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A Framework for Formative Evaluation and Impact Assessment of Mission-oriented Innovation Policies

Final report of the Scientific Support Action to the German High-Tech Strategy 2025 - volume 2

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Contents Page

Figures

Tables

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Executive summary for impact assessment

This report is part of the scientific support action to the German High-Tech Strategy 2025. Whereas the first volume provides an overview of the lessons learned for future mission-oriented innovation policies (MOIP) in Germany and beyond, this second volume outlines a novel framework for monitoring and impact assessment of MOIP. In particular, it emphasizes a toolbox approach consisting of six elements supporting mission owners during the realization of MOIP and provides guidance for evaluators for analyzing the context for impact materialization.

The turn towards MOIP is associated with a number of challenges for impact assessment. This includes the multi-dimensionality of impacts, levels of analysis, complex interactions, long-time horizons, empirical diversity of missions, and new requirements for evaluation that cannot be achieved with ex-post and summative elements alone. Drawing on these insights, the report argues that the following aspects are key for a sound framework for impact assessment. First of all, it requires a comprehensive perspective on the implementation of MOIP, taking into consideration the interconnected multiple translation processes that characterize MOIP. Secondly, the framework needs to combine summative and formative elements, with a strong role of ex-ante evaluations. Thirdly, it calls for a theory- and process-oriented perspective, acknowledging the new requirements MOIP as transformative policies impose on policy-making. Finally, given the empirical diversity of missions and the diversity of topics addressed, we propose a flexible, generalized and modular framework that can be adopted to the specific mission and its context.

This report proposes a toolbox approach for putting missions into practice and allowing for impact assessment. Given the multi-faceted and multi-phased character of missions, we develop a toolbox that can support mission owners in the implementation process and simultaneously provide the foundation for impact assessment. In this sense, the report serves as a guidebook for mission owners aiming to bring missions into practice, providing an overview of key elements and stages. At the same time, it serves as a flexible and hands-on tool to sup-port this process by the provision of stylized concepts for mission formulation, mission design and implementation that make research on MOIP useable for practical implication. Thereby, it addresses the high needs for process support that many policy-makers face when trying to implement MOIP. At the same time, besides practical process support it sketches a framework allowing to put the anticipated impacts of missions into the respective context and provides an analytical framework to explore the potentials for the materialization of these impacts.

Overall, the toolbox consists of altogether six closely connected elements that support missions and allow for impact assessment. First of all, an analysis of the underlying socio-technical system that is supposed to be transformed by a mission can support the process of mission formulation and support mission design. This may be achieved by a topic-centered system mapping, taking into consideration the key topics, actors, policies and their connections. Secondly, the process of mission formulation can be supported by a clarification about the transformative understanding, i.e. the way a mission aims to achieve its goals. Drawing on a typology developed in the context of the scientific support action, this sub-section points to the consequences and implications of missions that are associated with the different types of accelerator and transformer missions.

Next, we propose two toolbox elements that are closely associated with the process of mission design, i.e. linking mission goals with dedicated activities. A first step in this regard is the development of impact pathways, allowing mission owners to link the anticipated impacts with their own activities and inputs. Deriving impact pathways does not only provide orientation among involved stakeholders and mission owners on how to achieve mission goals, but also provides the foundation for monitoring the progress of missions and measuring their potential impacts. To support this process, the report outlines eleven stylized impact pathways that are of varying relevance for different types of missions. A second element closely related to the process of mission design is the identification of the instrument portfolio, i.e. the policy instruments that are mobilized by mission owners to achieve the anticipated benefits. While the analysis of the socio-technical system can help to identify relevant actors and policy instruments, we sketch a basic structure for mapping and systematizing the instrument portfolio that can help to link it to the requirements of a mission. Moreover, the development of impact pathways forms the foundation for a subsequent monitoring of mission progress. Based on the derived impact pathways it is possible to identify indictors measuring whether missions are "on track" and developing towards the desired impacts. Drawing on the stylized pathways developed earlier in this report, we provide suggestions for possible analytical dimensions that can serve as a starting point for the development of mission-tailored indicators.

The final element of the toolbox is an analysis tool for capturing the different translation processes of missions (mission formulation, mission design, mission implementation). Consisting of a comprehensive catalogue of analytical questions that best may be addressed by an external evaluator (28 analytical dimensions consisting of more than 140 individual questions), it allows to identify potential obstacles to the materialization of impacts throughout the different stages of MOIP.

Applying the framework to a selected mission of the German High-Tech Strategy 2025, the mission on combating cancer, the practical feasibility and its analytical value was clearly con-firmed, while at the same time pointing to some practical challenges. The analysis reveals a number of strengths (e.g. actor mobilization through a joint declaration, flexible forms of membership, high-level commitment), but also weaknesses (e.g. ambiguities in goal formulation, lacking integration of inputs with expected impacts) that are likely to obscure the realization of impacts of the mission. At a more practical level, the analysis demonstrates the potential benefits of strengthening the mission through the toolbox elements, while simultaneously emphasizing the need to embed the framework into the implementation of missions It also sheds light on risks arising from an overly static perspective and possible challenges for analysis arising from the hybrid character of the mission.

In sum, this report presents a comprehensive, modular, flexible, process-oriented and theory-based approach that combines process-support with impact assessment of mission-oriented innovation policies. Thereby it particularly relies on a modular approach that can be tailored to the specific mission-context, providing mission owners with tools supporting the implementation along the different translation processes of missions, and external evaluators with guidance for analysis to better understand the factors shaping the materialization of impacts.

1 A toolbox for supporting mission-oriented innovation policy and impact assessment

With governments in Europe and abroad increasingly initiating mission-oriented innovation policies (MOIP), the issue of how to monitor and evaluate these policies gained importance and urgency (Dinges et al. 2020; Janssen et al. 2021; Larrue 2021 Weber et al. 2014). This report, as one of the two final volumes of the scientific support action to the German High-Tech Strategy 2025 (HTS 2025), aims to address this issue by outlining a comprehensive and flexible toolbox approach to support mission realization and impact assessment. The developed concept relies on empirical insights from the study of selected missions of the HTS 2025 (Combating cancer, Reducing CO2 emissions in industry, Ensuring good living conditions throughout the country, Circular economy), the analysis of existing literature from evaluation mission-orientation and related strands (Wittmann et al. 2021d), as well as the exchange with national and international researchers and policy-makers.[1] Volume 1 of the final report of the scientific support action provides an overview of the lessons learned for future MOIP in Germany and beyond (Roth et al. 2021).

Against this background, this report presents an approach that combines formative elements of process support with a more summative-oriented impact assessment. Missions do not only represent a new quality of goals by focusing on societal challenges that are to be achieved by transformative change, but also require a different way of policy-making. However, the new requirements for policy-making often stand in contrast with established routines and practices and therefore expose implementing bodies to considerable challenges (Lindner et al. 2021). From this perspective, the proposed framework is not limited to a summative perspective aiming to assess the effects of missions, but also emphasizes the importance of learning processes and aims to support mission owners in implementing and managing complex missions. For this purpose, the framework is thought to be closely integrated in the processes of mission realization, perceiving it as an integral part of the mission, instead of merely providing a concept for ex-post evaluations and assessments (cf. also Teirlink et al. 2011).

To achieve these goals, the main elements of the proposed framework are the following:

- A comprehensive approach taking into consideration the whole process of mission-oriented policies. We perceive MOIPs as being characterized as a process of multiple translations towards transformative change, moving from societal challenges over goal formulation and policy implementation to complex societal impacts. Taking into consideration also early stages of mission implementation can help to tackle some of

[1] For an overview see https://www.isi.fraunhofer.de/en/competence-center/politik-gesellschaft/projekte/htf2025.html.

the key bottlenecks of implementation and account for the increased need for legitimacy and mobilization that are associated with MOIP.

- The combination of formative elements, aiming to support the implementation process and learning, with summative tools that provide insights about the overall progress of the mission and its contribution to societal impacts. This also implies a stronger reliance on ex-ante analysis instead of ex-post elements.
- The combination of a systemic and process-oriented perspective, thereby acknowledging both the transformative approach of missions and the new requirements they impose on policy-making. We perceive transformative policy-making as a prerequisite for transformative impacts, taking the argument serious that MOIPs constitute a new way of doing things, not just setting different goals.
- A modular, flexible and generalizable approach that acknowledges the empirical diversity of missions and accounts for the fact that missions do not emerge from scratch but usually are embedded in established policy fields. Being methodologically agnostic and allowing for different ways of implementation, the approach proposes a toolbox that can be tailored according to the needs of policy-makers/mission owners being in charge of mission implementation.

This focus has multiple implications about what the framework can achieve. Firstly, the framework is targeted towards policy-makers being in charge of (state-led) missions. We consider missions as a distinct process that comes with considerable agency. In a similar vein, with our focus on the implementation process we assume agency of mission owners. Secondly, the framework does not aim for making strong causal claims, thus focuses on contribution instead of attribution – in consequence, the framework will not be able to quantify effect sizes or determine the possible delta of mission-orientation, thus providing insights into the added value of MOIP. Thirdly, the framework rests on a realist approach (Arnold et al. 2018) that combines formative and summative elements. By embedding the implementation process explicitly into the socio-technical context and being interested in the outputs, it clearly deviates from a purely constructivist approach in evaluation that is highly reliant on stakeholder perspectives.

Overview of the framework

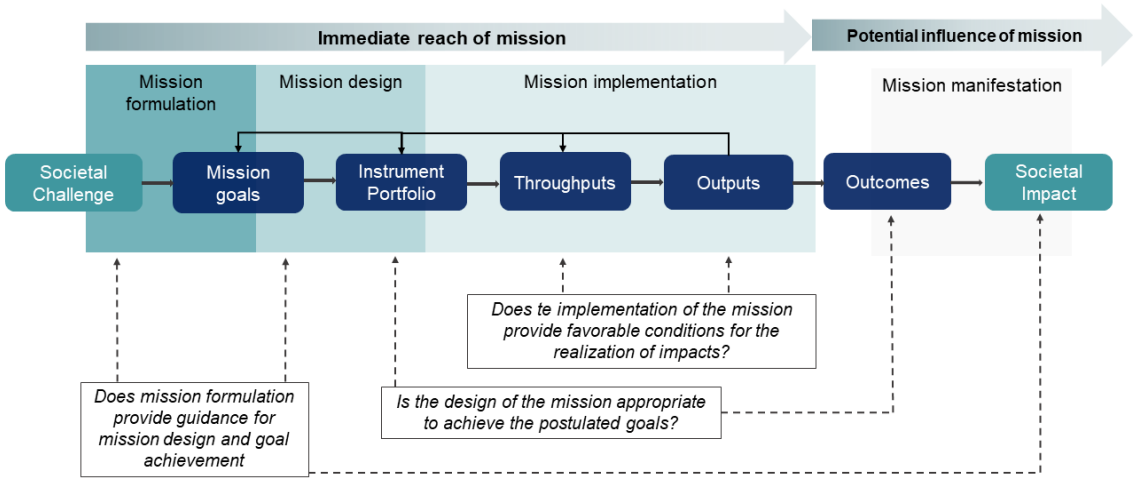
The framework can be considered as a hybrid approach, combining process-supporting toolbox elements with a more summatively-oriented analysis. Before turning to the underlying assumptions and the detailed description of the toolbox elements, this section provides a brief outline of the framework.

The overarching analysis is structured along the translation processes of MOIP – mission formulation, mission design and mission implementation –, exploring to what extent favorable or hindering conditions for the materialization of impacts are provided for (see

figure 1). This can be summarized by the three key guiding questions that are interconnected:

- Does mission formulation provide guidance for mission design?
- Is the design of the mission appropriate to achieve the postulated goals?
- Does the implementation of the mission provide favorable conditions for the realization of impacts?

Figure 1: Overview of the framework



Source: Own elaboration

In order to address these questions and support the processes of designing and implementing missions, we propose a toolbox consisting of six connected elements:

- An analysis of the underlying socio-technical system to clarify the scope of the mission,
- a conceptual clarification on the type of transformative understanding that links missions to ideal types and thereby helps to highlight their distinct challenges and obstacles,
- an inventory of inputs, gathering information about relevant activities, instruments etc.,
- the development of stylized impact pathways, linking mission goals with anticipated impacts and identifying problems/obstacles etc. that can be tailored to the context-specific requirements of a mission,
- an indicator set for different pathways that can serve as an inspiration for designing tailored set of indicators for impact measurement, and
- a comprehensive set of analytical question that allow to understand the development of missions through different steps of translation.

Structure of the report

The report is structured as follows: Section 2 provides an overview of key theoretical and conceptual foundations of the framework. Departing from a discussion about the challenges associated with impact assessment for MOIP, the key underlying assumptions of the framework are discussed in greater depth. Section 3 is devoted to a discussion of the toolbox elements, presenting their function in the overall framework and their key principles. The subsequent section 4 applies the framework to one of the missions of the German High-Tech Strategy 2025 – the mission on combating cancer. Thereby, it provides a – partial – application of the framework to an empirical case and discusses its implications, both at the level of the mission under study and with regard to more general insights. The key elements of this report are summarized in the final section 5.

2 Theoretical and conceptual foundations

This section sketches an overview of the main theoretical and conceptual foundations for the novel framework approach. For this purpose, it summarizes insights from literature concerning the challenge for impact assessment and evaluation of MOIPs and derives requirements for a functional framework. Based on these insights, it outlines a number of conceptual clarifications allowing to better grasp the specificities of MOIP.

2.1 Challenges of MOIP for impact assessment and evaluation

Constituting a novel approach, the concept of MOIP does not only impose new requirements on policy-makers, but also has profound implications and challenges concerning impact assessment and evaluation of these policies. Drawing on the insights of a literature review on MOIP and transformative policies (Wittmann et al. 2021d), the following aspects can be considered as key challenges for analyzing MOIPs:

- Multi-dimensionality of impacts: Aiming typically beyond technological change, missions are cutting across a variety of sectors and dimensions. Understanding the effects of missions therefore requires a scope that reaches beyond traditional perspectives of evaluation (Amanatidou et al. 2014; Arnold et al. 2018, p. 2; Edler et al. 2012).
- Multiple levels of analysis: Striving for systemic change, missions require the analysis of dynamics at different levels, including both program and systemic level. In missions, the effects of programs and initiatives (micro-level) are expected to shape higher levels including the system level (meso-/macro-level), making it necessary to distinguish between impact processes and impact levels (Kuittinen et al. 2018, pp. 62–64; Weber et al. 2014).[2]
- Complex interactions: Bringing together different stakeholders from different areas and bundling diverse types of instruments. In consequence MOIP are exposed to complex interaction effects (Weber et al. 2014), so that an analysis of interactions, conflicts and synergies between different types of instruments is necessary (Janssen 2016).
- Long-time horizon: Goals formulated by MOIP are often expected to materialize only in remote futures. This creates difficulties linking activities of MOIP with the distant outcomes that often exceed the time horizons of political cycles and may materialize in different points of time (Amanatidou et al. 2014, p. 425; Kuittinen et al. 2018, p. 67).
- New roles for evaluation: Moreover, the turn towards transformative changes requires evaluation to provide different perspectives (Magro et al. 2019; see also Sandin et al. 2019). It moves away from the summative aim to provide accountability towards a

[2] Teirlink et al. (2011, p. 29) emphasize that such policies "require a new methodological and indicator framework" (see also Walz 2016).

more formative approach that can support implementation. Consequently, there is a shift towards a stronger focus on ex-ante and formative components (Kuittinen et al. 2018, p. 67; Weber et al. 2014) and an emphasis on capacity building and learning (Arnold et al. 2018; Janssen 2016; Magro et al. 2019).

- Empirical diversity: With the growing popularity of the concept of MOIP, a growing number of initiatives and policies subsumed under the label of MOIP has surfaced. However, these MOIP reveal considerable variance regarding their priorities, ambitions and understanding of the way to achieve changes (Kuittinen et al. 2018; Larrue 2021; Polt et al. 2019; Wittmann et al. 2021a). Moreover, missions are no static policies but are expected to develop over time (Hekkert et al. 2020; Janssen et al. 2020).

2.2 Addressing the challenges of impact assessment of MOIP

Against the background of these insights, we sketch out four key aspects that are necessary to meet the identified challenges.

First of all, the experimental, long-term oriented and multi-stakeholder approach requirements implied by the new generation of MOIP and the challenges experienced by policy-makers (Lindner et al. 2021) make it pivotal to strengthen formative elements in the evaluation process (cf. also Magro et al. 2019; Molas-Gallart et al. 2021). In consequence, the framework does not focus on providing accountability from a summative perspective on what the mission achieved (which would be a challenge anyway, given the long time horizon), but explores to what extent favorable conditions for the emergence of the intended impacts are in place. Thereby, it adheres to demands for a better integration of both formative and summative elements in evaluation (Amanatidou et al. 2014; Arnold et al. 2018). A shift towards a more formative framework can actively support the process by providing guidance to policy-makers in the implementation process and enables feedback and learning (cf. also Amanatidou et al. 2014; Grillitsch et al. 2019; Janssen 2016). This also includes a an increased reliance on ex-ante elements to inform the process, as postulated by Weber and Polt (2014). Consequently, the framework needs to be integrated into the actual realization processes of missions, acknowledging the specific challenges and negotiation processes of missions at different levels in a path-dependent context (Wittmann et al. 2021b) and the dynamic and evolving character of missions (Janssen et al. 2020). In consequence, the framework pursues two main objectives:

Firstly, while providing a sense of the ongoing progress of a mission and exploring whether developments are "on track" as a tool for mission management, the key focus is to support internal learning and the necessary adjustments of the policies, by facilitating reflections among involved actors. However, this required reflexivity imposes several

methodological requirements that are addressed by different elements of the proposed toolbox.

Secondly, the complexity and multi-level, multi-dimensional character of missions requires a theory- and process-oriented approach. Theory-based evaluations in this regard were identified as a promising approach as they allow to contrast actual developments with expectations and to explore whether adequate conditions for impact are in place in a specific case (Arnold et al. 2018; Arnold 2019; Belcher et al. 2020; Bührer et al. 2019; Joly et al. 2015; Joly et al. 2017; Joly et al. 2019; Kalpazidou Schmidt et al. 2017; Miedzinski et al. 2013; Molas-Gallart et al. 2021). Putting impact pathways at the heart of the framework allows to gather insights on the progress of missions, even if the full materialization of effects exceeds the time horizon of an evaluation, and impacts are beyond the control of actors (cf. Belcher et al. 2020). At the same time, MOIP require a dual perspective on dynamics, as effects of missions may materialize at different levels (Amanatidou et al. 2014; Weber et al. 2014). For missions this in particular includes the level of individual instruments/programs, the meso-level of mission management as well as the systemic level where impacts are supposed to materialize. Consequently, the proposed framework combines input and process-oriented elements in order to explore to what extent a context with favorable conditions for the materialization of effects is created. Missions as a new policy paradigm do not only aim for transformative change at the systemic level but also require a different way of doing things within and outside the political sphere (Lindner et al. 2021).

Finally, missions are not only complex but also highly diverse, even within single strategies such as Horizon Europe or the German High-Tech Strategy 2025. Research has demonstrated that an increasing variety of policy instruments with varying scope, understandings of problems/solutions, ambitions, underlying logics for goal achievement, and thematic areas has been subsumed under the label of mission-oriented policy (Griniece et al. 2018; e.g. Kuittinen et al. 2018; Larrue 2021; Polt et al. 2019; Wanzenböck et al. 2020; Wittmann et al. 2021a). While assuming an overarching societal impact appears adequate for MOIP, there exists no blueprint of how the interaction between potential changes in science, the economy and society play out and what impact dimensions should be a priori considered as relevant. In consequence, we propose a flexible and modular toolbox approach that systematizes different types of missions and allows for a case-specific approach. At the same time, this approach is methodologically open, i.e. can be addressed by different methods. Whereas some authors strongly argue in favor of a mixed methods design combining qualitative and quantitative approaches (Arnold et al. 2018; Joly et al. 2017), Feller (2017) has highlighted that the insight depends less on the choice of the methods and more on the design of the evaluation itself. Moreover, in view of the different context conditions, the described elements of the framework also

explicitly encourage stakeholder involvement, however, without prescribing a certain mode of participation.

