Cultivating the Assertive Skeptic:
Human Agency and Flight Test Safety

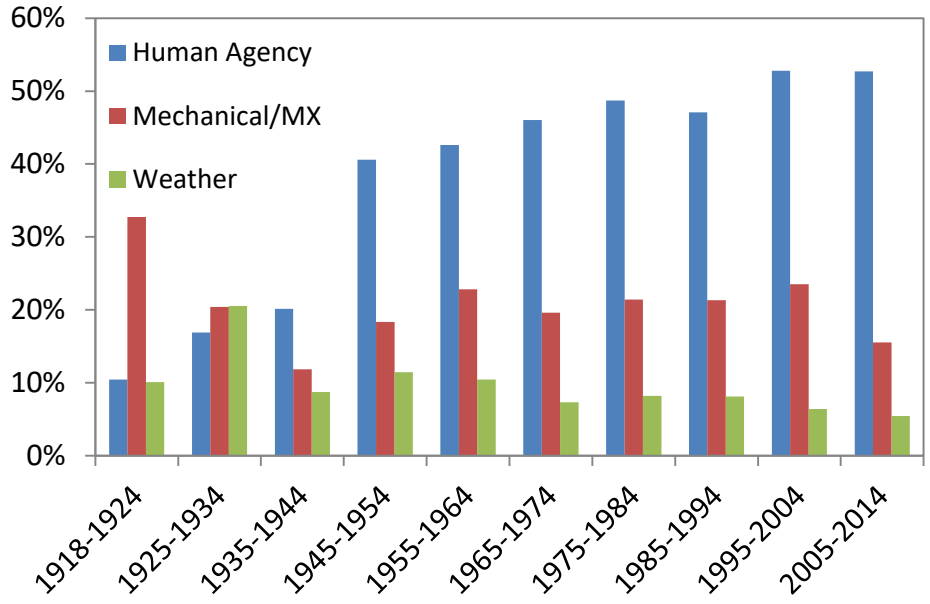
Dan “Animal” Javorsek
Air Force Test Center
Edwards AFB, CA

Motivation

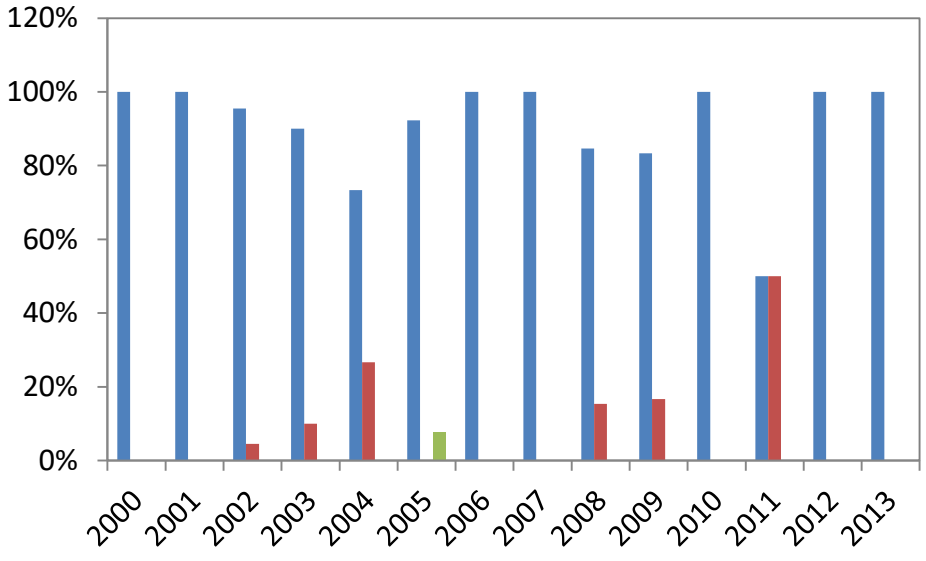
- Fatal Mishap Report Observations
  - Deterministic narrative
  - Retrospective predictability
  - Rarely consider human agency
- Can other fields of study help us?…*Yes!*
  - Challenge assumptions
  - Address inconvenient truths
  - Invest in preparedness

