Leading and Lagging Safety KPIs

The Analytic Hierarchy Process (AHP) & *The Aerospace Performance Factor (APF)*

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Gilles Le Galo SESI/CND

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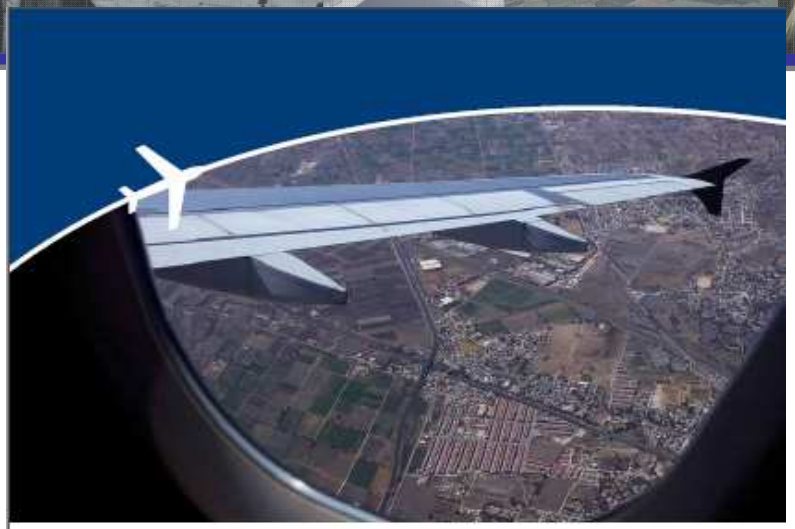
PC Safety KPI Roadmap
7 Recommendations



1. **Strengthen the ESARR 2 AST**
2. **Continuation of Safety Maturity beyond ESP lifetime and usage of ESIMs to derive REG KPIs**
3. **States to ensure adequate resources to populate AST**
4. **Cautious approach in adopting targets**
5. **by November 2009 SAFREP TF produce a range of key indices, which would measure the state or "health" of the ATM safety system. …make best use of existing practices, data flows, rules and regulations with the scope of minimising new approaches …to observe the roadmap described in Chapter 4 of the Roadmap Report**
6. **wide consultation with all interested stakeholders before any adoption**
7. **PC to agree on the Roadmap and stakeholders to provide adequate resources to ensure the development of Safety KPIs by 2009**

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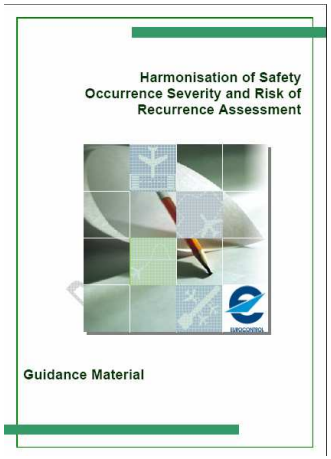
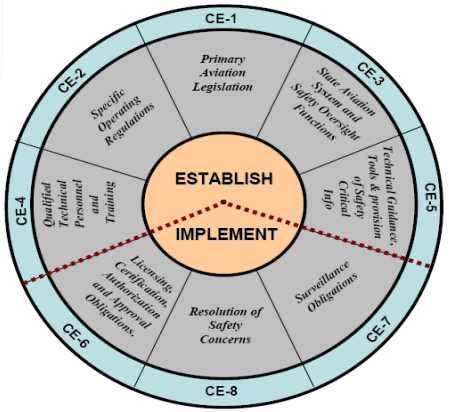
SAFREP TF 3rd report o PC
Improving European ATM Safety through SMART Safety Indicators

- **What is in the package**
  - **New Safety Maturity for ANSPs**
  - **New Safety Maturity for REGs**
  - **New Severity and Risk assessment Mark Sheets – RAT**
  - **New packaging for Lagging Indicators – APF**





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2010+ ANSPs ATM Safety Framework Study Areas (in partnership with CANSO)

Area No.	ANSP Study Areas
Safety Culture	
SA1	Development of a positive and proactive safety culture
Safety Policy	
SA2	Organisational and Individual Safety Responsibilities
SA3	Timely Compliance with International Obligations
Safety Achievement	
SA4	Safety standards and procedures
SA5	Competency
SA6	Risk Management
SA7	Safety Interfaces
Safety Assurance	
SA8	Safety Reporting, Investigation and Improvement
SA9	Safety Performance Monitoring
SA10	Operational Safety Surveys and SMS Audits
Safety Promotion	
SA11	Adoption and Sharing of Best Practices

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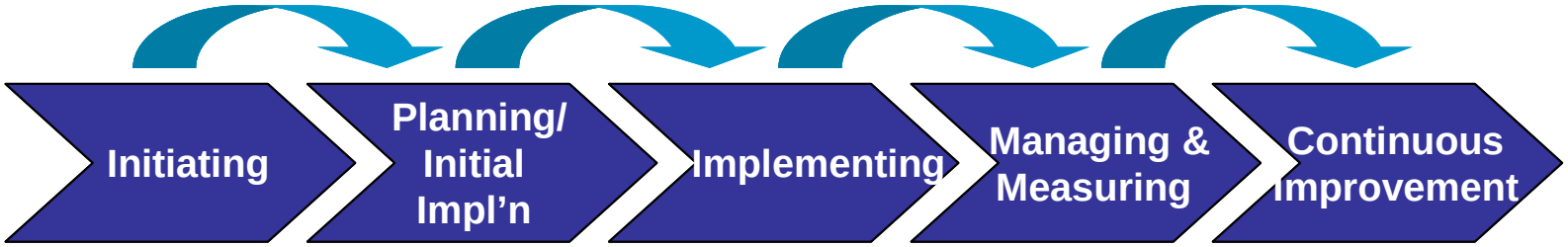
State ATM Regulators & ANSPs are asked to assess their ATM Safety Framework Maturity in the following categories:



Adapted from CMMI model recognised by Industry.

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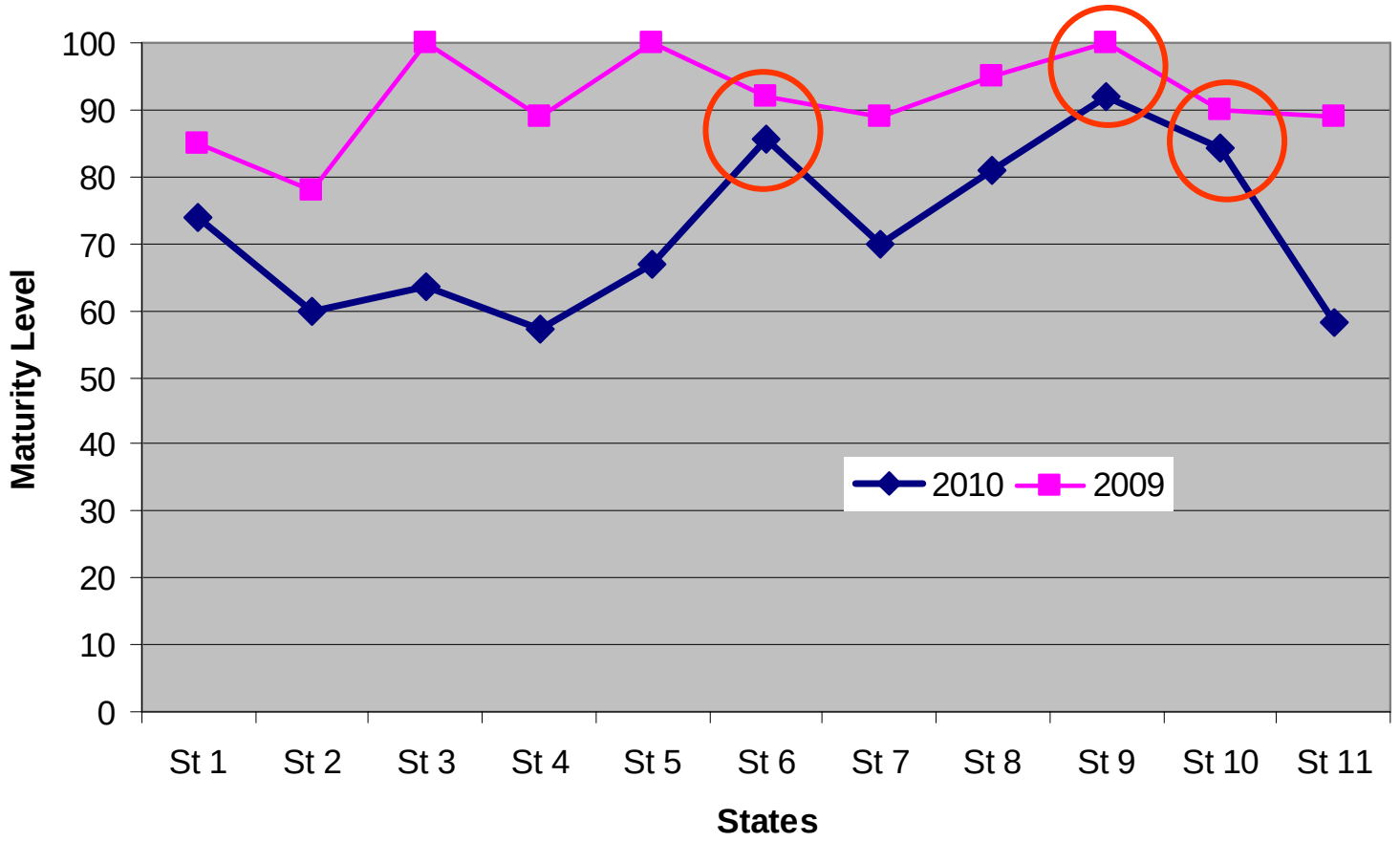
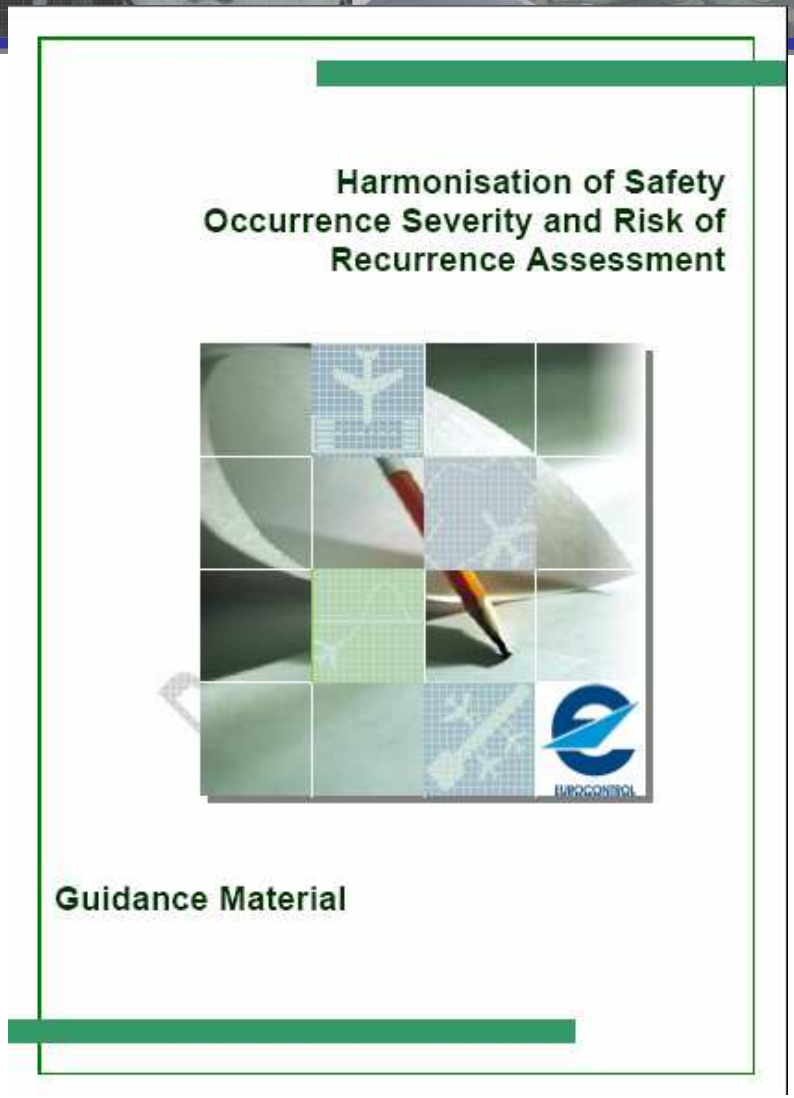
Validation Results - ANSPs


100
90
80
70
60
50
40
30
20
10
0
Maturity Level
2010
2009
St 1
St 2
St 3
St 4
St 5
St 6
St 7
St 8
St 9
St 10
St 11
States

Severity and Risk assessment of ATM Safety Occurrences – the RAT !



