



# Maintenance SPIs:

## From Stand-Alone Indicators to Valid Inputs for Operational Safety

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Olten, Switzerland

SMS is supposed to do one simple thing: allocate resources against risk


*“...let me give you four simple audit questions that are really easy to answer if you have an effective SMS, and impossible to answer if you haven't:*

1. What is most likely to be the cause of your next accident or serious incident ?
2. How do you know that ?
3. What are you doing about it ?
4. Is it working ? “

- TAP MAINTENANCE & ENGINEERING
1. We need to manage Safety, *but...*
  2. ...we cannot manage what we cannot measure, *so...*
  3. ...we need indicators (**SPIs**) to measure the system's performance.

PRESIDENT'S MESSAGE

## SMS Reconsidered



I don't write about safety management systems (SMSs) much because everybody else seems to be getting "burned out" on the subject. Back when the international standards for SMS were signed out at ICAO, we all knew we were going to launch a new industry full of consultants. We also knew that all these consultants couldn't possibly know much about the subject and would be forced to regurgitate the ICAO guidance material that was being put out. It was obvious that the process people dealing with ISO and QMS would embrace the concept of SMS and treat it as another process exercise. It was also clear that regulators were going to have a very hard time evaluating an SMS and would be forced to reduce the concept to a series of checklists.

All of those predictions have come true, so it is time to take an honest look at where we are and where we go from here. The ICAO guidance was built around the "four pillars," so now everybody has an SMS with four pillars. And of course, now every regulator has a checklist that counts the pillars. We all have policies, posters, forms, processes and meetings. This is all really very comforting to people who have never grasped the concept of risk management. They are reassured by the fact that all they really have to do is fill out the right form and show up at the weekly meeting. Many well-meaning operators have worked themselves into a position where they are spending lots of time and money, but are not necessarily getting the intended results. Many managers have figured this out, and thankfully a few of them have come to us. We are learning a lot from these operators and, as a result, the Foundation is now trying to drive SMS back to its core principles.

Before SMS was made complex by the consultants and process people, it was meant to do one simple thing — allocate resources against risk. I would suggest that we measure that instead of counting our meetings and posters. Please put away the checklist and try this approach instead. Go back to last year's budget, and see if you can find one single instance where information from your SMS caused you to spend money differently than you had planned. If you cannot find an example of that in your operation, you either have an extraordinarily brilliant budgeting process, or an SMS that is not delivering. I would bet on the latter.

If you want to go deeper, let me give you four simple audit questions that are really easy to answer if you have an effective SMS, and impossible to answer if you don't:

1. What is most likely to be the cause of your next accident or serious incident?
2. How do you know that?
3. What are you doing about it?
4. Is it working?

The easiest way to make people do silly things is to measure them against mindless objectives. I think SMS was always a serious and practical idea. It is supposed to change the way you manage risk. Find a way to measure those changes, and you will find a way to drive an effective implementation.

*William R. Voss*

William R. Voss  
President and CEO  
Flight Safety Foundation

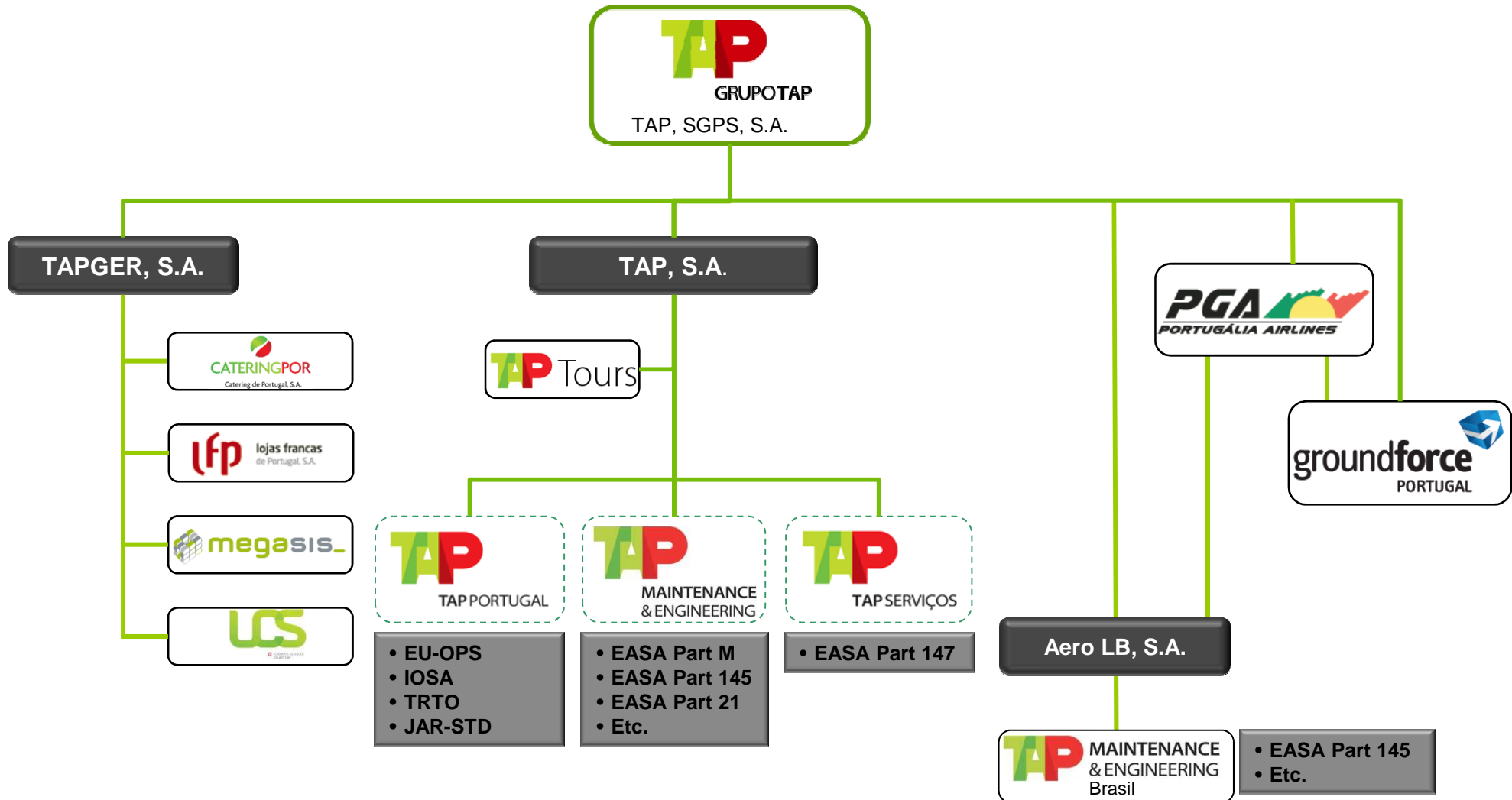
Source: Flight Safety Foundation, Aero Safety World, May 2012

# Summary Overview

- TAP M&E: overview and SMS roadmap
- SMS Rules: recap and update
- SMS Connections in the MRO World
- From a Maintenance Threat to an Unrecoverable End State
- What makes a meaningful Maintenance SPI ?
- How to choose Maintenance SPIs ?



