IT. 3502 - High-Rate Networks

FTTA Loop Design for Urban Backhaul Networks

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01 Introduction

Project Overview

Background

- The 5G rollout demands reliable, high-speed networks in urban areas with over 50,000 residents, like Blois, France.
- A Fiber To The Antenna (FTTA) loop is critical for ensuring secure and efficient backhaul for 5G infrastructure.

Objectives

1. **Expand Network Coverage:**
   - Develop a backhaul solution for 17 radio sites, 2 fixed nodes, and potential FTTO/A points.
2. **Optimize Resources:**
   - Define technical rules for fiber type, backhaul distance, and dual-path security.
3. **Justify Solutions:**
   - Propose scalable and future-ready deployment strategies.

Key Focus

- Use existing infrastructure and ensure scalability to meet future 5G needs.

02 Methods and Design

Design Principles

1. **Reliability:**
   - Dual physically separated return paths for key nodes (e.g., orange NRA/O nodes, green wireless stations).
2. **Cost Efficiency:**
   - Optimize fiber length and topology to minimize unnecessary dual-path setups and costs.
3. **Avoid Black Roads:**
   - Exclude black main roads to reduce construction restrictions and permit costs.
4. **Layered Topology:**
   - Critical nodes with dual-path connections; regular nodes with single-path connections.
5. **Future-Proofing:**
   - Reserve capacity for future expansions or bandwidth upgrades.

Topology

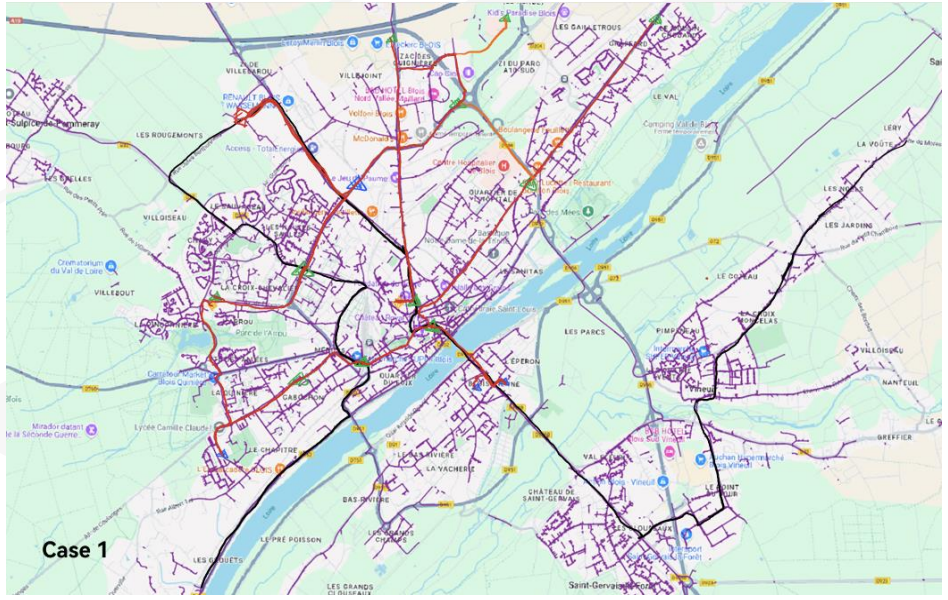
Topology Types

1. **Ring Topology:**
   - Redundant ring connections to reduce single-point failures.
2. **Star Topology:**
   - Aggregate stations to NRA/O nodes, then connect to anchor stations.
3. **Chain Topology:**
   - Serial connections for low-traffic areas to minimize fiber deployment.

Layered Topology

1. **Core Layer:**
   - Anchor stations connect to the operator's core network with dual-paths.
2. **Aggregation Layer:**
   - NRA/O nodes aggregate traffic and connect to anchor stations with dual-paths.
3. **Access Layer:**
   - Green wireless stations connect to NRA/O nodes via single-path or ring connections.

