



Radar Open System Architecture & New Development Efforts For The Lincoln Space Surveillance Complex (LSSC)

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- **John Harris – Waveform Generator**
- **Dr. Jonathon Twitchell & Jeffrey Hargreaves – PACT System**



Definitions

- **Open Systems (DOD/SEI)**
 - “ An open system is a collection of interacting software, hardware and human components, designed to **satisfy stated needs**, with the interface specification of **components fully defined** and **available to the public**, maintained according to group consensus and in which the implementation of components are conformant to the specification. ”
- **COTS (summary from Federal Acquisition Regulations)**
 - Customarily used for **nongovernmental purpose** and has been **sold, leased or licensed to the general public**
 - **Exists a priori** (in a catalogue or price list)



Outline

- ➔ • **Objectives & Motivation**
- **Radar Open System Architecture (*ROSA*)**
 - Radar Architectures Old & New
 - Benefits
- ***ROSA* Applications**
- **New LSSC Development Efforts**
- **Status & Summary**



Objectives & Motivation

- **Establish an open systems approach as the foundation for radar systems development in order to:**
 - Lower development time
 - Improve life-cycle costs
 - Increase systems performance
- **Improve :**
 - Portability
 - Interoperability
 - Compatibility
 - Reusability
 - Maintainability
 - Affordability - improve acquisition model
 - Scalability- quick insertion of new technology
- **Develop plug-and-play radar components**
 - Share components between DOD programs
 - Migrate to commercial world



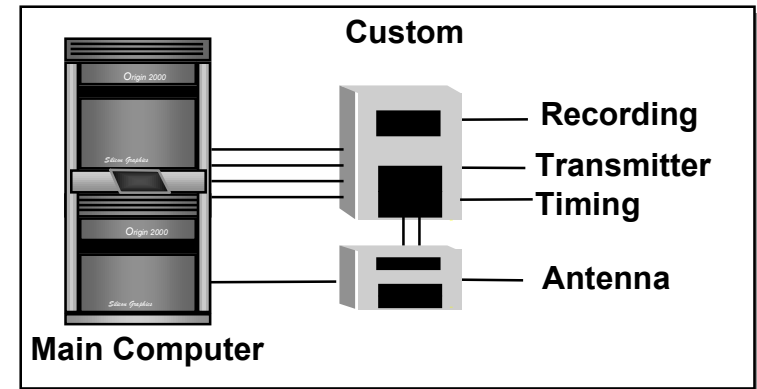
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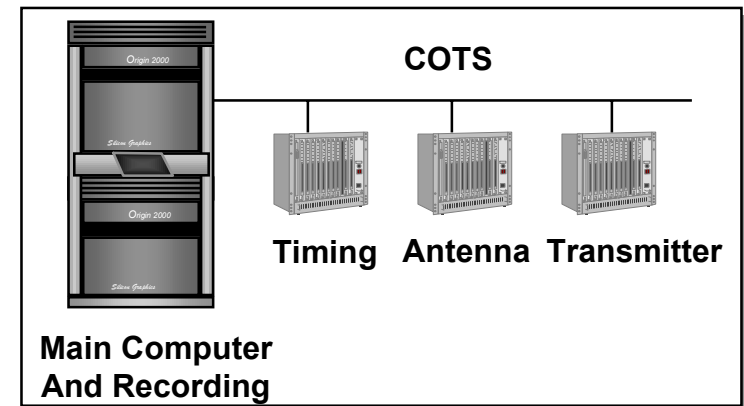


Radar Architectures Old & New

- **Traditional Radar Systems Model**
 - Master computer and centralized hardware
 - Custom development, proprietary HW & SW

