



SAPIENZA
UNIVERSITÀ DI ROMA

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**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.



ESARRs

ESARR 1

Safety Oversight in ATM

ESARR 2

Reporting and Assessment of Safety Occurrences in ATM.

ESARR 3

Use of Safety Management System by ATM Service Providers.

ESARR 4

Risk Assessment and Mitigation in ATM.

ESARR 5

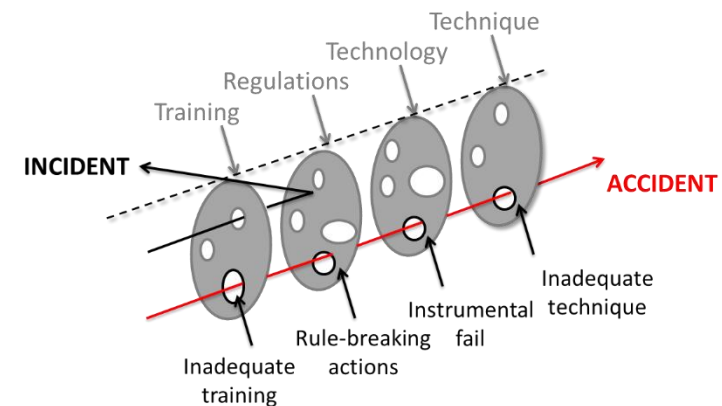
ATM Services' Personnel

ESARR 6

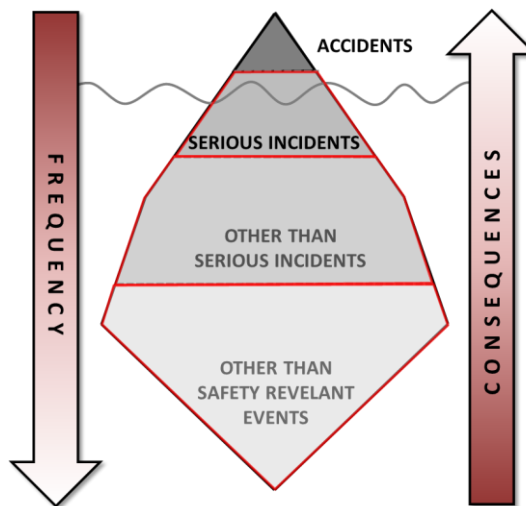
Software in ATM Systems

WHERE DO WE STARTED *(also these things...)*

REASON SWISS CHEESE MODEL



ICEBERG OF SAFETY



THESE MODELS are

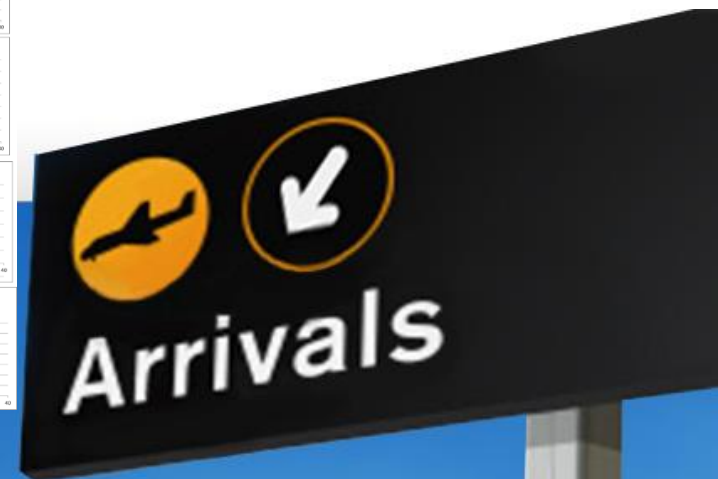
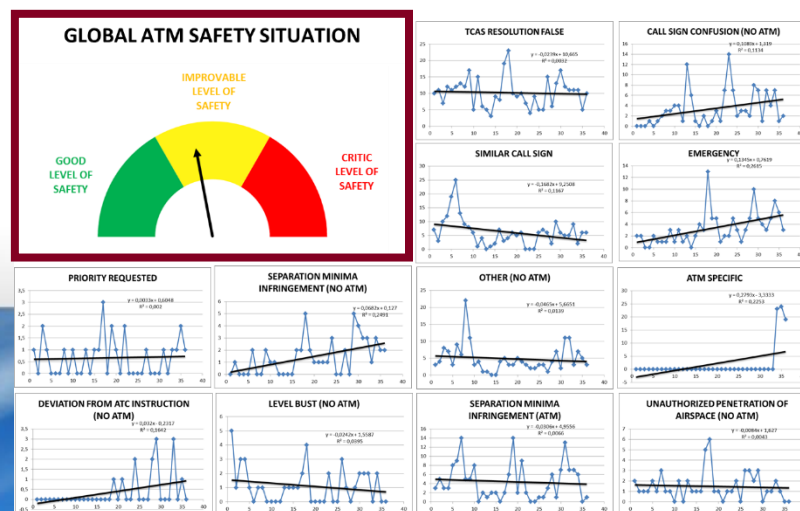
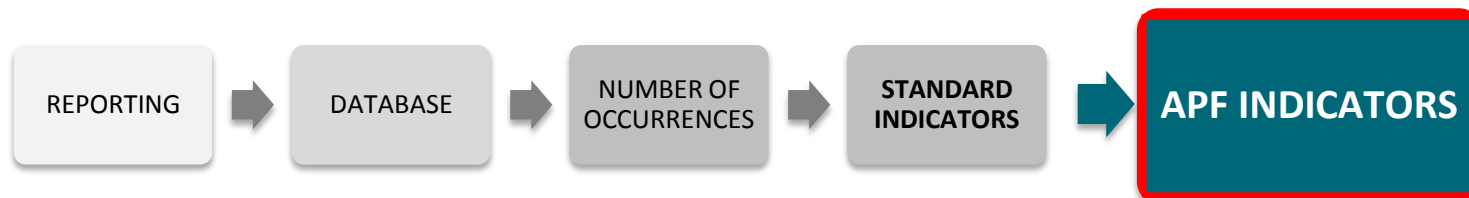
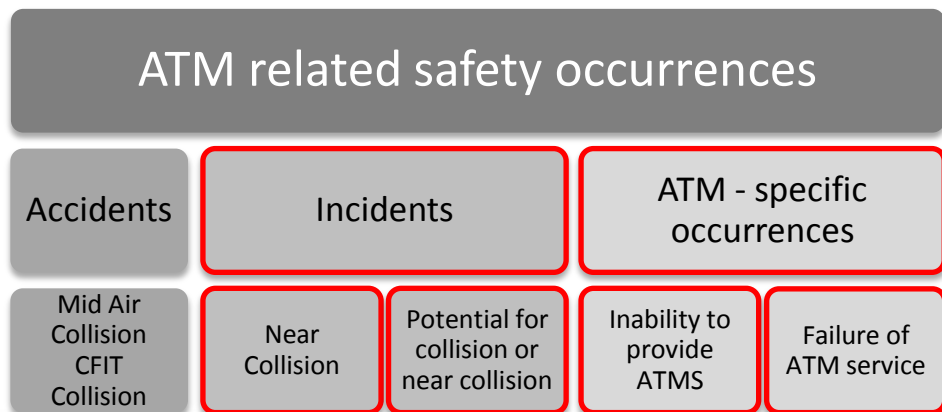
- Clear
- Evocative
- Easy to understand

