Widely Distributed Modeling & Simulation in Aerospace & Defense Using the HLA standard

MODPROD, Linköping 2010-02-10

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PITCH

www.pitch.se

Overview

- A few words about Pitch
- Simulation Interoperability – What is the problem?
- The HLA Standard
- Model Based Engineering, Modeling and Simulation and Interoperability
- Real world examples & challenges
- Widely distributed Modeling & Simulation
- Conclusions

Who We Are


Army


Navy


Air Force


PSO.

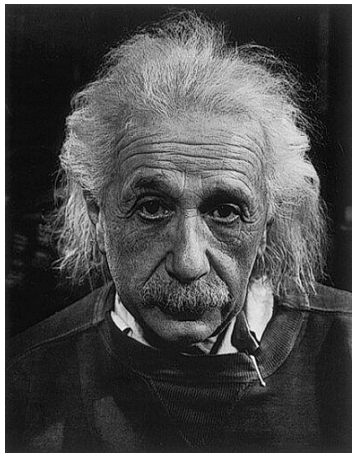

Space


Industry


Energy

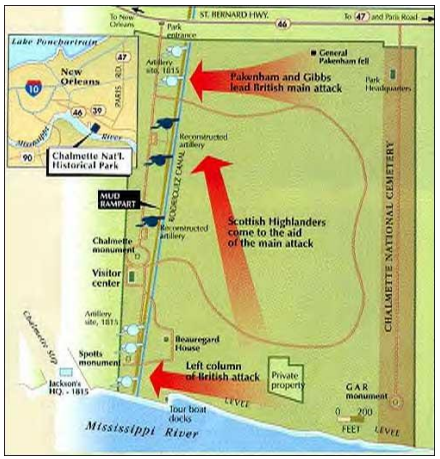
- World leader in standards-based interoperability products
- Provides standards-based tools to more than 300 customer organizations in more than 30 countries
- Strong focus on R&D and innovation
  - Develops and delivers cutting-edge, industry-strength products
  - International R&D leader with several research awards and certifications
- Small, agile company with our own brand and an international partner network
- Slogan: ”Make Your Systems Work Together”
- A BAE Systems company (head count: 100 000)

Why Distributed Simulation?



- One necessary requirement to develop a serious simulation model is a high level of domain knowledge
  - Different models are developed by different specialist companies, expert groups, researchers, etc
  - Simulation models may be acquired from different sources together with the real systems (for example a real aircraft + simulator)
  - The source may increase (or decrease) the credibility of the model
- Different models come from different sources and were developed in different ways

Why Distributed Simulation?

