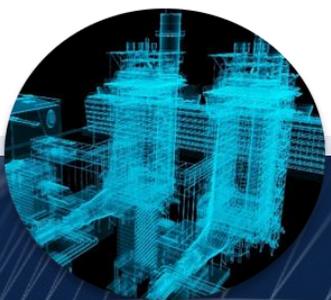




Industrial Digital Twins

LEVERAGING MACHINE HEALTHCARE



RUSTY IRVING

Digital Twin Platform Leader & Chief Engineer
GE Global Research

20 MARCH 2019

Healthcare – People vs. Automobiles

PEOPLE

- You manage your ‘maintenance appointments’
- You hope your doctor has your medical history with its scarce, discrete data
- You schedule appointments weeks to months ahead for non-emergencies

AUTOMOBILE

- Your car can tell you when to get an oil change, inflate the tires, add fluid, etc.
- Your dealer (and Carfax) has your data and OBD-II can provide more
- Most issues can be handled within days to a week

**HEALTHCARE FOR AUTOMOBILES IS EASIER TO MANAGE.
AUTOMOBILE HEALTHCARE HAS BEEN DIGITIZED LONGER.**



Healthcare – People vs. Automobiles



**HEALTHCARE FOR AUTOMOBILES IS EASIER TO MANAGE.
AUTOMOBILE HEALTHCARE HAS BEEN DIGITIZED LONGER.**



Healthcare ... for Humans and Machines

TODAY'S MACHINE HEALTH

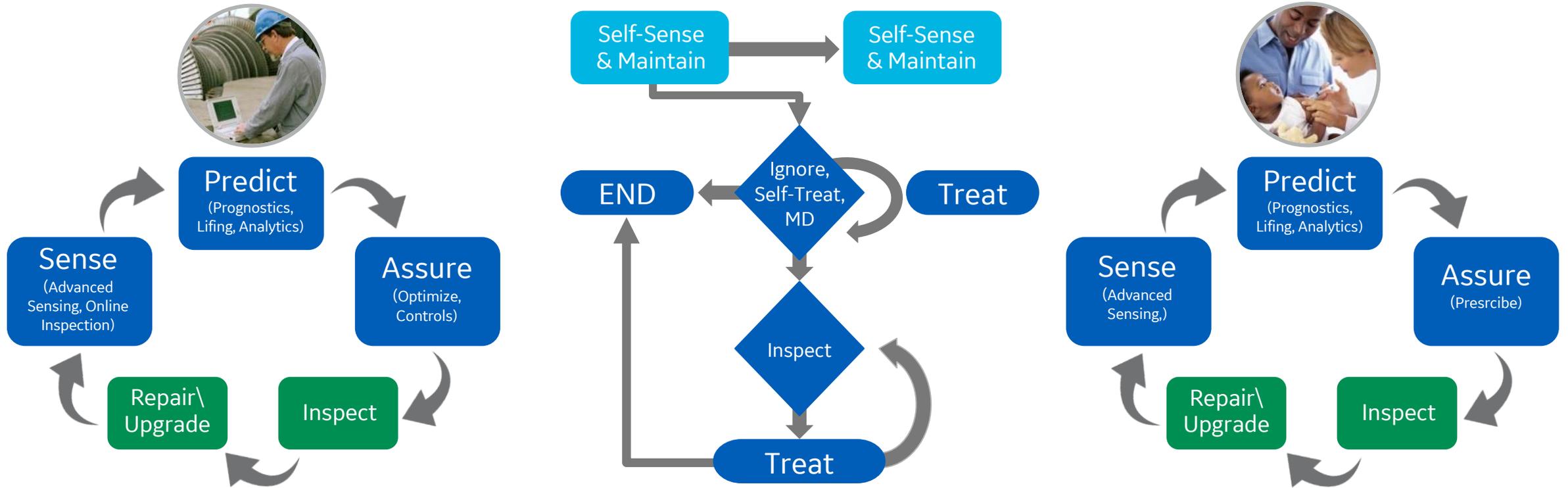
Monitoring, Diagnostics, Prognostics
Personalized Machinecare

TODAY'S HUMAN HEALTH

Healthcare System
You are the QB

FUTURE HUMAN HEALTH?

Healthcare System
Personalized Healthcare



LET'S TAKE CARE OF OURSELVES AS WELL AS WE DO THE MACHINES

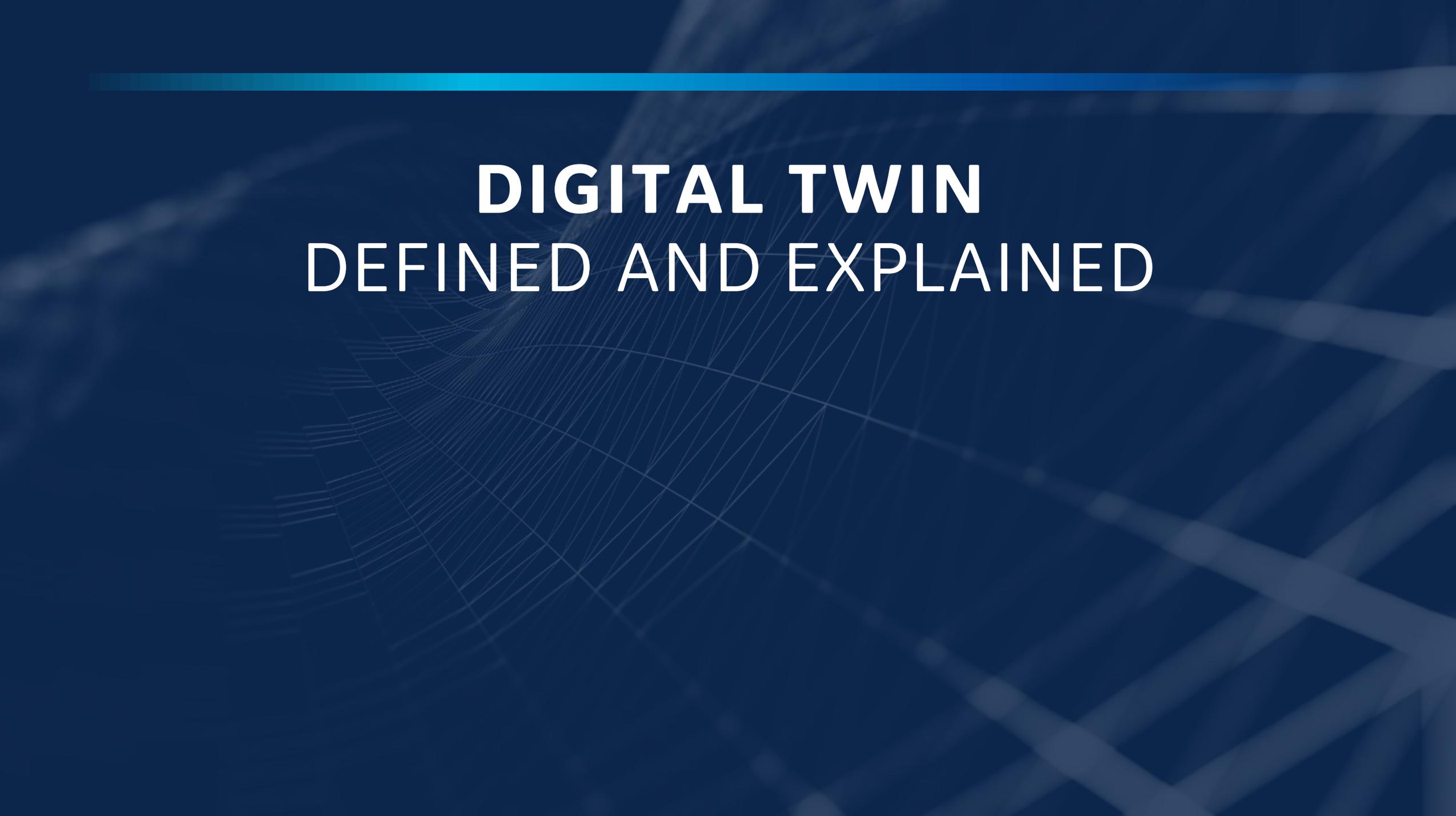


Outline

- **Industrial Machine Digital Twin** Defined and Explained
- **The Path** to Digital Twin
- **Digital Twin Examples** and Impact at GE
- **A Human Digital Twin** Example
- **Human Digital Twinning:** Possibilities, Benefits, Implications



DIGITAL TWIN DEFINED AND EXPLAINED



WHAT IS DIGITAL TWIN?



GE is a pioneer in Digital Twin

Digital Twins, a name created by General Electric to identify the digital copy of an engine manufactured in their factories, are now a reality in a number of industries. They can be almost “identical” to the real thing, like in the case of General Electric engines and some modern keys where you have to take their digital twin to get a copy, or pretty accurate replicas like in case of Tesla cars or more coarse representation in case of other products.

What about us? Can we imagine a digital twin for us. Actually it is no longer science fiction

The screenshot shows a webpage from IEEE Future Directions. The main article is titled "CAN WE HAVE A DIGITAL TWIN?" by Roberto Saracco, published on September 27, 2017, with 2,664 views. The article features an image of a person interacting with a digital twin of a human head. The text discusses the concept of digital twins, their applications in manufacturing, and their growing use in various industries. A callout box highlights a paragraph: "Digital twins, a name created by General Electric to identify the digital copy of an engine manufactured in their factories, are now a reality in a number of industries. They can be almost 'identical' to the real thing, like in the case of General Electric engines and some modern keys where you have to take their digital twin to get a copy, or pretty accurate replicas like in case of Tesla cars or more coarse representation in case of other products." The page also includes a search bar, a "Future Directions Newsletter" sign-up, and a list of related articles such as "Computer Vision and AI can make a difference" and "Lots of excitement and disappointment on foldable phones".

From: <http://sites.ieee.org/futuredirections/2017/09/27/can-we-have-a-digital-twin/>



GE's path to Digital Twin

SYSTEM OF ASSETS
INDIVIDUAL ASSETS



1980s

"BREAK & FIX"

- 1st M&D Systems **answered the question? "What Happened?"**
- Tech: Rule-Based
- Examples: GETS Diesel Locomotive Diagnostics



1990s

"M&D BUILD OUT"

- Systems still Reactive, **answered the question? "What is Happening?"**
- Online centers built out across GE
- CSA Cost Productivity becomes business model
- Tech: Mix of Neural Networks, Case-Based, and other



2000s

"PROGNOSTICS"

- **Answered the question? "What will break?"**
- Examples: Early Warning Systems
- Tech: Prior Methods, Machine Learning, Statistical



2010s

"REMAINING USEFUL LIFE"

- **Answered the question? "When will it break?"**
- Examples: GE Power OnLine CBM
- Tech: Prior Methods, Deep Learning, Usage Based Lifting

2015+

"DIGITAL TWINS"

- Now **answering many questions: "Can I run the asset hotter?," "When should I inspect?," "When should I replace?"**
- Enables What-If Scenarios, System Optimization
- Examples: GE Power Efficiency Optimizer, GE Aviation Analytics Based Maintenance
- Tech: Prior Methods, Cloud Computing, Learning

RULES



PHYSICS AND DATA BASED MODELS



PHYSICS MODELS WITH LEARNING ECOSYSTEM



What is a Digital Twin?

