

# Simplifying operations for cost and energy efficient mobile networks

Gaël Simon,<sup>1\*</sup> Philippe Chanclou,<sup>1</sup> Jérémy Potet,<sup>1</sup> Fabienne Saliou<sup>1</sup>

<sup>1</sup> Orange Research, 2 Avenue Pierre Marzin, 22300, Lannion, France  
\*[gael.simon@orange.com](mailto:gael.simon@orange.com)

MOPA Showfloor: Capitalizing on Optics in 5G, 6G and Cloud  
RAN with Higher Data Rates and Longer Reaches

The 18<sup>th</sup> of March 2026

**Orange  
Research**

Shape the future  
and value innovation



1. Mobile Network Technology Evolutions Beyond 2030
2. Reducing cost with Mono-Optics
3. Smart visual fault locators to ease operations

1. Mobile Network Technology Evolutions Beyond 2030
2. Reducing cost with Mono-Optics
3. Smart visual fault locators to ease operations

# Mobile Network Technology Evolutions Beyond 2030

**Beyond “G’s”, for a new approach of mobile network technologies evolutions**

Expectations for future mobile network technologies

- accessibility to a **larger number of devices**
- rather than to improve the maximum performance

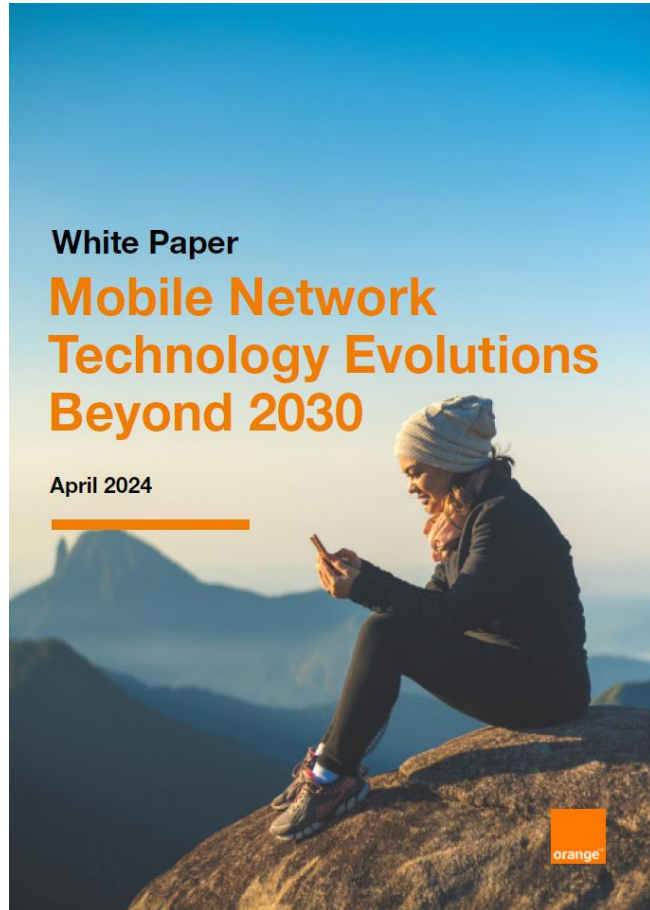
A new ‘G’ requires:

- new network equipment, to be added to or to replace the legacy ones,
- change the user terminals, leading to **massive cost** and **environmental impact**.

A right balance should be found between introducing innovative **connectivity services** and **capitalizing on legacy technologies** whenever possible.

