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Identifying and Utilizing Precursors

From Data to Products … Revisiting Key Concepts

Scope

- Sharing observations and lessons-learned :
  - Issues and perspectives in identifying and using precursors
- Sharing resources (Appendix 1 thru 3) :
  - Incidents / accidents, safety models, operating assumptions, risk factors, precursors, defenses / controls

Objective

- Elicit questions and answers :
  - How does this apply to my company / organization / operation ?
  - How do we achieve this objective, in a similar or equivalent manner ?
  - Where and how could we do more in identifying, analyzing and using precursors ?

Prevention … a Shared Challenge

Safety	=	***Aircraft***	+	***Operation***	+	***Operating Environment***
		Manufacturer	+	***Airline***	+	***State***
		Design ***Manufacturing*** ***Operations*** ***Maintenance***	+	***Regulatory Compliance*** ***Quality & Safety Management***	+	***Regulations*** ***Regulatory Oversight*** ***Infrastructures*** ***Air Traffic Management***

Prevention … in a Nutshell

- Awareness of hazards and risks (severity / probability)
- Identification of hazard-related risk factors (threats)
- Understanding of causal sequences / causality chains :
  - Causes of known types of event
  - Precursors of potential types of event
- Development and deployment of hazard-related interventions :
  - Defenses (prevention)
  - Controls (detection / recovery / mitigation)

Risk Reduction … a Multi-Facet Effort

- Operational risks :
  - Hazard-related risks (permanent risk factors / threats)
  - Risk level variation with changing conditions
- Systemic risks :
  - Cross-boundary risks (owned, shared, incurred)
  - Change-induced risks

