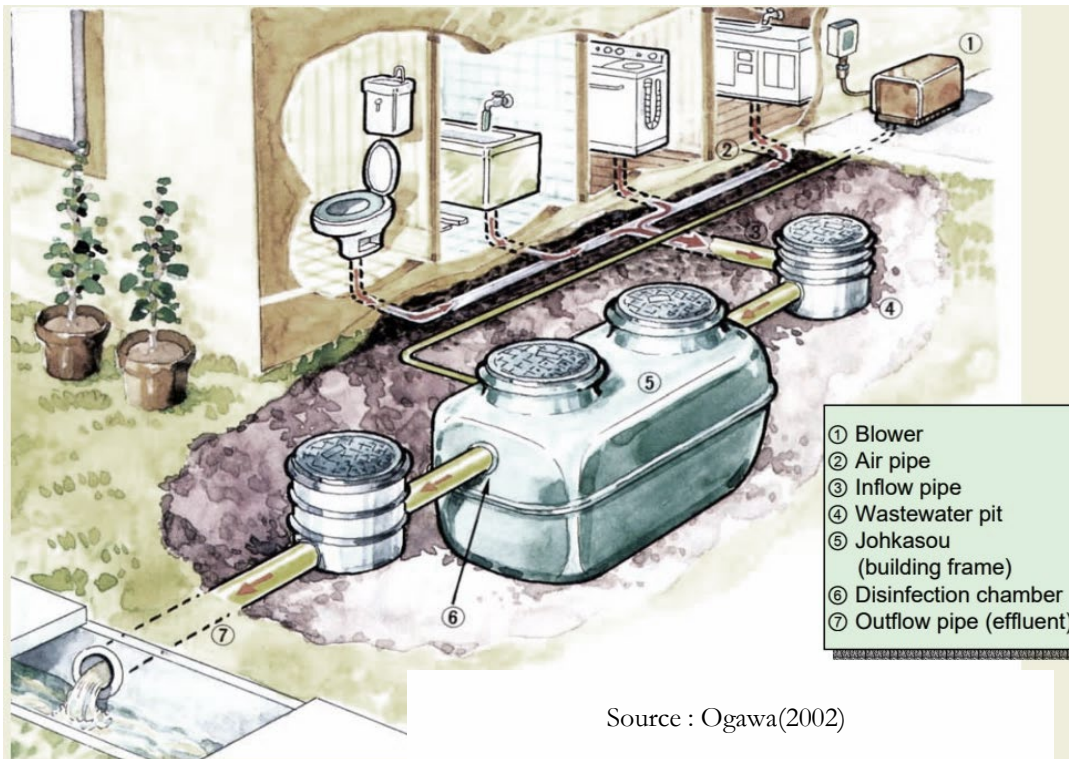


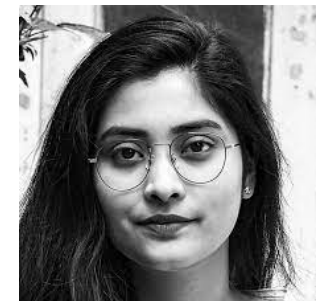
A Systems Theoretic Process Analysis (STPA) approach for analyzing the governance structure of Faecal Sludge Management (FSM) in Japan



Source : Ogawa(2002)



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10 June 2022



2022 STAMP
Workshop

A systems theoretic process analysis (STPA) approach for analyzing the governance structure of fecal sludge management in Japan

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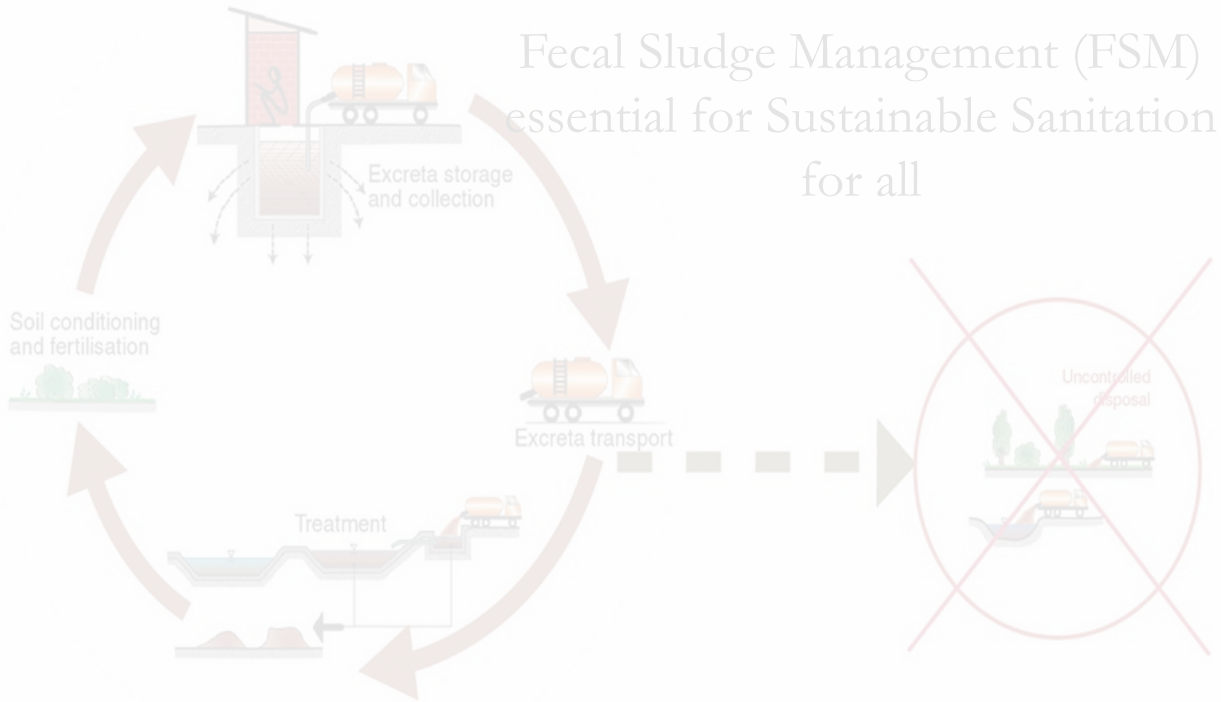
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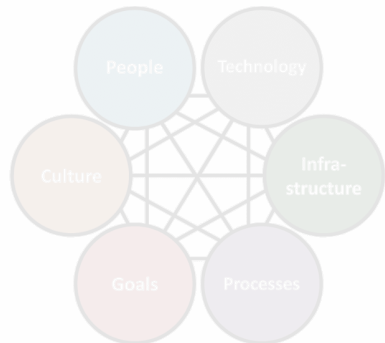
DOI: 10.1177/23998083221075639

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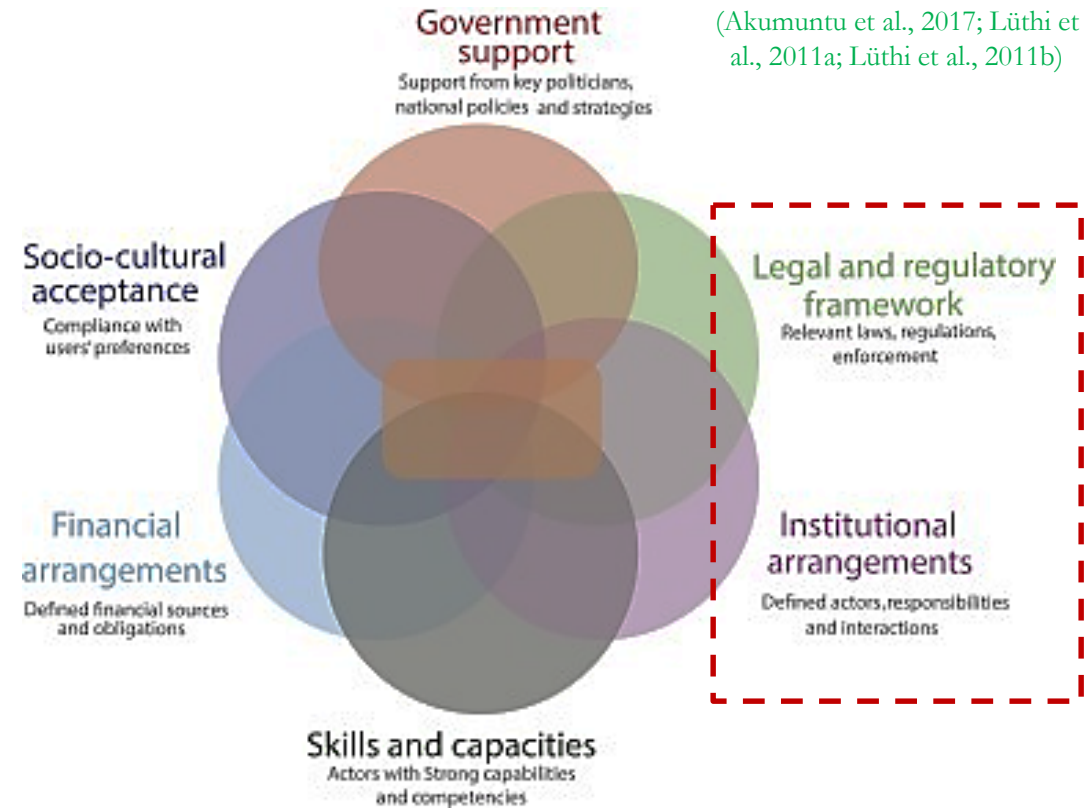


Systems-Thinking for FSM

(Clegg et al. 2017)

Dimensions of the enabling environment for FSM

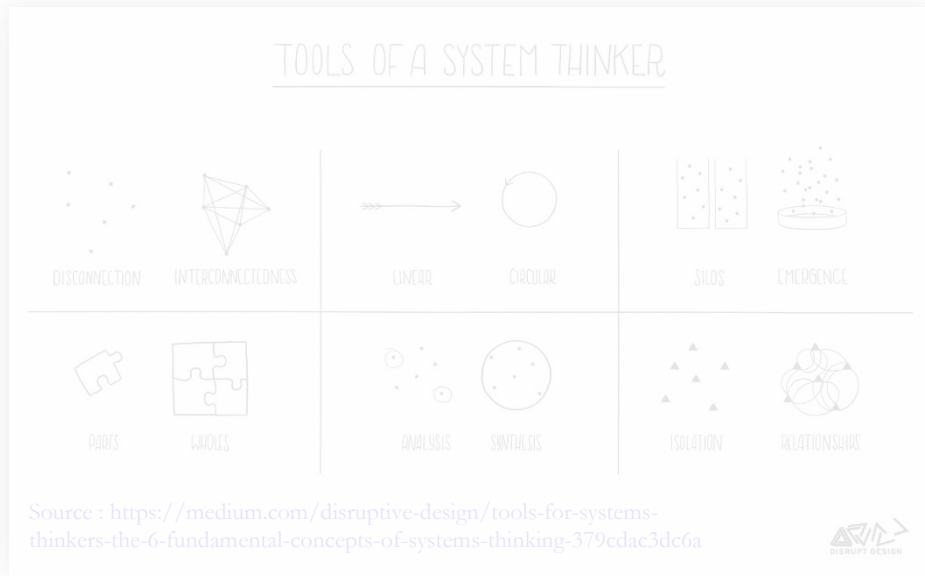
(Akumuntu et al., 2017; Lüthi et al., 2011a; Lüthi et al., 2011b)



