Minds & Machines

Towards the digital-industrial company

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Special Advisor

...with friendly support from

PLATAINE®
people-smart automation

SCIENCE|BUSINESS®
Bringing together industry, research and policy

> If you went to bed an industrial company, you're waking up a data & analytics company

Jeff Immelt, former Chairman & CEO (2014)

Investment goods – asset heavy industries

Source: General Electric Inc.

Digitalisation & Software

The Business Case

productivity improvements & customer outcomes (incl. risk)

The Challenge(s)

product vs. service, apps vs. platform, CoreCo vs. NewCo

Services evolution

Big Iron

'80s
+ Partners
+ Field engineers

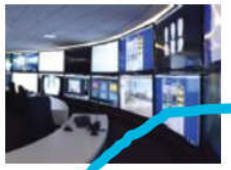
Repair Technology

'90s
+ Advanced repairs
+ Part upgrades

Contractual Services

'00s
+ Risk sharing
+ Monitoring & diagnostics

Digital Industrial



Today
+ Analytics-enabled uptime
+ Software-enhanced output/performance
+ Remote inspections

Technology Application

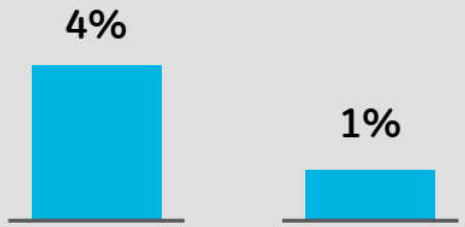
Customer Outcomes

Source: General Electric Inc.

Digital transformation

The Idea

Industrial productivity



Meets the Digital Twin

Physics + Analytics

The Principles

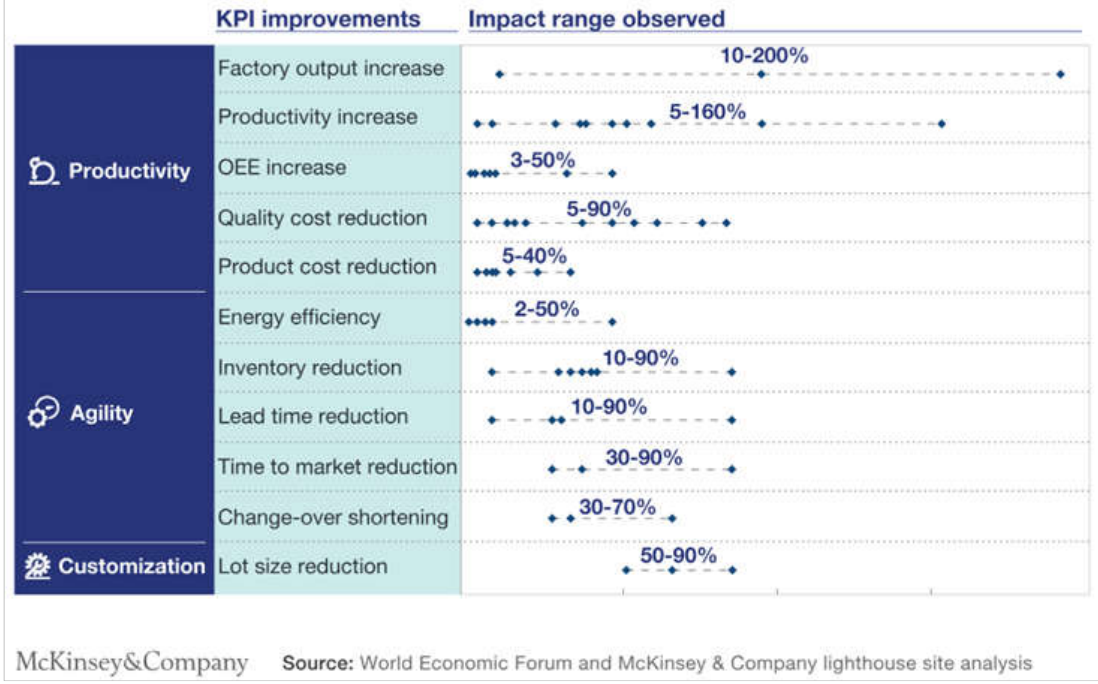
- Deliver outcomes
- Consumer ≠ industrial
- Talent follows ideas
- Assets + devices matter

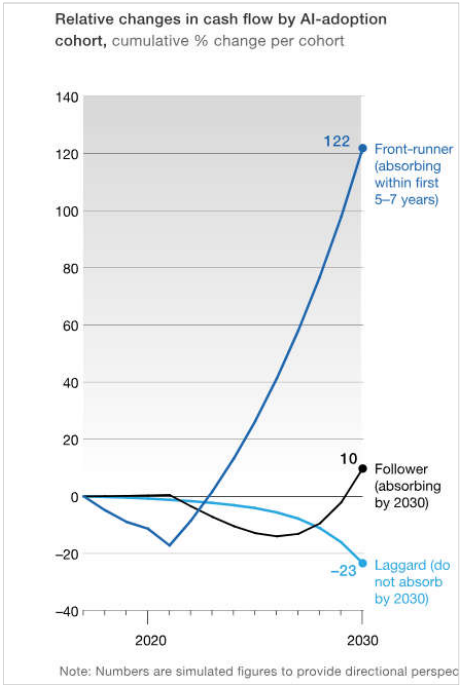
- Build digital content
- Reform IT
- Simplify culture
- Industrials trust each other

Source: General Electric Inc.

