D5.2 – Impact creation report and initial exploitation plan

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Abstract	The main purpose of this deliverable is to provide an initial report on the impact creation and an initial plan for the exploitation of the project results. Key aspects described in this deliverable are the achieved impact of the project achievements on society, dissemination to targeted groups such as potential customers, industry players, and end-users, and plans for exploitation of project results to other peers and exchange of results with other Horizon Europe/DEP/CEF and national QCI initiatives such as LUQCIA. This is the second version of the document, as its first version (D5.1, Dissemination and exploitation) was submitted on M05, and the final version of this report will be produced by M30 (D5.3, Final impact report, roadmap and exploitation plan), in line to further develop and improve the communication and dissemination of the project results in line also with the technical deployment of the results.
Keywords	Dissemination & Communication, engagement strategies, exploitation of project results

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V0.1	15.03.2024	Prepared the initial draft. Report prepared on dissemination and exploitation. Exploitation plan carried from D5.1.	Junaid ur Rehman(UNILU)
V0.2	18.03.2024	General review of the report	Rudy Stranen (SMC)
V0.3	10.04.2024	General review of the report	Christine Muller (SMC), Jorge Gonzalez (UNILU), Symeon Chatzinotas (UNILU), Arash Atashpenda (IAL)r, Antoni Hernandez (SES), Zaira Ambu (UNILU), Stefan Winter (RES)

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Nature of the deliverable:	**R**	
Dissemination Level		
PU	*Public, fully open, e.g. web (Deliverables flagged as public will be automatically published in CORDIS project's page)*	✓
SEN	*Sensitive, limited under the conditions of the Grant Agreement*	
Classified R-UE/ EU-R	*EU RESTRICTED under the Commission Decision No2015/ 444*	
Classified C-UE/ EU-C	*EU CONFIDENTIAL under the Commission Decision No2015/ 444*	
Classified S-UE/ EU-S	*EU SECRET under the Commission Decision No2015/ 444*	

* R: Document, report (excluding the periodic and final reports)

DEM: Demonstrator, pilot, prototype, plan designs

DEC: Websites, patents filing, press & media actions, videos, etc.

DATA: Data sets, microdata, etc.

DMP: Data management plan

ETHICS: Deliverables related to ethics issues.

SECURITY: Deliverables related to security issues

OTHER: Software, technical diagram, algorithms, models, etc.

EXECUTIVE SUMMARY

Deliverable D5.2, “Impact creation report and initial exploitation plan,” provides a first report on the impact creation during Lux4QCI activities as well as an initial plan for the exploitation of project results. This report includes the achievements for WP5 in light of the previously reported Dissemination and exploitation plan.

The impact creation report includes the development of communication and dissemination tools such as the project website, project poster, and specific channels for knowledge creation and sharing, such as training courses, project demonstration, and participation in national and international events. In addition to communication and dissemination activities envisaged in the proposal and in the earlier version (D5.1) of this report, further activities were identified and carried out, which are also reported in this document. During the project duration, possible new activities will be identified and added to the table in a continuous monitoring approach.

The initial exploitation plan considers specific stakeholders as possible early adopters of the technology. Targeting these identified stakeholders, two dedicated workshops were organized under WP2. Results of this interaction informed our exploitation plans, which we report here.

Moreover, the project performance is reported against the initially defined performance indicators, some of which are strictly related to communication, dissemination, and exploitation activities. This document is an intermediary version, and during the project duration, the final reporting version will be produced by M30 (D5.3, Final impact report, roadmap, and exploitation plan). An earlier version of this document was produced by M05 (D5.1 Dissemination and exploitation)

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ABBREVIATIONS

C&D&E	Communication, Dissemination, and Exploitation
BeQCI	Belgium QCI
CEF	Connecting Europe Facility
CYBERUS	Erasmus Mundus Joint Master in Cybersecurity
DEP	Digital Europe Programme
DLH	Digital Learning Hub
ESA	European Space Agency
ETWG	EuroQCI Thematic Working Group
EU	European Union
EuroQCI	European Quantum Communication Infrastructure
HSM	Hardware Security Module
HW	Hardware
ICT	Information and Communications Technology
ISM	Integrated Space Master
LHC	Luxembourg House of Cybersecurity
Lux4QCI	Luxembourg Experimental Network for Quantum Communication Infrastructure
OGS	Optical Ground Station
PMB	Performance Management Board
PSO	Project Security Officer
QCI	Quantum Communication Infrastructure
QIB	Quantum Industry Board
QKD	Quantum Key Distribution
SAB	Security Advisory Board
SMC	Service des médias, de la connectivité et de la politique numérique
SME	Small and Medium-Sized Enterprises
SnT	The Interdisciplinary Centre for Security, Reliability and Trust
SW	Software
TRL	Technology Readiness Level
TTO	Technology Transfer Office
UEP	User Endpoint

1 IMPACT CREATION REPORT

Within the framework of the Lux4QCI project, a concrete communication, dissemination, and exploitation (C&D&E) plan was elaborated in D5.1: Dissemination and exploitation.

The main objectives of the plan are:

- Ensure broad visibility and raise awareness about Lux4QCI, spreading knowledge about the project and its results.
- Reach, stimulate, and engage a critical mass of stakeholders from the various domains of intervention to ensure that LUX4QCI results are effectively showcased, leading to validation, expansion, and improvement.
- Facilitate the exploitation of the project's outputs and further adoption.
- Foster impactful contribution to relevant scientific domains and standardisation bodies, as appropriate and relevant to the planned exploitation plans
- Ensure close coordination with relevant initiatives, research, standardisation working groups and bodies
- Ensure and promote contribution to policies as planned

The plan will be used as a tool to inform all relevant stakeholders about the project's scope and objectives and to define the liaisons and interaction mechanisms with relevant entities and players, including further actions supported by DEP, Horizon Europe, Connecting Europe Facility, ESA, and others funded by further funding schemes and instruments. In order to achieve these results, the plan has been divided into the following phases (Fig.1):