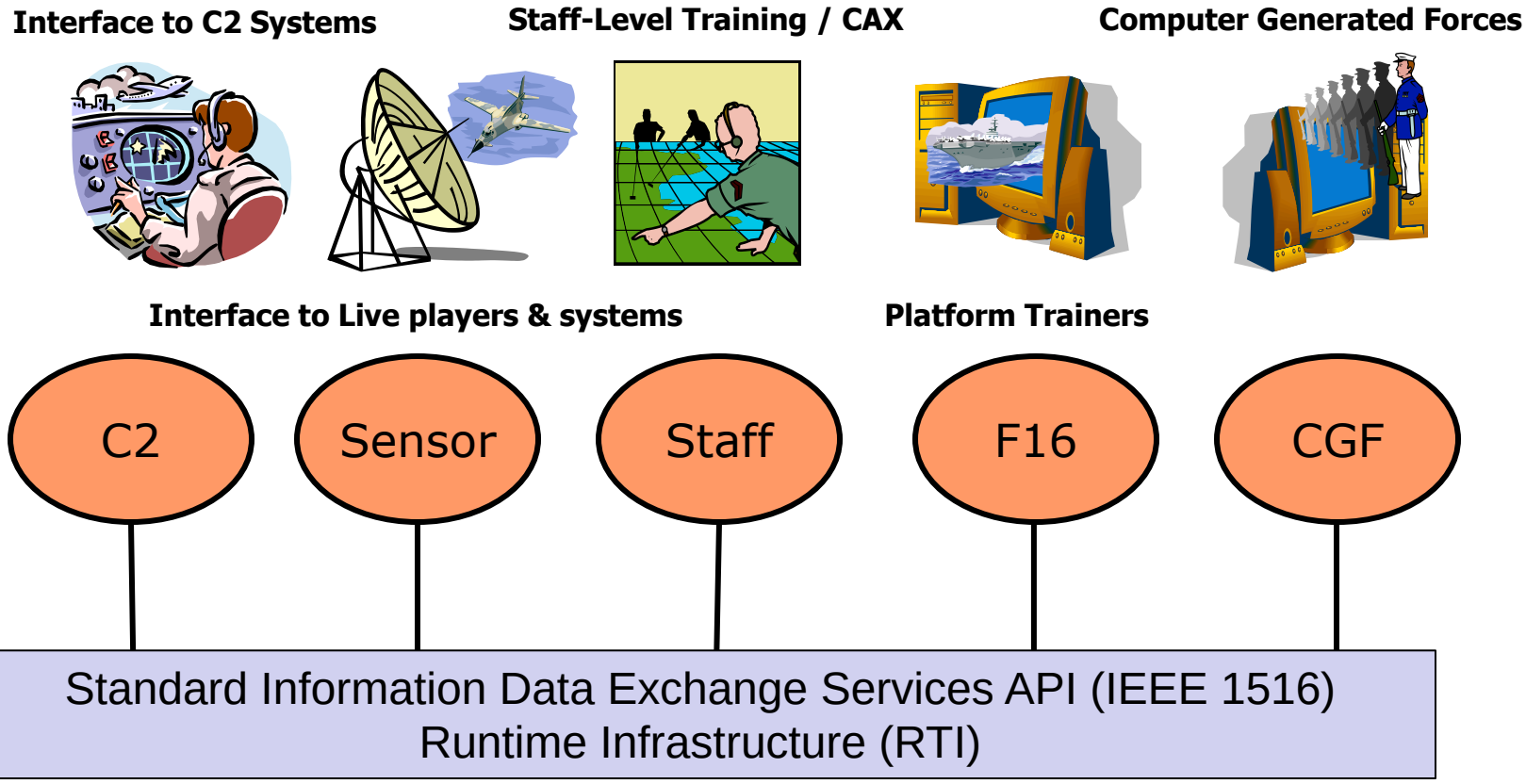


- To model ”the bigger picture” we need to combine many different simulation models from different sources. Examples:
  - Defense simulations: sensors, vehicles, weapons, effects, weather, tactical decision making, command and control...
  - Environment simulations: chemical processes, ecology, meteorology, hydrology, human behavior...
  - Offshore oil simulation: oil platforms, ships, drilling process, fluids, geology, people, ...
- There is no single ”correct” way to model a real world concept
- Simulation Interoperability – making simulations work effectively together

Modeling and Simulation Concepts

- Model
  - A physical, mathematical or logical representation of a system, process or other phenomenon
- Simulation
  - Execution of a model over time
- Distributed Simulation
  - Synchronized execution of multiple models over time
  - Models can be more or less distributed from using shared memory, LAN to WAN
- High-Level Architecture (HLA), IEEE 1516-2010
  - Open International Standard for Simulation Interoperability
- Federation (HLA Terminology)
  - A set of loosly coupled simulation systems, tools and infrastructure to support distributed simulation execution events

