

# BLUEPRINT FOR THE STIG1.0 – SETTING THE PERFORMANCE INDICATORS

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## Abstract

Spatial Data Infrastructures (SDIs) have been developed over the last decades all over the world. Currently, several SDI assessment methods exist. However, most assessment methods are analyzing the SDI as a whole which does not allow understanding their internal dynamics and none of these appear to meet the requirements of practitioners. As a result, SDI decision makers are still without any guidance on the success of their SDI.

The purpose of this paper is to define the Core SDI Principles based on the 29 Basel Core Principles. Additionally, a set of essential and additional assessment criteria for each Core SDI Principle will be defined. When implementing stress testing, challenges remain in modeling the interaction of different risk factors and their impacts. Such things as: integrating stress testing at different levels and making stress tests workable, realistic and timely remain complicated. These issues will be addressed in the research further developing the Stress Test for Infrastructure of Geographic information: the STIG. The paper ends with a shortlist of issues for discussion on the way to move forward.

**Keywords:** SDI, Stress test, Financial sector, STIG.

## **1. INTRODUCTION**

Increasing the effectiveness, efficiency and transparency of Spatial Data Infrastructures (SDIs) is an on-going concern of governments and of the international SDI community. Within the SDI community it has been recognized that increasing the effectiveness of the use of public funds requires the existence of an adequate SDI that meets international standards and that operates as intended. Currently, several SDI assessment methods exist. However, most assessment methods are analyzing the SDI as a whole which does not allow understanding their internal dynamics and none of these appear to meet the requirements of practitioners. As a result, SDI decision makers are still without any guidance on the success of their SDI.

The purpose of this paper is to define the Core SDI Principles based on the 29 Basel Core Principles. The research on this paper stands on an ongoing PhD research project on the development of a sound foundation for an academic theoretical framework for the STIG, Stress Test for Infrastructure of Geographic information. Under the auspices of Knowledge center Open data within OTB – Research for the Built Environment of TU Delft / Faculty of Architecture and The Built Environment, this research aims to develop a methodology and set of indicators that provide improvements in SDI assessment landscape.

### **1.1. Reading Guide**

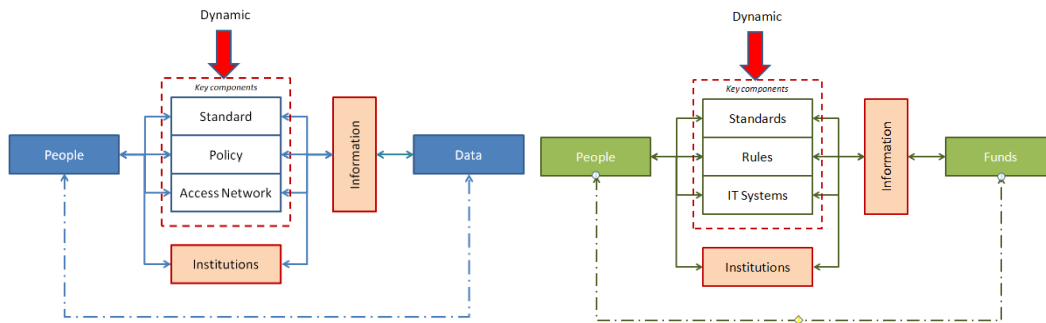
Chapter 2 focuses on the new insights started with the findings and conclusions of our previous STIG research, developments of the SDI indicators and new insights on the Basel Core principles. Finally in this chapter we are presenting several critics and flaws of the financial stress testing. In chapter 3 the framework of the STIG development is explained. First we translate the Basel Core principles to the SDI context. After that we explain and define the new set of indicators. At the end we explain the STIG implementation model. Paper ends with the conclusions and further work needed towards the finalization of the STIG framework.

## **2. NEW INSIGHTS**

### **2.1. Previous Research**

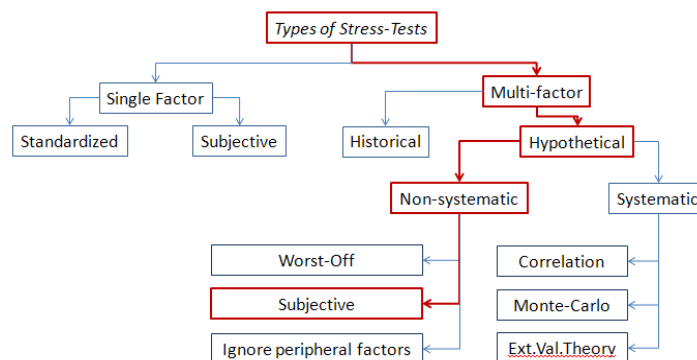
Nushi et al. (2015) assessed the extent to which stress test methodologies can be supportive to developing a new SDI assessment method that can provide the required information on the performance of SDIs. To be able to compare a Financial Infrastructure (FI) with a SDI, Nushi et al. (2015) used the new SDI model and adapted the key elements of the FI (figure 1).

**Figure 1: SDI and FI Components**



The core elements of a FI are similar to a SDI because both infrastructures have many different providers (institutions) involved, a vast amount of different users, use a range of the technological systems, there is a need for interaction between all stakeholders while each of them has its own agenda (interest), standards and rules are necessary and the strength of the infrastructure depends on the coherence of the individual parts. Additionally stress testing is very often used to assess complex financial systems or parts of it. Based on this review of the Spatial Data Infrastructure (SDI) and Financial Infrastructure (FI), Nushi et al. (2015) concluded that the stress test methodology is a promising approach for assessing SDIs and that in the next phase of this research the Core SDI Principles will be defined based on the Basel Core Principles. Additionally, a set of essential and additional assessment criteria for each Core SDI Principle were defined. From all the examined types of risk factors and methods to construct FI stress tests, the Multi-factor Stress tests (Hypothetical and a Non-systematic Subjective scenario model) are most promising as a basis for SDI assessment (Figure 2).

