



The Joint Simulation Environment Big Data--Analysis and Reporting Tool

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Joint Simulation Environment

- F-35 requires a high fidelity simulation for use during operational testing
 - A significant percentage of the operational test points are not executable on the open air ranges
- Using a simulation for scored operational testing drives JSE requirements
 - Unprecedented scale
 - Extreme number of entities
 - Major complexity
 - Unprecedented overall fidelity
 - Unprecedented levels of overall validation
- These conditions are not unique to the F-35 program
 - It is no longer possible to scale few vs few tests to assess what will happen in theater-wide conditions
 - The nature of modern system-of-systems capabilities makes testing prohibitively expensive



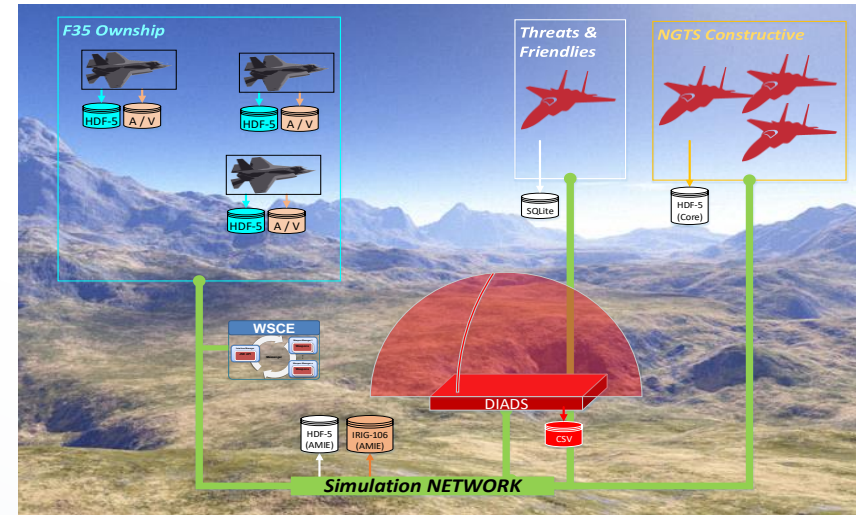
JSE Initial Operational Capability (IOC)

- Scalable, expandable, compose-able, inclusive
 - Federated where it can be but tightly coupled where necessary
- Combines constructive, virtual, hardware-in-the-loop, and anechoic chamber hosted entities
- Secure environment
- Maximum reuse of government elements and facilities
- Government leadership (Navy, Air Force, Intelligence Community)
 - Government integrator
 - Core components largely designed and built by government
 - Government owned/managed interfaces and architectures
 - Inherently protects proprietary information
 - Open enough to accommodate many government and contractor systems and architectures
- But still can accommodate proprietary models
 - Through government controlled interfaces
 - And with enough understanding to accredit for intended use



JSE Initial Operational Capability (IOC)

