# Big Data & Analytics for Wind O&M: Opportunities, Trends and Challenges in the Industrial Internet

**Bouchra Bouqata, Ph.D.,**
Senior Analytics Proram Manager
GE Renewable Energy Digital

Frontiers of Engineering
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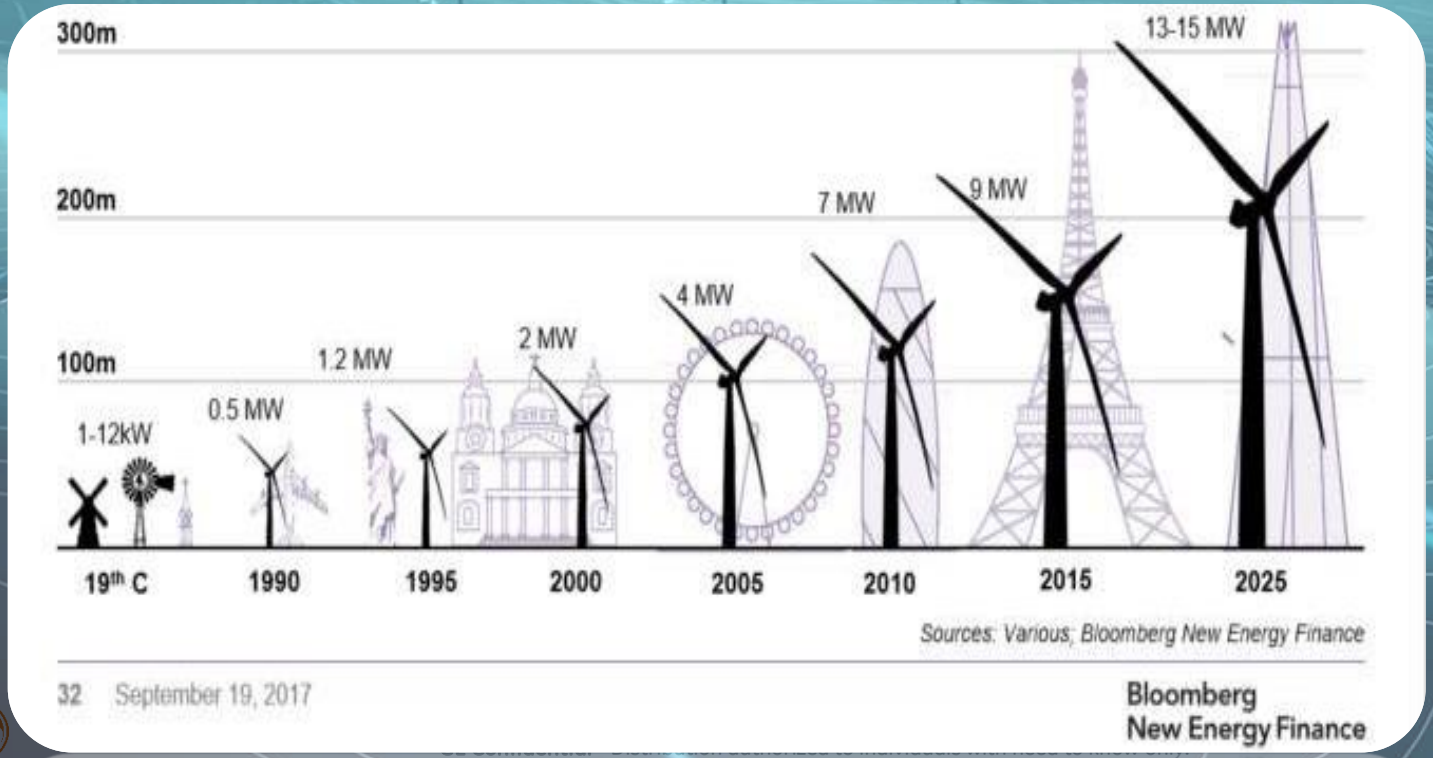
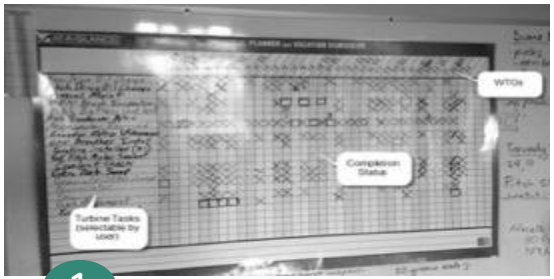
# Wind Technology Evolution



# How does industry manage Wind fleets?

## Plant Operators



1

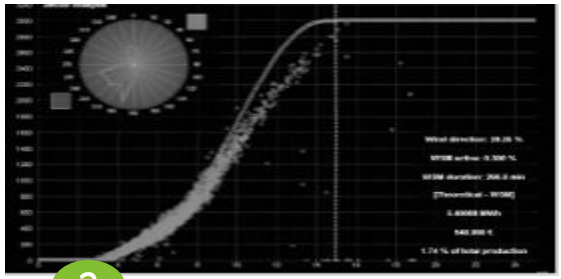
### Keep equip running by …

- Identify outages
- Reset turbines
- Equipment fixes

**Availability**
**Reliability**

Asset Performance

## Fleet/Asset Managers



2

### Improve operations by …

- Analyze historical perf
- Recommend improvements
- Upgrade/uprate opportunities