KPI	Possible extreme value	5G reference [12]	Complement, e.g., target scenario
User experienced data rate (at cell edge)	300 Mbit/s 100 Mbit/s	300 Mbit/s 50 Mbit/s	dense urban other outdoor environments  Note: 250 Mbit/s required for immersive experiences. The majority of identified future usages would require less than a hundred of Mb/s.
Area capacity	3 Tb/s/km <sup>2</sup> 450 Gb/s/km <sup>2</sup>	750 Gb/s/km <sup>2</sup> 100 Gb/s/km <sup>2</sup>	dense urban outdoor & wide area Note: 30% activity factor assumed
Connection density	35 000 / km <sup>2</sup> 15 000 / km <sup>2</sup> 1.10 <sup>5</sup> / km <sup>2</sup>	25 000 / km <sup>2</sup> 10 000 / km <sup>2</sup> 1.10 <sup>5</sup> / km <sup>2</sup>	mobile broadband – dense urban mobile broadband – urban macro massive IoT
Positioning accuracy	< 10cm < 1m	1m 3m	Indoor deployment outdoor & wide area
Energy efficiency	x10 vs. 5G	no quantitative requirement	at least as much as capacity increase, so that the network energy consumption remains stable or decreases
Minimum end-to-end latency	5 ms 0.5 ms (URLLC)	0.5 ms 0.5 ms	In generic deployments, for services that require it for specific services & use cases associated to specific deployments
Reliability	99.9 % 99.999 %	Idem Idem	for most of services, typically (mobile broadband for specific services & use cases associated to specific deployments
Mobility	500 km/h	Idem	for specific services (very high speed trains, planes)

# Mobile Network Technology Evolutions Beyond 2030



*Scan me!*

## Some 6G features under discussions...



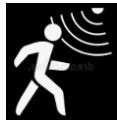
### Spectrum :

- A. Legacy band (4G/5G) : 3500 MHz for capacity, 700 MHz for coverage, 2100 MHz or other if Multi-RAT Sharing Strategies cost is low
- B. 6 GHz seen as prime 6G band
- C. 7 – 15 GHz as potential complement:
  - 7.125 to 7.25 GHz is a priority
  - 7.75-8.4 GHz & 14.8-15.35 GHz more uncertain



### Higher order MIMO and narrower beamforming

→ facilitate multi-user configuration within a cell



The use of small cells in 6G is not precluded but remains a second priority vs. macro deployments. Specific indoor coverage solutions, in particular in 6 GHz, may be of interest but should remain simple for economies of scale



### Satellite communication included as Radio Access Network

Specific interconnections to ensure real-time **seamless communication** and connect the unconnected



### 3GPP should remain agnostic of the implementation (traditional & cloud RAN)

On RAN split architecture, Open FrontHaul is a must have and should rely on 5G agreed splits as a baseline.

**Data-rate capacity  
x 10**

**New Applications**

**Seamless  
communications**



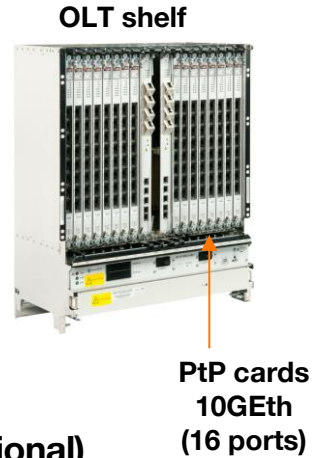
# PtP optical access to serve 5G and 6G

## Existing optical access connectivity

- for distributed RAN (in other word no Centralized RAN, no extended reach fronthaul), only Mobile backhaul
- 10GEth PtP is the regular connectivity required for Mobile backhaul (single fiber, bidirectional)
- 25GEth PtP is ready but not purchased
- OLT switching capacity : about 3 to 10Tbit/s

## Future optical access connectivity

- 25GEth PtP is ready but could be purchased
- OLT switching capacity evolution : about 100Tbit/s
- 100GEth PtP bidirectional (single fiber) is available (ITU & IEEE specifications in final discussion)
- 200 to 800 Gbit/s (1,6Tbit/s) is under investigation for PtP bidirectional
- new PtP transceivers include advanced signal processing, new FEC, coherent technology....
- for a tight synchronization, the transceiver parameters must be considered



## Surfing on Datacenters expansion

The need for short reach optical (intra DC pod level / inter rack connections) are booming for AI

