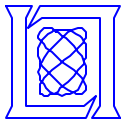

Wideband Networked Sensors

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Next Generation Internet
Principal Investigator Meeting

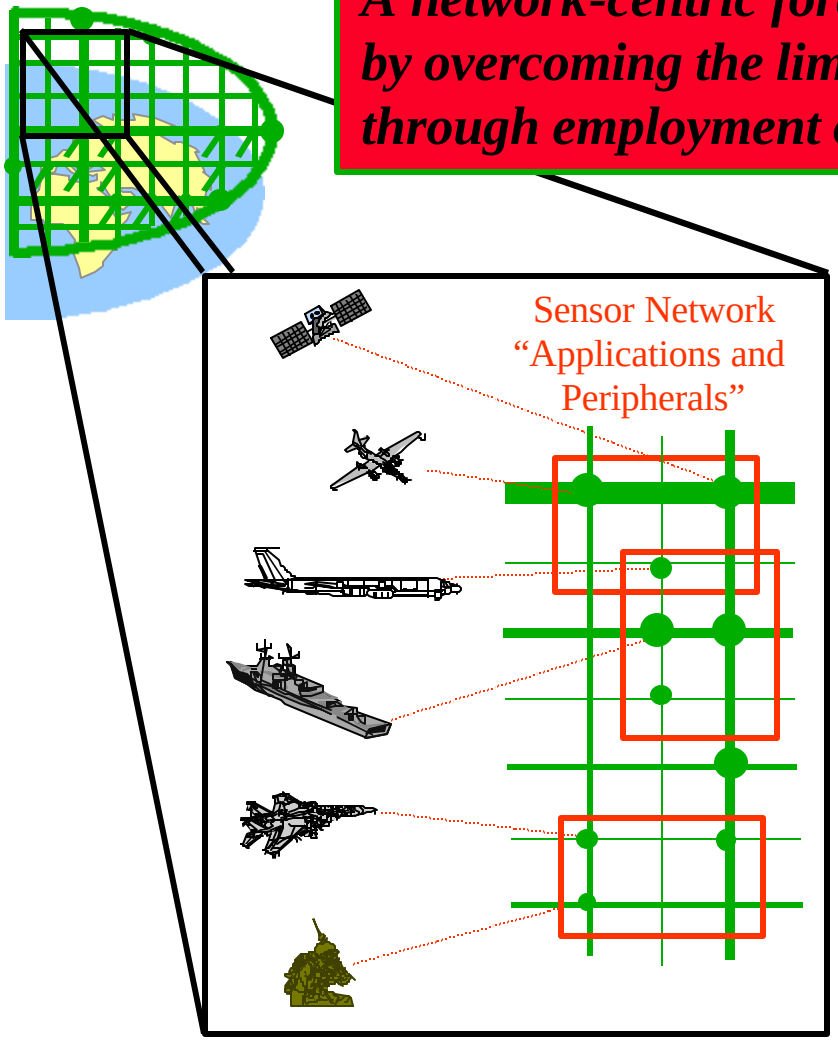
2-4 October 2000

Outline

- **Netted Sensors Through High Performance Connectivity**
  - **Enabled via Next Generation Internet**
- **Military Utility Examples**
- **Millstone Testbed Demonstration**
- **Summary**

Increased Awareness (JV 2010+)

A network-centric force increases battlespace awareness by overcoming the limitations of standalone sensors through employment of sensor networks



- **Sensor Networks enable Commanders to**
  - Rapidly generate Battlespace Awareness
  - Synchronized with operations
- **Components of Sensor Networks**
  - Space, Air, Sea, Ground and Cyberspace Based Sensors
- **Operational Capabilities**
  - Improved Data Fusion
  - Dynamic Sensor Tasking
  - Universal Sensor Recruitment