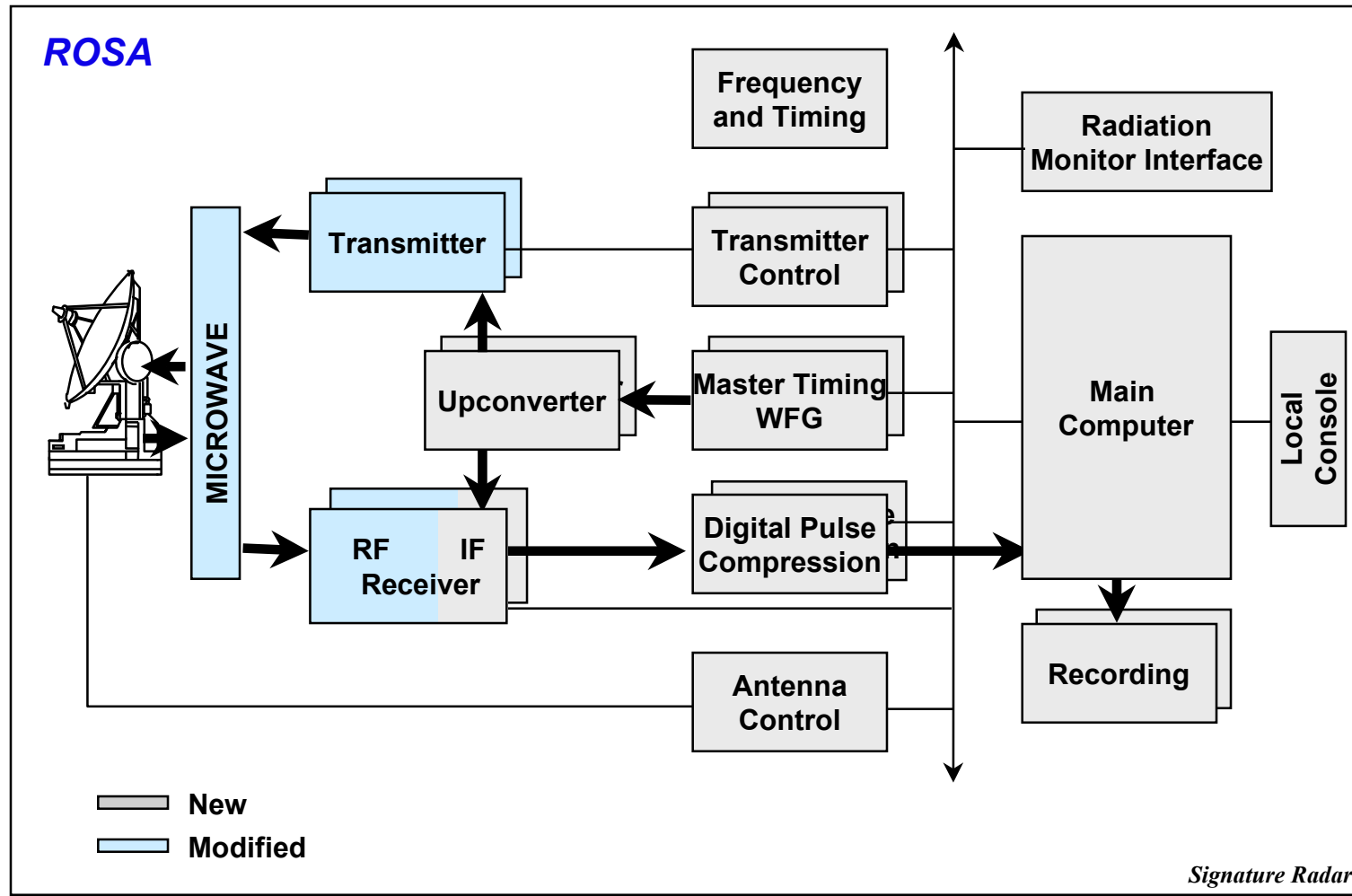


- **Open Systems Architecture**
 - Radar functionally decomposed into building block components
 - Industry standard COTS hardware and interfaces
 - Components available for technology transfer