Governance Structure : Interaction and decision-making between various actors, their roles, responsibilities, process, rules

(Brunet and Aubry, 2016)

Academic Gap – Methods to analyze governance structures? 4



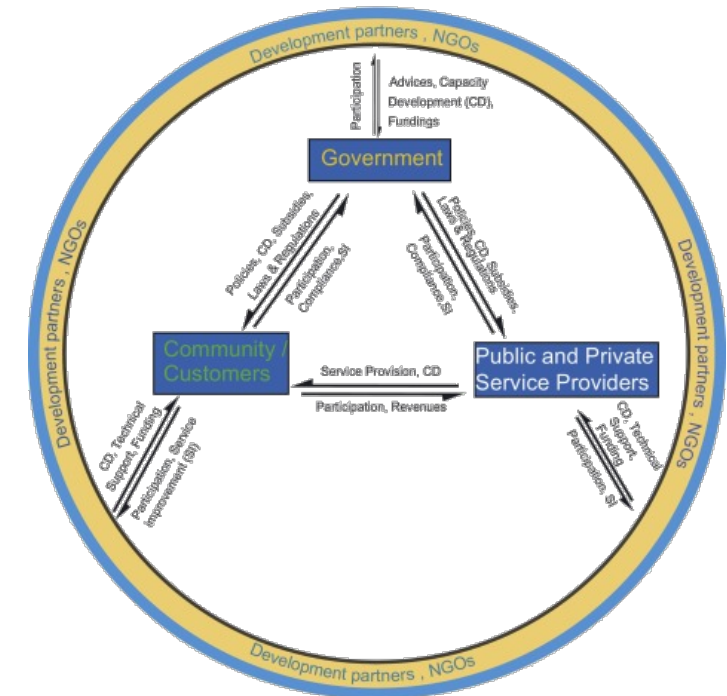
Lack of utilization of system-thinking based methods for analyzing FSM governance structure

(Narayan et al., 2020)



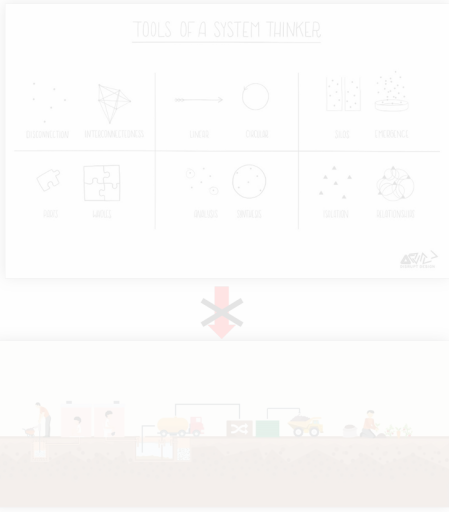
- 13-point framework for FSM success factors including focus on governance
- “Roles and Responsibilities should be clearly defined” – **Accountability and Coordination** Strande and Brdjanovic (2014)

- *Only Generic recommendations*
- Stakeholder’s experience itself may be limited to comprehend complexity involved



Akumuntu et al. (2017)

Academic Gap – Methods to analyze governance structures? 5



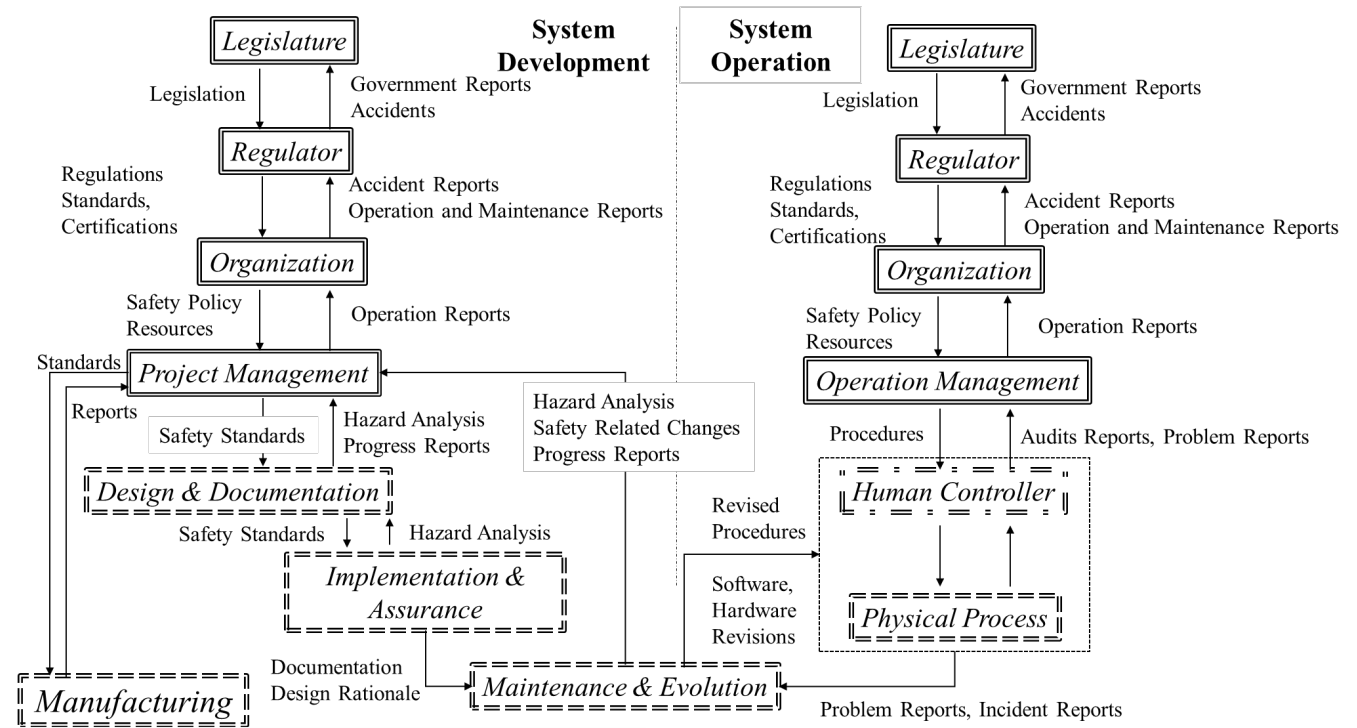
- Important step towards incorporating system-thinking in FSM
- However, SNA has its own limitations –
 - The meaning of linkages is not uniform
 - Results can only be obtained from comparative analysis
 - How do we account for important requirements from FSM governance structures – for example *accountability*? Strande and Brdjanovic (2014)

Social-Network Analysis (SNA) as a method to analyze the governance structures (Narayan et al., 2020)

Cited by 2361



Leveson et al. (2004)



■ Previous experience in “Water” sector –

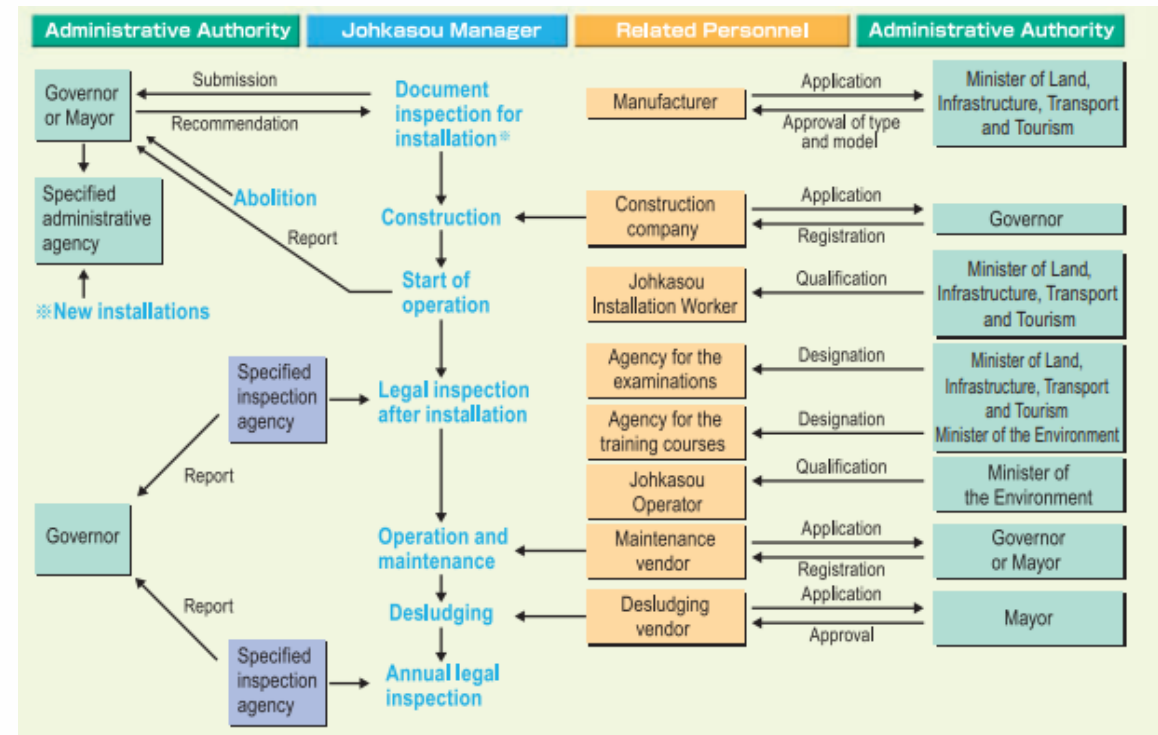
- Proactive analysis and leading indicators for water treatment
Dokas et al. (2013)
- Designing a new governance structure for “water source development” project
Merrett et al. (2019)
- Analysis of governance structure for a role in accident – Walkertown, Canada
Leveson et al. (2003)