Sample Federation



Models can be executed in the same process or across the world

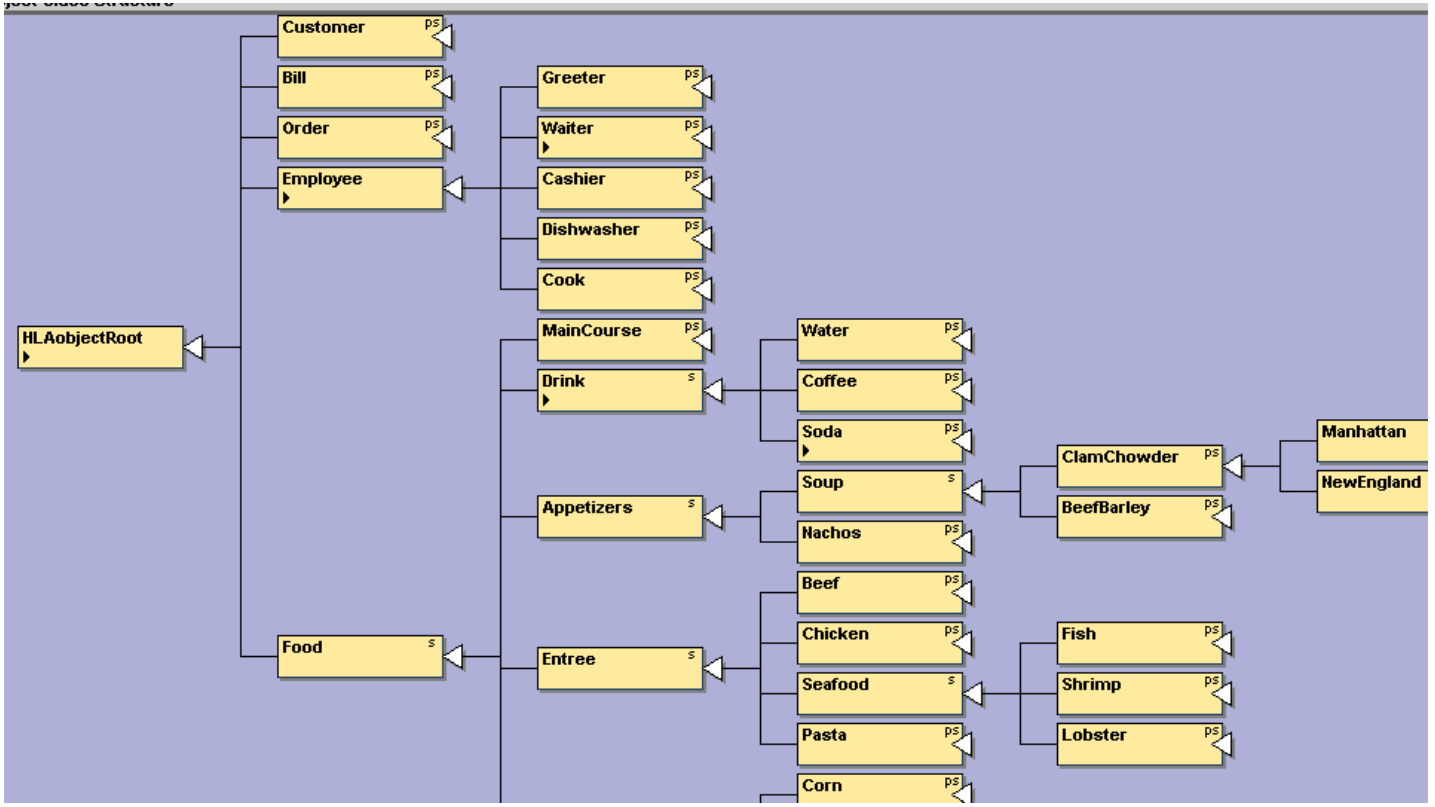
(with slightly different latency characteristics)

HLA - Six Categories of Services

Category	Functionality
Federation Management	◆Create and delete federation executions ◆Join and resign federation executions ◆Control checkpoint, pause, resume, restart
Declaration Management	◆Establish intent to publish and subscribe to object attributes and interactions
Object Management	◆Create and delete object instances ◆Distribute and control updates for attributes ◆Distribute interactions
Ownership Management	◆Transfer ownership of objects/attributes
Time Management	◆Coordinate the advance of logical time and its relationship to real time
Data Distribution Management	◆Control the efficient routing of information between federates

Supports different types or time management (real-time, logical time, event driven, ...)
High performance: 100 000 updates/s, 0.2 ms latency
Scalable: tens or hundreds of simulator
Implementations for a plethora of operating systems & languages/compilers