Physical Asset



$f(x)$
TRANSFER
FUNCTION

Digital Twin A Learning Digital Model



PHYSICS
MODELS

+

MACHINE
LEARNING

- 1 PER ASSET MODEL
- 2 BUSINESS OUTCOMES
- 3 CONTINUOUSLY LEARNS
- 4 SCALABLE
- 5 ADAPTABLE

DIGITAL TWIN INCREASES PRODUCTIVITY AND ACHIEVES
BETTER OUTCOMES FOR CUSTOMERS



5 Criteria for analytic to be digital twin

Drives business outcomes

GE's Digital Twin must drive demonstrable business value and outcomes

Per asset/Process/Person

GE's Digital twin is applied to individual assets, systems, process or person

Continuously learns

GE's Digital Twins continuously learn from new data to improve business outcomes

Scalable

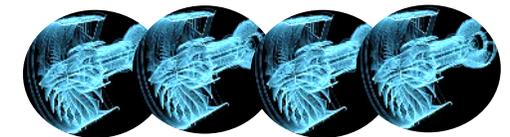
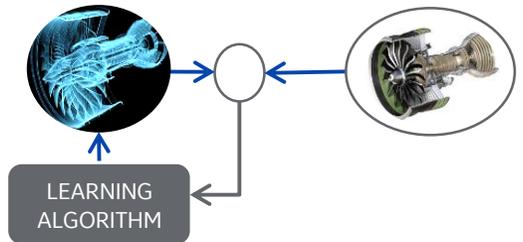
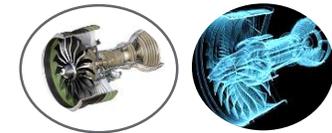
GE's Digital Twins are scalable so as to be able to run millions of them

Adaptable

GE's Digital Twins are adaptable to other parts or asset classes, new scenarios or factors



- Revenue
- Cost
- Customer Experience



RUN MILLIONS OF TWINS



GE TO NON-GE





**DIGITAL TWIN IMPACT AT GE:
SUPPORTABILITY OF
THE GE INSTALLED BASE OF
INDUSTRIAL ASSETS**

The GE installed base of industrial assets



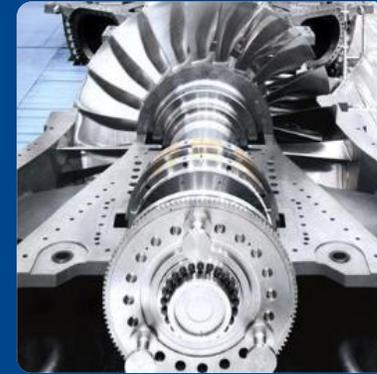
> 34,000
UNITS



> 20,000
UNITS



> 20,000
UNITS



> 10,000
UNITS



> 200,000
UNITS

GE MANAGES OVER 300,000 INDUSTRIAL ASSETS DAILY



Transactional Service vs. Contractual Service Agreements:



Transactional Service:

Traditional Parts & Services. Based on a per incident basis.



Contractual Service Agreement:

Based on a multi-year time period. Customer pays for asset usage and transfers maintenance risk.



Services levers

SERVICES PROFIT = SERVICES REVENUE - SERVICES COST



- 1 | Reduce the Cost of Servicing**
- 2 | Reduce the Frequency of Servicing**



**KNOW EVERYTHING YOU CAN
ABOUT THE ASSET**



Reducing the frequency of service

EBI = Borescope Inspection
CI = Combustion Inspection (Light)
HGP = Hot Gas Path (Medium)
MI = Major Inspection (Heavy)

A GENERIC INDUSTRIAL ASSET EXAMPLE

Today's maintenance practice



Tomorrow: Move 16K CI to 32K CI



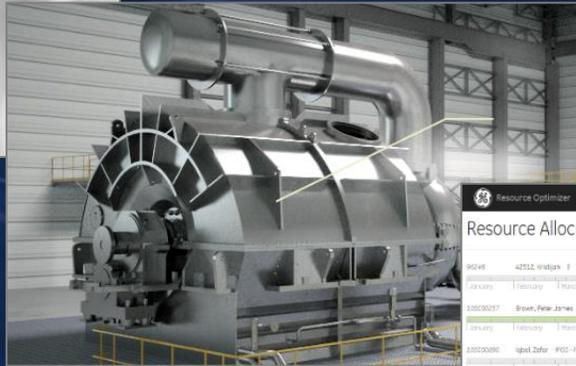
REDUCE CYCLE TIME (20%)
AVOID FORCED OUTAGE (\$2MM PER OUTAGE)



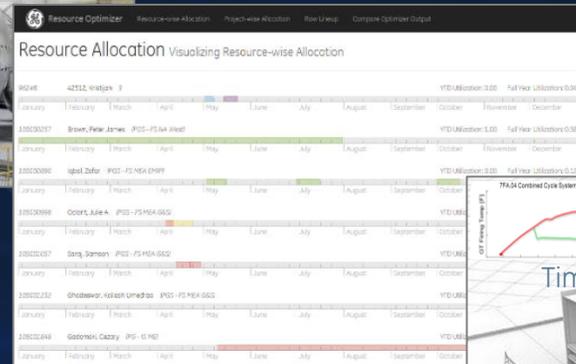
1,183,547 Twins and increasing



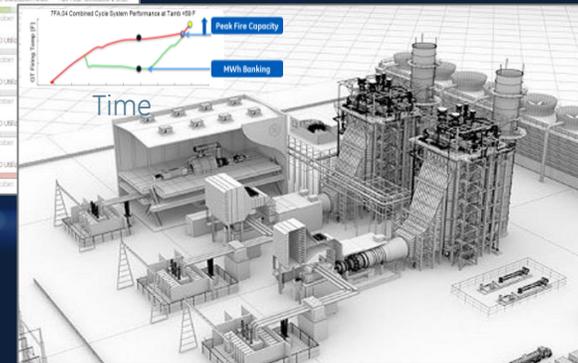
Parts Twins
Rotor failure prediction



Product Twins
Steam turbine life optimization



Process Twins
Field engineer scheduling



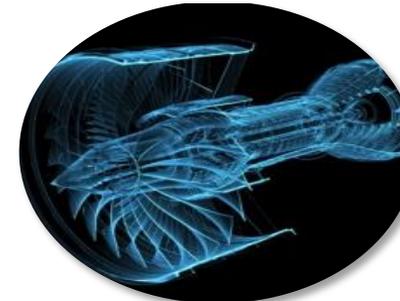
System Twins
Model based optimizer



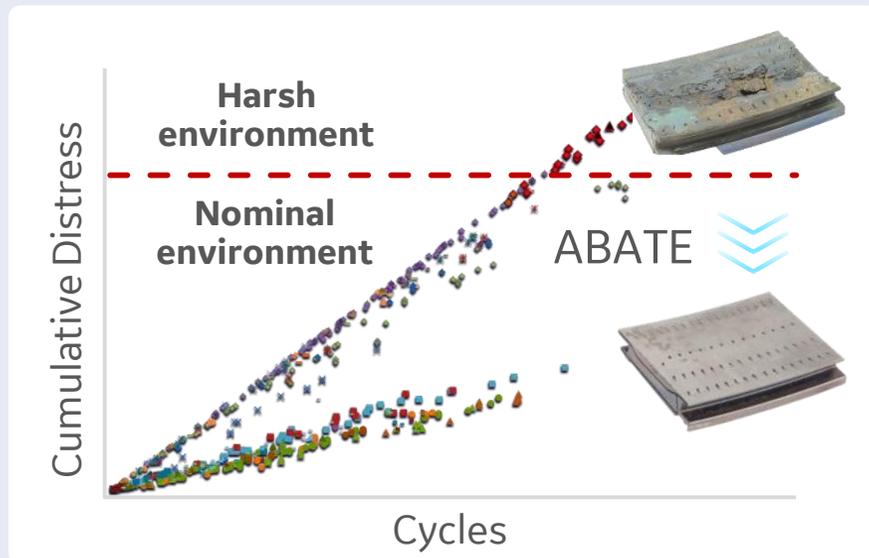
Continuous prediction Digital Twin – Aviation engine



Environmental conditions
Per flight data
Prior condition



Digital Twin
Physics + AI Models



**Optimized
inspection time
and Shop time**

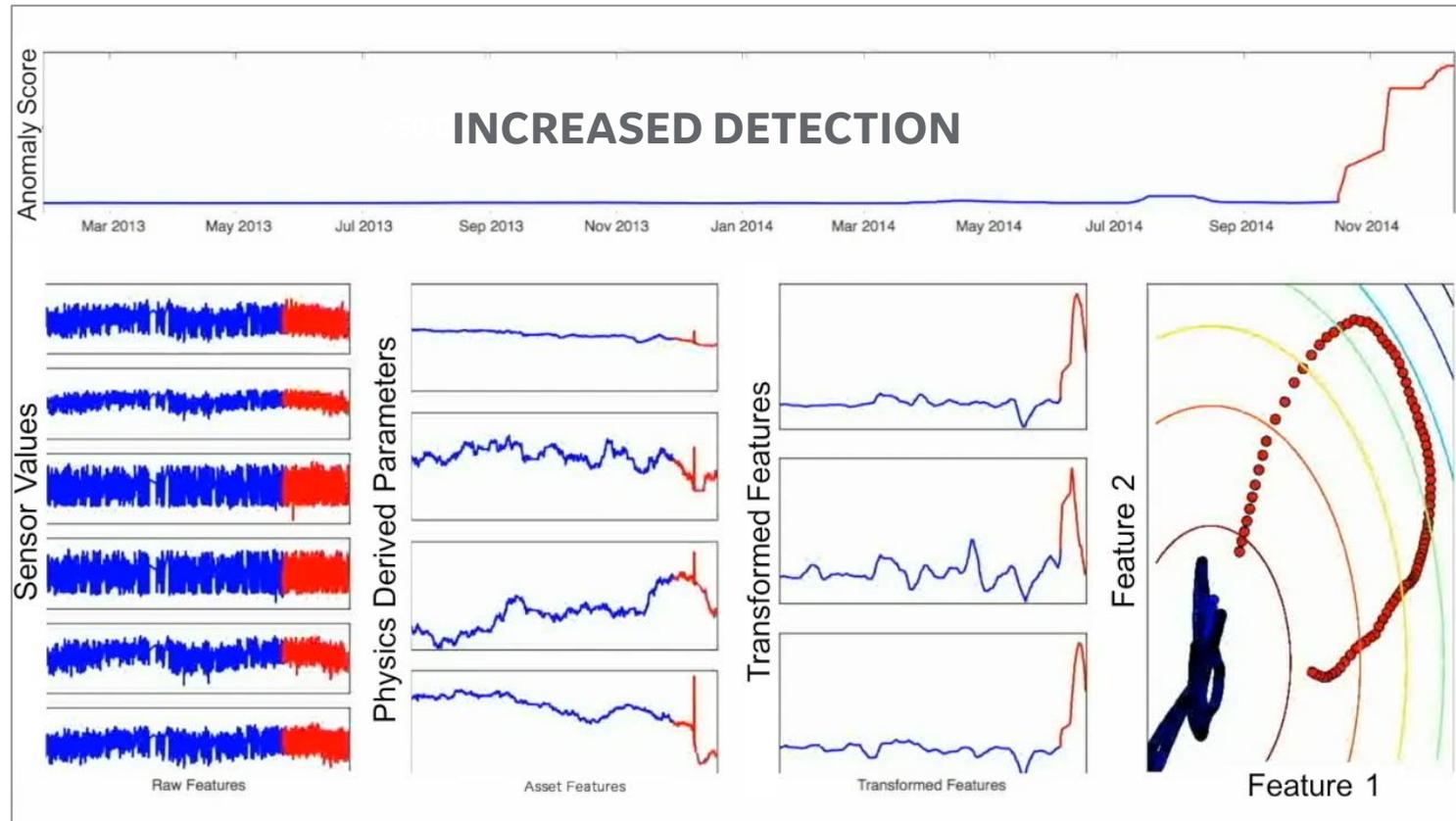


INCREASED AVAILABILITY TO CUSTOMER
SAVES TENS OF \$MM IN UNNECESSARY SERVICE OVERHAULS



Increase customer value ... Improved reliability

Sufficient early warning to avoid customer disruption



PHYSICAL ASSET



Compressor Pressure & temperature, Exhaust Gas Temperature, etc.

