



# The Aerospace Performance Factor (APF)

## *The Next Step In The Evolution Of Safety Management*

Presented:  
June 2010  
Rome, Italy

# Plan Overview: The Next Two Days.



- Day 1:
  - Overview of concepts. What the tool is & what it can do.
  - Introduction to mindmaps & AHP.
  - Understanding Weighting. Non-Aviation demo.
  - Building a mindmap.
- Day 2:
  - Review and Q&A from Day 1.
  - Build individual mindmaps.
  - Actual weighting session.

# ICAO Requirements



- ICAO SMM Ed. 2 (2009) The International Civil Aviation Organisation (ICAO) Safety Management System (SMS) manual Ed. 2 (2009) calls for an airline's SMS to be *systematic*; where the SMS employs a range of safety tools within a 'toolbox' to support hazard identification and safety risk management.
- ICAO SMS manual defines a Reactive, Proactive and Predictive risk capability as:
  - The 'post-hoc' investigation of accidents and incidents;
  - The minimization of system failures by identifying safety risks in the system before it fails and
  - The aggressive seeking safety information by identifying emerging risks from a variety of SMS sources. "Practical drift"

# The Challenge & Solution



- Assesses the impact of many different factors and events into a cohesive measurement tool. Find a reference point (a baseline) to measure “practical drift” via trending.
- Combine *tangible and intangible* elements to determine their *influence* on the overall system.
- APF Methodology- Aerospace Performance Factor: Presents a graphical representation of system data. “Translates” performance data for organizational decision making.

# APF Methodology-What Is It?



- A graphical representation of performance over time based on *historical indicators (lagging) from multiple databases.*
- Presents a *macro, system-wide view of organizational performance.*
- Drills down into data to search for contributing factors.
- Can use safety, operational, and/or equipment measures.
- Does not focus on a single measure to gauge performance.
- Incorporates organizational judgment and experience into equation. We all know not all things are equal-Your judgment makes that allowance.
- Allows for analysis and search for precursors.
- Can:
  - Support decision making.
  - Is expandable in size and scope.
  - Keep an organization “on track”
  - Will always “Follow the data”

How do we define  
“Performance”?

# A Concept of Small Incidents Leading to Trends

(The elementary version of precursors)



## *One concept of aviation 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.

## *One concept of neighborhood security...*

- A policeman drives through a neighborhood and sees a broken window.
- Next day the window is not repaired.
- Following day, another broken window.
- History proves these small events are indicators of change in neighborhood.

# The Role of Data: Measure What You Manage



- All organizations maintain data elements to gauge themselves.
  - Databases are lagging indicators but can infer future trends.
  - Data elements, used individually, are poor representatives of overall performance.
  - Presenting multiple data graphs to Leadership creates, “Death By PowerPoint” and does not answer the question, “So, how are we doing?”

# A Look At “Old” vs. “New” Data Displays

## Here, The “Classic” Data Presentation

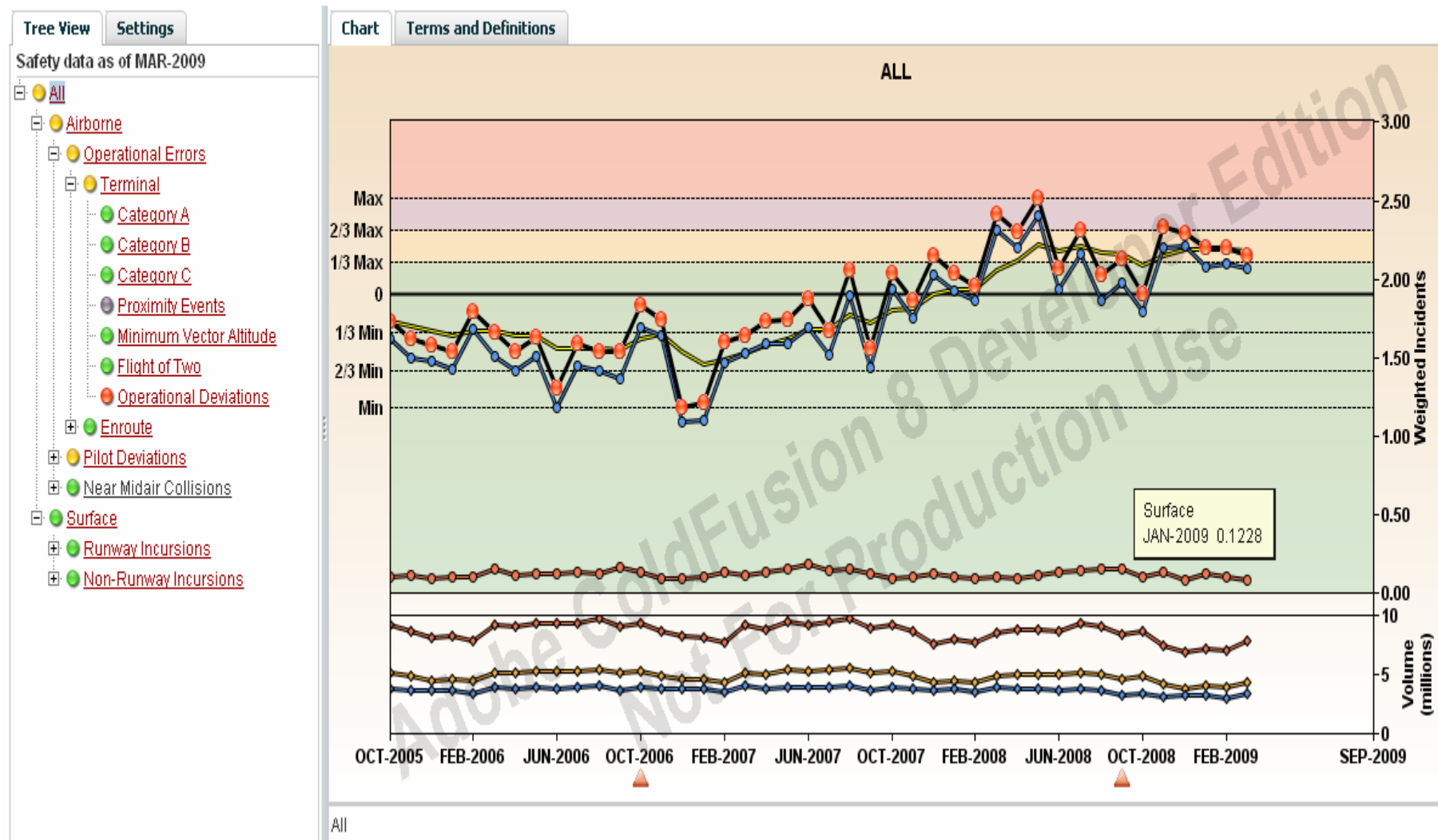


			2000	2004	Difference
<b>Aircraft Accidents</b>					
	Air Carrier		56	29	-27
	Air Taxi/Commuter		92	73	-19
	GA		1835	1614	-221
<b>NMAC</b>					
	PDs		1919	2628	709
	OE		1139	1216	77
	VPD		547	263	-284
<b>Surface Incidents</b>					
	Runway incursions		426	310	-116
<b>Aircraft Operations</b>					
			46,056,000	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
<b>Aircraft Hours</b>					
			318,000,000	273,000,000	-45,000,000