- RAT is a post-investigation Tool
- RAT (Excel sheet) works as follows:
  - Requires the user to answer questions looking as much as possible at the facts
  - Based on these answers RAT computes proposed Risk classifications for ATC, as well as for the Overall ATM/NAS (i.e. ATC plus pilot)
- Adopted as of 1st of Oct by FAA

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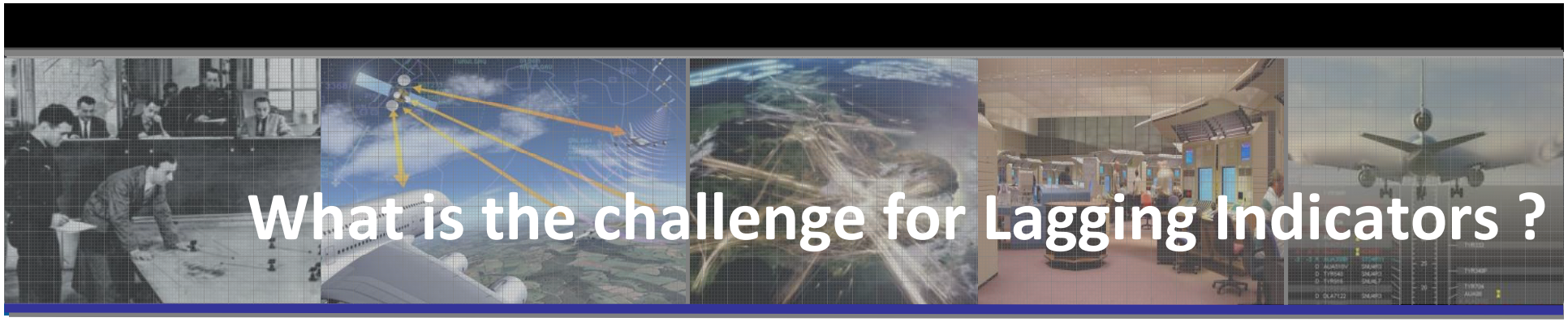

What is the challenge for Lagging Indicators ?

- **Assessing performance means assessing the impact of many different factors and events into a cohesive measurement tool.**

- **Always require to combine *tangible and intangible* elements to determine their *influence* on the overall system.**
  - Because humans are involved, “safety”, “efficiency” and “effectiveness” can become intangible due to different experience and perspectives.

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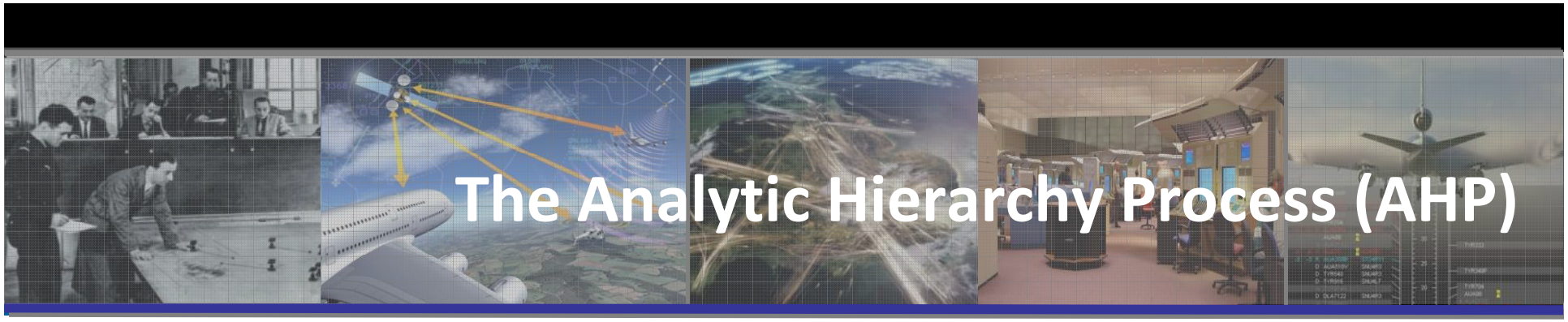

The Analytic Hierarchy Process (AHP)

- AHP is a structured technique for making complex decisions, based upon psychological and mathematical principles
- Developed in the 1970s
- AHP decomposes decision problem into a hierarchy of more easily comprehended sub-problems (criteria)
- Criteria can relate to *any* aspect of the problem – tangible or intangible
- Once hierarchy is built options are systematically evaluated and combined to produce 'local' and 'global' ranking of elements
- Evaluation by pairwise comparison
    - e.g. option A vs option B, option A vs option C, etc …

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Analytical Hierarchy Process (AHP)

- Uses expert judgment to prioritise these criteria, i.e. give weights
- Example: rank a pool of cars based on a combination of criteria such as cost, safety, style, capacity
  - Each car evaluated separately
  - Importance of each criteria also weighed
  - Then each car evaluated based on those weights

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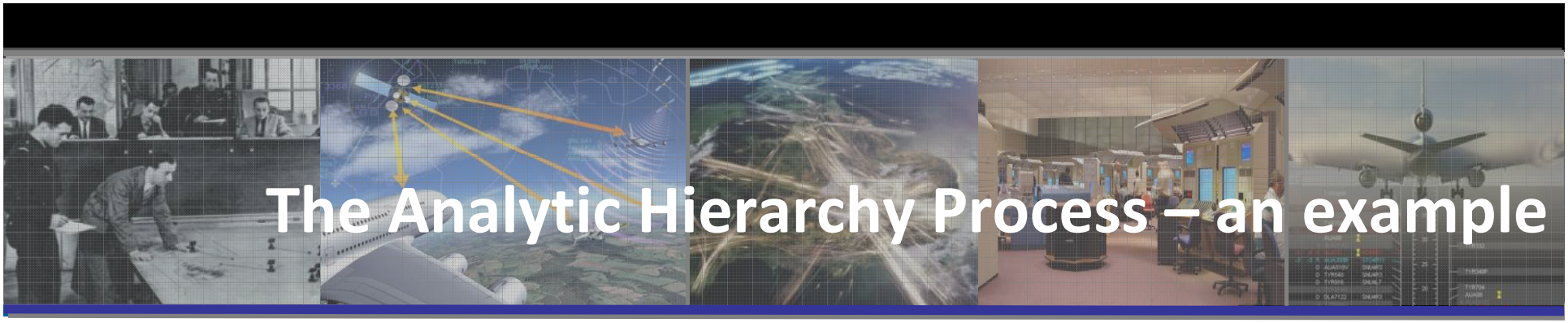
The Analytic Hierarchy Process – an example

GOAL

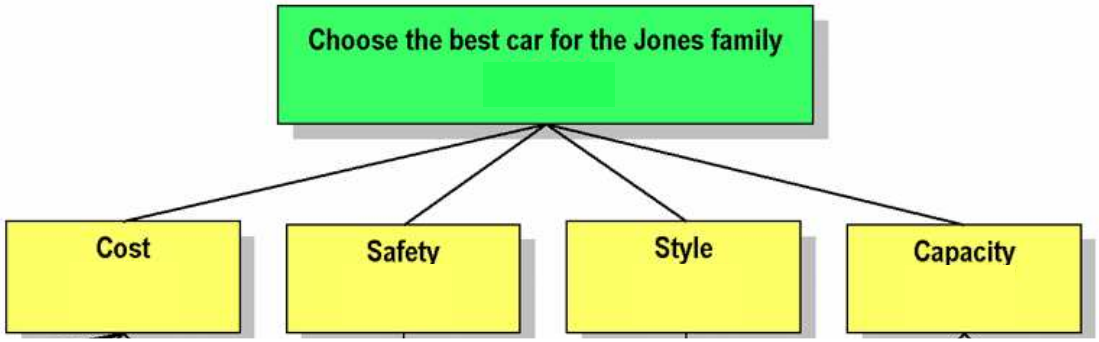
Choose the best car for the Jones family

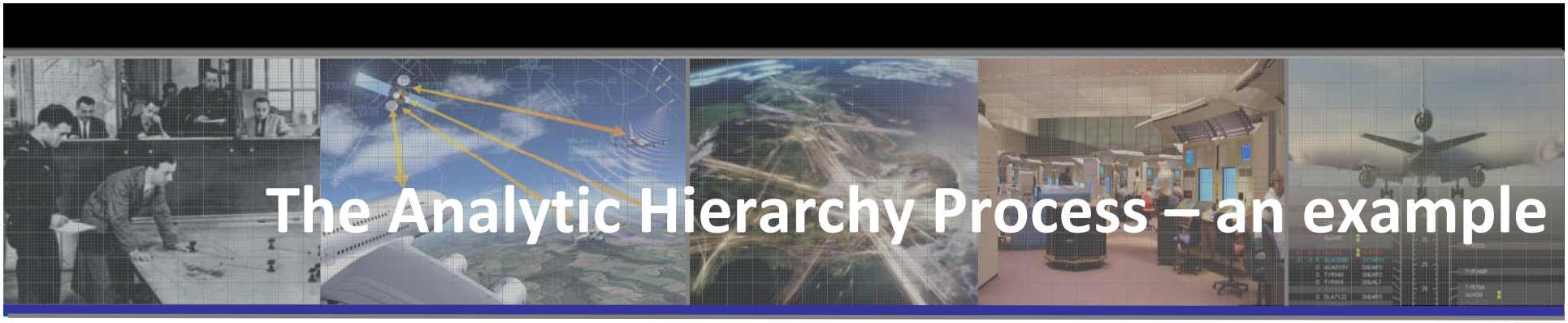


The Analytic Hierarchy Process – an example

GOAL

CRITERIA





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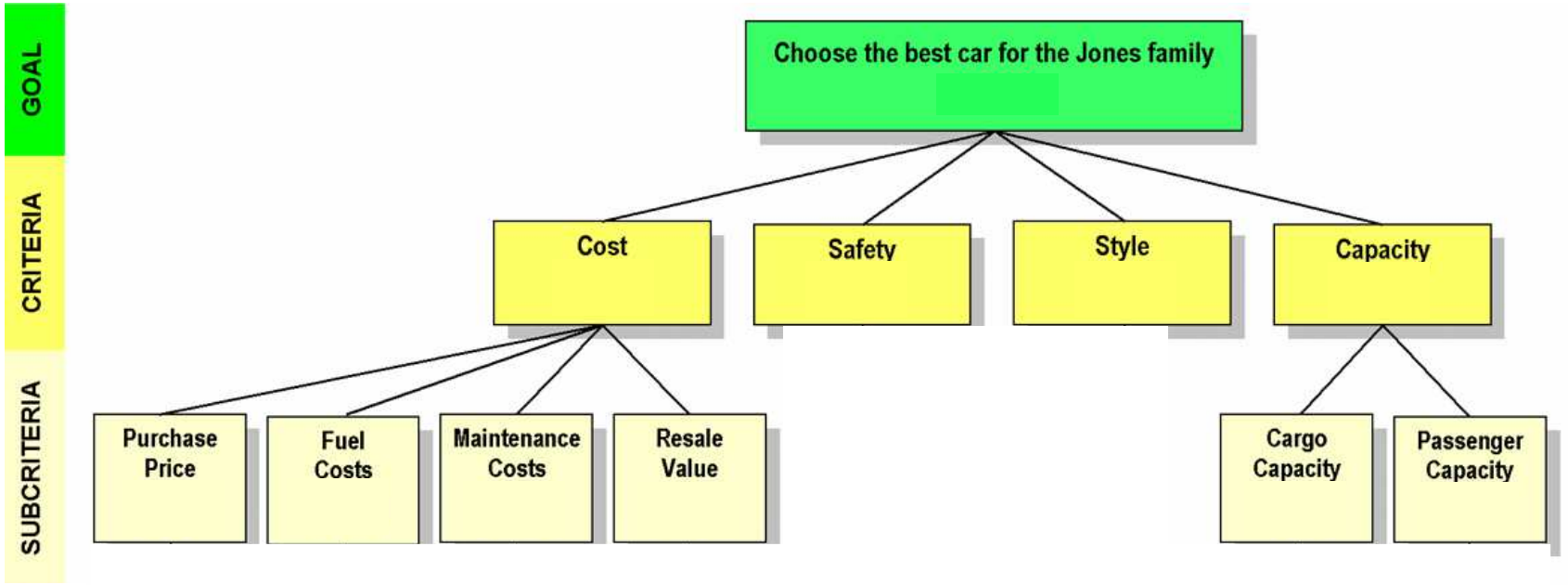

