QUASAT - AN ORBITING VERY LONG BASELINE INTERFEROMETER PROGRAM USING LARGE SPACE ANTENNA SYSTEMS

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Large Space Antenna Systems Technology - 1984
December 4-6, 1984

THE QUASAT MISSION CONCEPT

QUASAT, which stands for QUASAR SATELLITE, is the name given to a new mission being studied by NASA. The QUASAT mission concept involves a free-flying earth-orbiting large radio telescope, which will observe astronomical radio sources simultaneously with ground radio telescopes. The mission concept is illustrated in Figure 1.

The primary goal of QUASAT is to provide a system capable of collecting radio frequency data which will lead to a better understanding of extremely high energy events taking place in a variety of celestial objects including quasars, galactic nuclei, interstellar masers, radio stars and pulsars.

QUASAT's unique scientific contribution will be the increased resolution in the emission brightness profile maps of the celestial objects.

In 1980 the National Academy of Sciences' Astronomy Survey Committee listed an orbiting VLBI antenna as a high priority for a national astronomical endeavor.

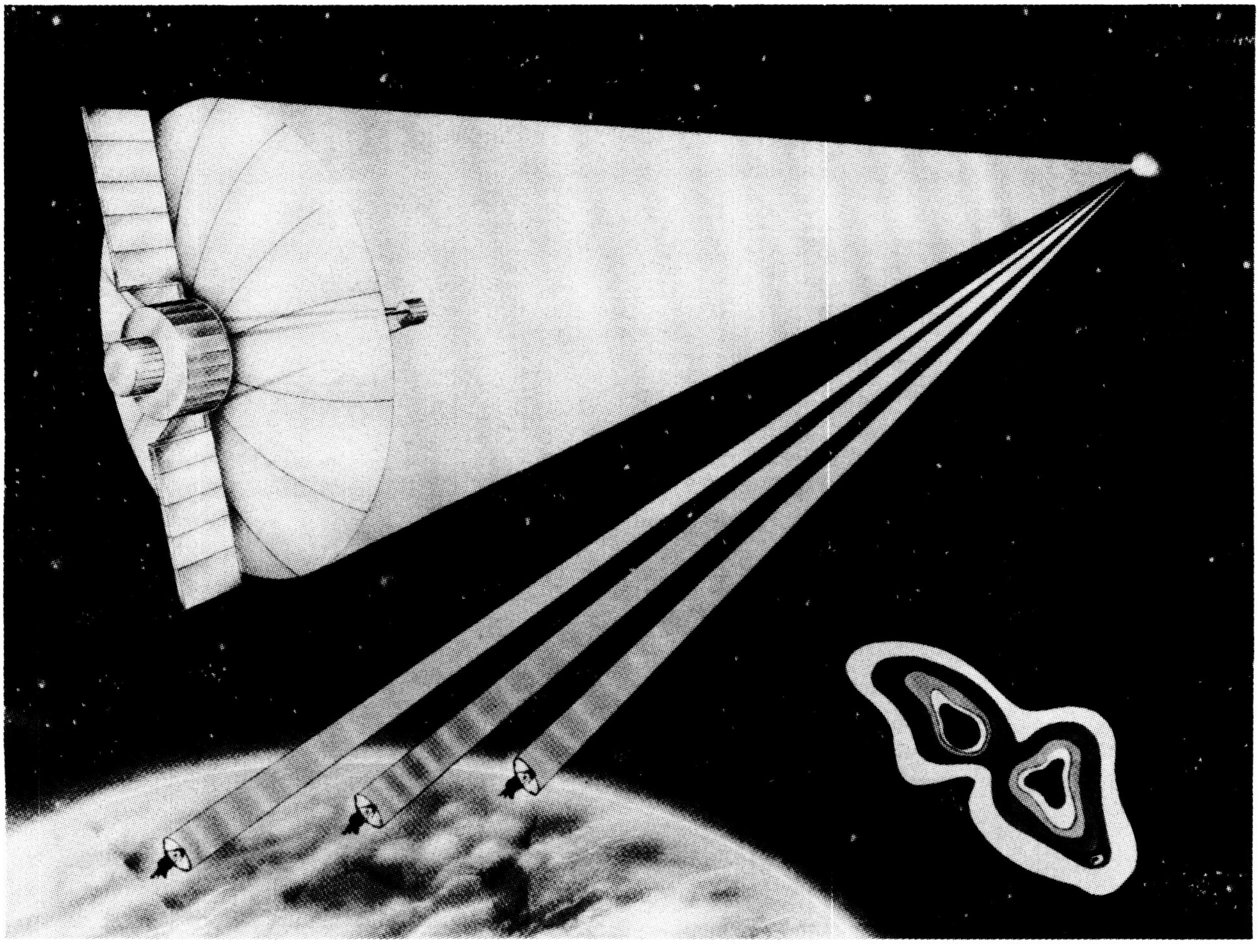

Figure 1
High Resolution Interferometry From Space

APERTURE SYNTHESIS

