Design and Optimisation of FTTA Backhaul Loop for Lorient

IT.3502 - High Rate Networks

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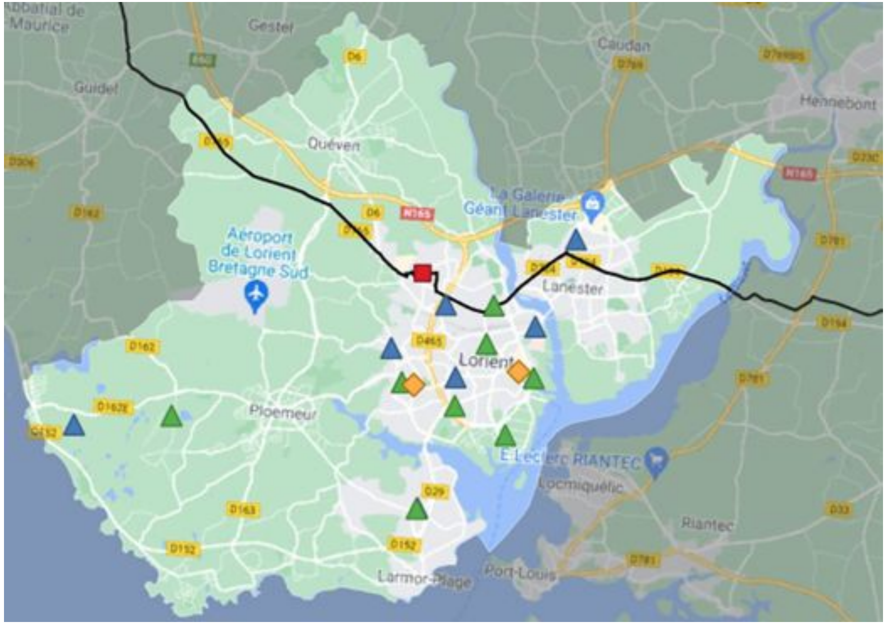
Project Context & Objective

- Design a resilient FTTA backhaul network
- Urban deployment in Lorient, France
- Minimize civil engineering costs
- Ensure dual-path security
- Backward compatibility and Future-proof

Project Scope

Type	Number	Symbol	Backhaul Principles
Radio sites	11	▲	Secure backhaul by two ways
NRA/O (fixed network)	3	◆	Secure backhaul by two ways
FTTO/A (potential)	—		A fibre
Anchoring site	—	■	Source/Termination node

- Integrate with the existing backbone (black line)
- Reuse Civil Engineering where possible
- Minimise total length of fiber deployment



Topology Selection: Physical Ring Architecture

Security-Driven Design Choice

- Selected a **Physical Ring Topology** to meet high availability and security requirements.

Key Advantages

- **Redundancy:** Ensures continuous service in case of:
    - Fiber cut
    - Node failure
- **Automatic Traffic Rerouting:**
    - Traffic is redirected in the opposite direction via a **Protection Path**.
- **Dual Path Security:**
- Guarantees resilient connectivity for all **14 sites** to the **Anchoring Site**.

Outcome

- Improved network reliability and fault tolerance without single points of failure.

Mathematical Optimization: TSP

Optimization Objective

- Minimize total fiber length while preserving the ring topology.

Applied Method

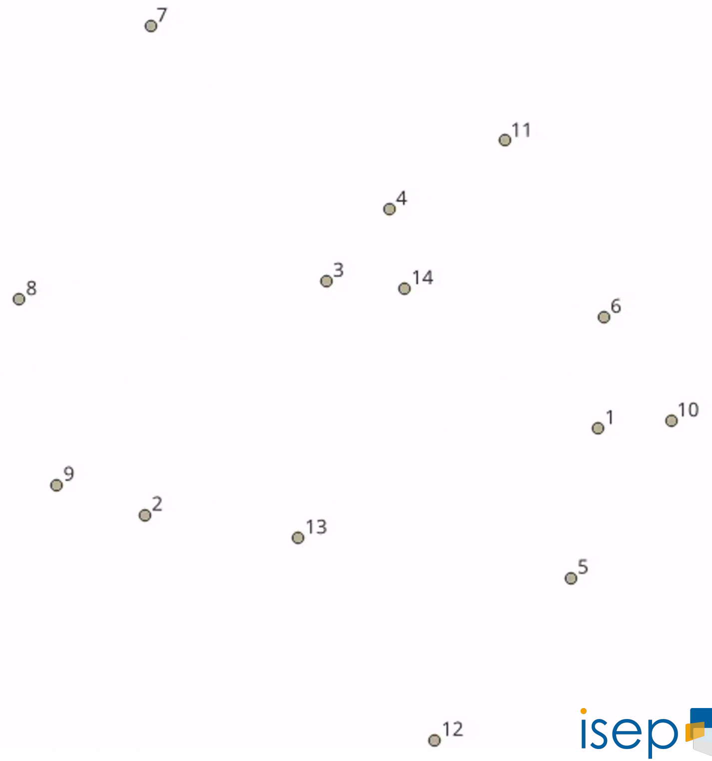
- Modeled the network design as a **Traveling Salesman Problem (TSP)**.
- The solution identifies a **minimum-weight Hamiltonian Cycle**:
    - Visits each radio site exactly once
    - Returns to the anchoring site (when feasible)

