

Improving the applicability of PCSI security innovation results

PCSI tech-transfer

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results

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Management Summary

The Partnership for Cyber Security Innovation (PCSI) is a long-running collaboration between TNO, ABN AMRO, ING, ASML, Achmea, and the Belastingdienst (the Dutch National Revenue Service). PCSI has the ambition to collaboratively innovate on cyber security. The actual innovation takes place in parallel projects governed by the program. The projects go through a short-cyclic innovation process and are staffed by experts from all PCSI partners.

Project results coming out of innovation projects can be e.g. methodologies, tools, software, concepts, newly defined roles. The PCSI has built up a good posture in sharing and disseminating these project results, but it proved to be difficult to actually get project results to be applied and used, either by PCSI partners or organizations outside the PCSI program. We call this the 'PCSI tech-transfer gap' in between innovation and the actual adoption and use of the result. The Ministry of Economic Affairs and Climate Policy has a high interest in the success of tech-transfer of innovation results. Therefore, they commissioned the PCSI tech-transfer project to find potential solutions to reduce this transfer gap for the PCSI; this report is the result thereof. They also asked to disseminate the PCSI results for broader application, with the aim to reduce the tech-transfer gap that is experienced in the security innovation community in Dutch society. This activity will be a short follow-up of the PCSI tech-transfer project and will be published in a separate report.

The PCSI tech-transfer project has collected information through desk research on tech-transfer state of the art, combined with interviews and workshops with stakeholders in cyber security innovation, both those that are currently involved in the PCSI and those that are currently not involved in the PCSI. This has led to a wealth of ideas to revise the PCSI way of working so it is better equipped to bridge the tech-transfer gap.

There are too many ideas to implement all at once and therefore a two-step approach is recommended: (1) implement four main categories of improvement and (2) evaluate the new situation after some time to assess whether additional improvement points should be implemented. The four main categories are:

- Categorizing projects after successful completion of the Explore phase;
- Increased Business focus for tech-transfer;
- Commitment of all PCSI roles to make tech-transfer projects successful;
- Increased business intelligence, preparation and support.

The PCSI Steering Committee accepted this recommendation.

Contents

Contents

Management Summary	3
Contents	4
1 Introduction.....	5
1.1 Context.....	5
1.2 Introducing the PCSI.....	5
1.3 The Tech-Transfer “gap”.....	6
1.4 Goal of the PCSI Tech-Transfer project.....	9
1.5 Methodology.....	10
1.6 Reader Guide.....	10
2 State-of-the-Art and PCSI learnings	11
2.1 State of the Art from Literature.....	11
2.2 Experiences and learnings from PCSI.....	13
2.3 Learnings from PCSI projects.....	20
3 Improvements to PCSI	24
3.1 Roles	24
3.2 Overall process.....	26
3.3 Topic selection.....	27
3.4 Ideation and decision making.....	28
3.5 Explore phase.....	29
3.6 PoC phase.....	30
3.7 Pilot phase.....	31
3.8 Exploit phase.....	31
3.9 Introduction of a Post-Exploit phase	32
3.10 Potential improvements outside the PCSI program.....	33
4 Conclusions and Way Forward	34
4.1 Overall conclusion and recommendation.....	34
4.2 Suggested improvements for the PCSI.....	34
References.....	37
Appendix A Interviewees and workshop participants.....	40
Appendix B Glossary.....	42
Appendix C PCSI terminology and process.....	43
Appendix D PCSI tech transfer project experience.....	47
D.1 Joint practices for security in agile	47
D.2 Collaborative Deception Fleet.....	47
D.3 Security Behaviour Coach	49
D.4 Purple AI	50

1 Introduction

1.1 Context

The Partnership for Cyber Security Innovation (PCSI, see next paragraph) is a collaboration between TNO, ABN AMRO, ING, ASML, Achmea, and the Belastingdienst (the Dutch National Revenue Service) with the ambition to collaboratively innovate on cyber security. The PCSI produces innovation results of technical, process or methodological nature.

One of the ambitions of the PCSI is to ensure that these results continue to be used after an innovation project has been finalized. This ambition could not be sufficiently fulfilled until now, due to various known and unknown reasons, we therefore experience a ‘PCSI tech-transfer gap’ in between innovation and the actual adoption and use of the result.

The Ministry of Economic Affairs and Climate Policy has a high interest in the success of tech-transfer of innovation results. Therefore, they commissioned a project to TNO to find potential solutions to reduce this transfer gap for the PCSI. This report is the result thereof. The results of this project proved to be sufficiently interesting, and the Ministry of Economic Affairs and Climate Policy intends to disseminate them to a broader context, for Dutch Society. This could help to reduce the tech-transfer gap that is experienced in the security innovation community in Dutch society. This activity will be a short follow-up of the current project and will be published in another report.

1.2 Introducing the PCSI

The PCSI program started in 2020 and it has been extended with another three years in July 2023. De Volksbank participated until July 1st 2023. An overview of PCSI roles and terminology can be found in Appendix B.

Besides the so called ‘core partners’ (TNO, ABN AMRO, ING, ASML, Achmea, and the Belastingdienst), the PCSI also has built an ecosystem of ‘Liaison Partners’. Liaison partners are organizations that are interested in the results of the PCSI. Most liaison partners are security vendors or security service providers; they are informed on projects and results but can also be invited to participate in specific projects when this is mutual beneficial.

Figure 1 shows the PCSI innovation process. Every four months, the PCSI Steering Committee selects 2 or 3 new topics from a PCSI security radar. For each chosen topic, an Ideation session on the topic is organised with experts from all core partners. In the Ideation session, innovative ideas are generated to either solve issues or grab opportunities within the selected topics. The ideas from the Ideation sessions are then pitched before a “Dragon’s Den” formed by the Chief Information Security Officers (CISOs) from the CISO departments of the PCSI core partner organizations.

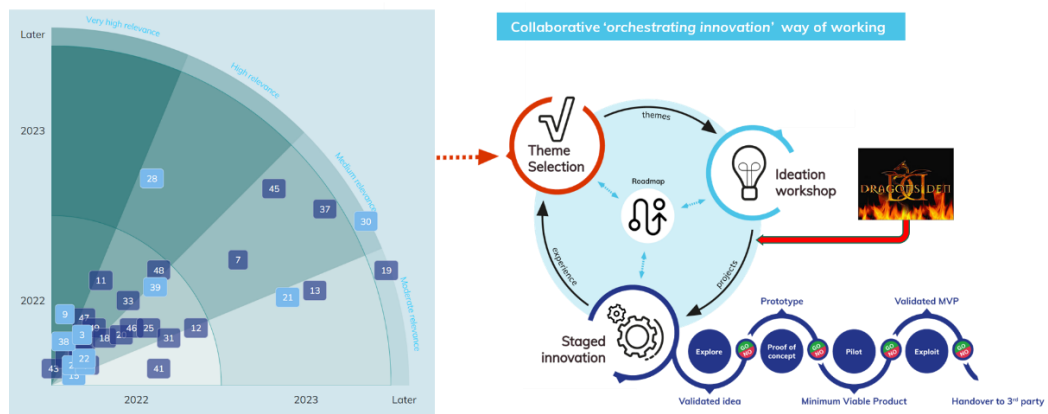
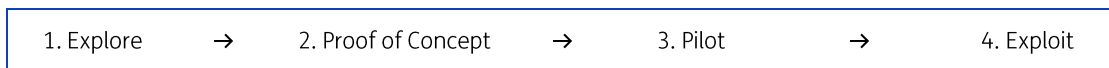


Figure 1: The PCSI innovation process

If the “Dragons” see value in the project ideas, they reward those ideas with an actual project start. For projects receiving a start, the PCSI program features a short-cyclic innovation process constituted of four subsequent 4-months phases:



After each phase project undergo a Go/No-go decision on whether the achieved results and the plans for the next phase are still viable and valuable. A project is finalized at the end of the Exploit phase. In the Exploit phase a plan is developed to ensure that the project results actually end up in a usable product, service, or solution (tech-transfer).

The implementation of the exploit plan (e.g. implementation at one or more partners or transfer to a third party) is outside the scope of the PCSI.

1.3 The Tech-Transfer “gap”

After an Exploit phase is concluded, the PCSI partners want a result to be used after the project has delivered it, or at least share it with the security community.

However, project results can be different in nature (see Figure 2): methodologies, tools, software, concepts, newly defined roles etc., each type demanding different exploitation requirements.

During the first PCSI period (2020-2023) it became clear that the success of sharing and disseminating results was pretty good, but it proved to be difficult to actually get results to be applied and used (red square in Figure 2), either internally or externally to the PCSI program. We have defined this as a ‘PCSI tech-transfer gap’, as depicted (also in Figure 2).

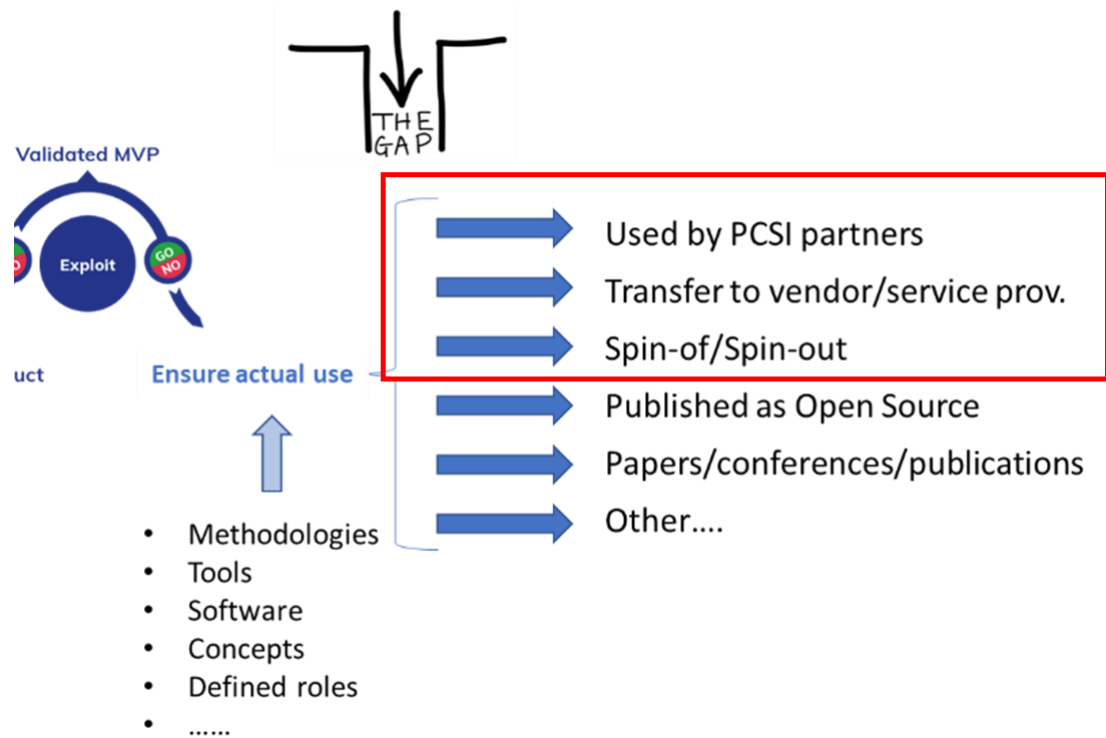


Figure 2 – PCSI results and tech-transfer gap

The same gap is also visible from a perspective of “Market & Technology Readiness Level”, a methodology that is used to evaluate how close to the market project outputs/products are.¹

The “Market & Technology Readiness Level” is a numerical scale combining:

- TRL – the Technological Readiness Level scale measuring the maturity of a technology being developed by a project.
- MRL – the Market Readiness Level scale measuring the commercial readiness of a technology in respect to the market.

