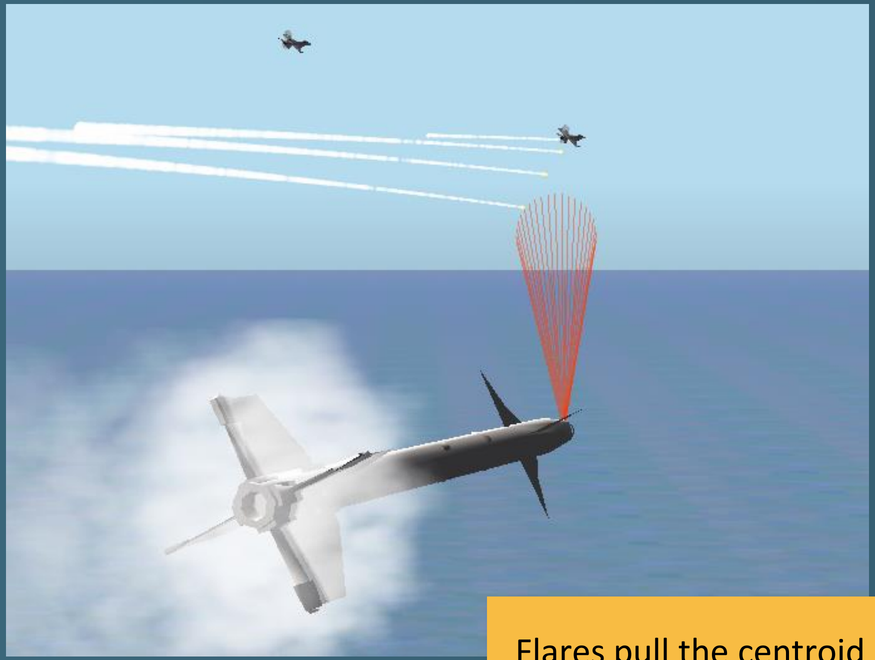


IR model overview

Flares

RTDynamics

- Flares are modeled as high intensity IR emitters.
- Gravity and air drag affect the flight path
- Flare appears as a powerful IR signature to IR sensors. IR sensor tends to track flare's signature if it is more powerful than target's signature.
- Emission frequencies, total radiant intensity, and the directional distribution of radiant intensity can be configured.
- “burn profile” can be specified as a time based schedule of radiant intensity.

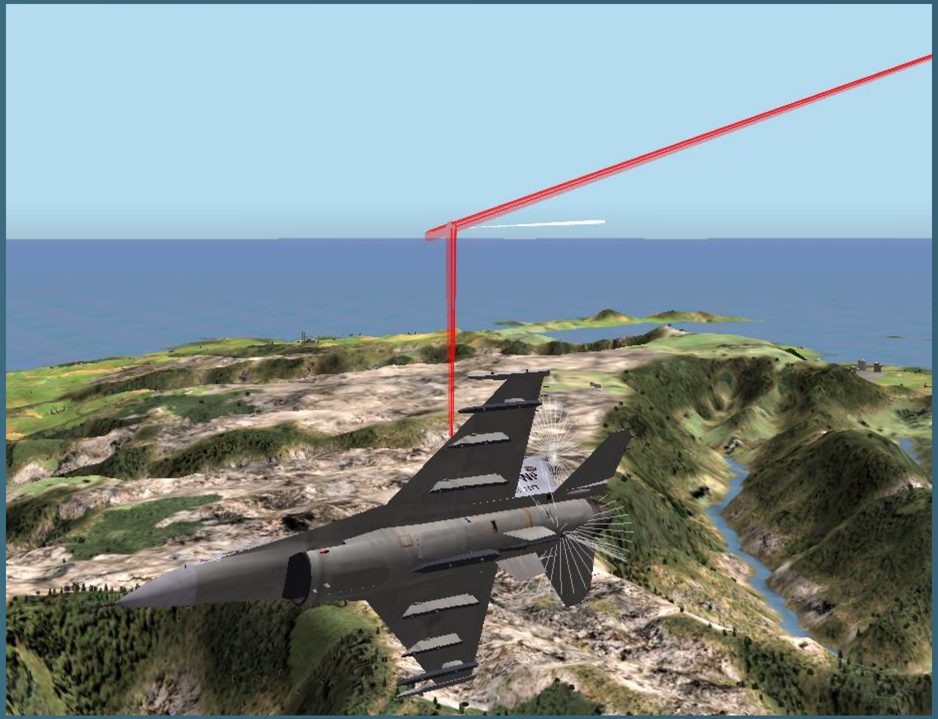


Flares pull the centroid of emission away from target

Directed Infrared Countermeasure

RTDynamics

- DIRCM model can detect missile threats and blind them with high intensity, directed IR emissions.
- It works similar to radar jammers.
- It is possible to configure the detection range, field of effect, emission frequencies and total power output.