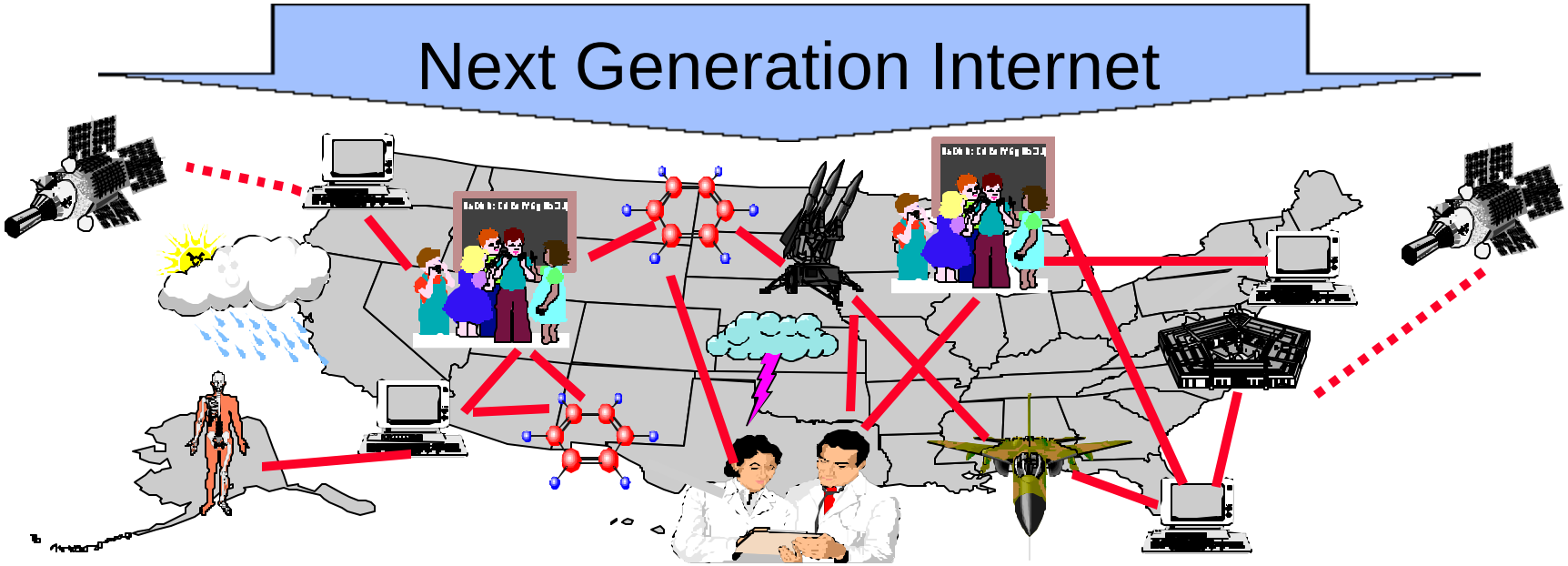
December 14, 1999

*From D. Alberts, and John J. Garstka. "Information Superiority/Command and Control Seminar: Keynote Presentation."

NGI VISION

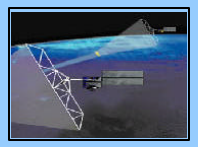
NSF DOE DARPA NASA NIST

Goal 1	Goal 2.1	Goal 2.2	Goal 3
Advanced Network Technologies	High Performance Connectivity	Ultra-High Performance Tech.	Revolutionary Applications



High Performance Sensor Networking

Web-based Broadband Sensor Fusion



Digital R_x | Signal Proc.

Digital R_x | Signal Proc.

Digital R_x | Signal Proc.

Digital R_x | Signal Proc.

Packetized Broadband Communications

Fiber

Wireless

Integration / fusion of distributed multi-frequency and multi-aspect systems for improved performance:

- **Sensitivity**
- **Metrics**
- **Discrimination/ combat ID**
- **Targeting**

Attributes:

- **Packetized with net-based timing**
- **Wideband open system architecture**
- **Net-based advanced imaging**
- **Land, air, and sea based**
- **Robust to countermeasures**

Outline

- Netted Sensors Through High Performance Connectivity
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Ultra-Wideband Target Imaging Using Distributed Sensors

High Speed Connectivity Enables Netting Sensors to Exploit:

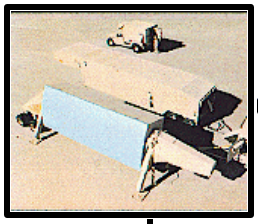
- Multi-Frequencies
- Multi-Aspects
- Polarization Diversity
- Waveform Diversity