Figure 3 shows the TRL and MRL scales and their levels. For a usable result that is also maintained and supported, the desired TRL level would have to be 9, a level in the scale which indicates an actual system proven in operational environment with support and maintenance and MRL level of 6 or 7, implying a stable business to ensure maintenance and support. However, the results delivered by the PCSI projects usually settle in the range of TRL 6 or TRL 7, a level where a technology has been demonstrated in relevant or operational environment, and MRL level 3 or 4, a result that is evaluated in pilots.

¹ source: https://swforum.eu/sites/default/files/2021-05/SWForum_MTRL_Webinar_26.05.2021.pdf



Figure 3 – TRL & MRL levels

It would be (economically) beneficial to bring the PCSI innovation results from TRL level 6 to 9 and from MRL level 4 to level 7. This way the PCSI partners and others could actually benefit from a usable product or service. One issue at hand is that the potential receiving parties (e.g. vendors or service providers) were not involved in the initial project definition; the projects were defined based on end-user need (the PCSI core partners) and the receiving parties usually only got involved later down the line of a project’s lifetime, when a TRL 6 innovation result had already been delivered. Moreover, we experienced that much energy has to be put into the search and selection of receiving parties that actually match with the innovation results. And even if a match is found, much time is needed for negotiations on what will be transferred exactly and all the legal agreements around it. An innovation result on TRL level 6 also cannot easily be transferred and implemented at a PCSI partner directly because it still lacks proper maintenance, support, and updates (although there have been exceptions).

The problem seems to be that the PCSI innovation results does not automatically fit the requirements of the receiving parties. Currently a ‘gap’ is experienced between innovation and actual use and adoption of the result. See Figure 4, where the blue square highlights the Market & Technology Readiness Level (MTRL) level that is delivered by the PCSI projects (which typically is in the tech-transfer phase) and the red square plots the desired MTRL level of a usable result (which has come out of the tech-transfer phase). We expect that additional activities and maybe a different way of working is required in the PCSI process in order to ensure a smoother transfer from innovation to production.

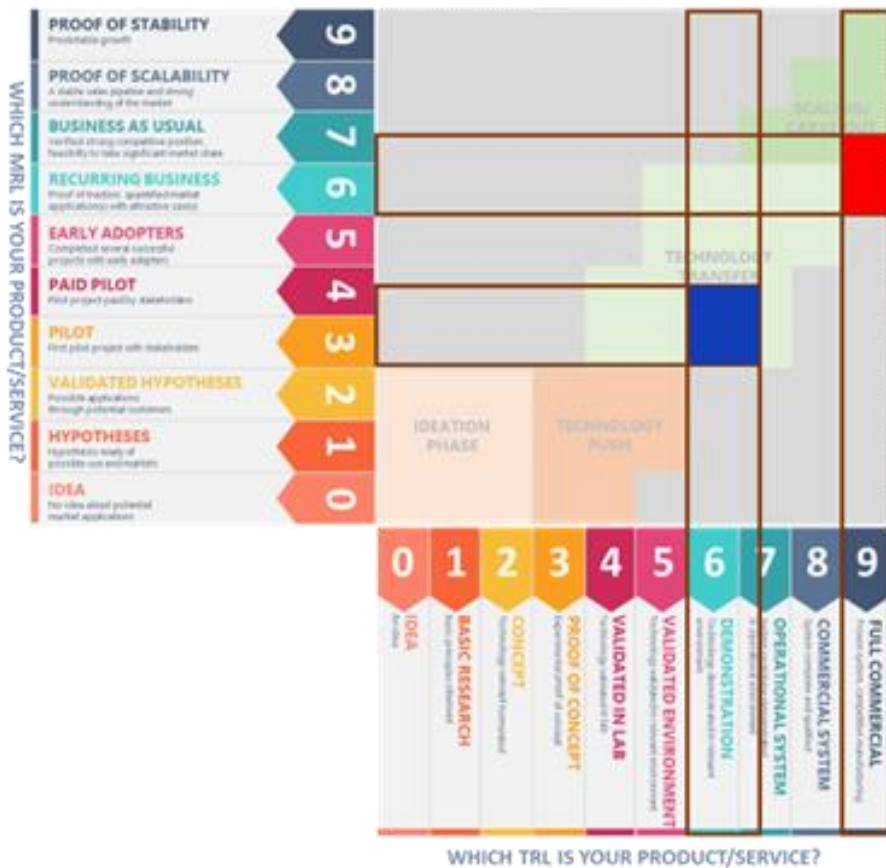


Figure 4 – The Tech-transfer gap in TRL & MRL

1.4 Goal of the PCSI Tech-Transfer project

The goal of the PCSI Tech-Transfer project is to ensure that the gap that exists between a PCSI project innovation result and actual operational use of the innovation result is reduced. The following research questions are formulated to reach this goal:

1. Which barriers within the PCSI or outside the PCSI are experienced, that prevent the continued use of PCSI innovation results after the project has delivered its results?
2. What are potential solutions to overcome the barriers that are found in research question one?
3. How can we integrate the potential solutions in the PCSI process or at the PCSI partners?
4. How can we facilitate the (adoption of) potential solutions that are outside of the scope and responsibility of PCSI partners?

A successful PCSI tech-transfer project should lead to:

- An improved number of PCSI innovation results that are actually used by end-users (PCSI partners and other end-user organizations), resulting in an increased cyber security posture of those end-users;
- A smoother integration of PCSI-created relevant innovative cyber technology and methodology in the products and services of Dutch cyber companies.

1.5 Methodology

The project methodology encompassed three phases: gathering information and state of the art, information assessment and definition of result, and production and dissemination of the results.

1.5.1 Gathering evidence

To gather evidence we looked at relevant scientific literature by conducting a desk research on the topic of bringing (security) innovations to the market.

In parallel, we also organized interviews and workshops with relevant groups of PCSI stakeholders: Steering Committee members, coordinators, project leads, Liaison Partners; also, we interviewed several stakeholders outside of PCSI: capital investors, Open Source specialists, security branch organization, dcypher, government.²

Finally, we selected some PCSI projects of the first period that generated interesting learnings for tech-transfer.

1.5.2 Assessment and result definition

We analysed all results, described them, and formulated improvement points for the PCSI process that can help in decreasing the tech-transfer gap.

1.5.3 Reporting and dissemination

Reporting includes the report you are reading right now, and a presentation.

In respect to dissemination, the results have been presented to interested parties, a.o. the Dutch Ministry of Economic Affairs.

Moreover, the improvement points for the PCSI process were presented to the PCSI Steering Committee together with the suggestion of implementing them in the ongoing PCSI process. The suggested improvements points were approved by the PCSI Steering Committee and will be implemented.

Finally, the project team will be looking for opportunities to publish the results in a journal article.

1.6 Reader Guide

Chapter 2 describes the State-of-the-Art and PCSI learnings, summarizing the findings from the literature search, relevant experience, and learnings from the first PCSI program period. Chapter 3 presents potential improvements of the PCSI process to decrease the tech-transfer gap.

Chapter 4 wraps up the report with conclusions and recommendations.

² A complete list of the interviews and workshops can be found in Appendix A.

2 State-of-the-Art and PCSI learnings

2.1 State of the Art from Literature

We have found several literature sources that are relevant for PCSI tech-transfer. Schuh and Latz [16] describe technology transfer as “the targeted transfer of technological and technology-related know-how between partners and as a necessity for innovation systems to succeed”.

McKinsey & Company [20] show that many promising technologies – yet uncertain and capital intensive – reach commercialization late or never, and argue that a change is needed in how technology is transferred from science to industry, especially in European innovation systems.

Maughan, Balenson, Lindqvist, Tudor [13] describe the barriers for innovation or success much like a “Valley of Death”, and suggest that promising technologies do not come to fruition due to factors such as: unqualified/unskilled team members, team composition, the lack of cooperation with industry, or motivation within the innovation ecosystem.

Below we present a summary of the relevant literature and related arguments regarding spin-off success and tech-transfer for highly technical spinoffs.

The right spin off team composition for success has research and business skills.

Adesola et al. [17] state that the entrepreneurial capital is a new venture’s most important asset. The experience and knowledge of the entrepreneurs, as well as their network capabilities are a multiplicative function of entrepreneurial competence and commitment. They mention that the combination of one very committed researcher and an external entrepreneur was the best combination for success for university spinoffs, due to the complexity and required width of knowledge of the different key factors of a spinoff. Compared to unsuccessful spinoffs, successful spinoffs have “an experienced business coach with complementary skills and experiences who committed one day per week to support the development of the new company. This means that by entering the incubation program they will get access not only to the founding team’s network and the existing network of the surrogate entrepreneur, but also to the existing network of the incubator coach”.

Sutopo, et al. [6] indicate the positive results of partnering with an experienced business entrepreneur gives better insights in market research, market proximity and knowledge. Which leads to higher startup success rates if outside academia such as industry partners, partner with the academic inventor(s).

High-tech spinoff strategy decisions should be made in an entrepreneur/researcher mixed team to prevent bias.

Colombo and Piva [19] argue that academic high-tech start-ups exhibit peculiar ‘genetic characteristics’ that the business strategy often prioritizes further improvement of technological and scientific competencies instead of being more business-oriented.

Nicolaou & Birley [21] & Halecker and Dotzel [4] found that US researchers took active steps to preserve their academic identity even when participating in technology transfer activities by either delegating the business or doing business as well as research activities.

The impact of an academic only team might be bigger with highly technical spinoffs, such as deep tech. The academic increased focus on technology and operations, as well as the typical risk averse mindset could harm the commercialization (tech-transfer) process. Even stronger, they mention literature that indicates that entrepreneurship and academia are contradictory and that there is a lack of entrepreneurial culture within academics.

Deep tech startups face unique challenges with tech-transfer because they need to develop their startup and the market in parallel.

Some studies looked at the commercialization of very technical spinoffs: what happens when the market finds it hard to understand the project and/or the end result?

Schuh and Latz [16] argue that highly technical spinoffs require different tech-transfer factors for success, and in different phases, than other spinoffs.

Adesola and Datta [17] state that the uncertainty and the iterative nature of the explorative R&D, results in high R&D costs required until successful exploitation occurs.

Studerus, and Hämmerle [18] state that deep tech startups face unique challenges since they originate from market niches without an existing market or market players and aim to disrupt existing or create new markets with deep technology innovations. They conclude that deep tech startups and spinoffs “(...) face the challenge of not only developing their organization, but also developing their technology and building a market in parallel”, but often fail because they focus on the operations and neglect to place emphasis on strategic planning and objectives.

Halecker and Dotzel [4] show that with deep tech spinoffs major market risk exists, as the end product and used technology are very novel, not yet embedded in society and during development it's not yet known how system integrators and end customers will react to these innovations. Therefore, the direct commercial applications of the core technology are not usually immediately evident.

They give an interesting alternative in their deep tech commercialization model: they argue that the activities of tech-transfer can be split in two. The technology development can be done by the academics on the spin-off team, to form a generic building block for the technology. At the same time, the entrepreneurs will work on the application of the generic building block of technology in the market. With this model they argue, seen in the appendix, that the often entrepreneurial lacking skills, familiarity with industrial use cases and venture capital within the development stage can be circumvented by outsourcing the final development steps and letting the researchers focus on the technology. The outsourcing can be done by transferring the final development steps not only in spinoffs but also through licensing existing or newly founded companies.

Financing Deep tech startups is different than other startups due to high cost-high risk, since the time to ROI more uncertain and longer.

These high risk-high cost circumstances limit the enthusiasm of financiers. Furthermore the high risk-high cost of deep tech startups increases the time needed to collect the financial means necessary, as well as the overall amount of money needed.

Fukugawa [10] argue that research institutions and universities should do research resulting in patents to signal to outside financiers such as venture capitalists how successful their spinoffs and IP is. He concludes that Venture Capital involvement is a positive influence for deep tech startups with the coaching and market connections they provide.

Cybersecurity and tech-transfer: practical application of research is only possible with cross sectoral partnerships and access to data & cyber systems of the industry.

The work of Kashef et al. [22] is of particular relevance because it is actual, and cybersecurity tech-transfer topic specific.

