

**DATA+AI**  
SUMMIT 2022

# Applied Predictive Maintenance in Aviation: Without Sensor Data

Data will talk to you if you are willing  
to listen

ORGANIZED BY  databricks



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# Agenda

- Randy Provence
  - Organization / Mission
  - Data pipeline
- David Taylor
  - Predictive maintenance



# FedEx Trunk Fleet

- 410 Wide Body Aircraft
- 16.5 Million Daily Package Volume
- 261,700 Flights Per Year



# Organization / Mission

## Organization

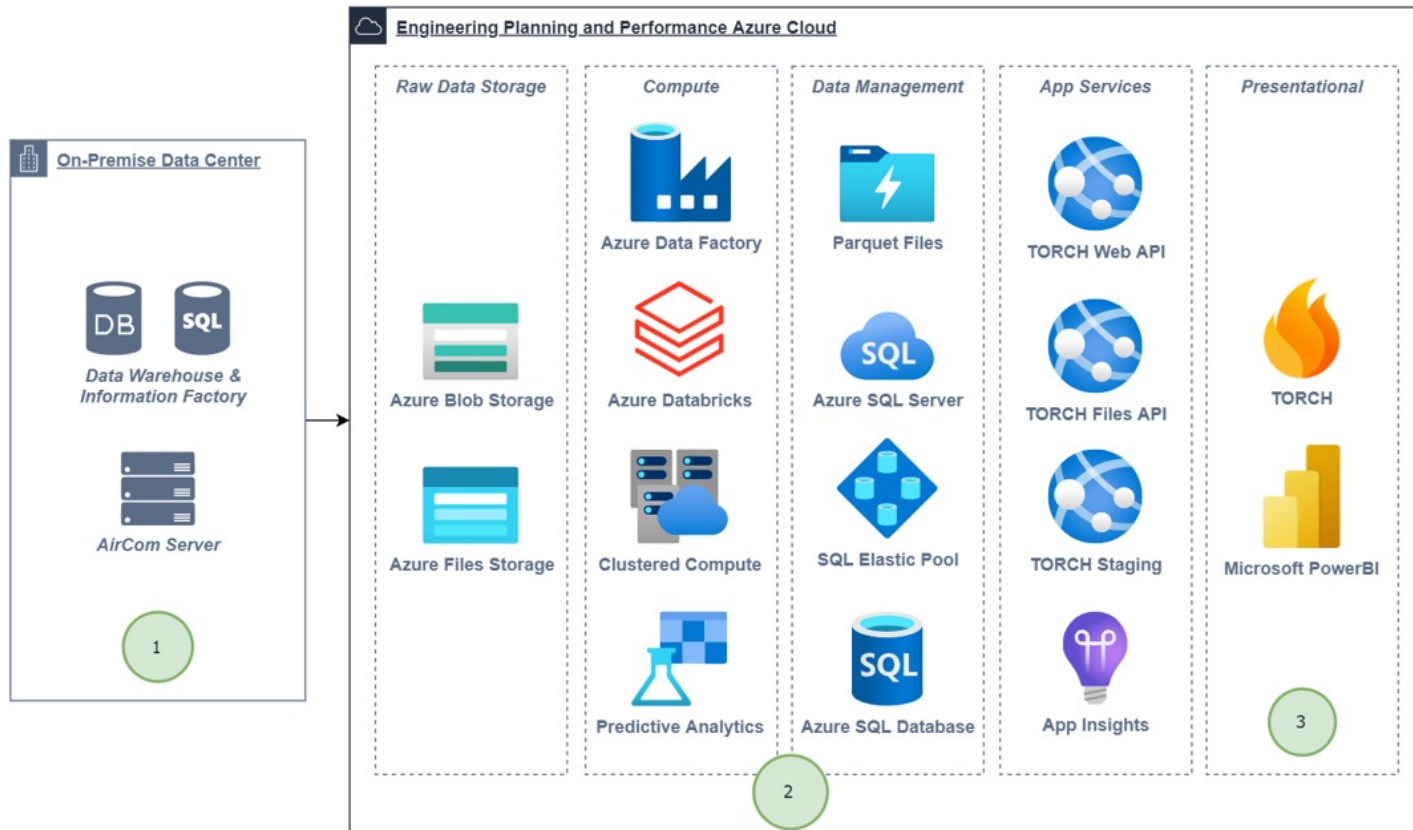
- Component Reliability Team

## Mission

- Prevent Aircraft Departure Delays
- Move unplanned component failures to planned removals
- Develop methods of predicting component failures without telemetry data