# TAP M&E Overview



Source: TAP Portugal



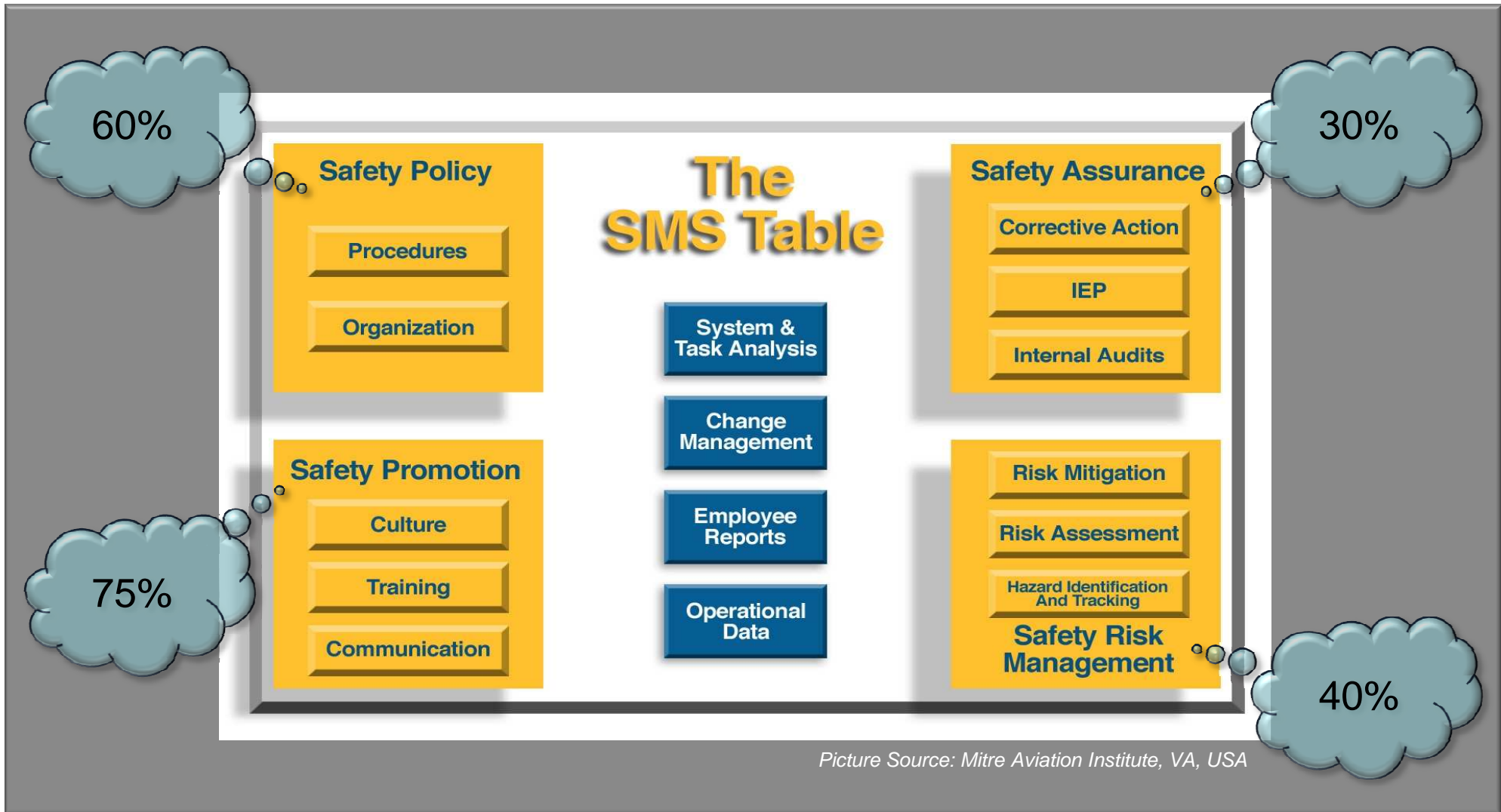
- Part M, Part 145, Part 147 and Part 21
  - ICAO Doc. 9859 Ed. 2
  - Stand-alone policies and procedures
  - Safety requirements from Customers
  - Extension to Part 147 planned for 2013
- TAP M&E: part of TAP Portugal
  - IOSA requirements
  - Air Operations Implementing Rule (EC) 965/2012, ORO.GEN.200
  - EASp requirements
- Waiting for
  - Portugal SSP requirements and targets
  - ICAO Doc. 9859 Ed. 3
  - ICAO Annex 19