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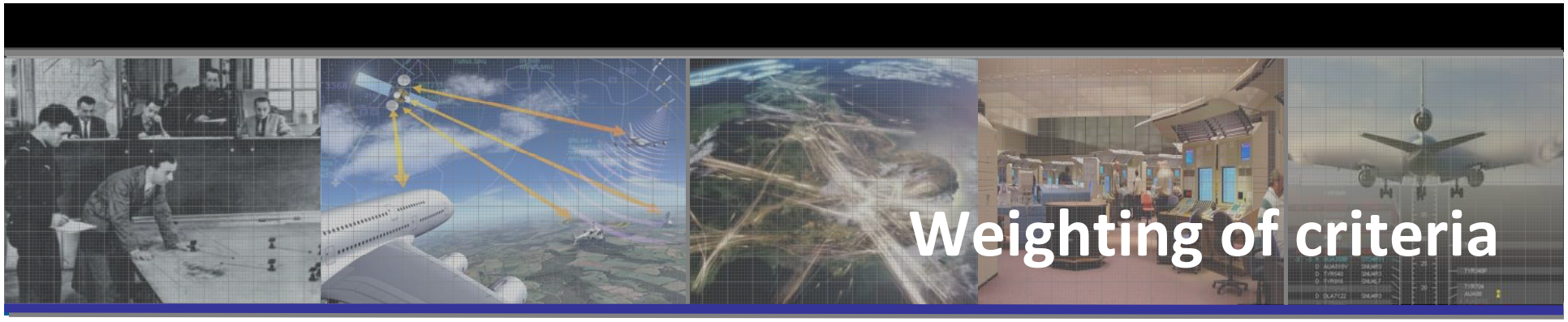

Weighting of criteria

- All criteria are equal, but some are more equal than others
- Therefore, criteria must be allocated weights
- Easiest way to do it: pairwise comparison
  - Between criterion A and criterion B, which one is more important?
  - By how much?
- The result: each criterion gets a weight between 0 and 1
- All weights add up to 1

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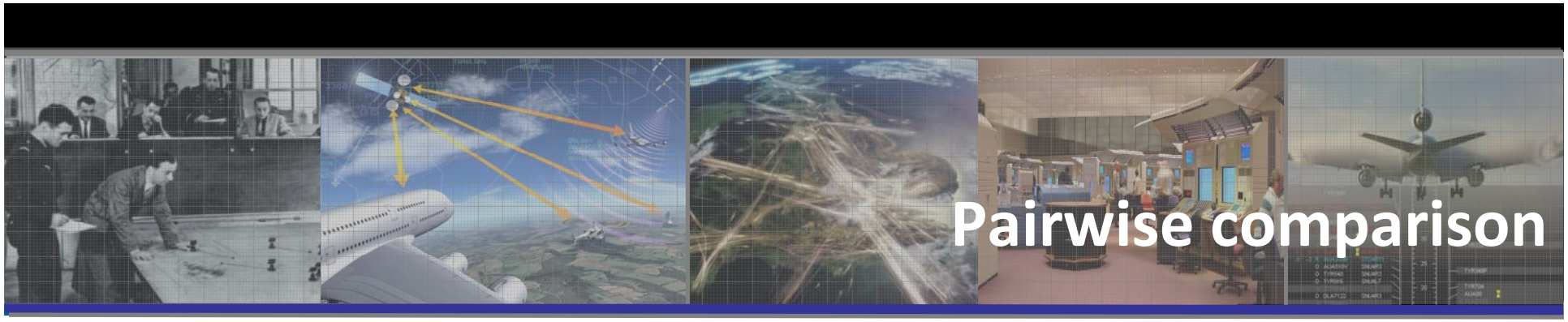
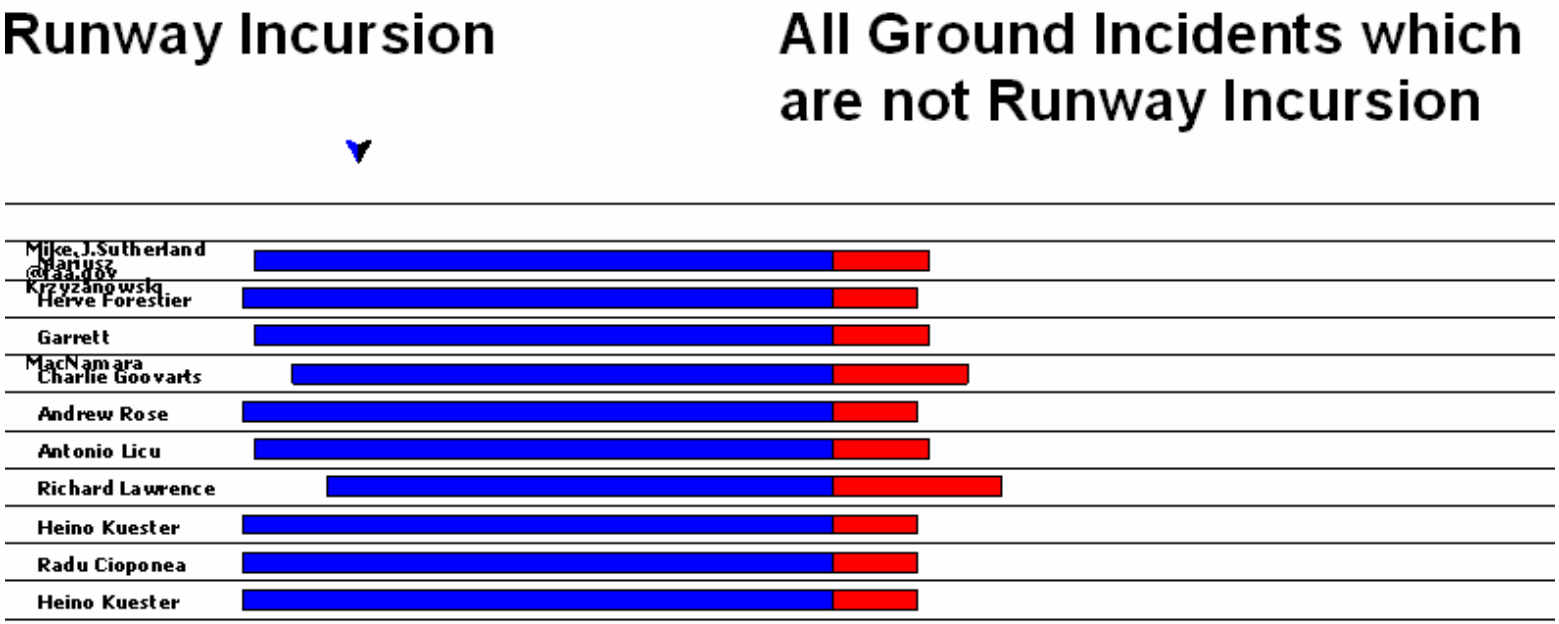


Pairwise comparison

- Very important: Subject Matter Experts
- Well prepared, good definitions, well explained
- Consistent weighting



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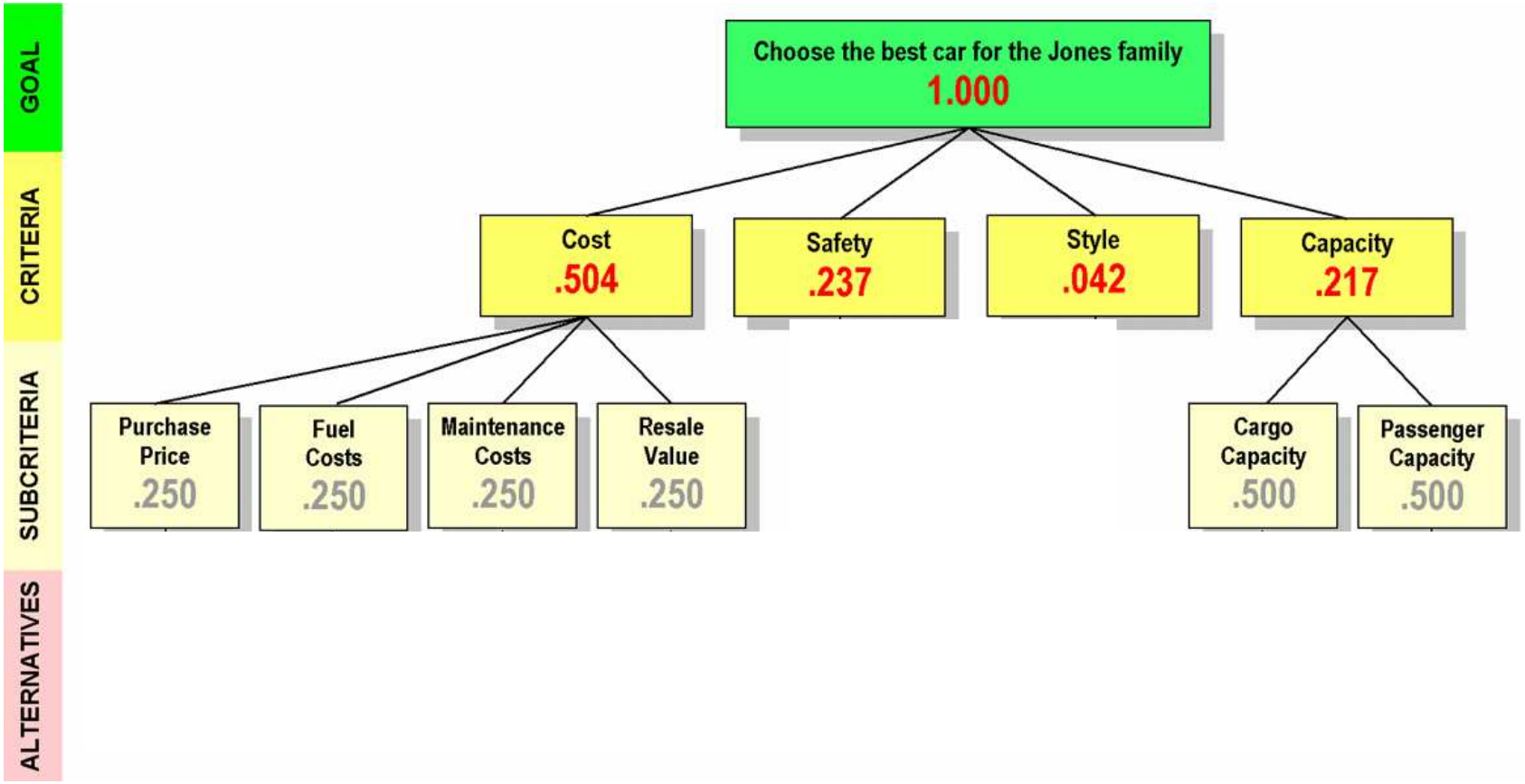
The Analytic Hierarchy Process – an example



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The Analytic Hierarchy Process – an example

