

# Application of Artificial Intelligence Techniques Enabling Coal Fired Power Plants the Ability to Achieve Higher Efficiency, Improved Availability, and increased Reliability of Their Operation

## 2019 Crosscutting Annual Review

DE-FE0031563

Stuart Gillen

*SparkCognition*





# Agenda

- Basics of Machine Learning
- Project Overview
- Questions



# Team Members

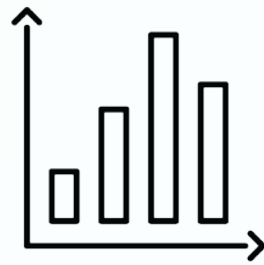
Name	Organization	Role
<b>Steve Seachman</b>	EPRI	Project Management
Stephen Hesler	EPRI	Program Mgr., Steam Turbines-Generators & Aux Equipment Program
Eric Prescott	EPRI	Snr Tech Lead, Steam Turbines-Generators & Aux Equipment Program
Kent Coleman	EPRI	Program Mgr., Boiler Life & Availability Improvement Program
<b>Josh Barron</b>	Southern Company	R&D Lead
Stacy Egnor	Georgia Power	Plant Lead
Johnny Howze	Georgia Power	Plant Manager
Nathan Ivey	Southern Company	Fleet Maint & Reliability Lead
Randy Jones	Southern Company	CBM & Analytics Manager
Randy Mullinax	Southern Company	General Manager



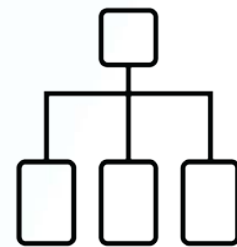
# Basics of Machine Learning



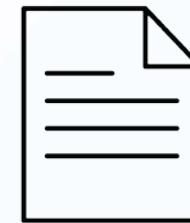
# What is a model?



**INPUT DATA**



**ALGORITHM**

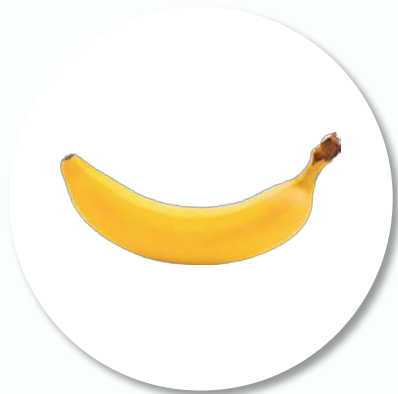


**MODEL**



# How would you write the code?

How would you tell the difference between a banana, apple, and grapes?



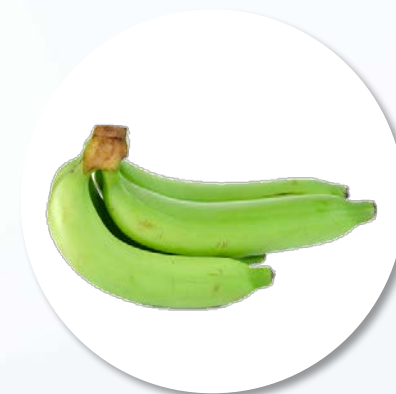
Bananas are **YELLOW**



Apples are **RED**



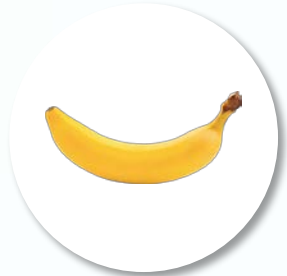
Grapes are **GREEN**





# What if we applied machine learning instead?

Let the algorithm define the relationships between the measurable characteristics and the fruit they embody.



