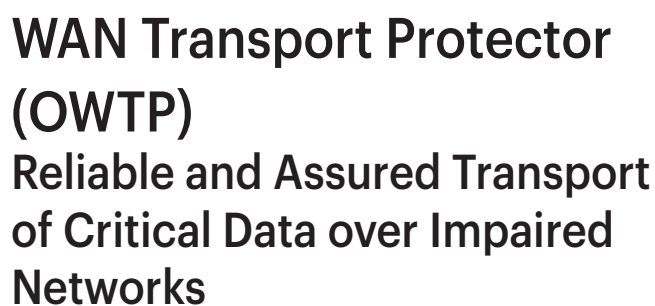




As more and more Earth Observation (EO) and Remote Sensing (RS) data is being beamed from satellites, it is critical to ensure the delivery of mission critical data to its destination reliably and with complete integrity.

Kratos' OpenSpace platform is the industry's only fully virtualized, software-defined and orchestrated satellite ground system platform that overcomes these transport challenges by enabling the delivery of critical IP streams over impaired WAN links to assure the reliable delivery of data.

As part of the OpenSpace Platform, Kratos offers a completely virtualized and software controlled service chain that enables a fully automated EO sensing mission downlink from the digitizer all the way to post satellite pass processing.

These OpenSpace VNFs are service chained together to deliver an EO and RS downlink without having to make changes in hardware.

The screenshot displays the DataDefender dashboard with the following metrics:

- Raw Link Performance:** A gauge chart showing 'Severity Degraded' with a needle pointing to the red section.
- DataDefender KRATOS Dashboard:** The central header area.
- DataDefender Performance:** A gauge chart showing 'All services connected' with a needle pointing to the green section.
- Packet Loss Rate (PLR):** 1.3e-2, represented by a trash can icon.
- WAN Data Rate:** 15.81 Gbps, represented by a network icon.
- Improvement Factor:** All services connected, represented by a line graph icon.
- Current Errors:** 24, represented by an exclamation mark icon.
- Number of Streams:** 2, represented by a double arrow icon.
- Current Repairs:** 24, represented by a first aid kit icon.
- Total Errors:** 308865, represented by a warning triangle icon.
- Unrepaired Loss:** 0, represented by a bell icon.

Buttons at the bottom include 'View Statistics' and 'Go to Details'.

WAN Transport Protector (OWTP) VNF can then assure the transport of digitized IP packets across any potential impaired WAN links.

The VITA 49 digital stream is then processed by the wideband OpenSpace Receiver (ORX) VNF and the OpenSpace Stream Processor/Recorder (OSPR) VNF records satellite-based sensor telemetry data during a spacecraft pass and supports real-time streaming of downlink data and routing to other processing chains in real-time.

As part of the EO/RS service chain, OWTP transports critical IP streams over impaired WAN links to assure the reliable delivery of critical data. The VNF protects application-specific data transfers against loss with no special router or network configuration.

- Assures reliable traffic delivery
- Protects data while transporting time critical data sets
- Moves data at high speed over global IP networks
- Overcomes packet loss, out of order packets, duplication, and jitter
- Boosts network visibility and Quality of Service (QoS)
- Maximizes bandwidth while controlling latency for mission critical needs

Systems that rely only on traditional network protocols like UDP or TCP have historically struggled to sustain the throughput and quality necessary for transporting digital IF across a WAN. Neither protocol is optimal for WAN distribution of real-time high throughput data.

The diagram illustrates the DataDefender architecture for real-time data protection over an IP network. It shows three main components connected via a Full Duplex IP Network:

- DataDefender Step 1:** Select Transport Protocol (PFEC, IRP). It receives Real-time Data (0101010, 01010101, 010101010, 1010101) and sends it to the network.
- DataDefender Step 2:** DataDefender Encodes and Controls IP Data Based on Select Protocol. It receives data from Step 1 and sends it to Step 3.
- DataDefender Step 3:** DataDefender Corrects for Packet Loss, Duplication, Re-ordering and jitter. It receives data from Step 2 and sends it back to the network.

The network is labeled **IP Network** and **Full Duplex**. Real-time data is shown entering and leaving the network at both ends, with the output data being corrected for packet loss, duplication, re-ordering, and jitter.

OWTP enables a network operator to assure traffic delivery in three easy steps.

caused by retransmissions. Based on the chosen protection protocol, OWTP encodes and controls the IP data latency, then corrects for packet loss, duplication, packets out of order and jitter to deliver the critical data.

