



Harmony Eband

Product Overview



BUILDING BETTER BACKHAUL
EVERYWHERE



Agenda | Harmony Eband Product Overview

- E-band Spectrum Overview

- Harmony Eband
 - Product Summary
 - Feature Highlights
 - Technical Product Details
 - Management Approach

- Operational Value Proposition
- Application Summary

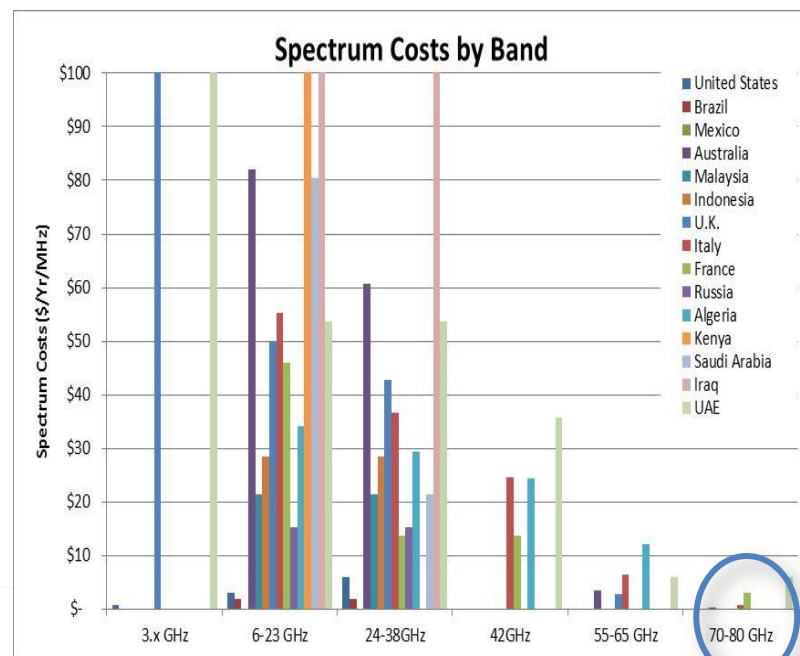
- Wrap-Up

E-Band (70/80 GHz) Spectrum Value

- Addressing the bandwidth bottleneck
 - Immense globally available spectrum
 - Up to multi-Gbps throughput per link

- Tailored Capabilities
 - Designed for short metropolitan applications
 - Low Latency

- Operationally cost-effective
 - Light spectrum licensing fees
 - Simplified Installation