- **Phase 1 Awareness creation and communication foundation:** this phase took place from M01 until M08, and it concerned the design of the C&D&E strategy and plan, including detailed definition and lists of target groups and selection of dedicated tools and community-building activities; to inform all relevant stakeholders about the project's scope and objectives; to define the liaisons and interaction mechanisms with relevant entities and players, including further actions supported by DEP, Horizon Europe, Connecting Europe Facility, ESA, and others funded by further funding schemes and instruments
- **Phase 2 Community outreach, initial results dissemination:** This phase is ongoing; it started from M09 and will last until M20, and it will aim to reach out to the main target stakeholders, generate interest in Lux4QCI, and increase awareness of the target groups in the first project results, development and deployment activities, active collaboration with other outbound national initiatives
- **Phase 3 Global outreach and sustainable impact:** from M21 until M30, the aim is to actively engage and support the adoption and deployment of the network, technologies, know-how, and research concepts and achievements of the project through dedicated promotional activities

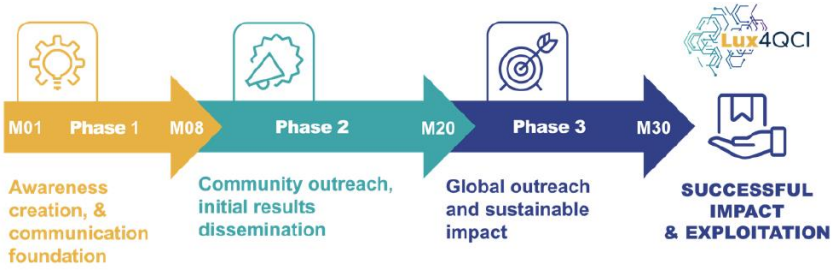

Figure 1: Three phases of impact creation and exploitation envisaged in Lux4QCI

1.1 COMMUNICATION AND DISSEMINATION MEANS

The project also established a set of communication and promotional tools. Here, we report on their status.

- **LUX4QCI visual identity and promo kit**, comprising brand guidelines needed for all applicable online or offline channels and collaterals. For example, Figure 2 below shows the poster designed to communicate Lux4QCI on various events.

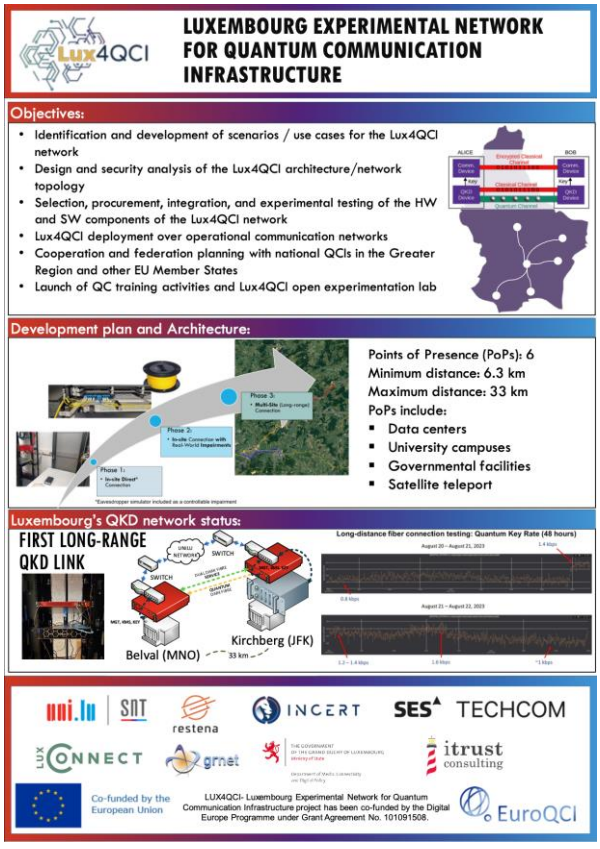

Figure 2: Poster to communicate Lux4QCI on several events. Information sanitized by the SAB.

- **LUX4QCI website** (www.Lux4QCI.eu): The Lux4QCI website is not active and is populated with general information on the project, partners' participation, aims, and all the information. In the future, the website will also contain produced results that have been classified as Public and have been allowed to be communicated widely after SAB (Security Advisory Board) and PSO (Project Security Officer) security evaluation.

- **PETRUS website:** The project is disseminated on the Petrus website, improving the visibility and allowing to connect to similar projects, exchanging knowledge and knowhow (https://petrus-euroqci.eu/?location=lu).

- **PETRUS network events:** within the framework of the joint participation, the LUX4QCI consortium also took part in events organized by the Petrus network on EuroQCI and QKD. Lux4QCI has participated in the following Petrus events:

    - A first event was held on the 11th of April 2023 for the NatQCI representatives to introduce the projects and the activities that will be carried out in each EuroQCI project, creating a network.

    - Various EuroQCI thematic working groups (ETWGs) events including:

        - Kickoff meeting of ETWG on Roadmap: October 12, 2023

        - In-person ETWG conference in Brussels (November 07-09, 2023)

        - Various online meetings for ETWG. For instance, SES Techcom attends the ETWG on Architecture meetings on a weekly basis

- **Social media:** The project was communicated on social media posts by the coordinator as well as by the consortium partners in various social media posts that reached a wide audience. For example, Figure 3 shows an excerpt of a LinkedIn post from SnT's official page. Figure 4 shows a LinkedIn post for the official SES Satellite page to advertise one of the organized workshops within Lux4QCI.