Federation Object Model

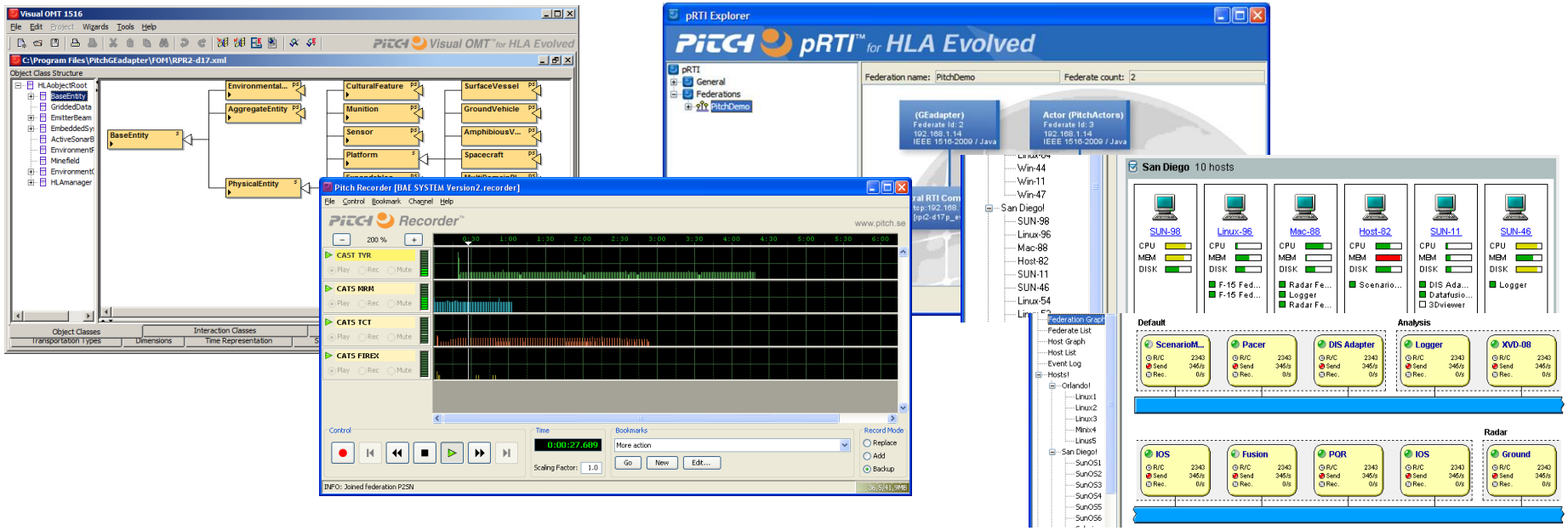


The information exchange data model used by the RTI

Provided as an XML file – HLA can support any domain

Example above shown in UML style using a FOM editing tool

Pitch Products and the Project Life Cycle



Pitch Visual OMT

Pitch Developer Studio

Pitch pRTI 1516

Pitch Commander

Pitch Recorder

Develop a model for information exchange that fits the need of your application	**Develop a software module that connects each system to the federation. Object Oriented HLA**	**Connect systems and exchange information. Synchronize time and data**	**Start up, monitor and troubleshoot simulations, applications, computers and networks.**	**Record, inspect and play back simulation data exchange. Review and analyze.**