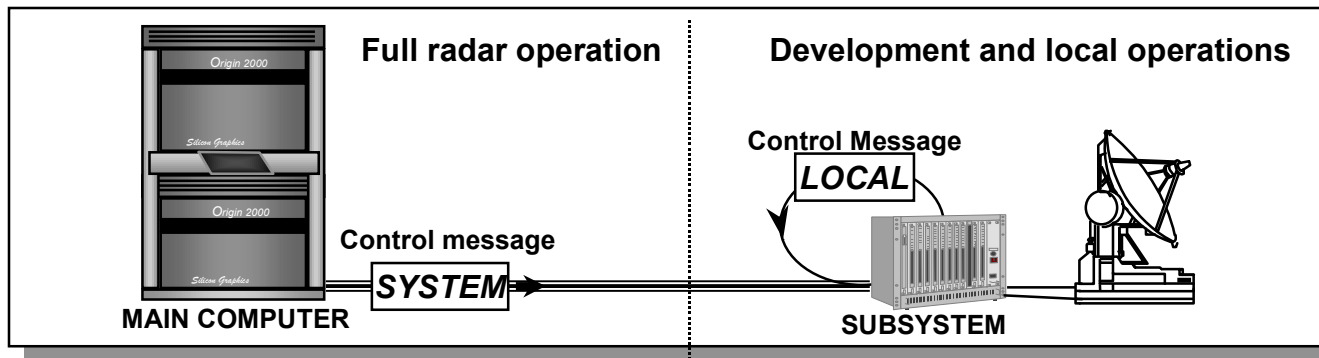
ROSA Block Diagram

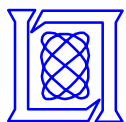




ROSA Benefits

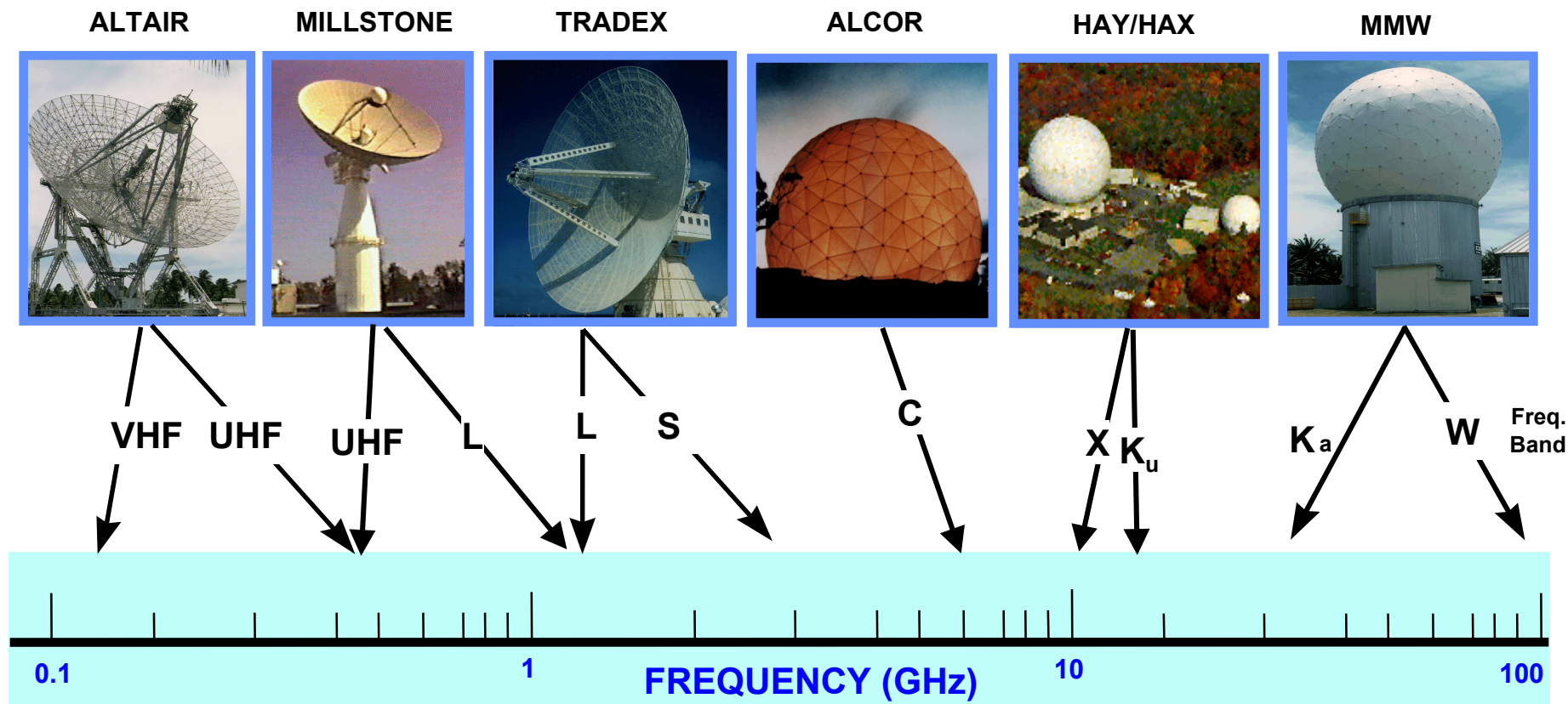
- **Reduced development time and O&M cost**
- **Decomposition provides efficient use of engineering resources**
 - Allows many small development teams (distributed locations)
 - Concurrent integration, test and evaluation
- **Components easily added, shared and modified**
 - Migration to new technology can be done at the unit level
- **New developments can begin with working components**
 - Better acquisition model, reduced NRE
- **Subsystems encapsulate specific radar function**
 - Underlying hardware and software is hidden
- **Communication is key to architecture**
 - Subsystem components completely define their functionality and interfaces to the outside world





