

Article

The Governance of INSPIRE: Evaluating and Exploring Governance Scenarios for the European Spatial Data Infrastructure

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Abstract: The development of a European Spatial Data Infrastructure (SDI) officially started with the entry into force of the INSPIRE Directive in 2007. INSPIRE's implementation phase should be completed by the European Union (EU) and its member states at the end of 2021: a pivotal point to evaluate INSPIRE's current governance and explore future scenarios. First, INSPIRE's governing system is evaluated through an online survey by its involved stakeholders. Second, these results are applied in an agent-based model to explore potential governance scenarios and strategies. The results show that strong aspects of INSPIRE's governing system are the supported vision and its formal structures, such as standards, technology and roles and responsibilities. Weak aspects are the access to resources, especially budget and time resources, and data use. The agent-based simulations show that INSPIRE is probably more constrained by its budget resources than its current dominant hierarchical interaction mix, although a combination of adaptive governance and continuous budget proved the most sustainable governance scenario.

Keywords: Spatial Data Infrastructure (SDI); governance; INSPIRE; governing system; agent-based modelling; European Union (EU)



Citation: Sjoukema, J.-W.; Samia, J.; Bregt, A.K.; Crompvoets, J. The Governance of INSPIRE: Evaluating and Exploring Governance Scenarios for the European Spatial Data Infrastructure. *ISPRS Int. J. Geo-Inf.* **2022**, *11*, 141. <https://doi.org/10.3390/ijgi11020141>

Academic Editor: Wolfgang Kainz

Received: 22 December 2021

Accepted: 11 February 2022

Published: 15 February 2022

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1. Introduction

INSPIRE, short for Infrastructure for Spatial Information in the European Community, is a directive of the European Union (EU) to solve problems around the 'exchange, sharing, access and use of interoperable spatial data and spatial data services across the various levels of public authority and across different sectors' [1] (p. 1) among the EU member states. These problems emerged from the notion that policy making on environmental issues becomes hard without integrated spatial information that transcends the local, regional and national boundaries. INSPIRE aims to solve this issue by requiring EU member states to harmonise spatial data on specified themes and provide these data through network services from their national Spatial Data Infrastructures (SDIs) in a standardised manner [1–3].

The INSPIRE Directive came into force in 2007 [3,4]. This Directive requires EU member states to implement the INSPIRE rules on metadata, interoperability, network services, data sharing and coordination into their national regulations [1]. From 2007 onwards, multiple milestones were set to implement INSPIRE on 34 spatial data themes in a step-wise manner. At the end of 2021, INSPIRE should have been fully implemented [2,5,6].

INSPIRE implements the SDI concept on a never seen before scale. By requiring all its 27 EU member states to implement the INSPIRE Directive and enabling also non-EU

member states to contribute, INSPIRE is 'one of the world's largest coordinated efforts for establishing a Spatial Data Infrastructure' [7] (p. 1).

INSPIRE brings many positive aspects to the member states. Crompvoets et al. [8] showed that INSPIRE has impacted the instruments and structures of national SDIs, which strengthens their governance. INSPIRE plays a key role in making public sector geographic information re-usable throughout Europe [9]. Borzacchiello et al. [10] further added that next to promoting open data, INSPIRE has directly and indirectly contributed to 'simplifying licensing, (...) supporting the drive towards harmonised data, (...) contributing to core reference data initiatives, applying the 'once-only' principle and resulting in public sector savings and private sector opportunities that have contributed to economic growth' [10] (p. 219).

However, there is also criticism on INSPIRE. According to Cho & Crompvoets [11], many facets of the implementation, such as the legal, technical and policy initiatives, appear to be top down. Besides INSPIRE, there are multiple other European directives which have similar ambitions on data sharing, which may overload member states and hinder swift implementation [11]. Several member states are also critical on the costs they have to make for harmonising and servicing INSPIRE data [12–14], while surveys among French SDI users show little and even decreasing interest in SDIs that transcend the national boundaries [15,16]. In addition, the complexity of the standards, the lack of a user-centric focus and the coordination and support for the Member States from the European Commission could be improved upon [10].

With the official implementation phase ending, INSPIRE is now at a pivotal point to evaluate its current governance. INSPIRE's hierarchical approach, fixed standards and technological requirements helped guide all member states into the same direction but now may constrain the use and acceptance of INSPIRE. Furthermore, several studies and evaluations have been conducted to evaluate SDI governance of member states (see, e.g., [8,17]), but there are currently no independent and critical studies which evaluate INSPIRE's governance at the European level. While it is at this level that important decisions on INSPIRE's structures can be made which impact all stakeholders.

The objective of this research is to evaluate the current state of the European INSPIRE governance and to explore potential future governance scenarios. This will be done by evaluating INSPIRE's current governing system. For this evaluation, we invited all official INSPIRE representatives which are involved in the European governance of INSPIRE for an online survey. By asking these very involved stakeholders, the perceived strong and weak aspects of INSPIRE's governance emerge. This evaluation is then used as input for an agent-based model on SDI governance to project how the governance dynamics might evolve from here. By casting multiple governance scenarios, the effects of potential governance interventions for INSPIRE can be explored.

First, a short overview of the used SDI governance theory and INSPIRE's current European governance is given. Thereafter, the method for evaluating INSPIRE's governance and set up for simulating governance scenarios is discussed. Thirdly, the results from the evaluating survey and the simulated scenarios are shown. This research ends with a broad discussion on INSPIRE's future and a conclusion with recommendations for INSPIRE's governance.

1.1. Spatial Data Infrastructure Governance

Both governance and SDIs are complex subjects. This complexity emerges from the countless local interactions between its stakeholders [18]. In this research, we view the SDI as the system to govern. As SDIs are open systems, which exhibit self-organisation, adaptability and feedback loops, SDIs are also classified as complex adaptive systems [19]. This does not mean that SDI governance does not need to be organised. An 'SDI should be able to self-organise and be open to create its own structure (...). However, without any coordinating mechanism it is difficult to successfully establish and manage an SDI' [19] (p. 457).

Like SDIs, which are considered as complex open systems, so is governance a complex open process. We define governance as the governing process aimed at solving societal

problems or creating opportunities, where multiple actors (both private and public) can influence this process through interactions. Governance is enabled and constrained by structures which give context and establish a normative foundation [20]. This definition and our understanding of governance is derived from the theoretical conceptions of Kooiman [20], who uses a socio-cybernetic system perspective on governance [21]. This approach fits well in the context of complex adaptive systems [22,23].