No, known application of STPA to FSM

To demonstrate the capability of STPA as a valuable framework for analyzing and improving governance structures for FSM

Analyzing : Identifying risks, and mitigation measures

- Through a case-study of the *Johkasou* system in Japan
- Complements the centralized wastewater mgmt. systems
- Known for its robust governance structure with sustained performance
Hashimoto et al. (2021)
- Lessons for Japan
 - Greying population, Recent issues
 - Only 43% annual inspection coverage in 2017
Hashimoto et al. (2021)
- Lessons for other developing countries

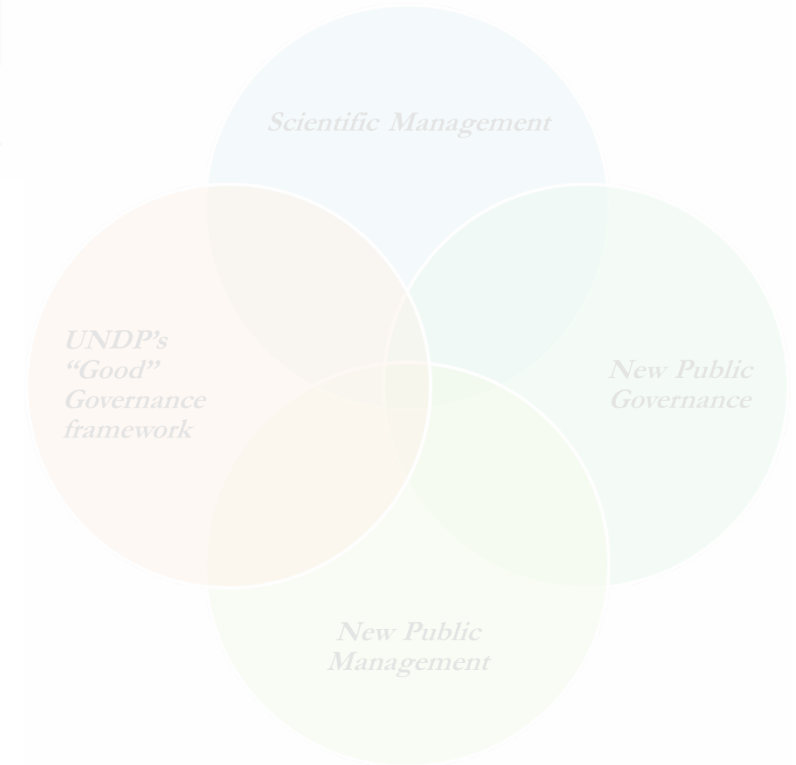


Ministry of Environment Japan, 2017

Features of “Good” governance structure

Efficiency	Maximum productivity without wasted efforts
Accountability	Legal answerability
Legitimacy	Acceptability to the degree of centralized decision-making

- Improved Efficiency and Enhanced Legitimacy –
 - ✓ Analytical reasoning-based structure over political decision-making
 - ✓ High degree of centralized control
- Increased Accountability
 - ✓ Comprehensive understanding of the underlying process with clear roles of division between actors



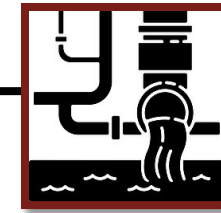
Brunet and Arbury (2016)

Prospective Study

Retrospective Study

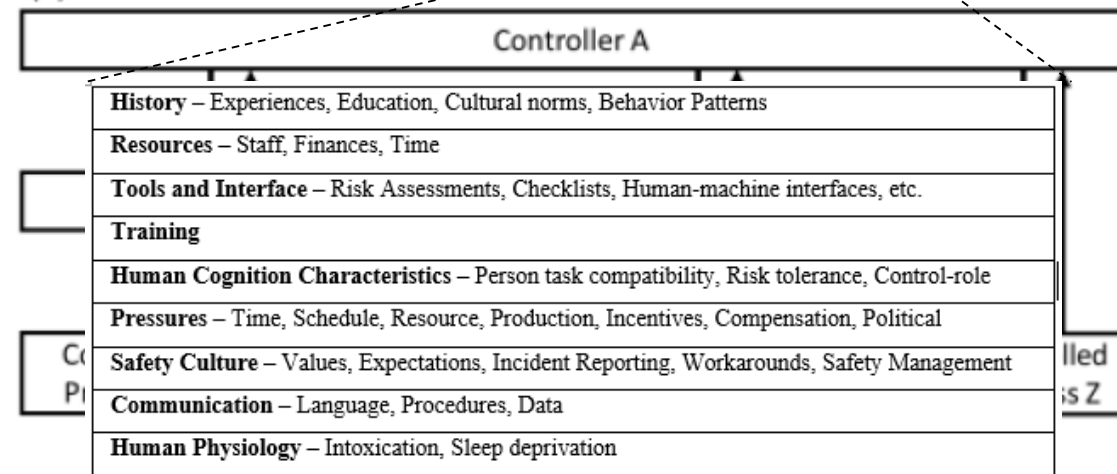
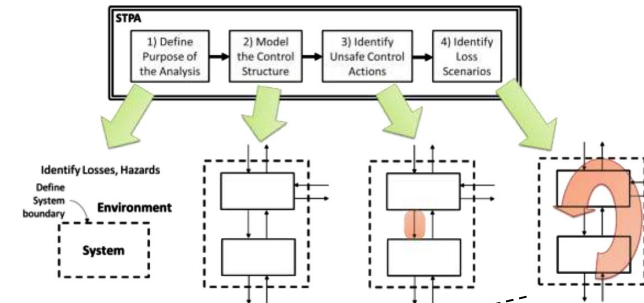
Time →

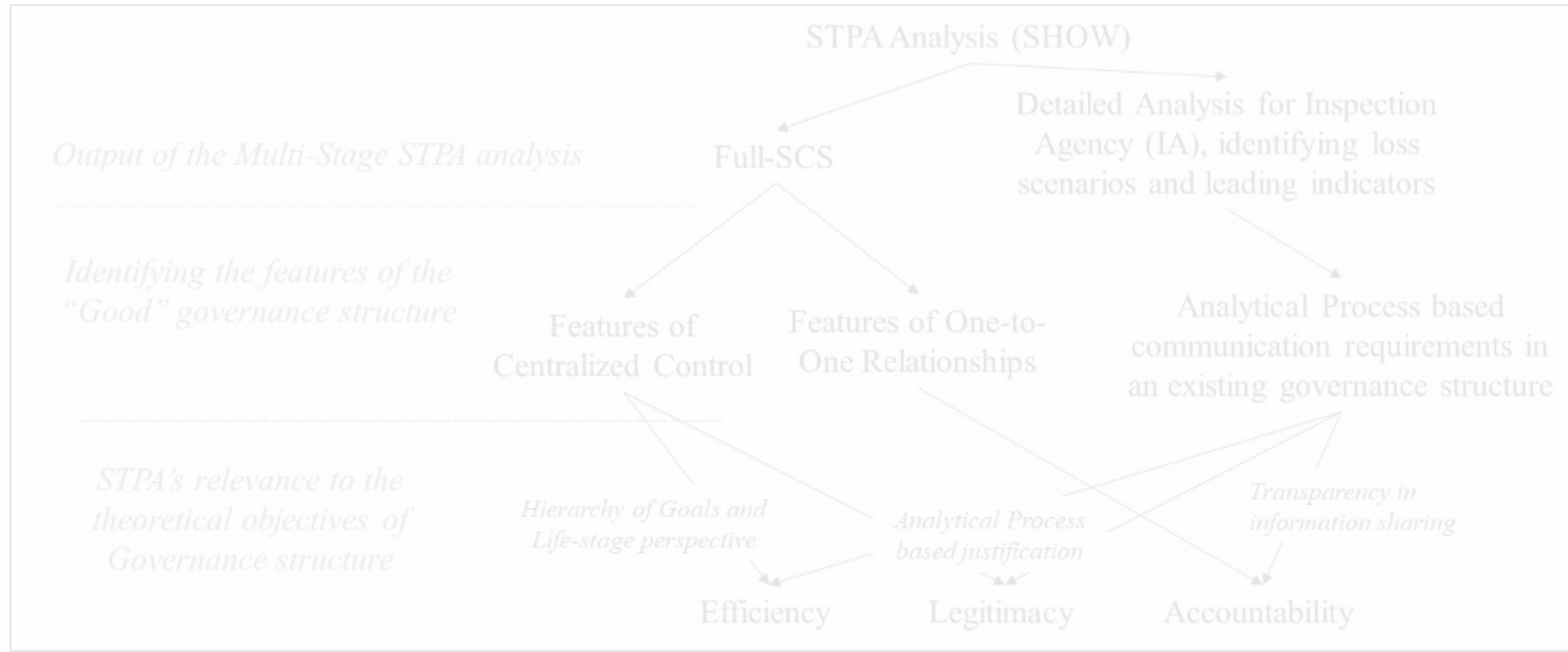
Risk Analysis of Existing Structure



Accident

- Full – SCS Analysis
 - One-to-One and Many-to-One relationships
 - Missing Feedback
 - Lack of Independent Oversight
- In-depth Risk analysis (using SHOW)
 - Leading Indicators development
 - Assumption based Indicators



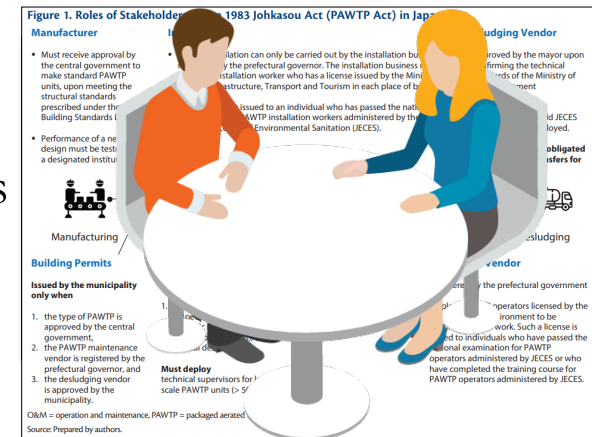


- **Full – SCS Development**

- Data – Laws, Acts, official brochure
 - Validation – Published secondary sources, Presentations by stakeholders

