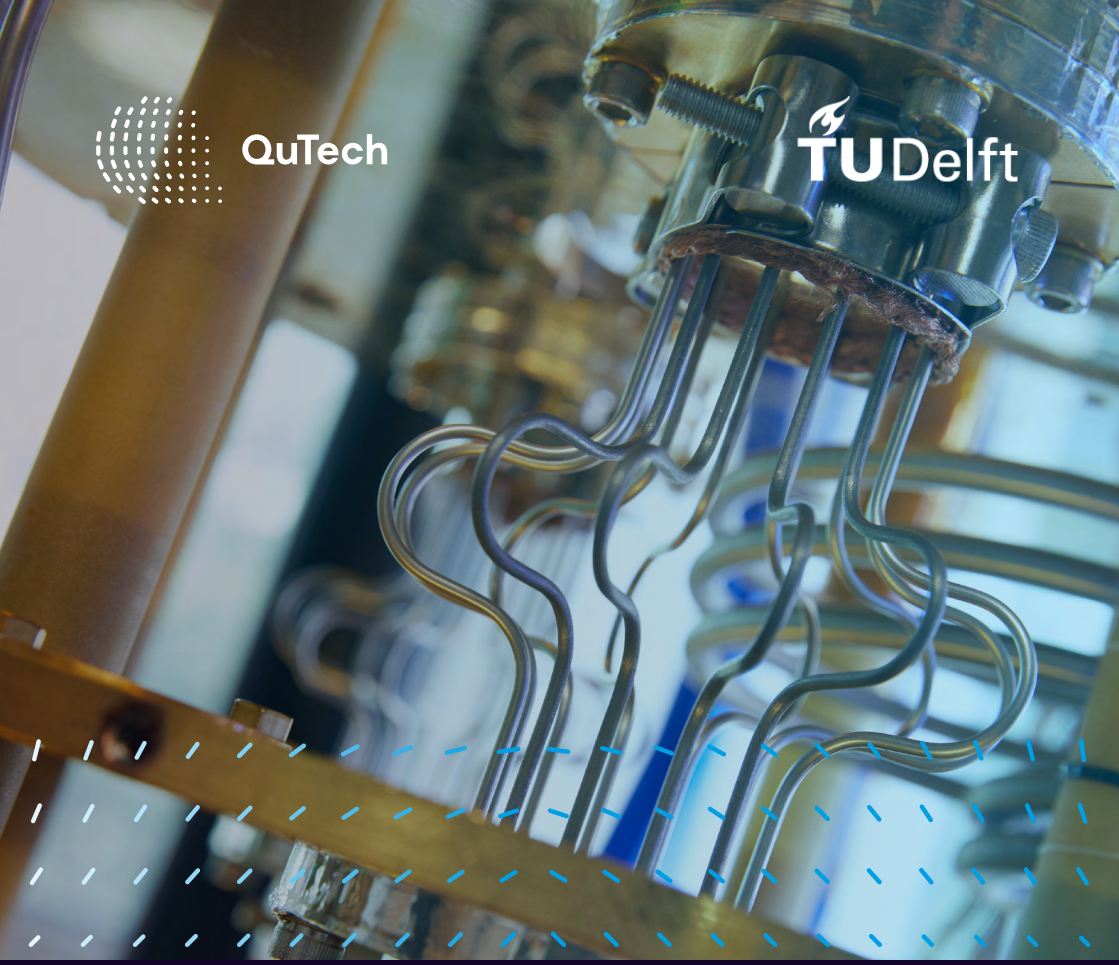


GUIDEBOOK

Future Value Mapping

Turning quantum technology uncertainty into collaborative value creation

Spring 2026

Introduction

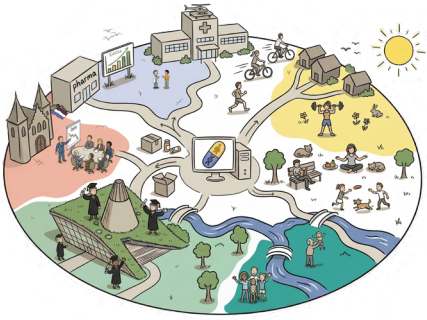
The future is dominated by uncertainty. In the context of technology development, this uncertainty may prevent organizations from engaging altogether. Collaborations that aim to stimulate the development or adoption of new technologies require a collective goal and direction. Articulating the value technology can create, while accounting for the differences between stakeholders, is important. Quantum technologies hold the potential to realize transformative value, but are filled with uncertainty.

Uncertainty, the need for clear value creation, limited collaborations, and widespread communication challenges all limit the adoption of and engagement in quantum technology development. Future Value Mapping (FVM) provides a structured approach to navigate the uncertainty of quantum technologies, bringing stakeholders together and highlighting the value and risks of quantum technologies. FVM uses three interconnected phases. The first involves creating normative scenarios that show the value a technology can bring for various stakeholders. These do not serve as speculation or prediction, but as a concrete vision that forms the starting point for looking back. The second phase is backcasting: identifying concrete interventions required to realize the future scenario based on *what-how-who* questions. The third phase involves developing what-if questions to identify the consequences, risks, and opportunities of the scenario. All three phases inform decision-making today.

