



JSS Phase 1 Final Presentation & Demos

15 June 2005

*Presented to Lockheed Martin Management
Maritime Systems & Sensors (MS2) Division
Moorestown, NJ*

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Prediction Systems, Inc.





Agenda Outline & Schedule

- Overview of PSI (separate slides) (20 Min)
 - Corporate
 - Technology
 - Projects
- Overview of Contracts (5 Min)
- Details on Subcontract Work (45 Min)
- Break (10 Min)
- Lab Demonstrations (60 Min)
- Opportunities Discussion (10 Min)



Overview of Contracts



Contracts

- JSS Phase 1 Contract
- B&P Subcontract in Support of JSS Phase 1
- IRAD Subcontract in Support of JSS Phase 2

17 PSI associates supported various aspects of these contracts

JSS Phase 1 Contract

- **Link-16 Network Management System:**
 - Ael Aligned Colors
 - Windows Look/Feel **GUIs DEMO** **Operation DEMO**
 - JDR Access
 - User Guide
- **Link-16 Monitor Feedback** **DEMO**
 - Mode 1 – Basic Position Updates from Ael
 - Mode 2 – Time Projection of Updates
- OV,SV & TV Reviews and Support
- Phase 1 Demo Planning
- SPAWAR Site Visit & Demo
- Monthly Status Reports



B&P Subcontract

(Work in Support of JSS Phase 1)

- Phase 1 Monitor Interface Documentation
- List & Document all interfaces & files
- **White Paper on Future MTA Planning**
- **MTA Planning Document**
- Materials for Customer Demo (Slides, Korona)
- **Link-11 HF/Term:**
 - Requirement Analysis
 - Architecture & Design Document
 - Models, Test Framework & Test
 - Release Notes & User Guide
 - Future Work Plan
 - **DEMO**
- Monthly Status Reports



IRAD Subcontract

(Development of Key Technologies for Phase 2 JSS)

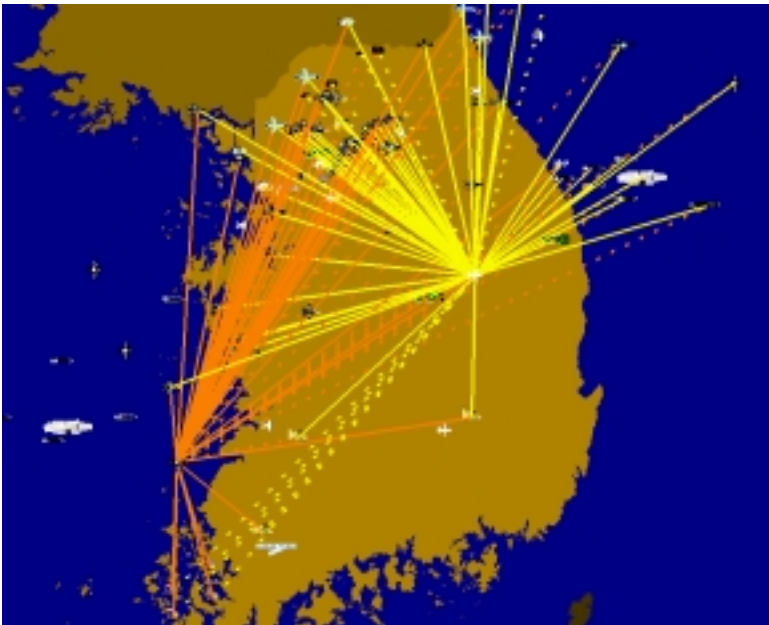
- Phase 2 Monitor Interface ICD & Design
- **Satellite & JREG:**
 - Requirements Analysis, Architecture & Design
 - Models & Test Framework
 - Release Notes & User Documentation
 - Future Work Plan
 - **DEMO** **DEMO**
- **MTN Integration:**
 - Requirements Analysis, Preliminary Architecture & Design
 - ID Tool Needs
 - Processor Assessment
- Monthly Status Reports



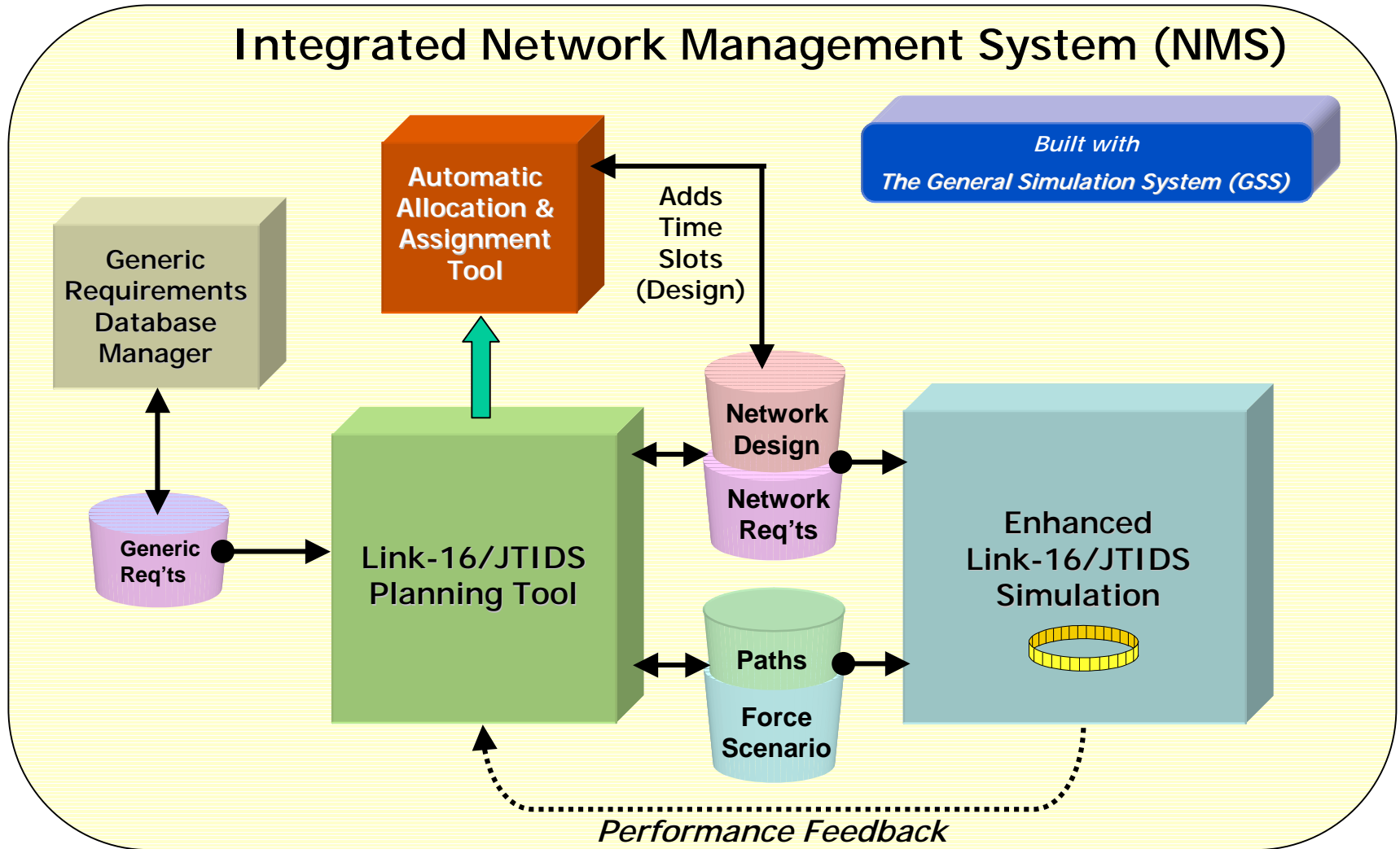
Details on Phase 1 Contract



Link-16 NMS



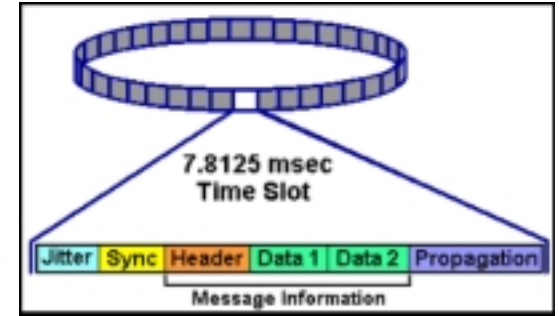
Link-16 Network Management System (NMS)



Link-16/JTIDS/MIDS Comm Architecture

(TDMA, FDMA and CDMA)

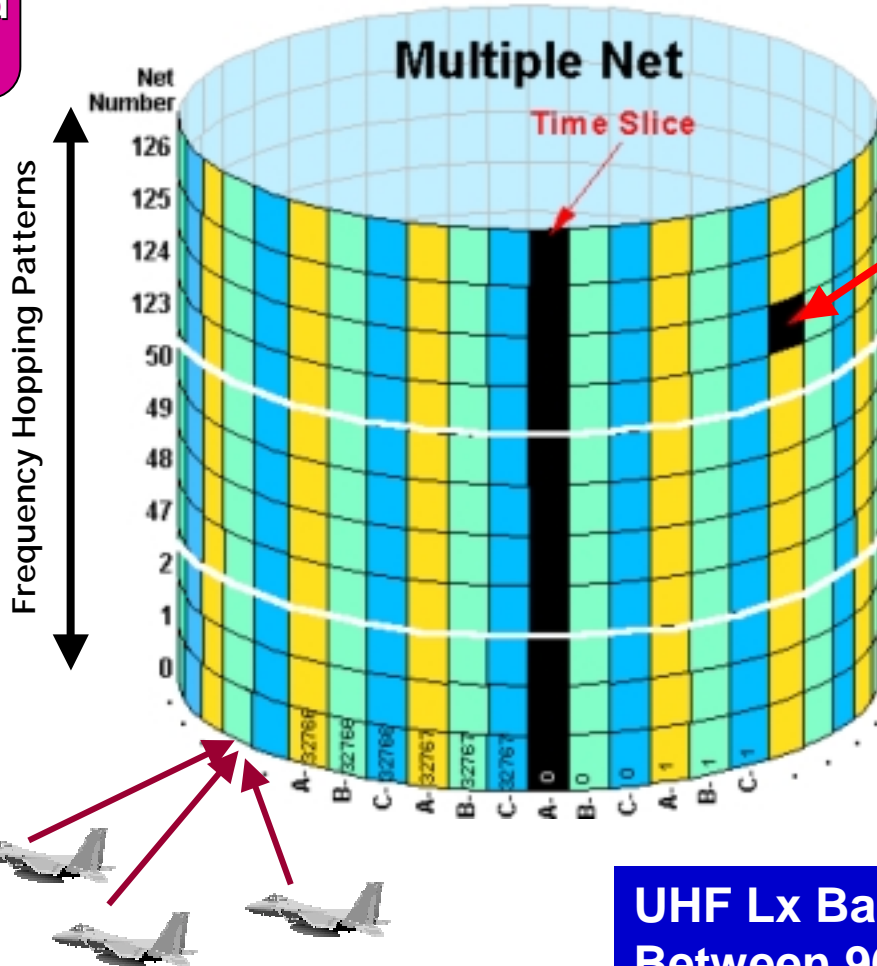
**Link-16 Networks
Must be designed
before use**



Time Slot

Time Division
Multiple Access
(TDMA)

Encryption Security
-Transmission (TSEC)
-Message (MSEC)

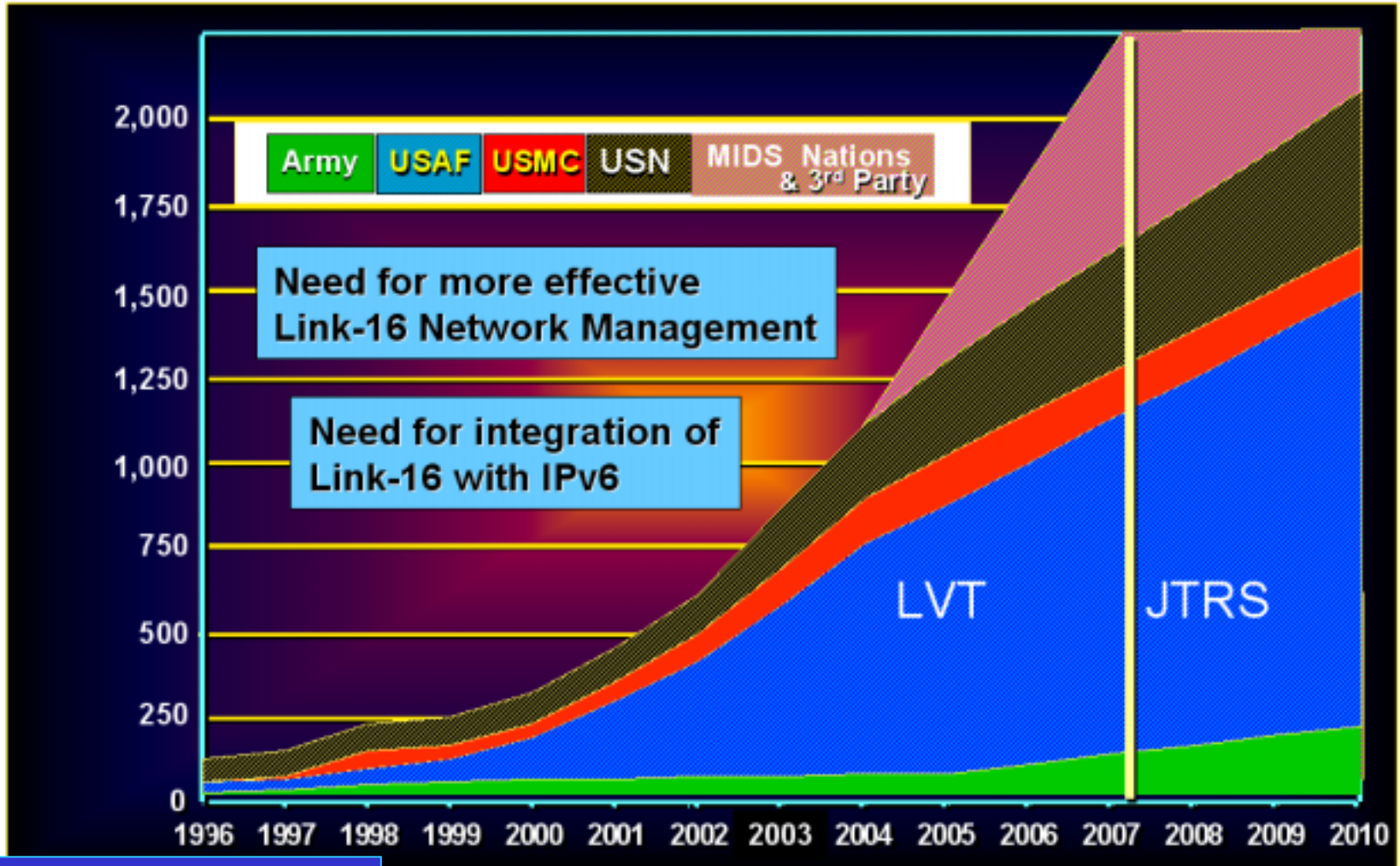


Frequency Division
Multiple Access
(FDMA)

Code Division
Multiple Access
(CDMA)

**UHF Lx Band frequency spectrum
Between 960 MHz and 1215 MHz.**

Exponential Growth in Link-16 Platforms



From: 102_USN_Tactical_Links_Overview,
 Capt S. Des Jardins, USN,
 March 2005 Multi Link
 Users Conf Presentation Material

MIDS Third Party Potential: 7625

Why is Link-16 Important?

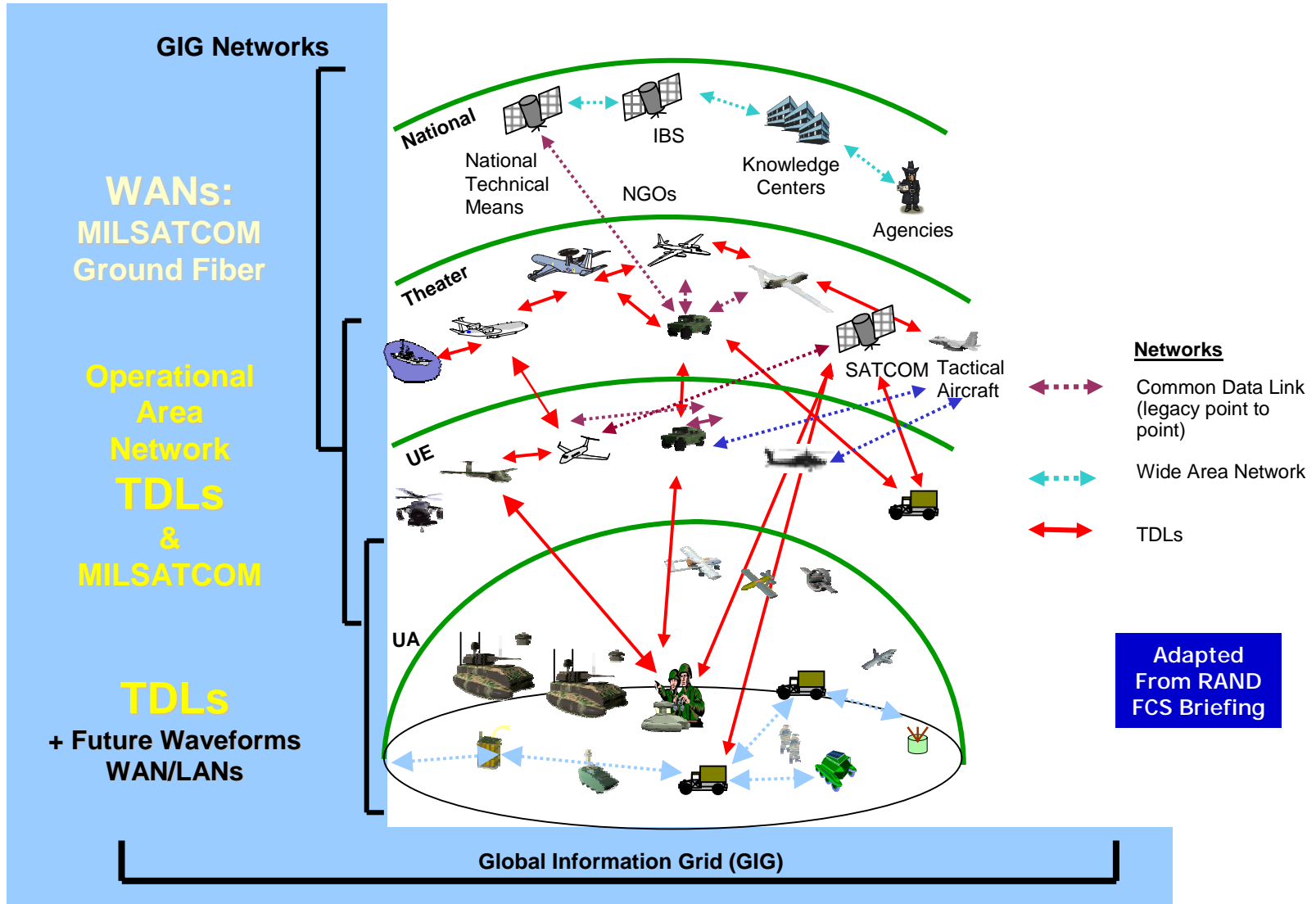
- Link-16 is the pre-eminent Tactical Data Link (TDL) in use today.
- Highest Bandwidth TDL. *Though not a LAN in the Sky.*
- Link-16 has low susceptibility to Jamming.
- Link-16 is over 20 years old, and use today is *accelerating* due to experience in ODS & OIF.
- Link-16 Supports:
 - Situational Awareness (PPLIs)
 - Tracks, Targets, Weapons Coordination



Why is Link-16 Important to NCO/NCW?

- Link-16 is *the* tactical RF communications heart of NCO/NCW.
- Link-16 is the “last digital mile” to the war fighter.
- Link-16 utilization is expected to increase over the next 5+ years.
- Link-16 platforms will be around for 10-20 more years. There is a HUGE investment in equipment, testing, deployments, etc.