The governing process starts with a perceived problem, defined as an ‘image’. Instruments are chosen to steer other actors into the desired direction to solve this problem. The choice for an instrument is influenced by multiple factors, such as the governing position of an actor and structures, including resources or legislation which enable or constrain the use of certain instruments. This instrument is then put into action, which will affect other actors. They will respond with feedback, which can be used to verify if the problem is solved. This interactive process, which is aimed at daily problem solving, is what Kooiman calls ‘first-order governance’ [20].

This process is enabled and constrained by a structural level consisting of resources, formal and informal structures. These structures are stable in the short-term and beyond control of a single actor [20,24]. However, these structures can be changed in the long-term through the process of ‘second-order governance’ [20]. In many cases, structures are able to change when a certain threshold (‘tipping point’) is reached or an external surprise appears [22]. Then, a so-called crucial decision is made to renew the governing system [25,26].

These events are also witnessed in SDI governance. SDIs adapt and evolve, but this is not always a linear path as governance crises occur which lead to these crucial decisions [26,27]. Some SDIs cease to exist or fuse due to external events [26,28] or fail because they could not gain momentum after initial start-up [29]. The latter shows that not only the interaction between actors shape the governance of an SDI, but also the SDI itself and its actors influence each other [28]. Increasing the adaptive capacity of SDI governance may prevent these crisis events, but this requires regular critical evaluations of the SDI governance in order to spot potential early warning signals and raise awareness of potential threats.

However, objectively evaluating governance is difficult due to multiple reasons. First, within governance, the perception of its stakeholders (‘image’) determines whether a situation is problematic or not [25]. Second, governance theories set a normative foundation which also changes over time (‘third-order governance’ [20]). For example, from the late 1970s to the late 1990s, there was a high focus on running governments as businesses in order to improve efficiency, which later changed into the current more inclusive focus on governance [30]. Third, like other complex adaptive systems, SDIs are path-dependent and open systems [19], which makes their governance highly case- and context-specific.

Therefore, Sjoukema et al. [26] used these theoretical conceptions to develop a governing system framework for SDIs to evaluate whether the governing system is enabling or constraining the current governance process. Based on findings in the SDI literature and in practice, important aspects of each part of the SDI governance process (images, instruments, action and structures) are identified (see Figure 1). By assessing each aspect whether it is enabling or constraining according to its stakeholders, the strong and weak aspects of the governing system of an SDI can become visible [26].

In this research, we will focus on the European level of INSPIRE’s governance and its governing system as at this level INSPIRE’s structures are set. This means that we do not focus on how individual EU member states implement INSPIRE, but look at how the overall European governing system of INSPIRE enables its current implementation and its future. The end of INSPIRE’s implementation phase is a natural moment to evaluate and adapt INSPIRE’s governing system through second-order governance before a tipping point event may push INSPIRE into an undesired direction. This research will contribute to this evaluation, but first the governance of INSPIRE is shortly introduced.

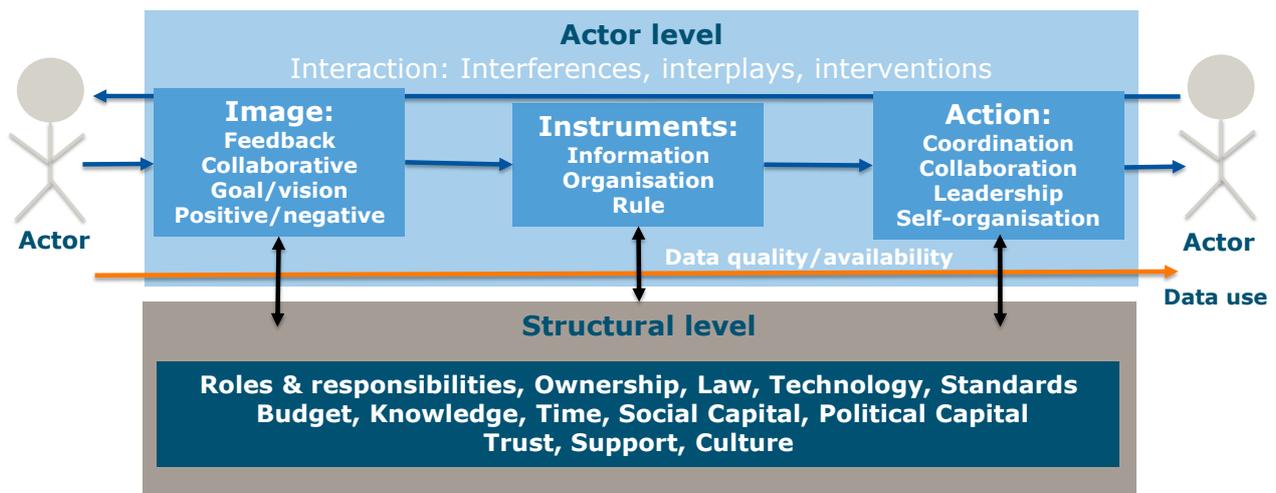


Figure 1. The Spatial Data Infrastructure (SDI) governing system as presented by Sjoukema et al. [26] consisting of an actor level where interactions, images, instruments and actions happen and a structural level which enables and constrains the actor level. The orange arrow flowing from the left actor to the right actor represents the spatial data flow of an SDI.

1.2. Governance of INSPIRE

INSPIRE is designed after the ‘SDI hierarchy’ pyramid (see Figure 2 [31–33]): ‘Inspire shall build upon infrastructures for spatial information established and operated by the Member States’ [1] (Article 2). By providing INSPIRE compliant data, metadata and services through these national SDIs, the European INSPIRE geoportal [34] is able to present the decentralised data and services at a central location. Within a member state, these data providing tasks can be delegated to the regional or even local level [2].