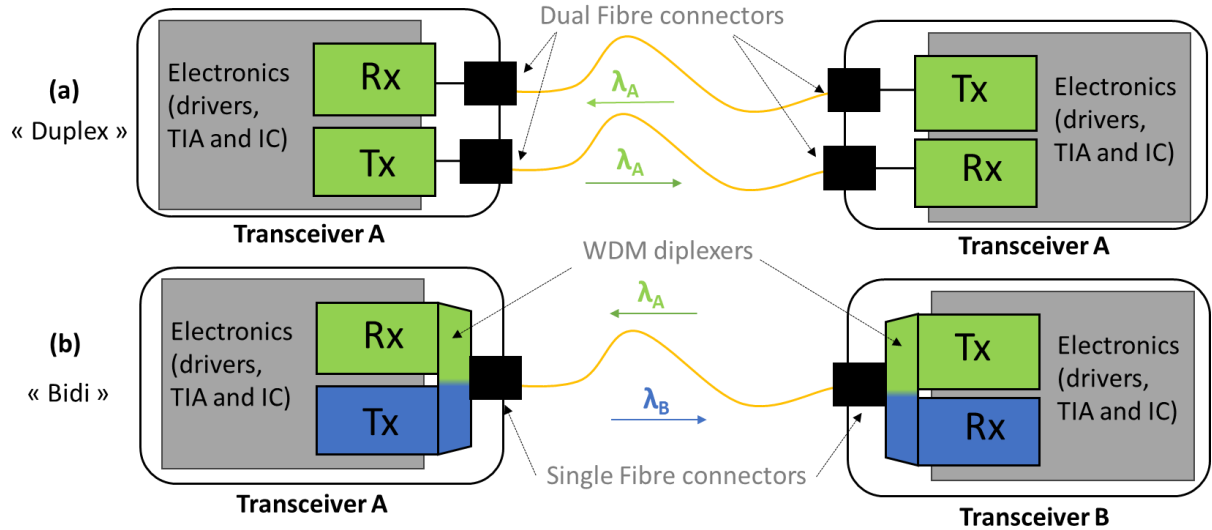
MMF VCSEL optics cannot be reused ...  
... but TIA, CDR, DSP, Receivers can be reused

Also, the development of low cost and low energy consumption based on co-packaged optics and silicon photonics will open new opportunities