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**





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 HIERACHY 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**)

$$Event_i \text{ APF Safety Index} = \frac{Event_i \text{ annual count}}{TOTAL \text{ traffic count}} Event_i \text{ AHP weight}$$

$$APF \text{ Safety Index}_j = \sum_i^n Event_i \text{ APF Safety Index}$$



REACTIVE INDICATORS (*stepwise safety 2/2*)



We have built 4 Indexes:

AIRPORT

SAFETY INDEX 1 APT

SAFETY INDEX 2 (ATM) APT

EN-ROUTE

SAFETY INDEX 1 ENR

SAFETY INDEX 2 (ATM) ENR

SAFETY INDEX 1 APT

Accidents (0,5)

Accidents (1,000)

Events (0,35)

Near collision (0,752)

- INSA + INSN
- NCFIT
- 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

Issues (0,15)

Procedural (0,375)

- ATO
- MA
- EME
- PRI

External (0,176)

- BS
- LASER
- TRA
- WS
- OTH

Communication (0,448)

- SCS
- CSC
- PLCC



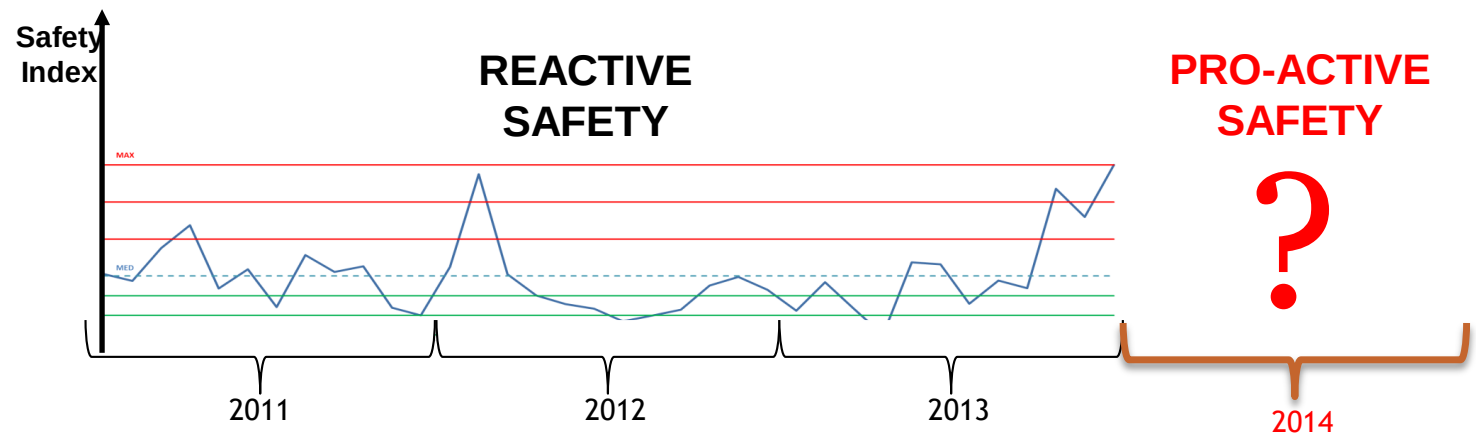
REACTIVE vs PRO-ACTIVE INDICATORS *(no clash, both are winners)*



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)*



HISTORIC FIT (*as things did, things will do*)



