Turutõrkepiirkondade lairibataristu maksumuse uuring

Final Presentation

December 05th, 2024

Index

1. Introduction

Introduction - Perimeter of the study

Public funds are used to support the establishment of access networks in case of market failures. A market failure analysis was carried out in 2021 by the Estonian Statistical Office, using data on existing and planned connections, and data from the Population Register and the Employment Register

On that basis, the Ministry of Economic Affairs and Communications decided to conduct a study, the aim of which is to:

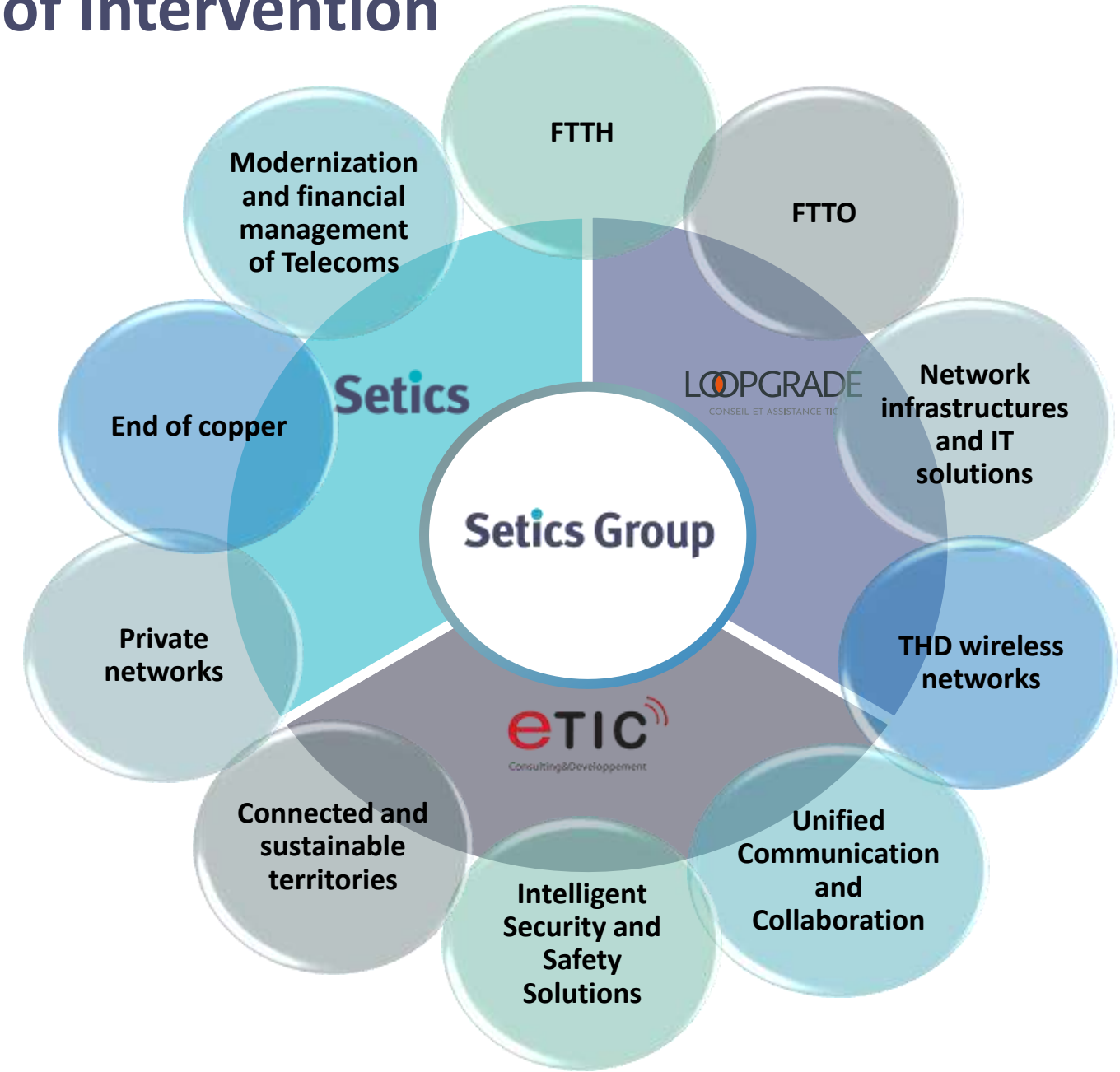
- Find out the cost of building broadband infrastructure with gigabit capacity using only FTTH technology in market failure areas
- Identify market failure areas for 5G FWA (5G Fixed Wireless Access)
- Find out the population units where it is more cost-effective to build gigabit capacity broadband infrastructure using FTTH technology and estimate its cost
- Identify population units where it is more cost-effective to build 5G FWA-based infrastructure and estimate its cost
- Find out the settlement units where it is possible to build connection with FTTH broadband infrastructure, at a cost of up to €5,000 and up to €3,000 per address
- Identify areas where it is not socio-economically justified to build gigabit capable broadband infrastructure and where residents/businesses should use satellite connections
- Create a public map application that would present results of this analysis, provide an overview of areas, and the cost of building FTTH and 5G FWA base infrastructure in them
- Make suggestions about the appropriate models of grants for the construction of broadband infrastructure in Estonian conditions

The study has been carried out on **129,797** addresses / **151,581** premises
Most of these addresses are in rural settlements, others in small settlements and small towns

2. Setics Presentation

Our Domains of Intervention

Setics
Setics Group



Setics services in Fiber Network Lifecyle

Setics

Global project management

Forecast demand planning
Context analysis (regulation, competition, geo-politic)
Risk assessment
Grants program allocation

High level Network Design
Capacity planning
Project management
Assistance with documentation & permits
Expertise/Advice

Detailed Network Design
Building Project management
Field survey control
Quality control
Network roll-out management
Cost/investment management

Audit
M&A, Due diligence
Economic valuation
Technical valuation
Synergies valuation

Revenue estimation
Strategic planning
Tender management
Cost estimation
Building area identification
Investment phasing

Detailed phasing
KPI definition
RFI/RFQ assistance
Sourcing process

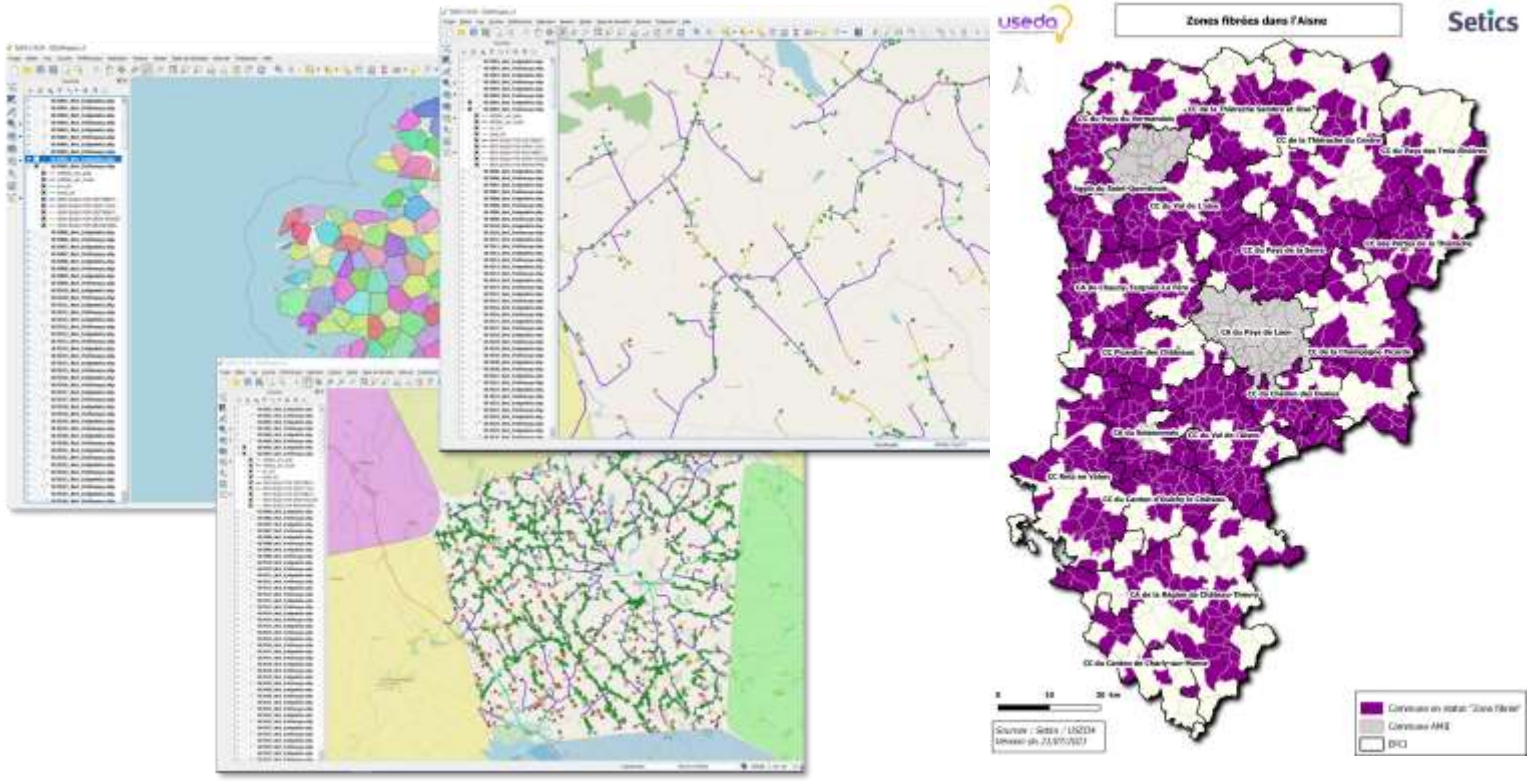
Cockpit management
KPI tracking
Capacity management
Quality Management
Physical operations management
Physical Network Inventory
Maintenance & repair
Sales & Marketing

- Setics Consulting Services
- Setics STTAR Phaser Tool, STTAR Advanced Designer, STTAR Planner
- Setics FiberState

Consulting services - Setics expertise

Setics

- Our clients :
  - Municipalities, local authorities
  - Operators
  - Publics bodies, regulation authorities
  - Investors, asset managers



- Our activities :
  - Strategic, technical and economic studies for communities, institutions and governments
  - Definition, monitoring and follow-up of public/private projects
  - Contracting assistance
  - Engineering assistance, including software supply and support : planning, project management, design, roll out control, final acceptance of equipment
  - Audit, assessment, technical and economic due diligence

Consulting services - Setics expertise

Setics

- Strategic decision-making roadmaps, in-depth analysis of technical, economic and regulatory issues
- Contracting and project management assistance of projects (public /private funding), progress and performance review, drawdown requests approvement, reports for grantors or lenders
- Engineering assistance combining consulting and software support (**Setics Sttar** and **FiberState**)
- Audit and assessments :
  - Design, build, operation, IT : assessment on processes, tools, organization, results and commitments, benchmarking
  - Contracting analysis : design, build, quality check and operation contracts, contract with the grantor, contractual interfaces
  - Business Plan analysis : CAPEX and OPEX analysis, benchmarking
- Asset valuation, remedial works cost valuation, quality audit

Setics Sttar: How It Works

Setics

Geographical Data

roads, ducts, HP, …

+

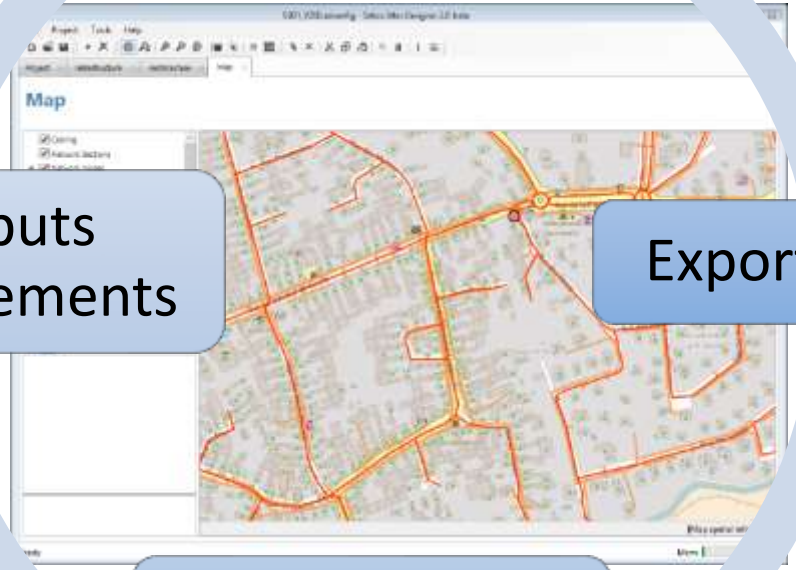
Engineering Rules
&
Equipments

Design Automation

Inputs Refinements

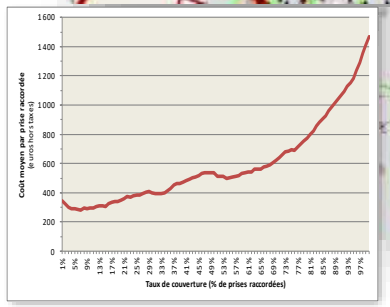
Exports

Fine Tuning



Detailed network layout

GIS/CAD data
Bill of materials
Analysis Reports



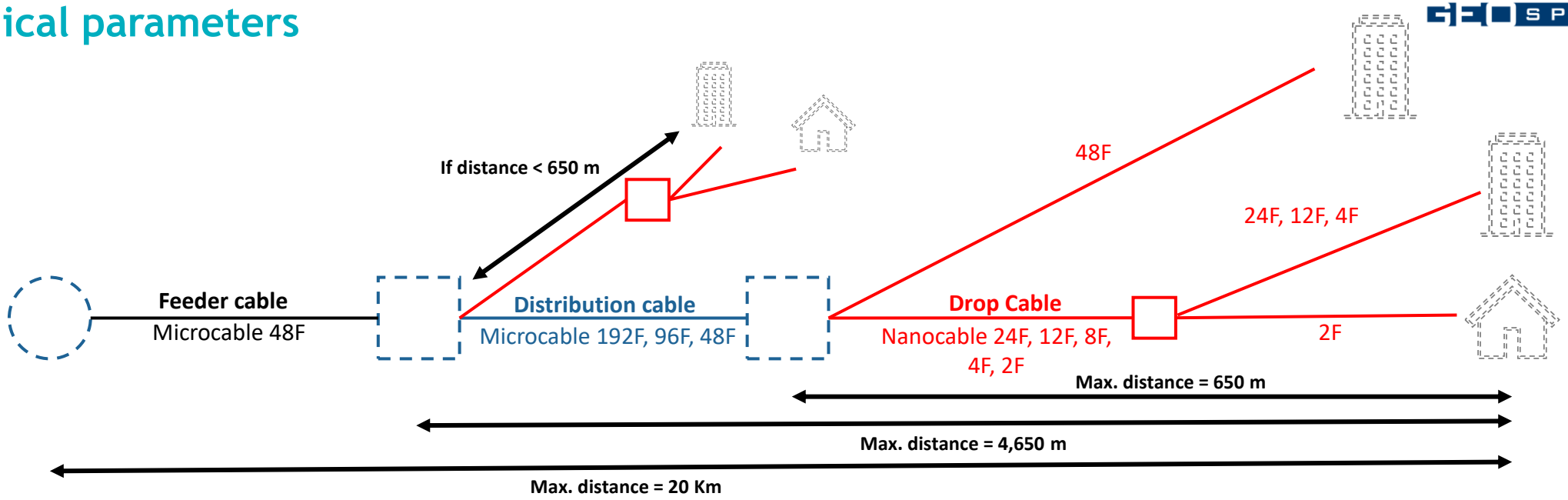
Setics References on tenders with public funding

Context	Clients	Size	Remarks
Plan France THD	Operators, Engineering companies	FTTH projects from 30 000 HP to 400 000HP	An aggregate amount of more than 2 000 000 HP Often 2 to 3 weeks to complete the job
Irish National Broadband Plan tender (Ireland)	ENET/NBI	FTTH/X for entire rural Ireland ~ 550 000 HP	We are able to re-run the model overnight to adapt for changes
Estonian tender for rural areas	Electricity company	150 000 HP rural + Tallinn and Tartu	Iterative process to scope the network according to budget
UK Local Regional tenders for enhancing broadband access	County Broadband	4 projects for aggregate amount of 60 000 HP	Very complex architectures
Stratum RFP (Northern Ireland)	Fibrus	80,000 + 155,000 in commercial area	Rural and semi-rural

3. Analysis of the cost of building gigabit broadband infrastructure in market failure areas using only FTTH technology

FTTH - Network architecture

Technical parameters



Elasa LP (BB Splice)

- Elasa PoP
- New manholes
- Existing manholes, splices or Cabinets
- Max. 3,000 premises

Peajaotuskapp (PJK / FCP[1])

- Cabinet capacity: 48, 144 or 288 terminals
- If the FCP <--> address distance less than 650m, it can bypass the FCP

Vahejaotuskapp (VJK / FDP[2])

- Cabinet capacity: 120 terminals
- Midspan joints enabled on FDPs

Piiritluspunkt (Demarcation Point)

- 1 per address

Addresses (LP)

- SDU - single building, a two-fiber cable is planned, from which one fiber will be connected
- MDU - apartment building, planned as follows:
  - 2 apartments: 4F
  - 4-11 apartments: 12F
  - 12-18 apartments: 24F
  - 19-37 apartments: 48F

- Fully underground FTTH network
- Drop network: passive optical network from FDP to house exterior.

[1] FCP = Fiber Concentration Point
[2] FDP = Fiber Distribution Point

FTTH Global Modelling

Cost model

Point objects	Unit	Material price	Labor cost	Total
Splicing	pc	0,12	9,00	9,12
FCP48-PJK48 (max 48 customers)-Includes 3 splitters and an operator panel	pc	450,00	600,00	1050,00
FCP144-PJK144 (max 144 customers)-Includes 3 splitters and an operator panel	pc	650,00	600,00	1250,00
FCP288-PJK 288 (max 288 customers)-Includes 3 splitters and an operator panel	pc	1450,00	1500,00	2950,00
FCP - panel (max 12pc/FCP)	pc	95,00	125,00	220,00
FDP24-VJK24 – FDP with 1 extension (connecting 24 fibers)	pc			985,00
FDP48-VJK48 – FDP with 2 extensions (connecting 48 fibers)	pc			1370,00
FDP72-VJK72 – FDP with 3 extensions (connecting 72 fibers)	pc			1755,00
FDP96-VJK96 – FDP with 4 extensions (connecting 96 fibers)	pc			2140,00
FDP120-VJK120 – FDP with 5 extensions (connecting 120 fibers)	pc			2525,00
Connecting FCP to an existing extension	Pc		750,00	750,00

Microducts	Unit	Material price	Labor cost	Total
DB 1x7/3,5+Cu	m	0,45	17,00 (1)	17,45
DB 4x7/3,5+Cu	m	0,90	17,00	17,90
DB 7x7/3,5+Cu	m	1,75	17,00	18,75
DB 12x7/3,5+Cu	m	1,45	17,00	18,45
DB 19x7/3,5+Cu	m	5,30	17,00	22,30
DB 24x7/3,5+Cu	m	7,50	17,00	24,50
DB 9x7/3,5+1x14/10+Cu	m	1,90	17,00	18,90
DB 12x7/3,5+2x14/10+Cu	m	2,40	17,00	19,40
DB 12x7/3,5+1x14/10+Cu	m	2,10	17,00	19,10
DB 16x7/3,5+3x14/10+Cu	m	3,10	17,00	20,10
DB 1x14/10+Cu	m	0,70	17,00	17,70
DB 4x14/10+Cu	m	1,80	17,00	18,80
DB 7x14/10+Cu	m	2,90	17,00	19,90

(1) 17 €/m : digging cost
(2) 0,80 €/m : blowing the cable into the pipe

Micro-cable, 10mm micro-puffed cable	Unit	Material price	Labor cost	Total
48xG652D	m	0,80	0,80 (2)	1,60
96xG652D	m	1,65	0,80	2,45
192xG652D	m	2,85	0,80	3,65

Customer connection 3.5mm tube blown nanocables	Unit	Material price	Labor cost	Total
Nano 2F	m	0,20		0,20
Nano 4F	m	0,25		0,25
Nano 8F	m	0,30		0,30
Nano 12F	m	0,38		0,38
Nano 24F	m	0,65		0,65
Blowing the customer cable into the pipe	pc		185,00	185,00