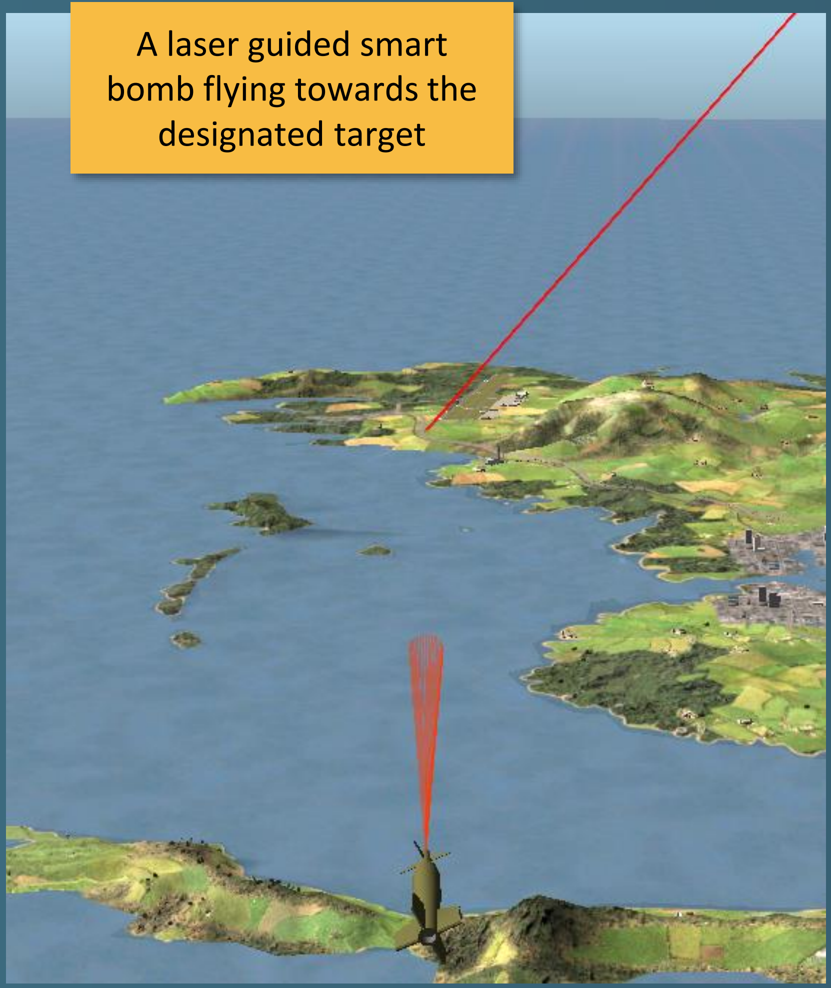
Models in detail

LASER SIMULATION

Laser Designator and Sensors

RTDynamics

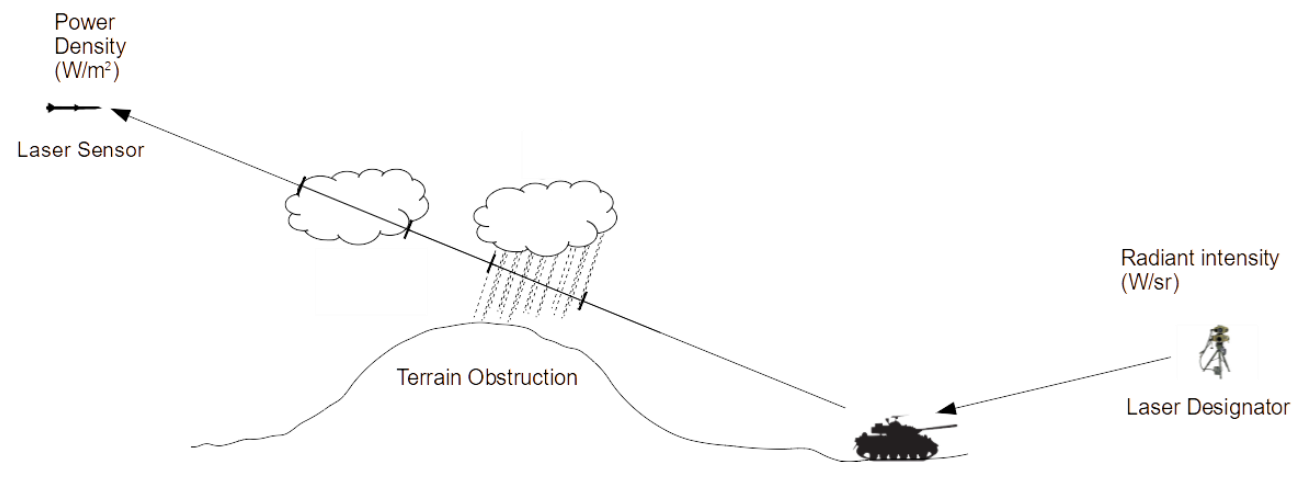
- Laser sensor, reflection and designator models
- Physically based models
  - Laser designator model emits laser rays.
  - Reflection model computes the reflected power.
  - Sensor model computes the S/N ratio and determines the detection.
- Used mainly for missile seekers.



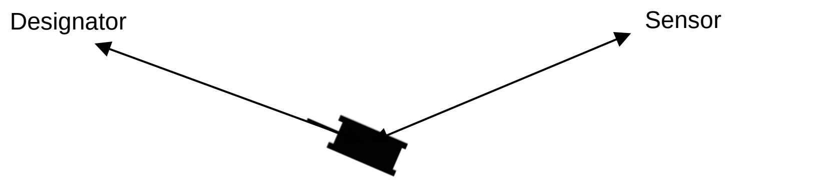
Laser Sensor Model

RTDynamics

- Laser sensor model computes the amount of energy reaching the sensor using radiometric principles.
- A target is detected if its S/N ratio exceeds the user defined threshold.
- Terrain obstruction
- Designator and sensor directions
- Atmospheric Attenuation
  - Pressure, temperature, humidity,
  - Rain fall, cloud coverage, fog/haze



Laser sensor model overview



Designator illuminates the front of the aircraft whereas sensor views the right side. Sensor won‘t be able to detect the target.

Models in detail

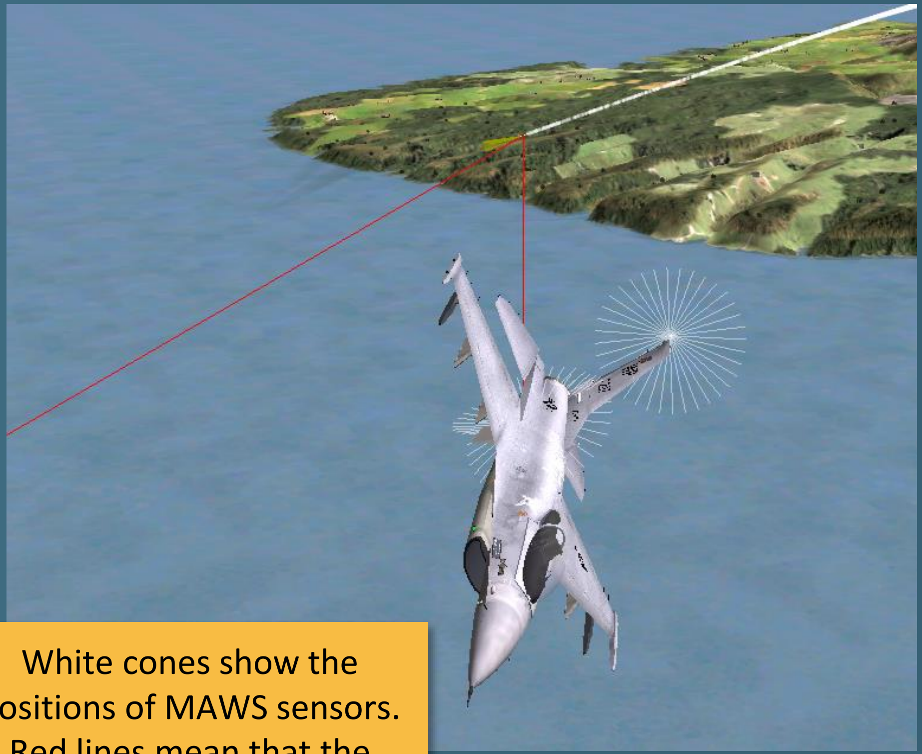
MISCELLANEOUS

Missile Approach Warning (MAWS) Sensor

- MAWS detects and reports approaching threats.

