

NORMAL OPERATIONS MONITORING TOOLBOX

A systemic approach to
everyday safety



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1. Introduction

Safe performance comes from the same processes which yield success and failure. We need to understand why, and how, for the vast majority of the time, things go right and do not result in incidents. We will then use this understanding of normal, day-in-day-out performance to be better and safer.

Our key goal as an ANSP community is to develop systems and processes to review everyday performance, like normal operations monitoring (NOM), to develop a new understanding of how the ATM system produces a safe operation. We will then use this understanding to strive for more consistent, robust, appropriate and repeatable levels of safety performance.

We want to be able to tell whether we are eroding our safety margins and exposing ourselves to increased risk. We want to be able to control the risk explicitly and dynamically using a wider variety of proven actions to control safety. We will use all useful information about how the service is being delivered as leading indicators of our safety performance to enable us to anticipate risk.

1.1. Evolution of normal operations monitoring (NOM)

Safety in air transport is in constant evolution, and ATM has adopted many approaches developed previously within the aviation domain, together with its own.

A major breakthrough in the ways safety was approached within cockpits for example was achieved by turning interest into what really happens at the front end.

Many years have passed since the first *line operation safety audit* trials that materialised this change within the aviation community, and whose impact in the future safety mind-set was immense.

These trials evolved into strategies for optimisation and safety improvement within the cockpit and active ways to create a strong safety culture, and led to concepts like cockpit resource management (CRM) and team resource management (TRM).

After this, the threat and error management concept was developed and widely adopted by airlines.

However, that has not been the case for ATM. It is important to note that ICAO documents refer to “the principles of threat and error management”, which is different from the TEM model developed by the University of Texas, that is a specific way of implementing those principles, although both are frequently considered the same in the available literature on the field.

Within the last decade there has been an effort to bring these concepts into the ATM world, influenced by the Safety II conceptual framework. Further influences appeared along the way, like systems thinking and resilience engineering, helping to shape the current normal operations monitoring (NOM) view and practices.

ICAO made an effort developing TEM for ATM, recommendations to implement normal operations safety surveys (NOSS); EUROCONTROL has supported and fostered the importance of the Safety II view, systems thinking and *resilience engineering* within the ATM community; and many ANSPs have taken these concepts on board and brought to life real activities and regular beneficial processes. In a way, they have turned Safety II as imagined into Safety II as done.

CANSO fostered further works in the NOM field through the CANSO European Safety Directors group (CESAF). In 2018, the European ANSPs started a series of workshops to create a reference community of NOM practitioners and safety experts to foster development of the field.

During a NOM workgroup meeting in 2019, they decided to develop documentation that compiles references to existing knowledge on the field from a practical point of view, and develop a *Normal Operations Monitoring Toolbox*.

Influenced by the current contemporary views on safety, this Toolbox is a philosophical crossroad that incorporates Safety II, Systems Thinking and Resilience Engineering approaches, explaining how they can be shaped into real activities to actively create safety within ANSPs. It is not just Safety II as done, but a brand new view of safety that encompasses the classical processes, shaped by the new view, and how new processes can tackle long known problems. In a way, we are evolving towards Safety III.

This document has been developed for a wide audience within the ANSP safety community. It encompasses a broad range of ideas and methodological details for any organisation developing its NOM activities, performing NOM but not fully aware, and those ones that have mature NOM processes and wish to tackle specific aspects. In addition, the viewpoints included might also help ANSPs rethink the way they approach safety I regulated processes in a far more complex and richer way, allowing them to reach new levels of safety understanding and standards.

NOM can be considered as an organisational metaprocess, that monitors, checks, verifies, observes, modulates and shapes other processes. As such, it must find a way to be geared within existing organisations and its processes, and this document also provides some ideas.

However, its implementation requires critical efforts in organisational cultural change. It requires a progressive strategy, at the same time bottom-up (from front-end operators upwards) and top-down (from high level management downwards).

The main objective of the document is to create awareness of NOM and demonstrate it's an achievable task.

A quote from Captain Chesley Sullenberger, known for his emergency landing with an A320 on the Hudson River, reiterates the importance of improving safety awareness and the role that all individuals play in transforming it:

"When I left the military, I became a safety advocate and a safety volunteer and an active investigator in my airline. I wanted to do more than just fly. I wanted to be the most complete, the most expert pilot I could be. And one of the things for which I am most professionally proud of, besides that famous flight of course, is my involvement along with dozens of other pilots in my airline ... in making air travel safer by changing the cockpit culture at our airlines over the last 40 years. (...) So we began to absorb how the best pilots interacted, how the best crews acted, how they built their teams, how they had more than technical skills, they had human skills, how they trapped errors, how they managed workload, how they made decisions, how they communicated the plan..."

2. Setting up the scene

After the development of ICAO TEM and its related observational monitoring methodology, NOSS, there were big efforts within some ANSPs to implement NOSS campaigns, although it did not gain the same level on traction as for airlines. Others developed and focused on specifically designed methodology fitting their purposes (for example, Day to Day Safety Surveys – D2D).

In parallel, EUROCONTROL contributed to safety surveying as a means to complement traditional safety data gathering reactive methods, by dissemination and training of ANSPs experts. As a result, a white paper in 2011 gathered the current experience of NOSS and D2D implementation at the time, comparing both methodologies and providing guidance for any organisation wishing to implement observational safety surveys.

A first workshop on Safety-II related methodologies was organised by CANSO Europe during 2018, where most European ANSPs contributed to understanding the overall level of maturity regarding normal operations monitoring. During the first workshop a wide range of experiences, methodologies, target processes and topics were shared, along with success stories regarding the benefits return of these processes back into the system.

In spite of the huge potential these methodologies may have in terms of safety improvements, most ANSPs expressed concerns regarding the lack of guidance and practical methodologies reference materials. In fact, all the ANSPs had somehow adapted existing philosophies and methods to their particular needs and available resources.

Lack of specific regulation in the field is beneficial in terms of relieving administrative burdens but sets up a scene where no guidance is available for ANSPs. Additionally, normal operations monitoring is not normally seen at the beginning as a necessary process by many organisations' management since they do not have a compulsory regulatory nature.

The need to jointly work on this scattered and unexplored field was identified and fostered through a second workshop in 2019, where a reduced ANSPs representatives continued sharing concerns, risks, processes and success stories. This group discussed the feasibility of developing reference material

for ANSPs in the NOM field, to be practical in understanding the process, the needs and the return into the system. Basic contents on the material was sketched, specifically on recognising the different maturity levels, the myriad of available methodologies and how to integrate NOM processes within an existing organisation.

A CESAF workgroup was set up to develop this document. It presents high level principles on the design of NOM processes, integration within ANSPs and compliance with current regulations. It features a compilation of ideas and suggestions to help implement NOM and influence other existing processes. It is a toolbox, for any ANSP to assess and decide what is suitable and how to use it, as ultimately the best way to perform NOM is what best fits an organisation.

Performing NOM has a great deal to do with organisational culture, since it also allows organisation's to measure and assess safety culture levels, and just by its existence within an organisation, has a profound transformational effect at all levels.

3. Normal operations monitoring applications: What for?

NOM started by questioning whether pilots really acted how they were trained, but quickly evolved into a process that was about understanding what really happened in a cockpit, and above all, why it happened.

Having a deep understanding of the underlying processes that modulate real behaviour provides a very complex and complete model of operation; what is neither specified nor written in the procedures and needs to be done, and how and why deviations from norms and procedure occur in a world we cannot fully predict and account for in operating manuals. This understanding requires observation and first line operations insight feedback.

Real world observation needs to be done from a non-judgmental distance and requires a highly mature mindset able to abstract itself from judging what is observed into understanding what is happening. The required mindset needs also to recognise that errors and threats are just social constructs condensed into terms used to summarise the undesired results of deeper system processes. Quite helpful in describing and characterising a system as a black box, but not helpful in understanding the reasons within.

NOM therefore equals understanding. How your system really behaves, what are the relevant underlying processes and why they happen. It provides highly valuable information about how we can avoid destroying a system that works and performs well, even providing information not initially related directly to safety but influencing it in the long run.

In addition, current safety levels are reaching a point where statistical relevance is at stake. This is what professor emeritus Ph. D Erik Hollnagel – a professor at the Institute of Regional Health Research, University of Southern Denmark (DK), Denmark, chief consultant at the Centre for Quality, Region of Southern Denmark, Denmark, and professor emeritus at the Department of Computer Science, University of Linköping (S), Linköping, Sweden – refers to as the ‘regulatory trap’, meaning that the system is so safe that the number of safety occurrences is too low to provide relevant information to further improve safety. Ultra-safe systems like ATM need to invest in further sources of information and understanding to maintain and improve current safety levels in terms of occurrences.

NOM in its quite wide range of varieties helps in several aspects, and have a big applications spectrum:

- Identification of relevant threats and frequent errors
- Deeper insight in safety concern areas
- Risk assessment processes
- Functional changes assessment
- Closer integration of safety and operations
- Fill the gap between top management and front-end operators
- Provides a smooth link with security and occupational health
- Broader scope than just ATM, but also may encompass CNS activities
- Basic ATM working modes characterisation (e.g. visual scan, communications, decision making, TRM skills description)
- Best practices identification and fostering
- Safety surveys
- Specific scientific studies
- Functional modelling
- System vulnerabilities detection
- Safety barriers effectiveness assessment (IRIS model)
- ATS units TEM profiles assessment
- Resilience profiles assessment
- A non-mainstream lagging indicators approach
- Leading indicators calculations

4. Basic concepts

NOM cannot be understood without its proper link to classical approaches to safety, and how these evolved into a deeper understanding of what safety means for the different actors.

Whereas safety II seemed initially to be a radical evolution of approaching safety, it does not invalidate safety I approaches. Regulations must be followed, and negative outcomes need to be investigated. What NOM brings into mind is that Safety I can help in managing its targets, allowing for a deeper look into those areas of concern and those areas where performance excels. On the other hand, Safety II can be deeply influential to investigation processes, changing the way a negative outcome is analysed, since the perspective naturally broadens.

A sound and effective combination of safety I and II approaches and methodologies can help air navigation service providers in evolving their safety management systems into a new modern paradigm.

4.1. Safety II

For a better understanding of the Safety II concept, we need to address the thinking behind Safety I, in which safety is considered as the absence of accidents and incidents (or as an acceptable level of risk). As such, safety may be defined as “a state where as few things as possible go wrong”.

It is important to point that, in this perspective, humans are predominantly viewed as the weak link of the system, considered by many as a liability or hazard, even knowing that (but not being able to explain why) humans practically always achieve successful performance.

This way of thinking about safety was developed between the 1960s and the 1980s. By that time, performance requirements were significantly lower and systems were simpler (tractable) and more independent.

In September 2013 EUROCONTROL published a white paper, *From Safety I to Safety II*, addressing the rising of a new paradigm in safety management: the systemic and positive approach to safety.

The authors (Hollnagel, E.; Leonhardt, J.; Licu, T.; Shorrock, S.) define Safety II as “the system’s ability to succeed under varying conditions, so that the number of intended and acceptable outcomes (in other words, everyday activities) is as high as possible”. This definition allows thinking about safety in a rather different way, fundamentally because the main focus is now turned to work success rather than work failures.

Also, it is understood that everyday performance variability, needed to respond to varying conditions, is the reason why things go right. Consequently, humans are now seen as a resource necessary for system flexibility and resilience.

This thinking has, however, a simultaneous simple and hard implication because, as the authors refer, “the basis for safety and safety management must therefore be an understanding of why things go right, which means an understanding of everyday activities”.

The concept looks simple but its systematic application may reveal itself harder than it seems: an understanding of everyday activities implies a recurrent in-depth routine observation of how the work is really done, so that we actually know how the system works and how it succeeds in delivering safe services.

Despite the difficulties to put in place this approach, we must thrive to succeed, knowing that the reason why things go right is not that people behave as they are told to, but that people can adjust their work to the existing conditions.

Consequently, safety improvements shall be based in the understanding of these adjustments, and its role as success factors of performance.

The foundation of Safety II lies in performance variability (and performance adjustments) rather than bimodality (success or failure, function or malfunction) and its mechanisms cannot rely on causality and linear propagations of causes and effects, but rather in “emergent ” outcomes.

When we think about the manifestations of Safety II we must consider all the possible outcomes of daily work, especially the typical, routine outcomes (things that go right) that usually are not taken into account by safety management. By doing this, safety will be

defined by what happens when it is present (successful performance), rather than by what happens when it is absent (failures). For instance, safety indicators will be directly related to the high frequency, acceptable outcomes, instead of being related to the low frequency non-safe events (accidents, incidents, safety occurrences).

As important as it is to consider moving forward toward Safety II we shall be cautious and consider the combination of the two ways of thinking. There is still a need for Safety I methods and techniques, although these may require some adaptation for usage with a different emphasis. However, a Safety II approach will need to include some new practices to look for success factors, focusing on frequent and routine events, but still remaining sensitive to the possibility of failure.

This “new” way of thinking may also facilitate the perception that an investment in safety is also an investment in productivity.

4.2. Safety surveys

According to EUROCONTROL, a safety survey may be defined as “a systematic review, to recommend improvements where needed, to provide assurance of the safety of current activities, and to confirm conformance with applicable parts of the [safety management system](#)” (this definition is taken from an old EUROCONTROL document – [ESARR3](#), and it’s referred in EUROCONTROL’s Skybrary).

Skybrary also mentions that “the objective (of this activity) is to examine procedures or processes related to a specific operation and provide a flexible and cost-effective method to identify areas for [safety improvement](#) within the aviation service provider organisation.”

ICAO’s Doc. 9859 – *Safety Management Manual*, refers to safety surveys as one amongst several activities that can provide sources to monitor and measure safety performance (other activities referred are safety studies, safety data analysis, safety audits, safety investigations and operational data collection).

This document states that “safety surveys are recommended to examine procedures or processes related to a specific operation and may involve the use of checklists, questionnaires and informal confidential interviews. The type of information collected is usually qualitative in nature and this may require validation via data collection to determine if corrective action

is required. Surveys may provide an inexpensive and valuable source of safety information.”

Commission Implementing Regulation (EU) 2017/373 refers, in its Annex III, Common Requirements for Service Providers (Part-ATM/ANS.OR), Subpart B — Management (ATM/ANS.OR.B), the following:

ATM/ANS.OR.B.005 – Management system

(a) A service provider shall implement and maintain a management system that includes:

- (1) .../...;
- (2) .../...;
- (3) the means to verify the performance of the service provider’s organisation in light of the performance indicators and performance targets of the management system;

As an Acceptable Means of Compliance for this requirement, the following is proposed:

AMC2 ATM/ANS.OR.B.005(a)(3) Management system

(ED Decision 2017/001/R)

Safety Performance Monitoring and Measurement — ATS Provider

- (a) Safety performance monitoring and measurement should be the process by which the safety performance of the air traffic services providers is verified in comparison to the safety policy and the safety objectives established by the air traffic services provider.
- (b) This process should include:
 - (1) .../...;
 - (2) .../...;
 - (3) .../...;
 - (4) .../...;
 - (5) safety surveys, examining particular elements or procedures of a specific operation, such as

problem areas or bottlenecks in daily operations, perceptions and opinions of operational personnel, and areas of dissent or confusion.

GM1 to AMC2 ATM/ANS.OR.B.005(a)(3) Management system provides guidance material on the execution of Safety Surveys in complex ATS providers.

Some surveys may be complementary to [incident and ATM occurrences investigation](#), since they examine systems under normal conditions to identify weaknesses, events and conditions that may have not been considered as possible direct or indirect contributory factors to a safety occurrence. Surveys may also be used as a [safety monitoring](#) tool to assess the adequacy of existing situations or organisational aspects and to review particular areas of safety concerns where hazards are suspected, as well as to check whether safety requirements and defined safety criteria are met. Therefore they can be an important part of the [hazard identification](#) and risk management processes within the [SMS](#).

Usually, these type of surveys are focused in specific areas of interest, with a narrowed scope. These fall under the category of *Targeted Safety Surveys* (TSS).

We may also consider that the role of a safety survey is quite similar to the one performed by audits in management systems. Both activities are conducted to check compliance with standards (or targets) and procedures, detect problems and facilitate the identification of solutions and improvements. Nevertheless, it is crucial to refer that safety surveys should be much more focused on the adequacy of applicable standards and procedures than on the compliance with those. These surveys can review operational units and particular operational and engineering activities or facilities. Surveys should also be performed to review SMS processes established to meet regulatory requirements. The objectives are to assess factors affecting safety of operations, significant activities, and SMS safety processes, and to facilitate the identification of corrective actions wherever necessary.

These type of surveys normally takes place on a periodic basis and have a broader scope. These fall under the category of *Periodic Safety Surveys* (PSS).

Surveys and programmes, such as LOSA (used in flight operations), NOSS and other similar methodologies (like D2D observations) are used to sample normal operations activities and provide

useful data for analysis of the daily operations, providing the organisation with proactive tools for hazard identification, risk management and [safety improvement](#). Besides the use of checklists, questionnaires and interviews to staff, these activities also make use of direct observation of workplaces under normal operations, reason why they are sometimes referred to as “observational surveys”. For that reason, this type of surveys is more aligned with the concept of Normal Operations Monitoring.

These shall take place regularly but without fixed intervals, and its scope is usually very narrow (a specific procedure, work routine, condition, event precursor, safety concern, etc.). These fall under the category of continuous safety surveys (CSS).

Regardless of its type, safety surveys should be conducted by independent and adequately trained personnel. The [safety manager](#) of the organisation should be in charge of the safety surveys programme and be responsible for the recruitment, training (with a special emphasis on observation techniques training) and review of the personnel conducting this activity.

Generally, the line personnel are aware where the areas of risk are. Line managers and operational staff typically have best perceptions of where to look for risks and areas for improvement in their fields of responsibility. Surveys completed by operational personnel can provide important diagnostic information about daily operations and valuable insight into the:

- Perceptions and opinions of operational personnel
- Level of teamwork and cooperation among various employee groups
- Problem areas or bottlenecks in daily operations
- Adequacy of standards, targets, processes and procedures
- Corporate [safety culture](#)
- Current areas of dissent or confusion

However, it is important for safety managers (as well as for the staff in charge of running these analysis) to realise that safety surveys can be obstructed by subjectivism. That is why close attention is needed when producing the safety survey report and interpreting the results from it. The bias can be found not only in the participant’s opinion but also during the creation and interpretation processes.

4.3. ICAO NOSS and TEM

A first word about Normal Operations Safety Surveys (NOSS): this is a tool that falls under the umbrella of “observational safety surveys”, which are considered key tools to help prevent gradual erosions in safety. Moreover, this type of tools (in which techniques such as LOSA and D2D observations are also included) allows observation of performance variability and helps detect possible undesirable trends in the day to day routine normal operations.

It is important to emphasise that observational safety surveys (including NOSS) are “over the shoulder” observations, focusing on safety improvements and are not competency checks. The focus is the ATM system, not the individual.