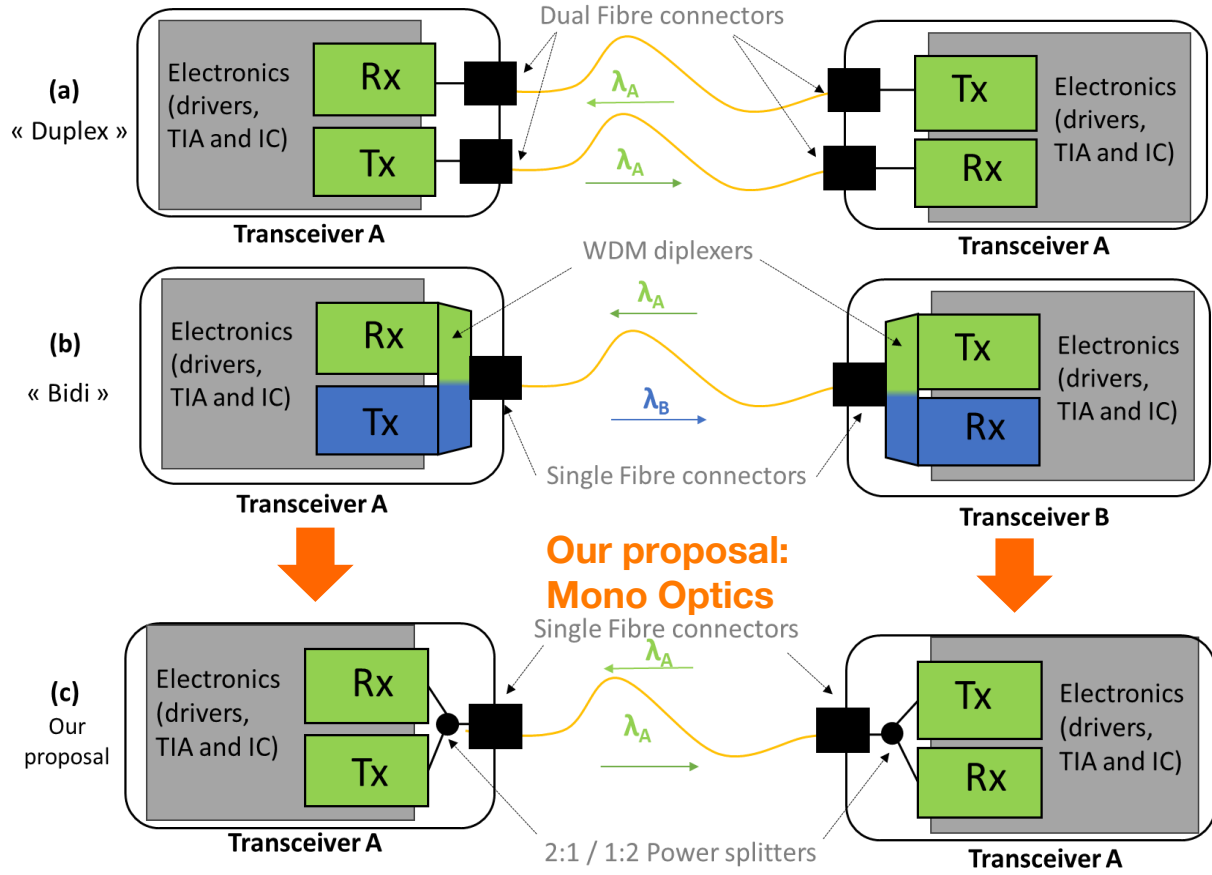
Interconnect type	Distance	Use case	Standard/Data Rates	Technologies
Long-haul	>800 km	National	400G/600G/800G Coherent	Optical retimed or coherent. Laser: InP, GaAs Modulator: InP, SiPho, TFLN/LNOI, BTO-Si TIA/Driver: SiGe, CMOS, InP (legacy) Waveguide: SiPho, LNOI, SiN Photodetector: InGaAs/GaAs, Ge-Si DSP: FinFET 5-7nm
Metro AccessCore	10–800 km	Regional	DWDM 400G ZR/ZR+ 800G ZR (future)	
Inter DC (datacenter) Campus	500 m to 10 km	DC to DC	800G-LR, ZR/ZR+ modules	
Intra DC Pod level	50–500 m	Spine-leaf switches	400G DR4/FR4 800G DR8/FR8 1.6T DR8/FR8 (future)	
Inter Rack	5–50 m	Rack to tack ToR switch	100G/400G Pluggable 800G/1.6T/3.2T	

1. Mobile Network Technology Evolutions Beyond 2030
2. Reducing cost with Mono-Optics
3. Smart visual fault locators to ease operations

# Optical transceivers (Single wavelength ones)



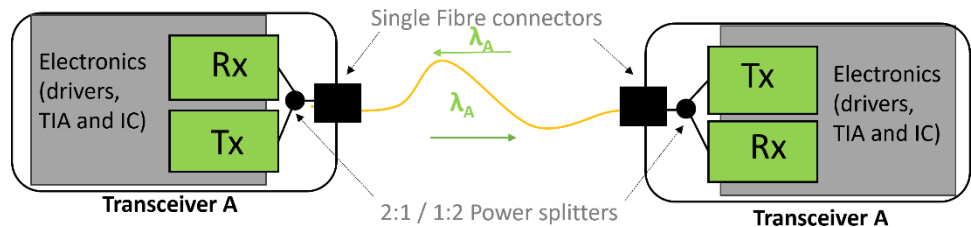
# Optical transceivers (Single wavelength ones)



