S19-17
358 368

Satellite Telemetry & Command Using Big LEO Mobile Telecommunications Systems

Fred Huegel, NASA Goddard Space Flight Center
Code 568

June 2, 1998

Objective

- Use Commercial Global Satellite Mobile Telecommunications Systems (Big LEOs) to provide Telemetry and Command Services to user satellites in LEO
  - The user spacecraft's transceiver would be a space qualified version of the systems User Terminal (mobile phone)
- Globalstar, ICO and Iridium have been studied

Targeted Capabilities

- Provide real time contact to LEO user satellites with a simple phone call
- Provide the capability for the satellite to "phone home"
- Command and telemetry data rates of 8K bits/sec
  - Higher rates with data compression
- At least one 5 minute contact per orbit
- Small, low power, low cost transceiver
- Simple omni antenna system
- Secure link

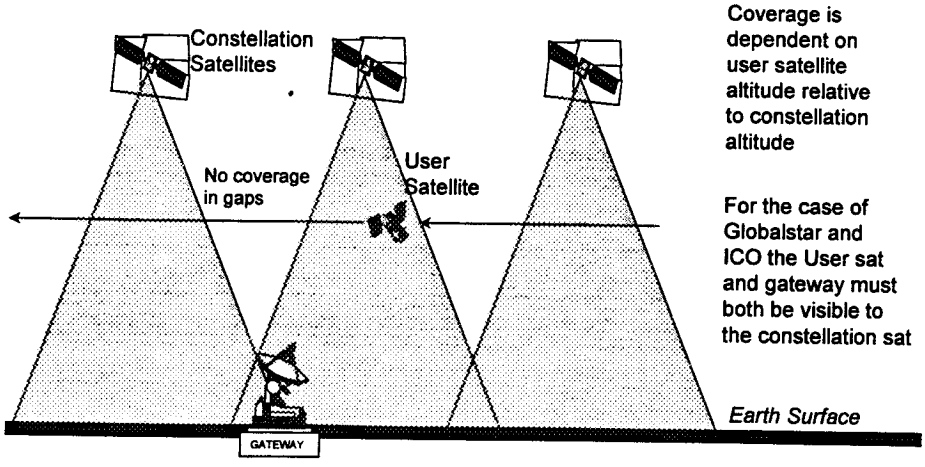
Rational - Make use of the Billions of $ of privately funded infrastructure to provide :

- Reduced Mission Communications System Cost
  - Reduces or eliminates the cost of ground stations and associated infrastructure
  - Eliminates the need for frequency assignments
  - Low cost transceiver, small size, low mass and low power
- Flexibility in Science Operations
  - Event monitoring and immediate reporting
  - Quick look data evaluation
  - Several Contacts per orbit possible
  - Real time access to user satellites from remote locations

Communications Satellite Constellations Studied

- Globalstar - LEO - operational in mid 99
- Iridium - LEO - operational mid 98
- ICO Global Communications - MEO - operational in mid 2000

Contact Limitations



Coverage is dependent on user satellite altitude relative to constellation altitude

For the case of Globalstar and ICO the User sat and gateway must both be visible to the constellation sat

Capabilities - Iridium

- The fairly low constellation orbit (780 KM) precludes significant coverage of user satellites
  - In general contacts are very short with large coverage gaps
  - Polar orbiting user satellites are an exception - adequate coverage is available in this case due to co-orbiting of the user sat with the constellation satellites
  - Data rates limited to 2400 bits/sec
- Possible use of crosslinks has been investigated
  - Could provide excellent coverage and Mbit/sec data rates
  - User Satellite would "take over" the intersatellite link
  - Technically feasible but not deemed operationally feasible by Iridium

Capabilities - ICO Global

- Excellent coverage for orbits up to 900 km
  - One 10 to 30 minute contact per orbit using only one gateway
  - Optimal coverage at 52° inclination
- Front end Doppler compensation required
- Data rates limited to 2400 bits/sec

Capabilities - Globalstar

- Good coverage for orbits up to 600 Km with inclinations up to 57°
  - The lower the orbit the better the coverage. Optimal coverage at 52° inclination
  - Better than one contact per orbit at 400 km using 4 gateways
  - contacts range from 5 to 18 minutes, the average is 11 minutes at 400 Km, 52° inclination
- No front end Doppler compensation required
  - Range rate between Globalstar satellite and user satellite no greater than that experienced for a user on the Earth's surface 90% of the time

Globalstar (Continued)

- Data rates up to 8 Kbits/sec possible
- At an orbit of 400km, 52° inclination
  - Total contact time per day is about 264 minutes
  - Total downlink per day is 127 Mbits
  - Average outage time is 56 minutes
- Initial feasibility study with Globalstar/Space Systems Loral completed 12/96
  - System issues identified
  - Link analysis performed
  - No show stoppers identified

Globalstar Link Analysis

- Assumptions
  - Omnidirectional coverage required
  - Coverage over full Globalstar FOV (108°)
  - Eb/No requirement as specified in FCC filing
  - Maximum link range used for a user satellite in a 300 Km altitude
  - Single Globalstar in view (no signal combining)
  - Maximum transmission rate of 9.6 kbps
  - On average during a pass 0 dB of additional dynamically supplied additional power required.
- Link closes under the following conditions
  - Transmit switch used rather than splitter
  - Low loss cabling used (Gore ~ 0.2dB/Ft)
  - Low noise amplifiers are located at the antennas

Globalstar Issues

- Protection of Radio Astronomy Sites (RAS)
  - Sensitive in the 1610.6 MHz to 1613,8 MHz range (Globalstar return link)
  - Requires operation at the upper end of the assigned L Band frequency range as well as the use of a transmit band reject filter
  - Or restrict operations when near an active RAS site (reduces potential contact opportunities)
- Location information required
  - Normal call handling procedures require the location of the user
    - This is normally determined by the Globalstar system but will not work for Space applications
  - Location can be determined by on board ephemeris or GPS and entered into the transceiver

Flight Transceiver

- Derivative of fixed User Terminal
  - easily adaptable for position input
  - Control and data interface to the spacecraft C&DH
- Size and weight are driven by the band reject filter
  - Approximate size 8 by 6 by 3 inches
  - Approximate weight is 7 pounds
- Power
  - Standby, 1.5 watts
  - Transmit, 20 watts

Security

- Gateway to User Satellite
  - CDMA inherently secure (spread spectrum system)
  - Encryption of traffic channels part of Globalstar baseline
- Ground segment
  - Call acceptance filtering by ground system blocks unauthorized calls
  - Phone numbers can be re-assigned if necessary
  - Use of unlisted phone numbers

Conclusions

- Feasibility study with Globalstar indicates that spacecraft command and telemetry through commercial telecommunications satellite constellations is feasible with little or no modifications to the system architecture
- The user would connect to their spacecraft via telephone/modem
- Frequent contact opportunities would be available
- Data rates are limited but adequate for command/telemetry and quick look science
- Further studies of the Globalstar and ICO systems are needed to better define the capabilities, limitations, and system impacts of the Space Mobile Service

Key Benefits

- Facilitator for low cost LEO missions such as University Explorers (UNEX), Small Explorers (SMEX) and others
  - Could provide significant savings per mission
  - Users pay only monthly access fee and per minute charges
- Provides flexibility and simplification in mission operations
  - Enhanced access to spacecraft

\section\PhoneLink2-97

Session 3
Architectures and Network Simulations