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

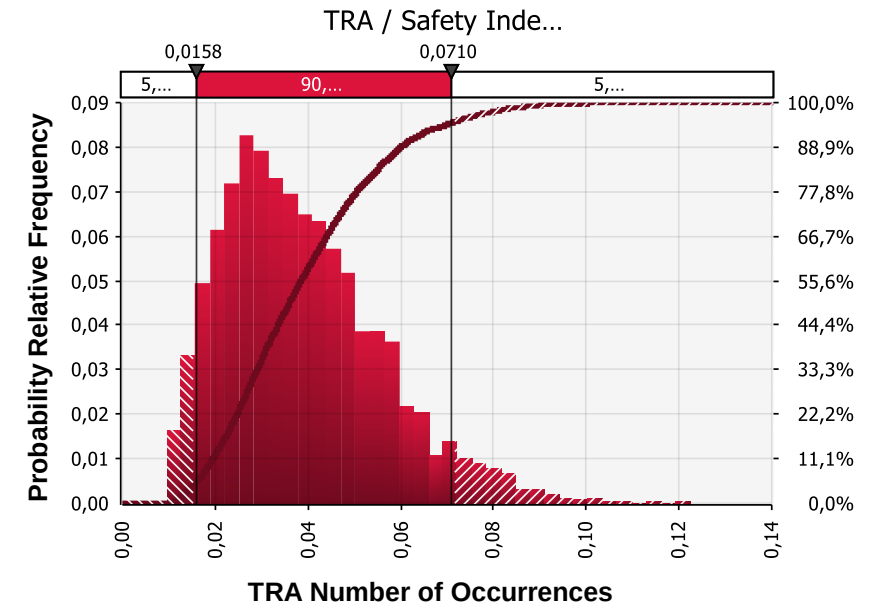
The **BEST** one according to the AIC rank that considers the **principle of parsimony** and has a good **accuracy/ease ratio** in case of many input data

\	TRA
gen-08	12
feb-08	8
mar-08	5
apr-08	4
mag-08	10
giu-08	11
lug-08	1
ago-08	17
set-08	13
ott-08	3
nov-08	5
dic-08	7
gen-09	5
feb-09	2
mar-09	12
apr-09	8
mag-09	20
giu-09	23
lug-09	3
ago-09	9
set-09	24
ott-09	7
nov-09	5
dic-09	9
gen-10	7
feb-10	5
mar-10	6
apr-10	6
mag-10	13
giu-10	17
lug-10	12
ago-10	8
set-10	11
ott-10	10
nov-10	15
dic-10	10

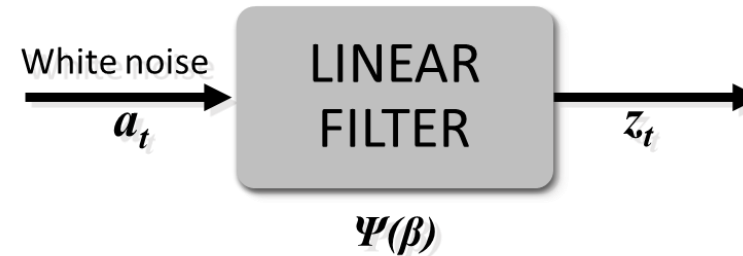
DISTRIBUTION FIT
FOR EACH EVENT
TYPE



APF PROCESS



TIME SERIES ANALYSIS (*forecast with maths*)



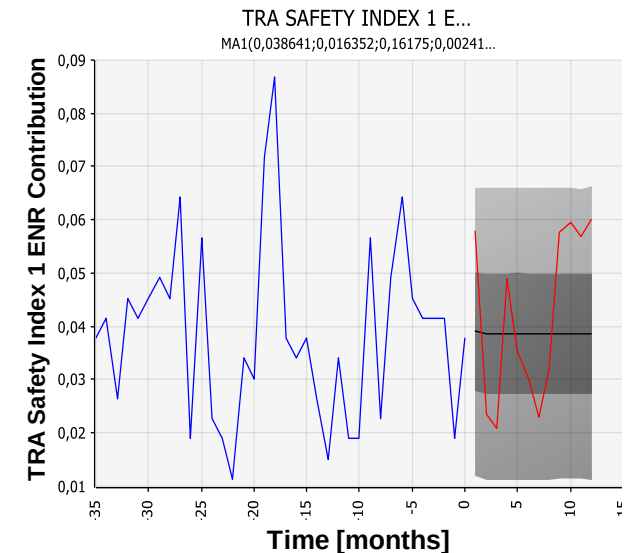
- Based on Yule's and Box and Jenkins' theories a **linear filter** has been built for each event type, according to its characteristics (AR, MA, ARMA, ARIMA, etc.)
- Analyzing (transformation, trends, seasonality):

