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From complexity to cooperation: Solving institutional challenges in digital road projects

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Abstract: This paper examines inter-institutional cooperative challenges in the context of implementing the digital road. Five supranational experts from industry, research, and road traffic were interviewed about existing cooperative challenges and how they can be solved. The interviews were analyzed using the grounded theory method. The theoretically developed challenges of complexity, trust, transparency, synchronization, information asymmetries, and conflicts of interest were confirmed and supplemented by the identification of institutions and roles, error culture, and power. According to the experts, these challenges can be overcome by using a strategic tool such as the Institutional Role Model. This tool can be used to involve all actors. In addition, transparency and trust are strengthened by clear role definitions and assignments. Furthermore, the tool ensures the completeness of the actors, improves inter-institutional communication, and identifies the potential for conflict. Therefore, the authors recommend the use of the Institutional Role Model as a steering instrument in complex projects.

Keywords: *Complexity, Cooperation, Digital road, Digitalization, European Union, Institutional role model, Mobility.*

1. Introduction

The digitalization of road transport infrastructure is an international undertaking because roads cross borders. This is particularly evident in Europe, where cultural and national borders are blurring. As can be seen in the international C-ROADS and Gaia-X projects presented in Chapter 4 and the BIM integration project, a large number of different institutions are involved in the implementation of the services and technologies developed there. This high number of participants and digitalization leads to an increase in the complexity of mobility projects. A high degree of cooperation in complex environments is required to implement the mobility projects mentioned above successfully. Therefore, this paper focuses on the following research question: What inter-institutional cooperative challenges exist in implementing a digital road, and what solutions does the IRM offer?

To this end, Chapters 2 and 3 describe the empirical research methodology used to answer the research question. Chapter 4 presents and describes various European digitalization projects in the road sector. In the following chapter, the concept of the institutional role model is introduced and explained using its four dimensions. Chapter 6 uses Niklas Luhmann's systems theory to theoretically elaborate six central challenges that exist primarily in cooperation projects. In the following seventh chapter, the empirical results are elaborated. In this context, the importance of cooperation, the associated challenges, and possible solutions are discussed. This chapter concludes with IRM as an enabler of cooperation. In the final chapter, the core statements are examined against the background of the international projects mentioned in the introduction, and possible follow-up research is highlighted.

2. Methods

The research question is the starting point for creating the questionnaire and selecting the interview partners. The questionnaire is a construction of the authors. In the context of the evaluation

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of the four expert interviews conducted, this means that it must also be reflected that when attempting to interpret the text material, the unknown or the non-text must always be the subject of the research. Ultimately, it is about the contingency of the text, which is not necessarily, but also not by chance, the way it is. The questionnaire could only be constructed by excluding other possibilities. The same applies to the written answers of the interviewees: they could have been entirely different, and therefore, it is essential to examine why it is the way it is and not otherwise, and what is not said must also be reflected upon. The evaluation of the interview texts is about observing written communication. The interviewees as people cannot be observed with the help of the text, as they are part of the environment of the social systems. The focus here can only be on communication.

At the beginning of the analysis, all data was subjected to coding based on Anselm's grounded theory methodology [1]. Only open coding was used, and an attempt was made to let the text speak for itself so that the codes were 'generated' by the text itself. The data analysis tool MAXQDA was used to help with data management and analysis, facilitating the preparation of the data material. The coding provided a total of 110 coding points in the material.

3. Introduction of the Experts

The experts were selected for their diverse experience in research, industry, management, and development, as this allows for a wide range of perspectives on the challenges of inter-institutional collaboration. Prof. Krubasik, a researcher at Stanford and Karlsruhe, has already accompanied innovations in several international (industrial) projects in his function as a former member of the central board at SIEMENS and as a partner at McKinsey [2]. He also gained experience in digital projects as Chairman of the Panel for Growth and Innovation at the German Economic Council and as Chairman of the Industrial Advisory Board of the Munich School of Robotics and Machine Intelligence (MSRMI) at the Technical University of Munich [3]. Dr. Henk Taale has more than 30 years of experience in the field of traffic models and traffic management, having been a project manager for a wide range of projects in these areas. His practical experience in leading positions with a mobility context qualifies him as an expert for this work and brings a supranational perspective [4]. The experts Dr. Torsten Geissler and Dr. Lutz Rittershaus work for the German Federal Highway Research Institute (BASt). While Mr. Geissler gained inter-institutional cooperation experience as a manager focusing on connected mobility, Mr. Rittershaus is responsible for the Mobility Data Marketplace (MDM), the national access point for mobility data [5, 6]. This broad range of digital and mobility expertise qualifies both individuals for this paper. Mr. Christian Göltl, the digitization expert of ASFINAG, completes the circle of experts with a further perspective beyond national borders. With the vision of becoming one of Europe's leading highway operators, the Austrian group ASFINAG offers a wealth of experience, especially concerning mobility-related cooperation in a digital context [7].