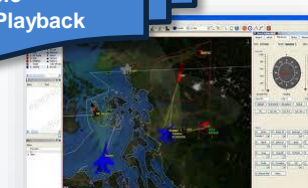
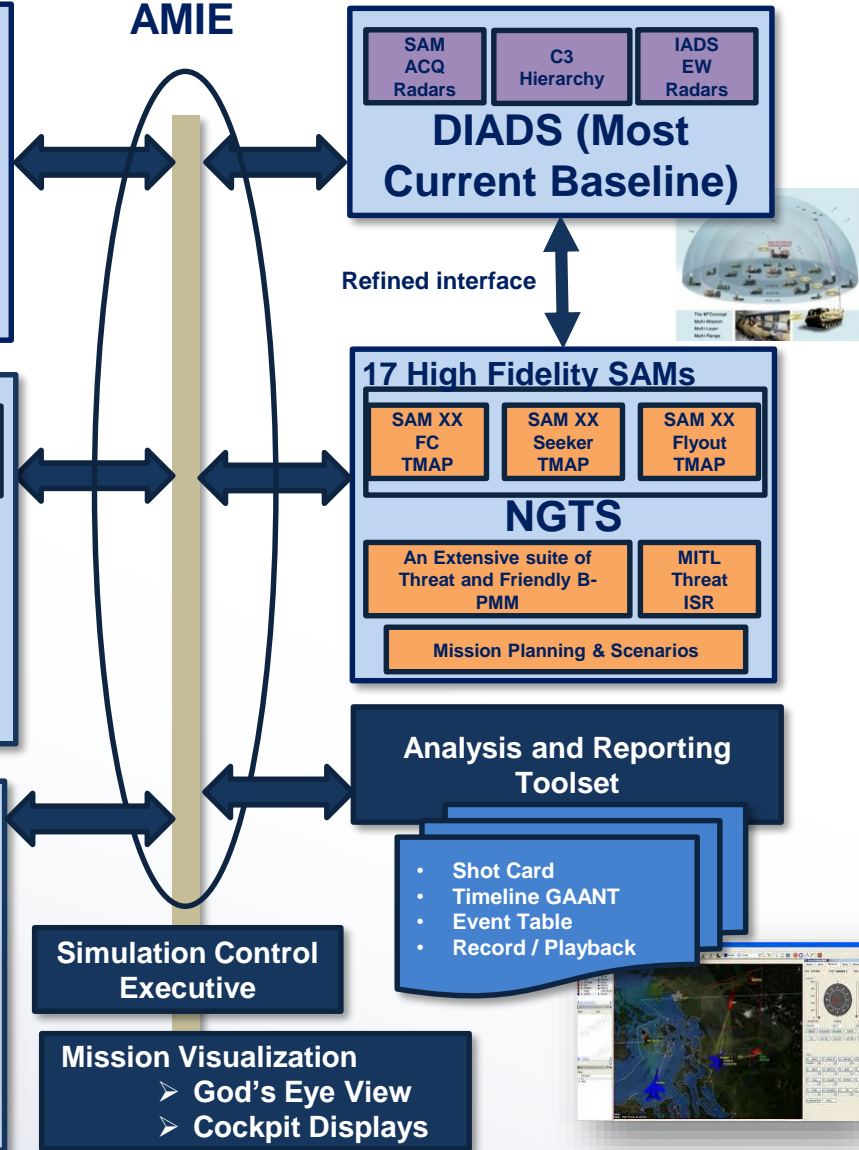
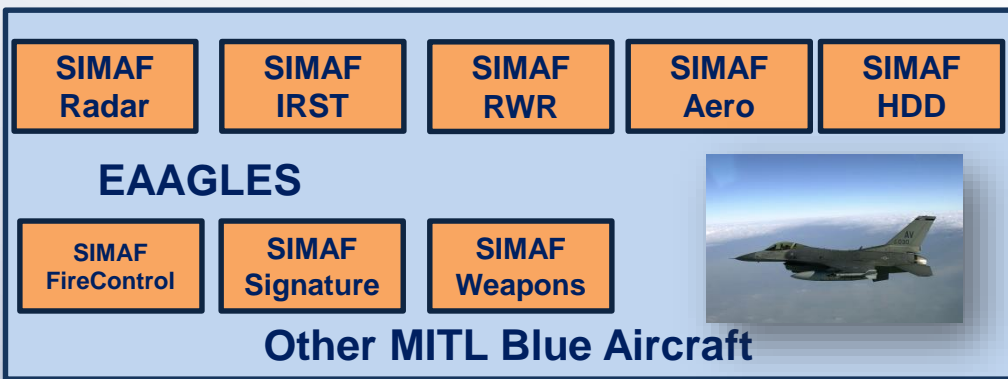
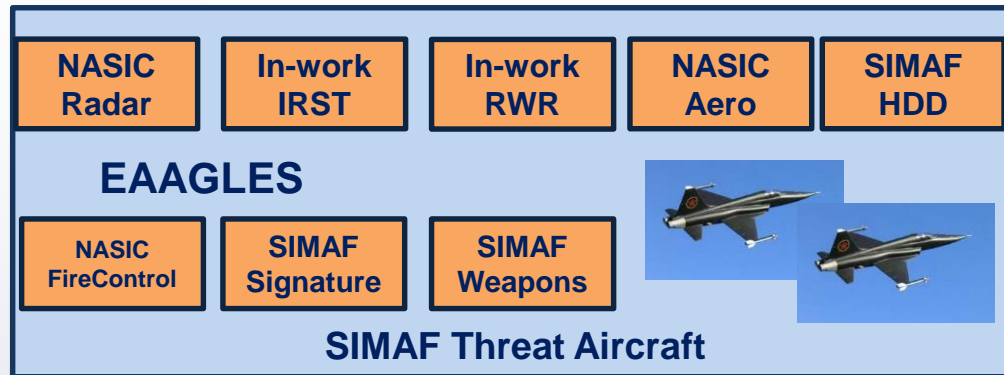
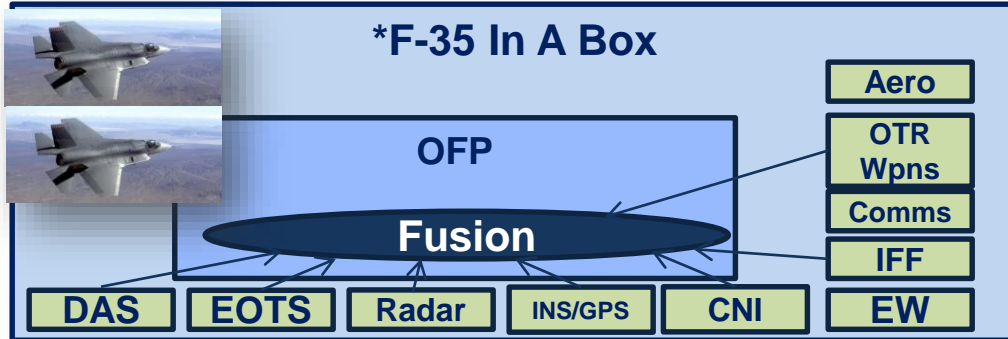
- Theater-wide simulation
- Can provide, literally, thousands of an extremely wide range of red, blue, and white entities including:
 - Aircraft with associated weapons
 - Ships with associated weapons
 - Extensive Integrated Air Defense Systems
 - Surface to Air Missiles
 - Fixed and mobile ground targets
 - Dismounted soldiers
 - *Many entities include electronic attack and electronic protection properties*
- Weather and smoke effects in visual and infrared
- Sun and moon diurnal effects





