

**Feasibility Study on the Implementation of  
Safety Performance Indicators in an Airline  
Operator – Hi Fly**  
(versão final após defesa)

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Dissertação para obtenção do Grau de Mestre em  
**Engenharia Aeronáutica**  
(ciclo de estudos integrado)

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**março de 2023**



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# **Dedication**

In memory of Professor Dionísio Garcia.

As my greatest academic inspiration and one of my greatest idols, you always motivated me to develop a love for the pursuit of knowledge and always inspire me to seek to become an increasingly better human being.

I will never forget the day you knew I chose to join the aeronautics and your immense pride in having a grandson studying this wonderful world of aviation. Unfortunately, your cycle here on Earth ended before I could share with you the achievements we both aspired to me.

Grandpa, wherever you are, be proud of what I did and know that I will always do everything so that the pride you have in me is as much as the gratitude and admiration I have for you.



# Acknowledgements

The development of this dissertation was only possible with the mentoring of Professor Lourenço da Saúde, to whom I express my deepest gratitude for his availability, rigor, guidance, recommendations and advice.

My sincere thanks to Hi Fly and its Safety Department for their collaboration in the development of this work and for the opportunity to be part of an exceptional team, in an excellent professional environment. I would also like to thank Carlos Sousa and Laura Martins for all the support throughout this incredible experience.

A special thanks to my parents, Luiz and Judite, who have always prioritized my education, to my brothers, Luis and Danilson, to my dear sister, Nídia, and to all my family who have been my base and my foundation throughout my life, giving me all the strength and support to pursue and achieve all my goals. No words can express my gratitude and how lucky I feel to have you in my life.

This dissertation marks the conclusion of another important and very challenging stage of my life, where I had the opportunity to meet incredible people. For all the support I have received, especially during the adaptation period, I cannot forget my friend José Albertino Varela and my dear uncle Gregório Semedo Cardoso.

Likewise, I want to express my gratitude to all my friends whose friendship and support made me stronger during this journey, especially to Edmar, Gerson and Bruno for being true battle companions.

Last but not least, my heartfelt and deepest gratitude to Jassica for her companionship, partnership, unceasing support, and unconditional love.



# Resumo

Dando sequência às mudanças que vinham sendo introduzidas progressivamente na gestão da segurança operacional, em 2013 a ICAO passou a exigir que todos os prestadores de serviços implementassem um Sistema de Gestão da Segurança Operacional estruturado em quatro componentes e doze elementos. A parte central deste sistema é a gestão do seu desempenho, que deve ser rastreada através de Indicadores de Desempenho da Segurança Operacional.

Embora a empresa onde esta dissertação teve lugar (Hi Fly) tenha um sistema para rastrear o seu desempenho de segurança operacional, a dinâmica da indústria da aviação civil requer atualizações periódicas a todos os níveis, não só para fazer face aos regulamentos, mas também para assegurar uma melhoria contínua.

Nesse contexto, este trabalho foi desenvolvido com o objectivo de estudar a viabilidade de criar um novo sistema para a implementação e gestão de Indicadores de Desempenho de Segurança Operacional que, alinhados com os objectivos da Hi Fly, responda aos requisitos estabelecidos nos regulamentos aeronáuticos.

Para o efeito, foi inicialmente realizado um estudo bibliográfico da estrutura e dos regulamentos em torno do Sistema de Gestão da Segurança Operacional, a fim de se compreender o papel dos indicadores no rastreio do desempenho da segurança operacional, visando alcançar os objectivos de segurança operacional. Posteriormente, foram analisados os regulamentos específicos para a criação, implementação e monitorização de Indicadores de Desempenho de Segurança Operacional e foram confrontados com o sistema já implementado na organização (Hi Fly) para se determinar que aspectos deveriam ser melhorados.

Este estudo resultou na criação de um novo processo para a implementação de novos indicadores e um instrumento de análise foi desenvolvido baseado em métodos estatísticos para estabelecer limites para cada indicador. Além disso, a referida ferramenta tem a capacidade de armazenar e amostrar dados relacionados com indicadores de desempenho de segurança.

Os resultados obtidos foram validados e aprovados pelo Gestor de Segurança Operacional da empresa, após várias simulações realizadas utilizando fundamentalmente dados reais obtidos previamente.

## **Palavras-Chave**

Segurança Operacional, Hi Fly, Sistema de Gestão da Segurança Operacional, desempenho de segurança operacional.

# Resumo alargado

Esta secção destina-se a apresentar um resumo do trabalho desenvolvido ao longo dos capítulos 1 a 5, apresentando o enquadramento e o objetivo da dissertação, as metodologias e os recursos utilizados em cada etapa, os resultados obtidos, as principais conclusões retiradas e a perspetiva de trabalhos futuros.

Ao longo da sua história, a aviação sofreu inúmeras alterações, tendo sempre como prioridade a mitigação dos riscos associados às suas operações. Deste modo, o conceito de segurança operacional também acompanhou a evolução da aviação e com o passar dos anos diferentes abordagens foram adotadas, onde sempre se notou uma certa tendência em quantificar o nível de segurança operacional por meio da contagem de ocorrências (acidentes e incidentes).

Atualmente, sabe-se que o conceito de segurança operacional transcende a ausência de ocorrências, exigindo uma abordagem sistemática e um conjunto de recursos e práticas que devem ser adotados para fazer face não só aos riscos conhecidos, como também aos riscos que podem emergir.

Nesse sentido, desde 2013 com a publicação do Anexo 19, a Internacional Civil Aviation Organization (ICAO) (órgão das Nações Unidas) estabelece o Sistema de Gestão da Segurança Operacional a ser implementado e mantido por todos os Estados e prestadores de serviços. Esse sistema é composto por quatro componentes e doze elementos, cuja centralidade do funcionamento consiste na gestão do desempenho da segurança operacional.

A Hi Fly (HFY), enquanto prestadora de serviços de transporte aéreo, pretende desenvolver um novo processo para a implementação e gestão de Indicadores do Desempenho de Segurança Operacional, de forma a rever, atualizar e melhorar o sistema de gestão do desempenho de Segurança operacional já existente.

Nesse âmbito, a presente dissertação tem como objetivo estudar a viabilidade de criar, implementar e gerir um processo de segurança operacional num operador aéreo, visando responder aos requisitos estabelecidos nos regulamentos aeronáuticos.

Para tal, foi realizada uma revisão bibliográfica aos manuais de gestão de segurança operacional da ICAO e da HFY para se perceber o contexto onde está inserida a

monitorização do desempenho, enquanto parte do sistema de gestão da segurança operacional.

Posteriormente, foram consultados os vários planos para a segurança operacional na aviação civil, quer a nível global, a nível europeu e a nível nacional nos dois países onde a HFY possui bases operacionais (Portugal e Malta). Para além das diretrizes emitidas pela ICAO através do manual de gestão de segurança operacional e do Anexo 19, foram levados em conta documentos de outras organizações internacionais.

Para a criação de um novo processo para a implementação de novos Indicadores de Desempenho de Segurança Operacional (SPIs), partiu-se do existente sistema de gestão dos SPIs onde cada departamento é responsável pela criação e definição de novos indicadores, considerando o campo de atuação do departamento e os objetivos de segurança operacional da organização.

Para o novo processo de implementação proposto, foi criado um modelo com as diretrizes para a definição de um indicador, o qual cada departamento deverá preencher e submeter à aprovação do Departamento de Segurança Operacional. Esta alteração foi introduzida com o intuito de garantir que cada SPI a entrar no sistema é devidamente definido e se encontra dentro dos padrões da empresa.

Outra alteração importante para a padronização dos SPIs foi a criação de um sistema de numeração única e comum a todos os departamentos. De acordo com este sistema, a cada SPI é atribuído um número de quatro dígitos que permite não só diferenciá-los entre si, mas também identificar o grupo, o departamento e o principal risco de segurança operacional associado ao indicador.

Para a análise de dados relativos aos SPIs, foi desenvolvida uma ferramenta em Excel composta por folhas de monitorização que aplicam o método estatístico baseado no princípio do desvio padrão para estabelecer metas e limites para cada SPI, além de possuir a funcionalidade de reportar níveis de alerta e metas alcançadas.

Finalmente, foi desenvolvida uma metodologia de cálculo do desempenho global da segurança operacional, conectado à avaliação de riscos associados a cada SPI feita pelo Departamento de Segurança Operacional.

Relativamente ao processo de validação para determinar a viabilidade do novo processo de implementação de novos SPIs, mereceu uma análise conjunta de diferentes membros do Departamento de Segurança Operacional e a ferramenta criada foi submetida a várias

simulações, utilizando dados reais presentes na base de dados da empresa e previsões de dados futuros, a fim de verificar a capacidade de análise da ferramenta e o correcto fluxo de dados entre os diferentes ficheiros que a compõem. No final, os resultados foram aprovados e validados pelo Gestor de Segurança da empresa.

Como perspectiva de trabalhos futuros, foi proposto o desenvolvimento de escalas qualitativas específicas para cada SPI qualitativo implementado na empresa, bem como a criação de um módulo exclusivo à gestão dos SPIs no programa informático integrado utilizado pela empresa para dar suporte ao Sistema de Gestão de Segurança Operacional (Softcraft SMS).



# **Abstract**

Following the changes that have been progressively introduced in the management of safety, in 2013 ICAO started to require all service providers to implement a Safety Management System structured in four components and twelve elements. The central part of this system is its performance management, which must be tracked through Safety Performance Indicators.

Although the company, where this work took place (Hi Fly), has a system to track its safety performance, the dynamics of the civil aviation industry requires periodic updates at all levels, not only to cope with regulations but also to ensure constant improvement. In this context, this work was developed with the objective of studying the feasibility of creating a new system for the implementation and management of Safety Performance Indicators which, in line with the Hi Fly objectives, responds to the requirements set out in the aeronautical regulations.

To this end, a bibliographic study of the framework and regulations surrounding the safety management system was carried out, in order to understand the role of the indicators in tracking safety performance, with a view to achieving safety objectives. Then, specific regulations for the creation, implementation and monitoring of safety performance indicators were analysed and compared with the safety performance management system already implemented in the organization to determine which aspects should be improved.

This study resulted in the creation of a new process for the implementation of new indicators and an analysis tool was developed based on statistical methods to establish triggers for each indicator. Additionally, this tool has the capacity to store and sample data related to safety performance indicators.

The results obtained were validated and approved by the Safety Manager of the company, after several simulations were performed using real data previously obtained.

## **Keywords**

Safety, Hi Fly, Safety Management System, safety performance.



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# List of Acronyms

<b>ACMI</b>	Aircraft, Crew, Maintenance, and Insurance
<b>ADS-B</b>	Automatic Dependent Surveillance - Broadcast
<b>ALoSP</b>	Acceptable Level of Safety Performance
<b>ANAC</b>	Autoridade Nacional da Aviação Civil
<b>AOC</b>	Air Operator Certificate
<b>B-RNAV</b>	Basic Area Navigation
<b>CAA</b>	Civil Aviation Authority
<b>COVID-19</b>	Coronavirus Disease
<b>EASA</b>	European Union Aviation Safety Agency
<b>EPAS</b>	European Plan for Aviation Safety
<b>ETOPS</b>	Extended-range Twin-engine Operations
<b>EU</b>	European Union
<b>EU MS</b>	European Union Member States
<b>FAA</b>	Federal Aviation Administration
<b>FANS</b>	Future Air Navigation Systems
<b>FDM</b>	Flight Data Monitoring
<b>GASP</b>	Global Aviation Safety Plan
<b>HFY</b>	Hi Fly
<b>IATA</b>	International Air Transport Association
<b>ICAO</b>	International Civil Aviation Organization
<b>INAC</b>	Instituto Nacional de Aviação Civil
<b>IOSA</b>	IATA Operational Safety Audit
<b>MNPS</b>	Minimum Navigation Performance Specification
<b>OM-A</b>	Operations Manual – Part A
<b>OSP</b>	Overall Safety Performance
<b>P-RNAV</b>	Precision-Area Navigation
<b>RNP10</b>	Required Navigation Performance – Specifications 10
<b>RNP4</b>	Required Navigation Performance – Specifications 4
<b>RVSM</b>	Reduced Vertical Separation Minimum
<b>SAFA</b>	Safety Assessment of Foreign Aircraft
<b>SAG</b>	Safety Action Group
<b>SARPs</b>	Standards and Recommended Practices
<b>SDPM</b>	Safety Department Procedures Manual
<b>SMM</b>	Safety Management Manual
<b>SMS</b>	Safety Management System
<b>SPAS</b>	State Plan for Aviation Safety
<b>SRB</b>	Safety Review Board
<b>SSP</b>	State Safety Plan
<b>TM-CAD</b>	Transport Malta - Civil Aviation Directorate







# **Chapter 1 – Introduction**

## **1.1 Motivation**

Since the early days of aviation, the risks associated with its activities have been a key issue, although the approaches to mitigate them have not always been the most appropriate.

For this reason, the concept of safety has evolved over the years, following the dynamics of the aviation world. However, regardless of the various approaches adopted over time, there has been a tendency to quantify the safety level of an organization by counting the number of occurrences (accidents and incidents), which may convey a false impression about the effectiveness of the organization's safety management.

Nowadays, it is known that safety is much more than the absence of accidents and incidents. The current approach is systematic and requires a set of resources and practices that must be adopted and maintained to cope with known risks and to address possible risks that may emerge.

The International Civil Aviation Organization (ICAO) had been progressively introducing Standards and Recommended Practices (SARPs), and in 2013 published Annex 19, through which it established the Safety Management System (SMS) framework with the four components: safety policy and objectives, risk management, safety assurance and safety promotion. From then on, the framework would apply to all service providers.

Central to the functioning of the SMS is safety performance management, which enables the organization to determine the effectiveness of its processes and activities in order to achieve its safety objectives. Therefore, as a service provider operating worldwide, Hi Fly needs to maintain the highest safety standards in line with the changing operations and regulatory updates from the relevant authorities. It is therefore necessary to develop a new process for the implementation and management of Safety Performance Indicators (SPIs) in order to review, update and improve the existing safety performance management system.

The implementation process to be created will have to be able to ensure that all SPIs to be implemented are the most relevant to the operation and have been created according to the rules and standards established by the company and by the civil aviation authorities.

In turn, the management process will require the creation of an analysis and data sampling tool that is able to, from the input data, calculate the SPIs implemented within the organization, display the status of each SPI and establish the alert levels based on the reference data and safety targets previously defined. Therefore, this tool should have its own database, connected not only to the sampling dashboard but also to the SMS/reporting scheme database.

## **1.2 Objective**

The objective of the dissertation is to study the feasibility of creating, implement and manage a safety process in an airline company (Hi Fly) in view of responding to the requirements set in the aeronautical regulations.

## **1.3 Methodology**

To carry out the objective of this dissertation, it is intended to first perform an approach to safety in general, through document review of the different plans and programmes for aviation safety at global (GASP), European (EASP) and national levels (SSPs).