NOSS is a methodology that may be used to collect safety data based on the observation of normal, everyday operations in an ATC unit.

Note: Normal operations in ATC are those where no accident, incident or event (requiring reporting and/or investigation) takes place.

The development of this methodology is the result of a partnership amongst ICAO and the NOSS study group, which comprised the University of Texas (with the role of scientific advisors), several ANSP's (namely Airservices Australia, Airways Corporation New Zealand, DFS and NAV CANADA), UK CAA, US FAA, EUROCONTROL and IFATCA.

The basis for the development of NOSS for ATC was the *Line Operation Safety Audit* (LOSA) used by airlines on the flight deck and the two methods are similar in the methodology and framework applied (both are based on the *Threat and Error Management* framework – TEM).

The *Threat and Error Management* (TEM) framework is based on a scientific model developed by the Human Factors Research Project of the University of Texas (Austin, USA) called UTTEM (University of Texas Threat and Error Management).

TEM is a conceptual framework that assists in understanding, from an operational perspective, the interrelationship between safety and human performance in dynamic and challenging operational contexts. It focuses simultaneously on the operational context and the people discharging operational duties in such a context.

The framework is descriptive (captures human and system performance in the normal operation context, resulting in descriptions of work-as-done) and diagnostic (allows quantifying the complexities of the operational context in relation to the description of human performance in that context, and vice-versa), and this is applicable for both human and system performance.

ICAO clearly states, in its Circular 314/AN178, *Threat and Error Management (TEM) in Air Traffic Control*, that one of TEM's objectives is “to lay the foundation for ATS providers for the adoption of a TEM-based tool that involves the monitoring of safety during normal operations as part of ATC safety management systems. The name of this tool is Normal Operations Safety Survey (NOSS)”.

As such, TEM and NOSS shall be looked upon as operational tools, designed to be primarily used by safety managers in the identification and management of safety issues, including the analysis of performance variability contribution for the achievement of safe operations.

Conducting a NOSS to evaluate normal everyday operations, using the TEM framework, allows characterising operations particularly in terms of threats, errors and undesired states. Following, is a description of each one of these concepts, in line with ICAO Circular 314/AN178.

Threats

Threats are events or errors that occur beyond the influence of the air traffic controller, increase operational complexity, and must be managed to maintain safety margins. Adverse meteorological conditions, airports located in mountainous areas, congested airspace, aircraft malfunctions, errors committed by other people outside the control room, are some examples of complexities that may become threats for ATC operation.

Under the TEM rationale, threats are situations and/or events that cannot be avoided or eliminated by operational personnel, they can only be managed. This is why TEM adheres to the notion of threat management as opposed to threat avoidance or elimination, and that notion is lined up with a fundamental premise of TEM that considers threats as unavoidable components of complex operational contexts.

Errors

Errors are actions or inactions by the air traffic controller that lead to deviations from organisational or air traffic controller intentions or expectations.

Unmanaged and/or mis-managed errors can lead to undesired states. Errors in the operational context thus tend to reduce safety margins and increase the probability of an undesirable event.

It is an objective of TEM to understand error management (i.e. detection and response) rather than focusing solely on error causality (i.e. causation and commission).

The TEM framework uses the “primary interaction” as the point of reference for defining three basic error categories: equipment handling errors, procedural errors and communication errors.

Undesired states

Undesired states are operational conditions where an unintended traffic situation results in a reduction of safety margins. Undesired states may be the last stage before an incident or accident and must be managed by air traffic controllers. Undesired states can be managed effectively, restoring safety margins, or the air traffic controller response may induce an additional error, incident or accident.

An important aspect is the switch required to the air traffic controller from error management to undesired state management. It is clearly more important to deal with a potential traffic conflict (undesired state) than it is to rectify an incorrect data entry into the system (error) that may have led to that potential conflict.

It is also important to recognise a clear differentiation between undesired states and outcomes. Undesired states are transitional states between a normal operation state and an outcome. Outcomes, on the other hand, are end states, namely reportable occurrences (i.e. incidents and accidents).

An undesired state is often the first indication to a controller that an earlier threat or error was not adequately managed.

The purpose of conducting a NOSS in an organisation is to find out what are the most pertinent threats and errors that controllers have to manage during normal operations and how these are managed. NOSS thus capture ATC system performance through the eyes of the air traffic controllers.

Once that information is available the SMS of the organisation can propose adjustments in the operational processes as required (e.g. changes in procedures, specific safety topics for recurrent training programmes, etc) as countermeasures to the threats and errors that the controllers are confronted with on a daily basis.

NOSS data is process-driven, not outcome-driven, there is no need for a triggering event to take place so that safety data may be captured. That data includes information on situations that resulted in uneventful outcomes, or successful system/human performance data.

The benefits of NOSS include, among others, a proactive hazard identification, prioritised safety actions, enhanced understanding of air safety incident trends, identification of areas of strength, verification of the quality and usability of procedures, and an understanding of controller shortcuts and workarounds (performance variability).

A crucial aspect of NOSS is the selection of observers. Observers shall be qualified air traffic controllers in the organisation, although it may also be possible to select observers from the non-operational instructor group, both inside or outside the organisation.

Training of the NOSS observers is an important element of the pre-data collection phase. It shall focus on the TEM framework as the observational concept that will guide observers towards what they are expected to look for and how to fill in the observation forms. This training will normally last up to five days.

The NOSS process begins with data collection in the operational setting by volunteer controllers. Following this, the data generated are de-identified immediately. Individuals and their workstations are not traceable from these data or from the subsequent report. Data are examined for inconsistencies and clarity (data cleaning) and then analysed prior to the NOSS report being produced.

Participation in the NOSS process is voluntary and individuals who are subject of a NOSS observation can stop it at any time and ask for records to be destroyed.

The operating characteristics that define NOSS's approach to collect safety data from normal operations are:

- Over-the-shoulder observations, with clearly defined stop rules, during normal shifts

- Joint management/controller association support
- Voluntary participation
- De-identified, confidential and non-disciplinary data collection
- Systematic observation instrument based on the threat and error management (TEM) framework
- Trained and standardised observers
- Trusted data collection sites
- Data verification process
- Data-derived targets for safety enhancement
- Feedback of results to the controllers

Once the information is available both the controllers and the ANSP can propose measures to reduce risk, such as changes in procedures, or specific safety topics for recurrent training programmes for air traffic controllers, as countermeasures to the threats and errors that the controllers are confronted with on a daily basis.

After conducting a NOSS, the organisation will be able to set clear targets for safety enhancement of its operation. Safety enhancement can be measured by conducting a follow-up or repeat NOSS. In the meantime, the effects of changes may be noticeable by comparing specific events trends from pre- and post-NOSS periods.

Some final considerations:

- NOSS is based on the threat and error management framework. That's the philosophy.
- NOSS requires the observer to write notes during the observation, then write a narrative and code the threats, errors and undesired states after the session. That's the data collection methodology.
- NOSS is observation only, no debriefing session is required. That's the observation methodology.
- NOSS has been around for a long time (ICAO Doc. 9910 AN/473 – NOSS, published in 2008), has wide endorsement and easily available materials. That's the maturity.

A word of advice: when planning to implement a NOSS project/ programme ensure that management, trade unions and professional associations get on

board. A promotional campaign may then take place to clarify the aims of the initiative, encourage participation and answer any questions or concerns.

4.4. Systemic approach

Although the concepts might seem independent, both Safety II and Systems Thinking are deeply intertwined. In fact, NOM processes embed the systems thinking principles as defined by the EUROCONTROL white paper in its *Systems thinking for Safety: Ten Principles*.

Normal operations monitoring implies observing the system, its parts and their interactions, not just the people. Consequently, the concept itself stems from a systemic thinking approach. NOM foundations consider air navigation service providers as complex socio-technical systems, not just a complicated machine. Complexity implies focusing on local and distant interactions, both visible and invisible, moving away from deterministic linear causal thinking (simplistic *root causes* for problems or events) towards emergent system behaviour, considering the system as a whole where its outcome depends from the whole, not from just one of its parts.

Complex systems cannot be simply managed by steering one of its parts, but rather they require their interactions to be managed and tackled. Those interactions that may trigger critical responses need to be functionally dumped. It helps considering an ANSP as an alive organism, considering its functions, what the system does, as a result of the whole. And this insight is essential to approach NOM. What you monitor, what you observe, is the system.

The systems thinking principles are embedded within NOM processes in a natural way. Therefore, it is essential to consider the field experts view when approaching a monitoring or observing process. It is their view of the work as done / work as disclosed what is relevant for the monitoring.

People behave in certain ways, not only front-end operators, but also supervisors, managers in charge of training, technical development or safety processes. There is always a reason behind people's action, and actions are a reflection of the local rationality principle. When monitoring or observing during NOM processing, both actions and the reasons behind are of equal importance.

Local rationality helps in understanding how demands and pressures affect, available resources and the current restrictions operate, what are the relevant interactions and workflows, and what trade-offs must people make. Additionally, NOM mindset advocates for recognition a performance variability, both inter-subject and intra-subject, which means that regardless of the procedures in force, people will show different ways in their applications, even the same person at different times. This is neither bad nor good, it just shows the human nature of a part of the system. An essential insight is that their actions are categorised as good or erroneous but only given their consequences. The same action can lead to a severe incident and be inconsequential a minute after, being both actions *equivalent*. What is relevant for NOM is not only the action, but the preceding factors explaining the why and the effect of these actions in other parts of the system.

All this needs to be protected under the umbrella of *just culture*. Otherwise the monitoring processes or the information gathering will lack quite relevant information to fully understand the system's behaviour.

4.5. Resilience engineering / resilient performance

Given the fact the importance of considering the system as a whole, some systems specific behaviour should also be an important target for monitoring. Current socio-technical systems show an adaptive behaviour that allows them to cope with a wide spectrum of situations. People adapt to current operational scenarios, often dealing with situations not fully managed by procedures. Organisations need to adapt to a changing demand, evolution in the constraints and its own internal forces, by rearranging their structure, changing procedures, and influencing their environment. All these show the inherent resilient behaviour at different levels, from the component (persons, procedures, technical systems) to the overall system level.

NOM processes can prove to be the best tool to assess the effectiveness of resilient behaviour in ANSPs. Using surveys, questionnaires, interviews, etc., the different resilient behaviour components can be described, analysed, assessed, and furthermore, used to derive safety leading indicators. These indicators can take the form of resilience profiles, measuring its essential dimensions. Erik Hollnagel proposes the development of tailored made questionnaires targeting for specific aspects of resilience. The four

essential dimensions of resilient behaviour are the capacity of response, the capacity to monitor, the capacity to anticipate and the capacity to learn. They are four highly abstract dimensions that can be easily thought of and adapted from a component level (a person), to a small unit (an ATS TWR unit), to a regional set of ATS units or to a complete organisation.

From a systems perspective, the NOM processes can observe and measure reality, what actually happens in the system, rather than what we think it happens based on what is written on the procedures. It provides a measuring set of tools that proves to be perfectly fitted to measure the system's capacity to actively create safety, thus enabling the evolution to safety leading indicators, those that can predict future systems safety behaviour rather than past performance.

Organisations need to adapt their resilience measuring tools by adapting their questionnaires from generic resilience assessment grids to their own reality and measuring needs, starting from instance from those proposed by Erik Hollnagel.

This might shed some light to the slippery topic of developing safety leading indicators.

4.6. A word on system safety states

Within this document there is a concept mentioned several times that relates to what safety is, to safety dynamics, and to overall system control.

The classical definition of safety is based on the absence of adverse outcomes in a systems' behaviour. However, this definition does not help in understanding what are the dynamics underlying making the systems to drift into a unsafe state, and what are the recovery mechanisms.

A system with such a complexity level such as ATM cannot but grossly modelised by a number of parameters describing the current, past and future state of the system. Even the ICAO TEM framework includes the undesired state concept, a transitional state from having the system under control to have a lower degree of control about its future evolution. This view will be more easily understood with an example, and then increasing the number of descriptive variables to understand what NOM is about.

Imagine an ATC sector, managed by two ATCOs. This sector only has at a particular moment two traffics. Is

there a function that could summarise how safe the sector is? We can imagine a function whose outputs are the current vertical and horizontal distances between both aircrafts. If they fly along parallel routes, many miles apart, there will be systems constraints and the distance between them will never diminish, maintaining the safety function within a desired range (e.g. above 5NM and 1000 ft). We can say that the system (based on this very basic model) is behaving in a safe way.

Imagine that we have three aircraft, flying intersecting routes. Situation is a bit more complicated, but we can still think of a function whose output is a vector of all the possible inter-traffics distances, and to make it a bit more complex, including also the rate of change of these distances. A function whose output is a six-dimensional vector. If the output vector provides distances higher than given values we can still say that the system is in a safe state. But what happens if the distances are higher than prescribed, but there is a decrease rate in the distances that will end up in having one or more of the distances lower than prescribed? We have an undesired state. The system is still safe but requires inputs so that the values will not decrease dangerously.

The key of this abstraction in this multivariable safety function are both the functions' constraints, and what is more important for NOM, the function inputs, in our case, everyday work. All the active actions and omissions that maintain the system within a safe range of values. If our three traffics are about to lose separation, the system is still safe, but in an undesired state that is drifting the system's safety function output towards undesired values. That requires intervention from the systems, be it from the ATCOs providing instructions, from the STCA providing an alert or from the TCAS instructing avoidance manoeuvres.

A more prosaic although illustrative of the same view could be pouring down a jar of slime on a small table. NOM would allow to understand how you keep the slime from falling down to the floor, what strategies you put in place, how you react and where the slime gets its way down to the floor. It would allow you to understand why the slime was poured down onto the table, and a quite interesting insight: there will always be slime to be kept from falling down. How you keep your system stable, how you constantly need to provide inputs to manage undesired states, how you keep your floor clean.

Normal, everyday work comprises a huge amount of actions, inactions, influences, interactions between all

system elements that change the safety output drift, that is its state and direction of change. An ATCO not capturing an incorrect readback does not necessarily imply that the system is automatically in an unsafe state, but rather changes the system safety function output trajectory and could eventually have one or more of its values outside the desired range.

Normal operations monitoring advocates for this view of safety, since the object of observation is how the system's elements work together and interact to change both the system's safety state and its drift towards a set of values ranges with desired values that is what we call behaving in a safe way.

NOM helps in understanding how these forces shape the system safety behaviour, how the external influences also create a safety drift, how human performance is driven by both systematic and random forces affecting it, how unlikely events dramatically distort the system safety output, and even how the system output itself reflecting the inter-relational model of multiple system elements, influences its own inputs, as expected of a system aimed to provide control.

Resilient behaviour can also be seen from this standpoint. Both normal and exceptional external events affect our system's safety function in many ways. First of all, in the output. Highly unstable systems can be highly affected by even the slightest disturbance. Resilient performance is observed when the effect in the system can be contained in case of extreme external conditions change, and even more, when the functions that characterises safety *changes* by learning and adaptation and becomes progressively more stable and controllable.

NOM provides a way to understand, and hence, improve all the internal control mechanisms and interactions that allow a system to remain within a desired multidimensional range of behaviours.

5. Expected benefits for ANSPs

Notwithstanding the fact that NOM processes require resources and time to implement, develop to a minimum mature phase, benefits can be expected from the very beginning of normal operations monitoring implementation.

A good awareness of the benefits NOM might bring to an ANSP is essential, since it can be the key to internal approval processes and a positive organisational perception, and eventually, access to resources.

There is a number of benefits that can be identified, both measurable and not-so-easily-measurable. Amongst them we can find the following:

- Increased EoSM
- Development of standardised leading indicators
- Development of lagging indicators not linked to occurrences, but on work as done
- Complementary and more robust safety processes with a proper combination of Safety I and Safety II tools and mindsets
- Reputational benefits for the organisation
- Further understanding of the systems behaviour, allowing for descriptions and observations at different functional levels
- Identification of the degree of effectiveness of safety barriers
- Allowing for more effective safety initiatives taken at the correct system level (ranging from component to organisation-wide actions)
- Active safety culture fostering along with safety awareness
- Direct connection of safety units to the different levels in the organisation
- Helps in identifying global and specific threats at the right level (procedures, persons, ATS unit, organisation) along with internal behavioural patterns that might need to be addressed (i.e. a recurrent type of error)
- Better insight to best practices
- Allows to identify cultural drifts through direct observation of what happens at the front end
- Allows to assess in depth how functional

changes have affected the system, unveiling unforeseen links and influences

- Increased corporate teamwork and cooperation
- Corporate mindset towards a better understanding of reality

NOM-induced changes and improvements are seen in the long run. It is a wise advice to adequately manage expectations on immediate results.

6. Normal operations monitoring objectives and principles

Normal operations monitoring needs a purpose, an objective. It needs to answer the question: *what do we do NOM for?*

Organisations start NOM activities due to a number of needs, that may differ from one to other. However, there are some objectives that are common up to a certain extent:

- Gathering system knowledge in terms of overall performance
- Continuous improvement
- Understanding how safety is actively created by the systems actors performance
- Understanding how safety is potentially degraded by the systems actors performance, even in the absence of incidents and accidents
- Gathering system performance information for decision making processes
- Improving safety records
- As a means to foster corporate safety culture
- To identify and foster best practices
- To address specific safety issues
- To answer the questions:
 - **What?** System's description
 - **Why?** Analysis of factors and reasons
 - **How?** Analysis of processes and interactions; How to prevent / foster / use the information for the system benefit
- To analyse a specific safety problem in depth
- To consider and explain the different varieties of work: work as imagined, work as prescribed, work as done, work as disclosed etc
- To change an organisation mindset in terms of safety thinking

There is a commonality in all of these objectives: system understanding.

In order to achieve these objectives, there is a set of principles upon which policies, strategies, processes, and activities should be based on.

- The object of NOM is the ATM system
- The activities scope should be based on systems thinking
- EUROCONTROL systems thinking principles provide an excellent basis to develop NOM
- Persons are just a part of the ATM system
- The focus of monitoring needs to be both the elements performance and their interactions with other elements
- System external interactions are also a source of driving forces that need to be approached
- A special care should be applied to understanding human performance, both from a psychological, physiological, and cognitive approaches
- Language needs to be adjusted to be neutral, descriptive, and not focused on classical negative safety concepts
- NOM activities need to be integrated with existing safety processes
- A full respect of just culture principles within the NOM processes should be stressed

7. History: From LOSA in the airlines to NOM in ATM

The comparison between work as imagined and work as done is not a brand new safety-II hype, but dates from the 90s, where a relevant question was posed within the airlines that triggered the process: does teaching non-technical skills to pilots actually make a difference in normal operations? A research project led by the University of Texas Human Factors Research Project and Delta Airlines in 1994 developed a methodology based on observing pilots' real behaviours in everyday work. Not an easy task, unveiling real practices by external observations without interfering and inducing non-normal behaviours. A careful design of the observation was developed, that was based mainly on trust. Trust from the observed people, trust in the process, trust from the managers. Anything distorting the trust would distort the results of a process, that would measure anything but real operations happening every day.

