

Risk, Event Management, and Precursors

What can be learned from the three time domains:

Past - Present - Future

Forensics - Diagnostics - Prognostics

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Outline

- Challenges for Aviation Policy Makers
- Spectrum of Accepted Risk
- Event Management: the Foundation of Safety Management
- Camouflage, Bluff or Real? Statistical Uncertainty of Rare Events
- Importance of Precursor Discovery
- Concluding Remarks & Challenge

Challenges for Aviation Policy Makers:

- Measuring whether improvements are producing desired effects or are having unintended, adverse consequences.
- Removal of technical, political, legal, and commercial barriers to implementation of system-wide, precursor discovery systems.
- Identifying and mitigating *overt* and *latent* precursors to undesired events:
 - Achieving consensus on a definition and taxonomy for entities called “precursors.” Precursor ≠ causal factor.
 - FAA CPS Finding 7 in Aviation Safety Data Management:
 - “There is no widely accepted process for analyzing service data or events to identify potential [*overt*] accident precursors.”
 - Boeing problem statement:
 - Several accident/incident investigations have revealed that information about a potential hazard was available to industry but not recognized - *latent* precursors.
 - Reliable methods for automated detection of accident & incident precursors and for measuring their frequencies and trends.
 - Determining whether precursors of *accidents* correlate with precursors of *incidents* and/or related atypical operational events.

The Spectrum of Accepted Risk:

Spencer, Canadian Association of Gerontology

Risk actively pursued as opportunity

Freely accepted risk

Reluctantly assumed risk

Risk accepted with little or no choice

Risks to be avoided like the plague

Risk is not a discrete entity, rather a relative concept. Risks, in fact, exist on a continuum ranging from those that are pro-actively accepted because the opportunity cost for failing to engage them is too high, to those that may be life threatening but must be accepted because there is no other alternative, to those that it would be foolish to accept.

Factors Influencing Decision to Accept Risk

- How does a person responsible for making a decision to accept or reject a particular aviation risk actually make that subjective call?
- Once a responsible party has been made situationally-aware in an “objective sense” (if that's indeed possible), what other latent, but important, factors are at work that influence her or his decision-making process?
- Factors may include:

Life experiences & Heuristics

Perceived Gains or Losses

Optimistic Biases

Fears of Regret

Short- versus Long-Term Consequences

Education

Personal Values

Gender/Ethnicity

Addiction

Sources of Bias in the Risk-Acceptance Process.

- Format
 - Mathematical notation itself contains strong human cognitive bias
 - Human brains are built for interpersonal relationships *not* for processing statistics.
 - <http://www.pangora.com/research/papers/cobias.htm>
- Failure to characterize uncertainty
 - Calculation and presentation of risk assessment results must include:
 - Assessment of uncertainty with narrative describing the rationale and assumptions
 - Quantitative uncertainty assessment in terms of probability distributions
 - Unacceptable practices:
 - Single point probability estimates with no characterization of uncertainty
 - Deterministic bright-line estimates; imply absolute certainty where none exists and hide true nature and level of ignorance relative to technical opinion of danger.
 - American Industrial Hygiene Association; <http://www.aiha.org/GovernmentAffairs-PR/html/GAWPrisk.htm>
- Politics
 - Involve senior science advisors to ensure that politics do not bias the assumptions, data, conclusions, or interpretations of the risk assessment.
 - U. S. Food and Drug Administration's guidance to Center for Food Safety and Applied Nutrition; <http://vm.cfsan.fda.gov/~dms/rafw-1.html>

Challenges for Risk Management Community:

- How to track and cross-check assumptions that prevail at each stage from initial design to operational use of technology.
- Need to have risk management tools tailored to proper target domain: manufacturer, regulator, user (air carrier/ATM) & research community
 - How can one configure a "Safety Management System" to reflect and acknowledge this reality?
 - Is operational risk the only one that *really* matters?
- Public perception of risk versus the way "risk expert" community treats the subject.
- New ways of managing risk within Low Cost Carrier (LCC) airlines as well as challenges faced by LCC's to maintain the safety records of larger legacy carriers.

Event Management is the Foundation of Systems Management.

