Mission-Oriented Transition Assessment as a reflective approach to mission governance

Coenen, Tom B.J.; Wiarda, Martijn; Visscher, Klaasjan; Penna, Caetano C.R.; Volker, Leentje

DOI
10.1016/j.techfore.2025.124257

Publication date
2025

Document Version
Final published version

Published in
Technological Forecasting and Social Change

Citation (APA)
Coenen, T. B. J., Wiarda, M., Visscher, K., Penna, C. C. R., & Volker, L. (2025). Mission-Oriented Transition Assessment as a reflective approach to mission governance. *Technological Forecasting and Social Change*, *219*, Article 124257. https://doi.org/10.1016/j.techfore.2025.124257

Technological Forecasting & Social Change 219 (2025) 124257

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

journal homepage: www.elsevier.com/locate/techfore

Mission-Oriented Transition Assessment as a reflective approach to mission governance

Tom B.J. Coenen [a,*], Martijn Wiarda [b,c], Klaasjan Visscher [d], Caetano C.R. Penna [c,e], Leentje Volker [a]

[a] Department of Civil Engineering and Management, Faculty of Engineering Technology, University of Twente, Enschede, the Netherlands
[b] Technology, Innovation & Society, Department of Industrial Engineering & Innovation Sciences, Eindhoven University of Technology, Eindhoven, the Netherlands
[c] Department of Values, Technology, and Innovation, Faculty Technology, Policy, and Management, Delft University of Technology, Delft, the Netherlands
[d] Section of Knowledge, Transformation and Society, Faculty of Behavioral, Management and Social Sciences, University of Twente, Enschede, the Netherlands
[e] Centro de Gestão e Estudos Estratégicos, Brazil

ARTICLE INFO

Keywords:
Mission-oriented innovation policy
Participatory governance
Technology assessment
Sustainability transitions
Infrastructure
Circular economy

ABSTRACT

The recent mission-oriented discourse in innovation policy increasingly recognizes the need for participatory, anticipatory, reflexive, and tentative governance modes to address the wickedness associated with societal challenges. In this paper, we introduce the Mission-Oriented Transition Assessment (MOTA) approach as a novel way to collectively anticipate and reflect upon current and future mission-oriented transition dynamics, and we subsequently demonstrate this approach in the context of the Dutch mission 'Circular infrastructure by 2050'. Using socio-technical scenarios, we apply MOTA to support stakeholders, particularly policymakers, in governing missions. Stakeholders reflect on their role in transitions to collectively find ways to overcome transition barriers and address tensions between the current and future socio-technical systems. Results indicate various ways in which MOTA contributes to stakeholders' awareness and preparedness, as well as the social robustness and alignment of action perspectives in the transition towards a circular infrastructure sector. As such, MOTA helps reveal valuable strategic and actionable insights to better understand and address societal challenges and mission barriers.

1. Introduction

Faced with major social and technical challenges that cannot be solved by existing economic growth-oriented policies (Schot and Steinmueller, 2018), contemporary science, technology, and innovation (STI) policies have become increasingly transformation-oriented and challenge-led, particularly in Europe (Brown, 2021; Janssen, 2020; Kuittinen and Velte, 2018). The uptake of mission-oriented efforts by the European Commission is a recent example (Mazzucato, 2018b). In this context, missions can be understood as "boundary objects around which heterogeneous communities […] gather and craft together shared understandings of what is at stake, what means are necessary, and what processes should ensue" (Janssen et al., 2023, p.2). Mission-oriented innovation policies (MOIP) are primarily aimed at mobilizing stakeholders and providing the conditions for socio-technical change in a predefined direction (Mazzucato et al., 2020; Schot and Steinmueller, 2018). MOIPs have the potential to instigate complex, open-ended, non-linear, and long-term transitions that are difficult to plan, predict, and manage (Hekkert et al., 2020; Köhler et al., 2019). These transitions involve multiple actors, dimensions, and levels (Grin et al., 2010) and suit the systemic nature of today's socio-technical challenges.

Although there is a growing body of literature on the formulation and design of missions and MOIPs (European Commission, 2018; Klerkx et al., 2024; Larrue, 2021), the governance of their implementation remains underexplored (Janssen et al., 2021). Mission governance will need to draw from participatory, anticipatory, and reflexive approaches to deal with the complexity, uncertainty, and contestation associated with the wicked problems that missions aim to address (Wiarda et al., 2024). While approaches do exist that incorporate such elements (e.g., Van Lente et al., 2017), Haddad et al. (2022) argue that "more work is clearly needed to help policymakers design and implement relevant formative and summative assessments of transformative innovation policy instruments and programs" (p.32). This underscores the need for reflective approaches that support policymakers in mission governance.

* Corresponding author at: Drienerlolaan 5, 7522 NB Enschede, the Netherlands.
E-mail address: t.b.j.coenen@utwente.nl (T.B.J. Coenen).

https://doi.org/10.1016/j.techfore.2025.124257
Received 21 October 2023; Received in revised form 2 June 2025; Accepted 20 June 2025
Available online 25 June 2025

After all, having and using such normative and substantive approaches is crucial for the co-construction of early-stage transitions (Pallett and Chilvers, 2013).

In this paper, we contribute to the governance of mission-oriented transitions by demonstrating the usefulness of reflective and anticipatory deliberations. We link existing deliberative approaches with the mission-oriented policy literature to conceptualize a new mission governance approach, called Mission-Oriented Transition Assessment (MOTA). It represents a collective appraisal of current and future socio-technical changes to support stakeholders, particularly policymakers. MOTA helps stakeholders reflect on mission governance with the aim of fostering a greater responsiveness to heterogeneous stakeholder values and worldviews (Kuhlmann et al., 2019; Stilgoe et al., 2013). We develop, demonstrate, and reflect upon MOTA by applying it to the case of the Dutch circular economy (CE) infrastructure mission.

The remainder of the paper is structured as follows. Section 2 draws from the mission governance framework of Wiarda et al. (2024) as an entry point for the conceptualization of MOTA in Section 3, which considers the governance challenges, modes, responsibilities, and envisioned outcomes of mission governance in wicked contexts. Section 4 shows the research approach to our case study, after which we report the results of our study in Section 5. Section 6 discusses the implications of both the conceptualization and case application, and Section 7 concludes the research and offers directions for future work.

2. Theoretical background

2.1. Transitions in the context of missions and societal challenges

The concept of missions has experienced a revival in the context of innovation policy (Mazzucato, 2017). Crucial in discussing these goal-oriented policies is the distinction between accelerator and transformer missions (Wittmann et al., 2020). Accelerator missions generally aim to achieve technological feats (Soete and Arundel, 1995; Wittmann et al., 2021), such as putting humans on the moon and returning them safely to Earth (Apollo Program's mission) or developing an atomic bomb (Manhattan Project's mission). Contrary to these relatively isolated and technology-focused missions, transformer missions are generally aimed at tackling wicked problems and driving transformative change (Larrue, 2021; Mazzucato, 2022), such as the transition towards climate-neutral cities, achieving gender equality, the transition towards a CE, or the elimination of cancer. Here, it is often not technology that poses the central challenge to transitioning but the socio-institutional characteristics within the system (Truffer et al., 2017) that can surface ranging from supranational to regional scales (Uyarra et al., 2025).

Mission-oriented innovation policies (MOIPs) are focused on achieving specific societal goals within a predefined timeframe through cross-sectoral innovation (Mazzucato et al., 2020). Because of their focus beyond technology, many contemporary MOIPs aim to mitigate transformative system failures – in particular directionality failures (Graaff et al., 2025; Weber and Rohracher, 2012) – and to promote transformative changes to address urgent societal challenges (Edler et al., 2024). Central to MOIP is its focus on an "urgent strategic goal that requires transformative systems change [or a transition] directed towards overcoming a wicked societal problem" (Hekkert et al., 2020, p.76). Wicked problems are generally understood as problems embodying high degrees of complexity, uncertainty, and contestation (Head, 2008; Rittel and Webber, 1973; Wanzenböck et al., 2020). The degree and interaction of these three dimensions indicate to what extent problems are wicked (Alford and Head, 2017). In addition to these dimensions, a mission orientation generally leans on the notion that socio-technical change is characterized by accumulation and directionality (Dosi, 1982; Kuhn, 1962; Laatsit et al., 2025) and recognizes that a redirection of socio-technical systems requires the explicit selection of problems and solutions (Bugge and Fevolden, 2019; Hekkert et al., 2020).

While efforts have focused on the upstream phases of establishing missions (e.g., Mazzucato et al., 2020; Rosa et al., 2021), the MOIP literature has placed less emphasis on the midstream governance processes of implementing them (Janssen et al., 2021). This disparity is apparent, for example, in recent mission-oriented initiatives in Europe (cf. Larrue, 2021), where implementing societal missions on various levels requires new forms of governance and collaboration (EC and DGRI, 2023). This includes geographical (e.g., Uyarra et al., 2025) and sectoral boundary-spanning (e.g., Janssen and Abbasiharofteh, 2022). Given the ambitious and transformative intentions of MOIPs, high levels of coordination are required to make ongoing changes compatible with each other (Wittmann et al., 2021). Such processes need a development of societal legitimacy and hence require forms of co-creation (Klerkx et al., 2025). Even further, such processes extend capacities of organizations that are traditionally in charge of these policy domains, requiring transformation not only of the processes but also of the organizations themselves (McLaren and Kattel, 2025).

In response, Wiarda et al. (2024) recently introduced a framework for mission governance as a way of working with wickedness in the context of transitions. It echoes the argument of Wanzenböck et al. (2020) that the complexity, uncertainty, and contestation associated with missions pose significant governance challenges for purposive transitions. Conventional roadmaps and top-down governance approaches that technically preselect innovation pathways based on an innovation's transformative potential (e.g., Miedzinski et al., 2019) tend to ignore this wickedness of the societal challenges being addressed (Kuhlmann and Rip, 2018). Next, we will discuss some of the mission governance challenges that follow from wickedness and adopt the framework of Wiarda et al. (2024) as our entry point for conceptualizing the MOTA approach.

2.2. Governance modes and responsibilities to address wickedness

Complexity, *uncertainty*, and *contestation* are three widely recognized wickedness dimensions (c.f. Farrell and Hooker, 2013; Ferraro et al., 2015; Head, 2008; Wanzenböck et al., 2020) that need to be dealt with when addressing societal challenges through MOIPs. These dimensions problematize mission governance as they result in an *intractability* of the transition, posing substantial governance challenges for policymakers (Campbell, 2003; Head, 2022). In the remainder of this section, we follow Wiarda et al. (2024) by arguing that the four governance challenges of *complexity*, *uncertainty*, *contestation,* as well as the *intractability* challenge require specific responsibilities (e.g., inclusion) and governance modes (e.g., participatory governance) to arrive at more effective and desirable outcomes.

2.2.1. Complexity

Complexity stems from the multi-actor, multi-dimensional, multi-scalar, and constantly changing nature of societal challenges (Wanzenböck et al., 2020; Wiarda and Doorn, 2023). Rittel and Webber (1973) argued that: "the information needed to understand the problems depends upon one's idea for solving it. That is to say: in order to describe a wicked problem in sufficient detail, one has to develop an exhaustive inventory of all conceivable solutions ahead of time" (p. 161). This is one of the reasons why the complexity dimension is generally irreducible and hence imposes an inherent knowledge deficiency on decision-makers (Stirling, 2008). To deal with complexity and resulting knowledge deficiency, inclusive approaches are needed to leverage the knowledge, moral judgment, and agency that is distributed among stakeholders (Head, 2008; Klerkx and Rose, 2020; Wanzenböck et al., 2020).

Among others, inclusion as a governance responsibility may be achieved through participatory governance modes (Newig and Fritsch, 2009), which allow for the early identification of the values and worldviews of stakeholders (Bauer et al., 2021). Participatory governance commonly requires engagement through shared spaces in the

shape of, e.g., hybrid forums (Callon et al., 2009) or arenas (Loorbach, 2010; Wesseling and Meijerhof, 2021), ideally facilitating mutual learning using forms of consultation and participation (Rowe and Frewer, 2005). The actors involved in participation will not replace policymakers, researchers, and innovators but rather ground those policymakers firmer into the real world (Harremoës et al., 2001). Therefore, participatory governance can play an essential role in the social construction of technology (Pinch and Bijker, 1984). As a result, inclusion is assumed to create more socially robust mission-oriented transition outcomes (Nowotny, 2003).

2.2.2. Uncertainty

Wicked problems are also associated with epistemic and normative uncertainty (Head, 2008; Wanzenböck et al., 2020). Epistemic uncertainty stems from the notion that decision-makers are faced with unknowns, for instance, regarding particular events' occurrence, likelihood, or severity (Hoffmann-Riem and Wynne, 2002). Normative uncertainty arises as "there is not one unequivocal right or wrong answer to an ethical question regarding risk – along with scientific and technical uncertainty" (Taebi et al., 2020, p. 2). Normative and epistemic uncertainty can, for instance, culminate in the economic uncertainty of whether solutions will be economically viable or accepted. Because these uncertainties are strongly linked to the desirability of innovations and socio-technical changes, they may give rise to demand articulation failures (Weber and Rohracher, 2012).

Anticipatory governance can help in dealing with uncertainties (Barben et al., 2007; Stilgoe et al., 2013) by "governing in the present to adapt to or shape uncertain futures" (Muiderman et al., 2020, p. 1). It goes beyond traditional risk-based governance by embracing uncertainties and unknowns (Hoffmann-Riem and Wynne, 2002; Stirling, 2010). While anticipatory governance cannot predict the future, it does help prepare for the diverse potential transition pathways and plausible mission outcomes. This governance mode calls for collectively defining the 'right' impacts and directionality (Shove and Walker, 2007; Von Schomberg, 2014), even though stakeholders may hold opposing views regarding the future (Muiderman et al., 2020). Hence, anticipatory governance requires a broad scope that crosses conventional policy domains to account for the dynamics in the socio-technical system (Edmondson et al., 2024).

