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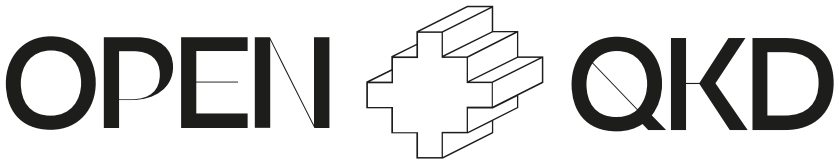
Open European Quantum Key Distribution Testbed



Report on Testbed and Use-Case Demonstrator Deployment

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More information available at https://openqkd.eu/.

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Version	Date	Reason/Change	Editor
1	9.3.2020	Templates for Input Request	HZ
2	20.4.2020	Draft out to Reviewers	HZ
2.1	23.4.2020	Corrections from contributors	HZ
3	24.4.2020	Corrections from reviewers	HZ, ChGo, ChGu

Executive Summary

This report gives the status-quo on the four main testbeds in Berlin, Madrid, Poznan and Vienna, as well as of the first use-case deployments in the test-site Geneva. This is a picture of the situation of mid-March, when almost all experimental activities had to stop in the involved institutions due to the covid-19 crisis, but this situation will not evolve until at least end of April, delivery date of this report.

Six QKD-links have been successfully installed in Geneva for the use-cases UC03 “quantum vault” and UC14 “SIG datacentre”. Whereas, secret keys have been exchanged on all link, the use-cases are not yet fully operating, since the testing phase had to be interrupted.

The main testbeds have been installed as planned and the activities should be able start following the deployment plan (D4.2), once the sanitary situation in the concerned countries allows us to so.

QKD device and encryptors installed at SIG Headquarter

Table of Contents

1. Introduction

1.1. Purpose and scope of the document

The purpose of this report is to give the status-quo of the 4 main testbeds in Berlin, Madrid, Poznan and Vienna, as well as of the first use-case deployments in the test-site Geneva. This is a picture of the situation of mid-March, when almost all experimental activities had to stop in the involved institutions due to the covid-19 crisis, but this situation will not evolve until at least end of April, delivery date of this report.

We give a rather detailed description of the use-cases already installed in Geneva. However, we just list the planned use cases and fibers at disposal for this purpose in the main testbeds, since we report on them in detail later.

1.2. Target audience

European Commission

1.3. Relation to other project work

WP7 is linked to many work packages and particular WP2 use cases and WP4 deployment. The situation on the deployment of the use cases at month 12 will be given in D2.2.

1.4. Structure of the document

The document has essentially two parts: Part one is about the installations in Geneva, part two gives the status-quo of the main test-sites in Berlin, Madrid, Poznan and Vienna.

2. Implementation of first use-cases in Geneva

2.1. Summary

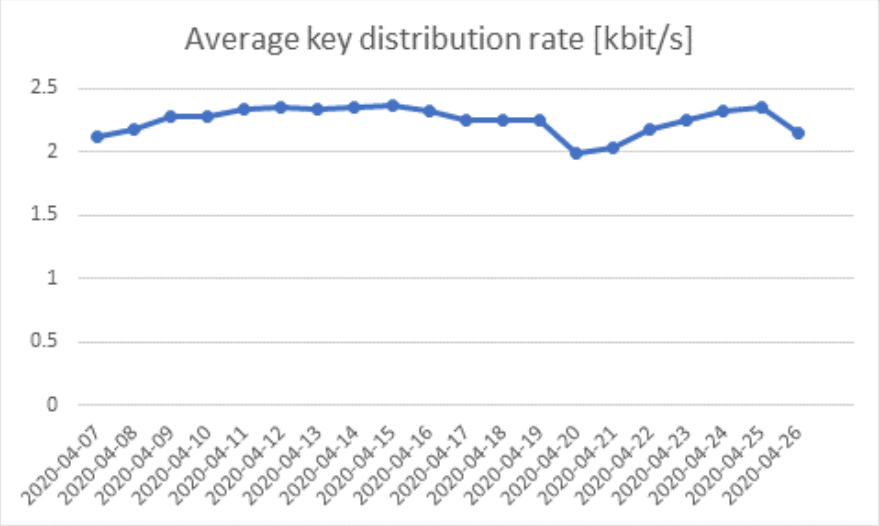
In Geneva two use-cases have been implemented so far:

- UC14 SIG Datacentre Replication:
  Interconnection between SIG headquarter and IBM Gigaplex Data Centre
- UC03: Quantum Vault:
  Main site SIG headquarter with key splitting to Data Centres Equinix 1 and 2, Safehost 1 , IBM Gigaplex and CERN.

Four stakeholders are involved in this project:

- ID Quantique
  - Provides QKD
  - Installation of the systems on site
- ADVA
  - Provides multiplexer, demultiplexer and encryptors for UC03's project
- SIG
  - Responsible for the fibre link between sites
  - Responsible for the hosting
  - Responsible for the management LAN network
- Mont Pelerin
  - Provides HSM for for UC14's project

Status: All QKD links are working since end of February 2020. See an example of the rate of distributed key over the last three weeks in the figure below:



Secret key rate distributed over one link for use-case 3.

Final tests for running the use-cases still have to be done after the confinement covid-19. Calls for new customers in the Geneva area interested in tests are open.