<http://www.research.ibm.com/journal/sj/413/hellerstein.html>

- Accidents & incidents spring from chains of undesirable events.
- Rules describing the correlation and interpretation of operational event patterns are needed to increase aviation system productivity and safety.
- Patterns of interest that may indicate underlying safety problems in event management:

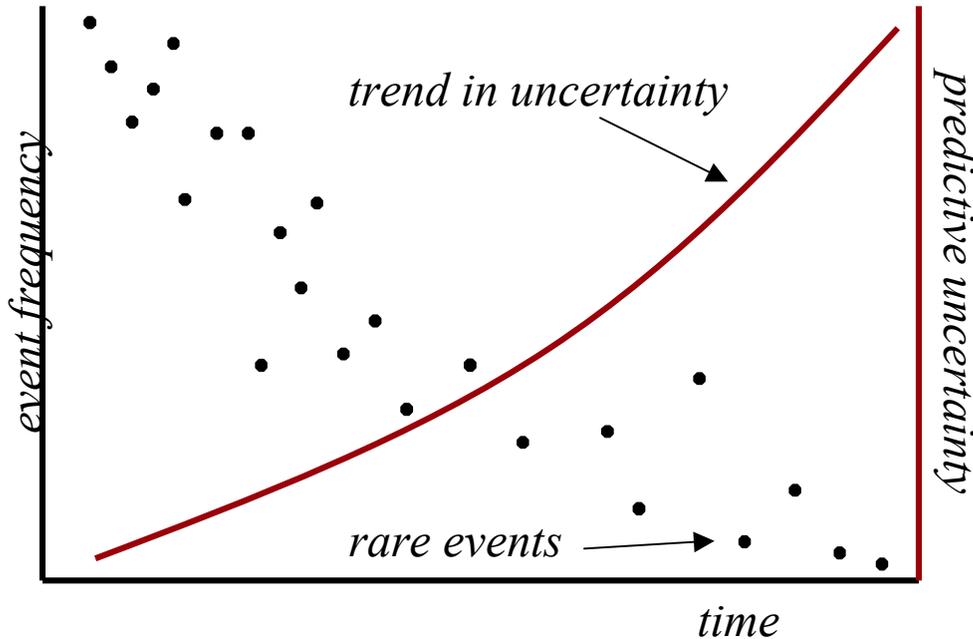
Event bursts	Patterns
Periodicities	Trends
Mutual dependencies	Commonalities

- Pattern discovery must be structured to exploit system-wide search capability, thereby improving scalability in discovery of actionable patterns.
- A challenge: develop frameworks that provide a means to systematically and efficiently explore related multiple attributes of event patterns that may correlate in different, unique ways.

Uncertainty in Predictive Value of Rare Events

Frey & Schär

Observational data describing rare events contain stochastic variations that limit the accuracy with which a long-term trend can be estimated.



**Current low rate of fatal aviation accidents
may not be indicative of long-term trend!**

Possible misinterpretations of data:

1. Estimate is erroneously taken as signal of long-term trend, but value is essentially controlled by stochastic variations in the record.
2. Existing long-term trend in the parameter not identified because it is masked by short-term stochastic fluctuations.

