NKS-494
ISBN 978-87-7893-591-1

Internal nuclear safety oversight as part of organizational defence-in-depth – Lessons learned for the Nordic nuclear industry
Final report from the NKS-R INSOLE activity

Kaupo Viitanen[1]

Teemu Reiman[2]

Fredrik Jakobsson[3], Carin Sylvander[3]

Sami Karadeniz[1]

[1]VTT Technical Research Centre of Finland Ltd

[2]Lilikoi

[3]Risk Pilot AB

February 2025

Abstract

The **overall goal** of the NKS-R INSOLE activity was to contribute to the development of **internal independent nuclear safety oversight functions (INSO)** at Nordic NPPs by applying a participatory approach. This final report describes the findings from the second and last year of implementing this activity.

A normative framework for the INSO function implementation was developed, which contains four dimensions (system perspective, context, management and organizing, and outcome). Each dimension contains descriptions of best practices and at-risk approaches, which were identified based on the integration of theoretical and empirical research results.

To concretize the research results, three tools were developed to facilitate the implementation of INSO function in practice. The three tools include maturity model for the INSO function, model of functional involvement, and role independence reflection tool. These tools aim to address the typical challenges associated with the implementation of the INSO function.

Key words

independent oversight, internal oversight, nuclear safety, INSO

NKS-494
ISBN 978-87-7893-591-1
Electronic report, February 2025
NKS Secretariat
P.O. Box 49
DK - 4000 Roskilde, Denmark
Phone +45 4677 4041
www.nks.org
e-mail nks@nks.org

Internal nuclear safety oversight as part of organizational defence-in-depth – Lessons learned for the Nordic nuclear industry

Final report from the NKS-R INSOLE activity

(Contract: AFT/NKS-R(24)138/3)

Kaupo Viitanen[1]
Teemu Reiman[2]
Fredrik Jakobsson[3], Carin Sylvander[3]
Sami Karadeniz[1]

[1]VTT Technical Research Centre of Finland Ltd
[2]Lilikoi
[3]Risk Pilot AB

Table of contents

1 Introduction

In the nuclear industry, **oversight** refers to the industry function that "verifies that the utility has the full capability to perform in a manner which achieves fundamental nuclear safety functions through appropriate staffing, processes, activities, actions and monitoring" (WANO & IAEA, 2018, p. 4). WANO and IAEA (2018) have identified four layers of oversight: In-process oversight (e.g., peer checking and self-assessment); Functional oversight (performed by senior managers); Independent oversight (performed independently of the line organization); and External oversight (e.g., regulator, WANO, IAEA).

The **overall goal** of the NKS-R INSOLE activity was to contribute to the development of **internal independent nuclear safety oversight functions (INSO)** at Nordic NPPs by applying a participatory approach. The project has collected the **experienced best practices and lessons learned** from nuclear and non-nuclear organizations operating in different sociotechnical contexts and examined the reasons for choosing certain approaches to internal independent safety oversight.

The **specific goals** of the two-year activity were:

- To study how internal oversight function has been implemented in the global nuclear industry and in non-nuclear safety-critical organizations
- To examine the different ways to organize and implement internal nuclear safety oversight function in nuclear power companies from a sociotechnical perspective
- To develop normative framework for internal nuclear safety oversight function in Nordic NPP context
- To facilitate participative development of internal nuclear safety oversight in Nordic NPPs

In this report, we describe work done within NKS-R INSOLE during its second and last year of implementation, focusing primarily on the last three goals. During the second year, the focus was on conducting empirical case studies in three Nordic nuclear power plants, developing a **normative framework for the INSO function implementation** (chapter 3 and Attachment A), and developing a set of **tools to facilitate the implementation of INSO function** in practice (chapter 4 and Attachments B, C, and D).

2 Research Approach and Methods

NKS-R INSOLE activity integrates cutting-edge organizational and safety science theories, existing knowledge concerning independent oversight, and participative case studies in Nordic nuclear power plants. The overall structure of the activity is summarized in Figure 1.

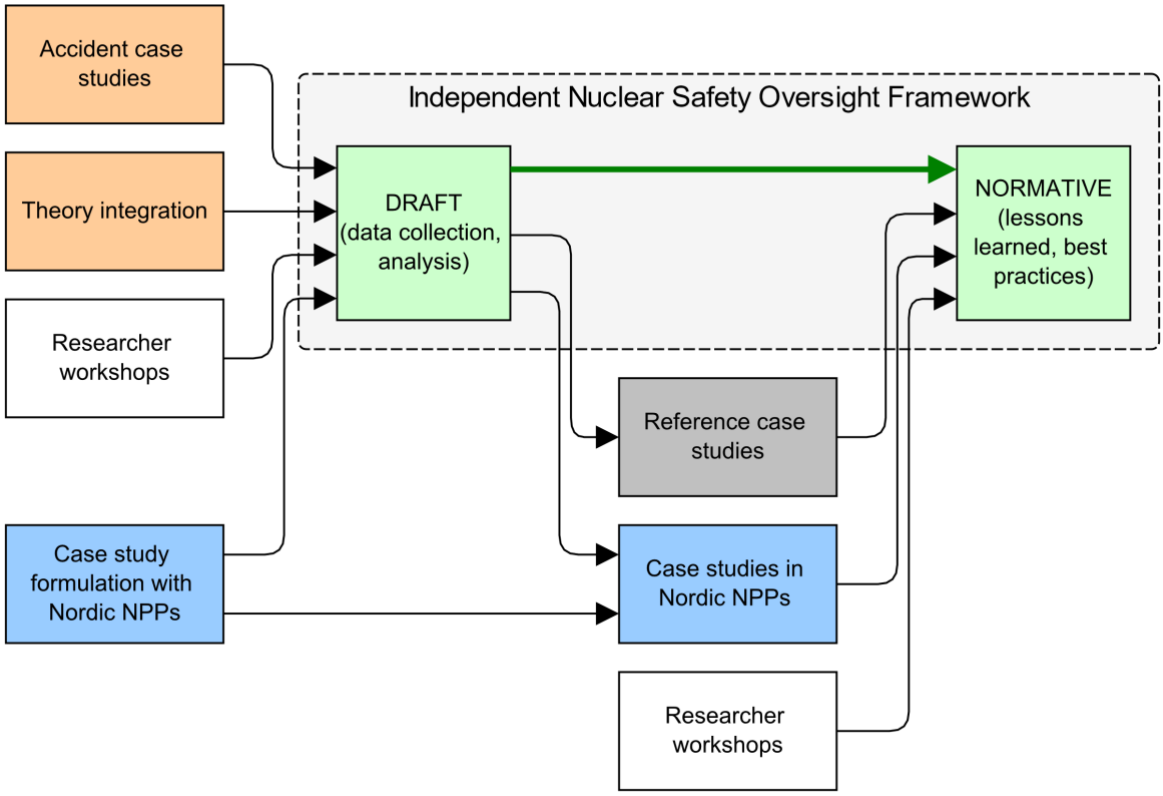


Figure 1. Overall structure of NKS-R INSOLE

The principal tool and outcome of the project is the **Independent Nuclear Safety Oversight Framework**. In the first phase of the project (2023), the framework was used to guide data collection and analysis. The draft framework was based on researcher workshops, theory integration as well as discussions held with representatives from Nordic nuclear power companies during case study preparation. The draft framework was described in detail by Viitanen et al. (2024) in the NKS-R INSOLE intermediate report.

In the second phase of the project (2024), the framework was developed into a normative form, and it describes lessons learned and best practices for internal independent nuclear safety oversight. The normative framework integrates the findings from all previous research activities, including accident case studies, reference case studies about INSO practices and lessons learned in non-Nordic nuclear and non-nuclear safety-critical domains, and main case studies in three Nordic nuclear power plants.

The main case studies used a qualitative methodology to gain insights into the organizational phenomena associated with the INSO function's implementation, applying a stakeholder approach by examining perspectives of both INSO experts and the line organization. The main case studies were conducted in three Nordic nuclear power companies in Finland and Sweden, all of which had implemented an INSO function and had been operating for over 40 years. Individual case studies were harmonized to ensure data compatibility for analysis by focusing

on similar themes and using compatible interview schemes. Data collection involved individual and group interviews, with a total of 36 semi-structured interviews conducted across the three main case studies.

An additional reference study with other experts was conducted to gain complementary perspectives, involving eight individual interviews with nuclear industry experts and four interviews with experts from other safety-critical industries (aviation and process industries). The reference study included interviews with INSO experts from non-Nordic nuclear power plants, international consultants with expertise in research or practice on organizational issues and oversight, consultants who have worked on INSO topics with WANO, and safety managers.

In this report, the results from the case studies are not described in detail, but their insights are utilized to illustrate the INSOLE Normative Nuclear Safety Oversight Framework (Chapter 3), and to create five example narratives of various INSO-related phenomena (Stories 1-5). The stories are anonymized and not necessarily based on a single nuclear power company.

3 Normative Nuclear Safety Oversight Framework

The INSOLE Normative Nuclear Safety Oversight Framework contains four overall dimensions and several subcategories in each dimension (Figure 2). The framework aims to capture the best practices and at-risk approaches of implementing an INSO function in a nuclear power company. The following four subchapters describe the dimensions, best practices and at-risk approaches, and the reasoning behind them, as well as examples and illustrative narratives. A summary poster of the framework is provided in Attachment A.