Scheme 1 - Compact and Efficient Loop



Deployment Characteristics:

- Core base stations and nodes are prioritized, with each station connected to the anchoring site through two independent paths, providing basic redundancy.
- Compact loop in the northern region

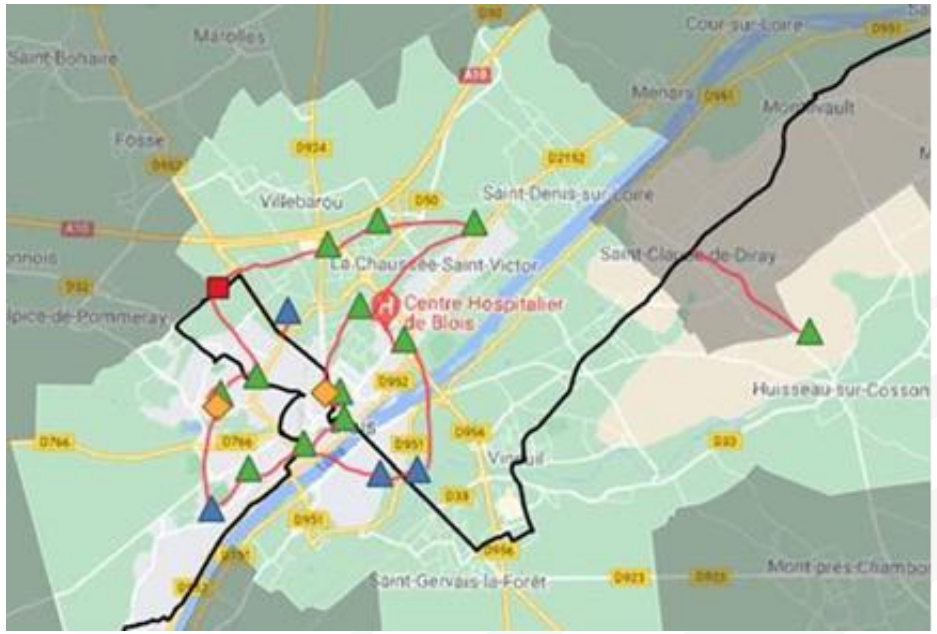
Advantages:

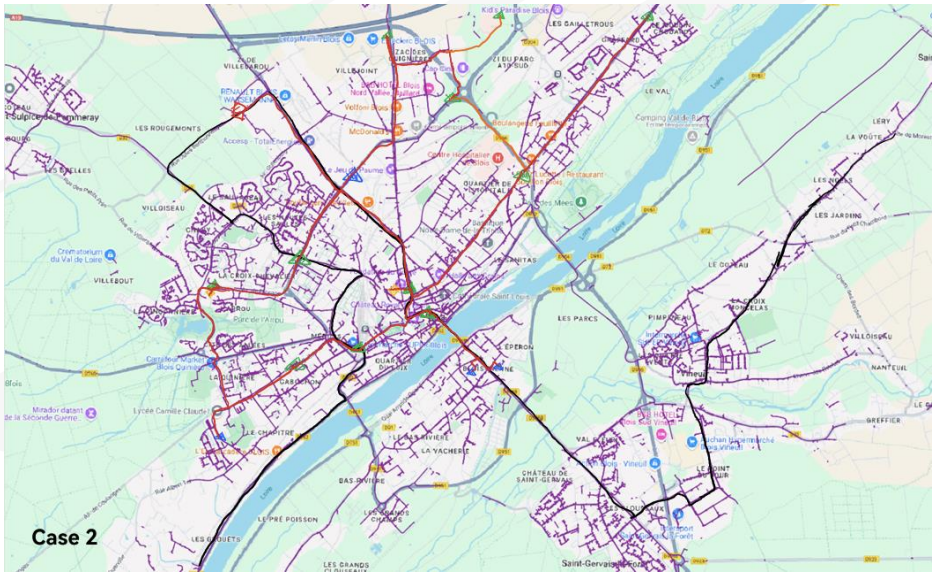
- Short path, lower cost
- Avoids black backbone lines, reducing latency risks

Disadvantages:

- Relatively low redundancy for large-scale failures

Scheme 2 - Balanced Expansion Loop





Deployment Characteristics:

- The loop extends in two directions: north and south, connecting base stations and nodes.
- The two directions form a large circular loop, balancing core and peripheral coverage.