**Figure 2: Stress tests method for FIs (Adapted from MAS, 2003)**



This hypothetical scenario first chooses and then stresses risk factors on the basis of expert inputs including users, producers, data owners, management, consultants etc. SDI practitioners can construct hypothetical scenarios when no historical scenarios match the special features of their situation or when they want to stress new combinations of risk factors.

## 2.2. SDI Indicators

Stuedler et al. (2008) presents and discusses major classes of factors which influence, or contribute to, the development of an SDI initiative followed by reviewing key components of SDIs as highlighted by Rajabifard et al. (2002) as policies, standards, access networks, people as well as data. The areas and possible indicators suggested in table 1 are only a general framework for evaluating SDIs but are nonetheless useful for providing a first-order evaluation of an SDI and eliciting valuable indicators.

**Table 1: possible SDI performance indicators per SDI component (Stuedler et al., 2008)**

<i>Level</i>	<i>Area</i>	<i>Possible Indicators</i>
Policy	Policy	existence of a government policy for SDI
		handling of intellectual property rights, privacy issues, pricing
		objectives for acquisition and use of spatial data
Management	Standards	standardisation arrangements for data dissemination and access network
		institutional arrangements of agencies involved in providing spatial data
		organisational arrangements for coordination of spatial data
		definition of core datasets
		data modelling
Management	Access Network	interoperability
		access pricing
		delivery mechanism and procedure
		access privileges
Operational	Access Network	value-adding arrangements
		type of network
		data volume
Operational	Data	response time
		data format
		data capture method
		definition of core datasets
		data maintenance
Other Influencing Factors	People	data quality and accuracy
		number of organisations and people involved
		opportunities for training
Performance Assessment		market situation for data providers, data integrators, and end-users
		degree of satisfying the objectives and strategies
		user satisfaction
		diffusion and use of spatial data and information
		turnover and reliability

The policy component can obviously be associated with the policy level and the standards component of the management level; while the access network and data components are attributed to the operational level. The access network component may have to be considered in both management and operational levels given the varying maturity of SDI developments that have been established over the last decade. The people component has an influence on all three organizational levels

and is therefore associated with the other influencing factors area. Further Steudler et al. (2008) describes the SDI levels, areas and possible indicators as:

- Policy Level Policy: One aspect to be considered for the policy component is the geographic, historic and social context of the country. A second aspect is how the government handles the overall policy regarding the collection, dissemination and legal protection of spatial data; for example the issues such as intellectual property rights, privacy issues and pricing. Indicators might be the existence of a government policy regarding the mentioned issues and how the issues are dealt with. Good practice is when the government has taken actions for an SDI and when issues have been handled in a comprehensive and satisfying way in relation to the geographic, historic and social context of the country.
- Management Level Standards: The evaluation of the standards component includes how the government administration is dealing with organizational arrangements for the coordination of spatial data. This component may include the assessment of government agencies involved in providing spatial data for land titles, for large- and small-scale mapping. The evaluation has to consider standardization issues like the definition of core datasets, data modelling practices and interoperability at the national level. Indicators for the management level might be a list and the size of government agencies involved in spatial data, their size and activities and how they communicate and cooperate with each other. In order to permit comparisons with other countries, indicators might point out the definitions of the core datasets, the data modelling techniques used for defining spatial datasets and the standardization decisions for the access networks.
- Management Level Access Networks: The evaluation of the access networks component may include issues like the definition of data summaries, formats of available data, delivery mechanisms for the data, whether access will have associated costs and whether data-access privileges will be defined for different user groups. Indicators might point out access pricing, access delivery mechanisms and procedures, whether access is defined by privileges or is open to all users, as well as whether there are inter-institutional links for data access, or value-adding arrangements established with the private sector.
- Operational Level Access Network: The responsibility for the operational level is with the government's operational units that have to make things happen in terms of access network and data provision. The access network component is to be evaluated by considering the type of available network and its capacity and reliability. Indicators might be the data volume and response time and good practice would be when the network can handle a large data volume reliable with a short response time.
- Operational Level Data: The data component can be evaluated by assessing the data models of the spatial datasets of the different agencies,

the creation of a national core dataset, the data formats, data capture methods, data maintenance as well as data quality and accuracy. Good practice might be when data is defined in clear and transparent ways (content, quality, accuracy) so that they can easily and readily be shared among the different agencies and users.

- *Other Influencing Factors: People:* The evaluation of the people or human resources component has to take the three groups into account which have been identified as relevant in the SDI context: end-users; data integrators. The evaluation will have to assess the situation within these three groups in terms of personnel, opportunities for training and capacity building and the market situation for spatial data. Good practice will be when end-users are easily and readily getting the data product that they are looking for, when integrators can operate and prosper in favorable market situations and when data providers are able to deliver the data in efficient and effective ways.
- *Performance Assessment:* This aspect has not significantly been addressed in SDI research papers so far, but is equally important for the overall assessment of national infrastructures. The assessment might include the review of objectives, strategies, performance and the reliability of the system, as well as user satisfaction. Indicators can be the adoption of SDI principles, its use and diffusion of spatial data and user satisfaction surveys. Good practice can be considered as when all SDI principles are adopted, when there is large use and diffusion of spatial datasets and when users indicate satisfaction about the products and services offered.