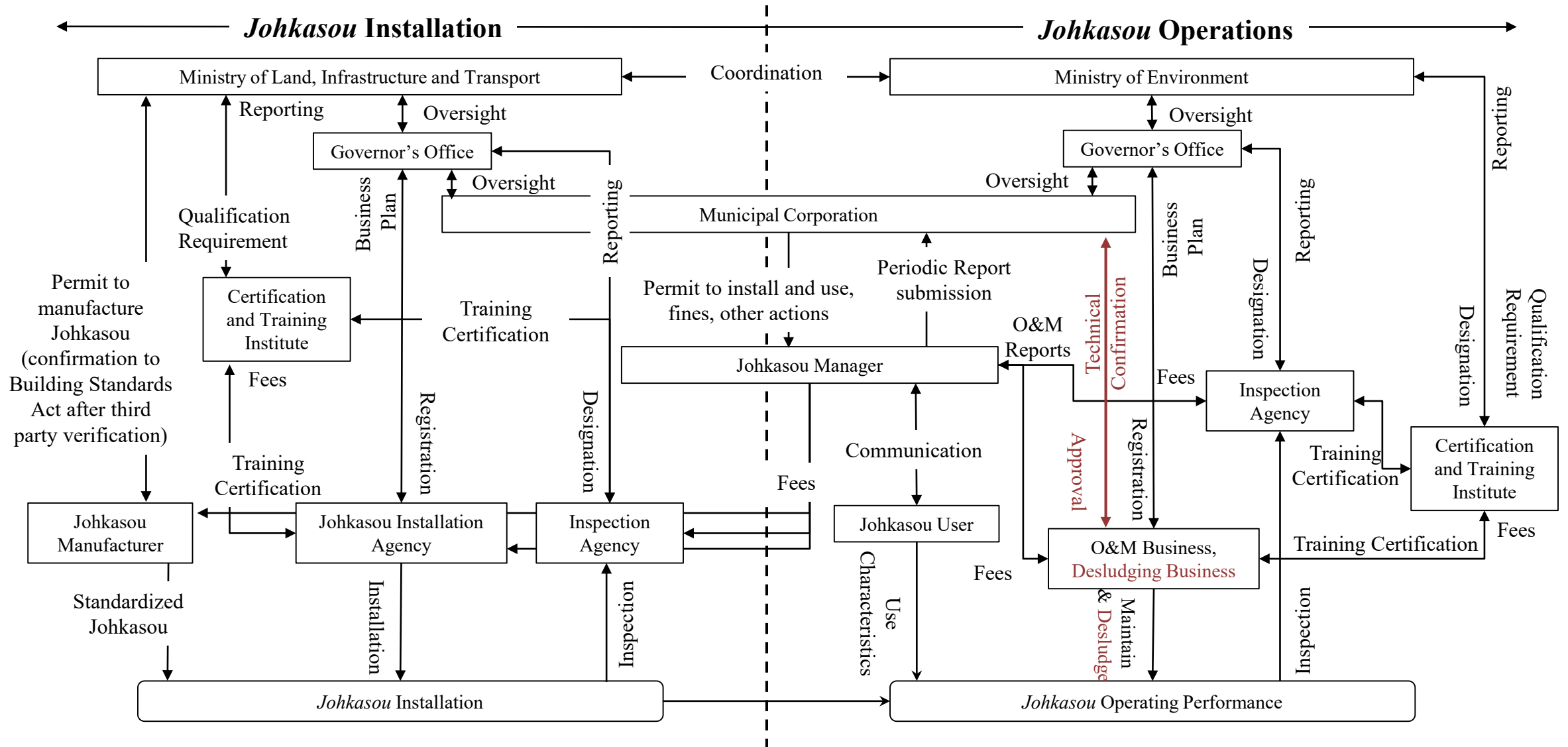
- **In-depth analysis of Inspection Agency (IA)**

- STPA Analysis – Identifying loss-scenarios, Leading Indicators for IA
 - Reliability -

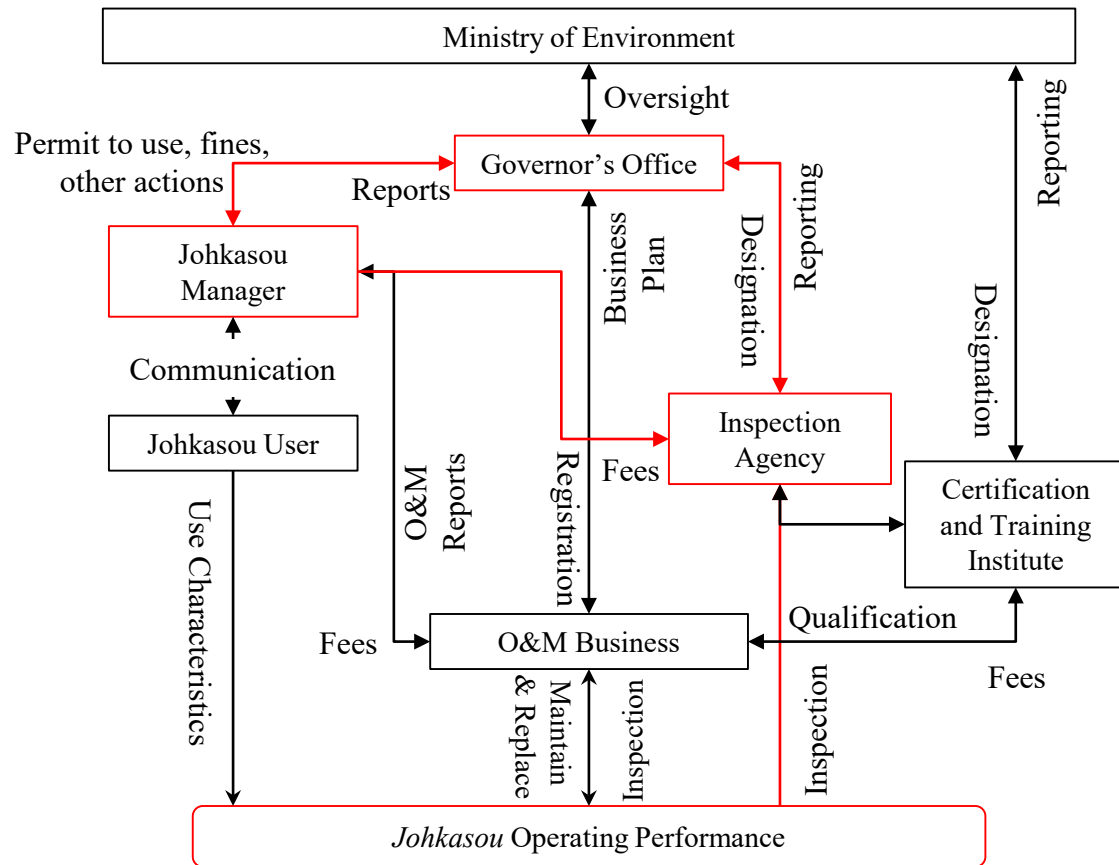


Ministry of Environment Japan, 2017

Hashimoto et al. (2018)

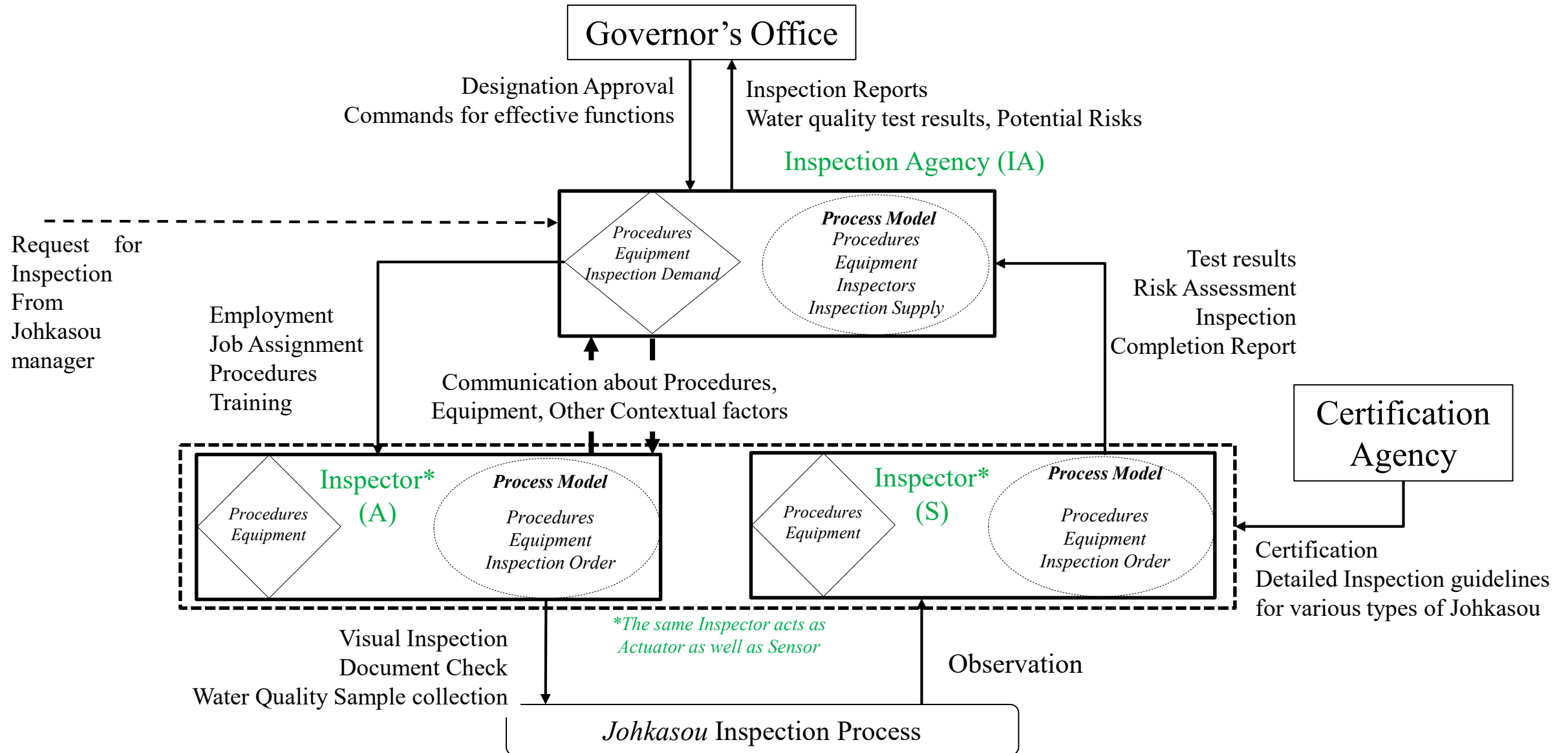


Johkasou Operations



- IA provides necessary independent-feedback enabling the governor's office to have suitable control
- The system-level safety constraint for IA is that the IA should always communicate the status and problems with the operating conditions of the *Johkasou* to the Governor's office
- If the feedback from IA is not suitable, the poor-quality effluent from the Johaksou could remain undetected for a long time, leading to potential environmental and public health issues