DIGITAL TWIN



Engine efficiency parameters, environmental data – predict probability of failure

VALUE OUTCOMES

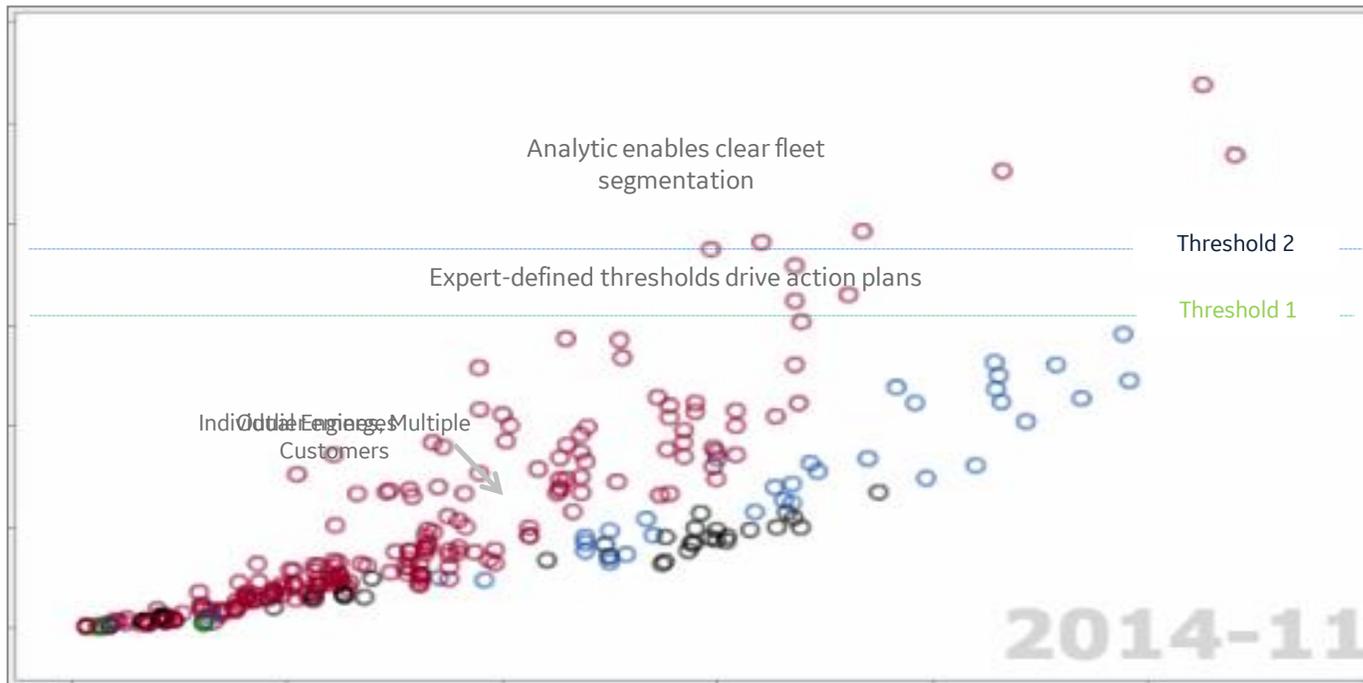


>30 days early warning of compressor issue



Increase customer value ... Improved availability

Continuous damage prediction to manage maintenance schedule



PHYSICAL ASSET



Engine sensor data, S1 Blade Thermal Barrier Coating, etc.

DIGITAL TWIN



Operating data, and environmental data (cities pairs, hot and harsh values) - predict level of deterioration.

VALUE OUTCOMES

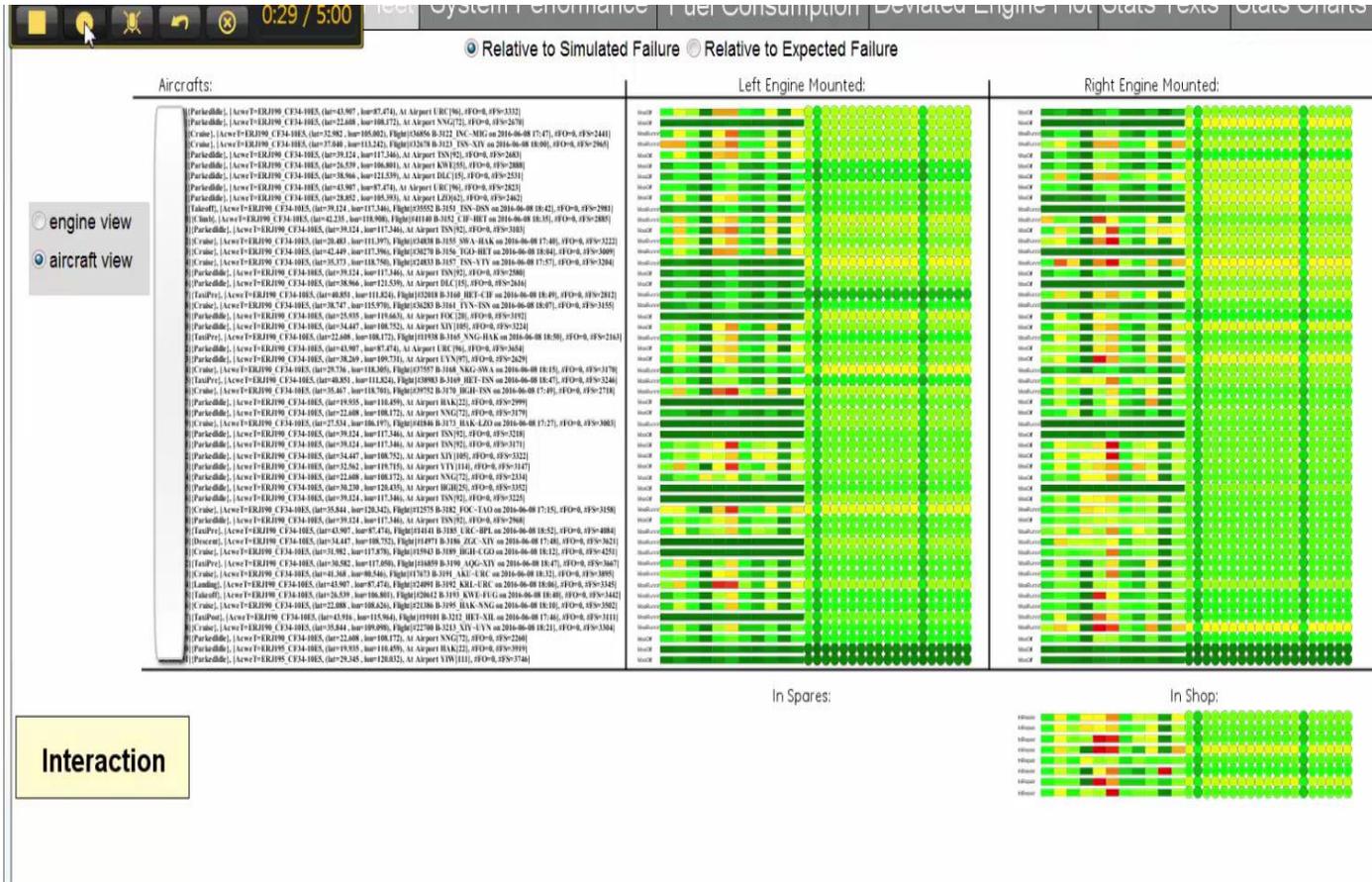


Optimal inspection schedule. **56% planned inspection reduction**



Increase customer value ... Asset utilization and cost

Understand and create fleet conditions for business flexibility

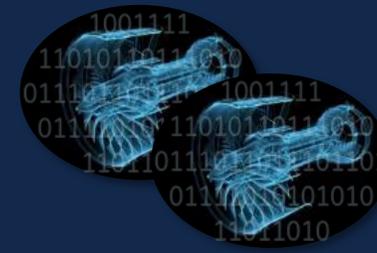


PHYSICAL ASSET AND STATE



Engine life and performance, flight schedules, operator details - thrust, etc.

DIGITAL TWIN



MRO Service data - Simulated 'What-if' Futures: Operations, Spares/MRO TAT, Financials

VALUE OUTCOMES



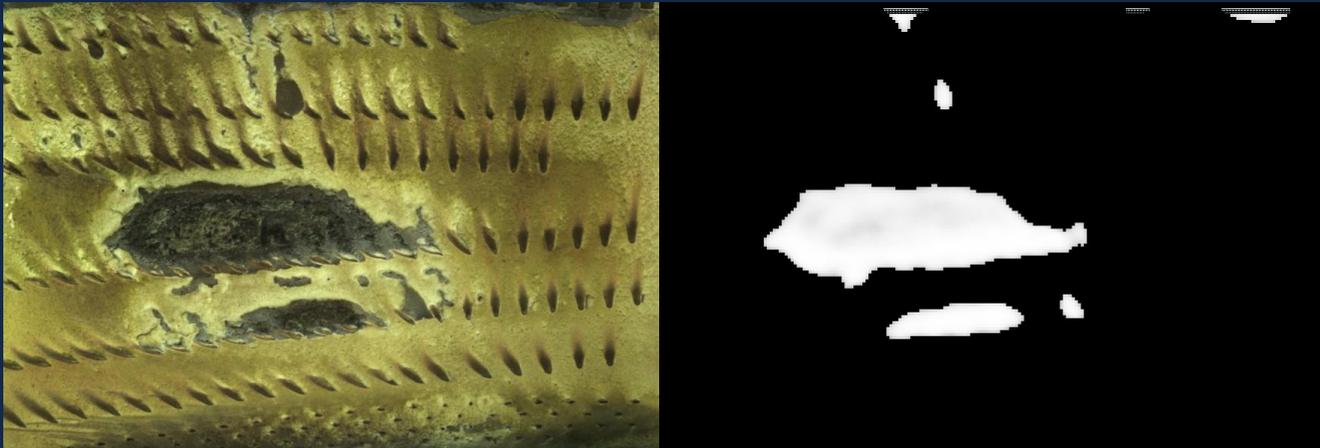
Optimal engine assignment to routes, on-wing operations and MX