2.3 Understanding of MOIP

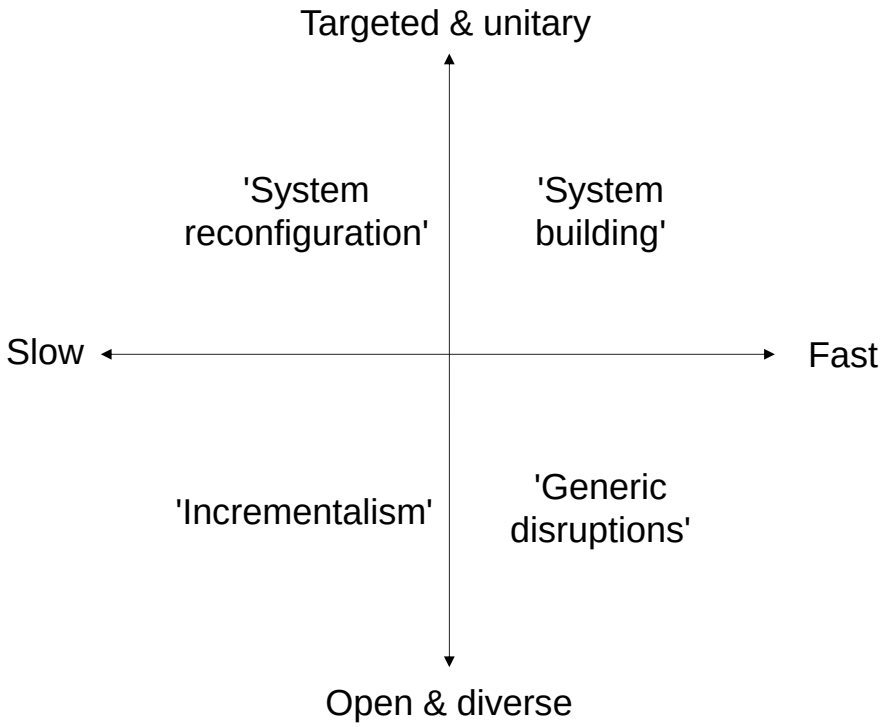
The term of MOIP is associated with an increasing diversity of understandings, not only at the empirical level, but also in literature (see also volume 1 of the final report of the scientific support action, Roth et al. (2021)). In the following, we understand MOIP as state-led strategies with a transformative ambition aiming at the intended, comprehensive, long-lasting change of the underlying socio-technical system. Thus, MOIP can be defined as:

> *"... a cross-sectoral and cross-policy approach to achieving ambitious and clearly formulated goals, via the generation and application of knowledge and innovation that address pressing s^*
>
> *cietal challenges. The goals must be clearly defined as well as being measurable and verifiable, and they must be implemented within a clearly defined timeframe. Only when missions aim at behavioral and structural change, in addition to generating knowledge and innovation, do they contribute to comprehensive system transformations. Practices, actors and institutions must all be reconfigured as a result of the transformations." (Lindner et al. 2021, p. 7)*

This understanding has several implications for the framework. First, aiming for a strong role of formative elements (cf. also Molas-Gallart et al. 2021) , we propose a framework that is closely embedded in the implementation processes and supports the key actors in the realization of the missions. In consequence, the scope of the framework is more focused than the literature dealing with transitions in general (Ghosh et al. 2021; Molas-Gallart et al. 2021). Weber and Matt (2021) distinguish four ideal types of transformation processes that vary along the dimensions of pace (slow/fast) and model of change (target & unitary/open & diverse). Figure 2 illustrates these different dimensions and the associated transition processes. In our understanding, missions – regardless of their diversity (see below) – can be found in the upper half of this figure, thus focusing on *system reconfiguration* and *system building*. The intentional character and agency of involved actors in our perspective sets missions apart from the more bottom-up driven processes and *incrementalism* and *generic disruption*. For this reason, we put particular emphasis on the role of actors actively involved in the mission (*mission owners*) and their interaction as a prerequisite for impacts and seek to provide support to these actors in the realization of their mission policy. This sets the framework apart from works that take a transitions perspective relying on the multi-level perspective (Geels et al. 2007; Geels et

al. 2016).[3] For example, Ghosh et al. (2021) develop a framework for transformative outcomes in the context of transformative innovation policy. However, in the discussion of cases, they highlight that "the cases [studied] confirm our proposed starting point on TIP: transformation is ongoing, even in cases where innovation policymaking is absent or connects only later to the process" (ibid., p. 13). While not downplaying the fact that missions may take up existing dynamics in a system, our starting point is the deliberate formulation of a mission by (political) actors.

Figure 2: Types of transformation processes



Source: Based on Weber et al. (2021)

Secondly, while considering missions to be driven by a transformative agenda, we acknowledge that missions may be driven by different logics facilitating the desired change. This notion is also reflected in the typology on mission types developed in the context of this project (Wittmann et al. 2021a, p. 727) . The ideal types of which "serve as deductive interpretations on how mission narratives and the assigned policy instruments pursue the associated mission goals". Whereas some missions may emphasize the importance of research to solve the challenge, others may focus on other types of activities, such as regulatory or structural changes, or aim for a modification of behavior

3 For a more detailed comparison highlighting similarities and differences between missions and transitions see Arnold et al. (2019, p. 17).

to achieve the desired outcomes. Consequently, even two missions addressing the same societal challenge might follow highly different approaches in the postulated way to achieve these goals (Edler et al. 2020).

Following this perspective, we do not aim to assess varying degrees of transformativity, but instead emphasize the importance of accounting for the different underlying notions that may be inherent to different missions. This implies that we do not associate a fixed set of impact dimensions with missions as in some frameworks (cf. for example Feidenheimer et al. 2019; Joly et al. 2015) , but assume that the desired societal impacts evolve out of the interaction of different dimensions that cannot be determined a priori.

2.4 Missions as multiple translation processes

Furthermore, we conceptualize missions as multiple, connected translation processes (Wittmann et al. 2021b). Thereby we follow the reasoning of Kroll that complex policies are shaped by multiple translation processes, which in turn are the result of negotiations between actors at different levels. These negotiations result in new impulses "into an existing path-dependent system of narratives and support policy practices" (Kroll 2019, p. 637). In consequence, Kroll (2019) calls for a separate analysis of these different translation processes, as the non-materialization of intended effects can have multiple sources, resulting from problems at the level of strategy formulation, the choice of instruments, or technical policy implementation. For example, despite a clearly defined and comprehensive strategy, effects of a policy may be impeded by the fact that the choice of instruments does not fit the postulated goals and instead relies on existing activities that were not designed for these purposes, rest on wrong assumptions or prioritize different aspects (see also Mickwitz et al. 2021, p. 292 for a brief discussion).

In consequence, the analysis of missions as multiple translation processes can better contribute to impact assessment and a better understanding of MOIP in general. Firstly, this perspective grasps the interfaces between different actors and levels of negotiations, drawing attention to potential sources of deviations and frictions in the implementation process. By disentangling the different negotiation processes taking place at different levels, it allows to delineate analytically potential bottlenecks and facilitating factors for the realization of impacts at different levels. Secondly, it allows to structure process support in a more targeted way, by identifying actor-specific toolbox elements aiming at specific challenges associated with each translation process.

As a result, we conceptualize missions as characterized by three closely connected translation processes taking place at different levels.[4]

- Step 1: Mission formulation: Translation of societal challenges into specific missions with dedicated priorities and goals
- Step 2: Mission design: Translation of mission goals into a specific set of instruments, activities and coordination structures
- Step 3: Mission implementation: Translation of mission activities into impacts

2.4.1 Mission formulation: Translating (societal) challenges into missions

The first translation process associated with MOIP is the translation of grand societal challenges into dedicated missions. Despite ambitious goals, no mission is equivalent to the underlying societal challenges, but prioritizes and balances certain aspects it seeks to achieve. Thus, the formulation of missions involves defining boundaries of the system to be transformed, and factoring out the role of other aspects related to a societal challenge. Larrue (2021, p. 9) describes missions as a process of narrowing down what in many instances starts from "challenge areas".

The process of negotiating mission goals is closely linked to the strategic level of policy-making where priorities of a mission are set, pointing to the importance of actor constellations and processes as key factors driving mission formulation, or as formulated by Janssen et al (2020, p. 6): "Missions emerge as a negotiated outcome between different interests, concerns and imperatives. This implies that in our view, they are neither apolitical in their formulation, nor neutral in their conduct". The underlying characteristics and the cross-cutting nature of MOIP imply a wide range of potentially relevant stakeholders for missions. A first issue of negotiation in this context is the question of who is involved at which stages, and to what extent do these actors actively participate in formulating missions and their priorities?

A second issue of negotiation is the question of scope and ambition. The concept of MOIP is closely linked to high requirements of legitimacy (Larrue et al. 2019) and the urgency of a societal challenge (Janssen et al. 2020), calling for ambitious and comprehensive mission goals. However, empirically not every mission is following an ambitious and comprehensive transformative agenda aiming at changing an entire socio-technical system. Yet, for those missions that do, the likelihood of politicization and contestation

4 The following sections provide a shortened description of Wittmann et al. (2021b), where a more comprehensive discussion of translation processes is presented.

of these policies increases (Boon et al. 2018; Hekkert et al. 2020) due to potentially uneven distribution of costs among actors (Wittmann et al. 2021a). This may, for example, lead to a weakening of the level of ambition or result in ambiguities of goal formulations in order to accommodate discontent actors. Finally, the choice of priorities and goals does not happen in a vacuum but is embedded in a broader social, political, economic and institutional context shaping the specific priorities and the scope of missions (Edler et al. 2020; Larrue 2021). In consequence, similar challenges may be perceived and addressed differently, e.g. in different countries, leading to different formulation of mission goals.

Table 1: Key characteristics of translation processes

	Mission formulation	**Mission design**	**Mission implementation**
Key actor	Strategic level (high-level politics, public discourse)	Operative level of political administration	Executive level of administrations, funding agencies, etc.
Type of translation process	Narrowing down societal challenge to specific mission goal	Choosing an adequate instrument mix and coordination structures fit for purpose to meet the goals	Effective and efficient implementation and coordination of instruments
Issues of negotiation	Legitimacy, directionality, level of ambition Stakeholder involvement and representation	Actor and resource mobilization/involvement, Combination of different types of instruments, generations etc.; Coordination structures	Administration of instruments Coordination processes, monitoring, flexibility, and learning
Influencing factors	Political and institutional context	Ideational frames Belief systems Existing policies Participating actors	Administrative capacity and resources for learning/evaluation Cognitive gaps and belief systems Administrative cultures

Source: Modified based on Wittmann et al. (2021b, p. 7)

2.4.2 Mission design: Translating goals into policy instruments and activities

The second translation step takes place when mission goals and the operationalization of these goals are translated into a set of specific policies and the development of adequate structures for exchange and coordination. In contrast to the process of mission

formulation at the strategic level, the translation process of mission design is usually located at a lower level, i.e. within the involved ministries, agencies, and other stakeholders representing different subsystems.

To put missions into actions, an understanding of the instruments and coordination structures that are necessary to achieve the postulated goals is needed. Thus, this translation step is centered on the identification, selection and mobilization of resources and inputs and the alignment of these activities towards the mission goal. At the same time, it creates the need for delineating the boundaries of a mission at an instrument-level, clarifying how the selected activities contribute to the mission goals, and separating them from other instruments that may already be implemented in the wider socio-technical system.

Negotiation processes therefore are likely to center around several aspects. Firstly, aiming for a broader cross-sectoral approach, MOIP require high level of commitments from different actors and their readiness to contribute to the postulated goals, making available own resources and contributing own activities on behalf of the overarching goal of a mission. These processes may be influenced by different policy traditions and understandings about the role of the state (Edler et al. 2020)[5], and different strategies to combine existing and new policy instruments (Janssen 2020; Larrue 2021, p. 9; Wittmann et al. 2021c). Secondly, complex interventions often require a bundle of different measures, implying that missions are more than the sum of their individual components and thus are defined by the interplay of the different instruments. And finally, negotiations also need to address the coordination of activities and actors, thereby finding adequate governance arrangements for steering mission implementation.

2.4.3 Mission implementation

The final step of translation focuses on the materialization of mission impacts through the implementation of instruments and activities. After having designed a set of interventions, the implementation process can be considered as the translation of policy inputs into impacts. In contrast to mission design dealing with the choice of instruments and their combination to maximize the potential synergies, this step focuses on the outputs of instruments and the coordination of activities contributing to an alignment of activities towards the postulated goals. Thereby, the materialization of desired impacts may be affected by problems inherent to the implementation process itself (e.g. Pressman et al. 1984) or the fact that changing circumstances undermine the anticipated effects of instruments and policies (Mickwitz et al. 2021, p. 292). Important factors influencing these

5 Cf. e.g. the question to what extent a mission may go beyond the confines of STI policy and employ additional means such as regulation in order to facilitate the required changes (Expertenkommission Forschung und Innovation 2021) .

translation processes, in addition to the implementation of individual instruments, are often related to resources and capacities at the individual, organizational and systemic level (cf. Considine et al. 2014; Wu et al. 2017). Common challenges of implementation include the avoidance of delays in the implementation of measures, the handling of the interdependency of different parts of the policy mix, or balancing bottlenecks. At the same time, (internal) learning processes, reflexivity and evaluation of on-going measures are potentially beneficial inputs for successful implementation of the mission (Larrue 2021).

2.4.4 Towards a perspective of interconnected translation processes

We perceive these three translation steps, representing different types of negotiation processes at different levels as constitutive for MOIP. While providing analytical value regarding the different processes around missions, we we believe that only an integrated view on the entire process provides a holistic picture of the dynamics of MOIPs. Thereby, we acknowledge that missions hardly follow a simple linear logic from design to effect, but instead are characterized by multiple interactions and feedback loops between the different translation processes (see figure 3). In practice, mission formulation, design and implementation should be understood as partly co-evolving and interrelated processes, as missions evolve over time (Hekkert et al. 2020; Janssen et al. 2020). Taking up the idea that the materialization of impacts is shaped by different stages acting as "filters", this conceptualization provides us with a useful perspective to design and structure the toolbox for impact assessment.

On the one hand, we see a logic downwards from mission formulation to mission implementation. Problems at earlier stages may cascade down to subsequent stages of mission implementation, as dynamics in many instances are hard to reverse. First of all, the development of a powerful narrative and a well-designed process of mission formulation are key prerequisites for actor and resource mobilization and therefore significantly shape mission design and implementation. A compelling mission goal is likely to strengthen the legitimacy and therefore ensure a higher degree of commitment of involved actors to contribute to the goals. In contrast, missions with poorly defined and ambiguous goals may not only limit the ability to mobilize actors to pursue the postulated goal, but also opens room for negotiation and contestation, providing actors with agency to interpret the goals according to their own preferences. Thus, the importance of mission formulation as a cornerstone and prerequisite for successful missions has been emphasized repeatedly (Janssen et al. 2020; Lindner et al. 2021).

Figure 3: Translation processes and feedback loops in MOIP

Source: Modified figure based on Wittmann et al. (2021b)

On the other hand, dynamics during the implementation process may also feedback intro earlier stages and affect the outcomes of negotiation processes. This points to the importance of feedback affects, acknowledging that many processes may have an iterative character or may take place simultaneously. Firstly, long-standing existing policy approaches and the availability of policy options may shape the understanding of goals and solutions, resulting in missions being centered on these policies. Secondly, the dialogue process in search of mission goals may alter the perception of the underlying societal challenges concerning urgency and relevance of the topic, resulting in a convergence of views on the solutions and/or problems (Wanzenböck et al. 2020). Moreover, early effects of a mission may reinforce the positive narrative of a mission and its credibility of intention, strengthen actor commitment, mobilization, and contribute to the level of agreement over certain solutions. Needless to say that besides such virtuous circles and learning processes, missions may be also affected by a vicious circle due to insufficient results, thereby undermining a mission's legitimacy and decreasing actor mobilization, while at the same time re-opening the discussion about goals and the legitimacy of a mission. Finally, we assume that insights on the ongoing implementation of specific instruments are likely to feed back into a potential (re)formulation of mission objectives and instrument portfolios. For example, if a mission fails to achieve the required behavioral change, mission goals might be watered down retrospectively in order to shift to a narrower, technology-focused accelerator type of mission.

3 Toolbox approach for MOIP implementation and impact assessment

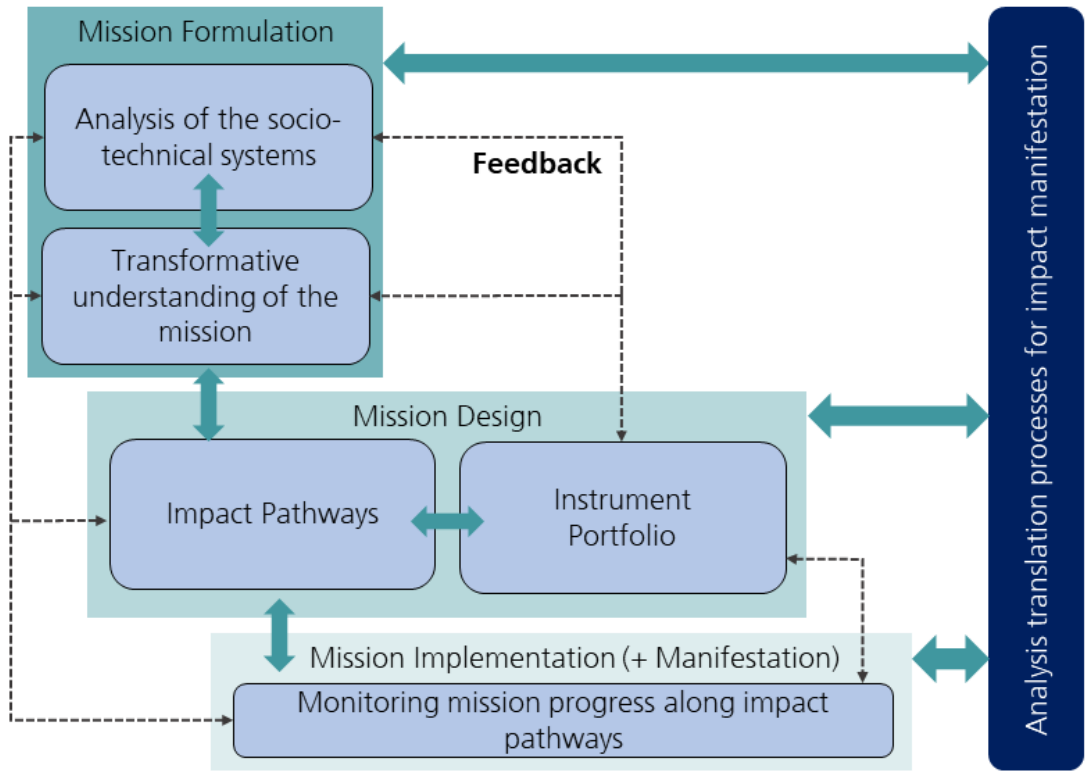
3.1 Concept for a toolbox

As outlined in section 2, missions are complex policies that act on multiple levels and are subject to different translation processes. To address the complexity of MOIP, we propose a modular approach that takes the previously identified requirements into account. The toolbox we propose consists of six closely connected toolbox elements that are designed to support the formulation, design and implementation processes by heightening the awareness of mission owners and stakeholders about key aspects, and providing the foundation for learning and feedback (see figure 4). Five of these elements are directly linked to the realization of missions, referring to the different translation processes and providing support for the actual realization of the mission.

In contrast, the sixth element (analysis translation processes for impact manifestation) provides a means to assess the overall progress of the mission by providing indictors for impact pathways. It cuts across the different translation processes, thereby allowing to explore to what extent favorable or hindering conditions for the materialization of impacts are created. Relying mostly on ex-ante analyzes, the insights generated by this rather analytical element do not only yield a summative component, but can feedback into the different stages of MOIP policy-making and consequently support the formulation, design, and implementation phases.

As indicated by the feedback loops, we do not see the toolbox application as linear process, but as an iterative practice, supporting learning effects by involved stakeholders between different elements (see table 2). In effect, this implies that activities may temporally overlap, as e.g. the development of appropriate impact pathways and the identification of appropriate instruments might affect each other. While emphasizing the importance of combining the different elements, the approach does not determine specific methods and only describes the overall frame. In this regard, we do not aim for a one-size-fits-all approach, but provide an overall framework that can be tailored to a specific context. Thereby, it acknowledges the existence of varying understandings, resources and priorities.

Figure 4: Overview of the Elements of the toolbox for assessing MOIP



Source: Own elaboration

3.2 System analysis

The first element of the toolbox has the purpose to support the systematic analysis of missions in their specific socio-technical system. As Allender et al. (2015, p. 2) describe, a systems approach "(...) takes complexity into account by considering non linear relationships between variables, accumulations, feedback loops, effects of time delays in systems and the unintended consequences that emerge as a function of these characteristics that would otherwise be missed in more reductionist approaches." Such a systems approach seems particularly useful for transformative missions aiming for systemic change: "Systems change is an intentional process designed to alter the status quo by shifting the function or structure of an identified system with purposeful interventions. (...) However, to change the system, you need to first understand the system, and mapping is a great way to do that" (Cook 2015, without page reference, own translation). The analysis can be carried out either by the implementing actors themselves, by or jointly with scientific support actions. The results of the system analysis can inform all translation steps, including the translation of challenges into goals and the choice of policy instruments. Further, it can contribute to a better understanding of the impacts of a mission

Table 2: Characteristics and functions of toolbox elements

Element	System analysis	Transformative approach of mission	Impact pathways	Instrument portfolio	Indicators for mission monitoring	Analysis of translation processes
Function	Awareness for socio-technical system/shared understanding of problem	Supporting goal formulation (awareness creation for understanding)	Linking goals with strands of activity/expected relationships	Identification and integration of instruments to achieve goals, clarification of responsibility	Monitoring of implementation progress for governance/communication etc.	Determining potential for realization of impacts
Translation process	Mission formulation		Mission design		Mission implementation	all
Benefits from stakeholder involvement	Expertise, divers perspectives, verification of mapping	Increasing ownership and commitment	Increasing ownership and commitment, expertise, verification	Resource mobilization, expertise, verification	Provision of data, feedback on realization	Provision of data, feedback on realization
Practical implementation	System analysis (different mapping approaches as extension)	Mission typology, Bundles of stylized pathways as orientation	Strategic process for operationalization of mission goals into pathways	Process for development instrument mix	Process for indicator development	Analysis based on analytical questions
Challenges	Depth of analysis, involving external expertise	Awareness concerning demands and room for maneuver	Integrating system analysis, awareness of boundaries of mission	Overcoming political silos, path dependencies, actor mobilization, creation ownership	Creation and implementation of governance structures	Integration analysis with implementation, timing for ex-ante analyzes

Source: Own elaboration

and support mission learning. Since the system analysis approach can facilitate learning during the implementation phase of missions, it is particularly valuable for formative evaluations.