2.2.3. Contestation

Contestation arises due to opposing value systems and worldviews of stakeholders (Wanzenböck et al., 2020). Wicked problems and possible solutions are contested because of the numerous ways of explaining, prioritizing, and addressing them (Rittel and Webber, 1973). For example, circularity was perceived differently throughout the Dutch construction sector, blurring the preferred direction of socio-technical change (Wiarda et al., 2023). While a direction of change may satisfy one stakeholder, it may not do so for others. Particular forms of contestation are irreconcilable in the context of wicked problems as they are rooted in fundamental disagreements (Popa et al., 2021; Scott, 2021). If left unattended, contestation could lead to reflexivity failures, when actors fail to critically reflect on and adapt to other actors' values and interests (Weber and Rohracher, 2012; Wesseling and Meijerhof, 2021).

Contestation can be addressed by forms of reflexive governance (Voß and Bornemann, 2011). Because policymakers do not always "know best" or "act best" in understanding problems and proposed solutions (Kirchherr et al., 2023, p. 4), incorporating reflexivity as a governance responsibility is crucial for collective sensemaking (Garud and Gehman, 2012). Preventing reflexivity failures relates strongly to the awareness of diverging and evolving problem understandings and alternative solution pathways (Weber and Rohracher, 2012; Wesseling and Meijerhof, 2021). Reflexivity acts as 'holding up a mirror' to reflect on how stakeholders' worldviews and value systems shape activities, assumptions, and commitments related to their institutional practices (Stilgoe et al., 2013). A distinction can be made between first-order reflexivity and second-order reflexivity. The former refers to forms of learning that take place "within boundaries of a value system and background theories" (Van de Poel and Zwart, 2010, p. 180). In the context of missions, this relates to how predefined missions may be achieved best concerning the prevailing or mainstream value system. In second-order reflexivity, however, the background theories and value systems become themselves an object of reflection. Reflexive governance may lead to more effective and desirable reformulations and adaptations of missions and strategies as values and theories evolve.

2.2.4. Intractability

The complexity, uncertainty, and contestation of wicked problems often make them unmanageable and incomprehensible, i.e., intractable (Campbell, 2003; Head, 2022). As a result, policymakers "cannot find meta-positions overlooking or unifying perspectives" (Termeer et al., 2019, p. 175) while socio-political and financial constraints often confine mission governance. However, the reluctance or inability to make decisions commonly exacerbates wicked problems, partly because it could favor incumbents' interests and reinforce business-as-usual. Policymakers, therefore, must act to unfold "a never-ending discourse with reality, to discover yet more facets, more dimensions of action, more opportunities for improvement" (Dery, 1984, p.6–7). This would require continuous reflection and intervention as a way of tentatively working with wicked problems to respond to anticipatory and reflexive insights while acknowledging one's limited knowledge and control (Jentoft and Chuenpagdee, 2009; Kuhlmann et al., 2019; Stilgoe et al., 2013).

As such, tentative (or adaptive, as mentioned by Folke et al., 2005) governance contributes to incrementally aligning MOIPs with stakeholder interests and creating alignment between stakeholders (Ison et al., 2014; Kuhlmann et al., 2019). Only then can MOIPs become "a strategy of incremental change with a transformative agenda" (Patterson et al., 2017, p.4). Although tentative mission governance centers around responsiveness to stakeholder input and changing circumstances, its success highly depends on the ability of policymakers to experiment with and learn from anticipatory and reflexive insights that emerge while the transition takes place (Stilgoe et al., 2013). The four modes of participatory, anticipatory, reflexive, and tentative governance must, therefore, be understood as a coherent, interwoven mission governance framework rather than four separate modes (Wiarda et al., 2024). In the next section, we show how this framework can be operationalized and used to develop and structure a process of anticipatory and reflexive deliberations for the development of our MOTA approach.

2.3. Mission governance through anticipatory and reflexive deliberations

To cope with the governance challenges mentioned, mission governance requires elements of participatory, anticipatory, reflexive, and tentative governance modes. A combination of these four modes and responsibilities is argued to increase the preparedness and awareness of stakeholders while simultaneously promoting the social robustness and alignment of MOIPs (Table 1). An important note is that these complementary governance modes are not mutually exclusive, and existing governance approaches can (implicitly) address elements of multiple

Table 1
The mission governance framework: governance challenges, responsibilities, modes, and outcomes (Wiarda et al., 2024).

Mission governance framework			
Challenges	Responsibilities	Modes	Outcomes
Complexity	Inclusion	Participatory governance	Social robustness
Uncertainty	Anticipation	Anticipatory governance	Preparedness
Contestation	Reflexivity	Reflexive governance	Awareness
Intractability	Responsiveness	Tentative governance	Alignment

modes. Policymakers may combine and operationalize these modes and responsibilities through reflexive and anticipatory deliberations that enable them to assess current and future socio-technical changes needed to promote transitions for achieving missions.

By addressing the four responsibilities of the mission governance framework such deliberations are believed to help stakeholders identify opportunities to overcome transition barriers, recognize and address tensions between the current and desired systems. Decisions can be made while considering the stakeholders' values and worldviews. Moreover, these deliberations are argued to help decision-makers deal with the so-called 'Collingridge dilemma' associated with uncertain transition outcomes (Collingridge, 1980; Lindner et al., 2016). This dilemma describes how decision-making around innovation is problematized by the uncertainty in the early stages of technology and simultaneously stresses the rigidity that arises when innovation becomes entrenched in society. The Collingridge dilemma highlights how both epistemic and normative uncertainty in the upstream developmental phases of innovation create problems for the societal construction of technology. When governing missions, stakeholder values and worldviews should, therefore, be considered before transitions materialize and cause novel lock-ins (Arthur, 1989), entrenchments (Collingridge, 1980), and path-dependencies (David, 1995).

Approaches to anticipatory and reflexive deliberations that address system tensions and the Collingridge dilemma through one or more of the four governance modes (Table 1) can be structured in several ways. These approaches are frequently placed under umbrella terms such as Responsible (Research and) Innovation (Stilgoe et al., 2013; Von Schomberg, 2013), Vision Assessment (Grin and Grunwald, 2000), Constructive and Real-Time Technology Assessment (Guston and Sarewitz, 2002; Schot and Rip, 1997), and Ethical and Legal and Social Aspects/Implications research (Fisher, 2005). Although the differences between these existing approaches are broadly appraised (e.g., Ryan and Blok, 2023; Van Lente et al., 2017; Zwart et al., 2014), they share the commonality of proactively exploring both normative and epistemic considerations through inclusive deliberations to mitigate possible risks and foster the social desirability of research and innovation (Ryan and Blok, 2023; Wiarda et al., 2021).

While the abovementioned umbrella terms experienced an uptake in research and innovation, their focus primarily lies on emerging – often single, technological – innovations and early innovation stages rather than socio-technical transitions. This is an important difference because many heated societal debates do not revolve around single innovations but rather relate to large-scale change comprising complex socio-technical reconfigurations. Societal debates about a CE, for example, cause upheaval because stakeholders have very different ideas about which socio-technical configurations of systems and related changes are needed for different contexts to close resource loops as effectively as possible (Velenturf and Purnell, 2021). Dealing with similar transition debates demands significantly different governance approaches, even more so when taking a mission-oriented perspective.

Technology Assessment (TA) approaches are increasingly used as structured and collective deliberations to formatively reflect on the many perspectives on the future (Kuk et al., 2023). Truffer et al. (2017) showed that technology is not central to these TA approaches but rather the socio-institutional contexts that interact with these technologies. In addition, Boni et al. (2023) report that such exercises stretch well beyond the conventional scope of assessment activities in innovation policy. In TA, the term 'assessment' can be understood in multiple ways. We understand 'assessment' as the appraisal of long-term action perspectives and consequences of socio-technical developments. Such assessments can be summative and formative (Haddad et al., 2022), where the former refers to assessments of final impacts and the latter to intermediate, often process-oriented assessments aimed at engendering adaptations of ongoing developments. Because the recency of missions limits opportunities for summative evaluations (European Commission, 2018; Larrue, 2024), we will develop MOTA as a formative assessment approach.

Within the group of TA-based approaches, scenarios are commonly used to explore potential futures. For example, scenario planning (Amer et al., 2013), technology/vision assessment (Grin and Grunwald, 2000), horizon scanning (Amanatidou et al., 2012), value scenarios (Nathan et al., 2007), technology roadmaps (Kostoff and Schaller, 2001), and anticipatory governance in the broader sense (Barben et al., 2007) show how scenarios-based reflections can inform decision-makers on plausible futures (Rip and Te Kulve, 2008; Truffer et al., 2008). In this context, scenarios can act "as a means for both experts and non-experts to contemplate the past with the benefit of hindsight, critically reconsider the present and creatively contribute to shaping the future" (Lehoux et al., 2020, p. 11). In the context of sustainability transitions, for instance, Eames and McDowall (2010) demonstrated how scenario-based workshops help identify which critical enabling technologies are deemed most promising by stakeholders and which may require additional support. The link between technological developments and socio-institutional aspects is central. By linking the long-term strategic goals and missions to specific socio-technical pathways, scenarios provide input for deliberations with stakeholders on an operational and tactical level (Sondeijker et al., 2006).

Using scenarios, constructive TA (also known as CTA) is a well-established approach to formatively assess changes in broader socio-technical systems (Rip and Te Kulve, 2008). CTA is an inclusive and reflexive approach that actively engages diverse stakeholders in collaborative discussions to assess emerging technologies, promoting normative orientation and iterative adaptation throughout the process (Rip, 2018). Grounded in CTA, an approach focusing on transitions at large, is Sustainability Foresight (SF). SF is a participatory approach that explores, assesses, and strategically shapes socio-technical transformations, aiming to guide sustainable development efforts through collective, future-oriented learning and reflexive governance (Truffer et al., 2008; Voß et al., 2006). However, governments play a leading role in defining end states in the context of missions and thus indirectly determining socio-technical futures. Therefore, Sustainability Foresight must be adapted to accommodate the dynamic interplay between top-down governance and collective input in the co-construction of transitions. Furthermore, SF focuses strongly on the social expectations of stakeholders, covering only the earliest stages of a participatory foresight exercise, and can hence only limitedly inform policy on the broader dynamics.

Taking these approaches together and considering the required mission-specific qualities of governance to be participatory, anticipatory, reflexive, and tentative, as well as the focus on transitions rather than single technologies, we use CTA as a point of departure and adopt several elements from SF to structure ways of scenario development. This point of departure offers the groundwork for adaptable and inclusive forms of mission governance, addressing normative and epistemic considerations through proactive stakeholder engagement in light of mission-oriented transitions. To this end, we aim to better navigate large-scale transitions, such as those towards a CE, through socio-technical pathways that align with long-term strategic goals and societal needs. The resulting conceptualization of the MOTA approach will be introduced in the next section.

3. Conceptualizing Mission-Oriented Transition Assessment

In this research, we define Mission-Oriented Transition Assessment (MOTA) as *a collective appraisal of current and future socio-technical changes to support stakeholders, particularly policymakers, in governing missions*. To allow for structured ways to appraise mission-oriented transitions collectively, we developed MOTA to take place in a confined space in which carefully selected stakeholders – i.e., system representatives – deliberate on the dynamics and consequences of mission-oriented changes, as well as their structural positions, action perspectives, and system configurations at large. We refer to these

spaces with system representatives as 'microcosms' (e.g., Fishkin, 2018). Similar to 'systems in the room,' these spaces contain controlled, simplified, yet representative environments to study complex social phenomena, such as mission-oriented transitions. While systems in a room are often created to interact with the real world, microcosms are deliberately protected from it (Miles et al., 2013). In addition, although mission or transition arenas (Elzinga et al., 2023; Hermann et al., 2022) have similar objectives, the difference with the microcosm is the careful selection of participants to create an accurate representation of the wider system to mimic the system dynamics to support policymaking, rather than focusing on co-creation in policymaking (cf. Fishkin, 2018). In addition to the system representation, such microcosms might act as vehicles for transformation: "A microcosm turns out to be a very powerful instrument for higher-order change as it allows the complexity to be directly experienced and addressed" (Vermaak, 2013, p.14).

Since socio-technical scenarios have proven themselves in previously mentioned approaches (e.g., CTA, SF), we use scenarios to highlight possible pathways as input for discussions in the microcosm. The scenarios should be explorative as they examine a range of possible futures and are strategic in that they help guide decision-making towards sustainable outcomes (Börjesona et al., 2006). Moreover, these scenarios should comprise plausible and potentially desirable narratives that articulate the wicked aspects of mission-oriented transitions. By mapping current socio-technical systems and mission goals as entry points, we propose a back-casting approach to establish narratives of transition pathways that are presented as socio-technical scenarios (cf. Rip and Te Kulve, 2008).

To appraise mission-oriented transitions, we propose the following steps in MOTA (Fig. 1). (1) The mission-oriented innovation system is first mapped to analyze its structure and ongoing dynamics, which forms the input for the abovementioned scenarios. (2) This is followed by exploring different pathways towards mission achievement through expert-based scenarios highlighting system tensions and stakeholder behaviors. (3) Next, a microcosm is established. Within the microcosm, which could be organized in a workshop setting, system representatives are confronted with the scenarios to provoke reflection, discussion, and exploration. These scenarios are assessed collaboratively in the microcosm, focusing on challenges and opportunities. In heterogeneous groups, moderated discussions take place around these scenarios to anticipate the systemic consequences of the transition at various timescales, considering the wide range of solution pathways. This step fosters debate, identifies common ground, and addresses conflicts related to mission interpretations and stakeholder positions. These activities involve reading and reacting to the scenarios, discussing the implications of the scenarios, reflecting on one's strategic positioning concerning potential futures, and envisioning the next transition steps. (4) Finally, the discussions in the microcosm are analyzed to gain insights into the transition's next steps and formulate policy recommendations. The analysis considers both the outcomes and the discussions leading up to them. This provides insights into potential pathways and their potential strategic consequences for mission achievement and systemic dynamics and tensions within the mission-oriented system. Accordingly, the desired outcomes of MOTA are bolstering the preparedness and awareness of stakeholders and promoting the social robustness and alignment of missions and action perspectives.

