Safety Intelligence tools for Executive and Middle Managers

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Short abstract: Future Sky Safety is a Joint Research Programme (JRP) on Safety, initiated by EREA, the association of European Research Establishments in Aeronautics. The Programme contains two streams of activities: 1) coordination of the safety research programmes of the EREA institutes and 2) collaborative research projects on European safety priorities.

This deliverable is produced by the Project P5 "Resolving the organisational accident". The main objective is to reduce the likelihood of organisational accidents in aviation via the development and implementation of a Safe Performance System. This deliverable concerns the use of Safety Dashboards to support safety intelligence at executive and middle management levels.

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Acronyms

Acronym	Definition
AIM	Accident Incident Model
ANSP	Air Navigation Service Provider
ATCO	Air Traffic Controller
ATS	Air Traffic Service
CAA	Civil Aviation Authority
CANSO	Civil Air Navigation Services Organisation
CISM	Critical Incident Stress Management
ESI	Executive Safety Intelligence
FDM	Flight Data Monitoring
FIR	Flight Information Region
KPA	Key Performance Area
KPI	Key Performance Indicator
LoA	Letter of Agreement
NSA	National Supervisor Authority
PI	Performance Indicator
RAT	Risk Analysis Tool
RI	Runway Incursion
RP	Reference Period
SDB	Safety Dashboard
SES	Single European Sky
SPI	Safety Performance Indicator
STCA	Short Term Conflict Alert
SMI	Separation Minima Infringement
UG	User Group
WP	Work Package

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EXECUTIVE SUMMARY

Problem Area

The central tenet of Safety Intelligence is that those at the top of an organisation can make the right (safe) decisions. This requires two things: the right understanding of safety, and accurate information. The first deliverable in WP5.1 "Safety Intelligence" of Future Sky Safety P5 "Resolving the Organizational Accident" (D5.1) concerned the 'understanding' part. This current deliverable from WP5.1 "Safety Intelligence" concerns ensuring that executive managers have the right information in front of them when making decisions that can affect safety. Since there is a plethora of information, all the sources of safety-relevant information need to be analysed, refined, reduced, and presented in an accessible way. Increasingly this is done via a Safety Dashboard (SDB).

The key question this deliverable addresses is *what* to present on safety dashboards. In more detail this means deepening our understanding of SDBs actually in use inside aviation organisations, in terms of *what* is represented on such SDBs, *how* they are used, and for *which purposes* by *whom.* The overall goal of this work is to determine how to improve Safety Intelligence, by generating best practice guidance on safety dashboards.

Description of Work

The Work described in this report is based on the analysis of SDBs from a Safety Dashboard User Group, created by ECTL in February 2016 and made up of five ANSPs - AUSTROCONTROL, AVINOR, MUAC, NATS and Skyguide. Two main activities occurred with the SDB User Group during a six-month period:

1. In-person interviews to Safety Directors / Safety Managers: aimed at acquiring knowledge on SDBs inside ANSPs: roles, users performance indicators, visualisations and platforms;
2. A workshop with all the SDB User Group members: to enable an exchange of experiences and best practices on SDB between members.

The analysis aimed at defining the status of each SDB inside the organisations, creating a scheme of levels of capability and identifying possible trajectories for the evolution of SDBs (from static to interactive, from manual to automated, etc.).

Results & Conclusions

On the base of the interviews result it was possible to identify the characteristics and uses of the different SDBs of the participants to the SDB User Group. The acquired overview paved the way for an initial classification of the different levels of capability in the design and use of SDBs and for a first recognition of unaddressed needs.

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The workshop led to the development of a potential 'best-in-class' safety dashboard for Executives, as well as guidance on how to use SDBs and how to avoid common pitfalls in their design and usage. The workshop also highlighted how SDBs need to evolve in the future, with the focus on the features and characteristics of the SDB that could be enlarged to include the design of an overall architecture in support of Safety Intelligence, based on the following principles:

- *Digitalisation* of safety information – as much as possible;
- Storage of the information in a *single database* (or any other technical solution that enables a seamless integration of data);
- Extended capability for *statistical analysis and data exploration* (e.g. drill-down, correlation, geo-localisation) – partly automated, partly manual;
- Extended capability for *information visualisation*, i.e. capability to prepare and present information in ways people can use it with efficiency and effectiveness

The Safety Dashboard User Group members agreed that middle managers need an "enhanced" SDB, i.e. a tool capable of accessing, processing and visualising a huge variety of different data sets, especially for what concerns those strictly connected to operations (e.g. ATS geography, time, environmental conditions, shift, status of equipment, procedures in use etc.). The reasoning is that middle managers are the most eligible staff members for the integration and sense-making of the results of safety data analysis as, by using their operational expertise, they can raise the "right questions" when looking for underlying causes. Considering that middle managers are not likely to be people with a background in statistics or IT, there is a need for equipping them with software tools that are *highly automated* in the retrieval and processing of data but at the same time extremely *intuitive* in their usage.

Applicability

The current focus is on Executive (Board-level) dashboards. Dashboards at middle management level are less frequently employed. This is a potential problem, as middle managers are often the people best placed to make sense of safety data and create risk profiles, and it is desirable to have safety intelligence 'joined-up' throughout an organisation. This aspect will be returned to in two future deliverables (D5.9 & D5.11). Additionally, in 2017, work will begin with airlines to see how they use SDBs and whether there is room for any type of data alignment across aviation sectors (e.g. between airlines and ANSPs).

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1. INTRODUCTION

1.1. The Programme

FUTURE SKY SAFETY is an EU-funded transport research programme in the field of European aviation safety, with an estimated initial budget of about € 30 million, which brings together 33 European partners to develop new tools and new approaches to aeronautics safety, initially over a four-year period starting in January 2015. The Programme focuses on four main themes:

1. Reducing risk of accidents
2. Improving processes and technologies to achieve near-total control over the safety risks
3. Building ultra-resilient vehicles and improving the cabin safety
4. Improving safety performance under unexpected circumstances.

The Programme which includes five projects with a risk-reduction focus in five technical areas (runway excursions; total risk picture, resolving the organisational accident; human performance envelope; and fire on board an aircraft) also helps coordinate the research and innovation agendas of several countries and institutions, as well as create synergies with other EU initiatives in the field (e.g. SESAR, Clean Sky 2). The Programme has started on the 1st of January 2015.

FUTURE SKY SAFETY contributes to the EC Work Programme Topic MG.1.4-2014 Coordinated research and innovation actions targeting the highest levels of safety for European aviation in Call/Area Mobility for Growth – Aviation of Horizon 2020 Societal Challenge Smart, Green and Integrated Transport. FUTURE SKY SAFETY also addresses the Safety challenges of the ACARE Strategic Research and Innovation Agenda (SRIA).

1.2. Project Context

The objective of P5 “Resolving the organisational accident” is to reduce the likelihood of organisational accidents in aviation via the development and implementation of a Safe Performance System. Safety focus has traditionally been on technical failures and human errors as they occur in operations, while new and promising approaches consider the overall socio-technical system in the full operational and organizational context. This Project addresses the effects of organizational structures, processes & cultural phenomena on safety performance in aviation organizations. The key areas comprising the resolution of the next aviation accidents are safety intelligence, safety culture, safety mindfulness and an agile response capability at organisational and inter-organisational levels. These elements are all available, but they need to be focused on the daily realities of aviation-related organisations, and then integrated into a cohesive system that will work for all parts of the aviation industry, whether ground or air, operational or support. P5 answers to Theme 3 “Building ultra-resilient systems and operators”, which aims at strengthening the resilience to deal with current and new risks of the humans and the organizations operating the air transport system. Outcome of the research (2017) will be a Safety

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Performance System model which will address safety in aviation under a more cohesive and collaborative approach. P5 consists of five inter-connected Work Packages, each addressing key-safety components:

- Safety Intelligence (WP5.1)
- Safety Mindfulness (WP5.2)
- Safety Culture (WP5.3
- Agile Response Capability (WP5.4)
- Safe Performance System (WP5.5)

EUROCONTROL (ECTL) leads WP5.1 "Executive Safety Intelligence" in cooperation with the following partners: Deep Blue (DBL), ENAV, Boeing R&TE, AIRBUS[1], KLM and LSE.

1.3. Research objectives

Directors and senior leaders of aviation organisations need to understand organisational safety, including the organisational roots of accidents, and be equipped with the tools and data to manage safety effectively. The objective of the WP5.1 "Safety intelligence" is to equip **senior** (CEO/Board) and **middle management** layers with a pragmatic understanding of organisational safety and how to optimise it. This will include guidance on safety culture leadership, and usage of tools such as safety dashboards and data feeds to ensure safe decision-making. Main work within the WP5.1 "Safety intelligence" is to take existing Executive Safety Intelligence (ESI) conceptual guidance and broaden it to fit across the entire aviation spectrum including airlines, airframe manufacturers, ATM organisations and airports.

This study aims at defining the status of Safety Dashboards inside organisations (six ANSPs), creating a scheme of levels of capability, and identifying possible trajectories for evolution of Safety Dashboards. It addresses how to improve Safety Intelligence, by generating best practice guidance on safety dashboards.

1.4. Approach

Executive Safety Intelligence has been developed over the past seven years, mainly in the air traffic domain, the term first being coined in 2009, linked to safety culture. Work led by EUROCONTROL and executed by the University of Aberdeen led to the development of a White Paper on safety intelligence[2] [1], with input from a dozen CEOs and other senior executives to elaborate the safety intelligence concept. More recently, there has been a recognition that the approach needs to be extended both *upwards* and *downwards*. It needs to be extended upwards in order to reach those who sit above organisations such as ANSPs and airlines, e.g. those who set industry or national targets (e.g. on performance) that can affect safety directly or indirectly. It needs to be extended *downwards*, since in a number of organisations, good safety understanding was found at the top and bottom layers of organisations, *but not in the middle management layer*. If middle management is not engaged for safety, then even if top management want

[1] Airbus is now co-lead for WP1, focusing on Middle Management Safety Intelligence
[2] http://www.eurocontrol.int/sites/default/files/article/content/documents/nm/safety/safety_intelligence_white_paper_2013.pdf

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to improve safety and safety culture, such ambitions are unlikely to be translated into processes that deliver safety, because of the disconnect.

