A Prototype Safety Dashboard for Air Navigation Service Providers

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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 presents a prototype safety dashboard for Air Navigation Service Providers, designed and developed for ANSPs in the context of P5 for different organisational audiences, principally at Executives Board level.

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Acronyms

Acronym	Definition
ANSP	Air Navigation Service Provider
ATCO	Air Traffic Controller
ATM	Air Traffic Management
ATS	Air Traffic Service
CEO	Chief Executive Officer
CISM	Critical Incident Stress Management
EU	European Union
FIR	Flight Information Region
FSS	Future Sky Safety
NSA	National Supervisor Authority
RAT	Risk Analysis Tool
SDB	Safety Dashboard
SES	Single European Sky
SESAR	Single European Sky ATM Research
SRIA	Strategic Research & Innovation Agenda
TCAS	Traffic Alert and Collision Avoidance System
UCD	User-Centered Design
WP	Work Package

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EXECUTIVE SUMMARY

In this digital age, there is no shortage of data and an ever-increasing number of tools and approaches to analyse, visualise and learn from data, including learning how to be safer. But at the end of the day, someone has to make a decision, to decide how to act upon these data. These decision-makers, usually at the top of organisations, do not wish to be deluged with data and myriad business intelligence graphics. They need the information to be boiled down to its essentials, so they can understand the heart of the issue, and make the right decisions based on clear information. *Safety Intelligence* does not only refer to information about safety, it implies smart presentation of such data, tailored to the decision-makers. Safety intelligence needs to be user-centred.

The safety intelligence research within the Future Sky Safety project therefore started at the top, examining 'safety wisdom', namely how chief executives and other leaders at the helm of their aviation organisations understood and managed safety, so they could get a sound night's sleep. We then visited a number of Air Navigation Service Providers (ANSPs) who were already engaged in safety intelligence, in particular using safety dashboards to present information to their Executive Boards – their Chief Executives and executive directors. A defining moment in the research was when six ANSPs came together and shared their dashboards. Everyone realised they had something to learn from each other.

This led to a prototype safety dashboard, but we wanted to take it one step further, from research into application and industrialisation. Working initially with a number of new ANSPs in order to gain more detailed safety dashboard requirements, we then worked with a single large European ANSP to develop a bespoke safety dashboard for their Executive Board, which was unveiled in early 2019, receiving strong positive feedback from the Executive Board.

Although this marks the end of the research project, it will not be the end of the story – safety dashboards will continue to evolve – their development is a continuing journey. What this White Paper does is show what we have learned along the way, including what to do and what not to do, and how to show the best visualisations that appear to map well onto the executive-level mindset. Although the context of this White Paper is ANSPs and air traffic management, the insights should be relevant and adaptable to other aviation organisations, and perhaps even other industries. It is therefore hoped that the contents in this White Paper will help other organisations navigate through the wealth of safety data and analytic techniques to a safer operational future. This should enable those at the top to keep a finger on the pulse of safety and make course corrections when needed, and to glimpse what safety issues, threats and opportunities might be just around the corner.

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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 its full operational and organisational context. This Project addresses the effects of organisational structures, processes & cultural phenomena on safety performance in aviation organisations. 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 organisations operating the air transport system. Outcome of the research (2018) will be a Safety Performance System model which will address safety in aviation under a more cohesive and collaborative approach.

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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).

ECTL leads WP5.1 "Executive Safety Intelligence" in cooperation with the following partners: DBL, ENA, BRTE, AIR[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 this WP is to equip **senior** (CEO/Board) and **middle management** layers with a pragmatic understanding of organisational safety and how to optimise it. This includes guidance on safety culture leadership, and usage of tools such as safety dashboards and data feeds to ensure safe decision-making. The main work 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 specific deliverable concerns giving senior management a good overall picture of safety via a comprehensive safety dashboard.

1.4. Approach

The first step towards developing a safety dashboard was to see what already existed, and to learn from current experience.

The approach to safety dashboards is part of safety intelligence. Many Air Navigation Service Providers (ANSPs) already utilize safety intelligence, some with dashboards, some without. For an ANSP the following questions are key to developing a safety dashboard capability at senior (Executive Board) level:

- Does your organization have a safety dashboard?
- Who is it designed for?
- What kind of information does it provide?
- What story does it tell?
- Is it a tool to show compliance, or to start a conversation about the adequacy of safety?
- Is the Executive Board happy with it?

[1]Airbus is now co-lead for WP1, focusing on Middle Management Safety Intelligence

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These are just some of the questions we used to investigate the 'state of the play' of safety dashboard in an ANSP. Starting from the last quarter of 2016 we approached a number of European ANSPs. We visited them, interviewed key people in safety departments, and shared the outcomes of our research in workshops.

Our goal was to understand what tools and data those organisations used to support their safety intelligence – with a focus on experienced issues and unmet needs. This helped identify a direction for evolving the dashboards in a way that fosters the safety intelligence of executive boards. It also enabled the building of a number of prototypes to turn the research into something more practical, to be used as basis for design and development of a next generation of dashboards.

The work went through five steps:

1. Interviews with safety managers and directors from 6 different ANSP to collect preliminary data about their safety dashboard and how they use them (March-April 2016);
2. A workshop where the interviewees were invited to share their experience and make a collective effort for designing an optimized ATM dashboard (October 2016);
3. A phase of visual prototyping, in which we iterated the design on the base of ANSPs' feedback, which ultimately delivered a first mock-up for a static dashboard (November 2016 –December 2017);
4. A series of three workshops endorsed by EUROCONTROL, in which the work on safety dashboard was presented to an audience of ANSP safety managers and directors not previously involved. In these sessions we collected feedback on the visual prototype and we extended the collection of needs and requirements (January 2018 – October 2018).
5. The collaboration with a major European ANSP to design and develop a digital interactive dashboard. The work adopted a User Centered Design approach, with an early involvement of the end users and frequent validation of intermediate mock-ups. The work ended up in a fully working prototype, fed by real safety data and tested during an Executive Board meeting (February 2019).