Height

Width



**BANANA**



Height/Width

Color



**APPLE**



Color Variation

Shape

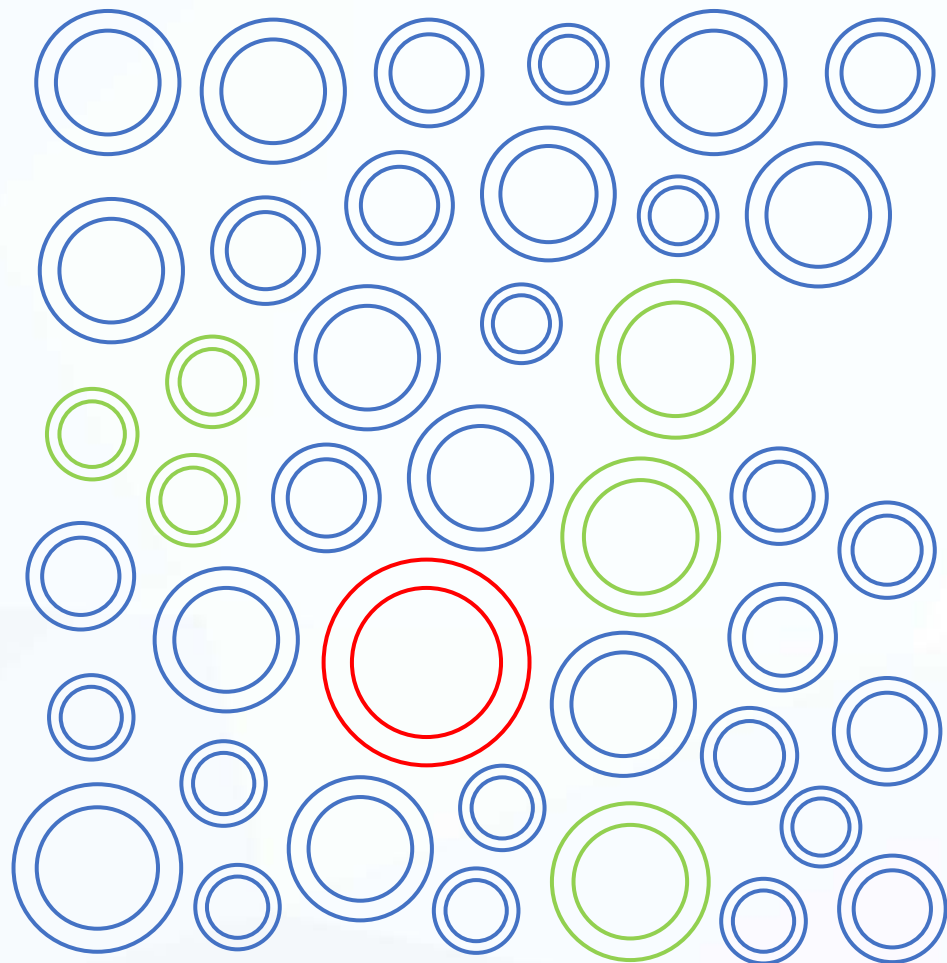


**GRAPES**



# Unsupervised Learning

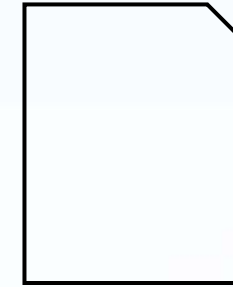
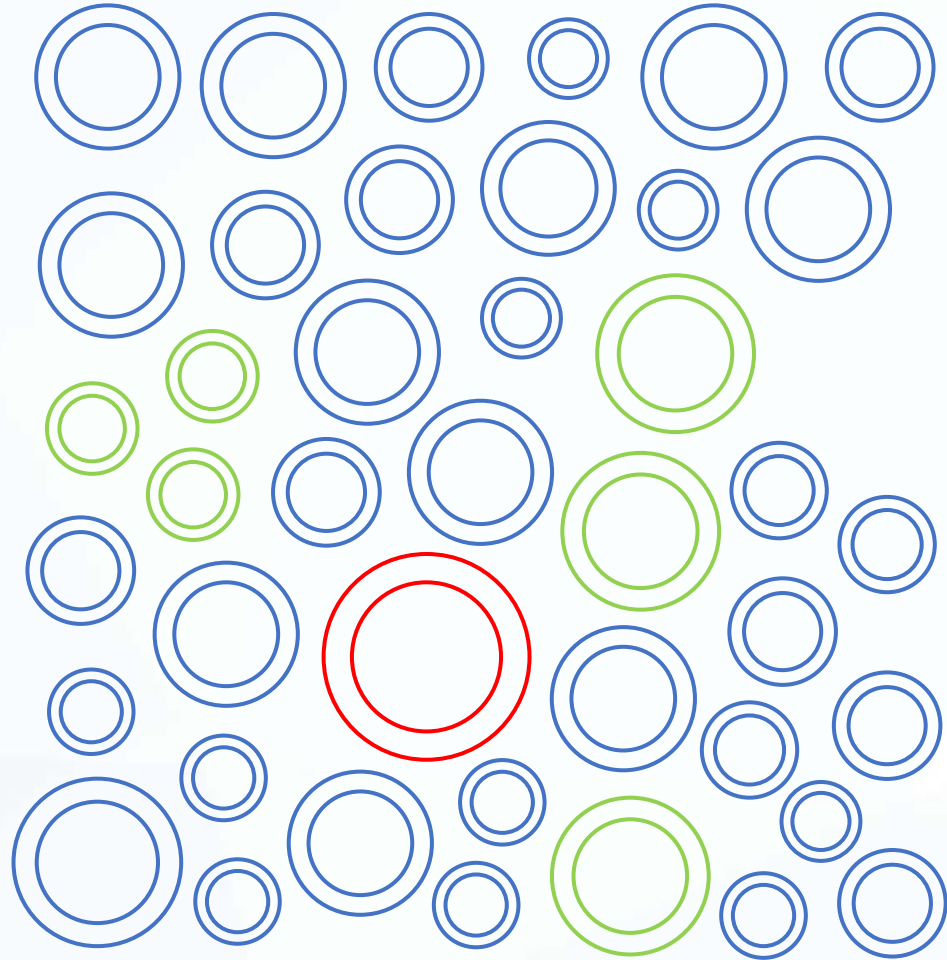
How do you label these?



