MOVING TOWARDS AN ALL-DIGITAL MULTI-CHANNEL TM RECEIVERS

Pierre BASTIE[(1)]
(1) VP Business Development, SEMCO, Vista, CA. (USA)
pierre.bastie@semco.com

ABSTRACT

Test ranges support increasingly complex weapon system engagement, some involving more than 10 telemetry (TM) equipped vehicles flying at the same time. While tracking these simultaneous targets is possible duplicating parabolic antennas, a modern approach is to use Digital Beam Forming (DBF) antennas capable of collecting and digitizing TM channels from multiple vehicles at the same time. Today, the digital samples of those TM channels are reconstructed in the analog domain and transported to multiple TM receivers. The innovative concept proposed by SEMCO is to rely on an all-digital multi-channel TM receiver, capable of ingesting those digital samples produced by the DBF antenna and transported via a high-speed IP-based Ethernet link. Either collocated with the DBF antenna for a compact airborne solution or far away when used in a distributed range architecture, this concept will enable the Digital Transformation of the range while reusing range-certified demodulators and TM transport modules.

KEYWORDS

Telemetry, Receivers, Digital Beam Forming (DBF), Flight test, IRIG 106, TMoIP IRIG 218-20, Digital I&Q, RF over IP, Data Quality Encapsulation/ Data Quality Metric, Multi-target, airborne TM station, SkyRange, MOZAIC, Low SWaP.

INTRODUCTION

Flight Test telemetry is the gathering of real-time Test Article behavioral information radiated through RF modulated signals and collected by one or several tracking stations located on the ground (land-based), at sea (ship-based) or while chasing the article (airborne).

While a typical legacy flight test today involves one or two test articles, each having one or two TM links (so a total of 2 articles to track and 4 TM links to process), new weapon systems require more complex mission engagement with up to 15 test separate articles, each with 3 or 4 separate TM links leading to a total of 15 targets to track and 60 TM links to process.

This paper will first touch on the legacy telemetry ground station architecture currently deployed at DoD ranges and highlight its limitations in this new paradigm. Then, we will provide some background behind the emergence of the Digital Beam Forming (DBF) antenna, the impact on the Telemetry station and why TM receivers are migrating towards Digital Multi-channel processors. After reviewing key attributes of the digital link needed to connect the DBF antenna and the Digital processor, challenges for its implementation will be covered and a preliminary test plan described to guarantee that this new concept of digital receivers is performing at least as well as the current analog interface.

LEGACY TM GROUND STATION

A range telemetry ground station typically consists of one or more parabolic tracking antennas (sensors) connected to several hardware intensive LRUs through dedicated analog cabling, as shown in Figure 1 below, and aggregating their individual signals to a gateway for injection into the range IP network infrastructure.

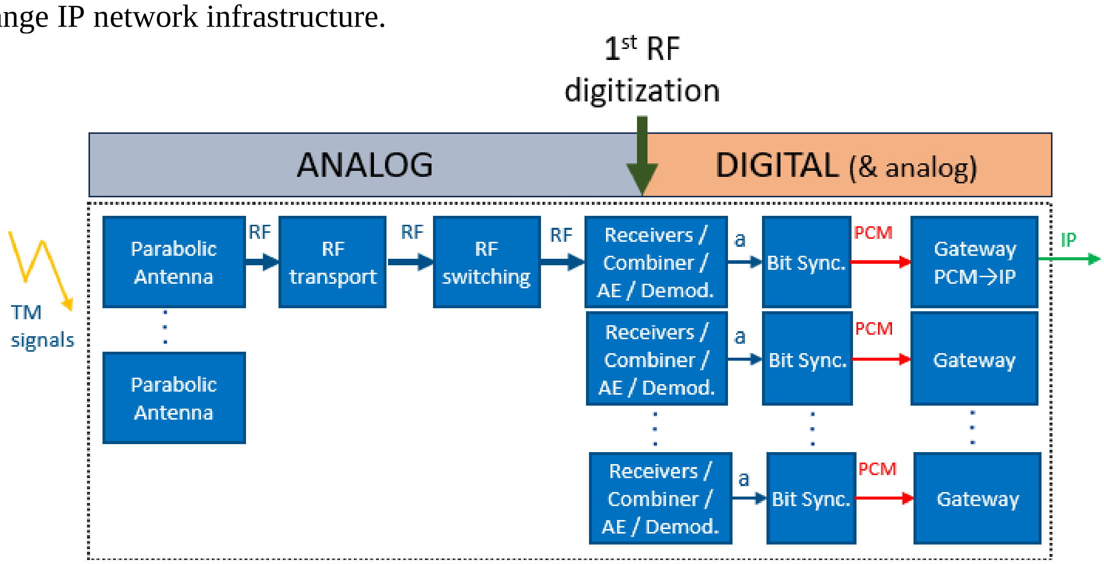

Figure 1 Block diagram of typical range TM station

When looking at the T&E ranges, the overall Telemetry reception capability is made up of a set of ground TM tracking stations spread across the range to cover all mission trajectory scenarios. Each remote telemetry tracking station delivers collected TM data through the range network to a central location – the processing facility – where the TM source with the best quality is selected, then potentially decrypted before the data is reduced into engineering units for consumption by stakeholders at the mission control center. Figure 2 below illustrates such architecture for the mission support of 2 separate test articles and 4 TM links.

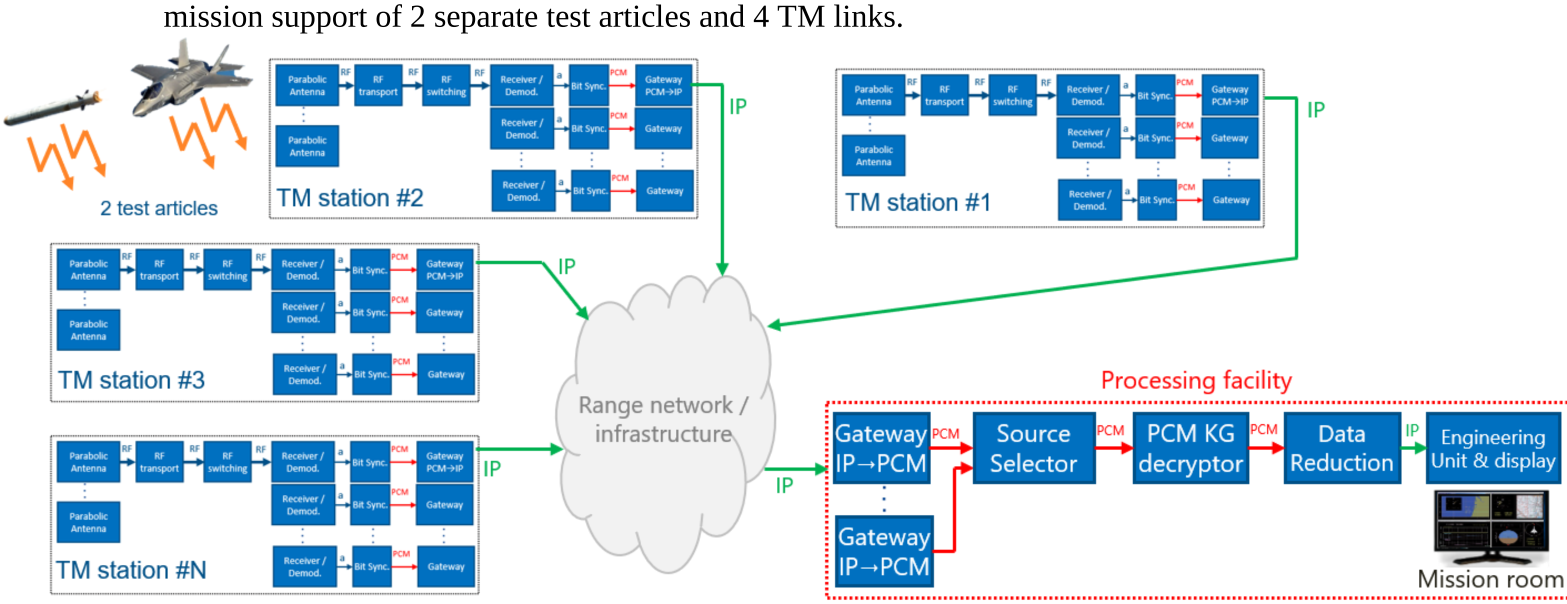

Figure 2 Typical Range architecture with several remote TM stations feeding the processing facility