1.5. Structure of the document

Chapter 2 presents the current state of play. Chapter 3 reviews some of the common pitfalls of Safety Dashboard. Chapter 4 presents avenues for developing a sound Safety Dashboard. A concrete example is provided in Chapter 5 with the template designed for an ANSP. Chapter 6 presents the Safety Stack concept before the last chapter covering the conclusions for this research.

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2 STATE OF PLAY

2.1. Fifty Shades of Safety

Running a safe business in aviation is a challenge: on the one hand, aviation is an 'ultra-safe' industry, with a very low accident rate, supported by a wealth of experience and safety 'know-how' that keeps us all safe. On the other hand, accidents, though rare, can and still do happen, and so leaders of aviation organisations have to keep an eye on safety. But how do leaders see through the forest of safety-related data to what really matters? How do they pick out the real signals that need to be acted upon, from all the other 'noise'. After an accident, with the benefit of hindsight, everything becomes black and white, and the signals stick out a mile. Before an accident, however, everything seems to be in shades of grey. How can leaders stay ahead of emerging safety threats, containing and resolving them before they manifest into circumstances that allow an accident to happen?

Staying ahead of safety threats requires three conversations. The first is at the so-called *sharp end*: the pilots, cabin crew, controllers, ground staff and services – the people who are closest to the accident 'surface'. They are usually the first to see something going wrong, whether new problems arising due to system design or operating changes, or safe procedures being compromised due to commercial pressures on productivity, or other issues. They have their hand on the wheel and are the first to feel the bumps in the road. If they report such issues, and can report their own mistakes without being punished, then this information can be fed up to the next layer. If not, the organization is running blind.

The second conversation about safety is with the safety unit or department. Whilst everyone is responsible for safety, the safety people in particular are the ones gathering all the data together and making sense of it. These are the people evaluating the threats from a range of sources, including investigations and reports, but also a raft of safety performance metrics (key performance indicators, or KPIs). The safety people have their fingers on the safety pulse of the organization, and take the key issues via their Director to the Executive Board for support and resolution.

The third conversation is one that is less often talked about. It is the safety conversation in the Executive Board. In some cases, there is very little discussion of safety at this level. Safety is not normally on the agenda, and safety issues are dealt with outside the Board room, e.g. in discussions between the Safety Director or Safety Vice President and the CEO. This White Paper challenges this view for the simple reason that other Board members, including those responsible for Operations, Finance, Human Resources, and Technology / Innovation, should be part of the resolution process, because often the roots of emerging safety threats, and their resolution, touches their domains. The entire Board has a stake in safety. It is often said that in aviation, without safety there is no business. Therefore, safety needs to be part of the business decision-making at the very top, not something handled separately. A limited conversation about safety at Board level means a limited approach to safety, and puts the entire business at risk.

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2.2. Bridging the Three Safety Conversations

A former CEO of a major low-cost airline was asked how she stayed on top of safety. She replied that she didn't entirely trust all the statistics, though she of course looked at them. What she did was ask each of her post-holders once a month where the problems were. This was a simple way of going to the heart of what really matters, and is still one of the best ways to keep track of safety issues. Similarly, in a recent study of senior managers in ten European aviation organisations including airlines, airports, air traffic organisations and airframe manufacturers, most people interviewed favoured an equal split between reviewing safety statistics and talking to other post-holders or those at the front line.

2.3. Data, data everywhere…

Yet in talking to various aviation organisations, a problem emerged. There are so many safety statistics that it is hard to see what matters, to condense them down to the essentials, and to then present a clear message to the Executive Board in a meaningful way so they can understand the issues and take effective decisions to improve or restore safety, and to overcome developing issues before they impact on operations.

In this era of Big Data, continuous real-time data, and even 'fake' and 'shallow' data, we are *data rich, yet information poor*. However, advances are appearing that can let the data tell a story, aided by powerful Business Intelligence (BI) software. Even so, as we obtain more and more data, and more powerful and diverse ways to analyse them, the challenge remains one of how to sift through the data sets and decide what matters – where do we need to act, where we need to watch closely, and what might be coming around the corner.

2.4. What we did

At the outset of the three-year study which has led to this White Paper, a number of organisations were contacted who had safety dashboards, as well as some others who did not. The dashboards we reviewed all dealt with safety, but differed in style, in content, and in the intended use by the Board. What everyone admitted, however, was that it was difficult to keep the Board engaged on safety issues with dashboards. No organization we spoke to felt it had achieved the 'magic mix' of format, style and content for an Executive-level Safety Dashboard. This project, funded by the European Commission's Horizon 2020 Future Sky Safety programme, therefore worked in three phases:

- Phase 1 – talking to senior leaders (CEOs etc.) in aviation organisations to find out how they ran their organisations safely[2]
- Phase 2 – working with six Air Navigation Service Providers (ANSPs) who already had mature safety dashboards used at Executive Board level to develop a generic prototype[3]

[2] https://safeorg.eu/beta/wp-content/uploads/2018/07/1_Safety-Wisdom.pdf
[3] https://safeorg.eu/beta/wp-content/uploads/2018/07/3_Safety-Dashboard.pdf

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- Phase 3 – working with another seven ANSPs who wanted to develop new safety dashboard approaches, culminating in a new safety dashboard for a single major European ANSP, which was successfully implemented at Executive Board level.

Although the detail of the safety dashboard discussions has been in the context of air traffic organisations (ANSPs), it is believed it will still be of interest to other aviation organisations. As an example, the principles in this white paper are currently being used to develop a safety dashboard at a UK London airport. The more general principles and examples of how a safety dashboard can be developed has also been published on the SAFEORG website[4].