The observations structure was linked to the threat and error management (TEM) concept. It led to analysing how pilots actually managed personal and team errors, and what strategies were applied, and which actions were performed to avoid threats become a real problem. These are CRM closely related concepts, which is somehow logical since what is observed normally points to the basic behavioural processes in terms of attitudinal competence and basic CRM skills in situation awareness, communications, taskwork management and decision making. Observing the real world can be quite overloading, and TEM/CRM conceptual frameworks helped (and still help) in structuring what needs to be observed, and, above all, in structuring data capture. The activity structure was developed and refined eventually on purpose to provide a structured framework for observers to collect data.

After the first 1996 LOSA experience, Continental conducted a follow-up LOSA in 1999. To quote Captain Don Gunther, Senior Director of Safety and Regulatory Compliance at Continental Airlines:

"The LOSA, when compared to the results of 1996, showed the pilots had not only accepted the principles of error management but incorporated them into everyday operations. LOSA showed a sizeable improvement in the areas of checklist usage, a 70 percent reduction in non-conforming approaches

(i.e., those not meeting stabilised approach criteria), and an increase in overall crew performance. It could be said that Continental had taken a turn in the right direction."

This success led International Civil Aviation Organization (ICAO) to increase the interest within its Flight Safety and Human Factors Program on LOSA. Finally, ICAO endorsed it as an industry best practice for normal operations monitoring (ICAO LOSA Manual, Doc 9803). The Federal Aviation Administration (FAA) also endorses LOSA as one of its voluntary safety programs (FAA Advisory Circular 120-90). As a result, TEM and LOSA are now two fully world-wide recognised concepts.

The FAA considers that the development and success of LOSA was based on ten essential characteristics:

- Peer-to-peer observations during normal operations
- Anonymous, confidential, and non-punitive data collection
- Voluntary participation
- Trusted and trained observers
- Joint management/union sponsorship
- Systematic observation instrument based on Threat and Error Management (TEM)
- Secure data collection repository
- Data verification roundtables
- Data-derived targets for enhancement
- Feedback of results to the workforce

Currently the TEM concept is used in particular in Commission Regulation (EU) No 1178/2011 Aircrew Regulation – Annexes I to IV – Flight Crew Licensing (FCL) and Medical (MED) Requirements, amended by Commission Regulation (EU) No 290/2012.

Transfer into the ATM world did not take long after ICAO LOSA 9803 edition was issued in 2003. A new methodology on ATM, Normal Operations Safety Survey or NOSS was introduced by recommendation 2/5 of the Eleventh International Civil Aviation

Organisation (ICAO) Air Navigation Conference, held in Montreal in 2003, which reads: "That ICAO initiate studies on the development of guidance material for the monitoring of safety during normal air traffic service operations, taking into account, but not limited to, the line operations safety audit (LOSA) programmes which have been implemented by a number of airlines".

It was not until 2005 that a joint ICAO/EUROCONTROL NOSS/TEM conference took place at IANS in Luxembourg, with examples of ANSPs having tried the methods and how were their results.

NOSS and LOSA have quite a few differences, but share the basic objectives, philosophy and have some methodological similarities. Both are based on the TEM conceptual framework; NOSS was developed with the assistance of the ICAO NOSS Study Group and is based on a similar method used in the flight deck environment. However, the major difference between cockpit and ATM is what you can observe. In the cockpit results can be inferred directly from observable actions. In ATM many actions happen inside people's minds when planning, so observation cues are indirect, and the reasons, objectives and intentions need to be confirmed. On the other hand, time references are different. Pilots need to perform in advance of the aircraft, which create a control loop that is observable through salient behaviour. In ATM the time planning window is highly dynamic, ranging from strategic decisions that may affect traffic many minutes later, to situations where the situations needs to be left to develop itself before plans can be updated and actions taken. There is another main difference of a cultural nature, which relates to CRM/TRM communication behaviours. Many CRM knowledge and strategies have been implemented through procedures that create observable behaviour; TRM in ATM does not have the level of implementation as in the pilots community, which has the adverse consequence of not generating directly observable behaviour related to non-technical skills.

Further efforts in the industry have been held, but little international support has been provided in the ATM world. In 2008, NATS developed the Day to Day methodology (D2D), inspiring other ANSPs since then. EUROCONTROL adapted NOSS to develop and apply EUROSS. In 2013 Austro Control developed ACToss.

EUROCONTROL has fostered through their documentation on Resilience Engineering, Safety II and Systems Thinking the impulse to develop Safety II practical methodologies.

The current situation in the industry is that there is a variety of philosophies and methodologies aiming for Safety II approaches, but combined applications are difficult due to the lack of standard methodologies, the difficulty to be adapted to ANSPs needs or simply because they aim for different objectives. Some concepts are of a more abstract nature (i.e. systems thinking) and are applicable to many other processes. This document provides an integrated view of Safety II philosophy, systemic thinking principles and resilience engineering. It gathers a set of tools that can be used in isolation, in combination with others or tailored in a creative way, to fit any ANSP needs and available resources while respecting those general principles.

8. NOM and quality management

Many of the organisations have implemented a Quality Management System (QMS). This system has a holistic approach and serves / covers the entire organisation and therefore it can be used as the basis system for an integrated management system (IMS). An IMS is a complete framework that combines all aspects of an organisation's systems, processes, and any standards such as compliance requirements that the business follows. This combined system allows a business to meet all of its obligations, addressing all elements of the management system as a whole rather than looking at the individual standards and their requirements separately. The IMS usually contains all ISO certified systems (e.g. 9001, 14001, 45001) and can be expanded by safety and security management system according to the regulations.

In the case of NOM the integration of quality and safety is the part of interest, since safety can be seen as a quality criterion. When we consider improving a quality criterion – such as safety – we always must keep in mind the dependencies between all quality criteria of the product – therefore an operational quality management system is essential for an effective operational safety management of an organisation.

Operational quality management is basically very simple. Each part of an organisation has customers, whether within or without, and the organisation needs to identify what the customer requirements are. Then quality means making sure that you build what you said you would. The NOM focuses on both: on internal and external customers, their needs, requirements, requests. Then, beside our external customers we also need to understand the needs of our internal customers just to be able to “produce” high quality products such as safe air traffic control.

During NOM we collect statistical data on procedure compliance which can be used for statistical process control (SPC) of service quality and compliance. Observations in the operations rooms can be a suitable tool for it.

At the same time, we cannot observe needs and requirements. To find out about requirements and request of the operations crew which are internal customers of the QMS we need another tool: results of interviews with operations staff give us a suitable insight into the needs of the operational crew of the organisation.

According to Austro Control experience in the field, most results out of a NOM-survey are primarily improving quality in terms of better effectiveness or improved efficiency – sometimes we can argue, that such improvements in effectiveness/efficiency are also enhancing the safety of the service, in all cases these measures make the system – the operation – more stable and resilient what helps us to keep us safe, even if this cannot be directly proven by performance indicators.

Then good performance requires the three hard management necessities: planning, including the right policies and strategies, processes (including procedures) and supporting management systems and improvement tools, such as SPC and people with the right knowledge, skills and training. It is important to remember, however, that the review of the current performance in all the operational areas, even when well established, should be a part of the normal operation in order to ensure continuous improvement.

9. NOM scope: What to monitor

Virtually, anything within the system can be monitored. However, there are some observables with a greater interest for the analysts, and the observable may determine the required techniques and processes.

9.1. Functional observables

9.1.1. Systems functions and processes

Bearing in mind that the system behaviour is described through its functional outcome we can decompose what our system does. This is based on the classical CNS/ATM services approach, with these services broke down into functions, the functions into tasks (that have a beginning and an end) and processes (performed continuously or through repetitive cycles), and these into actions performed by the different parts of the system.

This approach allows for a monitoring or observation which is not ATCO-centred, but system-centred, thus allowing for a better understanding of why the system function/task works well or not, and why.

A functional breakdown is presented below as an example that can be used as a map of the functional architecture to define the NOM observables. We must bear in mind, however, that complex socio-technical systems like an ANSP admit may different functional breakdowns.

- Air traffic control related functions (surveillance and control):
 - Separation monitoring
 - Information management and association from different sources
 - Flight trajectory modelling
 - Problems forecast
 - Solution planning
 - Tactical execution:
 - Clearances and instructions issuing
 - Coordination
 - Handling of technical systems
 - Application of procedures
 - Visual vigilance

- Information gathering and dissemination
- Information processing related functions
 - Weather information management
 - Flight plan information management
- Coordination related functions
 - Internal and external information transmission
 - Joint decision making
- ATFM related functions
 - Traffic demand management
 - Information feedback regarding real airspace status
- ATS metafunctions:
 - Tactical risk management
 - Teamwork related functions (like prioritising, decision making, shared mental models, authority and leadership)
 - Self-monitoring
 - Cross-monitoring

A wide function can be selected as a target for monitoring, or a quite specific function. If, for instance, TRM is an observable, the monitoring will identify the people different behaviours related with how the non-technical skills are actually applied during operations: how they communicate, how they take joint decisions, how they anticipate each other. If visual surveillance is the subject to be monitored, the visual scanning patterns will be observed, how ATCOs implement strategies to perform these scans, what are the interactions with the system influencing these patterns, if there are relevant environment factors like weather conditions or physical structures blocking the line of sight, etc.

It is important to recognise that even though the object of NOM is the system behaviour, our methodologies always start from observing humans. Therefore, it is necessary to define beforehand which function, task or action is to be observed, together with a behavioural breakdown in order to fully describe and assess it.

Furthermore, the monitoring or observation process can be systematic, thus trying to characterise and describe the way it is implemented, or rather random, only focusing on the salient aspects of the function which are relevant for the observation. This might introduce some bias to the NOM process but can be more powerful and reality-relevant.

9.1.2. Application of procedures

An observable of great interest for NOM analysts is how procedures are applied during normal operations. Observations of deviations of working procedures might help to identify systemic threats and errors, but this shouldn't be the main focus during the observations. Working procedures should rather be evaluated in terms of effectivity/efficiency of use by the operators than seeking for mere compliance! If regular deviations from working procedures are observed, it is crucial to find out the underlying issues *why* those deviations occur. Therefore, the insights received from NOM should be augmented with interviews asking the operations-staff why and how the procedure should be redesigned to meet the needs of operations.

When focusing on the application of procedures observers will expect many minor findings because of erroneous applications, like omitting activities, shortcuts in the application of procedures, wrong phraseologies, etc. It is paramount for observers and analysts to put those observables/records in the right context by evaluating any associated risks and bearing in mind the human factor with its adaptive capacities. However, it is inevitable that systematic tendencies to wrong application of procedures ("drift into failure") need to be addressed. In such cases it is important to use appropriate language avoiding judgements in the final report.

Systematic tendencies to wrong application of procedures is a possible root cause for incidents. Observations like this might help to understand why incidents happened in the past and will help to prevent them in the future.

9.1.3. Errors

Following the early approaches like in LOSA, one topic of interest is the number and type of errors associated to a particular operation. They are simply a deviation from intended actions or consequences.

The question is what errors are object of a NOM process. The selection of observables can be a generic approach to errors, thus measuring those relevant to the observer, or capturing those more frequent to an ATCO group or those that can have a greater impact on safety. On the other hand, errors can be monitored in a more specific way, thus focusing on one type or group of them, like communication errors, visual vigilance errors, technical systems handling and the like.

Errors admit a wide range of possible classifications. One that can be used is a cognitive based scheme like the general error modelling system (GEMS) developed by Reason, that does not focus on the action but on the cognitive aspects of the error.

Another possible well-known classification can be based on the TEM concept and its translation into the NOSS concept. It contains an error classification scheme that proves itself useful due to the ease of recognition of actions as errors, and not requiring deep cognitive knowledge so as to classify errors according to GEMS. Besides, it does not require a full NOSS application.

Error monitoring can be easily linked to one system functional dimension (like communication errors, visual scan errors, and decision making), thus allowing for a deeper understanding of how robust and resilient a function is, and by knowing the type and the sources of errors the functions resilience can be estimated.

It is important to highlight that in accordance with the systems thinking principles, errors, seen from this paradigm do not necessarily equal a safety issue; they rather reflect a systems behaviour reality whose reasons and systemic factors and patterns influencing their emergence can be unveiled through NOM processes. In addition to this, errors are considered as a reality and a natural consequence of the complexity of the system, including the complexity of each human itself. They do not imply any prejudice against the competence of the observed/monitored/surveyed people under the light of NOM.

Having in mind that errors are symptoms of human's adaptation difficulties, there can be two different approaches regarding them. They can be:

- Either measured in terms of numbers, failure/success ratios, etc, thus requiring a quite dedicated observation method and later analysis; or
- The error type prevalence can be measured in terms of what error types are more frequent, thus allowing to derive an errors profile.

9.2. Real and potential threats

Complementary to the identification of errors as explained in the previous section, but considering the system's boundaries, both real and potential threats can be also subject of a monitoring process.

NOM, depending on the methodology can help in the identification of potential threats to the operation and those that actually appear during operation time. If questionnaire-based or social dynamics surveys are applied as a basis for the NOM process, it is important that the observers make a clear distinction of the actual threats influencing the operation, together with the level of importance for the participants, frequency and severity. It does not differ much from a classical hazards identification process, including a wide spectrum of participants, from front-end operators to potentially top-level managers.

Observation-based NOM methodologies can have a deeper insight on what external threats are linked to actual operations and it is their severity and frequency. Additionally, an external independent observer can provide an unbiased view of the threats perceived during the observation periods. This might also help in providing an external view and identify hazards non-visible for the operators that are quite relevant.

This observable admits the application of the TEM concept and therefore can eventually allow the linkage of threats to induced errors (applying then the NOSS approach), and furthermore, how actual threats affect the application of procedures and the execution of front-end processes.

9.3. Other system components

9.3.1. Changes monitoring

Introduction of Regulation (EU) 373/2017 has stressed the importance of managing functional changes from a safety standpoint.

Some ANSPs have implemented processes based on observational surveys to assess the effect of changes on safety and work as done. In addition to this, some others also perform an observational survey prior any functional change to have a clear baseline to measure against.

It is considered consequently as a powerful tool to monitor how changes affect the system and to decide whether the changes had the desired effect, and to capture any other unexpected emergent consequences.

9.3.2. System performance scope

Based on a systemic approach it is important to define what is the level within the system the NOM process is applied to.

Following this approach, the methodologies can comprise a wide range of system scopes, starting from a single ATCO monitoring, an ATC sector and its inner interactions, several interacting sectors (even from different ANSPs), or even a complete ATS unit (from the smallest to the biggest).

The scope definition needs to be stated beforehand, since it will determine to what level the systems functions are monitored, what are the relevant observable components and how they interact. For instance, if the NOM scope is a sector, there will be a focus on the sector actors and how they interact, how the sector interacts with the collaterals, how ATS functions are performed and what are the relevant threat and errors at this level. If the NOM scope is how an ATS unit manages military-civil coordination, the functional level to be observed will imply higher layers in the organisation, not just tactical coordination, but also how traffic flow is managed, and how coordination procedures are defined, applied and modified along time.

Functional and organisational modelling can be quite helpful in this area in order to define a clear NOM scope, but NOM practitioners must

be aware that some degree of flexibility may be necessary regarding the scope. An observational survey can be set up in order to check how are the overall visual scanning techniques, but observers realise that these do not pose a real threat to the operation, being quite stable and non-error prone, but they detect an astounding level on how TRM skills are intensively applied naturally even without having received a comprehensive no-techs training. This might be quite relevant for the observers, and thus the NOM scope can change dynamically if the subject so merits.

10. Normal operations monitoring methodologies overview

During the past years a number of methodologies have emerged within the ANSP community. Their objective, monitoring targets, observables and safety strategy are different, but far from being a problem, this has provided the industry with a wide range of possibilities to tailor NOM to actual organisational needs.

Consequently, there is a non-neglectable experience thanks to, amongst others, simple over the shoulder monitoring, Normal Operations Safety Surveys, EUROSS, D2D, ACToss, interviews, workshops, adaptation of safety surveys and even TRM sessions.

All of them are consistent with the Safety II spirit, although they differ in terms of what is observed/monitored and the methodology.

It is important to highlight that NOM in its 'safety surveys' forms have an important task to pass on messages from ATCOs that are normally neither heard nor considered regarding factors that can be safety occurrences precursors or strategies that prevent them.

The following sections address the broad classification of methodologies based on direct observations, those based on questionnaires and those based on social dynamics. The reader is invited to bear in mind that the final application of the NOM concept may comprise a combination of different aspects to monitor together with one or more methodologies.

10.1. Observation-based methodologies

The first group of methodologies are based on over-the-shoulder or more general observations. They require prior planning, information for stakeholders and time spent in the ATS units, since they are the primary target in accordance to the methodology.

They are the most intrusive group of methodologies and can create an artificial working environment if due care is not taken regarding the observers. Ideally the observers must eventually merge with the environment, become a natural part of the unit. This must be achieved by acceptance from both operators and unit managers, non-intrusive observation techniques, observations on a voluntary basis,

confidentiality and a high degree of transparency and professionalism by observers.

The logical thinking regarding observing *work as done* would be limit interactions as much as possible of observers with the observed people, but their simple presence within the unit can distort the normal operating ambiance. A person observing and not interacting with anyone can be highly disturbing; it is more advisable that the interaction of observers adapts to local cultures, creates a trust atmosphere, considering the fact that observers should ideally be other ATCOs, and a clear message that NOM is part of just culture, where errors are a primary target not for punishment, but rather for explanation considering all proximal and distal factors. This is the reason why developing a structured observation record sheet and ensuring a statistically relevant set of observed conditions is crucial.

Normally NOM observation campaigns require several days of observations, these trying to maximise the number of ATCOs under observation along with different operational scenarios. Within a day, observation periods can range from 20 minutes to several hours, since observing is also a highly attentional task and creates fatigue on observers that may eventually impede the observation quality. Shorter periods are better suited for targeted surveys observing specific actions and can generate quite a lot of data. For less specific surveying, longer periods of observers physically at the operations room can help in lowering the external presence distortion effect, and operators tend to revert to their normal working habits. The main objective of observers *blending in* is to ensure consistency, statistical reliability and overcome observation bias.

The information gathered is then processed and analysed to process the observation conclusions and the project output. Conclusions can be of quite different natures: from error ratios to identified best practices, threat and error profiles, to unexpected relevant aspects observed during the process. These conclusions must then revert into the system, via two ways:

- Feedback to the observed/monitored unit, with all the relevant factors found, with a special

focus on the best practices identified and how to expand their usage.

- Actions stemming from the conclusions. These can address weaknesses, foster the identified good practices (even to other ATS units), increase the level of problems awareness to managers, or even identify systemic problems that need a global approach.

