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SPACEBORNE IMAGING RADAR PROJECT

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In June of 1985 the Project Initiation Agreement was signed by the Jet Propulsion Laboratory and the NASA Office of Space Science and Applications for the Spaceborne Imaging Radar Project (SIR). The thrust of the Project is to continue the evolution of synthetic aperture radar (SAR) science and technology developed during SEASAT, SIR-A and SIR-B missions to meet the needs of the Earth Observing System (EOS) in the mid 1990's. As originally formulated, the Project plans were for a reflight of the SIR-B in 1987, the development of a new SAR, SIR-C, for missions in mid 1989 and early 1990, and the upgrade of SIR-C to EOS configuration with a qualification flight aboard the shuttle in the 1993 time frame (SIR-D). However, the loss of the shuttle Challenger has delayed the first manifest for SIR to early 1990. This delay prompted the decision to drop SIR-B reflight plans and move ahead with SIR-C to more effectively utilize this first mission opportunity.

The implementation plan calls for combined SIR-C/XSAR mission on the Space Shuttle, presently scheduled for January 1990, and again in July 1990. The SIR-C, developed by NASA/JPL, will consist of L and C-band SARs. The XSAR operating at X-band will be developed by the Federal Republic of Germany (BMFT/DFVLR) in collaboration with Italy (CNR/PSN). Integration of the three SAR units and interfacing with the appropriate shuttle support teams are the responsibility of JPL. Separate, but coordinated, Announcements of Opportunity and Science Team Selection are planned for SIR-C and XSAR. There will be joint Science Team planning and mission operations. The schedule of SIR-C/XSAR activities is presented in Figure 1.

The SIR-C configuration is illustrated in Figure 2. The 12 x 4.1 meter antenna is a distributed, active element array for L- and C-band. There are 18 L-band panels each containing 14 transmit/receive (T/R) units and 18 C-band panels each containing 28 T/R units. The XSAR antenna is a waveguide array with vertical polarization. The baseline performance requirements are well documented in the SIR-C Science Working Group and EOS SAR Panel Reports. A summary of major design drivers common to SIR-C and EOS are:

- Bandwidth - 10 or 20 MHZ
- Polarization - H, V, HV, VH (any combination)
- Incidence angle - 15 to 60 degrees (selectable)
- Min. swath - greater than 15 km
- Wide swath - greater than 150 km (scan mode)
- Calibration - ± 3 dB absolute
  - ± 1 dB relative
- Recording - 5 channels at 45 Mbps

The major SIR challenges derive from the requirement for development of a SIR-C design which can be utilized on EOS. Some of the more significant comparisons between SIR-C and EOS needs follow:

		SIR-C	EOS
o	Performance altitude	250 km	500 - 800 km
o	Reliability	2 weeks	2 - 15 years
o	Processing	500 hrs/45Mbps in 1 year	45Mbps continuous with keep up
o	Mission operations and data distribution	Labor intense	Automated and user interactive

To meet the higher altitude performance demands of EOS, the distributed antenna will be expanded from 12 to 20 meters. Figure 3 is illustrative of the SIR-C and EOS performance with comparisons to that of SEASAT, SIR-A and SIR-B.

The distributed element antenna design is ideally structured to gracefully degrade with multiple element failures. This fact coupled with redundancy in all other SIR-C subsystems provides the reliability base needed for EOS. The following are examples of design fault tolerance:

- o Random T/R unit failures of 10% - 1dB gain loss and 2 dB in peak sidelobes
- o 1, 2, or 3 panel failures - 0.5 dB, 1.02 dB, 1.58 dB one way loss
- o Failure of RF feed, charging power supply, receiver - loss of one polarization
- o Failure of controller, stahlo, calibration unit, exciter - block redundant, loss of time to switchover
- o No single component failure causes loss of both L&C SAR
- o EOS provides modular replacement/ repair in two year intervals

The Advanced Digital SAR Processor (ADSP) developed under sponsorship from the NASA Office of Aeronautics and Space Technology (OAST) will complete engineering model performance tests in the summer of 1986. This processor can handle the 45 Mbps data in real-time. It will also be possible to simultaneously process H, V, VH, and HV channels to maintain uniform processing parameters and simplify registration to support polarization utilization investigations. There are numerous special products that must be handled off line, for example: precision calibration, geocoding, terrain correction, polarization synthesis, etc. While this is satisfactory for SIR-C, EOS needs more time efficient output of special products. It is anticipated that EOS will also need an onboard expert system to aid in the massive data management problems. The use of an onboard processor has a high potential for satisfying this need. The continuation of a strong research and advance development program by NASA OAST and Information Systems Offices is urgently needed to support these developments in preparation for EOS.