Safety Intelligence has two main facets. The first is safety understanding, and what was recently called 'Safety Wisdom' in a FSS White Paper[3] [2], which refers to having a good understanding of safety at the top of organisations. This includes the capacity to make reasoned and well-judged decisions concerning safety-related issues, threats and opportunities. The second facet concerns the information available to decision-makers, upon which they base their decisions. Safety Intelligence therefore also relies on a set of techniques and tools for the collection and transformation of data into actionable knowledge. A first task was therefore to identify the techniques, tools and data available to the different management layers inside the organisation. By collecting needs, limitations and 'desiderata' (wish-lists) with the support of real end-users, it becomes possible to envision how to extend and improve this set of techniques and tools.

The work presented in this deliverable has been carried out in the context of a restricted SDB User Group of ANSPs willing to share their experience on Safety Intelligence. Interactions with the SDB User Group took place in individual interviews with Safety Directors / Managers at their respective ANSP premises, followed by a workshop with all members of the SDB User Group held at the end of October 2016 in Rome. The present deliverable focuses on the primary tool supporting Safety Intelligence, i.e. the Safety Dashboard (SDB), and how it works across different levels in organisations.

This document divides into the following sections:

- Section 1 provides an overview of Safety Dashboards. This defines the context of intervention, the WP5.1 objectives and Research questions. Then the approach used in WP5.1 is outlined;
- Section 2 provides an overview of the analysis carried out on the Safety Dashboards of the participants of a SDB user group created to support the work on Executive Safety Intelligence;
- Section 3 describes the different types of Safety Performance Indicators (SPI) that have been identified in the context of the SDB User Group;
- Section 4 describes the different levels of capability/maturity of SDBs, and best practices for the SDB;
- Section 5 presents conclusions, recommendations and next steps.

[3] https://www.futuresky-safety.eu/wp-content/uploads/2016/04/FSS_white_paper_keeping_aviation_industry_safe-1.pdf

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2 SAFETY DASHBOARDS: AN OVERVIEW

2.1. Introduction

This section presents a summary of the knowledge acquired on Safety Dashboard in the context of two activities carried out by FSS P5 members: interviews to Safety Manager/Directors and a User Group workshop held in Rome at the end of October. The section is meant to provide a snapshot of the current status of SDBs, together with a list of shortcomings and ideas for improvement.

2.2. The Safety Dashboard User Group

Safety Dashboards (SDBs) are one of the most representative tools of Safety Intelligence, as they feature the outcome of data collection and analysis, translated into specific indicators, as input for decision-making. Moreover, they can have different types of users, ranging from Board members to middle managers[4] such as Heads of Units. For this reason, the attention of WP5.1 "Safety Intelligence" was focused on better comprehending better how SDB are used inside aviation organisations.
The Safety Dashboard User Group was created by ECTL in February 2016, with two main objectives:

1. Understand the current status of SDBs inside the organisations (benchmarking phase): what information they provide, to who, how they are used, what are the gaps and 'desiderata' (wish lists for improvement).
2. Setting up a place for the exchange of experiences and best practices on SDBs between the organisations.

Both objectives were considered to be beneficial for achieving the goals of WP5.1. To ease the creation of the group, it was decided to exploit the numerous links of ECTL with ATM organisations. Therefore the SDB User Group, as created, currently included only ANSPs. It is planned to extend the SDB User Group in 2017 to include other aviation actors, primarily airlines.
The Safety Directors/Managers of six ANSPs answered positively to the call for joining the group: AUSTROCONTROL, AVINOR, ENAV, MUAC, NATS and Skyguide.

2.3. Procedure

Interviews were set up and carried out by DBL and ECTL staff at the premises of the SDB User Group members. The interviews, lasting from one to several hours, were key in achieving the first objective.
The following areas were investigated in the interviews with Safety Directors / Managers:

- Number of SDB in use
- Users
- Content (indicators, data)
- Role of the SDB
- Scenarios of use
- Platforms

[4] A middle manager is generally defined as a manager who has other managers reporting to him/her.

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- Level of interactivity
- Update rate.

On 26th – 27th October a workshop with all the SDB User Group members was convened in Rome at DBL premises. The event was functional to the achievement of the second objective. On Day 1, SDB User Group members had the opportunity to see other members' SDB and listen to their experience of use. In addition to that, initial findings about SDB gaps and needs were discussed and refined. On Day 2, the conversation was focused on the future evolution of the SDB.
The rest of this document provides the outcome of the interviews and the workshop.

2.4. Findings from the interview

- **Number of SDBs in use:** all the SDB User Group members have more than one SDB. The main user of SDB is the Top Management, but four members out of six have SDBs for middle managers as well (Head of Units). The remaining users all felt the need to extend SDBs to the middle management layer.
- **Users:** all the members have "Top management" (Board of Directors of Executive Board) as a user. Other users include:
    - "Safety committees", which are sub-groups of Board of Directors or Executive Board
    - Specific "Performance Review Board", i.e. an extended audience with respect to the Executive Board, with a focus on Single European Sky (SES) Key Performance Areas (KPAs)
    - Head of Ops and Airports Unit
    - Individual Heads of Unit (ACC, APP, TWR…)
- SDBs for different users are customized, meaning that different types of data and visualizations are used depending on their needs. For example, when a SDB is delivered or presented to a Head of Unit, information on safety occurrences is limited to the specific Unit, while more aggregated information tends to be presented to top management.
- **Contents and indicators:** there is considerable variation across the different members. Section 3 of this document is dedicated to the presentation of the various safety indicators. Three main categories were identified: indicators addressing EU regulation, lagging and leading indicators. Indicators addressing EU regulation are in part lagging, in part leading (see Figure 1).

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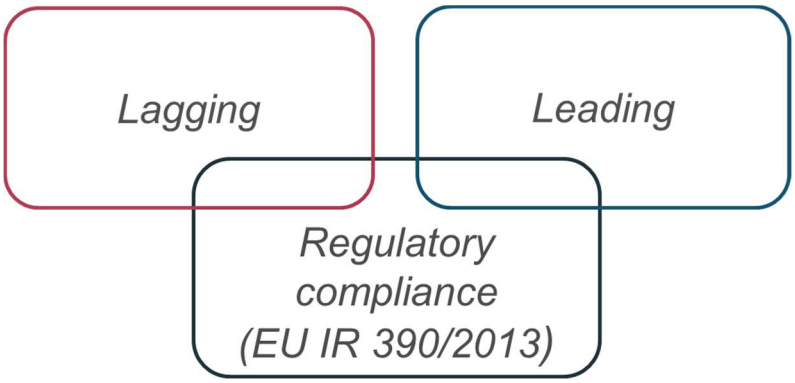

Figure 1 Types of indicators identified in the SDBs

- **Role of the SDB**: this varies from "strategic" to "analytical". Executive / Board members use SDB as a strategic tool to be aware of the status of safety at a high level, including the top current and future risks. Middle managers use SDBs to understand causes of specific safety events, look for emerging concerns, and make sense, in operational terms, of the safety performance of the Unit they manage. While more focused on business vision at the top, the SDB becomes richer in operational details as it moves down the organisational hierarchy (see Figure 2).

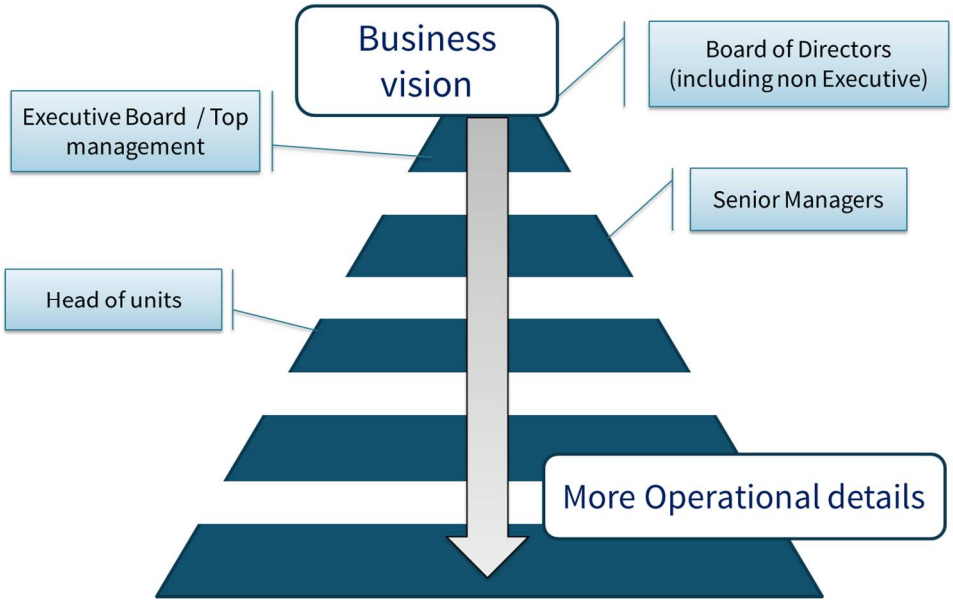

Figure 2 SDB vision, moving from top management to middle management

From the point of view of "who" is presenting the SDB, the participants agreed on a list of goals, starting from pure reactiveness/compliance to full pro-activeness:

- Showing that safety is monitored
- Showing that targets are reached
- Answering specific questions
- Triggering a reaction
- Supporting (safety-informed) decision making

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- Educating people
- Starting discussions with management
- Foreseeing «what is coming».