TDLs in Relation to the GIG





Link-16 NMS Components & Benefits

Generic Requirements Database Manager

Manage Communications Requirement Generically

Plan

Link-16/JTIDS Planning Tool

Link-16 Operational Network Planning Tool

- Provides facilities for adding, changing and deleting flight paths
- Flight paths can be created and modified graphically
- Provides facilities to create and view operational nets & links graphically
- Interactive creation, store and recall of operational scenarios

Solves Link-16 Saturation "Problem"

- Maximal Use of Existing Link-16 Capabilities, Full Use of Space, Time & Traffic Requirements
- New Terminal Algorithms to Maximize Capacity, Increased Terminal Assignments

Design

Automatic Allocation & Assignment Tool

Link-16 Automated Time Slot Allocation & Assignment

Builds Network in Minutes

- Provides Manual Time Slot Overrides

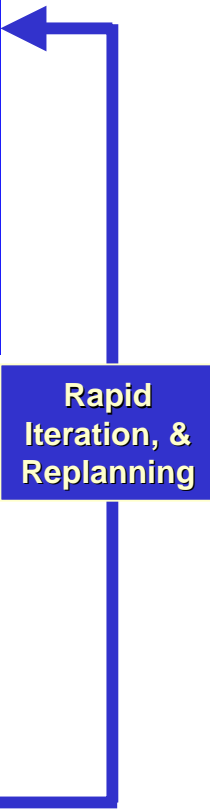
Test

Enhanced Link-16/JTIDS Simulation

High Fidelity Link 16 Simulation

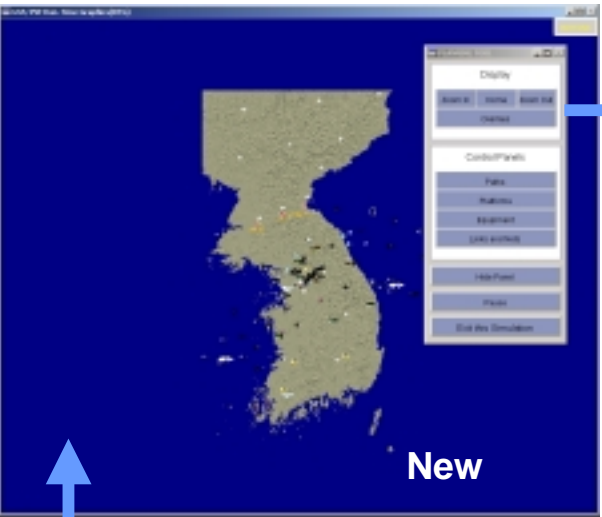
- Validate Network Designs Quickly
- Test Different Operational Scenarios
- Generate Network Traffic
- Produce Metrics

Low Risk, Low Cost Validation
High Speed Models
Dynamic Scenarios & Traffic
Automatically Collects: MOPs & MOEs

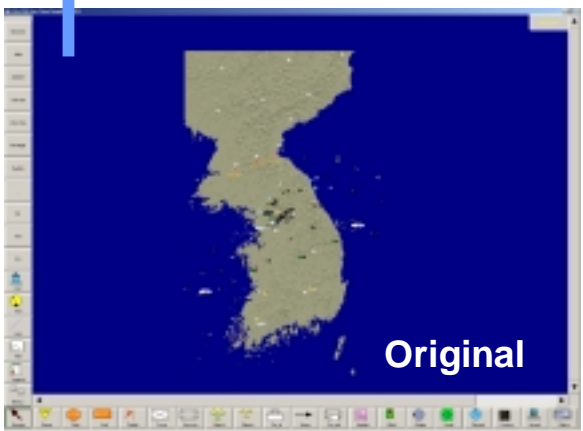




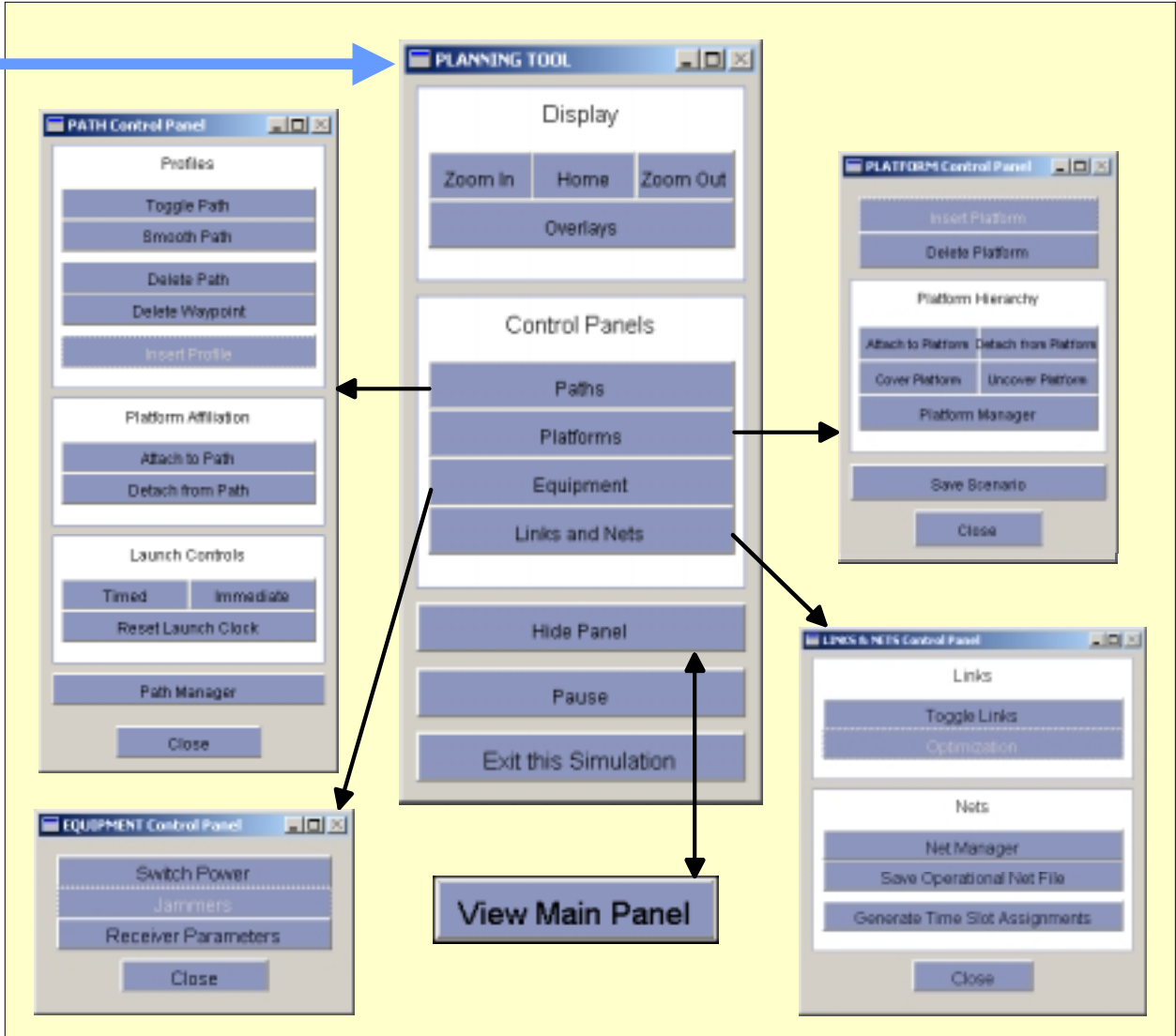
Windows Look & Feel



New



Original

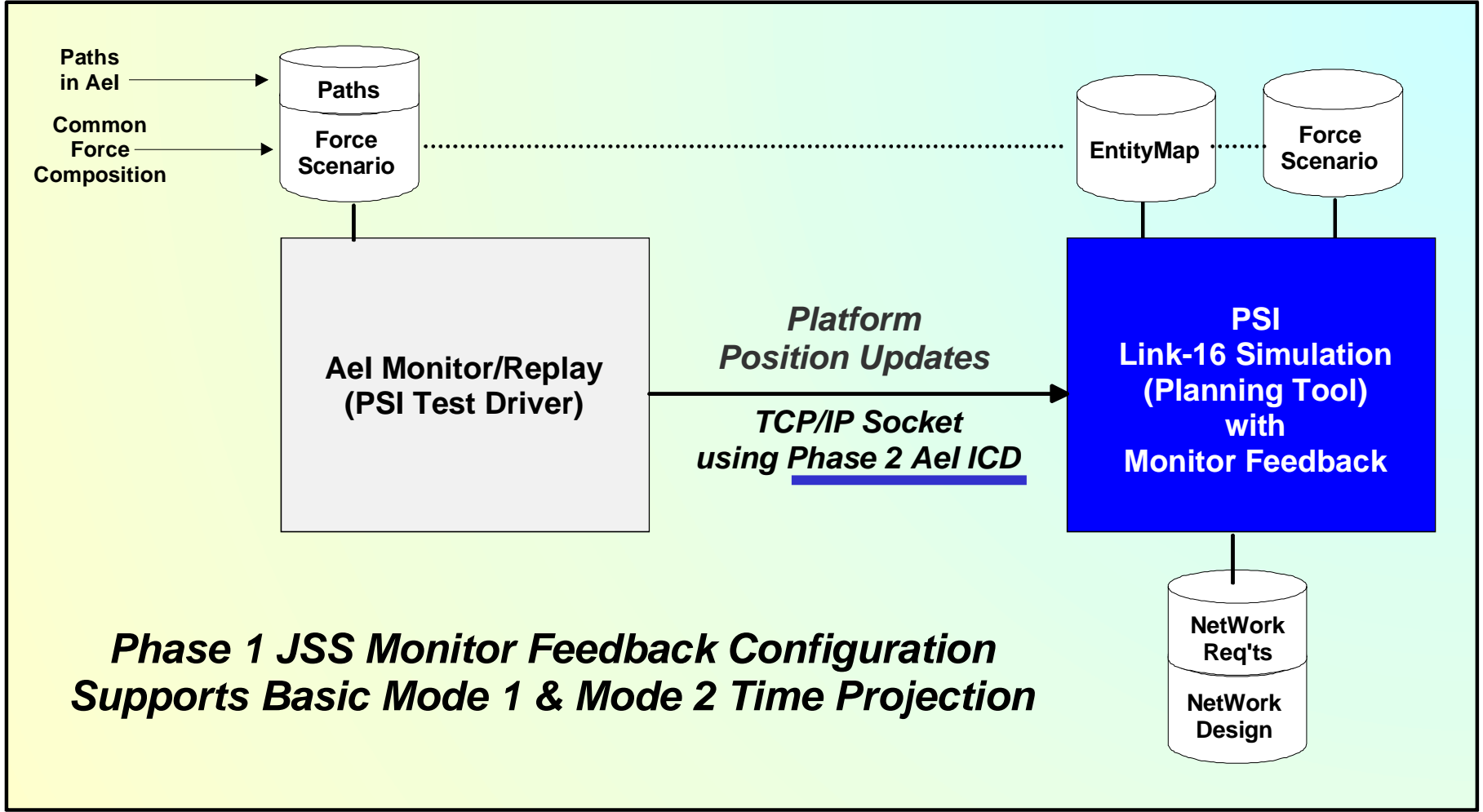


Link-16 Monitor Feedback

Purpose/Idea: Feed Ael Monitor data into Link-16 Simulation for Link Analysis & PBA

Mode 1: Simple Link-16 platform position updates

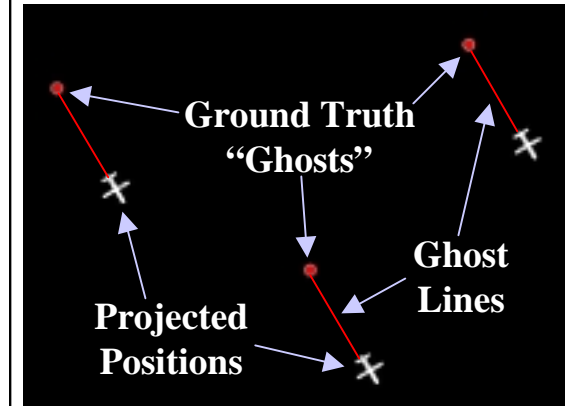
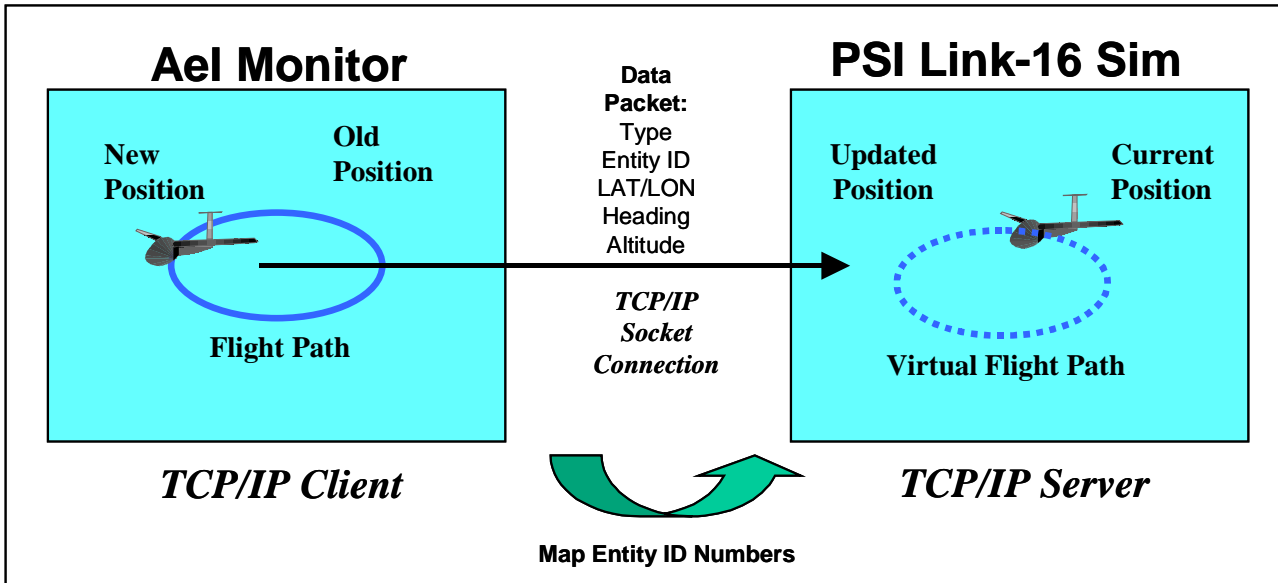
Mode 2: Dead reckoning time project of positions



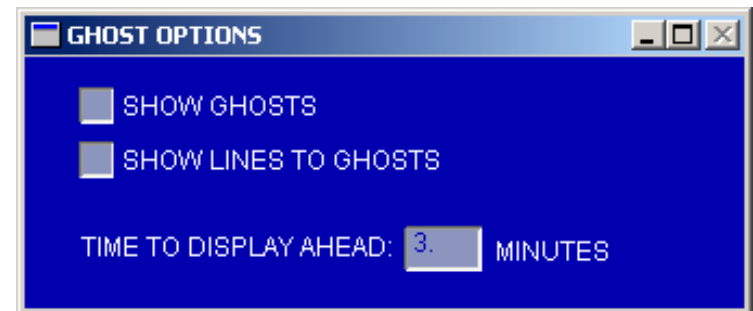
**Phase 1 JSS Monitor Feedback Configuration
Supports Basic Mode 1 & Mode 2 Time Projection**