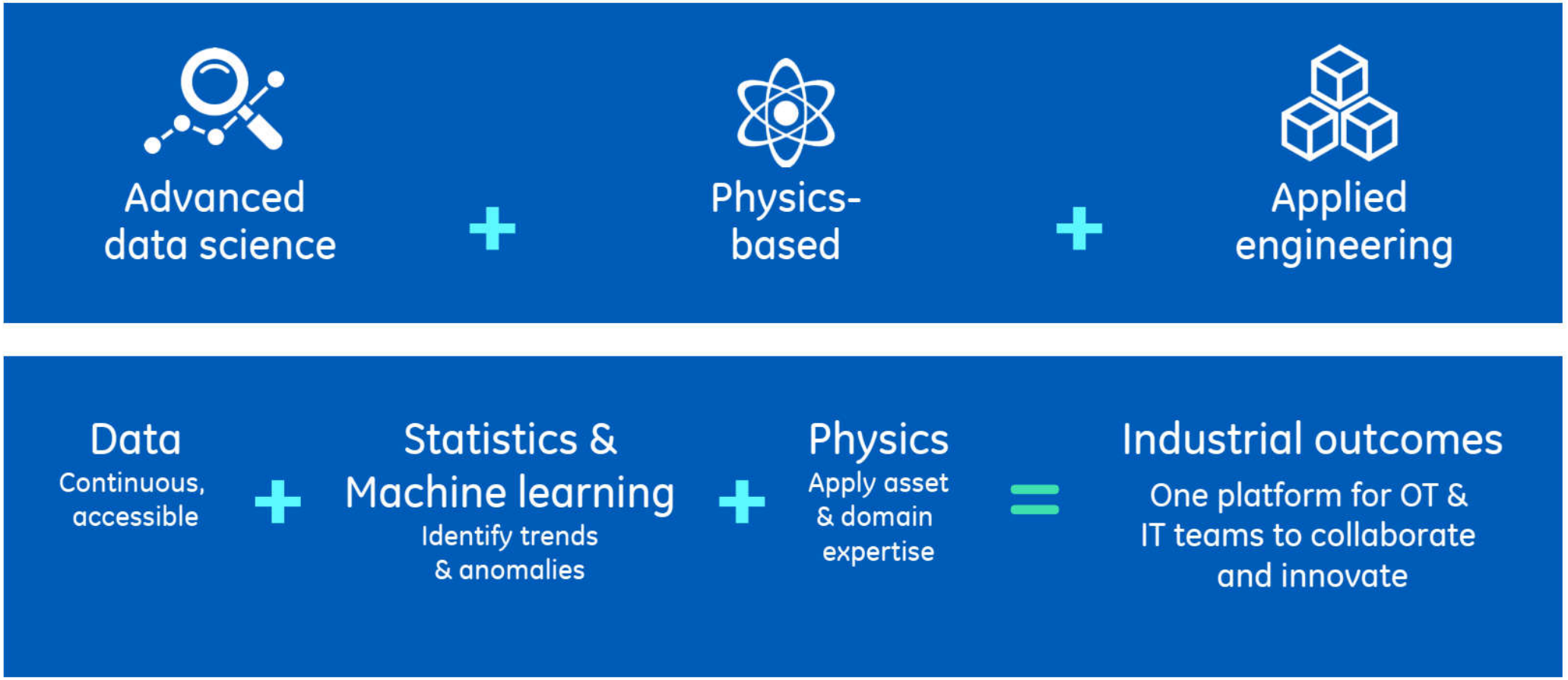
Industry 4.0 Opportunity

World Economic Forum & McKinsey & Company:
“Industry 4.0 dramatically improves both top & bottom lines“
“Early Adopters stand to gain significantly greater benefits”



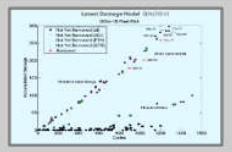
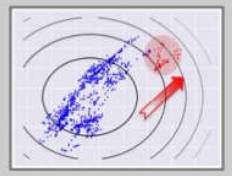
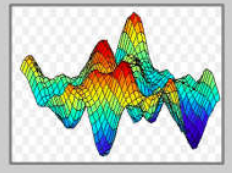
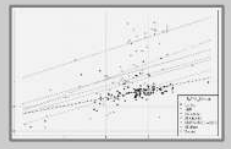


The building blocks



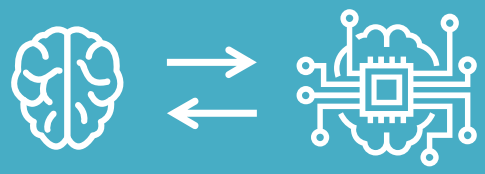
Source: General Electric Inc.

