Per Raytheon
(E-Systems)
Revised Final Rpt
960826

SeaWinds - 1B Technology Study Overview

October 1998

Study Summary

- Evaluated 4 options to improve nominal range resolution from 5.25 Km (QuikScat/SeaWinds - 1A) to 1 Km.
- identified changes and impacts to the SES modules. Defined new general purpose DSPs with greater programmability and increased systems flexibility.
- Developed candidate approach to improve receiver noise figure by 1.4 dB @ 25°C. Noise figure improves further to 2.2 dB by cooling the LNA @ 0°C.
- Defined 2 approaches to add a 3rd antenna beam port.
- Defined packaging concepts using SES-1A modules "as is" on SAS spinning side. Investigated fully repackaged SES on the SAS spinning skirt.

Program Summary (1)

Task (a)(1); WBS 1.0

Resolution Enhancement Performance Analysis

- Conducted SES system level analyses to evaluate 4 options consisting of timing schemes #4 and #6 configured with both digital and RF dechirp.
- Defined a new RF/digital hybrid dechirp approach that offers benefits over the individual RF and digital dechirp approaches.
- Developed an alternate approach to estimate receiver noise using the FFT frequency band outside the echo return bandwidth.
- Defined the changes and impacts of implementing the transmitter and receiver architecture including changes to the frequency plan.
- Defined the capability limits of the SeaWinds-1A hardware without modification (toward meeting the SES-1B options).
- Provided a preliminary SCP digital design and board layout for each signal processing approach using new DSP and other devices.
- Addressed FFT implementation options, increased A/D resolution, and revisions to the telemetry serial interface.

Program Summary (2)

Task (a)(2); WBS 2.0

Signal to Noise Ratio (SNR) Improvement

- Developed candidate approaches to reduce receiver noise figure and assessed implementation risks.
- Generated revised noise figure budgets through cascaded noise/gain analysis and with use of an OmniSys RF Simulation.

Task (a)(3); WBS 3.0

Interface changes

- Defined the implementation approach and assessed the impact of adding new commands to the SCP.
- Studied the impact of implementing a commandable exciter output level control to the SES and provided recommendations for an improved interface.

Program Summary (3)

Task (a)(4); WBS 4.0

Configuration Change/Performance Impact Assessments

- Defined a packaging concept and assessed the implementation risk of using the SES-1A modules "as-is" on the SAS spinning skirt.
- Investigated a new packaging concept and assessed implementation risk of a fully repackaged SES configuration on the SAS spinning skirt.
- Defined a TRS repackaging concept for a full redesign of the TRS and a minimal redesign approach to add a 3rd antenna beam port.

Task (a)(5); WBS 5.0

Development of a Stepped Calibration "Cold/Warm" Noise Source

- This task was originally "on-hold" and then deleted by JPL in August 97.

Task (b); WBS 6.0

Lessons Learned Report

- This task was deleted by JPL on 6/19/97.

Program Summary (4)

Task (c); WBS 7.0

Periodic Reporting

- This task covered three monthly reports provided for June, July and August 97.