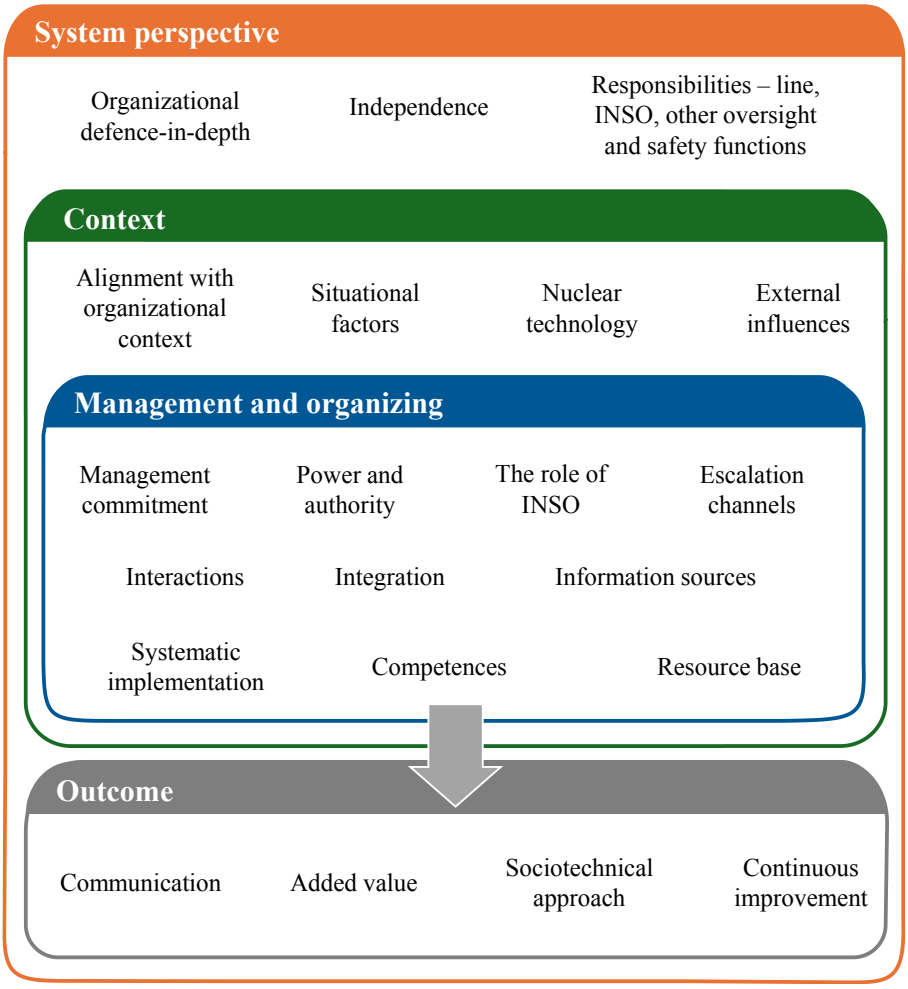


Figure 2. Overview of the INSOLE Independent Nuclear Safety Oversight framework

3.1 System perspective

We apply a **sociotechnical systems perspective** to gain a holistic understanding of the organizational dynamics and interactions involved with the INSO function. Key topics are positioning the INSO function within the overall sociotechnical system (the nuclear power plant and the organization that runs it) that it oversees and that surrounds it, how safety and oversight responsibilities are divided within the organization, and what is the expected type and level of independence of INSO.

The INSO function represents an **oversight function**, but it is not the only oversight function in a nuclear power company. Nuclear power companies also employ a variety of dependent oversight functions: in-process oversight which is performed before or during task performance by task performers and focuses on the work groups performing the work, functional oversight

which is performed periodically or on-demand and focuses on work processes and task performance, and management oversight, which focuses on leadership, management, and organizational processes (e.g., the management system). Each of these three oversight functions can have an **independent counterpart**: independent management oversight, independent functional oversight, and independent in-process oversight. In addition, there are external functions performing or contributing to oversight, such as external safety committees, the regulator, industry associations and peers, technical support organizations, etc. Together, they form an organizational defence-in-depth structure (Figure 3, see also Story 1).

The **INSO function** can be considered a subset or integration of these independent oversight functions, focusing on gaining an overall perspective of the nuclear safety situation at the plant. Care should be taken that the nuclear power company understands these roles and positions and avoids seeing INSO as a line function, or merely seeing INSO as a barrier that the line organization can rely on in catching its deficiencies or errors. Instead, INSO should primarily be seen as a nuclear safety assurance function to oversee and facilitate that the line organization takes care of its operative and oversight responsibilities. INSO should be its own distinct part in the defence-in-depth system and not take the place of the functions that it oversees. This not only applies at functional level, but also at the level of individual INSO experts, who should be aware of their functional and social dependencies.

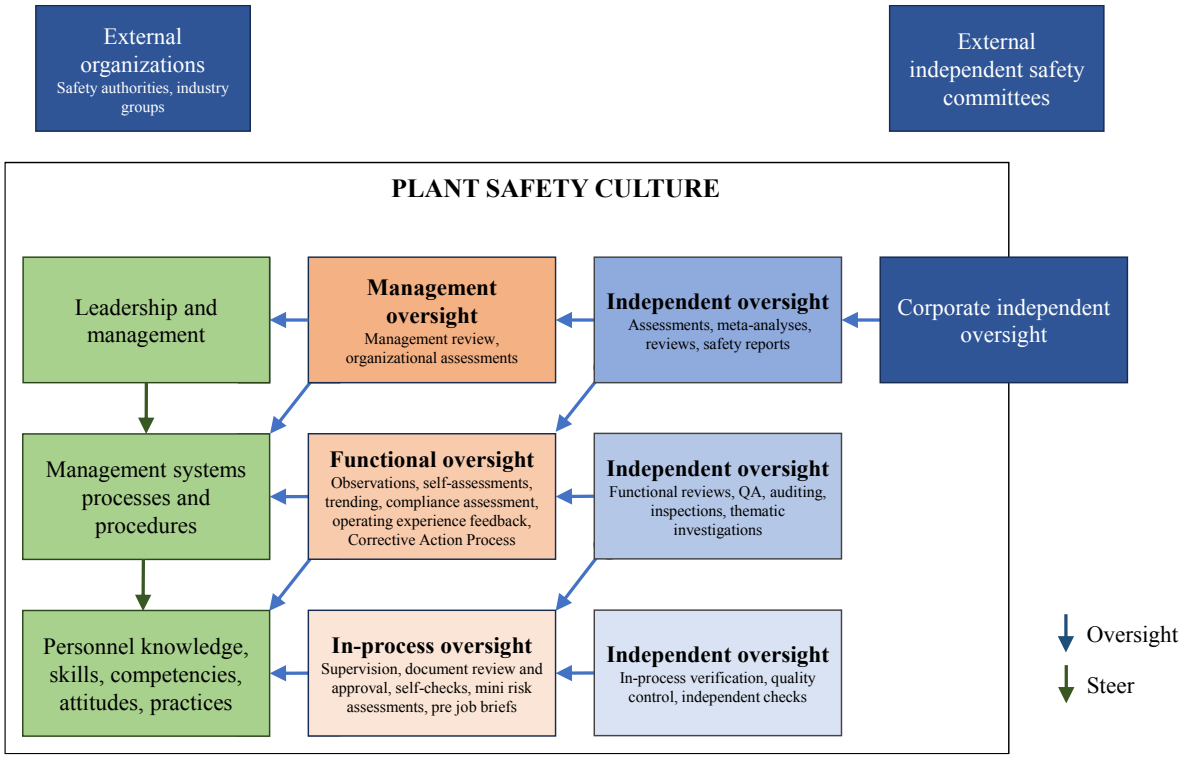


Figure 3. Levels and layers of oversights in a sociotechnical system – nuclear example of an extended defence-in-depth (influenced by Rasmussen, 1997; Reason, 1997; WANO & IAEA, 2018). Arrows indicate steering and oversight interactions, other interactions such as information flows are omitted from the figure

One of the primary unique characteristics of the INSO function is its **independence**. Independence is often defined as not being involved in or responsible for the activity that is being overseen. There are also other types of dependence relevant to INSO such as cultural or social dependence (e.g., identifying oneself as part of the same group – licensee organization or certain organizational function – as the overseen), and financial dependence (e.g., INSO resource base being affected by those being overseen). The INSO function should acknowledge

the different types of independence and manage its activities accordingly. The INSO function should also consider that independence is not a black-and-white phenomenon, and that extreme independence is not always desirable. In situations where INSO becomes passively independent (i.e., merely points out issues and does not participate or proactively interact with the rest of the organization), there is a risk that INSO becomes isolated, irrelevant and ultimately dismissed by the line organization. Consequently, the INSO function should continuously balance between independence and involvement (see Story 1).

Story 1. Focus on independence in the interpretation of INSO

Historically, independent safety review was an important part of the process for plant modification. This task was considered the clearest and thus perhaps the most important function that the safety department had. The independence part of the task was clearly defined in the management system and the focus on the independence required for an employee to be able to conduct the review was the reason for it being considered the clearest INSO task. However, in the case studies, not many interviewees reflected around the fact that when a case is approved or rejected, the independence ceases, and the activity could be considered just at part of the quality assurance. On the other hand, there were other activities carried out by the safety department, that were more of an oversight nature than the safety review, like daily supervision, cumulative assessments and internal audit (that was not always even considered to be a natural part of the INSO). This focus on the wording of independence lead to an imbalance in the supervision exercised by the safety department and gave technical details a predominance which also made it harder to take a systematic approach within the INSO function.

Key takeaway: An effective INSO requires a basic understanding of concepts such as independence but perhaps above all oversight. It is important that the INSO activities are based on this understanding and that the organizations do not build an INSO function only by including already existing functions.

	BEST PRACTICES	AT-RISK APPROACHES
SYSTEM PERSPECTIVE	Organization clearly understands INSO's position within the **organizational defence-in-depth** structure.	Utilizing the INSO function as a line function, or solely as a barrier for the line organization.
	INSO has clear strategy concerning the **type and expected level of independence** and the reasoning behind it.	Independence of INSO is conceptualized only functionally, and/or is seen as a black-and-white issue.
	The **responsibilities** of the INSO function and the line organization are clearly separated.	The INSO function regularly performs line tasks.
	INSO personnel is sufficiently **independent** from the line organization.	INSO members have ties to the line organization, which affects their independence in ways that are not recognized or understood.
	Clear division of labour and coordination between **other oversight or safety functions** (e.g., internal audit, QA, safety department, safety committees and councils).	INSO and other safety and oversight functions coordinate rarely or irregularly.

3.2 Context

The INSO function operates within the constraints of its operational environment and should align with its **context** to be effective. The context can influence the goals, arrangements, focus areas, and activities, as well as create constraints or possibilities for implementing the INSO function. The types of contexts relevant to INSO are licensee organization's characteristics (meso-sociotechnical), external operational environment (macro-sociotechnical), and technological. This also means that directly copying industry standards or INSO approaches from other companies might not be an effective strategy.

Licensee organization's characteristics include its established organizational (safety) culture, organizational design, and situational factors. The implementation of the INSO function – its goals, visions, how it is arranged, what it does, what are its focus areas and how it interacts with other organizational functions, should be aligned with the licensee organization's unique characteristics to avoid clashes with the rest of the organization, and to ensure that it is effective and relevant.