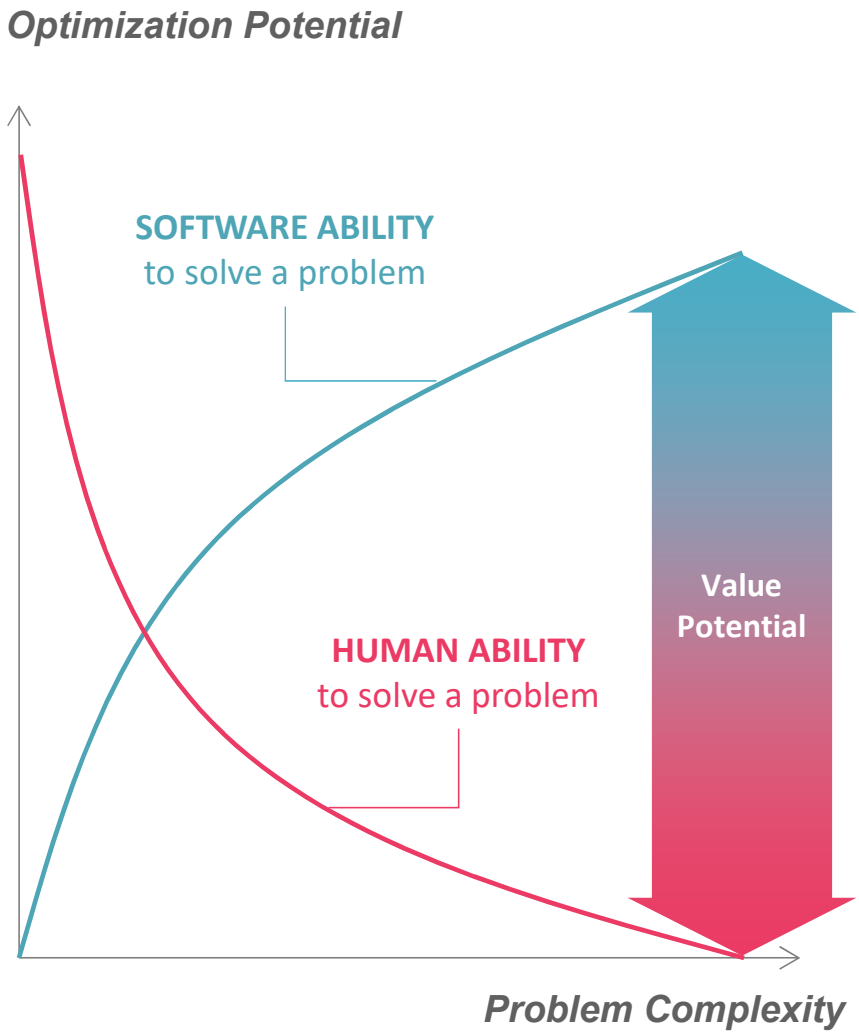
Physics and analytics – a portfolio approach

Business Problem	ML Technology	Physics Model	Business Outcome
 **Fleet Segmentation**	**Learning from a low number of events** Bayesian estimation, similarity search, clustering.	**Integration with Lifting Models** Spallation, and Metal Fatigue models	**Increased uptime, optimize maintenance schedule for aircraft engines**
 **Early Warning**	**Unsupervised and Supervised Learning of the Asset Operational Model** Gaussian Mixture Model, Similarity Based Model	**Integration with Performance Model** Using Thermal model to produce virtual sensors	**Move unplanned downtime to scheduled downtime in Aviation and locomotives**
 **Performance Optimization**	**Supervised Learning of Asset performance** Neural Network, Active Learning	**Systems Performance Models** Gate Cycle model of Power Plant, real time control of Power Plant	**Reduce fuel consumption while maintaining production MW target**
 **Services Optimization**	**Learning from a low number of Shop Events** Ridge Regression, Similarity Search	**Integration with Selected Domain Knowledge.** Survival analysis, domain features	**Decrease service turnaround time for engines in shop**

Source: General Electric Inc.

As the problem becomes more **COMPLEX**, the human ability to deal with it **DECREASES**, and the potential value of software **INCREASES**



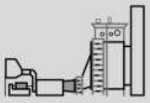


Courtesy Plataine

Portfolio solution map

BUSINESS OPTIMIZATION (BO)

- Market Intelligence & Forecasting
- Portfolio Optimization
- Fuel Nominations
- Financial Settlement



OPERATIONS OPTIMIZATION (OO)

