ATM safety management: reactive and proactive indicators
Forecasting and monitoring ATM overall safety performance
WHERE DO WE STARTED (*i know you know it*)

EUROCONTROL is developing a **harmonised framework for the safety regulation of ATM**, for implementation by States. Its core is represented by ESARRs.

In Italy ENAV s.p.a. follows ESARRs. We analysed the safety events’ reported data collected from 2008.
WHERE DO WE STARTED (also these things...)

REASON SWISS CHEESE MODEL

ICEBERG OF SAFETY

THESE MODELS are
• Clear
• Evocative
• Easy to understand

BUT ... HOW TO APPLY THEM FOR EVALUATING THE GLOBAL SAFETY LEVELS OF ATM?
WHERE WE WOULD LIKE TO GO (now you know also it!)

ESARRs’ reporting structure + ENAV s.p.a. reporting database permit the construction of SMARTER and HOLISTIC INDICATORS

ATM related safety occurrences

- Accidents
- Incidents
- ATM - specific occurrences
- Mid Air Collision
- CFIT Collision
- Near Collision
- Potential for collision or near collision
- Inability to provide ATMS
- Failure of ATM service

GLOBAL ATM SAFETY SITUATION

REPORTING → DATABASE → NUMBER OF OCCURRENCES → STANDARD INDICATORS → APF INDICATORS

ATM safety management: reactive and proactive indicators
**REACTIVE INDICATORS** *(stepwise safety 1/2)*

**AEROSPACE PERFORMANCE FACTOR**
- Determine the organizational factors that influence performance *(ESARR 4)*
- Determine the information available on those factors *(Literature analysis)*
- Organize the influencing factors *(Accidents/Incidents/Issues)*
- Determine the relative importance of the factors *(AHP)*
- Display information for decision makers *(Safety Index)*

**ANALYTIC HIERARCHY PROCESS**
- Structure the problem *(Mind Map)*
- Construct a set of pairwise comparison matrices *(Subject matter experts’ evaluations)*
- Use the comparison to obtain the weights *(FAA: Robust Model)*

\[
\text{Event}_i \text{ APF Safety Index} = \frac{\text{Event}_i \text{ annual count}}{\text{TOTAL traffic count}} \times \text{Event}_i \text{ AHP weight}
\]

\[
\text{APF Safety Index}_j = \sum_{i=1}^{n} \text{Event}_i \text{ APF Safety Index}
\]
We have built 4 Indexes:

**AIRPORT**

SAFETY INDEX 1 APT

SAFETY INDEX 2 (ATM) APT

**SAFETY INDEX 1 APT**

Accidents (0,5)

Events (0,35)

Issues (0,15)

Near collision (0,752)

• INSA + INSN
• NC/FP
• RINA + RINN (AAY)
• SMI
• TWI (AAY)

Potential for collision or near collision (0,107)

• DATC / DATS
• LBS
• PSMI
• REX
• RINA+RINN (AAN)
• TWI (AAN)
• UPA

System failure (0,142)

• AIS
• ASP
• MET

**EN-ROUTE**

SAFETY INDEX 1 ENR

SAFETY INDEX 2 (ATM) ENR

Procedural (0,375)

• ATO
• MA
• EME
• PRI

External (0,176)

• BS
• LASER
• TRA
• WS
• OTH

Communication (0,448)

• SCS
• CSC
• PLCC

**REACTIVE INDICATORS (stepwise safety 2/2)**
We obtained **REACTIVE safety analysis** based on:

- ENAV s.p.a. safety database
- APF Safety Indexes

We aim to obtain **PRO-ACTIVE safety analysis**
PRO-ACTIVE SAFETY: 3 strategies (*all 3 roads lead to Rome safety*)

DATABASE

- Historic Fit
- Forecast
- Causal Fit

- Probability Distribution Fitting
- Time Series Analysis
- Mixture Models

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HISTORIC FIT (as things did, things will do)

- Try to fit various probability distribution to data
- Select, for each event type the **BEST** distribution

The **BEST one** according to the AIC rank that considers the principle of parsimony and has a good accuracy/ease ratio in case of many input data

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<td>dic 10</td>
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**DISTRIBUTION FIT FOR EACH EVENT TYPE**

**APF PROCESS**

**TRA / Safety Inde...**
TIME SERIES ANALYSIS (forecast with maths)

Based on Yule’s and Box and Jenkins’ theories a linear filter has been built for each event type, according to its characteristics (AR, MA, ARMA, ARIMA, etc.)