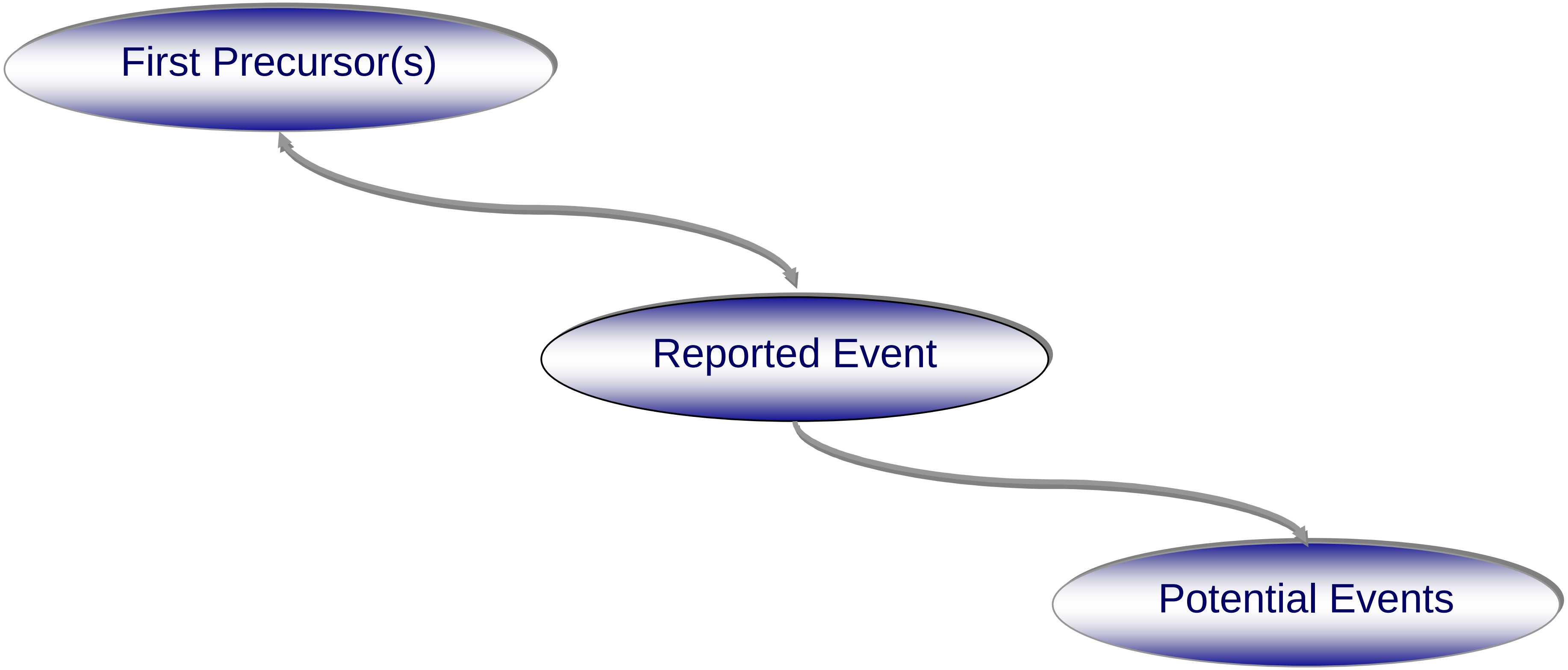
Defining Precursors

- Precursors (weak signals, early warnings, tremors …) of incidents / accidents may be found in :
  - Uneventful occurrences, that might have a more severe outcome
  - Inconsequencial deviations from flight path or procedures, that might result in undesired conditions
- Context and circumstances are critical pre-conditions
- Precursors usually are :
  - Known but … so far … ignored conditions
  - Unknown conditions, not detected by past analysis