The most known methodologies based on observations are the following:

- ICAO NOSS (normal operations safety survey)
- EUROSS (adaptation of NOSS for Maastricht)
- ACToss from Austro Control
- NATS Day to Day operations (D2D)
- DSN A O.S.P. "Observations Sur Position"
- NOSS tailorisations (targeted and unspecific observations)
- Scientific analyses
- Observed TEM profiling (threats and errors profiling), which is combined with an ATS unit self-perceived TEM profile

10.2. Questionnaire-based methodologies

The second group of methodologies is based on the conception, development, deployment, and analysis of questionnaires addressing a variety of issues. These range from latent threats, current ATS unit problems to specific targeted studies. They require less effort than other methodologies since they admit online surveying and thus the processing can be at least partially automatised.

It has the advantage to allow for gathering the self-reported view of front-line operators and managers and can be extensive to the whole ATS unit, not just limited to those operators present during monitoring periods.

However, their disadvantage is that the scope is fixed and cannot be adapted to existing circumstances. The distance from the unit does not allow for a real contact with the operation and sometimes the questions may be out of context and seem irrelevant to the respondents. Online surveying is also seen sometimes with lack of interest, so feedback must be considered, and there is a risk of not contextualising the answers properly.

They prove to be an exceptionally good methodology to complement when combined with other ones, they allow to contrast and validate what is observed or stated during workshops.

These methodologies fall under the umbrella of the broad concept *safety surveys*. Some more specific questionnaires have been developed under the light of Safety II, NOM concept, systems thinking and resilience engineering.

Within the surveying techniques, if specific questionnaires are used based on the resilience assessment grid (RAG), a resilience profile can be sketched. A generic RAG can be adapted to a specific questionnaire to be established as part of the NOM processes. This allows assessing the resilience levels at different environments, ranging from tactical in an ATS unit up to the managerial level. The questionnaire, that is developed at some companies by a group of experts, serves to measure the four dimensions resilience is comprised of capacity to monitor, adapt, respond and learn. They prove a valuable tool in profiling the resilient behaviour of an ATS unit or even a company, being a measurement of the capacity of an entity to actively create safe behaviour. This falls under the interest of what are known as leading indicators. Another interesting application of questionnaires is their analysis to scope a later NOM observation campaign and focus on the relevant issues.

Questionnaires reflect self-perception of the respondents, but they can provide a good hint of where strengths and weaknesses are and can serve as a starting point for a specific NOM observation or a baseline to compare if an observation is performed.

Like the previous one, questionnaires can be used to identify the probability profiles of threats and errors under a generic TEM model. These TEM profiles can be what the NOM detects through observations, and through questionnaires to the experts. Matching both profiles can allow to measure the quality of the observation and to identify the relevant topics to be addressed when parameters match. It is interesting to note that the TEM profile might not match the occurrences profile, simply by the fact that the captured errors and threats may not necessarily evolve and turn into an occurrence. They simply capture different aspects of reality: TEM profile summarises aspects of work as done while occurrences statistics gathers specific system outputs not meeting predefined criteria.

10.3. Ethnographic methods and social dynamics-based methodologies

Complementary to the previous methodologies, but not focused on directly monitoring the operation we can find a set where there is an interaction between the NOM practitioner and a group of interest. This interaction can make use of previous observations, or can be assisted by questionnaires, but they seek to feed the interaction in order to create an atmosphere that fosters analysis and trust. It is important to note that the real application of these methodologies may have features of several of them: an interview can be conducted using facilitation and progress into TRM aspects, a workshop can turn into a debriefing, and so on.

TRM training and facilitated sessions

TRM training and facilitated sessions are a very good opportunity to gather data related to work as done. They provide a human behaviour-focused perspective so that the work as done is explained and contextualised, so cross learning processes are triggered within the session. Strategies to adapt, cope, and actively create safety are identified and can be documented. They can also help in identifying latent or very active threats related to *real operation*. If the sessions do not limit the type of participants by including ATSEPs, flow officers, operations managers or even pilots, the discussion level is highly improved, and more interactions are identified and analysed. All this, after safety experts and systems thinking experts' analysis, can be properly documented and can trigger an observation NOM process or directly being discussed with operations areas in order to induce systemic improvements.

Workshops

Workshops are similar to TRM facilitated sessions, although the potential scope for discussion can be wider. Depending on the rules, they can operate under strict confidentiality, and therefore the organisational learning can be limited. Workshops outcome nature would require previous discussion in order to clearly define how the results will be managed.

Local safety surveys

Local safety surveys can take the form of a combined approach of observations, workshops, interviews combined with questionnaires.

Interviews

Interviews are a one-to-one method to gather information. They are usually performed by trained personnel, who know the interview objectives, the interview structure, the questions, how to handle the

interviewee, how to end an interview, how to provide a context for the answers and how to interpret them. They can be associated to a questionnaire fill-in activity, but if a real interaction is established, much more analysis can be developed during the interview and the insight will be greater. They need to have clear objectives, a backbone structure and set of questions, but they need a great level of flexibility. Semi-structured interviews are often used after the observation phase in order to ensure that the observers have correctly understood the situation and to capture ATCOs intentions during the observation.

Post-mortem debriefings

Post-mortem debriefings are intended for post-ending project analysis but can also be applied in situations where an incident or a big breakdown has occurred. It involves a group discussion and joint analysis (not a parallel investigation, but it can use results of investigations). This analysis is centred in normal practices, how is the real work done, identification of best practices, suggestions for changes, recurrent error and threats, and how really WAI-WAD interaction contributed to a particular incident.

10.4. Precautions on data management, analysis and ownership

In an era of huge data management regulation, NOM data management must be extremely careful. A good advice is to treat NOM data just like any other safety data. This implies as a baseline treating the raw data as confidential, processed data at a restricted level and the output of the process, the results, in accordance with the company policy.

NOM data management is owned by the organisation performing the process and is of an overly sensitive nature. The storage of the data at different levels must comply with regulatory provisions regarding the treatment, storage and access to safety data and also regarding any personal information gathered during the process.

Analysis of the data is to be performed by authorised and competent personnel, who must take care of security provisions to prevent any unauthorised access to raw, processed or results of NOM processes.

The company policy regarding safety information should provide guidance on how to correctly classify the NOM end products, specially the reports. They may range from a collection of good practices, visible even to other organisations to a document containing the threats and typical error profiles of an ATS unit. Typically, data to be contained in any safety

management dashboard should be considered of a restricted nature, and a process is recommended to determine whether the information is to be released openly within the organisation or outside it.

Even though the focus of NOM is of a positive nature, looking for understanding the systems behaviour, stressing good practices *inter alia*, their results might contain sensitive data that can be used in a misleading way, and due care must be taken accordingly. Mischievous or out-of-context use of the information managed by NOM can be very harmful not only to the unit under monitoring/analysis but can also damage any ANSP credibility and even trust in the aviation transport system.

10.5. Combining methodologies

From an overall NOM perspective, it could be necessary to combine elements from different methodologies. Every ANSP will need to match the available resources to the planned NOM activity and to succeed in the process, a selection of tools can be necessary.

There is a number of ANSPs that combine observations with interviews, others that complement workshop information with later confirmation observations, others that apply a reduced NOSS but presenting results using TEM profiling, others that enlarge the initial NOM scope and have a go into resilient performance profiling... The idea behind is that NOM is not an exact science and needs to take many cultural and organisational factors such as acceptance and trust into account. It might be advisable to consider if there is a need to reduce the NOM scope or to complement and combine methodological tools.

10.6. Cross-unit and cross-ANSP studies

From a *threats and errors management* perspective, if we limit the system boundaries to those areas of responsibility of an ATS unit or a complete ANSP, all interactions with external systems (collateral units, belonging or not to the same ANSP) are a potential source of threats and errors. They are known to be one of the most frequent scenarios where bad outcomes happen, and where there are the most strict procedures and standards that require tackling during operational time.

Consequently, all these characteristics render *interfaces* as one of the most interesting areas of study for NOM. Some ANSPs have organised cross-unit NOM activities in order to observe real operation from both sides of the border. Others have even managed to organise a similar activity with collateral units belonging to a different ANSP.

Careful planning, objectives and a previous selection and design of the methodology is required. They are activities expected to be more intensive in terms of resources, but there are a number of benefits, not limited to the NOM results. Operational knowledge is increased at both sides, aspects not limited to the NOM scope can be also discussed, and knowing the person at the other side of the border creates a bond and actively shapes the safety culture due to a better understanding of the whole.

10.7. Tailoring methodologies to an ANSP needs

One of the most interesting aspects of NOM processes is the flexibility they provide when applied at practical level. Based on pre-existing methodologies any organisation can adapt the required process to be tailored to specific needs.

It is known for instance that NOSS is a methodology that can be intensive in resources. If a high level of confidence is required, there will be a need to have competent observers, the time required to have a high number of samples/observations to have a high statistical significance, the time to process... all this can render a project unreachable for an organisation without an already existing minimum infrastructure and expertise. NOSS applies a thorough threats and errors scheme, and not all of them can be captured by an observer, even being an experienced one, linking threats to errors and if possible, to good practices. It provides a good starting and complete starting point to select those aspects of interest for the NOM activity, and which is better, the simple selection and adaptation task done by the observers will prepare their mindset to what they should target to observe, or what can be expected.

It could be wise, and many organisations have applied this principle, to tailor the methodology to the specific needs. A wise practical advice would be to start deciding a limited scope, putting aside advanced concepts like statistical significance unless the study is specifically targeted to measure specific things. A simple 'open' observation session, just standing,

observing, and listening would be enough to highlight normal practices, both best practices and recurrent actions that could be deemed as errors, mistakes or areas of improvement. An approximate qualitative assessment on the extension of these practices would provide a more than enough as a starting point to have a good insight of *work as done*. A good observer will be able to highlight the interesting aspects at first sight and if necessary, perform a dedicated observation on that.

An organisation may also apply an already existing methodology but discover during the process, or after having finished the data analysis and results, that it does not fully fit its needs or the resources it demands are far too much. It is important not to forget that NOM needs to be *practical and usable*. A good advice would be not to be too rigid with the selected methodology, start by a simple project, analyse the process and refine it in an iterative way, just like applying a *lean* methodology to develop the NOM process.

Due to the lack of restrictive regulation in the field of safety surveys it is noted that a methodology can be tailored to any ANSP's need. This gives even "smaller" ANSPs the freedom to select itself how to design a NOM process at manageable costs, which could be crucial for a sustainable implementation. Austro Control made use of this opportunity by evaluating already existing NOM-methodologies like NOSS, D2D (NATS) and EUROSS (EUROCONTROL observational safety survey) with the intention to take the best out of all to finally adapt the best fitting NOM-method to their own needs, considering organisational aspects, available resources and the prevailing safety culture. Austro Control also made use of EUROCONTROL's knowledge in the operational implementation of EUROSS by consultancy.

At the same time all future surveyor/observers – all recruited from ATCO-staff – were involved from scratch in the modelling process of the Austro Control methodology which was named ACToss (which stands for ACTIVE operational safety survey). Basically, real-time observations are combined with interviews to execute the assigned goals of each survey. The survey-team has got the opportunity to use structured questionnaires as well to accomplish their mission. The ACToss methodology has been further developed over the years in order to constantly meet the demands of the organisation.

11. Inter-ANSP cooperation examples

Some of the ANSPs have accomplished cooperation projects that have fostered a deeper understanding of their systems boundaries and interactions.

In 2018 Austro Control and DFS have agreed on a project where NOM activities were performed on both sides with the same (operational) survey-staff. Four days were spent at both ACC-locations in Vienna and Karlsruhe applying the respective NOM-method of each ANSP. The exploration of the interactions provided a better understanding of work as done on both sides of the ATC-interface to improve these interactions. As a result, many improvements in the common Letter of Agreement could be achieved on the operational level. Furthermore, the exchange of information on NOM-level was very valuable for all participating surveyors.

Austro Control and ENAIRE started a cooperation project based on experience sharing. It consisted on participating in workshops and real NOM activities to provide an opportunity to revisit own practices.

Austro Control has developed its own methodology in NOM (ACToss), having gathered a wide experience over many years. On the contrary, ENAIRE started flirting with NOM in 2016. Since then, despite the scarce resources, most efforts have been targeted towards learning by doing and by carefully observing what other more mature organisations do in the field. An essential objective was identified on collaborating with other European ANSPs and participating in specific international NOM workshops.

The cooperation between Austro Control and ENAIRE has allowed an exchange of information and know-how in fields such as observations techniques, methodology, internal processes, documentation, and information processing. It started as an invitation to participate in an Austro Control yearly workshop for observers. The objective, was simply to explain ENAIRE's short experience and achievements, learn from what Austro Control was presenting during the discussions and provide an opportunity to network with observers from different organisations. No matter how naive it might appear at the beginning, the experience proved to be one of the most powerful learning mechanisms for an organisation striving to implement a brand new process that requires method, experience, will and a sound mindset. All that acted as a seed that helped as a catalyst to gain confidence, refine processes, and rethink what was needed.

A fluid, open relationship was established between both organisations, keeping a communication channel open that allowed to maintain the level of cooperation and trust, enriching both ANSPs.

The result for ENAIRE has been an open NOSS-based methodology, evolved during four years and six campaigns.

Austro Control staff was invited to participate in a NOM campaign performed at Tenerife North TWR (GCXO), to give them the opportunity to assess, analyse and compare both processes and methodologies. It was also a special NOM, where a new observer was to be trained for ENAIRE, which also gave both organisations the chance to assess how observers training should be done.

It started by an exchange of information related to the organisation, resources and logistics needed prior of the observation. The strategies to approach ATS unit's management along with experiences regarding observers' profile selection and training were analysed and compared. The observables selection process has been an interesting issue to compare, being both organisations different in their approaches, since one focused on a shorter, targeted list of observables, and the other had a more *open and detect* strategy, based on very simple underlying processes structured under the TRM conceptual framework. The outcome was astonishing, since both could fit the objectives, whose dynamical combination could provide a much deeper insight into the reality of *work as done*.

Both ANSPs have compared their observer's documentation, emphasising the observer notepad, post-observation questionnaire and de-briefing interview guide. There were major differences in the post NOM documentation production: from a thorough long end campaign report describing all the findings, to a much more surgical approach describing facts and actions. The first approach is highly necessary for an starting organisation, that needs to document all what is done in order to allow internal future know-how transfer and self-explain to the management, while the more mature organisations need to be more efficient in document production and simply get to the point.

Cooperation allowed both ANSPs to identify strengths and aspects to improve in future reviews, defining a common approach to the different topics of the NOM, tuning up the selection of objectives, monitoring

targets, observables and safety strategy processes. This helped to verify that the methodology, structure, execution and results of NOM activities were on the right track for ENAIRE.

Cooperation in the NOM field is desirable and will allow for common objectives and understanding. This conceptual framework will contribute to influence the aviation safety community to favour NOM methodologies and spread modern safety mindset in already existing processes. Classical Safety I processes are highly evolved, and have achieved a great reduction in adverse outcomes, but the effectiveness curve is flattening, resulting in high investments and efforts to get significant reductions in safety records. On the other side, the significant low records in safety events statistics indicate that the current organisations might be reaching what Erik Hollnagel called the regulatory trap: safety records are so low that no significant conclusions can be derived from the numbers, due precisely to the lack of statistical significance to trigger systemic changes that improve safety globally. There is a feeling that many organisations may be reaching the bottom and need new methodologies for further significant improvements.

Cooperation helps in common learning, sharing experiences, and is an opportunity to revisit already existing processes and practices. Both organisations always benefit from the interaction, which, although difficult to measure and *provide regulatory evidences for*, is real.

12. Integrating safety approaches

12.1. Safety I&II interactions

What this document is advocating for is the evolution of current safety processes into modern paradigms considering how the system really performs, how the system actively creates safety, oriented towards knowing what the operational reality is.

Safety I approaches will always be necessary; when outcomes are outside the desired envelope of operations, it has to be investigated and understood. These approaches foster independence of activities, but tend to evolve into organisational isolation, thus limiting the impact of safety-induced changes.

These approaches do not stress the fact whether an action is good or bad, they simply need to understand the complete operational envelope. Popular knowledge among safety specialists tend to understand Safety II as an approach to know what makes things go right. However, sometimes there are systems flaws even when things go right, stemming from technical systems, procedures, or human actions. NOM provides a tool to watch the operational reality, regardless the outcome and considering the whole systems components behaviour and interactions, ranging from the flawed to the outstanding. In a way we could think of a Safety 3.0 approach.

However, ANSPs still must face a myriad of regulation requirements, audits, supervisory activities, even the *reviled* safety incident investigations under the light of these new approaches. They are still necessary and must remain so. Recognising their need is of the utmost importance, and NOM processes do not pose any threat to already existing processes.

On the contrary, past NOM experience has proved to be extremely useful since their activities have created a bidirectional influence: Safety I processes feed NOM processes, and NOM mindset and tools have influenced investigations in a positive and decisive ways. Errors and mistakes are considered as necessary by-products of a system activity, and the complexity of connections of human behaviour with the rest of the system have created a completely evolved mindset that is configuring a better understanding of why things go wrong, and to take actions in the right direction towards systemic and efficient, or at least better targeted solutions.

Safety I related processes help in the identification of areas of interest for NOM processes. Both outstanding safety performance and safety concerns at specific units or areas can be interesting triggers to NOM processes to perform in-depth studies.

Safety II, NOM, systemic thinking and the like are configuring an evolved mindset in its practitioners that are shaping, at different paces, ANSPs safety culture. This mindset and its tools and methodologies is influencing in a decisive way everything related to Safety I.

12.2. Safety I evolution in tools and methodologies based on NOM

One of the unexpected benefits of NOM activities has been the influence and shaping of processes related to Safety I concepts, mainly on investigations.

Due to this influence, investigations are now profiting from a deeper understanding of *work as done*, a more thorough human performance explanation and even detect best practices during negative outcome events like incidents. Good recovery techniques, teamwork or communication skills, operations room management, offering peers help after an incident, all can be good practices to foster. We must not forget that bad outcomes, although having a low frequency, are also a natural part of normal operations.

Some ANSPs have adapted, in accordance with these approaches, their investigation methodologies to have a broader systemic perspective, for instance evolving from linear causal models into more complex factorial models, thus allowing for broader scope system interventions. These ways to understand real operational life has a decisive effect on just culture approaches and its associated JC algorithms, de-stigmatising human errors and even helping to interpret even reckless behaviour as a consequence of personal and systemic factors, along with systemic barriers that didn't work previously. It helps in understanding that errors and mistakes are social constructs.

These new paradigms require a different approach regarding the usage of language. New taxonomies have emerged that help in describing, guilt-free, more accurately what happened during occurrences.

The simple fact of trying to describe normal operations through monitoring or having difficulties to express, verbalise and explain good practices show how deeply influenced and biased safety processes are. NOM has forced to find a new safety language, fair, neutral, accurate, holistic. Away from prejudices and more descriptive than judgmental.

This is helping safety experts to shape their mindset simply by evolving the language and the style safety topics are spoken of. This is serving a much deeper objective, which is conforming solid foundations of safety culture, transforming it into an organisational safety mindset.