### **2.3. The Basel Core Principles**

The Core Principles for Effective Banking Supervision (The Basel Core Principles) are the *de facto* minimum standard for sound prudential regulation and supervision of banks and banking systems (BIS, 2012). Originally issued by the Basel Committee on Banking Supervision in 1997, countries use the Core Principles as a benchmark for assessing the quality of their supervisory systems and for identifying future work to achieve a baseline level of sound supervisory practices (BIS, 2012). In the context of the Financial Sector Assessment Program (FSAP), the International Monetary Fund (IMF) and the World Bank uses the Core Principles to assess the effectiveness of countries' banking supervisory systems and practices (BIS, 2012).

The Core Principles define 29 principles that are needed for a supervisory system to be effective. Those principles are broadly categorized into two groups: the first group (principles 1 to 13) focuses on powers, responsibilities and functions of supervisors, while the second group (principles 14 to 29) focuses on prudential regulations and requirements for banks (BIS, 2012). Table 2 presents 29 Basel core principles.

**Table 2: The Basel Core Principles**

<b>Nr</b>	<b>Principle</b>
1	Responsibilities, objectives and powers
2	Independence, accountability, resourcing and legal protection for supervisors
3	Cooperation and collaboration
4	Permissible activities
5	Licensing criteria
6	Transfer of significant ownership
7	Major acquisitions
8	Supervisory approach
9	Supervisory techniques and tools
10	Supervisory reporting
11	Corrective and sanctioning powers of supervisors
12	Consolidated supervision
13	Home-host relationships
14	Corporate governance
15	Risk management process
16	Capital adequacy
17	Credit risk
18	Problem assets, provisions, and reserves
19	Concentration risk and large exposure limits
20	Transactions with related parties
21	Country and transfer risks
22	Market risk
23	Interest rate risk in the banking book
24	Liquidity risk
25	Operational risk
26	Internal control and audit
27	Financial reporting and external audit
28	Disclosure and transparency
29	Abuse of financial services

For assessments of the Core Principles the following four-grade scale is used: compliant (C), largely compliant (LC), materially non-compliant (MNC) and non-compliant (NC). A “not applicable” (NA) grading can be used under certain circumstances where the supervisors are aware of the phenomenon and would be capable of taking action, but realistically there is no chance that the activities will grow sufficiently in volume to pose a risk. A brief description of grading and their applicability:

- Compliant – A country will be considered compliant with a Principle when all essential criteria applicable for this country are met without any significant deficiencies.
- Largely compliant – A country will be considered largely compliant with a Principle whenever only minor shortcomings are observed that do not raise any

concerns about the authority's ability and clear intent to achieve full compliance with the Principle within a prescribed period of time.

- **Materially non-compliant** – A country will be considered materially non-compliant with a Principle whenever there are severe shortcomings, despite the existence of formal rules, regulations and procedures, and there is evidence that supervision has clearly not been effective, that practical implementation is weak, or that the shortcomings are sufficient to raise doubts about the authority's ability to achieve compliance.
- **Non-compliant** – A country will be considered non-compliant with a Principle whenever there has been no substantive implementation of the Principle, several essential criteria are not complied with or supervision is manifestly ineffective.

A stress test could be seen as a 'disaster exercise' for the systemic banks or the entire FI. Systemic banks are banks that may not actually become insolvent because of their size. Should that happen, then it would constitute a direct risk to the financial system as a whole. Possible scenario can be outlined based on these events: sudden fall of the real-estate prices, rising of the unemployment, the economy is stagnating, collapse of the financial markets or even countries cannot repay their debts. Banks should have at least 8% financial buffers reserved for these events so that national governments do not have to get involved in rescuing the banks by paying the financial buffers. The banks have to keep after the stress test more than 5.5% of their capital as a buffer. If a bank fails the stress test, it means that the capital buffers should be supplemented. A bank can supplement the capital buffers itself by trading certain organizational activities or by raising funds on the capital market. If this is insufficient, governments will get involved.

#### **2.4. Flaws of the Financial Stress Testing**

The global financial crisis of 2008 exposed flaws in the stress-test methodologies in the area of structured finance evolving into the economic downturn and basically took banks by surprise. Worse, most financial institutions were ill-prepared for such a turn of events, and initially had no idea how to react. Despite the fact that banks have been using stress testing internally for many years, the test results had little-to-no influence on the overall business decisions of banks (Kapinos et al. 2015) As a consequence, banks built excessive risk positions without considering how vulnerable they would be if things quickly went wrong. These shortages were a key contributor to the dramatic results of this imperfect financial system including the collapse of (until then) 'to-big-to-fall' financial giants like AIG and Lehman Brothers. Stress testing of financial institutions also lacked to produce a timely warning as the US real estate crisis morphed into a global financial crisis. As argued by Kapinos et al. (2015), no credit rating agency (CRA) gave a timely warning regarding Europe's sovereign debt crisis, which eventually overcome Greece, Portugal and Ireland, with its impacts still being felt today. In the rouse of these



crises, rating agencies, institutional investors and government oversight bodies have tightened their standards dramatically for judging creditworthiness, with the assessment of sovereign credit risk being particularly impacted. Based on the above situation, forceful criticism argues against the fundamental appropriateness of stress testing. Kupiec (2014) argues that stress testing amounts to regulators operating financial institutions. He also argues that since regulators are effectively operating the institutions, they may face difficulty in allowing equity-holders and creditors to take losses. According to Hirtle and Lehnert (2014), a closely related concern is that stress testing exposes regulators to reputational risk. If markets perceive that regulators give a particular firm or financial system a passing grade, only for it to fail soon thereafter, the regulators' reputations may be compromised. Another critique is that the requirement to conduct stress testing represents an unreasonable burden on financial institutions, especially smaller and less complex institutions (McLannahan, 2015).