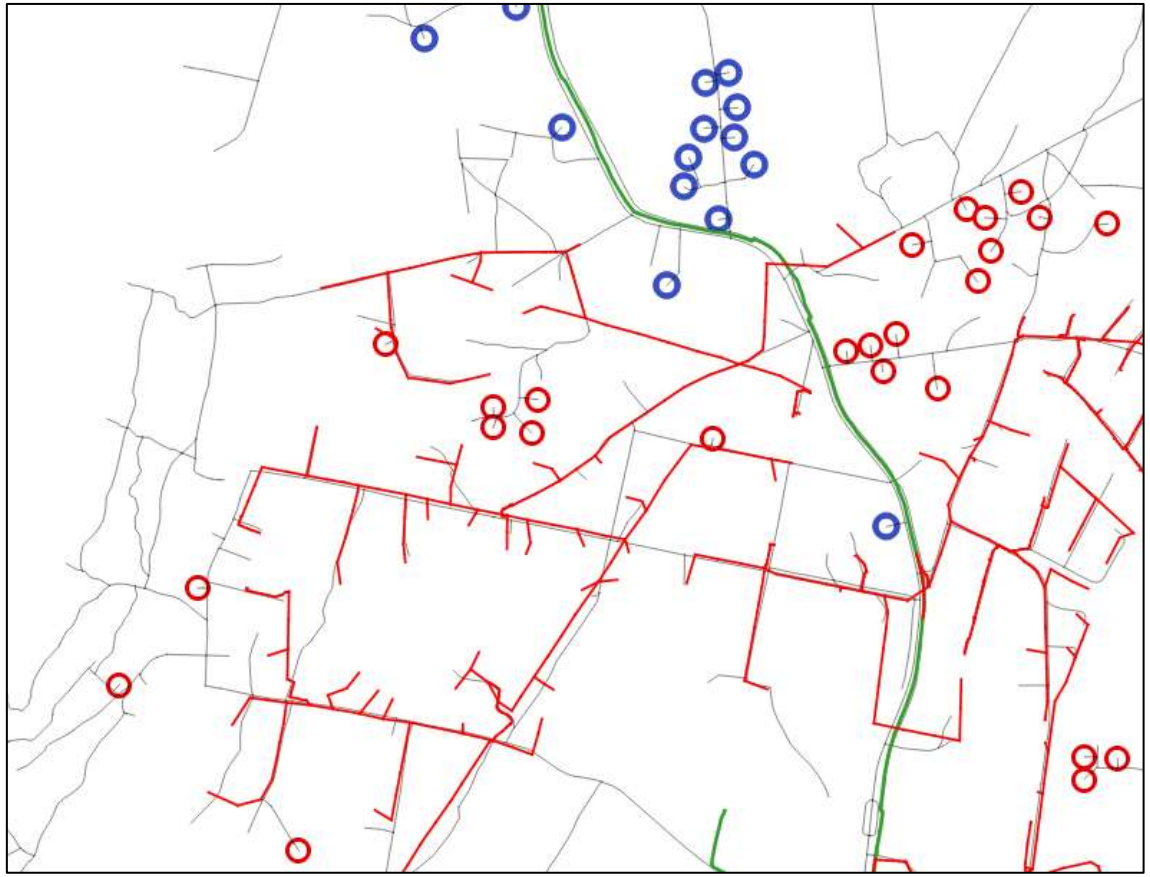
Terminal box and related	Unit	Material price	Labor cost	Total
LP (2xSC-APC) End point in the building	pc	14,00	100,00	114,00
LP (4xSC-APC) End point in the building	pc	20,00	110,00	130,00
LP (12xSC-APC) End point in the building	Pc	40,00	165,00	205,00
LP (24xSC-APC) End point in the building	pc	135,00	165,00	300,00

Remarks on costs used for global modelling:

- Reusing Elasa duct: 1€/m
- BB Access point average cost: 1,000€ (including OLT and FCP installation)

FTTH Global Modelling

Sites connected to the access network



Sites served by the access network

Sites not served by the access network

Access network

Elasa BB

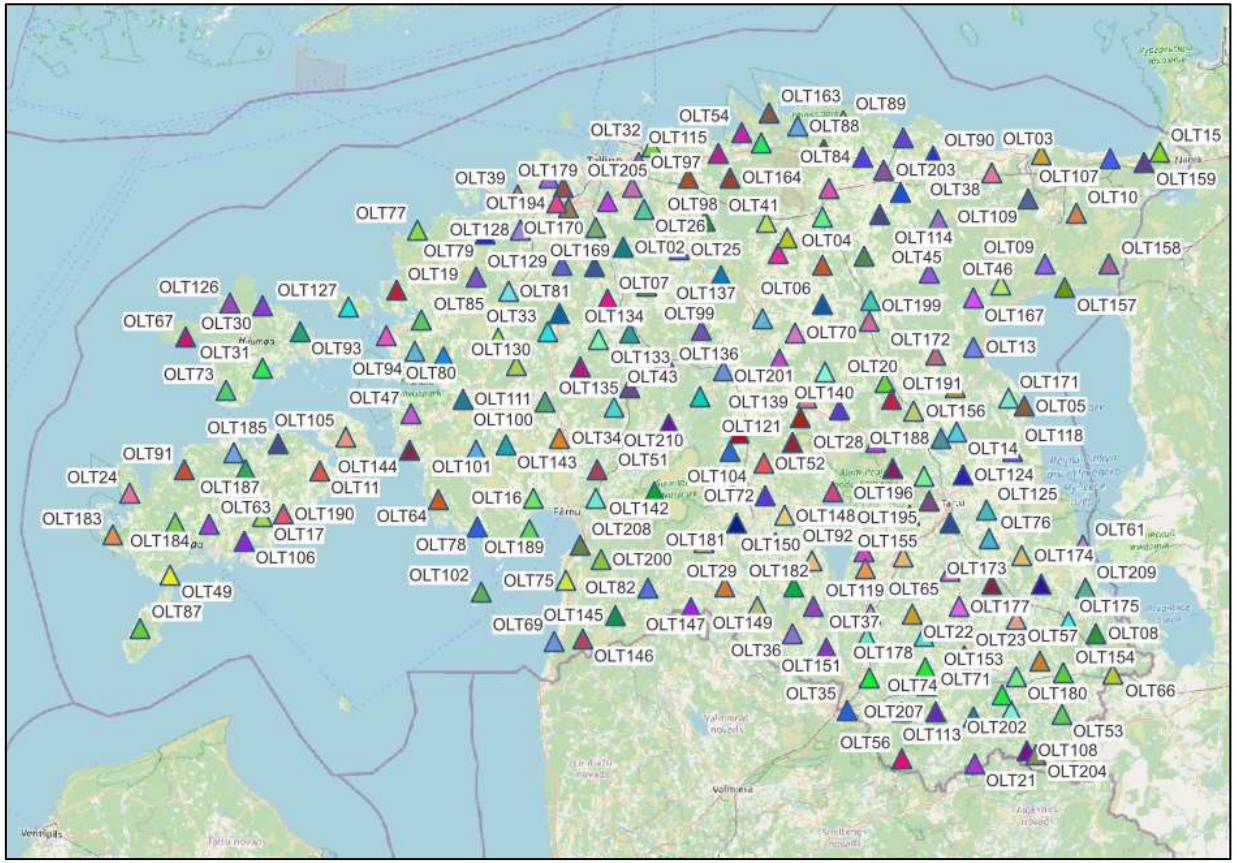
Roads/Parcels

Aim: Remove premises connected to *access network* within threshold of 850 meters

→ 8,201 (5.41%) premises - 6,268 (4.82%) addresses connected to the access network and **removed from the global modelling perimeter**

FTTH Global Modelling

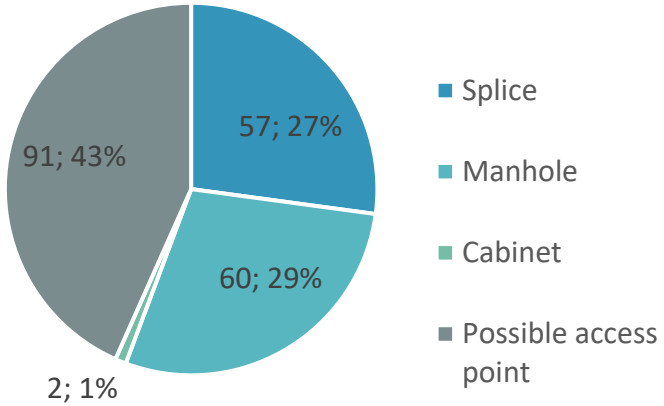
OLT zoning



Typology

- OLT – premise distance:
  - Maximum: 20 km (0.46% > 20 km)
  - Average: 9.87 km
- OLT size:
  - Maximum: 3k premises/OLT
  - Average: 680 premises/OLT
- Total: 210 OLT

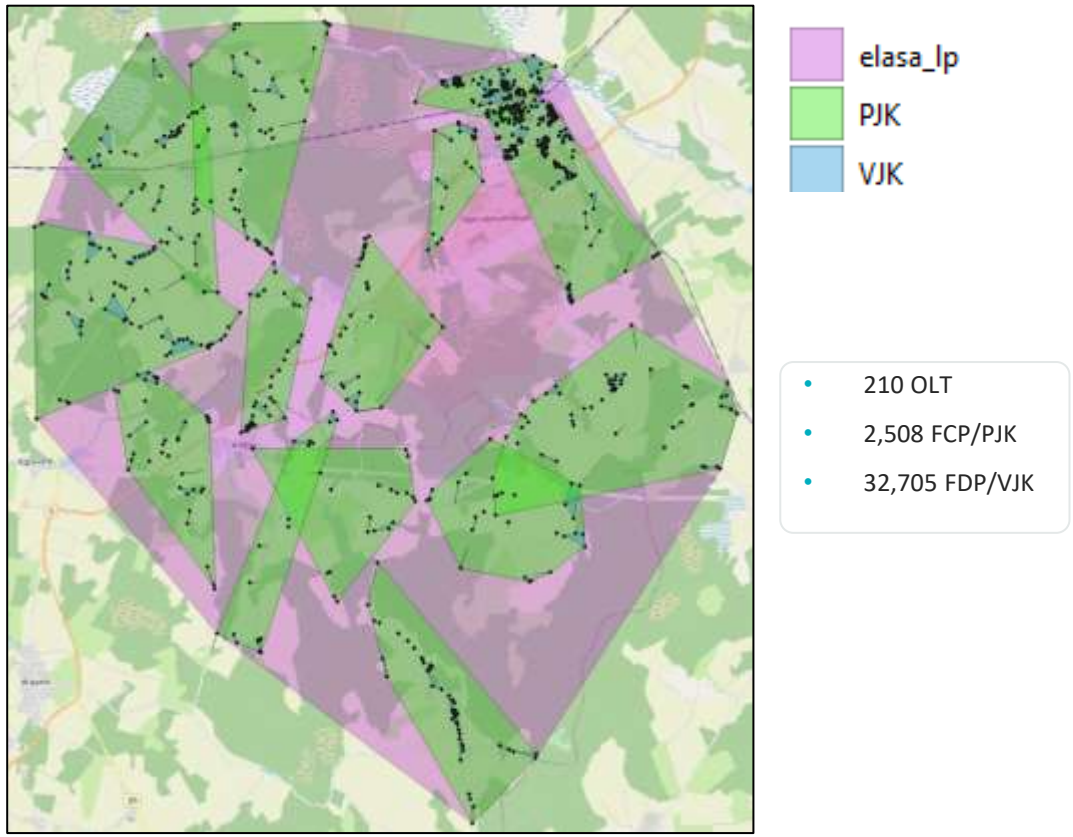
BB access point type



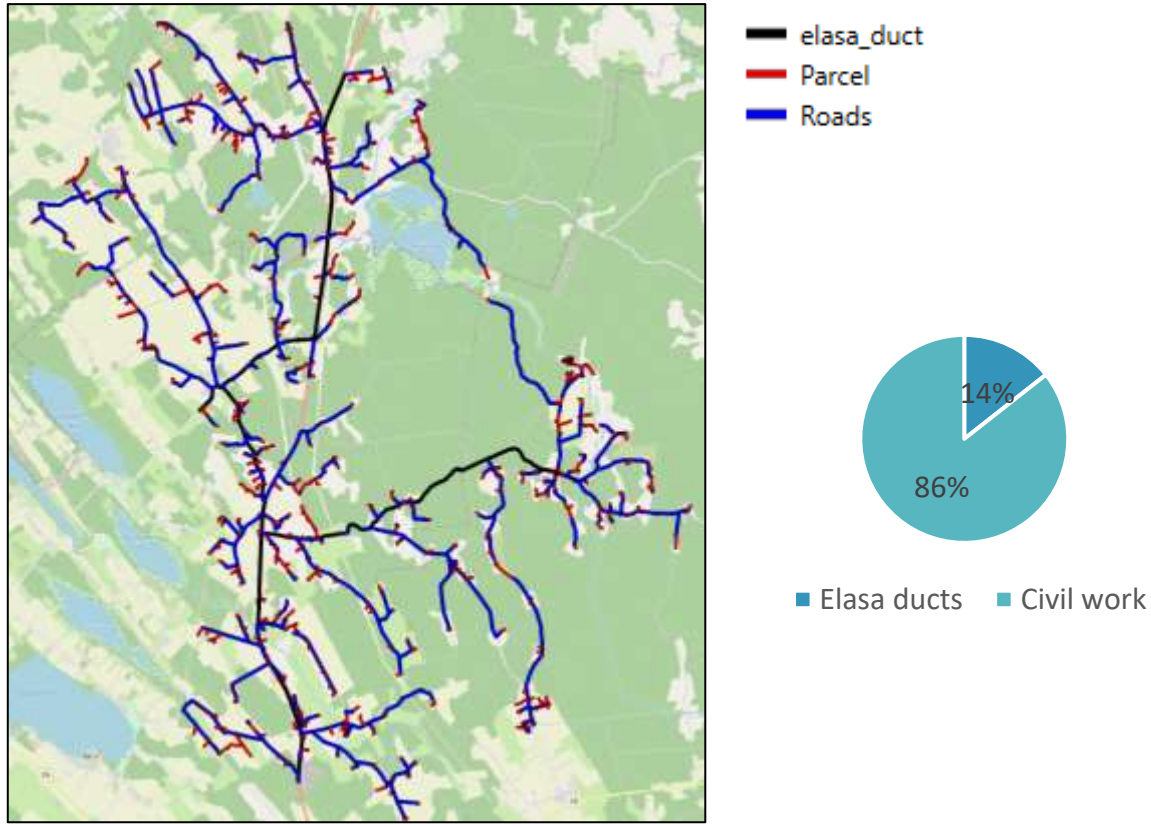
FTTH Global Modelling

Results - examples of maps

Clusters – example OLT01



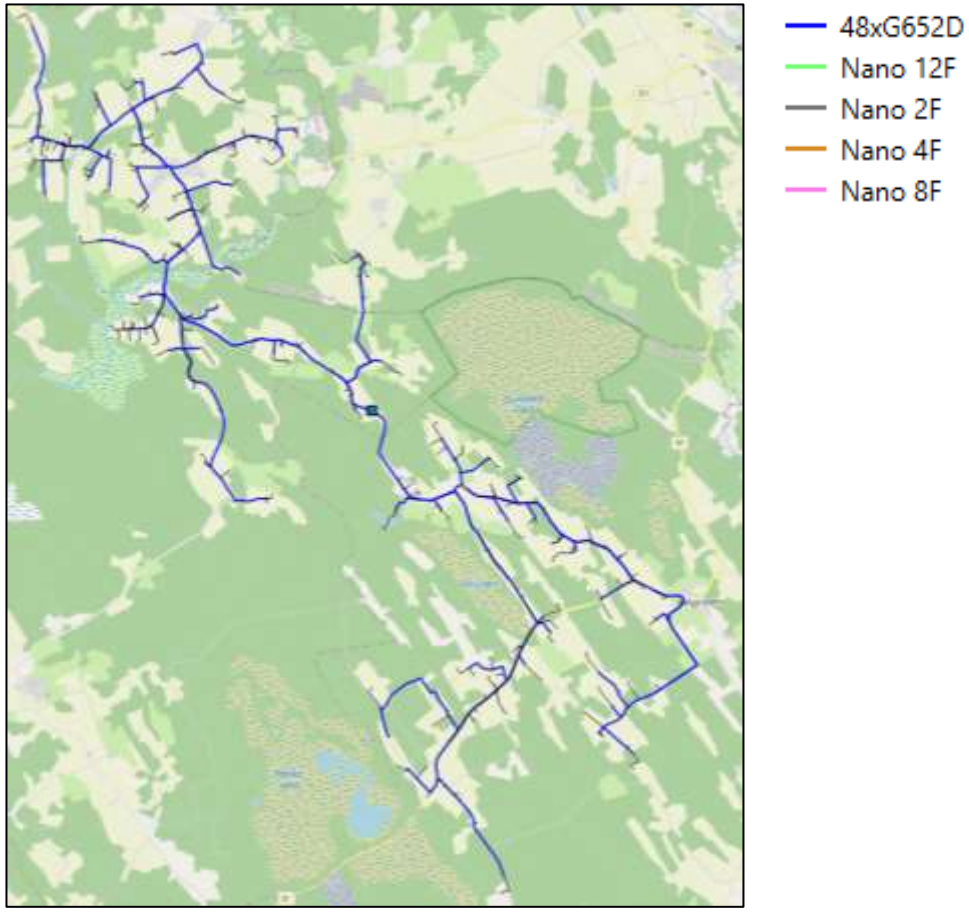
Pathways – example OLT14



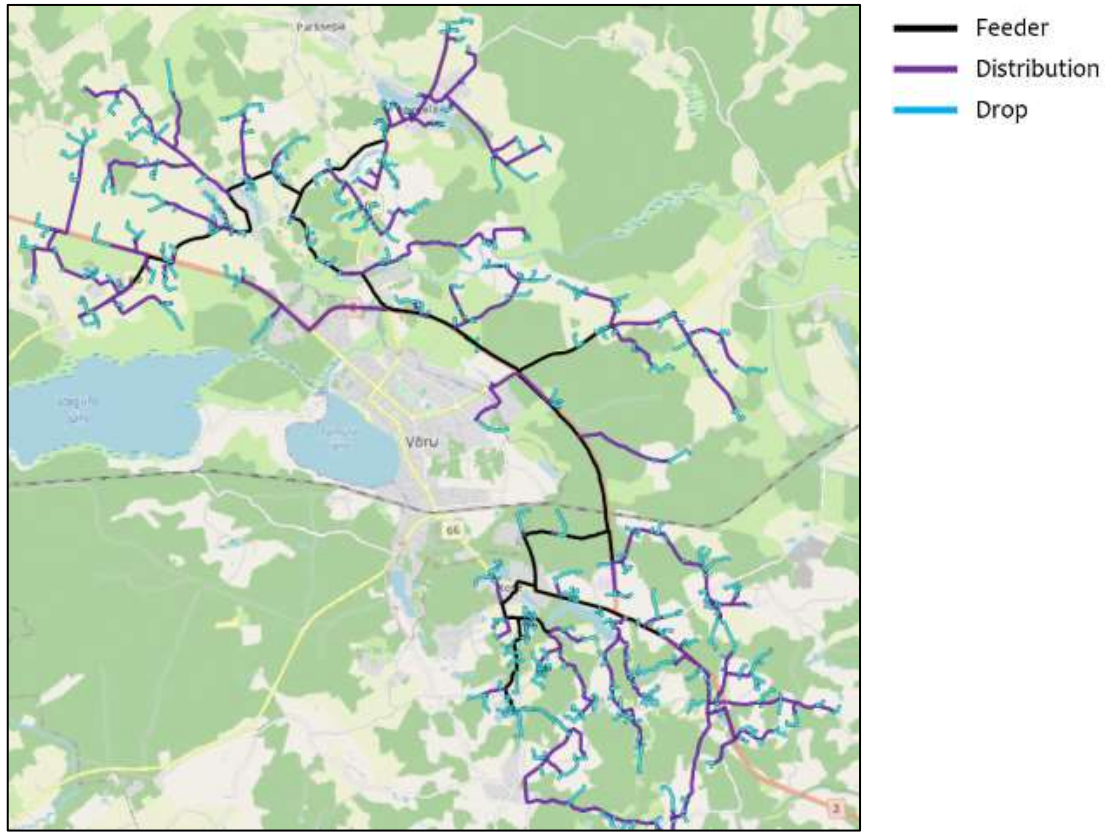
FTTH Global Modelling

Results - examples of maps

Cables – example OLT121



Ducts – example OLT180



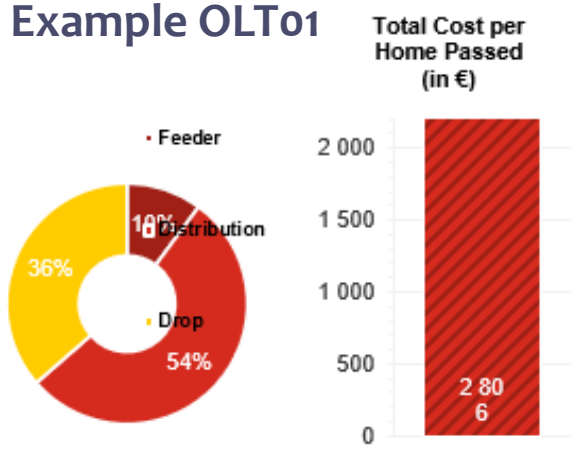
FTTH Global Modelling

Cost per OLT

Network Implementation Costs			
Feeder + Distribution	3 036 171 €	i.e.	2 806 € per HP
All drops	1 738 224 €	i.e.	1 606 € per HP

	Feeder	Distribution	Drop
Nodes - Infrastructure Setup	15 000	144 000	
Nodes - Equipment	23 898	282 014	
Endpoints - Infrastructure Setup			98 368
Endpoints - Equipment			0
Cabling	41 914	133 379	48 345
Ducts	106 081	168 864	48 555
Linear Infrastructure	297 059	1 823 962	1 542 956
Total	**483 952**	**2 552 219**	**1 738 224**