- MAWS consists of multiple sensors whose position and field of view can be modified in configuration files.

- DIRCM model uses MAWS to detect incoming threats.



White cones show the positions of MAWS sensors. Red lines mean that the MAWS detected a threat.

CM Launcher Model

- Interfaces with Radar Warning Receiver and Missile Approach Warning Sensor to detect and identify incoming threats.

- Automatic chaff and release launch

Models in detail

WEAPON SYSTEMS SIMULATION

Weapon Systems Simulation

RTDynamics

- Missiles
  - Air to air
  - Air to ground
  - Surface to air
  - Surface to surface
  - Cruise missiles
- Bombs
  - Free fall
  - Smart bombs (guided)

Weapon Systems Simulation

RTDynamics

- Mathematical model components:
  - Aerodynamics model
  - Engine model
  - Guidance model
  - Fuse model
  - Warhead model*

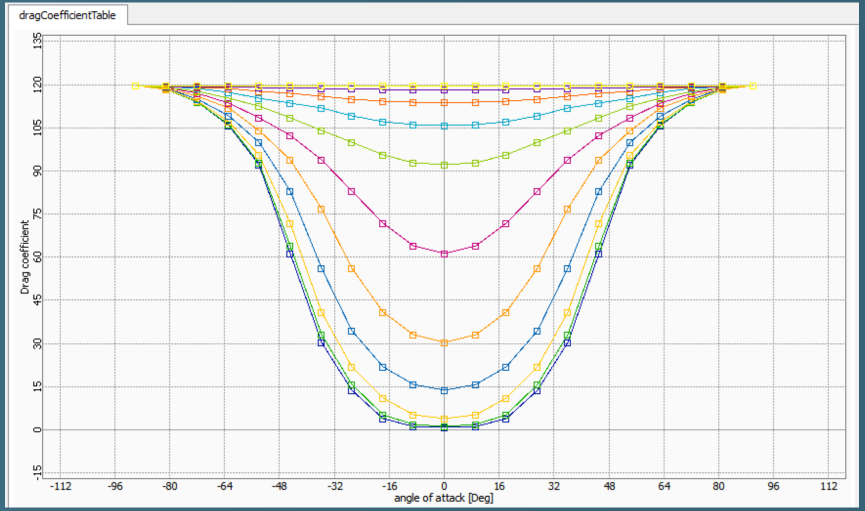
- The model is fully reconfigurable through GUI editor.

* In VRF, VRF Warhead model is used.

Aerodynamics

RTDynamics

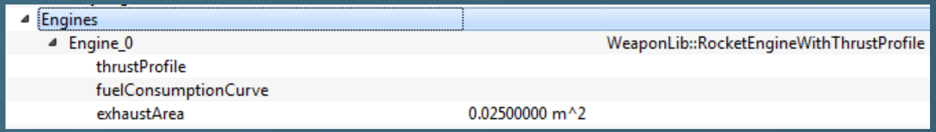
- Lift and side force are modeled as forces linear to angle of attack.
- Drag has a very profound effect on defining missile performance.
  - Drag characteristics can be described via a 2D table (side slip, angle of attack vs. drag force coefficient).
  - Wave drag is taken into account in the model.
- Pitch, yaw and roll dynamics are configured using performance data (e.g. maximum pitch rate curve).
- Air pressure, temperature and humidity taken into account
- Wind affects the fly out

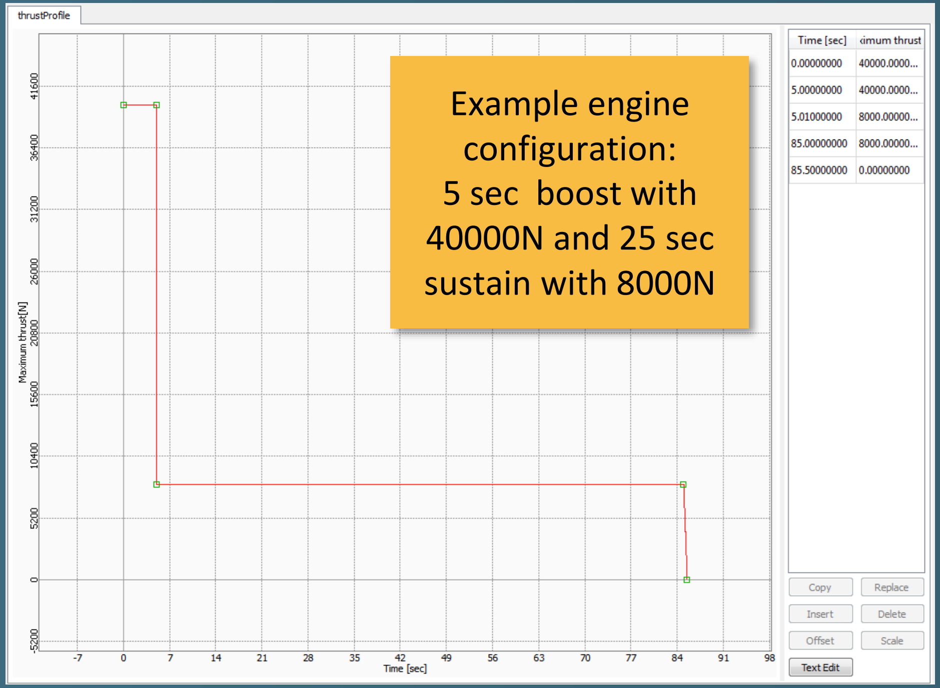


Drag table on the editor

Engine Model

- Rocket engine with a thrust and fuel consumption profile
- Sea level thrust vs. time curve
- Mass of fuel spent vs. time curve
- Missile mass actually changes during simulation
- Air pressure (altitude) affects the generated thrust



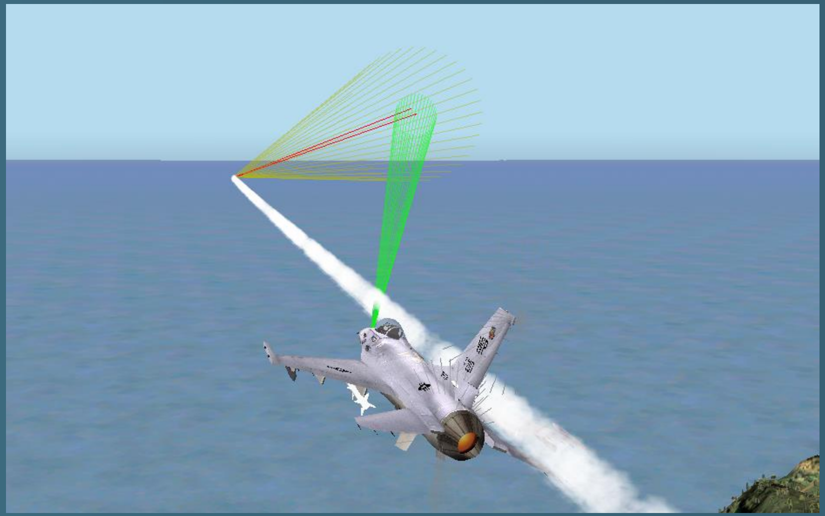


Time [sec]	ximum thrust
0.00000000	40000.0000...
5.00000000	40000.0000...
5.01000000	8000.00000...
85.00000000	8000.00000...
85.50000000	0.00000000