Results : Inspection Agency - SCS



Results : Inspection Agency - UCAs

Category	Not Providing causes Hazard	Providing Causes Hazard	Provided too early, too late, out of order
SC 1: Adequate sampling, inspection, testing, and analysis procedures	1. Standard procedures are not provided or provided incorrectly by IA (SC1-1) applicable to the Johkasou inspection process.	2. Standard Procedures applied are not adequate in capturing the state of the Johkasou operations (SC1-2)	3. Standard procedures are performed “too frequently” or “too distant” such that the frequency is different from once in a year. (SC1-3)
SC 2: Use good quality sampling, testing, and analysis equipment	4. The designated testing equipment is not used or misused for inspection of Johkasou operation or analysis of the collected samples (SC2-1)	5. Standardized equipment used during inspections and analysis is inadequate in capturing the state of the Johkasou operations (SC2-2)	-
SC 3: Deploy qualified Inspectors and other Human Resources	6. Qualified Human Resources are not deployed during the inspection and analysis process (SC3-1)	7. Qualified Human Resources are not able to carry out their work effectively during the sample collection and analysis process (SC3-2)	-
SC 4: Risk assessment and Risk identification	8. Risks are not identified by the IA based on the combined results of field and laboratory assessment (SC4-1)	9. Risks are identified incorrectly by the IA based on the combined results of field and laboratory assessment (SC4-2)	10. Risks are not identified on time by the IA based on the combined results of field and laboratory assessment (SC4-3)

Results : IA – Loss Scenario (Risks example)

UCA No

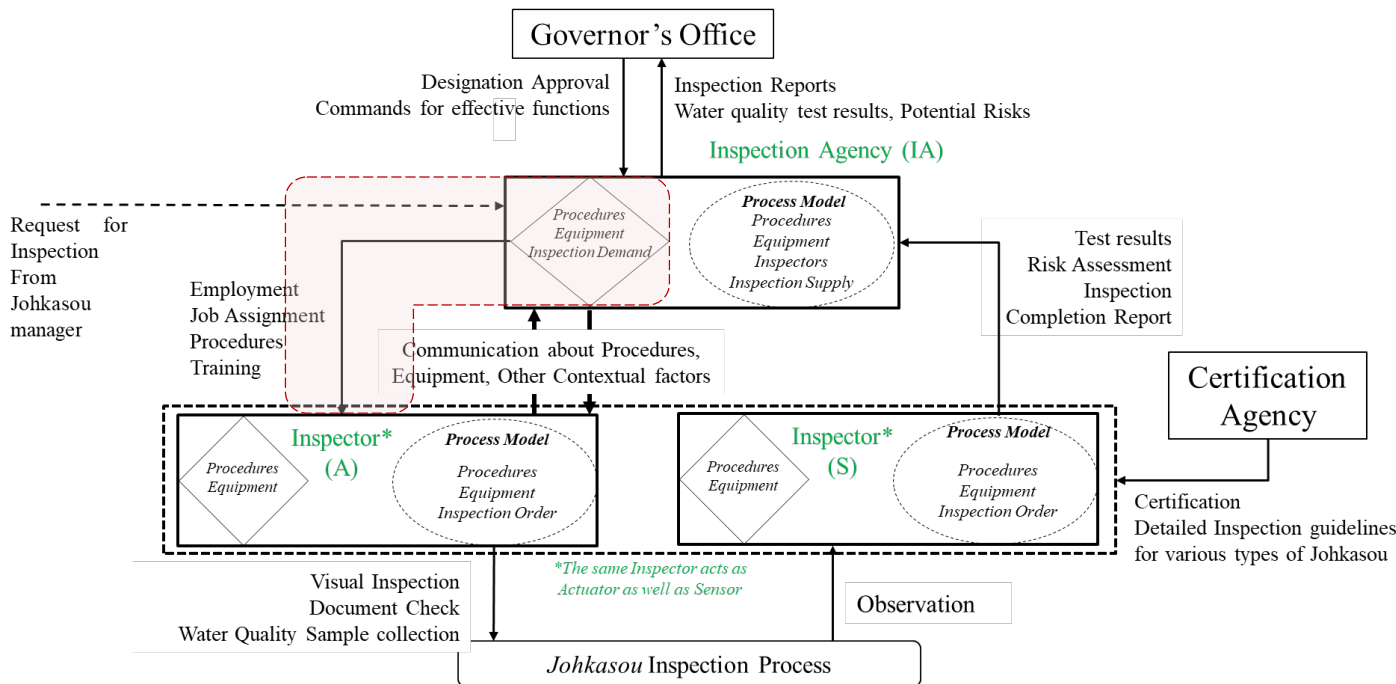
Control Algorithm is incompatible with control levers

UCA – 2

In the Japanese Johkasou system, the information about the procedures to be followed in the field is communicated by the IA to I's through on-the-job training, checklists, etc. In addition, the job-level requirements are communicated using paper, pre-decided formats, etc. Such practices are well-accepted among the Japanese people.

Standard Procedures applied are not adequate in capturing the state of the Johkasou operations (SC1-2)

In cases where such on-the-job training is not accepted by the Inspectors and Inspector's ability to understand the paper-based communication is affected, such UCA's could prevail.

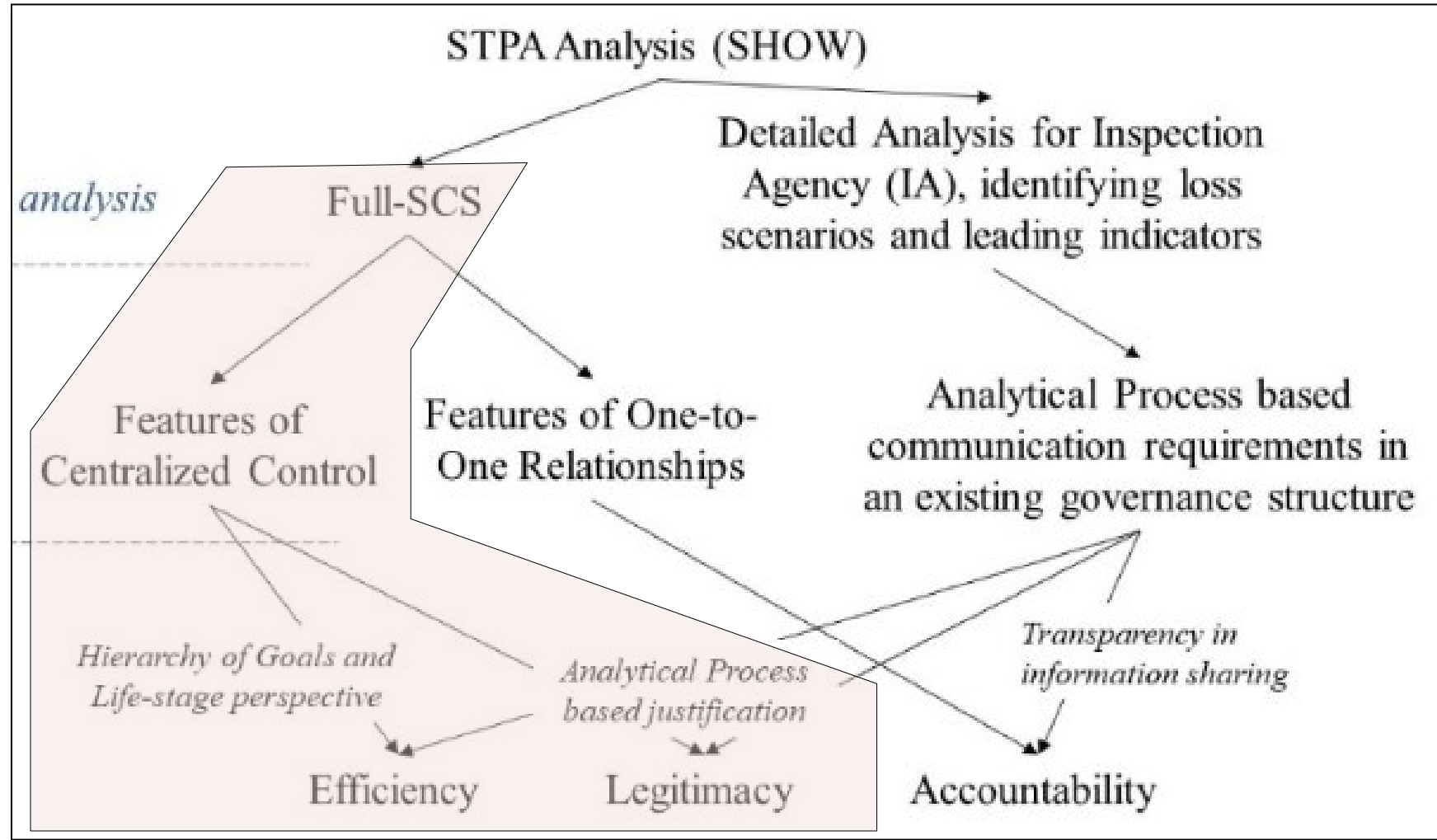


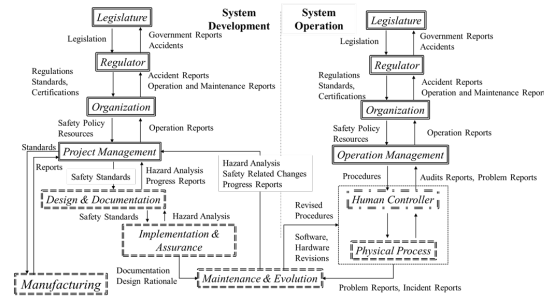
- STPA takes a pessimistic approach
- 67 Total scenarios identified
- Through participatory approach, more could be identified.