4. Applying MOTA to a real-world circular economy mission

4.1. Case selection and introduction

The MOTA approach presented in Section 3 is hitherto developed and discussed conceptually. The mission *Transition towards a CE in the Dutch infrastructure sector* has been selected as a case to explore and reflect on the real-world application of the MOTA approach. It was deliberately positioned as a mission with clear boundaries in scope and time, an extensive portfolio of related projects and strategies, a broad interpretation of the stakeholder field, and an inclusive governance approach (cf. Mazzucato, 2018a) through the Dutch 'Transition Team Circular Construction.' The Dutch infrastructure sector is understood as the socio-technical system that contains the transportation infrastructure and water works that serve transport, mobility, and water safety in the Netherlands (Coenen, 2024). This domain is also referred to as civil engineering or civil infrastructure sector.

Circularity has been selected because of its unique positioning in addressing a mission-oriented transition, in which the wickedness dimensions are clearly present (Hoffman et al., 2021). First, the mission is widely contested by various stakeholders who question its ability to address environmental concerns and of which many voice it has become a goal in itself (Coenen et al., 2023). Second, although the Dutch circular construction sector is a leader in waste management and reuse, it is still in an early transition stage (Giorgi et al., 2022). Third, the Dutch government's top-down policy on circular construction has created institutional fragmentation and high stakes. The sector requires systemic change beyond technological improvements to reconsider practices,

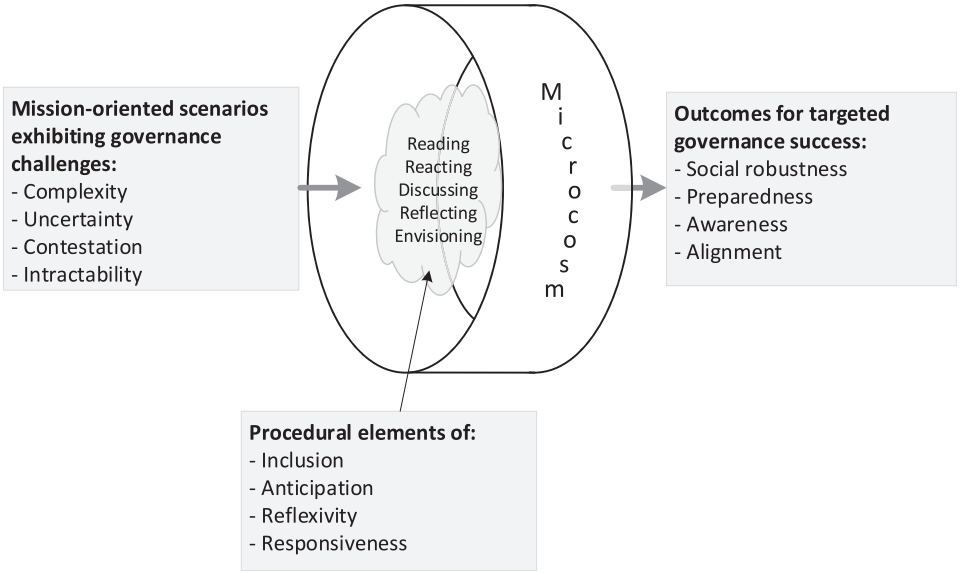

Fig. 1. Conceptual outline of MOTA.

institutions, organizational processes, and actor relations (Transitieteam Bouw, 2018). Although current innovations are mainly at the niche level (i.e., experimentation spaces protected from mainstream institutional pressures), several arduous efforts have emerged to scale them and institutionalize conditions leading to circular practices (Coenen et al., 2023). The slow transition dynamics in this complex, uncertain, and contested mission context provide a rich empirical setting for demonstrating MOTA to explore the next steps towards a circular future.

The Dutch infrastructure sector involves various public bodies coordinated by multiple ministries and regional governments. It comprises multiple subsectors, e.g., road infrastructure, waterways, and flood protection, with no clearly delineated boundaries, resulting in fragmentation by nature (Dave and Koskela, 2009). The stakeholders are highly interdependent due to the construction market's regional nature and the country's modest size. The sector involves over 1100 contractors, of which only 34 employ over 100 people (EIB, 2021), while demand comes from only a few large public clients and several hundred smaller ones. It also includes suppliers, consultancy, engineering firms, knowledge institutions, financiers, societal pressure groups, and lobby groups (Coenen et al., 2023). The stakeholders' involvement and impact in the (circular) transition process vary considerably. Road construction generates the most turnover, followed by concrete civil engineering structures (EIB, 2021).

The past decades were characterized by a neoliberal system where the market is dominant in determining the direction for solutions, putting responsibilities on the market side. Currently, public-private relations are slowly shifting towards a more collaborative approach (Kuitert, 2021). The sector is challenged by the huge task of renovating and replacing infrastructure assets across all tiers of government in the next few decades, with tight budgets and capacities (Bleijenberg, 2021). The infrastructure network is generally considered to be of high-quality, resulting in demanding requirements for circular alternatives. These context-specific conditions could affect a mission-oriented transition.

The central Dutch government set the mission for the country to be fully circular by 2050, including a separate mission for the construction sector addressing both building construction and infrastructure (IenW and EZK, 2016). This 'Circular Infrastructure by 2050' mission was supported by a strategy report that outlines three objectives (Transitieteam Bouw, 2018): (1) the high-grade utilization of available resources and waste flows; (2) the substitution of fossil and non-sustainably produced resources by widely available and renewable alternatives; and (3) the rethinking of consumption in conjunction with the reconfiguration of products and production methods. This mission aimed for comprehensive socio-technical change rather than the mere introduction of innovations. The same strategy report acknowledged that CE should be understood as a utopian vision to mobilize stakeholders in a shared direction. The Transition Team Circular Construction issued a strategic agenda to transform the sector into a circular one by 2050, with intermediate mission goals for 2030, and set out annual Implementation Programs to monitor the mission's progress. Given the high levels of uncertainty, we decided to select the intermediate mission goals for 2030 as our focal point instead of those for 2050 to support participants in formulating strategic insights to do things differently and to be better equipped to deal with the transition – i.e., action perspective. These action perspectives enable stakeholders to create managerial outlooks to shape the transition through bottom-up actions.

4.2. Case application steps

Following the conceptual framework (Section 3), the case application process consisted of four steps. In step 1, the system under scrutiny and its boundaries had to be identified to add relevant structural elements and dynamics to the scenarios. In our case, we used recent mission-oriented innovation system (MIS) analyses of the Dutch infrastructure sector in pursuit of the CE executed by Coenen et al. (2023) and Bours et al. (2022). A MIS is a recent approach to innovation systems that specifically addresses socio-technical systems in light of a specific mission (cf. Hekkert et al., 2020) and, therefore, matches MOTA's mission orientation. It maps both the structure and dynamics of the socio-technical system under scrutiny, which makes it particularly suitable as an input for writing the scenarios. We used the previous studies to define the system boundaries, mission formulation, key actors, ongoing transition developments, and major tensions and barriers. These elements were analyzed to understand recent multi-level dynamics regarding circular solutions, system actors, interactions, and institutions (cf. Geels, 2005). Next, we formulated a diverse set of plausible landscape events (i.e., exogenous events and long-term developments) to substantiate the scenarios with tensions that provoke stakeholders to take specific positionings regarding the circularity transition. While these external shocks were inherently contingent and partly sector-specific, they were carefully selected to relate to the heterogeneity of broader ongoing external developments, such as political and societal discourses, geopolitical dynamics, and socio-economic developments.

In step 2 we structured these system outlines and landscape events to design fundamentally different narratives to depict scenarios concerning the mission. These scenarios were used to explicate implicit expectations about the landscape (i.e., potential exogenous developments), regime (i.e., the socio-technical system formed by incumbent actors, mainstream technologies, and prevailing institutions), and niche-level dynamics (i.e., innovation and change initiatives executed in protected spaces) (Rip and Te Kulve, 2008; Schot and Rip, 1997) (see also Fig. 1). Following Rip and Te Kulve (2008), these scenarios included multiple technological, institutional, social, and organizational dimensions and explicitly described tensions between the existing and aspired systems. The narratives were open-ended regarding leaving space for many potential pathways, including different framings, interpretations, institutions, and solutions to attain the mission using a back-casting approach (Hofman et al., 2004). We designed two scenarios: one in which the government-led infrastructure clients and one in which the private sector parties would drive the convergence of circular solutions, as the distinction between public and private parties appeared from the two MIS analyses to be of major consequence for the transition dynamics.

Prior to the MOTA workshop, the two preliminary scenarios were assessed in a small-scale workshop with five practitioners from the infrastructure agency to review their richness, desirability, plausibility, and possibility. This workshop led to an improved set of events to increase plausibility and make the scenarios more accessible to stakeholders. As a result, both politics and governance gained a more prominent role in the revised scenarios as these were identified as crucial factors in the sectoral developments. We incorporated these changes in the two revised scenarios. Key elements of the external events and two scenarios are listed in Table 2.

In step 3, we used the two MIS analyses to select thirty representative stakeholders. Participants were selected to represent the diverse values

Table 2
Main elements of external shocks and developments, and two scenarios.

External events	Scenario 1: Proactive government	Scenario 2: Innovative market
Heavy storm Collapsing viaduct Extremely high material prices Stagnating climate policy Climate activists win a court case against large infrastructure project	Centralized planning and budgeting of infrastructure system Framework agreements for standardization of solutions Coordination between clients Lifecycle extension and reuse innovations Asset-orientation Standardization of circular solutions	Ownership of assets to market parties (as-a-service) Multi-year innovation public-private contracts Contractor networks Material innovations Project-orientation Large diversity of circular solutions

and roles in the infrastructure system and were either influential, strongly influenced by, or knowledgeable about the CE transition. We approached twenty-four individuals from this list, allowing four group discussions of a maximum of six persons. Of these twenty-four individuals, seventeen eventually participated in the workshop. The list of participants is shown in Table 3.

To both accommodate the strategic deliberation of participants and to provide input for mission governance, we took the following steps during the workshop. First, acting as moderators, the authors introduced the mission and scenarios. Next, participants were divided into four heterogeneous subgroups. To keep the narratives in the initial discussions separated, two groups received Scenario 1 and the other two groups Scenario 2. In the first discussion round, the groups spent an hour discussing the scenarios to critically reflect on their position towards the transition and to reveal possible system tensions. In the second discussion round, groups were recomposed into four new heterogeneous groups, each focusing on both scenarios to confront the many perspectives on the two possible futures discussed in the first round. The stakeholders collectively reflected on the transition, potential actions, future role changes, and possible barriers and opportunities for both the participants and the full sector.

Finally, in step 4, all discussions were recorded and transcribed, resulting in detailed accounts of the discussions between the stakeholders containing eight 7000-to-8000-word transcripts. Using a focused coding approach (Saldaña, 2013), coding categories were established iteratively on two levels, containing forty-four sub-categories (e.g., importance of technology, asset ownership, and transition phases) that were clustered into six main categories (i.e., stakeholders and roles, system change and upscaling, collaboration and networks, circular problems and solutions, transition approaches and programs, and sectoral developments and dynamics). This approach allowed us to compose an overview of the various perspectives on each stakeholder's problems, solutions, and roles. The coding of perspectives allowed us to identify a large diversity of issues related to contestation, complexity, and uncertainty to support decision-makers.

At the end of the workshop, a survey was distributed among participants to reflect on the perceived usefulness of the MOTA approach. Four questions were raised: (1) *How did the workshop correspond with your expectations?*; (2) *Did the scenarios help in reflecting and anticipating the circularity transition?*; (3) *What key insights did the workshop yield?*; and (4) *What would be your main advice to policymakers?* Fifteen out of the seventeen participants completed the survey. Finally, the coded quotations (translated from Dutch into English by the authors) and survey results were linked to the four proposed governance modes (i.e., participatory, anticipatory, reflexive, and tentative). This enabled us to explore how MOTA could contribute to mission governance, considering the various relevant governance modes.

Table 3
List of workshop participants and referring codes.

Code	Organization type	Role
AM1	Municipality	Alderman
BM1	Government committee	Board member
CM1	Construction firm	Commercial manager
CN1	Standardization institution	Consultant
CN2	Consultancy firm	Consultant
CN3	Sustainability consultancy	Consultant
DA1	Province	Director asset management
DM1	Ministry	Director
DM2	Sustainability consultancy	Director
PM1	Ministry	Policymaker
PM2	Sector association	Policymaker
SB1	Financial institution	Sector banker
SE1	Knowledge institute	Sustainability expert
SM1	Large construction firm	Sustainability manager
TM1	Infrastructure agency	Transition manager

5. Appraising MOTA

The analysis presented in this section is divided into two parts. First, we report the insights generated for the case-specific mission to illustrate the potential outcomes that MOTA yields. The second part addresses how MOTA helped the target groups and how the four mission governance dimensions (see also Table 1) appeared in practice.

5.1. Insights on the transition towards a circular infrastructure sector

5.1.1. Towards different practices and approaches

The systemic character of the circularity transition came quickly to the fore in all participating groups, leading to the call for different practices and approaches. In considering the next steps towards transitioning to circular infrastructure, participants frequently encountered practical barriers stemming from the structural characteristics and dynamics of the sector. A significant issue appeared to be the extended lead times associated with infrastructure projects, resulting in decisions taking years, if not decades, to come to fruition. The benefits of circularity could take longer to materialize, spanning multiple decades. As argued by a consultant (CN3): "Circular choices should be made much earlier in the process. Because of the long lead times, you are just playing catch-up constantly." The sector's conservative and risk-averse culture emerged as a pervasive barrier, with one of the primary consequences being its limited appeal to creative, ambitious, and socially engaged talent, further exacerbated by the sector's labor shortage. Moreover, the sector's narrow profit margins, high risks, and high stakes explained the market parties' protective stance, prioritizing their short-term financial interests over circular solutions. Both public and private entities acknowledged the scarcity of competitive markets for circular solutions.