# Data Flow



## Bronze Data

1

Bronze data is our raw, unscrubbed data that exists on our on-premise data warehouse and Information Factory

## Silver Data

2

Silver data is the processed, scrubbed, and formatted data that is considered high quality and ready to be analyzed

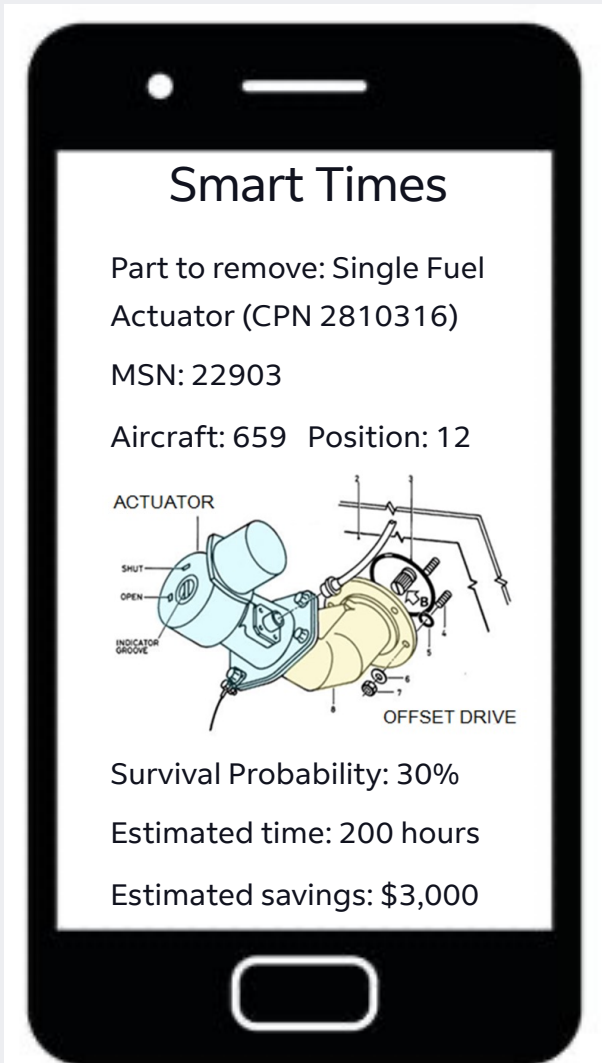
## Gold Data

3

Gold data is the post-analysis, aggregated data which enables analysts to quickly perform root cause analysis

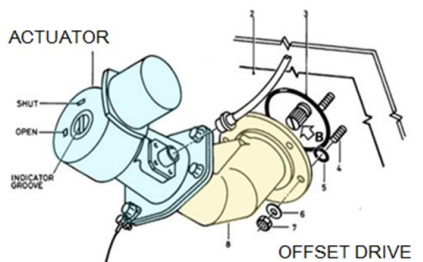
# What is a Smart Time?

- Business Rules: 350k serial numbers evaluated
- Machine Learning: 126 part number algorithms utilized
- Tailor Made for each Serial Number install



**Smart Times**

Part to remove: Single Fuel Actuator (CPN 2810316)  
MSN: 22903  
Aircraft: 659 Position: 12

