Supporting the DoD and HLS using NASA ACTS Satellites and Technologies

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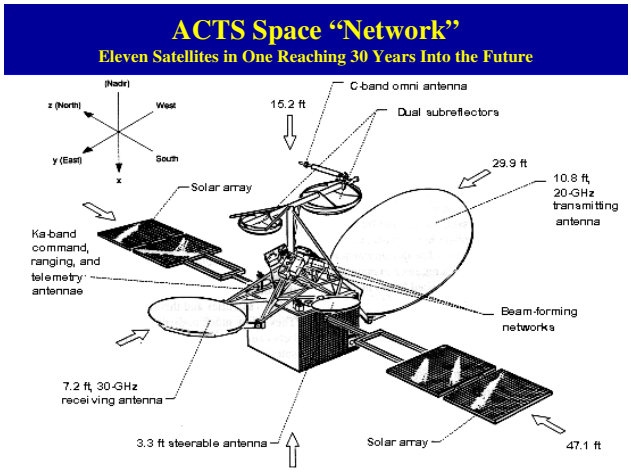
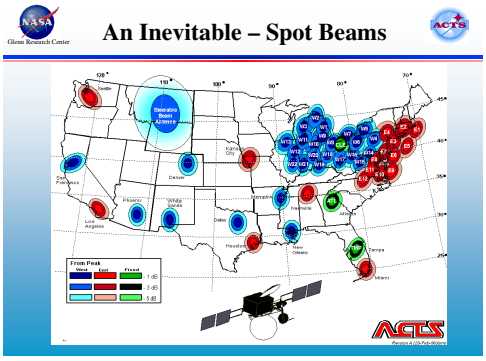
Abstract: ***A four-satellite constellation of ACTS satellites (replicas) will promptly provide the nation with a low cost, flexible high data-rate satcom system that can serve many varied users whose requirements are continually changing. NASA can develop, launch, test and checkout such a high data-rate satcom system, and turn it over to an operating organization; like NASA does for NOAA with the Weather Satellites. Certain UNIQUE capabilities of the ACTS and unique aspects of the ACTS program are largely unknown, even for those in the Comsat business community. This paper presents these capabilities and aspects of the satellite and the program in the context of a space network of communications satellites and a ground network of earth stations to support America's needs for advanced COM munitions systems.***



Perhaps the least known capabilities of the ACTS Satellite are that it was actually eleven satellites-in-one that implemented comsat technologies project to be in used for the next 30 years and could be reconfigured on orbit. It is remarkable that throughout the five year life of the program, it was reconfigured daily. Most communications satellites are launched into a geosynchronous orbit and left to provide bent pipe communications services throughout the life of the satellite. The ACTS had both an active onboard processing and switching capability that enable the satellite to work with a network of earth stations and a passive bent pipe repeater transponder that enables conventional reflector operations.

The ACTS satellite employed both hopping spot beams to up and down load communications mail on beams that were only 60 miles across at the surface of the earth and steerable spot beams that were only 120 miles across on the earth surface. These beams employed crypto encoding of the information being reflected through the ACTS. The steerable spot beam enabled NASA to support military missions and applications with



the ACTS without the need for special access clearances. The steerable beam could be placed at a location on the earth where it was thought the program would be of benefit to the military. It was up to the military users to go to the spot and use it to transfer information via satellite, without the need for time consuming clearance processing and approval. What was important was that the encryption keys were not available to NASA so the information was secure. This feature of ACTS proved so useful that that one can safely predict its inevitable use in the future communications satellites, whether for government or commercial communications.

Another feature of the ACTS was the capability of the satellite to support mobile high data-rate Army and Navy applications. The concept here was that the military applications were mobile and inaccessible by fiber communications. It is not possible to hook fiber to a moving military. The unique steerable spot beam enabled the ACTS to find and follow mobile military users, and thus provide mobile communications services at data rates which are unavailable by any other means. In one case the President and his team were on a train crossing the US, and the ACTS was used to provide communications between the President and other members of the armed forces.

The movable spot beam also served airborne applications with wideband high data-rate image and data transfer capability. This work is intended to provide communications capability basis for:

- Intelligence aircraft that would fly as a companion on military missions, and
- Onboard TV and internet services for commercial aircraft.

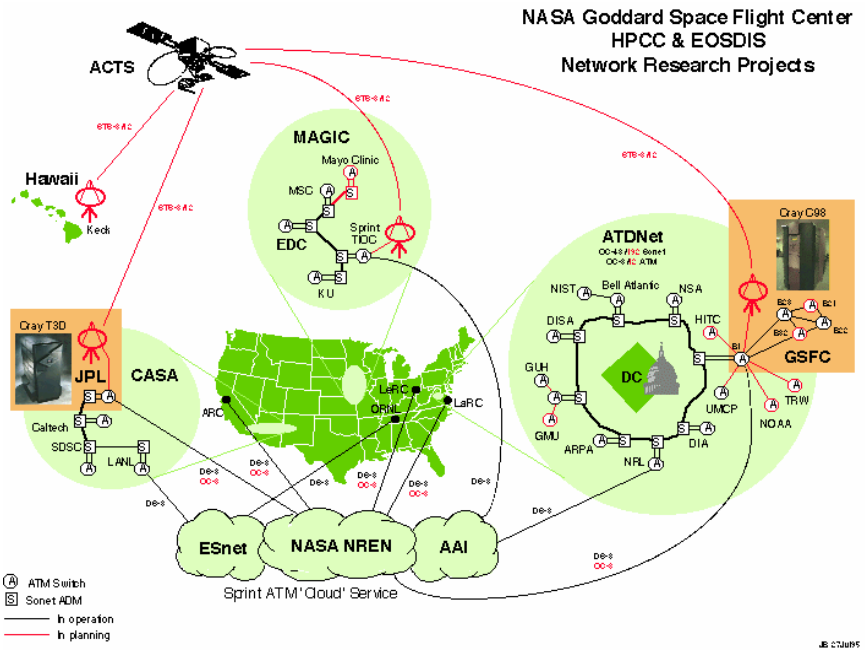
The ACTS experiments proved the concept of communications in fast movers that needed Doppler shift frequency control.