EVENT TYPE
HISTORIC
SERIES

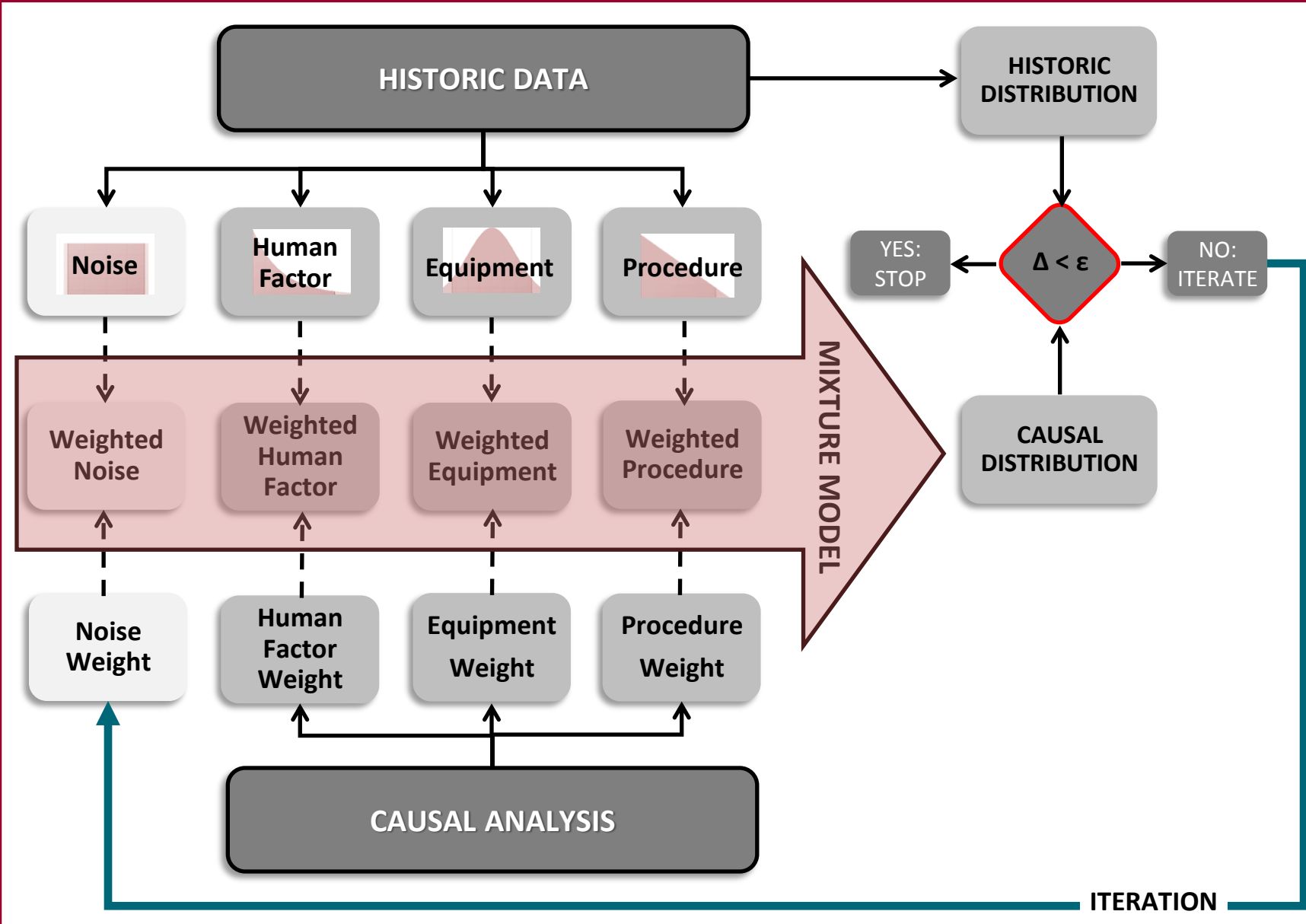
TIME SERIES
ANALYSIS FOR EACH
EVENT TYPE



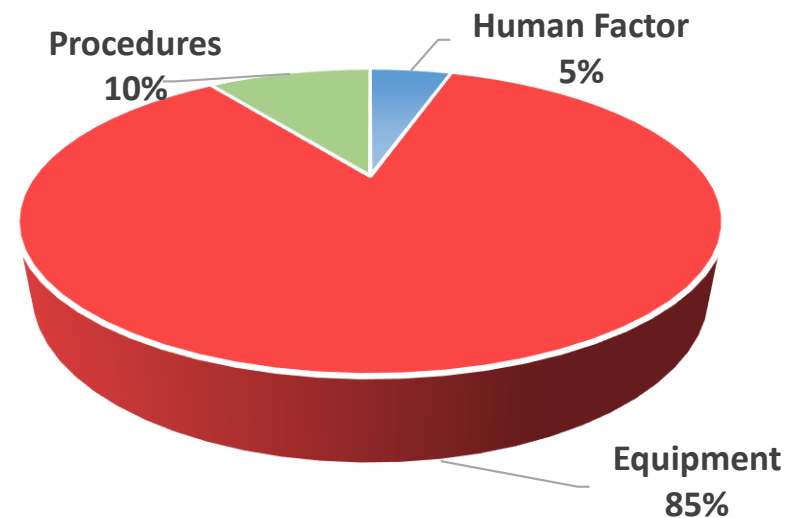
APF PROCESS



CAUSAL FIT (roots are fruits 1/2)



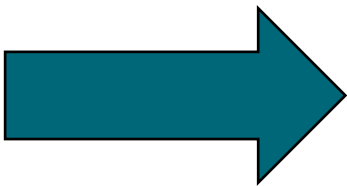
CAUSAL FIT (roots are fruits 2/2)