**AEP Enhancement**
**Productivity**

Operations Optimization

## Commercial Managers

3

### Make money by …

- Forecast & schedule power flows
- Project flip/refi/acquire decisions
- Negotiate service contracts

**Growth**
**Profitability**

Business Optimization

# Wind Specific O&M Challenges

## Troubleshooting + Return to Service

Poor visibility of current turbine status leads to slow RTS

Unknown reasons for turbines faulting

Repeat tower climbs

## Unplanned Maintenance + Parts Consumption

~70% of total O&M spend

Shrinking O&M budgets

Firefighting vs. proactive prioritizing

Improperly replacing good/ incorrect parts

## Planned Maintenance

Performing unnecessary maintenance tasks

Difficult tracking and documentation

Lots of data, not much insight

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# Get Data/ Get Connected

**Connect your assets** → **To operational drivers:**

- Wind turbines
- Strings/interconnects
- Grid
- Metmass + Lidar

- Weather
- Maintenance schedules
- Manpower

## Monitor the current state of your assets

## Capture information at every point

- Machines | People | Process

## Systematically catalog tribal knowledge

- Fault Handling Procedures
- Troubleshooting guides
- Past failure data

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# What happened when 1B people became connected?

Social networking

Mobility

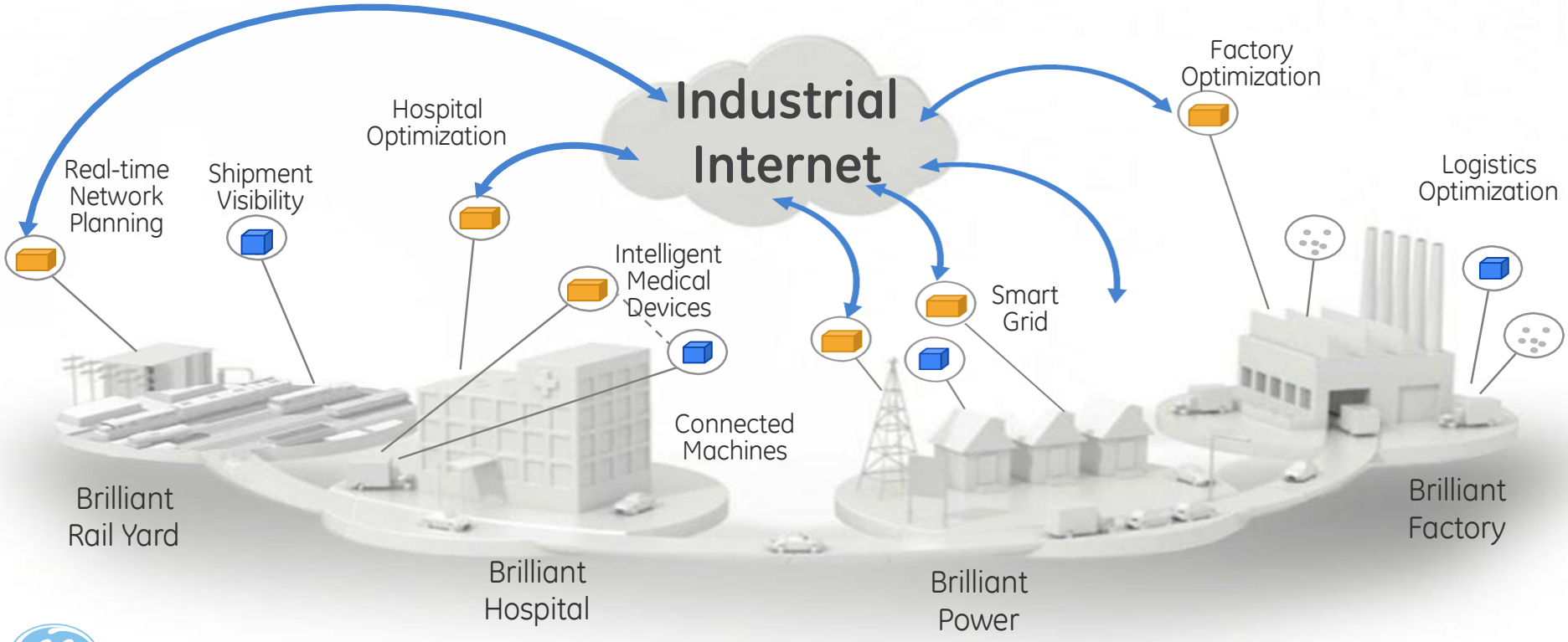
Consumer Internet

B2B standardized

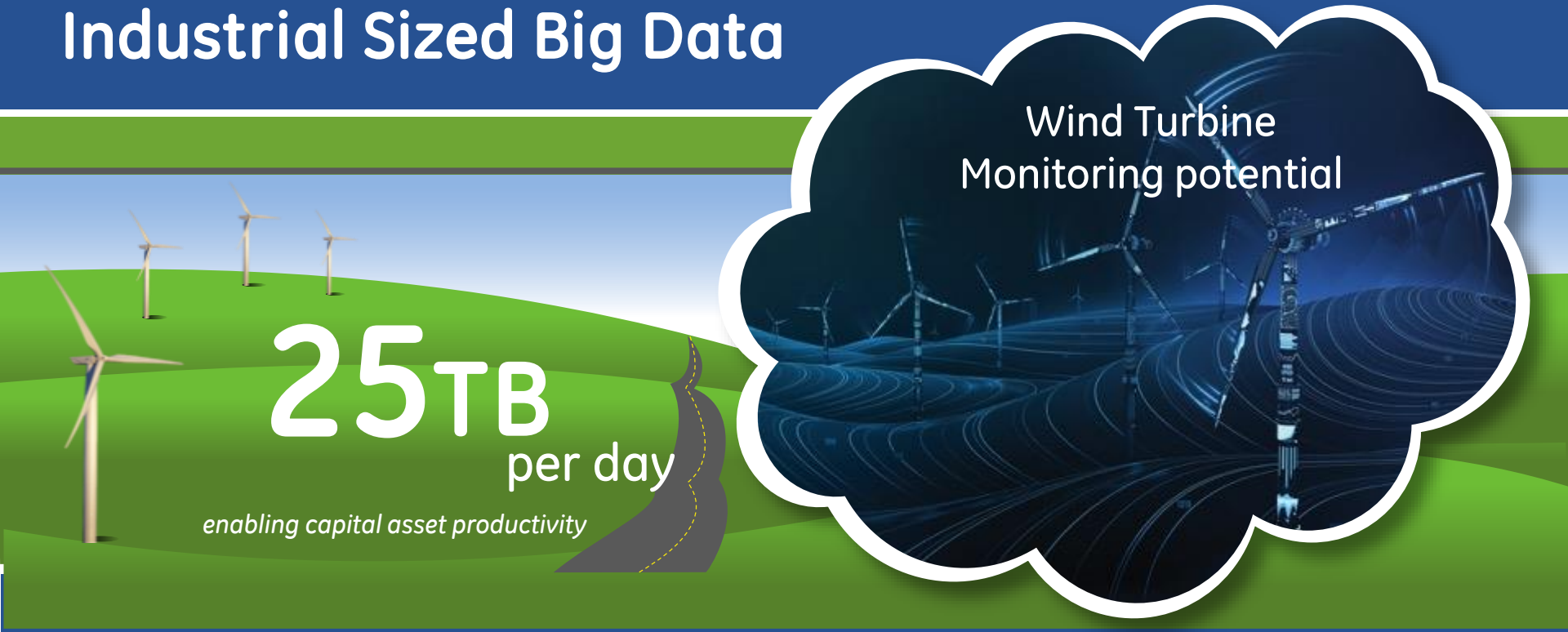
Retail & ad transformed

Entertainment digitized

# What happens when 50B Machines become connected?

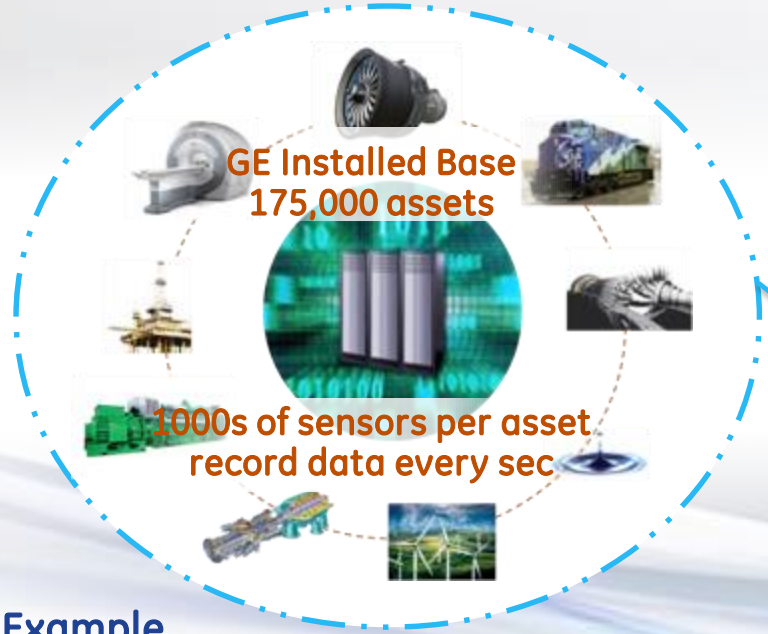


# Industrial Sized Big Data




Data volume potential is 4x greater from
Wind farms than Twitter (8TB/day)