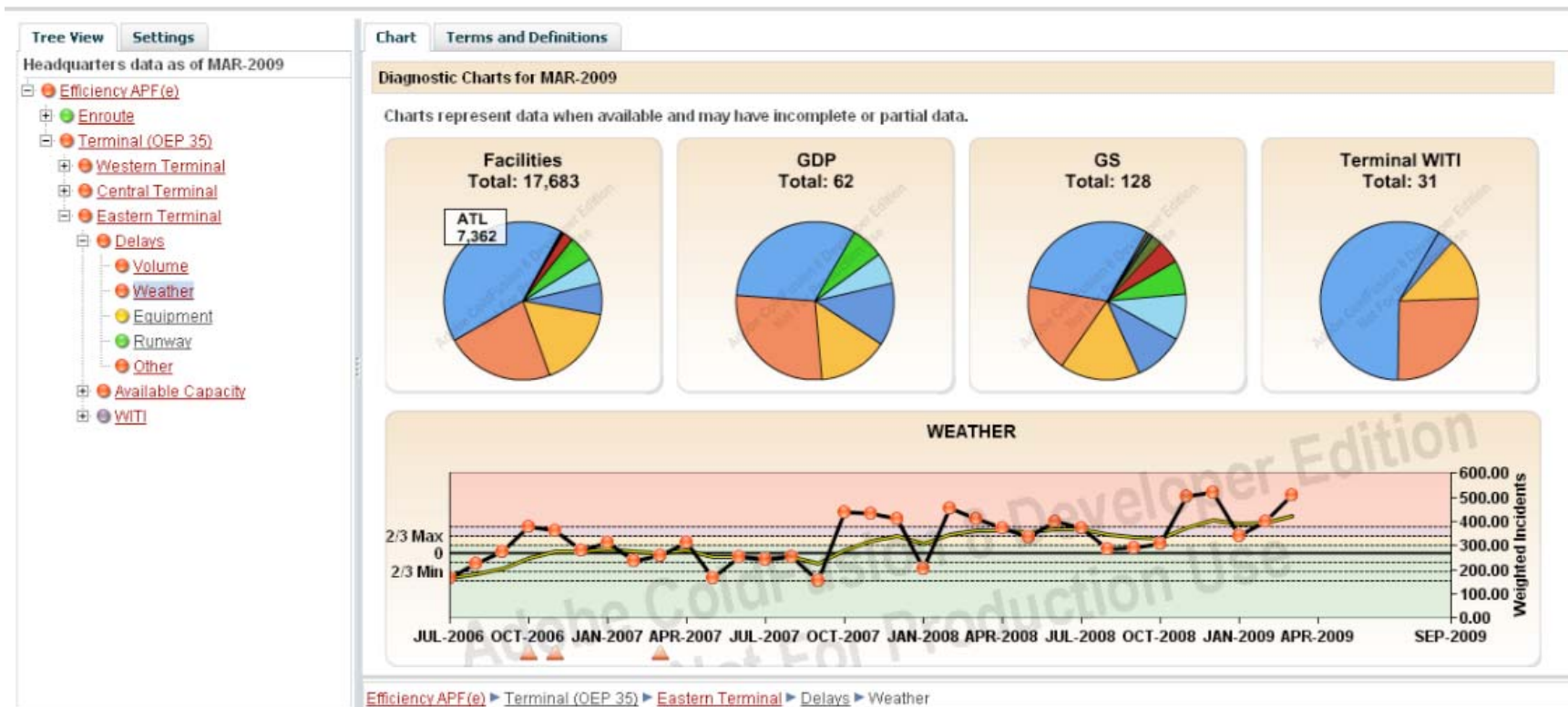
Can We Really Measure Total Organizational Change?



# An Example Of The “New” Data Display Methodology



# From Trending to Diagnostics & Drill Down: How the APF Presents Selected Raw Data



# The Role of Data: Manage What You Measure



- APF Methodology requires certain data characteristics:
  - Known values;
    - organizations must be comfortable with the data.
  - Known definitions;
    - organization must know what it means.
  - “Decent” amount of data to support trending;
    - 1-2yrs worth only gets us started.
    - 3-yrs is a realistic minimum for initial trending.
    - More always better than less.

# US Navy ORMAS Risk Tool: Based on APF Concepts

Flight Schedule

Command: HM-14

Aircraft Type: MH-53E

Squadron: AWSTS

Assigned Aircraft:

Date: August 2007

Sun	Mon	Tue	Wed	Thu	Fri	Sat
29	30	31	1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	1
2	3	4	5	6	7	8

Today: 6/17/2008

	Rise	Set	Illum
Sun	0634	1937	
Moon	2048	1012	96%

Schedule

Mission

Personnel

Weather

Execution

	Position	Crew Assignment	Note	Signoff	1	2	3	4	5
	HAC	Whetstone, David W., LT, USN (AWSTS)							
	C/P	Pope, Joseph W., LTJG, USN (AWSTS Students)		TAC 155					
	C/P	Gross, Joshua W., LTJG, USN (AWSTS Students)		TAC 155					
	C/P	Snyder, Sean C., LTJG, USN (AWSTS Students)		TAC 154					
				TAC 155					
	C/P	Bahr, James D., LCDR, USN (AWSTS Students)		TAC 155					
	CC	Lopez, Rodolfo, AWC, USN (AWSTS)							
	Crew	Duchaine, Timothy J., AW2, USN (AWSTS)							
	Crew	McCracken, Sharon E., AWAN, USN (AWSTS Students)							

Events

Rows: 2

Columns: 3

A/C #1	A/C #2	A/C #3
1	2	3
4	5	
	6	
A/C #4	A/C #5	
7	8	

New

Delete

Duplicate

Reports

Timeline

Risk Report

Schedule

ODO Report

Risk Score

Crew Experience: 3

Human Factors: 2

Crew Rest: 3

Mission: 4

Crew Day: 5

Weather: 5

Last Flight: 1

Operating Area: 3

Recovery Time: 3

Mission Factors: 3

Overall: 1

CO approval required

Personnel Risks

Name	MF	Total Hrs	TMS Hrs	DLQ	FCLP
Whetstone, David W., LT, USN		729.5	330.6	No data	9/09/04
Pope, Joseph W., LTJG, USN		N/A	No data	N/A	N/A
Gross, Joshua W., LTJG, USN		N/A	18.6	N/A	N/A
Snyder, Sean C., LTJG, USN		N/A	No data	N/A	N/A
Bahr, James D., LCDR, USN	DH	N/A	No data	N/A	N/A
Lopez, Rodolfo, AWC, USN		83.0	N/A	No data	No data