They mention the difficulty for cyber security research: it is a meta discipline based on cross sectoral partnerships. They state that there is a disconnection between ad hoc industry solutions and the research; conducting research is challenging due to restricted access to cyber systems and data in real-world applications.

This limits researchers from comprehending current cyber issues in practical settings, affecting industry and the public sector as well. This results in solutions from research that are often inaccessible or unsuitable for application environments. Also, the research solutions are often misaligned with industry's short-term goals of reaching the market with an innovative idea before competitors and immediate market-driven cybersecurity challenges.

They conclude that research spinoffs can be sped up in their transition to the industry if industry stakeholders must grasp the scientific rigor needed for academic publications, while academic partners should consider industry deliverables and need for market connection.

Finally they argue that the key component to success is academics and industry working together to clearly define the problem instead of only aligning primary outcomes, including collecting feedback from potential customers. With this alignment we accelerate knowledge transfer and optimize the internal drivers (operational effectiveness) of universities and industry.

2.2 Experiences and learnings from PCSI

2.2.1 Evidence from interviews

We have categorized the input collected in the interviews into the six following themes:

1. Market connection and exploitation
2. Connection to core partner internal roadmaps
3. Open Source development and policing
4. Enhanced Tech-transfer Practices
5. Improving collaboration and stakeholders engagement
6. Enhanced business models

Market connection and exploitation

Many PCSI stakeholders' suggestions hammered on the need of creating a strong connection with the cybersecurity market, a strategic endeavor that PCSI must prioritize to ensure proper exploitation of its innovations. Such a connection means: understanding the needs and dynamics of the market, establishing a presence within industry circles, and fostering relationships with key stakeholders who can successfully drive the entry and the growth of innovative PCSI results.

Of course, it all starts with the willingness of the Dutch cyber security market to adopt and implement innovation results. The real large vendors usually develop their products outside of the Netherlands and are therefore a less attractive partner in tech transfer.

Numerous suggestions referred to licensing and its nuances:

- Licensing agreements represent a pivotal element in the tech-transfer dynamics as they define the terms under which PCSI's innovations are used by others;
- Proper licensing ensures legal and IPR protection, and revenue streams (or discounts for the partners), as well as setting the stage for the positioning of innovation results in the market;
- Careful consideration of licensing terms significantly accelerates market uptake, leading to higher impact overall.

From the interviews, we have learned that a successful PCSI exploitation should have at the very least:

- a clear business case;
- a committed problem owner;
- one or more committed customers;
- one of the stakeholders (e.g. spin-off, Liaison Partner, foundation, OS community, etc.) willing to exploit the results of a project;
- clear and properly demonstrated tangible benefits that the end users will gain from adopting the innovation;
- measurable (SMART) financial and strategic gains that PCSI end-users could expect.

Other suggestions that were made:

- PCSI core partners often have insights in the existing market; PCSI partners also have relationships that can accelerate market penetration. Moreover, PCSI core partners should increase their role in shaping the right value propositions for the PCSI innovations to ensure those can resonate with the market needs;
- PCSI should continuously work on enhancing market connections by deepening existing relationships and forming new ones. This includes engaging with new core partners, liaison partners, investors, and targeted dissemination;
- PCSI must stay informed about market trends, adapt to shifting end-user needs, and respond promptly to relevant cybersecurity landscape events;
- By understanding how an innovative product could benefit the business continuities of potential clients, PCSI can strategically engage Liaison Partners and effectively focus its marketing efforts;
- Thorough market research is necessary to gain a complete understanding of the market environment and serve as the foundation for PCSI's market and technology transfer strategy;
- It would be wise involving a marketer role to support PCSI projects during the Explore, PoC, Pilot and Exploitation phase. A marketer's expertise in campaign management, digital marketing, and sales enablement would be driving innovation uptake within the right market(s) and sustain the market growth of PCSI results afterwards.

Connection to core partner internal roadmaps

In one interview, it was highlighted that aligning innovation projects with internal roadmaps is crucial for success and maintaining partnerships in a PCSI setting. Misalignment, could lead to:

- Sub-optimal project staffing from the core partners;
- Insufficient energy and support;

- Project failure because the result is not adopted/implemented by a partner's organization without the architectural department's attention or energy.

Open Source development

The decision to open-source specific innovations requires a strategic approach with long-term consideration. Factors such as which parts of the software stack to open-source, licensing choices, adherence to code quality practices, repository maintenance responsibilities, and monetization strategies need careful planning. Some suggestions to improve this process that were made:

- Ensuring code quality in projects that will publish Open Source code is of high importance. When code quality in lower TRL levels is at par with what is required at TRL 8~9, it will improve the chances of hand over to a 3rd party (other than TNO or the PCSI core partners);
- To ensure long-term success for Open Source projects, the innovation could be transferred to organizations with experience in managing Open Source initiatives;
- Making decisions regarding coding standards, security requirements, testing procedures, documentation practices, and community guidelines early in the development process is essential. Early decision-making significantly increases the likelihood that subsequent code contributions during PoC and Pilot phases will be consistent, secure, well-documented, and easily adoptable by targeted Open Source communities;
- Identifying and involving Open Source communities early in the development process can significantly improve the success rate of technology transfers. To ensure adoption by these communities, a clear and compelling value proposition for each project or innovation should be articulated. This includes demonstrating the benefits that the community will gain from adopting and contributing to the project, aligning the PCSI business case with the community's mission, and fostering long-term engagement and support for successful tech-transfer and maximum impact;
- When possible, standard APIs (Application Programming Interfaces) in software products should be used as they can increase interoperability and facilitate seamless integration with both Open Source projects and commercial products. Standard APIs simplify the process of building upon an Open Source project for other developers, accelerating adoption, and minimizing friction;
- Finally, managing intellectual property rights in an Open Source context requires finding a balance between flexibility for users and maintainers while preserving ample opportunities for PCSI partners, Liaison Partners, and commercial entities to build on the innovations. This can be achieved by carefully considering licensing terms and other IP strategies.

In the interview with Radically Open Security they proposed an intriguing concept: establishing a platform for non-profit start-ups that are financed through cross-subsidization from the profits of other businesses or activities. Instead of selling software licenses, these start-ups provide mentoring services around Open Source software. This idea emphasizes "open source stewardship" as a responsibility for technology companies within the PCSI ecosystem.

Enhanced Tech-transfer Practices

We have learned several improvement points in tech-transfer practices:

- The involvement of Liaison Partners in PoC phases and beyond should lead to exploitation trajectories that benefit both parties. However, it is important for PCSI not to assume the role of research and development for Liaison Partners but instead engage in a

collaborative process where problems owned by PCSI partners are addressed through mutually beneficial innovations. These collaborations can lead to enhanced product development and increased technology transfer opportunities due to TNO's expertise, the market access of Liaison Partners, and the reputational weight of the PCSI core partners;

- PCSI should strive to find appropriate IPR structures that protect innovations while fostering partnerships and market opportunities among various stakeholders, including public investors, private investors, end-users, and PCSI partners. The goal is to create an IPR framework with a decision tree that encourages sharing and commercialization of PCSI results while safeguarding partners' interests, ensuring a smooth tech-transfer process without surprises for any involved parties;
- The business sponsors involved in technology transfer often fail to assign adequate priority and dedicated time for this role, while projects request it. Clearer definition of responsibilities and tasks for the business sponsor role across various stages of the PCSI process will enable better strategic direction and resource allocation from business sponsors. This alignment with business goals will ultimately streamline tech-transfer activities;
- Involving the PCSI Steering Committee more extensively at critical Go/No-go junctures could ensure that market and tech-transfer-related decisions are made with better strategic (long term) oversight;
- Preparation for exploitation should commence as early as the PoC phase, enabling PCSI to anticipate market requirements and refine its innovations with commercialization in mind from the outset. This can be better facilitated with the introduction of a new Business Owner role in the team;
- Defining a number of SMART KPI indicators for successful tech-transfer may help evaluating points of continuous improvement in the tech-transfer efforts. The SMART KPI indicators could reflect on a number of qualitative and/or quantitative aspects from the TRL and MRL scales;
- The introduction of a tech-transfer radar is an innovative practice that can provide PCSI with a comprehensive overview of ongoing tech-transfer activities, market trends, and emerging opportunities. By offering comprehensive insight into ongoing tech-transfer processes, this tool helps proactively identify and pursue potential tech-transfer prospects and capitalize on current market trends;
- Establishing a (virtual) demonstration platform for PCSI products could streamline the tech-transfer process, serving as a repository for innovation and a "shopping window" for interested commercial parties (whether those may be potential investors, Liaison Partners, or end-users);
- Extending some of the PCSI phases from 4 to 6 months could allow for a more thorough development or a more thorough assessment in respect to the innovations being worked on (the need for this improvement is substantiated in part by the fact that many projects in the past had to either repeat or extend one or more phases).

Improving collaboration and stakeholder engagement

Many suggestions revolved around the themes of collaboration and stakeholders engagement. Several suggestions within this group intertwine with other suggestions in the other thematic groups.

- End-user involvement is essential for acceptance of innovations and successful tech-transfer. Engaging end-users at appropriate stages ensures user-centricity without affecting the development timeline or innovation process. Collaboration between PCSI partners can facilitate this inclusion and streamline the end-user engagement process.
- Strategically engaging investors during tech-transfer can improve odds of success; Investors should ideally be brought in towards the end of the pilot phase when there is a

functioning TRL 6 prototype and clear understanding of market potential and target demographics. For investors to invest, it's crucial that the innovation addresses a tangible need with a defined target market eager to buy the product or service;

- Knowledge exchange sessions between PCSI partners and external organizations (like Cyberveilig Nederland) are crucial for fostering idea exchange and sharing expertise. These interactions help expand the PCSI's knowledge base, keep it informed about current and developing cybersecurity trends, and strengthen its industry connections;
- To facilitate industry-wide collaboration, PCSI could compile and disseminate a catalog of its available innovations to sector organizations within the cybersecurity domain. This initiative would showcase PCSI's results and at the same time invite collaboration and feedback from other organizations and/or companies directly involved in the (Dutch) cybersecurity landscape;
- In the explore phase, input from selected Liaison Partners that is relevant for the topic at hand (yet without involving the Liaison Partners for the entire phase) should be incorporated. This moment of collaboration could make the Explore result more comprehensive, incorporating diverse viewpoints and enriching the project's market proposition;
- Securing buy-in from problem owners within partner organizations and the market is essential for the success of innovative products or services developed by PCSI. Problem owners must be willing to invest both financially and strategically, which serves as a commitment to the innovation's implementation and a key performance indicator (KPI) demonstrating added value to the cybersecurity landscape.

Enhanced business models

Suggestions in the context of Business Models consistently mentioned the pre-requisite of a strong connection with the market (previously discussed earlier in this section).

Understanding the market dynamics, the customer needs, as well as the current trends in technology are all essential inputs for tailoring innovative business models for PCSI.

Some suggestions that were made:

- Making an early decision about whether to make a project Open Source or not during the development process is crucial for business models involving Open Source deliverables;
- Identifying the optimal point for inviting active participation in the innovation cycles from market parties is another strategic decision that can lead to innovative business models for the tech-transfer. E.g. an engaged Liaison Partner who has contributed to the project as early as of a PoC phase and therefore feels (a strong) sense of ownership of the results. Nevertheless, engaging market parties too early or too late in the process can have implications for the innovation's development and market fit (e.g. because of a too hard commercial push from the Liaison Partner(s) involved);
- PCSI's Steering Committee plays a key role in making strategic decisions regarding tech-transfer business models, including continuing or discontinuing projects not suitable for market implementation. The Steering Committee's active involvement can also help highlight and support promising "crown jewel" projects to demonstrate the success potential of PCSI innovation;
- PCSI could strategically allocate financial gains from selling intellectual property rights back into research and development for continuous innovation. The feasibility and permissibility of such financial structures requires further exploration.