The TM station connectivity to the range infrastructure has indeed evolved from analog (microwave links etc.) to IP. Devices (like PCM→IP gateway) have emerged bridging the gap from not IP-capable "Receiving" equipment and the range infrastructure that already operated its migration to broadband IP-based network. The rest of the station still relies on aging equipment, where capacity extension (more targets to track, more links to receive) is made by the aggregation of more standalone LRU's (antenna farm, racks of receivers…). While some LRUs perform their function "digitally" (like TM receivers), their interfaces are always analog (with reconstruction from the digital domain) and most of them are not even natively IP-capable.
Budget constraints have led to partial or incremental upgrades and vendors were asked to deliver LRU's featuring modern digital and Ethernet interfaces…while still supporting decade old analog interfaces. This situation never allowed the legacy ground TM station to fully migrate into the digital age and take full advantage of IP-based interface for not only transport the low bandwidth processed TM data but also the high bandwidth raw RF data channel from the TM antennas, upstream.

Hosting a farm of parabolic antennas comes at a cost: dedicated land, towers to install parabolic antennas, buildings to house racks of LRU's and operating staff. In addition to the infrastructure and hardware cost, there is a large man-print incurred by manual operations, including setting up equipment, routing signals, operating the antenna as well as in conducting configuration quality checks for mission assurance.

Figure 3 – Notional representation of a current farm of antennas and racks of receivers

Figure 3 above provides pictures of a telemetry station with 3 parabolic antennas and TM equipment racks. Because not all LRU's can be remotely controlled and monitored, local presence at the station is needed. This labor cost is also driven by the need for calibration before each mission that is required by analog-based LRU's and parabolic dishes…whereas a fully digital-based solution will have a repeatable behavior.

Legacy tracking antennas are parabolic dishes, hence can point and track just one test article at a time (i.e., one aircraft or one missile). Antenna position is achieved by a 2-axis pedestal involving many moving parts (including motor, belt and gearboxes) that require periodic maintenance and tend to wear with time. The sheer number of moving parts makes the reliability of these sensors rather low, forcing the ranges to duplicate them at each station to ensure telemetry data collection. Duplicating systems to create mission assurance forces increases costs to the DoD for sensors as well as for the real-estate and infrastructure required to support them.

LIMITATIONS OF CURRENT TM GROUND STATIONS

While the typical range architecture as described on Figure 2 above meets the requirements of legacy flight test scenarios with 2 or 3 separate test articles and relatively few TM links, this architecture becomes rapidly inadequate with the multiplication of not only test articles but also telemetry links per test article to be tracked and processed simultaneously (the requirement is set at 60 TM links today). Besides, this inadequacy is exacerbated with the requirement to support more than one mission at a time (i.e., like multiple concurrent launches and/or rocket operation at the Eastern and Western ranges). Finally, current architecture is not viable to support airborne TM stations requiring a low SWaP (Size, Weight, and Power).

There are really three main limitations to overcome:

1 - How to track and collect telemetry signals from more than one target at a time with the same antenna sensor?
2 - How to increase the number of TM links being processed within a telemetry receiver LRU?
3 - How to better integrate tracking antenna sensors and receivers to achieve a lower SWaP?

EMERGENCE OF THE DBF TECHNOLOGY

Part of those limitations are addressed with the emergence of Digital Beam Forming (DBF) antennas. This technology as deployed by vendors like CDSI relies on a network of fixed tiles (called DBM for Digital Beamforming Module) used as a phased-array alternative to parabolic dishes. RF is digitized at the antenna front end and digital processing is used to form multiple simultaneous beams, functioning as 32 individual directional antennas. Figure 4 below illustrates the DBF concept leading to a reduction of individual antenna apertures while increasing the number of targets being tracked by a single sensor (addressing limitation #1).

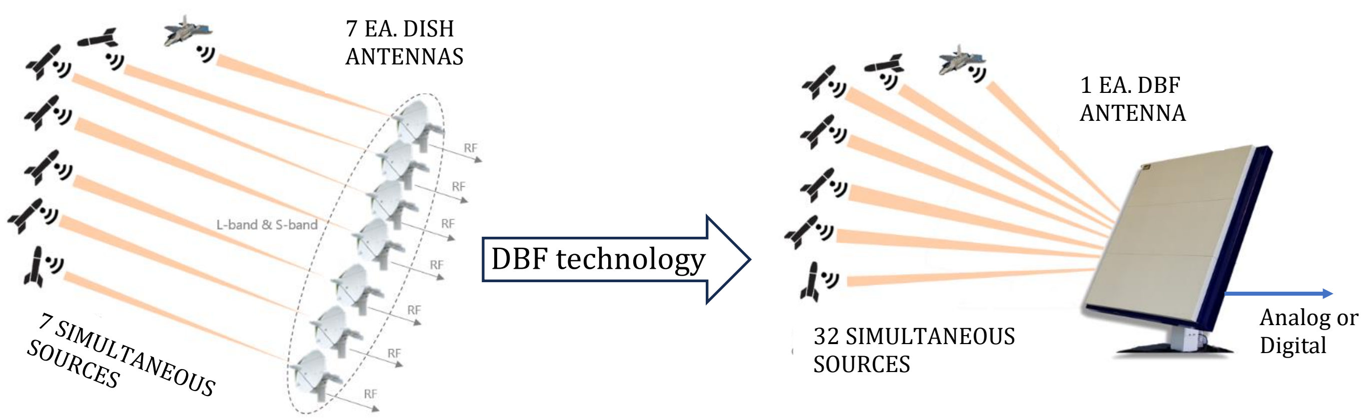

Figure 4 - Graphic illustrating the benefits of DBF antenna technology

Over the years, CDSI technology has matured and reached its current state with Universal Beamforming Technology (UBT), where DBM tiles can be arranged in a non-planar, non-contiguous network to operate individually or as part of a group to form a flexible coherent antenna aperture. Each DBM digitizes incoming RF energy at each antenna element in the tile, identifies the signal(s) of interest and optimizes the Signal-to-Noise Ratio (SNR) for each desired signal with respect to the other elements, as well as all elements in other DBMs that form the antenna system.

Since then, CDSI has redesigned the DBM with the current and much more capable RFSoC device, eliminating the front-end RF chain (Transceiver). These newer (v4) DBMs support 32 beams carrying data in excess of maximum DoD TM rates, and will be used in a large Ground Station array by the US DoD for multi-target tracking scenarios.

