Enhancing Boresight Telemetry

Distributed RF

061025

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The challenges of coaxial-based boresight testing

Boresight telemetry is key in the effective testing of airborne systems such as fighter jets, missiles and drones.

It enables the real time monitoring of their system performance metrics as part of test and evaluation trials, research & development (R&D) testing, or training.

Test range operators need a constant and uninterrupted flow of data transmitted from the platform under test to enable the most effective monitoring and analysis.

Reduced Data Throughput

Typical telemetry solutions have boresight antennas and positioners at the top of a mast, and associated analysis and control equipment in a control building at the bottom of the mast. They operate at P, L, S and C bands, which limits the data throughput – a significant constraint.

The higher frequency bands, such as X to K band, would provide significantly greater data throughput, but cannot be supported by the coaxial cable runs from the antenna on top of the mast to the control building at the bottom.

Reduced Test Range Coverage

If telemetry data passes through long coaxial cable runs (even at P, L, S and C bands), the cables will attenuate the RF signals carrying this data causing some (or all) of it to be lost in the noise floor. This means that boresight antennas and associated control buildings need to be placed close together, often limiting the number of antennas and their placement.

The constraints on the number of antennas and their placement can make it difficult to maintain consistent and reliable connections with the platform under test across the whole range.

Fixed Point-To-Point (P2P) Network Topologies

Typical telemetry solutions use a fixed point-to-point network topology, with antennas and positioners linked to a dedicated set of equipment in the associated control building.

This means that analysis of the telemetry data, and control of the antennas, is limited by the equipment and manpower available in the associated control building, which may be one of multiple buildings across the range.

The benefits of an RFoF-based boresight telemetry system

Increased Data Throughput

Losing only 0.02 dB over 30 ft compared with a loss of 3.6 dB over 30 ft for coaxial cables*, an RFoF-based solution has negligible attenuation on the telemetry signals across distances greater than 100 miles.

This means that an RFoF-based boresight telemetry system could use frequencies from X to Ka bands, significantly improving the data throughput and maximising the effectiveness of the test range.

Enhanced Test Range Coverage

With the ability to pass telemetry data and positioner control feeds across distances greater than 100 miles, an RFoF-based solution enables test ranges to employ more antennas linked back to a single, extant control building, with extant analysis and control equipment.

Increasing the number of antenna locations will allow test ranges to compensate for 'dead spots' behind mountains, or in valleys – increasing the effective test range area.

Any-to-Any Network Topology

An RFoF-based solution can use optical routing products to allow any antenna feed to be mapped to any analysis, control, or monitoring equipment in one or multiple control buildings.

This enables a greater number of antennas to be used for enhanced test range coverage, whilst controlling and processing their outputs from a single (or extant) control building – this increases test range effectiveness and capacity without increasing manpower or control / processing equipment requirements.

