WE
CAN DO
SO MUCH
TOGETHER

Railway Assets: a potential domain for big data analytics

Diego Galar

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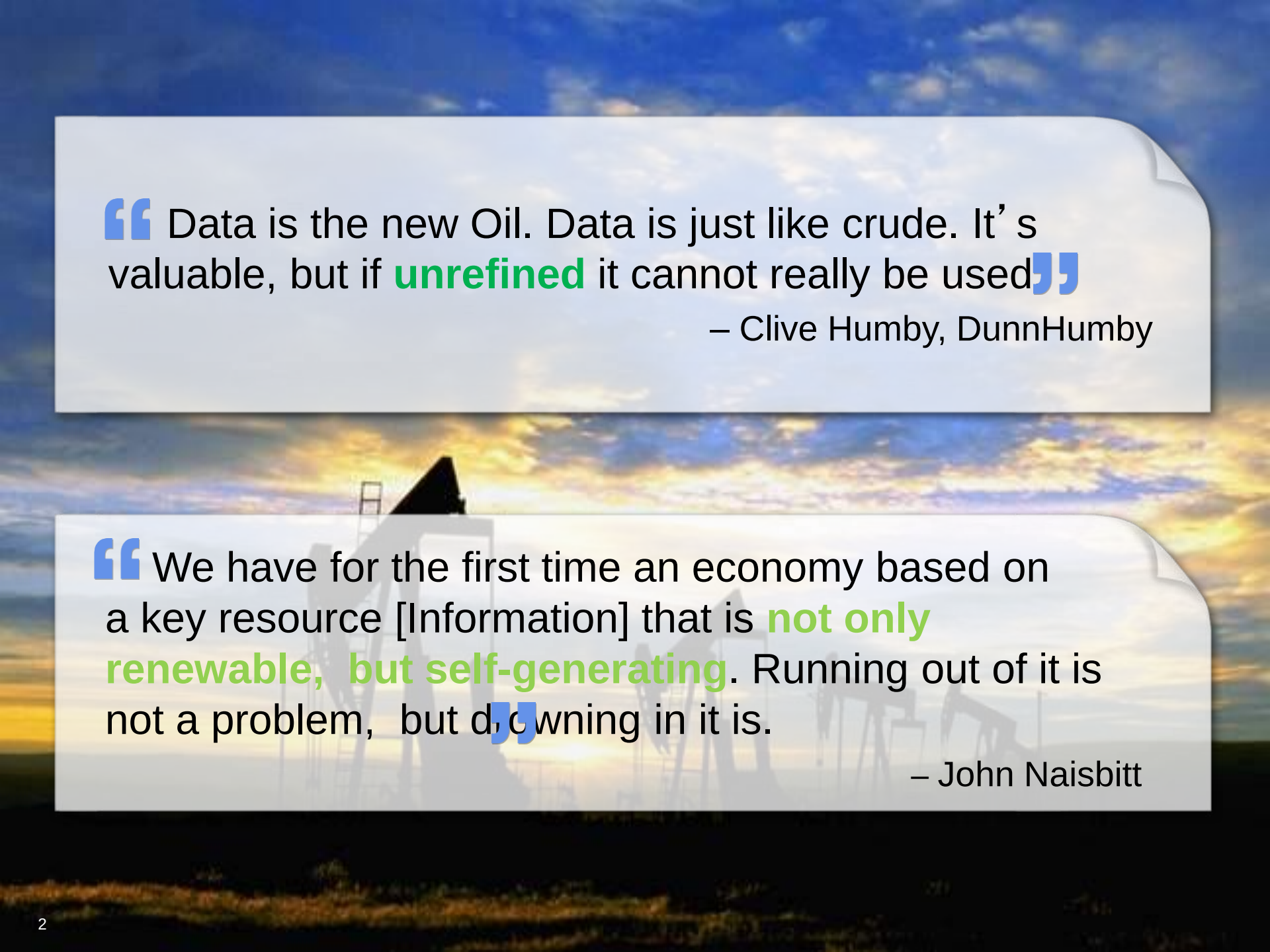
tecnalia Inspiring Business

JVTC LULEÅ RAILWAY RESEARCH CENTER
at Luleå University of Technology

DSS2016.EU

DSSINNOVA 2016


“Data is the new Oil. Data is just like crude. It’s valuable, but if unrefined it cannot really be used”
– Clive Humby, DunnHumby
“We have for the first time an economy based on a key resource [Information] that is not only renewable, but self-generating. Running out of it is not a problem, but drowning in it is.”
– John Naisbitt

Big Data ???

- 2010 = Structured, Homogeneous

- 2016 = Unstructured,Heterogeneos

Why Big Data in transportation?
How We Got Here?


10 .00 1563
SDG&E
00 000 000
M meter reads/month
B meter reads/day
Meter Reads
every 15 min.

Industrial and transportation data a late but powerful entry

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12+ TBs **of tweet data every day**

30 billion **RFID tags today (1.3B in 2005)**

4.6 billion **camera phones world wide**

100s of millions of GPS enabled **devices sold annually**

2+ billion **people on the Web by end 2011**

? TBs **of data every day**

25+ TBs **of log data every day**

76 million **smart meters in 2009… 200M by 2014**

An increasingly sensor-enabled and instrumented business environment generates HUGE volumes of data with MACHINE SPEED characteristics…

1 BILLION lines of code
EACH engine generating 10 TB every 30 minutes!

SMART infrastructure and Decision Support Systems for maintenancein railway: Fusion of IM and Operators info.....