Results : IA – Leading Indicators(Risks example)

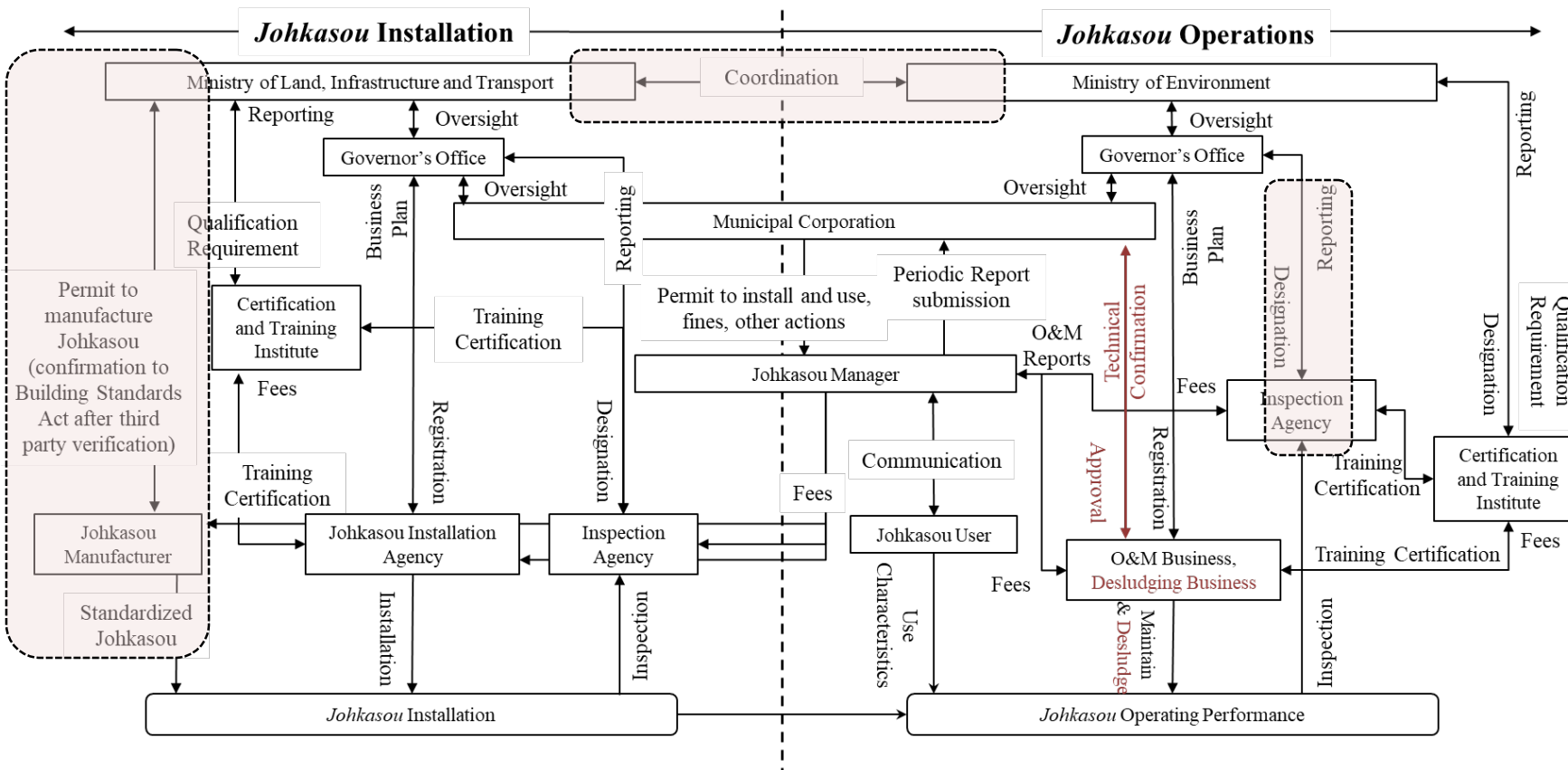
Safety Constraints	Risks	Leading Indicators	Remarks
SC1-1, SC1-2, SC1-3, SC3-1, SC4-3	Inspectors are not compatible with on-the-job training methods	<p>Work done by inspectors on the ground is not up to desired standards</p> <p>Inspectors are unable to understand the testing procedures during training</p> <p>Inspectors are unable to perform as per desired standards during training</p>	<p>Assumption: Training methods devised by IA caters to all known conditions faced by Inspectors on the job</p> <p>The compatibility of inspectors with training methods could be affected by external scenarios on the ground or unique conditions of each Inspector. While compatibility of inspectors with training methods is best analyzed during training, additional information can also be collected from the Quality of work done by inspectors post-training completion</p>

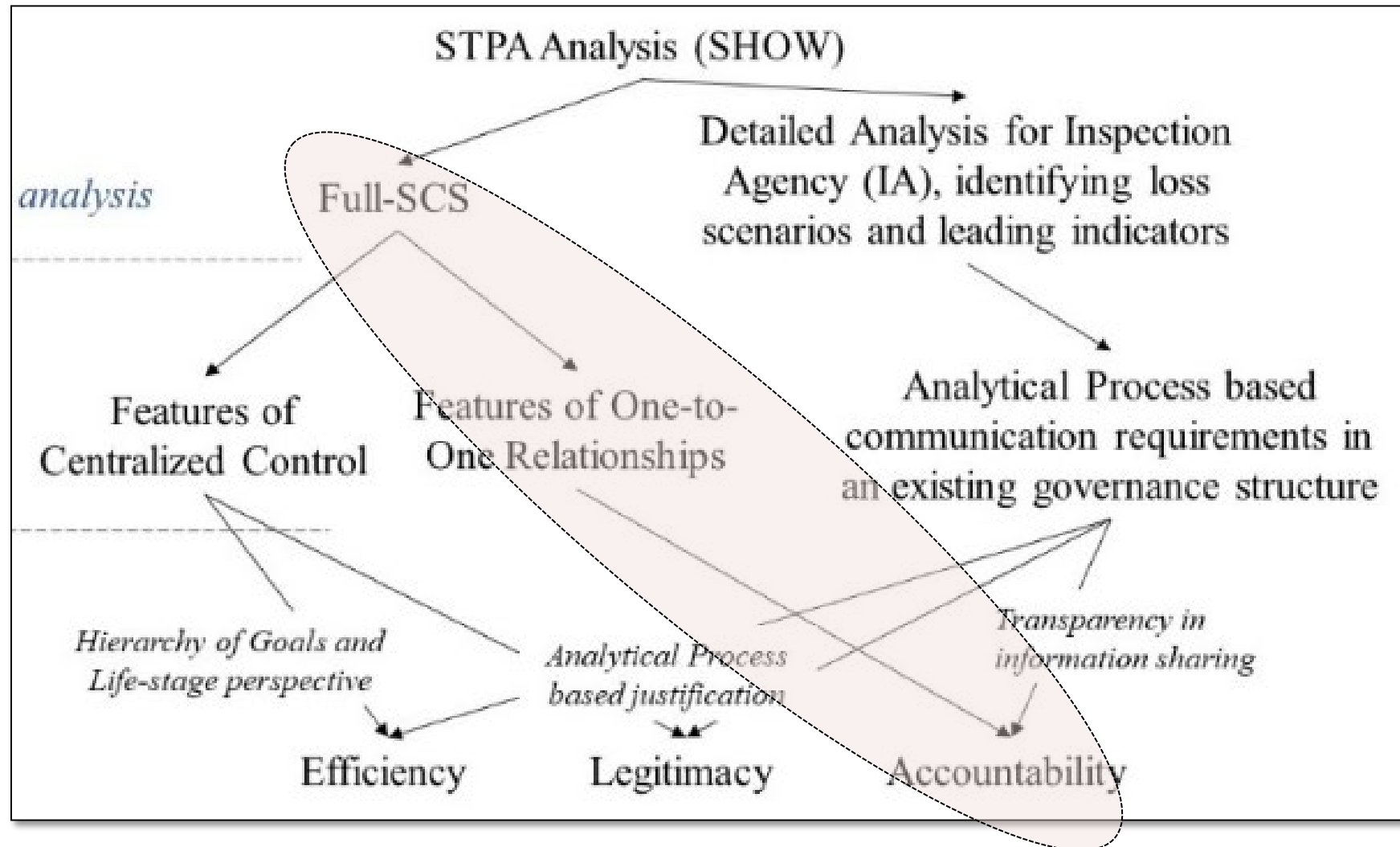
- A consolidated 25 leading indicators were identified