Task (d); WBS 8.0

Oral Report/Discussions

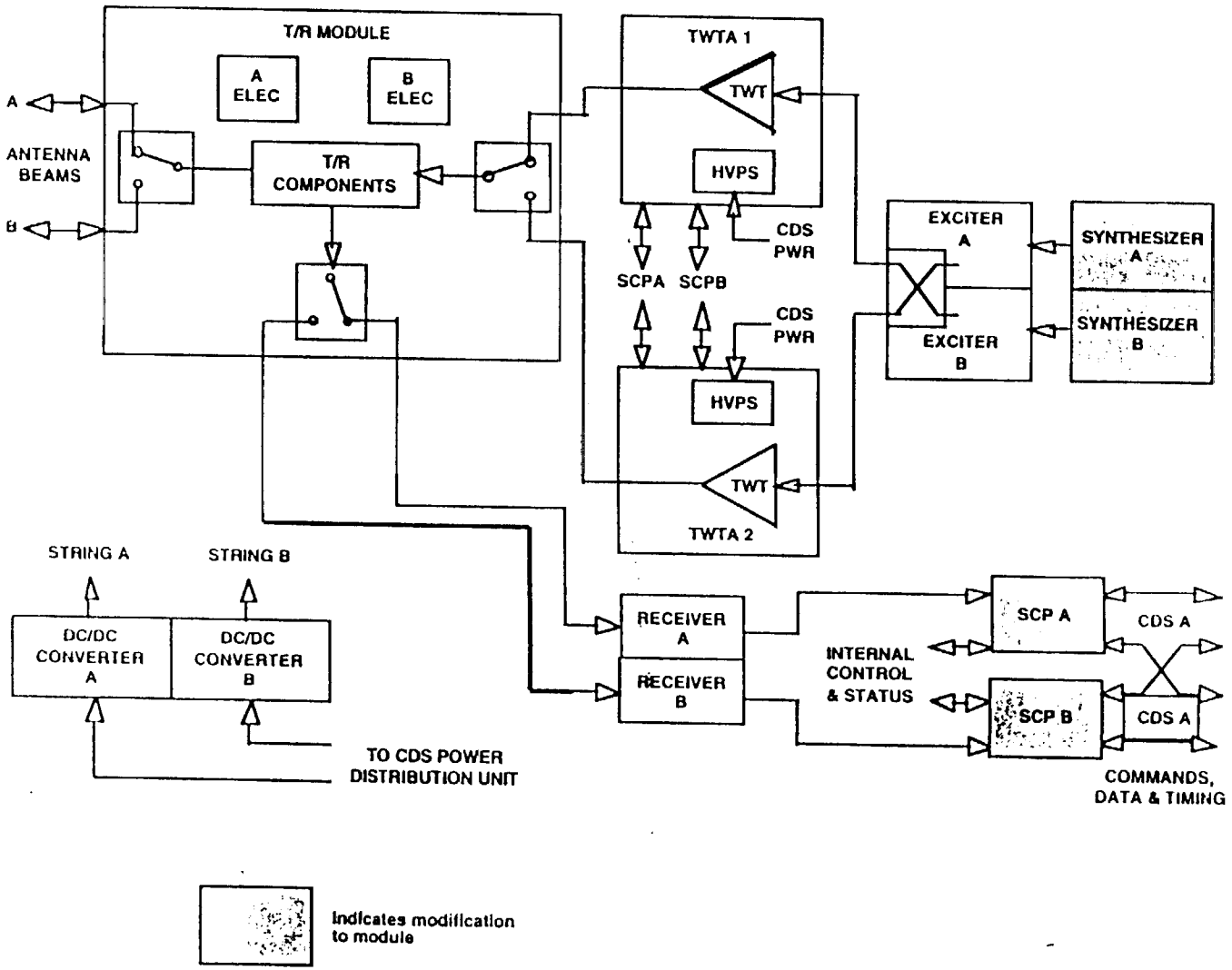
- This task was deleted by JPL on 6/19/97.