When reflecting on these barriers, participants also discussed ways forward, revealing multifaceted approaches. Notably, the deteriorating condition of existing infrastructure emerged as a pivotal factor in the transition. On the one hand, it presented opportunities for circular solutions such as extending the lifespan of infrastructure and promoting reuse. On the other hand, it posed challenges in prioritizing circularity within current infrastructure management paradigms. A regional infrastructure asset manager (DA1) pointed out: "No matter how much money we allocate to circularity, with the current approaches to managing infrastructure, we just won't make it". This sentiment was echoed by a contractor (CM1), who emphasized the need for transformative change: "Fully circular in 2050? How on earth could we manage this if we stick to the ways we did it in the past and continue doing it?". Given the multitude of challenges within the sector, with circularity being just one facet, it became evident that changes beyond circularity were imperative to realize the desired circularity goals.

The current dominant procurement and collaboration approaches have become a central domain of discussion in the workshop. These approaches have a strongly prescriptive character, offering little room for contractors to distinguish themselves in terms of circularity. However, new approaches were said to gain momentum, taking a more integrated perspective on asset lifecycle, asset portfolio, and stakeholder involvement. These procurement approaches prioritize collaboration skills, output quality, long-term benefits, and innovativeness, requiring market parties to adopt different practices to win tenders. Moreover, these approaches often include ambitious sustainability and circularity requirements, where quality-oriented market parties are argued to potentially better compete with cost-efficiency-oriented ones. While some participants foresaw challenges and financial losses for laggards, participants from both the public and private sector organizations indicated to accept this transformation, as articulated by a network organization manager (PM2): "Actors that don't want [to take part in the transition], will place themselves out of the market. I am convinced that, for example, when an SME doesn't make steps [on circularity], it won't exist anymore ten years from now." A significant debate revolved around asset ownership in revised business models. Circular business

models, such as producer-take-back systems and as-a-service contracts, were by many considered unhelpful due to the long lifespans of infrastructure assets. Participants argued that infrastructure is a public good and that ownership should, therefore, remain with public actors. This would limit the applicability of novel business models promoted in the CE discourse.

Nevertheless, novel procurement approaches were posited to strengthen the involvement and collaboration of stakeholders. Additionally, knowledge-driven entities, including universities and research institutes, could assume a more proactive role in co-developing solutions such as novel technologies and monitoring practices, thus expanding learning opportunities beyond individual projects. Research was stressed as a potentially critical enabler for justifying circular pathways and lending legitimacy to the selection of circular solutions, especially on the client side. Suppliers, a vital stakeholder group in the CE transition, were also anticipated to undergo substantial changes, particularly concerning their influence on the inflow of virgin materials and their potential to facilitate resource loop closures. However, their involvement in introducing substitute materials was foreseen to be challenging, given their vested interests in incumbent supply chains (e.g. concrete, steel), including profit motives. Notably, the utilization of scenarios within the microcosm setting appeared to be effective in sparking discussions that enhance the anticipation of forthcoming socio-technical changes, particularly considering stakeholder positioning.

5.1.2. Solutions and pathways towards circular infrastructure in 2050

The input scenarios sparked discussions on the various solution pathways towards circular infrastructure in 2050. It became apparent how infrastructure actors struggle to determine and steer the direction of solutions. Various participants emphasized that governance and organizational issues deserve priority over technological ones. However, these views on non-technological solutions were divergent. It appeared that an integral and relation-based approach to infrastructure management stages and stakeholders, such as involving contractors in pre-project stages or demolition companies in the design stage, is essential to achieve a circular sector. This requires new approaches to collaboration, procurement, contracting, and organizing. Although initiatives such as framework agreements and series-based approaches were mentioned as fruitful directions, they seemingly have not yet resulted in structural changes. Nevertheless, many participants, including a national government policymaker (PM1), considered these critical aspects for a future transition: "You need to become collectively part of a collaborative construction project team. You won't make it on your own, so this requires radically different ways of collaborating". A closer alignment between governments was argued to offer a collective perspective and create a level playing field for circular markets, which should match the long-term visions discussed earlier.

Participants explained that strategically investing in circular solutions would allow them to fulfill a particular duty towards society. At the same time, it could simultaneously provide them with a competitive advantage in the long term. Regarding technological solution pathways, the following directions were commonly discussed: a modular and adaptable design for reuse and lifespan extension, reducing emissions during construction and operation, reusing existing assets, components, and materials, and using low-impact and regenerative substitution materials. To illustrate the divergence of priorities, a sustainability consultant (DM2) stated: "We should focus on creating the conditions for future reuse by thinking about design principles that promote modularity and disassemblability […] since it is way easier to fix in long-term programming and less risky compared to reusing existing [infrastructure] that has never been designed, maintained, managed, or monitored to be reused". However, consensus emerged that a combination of these solutions is necessary, depending on the type of infrastructure asset and contextual factors. A public manager warned that some solutions that immediately contribute to circularity, such as high-quality recycling, merely increase efficiency in the current, linear system rather than promoting an inherently circular system. This could reinforce lock-ins and impede the attainment of long-term circularity goals.

During the MOTA workshop, participants' perspectives varied regarding the scale and radicality of socio-technical changes required for systemic transformation. While some advocated incremental steps to maintain feasibility, others championed the need for radical and holistic changes. An example of such a radical change involved the potential shift of asset ownership from government clients to market parties, incentivizing lifespan extension and reuse. This transformative step would necessitate a comprehensive restructuring of financing mechanisms, asset management practices, and risk management strategies. Conversely, some participants expressed skepticism about the likelihood and feasibility of such radical changes, irrespective of which stakeholder is taking the lead.

5.1.3. Roles, role perceptions, and interactions in transitions

Both public and private participants argued that, despite the need for inclusion, the government must take the lead in the transition towards the circularity mission in the infrastructure sector for several reasons. Firstly, the government established the mission and owns the infrastructure assets, giving them substantial power. Secondly, as asset owners, clients, and legislators, public clients possess the most effective tools to steer the transition compared to other stakeholders, including the ability to create and adapt markets. Thirdly, while it is a collective effort, other parties have comparatively less agency and fewer incentives to take the lead.

All these reasons meant that stakeholders allocated the primary responsibility for achieving the mission to the central government. To deal with the inherent subordination of market parties as contractors to public parties as clients, alignment between governments at all levels was mentioned to be essential for creating a collective action to develop and implement circular solutions. A municipal alderman (AM1) stated: "Only if you make collective agreements [as a local government], you can take steps in mobilizing the market." Achieving this was argued to require governmental interventions that guide solution pathways.

Despite the call for a guiding government, all participants encouraged the adoption of approaches with higher degrees of inclusion, mainly because governments tend to lack the skills and knowledge to formulate market conditions that promote circularity while remaining technically and organizationally feasible. A civil servant of the national government (DM1) argued: "[Including market parties] is the only way that it possibly could work. If civil servants are going to determine the technical specifications of a circular asset, then we have a big problem". While the central government may possess knowledge and capacity, its deficiency was argued to be more pressing for local governments. When involving market knowledge in infrastructure management, budgeting, and planning processes, new structures are necessary on the client side to enable collaborations beyond individual projects. However, an industrial policy maker (PM2) argued: "[Market parties] really appreciate these involvements because they are valued on their knowledge. This creates an equal and trust-based position at the table".

Several potential consequences associated with solution pathways came to the forefront of the discussion, which illustrates how greater alignment can be achieved. First, instilling a cultural shift within the sector necessitates a significant sense of urgency, a factor deemed unlikely to emerge organically. Various approaches were suggested, including inspirational lectures, integrating circularity into employment contracts across organizations, and utilizing stakeholder deliberations. Second, the call for broader and earlier stakeholder involvement was recognized as being in need for a more tentative approach, as prevailing procurement methods and organizational processes typically do not prioritize such inclusion. Lastly, participants noted that existing pilots and experiments often seem to be introduced on an ad hoc basis. Still, they could be significantly more effective if strategically linked to long-term visions aligned with CE goals, which promote learning and scaling.

5.1.4. Governance challenges of the mission-oriented transition in infrastructure

The insights above indicate that MOTA serves as a dynamic platform for stakeholders to collectively and deliberatively anticipate socio-technical changes induced by a mission. Participants seem better positioned to align their perspectives and collaborate towards sustainable solutions by actively engaging in discussions, sharing insights, and identifying barriers. Several insights potentially resonating with ways to govern and steer the transition are discussed below.

The public nature of our case has significant implications, particularly its dependence on short-term political cycles for budgets and objectives. This dependence is exacerbated by the Dutch construction industry's vertical and horizontal administrative fragmentation, making it challenging to introduce long-term perspectives for realizing circular markets. A lack of such perspectives becomes particularly problematic for societal challenges and missions dealing with contested solution spaces, which is the case for circular infrastructure. Not only does contestation hamper the mission's effectiveness, but it also sparks competition among public bodies for limited market capacity, with market parties favoring the least ambitious client.

The public and asset-based nature of the infrastructure sector puts public clients in a dual role. On the one hand, they need to define requirements for infrastructure projects, while, on the other, they are tasked with owning the infrastructure assets. The MOTA workshop revealed that clients actively engage in both the innovation enactment cycle, by shaping the conditions for innovation, and the selection cycle, for example, by acting as procurers of circular solutions or by acting as regulators (e.g., Lenderink et al., 2022). This blurs the boundary between those who initiate and those who select innovations, differentiating what has been called the enactment cycle of stakeholders within the innovation process from the selection cycle of external entities (Garud and Ahlstrom, 1997). Although the most intricate knowledge about infrastructure and novel circular technologies resides at the market side, clients were urged to act as change leaders because of their dual roles. Nevertheless, they were encouraged to involve market parties in defining solution pathways.

The results highlight a dilemma between incremental solutions that immediately increase circularity in construction projects (e.g., improving recycling efficiency) and radical solutions that are more challenging due to their systemic nature (e.g., closed supply-demand mechanisms for element reuse). While the former arguably risks creating a lock-in that prevents fundamental forms of circularity, the latter risks being too complex even though it holds long-term potential for achieving circularity goals. Discussions in the MOTA workshop often adopted a short to medium-term view on solutions of the former sort. However, at the same time, participants acknowledged that achieving systemic change in line with the mission necessitates a long-term perspective. This reconciliation becomes particularly challenging when mission goals are ambiguous – as with circularity – which complicates methods like back-casting. Governance frameworks introduced in recent literature, such as 'radical incrementalism' (Swilling, 2020) and the 'small wins framework' (Termeer and Dewulf, 2019), advocate incremental steps while pursuing long-term transformative change to address this tension. Such frameworks could prove valuable in empirical contexts of governing missions.

Finally, participants' discussions emphasize that the transition faces limited technological challenges. While discussions in both practice and literature often revolve around technological solutions and neglect social and institutional aspects, it is evident from the workshop discussions that organizational and institutional barriers represent the major impediments to the transition. Nevertheless, a substantial portion of experimentation and scientific research continues to concentrate on the technological facets of circular infrastructure, indicating a disconnect between recommendations and actions.

5.2. Appraising MOTA as a tool for mission governance

After discussing the insights that the MOTA approach generated for participants, this section illustrates how MOTA promoted the dimensions of social robustness, preparedness, awareness, and alignment for the envisioned mission governance outcomes as shown in Table 1.

5.2.1. Social robustness

The microcosm of our MOTA approach proved helpful in eliciting discussions beyond the narrow confines of individual stakeholder viewpoints. Regardless of differing viewpoints and animated debates, participants unanimously agreed that the workshop setting, characterized by its diverse participants, was instrumental in collectively charting a more robust path towards mission attainment. Illustrated by a board member of a governmental committee (BM1): "While most insights were not necessarily new, this approach reconfirms that it is a joint challenge to achieve the mission. It really stresses the importance of ambitious and predictably tightening mission goals". This statement underscores the importance of involving a diverse array of stakeholders to collectively appraise steps forward in mission attainment to absorb, adapt to, and benefit from the changes and innovation in line with the mission.

The involvement of diverse stakeholders in mission governance was argued to be crucial in creating more robust outcomes because both the challenges are too complex to be addressed by a single organization, and the interdependencies between the stakeholders require collective approaches. These discussions facilitated through MOTA led to greater recognition of each other's worldviews, with some stakeholders gaining an external perspective on their preconceived action perspectives. In these discussions, the mission, rather than specific solutions, remained at the center stage, which differed from earlier approaches to anticipatory deliberations, such as CTA.

An illustration of how the MOTA discussions promoted social robustness among the participants is the observation that the expectations and envisioned actor roles could shift stakeholders' power dynamics and mutual relations in the mission-oriented transition. As a result of these changing power dynamics, it was argued that novel interdependencies and power relations are likely to emerge between stakeholders. One example may involve other types of marketplaces to match demand and supply, for example, in the context of reusing materials. Additionally, the relationship between a portfolio planning (i.e., strategic management of a large set of infrastructure assets) and asset storage for reuse was said to require a reevaluation as the distinction between politicians and civil servants was obscured over the past decade. This calls for a decoupling of long-term circularity perspectives from short-cyclic political processes.

While assessing whether transition pathways are socially robust can only be determined in hindsight, the MOTA approach comprises several elements generally associated with social robustness. These include an inclusive yet heterogeneous setting, real-world grounding of the exercise, and elements of co-creation (cf. Harremoës et al., 2001). The discussion during the MOTA workshop was firmly grounded in practice by carefully selecting the sector's representation to include a wide diversity of perspectives. Moreover, the way MOTA helps in co-creating policy, through heterogeneous participation, offers a more nuanced consideration of sectoral dynamics. For instance, an alderman (AM1) argued: "These discussions between government and businesses are crucial to retain the confidence that it is a collective effort."

In conclusion, MOTA seemed to offer an inclusive governance approach that helped cope with the complexity ingrained in mission-oriented transitions. It appeared to assist stakeholders in identifying diverse values and worldviews while duly clarifying the unique governmental roles and responsibilities in the mission-oriented transition. The analysis of the discussions showed that the views of several participants on what the action perspectives should be prioritized changed based on particular solution pathways. As such, their position towards the transition appeared to be more firmly embedded in practice.