The rest of this paper outlines the mechanics of developing a safety dashboard that is user-centred, aimed at Executive Board level. The first step, therefore, is to understand this audience, namely the Executive Board.

2.5. Who is the Board, exactly?

Executive Board structures vary, but typically they include the following functions (some of these may be amalgamated into one Board member):

- CEO or Director General or Chairman of the Board – *the boss* – accountable to external agencies, regulatory authorities, business partners and shareholders as applicable, and also, should the unthinkable happen, the general public.
- Directors / Vice Presidents
  - Chief Operating Officer (COO)
  - Dir. Operations
  - Dir. Design / Development / Innovation / Engineering
  - Chief Financial Officer (CFO)
  - Dir. Human Resources
  - Dir. Strategy
  - Dir. Business Development
  - Dir. Safety (these days often Dir. Safety, Quality & Security)
  - Other

Many organizations have two Boards, an internal (Executive) Board who run the organization, and an external one which is more 'public', in which non-executive directors participate. The focus of this deliverable is on *Executive Boards*, though the information may also be useful for other types of Board.

[4] https://safeorg.eu/safety-dashboard/

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3 HOW TO GET IT WRONG: THE DIRTY DOZEN PITFALLS WITH SAFETY DASHBOARDS

By the end of Phase II, what was clearest was how *not* to do safety dashboards, as a number of ANSPs already had experience of what did and did not work. There are certain pitfalls with safety dashboards. The 'Dirty Dozen' are shown below.

Some of these were lessons given by several organisations, and counter-measures are available. Others, such as *Black Swans* and *Data Silos* are still works in progress in terms of determining how to get it right, and reinforce the fact that a safety dashboard is there to trigger and support a conversation, rather than replace it.

- **Forever green**: some indicators retain a status that is always looking "good", i.e. in which targets are achieved and thresholds never trespassed. There are two problems with this. The first is simply that the Board will stop looking at it. The second is that it can lead to complacency, or a failure to look deeper behind the numbers to know what is really going on.
- **Knee-jerk reactions:** Any performance indicator that becomes red does however need careful analysis, and careful reflection by the Safety people before presenting to the Board. Often the root causes may not be the most obvious ones. In one organization, issues would first appear 'Orange' for a short time before turning red, by which time more intelligence had been gathered to better understand the problem and the required resolution action.
- **Targetology:** This happens when there is such a strong focus to reduce risk to achieve a particular target, that risk information is distorted to give the *appearance* of reducing the risk. Often this takes the form of suppressing reporting, manipulating the way in which the safety stats are compiled, or exporting the risk to another KPI. Overall, safety may not improve and may actually worsen, whilst giving the Board or external stakeholders (e.g. regulators) the false impression they are on top of things.
- **Frozen indicators:** indicators that never change are probably insensitive to actual changes, i.e. they are not defined at the right level of granularity. Another variant of indicators that never appear to change, or do so at a glacial rate, is improvement plans intended to improve over a long period. Again, the solution is to change the granularity, perhaps by breaking down such actions into steps. Conversely, an indicator that remains stable despite the increase of traffic should be considered as a positive sign of safety, and this can be reflected on the SDB visualisation.
- **No Perspective:** the importance of safety events needs to be considered in relation to other factors, in particular the amount of traffic that was handled during the period over which the events occurred. This is known as normalization of data. Other 'normalising' factors might include seasonal effects, such as whether it was the summer period (the busiest for air traffic) or the onset of winter (often key for airports). Many organisations who chart number of events per month want to be able to compare against the equivalent figures for the previous year.

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- **The New Normal:** whilst normalization of data is necessary, it should not enable normalization of risk, wherein safety standards are allowed to slowly decline, as everyone adapts to 'the new normal'. This usually happens because of resource cuts in one or more areas, so that people 'have to make do.' This is yet another reason why Board members such as CFO and Director of Resources need to be aware of safety decision-making, because they influence resource availability and resource allocation.
- **Quantity is King, Quality is Queen:** some indicators look at process status (e.g. whether a process is in place). However, this says little about the *quality* of the activity carried out (is the process delivering?) For example an indicator can tell that an assessment is completed on time, or that a certain percentage of planned activities has been completed, but these numbers do not say anything about the value or effectiveness of the safety case or activities. This is a common fault when addressing safety improvements and tackling Top 5 Risks.
- **Black Swans:** the confirmation bias is a well-known human trait in which we look for reassurance that whatever we are doing is going well. We don't look for disconfirming evidence. Statistics often mask individual events or 'black swans' that show something is wrong. It is up to the safety people to ensure no such masking occurs, and to highlight specific events which 'go against the grain.' Talking to post-holders or asking people at the front line is also a good way to detect black swans.
- **Data silos:** It is often difficult to see the relationships between the various pieces of information displayed on dashboards. For example, being able to show the link between indicators or incident hot-spots, the causes in terms of new developments in the organization, and corrective actions in the safety plan. This area is still a work-in-progress, but is another reason for engaging the entire Board, as the links may touch on several Board Member's areas of responsibility.
- **The 'Other Top 5'**: Every organization has its top 5 risks, such as midair collision, runway incursion or excursion etc. These are the big headline events, and have to be monitored, but are very rare. Usually there is another top 5, linked to 'smaller' (i.e. less consequential) risks such as falls from an aircraft at an airport, or occupational injuries in maintenance and engineering, and other internal risks such as fatigue, loss of morale, chronic pressure of work, etc. Such internal risks are 'messy' and not easily described in neat KPI format, but they may well be the risks that really do need to be controlled. Otherwise they prepare the ground for the larger risks to happen.
- **Mirror, mirror, on the wall**: in certain cultures, including organizational cultures, there is pressure to only pass good news upwards. The safety people may feel it is their job to look after safety, either because they want to be seen to be doing their job, or to protect the Board, or because they firmly believe the Board has no time for safety. Such reasons are understandable, but they are not optimal for safety. It is up to the Board, and the CEO in particular, to cultivate a more open relationship where bad news is not only tolerated but welcomed. This can even be done for self-interest at Board level, since if an accident occurs, the media and investigators will focus on the top tier of the organization.