Low
spectrum
costs

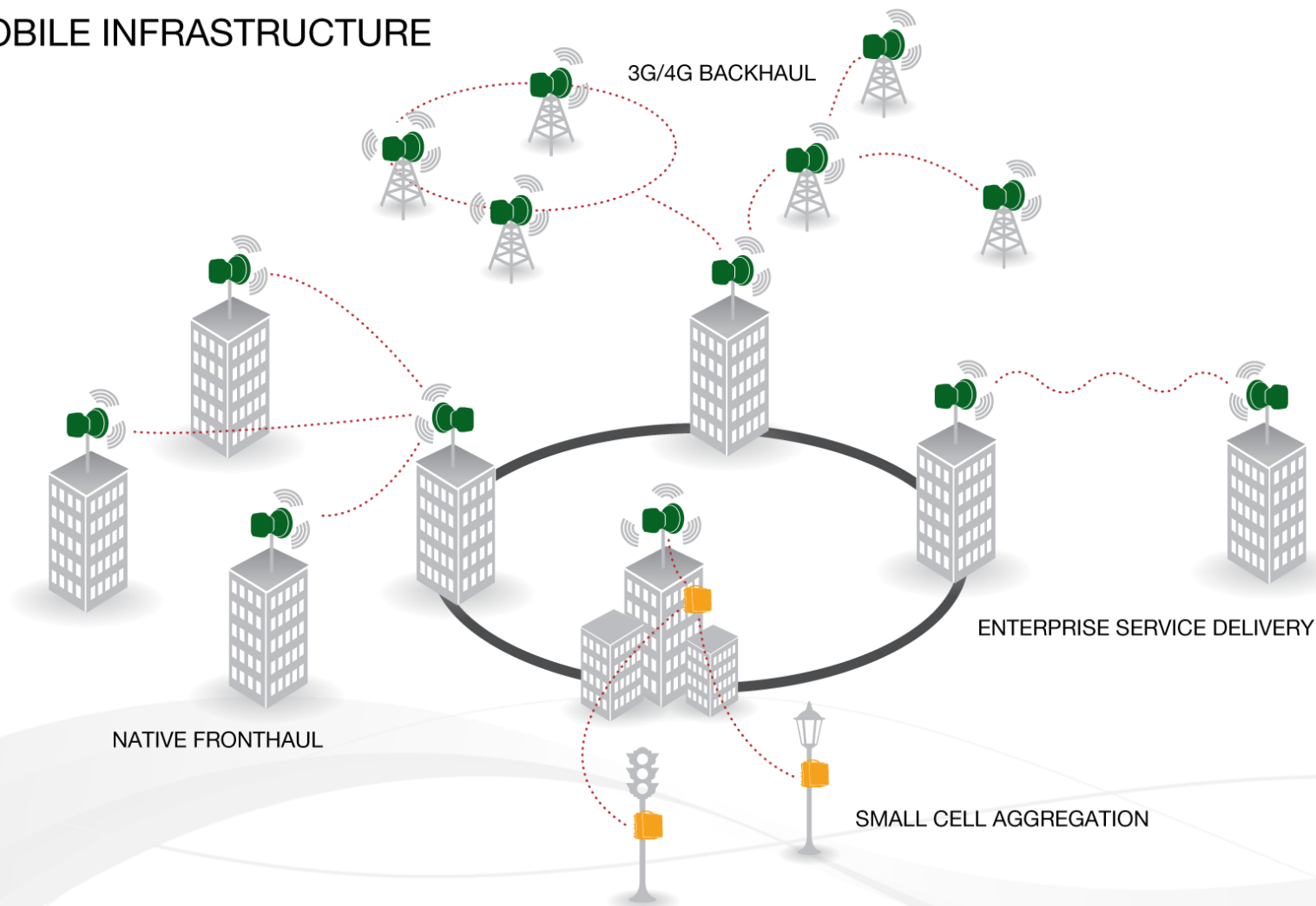
70/80 GHz Product Evolution

	Yesterday	Today	Tomorrow
Reach	1-3 Km	3-7 Km	
Capacity	Up to 1 G	Up to 2.6 G	Up to 10 G
Modulation	BPSK	64 QAM	256 QAM
Services	GbE	+ CPRI/OBSAI	+ 10GbE
Adaptive Modulation	Static	Yes	
Channel Size	1GHz	250-500 MHz	Up to 1 GHz
MIMO for Reach	No	Yes	
Adaptive Channel Size	Static	Yes	
Latency	Up to 1ms*	Low <10 μ s	
Synchronization	No	1588v2 & SynchE	

- Continued evolution promises immense link capacity gains
- Spectrally efficient to mitigate future spectrum congestion
- Redefining the 70/80 GHz application Space

E-Band Applications

MOBILE INFRASTRUCTURE



Harmony Eband

Product Summary

Harmony Eband | Product Value

Harmony Eband is the industry's first 70/80 GHz, extended reach platform designed to address both fronthaul and backhaul applications

- **Link Length**

- Reach Extender feature set for industry leading high output power and reach
- **Dramatically expands 70/80 GHz applicability**

- **Spectrum Relief**

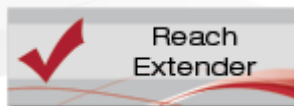
- Leverage Broad 70/80 GHz Spectrum with lower recurring spectrum costs

- **Capacity**

- Single-Carrier native 2.6 Gbps link capacity and up to 4 Gbps of compressed traffic
- Bandwidth Accelerator+ feature for higher capacity and spectral efficiency

- **All-Outdoor, multi-service**

- True “all in” Outdoor Unit design for ease of deployment
- Full-featured Carrier Ethernet supporting multi-service networks
- Fronthaul and Backhaul support with CPRI capabilities



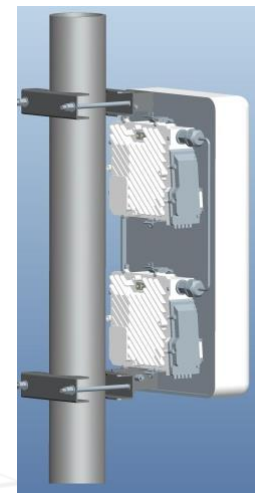
Relief | Efficiency | Reach

Harmony Eband | Reach Extender



DragonWave's Reach Extender feature combines Waveform Modulation Adaptivity and MIMO to deliver unprecedented E-band network reach

- Waveform and Modulation Adaptivity (WMA)
 - Automatically switches to lower modulation schemes if environmental conditions deteriorate to the point where a wireless link may otherwise fail
 - Continued deterioration will adapt the waveform for more system gain to harden the link
- Multiple Input, Multiple Output (MIMO)
 - MIMO significantly improves the overall system gain
 - Transmits same data stream on two transmitters to two receivers
- Delivers high system gain
 - 7dB improvement over traditional TDD output power



Reach Extender enables 70/80 GHz as a 23-38 GHz replacement.