- **Scenarios of use**: all the SDB User Group members agreed on the necessity of not "pouring" the SDB over people without explanation of the context. Using SDB in isolation (e.g. sending it by email) poses considerable risks of misunderstandings as, repeating the words of more than one member, "*Numbers do not tell the whole story*". SDBs are almost always used in the context of in-person meetings.
- **Platforms**: four members out of six use PowerPoint as a platform, i.e. they copy and paste graphs and charts created in Excel (or other worksheet) onto slides. This means that considerable manual effort is required for the preparation of the SDB. The number of slides varies from one to several, depending also on the different views and details given for each indicator.
- **Level of interactivity**: four members out of six have completely static dashboards. Two members have interactive and 'drill-down' capable platforms for data that concerns Operations managers (at all levels) and middle management (Heads of Units);
- **Update rate**: most SDBs are updated monthly or quarterly, with a tendency to have monthly reports more for middle management rather than top management.

Overall, most ANSPs of the SDB User Group have static dashboard that are not interactive, are displayed on slides, and mostly show lagging indicators. SDBs in most cases are available also for middle management and these versions tend to be more interactive and detailed in terms of operational information. SDBs are used for different reasons, from showing that a target is reached, to highlighting issues that could potentially evolve and affect safety if not adequately addressed.
The rest of this section provides the outcome of the discussions that took place during the SDB User Group workshop held in Rome on 26th-27th October. The content is based on the results of activities aimed at collecting shortcomings and potential improvements concerning SDBs.

2.5. Findings from SDB User Group workshop

The following subsections presents the findings about collected during the SDB User Group workshop in relation to the shortcomings and opportunities for improvement of the dashboard. It is worth noting that as said in 2.3, findings about gaps and needs were initially collected during the interviews and then discussed and refined in the context of the SDB User Group workshop. The workshop was functional to the collection of other findings as well (e.g. see Section 4); however in this specific sub-section only the findings related to the current situation of SDB as perceived by SDB User Group members are presented.

2.5.1. Current shortcomings of SDBs

The SDB User Group members reported experiencing the following 'gaps' in the usage of SDBs inside their organisations:

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1. **Too much green**: indicators could sometimes tend to remain too much in a status that is always looking "good", i.e. in which targets are achieved and thresholds never trespassed. This could be dangerous, as it may suggest people that things are always going well, preventing an in-depth look, i.e. lacking a more proactive and critical approach to safety, questioning what is behind the indicator. This is a critical point. Participants remarked that a good starting point is questioning what is concealed behind the numbers, and this remains one of the critical tasks to be accomplished by a SDB.
2. **Red makes people jump to conclusions:** similarly to the point above, any performance indicator that becomes red needs careful analysis, as causes could be not the most intuitive ones. Again, there is always a need for contextual explanation and discussion to avoid misunderstandings. However, this requires the people who will look at the SDB to be "educated" (see also next issue).
3. **"Targetology":** sometimes numbers and targets risk being seen as the only important thing for what concerns safety, especially when showing them to Board members, who are very much focused on figures and hard evidence. This is why it is recognised that the Board needs to be "educated" in reading and making sense of the information contained in the SDB. The risk is lower for people close to the operations, e.g. middle managers, as they are closer to the complexity of operations and tend to consider the presence of a number of causes behind a certain performance.
4. **Too much static indicators:** indicators that do not change are probably failing to detect changes, i.e. they are probably not working at the right granularity. Another problem with lack of change is connected to improvement plans, i.e. when safety performance for certain areas is intended to improve over a long period. Conversely, an indicator that remains stable despite the increase of traffic should be considered as a positive sign of safety. Normalisation of data play an important role and should always be addressed in SDB indicator representation.
5. **Quality of processes are hard to measure:** some leading indicators look at process status (e.g. is a process in place). However, this does not say much about the *quality* of the activity carried out. For example an indicator can tell that an assessment is completed on time, or that a certain percentage of planned activities has been completed according to the plan. However, these numbers do not say much about the value of the outcome or the plan.
6. **Information fragmentation:** some participants felt it was difficult to see the relationships between the various pieces of information displayed on their dashboards. For example, being able to visually show the link between indicators / events and a certain corrective action would be very useful in making clear the rationale for change. This would also help to strengthen the motivation of the people in charge of the actions, e.g. middle managers.
7. **Lack of safety dashboards for more operational people:** those SDB User Group members that do not have a dashboard for middle managers, expressed the need for it. In their opinion information on such dashboards should be richer in terms of operational details, as they would be able to make sense and use of them (e.g. showing that certain occurrences tend to repeat in a specific part of the sector could lead to start a review of the procedures in use in that area).

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2.5.2. Opportunities for improvement of SDBs

The SDB User Group members expressed the following 'desiderata' for their SDBs:

1. **Integration of safety and operational indicators:** while in some cases Safety is presented as one of the elements of a more general business dashboard, participants reported that they are still missing a clear connection of safety with operational areas. It would be beneficial to have an operational-oriented dashboard, in which the link with KPAs like capacity is robust and shown (e.g. how much the increase of capacity is increasing a certain type of safety risk?).
2. **Risk-based dashboard based on formal risk model:** participants expressed the need to have a more risk-based dashboard, showing a clear connection between collected information and risk. For example, if there is a change in the equipment of a Unit, how are the probabilities of a specific safety event are going to change? A possible candidate framework for ANSPs is the EUROCONTROL quantified risk model (called IRIS).
3. **"Drillability" & interactivity, but not without guidance:** all participants recognised the importance of dynamic interrogation of data, something that requires an online platform for dashboard together with drill-down capabilities. It was recognised that data exploration is more important for middle managers and people closer to Ops rather than high level management, as it is key for them to look at contributing factors and other contextual elements that can support deeper understanding of "why" things happen, and take appropriate action. For higher management, it could be useful instead to have pre-sets of interactive paths, where data exploration is limited and specifically tailored to show links between events and causes or any other particular interaction between data sets.
4. **Automated solutions for data collection:** participants are looking forward for tools to automate the collection of safety data. This is particularly true for safety-related occurrences and events (e.g. losses of separation; safety net alerts; etc.). This would relieve safety units from manual data collection and have potential benefits for level of reporting. Automated collection would also be the enabler for moving in the direction of real time update of data, i.e. how some airlines do thanks to the abundance of data of FDM (Flight Data Monitoring). Some participants have tools for the automated collection of STCA alerts, but in general automated data collection is lacking.
5. **Software solutions for data integration:** participants feel the need for an integration of information sources (single database), or for a tool that can seamlessly take information from different digital sources and enable the dashboard preparer to analyse it in a single place.
6. **Connected and interactive cascading dashboards for different users:** points 3, 4 and 5 together call for an evolution of the tool in the direction of an online business intelligence tool that permits data exploration according to different user profiles (top management, senior management, head of unit etc.). This would result in linked dashboards that would differ in granularity / functions / presentation at different levels in the organisation, but they would still be connected (joined-up) and serviced by a single software platform.

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2.6 Discussion

The goal of the section is to provide an overview of the current status of SDBs as understood in the context of in-person interviews and a workshop with the members of the SDB User Group.

However, it is worth making an initial consideration for what concerns middle managers. Tools for Safety Intelligence such as SDBs are considered of fundamental importance for the work of middle managers. SDB User Group members considered interactivity and "drillability" of dashboards as a priority for people managing Units, while top management should be more carefully guided in data exploration – or do no data exploration at all, and rely on static dashboard prepared by safety officers.

One participant, reporting about the work their ANSP is doing on the development of a SDB for middle managers, explicitly said that they want to enable Units managers to "play" with safety data and know more about their safety performance when safety officers "are not around". To do this, to render use by Ops middle managers autonomous, a key point is the provision of an intuitive digital tool for the exploration of safety performance.

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3. TYPES OF SAFETY PERFORMANCE INDICATORS

3.1. Introduction

This section describes in detail the different types of indicators that are featured in the SDBs of the User Group members. As shown in 2.4, indicators can be defined as:

- Required by EU regulation;
- Lagging, i.e. information that tells about outcome of past (including recent) safety performance, such as safety occurrences;
- Leading, i.e. information that tells about process status, people's attitudes and events that are not outcome events, including Air Traffic Controller's (ATCO) concerns.

The indicators are grouped depending on their type and the class of user (top or middle management) to which they are targeted. Finally some remarks on the indicators are provided.
The content of the sub-section comes from the analysis of the information collected during the in-person interviews. Understanding of the type and use of indicators was refined during the SDB User Group workshop.

3.2. Indicators addressing compliance to EU and State regulation

All the members of the User Group feature at least the Safety Key Performance Indicators (KPI) mandated by EU IR 390/2013, namely:

- Effectiveness of the Safety Management System (SMS);
- Application of RAT (Risk Analysis Tool) to Separation Minima Infringements (SMI) and Runway Incursions (RI);
- Level of Just Culture.

These KPI come with a target mandated by EU on the base of SES Reference Period (RP) 2, and the values in the dashboard are generally shown in relation to that threshold. Some SDBs also show the number of non-conformities identified by their National Supervisory Authority (NSA).
KPIs and the NSA audit results mostly refer to organisational factors and processes; hence they are displayed on the SDB with the top management target in mind, to show that "everything is working well" *from a regulatory compliance point of view*. It is possible to define such KPIs as *leading*, because they do not focus on losses of safety but on the status of the "organisational attitude" towards safety. However, most of the participants remarked that the indicators are actually more about compliance to rules, and probably not the best indicators for capturing processes and organisational shortcomings when it comes to safety.
"Use of automated tool for collection of safety data", "Level of reporting" and "Number of SMI, RI, airspace infringements and ATM-specific occurrences" are instead Performance Indicators (PI), for which no target is provided in the regulations of the current reporting Period (RP2: until 2020). Some ANSPs decide to show these indicators as well.