Monitor Feedback

Client/Server Operation + Data Packets



GUIs added for Monitor Feedback



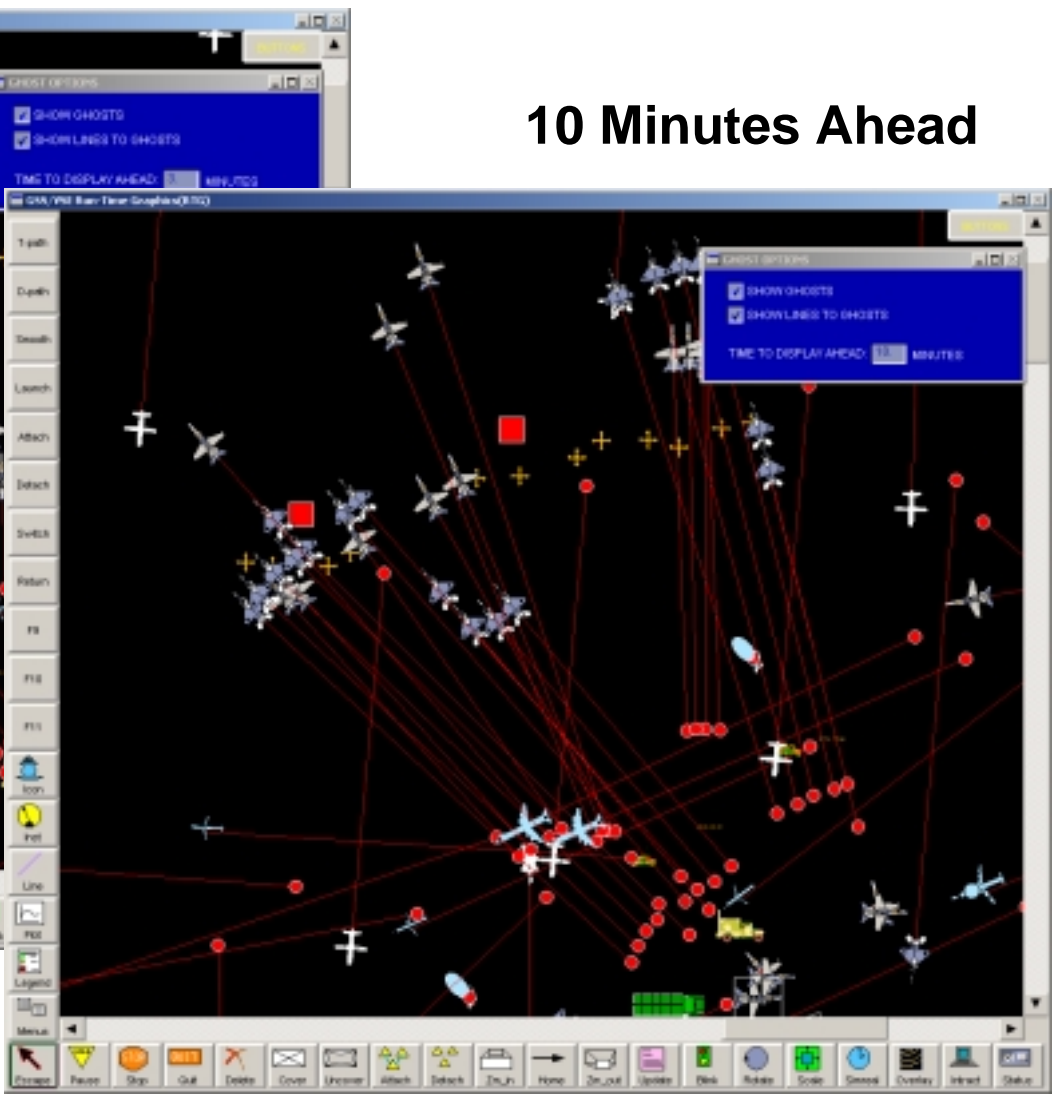


Monitor Feedback

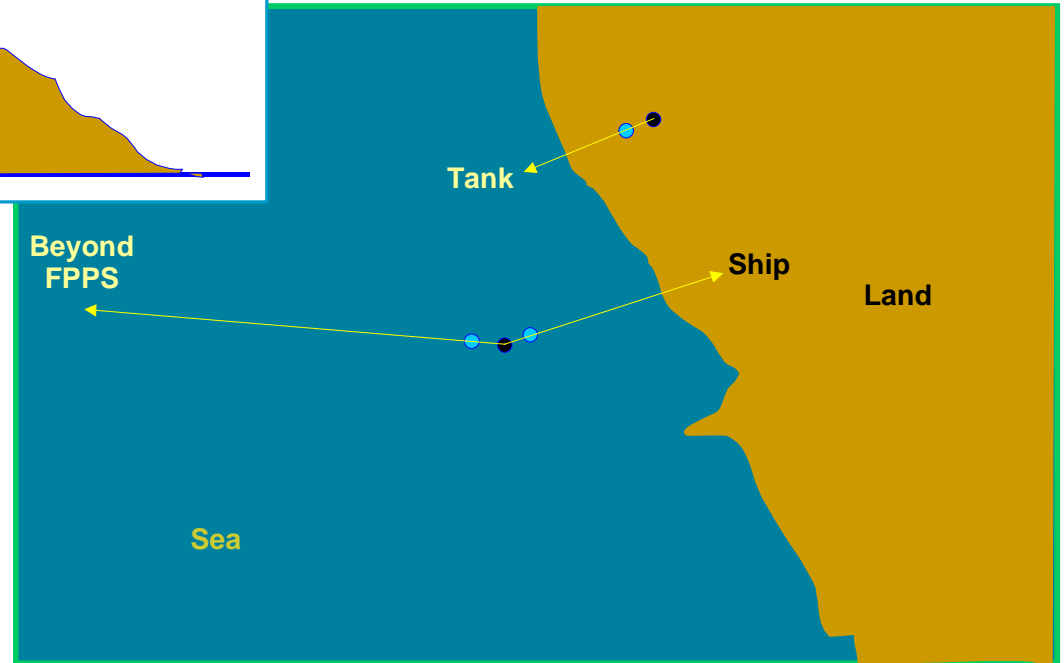
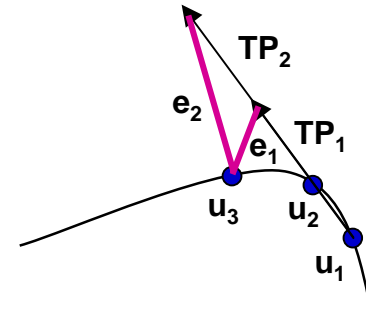
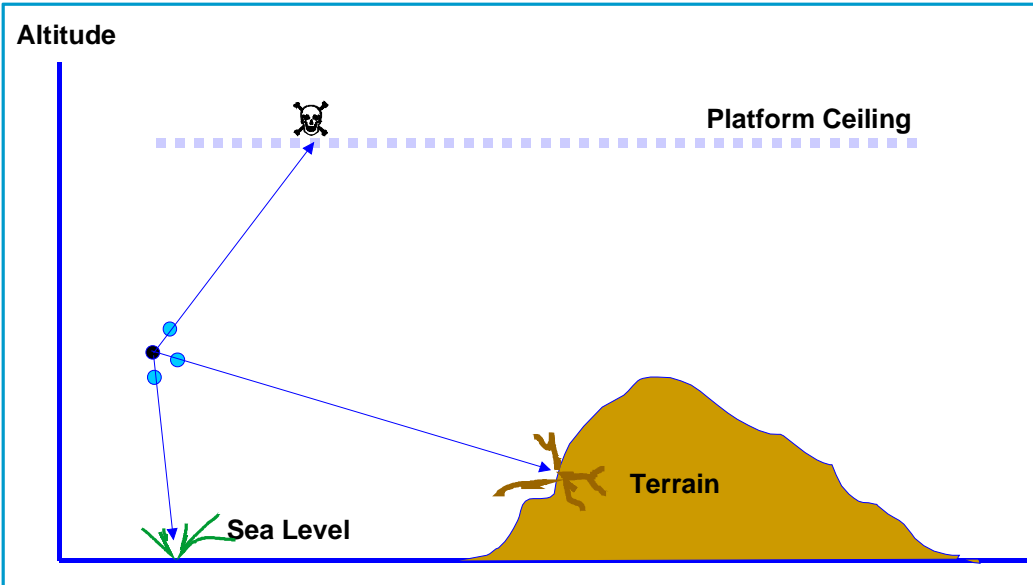
10 Minutes Ahead



3 Minutes Ahead



Challenges with Dead Reckoning





B&P Subcontract Work

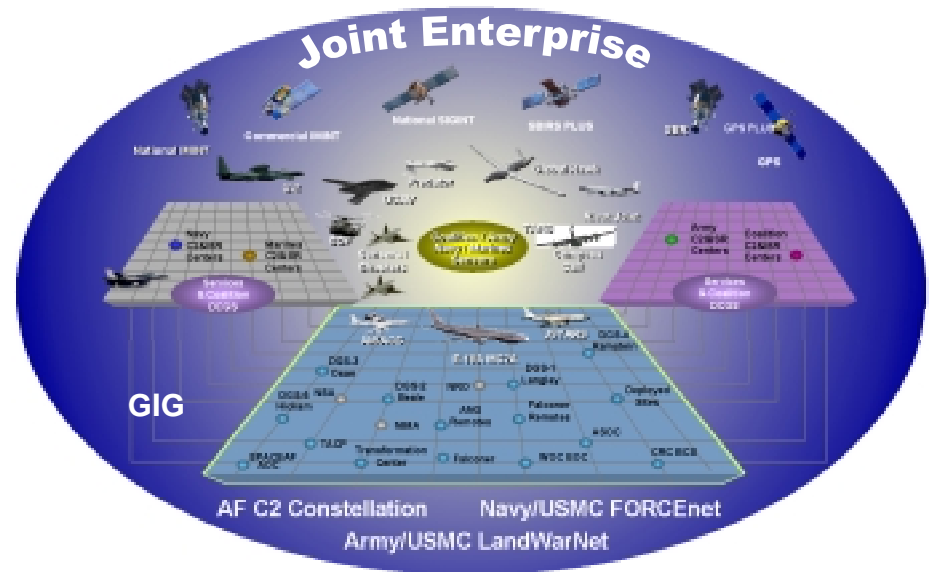
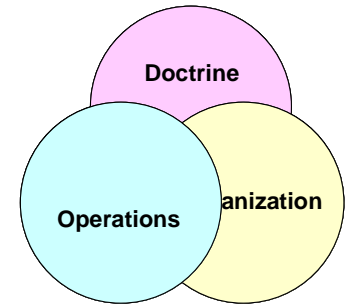


White Paper on Future MTA Planning

White Paper on Future MTA

- Drivers:

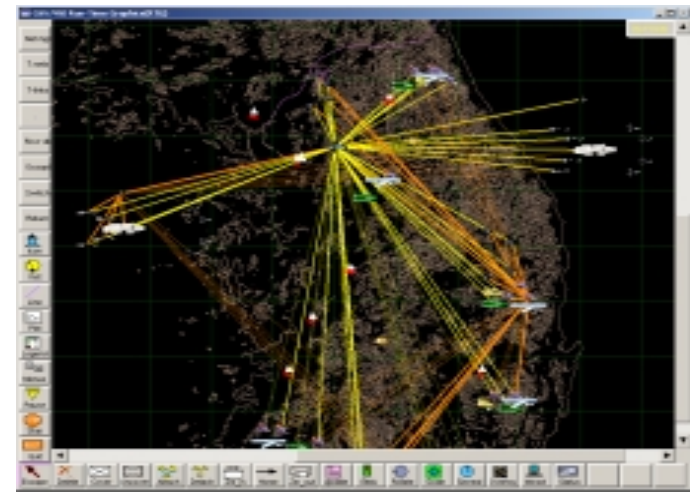
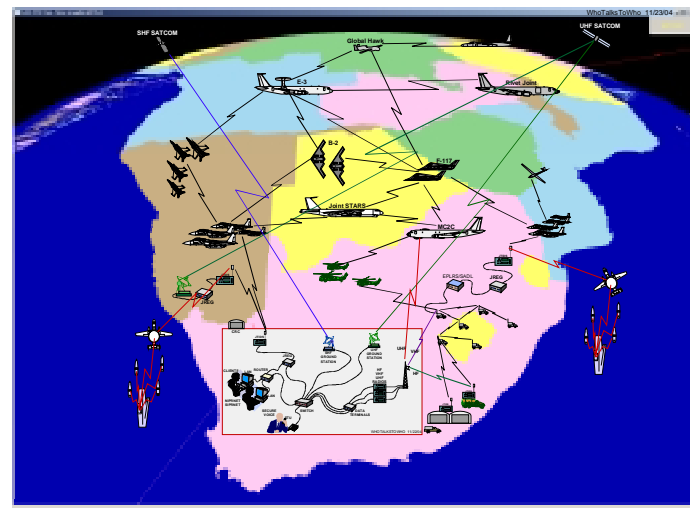
- Explosive growth in Link-16 platforms
- All roads lead to Link-16 Message Set
- Interface Change Proposals
- Evolution of Network Centric Operations/Warfare
 - Service Oriented Architectures
 - XML, Binary XML
 - Web Services/Portals
 - Global Information Grid
 - W2COG, NCOIC, AEI
- New Waveforms:
 - Link-22
 - TTNT, IP...





Future MTA Needs

- Rapid deployment (global)
- Databases:
 - Message Sets, ROEs, TTPs
 - Cap's & Lim's
- Ease of Use:
 - Comm Requirements capture
 - Network Design & Test
- Visualization
- Sufficient Prediction Accuracy
- Sufficient Speed of Operation
- Flexibility, Expandability



Evolution of MTA Planning Functions and Scope

Purely TDL

Automation and more powerful tools/capabilities expands scope of "JICO" job responsibilities

Net Centric

Additional TDL platforms, new waveforms, information & data centric operations, more dynamic platform relationships, greater introduction of IT-like operations

More sophisticated tools are required for Planning & Analysis.

Time-Slot & Interop Management Oriented

Information Management Oriented

Near-term Tool Opportunities

----- IPv6 Dominance ----->

JICO Today
Fragmented Support

JSS Basic
JICO Functions

Enhanced JSS
JICO Functions

New JSS
JICO Functions/
Waveforms

Transformational
Communications
Architecture
(TCA)

Future JSS
"JICO" as
NetCentric
Manager

MTA
Planning,
Monitoring,
Control

Additional
Automation:
JU Assignments,
TN Block Assignments
FU, PU, etc.

JTRS Radio
WNW
MDL
Etc.

Joint
Communications
Concept

Tactical &
IT merge
Advanced
planning & analysis

Link-16 Filter Analysis/Assignment
Relay/JRE Needs Analysis
etc., etc.

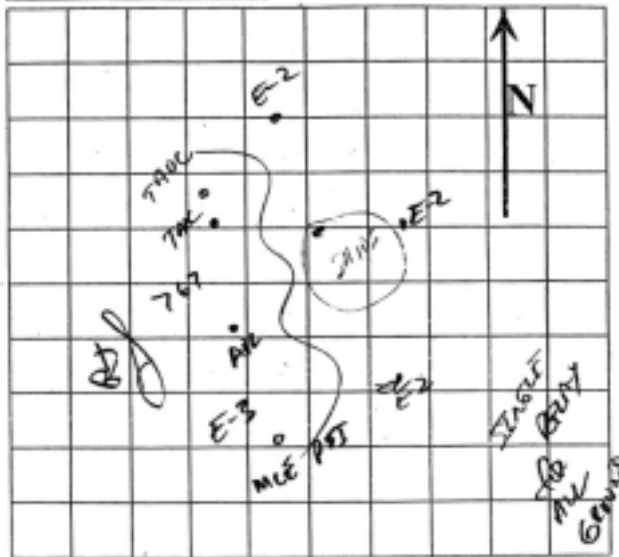
Automated OPTASKLINK Generation
Monitoring by Messages

Today

15-20 Years

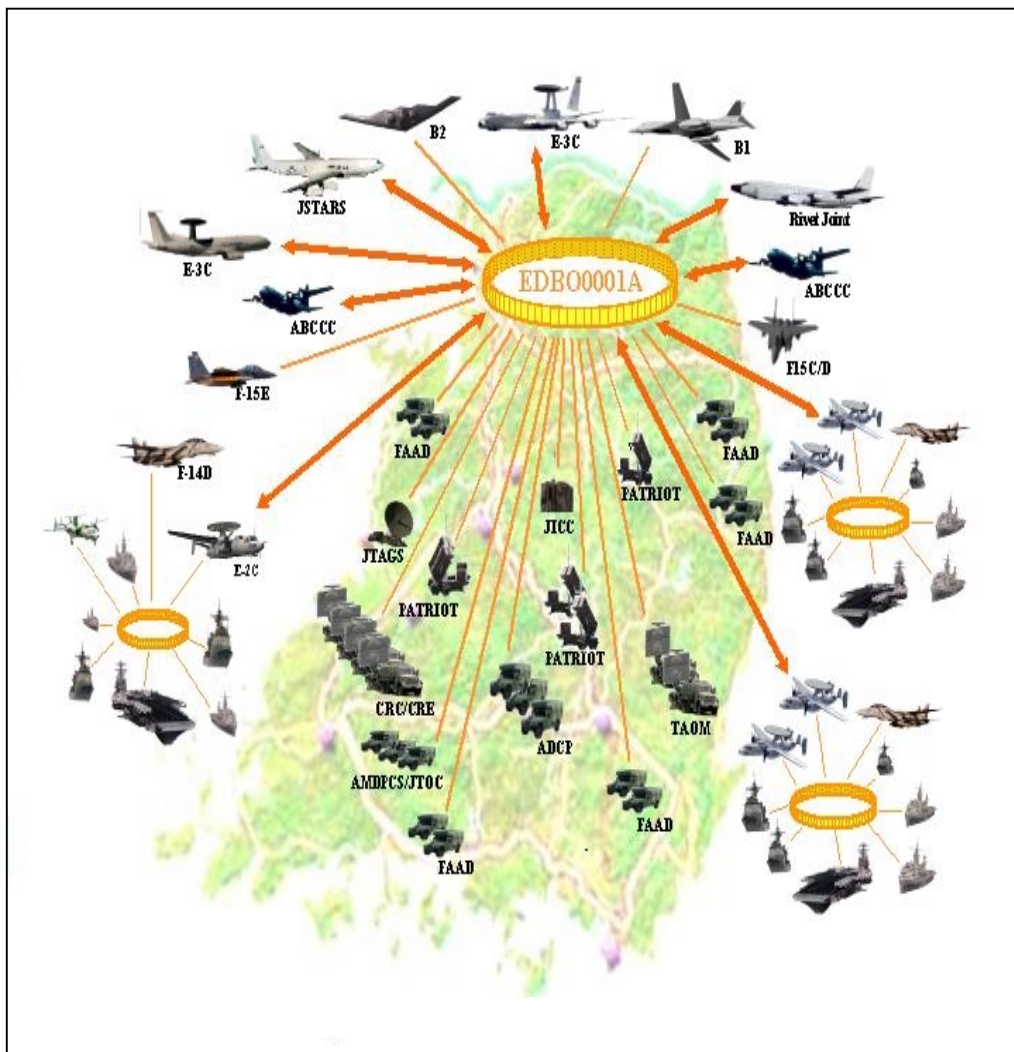
Multi-TDL Architecture (MTA) Planning

DIAGRAM OF FORCE LAYOUT





More MTA Pictures



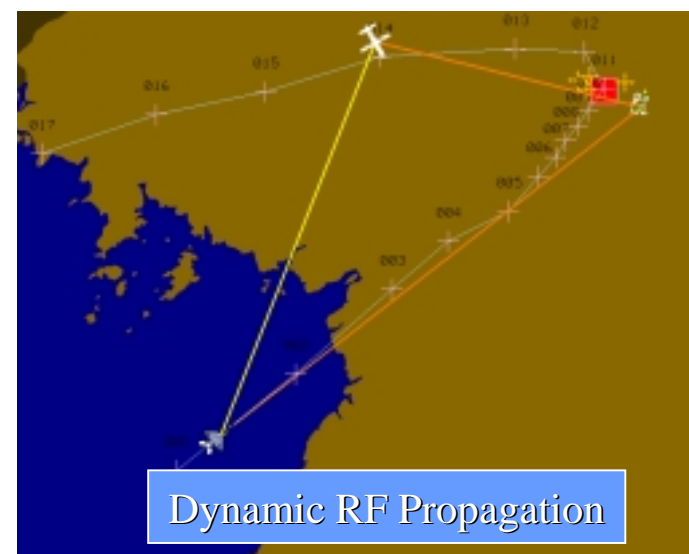
Line Of Sight Matrix

Color Key:
 Green = Acceptable
 Yellow = Marginal
 Red = Unacceptable
 Blue =elayed LOS

Numbers inside each field indicate the distance between Units (miles).

Static LOS

Participant	E30(1)	F15E(1.1.1)	F22(1)	E3(1)	F14D(1)	F15J(1.1)	CRC(1)	ADCP(1)	CV2(1)	CRC(2)	PAT_ICC(1)	PAT_ICC(2)
E30(1)		154	56.1	96	67.3	67.3	62.1	97.8	117	138	146	86.5
F15E(1.1.1)	154		60.9	101	106	106	81	120	60.7	101	100	100
F22(1)	56.1	60.9		106	106	76	94.4	118	96.9	136	135	92.3
E3(1)	96	101	106		98.4	96.1	115	115	110	96	112	100
F14D(1)	67.3	106	106	98.4		119	100	72.3	105	104	106	116
F15J(1.1)	67.3	106	76	96.1	119		93	96.5	115	101	81	100
CRC(1)	62.1	81	94.4	115	100	93		118	103	91	104	48.8
ADCP(1)	97.8	120	118	115	72.3	100.5	118		104	96	71	101
CV2(1)	117	60.7	96.9	110	105	105	103	100		106	106	135
CRC(2)	138	101	136	100	104	103	111	98	110		100	100
PAT_ICC(1)	146	100	135	112	104	103	101	71	100	100		100
PAT_ICC(2)	86.5	100	92.3	100	106	103.5	48.8	110	135	100	100	





