ATM over Satellite for the Warfighter

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ABSTRACT

As a New World order takes shape, one thing is for certain – United States military forces will be involved in armed conflicts in austere locations around the globe with minimal notice. The Joint Chiefs of Staff have recognized this and have called for an increased reliance on information technology at tactical, theater, and strategic levels. Reliance on Satellite Communications will undoubtedly increase, whether on military owned or commercially leased satellites. It is my belief that traditional terrestrial (fiber) based communication schemes such as Asynchronous Transfer Mode (ATM) will be fully ported to space vehicles.

ATM provides a means to transport voice, data, imagery, and video at high speeds while maintaining a negotiated quality of service. The soldier in the field no longer relies on voice alone. He is now required to send and receive imagery and video of his hostile surroundings. The fighter pilot needs not only his Air Tasking Order, but bomb damage assessment in real-time so that he may quickly strike again. The Naval Task Force Commander needs a fused picture of the battlespace in order to plan the next maneuver.

These scenarios require multiple types of traffic transferred at low, medium, and high bandwidths. Asynchronous Transfer Mode over Satellites is the key to meeting these requirements. My paper will discuss current commercial and military initiatives that are proving the benefits of ATM over Satellite. I will describe the challenges of hosting this technology on LEO, MEO, GEO, and hybrid satellite constellations. I will analyze the importance of using crosslinks for intersatellite communication and the constraints this may put on transmission Quality of Service. Finally, I’ll argue whether the military should own such a system outright, or possibly lease transponder space on a commercial platform.

THE NEED FOR ATM OVER SATELLITE FOR THE WARFIGHTER

ATM over Satellite provides the modern warfighter with the communications infrastructure necessary to carry out modern warfare and military operations other than war. A wide variety of message traffic can be sent at incredible speeds in a secure robust manner using satellites in an effort to provide low cost global grid that literally can “reach out and touch” friendly military forces.

Mixed Traffic Types

The modern warfighter is equipped with not only voice radios, but data devices, still imagery cameras and video cameras. Specifically, ATM over satellite will provide:

Voice – Secure and non-secure point-to-point and conferencing capability.
Data – Situation Reports, Air Tasking Orders, Emergency Action Messages.
Video – Everything from Battle staff videoconference rooms to Space, Aerial, and tactical reconnaissance.

Global Connectivity

Today’s warfighter can be deployed anywhere in the world at a moment’s notice. Not every theater he/she operates in will have the luxury of terrestrial-based fiber for high-speed communications. Simply put, the warfighter needs to effectively communicate anywhere in the world at any time.

The Defense Information Systems Agency has recognized this challenge and has laid out requirements for such a global grid in its Defense Information Systems Network (DISN) Strategy [10]:

“Bandwidth manager devices capable of supporting ATM will be used in a worldwide transmission grid to provide the DISN integrated transmission service. Circuit requirements for all types of telecommunication services will be provisioned on the integrated transmission service. ... Transmission services will also be provided on an integrated satellite transmission system through military and commercial satellite gateways that are being provided under DOD’s Commercial Satellite Communications Initiative (CSCI). This integrated satellite transmission...
system will be further interconnected with the Bandwidth Manager Transmission system in order to provide combined satellite/terrestrial circuits with an underlying transmission technology transparent to the users.”

**ATM BASICS**

ATM provides a high-speed switching network that supports a variety of user traffic. User traffic is segmented and multiplexed into 53 octet cells, with 5 octets dedicated to the cell header. An ATM network uses the cell header to relay user traffic from its origin, through high-speed switches, to its destination.

ATM is a connection-oriented service requiring both the user and distant end to negotiate a Quality of Service depending on the type of traffic to be transmitted over the ATM network. According to Black [5], “The challenge of the ATM network is to support the natural bit rates of all applications being serviced.” ATM supports several different services including Constant Bit Rate (Videoconferencing), Real-Time Variable Bit Rate (ATM Voice and Multimedia), Non-Real-Time Variable Bit Rate (Banking), Available Bit Rate (LAN interconnect) and Unspecified Bit Rate (E-mail).

**SATELLITE COMMUNICATIONS BASICS**

There are a wide variety of satellite platforms and communication payloads in operation and under development, which should be considered when deciding on a military satellite communications (MILSATCOM) system.

**LEO**

Low Earth Orbit (LEO) satellites typically orbit the earth at an altitude of 500-1500 miles. Numerous satellites are required to provide full earth coverage. Latency (transmission time from an earth terminal up to the satellite and back down to another earth terminal) is low (sub 0.03-second round trip) [8]. Traffic routing algorithms and traffic “hand-offs” between satellites in a particular coverage zone are very complex. LEO launch costs are typically lower than MEO and GEO launch costs.

**MEO**

Medium Earth Orbit (MEO) satellites maintain 6250-13,000 mile orbits. A handful of satellites can provide full earth coverage but latency increases to 0.06-0.14-second round trip [8]. Traffic routing algorithms and “hand-offs” are less complex. MEO launch costs are potentially more expensive than LEOs.

**GEO**

Geosynchronous Earth Orbit (GEO) satellites are placed at a fixed orbit of 22,300 miles requiring only 3-4 satellites for full earth coverage. However, latency is high at 0.24 seconds per round trip. Large geographic coverage areas lessen the need for intersatellite routing and “hand-offs.” GEOS have traditionally been the most expensive to launch.