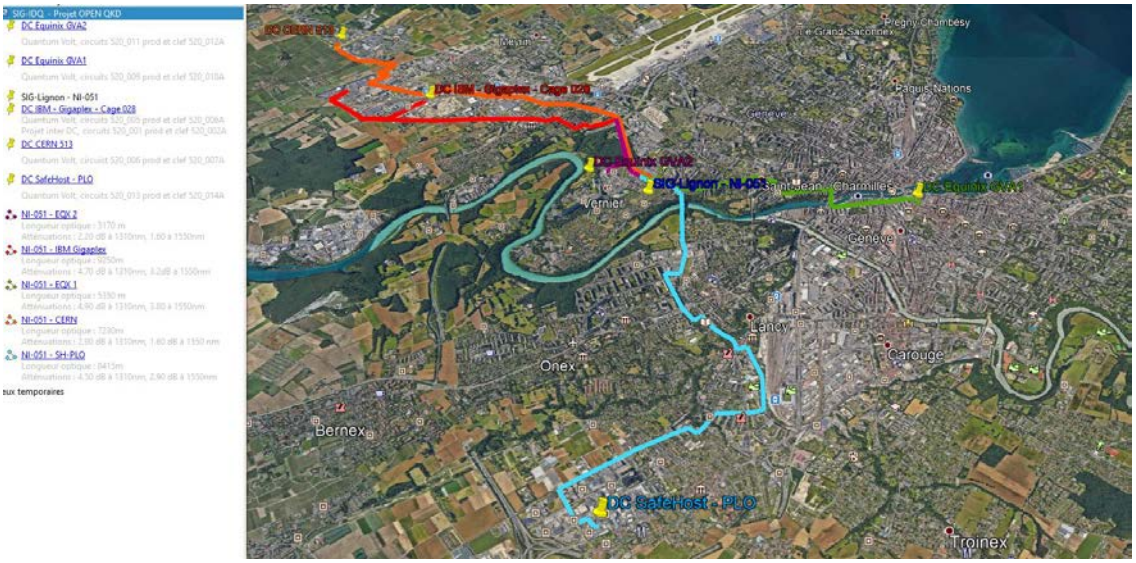
2.2. Network

Testbed location:	**Geneva**	**Responsible Partner**	**SIG**	
Number of nodes	6	Number of links	13	
Links PFO: pair of fibres SC: Service Channel QC: Quantic Channel	Length [km]	Loss [dB]	Dark/shared	Ready for use: yes/no
Ni51–Gigaplex, 4 PFO: 1 PFO for SC, 1 PFO for MUX, 2 PFO for QC	9.250	4.70 dB at 1310 3.20 dB at 1550	Dark	yes
Ni51–Safehost, 2 PFO: 1 PFO for SC1, PFO for QC	8.415	4.50 dB at 1310 2.90 dB at 1550	Dark	yes
Ni51–Equinix 1, 2 PFO: 1 PFO for SC , 1 PFO for QC	5.350	4.90 dB at 1310 3.80 dB at 1550	Dark	yes
Ni51–Equinix 2, 2 PFO: 1 PFO for SC, 1 PFO for QC	3.170	2.20 dB at 1310 1.60 dB at 1550	Dark	yes
Ni51 – CERN, 2 PFO: 1 PFO for SC, 1 PFO for QC	7.203	2.90 dB at 1310 1.60 dB at 1550	Dark	yes

Use case number	**14**	**Name**	**SIG Datacentre**	
Partners involved:	IDQuantique, SIG			
Starting date	01.2020	End date	12.2020	
No of used fibers (quantum/classical channel:	2 PFO (1 PFO and 1 single fibre effectively used)			
QKD equipment used:	IDQ01	Encryptors used:	Adva FSP3000 10G	
Comments:	Quantum and production channels are up and running but tests with real data production not started yet			

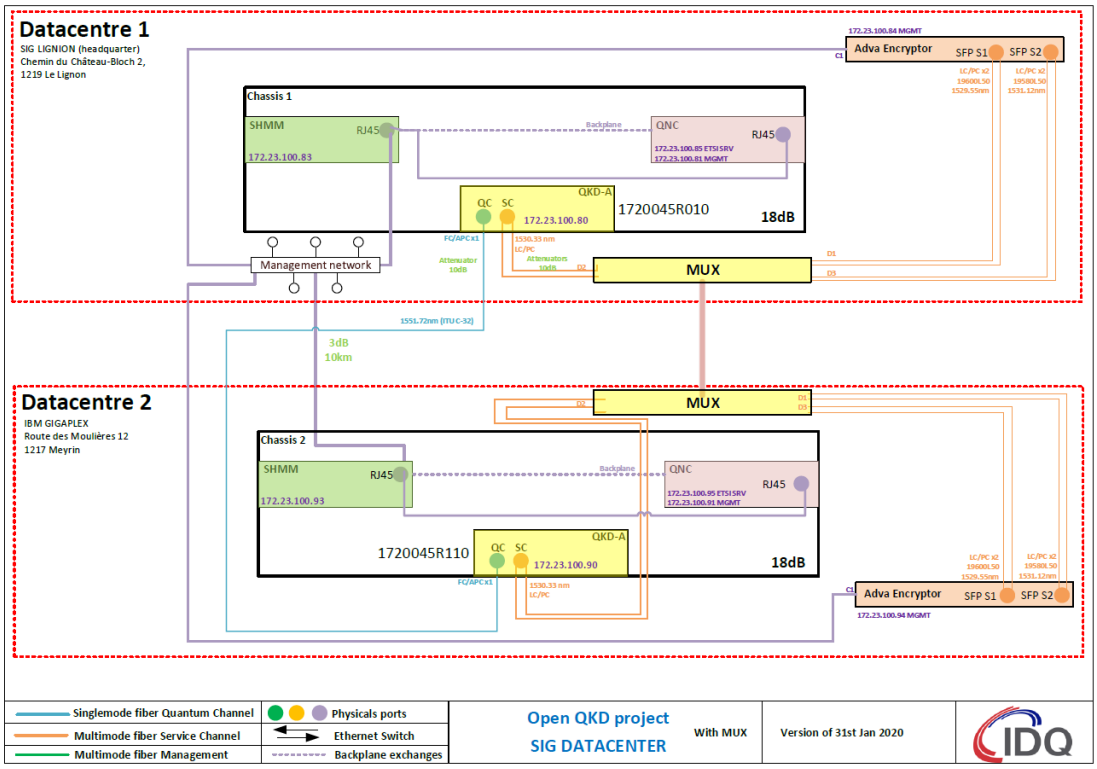
Use case number	3	Name	Quantum Vault	
Partners involved:	Mt-Pelerin	IDQuantique	SIG	
Starting date	03.2020	End date	12.2020	
No of used fibers (quantum/classical channel:	10 PFO (5 PFO and 5 single fibres effectively used)			
QKD equipment used:	IDQ02, IDQ03, IDQ04, IDQ05, IDQ06	Encryptors used:		
Comments:	Quantum and production channels are up and running. Key distribution (splitting) is working with success.			