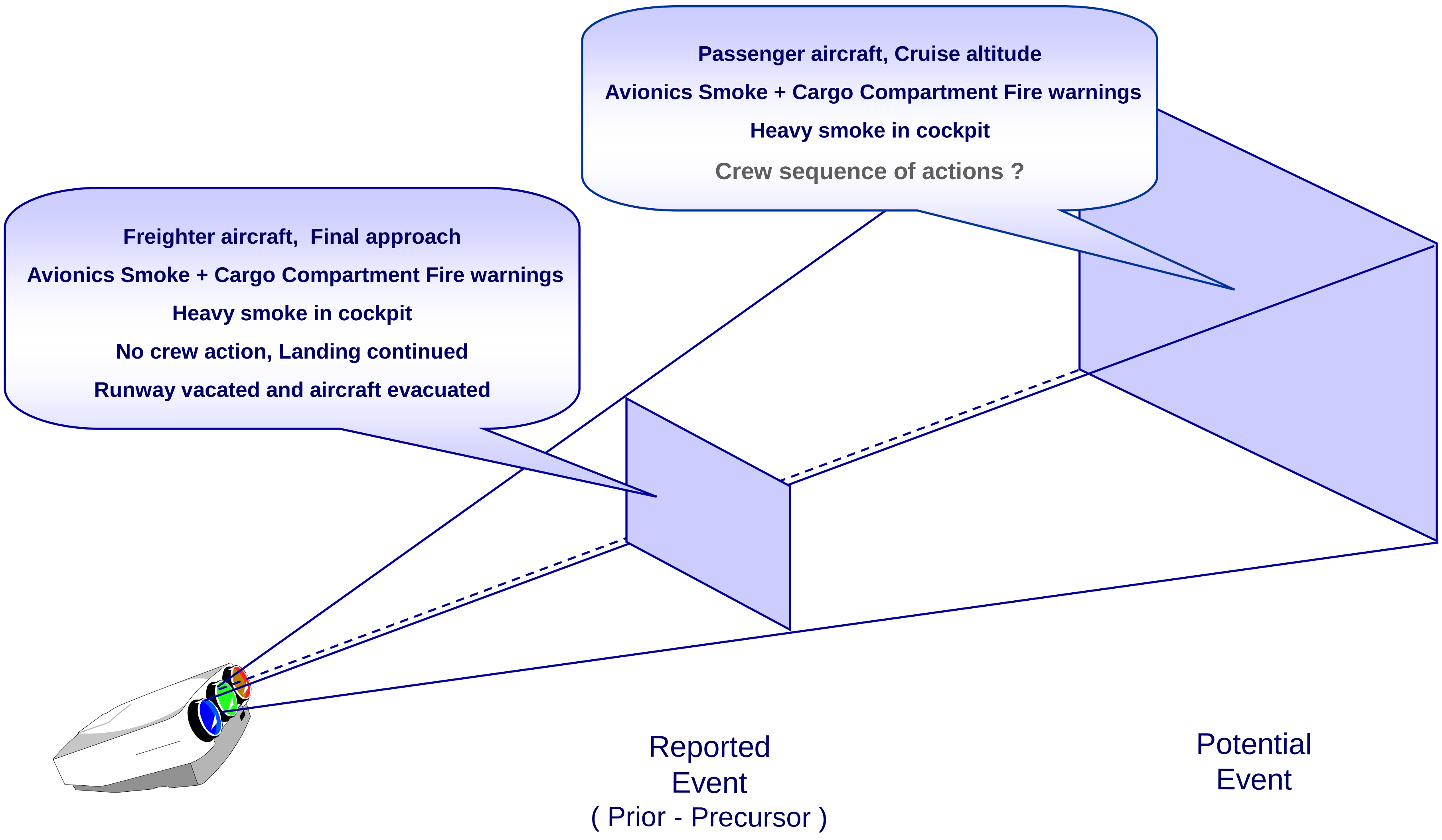
Precursors – Occurrences / Deviations

Incidents Accidents	Precursors		Risk Factors	Defenses / Controls
Hazards (Risk Domains)	**Occurrences** **(Uneventful Events)**	**Deviations** **(Procedural / Flight Path)**	Threats	Prevention Detection / Recovery
Runway Excursion **or** **Overrun** **(Takeoff)**	Takeoff from taxiway Runway confusion Inappropriate intersection takeoff or takeoff from incorrect intersection Line-up events Rejected takeoff (whether initiated below or above 100 kt) Tire burst Aircraft swerve / lateral excursion during takeoff roll Cautions / warnings (genuine or spurious) that may lead to a low-speed or high-speed rejected takeoff Other cockpit effects / malfunctions (genuine or spurious) occurring during takeoff roll Runway incursion Wildlife incursion Bird strike	Excessive taxi speed Inadequate technique for line-up or 180-degree turn on runway Inadequate engine stand-up technique Gross error in takeoff weight entry and/or in V_1 / V_R speeds assessment Incorrect stab-trim setting Undetected incorrect takeoff configuration Late rejected takeoff decision / initiation Premature rotation (i.e., below V_R) Late rotation (i.e., above V_R) Slow rotation (i.e., low pitch rate) Low pitch attitude after lift-off	Note 2	Industry prevention strategies and best practices (Note 2) Adherence to SOP's (task sharing, briefings, use of checklists, standard calls and excessive-deviation callouts, mutual crosscheck and backup) Cross-check of takeoff data : weight-and-balance, stab-trim setting, fuel distribution, runway conditions, wind component, outside air temperature, corrections (QNH, air conditioning, anti-ice, …) flaps setting, V_1 / V_R speeds, assumed temperature / reduced or full thrust setting, ... Awareness of prevailing takeoff performance-limiting factor (available acceleration-stop distance or other limitation) Compliance with "minimum turn-around time", as applicable, to ensure adequate brakes energy Takeoff briefing highlighting the specific / non-routine aspects of the takeoff Line-up technique Readiness for possible stop or go scenarios (being go-minded whenever warranted)

Identifying Precursors



Looking Beyond Reported Events



Analytical Tools - Dependency Models

- Establish hierarchy and relationships between risk factors, defenses and controls
- Describe causal sequences (causality links / chains) leading to given outcome
- Capture dependencies (inter-relationships) between causal sequences
- Measure robustness (effectiveness / reliability) of defenses and controls
- Generate automatic warnings on unanticipated combination of / interactions between « links / chains »

Analytical Tools - Classification Models

- Assist in encoding typology of individual occurrences :
  - Event / occurrence originator (trigger, root cause)
  - Operational consequences on flight conduct / continuation
  - Operational and human performance markers (including threat and error management)
  - Environmental factors and circumstances
  - Organizational / systemic factors
  - Challenged operating assumptions
- Enable statistical analysis of event data sets :
  - Focus on « big bars »