4. Cooperation in Digital Road Projects

The digitization of roads is being driven forward in numerous research projects. In Germany, for example, the Federal Ministry of Digital Affairs and Transport has presented its strategy for implementing BIM (Building Information Modeling) with its Master Plan for Digitization in Federal Highway Construction [8]. The BIM is primarily a linking, processing, maintenance, and visualization of data, for which a full-scale infrastructure digitization is necessary [9]. For example, some of this data could be contributed by sensors to record the structural condition of asphalt roads [10]. In this context, cooperation among the stakeholders involved is one of the crucial factors for the successful implementation of BIM [11]. However, it is not only at the national level that cooperation is needed in the digitization of roads. The C-ROADS research project, a joint initiative of European member states, is testing the operation of C-ITS technology in road transport [12]. C-ITS stands for 'Cooperative Intelligent Transport Systems'. This technology aims for vehicles to use digital technologies to inform each other about traffic and, in particular, dangerous situations. As a result, better-informed drivers approach danger spots more slowly and have to brake less intensively. They are also more alert and less easily distracted. The Finnish pilot says this technology can positively impact traffic patterns and emission intensity [13]. Different participants have to cooperate to implement the various country-

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specific research projects. For example, seven project partners are involved in the respective projects in Austria, eleven in the Czech Republic, 31 in Finland, and 29 in Germany [14]. At the same time, many partners have different backgrounds. The consortia are mixtures of companies, administrations, operators, research institutes, media representatives, public authorities, and universities. And, of course, each institution and player bring particular self-interests to the respective projects. Thus, within the project, harmonization is also described as the core of the C-ROADS platform. According to the project, this requires collaboration on a holistic level [12]. Similar parallels can also be drawn in the projects of the Gaia-X 4 Future Mobility lighthouse project family. The focus here is on distributed data and service infrastructures based on Gaia-X standards. Applications are being developed for the field of mobility, for example, to enable the establishment of cooperative system networks of intelligent traffic infrastructures and vehicles and the provision of data to automated vehicles. Thus, in this project family, similar to the C-ROADS project, about 80 participants from the aforementioned different sectors are working together to realize project success [15]. The insight from the national and supranational digital road projects is thus that cooperation of heterogeneous actors is the key to the successful implementation of various projects.

5. Theory of the Institutional Role Model

The institutional role model is a tool used in practice to overcome the challenges associated with cooperation between different institutions [16]. In a dynamic environment such as developing new digital services and products, it is advantageous to consider all the institutions involved within the entire value chain in advance and during development [16]. This is because when different data sets with different information are integrated into one another, additional information can be generated from this. If this data is subsequently used collaboratively, synergy effects can lead to an increase in the value of the data and thus increase the economic added value [17]. Therefore, to ensure the success of inter-institutional cooperation, organizations must develop a collaborative capability as a competence, which is then applied within a consistent and legally valid framework [16]. The Institutional Role Model (IRM) can be seen as a possible solution approach for this [16]. According to the developers of the IRM, this approach eliminates the disadvantages of traditional cooperation methods (for example, the operator model) and thus offers an organizational tool that incorporates a transparent and democratic process based on empirical standards [18].

The IRM builds, among others, on the theoretical approaches of the 'Linear Model of Innovation' by Godin [19], the 'Organizational Theory' by Nelson [20], and the theory of the 'Triple Helix' by Han et al. [21]. Another central pillar of the role model represents the system dynamics with the difference between the system and the environment [22]. It should be emphasized that a system in the sense of IRM consists of several elements between which relationships exist. Systems differentiate themselves from their environment, are adaptive, and orient themselves to their environment. Also, an exchange between the system and the environment can take place.

From an economic perspective, similar parallels can be found concerning small companies up to corporate conglomerates, as these also represent systems consisting of many subsystems and lively exchanges between them. The advantage of IRM lies in its ability to structure, develop, and analyze economic processes from the macro to the micro level. These processes can represent individual business processes, far-reaching corporate strategies, or complex cooperation models [16]. The basis of the IRM is that different actors can assume defined roles [16]. In terms of IRM, fulfilling this role is more significant than the actors' self-interest [23]. In developing the IRM-matrix, four dimensions are set in relation to each other within a structured process to harmonize technical, economic, and ecological roles see Figure 1. For this purpose, the temporal dimension is determined on a project-specific basis. For example, it can include market or project phases but also process steps. Furthermore, the dimension of roles is considered within the model. Roles can be understood as tasks that serve as the goal achievement of the subject area to be analyzed. Here, it is crucial to identify and define relevant roles and arrange them according to their granularity. The roles can have, for example, economic, technical, or ecological backgrounds. The dimension of institutions includes all institutions relevant to achieving the

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objectives (for example, authorities, companies, and organizations), which are identified together with all involved actors within the creation process of the IRM [16].