In addition, the regulations associated with Safety Management Safety are also analysed, namely the Safety Management Manual Doc.9859, fourth edition and Annex 19 - Safety Management, second edition, both from ICAO. On an internal level, Safety Management Manual and Safety Department Procedures Manual, both from Hi Fly, are analysed.

After the documentary analysis, a data storage, analysis, and sampling tool for the SPIs was developed using Microsoft Excel. After being developed, this tool is submitted to numerous simulations using real data recorded in the company's SMS database, so that, together with the implementation process created, they can be validated by the safety department (safety analyst and safety manager).

## **1.4 Work limits**

Despite the guidelines provided by competent authorities such as ICAO, there is a dearth of real benchmarking data available regarding SPIs, since they are a relatively new topic

in the context of airlines and comprise extremely confidential company data. As such, they are not disclosed.

Additionally, the data of the SPIs implemented and monitored at Hi Fly until 2022 are recorded in reports and Excel files prepared independently by each department, without the existence of a database common to all departments and exclusive to the SPIs.

## **1.5 Structure**

This dissertation is structured into five chapters as follows:

1. Introduction;
2. Brief presentation of Hi Fly Airline;
3. State of the art of Safety Performance Indicators (SPIs);
4. Case study;
5. Conclusion.

The present chapter (introduction) makes an introductory approach, contextualizing the chosen theme and framing it as a fundamental part of aviation safety nowadays. Then, the objective of the dissertation is presented, based not only on the company safety objectives, but also on the demands and requirements imposed by the applicable regulations. The methodology used is also described in this chapter, from the document analysis done, through the software used in the development of the tool and in the simulations, to the validation process. Finally, the limits of the work and the structure of the dissertation are presented.

The second chapter is dedicated to the description of Hi Fly Airline, giving a brief presentation of the company profile, history, fleet, operations as well as the organizational structure, with some focus on the safety department.

In a more general approach, the state-of-the-art chapter starts by analysing safety and its fundamentals from various perspectives, then narrows down to the SMS of the company, which is based on the four pillars and their respective elements. Within this scope, the subject of safety performance management is developed in a more detailed manner, framed in one of the four essential pillars of the SMS - safety assurance.

The fourth chapter describes in detail the process created for the implementation of new SPIs, as well as all the reasoning that supports the tool developed for the collection, analysis and sampling of data related to the SPIs, from the structure of operation, the statistical method applied in the analysis and the calculations made in determining the safety overall performance. Finally, the results obtained, the changes they provide, and the validation process of the methodology used are presented.

The last chapter presents the conclusions reached, as well as the recommendations and future work suggested in favour of the continuous improvement of the SMS through safety performance monitoring and measurement.

## Chapter 2 – Hi Fly

Hi Fly is a non-regular international airline, whose principal place of business is localized in Lisbon, specialized in Charter<sup>1</sup>, ACMI<sup>2</sup>, dry lease<sup>3</sup>, special missions and aircraft management. It is a go-to organization for airlines when they need additional capacity to cover their short/medium term or seasonal needs (HFY, 2021a).

### 2.1 History

Hi Fly was incorporated in 2005, by the Mirpuri Investments and concluded its initial certification in the next year, 2006, with the issuance of the first Air Operator Certificate (AOC) by INAC (now ANAC) from Portugal. Operations started with a leased Airbus A330 and, fleet has since grown at a steady pace to include additional Airbus aircraft. In 2011, Hi Fly (HFY) becomes an IATA Operational Safety Audit (IOSA) registered and two years later, obtained the second Air Operator Certificate by TM-CAD from Malta.

As a sign of its commitment to contributing to a more responsible and sustainable planet, in 2016 HFY has launched, in partnership with the Mirpuri Foundation, sustainability programmes to fight against especially prominent issues, as plastic pollution and carbon emissions. Because of these initiatives, all HFY's own flights are taking to the air without single-use plastics since January 1, 2020 (HFY, 2021a).

In 2018, HFY made history by acquiring and landing for the first time an A380 in Portugal. This acquisition, by a lease term of almost three years, made it the 4th European airline operating the model, the 14th global operator and the first leasing airline to fly the aircraft (HFY, 2021b).

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<sup>1</sup> A non-scheduled operation using a contractual arrangement between an air carrier and an entity hiring or leasing its aircraft (ICAO, 2009).

<sup>2</sup> Wet lease contract between operators, which includes aircraft, crew from the locator, maintenance and insurance (ANAC, 2015, p. 71).

<sup>3</sup> Aircraft lease without any crew, whose operation is performed under the lessors AOC (ANAC, 2015, p. 71).



*Figure 1: HFY A380*

*Source: (HFY, 2021b)*

Due to the impact of COVID-19 pandemic on aviation, in 2020 HFY converted some A380 (Figure 1), A340 (Figure 2) and A330 (Figure 3) aircraft into freighters to support the growth of its cargo division, and later, it decided not to extend the lease term of the A380, due to drastic reduction in demand for large aircraft.

On November 22, 2021, Hi Fly has made history once again, by landing, for the first time ever, an Airbus A340 in Antarctica (HFY, 2021b).



*Figure 2: HFY crew landed in Antarctica.*

*Source: (HFY, 2021b)*

## 2.2 Fleet

By March 2022, Hi Fly operates an all-Airbus fleet (Table 1), including the A330neo. It was the first non-regular and the second airline in the world acquiring an A330neo. At the moment, HFY owns a fleet with several models of the Airbus family covering the full range from cargo version to 436 seats and from medium haul to long haul.

Table 1: Hi Fly aircraft's registration (march 21, 2022)

Family	Quantity	Aircraft Type	Registration
A320	1	A321-231	CS-TRJ
A330	1	A330-202	9H-TQP
	3	A330-343	9H-PTP 9H-POP 9H-HFA
	2	A330-941	9H-SZN CS-TKY
A340	1	A340-312	9H-SUN
	5	A340-313	9H-FOX 9H-TQY 9H-TQZ 9H-JAI 9H-SOL
Total	13		

Source: (HFY, 2022a)



Figure 3: Hi Fly Airbus A330-941

Source: (Simacek, 2020)

## 2.3 Operation overview

Hi Fly is a licensed and certified airline, with two AOC, issued by ANAC and TM-CAD, both members of the European Aviation Safety Agency (EASA). Current certifications include (HFY, 2021a):

- Worldwide transportation of passengers or cargo;
- Transportation of Dangerous Goods<sup>4</sup>;
- All ICAO Air Navigation Regions;
- Low Visibility Operations;
- ETOPS 180 minutes for the twin engine aircraft;
- Compliant with: RVSM, MNPS, P-RNAV, B-RNAV, RNP10, RNP4, ADS-B, FANS<sup>5</sup>.

Different from a traditional airline that sells tickets to its passengers, HFY works on a Business-to-Business model and sells instead flight hours to the other airlines, helping them to cope with needs, where adding a full-time additional aircraft is neither possible nor efficient.

There are several types of airlines and each one has its own service level and requires diverse types of seating arrangements, ranging from high comfort to high-density interiors. In the cases of charter flights, the client - tour operators, companies or individuals - decides the route and the schedule and Hi Fly operates the aircraft on “all inclusive” basis for a fixed fee.

The aircraft can be deployed with very short notice (as little as three hours) to cover short/medium term transportation needs. Therefore, it is imperative that there is always an efficient work from the entire group composed of professionals from multiple areas who work interactively to make every single mission a success, taking care of every detail to ensure safe and effective operations (HFY, 2021a).

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<sup>4</sup> Articles or substances which are capable of posing a risk to health, safety, property or the environment and which are shown in the list of dangerous goods in the Technical Instructions, or which are classified according to those Instructions (ICAO, 2022).

<sup>5</sup> Acronyms referring to navigation standards whose titles can be found in the list of acronyms.

## 2.4 Organizational structure

To respond to its market demand, HFY has a team of professionals, according to the organizational structure represented by the scheme in the Figure 4.

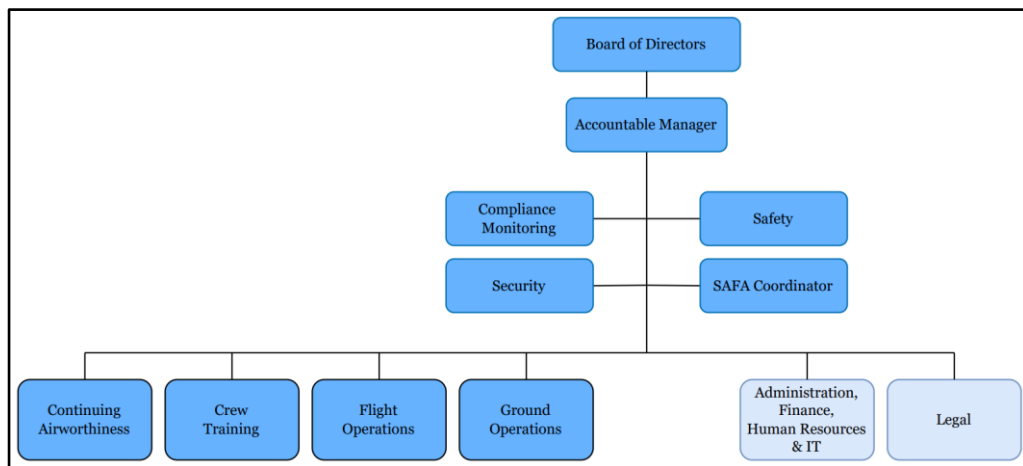


Figure 4: Hi Fly organizational flow chart

Source: (HFY, 2022b, p. OS/G 2)

The Accountable Manager has corporate authority to make policy and financial decisions for ensuring overall operational safety and security, and ensuring that all operations and maintenance activities can be financed and carried out to the standard required by the Portuguese Civil Aviation Authority (CAA) or the Maltese CAA, other applicable authorities and additional HFY requirements maintaining the validity of the AOC.

He is responsible for, among other responsibilities (HFY, 2022b, p. OMS 1):

- Providing the necessary resources and facilities to enable the AOC nominated persons to perform the respective tasks, for which they are responsible;
- Maintaining direct reporting links to the Compliance Manager and the Safety Manager;
- Establishing the company's formal written compliance monitoring policy statement defining the intent of the management system and his commitment to it;
- Establishing the company's safety commitment including a non-reprisal policy.

In the departments of Compliance Monitoring, Safety and Security there is a manager for each department, who has the independence, responsibility and authority to act on behalf of the Accountable Manager and of the senior management. In the other departments, Continuing Airworthiness, Crew Training, Flight Operations and Ground Operations there is a Nominated Person and a Deputy.

Nominated are persons that shall possess the appropriate knowledge, skills, training experience and licensing requirements which are listed below (HFY, 2022b, p. 1.2 3/6):

1. Practical experience and expertise in the application of aviation safety standards and safe operating practices;
2. Comprehensive knowledge of:
  - a. EASA operations and any associated requirements and procedures;
  - b. Hi Fly, AOC Operations Specifications;
  - c. The need for, and content of, the relevant parts of Hi Fly Operations Manual;
3. Familiarity with Management Systems;
4. Appropriate management experience in a comparable organization;
5. Five years relevant work experience of which at least two years shall be from the aeronautical industry in an appropriate position; and
6. Competence maintaining based on continued education and training, to satisfy continued technical competency requirements.

Likewise, a Deputy Nominated Persons shall possess the same experience and licensing requirements of the Nominated Persons.

### **2.4.1 Safety Department**

Hi Fly Safety Management Organization includes the Accountable Manager, a Safety Manager, a Compliance Monitoring Manager, a Safety Review Board (SRB), a Safety Action Group (SAG) and Departmental Safety Action Group, according to the diagram shown in Figure 5.

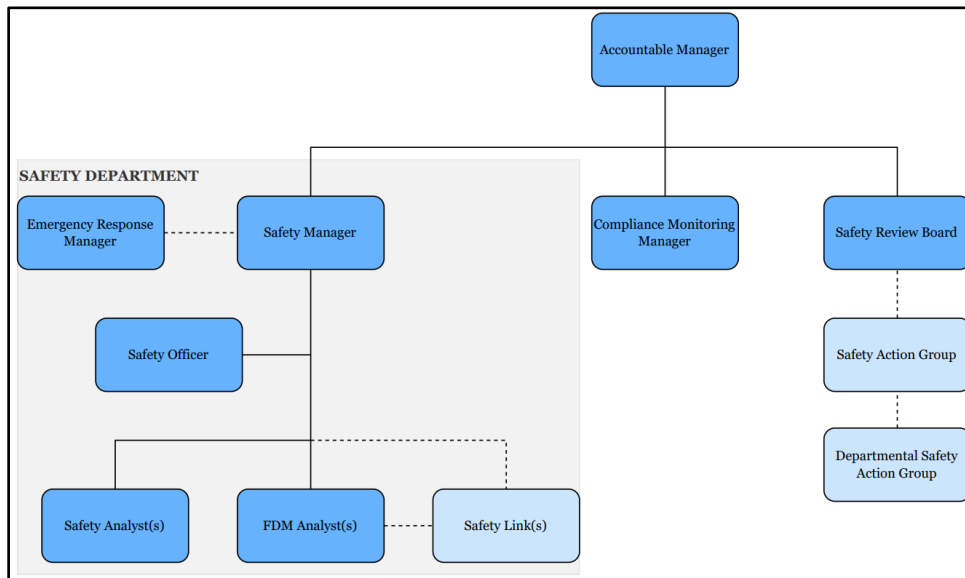


Figure 5: Hi Fly's safety management organization flow chart

Source: (HFY, 2022b, p. OS/SD 2)

The Safety Manager promotes and supervises operational safety as a representative of the Accountable Manager for all safety related matters. He shall regularly report about his function to the Accountable Manager and to the competent Authority to guarantee operational safety.

To ensure the functioning of the Management System within his area of responsibility, his duties and responsibilities are (HFY, 2021c, p. 1.3.2:1/2):

- Cooperation with all relevant sections of the Flight Operation Department regarding safety matters;
- Supervision of aircraft handling regarding matters related to safety in cooperation with ground support services and ground crew training;
- Assigned responsible for the implementation and maintaining the accident prevention and flight safety programme;
- Discovery of safety hazards and to assess their risks, and inform the relevant managers responsible for the process concerned;
- To test the knowledge of all flight and cabin crews regarding emergency procedures and supervision of safety training;
- Spot checks of stored flight documents of flights;
- Cooperation with the Maintenance Department regarding disposition and security of safety and emergency equipment on board.

The Safety Manager is assisted by (HFY, 2021d, pp. 3.3.1:1/2 - 3.3.3:1/2):

- The Safety Officer in all safety related duties, with a special focus on the Risk Management;
- The Safety Analyst who is responsible to perform the analysis of all the safety-related data obtained across HFY as part of the Safety Management System;
- The Flight Data Monitoring (FDM) Analyst who is responsible for ensuring the collection of all the flight data and related procedures.