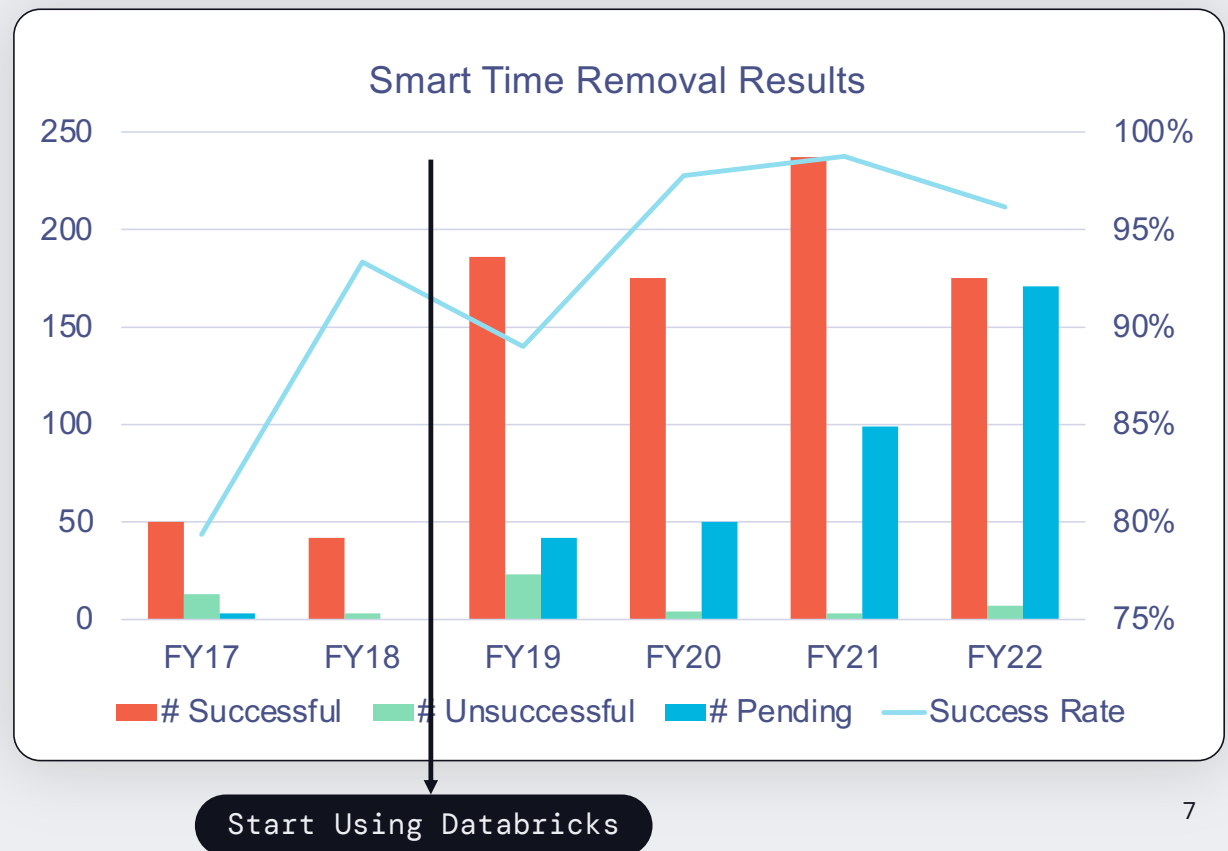


Survival Probability: 30%  
Estimated time: 200 hours  
Estimated savings: \$3,000