Organizational culture is a multi-level phenomenon consisting of behavioural, technological, and organizational artifacts, values, norms, beliefs, and assumptions. It defines what is considered the "correct" and accepted way of thinking and behaving in the given organization. Because of this, organizational culture can also be a resistance force for changes in the organization. Aligning the INSO function with the established organizational culture involves being aware of things such as how the line organization conducts and improves its activities, what is line organization's relationship with external parties (such as INSO), and how the line organization communicates and expects to be communicated with (see Story 2). When implementing INSO, it should be considered that it is likely to be easier to adapt the INSO to the established organizational culture than the other way around.

In addition, organizational culture can create **blind spots**, which can affect both the line organization and the INSO function. The INSO function should be able to reflect its organizational culture context to identify potential shared blind spots.

Story 2. Organizational culture as a backdrop for INSO

The organizational culture in a studied nuclear power plant can be characterized as self-reliant. Employees working at the plant had an exceptionally strong drive to solve issues by relying on their own organization and community. Parties outside of their community (e.g., corporate functions like corporate INSO) were faced with reservations and resistance. Indeed, the corporate INSO function was not always found effective in this organization, because its members were perceived as outsiders. Reflecting their work, corporate INSO experts felt that instead of insisting upon their findings, they should communicate in a facilitative manner – helping the plant personnel realize the issues themselves rather than just telling them. When the INSO function was restructured and plant-level INSO function was implemented, some INSO members became part of the plant community. This contributed to the INSO function becoming more appreciated and understood at the plant community.

Key takeaway: The established organizational culture may require certain communication styles or organizational structures for the INSO function to be accepted and integrated.

Organizational design refers to the formal aspects of the organization, such as its organizational structure, management system and processes. The **complexity of the organizational structure** is of key importance, including how many plants, sites, projects, or co-owned facilities the corporation has. The INSO function should be structured in accordance with the level of complexity of the corporation. For example, nuclear power companies with multiple sites or co-owned facilities seem to benefit from a division between corporate INSO and a local, plant-level INSO. Local, plant-level INSO can then focus on field-level work and integrating with the plant community (to the extent appropriate for an independent function), and the corporate INSO can focus on overseeing corporate functions and creating a fleet-level overview (see also Story 2).

INSO also has a role in independently assessing the safety implications of **organizational changes**, but it can also itself be a subject of organizational changes (see Story 3), which can affect its operational preconditions or independence.

Story 3. Remembering good practices throughout organizational changes

One of the organizations we studied implemented various activities to enhance engagement and to improve the relationship between INSO and the line organization. A new collaborative activity was introduced, where information about INSO assessments was discussed openly and transparently with the line organization before and after certain assessments. INSO found this approach to be a positive way to improve cooperation, particularly in communicating INSO recommendations. However, the activity was discontinued due to organizational changes that occurred shortly after its initiation, making it challenging to evaluate its long-term effectiveness.

Key takeaway: Organizational changes pose risks to the retention of good practices, especially when these practices are not yet established and when the organizational changes involve personnel changes in the INSO function. The risk of losing valuable practices and information from different experiments should be included in the risk assessment of organizational changes.

Situational factors at the licensee organization are dynamic and continuously changing, reflecting what is topical. They may include things such as life cycle transitions, sociotechnical changes or developments (e.g., modernizations, organizational changes), and topical challenges in nuclear safety. Situational factors should be reflected in the selection of INSO focus areas. In power companies, focus areas have often resulted in INSO conducting special investigations about them. Focus areas tend to be selected based on the overall findings of the INSO function (e.g., summary reports), or in cooperation with the INSO customers (i.e., CEO, CNO). When INSO customers are involved in steering INSO, care should be taken to avoid losing independence, which may occur either through inclusion or exclusion of focus areas.

INSO's alignment with the organizational characteristics should also be **continuously monitored** to avoid unwanted drift from the rest of the organization, and to maintain its strategic goals.

External operational environment refers to those factors and conditions that are outside the direct control of the power company but that can nonetheless influence it. These include the regulatory regime, the political landscape, social acceptance of nuclear power, shareholder interests, and the current economic situation, including potential competitors and the electricity market in general. National cultural influences can also be included in this category as well as various external threats such as earthquakes, floods and intentional harm. INSO should be aware of these influences upon the organization, and upon itself.

The INSO function should have a sufficient understanding of the **technological context** it oversees. One manifestation of this is understanding the risks of nuclear technology and the application of graded approach in managing and implementing the INSO function. All tasks or focus areas cannot be prioritized or performed at the same time, which means that INSO should intelligently choose those areas where it can have the most positive effect on nuclear safety. INSO functions (particularly CINSO) may also have very diverse facilities they oversee – from newbuilds, operating power plants, decommissioning projects to waste management functions and engineering projects. The INSO function should have the readiness to understand the technological (and organizational) context of each of these settings and adapt their oversight approach accordingly.

	BEST PRACTICES	AT-RISK APPROACHES
CONTEXT	INSO strategy and arrangements (e.g., vision, goals, structure) are aligned with the **organizational context and its structural complexity, and culture.**	Copying INSO strategy and arrangements from guidelines or from other companies without sufficient consideration of the unique characteristics and evolution of one's own organization.
	INSO focus areas and activities are aligned with the **situational factors** at the organization and at the plant(s) (incl. life cycle phase, sociotechnical changes or developments, current nuclear safety issues or challenges, etc.).	INSO rigidly doing the same things and having the same focus areas without adjusting to situational demands or changes.
	INSO considers **external influences** on the management, line operations and the INSO.	INSO function does not monitor external influences on its own or line's activities or considers them only when significant events or other changes take place.
	INSO focus areas and activities reflect an understanding of the **risks of the nuclear technology** applied by the overseen nuclear facility.	Prioritizing everything and not applying an effective graded approach to what is nuclear safety significant.

3.3 Management and organizing

Management and organizing focuses on the integration of INSO with other organizational functions, its information collection and utilization methods, and its structure and activities.

3.3.1 Interactions and interfaces

The key internal parties the INSO function interacts with are its customer (top management; typically, CEO, and/or CNO) and the operative line organization who is being overseen.

The most common types of interaction with the **senior management** include INSO delivering information and independent perspectives of the nuclear safety level; INSO giving advice and recommendations; INSO and senior management jointly agreeing on the focus areas or INSO receiving other forms of steering; INSO receiving organizational support for implementing INSO activities; and INSO providing coaching or education to the senior management. Challenges emerge if senior management does not see value in the INSO function or underutilizes it. Senior management should actively seek out INSO's advice and utilize INSO's perspectives in decision-making. Formal arrangements such as meetings, reporting practices as well as escalation channels should be in place that enable this. Senior management should also help mediate and promote the relationship between the line organization and INSO, especially in situations where the INSO and the line organization disagree. It is also important that when senior management steers INSO activities, care is taken to avoid losing the independence of the INSO function, for example through excessive steering.

A healthy relationship between the INSO function and the **operative line organization** who is being overseen by the INSO is essential to ensure that the INSO function is accepted. This acceptance helps provide the INSO function with better access to information from the line

organization, but also in converting INSO findings into improvement actions and continuous improvement. A common challenge is that INSO is perceived as an outsider, overly critical, or a "blocker" of progress. In unhealthy situations, this can easily result in adversarial and confrontative relationship between the INSO and the line, where neither party accepts nor understands each other's perspective. Disagreements on factual topics can still be healthy when they occur in a constructive way – attempting to achieve a complete consensus and harmony might in fact hurt the independence or effectiveness of the INSO function (see Story 4). This may happen, for example, if the line organization demands to modify INSO findings. A healthy interaction between the line and the INSO function should be positive and constructive, characterized by sufficient dialogue but without sacrificing INSO independence in doing so.

Story 4. Misinterpretation of the INSO output lowers the effectiveness of INSO

At one of the studied plants, the main output of the INSO function is a report that is published several times a year. In the report, INSO describes their observations for the intended time period, focusing on deviances and shortcomings. The authors of the report perceived that some recipients, both the line organization and recipients upwards in the hierarchy, seem to be of the opinion that the report is an objective account of the business situation and not the INSO perspective of safety related findings from the actual period. The line organization is not always comfortable with what is communicated in the report, among other things because the report is not considered sufficiently balanced with positive aspects, especially when it is going to be delivered to the board. Recipients at a strategic level expect an objective account of the situation at the licensee and may not have a clear picture of what an INSO report actually consists of and how the assessments are formulated.

These misconceptions complicate the writing of the report, which should not sound too sceptic but still highlight the shortcomings that have been observed. While the reporting might be too detailed for, e.g., the board, it is too brief to serve as insight-creating feedback to the line. There are many discussions, corrections and reformulations before the report is released. The work process to get an acceptable report feels unjustifiably heavy for those who are authors.

Key takeaway: Communication is an important success factor for the INSO function to create understanding and insight. Therefore, it is important that recipients of written information also understand what they are receiving and that the communication is adapted to the recipient. If the target group is too broad, there is a risk that the intended message will not reach the recipient, which will affect the effectiveness of INSO.

	BEST PRACTICES	AT-RISK APPROACHES
Interactions and interfaces	**Senior management** is committed to INSO implementation and actively seeks out its perspectives.	Senior management shows little or no interest to INSO or its findings, and only reluctantly accepts its activities.
	Formal and effective **escalation channels** are available and utilized.	Formal escalation channels do not exist, or their use is culturally not encouraged. Escalation occurs only informally.
	Healthy and appropriate interaction with the **line organization.**	The relationship between INSO and line is adversarial and confrontative, characterized with nonconstructive disagreements and a lack of dialogue.

3.3.2 Inputs and information

As gaining an independent overview of the nuclear safety situation at the organization is a primary task of the INSO function, it is important for the INSO function to **use information effectively**. Typical sources of information for an INSO function include operating experience feedback, findings from various other assessments (produced by internally by the line or other oversight functions, or externally by the regulator, WANO, IAEA), observing activities (incl. meetings, field operations), and examining the records the organization has produced.

However, the **independent position** of the INSO function sometimes hinders its data collection. For example, if the operative line feels threatened by the INSO function, it might not share or communicate their insights with INSO; or the INSO function may be overwhelmed by the sheer amount of written information available at the corporation, hence unknowingly neglecting relevant information. The INSO should engage in a positive interaction with the line organization to overcome these challenges, while maintaining its independent role.

It is also important that the INSO function is aware of the **limitations of the information** it utilizes. For example, when relying on materials produced by the line organization, the independence of INSO may be decreased because such information is biased or only shows some aspects of reality. This is why INSO should strive towards collecting first-hand information. This also means being aware of the target of one's oversight. The INSO should not only observe the operative line organization that is visible at the plant shop floor (e.g., actions of operators and maintenance, or condition of technology), but also office operations (e.g., engineering, safety analyses), and decision-making (e.g., meetings and/or records of the management team, board, and other internal decision-making authorities).