Example OLT01



Key Quantities	Input	Design Output			Total	Per HP
Level 1 Nodes	1	1	100,0%	Cables (m)	5 870 428	5 426
Level 2 Nodes	14	14	100,0%	Splice Closures	147	0,14
Network Terminations (HP)	1 082	1 082	100,0%	Splices	7 892	7,29
Linear Infrastructure (m)	1 133 996	250 741	22,1%			

Key Technical Indicators	Minimum	Median	Maximum	Average		
HP per Node at Level 1	1082	1082,0	1082	1082,0	Total Fibers in Cables	180 765 km (fibers)
HP per Node at Level 2	19	48,5	279	77,3	Used / Spare Fiber Ratio	41% / 59%
HP per Endpoint	1	1,0	12	1,3		
Level 1 to HP Distance (m)	2017	14702,6	19379	13482,5		

TOTAL	4 774 395,10

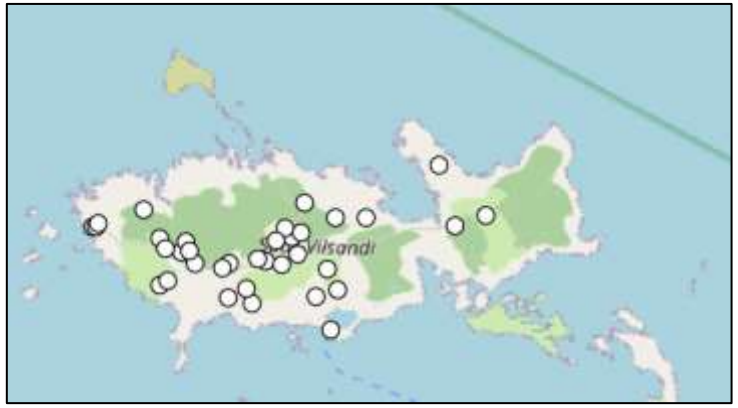
FTTH Global Modelling

Project remarks

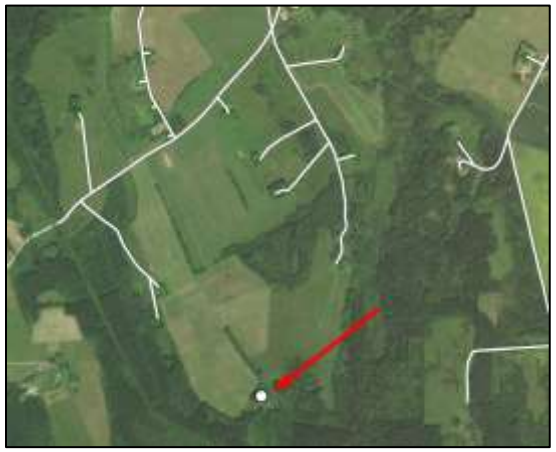
Address Points (excluding the ones served by the access network)

- Total number of served address points: 122,988 (99.56%) - 142,825 premises (99.61%)
- Total number of unserved address points*: 541 (0.44%) - 557 premises (0.39%)

* *Not connected due to no available infrastructure, too far from existing infrastructure, etc.*



Addresses on an island



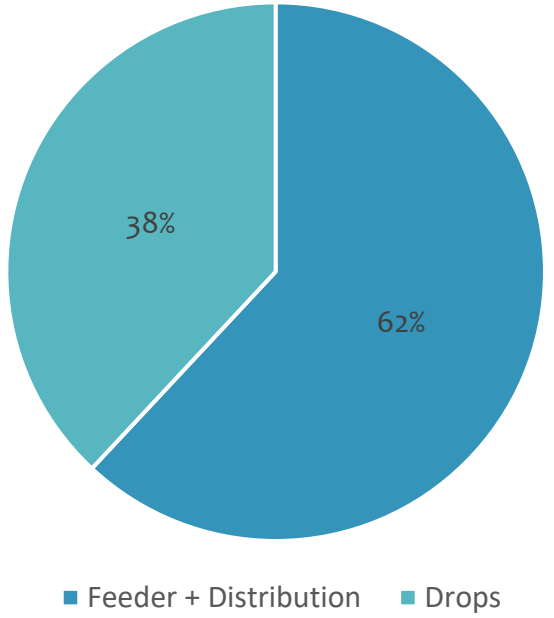
No available infrastructure

FTTH Global Modelling

Total cost

	Total cost	Average cost per premise(1)	Average cost per address(2)
Feeder + Distribution	513 M€	3,591€	4,171€
Drops	315 M€	2,204€	2,560€
TOTAL	**828 M€**	**5,795€**	**6,730€**

(1) *142,825 premises*
(2) *122,990 addresses*



4. APTICA Presentation

APTICA

aptica Setics

GEO SPATIAL

Telecommunications Company Specialised In Wireless Technologies

Mission, vision & value

SPECIALIZATION, INNOVATION, TECHNOLOGY, INDEPENDENCE + PERSONALIZED CUSTOMER COMMITMENT

Supporting our customers with efficient and independent management in their processes of network deployment, improvement and digital transformation.	Taking as one´s own the challenges and concerns of our customers through the commitment and trust of our expert professional team.	Creating value with integral innovation solutions to customer projects and business prospects through our Telecommunication knowledge and Information and Communication Technology (ICT) know how.

Services

Wireless Networks Solutions

- SW tools for network design, planning and optimization
- Coverage, simulations and feasibility studies
- Medium and High Resolution World Mapping (3D)

Professional Services: Insite y Onsite

- Specialist consultants onsite
- Highly qualified in-house back-office team
- Offering of ad-hoc services in outsourcing mode

Engineering and Project Management

- Organization and coordination
- Integrated Project Management
- Integration and configuration
- Measurements and certifications
- Models PMI, ITIL...

Strategic Technology Consulting

- Strategic Planning
- Integral Advice
- Standards and regulations
- Technical and economical feasibility
- Value Proposition

PRODUCTS

Advanced and complete range of solutions for network planning and deployment using wireless technology.

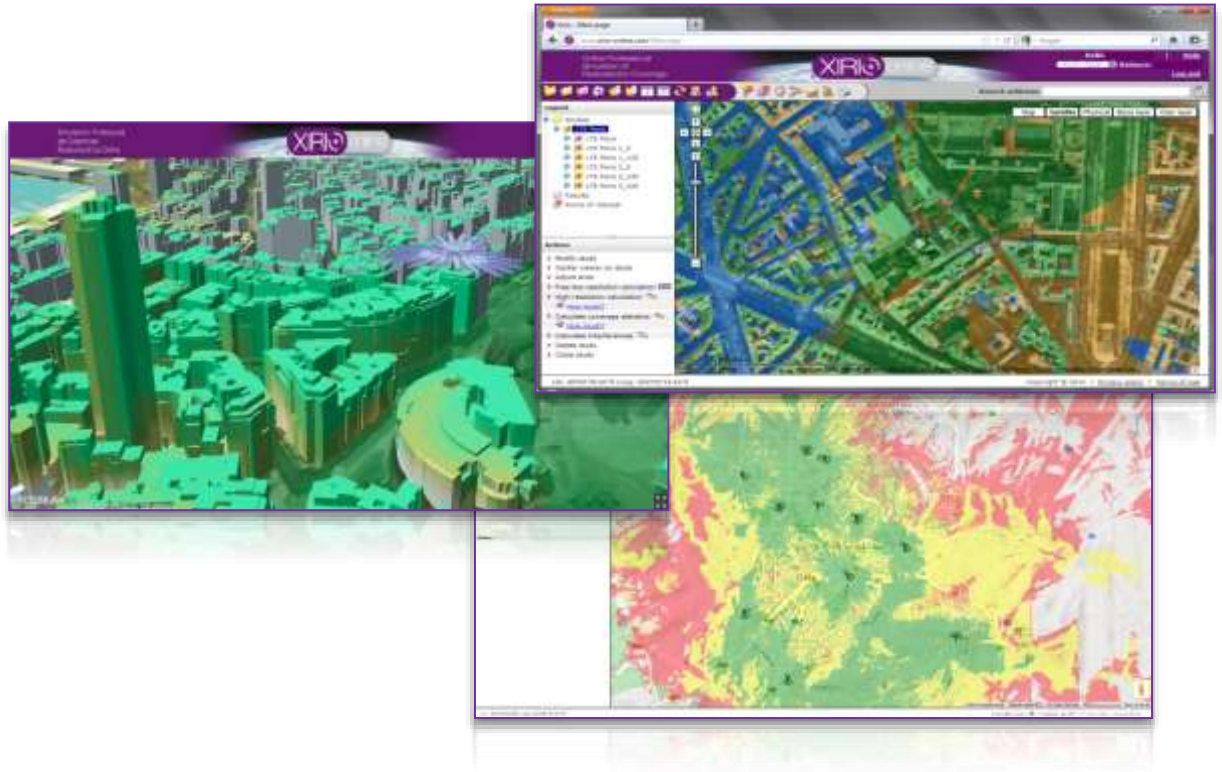
SERVICES

Professional Engineering Consulting Services with Project Management in the area of Information and Communication Technology (ICT).

XIRIO ONLINE

XIRIO ONLINE Radio Planning Tool

- XIRIO ONLINE is a professional online solution that enables efficient management in planning, design and optimization processes of wireless telecommunications networks.



PLANNINGTOOL: Radio Planning Tool
SHAREPLACE: Access to shared simulations with third parties

www.xirio-online.com

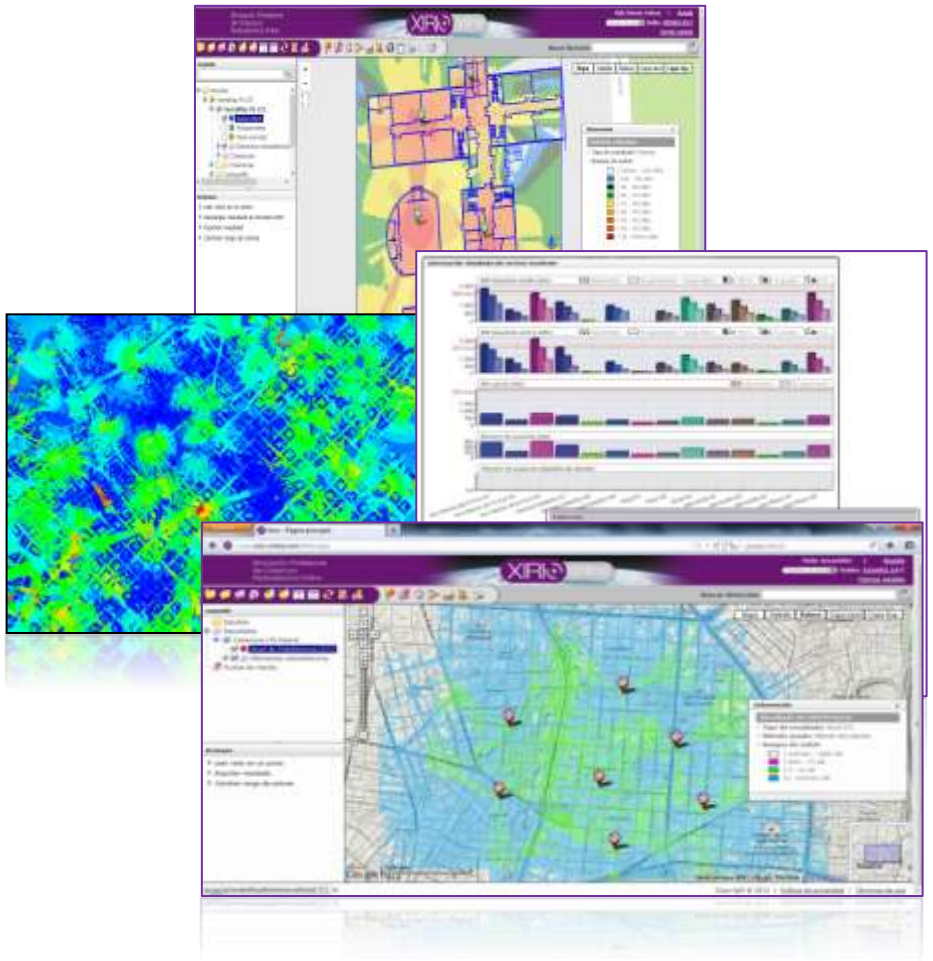
- Cloud or intranet mode
- High resolution cartography (3D) included
- Maximum accuracy and speed in calculations
- Access, transport and indoor design plus site management in a single platform
- Full integration with operator systems and data sources
- Latest wireless technologies:
  - **Mobile:** 5G, 4G, etc.
  - **MW:** Point-to-point, Point-to-Multipoint, etc.
  - **Corporate:** 5G Industry Automation, etc.
  - **IoT:** NB-IoT, 5G, M2M, SIGFOX, LORA, etc.
  - **PPDR:** TETRA, LTE, DMR, etc.
  - **Broadband Access:** FWA, LTE-TD, WIMAX, WIFI 6, etc.
  - **Broadcast:** DVB, ISDB, ATSC, DAB, FM, DRM, etc.

XIRIO ONLINE

XIRIO ONLINE Access Network Module Capabilities

- XIRIO ONLINE ACCESS Network module provides the simulation and planning of wireless networks ensuring coverage and QoS in the most simple, accurate and efficient way.

  - Complete network design: Macro, Micro y Pico Cells
  - Multi-technology: Mobile, PPDR, Broadband, IoT, Broadcast and Aeronautical Navigation
  - Combined Outdoor/Indoor Coverage
  - Powerful tool for network optimal design. Based on genetic algorithm and develop by APTICA's R&D department
  - Coverage, interferences and capacity simulations
  - Users distribution. Traffic demand models
  - Automatic Network Optimization
  - High resolution urban and rural models. SYNAPSE
  - Multi-RAN and concurrent technologies planning
  - SmallCell and DAS solutions



APTICA References

XIRIO ONLINE Access Network Module Capabilities

REFERENCES	CLIENT	DESCRIPTION
Telco Operator Projects	MASORANGE, Telefónica, vodafone	Operator mobile network calculation services and simulation studies for all technologies: 2G, 3G, 4G, 4G+, 5G
4G and 5G Mobile Communications Projects	vodafone	Homologation of 4G/5G functionalities in the operator's network
	AMERICAN TOWER	• Strategic analysis for the provision of services in rural areas within the 'Único-5G redes' programme. • Development of strategies for the orderly deployment of 5G small cells • Training on 5G technology
	VANTAGE TOWERS	Technical and statistical study of 5G sites
	MINISTERIO DE ASUNTOS ECONÓMICOS Y TRANSFORMACIÓN DIGITAL	Validation of 2G/3G/4G/5G operator technical projects for the Secretary of State for Telecommunications and Digital Infrastructure (SETID) of the Ministry of Economic Affairs and Digital Transformation.
	CDTI @CDTIoficial	• Research project on immersive and sensory technologies for collaborative industrial robot inspection environments (INMERBOT) using 5G technology. • Project on dynamic inductive charging with hydrogen for electric vehicles based on renewable energy sources over broadband mobile communications.

APTICA References

XIRIO ONLINE Access Network Module Capabilities

REFERENCES	CLIENT	DESCRIPTION
4G and 5G Mobile Communications Projects	Castilla-La Mancha	• Study, analysis and evaluation of 5G pilot development strategies in the Autonomous Community of Castilla la Mancha. Preparation and coordination of the project awarded in the 2nd Call for 5G RED.ES 5G Pilots. • Diagnosis and discovery of needs and subsequent design of 5G ecosystem use cases within the Action Plan of the Smart Territory Strategic Framework for Castilla-La Mancha.
	aena	Analysis and studies for the development and implementation of 4G/5G mobile services in airport environments.
	Comunidad de Madrid	• Supply of a 5G didactic model at the National Reference Centre for IT Development and Communications in Getafe. • Course on the installation, commissioning and integration of 5G network nodes.
	IBERDROLA	• Engineering services for a private Broad Band Mobile network • 4G and 5G mobile communications training course

	REPSOL	• Trunking LTE pilot at A Coruña refinery
		• Support for the implementation of Single Agenda projects for 5G projects.
		  • 5G use cases at Repsol
		  • Strengthening the telecommunications architecture of the service stations
		• Technological and strategic support for the Reference Architecture Broadband Mobile Services project.
		  • Development of a framework architecture and a reference architecture for Broad Band Mobile solutions
		  • Definition of architectural patterns for each use case of interest for different business areas of REPSOL.
		• Consulting and support services for the definition of the Broad Band Mobile connectivity services catalogue and support for the creation of the Broad Band Mobile platform.

5. Analysis of the cost of building gigabit broadband infrastructure in market failure areas using only 5G FWA technology

5G FWA Global Modelling

Project mission

5G Fixed Wireless Access

- **5G Fixed Wireless Access (5G FWA)**: Wireless technology that uses 5G cellular networks to deliver broadband speed connectivity. It is especially useful in areas where deploying wired infrastructure is challenging or expensive.
- 5G networks offer a open and flexible architecture that adapts to the conditions of each scenario and can be reprogrammed as services are required.

5G FWA Estonian Project

- The cost assumptions for 5G FWA technology require a speed of 1Gbps to be guaranteed to each user within a 4 km radius of the site.

Providing a 5G FWA service with 1 Gbps capacity per user requires a high capacity frequency band, such as mmWave frequency band (26 GHz).

5G 26 GHz Deployment in Europe[1]

- 5G 26 GHz (5G millimetre or mmWave), complementing the use of mid-band spectrum, will be used to:
  - deliver 5G for eMBB (enhance Mobile BroadBand) use in high-capacity areas.
  - deliver 5G FWA services to homes and businesses.
  - support industrial use cases.
- Significant economic benefit based eMBB network deployment:
  - For each usage examined such as smart factories and connected vehicles, the estimated benefit is between 5 and 20 times greater than the estimated cost.
  - Aggregated across a variety of use cases. the deployment of 5G mmWave would generate an estimated GDP increase (by 2040) of more than €140 billion (cumulative) in thirty European markets, at an additional cost of around €21 billion.

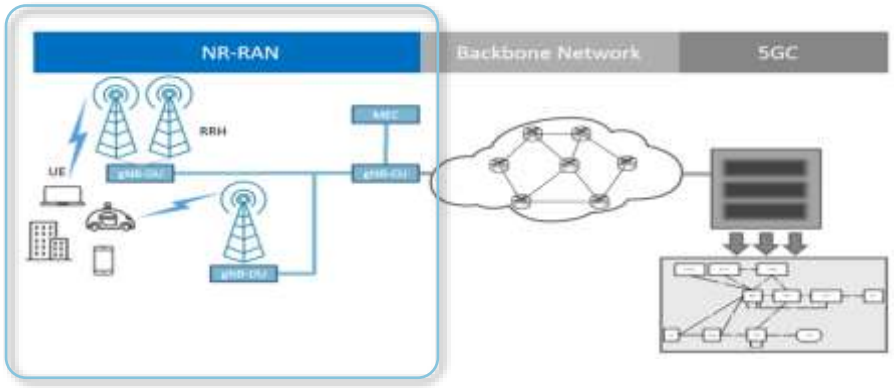
1. Source: Status, costs and benefits of 5G 26GHz deployments in Europe [Analysis Mason, co-sponsored by Qualcomm and Ericsson, 2021]

More info of 5G networks ➡

5G FWA Global Modelling

5G FWA project scope

5G network subsystems



- **Radio Access Network (RAN)**
- Core Network
- Transport Network
- CPE
- Passive Infrastructure
- Frequency band spectrum
- Network Management Systems

Project scope

- The following assumptions underpin the scope of this project:
  - 5G Radio Access Network (5G NR-RAN) planning only
  - Capacity of 1Gbps per user
  - Nationwide radio wireless simulations
  - White areas target coverage = 151,581 premises spread over 129,797 address points
  - Market penetration rate[2]: 75%
  - Use of existing and new sites (telecommunication towers)

151,581 Premises

1,303 Existing Sites

2. Market Penetration. Percentage of potential customers using a specific wireless network service.

5G FWA Global Modelling

5G FWA radio planning methodology

Site prioritisation algorithm

- The site prioritization algorithm determines the number of sites required for efficient distribution of premises. It proceeds in four stages:
  - Initial allocation: Allocation of premises to existing sites based on signal coverage, identifying uncovered premises and candidate sites.
  - Prioritized allocation: Allocation of premises to a single site, minimizing the number of existing sites required while respecting the maximum capacity (number of premises) per site.
  - Inclusion of new sites: Introduction of considerable random potential new locations to cover premises not allocated to existing sites, minimizing new site usage.
  - Final allocation for unreachable premises: Addiction of new site candidates with inaccessible site coordinates, ensuring all premises are allocated by the end.
- This approach balances efficiency and coverage requirements.

Site Optimisation: Based on the minimum number of sites required to guarantee a capacity of 1 Gbps per premise.

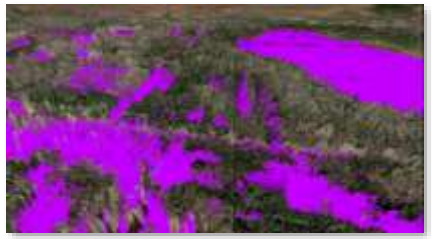
Objective: Minimise the construction of new sites by maximising the contribution of usable existing sites.