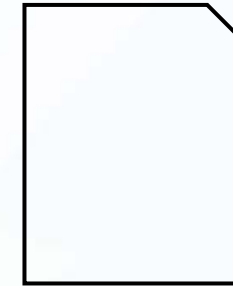




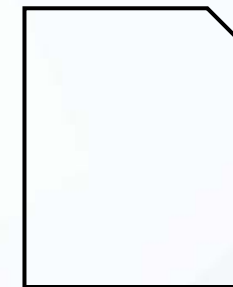
# Unsupervised Learning



Small



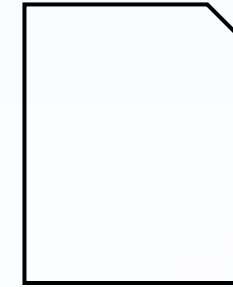
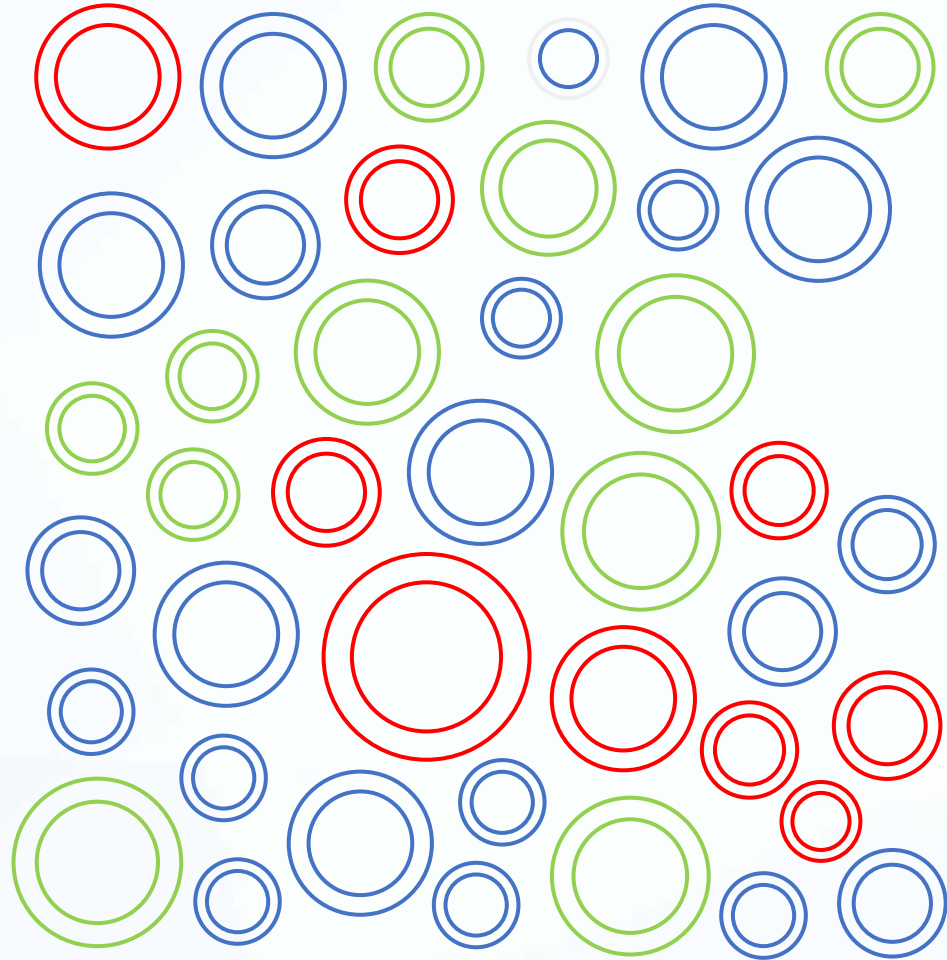
Medium



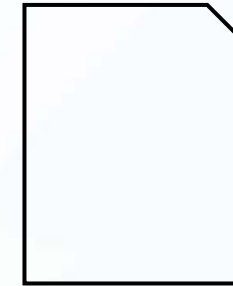
Large



# Supervised Learning



Red



Green



Blue



# Unsupervised vs. Supervised Learning

## Unsupervised

## Supervised

Index	Date	Time	Asset ID	Value
2	5-Apr-10	7:01	750	89
93	22-Mar-13	8:19	904	79
27	20-Oct-14	8:26	545	74
5	10-Jul-12	7:38	552	86
68	15-Sep-11	8:13	942	74
29	1-Jun-11	8:44	900	72
91	20-Jul-11	7:14	587	50
54	12-Jul-10	7:16	715	95
20	5-Sep-14	8:25	813	39
44	30-Jun-11	7:07	983	71
100	5-Oct-12	7:35	802	34
66	12-Mar-10	7:39	726	47
45	6-May-11	7:30	973	98
84	10-Dec-12	7:17	504	68
43	9-Jul-14	8:07	567	74