	BEST PRACTICES	AT-RISK APPROACHES
Inputs and information	INSO function has access to the **information sources** needed.	INSO's access to information sources is passively or actively obstructed by the line organization.
	INSO function understands the **nature, reliability, and limitations of the information** it utilizes.	INSO misunderstands the nature of the data it uses and what conclusions can be made from it, often making unjustified conclusions based on limited data.
	INSO strives to collect **first-hand** information.	INSO relies largely on the data collected by the line organization or third parties.

3.3.3 Activities and arrangements

The formal aspects of implementing the INSO function include organizational arrangements, and management of INSO activities, competences and resources.

The **power and authority** of the INSO function are linked to its independent position, but they are also task dependent. In many INSO tasks, its goal is to produce descriptions or recommendations, and therefore its organizational power is characteristically low. This is an INSO leadership challenge because situations where the line organization does not act upon INSO findings or recommendations can frustrate the INSO personnel. The INSO function should always have sufficient power and authority to bring up nuclear safety issues and to escalate them. In tasks where INSO does independent safety reviews or provides an authoritative interpretation of the regulatory requirements for the company it has more power. However, with organizational power, the independence of the INSO may be reduced. This means that the INSO function should also be cautious of having too much organizational power.

Organizational power may reside in **positions or individuals**. Situations where the power of the INSO function comes solely from individuals (e.g., INSO manager or similar leaders) should be avoided. Individual power has been observed to result in issues such as lack of transparency in decision-making concerning INSO focus areas, in communication of INSO findings towards the top management, and in additional turbulence during organizational changes when the INSO leadership changes. The authority of the INSO positions should not change when people change.

The INSO function is diverse, and it can have many **roles**. Common roles include offering an independent assessment of line functionality and safety, acting as a barrier and reviewer, advising top management, challenging and questioning the line organization, and interfacing with regulatory authorities. Regardless of what the specific content of the role is, the INSO function and the line organization should have a shared and integrated understanding of the role of INSO. Lack of such understanding may, for example, hinder strategic leadership of the INSO function (e.g., defining expectations for it) and the interaction between INSO and line (e.g., why and how they should communicate with INSO). Clear integration with the management system, communication from the top management, and continuous dialogue between INSO and line are examples of ways to help create this shared understanding.

The organizational implementation of the INSO function has been observed to vary depending on the licensee organization in question. The INSO function can be implemented as an **organizational function or as a distinct organizational unit**. When it is implemented as a function, individuals performing INSO tasks are formally working for a line unit (e.g., nuclear safety department). In such case, care should be taken that the reporting line does not hinder the INSO experts from having an independent perspective or an opportunity to bring up nuclear safety issues. Direct communication to the top management should be ensured, for example, through periodical meetings and written reports where INSO experts present their findings to the top management.

Many licensee organizations have implemented **multiple levels of the INSO** function: typically, corporate INSO (CINSO) and plant-level, local INSO (LINSO). Their organizational arrangements differ, with CINSO often being a distinct organizational unit, and LINSO often being integrated into the plant organization's nuclear safety department. They also have a different focus: CINSO should create a fleet-wide overview and oversee corporate functions, while LINSO should focus on the operations of the one plant it oversees. Overlapping work between CINSO and LINSO should be avoided, and the distribution of roles between CINSO and LINSO should be made clear: although there are opportunities for cooperation between CINSO and LINSO, the CINSO function should remain sufficiently independent from LINSO to oversee the effectiveness of the LINSO function.

The management of the INSO function should define the **strategy, work plans, and focus areas** for the INSO function, and document them in the management system. Performing work ad hoc or without a clear strategy often creates confusion among the INSO personnel and among the line organization, which can hinder the organizational interactions and acceptance necessary for performing independent oversight.

Typical **activities** of the INSO function include:

- Fleet-wide reviews (CINSO)
- Oversight of LINSO and safety department (CINSO)
- Observations in the field and in meetings
- Independent reviews of (technical) documents
- Review of event investigation practices
- Review of processes (rather than single documents)
- Evaluating organizational changes
- Safety culture and leadership assessments
- Preparation of reports

In the **selection of INSO activities**, it is important to ensure that the INSO function does not assume the role of the line organization and perform tasks that are the line organization's responsibility. This may occur, for example, in situations where the INSO function is the only entity in the licensee organization performing an assessment. The INSO as an independent

function should instead perform independent assessments that are complementary to the (dependent) assessments performed by the line organization.

The INSO function should have access to a wide range of **expertise and experience**, in technical fields and in human and organizational fields. This includes, for example, nuclear engineering, quality assurance and control, operating experience and event investigation, safety culture and leadership, and regulation. Staff rotation between the INSO and the line organization can be applied for INSO competence management, but care should be taken to avoid creating independence issues (e.g., persistent loyalty to or association with the line organization), competence draining (e.g., moving too much expertise from line to INSO), or involuntary reassignments.

The organization should also ensure that the necessary **resource base** is available to the INSO function in all situations. Although formally independent, the INSO function is still "financially" dependent on the line organization, and care should be taken that the top management does not obstruct the functionality of INSO function by withdrawing its resources. The INSO should be able to perform its planned tasks but also have sufficient resources for performing acute tasks such as on-demand assessments or event investigations.

	BEST PRACTICES	**AT-RISK APPROACHES**
Activities and arrangements	The **power and authority** of the INSO function are clear and at appropriate level.	The INSO function has no power and authority, or it has too much of it. Power and authority are person dependent.
	The **role** of INSO function is clear and communicated throughout the organization.	INSO role is not clearly known to INSO nor to the line organization.
	Systematic implementation of activities.	INSO activities are performed ad hoc, without formal strategy, planning, or follow-up.
	Clear integration with the **management system.**	INSO is not described or only described on a very general level in the management system.
	Necessary **resource base** is available.	There is little or no resources allocated specifically for INSO.
	Competent INSO personnel.	There is no formal INSO competence management strategy. Competences of individual INSO members vary or are based on opportunities rather than needs. INSO-specific training is limited or not available.

3.4 Outcome

The primary goal and desired outcome of the INSO function should be to help the licensee organization **maintain and improve its nuclear safety**. This includes producing added value, applying a sociotechnical approach to nuclear safety, communicating effectively, and facilitating continuous improvement.

The INSO – being an independent function – can produce **added value** to the line organization in several ways. Some examples include helping confirm line organization's observations through independent and complementary approach, bringing up novel perspective that the line has not considered, and providing an integrated overview of issues that the line only has a scattered view of (see Story 5).

Creating an integrated overview is enabled by applying a sociotechnical approach to nuclear safety. **Sociotechnical approach** involves seeing safety as emerging from the interactions between actors from different levels of the sociotechnical system (i.e., technology, individual operative staff members, work groups, organizational processes and structures, management, leadership and culture, interorganizational relationships, and external pressures). Consequently, the INSO function should not only focus on technical issues but instead complement their technological analyses with analyses of human and organizational issues, striving towards an integrated understanding of nuclear safety.

Due to INSO being an independent support function with little operational decision-making authority, the **communication** between INSO and its customers is in a key role in ensuring that its findings are used and accepted. The INSO function should strive towards communication that is clear, verifiable, justifiable and actionable (see also Story 4). Communication should include formal INSO reports and meetings with the top management. Continuous and informal relationships with the top management are beneficial to maintain joint situational awareness and positive relationships. However, when the INSO and top management engage in informal communication, care should be taken to avoid loss of independence or transparency. The INSO and its immediate customer (top management) should make sure that the INSO findings and reports are transparently communicated throughout the organization for joint reflection. Failure to do so may result in the line organization perceiving INSO as an adversary or not appreciating or identifying the potential of INSO findings as drivers of organizational development.

Story 5. More than circling the bullet holes – the added value of INSO

A power company had implemented a procedure for monitoring safety culture, which was managed as a line responsibility. Line performed an annual self-assessment of their level of safety culture. INSO noted that the self-assessments carried out by the line organization were very positive with few needed corrective actions identified. And when corrective actions were identified, they were quite operational and focused on the line function in question, seldom crossing organizational boundaries.

INSO decided to carry out its own independent assessment of safety culture at the power plant. The assessment included INSO's own data collection in addition to re-analysis of existing data. The results of that assessment were much more critical than the self-assessments were. They were also more focused on cross-cutting issues. INSO results were communicated to senior management as well as the line. INSO made sure they had the facts to back up their findings. They also included "weak signals" and "warning signs" as a way to address more sensitive organizational and cultural issues that could raise resistance in the line organization. They also made sure that the findings were discussed and that the line and the management were able to challenge them and correct any misunderstandings. This was done before the INSO formulated their final recommendations.

The INSO decided to conduct regular independent assessments and compare the findings with the self-assessments conducted by the line organization. They also decided to initiate dialogue with the top management concerning the corrective actions needed to address the assessments, as well as to follow-up on their implementation. Additionally, a long-term goal was to teach the line critical thinking and self-assessment skills to gradually improve their own evaluations.

Key takeaway: Internal independent oversight can often provide a more critical (truer) view of the organization than the organization itself can. INSO can bring added value in terms of providing an overview that is both external but contextual enough, so the line understands and accepts the results. However, the INSO needs to balance between giving the organization a completely frank assessment that would be rejected by the line and gradually teaching the line to self-assess themselves in a more critical manner. This requires that the INSO understands the current culture at the power company and understands the messaging and the approach that has to be taken. INSO has a role in identifying issues, in discussing with the line organization the best ways to resolve those issues, and finally, in following up the implementation and effectiveness of the chosen corrective actions.

In addition to its primary goal of being the independent oversight of nuclear safety in the license organization, as a formal organizational function, one of INSO tasks is the continuous assessment and improvement of **its own effectiveness**. For this purpose, the INSO function should utilize various general-purpose evaluations (e.g., internal audits, KPI's) and INSO-specific indicators (e.g., number of novel findings), collecting feedback from stakeholders, periodically conducting specialized, qualitative self-assessments, actively seeking independent perspectives (e.g., from WANO, IAEA, and the regulator), and performing **benchmarking** through peer groups or cooperation with other licensee organizations. When utilizing quantitative metrics for following up the effectiveness of INSO function, care should be taken to avoid oversimplifying the measured phenomena. For example, using the number of implemented INSO recommendations as an effectiveness metric may result in optimizing

behaviour in the INSO: defining easy-to-implement recommendations to maximize the indicator.