JSE Initial Software Architecture

*F-35 In A Box is the only element of JSE not under direct government design and configuration control





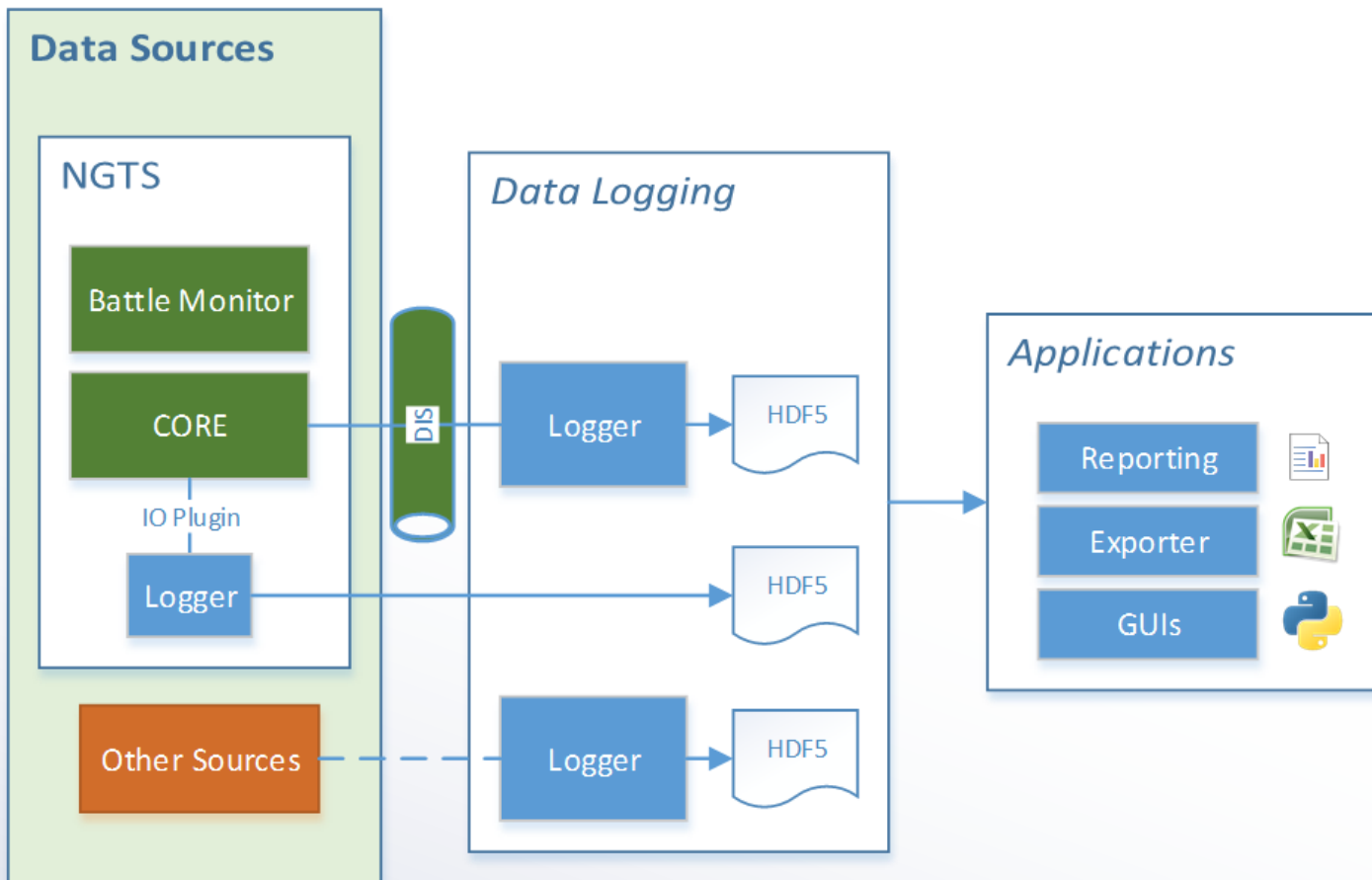
Analysis and Reporting

What can you do with that data?

- **System Performance Assessment**
 - Verification: Compare system data to expected results
 - Validation: Provide information so knowledgeable experts can make decisions
 - Data Mining: Look across many flights, identify patterns
- **Human Performance Assessment (Enhanced Debrief)**
 - Instructor-developed performance measures
