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# Soft Systems Methodology as an approach to the safety management of nuclear facilities: a case report

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**Abstract**: This manuscript presents an account of the Sociotechnical Systems Safety Analysis Group's (GASSST) application of Soft Systems Methodology (SSM) to a complex safety issue at the Nuclear and Energy Research Institute in São Paulo, Brazil (IPEN-CNEN/SP). Drawing from both theoretical foundations, based on the documentation produced by Peter Checkland and other researchers, and practical experiences, the study explores the SSM approach in addressing challenges that involved technical and human factors. The principal results include the identification of key stakeholder perspectives, the development of a rich picture to capture the complexity of the problem, and the initiation of potential solutions. However, the full application of SSM was curtailed due to proactive interventions by the facility staff, which resolved the initial problem before all SSM steps could be completed. The process was further interrupted by the COVID-19 pandemic-induced hiatus, during which facility staff were absent for 1 year and 10 months. The study concludes that timely application of SSM and the expertise of facilitators are critical for navigating complex safety issues effectively. This experience underscores the need for experienced practitioners and a more prompt application of SSM to fully leverage its potential in addressing organizational challenges. GASSST's reflections and documented experiences contribute valuable insights to the ongoing discourse on SSM's practical relevance in similar contexts.

**Keywords:** Sociotechnical Safety Issues, Systems Thinking, Complex Problems, Nuclear Safety Management.

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# Metodologia de Sistemas Flexíveis como uma abordagem para a gestão de segurança de instalações nucleares: um estudo de caso

**Resumo**: Este manuscrito apresenta um relato da aplicação da Metodologia de Sistemas Suaves (MSF) pelo Grupo de Análise de Segurança de Sistemas Sociotécnicos (GASSST) em um problema complexo de segurança no Instituto de Pesquisas Energéticas e Nucleares de São Paulo, Brasil (IPEN-CNEN/SP). Baseando-se tanto em fundamentos teóricos, com base na documentação produzida por Peter Checkland e outros pesquisadores, quanto em experiências práticas, o estudo explora a abordagem da MSF para enfrentar desafios que envolvem fatores técnicos e humanos. Os principais resultados incluem a identificação das perspectivas dos principais interessados, o desenvolvimento de uma Figura Rica para capturar a complexidade do problema e a discussão de soluções potenciais. No entanto, a aplicação completa da SSM foi prejudicada devido às intervenções proativas da equipe da instalação, que resolveu o problema inicial antes que todas as etapas da SSM pudessem ser concluídas. O processo foi posteriormente interrompido por uma pausa induzida pela pandemia do SARS-CoV-2, durante a qual a equipe da instalação esteve ausente por 1 ano e 10 meses. O estudo conclui que a aplicação oportuna da SSM e a expertise dos facilitadores são críticas para a navegação eficaz de questões complexas de segurança. Destaca ainda a necessidade de profissionais experientes e uma aplicação mais rápida da SSM para aproveitar plenamente seu potencial na resolução de desafios organizacionais. As reflexões e experiências documentadas pelo GASSST contribuem com insights valiosos para aplicação prática da MSF em contextos semelhantes.

**Palavras-chave:** Problemas Sociotécnicos de Segurança, Pensamento Sistêmico, Problemas Complexos, Gestão de Segurança Nuclear.

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## 1. INTRODUCTION

The body of knowledge concerning the theoretical and conceptual aspects of Soft Systems Methodology (SSM) can be divided into two parts: the one produced by Peter Checkland himself and the other produced by other Systems Thinking researchers. Both start from the assumption that human beings are social beings and that, before any intervention in a given situation, the observer must first understand and further interpret the observed discourse or actions.

The literature produced by Checkland, consisting of four books and numerous articles [1–10], has as its main merit to clearly establish the differentiation between "soft" and "hard" systems. Checkland points to the "hard" approach, strongly identified with positivism and functionalism, as suitable for solving well-structured, stable problems with little uncertainty [11]. On the other hand, Checkland demonstrates that problems involving complex and unstructured systems, such as those involving conflicts of interest in environments of great uncertainty or those involving political or interpersonal factors [12], referred by him as "soft systems", can be approached using SSM strongly based on interpretive paradigm and the subjective view that individuals have of a given problematic situation.

SSM encourages the active involvement of multiple stakeholders in problem-solving processes. Checkland's SSM approach emphasizes the importance of participation and collaboration in developing a shared understanding of problem situations and generating potential solutions. In SSM, stakeholders from various perspectives and backgrounds are encouraged to engage in discussions, contribute their viewpoints, and collectively explore the problem situation [13, 14]. The methodology promotes the inclusion of diverse perspectives to capture a broader understanding of the problem and its context.

Different stakeholders may have unique insights and interests related to the problem at hand, a concept regognized by SSM. By involving all relevant stakeholders, SSM aims to ensure that multiple perspectives are considered, fostering a sense of ownership and shared responsibility in problem-solving efforts [15–17]. The active participation of stakeholders in SSM typically involves activities such as stakeholder interviews, group workshops, brainstorming sessions, and structured discussions. These interactions enable stakeholders to articulate their viewpoints, challenge assumptions, and collectively explore potential solutions.