Task (e); WBS 9.0

Final Report/Study Review

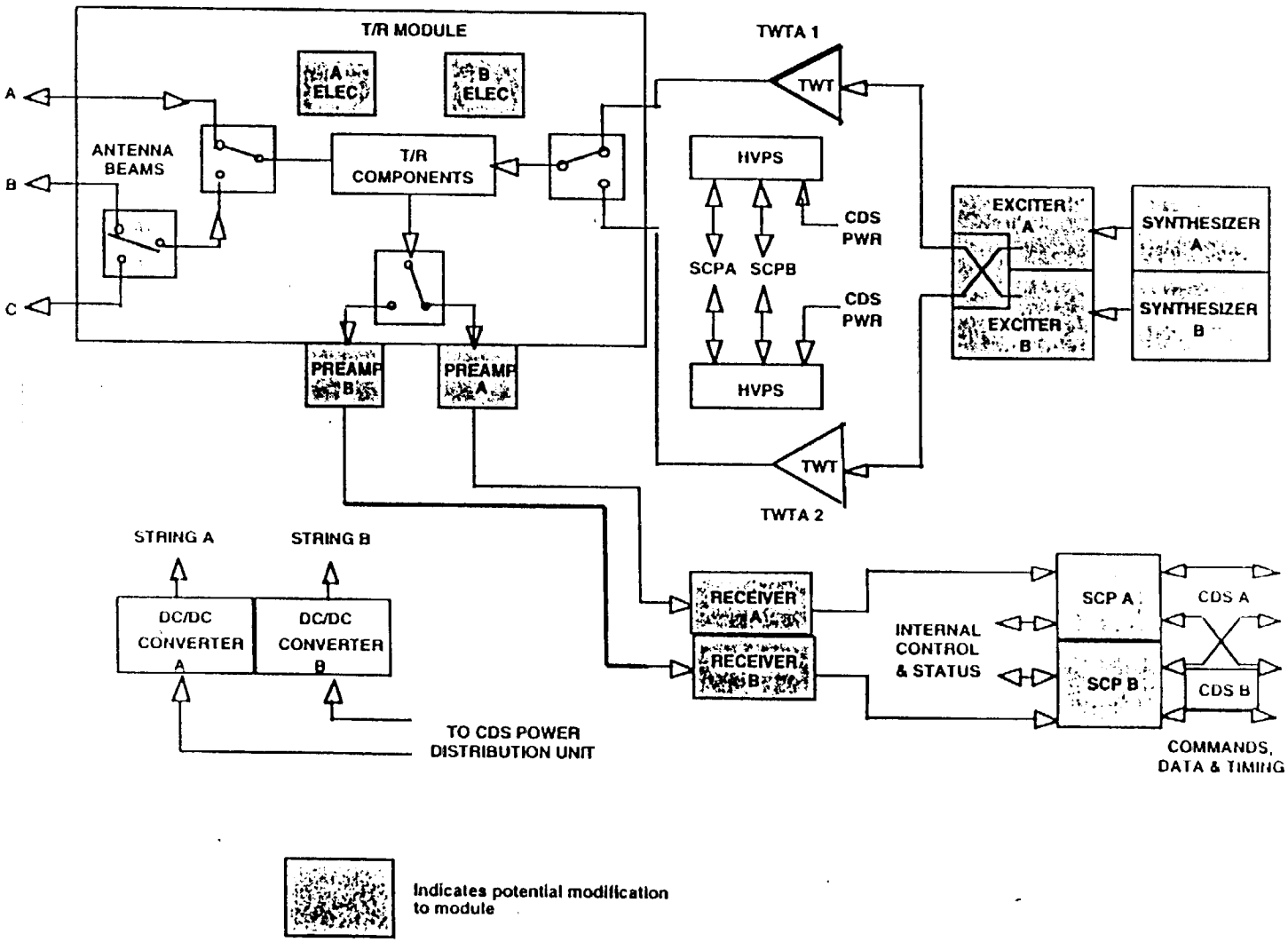
- The final report was sent to JPL on 9/9/97. The final study review scheduled for 9/12/97 was delayed until mid Oct per JPL direction.

SeaWinds -1A Enhancement Modifications



Indicates modification to module

SeaWinds-1B Configuration Option



Indicates potential modification to module

SeaWinds - 1B Study Program
Recommendations for Follow-On Study (1)

Resolution Enhancement Performance Analysis, WBS 1.1

- Perform in-depth analysis of hybrid RF/digital dechirp design
- Define the FFT noise estimation procedure
- Allocate module requirements vs high resolution cell specification
  - Investigate and define the absolute and relative calibration error budgets
- Investigate the DDS chirp rate quantitization effect
  - Approximately 1 kHz/msec chirp rate quantization current design
  - Less than 1 Hz/msec effective chirp rate quantization modified design
- Investigate methods to compress FFT data

SeaWinds - 1B Study Program
Recommendation for Follow-On Study (2)

Signal-to-Noise Ratio (SNR) Improvement, WBS 2.1

- Design, build, and test InP LNA to interface directly with the TRS
- Redesign the TRS RF preselect filter to partition the filter between the LNA input and output
- Continue investigation into cooling the LNA
- Investigate methods to eliminate antenna beam scan loss (phase center shift of single feed, phased array feed, and separate Tx and Rx feeds)
- Reduce RF loss with fewer receiver protect switches
  - Investigate MEMs switches

SeaWinds - 1B Study Program
Recommendation for Follow-On Study (3)

Interface Changes to SES-1B Interface, WBS 3.1

- Assess impact of splitting the SES-1B between the SAS stationary and spinning sides
- Assess impact on slip ring requirements with the SES-1B mounted on the SAS (spinning side)
- Investigate interleaved data and commands to/from the SES and Radiometers
- Investigate receiving and distribution power from the SPS interface to the SES and Radiometers
- Conduct detailed design on adding a 3rd antenna beam port to the TRS