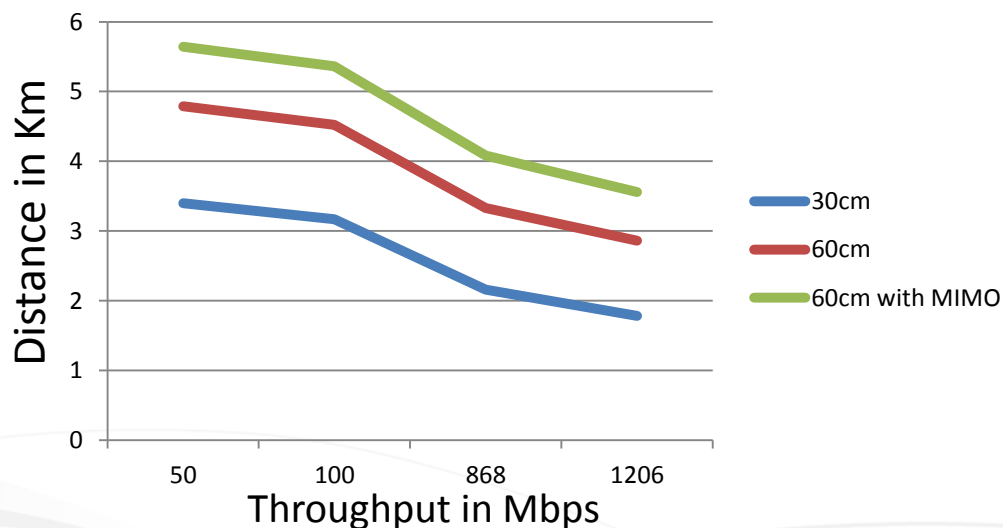
European Mobile Operator Case Study



Harmony Eband Case Study Summary:

- Restricting the solution to 30 cm antennas and MIMO:
 - No 15-18 GHz links can be replaced
 - 55% of the 23 GHz links can be replaced
 - 70% of the 26 GHz links can be replaced
 - 99% of the 38 GHz links can be replaced

Configuration		
23 GHz short	100%	55%
23 GHz medium	100%	
23 GHz long	50%	
26 GHz very short	100%	70%
26 GHz short	100%	
26 GHz medium	100%	
26 GHz long	62%	
38 GHz very short	100%	99%
38 GHz short	100%	
38 GHz medium	100%	
38 GHz long	98%	
TOTAL	62%	



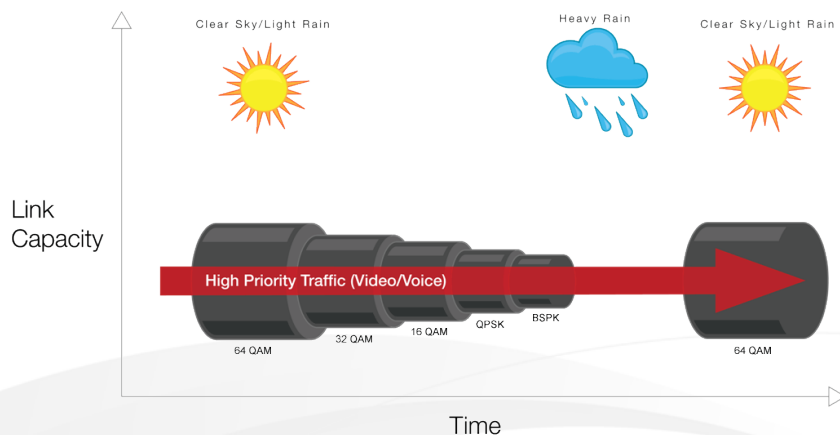
Addresses 75% of the 23-38GHz links, offering 10X Capacity with 90% spectrum cost savings.

Harmony Eband | Reach Extender Details



- **Waveform Modulation Adaptivity**
 - Autonomous modulation scheme adjustment
 - Autonomous waveform adaptation
 - User-definable thresholds
 - Hitless, non-service affecting

- **Priority services maintained with Ethernet QoS**



Modulation	Bandwidth	Speed
64 QAM	500MHz	2.6Gbps
32 QAM		~1Gbps
16 QAM		
QPSK		
BPSK		
QPSK	125MHz	
BPSK		

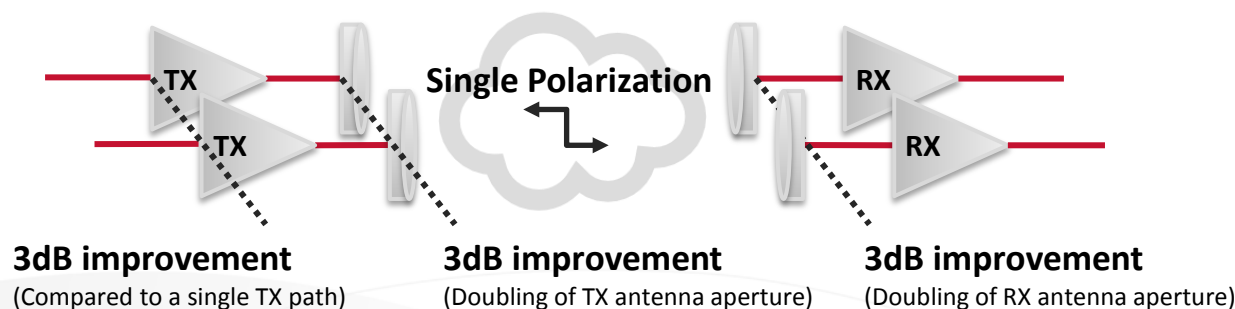
Delivers optimum performance in diverse and variable deployment situations

Harmony Eband | Reach Extender Details



- Multiple Input Multiple Output (MIMO)
 - Takes advantage of multipath signal behavior, using multiple transmitters and receivers with spatial diversity technology, to dramatically increase performance and range

- 2x2 MIMO implementation
 - Delivers +9dB of effective fade margin increase
 - Optimized performance with pre-aligned antennas in single radome