Sensor 1

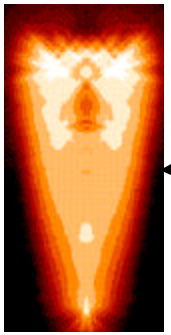
Lower Sub-band Image

Conventional Image Processing

Re-Entry Vehicle



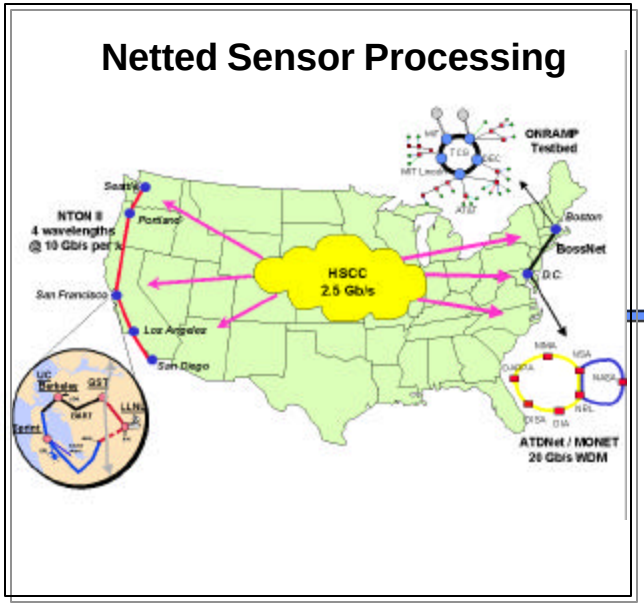
Sensor 2



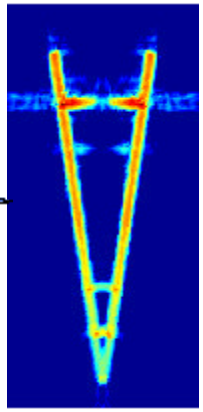
Conventional Image Processing

Upper Sub-band Image

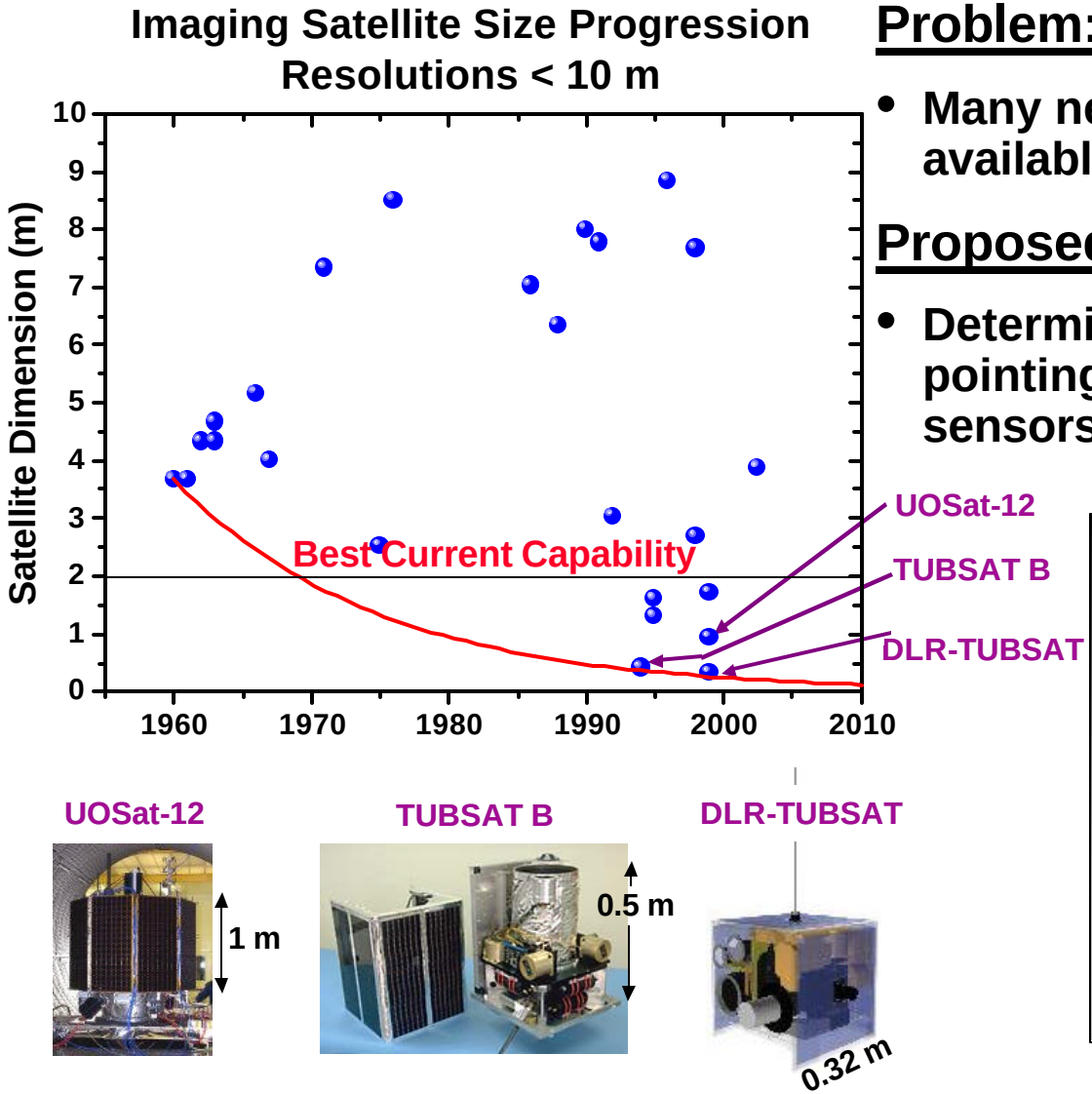
Netted Sensor Processing



Ultra-Wideband Target Image



Militarily Significant Payloads Doing More in Smaller Packages



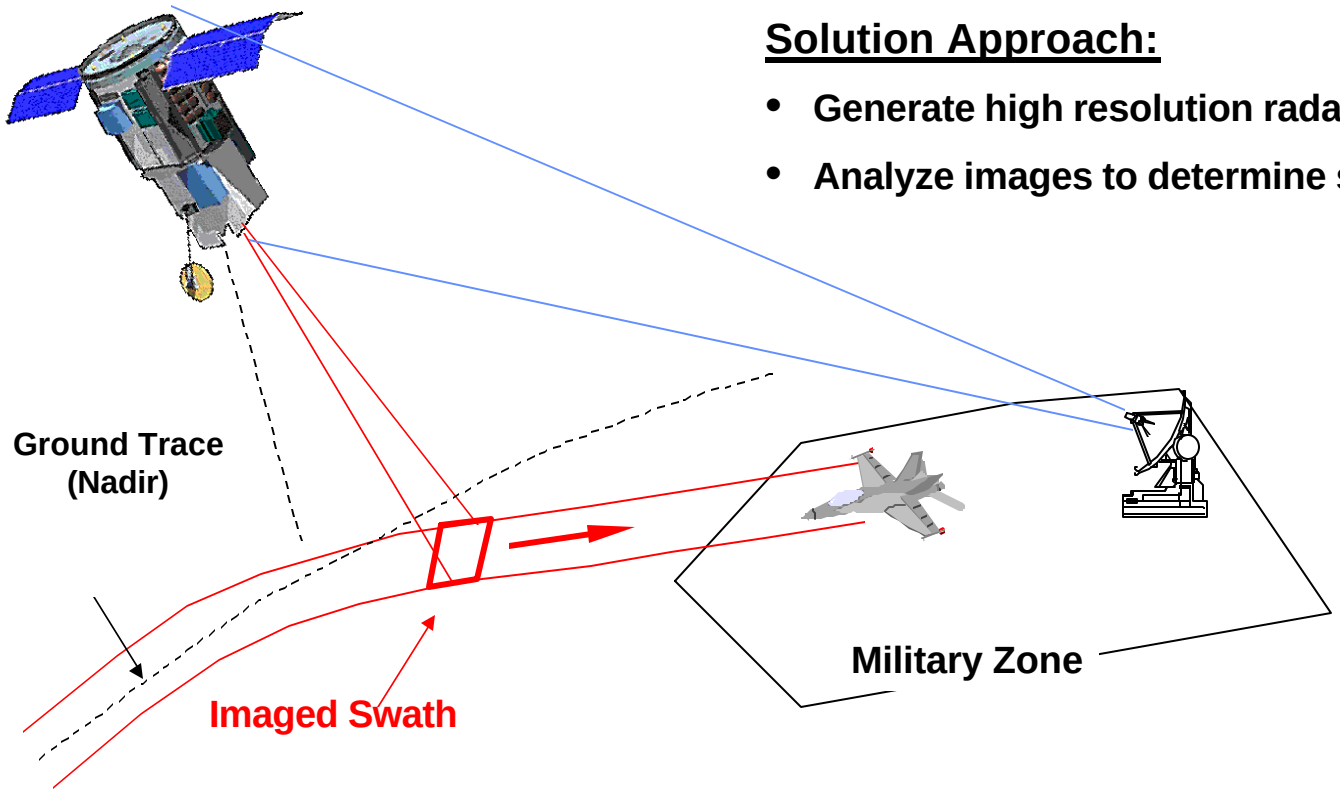
Problem:

- Many new imaging satellites will be available to potential adversaries

Proposed Approach:

- Determine imaging satellite status and pointing using wideband netted sensors

Satellite Threat Assessment



Problem:

- Many new imaging satellites will be available to potential adversaries in near future
  - Capable of off-nadir imaging
  - Dimensions shrinking (< 1 meter)

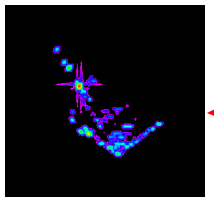
Solution Approach:

- Generate high resolution radar images
- Analyze images to determine satellite orientation

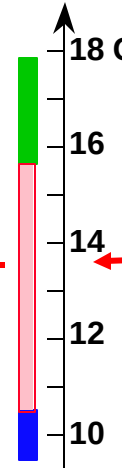
Wideband Networked Sensors
- WNS Program -

Objective

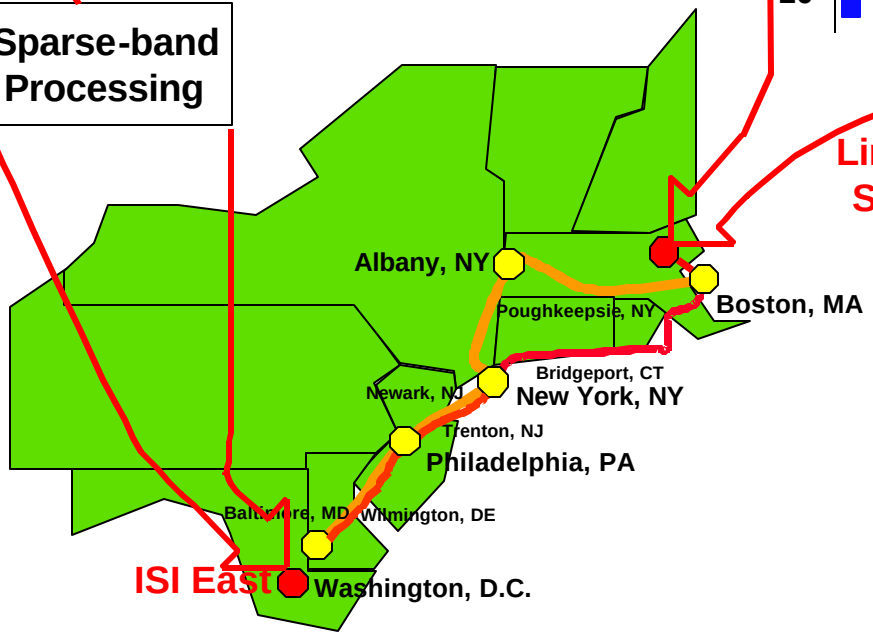
Demonstrate the use of the BoSSNET for advanced communication-intensive military applications

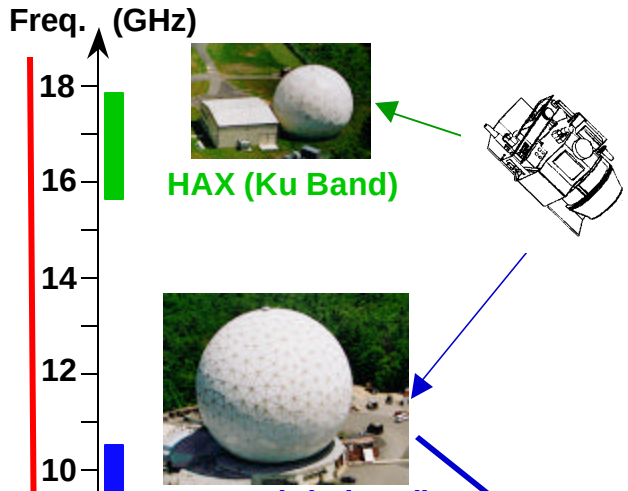


Dual Band Image
3-4 cm resolution
(Simulated)

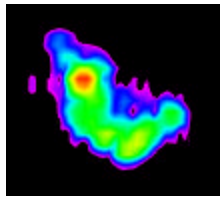


Sparse-band Processing





Lincoln Space Surveillance Complex



Conventional Image
25 cm resolution
(Simulated)