Use for mission formulation: A system analysis approach can support impact assessment in relation to the first translation process, where a societal challenge turns into a defined mission. Understanding the specificities of the socio-technical system with its spatial and institutional peculiarities is a prerequisite for deciding about the scope and ambitions of a mission. This way, it can help to understand the goal hierarchies and sequences when missions have multiple sub-goals. By making the often implicit decisions about the scope and ambitions explicit, the system analysis can contribute to making motivations and goals more clear. Ideally, the analysis should accompany the mission process from the start, in order to support the definition of the scope and priorities of a mission during mission formulation and include external experts and/or stakeholders in order to ensure the inclusion of broad perspectives.

Use for mission design and implementation: System analysis can also be employed to influence the mission design through revealing potential bottlenecks and constraints within the socio-technical system, providing a starting point for the development of appropriate impact pathways. A holistic system analysis can support the design of activities and interventions by rooting pathways in the socio-technical system and indicating potential stakeholders and other policies that should be taken into consideration. At the same time, the systemic mapping provides insights into the type of indicators required. Moreover, a system analysis can help to address so-called "moving target" challenges, which are typical when missions and their goals evolve over time (Janssen et al. 2020).

Use for mission assessment and learning: Ultimately, "zooming out" to the larger socio-technical system in which a mission is embedded can help to avoid falling back into established procedures and approaches, without rethinking the context. In addition, system analysis appears useful for assessing complex missions, when desired impact may rest on multi-faceted dynamics and changes. In this way, even if it does not aim to identify causal relationships or impacts, it still can function as the starting point for impact analysis, as it allows to map out key actors, policies and the relationships among them. Especially for a formative evaluation it appears pivotal to start thinking about the overall system that is intended to be changed or transformed. This prevents that a narrowing-down on a specific problem might overlook other challenges in the socio-technical system. While it is clear that not every mission can or needs to address all challenges at the same time, this "zooming out" can support the process of reflection and make both policymakers and evaluators aware of the complexities and interdependencies arising from the

overall socio-technical system. From this perspective, it can be a particularly useful tool for identifying blank sports and limitations. Further, a system analysis can contribute to identify potential unintended and undesired consequences.

3.2.1 A qualitative, collaborative mapping approach

System analyzes are conducted in a broad range of academic disciplines, from engineering, physics and informatics to ecology, economy, sociology and political science. Especially in natural sciences, quantitative system analyzes build on refined indicators and large data sets, for example to understand the processes of climate change, the effects of biodiversity loss on ecosystems or the vulnerability of critical infrastructures to shocks and disturbances (Miller et al. 2007). For the purpose of analyzing MOIP, qualitative methods appear more suitable that allow to explore complex systems also as the availability of quantitative measures are limited.

Qualitative approaches to system analysis have been applied for quite a while, e.g. to enhance the understanding of public health issues (Cavill et al. 2020), to model systemic interventions in welfare policies (Andersen et al. 1994), and the preconditions of organizational innovation (Talmar et al. 2020). Further, qualitative approaches are particularly useful to involve relevant stakeholders in the formulation process of policies and ensuring a shared understanding about the key motivations and necessities. Thereby, in its ideal form it should bring together policy-makers, thematic experts and stakeholders with expertise knowledge in potentially relevant fields (Cavill et al. 2020).

Typically, participatory mapping brings together different actors in a workshop or series of workshops. These workshops necessitate a detailed preparation to allow all participants to engage a constructive and creative manner. "The image for the planning phase is the preparation of an improvisational theater performance or a jazz concert. Every phase is carefully scripted in detail, but the live performance can deviate from the script, producing unanticipatable moments of productive creativity as well as the potential for unproductive distractions" (Andersen et al. 1997, p. 109). During the workshops, the participants collaboratively develop graphical representations of the system under study, for example causal loop diagrams. These diagrams include the various perceptions of important elements and (positive, negative or neutral) connections. This method requires a skilled note taker and moderator, as well as a "modeler" (Allender et al. 2015, p. 4), which can be an experienced individual or a team that turns the verbal contributions into a graphical representation. These forms of collaborative analysis can contribute to deriving a comprehensive and complex understanding of the socio-technical system as a starting point for the reflections about the required transformations. In the best case, as Ackermann et al. (1992, p. 2) describe, the mapping process (...) "may act as a cathartic

medium for interviewees who, through the process of explaining the ideas and how they fit together, begin to gain a better understanding of the issue." Therefore, the process of system mapping is often as important as the maps produced.

3.2.2 Defining the system center and boundaries

There are various ways to define and analyze systems related to MOIP. A common approach in system mapping is to develop cognitive maps around a problem. Following Ackermann et al. (1992, p. 2), such a cognitive map "(...) may provide valuable clues as to the client's perceptions of the problem giving indication as to where the 'nub(s)' of the issue may lie. Aims and objectives can be identified and explored, options examined to see which are the most beneficial and whether more detailed ones need to be considered. Dilemmas, feedback loops and conflicts can be quickly distinguished, explored and worked up." In the context of MOIP, this means to put a societal challenge the mission addresses at the center of the system and to analyze which factors influence the challenge and might help to overcome the challenge (Matti et al. 2020). We propose as an alternative to focus on a specific socio-technical system in which the mission is situated (Hettinger et al. 2015). For this purpose, we understand socio-technical systems as the "articulated ensembles of social and technical elements which interact with each other in distinct ways, are distinguishable from their environment, have developed specific forms of collective knowledge production, knowledge utilization and innovation, and which are oriented towards specific purposes in society and economy" (Borrás et al. 2014, p. 11). Each system is characterized by complex networks of technical innovations, but also by the societal functions these innovations provide, highlighting the importance of not only the production of technology, but also its diffusion and use (Geels 2004). This approach appears suitable to include all potential topics that may be relevant with regard to the specified mission, especially when the underlying challenge is not clearly defined.

A key step in the process of analyzing the socio-technical system is to define the system's boundaries. Due to the complexity of socio-technical processes and the limitations of analytical capabilities, not all factors and elements that could potentially influence a system can also be included in the mapping process. Defining the system boundaries includes, for example, identifying dynamics and actors that are beyond the mission scope and cannot be actively addressed, such as international dynamics that are best treated as a context factor. Setting the system boundaries is a theory-driven process, guided by considering which elements are expected to be most important for understanding the socio-technical system under study.

3.2.3 Mapping system elements and connections

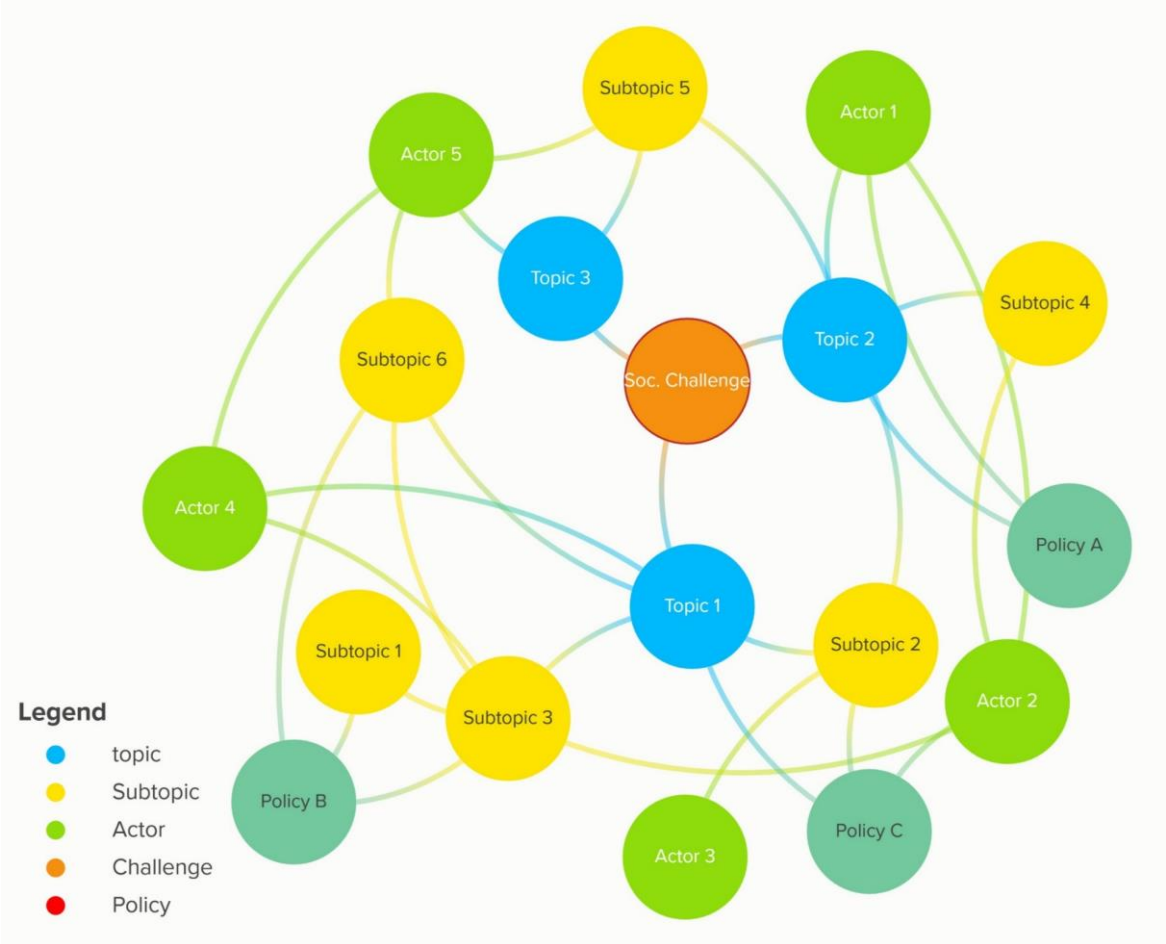
Once the system boundaries are defined, the main elements of the socio-technical system under study need to be identified. System mapping is a challenging task, especially if many elements and connections are to be included. Therefore it always necessary to exclude certain factors from the analytical process. This step should be made transparent in order to delineate the scope and limitations of the system map. The developed model of the system should be simple, but not simplistic (Magro et al. 2013, p. 1649). We propose to focus on topics, actors, policies and context factors as main system elements:

- **Topics and subtopics:** subdomains, sectors or topical clusters within the larger socio-technical system. The understanding of sub-topics is broad, including for example relevant technological innovations and solutions, societal issue areas, etc. A hierarchical and procedural/sequential structuring in this context can be helpful.
- **Actors:** relevant governmental, private sector, and civil society actors, regardless of their official involvement in the mission. "Since a Mission-oriented Innovation System (MIS) emerges around problems rather than solutions, it is not clear from the outset which actors play a role in developing and diffusing innovative solutions during a mission's runtime" (Hekkert et al. 2020, p. 77). To take into account the different roles and responsibilities in the mission process, it is possible to differentiate between mission owners (actors with primary responsibility for the formulation, design and implementation of a mission) and other relevant actors.
- **Policies**: Key policy instruments expected to have an impact on the system. The focus should be (a) on science, technology and innovation policies (STI policies) or other relevant policies in any other field that are currently in effect (not past measures or potential measures), (b) that have a clear connection to the overall system, (c) address and push for significant changes and (d) that are at least partially related to public, private or non-governmental actors (e.g. co-financed) (Walz et al. 2019, p. 62). Thereby, the mapping process can shed light on the constraints and boundaries of certain policy approaches.
- **Context factors and dynamics:** the socio-technical system may be shaped by the existence of general trends and dynamics that are beyond its own scope, such as inputs or regulation provided by international actors or larger macro-economic trends. However, it is important to include those into the mapping to clarify the boundaries (see also the next step) of the system.

The exploration of the connections between the system elements represents the final step of the system analysis. We can differentiate between positive, negative and neutral relationships. Further, connections can be one-directional, multi-directional or undirected. Finally, it is possible to develop a hierarchy of connections to represent the different strength or weight of connections. This differentiation is important for the entire

mapping process, as socio-technical systems are more than the sum of their parts, but defined by the complex interplay of hierarchies, feedback loops and self-organisation (Savaget et al. 2019). Identifying connections is particularly relevant for assessing the impact of policy instruments at a later stage of the project. To capture this complexity, the last step of the process involves structuring the socio-technical system and specifically to examine the linkages between the elements of the system. Figure 5 represents an exemplary systems map.

Figure 5: Exemplary system map: challenge connected to topics, sub-topics and actors



Source: Own elaboration

3.3 Transformative approach of mission

A key aspect related to mission formulation is the clarification of the transformative understanding and ambition as well as the way and scope of desired changes. The diversity of approaches manifests itself in academic literature highlighting the variety between real

world missions (Polt et al. 2019; Wanzenböck et al. 2020; Wittmann et al. 2021a). Missions often address the same societal challenge in different ways. While one mission may support sustainability through the reduction of greenhouse gases and strongly prioritize technological innovation and scientific solutions as the key drivers, other missions could take a broader perspective by explicitly addressing the role of human behavior and end users perspectives'. A clarification of a mission's transformative understanding can support the process of mission formulation and design by making the consequences and requirements of different types of missions explicit to policy-makers and to develop an approach that is feasible in view of the given circumstances and possible constraints that were identified in the analysis of the socio-technical system. Thereby, it can contribute to avoiding disappointment about overly ambitious or unrealistic goals or signal the need for taking a broader approach in the design phase as initially assumed.

In acknowledgement of the diversity of missions, we suggest draw on a typology of mission types, which was developed in the course of the scientific support action (Wittmann et al. 2021a), as a heuristic to support the process of clarifying the transformative ambition of a mission. The four ideal types of missions with their key dimensions, associated requirements and challenges provide a tool for orientation for mission owners to compare own ambitions, understandings and resources against the framework and possible interpretations of transformative policies/missions. The typology distinguishes between two types of more technology-driven accelerator missions (type 1, type 2) and two sub-types of transformer missions (type 1, type 2), which are characterized by a broader understanding of transformative change and the necessary tools to achieve them. Table 3 provides an overview of the key dimensions, requirements and distinct challenges during implementation.

The proposed ideal types provide the opportunity to cross check the coherence/consistency of the respective own understanding of the desired changes – ultimately a broader transformative approach including behavioral change will hardly be possible without a broader policy mix and the involvement of actors reaching beyond the sphere of STI. At the same time, mission owners lacking the capacity and willingness to step outside the sphere of STI and cannot actively invite broader interaction with diverse stakeholders from different areas, will face difficulties to implement missions leaning towards transformer type 1 or type 2.

Whereas the described types represent ideal types, empirical missions in many instances provide combinations of features of different missions. Nonetheless, the ideal types provide useful orientation for the key features and requirements of a mission, as in most cases certain elements will dominate the remaining features. At the same time, it

is worthwhile to keep in mind that a combination of different types may lead to an increasing list of challenges and possible tensions between requirements.

Table 3: Different types of missions and key features

	Accelerator Mission		**Transformer Missions**	
	Type 1 (A1)	Type 2 (A2)	Type 1 (T1)	Type 2 (T2)
Motivation	Problem-solving	Solution-driven	Solution-driven	Problem-solving
Main logic of change	Scientific/ technological change	Bringing knowledge to application	Reconfiguration of sectoral logics	Transformation of a system (including behavioral change)
Key stakeholders to be involved	Science	Science, Economy	Science, Economy, collective sectoral actors	Science, Economy, collective sectoral actors, civil society
Required Instrument mix	Mainly STI (distribution)	Mainly STI (distribution, systemic management)	Broad (distribution, regulation, information)	Broad (re-distribution, regulation, information)
Coordination requirements	Limited	Medium	High	Very high
Main challenges	Uncertainty, long-time horizons, shared understanding of problem, achieving critical mass for change	Ensuring appropriate framework conditions, overcoming existing bottlenecks, achieving critical mass for change	Dealing with path-dependencies/lock-ins, integration of sectoral policies, shift towards systemic change	Re-distribution/ compensating potential losers, involving society & different levels, shared understanding of problem. Shift towards systemic change

Source: Based on Wittmann et al. (2021a)

3.4 Impact pathways

As a key foundation of a theory-based approach for evaluation, the development of impact pathways constitutes as essential element of the toolbox. Building on a comprehensive Theory of Change (ToC), these impact pathways describe how mission inputs shall contribute to the anticipated impacts of a mission, assuming a logical sequence in which several steps need to happen first before certain impacts can emerge as the final results (cf. Griniece et al. 2020, pp. 5–7). As missions usually will combine several pathways, the figurative cipher of impact pathways allows for decomposing the complex and multi-

dimensional dynamics of missions into a set of multi-stranded activities and areas contributing towards an overarching goal. However, this implies that impact pathways may not necessarily act in isolation but might jointly contribute to a shared impact. Particularly towards their end (outcomes, impacts) they might contribute to the same mission goal/impact, resulting in an interaction or co-existence of pathways.

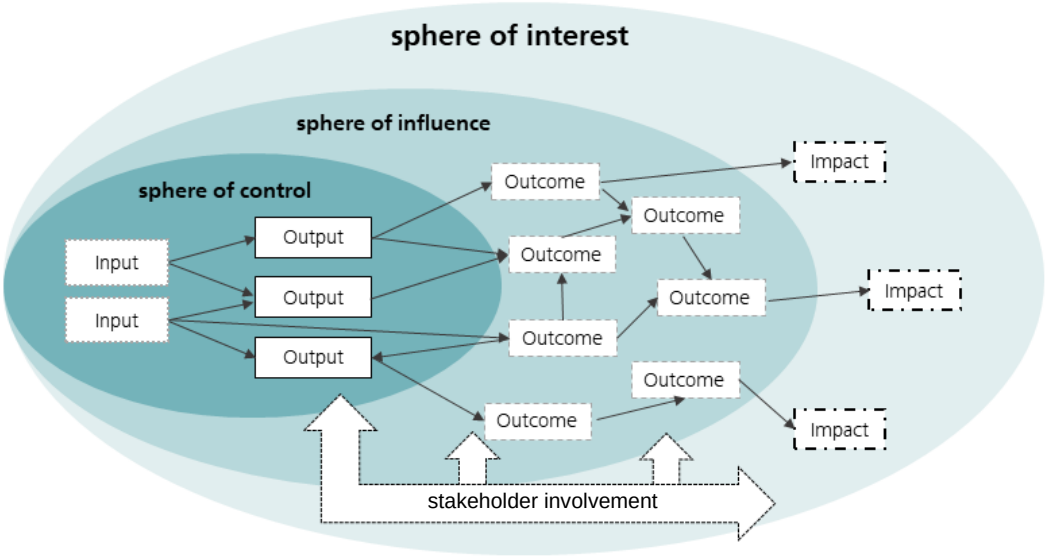
Drawing on the established Input-Output-Outcome-Impact approach, as proposed by RIPATHS (Griniece et al. 2020) and Belcher et al. (2020), three important aspects have to be considered:

Firstly, despite implying a certain sequencing of steps from inputs towards impacts, we do not assume a linear relationship. Instead, by their figurative character impact pathways allow to account for feedback loops and non-linear dynamics. For example, an increase in research outputs and the uptake by other researchers (outcomes), may reinforce each other, implying that impact pathways need to take such dynamics into consideration.

Secondly, the four main structuring elements of impact pathways also reflect the varying degree of control of the mission owners (Griniece et al. 2020, p. 6) that is also depicted in figure 6. The heart of missions are policy instruments and activities initiated by actors in charge of the mission (*mission owner*).[6] Both these inputs and their immediate outputs can be considered to be directly shaped by the mission owners (*sphere of control*). In contrast, outcomes are shaped by the uptake of outputs and interaction with other actors in the wider socio-technical system, such as the use of research results. While being influenced by the inputs/outputs of the mission owners, the short- and long-term outcomes are beyond their control (*sphere of influence*) and might be affected by other dynamics, so one cannot assume a causal linear reaction (Griniece et al. 2020). Furthermore, stakeholder engagement (interaction of mission owners with actors affected by and active in the mission) should ideally occur throughout all the stages of impact pathways manifestation.

6 The term does not necessarily imply the existence of a central superior actor (e.g. a unit in a ministry; lending agency) that takes over full responsibility for the whole mission. Rather, we suggest to use it as a cipher for those actors who are actively involved in the realization of the mission through the definition of goals and their involvement in coordinating the mission activities (cf. also the term mission arena by Wessling and Meijerhof (2020)). This sets them apart from other stakeholders that are mobilized/affected by the mission but do not actively shape the mission.

