GENERAL DYNAMICS
C4 Systems

ReachBack

White Paper

Reachback™ Iridium Inverse Multiplexer for Over-the-Horizon Worldwide Transmission of Voice, Video, and Data

1.0 EXECUTIVE SUMMARY

General Dynamics Decision Systems is pleased to provide this white paper that describes how Iridium®-based mobile satellite service can be utilized to provide bandwidth-enhanced, worldwide, on-the-move (OTM), beyond-line-of-sight (BLOS), transmission of voice, video, and data.

These improved, bandwidth-enhanced services are provided by our Reachback™ inverse multiplexing (IMUX) device, which simultaneously combines several Iridium channels to increase the total effective transmission bandwidth. The Reachback IMUX can be integrated into a variety of systems such as sensors, aircraft, vehicles, ships, and end user terminals (EUTs), or can operate as a standalone device.

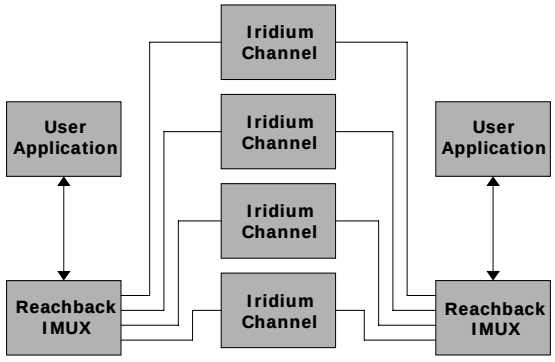

Figure 1. Block diagram of Reachback Iridium inverse multiplexer (IMUX).

This system requires **no** added terrestrial or airborne infrastructure, and no modifications to satellite payloads. Not only can this solution provide video and data communications, but the same device can also be used as multiple satellite telephones, utilizing the Iridium service to connect to other mobile users, or to virtually anywhere worldwide through the Public Switched Telephone Network (PSTN). By building upon the Iridium service, this capability is available globally, pole-to-pole, without reliance on any terrestrial infrastructure whatsoever.

2.0 IRIDIUM SERVICE OVERVIEW

The Iridium commercial system is a space-based global digital communications network designed to provide wireless communications *on the move*, to hand-held devices located anywhere, pole-to-pole, on or near the surface of the Earth.

Through its orbiting constellation, the Iridium system offers full-time, full-earth communications. The satellites act as a reconfigurable, packet-switched network in space, connecting remote users with other remote users and terrestrial telephone networks. Each satellite hosts user links (L-Band, user-to-satellite), cross links (Ka-Band, satellite-to-satellite), and feeder links (Ka-Band, satellite-to-gateway), completing the integration of the full-mesh packet network with the Defense Information System Network (DISN), and the PSTN.

3.0 REACHBACK IRIDIUM INVERSE MULTIPLEXER

Transmission of video/imagery/data over low-bit-rate, wireless links is extremely problematic due to limited channel bandwidth and inherent channel errors. In particular, since a single Iridium channel can support only 2.4 kilobits per second (kbps) of raw data throughput, data transmission tends to be slow, and the real-time transmission of video is infeasible. If several low-rate channels are available, however, these channels can be combined to form an effective higher-rate channel, where the total bandwidth is directly proportional to the

number of channels combined. This function is called *inverse multiplexing*, and the device that enables this functionality is called an *inverse multiplexer* (IMUX).

The General Dynamics Reachback IMUX addresses this bandwidth limitation by simultaneously combining a number of low-rate Iridium channels to form an effective higher-rate channel, with an aggregate bandwidth of 9.6 kbps. This procedure is illustrated in Figure 1. At the transmitter, the Reachback unit parses the input data, and sends different portions of the data over separate Iridium channels. At the receiver, another Reachback unit recombines the original data, using buffers to compensate for variations in delay of each link. The net result of the system is that the effective bandwidth multiplication is directly proportional to the number of channels combined. Note that this operation is completely transparent to the user.

Figure 2. 19-inch rack-mount version of Reachback IMUX, front (top) and rear (bottom).

The General Dynamics Reachback IMUX incorporates four Iridium channels in a small, self-contained unit. Additionally, the Reachback unit incorporates an internal Pentium-based mobile computer and a universal AC power supply (a DC power supply is optional). External connections include Ethernet, USB, monitor, keyboard/mouse, AC power, and external antennas. Figure 2 shows the 19-inch rack-mountable version of Reachback (an aircraft form factor is also available). Note that the unit can be connected directly to a network, or to any external computer via standard connections.

The data connectivity capabilities of Reachback are formidable, and can be implemented in a variety of configurations: *mobile-to-mobile*, *mobile-to-network*, and *mobile-to-PSTN*. The mobile-to-mobile configuration, as shown in Figure 3, establishes a connection between two remote or mobile Reachback units. In this configuration, standard IP-based tools like FTP can be used to transfer data between the two units. A mobile-to-mobile connection can be made between any pair of Reachback units.