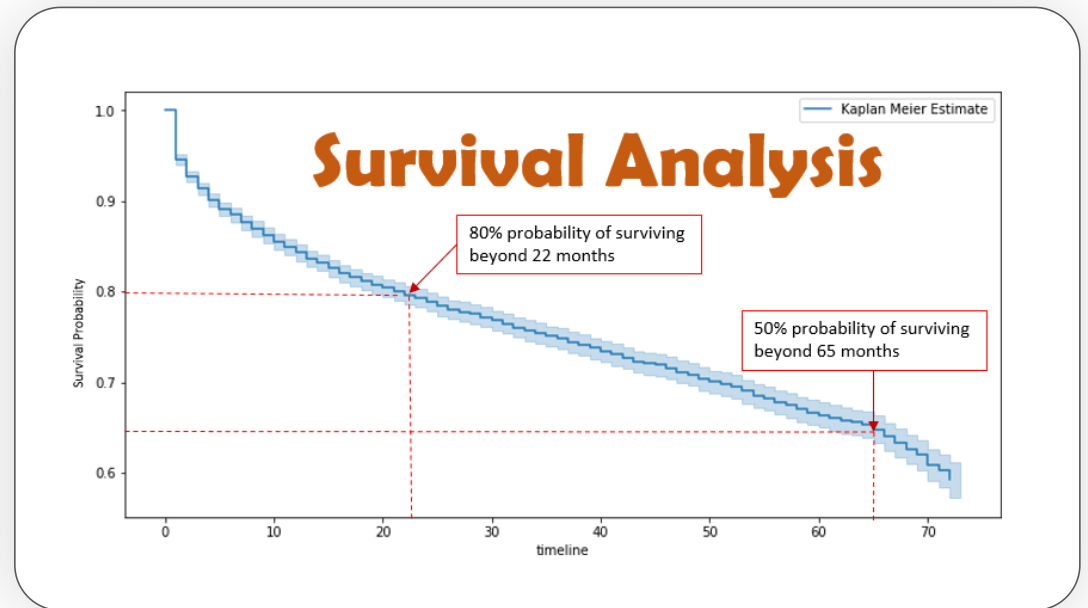
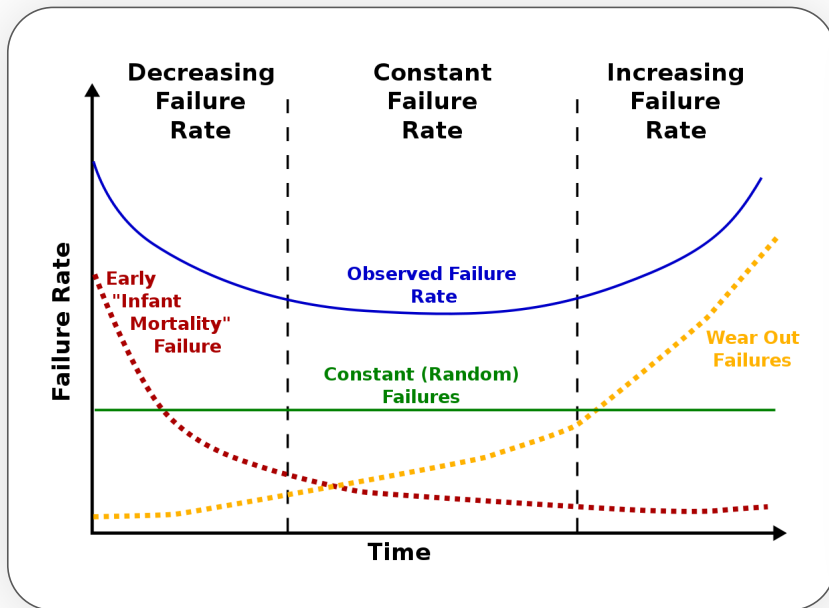


# Smart Time Removal Results

- Units are tracked after predictive removal and shop findings are used to determine success
- Prediction success rate (those with confirmed failures) has improved with experience selecting parts
- Number of parts removed are constrained by aircraft downtime and component sourcing availability



# Modeling Component Failures without Sensor Data

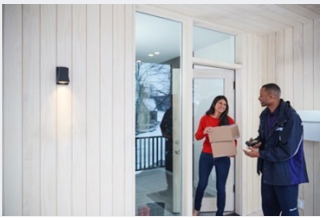


- Different models for different components
- Use historical data to model the life cycle of a part with Lifelines in Python. Each family of components would have a different model and we have over 4,000 component families.

- Customized for each part
- The component models are then applied to individual serialized parts that are currently installed to produce a probability of failure and an estimated remaining life.



# Current ML Models and Back Testing



- Because of the unique behavior of each part, we model each separately.
  - We currently model 126 part number algorithms using the past 5 years of data
  - 20,355 unscheduled removals with 5,826 of them predicted<sup>1</sup>
  - \$18.1 million of \$67 million in pain could have been prevented<sup>2</sup>
  - 27,594 serial numbers installed, 1,872 are at risk and show savings if removed<sup>3</sup>
  - Pain Index estimates cost impact of operational disruptions
  - **Cost Savings = Pain Cost – Cost of Repair \* Survival Probability**

# Smart Times Screenshot

## Smart TimeEx

acn

mtbur\_exceedance

 0  1

mech\_flag

 0  1

at\_risk

 1

Legend: flight\_tsi (purple), cum\_avg\_tsi\_by\_csn\_at\_inst (light purple), flight\_tso (orange), cpn\_mtbur\_5\_years (light orange), oh\_soft\_hrs (blue), install\_count (black dot)