# Industry Value of Big Data





**Example**

**DATA**

~30,000 + turbine records analyzed
~1000 parameters per turbine

**System & environment**

- ✓ Fleet & site level
- ✓ Wind Conditions
- ✓ Grid capacity

=

**Prognostics**

- ✓ Dispatch reliability
- ✓ Preventive maintenance
- ✓ Asset utilization

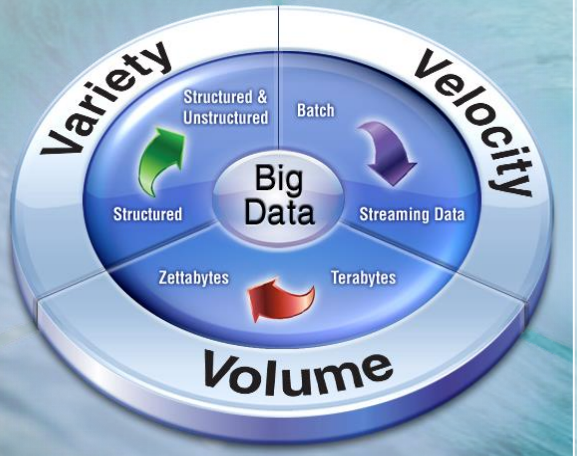
+

**Asset Productivity**

- ✓ Enhanced service offerings
- ✓ Cost structure
- ✓ Availability
- ✓ Performance

# The Big Data Opportunity

***Extracting insight from an immense volume, variety and velocity of data, in context, beyond what was previously possible.***




**Variety:** Manage the complexity of multiple relational and non-relational data types and schemas

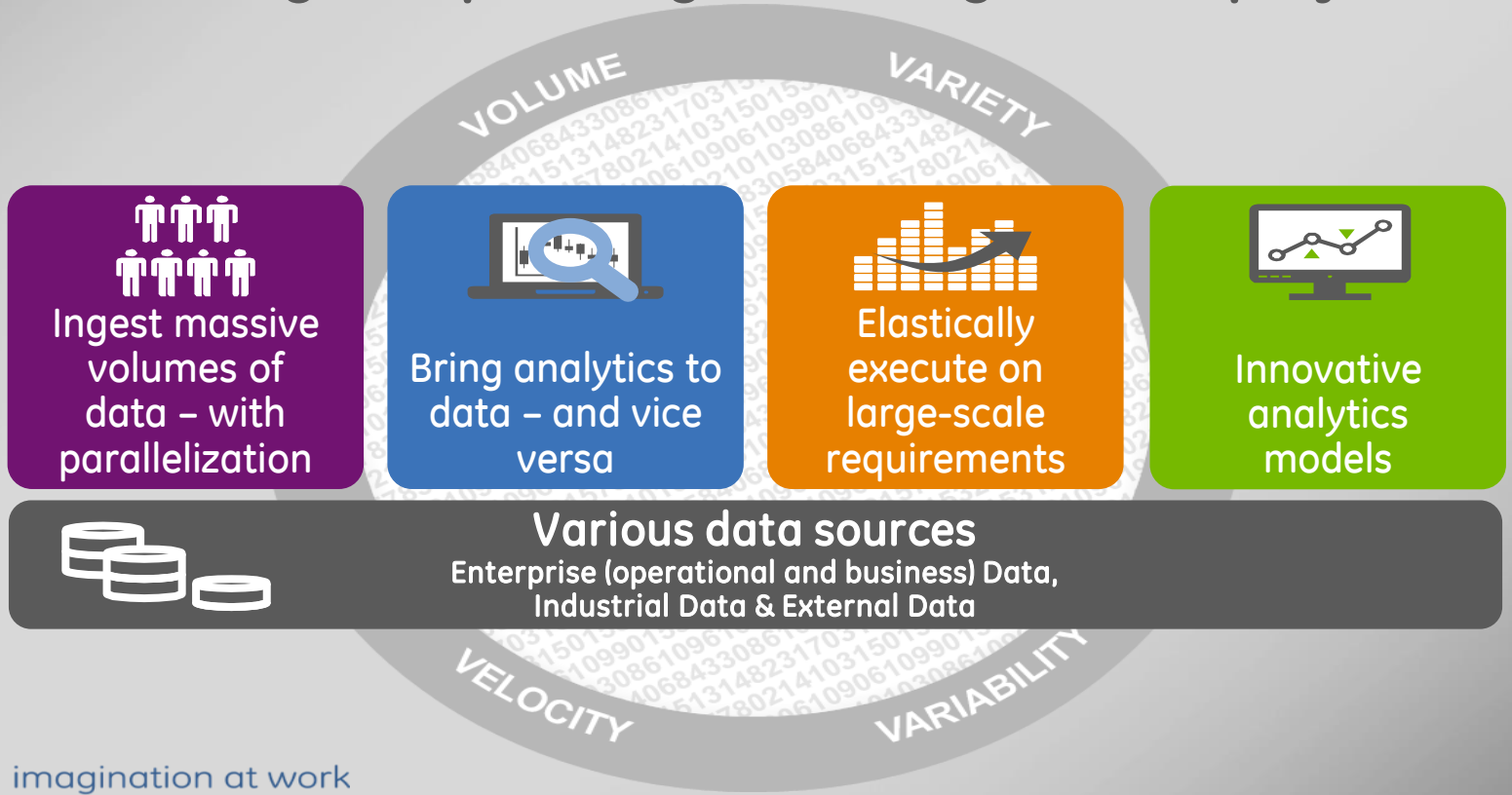
**Velocity:** Streaming data and large volume data movement