2.2.2 Evidence from workshops

Next to the interviews we also conducted two workshops with a group of people that all fulfilled the same role. We had one workshop with all the coordinators and one workshop with the project managers within TNO that manage the PCSI innovation projects. See Appendix A for the participants in the workshops.

The reason for core partners to collaborate in the PCSI

Several reasons for PCSI participation were mentioned:

- The belief that complex problems require collective efforts to be effectively tackled. Since partners are engaged in various collaborations, not all topics will be addressed within the PCSI due to resource limitations or overlapping focus areas. An example provided was Post Quantum Crypto being a topic currently handled outside of the PCSI;
- In a PCSI project, producing concrete, tangible, and innovative results with a scalable impact is crucial. The outcome should prevent potential negative impacts from cyber threats, be measurable and adaptable by core partners, contribute to Dutch society, generate experience and knowledge, inform decision-making, demonstrate the feasibility of an idea, improve expert understanding, and support more informed investments and product development;
- Core partners' involvement in the PCSI extends beyond just project outcomes. They value opportunities for knowledge exchange with diverse sectors and access to TNO expertise, including cybersecurity advancements;
- The emphasis is on creating innovative but practical solutions as opposed to purely research-focused projects. Tech-transfer is crucial because usable results are a primary reason for collaboration, but other non-tech transfer results are also highly regarded.

PCSI process: select the successful potential tech-transfer projects in an early stage

The starting point is that not every successful PCSI result produces a tech-transfer result, this is why the PCSI is an innovation collaboration. In several projects, the experience and learnings that are gained are the most valuable result; this knowledge can be used for e.g. RFP (Request for Proposal) discussion with vendors or contracting parties to build tailor made solutions.

New role of Business Owner: bring business need and project team closer to each other

To bring the business and project team close to each other, a good idea would be to introduce a business owner. The business owner's focus should be on incorporating end-user needs, and ensuring product fulfillment of all requirements, when scaling to TRL 9. This can bring business and project teams closer together. However, potential downsides could include the future business owner prioritizing their own interests, leading to conflicts. Having a business sponsor from one partner and a future business owner from another partner or making it a mandatory requirement during ideation for partners to nominate a future business owner can help ensure greater engagement and "skin in the game." Additionally, there is significant regulatory work involved, with business sponsors often having limited involvement at TRL 6. End users may not think in terms of high-level requirements, making it crucial for the future product owner to bridge this gap.

Role of Business Sponsor

The Business Sponsor role of a project is fulfilled by a member of the Steering Committee. The involvement of the Business Sponsors could be better in most projects. The minimal activity would be to meet with the project team to prepare the Go/No-go decisions, but it would be better if business sponsor joins the Presentation Day. If not possible, at least an email with his/her advice should be shown during the project presentation.

Endorsement by (a selection of) core partners

An idea is to work with a selection of core partners for certain products that are exclusively endorsed for a better requirement fit and more engaged partners that are willing to put forward a future product owner to put in the extra time and effort that is needed to bring the product to TRL9 and implement it in the company. To be successful in this, a market connection in the form of a business- developer and coach is needed. A selection (go-no go) should be made for deciding to go to commercialization, so that only projects that can result in a product are allowed to continue. This would also create a selection before interacting with a supplier.

Technology transfer support

An option would be to provide additional market support outside of the Liaison Partners. For instance, introducing a Tech-transfer coach who assists in the initial stages, or offers guidance in the transition from innovation result to usable product. Initially, it should become clear what each partner seeks in technology transfer for a specific project; the next step is to assign a Technology Transfer Coach for such a project to assist with exploitation and post-exploitation. Utilizing (pre-prepared) templates and tooling can aid in specifying technology transfer requirements. Additionally, learnings that were gathered in finalized tech transfer projects should be fed back into the tooling and templates.

Involvement of Steering Committee should increase towards the end of the project

The Steering Committee selects the topics for Ideation and decides which ideas can start as a project. After this initial phase the involvement of the Steering Committee is somewhat limited; projects present their Exploit plans at the end of the Exploit phase to Steering Committee . But this involvement needs to grow towards the end of the project, specifically in case of a tech-transfer result. For such results, business decisions need to be made e.g. on transfer of Intellectual Property or investment by the PCSI. This is the responsibility of the Steering Committee.

Role of coordinator board

An important role in tech-transfer success also lies at the coordinator board. One of the SuccessFactors is to ensure sufficient visibility of PCSI in their own organization, which makes inviting experts for Ideation and projects much easier. Also a coordinator should monitor the project attendance and interest in a project where experts of the coordinator's organization are involved. This could prevent escalations in projects. It would be good to have joint Steering Committee and coordinator board meetings once or twice a year, a.o. to discuss the success rate of tech-transfer projects.

Ideation depending too much on participation of individuals

For selection of Ideation topics, it is important to conduct a more comprehensive question/pain survey among our partners, which will lead to better scoping during theme selection/ideation. We should focus on preserving more ideas and reducing the amount of ideation. This way, the ideation process won't solely rely on the individuals present during those sessions. Currently, the best idea is not always chosen.

Project staffing

Depending on the project and tech-transfer opportunities, project teams should also incorporate a coordinator or project lead from business side, besides the technical experts. We could describe such a project team member as a 'business savvy co-worker'. When asking potential experts to join Ideation or participate in projects, it should be made clear to them what to expect (a PCSI flyer that explains the Ideation and expectations already is available). When experts are not available, it would be an option to involve external hires, but this will reduce the benefits of employee engagement of own staff and should be used with reluctance.

Enterprise ready vendors as tech-transfer partner

For large companies such as the core partners, start-ups or small supplier companies are usually less attractive to conduct business with (due to the lack of track record and stability). So PCSI results should preferably land at 'enterprise ready' vendors. Maybe interest Microsoft to become a Liaison Partners.

2.3 Learnings from PCSI projects

This section summarizes the most important learnings with respect to exploitation of results of the first PCSI period (2020-2023). In this period, a total of 8 projects made it to the Exploit phase. We summarize the learnings of four of those, and focus here exclusively on the actual use of the result. A more elaborate description can be found in Appendix D.

2.3.1 Joint practices for security in agile

What is the project about

CI/CD pipelines enable continuous software releases but also pose a challenge with potential vulnerabilities introduced during development. The "Joint Practices for Agile" team explored ways to ensure secure Agile development by engaging in DevSecOps communities, which offer collaboration opportunities. This led to the design of a self-governed and self-sustaining PCSI DevSecOps Community (independent of PCSI) with a communication platform and potentially expand to trusted partners in the Netherlands.

At the end of the Exploit phase, the individual Steering Committee members were asked to provide in-kind support (hours for their DevSecOps experts to participate) and small in-cash contribution (to implement and maintain the communication platform).

The Steering Committee granted a trial period for one year without providing funding for a communication platform. Although there was initial enthusiasm, the formal constitution of the community and appointment of its board were delayed due to Corona lockdown countermeasures. Unfortunately, during this delay, the Business Sponsor and a prospective board member became unavailable.

What are the learnings

- Innovative solutions addressing collaborative cybersecurity challenges, such as community engagement plans, can benefit the PCSI experts dealing with daily cybersecurity issues;
- After the exploit phase ends, the practical difficulties encountered by even highly motivated teams from other PCSI core partners in pursuing required tasks for innovation exploitation become apparent when dedicated TNO expertise is no longer available.

2.3.2 Collaborative Deception Fleet

What is the project about

The Collaborative Deception Fleet (CDF) is a project involving

- Active deception as a proactive defense to lure threat actors;
- Collaborative deployment among consortium members;
- Record threat actors' actions in "wiretapped" environments;
- Generate valuable customized threat intelligence for PCSI partners.

Due to long lead times for market selection and legal discussions, the project went through every phase twice. The (Spanish) Liaison Partner CounterCraft came out best from the market selection and joined in the 2nd PoC phase to help build the environment, and valuable experience was gained through red-team exercises. The 1st pilot phase focused on environment preparation and initiating a lengthy legal research process, while only one deception campaign could be carried out during the 2nd pilot phase. In the exploit phase proposed to start a federated entity either constituted by (or working for) the PCSI partners to conduct deception campaigns for count of the PCSI partners.

In response, the Steering Committee requested the CDF team for additional evidence of the real added value of this proposal. This led to a reboot of a new pilot phase in which the team has been challenged to prove the added value by checking a number of requirements.

What are the learnings

- Allocating sufficient time for market selection and reaching legal consensus between partners is essential;
- Closely collaborating with a reliable, competent Liaison Partner can expedite project progress but requires effective management to handle the associated dynamics;
- Commercial partners may use communication opportunities as acquisition prospects;
- The project gained valuable insights into collaboration dynamics and the role of a Liaison Partner in the PCSI program.

2.3.3 Security Behaviour Coach

What is the project about

The initial project concept revolved around applying marketer's 'customer journey methodology' to make employees more security-conscious. During exploration, this idea evolved into investigating the feasibility of a new role: Security Behaviour Coach (SBC). SBC identifies human behaviour causes of security vulnerabilities and revises business processes accordingly. The role was piloted at one PCSI core partner and valuable learnings were gathered despite setbacks due to the COVID pandemic.

The SBC job description and profile were shared for download. To promote this new position and continue the project's exploitation beyond the pilot stage, a 'round table' session was organized in-person, bringing together cybersecurity awareness professionals from companies, end-user organizations, sector organizations, universities, and the PCSI Business

Sponsor. During this event, participants discussed the role concept and created the name “Security Behaviour Coach”. While many expressed enthusiasm for the idea, only a few saw direct application in their day-to-day businesses. As a result, the Security Academy and Security & Continuity Institute (SECO) now are offering a dedicated training for the new role of Security Behaviour Coach as it was developed by the PCSI project.³

What are the learnings

- The original goal of the project was not to create a new security role, but rather to stimulate secure behaviour among employees. This evolved into developing the SBC role, aligning with the initial objective and providing a more concrete outcome than initially anticipated. We learned that during a project, the result can get more focus.
- The round table event proved to be effective for Exploitation as it allowed interaction with experts in the field, discussing the value of the role, and identifying partners willing to adopt it for further development.

2.3.4 Purple AI

What is the project about

The Purple AI project aimed to explore if AI could improve cybersecurity challenges such as red and blue team exercises by developing a learning system. The goal was to create a framework where red-team and blue-team agents could continually enhance their actions through machine learning. The PoC focused on building a Reinforcement Learning model and tested its ability to learn the right courses of action for privilege escalation through three experiments with increasing levels of complexity. The results showed that the model could effectively learn the optimal actions in the simplified environment. For Exploitation, several talks were held with interested companies that deal with red teaming, they indicated that the technology as such was very interesting, but also relatively niche. Also the possibilities of starting a spin-off that would further develop the framework and PoC was explored. However, the members of the project team decided that they were not interested in joining a spin-off. Also, there were a few meetings with a company specialising in Red-Team services and Application Security that might be interested to develop this concept further. Unfortunately they decided not to pursue this because of other priorities. The framework and PoC are available and described in a white paper⁴. A follow-up PCSI project has been started (PurpleAI2) to further explore the potential for red teaming tools that are AI based.

What are the learnings

- Purple AI is an ambitious and long-term effort from a technical perspective, and the original ambitions actually did not really fit the short-cyclic PCSI innovation process. Therefore the project was scoped down to be able to implement a PoC, but this took quite some time and discussion in the project team. We should recognize in an early stage (preferably during Ideation) that scoping is necessary;
- It has been proven difficult to find a good landing place for the project result; it was a rather niche result and also red teams are not yet used to applying advanced AI tooling in their red team exercises. To ensure a better landing place, we probably should have involved interested companies earlier in the process. Another option for this project would have been to involve developers that have the drive and ambition to start a spin-off with this project result;

³<https://www.securityacademy.nl/opleidingen-overzicht/vendors/security-academy/security-behavior-coach/>

⁴ https://pcsi.nl/uploads/downloads/Visionpaper-PurpleAI-20230907_Final.pdf

- When a result is not adopted because the timing is not right, it could be kept alive by low profile exposure activities over a longer period of time. Keeping it in the shopping window may lead to success (much) later on.