By encouraging everyone involved in the problem situation to contribute their ideas and perspectives, SSM aims to facilitate a collaborative and inclusive problem-solving process. This participatory approach increases the likelihood of generating solutions that are more comprehensive, acceptable, and sustainable [18–22].

SSM seeks to reconcile different concerns and interests by facilitating a process of dialogue, learning, and understanding among the various actors involved. Some key aspects of SSM that help in the search for accommodation are described below [23, 24]:

1. Rich Picture Development: SSM starts with the creation of a rich picture, which is a visual representation of the problem situation. The Rich Picture captures multiple perspectives, concerns, and issues expressed by the stakeholders. By collaboratively constructing the Rich Picture, stakeholders can identify areas of agreement, divergence, and potential conflicts, fostering a shared understanding of the problem context.

2. Root Definition: The next step in SSM is to develop a root definition, which is a concise description of the problem situation agreed upon by the stakeholders. This process encourages stakeholders to find common ground and articulate their concerns and aspirations in a mutually comprehensible way. The root definition serves as a foundation for exploring potential solutions that accommodate different concerns.

3. Conceptual Models and Comparison: SSM utilizes the development of conceptual models to explore and evaluate different solution ideas. Stakeholders contribute their perspectives, insights, and concerns in constructing these models. Through iterative discussions and feedback, the models can be refined to better accommodate various stakeholder concerns. The models also facilitate the comparison and evaluation of different solution options, considering their implications for each stakeholder.
4. Boundary Critique: SSM encourages stakeholders to challenge and refine the boundaries of the system being analyzed. This involves questioning the scope and assumptions made in defining the problem situation and considering alternative boundaries that may better accommodate different concerns. By engaging in boundary critique, stakeholders can broaden their perspectives and explore potential accommodations among different actors.
5. Feasibility and Desirability Assessment: SSM incorporates feasibility and desirability assessments as part of the process. Stakeholders collectively evaluate potential solutions based on their practicality, resource availability, and alignment with stakeholders' values and aspirations. This assessment helps identify solutions that are both feasible and desirable, taking into account the different concerns and interests of the actors involved.

Through these iterative steps and a participatory approach, SSM aims to create an environment for dialogue, learning, and accommodation among stakeholders. By actively involving all actors, considering their concerns, and seeking common ground, SSM supports the exploration and development of solutions that can accommodate the diverse perspectives and interests of the stakeholders involved [25].

The key is to help participants assess and realize that the intervention has led to an improved problem-situation [26]. Individuals must be aware that the situation has to be

changed for the better, even if they disagree or if they are not completely satisfied on specific points. There are some ways to which SSM facilitates the recognition of improved situations: (i) encouraging participants to reflect on and compare the current situation with the initial problem situation identified at the beginning of the process. By revisiting the rich picture, root definition, and other artifacts developed during the intervention, participants can assess how the intervention has addressed the initial concerns and improved the situation; (ii) emphasizing the importance of defining and monitoring performance measures to assess the effectiveness of interventions. Participants collaboratively identify relevant indicators that capture the desired changes or improvements. By regularly reviewing and tracking these performance measures, participants can evaluate whether the intervention has led to the expected improvements; (iii) encouraging ongoing feedback and reflection throughout the intervention process. Participants are encouraged to share their experiences, observations, and perceptions of the changes that have occurred. These discussions provide an opportunity to assess the impact of the intervention, identify areas of success, and acknowledge the improvements realized; (iv) promoting learning and adaption, since SSM is an iterative methodology. As participants engage in the intervention process, they gain insights, learn from their experiences, and make adjustments along the way. By reflecting on the iterative cycles of problem understanding, solution development, and implementation, participants can recognize how their collective efforts have led to an improved situation; (v) emphasizing the involvement of stakeholders throughout the intervention process. By actively engaging stakeholders and seeking their perspectives on the changes and improvements observed, SSM enables participants to gain a holistic understanding of the impact and effectiveness of the intervention [27].

By incorporating these mechanisms, SSM aims to facilitate participants' realization and recognition of the improvements resulting from the intervention. The ongoing evaluation,

reflection, and engagement with stakeholders help validate the positive changes and provide a basis for acknowledging the improved situation.

In GASSST's view, the concepts presented by Checkland in his literature are clear and sometimes repetitive, but require the reader to fit into the interpretive and subjectivist paradigm to properly understand it.

The critical literature on SSM, produced by other researchers in the field of systems thinking, such as Jackson, Mingers, Midgley [28–42], among others, highlights two fundamental points. The first is related to Checkland's perceived failure to incorporate and apply other methodologies as complements to SSM when dealing with complex unstructured problems, as advocated by Michael C. Jackson's multi-method approach. Some researchers [43, 44] argue that Checkland's approach tends to be self-contained and does not adequately leverage the benefits of integrating multiple systems thinking methodologies. They suggest that while SSM provides a valuable perspective in understanding and addressing complex problems situations, it may not fully exploit potential synergies that can arise from combining SSM with other methodologies. By relying primarily on SSM alone, it is argued that Checkland may miss out on opportunities to enhance the effectiveness and scope of his approach. In this regard, GASSST believes it is important to be parsimonious in adding other approaches to SSM. In the Group's view, this is possible, but it depends on a very careful case-by-case analysis and cannot be used indiscriminately. However, the Group agrees that integrating other methodologies could make SSM a more robust and versatile problem-solving approach.