Despite these indications, only after these insights have been incorporated into policy can we definitively assess whether and to what extent MOTA strengthened the social robustness of missions.

5.2.2. Preparedness

Preparedness among the participants was mostly bolstered through the collective assessment of the transition scenarios. We observed various ways in which the anticipation of socio-technical changes took shape in the discussions. An example is the acknowledgment of industry actors that they bear a social responsibility in the transition. Another instance is the recognition that particular solution pathways could reinforce lock-ins and impede the attainment of long-term circularity goals. These insights were plenarily shared, enabling the participants to position themselves more effectively and strategically to the CE mission.

Survey results showed that participants generally regarded the scenarios as appropriate to structure discussions on future pathways because they allowed participants to take positions on which people could explicitly agree or disagree. By discovering each other's underlying arguments, the scenarios helped gain insights into wider system dynamics. Furthermore, the scenarios were argued to channel discussions towards concrete and plausible transition pathways. While some groups actively discussed the mission regarding its directionality and feasibility, others took the mission for granted and focused on desired pathways. The introduced pathways were highly contested, including how various stakeholders perceived and expected their roles in the future circular system. Although the moderators were equipped with guiding questions and a list of possible system tensions to steer the conversations, discussions between participants proceeded without much moderation, presumably because the scenarios provided enough input for in-depth debates. Not only did the scenarios contribute to increased anticipation, but the workshop discussions were argued to also strengthen the preparedness of the participants. For example, discussions revealed that the proposed changes would significantly impact stakeholders and their roles. This illustrates that MOTA helps participants anticipate transition dynamics, offering them insights to inform strategic decisions. Still, moderation was needed to avoid discussions going too much into (technological) specifics and short-term barriers to keep the long-term perspective needed to act in an anticipatory way concerning the mission.

In conclusion, the anticipatory character of MOTA proved helpful in addressing the uncertainty inherent in mission-oriented transitions. Scenarios serve as useful tools in preparing participants for a multitude of potential solutions, facilitating discussions that explicate agreement and disagreement. As the discussions venture into technological solutions, they underscore the complexity of the transition and the need for adaptability and flexibility in the face of evolving socio-technical systems. While the results indicate that the MOTA approach contributes to the preparedness of the participants, it requires an extended application, both throughout the sector and throughout time, to contribute to the preparedness of the entire socio-technical system.

5.2.3. Awareness

Survey results shed light on the efficacy of MOTA, with an overall appreciation for its ability to stimulate reflection among participants regarding their roles in the transition. Out of the fifteen respondents, six explicitly acknowledged that MOTA had strengthened their awareness regarding the collaborative and interdependent nature of the transition. Additionally, some participants noted they gained an appreciation for reused and bio-based alternatives, recognizing their significance in the transition. This was the result of both the discussions with others and the scenarios. These insights into diverse solution pathways were regarded as critical prerequisites for stimulating system-level changes. The survey, moreover, reaffirmed the absence of a shared direction concerning circular infrastructure, an overemphasis on technology, and an incomplete overview of promising circular developments within the sector. Notably, the case application suggested that MOTA supported network building, as participants actively sought the contact details of their peers to facilitate future communication.

By putting the mission centrally in the scenarios, the participants were forced in the discussion to reflect on their action perspective concerning the mission objectives, their ideas on the challenges to tackle, and the solution pathways necessary to address those. For instance, a sustainability manager (SM1) noted, "perhaps we should look beyond the currently formulated transition pathways for 2030. Still, these steps are hard to imagine; I don't fully comprehend how we can arrive there", illustrating how MOTA enables to more comprehensively put the mission considering daily practice. Throughout the MOTA discussions, divergent ideas emerged concerning preferred solutions, governance approaches, and organizational implications. Consequently, transparency in the various solution pathways increased, which is conditional for a more precise and coherent vision for the future of circular infrastructure. To explore such a vision, participants expressed the need for a multi-decade back-casting approach to determine ways forward. This implicit call for reflexivity increased awareness of the diversity of, sometimes conflicting, stakeholder ideas and positions and was argued to increase the stakeholders' ability to strategically position themselves in the transition towards a circular future.

In conclusion, the scenario-based discussions in MOTA provided participants with diverse perspectives on how to best achieve the mission. These deliberations are thought to not only empower participants to position themselves strategically within the transition but also make policymakers aware of what solution pathways should (not) be promoted. Notably, the participants did not always agree more with one another but gained a better understanding of each other's perspectives. Similar to the preparedness dimension, these results improved the awareness of the specific group of participants rather than the system as a whole. Nevertheless, the impact likely extends beyond the participants as it also increases the policymakers' awareness of the sectoral dynamics and considerations with respect to the mission-oriented transition.

5.2.4. Alignment

As the MOTA scenarios take the status quo as an entry point, they incorporate forms of tentative governance to foster alignment as new insights emerge. In doing so, it aims to support the participants' responsiveness to the transition by exploring ways in which they can position themselves. This responsiveness also includes solution configurations and policy adaptations.

While most participants indicated that the discussions on the diverse perspectives were helpful, some expressed frustration when learning about the misalignment between the participants' outlook on the transition. This frustration was voiced by a consultant (DM2) who stated: "This is – again – a platform in which we all keep dreaming and talking, while there are so many ways in which we just can start doing things. We only need to define the concept by making its parts measurable". Despite this statement, participants widely recognized the significance of diverse discussions to better align their perspectives with each other, with policies, and with solution directions. A greater alignment between governments was argued to offer a collective perspective and create a level playing field for circular markets, which should match the long-term visions discussed earlier. The MOTA discussions helped consider such continuous collaboration in the transition effort.

The identification and sharing of barriers proved instrumental in defining actions for the participants. While discussing such barriers in a MOTA setting could appear demotivating or even paralyzing, it seemed to help align various perspectives on ways forward while avoiding or removing such barriers. For instance, several participants strongly argued that as-a-service business models would generally not work in infrastructure because most infrastructure was considered unquestionably a public good. As an illustration, a sustainability consultant (DM1) argued: "Citizens pay taxes to get these assets financed, so it would be strange to put these things on the balance sheets of commercial companies." This, in turn, convinced other participants not to pursue

solution pathways in that direction and to aim for collaborative approaches that more equally share the risk in infrastructure development. The scenarios were argued to show the repercussions of not responding adequately to specific challenges, which motivated individuals to act.

Furthermore, these insights hold the potential to inform policymaking geared towards effectively navigating the evolving landscape of the transition. For instance, pilot projects and experiments were considered significantly more effective if strategically linked to long-term visions aligned with CE goals, thereby promoting learning and scaling. These insights show how MOTA helped mobilize actors to participate and position themselves in the transition. Various examples emerged during the MOTA discussions to amplify the responsiveness of stakeholders. For example, the heightened focus on multiple lifecycles was expected to elevate the role of demolition contractors during the design and construction phases. In sum, through a tentative way of collectively appraising steps forward, MOTA seemed able to align stakeholders' action perspectives more with each other's views and with the mission objectives.

6. Discussion

In this paper, we conceptually developed, demonstrated, and reflected upon MOTA as a mission governance approach to deal with the complexity, uncertainty, contestation, and subsequent intractability of wicked problems and the associated mission-oriented transition. Our case applications for the mission towards a circular infrastructure industry in 2050 show how such an approach brings together stakeholders to reflexively anticipate possible, probable, and desirable outcomes and mission pathways, not by making predictions but by articulating and sharing expectations. Doing so strengthened the preparedness and awareness of stakeholders and improved the social robustness and alignment of their action perspectives. By articulating stakeholders' worldviews and values, MOTA addresses the urgent but unresolved question of "what is considered a desirable future, and (even if we assume consensus) how do we get there?" (Patterson et al., 2017, p. 8). As such, it aims to improve the governance and co-construction of mission-oriented transitions. In the remainder of the section, we discuss the implications of the case findings for mission-oriented transitions and reflect on MOTA's practical and theoretical implications.

6.1. Discussion of the findings

Through our research approach, first-order insights were gained regarding the structural transition barriers, possible ways forward, and the respective implications for stakeholders, roles, and forms of collaboration. As discussed in Chapter 5, these insights informed the participating policymakers on how to accelerate and shape missions. Notably, the application of scenarios in the workshop setting was regarded as helpful in preparing the participants for uncertainty, considering the broad range of potential solution configurations to address the mission. Second-order reflexivity emerged regarding the meaning, desirability, and feasibility of CE in the infrastructure context. While scholars argue that missions should be bold (Mazzucato, 2018b), stakeholders openly questioned the feasibility of the mission in the first place, which may undermine the legitimacy of the mission (Elzinga et al., 2023). This raised the dilemma of whether the mission formulation and strategy should be adjusted or if policymakers should value continuity. Nevertheless, results confirmed the value of using missions for providing direction and acting as boundary objects (cf. Janssen et al., 2023; McLaren and Kattel, 2025).

While it is argued that missions should be formulated precisely (Mazzucato, 2018b), precise definitions are often impossible given the complexity, uncertainty, and contestation associated with wicked problems (Head, 2022). Many participants held different understandings of circularity and advocated clearer visions and definitions before changing and monitoring practices. Simultaneously, policymakers argued that they did not possess sufficient knowledge, prompting standstill or waiting games (Parandian et al., 2012). As a result, mission governance was met with tensions between dimensions of directionality and feasibility and between clarity and open-endedness (cf. Bulah et al., 2024). Tentative governance could resolve this issue by stipulating that there is no straightforward answer and that decisions must be made while acknowledging an insufficiency of knowledge and diversity in stakeholder perspectives (Kuhlmann et al., 2019; Stilgoe et al., 2013; Taebi et al., 2020).

Change-oriented leadership coupled with broader stakeholder involvement could help overcome the 'waiting games' between market players seeking clarity on solution pathways and clients awaiting proven circular solutions (Parandian et al., 2012). Nevertheless, fragmented governance complicates such a guiding role, leading to policy coordination failures (Weber and Rohracher, 2012). One approach to address this failure is the subsidiarity principle, which calls for aligning national and supranational goals with local contexts to meet local conditions (Wanzenböck and Frenken, 2020). Results simultaneously call for intergovernmental alignment on preferred solution pathways to reduce market uncertainty and encourage investments in promising solutions that could transcend individual projects or contexts. Such an approach would also help consider the geographical and scale-dependent contexts in which missions are implemented (Uyarra et al., 2025). Although full alignment is not always possible, MOTA may help foster alignment through forms of reflexivity and inclusion of stakeholders in line with the principles of agonistic governance. Such agonism promotes decision-making while acknowledging fundamental and often irreconcilable disagreements (Popa et al., 2021; Scott, 2021) and thus represents one way of dealing with intractability.

6.2. Implications for practice and theory

Participatory, anticipatory, reflexive, and tentative governance require additional efforts to be effective (Wiarda et al., 2024). The uncertainty and non-linearity result in the continuous emergence of novel determinants on the progression of the transition. Similarly to SF and Real-Time Technology Assessment (Guston and Sarewitz, 2002; Voß et al., 2006), MOTA could benefit from being performed periodically throughout mission life cycles (e.g., mission formulations, implementations, and evaluations) to support governance along the way and serve as a monitoring exercise. Previous insights could inform new assessment exercises to support incremental mission governance and refine scenarios with novel developments, experiences, and insights, further promoting reflexivity and anticipation – and eventually mission-oriented innovation policy adaptation.

The results have been presented following the four governance outcomes used to structure the text. However, the governance modes are not mutually exclusive, nor does one mode specifically lead to one of the four governance outcomes (cf. Head, 2022; Stilgoe et al., 2013). Results confirm this overlap and interplay in several ways. For example, the participatory approach inherent to MOTA contributes to the preparedness of stakeholders, as the discussions between the participants generate interactions that result in the anticipation of the next transition steps. An even more explicit overlap is the tentative governance mode that builds on reflexive and anticipatory governance modes (Kuhlmann et al., 2019). Therefore, tentative governance not only leads to alignment but also to the other three outcomes. Resultingly, MOTA must be understood as an operationalized approach that builds upon and addresses the four governance modes to elicit the four outcomes in mutual coherence.

MOTA was primarily developed to operationalize the mission governance framework by Wiarda et al. (2024) as a way to support the midstream governance processes (cf. Janssen et al., 2021) in order to deal with wickedness and prevent transformative failures (Schot and Steinmueller, 2018). Nevertheless, the results suggest that creating a 'microcosm' also serves as a platform that addresses structural system

failures (cf. Weber and Rohracher, 2012). For instance, MOTA could potentially play an important intermediary function by connecting heterogeneous stakeholders, stimulating possible interaction, and addressing network failures. It furthermore led to a melting pot of new ideas and perspectives, creating spaces similar to 'small worlds' (Watts and Strogatz, 1998), 'trading zones' (Galison, 1997), 'local buzz' (Bathelt et al., 2004), and 'hybrid forums' (Callon et al., 2009) in which stakeholders can obtain and exchange both explicit and tacit knowledge for decision-making. Doing so, it may potentially contribute to transformative change at large (Vermaak, 2013). Future research could explore how such spaces could act as 'mission arenas' to govern missions collectively (Elzinga et al., 2023; Wesseling and Meijerhof, 2023), yet this would require a more nuanced reconsideration on what actors to involve.

The MOTA's application to the circular infrastructure mission allowed us to explore how it helps operationalize the mission governance framework and formatively assess the mission itself. Similarly to comparable approaches like CTA and SF, MOTA does not necessarily facilitate the allocation of responsibilities related to action and implementation (cf. Schot and Rip, 1997; Voß et al., 2006). A way to deal with this is not to view MOTA as a mere tool for innovation policy, but as a means to include policymakers who can affect the mission-oriented system (e.g., in our case, from the infrastructure department). Against this lens, MOTA becomes a complementary approach that adds another layer of reflexivity to better ground policy decisions in real-world dynamics.