We consider in this section the most salient of these critiques. While some reflect valid concerns and may warrant additional analysis going forward, we conclude that, if performed in a sound manner, stress testing remains an appropriate and useful regulatory tool. Unfortunately, many banks consider regulatory stress testing a burden and not an opportunity (Kapinos et al., 2015). Based on the above, we conclude that Basel Core principles for stress testing are a worthy approach for the creation of the new SDI assessment. Having in mind that Stress testing based on the Basel Core principles hasn't predicted timely and accurately the large economic crisis, the need for a new Basel framework with sound processes to perform the assessment of SDI is evident.

### **3. DEVELOPING STIG - STRESS TESTING FOR SDI ASSESMENT**

#### **3.1. Translating Basel Principles to the SDI Context**

We assessed compliance of 29 Basel Core Principles with the proposed SDI assessment indicators. We used the following three assessment scores as presented in table 3.

**Table 3: The compliance assessment of The Basel Core Principles with the SDI indicators**

Compliance	Score	Explanation	Applicable in STIG
Not compliant	0	This Basel principle is not in compliance with this SDI Indicator. Major adaptation or a brand new principle definition is required.	No
Partially compliant	1	This Basel principle need to be adapted to achieve compliance with this SDI Indicator	Maybe
Compliant	2	This Basel principle is in a close compliance with this SDI Indicator. Only a minor semantic adaptation is needed.	Yes

By using expert opinion judgement as a research method, we compared the 29 Basel Principles and 30 SDI Indicators and provided the compliancy scores of 0, 1 and 2 by evaluating the detailed definition and description for each principle and trying to reflect individual needs and requirements of each indicator SDI. Some of the Basel Core principles are applicable to the SDI context. For example, the principle 1 “Responsibilities, objectives and powers” addresses the operational independence, transparent processes, sound governance, adequate resources and accountability. This principle is reasonably relevant in a SDI context. Therefore, we maintain this principle in the STIG. Several Basel core principles may not all be applicable to the SDI context. The principle 2, “Independence, accountability, resourcing and legal protection for supervisors” addresses the operational independence, transparent processes, sound governance, budgetary processes and legal protection for the supervisor. This Basel principle can be maintained in the STIG but needs to be adapted to achieve compliance with the SDI Indicator “Existence of a government policy for SDI”. Other principles, such as Basel Core Principle 7 “Major acquisitions” addresses major acquisitions or investments by a bank, against prescribed criteria, including the establishment of cross-border operations, and confirming that corporate affiliations or structures do not expose the bank to undue risks or hinder effective supervision. In an SDI context such issues are unlikely to exist. This Basel Core principle is not in compliance with this SDI Indicator and can’t be maintained in the STIG. Major adaptation or a new principle definition is required. In similar way we assessed all Basel core principles resulting in an overall compliance assessment as shown in table 4. For more detailed overview of the final compliance score see appendix 1.

**Table 4: The overall compliance of 29 Basel Core Principles with SDI indicators**

Level	Area	Policy				Management				Management				Operational				Operational				Other Influencing Factors				Performance Assessment			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Powers, responsibilities and functions of supervisors	1. Prudential supervision	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	2. Independence	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	3. Objectivity	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	4. Fairness	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	5. Transparency	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	6. Accountability	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	7. Risk management	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	8. Supervisory approach	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	9. Supervisory	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	10. Supervisory activities	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	11. Supervisory and	1	1	1	1	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	12. Oversight	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	13. Oversight	1	1	1	1	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Prudential regulations and requirements	14. Prudential supervision	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	15. Concentration risk	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	16. Prudential supervision	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	17. Prudential supervision	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	18. Prudential supervision	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	19. Prudential supervision	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	20. Prudential supervision	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	21. Prudential supervision	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	22. Prudential supervision	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	23. Prudential supervision	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	24. Prudential supervision	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	25. Prudential supervision	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	26. Prudential supervision	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	27. Prudential supervision	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	28. Prudential supervision	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	29. Prudential supervision	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

The 29 Basel principles are categorized into two groups. The first group (principles 1 to 13) focuses on powers, responsibilities and functions of supervisors, while the second group (principles 14 to 29) focuses on prudential regulations and requirements for banks (BIS, 2012). To be able to understand which group of Basel Core principles is more compliant with the different SDI levels and areas, we calculated the average values per Basel Core principles group as shown in table 5.

**Table 5: The average compliance of Basel Core Principles Group with SDI Levels and areas.**

Level	Policy	Management		Operational		Other Influencing Factors	Performance Assessment
Area	Policy	Standards	Access Network	Access Network	Data	People	
Powers, responsibilities and functions of supervisors	1,36	0,91	0,31	0,33	0,42	0,54	0,86
Prudential regulations and requirements	1,69	1,28	1,02	0,44	0,46	0,46	0,83

To be able to compare the average compliance of Basel Core principles with the SDI levels and areas defined by Steudler et al. (2008) we have set the range of the average values between 0 and 0.75 in red as 'Non-Compliant', between 0.75 and 1.25 (yellow) as 'Need to be adapted' and between 1.25 and 2 (green) as 'In Compliance' with the corresponding SDI levels and areas.

Our analysis shows that the Basel Core principles are in relatively good compliance with general SDI principles and are reasonably straightforward applicable for the assessment of the SDI Policy level and with some minor adaptation for the SDI management level in area of Standards. However, the Basel Core principles need to be significantly adjusted to accommodate with the

assessment of the important SDI areas Access network, Data and People. Therefore a new set of essential and additional assessment criteria based on the approach of the Basel Core principles for each Core SDI Principle need to be defined.