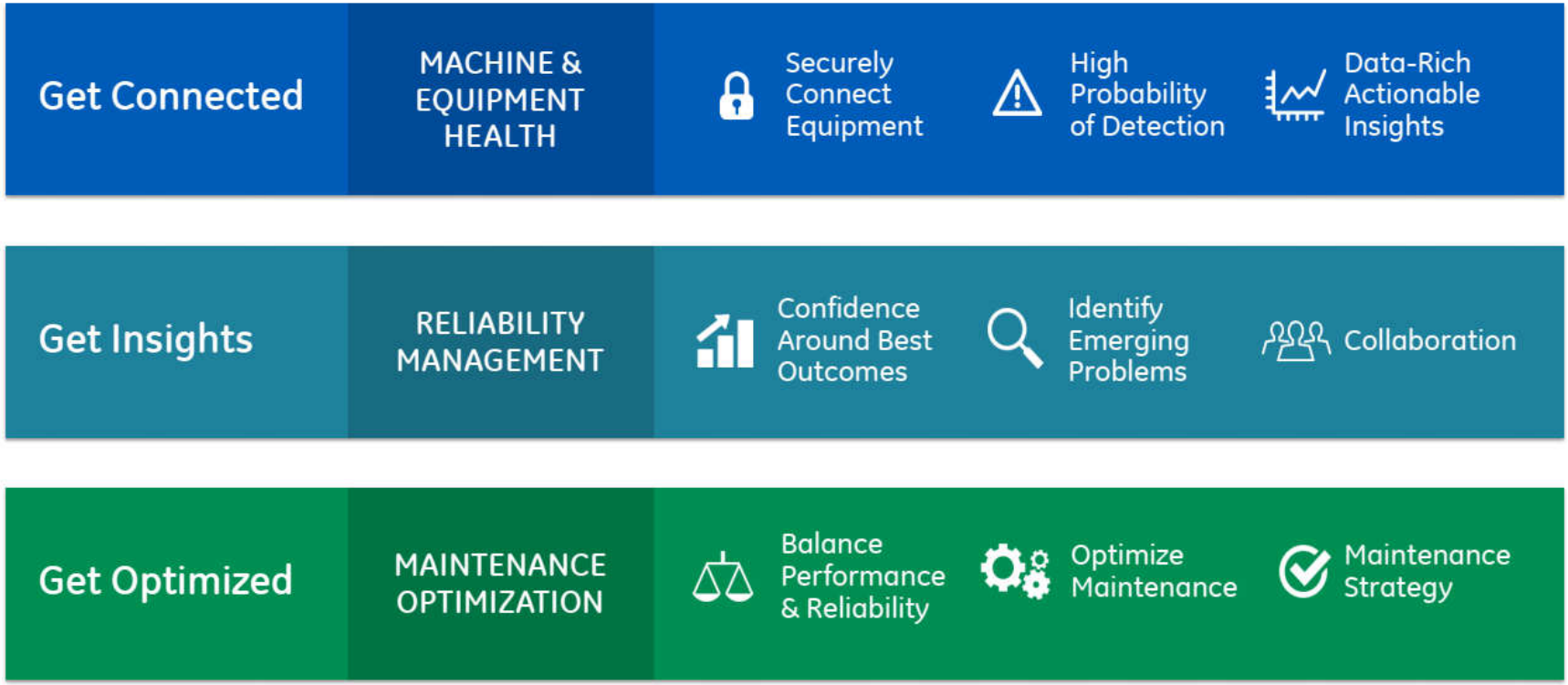
- Performance Metrics
- Plant Optimization
- Outage Management
- Fuel Supply Management
- Financial Planning
- Regulatory Compliance

ASSET PERFORMANCE MANAGEMENT (APM)

- Machine & Equipment Health
- Reliability Management
- Maintenance Optimization

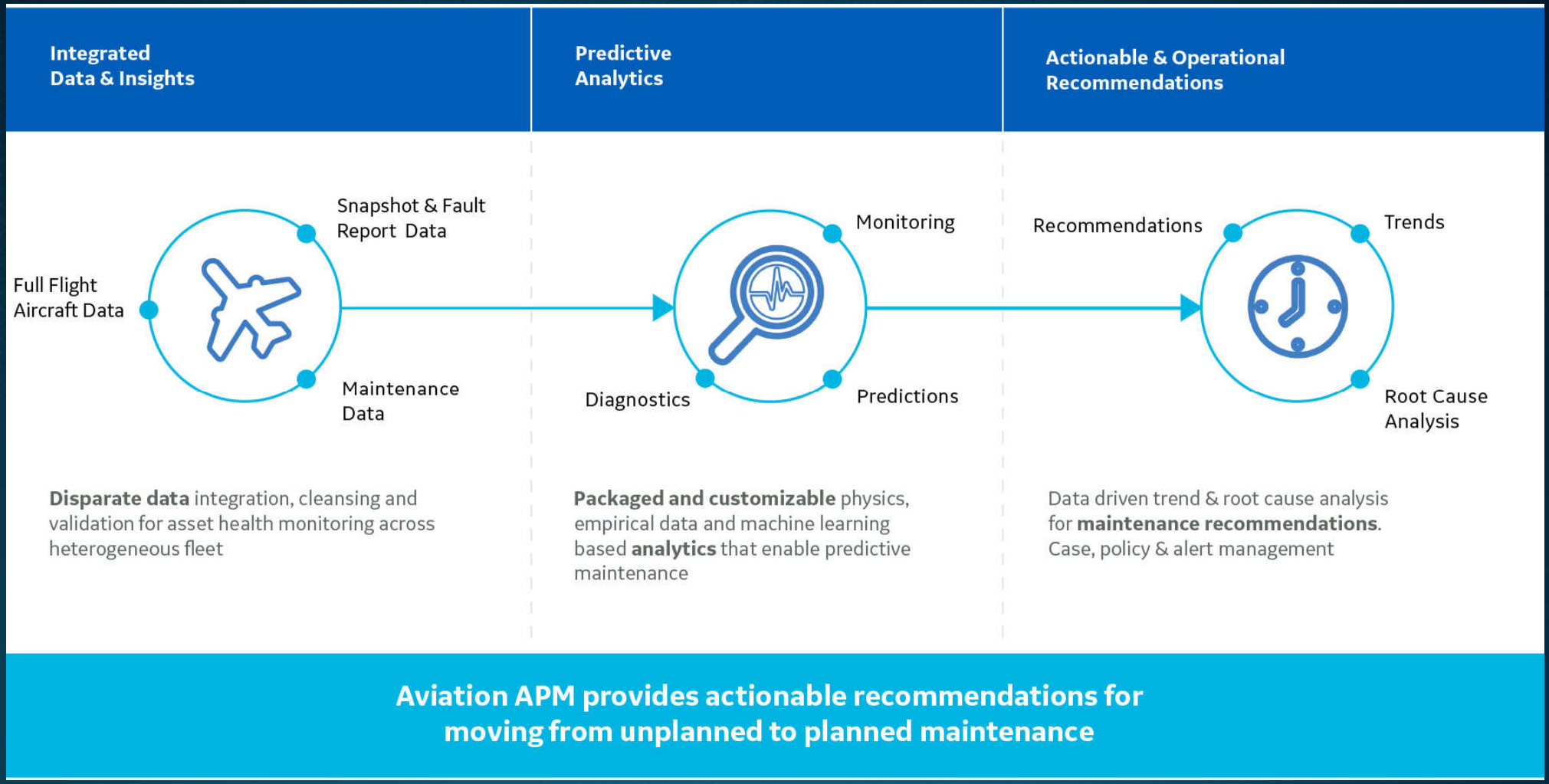
Source: General Electric Inc.