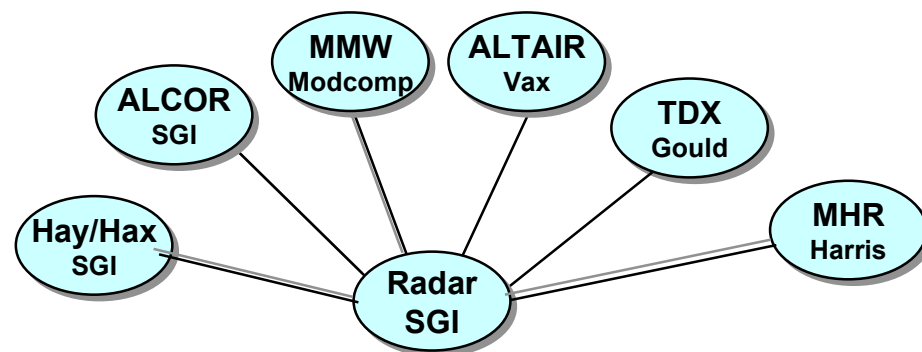
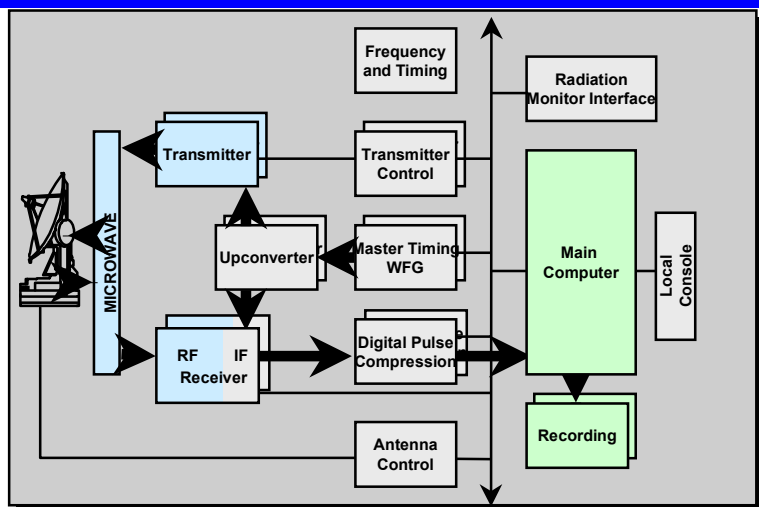
Lincoln Laboratory Modernization Radars with ROSA

Frequency Bands





Main Computer Real Time Program (RTP)



- **Common radar software for all radars**
 - 70% reduction in lines of code
 - 85% reduction in languages/OS/Platforms
- **Enormous capability**
 - >150 waveforms supported
 - 16 Channel coherent integration and detection
 - Multi-Target-Tracking (64 targets)
 - Bayesian Classifier (WB features)
 - Automated script-driven operations
 - Space surveillance functions
 - Common data recording format (> 80 Mbytes/sec)
 - Full PRI rate digital simulation
 - 64 targets and simulated targets over live data





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Kwajalein Radar Modernization



- **80% Reduction in custom hardware**
 > 85 % COTS
 Seven custom boards for all Radars
 70% reduction in number of racks
- **Automated and remote operations/diagnostics**
- **Dramatic improvement in flexibility**