Outline

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- Military Utility Examples
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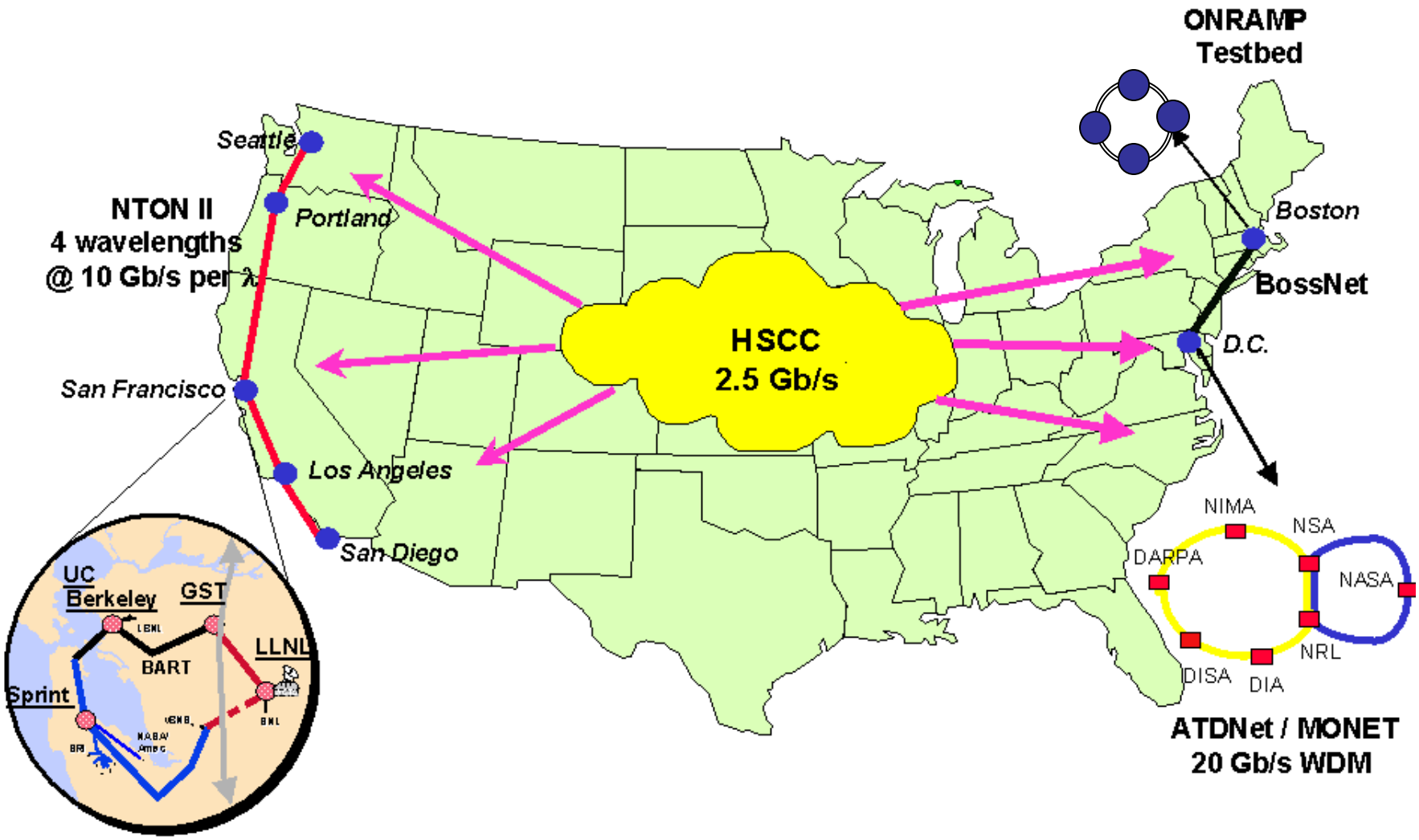
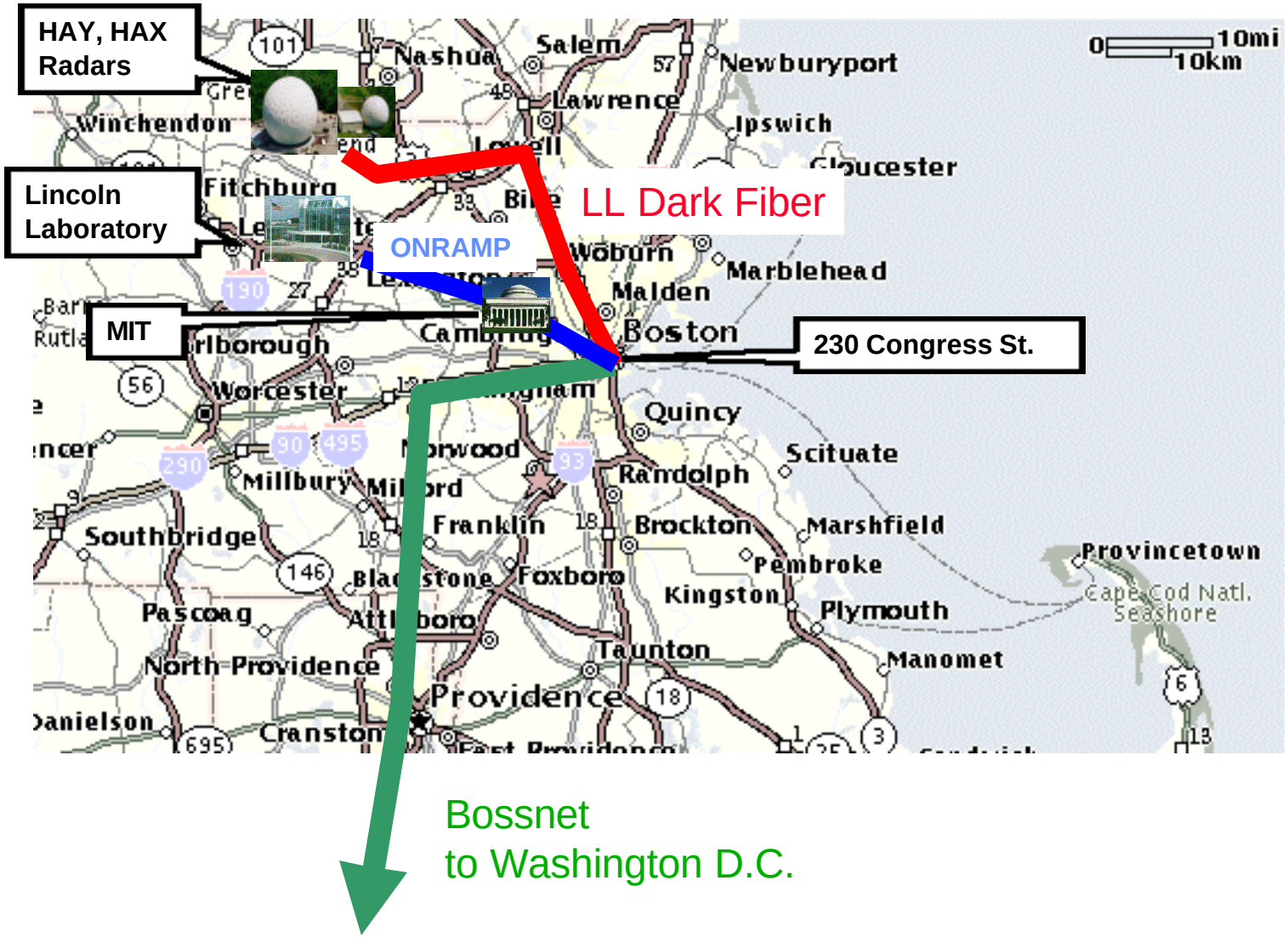
Connectivity to Other NGI Projects (Supernet)