**Volume:** Scale from terabytes to zettabytes

***Credit-*** *Paul Zikopoulos & Tom Deustch from IBM*

# Big data analytics

## Delivering sharper insights to "big model" projects

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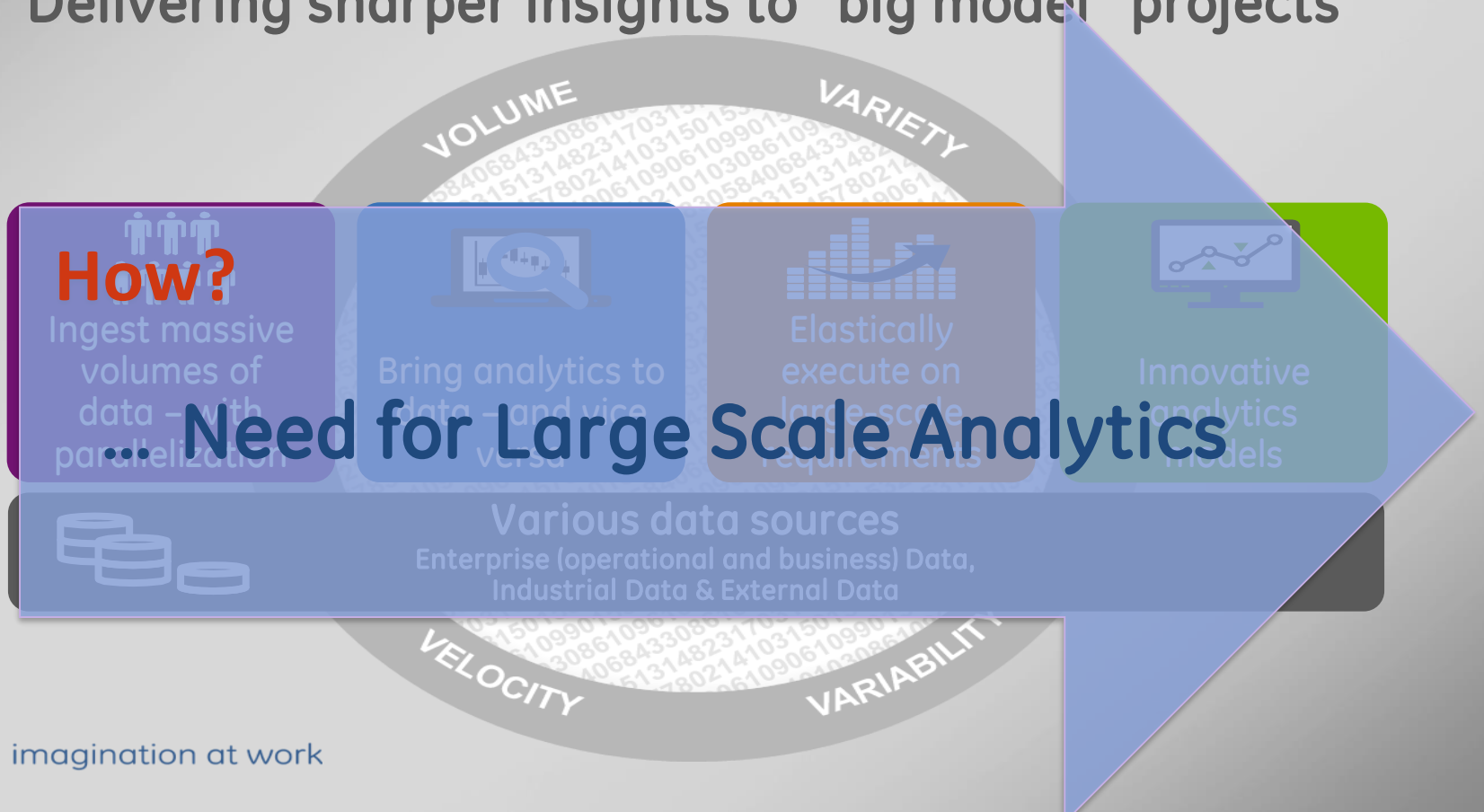
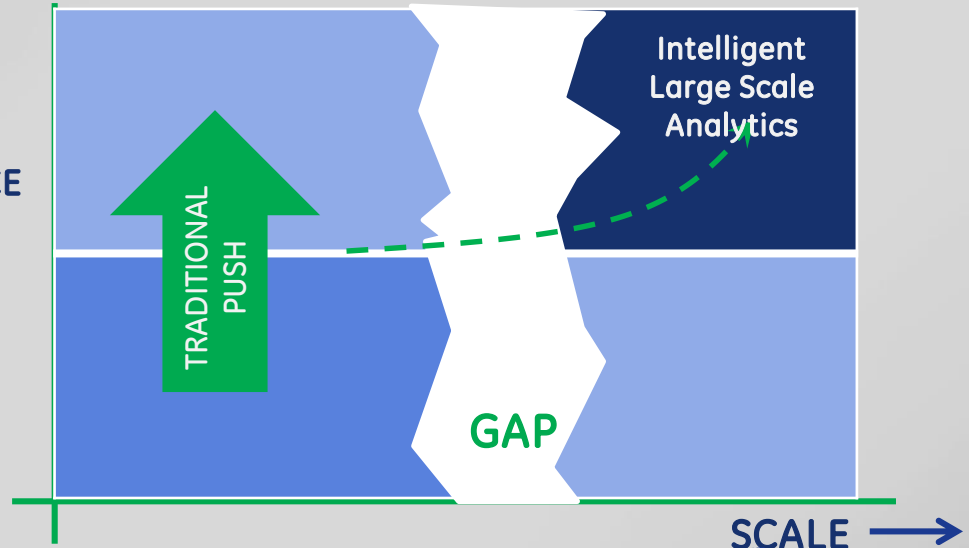
# Big data analytics