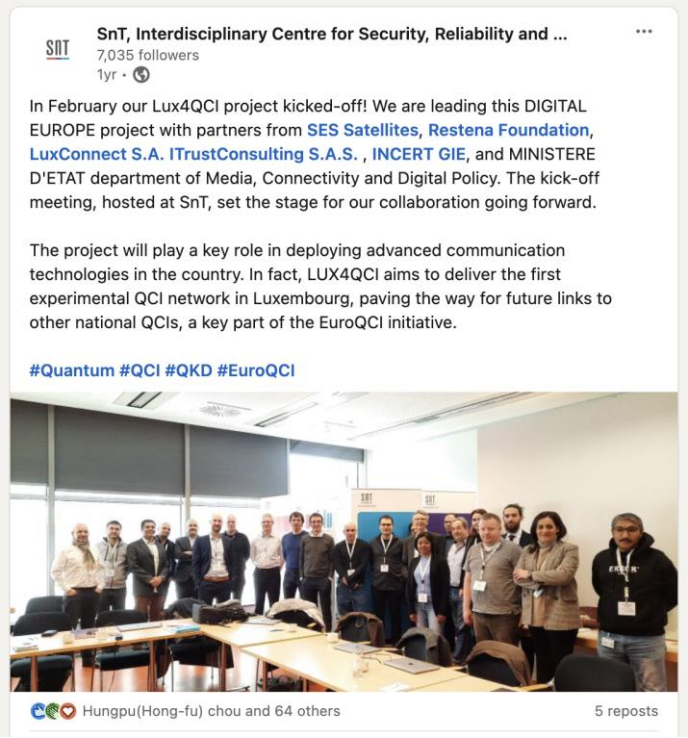

Figure 3: An excerpt of a LinkedIn post by SnT official channel.

Figure 4: LinkedIn post by official page of SES Satellites advertising the QKD for healthcare sector workshop,

- **Newsletter/newsflashes:** The Lux4QCI website was used to regularly update the information about the project activities, including the upcoming workshops, registration

information, and upcoming courses. Additionally, dedicated news items were reported on official links, including

  - News on UniLu website, including the news item as well as advertising the ICT spring keynote talk of Prof. Symeon Chatzinotas [Link]
  - Print interview of Prof. Symeon Chatzinotas [Link]
  - News article on the interview of Dr. Junaid ur Rehman on UniLu website [Link]

- **Dedicated events (workshops, exhibitions, webinars):** to help increase the visibility of the developed technologies and trials, non-related to EU Restricted information showcasing achievements and promoting the increased deployment of LUX4QCI results. In particular, the following activities were carried out under WP2:
  - **A QKD workshop for the Banking & Financial Sector was held at SnT on October 11, 2023.** The Lux4QCI consortium, in close collaboration with the ABBL (Luxembourg Banker's Association) and the LoHFT (Luxembourg House of Financial Technology), orchestrated this informative and interactive session. The convergence of experts and professionals from both sectors made this workshop a key milestone in stakeholder engagement and market development. The event provided a unique opportunity to unveil the transformative potential and security implications of Quantum Key Distribution within the banking and financial sector. Attendees were also treated to a firsthand experience through a demo lab visit, allowing them to witness the real-world application of QKD technology. This workshop exemplified the Luxembourg Financial and Banking sectors' commitment to innovation, security, and staying at the forefront of technological advancements.
  - **A QKD workshop for the Healthcare Sector was organized on December 07, 2023, at Luxembourg House of Cybersecurity**. Specific cryptographic needs of the healthcare sector and how Quantum Key Distribution (QKD) can be used to improve the security of healthcare data were discussed during dedicated roundtable discussions.
  - **Space Café Benelux** on July 27, 2023. It was an interview-style webinar to talk about the QCI project in Luxembourg carried out by SMC.
  - **Webinar on Quantum Technologies for Communications** by Prof. Symeon Chatzinotas discussed quantum technologies and QCI. [YouTube link]

- **Press releases:** Dedicated press releases were released on official channels (social media as well as Lux4QCI website) of the coordinator and partners, e.g., project kickoff and to advertise the two workshops and educational courses. For example:
  - Press release on the beginning of quantum communication classes [Link]
  - Press release on UniLu website about Lux4QCI workshop [Link]
  - LuxConnect press release for creating awareness on Lux4QCI [Link]

- Press release by Restena for creating awareness on Lux4QCI [Link]

The project has also envisioned a series of dissemination measures, which are:

- **Participation and organization of events and trainings:** in the form of webinars, workshops, demos, expert panels' discussions, and training will play a crucial role. The Consortium envisages organizing/participating in at least 20 workshops / sessions / webinars pursuing co-location with related national and EU initiatives, including actions from DEP/Horizon Europe/CEF/ESA, etc. Planned activities include: at least 2 events per year jointly organised with other liaised initiatives and the CSA funded under the same Call (>6), 2 showcasing events presenting and demonstrating the project validation activities and achievements, 5 international collaboration workshops with the liaised national representatives of EuroQCI, 3 yearly training webinars / sessions, at least 2 requirements workshops (and interviews). In particular, the following concrete activities have been currently envisioned to be carried out to support the application of quantum technologies and to provide a better understanding of their value for different kinds of stakeholders:

    - **Trainings:** Digital Learning Hub, a beginner training course for specialists in the sector of communication engineering looking to build expertise in the quantum area. The training aims to explain the primary motivation of quantum communications and quantum computing, the basic working of quantum information systems as well as to identify the potential use-cases of these technologies and explain the current status of these technologies. Three training courses were offered:

        - Introduction to Quantum Computing and Communications - Digital Learning Hub (dlh.lu) on June 02, 2023.

        - Quantum Computing: Basic Theory and Future Expectations – Digital Learning Hub (dlh.lu) on November 27, 2023

        - Quantum Communications: Theory and Applications – Digital Learning Hub (dlh.lu) on November 27, 2023

    - **Courses:** Quantum Communications and Quantum Key Distribution, this is a winter semester (2023/2024) course for University students as part of the Erasmus Mundus Joint Master in Cybersecurity (CYBERUS) that was held by Prof. Symeon CHATZINOTAS together with Dr. Junaid UR REHMAN. The course was designed to familiarize the attendees with the framework of quantum communication systems, and it covers the following topics:

        - Review of linear algebra

        - Quantum states and their properties

        - Fundamental protocols of quantum communications, tools of quantum information theory, and basic treatment of noise in quantum systems

        - Quantum cryptography techniques, including quantum key distribution protocols, their implementations, and their analyses

      A second iteration of this course will be offered in the winter semester (2024/2025).