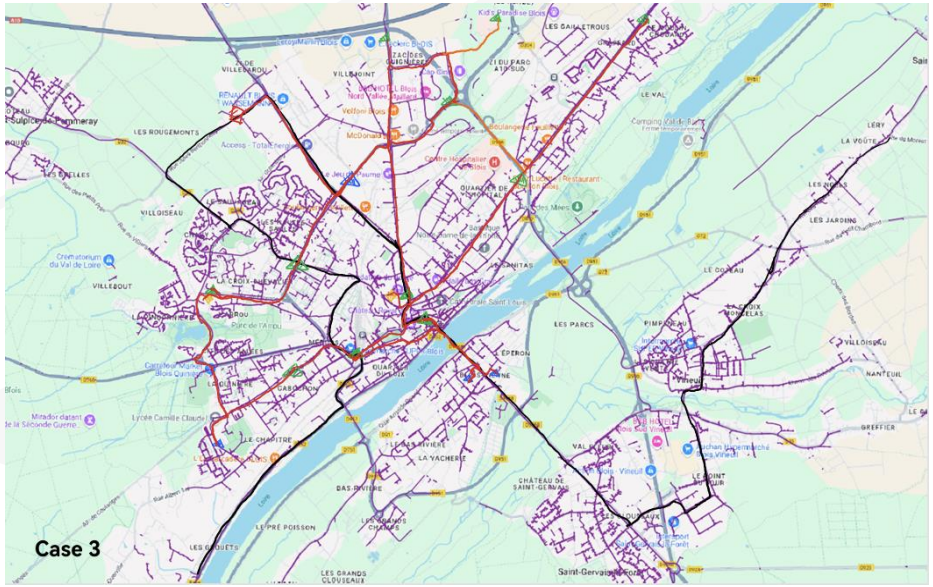
Advantages:

- Wider coverage than Scheme 1, better adaptability
- Relatively linear layout, easier for construction and maintenance with lower cost

Disadvantages:

- Lacks complete redundancy in certain sections

Scheme 3 - Comprehensive Redundant Network



Deployment Characteristics:

- Multi-path and multi-branch network for urban and suburban areas.
- Redundant paths interconnect key stations, maintaining network stability even during failures

Advantages:

- Widest coverage and strongest redundancy, preventing single-point failures
- Future-proof design, high reliability

Disadvantages:

- Longest path, highest cost
- Complex layout, challenging to manage

Methods and Design

Feature	Scheme 1	Scheme 2	Scheme 3
Complexity	Low	Moderate	High
Redundancy	Basic	Moderate	High
Cost	Moderate	Lowest	Highest
Deployment Speed	Fast	Moderate	Slow

Why Scheme 2 ?

- **Balanced Coverage**: Fully covers both urban and suburban areas without overcomplicating network
- **Cost Efficiency**: Moderate cost makes it feasible within the project's budget
- **Scalability**: Leaves room for future expansion or additional stations

03

Specific line and design costs

Rules Set up

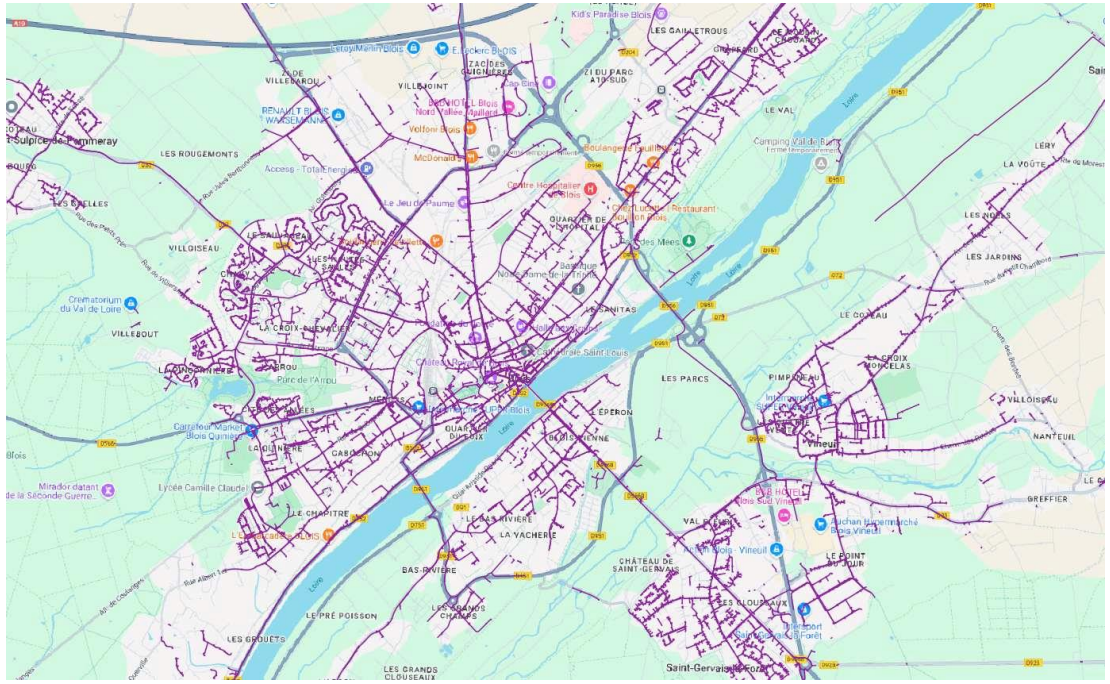
1. The cost of the optical fibre is set for **10€/m** in the cases of sharing the existing route, and **100€/m** if there is no existing