Maximizes overall link gain

Harmony Eband | True ODU Design

**Designed to simplify ODU deployments
addressing fronthaul and backhaul applications**

- True “all in” ODU platform
 - Integrated non-blocking Ethernet switch
 - Standard CAT5E connectors, field connectorized
 - Integrated CPRI/OBSAI interface
 - Direct mount antenna interface
- Compact, lightweight, low power
 - Industry-leading form factor
- Environmentally hardened to withstand the toughest conditions
 - -40 to +55C
 - IP66 & ETSI300-019 compliant
- Designed for rapid deployment



Harmony Eband | High Capacity Connectivity



Harmony Eband provides maximum throughput performance and spectral efficiency—a true high capacity fiber alternative

- Single carrier, 250 MHz and 500 MHz modes
- 2.6 Gbps single-channel native transport rate
 - 64 QAM modulation (500 MHz mode)
 - 5 Gbps on a single antenna using a coupler
- Up to 4 Gbps with wirespeed compression
 - Combined header and bulk payload compression
 - ~40% typical gain



Maximum capacity for high bandwidth next generation applications

Harmony Eband | Bandwidth Accelerator+



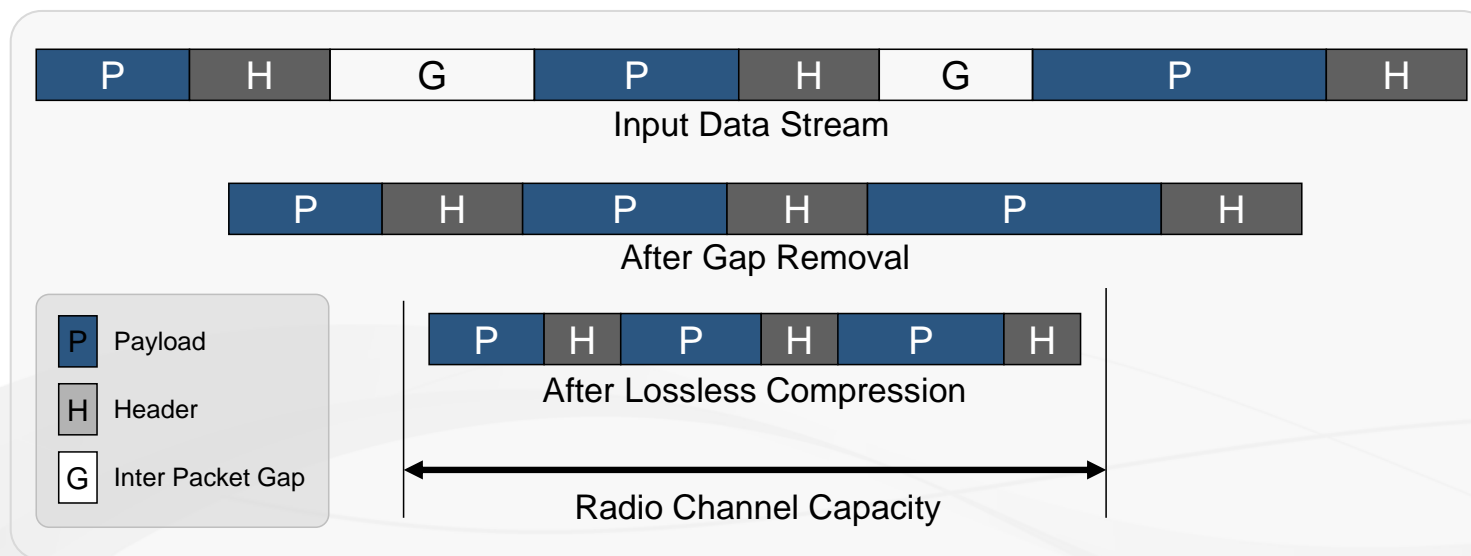
Harmony Eband's Bandwidth Accelerator+ feature provides extensive link capacity gains

- Combines white space suppression, lossless bulk compression, and header optimization technology to enhance the efficiency of microwave transmission
- Bulk data and header compression providing up to 4Gbps of throughput on a single radio
- Low latency, lossless compression strategy
 - Pattern-based approach used code words to represent longer bit strings