For a broader use of MOTA, it is crucial to highlight that scenarios should be linked to the transition stage to which MOTA is applied. In our case, the circular infrastructure transition was at an early stage (Bours et al., 2022; Coenen et al., 2023), while a more institutionalized transition would be associated with a more convergent solution space (Wanzenböck et al., 2020). Moreover, our study considered the public sector, i.e., infrastructure, which demands a distinct role of governments in sustainability transitions compared to other sectors (Borrás et al., 2024). These differences would likely require and invoke other types of scenario-based discussions. When preparing the MOTA workshop, the researchers developed scenarios using previous case-related studies. These scenarios could alternatively be developed inclusively, potentially resulting in other focal points and possible transition pathways deemed more acceptable, legitimate, and desirable (cf. Truffer et al., 2008). Ultimately, combining responsibilities of anticipation, inclusion, reflexivity, and presumably responsiveness could enable forms of 'collective stewardship,' potentially leading to more desirable outcomes (Stilgoe et al., 2013). Besides scenarios, other ways would be worth exploring to substantiate the discussions regarding complexity, uncertainty, contestation, and intractability, such as serious games, artworks, and role plays.

MOTA was employed to assess a specific mission and encouraged participants to consider the systemic consequences of a circular sector. The discussions that were fed by the predeveloped scenarios helped anticipate a circular system specifically. However, the reality is complex, with multiple missions and broader coinciding developments interconnected with the sector. Focusing solely on one mission may lead to blind spots for other sectoral developments. Therefore, it could be helpful to present MOTA results alongside other findings when informing policy to offer a range of pathways and potential interactions that help avoid the pitfalls of narrow, single-mission perspectives.

Finally, for participating actors, which could include both niche actors and incumbents, there are several managerial implications as well as reasons to either participate or not (Delmas et al., 2019). Participation in a MOTA process offers an opportunity to gain early visibility and legitimacy by positioning their strategies and interventions within credible transition pathways, while also helping them anticipate systemic shifts and align with emerging policies. Moreover, those organizations may benefit from anticipatorily translating abstract missions into concrete strategic actions and adapting themselves towards long-term goals in line with systemic changes. Furthermore, firms – especially the more powerful ones – may exercise leadership, influence policy direction, and reflect on their institutional roles in shaping or responding to missions. However, these benefits for organizations simultaneously pose risks for the broader MOTA processes, in which actors might exert disproportionately protective or opportunistic behavior, with negative benefits for the foresight activities and, by extensions, mission governance at large (cf. Avelino and Wittmayer, 2016). This could lead to power (im)balances in the microcosm that do not represent the real-world system's dynamics (Rosa et al., 2021). Prevention of such dynamics requires significant effort from the organizers and moderators, both during the preparation, execution, and analysis of interactions (Smith and Raven, 2012; Zambrano-Gutiérrez et al., 2023).

7. Conclusions and future research

In this paper, we develop, demonstrate, and reflect upon MOTA as an approach to govern mission-oriented transitions through reflexive and anticipatory deliberations by adopting the mission governance framework by Wiarda et al. (2024). In doing so, we draw from various streams of literature, including wicked problems, technology assessment, responsible innovation, and mission-oriented innovation policies (MOIP). The resulting procedural approach facilitates anticipation, inclusion, reflexivity, and responsiveness, which are identified to be necessary for dealing with the wickedness associated with mission-oriented transitions. To appraise transition pathways, we employed explorative scenarios as input for collective deliberations involving a diverse set of stakeholders (i.e., microcosm). In this paper, we not only developed the conceptual framework of MOTA but also demonstrated its application in practice. We applied it to the Dutch 'Circular infrastructure by 2050' case. Both the participants' reflections and the analyses of the discussions suggest that MOTA contributes to the preparedness and awareness of stakeholders while yielding more socially robust and socially aligned action perspectives.

The MOTA approach yielded various action perspectives for stakeholders of the transition towards a circular infrastructure sector. The approach was generally regarded as helpful by the case-specific participants, and several insights resulted from the discussion that offered input for policies. Considering the limited opportunities for summative assessments, the single-case application underlines the potential for further conceptualizing, testing, and advancing MOTA as a formative tool for mission governance. More broadly considered, MOTA offers a practical approach that addresses important challenges associated with the governance of missions, such as a lack of coordination between policymakers and multiple stakeholders or the disconnect between bottom-up experimentation and top-down directionality. Here, MOTA must be considered as a complementary approach that could strengthen existing policymaking approaches by firmer grounding them in real-world transition dynamics. In larger mission-oriented initiatives, such as the EU missions, coordinating the various stakeholders and aligning their efforts regarding the mission can be complex. In this regard, MOTA offers an easy-to-adopt approach for establishing an initial governance structure while creating a shared platform for stakeholder interaction.

The conceptual and single-case approach to our study inevitably comes with limitations that can be addressed by future research. First and foremost, our deductive and case-based approach allowed us to explore how MOTA could work in practice and yielded novel insights for researchers and participants. Its ability to promote the envisioned outcomes of bolstering preparedness, social robustness, awareness, and alignment requires more applications throughout time and within related cases to allow for the comprehensive ex-post evaluation of the MOTA approach. Future studies could provide a better understanding of whether and how the MOTA approach feeds into practice in the long run.

Beyond the results retrieved from the workshop, research can

explore the adoption of MOTA results by policymakers to reveal, for instance, whether and how MOTA contributes not only to the alignment of participant perspectives but also to the alignment of the mission, mission formulation, and related strategies. This requires analyses in the domain of mission governance and related policy-making bodies. A real-time form of MOTA could reveal how it can be used as a long-term monitoring approach. Research should further investigate the applicability of MOTA on other scales of mission-oriented governance. Further inquiry could help understand the interactions between national and supranational missions, such as the governance of EU missions by national governments. We believe that applying MOTA to higher levels of government (e.g., supranational) will likely face additional challenges in terms of stakeholder participation because it could add complexity to the stakeholder field.

To conclude, we present MOTA as a reflective approach to mission governance, emphasizing stakeholder participation for a collective appraisal of action perspectives related to mission-oriented transitions in order to tentatively adapt these in response to stakeholder feedback and changing circumstances. As such, our aim would be to introduce and position MOTA as an approach that contributes to better shaping mission-oriented transitions in response to the grand societal challenges of our time.

Acknowledgements and funding statement

We would like to express our gratitude to the Rijkswaterstaat infrastructure agency for their financial support of this study. This paper was furthermore supported by the European Union's Horizon 2020 research and innovation program Co-Change [grant number 873112] and Pro-Ethics [grant number 872441]. We would also like to extend our appreciation to the workshop participants for their invaluable contributions and time as well as to Max de Vries who supported us with the data collection. Finally, we like to thank Erik Fisher for his valuable input during the conceptual development of this paper.

CRediT authorship contribution statement

Tom B.J. Coenen: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Conceptualization. **Martijn Wiarda:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Conceptualization. **Klaasjan Visscher:** Writing – review & editing, Methodology, Investigation, Conceptualization. **Caetano C.R. Penna:** Writing – review & editing, Writing – original draft, Conceptualization. **Leentje Volker:** Writing – review & editing, Writing – original draft, Investigation, Conceptualization.

Data availability

Data will be made available on request.

References

Alford, J., Head, B.W., 2017. Wicked and less wicked problems: a typology and a contingency framework. Policy and Society 36 (3), 397–413. https://doi.org/10.1080/14494035.2017.1361634.

Amanatidou, E., Butter, M., Carabias, V., Könnölä, T., Leis, M., Saritas, O., Schaper-Rinkel, P., van Rij, V., 2012. On concepts and methods in horizon scanning: lessons from initiating policy dialogues on emerging issues. Science and Public Policy 39 (2), 208–221. https://doi.org/10.1093/scipol/scs017.

Amer, M., Daim, T.U., Jetter, A., 2013. A review of scenario planning. Futures 46, 23–40. https://doi.org/10.1016/j.futures.2012.10.003.

Arthur, B., 1989. Competing technologies, increasing returns, and lock-in by historical events. Econ. J. 99 (394), 116–131.

Avelino, F., Wittmayer, J.M., 2016. Shifting power relations in sustainability transitions: a multi-actor perspective. J. Environ. Policy Plan. 18 (5), 628–649. https://doi.org/10.1080/1523908X.2015.1112259.

Barben, D., Fisher, E., Selin, C., Guston, D.H., 2007. Anticipatory governance of nanotechnology: foresight, engagement, and integration. In: Handbook of Science and Technology Studies, Vol. 24, pp. 979–1000. https://doi.org/10.2307/2076663 (Issue 6).

Bathelt, H., Malmberg, A., Maskell, P., 2004. Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. Prog. Hum. Geogr. 28 (1), 31–56. https://doi.org/10.1191/0309132504ph469oa.

Bauer, A., Bogner, A., Fuchs, D., 2021. Rethinking societal engagement under the heading of Responsible Research and Innovation: (novel) requirements and challenges. J. Responsible Innov. 0 (0), 1–22. https://doi.org/10.1080/23299460.2021.1909812.

Bleijenberg, A.N., 2021. Renewal of civil infrastructure, Dutch national forecast for replacement and renovation. www.tno.nl.

Boni, A., Velasco, D., Molas-Gallart, J., Schot, J., 2023. Evaluating transformative innovation policy in a formative way: insights from Vinnova's food mission experiment. Research Evaluation 32 (3), 577–590. https://doi.org/10.1093/reseval/rvad029.

Börjesona, L., Höjer, M., Dreborg, K.-H., Ekvall, T., Finnveden, G., 2006. Scenario types and techniques: towards a user's guide. Futures 38, 723–739. https://doi.org/10.1016/j.futures.2005.12.002.

Borrás, S., Haakonsson, S., Hendriksen, C., Gerli, F., Poulsen, R.T., Pallesen, T., Somavilla Croxatto, L., Kugelberg, S., Larsen, H., 2024. The transformative capacity of public sector organisations in sustainability transitions. Environ. Innov. Soc. Trans. 53. https://doi.org/10.1016/j.eist.2024.100904.

Bours, S., Swartjes, J., Hekkert, M., 2022. Transitie naar een circulaire grond-, weg- en waterbouw - Een missie-gedreven innovatie systeem analyse. https://circulairebouweconomie.nl/wp-content/uploads/2023/01/Bours-et-al.-2022.-Transitie-naar-een-circulaire-GWW.pdf.

Brown, R., 2021. Mission-oriented or mission adrift? A critical examination of mission-oriented innovation policies. Eur. Plan. Stud. 29 (4), 739–761. https://doi.org/10.1080/09654313.2020.1779189.

Bugge, M.M., Fevolden, A.M., 2019. Mission-oriented innovation in urban governance: setting and solving problems in waste valorisation. From Waste to Value: Valorisation Pathways for Organic Waste Streams in Circular Bioeconomies 91–106. https://doi.org/10.4324/9780429460289-5.

Bulah, B.M., van Mierlo, B., Beumer, K., Gerritsen, A.L., Negro, S.O., Hekkert, M.P., Klerkx, L., 2024. Diversity and directionality: friends or foes in sustainability transitions? Science and Public Policy 00 (00), 1075–1092. https://doi.org/10.1093/scipol/scae044.

Callon, M., Lascoumes, P., Barthe, Y., 2009. Acting in an Uncertain World an Essay on Technical Democracy. MIT Press.

Campbell, M.C., 2003. Intractability in environmental disputes: exploring a complex construct. J. Plan. Lit. 17 (3), 360–371. https://doi.org/10.1177/0885412202239138.

Coenen, T.B.J., 2024. Governing the Mission-oriented Transition Towards a Circular Infrastructure Sector: From Ideals to New Socio-technical Systems [University of Twente]. https://doi.org/10.3990/1.9789036560252.

Coenen, T.B.J., Visscher, K., Volker, L., 2023. A systemic perspective on transition barriers to a circular infrastructure sector. Constr. Manag. Econ. 41 (1), 22–43. https://doi.org/10.1080/01446193.2022.2151024.

Collingridge, D., 1980. The Social Control of Technology. Martin's Press, St.

Dave, B., Koskela, L., 2009. Collaborative knowledge management-a construction case study. Autom. Constr. 18 (7), 894–902. https://doi.org/10.1016/j.autcon.2009.03.015.

David, P., 1995. Clio and the economics of QWERTY. Ninety-Seventh Annual Meeting of the American Economic Association 75 (2), 332–337.

Delmas, M.A., Lyon, T.P., Maxwell, J.W., 2019. Understanding the role of the corporation in sustainability transitions. Organ. Environ. 32 (2), 87–97. https://doi.org/10.1177/1086026619848255.

Dery, D., 1984. Problem Definition in Policy Analysis. University Press of Kansas.

Dosi, G., 1982. Technological paradigms and technological trajectories. 1982, 147–162.

Eames, M., McDowall, W., 2010. Sustainability, foresight and contested futures: exploring visions and pathways in the transition to a hydrogen economy. Tech. Anal. Strat. Manag. 7325. https://doi.org/10.1080/09537325.2010.497255.

EC, DGRI, 2023. EU Missions: implementation at the national level. https://data.europa.eu/doi/10.2777/788981.

Edler, J., Ostertag, K., Schuler, J., 2024. Social innovation, transformation, and public policy: towards a conceptualization and critical appraisal. Science and Public Policy 51 (1), 80–88. https://doi.org/10.1093/scipol/scad054.

Edmondson, D., Flachsland, C., Aus Dem Moore, N., Koch, N., Koller, F., Gruhl, H., Brehm, J., 2024. Anticipatory climate policy mix pathways: a framework for ex-ante construction and assessment applied to the road transport sector. Forthcoming in Climate Policy 25 (3), 438–467. https://doi.org/10.1080/14693062.2024.2397440.

EIB, 2021. Bedrijfs-economische kencijfers b&u- en gww-bedrijven 2019 (Economisch Instituut voor de Bouw).

Elzinga, R., Janssen, M.J., Wesseling, J., Negro, S.O., Hekkert, M., 2023. Assessing mission-specific innovation systems: towards an analytical framework. Environ. Innov. Soc. Trans. 48 (100745). https://doi.org/10.1016/j.eist.2023.100745.