Types of Distributed Simulation

Distributed Training

Distributed Test & Experimentation

Distributed Concept Development

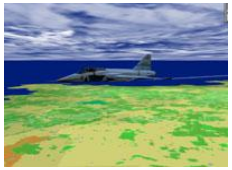
Distributed Analysis

Distributed Engineering

Distributed Test & Experimentation

FOI

FLSC



JAS-39 T3SIM

JAS-39 TI

3D Visualizer

Sensor

HLA Runtime Infrastructure

DIS/HLA Gateway

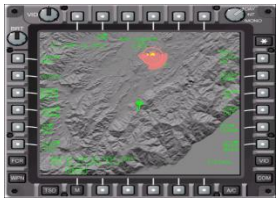
3D Visualizer

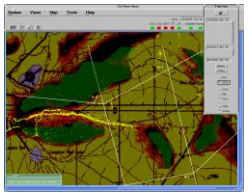
AH64D RWA

AD-64 TSD

Sensor

OPFOR Mod SAF

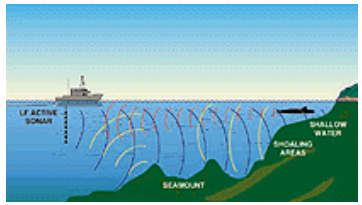




INTELLIGENCE & INFORMATION WARFARE DIRECTORATE
I2WD
LISTEN · INFORM · ATTACK · PROTECT
CECOM-RDEC

Subsurface Warfare

Distributed Analysis



FOI

Sonar Emitter

Sonar Receiver

Signal propaga-tion

Geometry

KOCKUMS

Signature

Environ-ment

Damage

- Signals
- Platform / Weapon
- C2 / Behavior
- SNE
- Effects
- Management

HLA IEEE 1516 Runtime Infrastructure (pRTI™ 1516)

Sub-marine

Operator

C2

KOCKUMS

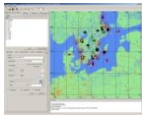
Torpedo

SAAB

Data Collection

Visualiza-tion

Execution manager



KOCKUMS

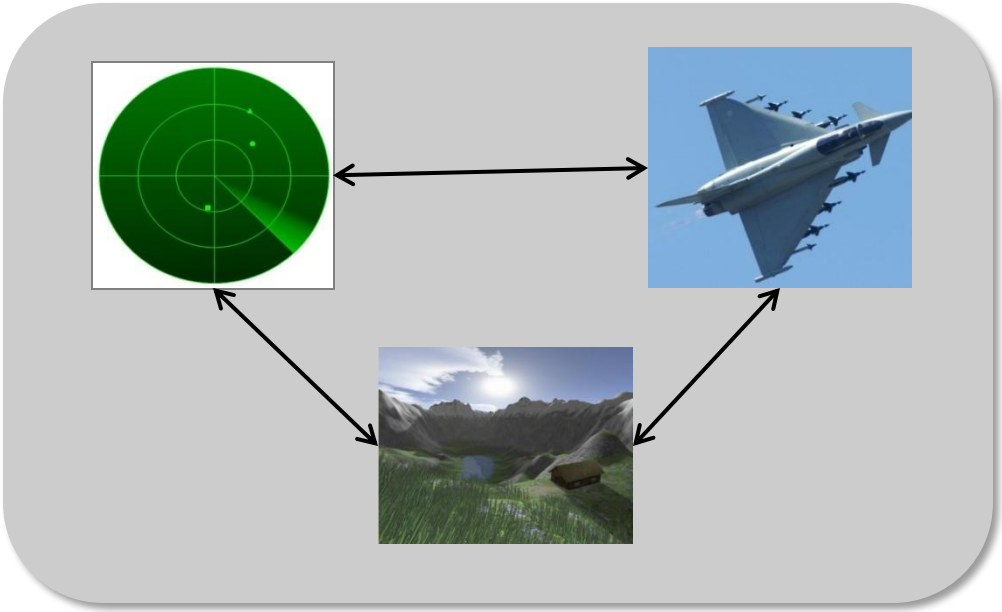
Model Based Engineering

"… advanced, systematic modeling techniques are needed to support engineering of complex, heterogeneous systems. Models provide blueprints for the development and assessment of systems through computer simulation, prior to their deployment."

J.W. Rozenblit, Arizona Univ.

The model is the executable blueprint of tomorrow!

Some MBE Challenges



Purpose: Model and asses a system, including environment, for effectiveness, performance, reliability, etc

- Create an overall design
  - System of Systems
  - Federation of Systems
- Find competencies to create accurate models for all components
- Create models for each component
  - Understanding the real or anticipated behaviors of each system
  - Focus on key aspects, optimal bounding/simplifications, optimal resolution, ...
- Make the models work together (model interoperability)
- Assessments, VV&A and many other challenges...