The Safety Link relates to any person, outside the Safety Department, who possesses relevant knowledge and expertise, in a specific technical or non-technical domain. The participation of the Safety Link can be requested by the Safety Department with the purpose of assisting in the analysis of identified safety issues<sup>6</sup> (HFY, 2021d, p. 3.3.4:1/2).

The Safety Review Board should be a high level committee that considers matters of strategic safety in support of the accountable manager's safety accountability. The board should be chaired by the accountable manager and be composed of heads of functional areas (ICAO, 2018, p. 9.7).

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<sup>6</sup> Manifestation of a hazard or a combination of several hazards in a specific context (HFY, 2021d, p. 6.2.8:1/2).

# Chapter 3 – State-of-art of the safety system

## 3.1 Safety Management and its fundamentals

### 3.1.1 The evolution of safety

The aviation system is an open, highly dynamic, and complex system with many different players, interactions, dependencies. That is why, new safety hazards and risks continuously emerge and must be mitigated.

Over the course of progress in aviation safety, several approaches have emerged, according to the focus of the safety endeavours of each era. These approaches are illustrated in Figure 6.

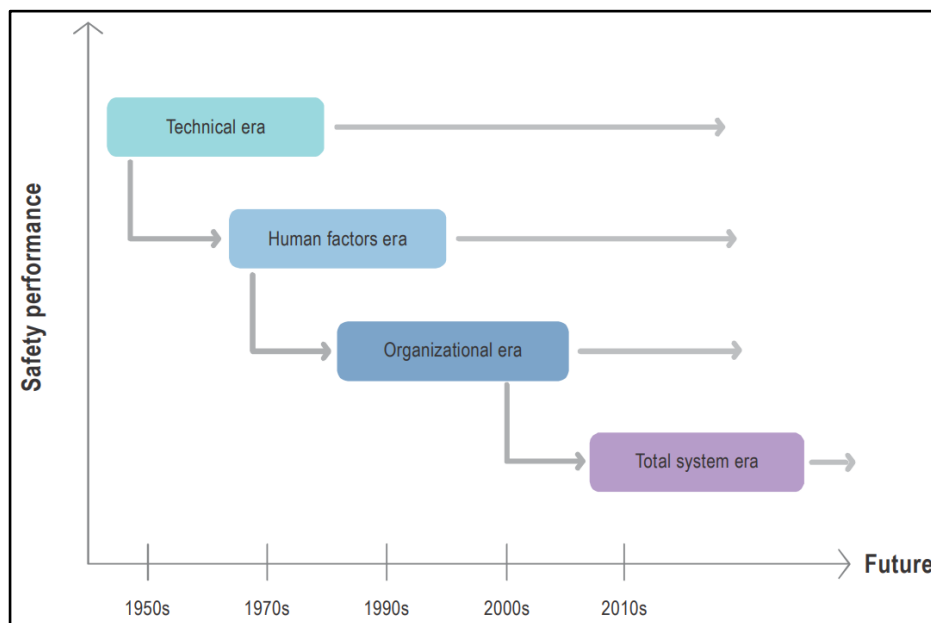


Figure 6: The evolution of safety

Source: (ICAO, 2018, p. 2.2)

The first approach took place between 1900's and 1960's. Over this period, most of the safety deficiencies were related to technical factors and technological failures and for this reason, it became known as the Technical Era. The focus of safety endeavours was therefore placed on the investigation and improvement of technical factors.

Due to major technological advances and enhancements to safety regulations, by the early 1970s, the frequency of aviation accidents had significantly declined, and the focus

of safety endeavours was extended to include human factors – Human Factors Era. Although aviation became a safer mode of transportation, human factors continued to be cited as a recurring factor in accidents, as this approach tended to focus on the individual.

In the early 1990s, it was acknowledged that individuals operate in a complex environment that included multiple factors which could affect behaviour. In the middle of this decade, started a new era where safety began to be viewed from a systemic perspective and began encompassing organizational factors as well as human and technical factors. Additionally, it was introduced the safety data collection and analysis routine, to monitor known safety risks and detect emerging safety trends.

From the beginning of the 21st century, most of the states and service providers evolved to a higher level of safety maturity, implementing State Safety Plan (SSP) and Safety Management System (SMS). Although the current approach brought great benefits to aviation safety, safety systems to date have focused largely on individual safety performance and local control, with minimal regard for the wider context of the total aviation system (ICAO, 2018, pp. 2.1, 2.3).

### **3.1.2 Safety management**

According to the International Civil Aviation Organization (ICAO), safety is the state in which risks associated with aviation activities, related to, or in direct support of the operation of aircraft, are reduced and controlled to an acceptable level. To achieve and maintain an acceptable level of safety, it is necessary to proactively mitigate safety risks before they result in aviation accidents and incidents. Hence, the role of safety management is to contribute to safe operations.

Its implementation enables States and service providers to manage their safety activities in a more disciplined, integrated and focused manner, prioritizing actions to address safety risks and more effectively manage its resources for the optimal benefit of aviation safety.

In order to strengthen the effectiveness of safety management, it shall be implemented in a formal and institutionalized way. Therefore, ICAO establishes the Global Aviation Safety Plan (GASP) with objectives that align with ICAO's requirements for the implementation of SSPs and SMSs, to progressively evolve States into a more sophisticated means of managing safety performance (ICAO, 2018, p. 1.1).

At a regional level, European Aviation Safety Agency (EASA) also establishes a safety plan to support the objectives and priorities of the Global Aviation Safety Plan (GASP) in the member states of European Union (EU). The European Plan for Aviation Safety (EPAS) has as objective to ensure that the system for the management of aviation safety in the EU delivers the highest level of safety performance, uniformly enjoyed across the whole Union, and continues to improve over time while taking into account other important objectives such as environmental protection (EASA, 2021a, p. 27).

Figure 7 gives a representation of the relationship between aviation plans and programmes.

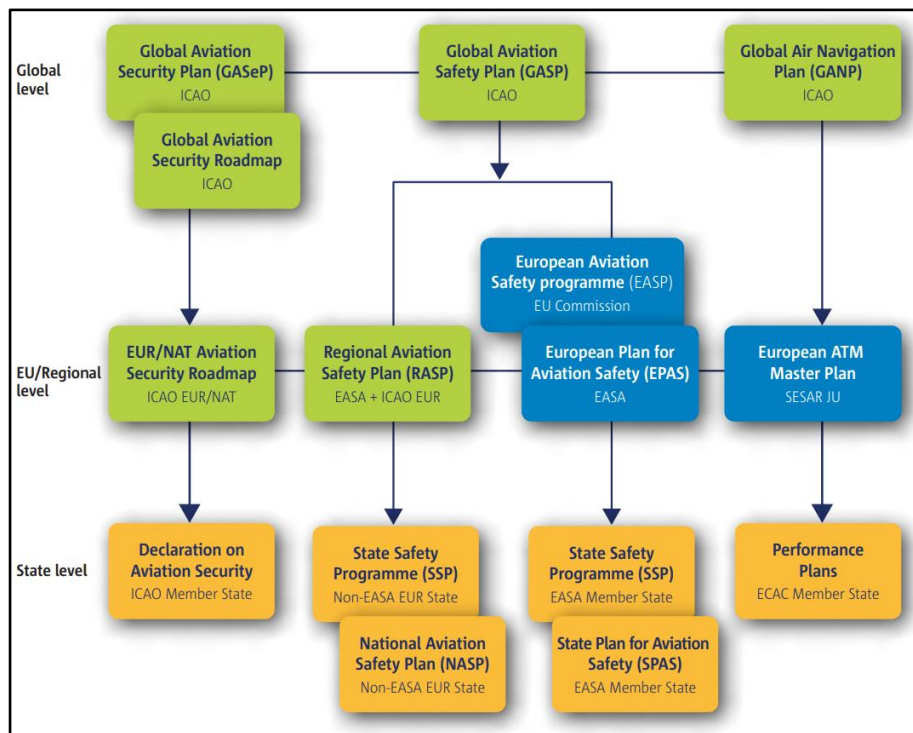


Figure 7: Relationship between the aviation programmes and plans

Source: (EASA, 2021a, p. 28)

Each State shall develop and maintain an SSP to assist in managing its aviation safety performance and require that an SMS is developed and maintained by those service providers under its authority, to continuously improve safety performance by identifying hazards, collecting and analysing data, and continuously assessing and managing safety risks (ICAO, 2018, p. 8.25).

### 3.1.3 Human factors

An organization safety performance is significantly affected by the way how people think about their responsibilities towards safety and how they interact with others to perform their tasks at work. According to *Aero Magazine*, human error has been documented as a primary contributor to more than 70% of commercial airplane hull-loss accidents (Boeing, N.D).

Human factors are about gathering information about human capabilities, limitations and interactions and applying it to tools, machines, systems, tasks, jobs, and environments to produce safe, comfortable, and effective human use. It allows us to understand the way in which people contribute, both positively and negatively, to organizational safety (Boeing, N.D).

Among the various models created to support the assessment of human factors on safety performance, the SHELL Model (Figure 8) is the most known and an extremely useful one to illustrate the impact and interaction of the different system components on the human.

This model contains the human at the centre of the model, surrounded by the four satellite workplace components, emphasizing the need to consider human factors as an integrated part of Safety Risk Management (SRM).

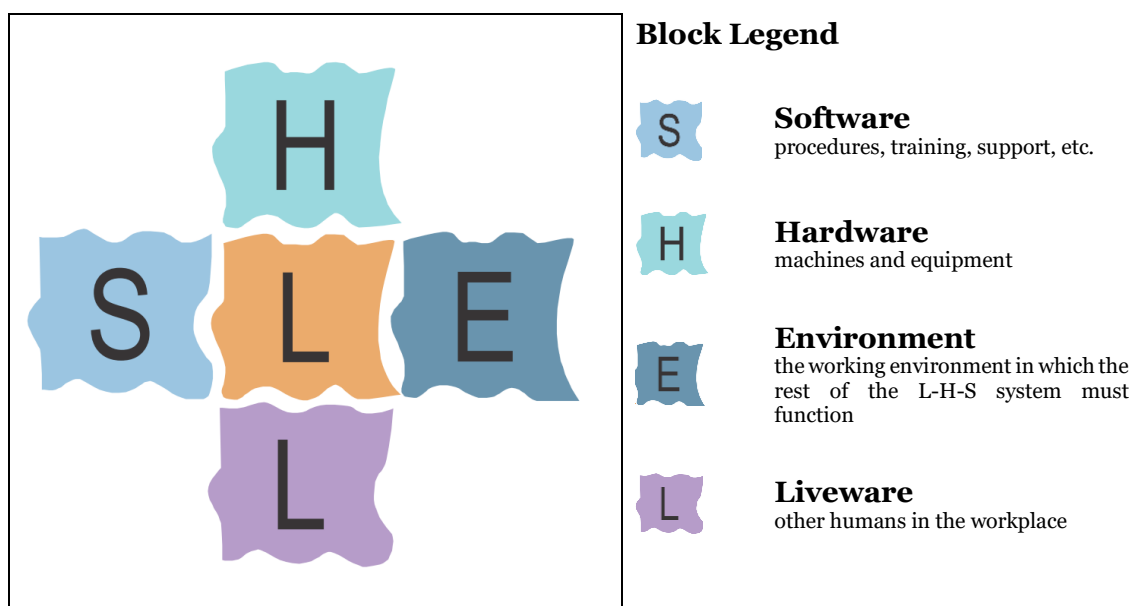


Figure 8: SHELL Model

Source: (ICAO, 2018, p. 2.5)

The central block (Liveware) is the most critical as well as the most flexible component in the system. Each interface with the other blocks has irregularities whose effects should be understood to avoid tensions that may compromise human performance (ICAO, 2018, pp. 2.5,2.6):

- **The L-H interface** refers to the relationship between the human (Liveware) and the physical attributes of equipment, machines and facilities (Hardware);
- **The L-S interface** is the relationship between the human (Liveware) and the supporting systems found in the workplace (Software), such as regulations, manuals, checklists, publications, processes and procedures, and computer software. It considers the processes and procedures - how easy they are to follow and understand;
- **The L-L interface** is the relationship and interaction between people in their work environment, both within the organization and between individuals from different organizations with distinct roles;
- **The L-E interface** involves the relationship between the human and the physical environment (temperature, ambient light, noise, vibration and air quality). It also considers the externally environmental factors, such as weather, infrastructure and terrain.

### **3.1.4 Accident causation**

Complex systems such as aviation are extremely well defended by several layers of defences. Then, a single-point failure is rarely consequential. Incidents and accidents involve successive breaches of multiple defences, which can be triggered by several enabling factors such as equipment failures or operational errors.

The Swiss-Cheese Model, represented in the Figure 9, illustrates the way failures, errors and weaknesses at different levels into an organization can result in undesired outcomes. Multiple defensive layers are built into the aviation system to protect against variations in human performance or decisions at all levels of the organization. But each layer typically has weaknesses, depicted by the holes in the slices of “Swiss cheese”. Sometimes all the weaknesses align (represented by the aligned holes) leading to a breach that penetrates all defensive barriers and may result in a catastrophic outcome.

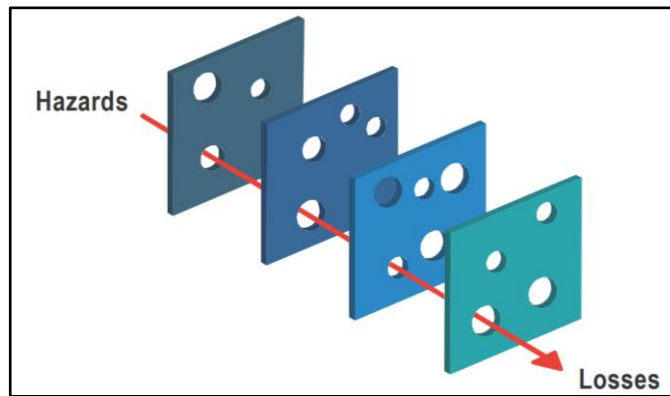


Figure 9: Swiss cheese model

Source: (ICAO, 2018, p. 2.7)

This model proposes that all accidents include a combination of both active failures<sup>7</sup> and latent conditions<sup>8</sup> and represents how the later ones are ever present within the system and can manifest through local trigger factors. Active failures are associated with front-line personnel (pilots, air traffic controllers, aircraft maintenance engineers, etc.), while latent conditions can be created even by people far removed in time and space from the event. Latent conditions in the system may include those created by the (ICAO, 2018, pp. 2.6,2.7):

- Safety culture;
- Equipment choices or procedural design;
- Conflicting organizational goals;
- Defective organizational systems; or
- Management decisions.

The model can be applied in several safety domains/cases, including Safety Risk Management (SRM) and safety surveillance, to consider which of the organization's defences are effective, which can or have been breached, and where the system could benefit from additional defences.

Aviation organizations define policies, trainings, rules, regulations and procedures which must be followed to the letter. Thus, theoretically, the chance of having an accident or incident is extremely low. But an organization rarely achieves and/or maintains baseline

<sup>7</sup> Actions or inactions, including errors and rule-breaking, that have an immediate adverse effect (ICAO, 2018, p. 2.6).