Benefits

- **Guaranteed minimum civil engineering and fiber deployment cost**
- Maintains the required **ring-based redundancy**

Implementation Tool

- **QGIS ORS Tool** used to compute and implement the TSP solution.



Engineering Results & Design Constraints

Optimized Link Characteristics

- **Total Fiber Length:**
  - **20.62 km**
- **Average Length:**
  - **1.47 km**
- **Longest Span:**
  - 3.11 km (critical for optical loss evaluation)

Engineering Considerations

- Long spans identified as **maximum loss segments**
- Certain links require:
  - **Dedicated civil engineering**
  - **Diverse duct routing** to enhance loop protection

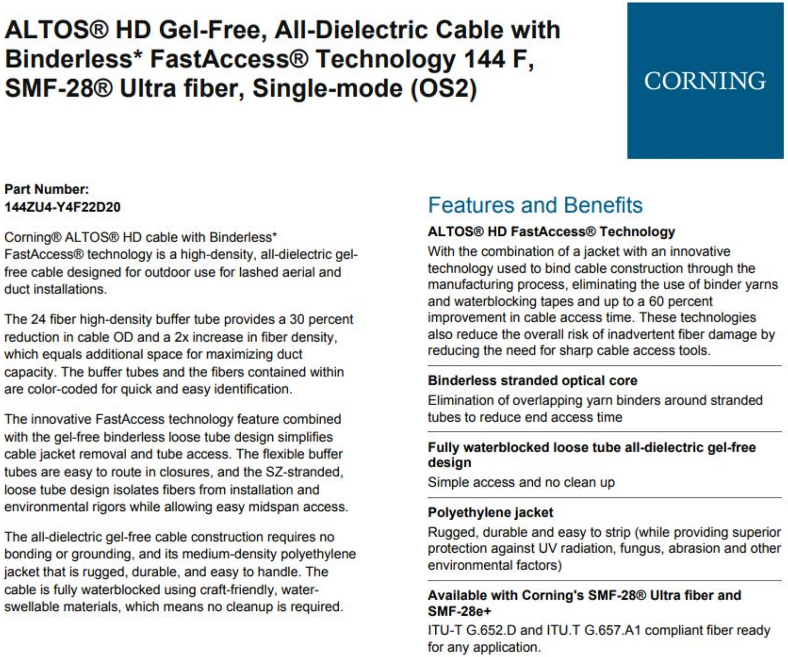
Next Design Phase

- Development of the technical solution based on:
  - Optical link budget
  - System capacity
  - Compliance with optical standards
  - Anticipated future network growth

Network design

Optical fiber

- G.657.A1 ... radius G.652.D?
- Dielectric) Cable (ALTOS® HD Gel-Free,
- For "FTTO" revenue generation without re-excavation



ALTOS® HD Gel-Free, All-Dielectric Cable with Binderless* FastAccess® Technology 144 F, SMF-28® Ultra fiber, Single-mode (OS2)

CORNING

Part Number:
144ZU4-Y4F22D20

Corning® ALTOS® HD cable with Binderless* FastAccess® technology is a high-density, all-dielectric gel-free cable designed for outdoor use for lashed aerial and duct installations.

The 24 fiber high-density buffer tube provides a 30 percent reduction in cable OD and a 2x increase in fiber density, which equals additional space for maximizing duct capacity. The buffer tubes and the fibers contained within are color-coded for quick and easy identification.

The innovative FastAccess technology feature combined with the gel-free binderless loose tube design simplifies cable jacket removal and tube access. The flexible buffer tubes are easy to route in closures, and the SZ-stranded, loose tube design isolates fibers from installation and environmental rigors while allowing easy midspan access.

The all-dielectric gel-free cable construction requires no bonding or grounding, and its medium-density polyethylene jacket that is rugged, durable, and easy to handle. The cable is fully waterblocked using craft-friendly, water-swellable materials, which means no cleanup is required.