Signal level rationale and capacity rationale[3]

- Technology and bandwidth: **5G 26 GHz/BW 800 MHz**
- Maximum distance to BS: **4 km**
- Receiver antenna height: **20 m**
- Signal reception threshold: **-100 dBm**
- Cartography:
  - Digital Terrain Model (**DTM**)
  - Digital Surface Model: **Vegetation layer**
- Propagation model: **Line Of Sight (LOS)**
- Radio Planning Tool: XIRIO online

Maximum capacity estimation:

No. Max. Premises per Sector = 145



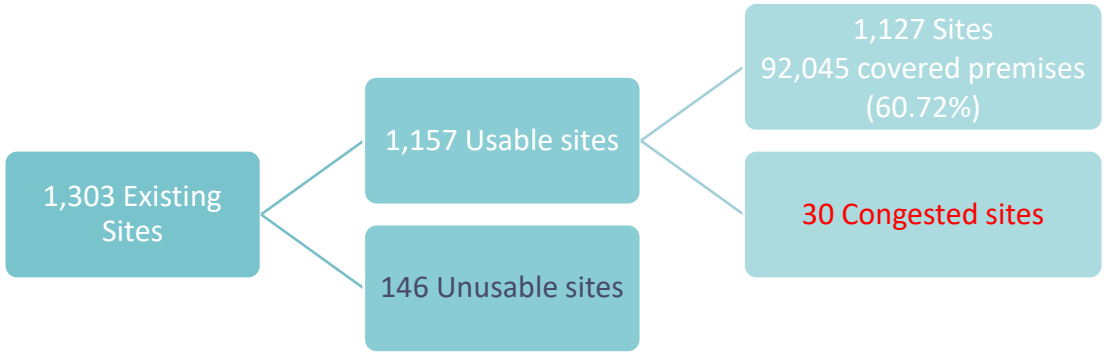
Vegetation Obstructing Radio Signal

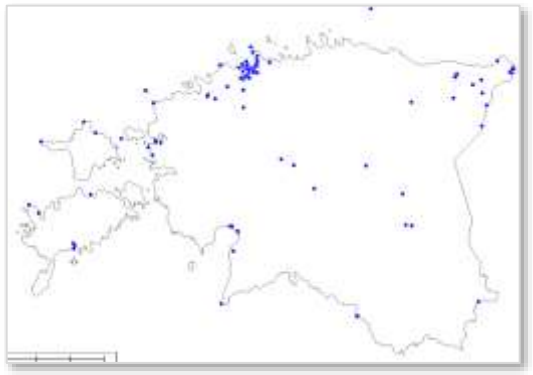
Given the morphological characteristics of Estonia, one of the most significant obstacles to signal propagation in the 26 GHz frequency band, using the LOS propagation model, is the presence of vegetation.

3. See signal level rationale and capacity rationale details in Back-up Slides Section

5G FWA Global Modelling

Simulation results for existing sites





Unusable Sites

Congested Sites

Definitions

- Related terms to the categorization of a site, sector and/or premise:
  - Usable site: Site that covers more than zero premises
  - Unusable site: Site that covers zero premises
  - Congested site: Site with at least one overloaded sector
  - Efficient site: Site that cover more than 15 premises
  - Non-efficient site: Site that cover up to 15 premises
  - Overloaded sector: Sector that covers more than 145 premises
  - Allocated premise: Premise assigned to a site sector
  - Non-allocated premise: Premise not assigned to any site sector

Efficiency of a site rationale

- The efficiency of a site is determined based on a cost threshold of €3,000 per premises, which is considered the worst case economic scenario.
- If deploying active infrastructure at an existing site exceeds this cost, satellite links will be used instead.
- Taking into account the approximate cost of a site's 5G NR-RAN infrastructure, installation and commissioning, one site must serve at least 16 premises with the required coverage and capacity to be considered efficient.
- Three scenarios are modelled based on the use of efficient and non-efficient sites in the 5G FWA framework.

5G FWA Global Modelling

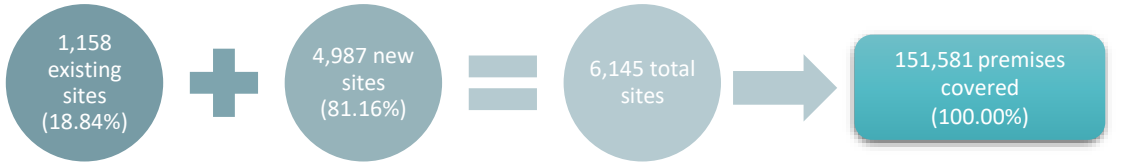
Simulation results for different scenarios

A) Global Coverage Scenario: Efficient and Non-Efficient Sites

Existing Sites

New Sites

Total Sites



B) Efficient Sites Scenario: Only Efficient Sites

Efficient Existing Sites

Efficient New Sites

Total Sites

C) Non-Efficient Sites Scenario: Only Non-Efficient Sites

Non-Efficient Existing Sites

Non-Efficient New Sites

Total Sites

5G FWA Global Modelling

Coverage of different scenarios

A) Global Coverage Scenario

151,581 premises covered (100.00%)

Global Coverage Scenario Network Sizing

- 6,145 sites required:
  - 1,158 existing sites
  - 4,987 new sites
- 151,581 premises covered (100.00%)

B) Efficient Sites Scenario

134,438 premises covered (88.69%)

Efficient Sites Scenario Network Sizing

- 1,617 sites required:
  - 952 existing sites
  - 665 new sites
- 134,438 premises covered (88.69%)

In order to reach the 100% coverage target, 4,528 sites need to be added, mostly new sites, even if they are not efficient.

A technologically and economically viable 5G FWA network deployment scenario considers only efficient sites, as the CAPEX estimate in the next section shows.

Optimisation Objective: Reduce CAPEX by minimising the construction of efficient new sites and maximising the contribution of efficient existing sites.

5G FWA Global Modelling

CAPEX estimate

CAPEX estimate budget items

- The Estonian government's broadband support models are based on subsidies that only cover the passive components of the network infrastructure, so the 5G FWA CAPEX estimate is split into two separate studies:
  - **Passive 5G NR-RAN infrastructure study**, considering only the latter three of the budget items.
  - **Active and passive 5G NR-RAN infrastructure study**, considering all of them.

CAPEX estimate general assumptions

- Adaptation of sites and premises infrastructures not included.
- Existing sites assumptions:
  - FTTH backbone network connectivity and power grid connectivity available at existing sites.
  - Preliminary works, earthworks and tower construction on the site not included.
- New sites assumptions:
  - Preliminary works, earthworks and tower construction on the site included.
  - Self-supporting site tower construction included.
  - FTTH backbone network connectivity and power grid connectivity included.
- The costs for Engineering and Documentation and Project Management services are calculated as a percentage of the cost of the infrastructure.
- V.A.T. not included.

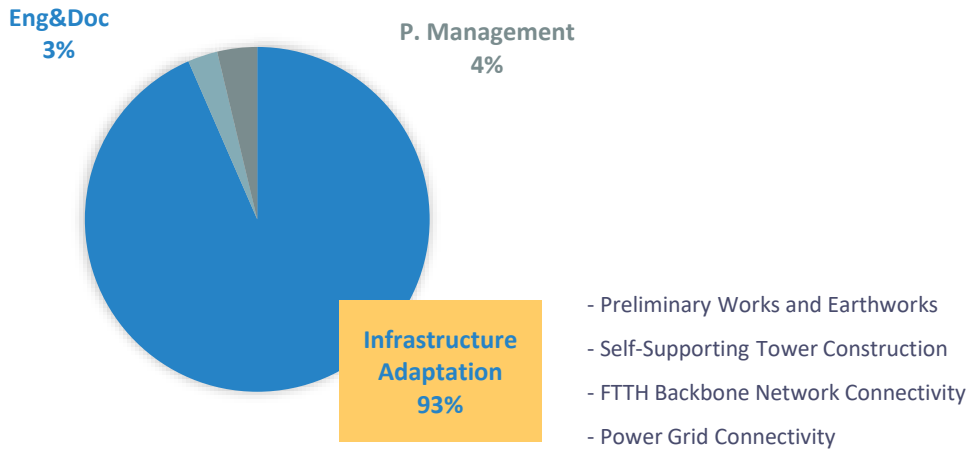
1. Active Infrastructure Supply
5G NR-RAN Active Infrastructure
CPE
2. Active Infrastructure Installation
Manufacturer's Implementation Support
Installation and Commissioning
3. Passive Infrastructure Adaptation
Preliminary Works and Earthworks
Self-Supporting Tower Construction
FTTH Backbone Network Connectivity
Power Grid Connectivity
4. Engineering and Documentation
5. Project Management

5G FWA Global Modelling

CAPEX estimate - Passive infrastructure study results

Global Coverage, Efficient Sites & Non-Efficient Sites Scenarios

- In this case, the budget items proportions remain unchanged in the three scenarios.



By far the largest contribution to investment is required to adapt the infrastructure of the existing or new sites.

- This 5G FWA network modelling study will be used at a later stage to perform the cross-analysis with the FTTH network modelling on a level playing field, i.e. considering only the passive infrastructure of both network solution.

CAPEX estimate

A) Global Coverage Scenario
CAPEX ~ 1,542 M€

B) Efficient Sites Scenario
CAPEX ~ 215 M€

C) Non-Efficient Sites Scenario
CAPEX ~ 1,327 M€

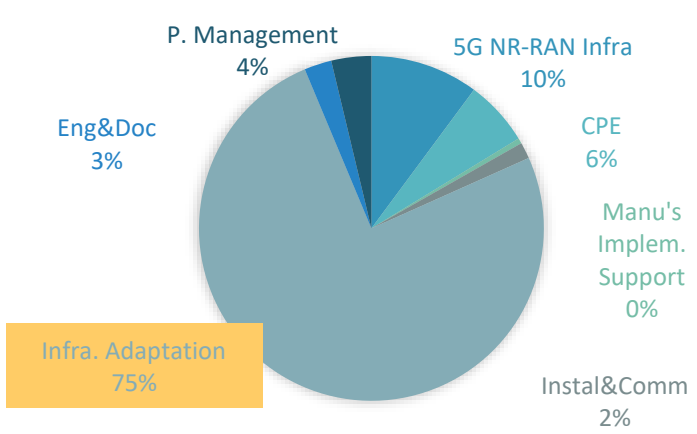
~ 14%

~ 86%

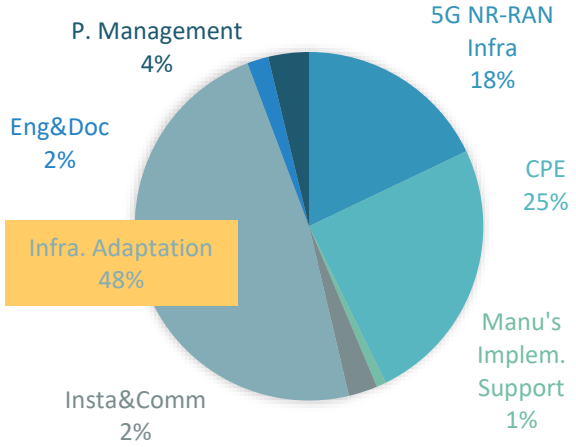
5G FWA Global Modelling

CAPEX estimate - Active and passive infrastructure study results

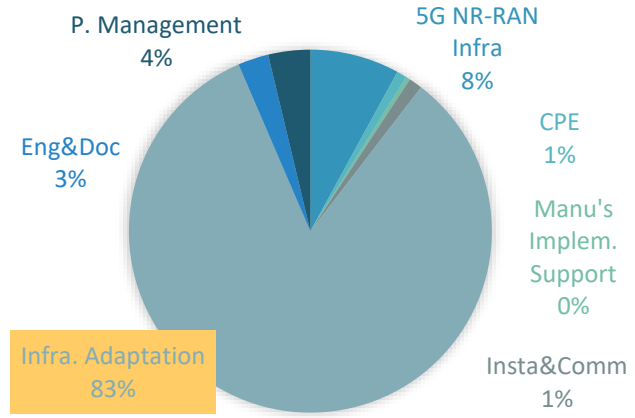
A) Global Coverage Scenario



B) Efficient Sites Scenario



C) Non-Efficient Sites Scenario



- As can be seen in both studies, the <u>largest contribution to investment is the adaptation of the infrastructure.</u>

CAPEX estimate

A) Global Coverage Scenario
CAPEX ~ 1,912 M€

B) Efficient Sites Scenario	C) Non-Efficient Sites Scenario
CAPEX ~ 419 M€	CAPEX ~ 1,493 M€
~ 22%	~ 78%

For both studies, a feasible 5G FWA network deployment scenario envisages coverage of 88.69% of premises with 1,617 efficient sites.

Full coverage would require an additional 280% more (non-efficient) sites, of which 95.45% would be new builds, with the associated high costs.

6. Cross-analysis: identification of areas where it is more cost effective to use FTTH or 5G FWA technology

Assumptions

Based on the results of cost studies for full FTTH or FWA coverage, cross-analysis to identify where it would be more cost effective to build infrastructure using FTTH technology or 5G FWA technology.

Premises that are not covered by FTTH network (557):

- If covered by an **efficient** 5G FWA site: **5G FWA** → 400 premises, 23 5G FWA sites
- If covered by a **non-efficient** 5G FWA site : **satellite** → 157 premises

Premises that are covered by FTTH network and 5G FWA (142,825):

- Only efficient (existing or new) 5G FWA sites are selected for the cross analysis
- If FTTH appears to be more cost effective on an OLT area, the entire cluster is covered by FTTH

Methodology

Example of OLT107

1) Determine per OLT the 5G FWA efficient site to deploy to cover the entire area and the percentage of premises this covers
2) Determine the cost to deploy all the 5G FWA sites that are concerned per OLT (passive infrastructure)
3) Determine the cost of satellite connexion to cover the remaining premises (not covered by an efficient 5G FWA site)
4) Compare the cost of the *FTTH* solution and the cost of the 5G *FWA + satellite* solution
5) Set a 5G FWA coverage threshold per OLT (95%)
6) If 5G FWA + satellite is cheaper than FTTH and 5G FWA coverage threshold is reached, 5G FWA + Satellite is chosen; if not, the OLT area is covered with FTTH

OLT	Site ID	# Premises
OLT107	NewSite_0000003	66
OLT107	NewSite_0000120	46
OLT107	NewSite_0000222	20
OLT107	NewSite_0000289	31
OLT107	NewSite_0000605	16
OLT107	Site_1946100	118
OLT107	Site_1946101	255
OLT107	Site_4307612	130
OLT107	Site_4307628	40
OLT107	Site_4307631	132
OLT107	Site_5147709	1
OLT107	Site_5639843	192
OLT107	Site_6675776	138
OLT107	Site_6831243	69
OLT107	Site_8902148	105
OLT107	Site_8903021	255
TOTAL		**1614**

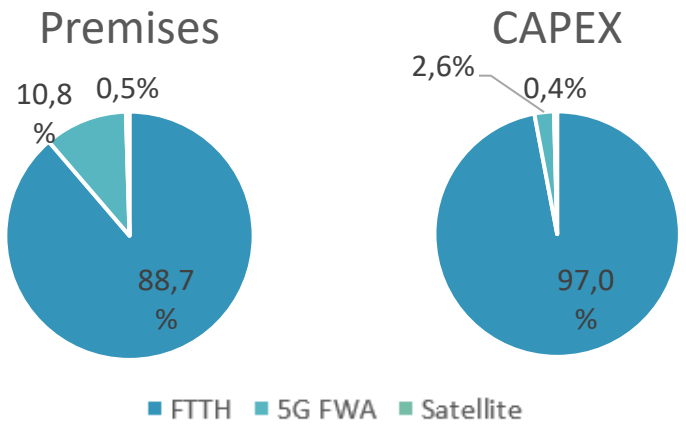
OLT	# Premises	FTTH total cost	Cost/ premise	Efficient 5G FWA sites cost	% premises covered by 5G FWA efficient sites	# premises to cover with satellite	Satellite cost	5G FWA + satellite cost	Cheaper	Scenario
OLT107	1671	4 485 890 €	2 685 €	1 446 781,83 €	97%	57	285 000 €	1 731 781,83 €	FWA+SAT	FWA+SAT

Cross-analysis

Results

- 15 OLT covered with 5G FWA + Satellite mix : 201 efficient 5G FWA sites, of which 55 new sites

	# of premises	Total cost (CAPEX)	Per premise
FTTH	127,209	772.5 M€	6,073 €
5G FWA	15,505	20.5 M€	2,690 €
Satellite	666	3.3 M€	5,000 €
TOTAL	**143,380**	**796.3 M€**	**5,554€**



	# premises covered	Total cost (CAPEX)	Cost / premise
Global FTTH	142,825	828 M€	5,795 €
Mix	143,380	796 M€	5,554 €

- 4% compared to global FTTH solution

7. Areas where the cost of setting up FTTH infrastructure is up to €5,000 per address and up to €3,000 per address

5K and 3K scenarios

Goal and methodology

Goal:

Identify areas by settlement units where it is possible to build a connection to the FTTH broadband infrastructure at an average cost of up to €5,000 per **address** (5K scenario) / €3,000 per **address** (3K scenario) for each OLT.

Methodology:

- Starting from the results of the global modelling, we removed addresses strategically with the aim of reducing the average cost per address to €5,000 (resp. €3,000). This process implies that the remaining addresses would become more expensive.
- We run Setics Sttar design tool with the remaining endpoints, using the same engineering rules than those used for the global modelling.
- This process was iterative until the average cost per address was €5,000 (resp. €3,000) per OLT.

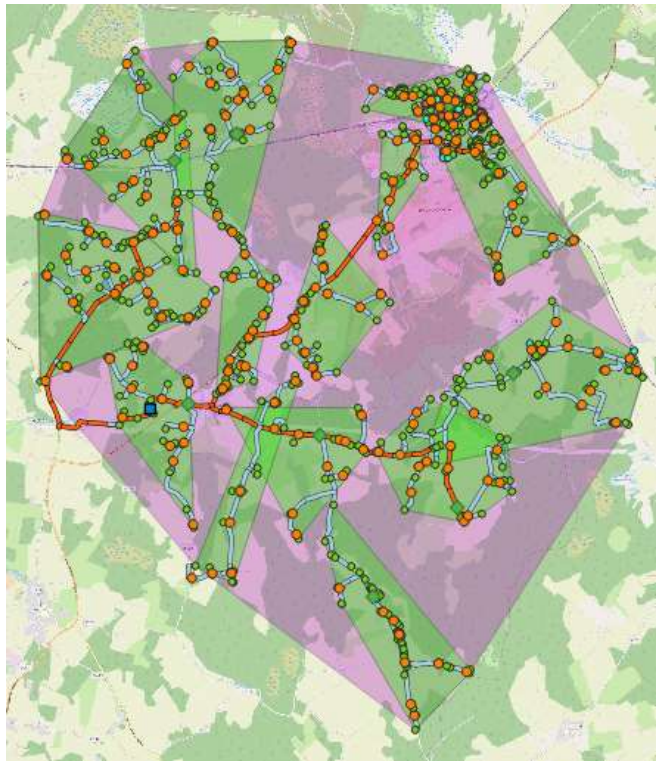
5K and 3K scenarios

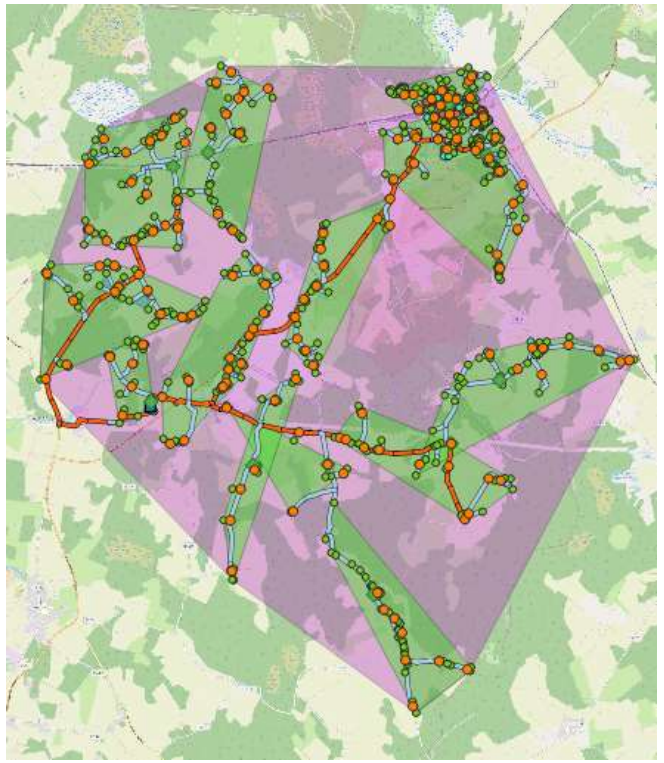
Results - example of OLT01

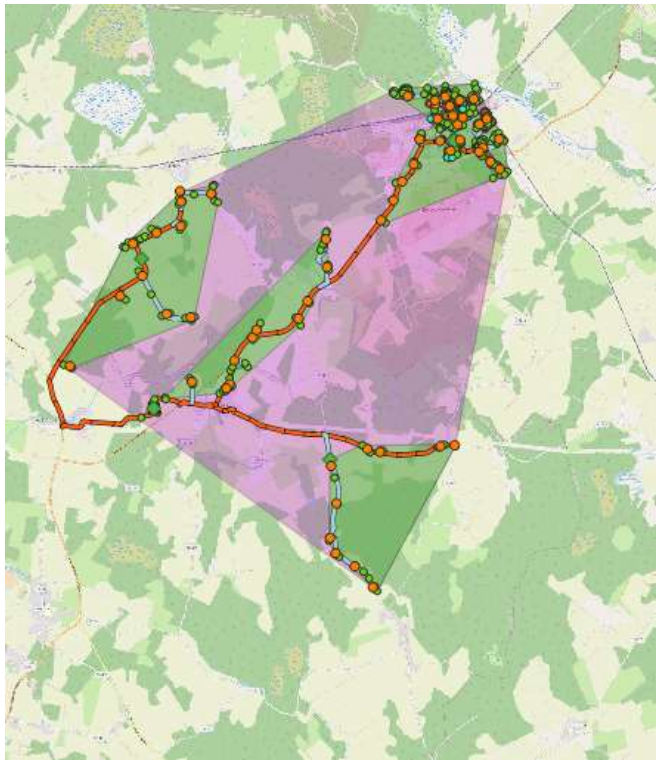
Global modelling		
# addresses	Total cost of OLT	Cost/add
838	4,810 k€	5,739 €