 - Analyze data, produce dimensions relevant to the audience
 - Answer questions with graphical interface
 - Display data in helpful ways
 - Shot Cards, Weapon Event Timeline w/subsystems, EW effectiveness, Harm Shots, 2C Reports, Training Rules and more
 - Multi-ship environment + Single-ship actions -> kill chain (winning or losing)
- **Incorporate into debrief - associate individual performance with a pattern**

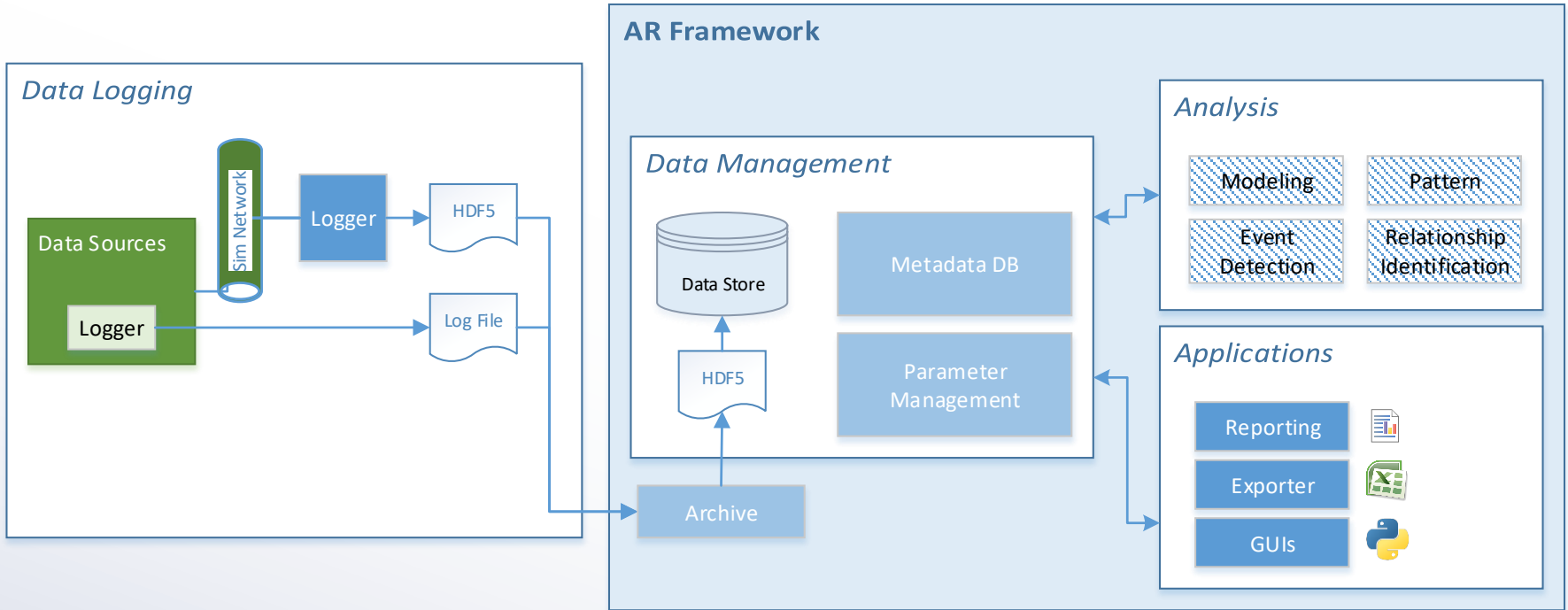


System Architecture





System Architecture





What is “Analysis and Reporting”?