Functional Hazard Analysis (FHA)

- FHA is a generic concept using a variety of subject-matter-specific methods and tools

- Common features include :
  - Analysis workflow (from data to interventions)
  - Fault-tree analysis (fault, error)
  - Checklists / questionnaires (elicitation techniques)
  - Mapping / cartography (threats, hazards)
  - Matrix / radar scope / … (risk scoring)

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FHA is a look-ahead risk assessment approach

Quantitative and Qualitatives Analysis

- Objective (quantitative, hard) data establish facts and figures

- Subjective (qualitative) data add layers of :
  - Subject-matter-expertise (experience, insight and hindsight)
  - Engineering judgment (educated guess, correlation)

- Integrating objective and subjective data helps :
  - Painting a more comprehensive risk picture
  - Reaching more balanced and complete conclusions and recommendations

Implicit Safety Models

- Set of historical references defining the current paradigm of commercial aviation :
  - ICAO standards
  - National laws and regulations
  - Industry standards and best practices
  - Industry hazard prevention programs
  - Research contributions
  - […]

Implicit Safety Models

Risk Domains	Defenses / Controls	Safety Models - Sources
Altitude Deviation Level Bust	Threat-related Prevention Strategies	**Eurocontrol - European Air Traffic Management Program** http://www.eurocontrol.int/eatmp and http://www.eurocontrol.int/safety Level Bust Safety Bulletins **IATA / Eurocontrol - Level Bust Tool Kit** European Action Plan for the Prevention of Level Bust Level Bust Briefing Notes **FSF - ALAR Toolkit** ALAR Briefing Notes 3.1 and 3.2

Operating Assumptions

- Design principles, operating procedures and training concepts reflect implicit / explicit operating assumptions about the intended « user » :
  - Airmanship / craftsmanship
  - Prior experience
  - Behavior (code of conduct)
  - Knowledge of systems operation and … of how to operate the systems
  - User's « Always do » and « Never do »
  - Day-specific information availability

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Real world differs from implicit safety models

Challenged Operating Assumptions

Domain	Operating Assumptions
	Transition training recalls the elements of basic airmanship and how to carry them over when transitioning to a new type
	When selecting a system or when setting a target value, the flight crew ensures that the correct selector / control is used and is actuated in the intended manner
SOP's	Flight crew strictly adheres to company SOP's, including task sharing, briefings, use of normal checklists, standard calls and excessive-deviation callouts, mutual crosscheck and backup
	Systems are always armed, engaged, used and monitored as per SOP's (e.g., automation, ground spoilers, autobrake, thrust reversers, …)
	Flight crew and cabin crew strictly adhere to the sterile cockpit rule, but cabin crew is aware of circumstances that warrant breaking this rule
	Flight crew maintains overall situation awareness during cruise by periodically reviewing systems operation on corresponding display unit
	Flight crew monitors FMS navigation, particularly during SID and STAR phases of flight
	Load-and-trim sheet is checked by both the dispatcher and the flight crew for possible gross errors
	Operating guidelines are available to support the flight crew's "stop-or-go" decision during the various phases of the takeoff roll (i.e., below or above 100 kt)