## Delivering sharper insights to "big model" projects




… Need for Large Scale Analytics

# Analytics : Dimensions of effectiveness




**Improve existing advanced analytics to:**

1. Maximize accuracy
2. Minimize false alarms
3. Maximize coverage, PoD
4. ...

**Cost-effectively automate analytics for :**

1. Quick and easy replication
2. Fleet-level analytics
3. 100000s of assets/components
4. Inexpensive customization
5. Use of diverse approaches tuned optimally
6. **Dealing with hundreds of variables, millions of data records (Big Data)**
7. ....

**Dealing with Big Data**

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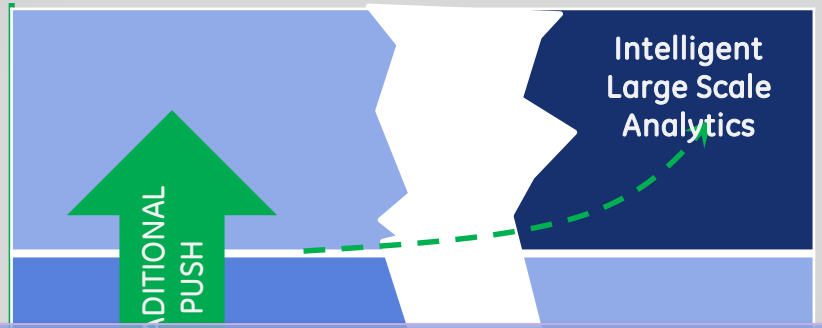
# Analytics : Dimensions of effectiveness




PERFORMANCE

**Improve existing advanced analytics to:**

1. Maximize accuracy
2. Minimize false alarms
3. Maximize coverage, PoD
4. ...

**However**

... to make it a reality

SCALE

Dealing with
Big Data

**Need Enablers...**

Cost-effective [illegible]

1. Quick and easy replication
2. Fleet-level analytics
3. 100000s of assets/components
4. Inexpensive customization
5. Use of diverse approaches tuned optimally
6. **Dealing with hundreds of variables, millions of data records (Big Data)**
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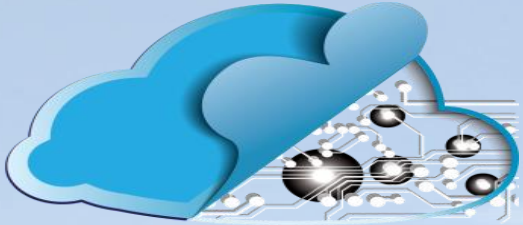
# Big Data Analytics Enablers for IoT