- A framework for collecting data...
 - while preserving the definitions of the source
 - Currently: NGTS, AMIE, DIADS, SIMAF. In Progress: F35
 - in ways that make accessing it efficient.
 - Data is collected in the HDF5 file format.
 - A metadata database is also assembled, providing a query language to find data of interest.
 - and extracting metadata through calculations (aka “crawlers”)
- Applications to analyze and report on the data by...
 - providing reports that extract data in a form useful to end users.
 - providing tools and interfaces that give analysts the ability to study the data.
 - providing administrative applications that centralize functionality and data management.



JSE CONOPS

- Run a mission
- Record data using Debrief Record Tool
- Debrief with Battle Monitor using Debrief Playback Tool
- Ingest Log files (AMIE, CoreLogger), HDF5 (ownership), CSV (DIADS), SqlLite (SIMAF)
- Generate reports or query/analyze data
- Notes:
 - Report generation can happen wherever NGTS 3.2 is installed or if requested via the standalone tool



Building Custom Reports

- We access data. The data is kept in a library of HDF5 files. A metadata index lets us quickly find data in the library.
- For exploratory analysis, we build analysis notebooks. The pattern is to identify a sub-population then analyze related data. Analysis often includes performing operations and creating visualizations. Jupyter is one tool that can be used. The Datastore GUI has a "Interactive Notebook" tool that is very similar and is bundled with the other functions we deliver.
- Once we have known good visualizations, they can be cemented in a report. The report can be created on-demand. We use D3js for this, which creates an interactive visualization in HTML. This makes user-friendly reports that are easily integrated with other applications.



Building Custom Reports

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— DRAFT —

March 8, 2017

DIADS Analysis

March 8, 2017

1 IADS Decision Timeline Analysis

Modern threat environments include an Integrated Air Defense System (IADS). DIADS is a product that simulates the IADS threat environment. This notebook explores data available in the DIADS product and the type of information that can be extracted from a DIADS simulation.

In this UNCLASSIFIED simulation, DIADS was executed with its demonstration mission. The DIADS product provided simulated red IADS threat environment. NGTS provided simulated blue-air entities, flying them in-range of the IADS system.

Out [1]:



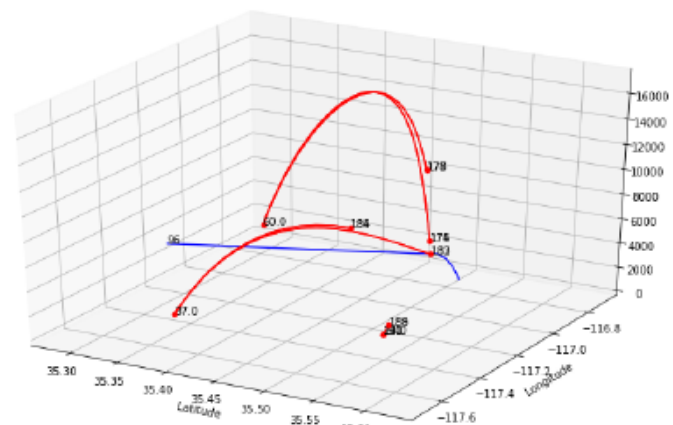
1

Out [6]:	source	target	missile	start	end
37	37.0	97	170	2017_03_02 22:35:49	2017_03_02 22:36:02
38	37.0	97	171	2017_03_02 22:35:50	2017_03_02 22:36:02
39	37.0	97	172	2017_03_02 22:35:53	2017_03_02 22:36:02
40	37.0	97	173	2017_03_02 22:35:54	2017_03_02 22:36:02
41	60.0	96	174	2017_03_02 22:37:05	2017_03_02 22:37:45
42	60.0	96	175	2017_03_02 22:37:05	2017_03_02 22:37:45
43	37.0	98	176	2017_03_02 22:37:06	2017_03_02 22:37:31
44	60.0	96	177	2017_03_02 22:37:09	2017_03_02 22:37:45
45	60.0	96	178	2017_03_02 22:37:09	2017_03_02 22:37:45
46	37.0	98	179	2017_03_02 22:37:10	2017_03_02 22:37:31

The analysis will progress into a closer examination of a specific weapon launch. Looking at the results of the missile dataframe, one of the target player ID's will be selected for graphing purposes. The analysis results include relationships between the missile and the DIADS player IDs that are connected to this target. The DIADS PAndO csv contains all of the positional data for every single player. During translation, the DIADS csv is split into one HDF5 node per player.