Increased resolution in the maps of celestial objects is made possible by the larger baselines, created by spaceborne antenna, compared to the maps created by networks of ground antennas alone. For the past 15 years, radio astronomers have employed Very Long Baseline Interferometry (VLBI) techniques to synthesize apertures whose size is determined by the distance between antennas rather than the diameters of the antennas themselves. The radio signals from two observing antennas are recorded on high density recording tapes simultaneously, and the tapes are, at a later time, correlated to produce information equivalent to the Fourier transform of the brightest profile of the observed celestial object at a frequency of λ/D, λ being the observed wavelength and D being the projection of the antenna-to-antenna baseline onto the plane perpendicular to the direction to the observed object. As more antennas are added to the observing network and the network geometry evolves as the earth rotates, an effective large aperture is synthesized. An antenna in space creates the ability to synthesize an aperture larger than the earth as illustrated in Figure 2.

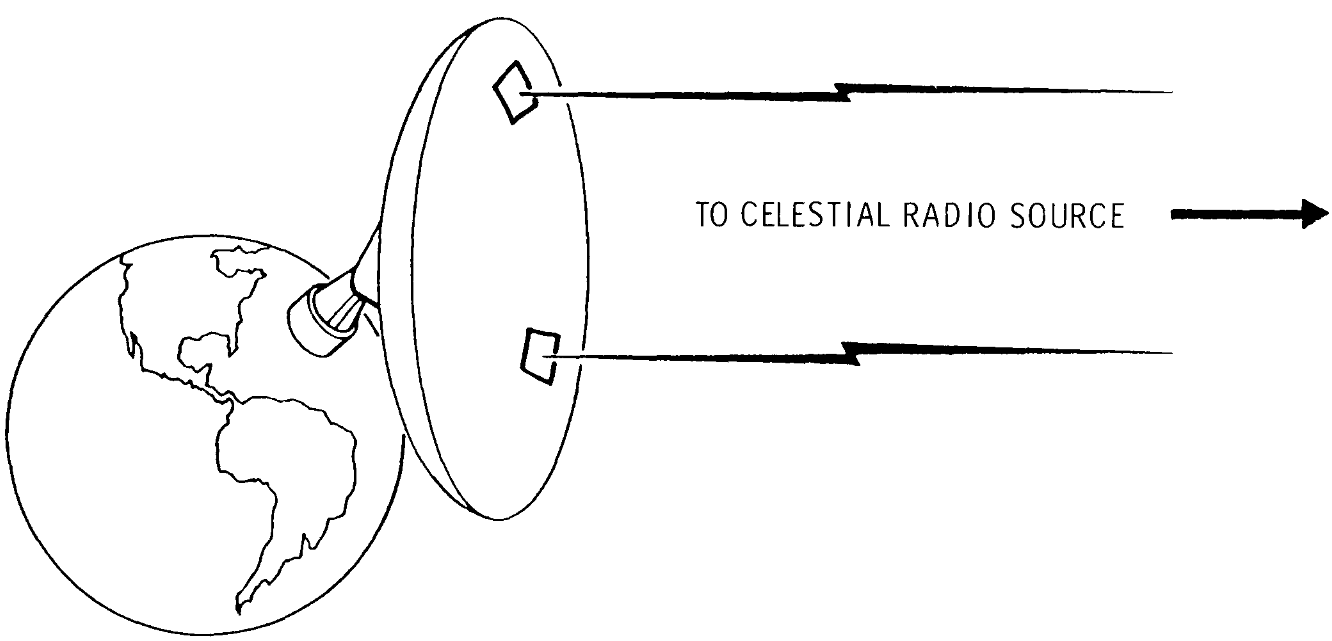

Figure 2
Synthesizing an Antenna Aperture Larger Than the Earth

MISSION ASSESSMENT STUDY

QUASAT has been studied jointly by NASA and the European Space Agency during the past two years. In 1982 a joint American-European science working team was established which produced the preliminary mission requirements.