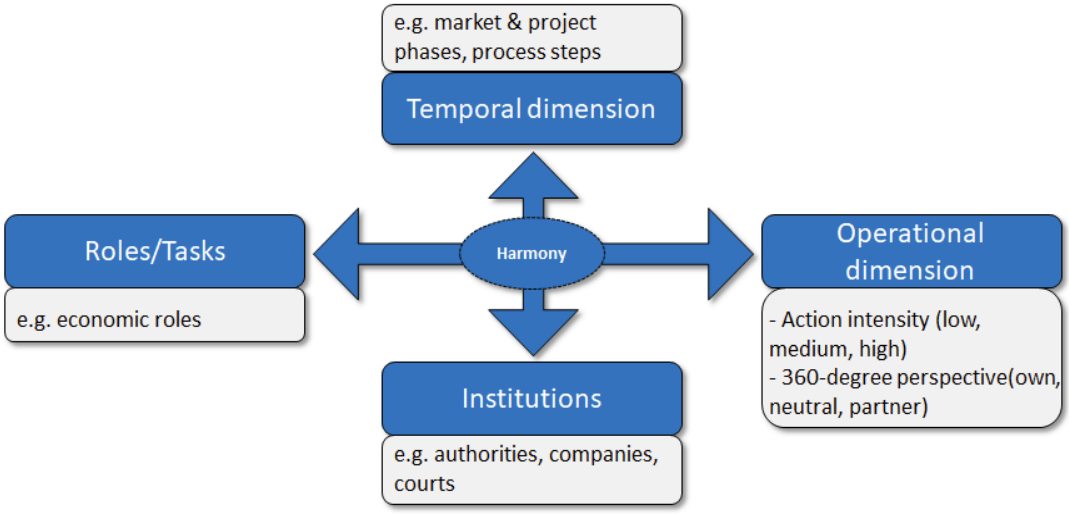

Figure 1.
The four dimensions of IRM (Own illustration, based on [24]).

So far, the fourth and last dimension of IRM is the operational dimension. It can include differentiation in terms of the intensity of action of a role or a 360-degree perspective in the assessment of role adoption carried out by participants in the further course of the process [16]. However, as Schulz et al. (2019) already state, there is a need for further research driven by technological progress regarding the dimensions and empirical evolution of IRM. According to the authors, this is particularly true in developing so-called 'cutting-edge' technology [23]. This cutting-edge technology is used in collaborations to develop digital road applications (see Chapter 4). The system dynamic and institutional economic background of the theory of IRM substantiate the relevance of this research need.

6. System-Theoretical Observation of Cooperative Challenges

Mobility innovations emerge from a complex network of heterogeneous economic, political, and scientific organizations. Cooperation is becoming increasingly important, as one organization can no longer manage the complex environment alone. However, cooperation between different companies is accompanied by a multitude of challenges, as each organization has its own specific decision-making rules. The elements that make up organizational systems and which they combine into consistent patterns through selective relation are ultimately decisions [25]. Decisions are nothing other than communications. Three types of decision premises can be distinguished: programs, communication channels, and persons (ibid, p. 286). Programs (sets of rules, work plans, or technicalized processes) fix the conditions of correctness of decision-making and thus ensure them independently of the decision-making process. Formalized communication channels in the form of hierarchies, departments, project groups, etc., prevent every member from being able to talk to every other member at any time. As an alternative to programs and communication channels, decisions can also be structured via people, as it is easier to understand a person's decision if you know them. Organizations are systems of information processing that gain and maintain their independence by treating environmental information according to their programs [26]. Organizations differentiate themselves from their environment through programs, personnel, and the organization of communication possibilities. Expectations and memberships sometimes differ significantly between the various organizations. Since both expectations and memberships are highly contingent and can be understood as relations that can be placed in relation to each other, organized social systems, therefore, form their structure in the form of the relation of relations [25]. This relationalization takes the form of reciprocal conditioning between expectations

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and membership. This means that there is an 'inside' and an 'outside' and that membership functions as a principle of differentiation and the constitution of boundaries.