The SIR-C instrument control center concept is presented in Figure 4. The basic elements of this system were developed in SIR-B and, as noted, require only subsets to be further modified for SIR-C. This approach using segmented, micro-computer based software elements can be readily updated for EOS. It is envisioned that these elements will be consolidated into one automated planning center for instrument control. Expansion of the control center to provide capability for user interaction, both in data acquisition and data distribution, is critical to EOS. A proposal is in development to add a telescience experiment to SIR-C. The concept is shown in Figure 5. Besides the real real-time control and data access capabilities of the telescience station, the real-time interaction through the data catalog and image processor would provide direction to the special products generation process.

The SIR Project provides significant advancements needed for effective and efficient EOS SAR application. In summary, these are:

- o Opportunities for scientific investigations with multiple frequencies, polarizations, and incidence angles.
- o A core instrument upgradable for EOS use.
- o Operational real-time processing.
- o Evolvable instrument control technology.

Important steps in the SAR evolution to EOS remain dependent on supporting research and technology sponsorship. In summary, these are:

- o Development of techniques to incorporate special products into the real time processing cycle.
- o Development of onboard processing technologies for use in end-to-end data management.
- o Development of telescience techniques for user mission optimization and effective data acquisition.

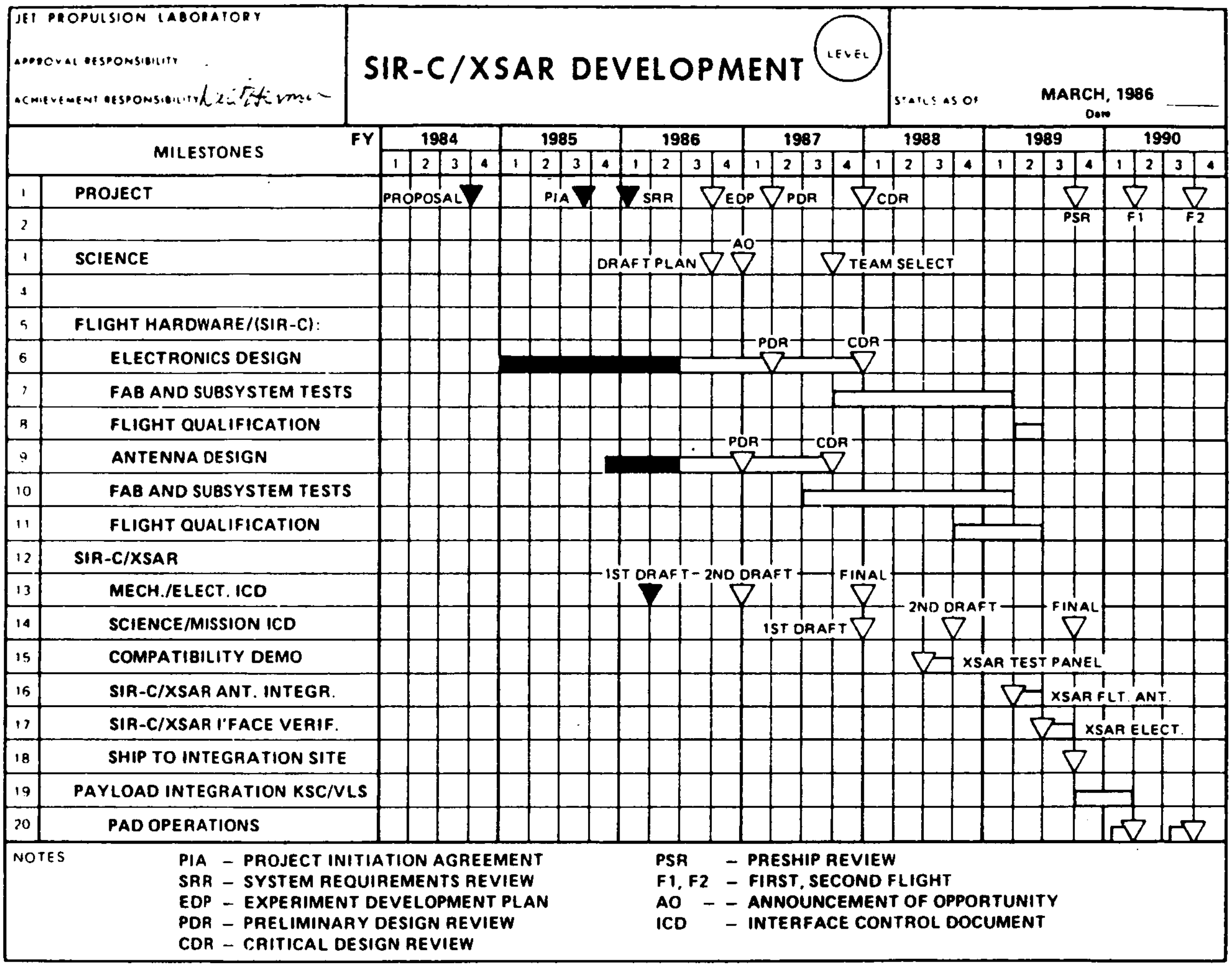
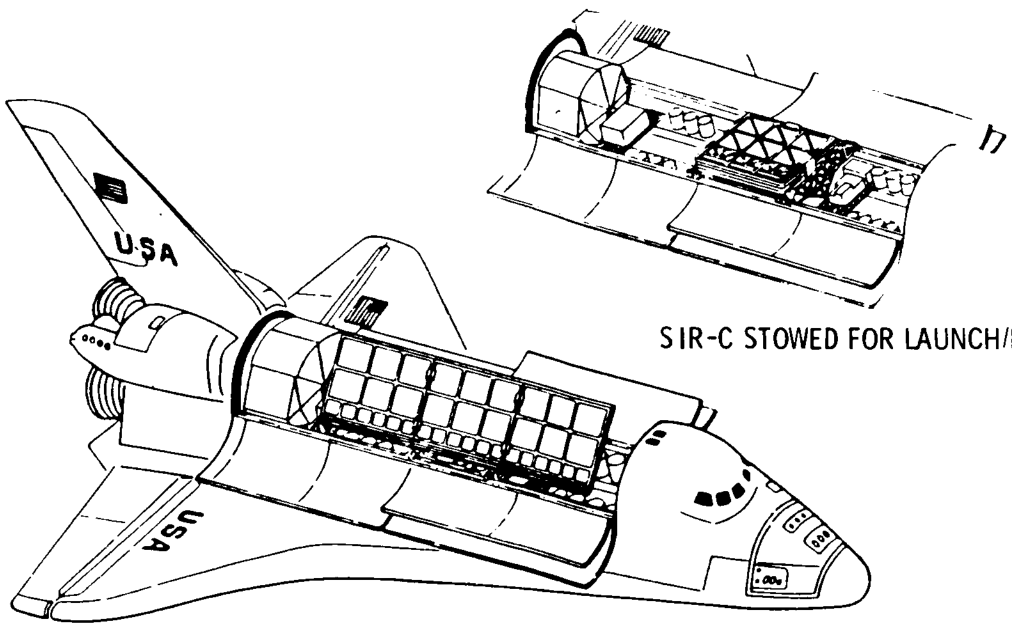
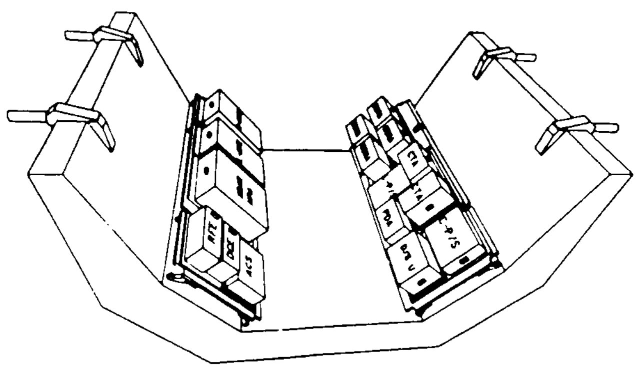