### **3.2. How to Assess SDIs in a New Way?**

In addition to reduce above mentioned concerns and increase system robustness of a SDI, STIG (Stress Test for Infrastructure of Geographic information) would attempt to provide new robust SDI assessment by aiming to deliver SDI reports that incorporate a more dynamic, multidisciplinary and forward-looking evaluation of SDI. It would try to avoid what often appears as a static approach used by traditional SDI assessment methods. Following the conclusion of Nushi et al. (2015) that the methodology of STIG 1.0 will be created based on the performance indicators based on the Basel Core Principles and application of the baseline quantitative and qualitative indicators. To achieve this goal, the STIG will consist of three main groups of principles and indicators: a subset of the Basel Core principles; a set of quantitative technological principles and indicators; and a set of the progressive quantitative principles and indicators.

### **3.3. The New Set of Principles and Indicators**

The first group, the subset of the Basel Core principles, consists of 10 Basel Core principles carefully chosen using the compliance assessment as presented in table 3. As described in paragraph 3.1, the objective was to screen all Basel Core principles available and strip the list down to those that are absolutely necessary, avoiding too many positive correlating indicators and insuring limited duplication. Having in mind that these 10 selected Basel core principles are mostly in compliance with the Policy and Management areas of SDIs, we decided to add a set of quantitative principles with their corresponding indicators to be compliant with SDI areas Access network, Data and People. This principle is based on the 8 key performance indicators focus on the implementation of the technological components of INSPIRE (INSPIRE, 2016). Furthermore, to be able to assess the organizational aspects of SDI, we have proposed a set of qualitative principles and indicators on several non-technological and technological topics. These principles are described in more details further in this paragraph.

#### **3.3.1 *Subset of the Basel core principles***

After this detailed compliancy assessment of the 29 Basel principles with 30 SDI Indicators we came to conclusion that the subset of the 4 Basel Core principles which define the 'Supervisory powers, responsibilities and functions' and 6 Basel Core principles defining so called 'Prudential regulations and requirements' will be adapted to fit the purpose of the STIG SDI assessment. In the category 'Supervisory powers, responsibilities and functions' authors have carefully

selected and adapted these 4 principles: Principle 1: Responsibilities, objectives and powers; Principle 3: Cooperation and collaboration; Principle 9: Supervisory techniques and tools; Principle 11: Corrective and sanctioning powers of supervisors. While regarding category 'Prudential regulations and requirements' we have adapted these 6 principles: Principle 14: Corporate governance; Principle 15: Risk management process; Principle 22: Market risk; Principle 25: Operational risk; Principle 26: Internal control and audit; Principle 28: Disclosure and transparency (table 6).

**Table 6: Subset of the Basel Core Principles**

Nr	Principle
1	Responsibilities, objectives and powers
3	Cooperation and collaboration
9	Supervisory techniques and tools
11	Corrective and sanctioning powers of supervisors
14	Corporate governance
15	Risk management process
22	Market risk
25	Operational risk
26	Internal control and audit
28	Disclosure and transparency

An example of the adaptation of Principle 1 to the SDI context:

- **Name:** Responsibilities, objectives and powers
- **Objective:** An effective system of SDI supervision has clear responsibilities and objectives for each authority involved in the supervision of SDI organization and key SDI stakeholders. A suitable legal framework for SDI supervision is in place to provide each responsible authority with the necessary legal powers to authorize, conduct on-going supervision, address compliance with laws and undertake timely corrective actions to address safety and soundness concerns.

Essential criteria:

1. The responsibilities and objectives of each of the authorities involved in SDI supervision are clearly defined in legislation and publicly disclosed. Where more than one authority is responsible for supervising the SDI system, a credible and publicly available framework is in place to avoid regulatory and supervisory gaps.
2. The primary objective of SDI supervision is to promote the safety and soundness of SDI organization. If the SDI supervisor is assigned

broader responsibilities, these are subordinate to the primary objective and do not conflict with it.

3. Laws and regulations provide a framework for the supervisor to set and enforce minimum prudential standards for SDI organization and SDI stakeholders. The supervisor has the power to increase the prudential requirements for individual SDI stakeholders based on their risk profile and SDI systemic importance.
4. SDI laws, regulations and prudential standards are updated as necessary to ensure that they remain effective and relevant to changing industry and regulatory practices. These are subject to public consultation, as appropriate.
5. The supervisor has the power to: (a) have full access to SDI organization and individual stakeholders boards, management, staff and records in order to review compliance with internal rules and limits as well as external laws and regulations; (b) review the overall activities of the SDI stakeholders, both domestic and cross border; and (c) supervise the foreign activities of SDI organization incorporated in its jurisdiction.
6. When, in a supervisor's judgment, a SDI is not complying with laws or regulations, or it is or is likely to be engaging in unsafe or unsound practices or actions that have the potential to jeopardize the SDI, the supervisor has the power to: (a) take (and/or require a SDI stakeholder to take) timely corrective action; (b) impose a range of sanctions; and (c) cooperate and collaborate with relevant authorities to achieve an orderly resolution of the SDI organization, including triggering resolution where appropriate.
7. The supervisor has the power to review the activities of parent companies and of companies affiliated with parent companies to determine their impact on the safety and soundness of the SDI organization.

The following four-grade scale will be used to assess each principle: compliant (C), largely compliant (LC), materially non-compliant (MNC) and non-compliant (NC). A "not applicable" (NA) grading can be used under certain circumstances.