Asset Performance Management (APM)



Source: General Electric Inc.

Asset Performance Management

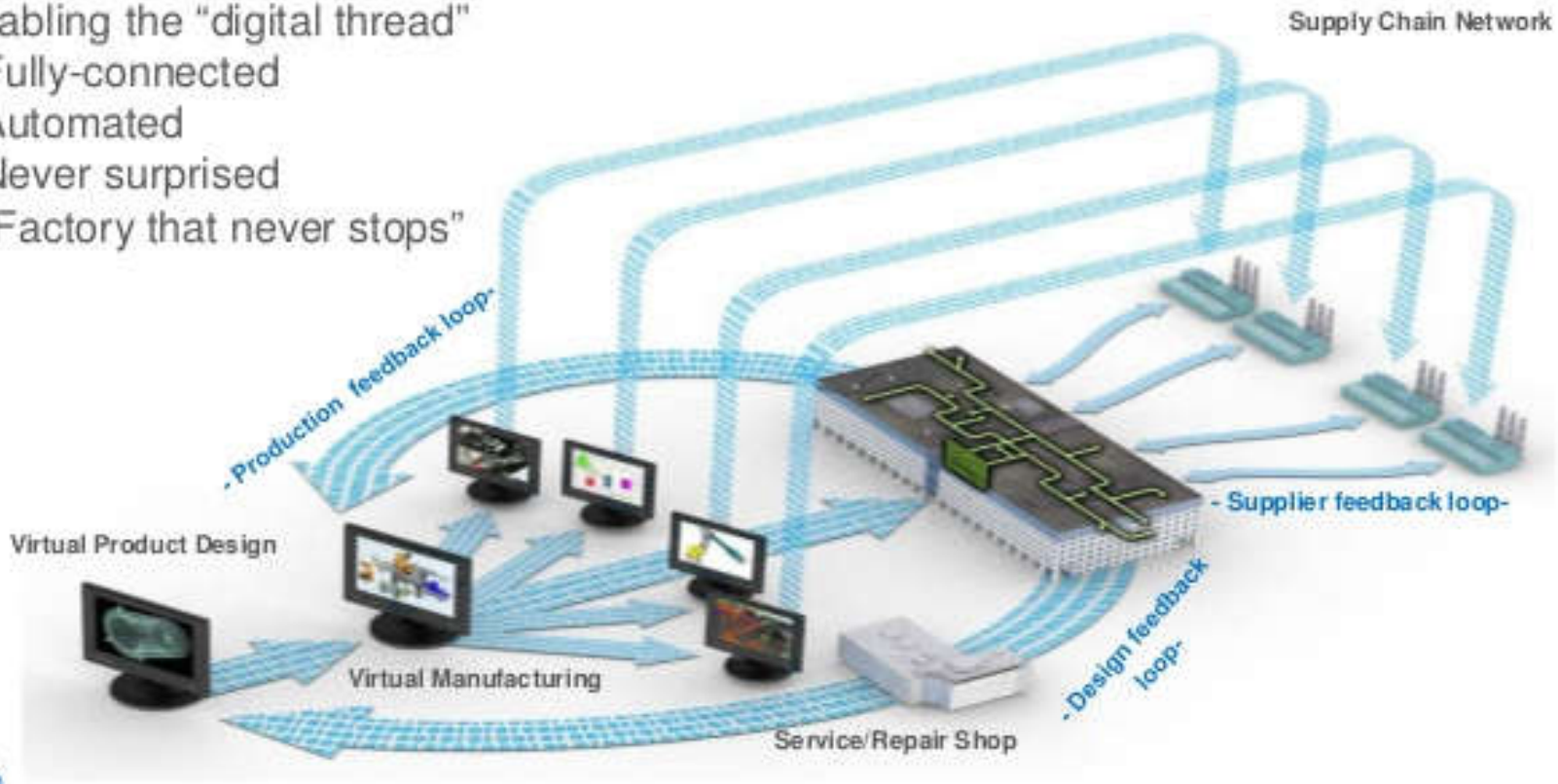


Source: General Electric Inc.