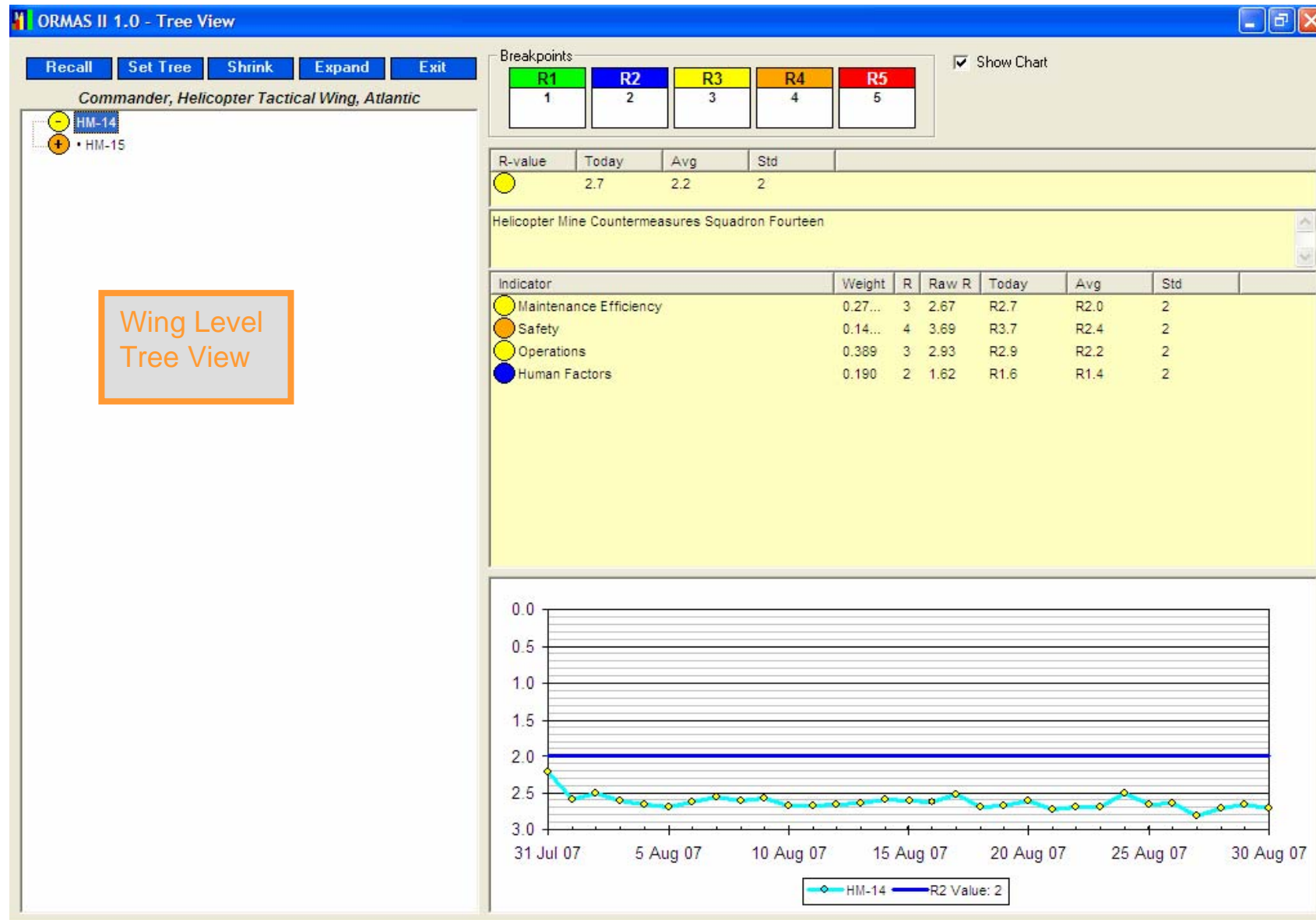
OK

Cancel

Apply

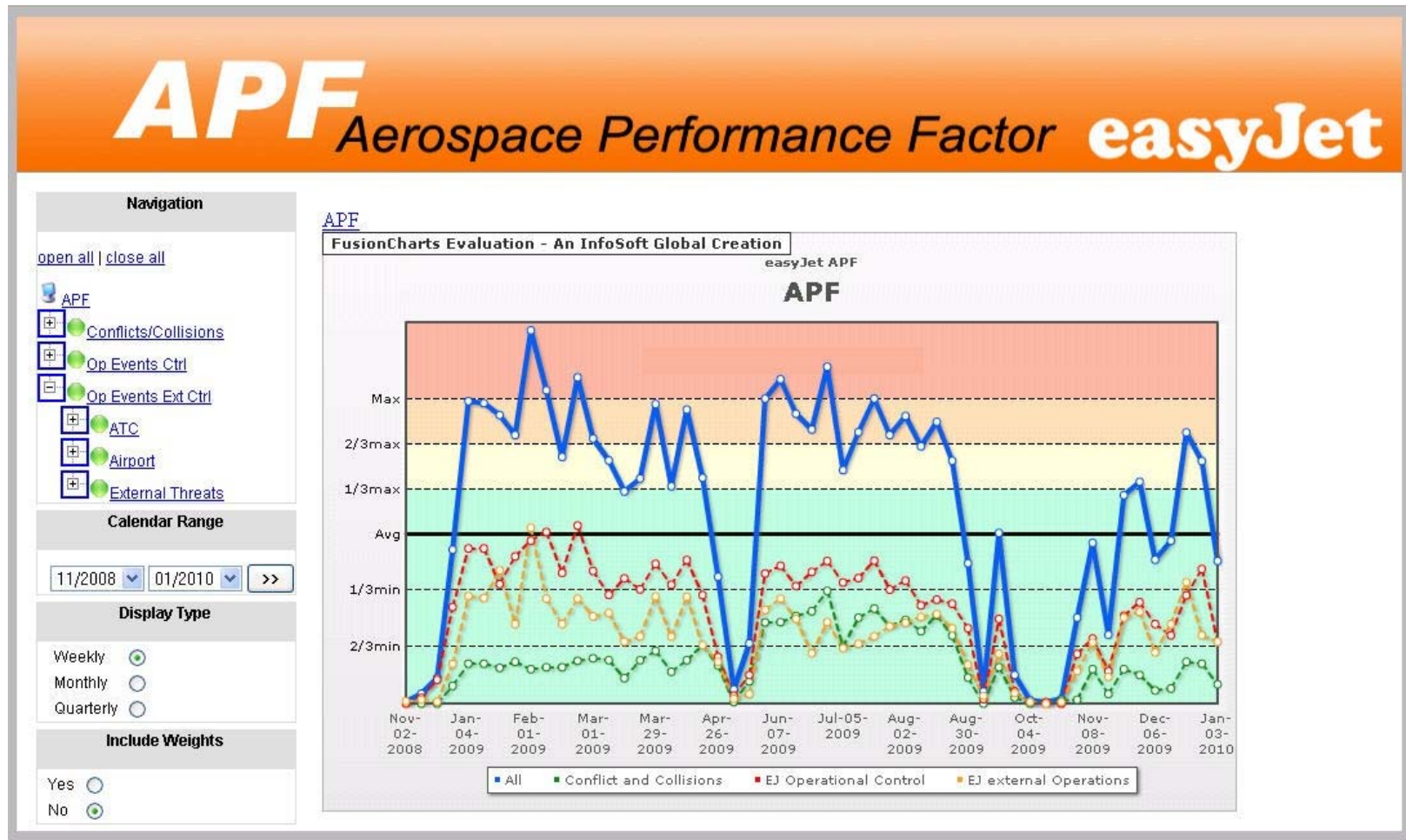
Revert

# US Navy ORMAS Risk Tool: Based on APF Concepts





# Airline Use of APF Methodology (Trial Data)



# Can We Build Something Like That?

## Yes! Here's How-



- Determine the goal. What are we measuring?
  - This is the foundation of the APF
- Determine what data we will use.
  - This is the “Clean Sheet of Paper Exercise”
- Construct a mindmap.
  - This is the magic part.
- Develop the weighting factors.
  - This is the science part.
- Put it all together.
  - This is the breakthrough.