### 3.3.2 *Quantitative principle and indicators*

To accommodate the assessment for the SDI components access network, data and people, the STIG will build on the INSPIRE monitoring methodology the new principle is introduced, "The implementation of the metadata, the data and the networks services". This principle consists of 8 technological INSPIRE indicators as defined in the implementing rules "Commission Decision of 5 June 2009 implementing Directive 2007/2/EC of the European Parliament". These 8 indicators focus on the implementation of the technological components of INSPIRE: i.e. the

implementation of the metadata, the data and the networks services. The table 7 below gives the overview of the 8 key technological INSPIRE indicators.

**Table 7 - The 8 key technological INSPIRE indicators**

Indicator Code	Indicator name	Meaning of indicator	Comments
MDi1	Existence metadata	Measures the existence of metadata for the spatial data sets and services	For each dataset and service whether it has or has not metadata
MDi2	Conformity metadata	Measures the conformity of metadata for the spatial data sets and services with the implementing rules for metadata	For each dataset and service whether it has or has not conformant metadata
DSi1	Coverage spatial datasets	Measures the extent of the Member States territory covered by the spatial data sets	The territory covered by the dataset is compared to the relevant territory that could be covered (e.g. x% of all the urban areas in the country)
DSi2	Conformity spatial datasets	Measures the conformity of the spatial data sets with the data specifications and the conformity of their corresponding metadata	Both the spatial dataset and metadata should be conformant
NSi1	Accessibility metadata	Measures the extent to which it is possible to search for spatial data sets and services on the basis of their corresponding metadata through discovery services	For each spatial data set and services it is checked whether it is possible or not to discover it through at least 1 discovery service
NSi2	Accessibility spatial datasets	Measures the extent to which it is possible to view and download spatial data through view and download services	For each spatial data set it is checked whether it is possible to view and download it through at least 1 view and 1 download service
NSi3	Use network services	Measures the use of all network services	Calculated by the annual number of service requests for all network services
NSi4	Conformity network services	Measures the conformity of all network services with the implementing rules for network services	This also includes the performance of the services

As stated in paragraph 3.1, there are some gaps which are not addressed by Basel Core principles such as Access network, Data and People. These gaps are partially addressed by introduction of this INSPIRE principle “The implementation of the metadata, the data and the networks services” with the proposed indicators as shown above. Other gaps such as organizational stability, reform capacity and behavior and resilience during the crises will be addressed by new set of qualitative principles and indicators proposed below based on our expert opinion.

### 3.3.3 *Qualitative principles and indicators*

For assessing a SDI’s ability and willingness to cope with future organizational risks, it is necessary to take into account a broad array of principles and indicators. To capture this element, the indicators have to go beyond purely technical

indicators to capture a meaningful picture of SDI's long-term organizational prospects and the potential social constraints. For instance, aspects such as legal certainty, the effectiveness and transparency of institutions, governmental steering capacities, as well as questions of sustainability are crucial for assessing a SDIs long-term stability, reliability and predictability and thus have to be included in STIG assessment method. The following section sketches out three basic thematic dimensions covering those qualitative principles: (a) Political, Economic and Social Stability; (b) Steering Capability and Reform Capacities and; (c) Lessons learned from past Crisis Management.

(a) Political, Economic and Social Stability

This dimension incorporates those indicators that are essential for judging a SDIs long-term political and social stability, as well as its performance in delivering sustainable public added value and setting the right priorities for promoting future growth. In this regard, it is necessary to take into account the following principles and their indicators as presented in table 8.

**Table 8 - The qualitative principles and their indicators regarding Political, Economic and Social Stability of SDIs**

Principle	Indicator	Meaning of indicator
Rule of Law	Legal Certainty	To what extent do SDIs act on the basis of, and in accordance with, legal provisions or culturally accepted norms to provide legal and practical certainty?
Rule of Law	Independent Judiciary	To what extent do independent auditors control whether organizations act in conformity with the law?
Rule of Law	Separation of Powers	To what extent is there a working separation of powers?
Transparency/Accountability	Corruption Prevention	To what extent are SDI officials prevented from abusing their position for private interests?
Transparency/Accountability	Public Participation	To what extent does the SDI organization enable the public participation in the SDI process?
Social Cohesion	Social Inclusion	To what extent is exclusion of SDI from society effectively prevented?
Social Cohesion	Trust in Institutions	How strong is the user approval of SDI objectives and procedures?
Social Cohesion	Societal Mediation	To what extent is there a network of stakeholders to mediate between users (society) and the SDI?
Social Cohesion	Conflict Management	To what extent is the SDI organization able to moderate domestic economic, political, and social conflicts?
Future Resources	Education	To what extent does SDI education policy deliver high-quality, efficient, and equitable education and training?
Future Resources	Research and Innovation	To what extent does SDI research and innovation policy support technological innovations that foster the creation and introduction of new products and services?
Future Resources	Employment	How successful is a SDI organization in increasing employment?
Future Resources	Environmental Sustainability	To what extent are environmental concerns effectively taken into account in SDI development and implementation?



### (b) Steering Capability and Reform Capacities

This aspect measures a SDIs effectiveness, efficiency, transparency and accountability. The indicators in this aspect address the issue of the SDIs actual reform capability and ability to act and formulate a range of strategic solutions. The following indicators as shown in table 9 are taken into account.