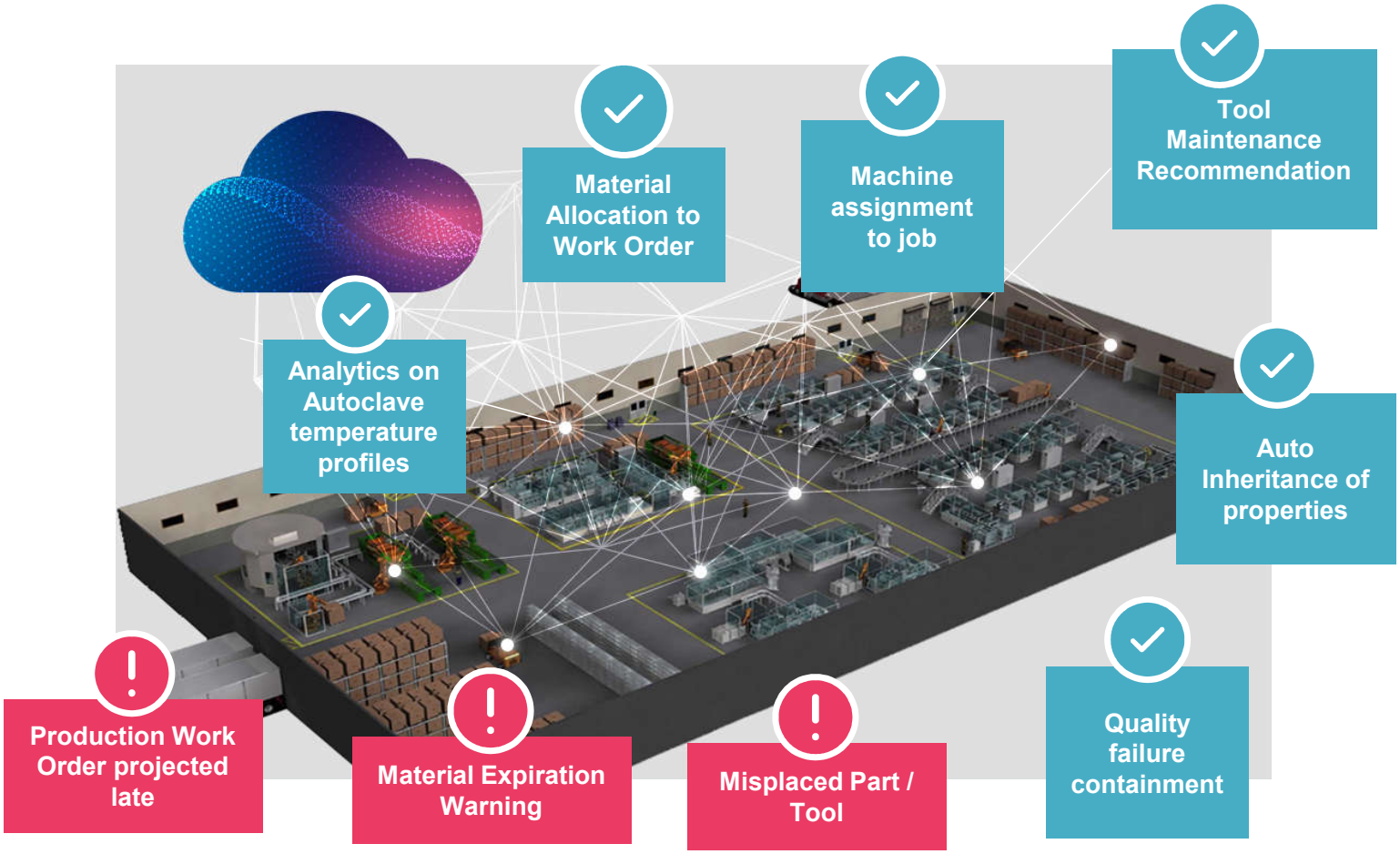
GE's Brilliant Factory

Enabling the "digital thread"

- Fully-connected
- Automated
- Never surprised
- "Factory that never stops"