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It is worth noting that all the ANSPs that have SDBs for middle managers provide them only with information about safety occurrences, i.e. “Number of SMI, RI, airspace infringements and ATM-specific occurrences”, related to their Unit, and not with the leading indicators.
The full list of KPIs used by the ANSPs is shown in Table 1.

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Table 1 List of regulation indicators used by SDB User Group members

Indicator	Type	Description	Unit of measure	Aimed at
Effectiveness of Safety Management	Leading	SMS is structured in 5 areas (ANSP safety policy and objectives, Safety risk management, Safety assurance, Safety promotion, Safety culture), divided in a total of 11 components, measured over five level (from "A" to "E")		Top management
Usage of RAT	Leading	Application of EUROCONTROL Risk Analysis Tool (RAT) to the analysis of Separation Minima Infringement (SMI) and Runway Incursions (RI)	Percentage: cases in which RAT is applied / not applied	
Just Culture	Leading	24 Questions (Yes/No) on reporting of Just Culture in 3 areas (Policy and implementation, Legal/Judiciary, Occurrence and reporting investigation)		
Use of automated tool for collection of safety data	Leading	Yes / No	-	
Level of reporting	Leading	The proportion of the occurrences received by the ANSP occurrence reporting schemes, compared to all the occurrences that happened.	Percentage.	
Number of non-conformities from CAA audits	Leading	Distributed per severity.	Absolute numbers	
Number of SMI, RI, airspace infringements and ATM-specific occurrences	Lagging		- Absolute number of occurrences - Number of occurrences per movements - SMI per 100k minutes of occupancy - SMI per 100k IFR flights - RI per 100k movements - Airspace infringements per 100k movements - ATM-specific occurrences per 1000 technical failures	Top Management; Middle management

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3.3. Lagging Indicators

Lagging indicators refer to the outcome of operations, i.e. indicate whether a loss of safety occurred. These indicators look *backward*, meaning that they can be populated only *after* an event has happened, and are generally linked to the idea of 'Safety I[5] [3], on the base of which safety can be measured only by counting *negative events*. Lagging indicators are aimed at informing both top management and middle management. For what concerns middle management, information is restrained to the occurrences related to the specific Unit (e.g. ACC, APP, TWR…).

Table 2 shows that most lagging indicators refer to different types of *distributions* of safety occurrences, normalised (or not) by different ratios (e.g. 1000 movements, 100k movements, 100k IFR flights etc.). These distribution can be done on the base of:

- Month or quarter
- Severity
- Unit
- Geographical location
- Reputation and legal risk
- Judiciary activities taking place
- Activation of specific process for re-appraisal and re-training

The last three indicators are quite different from all the previous ones, in the sense that they do not highlight operational characteristics of the occurrences (when, where, how "bad", which Unit was in control?) but the *possible or actual consequences* connected to the occurrence (i.e. are media making a big case of a specific incident? Is somebody being re-trained because of an occurrence?). Therefore, they are indicators that do not look for possible causes of the events but instead are focused on the risk or impact that they have at an organisational or even corporate level.

Two of the SDB User Group members have in place digital tools that allow data *drilling* and *visualisation* of a number of *operational and casual factors* associated to the occurrences. These digital tools are generally aimed at managers in Operations or middle managers, as they provide the capability to look at factors correlated to the collected occurrences. This capability is meant to enable the identification of recurring patterns of causal factors – e.g. repeated slight losses of separation due to a sub-optimal coordination procedure in a busy portion of a sector. In this sense, lagging indicators, enriched with correlations to operational factors, can support the focus of attention on "good questions" (e.g. do occurrences tend to happen at the same time of the day? Do they happen almost always with the same wind condition in approach?) and about what could be the underlying causes.

[5] http://www.skybrary.aero/bookshelf/books/2437.pdf

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Examples of operational factors quoted by two of the SDB User Group are the following:

- Flight level;
- Wind direction;
- Subjective workload;
- Time of the day;
- Causal factors (e.g. misperception, poor planning, forgot planned actions etc.).

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Table 2 Lagging indicators used by SDB User Group members

Indicator	Type	Description	Unit of measure	Aimed at
Number of SMI with more than 50% separation lost	Operational characteristics of the occurrence		Absolute numbers	Top management
Trends for SMI, RI, airspace infringements and level busts	Operational characteristics of the occurrence	Trend by month / quarter, with and without ATC contribution	Absolute numbers; per movements.	Top Management; Middle management
Severity distribution of safety occurrences	Operational characteristics of the occurrence	A, B, C and E occurrences.	Absolute numbers.	Top Management; Middle management
Geographical distribution of safety relevant events	Operational characteristics of the occurrence	SMIs, Airspace infringements, Losses of communication, TCAS RA.	Absolute number, plotted on ATS geography	Top Management; Middle management
Reported incidents per 1000 movements	Operational characteristics of the occurrence	Per month and per Unit (TWR, APP etc.)	Absolute numbers; per movements	Top Management; Middle management
Number of technical failures of ATM/CNS systems with OPS impact	Operational characteristics of the occurrence		Absolute numbers; in percentage / all technical failures.	Top management
A and B occurrences with high and medium reputation risk	Risk and impact for the organisation		Absolute numbers	
A and B occurrences with high and medium legal risk	Risk and impact for the organisation		Absolute numbers	
Number of running judiciary activities against ATCO	Risk and impact for the organisation		Absolute numbers	
Number of events for which re-appraisal and re-training process was activated	Risk and impact for the organisation		Absolute numbers	
ANSP contribution to RAT events	Operational characteristics of the occurrence	It shows the number of A, B, C, D, E and N events in the period and the trend of severity with respect to the target set for RP2. Also split per Airspace and Airports		Top management; middle management

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Safety events causal factors	Operational characteristics of the occurrence	List of the most recurrent / relevant causal factors of the collected safety events (based on causal factors analysis)	List of factors	

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3.4. Leading Indicators

Safety leading indicators do not represent outcomes of operations; rather, they inform people about the status of processes and actions, compliance to standards, and provide an indication of people's attitudes towards safety and try to collect all those phenomena that could be seen as symptoms of a not-yet-occurred degradation of safety (signals and concerns from the front-line).

Leading indicators seen in the SDB User Group appear to be almost exclusively used on the SDB aimed at Top Management. The reason for that could be the fact that these indicators are mostly about processes, i.e. they tend to speak of work-flows at organisational level. Therefore, middle managers seem to be excluded from the usage of such indicators, with the exception of one member that provided data about the status of the *actions coming out of the investigations* (completed/overdue), as they have a direct link with occurrences happened in the Units managed by them. However, all the participants recognised the need for more leading indicators for those roles that are close to Operations.

While leading indicators sometimes are seen as the most desirable type of indicators for real Safety Intelligence, during the workshop all the participants agreed on the need for a well-balanced mix of lagging and leading indicators.

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Table 3 Leading indicators used by SDB User Group members

Indicator	Type	Description	Unit of measure	Aimed at
Management attention for Safety	Attitude towards safety	It tells how many management meetings on safety are performed in comparison to the planned ones.		Top management
CISM Percentage of participation in recurrent training courses (peers)	Attitude towards safety	It tells the how many Ops staff member participate to CISM courses. CISM is a structured approach to the management of stress related to the occurrence of critical incidents. The indicator is meant to show the interest of staff in becoming CISM mentors, i.e. being able to take care of fellow ATCOs in case of an incident.	Percentage.	
Number of overload reports	Signals / concerns	An overload report is filed when the ATCO feels he has worked with excessive workload during the shift	Absolute number of reports.	
Unit Safety Surveys	Signals / concerns	The aim of the survey is to understand what are the daily hassles and worries for the controllers and not to evaluate if the Unit is “acceptably safe”. Perspective is very ATCO-oriented.	Number of surveys carried out + Qualitative information (content of the survey).	
Unit Safety Survey implementation and improvement management	Process	It tells: - if an implementation plan to address identified Unit safety concerns has been implemented - % of implementation actions performed	Percentage of actions performed plus qualitative information.	
Overview of Project Status Information	Process	-		
Risk from upcoming change	Process	-		
Safety strategy	Process	It tells if the ANSP is implementing the activities decided in the strategy. In other words: what is the progress in safety activities with respect to what has been planned?	Percentage of activities implemented.	
Number of changes without safety assessment completed beforehand	Process	-	Absolute number.	
Change management	Process	% of changes which were published at least 30 working days before the Change Implementation Date.	Percentage.	
Number of Corrective Actions	Process	- Number of corrective actions defined in time	Absolute number.	

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		- Number of corrective actions carried out in time - Number of expired corrective actions		
Safety Improvement	Process	% of actions agreed in internal investigation management responses fulfilled appropriately and within deadline	Percentage.	
Reporting and investigations	Process	It tells: - % of reported SMI spontaneously reported; - % of reported SMI (spontaneous and after notification); - Resources (days dedicated by ATCO investigators to reporting monitoring)	Percentage and absolute number of days	
Investigation timing	Process	No. of overdue / completed actions	Absolute number and ratio	Top management; middle management
Actions after investigation	Process	No. of investigations completed in time / overdue	Absolute number and ratio	Top management; middle management

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3.5. Discussion on the indicators in the context of SDB User Group workshop

Indicators were mostly identified, classified and discussed during the interviews. However, discussion on them took place also in the context of the SDB User Group.

During one of the discussion that took place in the context of the workshop, all participants agreed that some indicators could be "deceptive", meaning that they could mean something different than they are meant to be. This is particularly true for regulation compliance and leading indicators rather than lagging ones. The reason is quite clear, as lagging indicators refer to measured numbers of occurrences and their different characteristics. Leading indicators instead try to capture processes, attitudes and concerns. For example, participation to CISM recurrent training could be low because of the way the training is organised (e.g. timeframe, access etc.) and not because of lack of interest of the staff. Or change management indicators could show a delay in carrying out the planned actions, but again this could be caused not by lack of will in completing the actions, but by competing goals assigned by management. ATCOs concerns also cannot be taken as "raw" material, but need to be evaluated and filtered – they could complain about something which is not the real root of the problem.