- Optical splitters instead of wavelength duplexers can be used
- Same wavelength emitted and received at both side
- Same « twin » transceivers
  - No pairing needed
  - Easy maintenance
  - Easy inventory/spare
- Higher losses from splitters compared to duplexers (<1dB)
  - > 3 dB
  - Restricted power budget

Isolators are included in Emitters (Tx) sub-assemblies

# Potential issues of Mono-optics



- Reflections:
  - Experiments suggest to maintain the reflected signal 20 dB below the transmitted signal
  - PC connectors: 30-40 dB reflections
  - UPC connectors: 40-50 dB reflections
  - APC connectors: > 60dB
- Rayleigh Backscattering:
  - Limited for <1 km reach
  - 35 dB max. in standard conditions (20 km SSF)
- Optical beat interference:
  - Happens if both wavelengths are too close
  - Polarization dependent
  - Random wavelength tuning mechanism can avoid this effect

Fiber In-Premises Solution  
With Low-Cost Mono-Optics Transceivers  
Michael Straub<sup>(1)</sup>, Ronald Heron<sup>(2)</sup>, Philippe Chanclou<sup>(3)</sup>, Rene Bonk<sup>(4)</sup>

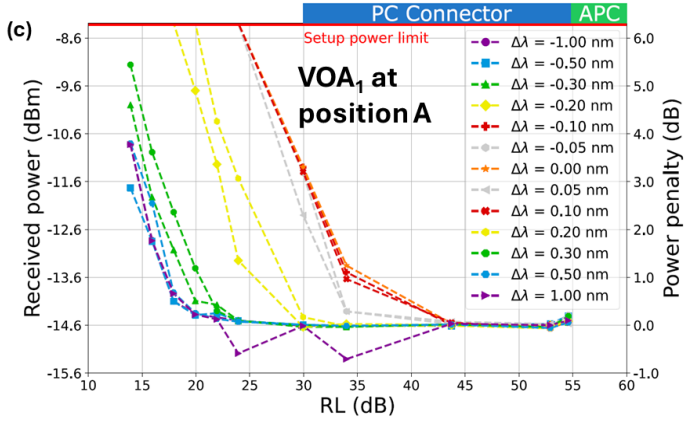
ECOC 2025 Pres. Tu.01.07.3, 10:15 Tuesday, Room B4 M1-4

02/04/2026

Single Fibre Transmission up to 25 Gbit/s with Twin  
Transceivers for Metro/Access/Datacom networks  
Fabienne Saliou, Théo Huguenin, Maël Bideau, Philippe Chanclou, Gaël Simon, Jérémy Potet  
Orange, 2 avenue Pierre Marzin, 22307 LANNION, France  
fabienne.saliou@orange.com

Optica Advanced Photonics Congress 2025  
(Marseille, France)

# Demonstration: 100Gb/s PAM4 transceivers



Poster session tomorrow: Th2A.39

**100 Gbit/s Bidirectional Transmission in a Single Fiber  
with Twin bidi Transceivers**

Theo Huguenin<sup>(1)</sup>, Fabienne Saliou<sup>(1)</sup>, Gael Simon<sup>(1)</sup>, Jeremy Potet<sup>(1)</sup>, Philippe Chanclou<sup>(1)</sup>,  
Mokhtar Korti<sup>(2)</sup>, Ronald Heron<sup>(3)</sup>

(1) Orange Research, 2 Avenue Pierre Marzin, 22300, Lannion, France, theo.huguenin@orange.com  
(2) III-V Lab, a joint laboratory of Nokia Bell Labs, Thales Research & Technology, and CEA-Leti, 1 Av. A. Fresnel, 91120 Palaiseau, France  
(3) Nokia Canada Inc, 600 March Road, K2K 2E6 Ottawa, Canada