# Listing Elements: “The Clean Sheet of Paper” Later: Determining Weighting Values



Airprox  
Groundprox  
Wake Turbulences  
Birdstrike  
Movement  
Wind and Windshear  
Runway/Taxiway Excursion  
Separation Issue  
TCAS  
Crew Illness - Injury  
Unstabilized Approach  
Icing  
Propulsion - Engine  
Under-carriage  
Fuselage  
Vehicle and/or Pedestrian  
Infrastructure  
Take off or Landing Clearance Issues  
Level Bust  
Insufficient Visual reference  
Security  
Non-Movement area  
Lightning  
Flight Plan  
Company and Engineering  
Weather  
Weather/Other  
Procedures  
Communication  
Bird - Damage  
Crew Fatigue - Stress  
ATC Services Standard  
Violation  
Configuration/Automation/Manual Skill  
Runway Conditions  
Military and Other  
APU  
Pushback Clearance  
Limited or No Communication  
Other Animal Strike

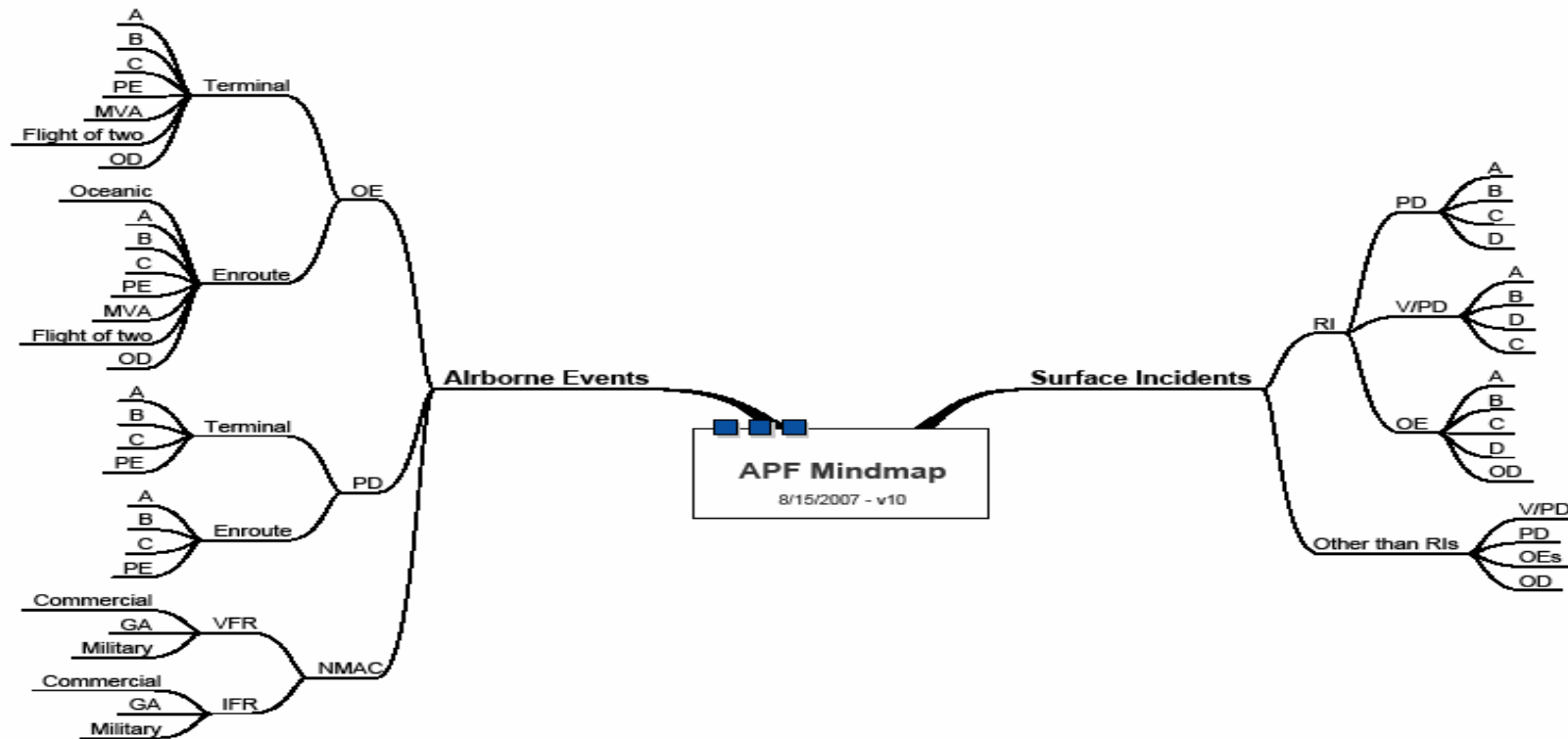


# Mindmaps: The Magic Part

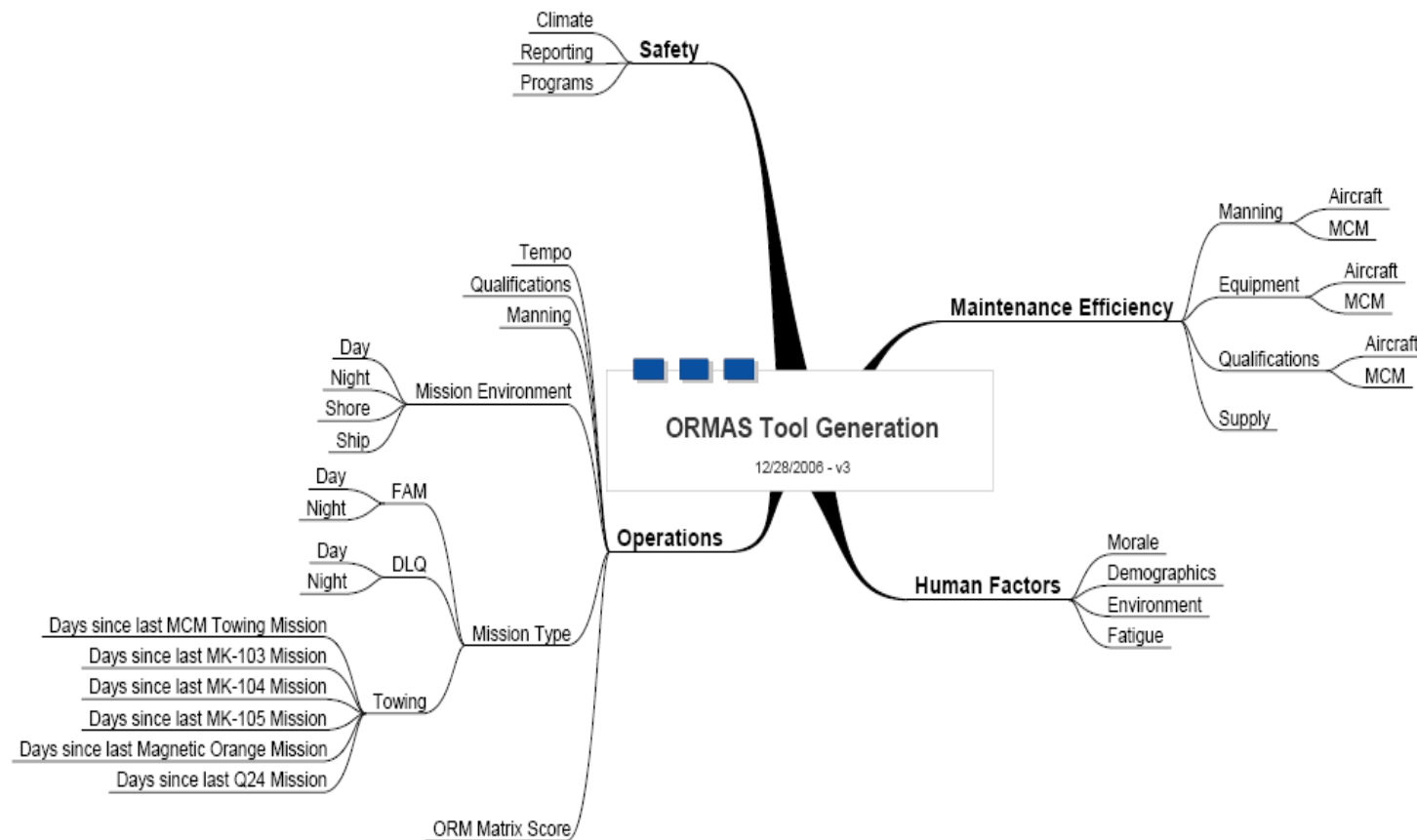


- This is where data is first grouped together.
  - Sort data based on relationships
- Relationships identified.
  - Based on goal of APF
- Underlining design of the APF is determined.
  - Establish format of how we want to see data
- Basic data vetting begins.
  - Is there enough data to trend or not?

# First ANSP (FAA) Mindmap; Development Of A Simple Version



# First US Navy Mindmap: More Complex

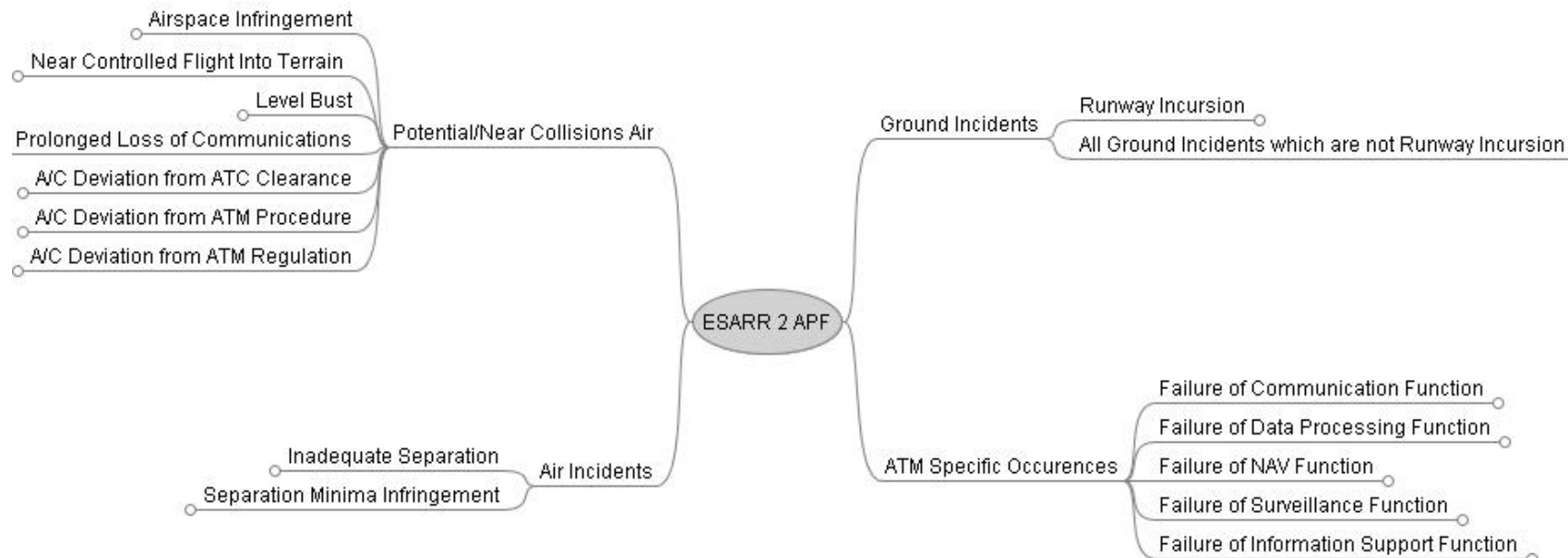


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# Current EUROCONTROL Mindmap

## Best Design To Date

Note The Symmetrical Shape:



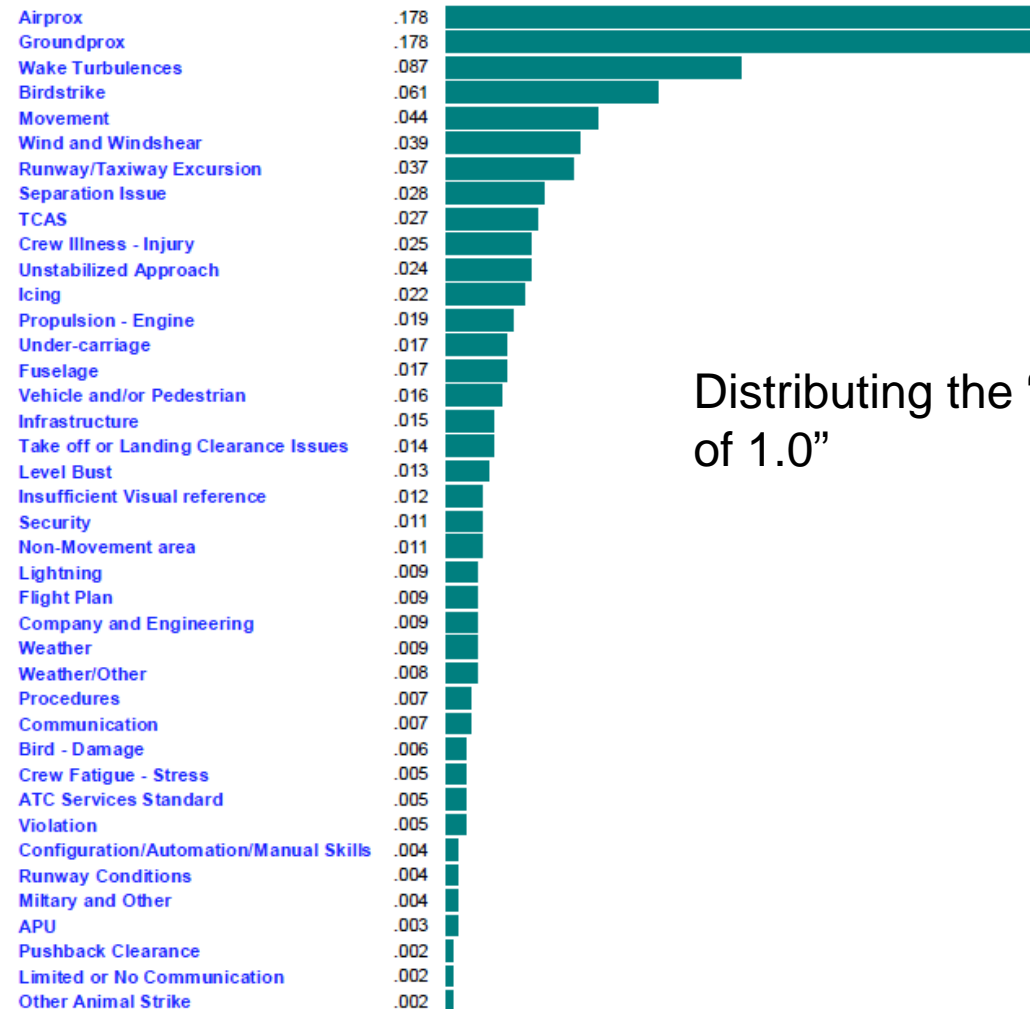
# Develop Weighting Factors With Experts

## This Is The Science Part



- Weighting of Factors:
  - Allows the organization to incorporate quantitative value of expertise and judgment.
  - Develops numerical value (that will be used as a coefficient) of “Importance” or “risk” or “influence” associated with a data element as judged by the organizations experts.
  - Distributes the “Value of 1.0” throughout the mindmap creating priorities (or weights). See next slide as example!

# Subject Matter Experts Determine the Weighting Values



Distributing the “Value  
of 1.0”

# Weighting the Data Elements

## The Analytic Hierarchy Process (AHP)



- AHP- Originally designed as a decision making process using input from many people.
- Developed by Dr. Thomas Saaty to use multiple factors involved in complex decisions.
- A “blend” of mathematics and the psychology of measuring intangibles.
- Uses a hierarchy (same as a mindmap) and pair-wise comparisons.
- For additional reading (easy versions) go to [http://en.wikipedia.org/wiki/Analytic\\_Hierarchy\\_Process](http://en.wikipedia.org/wiki/Analytic_Hierarchy_Process)

# The Analytic Hierarchy Process (AHP)



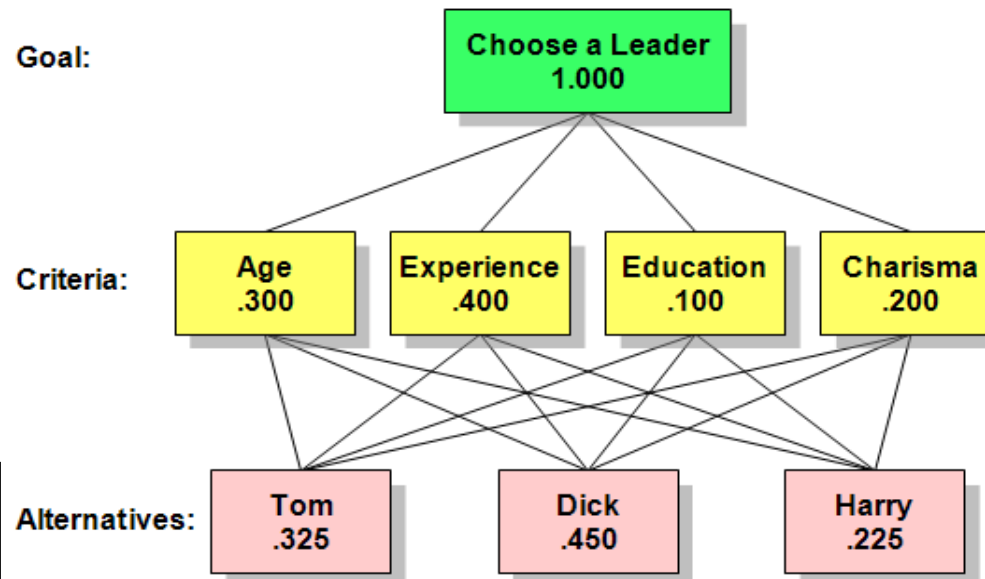
- APF uses a “simplified” version of AHP techniques to gather expert opinions for weighting.
- It is not used as a “multi criterion decision tool” but does use the pair-wise comparison process to determine weights within the hierarchy shown in a mindmap.
- Since no decisions are made, there is no assessment of “alternatives.”
- Examples to follow:



# Example 1: Classic AHP



## AHP: Selecting a Leader

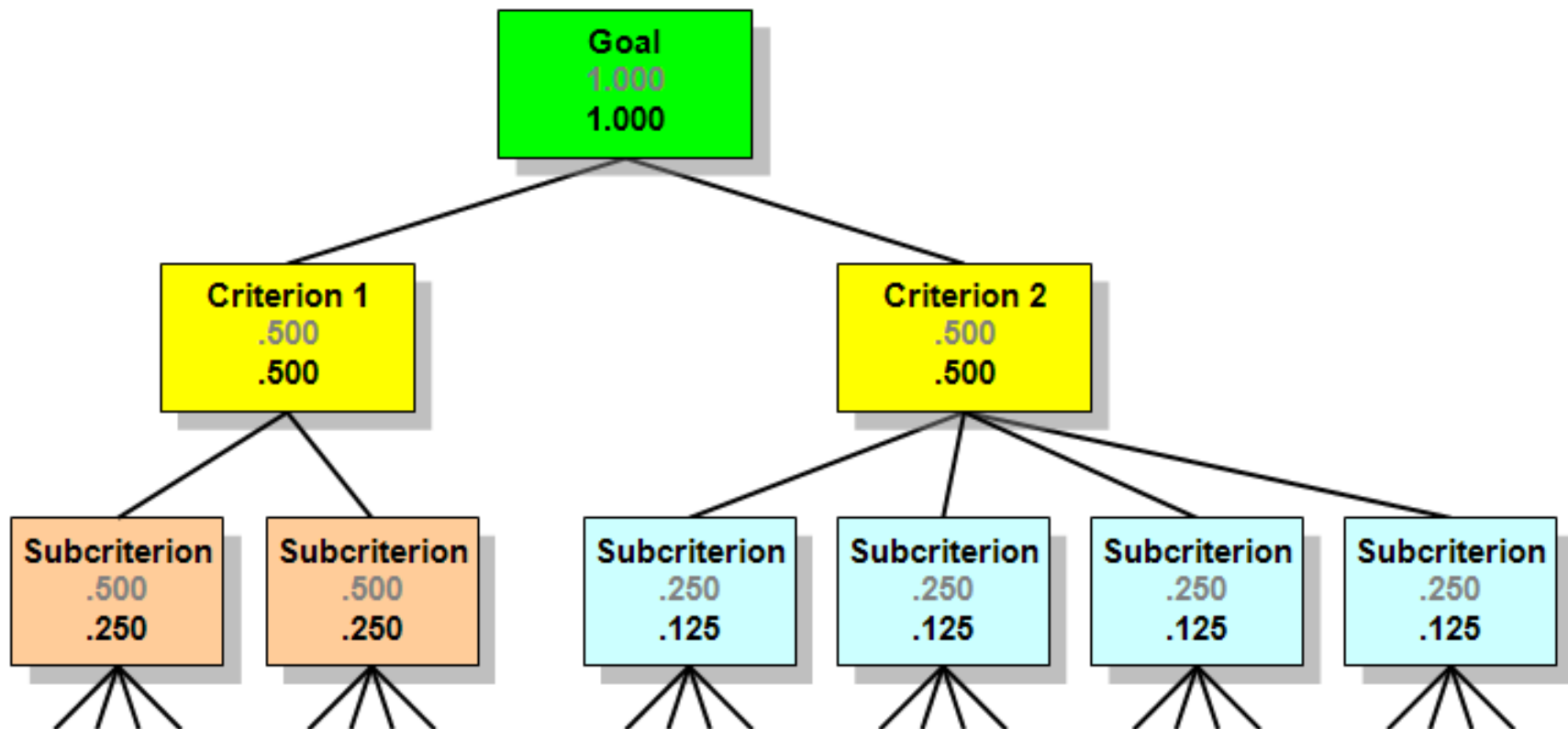


Alternatives not  
used by APF!

## Example 2: More Complex Mindmap



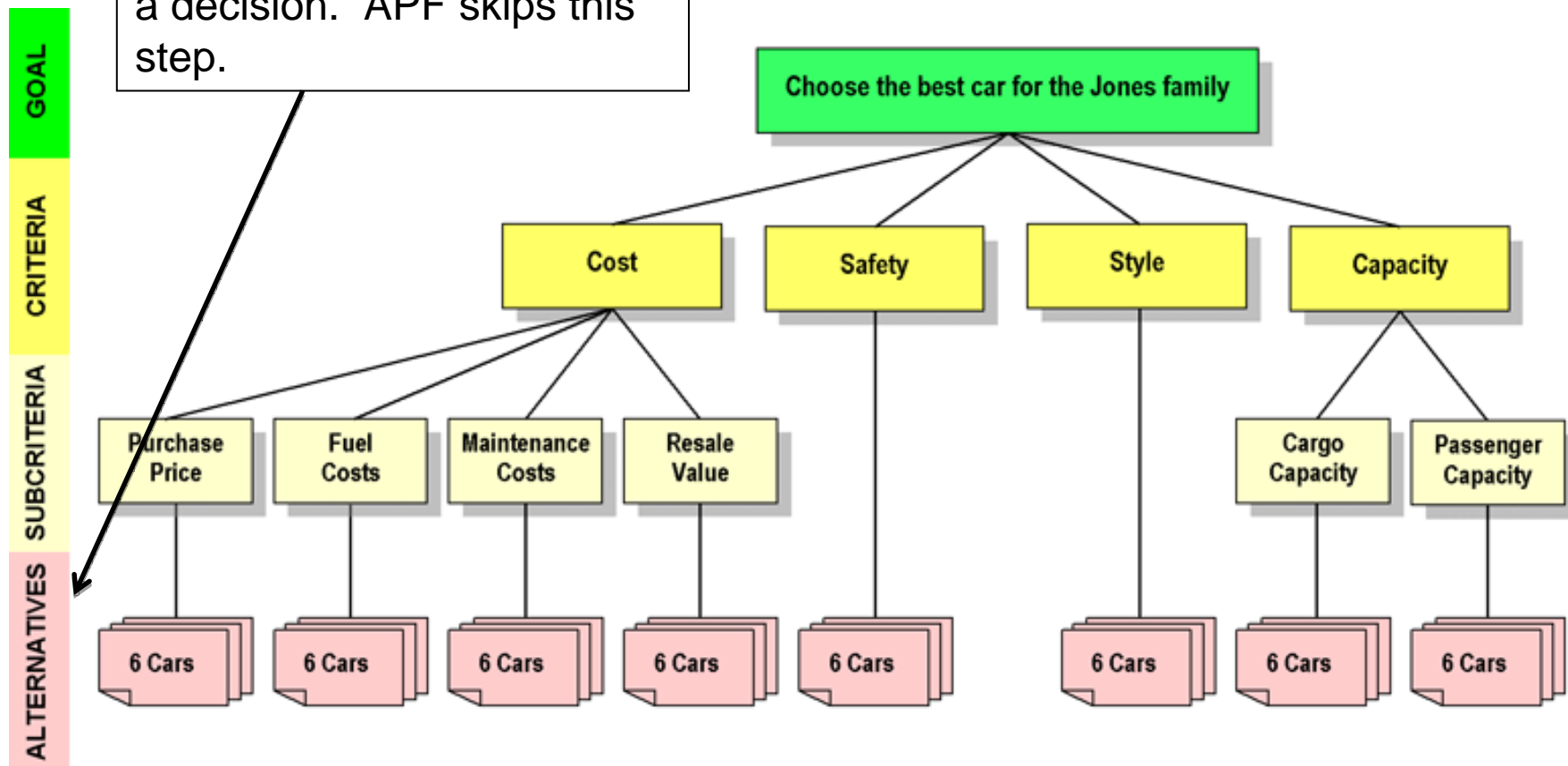
Local Weights & Global Weights



# The Classic Car Example



Remember, Alternatives are only used if you are making a decision. APF skips this step.



# Subjective Terms vs. Numbers



The Fundamental Scale for Pairwise Comparisons		
Intensity of Importance	Definition	Explanation
1	Equal importance	Two elements contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one element over another
5	Strong importance	Experience and judgment strongly favor one element over another
7	Very strong importance	One element is favored very strongly over another; its dominance is demonstrated in practice
9	Extreme importance	The evidence favoring one element over another is of the highest possible order of affirmation
Intensities of 2, 4, 6, and 8 can be used to express intermediate values. Intensities 1.1, 1.2, 1.3, etc. can be used for elements that are very close in importance.		

# Consistency vs. “Inconsistency”



- Consistency simply means your answers are following the same relative pattern:

Consistency = If  $A > B$  and  $B > C$ , then  $A > C$

Inconsistency = If  $A > B$  and  $B > C$ , you answer  $C > A$

- Inconsistency can happen for a number of reasons: (1) Getting “lost” in the mindmap; (2) “clicking” in the wrong direction, (3) unclear definition.