Brief History of Fatal Mishaps

Contribution to Worldwide Fatalities

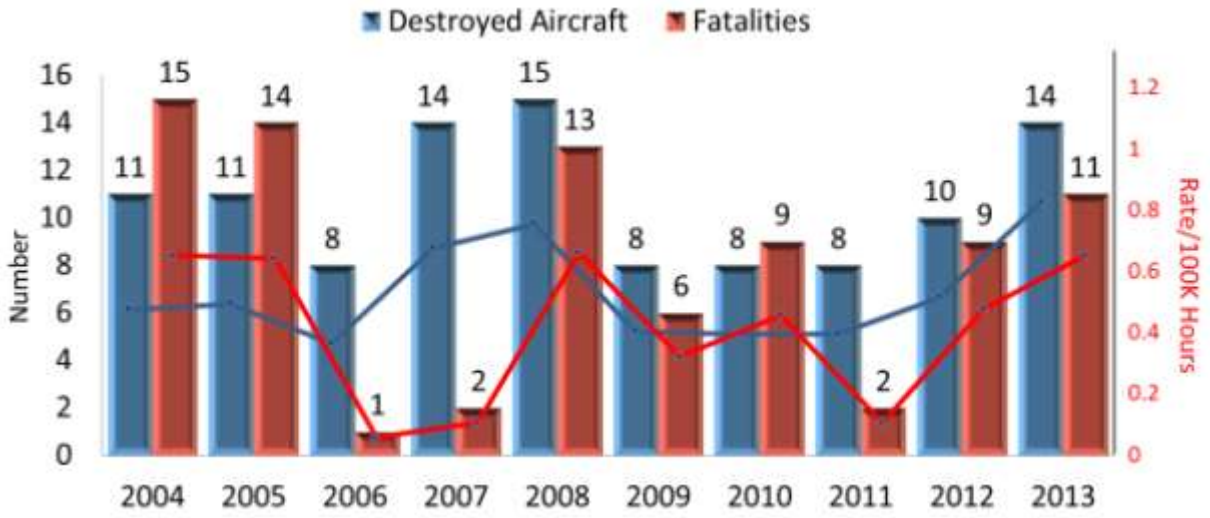


USAF Fatalities



- Human agency as root cause in AFMC mishaps
  - 60% of fatal accidents
  - 80% of fatalities
- Data from Bureau of Aircraft Accidents Archives (BAAA) and USAF JAG Accident Investigation Boards (AIB)

Breaking Through the Plateau



"While the last five years show continued improvement, the trending data illuminate a new concern – we've plateaued."

- MGen Woodward, Air Force Chief of Safety in reference to the $8.8 billion and 767 lives lost from 2002-2012

Change our approach to Human Agency

Complexity Theory 101

- Complex Adaptive System is made of agents that are:
  - Adaptable
  - Heterogeneous
  - Interdependent
  - Highly connected

- Used for systems that lack a clear set of governing equations
  - Embraced by economics, medicine, meteorology, ecology
  - Characterized by emergent macroscopic features
  - In such systems "control" is replaced by "influence"
  - Uncertainties can have disproportionately large impact