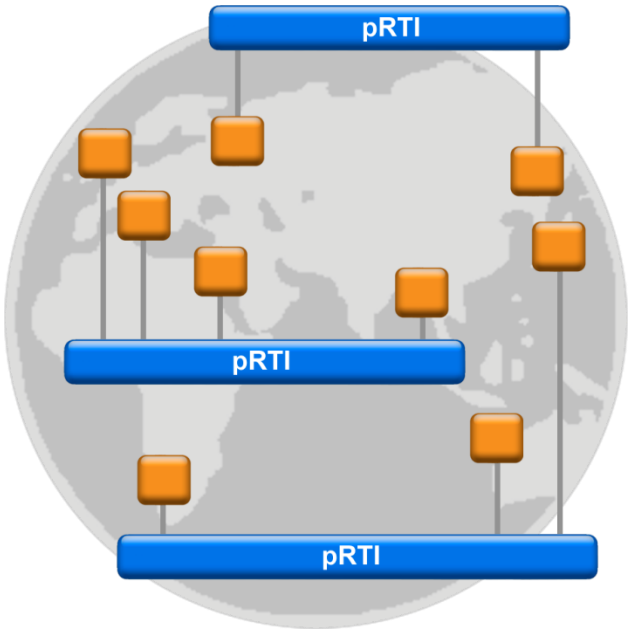
Benefits of Distributed Model Based Engineering

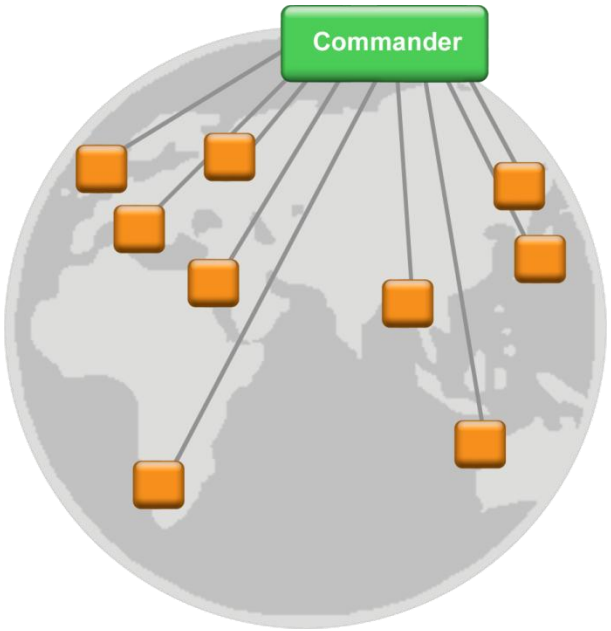
- Distributed design
  - Test and evaluate models from different vendors (Simulation Based Acquisition)
  - Leverage technical expertise by reusing model components developed by other expert teams
- Distributed testing of engineering components
  - Move electrons not people; Connect models of components using distributed simulation infrastructure
  - Move models not equipment; Perform test and integration events by sharing models before actual hardware/software integration
- Early integration of engineering components
  - Interface testing
  - Function testing
  - Interoperability testing
  - Replace models with equipment step-by-step

Key MBE Technologies

- Enable models from different sources (experts, groups, etc) to work together based on open standards
  - Runtime tools for interoperability, execution planning/monitoring/control, data collection
- Enable models from widely distributed sites to execute together (between cities or continents)
  - The ”Connected Enterprise”
- Development tools
  - Create Information Exchange Data Models between models , generate code, ...
- And more...