Figure 6: Impact pathways and different spheres of control



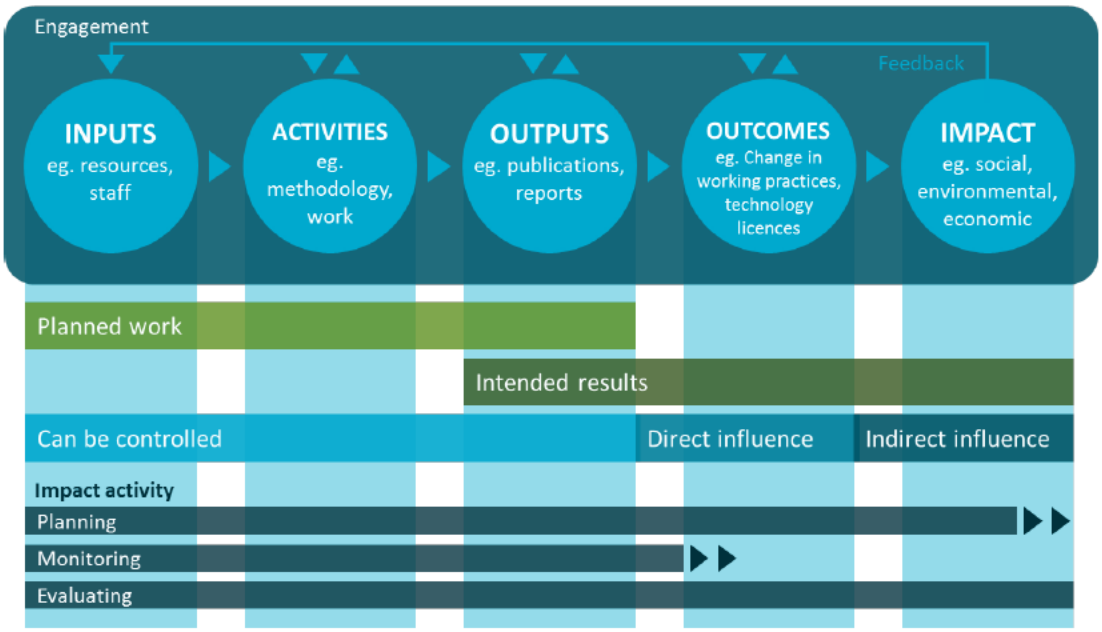
Source: Figure based on Belcher et al. (2020, p. 11)

Finally, impacts are contributions of inputs to intended changes that will only materialize over longer time periods at a systemic level, causing only a modest ability of the mission owners to steer the results as these affect the transformation of the overall socio-technical system (*sphere of interest*). In theory-based evaluation the materialization of impacts has been described "as a web of causes and effects that grow over time" (Griniece et al. 2020, p. 6), depending on previous contributions and inputs. It was also compared to a tree, where fruits (impacts) require the existence of roots (inputs), a tree-trunk (outputs) and branches (outcomes) that carry leaves/fruits (Griniece et al. 2020; Kalpazidou Schmidt et al. 2017).

The applicability of impact pathways for e.g. project planning and evaluation (Alvarez et al. 2010; Dowd 2016) or as a guideline for assessing the impact of research infrastructures (Griniece et al. 2020) as a supportive framework depicting static (e.g. stocktaking of activities) as well as procedural elements (e.g. feedback loops) has proven insightful in the past. Alvarez et al., for instance, applied the method of Participatory Impact Pathway Analysis (PIPA) which includes a project spanning stakeholder process of collecting and drafting expected impacts and their pathways at the outset of a project, e.g. in complex settings like the water or agriculture sector. Two logic models – one on expected medium-term outcomes and a second on expected impacts on society – are crafted in an interactive inclusive learning process of all project members and potential stakeholders. The key aim of a PIPA process is to "encourage participants to think beyond the

scope of a single project"[7] and take on a systemic view similar to mission orientation. A slightly different approach was taken on by the Australian national science agency CSIRO by introducing an impact framework as a participatory guiding tool for empowering researchers receiving funding. By reflecting their potential research contribution and the "end-user" of their insights (intended results might materialize after application), researchers could gain more clarity on the kind of activities they would like to pursue.

Figure 7: CSIRO's Impact Framework



Source: Dowd (2016)

As planning, monitoring and evaluating the fit of their activities with the intended impact pathways during the funding phase (and beyond) is part of the concept, researchers are empowered to better steer and adjust their project when applying this framework.

When it comes to applying impact pathways to missions they can provide guidance in a similar way: Impact pathways can clarify the link between mission goals and the practical implementation by translating mission goals into workable concepts, including intermediary steps and sub-goals on how to achieve the desired changes. For mission owners themselves this constitutes a key step of negotiations and awareness creation, allowing to clarify the own understanding of the mission goals. Therefore, the development of impact pathways fulfills multiple functions within this toolbox and relates to all other elements.

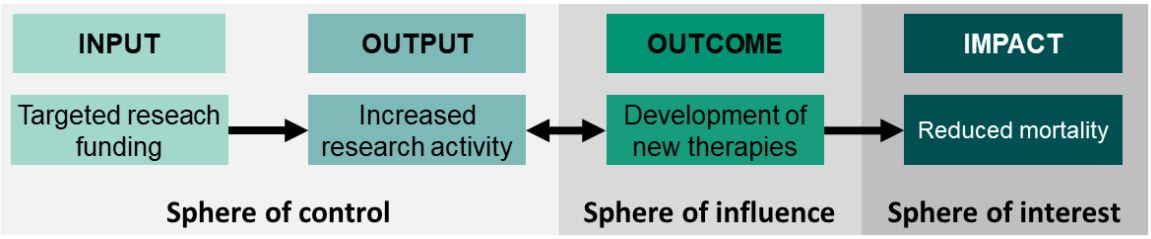
7 PIPA online wiki: http://pipamethodology.pbworks.com/w/page/70283575/FrontPage, last accessed 2.12.2021.

Accordingly, impact pathways form the backbone for the design of the policy instrument mix and the possibility to trace the mission progress over time via appropriate indicators (see section 3.6). Taking up insights from the analysis of the underlying socio-technical system (such as identification of key actors, topics and sub-topics, etc.) (see section 3.2) and the clarification of the transformative understanding (relative role of STI as a driver for change) (see section 3.3), will support this iterative process of impact pathways formulation. The process ideally incorporates stakeholders and experts (e.g. through strategy workshops, making use of expert/scientific support and effectively involving the perspectives of stakeholders like exemplified above) for gathering topical expertise, verification and critical review, while enhancing the commitment to shared goals and reducing the risk of unintended consequences. It is important to note that impact pathways should be considered as a starting point, not an end point for discussion. As missions may evolve over time and require re-adjustments (Janssen et al. 2020; Lindner et al. 2021), the development of impact pathways should be seen as an open and dynamic process ("living document") that allows actors to react to internal and external shocks and changes, critically reflect the progress of missions and obtain clarity on the fit between changes and requirements.

3.4.1 Application

Impact pathways consist of linking inputs/activities with anticipated impacts via the description of immediate outputs of these activities and outcomes. Presenting pathways along these four elements with varying degrees of control of the mission owners provides a narrative on how changes are intended to occur. Figure 8 presents an example for a hypothetical impact pathway, illustrating the idea in greater detail. Focusing on research funding to address a health-related challenge, the pathway describes the idea to improve health outcomes by improved treatments that in turn are driven by targeted research funding. Mobilizing research funding dedicated to a specific topic (input) is assumed to stimulate research activities in this field. Both the decision about the inputs and the immediate outputs are considered to be under control of the mission owner. In contrast, the uptake of these insights leading to the development of novel therapies cannot be directly influenced by mission owners, as these depend on a wider set of factors. This is also the place where positive feedback loops may play an important role. Increasing research activities may facilitate additional research outside of the mission that in turn may inspire projects and activities being part of a mission. Finally, the development of new therapies as a possible outcome can contribute to the postulated goals – an improvement of health-related challenges. The development of better and more effective therapies can contribute to an overall higher treatment success and thereby, for example, reduce mortalities.

Figure 8: Pathway Example



Source: Own elaboration based on Griniece et al. (2020)

3.4.2 Stylized pathways as a starting point for impact pathway development

Impact pathways need to be developed on a case-by-case basis, taking into consideration the specific context of the underlying socio-technical system. However, despite the empirical diversity of missions, there is conceptual leverage that can be mobilized to support the process. Drawing on existing research and empirical insights from the scientific support action to the German High-Tech Strategy, this report suggests eleven stylized and generic pathways that can serve as the starting point for mission specific impact pathways tailored to the systemic context, specific challenges and constellations. Besides incorporating practical empirical knowledge acquired during the scientific support action, these inductively developed pathways draw on insights from different strands of research such as transition studies, technological innovation systems literature (e.g. Ghosh et al. 2021; Wesseling et al. 2020) and research projects crafting impact assessment concepts (Helman et al. 2020).

Table 4 describes the identified pathways, their structure from an I-O-O-I perspective, their main focus and the possible existence of feedback loops.

Table 4: Overview generic pathways

P1: Research for problem-solving	
Support for research activities aimed at addressing a specifically defined problem (e.g. cancer, obesity, etc.) by producing knowledge and new developments in a specific area. This newly generated knowledge contributes to solving existing problems through stimulating research activities. This pathway may be particularly combined with other science-oriented impact pathways (P3/P4) and includes the search for promising solutions/approaches. Funding is the major policy instrument category at work and may be as diverse as to specific projects, infrastructure/skills/education in certain areas relevant for problem solving.	
Targeted research funding → Increased research activity ↔ New discoveries/New knowledge → Problem-solving	
Main focus: science	Feedback loops: yes

P2: (Basic) Research for knowledge generation	
Support for research activities not directed at the solution of a clearly-defined problem. This can manifest itself either in a support for general research activities and infrastructures to improve the uptake capacity/productivity or fostering a specific technical solution without a specific goal (*solution in search of a problem*, cf. Wanzenböck et al. 2020). This new knowledge may form the foundation for a number of other pathways or accompany other activities.	
Undirected research funding → Increased research activity ↔ New discoveries → Generation of new knowledge	
Main focus: science	Feedback loops: yes

P3: Collective intelligence/positive effects through academic exchange	
This pathway focuses on the process of knowledge generation through the facilitation of exchange between different actors of the scientific community. Enabling the dissemination of knowledge and research insights, it aims to achieve favorable outcomes (e.g. accelerating the research process, improving the quality, more comprehensive picture etc.). Empirically, this may materialize in e.g. digital platforms, data repositories, open access policies, funding of transdisciplinarity, dissemination of research results, measures enhancing research mobility and collaboration or the creation of new epistemic communities	
Measures to facilitate academic exchange → Creation of favorable conditions for knowledge diffusion → Faster dissemination/diffusion of knowledge → Accelerating research outcomes	
Main focus: science	Feedback loops: no

P4: Changing the research process	
This pathway can be combined with P1-P3, altering the way research is carried out. Whereas P3 focuses on the dissemination of research results, this pathway focuses on the way scientific knowledge is generated within a scientific project or research routine. Strengthening/ modifying certain elements of the research process, this pathway aims to increase the quality/robustness of scientific results. Activities may, for example, be targeted at scientific procedures and funding schemes, a strengthening of citizen science and inclusive approaches, capacity and capability building of research/research performing organizations, fostering a participatory setting of a research agenda, modified peer-review procedures, strengthening of responsible research and innovation practices, inclusiveness (e.g. applying diversity tools).	
Incentives/Measures to alter research process → Modified way of doing research → New research culture → More solid/better knowledge generation	
Main focus: science	Feedback loops: no

P5: Market creation to promote a solution/approach	
This pathway aims at stimulating/promoting a certain solution or area by targeted funding or demand-side oriented innovation policy. By providing financial resources for a given solution and engaging with industrial/scientific stakeholders it seeks to incentivize and strengthen a certain solution. While the underlying logic is highly similar to P8, P5 does not emphasize system transformation, portraying the efforts as rather distributive, without necessarily aiming to alter the distribution of powers in the socio-technical system. The main impact is the induction of positive economic effects through strengthening a promising area/approach.	
Creating incentives for a certain solution/area → Increased output dynamics in this area ↔ Improved results ↔ Market creation	
Main focus: economy	Feedback loops: yes

P6: Improving framework conditions	
This pathway aims at the improvement of systemic features that are expected to unleash positive (economic) effects and facilitate the uptake of new solutions and dynamics. In contrast to P5, it focuses on systemic factors and the constraints, e.g. through infrastructure/capacity building that might hamper the process of incorporating new developments and ideas/innovation as an accelerator of economic growth through higher system capacity. The pathway resembles P2 for the area of science.	
Creating incentives for a certain solution/area → Increased output dynamics in this area ↔ Improved results ↔ Higher system capacity	
Main focus: economy	Feedback loops: yes

P7: Bringing knowledge to application	
This pathway is driven by a problem-oriented perspective aiming to accelerate the translation of scientific knowledge into practical use. Thereby, it seeks to overcome potential problems of translation processes and lacking incentives to bring developments into application (technological problem-solving). In the end, these translation efforts should result in an increase of the application of novel solutions contributing to positive economic effects or problem-solving. Results of this applied knowledge can materialize on a spectrum of incremental process enhancement to breakthrough research resulting in disruptive innovation.	
Offers for financing/better infrastructure/context etc. to support translation of knowledge into practical use → Translation of knowledge into practical use → Accelerating successful translations efforts → Economic effects/technological problem-solving	
Main focus: economy	Feedback loops: yes

P8: Market creation to change system structure	
Similar to P5, this pathway aims at promoting a specific solution/approach through targeted funding or demand-side oriented innovation policy. What sets it apart from P5 is the stronger focus on systemic components, thus not only promoting a new area/actors, but imposing a higher degree of directionality aimed at strengthening and thereby preferring a certain solution to others. Whereas the type of intervention is similar to P5 (financial incentives, public procurement, actor/resource mobilization and self-commitment), especially regulation may play a more pivotal role to support these changes. In many cases, such attempts are complemented with destabilization/exnovation activities (P9). The main goal, besides the direct impacts of supporting a certain solution/approach, is the reconfiguration of a system.	
Creating incentives for a certain solution/area → Increased output dynamics in this area ↔ Strengthening of the area/solution → Changing systemic features of the socio-technical system	
Main focus: systemic	Feedback loops: yes

P9: Regime destabilization/Exnovation	
This pathway is often closely linked with P8 focusing on changing the architecture of an existing system. Whereas P8 focuses on promoting/incentivizing certain solutions/actors/approaches, P9 constitutes the complementary efforts to this by deliberately seeking to challenge existing constellations. Thereby it rests on the identification of a certain solution as inappropriate/harmful for goal achievement and strives for the destabilization of the status quo. Thus, it seeks to de-incentivize actors to rely on the solution, indirectly supporting other measures either through incentives or regulations. Moreover, this pathway may contain attempts of weakening/compensating actors to reduce potential opposition to transformative changes.	
De-incentivizing measures for a given solution or routine → decreased attractiveness of a solution or routine ↔ strengthened position of new solution/actor → changing actor constellation and stabilizing different routines	
Main focus: systemic	Feedback loops: yes

P10: Awareness building and changing public perception	
In this pathway a creation of societal debate and awareness building serves as a means to achieve a desirable outcome by affecting public awareness. This changed awareness can serve as a prerequisite for the success of other measures (e.g. by promoting certain solutions or types of societal behavior) or serve to legitimize certain activities. Policy instruments may for example include awareness building campaigns, the provision of scientific knowledge to support public discourse or the stimulation of public debate/deliberation through different fora/exchange formats etc.	
Information provision/stimulus for exchange and discussion → Outreach of activities ↔ increased societal debate → ↔ Changing perceptions	
Main focus: systemic	Feedback loops: yes

P11: Changing practices and behavior	
This pathway is often closely linked with P10 as a prerequisite, focusing on altering human behavior and existing practices through the creation of incentives or information. The stimulus can be based both on an increasing awareness for certain topics or the provision of incentives that result in an adjustment of behavior, thereby enabling a change of systemic practices. Possible stimuli in this context are approaches to engage the public, to enable social innovation and the facilitation of societal debates.	
Creating incentives for a certain behavior/Creating awareness for relevance of topic → Outreach of activities → reaction to incentives → change of individual behavior and system practices	
Main focus: systemic	Feedback loops: yes

Source: Own elaboration

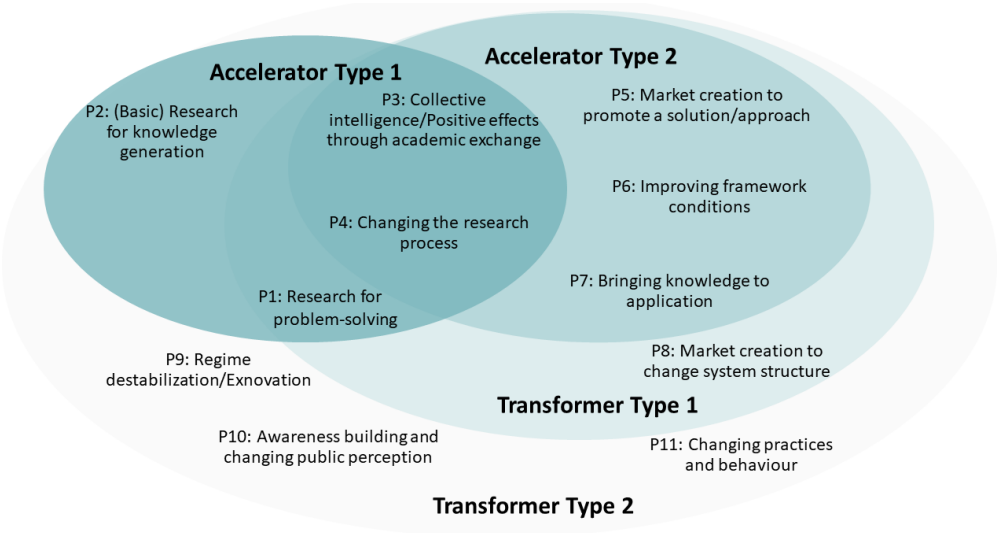
3.4.3 From impact pathways to bundles of pathways

Most missions will consist of a combination of different pathways, contributing jointly to the overarching societal goal to be achieved. For this purpose the phase of mission design does not only include the identification of appropriate impact pathways but also their alignment in order to maximize the synergies and their interplay, while reducing potential

contradictions and tensions. In sum, missions require the development of coordinated and well-aligned bundles of impact pathways. Taking the typology for different types of missions as a point of reference (see section 3.3), the toolbox proposes bundles of impact pathways for different types of missions and their specific requirements. Much alike the generic pathways, these bundles are only to be considered as a starting point to tailor the actual impact pathways and their combinations to the specific context. This grouping of impact pathways can support mission owners for cross-checking their own pathways and detecting potential blind spots that may require adjustments and ensure an alignment between the transformative understanding and the assumed pathways to achieve these. However, these bundles are not to be treated as blueprints or prescribe certain pathway combinations. Missions in reality often combine features of different mission types, and context conditions may impose additional constraints or facilitating factors for the realization of missions. Therefore, a mission, even though it is classified as an accelerator type, may, for example, require pathways at a more systemic level, when for example also aiming for behavioral changes.

Figure 9 illustrates the stylized bundles in the form of a Venn-Diagram. While impact pathways in general are compatible with many different approaches to MOIP (like P3-P7), some pathways are rather constrained to some mission types due to their more specific targets. Particularly those impact pathways targeting a systemic level (P9-P11) are particularly relevant for transformer (type 2) missions. Not surprisingly, missions with a broad and comprehensive understanding for transformation are likely to rely on a broader set of pathways that touches upon different spheres needed to transform (science, economy, society).

Figure 9: Bundles of pathways



Source: Own elaboration

3.5 Instrument portfolio

The essence of policy making is the application and implementation of specific policy instruments to initiate change. There are different types of policy instruments, which can be grouped into three broad categories: distribution/financing, regulation/systemic management and information (Hufnagl 2010). The compilation of a policy instrument portfolio (inventory) is a meaningful source of practical knowledge to support policy-making in the context of MOIP. The main aim is to capture all policy instruments that are part a specific mission. Such a portfolio provides a means to distinguish instruments that are deliberately included in the policy mix of a mission from those instruments that are not considered to be included. From this perspective, two approaches for the identification of policy mixes described by Ossenbrink et al. (2019) can be combined in a fruitful way: While system mapping (see section 3.2) may serve as bottom-up approach to identify thematically related instruments, the development of an inventory follows a top-down logic of strategic intent.

Based on the abovementioned distinction between distribution, regulation and information, the following sub-categories systematizing policy instruments have been introduced (Hufnagl 2010) and already applied in Wittmann et al. (2021c, p. 8):

> *"Building on the distinction between distribution, regulation and information by Hufnagl (2010), we rely on the following sub-categories to systematize policy instruments. Among distribution we follow the distinction between direct and indirect (subsidies, tax reductions, allowances) distribution with different sub-types. For direct distribution we distinguish between institutional support (financing of existing or new organizations/research institutes/etc.) and project support (financing targeted towards thematically oriented activities and projects, including early financing). Among the category of regulation, Hufnagl subsumes two main types of instruments: systemic management (support for strategic alliances, clusters and cooperation networks), regulatory measures (adjustment of laws, regulations, and rules). Finally, informational instruments can be grouped into transfer of knowledge (awareness raising for a topic through publications, events or other forms of coverage), policy expertise (support for decision-making such as foresight activities, technology assessment, evaluations, benchmarking, audits etc.), and discursive instruments (creation of fora for discussion, advice and exchange)."*

These categories form the bases for further investigating the policy instruments of each mission within the inventory. This toolbox element allows for necessary contributions and feedback loops during all phases of the mission (translation) processes, even though the

obvious utilization phase falls into the phase of mission design. In this context, the compilation of the inventory is ideally an integral part of a general strategically informed mission specific (negotiation) process at the outset, which is more than an editorial agreement on mission content, but closely linked to the joint definition and description of the explicit mission goals and the intended impact pathways among mission owners. Both – goals and pathways – ideally emerge from a participatory, inclusive and interdepartmental exchange, which includes concrete consultations and discussions on the potential benefits and fit for purpose of each policy instrument that already is or should become part of the policy instrument mix for achieving the mission goals.