Action Taken	Component
Repair	Blade
Unknown	Blade
Repair	Gearbox
Replaced	Gearbox
Replaced	Gearbox
NTF	Generator
Good	Generator
NTF	Blade
Repair	Generator
NTF	Gearbox
NTF	Blade
Repair	Gearbox
Unknown	Gearbox
Repair	Blade
Repair	Gearbox

Impending catastrophic failure

Advanced degradation warning

35 Days

Days Warning



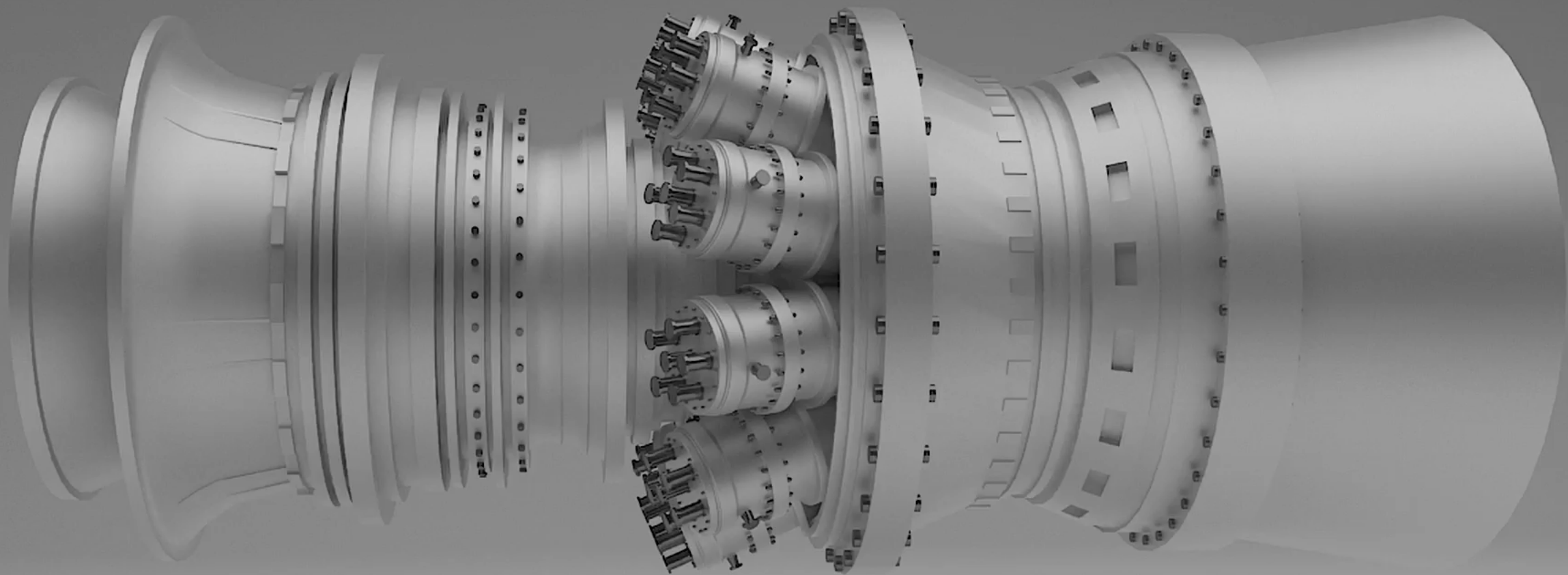