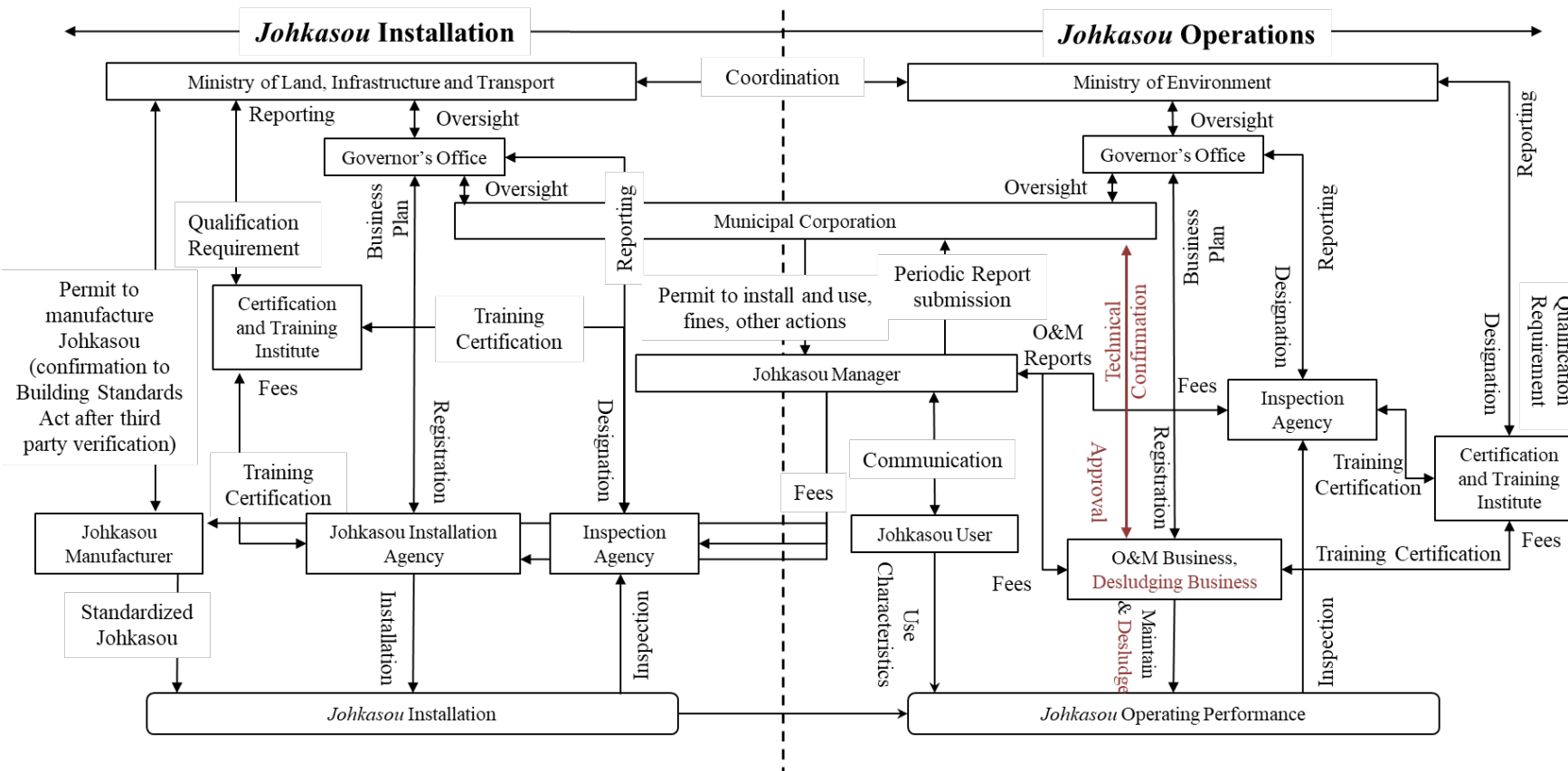




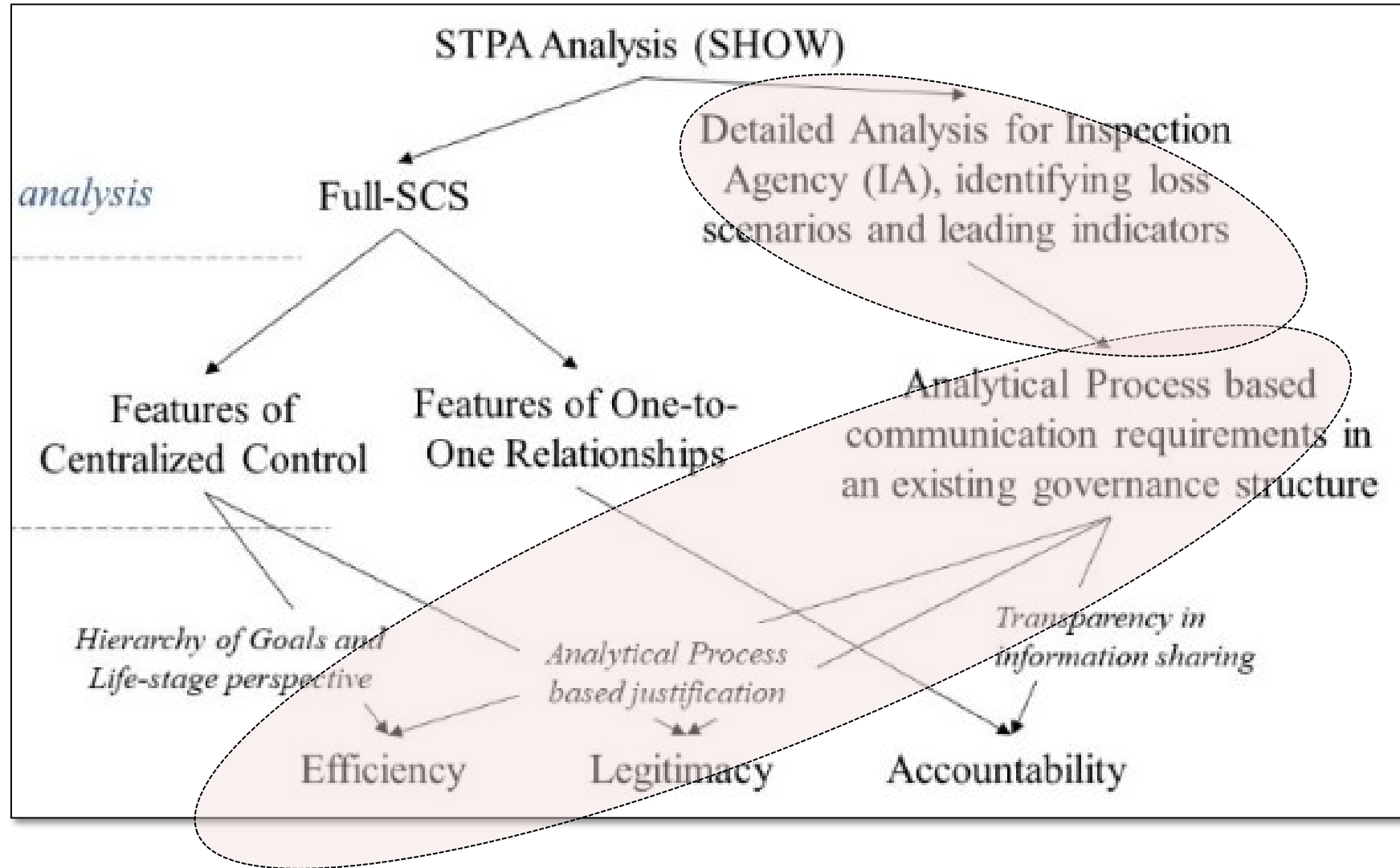
- Strong Centralized control in the Johkasou System
- Hierarchy of functional goals







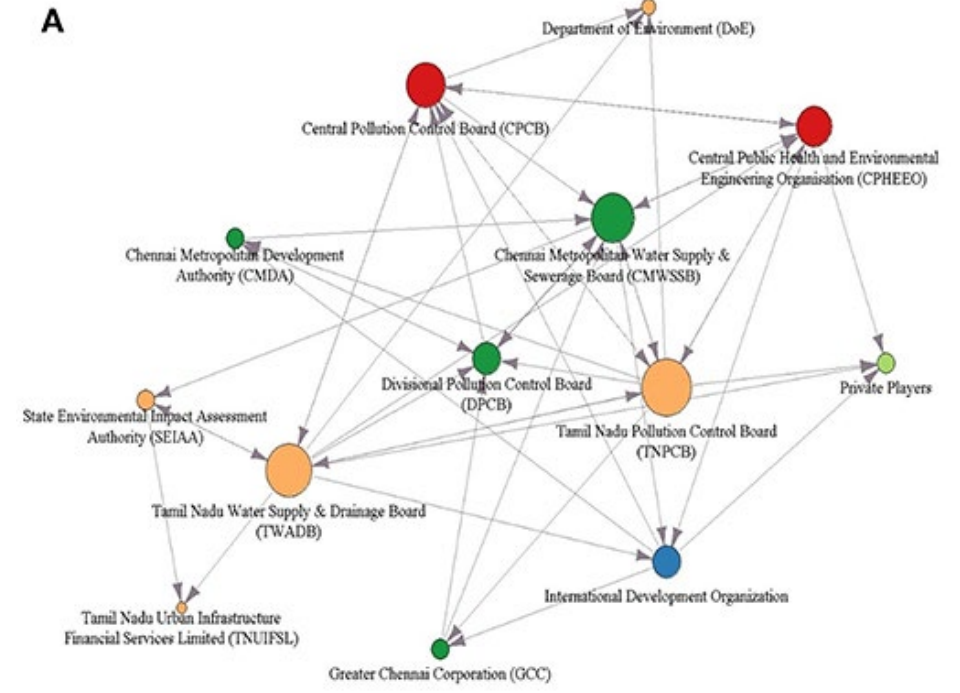
- One-to-one Control-Feedback relationships
- No missing feedback
- Each controller has clear reporting line
- No controller is providing multiple types of control actions
- Independent Feedback



	Leading Indicators	Status of Use
1	Operating profits are decreasing continuously	Yes
2	There is a backlog in fulfilling the inspection demand	Yes
3	There is a decrease in the hiring rate of inspectors	Yes
4	Inspectors face delays in license renewal	Yes
5	Testing equipment used on the ground is not compatible with the Johkasou system	Yes
6	Equipment does not conform to required standards	Yes
7	IA is not aware of technical specifications and knowledge of system	Yes
8	Analysis of documents provided by stakeholders show conflicts in the information provided	No
9	Training manuals/ instructions provided by IA are not compatible with law/ stakeholder requirements/ changes in technology	No
10	Standard procedures do not match testing requirements/ field conditions	No
11	IA lacks crucial ground information required to update testing procedures and instructions	No
12	Inspectors are unable to comprehend and work as per desired standards during training	No
13	Inspectors are unable to carry out the testing process on the ground with instructions/ resources provided by IA	No
14	Inspectors are unable to carry out testing due to sudden changes in working condition	No
15	Inspectors are overworked	No
16	Inspectors are unable to detect/ define errors in testing process/ equipment	No
17	Inspectors are not comfortable using specific equipment	No
18	Inspectors do not receive technical support from IA for testing procedures	No
19	Work done by inspectors on the ground is not up to desired standards	No
20	The inspection report is missing crucial information regarding the testing process	No
21	The average time for inspection request fulfillment is increasing	No
22	Lack of sustained communication between Inspectors and IA	No
23	Unique conditions of inspectors are not considered in existing methods of qualification	No
24	The smooth functioning of the testing process is disrupted despite standard working conditions	No
25	Identified conflicts are not resolved for an extended period	No

*Status of use denotes the fact that a given indicator is already measured for the Johkasou system. The conclusions are drawn based on information available from the ministerial ordinance as summarized in Table S3 in the supplementary material.