1. Mobile Network Technology Evolutions Beyond 2030
2. Reducing cost with Mono-Optics
3. Smart visual fault locators to ease operations

# Orders of magnitude



**OLT capable of covering the fiber access of a town of 5,000 customers ~800 kg CO<sub>2</sub>**  
**Manufacturing (excluding installation)**

**Construction of 1 new pylon mobile site:**  
**~37 000 kg CO<sub>2</sub>e**  
**pylon, slab, works, RAN equipment, energy supply**



**1 customer intervention:**  
**~35 kgCO<sub>2</sub>e**  
**travel, small equipment, others**

**1 FTTH installation - fiber infrastructure**  
**~65 kgCO<sub>2</sub>e per customer\***  
**Passive Equipment manufacturing, installations**



**1 residential fiber gateway:**  
**~30 kgCO<sub>2</sub>e**  
**Manufacturing (excluding installation)**

**1 vCPU on a dedicated server :**  
**~60 kgCO<sub>2</sub>e**  
**For a server host inside a datacenter**



**Smartphone:**  
**60-95 kgCO<sub>2</sub>e**  
**Fabrication, transport, distribution**

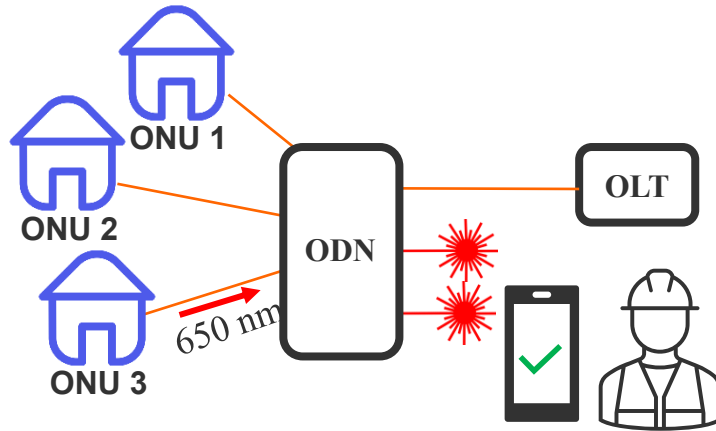
**TV 55 " 4k:**  
**~350 kgCO<sub>2</sub>e**  
**Fabrication, transport, distribution**