# Project Overview



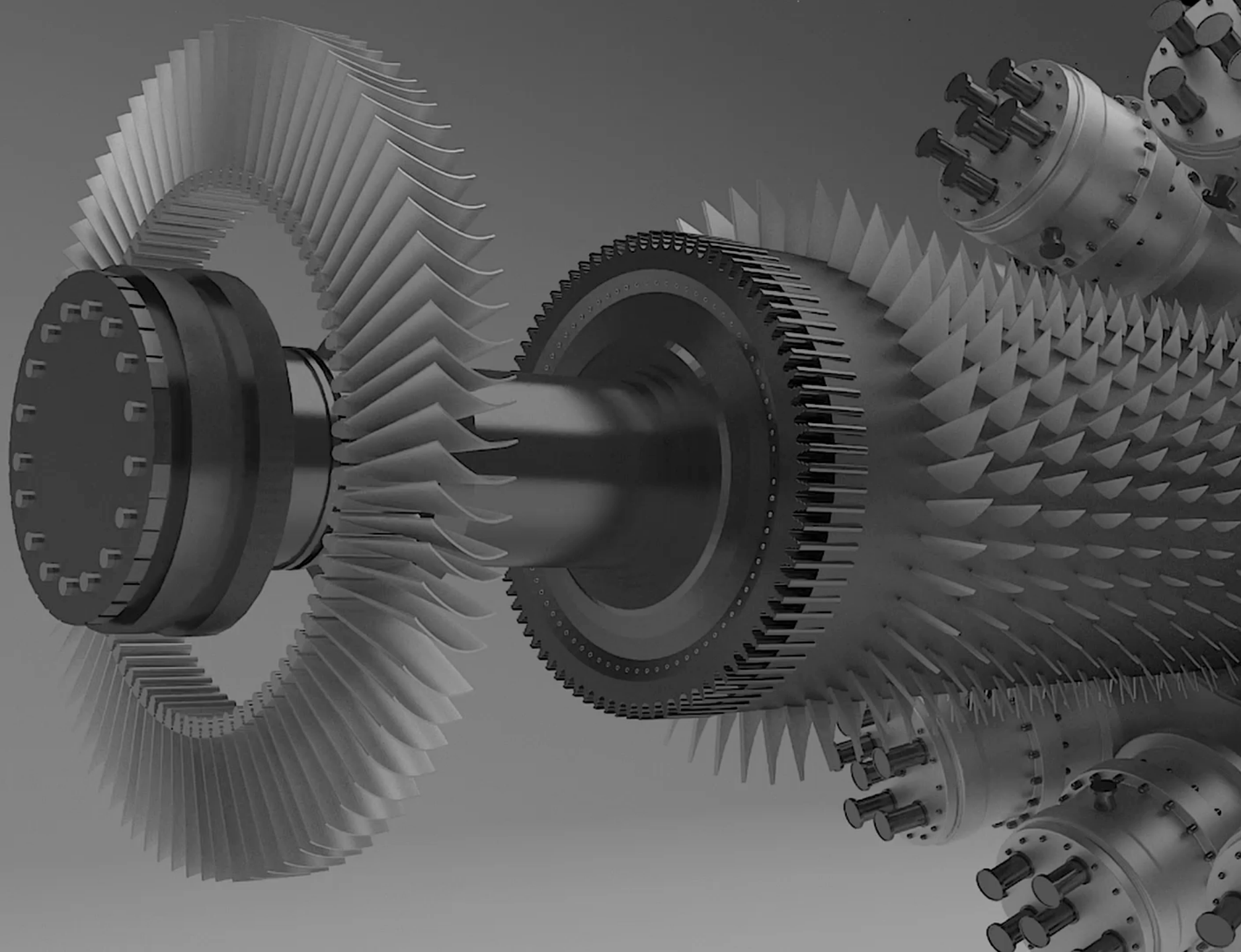
# Overview

- Use of Unsupervised techniques to understand operational conditions and flag anomalies
- Use of Natural Language Processing to parse Work Order history and use as data/features in the models
- Asset is a GE Steam Turbine put into operation 1/1/1997
  - GE Unit 818,000kW; 2400 PSIG; 1000F/1000F

