Reexamining Linear Causal Inferences Using Safety and Reliability Metrics

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Brief Introduction

Background

- Trained as a commercial pilot
  - Fixed wing and rotorcraft
- Safety background
  - Masters in Applied Aviation Safety
    - Focused on implementation and training

Current work

- Focuses on system safety and analysis
  - Examining underlying assumptions of current analysis approaches
  - Looking at different data integration and analysis methods
  - And, exploring what is required to analyze the aviation systemcomplex systems

Overview

Is Aviation Getting Safer?

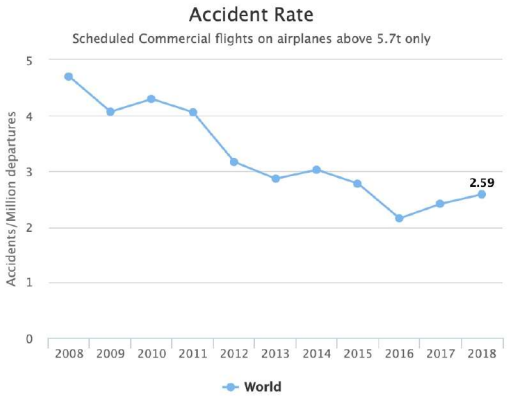
- Are the number of accidents per year decreasing?
- What do we mean by safe?

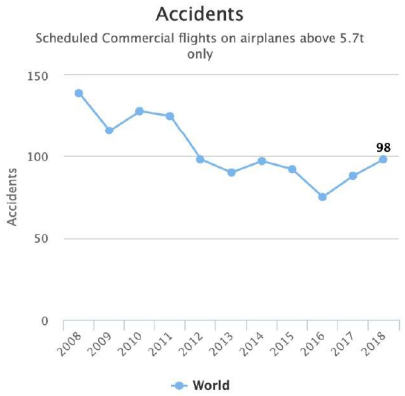
Are Our Current Tools Sufficient?

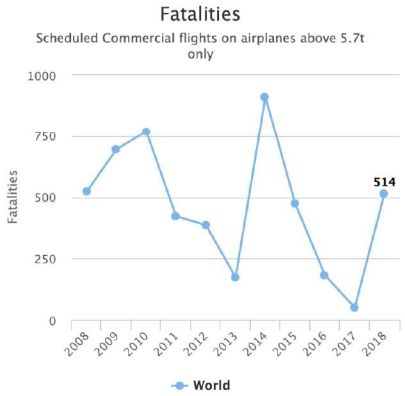
- How do the current tools work?
- Where do future tools need to work?

Is Aviation Getting Safer?

Yes, but…





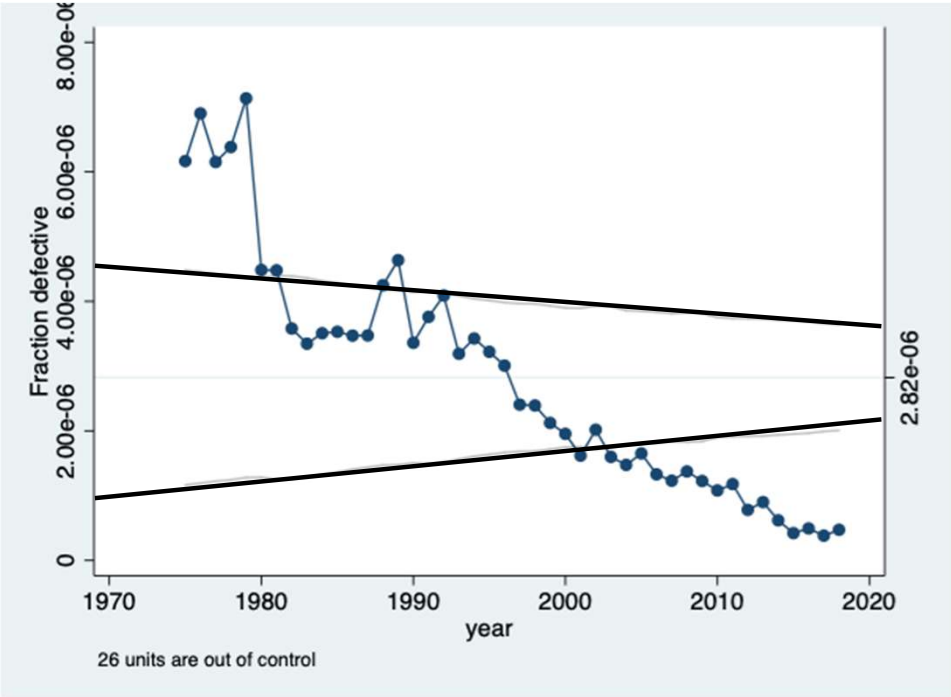


- While accidents per million departures is decreasing
  - Trends in aviation fatalities are not as clear
  - Not ‘fair’ comparisons
    - Need relative scales
    - Not absolute scales

Need to ensure that comparisons are meaningful so progress can be accurately assessed