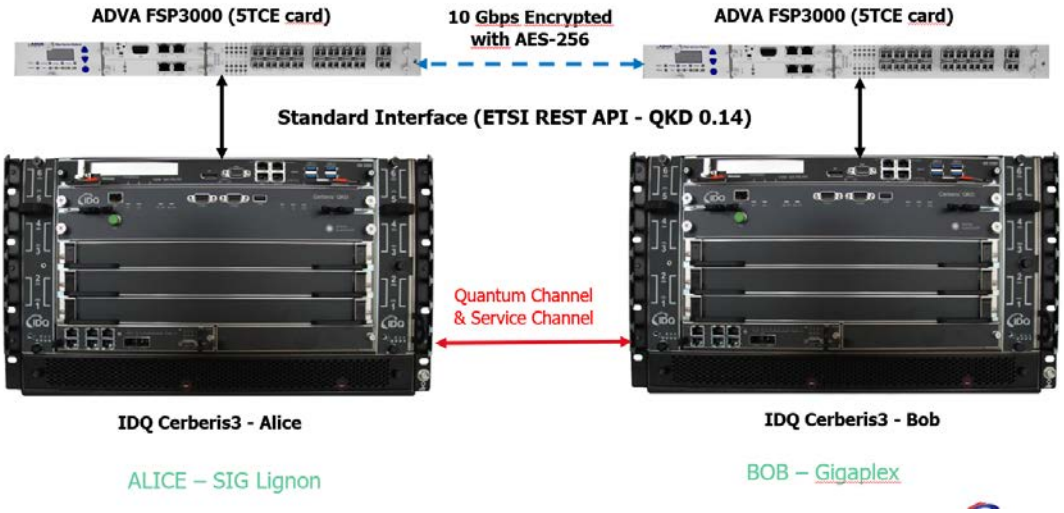
Map of the network:



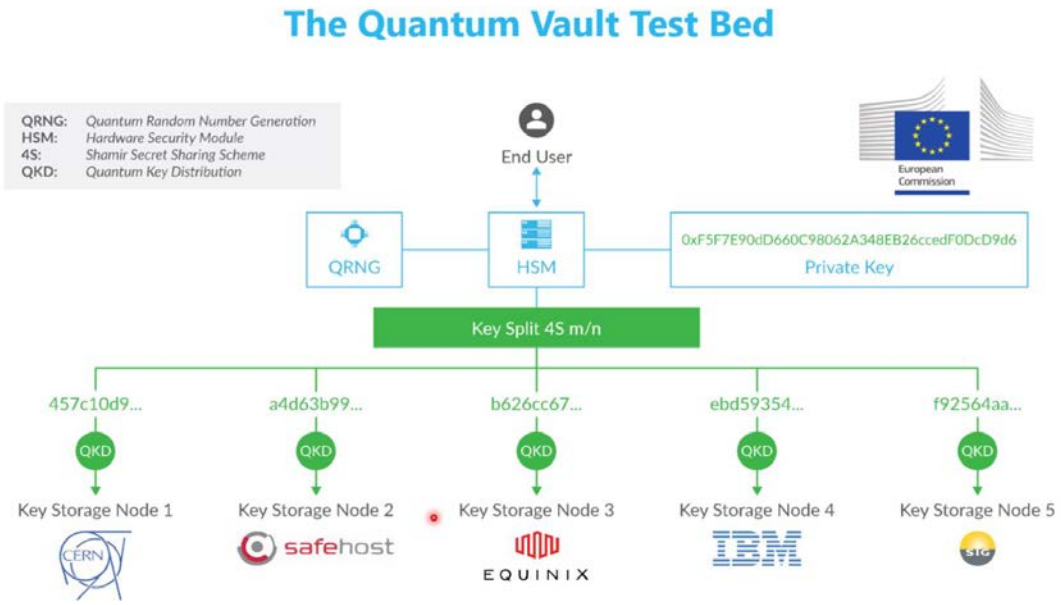
2.3. Schematics of the use-case layouts

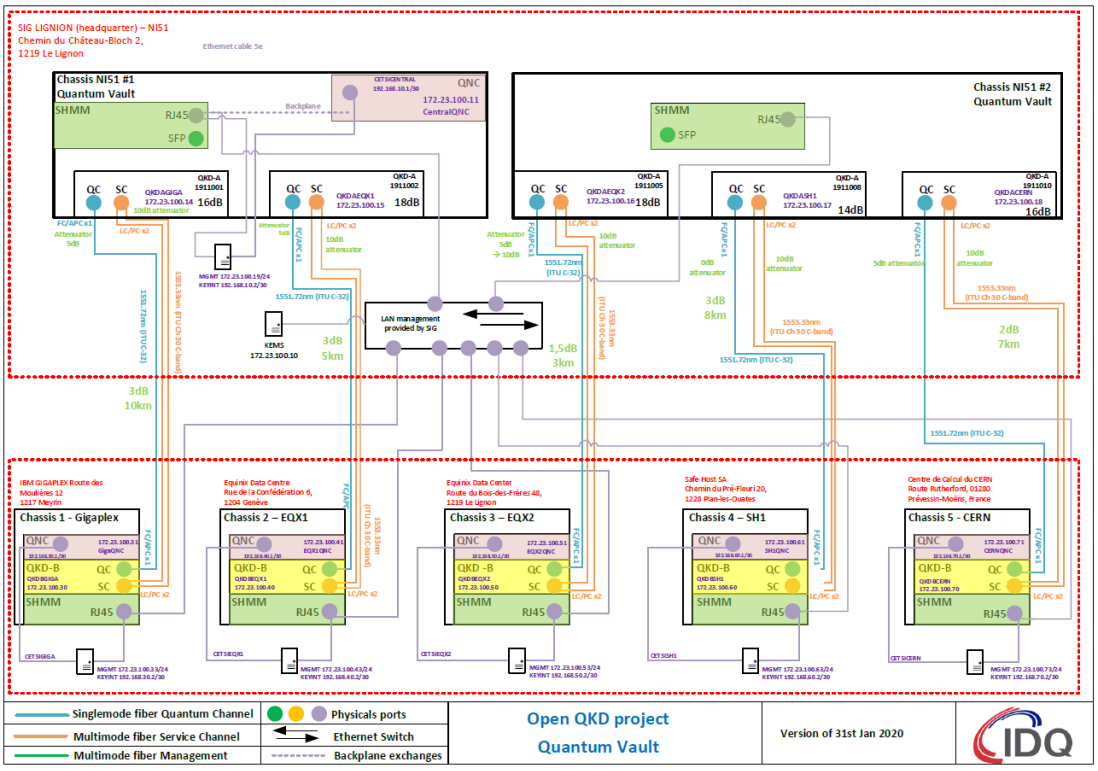
2.3.1. Use case #14 “data center”





2.3.2. Use case #3 Quantum Vault



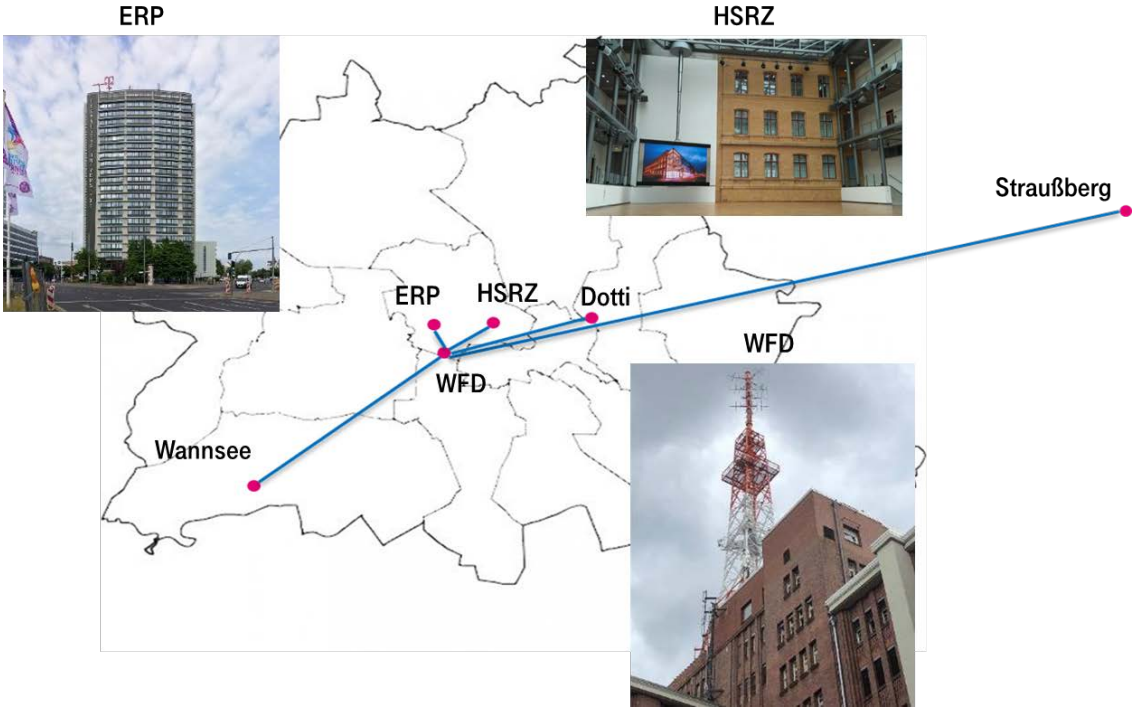


3. Status of the main testbeds

3.1. Berlin

The Berlin testbed can offer more than 8 links of various length, 4 of them are ready to use by April 2020. The first use-case is supposed to start in July 2020.