SeaWinds - 1B Study Program
Recommendation for Follow-On Study (4)

IPT Configuration Change/Performance Impact Assessment, WBS 4.1

- Perform detailed CAD studies of the antenna, feeds, SES, Radiometers, and waveguide interfaces
- Obtain accurate radiation view factor analysis using NEVADA for thermal fluxes, hot and cold orbits
- Optimize skirt truss and plate design by lowering stress margins and reduce mass
- Investigate momentum compensation requirements and balance mass techniques
- Perform detailed study of composite radiator performance and implementation
- Fabricate mechanical mock-up for spatial layout and validation testing

SeaWinds - 1B Study Program
Recommendations for Follow-On Study (5)

Development of a Stepped Calibration "Cold/Warm"Noise Source, WBS 5.0

- Design, build, and test Ku-Band and K-Band "C/W" Noise Sources to JPL requirements
- Integrate and test the Ku-Band Noise Source in the SES breadboard hardware
- Provide support to JPL to integrate and test both Noise Sources in JPL's Radiometers
- Validate test results in the RSC simulation

SeaWinds - 1B Study Program
Recommendation for Follow-On Study (6)

Improvements to Synthesizer and Exciter, WBS TBD

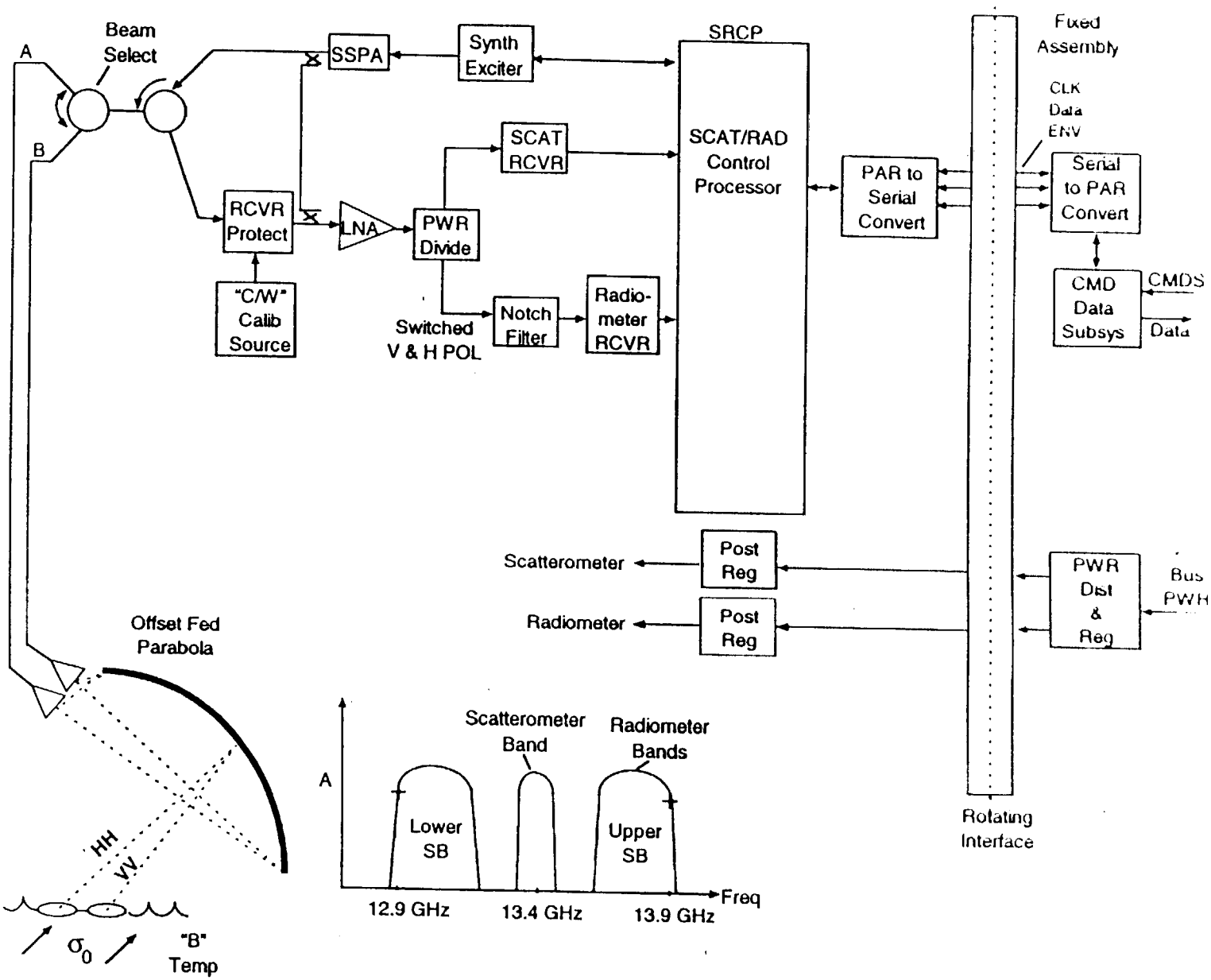
- Design, build, and test the wider chirp bandwidth filters and amplifiers
  - Demonstrate improved phase linearity
  - Demonstrate enhanced suppression of spurious signals
- Research alternate STALO vendors to assess improvement in frequency stability w/o additional power consumption
- Investigate improvements to the Exciter/TWTA cross strap interface
  - New methods of implementing cross strap
  - Moving power monitors to the TWTA input