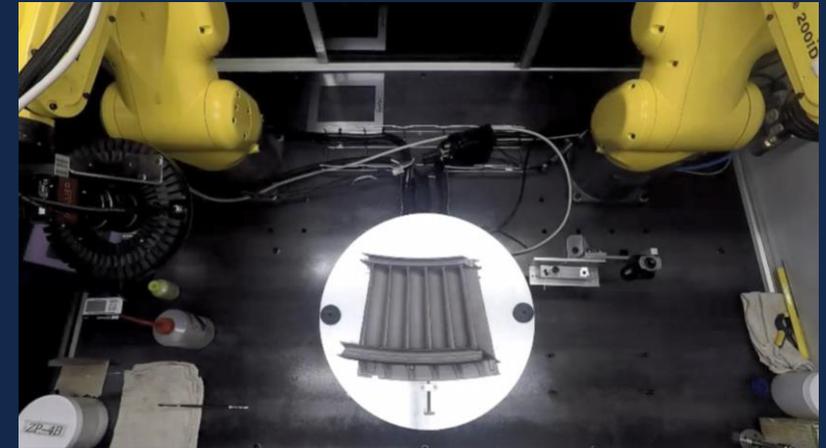
Improving data quality - Intelligent data acquisition

AUTOMATED DATA ACQUISITION TO CREATE AN AI INSPECTION ASSISTANT

Component distress ranking



FPI Robotic inspection in shops

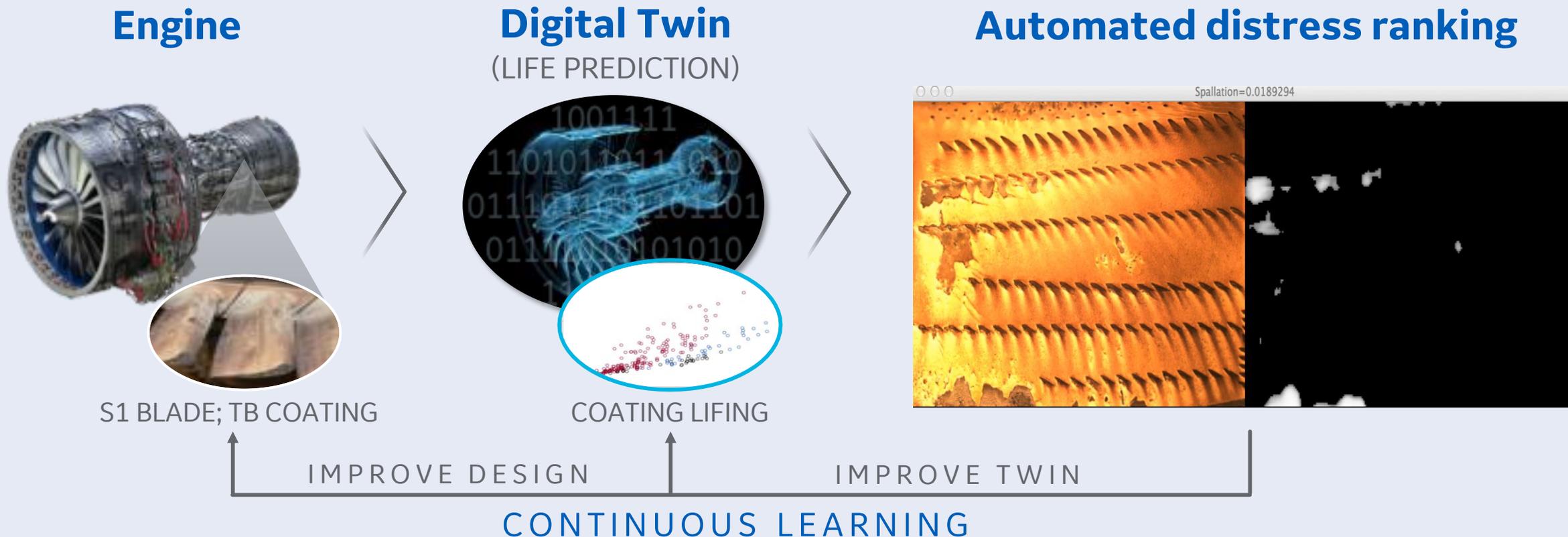


ASSISTANT FOR SCANNING, SORTING, DETECTION,
CLASSIFICATION AND REPORTING IN MAINTENANCE



Improving the product – Continuous learning

Continuous learning for service and design



PHYSICAL+ AI + DATA + COMPUTING SYSTEMS FOR CONTINUOUS IMPROVEMENT

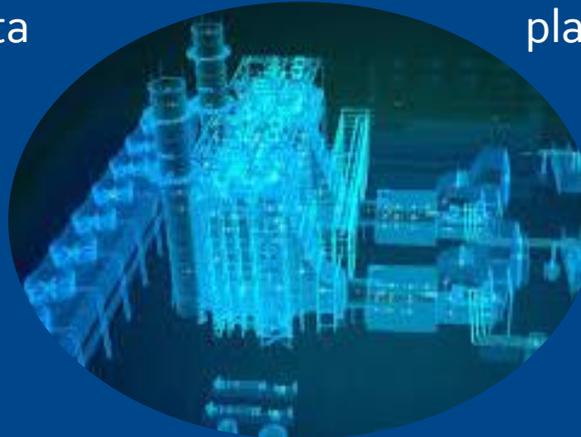


Optimization Digital Twin – 6FA Turbine CC Plant

Plant operational data;
Weather data



Operational set points for
plant optimization



KEY TECHNOLOGIES

Twins (gas turbines, bottoming cycle)
Learning
Optimizer

AUTOMATED OPTIMIZER + TWIN TARGETING 0.5% HEAT RATE IMPROVEMENT



Optimization Digital Twin – Locomotive

Track topology
Locomotive data



Optimal speed
and horse power



DIGITAL TWIN

32,000 GALLONS/LOCOMOTIVE-YEAR SAVED
174,000 TONS EMISSIONS REDUCED/YEAR



A HUMAN DIGITAL TWIN EXAMPLE

Home assurance – Providing an elder care solution for caregivers

MISSION

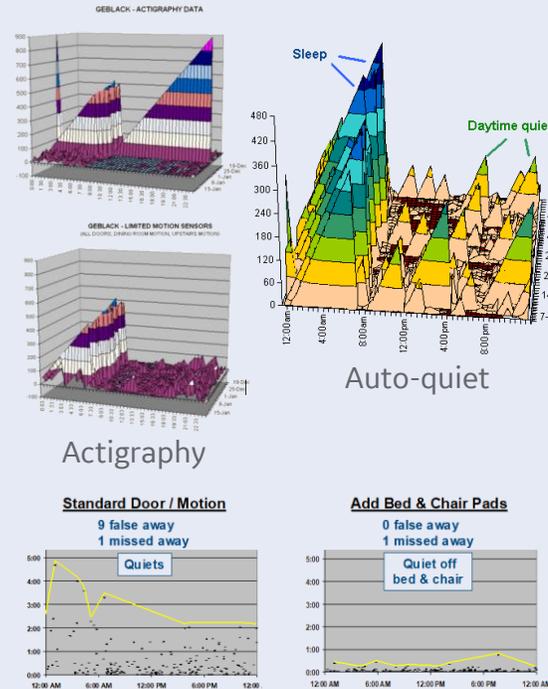
Reducing caregiver stress



1500 days of 24x7 data
10 homes

TECHNOLOGY

Sensor informatics adaptive models



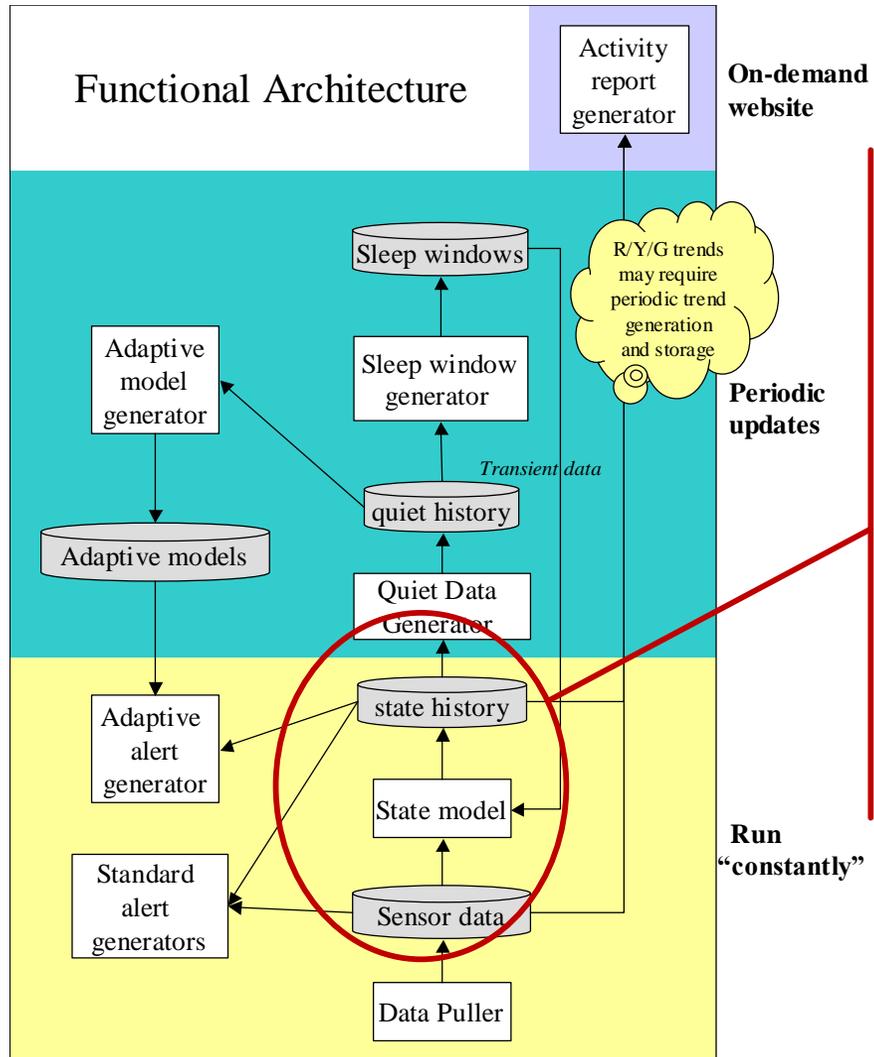
Pressure pads and PIRs

FUTURE

Unobtrusive health monitoring

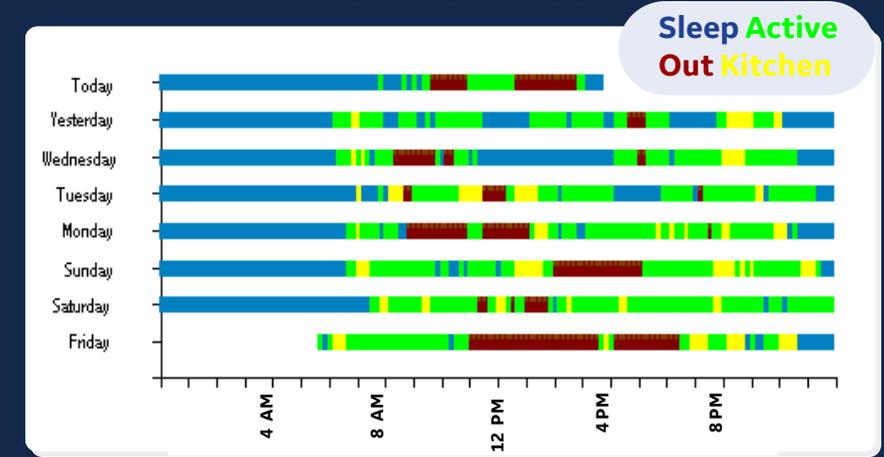


Home assurance algorithms



HOME STATUS DETERMINATION

HOME STATUS



State model

SENSOR DATA

SENSOR	EVENT	DATETIME	ACTIVITY
upstairs motion	opened	2003-05-27 07:31:41	Activity
dining room motion	opened	2003-05-27 07:59:47	
kitchen motion	opened	2003-05-27 08:00:07	
silverware drawer	opened	2003-05-27 08:01:15	Kitchen
silverware drawer	closed	2003-05-27 08:01:32	
upstairs motion	closed	2003-05-27 08:13:37	
dining room motion	closed	2003-05-27 08:16:26	
refrigerator	opened	2003-05-27 08:17:37	
refrigerator	closed	2003-05-27 08:17:52	