GOAL

CRITERIA

SUBCRITERIA

ALTERNATIVES

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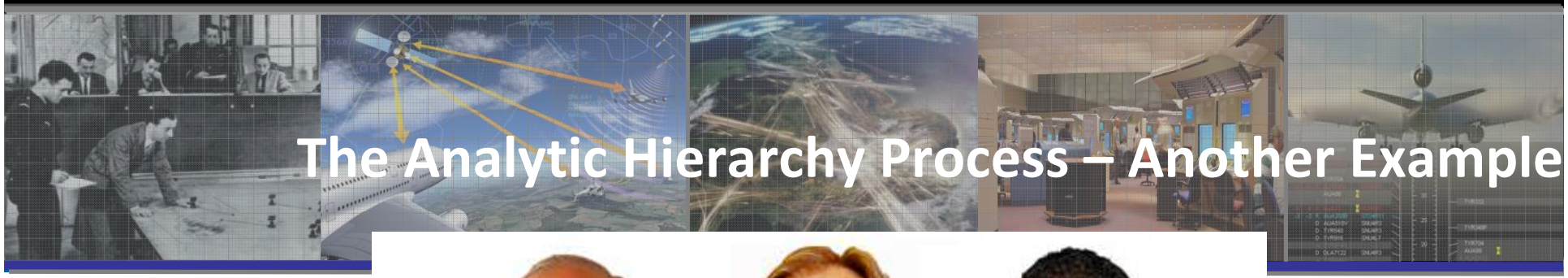
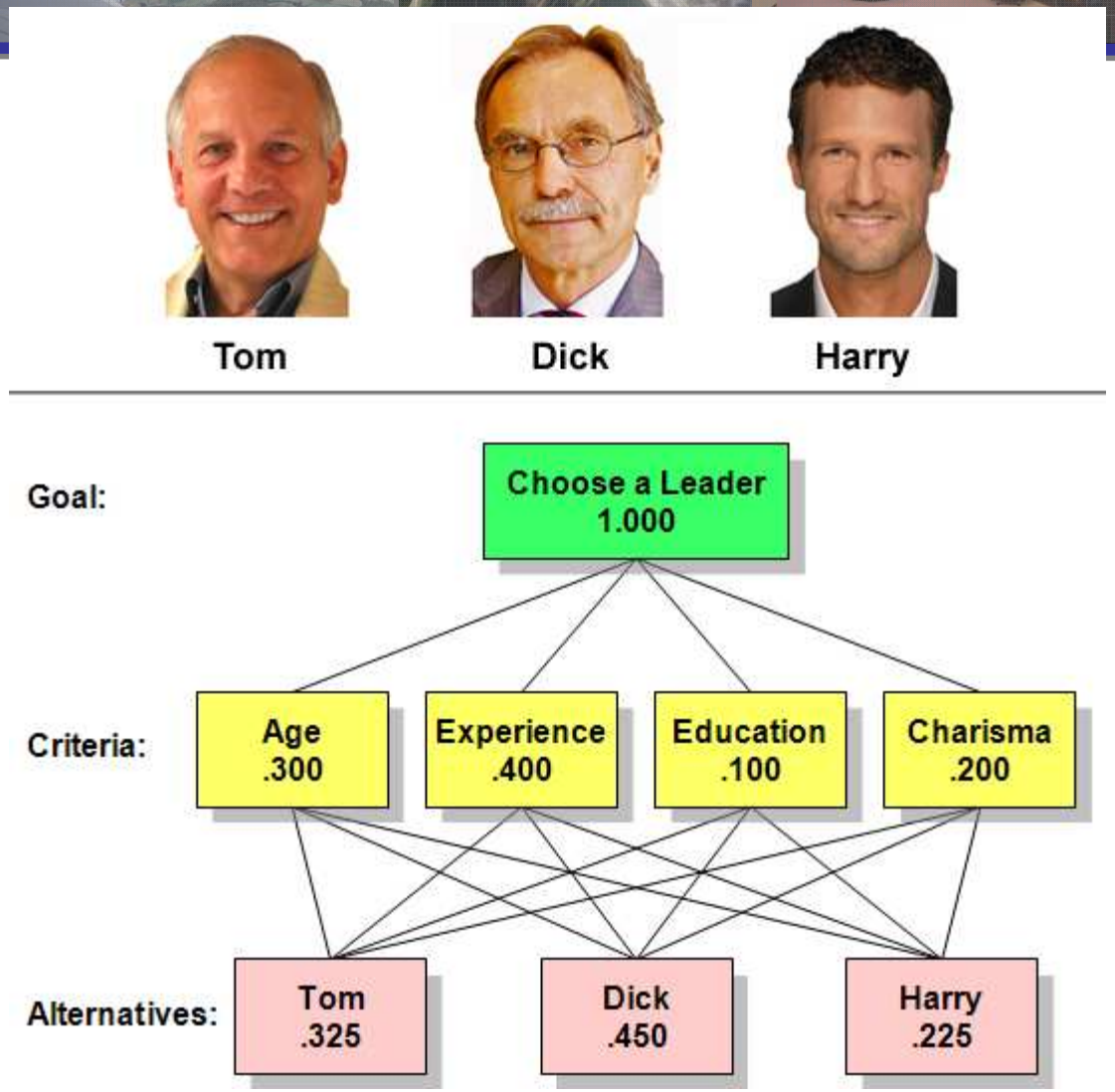
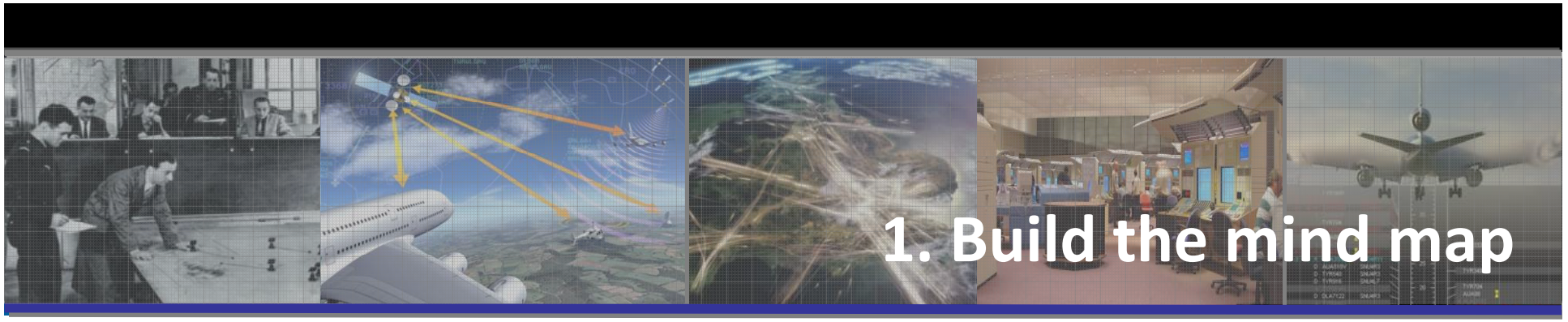
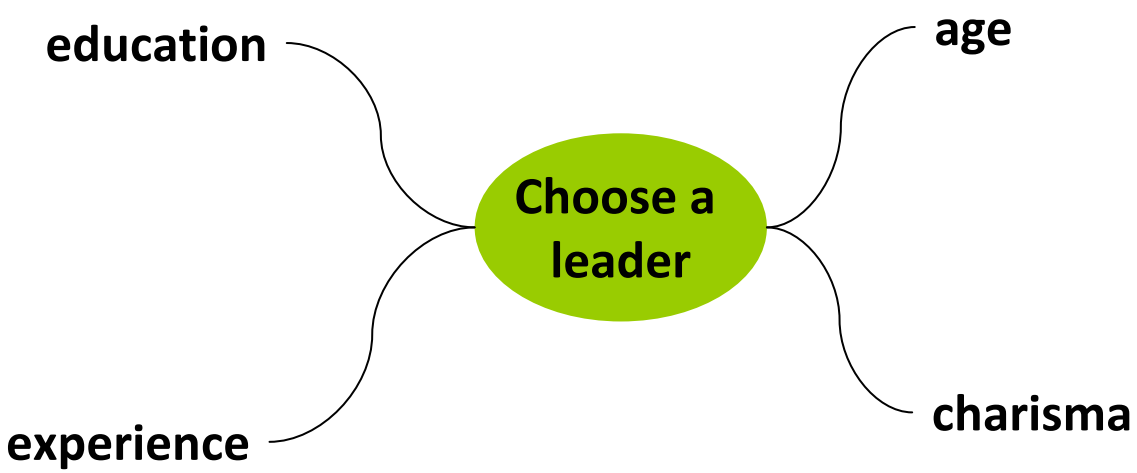


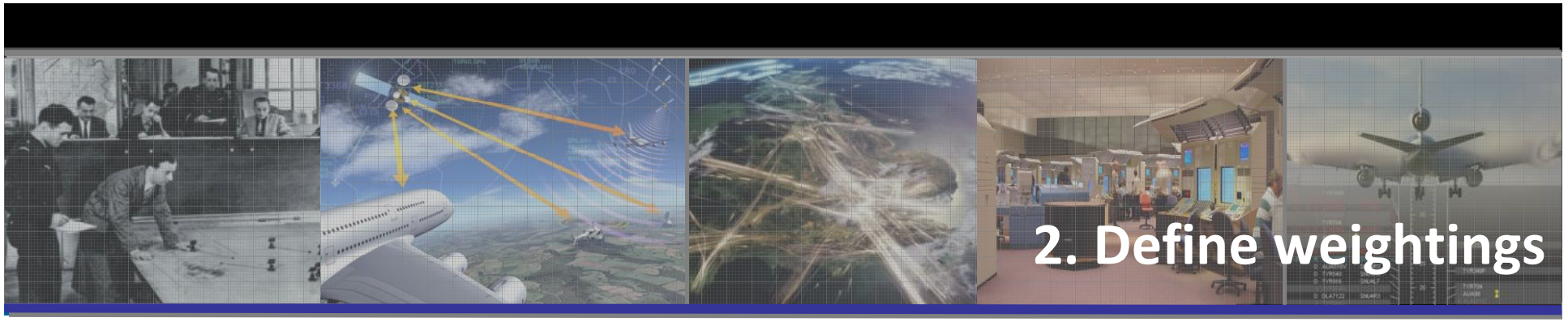
The Analytic Hierarchy Process – Another Example

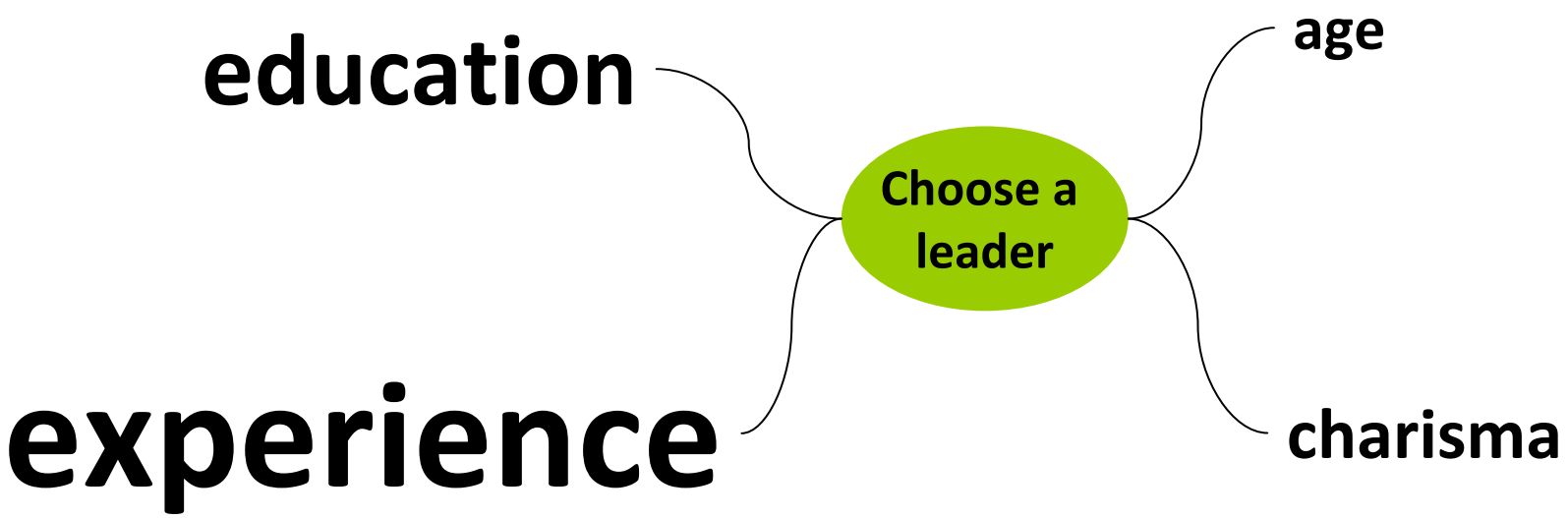




1. Build the mind map




2. Define weightings


education
age
Choose a leader
experience
charisma

3. Define metrics

		(age ranges: >20-<35=value 1, 35-<45=value 2, 45-<55=value 3, 55 and >=value 4)
Age	enter value	
TOM	3	54
DICK	4	57
HARRY	2	36