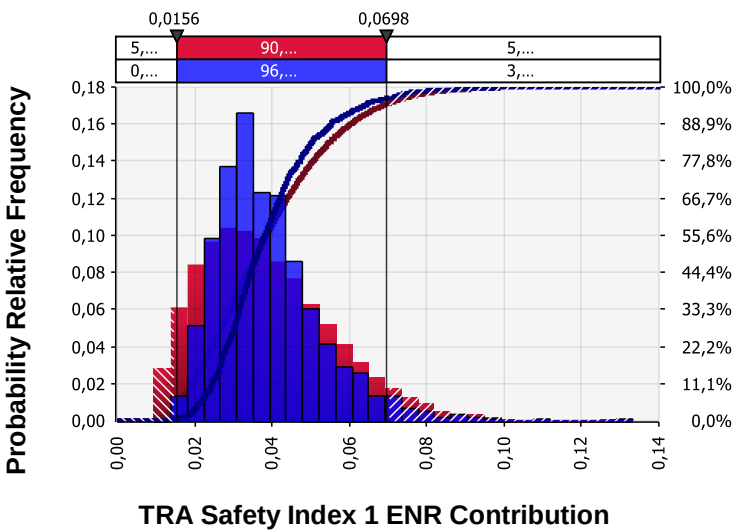
Causes	Causal Factor	Distribution mean	Distribution effect
Noise	0,05	12,9685	0,6484
Human Factor	0,0475	8,7573	0,4159
Equipment	0,8075	10,2097	8,2444
Procedures	0,095	10,2097	0,9699