- **Invited Talks & Lectures:** Lux4QCI consortium organized various invited talks and lectures on the technological innovation in QKD and its potentials. Specifically, the following talks were organized at SnT premises
  - **Security of quantum key distribution: from theory to practice** by Prof. Marcos Curty on February 26, 2024
  - **Quantum internet enabled by space** by Dr. Gustavo Amaral and Dr. Bob Dirks on March 05, 2024
  - **Secure communications in quantum networks** by Prof. Eleni Diamanti on March 07, 2024.

- **International events:** the Consortium has already participated in the following international events, namely:
  - The kick-off meeting of the Greek DEP project, called HellasQCI, which took place on 19-20 January 2023. The meeting took place in Athens (hybrid mode of participation), at GRNET's headquarters. Lux4QCI was invited to present Luxembourg's plan for the DEP call, and after the presentations of Greece's and Ireland's plans, synergies were discussed. Lux4QCI was represented by Dr. Wallace ALVES MARTINS, who attended the meeting remotely.
  - The DEP Call kick-off meeting, which took place on 24 January 2023, in Brussels (hybrid mode of participation). Each one of the granted DEP projects were allocated to a group, in total of 6 groups, and each group presented their national projects. Prof. Symeon CHATZINOTAS and Dr. Wallace ALVES MARTINS represented Lux4QCI and presented an overview of the project.
  - QCI Days is Vienna on January 25-26, 2024. Lux4QCI project poster was presented by Dr. Jorge Luis Gonzalez. This event provided an opportunity for all European stakeholders, DEP1 and DEP2 QCI projects, hardware suppliers and leading experts to exchange ideas and engage in an active dialogue with each other.
  - EC DEP-Petrus Work Programme 24-25 that was held on June 07, 2023. The aim of the participation in this workshop promoted by Petrus was to support the development but also implementation of marketing strategies within the framework of connecting with other projects.
  - HellasQCI 2nd PMB meeting (as part of HellasQCI - 1st Training Event) that was held in hybrid format on September 20, 2023. The participation to this dissemination activity was carried out within the framework of liaising with the corresponding initiatives by CY, NL, IE, BE, and DE. Lux4QCI highlights and achievements were presented in the internation session.
  - HellasQCI 3rd PMB Meeting that was held on February 08, 2024. This event aimed at sharing project updates between HellasQCI, IrelandQCI, and Lux4QCI.

- The workshop “Quantum Communication Networks” organised by the PT-QCI, where Pierre Muller from SES Techcom presented Lux4QCI. The workshop was hosted by the University of Aveiro from 26 to 27 of February.

- **Scientific/technology/industrial events:** Towards efficient dissemination and promotion of the project results the Consortium will have at least 5 participations/presentations in relevant events, such as OpenQKD Quantum Industry Board (QIB), EuroQCI Coordination and Support Action, ESA Workshops on Secure Satcom for Safety and Security (“4S”), GOVSATCOM, ISO JTC1 SC27 meetings, ICT Spring, LIST TechDay, ARCH Summit, Luxembourg Internet Days, Cybersecurity Week, IQT conference (https://iqtevent.com/), within this framework also a close collaboration with LU DoD be can be also established. Lux4QCI consortium participated in the following events for this

  - QCI Days in Vienna on January 25-26, 2024. Lux4QCI project poster was presented by Dr. Jorge Luis Gonzalez. This event provided an opportunity for all European stakeholders, DEP1 and DEP2 QCI projects, hardware suppliers, and leading experts to exchange ideas and engage in an active dialogue with each other.

  - ICT Spring 2023 that was held on June 29, 2023 in Luxembourg. Prof. Symeon Chatzinotas presented Lux4QCI and other related quantum activities to a wide audience.

  - Horizon Europe Day, Luxembourg that was held on December 07, 2023. Lux4QCI presented by Dr. Jorge Luis Gonzalez. annual event that brings together the research and innovation community in Luxembourg. Organized by LuxInnovation.

  - Technical Standardization – Quantum Technologies organized by ILNAS Luxembourg on November 21, 2023.

  - ILNAS workshop on Technical Standardization in Space and Cybersecurity on June 27, 2023

  - SnT Partnership Day 2023 was held on May 11, 2023. Lux4QCI project was presented and a demo was also organized.

  - “ETSI Conference on Non-Terrestrial Networks, A Native Component of 6G” on April 04, 2024. Lux4QCI activities were presented by SigCom members.

- **Journals/magazines/press:** The initial plan at the proposal of the project envisaged publication in IEEE Transactions on Quantum Engineering (TQE), IEEE Quantum Education Summit, Progress of Theoretical and Experimental Physics, Quantum Information Processing, Quantum Science and Technology, GEANT Connect Magazine, OpenSpace magazine, press releases in SMC and other partners and liaised initiatives and national networks websites, and more.

  However, due to the sensitivity level of the project, the publications required desensitization from a security advisory board (SAB). The setting of SAB and the defining relevant procedures is complete now, which allows the dissemination of non-sensitive Lux4QCI related results in traditional venues such as journals and conferences.

- Online simulation tools: inclusion of Lux4QCI-specific features into the consortium members' existing simulation software, allowing targeted end users to simulate various scenarios in an attempt to provide said potential users with a better understanding of the foreseen results. Such simulation software could also facilitate the testing and integration of Lux4QCI prototypes.

1.2 ENGAGING TARGET GROUPS

This subsection reports on the engagement with target groups that were identified as part of D5.1: Dissemination and Communication.

1.2.1 Public Authorities/Policymakers

Government and institutional entities are among the main targeted end-users of the intended QCI network. They will directly benefit from the expected enhanced cybersecurity delivered by Lux4QCI. Such benefits include the use of novel solutions for quantum-secure communication and the possibility to get acquainted with quantum communication technology in preparation for future, more sophisticated, developments.

The Lux4QCI project was presented at various venues where the public authorities as well as policymakers were in attendance. For example, the SnT partnership day that took place on May 11, 2023, and where Lux4QCI project was presented was also attended by then Prime Minister of Luxembourg H.E. Xavier Bettel (who was the keynote speaker) and other policymakers. Similarly, the training courses offered as part of DLH catalogue was attended by representatives of various public policy makers. Finally, by attending the ETWG workshops and events, Lux4QCI consortium is engaged with the policymakers at EC.

