NASA TECH BRIEF

Ames Research Center

Variable Side-Look Angle Concept for Radar Mapping

The radar mapping of planets can be accomplished at lower cost and with reduced emphasis on propulsion system capability from a spacecraft operating in an elliptical orbit (say, eccentricity of 0.5) than from a circular orbit. In an elliptical orbit, however, the change in range from the spacecraft to the planet surface poses problems relating to range-signal ambiguities, radar power, and changes in zero-Doppler pointing direction.

Range ambiguity occurs because the illuminated swath width in the range direction (perpendicular to the spacecraft orbit) increases with altitude. To circumvent range ambiguity and guarantee good image quality, a pulse repetition frequency (PRF) for radar operation must be selected between upper and lower constraints; the upper PRF constraint, which varies as a function of true anomaly or altitude, guarantees that the range ambiguity will be too small to degrade the image quality, while the lower PRF constraint guarantees that the Doppler ambiguity content will be small. Since the upper PRF constraint decreases rapidly with altitude, very large body-mounted antennas are required; thus, large attitude control systems are required to point the antennas. Mapping to ±30° true anomaly can be achieved by using a single beamwidth antenna with a constant PRF of 4500 pps.

The PRF-related problem can be solved by varying the side-look angle to obtain a better behaved upper PRF constraint. With a constant upper PRF constraint, a constant or variable PRF can be selected so that complete surface mapping can be achieved. Varying the side-look angle reduces the maximum range and thus reduces the power required because smaller antennas and also smaller attitude control systems can be used; for example, a power of 333 watts can be used for complete surface mapping (maximum altitude of 3600 km) for an orbit with an eccentricity of 0.5, whereas about 600 watts are required when using a constant side-look angle of 30° and mapping to ±55° latitude (maximum altitude of 1500 km).

If a clutterlock (automatic azimuth pointing) system is used to point the radar antenna, it is normally pointed along the zero-Doppler line. At periapsis, the antenna is pointed essentially in the radial direction; as the radial velocity increases with altitude, the zero-Doppler line deviates greatly from the radial direction. The antenna is pointed at higher squint angles at the higher true anomalies; when operated in the squint mode, it is pointed forward or aft and out to the side at the side-look angle. If the variable side-look scheme is used, an electronic-offset clutterlock system must be used to point the antenna a programmed angle from the zero-Doppler line so that it is always pointed essentially in the radial direction. Also, the antenna must have two gimbals: The azimuth gimbal is controlled by the clutterlock system to point in the radial direction; a Doppler-frequency command is used to point the antenna away from the zero-Doppler direction. The elevation gimbal is controlled to give the appropriate grazing angle.

Alternatively, the antenna can be biased forward with an angle of 26.6° in the first half of the mapping phase and then pointed rearward when the spacecraft passes periapsis; only one gimbal is needed. A constant upper PRF constraint is obtained so that a constant PRF of 5000 pps can be used. The antenna is pointed radially by the antenna control system, and the clutterlock system points the antenna by using the closest ambiguity to control the aperture. A constant side-look angle can be built into the antenna arm, so no gimbal is required about this axis.

(continued overleaf)

Note:

Requests for further information may be directed to:

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NASA has decided not to apply for a patent.

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