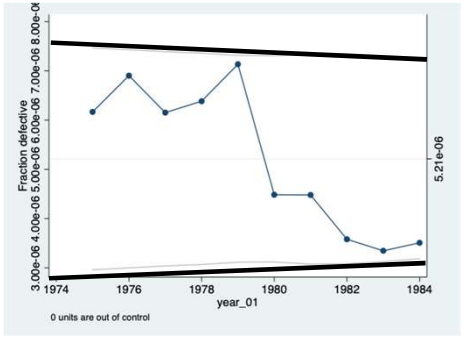
Aviation Accident Rates 1975-2018

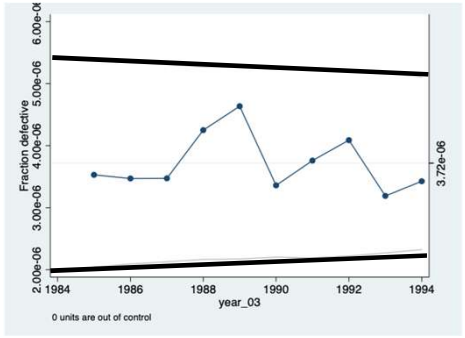
- We are making substantial progress
  - Improved almost 6σ (six sigma)
- While the quantification of accidents rates is a helpful benchmark
  - The biggest are qualitatively raising awareness within the system

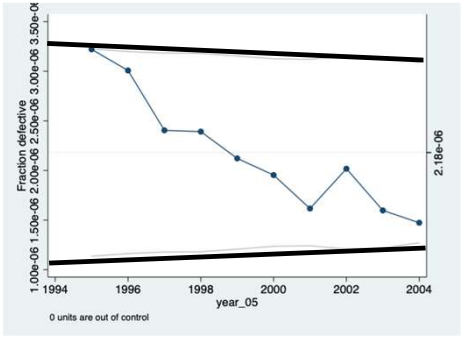


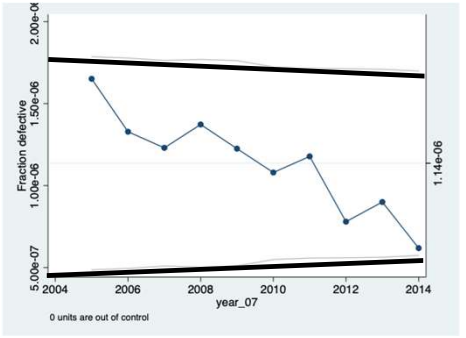
Aviation Accident Rate 1975-2018

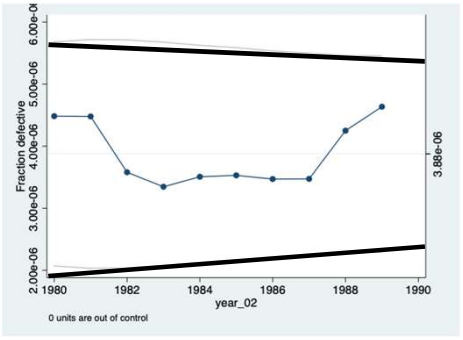
(10 Year Periods, Every 5 Years)

