Digital IF, FAST, and VITA-49

A Revolutionary New Architecture for SATCOM Terminals

WHAT IS DIGITAL IF?

TRADITIONAL ARCHITECTURES

Figure 1: MET Terminal Antennas and Electronics Buildings

Strategic fixed terminals often separate the antenna from the modems and baseband processing equipment. This is particularly true with large earth terminals such as the Army's MET[1] terminal (see Figure 1). For these enterprise terminals, the large number of modems and baseband equipment motivate the separation of these from the antenna pedestal, and they are often located in a nearby enclosure.

The inter-facility link (IFL) connection is usually at an analog intermediate frequency (IF), either coaxial or an analog fiber connection (see Figure 2).

For short distances coaxial cable can be used but it introduces insertion loss and also has undesirable characteristics for EMI and EMP requirements. An analog fiber connection mitigates these concerns but the limited dynamic range of the fiber transceivers can negatively affect performance, particularly with multi-carrier uplink fidelity and spectral purity. Also, current analog fiber technology limits the distance to less than 100 km.

An analog L-band Switching Subsystem (see Figure 2) performs combining/dividing as well as switching and routing of carriers via dedicated analog IF connections.

DIGITAL IF ARCHITECTURES

Emerging *Digital IF* technology enables more flexible switching and routing while also improving signal fidelity. In addition to terminal performance enhancements, *Digital IF* offers:

- Simplified operations, command, and control
- Ability to access terminals remotely across the globe
- Consolidated operations to reduce head-count
- Improved availability
- Improved performance monitoring and automated test
- Automated terminal calibration and alignment
- Better fault detection and failover
- Reduced maintenance labor

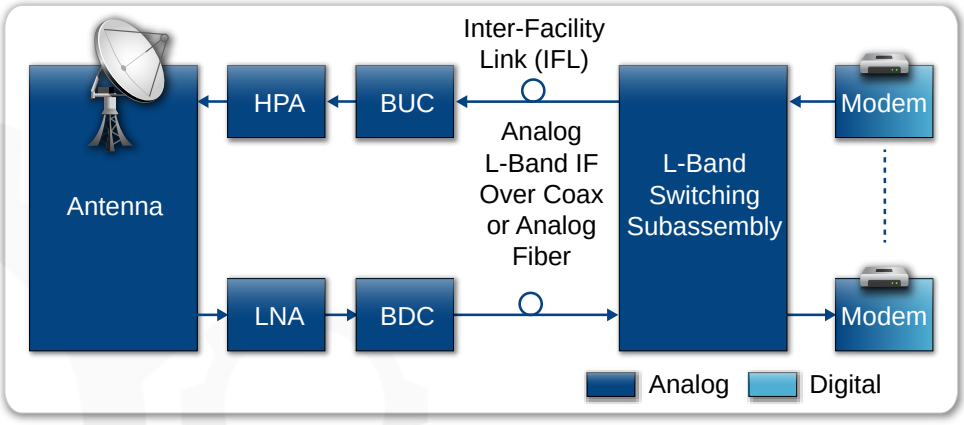

Figure 2: Traditional Fixed Terminal Architecture

[1] Modernization of Enterprise Terminals (MET)

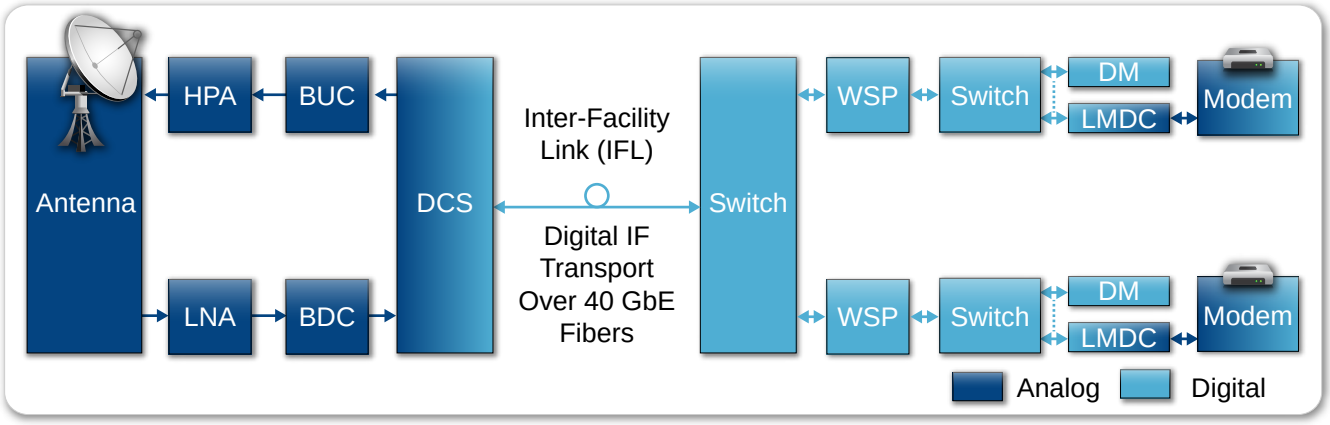

Figure 3: Army's FAST Terminal *Digital IF* Architecture

When *Digital IF* is used for signal transport over digital optical fiber, loss of signal fidelity on inter-facility cables need not be a consideration for antenna placement. This is a significant advantage to SATCOM-based networks by removing the constraint for the antenna and modem/baseband equipment to be colocated, or separated only by modest distances.