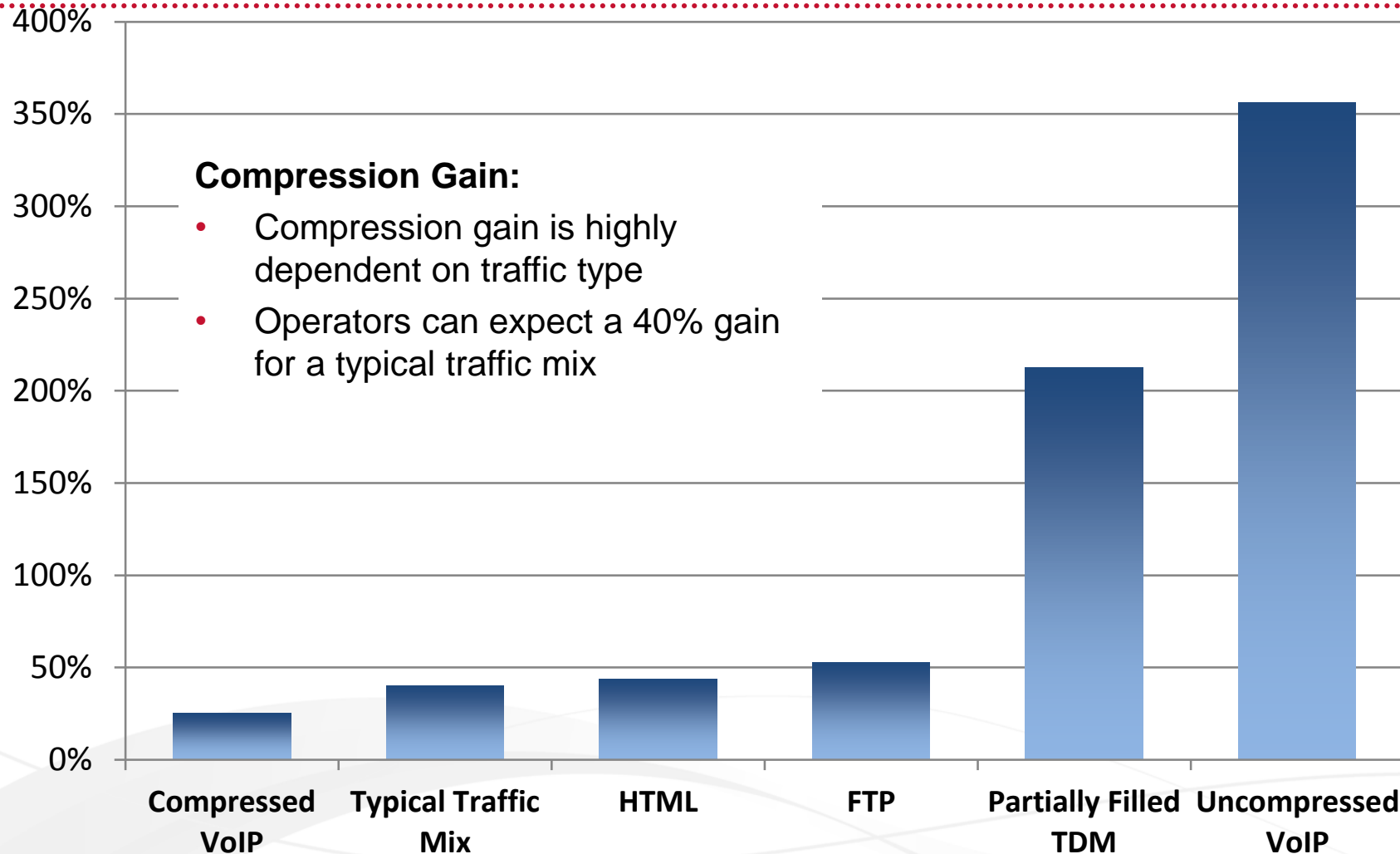
Maximum capacity for high bandwidth next generation applications

Bandwidth Accelerator

- Wire-speed lossless bulk data compression technology
- Typically compression gain of ~40% and up to 100% depending on traffic mix
- Ethernet frame data is compressed using the Lempel Ziv Ross Williams algorithm
- Existing behavior of the queuing system and air interface is preserved
- This feature can be turned on/off for individual queues



Bandwidth Accelerator+ Performance

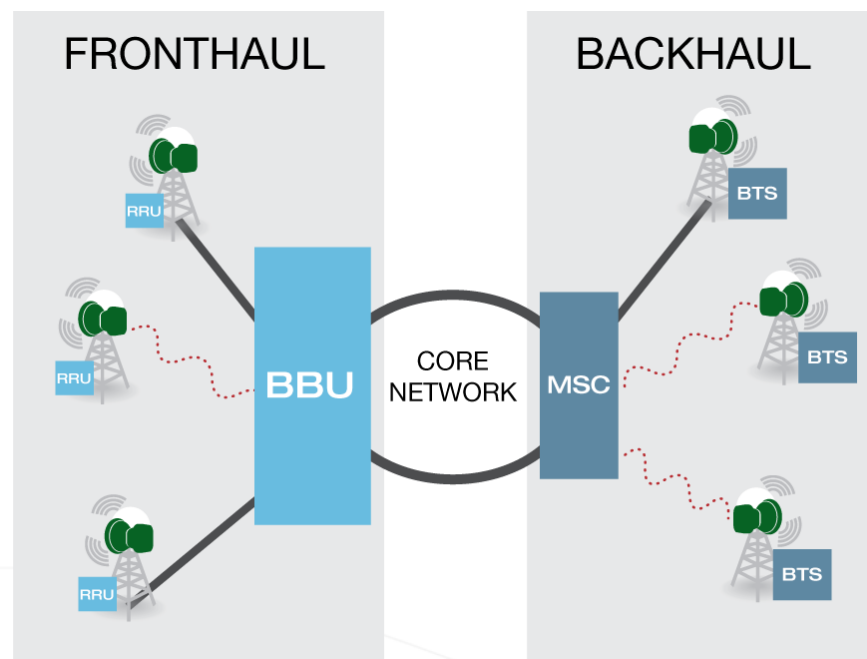


Harmony Eband | Multipurpose Capabilities

Harmony Eband is the industry's first E-band spectrum, multipurpose platform designed to address both fronthaul and backhaul applications