The RFSoC hardware allows direct sampling and processing of raw RF spectrum. The physical and electrical size of these RFSoC devices has made it possible to distribute these digital receivers throughout the antenna aperture, behind each antenna element, allowing the aggregation of signal for several simultaneous beams to happen completely in the digital domain.

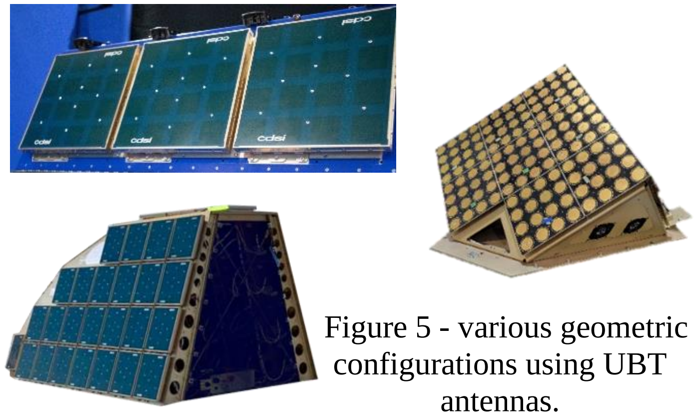

Figure 5 - various geometric configurations using UBT antennas.

The UBT antenna concept is seen in planar as well as non-planar geometries in Figure 5.

Note that this paper is not developing the ANALOG beamforming antenna technology. Indeed, although it addresses the requirements for multi-target tracking, the number of beams supported is much lower than DBM technology and the analog implementation is hardware intensive with a larger SWaP and requires calibration.

IMPACT ON THE TELEMETRY RECEIVER

In a legacy ground station, the RF signal is digitized within the telemetry receiver at 70 MHz after analog tuning, regulating and down-conversion as illustrated on Figure 1 on page 2.

When a DBF antenna is used to replace several parabolic antennas, the architecture evolves as illustrated in Figure 6 below.

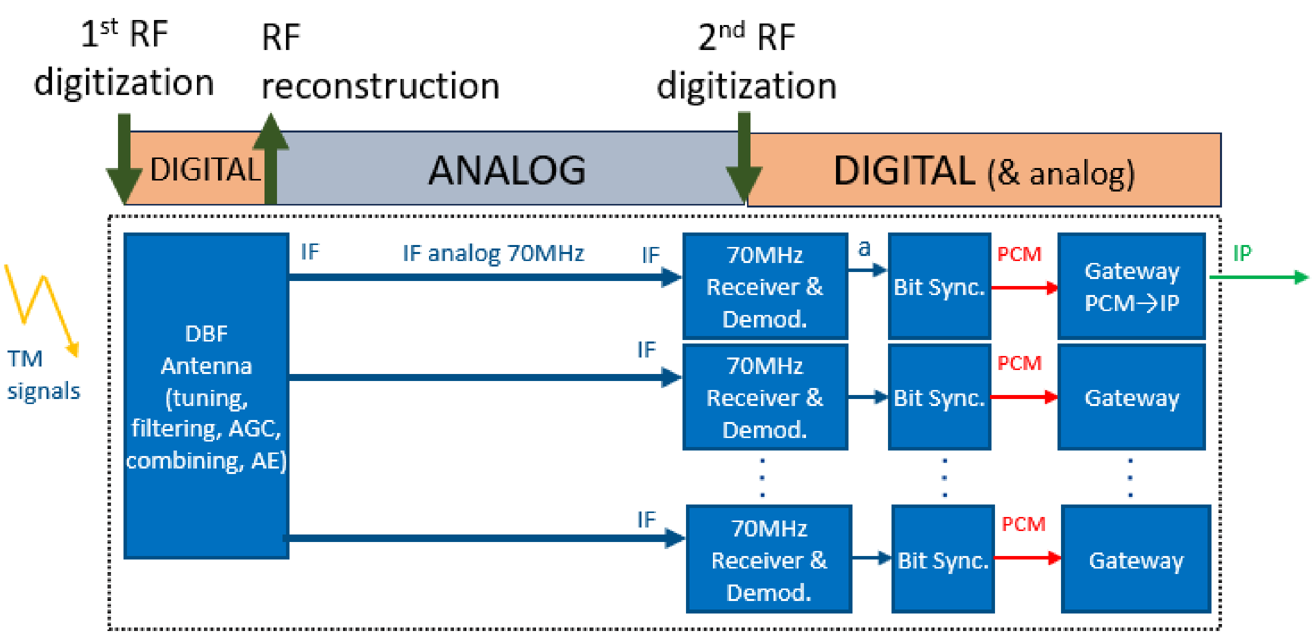

Figure 6 Evolution of the TM station architecture with a BDF antenna

As explained in the previous paragraph, the DBF antenna digitizes the RF signal received by each individual antenna element and performs “digitally” some functions that used to be performed “analogically” by the RF telemetry receiver, including channel frequency tuning, filtering, signal regulation, combining or even equalization (AE). The DBF then outputs (i.e., reconstructs from the digital domain) one analog IF signal centered at 70 MHz for each beam / channel it collects, with a maximum bandwidth per beam of approximately 40 MHz. The receiver then digitizes “again” this 70 MHz RF analog signal and performs the remaining functions of demodulation, decoding, synchronizing and TMoIP transport. Note that in this scenario, there is no more need for RF multi-couplers as the analog connections are point-to-point between the DBF and each individual 70 MHz receiver.

The Figure 6 block diagram is a representation for only 3 individual DBF beams, hence the 3 analog IF outputs and connections between the DBF antenna and the 3 Telemetry receivers…but with a DBF capacity up to 32 individual beams, there will be 32 individual analog connections between the DBF and 32 TM receivers. While some receiver configuration offers 4 IF 70MHz inputs, most are dual channel combiner systems with 2 IF inputs. Thus, the support of a 32-beam DBF requires 16 individual receiver chassis.

Therefore, to address limitation #2 listed above, telemetry receiver vendors have adjusted their products to increase receiving capability within a receiver LRU chassis. For example, SEMCO has developed a new 3U COTS product which is able to take up to 8 analog IF 70 MHz signals delivered by the DBF antenna and independently process those 8 TM links/channels, including TMoIP transport.
The front, rear and inside of the DTR300-8 for Digital Telemetry Receiver is shown below on Figure 7. Its 3U rack mount chassis embeds 8 identical processor cards (one per channel) using the latest version of SEMCO’s demodulator processor design that supports all IRIG-106 standard requirements including ARTM waveforms, AUQPSK, Adaptive Equalization, Viterbi and LDPC FEC decoders, Data Quality Encapsulation/ Data Quality Metrics (DQM/DQE) and TMoIP.