Radio reception at three distinct frequencies is desired; K-band (1.35 cm), C-band (6 cm) and L-band (18 cm), the primary interest being K-band. In addition, simultaneous right and left hand circular polarization reception with 30 dB separation between senses is desired.

High sensitivity is required. A signal-to-noise ratio of at least 6 to 1, which will allow detection of radio sources with source strength down to 140 mJy with an integration time of 300 seconds, is desired. The satisfaction of the requirement for high sensitivity and the short K-band wavelength forces a number of demands on the flight system: (1) a large deployable antenna of diameter 15-20 meters with sub-mm RMS surface accuracy, (2) a precision pointing system capable of control accuracy to within one minute of arc, (3) cooled receivers with system temperatures below 150K, (4) feeds and feed structures designed to accommodate optimal RF efficiency and (5) high bit rate (144 mbits/s) receiving capability along with the downlink to earth to enable real-time transmission of the signal to ground tracking antennas.

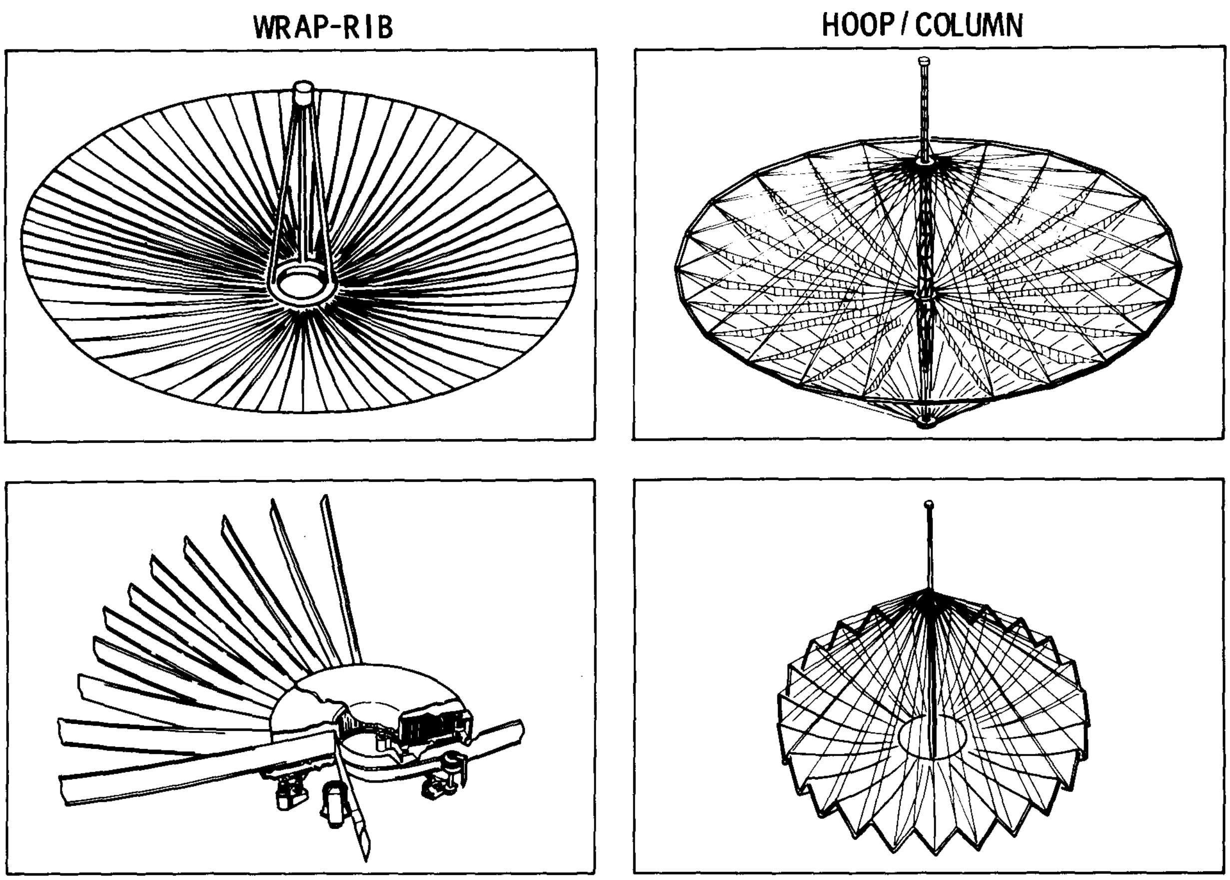

Figure 3
Surveyed Antenna Concepts

MISSION ASSESSMENT STUDY (Cont'd)

Since high resolution is achieved by the long baselines between the spaceborne antenna and the ground antennas, a high apoapsis altitude for the orbit, greater than 20,000 km, is desired. However, a low periapsis, less than 7000 km, is required to create the orbital precession necessary to evolve the optimal viewing directions throughout the celestial sphere. A high inclination, around 60°, is needed to provide the geometry for good aperture synthesis for viewing directions at a variety of celestial latitudes. Mission lifetime should be at least five years.