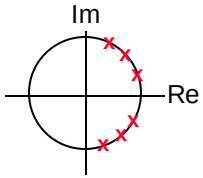
Lincoln Space Surveillance Complex (LSSC)

Lincoln Dark Fiber Plant, October 2000



Wideband Networked Sensors Development Path

Sparse-Band Algorithms



$$M(f_n) = \sum_{k=1}^{p} a_k p_k^n$$

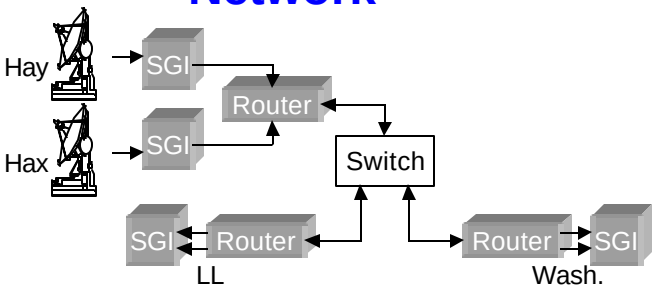
Combine X and Ku data to synthesize UWB radar in real-time

Processing and Integration

WNS Demonstration

Demonstrate Gbits/sec bandwidth as the enabler for advanced ultra wideband imaging

Network

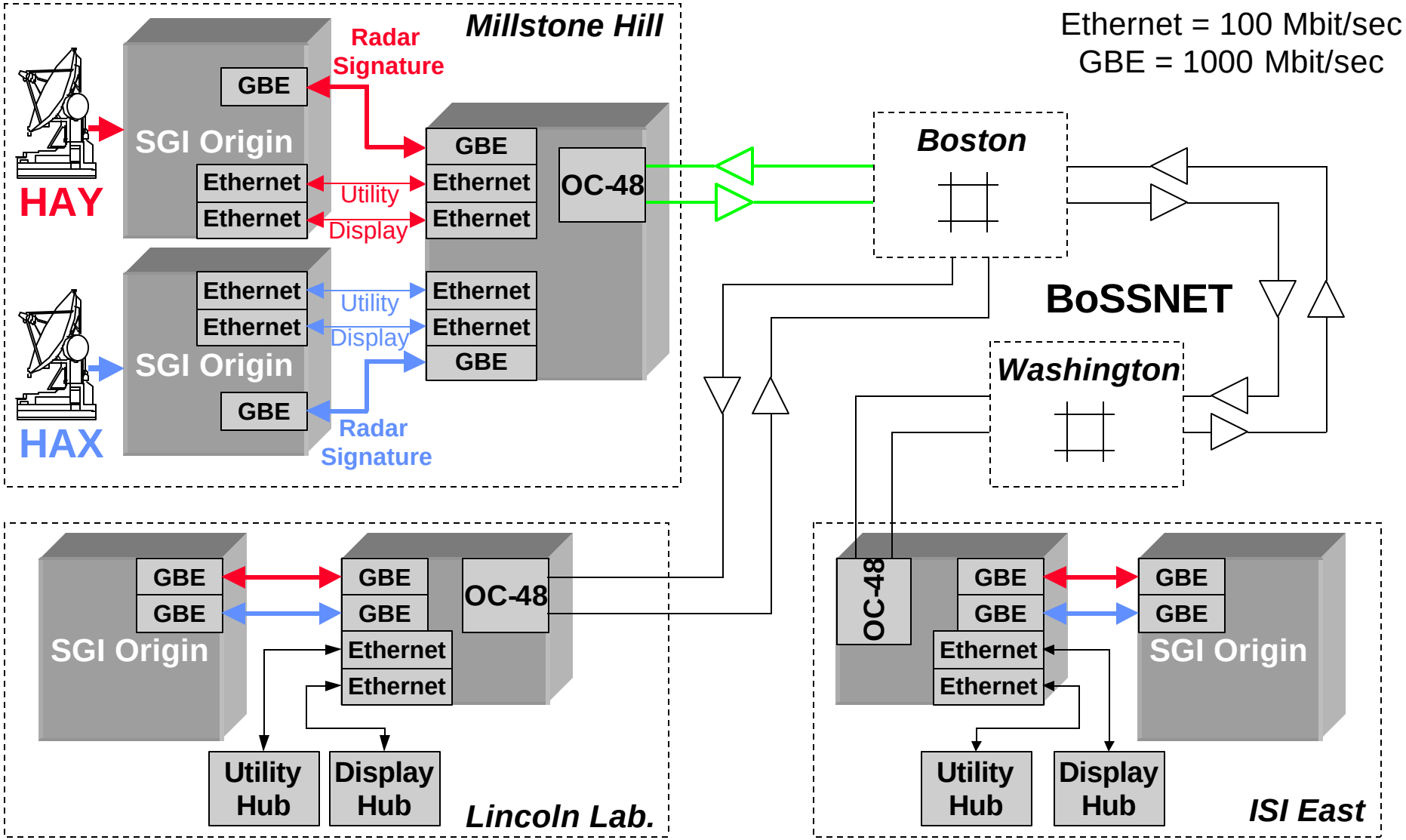


Hay/Hax Upgrade

X-band (10 GHz)