Together, the three phases and six steps form a coherent and iterative method that serves multiple purposes: stimulating dialogue between stakeholders with different values, goals, and expertise, highlighting interdependencies, and creating a shared direction. The purpose is not to predict the future, but to prepare stakeholders and stimulate development by transforming uncertainty into a starting point for action. FVM has been applied to two proof-of-concept cases, personalized medicine and secure quantum communications, demonstrating its adaptability across domains.

Case - Personalized Medicine

Scenario



Personalized medicine uses quantum computing and quantum sensing to better understand the complexity of individual biological systems. Quantum-enabled algorithms search through high-dimensional data, including electronic health records (EHRs), genetic information, lifestyle, and symptoms, to uncover patterns that improve the prediction of illness and shift the focus from curing to prevention. Combined with the ability to simulate complex molecular interactions, these tools help determine the most effective medication, dose, and scheduling before any drugs are administered. When new data is introduced, such as a change in lifestyle, the care plan can be adjusted accordingly, moving away from population-based statistics towards treatment tailored to the individual.

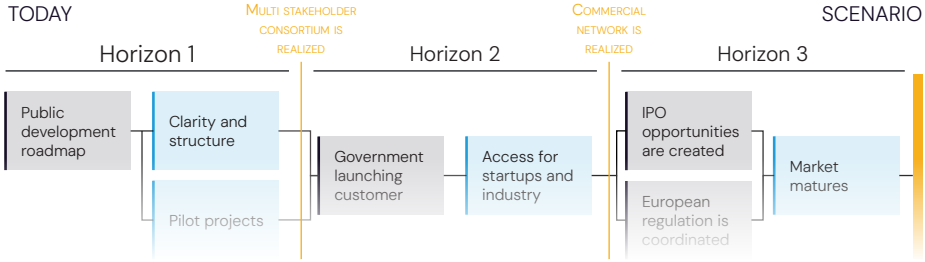
Stakeholder	Value
Government	Public welfare, costs, insight, better budgeting, ...
Academics	Scientific discoveries, education, ...
Investors	Investment opportunities, ESG alignment, ...
Startups	Business opportunities, new industries, ...
Industry	Lower costs and development time, improved success rate, ...
General public	Quality of life, better health, life expectancy, feeling of control, ...

Backcasting

Personalized medicine still has a long way to go before full integration in the Dutch healthcare system. Continuous action is required across qubit research, hardware development, and iterative reflection. Regulation, infrastructure, and standardization serve as enablers, while high costs, ethical dilemmas, and lagging regulation remain significant barriers to development. Looking back from the scenario, it becomes clear that the government should provide clarity through a public development roadmap in the first horizon. Once a multi-stakeholder consortium is established, the focus shifts towards commercialization. Hospitals should build quantum

capabilities, talent should be trained, and the government needs to incentivize investment. The deployment of a national infrastructure will ultimately enable nationwide integration of personalized medicine.

Below is a snapshot of the roadmap to indicate what it could look like.



What-if ***(example)***

What-if your health trajectory can be predicted with 98% accuracy?

Stakeholder story – Citizen – Mark – 33

Mark works in construction, just like his dad and granddad before him. After being on consultation for a THP, he is made aware of the increased risk of heart disease. A special program has been set up to help him lower the risk of cardiovascular disease. Great! Through coaching on nutrition, plans to help him adjust his work environment, and a discount to go to the gym, there are many initiatives to help. He does discover a downside… His medical record will get updated to 'medium risk for CVDs'. He is in the middle of acquiring a mortgage for his house, finally, after a long time, he might be able to buy a house. But the mortgage broker sees that his medical file has been updated from 'low risk' to 'medium risk'. This makes it more difficult to apply for the mortgage. He is in doubt whether he should join the program; his long-term health is very important to him, but should a prediction of the future dictate his life today?

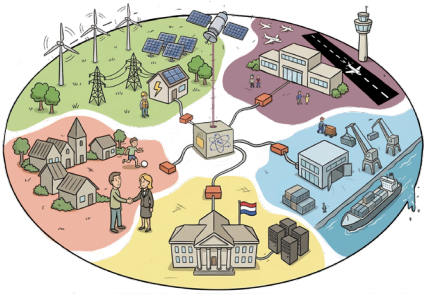
Reflection

Personalized medicine holds significant potential to improve the health and well-being of citizens. Realizing this potential requires collaboration across all stakeholders, given the interdependencies involved and the broad societal impact of the technology. Stakeholders engaging in development should remain aware of its implications, including ethical dilemmas, and pursue development that is purposeful and responsible. It requires action and collaboration today to ensure successful development later.

Case - Secure Communications

Scenario

Secure communications through Quantum Key Distribution (QKD) use quantum mechanics to generate encryption keys that are impossible to intercept or break. Using quantum communication lines, an encryption key is created and used to encrypt the data sent over classical communication lines. Any attempt to intercept the quantum connection line is physically detectable, exposing eavesdropping. This enables secure communication to be established between critical infrastructure, including energy grids, government data exchanges, airports, ports, and financial institutions. Such secure communication enhances sovereignty and strengthens resilience against hostile threats, helping to prevent failures caused by cyber-attacks.