Guidance Model

RTDynamics

- Supported guidance types
  - Active homing
  - Semi-active homing
  - Passive homing
  - Midcourse semi-active, terminal active
  - Midcourse data link, terminal active (e.g. AMRAAM)
  - Midcourse data link, terminal semi-active
  - GOLIS (Go-to-location-in-space)
- Custom guidance models can be added
- Target position estimation in case lock is lost
- Physics based seekers
  - Radar
  - IR
  - Laser



A/C radar illuminates target (green cone),
missile radar locks on return echoes (brown cone)

Guidance Model – Cont’d

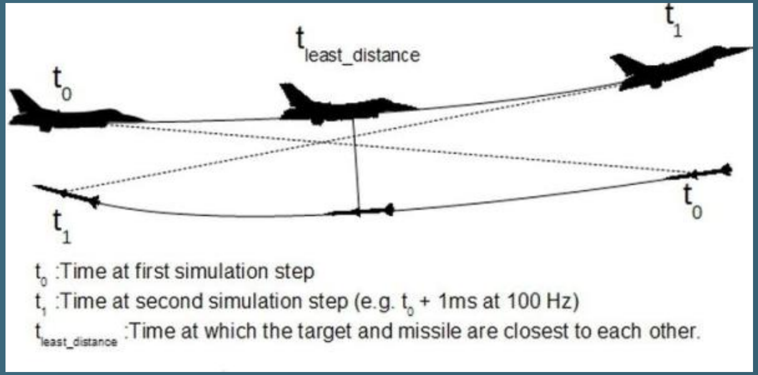
RTDynamics

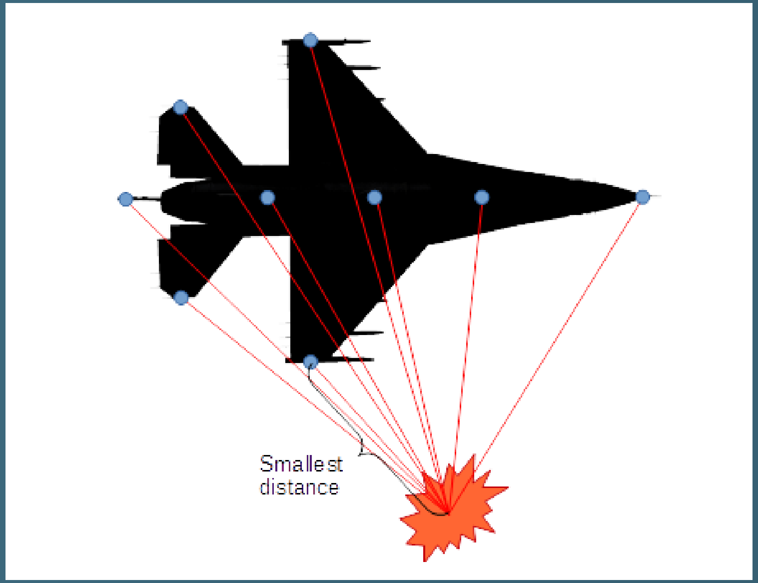
- Custom Guidance Models can be added using C++ API
- With C++ API following controllers can also be used with weapons:
  - Velocity controller : fly with a user provided velocity vector
  - Basic flight controller : fly in a given direction and altitude
  - Follow route : follow a predefined set of **waypoint**, supports **terrain following** flight
  - Proportional Navigation : Navigate by calculating an intercept course towards a moving target based on its relative velocity.

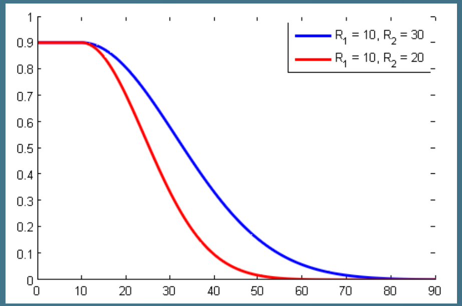
Fuse and Warhead Models

RTDynamics

- Fuse model
  - Detonates when the weapon is closest to the target.
- Warhead and vulnerability model*
  - Targets represented with multiple sampling points.
  - Vulnerability can be defined separately for each simulation entity as a 2D table (azimuth, elevation vs. vulnerability).
- Models can handle multiple targets (e.g. aircraft flying in close formation)





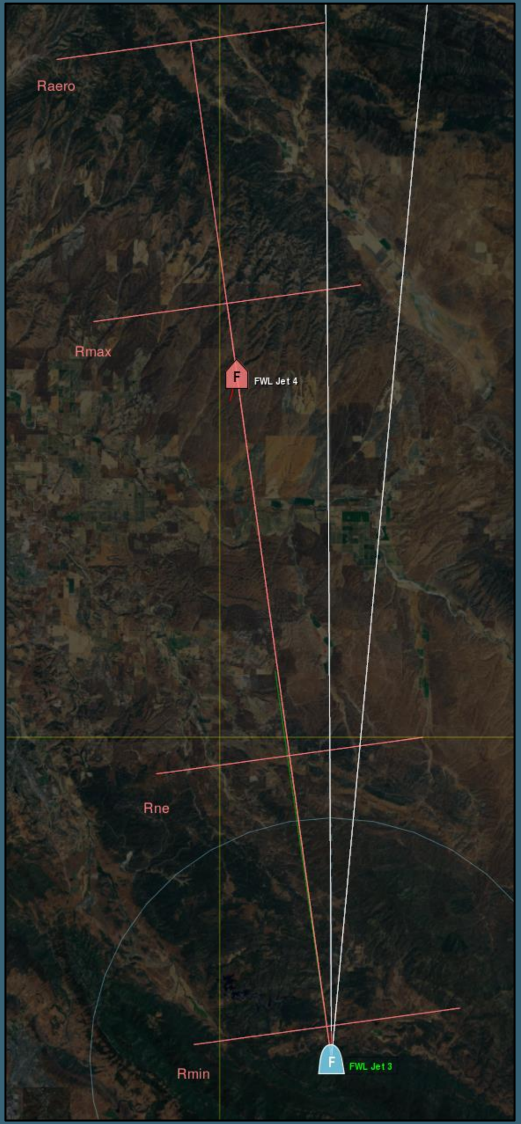


Example kill probability curves

* In VRF, VRF Warhead model is used.