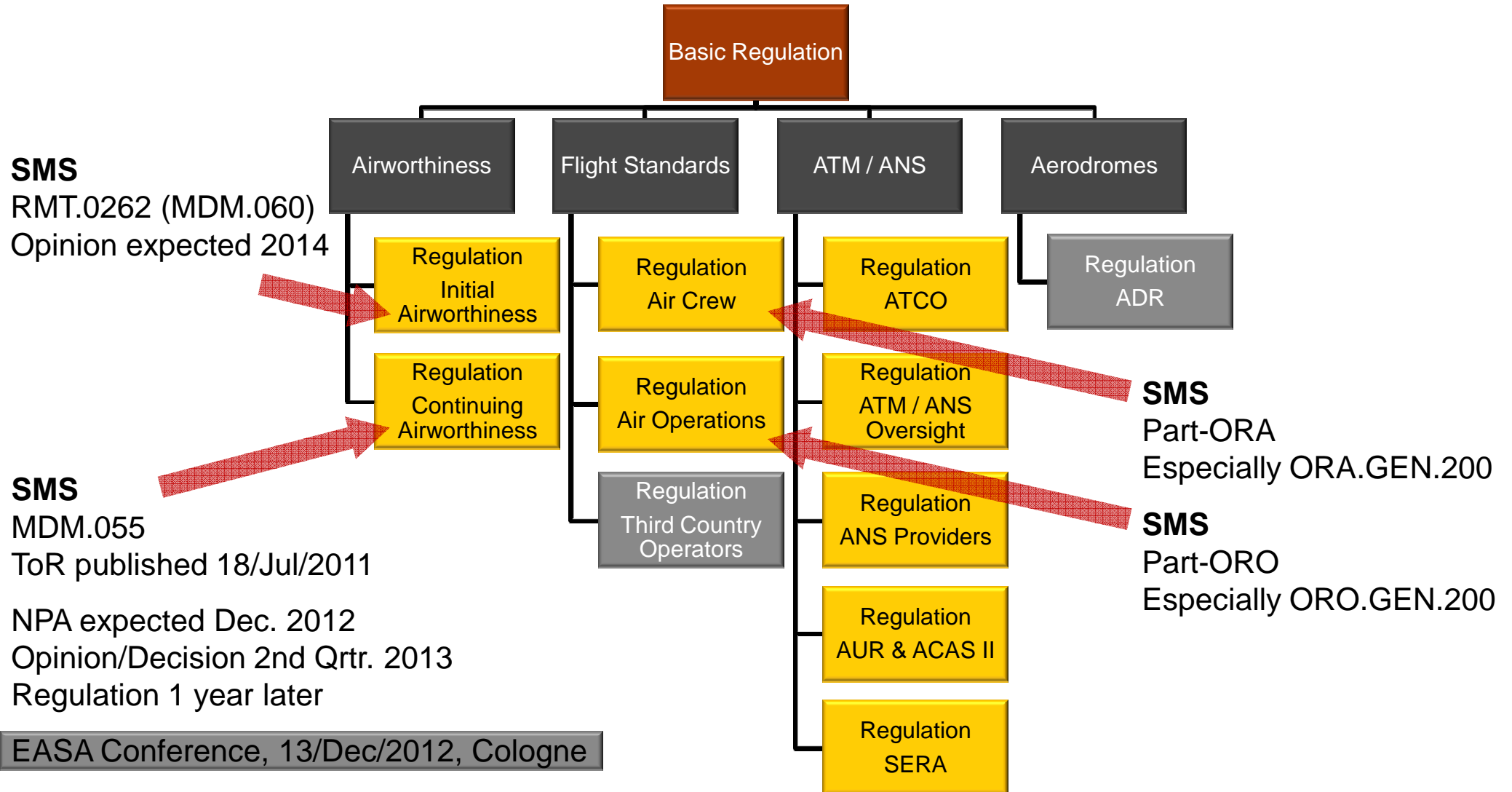
# SMS Roadmap at TAP M&E



# SMS Implementation Status in TAP M&E (Nov. 2012)

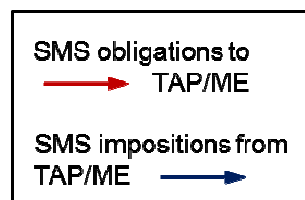
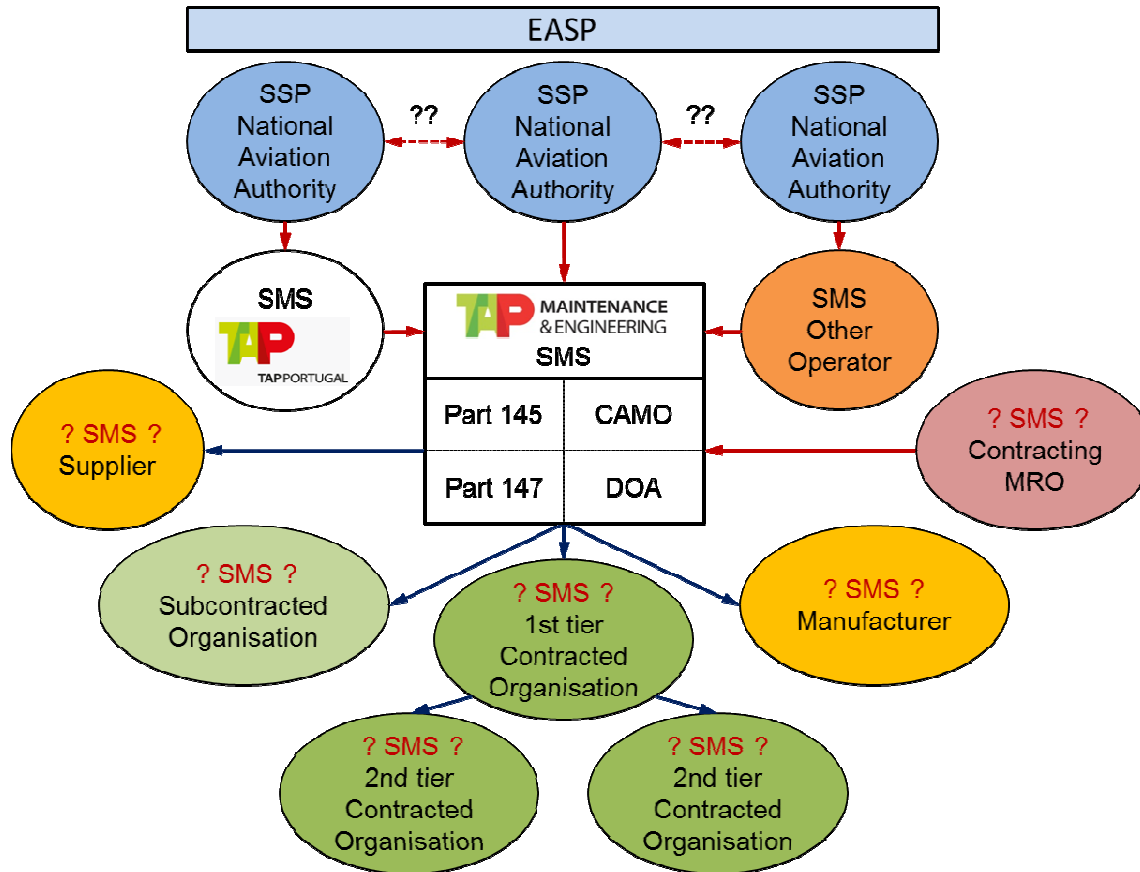