Planning Procedures



6016C-
Appendix V

Other TDL Std's

JM TOP



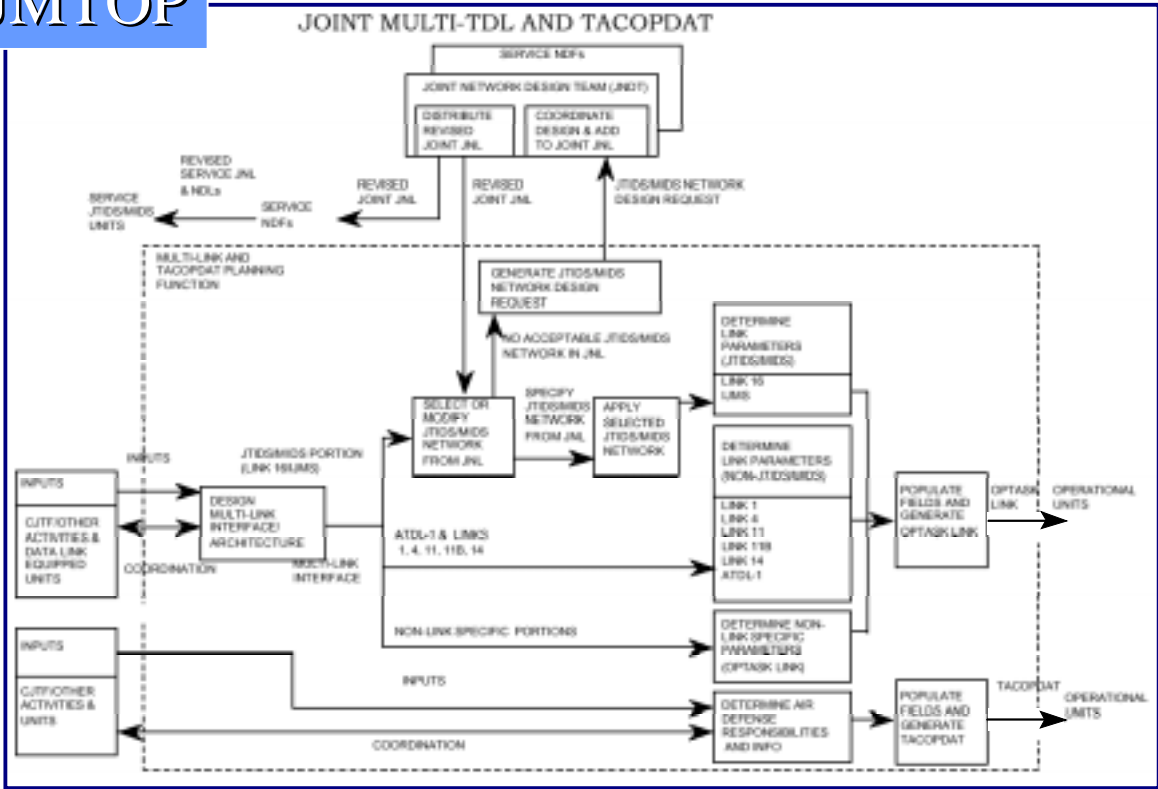
MAJIC

Rules of
Thumb



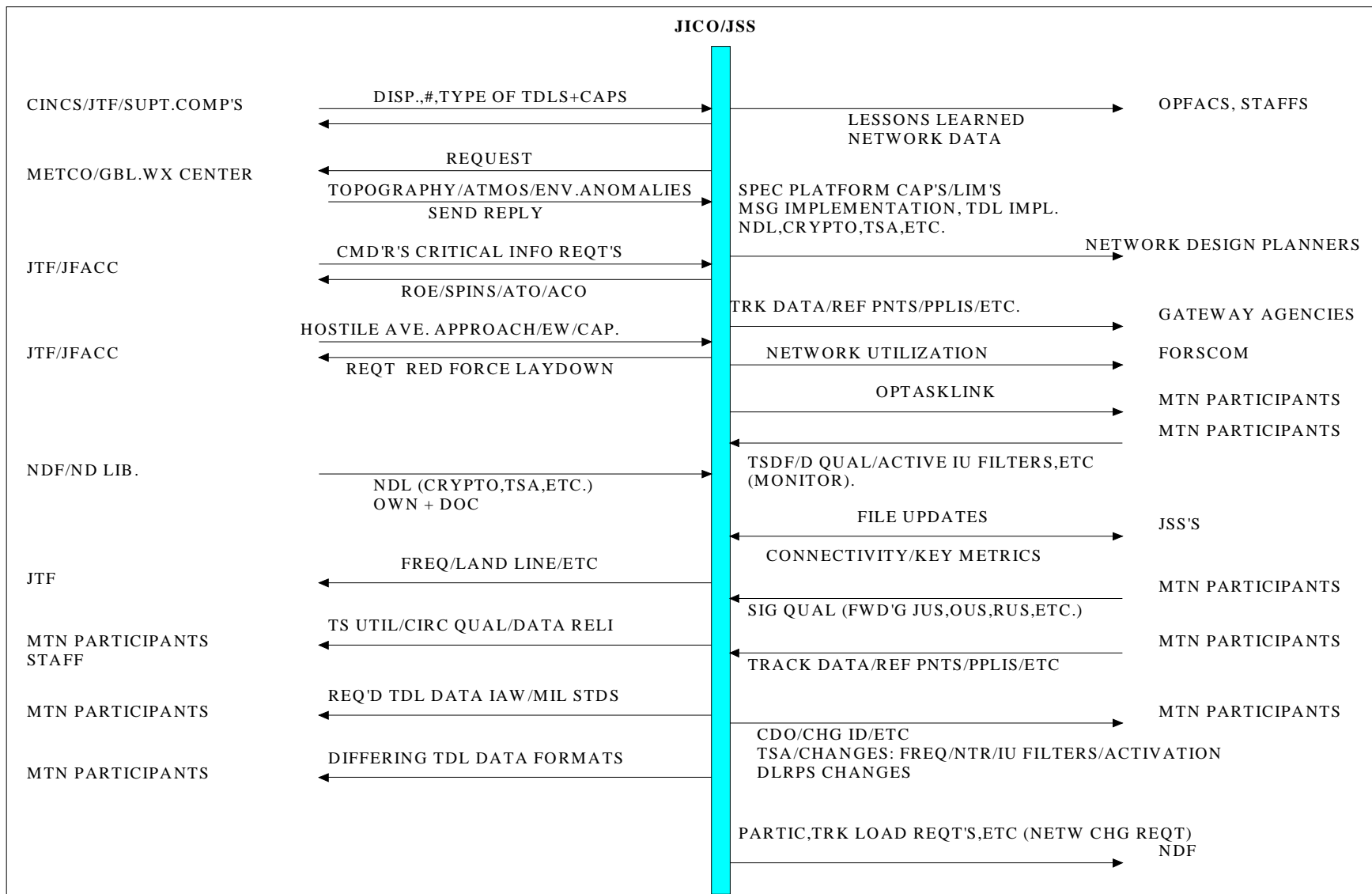
JTAO
Joint Tactical
Air Operations
Procedural Handbook

Other Operator
Handbooks





JICO & JSS IOs (From TRD)





MTA Planning Considerations

- Participation
- Platform Capabilities and Limitation
- Platform Tactics, Techniques and Procedures (TTPs)
- Commanders intent
- Force deployment and missions
- Connectivity
- Relays (and JREs)
- Message sets
- Capacity Allocation
- Spectrum Compliance
- Security
- Initialization Data Load (IDL) generation
- Design documentation production
- Network Distributions

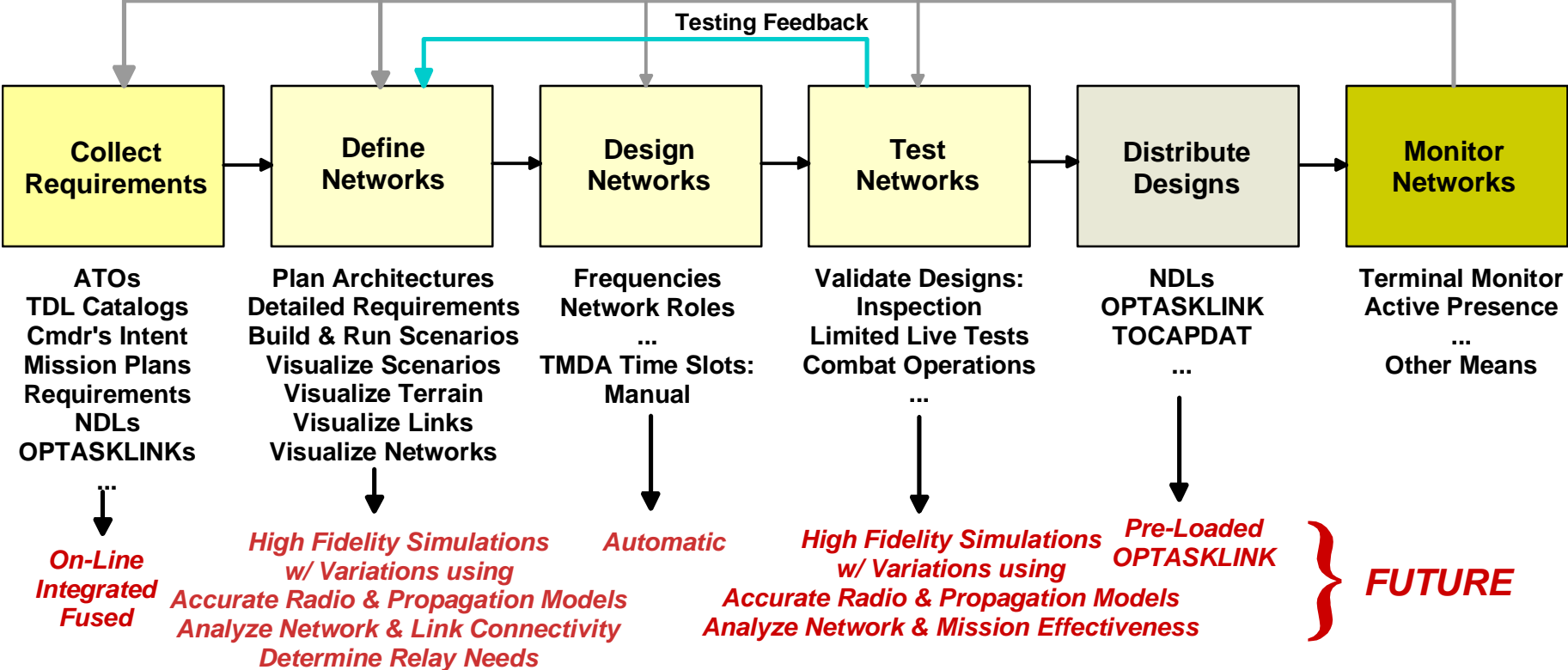
•Link-16
•IJMS
•Link-11/11B
•Link-4
•Link-1
•ATDL-1
•Link-22 (Future)

**US-Joint, Coalition,
Host Nations**

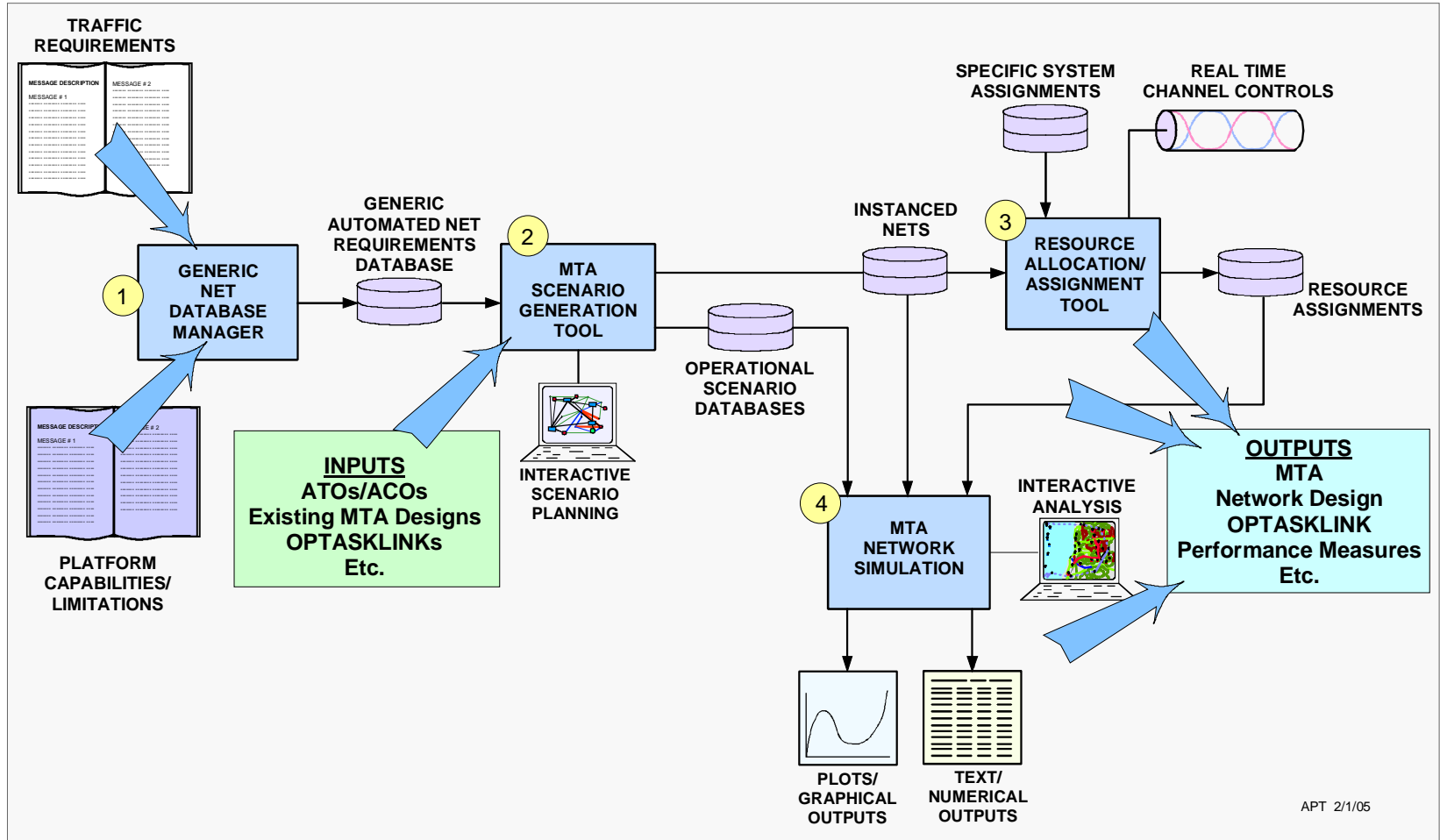
Overall Planning

Core Planning Functions

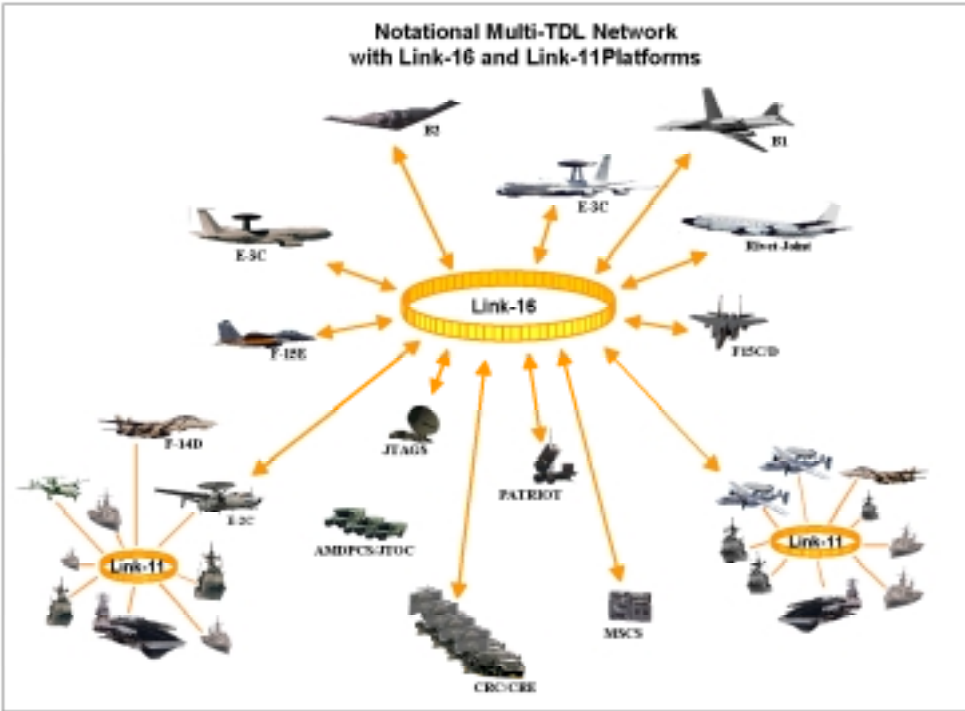
On-line Feedback: Manual, *Automatic*
Off-line Feedback: Manual, Playback



Functional Tool Needs



Link-11 HF/ Terminal Models

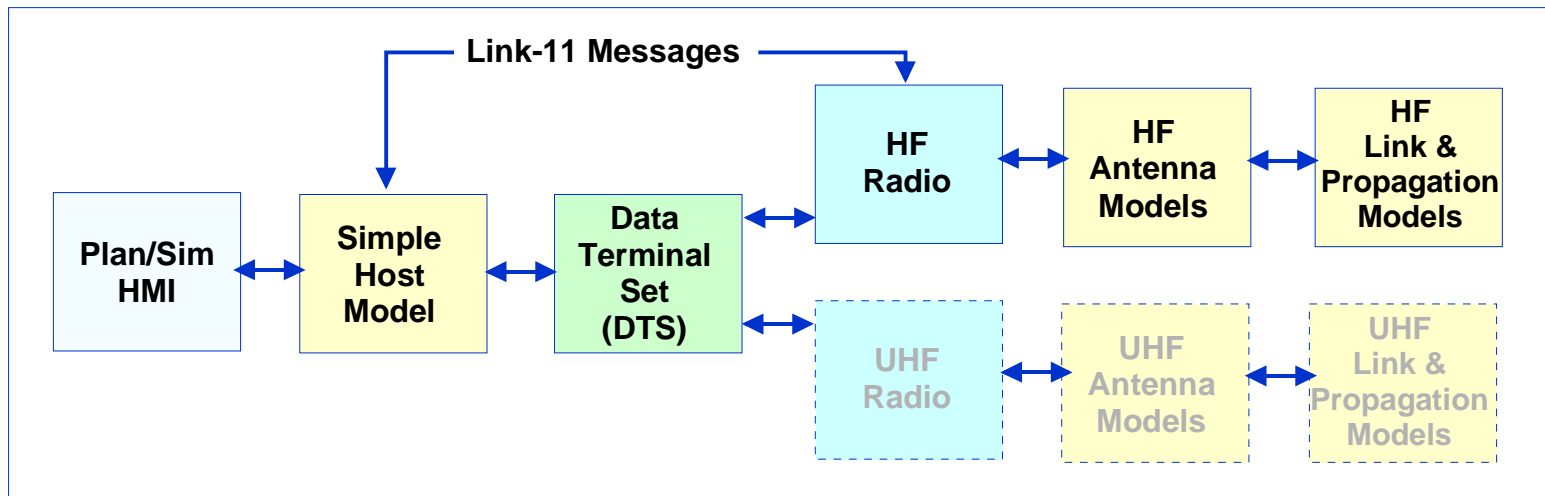


Link-11
Net 2

Link-11
Net 2

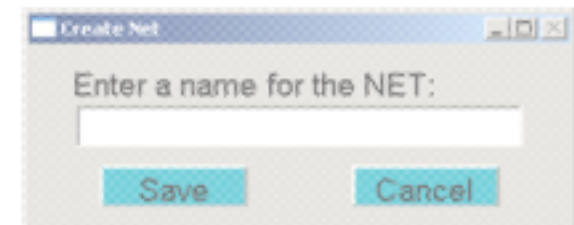
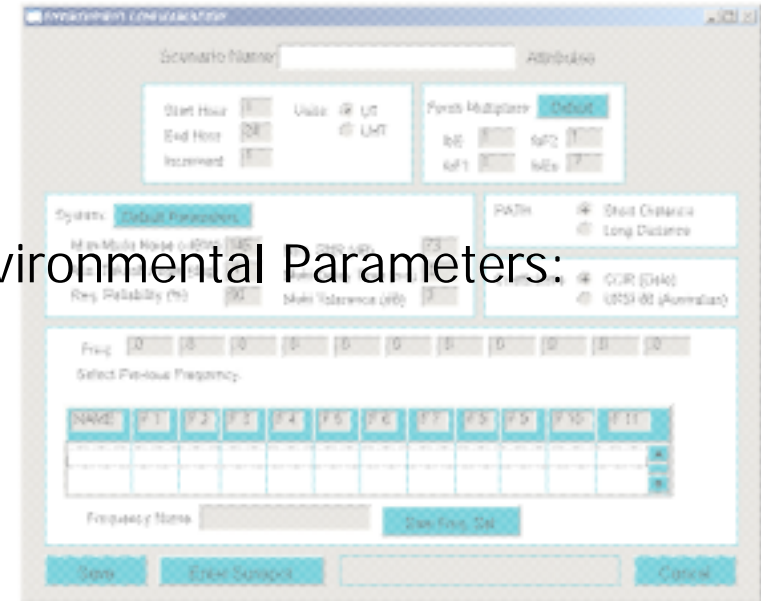
Link-11 HF/Terminal Modeling

- Requirements Analysis
- Model Architecture and Design for Link-11 HF and Terminal Models with IO File examples.
- Functional Planning Tool with Release Notes and User Guide.
- Future Plans



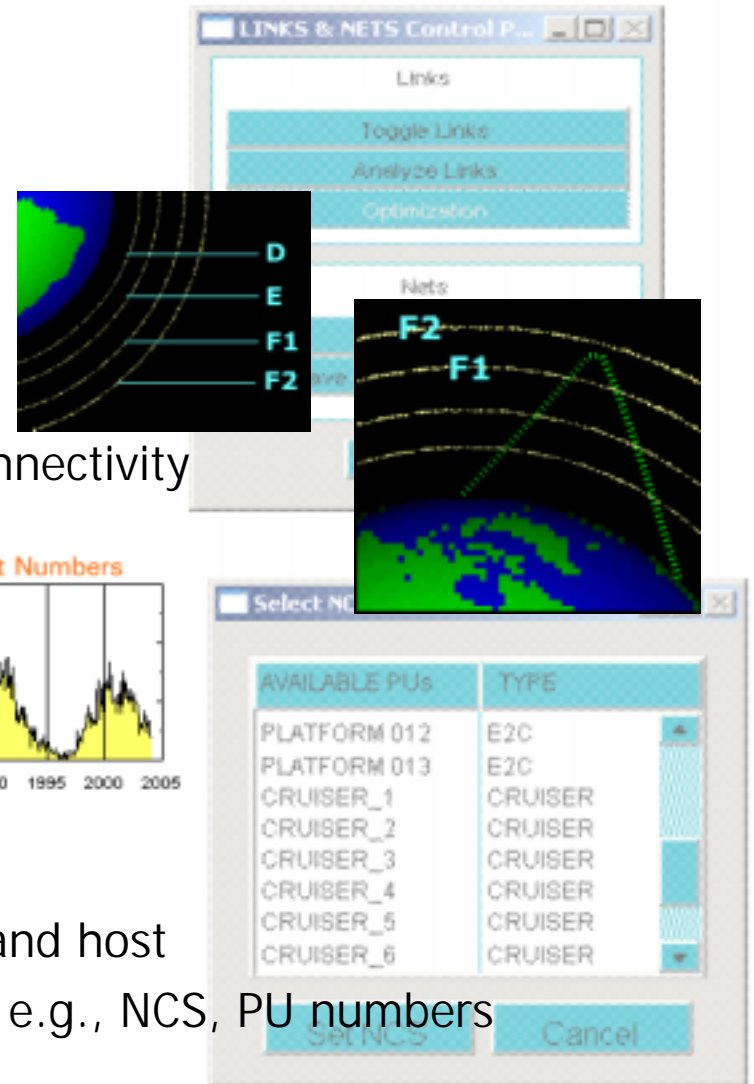
L-11 HF/Terminal Requirements

- Ability to interactively build, save and read-in a Link-11 HF Scenario:
 - Link-11 Platform deployments
 - Movement paths
 - Link-11 PU radio parameters
 - Link-11 PU antenna parameters
- Ability to create, save and read-in Environmental Parameters:
 - Man-made noise
 - Minimum takeoff angle
 - Required reliability
 - Required SNR
 - Multi-path settings
 - Sunspots
- Ability to interactively build, save and read-in Link-11 Nets:
 - Link-11 PU parameters, e.g., NCS, etc.
 - Net characteristics, e.g., audio signaling, etc.