Figure 1. SIR-C/XSAR Development



SIR-C STOWED FOR LAUNCH/LANDING

SIR-C DEPLOYED



SIR-C/X SAR PALLET LAYOUT

Figure 2. SIR-C Configuration

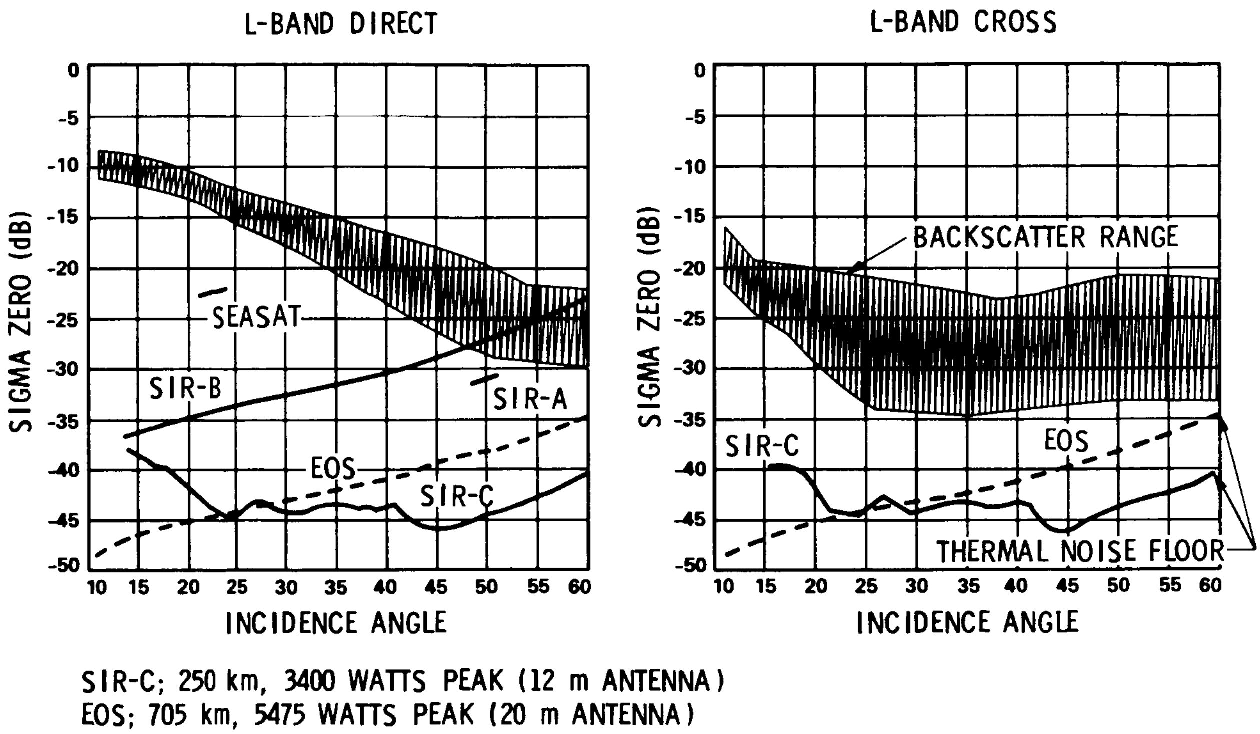
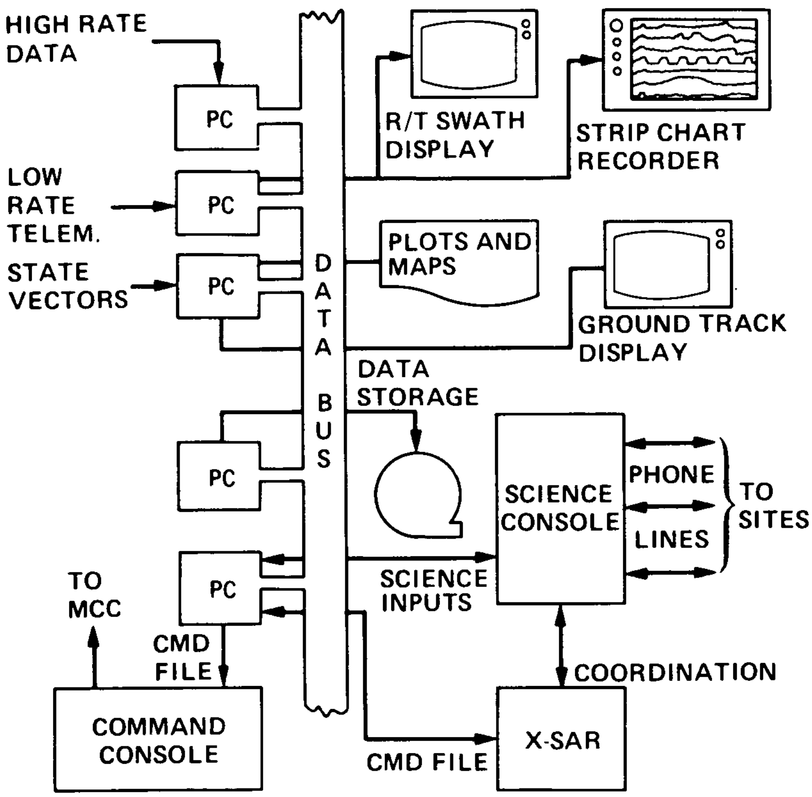