50

survival\_percentage

1

mtbur\_exceedance

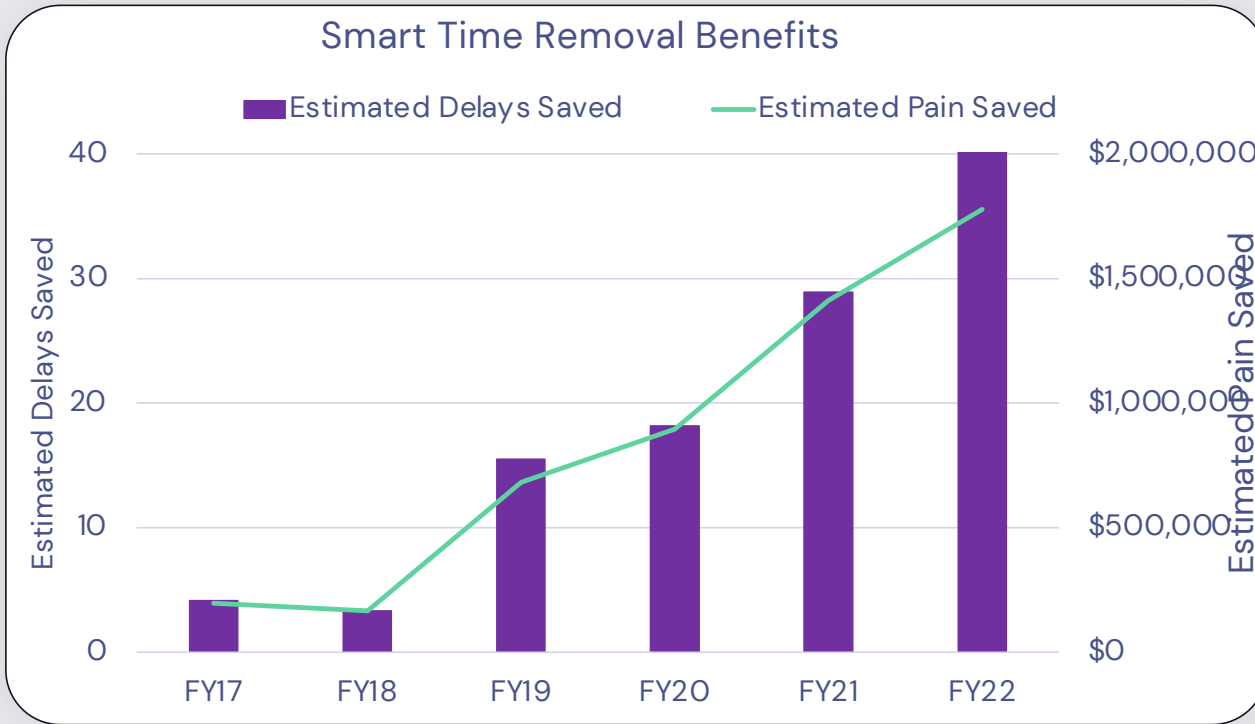
0

soft\_spec\_mtbur\_br...

hist_isn	lve	high_stage_control_valve	manifold_press_switch	soft_spec_mtbur_breach	survival_percentage	savings	avg_pain	avg_cost	gt_value	CRT_INVENTORY_DAYS_ON_HAND
159538		0	0	0	50	(\$503)	\$543	\$2,091	\$1,046	243.33
159769		0	0	0	50	(\$503)	\$543	\$2,091	\$1,046	243.33
161741		0	0	0	50	\$2,587	\$2,587	\$0	\$0	2,433.09
162780		0	0	0	50	\$966	\$3,380	\$4,827	\$2,413	0.00
162834		0	0	0	50	\$966	\$3,380	\$4,827	\$2,413	0.00
162955		0	0	0	50	\$966	\$3,380	\$4,827	\$2,413	0.00
163053		0	0	0	50	\$966	\$3,380	\$4,827	\$2,413	0.00
163238		0	0	0	50	\$966	\$3,380	\$4,827	\$2,413	0.00
163463		0	0	0	50	\$966	\$3,380	\$4,827	\$2,413	0.00

# Smart Time Removal Benefits

- Goal is to maximize overall financial benefit
- Steady decrease in delays and operational impact costs



# Vision for the Future

- Tune predictions for maximum financial benefit
- Further integrate into our custom user interface (TORCH)
- Find more Maintenance opportunities to perform removals
- Expand models to accurately predict more failures
  - Continue to add models and improve existing models
  - Collaborate to find more smart time opportunities
- Continue to add new technology
  - Incorporate more sensor data
  - Add AI models for Predictive Removals
- Begin modeling uninstalled components so that healthiest parts get repaired/installed first – Health on the Shelf



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Thank you



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