Features and Benefits

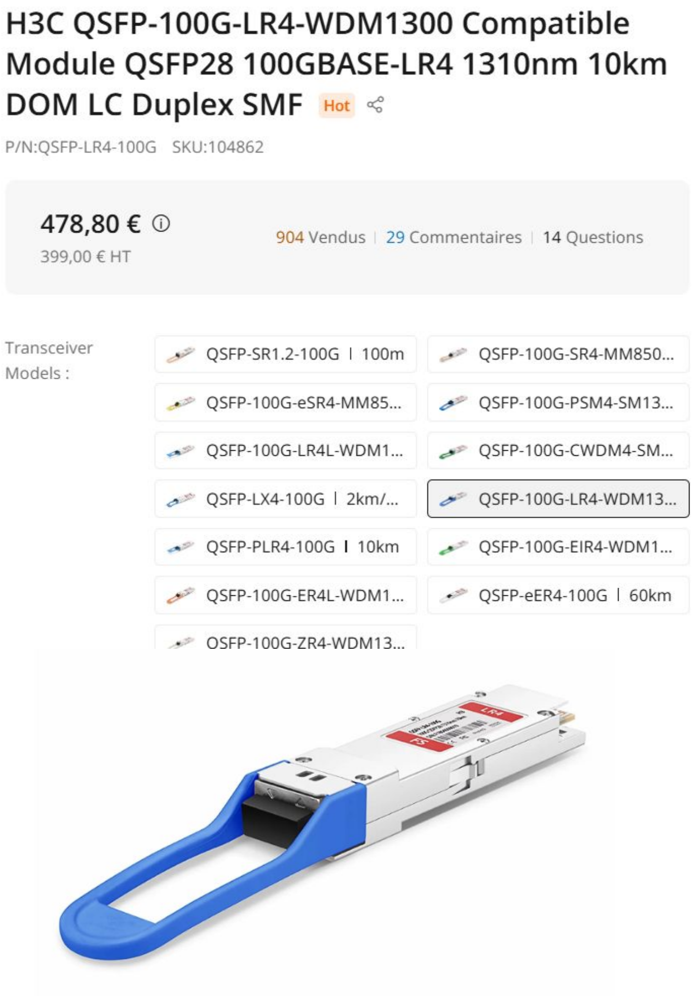
ALTOS® HD FastAccess® Technology
With the combination of a jacket with an innovative technology used to bind cable construction through the manufacturing process, eliminating the use of binder yarns and waterblocking tapes and up to a 60 percent improvement in cable access time. These technologies also reduce the overall risk of inadvertent fiber damage by reducing the need for sharp cable access tools.

Binderless stranded optical core
Elimination of overlapping yarn binders around stranded tubes to reduce end access time

Fully waterblocked loose tube all-dielectric gel-free design
Simple access and no clean up

Polyethylene jacket
Rugged, durable and easy to strip (while providing superior protection against UV radiation, fungus, abrasion and other environmental factors)

Available with Corning's SMF-28® Ultra fiber and SMF-28e+
ITU-T G.652.D and ITU.T G.657.A1 compliant fiber ready for any application.



Active Equipment

- Transceivers: SFP 25G LR (Long Reach).
  - ***Standardization***: We selected a single model (10km range) to cover all spans.
  - ***Justification***: The longest span is ~3.1 km. The 10km optic provides ample margin without need for amplification.

Link Budget

- [illegible]

Project Organisation

Team Structure

1. **Project Manager**
   Coordination and final reporting

2. **Civil Engineer**
   QGIS topology design and Analysis of street constraints and trenching requirements

3. **Network Architect**
   Network design and Optical equipment selection

4. **Financial Analyst**
   CAPEX/OPEX modeling and ROI calculation

Project Timeline

Phase	Activity	Month 1 1	Month 2 2	Month 3 3	Month 4 4
Study	Site surveys & Design (QGIS)				
Procurement	RFP for fiber & civil works				
Deployment	Civil eng, Duct laying, Fiber blowing				
Commissioning	Splicing, OTDR testing, Acceptance				

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Business Plan & Financial Expenditure

Capital Expenditure

Cost Item	Unit Price (Est.)	Quantity	Total Cost (€)
Civil Engineering (Targeted)	€50k–75k / km	Avoided/ just suggested in short distances to guarantee two way connection (like node 8,9)	€200,000
Fiber Supply & Install (144FO)	€20 / meter	20,620 m	€412,400
Splice Closures (Boites)	€300 / unit	14 Nodes	€4,200
Active Optics (SFP+)	€1,000 / pair	14 Links	€14,000
Subtotal			**€618,000**
Project Mgt & Design	—		€92,700
TOTAL CAPEX			**€710,000**
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Operational Expenditure

- Maintenance ~3% of CAPEX
- Duct Rental
- Energy - anchor site power consumption

Return on Investment

- Leasing 14 links -> 3k USD/site/year = **42k Eur/year**
- New Revenue (FTTO) -> 10 business clients, 200 Eur/month = **24k Eur/year**
- Total Annual Benefit -> **66k Eur/year**
- Payback Period = 710,000/66,000 = **10.8 Years**

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Thank You