- Air vehicle system with human in the loop is complex

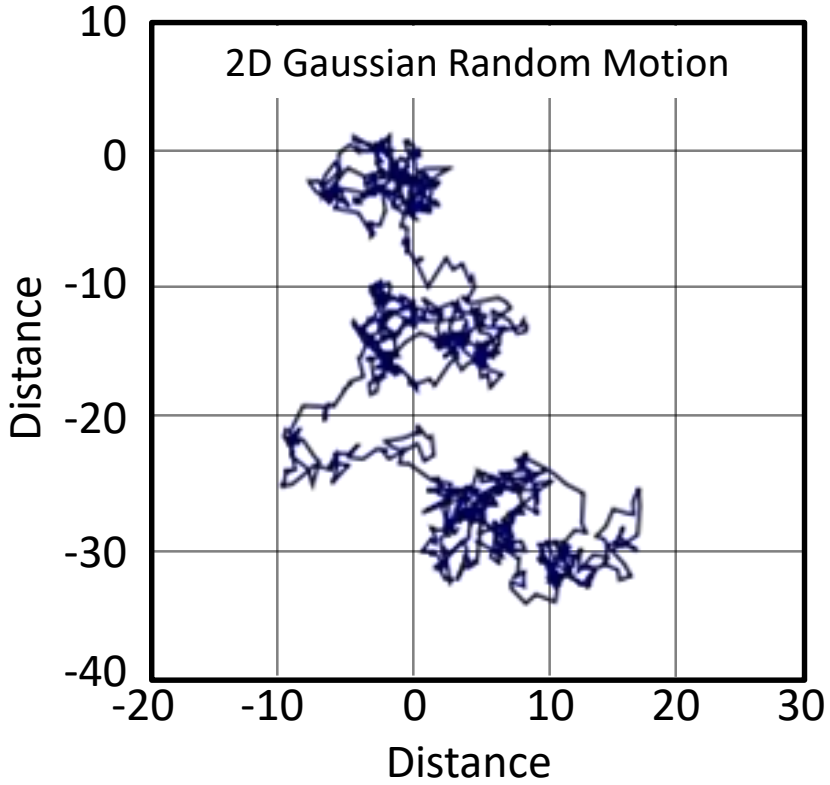
Complex Adaptive Systems

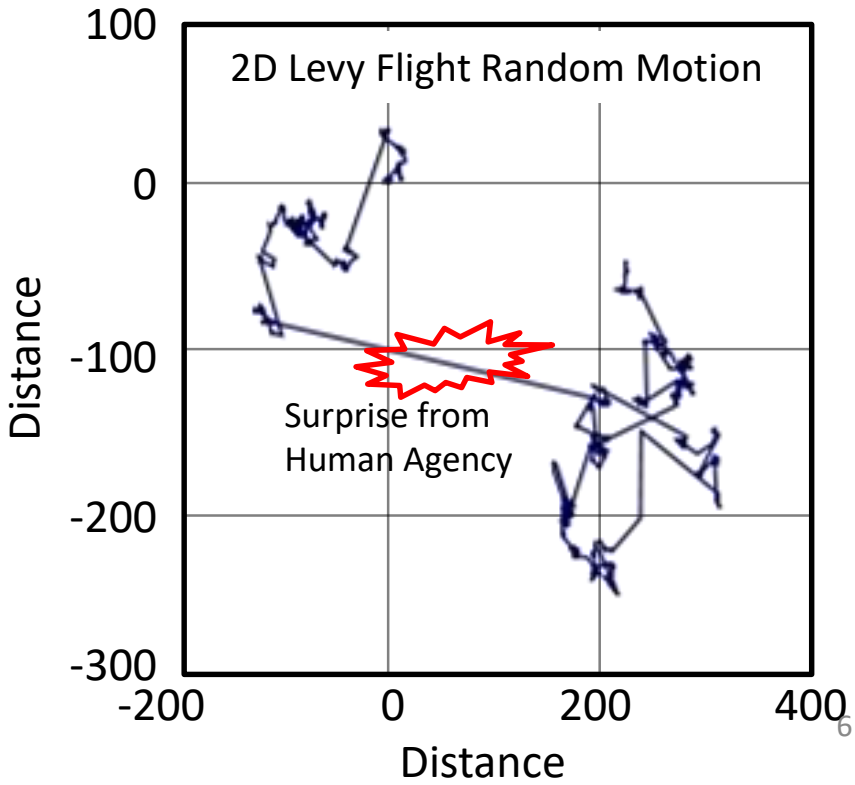
Complicated

- Example: Airplane
- Predictable
- Not as prone to surprise
- Distribution: Gaussian (bell curve)