5K scenario		
# addresses	Total cost of OLT	Cost/add
756	3,725 k€	4,927 €

3K scenario		
# addresses	Total cost of OLT	Cost/add
451	1,346 k€	2,926 €

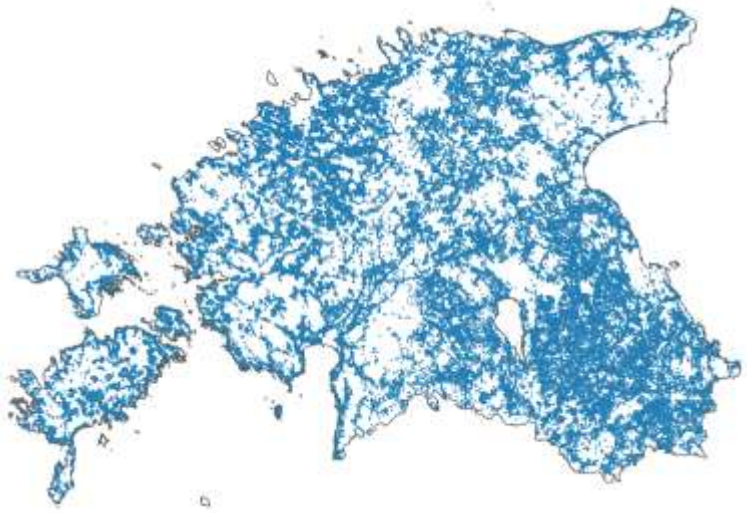




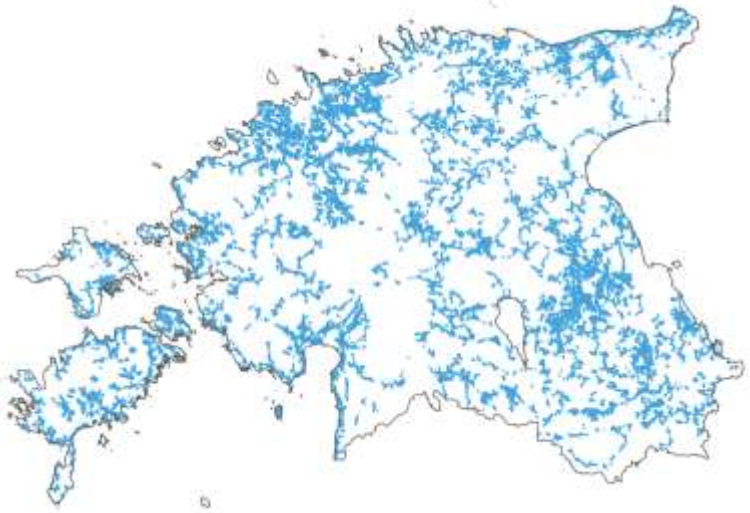


5K and 3K scenarios

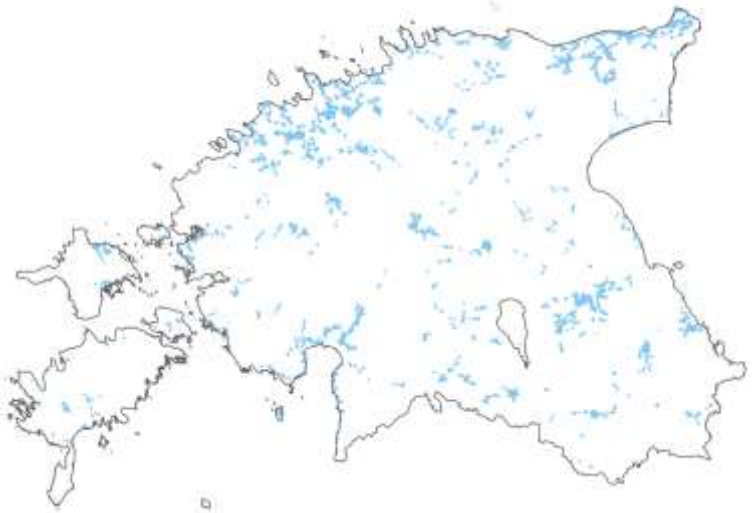
Results - comparison with global modelling



Global modelling

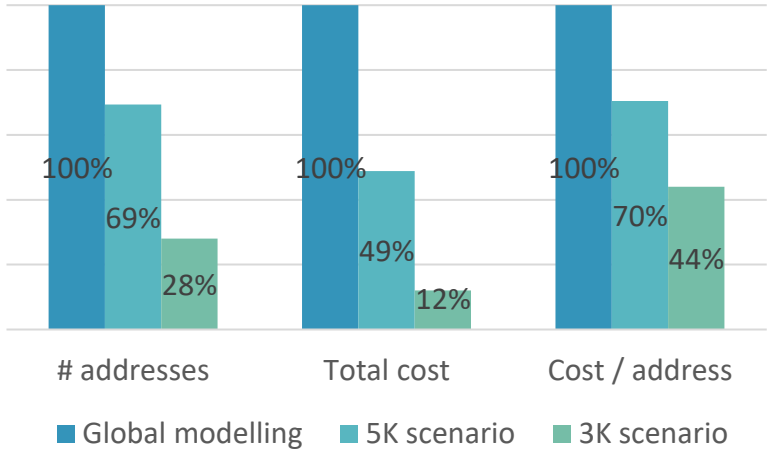


5K scenario



3K scenario

	Global modelling	5K scenario	3K scenario
# of addresses	122,990	85,349	34,575
Total cost (includ. drop)	824,778 k€	403,058 k€	101,180 k€
Cost / address	6,706 €	4,722 €	2,926 €



8. Addresses where it is not socio-economically reasonable to build a broadband infrastructure with gigabit capacity

10K scenario

Goal and methodology

Goal:

Identify addresses for which building a broadband infrastructure costs more than €10,000 per **address**.

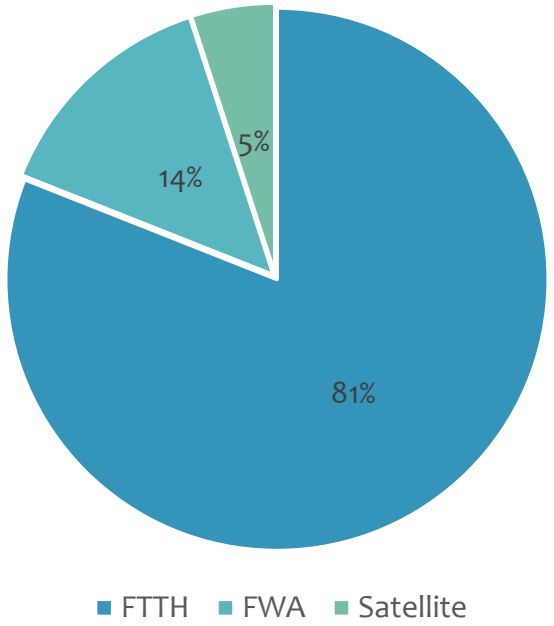
Methodology:

- If the address cost in FTTH is less than €10,000 → FTTH
- If the address cost in FTTH is more than €10,000 or if the address is not covered by FTTH:
  - If the address is covered by an existing 5G FWA site → 5G FWA
  - If the address is covered by a new efficient 5G FWA site → 5G FWA
  - If the address is covered by a new non efficient 5G FWA site → Satellite

10K scenario

Results

	# addresses	%
FTTH	99,642	81%
5G FWA	17,634	14%
Satellite	6,253	5%



5% of addresses for which it is not economically reasonable to build a broadband infrastructure with gigabit capacity

9. Granting support models

Models of granting support

European funding situation

- European framework is the Digital Decade Policy Program (Broadband Europe) : program launched in March 2021 by the European Commission, that sets full connectivity targets, for all the Member States of the European Union, by 2030
- Main ongoing European support/funding programs are :
  - The digital part of the European Regional Development Fund (ERDF) :
    - active until 2027
    - €2.36bn budget for connectivity: Members' projects support, with a focus on market failures
  - The Recovery and Resilience Facility (RRF) in the NextGenerationEU plan:
    - active until 2026
    - loan pooling program with €16,8bn programmed for connectivity
  - The digital part of Connecting Europe Facility (CEF) program :
    - active until 2027
    - €1.6bn budget: Members' projects support, with €800m for 5G coverage, €389m for backbone connectivity
  - EIB loans

Models of granting support

Estonian plan

- Estonian Digital Society 2030 Plan was adopted in October 2021
- It is the Estonian translation of Broadband Europe

- The Estonian plan aims to:
  - develop very high-capacity access networks, including in areas where communication companies do not make investments themselves
  - establish the basic infrastructure, to enable the creation of an uninterrupted 5G coverage area, on the most important transport corridors
  - cover in 5G some selected residential and business areas

- Target by 2030:
  - all residents and companies must be connected at least at 100Mb/s, increasable to 1Gb/s
  - at least 95% of populated areas must be covered in 5G
  - a basic infrastructure will be established in market failure areas, with the Estonian State support

- Our modelling contributes to this global plan

Models of granting support

Benchmarking

- A benchmarking has been done to provide Estonian Ministry teams with a comparison of the different financing solutions chosen in other European countries, most of them related to Broadband Europe :
  - Belgium
  - Denmark
  - Finland
  - France
  - Germany
  - Ireland
  - Italy
  - Latvia
  - Lithuania
  - Sweden
  - United Kingdom

Models of granting support

Benchmarking synthesis and recommendations

- Most European countries - European Union State members or not - have already launched State funding programs to support the investments that are necessary to connect the most rural and hard to reach addresses, in addition of the private investments
- Benchmarking shows that national broadband plans can be specific, but many parameters stay common, within the framework set by the European Commission. Same parameters are also often used by the non-Member State of the European Union

Main parameters comparison	Most frequent choice	Other choice
Perimeter	National Often the current management is later delegated to the local scale	Only on a regional or district scale, without national coordination
Type of service	Wholesale access contract including design, roll out and operation	Subsidy to the end-user connection (voucher scheme)
Origin of funding	Mix public and private funding	Only a public funding : - Most of the time it is a subsidy to the end-user - Creation of passive infrastructure
Contract	Turnkey global contract	Separate contracts

Models of granting support

Recommendations for Estonia

	Best choice for Estonia	Comments
Perimeter	A national plan dedicated to white areas	- National rationalization seems preferable, as the white areas concerns numerous agglomerates of small quantities of addresses and scattered addresses - The national scale appears necessary to obtain the best economic conditions
Type of service	- Global Wholesale access contract - Could be completed with a voucher scheme	- Wholesale access is a European framework constraint, and the best way to promote an effective competition across all services marketed on the network
Origin of funding	Mix public and private funding	- Best solution to benefit from private financing, and leverage of public money
Contract	Global turnkey contract	- Easier to manage and control by the Ministry teams - One rather than several procurement to award : simplification of the award process

Models of granting support

Benchmarking synthesis and recommendations

- Benchmarking shows average subsidy varies from ~ €500 per premise (ex. Italy, huge quantity of premises, national scale) to ~ €5,000 per premise (ex. Ireland, focus on particularly rural premises)
- On a regional scale (~200 000 premises), with a mix of little urban, rural and very rural premises, the current average subsidy is ~ €1,500 per premise (ex. most Départements in France / Cumbria, Norfolk, Suffolk in the UK, German Community in Belgium..). In these projects, there is often a mix private / public funding, and around €1,500 per premise remains paid by the State or the local authority
- The Estonian project includes much more very rural addresses / premises that is usually seen in projects in other countries, and seems to us more comparable to the Irish (around €5,000 per premise), the Latvian (around €2,700 per premise) or the Finnish (around €1,700 per premise) projects

- In case of a mix private and public funding project, by comparison with values and quantities observed in the countries in the benchmarking, especially the Irish, the Latvian and the Finnish projects, we consider that the Ministry could probably expect a unit subsidy in the range €1,500 - €3,000 per premise, depending on the scenario (complete, up to €3,000 per premise or up to €5,000 per premise) finally chosen by the Ministry. A unit subsidy in the range €1,500 - €3,000 per premise can be anticipated
- In case of an only public funded project:
  - the roll out expenses will stay fully in charge of the Estonian State: amount of the funding depending on the scenario - complete, up to €3,000 per premise or up to €5,000 per premise - chosen by the Ministry
  - the income coming from the rental of the network by the operators will be kept by the Estonian State
  - this scenario requires more investment at the start and generate more income later
- These valuations and principles are to be confirmed and specified in a provisional business plan, once the scenario, the method of financing and the type of contract will be chosen by the Ministry

10. Geospatial Presentation

Geospatial OÜ

https://www.geospatial.ee/

- Geospatial OÜ on Eesti erakapitalil põhinev ettevõte, mis asutati 2005. aastal
  - Ettevõtte põhitegevused on
    - **CAD/GIS/NIS**
      - Konsultatsioonid
      - Süsteemide arendamine, hooldamine, monitoorimine
      - Andmehaldusteenused
      - Koolitused
    - **FTTH**
      - Konsultatsioonid
      - Võrkude automaatplaneerimine
      - Ehitusdokumentatsiooni kontroll
      - Võrgu kirjeldamine (NIS)
    - **Geotee**
      - Tarkvara teenusena (SAAS) platvorm
      - Teenused:
        - omavalitsustele
        - võrguvaldajatele
        - geodeesia-, projekteerimis- ja ehitusettevõtetele

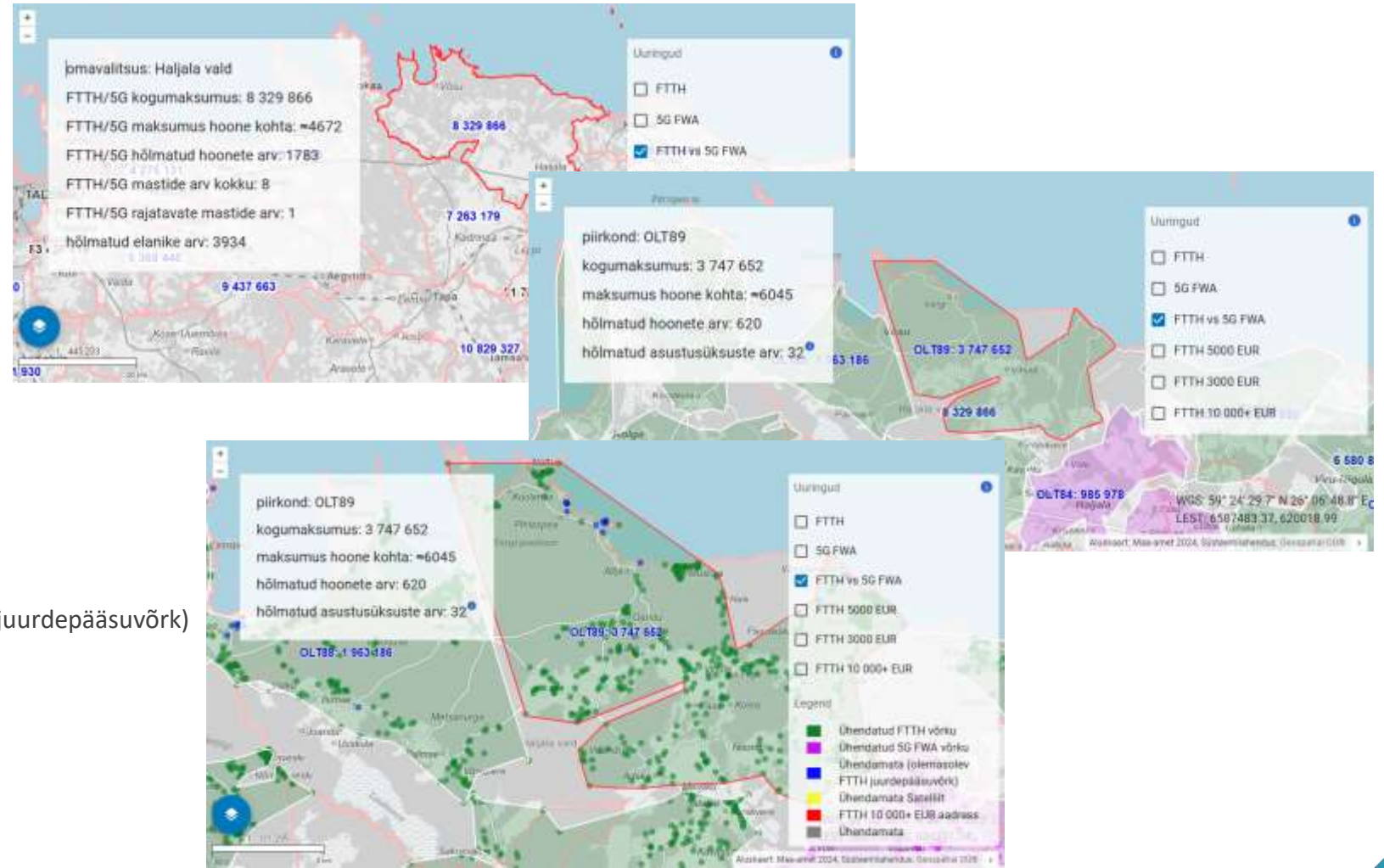
Meie kliendid

- **Võrguvaldajad**
  - ELASA (Eesti Lairiba Arenduse Sihtasutus)
  - Elisa Eesti
  - Telia Eesti
  - Eesti Energia
  - Gaasivõrgud
  - Tartu Vesi
  - Emajõe Veevärk
  - Saku Maja
  - Kehtna Vesi
  - ...
- **Omavalitsused**
  - Tallinn
  - Tartu
  - Narva
  - Harku vald
  - Viimsi vald
  - Rae vald
  - Tartu vald
  - Elva vald
  - ...
- **Teised**
  - Majandus- ja Kommunikatsiooniministeerium
  - Eesti Pank
  - Saarte Koostöökogu
  - ...

