Space-based SmallSat Networks Virtual Workshop

Summary and Results

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Introduction

Smallsats, satellites with masses approximately 100kg or less, are becoming more and more common while being used for increasingly complex missions. Communications for satellites is an integral part of these missions, and at some point data collected must be downlinked. Various new smallsat missions are using Iridium and Globalstar constellations for their communications. A link is established to the constellation which then downlinks data received from the smallsats. These satellite-to-satellite connections open up new possibilities as well as issues for smallsat missions. The Space-based Smallsat Networks Virtual Workshop was organized to exchange information and ideas on the topic of Iridium and Globalstar satellite communications.

Workshop attendees included representatives from various NASA Centers, industry partners, and a representative from Globalstar.

Discussion Summary and Results

Smallsats can currently use two types of communication constellations: Globalstar and Iridium. Using either system for communications negates the need for a ground station specifically to track or receive a smallsat's data. Using either the Globalstar or Iridium system provides for the use of the associated communications infrastructure. If Globalstar or Iridium is used and it is the sole communication method, only the link between the satellites needs to be taken into account for the smallsat's communications subsystem. Most smallsat missions so far have flown the Globalstar and Iridium to demonstrate the technology or as a backup for their primary communication system. Both Globalstar and Iridium may be considered a 'TDRS for CubeSats.'

Iridium

For the Iridium constellation (66 operational satellites with intercommunication capability at ~700km), the example missions shown during the workshop were NASA Ames Research Center's TechEdSat (TES) missions.

One communications uplink and downlink per orbit are required for the eventual high-precision de-orbiting technique demonstrated by TES's Exo-Brake device. The antennas are located under the ablative nose cap and are orthogonal to that antenna on the side of the satellite. The data transfers between the TES and Iridium satellites are 300 byte bursts. The TES-5 mission required 100-400 packets per day for reentry to achieve mission goals. The mission used a short burst data (SBD) modem and attempted a handshake every 30 seconds, resulting in 25-30 successful handshakes per day on average. The Iridium SBD system is not intended for high data rate applications – however, the 2 kbps data capability using the Iridium 9523 modem allows a significant improvement. This modem can work both in the short burst data and longer data transmit modes. The 9523 modem is being baselined as the 2nd Iridium communications device in TechEdSat-8.

The Iridium SBD modem has been found to achieve 30-40 packets per day pointed in the nadir-direction; 90-100 packets per day if the patch is pointed in the orbit velocity vector orientation; and 350-400 packets per day (>20/orbit) in the zenith direction. The TES team believes it is the only system capable of transmitting at least one packet per orbit (i.e., GPS), and delivering one command per orbit (due to the intercommunicating 'swarm' topology of the Iridium satellite network). The system offers true global coverage with no geographical limitations. Lastly, all modems conveniently fit within the 100x100 mm single board form factor (the modems are considerably smaller – and thus fit on a single board).

Globalstar

Similar to the Iridium constellation, Globalstar has been used on various smallsat missions for communications, in addition to a link from the smallsat to a ground station. The 36 Globalstar satellites are in a 1400 km orbit in a 'bent-pipe' topology. The satellites don't transfer data between each other – only to a ground station. Missions using Globalstar must be at or below the 52^{o} inclination of the Globalstar constellation. Missions using Globalstar and a simplex modem get a higher data rate than missions using Iridium, but use a different infrastructure. The STX-2 modem that is currently used has deterministic power consumption, allowing the system to change the power input to close the link between the two systems with a specific margin. In satellite use, instead of ground use, the power decreases due to the smallsat mission being closer to the Globalstar satellites at 1414 km. The STX-3 is the next version of the simplex, and performs the same function in a smaller package with a higher data rate: 36 bytes every 8 seconds for the STX-2 versus 144 bytes per 8 seconds for the STX-3. For missions that encrypt their data transmissions, the STX-3 allows for better encryption.

For duplex systems (in which commands would be uploaded), there have been some difficulties with delayed responses to satellites, caused by a queue for the Globalstar system when signals cannot be sent immediately. This typically occurs if out of range of the United States geographical area. Duplex systems must be over the coverage area in which they are registered in order for the signal to be processed. With attitude problems and position, the time for a signal to be sent to the smallsat can sometimes be multiple hours. The system will try to send the signal again at predetermined intervals. The Globalstar system does put new requests for communications at the top of the respective queues, so placing new requests to get a signal through can cut the wait time if the signal can be sent at that time. Also, the duplex board is currently >100 mm on one side, meaning that it must be accommodated along the long axis of the nano-satellite (or requires a 'double-wide' 6U).

National boundaries were a concern when Globalstar was first created, so the signals will only be sent over the registered coverage areas due to those reasons.

Current missions using Globalstar include Air Force Research Laboratory missions, along with TEMPEST-D, Halosat, CubeRRT, and CIRAS. Additionally, Blue Canyon is using Globalstar as a communications backup on some of their products.

General

The frequency band used for both Iridium and Globalstar is L-band. It is also a frequency band used by radio astronomers. Globalstar uses L-band as its ground-space communication frequency, but not for space-ground. Iridium uses L-band for both ground-space and space-ground, so the Iridium and other satellites using L-band that might interfere with radio astronomy must institute a plan to prevent radio astronomy interference before the mission begins.

Frequency allocation for the smallsats must go through the Federal Communications Commission (FCC), and is typically done using the National Telecommunications and Information Administration (NTIA) experimental license. This license allows the use of the frequency that is owned by a commercial organization. The mission must abide by the regulations of the commercial organization and be FCC compliant. To ensure compliance, requirements for the mission should be included in the information submitted to the FCC (e.g. emergency shutdown procedures, radio astronomy protections, etc.).