*LMR-400-DB coaxial cable and fibre optic cable at 6 GHz

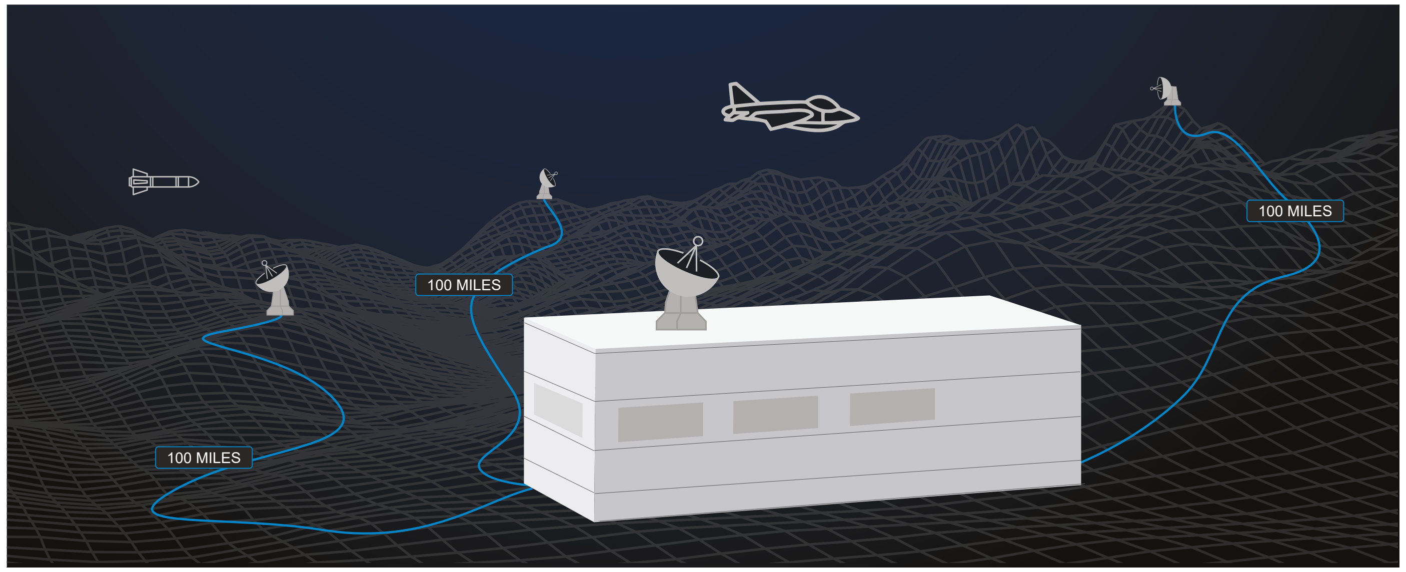
Centralised control hub with enhanced test range coverage

A test range used for the testing of fast moving air platforms such as fighter jets and missiles will often include obstacles such as mountains and valleys that make maintaining reliable telemetry connections difficult.

The installation of multiple antennas across the test range could be used to eliminate ‘dead spots’ where there is no telemetry connection. This would enable the air platform to manoeuvre in a realistic manner (fly at a low level) whilst keeping a constant flow of telemetry data.

Using RFoF, these antennas can pass the telemetry data back to a central control building where it can be losslessly split to multiple analysis and monitoring workstations for processing, whilst control workstations can pass control signals back to the antenna positioners to ensure alignment with the platform under test.

As the air platform moves across the test range, the operators in the central control building can switch to the antenna with the best connection. This concept is illustrated below, and ensures reliable data transmission, even whilst the air platform is manoeuvring around mountains / valleys.