EVENT TYPE
HISTORIC
SERIES

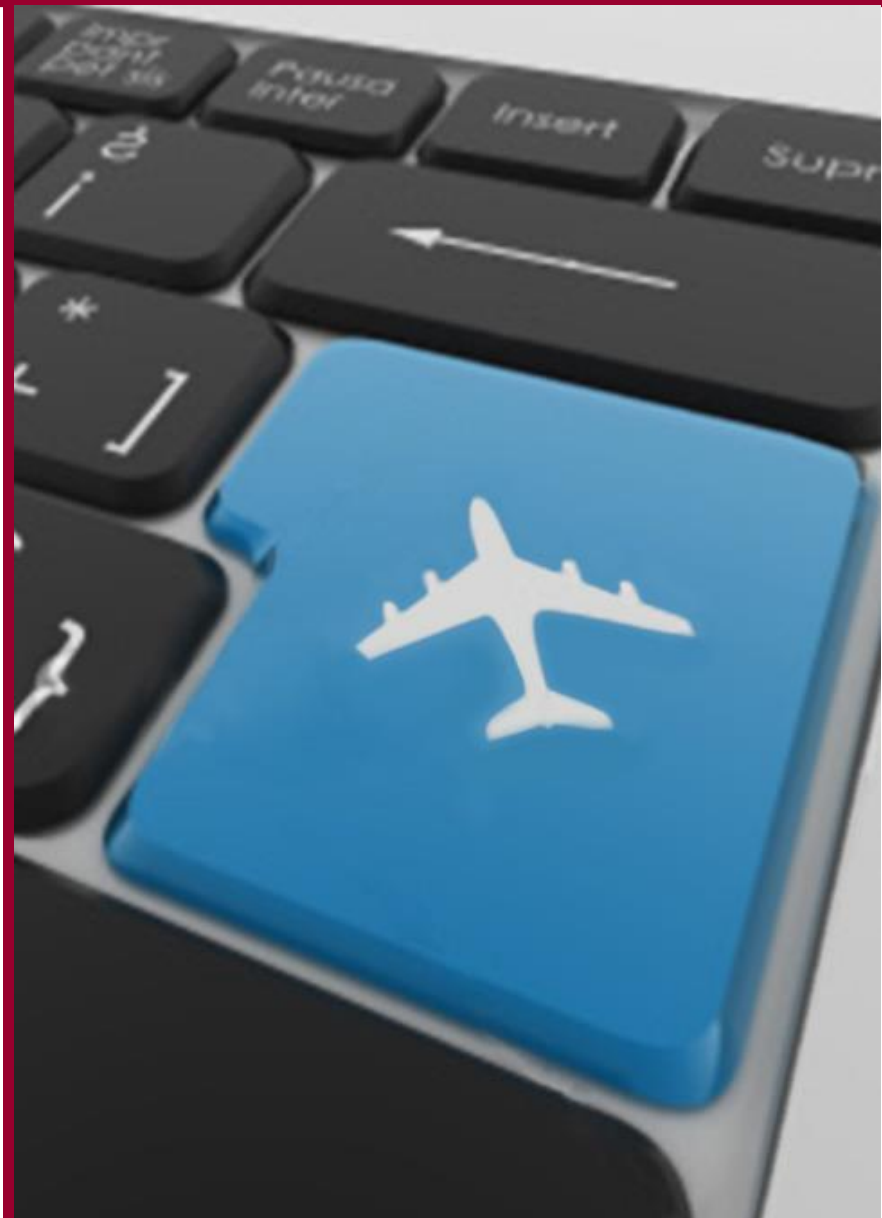
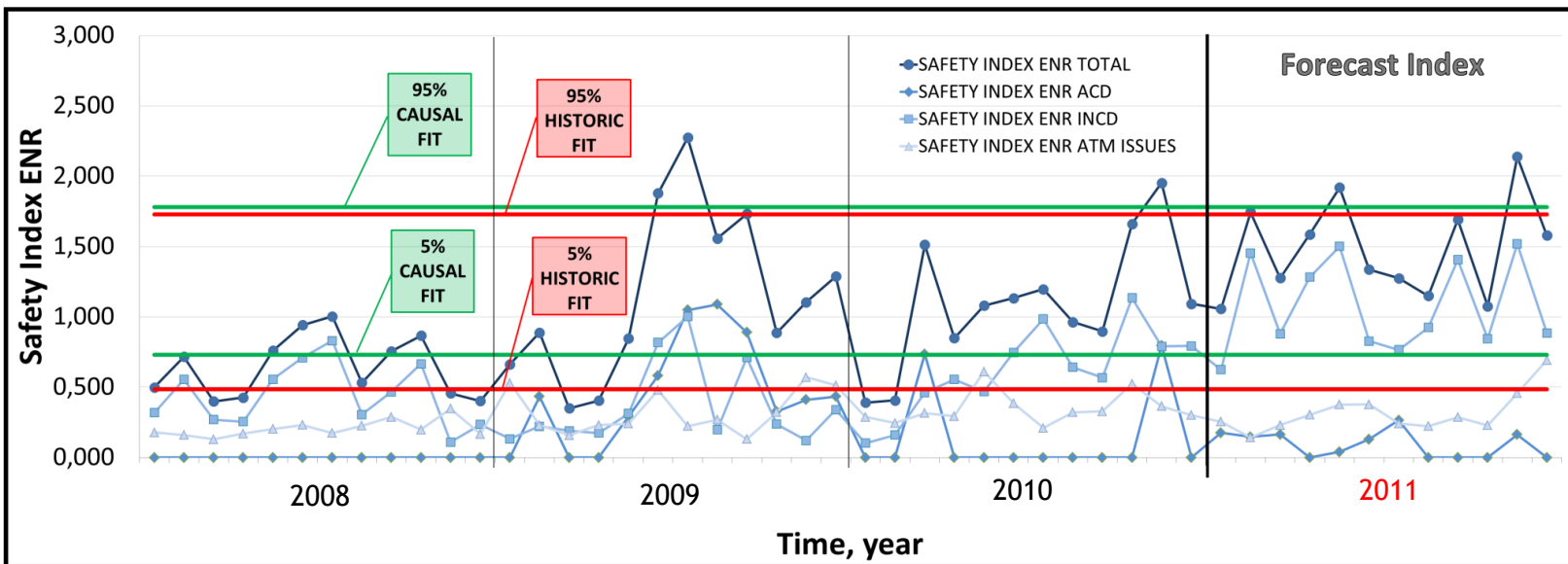
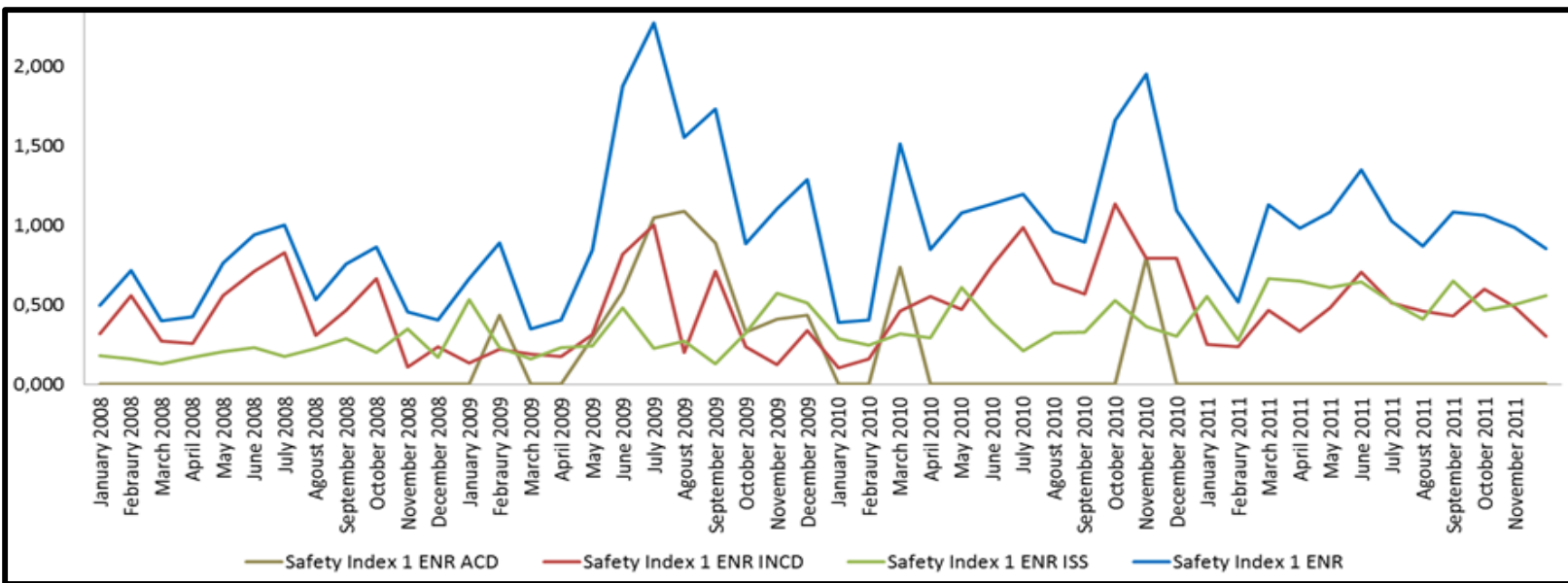
CAUSAL ANALYSIS FOR
EACH EVENT TYPE
COMPARED WITH
HISTORIC DATA