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- **Safety Myopia:** many safety dashboards are like rear-view mirrors in cars. They show what is behind. This is important, because they contain key learning points. But safe driving also requires looking ahead, beyond the 'now' issues to those coming up. There is a tendency for safety to be reactive, to wait until there is evidence of a problem. Safety needs to also look forward, to upcoming projects that will ultimately improve matters, but which might create safety 'pinch points' along the way. Safety therefore needs to highlight, in advance, where the business strategy might put the overall business temporarily at risk. This is what we mean by saying safety must be part of the business. It is not just words, it is meant in a very practical sense.

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4 HOW TO GET IT RIGHT

At a basic level, the safety dashboard is supporting the discussion of three fundamental questions:

1. *"Are we safe?"*
2. *"Is there anything we should worry about?"*
3. *"Is there any action we should take?"*

These questions can be answered by looking at different types of data. The conversation with the ANSPs during Phase III helped to identify the main areas in which safety data can be grouped. It was understood that there will never be a one-size-fits-all version, but an over-arching structure was agreed, including the following areas:

i. **OPERATIONAL SAFETY AND RISK**
   - The "hard" statistics in terms of safety occurrences in operations
   - The top causes
   - "Where are the key safety vulnerabilities?"

ii. **PEOPLE & CULTURE**
   - "How is the reporting culture?"
   - "Is there positive energy for safety in the organisation?"

iii. **TECHNICAL SYSTEM**
   - "How is the reliability of equipment?"
   - "Do technical issues force people to do workarounds?"

iv. **CHANGE MANAGEMENT**
   - "Are all changes safe when combined?"
   - "Are corrective actions done on time?"

The ANSPs involved in both Phase 2 and 3 do not use all the above areas in their current dashboards; however, those were identified as the ideal elements featuring in a well-balanced safety dashboard. Moreover, no rigid indication of specific KPIs emerged as the best one possible; rather we collected list of "good candidates" for populating each area, which includes both reactive and proactive indicators.

The specific indicators to be used would then vary depending on the *specific ANSP characteristics* (e.g. size, safety department "history", available manpower for data analysis and others) and on *type of conversation on safety* established with the Executive Board. A number of ANSPs reported how their dashboards changed over time, by means of a gradual fine-tuning between Board requests and expectations, and Safety department concerns and proposals. Changing and adapting the content of the dashboard occurs naturally via a proactive safety mindset and it is the right remedial against pitfalls like "Frozen indicators" and "Targetology". A good dashboard is an ongoing conversation on safety rather than a fixed set of indicators.

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Last, the importance of a User-Centred Design (UCD) approach stood out. A safety dashboard is generally a tool *designed* and *owned* by the Safety department but *used* mainly by the Board. This requires a careful understanding of the Board needs. For example, Board members are unlikely to need data drilling and navigation functionalities, which could risk to become pure clutter.

The *iterative approach* - the other component of a UCD – would then be addressed by the continuous fine-tuning of the dashboard.

4.1. A digital dashboard, not a data deluge.

While the source of data is obviously digital, we observed how most ANSP involved in the project were using "static" dashboards, i.e. collages of spreadsheet graphs on slides. The trend as noted in the workshops, however, definitely indicates a desire to move towards full digital solutions, which must be *integrated within the normal company software ecosystem*, meaning that they should require no effort from the user to enable the tool (e.g. installation of additional software).

While this change will surely open up a range of new opportunities for designing dashboards that are more and more exploiting the wealth of data inside the organisation, the risk is to be overwhelmed by the sheer availability of indicators and visualizations that can be created with just a mouse-click. Such a risk can be easily avoided by not forgetting to put end-users first, especially when it comes to Board members, who need to use the information to make decisions rather than 'deep-diving' into data exploration and sense-making, which is probably best done by the safety team in the organisation.

4.2. Making it real: safety dashboard content and key safety indicators

4.2.1. Operational Safety

The first area, used in all safety dashboards reviewed, is performance against targets on key risk categories. This usually shows the following:

(i) A graph of monthly incidents for the top 3 or 5 risk event categories (e.g. loss of separation between aircraft), normalized for traffic, but where it is possible to also see the absolute number of events each month at different severity levels. Often 'thresholds' are shown on such graphs, in order to see how close performance is to the edge of safety.

(ii) The top contributory factors 'driving' those events – this is where risk reduction effort can be targeted.

(iii) A geographic representation so the Board can see which units are most affected, and where the hotspots are.

(iv) Top highlights focusing on events and changes of strategic impact (e.g. temporary closure of a major airport; large modification to routes due to a conflict in a neighboring country; etc.).

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4.2.2. People and Culture

The second area is about understanding the reporting culture, and the attitude of people towards safety, and the collective 'energy' for safety that is evidence of a positive safety culture. Human Factors issues and related mitigation actions are a key area of interest. Usual indicators include:

(i) Trend of reporting rate for safety occurrences – distinguished according to their risk – across comparable timeframe (e.g. set of 12 months).

(ii) Trends of reports on fatigue and overload situations.

(iii) Rate of participation to training initiatives which are in connection with safety, like Human Factors courses, CISM training and the like.

(iv) Progress on safety culture initiatives, i.e. to see if there is enough "energy" spent in them or if they are "dragging".

A normalized measure of the reporting rate is by far the most popular indicator. This is an area of safety dashboard design where more research or innovation is needed, to properly capture and visualize effectively the state of the safety culture in the organization.