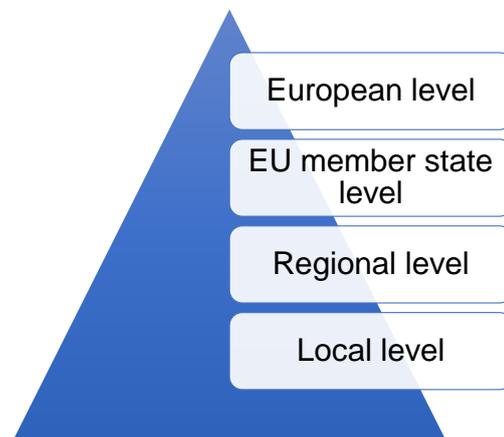


Figure 2. SDI hierarchy pyramid applied to INSPIRE. Adapted from Chan & Williamson [31].

The requirements for member states are set through legislation. EU member states had to transpose the INSPIRE Directive into their own legislation and comply to the Implementing Rules [5,35]. When a member state fails to comply to this legislation, an infringement procedure can be started by the European Commission. Through this legal procedure, compliance can be enforced through court procedures and financial penalties [36]. At the beginning of INSPIRE, against almost every member state an infringement procedure was started as they failed to transpose the Directive on time [11].

This does not mean INSPIRE is governed solely top down through enforcement. All EU member states are represented in the Maintenance and Implementation Group (MIG), together with EU candidate states, European Free Trade Association (EFTA) members and

the INSPIRE coordination team. This INSPIRE coordination team consists of the EU bodies: Directorate-General (DG) Environment, Joint Research Centre (JRC) and the European Environmental Agency (EEA). There is a technical sub-group of the MIG, called the MIG-T, for the technical aspects of INSPIRE such as its technical implementation and standards. Through participatory processes, the legally binding Implementing Rules on metadata, data specifications, network services and more, and the non-legally binding technical guidance documents were developed [5,37].

2. Materials and Methods

In order to evaluate the current European governance of INSPIRE and explore future scenarios, we used a two-step method. First, we evaluated the perceived governance state of INSPIRE by its MIG members through an online survey. Second, output of the survey was used to simulate INSPIRE's governance with the help of an agent-based model developed by Sjoukema et al. [38].

2.1. Survey on INSPIRE's Governance

To measure the perceived governance state of INSPIRE, we used the SDI governing system framework as developed by Sjoukema et al. [26] (see Section 1.1) and transformed this framework into an online survey. By asking questions on each aspect as indicated in Figure 1, stakeholders involved in the European governance of INSPIRE could indicate what their perception is. As most questions were Likert-type questions on a five-point scale, we used descriptive statistics to evaluate the results on each governing aspect. Then, an overall view on the perceived weak and strong points of the governing system of INSPIRE emerges.

A few modifications were made in the governing system framework to improve its suitability in an online survey and to use the results as input for the agent-based model (see Section 2.3). These modifications were mainly made in the instruments category. As it is difficult to evaluate the type of instruments used, we asked respondents which type of governance they think is the most dominant and if they could indicate how these governance types are distributed. The governance types which could be chosen are hierarchical governance (top-down governance, e.g., governing by legal obligations and requirements), network governance (horizontal governance, e.g., collaboration in working groups with a mix of stakeholders, exchanging knowledge and ideas) and laissez-faire governance (central governance is absent, which gives room for, e.g., self-organised public and private bottom-up initiatives). Furthermore, we split some aspects into multiple statements, such as the questions on data quality and availability, as these aspects can be broadly interpreted. All questions and how they relate to the governing system framework are added as supporting information.

2.2. Survey Dissemination

The survey was distributed among all MIG and MIG-T members. In addition, members from the European Commission and other involved European agencies were invited to participate. The reason to only distribute the survey among members of the MIG is that this a clearly identifiable research population of INSPIRE stakeholders which are highly involved in the European governance of INSPIRE and, therefore, also very knowledgeable about the subject. They have, for example, good knowledge on how collaborative decisions are made and how input from members is handled. Furthermore, with this group, the survey is distributed to all member states evenly and all persons are familiar with the English language, so no translations of the survey were needed.

Of course, there is also a downside by narrowing the research population to this group. Stakeholders in this position may have a different perspective on INSPIRE's governance because of their involvement than stakeholders and users on the operational side who might experience the governance of INSPIRE differently. However, distributing the survey among all INSPIRE stakeholders evenly would be difficult as INSPIRE's users are largely

unknown and most stakeholders are further positioned from the decision-making processes, which makes them less able to rate every governance aspect. Therefore, the MIG group seems to be ideal to evaluate the European governance of INSPIRE, but we have to be aware that the perspective of other involved stakeholders on the governance of INSPIRE is missing which may influence the results.

The survey was held from 9th of November till the 26th in 2020. The survey was distributed to 64 MIG members, 39 MIG-T members and 26 EU stakeholders through e-mail. Six e-mail addresses were not working or blocked the e-mail, which brings the total research population to 123. The survey was provided through an anonymous link, which means we could not check who responded and if the survey was further spread which was not encouraged or discouraged.

2.3. Agent-Based Model for SDI Governance

Governance is not a static but a dynamic process. As we do not only want to evaluate INSPIRE's current governing system, but also cast projections and stimulate discussion about the future governance of INSPIRE, we used the agent-based model on SDI governance as developed by Sjoukema et al. [38]. Agent-based modelling is a method to simulate complex adaptive systems. By programming local interactions, it becomes possible to reproduce complex emergent macro level behaviour. Even simple models help improve our understanding of the dynamic real-world phenomena they simulate [18,39].

Sjoukema et al. [38] developed a generic model to study SDI governance dynamics over time, which is validated by experts through face-validation. With this model, it is possible to simulate SDI governance interactions and modify parameters to project different scenarios. As the input values for the model are measured by the survey, it becomes possible to simulate multiple governance strategies and cast scenarios for INSPIRE. The following section will explain shortly the model working and the modifications we made to simulate INSPIRE. For a full understanding of the model, we refer to Sjoukema et al. [38] and the accompanied Overview, Design and Details (ODD [40]) protocol as Supplementary Materials.

The model works as follows: there are four actors (SDI executive, SDI data provider, SDI platform provider and SDI users) representing a group of SDI stakeholders with a specific role. Each actor has a satisfaction attribute on a 0 till 10 scale indicating their current satisfaction with the SDI and its governance. They can interact by sending three types of messages to each other: hierarchy messages, representing hierarchical governance, network messages, representing network governance and no messages, representing laissez-faire governance. The choice for these messages depends on their role and the chances on a certain message type, defined as input setting on a 0 to 100% scale.