Another criticism of the SSM is that it does not adequately address the problems related to power relations and policies and how this distorts the outcome of the debates [26]. Power relations play a significant role in shaping problem situations, decision-making processes, and policy formulation. By not explicitly addressing power dynamics, SSM may overlook important factors that can influence problem understanding and potential solutions. SSM's focus on subjective perceptions and qualitative analysis may limit its ability

to address policy-related issues comprehensively. Critics argue that SSM does not provide explicit guidance on how to analyze and address complex policy contexts and the broader political environment in which problems arise [45]. This can hinder the identification of systemic policy issues and the development of effective policy recommendations. SSM's emphasis on generating rich descriptions of problem situations and developing shared understanding may not fully consider the diverse perspectives and interests of different stakeholders. Thus, SSM may not provide adequate mechanisms to address power imbalances among stakeholders or actively engage marginalized voices. This can result in incomplete problem framing and potential bias in the analysis. SSM's focus on the social aspects of problem situations can overshadow the importance of structural factors that influence power relations and policy outcomes. SSM's emphasis on individual and group interactions may neglect the broader systemic and structural issues that contribute to power imbalances and policy challenges [46]. GASSST agrees that SSM has difficulties addressing these problems, but since SSM is a methodology and not a method, it has the flexibility to partially address these problems. Some researchers suggest integrating SSM with other approaches or methodologies that explicitly address power dynamics and policy analysis, such as Critical Systems Thinking (CST) or Participatory Action Research (PAR).

Other criticisms [47, 48] encompass SSM's: (i) lack of objectivity: SSM relies heavily on subjective interpretations and lacks objectivity in its approach. The emphasis on human perception and understanding can lead to biased viewpoints and make it difficult to generate universally acceptable conclusions; (ii) lack of rigor: some researchers argue that SSM lacks a rigorous theoretical foundation and fails to provide a clear set of rules or principles to guide its application. The methodology is often criticized for being too flexible and open to interpretation, which can lead to inconsistent results; (iii) limited scope: critics suggest that SSM is primarily suited for complex, unstructured problem situations and may not be as effective when dealing with well-defined and technical problems. The methodology's emphasis on the human element and qualitative analysis may not adequately address

quantitative aspects of problem-solving; (iv) complexity: SSM can be seen as a complex and time-consuming approach, requiring substantial effort and resources to implement. Critics argue that the process can become overly bureaucratic and hinder practical application in real-world problem-solving scenarios.

## 2. MATERIALS AND METHODS

### 2.1. Background

GASSST (from the Portuguese "*Grupo de Análise de Segurança de Sistemas Sociotécnicos*") was created in 2016 by Antonio Vieira Neto, an expert engineer in probabilistic risk assessment at the Nuclear and Energy Research Institute (IPEN, "*Instituto de Pesquisas Energéticas e Nucleares*") in São Paulo, Brazil. With more than 20 years of experience in the field, he could not fully explain the accidents in the nuclear area over the years, basing only on "hard" methods. Safety analysis recognizes the limitations of traditional approaches. Therefore, exploring other approaches to cover this deficiency was motivational for Vieira Neto. SSM is an interesting approach when one has to make decisions in complex and confusing environments that involve uncertainty and these situations are commonly observed in engineering problems (illogical decisions, conflicts of interest, authority, prevailing ideas, etc.). Decision-making in situations of high systemic uncertainty (contradictions, idiosyncratic views, etc.) many times, require a more comprehensive approach.

Vieira Neto decided to deeper study SSM and slowly gathered other colleagues with the same interest. He then started to share his recent knowledge with these colleagues, consolidating GASSST. The Group, however, had some ephemeral members over the years. Thus, the learning of the methodology by the group members evolved slowly, because for each member that joined the group, the acquired knowledge had to be disseminated to the new members for homogenization and the whole group had to go back over some steps so

that the general understanding was standardized. This often caused some frustration among the permanent members of the group, whose goal was to make a practical application of the methodology at IPEN.

It is worth noting that GASSST was quite heterogeneous, composed of people with different academic backgrounds (chemistry, physics, biology and engineering) and positions (managers, researchers, radioprotection supervisors, technicians, etc.), but with a predominant "hard" profile. The group participants were beginners in the methodology and volunteered to study SSM for a period of time and to help in its practical application in some problematic situation involving one of IPEN's Research Centers. Divergences were often observed within the group, either due to the misunderstanding of the method per se or to the "hard" consolidated profile of the members of the group, subverting the use SSM as a logical tool.