# SMS in EU Rules





# SMS Connections in the MRO World



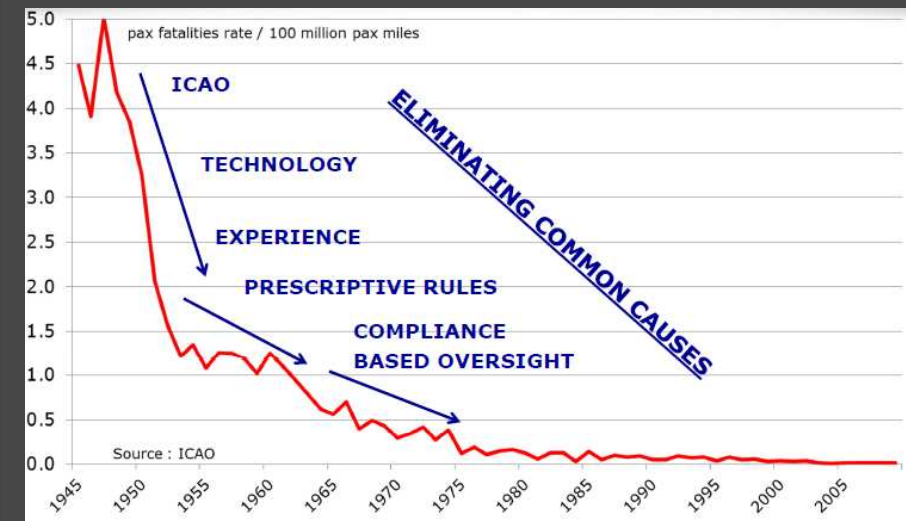
Source: TAP Maintenance & Engineering

- A Mx organization links its SMS **upstream** (NAA and operators) and **downstream** (suppliers and contracted organizations)
- When contracted organizations contract further downstream, the Mx organization SMS should **proceed** downstream
- Problems with different:
  - Cultures ? Customers ?
  - Suppliers ? Organizations ?

# Fatalities Rate must be reduced

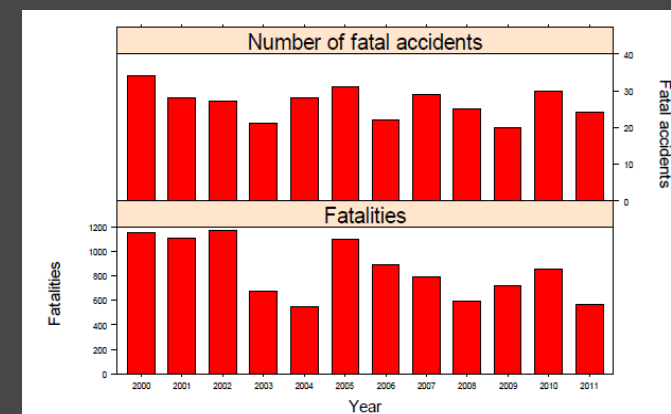
- Accidents today are **rare** events and their causes are **multiple** and **random**
- Fatal accidents and fatalities rate have dropped to a **very low** value
- Further drop is a **challenge**
- We cure the causes of these “random” accidents; but, if nothing had been done, probably that accident would **not repeat** itself anyway

How to reduce even more ?



Source: Trevor Woods, EASA

Almost flat trend !



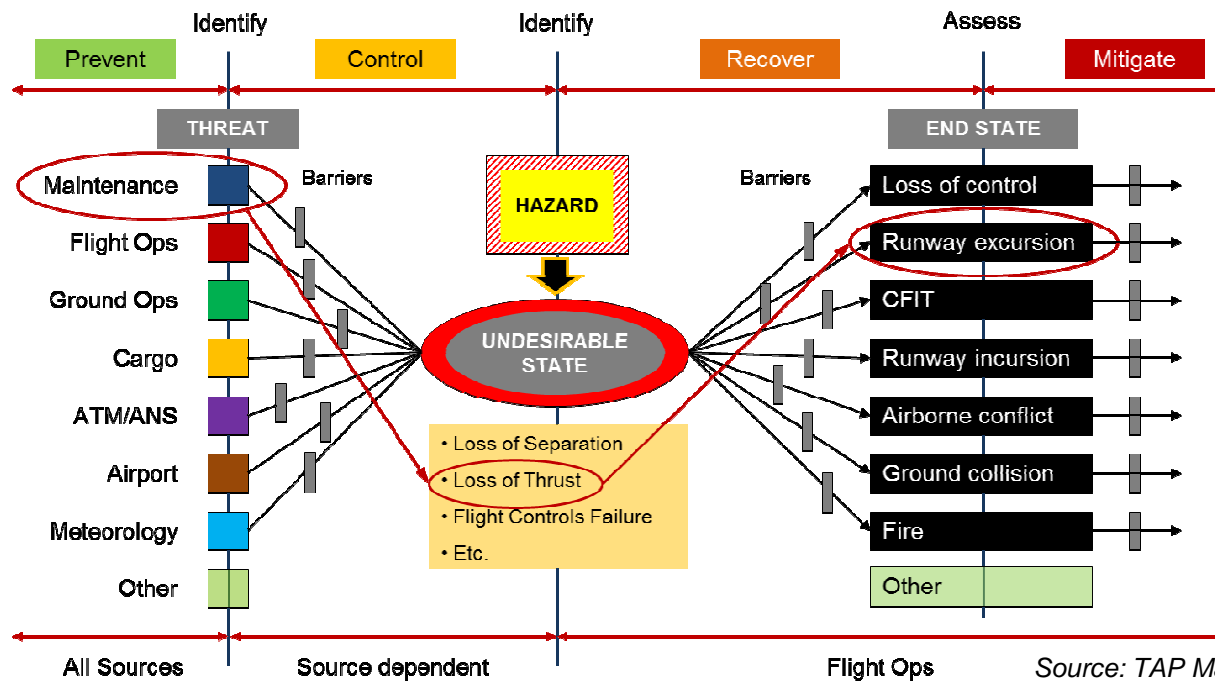
Source: Bem Alcott, CAA-UK

# When Maintenance is a Threat

40% of maintenance related accidents involved landing gear malfunctions

- IATA Safety Report 2011:

- Maintenance issues were the primary cause in 9% of the accidents
- Aircraft technical faults and maintenance issues was the 2<sup>nd</sup> most frequent category of contributing factors to accidents

