AVIATION SAFETY MANAGEMENT SYSTEM

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A BEGINNER'S
AVIATION
GLOSSARY
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DARK SIDE OF
AVIATION
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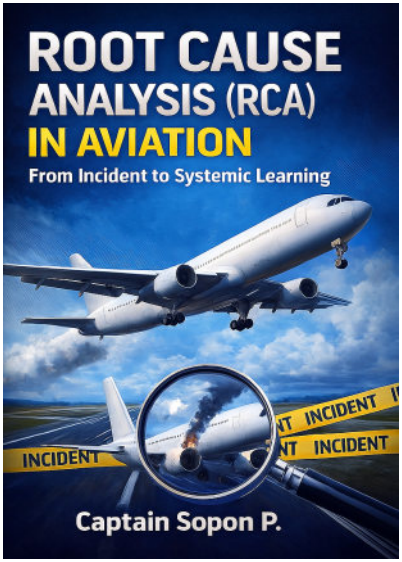
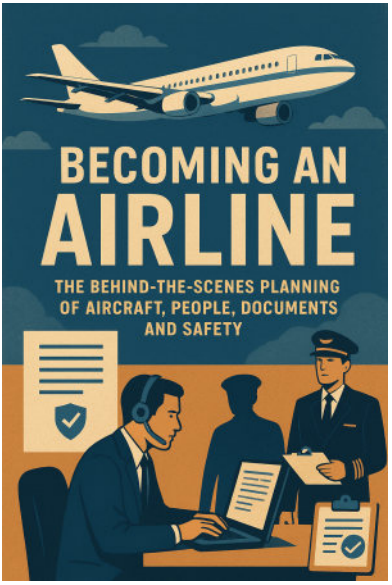

ROOT CAUSE
ANALYSIS (RCA)
IN AVIATION
From Incident to Systemic Learning
INCIDENT
INCIDENT
Captain Sopon P.


BECOMING AN
AIRLINE
THE BEHIND-THE-SCENES PLANNING
OF AIRCRAFT, PEOPLE, DOCUMENTS
AND SAFETY

PREFACE

The aviation industry is a system that is both complex and highly sensitive to even the smallest error. Safety management can no longer rely solely on personal experience or intuition. The Safety Management System (SMS) has therefore become essential as a systematic framework for managing safety, in accordance with ICAO Annex 19 – *Safety Management* (Edition 1, 2013) and the guidance provided in ICAO Doc 9859 – *Safety Management Manual (SMM)*.

This book aims to provide readers with a clear understanding of the theory, systemic concepts, and international best practices of SMS, covering the four main pillars:

Safety Policy & Objectives

Safety Risk Management

Safety Assurance

Safety Promotion

The content integrates academic foundations, practical frameworks, and real-world case studies from aviation service providers—both at the Air Operator level and the regulatory authority level (State Safety Programme – SSP). It also analyzes the impact of decision-making, risk management, and the development of a strong Safety Culture, including Just Culture, Reporting Culture, Learning Culture, and Informed Culture, enabling readers to apply

these principles to their own organizational context in a structured and practical manner.

In particular, understanding the Academic and Technical aspects of SMS equips practitioners to:

- Identify and analyze hazards and safety risks systematically
- Develop Safety Assurance processes to verify the effectiveness of safety measures
- Promote safety culture and organizational learning
- Coordinate strategically with regulators and stakeholders

This book therefore, serves not only as a practical guide for pilots, flight dispatchers, safety managers, and airline personnel, but also as a foundational reference for executives and anyone interested in safety management—applicable across industries, not limited only to aviation.

I hope this book helps deepen your understanding and becomes a valuable tool in developing aviation organizations that are safe, sustainable, and aligned with international standards.

Captain Sopon P.

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THE ORIGINS OF AVIATION SMS

Before Annex 19

The Aviation Safety Management System (SMS) is now recognized as a global standard framework required for all aviation organizations—airlines, regulators, airports, air navigation service providers, and all related sectors.

However, many may not realize that the SMS concept did not begin with ICAO Annex 19. Instead, it evolved over more than 70 years through various eras of change: technical advancements, human factors research, behavioral insights, major accidents, and modern safety principles.

This chapter explains *the evolution of aviation safety* from its early foundations to the formal establishment of Annex 19, helping readers understand why SMS has become the cornerstone of modern aviation.

The Technical Safety Era (1950s–1970s)

"Make the aircraft safer = Safety achieved"

From the 1950s to the 1970s, the industry focused heavily on jet engine development and new aircraft structures. Safety thinking during this period revolved around technology and engineering, rather than human or organizational factors, such as:

Structural strength

Engine performance

Maintenance procedures

Navigation systems and ground equipment

Accidents during this era were commonly attributed to simple causes like *"aircraft malfunction"* or *"pilot error"* without deeper investigation into Root Causes or organizational factors.

Therefore, this period is considered the technical era, where aviation safety was viewed primarily through an engineering lens.

The Human Factors & CRM Era (1970s–1990s)

“Human error is the primary cause of accidents.”

