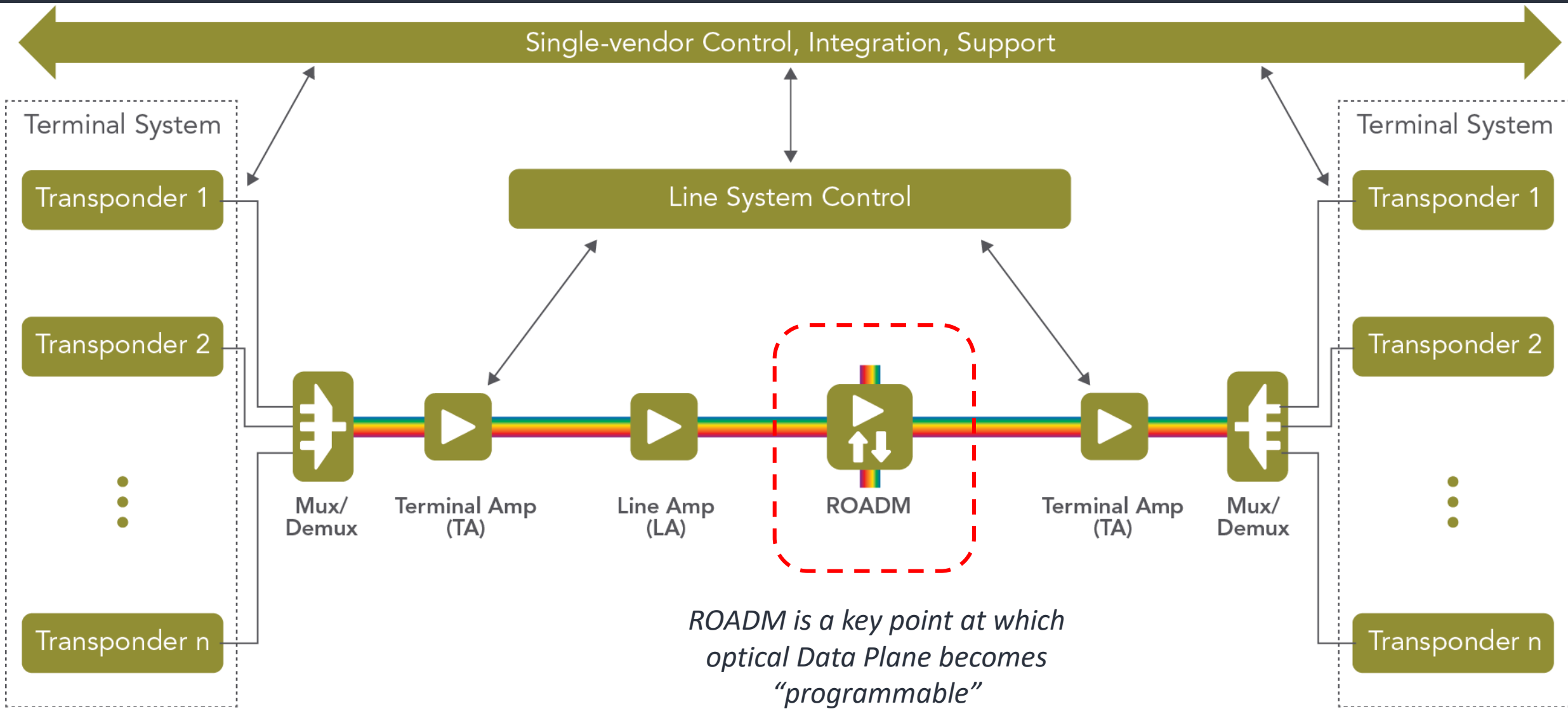


Open Line Systems and Open ROADMs: *How Open Is Your Line System?*

Geoff Bennett: Director Solutions and Technology



Traditional Model: *Integrated Optical System*



Fully Disaggregated Open Optical Network Vision

Robust ecosystem of integrators + deep DIY talent pool

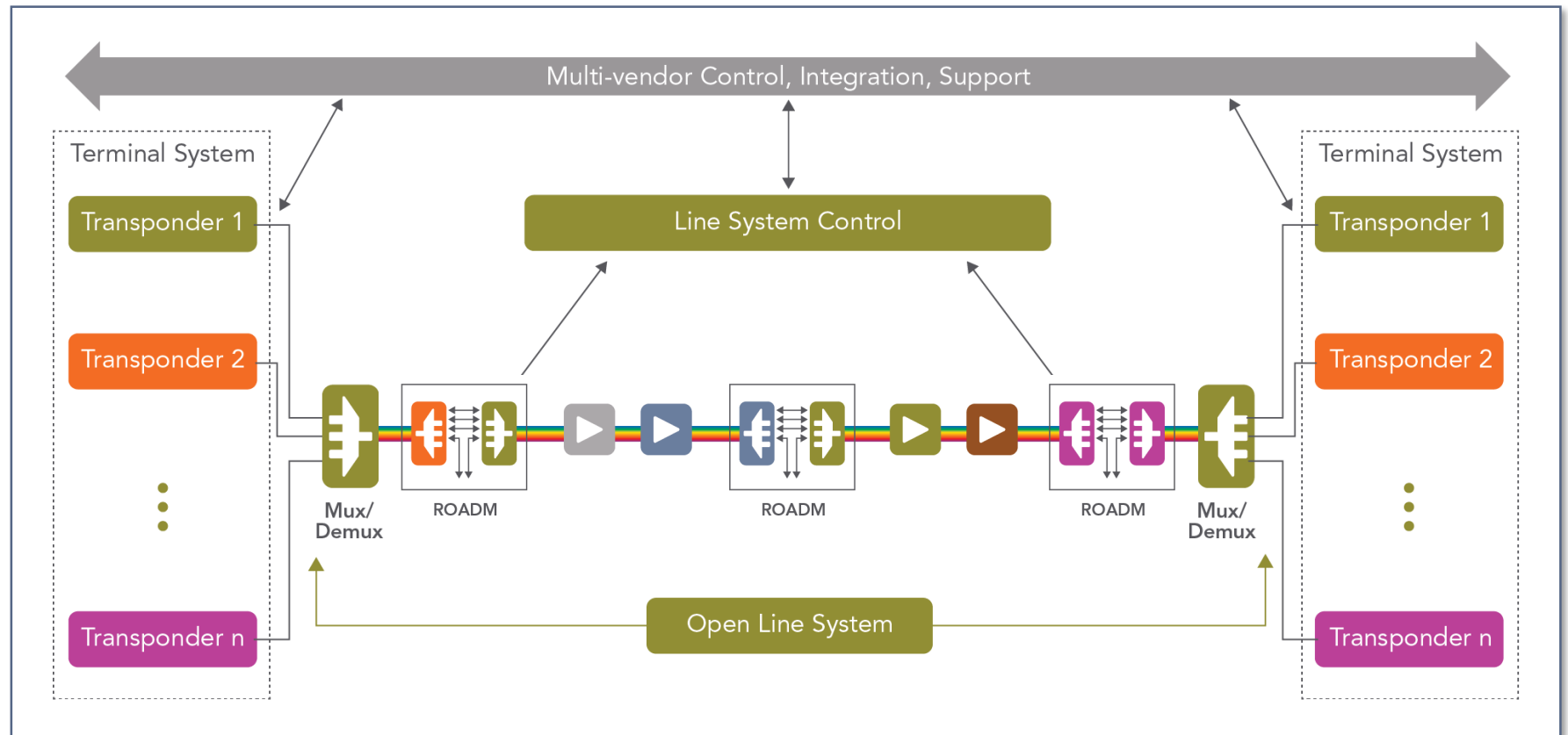
E2E multi-vendor management & orchestration (MANO)