Actors in the model prefer a mix of these interactions. This is based on theories of adaptive governance [41], where in general is noted that hierarchical governance provides more stability and reduces complexity, while network or self-governance can deal better with diversity and dynamics [20,22]. Both capacities from the rigid hierarchical governance and the flexible network-governance are needed to create robust governance that is able to deal with complex adaptive systems [22,42]. Furthermore, too much hierarchical governance will lead to resistance by actors, while too much focus on consensus building can create inertia [43]. This mixing of hierarchical and network governance is also found in SDI governance [27,44].

Therefore, actors in the model prefer that the received message types are alternating. An alternation will boost the satisfaction of the receiver positively and they respond with positive feedback. However, when they get too many messages of the same type in a row, their satisfaction will drop and they provide negative feedback. A single hierarchical message representing a 'hard' instrument (e.g., a new regulation or central coordination) boosts the satisfaction more than a 'soft' network message (e.g., providing information or advice). However, the receiver's tolerance for multiple hierarchical messages in a row is lower compared to the network messages. The no messages do not have a direct positive effect, but do count in the alternation of messages [38].

Meanwhile, the SDI data provider and platform provider have the role to provide data to the SDI user. The satisfaction of the data and platform provider does not only represent how they perceive the SDI and its governance, but also influences the data quality which is also represented on a 0 till 10 scale. Furthermore, for providing and servicing the data and keeping the data quality high (data quality is higher than 5), they need to spend structural resources in the form of maintenance costs. If they receive negative feedback on the quality from the user (data quality is lower than 5), they may spend extra resources to increase the data quality if these resources are available. The resources for these maintenance costs may be supplemented (partially) by other actors, depending on the selected budget allocation policy [38].

Translated to the context of INSPIRE, the role of SDI executive corresponds to the European Commission where especially the INSPIRE coordination team consisting of DG Environment, JRC and EEA play important roles. The role of SDI data provider corresponds with the EU member states. Responsibility for the SDI platform lies partly by the member states and partly by the European Commission. INSPIRE's users can be anyone, both on the European, national, regional or local level.

The model of Sjoukema et al. [38] allows to differentiate in budget policies. However, in all original budget policies of this model, budget flows from one actor (the SDI executive or SDI user) to the actors who are bearing the costs for providing the data (SDI data provider) and hosting the SDI platform (SDI platform provider). In INSPIRE, there are no direct funds from the user or executive (EU): member states have to cover their own costs they make by providing INSPIRE datasets and technical services. To simulate such a policy, we created a new budget policy in the model called 'INSPIRE financing'.

In this policy, the data and platform provider cover the maintenance costs for hosting and providing data. However, when they receive negative feedback on the data quality from the user (i.e., the data are degrading in fulfilling the INSPIRE requirements) and their resources are all depleted, they gain additional funds to improve the data quality in order to fulfil the INSPIRE requirements. Of course, this is a simplification of the reality where every member state has a different approach to financing INSPIRE. However, this approach simulates the balance member states may seek between conforming to the INSPIRE regulations and spending as little as possible, as multiple countries are critical on the costs for especially data harmonisation compared to the benefits (e.g., Austria [12], Belgium [13] and the Netherlands [14]).

To get a full understanding of this model and the technical modifications we made to the model of Sjoukema et al. [38], an updated version of their Overview, Design concepts and Details (ODD [40]) document is provided as Supplementary Materials.

2.4. Scenarios for Simulating INSPIRE's Governance

With the help of the agent-based model, we can simulate SDI governance dynamics and ask 'what if' questions. The simulation results serve as learning purpose to understand from what kind of governance interventions INSPIRE may potentially benefit. The following input settings of the model can be adjusted: the satisfaction of stakeholders, their budget, the chance on a message-type (hierarchical, network and no-message) and the susceptibility of actors to feedback. As these aspects are covered by questions in the survey, we can set these parameters according to the results as starting point for the simulations. Furthermore, the budget policy can be determined in the model.

We set up four scenarios to see what could happen to INSPIRE's governance: a baseline scenario, an adaptive scenario, a continuous budget scenario and a combined continuous budget + adaptive scenario (see Table 1). The baseline scenario acts as reference scenario. In this scenario, we use the results of the survey as input settings and keep these settings fixed (see Table 3 for the used settings). The budget policy is set to 'INSPIRE financing' as explained in Section 2.3.

Table 1. Overview of the four simulated governance scenarios.

Scenario	Input Settings	Budget Policy	Interaction Mix
Baseline	Survey response ¹	INSPIRE financing	Fixed
Adaptive	Survey response ¹	INSPIRE financing	Adaptive
Continuous Budget	Survey response ¹	Continuous budget	Fixed
Adaptive + Continuous Budget	Survey response ¹	Continuous budget	Adaptive

¹ See Table 3 for the used input settings from the survey response.

In the adaptive scenario, we explore what would happen if the interaction mix (i.e., the chances on a hierarchical, network or no-message) adjusts over time. After 15 timesteps, the average satisfaction of the actors is evaluated. If the average satisfaction is below 7.5 (on a 0 till 10 scale), the interaction mix is automatically adjusted based on the distribution history of sent messages: chances on a certain message type are set higher for the least sent messages while settings for the most sent messages are set lower. For example, if in the first run 7 hierarchy messages, 5 network messages and 3 no messages are sent, the chance on a hierarchy message is lowered, while the chance on a no message is increased. The chance on a network message remains stable.

The adaptive scenario also uses ‘INSPIRE financing’ as budget policy. However, in the continuous budget scenario the budget policy is set to ‘continuous budget’. In this budget policy, the SDI executive provides every time step resources to the SDI data provider and SDI platform provider to cover the structural maintenance costs. In this way, the scenario explores the dynamics when the availability of resources is less constraining. This scenario does not imply that all costs are always covered by the SDI executive as extra investment costs in the data quality are not covered. The interaction mix is kept stable at the input settings, like in the baseline scenario. In the combined adaptive + continuous budget scenario both interventions, the continuous budget policy and the adaptive interaction mix, are simulated.

2.5. Simulation Outputs

Like real world governance, a simulation run with the agent-based SDI governance model is always unique. Depending on factors such as chance and coincidence, a model run with the same setting can be either highly successful or a failure. To diminish this stochastic effect, we ran each scenario 1000 times, so we can distinguish reliable trends from each scenario. The simulation stops automatically when the average satisfaction of actors is 1 or less. Success of a scenario is measured by its average life span, which means counting the amount of time steps until it stops. A second measure for evaluating the success of a scenario is the success/failure ratio. This ratio is calculated by counting the amount of runs that run for 70 time steps or more, and divide these by the total amount of runs. The time steps resemble the development of the simulation over time and its relation with real time is not specific [38].