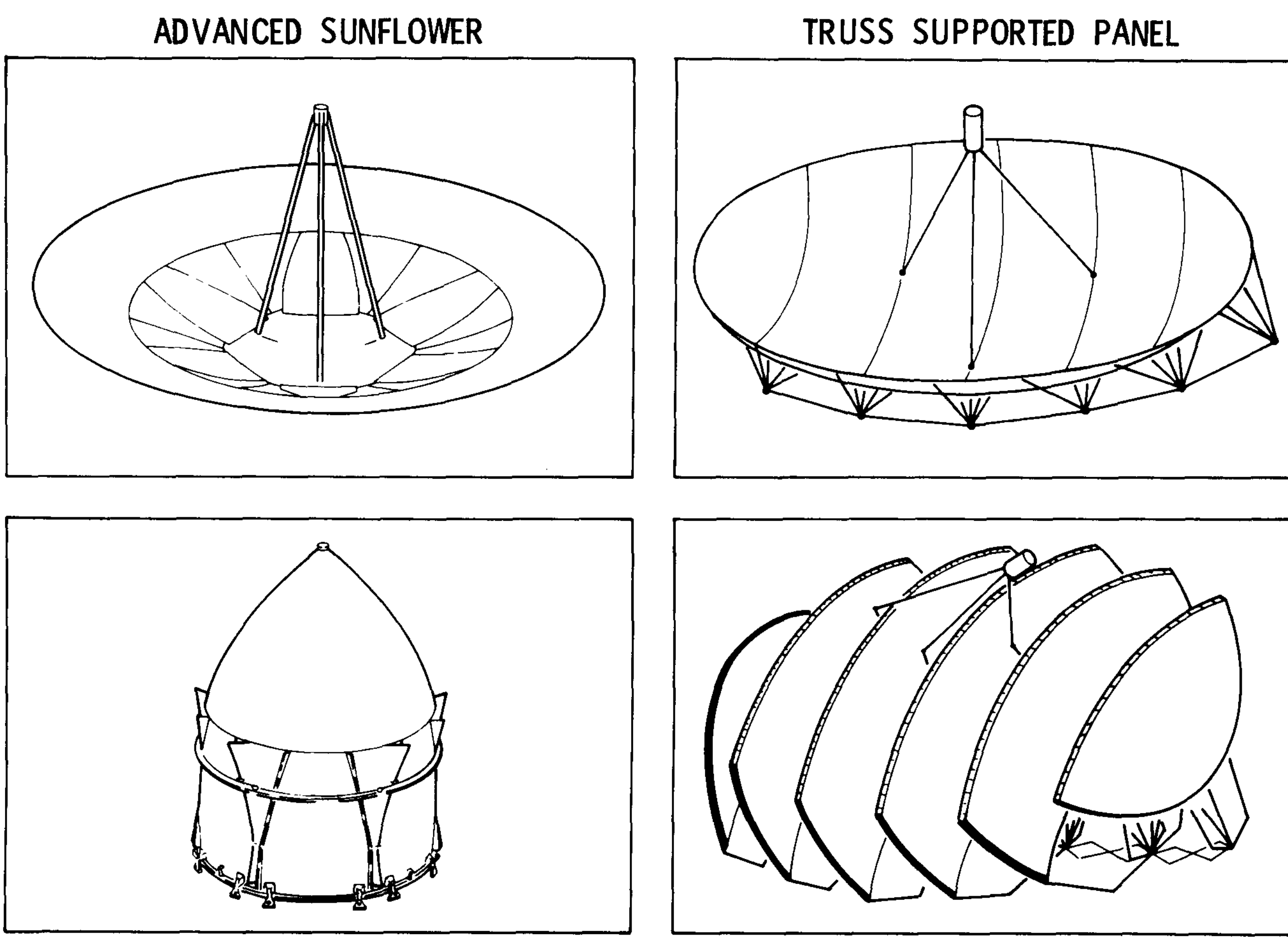

Figure 4
Surveyed Antenna Concepts (Cont'd)

MISSION ASSESSMENT STUDY (Cont'd)

In 1984, both NASA and ESA conducted mission feasibility assessment studies. On the American side, these studies were conducted by the Jet Propulsion Laboratory and consisted of an antenna feasibility study and a mission analysis/spacecraft and ground system preliminary design activity. Four small technology assessment contracts were awarded to American firms in order to obtain characteristics of the antenna concepts applicable to QUASAT. The four proposed concepts are illustrated in both a stowed or partially deployed state and a fully deployed state in Figures 3 and 4. The concepts include the Wrap-Rib antenna being developed at