SDN-based control architecture & algorithms

Open standard APIs for control & management

Mix and match transponders/terminals

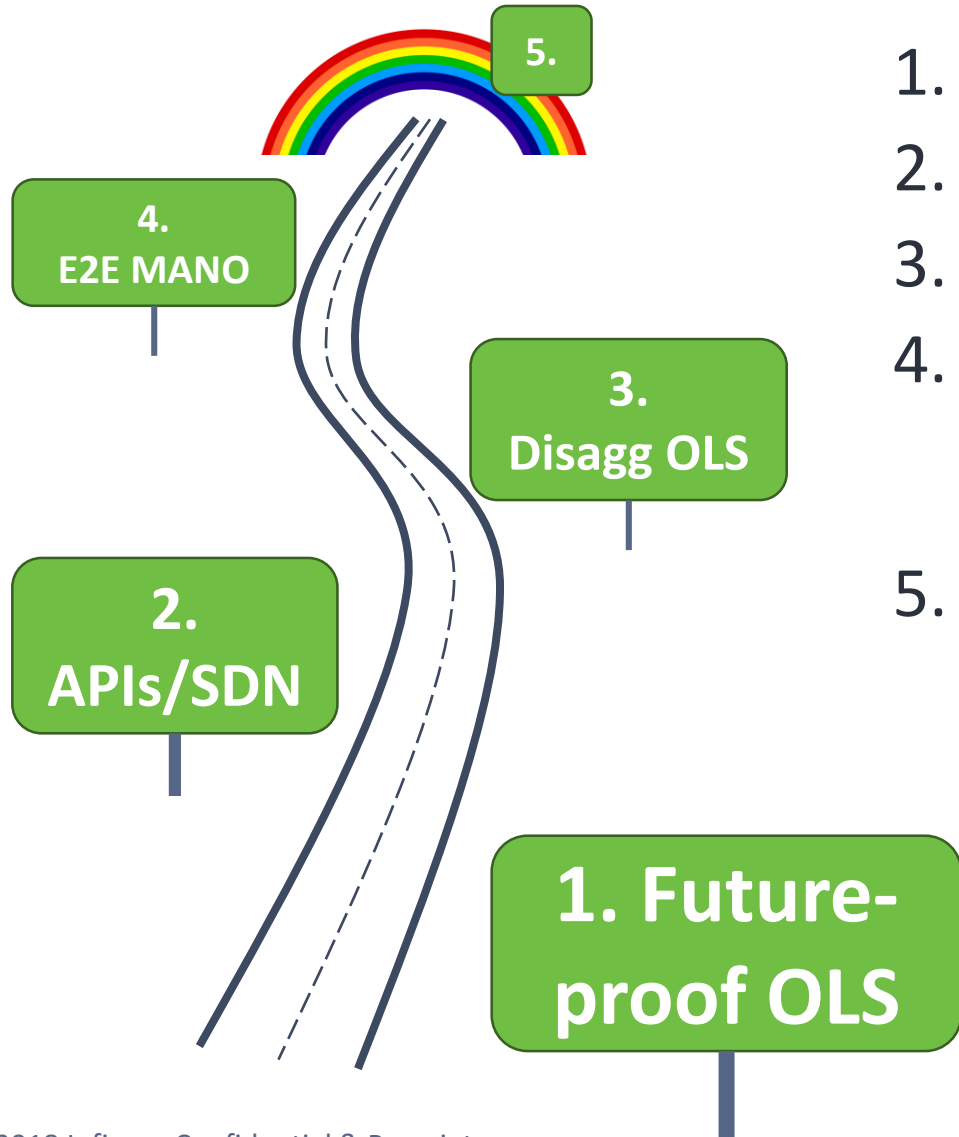
Mix and match open line system components



Fully disaggregated, standardized, interoperable, automated...



The Open Roadmap



1. Future-proof Open Line System
2. Open APIs + SDN-based control
3. Disaggregated OLS
4. End-to-end Multi-vendor Integration, Management & Orchestration (MANO)
5. Fully Disaggregated Open Optical Network Vision



Open Optical Network: *Vision vs. Value*

Why are we doing this?

Value driver	Value created	How do we achieve it?
Access best available transponder technology	Scale capacity with increased agility, lower capex	Open Line System (OLS): Decouple transponders & line system
Streamline, automate operations	Lower opex	Open APIs/SDN control + SW and process changes
Mix & match line system components	Incremental capex savings	Disaggregated OLS, standard device APIs/models, multi-vendor control