<sup>8</sup> Conditions which may remain dormant until their effects or damaging potential are activated by certain operating conditions (ICAO, 2018, p. 2.6).

performance. In reality, the operational performance often differs from the assumed baseline performance as a consequence of real-life operations in a complex, ever-changing and usually demanding environment.

The practical drift theory is used to understand how performance of any system “drifts away” from its original design. Since the drift is a consequence of daily practice, it is referred to as a “practical drift”. The term “drift” is used in this context as the gradual departure from an intended course due to external influences.

According to this theory the baseline performance (represented by a straight line in the Figure 10) implicitly assumes that technology needed to achieve the system production goals is available, personnel are trained, competent and motivated to properly operate the technology and, policy and procedures will dictate system and human behaviour.



Figure 10: Concept of practical drift

Source: (Horton, 2019)

Snook contests that practical drift is inevitable in any system, no matter how careful and well thought out its design, because people will generally make the system work on a daily basis despite the system’s shortcomings, applying local adaptations (or workarounds) and personal strategies, and these workarounds may bypass the protection of existing safety risk controls and defences.

In order to detect activities which are “practically drifting”, aviation organizations must develop safety assurance activities such as monitoring of Safety Performance Indicators (SPIs) with the aim of understanding why the drift is happening to mitigate the safety risks (ICAO, 2018, pp. 2.7,2.8).

### 3.1.5 Management dilemma

All organizations engaged in the delivery of service have limited resources to allocate to safety and must deal continually with the conflicting goals of safety versus productivity, efficiency, or customer service objectives, which ultimately determine profitability. The commitment to safety must be supported by appropriate resourcing - of technology and equipment, training and expertise, policies and systems - whose acquisition and maintenance have a huge impact on the organizations financial health.

The safety space metaphor assists to understand the way production/profitability and safety risks are linked into a service provider organization. It defines safety space as the zone where an organization balance desired production/profitability while maintaining required safety protection through safety risk controls (ICAO, 2018, pp. 2.9,2.10).

As represented in the Figure 11, the allocation of excessive resources to safety risk controls may result in the activity becoming unprofitable, thus putting at risk the viability of the organization. On the other hand, excess allocation of resources for production at the expense of protection can have a negative impact on the product/service and can ultimately lead to an accident.

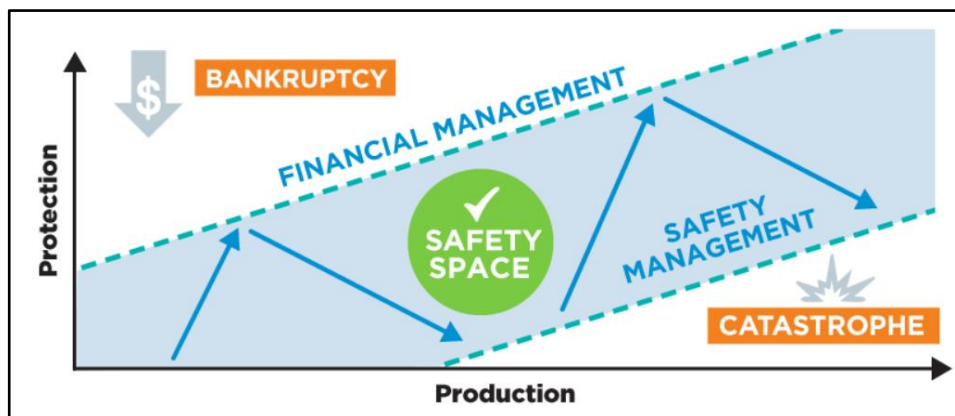


Figure 11: Concept of a safety space

Source: (VISTAIR, 2021)

It is still important to note that although the aim of safety risk controls is usually to improving safety performance, investments in “protection” can also improve production performance by reducing accidents and incidents and thereby their associated costs.

### 3.2 Safety Management System at Hi Fly

Since the first publication of Annex 19 in 2013, ICAO requires all States to establish an SSP which, in turn, suggests that all service providers within the airline industry must formulate their own Safety Management System (SMS). SMS is a systematic approach to managing safety, including the necessary organizational structures, accountability, responsibilities, policies and procedures (ICAO, 2018, p. viii).

The SMS should be implemented and maintained according to the following framework which comprises four components and twelve elements as the minimum requirements for SMS implementation, according to the Table 2.

*Table 2: SMS framework*

<b>Components</b>	<b>Elements</b>
<b>Safety Policy and Objectives</b>	<ul style="list-style-type: none"> <li>• Management commitment</li> <li>• Safety accountability and responsibilities</li> <li>• Appointment of key safety personnel</li> <li>• Coordination of emergency response planning</li> <li>• SMS documentation</li> </ul>
<b>Safety Risk Management</b>	<ul style="list-style-type: none"> <li>• Hazard identification</li> <li>• Safety risk assessment and mitigation</li> </ul>
<b>Safety Assurance</b>	<ul style="list-style-type: none"> <li>• Safety performance monitoring and measurement</li> <li>• The management of change</li> <li>• Continuous improvement of the SMS</li> </ul>
<b>Safety Promotion</b>	<ul style="list-style-type: none"> <li>• Training and education</li> <li>• Safety communication</li> </ul>

*Source: (ICAO, 2016a, p. APP 2.1)*

Hi Fly Safety Management System (SMS) is designed, implemented and integrated throughout the organization to ensure the identification of safety hazards and manage the safety risks associated with each element of Hi Fly operations and all its activities (HFY, 2021d, p. 1:1/2).

The primary objectives of HFY's SMS are (HFY, 2021d, p. 1:1/2):

- Identify safety hazards in operations and all its activities;
- Ensure remedial action is implemented to control safety risks;
- Provide for ongoing monitoring and assessment of safety performance;
- Make continual improvement to the level of safety in operations and all its activities.

### **3.2.1 Safety policy and objectives**

Hi Fly Safety Policy is the means established to maintain and, where practicable, improve safety levels and to minimize its contribution to the risk of an aircraft accident as far as is reasonably practicable. Considering its safety policy, HFY corporate safety objectives cover relevant aspects of the organization such as its operational environment, safety vision, top management commitment, safety milestones and safety performance (HFY, 2021d, p. 1:1/6).

HFY safety policy is highly committed to promote and maintain a positive safety culture<sup>9</sup> within the organization. As such, it is characterized by communications founded on mutual trust, shared perceptions of the importance of safety, and confidence in the efficacy of preventive measures. Therefore, in order to promote the just culture<sup>10</sup> within the organization, HFY method for collecting, recording and disseminating safety information guarantees the protection, to the extent permissible by law, of the identity of those who report safety-related information (HFY, 2021d, p. 2:3/6).

### **3.2.2 Safety Risk Management**

Safety Risk Management (SRM) is a formal system to analyse, assess and control safety risks associated with identified hazards to an acceptable level through the implementation of appropriate mitigation measures. It combines hazard identification and, safety risk assessment and mitigation (HFY, 2021d, p. 6.0:1/2).

Hazard identification is a prerequisite to the SRM that encompass processes of recognizing a condition, object or activity with the potential to cause death, injuries to personnel, damage to equipment or structures, loss of material, or reduction of the ability to perform a prescribed function.

Since hazards are an inevitable part of aviation activities, HFY has implemented a coordinated hazard identification programme with the purpose of collecting and analysing safety data on an on-going basis, at a cross-discipline level.

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<sup>9</sup> The product of individual and group values, attitudes, competences, and patterns of behavior that determine the commitment to, and proficiency of, the organization's management of safety (HFY, 2021d, p. 2:4/6).

<sup>10</sup> A culture in which front line personnel or others are not punished for actions, omissions or decisions taken by them that are commensurate with their experience and training, but where behaviors like gross negligence, willful violations and destructive acts are not tolerated (HFY, 2021d, p. 2:3/6).

Significant hazards, which are logged on the Safety Database, can come from various sources such as operational activities, organizational business change, human factors issues stemming from the organizational set-up, continuing airworthiness management activities, natural or environmental, unsafe acts or conditions, technical, physiological, economic.

Hazard identification consists of identifying hazards using three methodologies (HFY, 2021d, p. 6.1.2:1/2):

- **Reactive:** through analysis of past outcomes or events. Hazards are identified through investigation of safety occurrences;
- **Proactive:** through analysis of existing or real time situations. This involves actively seeking hazards in the existing processes;
- **Predictive:** through data gathering in order to identify possible negative future outcomes or events. Analysing system processes and the environment to identify potential future hazards and initiating mitigating actions.

Risk Assessment is the second step in the risk management process. Once hazards and their effects have been determined during the first step by means of hazard identification, an analysis is required to assess the probability of the hazard effects occurring and the severity of these effects on aircraft operation. Organizations must develop a safety risk assessment model and procedures which will allow a consistent and systematic approach for the assessment of safety risks (ICAO, 2018, p. 9.17).

HFY risk assessment process is actively implemented in all areas of the organization to ensure that identified safety hazards and associated safety risks are assessed in the context of the potentially damaging consequences. These SRM tools, whose methodology is also approved by ANAC and TM-CAD, must be reviewed and customized periodically.

The risk assessment will enable the determination of a safety risk index<sup>11</sup> that is expressed in two components: severity of the consequence of an occurrence and likelihood of an occurrence.

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<sup>11</sup> An alpha-numeric designator, indicating of the combined results of the severity and likelihood, of the identified hazard projected outcome (HFY, 2021d, p. 6.2.1:1/2).

Risk severity is defined as the extent of harm that might reasonably occur as a consequence or outcome of the identified hazard. The severity assessment should consider all possible consequences related to an unsafe condition or object, taking into account the worst foreseeable situation. Table 3 shows how the severity index of the risk is determined, based on its description and physical injury.

Table 3: HFY safety risk severity table

Risk Severity			
Severity	Description	Physical Injury	Value
Catastrophic	Hull loss.	One or more fatalities	A
Major	Major damage to aircraft (or equipment) and /or complete failure of a significant aircraft system.	Life threatening injury	B
Serious	Substantial damage to aircraft (or equipment) leading to AOG and/or partial loss of a significant aircraft system.	Serious injury	C
Minor	Minor aircraft (or equipment) damage and/or significant aircraft system degradation that hinder normal or efficient operations.	Minor injury	D
Negligible	No significance to aircraft (or equipment) related operational safety	No injury	E

Source: (HFY, 2021d, p. 6.2.2:1/2)

Risk likelihood is defined as the likelihood or frequency that a safety consequence or outcome might occur. In the context of safety risk management, likelihood is expressed qualitatively. The risk likelihood index is determined according to Table 4.

Table 4: HFY safety risk likelihood table

Risk Likelihood		
Likelihood	Description	Value
Improbable	May occur in exceptional circumstances; or Has occurred once or less during the past year	1
Remote	Could occur at some time; or Has occurred between 2 and 5 times in the past year	2
Occasional	Might occur at some time; or Has occurred between 6 and 10 times in the past year	3
Probable	Will probably occur at some time; or Has occurred between 11 and 20 times in the past year.	4
Frequent	Is expected to occur in most circumstances; or Has occurred more than twenty times in the past year	5

Source: (HFY, 2021d, p. 6.2.3:1/2)

The severity and likelihood assessment process can be used to derive a safety risk index (Table 5). The index created through the methodology described above consists of an alpha-numeric designator, indicating of the combined results of the severity and likelihood assessments. The respective severity/likelihood combinations are presented in the risk assessment matrix.

Table 5: HFY's safety risk matrix

Safety Risk Index						
Risk Assessment Matrix		Likelihood				
		Improbable 1	Remote 2	Occasional 3	Probable 4	Frequent 5
Severity	Catastrophic A	1A	2A	3A	4A	5A
	Major B	1B	2B	3B	4B	5B
	Serious C	1C	2C	3C	4C	5C
	Minor D	1D	2D	3D	4D	5D
	Negligible E	1E	2E	3E	4E	5E

Source: (HFY, 2021d, p. 6.2.4:1/2)

The safety risk index obtained from the risk assessment matrix must then be exported to a risk tolerability matrix that describes the tolerability criteria, as shown in Table 6.

Table 6: HFY safety risk tolerability table

Risk Tolerability /Acceptance				
Tolerability	Priority	Action Required	Output	Index
Extreme Risks (Intolerable)	Immediate	Immediate mitigation	SRB	Red
High Risks (Tolerable)	1 month	Short term improvement	SRB	Orange
Medium Risks (Tolerable)	3 months	Long term improvement	SAG	Yellow
Low Risks (Acceptable)	1 year	Monitor	Safety Statistics	Green

Source: (HFY, 2021d, p. 6.2.5:1/2)

Following the risk assessment process, when required, risk mitigation actions are developed and implemented to meet the desired safety and operational performance. Risk mitigation can be achieved through three generic approaches (HFY, 2021d, p. 6.3:1/2):

- **Avoidance:** the activity is suspended or cancelled because the associated safety risks are intolerable or deemed unacceptable vis-à-vis the associated benefits;
- **Reduction:** some safety risk exposure is accepted, although the severity or likelihood associated with the risks are lessened, possibly by measures that mitigate the related consequences;
- **Segregation (of exposure):** action is taken to isolate the potential consequences related to the hazard or to establish multiple layers of defences to protect against them.

Once agreed and implemented the safety risk mitigation, the safety performance is monitored to assure the effectiveness of the safety risk control, by verifying the integrity, efficiency and effectiveness of the new safety risk controls under operational conditions.

### 3.2.3 Safety assurance

Safety Assurance relates to the process of setting performance measures as a way to monitor the operational safety performance of the organization and to validate the effectiveness of safety risk controls.

As said in 3.2.1, HFY owns corporate safety objectives, and the achievement of those objectives represents an improvement in the operational performance. The use of performance measures is an effective method to determine if desired safety outcomes are being achieved and to focus attention on the performance of the organization in managing operational risks and maintaining compliance with relevant regulatory requirements.

Beyond the safety performance monitoring and measurement, which track and compare HFY operational safety performance to the overall safety policy and safety objectives, the following processes are also part of the safety assurance component (HFY, 2021d, pp. 7.2.1.1:1/2 - 7.2.1.7.1:1/2):

- **Safety studies:** through analysis on selected topics used to target broad safety concerns;
- **Safety reviews:** whenever new arising issues are observed ensuring that safety performance is at appropriate levels during periods of change;

- **Safety surveys:** through dedicated qualitative and quantitative surveys addressing specific safety subjects;
- **Safety audits<sup>12</sup>:** aiming to identify the operational strengths and weakness, as well areas of risk and promote mitigation/corrective measures;
- **Internal safety investigation:** conducted for the purpose of incident and accident prevention which includes the gathering and analysis of information, the drawing of conclusions, including the determination of root causes and/or contributing factors and, when appropriate, the making of safety recommendations;
- **FDM program:** applied to all aircraft on HFY fleet and built on the systematic download and analysis of electronically recorded aircraft flight data but also its correlation with information derived from other internal and external sources.