- **Carrier Ethernet backhaul**
 - Point-to-point and multipoint services
 - Extensive CoS feature set
 - Ring and linear protection switching
 - MEF-compliant implementation
 - Integrated synchronization

- **Native Cloud RAN fronthaul**
 - Optical low latency standard interfaces
 - CPRI/OBSAI support
 - Ultra low latency “bypass” transmission



Harmony Eband | Fronthaul Fiber Alternative

- Optimal performance with purpose-built fronthaul product architecture
 - Addresses extremely strict latency and jitter requirements—Ethernet isn't sufficient
- Delivers the capacity required to address growing wireless demand
 - CPRI (option 3 – 2.5 Gbps)
- Provides resiliency with redundant MWR links or as secondary to fiber



Designed for high capacity local connectivity in the last mile

Harmony Eband | Carrier Ethernet Networking

A full-featured carrier-grade networking solution to address multi-service, multi-CoS converged infrastructure applications

- Onboard 4-port non-blocking Ethernet switch
 - Optical (2xSFP): 100FX, 1000-SX/LX/ZX
 - Electrical (2xRJ-45) 10/100/1000bT
 - 20Gbps Ethernet switch

- MEF-compliant ELINE and ELAN service architectures
 - Private and virtual services supported; up to 16 services per radio
 - VLAN tagging (IEEE 802.1q) and stacking (IEEE 802.1ad)

- Aggregation & Switching Functionality
 - Per port rate limiting using two-rate, three-colour metering (CIR/PIR, CBS/PBS)
 - Differentiated services with 8 priority queues (2xSP + 6xWRR)
 - Classification by Ethernet attributes, IP DSCP, or MPLS Traffic Class (EXP) bits
 - Weighted Random Early Detection (WRED) congestion avoidance mechanism

Harmony Eband | Carrier Ethernet Networking

A full-featured carrier-grade networking solution to address multi-service, multi-CoS converged infrastructure applications

- **High Availability**
 - Link Aggregation (IEEE 802.3ad) for client interface resiliency
 - Fast Ethernet ring protection
 - Fault Propagation (link) shutdown

- **Advanced OAM capabilities**
 - **Service-, Port-, and Radio-based Performance Monitoring and Fault Isolation**
 - Service-oriented IEEE 802.1ag Connectivity Fault Management and Y.1731 Performance Monitoring
 - RMON port-based statistics
 - Radio performance monitoring

Harmony Eband | Synchronization

Advanced timing options supporting packet-based backhaul

- Addresses mobile technologies requiring frequency and phase synchronization
 - 1588v2 provides a time reference, from which phase and frequency can be derived
 - SyncE provides frequency reference
- Out-of-band for accuracy and reliability
 - Not reliant on service packet payloads, delivers nanosecond accuracy
 - Prioritized “platinum level” network flow

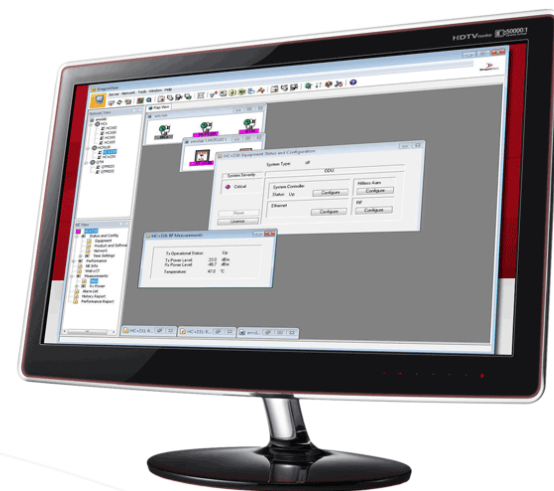
Protocol Support

- 1588v2 Transparent Clock
- SyncE w/ESCM

Delivering application-specific synchronization methods to the network edge

Harmony Eband | Management Overview

- Netviewer Element, Network, and Service Management
- Point-and-click GUI
- Service-oriented commissioning approach
 - End-to-end MEF-based service provisioning
- Comprehensive fault, configuration, administration, performance and security management
 - Alarm management
 - Events logging
 - Network inventory reporting
 - Administrative management
- Simplified OSS integration
- Supports full DragonWave product portfolio



Intuitive | Simple | Comprehensive Network Management

Harmony Eband

Technical Product Details

Harmony Eband | Technical Summary

- Ultra-high capacity ODU platform
 - 250 MHz and 500 MHz channels
 - BPSK-to-64 QAM modulation
 - 2.6 Gbps native, up to 4 Gbps with payload and header compression
- Reach, speed *and* availability
 - Waveform Adaptive Modulation
 - MIMO
- Secure links with AES256 Encryption
 - 256 AES Payload encryption
 - Secure management channel – SSL, SSH, SNMPv3
- Carrier Ethernet Networking
 - Integrated 4-port non-blocking switch
 - E-Line, E-LAN, and E-Tree services
 - Differentiated services with 8 queues
 - G.8031/8032 Linear and ring protection
 - OAM and performance monitoring
- Packet-based Synchronization
 - SyncE and 1588v2 Transparent Clock