2. Put all the radio sites by the main road as possible as we can to reduce the extra cost of the material and avoid private property and public.

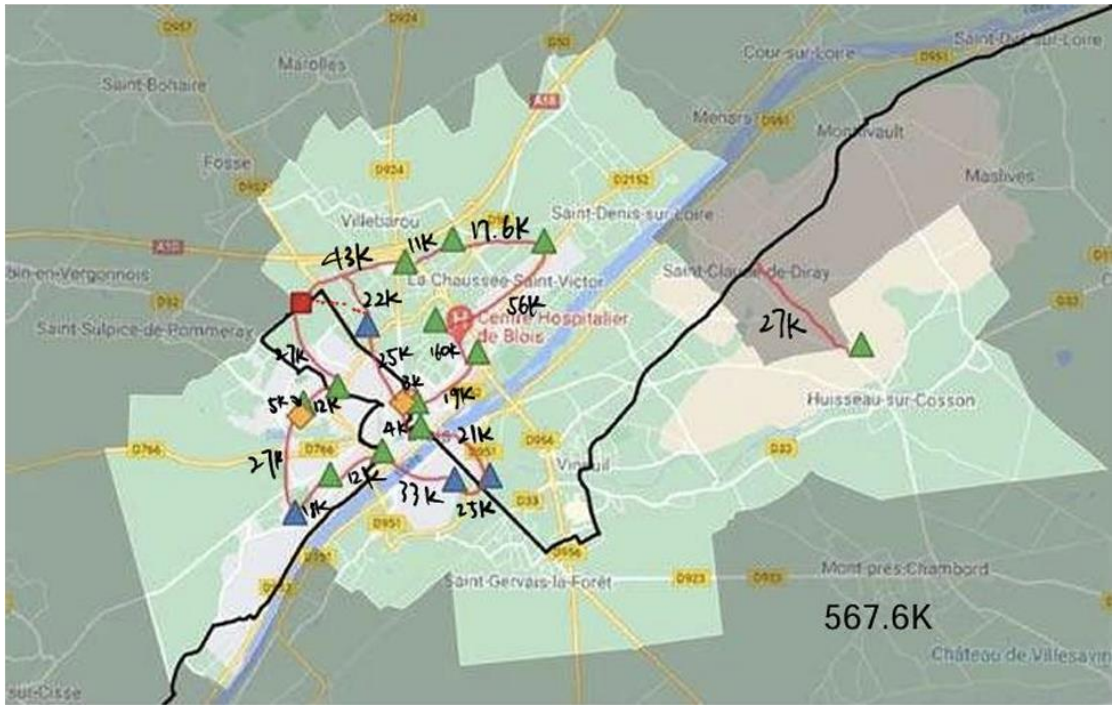
3. Keep all the line as straight as possible to reduce the difficulties of construction and maintenance.