1.2.2 Large Industry

Data-centres (e.g. LuxConnect), health industry, communications industry (e.g. SES, POST), and banking industry (e.g. FinTech UNILU partners) are examples of large industries that are also targeted as end-users of the intended QCI network. Therefore, they will benefit from the innovation results brought by Lux4QCI in the cybersecurity domain, e.g., for securing direct data-exchange communication lines between data centres having specific security requirements that could be satisfied via solutions envisioned within Lux4QCI.

Banking and Healthcare industries were directly engaged in the organization of Lux4QCI dedicated workshops. In particular, the QKD workshop for banking and finance sector was organized in close collaboration with the ABBL (Luxembourg Banker's Association) and the LHoFT (Luxembourg House of Financial Technology). The keynote speaker in the QKD workshop for banking and finance sector was Nasir Zubairi, the CEO of the LHoFT. The keynote speaker in the QKD workshop for healthcare was Ian Tewes, Director General of eSanté agency. The DLH trainings were also attended by representatives of large industries including telecom operator, satellite operators, and engineering.

1.2.3 Start-up/SMEs

Start-ups / SMEs within the Luxembourg cybersecurity ecosystem will benefit from an open testbed to validate their innovation within the quantum technology domain. Those actors will have access to expensive high-end equipment/infrastructure without the burden to build their own e.g., thereby, allowing them to experiment with and test prototypes that can interface with Lux4QCI key provision services.

Representatives of start-ups and SMEs attended the following events where Lux4QCI project was presented

- ICT Spring 2023 that was held on June 29, 2023, in Luxembourg. Prof. Symeon Chatzinotas presented Lux4QCI and other related quantum activities to a wide audience.
- SnT Partnership day 2023 was held on May 11, 2023. Lux4QCI project was presented, and a demo was also organized.
- QCI trainings with DLH.

1.2.4 Academic and Public Research

Academia and research centres will leverage the lessons learned and results developed within Lux4QCI to produce innovative research in QKD networks and train the next generation of QCI engineers. They were engaged by participation and presentation at technology/industrial events, targeted communications, online and offline presence and materials, project website, project workshops, presentations, newsletters, QCI training in postgraduate courses e.g., in CYBERUS and ISM.

1.2.5 National Representative of EuroQCI/National QCI Networks

They will benefit by knowledge exchange and collection of important information about best practices and approaches, increasing their awareness on the European and global challenges in QKD networks, and promote the research challenges, best practices, and research topics for better design for the future. Promoting Luxembourg as a key member state for the satellite-QKD segment.

Lux4QCI engaged in activities organized by Petrus and EuroQCI events where the representatives of other National QCI networks were present. As neighboring QCI initiatives, Lux4QCI has had discussions with representatives of Belgium and Netherland QCIs (BeQCI and QCINed, respectively) to explore options to collaborate in a BeneluxQCI through the CEF call, including potential connections via terrestrial networks in the future. Lux4QCI also appears as an associated partner in HellasQCI and regularly engages with them in the context of knowledge exchange and project update meetings.

1.2.6 Similar / complementary actions (EUROQCI-QKD, Horizon Europe / DEP / CEF / ESA, etc.)

Lux4QCI will ultimately enhance the capabilities developed in the projects (e.g. LUQCIA) funded by similar/complementary actions in terms of research, technical capabilities, and infrastructure.

Lux4QCI consortium engaged with multiple potential partners for grant proposals in the context of cybersecurity where QKD may appear as a potential solution. Examples include cybersecurity oriented SNS calls and national calls.

1.2.7 Certification, standardisation, accreditation bodies

Lux4QCI partners and liaisons will look for participating actively to the relevant ongoing standardisation/accreditation efforts. Participation in relevant events from ILNAS is part of this engagement.

1.2.8 Civil Society

Citizens will benefit from the outcomes of the project in terms of innovation and consequent preparation for a more secure digital transformation of society. This is ensured by press and media communications, publications in dedicated press, organisation of and participation at domain-focused events, newsletter campaigns, social media, project website, partners' communication channels, project presentation and flyer. The above-mentioned events where Lux4QCI was presented as well as newsletters and social media posts reached a large number public members creating awareness about the project.

1.3 LIST OF COMMUNICATION AND DISSEMINATION ACTIVITIES

Table 1: A list of Communication Activities with Target Audience

Description	how	who? Target audience
Linkedin post to advertise the start of the project LUX4QCI. [Link]	social media	public (citizens in the society domain)
Article to advertise the September 2023 classes in quantum communication as part of a training programme where professionals will be given the opportunity to learn about this topic from experts.	media article	industry stakeholders (companies)
Interview with Dr.Junaid ur Rehman, on the potentials of the project and the importance on developing a future quantum communication infrastructure.	interview	public (citizens in the society domain)
Article to create awareness on the importance of building quantum communication infrastructure in protecting governmental and business data and therefore on the key role of the projec	media article	public (citizens in the society domain)
Interview with Prof. Symeon Chatzinotas, on the potentials of the project and the importance on developing a future quantum communication infrastructure.	interview	public (citizens in the society domain)
Several X (formerly Twitter) posts by SES to advertise organized workshops and create awareness.	social media	industry stakeholders (companies)

Table 2: Organize/Participated Dissemination Activities in the Context of Lux4QCI

Name of the dissemination activity	**when?**	**what?**	**who? Target audience**	**number of participant/ audience reached (estimated)**	**Description of the objectives**
HellasQCI KOM	20.01.2023	collaboration with EU funded projects	miscellaneous	35-40	The aim was to present Luxembourg's plan for the DEP call, and to discuss synergies within the framework to connect with other countries that are involved in the development of the EU QCI baseline
EC DEP-call KOM	24.01.2023	collaboration with EU funded projects	miscellaneous	50	The aim was to connect and exchange with other projects ideas and expected results within the framework of the creation of cross-border connections with other countries
EC DEP-Petrus Work Programme 24-25	07.06.2023	collaboration with EU funded projects	miscellaneous	50+	Participation in this workshop promoted by Petrus aimed to support the development and implementation of marketing strategies within the framework of connecting with other projects.
Short Course: Introduction to Quantum Computing and Communications	13.06.2023	education and training events	public (citizens in the society domain)	19	Introductory course for quantum computing and communications aimed at individuals/professionals looking to start building expertise in these areas and, therefore, providing courses for users.
SnT Partnership Day	11.05.2023	education and training events	industry stakeholders (companies)	500	To present Luxembourg's activities in quantum communications and how the quantum technology will be used to secure sensitive data and communication