3. Results

This section describes the results from the survey and agent-based simulations. First, the survey response is discussed. Thereafter, an evaluation of INSPIRE’s governance is given by putting the survey results within the governing system framework as shown in Figure 1. The third part shows the results of the agent-based modelling simulations.

3.1. Survey Response

Table 2 shows the survey response. From almost every EU member state at least one response was registered. Only no stakeholders from Ireland, Lithuania and Poland responded. From the Czech Republic, more results (13) came in than the actual research population (4). Probably because the survey was shared broader. To control if this large response did not skew the results too much, we tested if the responses from the Czech

respondents and non-Czech respondents differed significantly with a Mann–Witney U test [45].

Table 2. Survey response compared to original research population.

	Research Population	Response	Response Rate
EU Member states	86	48 ¹	56%
Non-member states	14	3	21%
EU level	23	4	17%
Total	123	55	45%

¹ More responses (13) came from the Czech Republic compared to the original Czech research population (4), boosting the response rate for EU member states.

In total, 42 questions were tested, which resulted in only 3 questions with a significant difference ($p \leq 0.05$): organisational culture, data provision and data use. These questions were rated more positively by the Czech respondents. This led to small differences of +0.1 or 0.2 for these questions when we compared the average response of the whole population with the Czech response included to the average response with the Czech response excluded. Of course, totally excluding or aggregating this group would not give more accurate results as the original Czech research population existed of 4 respondents. Given this reason, the low rate of statistical differences and the minor influences on the resulting averages, we decided to use all responses for our analysis.

Response from the non-member states and the EU level was much lower compared to the EU member states. Especially, the relatively low response from the EU level is remarkable as multiple EU organisations are involved in INSPIRE’s governance as coordinator or as main user.

Most respondents have a long involvement in INSPIRE (see Figure 3a). The majority (80.0%) has an involvement for over 5 years or longer. When looking at SDI roles, most respondents (87.3%) classify themselves as SDI executives (see Figure 3b). This means they have coordinating tasks. As it was possible to select multiple roles, many also responded to be a data provider (58.2%) and/or a platform provider (47.3%), which means they are busy with delivering INSPIRE data and/or hosting INSPIRE webservices. These outcomes are not surprising, given the fact that MIG members are mostly the organisational or technical INSPIRE coordinators in their country. The role of researcher or data user was less frequently mentioned. Given the research population this is also not surprising, although it does indicate a relative low share of involvement of INSPIRE’s users in its core governance.

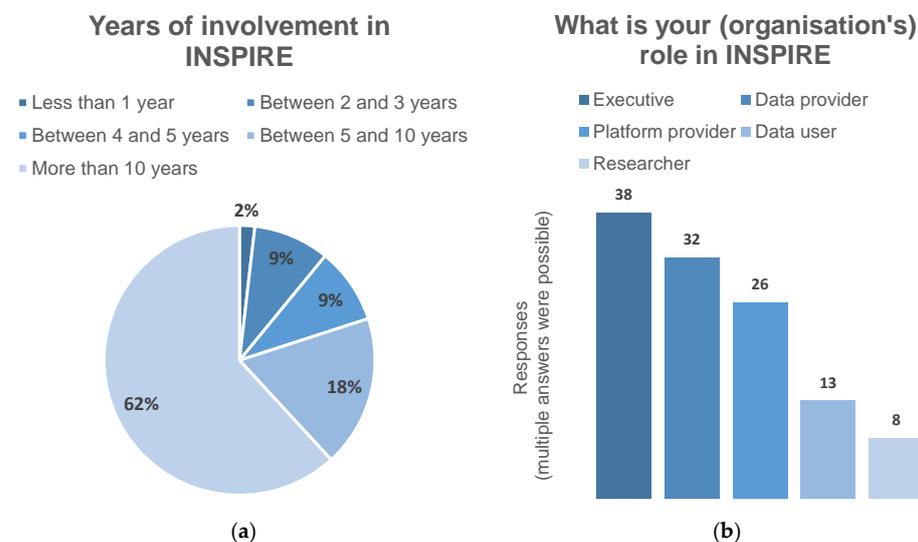


Figure 3. Graphs showing survey respondent’s characteristics. (a) Shows the years of involvement in INSPIRE of survey respondents, (b) shows respondent’s roles in INSPIRE (multiple answers were possible).

3.2. Evaluating INSPIRE's Current Governance

To discover the strong and weak aspects of INSPIRE's governance, we calculated averages, medians and modes on each aspect in the governing system framework. Figure 4 shows the averages and their place in the governing system framework. These scores are based on the Likert-type statements from the survey on a 1 till 5 range: 1 means very negative, 3 is neutral and 5 is very positive. Instruments are the only aspects which were not classified on a Likert scale, but as a percentage to get a feeling of the distribution of instruments. The results to each survey question and other statistics can be found in Supplementary Materials.