	BEST PRACTICES	AT-RISK APPROACHES
OUTCOME	Clear, verifiable, justifiable, and actionable **communication.**	INSO relies on informal and verbal communication without a paper trail of decisions. Communication style is not easily understandable for stakeholders (incl. customers and the line organization), and findings are based on opinions or rumours rather than facts.
	INSO produces **added value** to the organization.	INSO focuses on pointing out issues that the line organization already knows.
	INSO applies a **sociotechnical approach** to nuclear safety.	INSO focuses on technical issues and does not attempt to integrate human and organizational issues into nuclear safety.
	The effectiveness of the INSO function is **continuously monitored and improved.**	INSO largely neglects existing effectiveness indicators and does not apply specific measures designed to measure the effectiveness of INSO.
	INSO function facilitates organizational development through **benchmarking and international cooperation** (e.g., WANO, IAEA, professional events, scientific research).	INSO never or only occasionally engages in benchmarking and international cooperation. The benchmarking and cooperation activity rarely results in changes.

4 Tools for Assessment and Development of Independent Nuclear Safety Oversight

Three tools were developed to facilitate the application of the research results in practical INSO work. The three tools include maturity model for the INSO function, model of functional involvement, and role independence reflection tool (Table 1). These tools aim to address the typical challenges associated with the implementation of the INSO function. The tools were developed based on the integration of the theoretical and empirical findings in the NKS-R INSOLE activity. Draft versions of the tools were reviewed with Nordic INSO experts in workshops to tentatively validate their applicability.

The tools are primarily intended to be used by the licensee experts, however, with appropriate adjustments, they can also be utilized by other parties (e.g., TSO's, consultants, regulators) for assessing or developing the licensee INSO functions.

The tools have not yet been piloted in real-life settings and are subject to further development. We encourage the power companies to test out the tools and to provide feedback to INSOLE project team by sending email to activity coordinator: kaupo.viitanen@vtt.fi

Table 1. Overview of INSOLE tools and their primary target audience

	Primary target audience		
	Senior management	INSO management	INSO experts
INSO function maturity model	■	■	
Model of functional involvement		■	
Role independence reflection tool			■

4.1 INSO function maturity model

The purpose of the INSO function maturity model is to help **identify and define development needs of the INSO function**. The tool is structured as a conventional process maturity grid containing evaluation criteria, maturity levels, and archetypical descriptions of evaluation criteria at each of the maturity levels (e.g., Maier et al., 2012; Paulk et al., 1993). The maturity model is structured around the INSOLE Independent Nuclear Safety Oversight framework (chapter 3). It summarizes the best practices regarding the implementation of INSO function that have been identified throughout the whole INSOLE activity.

Four **levels of maturity** were defined for the model. They include one unacceptable level of maturity (Level 0, no implementation), and three levels of acceptable levels of maturity, ranging from basic to best practice implementation (Levels 1-3). The maturity levels were defined as follows:

- Level 0 (no implementation): evaluation criterion is not met
- Level 1 (basic): evaluation criterion is implemented at minimum acceptable level
- Level 2 (advanced): evaluation criterion is well-implemented and maintained

- Level 3 (best practice): evaluation criterion is fully met, and its implementation represents nuclear excellence and the principles of continuous improvement

The **evaluation criteria** were defined based on the integrated findings (best practices and at-risk approaches) identified during the INSOLE activity. All evaluation criteria were positively formulated and categorized in a way that is aligned with the INSOLE Independent Nuclear Safety Oversight framework (Chapter 3). This resulted in a total of 25 evaluation criteria in six categories.

Findings from INSOLE empirical case studies were utilized to formulate **cell descriptions** of the maturity grid whenever possible. Due to the sheer number of the cells, not all cells have a direct counterpart in the empirical case studies. In such cases, the cell descriptions were either extrapolated or interpolated jointly within the INSOLE research team based on the general insights gained throughout the INSOLE activity and tentatively validated in a workshop with INSO experts from the Nordic nuclear power companies.

The evaluation criteria are presented in poster format in Attachment A. The full maturity model is described in Attachment B.

4.2 Model of functional involvement

The purpose of the model of functional involvement is to help **position the INSO activities in the continuum of independence-dependence and to reflect on the advantages and disadvantages of various types of involvement**. The model helps in identifying both needed level and actual level of involvement of the INSO function. The model helps to balance independence of INSO with the requirements for contributing and involvement – and helps INSO function to avoid becoming too dependent on the line.

The model includes six dimensions:

- Planning: How INSO plans its daily and annual activities and selects its focus areas
- Verification: How INSO conducts activities aiming at verifying compliance
- Monitoring performance: How INSO monitors the performance of the line organization
- Issue identification & resolution: How INSO contributes to identification and resolution of various issues at the power company
- Continuous learning: How INSO contributes to continuous learning of the power company
- Communicating & reporting: How INSO communicates with the line, including how it reports and communicates its findings

Each dimension can be conducted with four different types of involvement, ranging from passive independence to active dependence. None of the types are categorically bad, but rather the INSO needs to balance involvement with independence so that it avoids isolation (excessive passive independence) and dependence (excessive active involvement). Furthermore, INSO may need to change its type of independence depending on the situation: For example, if the

line organization does not correct an issue on its own, INSO may need to momentarily sacrifice some of its independence by escalating the issue.

Findings from INSOLE empirical case studies were utilized to identify manifestations of INSO activities at various levels of involvement. The model was discussed and elaborated in a workshop with INSO experts from the Nordic nuclear power companies.

The full model is described in Attachment C.

4.3 Role independence reflection tool

The purpose of the role independence reflection tool is to help **reveal dependency-related biases and their consequent phenomena** in the role of an INSO expert. The underlying idea in this tool is that the dependency-related bias could stem not only from tasks (functional dependence), but also from group identity, loyalties or other associations (cultural dependence), and these (in)dependencies can contribute to isolation or lack of psychological safety of the INSO expert.

The tool is structured as a simple question battery, intended to be used by an INSO expert in any situation where they need to reflect upon the independence of their role.

The tool contains four categories of questions and things to consider:

- Cultural and social dependencies: group identity, loyalties or other associations
- Functional dependencies: involvement in or responsibility for the activity that is being overseen
- Isolation: informational or interaction-related isolation between the INSO and the line organization
- Psychological safety: comfort in expressing concerns without fear of retribution or other negative consequences from the line organization or from the INSO function

Findings from INSOLE empirical case studies were utilized to identify different types of dependencies and things to consider when conducting INSO work. The tool was discussed and elaborated in a workshop with INSO experts from the Nordic nuclear power companies.

The full reflection tool is described in Attachment D.

5 Conclusions

The NKS-R INSOLE activity aimed to contribute to the development of independent internal nuclear safety oversight functions at Nordic nuclear power plants. This final report described the findings from the second year of implementing this activity. This included a normative framework for the INSO function implementation, and a set of tools to facilitate the implementation of the INSO function in practice.

Acknowledgements

NKS conveys its gratitude to all organizations and persons who by means of financial support or contributions in kind have made the work presented in this report possible.

6 References

Maier, A. M., Moultrie, J., & Clarkson, P. J. (2012). Assessing Organizational Capabilities: Reviewing and Guiding the Development of Maturity Grids. IEEE Transactions on Engineering Management 59: 138–159. http://doi.org/10.1109/TEM.2010.2077289

Paulk, M. C., Curtis, B., Chrissis, M. B., & Weber, C. V. (1993). Capability Maturity Model for Software, Version 1.1. Fort Belvoir, VA: Defense Technical Information Center. Retrieved from http://www.dtic.mil/docs/citations/ADA263403

Rasmussen, J. (1997). Risk management in a dynamic society: a modelling problem. Safety Science 27: 183–213. http://doi.org/10.1016/S0925-7535(97)00052-0

Reason, J. (1997). Managing the Risks of Organizational Accidents. 1 edition. Aldershot, Hants, England; Brookfield, Vt., USA: Ashgate.

Viitanen, K., Reiman, T., Karadeniz, S., Airola, M., Jakobsson, F., Sylvander, C., & Lind, S. (2024). Internal nuclear safety oversight as part of organizational defence-in-depth. Lessons learned for the Nordic nuclear industry. Intermediate report from the NKS-R INSOLE activity (No. NKS-482). Roskilde, Denmark: Nordic nuclear safety research. Retrieved from https://www.nks.org/en/nks_reports/view_document.htm?id=111010214698535

WANO & IAEA. (2018). Independent Oversight (No. GL 2018-01). World Association of Nuclear Operators.

Attachment A. NKS-R INSOLE Independent Nuclear Safety Oversight Framework

System perspective

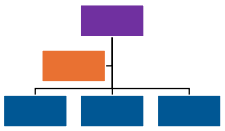
Organization clearly understands INSO's position within the **organizational defence-in-depth** structure

INSO has clear strategy concerning the **type and expected level of independence** and the reasoning behind it

The **responsibilities** of the INSO function and the line organization are clearly separated

INSO personnel is sufficiently **independent** from the line organization

Clear division of labour and coordination between **other oversight or safety functions**



Context

INSO strategy and arrangements are aligned with the **organizational context and its structural complexity, and culture**

INSO focus areas and activities are aligned with the **situational factors** at the organization and at the plant(s)

INSO focus areas and activities reflect an understanding of the **risks of the nuclear technology** applied by the overseen nuclear facility

INSO considers **external influences** on the management, line operations and the INSO

Management and organizing

Senior management is committed to INSO implementation and actively seeks out its perspectives

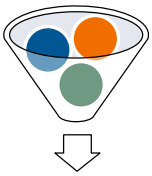
Formal and effective **escalation channels** are available and utilized

Healthy and appropriate interaction with the **line organization**

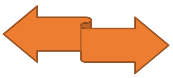
INSO function has access to the **information sources** needed

INSO function understands the **nature, reliability, and limitations of the information** it utilizes

INSO strives to collect **first-hand** information



The **power and authority** of the INSO function are clear and at appropriate level



The **role** of INSO function is clear and communicated throughout the organization

Clear integration with the **management system**

Necessary **resource base** is available

Competent INSO personnel

Systematic implementation of activities

Outcome

Clear, verifiable, justifiable, and actionable **communication**

INSO produces **added value** to the organization

INSO applies a **sociotechnical approach** to nuclear safety

The effectiveness of the INSO function is **continuously monitored and improved**

INSO function facilitates organizational development through **benchmarking and international cooperation**