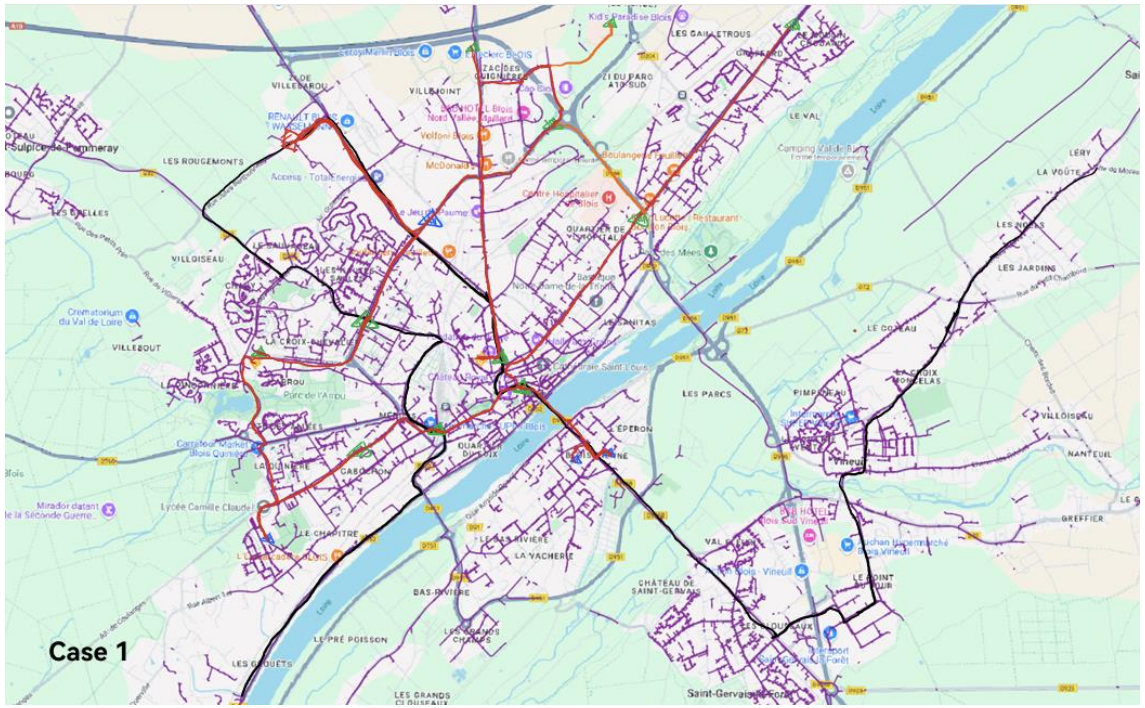
4. Reuse all the existing routes as much as possible to control the cost under a lower level.