Testbed location:	**Berlin**	**Responsible Partner**	**Deutsche Telekom**	
Number of nodes	> 4	Number of links	> 8	
Link Number	Length [km]	Loss [dB]	Dark/shared	Ready for use: yes/no
1 WFD – DOT	15,3	4,2	Dark	Yes
2 WFD – HSR	10,6	3,2	Dark	Yes
3 WFD - ERP	8,5	3,7	Dark	Yes
4 WFD - KST	2,3	2,0	Dark	Yes
Use case number	**#27**	**Name**	**5G Networks**	
Partners involved:	DTAG, ADVA, Idquantique, Toshiba, Max Plank Institute, Rohde&Schwarz, Thales			
Starting date	07.2020	End date	01.2021	
No of used fibers (quantum/classical channel:	Tbd together with partners			
QKD equipment used:	IDQ, Toshiba	Encryptors used:	ADVA	
Comments:	The number of used nodes and fibers has to be discussed with the involved partners.			
Use case number	**#28**	**Name**	**QKD Network**	
Partners involved:	DTAG, ADVA, Idquantique, Toshiba, Max Plank Institute, Rohde&Schwarz, Thales, tbd			
Starting date	07.2021	End date	01.2022	
No of used fibers (quantum/classical channel:	Tbd together with partners			
QKD equipment used:	IDQ, Toshiba	Encryptors used:	ADVA	
Comments:	The number of used nodes and fibers has to be discussed with the involved partners.			



Map of the Deutsche Telekom TestNet Berlin

It includes different locations which are connected via dark fibers to the central location at Winterfeldtstrasse (WFD). There the fibers may be connected with respect to the OpenQKD requirements. Other locations are available at

- Ernst-Reuter-Platz (ERP)
- Hauptstadt Repräsentanz der Deutschen Telekom (HSRZ)
- Dottistrasse (Dotti))
- Straußberg (STB)
- Wannsee (WAS)

which may be used within the OpenQKD project. This depends on the discussions with the partners and respective requirements for the setup of the use cases.

3.2. Madrid

In Madrid, there is the largest testbed, it includes 13 links of various length between 2 and 60 km. 10 of them are ready to use by April 2020. A total of 6 use-cases are planned, the first one is scheduled to start in May 2020.

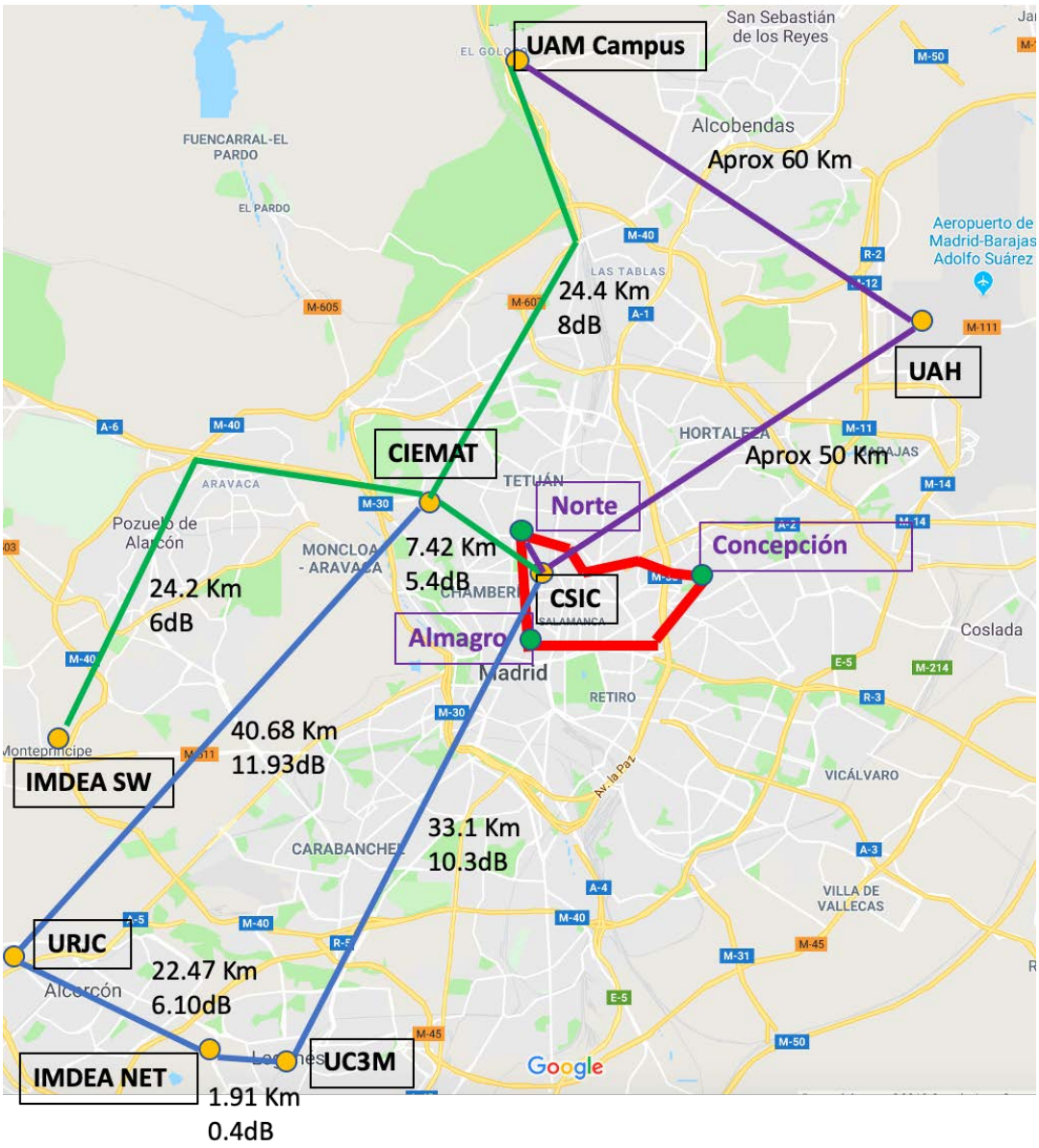
Testbed location:	**Madrid**	**Responsible Partner**	UPM (SW provider), TID (Testbed and SW provider), RM (Testbed provider),	
Number of nodes	11	Number of links	13	
Link Number	Length [km]	Loss [dB]	Dark/shared	Ready for use: yes/no
1 TID Almagro-TID Norte (TID)	3.9 Km	6	Dark	Yes
2 TID Norte-TID Concepción (TID)	5.5	7	Dark	Yes
3 TID Concepción-TID Almagro (TID)	6.4	7	Dark	Yes
4 CIEMAT-UAM (RM)	24.5	8	Shared	Yes
5 CIEMAT-IMDEA SW (RM)	24.2	6	Shared	Yes
6 CIEMAT-CSIC (RM)	7.42	5.4	Dark (1 pair) /Shared (1 pair)	Yes
7 CSIC- UC3M (RM)	33.1	10.3	Shared	Yes
8 UC3M-IMDEA Net (RM)	1.91	0.4	Shared	Yes
9 CIEMAT-URJC (RM)	40.68	11.93	Shared	Yes
10 URJC –IMDEA Net (RM)	22.47	6.1	Shared	Yes
11 NORTE-CSIC (in construction)	2 (approx.)	-	Dark	No
12 CSIC-UAH (pending)	50 (approx.)	-	Shared	No
13 UAH-UAM (pending)	60 (approx.)	-	Shared	No