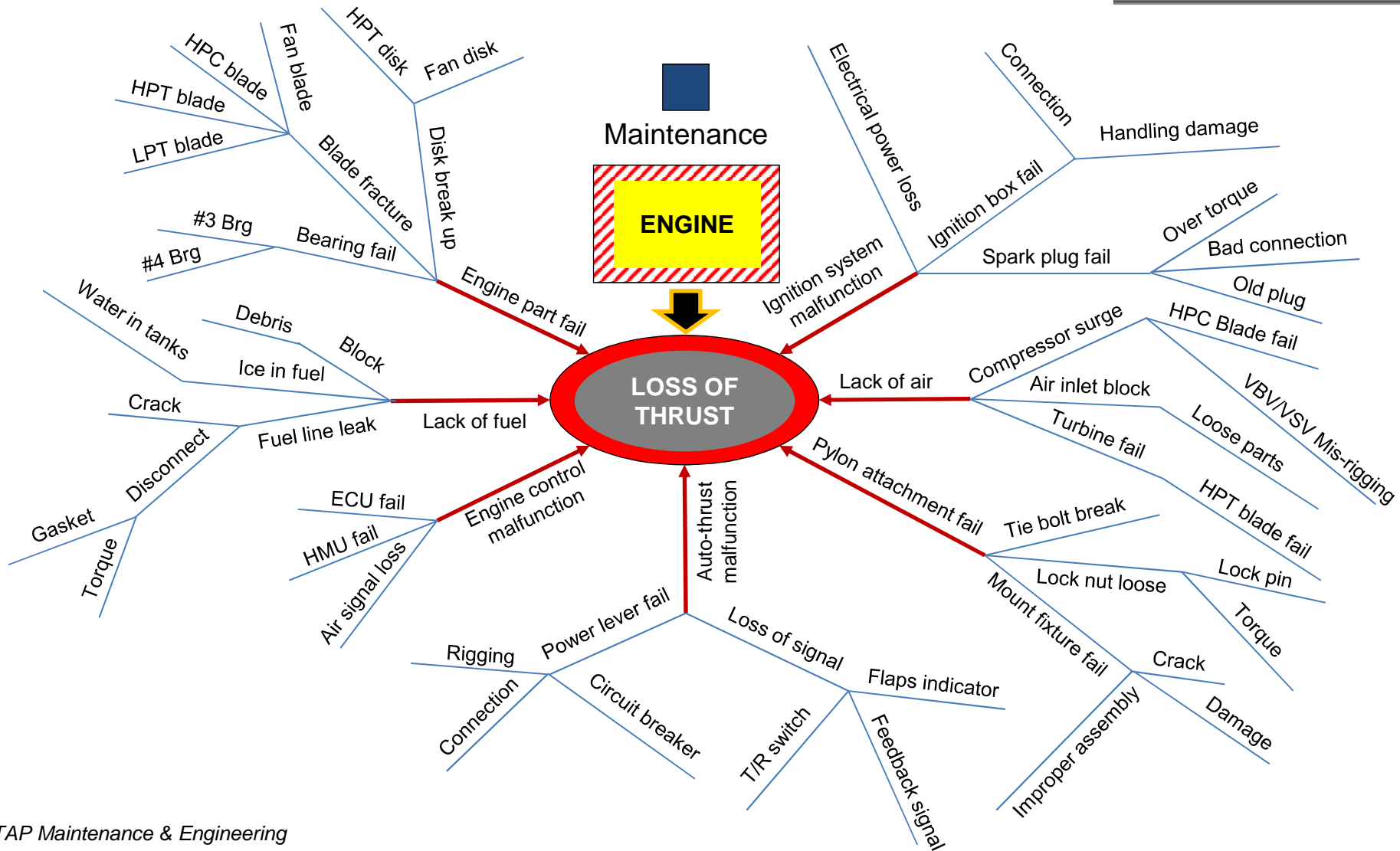


Note: example, not to be used in real work

Source: TAP Maintenance & Engineering

# Maintenance Fault Tree (example)

Note: example, not to be used in real work



Source: TAP Maintenance & Engineering





ICAO Doc. 9859 Ed. 2

## 8.2 Safety performance monitoring and measurement

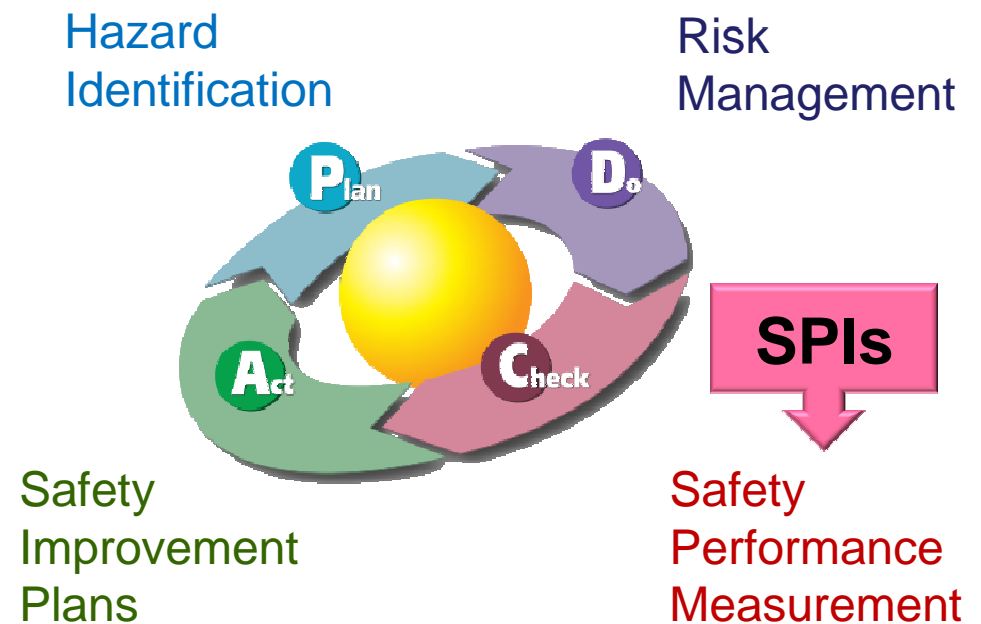
8.2.1 A service provider shall, as part of the SMS safety assurance activities, develop and maintain the necessary means to verify the safety **performance** of the organization in reference to the safety performance **indicators** and safety performance **targets** of the SMS, and to validate the **effectiveness** of safety risk controls.