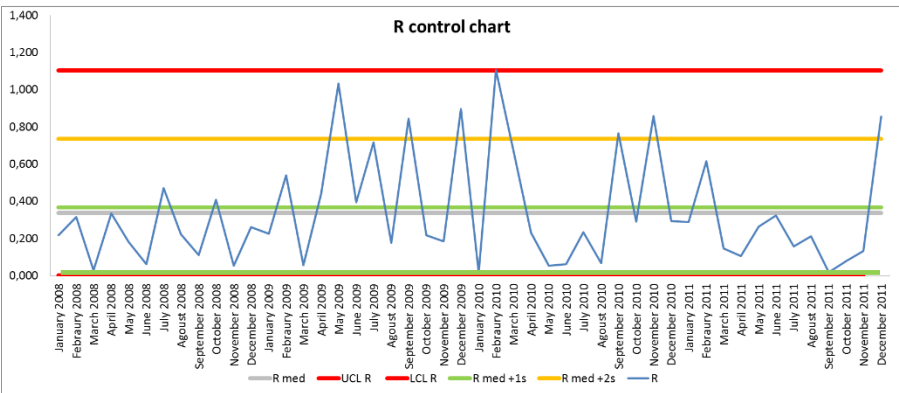
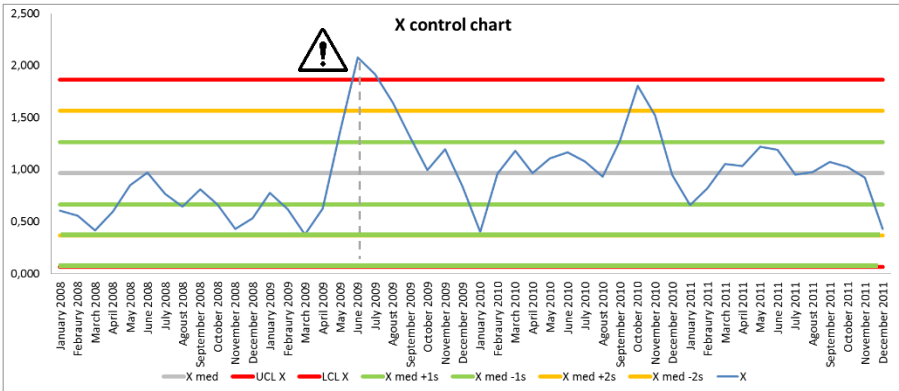
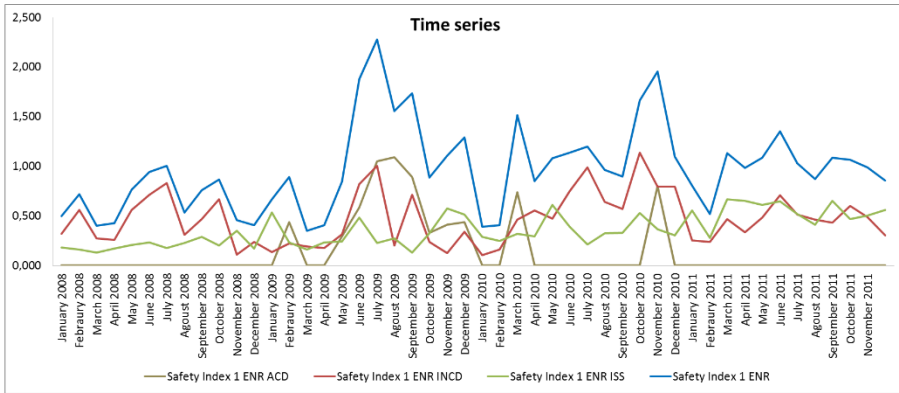
APF PROCESS