**Customized Analytics**

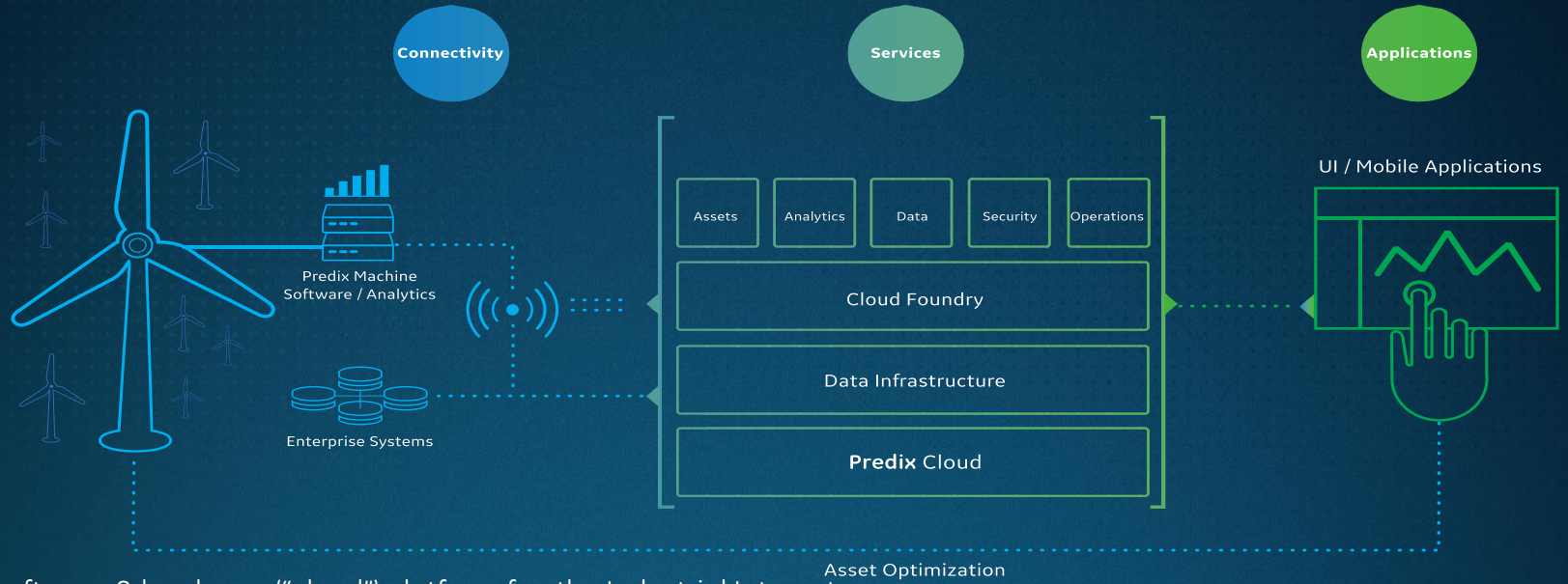


**Cloud Computing**


## Enabling Big Data analytics

- Customized Analytics - from Feature Selection exploration to Large Scale Models exploration
- Cloud – architecture of choice for the bulk of information technology needs

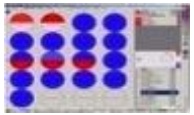
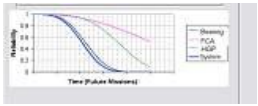
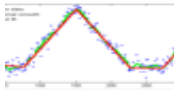
# Industrial Cloud Platform Example: GE's Predix Industrial Cloud Platform (Cont…)


A software & hardware ("cloud") platform for the Industrial Internet :

- Machine-embedded software
- Secure connectivity services
- Data services
- DevOps services
- Asset data services

# Asset Performance Mgt (APM): Customized intelligent Analytics

| *Stage 1: AD + RM&D* | *Stage 2: Prognostics* | *Stage 3: Control & Optimization* |
|---|---|---|
| **Data Acquisition:**  | **Prognostics** Life Prediction  | **Control** Advisory:  |
| Remote monitoring of a fleet of assets | Unplanned to planned maintenance | Real-time safety decisions |
| **Anomaly Detection:**  | | **Optimization:**  |
| Identification of deviating assets | | Offline decisions |
| **Diagnostics:**  | | **Feedback & Learning**  |
| Root cause isolation | | Validation of maintenance cases |

# Advanced Maintenance Strategies

## Today

### Reactive

*Known: failure mode*
*Known: occurrence*

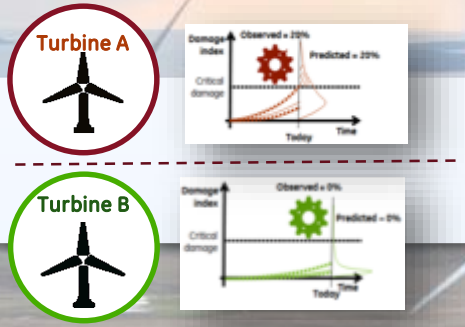
Gearbox diagnostic

Solving field issues once they have manifested in the field

## Tomorrow

### Predictive

*Known: failure mode*
*Unknown: occurrence*




Turbine specific Gearbox RCM

Predicting future occurrence of known problems before they occur in the field

### Proactive

*Unknown: failure mode*
*Unknown: occurrence*

Turbine wide RCM & Life Extension

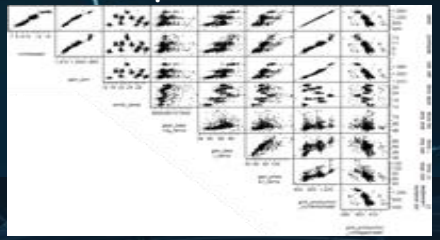
Detect new failure modes, identify future problems before they occur

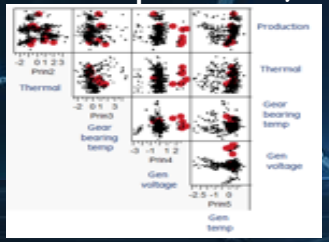
**Move from *Unplanned* to *Planned Maintenance & Extend Life***

# APM … Diagnostics

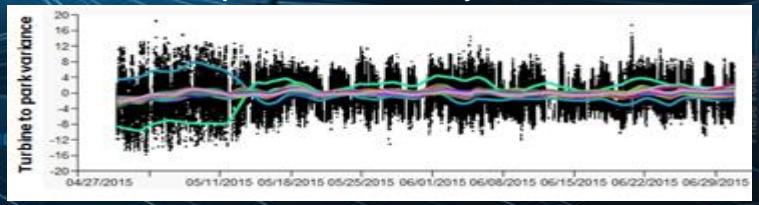
Ingest data into Cloud platform

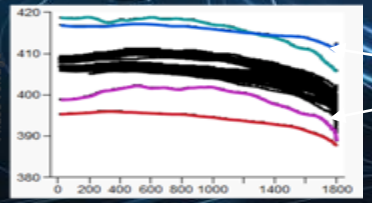
Learn data interdependencies … Principal components, data clustering