11. Public map application

Avaliku kaardirakenduse tasemed

- Avaliku kaardirakenduse eesmärk on anda interaktiivne ülevaade uuringu tulemustest ja statistilistest näitajatest erinevatel tasanditel:
  - Maakond ja omavalitsus
    - kogumaksumus
    - maksumus hoone kohta
    - hõlmatud hoonete arv
    - 5G FWA mastide arv kokku
    - 5G FWA rajatavate mastide arv
    - hõlmatud elanike arv
  - Võrgupiirkond
    - piirkond
    - kogumaksumus
    - maksumus hoone kohta
    - hõlmatud hoonete arv
    - hõlmatud asustusüksuste arv
  - Hoone
    - ühendatud FTTH võrku
    - ühendatud 5G FWA võrku
    - ühendamata (olemasolev FTTH juurdepääsuvõrk)
    - ühendamata Satelliit
    - FTTH 10 000+ EUR aadress
    - ühendamata



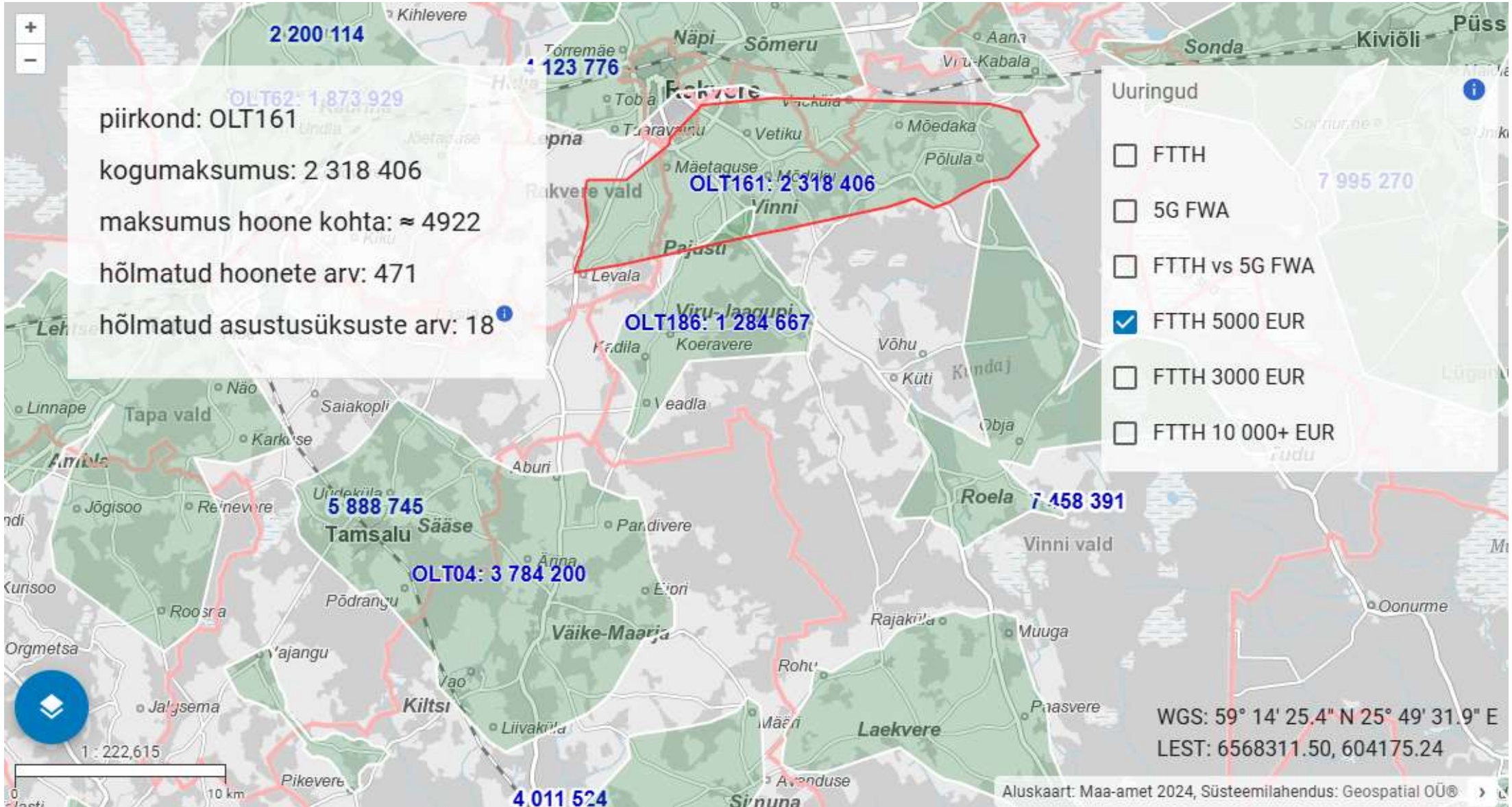
Avaliku kaardirakenduse uuringud

- Avaliku kaardirakenduses on kajastatud järgmiste uuringute tulemused:
  - FTTH
    - Infrastruktuuri ehitamise maksumus kasutades ainult FTTH tehnoloogiat
  - 5G FWA
    - Infrastruktuuri ehitamise maksumus kasutades ainult 5G FWA tehnoloogiat
  - FTTH vs 5G FWA
    - Piirkonnad, kuluefektiivsema tehnoloogia alusel
  - FTTH 5000 EUR
    - Piirkonnad, kuhu on võimalik ehitada liitumisvõimalused FTTH lairiba infrastruktuuriga keskmise maksumusega kuni 5000 EUR hoone kohta
  - FTTH 3000 EUR
    - Piirkonnad, kuhu on võimalik ehitada liitumisvõimalused FTTH lairiba infrastruktuuriga keskmise maksumusega kuni 3000 EUR hoone kohta
  - FTTH 10 000+ EUR
    - Asukohad, kuhu ei ole sotsiaalmajanduslikult põhjendatud ehitada gigabitise võimekusega lairibataristut ja kus elanikud/ettevõtted peaksid kasutama satelliitühendusi (st. hooned, kuhu taristu rajamine maksab rohkem kui 10 000 EUR)

Kaardirakenduses toodud hinnad ei sisalda käibemaksu

Avaliku kaardirakenduse esitlus

https://lairiba.geospatial.ee/



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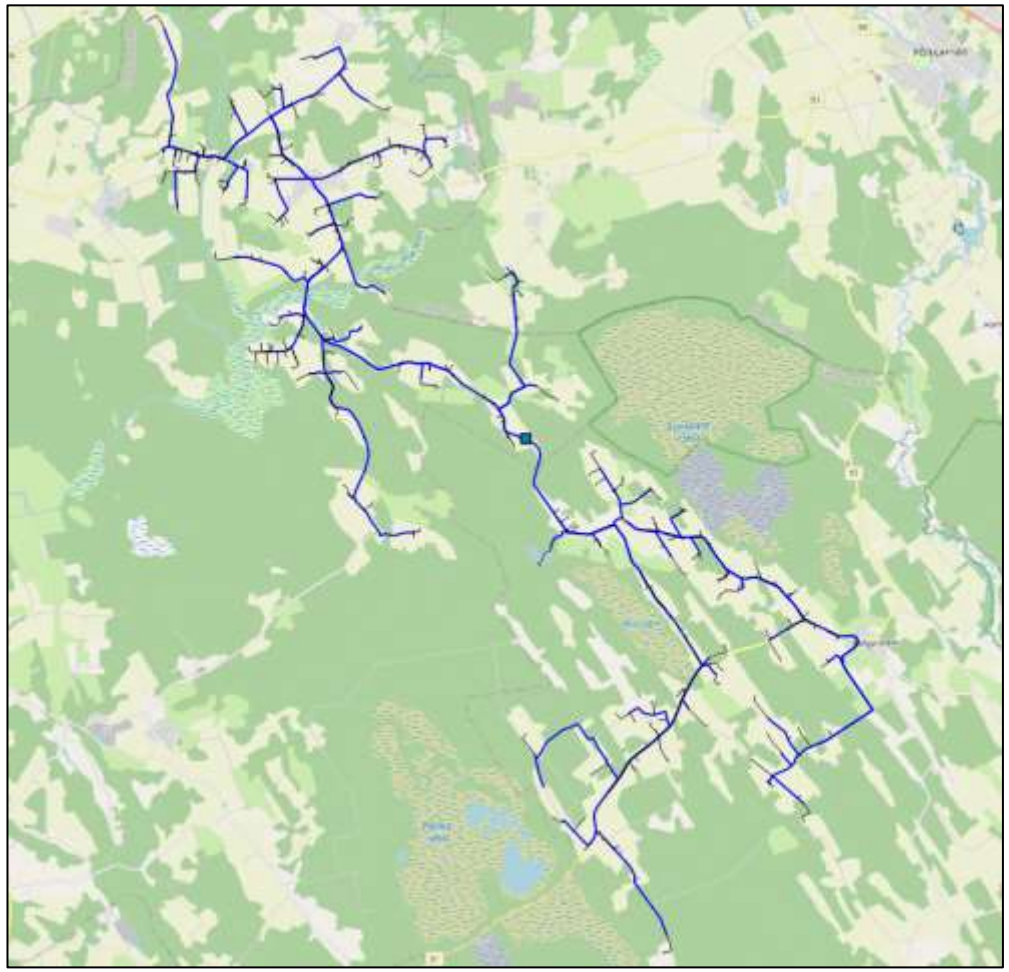
Back-up slides

FTTH Global Modelling - Cables

Example OLT 121

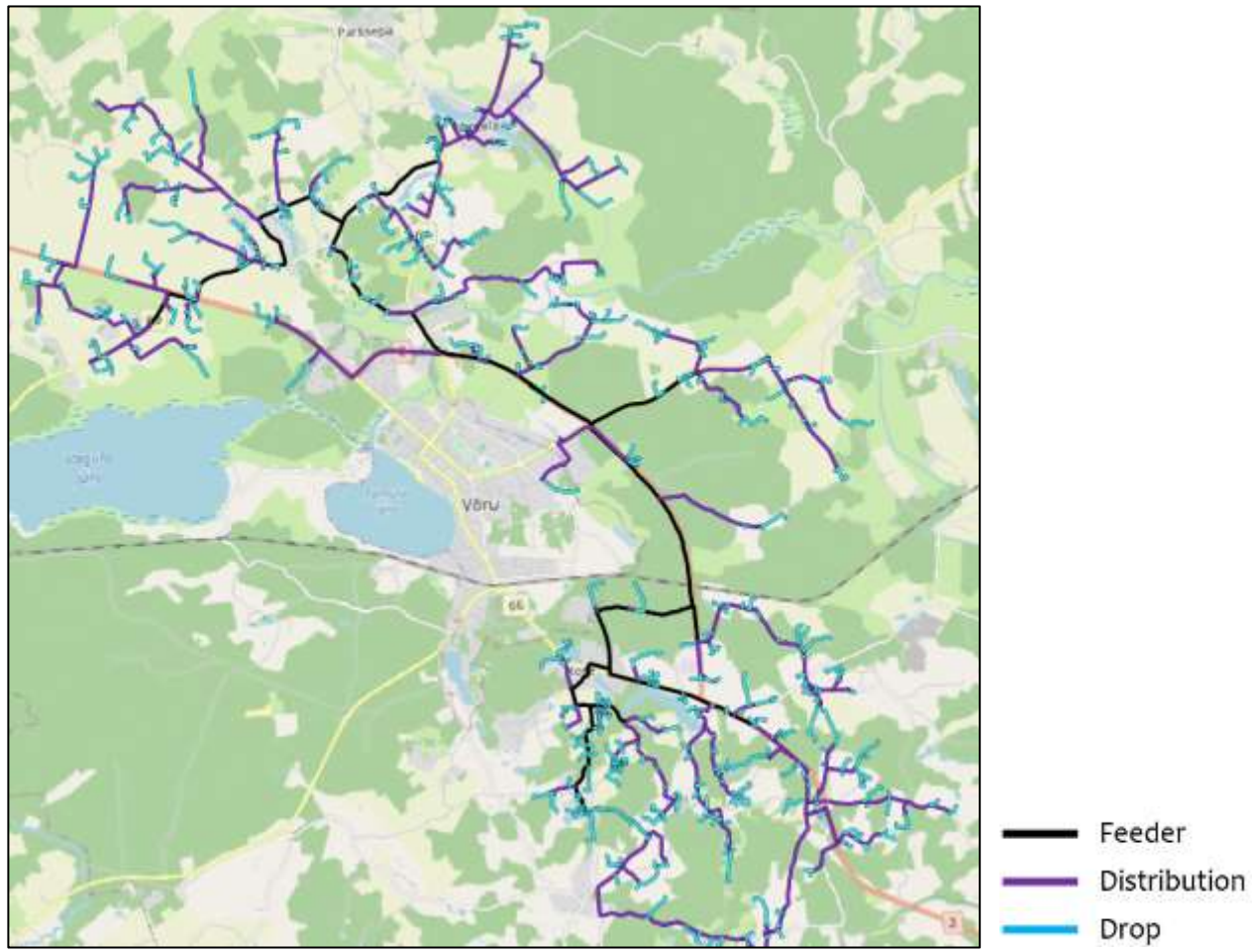


Length by cable model:

- 192xG652D: 59 Km (0.07%)
- 48xG652D : 33,813 Km (43.63%)
- Nano 24F: 31 Km (0.04%)
- Nano 12F: 133 Km (0.17%)
- Nano 8F: 382 Km (0.49%)
- Nano 4F: 480 Km (0.61%)
- Nano 2F: 42,586 Km (54.96%)

FTTH Global Modelling – Ducts

Example OLT 180



Duct models (length):

- 12 x 7/3.5: 154 Km (0.35%)
- 12 x 7/3.5 + 1 x 14/10: 151 Km (0.34%)
- 12 x 7/3.5 + 2 x 14/10: 1,877 Km (4.27%)
- 14/10: 7,362 Km 16.77%)
- 16 x 7/3.5 + 3 x 14/10: 1,296 Km (2.95%)
- 19 x 7/3.5: 24 Km (0.05%)
- 24 x 7/3.5: 98 Km (0.22%)
- 4 x 14/10: 8,267 Km (18.84%)
- 4 x 7/3.5: 1,378 Km (3.14%)
- 7 x 14/10: 32 Km (0.07%)
- 7 x 7/3.5: 282 Km (0.64%)
- 7/3.5: 14,622 Km (33.32%)
- 9 x 7/3.5 + 1 x 14/10: 8,332 Km (18.99%)

5G FWA Global Modelling

5G network design and framework of next generation of ITM standards

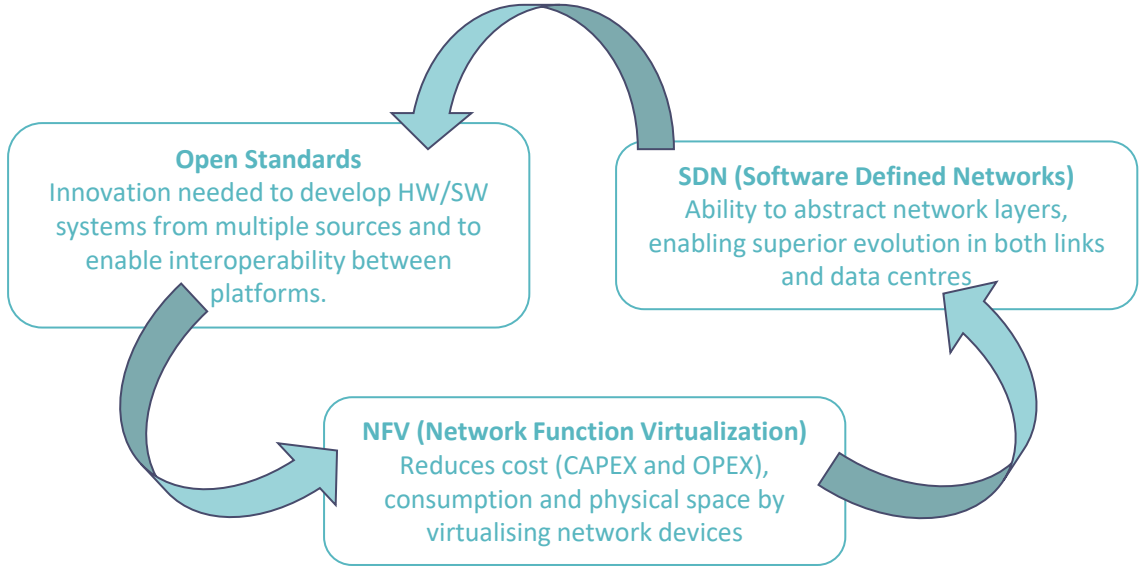
5G network design decisions

Service Oriented Architecture (SoA)

- Before: point-to-point connections between functional elements.
- Now: service-based interfaces in control plane design. Interactions between consumers and producers of services.

Open source model

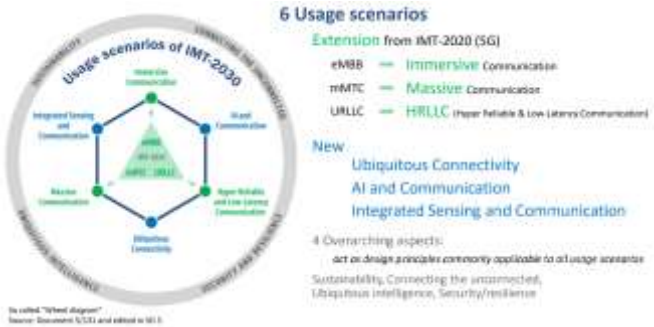
- A change in the governance model that allows new players to enter and creates a model of collaboration and sharing of information and software that accelerates the growth of technology.



ITU *IMT-2023 Framework**

- At its June 2023 meeting, ITU-R WP 5D has agreed the draft new Recommendation *Framework and overall objectives of the future development of IMT for 2030 and beyond*, which can be considered as the basis for the standardisation *fora* to develop the next generation of International Mobile Telecommunications (IMT) standards.

Usage scenarios



Capabilities of IMT-2030

Source: ITU. https://www.itu.int/en/ITU-R/study-groups/rsg5/rwp5d/imt-2030/Pages/default.aspx

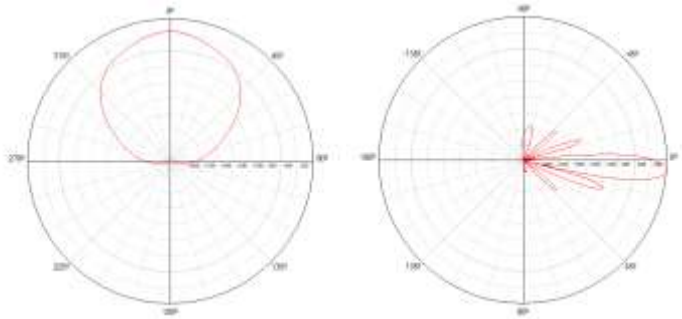
5G FWA Global Modelling

5G FWA Radio Parameters

- Frequency Band = 26 GHz [24.25 – 27.5 GHz] (mmW)
  TDD GH Bandwidth = 800 MHz
- SS-RSRP Power = 20.3 dBm
- Passive Losses = 1 dB
- BS Antenna Height:
  - Existing Sites: Real Height (m)
  - New Sites:
    - First Iteration: 60 m
    - **Optimisation: 30, 40 or 60 m**
- Receiver Antenna Height = 20 m
- Radiation System: 3 Sectoral Active Antennas
  (0°-120°-240° Azimuth Setting)
- Mechanical Downtilt = 4°
- Max. Throughput per Sector = 5,584 Mbps
- Max. Throughput per User = 1,024 Mbps
- Max. Distance = 4 km
- SS-RSRP Threshold = -100 dBm
- MU-MIMO = 2
- Max. No. Premises per Sector (Max. Capacity) = 145

	Bandwidth	
	400 MHz	800 MHz
Max. Throughput per Sector (Mbps)	2,792	5,584
MU-MIMO Factor (Nº Concurrent Beams)	2	2
Required Peak Throughput per User (Mbps)	1,024	1,024
Contention Ratio (X:1)	10	10
Market Penetration Rate (MPN) (%)	75	75
Max. No. Allocated Premises per Sector	72	145

Capacity Estimation



Antenna Radiation Patterns

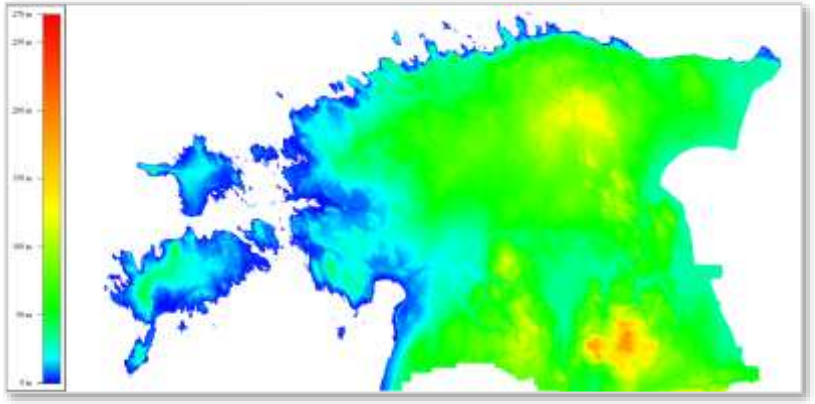
Target Parameters			
	Available Bandwidth (MHz)	400	
	Max. Throughput per Sector (Mbps)	2,792	
	Parameter	DL	Ratio
A	Transmit Power (dBm)	55	
B	Base Bandwidth (MHz)	380.16	
C	Transmitter Loss (dB)	1	
D	Transmit Antenna Gain Traffic (dBi)	24	
E	MIMO Factor	2	
F	Total EIRP	78	A-C+D
G	SINR (dB)	22.0	Efficiency
H	Noise Figure (dB)	7	
I	Noise Power (dBm)	-81.2	−114+10log(B)+H
J	Interference Margin	5	
K	Sensitivity (dB)	-54.2	G+I+J
L	Shadow Margin (dB) (90%)	10.25	
M	Average Receive Power (dBm)	-44.0	K+L
N	Receive Antenna Gain (dBi)	21	
O	Human Body Loss	0	
P	Receive Antenna Loss (dBi)	3	
Q	Receive Diversity (dB)	3	
R	Compensable Attenuation (dB)	143.0	F-M+N-O-P+Q
S	Subcarrier Bandwidth (MHz)	0.12	
T	Power per Subcarrier	20.0	A+10log(B/S)
U	Transmitting Broadcast gain (dBi)	17	
V	EIRP per Subcarrier (dBm)	43.0	T-C+U
W	Expected RSRP in Rx (dBm)	-100.0	V-R

Link Budget

5G FWA Global Modelling

Cartography

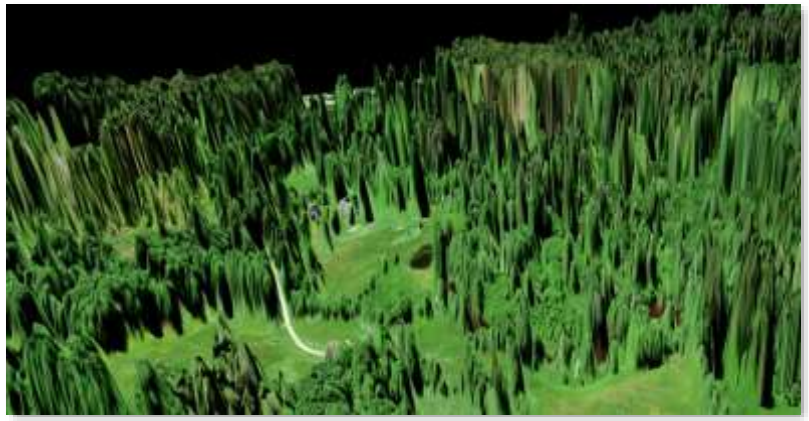
Digital Terrain Model



Digital Terrain Model

- Resolution = 25 m /pixel
- Source: Public information in https://geoportaal.maaamet.ee/eng/ LIDAR
- Year: December 2023- January 2024

Digital Surface Model



Digital Surface Model

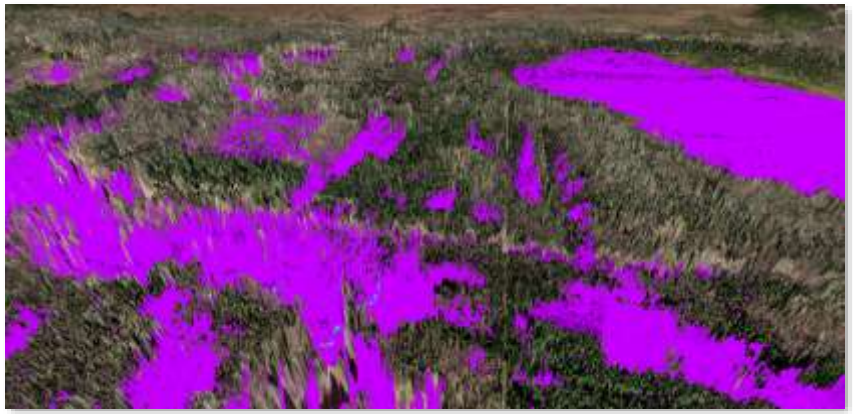
- Resolution = 5 m /pixel
- Source: Public information in https://geoportaal.maaamet.ee/eng/ LIDAR
- Year: December 2023- January 2024
- Vegetation, buildings and other obstacles over the ground included.