**Table 9 - The qualitative principles and their indicators regarding Steering Capability and Reform Capacities of SDIs**

Principle	Indicator	Meaning of indicator
Strategic Capacity	Prioritization	To what extent does the SDI organization set and maintain strategic priorities?
Strategic Capacity	Policy Coordination	To what extent can the SDI organization coordinate conflicting objectives into a coherent policy?
Strategic Capacity	Stakeholder Involvement	To what extent does the SDI organization consult with major stakeholders to support its policy?
Strategic Capacity	Political Communication	To what extent does the SDI organization consult with major stakeholders to support its policy?
Implementation	Government Efficiency	To what extent can the SDI organization achieve its own policy objectives?
Implementation	Resource Efficiency	To what extent does the SDI organization make efficient use of available human, financial, and organizational resources?
Adaptability	Policy Learning	How innovative and flexible is the SDI organization?
Adaptability	Institutional Learning	To what extent does the SDI organization improve its strategic capacity by changing the institutional arrangements of governing?

### (c) Lessons learned from past Crisis Management

To be able to learn from past crisis-management experiences this aspect analyzes a SDI's institutional settings and procedural track record of managing past crises (if applicable) to capture a capacity to deal with future crises. The indicators as presented in table 10 will be taken in consideration.

**Table 10 - The qualitative principles and their indicators regarding Lessons learned from past Crisis Management of SDIs**

Principle	Indicator	Meaning of indicator
Historical Evidence of Successful Crisis Management	Mastering the crisis	Is there evidence from historical events that the SDI organization have already mastered crisis in the past?
Crisis Remediation	Facilitating during the crises	Does the SDI organization facilitate crisis remediation in a timely manner?

Signaling Process	Communication during the crisis	Is the signaling process between the SDI organization (decision makers) so well established that confusion outcome of decisions by one decision maker on the others can be avoided or at least minimized?
Timing and Sequencing	Procedures during the crisis	Are the SDI procedures for sequencing and timing of countermeasures in a crisis anchored and broadly accepted by all stakeholders?
Protective Measure	Prevention during the crises	Are preventive measures in place that can protect the most vulnerable SDI aspects against the full effect of a crisis?
Automatic Stabilizers	Automatic back-up policies	Are automatic back-up policies and systems sufficiently strong to contain surges of massive SDI system shock?

### 3.4. The STIG core principles

The 24 STIG core principles are represented in table 11.

**Table 11: Subset of the Basel Core Principles**

<b>Nr</b>	<b>Principle</b>
	<b>Subset of the Basel Core principles</b>
1	Responsibilities, objectives and powers
2	Cooperation and collaboration
3	Supervisory techniques and tools
4	Corrective and sanctioning powers of supervisors
5	Corporate governance
6	Risk management process
7	Market risk
8	Operational risk
9	Internal control and audit
10	Disclosure and transparency
	<b>Technological INSPIRE principle</b>
11	The implementation of the metadata, the data and the networks services
	<b>Qualitative principles - Political, Economic and Social Stability</b>
12	Rule of Law
13	Transparency/Accountability
14	Social Cohesion
15	Future Resources
	<b>Qualitative principles - Steering Capability and Reform Capacities</b>
16	Strategic Capacity
17	Implementation
18	System Adaptability
	<b>Qualitative principles - Lessons learned from past Crisis Management</b>
19	Historical Evidence of Successful Crisis Management
20	Crisis Remediation
21	Signaling Process

22	Timing and Sequencing
23	Protective Measures
24	Automatic Stabilizers

The first group, the subset of the Basel Core principles, consists of 10 Basel Core principles carefully chosen using the compliance assessment as presented in table 3. Principle 11 focuses on the implementation of the technological components of INSPIRE. Principles 12 to 15 are qualitative principles with regard to Political, Economic and Social Stability of SDIs. Principles 16 to 18 are also qualitative principles referring to Steering Capability and Reform Capacities of SDIs. , and the last set of Core principles, 19 to 24 are specifically defined as qualitative principles safeguarding the SDI capability to learn from past Crisis Management events.

### 3.5. How to Score Indicators?

Each of the proposed STIG core principles will be supported by one or more indicators. To be able to gain objective input from these qualitative indicators each aspect and indicator will be anticipated with the set of possible answers. Given the degree of detail embedded in the existing rating scales of the financial stress testing, it is advisable to use similar ratings which might make the ratings more understandable for the broader public. The following four rating clusters are proposed: AAA to AA- (high answer quality); A+ to A- (medium answer quality); BBB+ to BBB- (low answer quality) and; <BB+ (speculative answer quality).

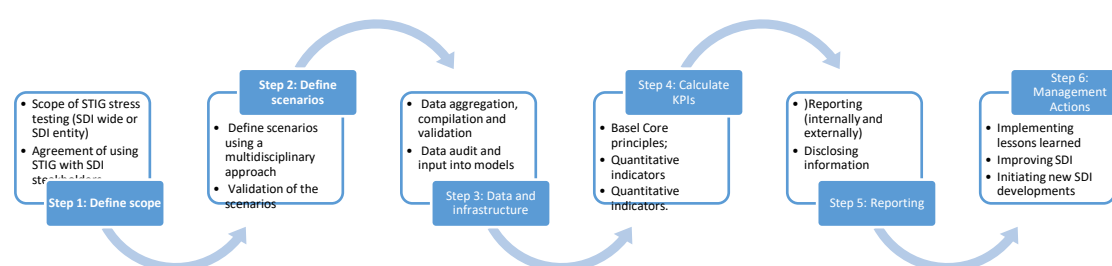
As an example on the question ‘To what extent does SDI research and innovation policy support technological innovations that foster the creation and introduction of new products and services?’ regarding the ‘Research and innovation’ indicator within the principle 15, Future resources, and the following answers could be applicable:

1. SDI research and innovation policy effectively supports innovations that foster the creation of new products and services and enhance productivity (rate AAA to AA-).
2. SDI research and innovation policy largely supports innovations that foster the creation of new products and services and enhance productivity (rate A+ to A-).
3. SDI research and innovation policy partly supports innovations that foster the creation of new products and services and enhance productivity (rate BBB+ to BBB-).
4. SDI research and innovation policy largely fails to support innovations that foster the creation of new products and services and enhance productivity (rate <BB+).