**BIGGEST
NEAR-TERM
WIN**

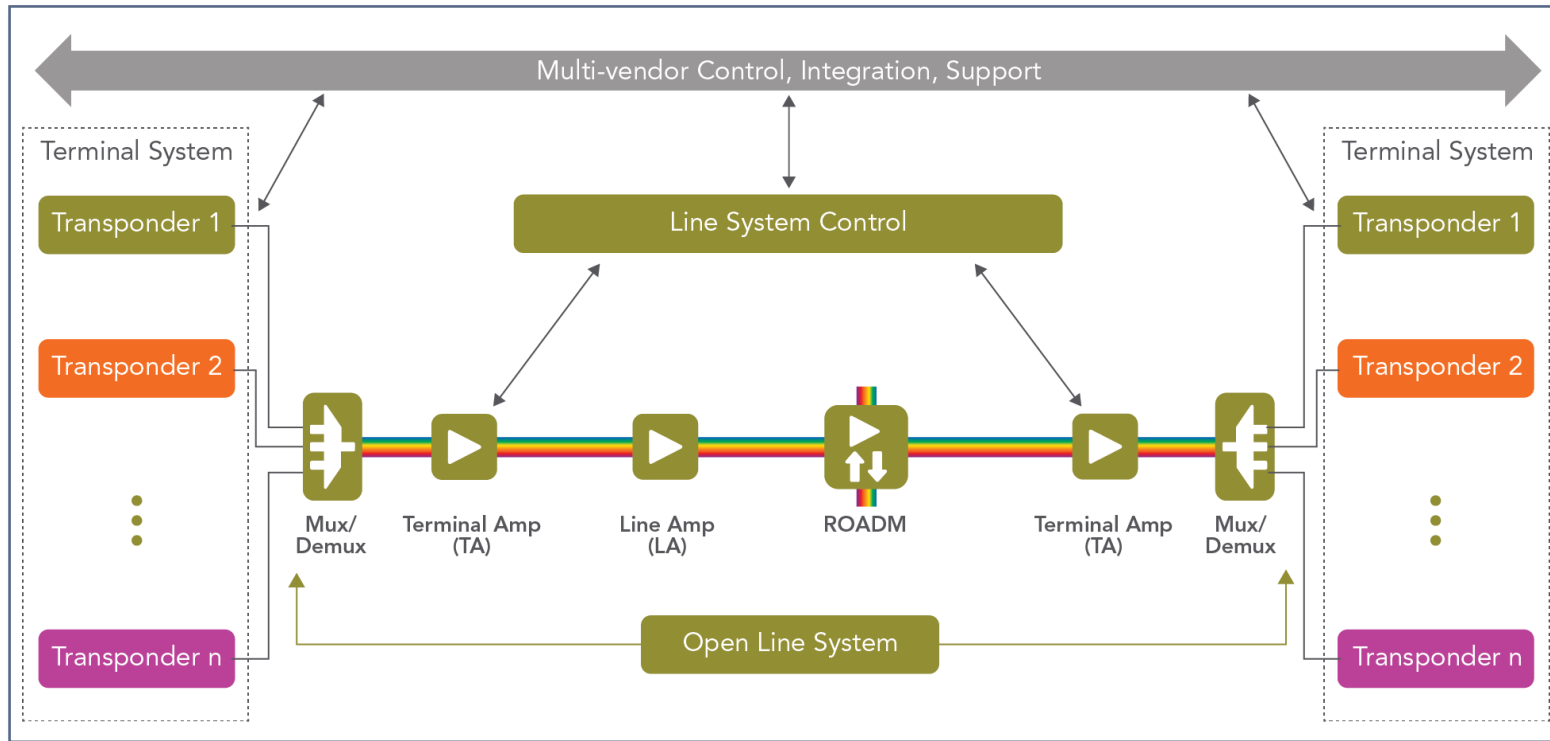


Transponder interoperability desired by some, but offers questionable value

- Innovation cycles are accelerating, ~2 years between generations
- Standardized/interoperable transponders tend to be at least 1 generation behind, deliver sub-optimal performance & cost

Step 1: *Future-proof Open Line System*

1. Future-proof OLS



Some transponders work over any OLS today

- ✓ Fixed or flex grid
- ✓ Flexible muxing / insertion / adaptation to OLS
- ✓ Alien wave management and operations tools, open APIs

Some systems meet future-proof OLS requirements today

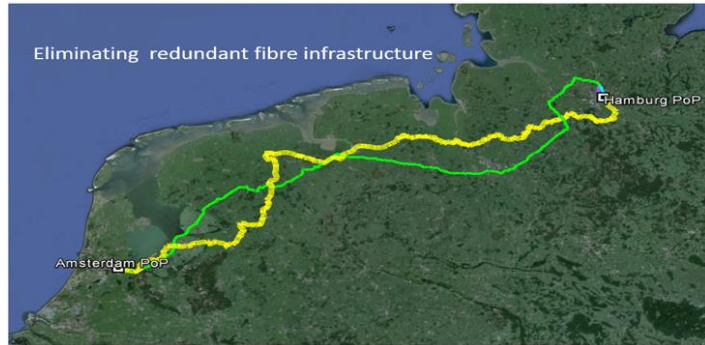
- ✓ Open to any transponder, channel format, etc. current & future
- ✓ Automatic power control
- ✓ Network-to-network ROADM interoperability
- ✓ Alien wave management and operations tools, open APIs

Future-proof Open Line Systems: *Industry Status*

1. Future-proof OLS

Fixed Grid 50 GHz Systems

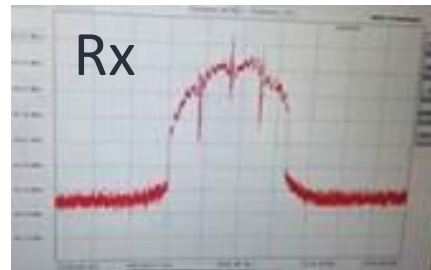
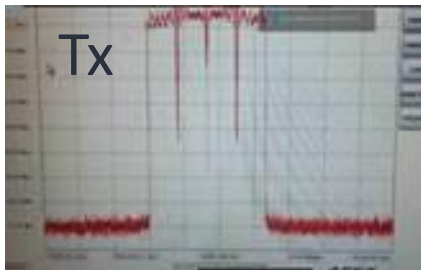
The Good



- Successful trials, now in production
- Operationally equivalent to native (Availability, MTTR)
- Happy customers