5G FWA Global Modelling

Propagation Model: Line-Of-Sight (LOS)

- This signal propagation model considers:
  - Signal transmitted through free space to a receiver located at a given distance from the transmitter.
  - No obstructions between transmitter and receiver.
  - Signal propagates along a straight line between the two.
  - No diffraction effects.
- In reality, the signal trajectory follows a curve caused by refractive index variations in the troposphere. To model the curvature of the signal trajectory in a rectilinear propagation representation, the concept of the Effective Earth Radius is used, which modifies the Earth radius by a constant k-factor with a typical value of 4/3.
- A condition of clear visibility is required in order to estimate the basic propagation loss using the LOS Model:
  - If the radio path between transmitter and receiver is obstructed, the received signal level is assumed to be zero.
  - Otherwise, free space propagation is then calculated using the procedures, recommended by the ITU-R Rec. 525-2:

$$L_{bf} = 32.4 + 20 \log f + 20 \log d \quad \text{dB}$$

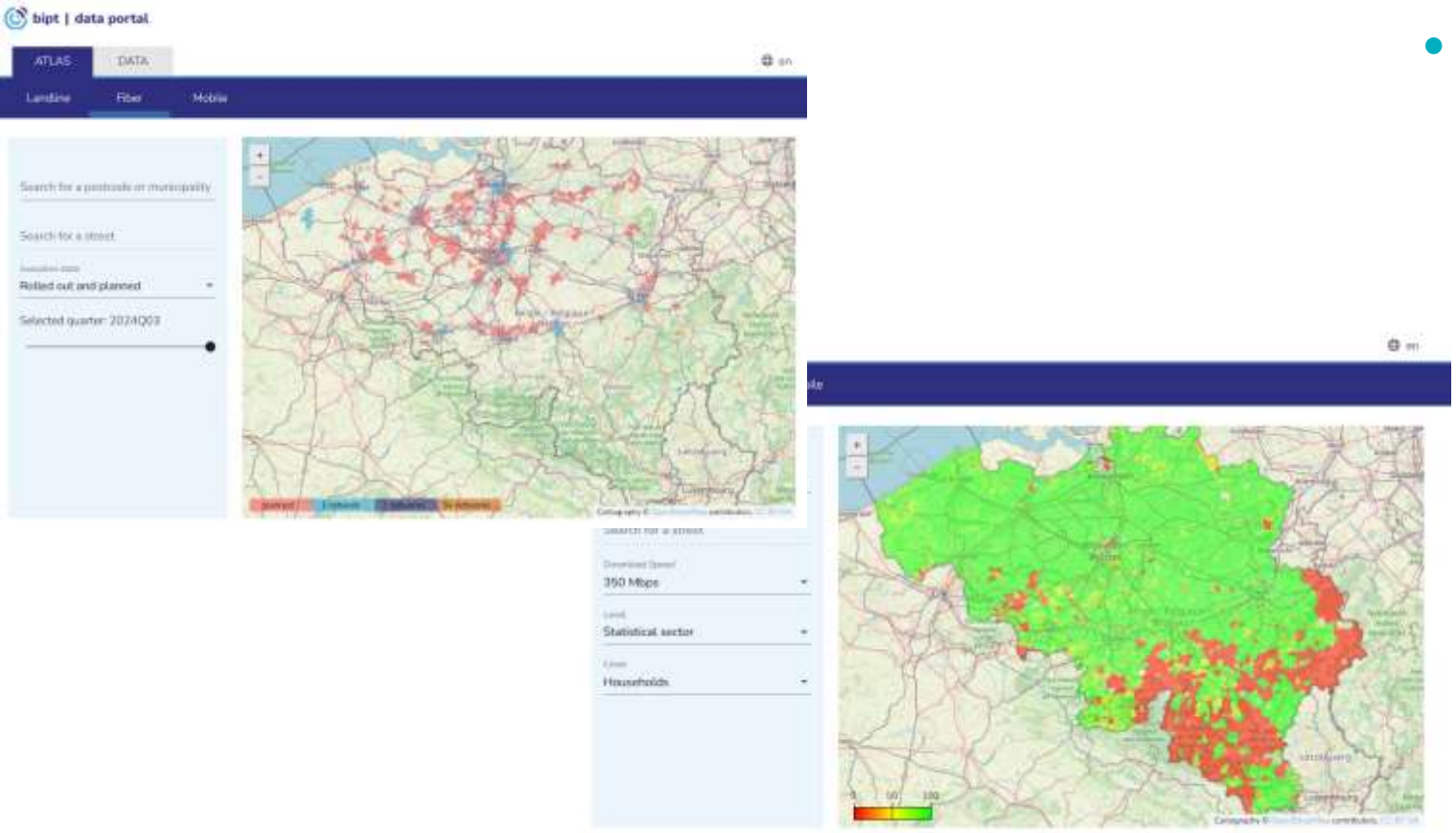


Obstruction of Radio Signal by Vegetation

Given the morphological characteristics of Estonia, one of the most significant obstacles to signal propagation in the 26 GHz band is the presence of **vegetation**.

Models of granting support - Benchmarking - Belgium

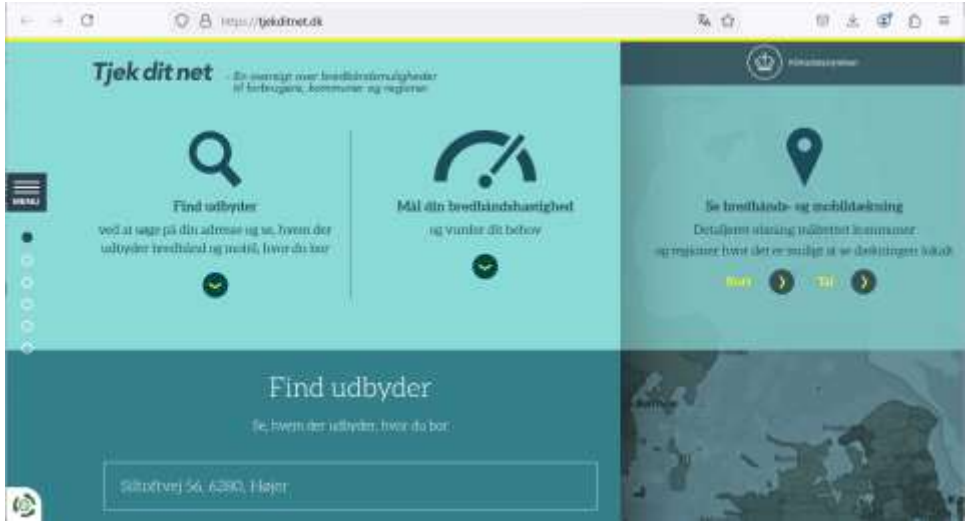
- The general rule in Belgium is networks' deployment on private funds by the operators: FTTH networks and HFC networks (which are very large and widely used)
- National plan Digital Belgium (approved in April 2021) aims to eliminate the remaining white areas where high speed – fixed (FTTH or HFC) and mobile - services are unavailable. This plan covers the period 2022 – 2024 and is consistent with the European gigabit connectivity 2025 targets. It concerns ~ 138 000 addresses
- Current situation: unbalanced situation between north and south of the territory



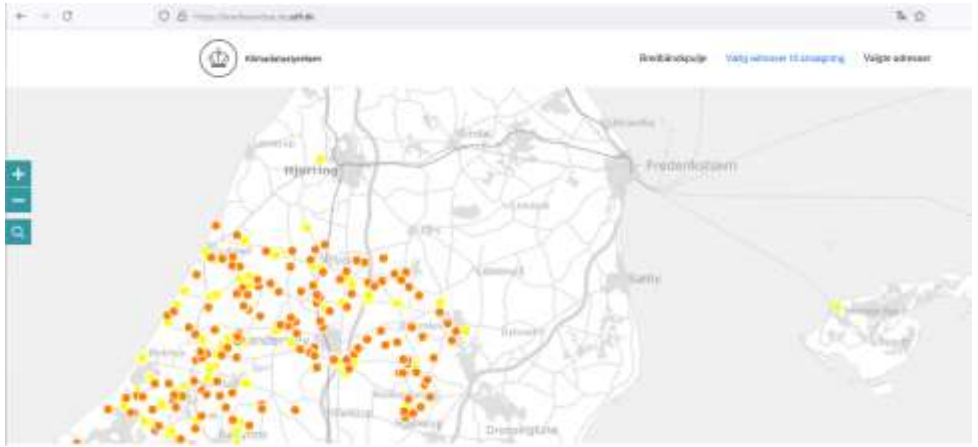
- Funding support :
  - Support of €41m from the Federal government, dedicated to white areas
  - Public funding completed by regions :
    - €70m for Wallonia, for business parks and schools' connectivity
    - €40m for German speaking community for a FTTH 40k premises network
  - Focus on the German speaking community project :
    - Project managed by an infrastructure private public society (joint-venture) : the shareholders are the local authority, Proximus (incumbent), a private equity fund
    - Contract is also a shareholder's agreement
    - Roll out, operation and relations with access seekers are delegated to Proximus (and its subcontractors)
    - Roll out is subsidized by the local authority (max €40m)
    - Wholesale open access network

Models of granting support - Benchmarking - Denmark

- Broadband plan is managed in common by several Ministries: Climate, Energy and Utilities / Industry, Business and financial affairs / Finance
- Danish broadband strategy, as agreed in 2021, is: cover all households and businesses by 100/30 Mbps connection by 2025 / cover 98% of households and businesses by 1 Gbps download speeds by 2025 / identify the needs and demand for gigabit speeds by 2030
- Danish State decided to let private/public operators deploy their own FTTH network. No infrastructure sharing is imposed (except for ducts), no monopoly was granted and overbuild is possible:
  - In urban clusters, FTTH is rolled out by operators, especially TDC Net, which is the TDC (incumbent) subsidiary dedicated to infrastructure / HFC networks are present and still widely used
  - In rural clusters, especially in Jutland (continental part of Denmark), FTTH is often deployed by utilities



State tool to know the eligibility and the ISP serving each address

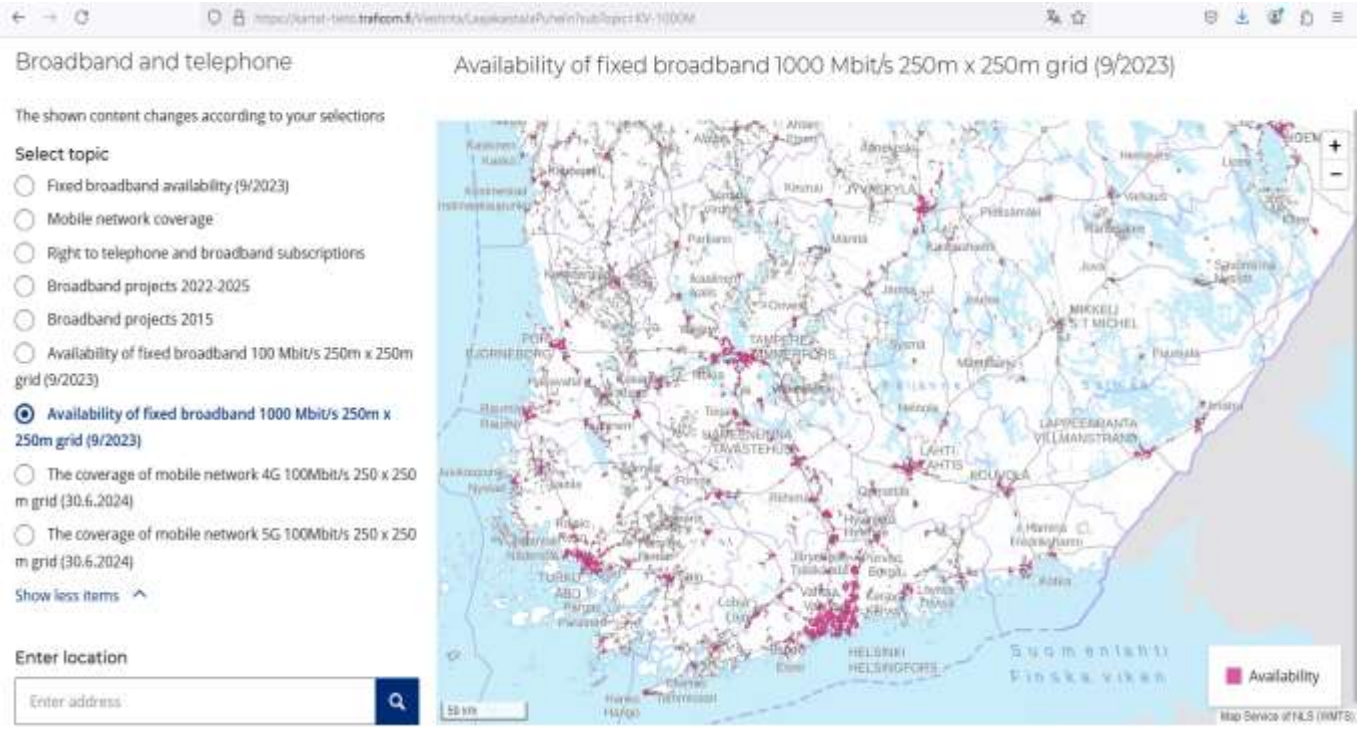


State tool to know subitizable addresses

- Isolated addresses with access to less than 100 Mb/s are eligible for an end-user subsidy : a budget of DKK80m (~ €11m) is available for that (DKK50m + DKK30m of carryover of unused budget) : avg. subsidy €270, max subsidy : €16,750
- Danish Business Authority estimation is a lack of coverage for ~ 40k addresses the "Restgruppe" beyond 2025, probably transferred to TDC Net or to the utilities. The funding of the Restgruppe seems not yet defined

Models of granting support - Benchmarking - Finland

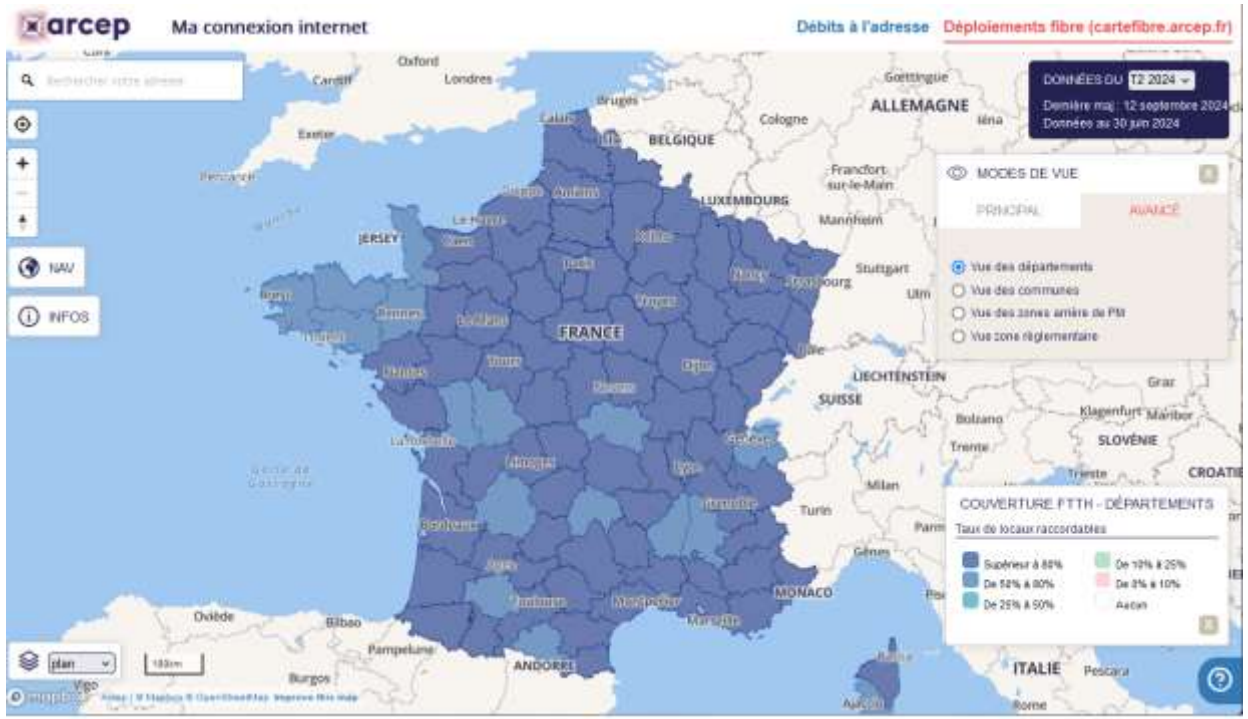
- The Finland's national roadmap to comply with the European Union Digital Decade Policy Program 2030 was published in 2024:
  - all end users at a fixed location to be covered by a gigabit network up to the network termination point
  - all populated areas to be covered by next-generation wireless high-speed networks with performance at least equivalent to that of 5G)
- The Finnish Government opted for a competition-driven, fibre-based network roll-out, with a special focus on the assistance for areas of dispersed populations and underserved areas



- Over the period 2014–2022, the Finish State (via European Agricultural Fund for Rural Development) provided funding of approximately €73m to a total of 179 local projects
- Finnish government also advise local authorities (regions and municipalities) on how to set up entities dedicated to deploying broadband, e.g. by joints ventures of multiple municipalities and/or in partnership with private operators
- Currently, the Finnish State funding consists in a broadband aid scheme in sparsely populated areas. In total €53m of funding has been allocated to broadband connections in rural areas, over the period 2023-2027
- 41 State aid decisions were already granted, amounting the aid scheme to €27m, to ensure that the 16,000 households will receive fibre connection by mid-2026 (~€1,700 per household)

Models of granting support - Benchmarking - France

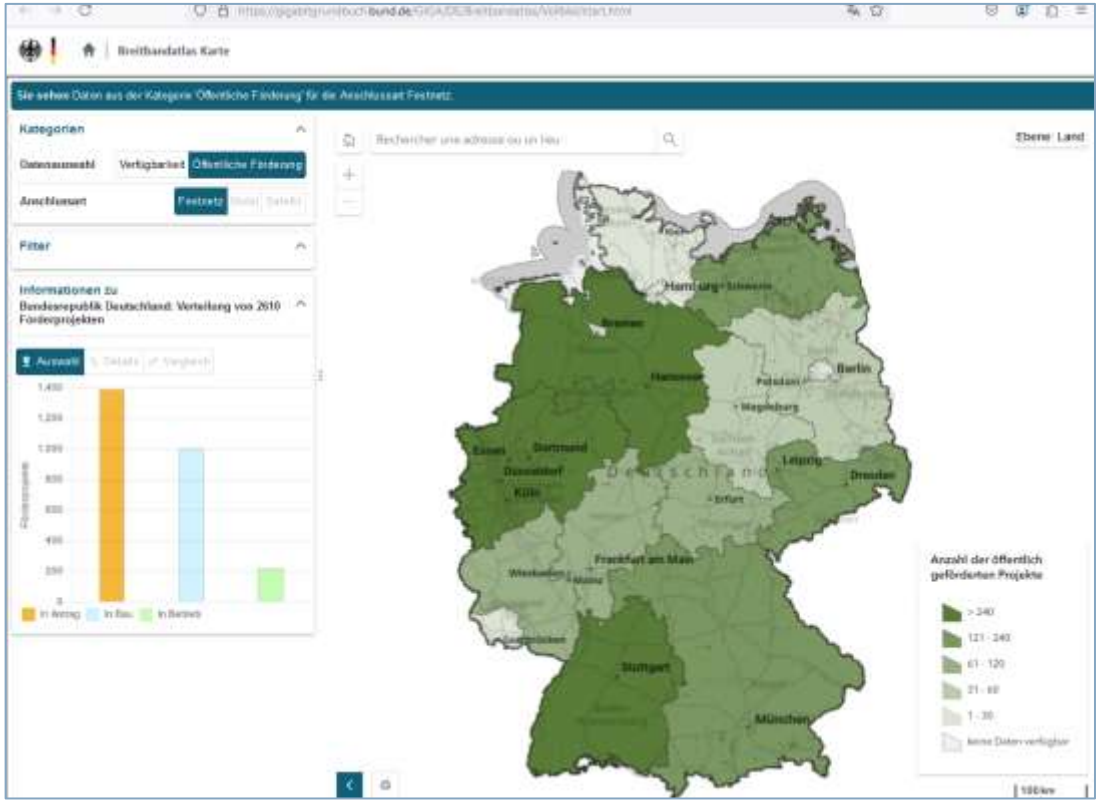
- National plan “France Très Haut Débit” was launched in 2010 : Entire French territory covered with high-speed broadband (30 Mbps) by 2022, extended to FTTH throughout the country by 2025
- Territory coverage has been distributed by the French State :
  - Private funding + possible overbuild in the denser cities (~ 100 cities / 7.8m addresses)
  - Private funding + local monopoly on urban areas chosen operators (~ 7500 cities / 19.1m addresses)
  - Mix private/public funding + local monopoly for the rest od the territory (~ 28000 cities / 17.3m addresses)