Waking up and going to kitchen

~150 messages/day

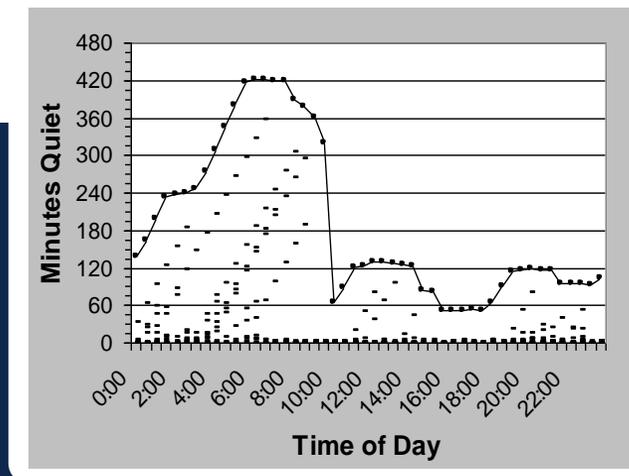
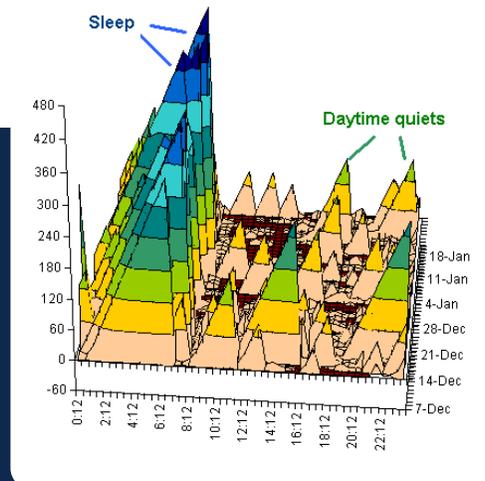
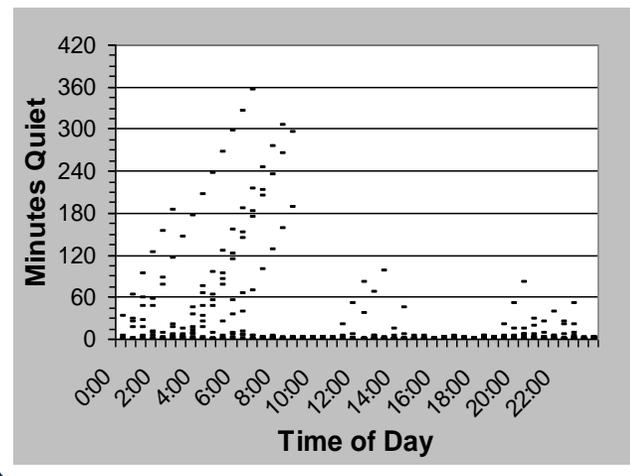


Home assurance algorithms – Automatic inactivity detection

INACTIVITY IS RECORDED AND BINNED INTO INTERVALS.

Date	0:00	...	6:00	6:30	6:00	7:00	7:30	8:00	8:30	9:00	9:30	10:00	10:30	...	23:30
12/1	96	...	251	281	311	25	0	14	44	0	15	3	33	...	42
12/2	52	...	412	442	472	502	12	0	0	2	16	8	0	...	-1
12/3	-1	...	-1	-1	-1	-1	-1	-1	-1	-1	0	2	32	...	45

RECORDING FOR SEVERAL DAYS ENABLES ALERT LINE CREATION.



ALERT LINE OPTIMIZED USING 1000+ DAYS OF REAL DATA.



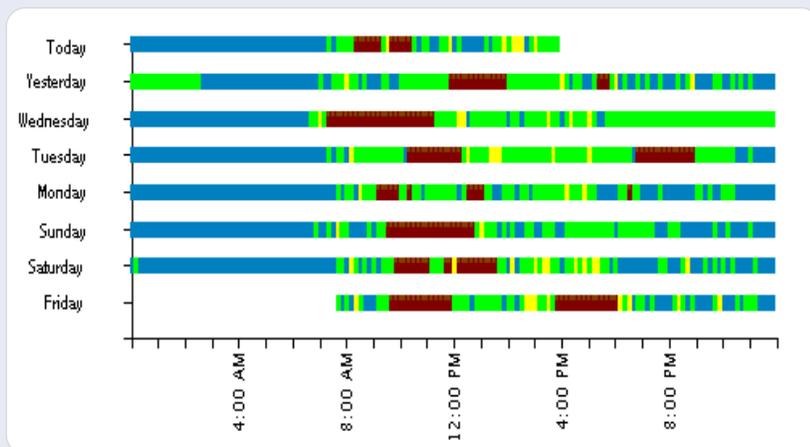
US Patent 7091865. System and method for determining periods of interest in home of persons living independently.

Sleep patterns

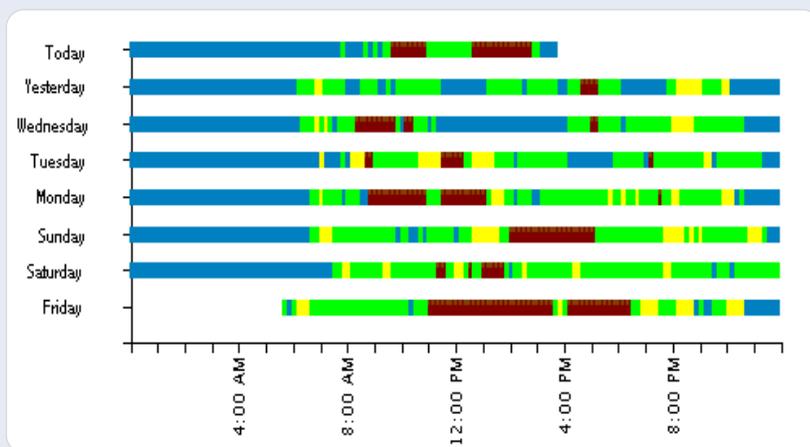


ANECDOTES FROM HOME ASSURANCE: PIR MOTION SENSOR PATTERNS SHOW BASIC HEALTH

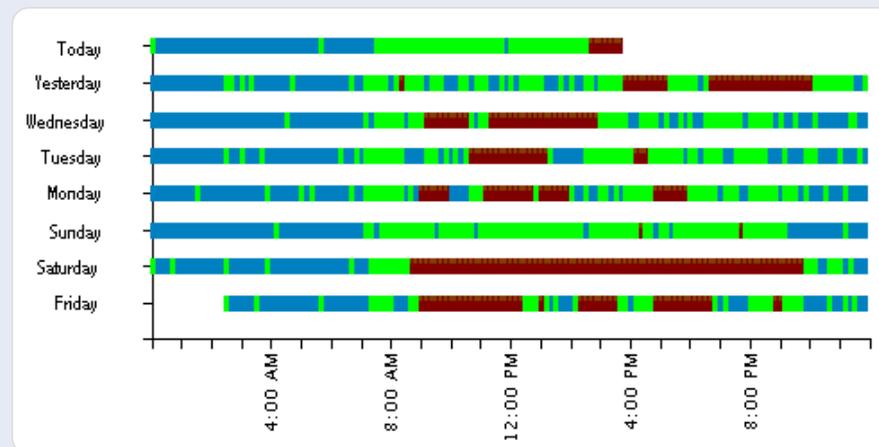
HEALTHY



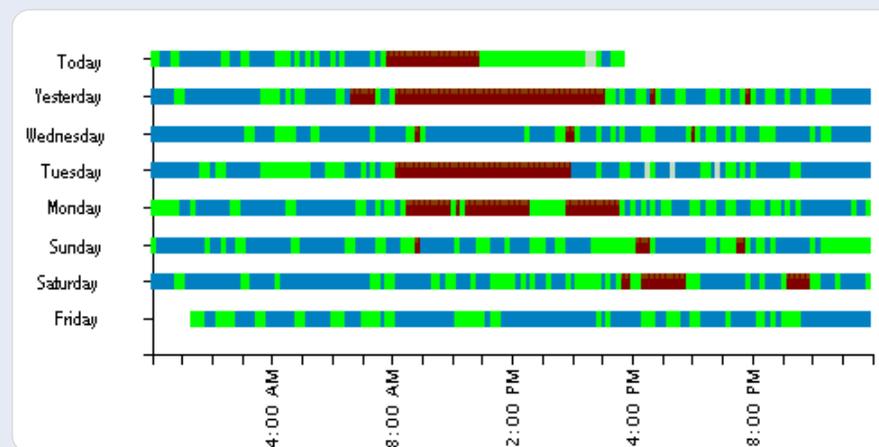
HEALTHY



SLEEP DISORDER



DEMENTIA



The commercial product



care innovations™
an Intel • GE company

Intel - GE Care Innovations™
QuietCare®

A new dimension of proactive care

Intel-GE Care Innovations™ introduces an innovative wireless monitoring technology to the senior living community, Care Innovations™ QuietCare®. The system provides for more individualized care while maintaining residents' privacy and independence. QuietCare® automatically identifies notable changes in each resident's daily activity levels allowing staff to be more proactive. Coupled with notifications of potentially urgent situations, QuietCare provides vital information to caregivers enabling them to be better **informed** and to **intervene** when needed. When integrated into a community's day-to-day operations QuietCare information can increase responsiveness and help **improve** care.

33%
of seniors
fall every year¹ and
25%
of all falls occur
at night²

UTIs are the
#2
reason for
hospitalizations
in seniors > 65³

Be informed.

Reliable and timely information is a vital element in delivering quality care. Many technology solutions alert caregivers only after an incident has occurred. QuietCare® uses multiple sensors combined with robust data analysis and empowers caregivers to be better informed about individual resident activity levels while maintaining privacy and independence.

