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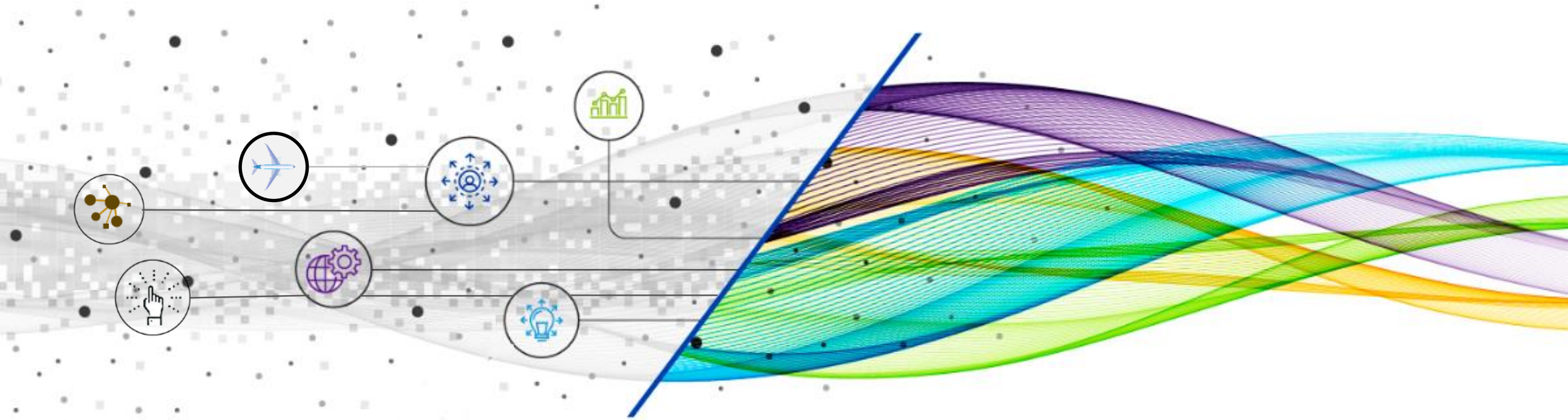

Assessing the Benefits of Advanced Analytics on Maintenance Processes and Costs

Andrew Hall, Director, Data Science

September 2019

Agree or Disagree?

The goal of predictive maintenance is to prevent AOGs.

Agenda

- Assessing Unscheduled Maintenance Costs
- Predictive Alerting
- Cost Effectiveness of Predictive Alerting
- Combining Predictive and Prescriptive Maintenance
- The Benefits of Predictive and Prescriptive Maintenance

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- **Assessing Unscheduled Maintenance Costs**
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Assessing Unscheduled Maintenance Costs

Flight Disruption

Disruption costs

Customer loyalty

Component Logistics

AOG shipping

Holding costs

Component Repair

Repair/replace

Repair cycle time

Maintenance Productivity

Over/under labor

No prep time

Engineering Costs

Inspections

Tracking

The Primary Assertion

The application of predictive and prescriptive maintenance capabilities will optimize many categories of maintenance cost, without compromising operational performance or passenger experience.

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- Assessing Unscheduled Maintenance Costs
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Developing a Predictive Alert Algorithm