SeaWinds - 1B Study Program
Recommendations for Follow-On Study (7)

System Engineering Support, WBS TBD

- Facilitate IPT Design Approach
  - Generate and maintain joint lists (JPL/RSC) of key radar parameters and design ranges (radar link, antenna, transmitter, receiver, calibration ----)
  - Analyze the RFI vulnerability of the polarimetric radiometer sensors to the scatterometer
- Define an approach to integrate a co-boresighted radiometer channel into the SES receiver
- Investigate the integration of the SES SCP functions with the CDS functions
- Next generation wind vector sensor
- Phased array antenna
  - Electrical vs mechanical scanning

Candidate SeaWinds 1B Scatterometer w/ Radiometer Channel



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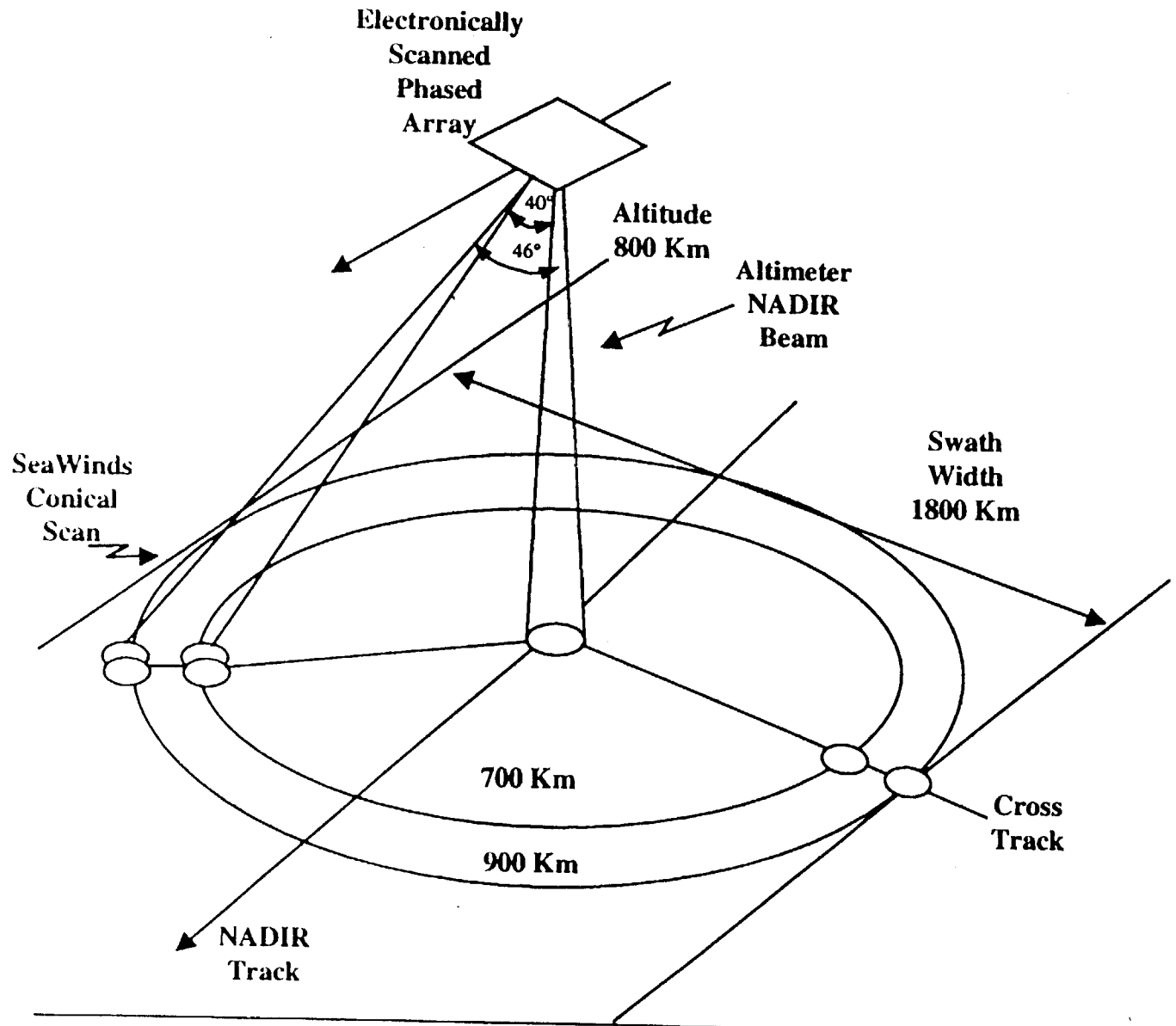
Concept for Multifunction Ku-Band Phased Array Antenna