Fully Connected, Intelligent, Digital Factory



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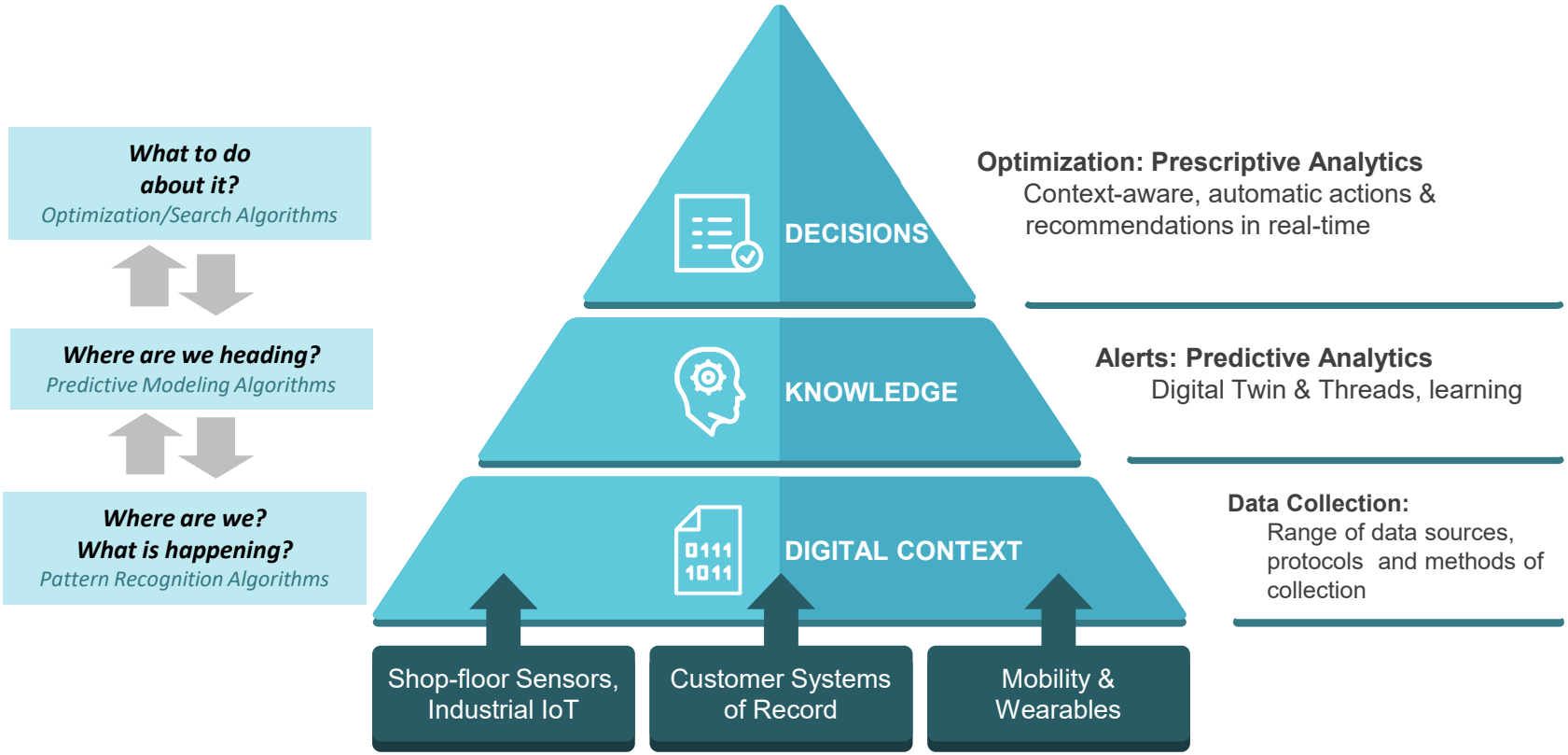
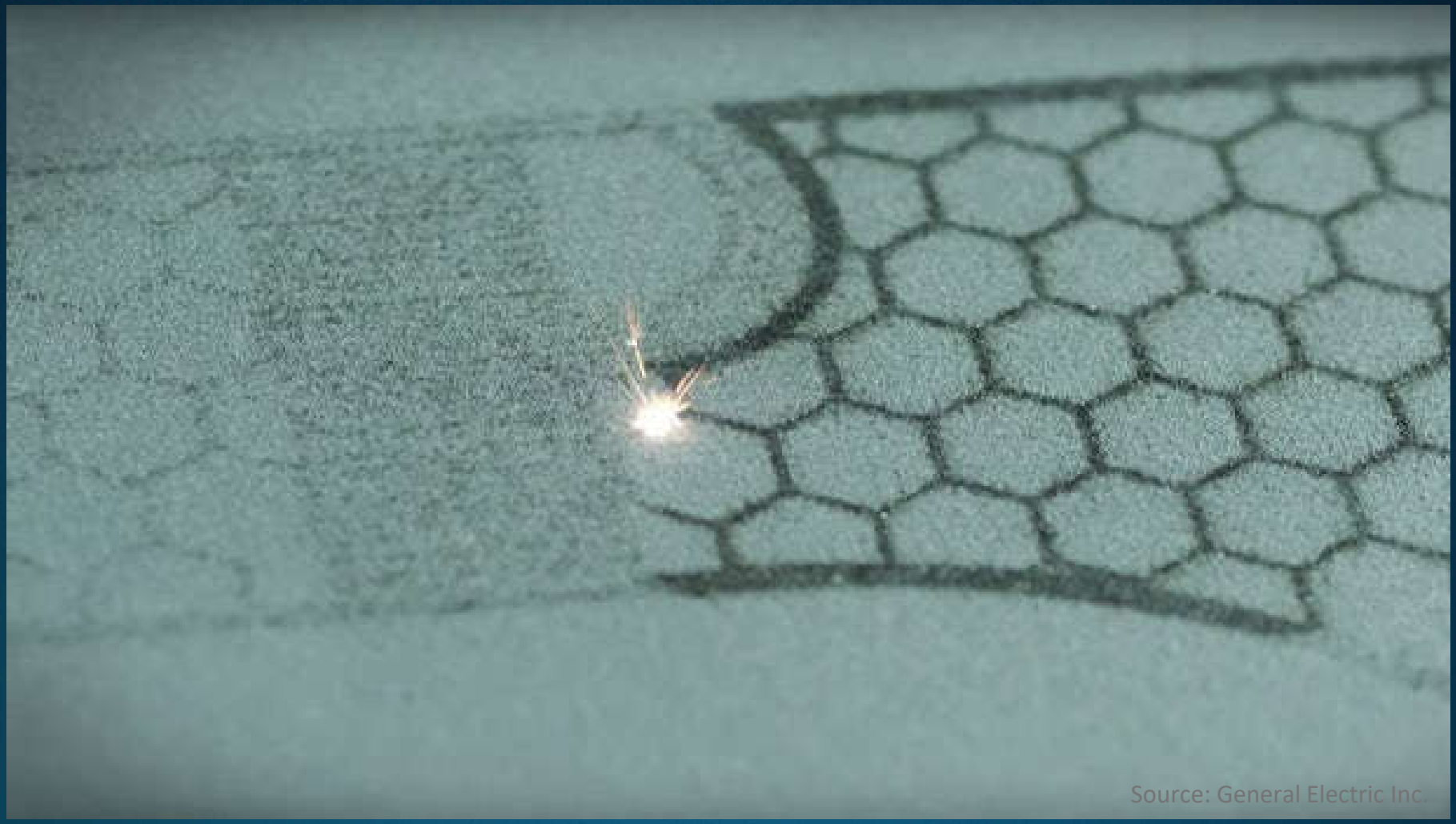
To creates superior value, AI must address the complete workflow:
Diagnosis, Prognosis and Treatment