Wittgenstein proposed that statements are meaningful if they can be defined or pictured in the real world, representing a logically possible state of things. But this is different from the fact that the proposition is right or wrong. As a consequence of this, logically structured judgmental language can be meaningful, but it can be taken as a true statement, being profoundly wrong.

Language is taken for granted, and its influence in the mindset is often underestimated. NOM can help through the care of the language to influence how facts are perceived.

13. Performance indicators using NOM

Since NOM monitors and allows system understanding, it is a highly valuable measuring tool. However, measuring must be taken carefully, since the systems complex behaviour cannot be reduced to a set of numbers. Upon defining *performance indicators*, a careful analysis of what is being measured must be considered. Generally aggregated figures are measuring big subsets of the systems behaviour and need to be broke down.

The relevant question, however, is to have a clear view of what safety in terms of system state is. Unless an ANSP has defined its own safety measuring policy, all measures will be flawed and will probably be misinterpreted.

There is a number of candidates for metrics aiming at measuring system performance in terms of safety. Measures have different dimensions: can be qualitative and quantitative, and can have a focus on the past (lagging indicators) or a focus in the future, thus helping to predict how the system will perform (leading indicators) based on characteristics not (only) centered in bad performance (safety I approach).

It is important to remark that many safety indicators only reflect a partial view of the systems safety performance, and in fact measure unsafety, instead of measuring the real system's capacity to actively create safe and controlled systems states.

It might be advisable to the NOM practitioner to consider the usage of indicators, both lagging and leading, considering the appropriate application level:

- At operational level, applied to a particular front-end operator or a group of them
- At an overall operational ATS unit
- At the ATS unit management level
- At a group of ATS units (collateral, regions, types)
- At intermediate operational management levels
- At the overall company level

NOM can provide a range of tools according to the diversity of methodologies to focus on systems

performance, its controllability and the capacity it has to maintain its own behaviour under a safe states' envelope. It does not limit to number of incidents, or errors or potential threats, but also the robustness of current practices, the way the system components interactions maintain the parameters under ranges considered as safe.

13.1. Lagging indicators

Lagging indicators are those indicators related to what happened in the past in terms of safety performance based on the classical safety view. The most common are related to number of incidents, with different levels of aggregation (from ATCO records to ANSP global numbers) and decomposition (types of incidents). They also allow for different manipulations in terms of geographical distribution, normalisation by number of operations, flight hours or flown miles. These indicators are also mandated by current regulations in order for ANSPs to effectively monitor this particular aspect of safety, but they are actually measuring how much a system behavioural parameters fell outside the 'safe' envelope, being this for instance separation miles or hundreds of feed, technical systems availability time and the like. In a way they provide for an aggregated view of the results of systems behaviours in terms of system output but does not provide much insight into what is really going on inside.

NOM provides an additional insight into understanding the systems performance in terms of undesired states or behaviours. However, they differ from the classical view in the fact that they allow to measure in everyday work, regardless their final results in terms of occurrences. Is it not to follow a procedure necessarily unsafe? Is it to have an error unacceptable or would we have a deeper understanding if we knew that a unit team performs exceptionally detecting errors and most of them are inconsequential in terms of occurrences?

Methodologies based on NOSS, TEM profiling and D2D allow for measuring how the system behaviour deviates from the prescribed desirable norm. How many errors of what type, how intense is the influence of external threats, regardless their evolution into incidents or not. They provide a better insight into the habits, the current expected behaviour that

could not equal to what is expected from well trained professionals (although human and thus subject to error) and the application of comprehensive procedures.

If these measures are then combined with other metrics providing information about the effectiveness of the barriers, allowing to understand how resistant is the system to human or technical errors to be maintained within the safe envelope, we are not just measuring how unsafe the system behaved. The division line with leading indicators is then blurred, since we are combining past *unsafe* behaviour with the system capacity to actively create safety.

Other organisational lagging indicators commonly used are related to number of recommendations and their effectiveness.

The main drawback of lagging indicators is that they are commonly used to extrapolate future safety performance (i.e. number of incidents) based on past performance, but the assumptions might be flawed and lead to wrong conclusions. If we have good safety records, we expect to maintain them, but we don't know why.

Somehow the problem resembles the old psychological discussion amongst behaviourism advocating for a black box view of the mind and the cognitivism that puts the focus on the inner mind processes. We aim through NOM to be the systems safety cognitivists.

They provide, however, an excellent tool for monitoring the overall system behaviour and its evolution along time.

13.2. Leading indicators

There have been long and hard discussions on what leading indicators are. We make here a difference with the lagging indicators by considering the leading ones to have a better predictive nature of future safety behaviour. The reason is that the leading indicator should measure and/or describe the system inner behaviour (more stable along time), in contrast with the lagging indicators, that measures the system past output which is more affected by external factors.

Leading indicators are incredibly difficult to conceptualise and define. They need to be focused on characterising how the system performs related to WAD, and therefore could help in having a predictive nature.

An example that could be cited is measuring the efficiency of systems safety barriers. This provides an insight of the functional dumping required to avoid that adverse effects propagate across the system. Measures could be how many times the barriers have been activated, whether they have accomplished or not their objective, and the like. This provides a better predictive measuring on the capacity of the system to remain within a desired envelope.

NOM processes can detect soft barriers like best practices or personal strategies that prevent, detect, capture, and confine errors and mistakes. They provide a more complete view of the safety damping functions inherent within the system, which is, by the way, consistent with the learnings of resilience engineering.

Consequently, we could propose generic purpose leading indicators like level of extension of good practices.

Other candidates can be the participation levels into voluntary NOM data capture, the acceptance levels, number of requests to perform NOM from ATS units, number of cross-border activities and the like. There is a clear link to safety culture indicators that need to be explored, with a focus on the predictive nature.

There is another potential area for exploration on predicting indicators, that is the level of extension of good or outstanding good practices. Not only following procedures, but being proactive, planning ahead, almost attitudinal aspects which cannot be turn into procedures but are an essential part of a competent professional, can be detected and described through NOM. Its level of extension can provide a potential measure of how well the system will perform to maintain its states within the safe envelope.

We should be careful about defining indicators as reduced to simple numbers. NOM philosophy seeks to measure complexity, tightly coupled interactions, and profiling (sets of numbers) seem to better suited to this purpose, but no possibility should be excluded.

13.3. TEM Profiling

TEM profiles allow to provide an average snapshot of how the system performs in terms of errors, what are the threats present in everyday work, and how they relate. They are inspired by the NOSS methodology constructed around the threat and error management concept.

It consists in providing a distribution of the relative frequency of a predefined set of error types, along with the relative frequency the threats happen to appear in the *work as done* and something needs to be done. ICAO NOSS provides a quite comprehensive list and classification that can be adapted to particular needs. Typically NOSS processes will end up in an output that can be formatted into a TEM profile, although a light NOSS observation process can be put in place to start having a reasonable representative TEM profile, if the organisation needs agility to have quick results. The longer the observation process and the more areas to be observed, the more accurate the TEM profile will be (hence the NOSS if this is the methodology), but the cost in terms of time and manpower will be higher.

This profiling can be based on measures performed by the observers, thus reflecting the observer perception of the TEM profile. It can also be based on the front-end operators' perception about these errors and threats.

The profile can provide a good insight of abnormal levels of error types, and if performed over time, for instance, after a system change, it will allow to measure the effect the system change has had on *work as done*.

If the externally observed profile and the self-perceived profile are compared and do not cast consistent results, interesting information can be extracted, nonetheless. They can provide a complementary view not seen by the observer, a low self-perception of some risks, a low awareness of the frequency of errors in front end operators or flaws in the observer techniques. They need to be interpreted on a case-by-case basis.

13.4. RAG profiling

Resilience is not an inherent system property, but a system can behave in a resilient way and/or can have a potential for resilient performance. This is of great interest in terms of leading indicators that allow to anticipate future safety related system behaviour.

Resilience assessment grids can be adapted to specific needs, and therefore its application can range from an ATS unit to a complete organisation. They can be derived from the original resilience assessment grids developed by Erik Hollnagel.

Resilience assessment grids or RAGs are questionnaires based on four resilience areas intended to be assessed. These four dimensions measure how resilient performance is materialised at different levels. According to Hollnagel, the definition of resilient performance and its characterisation can be more concrete by considering what makes resilient performance possible, and thus four basic abstract (domain independent) potentials are proposed (sic.):

- The potential to respond. Knowing what to do or being able to respond to regular and irregular changes, disturbances, and opportunities by activating prepared actions or by adjusting current mode of functioning.
- The potential to monitor. Knowing what to look for or being able to monitor that which is or could seriously affect the system's performance in the near term – positively or negatively. The monitoring must cover the system's own performance as well as what happens in the environment.
- The potential to learn. Knowing what has happened, or being able to learn from experience, in particular to learn the right lessons from the right experience.
- The potential to anticipate. Knowing what to expect or being able to anticipate developments further into the future, such as possible disruptions, novel demands or constraints, new opportunities, or changing operating conditions.

(Source: <https://erikhollnagel.com/ideas/resilience%20assessment%20grid.html>)

Since the assessments of these dimensions need to be adapted to the actual survey needs, it is advisable that a prior questionnaire design and validation phase is performed. Validity and pertinence of questions can be tested, along with the questionnaire length. The target population must also be considered in order to adjust the language to what is normally used within different organisation areas.

Since RAG profiling is based on questionnaires, they can either be performed by an online platform, paperback or even admits a side-interview to gather further information and deeper exploration by the interviewer.

RAG profile will be represented by the different scorings at dimensions levels or at specific questions

level. They provide a good description of the system potential to exhibit a resilient performance, and, if questions are chosen with care, the potential of the system to exhibit a resilient performance in those safety areas of interest.

A RAG profile can be used for comparison between different groups of interest perceptions (e.g. front-end-operators and unit managers, high level managers). Longitudinal studies would allow for having a good insight of the temporal evolution and any potential drift in any direction, also providing information about the reasons underneath.

14. Integrating NOM within an ANSP

14.1. The challenge to integrate new safety paradigms

Any new paradigm shift entails an uphill battle. Safety current paradigms, within aviation and even more in other industries, have deep links to what was wrong, inheriting many classical safety investigation methodologies that were originally derived from criminal investigation approaches. They still embed concepts linked to simplistic causal models, root causes and guilt. Besides, regulation is still strongly influenced by classical paradigms, and the lack of compulsory regulation on the field is beneficial for the freedom of action and methodology, but also relegates these approaches to non-priority ancillary processes.

Developing NOM processes within an organisation is a real challenge. It does not only imply the definition of procedures, gathering resources, learning how to do it and try to have a positive feedback of its results into the system. It also implies changing the organisation's perception of a topic which is not required by the regulations, may be deemed as unnecessary, costly, or just another safety burden or a safety hype. The cultural mindset might also be so old fashioned that the openness required by NOM would create a strong rejection, allowing the 'get your nose out of my business' syndrome to emerge. Even though the high level of organisational safety within the aviation industries, there is still a strong feeling that the lack of safety is only proximal to operations, neglecting other sources and, to make things worse, not recognising that day to day work is actively creating safety maintaining the system state within acceptable parameters. That feeling is exacerbated by normative and legal frameworks that assigns responsibility and accountability without considering the complex nature of all the interactions behind human actions.

A key topic in NOM integration is that their activities do not lead to actions on the organisation that have a real, visible, and perceivable impact, and this can lead to frustration on front-end operators. It is important to either take actions or explain why no action is initiated after a NOM on relevant topics. Otherwise, participation on NOM activities may be disabled in the long run. An organisation may think of defining indicators of the degree of impact of actions in the operations, on safety and on its *perceivability* to assess actions.

Safety units have a long way to run, since changing cultural and mindset aspects is a prerequisite to access the necessary resources to perform NOM. These units need to profit from marketing approaches to shape the safety perception around NOM. An important effort is to be done in terms of explaining the wide potential for safety improvements, to change the mindset regarding the fact that safety can be heavily influenced by factors distal from the operation (in space-time and within the organisation). A better system performance understanding would revert in all safety processes and could also allow for integrated safety and efficiency improvements altogether.

14.2. Organisation marketing

NOM requires organisational acceptance. There is a need to perform NOM marketing activities in order to *sell* NOM benefits. They tend to be intensive in terms of resources, and there will be managerial resistance to release resources. On the other hand, NOM can be seen as an intrusive process that unveils the operations room secrets, and therefore a sound, strong trust relationship must be established across the whole process.

Organisation marketing must be carefully planned and needs to be founded on a solid communication strategy. These activities could profit from marketing development strategies like segmentation and targeting. We will use this approach for its simplicity to illustrate; depending the level of maturity or the *safety cultural starting point* you may not need it or require more complex approaches.

There are several groups of interest, and the approach might need to be adapted to each group. The first step is to find the right segmentation variables, that need to be adapted to the reality of the ANSP. The approach might not be the same for a big ANSP, providing services in different regions that replicate a full organisational structure and report to the headquarters than another providing services in just a handful of towers.

The most important insight regarding NOM marketing is that an organisation must answer the question of who the NOM customer is. Is it *safety* as an abstraction? Is it the organisation itself? Is it the top-level management? Is it the front-end operators? Is it the system as a whole and NOM is part of the system self-monitoring function?

We advocate to consider all NOM customers. All of them need to invest something for NOM to work (resources, time, interest). All of them get something in return. Always.

Having this in mind, the approach should always be customer-centered, so the segmentation, targeting and output might require specific adaptation to *each customer*.

This allows for a good segmentation for your target audience. There are a number of segmentation variables:

- **Geographical:** Specially interesting if there is a wide dispersion of ATS units or the ANSP is big in size
- **Demographical:** Who is our audience? What is their age? What is their academical background? Are there relevant cultural aspects?
- **Psychological / profile:** What are their professional interests? What is the level of interest in safety in general?
- **Customer behaviour:** How often have they applied NOM? Are they recurrent? Are we imposing NOM or are they requesting it? Are there prejudices against NOM?
- **Problems, challenges and needs:** What do they value? What do they seek?

The appropriate segmentation allows for the right targeting. That is the selection of the right segment to address. There are several factors when selecting the segment (target) and how to address them:

- Priority in terms of safety concern
- Current safety culture status in the unit
- Objectives of the NOM process
- Expected output

All these questions help in anticipation to objections and shape correctly meetings with managers, elaboration of audio-visual material, presentations, results feedback and the like.

There is also a number of auxiliary material that can be used within the NOM marketing toolbox, like success stories of other ANSPs, cost-benefit analysis based on incidents reduction compared with manpower effort in investigation and recommendations implementations, reputational assets, expected

increase in effectiveness of safety management scoring, other practices like what is covered by this document, etc. All this material is especially useful when targeting management layers in the organisation.

An extremely helpful tip is to build from the very beginning a sound repository of information and documentation.

There are three keys, however, that seem to be common to every NOM success story. The first is to start NOM activities on a low profile, the second is to build acceptance by trust (by management and front-end operators) and a focus on the results. When the level of maturity is high enough a more open approach can be applied, when previous experiences can be exploited to be the foundations for further communication activities.

14.3. Communication strategy

As explained before, there is a need to perform some marketing activities to a certain extent that also considers the safety cultural organisation status. All NOM activities, and specially *marketing* activities need to be based on a sound and specific communication strategy that needs to be tailored to each organisation.

The communication strategy should consider inner and outer recipients of communication. Within the inner targets there are several groups of interests or targeting segments to which communications should be shaped for.

Every safety unit in charge of managing NOM processes could profit from defining its own communication strategy, based on the following principles:

- Adapting the message to the targeting segment
- Considering the current safety culture levels
- Anticipating communication to the need to know of each target
- Establishing clear baselines for language use, making an effort to develop neutral / positive language in all communications. This will be developed further in a section below.

A useful tip is to invest big efforts on positive examples, best results, effect of fixing

problems for ATCOs, ethical aspects and NOM methodologies promotion.

NOM provides a deep system insight. Once an organisation is applying NOM processes is taking the Matrix red pill, and it should be clear that all NOM is offering is the truth. An organisation should be prepared for unexpected NOM outputs, and the communication strategy should prepare everyone for that, managing expectations and former prejudices. A unit assumed to be very good performing might in reality have an abnormal TEM profile, but events do not develop to an incident, or this is not reported, and consequently the uncomfortable truth is unveiled. On the contrary, a unit considered to be a safety concern may reveal that there are operational threats that shape the work as done in a way that shadows exceptionally good practices.

14.4. Matching needs, capabilities and expected outcomes

Before depicting the different maturity levels an ANSP may go through, it is interesting to analyse how an organisation may synchronise the needs, their capabilities in terms of NOM and what type of outcomes can be expected.

The following diagram shows the different levels of techniques that can be applied to NOM. Starting from the most simple original LOSA programme techniques, these can be evolved (lower layer in the pyramid) to improved LOSA programmes, or their NOM equivalent methods for ATM. Each level of complexity improved by techniques, formalisations, interviews, even available resources, etc. allows different levels of insight, ranging to knowledge of the systems symptoms down to understanding how its lower level components behave, manage their behaviour and how this evolves along time. A standardised approach will give you only symptoms but a tailored/focused/expert approach will give you the underlying issues that allow you to improve your operations taking into account a finer understanding of people at work.

However, this is a company decision (i.e. gears below) about how much resource, how much adapted to the organisation culture the method is, how deep you want to dig into operations.

This approach may help an organisation to proceed in different phases: phase 1 diagnostic with standardised tools. Then a second phase can be performed,

including a focused investigation with refined observation tools.

One important insight from this diagram is that each level of complexity of the tools provides a different insight. NOM cannot provide answers to everything since it depends on the tools nature and the rules of engagement regarding the observation.

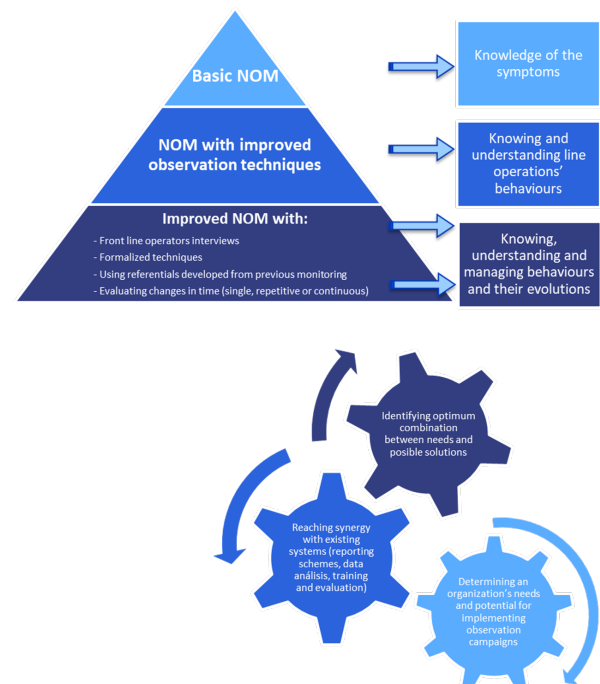


Figure 1: Levels of NOM techniques

14.5. NOM Maturity levels

When developing reference material intended for a wide range of organisation types it is important to recognise the different levels in terms of size, resources, knowledge, capacity, and the like. It can be quite hazardous if the reference material is understood as recommended best practices and an organisation strives to implement something at a level for which is simply not prepared. On the other hand, highly evolved experienced organisations might deem the material too basic for their use. This document just aims at gathering some general principles and provide an outlook of the availability of tools to manage NOM.