**SHF/EHF Communications**

Commercial satellites today communicate in the L-band (1.53-2.7 GHz), C-band (3.7 - 5.9 GHz), Ku-band (11.7-17.8 GHz), and the Ka-band (18-31 GHz). Military satellite communications by their inherent nature must be as secure as possible. The Super High Frequency (3-30 GHz), SHF, and particularly the Extreme High Frequency (30-300 GHz), EHF provide the bandwidth for high speed communications and jamming protection that is not available at lower ends of the spectrum [12]. Higher frequencies also permit the use of smaller antenna sizes for users on aircraft, ships, and on the ground.

SHF and EHF have known problems with rain fade and atmospheric attenuation, but more powerful transmitters and other technological means have addressed this.

**Crosslinking**

Crosslinking allows satellites to send data to each other without the use of ground stations. This provides a user in the Pentagon with a communications link to a user in Saudi Arabia with out the delay of intermediate ground station reception and transmission. Crosslinking provides the global connectivity mandated in the Defense Information Systems Network.

**ATM OVER SATELLITE**

**Current Initiatives – Military and Government**

**Airborne User Platforms**

During recent Joint Warrior Interoperability Demonstrations (JWID), phased array antennas have shown promise in receiving high-speed communications from satellites. This technology allows aircraft in motion to pinpoint and track a satellite's position relative to the aircraft. Servers and workstations processing weather, imagery, intelligence, and command and control...
information inside the aircraft are linked together on an ATM backbone. Tests have been conducted in the X, Ka, and EHF bands [9].

**Unmanned Airborne Vehicles**

The Defense Airborne Reconnaissance Office (DARO) have begun testing high speed secure communications on the Predator and Dark Star Unmanned Airborne Vehicles (UAV). “High-data-rate uplinks and crosslinks include extremely high frequency (EHF) air-to-satellite uplink, advanced antennas and EHF or laser air-to-air crosslink [9].”

**Ground User Platforms**

GTE Communications system division has been working on adapting ATM technology with the United States Army mobile subscriber equipment (MSE). This research is delving into molding ATM, typically associated with high bandwidth fiber-based communications, to relatively slow radio-to-radio wireless communications [9].

**NASA Advanced Communications Technology Satellite (ACTS)**

The NASA ACTS satellite was launched in September 1993 with the goal of developing advanced communications technologies. Specifically, ACTS is proving the benefits of Ka-band spot beam communication satellites with on-board baseband and microwave matrix switching [7].

**DISA Commercial Satellite Communications Initiatives (CSCI)**

COMSAT Laboratories New Technology Division under the auspices of DISA’s CSCI program have conducted numerous ATM over Satellite demonstrations. They have shown that ATM QOS can be maintained on a Geosynchronous satellite using an onboard switching mechanism.

**Current Initiatives - Civilian**

**KaSTAR**

The KaSTAR satellite system is designed to be an ATM data communications network providing data, voice, and video service to CONUS, Alaska, and Hawaii. It initially plans for 2 Geosynchronous satellites communicating in the Ka-Band via crosslinks with up to 2 more satellites in the future [7].

**Astrolink**

Lockheed Martin’s Astrolink includes on-board processing and spot beam technology on 9 Geosynchronous satellites communicating in the Ka-Band via crosslinks. Astrolink will provide 155Mbps data rate using multi-frequency TDMA [3].

**Celestri**

Motorola has combined two proposed projects, Millennium and M-Star, into its ambitious Celestri satellite constellation. Celestri will eventually consist of 9 GEO and 63 LEO satellites. Broadcast and Multicast traffic will be delivered via the GEO payloads, while interactive voice and data will be routed through the LEO payloads. The Celestri constellation will use innovative Laser crosslinks [2].

**SOLUTIONS AND CHALLENGES**

While LEO satellites do offer low latency per satellite, when satellite crosslinking is involved this latency can be substantially increased (as a factor of n hops). Add to this the necessity of encryption and decryption and latency will indeed be a concern. Furthermore, the routing algorithms and “hand-overs” required for global connectivity require a complex ground control segment. MEO satellites over some advantages over LEOs for ATM traffic, but not enough to convince this author.

The author proposes using 4-6 Geosynchronous satellites using the EHF spectrum and crosslinks for communications. Each satellite should carry an ATM switching mechanism capable of Dynamic Bandwidth Allocation and with enough buffer space to handle congestion from the hundreds of potential warfighters using the constellation.

Research needs to be conducted on latency as it relates to crosslinks and encryption. Preliminary research of a new encryption device known as FASTLANE over an ATM network has shown that QOS can be maintained over the Global Broadcast Service Satellite System [6]. Further research is needed in slowing down high-speed ATM communications to speeds comparable to tactical radios (19.2 Kbps and lower). Finally, the practicality of Laser crosslinks (Celestri) should be observed.

Who will own and operate such a system? The author believes that even in this era of privatization and outsourcing, there is a need for the military to operate and maintain its own secure satellite communications network.
This system should be owned and controlled by the Department of Defense. Specifically, the Air Force Space Command has space operators with experience flying Crosslinked GEO satellites.

References


3. *Astrolink Technical Overview*  
   http://www.astrolink.com/tech_info.html

4. *ATM VIA Satellite*  
   http://www.ntd.comsat.com/viasat.html


7. *KaSTAR Overview*  
   http://www.kastarcom.com/home.html