Increased Network Visibility and QoS

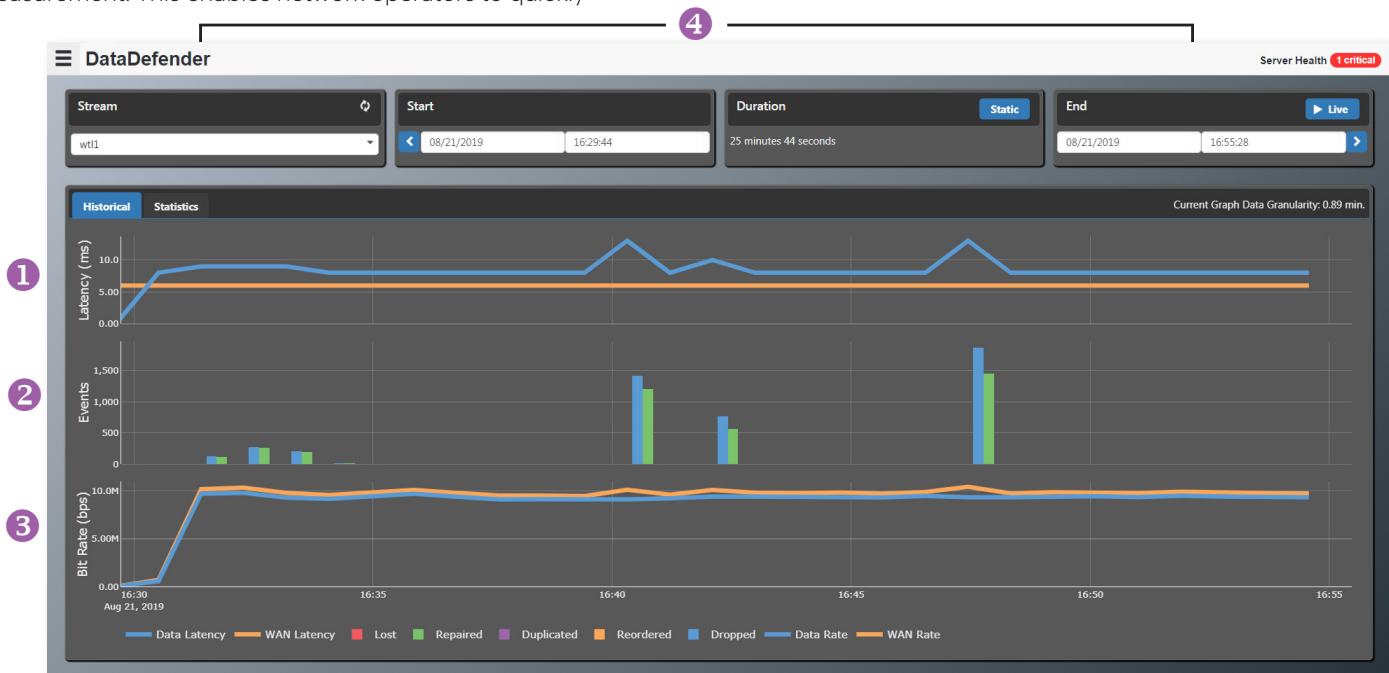
In addition to correcting WAN impairments, WTP provides network situational awareness by reporting detailed metrics about each flow.

WTP delivers visibility into data transport and performance by displaying errors and corrections at a sub-second measurement. This enables network operators to quickly

identify and isolate network problems to overcome them and boost network quality of service.

Network Insights and Analytics

Measurements are recorded for each stream, and include packets lost, distance in between loss events, burst loss length, number of packets re-ordered, and latency distributions, among others. In addition, a complete history of WAN link events is maintained and is viewable down to a resolution of 100ms. This data can be fed into OpenSpace's management capability OpsCenter Platform which allows the entire system to detect and respond to faults and threats.



Sub-second display of packets dropped/repaired and WAN throughput.

- 1 Latency: shows input data rate latency and how it is controlled on the WAN side
- 2 Events: displays dropped and repaired packets
- 3 Bit Rate: indicates that WAN rate with protection is slightly higher than data rate
- 4 Streams: control and view details of stream

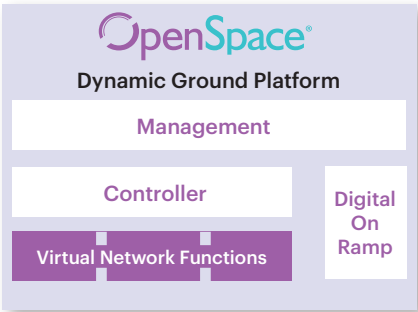
Technical Specifications

When hosting WTP on premise or in the cloud, these are the recommended server requirements that will support the number of protected streams as identified in the stream count.

Minimum Suggested System Requirements

VNF	Stream Count	LAN Interface	WAN Interface	CPU	vCPUs*	RAM	Storage
100 Mbps	10	1 Gbps	1 Gbps	1x2 GHz	12	8 GB	1 TB
1 Gbps	50	1 Gbps	1 Gbps	1x3.6 GHz	24	24 GB	1 TB
10 Gbps	100	10 Gbps	10 Gbps	4x3.1 GHz	48	192 GB**	1 TB

* The vCPU number represents the HyperThreaded CPU count. For example for the Intel Xeon Gold 6242R processor (24C/48T) the vCPU count is 48.
** Imperative to maximize CPU-2-memory throughput by implementing a balanced 6-lane configuration by deploying six RAM modules per CPU socket. For example 6x16GB RAM modules to achieve 192GB of RAM



OpenSpace is the industry's first and only fully virtualized, software-defined and orchestrated satellite ground system platform. The OpenSpace platform includes Virtual Network Functions, such as OWTP for the reliable transport of data that form a virtual service chain. The OpenSpace Controller to administer how service chains are deployed and OpenSpace OpsCenter to provide unified management across the entire satellite ground system.