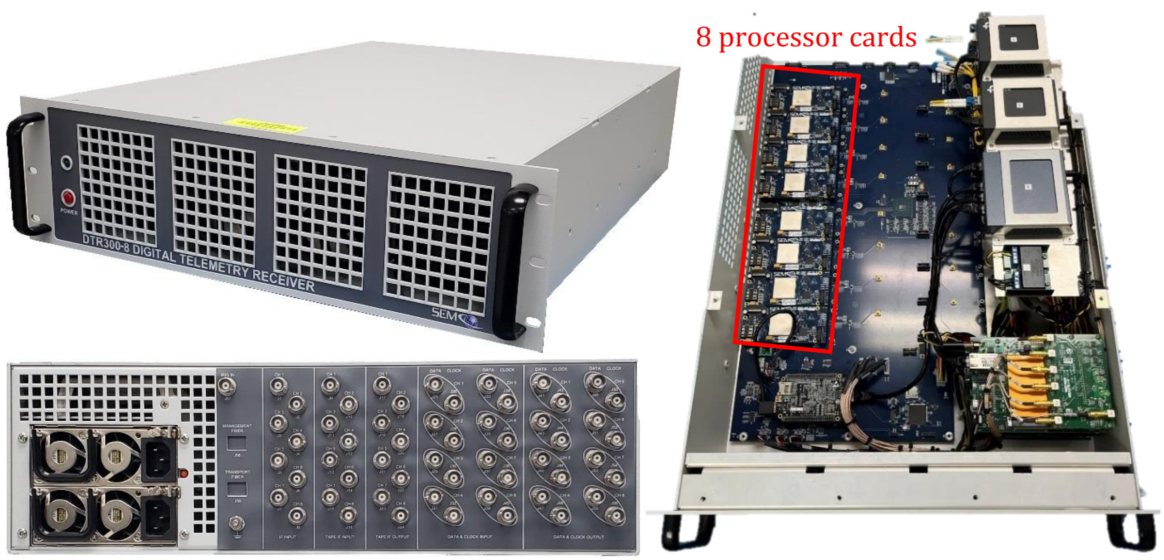

Figure 7 - SEMCO DTR300-8, COTS telemetry receiver to process up to 8 telemetry channels

Each of the 8 ea. 70MHz IF inputs can be dynamically assigned to any of the 8 demodulator cards for processing making the solution very agile with the function of RF switching embedded into the DTR300-8.
It is important to note that the demodulator design is the same one that populates all the recent SEMCO RC300 and RC100 series receivers delivered in the last 3 years to the MRTFB and DoD test ranges like PMSR, SLD30, SLD45, NASA Wallops… and which have been "Range certified" by the USG / USSF.

In the current DTR300-8 product configuration, while the demodulator and processing on the receiver are digital, the 8 inputs are still analog (i.e., IF 70 MHz centered signals) as shown in Figure 8 below.

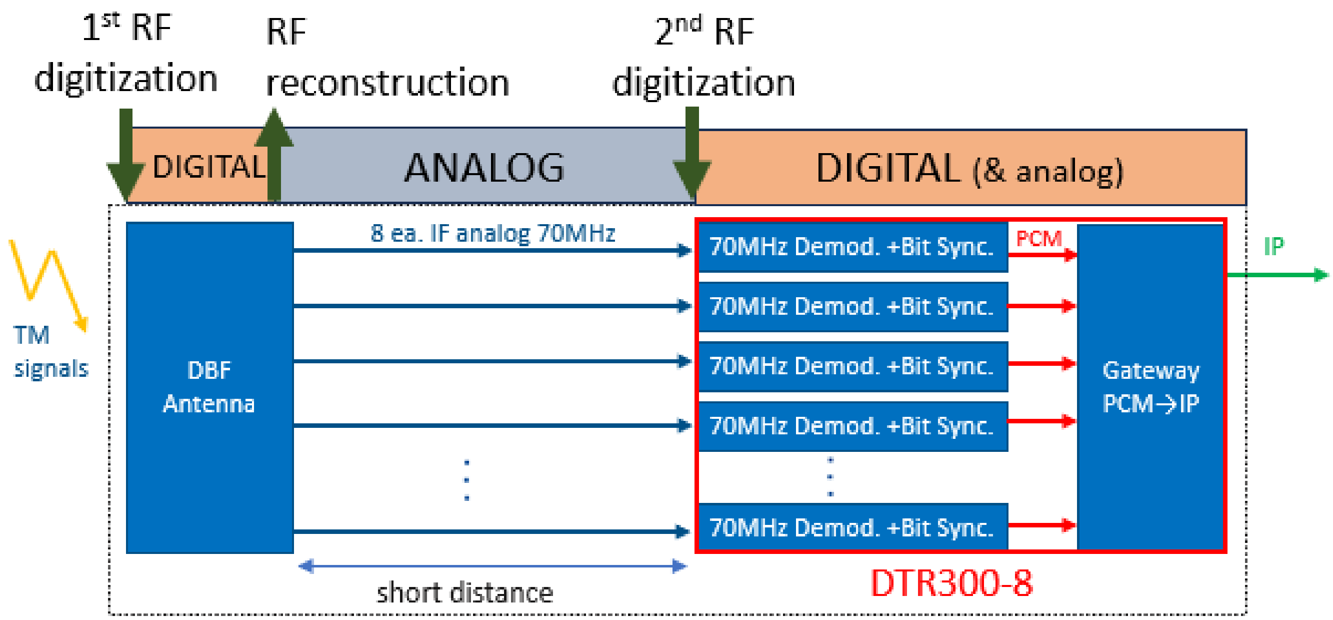

Figure 8 – DBF antenna architecture with SEMCO DTR300-8 receiver for 8 telemetry channels

The use of a DTR300-8 reduces the number of receiver LRUs by an approximate factor of 4, and therefore reduces the receiver footprint when a DBF antenna is used.

Notwithstanding, there are still some limitations:

- The connectivity between the DBF antenna and DTR300-8 requires 8 individual RF cables.
- Due to the analog IF 70 MHz connection, the DBF antenna and DTR300-8 need to be close to each other (almost co-located), thus preventing any distributed architecture approach.
- The successive digitization of the analog signal will most likely impact signal quality because the RF signal is first digitized and processed as I&Q samples at the DBF antenna before being reconstructed into the analog domain to connect to the DTR300-8 where the RF/IF signal is digitized again before digital processing.

While limitations #1 and #2 have been addressed, there remains the limitation #3: "How to better integrate tracking antenna sensor and receiver to achieve a lower SWaP?"

NEED FOR A LIGHTWEIGHT, LOW LATENCY IP COMMUNICATION

The need for a lightweight IP protocol, low latency digital communication between a digital DBF system and a multi-channel telemetry processor becomes inevitable to overcome limitation #3. In collaboration with CDSI, SEMCO has studied the possibility of a high-speed point-to-point serial link communication like the SerDer offered in current FPGAs. However, while it offers the required communication speed, it does not solve the requirement to separate the DBF antenna and the telemetry processor device. This approach has been discarded and preference is now directed towards an IP-like interface.

A. Digital communication link requirements

The objective is to define a digital link that features the below attributes:

- High-speed transport of digitized I&Q samples – to cover a minimum of 200 MHz of aggregate bandwidth *containing the telemetry signal of interest*. Note that a capability of 200 MHz bandwidth allows a support scenario where the entire S-band spectrum (i.e., extended S-band spectrum from 2,200 MHz to 2,400 MHz) would be used to carry telemetry signals. Another scenario could be to simultaneously use part of the S-band and part of the L-band (1,435MHz to 1,535MHz) to carry multiple telemetry signals aggregating 200 MHz of bandwidth. In this scenario, a 10 GbE Ethernet connection is sufficient and very common network infrastructure devices can be used (copper or fiber SFP connector, switch…). If there is a need for more aggregated spectrum (typical > 230MHz of aggregate BW which would be the case once considering tapping into the 500+ MHz bandwidth from the C-band telemetry spectrum), then the network infrastructure will need to migrate to 25 GbE (the capacity of such network will be around 600 MHz of aggregate BW). While these network devices do exist, they are less standard and more expensive. In this paper, the focus is on first establishing a 10 GbE network.
- Leveraging existing and documented communication protocol
- Data can be distributed by Ethernet switch.
- Supports long distance: to distribute the system and have the multi-channel telemetry processor positioned anywhere, assuming it can establish the proper connection with the DBF antenna.
- Low latency with rather small payload messages for quasi real-time transport. Note that telemetry processing cannot be delayed by more than a few milliseconds for reasons of safety and situation awareness.
- Focus on timing reliability with the inclusion of an absolute time stamp.
- Lightweight protocol for an overall overhead < 10%
- Flexible and scalable to adjustment during development and future upgrade to support new requirements,
- Capability to capture data and do real-time debugging with standard diagnostic tools like Wireshark.