Additive … born-digital manufacturing



Source: General Electric Inc.

Enterprise level disruption

Design | Manufacturing | Services

Additive

Turbine frame

1 Digital Twin

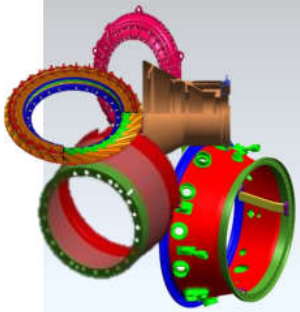
6-8 Engineers

1 Mfg. sources & Inspection Sys.

1 Repair Source

1 data lake ...powering PREDIX

Conventional



Same frame

300 parts

60 Engineers

50+ Mfg. sources

5 Repair sources

40 data systems

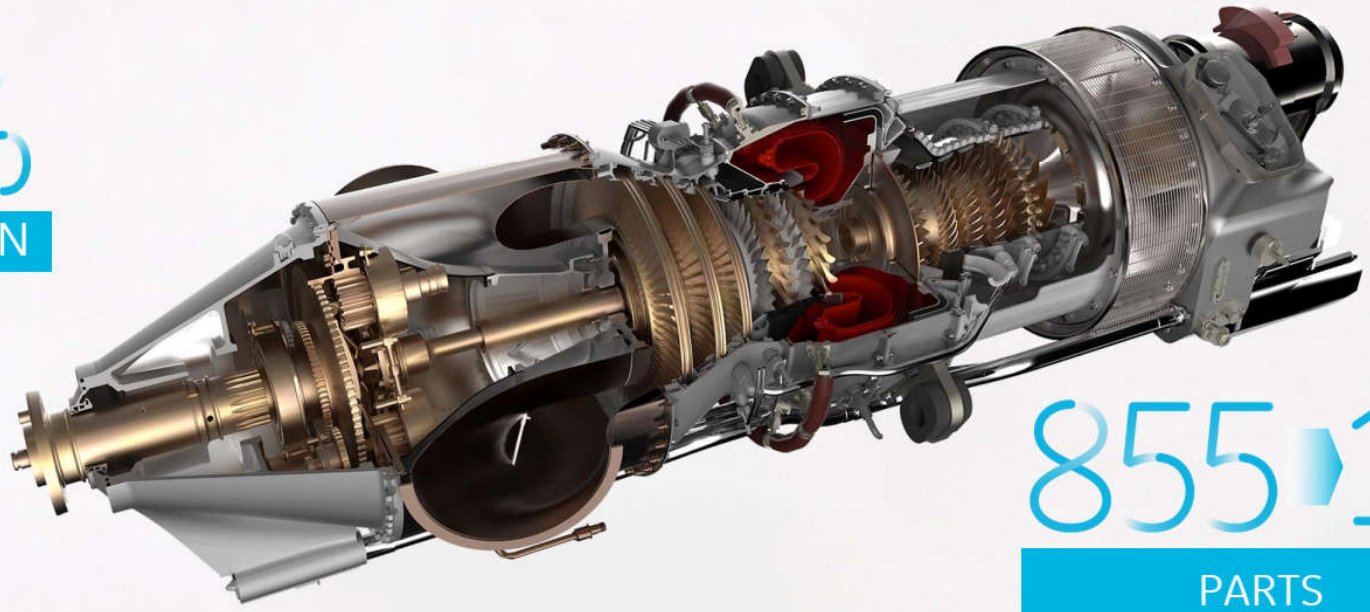
Source: General Electric Inc.

Advanced turboprop engine (ATP)

Combustor test schedule reduced
from **12 months** to **6 months**

5%
WEIGHT
REDUCTION

20%
LOWER MISSION
FUEL BURN



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PARTS

Digital technologies in industry

think productivity and customer outcomes (incl. risk)

all levels matter: product- / operations- / business-optimization

investment lifecycle setting the pace (not Moore‘s law)

small changes can mean big wins (it‘s not a 10X world)