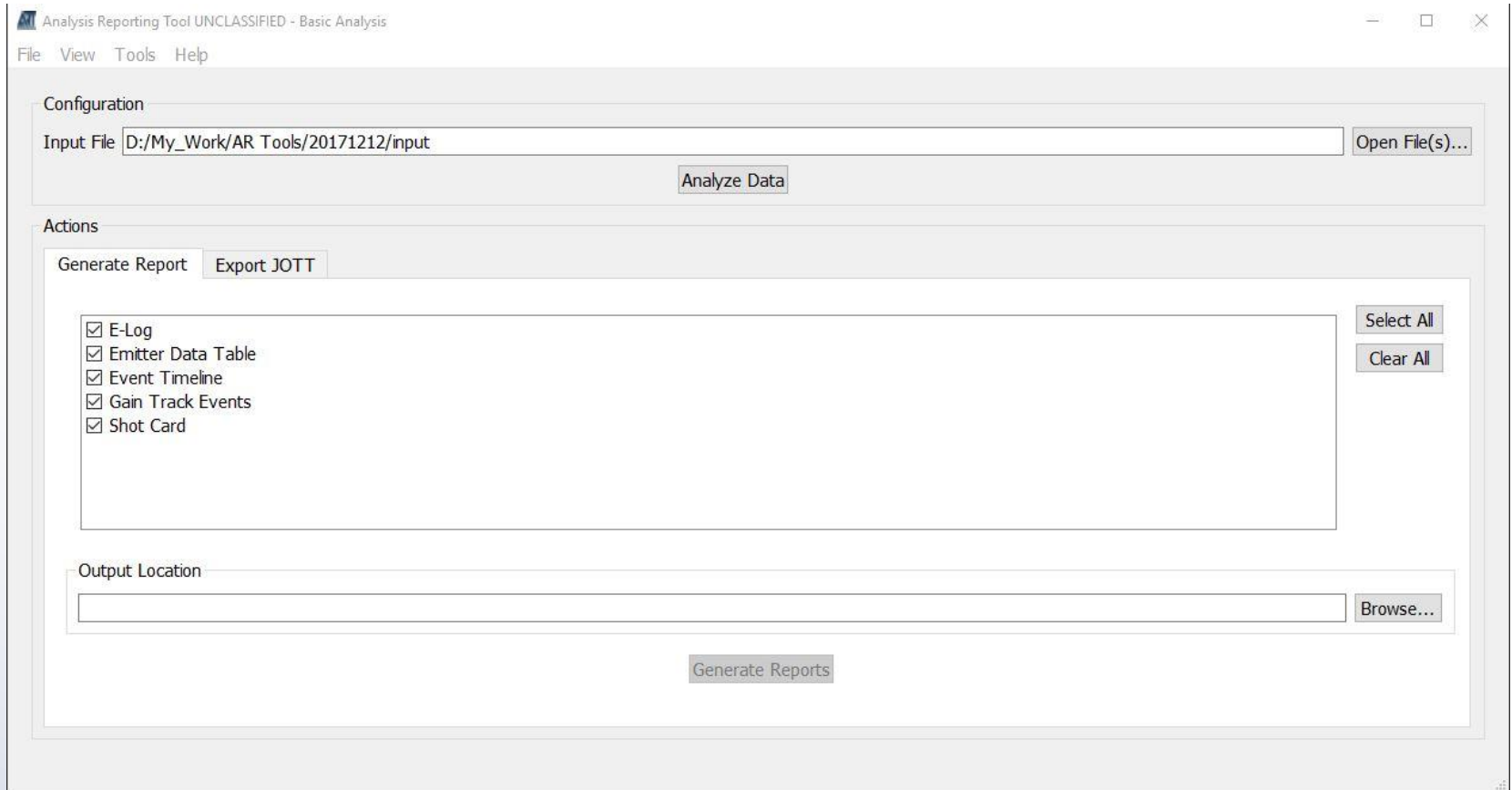
We'll pick PID#96 as our target for this demonstration.