5. The plan directly **rejected the use of radio**, which requires a monthly fee.



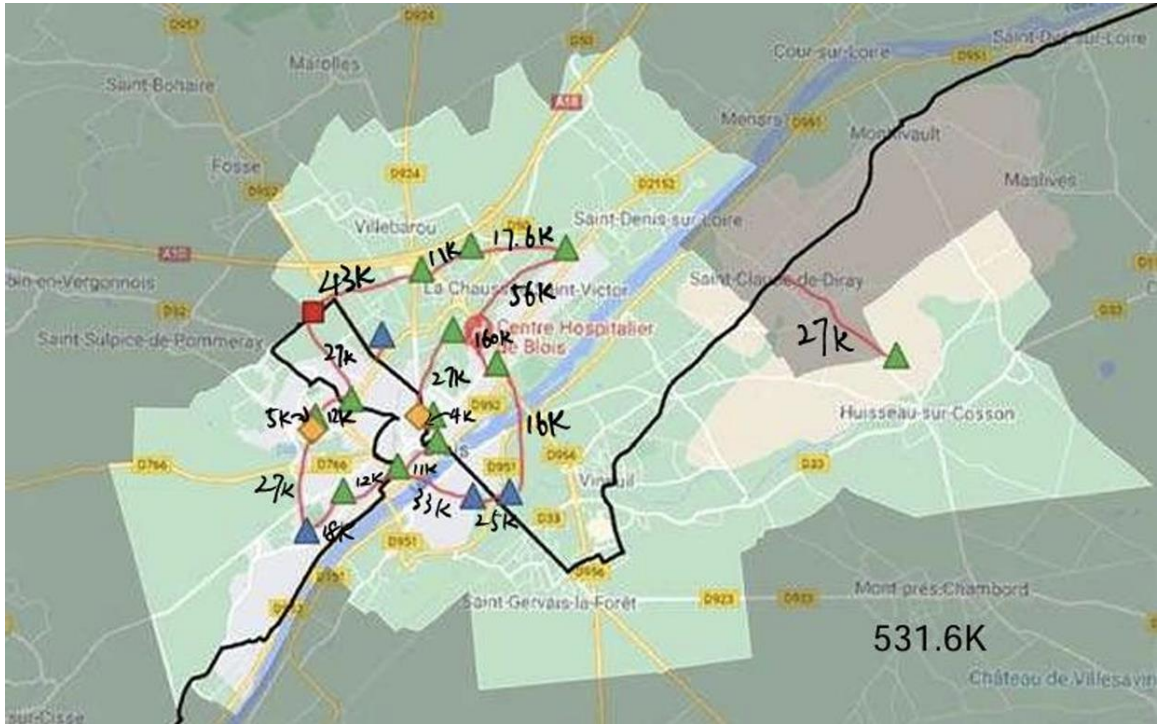
Design 1 - Compact and Efficient Loop

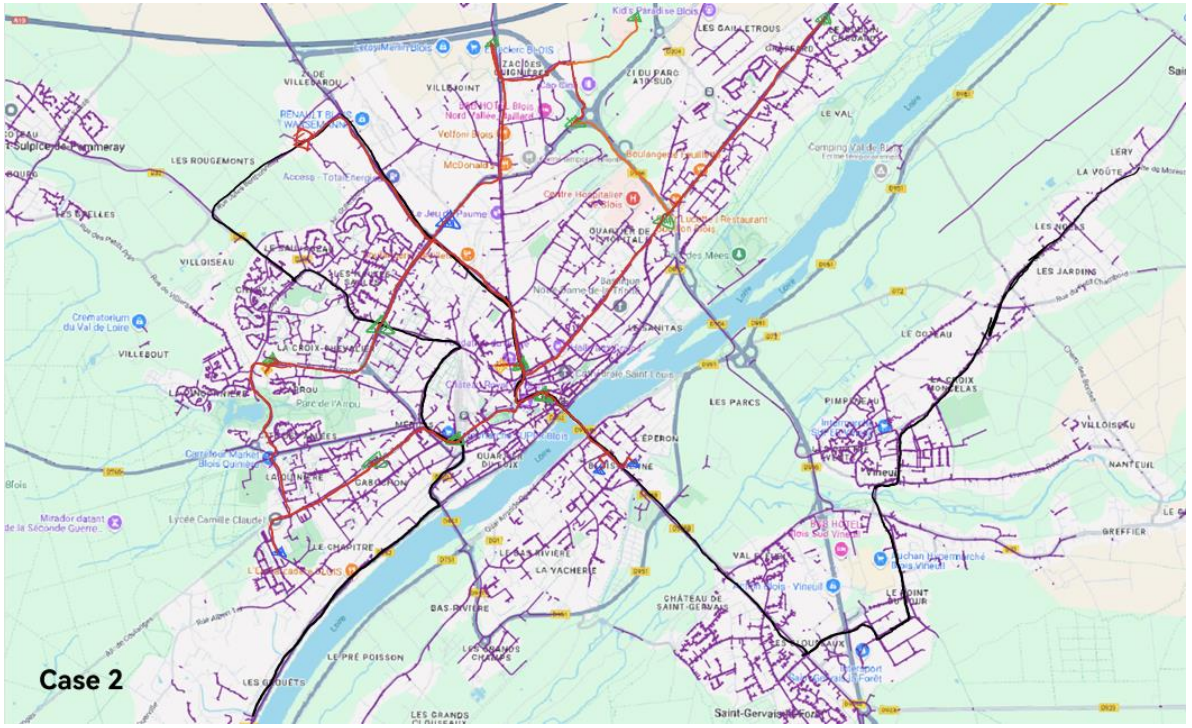




- The total cost of Design 1 is **567.6K**.
- The black line is the main bus connected only to the red base station in the city center area.
- For the isolated point, it's directly connected to the black line.