Commandable Antenna Beam Options

- **Conical Scan (40° and 46°)**
  - SeaWinds; Dual Beam, HH & VV, Scan Rate - 18 RPM
  - Alternate Incidence Angles, Switched Beams, Polarizations, and Scan Rates
- **Fixed NADIR Beam (0°)**
  - Altimeter Applications
- **NADIR Beam (0°)/Spectrum Beam (10°)**
  - TPFO candidate to provide directional wave spectrum
- **Fixed Side Looking Beams (20° to 50°)**
  - SAR Applications

Candidate SeaWinds 1B Activities (Near Term)

- Chirp Generation Modification
  - Implement a 1 MHz/ms chirp scheme to support 1km resolution
- Upgrade SCP Design
  - New DSP design to support 1km resolution and 1B timing requirements
- SES Miniaturization Study
  - Explore use of Raytheon capabilities in the areas of MCM's, MMIC's, Hybrids and new device technologies
- TWTA Replacement
  - Demonstrate a 13.4 GHz 50 W solid state power amplifier capability
- Receiver Noise Figure Improvement
  - Lower SES NF employing Raytheon (HRL) InP technology
- Radiometer Investigations
  - Provide support to Linwood Jones efforts

CHIRP Generation Modification

- Complete system analysis to finalize frequency step size and optimize RF/Digital CHIRP partitioning
- Breadboard new CHIRP generator
  - Select high speed DDS to generate higher output frequency and wider Tx CHIRP bandwidth
    - » Simplify existing 1A Tx upconversion scheme
    - » Eliminate narrow band filter requirements
  - Provide Rx DECHIRP output capability
- Verify instrument performance
  - Integrate with 1A SES breadboard
  - Evaluate linearity effects

Labor Hours
(Chirp Modification)

	Sept	Oct	Nov	Dec	Jan	Feb
M. Beaulieu	40	40	40	40	40	40
W. Boller	40	40	40	40	40	40
R. Crowley	10	10	10	10	10	10
E. Chou						
W. Plamowski						
B. Roeder						
M. Smith	20	20	20	20	20	20
M. Wrubel	40	40	40	40	40	40

Material Cost: $2000

Upgrade SCP Design

- Implement 12 bit I/Q A/D
  - Modify 1A signal conditioning circuits for 12-bit A/D performance
  - Integrate with 12 bit A/D's and characterize

- Build and test new signal processor design
  - Purchase ADSP21020 demonstration board to evaluate memory access timing and algorithm timing required for 1B
  - Build all required interface circuits to provide the proper input samples and retrieve processed data for analysis
  - Integrate with 12 bit A/D circuits and test performance

- Perform subsystem evaluation
  - Integrate and test with breadboard 1A SES

Labor Hours
(Upgraded SCP)