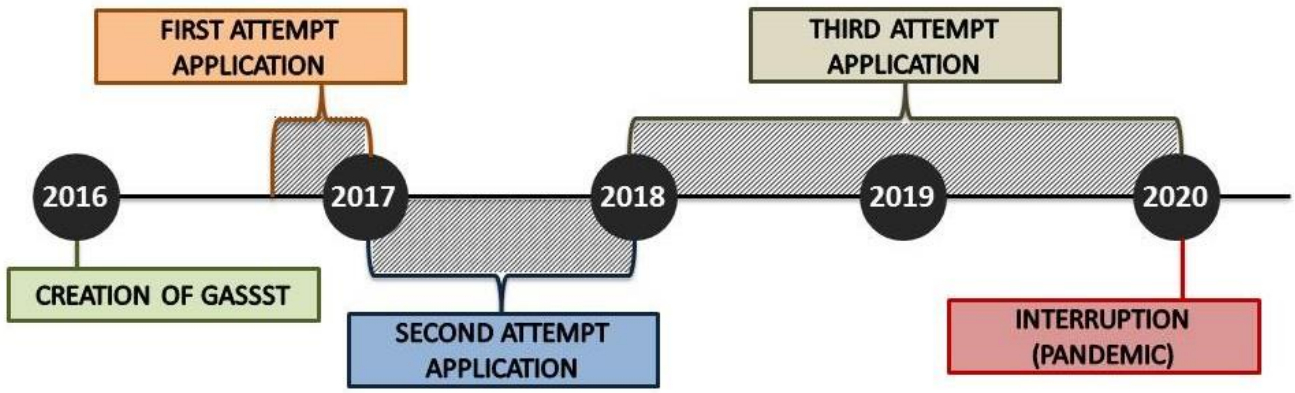
In September of 2016, GASSST proposed, as first intitutional application of SSM, the problematic situation involving a deactivated facility with contaminated nuclear wastes at IPEN. Unfortunately, this first initiative did not succeed, most likely because GASSST, at that point, was unable to outline the potential benefits of adopting SSM and its potential impact on circumstantial problem-solving.

In 2017, the Group's second proposal involved the staff of one of IPEN's research reactor. The Group managed to have a 3-year project (2018-2020) institutionally approved to apply SSM in structuring and treatment of complex problems involving the safety management of the reactor. Coincidently, at that time, the replacement of the reactor's experimental core demanded the staff to be fully dedicated to that task, which jeopardized their participation and, therefore, the continuity of the SSM project in that place.

Because of that, the Group had to identify other possible wicked problems involving other facilities at IPEN. Notedly, this was the first discrepancy with SSM, since the owner of the problem should be the one reaching out for help, not otherwise.

Finally, a facility for radioactive waste management was selected. Although it did not present ideal characteristics to be qualified as a wicked problem, the problem identified by the management of this facility encompassed some underlying conflicts, typical of complex problems, such as trade-off situations (conflicts between choices requiring a compromise solution between stakeholders). Two antagonistic positions were immediately identified. One that favored ease of access for personnel to their work controlled areas and another that emphasized the importance of radiological safety and compliance with safety protocols involving personnel in transit in the area (employees, research fellows, visitors, contractors, etc.).

**Figure 1:** Timeline of SSM application attempts at IPEN




- **2016 -** Creation of GASSST
- **2016 (september to december) -** First attempt of SSM application: IPEN's nuclear waste facility
- **2017 to 2018 -** Second attempt of SSM application: IPEN's nuclear reactor
- **2018 to 2020 -** Third attempt of SSM application: IPEN's radioactive waste management facility
- **2020 -** Interruption of SSM application due to the pandemic

During the application at this facility, some factors were identified to positively or negatively influence the success of the methodology. The staff openness and participativity, for instance, was recognized as a positive aspect. Their concern on acting on the discussed problem was seen as a negative aspect of the methodology, because by trying to improve their situation, they were always changing the initial problem.

Moreover, the conclusion of this project was severely hampered by the pandemic. Unfortunately, the project deadline has expired and GASSST was not able to complete the SSM study in the selected area. Nevertheless, the local staff has actively acted on the problem and the situation, according to recent communication, has improved in general.

## 2.2. The Problem

The uncomfortable situation, as described by the selected facility's manager, was the access by unauthorized personnel into the controlled areas, sometimes authorized by other members of the local staff, but not by the manager himself. The unauthorized access evidenced a lack of efficient control and flawed training of the staff, but when the Group learned more from the participants, it was clear that there was an underlying problem regarding conflicts of interest, in especial, the duality of practicality with safety vs safety with practicality.

One of the manager's main concerns regarded the safety of the unauthorized person in the controlled areas, while some of the staff's counterpoints were that the excessive safety protocols jeopardized the routine activities (time-consuming, bureaucratic and unproductive).

## 2.3. Application

GASSST conducted an applied SSM research involving one of IPEN's departments. This application lasted approximately 6 months and some of the difficulties and findings are reported below.