It is important to recognise and correctly identify what is the maturity level in an organisation, from a qualitative point of view. This would allow to correctly

identify the following steps for further improvement and will relieve organisational stress for newcomers into this concept.

We could propose a remarkably simple qualitative scheme for the different maturity levels, inspired by a classical scheme for safety culture. Of course, the phases are theoretical, and there can be some elements of several phases in an ANSP reality:

- **Basic-emerging**

NOM is not known or not considered as an important area of development, except for safety units interested in new safety approaches. Management is not familiar with this approach. Some simple activities, mainly using questionnaire-based methodologies, can be done at this stage, with limited results and feedback to the system. Operations management is not involved at this stage.

- **Reactive-managing**

NOM is partially known to the management, probably for its relationship with compulsory safety surveys demanded by national supervisory bodies. But in many cases, they are performed undercover, even using special names if the NOM is based on observations, not providing any hint of what it is about. NOM is applied to a limited number of cases, and all interventions are triggered by Safety I processes or safety monitoring. More advanced methodologies involving over the shoulder observations can be applied if enough resources are provided. This is a critical phase to gain organisational momentum since it will be the first time an organisation will have this kind of insight into *work as done* and leave this written into reports. It will provide an excellent opportunity to show its potential to unveil hidden problems, hidden outstanding practices and a different way to approach and solve otherwise unsolved everlasting problems. A diversity of reactions and acceptance can be expected at this time: mistrust (ATCOs might wrongly think they are a competence assessment or an attempt to spy on their activities; managers might consider a waste of resources), curiosity, hope, interest. Some first line operators may refuse to cooperate. All concerns must be duly noted and managed, explaining beforehand what is to be done, how is it to be accomplished, how privacy and confidentiality is to be guaranteed, how data are to be managed and the expected results. Lack of participation must always be

respected, and it should not be challenged until higher maturity levels are reached. It is a phase that requires extensive communication to all stakeholders and needs their involvement and acceptance. The number of NOM practitioners is very reduced; organisations might have plans to select and train a stable team. Operations management is informed of NOM activities and is provided feedback of results for their consideration.

- **Planned-involving**

NOM is known and has proven some practical results, gaining trust both at managerial levels and at operations level. The NOM team is growing, and the organisation combines its application to areas or units of concern, but not limited to incidents. Interventions are planned and done up to a certain extent proactively proposed by management and ATS units, which makes a breaking point in the implementation of NOM. Even units where there is no special safety concern are candidates for NOM. Feedback into the system provides safety improvements. Operations management could request or even participate in the process, even observing.

- **Proactive-cooperating**

ATS units and high level actively request NOM activities to have a deeper insight and knowledge of their activities. Cooperation of stakeholders is highly proactive, anticipating NOM needs and promoting participation. The NOM team has reached a certain maturity level in terms of experience, is widely known, accepted and trusted. Cooperation with other organisations is regular, joint NOM activities are planned. Major insights have been provided by processes and NOM has been the key to solve some problems. Operations participation is active, even proposing areas for monitoring.

- **Resilient-continually improving**

Planning process is done on a regular basis, and the NOM team has reached a stability level in its composition matching the organisation's needs. Cooperation and cross-ANSP NOM activities are performed. NOM is an integral and essential part of safety processes. Operations has integrated some NOM spin-off methodologies for their own continuous improvement processes.

14.6. Involving Operations Management

Due to the importance of operations in NOM processes, it is essential to involve operations management from the very beginning. NOM processes should not be applied without their support, and they always need to be informed. Ideally operations management should be involved at the identification of needs, at the planning phase, during the execution with regular feedback on how the NOM is evolving and eventually as part of the observers team. This helps eventually in managing the classical oppositional dynamics of safety versus operations, gain efficiency in the NOM process, time saving, etc.

In mature organisations, operations profits from the mindset and methodologies allowing operations specialists and managers to apply them to procedural design and verification in an agile way, thus shortening the design and optimisation cycle times.

NOM might help in having a closer integration of safety and operations, along with filling the gap between high level management and the front-end operators.

14.7. NOM observers selection and training

Observers are the professionals in charge of over-the-shoulder observations, and by extension they can also take over somehow different activities like interviewing, questionnaire campaigns and the like.

There is a wide consensus on the fact that the closer the contact with the operation (especially over-the-shoulder observations), the more critical the observer profile is. Consequently, a special care should be taken when selecting and allocating observers within NOM processes.

If we had to describe a competence scheme for observers, we would find that there is a number of technical skills, but these are outweighed by attitudinal factors and non-technical skills.

Selection of observers needs to consider factors like professional reputation and expertise, capacity to observe and disregard prejudices, capacity to listen and previous knowledge of safety topics. It should be a recognised and respected figure, and it is important not to disregard the social actors' opinion within the observers' selection, although the final decisions should be independent from them. A good advice

would be to work on candidates' pools so that the most desirable profiles are finally selected.

Since the NOM process, if based on observations, is pretty like competence assessments, it is advisable not to have the same persons performing both activities. In some organisations NOM processes are feared to be stigmatised by the similarities with the competence assessment, and therefore no competence assessor should perform NOM observations.

If NOM observers are to perform additional activities other than observing, namely social dynamics like TRM, facilitation and interviewing, further specific profile requirements could be necessary.

There is however some debate regarding whether it is better to have observers internal to the ATS unit or they should come from a different unit. There is no clear rule for this. Internal observers can provide a much deeper insight into the work as done, know the problems and can provide more *surgical* observations, but they can be strongly influenced by their personal biases. On the contrary, external observers to the unit can provide a fresh new look into WAD, but will probably keep, especially if the time is limited, a high-level view of the relevant topics of the NOM. The lack of biases and the possibility to compare what they observe with other units WAD is likely to provide a fresh new insight and questioning on the reasons behind the WAD practices they observe. An interesting strategy is combining observers from within the unit with observers from outside.

Regarding the observers training, there are several options. An ANSP may profit from existing training companies, but they normally focus on NOSS approaches. As a starting point it could be reasonable to have external training, but eventually every ANSP will tend to tailor any methodology to its needs and particular organisational environment and constraints. It is advisable that the ANSPs have their own NOM training process for observers, that should be mainly based on practice. The optimum is to have a team of observers that can profit from their observations experience in different units, so another advice would be to allocate observers to activities in as many different units as possible, and benefit from the reports and lessons learnt in NOM activities performed by other observers.

Practical advice would be to allocate the observers in accordance with your organisations needs and resources. However, NOM management should strive

to provide some cross-unit experience for observers, so that they can perform NOM at different locations and gain a deeper insight from the comparison of different practices across different units. An interesting hint is to allocate an observer with a background in the unit type NOM is to be performed on. For instance, if a NOM is to be performed at a TWR unit, the observer(s) should have at least prior TWR experience or have a current TWR endorsement.

It is also interesting to keep in mind the possibility to have more than one observer. This helps in reducing any possible bias, allows for checking emerging areas of interest and they can also perform observations in parallel.

In the long run every ANSP will experience the emergence of a team of observers, distinct from other reference groups, with a special spirit and mindset that should be taken care of. Consider setting up infrastructure for social networking, NOM workshops, specific courses, and the like. Observers are considered by many organisations as “safety ambassadors”. It is important that they have at least a minimum safety knowledge in terms of safety processes, safety policy, the current status in terms of safety-I related indicators, etc. It is also highly advisable that their professional behaviour matches what is expected from a *safety ambassador* and observing the good and bad things in everyday work.

14.8. NOM risk management

NOM activities are not exempt from hazards to their own existence. The concept itself is a disruption into existing culture, mindset, and organisational practices. These require a proper risk management in terms. This section provides a high-level managerial approach to the hazards any organisation wishing to implement NOM might face.

- **Managerial non-acceptance** implies not having sufficient resources to perform NOM in terms of time and manpower, and there can be a full rejection and prohibition to be performed. A sound communication strategy based on international recognised practices, success stories, showing that NOM poses no threat and disruption to existing practices might help in this. Special care with the usage of language is recommended when managing this risk.
- **Organisational rejection** can happen in different ways: it can be shown by other units, or by ATS unit managers, or by staff. It is advised

to manage rejection by a proper stakeholder’s segmentation and approach. For instance, a good way to manage rejection from ATS unit’s management is to carefully select the priorities to perform NOM, prioritising those whose acceptance and support by the management is more likely. Eventually, those managers more prone to reject new practices will even request NOM at their own units. Language should be adapted to this layer as well, and beforehand prepared material can be ready to present to anyone needing to know.

- **Front line operations non-acceptance and distrust.** This hazard can be managed by involving the social actors beforehand, explaining what NOM is about, how is it to be performed, how wilfulness and confidentiality is to be guaranteed, and putting a special effort into positive safety language. Looking for excellence, good practices, recognition of the complexity of the socio-technical system an ANSP is as a source for errors and mistakes, their non-criminalisation and rather a search to understand the mechanisms behind, all leads to destigmatising errors, considering them as part of the WAD supporting a sound and effective non-blame culture, essential for just culture and to allow the best practices to emerge. A sensible prerequisite for a successful NOM general process is a sound organisational Just Culture; otherwise reluctance will be a major topic.
- **Lack of resources.** This is a very real risk to every ANSP which is likely to happen at the lowest maturity levels. The strategy is to grow by success, adapting the activities to the resources taking as much care as possible that the NOM results are significant, provide a good feedback to the ATS unit and its managers, and provides new, fresh ways of understanding the underlying problems and good practices.
- **Lack of training and practice.** The advice here is simply to recognise it and just start observing. New observers can start assisting more experienced observers, working as a team, sharing what they observe and interpret and their own experiences. This *soft* training should not be neglected, but rather considered as the essential part of observers’ education and training, since it is adapted to the specific organisation’s needs and reality. Participation in external workshops and webinars, provision of reading material and a company library would be good minimum necessary things to be done to help observers that in many cases will have to start from scratch.

14.9. Impact of NOM in safety culture

Culture does not come easy and has the disadvantage of being extremely fragile. Culture needs to be continuously fed and actively developed and tends to degenerate when an organisation believes that it develops itself by the front-end operators. That is a flawed assumption that is creating many problems in complex organisations, especially if they perform a safety critical task. Culture requires a highly active approach.

Line operation safety audits or LOSA provided much more than a platform to develop over the shoulder observation methodologies. The use of the TEM concept structured observations in such a way that it created an interaction between observers and pilots that had a profound effect. The simple fact of thinking about one's errors and the threats that can affect the operation induces a mindset that prepares oneself better to face operations. The observer effect can also have something to do, inducing a kind of overperformance, but this effect tends to dissipate along time.

As one of the reasons for success of LOSA was the participation of reference professional pilots on the observations. Performing observations in a non-judgmental way allowed to develop interactions that shapes safety culture mindsets. And this has two critical features: it is permanent along time and tends to spread across an organisation.

Following the experience of ANSPs that have already performed NOM in some or other way, the reaction is similar. NOM helps in creating a trust environment.

Something that needs not to be neglected is that NOM is one opportunity to have a direct contact between safety practitioners and front-end operators. In some cases, it might be the first opportunity for operators to directly interact with safety units, outside the classical expected relation after an air traffic incident. There is an effect on the observed teams that positively shapes their perception of safety units, and this is extremely beneficial in the future. It brings trust, understanding, respect, and professional reputation. Safety is since then something more than incidents.

NOM also brings the possibility of tackling the level of safety culture by the preconceptions, practices, and mindset of a team of operators. This provides a highly interesting point since it allows to detect safety culture drifts hiding behind normal behaviour.

It also helps unveiling undetected problems like underreporting and its causes.

There is a need to continuously maintain and develop safety culture. One of the challenges faced by safety culture managers lies in deciding the right approach to do that. Just like NOM is addressing *work as done*, there are deeper levels that shape this WAD, that lie on how people think, what do people actually know, what do they expect, in a way it is *thoughts as done*. NOM helps in unveiling what those thoughts are, allowing to measure an accurate safety culture level. Knowing what is your starting point is essential in order to define your target; any safety culture related activity needs to be located in the area of proximal development, sufficiently close to the current *cultural* development state, but sufficiently challenging.

15. The importance of language

15.1. The overuse of the term 'survey'

One of the difficulties for those new to NOM is the number of occasions where the word survey is used, sometimes referring to different things and actions. The term is somehow overused due to its flexibility to be applied to a great number of activities, and there is a need to clarify its different meanings. It is important, consequently, to know what we are referring to, especially if there are different approaches to perform a survey within the myriad of NOM methodologies.

The Oxford dictionary has different definitions for the noun survey:

- an investigation of the opinions, behaviour, etc. of a particular group of people, which is usually done by asking them questions
- a general study, view or description of something

Within the current safety regulation and reference documents managed by safety experts there are several references to the word survey. Safety surveys are referred to in a number of documents such as:

- Regulation (EU) 373/2017, within AMC2 ATM/ANS.OR.B.005(a)(3) Management system, where safety surveys are identified as a part of the safety performance monitoring and measurement process. They are recognised as processes "examining particular elements or procedures of a specific operation, such as problem areas or bottlenecks in daily operations, perceptions and opinions of operational personnel, and areas of dissent or confusion". They encompass, as can be seen, a wide range of applications.
- ESARR 3 considers safety surveys as "a systematic review, to recommend improvements where needed, to provide assurance of the safety of current activities, and to confirm conformance with applicable parts of the safety management system" (source: skybrary).
- ICAO also refers to surveys within the NOSS published as "a methodology for capturing safety data during normal air traffic control (ATC) operations".

When addressing the different types of safety surveys related to safety assurance activities there are a few references to this type of activities, but they differ in methods, data collection and analysis.

- Proactive methods:
 - Periodic safety surveys
 - Targeted safety surveys
 - Continuous safety surveys
- Operational survey methods
- Engineering survey methods

Other interesting documents such as the EUROCONTROL *Ensuring Safe Performance in ATC Operations: Observational Safety Survey Approaches. A White Paper*, EUROCONTROL/FAA *Action Plan 15 Safety*, July 2011, introduces the reference to "observational safety surveys", analysing the commonalities and differences between the NOSS and the D2D approaches. Observational safety surveys are then those NOM processes based on normal operations observations.

The term survey is referring to a general process that gathers information based on facts or opinions to provide a description of a general or particular aspect.

It is important therefore to be specific when referring to surveys, since we can be talking about questionnaires, interviews, documentation examination or operations observations. Above all it is important to be aware of the many different processes and methods the word survey may be referring to.

15.2. Safety language or the triumph of the failure

Safety is inevitably linked to language describing negative outcomes. Ironically, the language we commonly used on safety communication refers to unsafety states and unsafe actions. This shapes profoundly the mindset and the perception of safety topics, and limits somehow the scope of what safety is about.

Language is extraordinarily rich when describing failure, errors, mistakes, problems, incidents, occurrences, accidents, etc. A common problem the new safety paradigm has to face is that they lack such an enriched and wide language to describe work as done, success stories, factors in a neutral way. Anyone who has tried to avoid judgmental language will know how difficult it is to remain neutral and adhere to the facts. We simply are victims of a linguistic inertia that acts as a ballast and renders difficult new ways of expressing safety topics.

Safety language is mainly focused on Safety I related processes and a great part of investigation terminology has been inherited from criminal investigations. No wonder why it is so difficult to implement just culture approaches if we use a language to help in safety improvements that was originally intended to identify guilt and search for justice.

A specific effort must be done to decouple abstractions like safety and failure. New ways to express ourselves must be found. There is a need to make a distinction if NOM is to be integrated within an organisation and get rid of wrong preconceptions regarding safety.

15.3. The NOM terminology toolbox: a word box for success description

NOM relates to everyday work. Errors and mistakes are an essential part of WAD, but they are only recognised as such if the actions evolve to *visible* negative outcomes. Otherwise they remain undetected and are inconsequential actions, quasi-errors or simply turn the blind eye on them.

Imagine a highly safety critical situation where both pilots and ATCOs manage to solve it quickly and without disruption to overall traffic and passengers. There might be errors in the actions, but we will probably obviate them and just describe what went right and how. There would be also a tendency to judge the actions as good, very good, outstanding, etc. which is also shaping the reader's perception. But this will neither reflect work as done. There is an intermediate point that adheres to the facts and gets rid of prejudices.

This does not preclude the usage of well-known terminology related to safety I. We have seen that errors are a consequence of everyday work due to normal human performance. Errors are labels assigned to human actions or inactions that deviate

from intentions and have undesired consequences. If errors are to be mentioned in NOM documentation, it is advisable that they are described using a classification scheme such as GEMS *General Error Modelling System*, being more specific (e.g. slip or lapse), or describe the actions themselves instead of using higher order full of prejudices like the words *error* and *mistake*. However, a good explanation of what errors are is necessary during the first stages of NOM implementation within an ANSP.

It is advisable that NOM practitioners develop their own black book including a word box and an expression box that supports the communication strategy. In general, it is preferable to explain why something did not get the expected results than summarising it as a mistake, and why an action can be considered a best practice given its contribution to keeping the system safety state within acceptable parameters.

15.4. Writing style guide

Each culture has subcultures, and safety is no exception. An expression of this is the existence of particular language extracts, normally used by the subculture groups. It is important to recognise that Safety II requires a specific safety language register related with normal operations, ranging from bad outcomes to outstanding performance. The hope is that this neutralised language will spread through more safety activities and influence global organisational languages. It is advisable therefore that each organisation considers the development of a style guide.

The effective application of systems thinking principles to safety related with the person within the system requires the use of a language characterised by its objectivity: lack of subjective considerations (and hence, different for each individual), that presents facts, that allows to extend safety culture to all aspects of the system, not to isolated parts, influencing a disagreement climate that is the seed to confusion between facts and opinions.

This kind of language will help in casting away judgements and foster information (vs. opinion) flow, a right participation and learning and will help in understanding a situation which is contextualised through different perspectives.

The linguistic uses are described by its objectivity and equanimity. There is a number of features

that should be pursued when using language with these objectives:

- Defined by an impersonal language that makes the presented facts independent from both the writer and the reader.
- Oriented towards the exposition of particular and specific facts, instead of thoughts, which are closer to personal judgements and beliefs rather than evidences.
- Conformed by the discourse neutralisation, avoiding appealing to emotions or values.
- Fed by a taxonomy that fosters a common vocabulary

Common safety language has inherited an analysis methodology that does not filter certain cognitive biases that affect all safety information managed and presented, which are known and should be avoided, like the hindsight bias, the counterfactual analysis, the personal actuations judgment, micro combinations, proximal analysis and causal simplification. There is a very simple strategy to mitigate the influence of these biases, which is based in the old analysis structure, that should be the basis to describe *work as done*:

- **What?** What happened? What actions or inactions have happened? What are the results of the events sequence?
- **Why?** Why did the actions or inactions happen? Why was a decision taken? Why did the factors could induce the facts? What distal factors could influence in the individual or collective behaviour?
- **How?** What are the mechanisms facilitating the interactions amongst the factors? How can we influence those mechanisms to prevent future events with similar results? How can we value other influences of change in the system?