New common radar system

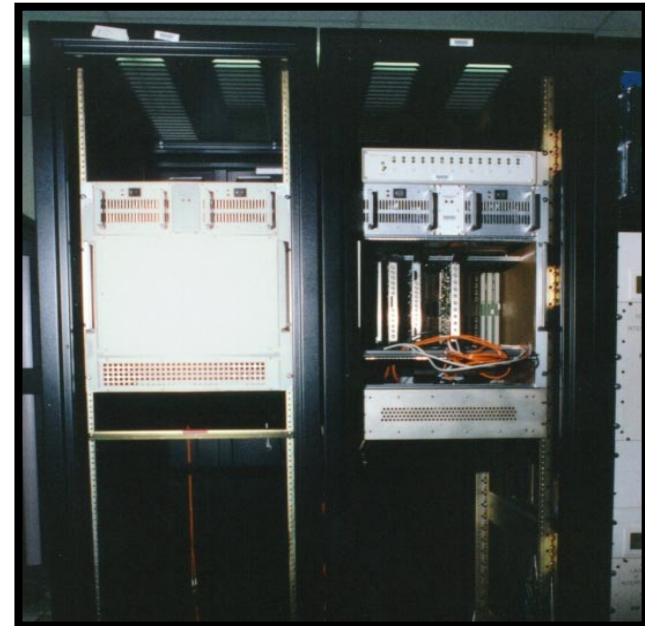


HAY/HAX Modernization

Disk Recording Radar Computers Digital Pulse Compression Master Timing



HAY Transmitter Control System (TCS) Master Timing System (MTS)





LSSC Software Development for Core RTP

- **Debris Mode**
 - Stare at Fixed Azimuth and Elevations and detect and record Debris objects as they go through beam
- **Trajectory Scans (α/β Scan) & (Progressive α/β Scan)**
 - Scans along satellite trajectory in time and orthogonal by beam width
- **Satellite Tracking Displays**
 - Simplified Displays for Satellite Tracking
- **Selective Radar Channel Recording**
 - Ability to record selective Radar Channel data (PP; PP/OP or all four channels)
- **Deep Space Tracking (MHR SATCIT)**
 - Integrate SATCIT on MHR and then HAY and HAX radars



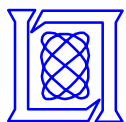
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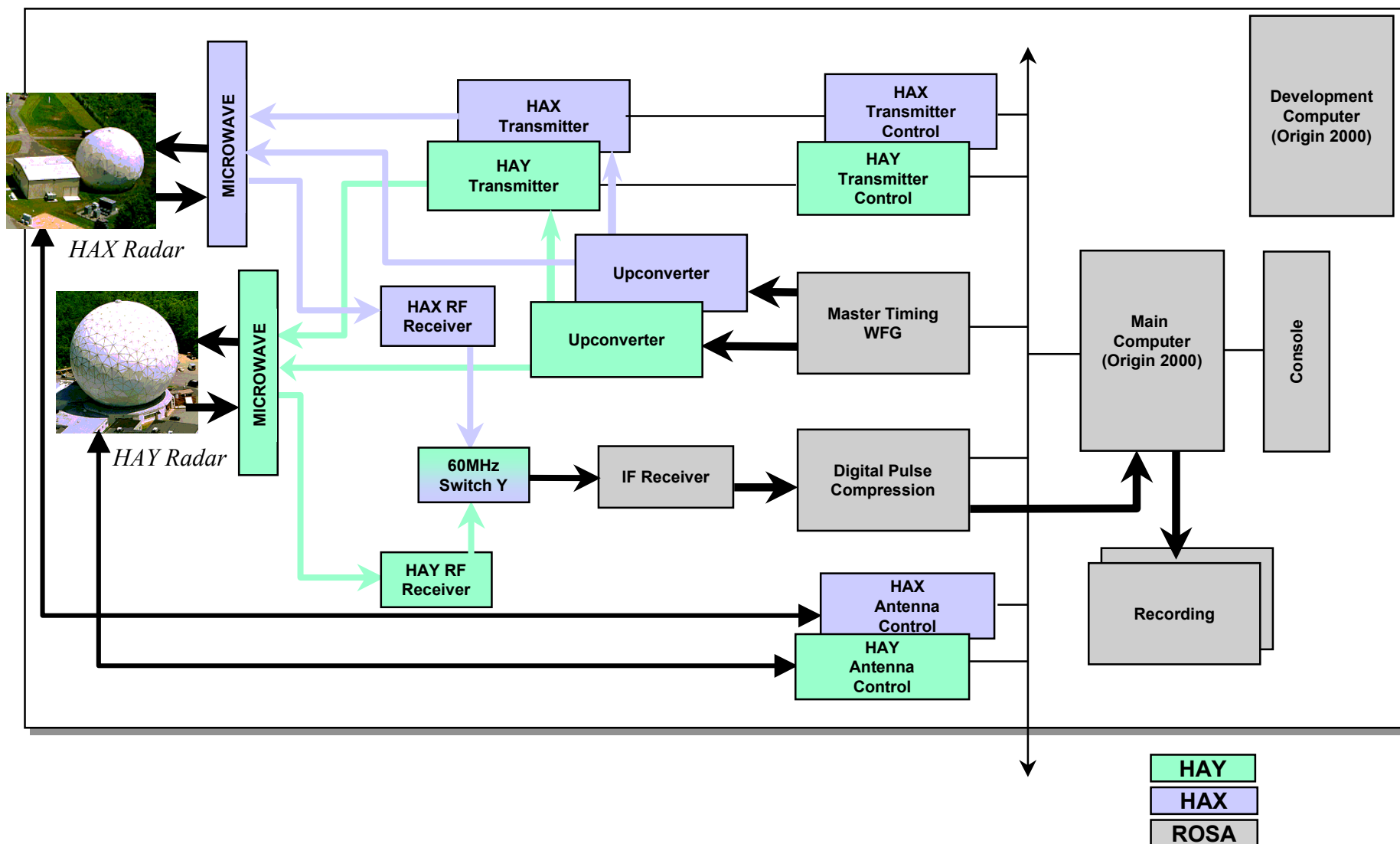