Name of the dissemination activity	**when?**	**what?**	**who? Target audience**	**number of participant/ audience reached (estimated)**	**Description of the objectives**
Master's Course: Quantum Communications and QKD	Winter Semester 2023-2024	education and training events	academic researchers and end users	3MS + 2PhD students + 2-3 PostDocs	Master level (3 ECTS) organised by UNILU and contributing to the achievement of the KPIs related to the QCI courses implementation and training users, showcasing the QCI importance and applicability.
Short Course: Quantum Communications: Theory and Applications	27.11.2023	education and training events	public (citizens in the society domain)	15	The course aims to provide notions on quantum states, the difference between quantum and classical information, etc., contributing to the KPIs related to the QCI courses implementation and trained users.
Short Course: Quantum Computing: Basic Theory and Future Expectations	27.11.2023	education and training events	public (citizens in the society domain)	18	The course aims is for beginner-level on how quantum computing provides the advantage in computation, contributing to the achievement of the project KPIs related to the QCI courses implementation and trainined users.
GovTech Afterwork	11.07.2023	seminar	miscellaneous	20-25	Through this event, the GovTech Lab wants to facilitate the exchange between the private and the public sector in the field of quantum computing. Rudy Stranen presented Lux4QCI.
HellasQCI 2nd PMB meeting (as part of HellasQCI - 1st Training Event)	20.09.2023	clustering activities	miscellaneous	15-20	The participation to this dissemination activity was carried out within the framework of liaising with the corresponding initiatives by CY, NL, IE, BE, and DE.
QCI DAYS 2024 in Vienna	25-26.01.2024	clustering activities	miscellaneous	250 +	To discuss cutting-edge trends in quantum-secure communication. Network with professionals from Digital Europe Programme (DEP), Quantum Flagship projects, and industry leaders in Vienna

Name of the dissemination activity	when?	what?	who? Target audience	number of participant/ audience reached (estimated)	Description of the objectives
Horizon Europe Day, Luxembourg	07.12.2023	meetings	miscellaneous	150	To discuss experiences with European funding for research and innovation projects carried out in Luxembourg.
Quantum Key Distribution Workshop for the Luxembourg Financial and Banking sectors	11.10.2023	seminar	industry stakeholders (companies)	29	QKD workshop for target group
Workshop on QKD for Healthcare Sector	07.12.2023	seminar	industry stakeholders (companies)	16	QKD workshop for target group
EuroQCI Thematic Working Group Workshop	07-09.11.2023	meetings	miscellaneous	All representatives of NatQCIs	Liaison with EuroQCI and other NatQCIs for a unified EuroQCI
LHC Forum	28.06.2023	meetings	miscellaneous	30	Discussion of the security risks in the post-quantum context and potential solutions, including QKD
ICT Spring	30.06.2023	educational training events	miscellaneous	2000	To disseminate Lux4QCI and quantum-related activities to a wide audience including business decision-makers, innovation managers, startups, researchers and venture capitalists on a European scale
SecITC conference	23.11.2013	conference	academic (researchers/scientists)	100	A scientific article that explores the notion of deniability in public-key authenticated quantum key exchange (QKE), which allows two parties to establish a shared secret key without leaving any evidence that would bind a session to either party.

Name of the dissemination activity	when?	what?	who? Target audience	number of participant/ audience reached (estimated)	Description of the objectives
LHC Forum #2 – Podcast – Post-Quantum Security	23.10.2023	Outreach	General public	30+	A technical and pedagogical discussion about the current landscape in the context of migration to quantum-secure systems.
Space Café Benelux	27.07.2023	seminar	miscellaneous	50-60	Interview style webinar to talk about the QCI project in Luxembourg carried out by SMC
HellasQCI 3rd PMB Meeting	08.02.2024	meetings	academic (researchers/scientists)	15-20	The participation to this dissemination activity was carried out within the framework of liaising with the corresponding initiatives by CY, NL, IE, BE, and DE.
Invited talk by Marcos Curty	26.02.2024	seminar	academic (researchers/scientists)	15-20	Marcos Curity delivered a lecture at SigCom. Lux4QCI project and other related initiatives were briefly explained to him.
Invited Talk by Dr, Gustavo Amaral and Dr. Bob Dirks	05.03.2024	seminar	academic (researchers/scientists)	15-20	TNO researchers delivered a talk at SigCom. Lux4QCI project and other related initiatives were briefly explained to them.
Invited Talk by Prof. Eleni Dimanti	07.03.2024	seminar	academic (researchers/scientists)	15-20	Eleni Diamanti delivered a talk at SigCom. Lux4QCI project and other related initiatives were briefly explained to her.
HellasQCI 1st Project Review Meeting	14.03.2024	meetings	policymakers	38	Liaison with HellasQCI and participation as associated partners in their review meeting.
ETSI Conference on Non-Terrestrial Networks, A Native Component of 6G	04.04.2024	Conference	miscellaneous	200	Lux4QCI and related quantum activities presented by SigCom

2 EXPLOITATION PLAN

In relation to the exploitation of the project results, close coordination, collaboration, synergies and liaisons with the EC, the various ongoing relevant initiatives under CEF/Horizon Europe/ESA/DEP, will be initiated also taking advantage of the already extended network of the partners participating actively in several relevant initiatives such as Quantum Technologies Flagship, OpenQKD, QTEDU, ISO, JTC1 SC27 WG3, ETSI QKD and more.