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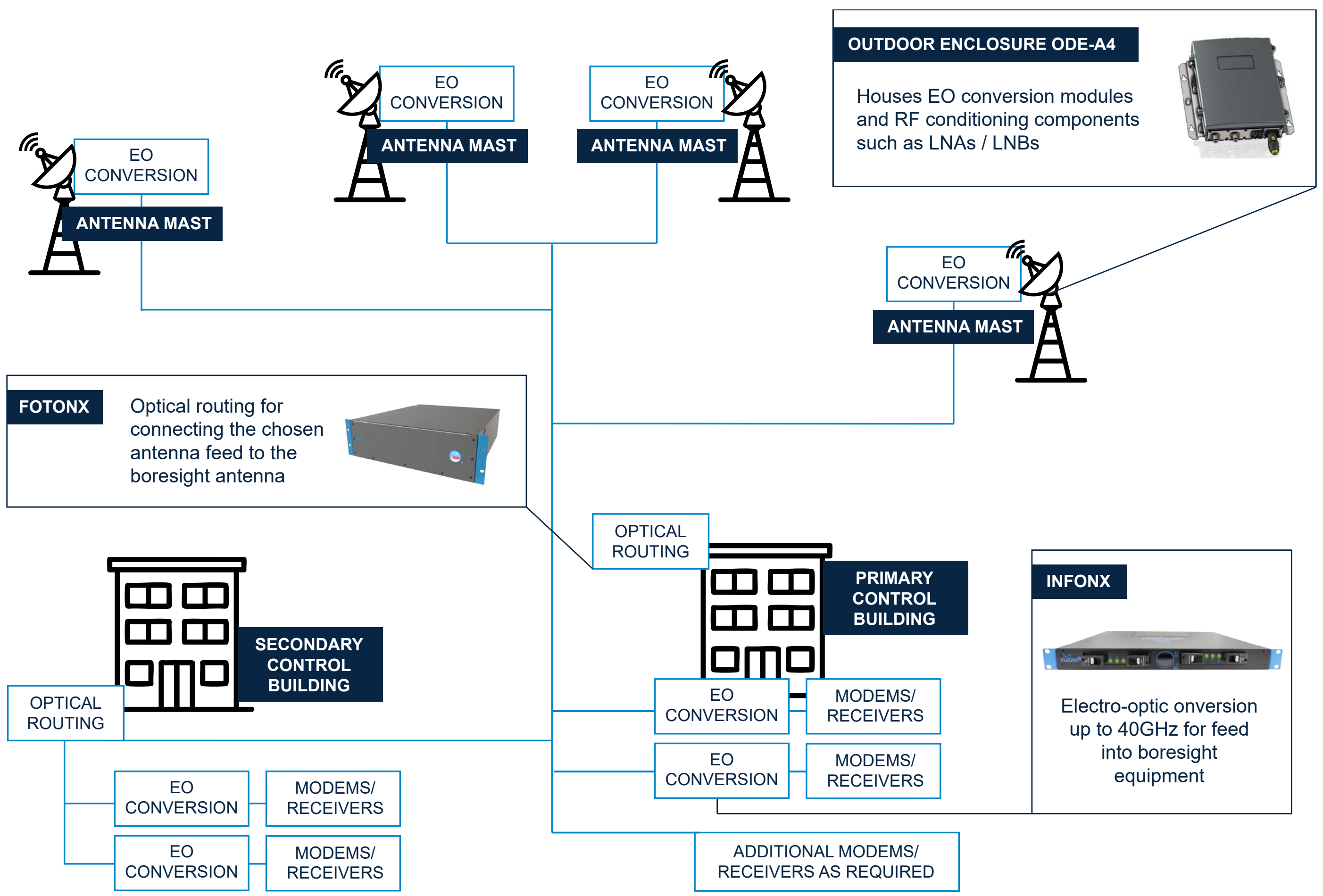


Frequency range	P, L, S and C bands, noting modular architecture enables EO conversion modules to be swapped to enable up to Ka band.
RF performance	NF of 3 dB, unity gain, P1dB of -30 dBm, IIP3 of -17 dBm, and SFDR of 106 dB/Hz2/3. Performance can be further tuned to customer requirements.
Environmental	IP67 with operating temperature -40°F to +131°F for all external elements (ODE-A4).
Optical Routing	Bi-directional to support received telemetry data and transmitted antenna positioner control data. Supports greater than 15 antenna / control feeds to 20 receiver / controller ports. Additional feeds and ports can be added if required.
Control Interface	Easy to use web-GUI with operator selected routing implemented in <10 ms. Monitoring and control of RFoF link also available through web-GUI.