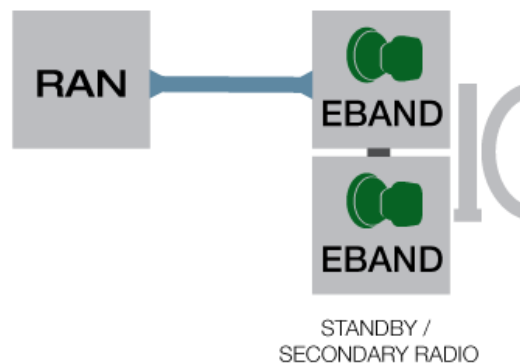
- Fronthaul/Cloud RAN Transport
 - External optical CPRI/OBSAI interfaces
 - “Bypass” mode for ultra-low latency
- Compact, lightweight, low power
 - Dimensions: 178 mm x 216 mm x 51 mm [WxHxD]
 - Weight: 3.0 kg
 - Power Consumption: <37W
 - Power Feed Options: -48Vdc and PoE

Harmony Eband | Architectures

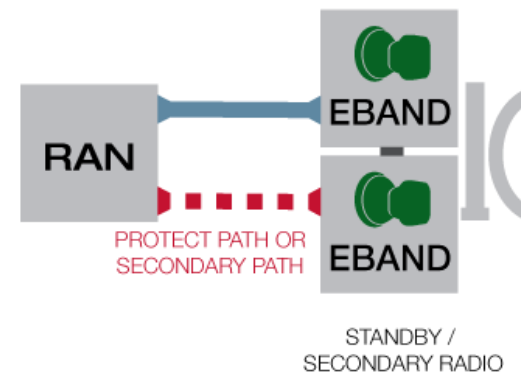
STANDARD DEPLOYMENT



HSB OR 2+0



HSB OR 2+0



- Address both standard and mission-critical network implementations
- Hot standby* (HSB) configuration for 1+1 and 2+0 architectures
 - Rapid protection detect + switch times (<100ms)
 - Switch on 3x3.3ms interval CCM messages

Focused on Simplified Operations

- Flexible solution
 - Address fronthaul and backhaul with one product strategy
 - Standardized approach drives familiarity and efficient engineering with operations staff
 - Offload—or limit deployment of—more costly spectrums and technologies

- Ease of deployment
 - Industry leading form factor, true “all in” ODU design
 - Single element attachment alleviates building permit and installation time
 - Clip mount based Flat Panel and Parabolic antennas
 - Innovative connectivity strategy provides plug’n’play in minutes vs. hours/days

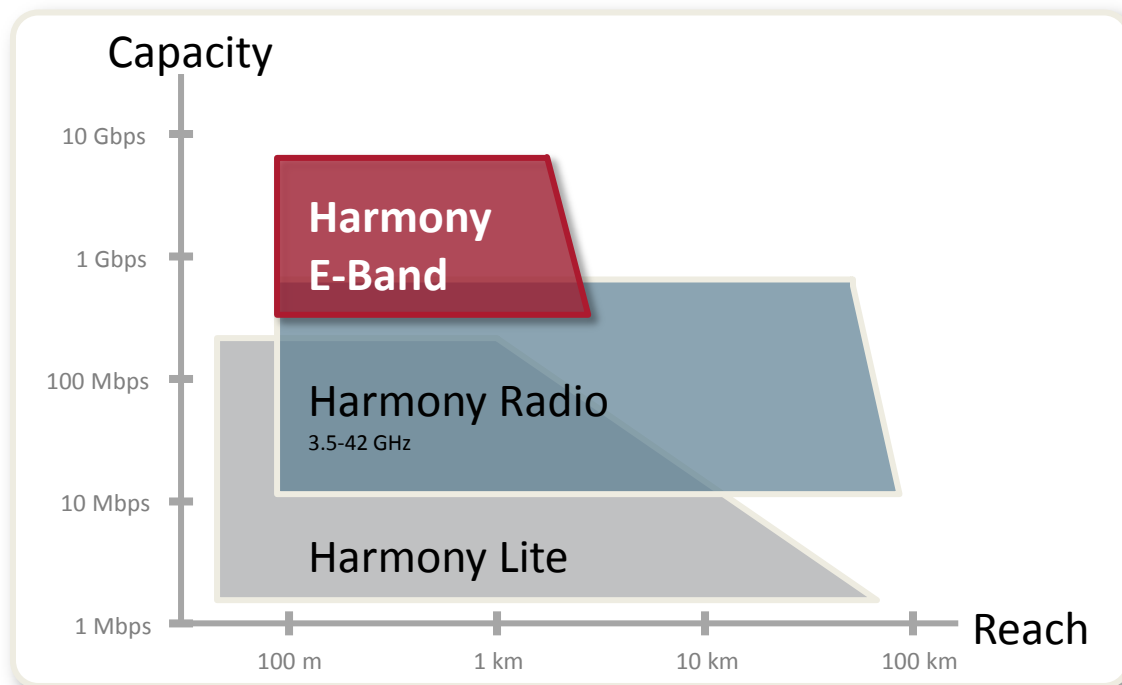
- Maximum availability for limited touch support
 - Autonomously adjusts modulation strategy and waveform to maintain connectivity
 - Hardware resiliency options