Examples: Infinera over Ciena & Huawei in R&E networks

The Bad



Example: Shoulder attenuation in an OLS trial

The Ugly

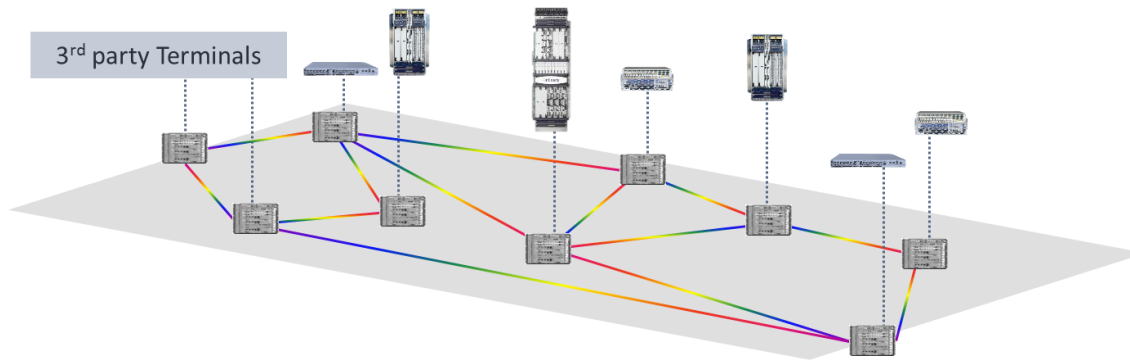
- Inflexible muxing & insertion options
- Proprietary power control systems that require additional hardware for alien insertion
- Punitive RTU pricing, as high as \$25k/wavelength
- Operational sabotage

Future-proof Open Line Systems: *Industry Status*

1. Future-proof OLS

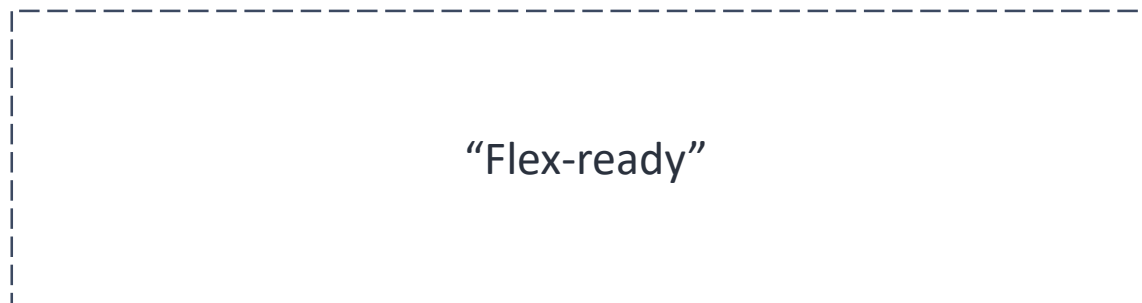
Flex-grid Systems

The Good



- A few vendors have deployed working flex-grid systems
- Even fewer meet all “future-proof” OLS requirements, including full support for alien waves

The Bad



- Some deployments of “flex-ready” hardware
- Software support lagging
- Much work to be done

What is Open ROADM?

2. APIs/SDN

Open ROADM

Mission: “disaggregation and opening up of traditionally proprietary ROADM systems and SDN-enablement of traditionally fixed ROADMs”

Organization: Multiple Source Agreement (MSA), initiated by AT&T and three vendors

Membership Philosophy: Service-provider led, maintain an even balance between SPs and vendors

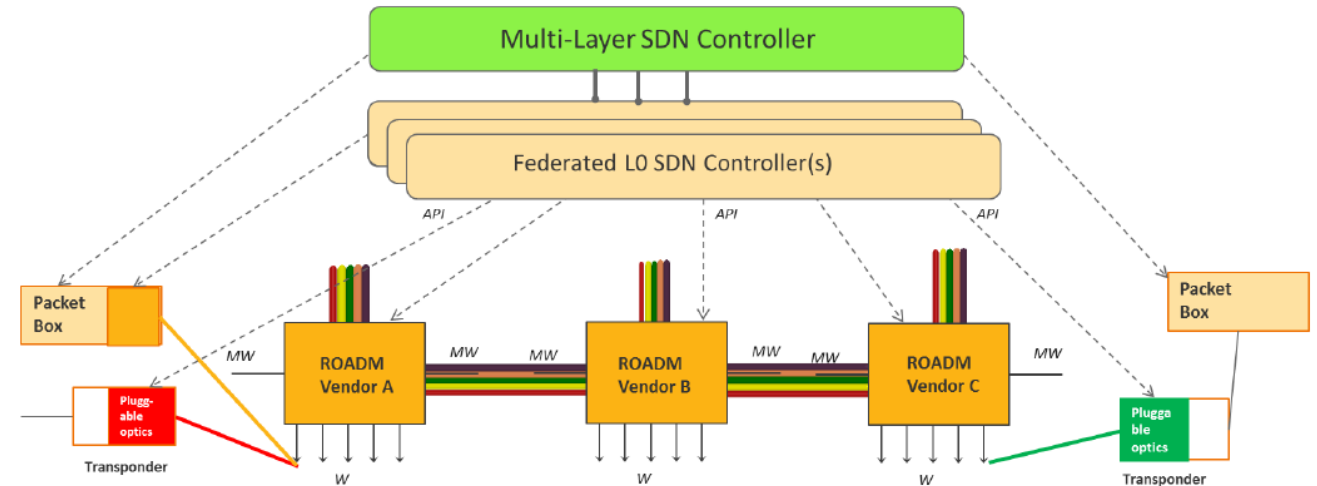
Members:

- **SP:** AT&T, Deutsche Telekom, KDDI, Orange, Rostelecom, Saudi Telecom, SK Telecom, Telecom Italia
- **Vendor:** Ciena, Cisco, Coriant, Fujitsu, **Infinera**, Juniper, Nokia

History:

- Open ROADM 1.0 (2016): Metro, fixed-grid focus
- Open ROADM 2.0 (2017): Add support for flex-grid, amps, etc.
- Open ROADM 3.0 expected 2018

Open ROADM 1.0 Architecture



Evolution of Open ROADM Specifications

2.
APIs/SDN

Open ROADM

V1

First release: March 2016
Final release: May 2016

Scope:

- CD ROADM only (*no CDC*)
- Fixed 50 GHz grid (*no flex*)
- Metro reach (*no amplifiers*)
- Transponder interop using 100G Coherent PM-QPSK, staircase FEC (*no proprietary FEC, no higher order modulation*)

V2

Release: November 2017

Additional Scope:

- Flex grid with 12.5 GHz granularity
- Amplifier support
- 10G / 100G Muxponders

V3

Initial release: March 2018

Additional Scope:

- Additional client interfaces
- In-band remote muxponder monitoring
- Availability, manageability, operability enhancements

Future

2H 2018 and beyond

Additional Scope:

- Expanding use cases
- Transponder interop at 200G+



TELECOM INFRA PROJECT

Initiated by Facebook

Mission: “disaggregate the traditional network deployment approach”
5 areas, 11 projects, dozens of working groups, hundreds of members

Access **Backhaul** Core & Management TIP Community Labs TEAC

Open Optical Packet Transport (OOPT) Project

- **Open Line System WG – Infinera Co-chair**
- Physical Simulation Environment WG
- Common API WG
- Disaggregated Transponders & Chips WG

- ▶ Infinera co-chairs OLS working group
- ▶ Focusing on SDN control of disaggregated OLS
- ▶ Defined and demonstrated proposed standard interfaces and information models: OpenOLS and OpenDevice

OpenConfig



- ▶ Google-driven “standard” YANG models
- ▶ Started with routers/switches, extending to transport layer

ODTN

(Open Disaggregated Transport Network)