4.2.3. Technical system

The third area is about understanding the health status of the equipment. Usual indicators include:

(i) Normalized trend and distribution and severity of ATM-specific occurrences (engineering and maintenance).

(ii) Number of technical issues identified in the context of safety surveys by Unit.

(iii) Number of workarounds put in place by personnel to overcome technical issues.

(iv) Ratio between planned/unplanned maintenance interventions.

(v) Trends and thresholds related to the cumulative duration of technical failures with operational impact over time (e.g. how much 'downtime' has been experienced for key systems).

4.2.4. Change management

The fourth area is about monitoring how change is potentially affecting the safety level of the organization. Change is important in aviation as the industry does not tend to stand still, and continues to see growth and expansion on a rate exceeding that found in many other industries. Some typical indicators include the following:

(i) Trend of corrective actions, their number and their timeliness.

(ii) Status of ongoing change projects, to identify combined risk and 'pinch points'.

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(iii) Top change recommendations - in terms of importance - coming from external bodies (e.g. national [NSA], and European-wide regulatory bodies [EASA]) and their implementation status (e.g. on time, delayed, etc. with an indication of the deadline).

(iv) Safe Change Management – an overview of the most notable forthcoming changes and their potential impact on safety.

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5 THE CRITICAL 'SAFETY REAL-ESTATE' ON A SAFETY DASHBOARD

The work done in Phase III culminated in designing and developing a prototype of a new digital and interactive safety dashboard for a major European ANSP. This prototype was successfully presented at the Executive Board and became the starting point for evolving the previous dashboard used inside the organization.

The work on the dashboard did not stop there; rather it was further fed by the discussion triggered by presenting the prototype during its development to a larger ANSP audience, and by the feedback received from the European ANSP experimenting with the dashboard.

This ultimately led to developing a final visualization of the dashboard, which proposes a selection of safety data and visualization, laid out according to the four main areas of interest. The full dashboard is presented in Figure 1. As it is presented here as a double-page static representation of a digital tool, not all of the data display options can be represented, but indications of points of interaction are given.
Each area of safety dashboard 'real estate' is presented below together with explanatory information.

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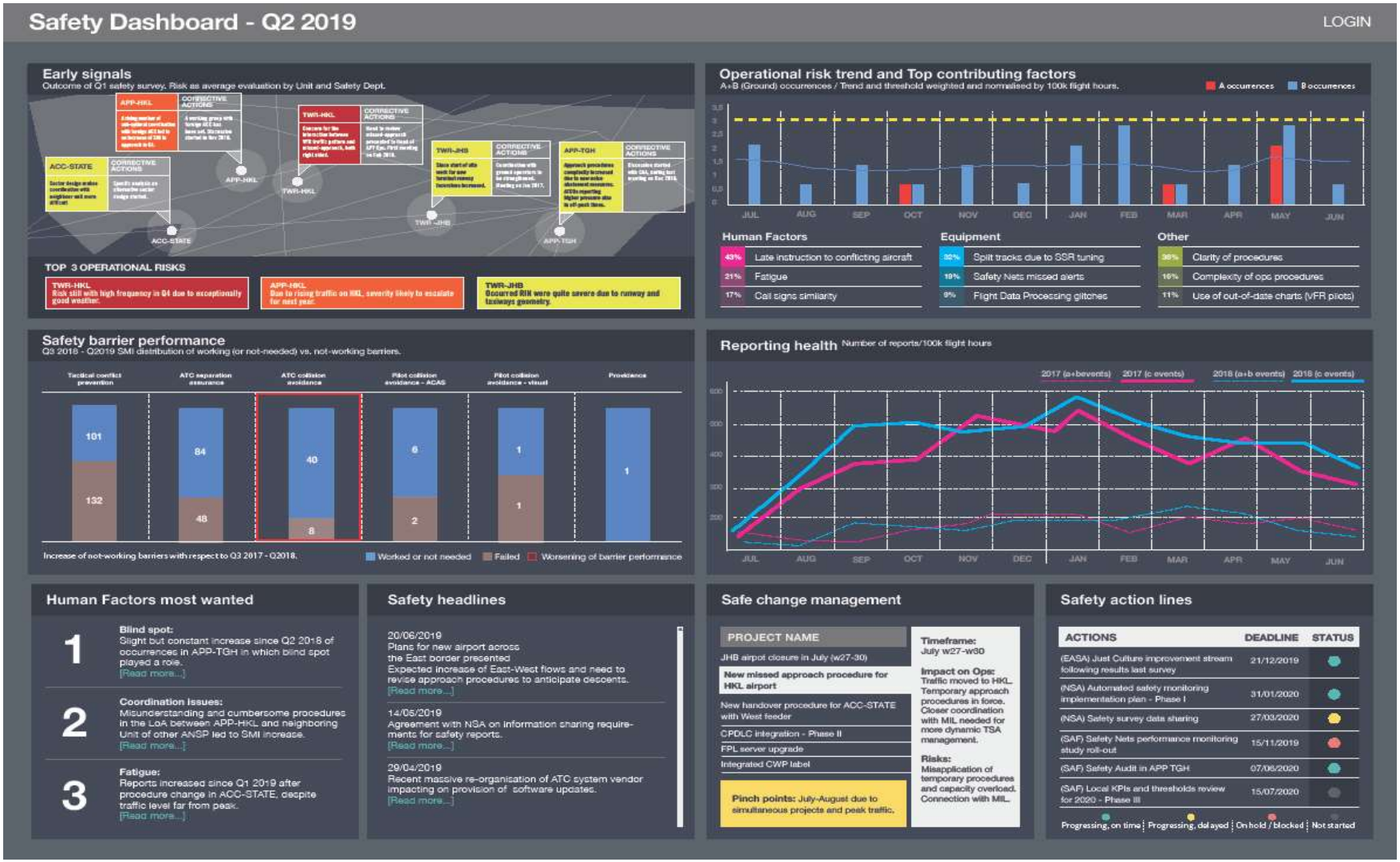