The following key insights of the inventory are likely to support mission orientation, but can only develop their potential in combination with other toolbox elements (see sections 3.3 and 3.4):

- The inventory provides descriptive indications of the mode of operation of single policy instruments and can help to understand their contribution (to the outlined mission goals and impact pathways):
  - How does the policy instrument work: distribute, regulate, nudge, educate etc.?
  - Whom does it target?
  - How much budget is allocated?
  - Which time period is covered?
- The inventory also allows for tentative signs in case the policy instruments relate to each other: do policy instruments "work in combination", are they part of a specific strategy or thematic program besides the specific mission? Is there a balanced policy instrument mix?
- It can help to uncover which mission goals may not be addressed by policy instruments at all, pointing out gaps in targeting certain important areas or actors. The inventory therefore can support mission design and the monitoring of activities as an input/analytical tool for guiding the choice and combination of inputs.
- Understanding the context and interrelationship of policy instruments as well as the chronology of implementation (e.g., to detect policy-layering or policy refurbishing) might help to identify meaningful process indicators (e.g., differences between existing and newly created policy instruments) and furthermore indicate which policy instruments are subject to a mission specific impact assessment.

Table 5: Template for inventory of policy instruments

Overarching category	Category	Description/further details
Policy Instrument name	Name of the overarching program family	If applicable, for policy instruments that are part of larger program/strategy
	Name of policy instrument	As indicated in the key strategy document of the specific mission
Link to pathways	Association with mission pathways	Indication whether policy instrument is relevant for a certain pathway
Characteristics of policy instrument	Type of activity	Classification of the policy instrument building on to Hufnagl (2010) that distinguishes three main types of instruments (distribution, regulation, information) with several subtypes.
	Actor responsible for policy instrument	Name of actor/unit in charge of implementation/execution of policy instrument
	Duration/temporal dimension	Start and end date of the policy instrument
	Budget	In million EUR, where applicable
	Target group	Short description of main target group (e.g. research, SMEs, civil societies, municipalities, etc.) of the policy instrument
	Thematic priority	Reference to relevant topics possibly identified during system mapping, as policy instruments may address a certain topic more broadly or only cover certain facets of it
	Focus of the policy instrument	Description of the main goal and priorities of the policy instrument

Source: Wittmann et al. (2021c)

Since compiling and keeping track of the relevant information for each policy instrument is time-consuming and research-intensive, a central actor or office with mission responsibility (ministry department or project executing agency) should be appointed collecting all available information on the mission instruments at the beginning of a mission and provide regular updates. As an inventory can only "take stock" at a certain point in time, such regular updates take into account that missions may develop and change over time (Janssen et al. 2020, p. 10) and further instruments may be added at a later phase. This approach increases both the transparency regarding the existence of individual policy instruments by a systematic documentation as well as helps monitoring – and at best keeping a controlled overview – the progress of policy implementation as a support for mission management.

As the aim of the inventory is the documentation of main features and categories of policy instruments, the collection can be gathered in an excel spreadsheet or any other straightforward list.

3.6 Indicators for mission monitoring

Drawing on the stylized impact pathways presented above, this section focuses on monitoring the progress of missions along these pathways. This toolbox element therefore fulfills a hybrid function, combining internal and external purposes. On the one hand, it aims to provide the foundation for mission owners to track the progress of missions and, where necessary, take steps to bring missions "back on track". On the other hand, monitoring mission progress does not only serve as a tool for mission management but also is the backbone of linking mission activities to the anticipated impacts, thus, providing the foundation for reporting and justifying mission activities and their success. Similar to previous toolbox elements, stakeholders can play an important role in this step, bringing in their expertise and capacity for developing appropriate indicator and gathering/providing the relevant data.

While the stylized impact pathways provide a point of orientation for indicator development, the diverse fields that are likely to be addressed via MOIP make it difficult to develop generalized indicators that are both sufficiently specific and yet abstract enough to serve as a point of reference. However, to support the process of indicator development that is closely bound to the specific case, the impact pathways, and its context in this section, we propose an intermediary step by providing a more detailed description of the pathways and possible foci for analysis. However, it should be noted that the aspects presented in table 6 only provide an overview of possible stylized dimensions. Depending on the specific pathways it might be necessary to add additional dimensions, or remove some of the aforementioned, before turning to the development of appropriate indicators.

Table 6: Possible dimensions for indicator development along stylized impact pathways

Pathway	Input	Output	Outcome	Impact
P1: Research for problem-solving	Targeted research funding • for research projects • for applied scientific instruments/infrastructures • for scientific staff, PhDs, Post-Docs • for companies using research facilities • for problem-oriented research infrastructure	Increased research activity • Increased number of research projects and problem-related activities • Researchers working in an area • Scientific outputs (publications, patents, doctoral students) • Creation of new research infrastructure and collaborative platforms	New discoveries/new knowledge • Uptake of research results (citations, patents) • Re-Use of (open) data • Growth of problem-related topics/areas in research	Scientific contributions to problem-solving • Development of new technologies, therapies, solutions, etc.
P2: (Basic) Research for knowledge generation	Undirected research funding • Support for existing research infrastructures • Creation of new research centers • For scientific staff, PhDs, Post-Docs	Increased research activity • Number of research projects and problem-related activities • Researchers working in an area • Scientific outputs (publications, patents, doctoral students) • Creation of new research infrastructure and collaborative platforms	New discoveries/ new knowledge • Uptake of research results (citations, patents) • Re-Use of (open) data • Re-use of insights in other fields/disciplines • Increased capability of research/innovation system	Generation of new knowledge • Improved understanding of systemic relationships • New approaches and methods • Scientific breakthroughs

Pathway	Input	Output	Outcome	Impact
P3: Collective intelligence/ Positive effects through academic exchange	Measures facilitating academic exchange • Support for fora/networks for exchange • Support for cross-/interdisciplinary activities • Support for open access/data repositories • Support for researcher mobility and collaboration • Incentive schemes for scientific cooperation	Creation of favorable conditions for knowledge diffusion • Productive interactions between researchers, disciplines, etc. • New repositories, platforms, etc. • Researcher mobility • New scientific cooperations	Faster dissemination/diffusion of knowledge • Co-publications and joint-projects • Interdisciplinarity of projects/publications • Research using open data /open access	Improved and accelerated research results • Multi-perspective research • Increased scientific productivity • Increased flow of information between different communities
P4: Changing the research process	Incentives/Measures to alter research process • Awareness raising for topics • Modification of incentives structures (application procedures, requirements etc.) • Dedicated support for key groups or approaches (e.g. citizen science) • Self-declarations and self-commitments	Modified way of doing research • Composition of advisory boards/ monitoring bodies • Projects following certain principles/requirements (e.g. RRI) • Funding schemes setting out specific principles/requirements	Improved results • Publication, citation, patenting patterns (of underrepresented groups) • Career paths of researchers • Patterns of co-publication, citation, diversity and multi-disciplinarity	More solid/better/differentiated knowledge generation • Robust results through multiperspectivity • Embedding science into society • More inclusive research

Pathway	Input	Output	Outcome	Impact
P5: Market creation to promote a solution/ approach	Creating incentives for a certain solution/area • Subsidies and financial support • Public procurement • Supporting science-industry co-operation	Increased output dynamics in this area • Improved production capacities/ volume • Recipients of support • Contracts, number and volume of collaborations with industry	Improved results • Offered solutions on the market • Awareness among potential clients • Decrease of production costs • Reaching "tipping point" of profitability	Market creation • Emergence of a new market for solutions/approaches/Growth rates • Generation of sufficient demand to ensure sustainability of solution
P6: Improving framework conditions	Efforts to create better framework conditions by: • Addressing potential legal obstacles (regulations, etc.) • Capacity-enhancing measures • Incentives for knowledge exchange and collaboration	Changed conditions: • New/improved infrastructures • Reduced burden on activities • Productive interactions • Increased capacities (resources, personnel, etc.)	Improved systemic conditions • Higher productivity of relevant subsystem • Increased speed of up-take of new insights/impulses • Broadening the range of activities	Higher system capacity • Capable (innovation) system
P7: Bringing knowledge to application	Support aimed at improving application of knowledge • Investments in infrastructures for knowledge transfer • Support for applied research activities • Exchange fora between science and industry • Support for science-industry co-operation	Translation of knowledge into practical use • Spin-offs • Co-patents of industry/science • Industry-Science collaborations • Intermediaries between science and industry	Accelerating successful translations efforts • Products entering markets • Sustainable industry-science collaborations and networks	Technological problem-solving • Shorter time periods between scientific discovery and market introduction • Overcoming science-industry gap/"valley of death"

Pathway	Input	Output	Outcome	Impact
P8: Market creation to change system structure	Creating incentives for a certain solution/area • Subsidies and financial support (incl. public procurement) • Regulatory changes, norms and standards • Political support/signaling for future • Creation of networks • Investments into infrastructure relevant for solution	Increased output dynamics in this area • Projects/activities supported by funding • Infrastructure units installed • Units ordered by public procurement	Strengthening of the area/solution • Decrease of unit costs/Reaching "tipping point" of profitability • Emergence of new companies/producers/etc. • Public awareness for new solution • Re-allocation of resources to new area	Changed system • Market share of solution • Growth rate of solution/area • Substitution behavior of clients/customers
P9: Regime destabilization & exnovation	Efforts to destabilize existing regimes • Regulatory/fiscal instruments • Adjustment of norms and standards • Modification of eligibility/application criteria • Political statements and signals	Decreased attractiveness of solution • Altering costs of to-be out-phased solutions • Limiting access to solution • Adjustment of advisory boards/project councils etc.	Pressures on existing structures • Increased competitiveness of alternative solutions • Reconfiguration of networks • Decreasing support/availability of certain solutions • Reconfiguration of value chains through replacement/substitution	Changing constellation • Decreasing market share/relevance of problematic solution

Pathway	Input	Output	Outcome	Impact
P10: Awareness building and changing public perception	Information provision • Articles/publications with scientific expertise • Information campaigns/activities • Public statements, strategies, and speeches relating to a certain topic • Creation of fora for societal debate	Outreach of activities • Readers/audience of relevant news/information/campaign • Participants in events and campaigns	Increased societal debate • Uptake of statements in press • Retweets/shared content • Changes in public discourse • References to statements and arguments in public debates • Changing role of topic in public debate/party manifestos/etc.	Changing perception • Changing societal perception on salience and/or issue
P11: Changing practices and behavior	Creating incentives/awareness • Instruments creating incentives for behavior • Instruments imposing costs on certain behaviors • Awareness-raising instruments • Labels/certifications/standards • Public statements and official declarations	Outreach of activities • Users reached by activities • Scope of policy instruments • Direct subsidies/costs imposed • Provision of message in favor/opposition to certain practices	Reaction to incentives • Changes in market (offers, pricing) • Users reacting to incentives/programs/etc. • Emergence of new solutions/initiatives at societal level • Awareness of customers for labels/standards/norms	Change of individual behavior and system practices • Changes in consumption patterns • Change in behavior/practices • Change of societal norms and standards

Source: Own elaboration

3.7 Analysis of translation processes

The final element of the toolbox consists of a catalogue of analytical questions that cuts cross the translation processes of MOIP and the previously described process supporting toolbox elements. The analytical questions provide a comprehensive and interconnected perspective on the translation processes, conceptualized as "filters" for the subsequent stages. In effect, they provide insights in the framework conditions in which the expected impacts are intended materialize, revealing potentially supporting and hindering factors. This perspective does not only incorporate the organizational/institutional context but also sheds light on the systemic level and the implications of missions that reach beyond individual pathways and affect different impact dimensions (cf. also Magro et al. 2013). At the same time, the foci postulated in this analysis can also provide guidance for the implementation of missions, pointing to pivotal aspects during the different translation processes.

The analytical questions were developed based on insights of the scientific support action of the High-Tech Strategy 2025 (Wittmann et al. 2020; Wittmann et al. 2021c) as well as related literature (Hüsing et al. 2017; Wesseling et al. 2020) focusing on key junctures that were identified as crucial for the development of missions. The list of analytical questions in this regard provides an orientation for the analysis without claiming that it is an exhaustive list covering all potentially relevant questions. In consequence, depending on the context it may be necessary to add additional questions emerging during the implementation process or leave out questions that are not considered as relevant for a certain mission. Table 7 provides an overview of the analytical questions.

The analytical questions are grouped into different analytical dimensions along the three translation processes. This approach has two main advantages. Firstly, it allows to derive thematic clusters of related question that can be jointly applied to assess the strengths and weaknesses of a mission in this area and communicate the findings to mission owners. However, there is no obvious rule how to aggregate the insights from different related analytical questions. In some cases, problems detected by a single question might be considered as a serious constraint, whereas in others this might not affect the mission at all (e.g., because priorities are different or it mainly is relevant in a given context). Secondly, it allows to cover a wider range of questions, potentially including questions with a more open or formative character.

The process of analysis should be carried out by an external evaluator, accompanying the mission. For the purpose of discussing the analytical questions, it will be necessary to both draw on other toolbox elements supporting the mission process in general as well as a wider set of sources, such as strategic/program documents, interviews with

stakeholders, expert assessments, (external) program evaluations, public opinion data etc. (see table 7 for an overview). The analysis of the first two translation processes (mission formulation, mission design) should be considered as ex-ante approaches that generate insights in the mission process that may provide feedback to refine the mission goals and its design. At the same time, the combination of the assessment of the three translation processes with the indicator-based monitoring of the impact pathways allows to derive more general statements about potential impacts of the mission.

Table 7: Dimensions and analytical questions

Transl. proc.	Key elem.	Analytical dimension	Sources
Mission formulation	Mission goals formulation	Definition of scope of the mission • Does the mission formulate a clear vision/desirable state to be achieved? • Is the mission explicit in the areas it strives for change/solutions? • Does the mission explicitly exclude topics or policy fields? • Does the mission contain a justification for its priorities? • Are mission goals connected to a specific technology? • Is the geographical scope of the mission clearly defined?	Analysis of key strategic documents
		Definition and operationalization of goals • Does the mission have explicitly formulated goals? • Does the mission include quantitative indicators corresponding to the mission goals? • Are mission goals measured on nominal, ordinal, interval or relational scales? • Does the mission specify data types or sources to be used for measuring goal achievement? • Do mission goals explicitly define complex constructs that are linked to goal (e.g. quality of life/happiness etc.)? • Does the mission define a clear baseline/ measurement of the status quo for the intended changes? • Are mission goals defined in terms of international comparisons or rankings (e.g. become global market leader in a specific field)? • Is a clear time horizon defined for the achievement of mission goals? • Does the mission include interim goals or milestones? • Do the goals include flexible elements, e.g. if/when context conditions change throughout the mission? • Is there a defined process for the adjustment of goals throughout the mission?	Analysis of key strategic documents

Transl. proc.	Key elem.	Analytical dimension	Sources
		Relationship between different goals • Does the mission define more than one goal? • Is the prioritization of goals clearly defined? • Does the mission define if/how one mission goal contributes to other goals? • Are postulated goals coherent/non-contradictory or is there a possible tension between goals?	Analysis of key strategic documents
	Legitimacy, urgency, and process of mission formulation	Legitimacy of goals • Does the mission name a specific societal problem it seeks to address? • To what extent is there a societal consensus about the importance of the underlying problem (cf. Wanzenböck et al. 2020)? • Is there a societal consensus on the urgency of the problem? • Do the problems the mission aims to address rank high on the political agenda?	Expert assessments, public opinion survey, analysis of party manifestos
		Level of ambition • Are mission goals realistic? Are goals also realistic if context conditions change? • Do goals go beyond existing trends or even push for radical change? • Do mission goals appear ambitious compared to similar missions in other countries? • Does the mission aim for altering the functioning of the system, i.e. is it transformative? • Is the realization of mission goals linked to best-case expectations?	Expert assessment
		Embedding/Inclusiveness in political and administrative context • Is a single mission owner or group of mission owners clearly defined? • Can the main mission owner(s) credibly claim capacity/mandate for change (through activities or bringing together relevant actors)? • Are all relevant political actors and administrative units involved in the mission formulation process? • How intense is the collaboration during the mission formulation process? • What role does the main mission owner play (cf. Borrás et al. 2020) for driving change? • How much attention and support does the mission receive at higher political levels? • Is the initiator of the mission also responsible for managing the mission?	Analysis of key strategic documents, expert assessments, interview with stakeholders, participatory observation, insights from system analysis

Transl. proc.	Key elem.	Analytical dimension	Sources
		• Does the mission refer to existing policies or is overlapping/duplicating structures at the national level? • Does the mission describe how to create synergies based on existing policies? • Is it clear what the added value of the mission is, compared to existing policies? • Does the mission explicitly refer to goals of international strategies? • Do the mission goals appear to be in line with international strategies (SDGs, etc.)? • Are mission goals aligned with initiatives of supra-national organizations (e.g. EU)?	
		Suitability to enhance mobilization and legitimacy among stake-holders (actors representing society, science, industry) • Are relevant stakeholders (actively) involved in the mission formulation process? • Which stakeholders are involved in the process of mission formulation? • How are stakeholders identified and selected? • Are key stakeholders missing? • How does the formulation process deal with possible resistance from key actors/veto players? • Did mission owners reach a mutual understanding of mission goals? • What are drivers for stakeholders to participate? • Are stakeholders incentivized to participate in the mission formulation process? • Are topical expertise, insights from foresight, or perspectives of stakeholders integrated into the process of mission formulation? • Does the involvement of stakeholders include the development of a shared vision? • Do stakeholders (formally) commit to the goals formulated? • Is the strategic process of mission formulation designed and equipped with sufficient resources (personnel, financial, temporal)?	Expert assessment, insights from system analysis, interviews with stakeholders, analysis of program documents/ reports, participatory observation

Transl. proc.	Key elem.	Analytical dimension	Sources
Mission design	Appropriateness of Impact pathways	Process of pathway development • Do mission documents (or later provided documents) describe the links between instruments and goals? • Who leads the process of impact pathway development? • To what extent is the development of impact pathways supported by stakeholders or external expertise? • What resources are available for the development process?	Analysis of key strategic documents, stakeholder interviews, participatory observation, impact pathways
		Fit between pathways and postulated goals • Are all mission goals addressed by pathways? • What approach do pathways suggest for achieving the postulated goals? • Do goals match with underlying understanding for transformative change?	Analysis of key strategic documents, impact pathways
		Consistency of pathways • Which obstacles need to be overcome to successfully realize the pathways? • Are pathways appropriate to achieve the desired goals? • Do pathways aim at second order effects/ cascading effects?	Expert assessment, insights from system analysis
		Coherence of pathways • Do several impact pathways relate to a shared goal? • Are there any contradictions/tensions or conflicts arising between pathways?	Expert assessment, Analysis of key strategic documents, impact pathways
	Instrument mix	Fit between pathways (intended impact) and instruments • Are all impact pathways addressed with instruments/activities? • Are pathways highly dependent on one or few dedicated instruments? • How specific is the alignment of instruments with pathways?	Expert assessment, inventory, Average Instrument Diversity (Fernández-i-Marín et al. 2021)

Transl. proc.	Key elem.	Analytical dimension	Sources
		Character of policy instruments • What are the main characteristics of the instrument mix applied in the mission (combination of regulation, distribution/incentives, information)? • Are relevant target groups addressed by the instruments? • Does the policy instrument mix for individual pathways show gaps or does only address parts of them? • Do the mission instruments focus on research output and scientific knowledge production? • Do the mission instruments focus on fostering transfer (research to application) and/or adjustment of regulatory frameworks? • Do the mission instruments focus on reconfiguring an existing system (e.g. by facilitation of new solutions; building new networks)? • Do the mission instruments aim for behavioral change?	Inventory, expert assessment
		• Do the mission instruments focus on exnovation/regime destabilization/phase out? Are there compensation mechanisms or incentives for potential losers/actors resisting the anticipated changes? • Does the policy instrument mix fit the corresponding pathway? • Does the instrument mix entail room for experimentation (policy experiments, real labs, etc.)? Are there any plans for institutionalizing successful instruments (e.g. pilot projects)?	
		Leverage of policy instruments • What leverage do these instruments possess in the relevant socio-technical system (size, scope, centrality)? • To what extent does the instrument create synergies with other policies in the field (beyond the mission)? • Can the suggested instruments plausibly contribute to a change	Expert assessment, insights from system analysis

Transl. proc.	Key elem.	Analytical dimension	Sources
		Process of instrument mix development and commitment by authorities and other actors • What actors are mobilized to participate in the mission? • Does the mission mobilize the relevant key stakeholders in the field? • Which actors are involved in developing the instrument mix? • How are instruments identified and selected for the mission? How was the process implemented? • What actors are responsible for instruments of the mission? • Were all ministries/public actors active in the field involved in this process? • What share of resources is provided by non-public actors that are relevant in the field? • Are there incentives for stakeholders to contribute to the mission? To what extent is their contribution formalized? • Is there a dedicated mission budget? • Is there a formal commitment of actors to provide resources? How precisely is this defined? • Does the commitment include the necessity to adjust/modify existing instruments/activities? • How is their implementation coordinated between different actors? • Are the instruments designed specifically for the purpose of the mission or how are existing measures aligned? How are new instruments developed? • What resources are available for mission design?	Interview with stakeholders, insights from system analysis, analysis of program/strategic documents
		Coordination of policy mix & governance structure • What kinds of coordination arrangements are created for the mission? • What are their competencies? Who is member of them? • How regularly are those planned to convene? • How is the implementation of instruments coordinated between different actors? • Are there any pre-defined approaches for mission monitoring, evaluation and learning? How are these to be achieved?	Program documents, interviews with stakeholders