Use case number	**16**	**Name**	**Critical Infra-structure protection (Telco)**
Partners involved:	UPM (SW provider), TID (Testbed and SW provider), RM (Testbed provider), TREL (QKD System provider), IDQ (QKD System provider)		
Starting date	05.2020 (1st phase)	End date	08.2020 (1st phase) 12.2020 (2nd phase)

	09.2022 (2nd phase)		
No of used fibres (quantum/classical) channel: Note: this point refers to Madrid Testbed optical link detailed description above.			
QKD equipment used: 4 links (TREL,IDQ) in the 1st phase	Encryptors used: Encryptors would be welcome, but not strictly necessary since the required encryption can be done in SW.		
Comments: 1. -4 Links first phase (UPM-CIEMAT-CSIC-UC3M-IMDEA NW) 2. -8 links second phase (previous ones plus the Telefónica Ring and the CSIC-NORTE link connecting RM network and Telefónica Network). Possibility to add two links more for demonstrating alternate routes.			
Use case number	**24**	**Name**	**QKD for B2B and 5G networks**
Partners involved:	UPM (SW provider), TID (Testbed and SW provider), RM (Testbed provider), TREL (QKD System provider), IDQ (QKD System provider)		
Starting date	05.2020	End date	08.2020
No of used fibres (quantum/classical channel): Note: This point also refers to Madrid Testbed optical link detailed description above.			
QKD equipment used: 4 Links first phase: CSIC-UC3M (TREL-1 tbc), UC3M-IMDEA NW (TREL-2 tbc), CSIC-CIEMAT (IDQ-10), CIEMAT-IMDEA SW/UPM (IDQ-11) 8 Links second phase (the 4 above plus CSIC-Norte, Norte-Concepción, Concepción-Almagro and Almagro-Norte)	Encryptors used: Encryption possible in SW for the first phase 6 links in the second phase		
Comments:			

Use case number	**18**	**Name**	**Security in e-health services**
Partners involved:	UPM (SW provider), TID (Testbed and SW provider), RM (Testbed provider), TREL (QKD System provider), IDQ (QKD System provider)		
Starting date	10.2020	End date	02.2021
Starting date	09.2021	End date	01.2022
No of used fibres (quantum/classical) channel: Note: this point refers to Madrid Testbed optical link detailed description above. Nine possible places (fiber) can be used for this test, plus 1-2 free space links. Six of them (fiber) are in the RM network and they can be accessed with less restrictions and the other three are within the Telefonica production network, with much more restricted access.			
QKD equipment used:	4 systems (TREL,IDQ)	Encryptors used:	3 link encryptors would be needed.