The first issue that really surprised the SSM team was the difficulty in deciding whether the problematic situation presented by the customer was compatible with SSM. The team had a problem in identifying whether the seemingly "hard" problematic situation had its origins in hidden conflicts involving different views on how to deal with it. This issue is not highlighted in the SSM literature, and it required from the team some preliminary interviews not initially planned with the study subjects (client) as well as internal meetings of the Group,

responsible for the application of SSM. It took GASSST more than 10 hours of work over several days just to reach this decision.

## 2.4. Collecting the Objective Information

At this step, the SSM team collected institutional data such as the sector's organization chart, position and function of the employees involved in the problem, formal norms and procedures, layout of the facilities involving the problem situation, timeline, site visits, etc. The team's main difficulty was to produce much of this necessary material themselves, since it was not available in the studied department. This process was very time-consuming as well.

After obtaining this initial objective information, it was not difficult to define the role of those involved in the study and the preliminary schedule of the people to be interviewed.

## 2.5. General Meeting with Staff

By conducting first general meetings with the staff (key stakeholders), SSM team ensures that participants have a common understanding of the problem context, establishes relationships and expectations, and lays the groundwork for effective collaboration. These meetings provide a solid starting point for further exploration, analysis, and problem-solving activities in subsequent stages of the SSM process.

At this stage, the SSM team was introduced to the staff and an outline of the study was presented. There was some discussion about the purpose and duration of the study. The staff was participative and open to assisting the team.

The challenge was to make all stakeholders understand that the SSM was neither a consultancy nor an application of the traditional action-research methodology. GASSST made it clear that the solution would be developed and implemented by the efforts of those involved in solving the problem, i.e., the local staff. The SSM team would act as a facilitator.

## 2.6. Interviews

SSM utilizes interviews as a means of gathering information, insights, and perspectives from relevant stakeholders. Interviews play a crucial role in understanding the problem situation, exploring different viewpoints, and capturing the complexity of the system under investigation.

The first step in SSM is to identify the key stakeholders who have a stake in the problem situation. These stakeholders may include individuals or groups who are directly involved in or affected by the problem. The facilitator, in consultation with participants, determines the appropriate stakeholders to interview.

SSM typically involves conducting structured interviews with identified stakeholders. These interviews are guided by a set of pre-determined questions or topics relevant to the problem situation. The questions aim to elicit stakeholders' perceptions, experiences, concerns, and aspirations related to the problem.

Interviews are usually recorded (with stakeholders' consent) to ensure accuracy in capturing stakeholders' responses. Detailed notes are taken during or immediately after the interview to document the key points discussed. This documentation becomes valuable input for subsequent analysis and synthesis.

At this stage GASSST sought to interview representatives of groups of people who had the same view of the problem. However, the team soon discovered that their initial interview schedule, which originally involved 6 people, needed to be changed, because during the interviews the SSM team found out that each person involved in the problem had a different view of it. The team had to change the number of interviews from 6 to 11 (the total number of people directly involved in the problem situation). This process lasted approx. 4 months.

The interviews were conducted in a place isolated from the work environment and with adequate discretion. Respondents were given the option to record the audio of the interviews. Surprisingly, all respondents agreed to be recorded in a confidentiality

undertaking signed by the SSM team. The audios were very useful later for consultation and confirmation of ambiguous issues. The respondents were questioned about the same parameters (access, safety, management, staff and communication), the importance attributed to these parameters and their influence on the problem. The interviews basically focused on the key questions shown in Table 1.

**Table 1 :** Interview Questions in the SSM Approach to Analyzing the Problematic Situation at the Radioactive Waste Management Facility.

| ITEM | DESCRIPTION | JUSTIFICATION |
|---|---|---|
| 1 | Definition of the problematic situation "access to the radioactive waste management facility" | Understanding how stakeholders perceive the core issue is essential for framing the problem accurately |
| 2 | Scale of dissatisfaction regarding the problematic situation, with justification for the provided assessment | Gauging the level of dissatisfaction helps prioritize the problem's impact on different stakeholders |
| 3 | Assessment of concerns related to the problematic situation, such as ease of sabotage, difficulty in accessing emergency areas | Identifying specific concerns allows for targeted solutions to be developed |
| 4 | Analysis of the nature of the solution to the problematic situation, considering the relative contribution of technical and human relationship aspects | Differentiating between technical and relational aspects aids in crafting a balanced and effective solution |
| 5 | Reflection on the possibility of earlier elimination of the problematic situation, with justification | Understanding missed opportunities for early intervention provides insights into potential preventative measures |
| 6 | Identification of homogeneous groups within the radioactive waste management facility with similar views on the problematic situation | Recognizing groups with similar views helps in understanding collective perspectives and possible group dynamics affecting the situation |
| 7 | Observation of the formation of affinity groups within the radioactive waste management facility and their identification | Mapping affinity groups helps in understanding social structures that might influence problem resolution |
| 8 | General evaluation of interpersonal relationships within the radioactive waste management facility, highlighting cordiality and possible exceptions | Analyzing interpersonal relationships reveals underlying social factors that may contribute to or mitigate the problem |
| 9 | Analysis of the management and decision-making approach adopted by the administration, verifying its contribution to the existence of the problematic situation | Evaluating management and decision-making processes uncovers organizational factors influencing the problem's persistence |
| 10 | Identification of individuals within the radioactive waste management facility who (a) contribute with ideas and are committed to solving the problem, (b) do not engage in the improvement process, and/or (c) hinder the improvement process of the problematic situation | Identifying key individuals helps in understanding the roles and influence of different stakeholders in problem-solving efforts |