New LSSC Development Efforts

- **Wideband Network Sensors (WNS)**
 - High speed network demonstration with Radar Data >1gbit/sec
 - Second Signal Processing System to allow dual HAX/HAY operation
- **Wideband Waveform Generator Development**
 - Initial development of Medium Bandwidth Waveform Generator (MBWFG) with 64MHz Bandwidth clocking at 320MHz
 - Future development of Wideband Waveform Generator (WBWFG) with 256MHz Bandwidth clocking at 1GHz
- **Photonic ADC Technology (PACT) System**
 - Multiple Phase Program with initial sampling of PP data only at 63.125 MS/s and future sampling to 505 MS/s

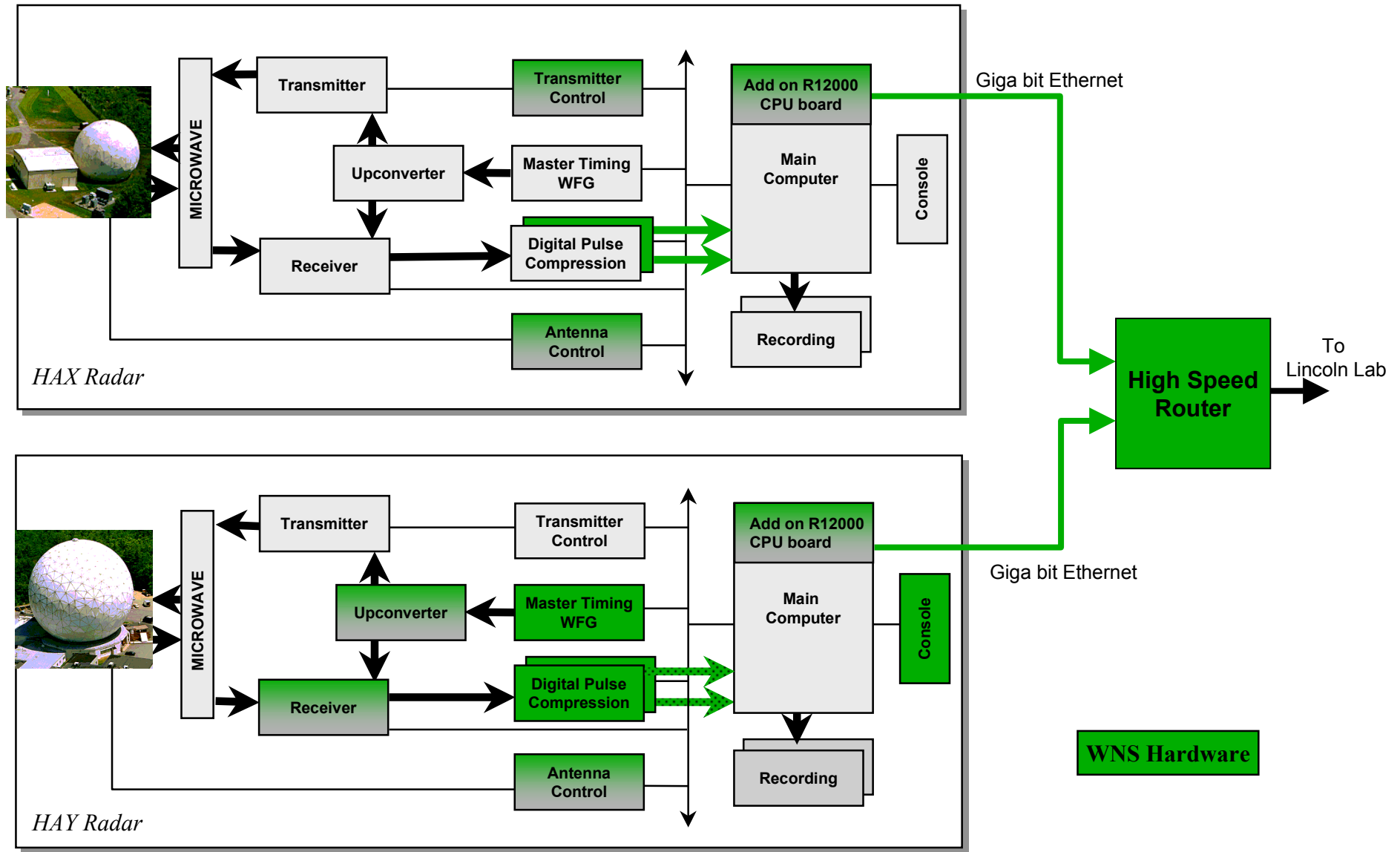


HAX/HAY ROSA Modernized Block Diagram (Pre-WNS)