Lockheed Missiles and Space Company, the Hoop-Column antenna being developed at Harris Corporation, an advanced Sunflower concept proposed by TRW and a truss-supported panel-deployable concept proposed by Astro-Research Corporation. All four antenna concepts appear applicable to QUASAT.

In Europe, the ESA studies have concentrated on an inflatable antenna being developed by Contraves Corporation in Switzerland. See Figure 5.

Both American and European mission study results were presented at a workshop on Space VLBI and astrophysics, sponsored by the U.S. National Academy of Sciences and the European Science Foundation and held in June 1984 in Vienna, Austria.

INFLATABLE

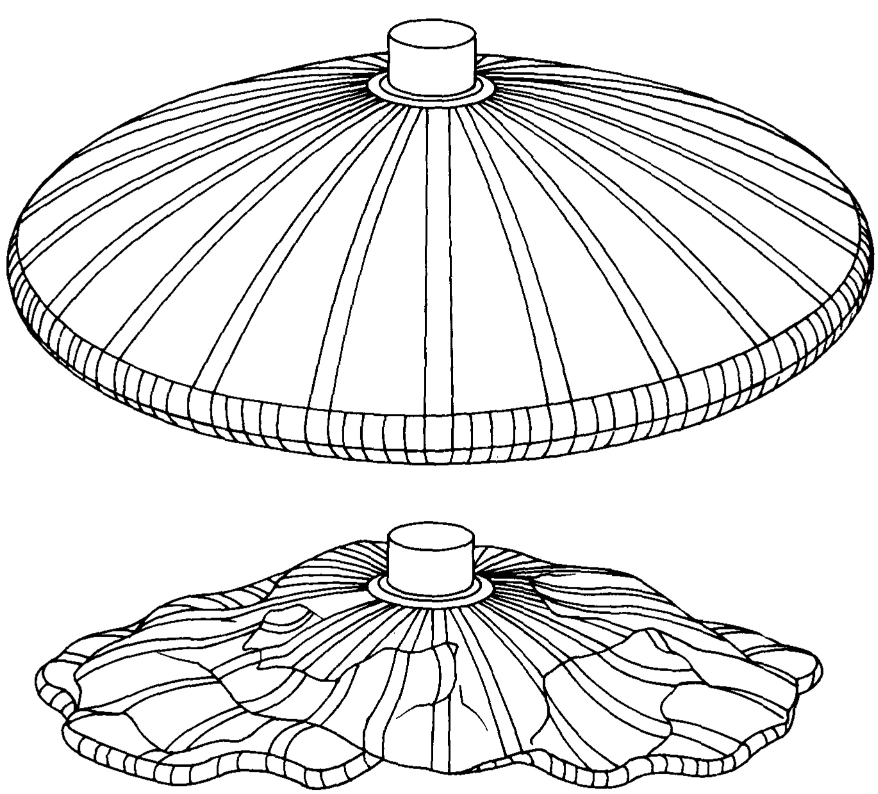

Figure 5
Surveyed Antenna Concepts (Cont'd)