Attachment B. INSO function maturity model

WHO: INSO management, senior management

WHEN: Regularly when self-assessing the effectiveness of the INSO function

WHAT FOR: Identify and define development needs of the INSO function

HOW:

1. Understand the maturity levels
    - Level 0 (no implementation): evaluation criterion is not met
    - Level 1 (basic): evaluation criterion is implemented at minimum acceptable level
    - Level 2 (advanced): evaluation criterion is well-implemented and maintained
    - Level 3 (best practice): evaluation criterion is fully met, and its implementation represents nuclear excellence and the principles of continuous improvement
2. Familiarize yourself with the criteria
3. Evaluate each criterion and gather necessary information to support your evaluation
4. Record the results
5. Analyse the results and identify strengths and areas for improvement
6. Develop an improvement plan to maintain criteria at higher maturity levels and to raise criteria from lower maturity levels
7. Regularly reassess to track progress and to ensure continuous improvement

SYSTEM PERSPECTIVE / Organizational defence-in-depth and independence				
Evaluation criterion	**Level 0: no implementation**	**Level 1: basic**	**Level 2: advanced**	**Level 3: best practice**
Organization clearly understands INSO's position within the **organizational defence-in-depth** structure	The organization sees INSO as a line function.	The organization sees INSO solely as a barrier to prevent the propagation of errors from the line organization.	The organization sees INSO as an assurance function overseeing that the line takes care of its own responsibilities, including line's own oversight.	The organization sees INSO as an assurance function overseeing that the line takes care of its own responsibilities, including line's own oversight. In addition, the value added by INSO's findings to line development is understood.
INSO has clear strategy concerning the **type and expected level of independence** and the reasoning behind it	INSO strategy does not reflect an understanding of what independence means.	INSO has implicit understanding of its desired level of independence, but it is characterized by functional terms (participation in tasks), and black-and-white thinking (fully independent, fully dependent).	INSO has an understanding of its desired level of independence and the various sacrifices to independence that INSO needs to make in order to contribute to nuclear safety.	INSO function acknowledges the several types of dependencies it is affected by and dynamically balances their level between independence and involvement.
The **responsibilities** of the INSO function and the line organization are clearly separated	INSO function regularly performs tasks that are or should be the responsibility of the line organization.	The processes owned by the INSO are formally separated from line processes. INSO experts are regularly needed to perform tasks for the line organization.	The processes owned by the INSO function are separated from line processes. Individual INSO experts may occasionally perform tasks for the line organization, and vice versa, but there is clear awareness of how this affects their independence.	The processes owned by the INSO function are clearly separated from line processes, including the resources and competence required for their implementation.
INSO personnel is sufficiently **independent** from the line organization	All or almost all INSO personnel have formal, continuing associations (tasks, responsibilities, etc.) with the line organization.	INSO personnel have informal associations with the line organization, and their implications on independence are not fully acknowledged or understood by the INSO function.	The INSO function has identified the formal and informal associations, helping INSO personnel be aware of when and how their independence may be compromised.	The INSO function continuously follows-up and actively manages the formal and the possible informal associations with the line organization.
Clear division of labour and coordination between **other oversight or safety functions** (e.g., internal audit, QA, safety department, safety committees and councils)	The INSO function and the other oversight and safety functions do not coordinate, share information, or do not know about each other's activities.	Coordination between the oversight and safety functions is irregular. Information is occasionally exchanged through reports or other non-interactive means.	Representatives from the different oversight and safety functions are periodically invited to each other's meetings to present and discuss their observations. Their roles are understood by all parties, including their place in the organizational defence-in-depth.	Oversight and safety functions systematically meet to coordinate and reflect upon their findings. INSO oversees how the other oversight and safety functions perform their oversight.

CONTEXT				
Evaluation criterion	**Level 0: no implementation**	**Level 1: basic**	**Level 2: advanced**	**Level 3: best practice**
INSO strategy and arrangements (e.g., vision, goals, structure) are aligned with the **organizational context and its structural complexity, and culture**	INSO strategy and arrangements is a direct copy from industry guidelines or from other companies with no consideration of its own unique organizational context.	The alignment of the INSO function with the organizational context has taken place during the INSO formation phase but has not been followed up.	The alignment of the INSO function with the organizational context takes place during significant organizational changes or other significant events.	The organization continuously and systematically evaluates the alignment of the INSO function with organizational context. The development of the INSO function is deeply integrated with organizational development and safety culture maturity. National culture influences are considered.
INSO focus areas and activities are aligned with the **situational factors** at the organization and at the plant(s) (incl. life cycle phase, sociotechnical changes or developments, current nuclear safety issues or challenges, etc.)	INSO function performs its activities completely rigidly with no situational adjustments.	INSO function adjusts its focus areas or work plans in reaction to significant situational changes.	INSO function has a formal and systematic approach to adjust and revise its focus areas and work plans to match the situational demands.	INSO proactively identifies situational factors and future needs and prepares necessary contingency plans or scenarios describing its focus areas or activities.
INSO focus areas and activities reflect an understanding of the **risks of the nuclear technology** applied by the overseen nuclear facility	INSO function does not apply graded approach in defining its focus areas or activities, and everything is prioritized.	INSO function applies an implicit graded approach, prioritizing certain focus areas, but without clear criteria, transparency, or process.	INSO function applies a formal graded approach. Grading is used as one input in selecting focus areas.	INSO function applies a systematic and transparent means to grade its focus areas or activities in relation to their nuclear safety significance. Grading reflects the resources and attention given to the selected areas.
INSO considers **external influences** on the management, line operations and the INSO	INSO function does not monitor external influences on its own or line's activities.	INSO function considers external influences when significant events or other changes take place in the external environment.	INSO function monitors the external environment for changes and considers their potential impact on the line organization and the management.	INSO function actively monitors the external environment for changes and anticipates how the environment will affect the line organization, management and the INSO itself.

MANAGEMENT AND ORGANIZING / Interactions and interfaces				
Evaluation criterion	**Level 0: no implementation**	**Level 1: basic**	**Level 2: advanced**	**Level 3: best practice**
Senior management is committed to INSO implementation and actively seeks out its perspectives	Senior management shows no interest in INSO function and/or does not know what it does or how it is organized. Findings made by INSO are ignored.	Senior management reluctantly accepts the INSO function, often motivated by external requirements. Senior management underutilizes INSO's output and sees little value in it, often acting only after required by authorities.	Senior management interacts with the INSO function periodically as part of formal meetings, occasionally considering its findings in decision-making. Senior management sees value in INSO, but often in terms of evaluating the operative functions of the organization, or as a verification function.	Senior management actively seeks out and values INSO's perspectives and assessments, utilizing it in decision-making and leadership development. Senior management promotes a constructive and positive relationship between INSO function and the line organization and helps communicate the value of the INSO function.
Formal and effective **escalation channels** are available and utilized	INSO has no formal or informal escalation channels.	INSO escalates issues mainly through informal channels (e.g., personal relationships between INSO manager and senior management). Formal channels have been defined.	Formal escalation channels have been defined, documented and communicated.	The organization formally and culturally ensures that – if necessary – all INSO personnel can escalate issues beyond their administrative reporting line and directly to highest top management.
Healthy and appropriate interaction with the **line organization**	Relationship between INSO function and the line organization is adversarial and confrontative. INSO communicates with the line organization primarily through non-interactive means such as reports.	The relationship between INSO function and line is neutral, with occasional disagreements on factual issues. INSO function and line organization occasionally interact directly.	The relationship between INSO function and line is neutral, with occasional constructive disagreements on factual issues. INSO function and line organization interact frequently.	Relationship between the INSO function and the line is positive and constructive. INSO engages in continuous and dialogic relationship with the line organization when appropriate and has the readiness to adopt a different role when strict independence is necessary.

MANAGEMENT AND ORGANIZING / Inputs and information				
Evaluation criterion	**Level 0: no implementation**	**Level 1: basic**	**Level 2: advanced**	**Level 3: best practice**
INSO function has access to the **information sources** needed	INSO function does not have access to relevant information sources (e.g., safety-related documents, people performing safety-related work, or the plant). The line organization actively denies access.	INSO function has access to limited set of relevant information. The line organization provides additional information when asked.	INSO function has access to most of the relevant information sources. The line organization is cooperative in providing the information.	INSO function has comprehensive access to relevant information sources. The line organization actively strives to help INSO in identifying additional information sources.
INSO function understands the **nature, reliability, and limitations of the information** it utilizes	INSO function misunderstands the nature of the data it uses (e.g., informal vs. formal, line-produced vs. self-collected, raw data vs. complete assessment, etc.) and what conclusions can be made from it. INSO often makes unjustified conclusions based on limited data.	INSO makes justified but limited conclusions based on the data it uses. The data INSO uses is often limited to formal, written, and quantified data, excluding many qualitative and informal sources.	INSO has a wide understanding of the potential data sources it can use. INSO balances and weighs information from different sources regarding their nature, reliability and limitations. INSO systematically documents and explains the reliability of the conclusions in relation to the information sources.	INSO also utilizes reactions of the line organization to INSO assessments as a source of information, to validate or elaborate its findings. INSO uses the information it has collected to improve their assessments and assessment processes.
INSO strives to collect **first-hand** information	INSO function relies fully on the information produced by the line organization (e.g., reports, observations, records, etc.)	INSO function occasionally engages in its own information collection. INSO function has a general plan concerning what type of first-hand information it should collect, but it mostly focuses on performing technical or plant shop floor observations.	INSO function applies a systematic approach to its own information collection. A plan is made and revised according to emerging information needs. In addition to observations, first-hand information consists of focused investigations and assessments.	INSO function acknowledges the full range of opportunities for first-hand information collection, including knowledge work, decision-making instances, etc.