Considering that hazards may exist in ongoing operations or be inadvertently introduced whenever changes occur, hazard identification and risk management are integral elements of HFY management of change process. The management of change is a documented process aimed to identify and manage external and internal changes that may have the potential to affect the level of safety risks associated with HFY activities within its operational environment (HFY, 2021d, p. 7.3:1/4).

HFY, as committed on its Safety Policy, seeks the continuous improvement of its safety and operational performance and this can be achieved through (HFY, 2021d, p. 7.4:1/2):

- Proactive and reactive evaluations of facilities, equipment, documentation, processes and procedures;
- Ongoing monitoring to verify the effectiveness of the system for hazard identification and control of safety risks;
- Assessment of how the SMS is functioning and revising its safety objectives;
- Identification and analysis of possible issues/challenges associated with the SMS;
- Implementing changes aimed at improving the SMS;
- Monitoring and reviewing the possible effects of any changes in the system.

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<sup>12</sup> A proactive safety management activity which provides means for identifying potential hazards before they have an impact on safety (HFY, 2021d, p. 7.2.1.4:1/2).

### **3.2.4 Safety promotion**

Safety Promotion is a process aimed at promoting a just and positive safety culture by ensuring that all personnel in HFY are aware of ongoing information on safety issues, safety metrics, specific hazards existing in the workplace, and initiatives to address known safety issues. It supplements the organization's policies and procedures in order to achieve an effective safety management (HFY, 2021d, p. 8.1:1/2).

Because training and education are essential elements of the safety promotion component, HFY is committed through SMS training to provide all employees with the skills and competencies to work safely and effectively commensurate to their safety responsibilities. There is a link between training and SRM as training and competence development is one means through which identified risks can be reduced.

Additionally, HFY has implemented a communication system aiming the dissemination of safety related and/or operational and airworthiness relevant issues throughout the organization and areas of operation/activities, derived from the management system such as, but not limited to, data collection from the FDM program, the Flight Safety Analysis Programme and the internal safety reporting scheme, targeting to promote a positive safety culture and continuous improvement of the safety operational performance. Safety information is disseminated through various channel of information to all areas of the organization and all staff are encouraged to give feedback and suggestions on safety topics (HFY, 2021d, pp. 8.2:1/2 - 8.2:2/2).

### **3.2.5 Softcraft SMS**

Softcraft SMS is an integrated software, developed by Softsegment,<sup>13</sup> which aggregates information from different sources and areas of an organization in order to produce an integrated view of the safety status of that organization. According to the developer, the software has some modules such as (Softsegment, 2020):

Compliance Monitoring is the module for quality management within the organisation. It is organized with an auditor's perspective, and after the initial setup all internal audits are managed automatically. Over time, statistics are built up, giving management hints

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<sup>13</sup> It is a portuguese software house (note from the author).

on root causes and trend analysis on them, allowing the organisation to have a better understanding of its compliance performance. This functionality is integrated with risk assessment, allowing auditors/auditees to pre-assess the results found, making them visible to the Safety Department.

Reporting System aims to handle all occurrence reports at the organisation level, as well as their impact on quality and safety. The module has a central structure to collect and manage the reported information coming from different sources and they are usually related. Related information is aggregated into cases, which may contain the same event reported from different sources. This module is integrated with risk assessment and users perform a pre-assessment risk for each event.

The Risk Management module allows the management of the risks identified in the organisation. These risks may arise from non-conformities raised in the compliance module, from reports coming from occurrence reports, from events in the Hazard Register, etc. Mitigation can be done by defining the whole set of necessary tasks, which, when executed, guarantee the reduction of risk to the desired levels.

The Library module is designed for an organisation to provide users with the latest versions of existing documentation. To do this, publication lists are created, and user groups are added. Whenever a new document is placed on the list, all users belonging to the group on the list are notified. The system also stores which users have consulted the new documentation and reminds those who have not yet done so after some time.

### **3.3 Safety Performance Management at Hi Fly**

As stated in 3.1.1, all the different approaches of safety concept throughout the aviation history have been concerned with measuring the safety performance. At the beginning, it was done through accident rates, but with the increasing of aviation safety, incidents and accidents became rare and therefore it is required alternative ways to effectively derive safety performance.

Safety performance is a State's or service provider's safety achievement as defined by its Safety Performance Targets (SPTs) and Safety Performance Indicators (SPIs) (ICAO, 2018, p. viii). Therefore, service providers must develop processes and activities to determine whether the SMS is operating according to expectations and requirements.

### **3.3.1 Safety objectives, SPTs and SPIs**

Safety objective is a brief, high-level statement of safety achievement or desired outcome to be accomplished by the State safety programme or service provider's safety management system. Objectives are developed from the organization's top safety risks and should therefore be consistent with the safety policy that sets out the organization's high-level safety commitment, explaining the reason some process or activity should be monitored (ICAO, 2018, p. 8.10).

Once a safety objective is established, it is necessary to define a performance objective (target). The Safety Performance Targets (SPTs) provide confidence that the organization is on track to achieving its safety objectives and provide a measurable way of verifying the effectiveness of safety performance management activities. The choice of targets at HFY is based on historical data, in accordance with the structure and measurement units. SPTs are typically expressed as a rate or number reduction, indicating its aim and the period to achieve it. Along this period, the organization use a data-based parameter for monitoring and assessing safety performance – safety performance indicators (HFY, 2021e, p. SPI 1).

Safety performance indicators are used by an operator to track and compare its operational performance against the achievement of its safety objectives and to focus attention on the performance of the organization in managing operational risks and maintaining compliance with relevant regulatory requirements.

### **3.3.2 Types of Safety Performance Indicators**

According to the way they are expressed, SPIs can be classified as quantitative or qualitative.

Quantitative indicators can be expressed as a number or as a rate (absolute values, mathematical models, statistical analysis etc.). In some cases, a numerical expression will be sufficient. However, just using numbers may create a distorted impression of the actual safety situation if the level of activity fluctuates.

Due to the nature of the change, the acceptable level of safety cannot be expressed in quantitative terms, as the safety assessments may rely on operational judgment (ICAO,

2016b, p. 2.4). Qualitative indicators are descriptive and measured by quality (work experience, professional judgement etc.).

The choice of indicator depends on the availability of reliable data that can be measured quantitatively. Although quantitative indicators are preferred over qualitative indicators because they are more easily counted and compared, the combination of both sorts of arguments can be used to provide a solid level of assurance that all identified safety objectives and requirements are met.

Based on the three methodologies of hazard identification described in 3.2.2, SPIs can be divided in two categories. According to the methodology the SPI is associated, it can be classified as leading or lagging. Figure 12 gives a representative illustration of classification, categories and types of SPIs.

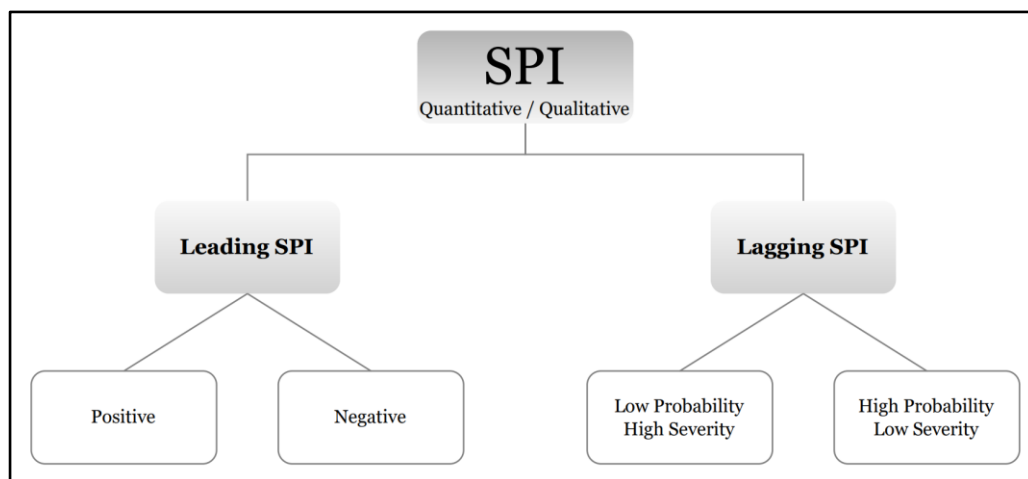


Figure 12: Types of SPIs

Source: (IATA, 2019)

Leading indicators are focused on future safety performance and continuous improvement. They are leading in the sense that they measure safety before any event in the actual operation needs to take place. Once these measures are proactive in nature, both proactive and predictive processes can be measured using leading indicators. These indicators are an especially useful tool for safety improvement because mitigating measures can be realized before any harm takes place. This could potentially result in a significant improvement of safety, i.e., a significant reduction of the probability of an accident.

Leading indicators can be positive, i.e., they can be used to monitor conditions which contribute to safety; or negative, i.e., used to monitor conditions with potential to contribute to a negative outcome.

Lagging indicators are the traditional safety metrics used to indicate progress toward compliance with safety rules. They are mostly very straightforward and widely used (Verstraeten, Roelen, & Speijker, 2014). Considering that they are used to monitor safety events that have already taken place, these indicators are associated to reactive processes.

Lagging SPIs are divided into two types (ICAO, 2018, pp. 4.5, 4.6):

- **low probability/high severity:** outcomes such as accidents or serious incidents. The low frequency of high severity outcomes means that aggregation of data (at industry segment level or regional level) may result in more meaningful analyses;
- **high probability/low severity:** outcomes that did not necessarily manifest themselves in a serious accident or incident, these are sometimes also referred to as precursor indicators. SPIs for high probability/low severity outcomes are primarily used to monitor specific safety issues and measure the effectiveness of existing safety risk mitigations.

### **3.3.3 Criteria for proper Safety Performance Indicators**

In order to have efficient indicators, HFY establishes a set of leading and lagging SPIs that include system failures, human error and the whole spectrum of airside operations. Additionally, each indicator should be (HFY, 2021e, p. SPI 2):

- Easy to measure;
- Company and department-specific;
- Creditable and accepted by staff;
- Causally related to accident and incident frequency and severity.

In order to accomplish with the requirements of the SPI's, HFY follow the seven steps process recommended by the "Safety Management International Collaboration Group" (HFY, 2021e, p. SPI 2):

- Step 1: Designate responsibilities;
- Step 2: Review safety policy and objectives – identify key issues and main focus;
- Step 3: Determine data needs;
- Step 4: Define indicator specifications;
- Step 5: Collect data and report results;
- Step 6: Analyse results and act on findings from SPI’s monitoring;
- Step 7: Evaluate SPI and make changes as appropriate.

### **3.3.4 Safety Performance Indicators measurement**

The performance measures may target a specific area or be broad and encompass the entire system. In both cases, they are designed to be challenging to enhance the effectiveness of the risk management process.

In order to create a more reliable monitoring process, HFY safety department establishes a template, which can be seen in Annex A, followed by the whole organization, to identify each SPI by indicating the SPI number, a short description, the way how it is intended to measure performance (in number, in percentage or any other statistical measure), and what specific source will be used: Softcraft, FDM, reports or any other source of information that may be relevant to monitor performance. Each SPI can be measured monthly or quarterly according to the decision of the department it belongs. Nevertheless, SPIs are reviewed every quarter to be presented at the SRB meeting (HFY, 2021e, pp. SPI 3, 4).

### **3.3.5 AloSP**

One of the main purposes of the SPIs and their monitorization is to show that safety effectively managed and build on the foundation of implementation of existing ICAO safety-related Standards and Recommended Practices (SARPs).

Therefore, ICAO Annex 19 requires the ICAO contracting states to establish the acceptable level of safety performance (ALoSP) to be achieved through the implementation and maintenance of the SSP as well as SPIs and SPTs.

According to *Regulation (EU) 1139/2018*, the European Plan for Aviation Safety (EPAS) shall specify the level of safety performance that express the ambition of the Union and of the European Union Member States (EU MS) and, ICAO, EASA, the EU MS and Aviation Organizations shall jointly aim to achieve that level of safety performance (European Parliament and The Council of The European Union, 2018, p. L 212/3)

In other words, each EU MS must consider EPAS risks and actions in their own SSP and their State Plan for Aviation Safety (SPAS), and organizations, in turn, should take into account the states safety objectives in their SMS and progress towards that level of safety performance (see Figure 13).

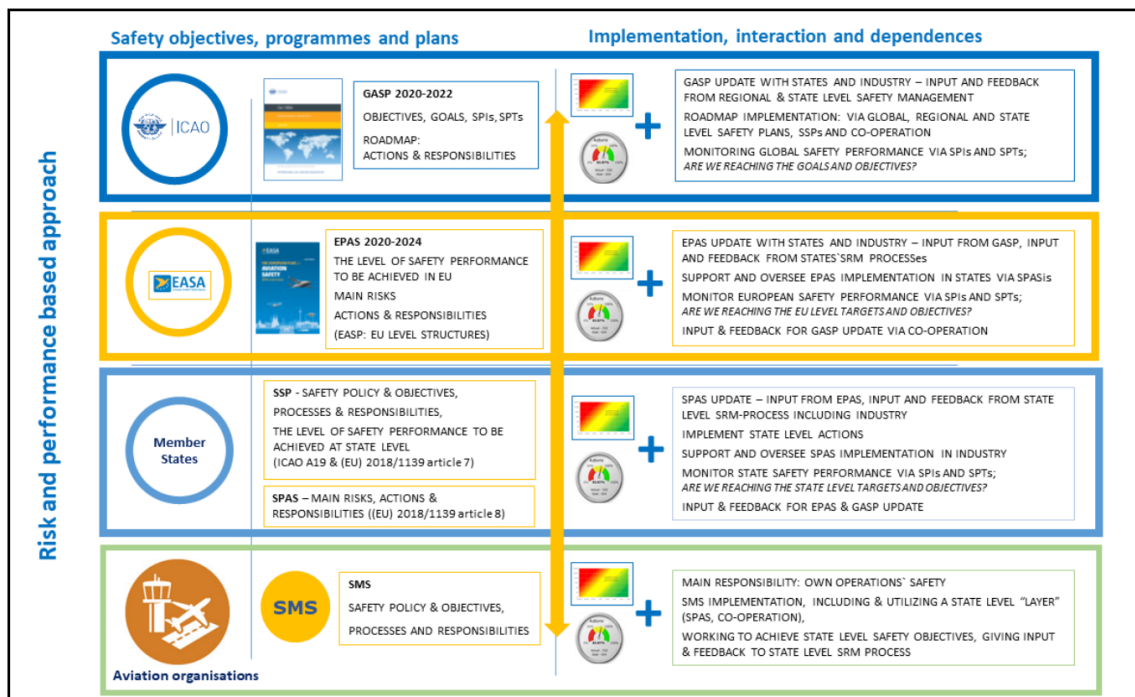


Figure 13: Relationship between GASP, EPAS, SSP and SMS

Source: (EASA, 2021b)

ALoSP is defined as the minimum level of safety performance agreed by State authorities to be achieved for the civil aviation system in a State, as defined in its state safety programme, expressed in terms of safety performance targets and safety performance indicators (ICAO, 2018, p. vii).