THE FLIGHT SYSTEM

A preliminary flight system has been designed based on the Wrap-Rib antenna concept. It should be considered as an example flight system since at this time the antenna has not been selected. The flight system is illustrated in Figure 6. The spacecraft is solar powered with nine square meters of panel, which generate about 1000 watts. The feed tower is constructed of tubular truss links, which deploy from a tightly folded launch configuration, F/D is .4. The feeds and receivers for all three reception frequencies are located at prime focus, and cooling is provided passively from a two-square-foot radiating plate. Attitude is controlled by momentum wheels driven from star sensor readouts, and the rotational effects of gravity gradients are compensated by torquer bars.

The flight system is compatible with a launch using the Space Transporation System or the French Ariane launcher. If launched from the Shuttle, this flight system can fit on the Pam-D spintable, with a Star-48 solid fuel rocket providing the boost from Shuttle orbit to the proper apoapsis. The Star-27 solid-fuel rocket provides for raising the periapsis altitude.

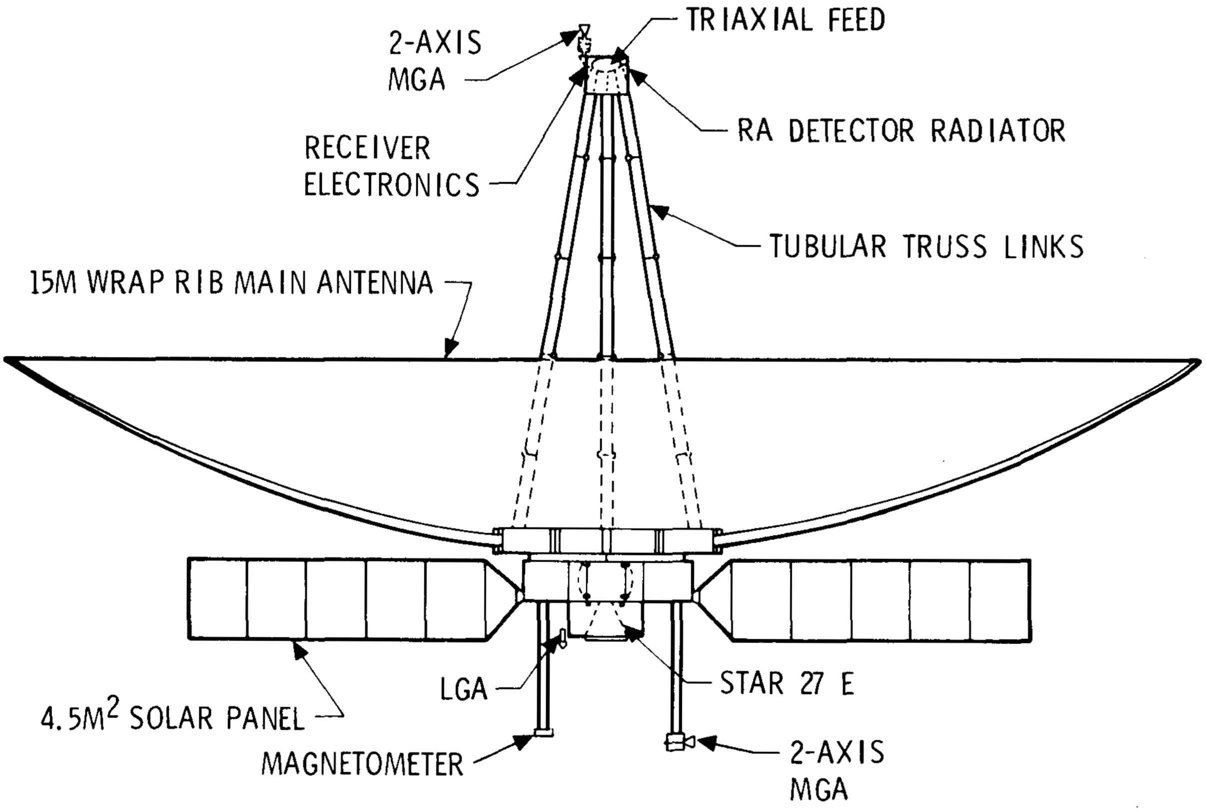

Figure 6
Assessment Study Flight Configuration

THE GROUND SYSTEM

Figure 7 provides a schematic diagram of the ground system which would support QUASAT. The spacecraft will be tracked by the NASA Deep Space Net. Radio telescopes around the world will co-observe with QUASAT. The network will include those in the Very Large Baseline Array (VLBA), a new VLBI-dedicated ground array being developed by the National Science Foundation.

The up and downlinks have been designed to utilize either the 26-meter or 34-meter antennas, the Deep Space Network communications, and the navigation capabilities of the DSN to optimize the science output. The DSN 70-meter DSN antennas may also be used, as required, to enhance the observational sensitivity.

Both the flight system and the radio astronomy ground antennas will produce similar data recordings at rates up to 144 MEGABITS per second, which will be correlated and analyzed at a central facility.