Transl. proc.	Key elem.	Analytical dimension	Sources
Mission implementation	Contribution of key instruments (program evaluation)	Characteristics of key policies • What are key policy instruments of the mission that are crucial for the success of the mission? To which pathways do they contribute? • Was the instrument implemented on time? • Did the financial volume of the instrument change? • Did the policy instruments experience changes in thematic priorities, application regulations etc.? • Was the program evaluated?	Inventory, pathways, expert assessment,
		Effectiveness of instruments and activities • Did the implemented policy instruments have their intended effects? • Is the instruments implemented in line with the described goals?	External evaluations, program evaluation
		Efficiency • Was the implementation achieved at reasonable efforts/costs?	Program evaluation
		Unintended consequences • Did the instrument lead to unintended and undesirable side-effects or secondary effects? • Did the instruments lead to unintended but desirable side-effects or secondary effects? • To what extent did learning take place during the implementation process?	Program evaluation
	Mission management	Coordination of policy mix & governance structures • What are their competencies and routines (members, main tasks, budget)? • Were there additional coordinative bodies created after mission initiation? • How regularly do governing/steering bodies of the missions meet? • Are stakeholders involved in mission governance, e.g. by creation of an advisory board? How are they involved and what are there competencies?	Program/strategic documents, stakeholder interviews
		Robustness of implementation • Were the policy instruments implemented as planned? • Which policy instruments were stopped or delayed?	Inventory, stakeholder interviews

Transl. proc.	Key elem.	Analytical dimension	Sources
		Flexibility of instruments and pathways • Were policy instruments adjusted? For which reasons? • Were there any developments/events that would have made a modification of the impact pathways necessary? • Were instruments able to adapt to exogenous shocks, changing contexts etc.? • How fast were instruments adapted? • Were adaptive measures successful in overcoming obstacles? • Is there a regular/scheduled review of the instrument mix and appropriateness of the pathways?	Stakeholder interviews, expert assessment
		Responsiveness of mission management • How is information (e.g. foresight, evaluations of individual instruments) exchanged within the mission? • When obstacles or challenges occurred during mission implementation, were the governing/steering bodies able to find and agree on suitable instruments? • How is the mission progress communicated within the authorities/administration? • What resources and capacities are available for the coordination of the mission?	Stakeholder interviews, expert assessment, program/strategic documents, participatory observation
		Spill-over effects and mobilization of additional actors • Does the mission mobilize additional activities/spill-overs for actors that are not part of the mission? • Does the implementation of the mission contribute to a changing understanding of the underlying problem and its possible solutions for a) the involved actors and b) the general public?	Expert assessment, stakeholder interviews (beyond mission), system analysis public opinion survey
		Monitoring structures • Is there a defined process for assessing the progress of the policy instruments of the mission? • How regularly is the progress of the instruments assessed? • Are there defined standards for the reports on instrument progress? • Is there a clear responsible actor to manage the monitoring process? • Is there a sufficient budget foreseen for monitoring and evaluation?	Program/strategic documents, stakeholder interviews

Transl. proc.	Key elem.	Analytical dimension	Sources
		Transparency • Is the progress of the mission regularly discussed at the level of political decision-makers? • Is the progress of the instruments part of the mission regularly discussed with stakeholders? • Are reports on instrument progress regularly communicated to the general public? • Is there a unified communication strategy/shared label/website/etc. or does each partner communicate independently? • How can the outreach of mission activities be assessed?	Program/strategic documents, stakeholder interviews, expert assessment
		Feedback & learning • Does the monitoring feed into the adjustment of instruments? • Are there processes for collecting experiences/good practices made during mission implementation? • Are there structures for institutional knowledge management? • Is there a process to inform and improve future policies?	Program/strategic documents, stakeholder interviews, expert assessment, participatory observation

Source: own elaboration

4 Case study: The mission on combating cancer of the High-Tech Strategy 2025

The section applies the previously developed framework to an empirical example of the German High-Tech Strategy 2025, the mission on combating cancer. The purpose of this case study is to illustrate the application of the often abstract toolbox elements in practice and highlight the insights that can be derived from its usage. This section extensively draws on insights of earlier works of the scientific support action, and in particular from the empirical analysis of the different missions (Wittmann et al. 2020; Wittmann et al. 2021c), summarizing and re-considering its results against the background of the developed framework. However, this section does not provide a full application of the framework, in particular it does not provide empirical evidence on outcomes and impacts of the mission and implementation processes. Due to the short time horizon of the scientific support action it was not possible to trace the progress of the mission at this point in time. Moreover, the analysis of translation processes restricts itself to the first two stages (mission formulation, mission design) and faces the limitation that some of the toolbox elements were developed retrospectively by the team of the scientific support action. In the following, a brief overview of the mission on combating cancer is provided as an introduction for the application of the toolbox approach. In the final sub-section, the insights and results are discussed.

4.1 The mission on combating cancer in the German High-Tech Strategy 2025

The mission on combating cancer is one of the twelve dedicated missions that were formulated in the German High-Tech Strategy 2025. Together with the mission on intelligent medicine it is a mission focusing on societal challenges in the field of health and care that draw on a long-standing tradition of health-related topics in earlier editions of the High-Tech Strategy (BMBF 2006, 2010, 2014). The core initiative of the mission is the National Decade against Cancer (NDK) (BMBF 2018, p. 17; Wittmann et al. 2020). The NDK is led by the BMBF and brings together stakeholders from different spheres, including public administration, (medical) professional organizations, representatives from industry, patient organizations and foundations (see table 8). Moreover, beyond the partners of the mission, there is a wider network of supporters of the NDK.

Table 8: Partners of the NDK

Type	Organization
Public	• Federal Ministry of Research and Education, BMBF (lead) • Federal Ministry of Health, BMG • Federal institute for drugs and medical devices (BfArM) • Ministry of Education, Science and Culture of Schleswig-Holstein (representing the German Länder)
Medical associations & research institutions	• Professional organization for physicians specialized in Hematology and Oncology, BNHO • German Society of Hematology and Oncology, DGHO • German Cancer Research Center, DKFZ
Other associations and organizations	• Cluster for individualized immune intervention, Ci3 • German medical faculty association, Dt. Hochschulmedizin e.V. • German Cancer Society, DKG • National Association of Statutory Health Insurance Funds
Foundations	• German Cancer Aid, Dt. Krebshilfe, Felix Burda Foundation
Patient organizations	• House of Cancer Self-Help- Federal Association[8] • Patvocates GmbH
Private enterprise	• Roche Pharma AG

Source: Wittmann et al. (2020)

4.2 Application of the toolbox approach

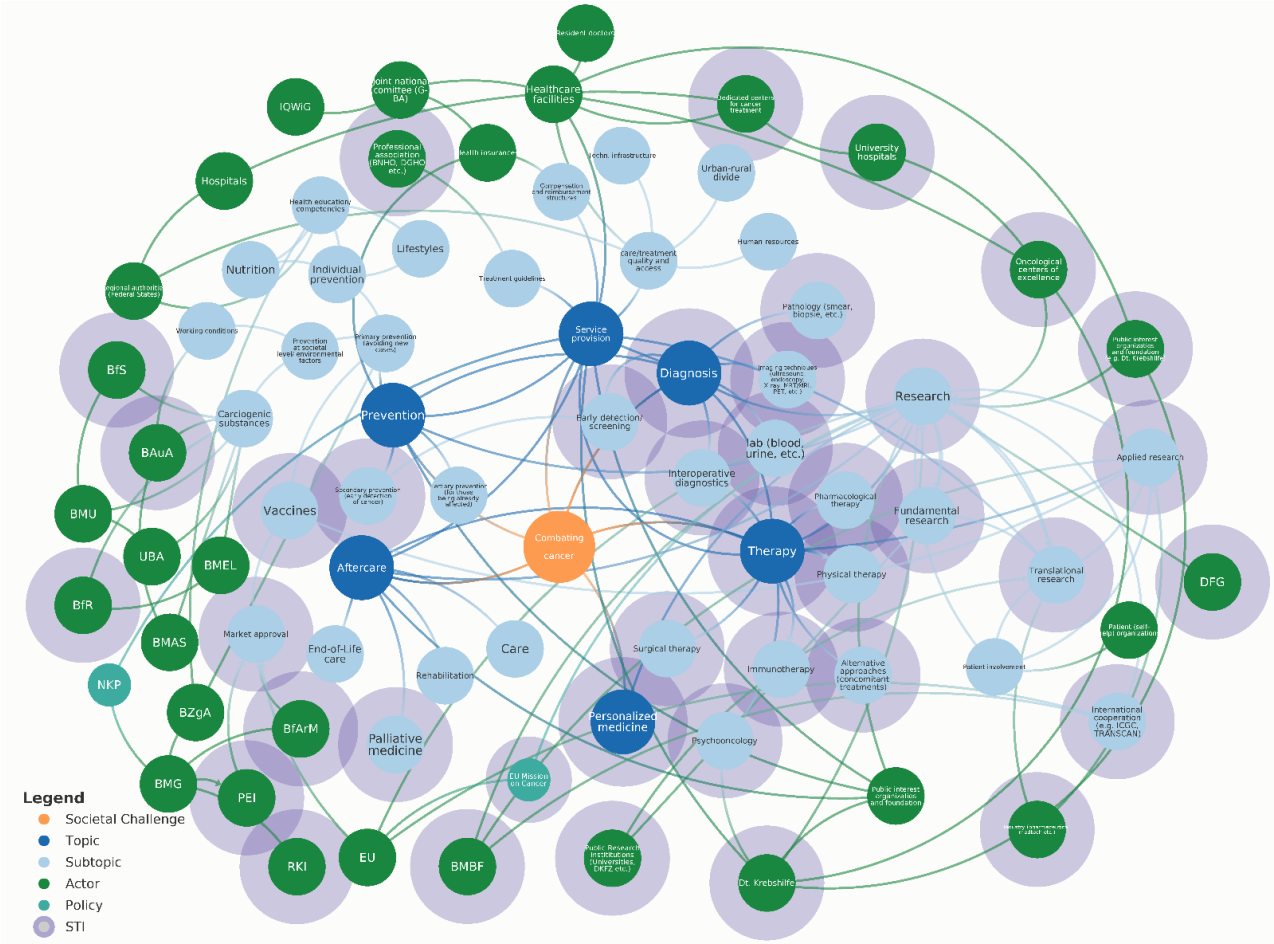
The following section uses the case of the mission on combating cancer to explore the applicability to different toolbox elements. As the ex-ante approach in many instances would have required an implementation of most of the toolbox elements in parallel with the mission, in several cases the analysis must rely on ex-post developed elements by the team of the scientific support action. While limiting the formative character, this approach allows to explore to what extent the proposed toolbox elements may provide added value to the study of missions.

8 Initially the member list of the NDK included the Bundesarbeitsgemeinschaft Selbsthilfe von Menschen mit Behinderung und chronischer Erkrankung und ihren Angehörigen e.V. (BAG SELBSTHILFE).

4.2.1 Analysis of the socio-technical system

An expert workshop with representatives from Fraunhofer ISI developed a topic-oriented map that is presented in figure 10. It identified four main topics with numerous sub-aspects of the socio-technical system that can be considered as relevant: prevention, diagnosis/early detection, treatment, and aftercare. Additionally the system is characterized by two cross-cutting topics: On the one hand the recently emerging paradigm of personalized medicine emphasizing the diversity of patients and requirements. On the other hand the issue of service provision and the question how access to different services in the aforementioned fields are possible; an issue that is characterized by complex multi-level constellations with regard to the responsible actors.

Figure 10: Topics and actors for system of combating cancer[9]



Source: Wittmann et al. (2020)

9 Access to the full map is available under: https://embed.kumu.io/e323326c30db34997e3ed6e4f0a3fb9d.

The socio-technical system displays a strong STI orientation, particularly with regard to diagnosis and treatment. This manifests itself in a dense network of different research actors, involving universities, research institutes such as the DKFZ and private enterprises as well as medical professional organizations etc. In contrast, the topics of service provision, prevention and aftercare reach more clearly beyond the STI context. Whereas STI can provide important inputs to the development of these fields, they are also driven by other sectoral policies such as aspects related to education, health insurances, working and health regulations and so on, involving a broad variety of actors including other ministries and agencies.

Moreover, the socio-technical system is characterized by a diversity of long-standing and large instruments mobilizing considerable resources. At the federal level, the National cancer plan (NKP) is a flagship policy that was initiated in 2008 and is led by the BMG, focusing on aspects related to service provision. At the same time, given the importance of STI as a driver for change, the socio-technical system reaches beyond its national boundaries. This includes the exchange and cooperation at an international level that may spill-over to domestic systems. Example policies in this regard are EraNET TransCan, the European Partnership for Actions Against Cancer (EPAAC), or the newly defined mission area on cancer in the Horizon Europe research strategy of the EU for the next budget period (2021-2027).

4.2.2 Transformative understanding

Similar to the following toolbox elements, the assessment of the transformative understanding was derived ex-post by the research team, creating the challenges to delineate the actual mission formulation from design choices such as actors' involvement and focal points of the instrument mix. Key reference point for the assessment of the transformative understanding is the joint declaration of the NDK (NDK 2019) that has been identified as the main vehicle for the mission on combating cancer. Drawing on the proposed framework developed in the context of the scientific support action (Wittmann et al. 2021a), the mission can be classified as leaning towards an accelerator type 1 mission. Firstly, concerning its underlying motivation that can range from a problem-oriented to a solution-oriented approach, the mission is located at the former end of the spectrum (problem-oriented).

The mission departs from a problem-oriented approach with a focus on the challenge of an ageing society and changing lifestyle, not proposing a defined solution/approach but instead it aims to explore the underlying problem. Secondly, concerning the main driver for the changes, the understanding of the mission follows a clear orientation towards STI policy. The joint declaration explicitly defines the NDK as a research strategy (NDK 2019,

p. 1) aiming to complement the more service-provision oriented national cancer plan (NPK). This orientation is also visible in the postulated goals emphasizing the need to improve treatment success that can be achieved through an improvement of therapies. However, this focus is complemented by a second set of quantified goals focusing on strengthening prevention measures reaching into the domain of behavioral change. This is also reflected in some of the mission's sub-goals (de-tabooization of topic of cancer/awareness raising, new culture of patient involvement). The overall STI-oriented focus manifests itself in the composition of members of the NDK, pointing to limited coordination requirements at the horizontal levels (Federal ministries of Health and Research and education), while from a vertical perspective the mission gathers a wide range of stakeholders. In sum, this leads to the conclusion that the mission resembles the logic of an accelerator type 1, even though it includes some elements of transformer missions.

This choice has numerous implications for the mission as such, pointing to a number of case specific obstacles. Drawing on the aforementioned challenges in section 3.3, the following aspects need to be taken into consideration during mission implementation:

- Accelerator Type 1 missions are characterized by high levels of insecurity about the desired outcomes, involving a long time horizon. Therefore the mission needs to create a stable structure ensuring continuity over time.
- Emphasizing the role of STI policy as the main driver for changing a complex socio-technical system requires the creation of an impulse strong enough to effectively contribute to systemic change in an already established field.
- Entailing a hybrid character that combines a strong orientation towards STI with aspects of behavioral change, the mission faces the challenge of reaching beyond the boundaries of STI. In consequence, the mission needs to credibly communicate its ambitions in order to mobilize actors beyond the sphere of STI and to achieve a mandate for change.

4.2.3 Impact pathways

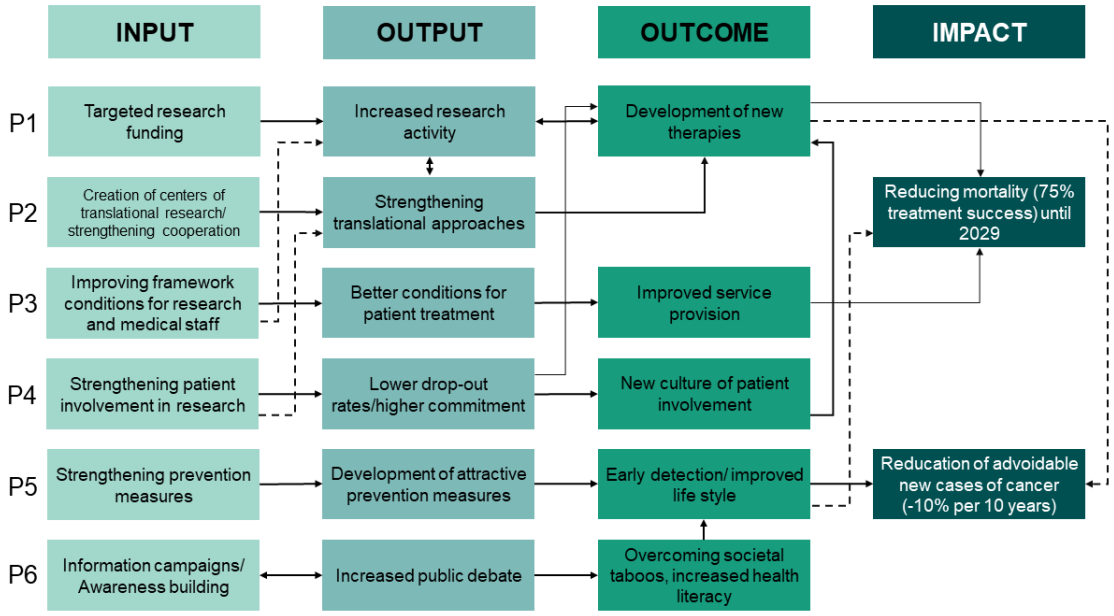
Based on the joint declaration of the NDK with its five postulated goals (NDK 2019), the research team of the scientific support actions developed six impact pathways that describe the relation between goals and possible inputs (see figure). The main overarching priorities in this context are the two quantified goals aiming for the reduction of mortality by achieving 75% of treatment success until 2029, and the reduction of avoidable cases of cancer by 10% per every ten years. Whereas these goals are directly addressed by the pathways focusing on research funding (P1) for treatment success and strengthening

of prevention measures (P5) respectively, the remaining pathways complement these dynamics. In sum, the following impact pathways were identified:[10]

- P1: Through the provision of dedicated research funding this pathway has the objective to stimulate research activities and thereby facilitate the development of new therapies that can contribute to improving treatment success. Moreover, such insights might also benefit attempts in the field of prevention, e.g. through the development of vaccines.
- P2: This pathway aims for the development of new therapies by the means of strengthening translational research activities allowing to better link clinical practice and research.
- P3: By improving the overarching framework conditions for research and service provision for patients under treatment, both research activities and treatment success are assumed to be influenced positively.
- P4: This pathway seeks to strengthen the research process through patient involvement, improving the quality and speed of the process and thereby contributing to treatment success (P1).
- P5: Referring to the second overarching goal, this pathway aims to strengthen prevention measures in order to reduce avoidable cases of cancer, which might be achieved through a modified life style or earlier detection of cancer.
- P6: The final pathway is closely linked with P5, aiming to reduce the societal taboo of cancer through information provision and awareness raising, and thereby supporting the readiness of the wider society to participate in prevention measures.

10 These pathways were particularly inspired by the following generic pathways: P1: Research for problem-solving; P2: (Basic) Research for knowledge generation; P3: Collective intelligence/Positive effects through academic exchange; P4: Changing the research process; P7: Bringing knowledge to application; P10: Awareness building and changing public perception.

Figure 11: Identified impact pathways for the mission on combating cancer



Source: Own elaboration, revised figure based on Wittmann et al. (2021c)

4.2.4 Instrument inventory

Similar to the pathways, the inventory of mission activities was developed retrospectively, drawing on insights from the official strategy, the mission progress and the website of the NDK[11]. Table 9 shows the instruments that are considered as actively contributing to the mission. In contrast to a compiled list of instruments, the table highlights to which pathways the instruments are intended to contribute to and clarifies their size, temporal dimension and thematic priorities, thereby giving an overview on how the anticipated goals are to be achieved.

11 https://www.dekade-gegen-krebs.de/de/home/home_node.html

Table 9: Inventory of instruments for the mission on combating cancer

No.	Prog. family	Input	P1	P2	P3	P4	P5	P6	Type of activity	Actor	Duration (start/end)	Budget (mio. EUR)	Target group	Thematic priority
1	Rahmenpr. Gesundheitsf.	"Praxisverändernde Studien"	X		X	X	X		Direct distribution	BMBF	2019-2029	62	Research	Prev., diagnosis, therapy, aftercare
2		"Tumorheterogenität, klonaler Tumor-Evolution und Therapieresistenz"	X		X				Direct distribution	BMBF	2021-	n/a	Research	Therapy
3	Medizininformatikinit.	"Digitale FortschrittsHubs Gesundheit"	X						Direct distribution	BMBF	2020-2023	n/a	Research	Therapy
4		New locations for NTC		X	X				Direct distribution	BMBF	2019-2025	13mio (per Center)	Research/ health infr.	Therapy, service provision, diagnosis
5		DKFZ-Hector Krebsinstitut		X	X				Direct distribution	DKFZ/ Hector Found.	n/a	2.5 (per year)	Research/ health infr.	Service provision, therapy
6		Research network ("Früherkennung und Prävention von Leberkrebs (LiSyM-Krebs)")					X		Direct distribution	BMBF	2020-2023	n/a	Research	Diagnosis
7		Research network (Präv. von Darmkrebs in jüngeren und künftigen Generat.)					X		Direct distribution	BMBF	2021-2029	n/a	Research	Primary and secondary prevention
8		Prevention week (1st/2nd edition)					X		Information	DKH/ DKFZ	2019-2020	n/a	Civil society	Primary prevention
9		Online dialogue of the NDK						X	Information	NDK	2020	n/a	Civil society	Patient involvement
10		Cancer prevention center						X	Information	DKFZ/ DKH	2020-	25	Research/ health infr. /civil society	Patient involvement, primary prevention

Source: Wittmann et al. (2021c)

4.2.5 Indicators for measuring mission progress

Building on the previously developed impact pathways, the subsequent step is to identify a set of appropriate indicators to explore whether the mission is "on track" and is moving in the right direction. Relying on ex-post developed indicators by the team of the scientific support action that were subjected to internal expert review, this section proposes a collection of possible indicators for this purpose. However, for bringing these indicators into practical implementation, in many instances further clarification and specification would be necessary – thus, this compilation provides an empirical illustration of possible items to be measured without providing a full-blown operationalization.