# Deming Cycle in TAP M&E SMS

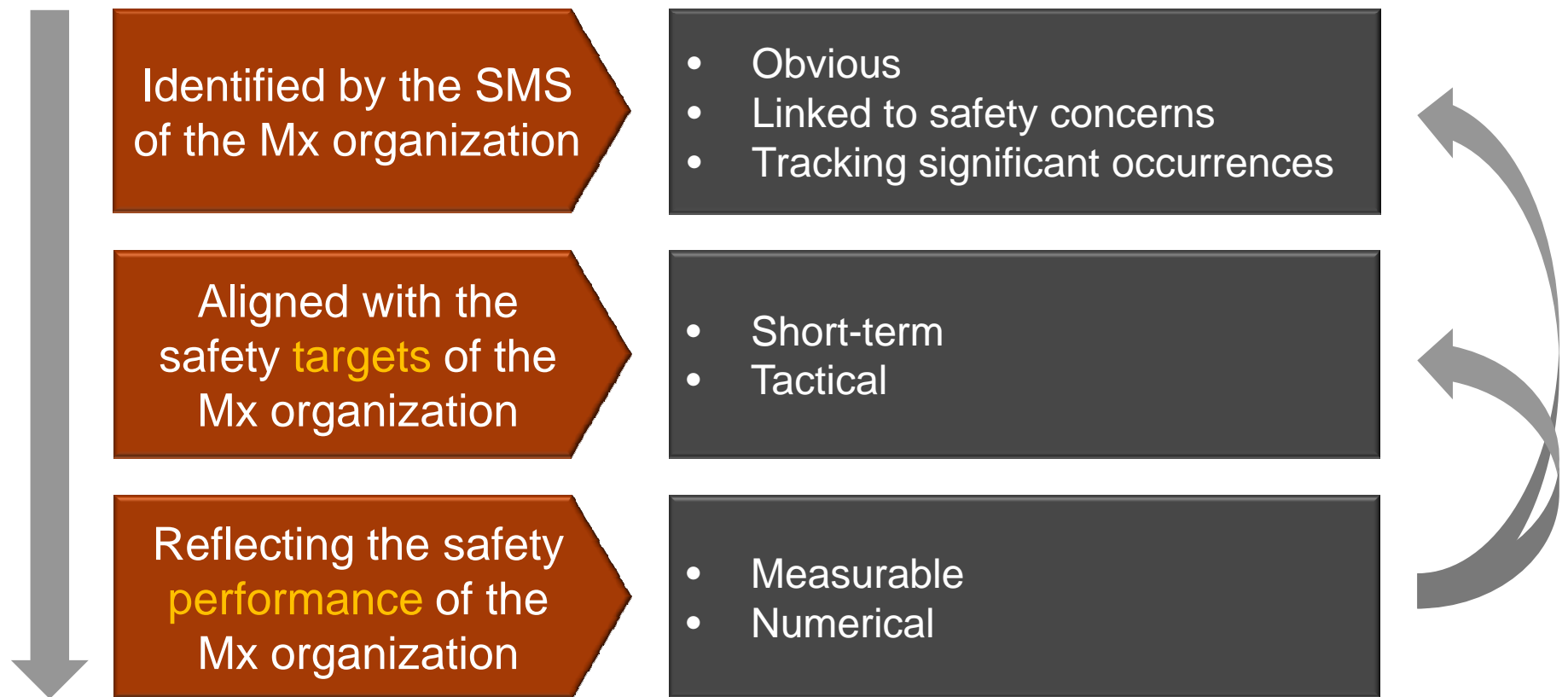
- TAP M&E is also certified per ISO 9001 and EN 9110, which provides broad QMS **experience** in:

- Applying the Deming Cycle
- Mapping Mx processes
- Using QMS KPIs
- Setting targets and alerts
- Doing management reviews
- Setting action plans
- Continuous improvement

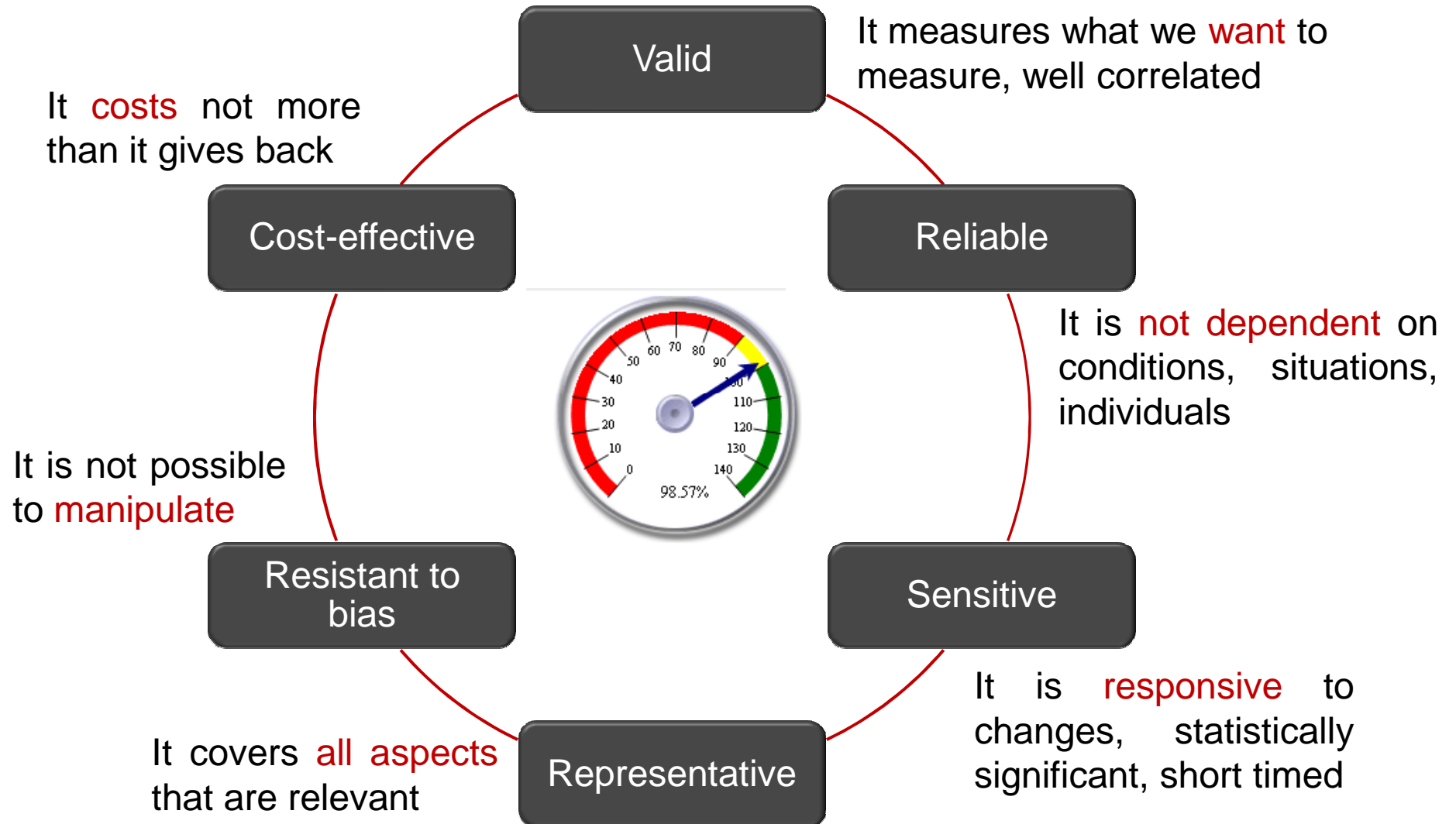
- The **same approach** has been followed during the development of SMS in TAP M&E