Data Scientist

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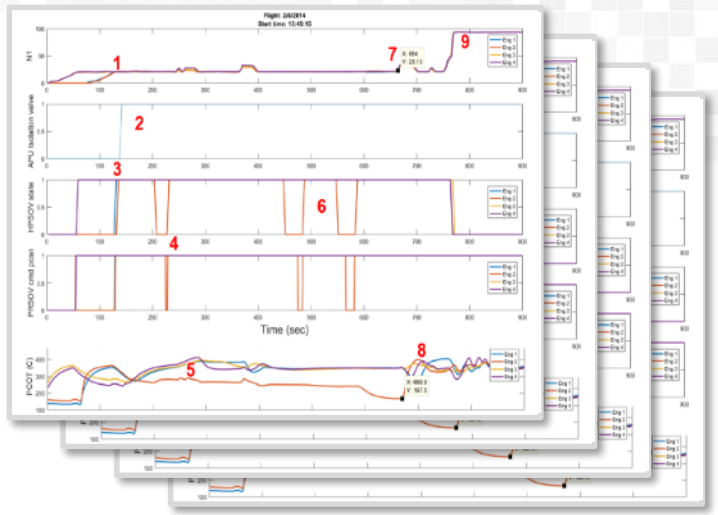
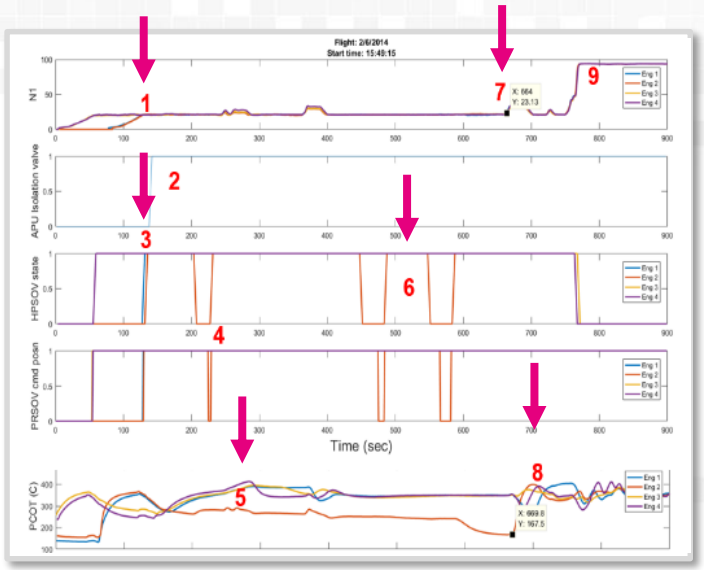
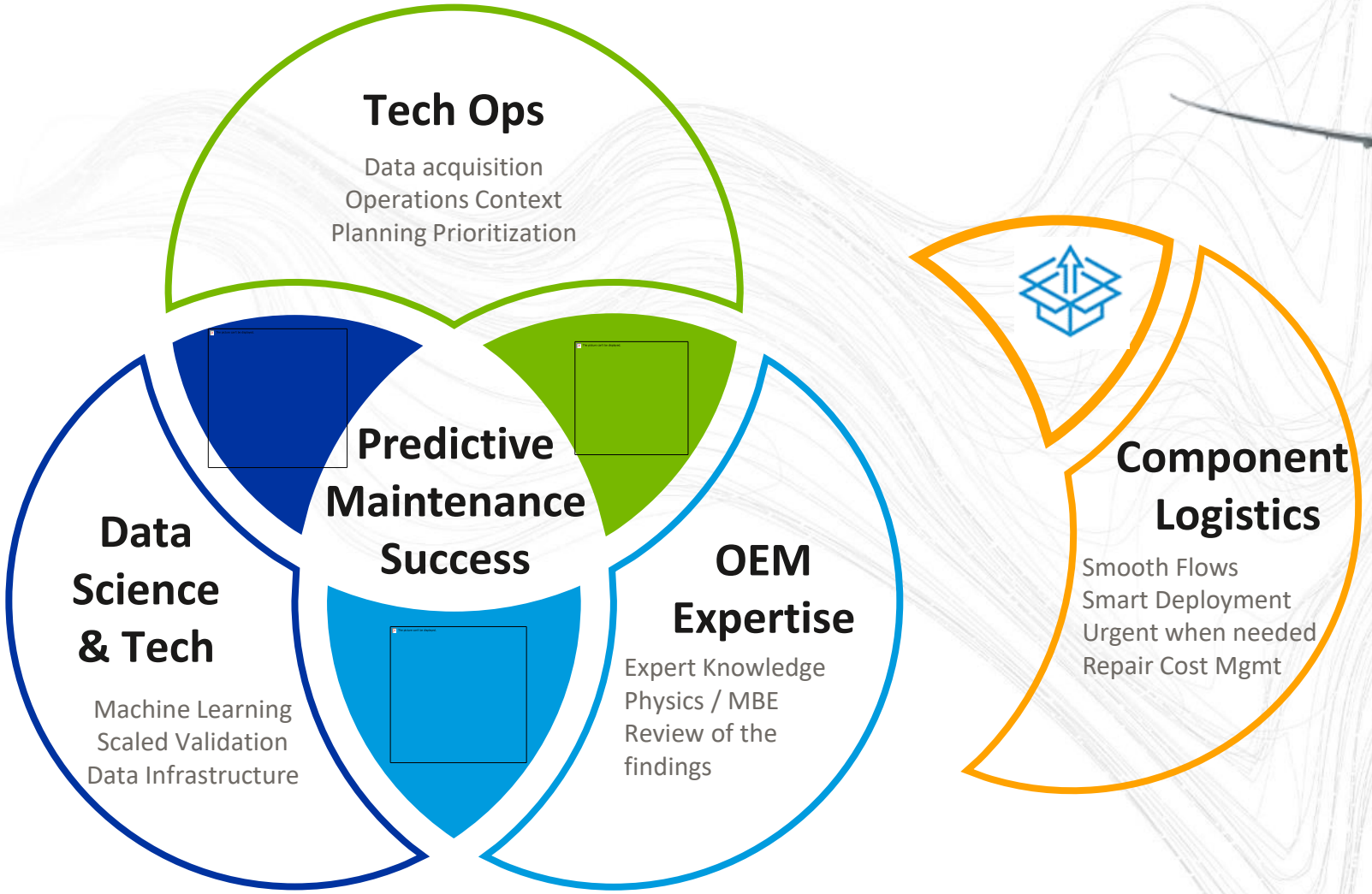
Engineer