As an example, if the NOM activity consists of over the shoulder observations regarding visual scanning techniques, there will be a number of occasions where the ATCO will not perform the visual scan. Note the difference between stating: the ATCO committed an error in the airfield visual surveillance *versus* the ATCO did not perform the visual scan due to having its attention focused on a problem with the CWP that was blocking flight plans. This guide does not advocate to avoid error recognition and its management, but to consider them an entry point into understanding work as done.

As already stated, traditional language used in safety investigation has been focused in the identification and description of the human actions or omissions within complex systems. The characteristics of this kind of language flow around the idea of what went wrong, which essentially betrays the seek objectivity, ignoring the rest of approaches, not considering what is intimately linked to, which is what went right, and therefore biases the reader towards a certain opinion. Traditional language is targeted exclusively to the reconstruction of failures, linear along time, to find the system subcomponent that failed (normally the human), eliminate root causes within the systems elements and subsystems, neglecting the importance of its interactions.

This section advocates for organisations to develop their own style guides in order to implement an effective linguistic neutralisation. This seeks ways to describe what went right, the description of the typical human performance adjustments, in reversing the understanding of these adjustments in the actuations, exploring what are the implications of the typical work, looking for different analysis perspectives, exploring the system and the way it works in terms of interactions, restrictions, latency, etc.

Ironically, it is easy recommending what not to use in order to change language to meet the previous objectives. As a general rule, expressions like the following should be avoided: failed to, he should have known/listened/seen, he could have, inadequate, loss of situational awareness, pilot/ATCO failure, erroneous judgement, wrong decision, if he had, unfollowed the procedure/norm, did not follow the standards, did not survey adequately, what he should have done was etc.

It is common to find assessments about the frequent occurrence of these situations. These are fundamentally qualitative, without the argumentation based on frequency data, and consequently having a strong subjective meaning.

Sometimes there is a usage of paternalistic language, or that stems some moral superiority, eluding the influence of other components, and leading to conclusions not induced by the logic of the facts, but starting from judgements, supported by beliefs whose effectivity is not predictable.

This section advocates to take care of the way language is presented, avoiding for instance certain typographic elements that suggest certain judgements; characters that outline certain actions (that could be identified as wrong actions), as could

be the capital letters, italics, bold fonts, underlining and the like. This has an influence on the reader and is opposed to the neutral style.

There are several recommendations, but they can also depend on the language specificities, and consequently each ANSP should derive its own ones. Use language always with a referential function, never expressive; favour impersonal language; use affirmative enunciative sentences; mind the right usage of discourse connectors to organise the story, respecting the time line and facts logic and avoiding indefinite areas that might lead to reader speculation; avoid the conditionals; avoid accusatory, emotional (figurative or metaphoric) terms in favour of specific, objective and particular; only use specification adjectives that marks off the names meaning (augmenting the precision of what is written); favour simple syntactical structures that help understanding messages better; consider subordinate sentences and watch the order and sentence marks to avoid ambiguities.

16. Conclusions – The future of NOM

As of today, the future of normal operations monitoring environment is uncertain although its applications are very promising. There is an increasing interest in ANSPs fostering normal operations monitoring and the benefits already reverted into the system have shown that further safety improvements can be achieved.

But the real power of normal operations monitoring lies within its capacity to actively create safety culture at all levels within an ANSP. An unexpected result reported by all ANSPs is the strong transformational power NOM has. Classical approach safety processes are definitely and irreversibly modulated by the mindset proxied by *Safety II* and *systems thinking*.

Through such practices an organisation starts to have safety reports where good practices are recognised, and errors are not stigmatised but rather accepted as a natural consequence of human performance variability and managed as such. Everyday work is an area of interest, to have a real understanding of the underlying and invisible processes, instead of being the area of bad human performance that management has to harness through stricter procedures, more training, more admonishing and more coercive measures. There is a breaking point related to the introduction of NOM, even not having that name, where a new viewpoint permeates the safety perception of the system performance, and this transcends the safety units and expands across the whole organisation.

To achieve this language is key. The way to communicate how the system performs and how can it be managed shapes the perception of all stakeholders.

As of today, NOM is thought to be applied to more activities different from front-end operations. A promising area is maintenance and the work of ATSEPS, as well as training, but it could virtually be applicable to any other ANSP process.

No regulation change is envisaged, but the recent Regulation 373/2017 and possibility to use NOM as a verification means for risk management related changes, could open the door for more visibility of these activities and its potential for NSAs and eventually for EASA.

We need to maintain a NOM strategy aligned with higher order safety strategies. Currently it might be wiser to gain maturity in methodologies, best practices, experience sharing, a common organisational momentum, than promoting lobbying activities for an unregulated aspect of safety. New regulations could be an opportunity since it recognises a need and creates pressure on organisations, but it could at the same time be dangerous for unprepared organisations or those that do not have enough resources.

The safety strategy should recognise the NOM potential, the need to foster its application and the allocation of resources, build presence in international bodies and prepare ANSPs to have an informed, decisive influence in any regulatory decision-making body.

This document should be alive. It should be updated regularly to reflect ANSP experiences so newcomers have a sound reference document and more experienced ANSPs can contrast their view and practices with fresh new ideas. It should also serve a basis for industry discussions.

Any CANSO ANSP is welcome to add an annex to this document describing the relevant aspects of their NOM activities.

NOM has a great potential and it has just started.

17. Appendix 1: ACToss – Active Operational Safety Survey



The Austrian ANSP, Austro Control, implemented a safety survey method for normal operations monitoring in 2013. The method is called ACToss which stands for ACTIVE operational safety survey, and was one of the first major pillars in the implementation of Safety II principles in Austro Control's Safety Management System.

Implementation was supported by experts of EUROCONTROL's MUAC, since they had some experience with their own NOM-method called EUROSS – EUROCONTROL operational safety survey.

Austro Control's safety and auditing experts have formed a team consisting of highly motivated ATCOs in order to design the ACToss-method in accordance with their needs and obtain acceptance by ATCOs. During the implementation phase, Austria's ATCO association and unions were involved, as well as all applicable ATM managers. The main selling argument was to rather help operations-managers understand how work is done on daily business and explain why things go right, instead of carrying out internal compliance-based audits with little benefit and impact on sharp-end operations. Another claim was to go beyond the threat and error management approach used by LOSA or NOSS. Therefore, Safety II thinking principles as demonstrated by NATS' D2D-surveys should be incorporated in this method.

The first trial surveys were carried out 2013 and 2014 with regular analysis of the method's usability. All stakeholders were asked and integrated in this analysis, namely the ATCOs carrying out the survey-tasks, the ATCOs being interviewed and observed during the survey-activities and the managers (safety-department and ATM-department) as main customers of the results. Many minor and major adaptations were made in the last years until all stakeholders got satisfied.

In the beginning ACToss-surveyors were recruited from available internal audit staff holding a valid ATCO-license. ATCO and auditor-competence is still a prerequisite for being an ACToss-surveyor. Even if the survey method significantly differs from auditing, the surveyor needs competence in interview techniques, data collection and analysis as well as report documentation. Over the years further trusted and well-accepted ATCOs joined the ACToss-team until a total number of 12 surveyors was reached. Besides the prerequisites, all surveyors receive a tailor-made in-house training, focusing on planning, preparation, execution (observing/interviewing) and report-writing. Participation in the annual ACToss-meeting and regular practical survey-experience is mandatory to keep proficiency high. ACToss-trainings and meetings are prepared and executed by experienced in-house Safety experts and augmented with speeches of non – Austro Control safety survey experts.

ACToss makes use of different methods including over the shoulder observations, interviews and (if deemed necessary) questionnaires. Over-the-shoulder observations are the backbone of each ACToss, but in addition – as the 'active' part – the ACToss-team conducts structured staff interviews (not at the working position) – either through personal oral interviews or through a questionnaire to be filled out by the surveyed personnel.

Observations and interviews/questionnaires are prepared by the nominated survey-staff, which are selected in agreement with all ACToss-members and consists usually of 3 or 4 surveyors. The assignments for each survey are determined by the Heads of Safety and Operations in line with subordinate managers, including local (Safety) management roles. Detailed planning and promotion for any particular ACToss starts about 3 months before the team is conducting the survey on site. The execution phase on site is completed after four days, including observations, interviews, data-analysis and a proper presentation of the results to the local operations-management. Even the final report, which is reduced to the relevant content, is available after these four days.

Over the shoulder observations are solely carried out under "normal conditions", whereby the focus is on the working position irrespective of the ATCO

on duty. In parallel, ATCOs off duty (e.g. on break) are interviewed in line with the prepared structured interview-sheet. Both, observations and interviews are targeting on the demand of the assignments asked by management. The final report is prepared together with the presentation of results and agreed with the local management during the concluding face-to-face presentation. It includes not only answers to the assigned questions but also agreed necessary actions to be taken by management in future.

While observations/interviews are performed by ATCO-surveyors only, the surveyor-team is supported by Safety experts during data-analysis, for the presentation of the results and for writing the final report.

Management receives the final report with strengths/weaknesses and extensive information regarding 'work as done'. Necessary actions to be taken are included in the report as well, which are later tracked by Safety-management-experts until effectiveness is achieved.

All observation-data collected as well as information received during interviews is considered as confidential and will be destroyed after the aggregation of results. The final report remains within the ACToss-group and is sent exclusively to all relevant/involved stakeholders, including the unit being surveyed.

Austro Control is carrying out up to four surveys per year at various operational ATM-units, including FIS-positions. On demand also cross-border surveys with adjacent ANSPs can be set up in order to gain deeper insights into the interfaces.

So far, the outcome of numerous ACToss has proven the success of this method, since results are satisfying both, Safety- and ATM-management, and furthermore noticeable improvements for operations-staff could be achieved.

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18. Appendix 2: DFS local safety surveys

General

In contrast to conventional audits, which aim to check compliance with requirements, Local Safety Surveys (LSS) serve to identify the difference between “work-as-imagined” and “work-as-done”. The focus of LSS is on the question why specifications or processes are not always lived as they are written on paper and how theoretical processes can be improved in order to make them better compatible with practice.

LSS is a moderated, expert-based approach that provides first-hand, up-to-date and practical information from the frontline operators about the safety situation in the respective air navigation services. With the help of workshops either the overall picture of a branch or – tailored to a particular part of a unit – a partial section (e.g. a certain sector group) is analysed. These workshops are supplemented by visits to the working positions within the operations-rooms to verify and complete the aspects discussed in the workshops.

In addition to operational staff (“sharp end”), in order to integrate several perspectives and to meet the most holistic approach, staff of the safety management, training management, project management, or operational assistance and finally all managers (“blunt end”) are involved in the LSS.

During the workshops with operational employees, it is particularly important to ensure that they don’t only focus on identifying and addressing weaknesses. They are also invited to propose, discuss, and reflect on specific opportunities for improvements.

It is always to be stressed that the information from the workshops are local perspectives and subjective perceptions not necessarily reflecting only objective facts.

Accordingly, the statements of the employees involved must be integrated into an overall picture, resulting in so called “aspects”. Formal audit findings, as it is common in conventional audits, are fundamentally not desired in this context.

Handling of the results

During a Local Safety Survey, many statements from operational employees, as well as executives result from the workshops. These statements are recorded in writing, analysed and finally documented in the so

called “aspects” in specific forms by the moderators. Within these forms, there is not only a detailed description of each aspect, but also the proposals for improvements from the participants.

The evaluation and implementation of the proposals or other measures is the responsibility of the unit management. After a certain period, a review is carried out to jointly address the development after the LSS.

Communication

The communication of results is of great importance for the relationship of trust as well as further activities of this kind. Therefore, the handling of the LSS results and any changes that have been initiated should be communicated and made visible to the employees. This poses a challenge to the dissemination of the results of the Local Safety Survey. Awareness about decisions, both made or neglected, is valuable information for operational staff and their managers.

19. Appendix 3: ENAIRE one-to-one safety

All NOM activities follow a lifecycle. From management, planning and preparation to the later effectiveness assessment. The following sections describe in a practical way how we manage NOM. It is an activity that goes beyond monitoring normal operations, it is the best opportunity to actively create safety awareness and build safety culture. It is done by pure presence and contact with the operators and the incredible positive effect this direct interaction has on everyone: on operators to think safety in a different way and on safety practitioners to perceive operations in a way closer to reality. We like to think of this process as *safety one-to-one*.

Management, planning and preparation

ENAIRE started NOM activities in 2016 as part of a safety plan for a TWR ATS unit. There were concerns regarding the safety records; there was an abnormal rate of incidents of a particular type, and organisational measures previously taken had proved little or no effect. Consequently, what we called “an observational survey” was planned and performed. It became evident during the NOM what the normal practices were, and how they were linked to the safety records and the investigations findings. Not only the normal practices and its extension were measured, but explained from the reality of the operations, and also from an organisational and historical perspective. There were several recommendations that after being translated into actions managed to achieve a dramatical drop in the number of incidents that were causing the safety concern.

Since then, NOM has been applied to very different scenarios: a pre-approach en route sector highly critical but with no safety record; to civil-military coordination within a complete region; to a complex ATS TWR unit with a high percentage of staff turnover and having most of the ATCOs a low average experience where the issue was not experience itself but interaction with technical systems and areas of improvement on TRM skills (equally necessary for some ATCOs both expert and novices); an ATS TWR unit where single RWY operation was analysed; and another ATS TWR unit where concerns regarding visual vigilance had been raised, but on the contrary previously unveiled, outstanding practices on visual scan and spontaneous, untrained, team resource management have been identified. Some NOM activities have been performed in phases where there is a wide variation of the traffic pattern along the year.

NOM is performed under the Safety Division and is done in close coordination with the Regional Directorate, the ATS unit management, the regional ATS directorate (operations management) together with the ATS unit staff representatives. There is also a strong link with operations management, who is provided regular feedback of the NOM process ongoing and if there is any issue. They should also be part of the observations from time to time to gain trust and provide visibility of the NOM findings dynamically. This creates an interaction that is highly positive, since they provide the historical records, reasons for procedures, and can witness work as done, centred in the system performance and not on traffic.

NOM is being applied on an ad-hoc basis. The main source to identify the upcoming NOM campaigns are safety I investigations, but organisational reality is also a source to trigger some activities. These sources provide the area of interest for the NOM, although some have been quite unspecific and have been difficult to plan in terms of defining the observables. In the case of the civil-military coordination there was a plan to observe how it was done at operational time, but the feedback and interviews suggested a better line of action, and much more effort was given to regional managers interviews to apply NOM to preoperational and company policy activities. In the case of the concern about the lack of wide experience of a big part of a unit it was also difficult to plan the observables, but TEM showed to be the best tool ever. It is flexible enough to start a NOM from scratch without having a predefined observable. There was just a need to sit down, observe and listen to those elements relevant to the observer, and the topics simply emerge. It was a demonstration that NOM is a highly flexible tool that can be applied to unspecific problems or concerns.

Meetings are organised with the regional management and the ATS unit to decide the best dates to perform the NOM. Their feedback is essential to select the best observation periods and how to approach the staff representatives. Some presentations are prepared beforehand explaining what NOM is, what are the objectives and the observation rules regarding confidentiality and voluntary participation. It also helps if previous experiences are summarised in the material provided to the unit.

The observer is nominated so that the ATS unit knows who is performing the NOM. The ATS is requested to send a message to the ATCOs and supervisors, especially those ones that will be working during the observations.

In some cases, it could be necessary that the ATS unit nominates a person to act as a liaison, helping with access to the operations room, introducing the observer to the staff, etc.

NOM preparation and execution

Prior to the execution of NOM there are a number of activities to be completed, like having informed all stakeholders, security permissions granted, presentations for ATCOs, material gathered, a previous safety dashboard including number of occurrences, severity and types, expected traffic patterns.

It is also advisable to have a NOM observer logbook to take notes and data. If there are interviews foreseen to be done, material should be prepared beforehand and it could be attached to the logbook.

These are standard activities that can be recorded in a checklist to ensure that everything is prepared for the observations.

Once the dates are agreed, and all stakeholders have been informed about the dates and time periods of the NOM activities, the observer(s) travel to the ATS unit, where they meet the unit managers and/or the liaison ATCO so that they are accompanied at all times and introduce them to the working team.

ENAIRE performs mostly over the shoulder observations. Before starting any data gathering or observation period permission is requested to supervisors and the ATCOs occupying the observed position. Observation periods vary from 30 minutes minimum up to several hours. After the observations, if there is willingness from the ATCOs a short debriefing is performed to understand specific actions. Following our experience, even though the observation periods are limited there is a strong benefit of the observers to remain in the operations room most of the time. This helps in *blending in*, and after some time the ATCOs tend to revert to their normal habits, so the observation of WAD is closer to what happens without observers. It is recommendable to take some rest periods and still observing without gathering data, up to a moment where *normal behaviour emerges again*.

Observations focus on the predefined areas of interest, that can be observed jointly or alternatively, and workload can be managed if there is more than one observer, which is strongly recommended.

Notes are taken in the logbook, although other means like laptop tools, scripts, even self-developed apps (for instance if time measures need to be taken).

ENAIRE uses NOSS as the basis for the methodology, although it is applied in a reduced way to optimise the observation times. In addition to this, the preferred scheme is to identify the TEM profile (both the observed and the self-perceived at the unit), along with the observed best practices, which are not limited to operational actions, but overall operations room management as well. The areas of interest allow restricting the catalogue of possible threats and errors, making it possible to have just one observer.

Observed operators are informed that the observation can be stopped at any time or if there is a safety situation. Sometimes they get nervous about someone writing down while they are working, so it could be interesting explaining what is being written down, even showing the notes, or moving to a position which is not visible to the ATCO.

There is some debate about the observer and observed interaction. This interaction during observations should be minimal for several reasons. The first one is that the observer should not be an element of distraction. The second is that the presence of the observer is modifying the normal behaviour of the observed person. However, it is important to know what the organisational and local cultures are, and the main objective should not be the interaction minimisation, but rather the observer blending in, and being one of them. If the observed person starts a conversation during a period of low traffic, this should not be avoided, since this creates an interpersonal barrier that might affect even more the observation due to additional stress for the observed. A good advice is to keep this interaction at the operational level asking questions about the normal practices, habits, specific elements observed previously and the like.

After the observations, or in parallel to them with other ATCOs not being observed, the observer performs a survey by using questionnaires to gather data for the unit TEM profile self-perception. It is advisable that different roles are surveyed, like supervisors, instructors, and unit managers since all of them provide a different view of the set of elements

that conform the unit reality.

This information can be complemented with further abstract observations and a RAG survey can be performed to define the resilience profile. It is advisable that this resilience profile is derived from different questionnaires: one for ATCOs and another one more specific for the unit managers.