# The Mechanics of How Experts (You) Use Pairwise Comparison



Evaluate Project — APF(ARTCC) [svs6km8h] - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Home Search Favorites Print Mail

Address: https://core.expertchoice.com/Project/Evaluate/Default.aspx

English

Navigation

**Task:** Consider "System Efficiency".

- Which of the two objectives displayed, "Facility Resources" and "Facility Equipment", is more important with respect to "System Efficiency"?

**System Efficiency**

Facility Resources

Facility Equipment

Extremely Very strongly Strongly Moderately Equal Moderately Strongly Very strongly Extremely

Erase Judgment

Navigation Box

Steps: 1 2 3 4 5 6 7 8 9 ... 93 Evaluated: 77/77

Next Unassessed

Previous Next

Auto advance

Logged in as: Tom Lintner (Account Manager, FAA Workgroup)  
Current project: APF(ARTCC) [svs6km8h]

Core version: 2009.3.0.523.2429  
Powered by Comparison Suite © 2007-09 Expert Choice, Inc.

Done

start Thomas Lintner - Inb... Evaluate Project — A... EC 1.bmp - Paint

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# Obtaining Feedback As You Go



Evaluate Project — APF(ARTCC) [svs6km8h] - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Home Search Favorites Refresh Print Mail Print Mail Print Mail

Address <https://core.expertchoice.com/Project/Evaluate/Default.aspx> Go

comparison SUITE English

Navigation

**Task:** Review your results

- You have completed prioritizing your objectives with respect to "System Efficiency ". Review your results below to ensure they make sense to you. If not, you may navigate back to the previous judgments to edit them.

**Priority of Objectives for 'System Efficiency '**

Name	Participant results ▾	Graph Bar
Facility Resources	59.36%	<div></div>
Facility Equipment	24.93%	<div></div>
Facility Constraints	15.71%	<div></div>

Inconsistency ratio: 0.05

**Navigation Box**

Steps: 1 ... 4 5 6 7 8 9 10 ... 93 Evaluated: 77/77

Next Unassessed

Previous Next

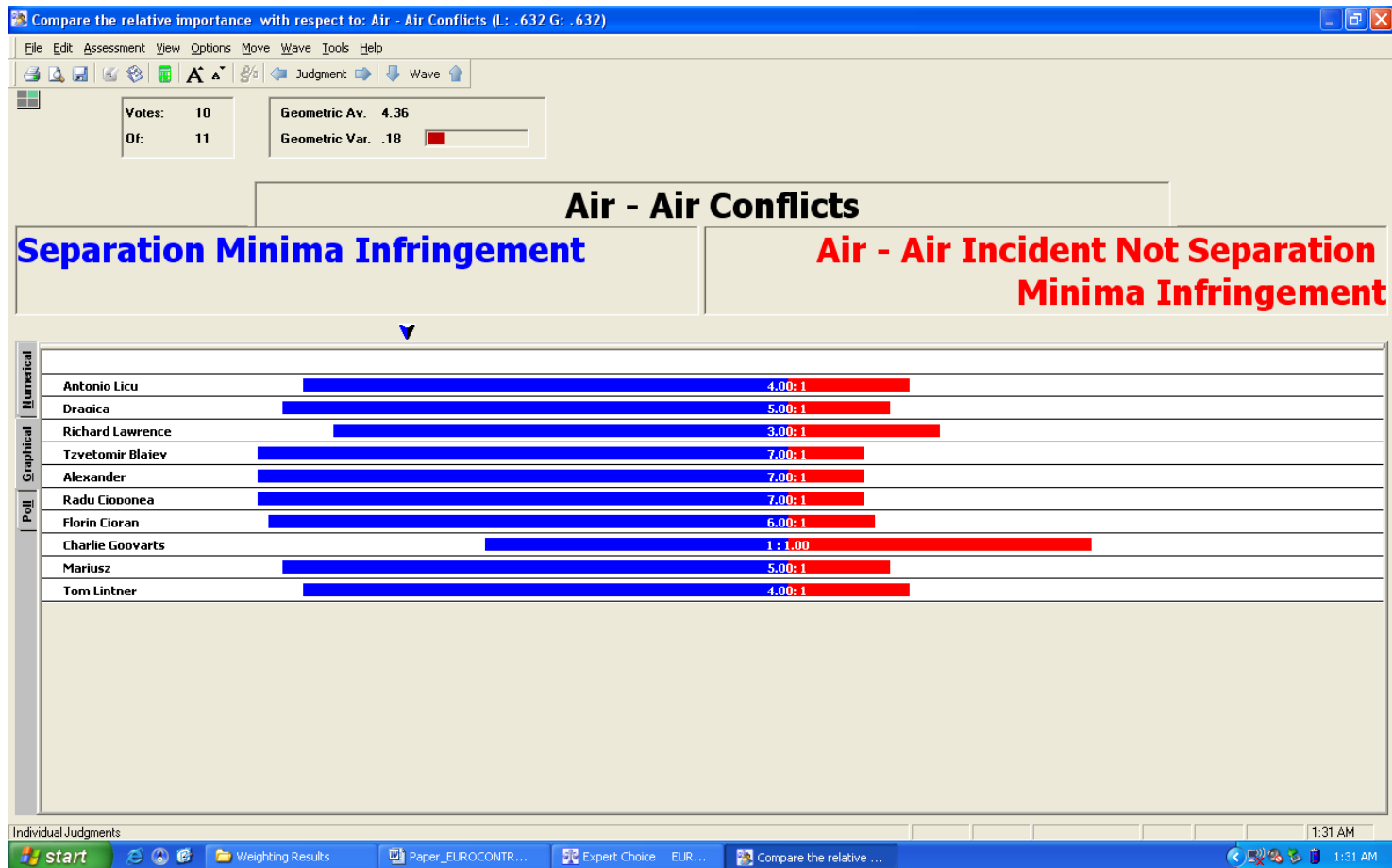
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Core version: 2009.3.0.523.2429  
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Done

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# Group Results- A Combination of Expertise





# Observations Before the Practice Exercise

Recall that....



- The APF is not a stand alone tool and current measurements must be maintained.
- The APF identifies “what” is happening, “where”, and “when” thru both trending and diagnostics:
  - **This allows for focus of resources to identify problem area.**
  - **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.**

# Starting the Practice Weighting Exercise



- Determine the goal question.
  - The group develops and agrees on question.
- Review the mindmap (keep a copy close by).
  - You will get “lost” in the pair-wise combinations.
- Go with your instinct!!! Shoot from the hip!!!
  - Don’t think and debate with yourself! Depend on your experience!
- Understand “Inconsistency”
  - We’ll discuss..it’s important but don’t drive yourself crazy
- Enjoy the post-exercise discussion!
- Agree on results!

# Overview Of AHP Process



- Important Aspects For A Car (Goal)
- Body Type (Element)
  - 2-Door (sub criteria)
  - 4-Door (sub criteria)
- Engine Type
  - Gasoline
  - Diesel
- Transmission Type
  - Manual Transmission
  - Automatic Transmission
- Manufacturer Type
  - European Manufacture
  - Asian Manufacture