European Commission, 2018. Mission-Oriented Research and Innovation: Assessing the Impact of a Mission-Oriented Research and Innovation Approach (Issue April). https://doi.org/10.2777/373448.

Farrell, R., Hooker, C., 2013. Design, science and wicked problems. Des. Stud. 34 (6), 681–705. https://doi.org/10.1016/j.destud.2013.05.001.

Ferraro, F., Etzion, D., Gehman, J., 2015. Tackling grand challenges pragmatically: robust action revisited. In: Organization Studies, Vol. 36, pp. 363–390. https://doi.org/10.1177/0170840614563742 (Issue 3).

Fisher, E., 2005. Lessons learned from the Ethical, Legal and Social Implications program (ELSI): planning societal implications research for the National Nanotechnology. Program 27, 321–328. https://doi.org/10.1016/j.techsoc.2005.04.006.
Fishkin, J.S., 2018. Random assemblies for lawmaking? Prospects and limits. Politics and Society 46 (3), 359–379. https://doi.org/10.1177/0032329218789889.
Folke, C., Hahn, T., Olsson, P., Norberg, J., 2005. Adaptive governance of social-ecological systems. Annu. Rev. Env. Resour. 30, 441–473. https://doi.org/10.1146/annurev.energy.30.050504.144511.
Galison, P., 1997. Image and Logic: A Material Culture of Microphysics. University of Chicago press.
Garud, R., Ahlstrom, D., 1997. Technology assessment: a socio-cognitive perspective. Journal of Engineering and Technology Management - JET-M 14 (1), 25–48. https://doi.org/10.1016/S0923-4748(97)00005-2.
Garud, R., Gehman, J., 2012. Metatheoretical perspectives on sustainability journeys: evolutionary, relational and durational. Research Policy 41 (6), 980–995. https://doi.org/10.1016/j.respol.2011.07.009.
Geels, F.W., 2005. The dynamics of transitions in socio-technical systems: a multi-level analysis of the transition pathway from horse-drawn carriages to automobiles (1860-1930). Technology Analysis and Strategic Management 17 (4), 445–476. https://doi.org/10.1080/09537320500357319.
Giorgi, S., Lavagna, M., Wang, K., Osmani, M., Liu, G., Campioli, A., 2022. Drivers and barriers towards circular economy in the building sector: stakeholder interviews and analysis of five European countries policies and practices. J. Clean. Prod. 336 (December 2021), 130395. https://doi.org/10.1016/j.jclepro.2022.130395.
Graaff, S.E. De, Wanzenböck, I., Frenken, K., 2025. The politics of directionality in innovation policy through the lens of policy process frameworks. Science and Public Policy scae083, 1–15. https://doi.org/10.1093/scipol/scae083.
Grin, J., Grunwald, A., 2000. Vision Assessment: Shaping Technology in 21st Century Society. Springer, Berlin.
Grin, J., Rotmans, J., Schot, J., Geels, F.W., Loorbach, D., 2010. Transitions to Sustainable Development: New Directions in the Study of Long Term Transformative Change, 1st ed. Routledge.
Guston, D.H., Sarewitz, D., 2002. Real-time technology assessment. Technol. Soc. 24 (1–2), 93–109. https://doi.org/10.1016/S0160-791X(01)00047-1.
Haddad, C.R., Nakić, V., Bergek, A., Hellsmark, H., 2022. Transformative innovation policy: a systematic review. Environ. Innov. Soc. Trans. 43, 14–40. https://doi.org/10.1016/j.eist.2022.03.002.
Harremoës, P., Gee, D., MacGarvin, M., Stirling, A., Keys, J., Wynne, B., Guedes Vaz, S., 2001. Late lessons from early warnings: the precautionary principle 1896–2000. In: Environment Issue Report. https://doi.org/10.4324/9781315071985-14 (Issue 22).
Head, B.W., 2008. Wicked problems in public policy. In: Public Policy, Vol. 3. Springer (Issue 2).
Head, B.W., 2022. Wicked Problems in Public Policy: Understanding and Responding to Complex Challenges, 1st ed. Palgrave Macmillan Cham. https://doi.org/10.1007/978-3-030-94580-0.
Hekkert, M., Janssen, M.J., Wesseling, J.H., Negro, S.O., 2020. Mission-oriented innovation systems. Environ. Innov. Soc. Trans. 34 (November 2019), 76–79. https://doi.org/10.1016/j.eist.2019.11.011.
Hermann, R.R., Pansera, M., Nogueira, L.A., Monteiro, M., 2022. Socio-technical imaginaries of a circular economy in governmental discourse and among science, technology, and innovation actors: a Norwegian case study. Technological Forecasting and Social Change 183 (August), 121903. https://doi.org/10.1016/j.techfore.2022.121903.
Hoffman, J., Pelzer, P., Albert, L., Béneker, T., Hajer, M., Mangnus, A., 2021. A futuring approach to teaching wicked problems. J. Geogr. High. Educ. 45 (4), 576–593. https://doi.org/10.1080/03098265.2020.1869923.
Hoffmann-Riem, H., Wynne, B., 2002. In risk assessment, one has to admit ignorance. Nature 416 (6877), 123. https://doi.org/10.1038/416123a.
Hofman, P.S., Elzen, B.E., Geels, F.W., 2004. Sociotechnical scenarios as a new policy tool to explore system innovations: co-evolution of technology and society in the Netherland's electricity domain. Innov. Manag. Policy Pract. 6 (2), 344–360. https://doi.org/10.5172/impp.2004.6.2.344.
IenW, EZK, 2016. Nederland Circulair in 2050. Rijksoverheid. https://www.rijksoverheid.nl/onderwerpen/circulaire-economie/documenten/rapporten/2016/09/14/circulaire-economie.
Ison, R.L., Collins, K.B., Wallis, P.J., 2014. Institutionalising social learning: towards systemic and adaptive governance. Environ Sci Policy 53, 105–117. https://doi.org/10.1016/j.envsci.2014.11.002.
Janssen, M.J., 2020. Post-Commencement Analysis of the Dutch 'Mission-Oriented Topsector and Innovation Policy' Strategy.
Janssen, M.J., Abbasiharofteh, M., 2022. Boundary spanning R&D collaboration: key enabling technologies and missions as alleviators of proximity effects? Technological Forecasting and Social Change 180 (April), 121689. https://doi.org/10.1016/j.techfore.2022.121689.
Janssen, M.J., Torrens, J., Wesseling, J.H., Wanzenböck, I., 2021. The promises and premises of mission-oriented innovation policy - a reflection and ways forward. Science and Public Policy 48 (3), 438–444. https://doi.org/10.1093/scipol/scaa072.
Janssen, M.J., Wesseling, J.H., Torrens, J., Weber, K.M., Penna, C., Klerkx, L., 2023. Mission as a boundary objects for transformative change: understanding coordination across policy, research, and stakeholder communities. Science and Public Policy scac080.
Jentoft, S., Chuenpagdee, R., 2009. Fisheries and coastal governance as a wicked problem. Mar. Policy 33 (4), 553–560. https://doi.org/10.1016/j.marpol.2008.12.002.
Kirchherr, J., Hartley, K., Tukker, A., 2023. Missions and mission-oriented innovation policy for sustainability: a review and critical reflection. Environmental Innovation and Societal Transitions, xxxx 100721. https://doi.org/10.1016/j.eist.2023.100721.
Klerkx, L., Rose, D., 2020. Dealing with the game-changing technologies of Agriculture 4.0: how do we manage diversity and responsibility in food system transition pathways? Glob. Food Secur. 24 (October 2019), 100347. https://doi.org/10.1016/j.gfs.2019.100347.
Klerkx, L., Begemann, S., Janssen, M.J., 2024. Mission Co-Creation and the Balance between Exploitative and Explorative Innovation: Insights from the Dutch Circular Agriculture Transition. Science and Public Policy.
Klerkx, L., Begemann, S., Janssen, M., 2025. Mission cocreation or domination? Explorative and exploitative forces in shaping the Dutch circular agriculture mission. Science and Public Policy 52 (1), 128–145. https://doi.org/10.1093/scipol/scae061.
Köhler, J., Geels, F.W., Kern, F., Markard, J., Onsongo, E., Wieczorek, A., Alkemade, F., Avelino, F., Bergek, A., Boons, F., Fünfschilling, L., Hess, D., Holtz, G., Hyysalo, S., Jenkins, K., Kivimaa, P., Martiskainen, M., McMeekin, A., Mühlemeier, M.S., Wells, P., 2019. An agenda for sustainability transitions research: state of the art and future directions. Environ. Innov. Soc. Trans. 31 (January), 1–32. https://doi.org/10.1016/j.eist.2019.01.004.
Kostoff, R.N., Schaller, R.R., 2001. Science and technology roadmaps. IEEE Transactions on Engineering Management 48 (2), 132–143. https://doi.org/10.1109/17.922473.
Kuhlmann, S., Rip, A., 2018. Next-generation innovation policy and grand challenges. Science and Public Policy 45 (4), 448–454. https://doi.org/10.1093/SCIPOL/SCY011.
Kuhlmann, S., Stegmaier, P., Konrad, K., 2019. The tentative governance of emerging science and technology—a conceptual introduction. Research Policy 48 (5), 1091–1097. https://doi.org/10.1016/j.respol.2019.01.006.
Kuhn, T., 1962. The Structure of Scientific Revolutions. The University Chicago Press.
Kuitert, L., 2021. The Balancing Act - how Public Construction Clients Safeguard Public Values in a Changing Construction Industry. Delft University of Technology (PhD Thesis.).
Kuittinen, H., Velte, D., 2018. Mission-Oriented R&I Policies: in- depth case studies: Energiewende (Germany): case study report. In Publication office. https://doi.org/10.1080/15459620802208784.
Kuk, G., Faik, I., Janssen, M., 2023. Editorial technology assessment for addressing grand societal challenges. IEEE Trans. Eng. Manag. 70 (3), 1055–1060. https://doi.org/10.1109/TEM.2022.3233460.
Laatsit, M., Grillitsch, M., Fünfschilling, L., 2025. Great expectations: the promises and limits of innovation policy in addressing societal challenges. Res. Policy 54 (3), 1–24. https://doi.org/10.1016/j.respol.2025.105184.
Larrue, P., 2021. The design and implementation of mission-oriented innovation policies: A systemic policy approach to address societal challenges Issue 100.
Larrue, P., 2024. Monitoring and Evaluation of Mission-Oriented Innovation Policies: From Theory to Practice (EU-SPRI Annual Conference).
Lehoux, P., Miller, F.A., Williams-Jones, B., 2020. Anticipatory governance and moral imagination: methodological insights from a scenario-based public deliberation study. Technological Forecasting and Social Change 151 (October 2019), 119800. https://doi.org/10.1016/j.techfore.2019.119800.
Lenderink, B., Boes, J., Halman, J.I.M., Voordijk, H., Dorée, A.G., 2022. The development of a typology and guideline for selecting innovation-encouraging procurement strategies in civil engineering. Innovation: The European Journal of Social Science Research 1–35. https://doi.org/10.1080/13511610.2022.2094898.
Lindner, R., Daimer, S., Beckert, B., Heyen, N., Koehler, J., Teufel, B., Warnke, P., Wydra, S., 2016. Addressing directionality: orientation failure and the systems of innovation heuristic. Towards reflexive governance Fraunhofer ISI Discussion Papers-Innovation Systems and Policy Analysis, No. 52. Fraunhofer ISI. www.econstor.eu.
Loorbach, D., 2010. Transition management for sustainable development: a prescriptive, complexity-based governance framework. Governance 23 (1), 161–183. https://doi.org/10.1111/j.1468-0491.2009.01471.x.
Mazzucato, M., 2017. Mission-Oriented Innovation Policy. UCL Institute for Innovation and Public Purpose Working Paper, p. 1.
Mazzucato, M., 2018a. Mission-oriented innovation policies: challenges and opportunities. Ind. Corp. Chang. 27 (5), 803–815. https://doi.org/10.1093/icc/dty034.
Mazzucato, M., 2018b. Mission-oriented research & innovation in the european union. A problem-solving approach to fuel innovation-led growth 58, Issue 1. https://doi.org/10.2777/36546.
Mazzucato, M., 2022. Mission Economy: A Moonshot Guide to Changing Capitalism. Penguin.
Mazzucato, M., Kattel, R., Ryan-Collins, J., 2020. Challenge-driven innovation policy: towards a new policy toolkit. J. Ind. Compet. Trade 20 (2), 421–437. https://doi.org/10.1007/s10842-019-00329-w.
McLaren, J., Kattel, R., 2025. Policy capacities for mission-oriented innovation policy: a case study of UKRI and the industrial strategy challenge fund. Technol. Forecast. Soc. Chang. 214 (February), 124049. https://doi.org/10.1016/j.techfore.2025.124049.
Miedzinski, M., Mazzucato, M., Ekins, P., 2019. A framework for mission-oriented innovation policy roadmapping for the SDGs: the case of plastic-free oceans. https://www.ucl.ac.uk/bartlett/public-purpose/wp2019-03.
Miles, M.B., Huberman, A.M., Saldaña, J., 2013. Fundamentals of qualitative data analysis. In: Qualitative Data Analysis: A Methods Sourcebook, third. Sage.
Muiderman, K., Gupta, A., Vervoort, J., Biermann, F., 2020. Four approaches to anticipatory climate governance: different conceptions of the future and implications for the present. Wiley Interdiscip. Rev. Clim. Chang. 11 (6), 1–20. https://doi.org/10.1002/wcc.673.