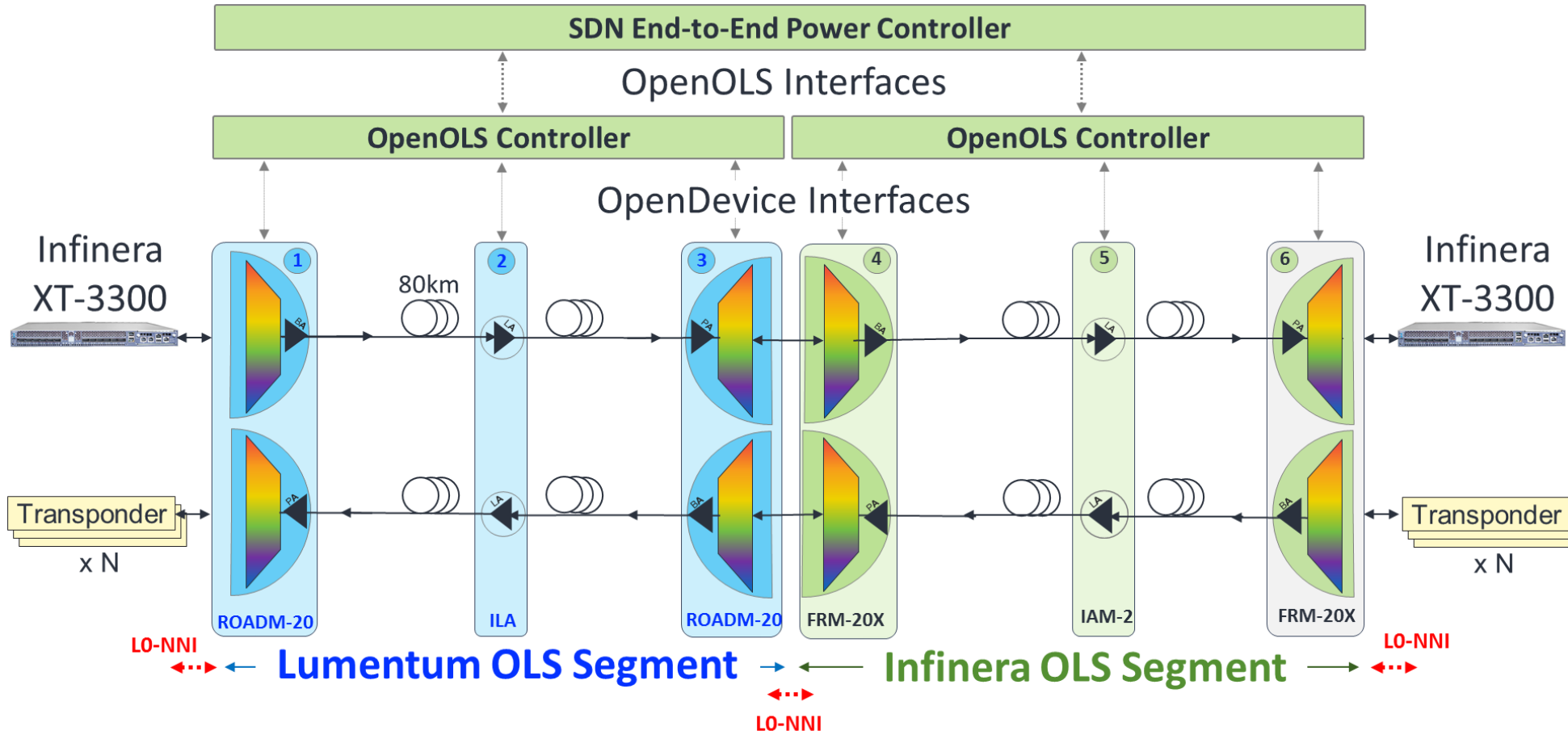
- ▶ Launched 2018
- ▶ Focus on end-to-end control of open network
 - Multi-vendor transponders over single-vendor OLS
(Transponder interop not in scope)
 - ONF-developed ONOS controller
- ▶ Leverage best existing standard APIs
