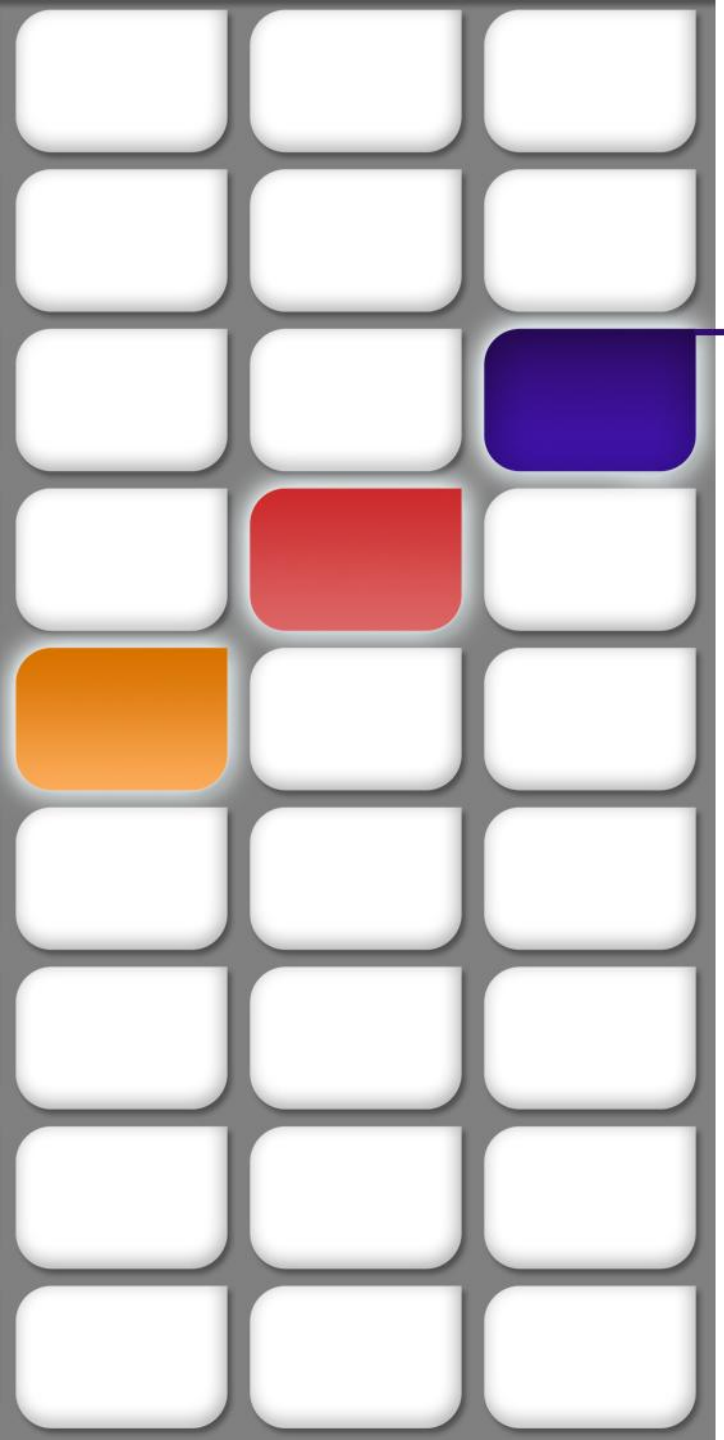
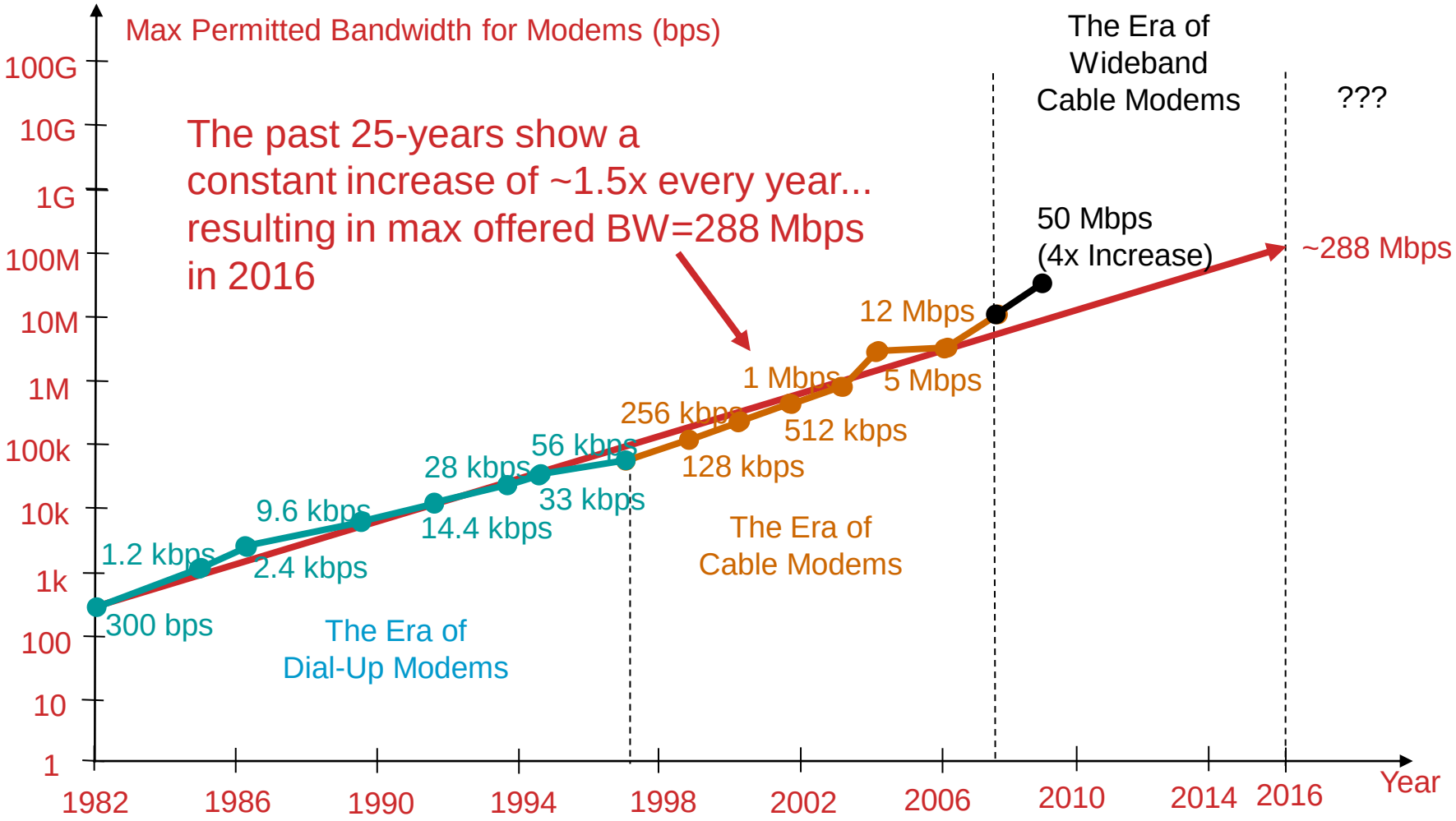


ARRIS

Convergence Enabled.