Ku-band (17 GHz)

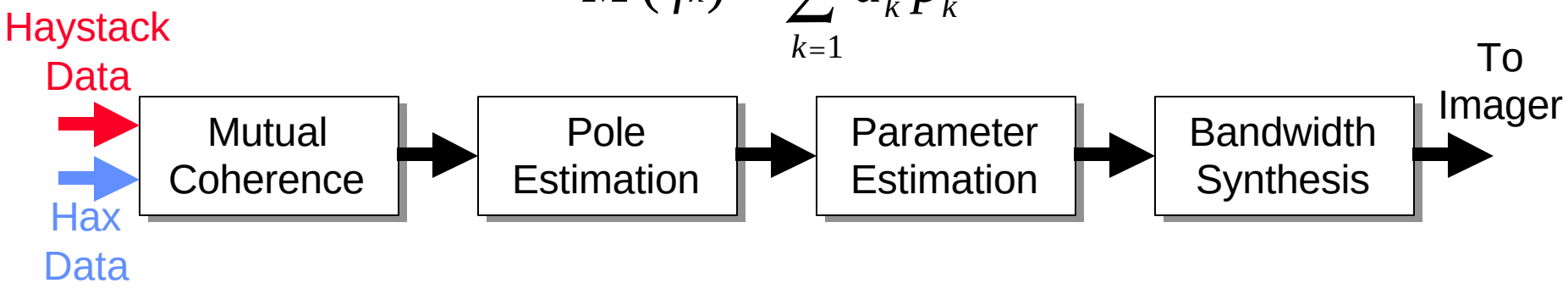
System Network Architecture

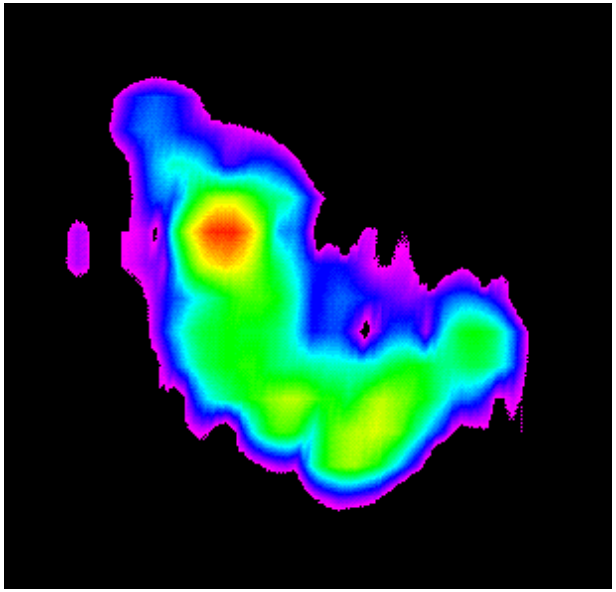


Sparse Band Processing

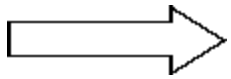
All-pole signal model

$$M(f_n) = \sum_{k=1}^{P} a_k p_k^n$$

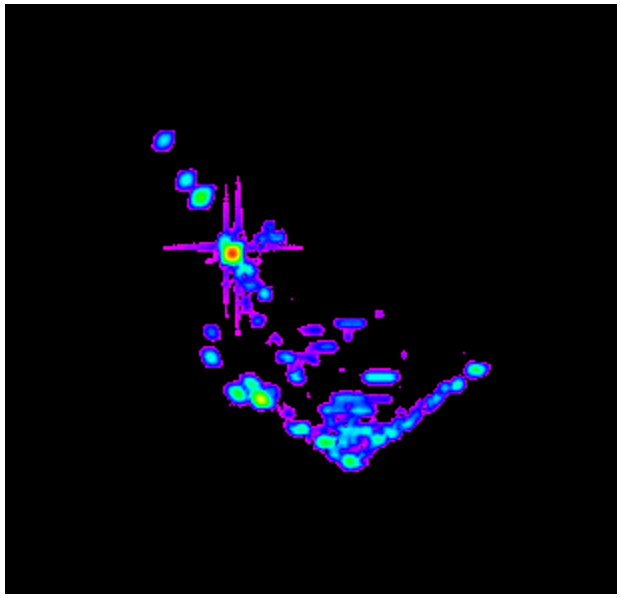




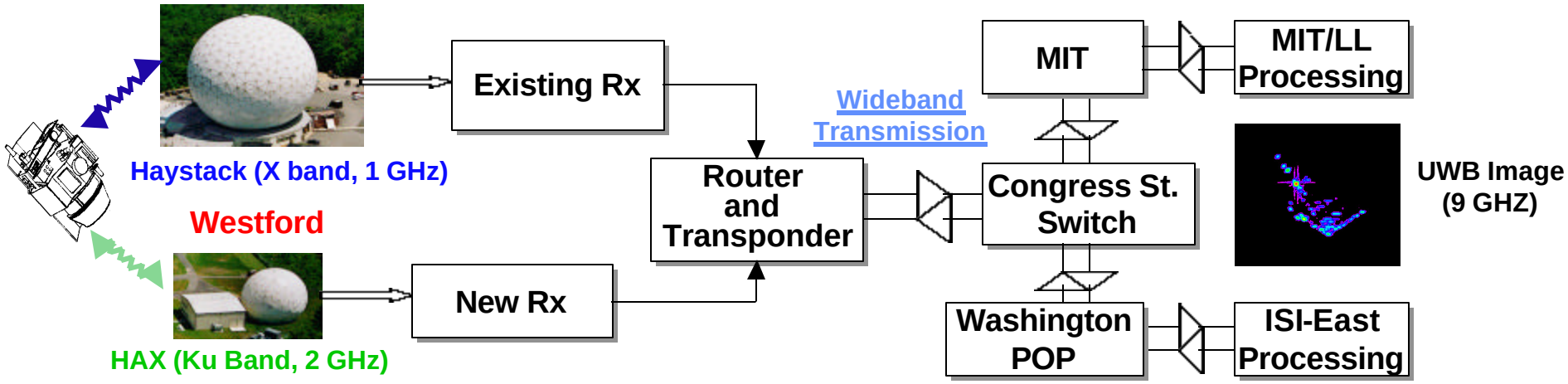
Simulated MSTI



UWB Processing



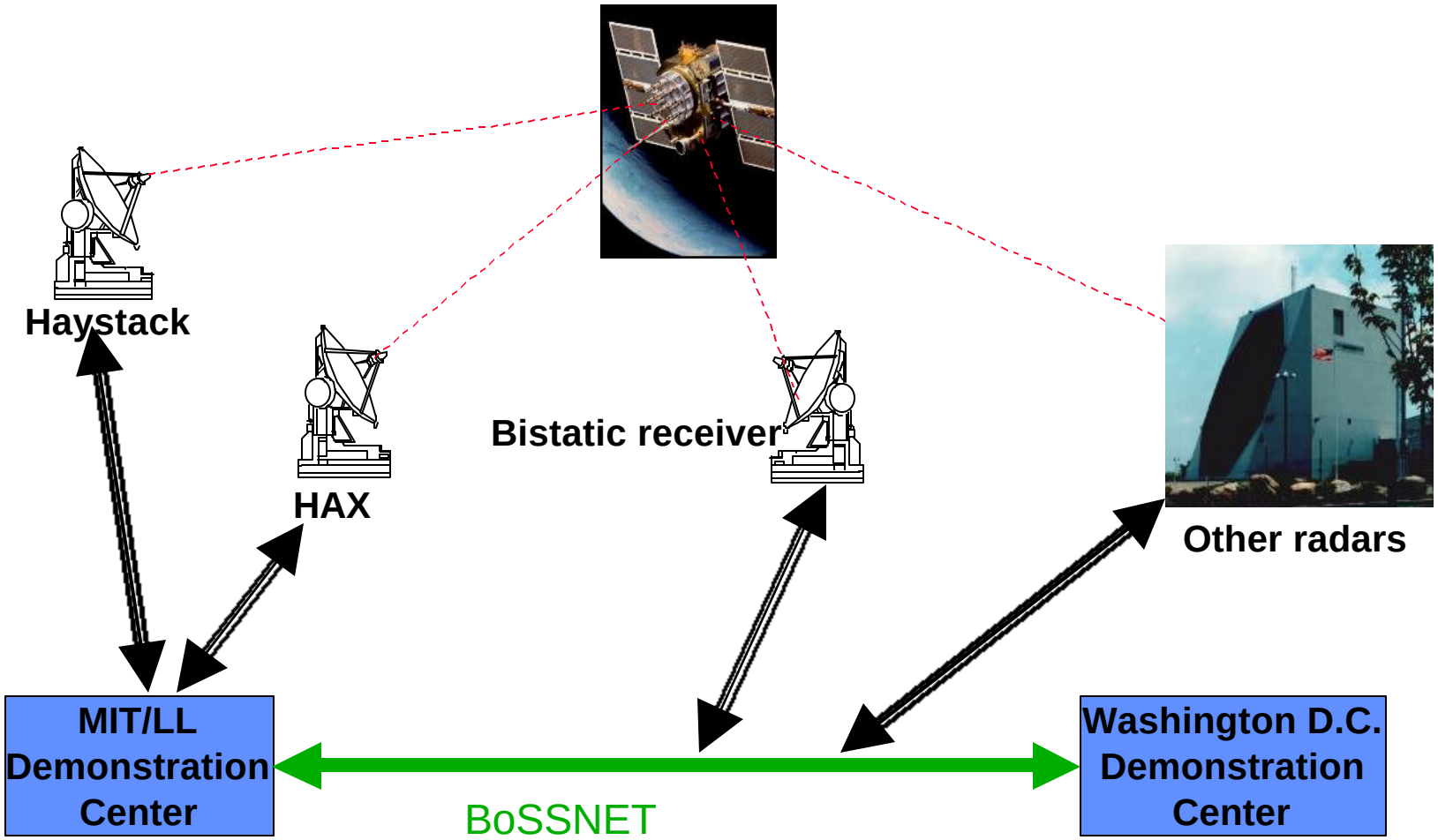
WNS Program Milestones



Milestone	2000									2001										2002								
	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Program Kickoff	◆																												
First Software Build	———	———	———	———	———	◆																							
Wideband Transmission Westford to MIT/LL		———	———	———	———	———	———	———	◆																				
Single Radar Imaging at LL						———	———	———	———	———	———	———	———	———	———	———	◆												
Sensor Upgrade Completed						———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	———	◆					
Initial UWB Imaging at LL													———	———	———	———	———	———	———	———	———	———	———	———	———	———	◆		
Final UWB Imaging Demo at ISI East																									———	———	———	———	◆

◆ Program Milestones

Bistatic Imaging Radar and Sparse Aperture Processing (Future)



Summary

- Demonstrate utilization of wide bandwidth networks to fuse multiple sensor data to support C^3I and Battle Management
- Packetized broadband communications is the enabler for multi-sensor coherent netting and exploitation
- Millstone testbed will provide a demonstration of wideband networked sensors at over 1 Gbits/sec:
  - Wideband multi-frequency coherent processing
- Program leverages existing advances in the following areas:
  - BoSSNET high bandwidth long distance optical link
  - Haystack and Hax radars with existing Radar Open Systems Architecture (ROSA)
  - Sparse Band Processing (SBP) algorithms from BMD efforts
  - High resolution satellite image generation and analysis tools