Complex

- Example: Air traffic
- Can appear predictable
- Susceptible to great surprise
- Distribution: Heavy Tailed





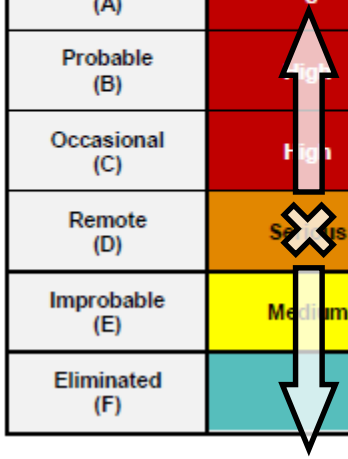
Cognitive Biases Increase Unpredictability

- Errors in judgment and decision making occur:
  - Subconsciously
  - Independent of demographics (age, income, education, etc.)
  - Due to neurological limitations
  - Due to limited capacity for info processing
- Lead to…
  - Perceptual distortion
  - Inaccurate judgment
  - Illogical interpretation

Bias	Description
Anchoring/Focalism	Rely too heavily on one piece of info
Automation Bias	Overdependence on automation
Base rate/Conjunction Fallacy	Focus on specific and ignore general info
Expectation/ Confirmation Bias	Focus on preconceptions
Halo Effect	Overall impression underestimates errors
Overconfidence Effect	Underestimation of uncertainty
Regressive Bias	Under estimation of low likelihoods and vv
Retrospective Distortion	Unpredictable event was preventable

Risk Assessment of Human Influenced Hazards

RISK ASSESSMENT MATRIX				
SEVERITY / PROBABILITY	Catastrophic (1)	Critical (2)	Marginal (3)	Negligible (4)
Frequent (A)	High	High	Serious	Medium
Probable (B)	High	High	Serious	Medium
Occasional (C)	High	Serious	Medium	Low
Remote (D)	Serious	Medium	Medium	Low
Improbable (E)	Medium	Medium	Medium	Low
Eliminated (F)	Eliminated			



Pros

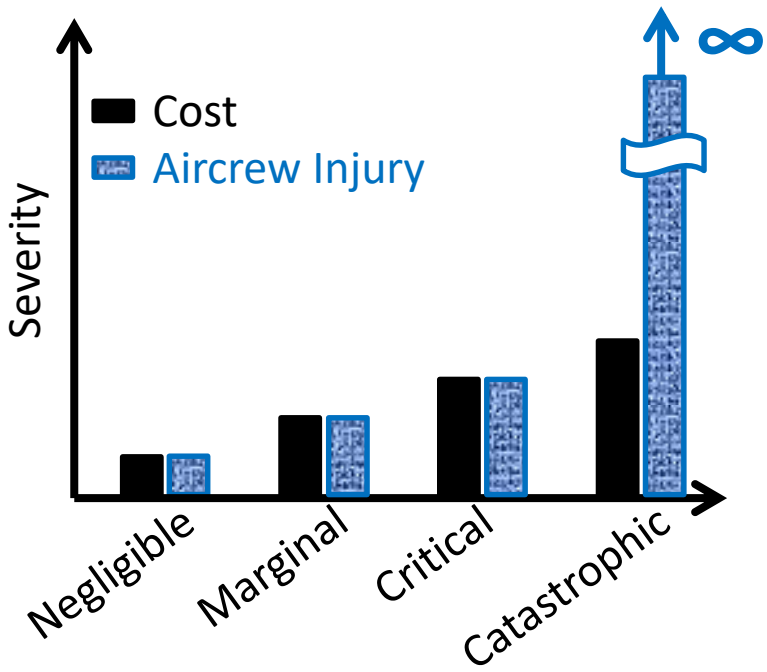
- Easy to use
- Widely distributed
- Responsible for reduction in absolute number of fatalities