The mobile-to-network connection, as shown in Figure 4, is ideal in situations where multiple Reachback units are accessing a central server. With a mobile-to-network configuration, the Reachback unit can be used to transfer files, run web-based applications, or access secure HTTP sites. Connections can be made to the Internet via the commercial Iridium gateway in Tempe, AZ, or to the NIPRNET via the DoD Iridium gateway located at NCTAMS-PAC Wahiawa, Oahu, HI. Alternatively, a private connection can be established by installing a T1 line directly to the Iridium gateway.

Mobile-to-PSTN connectivity can be established by using our prototype 4-channel PSTN-based Reachback IMUX, which can communicate with any mobile Reachback unit. The PSTN Reachback IMUX facilitates multichannel Iridium connectivity by simply using four standard PSTN phone lines to communicate with any mobile Reachback IMUX via Iridium-to-PSTN connection capability. The PSTN version of Reachback can facilitate the same services as provided by the central gateway server by acting as a bridge between the mobile Reachback unit and the host base-station network. This configuration can provide an alternative to gateway-based Internet services, and would be ideal for applications where PSTN infrastructure is readily available on either side of the link. Note that the prototype PSTN Reachback IMUX uses

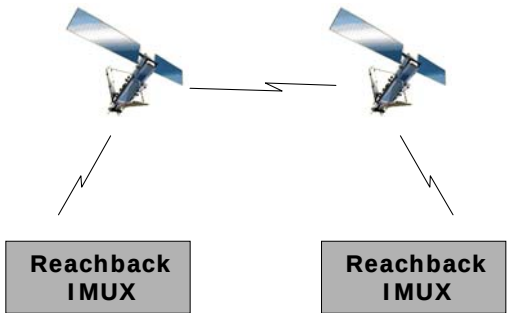

Figure 3. Mobile-to-mobile configuration.

hardware and software components that are identical to those found in the mobile Reachback IMUX, and simply incorporates four standard modems in place of the mobile unit's Iridium transceivers.

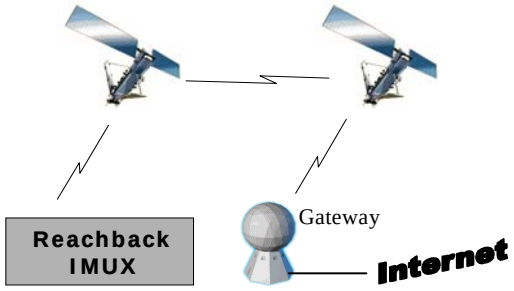

Figure 4. Mobile-to-network configuration.

To provide comprehensive BLOS, over-the-horizon communications capability, the Reachback IMUX incorporates three modes of operation: (1) Data transmission mode; (2) Image/video transmission mode; (3) Voice mode. Each of these modes is discussed below.

Data Transmission Mode: The transmission of data requires a reliable mechanism to ensure that the data is not altered during transmission. For the multi-channel, inverse-multiplexed scenario, an overall packet control and retransmission scheme is incorporated within Reachback to ensure that the packets being transmitted over the multiplicity of channels can be recovered and ordered appropriately at the receiver. The developed system provides an overall reliable packet retransmission scheme that supports an arbitrary number of channels. Because of its on-board, general-purpose processor, Reachback can be configured for a wide variety of applications, including automated file transfer from remote locations, and can be optioned to compress data/imagery prior to transmission, thus increasing the effective transmission throughput. Additionally, Reachback can serve as an IP bridge, and can be combined with our Sectera® line of encryption products to provide Type 1 secure network connectivity.

Video Transmission Mode: To further the utility of Reachback, we have developed video coding technology that allows the real-time transmission of video over the multiple, low-bit-rate, inverse-multiplexed Iridium channels. The video transmission system uses unreliable/unacknowledged transmission, whereby no packet retransmission whatsoever is allowed. This facilitates real-time video transmission through the system, since the delays associated with packet retransmission would not be acceptable. The developed video codec is designed specifically for use with the multiple Iridium channels, and is resilient to both packet and channel losses. This optional capability facilitates worldwide, real-time video transmission over the Reachback IMUX units.

Voice Mode: To address the need for comprehensive, over-the-horizon communications capability, the Reachback IMUX incorporates full voice transmission capability. Any combination of channels can be used for separate voice communications, while the remaining channels are available for inverse-multiplexed data/video transmission. Each Reachback IMUX channel supports direct connection to the Motorola® 9520 handset, via an RJ-45 connector. The 9520 handset provides complete keypad, display, microphone, and speaker provisions.

4.0 CONCLUSION

The General Dynamics Reachback Iridium inverse multiplexer leverages the existing and proven Iridium satellite network, and enhances its functionality by providing vastly increased bandwidth for the transmission of data and video, as well as providing voice capability. This combination of voice, video, and data services in a single, compact unit provides a unique, low-cost, no-terrestrial-infrastructure, beyond-line-of-sight, over-the-horizon communication system. No other solution can provide this combination of capability, low life-cycle cost, and transitionability.

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