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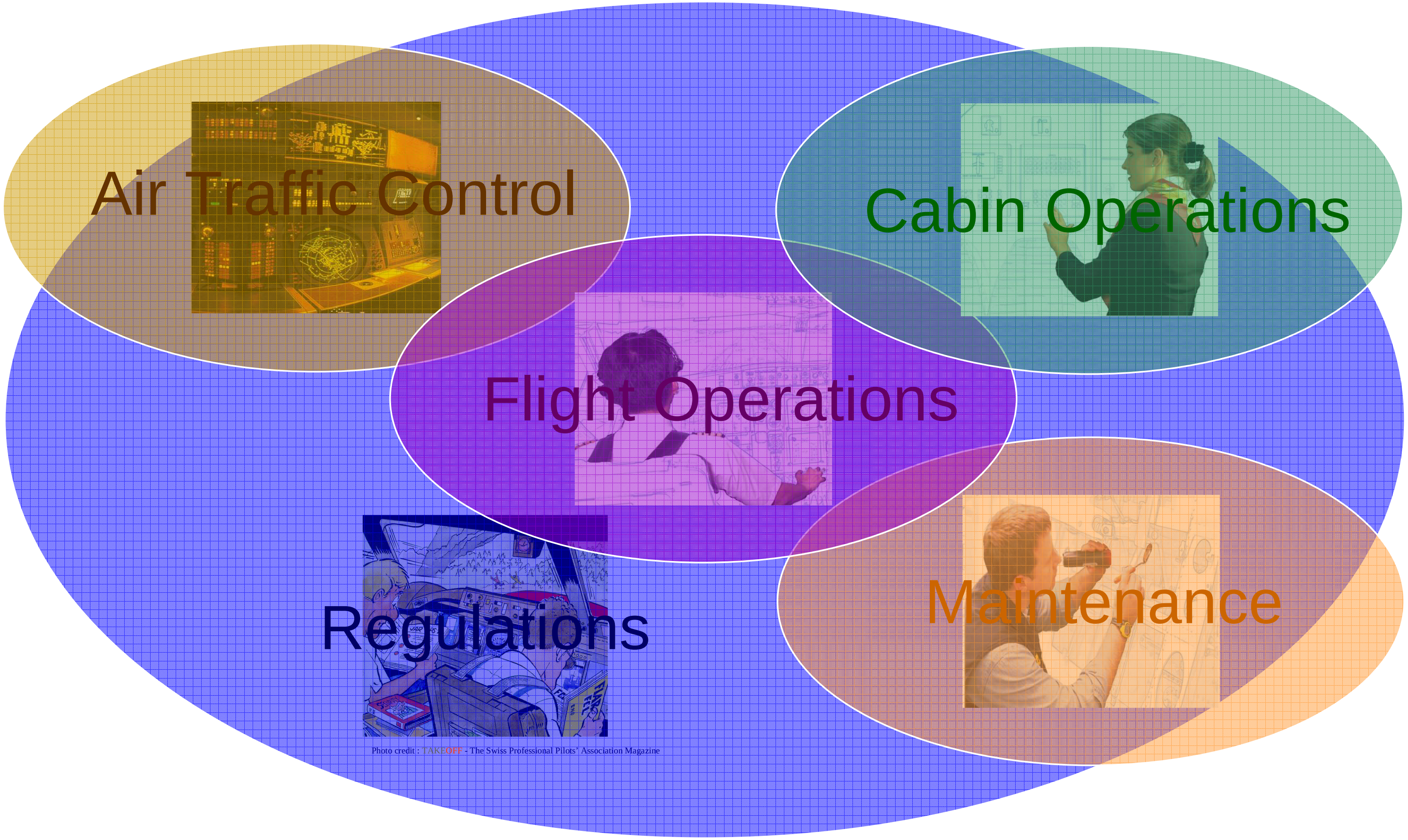
We need to challenge our operating assumptions