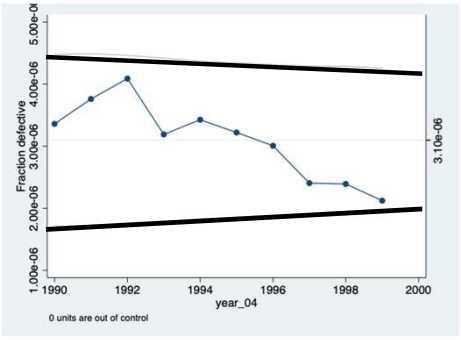


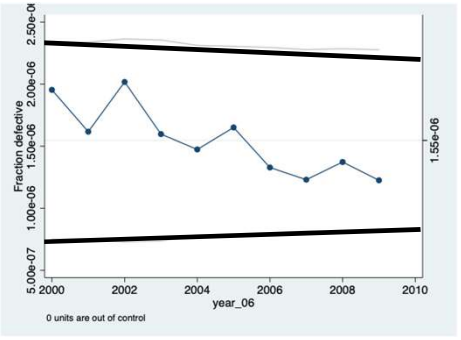


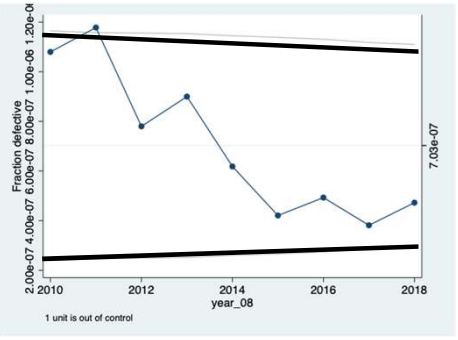






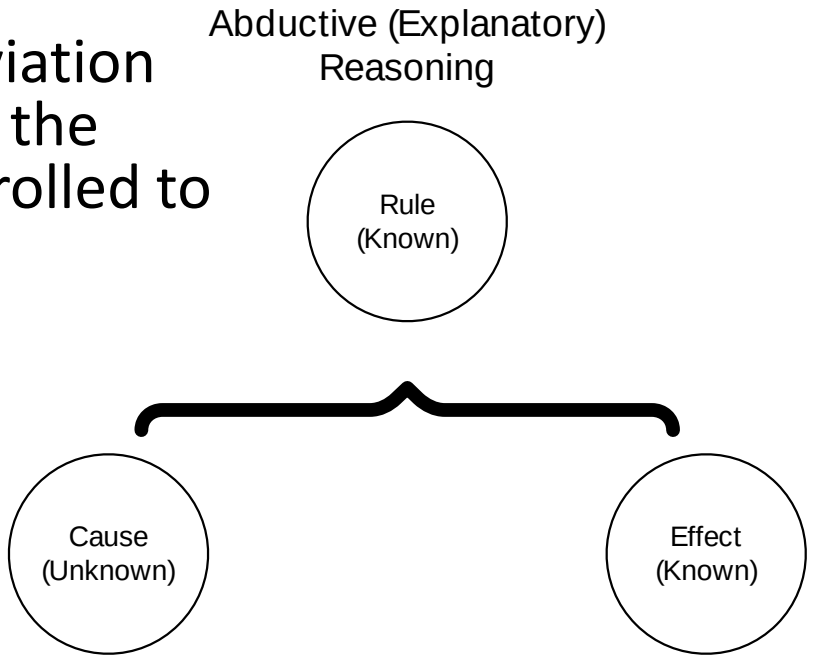






Safety within the Air Transport System

- "The state in which risks associated with aviation activities, related to, or in direct support of the operation of aircraft, are reduced and controlled to an acceptable level"
  - ICAO (2018) *Safety Management Manual*
- "Freedom from accidents (loss events)"
  - Leveson (2011) *Engineering a safer world*
- "A dynamic non-event"
  - Hollnagel (2014) *Safety-I and Safety-II*



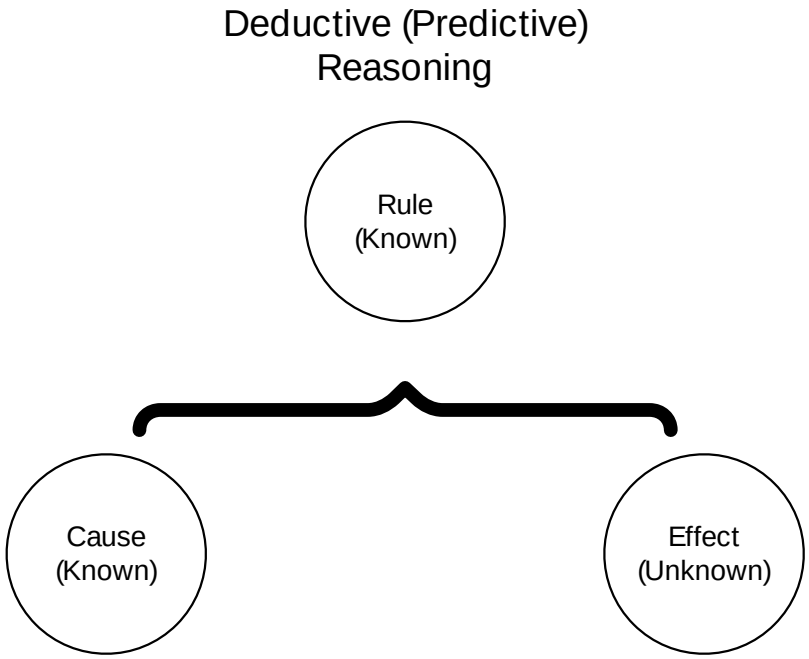
Safety as Commonly Used

Hollnagel's (2014) three examples:

- 'have a safe flight'
- 'drive safely back'
- 'you will be safe here'

All of which means that:

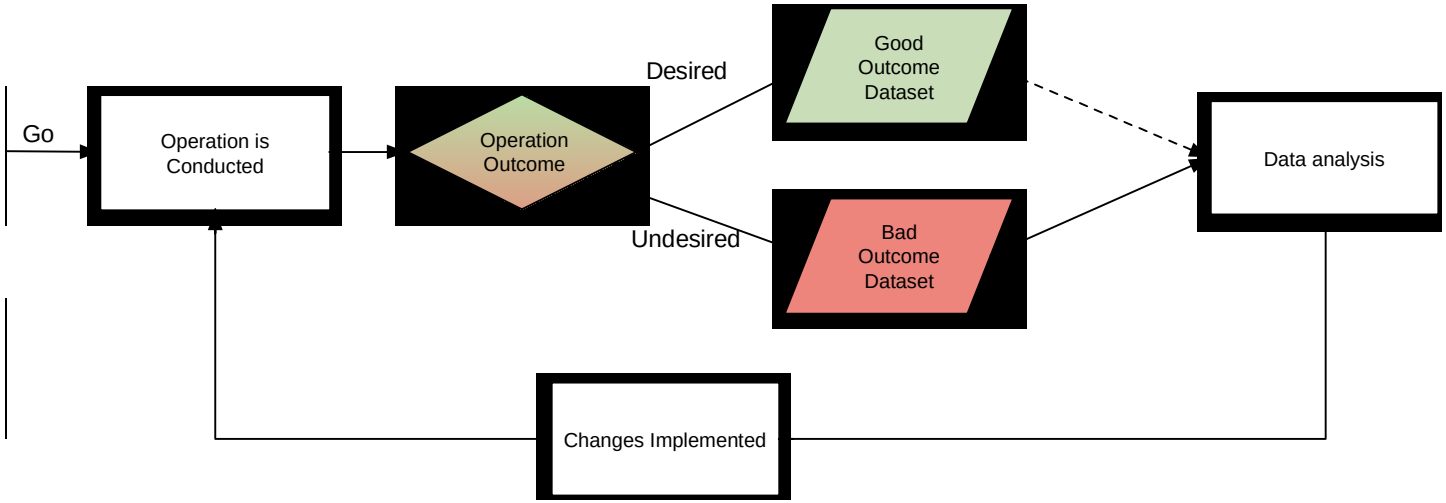
- 'being safe' is that the outcome of whatever is being done will be as expected