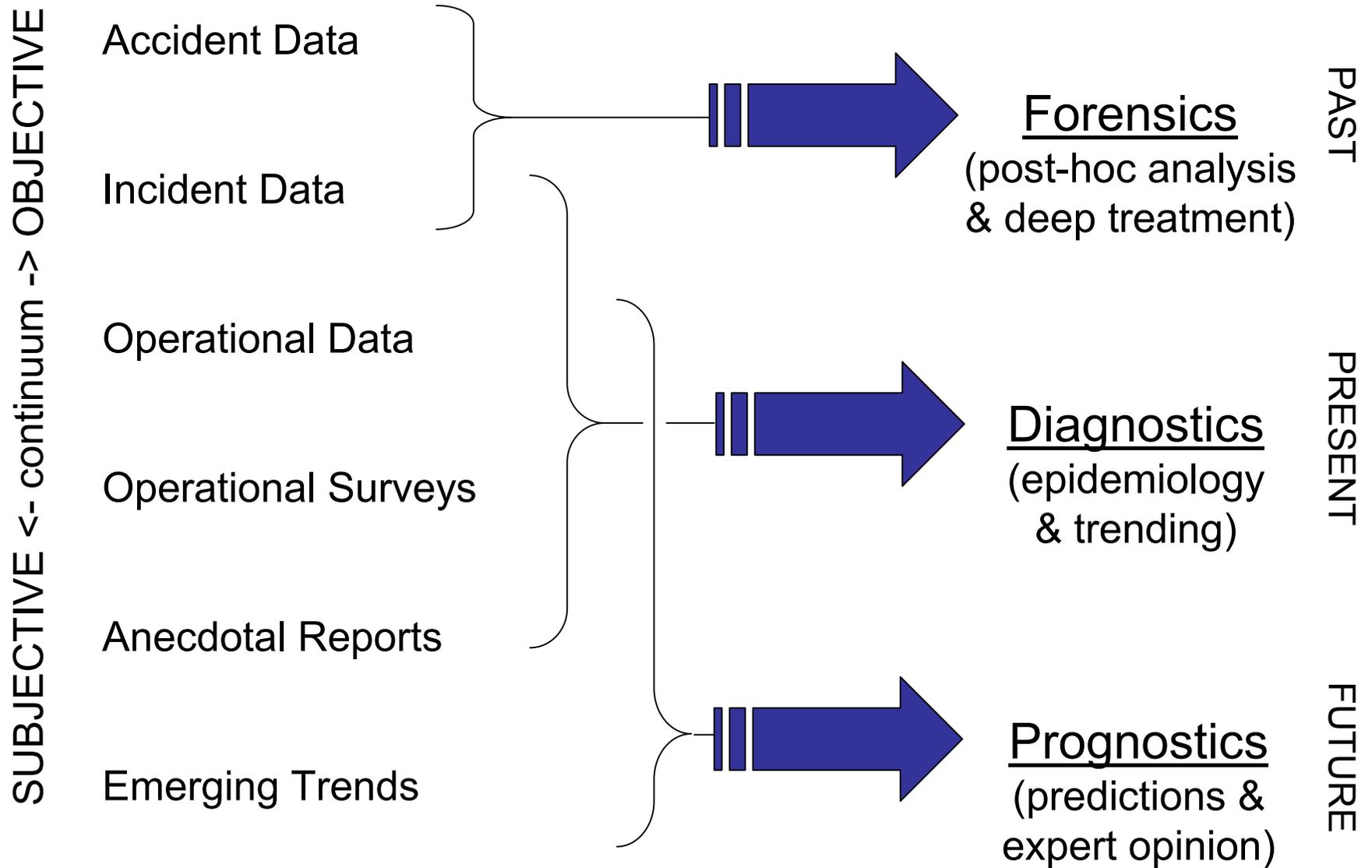
What is a “Precursor” of a Rare Event?

- Confluence of context-dependent factors conducive to undesired system behavior that results in *higher probability* of an anomalous, unintended unsafe situation.
- Can be a discrete event or a pattern of circumstances.
- Causal factors consist of single or multiple precursors.
- Challenges for precursor discovery and analysis:
 - Establishing a consensus for the definition of a precursor that goes beyond the simple “threshold exceedence” used in most FOQA programs.
 - Identifying the precursors of the *next* accident or incident within the complex and distributed aviation environment in which there are many interacting elements.
 - Finding precursors or pointers to future adverse situations that are *scenario-independent*.

Beyond *The What?* To *The Why?*

- Quantitative data sources reveal the *objective* aspects of “*what*” happened.
- Qualitative data sources lead to an understanding of the *subjective* aspects of “*why*” an event occurred.
- *Both* sources of data provide domain experts - the human risk managers - with complementary and synergistic information for causal analysis.
 - Can’t manage safety risk without understanding what contributed to the undesirable event.
- Precursors are found in *both* objective and subjective data.