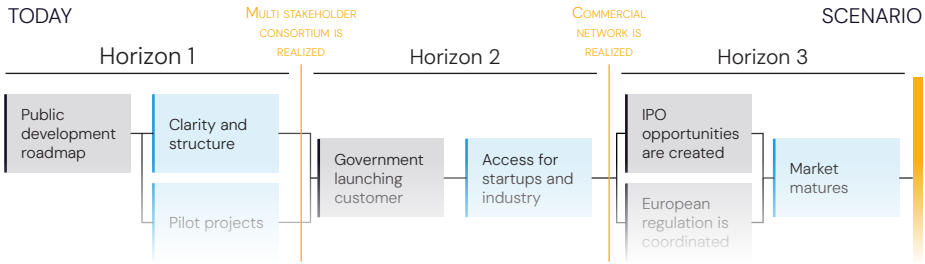


Stakeholder	Value
Government	National security, strategic autonomy, sovereignty, ...
Academics	Scientific advancement, quantum internet research, education, ...
Investors	Investment opportunities, growing security market, ...
Startups	Hardware development, business opportunities, ..
Industry	Infrastructure development, first-mover advantage, ...
General public	Privacy, sense of security, trust in digital systems, ...

Backcasting

QKD is far along in its development and valorization compared to many other quantum technology applications. But it requires further development in hardware, network infrastructure, and standardization. Quantum repeaters, error correction, and interoperability with classical networks are key technical milestones that need to be achieved. The development of compatible infrastructure, the creation of launching customers and supply chain providers are enablers, while high costs, a debated reputation, and range scaling issues are barriers to development. Governments, infrastructure developers, and critical infrastructure organizations should align on data security acts and implementation plans. Incentives from the

government should provide a clear reason to switch. Through pilot projects and expansion, a national network ought to be created.
Below is a snapshot of the roadmap to indicate what it could look like.



What if ***(example)***

What if we start to rely too much on the technology for security?

Stakeholder story – Port employee – Erik - 58

Erik has worked at the Port of Rotterdam for 35 years. He was once the most tech-savvy person, so he slowly grew into a role where he was responsible for maintaining secure data communications within the port. A new QKD communication system rollout promised unhackable, future-proof communication links. Fiber optics, quantum entanglement, and key management, all too complicated for him in this day and age. But he kept being told: *"You don't need to understand how it works, it just works"*.
For Erik, it's a black box. Every month, an employee of the QKD company comes to the port to update some systems and to verify that everything is still functioning properly. Erik trusts that it all works well, but how can he be responsible for something that he does not understand? Is the Dutch government's attempt to future-proof its critical infrastructure not just one that makes it more complicated? Are we not replacing one dependency with another, a dependence on a technology that is a black box to many?

Reflection

QKD can play a big part in setting up secure communications. During a time when cybersecurity threats are increasing, these innovations can make a difference for national security. But the infrastructure needs to be developed, and launching customers are required. Collaboration between government, industry, telecom providers, and academia is needed to scale the technology. Stakeholders must be mindful of the risks and dependencies associated with the technology. Standardization, pilots, and cross-sector alignment are required today to secure a digital future.

FVM Method

The Future Value Mapping method consists of six structured steps designed to connect a desirable future to actionable steps today, while keeping value creation central throughout.

1. Orientation — Familiarize yourself with the content, stakeholders, and the scope. This grounds the process in reality rather than speculation.
2. Scenario creation — Generate and develop normative future scenarios, followed by an initial value analysis. Scenarios serve as a dot on the horizon leading to a shared direction rather than a rigid goal.
3. Backcasting — Starting from the scenario, work backward using What-How-Who questions to identify what steps are needed, how they can be realized, and who is responsible, using input from external stakeholders
4. Refinement — Refine the scenario using the gathered input and build a roadmap across three collaboration-based horizons, analyzing key risks and value opportunities.
5. What-if creation — Explore speculative consequences of the scenario to surface unforeseen risks and opportunities, stimulating stakeholders to act preventively today.
6. Reflection — Assess what the results actually mean in practice, verify alignment with the original goal, and reflect on any biases in the process.

More information can be found at: https://qutech.nl/FVM

Step 1: Orientation	
1A	Content familiarization
1B	Stakeholder analysis
1C	Scope setting
Step 2: Create scenarios	
2A	Idea generation
2B	Scenario development
2C	Initial value analysis
Step 3: Backcasting & Input gathering	
3A	Initial What-How-Who analysis
3B	Participatory value analysis
3C	Participatory What-How-Who analysis
Step 4: Refinement	
4A	Scenario refinement
4B	Roadmap development
4C	Analysis
Step 5: What-if creation	
5A	Idea generation
5B	What-ifs development
5C	Analysis
Step 6: Reflection	
6A	So what?
6B	What does this mean?
6C	Goal alignment

"The future is uncertain... but this uncertainty is at the very heart of human creativity."

ILYA PRIGOGINE
Nobel Prize winner in Chemistry

Author
Lennart Hessels
QuTech
TU Delft

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