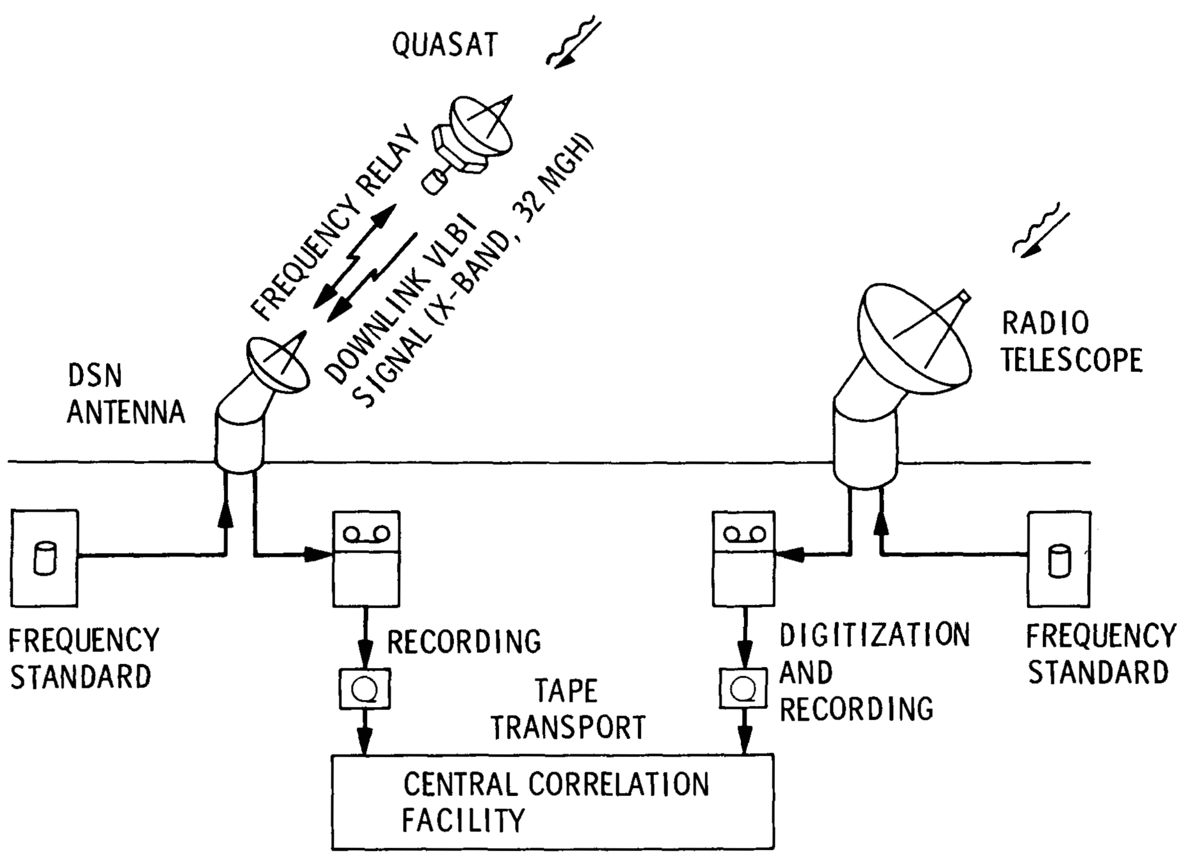

Figure 7
Baseline Ground Configuration

PROGRAM SCHEDULE

QUASAT is currently envisioned as a jointly supported NASA-ESA mission, with the mission costs lower to each agency. Of course, the mission may eventually be undertaken by a single agency. It is hoped that JPL and the Langley Research Center may develop joint advocacy for the mission, with LaRC taking the lead in flight antenna