| ITEM | DESCRIPTION | JUSTIFICATION |
|---|---|---|
| 11 | Identification of individuals with influence over others, those with communication across all involved parties, and those with a moderating/aggregating role in conflict resolution, contributing to problem-solving within the radioactive waste management facility | Knowing who holds influence and facilitates communication is crucial for effective conflict resolution and problem-solving |
| 12 | Identification of key individuals deemed essential for SSM team interviews | Ensuring that critical perspectives are included in the interviews helps in gaining a comprehensive understanding of the problem situation |

## 2.7. Elaboration of Rich Pictures

Elaborating the Rich Pictures was challenging, as it was difficult to capture the complexity of the problem situation. The abundance of details, relationships and interconnections can make it overwhelming to depict everything effectively. Balancing the level of detail and abstraction becomes a challenge to ensure the Rich Picture remains clear and understandable.

SSM encourages the participation of multiple stakeholders with diverse perspectives. This can lead to varying interpretations of the problem situation, making it difficult to create a rich picture that adequately represents everyone's viewpoints. Reconciling different perspectives and ensuring inclusivity can be a challenge during the elaboration process.

From this particular experience, GASSST noticed that not all participants had strong communication or visualization skills, which can hinder their ability to effectively translate their thoughts and perspectives into visual representations. Some participants have struggled to express their ideas visually, leading to potential misinterpretations or incomplete depictions within the Rich Picture.

One of the concerns of the Group was balancing simplicity and complexity, because the Rich Picture should strike a balance between simplicity and capturing the necessary complexity of the problem situation. GASSST believes that some participants may struggle with simplifying complex concepts without oversimplifying them to the

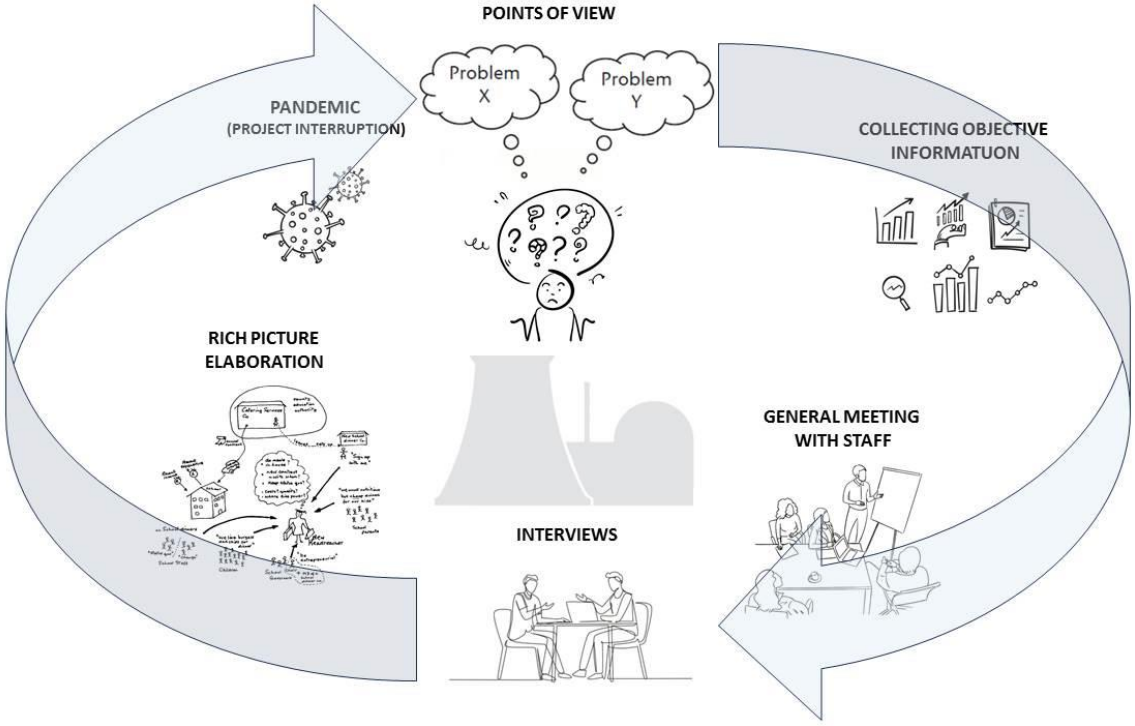
point of losing crucial details. Finding this balance requires careful consideration and communication among participants.

Incorporating systemic aspects can also be difficult. The Rich Picture aims to capture the systemic nature of the problem situation, including relationships, feedback loops, and influences among different elements. Participants may find it challenging to identify and represent these systemic aspects accurately. Grasping the systemic perspective and representing it visually can be a difficulty for some participants.