Cross-boundary Risks



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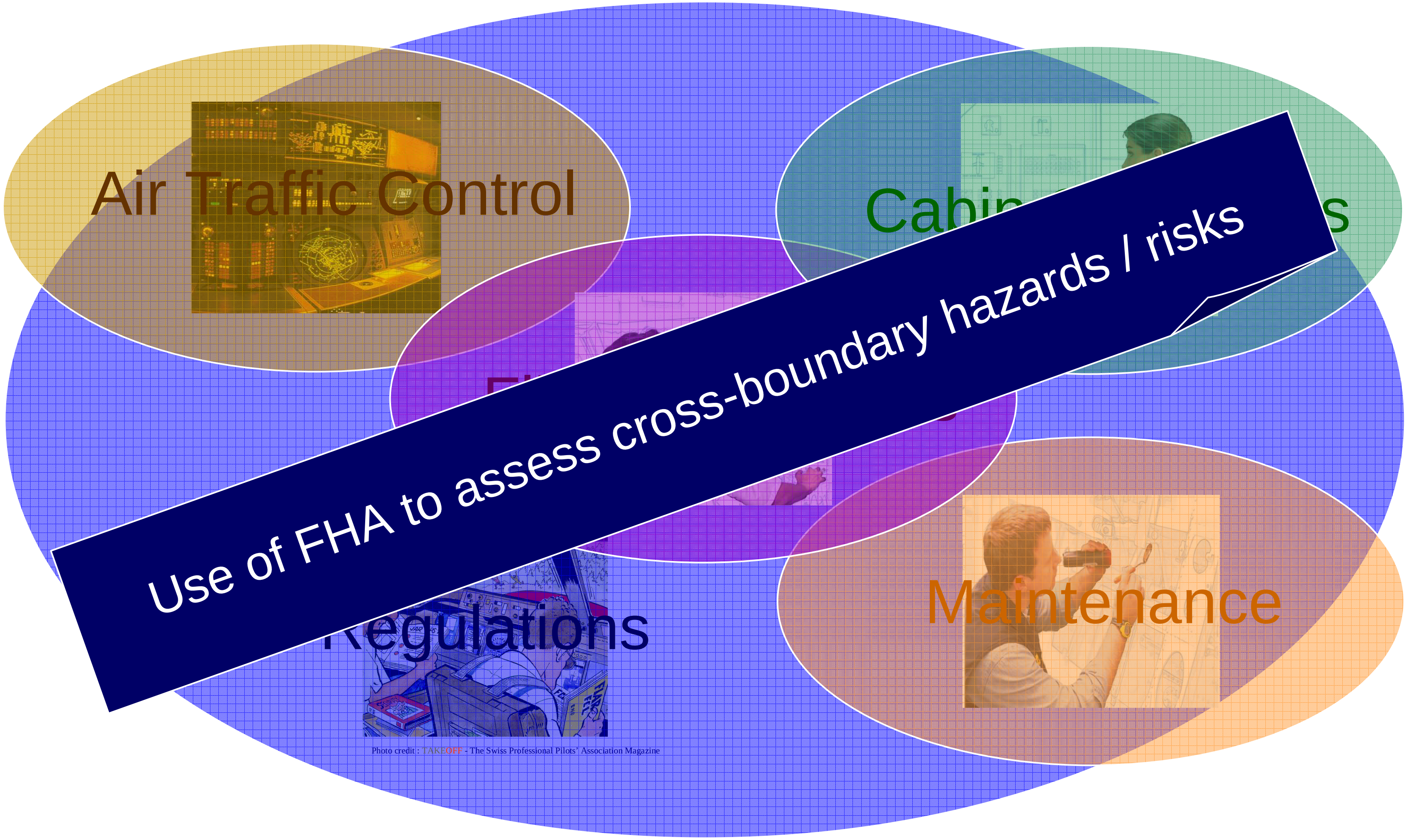

Risk Variation with Changing Conditions

- Risk prevalence varies from flight to flight, e.g. :
  - Dispatch under MEL
  - Crew factors :
    - Experience on type / pairing
    - Route familiarization
    - Duty day
  - Weather conditions :
    - Enroute, at destination
  - NOTAM's :
    - Unserviceable navaids / letdown aids
    - Work-in-progress

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Make use of “ Risk Assessment Tools ”

(Hazard-related or flight-phase-related RATs or TEM checklists)

Change-induced Risks

- Changes always are introduced for good reasons
- Changes carry their own risks
- Changes should be evaluated using subject-specific FHA methodologies :
  - Organization :
    - Policies, processes, procedures
  - Products :
    - Design, operations, maintenance, training
  - […]