The consequence is that an organization has many combinatorial possibilities and possible structural changes. An organization is, therefore, already highly contingent and complex in nature. How can organizations already confronted with specific internal problems such as bureaucracies, member recruitment and loyalty, member motivation, etc., cooperate with organizations in their environment? How can such cooperation between different organizations succeed? What problems arise during cooperation, and how can these be solved? This is followed by the following functional question: For which problems are cooperations a solution?

6.1. Complexity

Organizations, like all social systems, can be distinguished from their environment. There is a complexity gap between the system and the environment, as the system cannot react to every state of the environment. Despite this complexity gap, a difference must be established and maintained by compensating for the system's complexity inferiority through selection strategies [27]. In organizations, communication channels, programs and people help reduce complexity and enable the production of decisions. Defined programs reduce the number of possible decisions, as some decisions do not conform to the organizational rules and can, therefore, be directly excluded. For example, if communications do not conform to the system logic of administrations or do not pass through the bureaucratic processes, they do not penetrate the system's boundaries. Formalized communication channels in organizations, therefore, also help to reduce complexity. It is also up to the individual whether to connect to communications from the environment. Despite all these complexity-reducing instances that increase the probability of producing decisions, organizations are sensitive to complexity. The more decisions an organization takes, the more it overloads the various decision-making bodies - especially those that specialize in setting decision premises for other decisions.

6.2. Problems of Synchronization

Synchronization can only be observed if a distinction is made between the actuality of the system and the inactuality of the environment at the same time. Without the system/environment difference, there is also no synchronization, as there would be only one actuality and nothing actual. It is essential to understand that synchronization cannot be understood as the creation of simultaneity, as simultaneity always exists in every present [28]. Instead, synchronization is about binding the loosely coupled medium of time into favorable forms: The current present can be controlled and with reference "[...] to this present problem of aftercare or precaution we want to speak of synchronization" (ibid., p. 117). With the help of synchronization, a system's present, which is only given with a small extension, can be coordinated about past and future [28]. Simultaneity arises with the differentiation of system and environment since only such a difference places system and environment simultaneously in the world, and this can be observed in this respect: Without this difference, the world would be "[...] an 'unmarked state in the sense of George Spencer Brown" (ibid., p. 99f.) in which nothing can be observed. The system/environment difference is thus a prerequisite for simultaneity, and the ineluctability of the simultaneity of system and environment corresponds to the restrictibility of the synchronization of the various system processes [29]. The different current presences of the system and environment must always be coordinated from the perspective of the system-internal current present, whereby the system must forego complete synchronization with the environment and must be able to intercept the risks of momentary non-concurrence that this entails [27, 33]. Due to the inescapable simultaneity of system and environment and the differentiation of time regimes, synchronization is needed. Never the whole environment, but only a selected part of it, can be synchronized, which is why constant synchronization is necessary. The synchronization problem becomes the fundamental problem of temporal coordination for the functionally differentiated society.

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6.3. Trust / Transparency

The problem of trust is understood as a problem of risky advance performance [30]. Actors or organizations can engage in cooperation that does not pay off immediately if they have trust (ibid. p. 28). Cooperative action develops trust by reducing the complexity of possible courses of action that would have remained unlikely and unattractive without trust. Despite all efforts to organize and plan, uncertainties remain. Therefore, there must be roles that have the task of planning. However, as success is not yet apparent at the beginning of the role assumption, a leap of faith must be granted to bridge the gap until success is achieved. For the time being, it is trusted that someone will successfully take on the role, which reduces complexity as other possibilities are ruled out. Due to the leap of faith, the chance of success is greater. Although there is a risk that the trust will be disappointed, this risk must be taken, as cooperation is impossible without trust. Through trust, expectations can be generalized. Generalization and trust make complex cooperation projects possible in the first place.

6.4. Principal-Agent-Problems

The extent to which information asymmetries between two or more business partners can lead to inefficiencies within the economic relationship is examined in principle-agent theory. For example, hidden actions or hidden information that is not transparently communicated to the other transaction partner ex-post (i.e., after the contract has been concluded) contribute to information asymmetry [31]. This post-contractual opportunism between transaction partners leads to a conflict of interest and, thus, to the so-called "moral hazard" [32]. However, information asymmetry at the time of contracting can also lead to inefficiencies. In this case, economics refers to a principal-agent model with hidden characteristics [31]. Therefore, it must be stated that information asymmetries lead to inefficiencies both at the time of concluding the agreement and afterward, which must be avoided in cooperation.