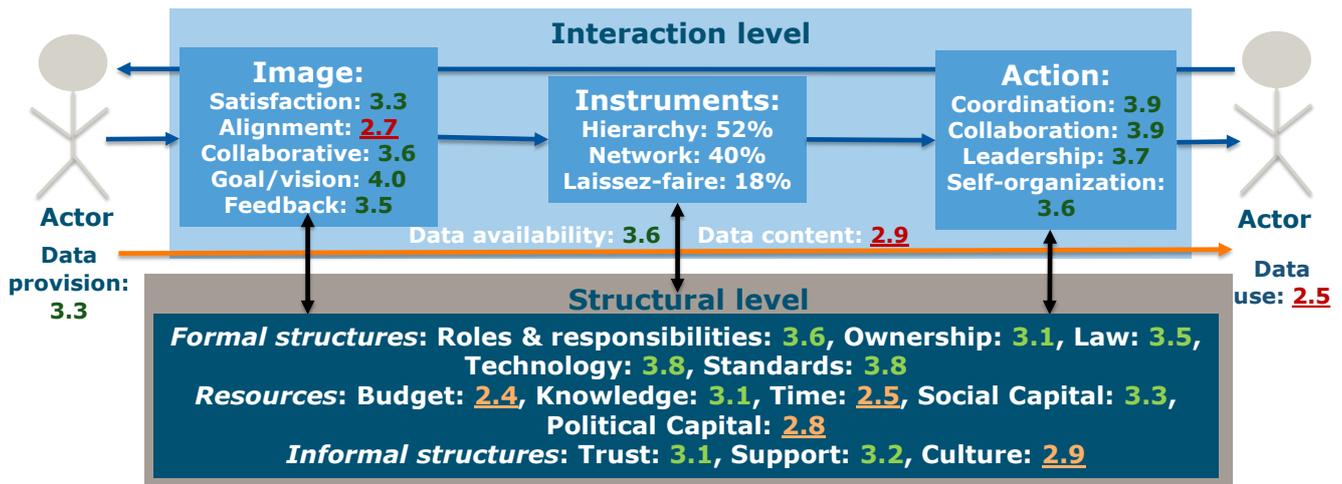


Figure 4. This figure presents in the SDI governing system framework of Sjoukema et al. [26] the average scores from the survey results on each governing aspect. Each aspect is scored on a 1 till 5 range: 1 means very negative, 3 is neutral and 5 is very positive. Aspects scoring less than a 3 are underlined.

Overall, the governing system of INSPIRE is rated positively as most aspects score above 3. When looking at the image category a paradox emerges: the goal and vision of INSPIRE was highly rated and the statement *'I support the goal and vision of INSPIRE'* scored the most positive of all questions. However, a statement about alignment of opinions among its stakeholders scored much worse. A possible explanation lies in the fact that the bigger vision and goals of INSPIRE could be clear and supported, but the way to get there can be a point of discussion. From a governance perspective, a diversity of opinions does not necessarily have to be a bad thing. *'People bring varying perspectives, interests, and fundamental philosophies to problems (...), their conflicts, if they do not escalate to the point of dysfunction, can spark learning and change'* [41] (p. 1909). A clear, common and supported vision helps steer the SDI in the desired direction [46].

When looking at the instruments category it is clear that INSPIRE is largely hierarchically governed. This is not surprising as its implementation strategy is largely based on regulations which require member states to comply with. From the additional comments left by respondents, this is on the one hand positive: *'I am an advocate of (...) the centralized way of building INSPIRE. Otherwise we do not have any standards.'* Another adds it should be even stricter: *'By being stricter, (...) the results would have been better for use much earlier. The easiest example is an obligation to provide metadata in English.'* However, it is also negatively reviewed: *'The strong binding to legislative aspects does not allow the suitable flexibility for technical implementation that would reach to better operable solutions.'* Or as one respondent summarises: *'The legal obligation has been the key motor for implementation and the biggest constraint.'*

All action aspects are positively reviewed, which enables the implementation of INSPIRE. Although one respondent adds that although leadership is strong, users are largely uninvolved and INSPIRE would need to focus on the user more. This data push

approach is also apparent from the evaluation on INSPIRE's data: the availability and provision are positively rated, but the data content (i.e., its usefulness and quality) and its use are negatively evaluated. This is currently a main challenge for INSPIRE.

At the structural level, we can see that most formal structures such as roles and responsibilities, law, technology and standards are seen as enablers. Many resources are negatively reviewed, such as the access to political capital, time and especially budget resources. In fact, the statement on budget resources was the lowest scoring statement. Again, this is explainable as the EU does not provide any budget to member states to provide harmonised data and services and, in many cases, member states do not directly benefit from the INSPIRE obligations. The informal structures, such as trust, support and culture balance around a neutral score: they are not very enabling, but also not constraining.

3.3. Exploring Future Scenarios for INSPIRE's Governance

Table 3 shows how the survey results are used as input settings for running the agent-based model simulations. Some results had to be converted in order to fit the model inputs. These settings are then used to simulate the four scenarios (baseline scenario, adaptive scenario, continuous budget scenario and adaptive + continuous budget scenario) as discussed in Section 2.4 and shown in Table 1.

Table 3. This table shows how the survey results are converted in input settings for the agent-based model. The settings for the susceptibility to feedback and budget resources had to be converted in order to fit the model inputs. Please see Supplementary Materials for all survey results.

Parameter	Survey Result	Model Input Setting
Satisfaction of INSPIRE stakeholders ¹	6.5/10	6.5/10
Susceptibility to feedback	3.5/5	70%
Budget resources	2.4/5	5/10
Hierarchy messages	52%	52%
Network messages	40%	40%
No messages (laissez-faire)	18%	18%

¹ Please note that we do not differentiate the satisfaction per actor (SDI executive, SDI data provider, SDI platform provider and SDI users) in the model as due to the multi-level nature of INSPIRE, respondents have multiple roles as indicated by Figure 4b.

Figures 5 and 6 show the simulation results. Figure 5 shows the average life span per scenario, which is the average amount of time steps a simulation took before it failed. Figure 6 shows the success/failure ratio for each scenario. Compared to the other scenarios, the baseline scenario performs the worst. Interestingly, the adaptive scenario performs less than the continuous budget scenario. An explanation could be that INSPIRE's financing is constraining its governance dynamics more than the current interaction mix. This seems to correspond with the survey results (Figure 4) as budget resources were the lowest scoring aspect. However, by combining the adaptive scenario and continuous budget scenario, the simulation performs the best. The following section discusses these results further and provides recommendations for INSPIRE's governance.

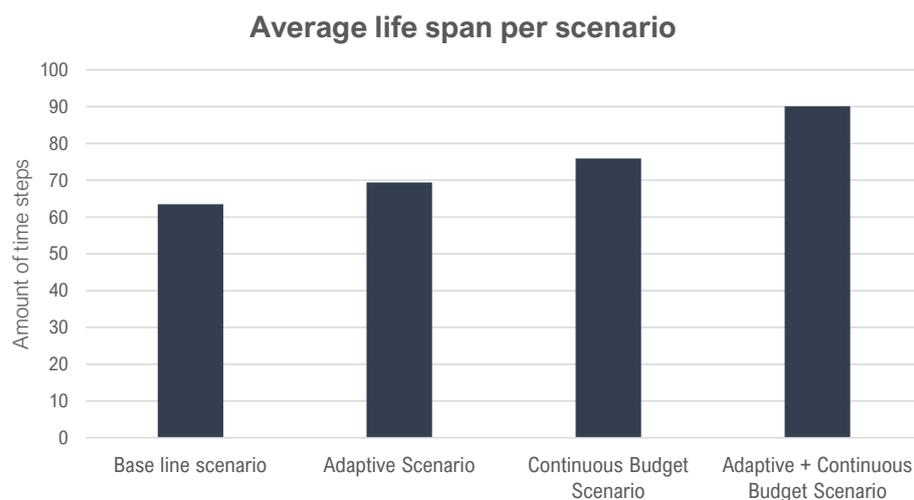


Figure 5. Average life span in time steps per simulated scenario.