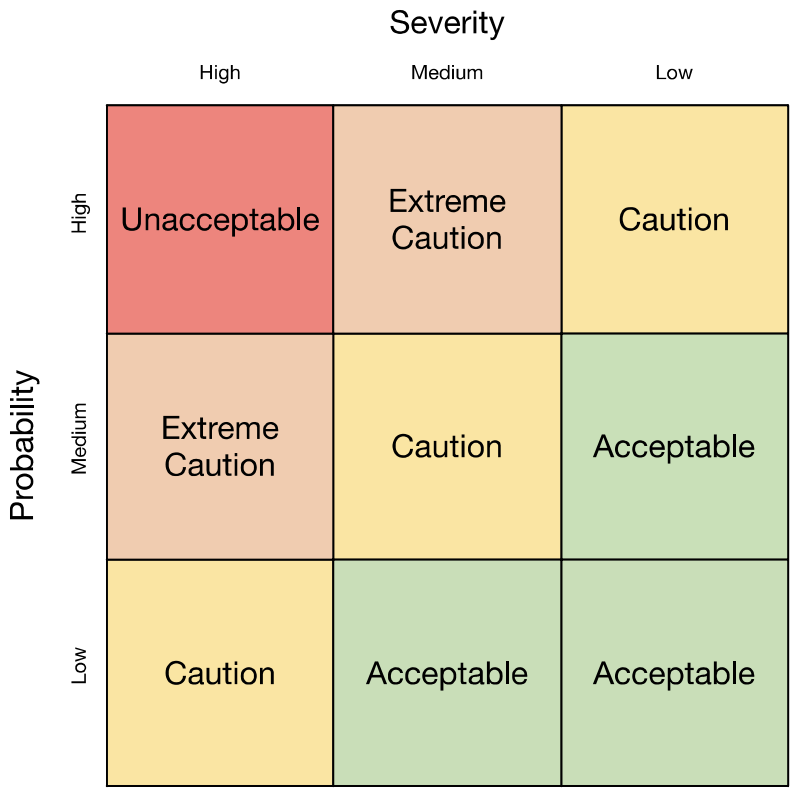
Are Our Current Tools Sufficient?

Not if used alone; because…

- Usually used to assess what went wrong (Safety-I)
  - Starting to be used to assess what goes right (Safety-II)
- Only looks at operations that take place
  - Instead of what could occur