Accepting the level of safety performance is a performance-based concept, demonstrating (EASA, 2021b, p. 17):

- What the level of safety performance is in that State at that moment, for different sectors or for different safety-related issues;

- How far the organization is from achieving the safety objectives;
- Whether the SPIs and SPTs being monitored are providing the information needed;
- Whether the agreed actions are working and delivering as planned;
- What the state/organization does when the safety objectives are not met;
- What the next steps are when the expected level of safety performance is met (i.e., continuous improvement).

The level of safety to be achieved by states and service providers is defined by establishing safety objectives that can be set at all levels, to determine when the achieved level is acceptable or more action is required to improve safety performance. Both states and service providers should share efforts as part of a collaborative process between the SSP/SPAS and the SMS. Thus, some of the service providers' SPIs and SPTs can be linked to state SPIs and SPTs to measure and monitor ALoSP.

## **Chapter 4 – Case study**

This chapter provides a detailed description of the entire SPIs management process proposed to the organization, emphasizing the main changes on the implementation process as well as the tool developed to analyse data from each indicator and record those data throughout the years.

The implementation process and the analysis tool were both developed taking into account the organization's profile, structure, and operational field (chapter 2). As an airline company, Hi Fly has several professionals from different departments involved on the SPIs management process and each significative change implies additional training and an adapting period. Therefore, it is imperative to keep part of the old management process while introducing changes as smoothly as possible, in order to have a more effective transition to the new one.

### **4.1 SPI implementation process**

Every department has a person, nominated by the Safety Department, who is responsible for feeding the SPIs monitoring sheets and reporting the safety departments the target achievement, the alert avoidance as well as main notes and considerations about the SPIs. Taking advantage of their knowledge, training, and experience related to SPIs, it was decided to assign them similar roles in the new implementation process, as they are part of the Safety Department as Safety Links (see figure 5).

Creating a department-specific SPI requires an in-deep knowledge, since they are defined according to the department operational field, available data, internal objectives, etc. That is why, each department has its own process to define SPIs and propose to Safety Department their implementation by means of an SPI definition template (presented in Annex B) whose fields correspond exactly the SPI Catalogue fields.

After fulfilling a template, it is sent to the Safety Department to be analysed and approved. There might be some iterations on this process until the proposed indicator is considered properly defined and introduced in the SPI Catalogue, presented in Annex C. Once introduced in the catalogue, the indicator is automatically sent to the department file with an individual monitoring sheet which be filled throughout the monitoring

period. At the end of this period, every data is stored in the database, and they might be used as reference in the next period.

It was also created worksheets that contain charts, views, filters and timelines that are backed by data stored on the SPI Catalogue and Departments Database, providing quick overviews of data reports, in order to track the progress on safety performance. It is a dashboard with restricted access where Safety Manager and Safety Analyst can easily track an SPI individually or have an overview on global safety performance as well as access important statistical information. Figure 14 gives an illustration of the proposed implementation and management process.

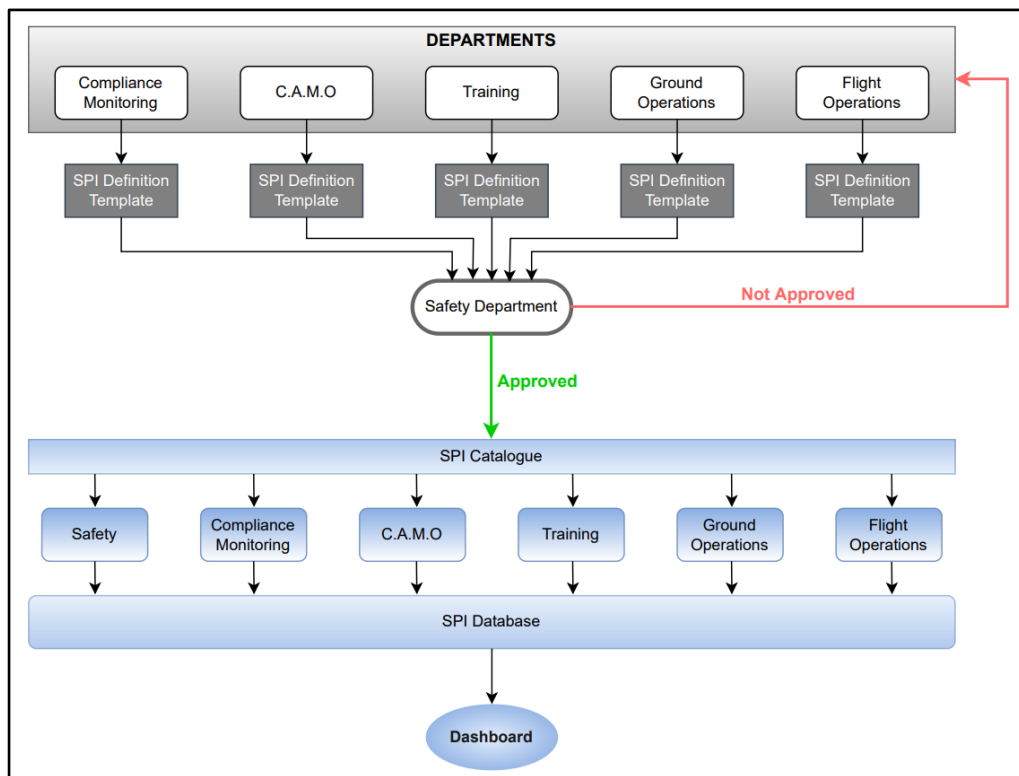


Figure 14: SPI management framework

Source:(Author, 2022)

## 4.2 Analysis and recording tool

To assist in analysing indicators performance during monitoring periods and record those data after end each monitoring period, it is essential to have a tool that fits the size, structure, and operational profile of the organization. Considering these factors, a software programme was chosen that allows the implementation of an appropriate

monitoring methodology in spreadsheets. Microsoft Excel is an immensely powerful resource used in the organization for years, so the professionals are familiar with it.

Additionally, Excel allows to run macros, create templates to standardize data collection and dashboard which can easily be printed and presented in SRB meetings. Taking advantage of these functionalities, lines of code were implemented in Visual Basic Analysis<sup>14</sup> to automate not only the application of stylistic analysis methods, but also the flow of data between worksheets and workbooks.

The analysis tool is composed by two types of workbooks whose displays can be found in Annexes D and E, respectively:

- **Department - SPI** composed by declared SPIs worksheet and a monitoring sheet for each declared SPI. Each department has a file with its declared SPIs, and they are all connected to the SPI database.
- **SPI Database** which contains the catalogue, the record of all SPI and the dashboard. It is the main file, and it is connected to all the department files.

Figure 15 gives a representation of the data flow among the worksheets that compose the workbooks.

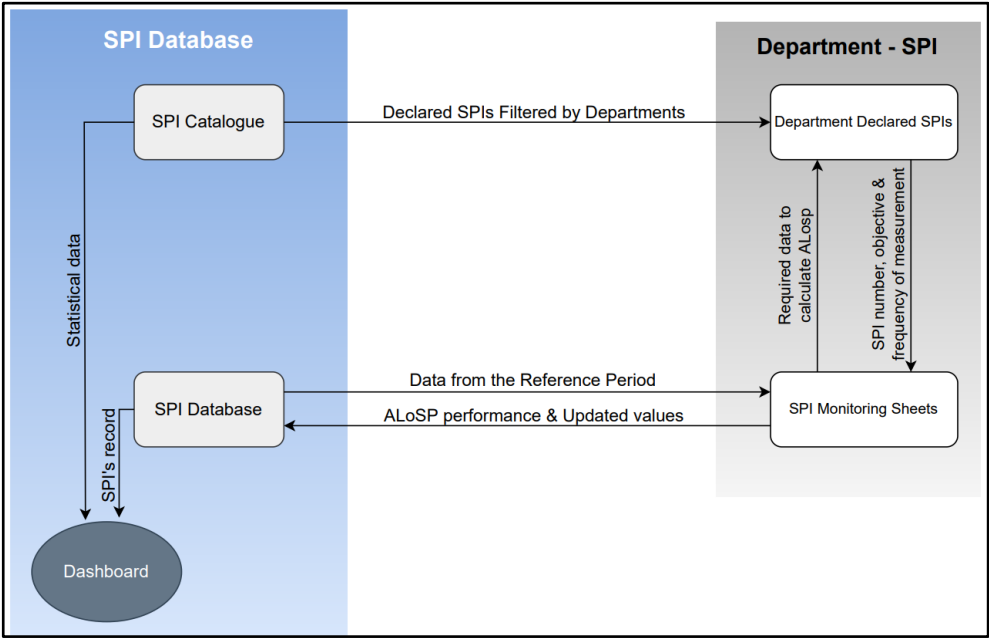


Figure 15: Data flow chart of the workbooks

Source:(Author, 2022)

<sup>14</sup> Microsoft's programming language for Office applications such as MS-Excel, MS-Word, and MS-Access.

### 4.2.1 SPI numbering system

Considering the nature and the objective of the SPIs, it was decided to cluster them in three main groups:

- **SPIs related to State Safety Plan** – aims to assure compliance, satisfy state safety goal, meet public expectation and European Union vision;
- **SPIs related to Organizational Objectives** – monitors internal safety objectives, targets and risk levels;
- **SPIs related to Customer or Contracted Services** – enables continuous contract monitoring, to assure contractual safety compliance and satisfy customers safety goals.

Since the catalogue contains SPIs from all areas and departments throughout the organization, it is mandatory to create an effective mechanism able to assign a serial number to each implemented SPI. The four-digit numbering system allows to easily identify each SPI, indicating the corresponding group, department and associated key safety risk, according to the tables 7, 8 and 9:

*Table 7: First digit of the numbering system*

First Digit	
Number	Group
1	State Safety Plan Related
2	Organizational Objectives Related
3	Customer or Contracted Services Related

*Source: (Author, 2022)*

*Table 8: Second digit of the numbering system*

Second Digit	
Number	Department
0	Safety
1	Compliance Monitoring
2	Training
3	Continuing Airworthiness Maintenance Organization
4	Ground Operations
5	Flight Operations

*Source: (Author, 2022)*

Table 9: Third digit of the numbering system

Third Digit	
Number	Associated Key Safety Risk
0	Hull Loss
1	Cabin Operations
2	Security
3	Fatigue
4	Health and Human Performance

Source: (Author, 2022)

The fourth digit is intended to enumerate SPIs with the same first three digits, i.e., it ensures that each assigned number is unique regardless of the SPI group, department or associated key safety risk.

#### 4.2.2 SPI description and classification

An indicator is an algorithm or formula that expresses the qualitative or quantitative relationship between two or more variables, and it must be defined in order to measure the performance level regardless of the level of activity, providing a normalized measure of performance.

$$Accident\ rate = \frac{accidents}{departures} \times 1.000.000 \quad (1)$$

As mentioned in 4.1, Safety Department approval was introduced in the SPI implementation process as a way to ensure that each indicator is properly defined, in the sense that they should be:

- SMART (specific, measurable, achievable, relevant and timely);
- Cost-effective;
- Reliable and resistant to bias.

Therefore, when an SPI is introduced in the catalogue, several fields are filled specifying how is it measured (any requirement for its calculation and the units of measurement), what source(s) of data should be used, the frequency of measurement, the safety objective they aim to indicate as well as who is responsible for collecting, validating, monitoring, reporting and acting on the SPI.

Based on the content presented in 3.3.2, SPIs are classified according to the way they are expressed and categorized in line with the associated hazard identification methodology. Thus, the SPI catalogue specifies whether each indicator is classified as quantitative or qualitative; and categorized as leading or lagging.

In addition, the catalogue indicates the SPI status (active or inactive), thereby making it possible to allow safety department to decide which indicators should be taken into account during each monitorization period. Although all the indicators are kept in the catalogue as well as their serial number, the departments can only access the indicators labelled as ‘active’ by the safety department.

### 4.3 Standard Deviation Method

As represented in the Figure 15, each department file of the analysis tool contains monitoring sheets with an associated methodology for setting out-of-limits trigger criteria for safety triggers, using the population standard deviation principle. This method derives the standard deviation (SD) value based on the preceding historical data points of a given safety indicator.

The standard deviation (SD) is the average deviation of the individual collective deviations of the data set from its mean. Thus, the more volatile the data set, the larger the SD.

$$SD = \sqrt{\frac{\sum(x - \mu)^2}{N}} \quad (2)$$

Where:

$$\mu = \frac{\sum x}{N}$$

“*x*” is the value of each data point;

“*N*” is the number of data points;

### 4.3.1 Safety triggers

A trigger is an established level or criteria value that serves to trigger (start) an evaluation, decision, adjustment or remedial action related to a particular indicator (ICAO, 2018, p. 4.15).

For each SPI there are three trigger levels defined based on the historical data, in accordance with data points, average and standard deviation of previous year(s). Thereby, the three trigger levels (1, 2 and 3) are calculated by adding, respectively, 1 SD, 2 SD and 3 SD to the average of the previous year or any other monitoring period taken as reference.

In some cases, there might be necessary to manually enter the trigger values into the analysis tool. This is the case when an SPI is being measured for the first time, when an SPI has specific targets defined by CAAs, when there is not a sufficiently volatile period in the data record, etc.

Once defined the target and the trigger levels for each SPI, an alert graph is plotted, and the alert condition is breached whenever:

- Any single point is above the 3 SD line;
- Two or more consecutive points are above the 2 SD line;
- Three or more consecutive points are above the 1 SD line.

Figure 16 gives a representation of the trigger levels for an SPI monthly measured.

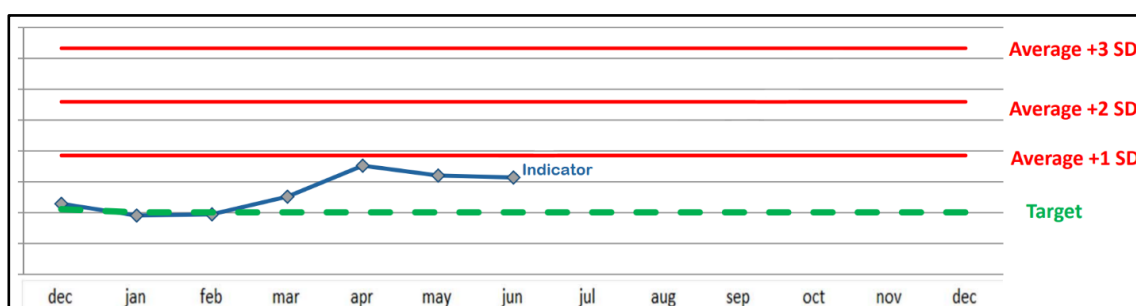


Figure 16: Example of an alert graph

Source: (Thong, 2015)

Trigger values serve to monitor performance and alerting when breaching unsatisfactory performance, so an SPI being triggered is not necessarily catastrophic or an indication of failure. It is merely a sign that the activity has moved beyond the predetermined limit.