Between the 1970s and 1990s, aviation experienced several major accidents that marked a turning point:

Tenerife (1977) – the deadliest accident in aviation history

United Airlines 173 (1978) – crew focused on a landing gear issue and ignored fuel status

Eastern Air Lines 401 (1972) – occurred before CRM development

These events highlighted a critical truth:
Safety issues arise not only from technical failures, but primarily from human factors.

This era introduced major concepts such as:

Crew Resource Management (CRM)

LOFT (Line-Oriented Flight Training)

Standard Operating Procedures (SOPs)

For the first time, aviation began adopting a holistic view of safety, emphasizing communication, teamwork, and human behavior.

The Modern Safety Era / Swiss Cheese Model (1990s)

"Organizations must implement multiple layers of defense—not rely on individuals alone."

In the 1990s, James Reason introduced the Swiss Cheese Model, which became a core foundation of SMS.

Key principles include:

- Accidents occur due to multiple layers of system weaknesses
- Not caused by a single human error
- Organizations must manage risks proactively

The aviation community began to understand that true safety requires a system, not merely compliance with rules.
This shift in thinking laid the groundwork for the development of SMS in the years to follow.

ICAO Begins Developing Safety Management (2000–2005)

The Birth of SSP & SMS

In the early 2000s, the global aviation industry was expanding rapidly, while many accidents continued to result from increasing system complexity. ICAO responded by developing a new framework and published ICAO Doc 9859 – Safety Management Manual (SMM).
This was the first time the concepts of the State Safety Programme (SSP) and Safety Management System (SMS) were officially defined. ICAO stated that:

> States must implement SSP to manage safety at the national level.
>
> Air operators and service providers must implement SMS to manage safety at the organizational level.
>
> This marked the beginning of the shift toward system-based safety management.

SMS Requirements Spread Across Multiple Annexes (2006–2012)

During this period, ICAO introduced SMS requirements, but they were scattered across several Annexes, such as:

Annex 1 (Personnel Licensing)

Annex 6 (Aircraft Operations)

Annex 8 (Airworthiness)

Annex 11 (Air Traffic Services)

Annex 14 (Aerodromes)

This created recurring issues:

Inconsistent requirements

Confusion among operators about *"what exactly needs to be done"*

Greater difficulty for regulators to oversee compliance

The aviation industry began calling for a single consolidated Annex for all SMS requirements.

High-level Safety Conference 2010

At the 2010 High-Level Safety Conference (HLSC), ICAO made a landmark decision to consolidate all

SSP and SMS requirements into one Annex to eliminate duplication and create global consistency.

This decision initiated the development of Annex 19 – Safety Management.

Annex 19 Edition 1 (2013)

On 14 November 2013, ICAO officially released Annex 19 – Safety Management, Edition 1.

For the first time, the industry had an Annex dedicated purely to safety management, covering:

Safety Policy & Objectives

Risk Management

Safety Assurance

Safety Promotion

Most importantly, this edition consolidated SMS requirements from various Annexes, aligned SSP and SMS concepts, and emphasized organizational safety accountability—a major turning point toward modern global safety management systems.

Annex 19 Edition 2 (2016–2019)

Edition 2 introduced several significant topics, including:

- Safety Data & Safety Information Protection
- Safety Information Sharing
- Data-driven Safety Management
- Development of ALoSP (Acceptable Level of Safety Performance)

Annex 19 Edition 2 transformed SMS into a fully mature system—structurally, procedurally, and data-wise.

(As of now, ICAO has released Annex 13, 3rd Edition, November 2025.)

Why SMS Became Essential

The aviation industry is too complex to rely on luck or individual expertise.

Human error is a natural part of human performance.

Risks must be managed proactively, not only after events occur.

Decisions must be data-driven.

Safety must be everyone's responsibility within the organization.

Therefore, SMS is not just a document, and not the responsibility of a Safety Manager alone—
it is an organizational culture that everyone must build together.

THE EARLY ERA OF SAFETY MANAGEMENT

Technical Safety Era

The Technical Safety Era is considered the foundation of aviation safety management, with its primary focus on technology. This era spans the 1950s–1970s.

After World War II, commercial aviation entered its first global boom. Aviation technologies originally developed for military use were adapted for civil operations. Aircraft became more capable, faster, and able to carry more passengers. Air travel gradually became a normal part of modern society.

However, the rapid growth of aviation during the 1950s–1970s presented new safety challenges that needed to be addressed. During this period, regulators, airlines, and aircraft manufacturers worldwide believed that "technology and human skill" were the keys to safety. If an aircraft was well-

designed, pilots were rigorously trained, and infrastructure met proper standards, then safety would naturally follow.

Thus, this period became known as the Technical Safety Era—a time when safety was viewed primarily through the lens of machinery, equipment, and engineering standards. It provided the critical foundation that later enabled the industry to evolve into system-based safety management.