LAR generator add-on

- LAR (Launch Acceptability Region) defines a region of conditions where a weapon can be successfully launched to reach a specified target.
- EWAWS LAR generator add-on performs thousands of test launches to determine the launch success and other relevant engagement variables.
  - Several multidimensional tables are generated that contain various outputs for different combinations of launch parameters.
  - Tables can be used during modeling to validate a new weapon model
  - They can be loaded into the simulation and used in runtime e.g. to drive weapon related HUD components
- Following launch parameters are taken into account
  - Launcher speed
  - Launcher altitude
  - Target speed
  - Target altitude
  - Target aspect
  - Target bearing
  - Target range
- Outputs
  - Aerodynamic range, max range, never escape range, minimum range
  - A-pole, F-Pole, time to target

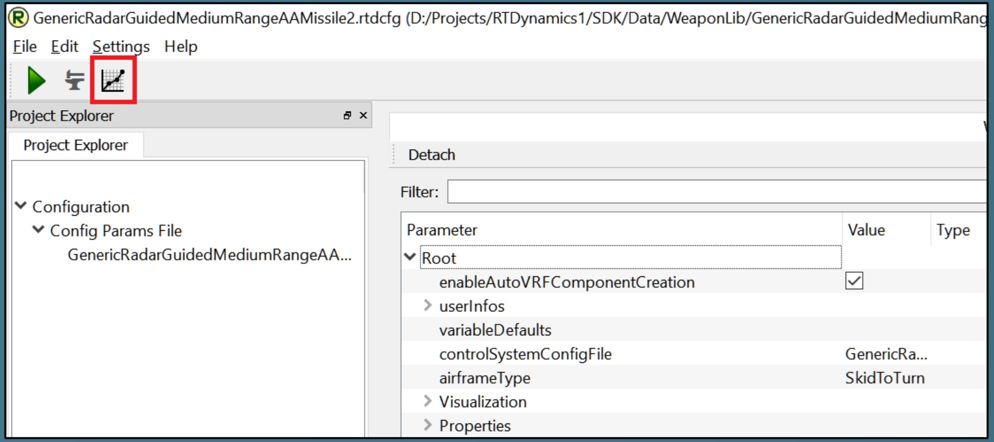


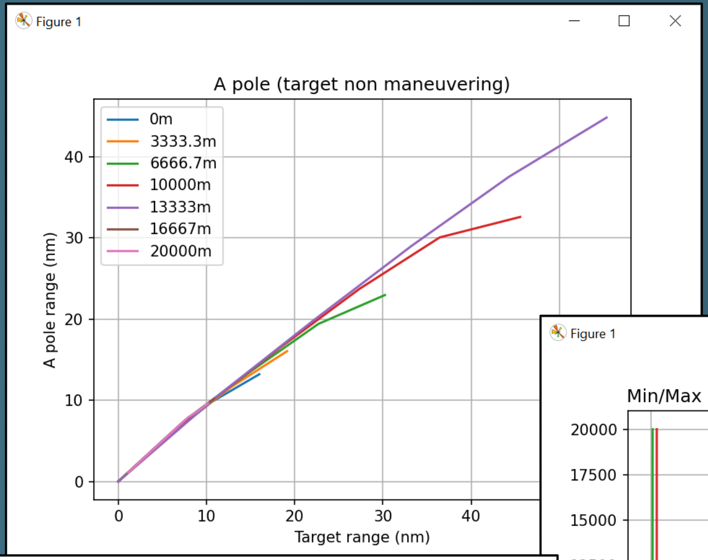
Visualization of LAR ranges during simulation on VR-Forces

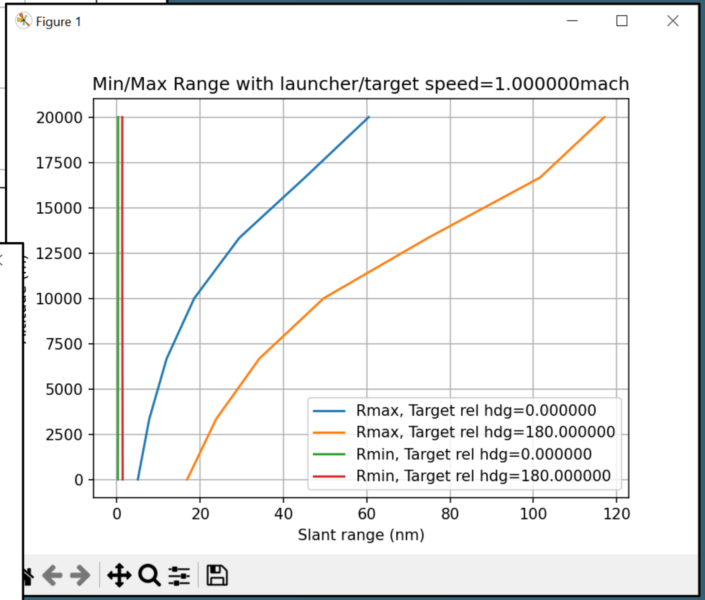
LAR generator add-on

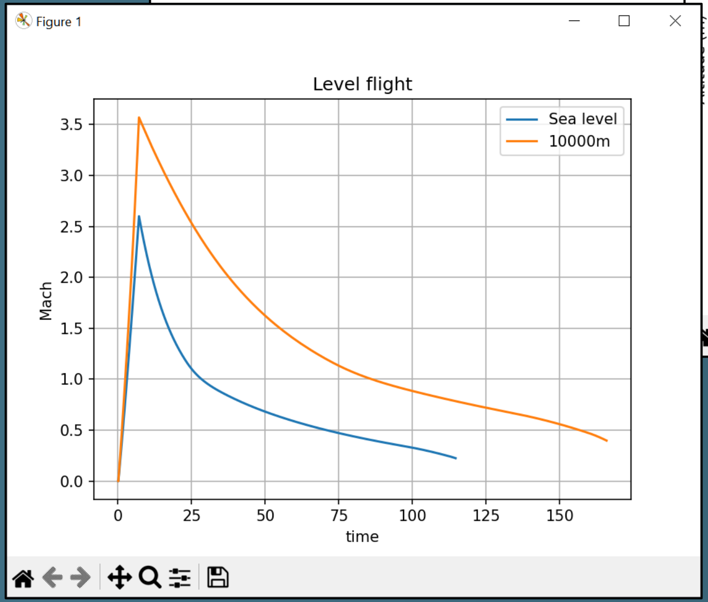
RTDynamics

- Rime can be used to generate and visualize LAR tables during modeling.
- LAR generator also has a C++ API which allows automation and customization.
- Large LAR tables to be used in runtime can be generated with a special executable.