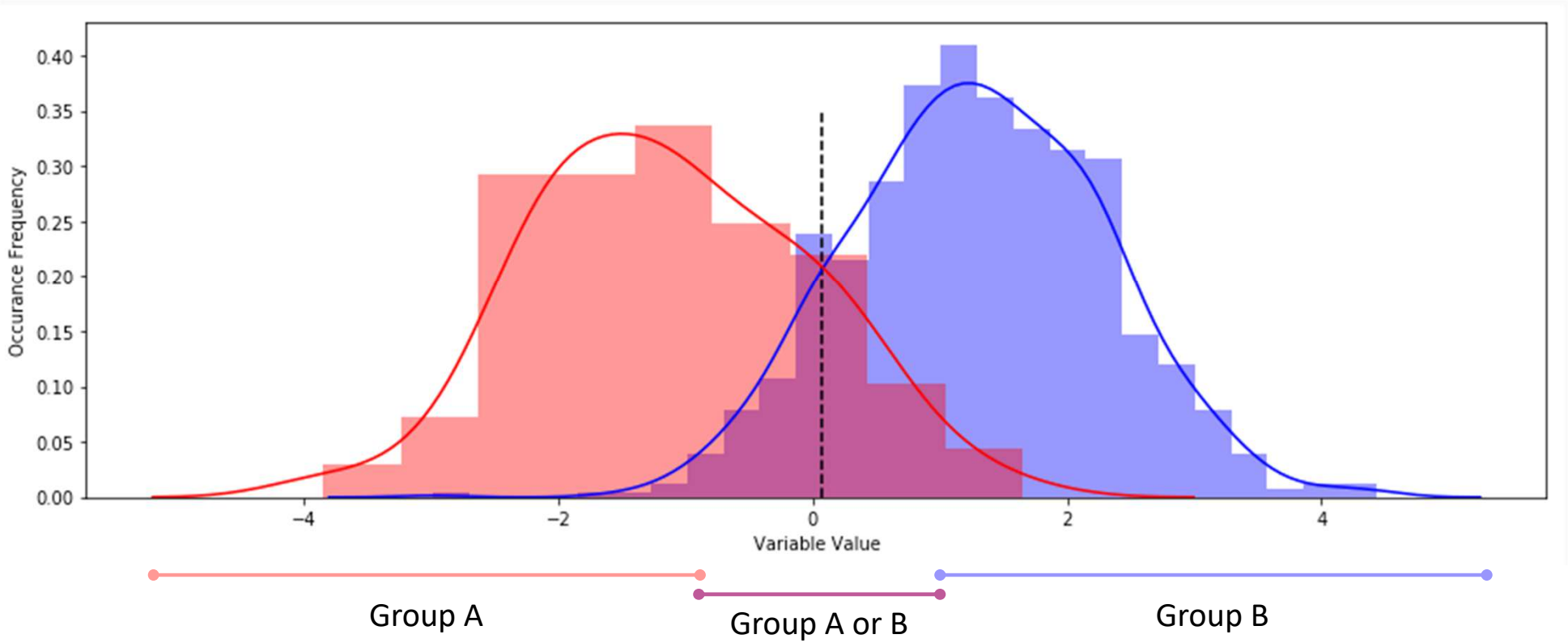


Generalized Risk Matrix



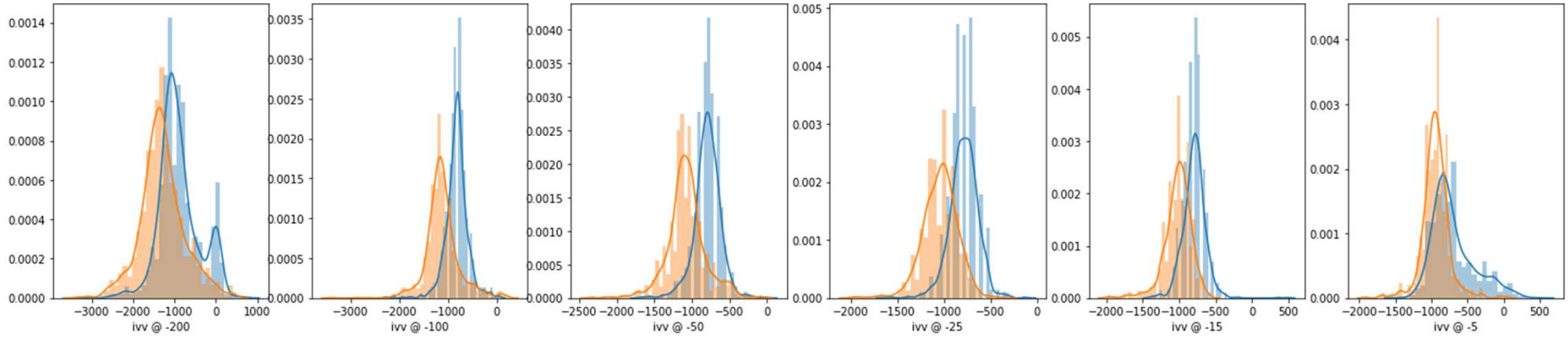
- Advantages
  - Popular method by which safety risk is assessed
  - Easy to understand
    - Can be understood by entire organization
- Limitations
  - Overly generalized
  - Static representation of dynamic processes
  - Difficult to standardize assessment process