The system flags certain deviations from normal daily routines, enabling improved response times and identification of potential problems before they become urgent situations. This information has the potential to help caregivers discover emerging health issues or conditions that put residents at risk of falling before a fall may occur.



Only
50%
of hospitalized
residents return
to their
communities³



Improved care and increased resident independence begin with QuietCare's advanced analytic algorithms that provide robust activity and urgent alert data.

¹ Hausdorff JM, Rios DA, Edelber HK. Gait variability and fall risk in community-living older adults: a 1-year prospective study. Archives of Physical Medicine and Rehabilitation 2001;82(8):1050-6.
² Jensen J, Lundin-Olsson L, Nyberg L, Gustafson Y. Falls among frail older people in residential care. Scand J Public Health 2002; 30: 54-61
³ Sartin RW, Lambert Huber DA, DeVito CA, et al. The incidence of fall injury events among the elderly in a defined population. Am J Epidemiol 1990; 131:1028-37
⁴ Juthani-Mehta, M. Chapter 32: Urinary Tract Infections in Elderly Persons. Geriatric Nephrology Curriculum. American Society of Nephrology, 1-5, 2009



Introducing an innovation in proactive care technology

QuietCare[®]

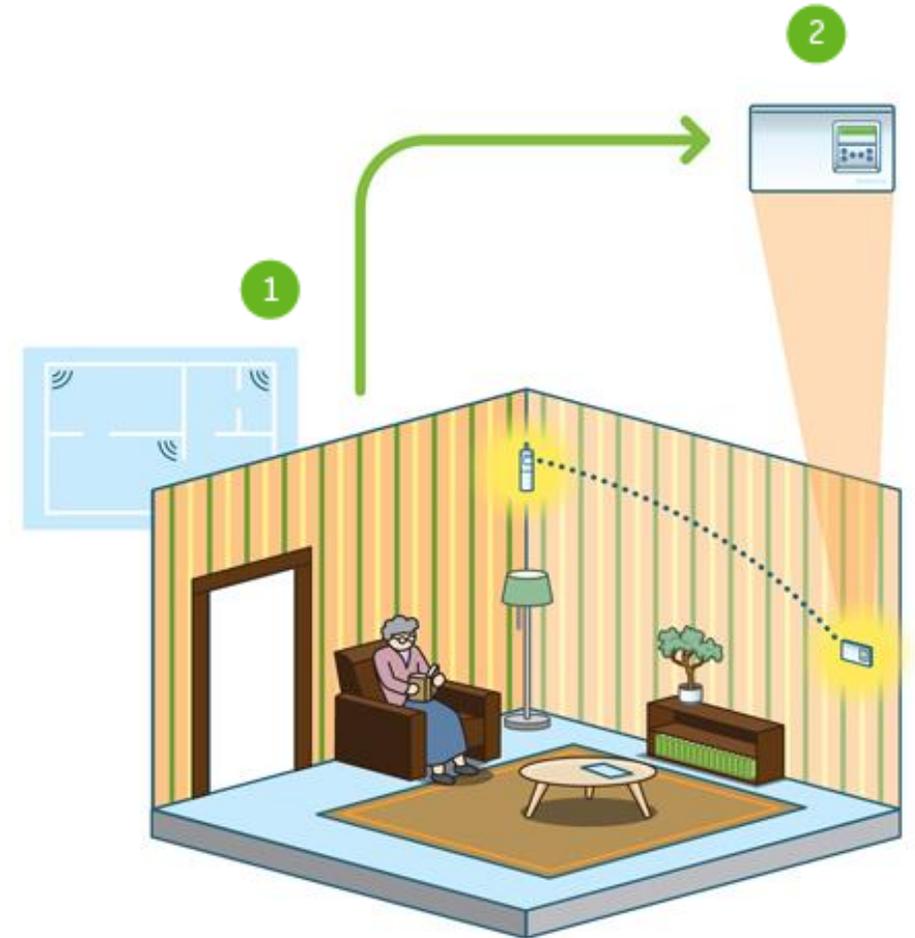
- Motion sensors vs. cameras
- Learns residents' daily in-home routines
- Sends alerts when out-of-the-ordinary situations occur



How proactive care works

SENSORS ARE PLACED THROUGHOUT THE RESIDENCE TO TRACK DAILY ACTIVITIES.

Sensors transfer resident's data to a communicator, which then relays the information to the QuietCare server. Powerful software analyzes data and automatically establishes individualized norms.



Data reporting tools to track patients

QuietCare™



HELP LOG OUT

Welcome:

02:27 PM on Fri Sep 12, 2008

Current Status [Show all active clients](#)

Resident #	Bedroom Exit	Bath Falls	Meds	Meals	Activity	Night Bath	Bathroom Visits	Door Motion	Room Temp	Client Settings
Anna Marie S F116	●	●		●	●	●	●	●	●	●
Ruth D Vac F117	10:20 AM ●	●		●	●	●	●	●	●	●
Vita B F122	●	●		●	●	0	●	●	●	●
Margaret K F139	●	06:24 AM ●		●	●	●	●	●	●	●
Daniel R Vac F140	01:29 PM ●	●		●	●	●	●	●	●	●
Inez M Vac F141	09:27 AM ●	●		●	●	●	●	●	●	●
Helen M D106	●	●		1	●	●	●	●	●	●
Marguerite H D107	●	11:01 AM ●		●	●	●	●	●	●	●
Evelyn Lo D125	Base station disconnected from phone jack or power outlet, power/phone outage, or phone off the hook.									
Marilyn S D128	●	02:16 PM ●		●	●	●	●	●	●	●
Donald W Vac D133	unknown ●	●		●	●	●	●	●	●	●

Review [Alerts/Actions](#) or [Motion Through Door](#) or [Client Norms](#) or [Client Outcomes](#) for Group AL

● Green light means that everything is normal.

● Yellow light means that this situation requires monitoring.

● Red lights mean that situation requires immediate attention!



Digital Twinning – People and machine differences

PEOPLE

- We don't have all the blueprints
- We make artificial materials
- Many confounding factors
- Very limited sensor data
- Understand little about environmental exposure
- People are unpredictable

MACHINE

- We have the CAD models
- We make the materials
- Fewer confounding factors
- Massive sensor data
- Environmental exposure can be tracked
- Machines are more deterministic



**EACH PERSON IS MUCH MORE UNIQUE THAN INDIVIDUAL MACHINES.
UNDERSTANDING THE TRANSFER FUNCTIONS IS MUCH HARDER FOR PEOPLE.
THE BOUNDARY CONDITIONS HAVE MORE VARIANCE.**



Digital Twinning of humans – Possibilities, Benefits, and Implications

POSSIBILITY

- Basic biometrics
- DNA Analysis
- Real-time Control
- Addiction Control
- Redesign Parts

BENEFIT

- Heart attack and stroke remediation
- Disease prediction
- Human performance enhancement
- Prevent overdoses
- Increased Quality of Life



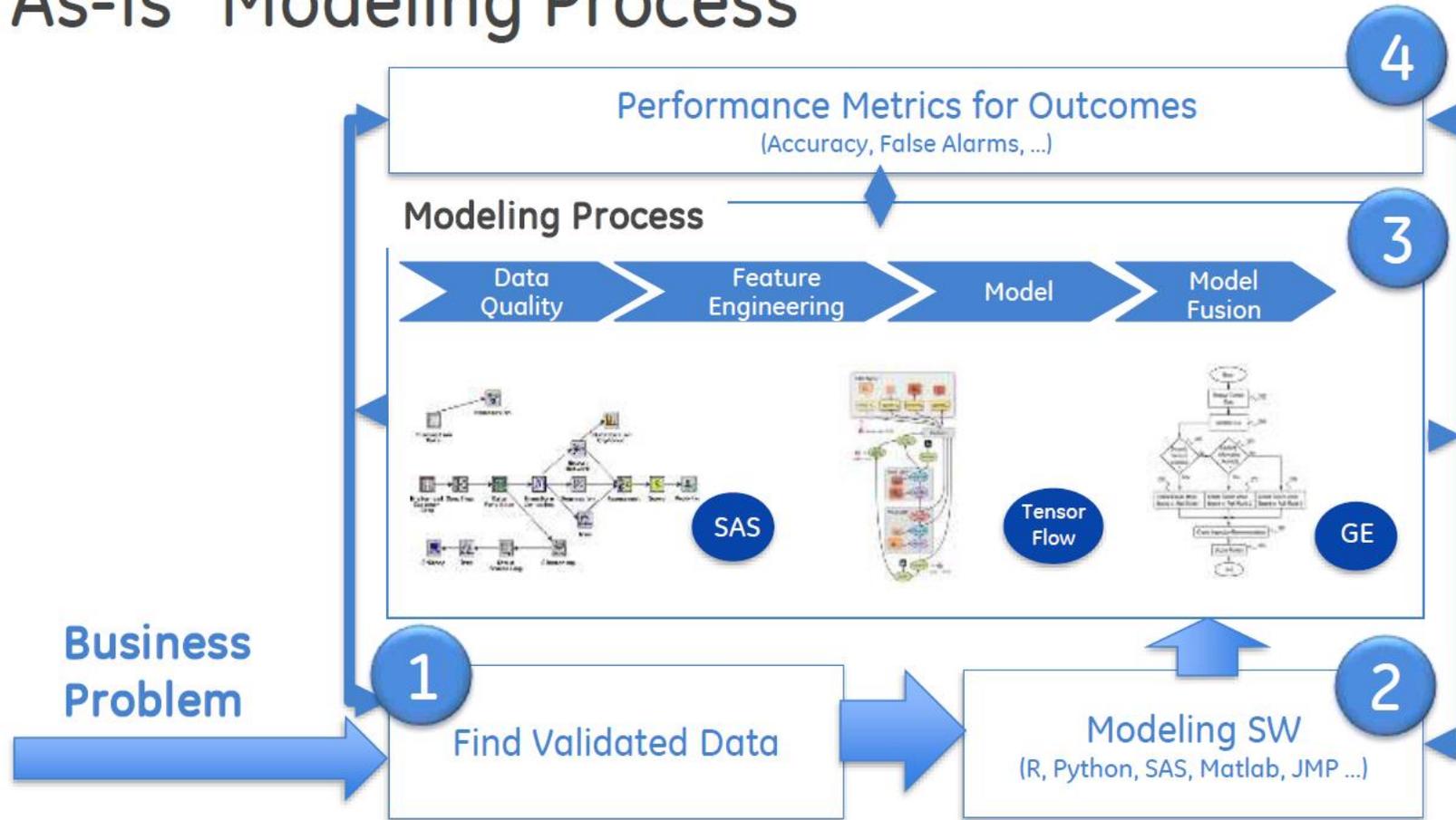
**The Technical Possibilities Can Outpace Our Regulatory Development.
There Are Also Economic Consequences that Are Not Understood.
Do We Mess With Evolution?**



TUTORIAL: HOW TO BUILD A DIGITAL TWIN

Digital Twin Technologies – Why?