 - TAPI, OpenConfig, TIP OpenOLS...

Members



+ 10 vendors including Infinera

TIP OLS Demo: *Flex-grid OLS and Open ICE with SDN Control*



Watch!
[TIP OLS Demo Video](#)

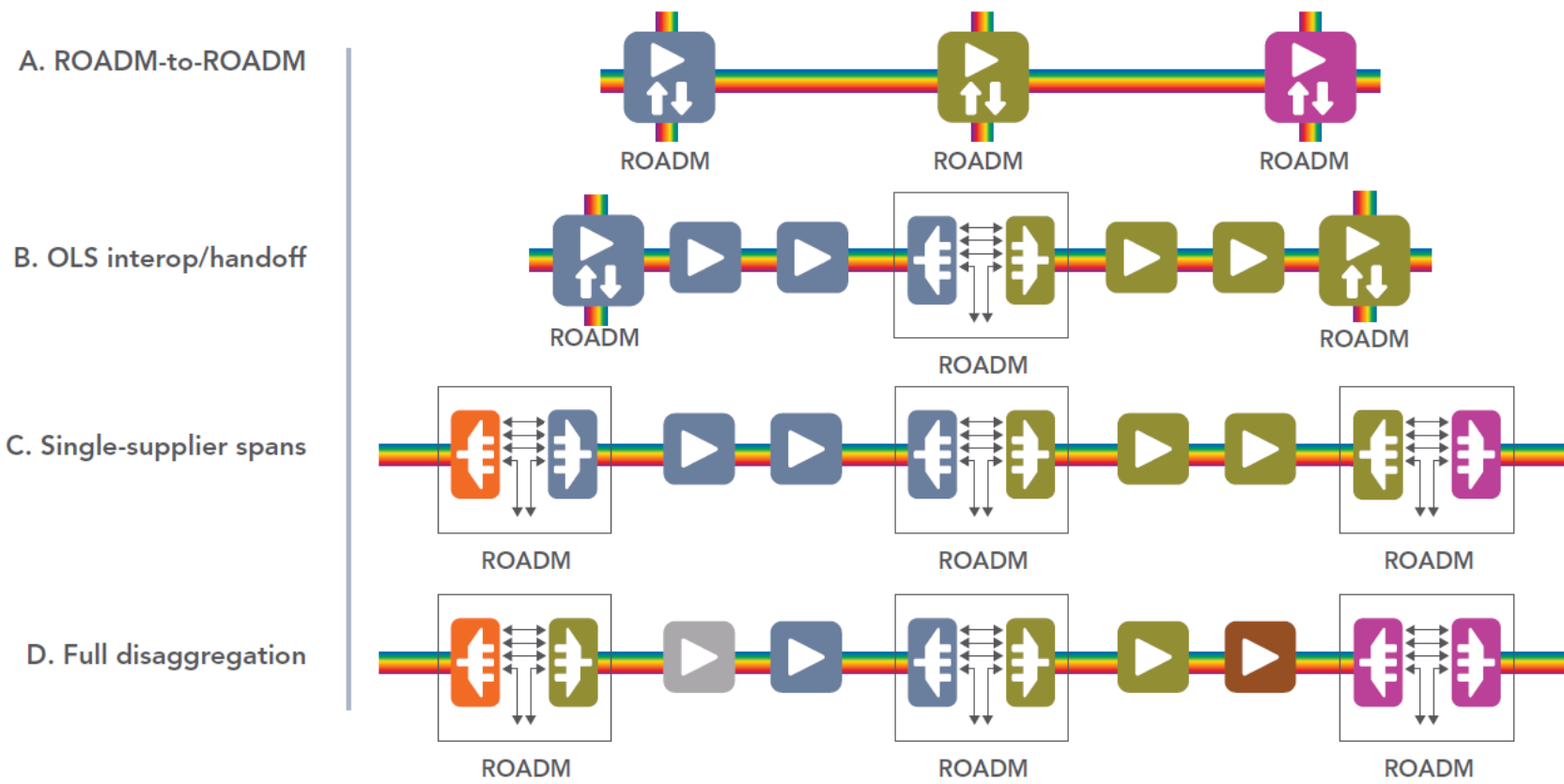
What Needs to be Standardized?