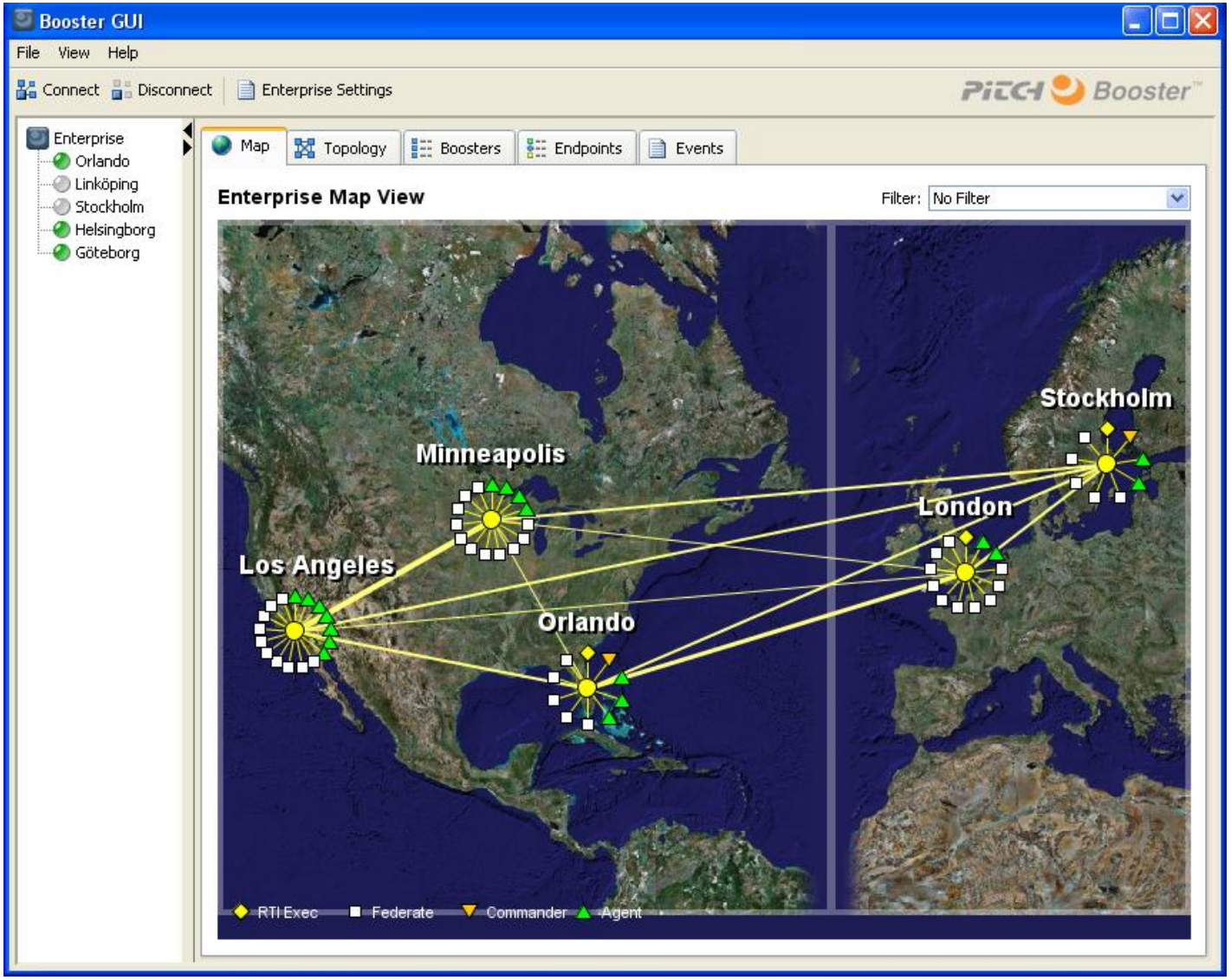
Pitch Booster





- The Booster network connects RTI:s and federates into federations.
- The Booster network connects hosts and Commanders for monitor and control of resources.

Pitch Booster Management GUI



Use Case: NASA

- Technology development is carried out across several NASA centers where different competencies and thus models are available
- To simulate for example a full launch several models from different centers need to interoperate.
- Example missions: ”Return to the Moon”, ”Mars Exploration”

Summary

- This short presentation provided an overview of distributed simulation and interoperability
- Many of these technologies were originally developed in the Aerospace and Defense sector but are now becoming increaslingly used in other areas
- HLA (IEEE 1516) is the leading simulation interoperability standard
  - Supports any domain and information model
  - Supports many types of time management
    - Real-time, frame-based, event-driven, etc
  - Excellent performance and scalability
  - Support for widely distributed M&S
- Major application areas include training, analysis, distributed engineering, test&experimentation and concept development