“As-Is” Modeling Process



Too Much Iteration, Validation Data Difficult to Get, Little Sharing, Scaling Difficult



Digital Twin Framework - Technologies

Driving Speed, Scale, Accuracy & Differentiation

Outcomes/
Action

Inspection
Optimization

Failure
Prevention

Work
Planning

Work
Optimization

Service
Optimization

Design
Improvements

New Service
Creation

4

Industrial
Blueprints &
Templates

Power Plant

O&G

Renewables

Healthcare

Recip Engine

Aircraft

KPI Monitoring

Early Warning

Continuous
Prediction

Performance
Optimization

Schedule
Optimization

Dispatch
Optimization

3

AI-Based
Modeling
Technology

Auto-DQ

Auto-Feature

Auto-Model

Auto-Suggest

Auto-Learn



1

Gold Data

Motors

Gearboxes

Turbines

MR

Compressor

Inverters

Heat
Exchangers

Ultrasound

Machine
Learning



Physics

Reliability

Domain Text

Image/Video
Analytics

Optimization

Simulation

Kernel
Catalog

2

Edge

(Edge, Inspection, Controls)

Runtime

(Cloud Foundry, Docker)



GE Internal - For GE Internal Use Only.

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Steps to Build a Digital Twin

1. Decide the business outcome you are trying to change. Start with your Pareto of Pain.
2. Determine the model(s) that need to be built.
3. Build the team that builds, feeds, and validates the model.
4. Identify the data need to build, train, and validate the model.
5. If the model does not meet the need, determine why not. Is proper data unavailable?
6. Determine computing requirements.
7. Build process for model operationalization.



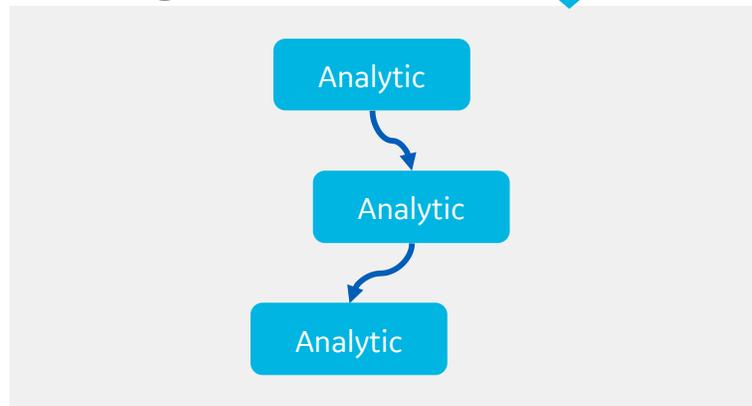
Digital Twin Build, Run, & Manage Process



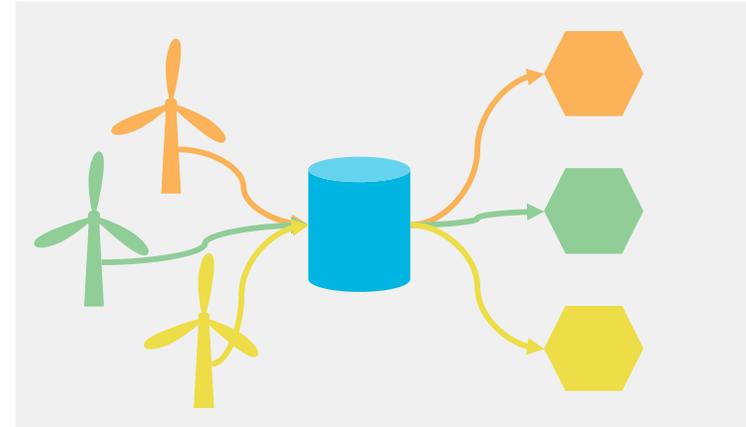
1) Build, Orchestrate



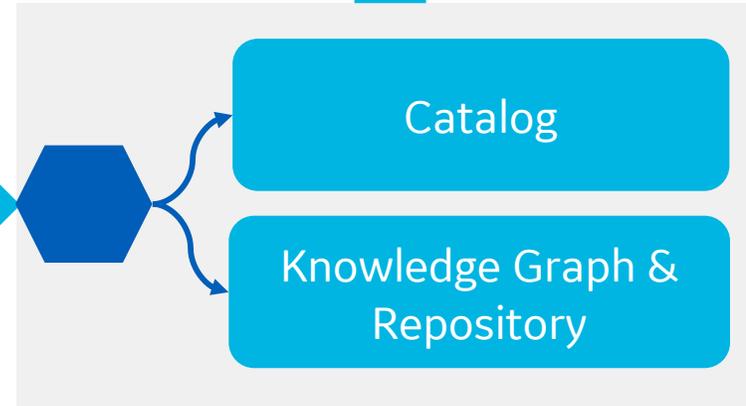
2) Integrate & Validate



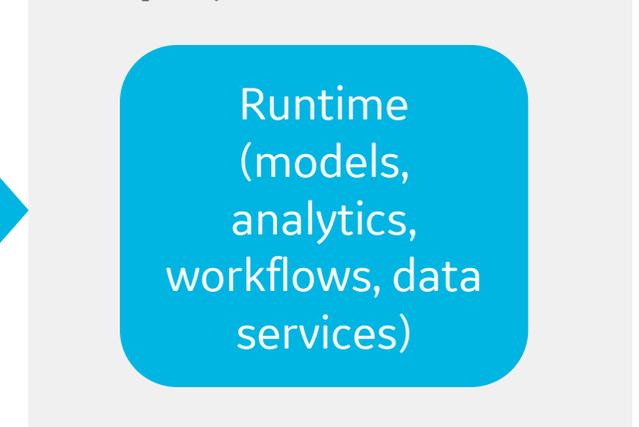
4) Configure



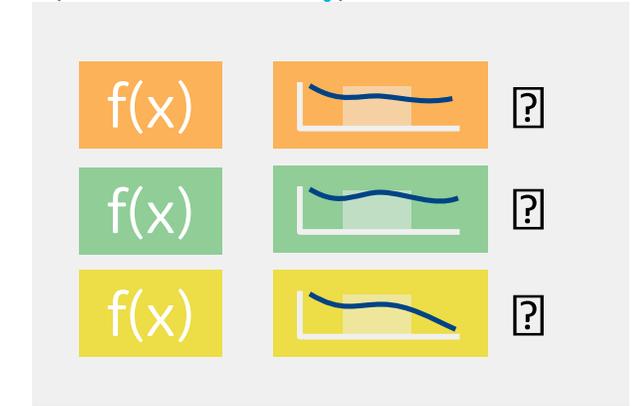
3) Publish



5) Deploy & 6) Run



7) Monitor & 8) Learn



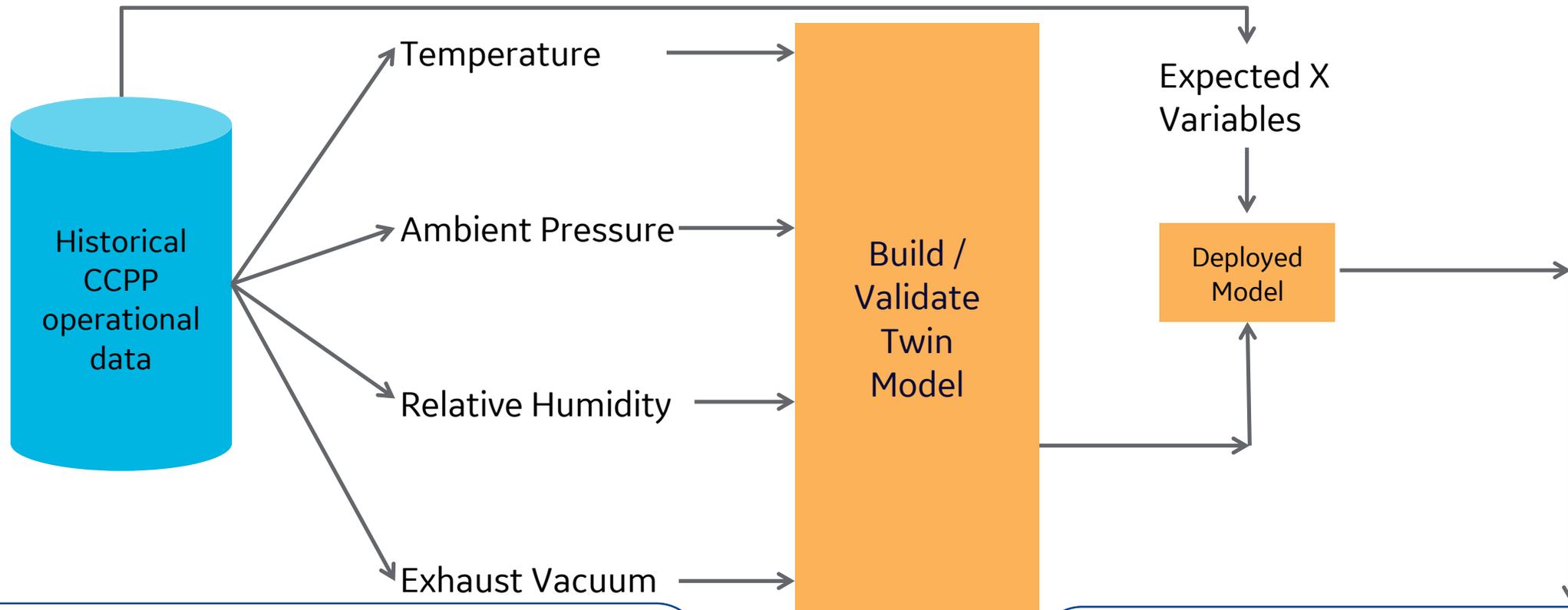
Digital Twin Example: Combined Cycle Power Plant (CCPP) Output Prediction

Build a Digital Twin for a particular CCPP that predicts the Power Output using using public data from:

<http://archive.ics.uci.edu/ml/datasets/Combined+Cycle+Power+Plant>



Digital Twin **Build** for Output Prediction



Training Data

Temp	ExhaustVacuum	AmbientPressure	RelativeHumidity	EnergyOutput
9.44	40	1015.62	81.16	471.32
23.49	49.3	1003.35	77.96	442.76
4.99	39.04	1020.45	78.89	472.52
18.24	58.46	1017.38	86.92	449.63
27.49	63.78	1015.43	47.45	445.66
13.61	41.16	1020.49	75.09	462.67

- ### Regression Model
- Lasso Regression
 - R-squared 0.958
 - Correlation 0.98

Power Predictions

Temp	AmbientPressure	RelativeHumidity	ExhaustVacuum	EnergyOutput_predicted
23.25	1008.05	71.36	71.29	438.7847826
13.87	1007.45	81.52	42.99	466.6762397
16.91	1013.32	79.87	43.96	462.0567857
10.09	1012.99	72.59	37.14	475.563
12.72	1013.45	86.16	40.6	471.8331579
17.77	1020.11	81.51	52.9	456.9463333



Combined Cycle Power Plant (CCPP) Output Prediction Demonstration

The screenshot shows a web browser window displaying the Digital Twin Genix application. The browser's address bar shows the URL <https://genix.showcase.atscale.research.ge.com/digitaltwins>. The application interface includes a dark sidebar on the left with a menu icon and options for 'Digital Twins' and 'Publish Analytics'. The main content area is titled 'Digital Twins' and features a blue 'Add Twin' button. Below this is a table with the following columns: TWIN NAME, DATE MODIFIED, CURRENT DATA SET, CURRENT METHOD, CURRENT TASK, NUM MODELS, STATUS, and OPTIONS. The table contains one entry: 'Aircraft Engine Twin 1', with a date of '2018-03-30 11:46:17', data set 'GE90_50Engines1997_2004.csv', and status 'Editing'. At the bottom of the table, there are pagination controls showing '10' items per page and '1-11' pages, with the first page selected. The Windows taskbar at the bottom shows the time as 8:27 AM on 6/4/2018.