CHP Max™
CORWave™ Full Spectrum Multi-Wavelength Forward Transmitters

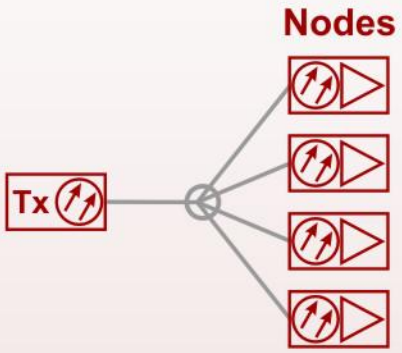
Bandwidth Usage is Expanding



HFC Today

Progressive Segmentation with Optical Links

Late 1990s

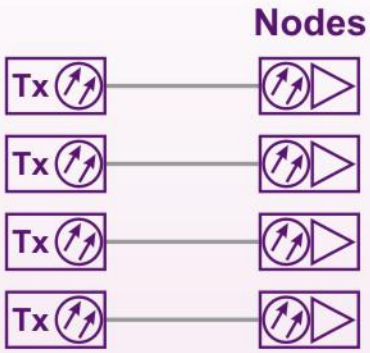


1:4 Tx / Node ratio

2 - 6 fibers per node

2000 homes per node

Mid 2000s

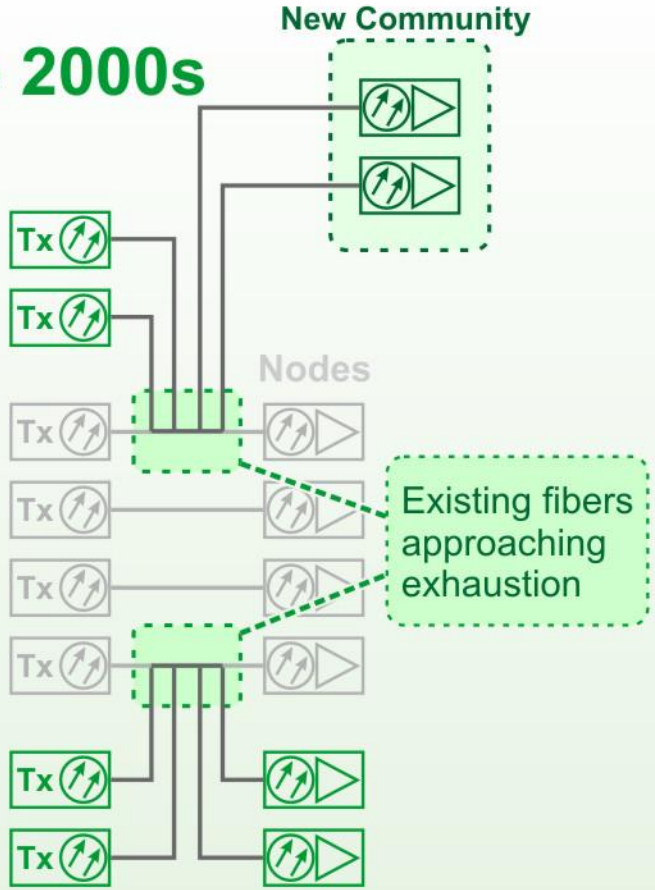


1:1 Tx / Node ratio

2 - 6 fibers per node

500 homes per node

Late 2000s



Number of homes per node being reduced even further as needed

Convergence Enabled.

Multi Wavelength Solutions

When to Use	Benefits
When spare fibers are not available	Saves installation of costly fiber runs
When fibers are leased from other service providers	Maximizes fiber use with minimum costs
When business and residential services need to co-exist on one fiber	Business and residential services can be run on a few as one fiber without service interruptions caused by optical impairments
When ‘dark fibers’ need to be kept in reserve	Maximizes services on available fiber
When new fiber runs are difficult to install	New services can be deployed quickly without delays due to right of way and government ordinances

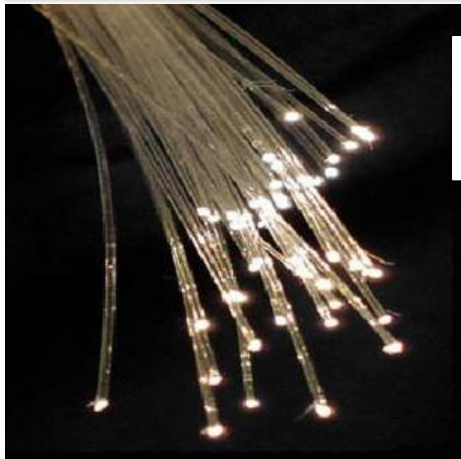
CORWave Technology

- A multi wavelength plan that facilitates future expansion with minimal disruption is highly challenging due to the complexities of optical physics.

- ARRIS has conducted exhaustive research on the effects of optical non-linear impairments and has overcome the scientific challenges inherent in multiple wavelengths over a single fiber.

- This enables MSOs to load video, data, and voice services on one fiber and recover additional fibers for other revenue generating services.

Why is the CORWave Multi Wavelength Plan Significant?