Cons

- Probability assessment relies on “engineering judgment”
- Human agency treated same as other factors
- Assumes linear severity

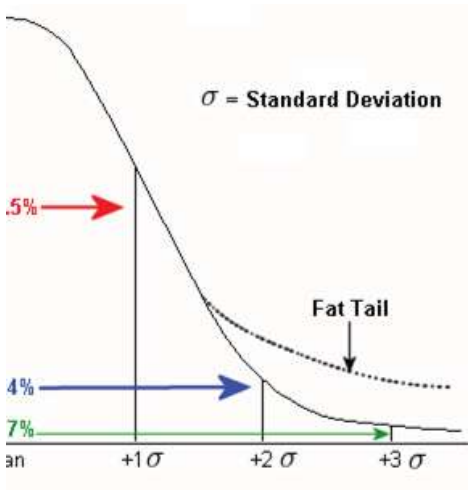
Partitioned Multiobjective Risk Method

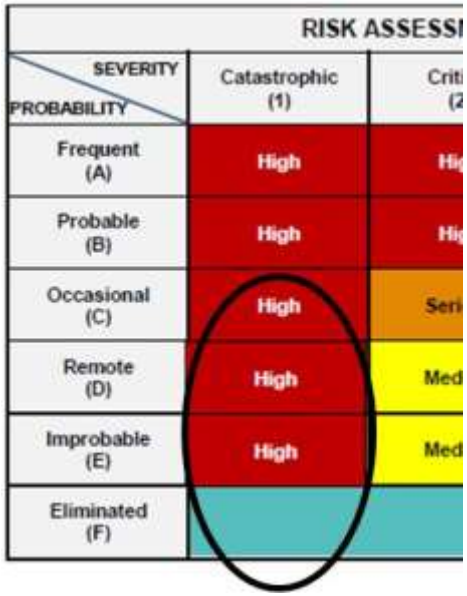
- Multiobjective problem
  - Severity levels of aircrew injury are not linear
  - Unable to treat cost and aircrew injury the same
  - Cost can use typical Bayesian expected value



- Traditional expected value is inadequate for catastrophic events
  - Unable to differentiate between extremes
  - Fatal catastrophic loss must be handled differently from non-fatal incidents

Recommendations





- Shift culture away from determinism
  - Anticipate and plan for human agency
  - Teach non-Gaussian statistics
  - Teach psychology of judgment & decision making
- Modify risk assessment for catastrophic events
  - Remove dependence on probability uncertainty
  - Employ the Partitioned Multiobjective Risk Method
- Continue to research and investigate complexity applications

Takeaways















- Be the assertive skeptic
- Nudge at every opportunity
- Remain vigilant for cognitive biases
- Plan for inevitable human agency

Questions?

Acknowledgments

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  - Steve Rainey
  - John Schwitz
  - Brad Carlson
  - Mike Nielsen

Recommended Reading

- Flight Test Mishaps
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Database Information

- Worldwide data compiled from the Bureau of Aircraft Accidents Archives

  http://www.baaa-acro.com

- USAF data compiled from the Judge Advocate General Legal Operations Agency Claims and Tort Litigation Accident Investigation Board Repository

  http://usaf.aib.law.af.mil

PMRM Example: Hypothetical First Flight

- Assumptions:
  - Contractor facility outside metropolitan area
  - Contractor facility flight time over populated areas = 1%
  - Remote location flight time over populated areas = 0%
  - Probability of accident = 1/10,000
  - Remote area cost (vehicle) = $75M
  - Populated area cost (civilian casualties+law suits+collateral damage+vehicle) = $500M
- Expected Loss Cost Assessment:
  - Remote Location = $75M/10,000
    = $7,500
  - Contractor Facility = 99%($75M/10,000)+1%($500M/10,000)
    = $7,425+$500 = $7,925
- PM Decision: Expected Loss << Move to Remote Location
- According to PMRM….NO!!! A populated area crash is unacceptable!