The US Army Communications Electronics Research & Development Engineering Center (CERDEC) sponsored the Future Advanced SATCOM Technologies (FAST) program to develop *Digital IF* SATCOM terminal prototype equipment. With the FAST *Digital IF* architecture (Figure 3), wideband A/D and D/A conversion is performed close to the antenna with the Digital Conversion Subsystem (DCS). The traditional analog IFL is replaced with GbE (Gigabit Ethernet) over digital fiber, and commercial-off-the-shelf (COTS) Ethernet switches are used in the equipment building/trailer. The example in Figure 3 shows two Wideband Signal Processors (WSPs) connected to GbE switches on both sides of the WSP.

New, lower cost, Digital Modems (DM) can connect directly to the WSP via a COTS Ethernet switch. The Legacy Modem Data Converter (LMDC) enables legacy analog L-band modems to operate within a *Digital IF* terminal.

With *Digital IF*, high-speed Ethernet packet switches or routers replace analog L-band switches or patch panels. Combined together, the *Digital IF* advantage of long distance signal transport and routing flexibility allow today's analog L-band modems, when coupled with an LMDC[2], to connect to a distant antenna. Advantages are:

1. Distributing traffic over multiple terminals. For instance, a distant terminal may have underutilized uplink capacity, which can be used to uplink traffic from another terminal.
2. Removing the need for large and unmistakable SATCOM antennas to be colocated with the baseband equipment, which may be desired for stealthy operations.
3. Mitigating natural and wartime link degradations. For example, a distant antenna may have superior downlink quality, throughput, or C/No relative to a local antenna that is disadvantaged due to weather related fading, jamming, or scintillation.
4. Allowing more options for terminal failover, improving link availability.
5. When modems can be paired with antenna in a different terminal, it allows more freedom in the modem set installed for a particular terminal, possibly reducing cost and maintenance while improving availability.

[2] Using an LMDC in both terminals, these advantages are possible even when the local and distant terminals are not enabled with *Digital IF* capability.

STANDARDS & SPECIFICATIONS

Traditional terminals are built to standard military specifications such as MIL-STD-188/164B and MIL-STD-188/165A. However, these MIL-STD's inherently assume an analog terminal architecture and are difficult to apply directly to the *Digital IF* architecture. To address this, CERDEC sponsored development of an Open Standard *Digital IF* Interface (OSDI) document. A working group consortium of government engineers and six DoD contractors participated in developing the OSDI to ensure interoperability between FAST equipment developed by independent suppliers. The OSDI standard is currently being verified and validated on prototypes developed by Welkin Sciences, Comtech EF Data, and Harris.

DIGITAL IF, FAST, VITA-49 AND INTEROPERABILITY

Digital IF, FAST, and VITA-49[3] are not synonymous terms. *Digital IF* is a generic phrase denoting an architecture with A/D and D/A conversion at IF frequencies higher than traditional architectures (e.g. A/D and D/A conversion directly at L-band rather than 70 MHz). The phrase *Digital IF* is not specific to SATCOM and can be used in other applications such as EW, radar, and SIGINT, just to name a few. FAST is a specific and unique implementation of *Digital IF* as defined by the FAST OSDI to ensure interoperability. Hence, equipment built by two vendors in compliance with the FAST OSDI will be interoperable. The FAST OSDI ensures the government is not locked into a single vendor solution, allowing procurement and upgrade of components based on price and performance.

VITA-49 is a generic packet-based protocol to convey digitized signal data and metadata pertaining to different reference points within a radio receiver. VITA-49, like *Digital IF*, is not specific to SATCOM. The FAST OSDI extends VITA-49 to the transport of all packets, transmit as well as receive. Additionally, the FAST OSDI includes many specifications not included within VITA-49 (such as monitor and control).

To ensure interoperability, equipment must be compliant with the FAST OSDI.

WELKIN SCIENCES' FAST-COMPLIANT PRODUCTS

Welkin Sciences is the leader in the development of the DCS, WSP, and LMDC, having built prototypes of these products, which are currently being used at CERDEC to verify and validate the OSDI specification. Additionally, Welkin Sciences has delivered firmware cores to DM developers to expedite development and ensure interface compatibility with the WSP. Data sheets for FAST-compliant products are available at www.welkinsciences.com or by emailing us at info@welkinsciences.com.

[3] VME bus International Trade Association (VITA) 49 standard