It is the extraordinarily high intensity of light in the optical fiber that generates various optical non-linear impairments

Optical Impairments

Optical Non-Linear Impairments
Generally Dependent on Optical Intensity

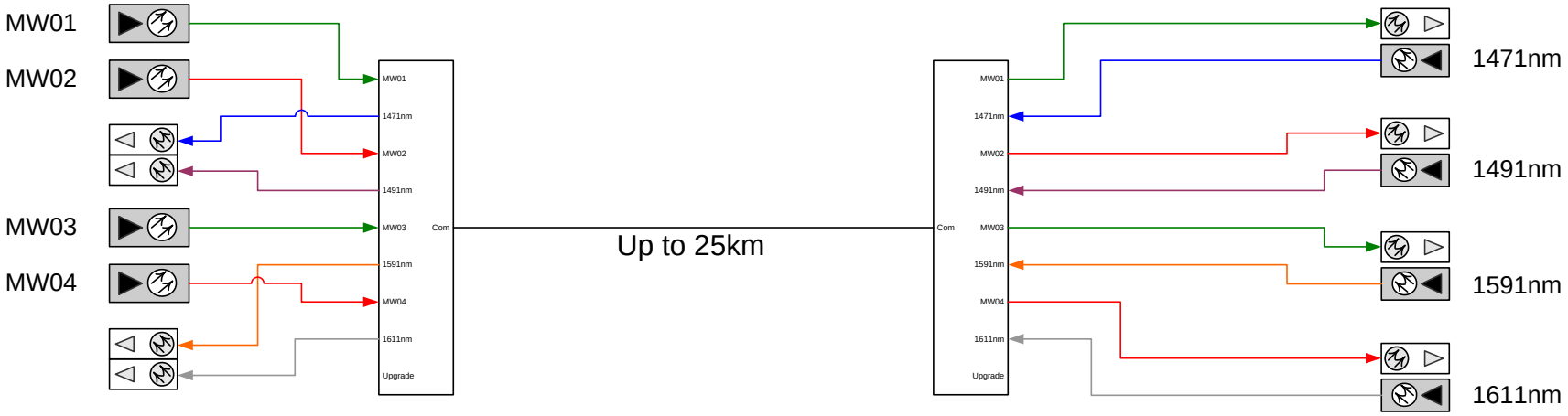
- **Single Wavelength Optical Non-linearities**
  Occur in the presence of one or more wavelengths
  - SBS: Stimulated Bruillion Scattering
  - SPM: Self Phase Modulation
- **Multiple Wavelength Optical Non-linearities**
  Occur in the presence of one or more wavelengths
  - SRS: Stimulated Raman Scattering
  - XPM: Cross Phase Modulation
  - 4WM: Four Wave Mixing

Optical Linear Impairments
Generally Dependent on Optical Intensity

- **Fiber Linear Effects**
  Due to Fiber Design/Manufacture
  - Fiber Dispersion
  - Fiber Loss
- **Impairments due to Optical Passives**
  Due to Optical Passives Design/Manufacture
  - Insertion Loss
  - Isolation
  - Passband/Passband Ripple

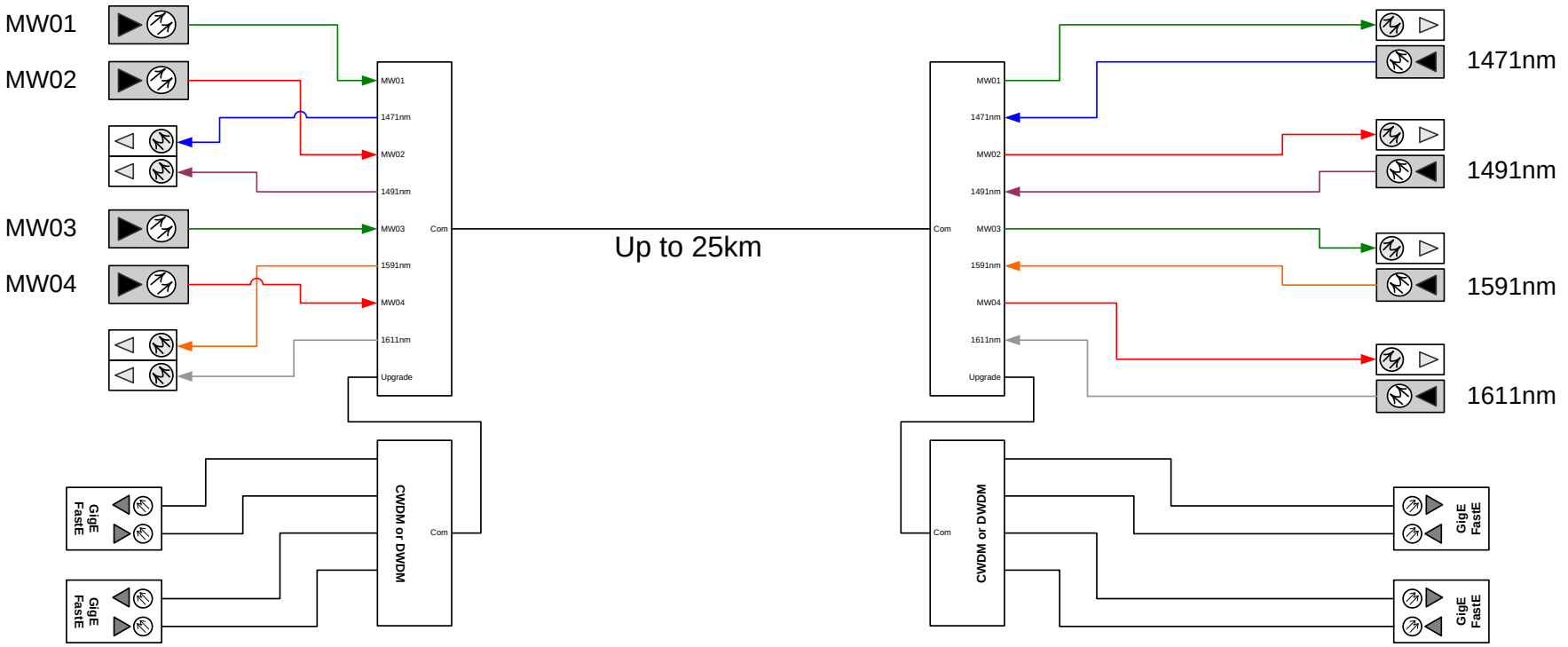
ARRIS has a superior solution

CORWave – Expanding the Capabilities



- The CORWave solution provides up to 25km of reach using…
  - Four O-Band wavelengths (1310nm window) for downstream signals
  - 1471, 1491, 1591 and 1611nm for return signals (same as CWDM)
- The choice of both forward and return wavelengths allows the entire1550nm C-Band to remain unused.