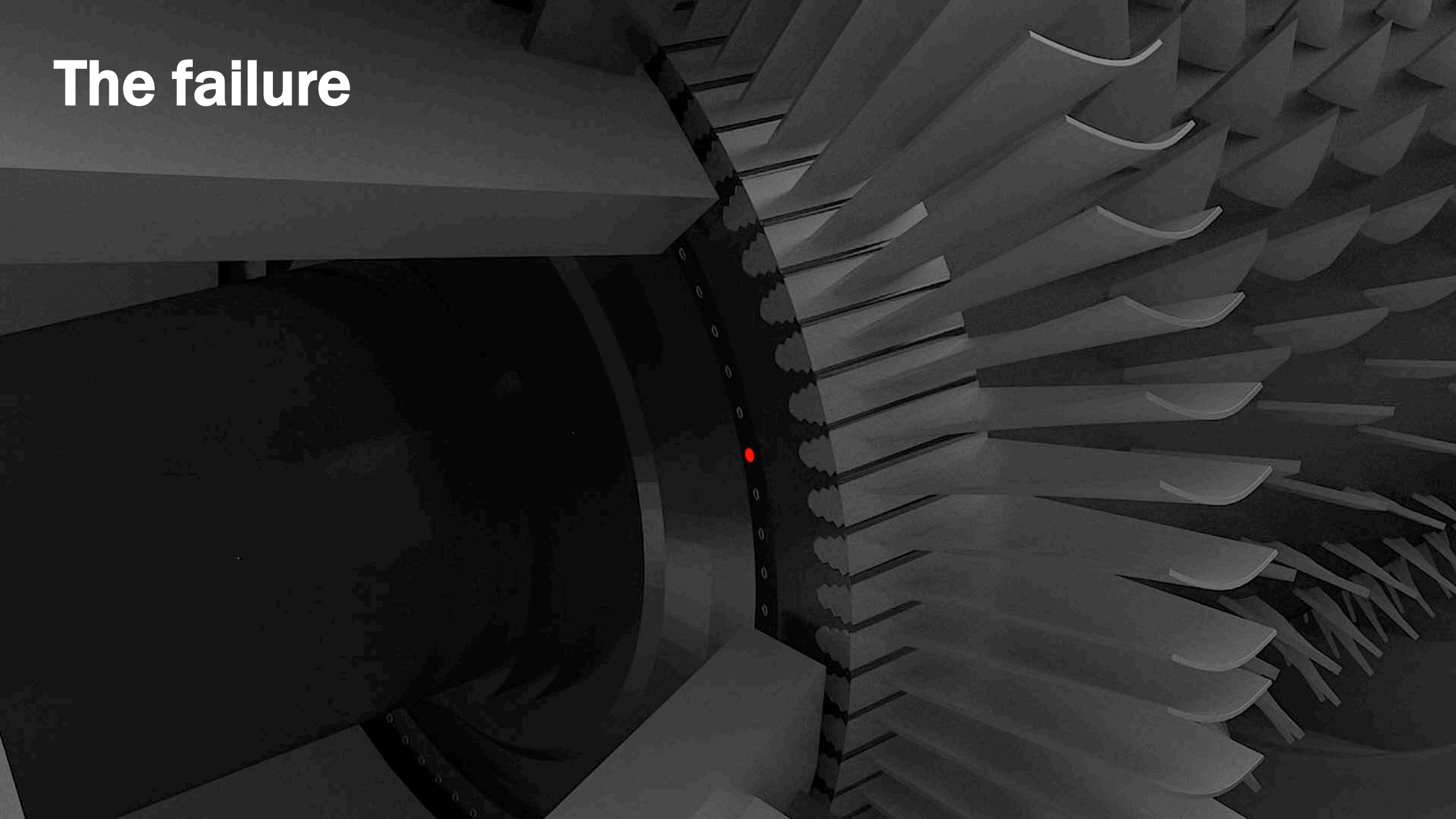
# The failure



# The failure



# The failure



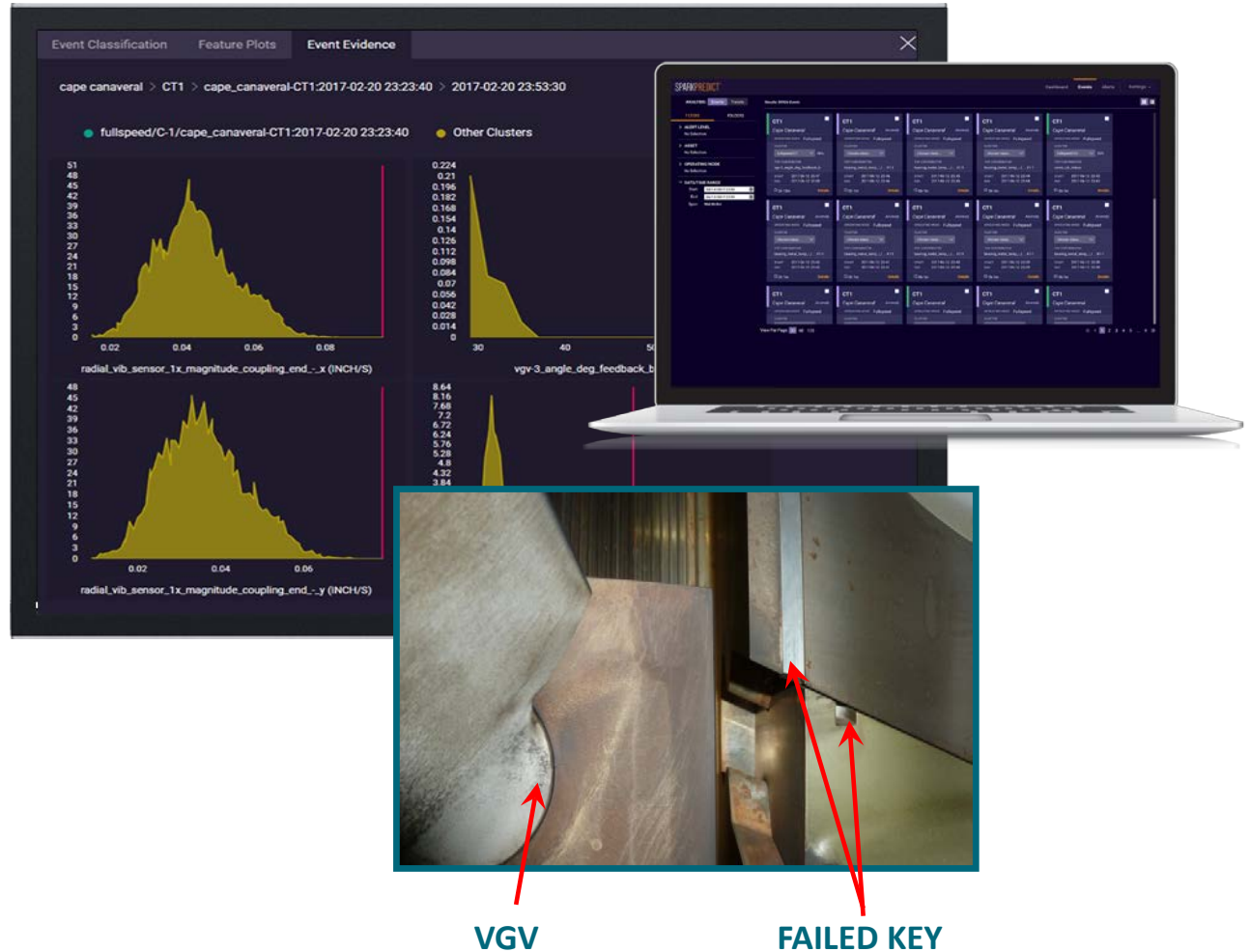


# How did machine learning deliver?



# How did machine learning deliver?

- Detected anomaly with one month lead time
- APR and other monitoring methods did not detect it
- Identified never-before-seen issue
- Failure was a manufacturing defect unlikely to occur again