Nathan, L.P., Klasnja, P.V., Friedman, B., 2007. Value scenarios: a technique for envisioning systemic effects of new technologies. Conference on Human Factors in Computing Systems - Proceedings 2585–2590. https://doi.org/10.1145/1240866.1241046.
Newig, J., Fritsch, O., 2009. Participatory governance and sustainability. Findings of a meta-analysis of stakeholder involvement in environmental decision-making. In: Reflexive Governance in the Public Interest. MIT Press, pp. 1–28.
Nowotny, H., 2003. Democratising expertise and socially robust knowledge. Science and Public Policy 30 (3), 151–156. https://doi.org/10.3152/147154303781780461.
Pallett, H., Chilvers, J., 2013. A decade of learning about publics, participation, and climate change: Institutionalising reflexivity? Environ Plan A 45 (5), 1162–1183. https://doi.org/10.1068/a45252.
Parandian, A., Rip, A., te Kulve, H., 2012. Dual dynamics of promises, and waiting games around emerging nanotechnologies. Technology Analysis and Strategic Management 24 (6), 565–582. https://doi.org/10.1080/09537325.2012.693668.
Patterson, J., Schulz, K., Vervoort, J., van der Hel, S., Widerberg, O., Adler, C., Hurlbert, M., Anderton, K., Sethi, M., Barau, A., 2017. Exploring the governance and politics of transformations towards sustainability. Environ. Innov. Soc. Trans. 24, 1–16. https://doi.org/10.1016/j.eist.2016.09.001.
Pinch, T., Bijker, W.E., 1984. The social construction of facts and artefacts: or how the sociology of science and the sociology of technology might benefit each other. Soc. Stud. Sci. 14, 399–441.
Popa, E.O., Blok, V., Wesselink, R., 2021. An agonistic approach to technological conflict. Philosophy and Technology 34 (4), 717–737. https://doi.org/10.1007/s13347-020-00430-7.
Rip, A., 2018. Constructive technology assessment. In: Futures of Technology, Science and Society. Springer US, pp. 97–98.
Rip, A., Te Kulve, H., 2008. Constructive Technology Assessment and Socio-Technical Scenarios. In *The yearbook of nanotechnology in society*, Springer.
Rittel, H., Webber, M., 1973. Dilemmas in a general theory of planning. Policy. Sci. 4, 155–169. https://doi.org/10.1007/BF01405730.
Rosa, A.B., Kimpeler, S., Schirrmeister, E., Warnke, P., 2021. Participatory foresight and reflexive innovation: setting policy goals and developing strategies in a bottom-up, mission-oriented, sustainable way. Eur. J. Futures Res. 9 (1). https://doi.org/10.1186/s40309-021-00171-6.
Rowe, G., Frewer, L.J., 2005. A typology of public engagement mechanisms. Science Technology and Human Values 30 (2), 251–290. https://doi.org/10.1177/0162243904271724.
Ryan, M., Blok, V., 2023. Stop re-inventing the wheel: or how ELSA and RRI can align. J. Responsible Innov. 0 (0), 1–19. https://doi.org/10.1080/23299460.2023.2196151.
Saldaña, J., 2013. The Coding Manual for Qualitative Researchers, 2nd ed. SAGE.
Schot, J., Rip, A., 1997. The past and future of constructive technology assessment. Technological Forecasting and Social Change 54, 251–268. https://doi.org/10.1016/s0040-1625(96)00180-1.
Schot, J., Steinmueller, W.E., 2018. Three frames for innovation policy: R&D, systems of innovation and transformative change. Research Policy 47 (9), 1554–1567. https://doi.org/10.1016/j.respol.2018.08.011.
Scott, D., 2021. Diversifying the deliberative turn: toward an agonistic RRI. Sci. Technol. Hum. Values 016224392110672. https://doi.org/10.1177/01622439211067268.
Shove, E., Walker, G., 2007. CAUTION! Transitions ahead: politics, practice, and sustainable transition management. Environment and Planning A 39 (1998), 763–770. https://doi.org/10.1068/a39310.
Smith, A., Raven, R., 2012. What is protective space? Reconsidering niches in transitions to sustainability. Research Policy 41 (6), 1025–1036. https://doi.org/10.1016/j.respol.2011.12.012.
Soete, L., Arundel, A., 1995. European innovation policy for environmentally sustainable development: application of a systems model of technical change. J. Eur. Publ. Policy 2 (2), 285–315. https://doi.org/10.1080/13501769508406986.
Sondeijker, S., Geurts, J., Rotmans, J., Tukker, A., 2006. Imagining sustainability: the added value of transition scenarios in transition management. Foresight 8 (5), 15–30. https://doi.org/10.1108/14636680610703063.
Stilgoe, J., Owen, R., Macnaghten, P., 2013. Developing a framework for responsible innovation. Research Policy 42 (9), 1568–1580. https://doi.org/10.1016/j.respol.2013.05.008.
Stirling, A., 2008. "Opening up" and "closing down": power, participation, and pluralism in the social appraisal of technology. Science Technology and Human Values 33 (2), 262–294. https://doi.org/10.1177/0162243907311265.
Stirling, A., 2010. Keep it complex. Nature 468 (1031).
Swilling, M., 2020. The Age of Sustainability: Just Transitions in a Complex World (Issue 1). Routledge.
Taebi, B., Kwakkel, J.H., Kermisch, C., 2020. Governing climate risks in the face of normative uncertainties. Wiley Interdisciplinary Reviews: Climate Change 11 (5), 1–11. https://doi.org/10.1002/wcc.666.
Termeer, C.J.A.M., Dewulf, A., 2019. A small wins framework to overcome the evaluation paradox of governing wicked problems. Polic. Soc. 38 (2), 298–314. https://doi.org/10.1080/14494035.2018.1497933.
Termeer, C.J.A.M., Dewulf, A., Biesbroek, R., 2019. A critical assessment of the wicked problem concept: relevance and usefulness for policy science and practice. Policy and Society 38 (2), 167–179. https://doi.org/10.1080/14494035.2019.1617971.
Transitieteam Bouw, 2018. Transitie-agenda circulaire bouweconomie. https://www.rijksoverheid.nl/documenten/rapporten/2018/01/15/bijlage-4-transitieagenda-bouw.
Truffer, B., Voß, J.P., Konrad, K., 2008. Mapping expectations for system transformations lessons from sustainability foresight in German utility sectors. Technological Forecasting & Social Change 75, 1360–1372. https://doi.org/10.1016/j.techfore.2008.04.001.
Truffer, B., Schippl, J., Fleischer, T., 2017. Decentering technology in technology assessment: prospects for socio-technical transitions in electric mobility in Germany. Technological Forecasting and Social Change 122 (March), 34–48. https://doi.org/10.1016/j.techfore.2017.04.020.
Uyarra, E., Bugge, M.M., Coenen, L., Flanagan, K., Wanzenböck, I., 2025. Geographies of mission-oriented innovation policy. Environmental Innovation and Societal Transitions, xxxx. https://doi.org/10.1016/j.eist.2025.100970.
Van de Poel, I., Zwart, S.D., 2010. Reflective equilibrium in R & D networks. Science Technology and Human Values 35 (2), 174–199. https://doi.org/10.1177/0162243909340272.
Van Lente, H., Swierstra, T., Joly, P.B., 2017. Responsible innovation as a critique of technology assessment. Journal of Responsible Innovation 4 (2), 254–261. https://doi.org/10.1080/23299460.2017.1326261.
Velenturf, A.P.M., Purnell, P., 2021. Principles for a sustainable circular economy. Sustainable Production and Consumption 27, 1437–1457. https://doi.org/10.1016/j.spc.2021.02.018.
Vermaak, H., 2013. Planning deep change through a series of small wins. In: Academy of Management 2013 Annual Meeting, AOM 2013, November 2013, pp. 237–242. https://doi.org/10.5465/AMBPP.2013.68.
Von Schomberg, R., 2013. A vision of responsible research and innovation. In: Responsible Innovation: Managing the Responsible Emergence of Science and Innovation in Society. https://doi.org/10.1002/9781118551424.ch3 (Issue June 2013).
Von Schomberg, R., 2014. Prospects for technology assessment in a framework of responsible research and innovation. SSRN Electronic Journal, May. https://doi.org/10.2139/ssrn.2439112.
Voß, J.P., Bornemann, B., 2011. The politics of reflexive governance: challenges for designing adaptive management and transition management. Ecol. Soc. 16 (2). https://doi.org/10.5751/ES-04051-160209.
Voß, J.P., Truffer, B., Konrad, K., 2006. Sustainability foresight: Reflexive governance in the transformation of utility systems. In: Voß, J.P., Bauknecht, D., Kemp, R. (Eds.), Reflexive Governance for Sustainable Development. Edward Elgar, pp. 162–188. https://doi.org/10.4337/9781847200266.00017.
Wanzenböck, I., Frenken, K., 2020. The subsidiarity principle in innovation policy for societal challenges. Global Transitions 2, 51–59. https://doi.org/10.1016/j.glt.2020.02.002.
Wanzenböck, I., Wesseling, J.H., Frenken, K., Hekkert, M., Weber, K.M., 2020. A framework for mission-oriented innovation policy: alternative pathways through the problem–solution space. Science and Public Policy 47 (4), 474–489. https://doi.org/10.1093/scipol/scaa027.
Watts, D.J., Strogatz, S.H., 1998. Strogatz - small world network nature. Nature 393 (June), 440–442. https://www.ncbi.nlm.nih.gov/pubmed/9623998.
Weber, K.M., Rohracher, H., 2012. Legitimizing research, technology and innovation policies for transformative change: combining insights from innovation systems and multi-level perspective in a comprehensive "failures" framework. Research Policy 41 (6), 1037–1047. https://doi.org/10.1016/j.respol.2011.10.015.
Wesseling, J.H., Meijerhof, N., 2021. Developing and Applying the Mission-oriented Innovation System (MIS) Approach.
Wesseling, J.H., Meijerhof, N., 2023. Towards a Mission-oriented Innovation Systems (MIS) approach: application for Dutch sustainable maritime shipping. PLOS Sustain Transform 2 (8). https://doi.org/10.1371/journal.pstr.0000075.
Wiarda, M., Doorn, N., 2023. Responsible innovation and societal challenges: the multi-scalarity dilemma. Journal of Responsible Technology Journal 16 (100072). https://doi.org/10.1016/j.jrt.2023.100072.
Wiarda, M., van de Kaa, G., Yaghmaei, E., Doorn, N., 2021. A comprehensive appraisal of responsible research and innovation: from roots to leaves. Technological Forecasting and Social Change 172, 121053. https://doi.org/10.1016/J.TECHFORE.2021.121053.
Wiarda, M., Coenen, T.B.J., Doorn, N., 2023. Operationalizing contested problem-solution spaces: the case of Dutch circular construction. Environ. Innov. Soc. Trans. 48 (November 2022), 100752. https://doi.org/10.1016/j.eist.2023.100752.
Wiarda, M., Janssen, M.J., Coenen, T.B.J., Doorn, N., 2024. Responsible mission governance: an integrative framework and research agenda. Environ. Innov. Soc. Trans. 50 (January), 100820. https://doi.org/10.1016/j.eist.2024.100820.
Wittmann, F., Hufnagl, M., Lindner, R., Roth, F., Edler, J., 2020. Developing a Typology for Mission-oriented Innovation Policies.
Wittmann, F., Hufnagl, M., Lindner, R., Roth, F., Edler, J., 2021. Governing varieties of mission-oriented innovation policies: a new typology. Sci. Public Policy 48 (5), 727–738. https://doi.org/10.1093/scipol/scab044.
Zambrano-Gutiérrez, J.C., Valente de Macedo, L.S., Picavet, M.E.B., Puppim de Oliveira, J.A., 2023. Individuals in collaborative governance for environmental management. Environ. Manag. 71 (3), 565–586. https://doi.org/10.1007/s00267-022-01693-w.
Zwart, H., Landeweerd, L., van Rooij, A., 2014. Adapt or perish? Assessing the recent shift in the European research funding arena from 'ELSA' to 'RRI.'. Life Sci. Soc. Policy 10 (1), 1–19. https://doi.org/10.1186/s40504-014-0011-x.

Tom B.J. Coenen is Assistant Professor at the department of Civil Engineering and Management at the University of Twente. His main research focuses on the transitions in the context of the infrastructure sector from governance and management perspectives. Moreover, he studies the wider implementation of missions from both an organizational and governance perspective. Other research interests include organizational responses to societal challenges and missions, including ecosystems as well as the diversity of solution pathways towards addressing societal challenges in infrastructure.

Martijn Wiarda is a postdoctoral researcher at Technology, Innovation & Society at the Eindhoven University of Technology and is affiliated with the department of Values, Technology, and Innovation at the Delft University of Technology. He obtained degrees in Mechanical Engineering and Innovation Sciences, and received his PhD degree for his dissertation on Responsible Innovation for Wicked Societal Challenges. Martijn was involved in multiple large scale research projects, including the EU-funded H2020 Projects, 'Co-Change' and 'PRO-Ethics'. His current research focuses on energy communities from the perspective of responsible innovation.

Klaasjan Visscher is Professor of Innovation in Higher Education and Society. He is head of the Knowledge, Transformation & Society section and Scientific Co-director of DesignLab at the University of Twente. His current research focuses on transdisciplinary education, innovation ecosystems, and sustainability transitions. His research has been published in journals such as *British Journal of Management*, *Creativity and Innovation Management*, *European Journal of Engineering Education*, *Journal of Product Innovation Management*, and *Technovation*.

Caetano C.R. Penna is currently director of the Centro de Gestão e Estudos Estratégicos in Brasil. He served as Assistant Professor in Economics of Technology and Innovation at Delft University of Technology (Netherlands) and as Adjunct Professor in Industrial and Technology Economics at the Federal University of Rio de Janeiro (Brazil). He holds a PhD in Science and Technology Policy Studies from University of Sussex (UK) and an MA in Technology Governance from TalTech (Estonia). His broad areas of research include industry, technology and innovation economics and policy.

Leentje Volker is a Full Professor of Integrated Project Delivery at the Department of Civil Engineering and Management of the University of Twente, the Netherlands. She is an expert in public procurement, public-private collaborations in project-based industries and value-based networks from an ecosystem perspective. Her work focuses on innovation and change in the construction industry to enable addressing the societal challenges of today. This includes circularity and digitalization of economic infrastructure systems but also human capital and social innovations that improve the quality of our built environment.