- Simplified Management
 - One screen infrastructure and service commissioning, fault and performance monitoring

Harmony Eband

Portfolio Positioning

Harmony Eband | DragonWave Portfolio Offering



- Single partner for all spectrum requirements and applications
- Complements Harmony Family with short-reach, ultra high capacity solutions
- Supports established (6-42GHz) spectrum offload

Harmony Eband | Product Value

Harmony Eband is the industry's first E-band spectrum, multipurpose platform designed to address both fronthaul and backhaul applications

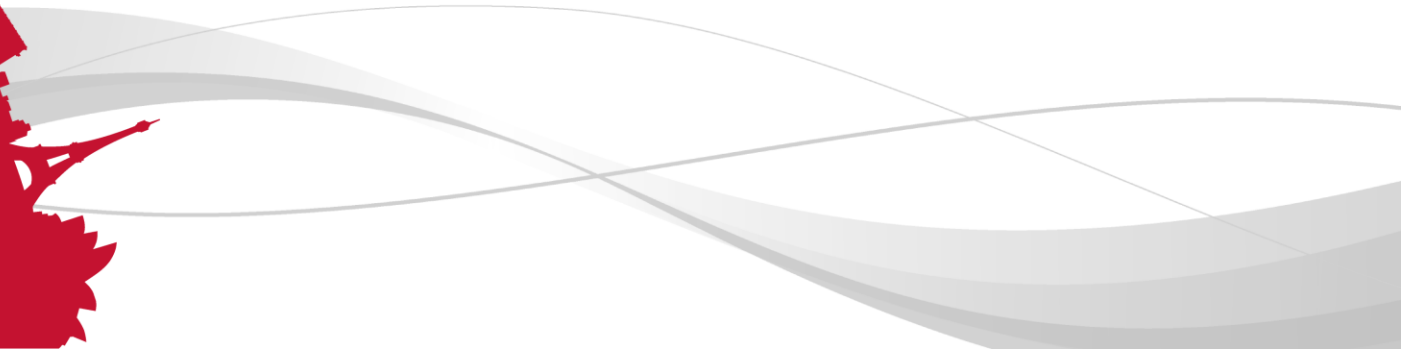
- True “all in” Outdoor Unit design for ease of deployment
- A fiber alternative with single carrier native 2.6 Gbps link capacity and up to 4Gbps of compressed traffic
- Bandwidth Accelerator+ feature for higher capacity and spectral efficiency
- Reach Extender feature for industry leading high output power and reach
- Full-featured Carrier Ethernet supporting multi-service, multi-CoS networks



Relief | Efficiency | Reach



BUILDING BETTER BACKHAUL
EVERYWHERE



Harmony Eband

Performance Specifications

Performance Specifications

500MHz Bandwidth

Modulation	Average Packet Throughput (Mbps)	Max Tx Power	Threshold (10-6 BER)	Saturation (BER 10-6)	SNR (BER 10-6)	Latency (us)	System Gain
BPSK-WMA	109	15	-75.5	-22	4	612	90.5
QPSK - WMA	217	15	-72.5	-22	7	212	87.5
BPSK	434	15	-69.5	-15.5	8	85	84.5
QPSK	869	15	-66.5	-15.5	11	35	81.5
16QAM	1738	13	-60.5	-18.5	17	21	73.5
32QAM	2172	13	-57.5	-20	20	19	70.5
64QAM	2607	13	-54.5	-21.5	23	17	67.5

250MHz Bandwidth

Modulation	Average Packet Throughput (Mbps)	Max Tx Power	Threshold (10-6 BER)	Saturation (BER 10-6)	SNR (BER 10-6)	Latency (us)	System Gain
BPSK-WMA	54	15	-78.5	-15.5	8	1215	93.5
QPSK - WMA	109	15	-75.5	-15.5	11	415	90.5
BPSK	217	15	-72.5	-15.5	8	161	87.5
QPSK	434	15	-69.5	-15.5	11	61	84.5
16QAM	869	13	-63.5	-18.5	17	32	76.5
32QAM	1086	13	-60.5	-20	20	27	73.5
64QAM	1303	13	-57.5	-21.5	23	24	70.5

Mechanical & Antenna Specifications

Antenna Specifications

Type	Size	Electrical Compliance	Beamwidth	XPD	FtoB Ratio	Mid Band Gain	Net Weight
Direct Mount Parabolic	60cm	ETSI Class3, FCC Cat A	0.5	25dB	68dB	50.5dBi	9kg
Direct Mount Parabolic	30cm	ETSI Class 3, FCC Cat A	0.9	25dB	61dB	43dBi	6kg
Direct Mount Parabolic	20cm	ETSI Class 3	1.4	27dB	58dB	41dBi	6kg
Direct Mount Flat Panel	280 x 280 x 33.6 mm	ETSI Class 2	1	40dB	60dB	43dBi	1.0kg
Direct Mount Flat Panel	221 x 190 x 12 mm	ETSI Class 2	1.8	40dB	60dB	38dBi	0.5kg

Radio - Mechanical

Power	P+E; PoE+; Direct 48VDC
Power Consumption	37Watts
Antenna Interface	WR12
Dimensions	87x190x221 mm
Weight	5.4kg