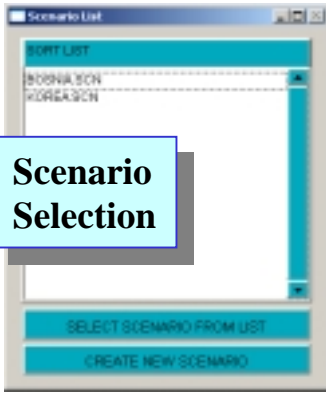
L-11 HF/Terminal Requirements

- Ability to visualize:
 - o HF RF connectivity
 - o Link-11 network connectivity
 - o Dynamic platform movements
- HF Radio Propagation Model:
 - o Dynamic computation of HF radio connectivity
 - ❖ Against 3D terrain (future)
 - o Input and operation with:
 - ❖ Solar events
 - ❖ Time of day and year
 - ❖ Antenna characteristics
- Link-11 Terminal Model:
 - o Basic simulation of Link-11 terminal and host
 - o Specification of terminal parameters, e.g., NCS, PU numbers

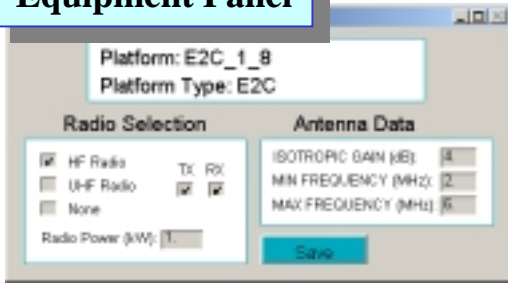


L-11 HF/Terminal HMI

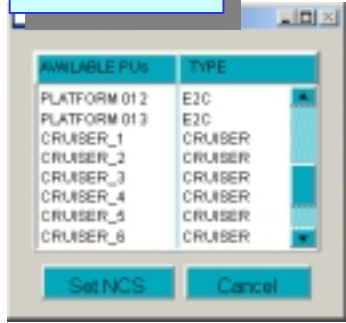
Scenario Selection



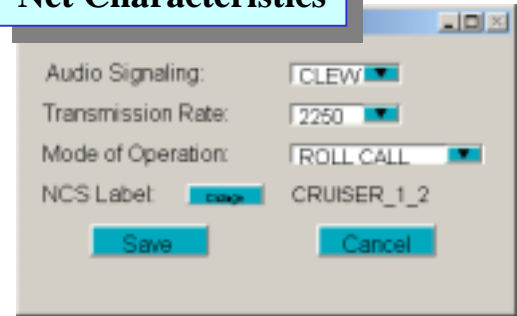
Equipment Panel



NCS Panel



Net Characteristics



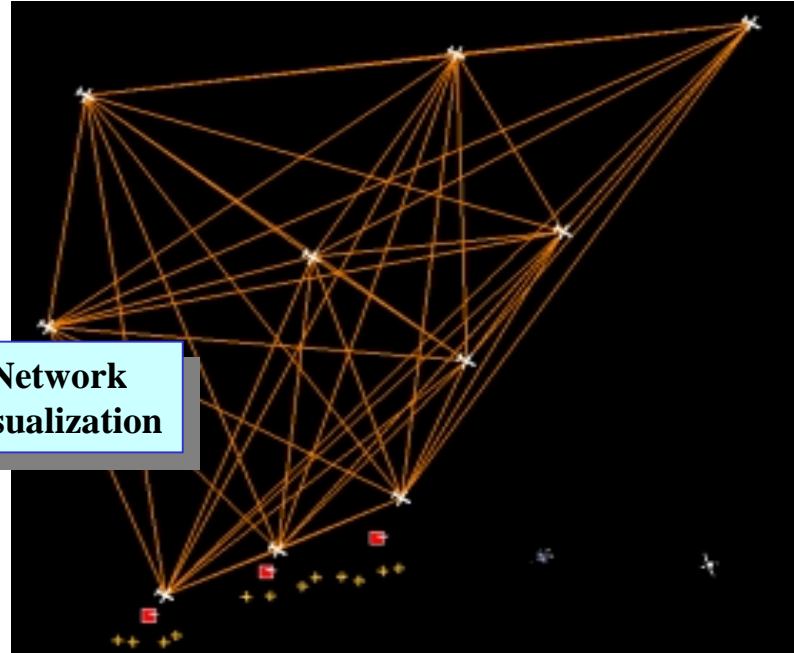
Environment Selection



Network Selection



Network Visualization





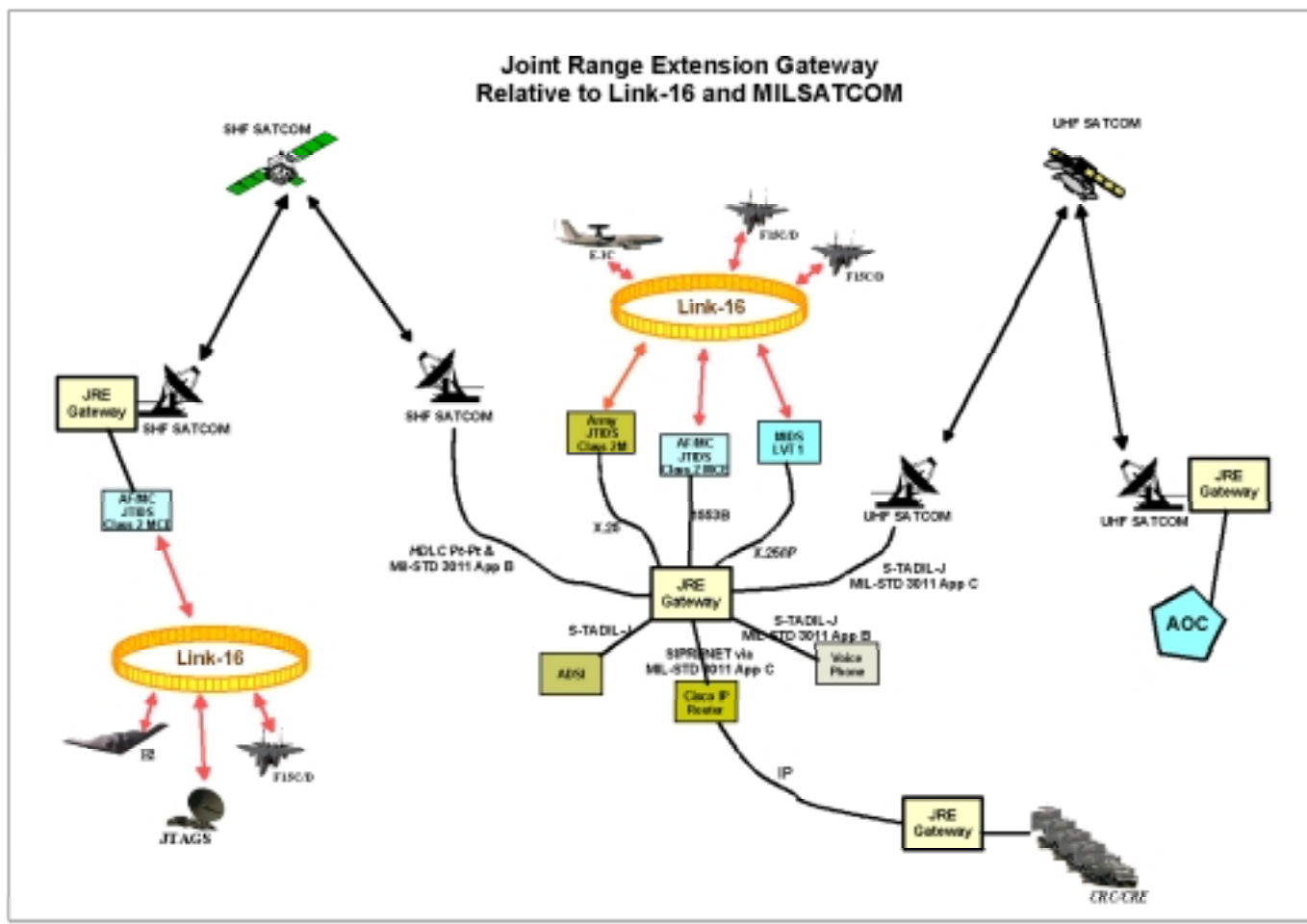
Link-11 Future Direction

- Enhancements:
 - HF terrain masking
 - Additional modulation types, e.g., MFL
 - TADIL-A message handling
- New Models for:
 - Link-11 UHF
 - Link-11B (Point to Point)
- Complete Link-11 Planning and Validation Toolset
- Migration to Link-22
- MTN Integration:
 - Data Forwarding through Link-16
 - Link-11 Monitor Feedback

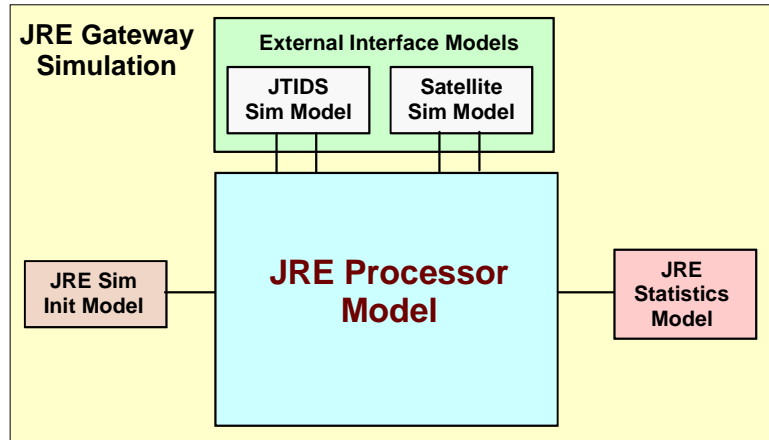


IRAD Subcontract

JRE & Satellites

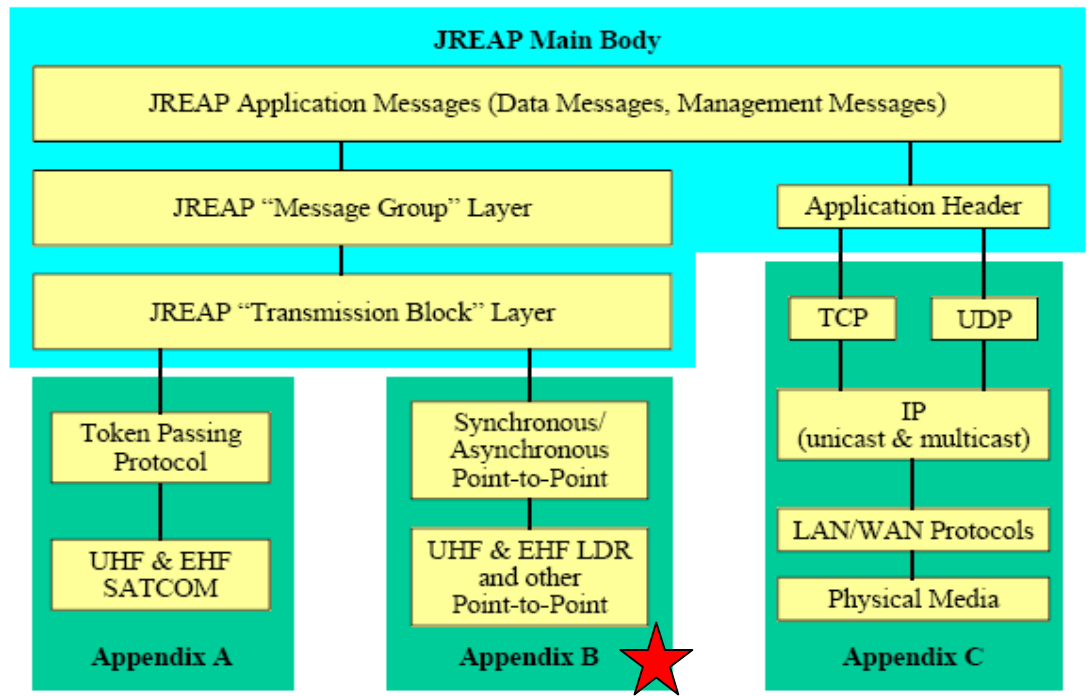


Joint Range Extension (JRE) Modeling

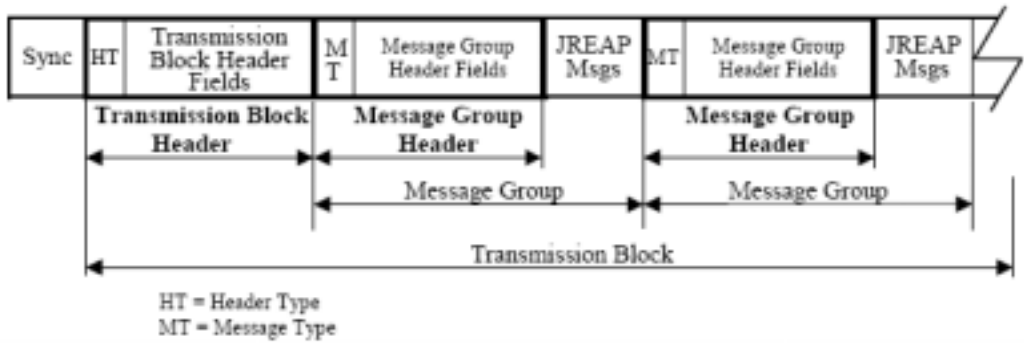


JREAP Requirements Analysis

- Model MIL-STD-3011:



- Full Stack JREAP Protocol:

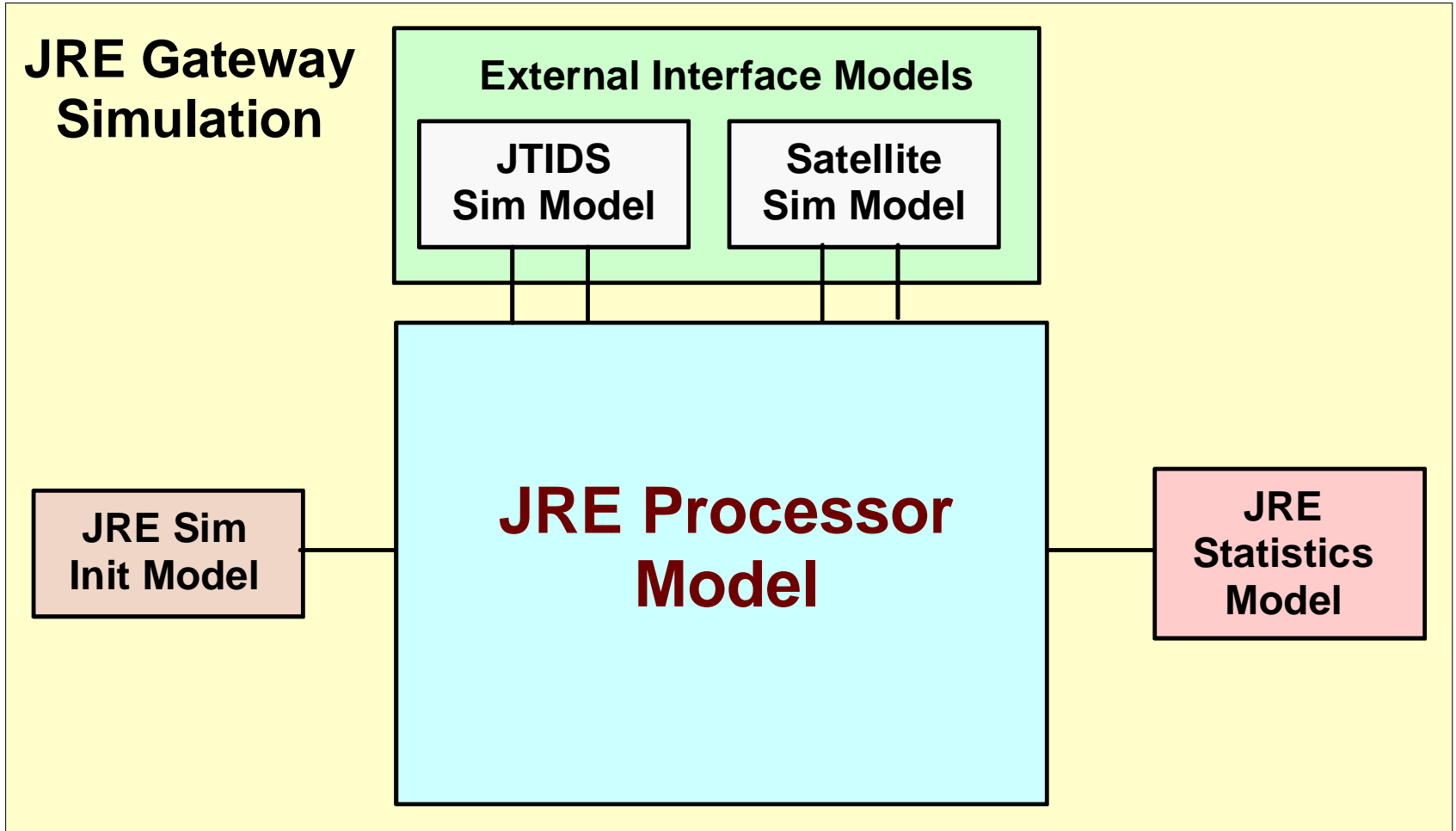




JRE Assumptions & Constraints

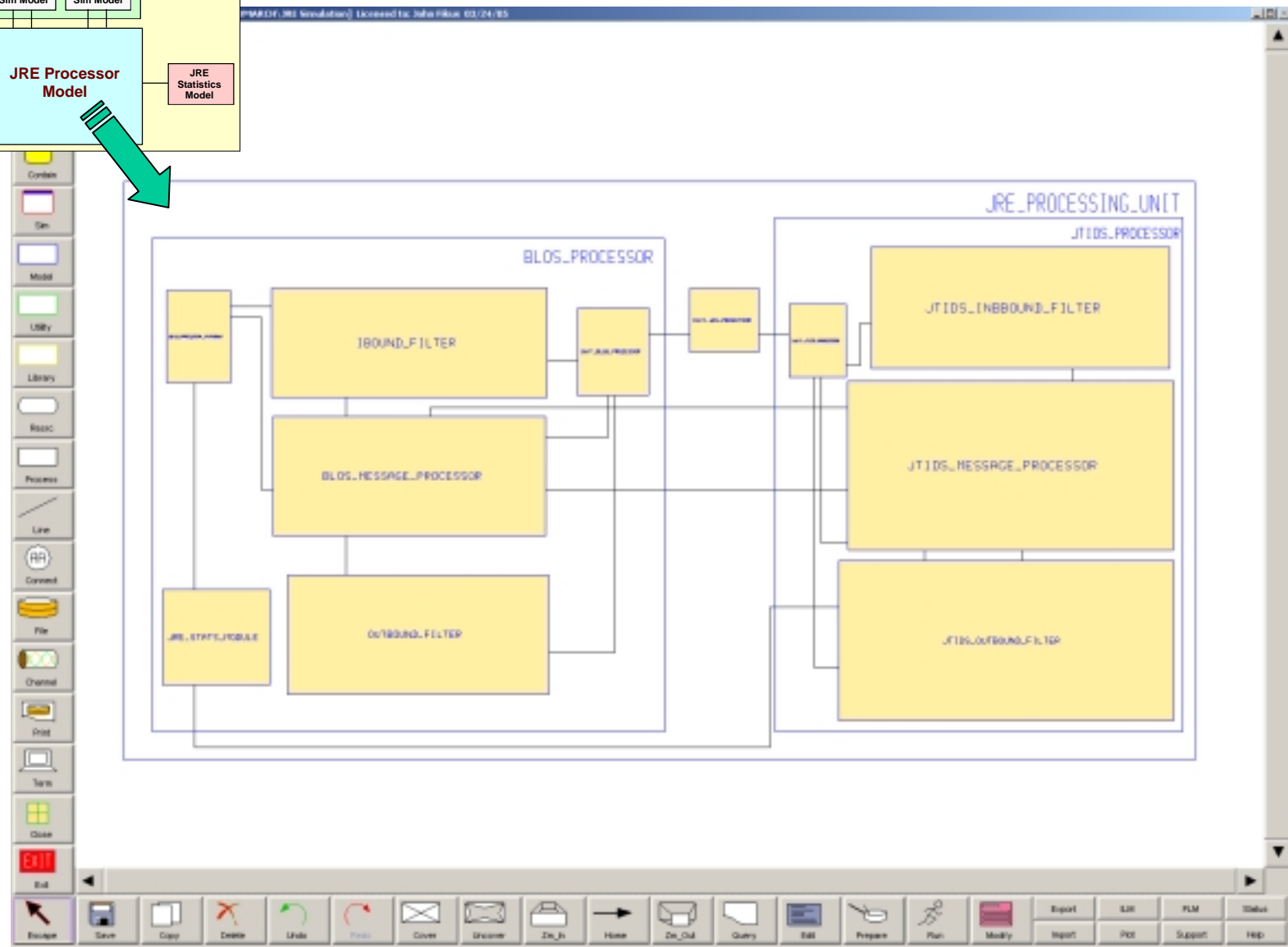
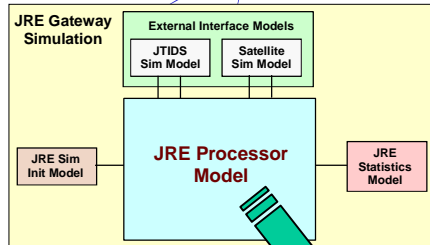
- Only modeled Point-to-Point Network Interfaces; 3011 Appendix B – relevant to Link-16 and MILSATCOM.
- Assumptions:
 - All JREs use same time reference.
 - JRE messages are sent whole, not fragmented.
 - J-Messages sent one at a time with JRE management messages piggybacked on same transmission.
 - JRE filtering modeled:
 - Label/Sub-Label, STN and Data Age; Filter overrides not modeled.
- JTIDS (J-Series) Message Content Modeled:
 - Header:
 - Message ID, STN, Label/Sub-Label, Message Length < 75 Kb
 - Data Portion:
 - Time Stamp, Track Number (TN)
 - Other data in terms of size
- Modeling JREAP Application Messages is not necessary

JRE Model Architecture





JRE Processor Model

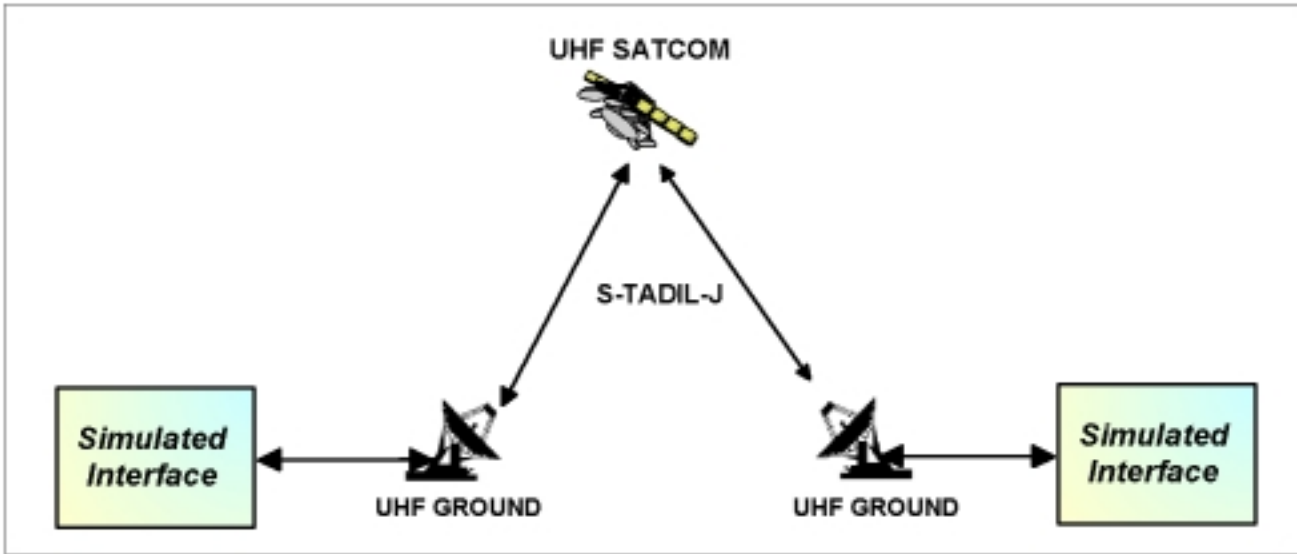




JRE Future Direction

- Enhancements:
 - Support multi-hop message transmission
 - JREAP message fragmentation
 - Implement Start of Transmission (STS) in headers
 - Implement CRC field in headers for error detection
 - Implement Relay flags in JRE message transmission
 - Implement other message filters (J-message fields)
- New:
 - Add TCP/IP interface and IP-network models
 - Interactive visualization
 - MTN Integration: Link-16, Satellite, IP models...

Satellite Modeling



Satellite Overview

Satellite Frequency Bands

Satellite Band	Frequency Range	Environmental Susceptibility
UHF	200-400 MHz 1.5 – 1.6 GHz	Low
SHF	4-30 GHz	Moderate
EHF	20-64 GHz	High

Many MIL Satellites are Multi-Band

UFO Satellite Positions

UFO Satellites (Longitude Position)	Approximate Coverage Area
15° W	LAN
22.5° W	LAN
29° E	IO
72° E	IO
72.5° E	IO
100° W	CONUS
105° W	CONUS
177° W	PAC
172° E	PAC
Ground Spare	TBD

UHF Tactical Satellites are Primarily Geo-synchronous



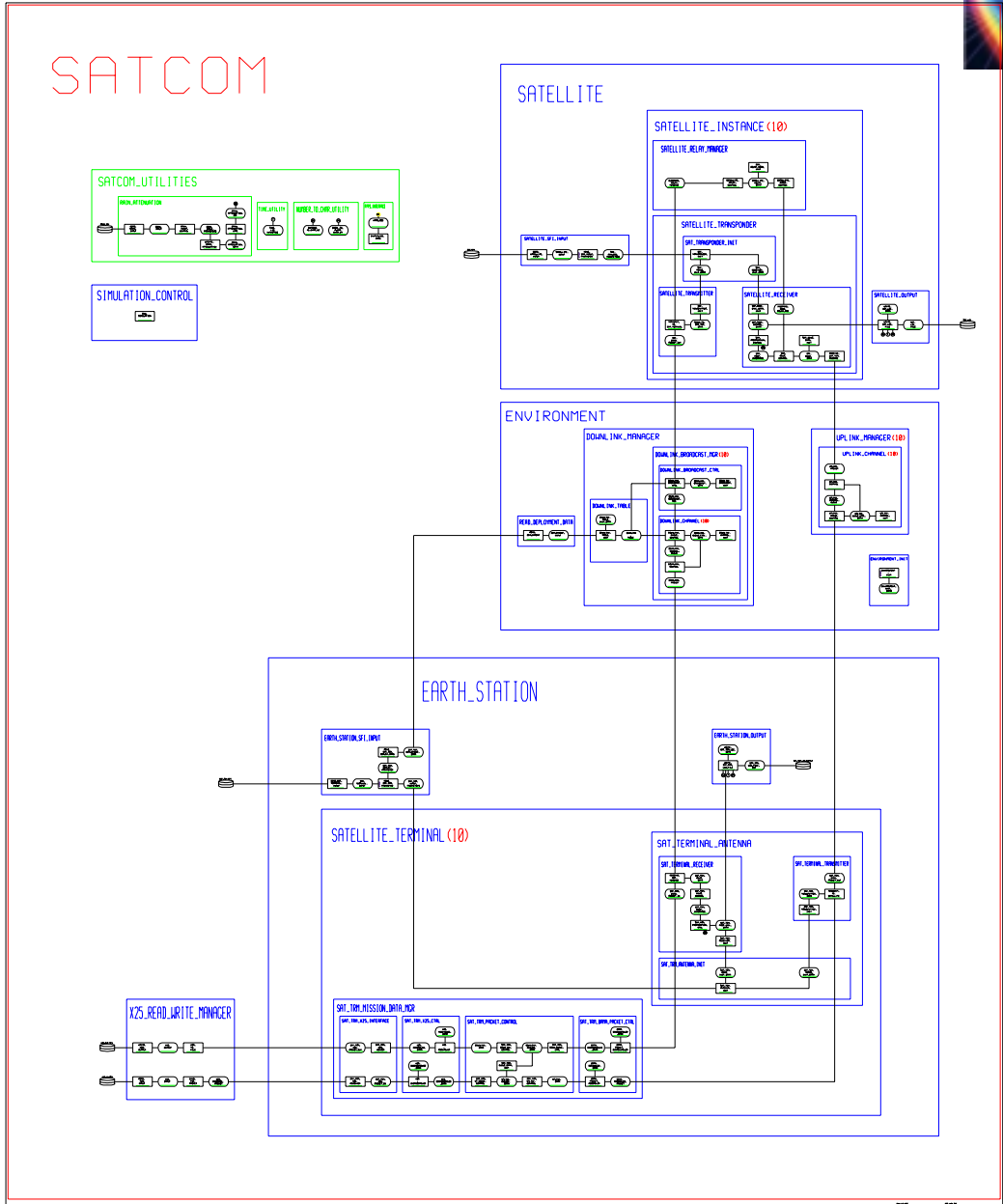
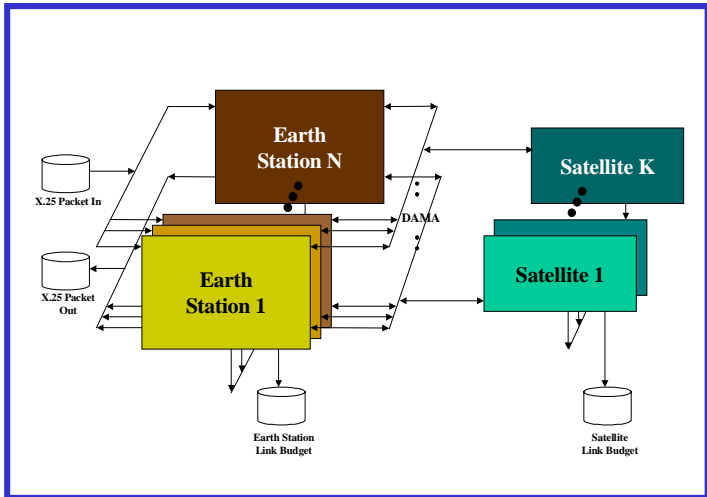
Satellite Modeling Requirements



- UHF (tactical) and SHF (long haul com) are most relevant to JSS since they are used by the JREG to extend Link-16 beyond line of sight (BLOS).
- Space and ground segments of MILSATCOM UHF/SHF must be modeled.
- Need to model communications protocols: S_TADIL-J, DAMA, interfaces.
- New additions to PSI RF propagation calculations are required for Satellites.
 - Noise from terrestrial, solar and galactic sources must be addressed.
 - Antennas are important to satellite operations therefore need antenna models to handle antenna sizes and orientation. Antenna orientation with respect to the sun, and relative to the ground can contribute to noise inputs.
 - Atmospheric affects (H_2O , O_2 , Rain and Humidity) must be introduced to account for effects on SHF MILSATCOM. These have a negligible affect on UHF communications.
- GEO orbits must be modeled along with positions of ground stations in order to compute associated propagation delays.
- Up/Down link frequencies and power levels are required inputs.
- Interconnectivity between the MILSATCOM models and simulations and the JREG models and simulations must be addressed.

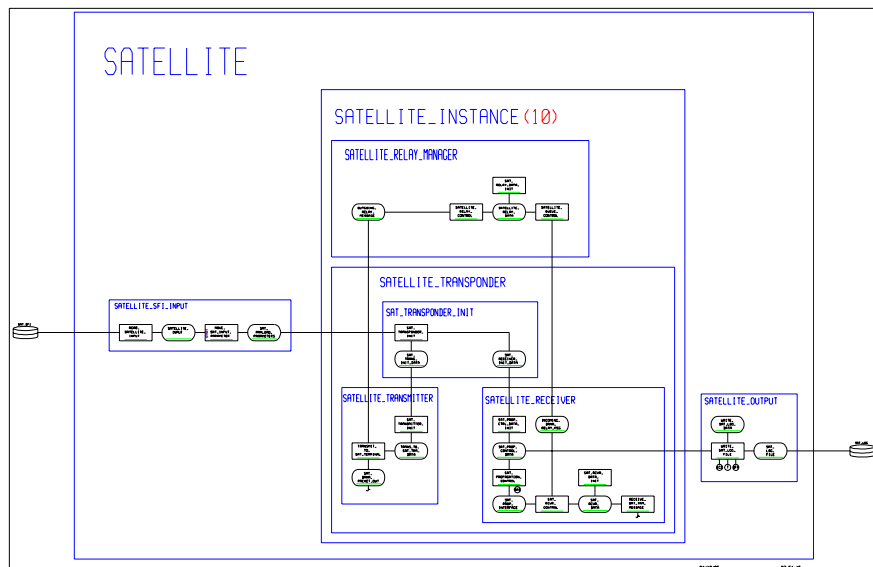


Satellite Simulation Architecture

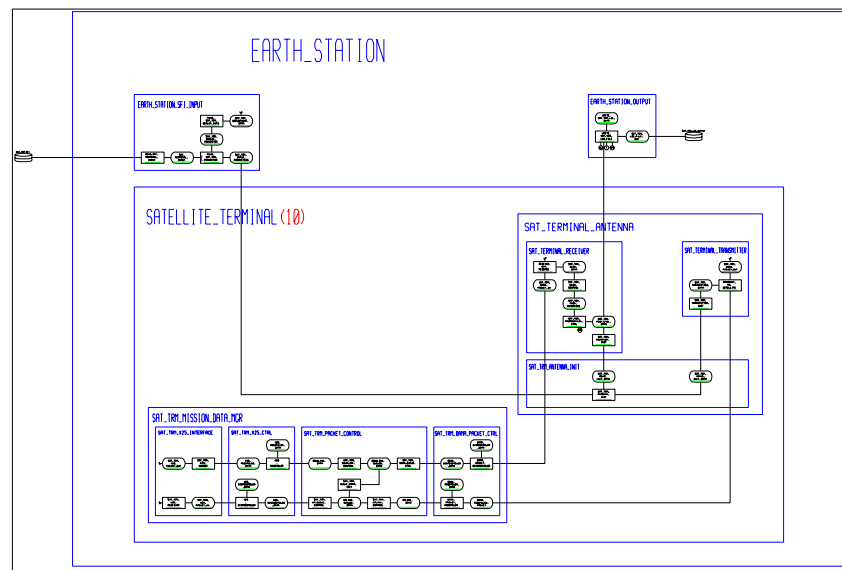




SATCOM Models



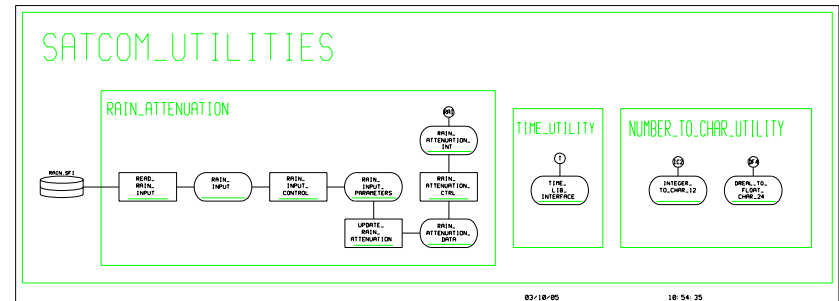
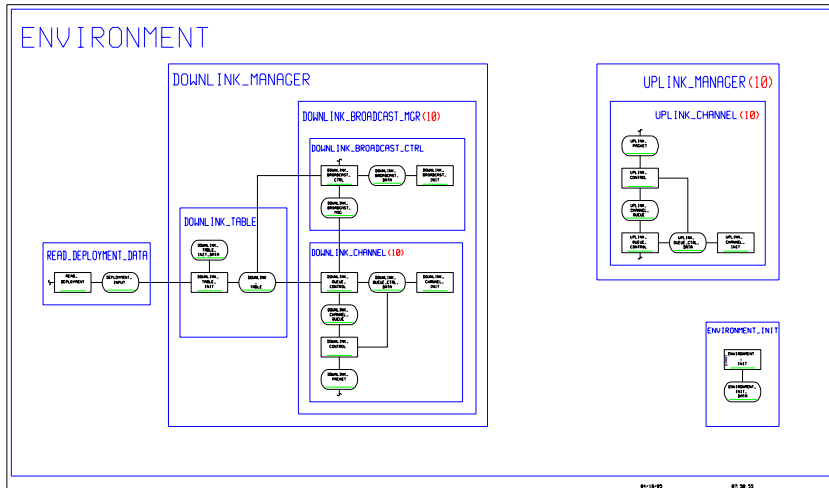
- Bent-Pipe Transponder.
- Manages Packet Delay.
- Reads satellite positions & data.
- Handles satellite uplink budget:
 - Antenna Gains
 - Noise (Receiver only)
- Outputs uplink budget data.