Experience	enter value	(number of years in field 1(X2)+ number of years in field 2 (X3)):100
TOM	7,4	22x2=44, 10x3=30
DICK	7,5	30x2=60, 5x3=15
HARRY	3,6	12x2=24, 7x3=21

Education	enter value	(secondary education diploma (1) + university degree (2)+ PhD (5)
TOM	3	Secondary plus university degree
DICK	1	Secondary
HARRY	5	secondary plus university degree plus Phd

Charisma	enter value	(subjective mark allocated during interview-range 1 to 5)
TOM	4	
DICK	2	
HARRY	4	

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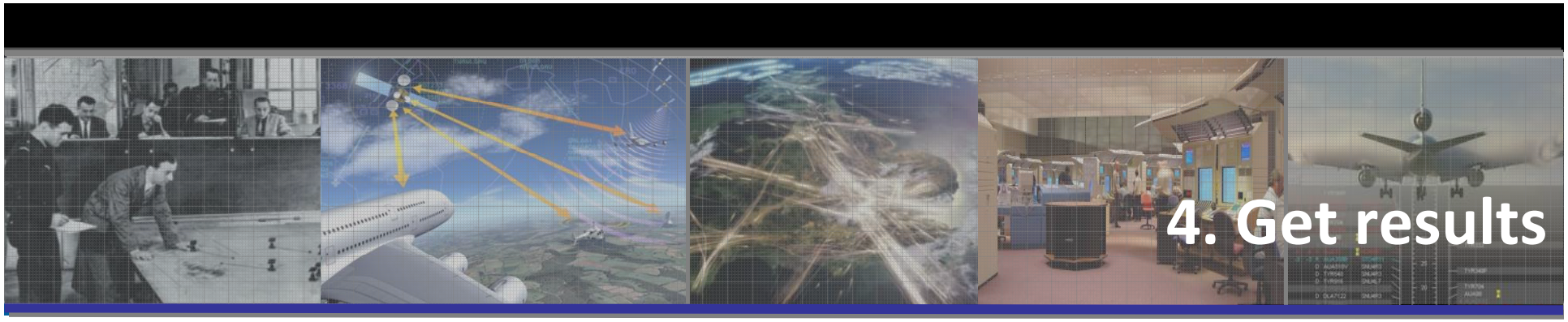


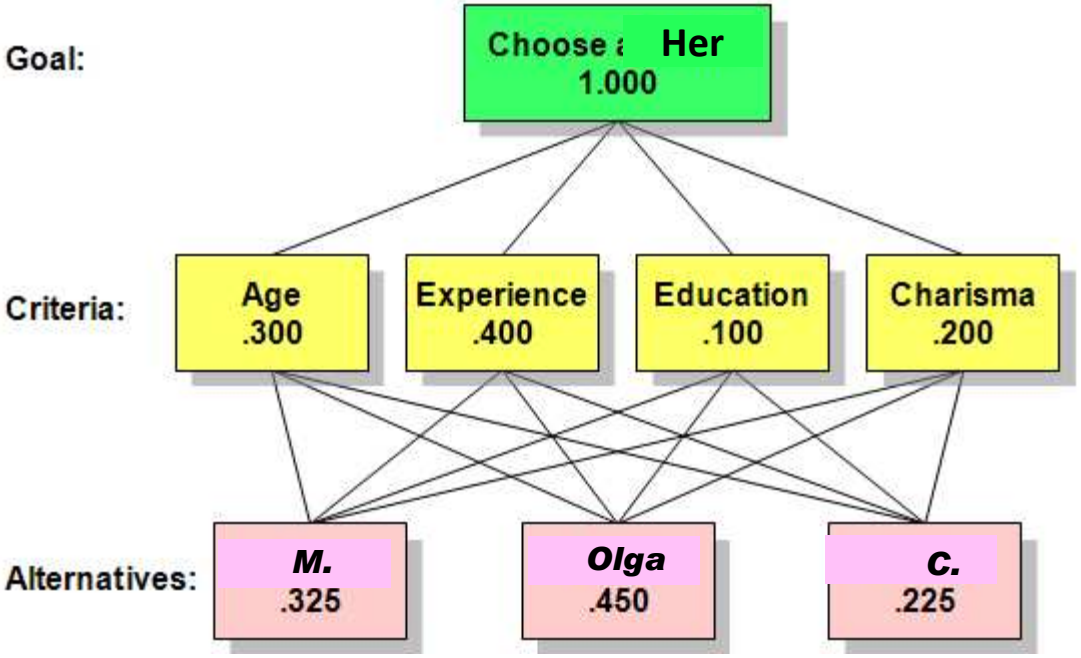
TOM (?)

The Analytic Hierarchy Process – Another Example

M.

Olga

C.



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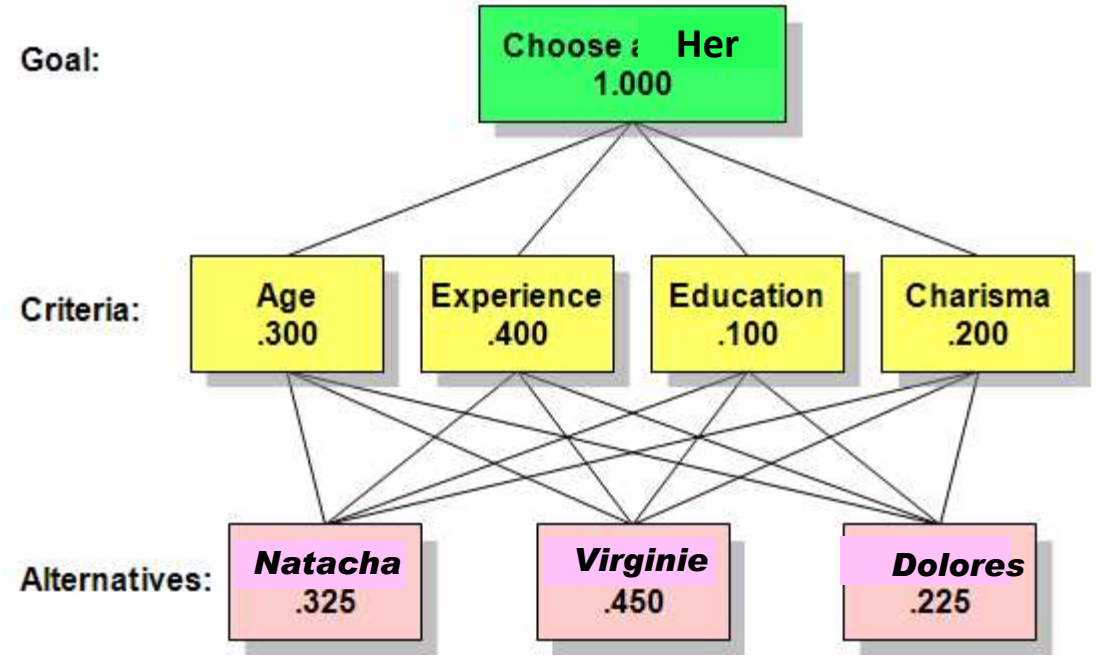
The Analytic Hierarchy Process – Another Example

Natacha

Virginie

Dolores

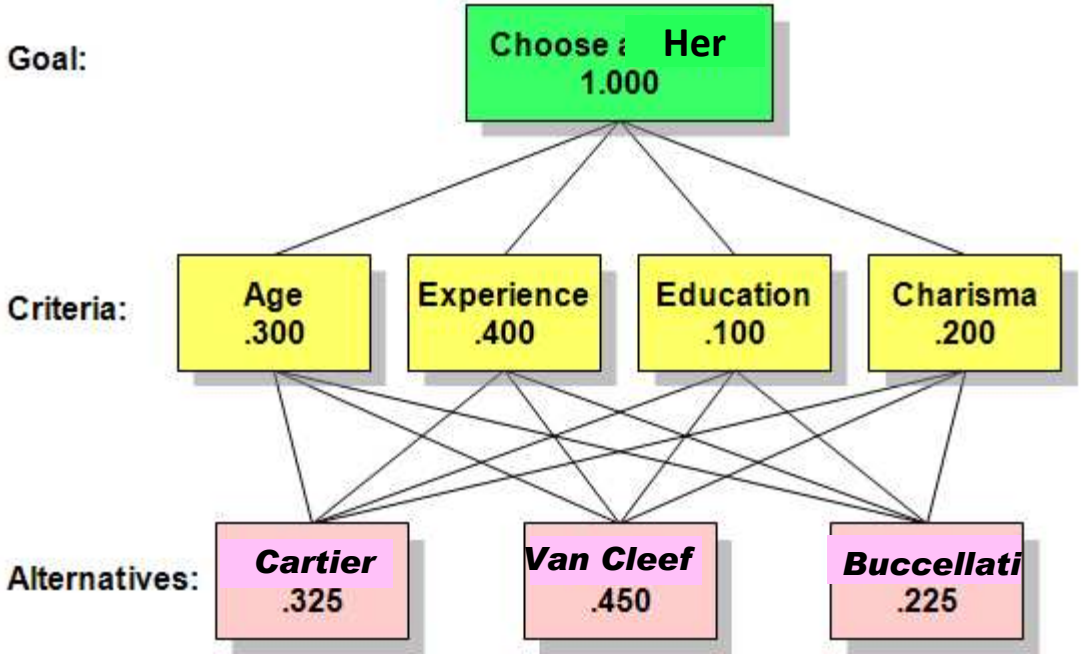


The Analytic Hierarchy Process – Another Example

Cartier

Van Cleef

Buccellati



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AHP applications

Described applications below

- use a “hybrid” or “simplified” version of AHP techniques to gather expert opinions for weighting.
- Are not used as a multi criterion decision tool but pair-wise comparison process determines the weights
- Can finally merge “apples’ and “oranges”
- “Between these two elements, which one has more influence on the organizations goal?”

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AHP application
Aerospace Performance Factor (APF)

- The APF presents a graphical view of performance.
  - based on *historical indicators (lagging) from multiple databases.*
- Allows organization to have a *macro-system-wide view of performance.*
  - then "drill down" into data to search for causal factors.
- Tracks organizational performance over time.
  - using safety, operational, and/or equipment metrics.

- Does not focus on a single metric to measure performance.
- Incorporates organizational judgment and experience of factors.
  - Measures intangibles
- Allows for analysis and search for precursors.
- Can function as a model for decision making & is expandable is size and scope.

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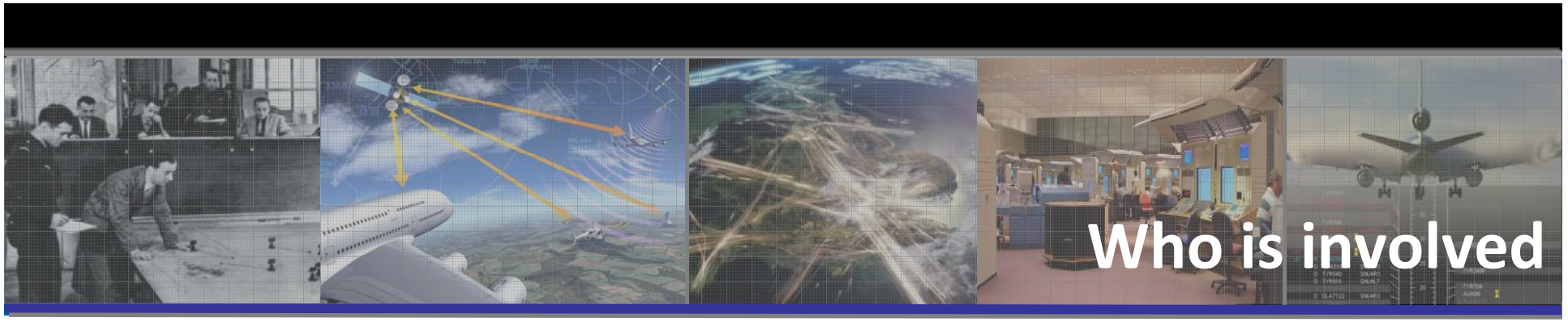

- FAA
  - Imperial College, London
  - easyJet Airlines
  - U. S. Navy's Aviation Safety Center
  - Albuquerque New Mexico and Denver Colorado Air Route Traffic Control Centers (ACCs)
  - Southwest Airlines
- EUROCONTROL &
  - Ireland (IAA)
  - UK (NATS)
  - Germany (DFS)
  - France (DSNA)
  - Poland (PANSA)
  - Netherlands (LVNL)
  - Hungary
  - FABs

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One Concept: Incidents & Trends

•One concept of safety….