B. communication link format

As shown in Figure 9, the link format is based on an Ethernet/IP/UDP format.

Suggested communication protocol for digital transmission of channel data						
Bandwidth/channel	10	MHz				
Sample rate	12.5	MSPS				
	Bytes	border signifies 4-byte groups				
IPv4	20	Internet Protocol standard				
UDP	8	User Datagram Protocol standard				
Absolute Timestamp	12	8 bytes UNIX time + 4 bytes sample number				
Type	1	Time Stamp type (4 bits), Data type (4 bits) - default:1 = Integer				
Channel / beam	1	inform on the channel #. 1 byte allows up to 256 different channels				
Reserved	2					
Reserved	4					
Data	1024	256	pairs of I&Q samples, each represented over 2 bytes			
TBD	4	reserved				
gap	12	reserved		Total BW (MHz)	200	
total/channel	1088	bytes/message		msg/sec	48828.13	
				bits/byte	8	
				# of channels	20	
Total OH	6.25%		**Average Link Data Rate (Gbits/sec)**		**8.5**	**<10GbE**

Figure 9 - Sample data stream for 20 simultaneous channels, each 10 MHz wide. Total data rate = 8.5 Gbps. Format is UDP/IP

The data message format (i.e. layers 5&6 for Session and presentation) proposes to use the below fields:

- Absolute Time stamp: accurate timing information in each packet allowing the ability to coherently re-arrange the packets at arrival. This cancels the need to use RTP protocol.
- Type: 1 byte to inform about the type of Time stamp and Data used
- Channel (or beam): 1 byte to inform about channel # (or stream # or beam #) whose I&Q samples are being transported in the subsequent payload data field. Note that a DBF antenna front end typically supports up to 32 beams simultaneously, so 1 byte allows coding of up to 256 different beams while leaving room for expansion and / or aggregation of more than one DBF antenna into the same network.
- Payload Data: this 1024-byte field contains the I&Q digital samples of the spectrum bandwidth of interest for a given beam (i.e., channel) of the DBF front end. With I and Q sample represented using 16 bits, 512 samples or 256 pairs of both I&Q sample data can be stored in one data packet. This 1024-byte size for the packet payload seems to be a good trade-off between maximizing the packet size to transport more samples at once and

therefore limiting the Ethernet communication to a reasonable speed of < 10 GbE on one hand and reducing it to rather low size to limit the latency induced by the digital link. With 1088 bytes and a link speed of 10 Gbps, the calculation for the packet latency is <1µS (Microsecond). One test below verifies that the digital link definition should not impact the overall latency of the receiving system.

Standardized RF over IP interfaces like VITA-49 have been reviewed but deemed inadequate for the real-time telemetry application, hence the presentation of this custom protocol tailored to the range telemetry application.

The objective is to present this proposed protocol for digital transport of RF Telemetry data channel (i.e. Bandwidth) to the IRIG106 RF system committee for standardization into chapter 2.

C. Digital communication link implementation

The objective is to remove the point-to-point analog connection between the DBF antenna and the multi-channel TM processor and implement an IP-like digital communication link instead, as shown in Figure 10 below.

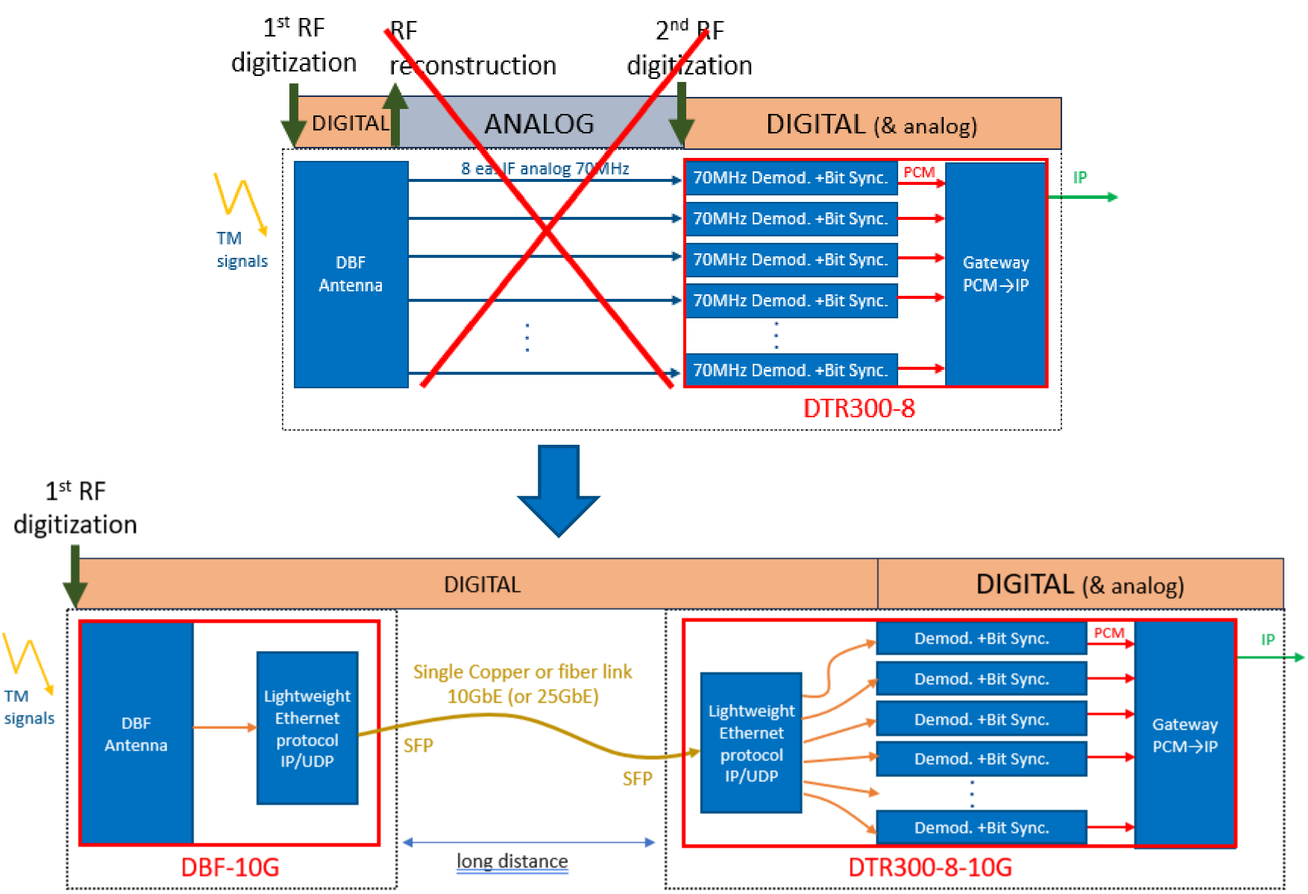

Figure 10 – Replace the analog point-to-point connections between the DBF and multi-channel processor with a digital IP-like link