6.5. Power Struggle and Conflict of Interests

Organizations are a type of system that is set up under highly restrictive conditions for the sake of specific services [25]. The particular services and goals can diverge significantly from organization to organization, leading to conflicts of interest. There are tensions within the organization due to the difference between expectations and concrete actions, as well as tensions between the organization and the environment. For example, organizations are subject to their environment's expectations and must endure internal tensions, such as the non-fulfillment of duties tied to a role. Every employee and every organization have its own agenda.

7. Results

This chapter deals with evaluating the data collected from the expert interviews. It discusses the general importance of cooperation and outlines the cooperative challenges identified. This is followed by a description of the solutions made possible by the IRM and an outlook on the institutions and roles that are particularly necessary for implementing the digital road. The information in this chapter was all taken from the expert interviews.

7.1. Importance of Cooperation

The code 'Importance of cooperation' was set 7 times in the data set. The experts emphasized that a lack of cooperation can lead to chaos, which, according to one expert, can lead to a drop in efficiency. Therefore, according to the experts, stakeholder cooperation is crucial. Another building block, according to the experts, is the intercultural aspect. Cooperation is necessary in international projects, as it allows different perspectives to be united despite diversity and heterogeneity. This unification also develops a common 'language' and thus creates a common understanding. If this does not happen, it can lead to frictional losses within a project, according to one expert. It is essential in digital projects to achieve a critical mass of cross-sector project participants to transfer the project results into practice successfully.

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7.2. Cooperative Challenges

In the category of cooperative challenges, 22 codes were identified and set 53 times (see Appendix 2: Code System). The first code is interaction and was set three times. Here, the experts stated that in the digital age (e.g., in online meetings), creating interaction between the participants is a challenge. It is advantageous to hold social events that promote a good atmosphere and mutual acceptance (Code Interaction). The following code is error culture and was set once. According to one expert, one challenge is that a different error culture prevails in academia and commercial enterprises, leading to problems in cooperation between these institutions (Code Error Culture). Code number three is communication and was set 18 times. As with interaction, communication deteriorates in projects with a strong digital focus, according to the experts. Communication is at the heart of cooperation and must, therefore, be precise. The major challenge is exactly this precise communication, not only on an interpersonal level but also on a technical level, such as at interfaces. According to the experts, developing a common language within a project represents a significant challenge, as described in the previous chapter. Terminology in projects must be clearly defined so that there are no misunderstandings. In addition, heterogeneous expectations lead to challenges in cooperation (Code Communication). The following code is trust, which was set once. One expert thinks that it is crucial to rely on a project partner's performance. If this is not the case, it can lead to a loss of trust (Code Trust). Two sub-codes (Complex and Complicated) were identified within the complexity code. According to the experts, chaos quickly arises in complex cooperation projects if the functions and roles are unclear. The degree of complexity increases with the size of the project as well as the heterogeneity and internationality of the actors and institutions (Code Complexity, 7). Due to the lack of differentiation of the terms in practice, the two sub-codes were subsumed under the complexity code. The challenge regarding speed (Code Speed, set twice) is to synchronize all institutions involved in the project to reach all agreed milestones at the right time. For this reason, it makes sense to act early if there is potential for conflict and to identify suitable partners before embarking on a cooperative venture. Different system times collide, especially due to digitalization and the associated breaking down of industry boundaries, which leads to synchronization problems. For example, a synchronization problem can arise when smaller agile companies have to cooperate with large, cumbersome companies (Code Synchronization Problems, set twice). Another major challenge within the cooperation in large projects is that there is no authority to issue instructions to project partners outside the institution, which can jeopardize achieving objectives. In addition, the collapse of sectors and industries leads to a heterogeneous market. The power structure of the formerly hierarchical market is eroding, which jeopardizes cooperation as there is no longer a superordinate central authority (Code Power, 2). The following code is the Heterogeneity of participants (set 9 times). The experts see a challenge in the conflict of interests resulting from heterogeneity. For example, research institutions have a publishing focus, while commercial companies are generally reluctant to publish internal information not to jeopardize their information advantage. The legal, organizational, and regulatory framework conditions also differ significantly as the internationality of the project increases, which, according to the experts, can have a negative impact on cooperation (Code Heterogeneity of Participants). In the case of the self-interests code (set twice), the 'hidden agendas' of the participants are particularly noteworthy. The different goals of the participants are often not recognizable and contradict the jointly defined goal. Identifying the appropriate institutions and their tasks and roles poses a further challenge. Due to the large number of participants, it is often difficult to identify the most suitable project partner for a specific task and to assign this role to them (Code Identification of Roles and Institutions, set 4 times).