CORWave – Expanding the Capabilities



- Avoiding the C-Band allows a convenient upgrade path for adding advanced digital services (FastE, GigE) over the same fiber.
- The CORWave solution can also provide up to 30km of reach by
  - Two O-Band wavelengths (1310nm window) for downstream signals

CORWave Optical Passives

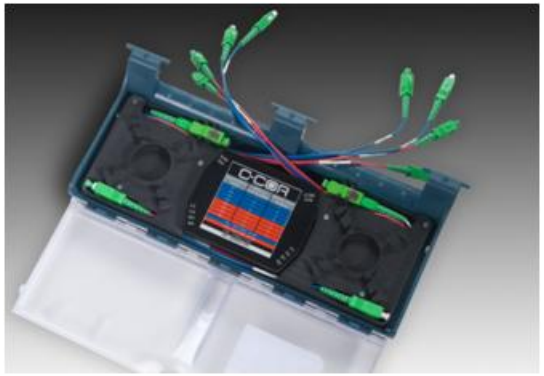
- Passives are yet one other important ingredient of a solid multiple wavelength system solution.
  - Characteristics must be defined such that the passives can be built repeatably and are stable over required temperature ranges

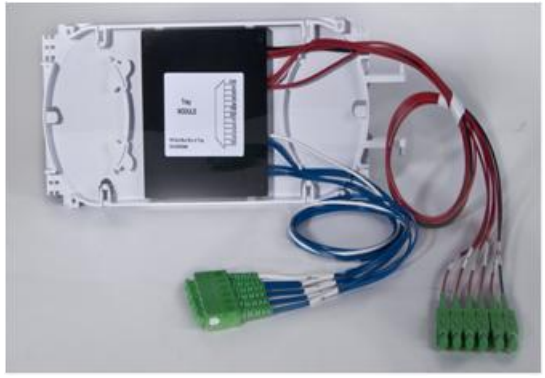
- ARRIS has extensive experience in the design of overall multi-wavelength system

- The CHP CORWave solution passives are custom designed for ease of installation and maintenance

CORWave Optical Passives – Features/Benefits

- Facilitates quick segmentation without costly fiber construction
- Easy installation without the need for specialized equipment or complex fiber routings in the field
- Superior isolation and low insertion loss over the entire operating temperature range
- Allows pay-as-you-grow upgrades while installing additional receivers and transmitters
- Upgrade ports available for future network expansion
- User-friendly with ergonomic design





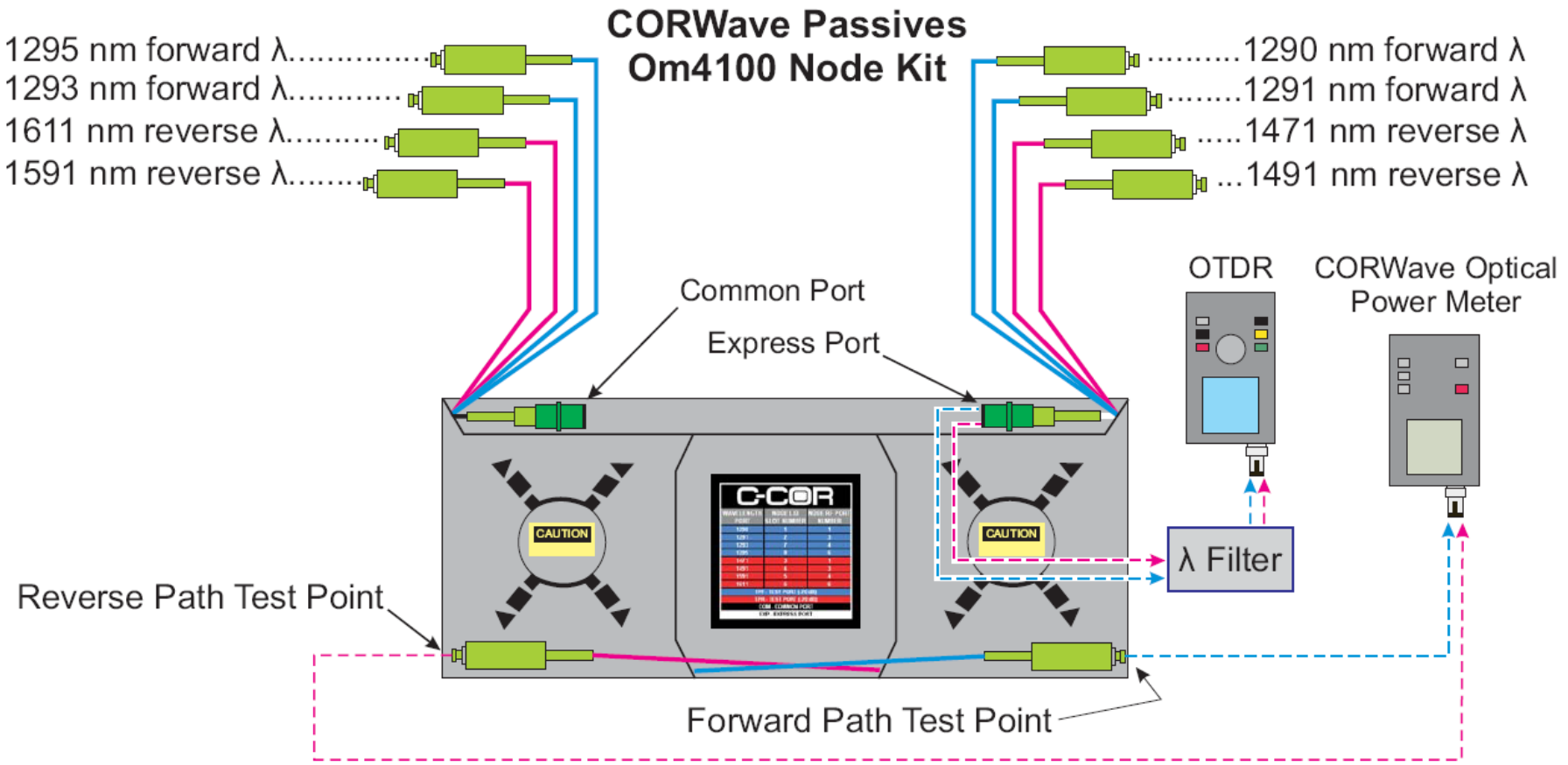
CORWave Optical Passives – Test Point and Ergonomic Design

- Test point of a CORWave optical passive can be used to measure the optical power of both forward and reverse wavelength – **without service interruption**

- Express port can also be used as an OTDR injection port to:
  - Perform inspection, verification, certification, troubleshooting, and documentation of fiber cabling in a single, easy tool
  - Save time and money when diagnosing fiber cabling problems that are causing network performance issues
  - Easily locate and eliminate fiber problems

- Fibers are 2mm jacketed for protection from pinching and micro-bending
- All angled clips keep stub fibers in place
- Fiber lengths precut to specific lengths and built with the proper amount of strain relief for the length