Indicators keep a very important role in showing that "something is happening", but this has to be the *start of discussion* and analysis not the end point. As one participant said, "*Indicators are good as long as you analyse and discuss the results, and learn something on the underlying causes. That is what we want to achieve*".

Therefore, the classification in "types" used for leading indicators is primarily meant to describe what the SDB designer would like to measure with a certain indicator; however, the causes behind the number could be different from what is expected.

Another discussion started in the workshop, on the basis of information collected during the interviews, was about the importance of *empowering middle managers*, i.e. people closer to the operations. At the end of the discussion all SDB User Group members agreed on the importance of enabling them *to explore and dig into data*, as they are the ones who are at the "right distance" to define better operational safety issues and look for causes and possible solutions.

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4. LEVELS OF CAPABILITY AND BEST PRACTICES FOR SAFETY DASHBOARDS

4.1 Introduction

This section provides the outcome of the discussion related to the levels of capability of SDBs that took place during the SDB User Group workshop held in Rome on 26th-27th October 2016.

4.2 Levels of capability

The concept of "SDB levels of capability" was originally formulated as "SDB levels of maturity" by the project members, similarly to what was done by CANSO when defining the Standard of Excellence for SMS. However, the SDB User Group members remarked how the term "capability" would be more appropriate for SDB, as a possible scheme of levels would be referred more to features and functionalities rather than "maturity", which is a term more appropriate for organisational processes and culture. Moreover, the level of capability of the SDB could be de-coupled by the SMS level of maturity, just because of technical limitations. Therefore, it was preferred to use the expression "levels of capability".

An initial scheme presented by the project members (provided in **Error! Reference source not found.**) was discussed in the context of the SDB User Group workshop on Day 2. However, an agreement on the validity of the proposed 5-level scheme, and what are exactly the differences between subsequent levels was not reached. Nevertheless, a number of elements and criteria indicating higher capability were identified and are reported hereafter.

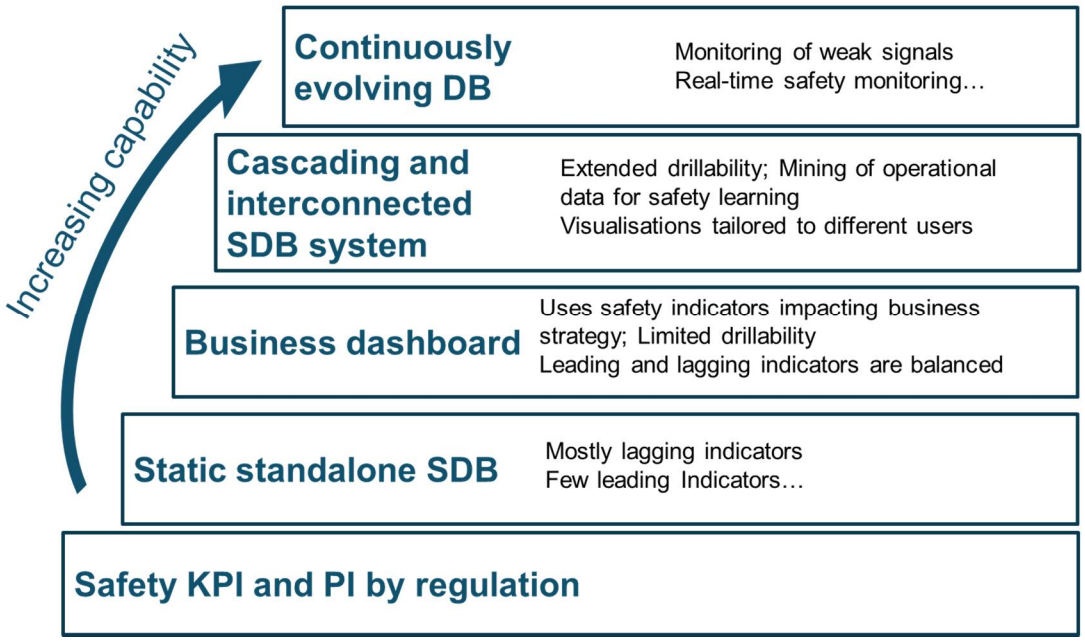

Figure 3 Proposed scheme for SDB levels of capability

Participants agreed that an increase in the capabilities of SDB can be observed in the evolution of the following features and functionalities:

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- **Number of SDB:** from a single SDB for top management, to a system of inter-connected SDBs, tailored around the needs, responsibilities and scope of action of each user;
- **Indicators**: from regulation KPIs only, to a balanced mix of leading and lagging indicators;
- **Weak signals**: from collection of safety occurrences to daily hassles and issues that could evolve into major problems;
- **Data mining capabilities**: from a full static SDB to an online tool that allows data drilling;
- **Connection to business strategy**: from an isolated SDB to one that is connected with (or at least considered at the same level as) other organisational KPAs;
- **Data acquisition:** from manual feeding, which is inevitably delayed, to automated and real-time collection;
- **Integration of data into a risk model:** from scattered information to an overall picture exploiting for example a barrier model, i.e. to understanding of inter-relationships as well as where system weaknesses are.

4.3 Lessons learnt in Safety Dashboard development

During the interviews and the workshop it was possible to collect relevant information about the way Safety Dashboards "come to life" inside the organisations and the way in which they have been developed. The most important lesson learnt is that most of the times SDBs are the product of an **interaction between users and designers**. In some cases it can be a long refinement process with periodical checks.This is especially true for SDBs aimed at top management, as directors or board members are more likely to ask (and to be "heard") for adaptation and tailoring of the presented information. For example, one ANSP reported the need for "tidying up" the SDB by using simpler graphs and synthetic indicators like traffic lights to signal that a critical threshold is being reached or a trend is worsening / improving. Maintaining this never-ending interaction was recognized as a best practice. In fact, it results into a **continuous evaluation of the usefulness and intuitiveness** of the information provided by the SDB: what is not meaningful anymore is suppressed or modified, new indicators can be added or substitute old ones. Representations that do not clearly convey the message are targeted for change or removal.
Some other User Group members stressed the importance of considering the background of the managers to which the SDB is presented, e.g. whether they are statisticians or former operational staff. Depending on that, there is, for example, the need to use different data visualisation and add / modify textual or verbal explanations. In this sense, the SDBs recognised as best-in-class are those in which a **User-Centred Design** approach is adopted, i.e. there is careful consideration of user characteristics, needs and skills. Something that has been understood to be a common practice is the use of **ad hoc indicators** depending on management requests or the issues that Safety Manager / Director wants to emphasise. Therefore, while some indicators remain stable and form a core part of the dashboards, some others can be "mobile". While it can be extremely beneficial to focus the attention on specific safety issues, there can also be the risk of having indicators asked by the board / top management and that remain in the SDB even though they lose meaningfulness or relevance – i.e. when they remain "always green" and for this reason are liked by managers or never change (or change with a pace that is much slower than a quarterly update).

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The above highlights the importance of **building a dialogue** between SDB designers (safety) and users, together with the need for educating them in reading the dashboard. One User Group member noted that it took a long time and considerable for the board to drop a "reactive" modality of looking at SDB data. SDB can trigger management to jump to conclusions too fast and make them feel obliged to act; however, safety always requires some degree of analysis and understanding below the surface of the numbers. User Group members recognised that SDB users are mature when they keep a "Stop, think, act" mind-set when confronted by data, and question their interpretation and use the SDB to have a discussion on what is driving the data.

4.4 Two examples of optimised safety dashboard

One of the activities performed with the SDB User Group members was the design of an optimized dashboard for a hypothetical ANSP that wants to create its first SDB. In this sense, the exercise was intended to create a "level 3" SDB – neither top-of-class, nor limited to regulatory KPIs. The participants were divided in two groups and had to select ten indicators to populate the SDB. The rest of the subsection presents the results of this exercise.

4.4.1 Group 1 SDB

In Figure **4**4 it is possible to see the SDB prototype prepared by Group 1. The general concept proposed by the group was to provide "areas of attention" rather than specific indicators, in order to make the SDB content adjustable on the capabilities of the ANSP (e.g. available human resources, tools for data collection, education of people etc.). Indicators include:

1. **Top 10 operational safety risks:** description, current risk level, actions that are being taken & Units affected (free text + visual indicator for risk level).
2. **Unit at Risk:** any operational relevant area (unit, geographical area, airport…) that needs to be under observation on the base of experts' judgement (free text).
3. **People in the system:**
    a. Reporting rates (MOR and voluntary);
    b. Data on CISM (e.g. participation to CISM training, n. of cases in which CISM was needed etc.);
    c. Safety culture level (e.g. measured by surveys);
    d. Interest in participating to safety activities (e.g. measured by surveys, number of participants to a certain activity etc.).
4. **Effectiveness of Management system:**
    a. Safety;
    b. Security (internal procedures);
    c. Compliance to management procedures.
5. **Safe Design, Safe Change:** a section to highlight:
    a. Number and scale of changes;
    b. How risk and complexity of changes are managed;
    c. How people's adaptation to change is managed (e.g. provision of training etc.).