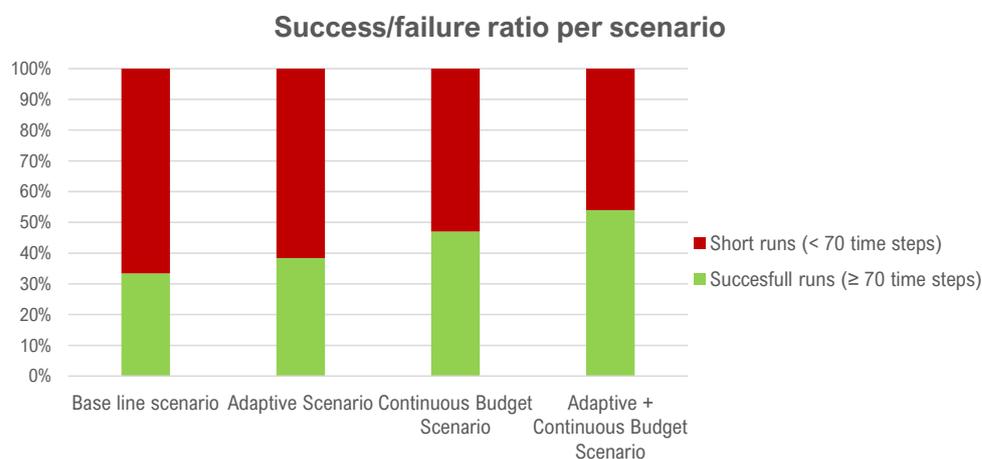


Figure 6. Percentage of runs that are classified as successful compared to the other runs. Success is defined as running for 70 time steps or longer.

4. Discussion

This research evaluated the current governance of INSPIRE through a survey followed by an exploration of potential governance scenarios by using an agent-based model. The survey proved to be an efficient and effective approach to evaluate the current governing system of INSPIRE. By visualising the results in the governing system framework (see Figure 4), a concise overview of the governing system appears. With some minor modifications, this survey can be useful for SDI governors and researchers to evaluate the perceived governing system of other SDIs. Furthermore, by using the survey results as input data for the agent-based model, potential effects of governance interventions can be explored.

However, when using the survey attention should be paid to the research population. The survey was now only sent to stakeholders with a high involvement in INSPIRE's European governance (MIG and MIG-T members). From the survey results, it is clear that few respondents identify themselves as user (see Figure 3b). For the evaluation of the governing system of an SDI, it is a valid choice to ask the highly involved stakeholders in the governance of the studied SDI as these stakeholders have probably the best view on all aspects of the governing system. However, a blind spot in the governance of an SDI, in this case a lack of user involvement, may result in a blind spot in the research results. Here lies a challenge: by asking a broader group of stakeholders, stakeholder's satisfaction and perception on the governance of the SDI will be better measured, although due to the distance of these stakeholders to the core governance process, the image of the governing system

may be less accurate. Nevertheless, in order to get a full understanding of stakeholder's satisfaction around an SDI, complementary surveys to all stakeholders including users are necessary. Further research could indicate whether the current governing system survey is also suitable for stakeholders with a further distance to the core governance processes and if this will lead to different results.

Another limitation lies in the richness of the agent-based model to simulate SDI governance. As some modifications were necessary to adjust the agent-based model to the INSPIRE circumstances, further development of this model is advisable to make it better applicable and more refined for other SDIs in different contexts. For example, the model could be further extended to incorporate the SDI hierarchy architecture of INSPIRE. Now, the generic model only represents one SDI, but in fact INSPIRE consists of multiple SDIs feeding one central SDI. By linking multiple SDIs to a central SDI in the model, the national SDIs of member states with their different approaches and policies and how these may affect the data quality of the central SDI may be simulated.

Nevertheless, even by using a simple agent-based model of SDI governance, the simulations proved to be valuable as a contribution to the discussion on the complex subject of INSPIRE's governance. To our surprise, the adaptive scenario performed less compared to the continuous budget scenario. We expected that by making the interaction mix adaptive, the governance would behave more like a complex adaptive system and become more sustainable than when the interaction mix is fixed. However, the simulations inform us that without structures which enable the governance, the adaptive effect is small. This may not be very surprising as also the results from the survey show that budget resources are the most constraining factor to INSPIRE's current governance.

The continuous budget scenario shows that INSPIRE's governance will be enabled by a constant flow of resources which will cover most of the costs that member states make for providing INSPIRE data. Central financing from the EU seems a logical approach to create a stable flow. One may argue that centrally and continuously financing INSPIRE is unnecessary, as EU budget comes from its member states and thus from their own pockets. However, allocating budget to member states may remove the financial constraints to contribute to INSPIRE and with financial incentives, innovation and self-organisation around INSPIRE may be stimulated. A downside could be that member states' incentive to operate cost-effectively in their contribution to INSPIRE may be less. However, one may wonder if that is a negative outcome as member states now may try to do as little as possible for INSPIRE in order to adhere to the legal requirements, while keeping its own costs low. Such attitude will hinder INSPIRE to reach its full societal value.

On the other hand, in general, extrinsic motivations such as legal obligations or financial incentives may be weaker motivators compared to intrinsic motivations: motivations that come from within [47]. It is important that INSPIRE's stakeholders have the feeling that their efforts are meaningful, which is highly related to its use. Use may be one of the most important factors to measure SDI success [48], but the survey results indicate a relatively low score on data use (see Figure 4).