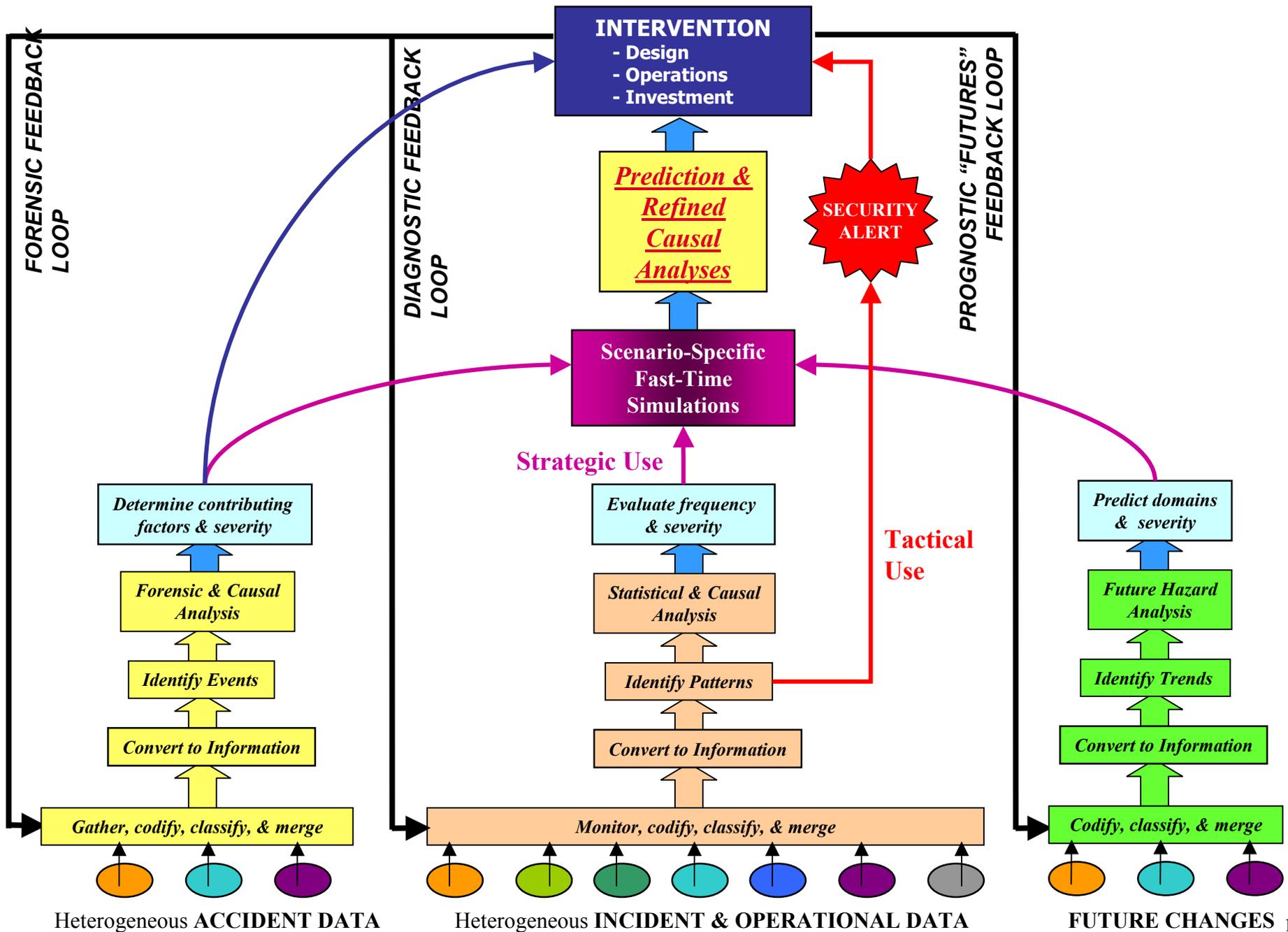
Where are “Precursors” found?