TWIN NAME	DATE MODIFIED	CURRENT DATA SET	CURRENT METHOD	CURRENT TASK	NUM MODELS	STATUS	OPTIONS
Aircraft Engine Twin 1	2018-03-30 11:46:17	GE90_50Engines1997_2004.csv		Explore	0	Editing	▼





Hot Intake Manifold Prognosis (EVO/FDL Locomotives) (Modular Workflow)

Hot Manifold Prognosis: Objectives

Asset

Locomotives (models EVO & FDL)

Objective

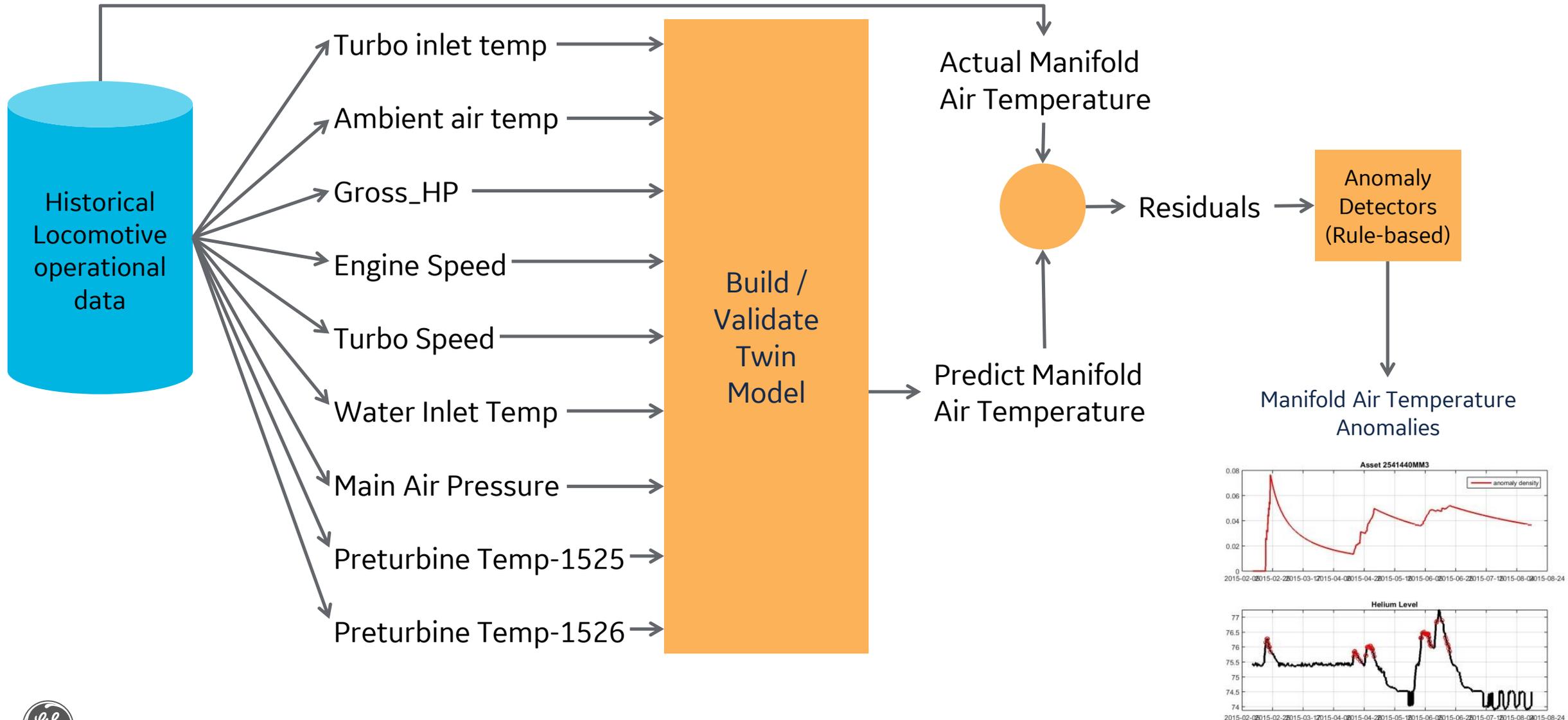
- Develop a model to proactively predict road failures due to rise in manifold air temperatures.
- Reduce the unscheduled outage & increase the availability to customers.
- Increase coverage of existing RX while ensuring an accuracy of ~90%.

Business Impact

- 55 mission failures EVO Tier 2 & 3 cooling system for year 2016
- 66 mission failures for 2015
- \$15K average cost incurred by customer for each failure



Digital Twin **Build** for Detection



Locomotive Hot Manifold Anomaly Detection Demonstration

The screenshot shows the Digital Twin Genix web application interface. The browser address bar displays the URL <https://genix.showcase.atscale.research.ge.com/digitaltwins>. The application header includes the GE logo and the text "Digital Twin Genix". A left sidebar contains navigation options: "Digital Twins" and "Publish Analytics". The main content area is titled "Digital Twins" and features an "Add Twin" button. Below this is a table with the following columns: TWIN NAME, DATE MODIFIED, CURRENT DATA SET, CURRENT METHOD, CURRENT TASK, NUM MODELS, STATUS, and OPTIONS. The table contains two entries:

TWIN NAME	DATE MODIFIED	CURRENT DATA SET	CURRENT METHOD	CURRENT TASK	NUM MODELS	STATUS	OPTIONS
<input type="checkbox"/> Combined Cycle Power Plant Output Predictor	2018-06-04 08:31:14	CCPP Training Set 2.csv	lassoregression	Predict	2	Editing	▼
<input type="checkbox"/> Aircraft Engine Twin 1	2018-03-30 11:46:17	GE90_50Engines1997_2004.csv	-	Explore	0	Editing	▼

At the bottom of the application, there is a pagination control showing "10" items per page and "1-22" total items, with page "1" selected. The bottom of the screenshot shows a Windows taskbar with various application icons and a system tray with a timer at "00:00:00" and the date "10:41 AM 6/4/2018".



Aircraft Engine Overhaul Level: A Classification Example

Asset

Aircraft Engine



Objective

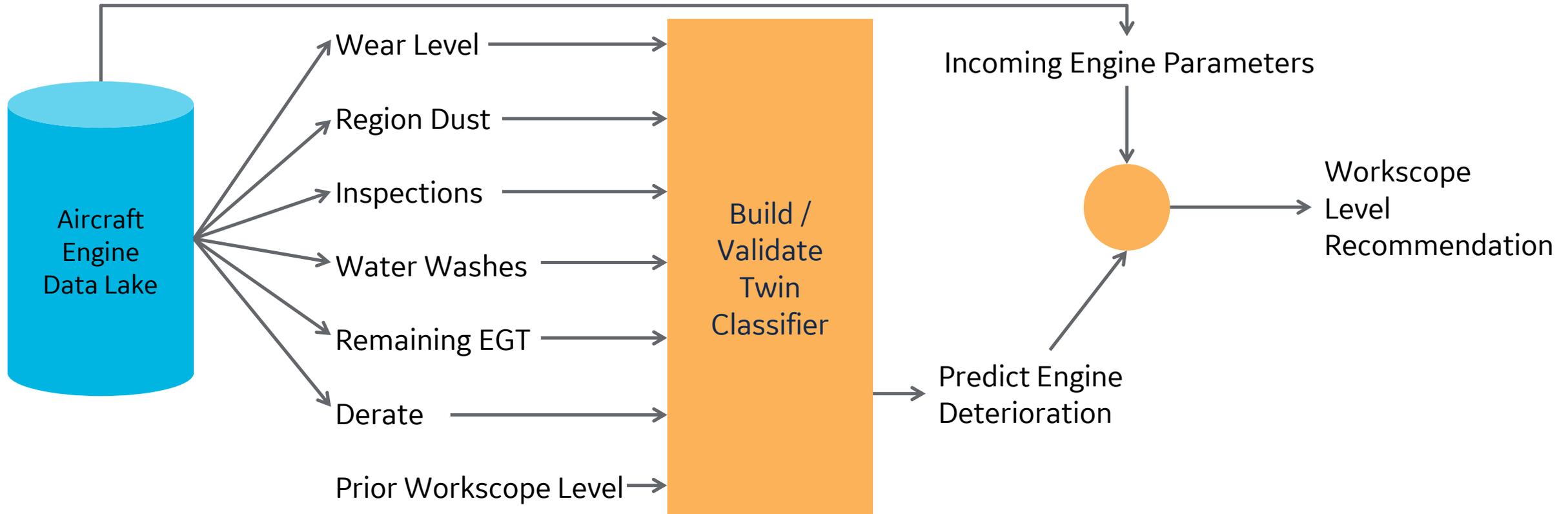
Develop a model to predict the overhaul level: Light, Medium, Heavy

Business Impact

Keep overhaul Turn-Around-Time low by anticipating parts needed based on recommended workscope level



Digital Twin **Build** for Overhaul Classification



Wear Level	1=vhigh, 2=high, 3 =med, 4=low
Region Dust	1=vhigh, 2=high, 3 =med, 4=low
Inspections	2, 3, 4, 5 (# of inspections)
Water Washes	2, 4, 5 (# of washes)
Remaining EGT	small, med, big
Derate	Low, Med, High
Prior Workscope Level	heavy, med, low



Aircraft Engine Workscope Classification Demonstration

The screenshot displays the Digital Twin Genix web application. The browser address bar shows the URL <https://genix.showcase.atscale.research.ge.com/digitaltwins>. The application header includes the GE logo and the text "Digital Twin Genix". A left-hand navigation menu contains "Digital Twins" and "Publish Analytics". The main content area is titled "Digital Twins" and features an "Add Twin" button. Below this is a table with the following columns: TWIN NAME, DATE MODIFIED, CURRENT DATA SET, CURRENT METHOD, CURRENT TASK, NUM MODELS, STATUS, and OPTIONS. The table contains three entries:

TWIN NAME	DATE MODIFIED	CURRENT DATA SET	CURRENT METHOD	CURRENT TASK	NUM MODELS	STATUS	OPTIONS
Filter	Filter	Filter	Filter	Filter	Filter	Filter	
Locomotive Manifold Air Temp Anomaly Detector	2018-06-04 10:44:49	TrainData_LC.csv	lassoregression	Predict	2	Editing	▼
Combined Cycle Power Plant Output Predictor	2018-06-04 08:31:14	CCPP Training Set 2.csv	lassoregression	Predict	2	Editing	▼
Aircraft Engine Twin 1	2018-03-30 11:46:17	GE90_50Engines1997_2004.csv		Explore	0	Editing	▼

At the bottom right of the table area, there is a pagination control showing "10" items per page, "1-33" total items, and a page indicator "1". The bottom of the screen shows a Windows taskbar with various application icons and a system tray with the time "11:18 AM" and date "6/4/2018".



Considerations on Building Digital Twins