Increased data throughput with X to Ka bands

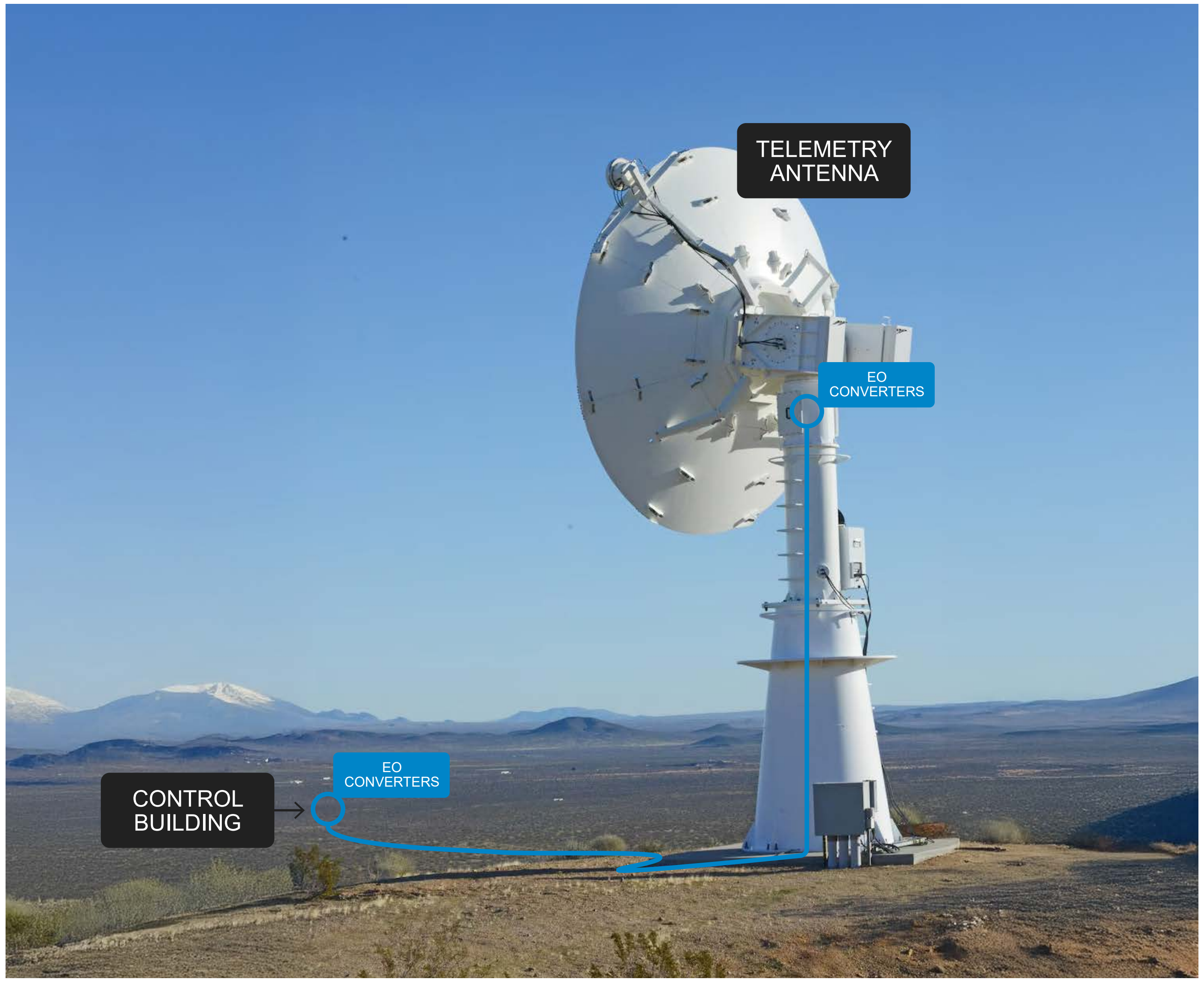
Although many test ranges typically use L, S and C bands for telemetry, the data throughput with these frequencies is relatively low, which could limit the analysis of the test data.

This throughput issue can be addressed by moving to higher frequencies such as the X to Ka bands. These frequencies only require small antennas, which can either be easily retrofitted to extant antenna masts / positioners, or 1 to 18 GHz horn antennas may already be used (Edwards AFB).

In these instances, EO converters in ruggedised / environmentally sealed enclosures can be mounted to the back of the antenna, on top of the positioner to convert these feeds into the optical domain with negligible losses.

The increased volume of telemetry data can then be losslessly transported over distances greater than 100 miles to a central control building where the feeds are converted back into the electrical domain for processing.

This concept is illustrated below.