What is Needed for These Tools to Work

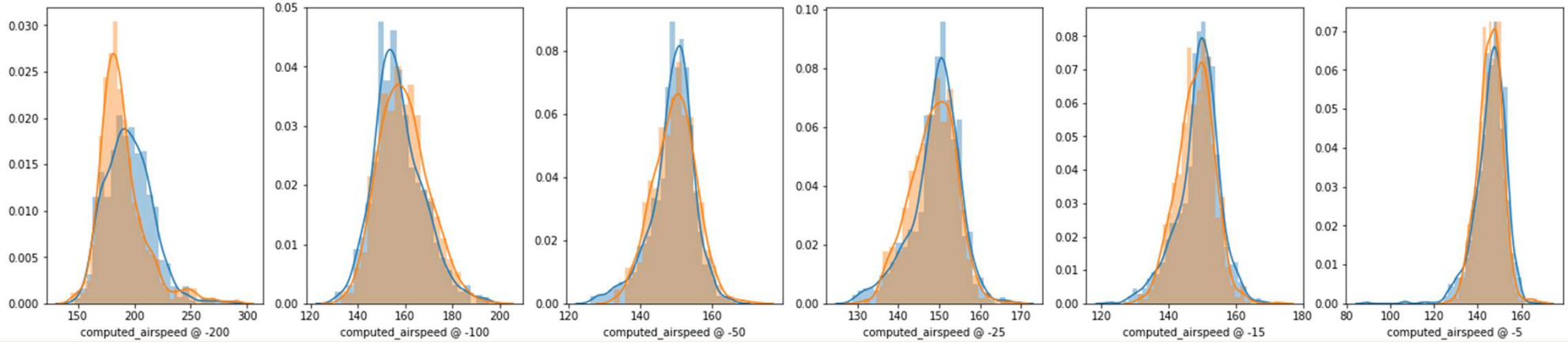


What We Actually Saw

Instantaneous Vertical Velocity



Computed Airspeed



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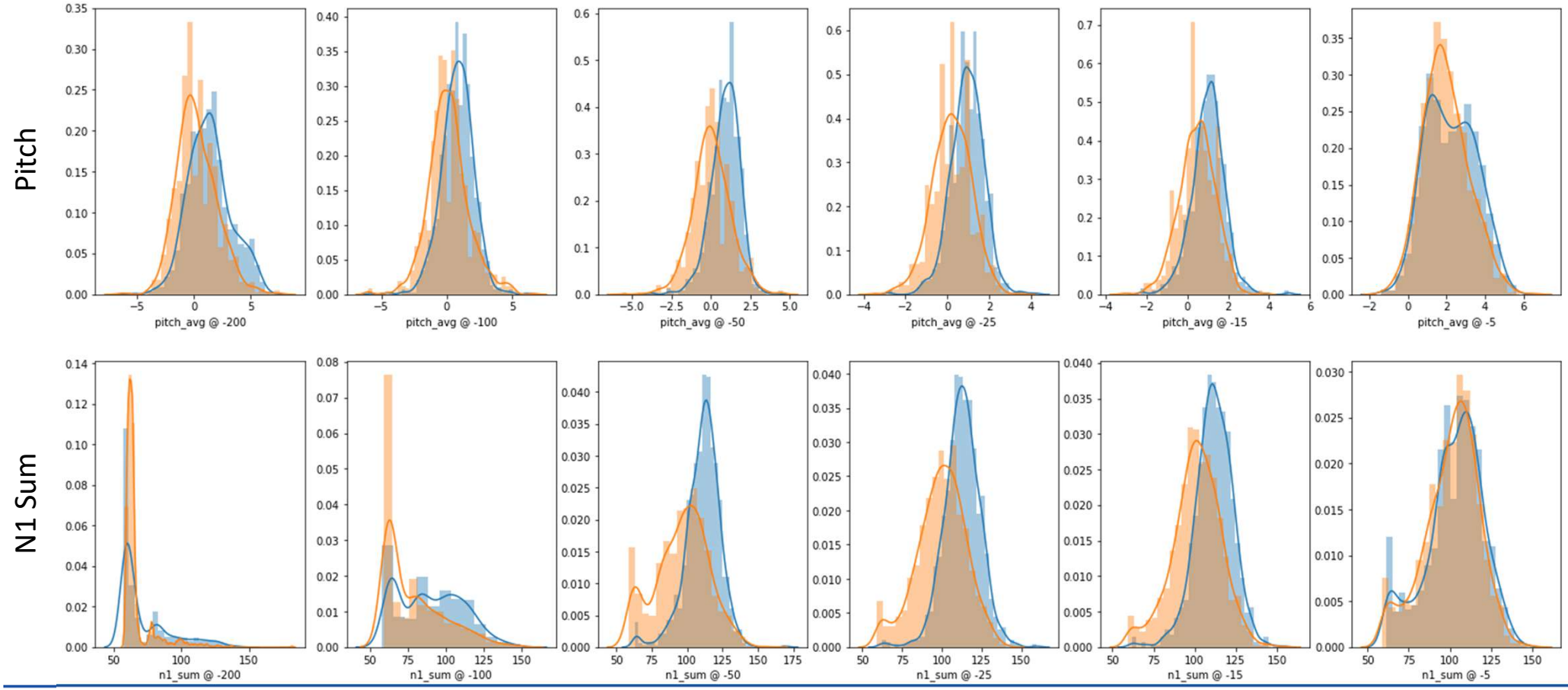
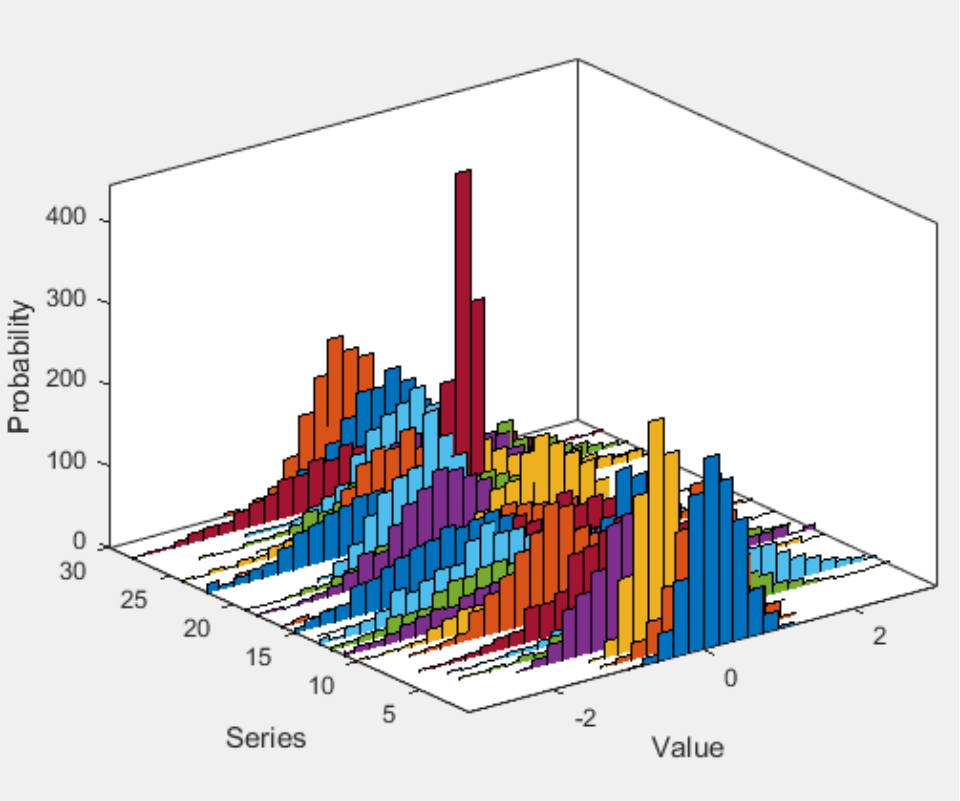