Determine comparative analytic … Time series, multivariate analysis

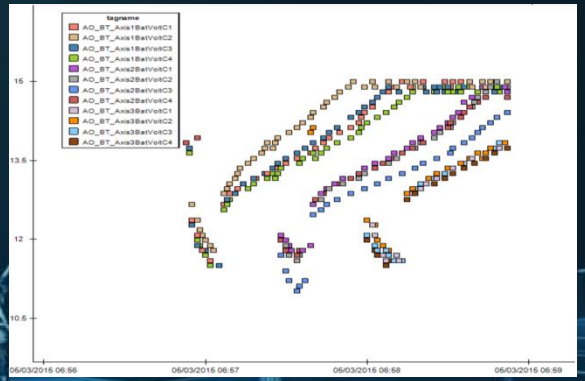


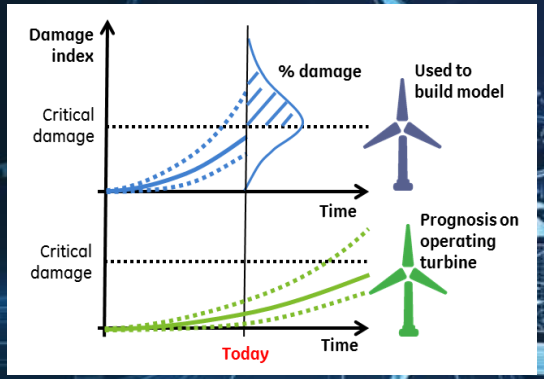



Affected Turbines

Deploy analytics for automated detection and notification

# APM … Prognostics




**Condition based**

Physics/Empirical damage accumulation
Risk-Based Inspections

**Reliability centered**

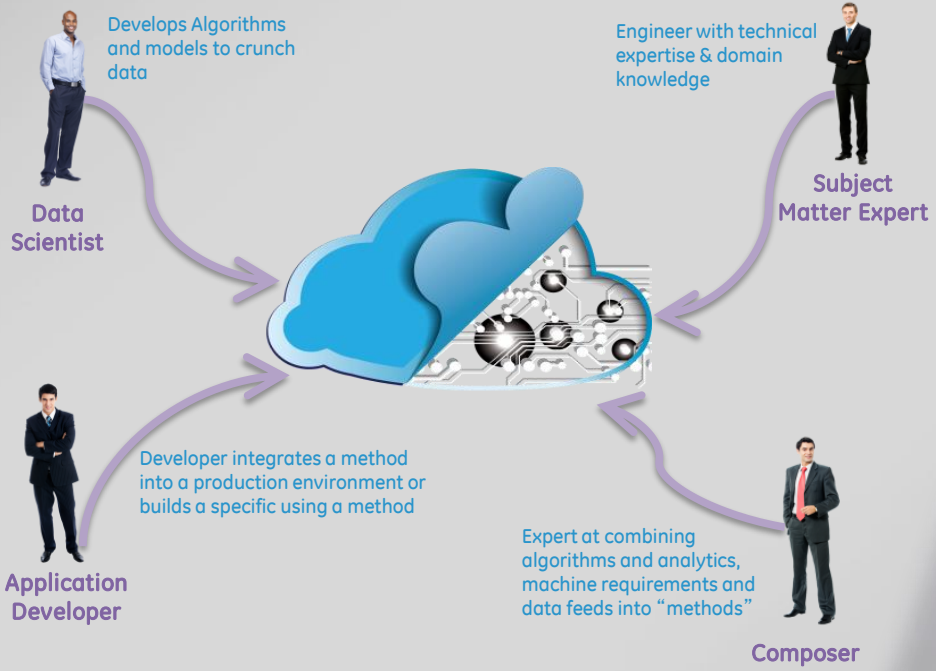
Intervals based on reliability bathtub curve
Useful for unobserved failures

**Operating costs benefits**

- Reduced O&M costs, lower unplanned to planned ratio
- Optimal part life usage, improved reliability, availability, maintainability & safety

# Analytics + Cloud + Domain Knowledge = Value

## Ecosystem for collaborative analytics development




- Make analytics scalable & repeatable
- Accessible & amenable: empower different users
- Speed up learning process, discover what we don't know
- Deploy analytics into applications & processes

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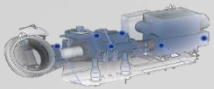
# Challenges



**Data:**

- Integrate large volume and variety of data to find new insights.
- Deal with missing data

**Analytics:**

- How to marry Data Driven and Domain based analytics
- How to create/maintain models over time and reuse them…

**Security:** Commercial clouds vs proprietary clouds

**Infrastructure:** Access and emerging Data-Driven Applications need support beyond Enabling Infrastructure


THANK YOU