7.3. Solutions for Inter-Institutional Cooperative Challenges

The experts say that cross-border projects, which are primarily digitally oriented, increase complexity. This is because cooperation between previously unknown parties and informal communication has become significantly more complicated. According to the experts, this creates the need for a cooperation-promoting tool that transparently presents individual players' responsibilities, roles, tasks, and processes (Code Possible solutions through IRM, set 5 times). One expert adds that the definition of a common goal counteracts the pursuit of individual interests and thus reduces potential

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moral hazard (Code reduction of moral hazard, set once). He also believes that a holistic view and a presentation of all parties' competencies are necessary to identify the best contact partners. According to the expert, this also ensures that cautious institutions are considered and prevents them from being submerged in large consortia (Code survey of all stakeholders, set 2 times). According to the experts, it is advantageous in terms of target achievement if the actors commit to the agreed course. This creates a sure certainty of expectation, which builds trust between the actors (Code agreement for reliability, set 3 times). Another vital point for improving inter-institutional cooperation is the flexible and complete identification and selection of suitable institutions for achieving the project objectives (Code Identification of further relevant institutions, set twice). Clarity regarding roles and institutions also contributes to harmonizing goals and tasks. The undermining of competence and questioning of authority can be avoided by clearly defining and assigning roles (Code Harmonization of goal and roles, set twice). An essential factor in analyzing suitability for taking on roles is the differentiation between self-assessment and external assessment, as this represents a basis for legitimacy (Code Operational dimension reduces frictional losses, set once). In addition, a clear definition of terms and roles contributes to the measurability and evaluation of progress and success and creates understanding (Code Role definition enables evaluation, set 3 times & Code Role definition creates understanding, set 5 times).

7.4. IRM as an Enabler for Cooperation

The IRM introduced in Chapter 5 contributes to solving the identified challenges in many ways. It provides the instrument experts require to improve cooperation by reducing complexity. In the first step, a common goal is defined by all participants. Building on this, roles are identified and described using the standardized IRM process and visualized in the IRM matrix. All stakeholders are consulted to ensure a holistic approach. In the next step, the actors are questioned about their suitability for the role, as foreseen in the IRM procedure, and whether further institutions are required to achieve the objective. Suppose institutions commit themselves to taking on a role based on identifying suitability and following the logic of the IRM. In that case, as described in the solution approaches, there is a certainty of expectation. The operational dimension of the IRM also makes it possible to integrate an external assessment desired by the experts into the evaluation. The trust in the respective actors and the results gained through the IRM process can thus facilitate inter-institutional cooperation.

8. Conclusion

If the number of participants, the degree of internationality, or the digital focus increases in the presented international projects C-ROADS and Gaia-X, as well as the BIM project, then the complexity also increases. This results in inter-institutional challenges for cooperation in such undertakings. This creates the need for a steering instrument such as the IRM. By defining roles, involving all stakeholders, identifying relevant institutions, jointly defining objectives, and reaching agreement among the stakeholders, the IRM is suitable for overcoming the identified inter-institutional challenges. In this way, the IRM can serve as an enabler in complex projects and strengthen stakeholder trust. It thus serves as a cooperation architecture and reduces complexity by determining and visualizing key areas of suitability in cooperation networks. Concerning the further development of the IRM, it should be noted that the dimensions of the IRM can be further developed in terms of their topicality and suitability for digital project structures.

References

[1] Glaser, B. G., Strauss, A. L., & Hildenbrand, B. (2010). Grounded Theory: Strategien qualitativer Forschung (A. T. Paul & S. Kaufmann, Übers.; 3., unveränd). Hogrefe AG.

Edelweiss Applied Science and Technology
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Vol. 8, No. 6: 1275-1286, 2024
DOI: 10.55214/25768484.v8i6.2237