Comments:			
Use case number	**15**	**Name**	**Network security and attestation**
Partners involved:	UPM (SW provider), TID (Testbed and SW provider), RM (Testbed provider), TREL (QKD System provider), IDQ (QKD System provider)		
Starting date (1st phase)	05.2020	End date	08.2020
Starting date (2nd phase)	05.2022	End date	08.2022
No of used fibres (quantum/classical) channel: Note: this point refers to Madrid Testbed optical link detailed description above.			
QKD equipment used: 3 Links in first phase 7 links in second phase (TREL,IDQ)		Encryptors used: Encryptors are required	
Comments: First phase deployment: three Links, May-Jul 2020			
Use case number	**25**	**Name**	**Self-healed network management**
Partners involved:	UPM, TID, RM, TREL, IDQ		
Starting date	09.2021	End date	12.2021
No of used fibres (quantum/classical) channel: Note: this point refers to Madrid Testbed optical link detailed description above.			
QKD equipment used: 6 systems (TREL,IDQ)		Encryptors used: Encryptors are not strictly necessary since the required encryption can be done in SW.	
Comments:			
Use case number	**17**	**Name**	**QKD as a Cloud Service**
Partners involved:	UPM (SW provider), TID (Testbed and SW provider), RM (Testbed provider), TREL (QKD System provider), IDQ (QKD System provider)		
Starting date	12.2021	End date	04.2022



Map of the Madrid Network

3.3. Poznan

The Poznan testbed has 9 links of various length between 4 and 71 km, 7 of them are ready to use by April 2020.

The first use-case is supposed to start in May 2020.

Testbed location:	**Poznań Poland**	Responsible Partner	PSNC	
Number of nodes	8	Number of links	9	
Link Number	Length [km]	Loss [dB]	Dark/shared	Ready for use: yes/no
1. PSNC-01 to PSNC-04 (UC-09)	8	2	Dark and shared	no
2. PSNC-01 to PSNC-05 (UC-08)	4	2	Dark and shared	yes
3. PSNC-01 to PSNC-03 (UC-07)	9	2.5	Dark and shared	yes
4. PSNC-01 to PSNC-02 (UC-01)	6	1.5	Dark and shared	yes
5. PSNC-01 to PSNC-02 (UC-01)	4	1	Dark and shared	yes
6. Data Center VSB – Cieszyn PSNC PoP (UC-06)	71	25	Shared	yes
7. PSNC-01 to PSNC-07 (UC-10)	5	2	Dark and shared	no
8. PSNC-01 to PSNC-02 (UC-11)	6	1.5	Dark and shared	yes
9. PSNC-01 to PSNC-02 (UC-11)	4	1	Dark and shared	yes
Use case number	**UC-01**	**Name**	**High Performance Computing**	
Partners involved:	PSNC, ADVA, TOSHIBA			
Starting date	01.04.2020	End date	30.06.2020	
No of used fibers (quantum/classical channel:	2/4			
QKD equipment used:	TRL	Encryptors used:	ADVA	

Comments:	none			
Use case number	**UC-06**	**Name**	**High Performance Computing**	
Partners involved:	PSNC, TRL, VSB, ADVA			
Starting date	01.07.2020	End date	30.09.2020	
No of used fibers (quantum/classical channel:	Shared – existing 2 fiber transmission			
QKD equipment used:	TRL	Encryptors used:	ADVA	
Comments:	none			
Use case number	**UC-07**	**Name**	**Healthcare**	
Partners involved:	PSNC, TRL, ADVA			
Starting date	01.08.2020	End date	31.10.2020	
No of used fibers (quantum/classical channel:	1/2			
QKD equipment used:	TRL	Encryptors used:	ADVA	
Comments:	none			
Use case number	**UC-08**	**Name**	**e-Government**	
Partners involved:	PSNC, TRL, ADVA			
Starting date	01.01.2021	End date	31.03.2021	
No of used fibers (quantum/classical channel:	1/2			
QKD equipment used:	TRL	Encryptors used:	ADVA	
Comments:	none			
Use case number:	**UC-09**	**Name:**	**Banking**	
Partners involved:	PSNC, TRL, ADVA			
Starting date	01.06.2021	End date	31.08.2021	
No of used fibers (quantum/classical channel:	1/2			

QKD equipment used:	TRL	Encryptors used:	ADVA	
Comments:	none			
Use case number	**UC-10**	**Name**	**Police**	
Partners involved:	PSNC, TRL, ADVA			
Starting date	01.04.2021	End date	30.06.2021	
No of used fibers (quantum/classical channel:	1/2			
QKD equipment used:	TRL	Encryptors used:	ADVA	
Comments:	none			
Use case number	**UC-11**	**Name**	**Time signal reference distribution**	
Partners involved:	PSNC, TRL, ADVA			
Starting date	01.09.2021	End date	28.02.2022	
No of used fibers (quantum/classical channel:	2/4			
QKD equipment used:	TRL	Encryptors used:	ADVA	
Comments:	none			