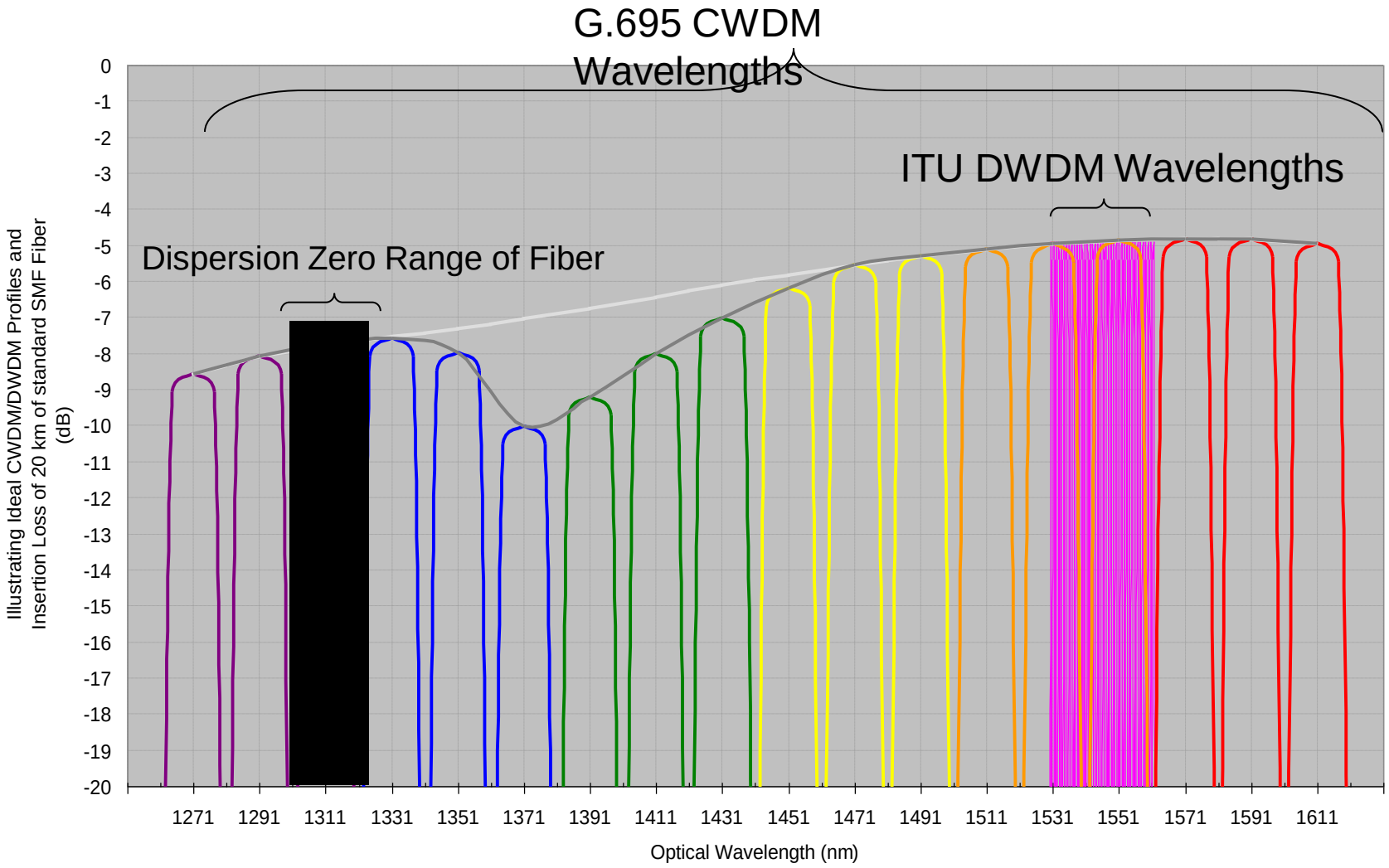
CORWave Optical Passives – OM4100 Node Kit



Multi-Wavelength Solution Key Factors

- Fiber characteristics
- Wavelength Plan and Spacing
- Wavelength Stability
- Passives characteristics
- Quality of Services (QoS)
- Efficient and robust migration path to 4x4 segmentation

Illustrating the Optical Spectrum



Dispersion Zero (DZ) Considerations

- All fiber conforming to the G.652 specification has a DZ range of 1300nm to 1324nm.
- Low dispersion is preferred when utilizing single wavelength systems, specifically because linearizing lasers is much easier in this region. (The is one of the main reasons why forward transport is in the 1310nm range.)
- However, with multiple wavelength systems, DZ becomes a significant problem due to a phenomenon called Four Wave Mixing (FWM) causing unacceptable CSO degradation on a system.
- Typical links are composed of several fiber sections. These fiber links will actually have many DZ points, exacerbating the already complicated issue.

Dispersion Zero (DZ) Considerations

- Thus, in order to ensure a robust solution, multi-wavelength system designers should avoid the DZ range if utilizing closely spaced forward wavelengths.
- Depending on the number of wavelengths and the spacing, the DZ range may need to be significantly away from the DZ point.

Wavelength Spacing Considerations

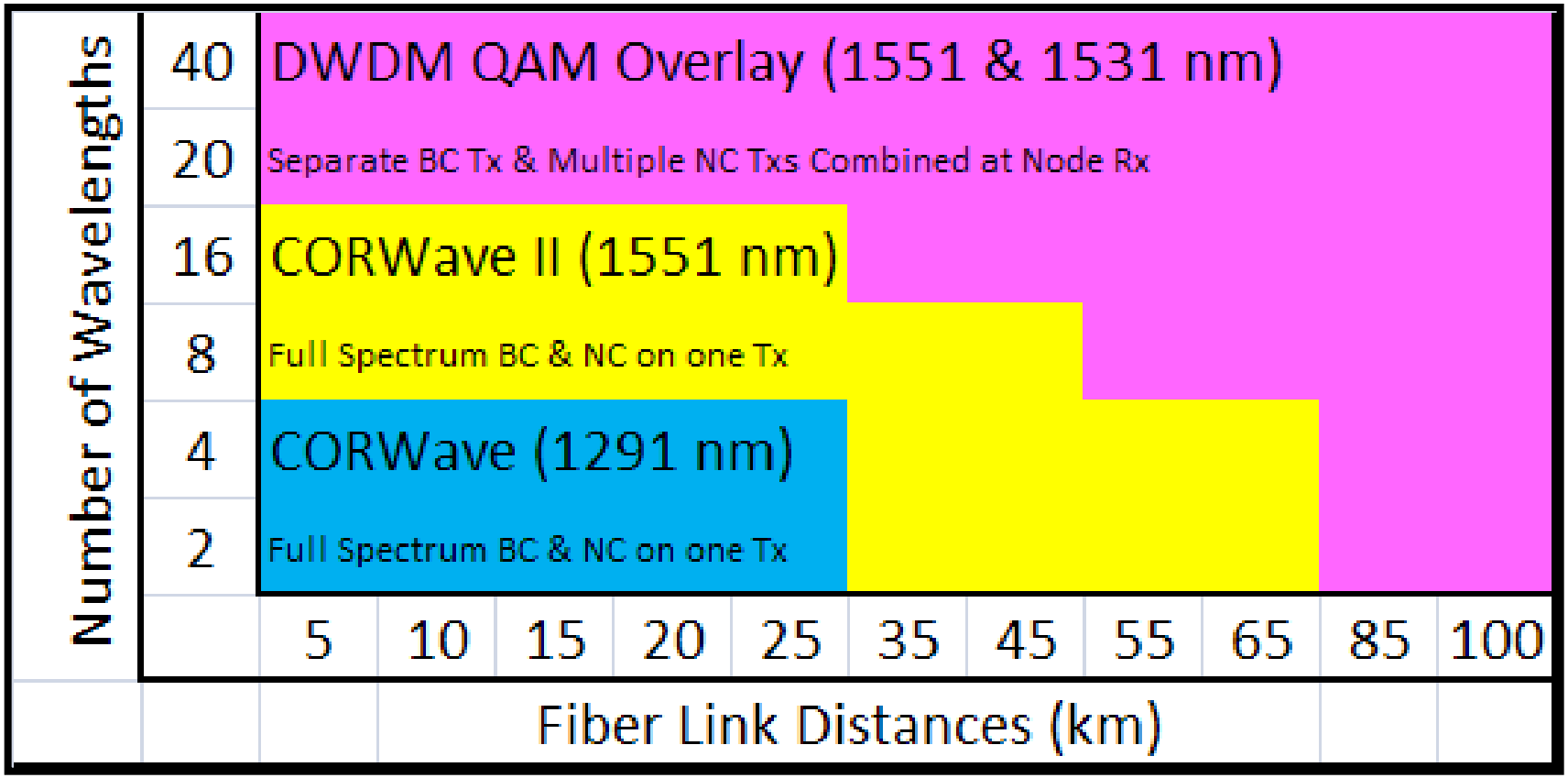
Another key attribute of multi-wavelength systems is the actual wavelength spacing.