[2] Krubasik. (2023). Prof. Edward G. Krubasik | Startseite | Beiträge Vorträge Themen Leitmärkte Produktivität neue Technologien »Produktivität durch Innovation und Wachstum« und »mehr Wertschöpfung für Europa und Deutschland«. http://krubasik.com/index.html
[3] TUM. (o. J.). Krubasik_Edward G. Abgerufen 27. September 2023, von https://www.professoren.tum.de/honorarprofessoren/k/krubasik-edward-g
[4] TU Delft. (o. J.). Dr.ir. H. (Henk) Taale. TU Delft. Abgerufen 27. September 2023, von https://www.tudelft.nl/citg/over-faculteit/afdelingen/transport-planning/staff/persoonlijke-paginas/taale-henk?0%5BL%5D=&cHash=bb8b216aa7c8242598c89db69994367f
[5] LinkedIn. (o. J.). Torsten Geißler – Head of Section – Federal Highway Research Institute | LinkedIn. Abgerufen 27. September 2023, von https://de.linkedin.com/in/torsten-gei%C3%9Fler-a7b6aa8
[6] MDM. (o. J.). Kontakt. MDM Portal. Abgerufen 27. September 2023, von https://www.mdm-portal.de/kontakt/
[7] ASFINAG. (o. J.). ASFINAG: Neuer Leiter der Abteilung Systementwicklung bestellt. OTS.at. Abgerufen 27. September 2023, von https://www.ots.at/presseaussendung/OTS_20091119_OTS0289/asfinag-neuer-leiter-der-abteilung-systementwicklung-bestellt-bild
[8] BMDV. (2021). BMDV - Masterplan für die Digitalisierung im Bundesfernstraßen-Bau. https://www.bmvi.de/SharedDocs/DE/Artikel/StB/masterplan-bim-bundesfernstrassen.html
[9] Höhnscheid, K.-J., Lehan, A., Pinkofsky, L., Schüller, D., & Zander, U. (2021). Building Information Modeling als Forschungsgegenstand der Bundesanstalt für Straßenwesen. Straße und Autobahn, 72(4), Article 4. https://trid.trb.org/view/1928857
[10] Bald, J. S., Böhm, S., Čičković, M., Tielmann, M., Hill, T., Peitsch, P., Gablovský, J., Muschalla, M., Czaja, S., Ulrich, A., Farbischewski, V., & Huczek, J. (2022). Informationssystem Straßenzustand Teil 2: Entwicklung von Sensoren zur Erfassung des strukturellen Zustandes von Asphaltstraßen. https://bast.opus.hbz-nrw.de/frontdoor/index/index/docId/2593
[11] Schapke, S.-E., Beetz, J., König, M., Koch, C., & Borrmann, A. (2015). Kooperative Datenverwaltung. In A. Borrmann, M. König, C. Koch, & J. Beetz (Hrsg.), Building Information Modeling: Technologische Grundlagen und industrielle Praxis (S. 207–236). Springer Fachmedien. https://doi.org/10.1007/978-3-658-05606-3_12
[12] C-Roads. (2022). C-Roads—The platform of harmonised C-ITS deployment in Europe [Factsheet]. https://www.c-roads.eu/fileadmin/user_upload/media/Dokumente/C-Roads_fact_sheet_2020.pdf
[13] C-Roads. (2019). Evaluation and Assessment Plan (S. 104) [Working Group 3 - Evaluation and Assessment]. https://www.c-roads.eu/fileadmin/user_upload/media/Dokumente/C-Roads_WG3_Evaluation_and_Assessment_Plan_version_June19_adopted_by_Countries_Final.pdf
[14] C-Roads. (2021). C-Roads annual pilot overview report 2020 (S. 119) [Annual Report]. https://www.c-roads.eu/fileadmin/user_upload/media/Dokumente/M16_Annual_pilot_overview_report_2020_v1.0.pdf
[15] Deutsches Zentrum für Luft und Raumfahrt. (2022, September 30). GAIA-X 4 Future Mobility. https://www.gaia-x4futuremobility.dlr.de/
[16] Schulz, W., Franck, O., & Smolka, S. (2021). Die Theorie der institutionellen Rollenmodelle als Grundlagentheorie für Transformationsprozesse in Organisationen (S. 77–100). https://doi.org/10.1007/978-3-662-62148-6_5
[17] Krotova, A., Rusche, C., & Spiekermann, M. (with Institut der Deutschen Wirtschaft Köln Medien). (2019). Die ökonomische Bewertung von Daten: Verfahren, Beispiele und Anwendungen. Institut der deutschen Wirtschaft Köln Medien GmbH.
[18] Schulz, W. H., & Franck, O. (2022). The Institutional Role Model: A System-Dynamic Approach to Reduce Complexity. International Journal of Sustainable Development and Planning, 17(2), Article 2. https://doi.org/10.18280/ijsdp.170201
[19] Godin, B. (2006). The Linear Model of Innovation: The Historical Construction of an Analytical Framework. Science, Technology, & Human Values, 31(6), Article 6. https://doi.org/10.1177/0162243906291865
[20] Nelson, R. R. (1959). The Simple Economics of Basic Scientific Research. Journal of Political Economy, 67(3), Article 3.
[21] Han, S.-Y., Auh, Y.-B., & Sawng, Y.-W. (2001). The triple helix model in Korean mobile communication technology innovation. 1. https://doi.org/10.1109/PICMET.2001.951904
[22] Schulz, W. H. (2005). Application of System Dynamics to Empirical Industrial Organization—The Effects of the New Toll System. Jahrbuch für Wirtschaftswissenschaften / Review of Economics, 56(2), Article 2. https://doi.org/10.2307/20715061
[23] Schulz, W. H., Joisten, N., & Arnegger, B. (2019). Development of the Institutional Role Model as a Contribution to the Implementation of Co-Operative Transport Systems (SSRN Scholarly Paper 3421107; Nummer 3421107). Social Science Research Network. https://doi.org/10.2139/ssrn.3421107
[24] Kleis, H. (2024). Tech Tides: Steering Through Cooperative Complexities with the Institutional Role Model as an Economic System Architecture. International Journal of Sustainable Development and Planning, 19(8), 3189–3199. https://doi.org/10.18280/ijsdp.190831
[25] Luhmann, N. (2019). Organisation und Entscheidung. In N. Luhmann, E. Lukas, & V. Tacke (Hrsg.), Schriften zur Organisation 2: Theorie organisierter Sozialsysteme (S. 237–306). Springer Fachmedien. https://doi.org/10.1007/978-3-658-23210-8_10
[26] Luhmann, Niklas. (1997). Recht und Automation in der öffentlichen Verwaltung | Duncker & Humblot. https://www.duncker-humblot.de/buch/recht-und-automation-in-der-oeffentlichen-verwaltung-9783428009602/?page_id=1