Figure 3. SIR-C Sensitivity, Geologic Targets



CONCEPTS

- INTERACTIVE, MENU DRIVEN, GRAPHICS ORIENTED SOFTWARE HAS PROVEN TO BE AN EFFICIENT PLANNING TOOL
- SEGMENTED, MICROCOMPUTER BASED SOFTWARE ELEMENTS OF SIR-B NEED ONLY SUBSETS MODIFIED FOR SIR-C
- XSAR MISSION PLANNING TO BE DONE WITH SAME SOFTWARE
- XSAR COMMANDS WILL BE INTERLEAVED WITH SIR-C's PRIOR TO UPLINK

Figure 4. SIR-C Instrument Control Center

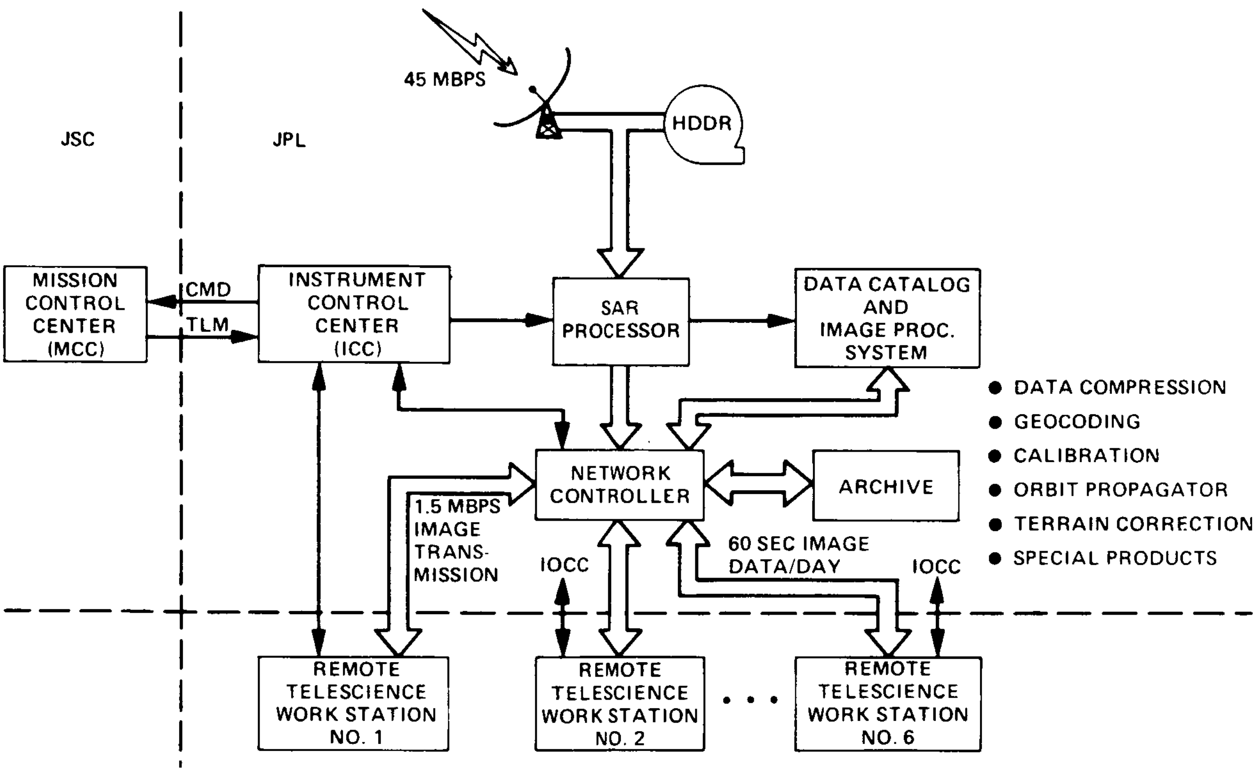


Figure 5. SIR-C Telescience Testbed Concept