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6. **Technical system performance:** to answer to the question "How well is the machine working?" It provides a picture of equipment performance (e.g. failures with impact on Ops).
7. **Top 10 external safety factors:** what external actors/constrains (political, regulation, noise, etc.) are identified as potentially impacting safety (e.g. need to put in place a less than optimal procedure for landing at a major airport due to noise abatement restrictions).
8. **Potential or emerging risk areas:** selected narratives describing selected concerns coming from the front-line.
9. **Operational safety performance:** free text + data drill down (which is allowed depending on the SDB level) to explore contributing factors and the operational context of collected safety events. The section is meant to be created on the contribution given by middle managers, who can enrich the analysis of safety events by looking for significant correlations.
10. **EU KPI: as required by current regulation.**

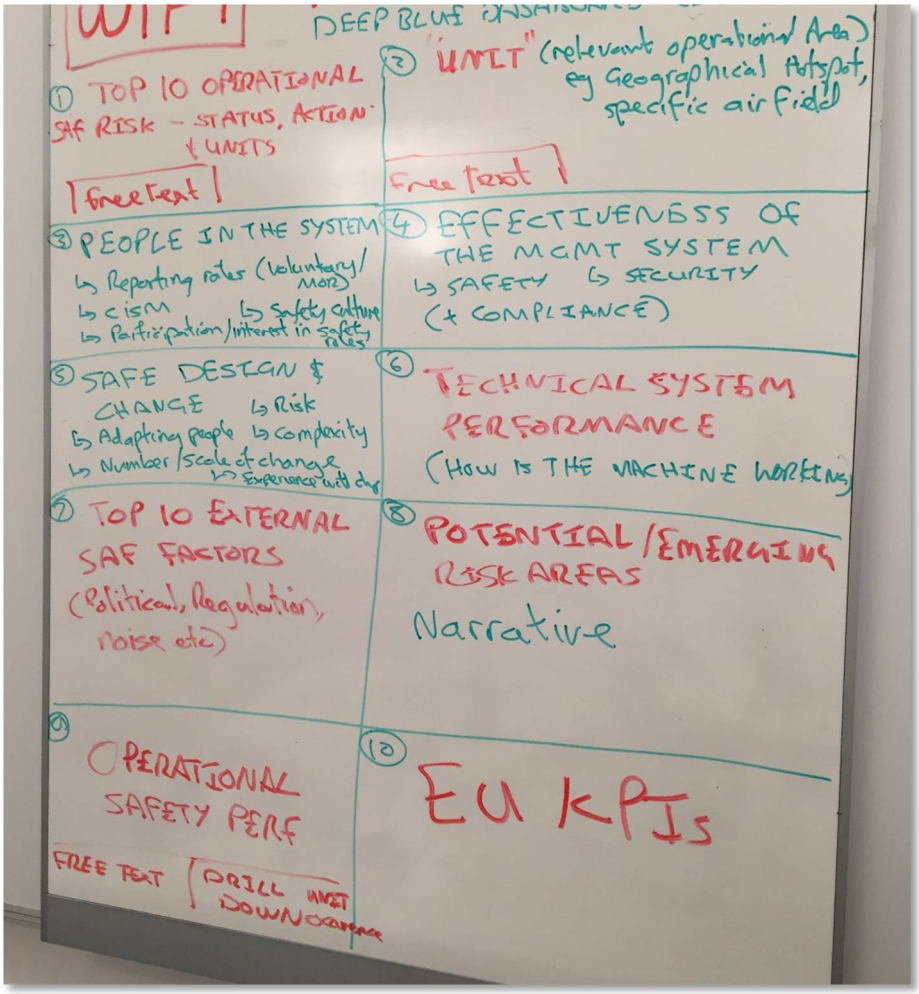

Figure 4. Group 1 SDB

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4.4.2 Group 2 SDB

In Figure **5**5 it is possible to see the SDB prototype prepared by Group 2. The general concept proposed by the group was to achieve a good mix of lagging and leading indicators, in addition to the ones required by European/State regulations. Indicators include:

1. **Regulatory compliance (SMS, Just culture)** – on the base of what is required by EU;
2. **State set targets:** compliance with any target required by the State;
3. **Loss of separation/severity** (normalised) + **RI per severity per movements + Airspace infringements** (lagging);
4. **Hotspot and coordination with other ANSPs** (lagging): a geographical visualization of where hotspots of occurrences with a highlight on any of those that should be at the FIRs border;
5. **Reporting culture** (lagging): level of reporting;
6. **Open and closed actions from investigations + Safety culture actions** (leading): description of what is put in place to address outcome of investigations / safety culture shortcomings and improve them;
7. **Top 3 Risks/Issues** (leading): group members said that three risks / issues would be a better number than ten, because ten would mean having too many prioritised items and they would probably never (or just rarely) change;
8. **Unit risk graph** (leading): a map that shows the level of risk in each Unit, based on survey performed at Unit level about Ops people concerns;
9. **Steady state assessment** (leading): compliance with safety processes;
10. **Change/Rate of change** (leading): number and complexity of changes, ratio of changes / unit.

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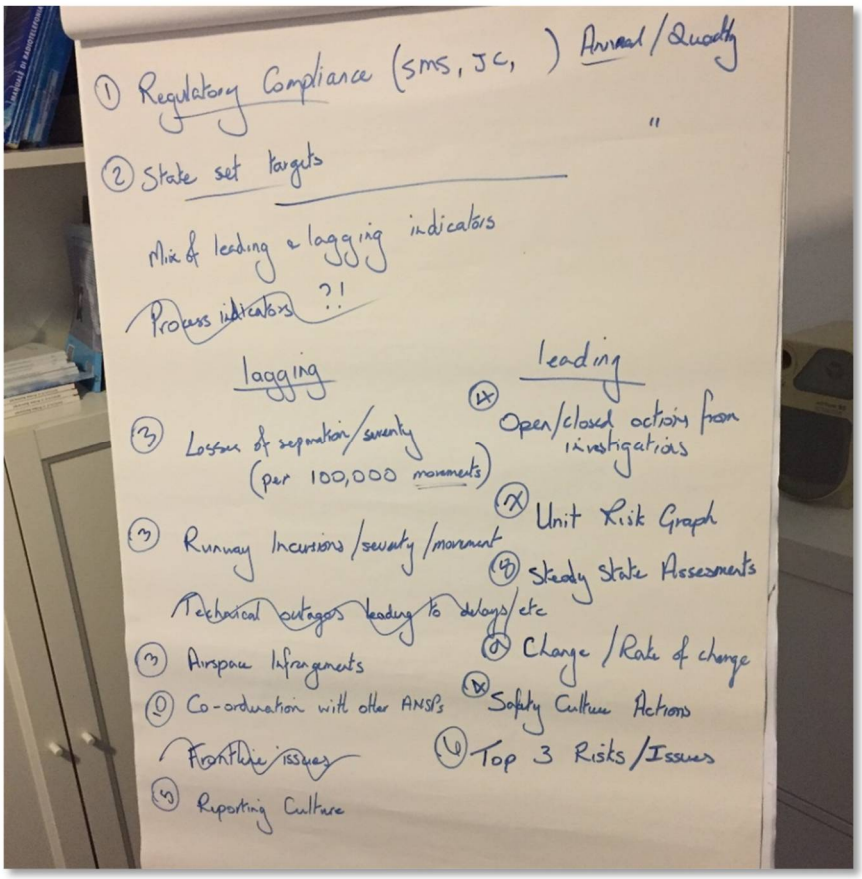

Figure 5. Group 2 SDB

4.5 Envisioning a top-class SDB

During the workshop, the participants discussed enablers and features that a top-class SDB would have. The discussion was connected to the levels of capability theme. The list presented hereafter was created by what the users considered to be the enablers and features for a Level 5 SDB:

1. **Boost the dashboard "engine":** there is a recognition that getting a comparable amount of data as Flight Data Monitoring would be a big step forward. Access to large sets of data in a digital format is the pre-requisite for discovering correlations between system elements (human, equipment, procedures) and their potential impact on safety.
2. **Automated tool for data analysis:** another step forward would be the deployment of analytical tools, in order to go from full manual analysis to "data by the click of a button". This requires the design of a digital platform with intuitive data mining and visualisation functionalities, so that not only statisticians can use it.
3. **Extended "drillability":** the digital tool would ideally allow data drilling in all directions, again with automated functionalities. This would enable the users (safety, ops etc.) to be in full control of data exploration, without external support of a data analyst, or IT staff.

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4. **Different visualisations:** the SDB users should be able to choose the visualisation they deem to be most beneficial in highlighting a certain aspect of the information they are focusing on, e.g. showing events on map, by Units etc.
5. **User profiling:** while data exploration is needed to find patterns of contributing factors and foresee changes in risk level, there is also a requirement for user profiling, i.e. giving the right level of access to data to the right people. Top management and Heads of Units have different needs and tasks – giving the same information to different users could be useless, or worse, misleading.
6. **Inclusion of external safety factors:** at the moment all dashboards are very much focused on "internal" factors, i.e. outputs or processes that are part of the work of the organisation. However, it was recognised that there is a need to take into account "external" factors (e.g. politics), and look for their potential impact. These factors tend to be off the radar and for this reason they are likely to become "hidden threats".
7. **Connection with other aviation actors:** in line with the enlargement of the dashboard scope, the connection with other organisations can be beneficial. Most beneficial links would be with airlines, airports and neighbouring ANSPs – in some cases this already happens.
8. **Collecting early signals**: there is a need for increasing the collection and use of data that can tell safety degradation is potentially around the corner. This could be done by looking at the status of processes but also at the daily problems and concerns experienced by people at the front-line.
9. **Risk-based dashboard:** a full developed dashboard would provide a view on safety risks resulting from the application of a solid framework. All the elements that can be monitored would ideally contribute to form a (as far as possible) quantitative risk picture.
10. **Predictive metrics:** in line with the previous point, the ultimate feature of an ideal safety dashboard would be a set of predictive metrics. For example, if certain values drift above a specific threshold, then the safety unit would be alerted on the need for putting in place corrective actions.

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5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Work with a Safety Dashboard (SDB) User Group, consisting of six ANSPs, has shed some light on current practices in the use of SDB inside European ANSPs. All the involved users have some kind of SDB, which at its minimum is aimed at top management only and includes EU mandated Key Performance Indicators (KPIs). The analysed SDBs are at different levels in terms of the approach to safety monitoring: some of them mostly rely on lagging indicators, while others include leading indicators that try to collect status of internal processes and concerns from the frontline. Most users have a SDB for middle managers, e.g. heads of Units, again with different capability levels. Some dashboards are fully static, while others, built on digital platforms, offer drill-down and data exploration capabilities.