Formulating Problem Statements

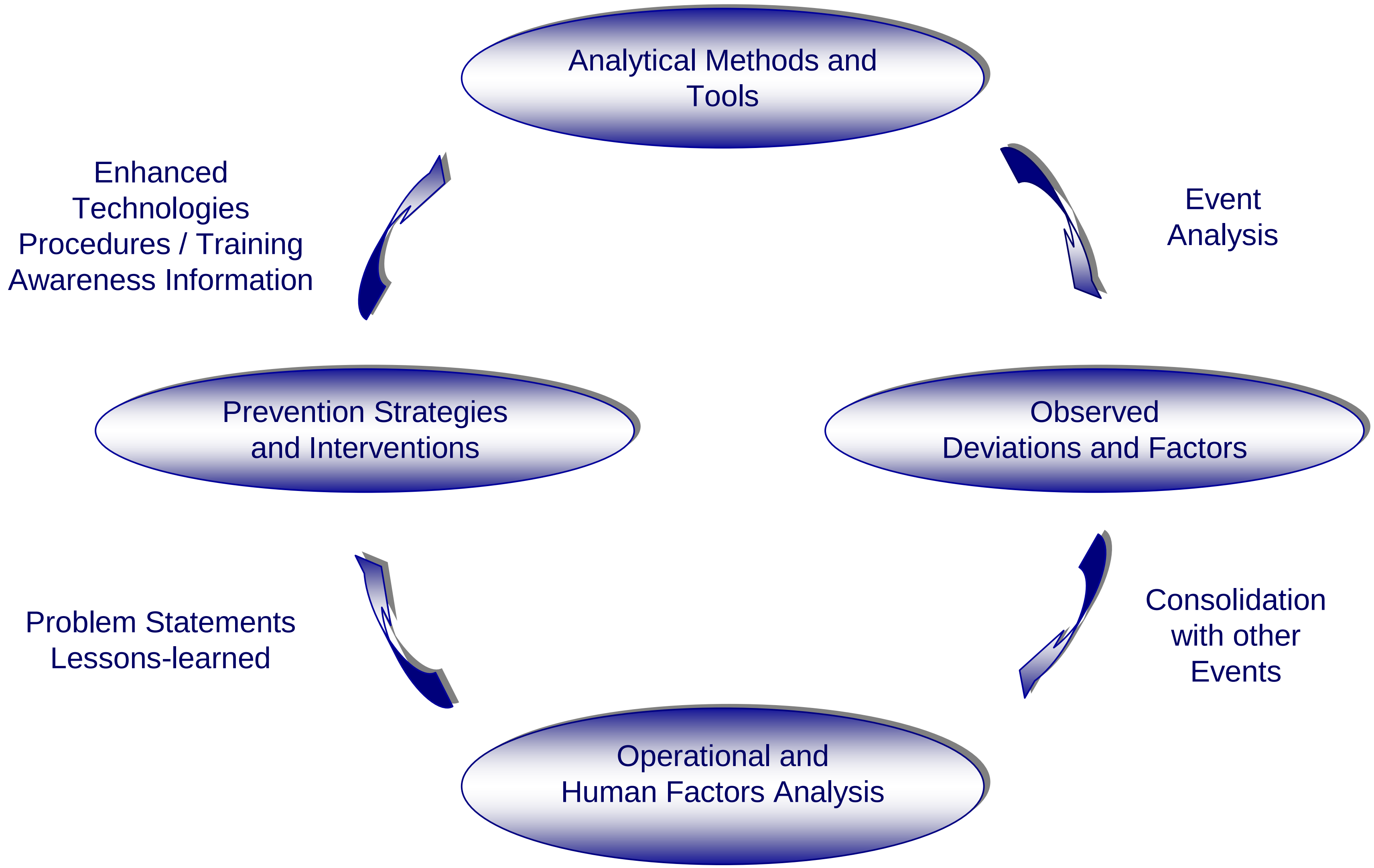
- Raising the problem :
  - Do we have a problem ? … or … We have a problem !
- Formulating accurately the problem :
  - What went wrong, how and why ?
- Quantifying the problem :
  - Why is this important ?
  - What are the challenges ?
- Evaluating the solutions :
  - What are the possible interventions ?

Identifying Interventions

	Technology	Operating Standards	Training Standards	Safety Awareness
Hazard	✓	✓	✓	✓

Deploying Interventions

Aviation Safety Enhancement Loop



Quotes from our peers

« You cannot fix a category of accident, you can just fix the contributing factors »

Paul Russell - Boeing - US CAST - FSF

« Find the reasons, stop feeding the causes … and let the reasons starve »

Dr Robert O. Besco - American Airlines, retired

« Leave no stone unturned »

[…] - Accident Investigator - US NTSB