- MxSPIs are **data** based expressions of the **frequency** (**ratios**) of occurrence of some events, incidents or reports



# Validating useful MxSPIs



- MxSPIs in development at TAP M&E are classified in the following **3 categories**, depending on their strategic scope:

## Mx organization

- Monitor Safety Objectives and Safety Targets
- Monitor Risk level
- Control impact on Survivability, Competitiveness and Corporate Image
- Control impact on Credit Rating and Insurance Cost
- Assess contingency preparedness and management of change
- Control suppliers, contracted and subcontracted organizations





## SSP (connected to End State analysis)

- Assure regulatory compliance
- Satisfy operator's safety goals
- Assure safety for the public domain, community, EU aviation image



## Customer's safety objectives

- Assure contractual safety compliance
- Satisfy customer's safety goals
- Provide competitive edge
- Enable continuous contract monitoring
- Expand Mx organization market share (differentiation)



- In relation to each MxSPI, the following questions must be answered:

1. Which risk control (barrier) is **weaker** and needs to be **reinforced** ?
2. What specifically is the **issue** ? What does that weakness **relate** to ?
3. What is the most appropriate **metric** for the indicator ?
4. **How** will the data be **collected**, and **who** will do it ?
5. How will the **results** be monitored and **corrective** actions identified ?
6. What **target** would we aim for ?
7. What **alert level** would we set up ?

# Sources of data for MxSPIs

## Reactive

analysis of **past** outcomes and events

- ASR, MOR, SAFA
- Incident and Accident Reports
- Hazards identified
- Internal Safety Investigations

## Proactive

analysis of **present** or real time situations

- ASR
- Voluntary Safety Reports
- Safety Surveys and Safety Audits
- Safety Studies and Safety Improvement Plans (SIP)
- Trend analysis

## Predictive

data gathering to identify possible negative **future** outcomes or events

- FDM, Continuous monitoring of Mx processes
- Statistical and probability analysis

# Facts about MxSPIs

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- There is no **single** MxSPI appropriate to **all** Mx organizations
- Chosen MxSPIs should correlate to **relevant** safety objectives
- It is difficult to choose **good (and few)** MxSPIs
- It's easy to end up with a **lot** of indicators
- But, in reality, they may **fail** to give accurate trend information
- **Registered** in the safety library with relevant information

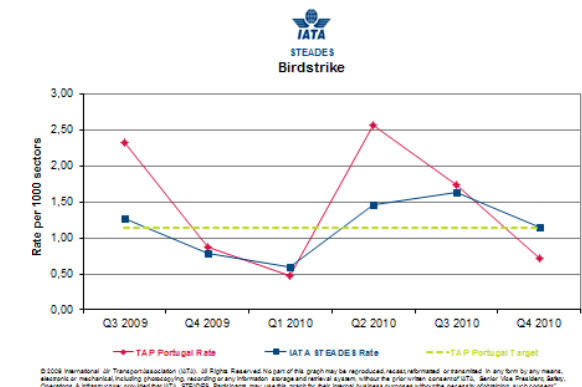
# MxSPIs: based on TAP Portugal End State data

End State (ES)	Undesirable State (US)	MxSPI
Runway Excursion (EASp)	Unstable Approach	Mass and Balance Occurrence
	EGPWS/GPWS Windshear	N/A
	Rejected Take-Off	Engine Loss of Power
	Hard/Heavy Landing	Brakes Failure
Mid-Air Collision (EASp)	Call Sign Confusion	COM Technical Incident
	Altitude Deviation	NAV Technical Incident
	TCAS RA	TCAS Technical Incident
Controlled Flight Into Terrain (CFIT) (EASp)	EGPWS/GPWS Warning	N/A
	Altitude Deviation	NAV Technical Incident
Loss of Control in Flight (EASp)	Alpha Protection	Airspeed Indication Failure
	Severe Turbulence	N/A
Undershoot	Alpha Protection	Engine Loss of Power
	EGPWS/GPWS Glide Slope	N/A
Runway Collision	Call Sign Confusion	COM Technical Incident
	Runway/Taxiway Incursion	Brakes Failure
In Flight Damage/Injuries	Bird Strike	N/A
	Severe Turbulence	N/A
Ground Collision/Damage (EASp)	Call Sign Confusion	COM Technical Incident
Hard Landing with Aircraft Damage	Hard/Heavy Landing	Engine Loss of Power
Tail Strike	Pitch High at LDG/TO	Mass and Balance Occurrence

MxSPIs track the most **significant** contributing factors for each US

Correlation between some US and Mx activities is **weak**, not enough data (N/A for the moment)