The trigger aims to attract the attention of decision makers who are now able to take remedial action, or not, depending on the circumstances.

### **4.3.2 Safety target**

The process of measurement of an SPI has a realistic target (represented in Figure 16) to be achieved at the end of each monitoring period. Target setting is a less complex process than alert setting, and it should be done at the beginning of the monitoring process.

There are some SPIs that all have specific associated targets (planned or desired), for example, the target for accidents or serious incidents is always zero, regardless flight hours or number of departures. On the other hand, most of the SPI targets are expressed as a reduction of current average over reference period average. This approach focuses on achieving a positive trend in the SPIs, without specific target values. The package of selected performance metrics will usually employ a combination of both approaches.

## **4.4 Overall Safety Performance**

Once targets and trigger settings have been defined, their associated SPI may be tracked for their respective performance status. A consolidated summary of the overall target and trigger performance outcome of the complete SPIs package is also compiled and/or aggregated for a given monitoring period.

Numeric values (points) are used to provide a quantitative measurement of the overall performance of the SPIs package and, generally, SPIs are clustered in two groups with different weights when calculating the Overall Safety Performance (OSP), according to the associated consequences.

Annex F shows an example of a traditional ALoSP table and how overall performance is calculated by states or service providers. SPIs classified as "Safety Indicators of High Consequence" are given a higher weighting than "Safety Indicators of Lower Consequence", as well as alert avoidance is considered more relevant than target achievement.

In order to have a more accurate, effective and appropriate methodology for calculating the OSP, the weighting of SPIs was linked to the risk assessment process that is actively implemented at HFY.

Thus, each SPI weighting for the OSP calculation is determined based on its associated risk assessment done by the Safety Department using SRM tools for risk assessment which allows the determination of a safety risk index.

In practical terms, each department defines its indicators internally, filling out templates that will later be submitted for approval by the safety department, which at this stage makes the risk assessment associated with each SPI and consequently determines the weight of the SPI in the OSP calculation.

This innovative approach for the OSP calculation is better suited to the organization's SMS in the sense that it corresponds perfectly to the SRM tool described in 3.2.2. It is also more accurate because it allows four possible ratings with four different weightings instead of two. Therefore, its implementation was preceded by a case study that considered four possible weighting classifications in order to analyse the relevance of each index of the associated risk assessment as well as the associated alert avoidance and target achievement.

It was considered four cases of weight assignments. For each case, it was elaborated a table which represent the percentage of relevance of each safety risk index as well as their respective parameters.

The first weight assignment case (Table 10) prioritizes the associated risk index and then the alert avoidance over target achievement. That is why the highest weights were assigned to SPIs whose associated risk is more severe and more likely.

Table 10: Weight assignments - CASE I

Associated Risk Assessment	Parameter	Weight	Partial %	Total %	OSP %
Extreme	Alert avoidance	8	53%	22%	42%
	Target achievement	7	47%	19%	
High	Alert avoidance	6	55%	17%	31%
	Target achievement	5	45%	14%	
Medium	Alert avoidance	4	57%	11%	19%
	Target achievement	3	43%	8%	
Low	Alert avoidance	2	67%	6%	8%
	Target achievement	1	33%	3%	

Source: (Author, 2022)

The following equations give an example of the calculations done in order to obtain the values presented in the above.

$$\begin{aligned} & \text{Partial \% (Extreme)} \\ & \left\{ \begin{aligned} \text{Alert avoidance} &= \frac{8}{8+7} \times 100 = 53\% \\ \text{Target achievement} &= \frac{7}{8+7} \times 100 = 47\% \end{aligned} \right\} \end{aligned} \quad \begin{matrix} (3) \\ (4) \end{matrix}$$

$$\begin{aligned} & \text{Total \% (Extreme)} \\ & \left\{ \begin{aligned} \text{Alert avoidance} &= \frac{8}{8+7+6+5+4+3+2+1} \times 100 = 22\% \\ \text{Target achievement} &= \frac{7}{8+7+6+5+4+3+2+1} \times 100 = 19\% \end{aligned} \right\} \end{aligned} \quad \begin{matrix} (5) \\ (6) \end{matrix}$$

$$\text{OSP \% (Extreme)} = \frac{8+7}{8+7+6+5+4+3+2+1} \times 100 = 42\% \quad (7)$$

In the other hand, the second weight assignment case (Table 11) gives priority to the alert avoidance over the associated risk index. Therefore, alert avoidances take the highest weight while target achievements take the lower ones, all of them according to the associated risk index.

Table 11: Weight assignments - CASE II

Associated Risk Assessment	Parameter	Weight	Partial %	Total %	OSP %
Extreme	Alert avoidance	8	67%	22%	33%
	Target achievement	4	33%	11%	
High	Alert avoidance	7	70%	19%	28%
	Target achievement	3	30%	8%	
Medium	Alert avoidance	6	75%	17%	22%
	Target achievement	2	25%	6%	
Low	Alert avoidance	5	83%	14%	17%
	Target achievement	1	17%	3%	

Source: (Author, 2022)

Compared to the first case of weight assignment, the second case results in a larger difference in relevance between alert avoidance and target achievement for the same risk index (both partial and total), while the difference in relevance between risk indices in

OSP (16% between ‘extreme’ and ‘low’) is smaller than in the first case (34% between ‘extreme’ and ‘low’).

Then, according to the Table 11, it is more important to avoid alert situation of every SPI than achieving their target, regardless of the associated risk indexes. For example, avoiding the alert of SPIs with low-risk index represent 14% of the OSP, while achieving the targets of the SPIs with extreme risk index represent only 11% of the OSP.

The third weight assignment case (Table 12) is similar to the first one, with double weight difference between alert avoidance and target achievement.

Table 12: Weight assignments - CASE III

Associated Risk Assessment	Parameter	Weight	Partial %	Total %	OSP %
Extreme	Alert avoidance	8	57%	22%	39%
	Target achievement	6	43%	17%	
High	Alert avoidance	7	58%	19%	33%
	Target achievement	5	42%	14%	
Medium	Alert avoidance	4	67%	11%	17%
	Target achievement	2	33%	6%	
Low	Alert avoidance	3	75%	8%	11%
	Target achievement	1	25%	3%	

Source: (Author, 2022)

This assignment of weights brackets the risk indexes into two groups once the highest weights are attributed to the first part of the table (extreme and high indexes), prioritizing alert avoidance and only then risk index. The same happens in the second part of the table (medium and low indexes), but with the four lowest weights in the distribution.

As a consequence of this, the difference in relevance between ‘extreme’ and ‘high’ risk indexes is the same as between ‘medium’ and ‘low’ (6%), which in turn is much smaller than the difference between ‘high’ and ‘medium’ (16%).

The discrepancy between the relevance differences of the risk index affects greatly and negatively the role of the associated risk assessment made by safety department for each SPI.

The last considered case (Table 13) is the result of a combination between the approaches used in the first and the second cases. For the SPIs whose associated risk were assessed as “extreme” or “low” take the highest and lowest weight, respectively. At the other hand,

the intermedial indexes (“high” and “medium”) takes the intermedial weights, with double discrepancy between the alert avoidance and target achievement.

Although the distribution is different, the weight assignment represented in the table 13 (CASE IV) has the same drawback as the approach used in CASE III: the differences in relevance between risk indexes are much different from each other, for example 14% between ‘extreme’ and ‘high’, while 6% between ‘high’ and ‘medium’.

*Table 13: Weight assignments - CASE IV*

Associated Risk Assessment	Parameter	Weight	Partial %	Total %	OSP %
Extreme	Alert avoidance	8	53%	22%	42%
	Target achievement	7	47%	19%	
High	Alert avoidance	6	60%	17%	28%
	Target achievement	4	40%	11%	
Medium	Alert avoidance	5	63%	14%	22%
	Target achievement	3	38%	8%	
Low	Alert avoidance	2	67%	6%	8%
	Target achievement	1	33%	3%	

*Source: (Author, 2022)*

All four cases of weigh assignment have some points in common, so that they comply with the basic principles of overall safety performance calculation, which in turn help in determining and achieving the ALoSP defined both at organizational and national level, as described in 3.3.5.

As shown in the tables above, for all the distributions considered, it is clear that the higher the associated risk index, the greater is the weight of the SPI in the calculation of the OSP and, for the same risk index, avoiding the alert is considered more relevant than achieving the target.

After the analysis of the four considered weight assignment cases, through the four tables of relevance elaborated and simulations made with real and confidential HFY data, it was decided that the first case of weight assignment is the one that guarantees the best balance in terms of the difference of relevance between the levels and

The first case of weight assignment gives more value to the evaluation of the associated risks made by the safety department, which makes this calculation methodology a more precise and more specific extension of the traditional methodology that only counts on two possible indexes (as shown in the Annex F).

## 4.5 Discussion of results and validation

The case study described in the previous chapter provided a set of changes to the safety performance indicators management system in the company, not only at the level of the tool and method for analysing data related to SPIs, but also in the processes for implementing new indicators and sampling data obtained during each monitoring period. Table 14 shows the main differences between the existing SPI management systems until 2022 and the one implemented in 2023.

Table 14: Difference between both SPI management systems

SPI Management Systems	
Until 2022	As from 2023
SPIs defined individually by each department	New iterative process of definition of the SPI common to all departments and subject to the approval of the safety department
Mandatory / SSP-related SPIs	Three new groups of SPIs, related to: SSP, Organizational objectives and customer/contracted services.
Simple number assignment system, different for each department	New numbering system common to all departments, according to the group, department, and area to which the indicator belongs
Data stored in the reporting database and Excel files in the different departments	New database common to all departments, containing data from several years
Reference indicators manually entered the monitoring sheet	New reference indicators system automatically imported from the database into the monitoring sheet
Target expressed in terms of percentage improvement over the previous year. First SPI monitoring period has no target.	New monitoring process sheets that determine the target from the reference indicators and allow the introduction of target based on safety objectives
Overall safety performance calculated in the conventional way (2 possible weights for SPI)	New overall safety performance calculation process associated with risk assessment by the safety department (4 possible weights for SPI)
AloSP monitored through the achievement of safety objectives	AloSP is monitored through the automatic calculation of the overall safety performance of each department and of the company.
Excel files printed and reported to the safety department	New SPI data sampling dashboard

Source: (Author, 2022)

In addition to being more up to date, since it is based on more recent guidelines, regulations and safety objectives, the new SPI management system brings a more automated and standardised approach among the various departments involved in this process.

This new system provides the Safety Department with more control over the management process and easier access to updated data, while maintaining the interaction and connection between the various departments through the Safety Links, which are extensions of the Safety Department in all other departments.

Safety Links play a fundamental role in the safety performance management system, since they are people with knowledge and expertise on the subject, regarding the constitution, operation and field of action of the department to which each one belongs.

With regard to the validation process to determine the viability of the new process for the implementation of new SPIs deserved a joint analysis by different members of the Safety Department and the tool created was submitted to several simulations using real data present in the company database and future data forecasts.

The simulations were performed with the aim of verifying and guaranteeing the tool's analysis capacity and the correct data flow between the different files that compose the tool. At the end, the results were approved and validated by the Safety Manager of the organization.

# Chapter 5 – Conclusions and future work

## 5.1 Conclusion

Aviation is a very dynamic industry in which the constant transformations that it has been subject to throughout its history have allowed to create very solid bases and to captivate the interest in the constant search for improvements, focusing on the efficiency of operations and above all on the safety of all who are directly or indirectly connected to it.

In this way, all updates and changes are introduced progressively, in order to increasingly improve the solid foundations built over time and at the same time follow the scientific and technological progress that results from multidisciplinary experiences and studies carried out by professionals from different areas.

Since 2013, ICAO has established that within the scope of the SMS, states and service providers must define a minimum safety performance level to be reached at the end of a specified period. This level must be expressed in terms of targets, and must be tracked throughout that period through SPIs. Since then, safety performance monitoring and measurement has gained a regulatory character and the notion of its importance has been increasing, even among airline operators. Nowadays, it is known that the importance of SPI goes far beyond the compliance with regulations.

Although the guidelines have been issued some years ago and Hi Fly has several SPIs already implemented and been monitored, the SPI management system needs to be regularly updated, with the development of specific methods and tools that best fit the operational profile of an airline operator and address the vision adopted by the various aviation safety strategies and plans such as GASP, EPAS and SPAS/SSP that are being updated by the competent authorities.

In this context, the present dissertation was carried out with the objectives of study the viability of creating a process for the implementation of new SPIs and developing a tool that assists the whole process of collection, analysis, sampling and storage of data related to the SPIs.

Initially, a bibliographical review was carried out of both ICAO and Hi Fly safety management manuals, in order to understand the context in which the element of monitoring and measuring safety performance is inserted, as part of the SMS.

Alongside these manuals, Annex 19 of the ICAO and several other documents made available by international organizations such as EASA, IATA, FAA and United Kingdom CAA were consulted. Since Hi Fly has operational bases in Portugal and Malta, the guidelines and documents issued by ANAC and TM-CAD were also taken into account in this feasibility study.

In order to create a process to implement SPIs, it was crucial to consider that each department is responsible for creating its own SPIs, according to its safety objectives. However, the experience of the last few years has shown that these SPIs are not always defined in the best way. Therefore, it was decided to create an iterative implementation process where the departments receive the guidelines and propose the definition of the SPI to be implemented, which will always be subject to the approval of the Safety Department.

This new process allows a standardization in the definition of the SPIs and in the data used for their calculation, as well as guarantees that all SPIs are properly defined. Another important step in the standardisation of SPIs was the creation of a serial numbering system that not only allows the SPIs to be distinguished from one another but also identifies the group, department, and area to which each one belongs.

To analyse the data collected in relation to the SPIs, we chose to apply the statistical method based on the principle of standard deviation to each monitoring sheet, which has automatic feedback boxes to assist in the reporting and decision-making processes.

Bearing in mind that the management process of the SPIs is aimed at helping to define the ALoSP and to track its achievement over time, a method was created to calculate the overall safety performance directly connected to the evaluation of the risks associated with each SPI, carried out by the Safety Department.

The development of this work resulted in proposing the creation of an implementation process and a tool that supports the management of data and activities related to SPIs in a more standardized, efficient and effective way, not only by the Safety Department but also by all departments of the organization.

In this way, the validation process of all the work developed relies on simulations involving real data and the participation of professionals from different departments (safety links) until it is approved by the Safety Manager, who coordinates the whole process.

## **5.2 Future work**

As this work was developed starting from the SPIs already implemented within the organisation and the vast majority of them are quantitative SPIs, since these are calculated more directly from the available data, whereas qualitative SPIs require more time to be defined and analysed.

Although the database already contains some qualitative SPIs measured by means of the percentage scale, it is recommended that other qualitative scales be developed which are more adjustable to the nature of each qualitative SPI and which enable not only numerical but also qualitative data to be collected.

It is also recommended that in the future the work developed is implemented in Softcraft software through the creation of an exclusive and specific module for the management of the SPIs and that at the same time it remains connected to the rest of the safety database.