### 3.6. A Six Step STIG Implementation Model

Implementing STIG practices across the various SDIs is a complex process. In order to address the need for an implementation framework, authors are proposing this six steps STIG implementation model. The model represents a process to implement a comprehensive, rigorous, and forward-looking SDI stress testing assessment. The model is represented in this figure 3 which highlights key activities for each step in the process.

Figure 3: The six steps STIG implementation model



#### Step 1: Define scope

First the scope of the STIG stress testing implementation SDI wide or per SDI entity should be defined. After that the agreement has to be made with the SDI stakeholders regarding the STIG implementation. Organizational silos within different SDI entities can make efficient SDI-wide stress testing an ongoing challenge. However, SDI entities should establish dedicated teams tasked with defining objectives and guidelines and ensuring proper coordination among the different departments. A direct relationship of these teams to executive management is critical.

#### Step 2: Define scenarios

The scenarios need to be defined using a multidisciplinary approach. Defining scenarios that are useful for SDIs require the effective participation and cooperation of multiple teams and specialists. Chosen scenarios need to be carefully validated before starting collecting the data. This step can be also used to create and enlarge awareness of risk culture in decision-making across SDI entities.

#### Step 3: Data and infrastructure

Data quality, availability, and comprehensiveness of data are still struggles for all SDI entities. Shifting and uncertain demands also complicate progress in this area. Therefore, a flexible platform for aggregating the data, compilation and validation

from across the SDI is crucial. After that the data need to be audited and prepared to be entered into STIG models.

#### Step 4: Calculate stressed key performance indicators (KPIs)

Once the data is captured and centralized, the next step is to define and calculate the stressed key performance indicators of chosen scenarios. These KPIs are divided in the subset of the Basel principles, the set of quantitative technological indicators and a set of progressive qualitative indicators as described in paragraph 3.3. Common implementation challenges can include lack of internal skills and data, shortage of relevant resources, time constraints, and a lack of skilled personnel.

#### Step 5: Reporting

Reporting tools that address STIG requirements that can also be leveraged for SDI organizational improvement purposes will offer significant benefits and should be considered a best practice. The STIG reporting will be prepared for internal and external purposes. Important part of the reporting is disclosing information on data used in the models.

#### Step 6: Management action

Ultimately, STIG must be part of planning process and the SDI entities periodic risk management practice. After the SDI senior management has thoroughly analyzed the STIG report, appropriate management actions need to be implemented. Possible actions can be: implementing lessons learned, improving SDI processes which has poorly performed during the risk scenarios, initiating new SDI developments.

## **4. CONCLUSION AND FURTHER RESEARCH**

### **4.1. Conclusions**

In our previous research paper (Nushi et al. 2015) we concluded that stress testing based on the Basel Core principles and used in the financial infrastructures can be a promising approach for assessing SDIs and that the Core SDI Principles will be defined based on the Basel Core Principles. In this paper we tested the compliance of Basel Core principles with the SDI indicators. After the detailed compliancy analyses of the 29 Basel principles with 30 SDI Indicators proposed by Steudler et al. (2008) we came to conclusion that Basel principles are partially useful for the assessment of the SDIs but cannot be implemented for the assessment of entire range of the SDI areas. This is due to the non-compliance with the important SDI areas as Access network, Data and People. The objective of the compliancy analyses was to screen all Basel Core principles available and strip the list down

to those that are absolutely necessary, avoiding too many positive correlating indicators and insuring limited duplication. Therefore a new set of essential and additional assessment criteria based on the approach of the Basel principles for each Core SDI Principle is defined. The STIG assessment method will provide new robust SDI assessment based on subset of the Basel Core Principles combined with the set of the new quantitative and qualitative principles and indicators. The first group, the subset of the Basel principles, consists the four Basel Core principles which define the 'Supervisory powers, responsibilities and functions' and 6 Basel Core principles defining so called 'Prudential regulations and requirements'. The quantitative technological principle is based on the 8 key performance indicators focus on the implementation of the technological components of INSPIRE. To be able to assess the organizational aspects of SDI, we have proposed a set of progressive qualitative indicators on several non-technological and technological topics.

#### **4.2. Further research**

Next step in this research process is to test in theory and practice the proposed STIG core principles, indicators and the implementation model. We are aiming to organize a theoretical workshop with SDI assessment experts to test the STIG. In this workshop we intent to assess the relevance and relative importance of each principle and per principle the relative importance of each indicator. The expected constructive feedback will be used to modify the STIG assessment framework and user-friendliness and applicability. In the following workshop with the potential users of STIG assessment method we will try to test the applicability and user-friendliness of STIG in practice. Using different case studies, the STIG will be used to value the impact of a stress event on the SDI. In this process the SDI assessment experts have to go through the statements of each core principle and corresponding indicators using their expertise, and estimate the range and impact of each stressful event occurring. After that, we will calculate the stress factor. Once the new range for each core indicator/principle has been estimated, the total stress failure that the SDI is likely to acquire given the stressful event, will be calculated.

Based on the findings of these two workshops, the final STIG indicators and principles will be implemented in final version of the STIG.

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