Although there is a predefined area of interest, ENAIRE's observations have a great deal of flexibility. If during the observation of a specific position, there are other elements worth recording or changing the observed aspects. Sometimes a situation emerges or there is an ATCO or a team performing in an interesting way to be observed and described. Or there is a practice that excels in an area and the observer decides to jot down the relevant aspects to be transferred to the results report.

ENAIRE normally focuses the areas of interest in low level processes that shape higher order behaviours. The selected areas of interest are those that are critical for them. For instance, at TWR ATS units a critical element is the visual scanning patterns. Therefore observables like the different sequences of elements applied by ATCOs, success ratios, what are the elements affecting these scanning patterns and their coverage capacity, the influence of technical systems and the physical environment, time looking in and out are incredibly interesting to describe how this specific process shapes upper level actions like how decisions are taken or the influence over traffic separations.

The observers need to feel the support that they have this possibility to change the focus of observation to what they consider relevant. On the other hand, they must have some experience looking for elements to derive the TEM profile, need to identify actual and potential threats along with analysing in real time normal behaviour, in order to identify the factors influencing the observed behaviour. Good practices can be then detected from the logbook and using TRM conceptual structure can help a lot in verbalising and expressing why the observed actions can be deemed as good ones.

It is recommended that the NOM observers have some knowledge about TRM. Most invisible interactions and processes can be easily traced down to TRM skills and areas, and analysis is far easier. In addition to this, it is recommendable that the observer has facilitation skills so the debriefing/interviews after observations are turned into an opportunity

for ATCOs to perform a self-analysis of the factors they deem important under their actions. Facilitation skills help through structured questions and listening skills to perform a deep analysis. This serves a much deeper purpose. If the observed actions are within the range of outstanding performance or best practices, it can be jointly analysed how these were developed, how can they be disseminated to other operators, etc. If the observed actions fall within the range of unsafe performance (low attention levels, information not disseminated, plans not communicated, runway not visually scanned), debriefings pose a good opportunity to trigger a self-analysis on the factors behind the observed practices. This turns into an interesting one-to-one discussion that is actively creating awareness, safety consciousness and actively improving safety culture without using classical admonishing paradigms.

At the moment, the best strategy to capture relevant aspects during the observation periods is to enter the operations room with a mindset resembling a blank page, with no prejudices nor expectations. Just sit down, shut up, look and listen. Don't judge, ask yourself why.

Offline observation methodologies

There are quite a number of advantages in terms of a much wider "observable space", if offline observation methodologies are applied to specific areas. Usage of raster and comms recordings can provide information about *work as done* patterns and habits. They provide much more data but have the disadvantage that the data are not put in context, and there is analysis on the reasons behind the recorded actions. These are simply raw data that could eventually trigger a specific observation to challenge what has been observed offline. There are some disadvantages like possible legal issues if they are not performed under the umbrella of safety analysis activities and might raise distrust from front line operators.

Post execution analysis and results report

Data gathered is processed to edit a results report. It is advisable that the report contains background information regarding NOM, along with the unit contextual information. This helps in the understanding of data and provides a context to what is presented in the results.

There are several key results the report should pivot on. The first one is the TEM profile, where weaknesses in operation and vulnerabilities to threats can be analysed and prioritised when issuing recommendations. The second one is the best

practices detected and the level of extension across the observed population.

Recommendations are targeted towards the dissemination of best practices, the management of vulnerabilities and the optimisation of operation weaknesses. Recommendations are primarily designed to avoid additional burdens on the ATS units and are mostly focused on safety units to provide support in their implementation. For instance, if there are system vulnerabilities regarding external actors, recommendations are directed to the safety unit to manage them. If there are areas where specific training is recommended, the safety units are tasked with providing the basic material and help in adapting it to the ATS unit. There is an essential secondary objective, linked to the perception of safety units not being the reason for additional burdens.

There is also an important aspect, which is the expectations management. Sometimes the ATCOs believe that these actions will solve all their problems, or the ATS unit that the incidents will drop to zero. It is important that at all stages the NOM personnel informs that the activity targets the description and analysis of work as done, helping in damping those weaknesses and vulnerabilities fostering good practices, but continuous improvement is an ongoing process and there will always be room for improvement everywhere.

The report is presented to the safety managers, both national and regionals, together with the ATS management / operations managers, together with the ATS unit management.

ATS units feedback

There is an essential step that is the provision of feedback to the ATS unit. Apart from developing a disclosed report that can be read by everyone at the unit, it is advisable to organise some specific feedback activity on the result. Meetings, presentations, workshops are highly advisable. This allows for questions, explanations, and even further suggestions by the operators.

It is advisable that the feedback is provided personally by the safety units, avoiding publications, and not being seen by the unit. If there is geographical distance, the usage of webinars, that can also be recorded, is an option to explore.

System return

There are always elements after a NOM that are common to units different from the analysed one.

The results should be disseminated throughout the organisation having into account the restrictions. The very first level is to build a knowledge base within the safety unit that complements safety I information that can be made known to other safety managers. ENAIRE manages five different regions, each one having a safety manager in charge of several ATS units. All our activities are disseminated to each one of them in order to create this NOM knowledge and try to disseminate good practices.

Assessment

Never forget assessing the NOM campaign effectiveness. Difficulties, strong and weak points, improvement opportunities for your NOM processes, etc. The best way to assess the NOM activity results is to ask yourself: is the system better after the NOM campaign? In which way? How to assess that? Can you measure it? Is it a qualitative perception? Is there a measurable perception of the ATS unit of the benefits of the NOM campaign?

20. Appendix 4: DSNA O.S.P. “Observations Sur Position”

20.1. The NOM lifecycle: From planning to safety improvements

Observations Sur Position (OSP) at DSNA is the result of a long process of trials and errors. The method reflects the accumulated knowledge gained thanks to the commitment and curiosity of many people over the years. Many different situations were observed ranging from local small scale experiment to large modernisation programs, including safety issues, always with a view towards achieving a scientifically valid but operationally pragmatic approach and with a high degree of respect towards the professional expertise of those being observed.

MANAGEMENT: WHAT IS DONE AT DSNA

DSNA has a small pool of qualified NOM safety practitioners, some with appropriate formal academic training. Only a couple of people are able to teach NOM practices. NOM is used for Safety Risk Assessment of large changes (e.g. electronic stripping and new CWP) and also for some local change; it is part of the new SRA process compliant with 2017/373 as a possible tool.

In the short-medium term, DSNA will include NOM in a toolbox for human and organisational factors (SYNERGIE project).

PLANNING : WHAT IS DONE AT DSNA

First, informal contacts are made with the relevant local or program hierarchy to plan the observation campaign. Then, during a first meeting, the appropriate people are identified to carry out the project and observations. The populations that will be observed is also identified based on the analysis of the scope of the issue. Training session for observers can be planned in parallel with the development of the observation strategy (what, when, how).

EXPERTS/OBSERVERS SELECTION AND TRAINING: WHAT IS DONE AT DSNA

DSNA's NOM experts either have received academic training in human and organisational factors in aviation or similar or have received observation training provided by DSNA experts. NOM approach at DSNA is framed by reference documents as summarised in this template.

Observers are usually ATCOs in order to avoid the difficulty of understanding local controlling strategies and be focused on issues identified in the planning phase.

PREPARATION : WHAT IS DONE AT DSNA

The training experts helps in the preparation of NOM. Observation topics to be monitored in NOM are identified via an analysis of the topic (nature of the change, type of safety issue), with possible calibration of the observation grid in simulator. Examples of expected observable cues are used to illustrate what to look for during the observation and what to write down. The timing of the observation planning is also crucial, as one needs to ensure that the right traffic or the right sequence of events are expected to occur during the observation.

Everything is compiled in an observation data sheet that will be used to collect data during the observation phase.

Use of theoretical and academic knowledge may be necessary for development of questionnaires for semi-directed or free interviews after NOM, use of cognitive-discursive analysis with appropriate software etc.

EXECUTION : WHAT IS DONE AT DSNA

Presentation to the observed teams or communication about the observations are done several days in advance, how the NOM will take place, in order to gain buy-in and trust. This involves planning of the days, schedules, and sectors / time of day observed, explaining how the observers will be positioned in the control room or tower in relation to the ATCOs being observed and adapting as necessary, describing the modalities of interacting (or not) with ATCOs while they are carrying out their task, agreeing on possibility for debriefing sessions, and so on.

NOM LOGBOOKS : WHAT IS DONE AT DSNA

DSNA's NOM experts develop tools such as: interview grids, observed data record sheets, or any other useful tool for a NOM campaign. Also, in order to be able to complement the observations with additional data, the logbooks often indicate the start and end times of a NOM, tools/functionalities and controller

working position details that have been observed in order to provide contextual elements that can help in the subsequent interpretation of the data collected during the NOM.

OFFLINE OBSERVATION METHODOLOGIES :

WHAT IS DONE AT DSNA

DSNA bases its offline observation methodologies on the same robust and proven methods that are used for real-time observations.

FLEXIBILITY: WHAT IS DONE AT DSNA

In practice, the observers are trained and can rely on experts for advice. They are expected to be reactive to, for example, adapt the observation data sheet to overcome a difficulty in observing a phenomenon on site. Flexibility is one of the principles of the NOM method of DSNA in order not to disturb operations and avoid intrusiveness.

POST EXECUTION ANALYSIS: WHAT IS DONE AT DSNA

A range of tools is used to analyse collected data depending on its nature. If possible, experts different from those who conducted the NOMs do crosscheck. Over the time, the method is improved with different complementary analysis approaches to increase robustness of the results. As an example, recently, cognitive-discursive analysis was tested.

RESULTS: WHAT IS DONE AT DSNA

The presentation of the results may vary depending on the type of NOM conducted. It ranges from informing specific issues of a safety risk analysis of a change to a research report. The deliverables presenting the results can cover different aspects of the situations or topics being observed.

ATS UNITS FEEDBACK: WHAT IS DONE AT DSNA

At DSNA, a post observation interview is usually performed after the observation period – this helps validate observed data and ensure that observed ATCOs can contribute their perception of the situation. This makes it possible to identify possible misunderstandings or inconsistencies.

Then feedback once the results are consolidated can be provided. Depending on the unit, they can be formalised in newsletters, instruction letters, presentation, or any other communication medium.

SYSTEM RETURN: WHAT IS DONE AT DSNA

Depending on the purpose of the NOM, outputs are used for safety risk analysis, monitoring of specific issues after a change or investigation of a

safety concern.

Under the Integrated Management System, DSNA uses NOM outputs to improve and inform safety management.

ASSESSMENT: WHAT IS DONE AT DSNA

DSNA performs two types of assessments. The first is the evaluation of the progress of the observation campaign, which tracks the quality of the project and the choice of the most relevant way of producing a rigorous analysis.

A second type of evaluation occurs if the NOM campaign is part of an analysis for implementing a modification of the working methods of ATCOs. This assessment consists in an additional NOM that aims to assess whether the recommendations from the first analysis are properly implemented, to uncover issues that could have been overlooked, or emergent issues related to the change.

21. Appendix 4: ICAO normal operations safety survey – NOSS

21.1. Introduction

NOSS was developed by a partnership formed by ICAO, the University of Texas, and ANSPs such as DFS, UK CAA, US FAA, NAV CANADA, Airways Corporation New Zealand, Airservices Australia and organisations such as EUROCONTROL and IFATCA.

ICAO NOSS has been the LOSA heir by default, bringing its conceptual framework from the cockpit to the operations rooms within the ATM world. It provided a means to view safety as an active activity across all actors within an organisation, allowing for a more accurate view of what really happens in the front line, without judgmental labels. In addition to this, the usage of the TEM framework allowed the development of CRM and eventually TRM in the ATM domain, shaping safety-oriented minds within a new broader conceptual structure closer to operations providing contextual information at the same time. NOSS has opened the view of many organisations by unveiling what really happens at the front end and why, and how safety is a dynamic and slippery abstraction. They have realised that current safety information and safety intelligence data based on reactive processes may not be sufficient to fully manage a systems' safety.

NOSS has been applied in a number of ANSPs and continues to be the basis for NOM tailored approaches matching an organisations' needs and resources. It is not the intention of this appendix to fully describe NOSS, since there is enough reference material for its implementation, specially within the document *ICAO (2008) Normal Operations Safety Survey (NOSS). 1st Edition. ICAO. Order No. 9910*. A brief summary of the characteristics of this methodology is presented below.

21.2. Main characteristics

NOSS is an over-the-shoulder survey methodology based on observing real operations during normal times. They are performed by trained who are recommended to be adequately selected and trained ATCOs. The participation of the front-end operators in the observations is required to be voluntary, upon

the requirements of anonymity, confidentiality and not taking any punitive action.

NOSS underlying conceptual framework is TEM (Threats and Error Management), and consequently the focus is on threats, errors, and undesired states. Consequently, it aims at detecting, identifying, classifying and measuring these three main aspects, that can be complemented with strategies and best practices applied by ATCOs (and other personnel) to detect and confine errors, damp the effects of threats if they come alive, detect and correctly manage undesired traffic states, if that concept can be transposed from the cockpit into an operations room, a sector or a controller working position.

Observations have clear start and stop rules, where an observed professional may stop at any time, and they are performed during normal shifts. Pure NOSS precludes a briefing after the observations, although some ANSPs have adapted the methodology including a post observation briefing to seek for further explanation of actions and a more thorough identification of threats and errors. Participation in the surveys is voluntary, and in order to manage and foster participation it is a good strategy to look for management and social representatives' associations support.

All the information is de-identified and managed through the confidentiality measures taken as if they were occurrence related data. Data is verified and collected under secure sites, and special care is taken when analysing them and deriving conclusions. Some organisations use a third party to analyse the data independently, although this is subject to the ANSPs availability of resources and is not required by the ICAO methodology.

It is important that the observers are carefully selected and trained. It is normally recommended that they are selected among air traffic controllers, and organisations should find a balance between selecting ATCOs from the observed unit or ATCOs from other units, maybe less subject to bias but less experienced in detecting subtleties during observations.

A good strategy is to launch a promotion

campaign that explains what is to be done, how, who is performing the observations, what is the objective, and maybe referring to previous experiences within the ANSP. It is also essential to provide feedback of the survey results to the staff: findings, recommendations, actions taken, and recommendations that have not been followed.

As a general recommendation, a NOSS programme should be addressed under a complete lifecycle management approach: overall management, planning, experts and observers selection and training, preparation, execution, tooling (logbooks, computers, data management software), complementary offline observations and safety related data, flexibility, post-execution analysis, results, feedback, return to the system and programme assessment.

NOSS can also serve as a tool to verify the effect of a previous NOSS, something also linked to changes safety management process now recognised within Regulation (UE) 373/2017.

According to the previous experiences of organisations that have applied a full NOSS approach, it is an intensively resources-demanding methodology in order to have a good data representativity from an statistical point of view. Other organisations have had a much more limited approach and have successfully applied the method to specific positions within an ATS unit. This advocates for the flexibility provided by the concept rather than the method followed to the letter, turning NOSS into an extremely versatile tool that can be adapted to virtually any organisation size and observation target. Most organisations have adapted up to a certain extent their observational methodologies based on the NOSS concept.

21.3. Reference material

- ICAO (2008) Normal Operations Safety Survey (NOSS). 1st Edition. ICAO. Order No. 9910.
- ICAO: Threat and Error Management (TEM) in Air Traffic Control Approved by the Secretary General and published under his authority PRELIMINARY EDITION – 2005
- Ensuring Safe Performance in ATC Operations: Observational Safety Survey Approaches. A White Paper. EUROCONTROL/FAA Action Plan 15 Safety. July 2011

22. Appendix 5: Team resource management and facilitated analysis sessions

Team resource management training, whether fully formal training as established in the regulations or specific, dedicated or as a result of a safety recommendation, is an excellent opportunity to access *work as done* as perceived and experimented by the front-end operators.

If the TRM sessions are part of the regulated training plans and are compulsory, they have the advantage of providing a full coverage of an ATS unit population, and therefore the sampling possibilities if compared to other methodologies.

Even though the main TRM training objectives are focused on non-technical skills development, if TRM training is performed using facilitation techniques, it provides an excellent platform to identify the most preoccupying threats, most frequent and most relevant errors, undesired states together with a set of countermeasures that serve as strategies to actively create safety. Best practices, crosschecks, cross-monitoring techniques, not phraseology-based communications (mainly between ATCOs), how to recognise undesired states and tips to manage them. A good example is the identification of specific communication tips between controllers to manage their coordination. They are not subject to phraseology subject to regulations, and ATCOs need to adapt it to their needs. If there are good practices and are adopted and applied by an ATS unit, they can become part of the standard operating procedures thus reverting WAD knowledge into a global permanent system modification. Well known CRM-related expressions such as *my plane – your plane* can have their translation into ATM language like *my sector – your sector* during a handover – takeover strengthening the process.

Sessions can be summarised by the facilitators. Even a simple half a page report per session can provide a good insight that, if carefully analysed, can provide many ideas for improvement apart from the systems knowledge looked for by NOM processes. If a whole ATS unit population is to be trained during a campaign, information gathering can be a lengthy process. Analysing and structuring all the information can also be a lengthy process but can provide a highly valuable side product from the TRM sessions.

They can, however, have the disadvantage of not being as systematic as other approaches such as NOSS, having a more random approach or just focusing on the campaign theme. Facilitators might need support from observers or require training on the TEM framework to drive the sessions.

Specific sessions can be organised to analyse an occurrence, a scenario, an event where everything went smooth, virtually anything, and a selected group of participants can provide their views and if correctly facilitated, can provide a deep insight into work as done and ways to provide further and easier adaptive capabilities to the system in particular areas of concern.

It is essential that the results are reported back to safety units and also to operations management units.

23. Appendix 6: Offline observation methodologies

Current (and old) technology developments have allowed the introduction of new uses of existing systems. Observations, though preferred to be done on site, can be performed offline using data recording systems.

Although by using the systems there is a broad filtering effect and many relevant data are lost in the process, their usage should not be discarded easily. They allow to trigger in-depth NOM activities, complement previous observations, help in validating or confirming previous data from investigations or from NOM.

Their potential comes when applied to specific scenarios and action categories. Observation of current communication practices (with pilots or even between ATCOs) can reveal current practices, determine a TEM profile for instance and identify best and worst practices.

If radar data is used, behavioural patterns can be derived and used as a basis for analysis of a dedicated NOM process. For instance, observing offline how ATCOs provide separation between an arrival and a preceding departure using a single runway provides a much broader sampling that allows the identification of patterns and likely scenarios associated both with success and failure in the separation provision. Once these scenarios are defined, they need to be further understood by analysing the interactions influencing the systems actions.

It should be noted, however, that offline observations, by their own nature, do not provide a complete insight into work as done, it will help in the descriptive phase of any analysis, but will have many difficulties in providing answers to *why*.

More than a methodology itself, offline observations are an auxiliary tool that will support and greatly enhance any NOM process.



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