The first graph will display a single aircraft and all of the missiles that were fired at it. Extended information for each weapon event will be included, such as the player ID number that is a reference for subsequent analysis.





Screenshots





Screenshots

Analysis Reporting Tool UNCLASSIFIED - Advanced Analysis

File View DataGraphs Tools Help

Data Graphs

Name	Version	Description
datagraph	1.0.0	Conjunctive Graph for Persistent ...
OntoRepo	1.0.0	File repository management ontol...
Repo		D:/My_Work/AR Tools/20171212/...
OntoProvenance	1.0.0	Provenance ontology for tracking ...
OntoNgts	1.0.0	NGTS Loggers population of Tacti...
OntoDiads	1.0.0	DIADS Loggers population of Tact...
OntoTacair	1.0.0	Definition of the Tactical Airborne ...
OntoLvcr	1.0.0	LVCR Loggers population of Tactic...

Call Graph Session Explorer Ontology Explorer Query Data Graph

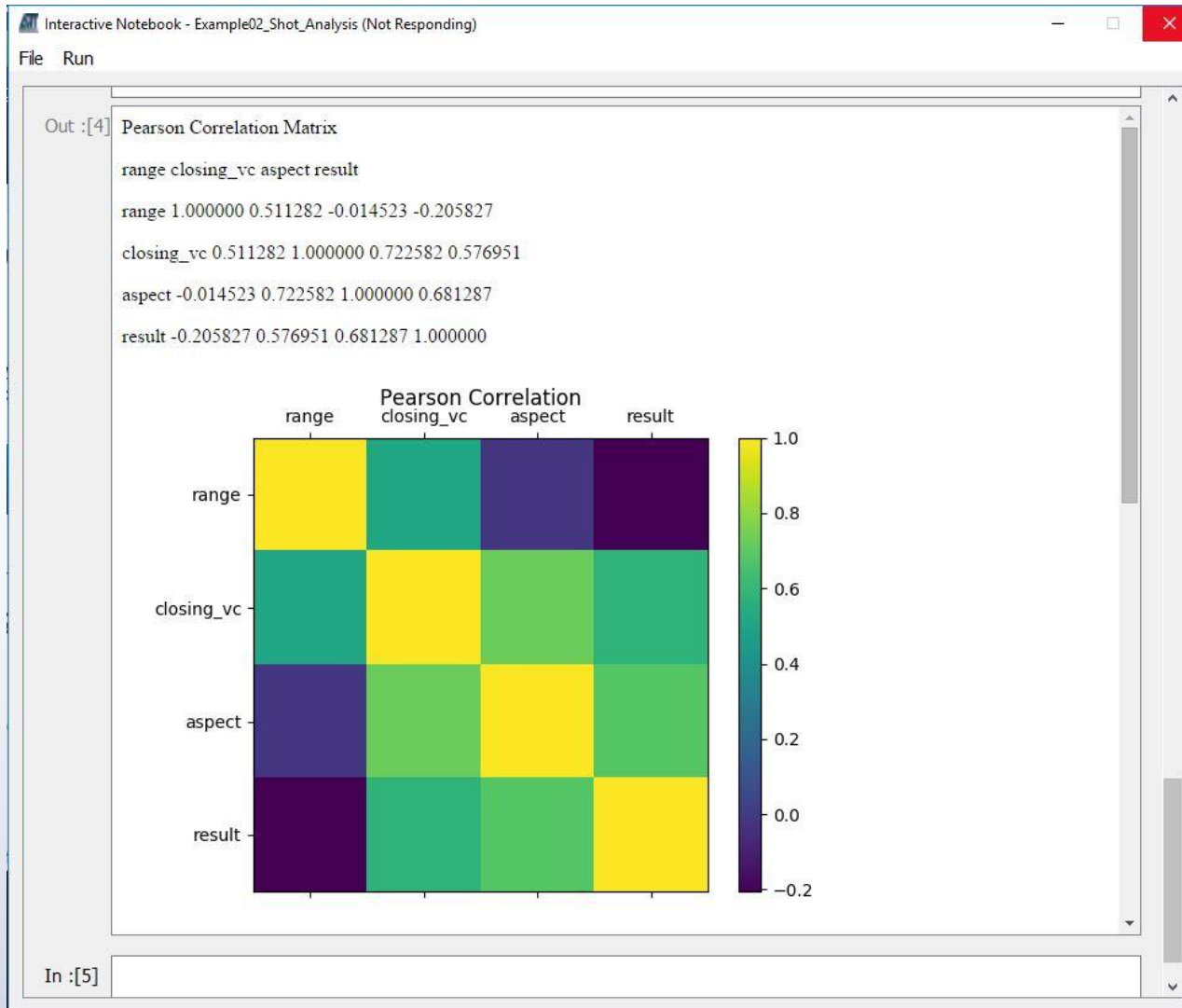
DataSet

datagraph

Crawl



Screenshots





Screenshots

V and V Sample Report

Scenario: 1 Equipment: SAM10

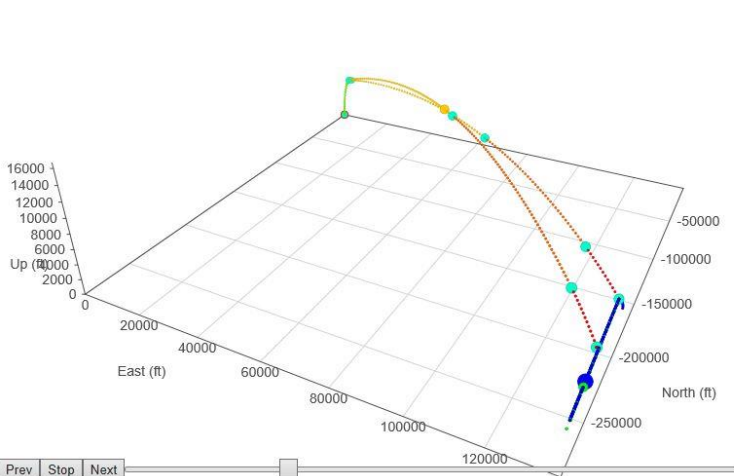
Maneuver	Crossrange (km)	DYN Run?	Speed (m/s)	Target RCS (dBsm)	Multi-Target	Heading (deg)	Downrange (km)	Altitude (km)	Test Case
Benign Straight and Level	0	Yes	237	-10	No	18	90% MKR	6.096	1

Executive Summary

Explanation

Missile_Flyouts_with_Events

Time (seconds from sim start): 9



Legend:
• G2 • SAM • Event • G1 • F18

Tracking Results:

NGTS vs Truth:
R2 = 99.6%