- The worst event in aviation is an accident.
- The system has multiple checks and balances, “threads of safety” that help prevent accidents.
- Everything that is not an accident is an incident.
- Incidents represent “breaks” in the “threads of safety” and may represent gross precursors of safety.

- Air Traffic Incidents
  - Operational Errors (OE)
  - Operational Deviations (OD)
  - Near Mid-Air Collisions (NMAC)
  - Pilot Deviations (PD)
  - Runway Incursions (RI)
  - Vehicle or Pedestrian Deviations (VPD)

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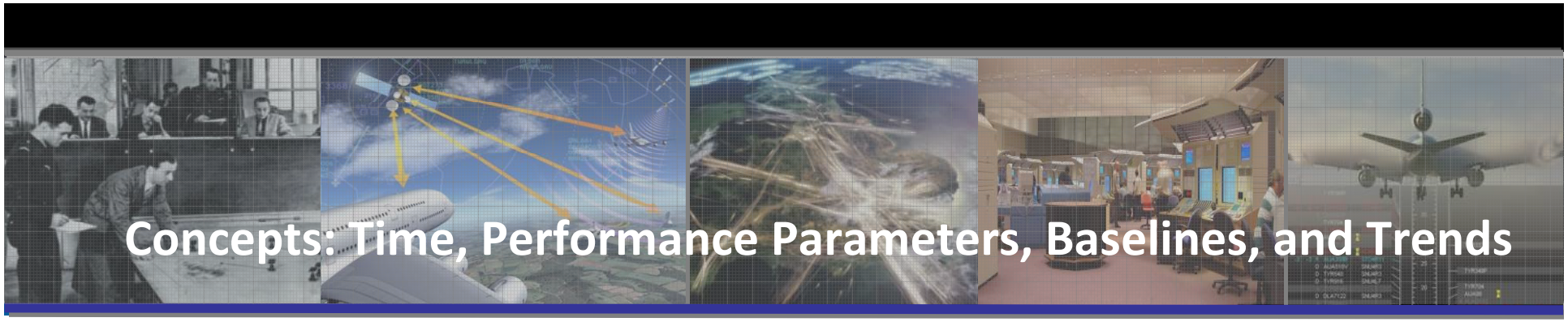
"Historical" Presentation Format

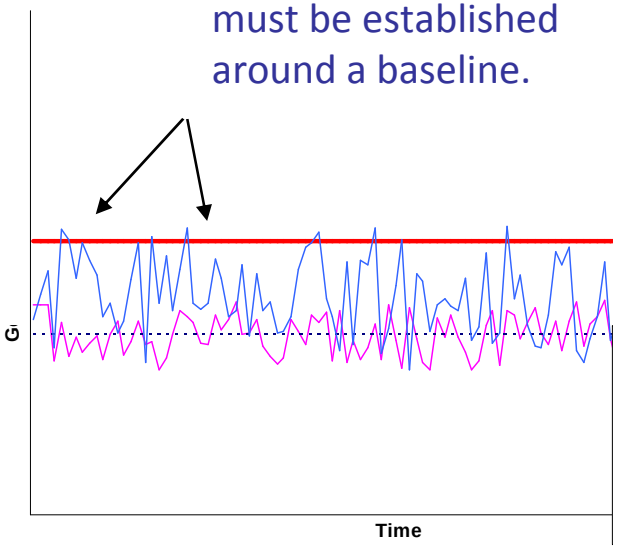
	2000	2004	Difference
Aircraft Accidents			
Air Carrier	56	29	-27
Air Taxi/Commuter	92	73	-19
GA	1835	1614	-221
NMAC	237	145	-92
PDs	1919	2628	709
OE	1139	1216	77
VPD	547	263	-284
Surface Incidents	1396	882	-514
Runway incursions	426	310	-116
Aircraft Operations			
	46,056,000	46,762,000	706,000
Air Carrier	25,080,000	24,278,000	-802,000
Air Taxi/Commuter	8,164,000	10,029,000	1,865,000
GA	8,634,000	8,374,000	-260,000
Military	4,178,000	4,071,000	-107,000
Aircraft Hours	318,000,000	273,000,000	-45,000,000

Can We Really Measure Total Organizational Change?

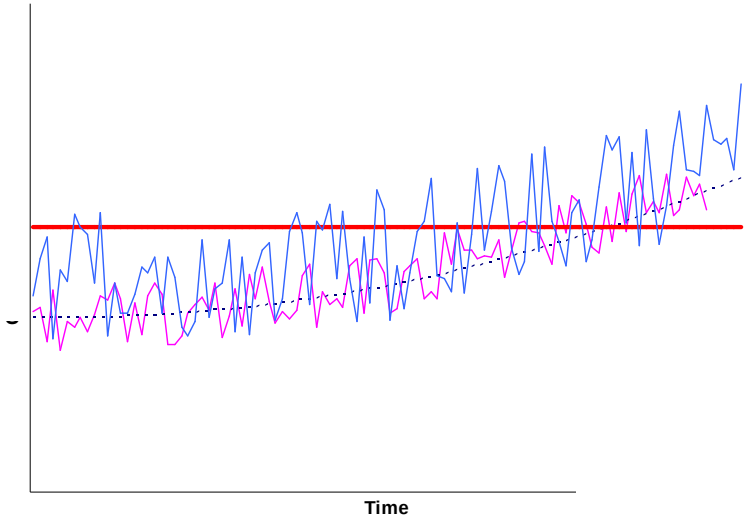


Concepts: Time, Performance Parameters, Baselines, and Trends

Organizations can fluctuate. An acceptable parameter must be established around a baseline.



Trends assist in seeing gradual changes. Drill down into the trend data focuses on specific problem areas.



Avoids the "Boil the Frog" Syndrome

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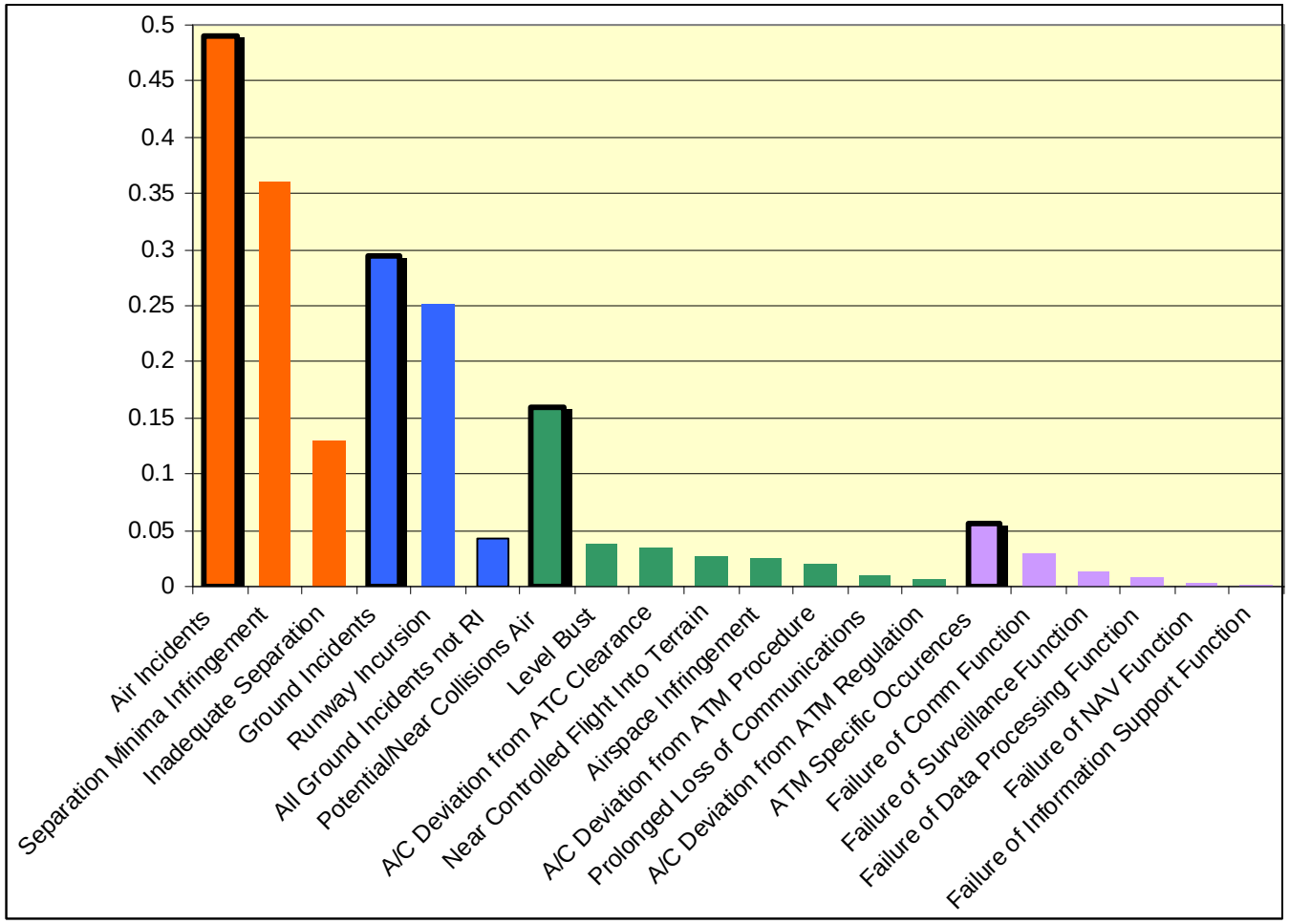
Weights



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The Role of Weighting Factors, Time, and Operations: "Risk Exposure" & Expert Judgment

- **The Denominator~ The Positive Side**

- **Weighting of Factors~**
  - Allows the organization to incorporate quantitative value of expertise and judgment.
  - "Importance" or "influence" or "risk" associated with a data element as perceived by the organizations experts
- **Term "risk" is normally associated with the future. The APF uses lagging indicators from the past to establish a trend line whereby future changes may be inferred.**

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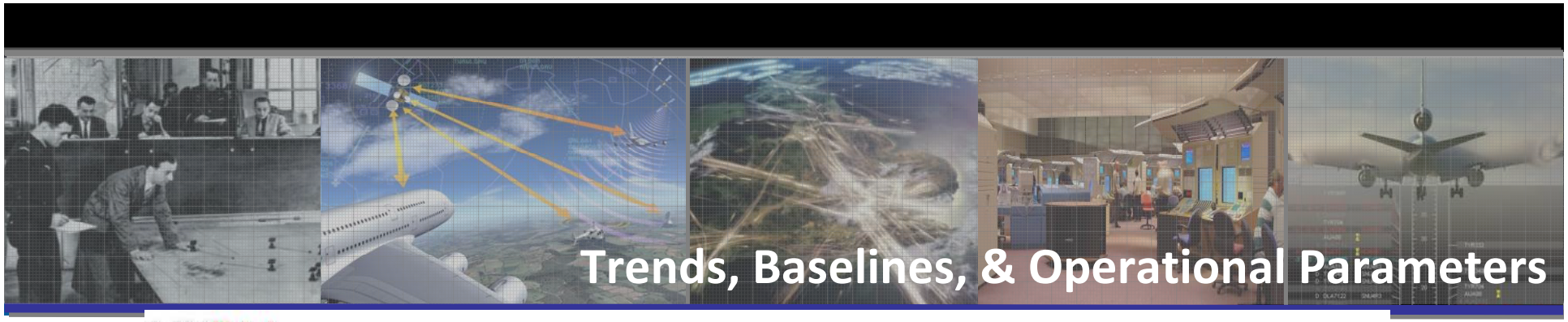