- If wavelengths are spaced too close, there is difficulty in obtaining passives with the key characteristics.
- If they are spaced too far away, other phenomena can occur such as Stimulated Raman Scattering (SRS).
- In the case of more than 2 forward wavelengths, if they are improperly spaced, the beats will cause distortions, especially if they are near the DZ area.

In addition, wavelength stability is crucial to ensure a stable and robust solution.

- The lasers should be very stable, and the circuitry to monitor and control the wavelength should be precise over the life of the product.

ARRIS Multi Wavelength Solutions



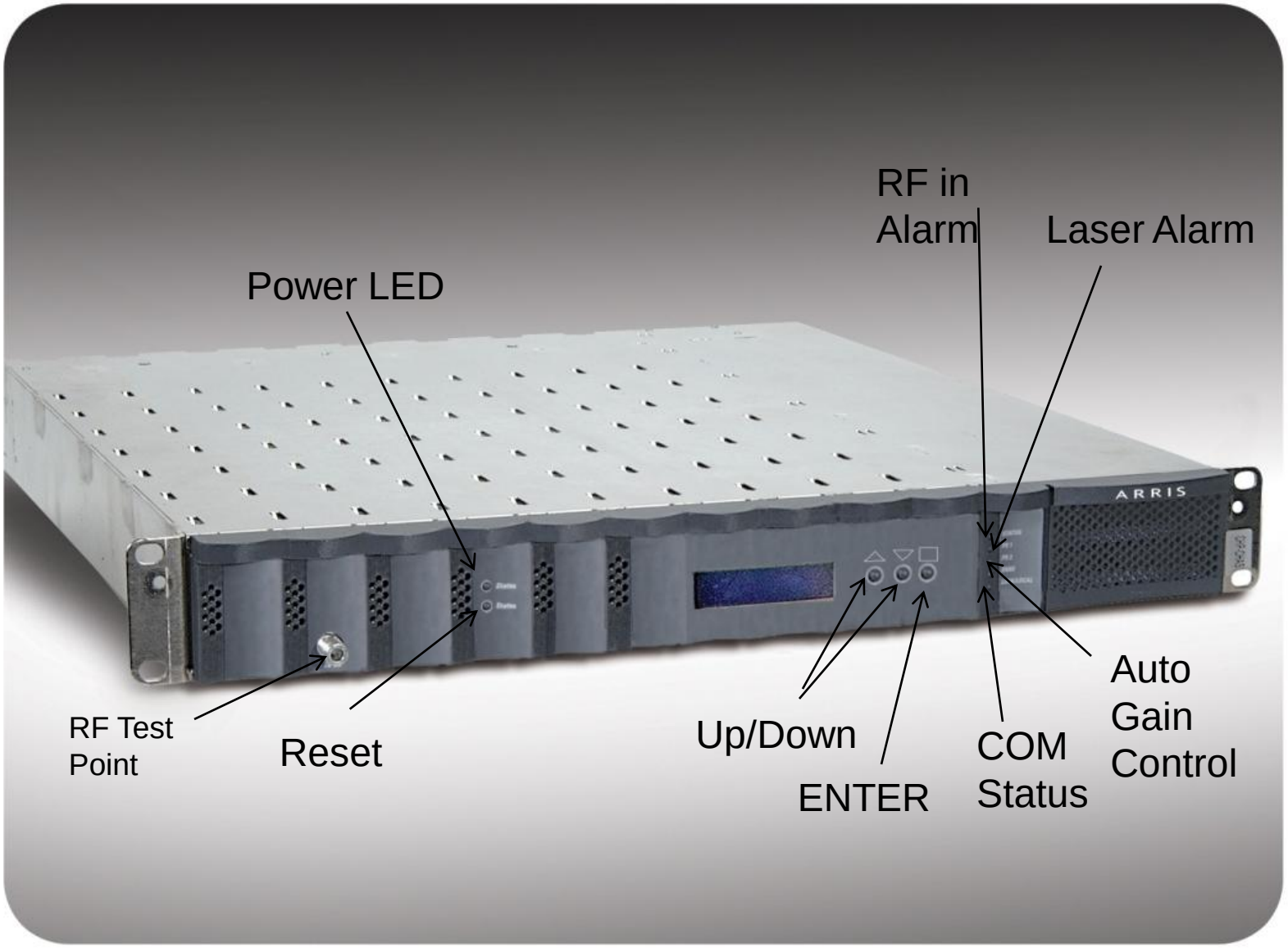
ARRIS supports all of the above architectures. Each provides an optimum solution

for specific needs or requirements.