Going Forward

Integration of Multi-Source/Modal Data

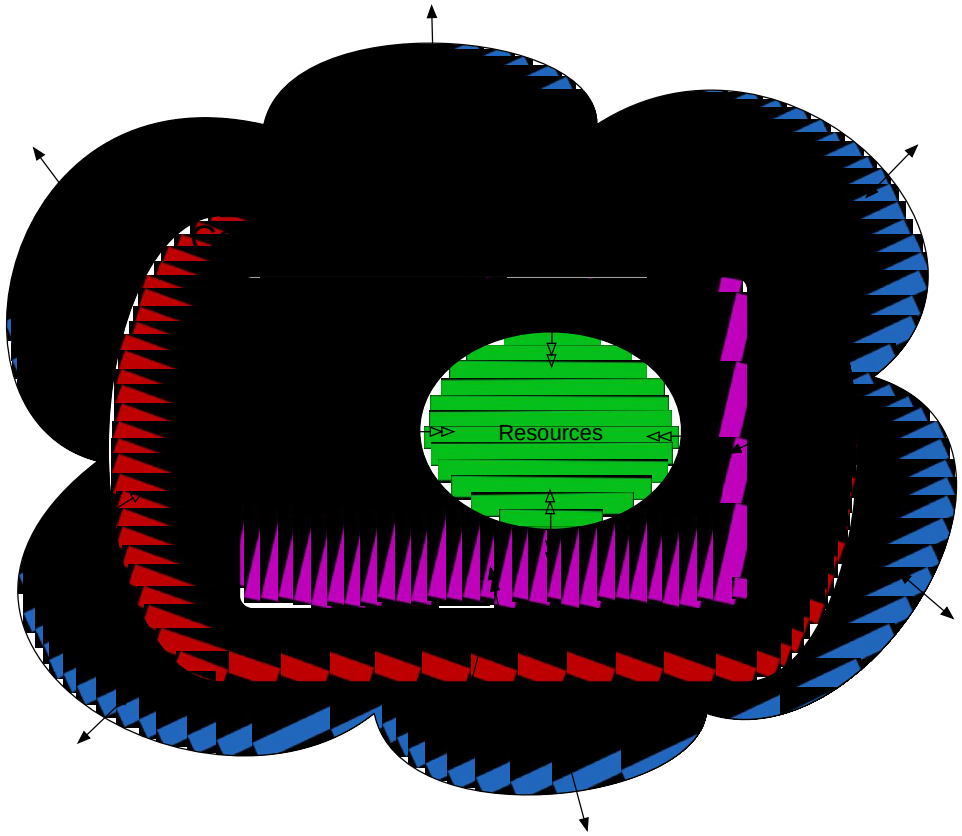
- Amount of data being collected is increasing dramatically
  - From many sources
  - With many types
- The processes are constantly changing
  - Exceedances are ill suited for this situation

Needs more holistic and dynamic approach

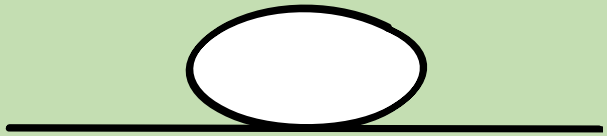
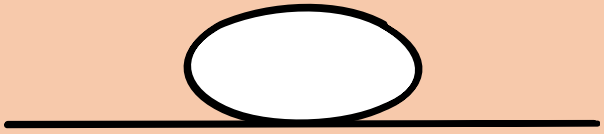


Need For Balance

- Current methods are overly influenced by historical events
  - Works great when the system and environment are known
  - But what happens when
    - The system grows to fast?
    - The technology being used is being updated or upgraded?
    - The environment is changing?
- In such cases can we be assured that history is the best teacher?