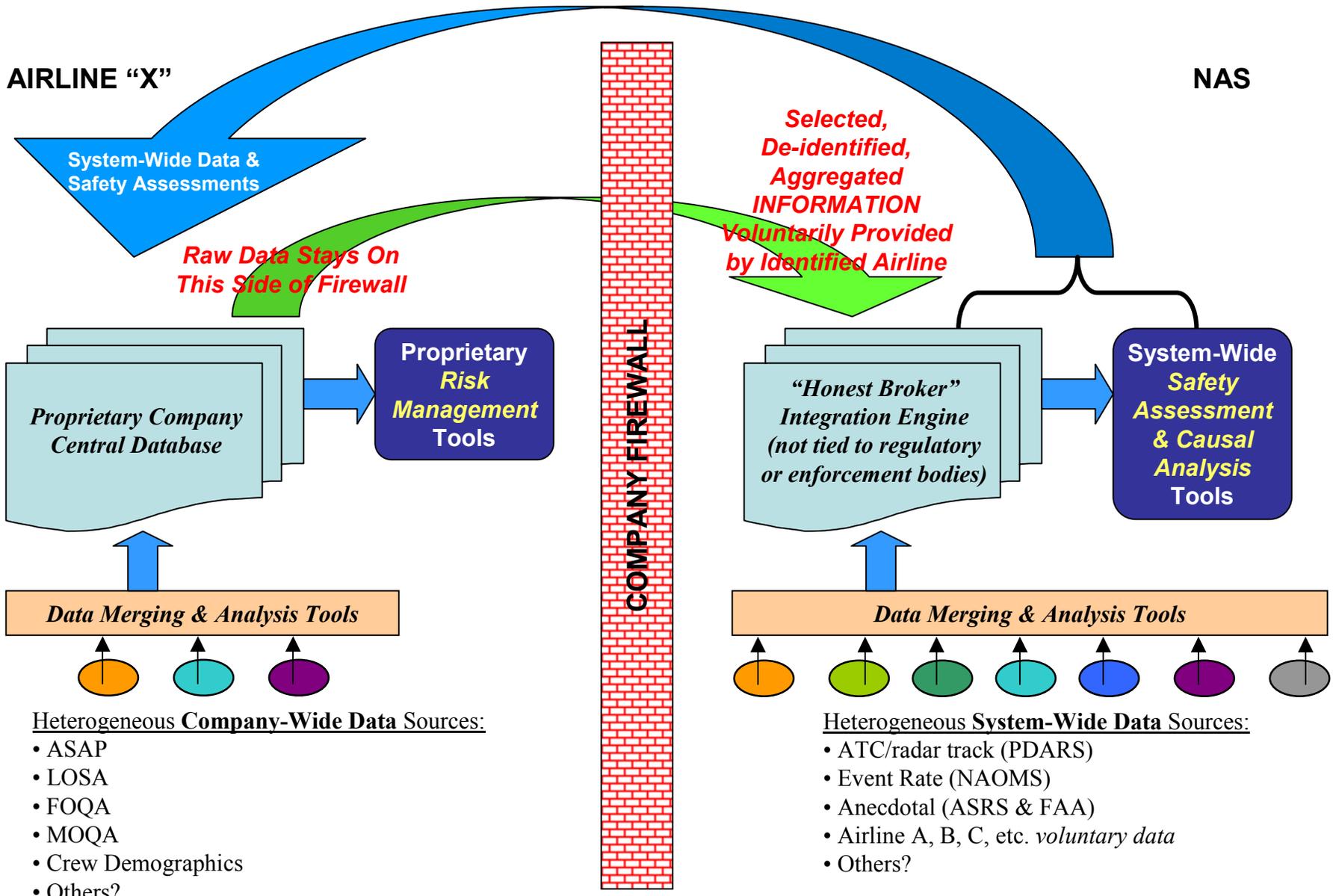
How can Precursors be uncovered?

- Data-driven methods: Data-driven approaches based directly on process data and are model independent.
- Model based methods: Analytical methods based on system models. *Approach*:
 - measure actual system data
 - compare with expected output based on a model built from first principles
 - detect large process-model mismatch, a fault (or possible precursor)
- Knowledge based methods: These approaches use qualitative models (such as neural networks) for process monitoring.
- *Challenges*:
 - Establishing consensus on operationally-significant precursors
 - Extracting true precursors from huge, heterogeneous datasets
 - Minimizing false-positives

Pro-Active Management of Aviation Risk - Past, Present, Future



Example of How an Airline or ATM Facility Can Use All Available Safety Data





Time to stir the pot a little!

Lessons learned from Report of Senate Intelligence Committee on Iraq War Intel Failures:

- *Dangers of group think* and pressure to achieve consensus:
 - The US intelligence community...
 - Extrapolated conclusions from sketchy data poorly presented.
 - Was unwilling to send forward unfavorable information.
 - Failed to conduct a “Red Team” challenge to collective assumptions.
 - Failed to either emphasize or thoroughly digest caveats attached to summary conclusions.
- We had a fundamental breakdown of the intelligence process...
 - Did not identify or validate sources of key information.
 - Did not seek out new information that may have gone against political agenda.
 - Too many layers of review (five to seven management layers between intel analyst & President).
- There are no-so-faint echoes of the two Space Shuttle tragedies here.
- Common government propensity to succumb to these phenomena.

“If everybody around the table agrees, somebody is wrong.”

How to prevent “group-think” dynamics this week...

- Perform continuous contrarian analyses rather than seeking lowest-common-denominator consensus on how to manage aviation safety risk.
- Thoroughly explain to policy makers in your organizations doubts about uncertain conclusions from this workshop.

Tell them what you know;

Tell them what you don't know;

Tell them the difference between the two!

- Place any and all major dissenting views in the main body of your final set of minutes or actions and don't relegate them to footnote status.
- Question to ponder: What procedures are in place within your Agencies, universities or companies to prevent an atmosphere of “group think?”

***Thank you for your kind
attention...***

Questions?

Comments?