	Sept	Oct	Nov	Dec	Jan	Feb
M. Beaulieu	10	10	10	10	10	10
W. Boller	40	40	40	40	40	40
R. Crowley	80	80	80	80	80	80
E. Chou						
W. Plamowski	80	80	80	80	80	80
B. Roeder						
M. Smith						
M. Wrubel	40	40	40	40	40	40

Material Cost: $1100

SES Miniaturization Study

- Investigate direct miniaturization techniques
  - SCP implementation as an MCM
  - Power converter hybrids
  - MMIC implementations for microwave circuits
  - Employ existing state-of-the-art capabilities within Raytheon

- Receiver/Transmitter architecture optimization
  - Convert RF stages to high speed integrated digital devices
    - » High speed A/D's in place of receiver IF/baseband stages
    - » Replace transmit upconversion stages with high speed DDS Chirp Generator
    - » Permits Rx & Tx functions to move into an SCP MCM

Labor Hours
(SES Miniaturization Effort)

	Sept	Oct	Nov	Dec	Jan	Feb
M. Beaulieu						
W. Boller	40	40	40	40	40	40
R. Crowley	40	40	40	40	40	40
E. Chou						
W. Plamowski						
B. Roeder						
M. Smith	40	40	40	40	40	40
M. Wrubel	20	20	20	20	20	20

TWTA Replacement

- Finalize topology selection for final output stage
  - Design for 50W output power minimum
  - Select device type
    - » PHEMT, MESFET, GaN, other
    - » Raytheon (ADC, HRL)
    - » Fujitsu, others outside Raytheon
  - Select power combining method

- Breadboard 50W output stage
  - Test existing Raytheon HRL amp at 13.4 GHz
  - Evaluate pulsed amplitude and phase linearity performance
  - Integrate with SES breadboard to evaluate system performance

Labor Hours
(TWTA Replacement)

	Sept	Oct	Nov	Dec	Jan	Feb
M. Beaulieu	40	40	40	40	40	40
W. Boller	10	10	10	10	10	10
R. Crowley						
E. Chou	40	40	40	40	40	40
W. Plamowski						
B. Roeder						
M. Smith	40	40	40	40	40	40
M. Wrubel						

Material Cost:

Receiver Noise Figure Improvement

- Breadboard new receiver downconverter
  - Evaluate Raytheon (HRL/ADC) InP LNA MMIC at 13.4 GHz if available
  - Build an MIC InP LNA if MMIC version at 13.4 GHz is not available
  - Integrate LNA into 1A downconverter assembly modified for remote mounting at the TRS assembly
  - Perform downconverter assembly noise figure testing over temperature
- Perform subsystem evaluation
  - Simulate remote downconverter mounting at the TRS
  - Integrate with 1A SES breadboard to demonstrate subsystem noise figure improvement
  - Verify receiver dynamic range and linearity

Labor Hours
(Improved Noise Figure)

	Sept	Oct	Nov	Dec	Jan	Feb
M. Beaulieu	40	40	40	40	40	40
W. Boller	10	10	10	10	10	10
R. Crowley						
E. Chou	40	40	40	40	40	40
W. Plamowski						
B. Roeder						
M. Smith	40	40	40	40	40	40
M. Wrubel						

Material Cost:

Labor Hours
(Radiometer Studies)

	Sept	Oct	Nov	Dec	Jan	Feb
M. Beaulieu	10	10	10	10	10	10
W. Boller	10	10	10	10	10	10
R. Crowley	10	10	10	10	10	10
E. Chou	40	40	40	40	40	40
W. Plamowski						
B. Roeder	80	80	80	80	80	80
M. Smith	10	10	10	10	10	10
M. Wrubel	40	40	40	40	40	40

Radiometer Investigations

- QuikScat receiver radiometer characterization support
  - Provide requested design and test data to support Linwood Jones receiver radiometer math model generation
  - Perform requested tests on breadboard SES receiver
    - » Simulate losses external to the SES and perform noise calibrations
    - » Evaluate stability and performance as a radiometer
    - » Validate radiometer math model

- Integrated radiometer study
  - Investigate methods to incorporate integrated radiometer with SES for water vapor correction
  - Evaluate use of Raytheon HRL high performance digital and RF device technologies to minimize size and weight impact