Std. Error = 5.6 ft

IC vs Truth:
R2 = 99.6%
Std. Error = 5.6 ft

IC vs NGTS:
R2 = 99.6%
Std. Error = 5.6 ft

Decision:
NGTS and IC are statistically matched

Detailed Plots

Explanation

Top-Down View of Scenario

Explanation



Screenshots

Analysis & Reporting

File

shotcard.html x eventtimeline.html x emitterDataTable.html x elog.html x



Air Target Weapon Launch

UNCLASSIFIED FOR OFFICIAL USE ONLY

Select an option ▾

Select Shooter(s)

- SA-10
- F-16_1
- mig-29_2
- FA-18_3
- FA-18_2
- FA-18_4
- F-16_2

TRIGGER SQUEEZE									LAST SUPPORT											
Shooter	WPN	Shot Valid	Time mm:ss	ALT	BRAA	Closure Vc	CAS / AOA / G	RWR Status	Group/Name	Shot Valid	Time mm:ss	ALT	Strength	PB or CS	EA	BRAA	BULL	A-Pole/ F-Pole mm:ss	Time of Flight (secs)	Remarks
FA-18_4	Aim-120-1		20:34		52/29/25/0R	483.6	216.1/0.0/0.0		mig-29_3		21:34		2			53/14/25/0R		00:59	59.3	Entity Impact
FA-18_4	Aim-7-1		19:03		327/9/24/0L	330.7	215.4/1.7/-0.5		mig-29_2		20:13		2			101/1/25/49R		01:10	70	Miss
FA-18_4	Aim-9-1		19:36		2/4/24/8R	230.4	216.1/0.0/0.3		mig-29_2		19:51		2			38/2/24/12R		00:15	15.4	Entity Impact

NAVAIR Public Release 2018-357. Distribution Statement A
 Approved for public release; distribution is unlimited.



Looking Forward

- Crawler SDK
- Data Charting SDK
- Exploratory Data Analysis
- Ontology SDK
- Live Analytics & Reporting
- Big Data Integration
- Graph Database
- Auto-ingestor for new data sources
- Abstract Parameters



Questions?