As shown in Figure 10 above, the implementation of this digital IP-like link requires the addition of a new dedicated FPGA-based card in each product (DBF and DTR300-8) to manage the Ethernet IP/UDP protocol:

- one at the output of the DBF antenna to act as a gateway between the internal digital links and the newly defined protocol.
- one at the input of the multi-channel TM processor to convert this protocol into sub-sets of I&Q samples for each of the 8 demodulator / processor cards. (Figure 11 illustrates this new FPGA-based card for traffic management)

Figure 11 – addition of new FPGA card to build the DTR300-8-10G

Note that on the telemetry processor side, the current architecture made up of 8 identical FPGA-based processor cards (performing demodulation, synchronization, FEC decoding, DQE/DQM as well as the TMoIP interface) remain unchanged. This evolution of the DTR300-8 (named DTR300-8-*10G* for the new 10GbE interface) runs the exact same demodulator FPGA image as the ones currently used in the DTR300-8 or any other SEMCO telemetry receivers (i.e., like the RC100 and RC300 series). Those images have been field-proven and qualified at multiple DoD ranges including SLD30 and SLD45 where they are "Range certified". The FPGA-based card added upstream will act "traffic management" to route the incoming I&Q samples to the correct demodulator card and to convert the samples into the current interfaces used on this demodulation card.

TEST PLAN TO VALIDATE THE DIGITAL LINK IMPLEMENTATION

To validate the proper definition of the digital link and then its implementation by vendors, SEMCO has defined a preliminary test plan with basically 3 levels of testing:

- Functional test to validate the integrity of the suggested protocol.
- Qualification tests of the digital link with comparison to a reference analog connection in terms of latency, (re)acquisition time, sensitivity / signal quality (DQM, BER).
- Capacity of the digital link to support the required bandwidth (200 MHz or more of aggregate RF spectrum).

A. Functional test to validate the message format integrity

The objective of this test is to validate the suggested protocol for the digital link communication of RF data channel works. It will check the lower layer implementation (Data Ethernet layer 2, Network IP layer 3 and Transport UDL layer 4) as well as the message format payload as previously shown in Figure 12.
To perform this test, a simulated TM signal (e.g., 5 Mbps PCM-FM or SOQPSK-TG) is radiated in S-band over the air into the DBF antenna front end and the Bit Error Rate (BER) of the corresponding demodulator PCM output is measured; both internally to the DTR300-8-10G (using

the embedded BERT) in each demodulator card and externally using an external BERT (as illustrated in Figure 14 below).

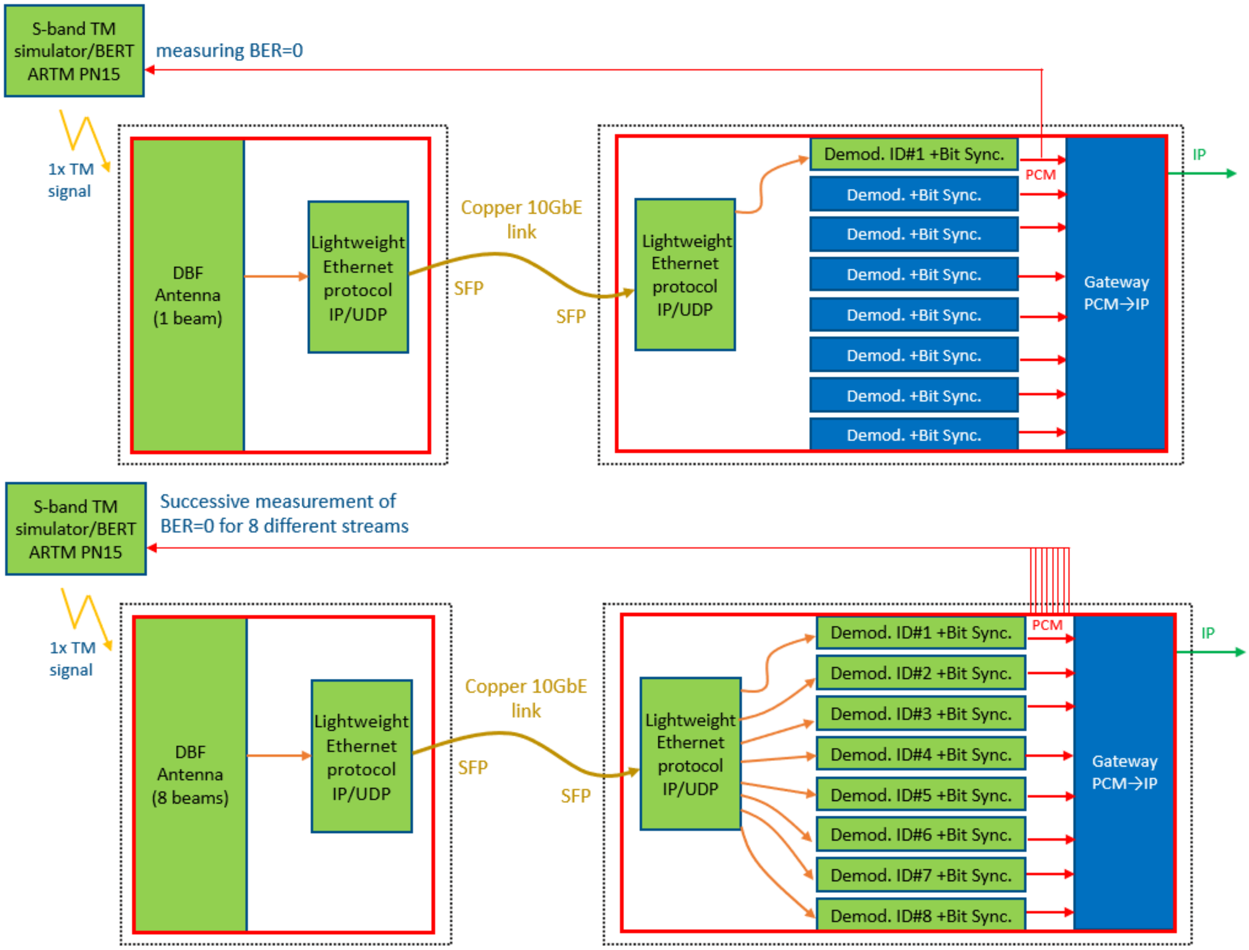

Figure 12 – Functional test to validate the suggested digital protocol (first for 1 and then for 8 data channels)

The same single S-band TM link can be used for both 1 and 8 data channels. For example, instead of tracking one beam and feeding one data channel to channel ID#1, the DBF can be configured to track the same S-band signals 8 times and feed 8 data channels through the digital interface using channel ID#1 thru ID#8.

B. Qualification tests

Once the functional test above validates the integrity of the newly defined digital link, extensive qualification tests of the digital multi-channel receiver (DTR300-8-10G) can begin to thoroughly assess the performance of the digital link with respect to today's reference, which is the 70 MHz analog IF connection. This reference analog connection between the DBF antenna and the DTR300-8 processor can be achieved as this is how these 2 COTS products currently connect.
One S-band TM link is radiated from an external source and the DBF is configured to track it and output the received signal in the analog domain on a dedicated IF 70 MHz port. This signal is then connected to IF input #1 of the DTR300-8-10G which is configured to assign the analog source to

its demodulator #1. In parallel, the same received signal is shared thru the digital interface and assigned data channel ID#2 to be processed by demodulator #2 inside the DTR300-8-10G. Figure 13 below illustrates the test setup.