The SSM team concluded that the Rich Picture should have been prepared shortly after the interview, together with the interviewed person, but this was not possible due to the respondents' lack of time availability. Also, GASSST believes that, as facilitator of SSM, the Group can encourage active participation, promote dialogue among participants, and provide visual aids or templates to support the elaboration of Rich Pictures next time.

The elaboration of the Rich Pictures was also hampered by the pandemic, because the Group were not able to gather the respondents for a second round. The Group also found difficult translating the reports into drawings, probably because of the team's inexperience. Some certain inhibition was also noticed among the Group members in the sense that they didn't feel skilled in drawing as well. The sequence of events involved in the application of SSM for safety management in a nuclear facility is summarized in Figure 2.

**Figure 2:** Sequential Events in Addressing Complex Issues in Nuclear Facility Safety Management




## 3. RESULTS AND DISCUSSIONS

### 3.1. Results

The SSM team observed that the most substantial information was provided by the people with the least influential power. They seemed to be able to speak openly about the problems, without external pressures. According to their own statements, they felt valued for the opportunity to be heard. As a result, the team reached the conclusion that, if given the opportunity, they would prefer to contribute more.

The senior and decision-making staff gave impersonal and rather polite descriptions of the problem, but they did not touch the core of the problem. These participants chose to discuss other aspects rather than address the sensitive issues. The Group noticed that there was an undeclared conflict, in principle hidden by political correctness (the staff says they

have to follow the rules, but, in practice, they do not) and hampered by communication problems triggered by interpersonal issues.

Moreover, at the same time that the SSM team was conducting the interviews, the staff itself initiated some interventions in an attempt to change the existing situation. This showed the team that the interviews motivated them to act on the problematic situation on their own initiative and perception of the problem. This was not predicted by the Group and made them re-evaluate how the Group applied the methodology, because every time the Group addressed the problem, it had changed from the initial situation.

In any case, the participants were somehow prompted to act on the problem after taking acknowledgement of it and the Group's intervention somehow triggered a precipitated response as if the participants felt uncomfortable sharing the department's problems. After a while, the Group noticed that the initial problem has been completely solved by staff.

## 3.2. Discussion

As inexperienced facilitators, the Group encountered several challenges while attempting to apply Soft Systems Methodology (SSM). The main difficulties faced by the Group are listed below:

a) **Limited Familiarity with SSM Concepts:** the Group's limited understanding of SSM concepts, principles, and techniques has jeopardized an effectively guidance of the participants through the various stages of SSM. Lack of familiarity with SSM may lead to confusion, inefficiencies, or missed opportunities for learning and problem-solving.

b) **Managing Group Dynamics:** acting as SSM facilitators requires skill in managing group dynamics and fostering effective communication and collaboration among participants. Inexperienced facilitators may struggle to navigate group interactions, handle conflicts, encourage participation from all

stakeholders, and maintain a positive and inclusive atmosphere. This can hinder the productive progression of the SSM process.

c) **Balancing Structure and Flexibility:** SSM requires a balance between providing a structured framework and allowing flexibility for participant contributions and exploration. Inexperienced facilitators may struggle with finding this balance, potentially leading to overly rigid or loosely structured workshops. Finding the right level of guidance and flexibility is crucial for maintaining focus and achieving meaningful outcomes.

d) **Grasping the Complexity of the Problem:** SSM is often applied to complex problem situations that involve multiple stakeholders, diverse perspectives, and intricate interrelationships. Inexperienced facilitators may find it challenging to fully grasp the complexity of the problem and adequately guide participants through the process.

e) **Understanding the problem context:** recognizing relevant system boundaries, and identifying key issues can be demanding for novice facilitators.