SDB User Group members agreed on considering middle managers as those who mostly need an "enhanced" SDB, i.e. a tool capable of accessing, processing and visualising a huge variety of different data sets, especially for what concerns those strictly connected to operations (e.g. ATS geography, time, environmental conditions, shift, status of equipment, procedures in use etc.). The reason is that middle managers are the most eligible staff members for the integration and sense-making of the results of safety data analysis as, by using their operational expertise, they can rise the "right questions" when looking for underlying causes (i.e. "*Ok, there is an increase of altitude busts close to that waypoint. What about the change in the LoA with our neighbours?").* In turn, the in-depth analysis operated by middle managers can feed an overall risk model, which can then be part of the SDB directed to top management (*"What are the causes behind an upcoming risk?"*). In this sense, middle managers have a two-faceted role, as both "*producers*" of safety data (and hence safety dashboards) and *users*. An overall scheme depicting an ideal process featuring the roles of middle management, safety manager and top management in relation to the use of SDBs and Safety Intelligence tool is provided in **Error! Reference source not found.**.

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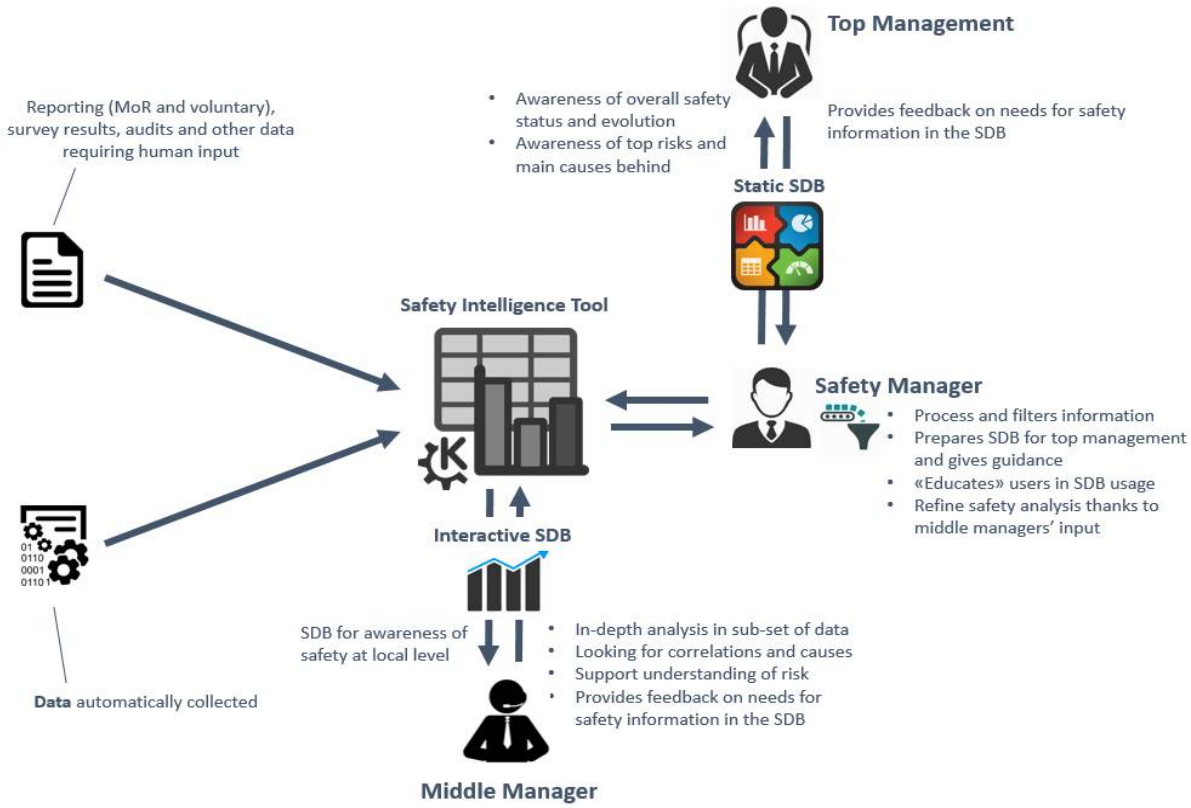

Figure 6 Best practice for the use of Safety Intelligence Tool and SDBs by different users inside an organisation

A systematic view of the different characteristics of users in relation to Safety Intelligence and SDB is provided in Table **4**.

Table 4 Users – Safety Intelligence / SDBs mapping

	Top Manager	Middle manager	Safety manager
Relation with SDB	Mostly as user	User and contributor	Designer and user
Usage of SDB	• Awareness of overall safety status and evolution • Awareness of top risks and main causes behind	• Awareness of safety status at local level • Insights to further understand/explain the safety status at local level thus refine the risk analysis at local level	• Support to risk analysis • Presentation of safety status at different levels of details for different scopes of activity (inform organisations of safety status)

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SDB expected capabilities to support the various usages	• Friendly presentation	As a *presentation* tool: • Friendly and flexible presentation As an *analysis* tool: • In-depth analysis in sub-set of data • Looking for correlations and causes	As a *presentation* tool: • Friendly and flexible presentation As an *analysis* tool: • In-depth analysis of data • Flexibility in the data that can be processed e.g. integration of insights of detailed risk analysis coming from MMs / Refine safety analysis thanks to middle managers' input
Contribution to the SDB	Feedback on needs for safety information to be aware of	Feedback on needs for safety information and capabilities in the SDB	• Specs & feedback on needs for safety information and capabilities in the SDB • «Educates» users in SDB usage
Access to data	Wide, but not in depth	Subset of data, in depth	All + capability to put in new data
Degree of interaction with data	Mostly static	Mostly interactive	Interactive

Considering that middle managers are not likely to be people with a background in statistics or IT, there is a need for equipping them with software tools that are *highly automated* in the retrieval and processing of data but at the same time extremely *intuitive* in their usage. Therefore, the focus on the features and characteristics of the SDB should be enlarged to include the design of an overall architecture in support of Safety Intelligence, which should be based on the following principles:

- *Digitalisation* of safety information – as much as possible;
- Storage of the information in a *single database/platform* (or any other technical solution that enables a seamless integration of data);
- Extended capability for *statistical analysis* (e.g. drill-down, correlation, geo-localisation) – partly automated, partly manual;
- Extended capability for *information visualisation*, i.e. capability to prepare and present information in ways people can use it with efficiency and effectiveness.

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Figure 7 provides instead a visual representation of Safety Intelligence architecture for middle managers.

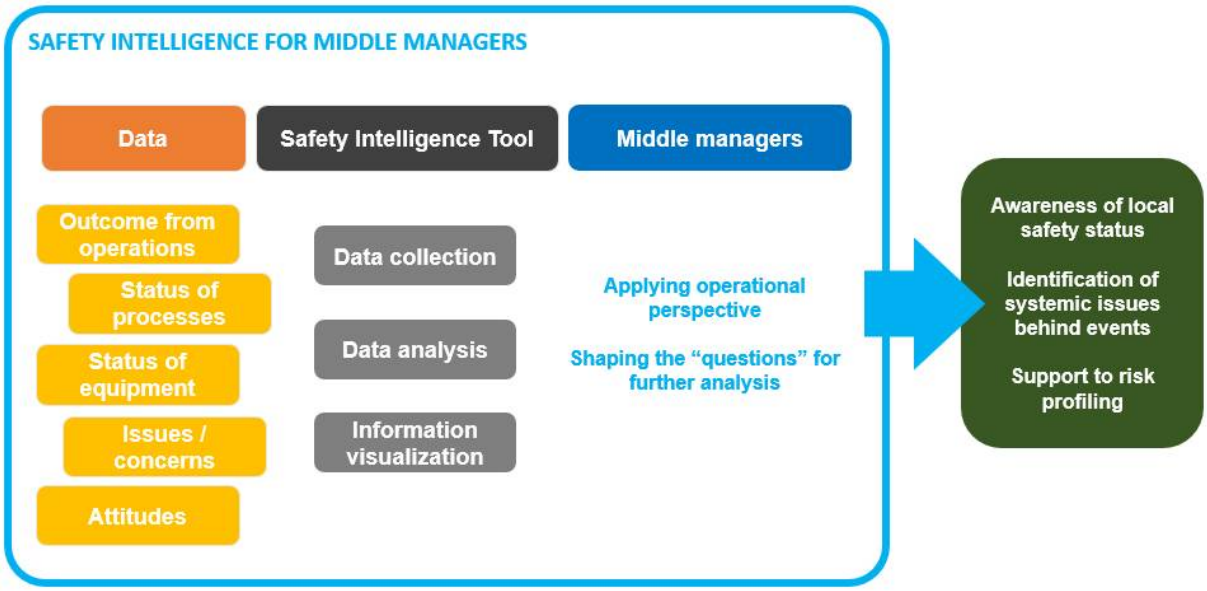

Figure 7 Safety Intelligence for middle managers

If the reasoning carried out so far is valid, the next step concerns the definition of a "Safety Intelligence for MM Tool" prototype, on the base of principles and architecture described in this section. This will require the identification of a number of requirements not only related to the SDB, but to the whole structure (types of data, data acquisition, analysis and visualisation) depicted above. Information on types of data have already been collected during the interviews and the workshops with SDB User Group – see also Appendix A. Completion of the work on Safety Intelligence will be documented in D5.9 "Executive Safety Intelligence Tools" and D5.11 "Executive Safety Intelligence Toolset".