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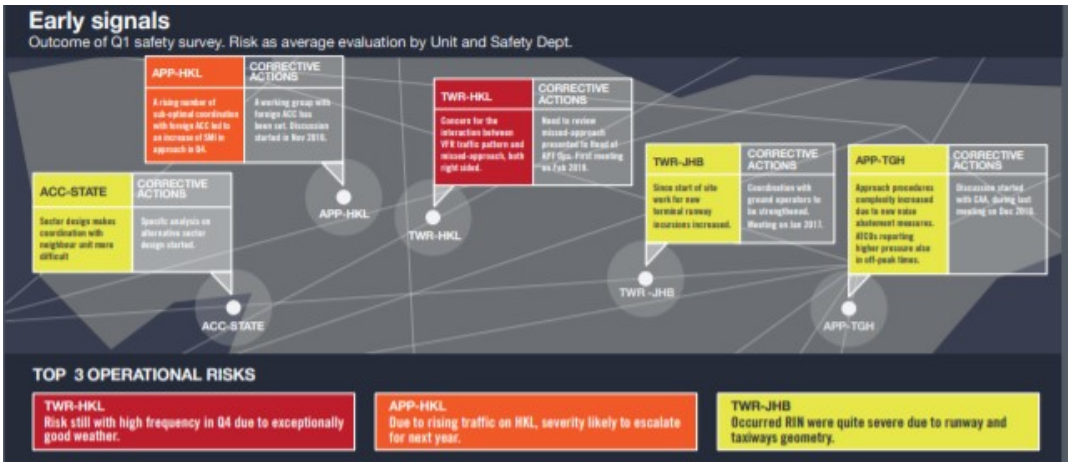
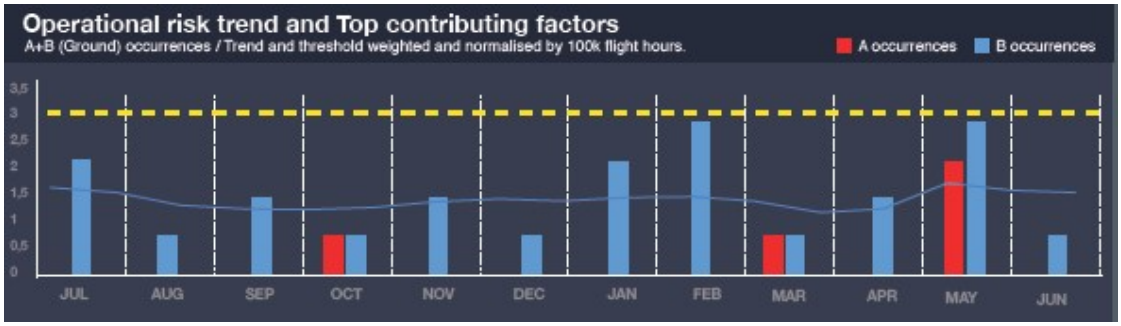
5.1. Geo-localisation of early signals of risk



This map displays the top risks as perceived and expressed by first line operators (e.g. air traffic controllers or ATCOs) in each Unit. The perspective is very sharp-end-oriented, looking for early signals of lurking or upcoming criticalities. The top three risks are shown in a dedicated space below the map. Risk severity is represented by using color coding (decreasing from red to orange to yellow). The map can be seen as the output of a Unit Safety Survey. In the digital version, it is possible to 'zoom in' to particular areas, for example where there may be several airports in close proximity.

5.2. Operational risk trend



This graph represents the trend over a moving window of the last 12 months of severity-level A and B safety occurrences, normalized per 100k flight hours. The trend line is a weighting of A and B events (with A considered as "2 times B"), and is compared against a threshold set by the ANSP in conjunction with the regulator.

This graph answers the need of immediately getting an understanding of the safety performance during the last period of time. This is the main "rear-view mirror" in terms of safety performance, and is a very common 'lagging' indicator.

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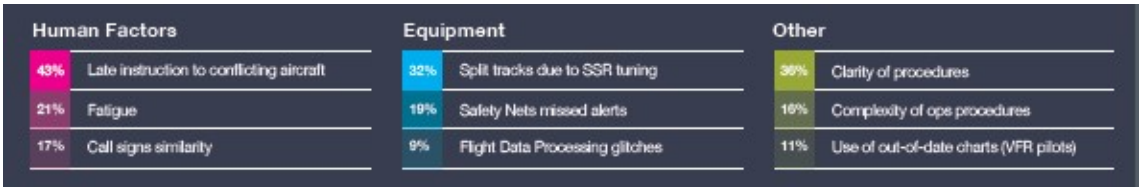
5.3. Top contributing factors



This section, displayed immediately below the Occurrences trend graph, provides a list of the top risk factors, categorized in three areas: "Human", "Technical", and "Other". The adopted criterion is to show the most frequent contributing factors identified during the investigation of safety occurrences. A further sorting of the risk factors according to the type of occurrence (e.g. Separation Minima Infringement, Runway Incursion, and Airspace Infringement etc.) can also be provided.

5.4. Safety barriers performance

This section compares two moving windows of 12 months by showing the distribution of safety occurrences according to the number of barriers infringed. This section is using the 'Swiss Cheese' metaphor, showing the safety performance of the principal barriers against an accident. The stages of safety deterioration selected for air traffic management – starting from the one farthest from the accident – are the following: i) "Tactical Conflict Prevention"; ii) "ATC Separation Assurance"; iii) "ATC Collision Avoidance"; iv) "Pilot Collision Avoidance – ACAS"; v) "Pilot Collision Avoidance – visual" and vi) "Providence". Different stages/barriers scheme can be elaborated, but the goal is the same: show what proportion of barriers was infringed and if any notable changes has occurred between the two periods. Note that this part of the safety dashboard was developed following the finalization of the dynamic dashboard for the ANSP, and so has not been 'validated' by the Board. Nevertheless, from all the discussions and workshops, this seemed to be a useful segment of the dashboard, giving a clear picture to the Board of how close to an accident they may come, and where to invest in safety 'upstream'.