3 Improvements to PCSI

3.1 Roles

Steering Committee

Enhancing the PCSI process could include closer involvement of the Steering Committee in specific Go/No-go decisions about projects, such as transitioning to a "market readiness" phase, granting special mandates for project success, or taking a more proactive stance on project lines to discontinue.

Business Sponsor

Ideally, the name of a PCSI project's business sponsor is already known before the explore phase of the project starts. Project managers are usually free to agree with the business sponsors themselves how often and in which way to interact throughout the run of a project. To better exploit the business sponsor's role for the scope of tech-transfer the role as well as the responsibilities and tasks at specific points in the PCSI process will have to be made clearer.

Business owner

To enhance the business focus, we suggest to create the new role of "business/product owner". The new role will be involved in several project-related decisions, and should primarily address the following points:

- a. Partner involvement and readiness when progressing to the pilot and exploit phases.
- b. Emphasizing the need for more stringent "no-go" decisions, especially during pilot phases that demand greater commitment from partners. Resources and motivation become crucial prerequisites that we must insist on. Suggestions were made to be more assertive and willing to halt a project if enthusiasm from partners is lacking.
- c. Honesty regarding project ideas and outcomes, with a willingness to terminate projects earlier if they are not likely to result in a successful product.
- d. Recommendation to be highly selective when choosing projects to advance to the "red" phase. Red being market readiness level 7 and TRL9. If a project reaches this phase, partners should commit formally, both in kind and financially.

This approach ensures a more structured and committed approach to project development, aligning better with market needs and partner engagement. Less successful projects often experience a shortness in time and too little priority with stakeholders such as the business sponsors, as well as a too little market connection.

Experiment Coach

While the experiment coach role was extremely important at the very beginning of PCSI to bootstrap and adjust the process. At this moment, the largest part of the operational experience resides with the Project Leads and the Coordinators. More and more often pragmatic solutions are found through the active and constructive interaction of the two above-mentioned roles. The Experiment Coach did not play a role in tech-transfer. All in all, this has led to the decision of phasing out the role of experiment coach.

Project Lead

The Project Lead should be stimulated to have an increased open eye for the business aspects of a project and also involve the Business Sponsor closely in the project. It would be good to have available a pool of Project Leads that are experienced in tech-transfer projects and can be assigned to such projects.

Core Partners' Innovation department(s)

At the moment, PCSI does not actively involve the knowledge and/or expertise from the innovation departments of the PCSI core partners.

From the interviews we learned that not all PCSI partners have equally mature innovation departments. Nevertheless, wherever such departments exist and have capacity that can be made available for PCSI, that could be used to contribute business expertise to the PCSI innovation cycles, either in structural or in need-to-consult form.

External Investors and/or Financing

At the moment, PCSI does not involve external investors. In the future PCSI could organize presentation events for external investors who might be interested in taking some of the innovation developed within PCSI in their investment portfolios or support in finding entrepreneurs that could start a start-up company for a certain product. The interviews we had with investment companies showed that they are interested in such collaborations.

TNO Tech-Transfer

TNO has a tech-transfer program, in which promising TNO research results can be supported (both financially and with knowledge and expertise) in bringing this to the market. We have had one TNO tech-transfer project the Shared Research Program Cyber Security, from which we learned a lot but it did not lead to concrete results. At the moment, PCSI has involved the knowledge and the expertise of the TNO tech-transfer department on a need-to-know/need-to-consult basis. In the future, we should keep an open eye for results that could potentially be moved to a TNO tech-transfer project. TNO tech-transfer can certainly provide support with questions in this area and maybe even can support in finding entrepreneurial TNO staff that would be willing to be involved in a start-up company.

Marketing & Communication

As of today, PCSI has made large use of Marketing & Communication. That includes numerous social media campaigns on LinkedIn, organization of both physical and virtual events for core and Liaison Partners, lectures, webinars, expert workshops, and presentations online as well as at conferences. The Marketing & Communication of PCSI has certainly contributed to making the program well known within the reference target group (the Dutch cybersecurity landscape) and has greatly increased the media exposure of some of the topics and the results the PCSI experts have been working on. A point of improvement for the marketing and communication role would be to have an increased role in the business side of tech-transfer. One example could be the involvement of a marketer role. A marketer looks at the market and is able to define and identify the right target groups that PCSI should be approaching. Also, the expertise of a marketer would come a long way in helping answering questions such as "to what extent does a PCSI innovation product meet the needs of the end-user?" from the perspective of market research. Last but not least, a marketer role could function as a supporter for projects in the exploit phase. Good marketers are able to balance strategy, market research, value proposition, as well as the message to be communicated to the potential end-users.

Liaison Partners

In the past the PCSI already decided that joining a PCSI project is possible for the Liaison Partners only from the proof of concept phase onwards. This is done to mitigate the risk of Liaison Partners interests interfering with the tactical needs of the PCSI core partners in respect to the innovation being explored.

An improvement one can bring to the PCSI process is a more thorough classification of the current Liaison Partners by inventorying (some of) their key strategic goals so that an overall improvement can be made in matching innovation projects with the right Liaison Partners and vice-versa.

3.2 Overall process

Overall, the PCSI innovation process as it was set up in 2020 – and has been carried on until 2023 – has received high appreciation. Many refer to the PCSI as a positive example for short-cyclic applied (security) innovation. Most often mentioned are: the innovative results produced, the collaborative aspect of the program, the high energy and the high employee engagement. Nevertheless, based on the assessment as described in chapter 2, there is room for improvement of tech-transfer on the following topics.

Result Type-based Tech-Transfer Guidelines

As described in chapter 1, the PCSI produces various outcomes, including Tools, Open Source Software, and Methodologies, which require distinct approaches for technology transfer (tech-transfer). A comprehensive document detailing the steps for successful tech-transfer for each result type would be beneficial. For instance, when transferring Open Source Software, aspects such as legal considerations, license models, library usage, community building, and support structures need to be addressed. This document should be updated regularly with new experiences and learnings gathered from each project to ensure its accuracy and effectiveness.

Go/No-go requirements and thresholds and Business Sponsor/Owner Involvement

The Go/No-go decisions until now are based on 5 items that receive a score from the coordinators. The average over the coordinators provides an indication of the quality of the project and its results. But these could be elaborated and turned into clear requirements and thresholds for Go/No-go per phase (e.g. sufficient number of partners involved, insufficient visibility of results, previous coordinator board advice followed). And then also specific requirements for a (potential) tech-transfer result should be included, such as whether a receiving partner already has committed to bring a result to a TRL product, whether budgets are secured, whether there is sufficient business support. Also, a Go/No-go decision should not be taken without involvement of the Business Sponsor and Business Owner of the project. They should be put in written advice and preferably be present during Presentation Day, during which the Go/No-go decisions are taken.

Timeliness of project-to-market transition

When a project is expected to produce a result which potentially qualifies for tech-transfer, it is important to start the tech-transfer activities as early as possible, but also to decide a ‘let-go’ moment from PCSI perspective (see the improvement below).

Based on the evidence gathered in chapter 2, the ideal first decision should be in the Go/No-go at the end of the Explore phase.

In the PoC plan delivered at the end of the Explore phase, it should already be clear what the nature of the result of the project will be, and whether this result potentially qualifies for tech-transfer. Henceforth, all kinds of activities that are geared towards tech-transfer can be initiated in such a project.

Additional “Post Exploit” phase

In the Exploit phase, a plan is made for Exploitation. The end of Exploit was intended as the end of PCSI involvement and for tech-transfer, this would mark the ‘let-go’ moment, in which the PCSI stops its activities and the result is transferred to a receiving party. What we have learned in chapter 2, is that the end of the Exploit phase comes too soon for most tech transfer results. To make it successfully to TRL 9, the results needs an extra ‘push’. This is why we recommend to define an additional PCSI phase specifically for tech-transfer results. In this phase, the first part of the Exploit plan can be implemented and a smooth hand-over to the receiveing party can be guaranteed. Whether the Post-Exploit phase actually is started and time and budget is spent for this phase is a Go-NoGo decision that is taken by the Steering Committee on advice of the Business Sponsor and Business Owner.

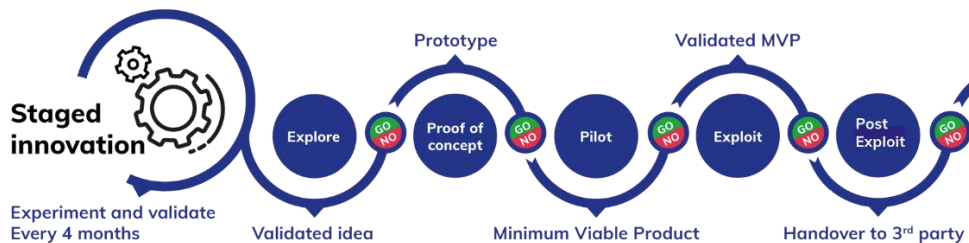


Figure 5: Additional PCSI phase: ‘Post-Exploit’

3.3 Topic selection

The PCSI Steering Committee selects topics for new innovation projects, and the PCSI security radar serves as the primary source of new topics for the selection. The selection process is going well, but we have identified some improvements for the selection and preparation phase based on the evidence gathered in Chapter 2.

Prepare

To ensure sufficient support within the partner organization and to ensure that staffing of the PCSI projects is seen as priority, it is important to prepare the topic selection internally at a core partner. There should be consensus that the topics chosen are important topics for the core partner and the core partner should ensure availability of expert resources to participate in Ideation and a potential project resulting from the Ideation.

Very important is to ensure that the selected topics for Ideation are in line with the (architectural) roadmaps of the partner. This ensures sufficient attention and energy on the topic but also specifically is of interest when results are adopted as tech transfer by a PCSI partner. We have seen evidence in at least on case that implementation of tool (that resulted from a project) was not on the roadmap of the architectural department and consequently, this implementation failed.

Motivate Clearly

It would be very helpful if the Steering Committee members would clearly motivate why they would like to select a specific topic. These reasons should then be written down and used for the selection of experts but are also useful in the Ideation session. In some cases, when the preparation for the topic selection was not so well prepared due to time pressure, we saw a disconnect between the Steering Committee member of a core partner (that selects the topics) and the coordinator of a partner (that usually assigns experts for Ideation and project). A well-motivated topic selection would also help to solve this issue. As of 2024, the Steering Committee agreed to also invite all coordinators to the topic selections, which also will help to synchronize between all involved.

3.4 Ideation and decision making

For each of the topics that is selected by the Steering Committee, an Ideation session is organized to assess the issues of the core partners with the topic and to generate innovative ideas to tackle the identified issues. Since the COVID pandemic has ended, we organize these sessions as a full day face-2-face session, in which the Ideation sessions are held in the morning (led by a dedicated facilitator), a pitch for each project idea is prepared in the early afternoon and the Steering Committee decides which idea is selected to start as a project; this is organized in a Dragon's Den setting. These face-2-face Ideation days are highly appreciated and are full of energy. However, we have identified some improvement points based on the Chapter 2 assessment, which are described in this paragraph.

Prepare

The time between topic selection and Ideation is pretty short, usually 4-6 weeks. In this time, the core partners need to select experts that can participate in Ideation (or hopefully already have done this in the internal preparation of topic selection, see previous paragraph). In an Ideation session, all experts start reasonably 'blank'. They are experts on the topic, but the topics mostly cover many sub-topics because they are formulated on a high level. To be better prepared in the Ideation session, it would be a good idea to extend the time between topic selection and Ideation.

In that time, the topic can be prepared, e.g. by:

- Scoping the topic down;
- Performing a market scan for products and tools that are available;
- Making an overview of State of The Art research on the topic;
- Assess the potential tech-transfer areas for this topic.

In that way, the Ideation is expected to be even more effective. The preparation could be done by a small number of experts of various partners, that are assigned to the Ideation on the specific topic. Of course, we should take care not to limit the topic too much, because the Ideation should be a creative process with broad perspective.