C++ API

Software Features

- C++ libraries for Windows™ and Linux
- Real-time simulation
- Deterministic simulation model (i.e. repeatable simulation results)
- Extensible/Replaceable Model Classes
- Data logging
- Support for saving/loading simulation state (allows scenario snapshots)
- GUI based configuration editor
- Integrate with any simulation environment

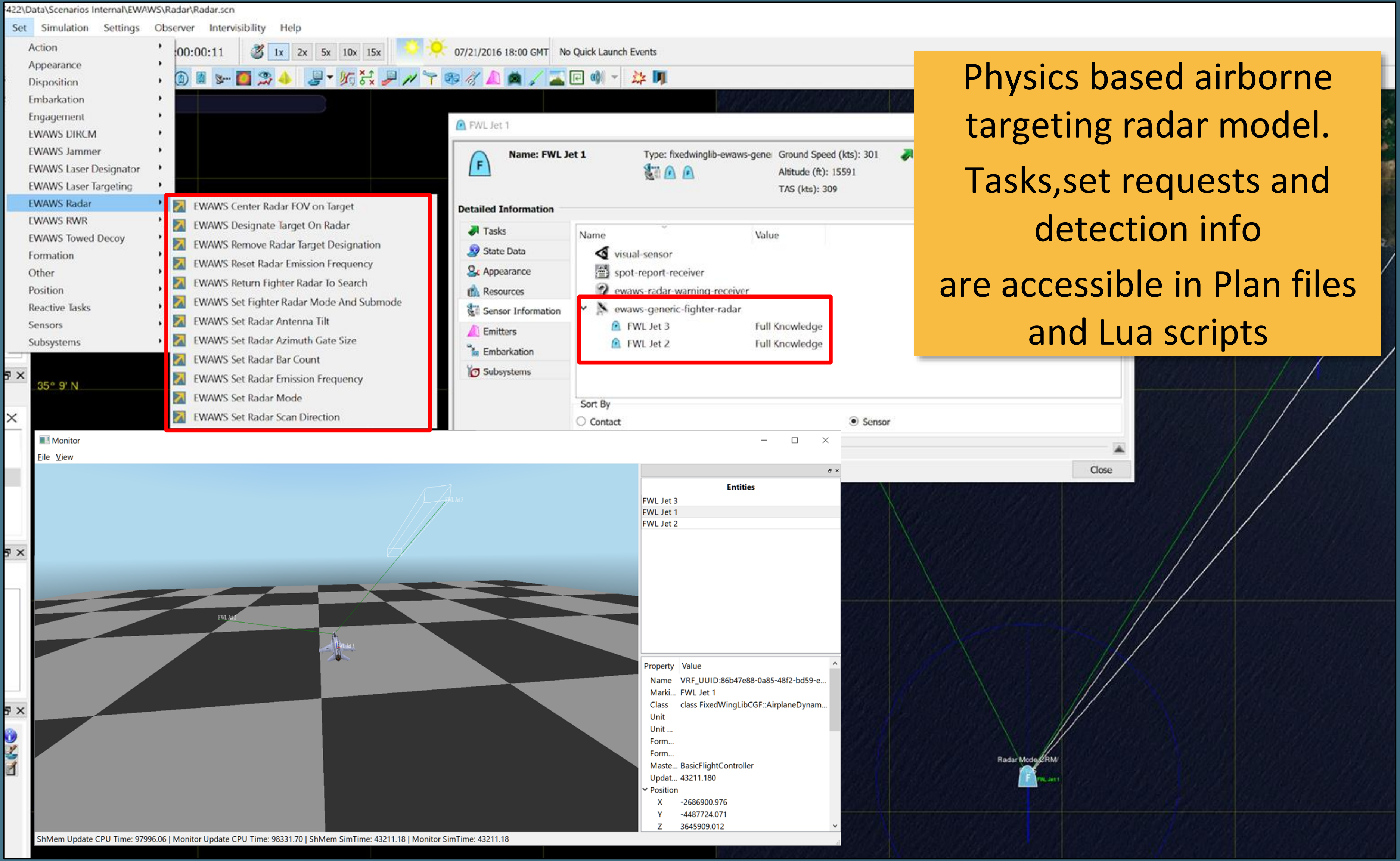
EWAWS FOR VR-FORCES

Plug-in Overview

RTDynamics

- Ideal for VR-Forces users. No programming necessary.
- Allows using realistic physics based sensor, dynamics and electronic warfare models on VR-Forces entities
- Support for VR-Forces Lua Interface
  - All functionality is defined as set request, tasks and simulation commands and is available through Lua interface.
- HLA/DIS integration
- Support for multithreading and multiple VR-Forces backends
- C++ API for extending the capabilities