- Correctly pointed to problem area of turbine (explainable AI)



# Natural Language Processing

Cognitive Analytics to Address Workforce Challenges



## Analyzes Unstructured Data

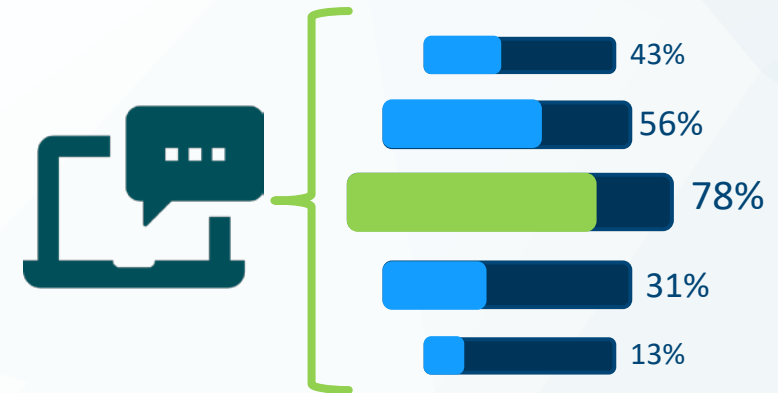
Adds structure to documents to understand grammar and context

“What was the **recoverable oil** by **Statoil** between **2010 and 2015**?”