A Balanced Representation

The Ideation needs to be staffed with experts. Not all partners participate in each Ideation and the number of experts per partner varies; we do not have defined a limit to the number of experts per partner. This sometimes leads to an imbalance in the Ideation staffing, in which e.g. three experts from one partner are represented while the other partners only have one representant. Also, we experience in some cases that one expert has major influence on the outcome of Ideation, because he or she is an extravert and self-confident person that leads the discussion. We therefore propose the following improvements:

- Limit the number of experts per partner to two;

- In case of voting in the Ideation group, each core partner can only cast one vote;
- The facilitator of the Ideation session will pay even more attention in balancing the discussion and ensuring an outcome that is based on consensus;
- The facilitator will also ensure that (initial) tech-transfer potential is discussed .

Assignment of Business Sponsors and Business Owners

When the Dragon's Den (Steering Committee) decides to start a project that is pitched, they should have assigned a Business Sponsor (a member of the Steering Committee) already and announce this to the Ideation team. The Business Sponsor on its turn should find a Business Owner (someone from a business department that is experiencing the pain that the project tries to solve) within one month after Ideation. A Business Owner preferably is from a different core partner than the core partner that provides the business sponsor, but could also be a colleague of the Business Sponsor.

3.5 Explore phase

Categorize projects

We clearly have seen that the results that are produced by PCSI projects differ in nature. The PCSI has a mix of different projects which do not all lead to a result that is ready for tech-transfer, such as projects only leading to an increased knowledge position. To better steer projects in line with the envisioned result, it is worthwhile to already categorize projects in an early stage.

The topic selection and Ideation are too early to do this categorization, but at the end of the Explore phase it should be clear which kind of result is delivered by the project, to the point that it should be possible to assign each project a tag.

Of course, these tags are not mutually exclusive and will have overlap, but it seems wise to select one of them as the major project label, to canalize the project efforts.

These are the categories we have defined:

- Tech-transfer: the project has a high chance to lead to a result that is suitable for a tech-transfer, e.g. either to become a commercial product (TRL 9) or published as Open Source software. Based on the path chosen, certain stakeholders should be more or less involved, such as external suppliers and market connections. Several possibilities can be explored, e.g.:
 - Include staff in the project that is willing to initiate a spin-off;
 - Already select one or more Liaison partners that could help building the PoC and/or would be interested to receive the result and include it in their product portfolio and include them in the project team;
 - Look for OS communities in which the result could be published as Open Source.
- Core Partner implementation: the project has a high chance to lead to a result that can be implemented by one or more PCSI core partners. The core partners that are most interested should play a leading role in the follow-up phases of the project. Probably these partners should provide the Business Owner for the project. Liaison Partners could be involved starting from the PoC phase;
- Knowledge gain: the project will go through the PCSI phases, but the end result will probably not be suitable to be implemented or put in a tech-transfer. Other parties (such as Liaison Partner) could be involved in the project, but it should be made clear to them that there will not be an Exploitable result coming from the project;
- Exploratory: the project will stop after the Explore phase (because e.g. good products are available on the market or the project idea was too ambitious), but the Explore phase has

led to collaborative knowledge gain on this topic and also could lead to a new idea for a PCSI project. There will be no Liaison Partner involvement.

Other changes

Composition of the project team	The project team members are in principle the same experts that were involved in the Ideation session.
Role of Business Sponsor/Business owner	There needs to be more regular contact between the project team and the Business Sponsor/Business owner
Involvement of Liaison Partners	No involvement of Liaison partners in the Explore phase, to ensure freedom for the core partners to choose the direction of the project.
Use of templates	We need to include specific items in the PoC plan for (potential) tech-transfer results.

3.6 PoC phase

Scoping and quality of the PoC

Building a PoC in only four months is challenging, in practice we have experienced this in several projects. Therefore it is necessary to scope down the PoC functionality to be able to actually build a PoC. On the other hand, when a project really has to produce a tech-transfer result, the quality of the PoC is the foundation of the exploitable end result of the project. So e.g. design and coding quality should be on acceptable level and also the PoC design should not block performance requirements of a commercial product. The involvement of external parties, preferably from the Liaison Partner community could ease the effort that is needed to build a PoC and improve quality; we have experienced this in the Collaborative Deception Fleet project.

Other changes

Composition of the project team	The project team should be evaluated and if necessary revised to effectively build the PoC.
Role of Business Sponsor/Business owner	The Business Sponsor/Business Owner should be involved, but more in a reflective role and supporting in making the pilot plan.
Involvement of Liaison Partners	Liaison Partners can have a valuable contribution in building the PoC. But involvement of one specific Liaison Partner should not prevent the result to be adopted by other (Liaison) partners at a later stage.
Use of templates	We need to consider appropriate coding and testing practices. We need to include specific items in the pilot plan for (potential) tech-transfer results.

3.7 Pilot phase

Include Product requirement in the pilot KPIs

For a tech-transfer result, it is important to think about the requirements that will be put on the end result on TRL level 9. These could be partly taken into account already in the pilot set-up and evaluation. For this, it would be good to already have an Exploitation partner that is willing to receive the project result and bring it to TRL 9. Such an exploitation partner could bring valuable input into the pilot evaluation.

Other Changes

Composition of the project team	The project team should be evaluated and if necessary revised to effectively run the pilot. Especially people from the pilot location should be involved in preparing, running and evaluating the PoC. They also should provide input for the evaluation parameters.
Role of Business Sponsor/Business owner	There needs to be regular contact between the project team and the Business Sponsor/Business owner. Pilot progress should be discussed regularly with them and they should be closely involved in making the plan for the Exploit phase.
Involvement of Liaison Partners	Depending on how the PoC was built, either none, one or more Liaison Partners will be closely involved in the Pilot.
Use of templates	We need to make use of standardized pilot evaluation methods. An Exploit plan has to be made. We need to include specific items for (potential) tech-transfer results in the Exploit plan.

3.8 Exploit phase

Solid tech-transfer plan

At the end of Exploit phase, the result should in principle be transferred to the receiving tech-transfer partner (but see also next paragraph). In the PCSI process, the result of the Exploit phase is presented in the Steering Committee. It is important to address all the important topics for the transfer, so the Steering Committee can make a balanced decision on the transfer.

Role of TNO

For projects intending to bring innovations on the market as a result of tech-transfer, it is important to keep in mind that the required TRL level is out of the range of what TNO is normally equipped for. This means that after a TRL 5-6 is achieved and consequently the end of Exploit, it is important TNO can reduce the involvement and let a market-partner support the tech-transfer trajectory, or transfer to TNO tech-transfer.

Other Changes

Composition of the project team	The project team should be evaluated and if necessary revised to effectively prepare the transfer. This could involve Open Source expertise, contractual and legal expertise or business development expertise. The expertise should be
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	sought with the PCSI partners but if not available, could also be hired externally.
Role of Business Sponsor/Business owner	The Business Sponsor/Business owner plays a major role in the Exploit phase and should stay in close contact with the project team, providing support and advise.
Involvement of Liaison Partners	Liaison Partners or Core Partners typically are the receiving partner for a tech-transfer result, so the specific receiving party plays a crucial role in the Exploit phase and should be closely involved.
Use of templates	In the steering committee presentation, we need to include specific items in the for (potential) tech-transfer results and also include the existence of a Post-Exploit phase in the plan (see next paragraph). Also legal and business templates are used for laying down agreements with external parties. This is not something that PCSI develops but we rather use existing templates of PCSI partners.

3.9 Introduction of a Post-Exploit phase

Additional step towards tech-transfer

The experience that has been built up in the PCSI shows that the Exploit phase is a complex phase. A lot of business, legal and technical activities need to be executed in parallel that mostly have long lead times. The Exploit phase is finalized by presenting to the Steering Committee a plan for the next steps and requesting decisions on the follow-up. In case of tech-transfer this is the actual transfer of the project result to a receiving party. But the plan also needs to be executed and in most cases, additional attention is needed for successful execution. This is why we propose to add an additional phase to the PCSI process, the ‘Post-Exploit phase’:

- This phase is only started when needed, typically for a tech-transfer of a project result;
- This phase does not have a fixed timeslot or defined budget. For each project there needs to be a dedicated proposal and plan for this phase, showing the benefits and costs;
- This phase will still be governed by the PCSI, specifically the Steering Committee.

At the end of this phase, the results will presented to the Steering Committee one final time which will conclude the PCSI involvement in the project result.

Other changes

Composition of the project team	The project team should be evaluated and if necessary revised to effectively implement the transfer. This could involve contractual and legal expertise or business development expertise. The expertise should be sought with the PCSI partners but if not available, could also be hired externally.
Role of Business Sponsor/Business owner	The Business Sponsor/Business owner plays a major role in the Post-Exploit phase and should stay in close contact with the project team, providing support and advise.
Involvement of Liaison Partners	Liaison Partners or Core Partners typically are the receiving partner for a tech-transfer result, so the specific receiving party plays a crucial role in the Exploit phase and should be closely involved.

Use of templates	No specific templates are foreseen in this phase.
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3.10 Potential improvements outside the PCSI program

Collaborations with other communities and branch organizations

The PCSI is a security innovation community. In the attempt to generate more tech-transfer success, PCSI could make optimal use of other existing communities. One example is CyberVeilig Nederland, a branch organization for cyber security companies. The members of CyberVeilig Nederland typically are companies that could be interested in receiving cyber security innovation results as produced by the PCSI. Another example is Connect2Trust, which already is a Liaison Partner and constitutes a cross-sectoral collaboration that shares best practices and relevant cyber threats. We recommend to expand the collaboration with such communities, specifically to enhance the tech-transfer process.

4 Conclusions and Way Forward

4.1 Overall conclusion and recommendation

The desk research on the state of the art on tech-transfer, combined with evidence from the interviews and the workshops have provided a wealth of ideas to revise the complex – yet well-functioning – PCSI partnership so it is better equipped to bridge the tech-transfer gap. There are too many ideas to implement all at once. We therefore recommend to take a two-step approach:

1. We have defined four main categories of improvement that we recommend to implement on short notice, see par. 4.2. One category specifically focusses on the Explore phase (see par. 3.5) and the other three are overall improvements and relate to most of the paragraphs in chapter 3. As a consequence, these four categories encompass already many underlying ideas for improvement;
2. After these revisions have been made, we recommend to evaluate (after some time, say one year) the new situation and then assess whether other suggestions made in the report also could be implemented.

4.2 Suggested improvements for the PCSI

In this section we present the four main categories of improvement for the PCSI program. These points have been selected based both on the input collected in the interviews and the workshops and their expected achievability in the short-medium term (in any case within the span of the current PCSI program, 2023-2026). The points of recommendation are:

- Categorizing projects after successful completion of the Explore phase;
- Increased Business focus for tech-transfer;
- Commitment of all PCSI roles to make tech-transfer projects successful;
- Increased business intelligence, preparation and support.

4.2.1 Categorize projects after the explore phase to canalize tech-transfer efforts

We recommend to distinguish between four categories of projects and put each project in one main category after Explore Phase to better steer a project in a way that is in line with the ultimate project result:

- Tech-transfer - this project has a high chance to lead to a result that is suitable for a tech-transfer, e.g. either to become a commercial product (TRL 9) or published as Open Source software;
- Core Partner implementation – this project has a high chance to lead to a result that can be implemented by one or more PCSI core partners. The core partners that are most interested should play a leading role in the follow-up phases of the project;
- Knowledge gain – this project will go through the PCSI phases, but the end result will probably not be suitable to be implemented or put in a tech-transfer;
- Exploratory – The project will stop after the Explore phase (because e.g. good products are available on the market or the project idea was too ambitious), but the Explore phase has led to collaborative knowledge gain on this topic.

Of course, these categories are not mutually exclusive and will have overlap, but it seems wise to select one of them as the major project label, to canalize the project efforts. The Steering Committee should be made aware of these categories and approve the assignment of the project to a specific category.