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5.5. Reporting health

This section shows the trend of ATCO reports normalized by 100k flight hours, over a rolling window of 12 months. Three rolling periods are shown (e.g. 2018 vs 2017 vs 2016), updated depending on the quarter. The reports are differentiated by risk level (A and B vs C: an increase of C reports should be taken as a sign of good reporting culture considering the smaller safety-relevance of these events).

5.6. Human Factors "Most wanted"

This section shows the most important Human Factors issues as identified by the organisation through a continuous monitoring of available safety data. The importance is related to the contribution the issues have in safety occurrences but also in perceived risks. Examples include topics such as events due to 'blind spot' phenomenon (wherein an aircraft is over-looked, leading to a loss of separation with another aircraft), coordination issues due to misunderstanding, and fatigue. Such issues are commonly raised by the safety manager, the incident investigators, the Human Factors people if the organization has them, or by controllers and supervisors themselves.

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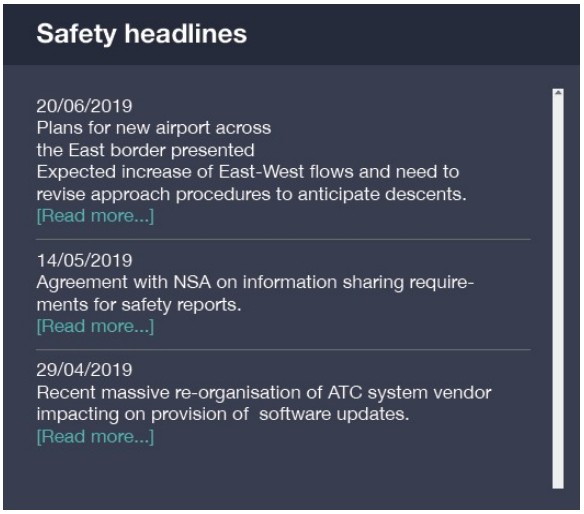
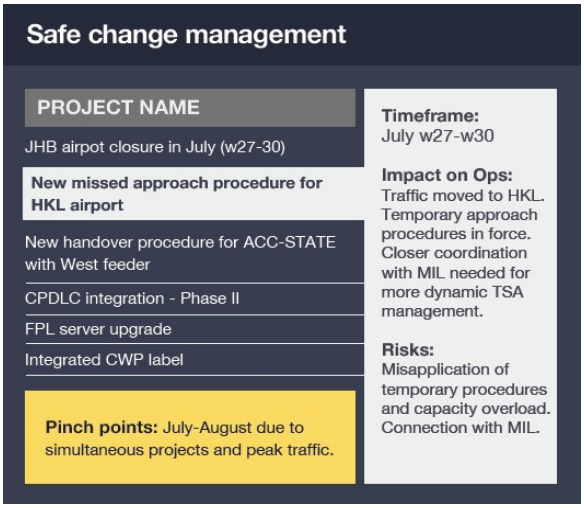
5.7. Safety Headlines

This section lists the most important "news" related to safety. Examples include items such as plans for building a new airport in a neighbouring country; a major agreement with the NSA on safety matters; or changes occurring in external organisations such as a key supplier that may have an impact on safety. The goal is to provide an overview of the most notable things "around" safety that should be known, particularly in case the CEO or other directors are involved in discussions with regulators, external stakeholders and other partners.



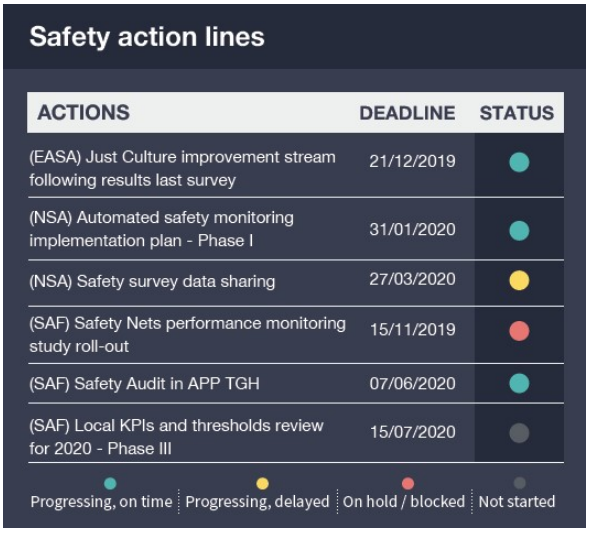
5.8. Safe Change Management

This section provides an outlook on the next two quarters, by listing the major projects and changes that can have an impact on safety. More information about the timeframe, impact on operations and associated risk can be displayed. The goal is to provide a chance for warning the Board about potential 'pinch points' and dysfunctional interactions between activities.



5.9. Safety action lines

This section lists i) the most important strands of activities in the Safety Plan together, and ii) the top recommendations and corrective actions provided by external organizations (e.g. NSA, EASA) that must be put in place by the ANSP, both of them with their respective deadlines and current status (on time, delayed, not yet started, etc.). The goal is to provide an overview of how well the various agreed actions are progressing, and if there are any obstacles hindering their implementation, and to avoid surprises for the Board in terms of compliance with requests coming from the regulator.



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6 A WAY FORWARD FOR SAFETY DASHBOARDS: THE STACK CONCEPT

Although the delivery of a full-working digital prototype to a major European ANSP marked the end of the research activity on safety dashboards in the context of Future Sky Safety, it will not be the end of the story, as safety dashboards are getting more and more traction not only in the ATM community but in the entire aviation domain, and they will continue to evolve as the demand for their implementation is soaring.