Operator      Target      Date Range

## Understands Complex Questions

Evaluates possible meanings and determines what is being asked

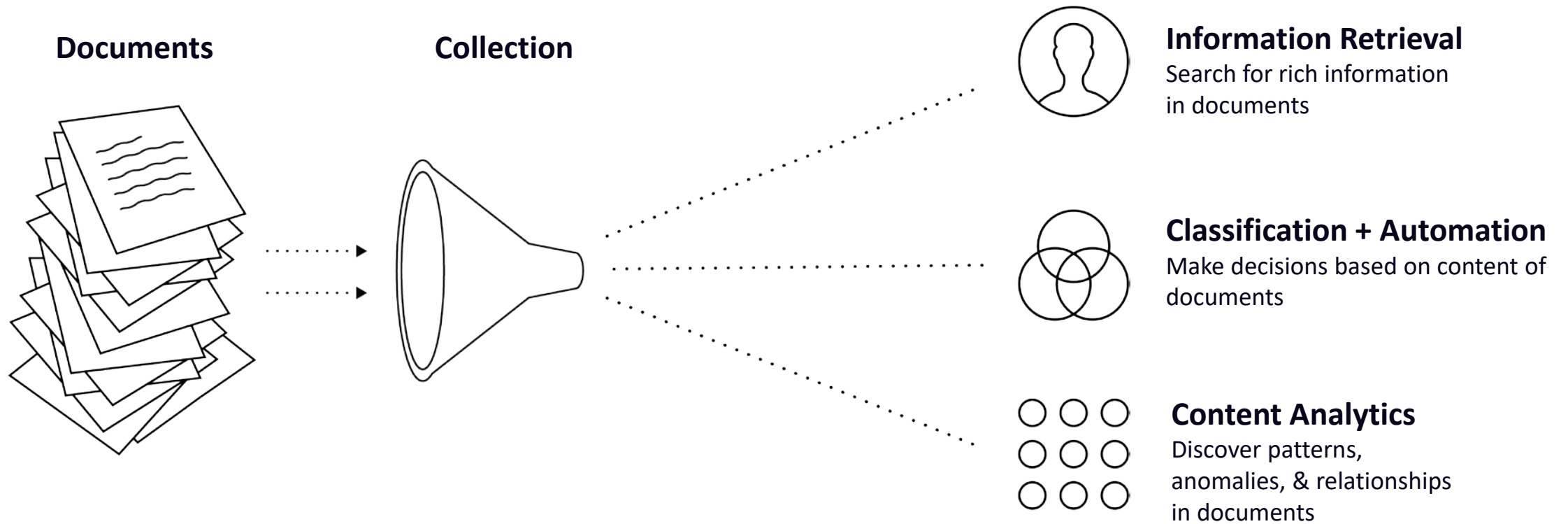


## Presents Answers and Solutions

Based on supported evidence and quality of information found

# What is DeepNLP™?

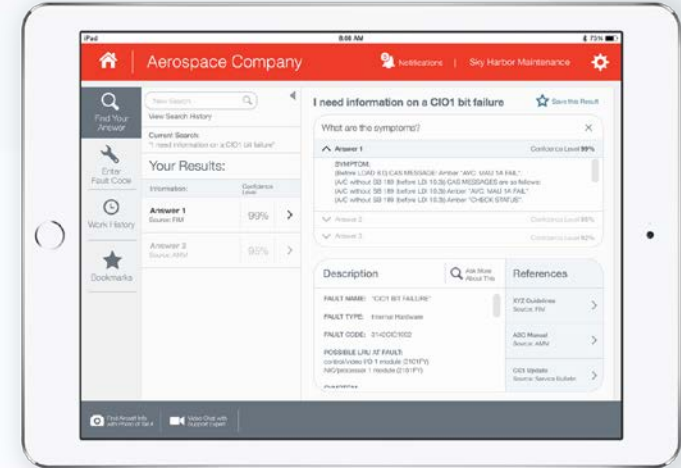
Extract value from unstructured data



# Natural Language Processing Applied to Maintenance Records

## Prescriptive Maintenance for High Value Assets

- Analyze historical data to prescribe most effective fix for problems
- Capture and codify “tribal knowledge” from your own fleet
- Deliver prescriptions directly to front-line maintainers



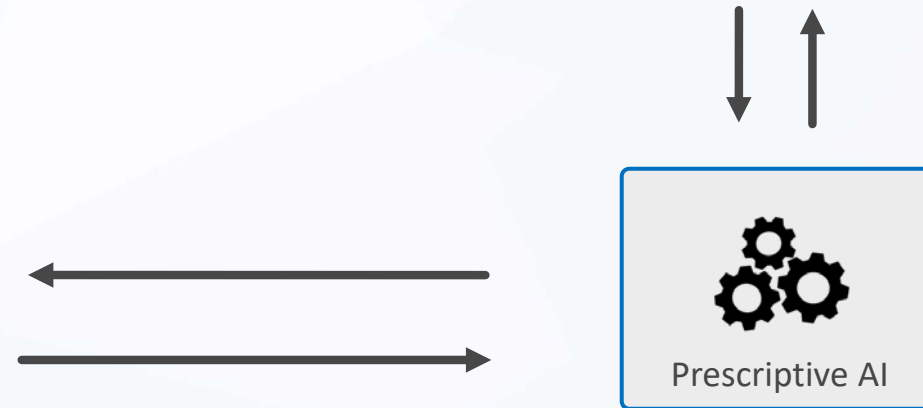
Prescribe historically successful corrective actions and link instructions from manuals

For **AFT CRG VENT FAULT** performed diagnostic IAW [TSM-0100.9.1](#)  
Reset HVAC breaker 2 IAW [AMM-500.9.3](#)

~~~~~  
~~~~~

Fault Code **AFT CRG VENT FAULT** still unresolved. Most likely resolution  
Replaced HVAC breaker board and cable harness IAW [AMM-300.7.2](#)  
Fault did not reoccur.

From maintenance logs,  
Extract faults and corrective actions that worked



Historically, which corrective action is “most likely” to resolve a fault



# Milestones

Milestone	Completion Date
M1-Project Kick-off Meeting	11/16/2018
M2-Completion of historical data pull from plant historian	2/28/2019
M3-Initial Algorithm Completion	9/30/2019
M4-Model Refinement based on SME Input	2/3/2020
M5-Annual Briefing	10/1/2019
M6-Completion of User Interface customization	1/31/2020
M7-Integration of User Interface and Completed Model into on-line, plant system	3/2/2020
8-Final Project briefing	10/1/2020



# Status

- Currently working on sub awardee contracting
  - Gate for starting to pull data
  - Expect to occur within the month
- Starting on initial research into improved anomaly detection



# Questions