experiments using the QUASAT antenna as a long-term spaceborne laboratory for structural and RF testing.

The earliest new-start year is FY88, but a more realistic new-start year is 1990. Figure 8 provides a project schedule associated with the earliest possible new-start. The schedule calls for a 3½-year antenna procurement cycle and a possible launch by 1993.

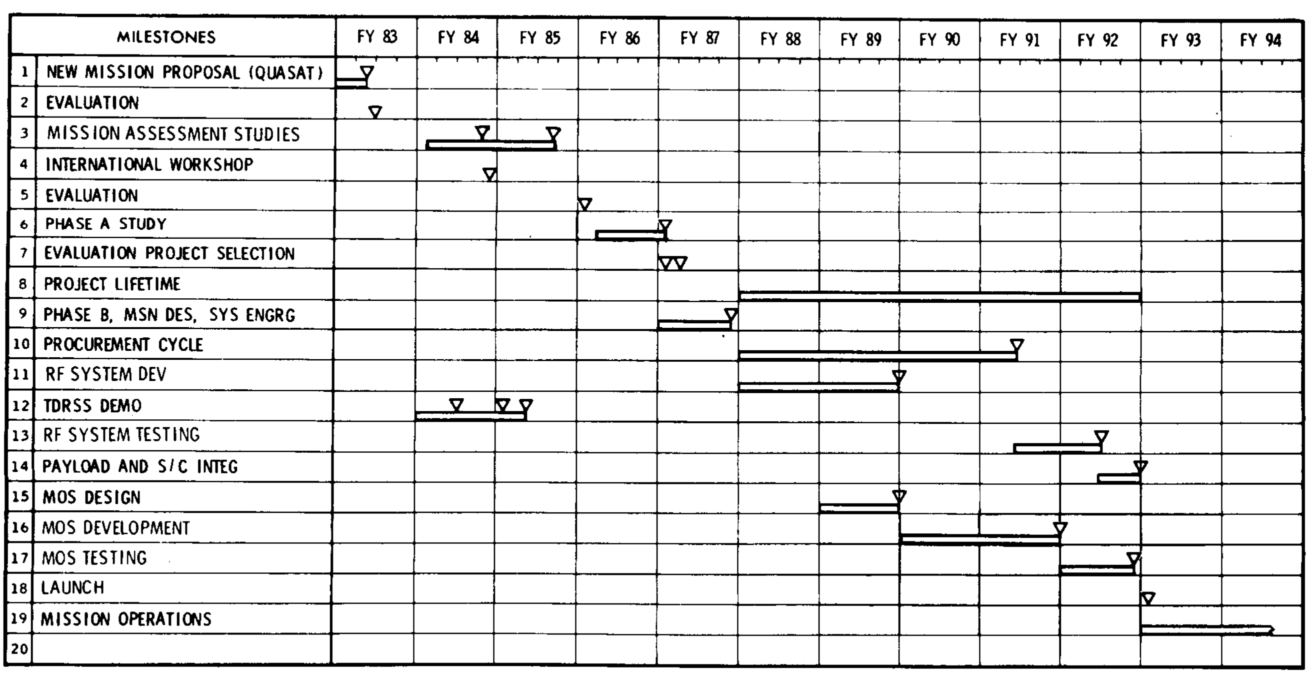

Figure 8
Program Schedule