Interestingly, there is a high score on data availability. This may reflect the vast amount of available data in the INSPIRE geportal. In 2019, Kotsev et al. [7] showed that this geportal contained 250,000 metadata records, although the datasets you can actually view and download are respectively 24,000 and 13,000. Noucher et al. [49] found out that of the 160,000 metadata records in French SDIs, only 15.7% contained open accessible data. This may frustrate users. At this moment, February 2022, the numbers in the INSPIRE geportal seem to have become more in balance with around 88,000 metadata records, 53,000 downloadable and 55,000 viewable datasets [34]. Nevertheless, currently little is known about the use and users of INSPIRE.

SDI use may follow an S-shaped diffusion curve, with a few early adopters at the start and an increasing growth after the SDI is valued and trusted broader [50]. This growth period may already have been started as a Dutch vision document on INSPIRE notices: *'What stands out is the huge increase in the number of [INSPIRE service] hits from 2015 onward,*

(...) *which somewhat undermines the overall impression that INSPIRE is not being used* [51] (p. 11). To counter this negative image, it is important that INSPIRE's use is measured, monitored and communicated. When use is perceived low, stakeholders will question if it was worth the costs. On the other hand, if INSPIRE's use is visible and communicated enthusiastically, it can motivate both INSPIRE's data providers and potential INSPIRE users. Shortly put: INSPIRE could inspire more.

Recently, the INSPIRE work programme 2021–24 was launched [52]. This programme focusses on five objectives: provide a future vision, prioritise datasets and themes, diminish the current heterogeneity of data, simplify technical requirements and transform INSPIRE from a legal framework towards a *'digital ecosystem for environment and sustainability'* [52]. Furthermore, these goals are related to the European Green Deal [53] and the EU Common Data space.

Multiple governance issues found by this research are addressed by these new objectives. By appending INSPIRE to the large strategic programmes of the EU such as the Green Deal [53] and Digital Europe Programme [54], access to political capital can be enhanced. This is an interesting opportunity because notions on informational or data-driven governance become now more popular [55–57]. By diminishing the heterogeneity of the data and focussing on the *'crown jewels'* [52] whereby quality becomes more important than quantity, the data content (i.e., its usefulness and quality) and, thereby, the use of data may be improved. Simplifying the technical requirements may both reduce costs for member states as well as for users to implement the data. By striving for an *'agile approach and sandboxing'* and the creation of *'communities'* [52], the interaction mix changes with more network interactions and self-organisation, which will increase the flexibility and adaptiveness.

However, this will probably not solve all identified issues by this research. Although the working programme has an action for a *'need-driven data prioritisation'* and users are mentioned a few times as relevant stakeholders [52], most INSPIRE users are not yet structurally embedded in its governance. This provides a risk that these need-driven priorities do not necessarily correspond with the broader user needs of INSPIRE's stakeholders. It is important that a broad and vivid user community around INSPIRE emerges. A strategic user group which advises the MIG may be essential to structurally embed the involvement of users in INSPIRE. Furthermore, the INSPIRE work programme does not address the budget issue, which may constrain the implementation of these changes and the desired flexibility.

5. Conclusions

The objective of this research was to evaluate the current European governance of INSPIRE and to explore potential future governance scenarios. With the help of the governing system framework, we evaluated INSPIRE's governing system. Based on this research, strong aspects of INSPIRE's governing system are in the supported vision and formal structures, such as standards, technology and roles and responsibilities. Weaker aspects are in the access to resources, especially budget and time resources, and data use. The agent-based simulations showed that INSPIRE is probably more constrained by its weak access to budget resources than its current predominantly hierarchical interaction mix. However, by removing the budget constraints and combine this with a more flexible and adaptive governance approach, this might enable INSPIRE's sustainability for the future.

INSPIRE helped forge a common base of policies, standards and technology among the EU member states. For the future of INSPIRE, it is key to consider its strategies for the next phase. In general, we recommend that INSPIRE focusses now on how to increase its value. A more flexible way of governance, with especially more room for network and self-organisation and a better inclusion of users, can help shift this focus. The new INSPIRE work programme takes steps in this direction, although it does not address the identified budget issue or embed users structurally in its governance. However, by appending to the

large strategic programmes of the EU such as the Green Deal, INSPIRE can prove its value and may increase its access to political and budget resources.

This research used and refined two previously developed methods [26,38] to evaluate SDI governance and applied it to INSPIRE. These methods helped gain a better insight in the European governance of INSPIRE, although limitations are in the research population and the simplicity of the agent-based model compared to the real-world governance complexities. Future research could focus on making agent-based models more refined and applicable in different SDI governance contexts. For INSPIRE, especially more research on its users and how to incorporate them in its governance is recommended.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/ijgi11020141/s1>. This supporting information contains the survey results and a technical description of the agent-based model and the modifications according to the overview, design concepts and details protocol (ODD).

Author Contributions: Conceptualization, Jaap-Willem Sjoukema, Jalal Samia, Arnold K. Bregt and Joep Crompvoets; methodology, Jaap-Willem Sjoukema and Jalal Samia; software, Jaap-Willem Sjoukema and Jalal Samia; validation, Jaap-Willem Sjoukema and Jalal Samia; formal analysis, Jaap-Willem Sjoukema; investigation, Jaap-Willem Sjoukema; data curation, Jalal Samia; writing—original draft preparation, Jaap-Willem Sjoukema; writing—review and editing, Jaap-Willem Sjoukema, Jalal Samia, Arnold K. Bregt and Joep Crompvoets; visualization, Jaap-Willem Sjoukema; supervision, Arnold K. Bregt and Joep Crompvoets; project administration, Arnold K. Bregt; funding acquisition, Arnold K. Bregt and Joep Crompvoets. All authors have read and agreed to the published version of the manuscript.

Funding: This work is part of the research programme Maps4Society with project number 13717 (GOV4SDI), which is (partly) financed by the Dutch Research Council (NWO). The NWO did not have any involvement in the contents of this research.

Institutional Review Board Statement: Ethical review and approval were waived for this study due to the research design. The survey contains no personal data and was used at a level which does not lead to personal identification. Furthermore, all respondents volunteered to respond to the survey and were not forced or seduced.

Informed Consent Statement: Not applicable.

Data Availability Statement: The survey results are added as supplementary materials. These are aggregated to protect the privacy of the respondents.

Acknowledgments: We would like to thank all survey respondents from the INSPIRE maintenance and implementation groups (MIG & MIG-T). Furthermore, we would like to thank the GOV4SDI user committee for their time and feedback.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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