Relevant historical data → **Identify features & models** → **Validated alert logic**



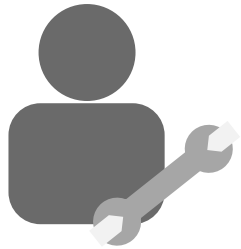


Predictive Maintenance is a “Team Sport”



Asset Productivity

Efficient Maintenance



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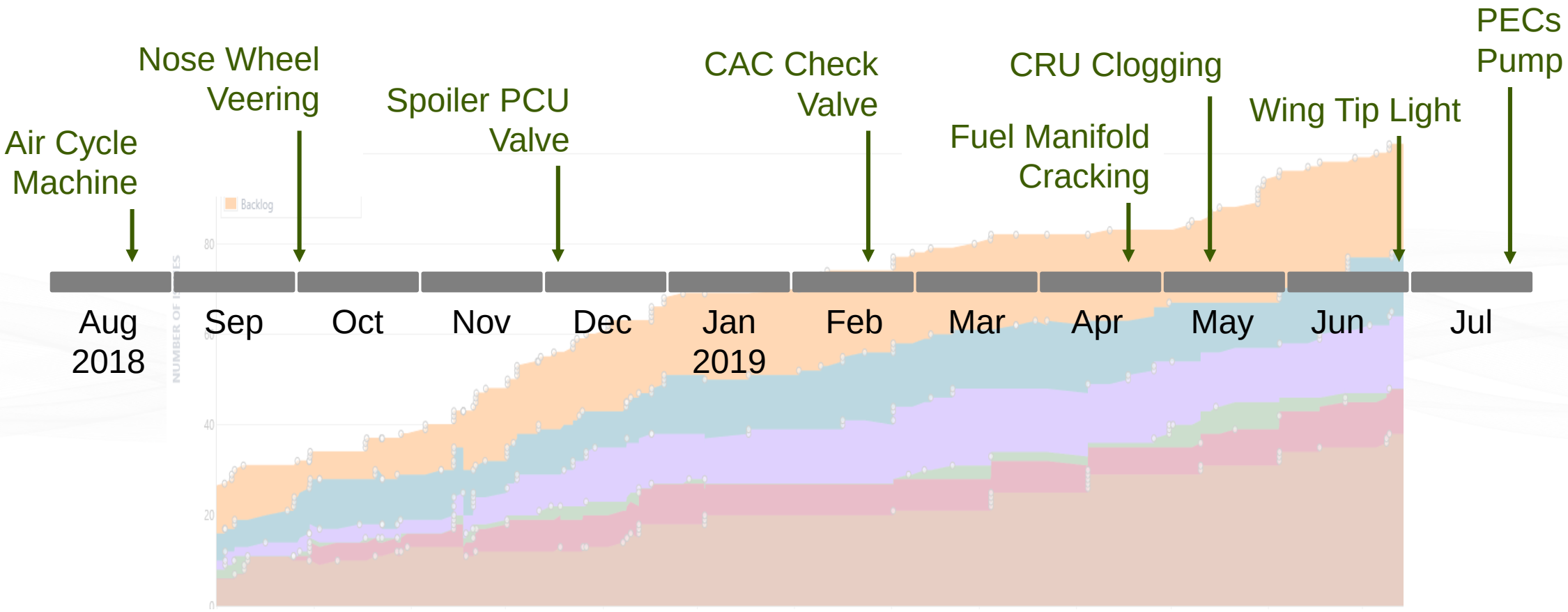
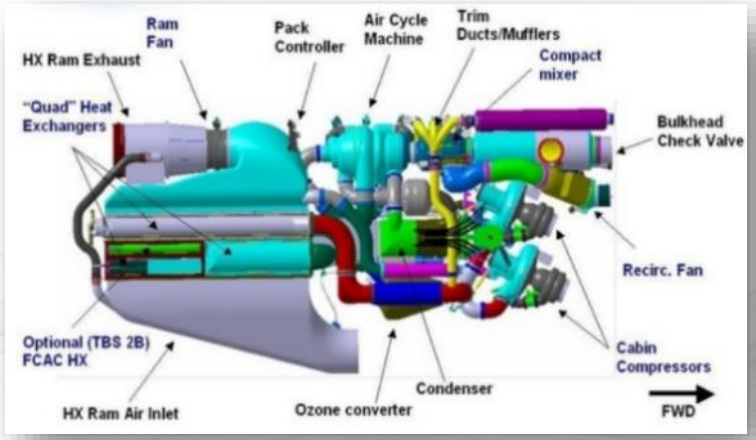
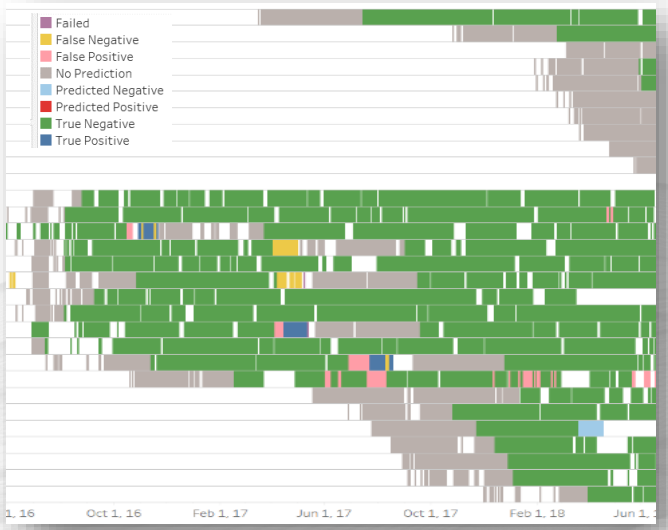
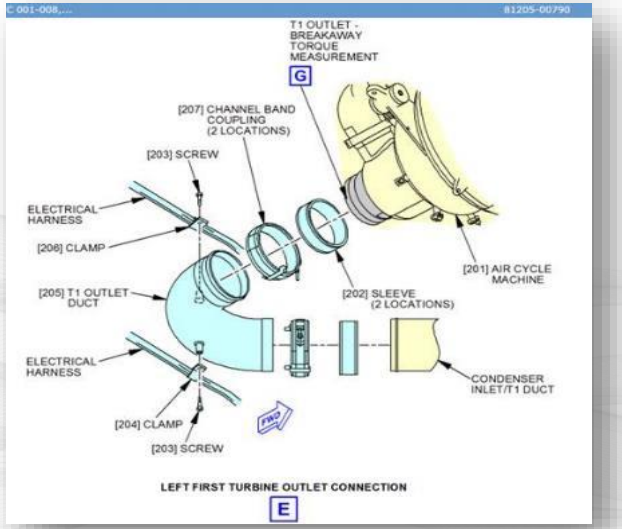
Advanced Alerts are Scaling