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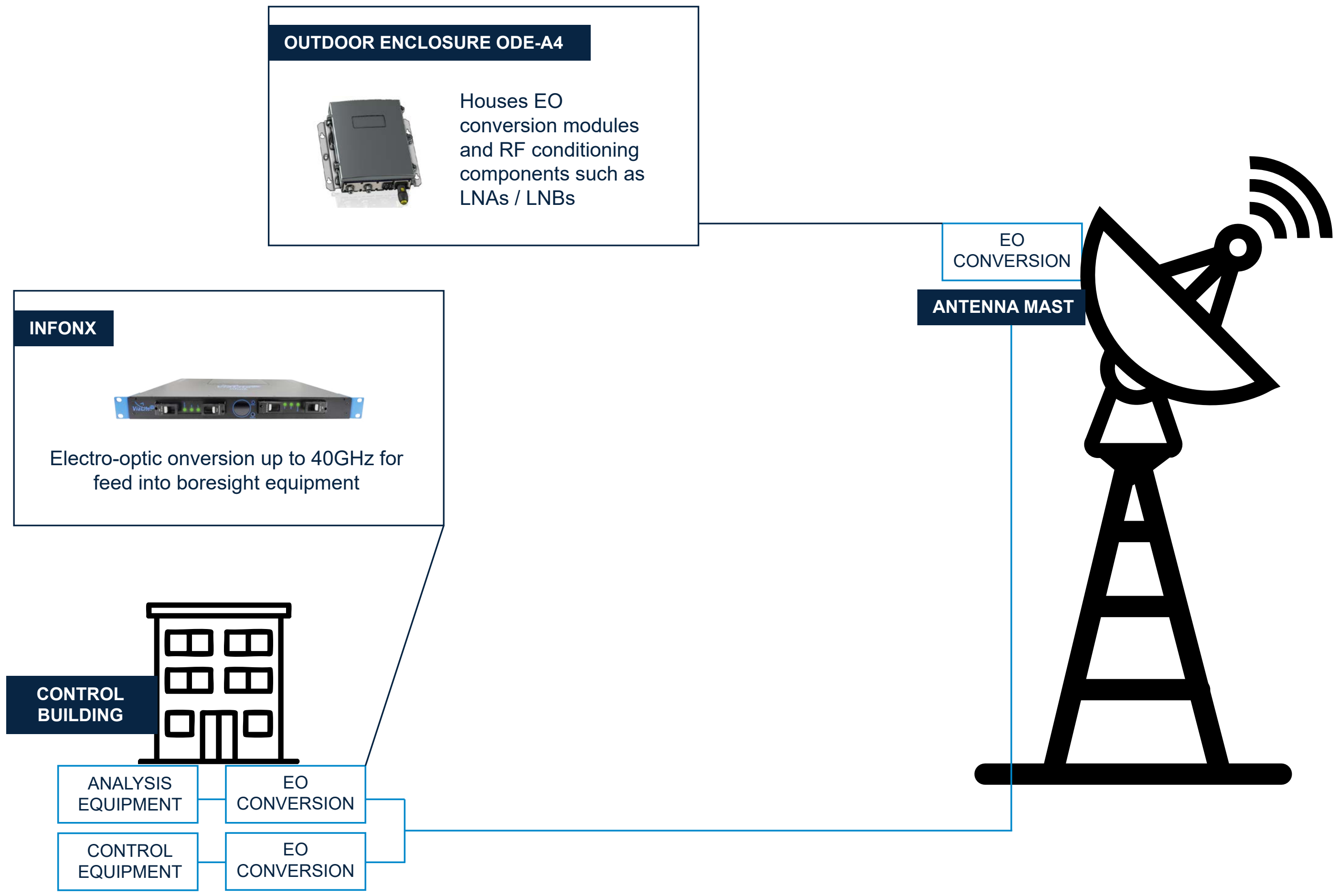

Frequency range	L-band to Ka-band (1 to 40 GHz).
RF performance	NF of 10 dB frequency dependent, P1dB of -20 dBm, IIP3 of -13 dBm, and SFDR of 100 dB/Hz2/3. Performance can be further tuned to customer requirements.
Environmental	IP67 with operating temperature -40°F to +131°F for all external elements (ODE-A4).
Mechanical interfaces	ODE-A4 designed for ease of installation at the antenna, 12” x 9” x 3” and <15 lbs. 19” rack mounted chassis for the EO converters in the control building.
Modular architecture	Easily extend the system to add other antennas, additional control feeds, or change frequency bands, by swapping 19” rack chassis or ODE-A4.

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