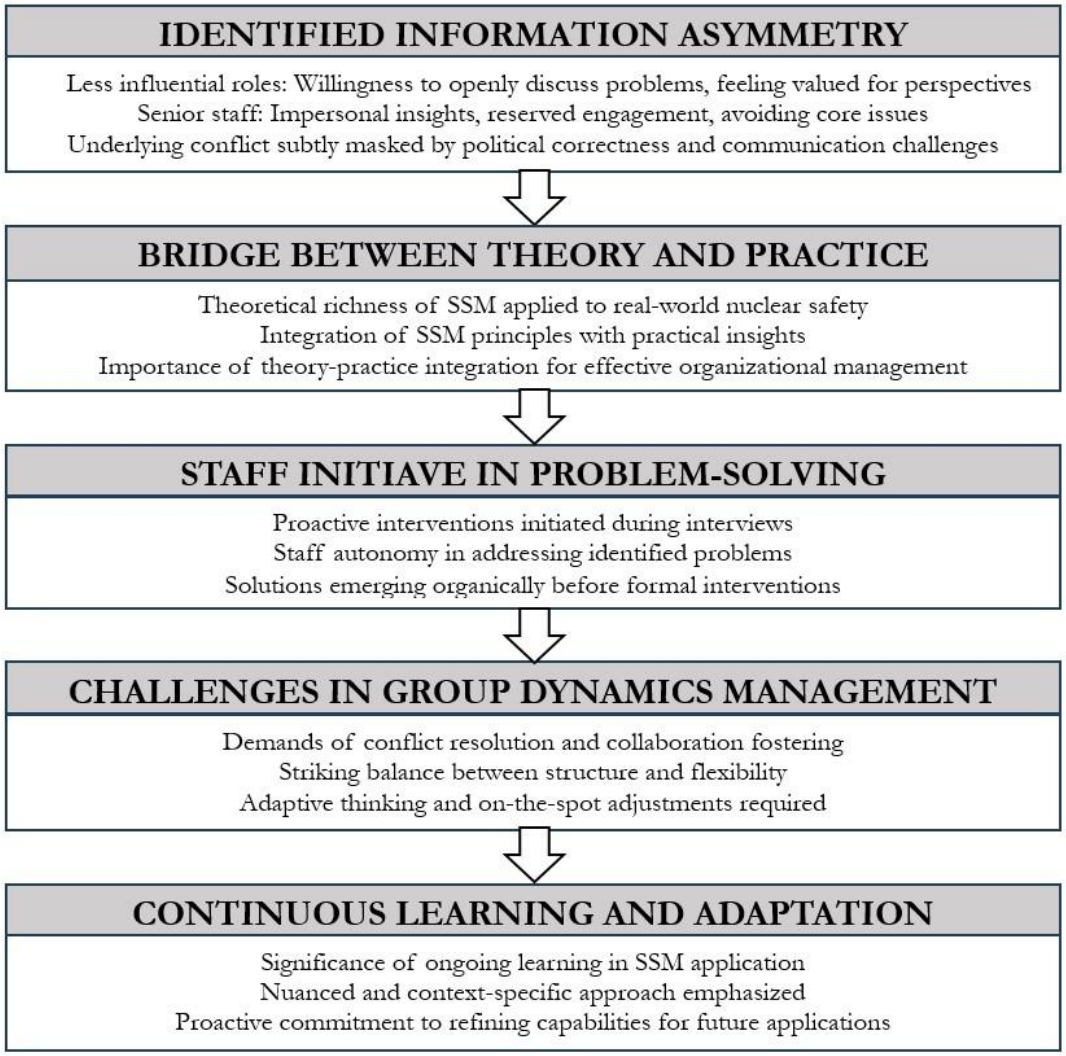
f) **Adapting to Unexpected Challenges:** SSM workshops can encounter unexpected challenges or deviations from the planned agenda. Inexperienced facilitators may struggle to adapt to these situations, potentially leading to confusion or uncertainty. Being able to think on their feet, make timely adjustments, and guide the group through unforeseen circumstances is a skill that may take time to develop.

Seeking mentorship or guidance from experienced SSM facilitators to learn best practices and gain insights is also a challenge given the small number of people who uses SSM in Brazil and, more specifically, in the nuclear area.As the Group navigated the challenges of applying Soft Systems Methodology (SSM) within the context of nuclear safety, several key themes and dynamics emerged. These included the identification of information

asymmetry among participants, the complex relationship between theoretical principles and practical application, and the role of staff initiative in proactively addressing problems. Additionally, the difficulties encountered in managing group dynamics and the continuous learning required for effective SSM facilitation were prominent.

To better illustrate these interconnected elements, a Dynamic Relationships Diagram that visualizes the key interactions and challenges experienced by the Group during the SSM process is presented in Figure 3. This diagram serves as a synthesis of the core issues, highlighting the interplay between theory and practice, the emergent problem-solving behaviors of staff, and the need for ongoing adaptation and learning.

**Figure 3:** Dynamic Relationships Diagram in the Application of SSM to Nuclear Safety



The Group believes that, as an emerging SSM team, it must first acquire a thorough understanding of SSM principles, techniques, and the overall process through study and practice, and then prepare extensively before workshops, including developing clear objectives, designing activities, and anticipating potential challenges.

## 4. CONCLUSIONS

When utilizing this approach in the future, one of the team's challenges will be to encourage individuals to recognize their own perspectives within the Rich Picture and to be open to differing viewpoints, without causing conflicts within the group. Additionally, it will be necessary to present the Rich Picture to the group with shorter notice. In this context, the prompt application of SSM was identified as a key factor for the methodology's success. The SSM team faces the challenge of not becoming overly focused on details or being excessively perfectionistic in their execution of SSM. The group's lack of experience also contributed to this issue, as the application was already underway while everyone was still attempting to grasp the methodology, leading to uncertainties and discussions within the group. By dedicating time and effort to enhancing their facilitation skills, inexperienced facilitators like GASSST can gradually overcome these challenges and effectively apply SSM in problem-solving contexts in the future. The insights gained from this practical study can inform future applications of SSM, providing guidance to researchers and practitioners in effectively leveraging the methodology to navigate complex problem situations.

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## CONFLICT OF INTEREST

All authors declare that they have no conflicts of interest.

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