This transition to a more specialised software would further improve the automatic processing of data in order to facilitate the updating of data in real time, thus requiring less time from the users and reducing the possibility of human error.

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# Annex A - SPI definition template (until 2022)

SPI NUMBER	SAFETY INDICATOR TITLE (and short description)	AREA	SOURCE (how is it measure)	SPI STRUCTURE (how often it will be measured)	TARGET	ALERT LEVEL 1	ALERT LEVEL 2	ALERT LEVEL 3	START DATE	END DATE
1	Example: Reporting Scheme	Example: Safety	Example: Number of _____ per 100 flights	Choose between: Monthly / Quarterly	Example: AVG of _____ (+10% than 2020)	Example: AVG 2020 -30%	Example: AVG 2020 -40%	Example: AVG 2020 -50%	1/1/2021	12/31/2021

# Annex B – New SPI definition template

<b>SPI Definition Template</b>		
<b>SPI Number</b> <small>(Assigned by Safety Department)</small>	<b>Date Form Completed:</b>	<b>Form Completed By:</b>
	January 27, 2023	
<b>Title or Acronym</b>		
<small>Define a short title or an acronym that should be unique within the department.</small>		
<b>Description (How is it measured/calculated?)</b>		
<small>NOTE: an indicator is an algorithm or formula that expresses the qualitative or quantitative relationship between two or more variables and it must be defined in order to measure the performance level regardless of the level of activity, providing a normalized measure of performance. If applicable, specify the units of measurement and the requirements for its calculation</small>		
<b>Related Safety Objective(s)</b>		
<small>State the safety objective(s) this SPI aim to indicate. Examples of safety objectives: Increase safety reporting levels; Reduce the annual number of safety events in sector X</small>		
<b>Data Source</b>	<b>Frequency</b>	
<small>The SPIs should be measured using existing [internal and/or external] data sources, but may also require the collection of <b>additional data</b>. Examples of data source: Reports, FDM, SOFTCRAFT, etc</small>	<small>How often should it be measured?</small>	
	<input checked="" type="radio"/> <b>Monthly</b> <input type="radio"/> <b>Quarterly</b>	
1/3		

## SPI Definition Template

<b>Associated Risk Assessment</b> (made by Safety Department)	<b>Severity</b> Catastrophic	<b>Likelihood</b> Frequent	<b>Risk Assessment</b> Extreme
According to the Appendix 1 (page 3/3), make the assessment of the risk associated to this SPI.			

<b>Related to</b>	Customer or Contract Services (CoCS)
<p><b>SPIs related to SSP</b> – aim to assure compliance, satisfy state safety goal, meet public expectation and European Union vision.</p> <p><b>SPIs related to Organizational Objectives</b> – monitor internal safety objectives, targets and risk levels.</p> <p><b>SPIs related to CoCS</b> – Enable continuous contract monitoring, to assure contractual safety compliance and satisfy customer’s safety goals.</p>	

<b>Department</b>	CAMO
Safety Department Procedures Manual (2021): Each SPI should be company and <b>department-specific</b>	

<b>Key Safety Area</b>	Health and Human Performance
State the key safety area this SPI is associated to.	

<b>Category</b>	Leading
<p><b>Lagging SPIs</b> - “outcome-based SPIs” which measure events that have already occurred. Normally, but not always, the negative outcomes the organization is aiming to avoid.</p> <p><b>Leading SPIs</b> - “activity or process SPIs” which measure processes and inputs being implemented to improve or maintain safety. They monitor and measure conditions that have the potential to lead to or contribute to a specific outcome.</p>	

<b>Class</b>	Quantitative
<p><b>Quantitative SPIs</b> are expressed as a number or as a rate.</p> <p><b>Qualitative SPIs</b> are descriptive and measure by quality (work experience, professional judgement ...)</p>	

Responsibility	
State who is responsible for [data]:	
Collecting:	Monitoring:
Validating:	Reporting:
Acting:	

# SPI Definition Template

## Appendix 1

Risk Severity			
Severity	Description	Physical Injury	Value
Catastrophic	Hull loss.	One or more fatalities	A
Major	Major damage to aircraft (or equipment) and /or complete failure of a significant aircraft system.	Life threatening injury	B
Serious	Substantial damage to aircraft (or equipment) leading to AOG and/or partial loss of a significant aircraft system.	Serious injury	C
Minor	Minor aircraft (or equipment) damage and/or significant aircraft system degradation that hinder normal or efficient operations.	Minor injury	D
Negligible	No significance to aircraft (or equipment) related operational safety	No injury	E



Risk Likelihood		
Likelihood	Description	Value
Improbable	May occur in exceptional circumstances; or Has occurred once or less during the past year	1
Remote	Could occur at some time; or Has occurred between 2 and 5 times in the past year	2
Occasional	Might occur at some time; or Has occurred between 6 and 10 times in the past year	3
Probable	Will probably occur at some time; or Has occurred between 11 and 20 times in the past year.	4
Frequent	Is expected to occur in most circumstances; or Has occurred more than 20 times in the past year	5



Safety Risk Index						
Risk Assessment Matrix		Likelihood				
		1	2	3	4	5
Severity	A	1A	2A	3A	4A	5A
	B	1B	2B	3B	4B	5B
	C	1C	2C	3C	4C	5C
	D	1D	2D	3D	4D	5D
	E	1E	2E	3E	4E	5E



Risk Tolerability / Acceptance					
Tolerability	Priority	Action Required	Output	Index	Risk Ass.
Intolerable	Immediate	Immediate mitigation	SRB	Red	Extreme
Tolerable	1 month	Short term improvement	SRB	Orange	High
Tolerable	3 months	Long term improvement	SAG	Yellow	Medium
Acceptable	1 year	Monitor	Safety Statistics	Green	Low

# Annex C – SPI Catalogue Preview

## SPI Catalogue

The 2nd worksheet contains a table with 20 columns describing all the SPIs implemented so far within the organization. Additionally, there are 2 macro-enabled buttons used to introduce new SPI in the catalogue.

In order to implement a new SPI, follow these steps:

- Step 1: Click on "Insert New SPI in the Catalogue" and enter the password
- Step 2: Fill all the fields of the last table's row, except NUMBER:
- Step 3: Click on "Assign a Number to the Last SPI Introduced"

Note that some table's fields have data restrictions according to these tables:

<b>Frequency</b>	<b>Associated Risk Assessment</b>	<b>Group</b>	<b>First Dight SPI #</b>	<b>Department</b>	<b>Second Dight SPI #</b>	<b>Key Safety Risk</b>	<b>Third Dight SPI #</b>	<b>Category</b>	<b>Class</b>	<b>Occurrences must be</b>	<b>Status</b>
Monthly Quarterly	Low Medium High Extreme	SSP Related Organizational CACS Related	1 2 3	Safety Compliance Training CAWO Ground Ops Flight Ops	0 1 2 3 4 5	Hull Loss Cabin Ops Security Fatigue HHP	0 1 2 3 4	Leading Lagging	Quantitative Qualitative	Maximized Minimized	Active Inactive

# Annex D – Department-SPI workbook display

Note: dummy data

Source: (Author, 2022)

CONTINUING AIRWORTHINESS MANAGEMENT ORGANIZATION DEPARTMENT

ALoSP Performance		2024
Overall		53.3%
Alert Avoidance		100.0%
Target Achievement		0.0%

Commands

Start New Monitoring Period (New Year)

SPI introduced after starting the monitoring period

Upload Values into SPI Database

End Monitoring Period

SPI #	Title and Description	How is it measured	Source	Frequency	Risk	Alert Level Not Breached	Target Achieved
2401	TEST 1	(Occurrences/Departures) x 1,003	0	Quarterly	Extreme	8	

SPI\_ 2101
SPI 1
(Occurrences/Departures) x 1,000

For this SPI, the number of occurrences must be:

Ref Year	2022
Jan-22	3
Feb-22	3
Mar-22	3
Apr-22	5
May-22	5
Jun-22	5
Jul-22	2
Aug-22	2
Sep-22	2
Oct-22	4
Nov-22	4
Dec-22	4

Current Year	2023
Jan-23	0
Feb-23	
Mar-23	
Apr-23	
May-23	
Jun-23	
Jul-23	
Aug-23	
Sep-23	
Oct-23	
Nov-23	
Dec-23	

Target	Trigger 1	Trigger 2	Trigger 3
3.85	2.382	1.264	0.146

Average	2022	2023
3.5	3.5	0.000
Standard Deviation	1.118	0.000

Alert Level Not Breached

Target Not Achieved

3.85 units away from target

Before filling the table above, answer the following questions:

- 1 - Select the current year:
- 2 - Select an year as a reference (usually, last year):
- 3 - What is the intended improvement over the 2023's average? (Target)

Target Setting

The target should be realistically achievable, considering the recent performance of the particular SPI and factors such as:

- The prevailing level of safety risk,
- Safety risk tolerability,
- Expectations regarding the safety of the particular aviation sector.

Standard Deviation Method

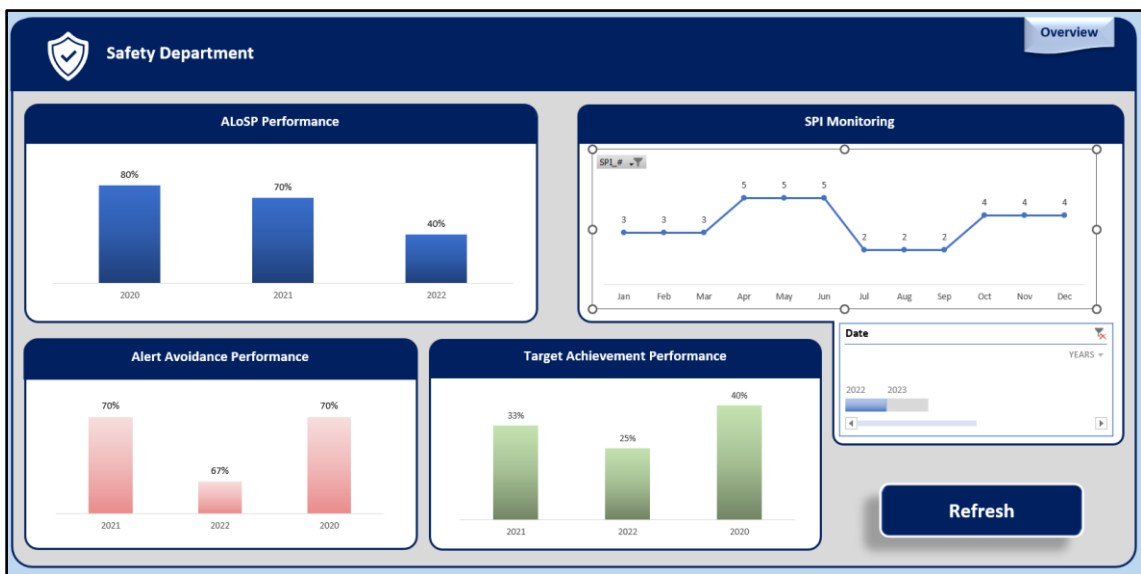
Trigger 1	2.38197
Trigger 2	1.26393
Trigger 3	0.1459
Target	3.85

60

# Annex E - SPI dashboard display

Note: dummy data

Source: (Author, 2022)



## Annex F – Overall ALoSP Performance Example

Source: (Thong, 2015, pp. 30, 31)

At the beginning of a new monitoring period - } Organization establishes its desired minimum consolidated Alert & Target achievement outcome (i.e., ALoSP), after taking into consideration the previous period's performance (57.8% in table below).

High Consequence Safety Indicators					
	Safety Indicator (SI) Description	SI Alert Level/ Criteria (for 2010)	Alert level Not Breached [Yes (4), No (0)]	Target level/ criteria	Target Achieved [Yes (3), No (0)]
1	CAA aggregate Air Operators monthly accident/ serious incident rate [per 1000 FH]	2009 Average Rate + 1/2/3 SD. (annual reset)	4	5 % improvement of the 2010 Average Rate over the 2009 Average Rate.	0
2	CAA aggregate Aerodromes monthly ground accident/ serious incidents rate - involving any aircraft [per 10,000 ground movements]	2009 Average Rate + 1/2/3 SD. (annual reset)	4	3 % improvement of the 2010 Average Rate over the 2009 Average Rate.	3
3	CAA aggregate ATS monthly FIR serious incidents rate - involving any aircraft [per 100,000 air movements]	2009 Average Rate + 1/2/3 SD. (annual reset)	0	4 % improvement of the 2010 Average Rate over the 2009 Average Rate.	0
		Sub-total	8	Sub-total	3
		Max	12	Max	9

Lower Consequence Safety Indicators					
	Safety Indicator (SI) Description	SI Alert Level/ Criteria (for 2010)	Alert level Not Breached [Yes (2), No (0)]	Target level/ criteria	Target Achieved [Yes (1), No (0)]
4	CAA aggregate Air Operators Organization annual surveillance/ audit outcomes	>25% Average LEI; OR any level 1 finding; OR >5 level 2 findings per audit	2	<10% Average LEI; AND <1 level 2 finding per audit	0
5	CAA annual Air Operator Line Station surveillance inspection Ave LEI% (for each Operator).	>25% Average LEI; OR any level 1 finding; OR >5 level 2 findings per audit	2	<10% Average LEI	1
6	CAA annual Foreign Air Operators Ramp sampling inspection programme.	>25% Average LEI; OR any level 1 finding; OR >5 level 2 findings per audit; OR <25% of Foreign Operators inspected	2	Not less than 50% of Foreign Operators to be inspected	0
7	CAA aggregate Aerodrome Operators Organization annual surveillance/ audit outcomes	>25% Average LEI; OR any level 1 finding; OR >5 level 2 findings per audit	0	<10% Average LEI; AND <1 level 2 finding per audit	0
8	CAA aggregate ATS Operators Organization annual surveillance/ audit outcomes	>25% Average LEI; OR any level 1 finding; OR >5 level 2 findings per audit	2	<10% Average LEI; AND <1 level 2 finding per audit	1
9	CAA aggregate ATS quarterly FIR TCAS RA incidents rate - involving any aircraft [per 10,000 flight movements]	2009 Average Rate + 1/2/3 SD. (annual reset)	2	5 % improvement of the 2010 Average Rate over the 2009 Average Rate.	0
10	CAA aggregate D&M/ MRO Organization annual surveillance/ audit outcomes	>25% Average LEI; OR any level 1 finding; OR >5 level 2 findings per audit	2	<10% Average LEI; AND <1 level 2 finding per audit	1
11	CAA aggregate AMO (MRO) quarterly rate of component warranty claims due to (Major) technical defects.	2009 Average Rate + 1/2/3 SD. (annual reset)	0	5 % improvement of the 2010 Average Rate over the 2009 Average Rate	0
Sub-total			12	Sub-total	3
Max			16	Max	8
No Alert %			71.4%	Target Achieved %	35.3%
Overall ALoSP Performance				57.8%	