Airborne Targeting Radar

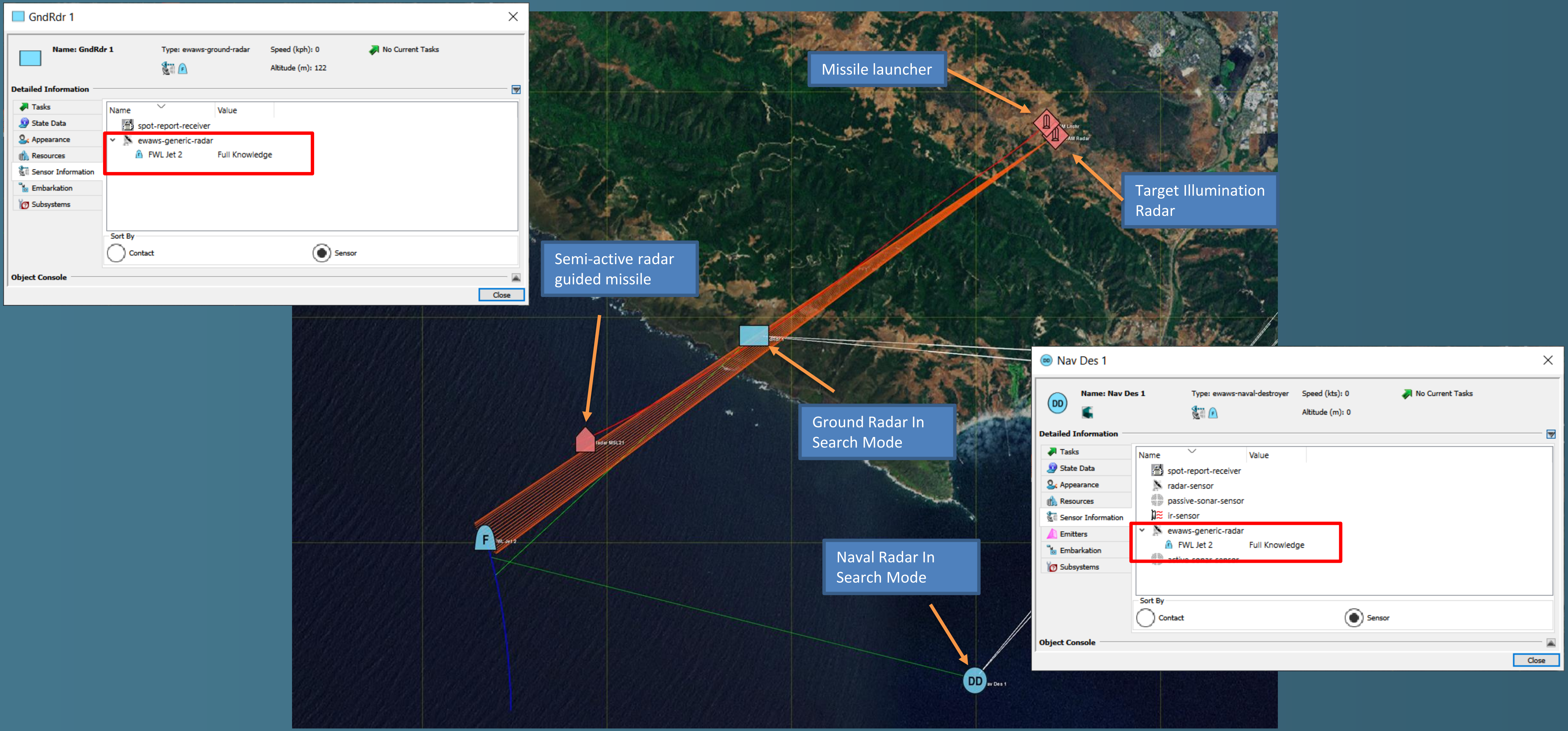


Physics based airborne targeting radar model.