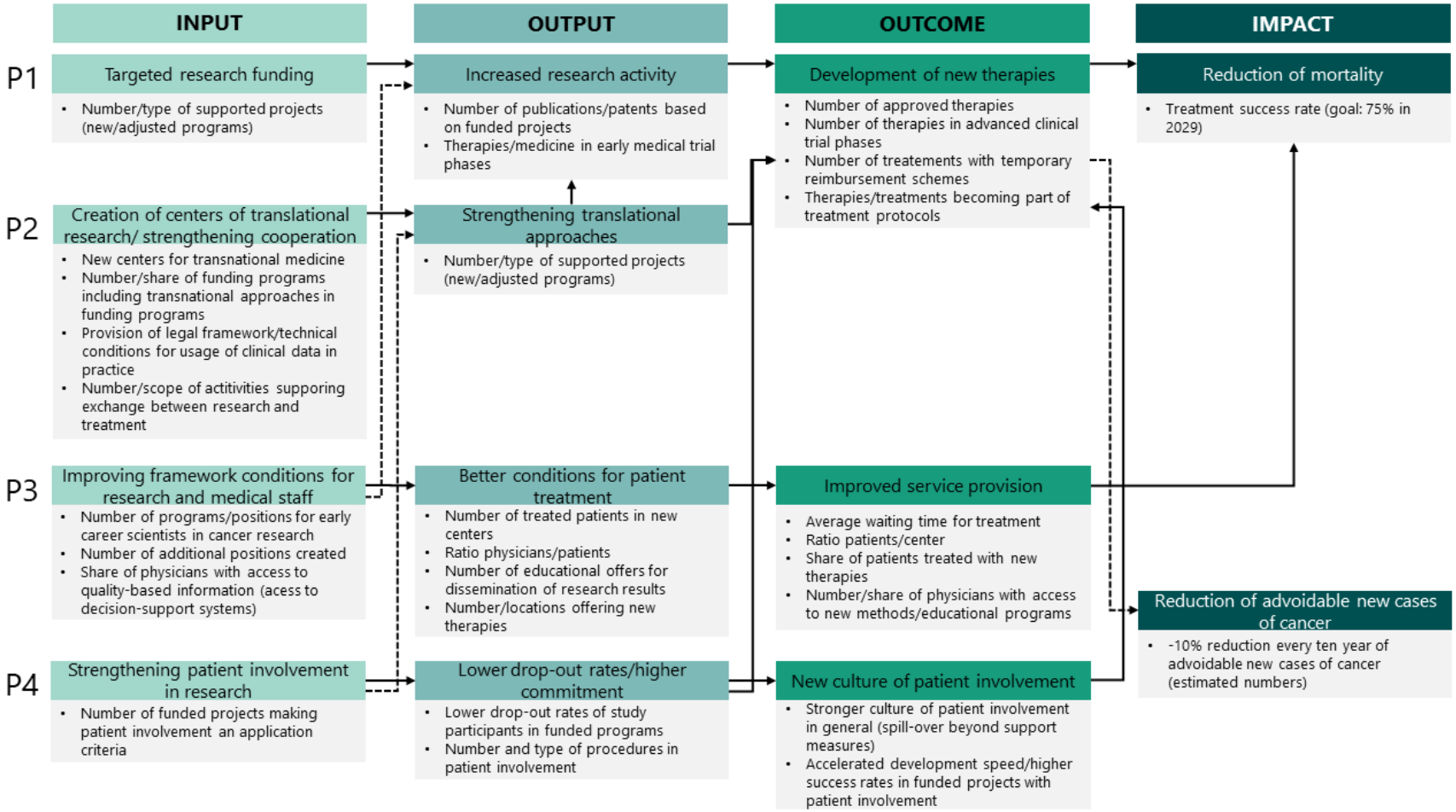
For the sake of understandability, the following figures (see figure 12 and figure 13 below)visualize the impact pathways and possible ways to understand the progress of missions along the two main strands of pathways (therapy improvement to reduce mortality, strengthening prevention for the reduction of avoidable cases of cancer). The remainder of this section discusses the possible operationalizations for individual pathways, pointing to possible ways for deriving adequate indicators.

- Targeted research funding (P1): Relying on a rather classical mix of input (funded programs) and output (publications/patents) indicators, therapy development is a years-long process. Therefore, it may be worthwhile to focus the analysis not only on approved therapies/therapies being part of clinical protocols, but also to take into consideration earlier stages of promising therapy development emerging out of funded projects as early signs (therapies in clinical trial/temporary reimbursement), data that needs to be collected from responsible authorities. As this pathway potentially may contribute to prevention through the development of vaccines, a reconsideration of the aforementioned indicators with a focus on vaccine-related research activities and approved vaccines may be useful.
- Strengthening translational research (P2): This pathway feeding into P1 at the input level might focus on a wider set of activities including funding schemes, created centers, adopted changes in the legal framework and events enabling the exchange. These activities may accumulate in outputs of these activities that can be measured by bibliometric data (publications/projects using clinical data/co-patents/co-publications).
- Improving framework conditions for research and medical staff (P3): This pathway combines different strands of activities. At the input level, possible indicators might rely on funding schemes/programs/funds supporting the growth of personnel for these purposes, as well as approaches granting access, e.g. to relevant information systems. Outputs may either directly materialize in P1, or can be measured in different aspects of patient treatment (patient/physician ration, additional treatments in new centers, expansion of knowledge/expertise). In consequence, such changes might enhance outcomes that reduce waiting time and improve the share of patients with

access to better educated physicians/personnel. Such data would require data collection across different medical centers to obtain a comprehensive picture of the treatment situation in Germany.

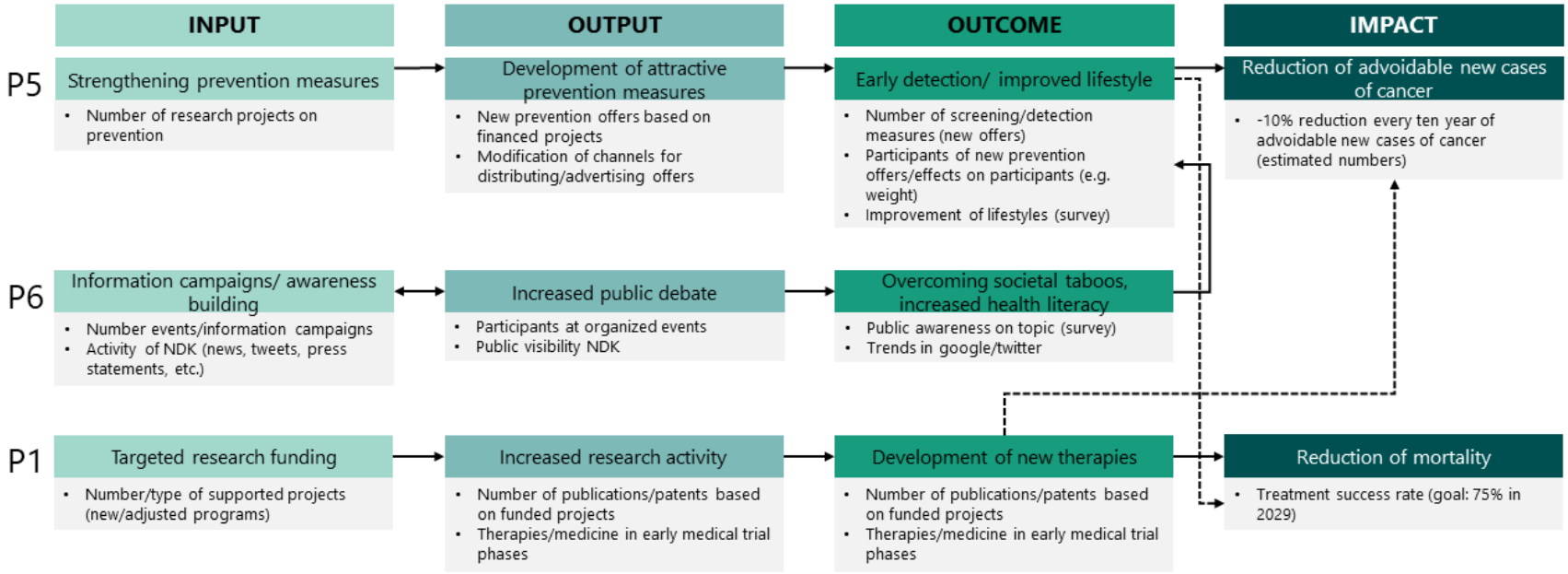
- Strengthening patient involvement (P4): Departing from a list of programs strengthening the involvement of patients as a funding requirement (Input), one can explore whether these programs produce the expected outputs of lower drop out rates (outputs) and thereby accelerate/improve the research process (outcome). Moreover, depending on the number and type of involvement processes that are stimulated through these programs (outputs), this practice may spill over to other programs (either through involvement in funding requirements or inclusion by applicants regardless of requirement).
- Strengthening prevention measures (P5): Pursuing a research-oriented approach to strengthen prevention, the main input will be the number of related research projects. Based on these projects, potential outputs are newly developed offers and new channels for the distributions of these offers. Outcomes may be measured by the uptake by patients, either through healthcare data (number of new screening/early detection measures and participation of these) or an improved lifestyle. The latter might require a survey approach to explore among participants or wider society how the attitude towards prevention has changed in general.
- De-tabooization of the topic of cancer (P6): This pathway contributing to P5 might require a different indicator approach. Whereas inputs can by measured by outreach activities of the NDK (number of events/information campaigns, press releases, tweets, press statements etc.), immediate outputs are for example the number of participants or the public visibility of the NDK (measured by appearance in media etc.). Moving towards the stimulation of a public debate and overcoming the taboo might be captured by a survey in the general public focusing on the awareness of the topic (and its possible links to the NDK) or other data such as google/twitter trends.

Figure 12: Possible indicators for treatment-related impact pathways



Source: Own elaboration

Figure 13: Possible indicators for prevention-related impact pathways



Source: Own elaboration

4.2.6 Analysis of translation processes

The final element in the toolbox constitutes the analysis of the translation processes of MOIP by a comprehensive set of clustered guiding questions. This section provides an overview of the results, summarizing the key insights from the analysis and presenting an aggregated assessment of the analytical dimensions (see table 10), a more comprehensive assessment for individual analyzing questions can be found in the appendix of this report. In order to enhance readability, each dimension was aggregated into an assessment referring to the need of adjustments (dark grey – no/low needs for adjustment, medium grey – medium need for adjustment, light grey – strong need for adjustment). Given the short time of mission implementation and constraints in data access, mission implementation is beyond the focus of the chapter. Instead, the analysis focuses only on the first two steps of missions: mission formulation and mission design.

4.2.6.1 Mission formulation

The process of mission formulation is characterized by both strengths and weaknesses. While the overall legitimacy of the mission is without doubt high, several dimensions of the mission goals and the formulation process show shortcomings. Whereas the overall scope of the mission is defined in a rather problem-oriented way, emphasizing its role as a long-term research strategy (NDK 2019) without explicitly specifying its boundaries, the clarity of goal formulation reveals a mixed picture. Goals of the missions have a nested character, as explicit goals are listed in the Joint declaration of the NDK as the main vehicle of the mission, combining two quantified goals on treatment success and prevention with three rather vaguely specified goals that can be considered as complementary to the overarching goals of improving treatment success and a reduction of new avoidable cases. At the same time, the goal definition does not entail information about adequate data sources, certain ambiguities that are not defined in the main strategic document (linking treatment success to good quality of life, reduction of avoidable cases of cancer) and lacks interim goals which might be problematic given the long-term character of the goals exceeding the implementation period of the NDK.

The mission enjoys a high level of legitimacy given the fact that it is the second top reason for deaths, an expected increase of cases in the future, and in view of multiple agendas at the supra-national level. This is also supported by the fact that the goals formulated are not unrealistic but appear to be a useful focal point for actors in the field, putting more emphasizes on the issues of prevention and the role of patient involvement. A potential pitfall might be the limited leverage of the Federal Ministry of Research and Education, which took the lead of the mission, for promoting activities in the field of prevention and questions that relate to service provision. Aiming to stimulate the postulated

goals seem to reach beyond the confines of STI policy. While enjoying a high level of commitment from the top-levels of BMBF, involving the Federal Ministry of Health as the unit responsible for the National Cancer Plan (NKP) could ensure alignment of these policies. Nonetheless, the mission does not exhibit a strong cross-ministerial character. A strong feature of the mission is the mobilization of a wide range of relevant stakeholders, including patient representatives jointly defining the goals of the mission and even formalized expectations for each partner concerning their respective contributions. Such a joint declaration of goals is likely to generate a high level of commitment. The downside in this regard might be the fact that while representing all key stakeholder groups, individual actors, such as private enterprises, are often not directly represented, and the role of contributions needs to be formulated more precisely.

Table 10: Aggregated assessment of translation processes

Transl. process	Key element	Analytical dimension
Mission formulation	Mission goal formulation	Definition of scope of the mission
		Definition and operationalization of goals
		Relationship between different goals
	Legitimacy, urgency, and process of mission formulation	Legitimacy of goals
		Level of ambition
		Embedding/Inclusiveness in political and administrative context
		Suitability to enhance mobilization and legitimacy among stakeholders (actors representing society, science, industry)
Mission design	Impact pathways (intended impact)	Process of pathway development
		Fit between pathways and postulated goals*
		Consistency of pathways*
		Coherence of pathways*
	Instrument mix	Fit between pathways (intended impact) and instruments
		Character of policy instrument mix*
		Leverage of instruments*
		Process of instrument mix development and commitment by authorities and other actors*
		Coordination of policy mix & governance structure

Source: Own elaboration (* indicates assessment of elements developed ex-post by the team of the scientific support action, darker colors reflect stronger performance)

While mission formulation provided a sound starting point based on high levels of legitimacy and a successful mobilization of actors resulting in a joint declaration of goals, a

more clearly developed description of goals and stronger anchoring in the political sphere could have supported the process of mission design, creating more leverage and guidance for the relevant actors and the required resource mobilization.

4.2.6.2 Mission design

The mission design process in turn is characterized by multiple obstacles, manifesting itself mainly in the absence of a sound strategic process to translate mission goals into a more operationalized and workable concept. First, the formulated goals were not supported by the development of an explicit understanding on how to achieve them. For the purpose of the analysis, the scientific support action derived impact pathways based on the goal description. A key challenge in this regard is to bridge the gap between the strong STI orientation of a research strategy and the wish to strengthen prevention measures in order to decrease avoidable cases of cancer which requires to reach beyond the traditional confines of STI and above all necessitates behavioral change and a stronger mobilization of the population.

In a similar vein, the mission cannot draw on a compiled overview of the mission activities. In its place, for the purpose of this analysis, such a list was compiled by the team of the scientific support action drawing on publicly available sources. While actor mobilization via the joint declaration and the flexible modes of engagement might be considered as a strong side of the mission, it does not yet use its full potential to mobilize resources from actors. While in contrast to many other missions of the German High-Tech Strategy, the mission entails contributions from selected mission partners (DKH, DKFZ, Hector Foundation), the joint label of the NDK as a flagship seems to be a helpful factor in this regard. However, the overall mode of instrument provision remains to be characterized by a top-down approach, primarily driven by the Federal Ministry of Education and Research. The additionally of these inputs from partners remains unclear. At the same time, it is noteworthy that neither the Federal Ministry of Health (BMG), being responsible for the national cancer plan (NKP), nor private enterprises provide any inputs to the mission, underlining the character of its strong research-orientation. The instrument mix can be described as strongly STI policy oriented, combining a range of newly established instruments, suggesting a high degree of alignment with the postulated goals. The instrument development is supported by input from working groups defining priorities. Among the obstacles for the policy mix, the following aspects can be identified: the potentially limited leverage of the instruments compared to the overall socio-technical system, a rather problem-/gap-oriented instead of a systemic approach, the indirect link between some pathways and instruments (strengthening patient involvement), and a potentially too narrow scope of instruments related to the prevention-oriented pathways (P5, P6).

4.2.6.3 Discussion

The analysis of translation processes revealed a highly faceted and complex picture. Whereas the mission shows numerous strengths when it comes to involving different stakeholder groups via the joint declaration, which is a promising approach of differentiated membership and ensures an overall high degree of legitimacy, the potential impacts of the missions are constrained by ambiguities in the mission formulation and the absence of a sound strategic process connecting mission goals with impact pathways and a comprehensive instrument mix – shortcomings characteristic for many of the missions of the HTS (Wittmann et al. 2021c). While the reliance on STI as the main driver is generally not in conflict with the transformative understanding of the mission, the narrow focus of the mission as a research agenda is likely to constitute an obstacle for achieving more comprehensive goals in the field of prevention. In line with this, it is rather unlikely that the mission will be able to generate sufficient critical mass for stimulating changes in the relevant fields. While the materialization of effects of the mission cannot not be measured until a couple of years from now (first goals are supposed to be reached in 2029, others even later), the foundations for impact materialization do not rest on entirely sound foundations.

4.3 Discussion of results

This chapter provided a brief application of the framework to the mission on combating cancer of the German High-Tech Strategy 2025. A main limitation in this regard is the ex-post character of the analysis that did not allow to incorporate feedback continuously into the process of mission realization. This applies both to the analytical questions on the translation processes as well as the remaining toolbox elements that may have supported the development and implementation of the mission. For example, conducting a system mapping or sound development of pathways is likely to have uncovered the ambiguities in goal formulation and the tension between the research agenda approach and comprehensive goals in the area of prevention. In consequence, the mission might have been developed further by sharpening priorities or more appropriate ways to achieve them.

Secondly, the analysis demonstrated the need for impact assessment to be integrated into mission realization as the analysis requires comprehensive and empirically saturated insights into the mission. Without being closely linked to mission owners it appears challenging to obtain a thorough understanding of all on-going processes, particularly at the level of mission implementation. Taken seriously, the approach of MOIP assessment requires considerable efforts and resources not only at the different stages of the missions but also for the impact assessment and constant monitoring of the missions at

impact pathway/instrument level mix. In addition to mission guidance and implementation, this underlines the importance of a clear definition of mission goals and well developed impact pathways – without a sound understanding of the expected dynamics of the mission, it will be extremely difficult to develop an appropriate set of indicators to monitor the development of missions along the impact pathways. While imposing high demands concerning the availability of internal data from the mission, the systemic character of MOIP also makes it necessary to gather a wider range of data from external sources. This can include surveys of public opinion/key stakeholder groups or experts assessments to understand the developments of the socio-technical systems.

Thirdly, the analysis points to the challenges that are associated with hybrid mission types, combining different transformative understandings. The combination of different features does not only impose additional obstacles to the analysis of missions but also for implementation, as it introduces ambiguities concerning goals and pathways. The mission on combating cancer in this regard revealed a tension between a research-agenda approach on the one hand and the attempts to achieve behavioral changes in the field of prevention on the other hand that are hard to reconcile in practice.

At the same time, there are risks associated with the suggested toolbox elements and the framework. Firstly, the toolbox elements are a way of reducing the complexity of missions by introducing different steps and structuring the complexity by means of lists, logical charts etc. However, this should not lead to an overly static perspective denying that the overall process is an iterative one. The toolbox elements should be used in a way to allow for feedback provision into ongoing processes of mission implementation and also adjustments of the instrument mix of a mission. Secondly, the framework does not provide a comprehensive blueprint for carrying out missions. While emphasizing supporting elements, the framework acknowledges that missions and their assessment are always context-bound and therefore need to be interpreted in their specific context. Consequently, the framework does not propose a standardized way of rating missions or makes it necessary to answer all analytical questions in similar depth. However, the framework does require an understanding which aspects in a given context are most crucial for a mission-oriented approach.

5 Conclusion and discussion

This report presents a comprehensive, flexible, process-oriented and theory-based approach for supporting mission implementation and impact assessment of mission-oriented innovation policies. Following the objectives of a formative approach, the framework proposes a toolbox of different elements intended to contribute to impact assessment and support the implementation process along the three key translation processes of missions: mission formulation, mission design, mission implementation. For this reason, the framework should be closely integrated into the realization of the mission as a whole, as mission monitoring and impact assessment impose high degrees of information requirements and close exchanges between mission owners and evaluators. The strong formative orientation of the framework is also reflected by the emphasis on ex-ante elements in the analysis that can provide feedback for the realization of the missions. At the same time, the framework does not aim to quantify impacts but rather focuses on exploring conditions for a materialization of impacts.

Acknowledging the empirical diversity of missions, the framework proposes a flexible approach. To this end, the conceptual insights based on research on MOIP can be tailored to the specific requirements of real-world missions. In line with this, the methodological approach is rather agnostic, not prescribing specific methods or ways of implementation. The framework acknowledges that mission owners may face different constraints concerning context and resources and therefore may opt for different ways of implementing the selected toolbox elements. Providing sufficient resources for mission governance, monitoring and impact assessment will therefore be key also for success of the framework. Moreover, the framework presumes a certain level of absorption capacities at the level of involved mission owners. Without the willingness and capacity to process the feedback provided throughout the process and feed it into ongoing processes of mission realization, the effects of the framework are likely remain weak.

Moreover, it is important to note that the proposed framework provides a starting point for the analysis – it does not provide a one-size-fits-all blueprint. Consequently, the framework always needs to be tailored to a specific context. Incorporating new insights from the increasingly growing body of literature dealing with evaluation and impact assessment of MOIP and transformative policies in this regard can contribute to a further improvement of the framework, e.g. by adding new analytical questions.