CORWave II Multiplies Existing Fiber Capacity

- The latest addition to ARRIS's extensive line of CORWave multi wavelength transmitters
  - 4 -16 DWDM wavelengths in the forward path on one fiber
  - Supports 54 - 1002 MHz
  - Reach up to 65 km
  - The longest reach for a full spectrum 8 wavelengths (45 km) on one fiber
  - Supports 16 reverse wavelengths in a mix and match fashion for advanced segmentation applications
  - Single transmitter combines broadcast and narrowcast RF signals for full spectrum optical transmission
  - Integrated with CORView™ element management system
  - Full ARRIS parts and labor warranty
  - 24/7 service support

CORWave II Full Spectrum Multi Wavelength Forward Transmitters

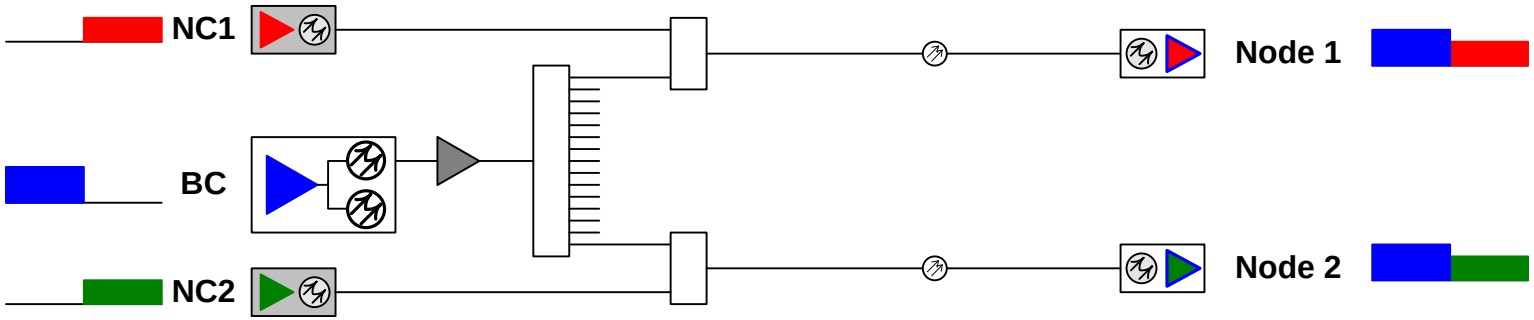


CORWave II Full Spectrum Multi Wavelength Forward Transmitters

MSO Benefits
CORWave II is the most cost effective technology to install and maintain for long haul, multi-wavelength and greenfield applications such as RFoG, **improving margins**
The most multi wavelength capability over one fiber reduces the need for new fiber runs, **saving CAPEX**
Maximum reach and wavelength counts with **excellent end of line performance**
Maximum narrowcast bandwidth provides 5X more targeted services and allows faster deployment of new services, **enhancing competitiveness**
More wavelengths and longer optical reach lets the operator collapse or eliminate OTNs, **optimizing balance sheets**
Nodes can now be split in distant areas for success-based expansion, **providing superior subscriber experience**
Fewer spares reduce inventory, **saving OPEX**

QAM Overlay Architecture

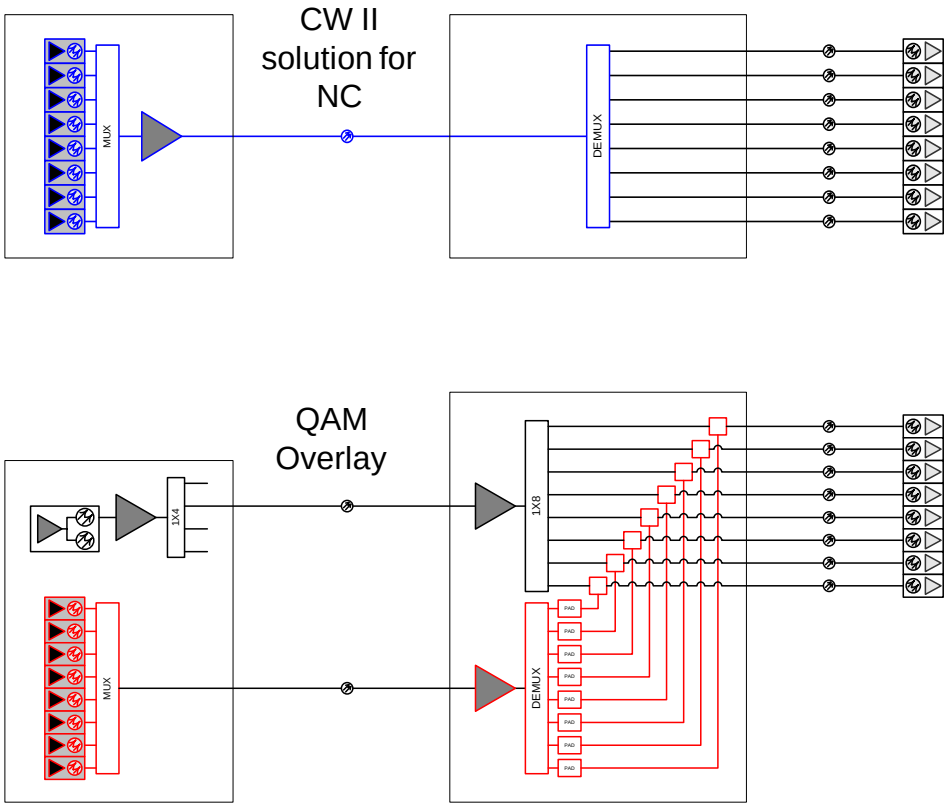
- Designed to supply targeted (NC) content to service groups by ‘overlaying’ NC signals with broadcast signals
- Separate transmitters for BC (content common to all users) and NC (user specific content)
- BC/NC signals are combined in the field at the node
- Up to 40 ITU gridded channels for over 100 km
- Supplies many nodes with the BC/NC signals



CORWave II – an alternative to QAM Overlay

CORWave II uses a single transmitter to combine BC and NC signals in the headend

- Balancing can be done by means of a software GUI in the headend rather than field adjustment, both in initial deployment, and if changes are made
  - Initial capital deployment and operational costs are dramatically reduced
  - Time to market is greatly reduced
- Single transmitter only for BC/NC combining, therefore CNR is not affected (including initial performance levels)
- Narrowcast channel loading can be specific to a single node (recall that QAM overlay architectures transmit BC/NC signals to many nodes)