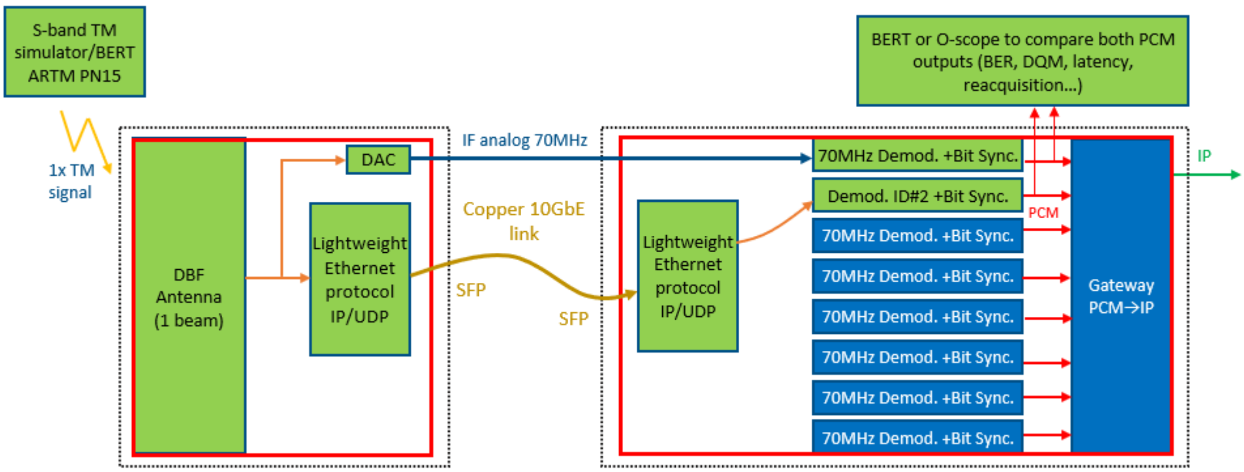

Figure 13 – Qualification test to assess the performance of the digital protocol with respect to the reference analog link

Several attributes will be verified and compared:

- sensitivity of the reception (by radiating an RF signal with configurable calibrated noise to plot the waterfall curve for each demodulator output using BER); DQM can also be verified,
- latency using an external oscilloscope to capture any time difference between the 2 PCM outputs,
- Acquisition and re-acquisition time using an external oscilloscope to capture the time needed to (re)synchronize once the emitted signal turns-on and after a fading cycle

Several signal types - various modulation (ARTM waveforms), range of bit rates (100 kbps to 40 Mbps), and LDPC coding – will be tested.
The expectation is that the result obtained through the digital transport of the RF data channel is at least as good if not better than the current analog reference, or at least within the acceptance range (to be defined). This will confirm that the new digital link does not introduce any degradation at the system level; like adding latency or acquisition time to what is already known from the DBF and the block-type decoder (like LDPC) in the demodulator, or a loss of system sensitivity.

Finally, the analog baseline will ensure that local RF interference does not play a part during the testing and comparison.

C. Capacity expansion tests

The last test intends to push the digital link to its maximum capacity of transporting an aggregate bandwidth of 200 MHz. Figure 14 below shows 2 test scenarios for reaching this maximum capacity condition:

1) Having the DBF collect a high bitrate TM link (i.e., 50 Mbps SOQPSK-TG or 40 MHz BW) thru 5 of its beams and assign those 5 data channels to the first 5 demods on the multi-channel processor (ID#1 thru ID#5).
2) Having the DBF collect a lower bitrate TM link (i.e., 20 Mbps PCM-FM or 25 MHz BW) thru 8 of its beams and assign them to all 8 demods of the multi-channel processor (ID#1 thru ID#8).

In both cases, the demodulated data is then transported over Ethernet via TMoIP and processed by an external multi-channel software decom where simultaneous BER for all channels (i.e., 5 or 8) can be performed. An error-free BER needs to be confirmed.

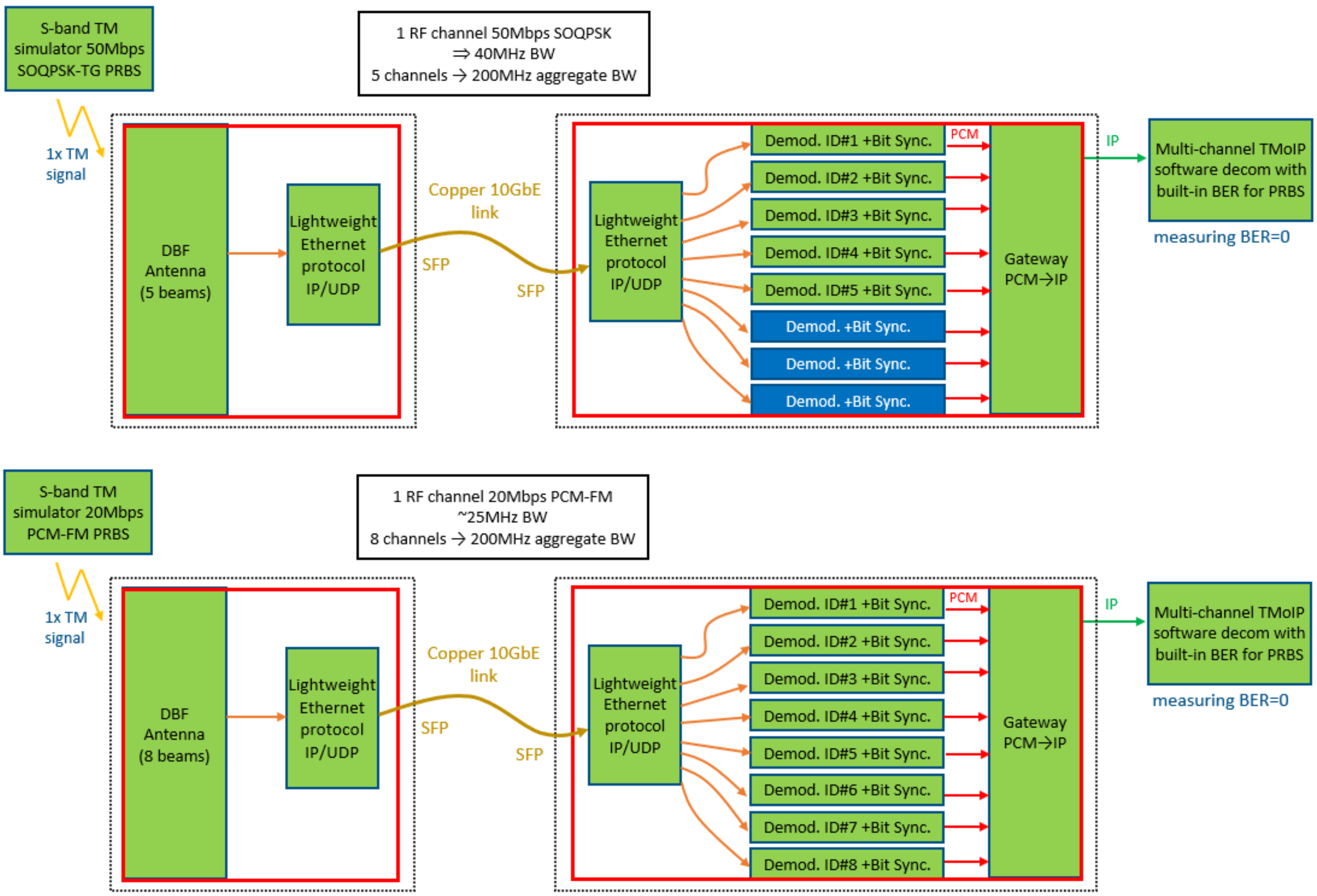

Figure 14 – Examples of expansion tests to validate the max capacity of 200MHz BW of the digital link

A final test consists of demonstrating that more than one multi-channel digital processor (i.e., DTR300-8-10G) can be connected digitally to the BDF using an Ethernet switch. When properly configured, the 10 GbE switch will act as an “IP-like RF switch / multi-coupler” and route the corresponding UDP packets to the right DTR300-8-10G. Figure 15 below gives an example showing 2 ea. DTR300-8-10G channels connected to the same DBF through a 10 GbE network switch.