Example: 787 Air Cycle Machine (ACM) Predictive Alert

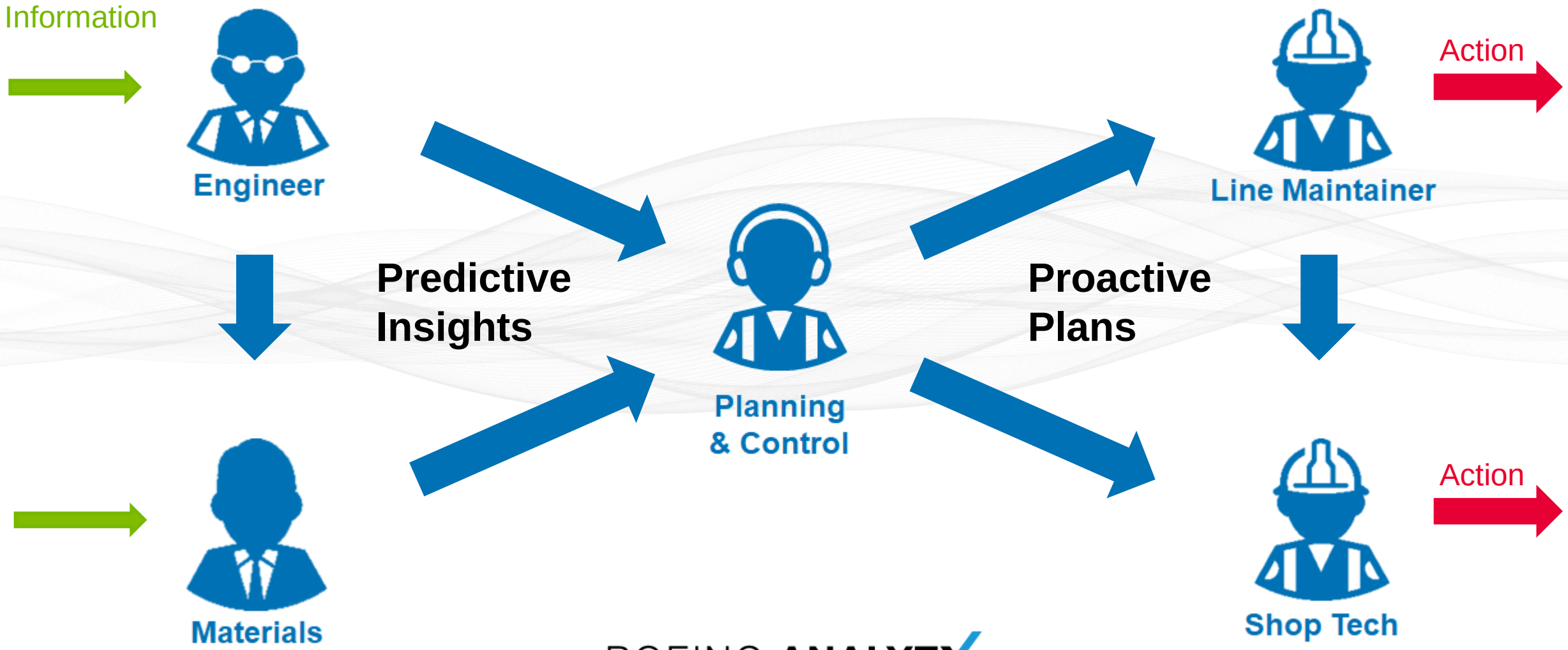






OEM Knowledge → **Validated Machine Learning** → **Prognostic-Driven Action**

Achieving Flow in Line Maintenance – ACM example



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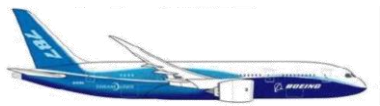
Predictive Alerts Lead to Maintenance Optimization



Alerting Software

Engineer or Ops Center

Other Boeing Applications

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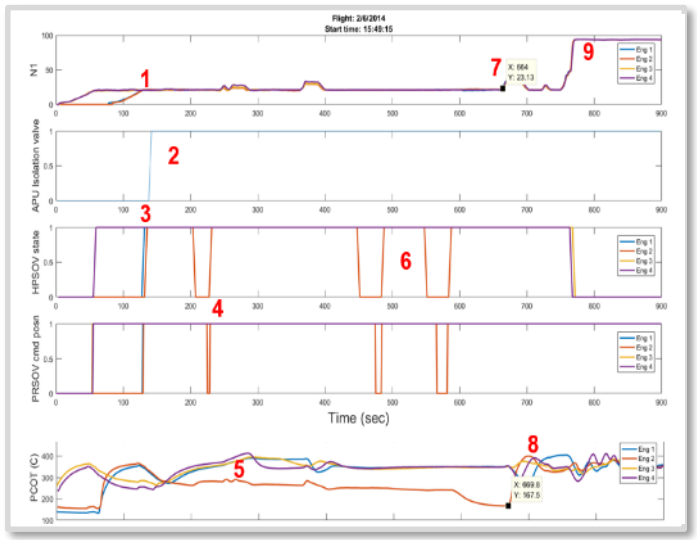
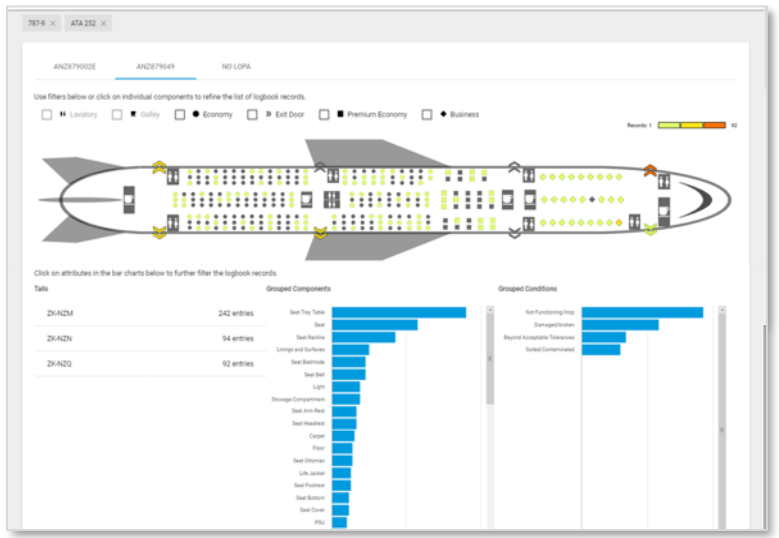
Maintainer