"Strong Aircraft = Safety" (Engineering-Centric Thinking)

The Beginning of Modern Aircraft Design

After World War II, aircraft design saw rapid advancements in materials, structural engineering, flight control systems, and engine technologies. Key commercial aircraft models, such as the Boeing 707 and Douglas DC-8, were developed during this time, marking the beginning of the Jet Age.

The dominant belief was:

"If the aircraft is well-designed,
accidents can be minimized."

This drove stricter airworthiness standards and more rigorous testing procedures.

Lessons from the Comet Accidents

One event that changed aviation history was the series of De Havilland Comet accidents in 1954, caused by metal fatigue resulting from the square-window design, which caused stress concentration at the corners.

These accidents led to major reforms in structural testing and fatigue analysis, forming the basis of modern aircraft design philosophies.

Maintenance: A Critical Layer of Defense

Establishing Clear Maintenance Standards

As aircraft became more complex, maintenance systems also had to become more robust. This era marked the beginning of Preventive Maintenance and the introduction of Mandatory Checks based on flight hours or cycles.

Regulatory Oversight

ICAO, FAA, and national aviation authorities began establishing systematic maintenance standards, including:

- Maintenance Schedules
- Inspection Intervals
- Strict adherence to AMM, SRM, and maintenance procedures

The prevailing belief was:

“If maintenance follows the manual,
the aircraft will not fail, and accidents will not occur.”

Although overly mechanical by modern standards, these steps were essential for the technical safety of that era.

Aviation Infrastructure: The Backbone of Risk Reduction

Airports and Navigation Systems Undergoing Major Upgrades

Countries invested heavily in airports, runway lighting, and air navigation systems (NAVAIDs), such as:

ILS (Instrument Landing System)

VOR

DME

ATC radar systems

These improvements enabled safer operations in poor weather, reduced CFIT accidents, and enhanced aircraft separation efficiency.

Early Air Traffic Control Systems

Radar-based Air Traffic Control (ATC) became widespread, enabling controllers to manage traffic

more safely and accurately. This was a major leap in technical safety.

Core Belief of the Era:

"Good Pilots + Good Aircraft = Safety."

This era lacked system-level thinking. Accidents were viewed as the result of:

Pilot error

Aircraft system failure

Technical malfunction

Accident investigations often concluded with "Human Error" as the final cause, without exploring deeper organizational factors such as:

Time pressure

Internal communication

Training adequacy

Operational policies

Today, we recognize these as critical components of safety.

Limitations of the Technical Safety Era

Despite establishing a strong technological foundation, the increasing complexity of aviation exposed several limitations of this “technology-centric” mindset:

Human Error was treated as the end of an investigation, not the starting point for improvement.

Lack of a data-driven safety culture.

Risk management was not yet systematic; tools like Hazard Identification or Risk Assessment were not used.

Human Factors and Organizational Factors were largely overlooked.

These limitations eventually led to the next major evolution in aviation safety—the Human Factors Era (1980s–1990s).

Conclusion

The Technical Safety Era laid the essential groundwork for global aviation safety: strong aircraft design, standardized maintenance, and improved infrastructure. Although it lacked consideration for human and organizational factors, it was the first major step toward the development of Human Factors, CRM, and was further developed into Safety Management System.

THE ERA OF HUMAN FACTORS & CRM

1970s-1990s

When operational errors were increasingly traced to people, *Human Error* became a central variable in aviation safety. The 1970s–1990s marked a major turning point in the evolution of aviation safety. It was a period when the global aviation industry accepted the reality that accidents were not caused solely by technical failures, but by *humans*—their decisions, communication, discipline in following standards, and the way crew members worked together.

In this chapter, we explore the key events that became turning points, the emerging Human Factors concepts of that era, and the birth of tools that transformed crew training—such as CRM, LOFT, and modern SOPs, which became the

foundation of Safety Management in later decades.

Major Accidents That Opened the World to Human Factors

Tenerife (1977)

The deadliest accident in aviation history—nearly 600 fatalities—occurred at Tenerife Airport, Spain, when two Boeing 747s from KLM and Pan Am collided on the runway in heavy fog.

Key Human Factors elements included:

- Ambiguous communication between pilots and air traffic control
- Time pressure leading the KLM captain to initiate takeoff without clearance
- Crew reluctance to challenge the captain (Authority Gradient)
- Misinterpretation of the phrase *"We are now at takeoff"* by both parties

This event became a global wake-up call that poor cockpit communication and inappropriate authority structures could lead to catastrophe.

Eastern Air Lines 401 (1972)

One of the clearest examples of the *Attention Trap*. EAL401, an L-1011, crashed into the Florida Everglades because the crew became preoccupied with troubleshooting a landing gear indicator light and completely neglected the aircraft's flight path.

Contributing factors:

- All three crew members focused on a minor issue
- No one monitored altitude
- Autopilot was disengaged unintentionally
- Poor task distribution

This case became fundamental to the concepts of *Task Sharing* and *Workload Management*.

United Airlines 173 (1978)

A widely studied accident in pilot training. A DC-8 crashed near Portland after the crew focused on a landing gear issue and failed to monitor rapidly decreasing fuel.