Requirements of Governance structure	STPA	Participatory Approaches	SNA
Efficiency and Legitimacy	Features of centralized control can be identified based on rigorous processes deduced by a strong safety-theory	Inductive approaches only leads to generic recommendations	Can mislead “Degree of Centralization”
Accountability	One-to-One relationships can help in clearly delineating Accountability		Not explicit enough



- Although, STPA may loose in
 - Visual Appeal
 - Ease of use in Field Implementation

- STPA results are comprehensive, but analyst's skills are necessary
- STPA results can be further enhanced using a participatory approach



Core team
(Experts in Sanitation, and STPA)

- Hence, for the design of new FSM systems a multi-layered team is necessary
- Field validation for such an approach is necessary



Peripheral team
(Coordination between
community and Core Team)



Community

- STPA is a valuable framework for analyzing and improving governance structures for FSM
 - Aspects of Governance – Efficiency, Accountability, Legitimacy
 - STPA Analysis – Full-Scale SCS, and in-depth analysis
- The STPA can improve the risk-assessment for the efficient Johkasou system of Japan
 - Detailed leading indicators could enhance the proactive risk-management
 - The ground reality of inspection process needs to be carefully monitored
- Lessons for sustainable sanitation in other countries
 - Centralized Control
 - Hierarchy of functional goals, and one-to-one relationship
 - Independent Feedback

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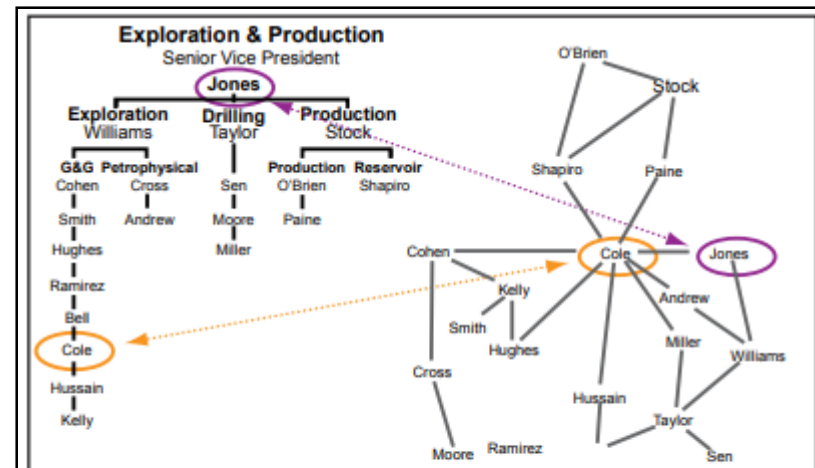
Thank You



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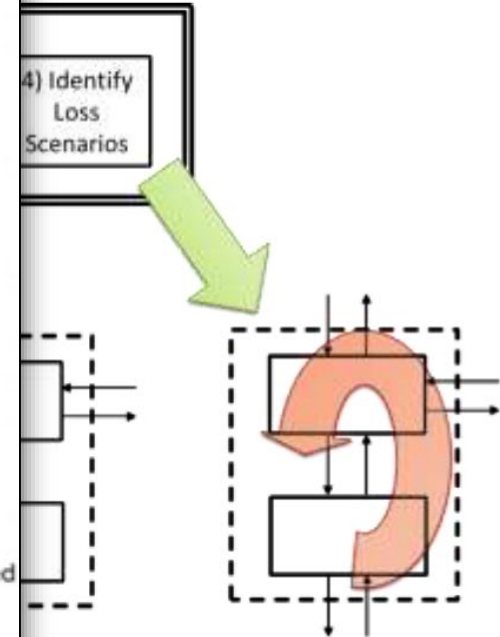
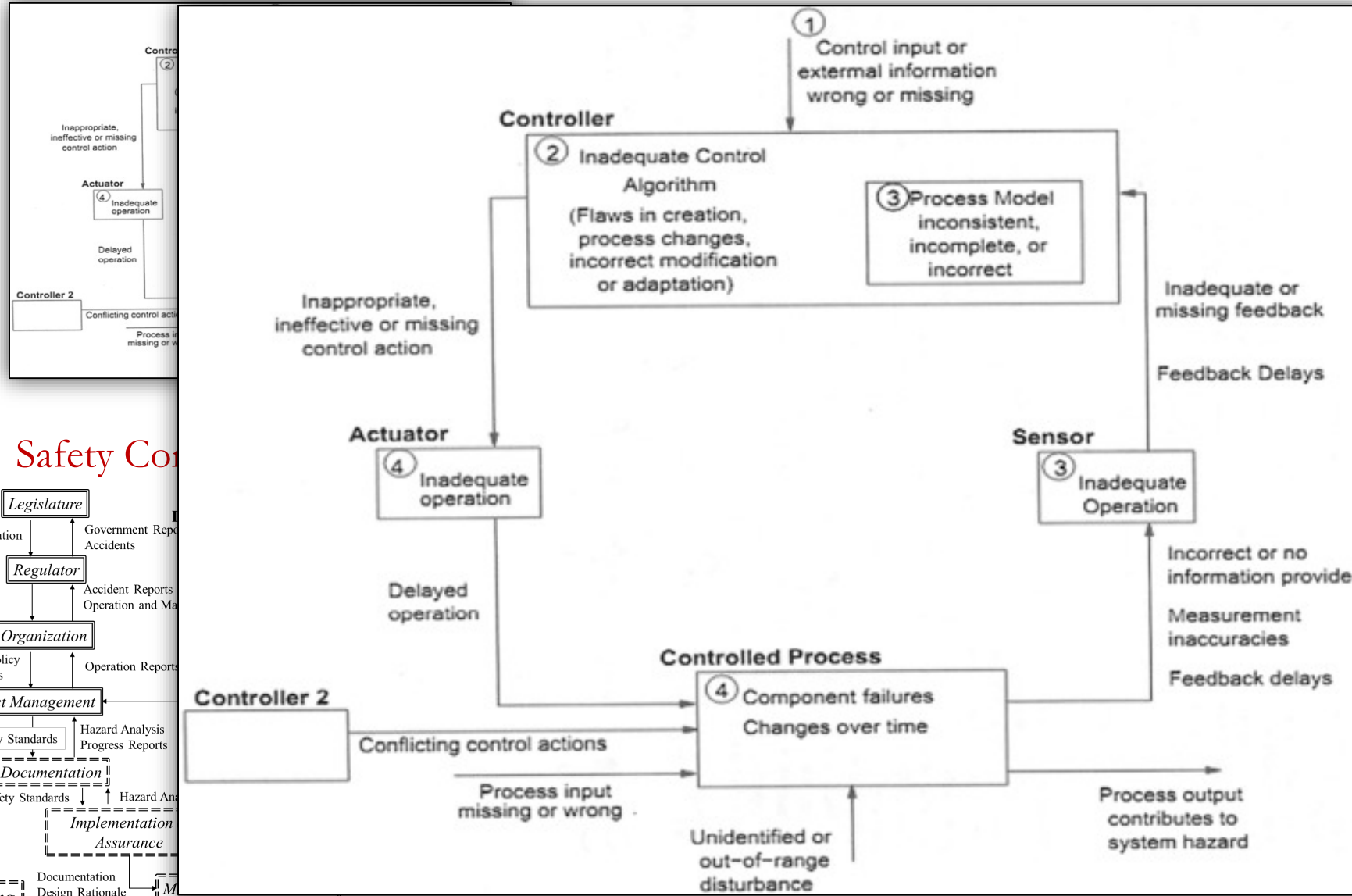
missing relations among actors. Types of connections vary by case; in governance, typical connections include information exchange (technical and administrative), collaboration, line reporting, etc. (Victor et al., 2016). These connections could be formal only, or informal only, or both- as required by the network graph. Initially, the obvious connections

Secondly, clarity in criteria for connections is important to establish at the beginning. Interpretation of the requirements of an existent connection varies depending on experts, and has to explicitly clarified. These assumptions could result in inaccurate connections (for example: are solely funding agencies of decentralized STP projects involved in governance, even if they have no responsibility apart from their financial contributions?).

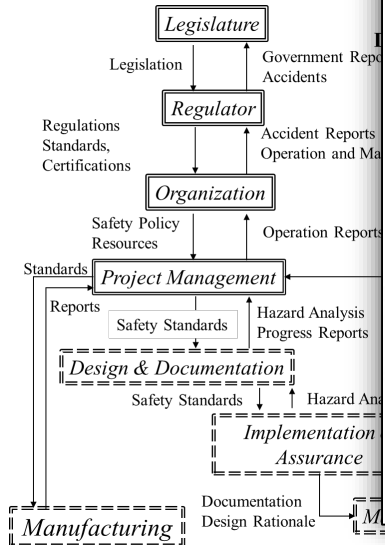


Source: Rob Cross, Andrew Parker, Laurence Prusak, and Stephen Borgatti. 2001. Knowing What We Know: Supporting Knowledge Creation and Sharing in Social Networks. *Organizational Dynamics*. Vol. 30, No. 2, pp. 100–120. Elsevier Science, Inc.

Control-Feedback Loop



Safety Co



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*Status of use denotes the fact that a given indicator is already measured for the Johkasou system. The conclusions are drawn based on information available from the ministerial ordinance as summarized in Table S3 in the supplementary material.

- Systems are dynamic and sustainable in the past may not be sustainable in future
- Comprehensive risk-assessment such as STPA can be done to periodically assess the risk and identify leading indicators
- Specifically – testing the ground reality of the Inspection agency is necessary, as human-errors could manifest due to systemic pressures

- High Degree of Centralized control through out the value-chain
- Hierarchy of functional goals – standards > skills > business sustainability
- One-to-One coordination structure
- Independent Feedback about the reality of the system – Role of inspection agency
- Findings consistent with practitioner’s account

Table 1: The Challenges of Onsite Systems in Developing Countries and Japan’s Public Sector Responses to the Corresponding Issues

Challenges	Japan’s Response
Improper design	Structural standards, government approval, performance testing
Lack of monitoring of compliance with the building standards	Building confirmation by the building officials deployed by the local government
Poor installation	<ul style="list-style-type: none"> • Registration for installation businesses • Certification and examination system for the installation workers
Improper management of the sludge	<ul style="list-style-type: none"> • Enactment of the Onsite System Act (Johkasou Act) • Regular desludging obligation
Unregulated desludging operators working in the difficult conditions	Approval system for desludging vendors
Improper treatment/disposal of onsite sludge	Development of sludge treatment facilities nationwide
Improper operation and maintenance	<ul style="list-style-type: none"> • Enactment of the Onsite System Act (Johkasou Act) • Owner’s legal obligation for operation and maintenance • Owner’s obligation of deploying a Technical Supervisor for a large onsite system (≧501 population equivalent) • Registration system for operation and maintenance vendors
Lack of human resources for the maintenance work	Training, certification, and examination system for operation and maintenance technicians.
Lack of awareness of onsite systems among the system owners and local governments	Establishment of the training institution for the professionals in the business related to the onsite systems
Lack of accountability	Legal inspection
Poor operation and maintenance of the large-size onsite systems of commercial users	Monitoring under the Water Pollution Control Law (compliance with the effluent standard, measurement, report, and inspection)

- First attempt to evaluate the viability of system-thinking tools for analyzing governance structure against a framework of theoretical requirements –
 - Even within STPA, standardized methods of defining features such as centralization etc. should be developed
 - A FSM specific requirements from governance structure is needed
 - More system-thinking based tools, such as FRAM, could be evaluated comprehensively to reveal relative merits/demerits of different tools