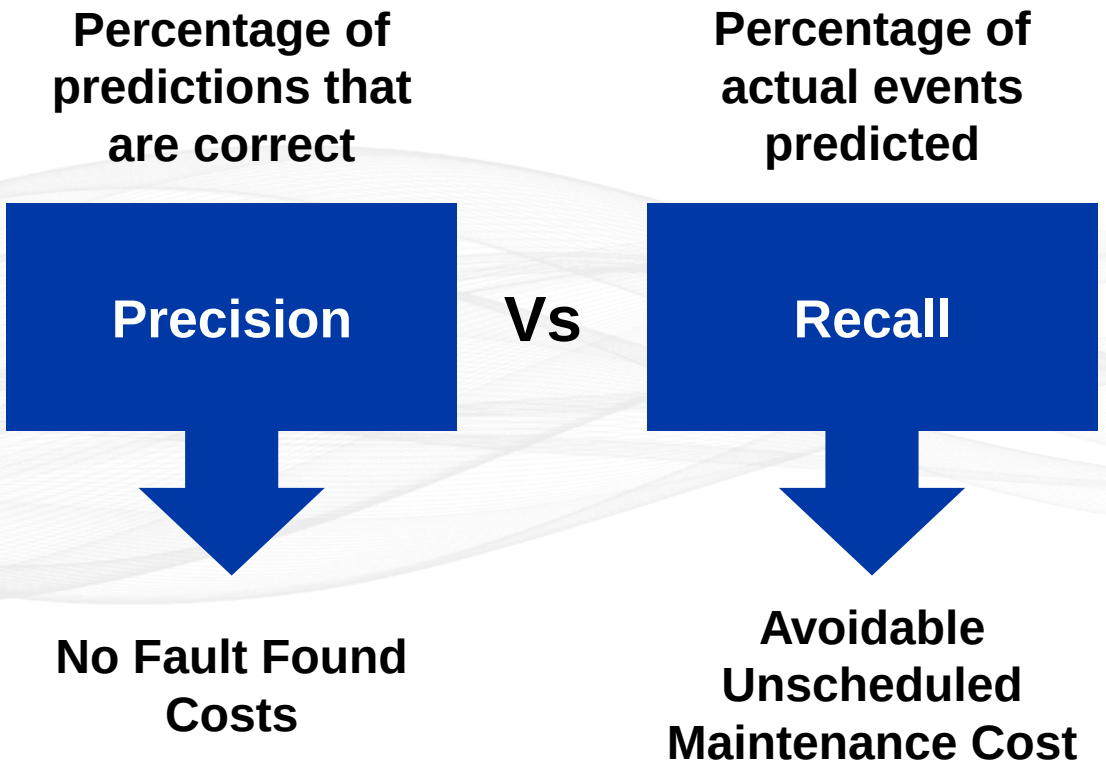
Predictive Condition → Decision Support → Optimized Actions





Assessing the Effectiveness of a Predictive Alert

- Imagine a ‘perfect’ alert
- Trade-off between precision and recall, given horizon
- Costs of NFF versus cost of Avoidable Unscheduled Removal
- **Ability-to-act is key**
- Confidence in a specific prediction