- Reads terminal deployments & data.
- Manages "X.25" IO
- 25 KHz DAMA-like comm:
 - Models headers & overhead
- Handles satellite downlink budget:
 - Antenna Gains
 - Noise (Receiver only)
- Outputs downlink budget data.



SATCOM Models



- Manages up and down link propagation delays.
- Manages satellite down link broadcast.

- Computation of rain attenuation for links.
- Utilities:
 - Time
 - Number conversion



Satellite Model Inputs

Satellite Inputs

- Longitudinal positions of the GEO satellites
- Receiver Characteristics:
 - Antenna Gain
 - Receiver Noise Figure
 - Feeder Loss
 - Bandwidth
 - Bit Error Rate Threshold
 - Bit and Code Rates
- Transmitter Characteristics
 - Antenna Gain
 - Power
 - Cable Loss
 - Transmit Frequencies

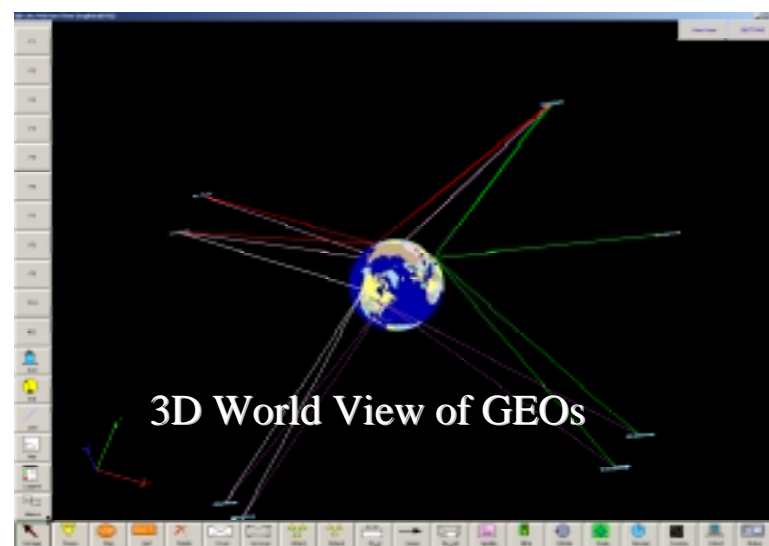
Satellite Terminal Inputs

- LON/LAT positions and elevation of ground terminals
- Receiver Characteristics
 - Antenna Gain
 - Noise Figure
 - Feeder Loss
 - Bandwidth
 - Bit Error Threshold
 - Bit and Code Rates
- Transmitter Characteristics
 - Antenna Gain
 - Power
 - Cable Loss
 - Frequencies

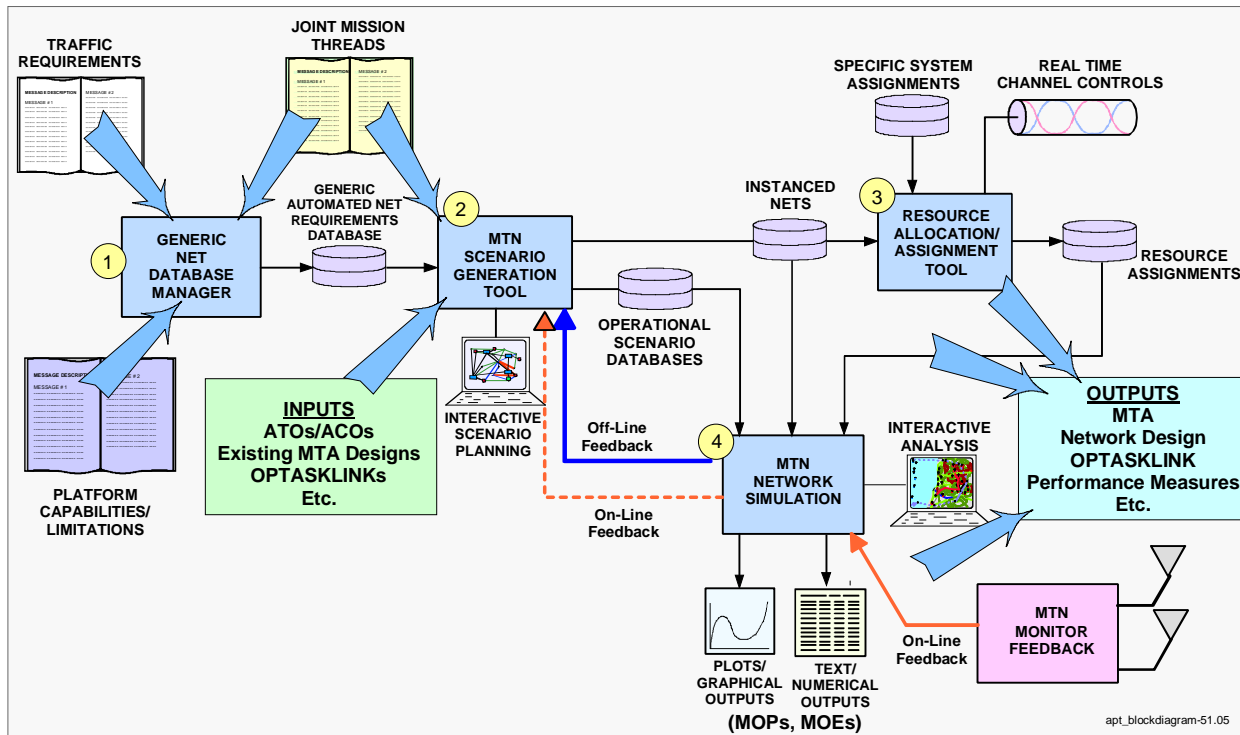


Future SATCOM Direction

- Higher Resolution Models:
 - More complete DAMA
 - Handle more noise sources
 - Antenna/Coverage
- New Models:
 - SHF and EHF satellites
 - Other satellite constellations
 - LEO, MEO, Polar
 - Dynamics
 - Atmospheric Attenuation
- 2D/3D Visualization
- MTN Integration



Multi-TDL Network (MTN) Integration Architecture

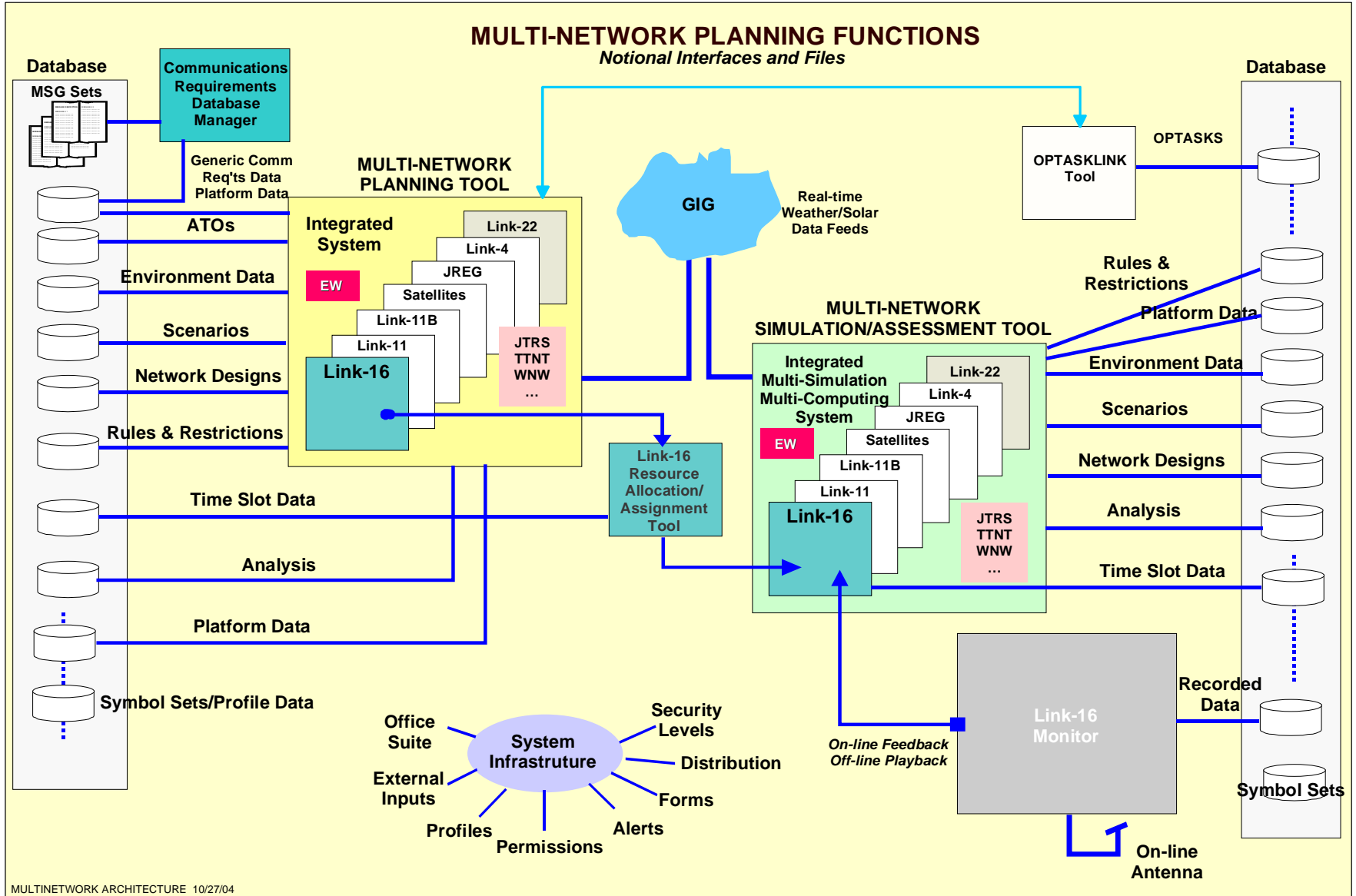




MTN Integration

- Functional system needs.
- Scope and size of MTNs.
- Target applications of MTNs with respect to Mission Threads.
- MTN environmental considerations and their impacts on model architectures and processing requirements.
- Future MTN evolution.
- Required model and simulation tool components.
- Flexibility, scalability and extensibility of architectural solutions.
- Operational performance requirements of the tool sets.
- Processor needs and selection.

Phase 2+ JSS Vision



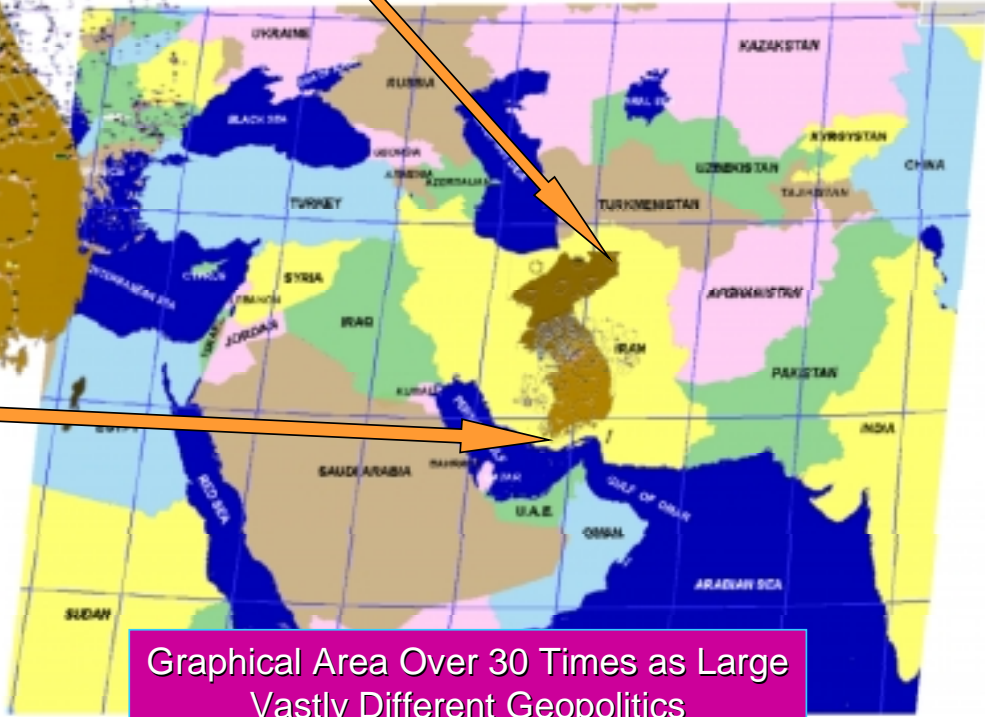
MULTINETWORK ARCHITECTURE 10/27/04

Expanding Scenario Sizes

NEA III 2010 Scenario
130+ Link-16 Platforms

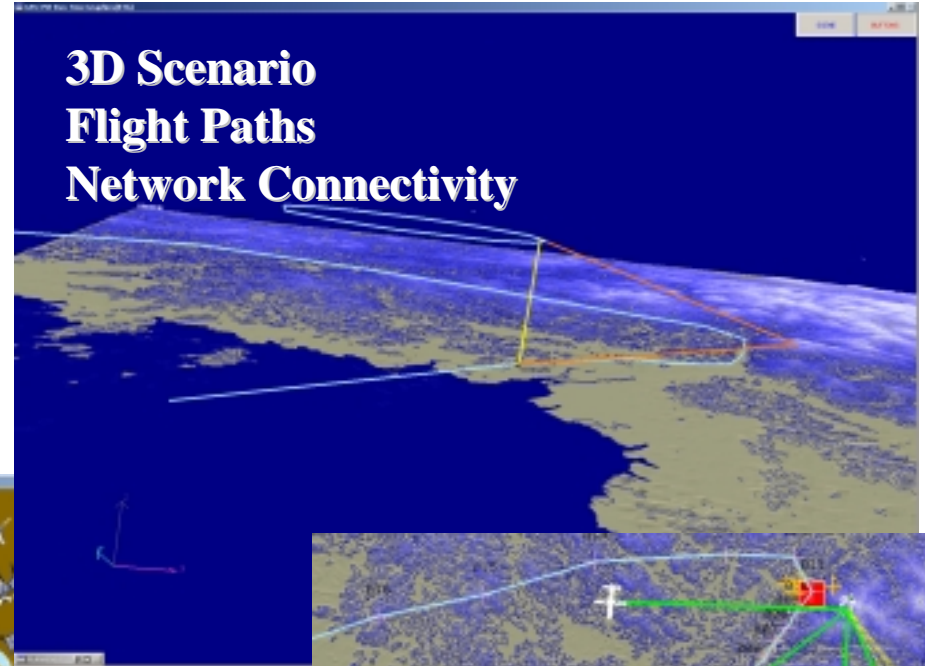
Potential Mid-East Scenario
500+ Link-16 & Other TDL Platforms