Lux4QCI contributes in a very concrete manner to the digital transformation primarily of Luxembourg society but also of European society as a whole. Digital transformation is the key expression that summarises much of the efforts that public and private players have been putting into policies, strategic activities, and innovations to interconnect people, devices/machines, and things in general via communication networks. Through this, the society can greatly benefit from the existing computational power and the integration of artificial intelligence into virtually all processes where reasoning is demanded. We are all witnesses of how strong digital transformation can affect our daily lives. A case in point is the invention, followed by their widespread adoption, of smartphones; just think of the way people interact with them today, and all the applications and broadband mobile services that appeared (and continue to appear) sparked by such invention; and it is rather likely that this was just a minor transformation considering all the potential of what is to come: a real digital transformation. Of course, all of these efforts are made for the better of the society and for economic reasons, but along with great and powerful tools usually come on par threats. The clear trend is that almost all aspects of our lives will be highly virtualized (in a way that we can only have a glimpse today) and, therefore, extremely susceptible to cyber-attacks. Those societies that embrace digital transformation while accounting for all the associated threats will be clearly in the vanguard in terms of economic competitiveness and efficiency, as well as with respect to welfare. The EU wants to play a pivotal role in this regard and has set forth several policies and concrete initiatives to implement a reliable digital transformation. Luxembourg stands out as a country running several initiatives to play a central part in the EU's digital transformation.

It is precisely in this context that Lux4QCI finds its way to support Luxembourg's initiatives towards its digital transformation, which is in line with the EU's. More specifically, Lux4QCI will provide a real network testbed for quantum-enhanced secure communications, with demonstrated integration with operational communications networks, eventually strengthening the security and resilience of digital infrastructures in Luxembourg. In fact, at least two use cases and two test scenarios will be selected based on technical/business value and national relevance. This has the great potential of making an unprecedented impact on the current Luxembourg cybersecurity ecosystem, which counts over 300 organisations (private, public and civil sectors) that may directly benefit from an open testbed to validate their innovation within the quantum technology domain. Such a rich innovation-oriented environment may provide many products and services for a secure digital transformation for the betterment of society. In addition, Lux4QCI will work through bilateral cooperation with other national QCIs and multilaterally with EuroQCI to plan future concrete actions towards a European QCI. Lux4QCI will exchange design directions and lessons learned from the intended QCI deployment with several similar initiatives currently running in other EU Member States. In this context, Lux4QCI emulation of international connectivity via OGS (Optical Ground Station) interfaces towards already planned satellite assets, such as SES' EAGLE-1, will empower the

society with the possibility to distribute quantum keys to farther remote regions. Another impact of paramount importance on society will come from Lux4QCI's intended educational support for Luxembourg professionals. More specifically, society will have access to theoretical and practical training on quantum communications. Thus, Lux4QCI will contribute to building trust in the digital world by making people aware of the benefits of this technology for the development of highly secure communication and data networks, by introducing selected topics from this area in the related postgraduate and undergraduate courses in Luxembourg. A third-party access framework will be set up for national stakeholders outside the project consortium to engage in both training and joint experimentation activities.
The project aims in fact to use the testbed as demonstration pilot during the training activities, therefore creating a bridge between dissemination and exploitation of the project results,

2.1 PROJECT RESULTS TARGETED FOR EXPLOITATION

A selection of the project results that will be exploited has been made (Table 3) and grouped based on expected overall project results, mechanisms and targeted groups:

Table 3 Exploitation Table

Exploitable result	Description	TRL (start)	TRL (end)	Responsible partner	Exploitation mechanism	Target groups
Updated simulation SW	A simulation software developed by ALab for educational purposes that simulates point-to-point QKD with potential updates to include Lux4QCI-specific features	3	4	ITR, ALab	Online web application that can be made available to the general public if deemed appropriate	All considered targeted groups
HSM-enhanced key storage and cryptographic processing	Design of a security concept considering the use of HSMs and the deployment	3	4	ITR, Alab	HW+SW connected to Lux4QCI UEP	SMEs, public authorities, large industry, academia, infrastructu

	and testing of an HSM interfacing with the Lux4QCI key provision service, as well as the development of necessary software.					re providers
Implementation of novel hybrid key exchange solution	A prototype implementation of a hybrid key exchange protocol combining QKD-generated keys with keys generated by classical, quantum-secure cryptographic constructions developed in Lux4QCI	2	3-4	ITR, Alab	SW	All partners
Key Exchange on fibre with production payload	Setup and Proof that a single fibre can be used for QKD in parallel with unrelated internet traffic	3	6	RESTENA	News Article/Publication	All considered target groups

One of the cornerstones of the project is the proof that it is not required to provision dedicated fibre for the QKD links; but that instead existing fibre infrastructure can accommodate QKD traffic so long as several channels on the fibre are available. With this proof, the required investment for QKD becomes much smaller because existing infrastructure can be re-used. Restena Foundation will exploit the corresponding finding by communicating on all appropriate channels that this has been proven to work under relevant conditions, and that the option to encrypt payload traffic becomes available for its connected institutions using their existing fibre uplink.

2.1.1 Simulation software (ALab+ITR)

Depending on resource availability, the goal would be to design and develop a piece of QKD simulation software that would combine a customizable point-to-point full-stack QKD protocol simulator (based on the BB84 protocol), with Lux4QCI-specific features, e.g., the simulation of network-based QKD by incorporating network simulators such as Ns[1].

The intended exploitation of the QKD simulation software can be summarized as follows:

- In terms of dissemination, the developed QKD simulation software will be released as an online web-application to provide tool support for pedagogical efforts aimed at introducing a larger audience to quantum technology;
- In terms of user acquisition, the simulation software will be made available for potential end-users to prepare for the migration to quantum-secure solutions by being able to simulate various scenarios and using the results to map out, among other things, technological and integration requirements as well as expected performance;
- In terms of development, the simulation software could be used during the development of Lux4QCI systems to facilitate the testing and integration of prototypes.

2.1.2 HSM-enhanced key storage and cryptographic processing (ALab+ITR)

Hardware security modules (HSM) are hardware computing appliances aimed at protecting and managing cryptographic keys as well as performing various cryptographic operations. As part of the envisaged security concept for Lux4QCI, an integration of HSMs in the form of COTS into the architecture is foreseen. This would be to provide more sophisticated key storage and transfer mechanism.