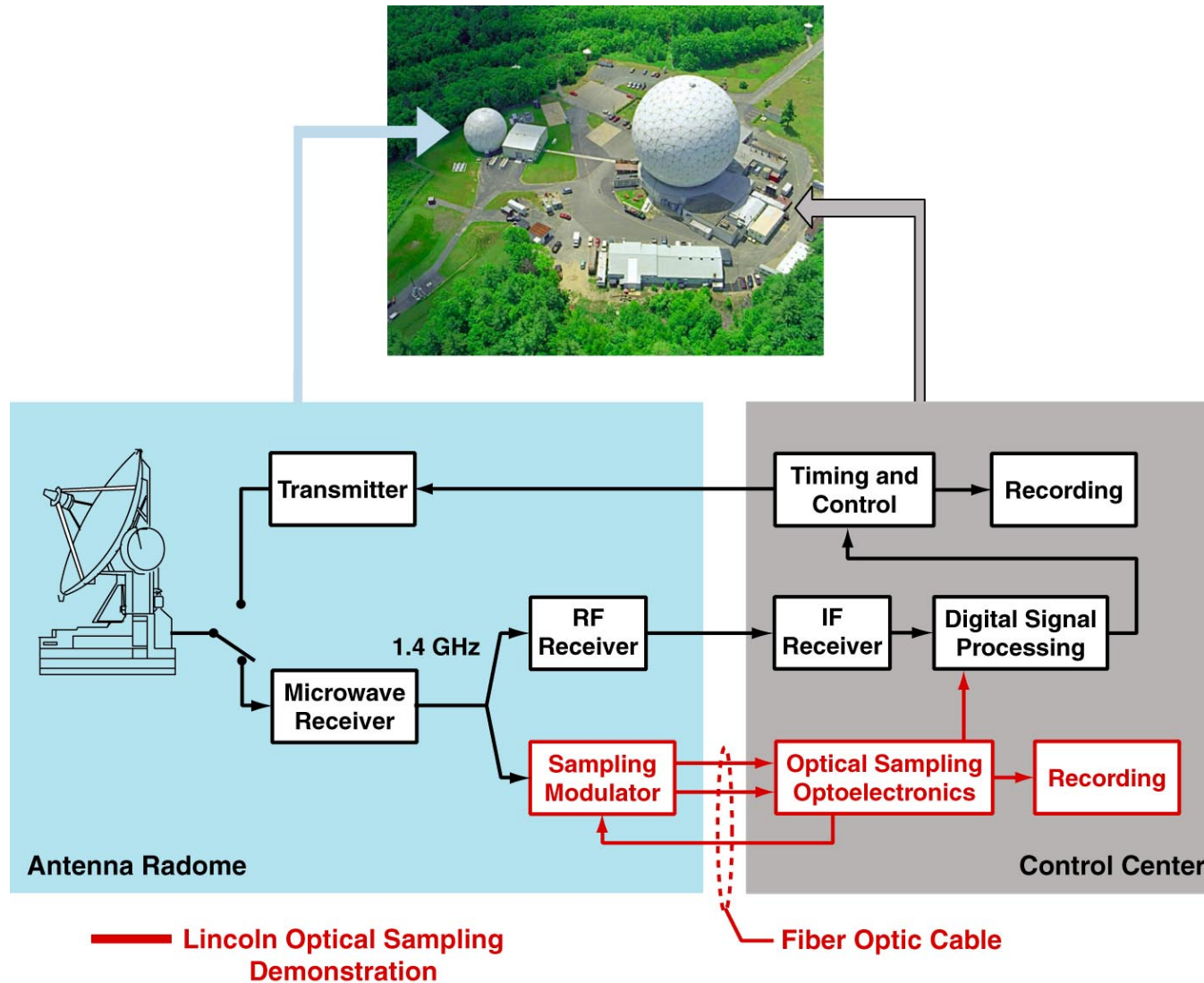


HAX/HAY ROSA WNS Block Diagram





PACT Radar Demonstration





PACT Objectives at HAX

FY00/01 Single receiver channel integration and test

(Internally Funded)

- Install fiber between control room and HAX antenna
- Fabricate new Correlation Receiver
- Fabricate 63 MS/s PACT system
- Integrate subsystems
- Record data for post-processing

$F_s = 63.125$ MS/s
31.5 MHz BW @ 1.38 GHz
66 dB SNR 70 dB SFDR

FY01/02 Initial system demonstration

(Not Funded)

- Single receiver channel wideband imaging
- Investigate real-time processing
- Investigate 4-channel implementation

$F_s = 505$ MS/s
8 x 63.125 MS/s, 1:8 optical
252.5 MHz BW @ 1.38 GHz
72 dB SNR 80 dB SFDR

FY02/03 Extended bandwidth demonstration

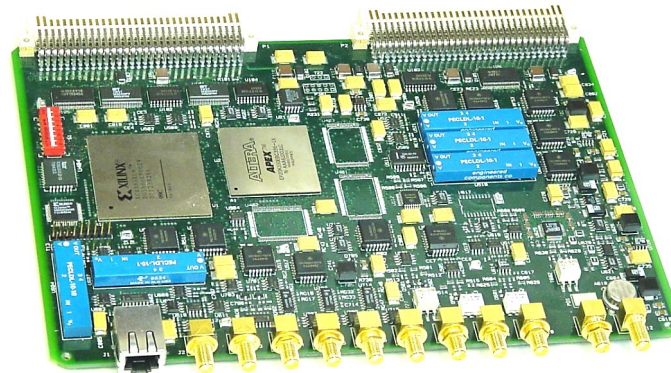
(Not Funded)

- Single channel extended bandwidth imaging



Waveform Generators Development

- **Medium Bandwidth Generator**
 - Simplified IRP Wide Bandwidth Generator
 - Single Slot VME 6u-160
 - Interfaces directly to Master Timing System Start Trigger
 - Arbitrary Waveform Capability
 - COTS Analog Devices DAC at 320MHz with 64MHz Bandwidth
- **Wide Bandwidth Generator**
 - Same as Medium Bandwidth Generator
 - Clock at 1000MHz with 256MHz Bandwidth





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LSSC Modernization Status

- **Haystack Auxiliary Radar (HAX)**
 - Tracking & Imaging operational
 - Debris in data verification mode
- **Haystack Radar (HAY)**
 - All subsystems operational except Transmitter which is being integrated with ROSA
- **Millstone Hill Radar (MHR)**
 - All Modernization Hardware has been procured
 - Antenna Control System is being integrated with ROSA
 - Deep Space Tracking (SATCIT) software being rewritten in modules that can be incorporated into KMAR CORE RTP



Summary

- **Radar Open Systems Architecture (*ROSA*) dramatically reduces the development time and cost of building radar sensors**
 - Efficient use of engineering resources
 - Abstraction of hardware layer from software
 - Portable building block components
- **Major use of *ROSA* in large radar development and modernization programs**
 - Dual Band Radar - 2 year development of land-based radar
 - Kwajalein Missile Range - Common architecture for 4+ radars
 - LSSC - Common architecture for 3 radars & large cost saving
- **Technology migration of *ROSA* components to industry**
 - Technology transfer within the DOD is more efficient at the component level than the system level
 - Future radar development could start with existing plug and play components from the commercial marketplace