MANAGEMENT AND ORGANIZING / Activities and arrangements				
Evaluation criterion	**Level 0: no implementation**	**Level 1: basic**	**Level 2: advanced**	**Level 3: best practice**
The **power and authority** of the INSO function are clear and at appropriate level	Characteristically, INSO has no power and authority, or it has too much power and authority. INSO authorities are not formally defined.	The authority of the INSO function is formally defined. In practice, the authority of INSO function is somewhat person dependent, reflecting the relations between INSO manager and top management.	Organizational arrangements have been applied to ensure that INSO authority is positional rather than personal. Authority of the position does not change when people change.	INSO function has sufficient organizational and cultural authority and freedom to bring up nuclear safety issues in any situation. The organization takes steps to prevent excessive concentration of power into the INSO function.
The **role** of INSO function is clear and communicated throughout the organization	Neither the line organization, nor the INSO function itself knows what its role is.	The role of INSO and those members of the line organization who frequently interact with the INSO function know its role, but the role is vague to other personnel.	The role of INSO function is formally defined and communicated throughout the organization. Everyone in the organization knows at least on a general level what INSO is and what it does.	The role of INSO function and what it means in practice is understood throughout the organization. Forums with participation from INSO and line organization are established to facilitate this. If INSO role is adjusted, it is made transparently.
Systematic implementation of activities	Activities are performed ad hoc, without strategy, planning, or follow-up.	INSO activities are performed on an implicit basis, without pre-defined, written work plans.	The main INSO activities are implemented in a planned and systematic manner.	INSO activities are formally defined in strategies, work plans, followed-up, and transparently modified if necessary.
Clear integration with the **management system**	INSO function is not described in the management system.	INSO function is referred to on a general level in the management system.	INSO function has been defined in all relevant levels of the management system documentation (e.g., policies, processes, procedures, instructions).	The development of INSO function and management system is continuous and interlinked.
Necessary **resource base** is available	INSO function has no allocated resources, persons perform INSO tasks alongside their primary tasks.	Bare minimum resources have been allocated for INSO function. They allow performing the selected INSO activities but leave no room for development or for the unexpected.	INSO function has the necessary resources to perform the tasks defined in its strategy and work plan. INSO function can acquire some more resources for acute issues such as investigations.	INSO function has top management support, sufficient slack resources and/or readiness to use external resources in case of findings that require deeper analysis or investigations, and enough resources to develop its activities.

Competent INSO personnel	INSO personnel has no relevant previous experience. INSO personnel do not understand what the line organization does. Inexperienced personnel are utilized in many areas. INSO-specific training is not available.	INSO personnel competence varies and is person dependent. INSO-specific training is available for INSO personnel.	INSO personnel have extensive competence and practical experience in the areas they oversee, as well as competencies in performing oversight. There is a competence development program for INSO.	In addition to competence and experience, the INSO personnel have fully understood and adopted their role as overseers. The INSO function attracts knowledgeable and experienced experts.

OUTCOME AND CONTINUOUS IMPROVEMENT				
Evaluation criterion	**Level 0: no implementation**	**Level 1: basic**	**Level 2: advanced**	**Level 3: best practice**
Clear, verifiable, justifiable, and actionable **communication**	INSO function communication is predominantly informal and verbal. Written reports are not prepared systematically, and they often use language or style that is confusing to end users (e.g., CEO, CNO, line functions being overseen).	INSO function prepares periodic assessment reports, which are delivered to top management. Occasionally, the reports are discussed jointly with top management.	All INSO reports are carefully prepared, and end users are considered in communication style. INSO reports are always presented, discussed, and jointly validated in appropriate top management meetings.	INSO findings are shared to the larger organizational community for joint reflection to facilitate participative development.
INSO produces **added value** to the organization	INSO function only points out mundane issues that the line organization already knows.	INSO findings help confirm line organization's observations through independent and complementary approach and point out errors that line had not perceived.	INSO occasionally brings up novel perspectives that the line has not considered.	INSO brings up novel perspectives that the line has not considered and presents overviews and trends of issues that the line has a scattered view of.
INSO applies a **sociotechnical approach** to nuclear safety	INSO function predominantly focuses on technical details. Human and organizational issues are not seen as the focus area of INSO.	INSO function performs analyses on technical issues and analyses on human and organizational issues, but there usually is no process or practice to integrate them systematically.	INSO function has a systematic approach to consider human, organizational and technological factors. INSO creates integrated analyses, but mostly within domain areas (technical, human, organizational).	INSO function applies a long-term and high-level perspective to nuclear safety, focusing particularly on cross-functional issues, human and organizational phenomena, and their systemic interrelations with technology.
The effectiveness of the INSO function is **continuously monitored and improved**	INSO effectiveness is not monitored internally, and external findings (e.g., WANO, IAEA, regulator) are not utilized.	INSO relies on general-purpose internal evaluation (e.g., management system audits, administrative KPI's) for development. Findings from external sources are occasionally used.	INSO utilizes a limited set of purpose-built indicators to follow-up its effectiveness. In addition, self-assessments and external assessments are utilized as well as "customer" feedback.	INSO applies a wide range of specialized, qualitative self-assessment methods for monitoring its effectiveness. External and independent perspectives are actively sought.
INSO function facilitates organizational development through **benchmarking and international cooperation** (e.g., WANO, IAEA, professional events, scientific research)	INSO personnel do not participate in international forums and are not involved in benchmarking activities.	INSO personnel participate in developmental forums on occasion, but do not have the capacity to make a transformation in reality.	INSO function leans on national cooperation for experience exchange and development.	INSO is involved in active benchmarking with nuclear as well as with other safety-critical fields. Lessons learned are interpreted and translated to the particular context.

Attachment C. Model of functional involvement

WHO: INSO management

WHEN: Regularly when developing INSO activities

WHAT FOR: Identify strengths and weaknesses of the current activities and define development actions

HOW:

1. Understand the types of involvement
    - Independent - passive: INSO works independently, but has limited effect on safety
    - Independent - contributing: INSO works independently, but contributes to safety of the power plant
    - Involved: INSO sacrifices independence by getting involved in line activities but not getting dependent on the line.
    - Dependent: INSO works as a line function and INSO activities are controlled by the line organization.
2. Familiarize yourself with the dimensions and their manifestations at various involvement types
3. Review the type of INSO activities at each dimension or select an area of interest and review how the area is currently conducted
4. Record the results
5. Analyse the results and identify strengths and areas for improvement
6. Develop an improvement plan to maintain adequate balance between independence and involvement
7. Regularly reassess to track progress and update the plan

PLANNING				
	Independent - passive	**Independent - contributing**	**Involved**	**Dependent**
Activity	Selecting focus areas and assessment topics.	Discussing focus areas and assessment topics together with the line.	Selecting focus areas and assessment topics together with the line.	Focusing only on areas and topics proposed by the line organization.
Pros and cons	INSO remains independent. Focus areas might differ from what the line considers important, which may be a good thing if the line has the wrong focus but can also cause tension.	INSO remains independent but contributes to line commitment by discussing its topics in advance.	INSO sacrifices independence by selecting topics in collaboration but may get better line commitment to the assessments. The negative side is that the line may want to avoid sensitive (or long standing) topics.	INSO works as part of a line function while doing this. May help in solving acute challenges that the line is unable to solve without help. In the long run it threatens the organizational defense-in-depth principle by removing INSO's independent focus.

VERIFICATION				
	Independent - passive	**Independent - contributing**	**Involved**	**Dependent**
Activity	Conducting independent review of safety analyses (that have already been reviewed once or twice).	Making recommendations or advice based on the review on issues to correct in the analysis.	Acting as gatekeepers or reviewers: approving documents as part of the document approval process.	Correcting documents or conducting analyses for line organization.
	Verifying review process of documents with safety significance.	Conducting safety review of documents with safety significance.	Approving (or rejecting) documents with safety significance.	Writing technical documentation.
Pros and cons	Remains independent and verifies that the primary barriers work. Does not contribute to the development of safety, only maintaining the status quo.	Remains independent but contributes by commenting and giving advice.	Acts as a barrier in the defense-in-depth approach but sacrifices independence.	INSO works as part of a line function while doing this. In case of competence gaps in the line organization, this can contribute positively to nuclear safety. In the long run it makes INSO a de facto line function and removes one layer of organizational defense-in-depth.

MONITORING PERFORMANCE				
	Independent - passive	**Independent - contributing**	**Involved**	**Dependent**
Activity	Observing issues in the field or in meetings and documenting them.	Asking relevant questions in meetings and safety walks, having dialogue with personnel.	Making safety observations during the safety walks into the line organization's observation system.	Monitoring performance in areas where line has identified a need or gap.
	Reading safety analyses, technical documentation and investigations.	Providing comments on safety analyses, technical documentation and investigations.	Approving or rejecting safety analyses, technical documentation or investigations.	Correcting documents or conducting analyses for line organization.
	Participating in selected investigations, audits or assessments as observers.	Participating in selected investigations, audits or assessments and contributing with questions.	Participating in selected investigations, audits or assessments as a member of the team.	Taking responsibility for investigations, audits and assessments.
Pros and cons	INSO remains an independent observer. Usefulness depends on the way of summarizing and reporting the findings.	INSO remains independent but contributes by prompts, comments and questions that, in addition to providing more information to INSO, can facilitate reflection in the line organization. Comments and questions can steer line decisions (especially if considered "hints" about later INSO review), which sacrifices independence.	INSO sacrifices independence by taking part in a process owned by the line organization (review & approval, experience feedback). INSO can have a positive effect on those processes, but care must be taken by INSO when/if later assessing those processes (not by the same persons who participated in them).	INSO works as part of a line function while doing this. Can contribute to nuclear safety in case of acute resource or competence gaps in the line organization. In the long run it makes INSO a de facto line function and removes one layer of organizational defense-in-depth.

ISSUE IDENTIFICATION & RESOLUTION				
	Independent - passive	**Independent - contributing**	**Involved**	**Dependent**
Activity	Summarizing INSO observations and identifying trends.	Making recommendations or advice to the line on issues to consider.	Making recommendations or advice to the line on corrective actions to take.	Formulating, adjusting and implementing corrective actions together with the line organization.
	Keeping track of identified issues.	Following up on identified issues by informing and enquiring about the status of corrective actions.	Elevating and/or escalating issues, requiring immediate action on important issues.	Fixing line issues together with the line organization.
Pros and cons	INSO remains an independent observer. Usefulness depends on the way of summarizing and reporting the findings.	INSO remains independent but contributes by prompts, comments and questions that, in addition to providing more information to INSO, can facilitate reflection in the line organization. Comments and questions can steer line decisions (especially if considered “hints” about later INSO review), which sacrifices independence.	INSO sacrifices independence by escalating issues that should be handled by the line organization. INSO can have a positive effect on safety as the issues have not been adequately dealt with, but care must be taken by INSO to avoid escalation becoming standard practice.	INSO works as part of a line function and their corrective action program while doing this. Can contribute to nuclear safety in case of acute resource or competence gaps in the line organization. In the long run it makes INSO a de facto line function and removes one layer of organizational defense-in-depth.