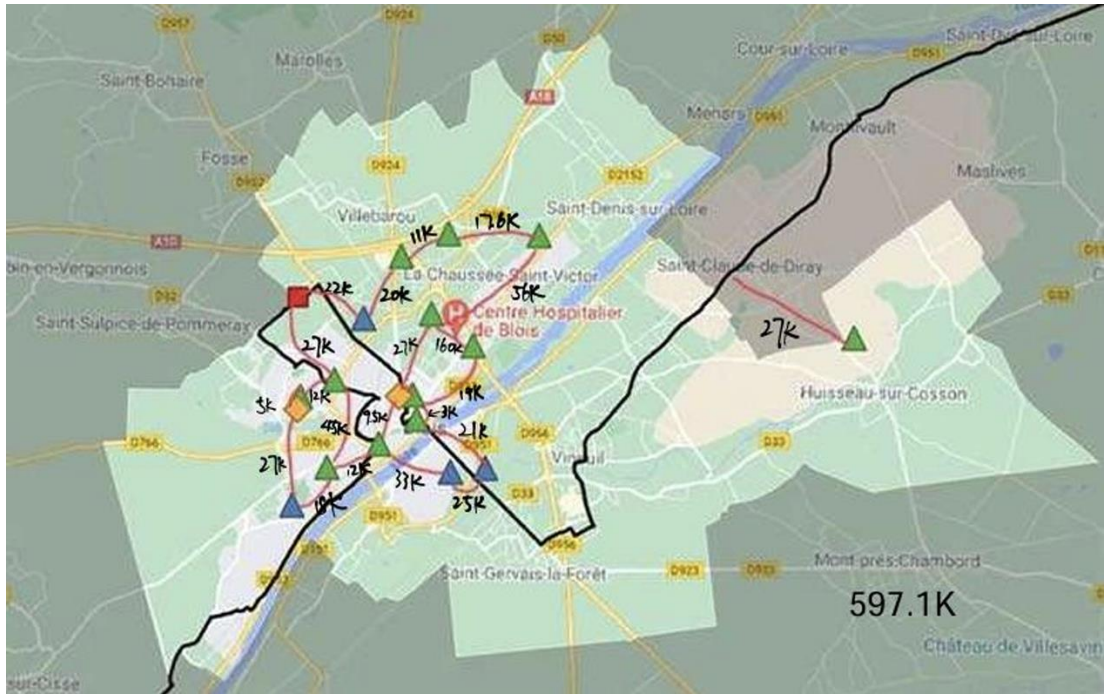
Design 2 - Balanced Expansion Loop

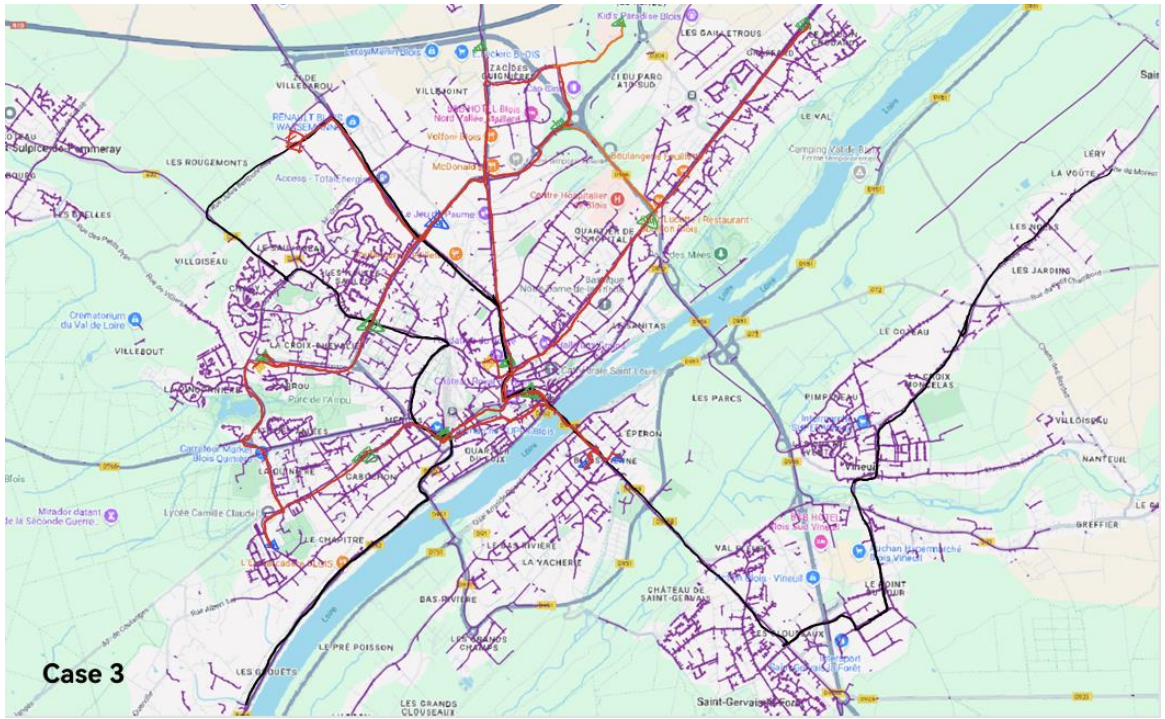




-The total cost of Design 2 is **531.6K**, which is the least expensive
-There are two radio stations connected to the main black bus, one is in the city center, and another is far away.
-Most of the deployment is similar to Design 1 in a practical situation.