Understanding CORWave II and DWDM QAM Overlay

CORWave II

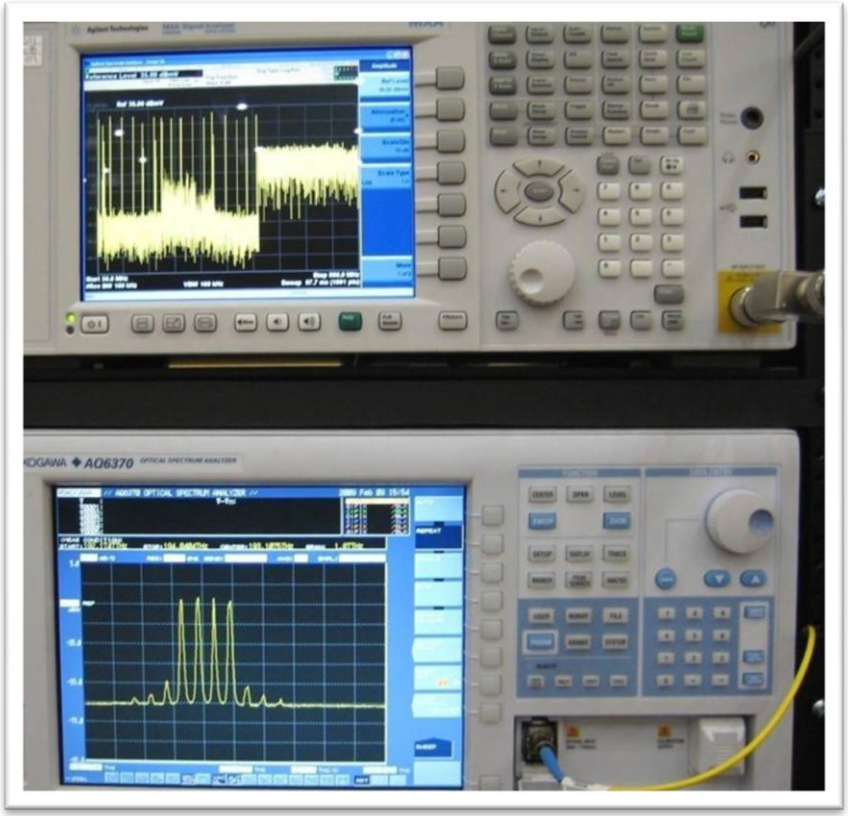
- New technology, suitable for 4 – 16 full spectrum wavelengths and medium reach links (up to 65 km)
- Single full spectrum transmitter with RF broadcast and narrowcast combining at the headend
  - Eliminates optical combining in the field – creates ‘virtual’ links
- Broadcast and narrowcast RF loads can be changed in the RF domain alone
- Narrowcast loading is mostly independent of broadcast CNR, allowing maximum narrowcast bandwidth

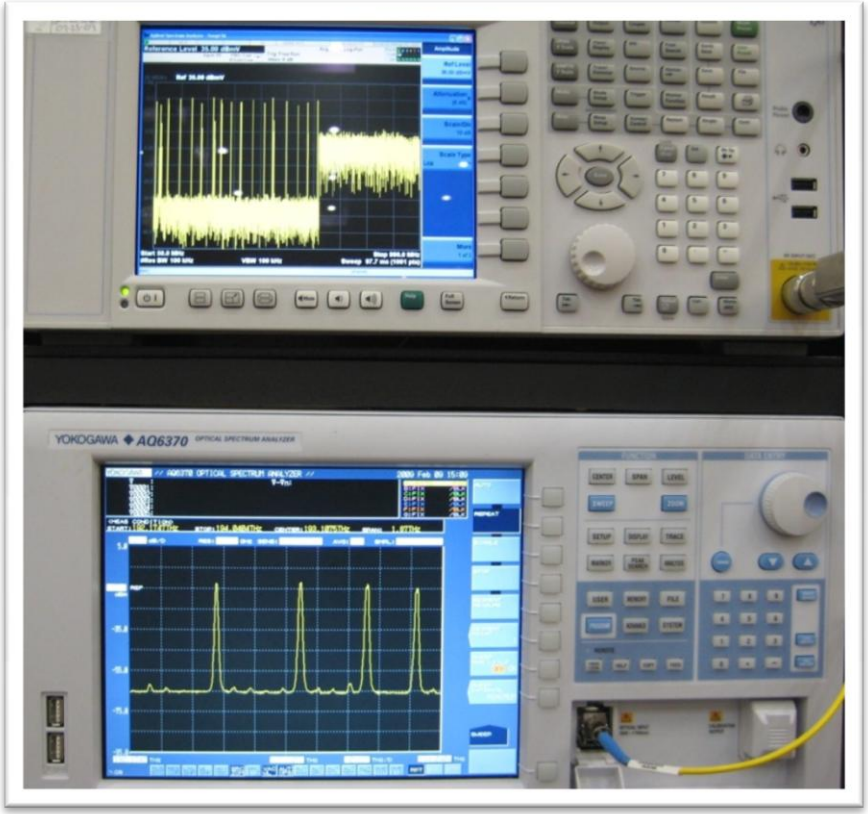
DWDM QAM Overlay

- Older technology, suitable for many narrowcast wavelengths and long reach links
- Separate broadcast and narrowcast transmitters with optical combining in the field
  - Optical combining in the field requires truck roll when narrowcast is changed
- Changes in the RF broadcast load affect the narrowcast optical level (and vice versa)
- Increasing narrowcast loading could reduce broadcast CNR, thus potentially limiting total narrowcast bandwidth

Performance demonstration

Standard DWDM Wavelengths vs. **CORWave II Wavelengths**





Output Quality

Standard DWDM Wavelengths

Output Quality

CORWave II Wavelengths

Understanding Externally Modulated vs Directly Modulated Transmitter Technologies

Directly modulated transmitters (DMODs) tend to be less expensive from a capital equipment standpoint than externally modulated transmitters (XMOD) but have performance limitations in terms of reach and if optical splitting to many receivers is required.

In order for DMODs to emulate the performance of an XMOD, the following compensators will be needed which can affect the cost of the network design;

- Carefully selected wavelength spacing to mitigate 4 wave mixing
- Specialized optical passives
- Different equalizers targeted to specific distances to compensate for fiber dispersion
- Specific self-linearizing receivers to compensate for filters and fiber

In addition to the extra CAPEX outlay for these additions, highly skilled and frequent maintenance of the system must be maintained since performance will not remain static over time (bandwidth limitations, EDFA artifacts, variants in passives performance).

CORWave Provides Solutions for Today and Capacity for Tomorrow

- Robust multi wavelength solution provides superior subscriber experience and enhanced competitiveness
- Reduced complexity of the architecture reduces OPEX, optimizes balance sheets
- Re-use of the existing architecture leverages the installed base, reducing CAPEX

ARRIS Access and Transport Solutions – Expect More From Your Network

Thank You!