Analyzing (transformation, trends, seasonality):

- **White noise** \( a_t \) → **LINEAR FILTER** \( \Psi(\beta) \) → **z_t**

**Event Type**

**Historic Series**

**APF Process**

**Time Series Analysis for Each Event Type**

**Correlation Coefficient** -0.0563

**Function Type** MA1

**R^2** 0.0032

**Mean, \( \mu \)** 0.0386

**Trend** NO

**Volatility Parameter, \( \sigma \)** 0.0163

**Causes**
- **Human Factor** 5%
- **Noise** 5.00%
- **Equipment** 85%
- **Procedures** 10%

**Effect**
- **Human Factor** 4.75%
- **Equipment** 80.75%
- **Procedures** 9.50%

**IDEAL CAUSAL ANALYSIS**

**OPTIMIZED CAUSAL ANALYSIS**

**SAFETY INDEX 1 ENR TRA HISTORIC/CAUSAL FIT COMPARISON**

The other parameters are listed in the following figure. For their definition see § 4.6.1.

**Event Name**

**Event Category**

**Pareto Rank**

**HISTORIC DATA**

**TIME SERIES ANALYSIS**

The other parameters are listed in the following figure. For their definition see § 4.6.1.
CAUSAL FIT (roots are fruits 1/2)

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CAUSAL FIT *(roots are fruits 2/2)*

### Causal Factor Distribution

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<th>Causes</th>
<th>Causal Factor</th>
<th>Distribution mean</th>
<th>Distribution effect</th>
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<td>Noise</td>
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<td>12,9685</td>
<td>0,6484</td>
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<td>Human Factor</td>
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<td>8,7573</td>
<td>0,4159</td>
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<td>Equipment</td>
<td>0,8075</td>
<td>10,2097</td>
<td>8,2444</td>
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<tr>
<td>Procedures</td>
<td>0,095</td>
<td>10,2097</td>
<td>0,9699</td>
</tr>
</tbody>
</table>

**Causal Analysis for Each Event Type Compared with Historic Data**

**Event Type**
- Historic Series

**APF Process**

**TRA Safety Index 1 ENR Contribution**

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GLOBAL RESULTS (the best is yet to come)
GLOBAL RESULTS *(a view from afar...)*

SAFETY INDEXES LIKE PAST PERFORMANCE EVALUATORS

Individuate criticalities by X-R analysis based on Shewart control charts

**WARNING**

THIS SIGN IS ONLY A DISTRACTION
GLOBAL RESULTS *(a bit closer...)*

**CAUSAL ANALYSIS vs REAL DATA**

3 methodologies to FORECAST SAFETY INDEXES and thus, SAFETY LEVELS

Which one is the *best* one?
GLOBAL RESULTS *(let’s recap)*

- **HISTORIC FIT**
  - Good to summarize historic behavior
  - Not enough accurate to forecast data

- **TIME SERIES**
  - Satisfactory for forecast sample short paths
  - Difficult mathematical implementation

- **CAUSAL FIT**
  - Based on logic and causal analysis
  - Good for forecasting and monitoring
  - Easy implementation

### CAUSAL FIT

- **A priori: Warning device**
  - Comparison between obtained values and desired safety values

- **A posteriori: Causal Sensor**
  - Analyze the events over the upper limits (unsafe)
    - Evaluate the causes and take action
  - Analyze the events beneath the lower limits (safe)
    - Safety’s enhancement
    - Reduced reports
    - Filter our database

CAUSAL FIT under development with application to ENAV s.p.a. ATC:

- Weighting procedure must be enhanced
- Just Culture implementation to enhance reporting data quality
- Yet possible the application to specific APT/ROUTE
THE LAST SLIDE (you can clap your hands now!!!)

THANK YOU

KEEP IN TOUCH

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