5.2 Recommendations

The Safety Dashboard (SDB) User Group so far includes only ANSPs. One of the next steps will be the extension of the group to other aviation organisations, first candidates being airlines. In that sense, links have been already established with two major airlines. This first extension of the SDB User Group is meant to deepen the understanding of the way in which Safety Dashboards are used by airlines, identify best practices and differences with ANSPs. This will pave the way for exploiting cross-fertilization opportunities amongst organizations, through an exchange of paradigms, and possibly analysis methods and data visualizations. Last, the extension will be a major step forward in framing an overall conceptual guidance for Executive Safety Intelligence at the aviation system level.

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Appendix A INTERVIEW TEMPLATE

The text provided hereafter is the interview template used with the members of the SDB User Group. The interview were always carried out by two persons at the premises of the users.

STRUCTURE OF THE INTERVIEW

Introduction - work and dashboard introduction

- What does your **job** consist of (including operational division / support function)?
- Can you please describe your main **responsibilities**?
- In your job, do you use **safety dashboards**?
- What is the **dashboard role**? (Strategic, Tactical, or Operational)
- Can we see it?
    - ***Time to the interviewed to describe the dashboard***

Stimulate the dashboard description with respect to:

- ***contents,***
- ***data visualisation & interactivity,***
- ***connection to other dashboards (cascading dashboards)***
- ***and use of the dashboard***

Ensure that the all the aspects are covered and, if needed, use the following questions to stimulate the discussion

Safety Dashboard: contents

- What **type of information** is included? (Quantitative or qualitative, or both types)
- Where does the **information come from**? More in detail, what does it consist of? For example:
    - Number of occurrences distributed by severity;
    - Number of investigations concluded/open/in progress;
    - Measurement of Effectiveness of safety management;

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- Percentage of Risk Analysis Tool application;
- …what else? Anything from **outside the organisation**?

- Is any **non-safety information** included?
- How is the information fed to the SD?
- What Performance Indicators (**PIs**) are included?
  - Can you describe **how these PI are built**?
  - Are both **leading** and **lagging** PIs present?
- Are there any Key Performance Indicators (**KPIs**) – *PI aggregations, relevant areas*?
  - Can you describe **how these KPI are built**?
  - Are both **leading** and **lagging** PIs present?
- Does the DS use (or shows the result of the application of) a **weighting system** when combining different pieces of information?

SD: visualisation & interactivity

- How are the different **indicators visualised**?
- Are **visualisations different** depending on the users (if you are not the only one)?
- Can the indicators be **drilled**? At which granularity?
- Does the SDB trigger **alerts** in case **thresholds** are **infringed**? If that is the case, how the alerting system works?
- How **data visualisation** has **evolved** during time? Have you tried other visualisations that have now been changed? Why?
- What is the **most effective visualisation format** in your dashboard? Why?

SD: cascading dashboards

- Is the SD **shared?**
- Does it **link to a higher-level business DB**? **Who** can access it?
  - Do you need to **re-design** the way information is visualised **when sharing** it with non-safety executives?

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- Does it **link to a lower-level DB**? **Who** can access it?
- Are there other **SD users above/below** you? Are these **dashboards connected**? Are they similar or different?
- Does your dashboard **feed** something **outside** the organisation? What?

SD: using it

- How much do you **rely on the SD** to be **aware** of the organisation overall safety performance?
- How **frequently** do you use the SD (daily, weekly, monthly etc.)?
- How critical is the SD in **supporting your short-term decisions**?
- And what about **long-term decisions**?
- Do you find yourself looking for **complementing** the SDB with other data in the moment of decision-making? Which ones?

Dashboard impact – a real story

- Can you tell us about an example where the information contained in the **SDB** was **critical to inform a decision**? (*specify if it was a long-term or short-term decision*)
- Can you tell us about when it might have, but other criteria (experience, judgement) out-weighed the data on the SDB? **OR** Any examples where people did not really believe/trust what was on the SDB?

Needs & Desiderata

- Do you feel the current SDB in use **supports you properly**?
- Can you identify **gaps and issues** in your current dashboard? Can you mention **areas of improvements** and desiderata for your dashboard?
- Can you tell us what you like most of your dashboard?
- Do you have **examples** of other SD that you consider as **best in class**? Can you explain why?

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Appendix B SAFETY INDICATORS IN SAFETY DASHBOARDS

The five tables provided hereafter contain the indicators used in the SDBs presented by the participants. All the participants stressed that there is a certain flexibility in the choice of indicators, i.e. in some cases they are not always the same. More specifically:

- *Temporary changes* may be needed to address particular needs to the Board, e.g. show information in relation to a specific safety issue that is salient at that moment in time.
- *Permanent changes* occur when the indicators are not informative anymore, e.g. being always "red" or always "green" does not tell much in terms of what is going on underneath.

Table 5 Safety indicators – ANSP 1

Name	Description
Number of SMI	By type, severity and location; normalised by traffic
Number of overload reports	An overload report is filed when the ATCO feels he has worked with excessive workload during the shift
Number of ATM technical specific occurrences;	-
Number of Corrective Actions	- Number of no corrective actions defined in time - Number of corrective actions carried out in time - Number of expired corrective actions
EU Safety PI	- Application of automated safety monitoring tool - Level of reporting - No. of airspace infringements

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Table 6 Safety indicators – ANSP 2

Name	Description
Number of RI and SMI	**Runway incursions and loss of separation per 1000 movements**; only the safety events in which there is ATM contribution, and the trend from the previous year is represented in the graph as well.
Distribution of occurrence severity	**Distribution of occurrences severity per 1000 movements**, classified by RAT. All the RAT categories are represented here (A, B, C, D & N).
Number of ATC occurrences;	**Number of ATC occurrences per 1000 movements**, with three lines representing accidents (white line), severe incidents (orange line) and normal occurrences (purple line).
Just Culture level	-
Non conformities from CAA audits	-
Investigation timing	No. of investigations completed in time / overdue
Actions after investigation	No. of overdue / completed actions
Trend for SMI, RI, level busts and airspace infringements	With and without ATC contribution
Top 3 challenges or risk for the next quarter	Identified on the basis of safety occurrence data, together with risk assessment and foreseen mitigations.
Quarterly highlights	It can include everything relevant happened in that period (runway excursion, safety culture workshop, new systems implemented, training etc.).

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Table 7 Safety indicators – ANSP 3

Name	Description
RAT usage	As required by EU regulation
Safety Management maturity level	
Number of Safety Significant events – RI and SMI	
Number ATM specific occurrences	
Number of changes without safety assessment completed beforehand	-
Trends of safety occurrences distribution	-
Severity of RI, SMI and ATM specific occurrences	-
"Non-adequate separation" distribution by: - Wind direction - Time of the day - Workload	-

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Table 8 Safety indicators – ANSP 4

Name	Description
Overall Safety performance	Overall safety performance, based on ANSP contribution to the RAT scores for the last five years. It shows the number of A, B, C, D, E and N events in the period and the trend of severity with respect to the target set for RP2.
Operations Safety performance	Airspace and Airports safety performance expressed in RAT Points per 100,000 movements.
RAT targets	Comparison between the actual RAT points and the target set for the end of RP2. Together with the global picture, specific (normalised) data for Airspace and Airports operations are shown.
Safety events causal factors	A table showing the list of the most recurrent/relevant causal factors of the collected safety events (based on causal factors analysis). It also illustrates the number of Observations and MORs collected per year.
Traffic Figures	No. of movements per type of operation (Airspace and Airports), including the percentage of increase/decrease compared to the average of the period.
ATC Investigations	Highlights on events of significance. Each event is briefly described, together with its RAT score.
Engineering RAT scores	-
Number of Airprox	It shows all the Airprox reported, and compares the overall figure with the number of Airprox attributable to the ANSP.
Track of reporting rates	Rate of MORs and Observations per 100,000 movements.
Overview of Project Status Information	It shows the status of the different projects/changes implemented by the ANSP. Different pieces of information are presented per each project such as implementation phase, outcome, benefits, status and outcome.
Risk from upcoming change	It provides a picture of forthcoming risk from technical, human factors, airspace design & APSA.

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Table 9 Safety indicators – ANSP 5

Name	Description
Compliance with EU Safety Indicators	- SMS Maturity - Just Culture - Use of RAT
Unit Safety Surveys	The aim of the survey is to understand what are the daily hassles and worries for the controllers and not to evaluate if the Unit is "acceptably safe". Perspective is very ATCO-oriented.
Management attention for Safety	It tells how many management meetings on safety are performed in comparison to the planned ones.
Safety strategy	It tells if the ANSP is implementing the activities decided in the strategy. In other words: what is the progress in safety activities with respect to what has been planned?
Unit Safety Survey implementation and improvement management	It tells: - if an implementation plan to address identified Unit safety concerns has been implemented - % of implementation actions performed
Reporting and investigation	- % of reported SMI spontaneously reported; - % of reported SMI (spontaneous and after notification); - Resources (days dedicated by ATCO investigators to reporting monitoring and investigations).
Audits	- Number of B-findings closed in time; - Number of C-findings closed in time; - CAA non-conformities solved in time; - Completion of internal audit (in %); - % of postponed deadlines for internal audits
Safety Improvement	- % of actions agreed in internal investigation management responses fulfilled appropriately and within deadline; - After 90 days, a relevant problem analysis of the SIR AND an appropriate action plan to correct the situation and thereafter, every 90 days a progress report is delivered (except if no action is due).
Change management	- % of changes which were published at least 30 working days before the Change Implementation Date.
SMI and RI	- Number of LoS validated on reported basis; - Number of LoS less than 50% (both vt and hz planes); - Number of RI (A+B severity).
Company Risk Management (Reputation and legal aspects)	- The total number of reported serious and major incidents in the ANSP area of responsibility with high

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	and medium REPUTATION Risk; - The total number of reported serious and major incidents (Risk A and B) in the ANSP area of responsibility with direct or indirect SG contribution with high and medium LEGAL Risk. For information only: - Number of events where the MOSI process has been activated; - Number of running judiciary activities against ATCO; - CISM Percentage of participation in recurrent training courses (peers).

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