4.2.2 Increased Business focus for tech-transfer

Since the Business Owner role has not yet been implemented in projects, we have not had the chance to evaluate whether this actually helps,. But we recommend to continue with this set-up. Furthermore, for tech-transfer results, it is important that the project focus and project team change to a business driven project instead of a technical driven project. This could mean changing the team members to people with specific business expertise, seeking external business support or collaborate more closely with business or innovation departments of the core partners (instead of the security department)

4.2.3 Commitment of all PCSI roles to make tech-transfer projects successful

Especially for tech-transfer projects, that require decision making on both technical level and on Business, human resource, legal and contractual level, it is important that there is commitment on all levels of governance within the PCSI. We will shortly address: the Steering Committee, Business departments, Program Manager, Coordinator board and Project team.

Steering Committee

The Steering Committee should take the role of Business Sponsor more seriously, even more with the new role of Business Owner that recently was introduced. A good change made in the most recent Ideation was to directly assign a Business Sponsor to a new project. But also the fulfilment of the role should be taken seriously, such as presence or at least written advice at Presentation Days and reflecting on project progress when asked by the project team. The Business Sponsor and Steering Committee finally are crucial in inviting and assigning the new roles of Business Owner.

Business department

For tech-transfer projects, the business departments of the core partners should have a larger role in the projects. They need to be made aware of the existence of these projects and the resulting benefits for them. This mainly is a task that should be taken up by the Steering Committee members, the Business Owner and the coordinator board members.

Program manager

The Program Manager should pay specific attention to the projects that are categorized as tech-transfer. Ensure that the progress reports will have more business focus, facilitate the projects where possible and also support in contacts with Liaison partners. For tech transfer projects it is also important to be as strict as possible on planning because business interest could fade under delays in the development phase.

Coordinator board

The Coordinator board is functioning pretty good, but their focus and discussion mainly is on the technical progress and staffing of projects. In project team staffing for tech-transfer

projects, the coordinator board needs to take initiative and arrange for more business oriented people added to the projects. This also requires internal lobbying, to make the PCSI and its benefits more known within a core partner organization.

Marketing & Communication lead

The marketing and communication lead has to put more focus on the business side of tech-transfer. One example could be to use more 'business language' in the communication messages and try to attract a more business oriented audience. One other example could be the involvement of a marketer role that looks at the market and is able to define and identify the right target groups that PCSI should be approaching.

Project team

In the project team, commitment in terms of motivation, curiosity, enthusiasm, and expertise is almost always at the highest levels. What certainly can use improvement is the commitment in terms of capacity throughout the lifetime of a project and the business focus of the project teams. It can sometimes happen that an expert from one of the PCSI partners (TNO included) suddenly leaves the team, is sick for a longer period or makes a substantial step back in commitment.

This is hard for any PCSI project, but could influence the ambitious tech-transfer projects even more. Also, most project teams start-off with technical experts. For a tech-transfer project, there needs to be a shift in team composition from technical to business focus. The best thing to do is take a gradual approach. Already involve business oriented people in the team after the decision to categorize a project as tech-transfer, which is taken at the end of the Exploit phase. And then gradually shift the focus in each phase, so at the end of Exploit and in Post-Exploit the project team mainly is business focussed.

4.2.4 Increased business intelligence, preparation and support

To be successful in a tech-transfer project, we need to prepare tooling and ways of working that specifically can support tech-transfer projects. And also record the learnings from previous tech-transfer projects so we can use them for future projects.

Some examples:

- Ways to perform a market selection when we want to include a Liaison partner in a tech-transfer project (e.g. sending out questionnaire, organizing a round-table, etc.);
- Legal requirements/documents that are needed to include a Liaison Partner or to transfer a tech-transfer result;
- Templates for business cases;
- Internal and External business advisors that we can consult when needed;
- Agreements with investment companies to occasionally meet up and exchange information;
- Ways to learn more about the strategic goals of the Liaison Partners, so we can match these with promising tech-transfer projects.

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Appendix A Interviewees and workshop participants

Interviewees

The table below shows the people that were interviewed during the project. The table shows the name of the interviewee, the company the interviewee is employed, the specific role (that we distinguish in the PCSI process) that we have interviewed this person for and a short description of the role. For each role, specific questions were prepared.

Name	Company	Role	Role description
Kees Stammes	Securify*	Commercial Service provider/vendor	Providing commercial security services and products
Fred van den Heuvel	Countercraft*		
Olaf Hasker	Sightlabs*		
Melanie Rieback	Radically Open Security*	Open Source service provider	Providing OS security services and products
Richard Kerkdijk	TNO	Initiator of OS platform COSSAS	Maintaining an OS community for automated security tools
Karim el Hassal	TNO	OS coordinator in TNO unit ISP	Stimulate the OS publication of TNO project results
Eddy Zwier	TNO	TNO tech-transfer	Provide support for spin-offs and start-ups
Maarten Everts	LinkSight	Start-up/Spin-off	Starting a start-up or spin off
Dimitri Hehanussa	TNO/Sightlabs		
Liesbeth Holterman	CyberVeilig Nederland	Branche organization	Representing interests of collective cyber security companies in the Netherlands
Gert-Jan Schutte	Belastingdienst	Innovation department Belastingdienst	Initiating innovations within PCSI core partner
Vivian van Bruggen	TNO	PCSI M&C project manager	Ensuring visibility and impact of PCSI and its project results
Martijn Dekker	ABN AMRO	PCSI Steering Committee member/PCSI Business Sponsor	Steering the PCSI program on strategic level/ connect projects to business goals
Paul Geurts	Achmea		
Paul Landsmeer	Belastingdienst		
Aldebert Wiersinga & Victor Boskamp	Value Creation Capital	(Cyber Security) investment companies	Provide promising ideas/startups with financial means to grow
Reinout van der Meulen	TIIN Capital		
Eddy Boot	dcypher	Cybersecurity cooperation platform for research and innovation in NL	Bring organizations together in education, research and innovation for the development of concrete applications

* This organization also is a PCSI Liaison partner

Workshops

Workshop 1: PCSI project leads

Name	Company
Erik Meeuwissen	TNO
Rick van der Kleij	
Bram Poppink	

Workshop 2: PCSI Coordinators

Name	Company
Olaf Streutker	ABN AMRO
Rob Stübener	Achmea
Tom Huitema	
David Curcubet	ASML
Ton van Ginkel	Belastingdienst
Jordy Groters	

Appendix B Glossary

Glossary

BMC – Business Model Canvas

BO – Business Owner

BS – Business Sponsor

CDF – Collaborative Deception Fleet

CI/CD – Continuous Integration/Continuous Development

CISO – Chief Information Security Officer

IPR – Intellectual Property Right

KPI – Key Performance Indicator

M&C – Marketing & Communication

MRL – Market Readiness Level

PCSI – Partnership for Cyber Security Innovation

PoC – Proof of Concept

SBC – Security Behaviour Coach

SC – Steering Committee

SMART – Specific, Measurable, Assignable, Realistic, and Time-bound

TRL – Technology Readiness Level

VC – Venture Capitalist

Appendix C PCSI terminology and process

(PCSI) Terminology

DevSecOps – A process in which one team is responsible for both development and operations and security is an integrated responsibility of the team. The team works according to agile principles. By integrating application security principles and practices into software development and operations, teams can deliver new software and services at agile speed without compromising application security.

Ideation

Steering committee - The PCSI Steering Committee comprises high-level representatives from the CISO departments of the PCSI partners, the TNO program manager, and the TNO ISP Business Director. The steering committee meets 3-5 times a year to oversee the strategic direction of PCSI: deciding on trends and topics for exploration, selecting themes for ideation sessions, approving new partner entrances, and determining which project results move beyond the exploitation phase.

Business sponsor - The business sponsor of a PCSI project is selected among the staff of the PCSI partners and he/she is usually a member of the Steering Committee (or managerial figures at a similar level). Business sponsors are supposed to "adopt" one or more PCSI projects, supporting and facilitating the projects in respect to the Go/No-go decision moments.

Program manager – The program manager manages the overall program. He/she organizes steering committee meetings, Coordinator Board meetings, Project manager meetings, Ideations, Presentation Days, coordinates overall REsponDelegated responsible of the coordinator

Coordinator Board – The coordinator board steers the program on tactical level. It consists of one representative of each Partner and the Program Manager. The coordinator board will meet each three weeks. It has four main duties:

1. Make sure that any issues that arise in running projects will be solved. To inform the coordinator board of project progress and issues, a status report, that contains an overview of the status of all running projects, will be distributed before the meeting.
2. Decide on Go/No-Go between the innovation stages on Presentation Day.
3. Prepare the steering board meetings
4. Prepare the Ideations (assigning experts to the Ideation sessions)

Marketing & communication lead – The M&C lead will maintain the PCSI marketing and communication strategy and plan, initiate communication activities, coordinate communication activities over all partners, maintain website and social media channels, coordinate development of communication means, actively trigger PCSI projects and partners to generate communication content. There is close contact with M&C departments of all PCSI partners.

Project office - The PCSI project office supports in administrative tasks, supports in marketing and communication activities, organizes meetings and events, and performs many other support functions.

Experiment Coach - The experiment coach is a role covered by a senior TNO innovation orchestrator. Besides designing and organizing the process of the PCSI program together with the program manager, the experiment coach also facilitates the workshops in the innovation cycles, and assists the project teams in several ways and facilitates decision making (e.g. at the Go / No Go moments).

Project Lead - PCSI project leads are TNO project managers or experts. Project leads are responsible for managing the short-cycled phases of PCSI projects: explore, proof of concept, pilot, and exploit. Besides managing the tasks within each phase, and keeping a proactive eye on planning and budget, the project leads report every three weeks to the PCSI program manager in a PCSI PL meeting, and to the PCSI coordinators in a written form.

Project team - PCSI is a real collaborative innovation effort. In the project team, all core partners can participate with their experts; experts are expected to spend an average of 2-4 hours weekly on project contributions. A project team always has a TNO project lead and there should be experts from at least two non-TNO partners in the team.

Liaison Partner - Liaison partners are organizations that are strongly interested in both learning from and contributing to current and future cyber security innovations being worked on within PCSI. Liaison Partners are organizations that do not have the resources or scale to become a core partner or are organizations offering commercial security services (and therefore cannot become a core partner). All liaison Partners are invited at least once a year for a PCSI Liaison Partners' event. By acceptance of the PCSI coordinators (and under continuous scrutiny of the independent TNO Project leads) Liaison Partners can be invited to join specific projects in which their expertise can mutually beneficial combine with the expertise of the PCSI core partners.

PCSI innovation process

The PCSI innovation process is a continuous cycle of four months; each four months, new projects will start and running projects are assessed on several aspects after which they will receive a Go or No-go for the next cycle. The process currently has four cycles: Explore, PoC, Pilot and Exploit.

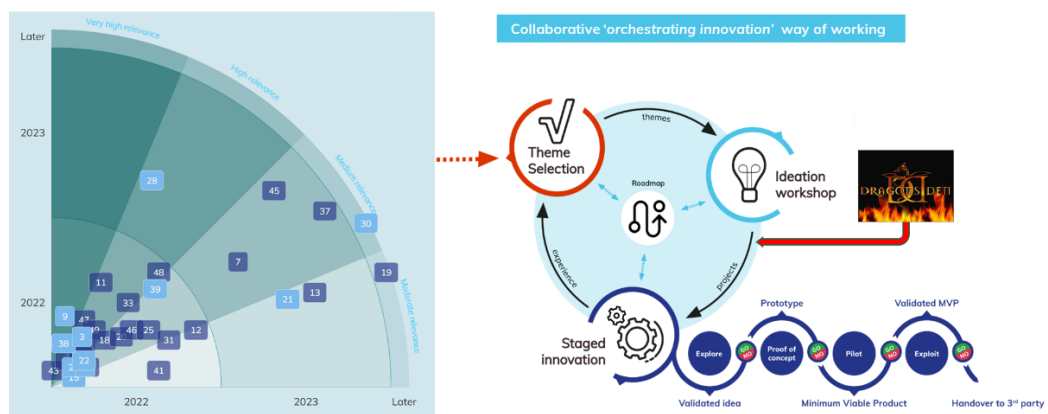


Figure 6: The PCSI innovation process

Security Radar - The security radar contains relevant security themes for the partners in the PCSI, actual themes but also looking into the future. It will assess the relevance of those

(future) security themes for the participating partners and Dutch society. Themes include emerging threats, but also security-relevant developments on technical, organizational society level. A continuous activity in the PCSI is dedicated to keep the security radar up-to-date.