Design 3 - Comprehensive Redundant Network





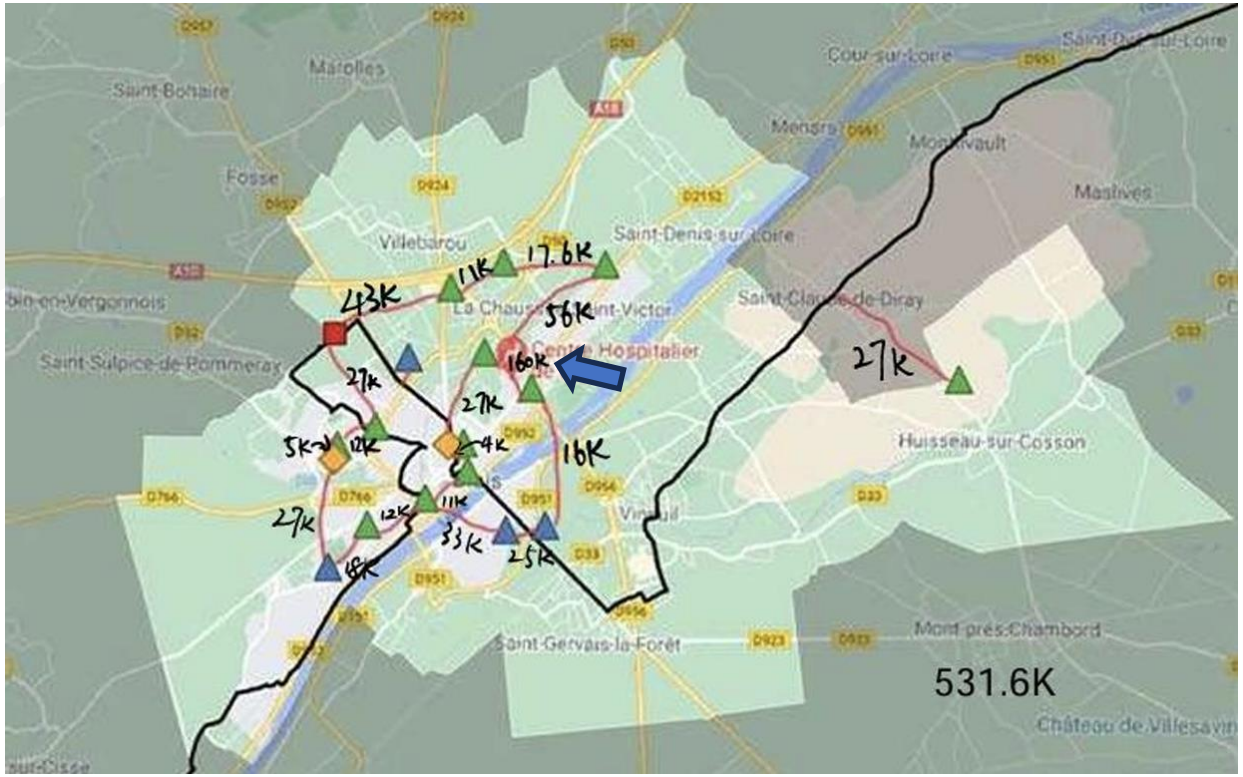
- The total cost of Design 3 is **597.1K**, which is the most expensive one.
- No station connected to the main bus except the non-city-center one.

Design challenge

1) The 3 cases are similar to each other when it comes to the practical situation on map.

2) The total cost between one and another is around 30K, and they all follow the Backhaul principles

3) Two of the stations are near to each other but there is no exist route for connection, so we have to spend more for construction. However, we can reuse this route for other radio stations



04 Conclusion

Conclusion

Key Findings:

1. Design Evaluation:

- **Design 1:** Compact and centralized, optimized for high-demand urban areas; minimizes fiber deployment and avoids major roads to reduce risks and costs.
- **Design 2:** Balanced solution; two-branch layout expands coverage to both urban and suburban areas, achieving the lowest cost.
- **Design 3:** Comprehensive coverage and redundancy, ensuring fail-safe operations with multiple alternative paths; suitable for critical infrastructure but at a higher cost.

2. Trade-Off Analysis:

Taking cost, stability, and coverage into comprehensive consideration,

Design 2 is optimal choice.