We try to have at least **one** MxSPI for **each** item under EASp





# MxSPIs: based on Star Alliance WG

TAP SPI MAINTENANCE			SPI (Safety Performance Indicator)			
RESPONSIBLE DEPARTMENT / SYSTEM			MNT (MAINTENANCE & ENGINEERING)	METRICS	ALERT	TARGET
ME	EG/FP	COSMOS	AIRCRAFT DEFECT RATE	(N° of A/C defects logged by Flt Crew) / XXXX Flight Hours		
ME	MA/MO/TS	COSMOS/HIL's	OPEN MEL, NARROWBODY	Average open MEL items (NB) / day		
ME	MA/MO/TS	COSMOS/HIL's	OPEN MEL, WIDEBODY	Average open MEL items (WB) / day		
ME	MA/MO/TS	COSMOS/HIL's	MEL, ONE-TIME EXTENSION	N° of MEL receiving a one-time extension		
ME	QL/EG/AE	TSO	AD EXCEEDANCE	N° of Airworthiness Directives exceedances		
ME	QL/EG/AE	TSO	MR EXCEEDANCE	N° of MR exceedances		
ME	N/A	N/A	MP EXEMPTIONS, NARROW BODY	N° of Maintenance Program exemptions on NB A/C		
ME	N/A	N/A	MP EXEMPTIONS, WIDE BODY	N° of Maintenance Program exemptions on WB A/C		
ME	LG/GR	Aries	CANNIBALIZATION	N° of Cannibalizations		
ME	EG/FP	COSMOS	ENGINE	N° of Engine related failures Incidents / 1000 cycles		
ME	EG/FP	COSMOS	LANDING GEAR	N° of Gear related failures Incidents / 1000 cycles		
ME	EG/FP	COSMOS	FLIGHT CONTROLS	N° of Flight control Incidents / 1000 cycles		
ME	EG/FP	COSMOS	ELETRICAL	N° of Electric related Incidents / 1000 cycles		
ME	EG/FP	COSMOS	FUEL	N° of Fuel system Incidents / 1000 cycles		
ME	EG/FP	COSMOS	FIRE / SMOKE	N° of Fire or smoke Incidents / 1000 cycles		
ME	EG/FP	COSMOS	DUE MAINT. TECH. BREAKDOWN	(N° of Events / N° of Flight Legs) x 100		
ME	EG/FP	COSMOS	ERROR RATE IN MAINTENANCE	(N° of Errors / N° of tasks) x 100		

- Most MxSPIs track already **known** hazards and threats
- Some MxSPIs result from **predictive** analysis of possible failure scenarios
- Due to lack of data, in some cases positive correlation with End States is **weak**

# MxSPIs: based on TAP M&E Safety Objectives

SPI	CALCULATION METHOD	SOURCE	TARGET	REVISION
1) N° Accidents	N° Accidents / Year	EG/FP		Annual
2) N° TIR's	N° Open TIRs /Year/Flight Hours	EG/FP		Annual
2a) N° ATO	N° Aborted Take Off/Year/TAP Fleet Departures	EG/FP		Annual
2b) N° FR	N° Flight Returns/Year/Flight Hours	EG/FP		Annual
2c) N° DVF	N° Diverted Flights/Year/Flight Hours	EG/FP		Annual
2d) N° FC	N° Flight Cancelations/Year/Departures	EG/FP		Annual
2e) N° FOD	N° Foreign Object Damage (Bird Strikes)/Year	EG/FP		Annual
2f) N° IFSD	N° In Flight Shut Downs/Year/Flight Hours	EG/FP		Annual
3) N° OTH	N° Overweighth Landings/Year/Flight Hours	EG/FP		Annual
4) N° RR	N° Ramp Returns/Year/Departures	EG/FP		Annual
5) N° Unschedule	N° Unscheduled Removals/Year/Flight Hours	EG/FP		Annual
5a) N° Engines	N° Unscheduled Engine Removals	EG/FP		Quarterly
5b) N° Units	N° Unscheduled Components Removals	EG/FP		Quarterly
6) N° Incidents	N° Incidents in Maintenance Actions/Year	All		Annual
6a) N° Emergency Equipments	N° Faults in Emergency Equipments during Scheduled Tests/Year	MA/EQ		Annual
6b) N° Unwanted Damages to A/C	N° Unwanted Damages to A/C caused during Maintenance Actions/Year	MA/EQ		Annual
7) Risk Index	Average Risk Level for All Occurrences	ME/SO		Monthly
8) N° Reports	N° Reports/Year	ME/SO		Annual
9) N° AD Irregularities	N° AD with Irregularities/year	QL/EG/AE		Annual
10) N° Claims	N° Claims/Year	ME/MV		Annual
11) N° Claims to Service Providers	N° Claims to Service Providers/Year	ME/MV		Annual
12) N° Customer Claims	N° Customer Claims/Year	ME/MV		Annual

- Some MxSPIs are similar to Star Alliance WG, but the majority reflects strategic objectives of TAP M&E and the application of the Safety Policy

# MxSPIs: based on other requests / recommendations

Customers	Airbus
Inspection and maintenance backlog	Number of deferred items / month
Failures at inspection and testing	Average time and trends to close a MEL item
Training carried out	Number of requested extension time for MEL items / month
Operator years of experience	Number of failures for each ATA / flight hour
Process safety critical roles filled	% of repaired equipments with No Fault Found
Process safety management system audit compliance	Found (NFF) per repaired equipment
Overdue audit actions	Etc.
Etc.	

- It is not obvious that different Customers would have **similar** safety requirements (different countries, safety systems, economic and social constraints, etc.)
- Should an MRO have a **fixed set** of MxSPIs and provide a standard safety performance package for its works, independent of each Customer's policy ?
- Or should MROs have the **flexibility** to adapt their MxSPIs to specific safety requirements from different Customers ?

- Without enough **data**, it is not possible to have **good** SPIs
- However, **too much** data may **clutter** important safety **threats**
- The typical operator produces **huge** amounts of safety data (thousands of flights/year)
- For MROs it is more **difficult** and in small MROs even **worse**
  - less data
  - (ex.) a dozen occurrences, or so (MOR)
  - (ex.) a hundred reports per year, or so (by voluntary incident reporting)
- How to analyse **trends** in MRO without **enough** data ?
- Besides, many MRO reports do not translate into **significant** safety data (social, SST, administrative, environment, etc.)

- Performance measurement: essential to manage Safety
- Safety continuous improvement: needs reliable SPIs
- Not enough data → weak correlation
- Too much data → information clutter
- Fewer accidents → multiple / random causes
- Difficult to connect End States with MRO Contributing Factors
- MROs need to comply with State and Customers objectives
- MROs need also to track their own Strategic indicators
- Flexible indicators ?? vs. “one-size-fits-all” package ??

# The Future of SMS at TAP M&E



So far so good...

Let's keep it simple...

Still work ahead...



Thanks for your attention



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