Edelweiss Applied Science and Technology
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DOI: 10.55214/25768484.v8i6.2237

[27] Niklas Luhmann. (2021). Soziale Systeme. Buch von Niklas Luhmann (Suhrkamp Verlag). Suhrkamp Verlag. https://www.suhrkamp.de/buch/niklas-luhmann-soziale-systeme-t-9783518282663

[28] Luhmann, N. (1990). Gleichzeitigkeit und Synchronisation. In N. Luhmann (Hrsg.), Soziologische Aufklärung 5: Konstruktivistische Perspektiven (S. 95–130). VS Verlag für Sozialwissenschaften. https://doi.org/10.1007/978-3-322-97005-3_5

[29] Armin Nassehi. (2008). Die Zeit der Gesellschaft. VS Verlag für Sozialwissenschaften. https://doi.org/10.1007/978-3-531-91099-4

[30] Luhmann, N. 1927-1998 V. (with Internet Archive). (2000). Vertrauen ein Mechanismus der Reduktion sozialer Komplexität. Stuttgart Lucius und Lucius. http://archive.org/details/vertraueneinmech0000luhm

[31] Erlei, M., & Schmidt-Mohr, U. (o. J.). Definition: Prinzipal-Agent-Theorie [Text]. https://wirtschaftslexikon.gabler.de/definition/prinzipal-agent-theorie-42910; Springer Fachmedien Wiesbaden GmbH. https://doi.org/10/version-266250

[32] Erlei, P. D. M., & Szczutkowski, A. (o. J.). Definition: Moral Hazard [Text]. https://wirtschaftslexikon.gabler.de/definition/moral-hazard-41628; Springer Fachmedien Wiesbaden GmbH. Abgerufen 12. September 2023, von https://wirtschaftslexikon.gabler.de/definition/moral-hazard-41628/version-264990

[33] Luhmann, N. (2022). Organisation als soziales System. In N. Luhmann, V. Tacke, & E. Lukas (Hrsg.), Schriften zur Organisation 5: Vorträge • Lexikonartikel • Rezensionen (S. 133–137). Springer Fachmedien. https://doi.org/10.1007/978-3-658-23434-8_12

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Appendix 1.
Questionnaire.

The aim of this paper is to find out which inter-institutional problems arise during the cooperation in projects with many heterogeneous actors and how they can be solved. For this purpose, this questionnaire is divided into two categories. Category one deals with the inter-institutional challenges regarding cooperation in a complex environment. Category two questions the extent to which the institutional role model as an instrument can contribute to solving these challenges.

In a qualitative scientific process, the institutional role model identifies all tasks (roles) that contribute to the achievement of the jointly set goal. Subsequently, on the basis of quantitative analyses, it is determined which institution is most suitable to assume the various tasks.

Please try to keep your answers short and not exceed three quarters of a page.

Category 1:

What challenges generally arise when collaborating on projects with many participants?

What challenges arise when collaborating on projects with many participants across national borders?

What challenges arise when collaborating on projects with a digital focus and many stakeholders?

Category 2:

How can a sensible assumption of tasks by the respective suitable institutions contribute to the success of the project?

What needs to be considered when identifying appropriate institutions?

Are there new tasks that have arisen as a result of digitization and international cooperation?

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Appendix 2.
Code system

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