PSI
Korona

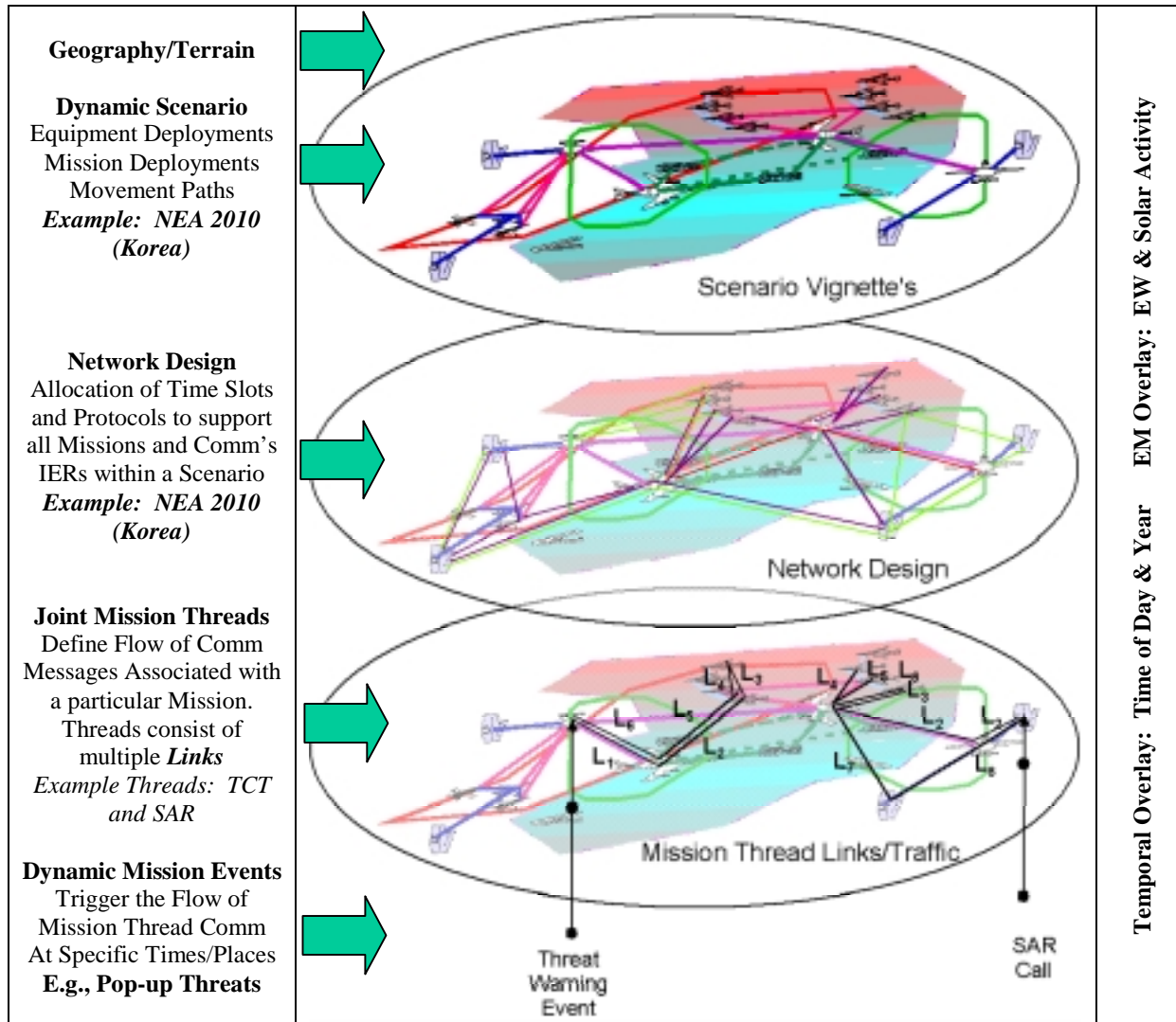


Graphical Area Over 30 Times as Large
Vastly Different Geopolitics

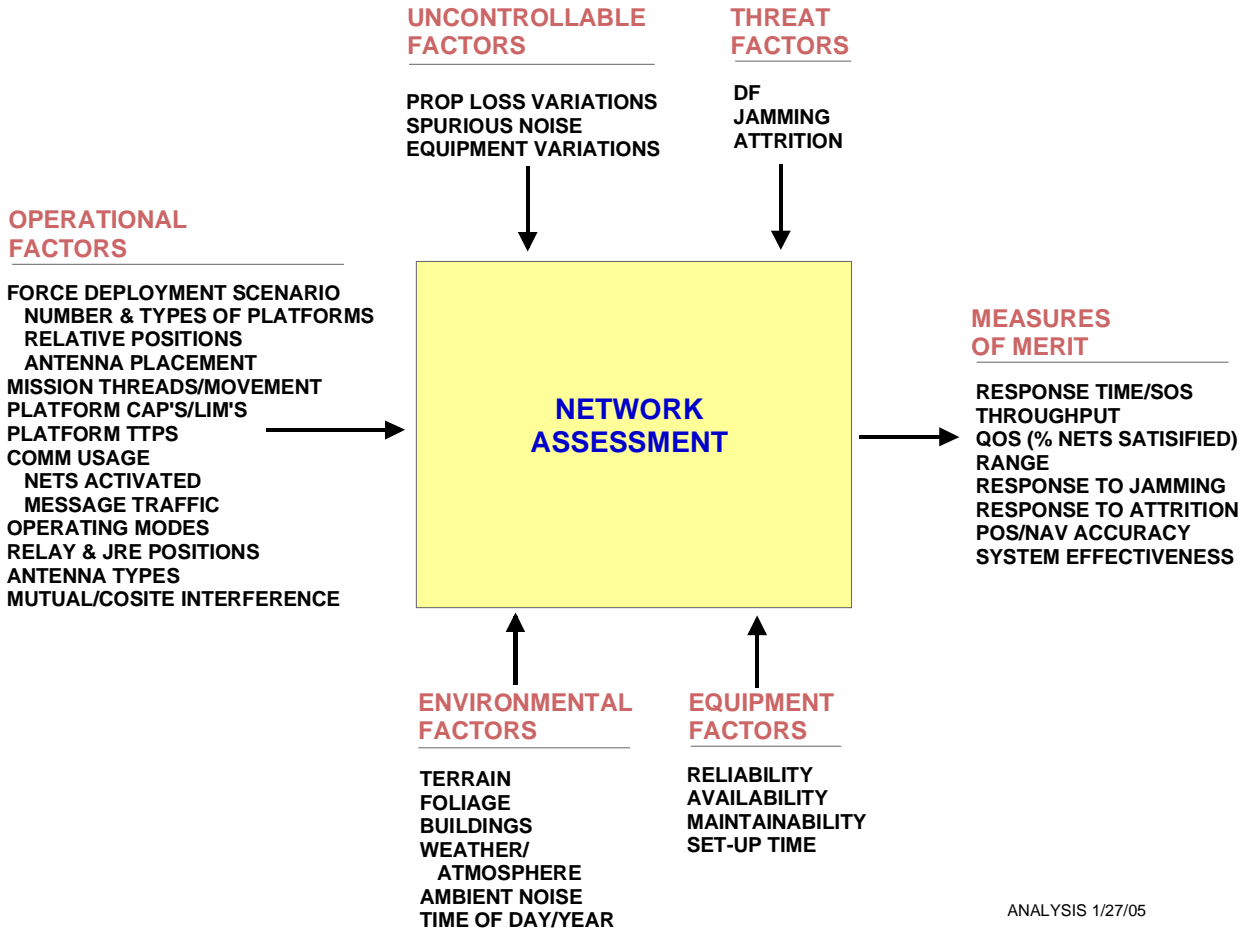
Interactive Visualization



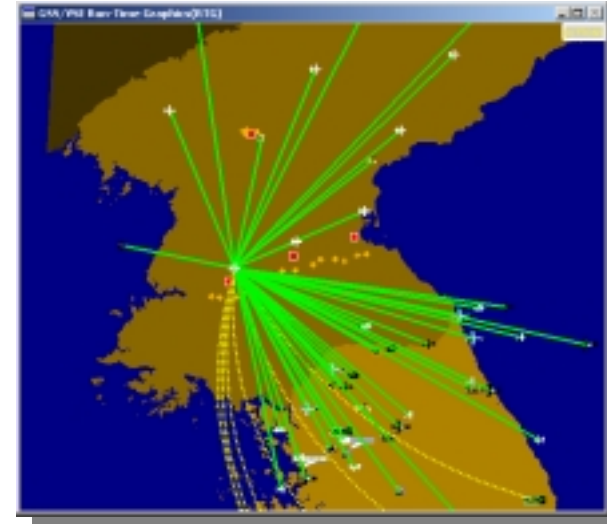
Scenario & Network Design



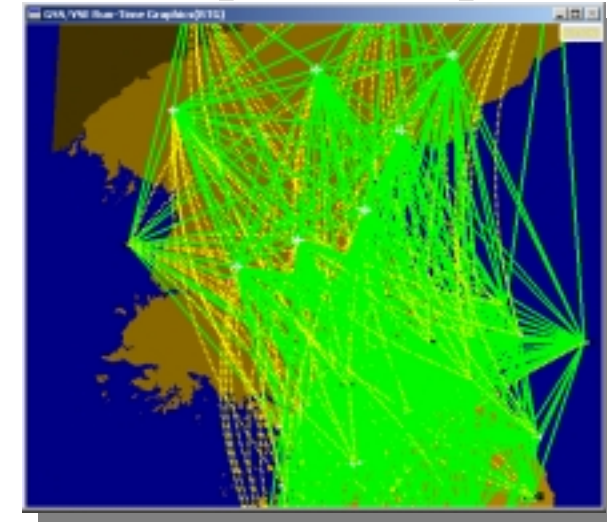
Computational Factors



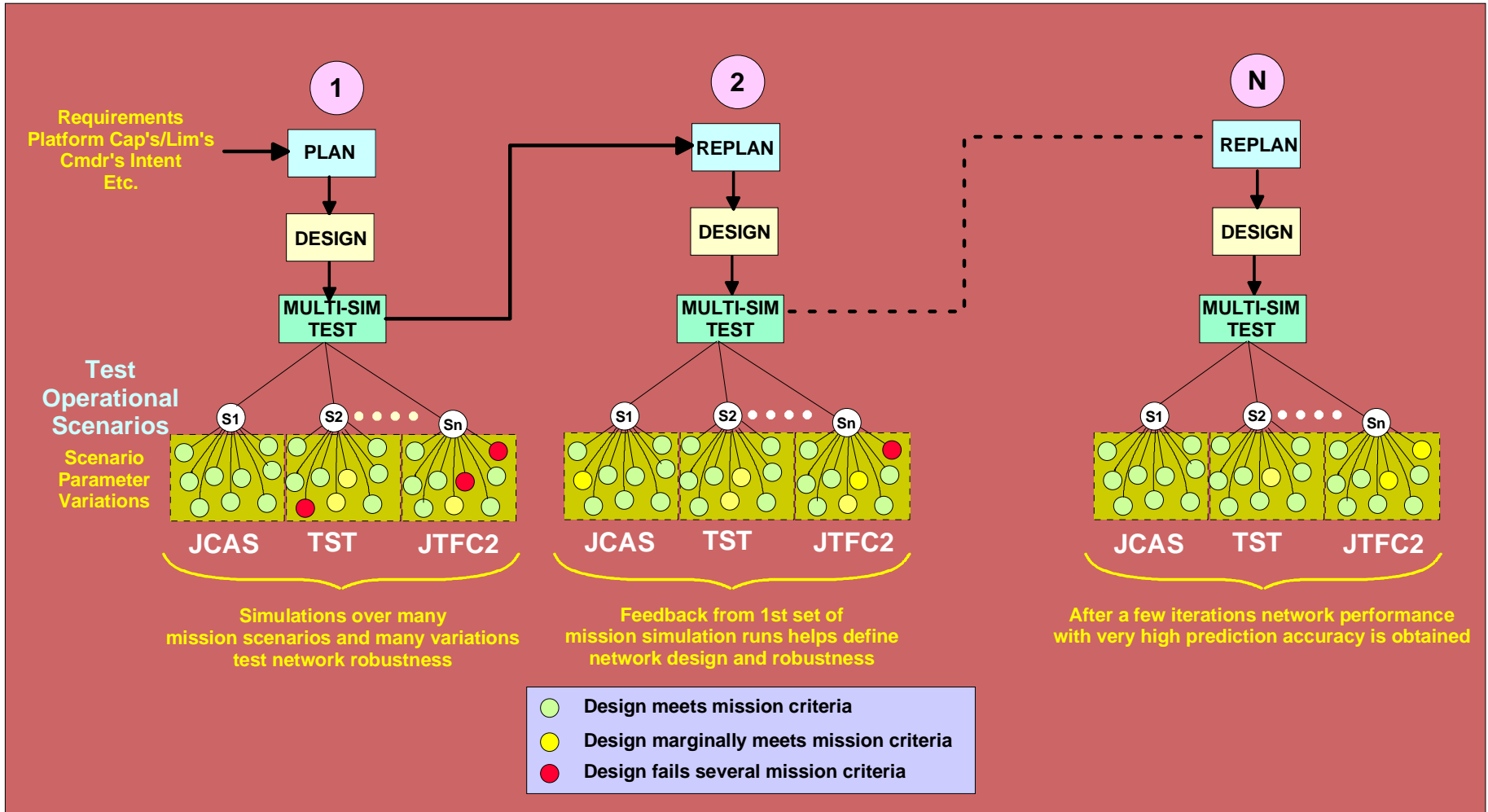
ANALYSIS 1/27/05



Coupled EM Space



Iterative Planning & Validation



Processor Requirements

GHz Needs Analysis

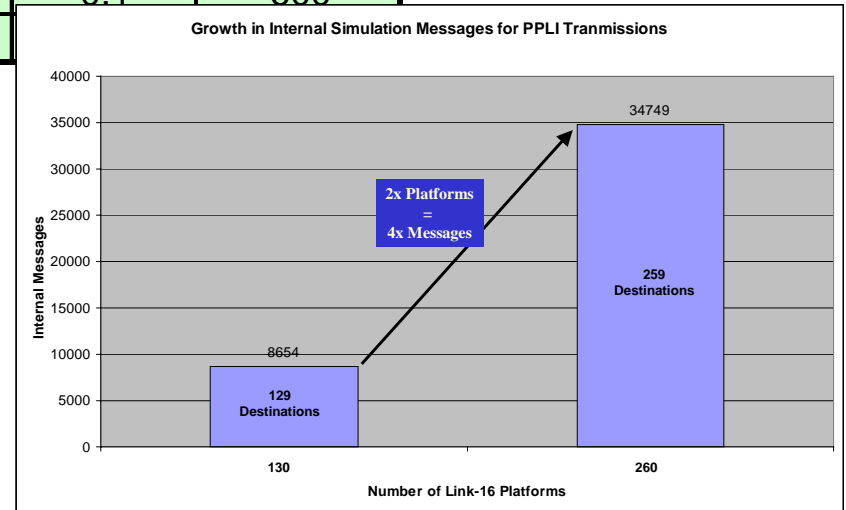
PSI Korona Reference Scenario						
Single Scenario Duration (Hrs)	Sim/Real Ratio Achieved	Platforms in Scenario	Simulation Execution Time (Hrs)	PC GHz	Desired Run Time (Hrs)	Needed GHz
1	1.0	130	1.0	3	0.1	30
2	1.0	130	2.0	3	0.1	60
1	0.2	130	5.00	3	0.1	150
2	0.2	130	10.00	3	0.1	300
1	0.1	130	10.00	3	0.1	300
2	0.1	130	20.00	3	0.1	600
1	0.05	130	20.00	3	0.1	600
2	0.05	130	40.00	3		

Processors Choices:

- Beowulf
- DIS/HLA
- MPP ✓

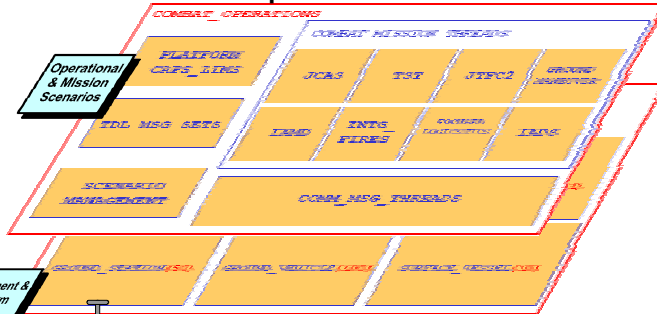
Rapid Growth in Messages

$$\Omega_{PPLI} \propto N_{PPLI}^2$$



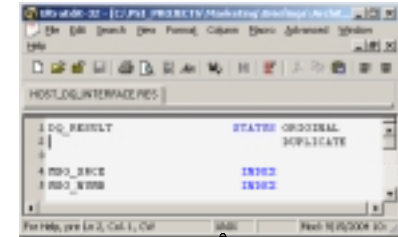
Instanted Model Architecture for MPP

Top Level Hierarchical Models



GSS Layered Architecture to Code

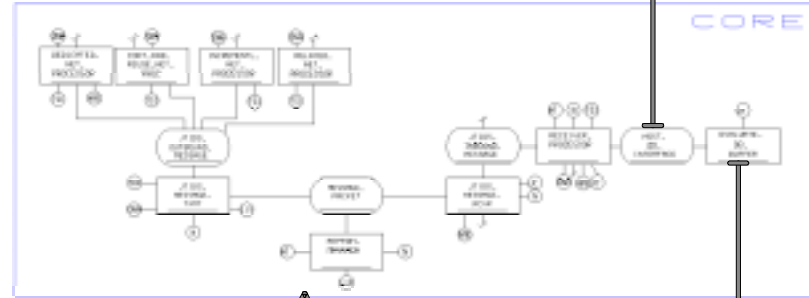
GSS Resource Holds State Data



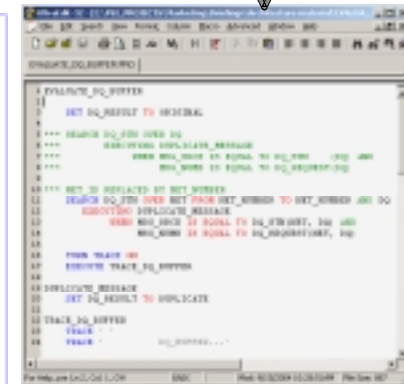
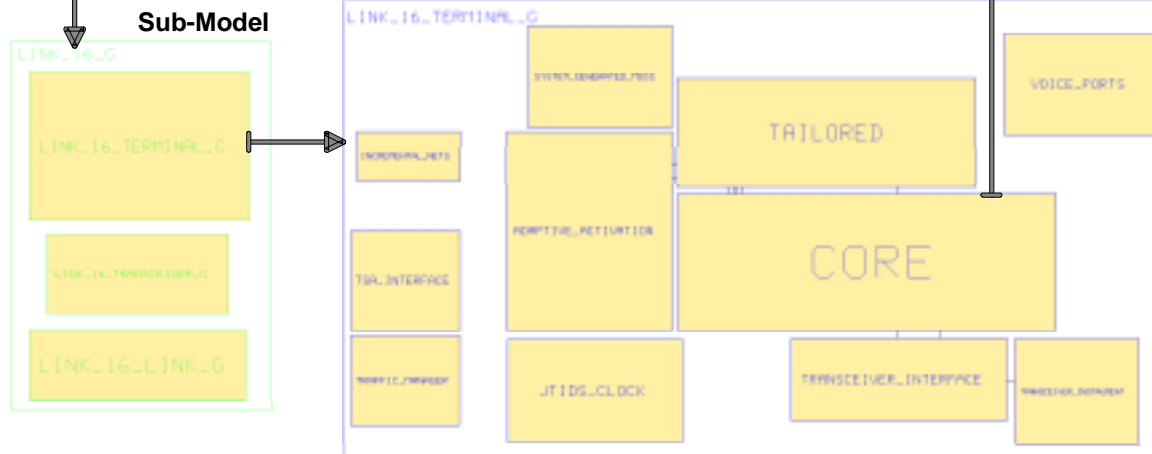
Instanted Model



Elementary Model



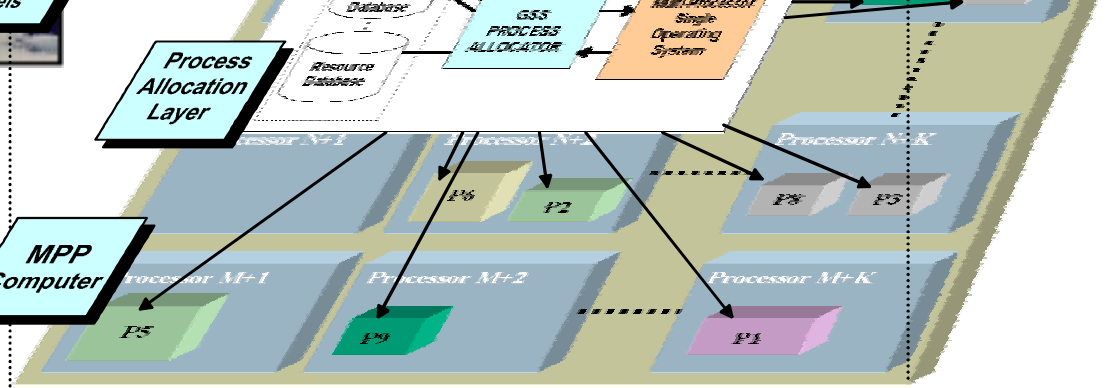
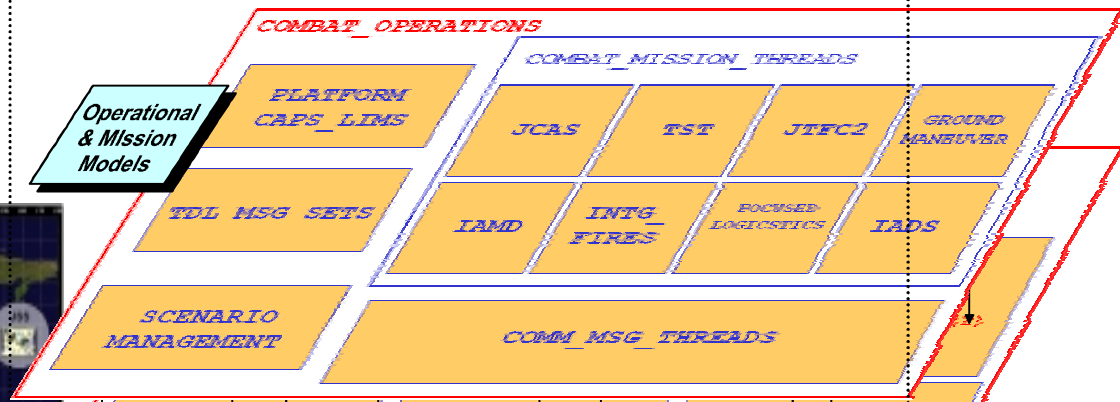
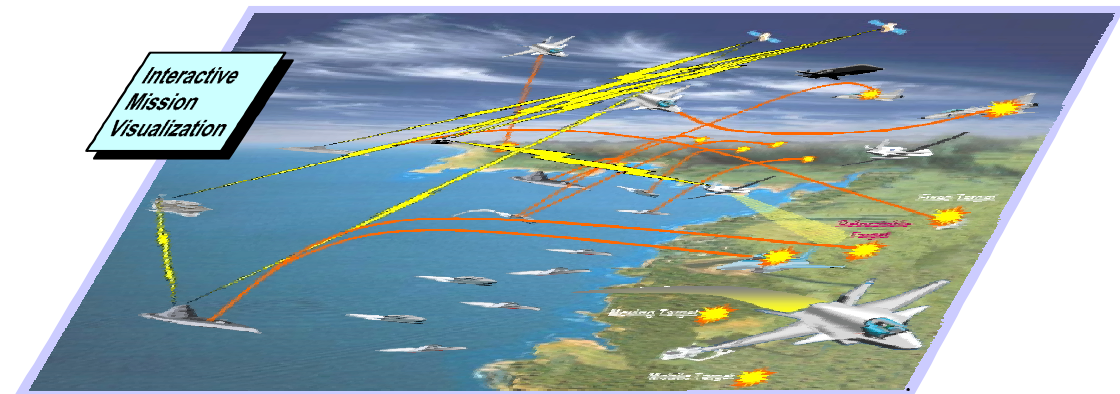
Sub-Model



GSS Process Changes Data States



MTN Integration Solution



**1st Target
SGI Altix 3000**



Break (10 Min)

Lab Demos (60 Min)

Link-16 NMS

- Windows Look/Feel** **5 Min Corinne Zaffos**
- Operations** **15 Min John Fikus**

Link-16 Monitor Feedback **10 Min Roger Grayson**

Link-11 HF/Terminal **10 Min Roger Grayson**

JRE Modeling/Sim **10 Min Roger Grayson**

Satellite Modeling/Sim **10 Min Corinne Zaffos**



Opportunities Discussion (10 Min)