- For territories with public funding :
  - €13bn of public funding shared between all levels of local authorities : French State, Départements (100 Départements in France), and groups of cities
  - Loan facilities : Caisse des Dépôts et Consignations (French State public bank)
  - French State subsidy of €3.5bn :
    - Project management delegated to local authorities
    - Minimum scale = Département, State subsidy is caped from 30% of the public expenses for dense Départements to 55% of the public expenses for the most rural Départements
  - Local authorities often award long-term turnkey contracts to wholesale operators
  - Roll out and operation can be in the same contract or in dedicated contracts
  - Private and public equity funds have invested massively in the public FTTH networks (shareholders + financing)

Models of granting support - Benchmarking - Germany

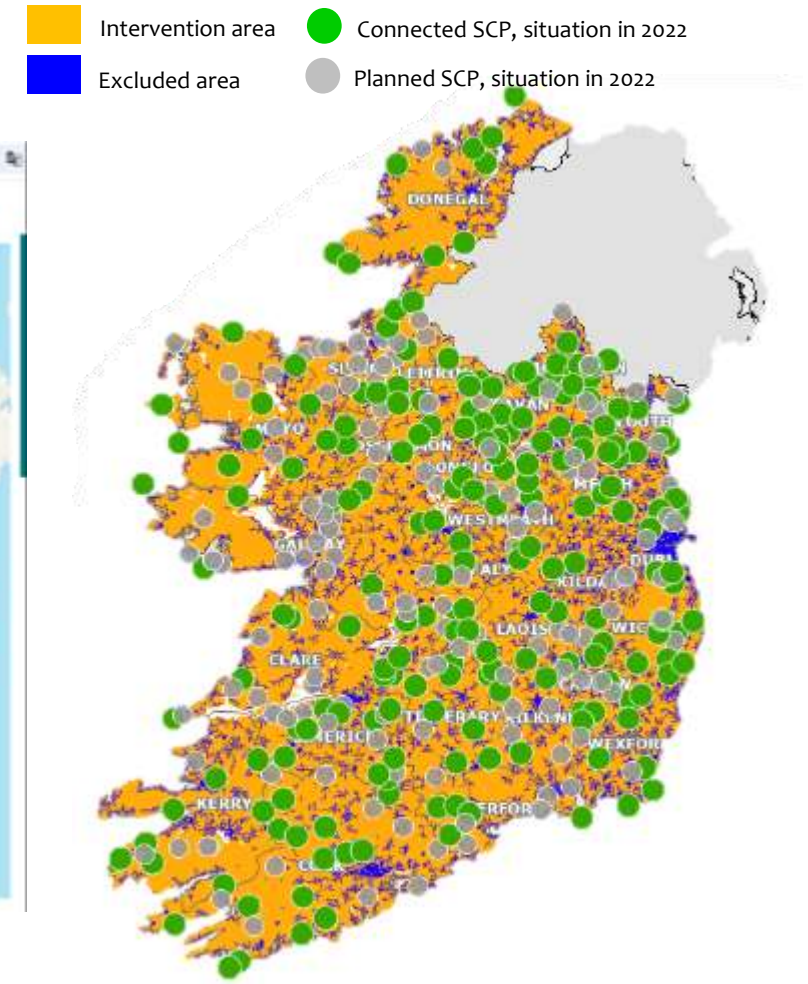
- Federal Digital Strategy for Germany (launched mid-2022). It aims at nationwide coverage with fibre optic connections of all people by 2030. The German strategy plans that half of all households and businesses will have fibre connectivity by 2025
- European Gigabit Strategy foresees measures that will simplify, speed up and digitize permit granting and strengthen use of alternative deployment methods, which is a great difficulty in Germany.
- Currently, in Germany, there is no regulated rental offer for existing ducts, few possibility to create poles, what makes roll out very difficult in urban clusters. Consequently, public / private operators mainly deployed FTTH networks in rural/little urban clusters so far, without necessarily covering all the addresses, with a very large part of civil works



- Funding support :
  - The support of the Federal government (approx. €12bn in total) is dedicated to expansion of minimum 1 Gbps connections in underserved clusters.
  - The maximum amount (subsidy) of federal funding per project is €30m: usually combined with other funding programs from “Länder” or districts.
  - German government completes its support by providing loan facilities : up to €50m by project, up to 30 years, with subsidized interest rates
  - Federal government funding requirement : to be eligible, a city or a community must be able to complete its FTTH coverage with less than €1m CAPEX
  - Note: Engineering rules and network architecture are usually imposed to the operator by the public grantor as a counterpart of the public funding. This leads operators to operate different architectures in their networks, which leads to complexity and additional Opex costs

Models of granting support - Benchmarking - Ireland

- National Broadband plan is managed by the Irish State : Department of the Environment, Climate and Communications (DECC)
- Procurement process led over the period 2018-2019 : exclusive turnkey 25-year contract with NBI (wholesale operator) to build and operate an open access fibre network



- Public funding :
  - NBP/State support a selection of 555.000 addresses, included over 65.000 farms, 44.000 non-farms businesses, and 1.100 strategic connection points (schools and community facilities for public access)
  - Contract plans max 230 deployment areas, of at least 250 premises
  - State Subsidy of up to €2.6bn : core subsidy of 2.1bn / subsidy cap includes 0.5bn of contingent payment to mitigate variables as new premises and Capex overruns
  - Roll out and connection milestones, for subsidies payment. Ministry can reallocate subsidy between deployment, connections and post deployment

Models of granting support - Benchmarking - Latvia

- In Latvia, the main program for expanding access in rural and remote areas is a State aid program named “Next generation network for rural areas” (2013-2020). This project was divided in two stages:
  - the first stage, completed in 2015, aimed at deploying 180 access points and 1 800 km of fibre
  - the second stage, completed in 2022, aimed at deploying further 220 access points and 2 000 km of fibre
- A public funding of €75m was granted for that. About 137,000 households are connected to this network
- The network is now fully rolled-out and rented to the commercial operators (wholesale access)

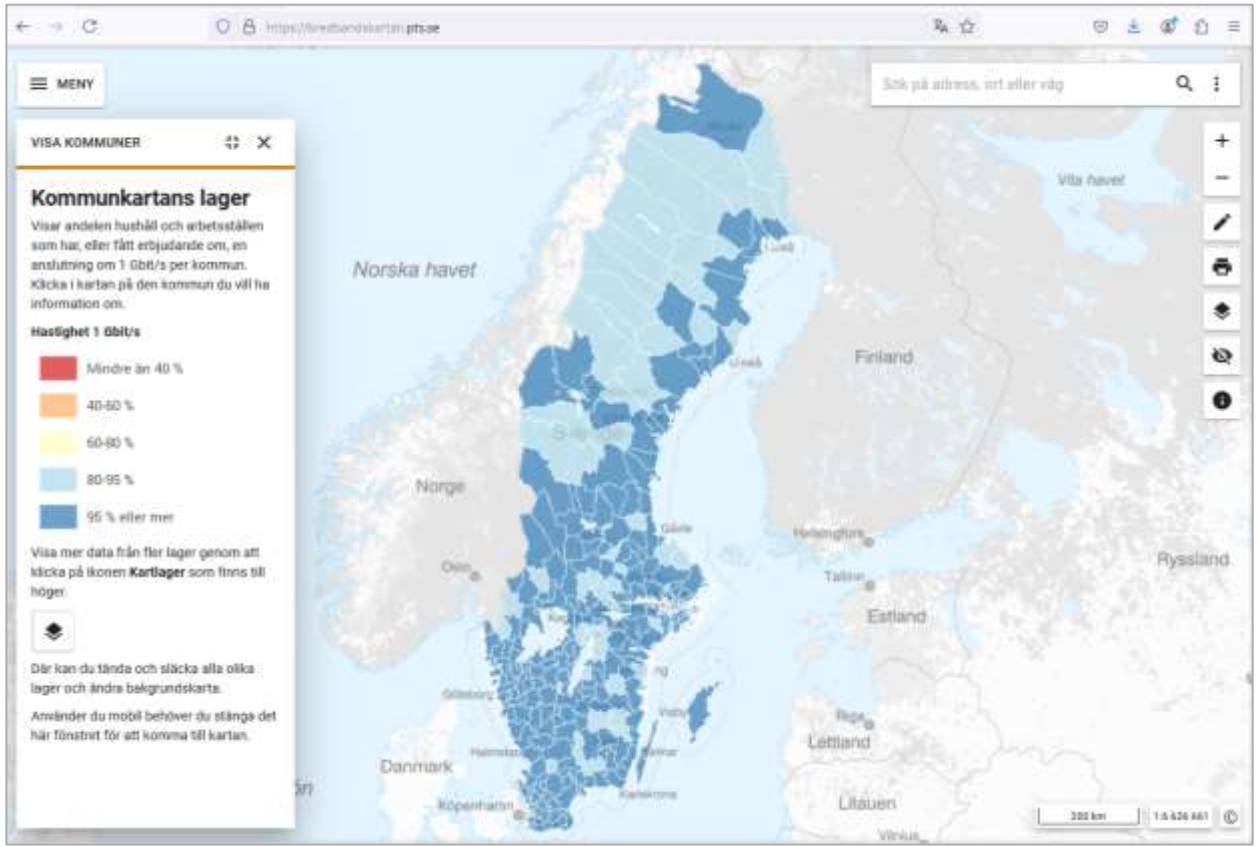
- Current Latvia’s Recovery and Resilience Plan includes two additional new measures on connectivity infrastructures, with a combined budget of €16.5m. These two measures address the last-mile connectivity in rural areas and passive infrastructure building on the Via Baltica 5G corridor:
  - This broadband last-mile infrastructure development measure foresees to provide connectivity to 1,500 households, businesses, schools, hospitals and other public buildings in rural areas. A budget of €4m has been voted for that
  - An investment of €12.5m is also planned for the construction of passive infrastructure on the Via Baltica corridor for 5G coverage, to ensure 100% fibre backhaul availability along the Latvian part of the Via Baltica

Models of granting support - Benchmarking - Lithuania

- The development of fibre wholesale broadband networks began in 2012. It was the RAIN, RAIN2 and PRIP projects. Thanks to these projects, a fibre network of 9,500 km was created during the period 2012 – 2023. This network has reached 1,850 rural areas on the whole country
- Afterwards a budget of €75m was allocated for that Ultra-fast Broadband Development Plan. This funding was planned to be used to build communication towers and lay fibre optic lines, giving a priority to the main public and economic activity spaces and public institutions not yet connected to a broadband network
- In that plan, the Lithuanian State pledged €49m for infrastructure investments, including :
  - the building of 12 new towers
  - the rolling out 2 050 km of fibre and related active equipment with appropriate maintenance and administration
  - the gigabit speed connection of 5,000 entities in rural or remote areas
- That new plan implementation deadline is April 30, 2026
- The financing agreement of the new plan was signed in February 2024

Models of granting support - Benchmarking - Sweden

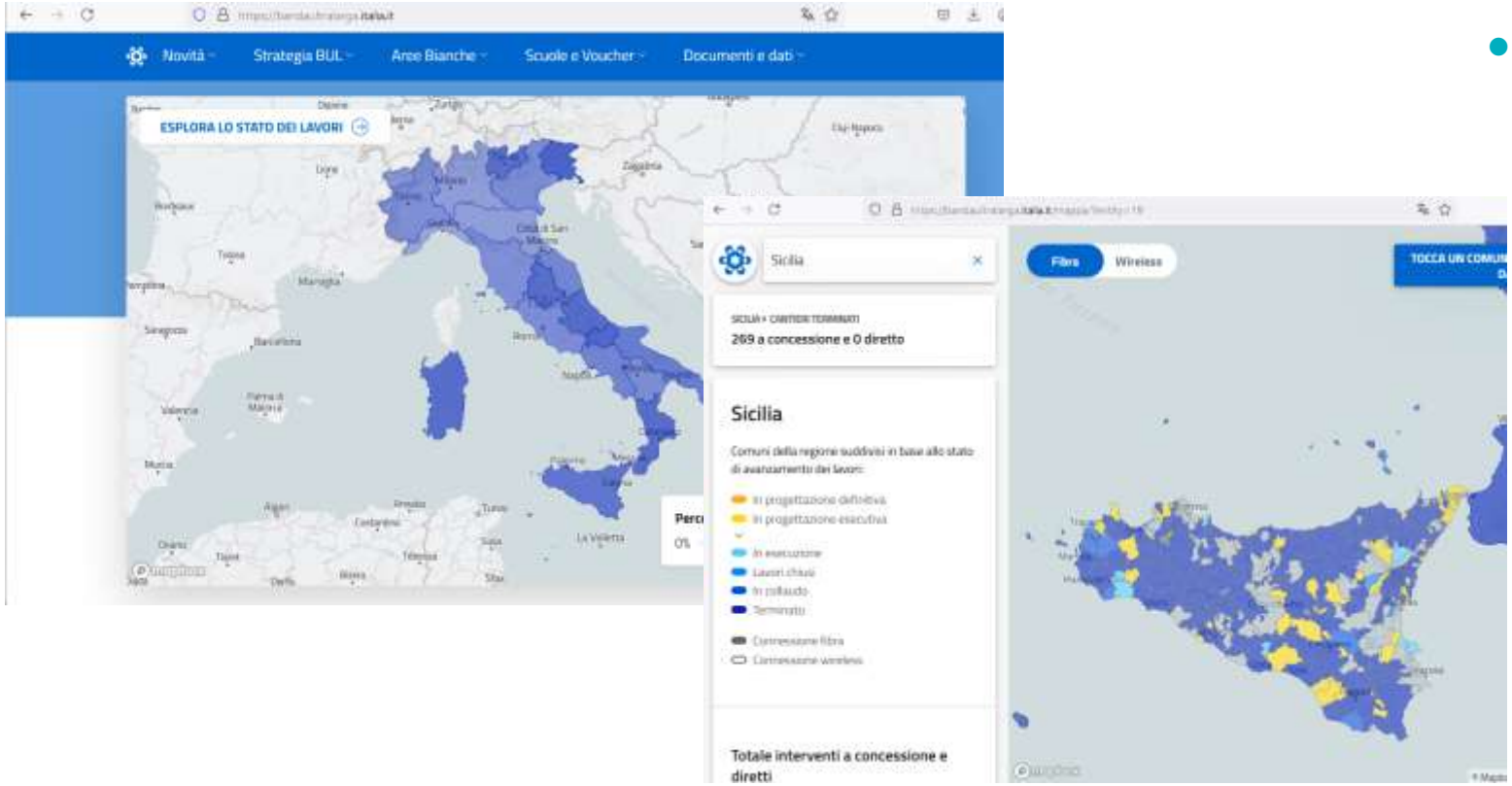
- The Sweden's national broadband plan was adopted in 2016. It had the vision of an entirely connected Sweden and had goals for both mobile coverage and for high-speed broadband connections for households and businesses
- The Swedish government objective was that :
  - 98 percent of the population should have access to broadband at a minimum capacity of 1 Gbps home, as well as in the workplace
  - the remaining 1,9 percent should have access to a minimum capacity of 100 Mbps
  - the residual 0,1 percent should have access to a minimum capacity of 30 Mbps, no later than the year 2025



- During the period 2014-2020, the Swedish government allocated for the rural development SEK4.45bn (~€0.4bn) in broadband support for expansion in areas where it is not commercially profitable to expand
- Later, through the Recovery and Resilience Fund, the Swedish government planned to invest SEK1.4bn in 2021, SEK500m in 2022, and thereafter SEK100m annually during the period 2023-2025, to expand the broadband throughout the country, and achieve the Swedish national broadband targets
- In addition, the Swedish government also made investments of SEK1.2bn within the regional fund for the expansion of larger local interconnection broadband networks in the three northern regional fund programs

Models of granting support - Benchmarking - Italy

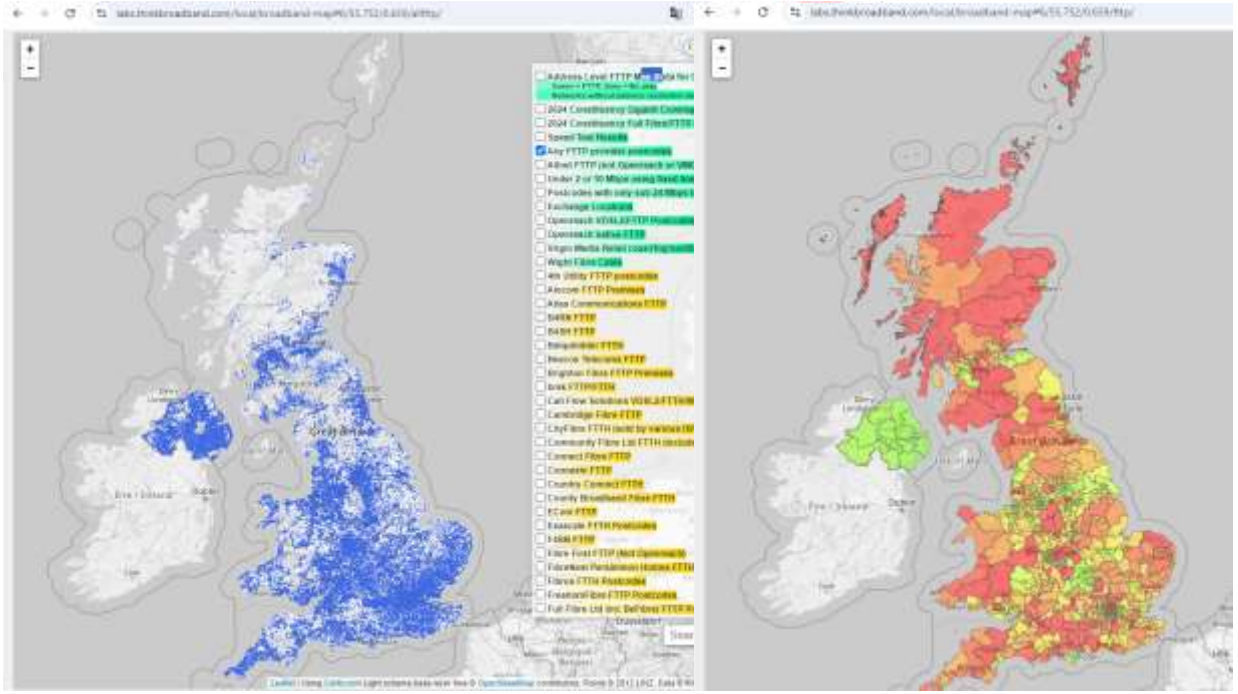
- Black areas rolled out with private funding
- National plan 1 - Banda Ultra Larga (Ultra Broadband), period 2020 – 2024: Mix FTTH/FWA plan for white areas (selection of 8.6m addresses in 7600 cities) + selected public site (health and school sites)
- National plan 2 - Banda Ultra Larga extension, period 2022 – 2026 (through European Recovery and Resilience Facility plan) : Extension to grey areas (selection of 6.9m addresses in the same and other cities than Plan 1),
- Private and public funded networks can be present in a same city



- For addresses with public funding :
  - Total of €6.8bn of public funding
  - Project divided into 15 regional lots, for each plan, all managed by Infratel (Italian State agency)
  - Technologic mix : FTTH (> 80%) / FWA (<20%)
  - Infratel uses turnkey contracts (concessions)
  - Public grant is capped to 70% of the expenses (as modelled in its offer by the operator selected to build and operate the network)
  - Concession contracts were won (~ half/half) by two operators : TIM (incumbent) and Openfiber
  - Private and public funds have invested massively in these public FTTH networks (shareholders + financing)

Models of granting support - Benchmarking - United Kingdom

- Project Gigabit plan is a nationwide coverage plan by 2030: nationwide means at least 99% of premises, wireless networks are considered as the most economically viable option in very hard to reach areas
- Project Gigabit is delivered by Building Digital UK (BDUK), an executive governmental agency within the Department for Digital Culture Media and Sport (DCMS)
- Government's policy is that gigabit-broadband infrastructure will be mostly built with private investment. Government's funding only targets homes and businesses that are not included in broadband suppliers' plans : rural and hard to reach areas
- Government promised £5b funding (subsidies) to deliver gigabit-broadband to properties not reached by the commercial market (around 20% of the UK / 5m addresses)



- Public funding :
  - £1.2bn budget / target of 1.6m addresses funded for the period 2020-2025
  - A complement of £3.8bn is planned for the years after 2025
  - £1bn government deal with the UK's four mobile network operators (EE, Three, VMO2 and Vodafone) to improve 4G coverage
- Government methodology :
  - 1 - Series of procurements (Superfast Program) subsidizing the roll-out in specific areas : Broadband suppliers bid for contracts to build a fibre access network in the area
  - 2 - A voucher scheme for residents and businesses in eligible rural areas to subsidize the cost of the connection (website with a postcode-checker to see if an address is in an eligible area) : up to £4,500 for homes and businesses help to cover the costs of installing gigabit broadband to people's doorsteps
  - 3 – Dedicated funding (GigaHubs) to connect public sector buildings such as schools