Trends, Baselines, & Operational Parameters

MYFAA
Employee Site

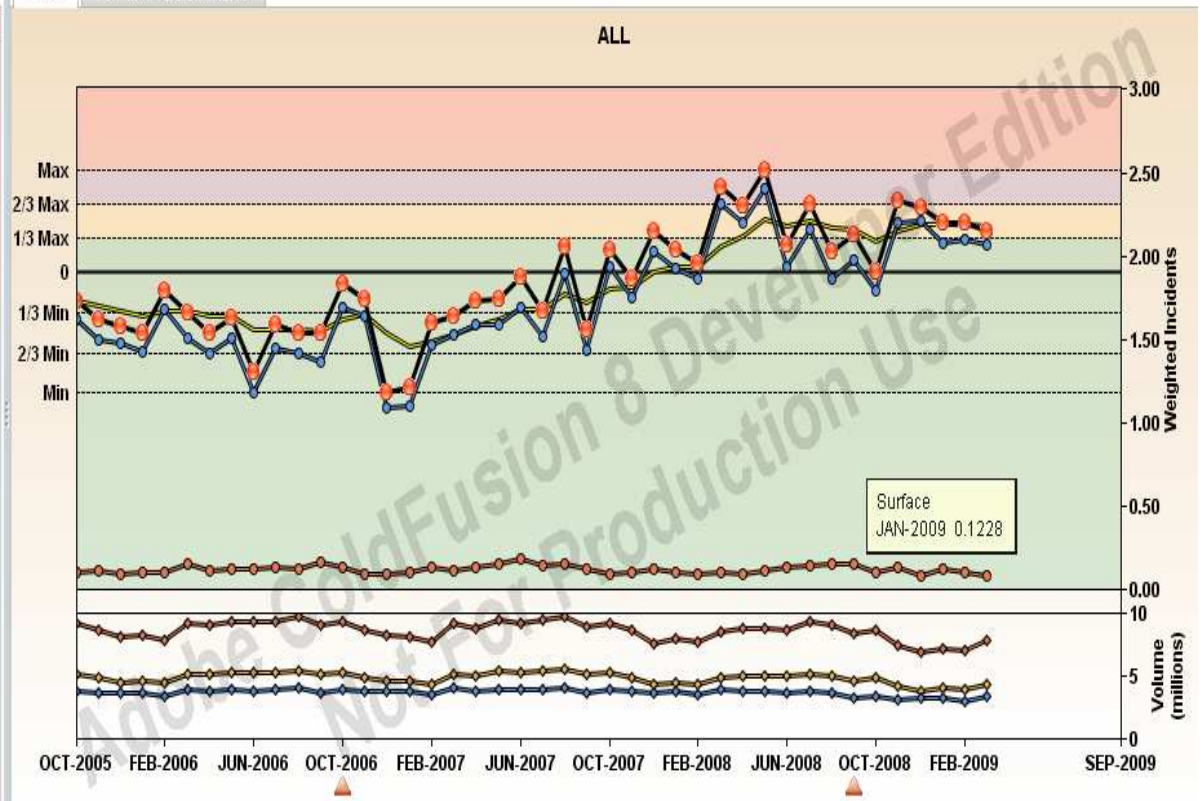
APF Help MyFAA Home

Tree View | Settings

Safety data as of MAR-2009

- All
  - Airborne
    - Operational Errors
      - Terminal
        - Category A
        - Category B
        - Category C
        - Proximity Events
        - Minimum Vector Altitude
        - Flight of Two
        - Operational Deviations
      - Enroute
    - Pilot Deviations
    - Near Midair Collisions
  - Surface
    - Runway Incursions
    - Non-Runway Incursions

Chart | Terms and Definitions



Adobe ColdFusion 8 Developer Edition
Not For Production Use

All

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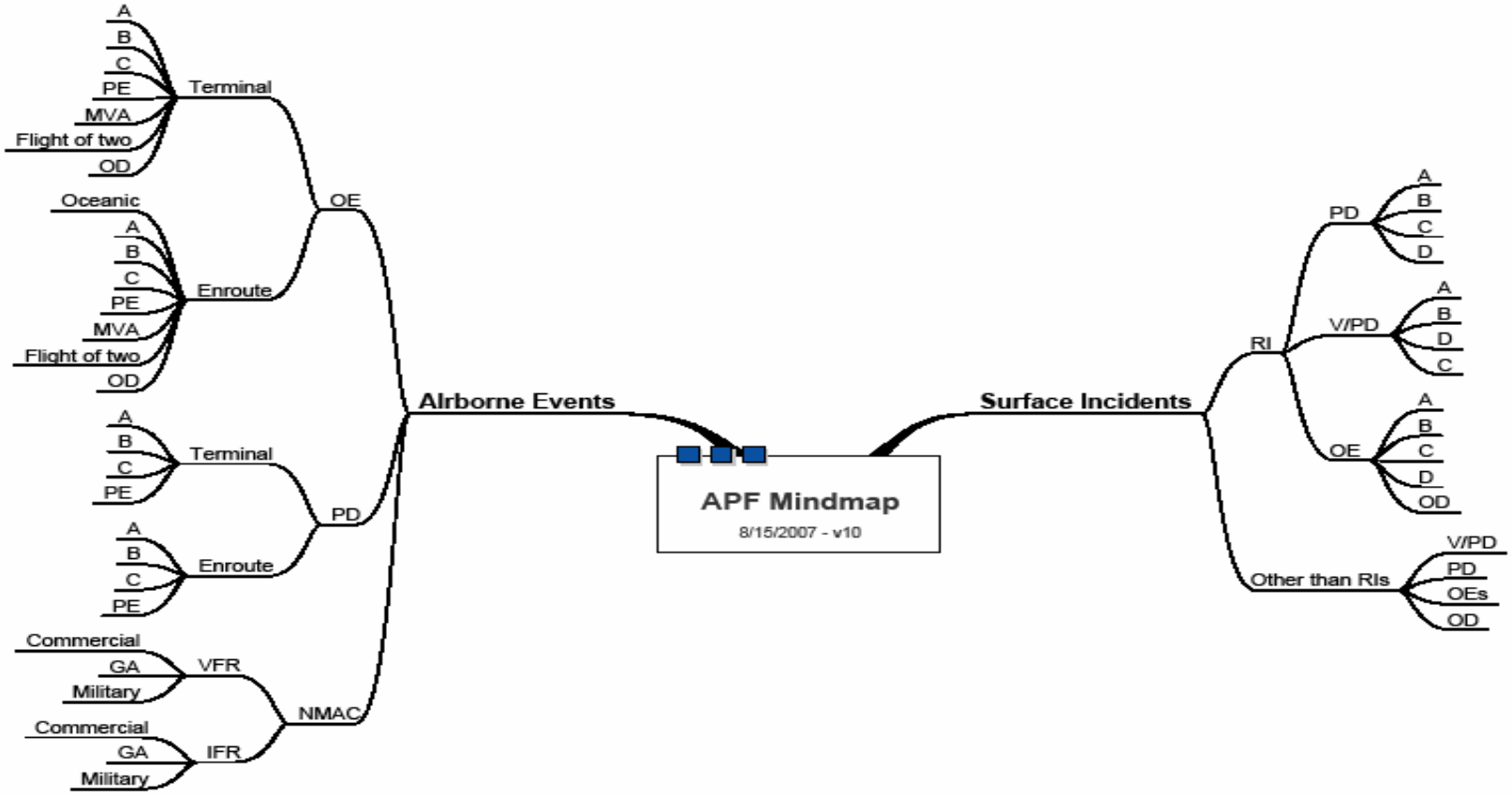
First ATO Mindmap & APF: A Simple Version



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  - Measures intangibles
- Allows for analysis and search for precursors.
- Can function as a model for decision making & is expandable is size and scope.

SAS

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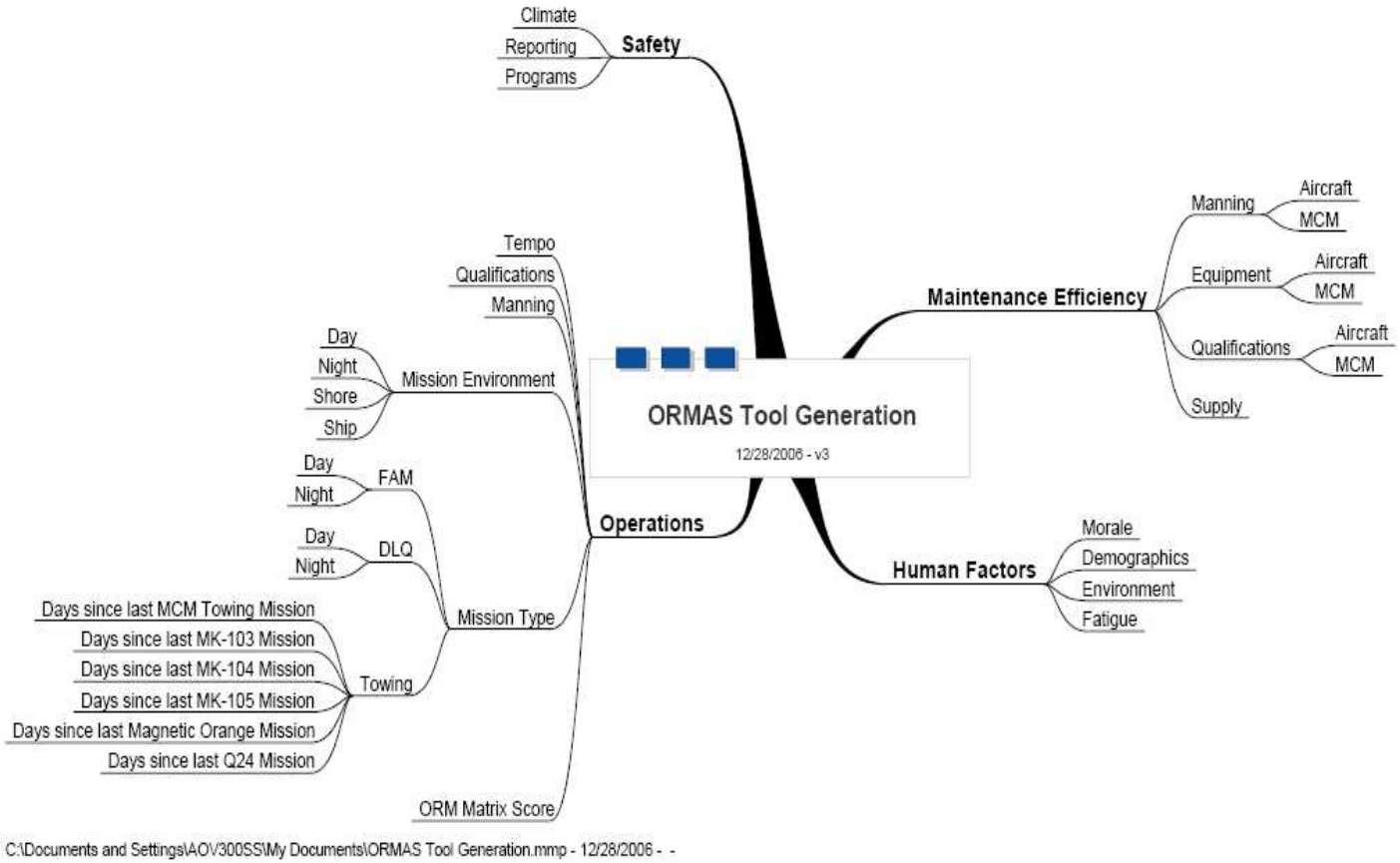
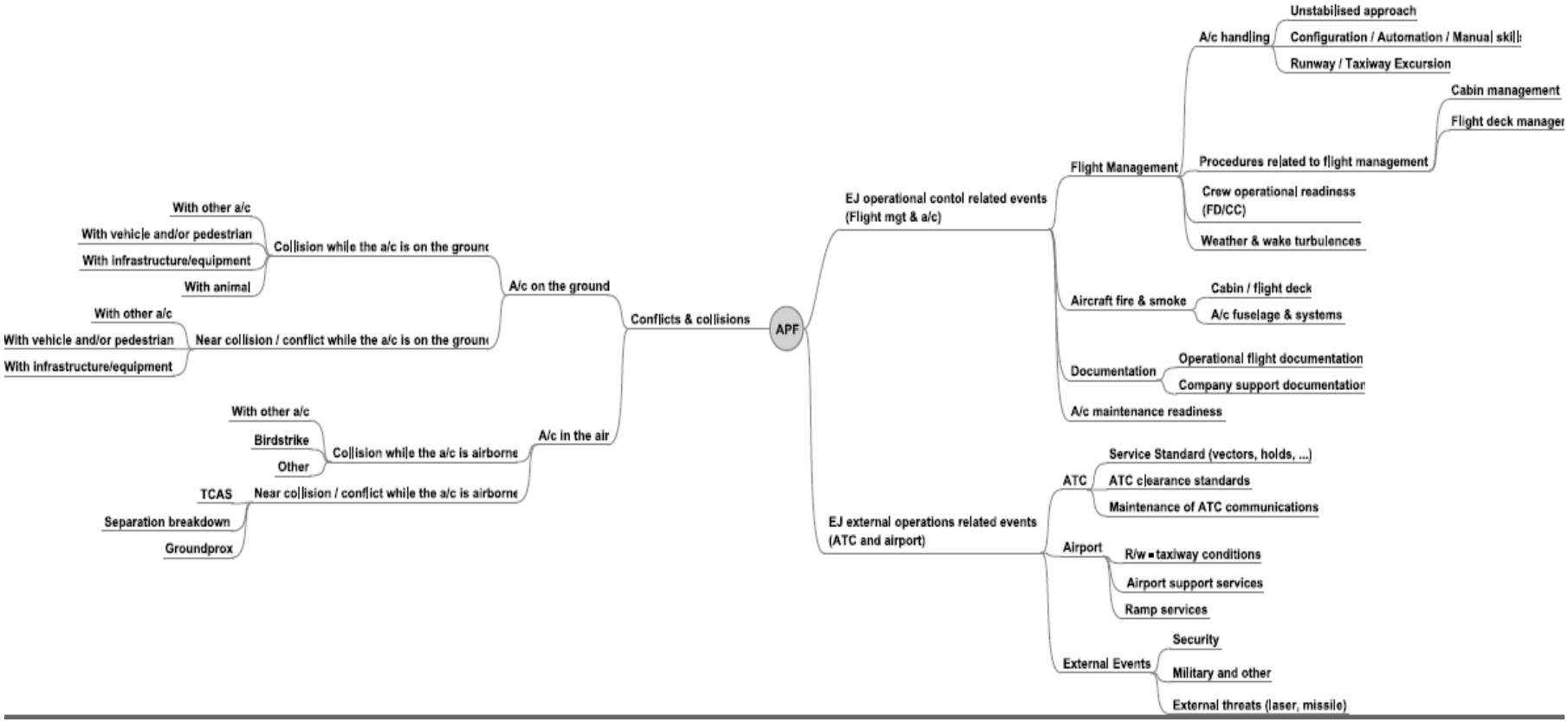
Other AHP application
US Navy Mindmap & Risk Tool-More Complex