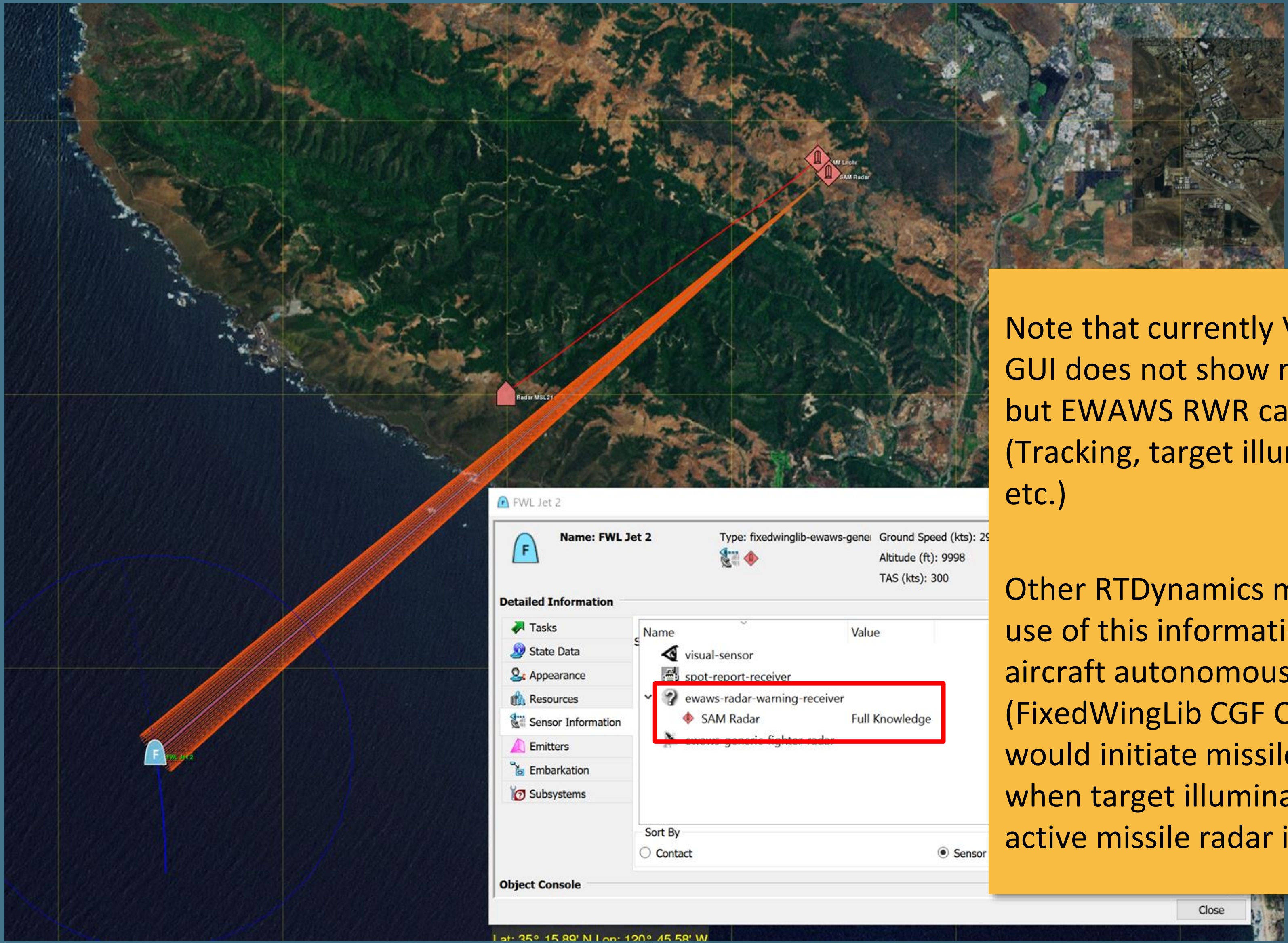
Tasks,set requests and detection info

are accessible in Plan files and Lua scripts

Surface Radars



Radar Warning Receiver

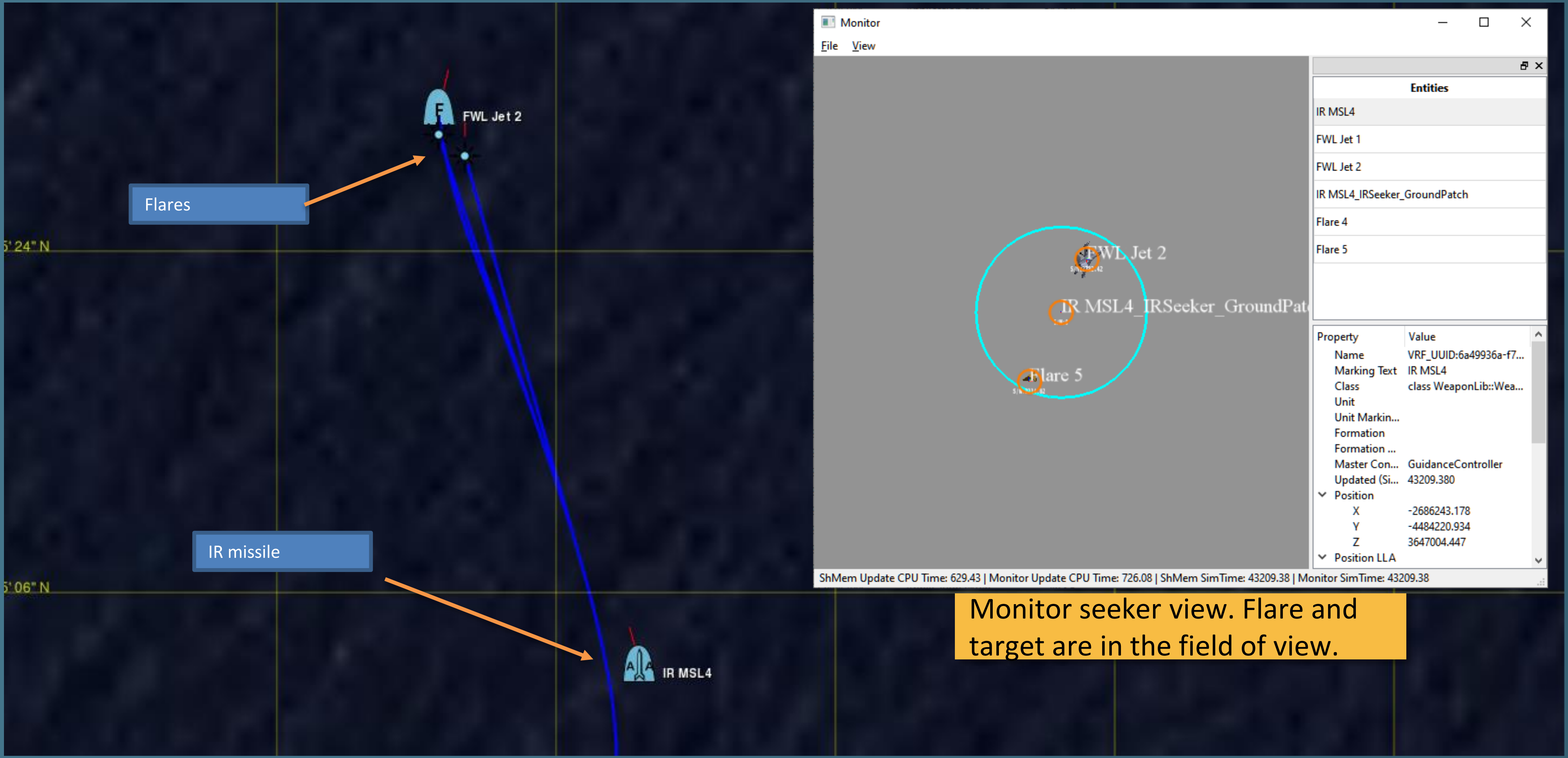


Note that currently VR-Forces GUI does not show radar mode but EWAWS RWR can detect it (Tracking, target illumination etc.)

Other RTDynamics modules make use of this information. E.g. aircraft autonomous agent (FixedWingLib CGF CML product) would initiate missile evasion when target illumination or active missile radar is detected.

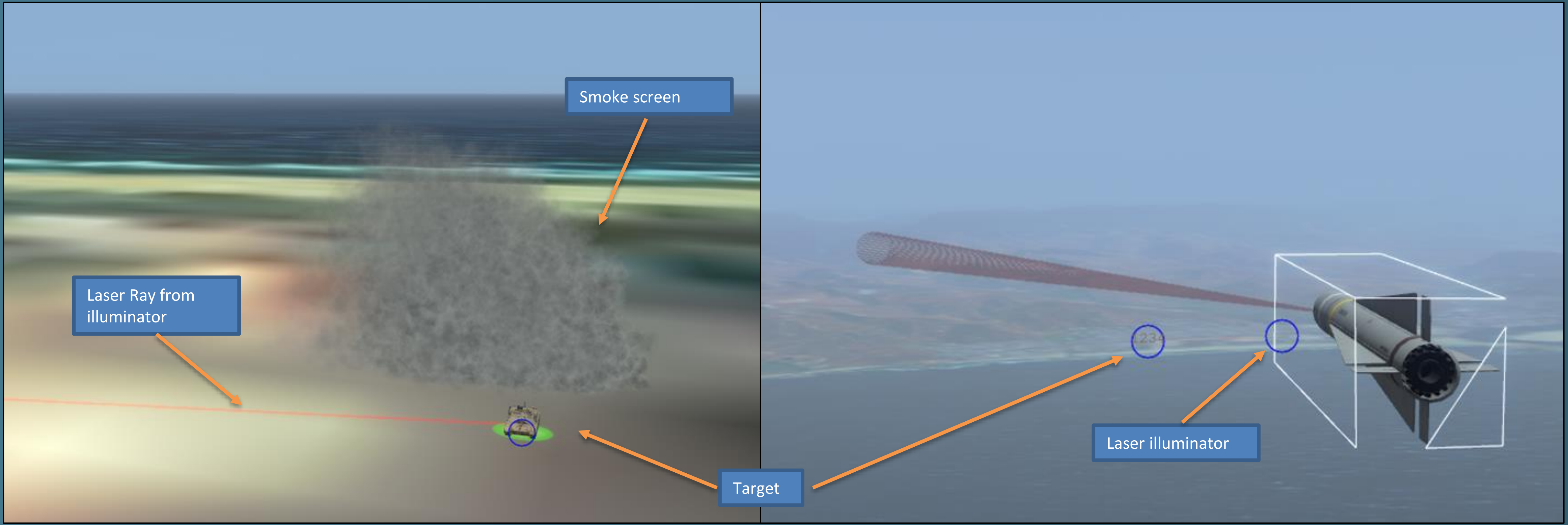
IR Simulation

RTDynamics



Monitor seeker view. Flare and target are in the field of view.

Laser Guidance



Laser guided missile loses the lock due to smoke screen. This can be seen from the fact that the seeker is not looking at the target (seeker is in spiral search model to find the target again)

Visit

rtdynamics.com