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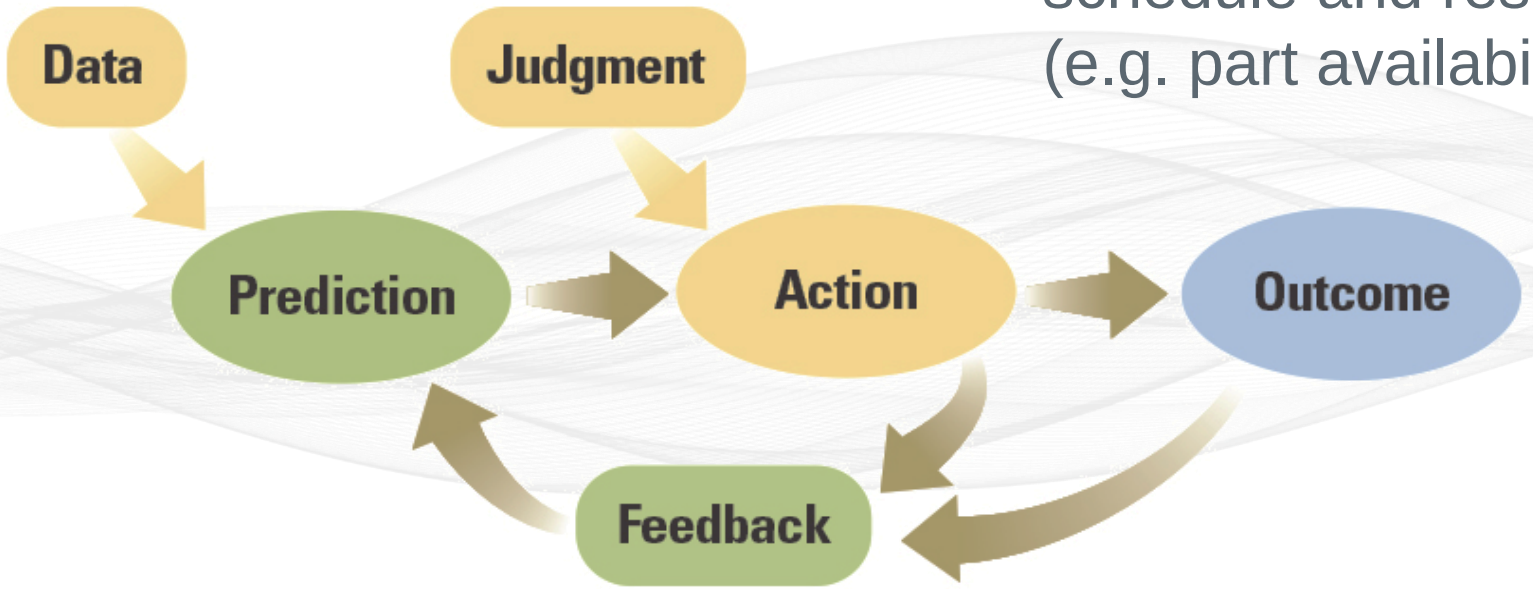
Decision Model for Maintenance Action

Judgment required to assess fix effectiveness and backlog of work

Action space defined by schedule and resources (e.g. part availability)



Prescriptive Maintenance combines predictive alerting with resource planning and maintenance decision support

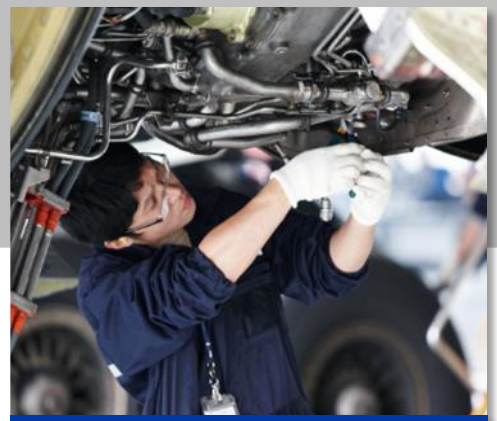
Diagram Source:
MIT Sloan Management Review: Spring 2017 Issue
Ajay Agrawal, Joshua S. Gans, and Avi Goldfarb

Combining Predictive and Prescriptive Maintenance

Program

Inventory

Flight Schedule



Labor

Planning Decision Support

Predictive Alerts

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The Value of Predictive and Prescriptive Maintenance

Flight Disruption	Component Logistics	Component Repair	Maintenance Productivity	Engineering Costs
Saves / avoided Disruptions	Reduced AOG logistics costs	Reduced repair cost	Balance labor supply and demand	Reduced investigations
Increased utilization & revenue potential	Reduced holding costs	Smoothed repair cycle time	Lead time for job preparation	Prioritized mod campaigns
	Avoid spot buys			

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OPERATE WITH CONFIDENCE