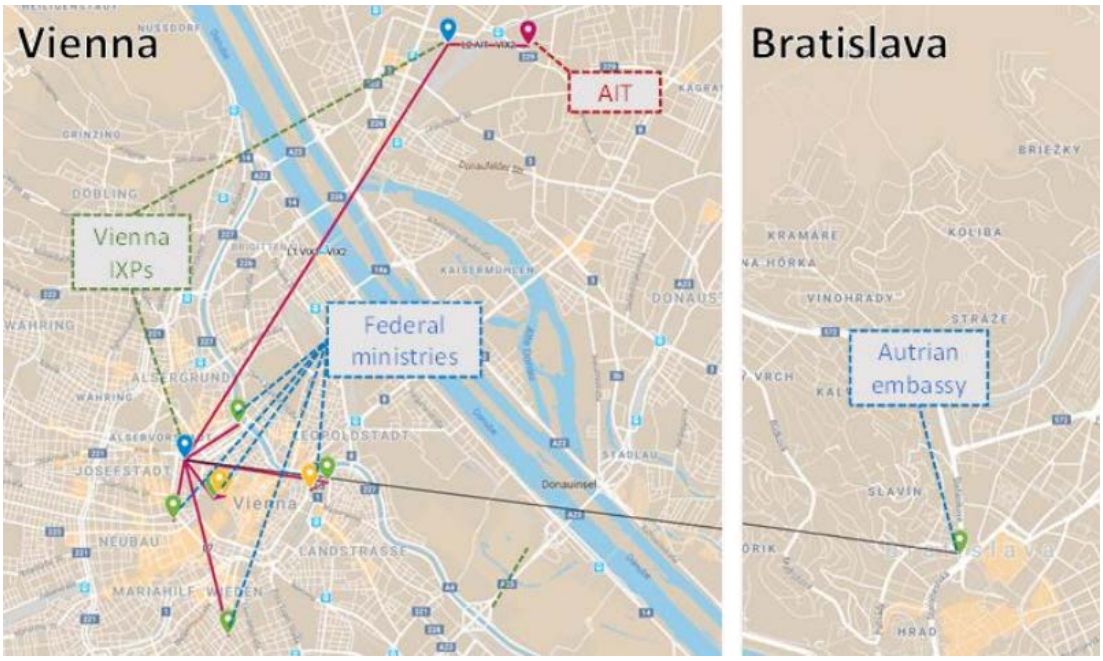
Map of the Poznan network

3.4. Vienna

The Vienna testbed has 7 links of various length between 2 and 70 km. As foreseen, only the longest link is ready to use by April 2020. The fiber link between AIT and Vienna Internet eXchange node 2 is currently tendered and is expected to be operational in autumn 2020. Negotiations with the Austrian Ministries are currently under way to finalise the location of the demonstrating sites. The first use-case in Vienna is supposed to start only in January 2021.

Testbed location:	Vienna	Responsible Partner	AIT	
Number of nodes	8	Number of links	7	
Link Number	Length [km]	Loss [dB]	Dark/shared	Ready for use: yes/no
1	2,1	0,74	dark	no
2	13,6	4,75	dark	no
3	4,3	1,52	TBC	no
4	5,2	1,81	TBC	no
5	4,5	1,57	TBC	no
6	2,3	0,78	TBC	no
7	70	16,1	dark	yes
Use case number	**5**	**Name**	**Data encryption between governmental agencies**	
Partners involved:	AIT, Usecase Coordinator MPL, QKD device provider AIT, Testbed provider ADVA, Encryptor provider RSCS, Rohde & Schwarz Cybersecurity GmbH IDQ, QKD device provider TREL, QKD device provider			
Starting date	01.2021	End date	06.2021	
No of used fibers (quantum/classical channel:	6/12			
QKD equipment used:	MPL, IDQ, TREL	Encryptors used:	ADVA, RSCS	
Comments:				
Use case number	**29**	**Name**	**Distributed cloud storage secured by ITS QKD**	
Partners involved:	AIT, Usecase Coordinator MPL, QKD device provider AIT, Testbed provider ADVA, Encryptor provider RSCS, Rohde & Schwarz Cybersecurity GmbH FRX, Encryptor provider IDQ, QKD device provider TREL, QKD device provider			

Starting date	07.2021	End date	12.2021	
No of used fibers (quantum/classical channel:	6/12			
QKD equipment used:	MPL, IDQ, TREL	Encryptors used:	ADVA, RSCS, FRX	
Comments:				
Use case number	**19**	**Name**	**Academic network backbone**	
Partners involved:	OEAW, Usecase Coordinator OEAW, Testbed provider and QKD device provider AIT, Testbed provider and QKD device provider ADVA, Encryptor provider RSCS, Rohde & Schwarz Cybersecurity GmbH IDQ, QKD device provider TREL, QKD device provider			
Starting date	01.2022	End date	06.2022	
No of used fibers (quantum/classical channel:	3/6			
QKD equipment used:	OEAW, IDQ, TREL, AIT	Encryptors used:	ADVA, RSCS	
Comments:	One long distance QKDsystem needed			
Use case number	**20**	**Name**	**Inter-government cross-border link**	
Partners involved:	AIT, Usecase Coordinator OEAW, Testbed provider and QKD device provider AIT, Testbed provider ADVA, Encryptor provider RSCS, Rohde & Schwarz Cybersecurity GmbH IDQ, QKD device provider TREL, QKD device provider			
Starting date	03.2022	End date	06.2022	
No of used fibers (quantum/classical channel:	4/8			
QKD equipment used:	OEAW, IDQ, TREL	Encryptors used:	ADVA, RSCS	
Comments:	Maybe one additional link in Bratislava			



Map of the Vienna Network

4. Overview on the other test sites

Beside the four main test-beds, use cases will be run on ten other sites all over Europe.

The following tables gives an overview:

Location	Country	Responsible Partner	Use case	# of Links	Fiber lengths	Comments
Athens	GRE	MLNX	12	1	< 1km	INTRA data center demonstration
Barcelona	ES	ICFO	32	1	10-30 km	CV QKD
Cambridge	UK	TREL	30, 31	12	0-12 km 500 km	Metro network long-distance back-bone
Delft	NL	TUD	22	1	10 km	
Geneva	CH	SIG	2, 13, 14	13	3-10 km	
Graz	A	MUG	21	6	9-30 km	
Oberpfaffen-hofen	D	DLR	23	2	0.2-2km	Link1: Emulated Satellite link Link2: inter/intra building fiber link
Ostrava	CZ	VSB	6	1	75 km	
Padova	I	UNIPD	24	2	0.1-10	1 Free space 1 fiber
Paris	F	CNRS	4	3	0.2 – 28.5 km	