- ▶ Definitely:
 - Target use cases
 - Open APIs
 - YANG information models (device, span, OLS, network...)
- ▶ Maybe not:
 - SDN control software architectures
 - Control algorithms
- ▶ Why not?
 - Customer requirements vary (some planning DIY control)
 - Supplier innovation may deliver greater value

Step 3: *Disaggregated Open Line System*

3. Disagg
OLS

OLS Disaggregation Options



Open ROADM 1.0
Open ROADM

Early deployments,
TIP Summit demo



Stretch goal: align standardization efforts to enable all of the above with common models, APIs.



Likely spectrum of customer directions

Primary Supplier = Network Integrator

Still one neck to grab.
Open network is
insurance, used
selectively.

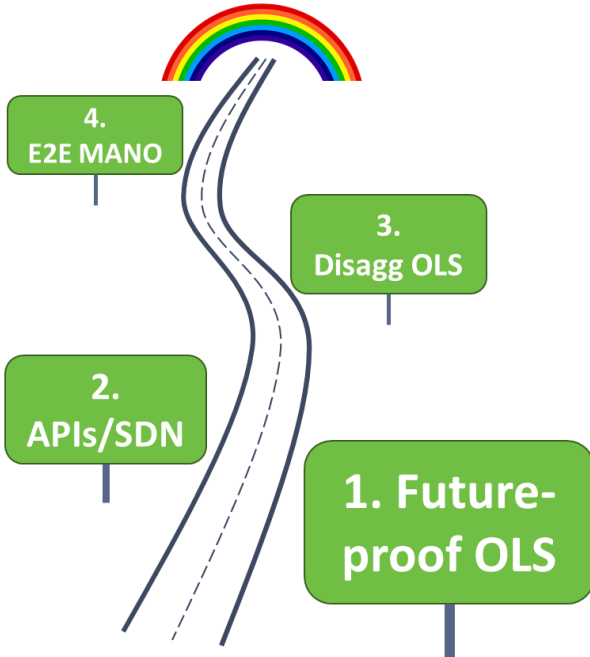
Orchestration Vendor = Network Integrator

More complex to set up
and manage.
Probably more hands-on
for operator.

DIY: Operator = Network Integrator

Stated direction for some
ICPs.
Requires deep in-house
SW expertise & optical
skill set.

What Do I Do Now?



- Take stock of your current line system
 - Can I insert alien waves today? Will it work technically?
 - Try it! Persuade your vendor that cooperation is in their best interest.
 - Does my line system meet all the “future-proof” requirements? Does my vendor have a convincing roadmap to plug the gaps?
- Check your current contract
 - Are alien waves allowed?
 - Is there a punitive RTU price?
- Get a real, future-proof open line system and ensure contracts/pricing are in line with your needs
- Incorporate open optical networking into your SDN vision and strategy

Thank You