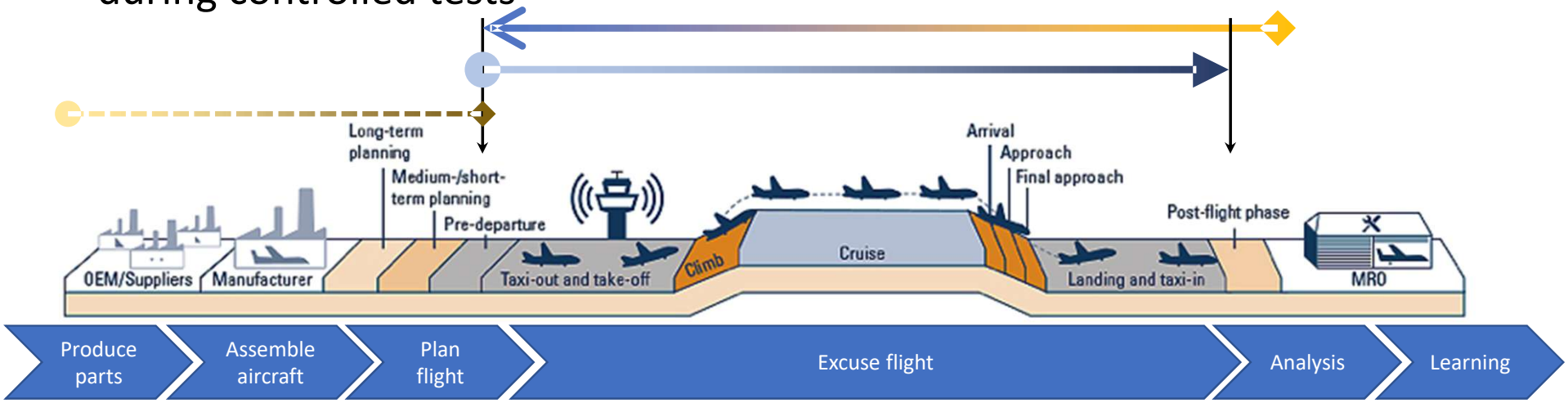


System/Environmental Analysis Considerations

	System Dynamics Stable	System Dynamics Unstable
System Environment Stable	• Known System Dynamic • Known Environmental Dynamics 	• Unknown System Dynamics • Known Environmental Dynamics 
System Environment Unstable	• Known System Dynamics • Unknown Environmental Dynamics 	• Unknown System Dynamics • Unknown Environmental Dynamics 

Embracing Linear Operational Causality (Bounded)

- Many non-linear causal influences shape the operational environment and context
- Once a flight takes off it becomes constrained to mostly linear rules
  - Many of which we already know, and the goal is to only learn the others during controlled tests

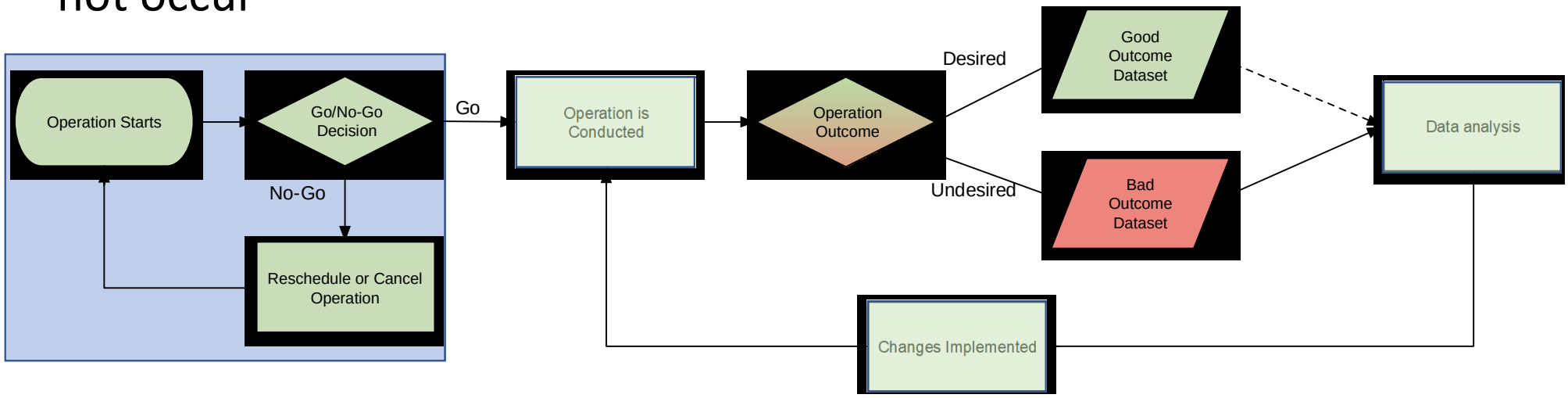


https://www.bauhaus-luftfahrt.net/en/

Looking at What Has Not Happened

- In evaluating only the outcomes
  - Only what has been seen in the past can be analyzed (good or bad)

- To truly look at what goes right, we must look at the flights that do not occur



Conclusions

- While aviation is getting safer, the rate of improvement is plateauing
  - Requires an analysis of the current tools we are using
- Current tools are still invaluable however
  - Many of the assumptions are hard to justify
  - Are not suited for creating predictive insights
- Causality will be difficult to determine
  - Without the questions we are asking are fundamentally causal

Thank you for your attention

Questions?