GLOBAL RESULTS *(the best is yet to come)*



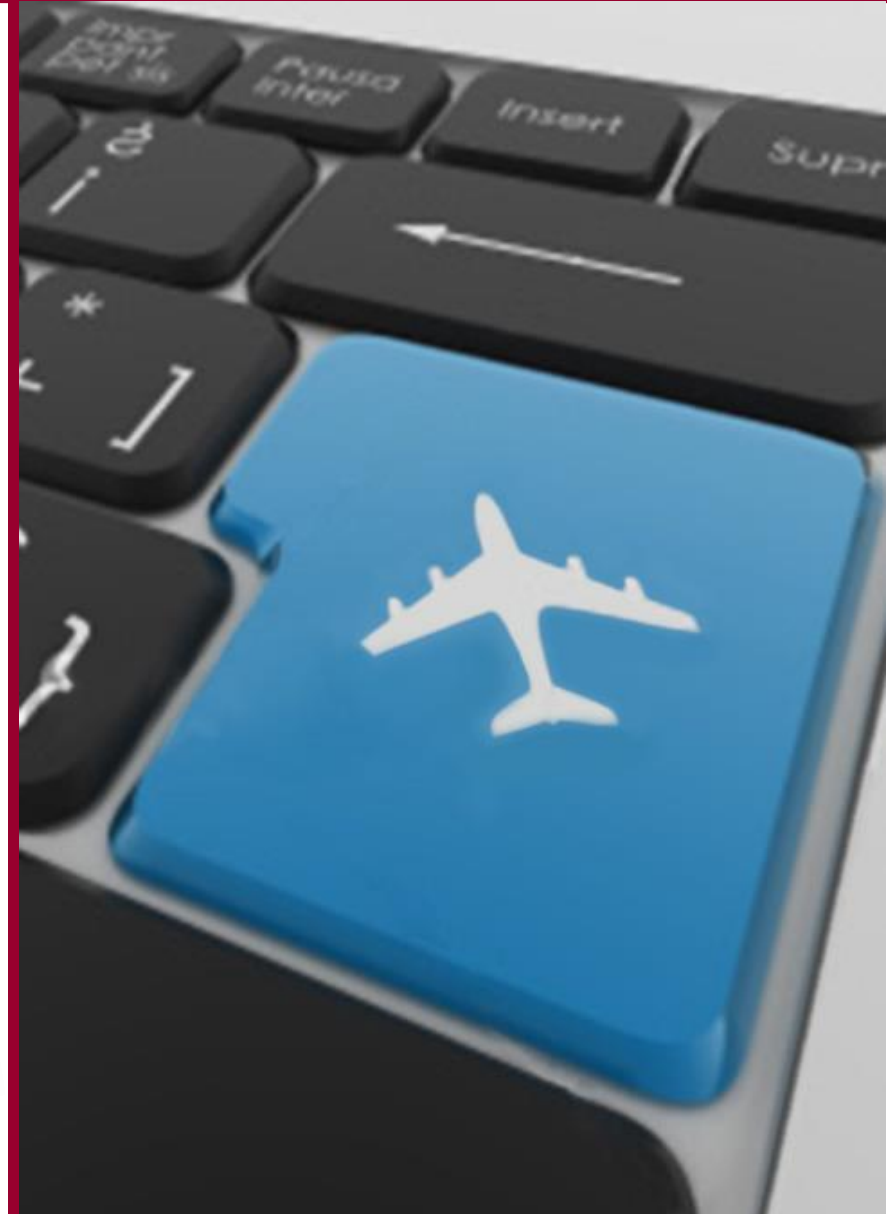
GLOBAL RESULTS *(a view from afar...)*



SAFETY INDEXES LIKE PAST PERFORMANCE EVALUATORS

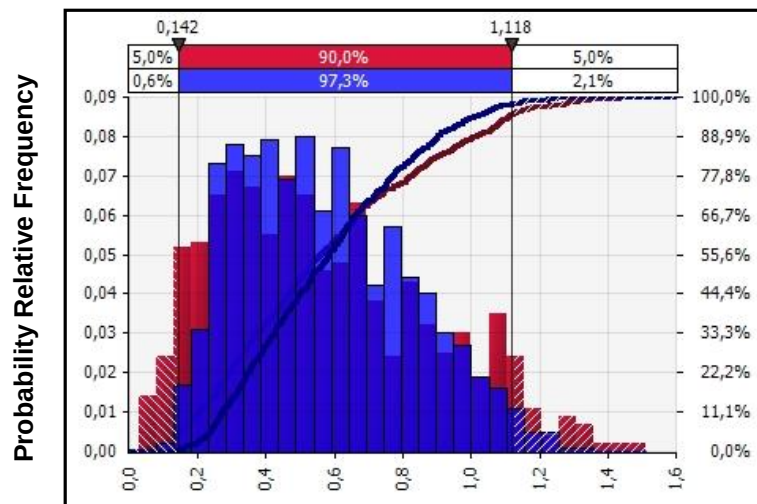
Individuate criticalities
by X-R analysis based on
Shewart control charts

WARNING
THIS SIGN
IS ONLY A
DISTRACTION



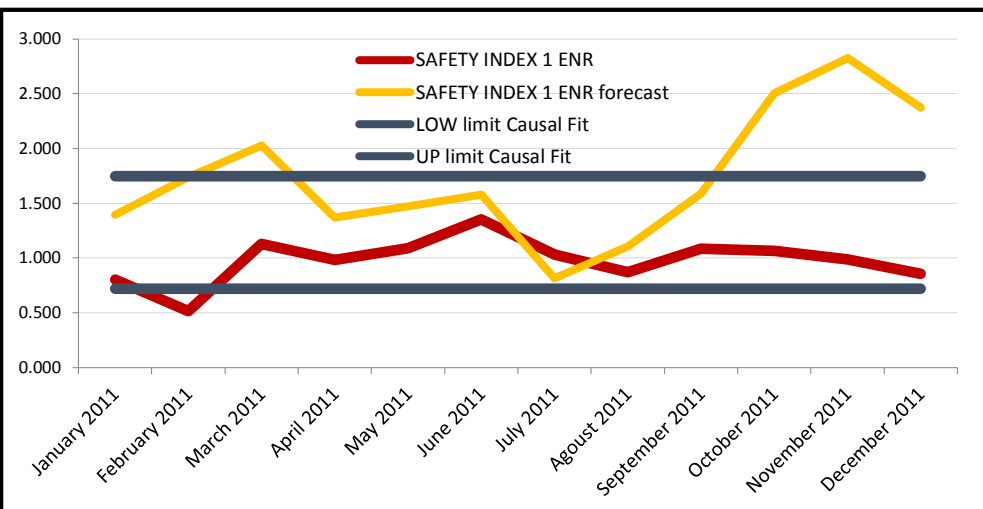
GLOBAL RESULTS *(a bit closer...)*

CAUSAL ANALYSIS vs REAL DATA



TRA Safety Index 1 ENR Contribution

CAUSAL vs TIME SERIES 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