Perhaps one of the most challenging developments was providing communications services for massive geological data base transfers from ship to shore and verification of real-time vectoring of ships at sea for petroleum exploration. The implications to military or drug interdiction operations are obvious. The challenge was the prompt transfer of massive databases, using a communications satellite, quickly enough that real-time vectoring of ship was possible. Prior technology involved the use of sonar arrays gathering geological information and bringing it back to port on tape for non real-time processing. The delays from the time the record was made to the analysis of the data and vectoring the fleet back to a promising area was measured in months.

Little known operations that the ACTS program supported were the many and varied civil and military applications with our 622, 45 and 1.56 Mbps services. The most unique, was the support to the troops during the army operation “Uphold Democracy” in Haiti. During this operation the ACTS was employed on a mission to maintain morale among the troops. With the wideband com between Haiti and Fort Bragg provided by the ACTS, the troops were allowed to communicate by video with their families. This operation was an outstanding success that was left undocumented but showed the benefit of wideband com for military operations as a morale builder for troops remotely located from their families.

The very nature of the ACTS program was to serve many users with widely different communications needs and do it PROMPTLY without a lot of paperwork. The entire sets of earth stations were transportable and could be transported by truck, rail or C-130 aircraft. The terminals included a large high data rate terminal, a medium size medium data rate terminal and a very small terminal. Each had their own capability and services their own markets.

From a pure technology point of view the ACTS verified the transfer of information at 1.2Gbps through the satellite. This capability had sufficient reserve to be able to surge to 1.8Gbps. The implications to a second generation Internet services are that an ACTS-like communications satellite can keep up with Internet command, control, communications and data base transfers. These capabilities were demonstrated by successfully linking earth based fiber networks through the satellite.



Additionally the ACTS was reconfigured daily to meet different user bandwidth needs for either onboard switching or bent pipe applications. This is totally unlike traditional communications satellite designs. Doing so enables the satellite to accommodate an ever-changing communications markets. For military or other government services this remarkable service show the benefits of wide-band communications to businesses whose customer demands change quickly and without explanation or time to prepare for communications needs in advance.

To interface with these networks and to develop the ACTS earth station networks we had to develop the principles for configuring our own ACTS networks. These principles should be considered when developing ground networks to support future space operations. These principles are:

Principle 1… Employ Commercial Service Providers wherever possible. The commercial service providers are immersed in the day-to-day operations of high performance communications system and know many tricks of the trade for fielding, operating and maintaining operational systems. This experience is invaluable when prompt response to changing requirements from knowledgeable users and markets.

Principle 2… Use a mesh network of stations to achieve 0.99 availability using individual stations each operating at 0.95 availability. The benefit from working with mesh networks of commercially operated ground stations is that if one commercial firm fails, for whatever reason; another can pick up the load with barely a hitch. In government applications the mesh network must be operated under an ordering agreement to provide the flexibility to promptly move another contractor into place.

Principle 3… Use the fewest number of earth stations to achieve the lowest cost network. The notion here is born out of the approach used in the ACTS program management of using linear programming to assign the terminals in such a way that the maximum number of experimenters given the limited resources of money, terminals, team members and the management policy of accomplishing at least 40% of the experiments were HDRT experiments, 30% were VSAT experiments and the rest were USAT experiments.

For those less inclined to use analytical tools and approximations, the approach to determining the locations is to start with a mission model programmed into STK and then add a single station of know location for communications, then, use STK, to determine the percent of time the communications links close and the communications infrastructure is available. Then add another earth station and another until 100% availability is reach. Iterate the process selecting from available earth stations until the number of stations is minimized.

Principle 4… Locate the earth stations on the nodes of the Terrestrial Internet backbone to assure wideband access to all users of the networks and provide for future growth with the Internet. Again the rationale is to meet the ever-changing demand for high performance communications by experience users already using the internet at remote locations.

Principle 5… Employ Internet command and control of Space Assets to enable mesh networks of space assets for prompt, reliable communications for science, commercial and military space applications. Here the concept is to make full use of all of the nation's space assets, whether commercial, civil government or military in support of the nation's information needs.

The idea that underlies this principal is that a Government agency may need images of a natural disaster situation that a commercial remote sensing satellite may be able to capture. It is envisioned that the government manager would buy time on the commercial satellite with the swipe of a credit card, and then take control of the satellite to capture the image he needs. Once the satellite has the image, the manager would contact other

wideband comsat service providers, such as the network suggested here of ACTS like satellites and earth stations, and order a relay service to return the imagery to locations where it is needed using terrestrial internet services.

Principle 6… Avoid any network development that would preclude the future development of the Space Internet infrastructure. The idea that underlies this principle is the notion that a space based internet that girdles Earth will emerge in the same way the earth based fiber network emerged. It is inevitable. These two services have similar wideband communications capabilities but significantly different reach into remote battlefield locations and remote rural commercial market areas throughout the world. What ever the earth-station infrastructure is developed to support space operations now and into the future should not preclude this inevitable future.