CONTINUOUS LEARNING				
	Independent - passive	**Independent - contributing**	**Involved**	**Dependent**
Activity	Analysis and synthesis of documentation.	Presenting results of analyses and synthesis to the line organization and discussing the findings.	Recommending corrective actions based on results of analyses and synthesis.	Formulating, adjusting and implementing corrective actions together with the line organization.
	Specific desktop assessments of identified topics.	Specific assessments that require interaction with line.	Giving concrete suggestions for development activities for the line organization based on specific assessments.	Developing line activities together with the line organization.
	Searching for information about external lessons learned and best practices to be used by the INSO as reference material.	Informing the line organization about the external lessons learned and best practices.	Formulating together with the line organization improvement actions based on external lessons learned and best practices.	Helping the line organization with implementing lessons learned and best practices.
Pros and cons	INSO remains fully independent.	INSO remains independent but contributes to the development of line organization practices and culture by providing information to the line about gaps and potential improvements.	INSO sacrifices its independence by getting involved in line development activities / process. This involvement can be very beneficial for nuclear safety as it facilitates the line organization focus on the correct issues.	INSO works as part of a line function while doing this. Can contribute to nuclear safety in case of acute resource or competence gaps in the line organization, or sensitive issues the line is not capable of correcting by themselves. In the long run it makes INSO a de facto line function and removes one layer of organizational defense-in-depth.

COMMUNICATING & REPORTING				
	Independent - passive	**Independent - contributing**	**Involved**	**Dependent**
Activity	Informing the line organization about assessment goals and areas.	Pre-assessment meetings with the line organization where line can provide their expectations.	Discussing assessment results with the line organization and helping them to produce corrective actions.	Formulating assessment results and report recommendations with the line organization – line reviews and approves oversight reports.
	Quarterly and/or annual oversight report on oversight observations.	Oversight report that synthesizes information produced by the line organization and analyses the line organization's practices.	Oversight report that includes recommendations for corrective actions.	Oversight reporting that replaces line organization overview.
Pros and cons	INSO remains independent by only reporting the observations they have made in meetings and in the field.	INSO contributes to line organization practices and line oversight by analyzing the line processes and reporting gaps, and areas of improvement in the line operations.	INSO sacrifices independence by getting involved in line development activities / process. This involvement can be very beneficial for nuclear safety as it facilitates the line organization understanding of INSO recommendations.	INSO works as part of a line function while doing this. In the long run it makes INSO a de facto line function and removes one layer of organizational defense-in-depth.

Attachment D. Role independence reflection tool

WHO: INSO experts

WHEN: Regularly when performing INSO activities

WHAT FOR: Reveal dependency-related biases in the role of an INSO expert

HOW:

1. Select one or more of the topics:
    - Cultural and social dependencies
    - Functional dependencies
    - Isolation
    - Psychological safety
2. Read the reflection questions of the selected topic, by yourself or together with other colleagues from the INSO function.
3. Respond to the reflection questions. Use the "Consideration" column in the right for further help. Think, for example, the following:
    - Do the issues covered in the reflection questions apply in your INSO work?
    - What is the extent to which the issues affect you in performing your tasks effectively?
    - How do they affect your independence?
    - What corrective or improvement actions (leadership, organizational, managerial, behavioural) can be taken to address the covered issues?

CULTURAL AND SOCIAL DEPENDENCIES	
Reflection question	**Considerations**
Do you spend time informally with the people you oversee?	Spending too much time with those you oversee can lead to cultural and social dependency – sharing the same assumptions and blind spots and becoming too close to provide constructive criticism. On the other hand, informal interactions can help getting to know line organization staff and gain their acceptance of INSO, as well as obtain first-hand understanding of the situation and climate in the line organization.
Do you oversee groups where you previously worked?	Overseeing groups where you previously worked may hinder independent oversight due to loyalty to former colleagues, potential difficulty in challenging them, and discipline blindness (having shared blind spots with the overseen). On the other hand, overseeing familiar groups may help focus and contextualize oversight, and better make sense of the oversight findings due to having an experience-based understanding of the local conditions, ways of working, and culture.
Do you usually spend time with people who think the same way as you?	Spending time and/or working with people who think the same way as you can make it easier to understand each other, and it can be easier and quicker to work with and make decisions. On the other hand, not having sufficient diversity of thinking in a work group can contribute to groupthink, complacency, and a lack of challenge and questioning attitude – all of which can adversely influence INSO effectiveness as an independent, “second opinion”.

FUNCTIONAL DEPENDENCIES	
Reflection question	**Considerations**
If you have history in line organization, do you continue to perform line organization tasks while working in the INSO function?	The responsibilities between the line organization and INSO may become blurred if the same individual performs line organization tasks and independent oversights. However, there are several reasons for continuing line organization tasks. These include lack of competent resources in the line or the oversight task taking up only part of the work time. Nonetheless, while performing both line tasks and oversight, the expert needs to be extra careful about maintaining sufficient independence. Conflicts of interest may also arise in situations where the person has two supervisors, one from the line and one from the INSO.
Does the supervisor you report to also have line organization responsibilities?	Conflicts of interest may arise in situations where INSO supervisor also has line responsibilities. For example, the supervisor might intentionally or unintentionally filter INSO messages towards the line organization or steer the INSO function in a manner that is influenced by the line responsibilities. In such cases, INSO experts can take a role in facilitating the supervisor in identifying the potential conflicts of interests.
Where do the themes for INSO work primarily come from?	Themes for the INSO work (e.g., its strategy, working plan, topics of assessments) can come from many sources, including the CEO, CNO, line organization, INSO supervisor, or the INSO experts. Harnessing the organization's knowhow in steering the INSO function can be beneficial in ensuring that the right and topical areas are being overseen. However, if INSO themes come only from the line organization, or if their selection criteria are not transparent to INSO experts, there is a risk of losing INSO's independence. If INSO's supervisor has multiple roles (see above question), it may also be difficult to know whether the INSO task is a line task or an INSO task. Examining the justification and paper trail for the selected INSO themes and activities can help identifying the level of external steering.
How often do you have to solve the line organization's issues?	Reoccurring instances where the INSO experts feel they have to solve the line organization's issues (e.g., by preparing overly specific and action-oriented recommendations, or concrete action plans) may indicate that the line has no interest or readiness to take ownership of their continuous improvement based on INSO recommendations. In such cases, INSO's role should be made clear to the line organization, and – if necessary – backed by top management. INSO can facilitate the line organization in defining what they should do in response to INSO recommendations, and in taking ownership in their implementation.

ISOLATION	
Reflection question	**Considerations**
Do you know what is happening in the operative functions?	Working in an independent oversight function introduces a risk of detachment from operational reality. Reviewing processes, records, minutes of meetings, and other written materials provides some information about the operational reality, but these types of sources do not paint the whole picture and cannot replace first-hand data collection. First-hand data collection involves not only power plant shop-floor observations such as equipment, its operation and maintenance, but also observation of decision-making instances (e.g., management and board meetings) and office functions (e.g., engineering, safety analysis).
Do you have to rely on the information produced by line organization?	The line organization can have a detailed and profound understanding of their operations. Examining what they know and how they perceive their operations is an important source of information for independent oversight. On the other hand, the information produced by the line organization is inevitably biased and might not provide a sufficiently integrated overview of the operational reality. First-hand information collection by the INSO can counteract this bias. Good access and relationship with the line organization and sufficient INSO resources are preconditions to prevent overreliance on the line organization as an information source.
Whenever you meet line organization members, do you have to explain your task and position?	Isolation of the INSO function can stem from the line organization not knowing or accepting what the INSO function does, needs, or provides. This can be addressed by building a positive and constructive relationship with the line organization. Consider how you approach and interact with the line organization before, during and after INSO tasks (e.g., independent assessments). This can include engaging in continuous dialogue with the line (as opposed to interacting only during assessments), preparing well for the assessments, and conducting pre-job briefings and post-job reviews together with the line organization.

PSYCHOLOGICAL SAFETY	
Reflection question	**Considerations**
Do you feel comfortable escalating nuclear safety issues?	INSO expert may feel uncomfortable escalating nuclear safety issues due to several reasons. The expert may have bad experience from a previous occasion, or they may have heard examples of negative consequences from a colleague. The expert might be unsure of the authority of the INSO function, or they might be unsure about the issue itself (its safety significance, uncertainties associated with data, etc.). Discomfort can also be caused by feelings of disloyalty towards the line organization in case an issue needs to be escalated. There can also be other cultural norms at the workplace that affect which issues should be escalated and which not.
Do you feel comfortable raising nuclear safety issues or concerns in INSO team?	INSO expert may feel uncomfortable raising nuclear safety issues or concerns in INSO team if there is lack of psychological safety in the team. Another reason might be that the expert is unsure about the issue itself (its safety significance, uncertainties associated with data, etc.). Discomfort can also be caused if the issue is somehow sensitive, e.g., something that the expert struggled with when working in the line organization.
Do you feel pressurized to tone down your observations to avoid conflicts with the line organization?	INSO expert may feel pressured by the line organization to tone down observations. There is a tension since the INSO expert must present constructive criticism to line, while maintaining positive relationships with them, but also facilitating the line safety development.

Bibliographic Data Sheet **NKS-494**

Title	Internal nuclear safety oversight as part of organizational defence-in-depth – Lessons learned for the Nordic nuclear industry Final report from the NKS-R INSOLE activity
Author(s)	Kaupo Viitanen[1] Teemu Reiman[2] Fredrik Jakobsson[3], Carin Sylvander[3] Sami Karadeniz[1]
Affiliation(s)	[1]VTT Technical Research Centre of Finland Ltd [2]Lilikoi [3]Risk Pilot AB
ISBN	978-87-7893-591-1
Date	February 2025
Project	NKS-R / INSOLE
No. of pages	46
No. of tables	1
No. of illustrations	3
No. of references	6
Abstract max. 2000 characters	The overall goal of the NKS-R INSOLE activity was to contribute to the development of internal independent nuclear safety oversight functions (INSO) at Nordic NPPs by applying a participatory approach. This final report describes the findings from the second and last year of implementing this activity. A normative framework for the INSO function implementation was developed, which contains four dimensions (system perspective, context, management and organizing, and outcome). Each dimension contains descriptions of best practices and at-risk approaches, which were identified based on the integration of theoretical and empirical research results. To concretize the research results, three tools were developed to facilitate the implementation of INSO function in practice. The three tools include maturity model for the INSO function, model of functional involvement, and role independence reflection tool. These tools aim to address the typical challenges associated with the implementation of the INSO function.
Key words	independent oversight, internal oversight, nuclear safety, INSO