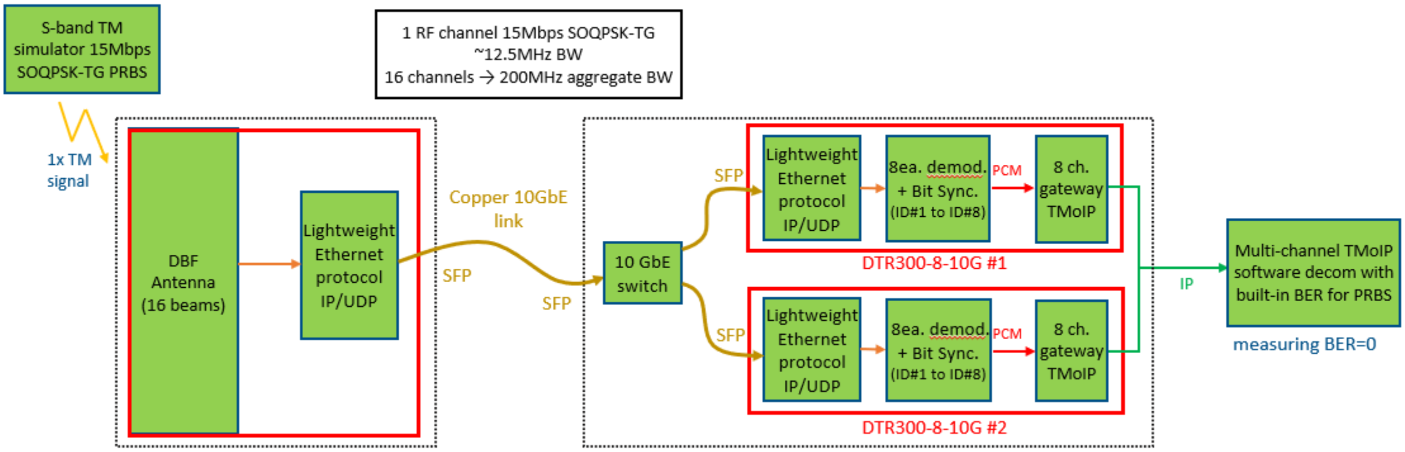

Figure 15 – Examples of expansion tests to validate the max capacity of 200MHz BW of the digital link

This time, the DBF tracks and collects 16 beams from the same telemetry source (i.e., 15 Mbps SOQPSK or about 12.5 MHz BW) and assign the data packet channel ID#1 thru ID#16. The first 8 channel data packet (ID#1 thru ID#8) goes to the 1st DTR300-8-10G while the remaining 8 channel data packets (ID#9 thru ID#16) go to the 2nd DTR300-8-10G. Similarly, a network-based TMoIP decom ensures that the BER is error-free for all 16 channels.

Note that rather than having all DBF channel data packets go to each DTR300-8-10G, the 10GbE Switch upstream can be configured and managed to only distribute the corresponding packets to each DTR300-8-10G. This approach will require packet filtering to be performed outside of the payload message (i.e., not using the channel / beam #) and using lower layers like the Data port # or destination address group (in a UDP multicast protocol).

AN HYBRID SOLUTION FOR ANALOG AND DIGITAL INPUTS

Because its all-digital input version is built upon the current analog COTS product, the analog capacity remains available on the DTR300-8-10G and therefore the all-digital multi-channel TM processor can accept either an analog or a digital input for each of its 8 processor cards. The selection is performed from the DTR300 Graphical User Interface (GUI). The GUI illustration given on Figure 16 to the right shows a configuration where the processors ID#1 to ID#4 are fed with Analog IF input #1 to #4 and processors ID#5 to ID#8 are fed with I&Q samples assigned data channels ID#5 to ID#8.

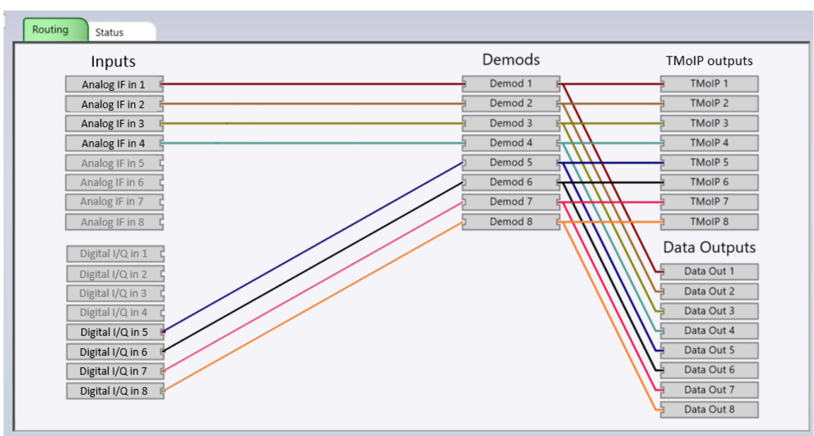

Figure 16 – DTR300-8-10G showing configuration for both Analog and Digital RF inputs

CONCLUSION

This paper explained why the new flight test requirements imposed by more complex weapons systems bring new paradigms for the test range and redefine the telemetry station architecture with the deployment of DBF antennas. Legacy dual channel combiner RF receivers quickly become inadequate with such DBF technology and the concept of a multi-channel telemetry processor LRU arises. While an 8 analog IF version (DTR300-8) tremendously reduces the footprint compared to legacy receivers, it still has some limitations, including burden of a rigid point-to-point integration, imposed co-location with DBF and successive RF digitizations. These limitations are addressed with an all-digital multi-channel TM processor receiving digital I&Q samples of RF data channel thru a high-speed IP-like communication link. After describing a proposed definition for the link, this paper reviewed a test plan allowing its validation and then the qualification of the all-digital multi-channel TM processor (DTR300-8-10G). While this paper focuses on a 10GbE network implementation (to allow 200 MHz of aggregate BW transport), the concept can be scaled-up with a 25GbE network allowing the concurrent manipulation of 500 MHz of aggregate TM bandwidth. Thanks to its hybrid architecture, the DTR300-8-10G can dynamically configure its bank of 8 telemetry processors to either be fed with analog IF 70 MHz signals (through the 8 dedicated analog input ports) or with digital I&Q samples (through the digital link). This configurability will facilitate its adoption by ranges and users not willing to switch over night from an analog to a digital connection.

Once the digital integration between the DBF and the TM processor is achieved, the 19" rackmount of the DTR300-8-10G can be repackaged into a compact, low consumption and/or airborne qualified enclosure to become the perfect companion of a DBF antenna when used onboard an aircraft / drone (i.e., Sky Range) or an Unmanned Surface Vehicle (Navy USV's).

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