Depending on resource availability and assuming that adequate HSMs are procured during the project lifetime in a timely manner, once the technical details of the security concept including an interfacing of Lux4QCI's key provisioning services with HSMs are fleshed out, various use case scenarios will be formulated that will revolve around the use of HSMs. Taking this concept into account, corresponding software will be developed by ALab and ITR that supports the deployment of HSMs within Lux4QCI.

itrust and ALab intend to exploit this for the acquisition of an HSM that can be integrated into Lux4QCI user endpoints. Furthermore, the developed hardware and software package can be installed at every user endpoint allowing potential end-users to use it.

2.1.3 Implementation of novel hybrid key exchange solutions (ALab+ITR)

Hybrid authenticated key exchange protocols combine keying material from different sources (post-quantum, classical, and quantum key distribution (QKD)) to build protocols that are resilient to various types of failure which may be due to advances in quantum computing, implementation vulnerabilities, or our evolving understanding of the security of supposedly quantum-secure primitives. Such constructions represent viable candidates for initial deployment of post-quantum-secure cryptographic primitives as they hedge against undiscovered weaknesses.

[1] ns (simulator) - Wikipedia

As far as exploitation by ALab and ITR is concerned, the developed hybrid scheme will be disseminated via publications in relevant journals and conferences and the developed software made available to consortium members and potentially released as open source.

3 MODALITIES OF THIRD-PARTY ACCESS

As a transformative technology, quantum key distribution remains a topic of interest for several academics and industries around the globe. At the same time, concrete modalities need to be defined in order to provide third-party access that promotes the collaborative spirit while respecting the restrictions imposed by the sensitivity level (classified EU RESTRICTED and SENSITIVE information) of the project.

In facilitating third-party access to Lux4QCI, several modalities ensure seamless collaboration and utilization of the infrastructure. Firstly, a structured documentation process will be established, allowing interested parties to provide documentation, either directly or through a partner, outlining their specific requirements and intended use of Lux4QCI. These documents will undergo evaluation by the coordinator. The coordinator may decide to involve other Lux4QCI partners in the evaluation process or in the proposed research.

Upon mutual agreement, chosen parties will gain access to Lux4QCI infrastructure under predefined terms and conditions. This access may encompass various components of the infrastructure, including QKD devices, software tools, and historical experimental data, depending on the nature of the proposed research. Collaborative agreements will be formalized, outlining the scope of access, duration, IPR agreements, data sharing protocols, and any associated costs or obligations. Throughout the collaboration, Lux4QCI coordinator will provide necessary support and guidance to facilitate the smooth execution of experiments and research projects, fostering a productive and mutually beneficial partnership. Technology-transfer office (TTO) at UniLu has experience with granting third-party access to university equipment/infrastructure in form of leasing. The coordinator will take advice and support of TTO in facilitating third parties to grant access to Lux4QCI infrastructure.

3.1 ACADEMIC AND RESEARCH INSTITUTIONS

Specifically, academic and research institutions can request access to Lux4QCI in the following scenarios:

1. **Joint Projects:** Academic and research institutions can join the Lux4QCI coordinator in a joint project where the infrastructure of Lux4QCI improves the technical and scientific significance of proposed project.

2. **Joint Research Publications:** Another mode of access for academic and research institutions to access Lux4QCI is through collaborative research that may result in joint publications.

3. **Collaborative Experiments:** Academic institutes may request access to Lux4QCI to conduct collaborative experiments or studies that require specialized equipment or expertise available within the infrastructure.

4. **Student Internships or Research Projects:** Academic institutions could seek access to Lux4QCI to provide students with internship opportunities or research projects, allowing them to gain practical experience and contribute to ongoing quantum communication research.

5. **Workshops and Conferences:** Academic partners may utilize Lux4QCI's facilities to organize workshops, conferences, or symposiums focused on quantum

communication and information science, bringing together experts, researchers, and industry professionals for knowledge exchange and collaboration.

6. **Technology Transfer Initiatives:** Academic institutes may engage with Lux4QCI in technology transfer initiatives, leveraging the infrastructure's capabilities to develop and test prototypes or proof-of-concept demonstrations for commercialization or industrial applications.

3.2 INDUSTRIAL ENTITIES

In addition to the joint projects and joint research publications, industrial partners may access Lux4QCI under the following scenarios:

1. **Product Development and Testing:** Industrial partners may request access to Lux4QCI to develop and test quantum-based products or solutions, leveraging the infrastructure's capabilities to accelerate the innovation and commercialization process.

2. **Collaborative Research Projects:** Industrial entities could collaborate with Lux4QCI on research projects aimed at advancing quantum communication technologies, exploring new applications, or addressing industry-specific challenges.

3. **Technology Evaluation and Benchmarking:** Industrial partners may utilize Lux4QCI's infrastructure to evaluate the performance of quantum communication technologies, compare different solutions, and benchmark their capabilities against industry standards.

4. **Training and Professional Development:** Industrial organizations may seek access to Lux4QCI to provide training programs or professional development opportunities for their employees, enabling them to gain insights into quantum technologies and their potential applications in the industry.

Additionally, to promote knowledge exchange and foster a vibrant research community, academic and research institutes granted access to Lux4QCI will be encouraged to participate in workshops, seminars, and collaborative projects hosted by the infrastructure. These events will serve as platforms for sharing insights, discussing findings, and forging new collaborations within the quantum communication and information community within EU. Opportunities for joint publications and dissemination of research outcomes will be encouraged, showcasing the collective contributions of academic and research institutes to the advancement of quantum communication and information science through Lux4QCI collaborations. By fostering an inclusive and collaborative environment, Lux4QCI aims to catalyze advancements in quantum research while nurturing the next generation of scientists and innovators in this transformative field.

4 CONCLUSIONS

The Lux4QCI project has successfully engaged the target groups that were identified earlier to create awareness about the potential threats to cybersecurity and potential solutions. To this end, several communication and dissemination activities were carried out in the framework of Lux4QCI project. These and other similar activities will continue throughout the execution of the project.

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