Interventions & support are a source of both cost and CO<sub>2</sub> emission

*\* Fiber Broadband Deployment is Paramount To Achieve Zero Carbon Footprint*

# Smart visual fault locator for ONU identification - FTTH

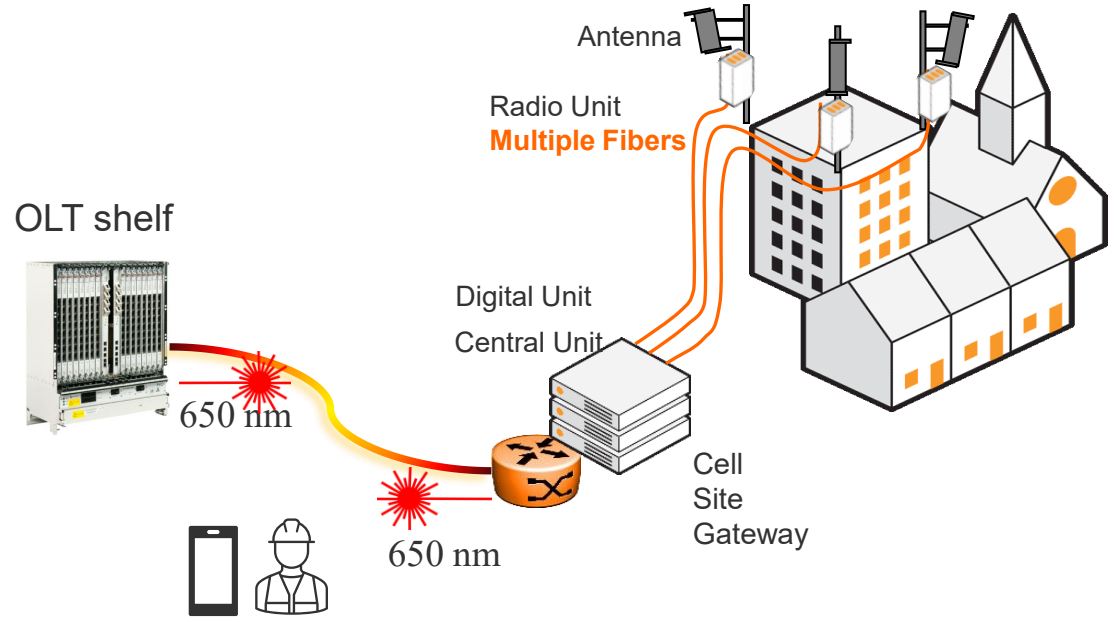


- Integrated red light in the TOSA/ROSA
- A light signature (ex: ONU ID, serial number, status, ...) is transmitted on the red light (bits/s)
- Technician's smartphone can read this signal



« TriOSA »:  
integrated TOSA + ROSA + red light emitter

# Smart visual fault locator for ONU identification – In-building



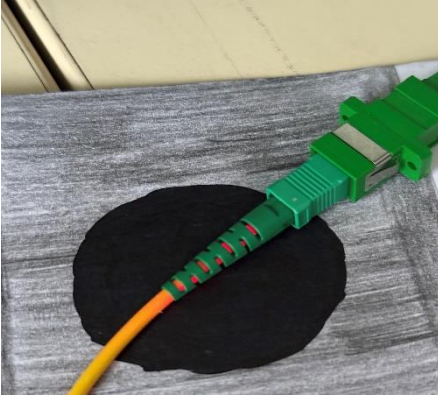
- Integrated red light in the TOSA/ROSA
- A light signature (ex: SFP ID, serial number, status, ...) is transmitted on the red light (bits/s)
- **Operator's** smartphone can read this signal



« TriOSA »:  
integrated TOSA + ROSA + red light emitter

# Interest

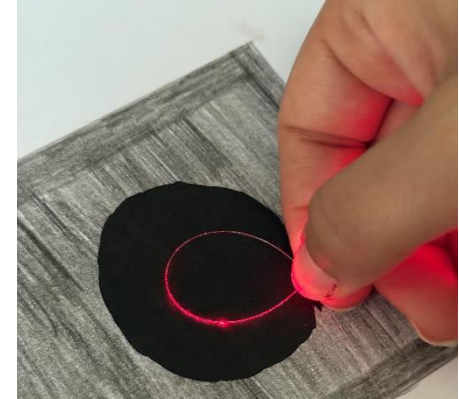
**Faulty connector**



**Bad splice**



**Fiber bending**



- **ONU serial number can be recovered: outage resolution by the customer**

Smartphone Camera Detection of ONU Identification Carried by  
Modulated 650 nm LED Integrated with ONU Optics

Jeremy Potet<sup>(1)</sup>, Rania Boukheit<sup>(1)</sup>, Dylan Chevalier<sup>(1)</sup>, Gaël Simon<sup>(1)</sup>, Georges Gaillard<sup>(1)</sup>,  
Fabienne Saliou<sup>(1)</sup>, Philippe Chanclou<sup>(1)</sup>

ECOC 2025 Pres. W.02.01 SC7 (poster), 11:00 Wed., Auditoria 10+11+12

# Summary

1. Mobile Network Technology Evolutions Beyond 2030  
Be ready for a mass market 100Gbit/s PtP bidirectional (single fiber) operation
2. Reducing cost with Mono-Optics  
Mono-Optics can meet PtP use cases  
Next step: transceiver integration
3. Smart visual fault locators to ease operations  
Red light already available on field ONUs (FTTH)  
Transposition to in-building networks seems feasible

# Thank You