EUROCONTROL

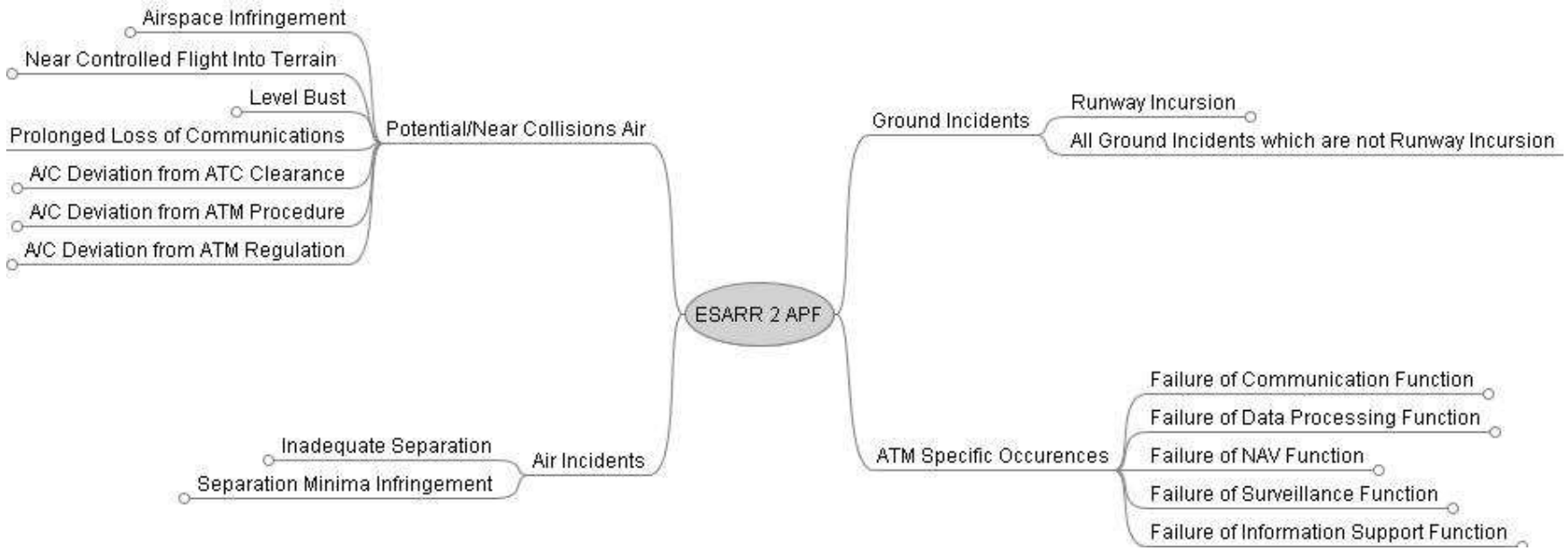
Other AHP application

easyJet Flight Operations Mindmap-Complexity Increasing



EUROCONTROL

Other AHP application
EUROCONTROL MINDMAP
(abbreviated version)



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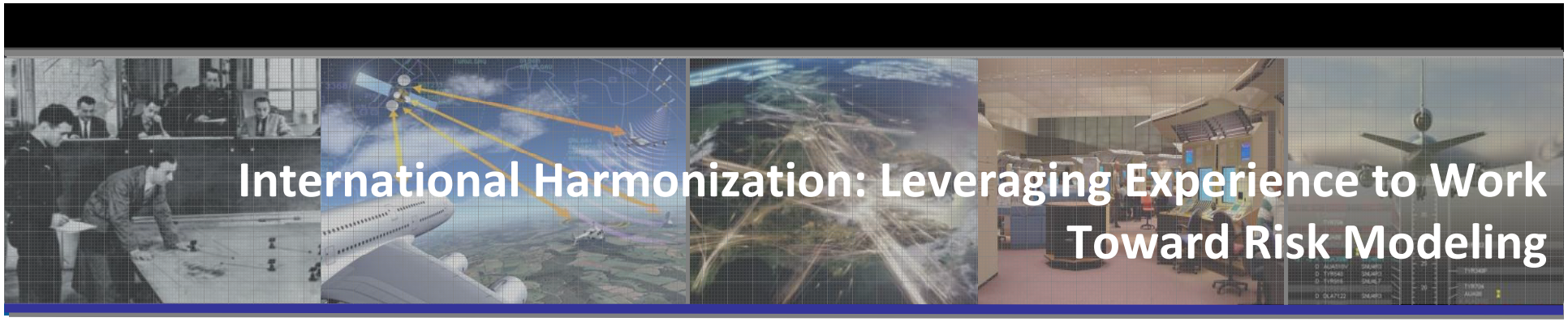

International Harmonization: Leveraging Experience to Work Toward Risk Modeling

- EUROCONTROL
  - Multiple ANSPs involved.
  - 2009 Work Project of EUROCONTROL
  - Using ESSAR 2 measures (safety)
  - Proposed for European deployment as of 2010 within ESP+ Programme
- easyJet Airlines
  - 2nd largest LCC airline in Europe
  - Focused on flight operations measures
  - FDM, FOQA, and other data feeding metric
- Southwest Airlines
  - Most successful LCC in the world
  - Started the process of defining their APF

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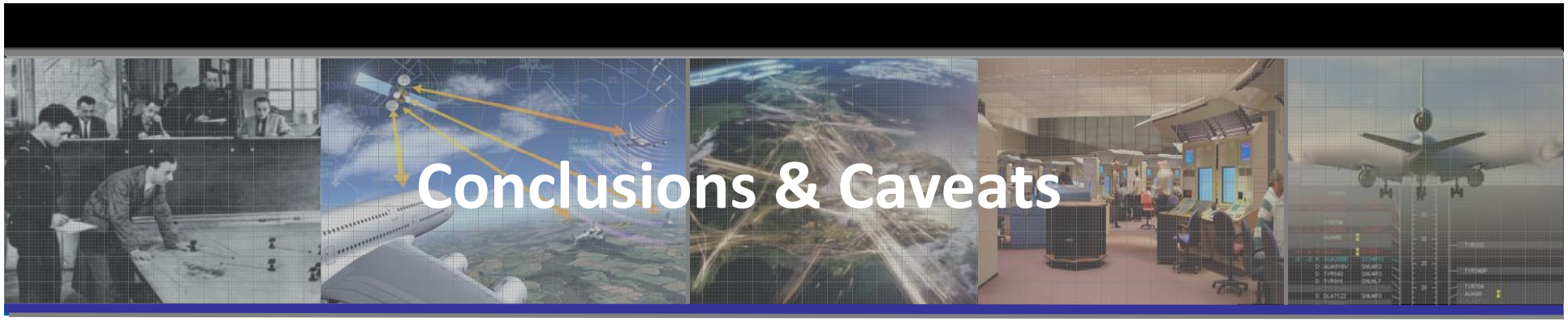

Conclusions & Caveats

- The APF is not a stand alone tool
  - Current measurements must be maintained.
- The APF identifies “what” is happening, “where”, and “when” thru both trending and diagnostics:
  - As additional metrics, with greater granularity, are introduced into the APF, it will enable the quest for “why.”
- The APF *is not* a direct indication of risk.
  - But does reflect the organizations assessment of relative risk within the operation.
- The APF can be used to measure efficiency & effectiveness depending on what measures are used.

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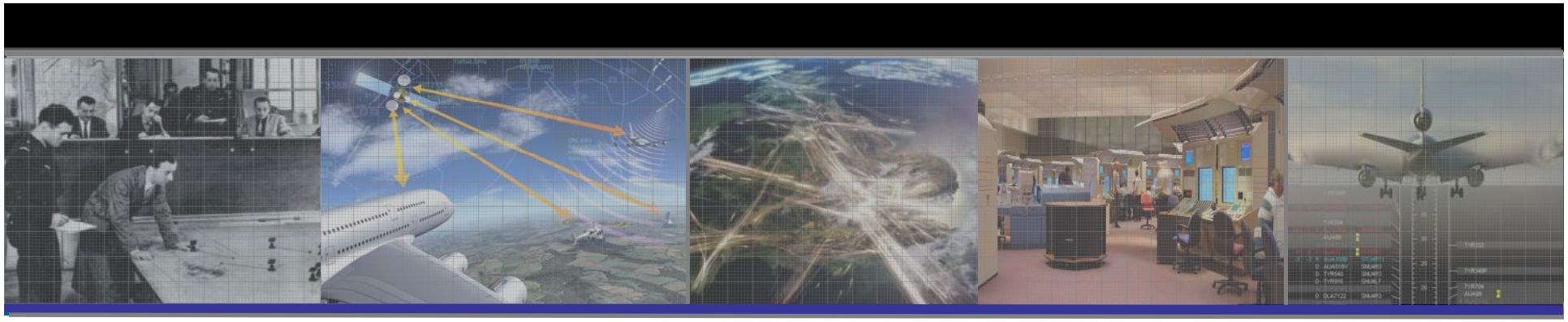
EUROCONTROL