While working on the dashboard prototypes, we collected many requests from the users. While most of them are of a technical nature, including for example more advanced predictive metrics and database-dashboard software integration, one was about creating a shared dashboard for a community of organisations, something that would be useful in those contexts in which safe operations critically hinge on smooth collaboration between many different actors.

An example of such a context is the airport; in here the safety actors include airlines, air traffic control, ground handlers, de-icers, fuel services, baggage handlers, caterers and cleaning services. All of them are so tightly connected that if one of them has a problem, then they all do.

To some it made sense to start working together on safety, and the work on the so-called Safety Stack began in late 2016 at London Luton Airport (LLA). The Stack members meet regularly, share information, keep mutually up to date on safety matters and collaborate to streamline operations, for example by harmonising all ground-handling procedures.

The Stack identified a shared safety dashboard as a powerful tool for rapid sharing of information and mutual awareness on top risks and forthcoming changes which can affect operations. The Dashboard for LLA is currently under implementation, but an example layout is shown below. One aim of the Safety Stack is to have a version of the dashboard that can be viewed on smart-phones and tablets (e.g. showing one dashboard segment at a time). Such usage is more intended for staff and managers than senior executives, as a way of keeping staff up to date on daily safety issues.

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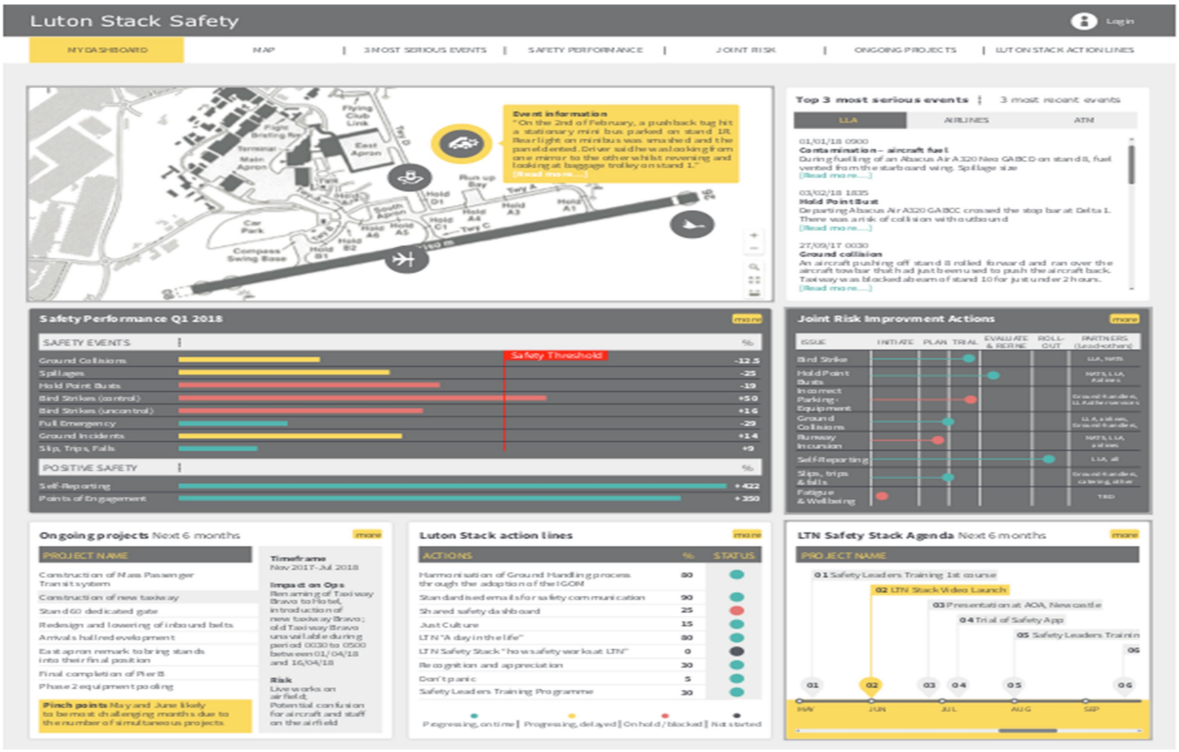

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7 CONCLUSIONS AND RECOMMENDATIONS

The safety dashboard is intended to improve the collective safety intelligence of the organisation, particularly at the top. As such, the dashboard must clarify rather than confuse, and focus on the key safety issues, threats and opportunities the organisation is facing, so that those at the top can safely navigate through them.

The principles, ideas and detailed visualisations in this paper are intended to point the way, rather than constitute an off-the-shelf 'here is your dashboard' solution, because each organisation's requirements will differ, and every Executive Board will also differ in their safety understanding and their approach to safety. Developing and implementing a safety dashboard is therefore an ongoing journey, and there will be many safety conversations along the way, which is a good thing.

Nevertheless, it is hoped that the dashboard images, and the experiences behind them, can help organisations develop effective safety dashboards that are seen as useful by the Board, and are used by them for safety.

As a final comment, it should be noted that a safety dashboard is only one component of safety intelligence. The Board should still seek to consult with staff and post-holders to obtain a richer picture of the true status of safety, seeing behind and beyond the statistics and graphs. This will give a deeper understanding of the context around the dashboard, and lead to better and safer decisions in aviation organisations. As noted earlier, in safety intelligence, quantity is king, but quality is queen, and both are needed to stay on top of safety.

For further reading

ICAO Safety Intelligence web site
www.icao.int/safety/SafetyManagement/Pages/Safety-Intelligence.aspx

SAFEORG – Tools for organisational safety (Safety dashboard section)
https://safeorg.eu/safety-dashboard/

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