As every framework is a simplification of complex realities, this work is no exception. In particular we wish to highlight the following aspects that are not yet directly addressed. First, the framework does not explicitly account for unintended effects or alternative pathways. While the risk of unintended effects can be reduced through the development of

respective impact pathways, an explicit integration might have gone at the expense of applicability of the framework. Accordingly, these aspects might be better dealt with on an ad-hoc basis, wherever it is deemed as relevant. Secondly, the framework does not explicitly model the overall context in which a mission is implemented. Instead, it assumes that insights of the system analysis can be a tool for setting up pathways that reflect the specific context conditions of the underlying socio-technical systems. Moreover, as Amanatidou et al. (2014) argue, one complexity of missions is the interdependence between different societal challenges. Understanding missions as being located within a specific socio-technical system, possible interaction effects between different missions will be difficult to systematically account for. Finally, being developed primarily for policy-makers, the tool will be less suitable for analyzing transition processes in general, as it takes an actor-centric perspective, exploring how a set of mission owners can set up and implement missions in a way to maximize their effects.

In the context of transformative policies, it can generally be observed that research on evaluation and impact assessment concepts are increasingly emphasizing formative elements (Molas-Gallart et al. 2021), thereby abandoning the idea of providing accountability through summative elements. The framework presented deliberately has been designed to incorporate both formative and summative pillars, thereby following a realist approach (cf. Arnold et al. 2018). To this end, we consider the framework not only to be an instrument providing support and opportunities for learning and reflexivity to mission-owners at the different phases of MOIP, but also allowing for accountability based on measurements and appropriate metrics. This later perspective is relevant not least due to the fact that MOIP and their aspirations to cause deep changes in social spheres if they want to succeed, significantly higher levels of legitimacy compared to classical STI policies are required (Lindner et al. 2021). Developing a better understanding of the interfaces between formative and summative elements, allowing to maximize the synergies between them in evaluatory and assessment frameworks, will be an important task for future research in this field.

6 Literature

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Appendix: Detailed answers to analytical questions for the mission on combating cancer

Mission formulation

Key element	Analytical dimension	Analytical question	Assessment
Mission goals formulation	Definition of scope of the mission	Does the mission formulate a clear vision/desirable state to be achieved?	No overarching vision is formulated, access to mission is rather problem-driven.
		Is the mission explicit in what areas it strives for change/solutions	Partly: The mission defines itself as a research agenda, defining seven fields of activity contributing to five dedicated goals, research focus in the field on combating cancer but also links to service provision. Priority on treatment and prevention.
		Does the mission explicitly exclude topics or policy fields?	No explicit limitation of mission, rather implicit limitations through link to national Cancer Plan as complementary strategy and understanding as research strategy.
		Does the mission contain a justification for its priorities?	Yes, problem-driven approach. High urgency in Germany as cancer is second reason for death, high increase of cases of cancer is expected. NDK is presented as research strategy complementing national cancer plan (NKP).
		Are mission goals connected to a specific technology?	No.
		Is the geographical scope of the mission clearly defined?	Primarily national focus, however, realization in some instances will have a regional dimension, e.g. concerning access to treatment.
	Definition and operationalization of goal	Does the mission have explicitly formulated goals?	Yes, goals are stated in the joint declaration of the NDK, while the HTS only defines the creation of the NDK as mission goal. Ability to provide guidance may be hindered through the nested structure.
		Does the mission include quantitative indicators corresponding to the mission goals?	Partly: Especially for overarching goals that provide quantified goals (including further qualifications), the remaining three goals entail no quantified/clearly qualified goals, the definition of good living quality as a condition for goal achievement remains unclear
		Are mission goals measured on nominal, ordinal, interval or relational scales?	Mixed: partly relational scales (quantified goals).
		Does the mission specify data types or sources to be used for measuring goal achievement?	No.

Key element	Analytical dimension	Analytical question	Assessment
		Do mission goals explicitly define complex constructs that are linked to goal (e.g. quality of life/happiness etc.)?	No, there are ambiguities concerning the qualification of treatment success that is supposed to be linked to good quality of life. Moreover, the term of avoidable cases of cancer leaves room for interpretation.
		Does the mission define a clear baseline/ measurement of the status quo for the intended changes?	Goals concerning prevention would require counterfactual in case of avoidable cases of cancer. Goals entail multiple ambiguities such as the lack of a definition of good quality of life as a prerequisite/condition for treatment.
		Are mission goals defined in terms of international comparisons or rankings (e.g. become global market leader in a specific field)?	No.
		Is a clear time horizon defined for the achievement of mission goals?	Period of NKD (2019-2029) and formulated goals (up to 2040) exceed the time period of the German High-Tech Strategy 2025. This may constitute a challenge to the continuity of the mission.
		Does the mission include interim goals or milestones?	Partly (for prevention goals are to be achieved in ten-year steps), otherwise no intermediary steps are defined.
		Do the goals include flexible elements, e.g. if/when context conditions change throughout the mission?	No information available.
		Is there a defined process for the adjustment of goals throughout the mission?	No information available.
	Relationship between different goals	Does the mission define more than one goal?	Yes, five goals.
		Is the prioritization of goals clearly defined?	No explicit hierarchy of goals, but goals imply hierarchization: Access to high-quality treatment/translational approaches, and high levels of education in research/service provision contribute to overarching goals of increasing treatment success and reduction of avoidable cases of cancer.
		Does the mission define if/how one mission goal contributes to other goals?	Links are only implicitly defined.

Key element	Analytical dimension	Analytical question	Assessment
		Are postulated goals non-contradictory or is there a possible tension between goals?	No obvious contradictions/incoherencies visible, two main sets of goals clustered around treatment and prevention, with remaining goals potentially contributing to overarching goals. The understanding of the NDK as a research strategy may conflict with the aim to alter public awareness that has a wider scope.
Legitimacy, urgency, and process of mission formulation	Legitimacy of goals	Does the mission name a specific societal problem it seeks to address?	Yes, high prevalence of cases of cancer in Germany (second major reason for death), expected increase in the future.
		To what extent is there a societal consensus about the importance of the underlying problem (cf. Wanzenböck et al. 2020)?	High importance of problem at domestic and international level and awareness among policy-makers (e.g. EU mission on combating cancer, EU's combating cancer plan etc.), public awareness might be less clear.
		Is there a societal consensus on the urgency of the problem?	According to public opinion surveys, cancer is usually considered to be a key concern among illnesses. Fear of severe illness ranks relatively high in society but is usually overturned by current political dynamics and events, so that the perceived urgency in public might be lower compared to other challenges like climate change/sustainability.
		Do the problems the mission aims to address rank high on the political agenda?	Generally high level of awareness.
	Level of ambition	Are mission goals realistic? Are goals also realistic if context conditions change?	Based on expert assessment goals generally appear achievable and fairly realistic, though assessment of level of ambition varies. According to Bruns et al. (2019) the goals in prevention are relatively ambitious (cf. also goals of international strategies below).
		Do goals go beyond existing trends or even push for radical change?	No.
		Do mission goals appear ambitious compared to similar missions in other countries?	No direct comparison possible, as point of departure is different. EU's plan on combating cancer is more service-provision oriented including broader like about carciogenic substances. The mission on cancer in Horizon Europe is more research-driven. The latter defines more ambitious goals concerning prevention (reduction of avoidable cases by 25% until 2030), whereas no immediate success rates for treatment are defined.

Key element	Analytical dimension	Analytical question	Assessment
		Does the mission aim for altering the functioning of the system, i.e. is it transformative?	Only moderate changes, e.g. strengthening patient involvement as a new element, however, overall understanding of goals appears to be rather towards improvement of existing system. Main exception in this regard is the creation of awareness of society for the importance of prevention.
		Is the realization of mission goals linked to best-case expectations?	Given the ambiguity of some underlying, it is not possible to provide a definite answer.
	Embedding/ Inclusiveness in political and administrative context	Is a single mission owner or group of mission owners clearly defined?	Federal Ministry for Research and Education (BMBF) takes lead in coordination of National Decade against Cancer (NDK).
		Can the main mission owner(s) credibly claim capacity/mandate for change (through activities or bringing together relevant actors)?	Partly ambiguous. Wide range of involved stakeholders groups but not immediate involvement of all relevant stakeholders, limited leverage of main mission owner for prevention-related topics, ambiguities over role of BMG in the mission.
		Are all relevant political actors and administrative units involved in the mission formulation process?	Federal Ministry of Health is partner of NDK, allowing to align activities with NDK. However, mission is primarily implemented by Federal Ministry of Research and Education. Agencies and ministries that might be of importance for regulation in the field of prevention are not part of the mission.
		How intense is the collaboration during the mission formulation process?	No information available.
		What role does the main mission owner play (cf. Edler and Borras 2021) for driving change?	Initiator/Promoter/Moderator.
		How much attention and support does the mission receive at higher political levels?	Active involvement of state secretary from BMBF in mission implementation, at the same time no anchoring at higher political levels, e.g. Bundeskanzleramt.
		Is the initiator of the mission also responsible for managing the mission?	Yes.
		Does the mission refer to existing policies or is overlapping/duplicating structures at the national level?	Complementary to National Cancer Plan with focus on service provision (NDK includes representatives of Federal Ministries of health responsible for NKP -> alignment and coordination).
		Does the mission describe how to create synergies based on existing policies?	No, reference to National cancer plan that is supposed to be complemented by NDK.

Key element	Analytical dimension	Analytical question	Assessment
		Is it clear what the added value of the mission is, compared to existing policies?	Mission is presented as a long-term research strategy, complementing existing National Cancer Plan that focuses on service provision.
		Does the mission explicitly refer to goals of international strategies?	No.
		Do the mission goals appear to be in line with international strategies (SDGs, etc.)?	No explicit linkage to SDGs provided, main links may be found to European-level initiatives (see below).
		Are mission goals aligned with initiatives of supra-national organizations (e.g. EU)?	Wide range of activities at international level (EU mission on cancer starts after NDK, EraNET TransCan or the European Partnership for Actions Against Cancer (EPAAC), without clear connection, EU Mission on cancer was initiated after NDK.
	Suitability to enhance mobilization and legitimacy among stakeholders (actors representing society, science, industry)	Are relevant stakeholders (actively) involved in the mission formulation process?	Yes, mission goals of NDK are formulated by joint declaration of mission.
		Which stakeholders are involved in the process of mission formulation?	Relatively broad actor mobilization within the NDK, covering different key stakeholder groups (health insurance, federal ministries, agencies, private enterprises, professional organizations etc.).
		How are stakeholders identified and selected?	No information available on identification process.
		Are key stakeholders missing?	Limited direct involvement of private companies (research-oriented), partly only via associations or only indirect involvement of key actors in the field of prevention (e.g. via health insurances). Focus seems to be on a representation of stakeholder groups not necessarily key stakeholders.
		How does the formulation process deal with possible resistance from key actors/veto players?	No information available, difficult to assess ex-post.
		Did mission owners reach a mutual understanding of mission goals?	Yes, formulated in joint declaration.
		What are drivers for stakeholders to participate? Are stakeholders incentivized to participate in the mission formulation process?	Insights might be best collected through interviews with involved stakeholders that are difficult to carry out ex-post. Creation of coherent label may create a pull-effect to mobilize stakeholders.

Key element	Analytical dimension	Analytical question	Assessment
		Are topical expertise, insights from foresight, or perspectives of stakeholders integrated into the process of mission formulation?	No information available.
		Does the involvement of stakeholders include the development of a shared vision?	Yes, creation of a joint declaration stating shared areas of activity and goals.
		Do stakeholders (formally) commit to the goals formulated?	Joint declaration of NDK formulating key goals. Every partner (and potential supporters) agrees with this agenda and declares to contribute to these goals. Description about type of contribution is relatively vague/limited to experiences/perspectives in some cases.
		Is the strategic process of mission formulation designed and equipped with sufficient resources (personnel, financial, temporal)?	No information available.

Mission design

Appropriateness of impact pathways	Process of pathway development	Do mission documents (or later provided documents) describe the links between instruments and goals?	No - pathways were developed retrospectively by team of the scientific support action for the purpose of analysis. No comprehensive strategic process visible translating mission goals into logic chart/impact pathways.
		Who leads the process of impact pathway development?	Not applicable.
		To what extent is the development of impact pathways supported by stakeholders or external expertise?	Not applicable.
		What resources are available for the development process	No information available.
	Fit between pathways and postulated goals	Are all mission goals addressed by pathways?	Not applicable, as pathways were developed retrospectively. Goals allow to derive distinct pathways.
		What approach do pathways suggest for achieving the postulated goals?	Strong focus on research activities and STI actors for treatment and diagnosis, however, impact pathways are cross-cutting issues of service provisions, education, working conditions and civil society.

Key element	Analytical dimension	Analytical question	Assessment
		Do goals match with underlying understanding for transformative change?	While there is a general fit, the emphasis on research driven change may conflict with attempts for strengthening (primary) prevention measures.
	Consistency of pathways	Which obstacles need to be overcome to successfully realize the pathways?	Creating a critical mass will be a key factor for many pathways (research, prevention measures/awareness creation) for successful change in a socio-technical system that involves considerable actors and resources (high threshold). Multiple pathways aim to contribute to postulated goals, however, they might be driven by a variety of other factors and are influenced by exogenous dynamics (especially P1) beyond the national focus of the mission.
		Are pathways appropriate to achieve the desired goals?	Not applicable, as pathways were developed retrospectively. Research-oriented pathways are plausible. However, there might exist a tension concerning the labelling of the mission as a long-term research strategy and an adequate pathway that aims to reduce avoidable cases of cancer, as the development of new approaches alone might be insufficient to achieve these goals.
		Do pathways aim at second order effects/ cascading effects?	Not applicable, as pathways were developed retrospectively. Patient involvement/strengthening translational is supposed to facilitate additional research findings, besides improving quality/speed.
	Coherence of pathways	Do several impact pathways relate to a shared goal?	Not applicable, as pathways were developed retrospectively. Two main pathways (research funding & improving prevention), other pathways are supposed to contribute to these pathways.
		Are there any contradictions/tensions or conflicts arising between pathways?	Not applicable, as pathways were developed retrospectively. No contradictions as pathways were developed retrospectively, some pathways are thought to support/reinforce the overarching goals so main question is about defining the interface between these pathways.
Appropriateness of instrument mix	Fit between pathways (intended impact) and instruments	Are all impact pathways addressed with instruments/activities?	Not applicable, as instrument were identified retrospectively by research team of the scientific support action based on official documents and website of the NDK. All pathways are - at least indirectly - addressed by instruments that are part of the mission.
		Are pathways highly dependent on one or few dedicated instruments?	Pathways are usually associated with multiple instruments. Main exception here is P4: Here only indirect attempt to achieve a changing culture by application requirements by one funding instrument (direct distribution).

Key element	Analytical dimension	Analytical question	Assessment
		How specific is the alignment of instruments with pathways?	New instrument for research funding that is cross-cutting pathways (4 of 6), remaining instruments are usually contributing towards one or maximum two pathways (may be dependent on selected projects). Some goals are supposed to achieve indirectly (strengthening patient involvement though application regulations), no dedicated instrument for achievement stronger patient involvement. Some instruments (especially flagship policy on praxisverändernde Studien) seek to combine different goals, making actual contributions specific on selection/choice of funded projects.
	Character of policy instrument mix	What are the main characteristics of the instrument mix applied in the mission (combination of regulation, distribution/incentives, information)?	Strong reliance on creation of incentives (research funding) for treatment-oriented pathways (P1-P4), prevention mainly through direct subsidies/information (not touching upon regulatory aspects). Strong reliance on incentive creation may entail risk of lacking ability to mobilize additional contributions from other actions.
		Are relevant target groups addressed by the instruments?	Main focus on researchers and actors involved in health care service provision. The outreach to the wider public (pathways dealing with prevention) appears to be limited and might not be sufficient to reach a wider population.
		Does the policy instrument mix for individual pathways show gaps or does only address parts of them?	Instrument approach appears rather focused on selected problem/flagship policies aiming to closing existing gaps. For a systemic approach a broader and more integrated approach might be worth considering.
		Do the mission instruments focus on research output and scientific knowledge production?	Yes, main driver of the mission, particularly flagship policies (Praxisverändernde Studie, creation of new research networks).
		Do the mission instruments focus on fostering transfer (research to application) and/or adjustment of regulatory frameworks?	Partly, creating incentives for translational medicine through strengthening infrastructure and provision of dedicated funding scheme.
		Do the mission instruments focus on reconfiguring an existing system (e.g. by facilitation of new solutions; building new networks)?	Partly, strengthening patient involvement as a requirement for funding applications in some cases, creation of new centers for translational research.
		Do the mission instruments aim for behavioral change?	Yes, focus on provision of access to information/creation of new institutions and research on prevention offers.

Key element	Analytical dimension	Analytical question	Assessment
		Do the mission instruments focus on exnovation/regime destabilization/ phase out? Are there compensation mechanisms or incentives for potential losers/actors resisting the anticipated changes?	No, not relevant for type of accelerator mission.
		Does the policy instrument mix fit the corresponding pathway?	Strong reliance of STI policy instruments (research funding) - mostly adequate for research related pathways (P1-P4), concerning the prevention-related pathways there is a stronger reliance on information-oriented instruments.
		Does the instrument mix entail room for experimentation (policy experiments, real labs, etc.)? Are there any plans for institutionalizing successful instruments (e.g. pilot projects)?	No explicit policy experimentation. Research funding 'Praxisverändernde Studien' seeks to finance a variety of different projects in different areas exploring new treatment approaches.
	Leverage of instruments	What leverage do these instruments possess in the relevant socio-technical system (size, scope, centrality)?	Overall, the sum of resources appears to be limited in the context of the socio-technical system (for those where information was available).
		To what extent does the instrument create synergies with other policies in the field (beyond the mission)?	Newly designed programs addressing so far undervalued questions. Development of questions supported by working groups that allow priority setting. While there is implicit link to other cancer-related activities (such as the NKP) the mission does not explicitly subsume these activities or clarify their relationship.
		Can the suggested instruments plausibly contribute to a change?	Projects may rather serve as lighthouse projects for further facilitating developments but independently may lack the leverage for comprehensive change while they might provide. Strong focus on research actors, public outreach for prevention activities may be limited to interested/immediate audience, questionable whether the general public can be reached.

Key element	Analytical dimension	Analytical question	Assessment
	Process of instrument mix development and commitment by authorities and other actors	What actors are mobilized to participate in the mission?	Mission relies on a differentiated system of cooperation, distinguishing between mission partners (part of joint declaration) and supporters. Supporters require acceptance of goals and approval by partners, but are not expected to provide contributions.
		Does the mission mobilize the relevant key stakeholders in the field?	Comprehensive mobilization of actors from different spheres (science, politics, civil society, industry). However, mode of representation is not comprehensive at the level of stakeholders, rather at the level of different stakeholder groups (e.g. industry). E.g., only one pharmaceutical company is a partner of the mission, other are only represented indirectly.
		Which actors are involved in developing the instrument mix?	Mission partners defined contributions in joint declaration.
		How are instruments identified and selected for the mission? How was the process implemented?	No information available, retrospective identification of instruments based on website and progress reports.
		What actors are responsible for instruments of the mission?	Overall a top-down mode of resource provision with limited mobilization of resources. Majority of instruments is provided by the Federal Ministry of Research and Education (lead of mission). Website/progress report entails information about contributions by DKFZ/DKH/Hector Foundation. Several activities are presented as instruments under the umbrella of the NDK as the main vehicle of the mission.
		Were all ministries/public actors active in the field involved in this process?	No contributions of Federal Ministry of Health or ministries/agencies that might deal with question of prevention beyond BMBF, only provision of resources by BMBF.
		What share of resources is provided by non-public actors that are relevant in the field?	Mission involves contribution of private actors (DKH, DKFZ, Hector Foundation), additionality of these contributions cannot be determined. No immediate contributions of private enterprises.
		Are there incentives for stakeholders to contribute to the mission? To what extent is their contribution formalized?	Joint label of NDK may create incentives for actors to highlight their own activities.
		Is there a dedicated mission budget?	Budget for NDK for website etc. and own activities (online survey).
		Is there a formal commitment of actors to provide resources? How precisely is this defined?	Joint declaration entails statement of contributions of partners, however, the descriptions in many cases are rather vague/focus on non-material contributions only. No formalized contributions.

		Does the commitment include the necessity to adjust/modify existing instruments/activities?	No information available in official documents.
		How is their implementation coordinated between different actors?	Part of coordination is internalized (BMBF projects), no overall coordination scheme could be detected (internal agreements). Priority setting based on working groups.
		Are the instruments designed specifically for the purpose of the mission or how are existing measures aligned? How are new instruments developed?	All mission instruments/activities were initiated 2019 or later, therefore one can assume a high degree of alignment with the goals of the mission NDK. Priorities for funding program were developed by working group of NDK, ensuring strategic prioritization and focus on relevant questions.
		What resources are available for mission design?	No information available in official documents.
	Coordination of policy mix & infrastructure	What kinds of coordination forms are created for the mission?	Creation of a strategy council and subordinated thematically-oriented working groups.
		What are their competencies? Who is member of them?	Strategy council consists of 17 members, representing the mission partners. Working groups also involve other stakeholders e.g. researchers from relevant institutions. Working groups are supposed to define priorities (that for example are feeding into development of instruments).
		How regularly are those planned to convene?	No information publicly available.
		How is the implementation of instruments coordinated between different actors?	No information publicly available.
		Are there any pre-defined approaches for mission monitoring, evaluation and learning? How are these to be achieved?	No information publicly available.