Theme selection - The Steering Committee will select each four months the themes that are addressed in the coming period. Input for this selection is the Security radar. The number of themes varies between one and three, depending on the number of projects that are already running.

Ideation Day - Ideation on the selected themes is organized as a face-to-face full day event; in the morning, Ideation workshops are organized in parallel, early afternoon pitches are prepared and late afternoon the project ideas are pitched before the Dragons, which then will decide which pitch is allowed to continue as a project

- Ideation workshop- An Ideation workshop is organized for each of the selected themes from the theme selection step. We apply a specific brainstorming format to organize this effectively and it is facilitated by an Ideation expert. All partners are invited to delegate their relevant experts on the theme to the Ideation session. Typically, several project ideas are generated in each Ideation session, but eventually one project idea is selected. The experts that staffed the Ideation session will get the opportunity to work on it in the project.
- Dragon's Den - The selected project idea(s) from the Ideation session(s) are pitched before a Dragon's Den (the PCSI steering committee). They decide whether a project pitch actually is rewarded and can enter the short cyclic innovation process.

Staged innovation

- Presentation Day - Each three months, a PCSI Program presentation day is organized, during which the project results for the concluded phase are presented and discussed and the Go/No-Go decision is made for each project to enter the next phase. A project that receives a 'Go' to enter the next phase will only be provided with budget and means for this next phase, At the end of the next phase, the project again will have a Go/No-Go decision.
- Explore phase - The goal of the explore phase is the Explore the project idea further. An assessment will be done on the Stat-of the-Art of the selected topic and the anticipated end result of the project will be further defined. At the end of the Explore phase there should be either a plan to build a PoC or a proposal to stop the project (e.g. because there already are products on the market that fulfil the innovation need).
- PoC phase - In the PoC phase, a proof of concept will be built. This can be a technical tool, a methodology, a process or even a new role description. At the end of the PoC phase the PoC should be ready and a plan to conduct a pilot with the PoC must be available. Alternatively, the project team could also propose to stop the project because no realistic pilot can be conducted.
- Pilot phase - In the pilot phase, the PoC is tested in a realistic (operational) environment at one of the PCSI core partners. At the end of the PoC phase, a pilot evaluation must be available and also a proposal for Exploit phase activities. Alternatively, the project team could also propose to stop the project because the pilot results proved that continuing with Exploitation is not a good idea.
- Exploit phase - In the Exploit phase, a plan is made to ensure that the result is not ending up in a drawer. Exploitation can have several forms, such as transfer to a security vendor, publishing as Open Source, publishing articles or whitepapers etc.

The final result and follow-up plans are presented to the Steering Committee for approval.

Appendix D PCSI tech transfer project experience

In this appendix, we describe the four projects that we highlight in par. 2.3 (Learnings from PCSI projects) in more detail.

D.1 Joint practices for security in agile

What is the project about

CI/CD pipelines enable continuous software releases but also pose a challenge with potential vulnerabilities introduced during development. The "Joint Practices for Agile" team explored ways to ensure secure Agile development by engaging in DevSecOps communities, which offer collaboration opportunities. Although several strong DevSecOps communities exist, the team recognized the need for more confidential and consolidated collaboration among PCSI partners. The project yielded a plan for a self-governed and self-sustaining PCSI DevSecOps Community with a communication platform to grow within the program and potentially expand to trusted partners in the Netherlands. This community should operate independently of the PCSI program.

Which exploit efforts were made

The governance of the community was well described and a plan was presented to the Steering Committee to start this community and start implementing the communication platform. The individual Steering Committee members were asked to provide in-kind support (hours for their DevSecOps experts to participate) and small in-cash contribution (to implement and maintain the communication platform).

What was the final result

The Steering Committee granted a trial period for one year without providing funding for a communication platform. Although there was initial enthusiasm, the formal constitution of the community and appointment of its board were delayed due to Corona lockdown countermeasures. Unfortunately, during this delay, the Business Sponsor and a prospective board member became unavailable.

What are the learnings

The project offered valuable insights:

- Innovative solutions addressing collaborative cybersecurity challenges, such as community engagement plans, can benefit the PCSI experts dealing with daily cybersecurity issues.
- After the exploit phase ends, the practical difficulties encountered by even highly motivated teams from other PCSI core partners in pursuing required tasks for innovation exploitation become apparent when dedicated TNO expertise is no longer available.

D.2 Collaborative Deception Fleet

The Project

The Collaborative Deception Fleet (CDF) is a cybersecurity project involving deception techniques to lure threat actors, record their actions in "wiretapped" environments, and generate valuable threat intelligence for PCSI partners. Key innovations include using active

deception as a proactive defense, generating customized intelligence, and collaborative deployment among consortium members. Due to long lead times for market selection and legal discussions, the project went through every phase twice. A Spanish company called CounterCraft joined in the 2nd PoC phase to help build the environment, and valuable experience was gained through red-team exercises. The 1st pilot phase focused on environment preparation and initiating a lengthy legal research process, while only one deception campaign could be carried out during the 2nd pilot phase. Eventually, the project entered the exploit phase.

The Exploit Efforts

In the exploit phase the team (together with CounterCraft) envisioned a federated entity either constituted by (or working for) the PCSI partners which can make use of a number of products and/or services (among which the ones offered by CounterCraft) to conduct deception campaigns for count of the PCSI partners.

The Final Result

The exploit idea was pitched to the Steering Committee of PCSI. In spite of the coordinators' "go" received at the end of the pilot phase (thus before entering the exploit phase) the Steering Committee requested the CDF team for additional evidence of the real added value of the innovation. This led to a reboot of a new pilot phase in which the team has been challenged to prove the added value of the envisioned innovation by checking a number of requirements (among which conducting different types of campaigns and seeing real world threat actors' activity on the deception systems (in the first pilot the team only deployed selected malware in the deception environments).

The Learnings

During the initial Explore phase of a project focused on developing an active deception environment, the team determined that the project was too ambitious due to the requirement for building such an environment from scratch. Despite this realization, the project was renewed for a second Explore phase during which commercial partners capable of providing production-level solutions were sought.

Market selection proved to be time-consuming, leading to a prolonged lead time for the project. Legal agreements between partners for creating a collaborative environment were also a lengthy process due to potential reputational risks for PCSI partners. Consequently, every phase of the project except for the exploit phase was repeated.

Collaborating with a Liaison Partner (a commercial party in this case) during the project resulted in various gains, including faster progress towards having a fully functional deception environment and increased support through presentations at events. However, it also introduced additional management challenges and overhead. The final balance of working closely with a Liaison Partner proved to be beneficial for the PCSI program.

Key learnings from this experience included:

- Allocating sufficient time for market selection and reaching legal consensus between partners is essential.
- Closely collaborating with a reliable, competent Liaison Partner can expedite project progress but requires effective management to handle the associated dynamics.
- Commercial partners may use communication opportunities as acquisition prospects.

The project gained valuable insights into collaboration dynamics and the role of a Liaison Partner in the PCSI program.

D.3 Security Behaviour Coach

The Project

The initial project concept revolved around applying marketer's 'customer journey methodology' to make employees more security-conscious. During exploration, this idea evolved into investigating the feasibility of a new role: Security Behaviour Coach (SBC). SBC identifies human behavior causes of security vulnerabilities and revises business processes accordingly. The role was piloted at one PCSI core partner but faced challenges due to the COVID pandemic; most employees worked from home instead of being in an office environment, causing delays and partial implementation through video connections and face-to-face interactions. Valuable learnings were gathered despite these setbacks.

The Exploit Efforts

The project introduced a novel role in cybersecurity named "Security Behaviour Coach". The job description and profile were shared for download. To promote this new position, a 'round table' session was organized in-person, bringing together cybersecurity awareness professionals from companies, end-user organizations, sector organizations, universities, and the PCSI Business Sponsor. During this event, participants discussed the role concept and created the name "Security Behaviour Coach". While many expressed enthusiasm for the idea, only a few saw direct application in their day-to-day businesses. A participant from the Security Academy proposed adapting their existing security awareness training to cater to the new role, recognizing the potential opportunities it presented.

The Final Result

The Security Academy and Security & Continuity Institute (SECO) now are offering a dedicated training for the new role of Security Behaviour Coach as it was developed by the PCSI project.⁵

The Learnings

The original goal of the project was not to create a new security role, but rather to stimulate secure behavior among employees. This evolved into developing the "security behavior coach" role, aligning with the initial objective and providing a more concrete outcome than initially anticipated. To continue the project's exploitation beyond the pilot stage, a round table event was organized instead of individually approaching potential partners. This event proved to be effective for Exploitation as it allowed interaction with experts in the field, discussing the value of the role, and identifying partners willing to adopt it for further development.

⁵<https://www.securityacademy.nl/opleidingen-overzicht/vendors/security-academy/security-behavior-coach/>

D.4 Purple AI

The Project

The Purple AI project aimed to explore if AI could improve cybersecurity challenges such as red and blue team exercises by developing a learning system. The goal was to create a framework where red-team and blue-team agents could continually enhance their actions through machine learning.

The framework consists of two main components:

- A Reinforcement Learning model that optimizes sequential courses of action, such as the optimal route for privilege escalation on a host.
- A Simulator that logically mimics the behavior of an IT environment, allowing the model to converge within a reasonable timeframe instead of training in real environments.

The PoC focused on building a Reinforcement Learning model and tested its ability to learn the right courses of action for privilege escalation through three experiments with increasing levels of complexity. The results showed that the model could effectively learn the optimal actions in the simplified environment.

The Exploit Efforts

Several talks were held with interested companies that deal with red teaming, they indicated that the technology as such was very interesting, but also relatively niche. Also the possibilities of starting a spin-off that would further develop the framework and PoC was explored. However, the members of the project team decided that they were not interested in joining a spin-off. One of the PCSI partners had contacts with a company specialising in Red-Team services and Application Security (<https://www.varte-group.com/>), that became interested in the Purple AI PoC and had intention to develop this concept further. Unfortunately they decided not to pursue this because of other priorities.

The Final Result

The project team concluded that it is technically feasible to build an agent that can autonomously learn how to escalate privileges on a Windows target machine. The framework and PoC are available and described in a white paper⁶. A follow-up PCSI project has been started (PurpleAI2) to further explore the potential for red teaming tools that are AI based.

The Learnings

Purple AI is an ambitious and long-term effort from a technical perspective, and the original ambitions actually did not really fit the short-cyclic PCSI innovation process.

It was a good choice to scope down the project to be able to implement a PoC, but this took quite some time and discussion in the project team.

Several times a discussion was held in the Steering Committee to have one or more 'long term' innovation projects that would run outside the short cyclic innovation.

This has not led to a decision, but Purple AI would have been one of the candidates for such a long-term innovation project.

It has been proven difficult to find a good landing place for the project result; it was a rather niche result and also red teams are not yet used to applying advanced AI tooling in their red

⁶ https://pcsi.nl/uploads/downloads/Visionpaper-PurpleAI-20230907_Final.pdf

team exercises. To ensure a better landing place, we probably should have involved interested companies earlier in the process. Another option for this project would have been to involve developers that have the drive and ambition to start a spin-off with this project result.

Alternatively, when a result is not adopted because the timing is not right, it could be kept alive by low profile exposure activities over a longer period of time. Keeping it in the shopping window may lead to success (much) later on.

ICT, Strategy & Policy

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