Condition indicators from track side

Off line information provided by measurement vehicles

DATA REPOSITORIES And INFORMATION FUSION

Condition indicators from real time data collection like:
load, vibration, temperature

On line information

On board data collection

Vehicle as moving sensor

GPS

Track information

SMART bearings as a sensor for condition monitoring

Error detection of bearing

Detect wheel damage

Operation planning

Position of the car

Error detection in boggie

Load in the car

Maintenance planning

LKAB

Detect rail damage

TRAFIKVERKET

Continuous scanning of rail

Way side monitoring: enablers for big data services

Vibration, acoustic And strain gages
- Weight
- Rail forces
- Wheel damages
- Bearing damages
- Hunting, speed

Track geometry
EMC
Interoperability

Scale of Industrial Internet (of Things IIoT)

Social media versus electric generating power source

2012 Twitter Usage

80 Gigabytes per day

enabling social connections

vs.

Gas Turbine Compressor Blade Monitoring potential*

588 Gigabytes per day

enabling capital asset productivity

Data volume potential is 7x greater from a gas turbine than current Twitter usage

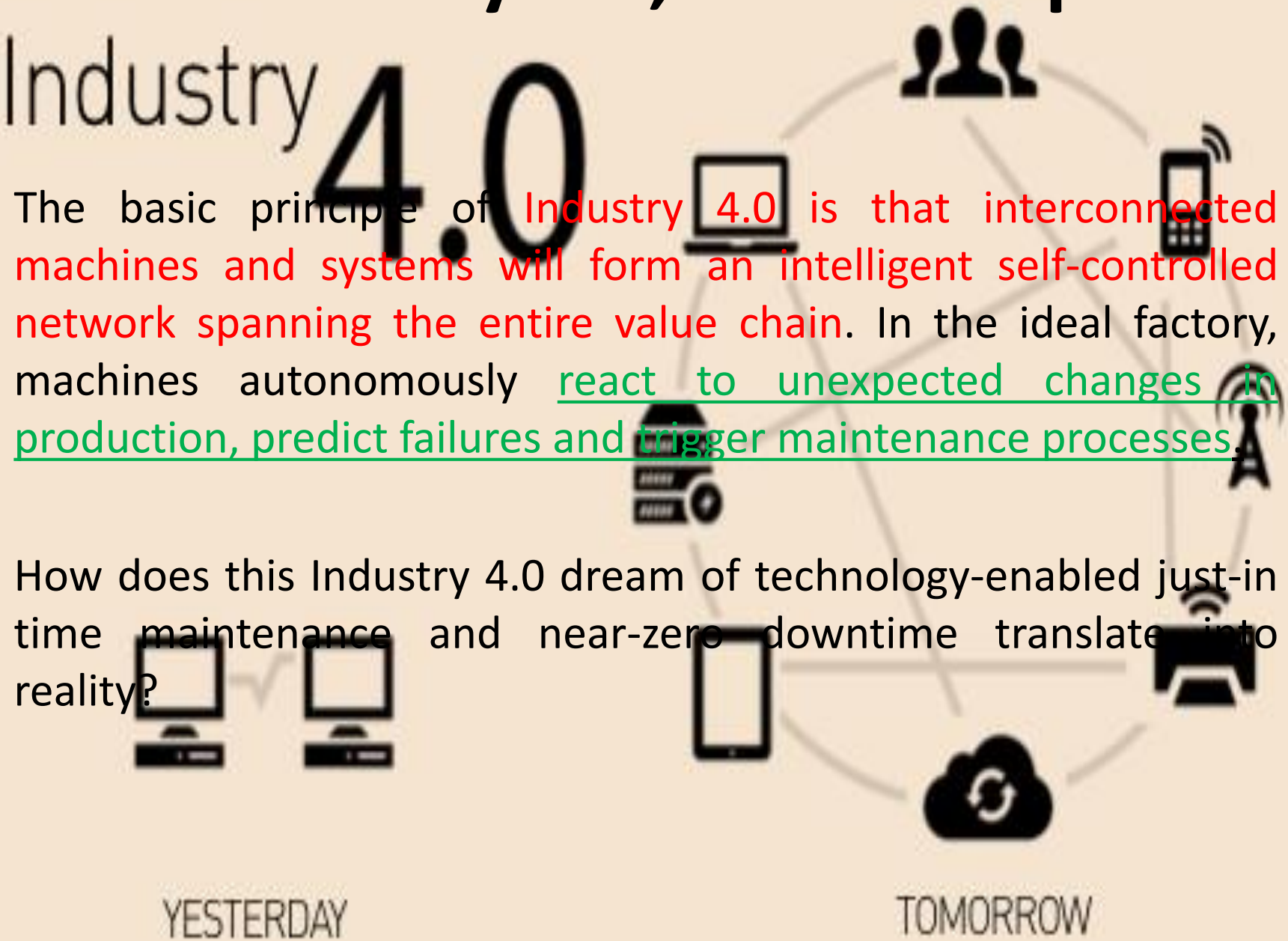
imagination at work

* Note: Assumes operational gas turbines (generating units only) >50MW are equipped with Blade Health Monitoring capabilities

Big Data is mostly machine generated data

Volume | Velocity | Variety | Variability

Industry 4.0, the concept



The basic principle of Industry 4.0 is that interconnected machines and systems will form an intelligent self-controlled network spanning the entire value chain. In the ideal factory, machines autonomously react to unexpected changes in production, predict failures and trigger maintenance processes.

How does this Industry 4.0 dream of technology-enabled just-in time maintenance and near-zero downtime translate into reality?

The idea of Maintenance 4.0 and the connection with IoT

The IBM idea of Internet of things for maintenance

The IBM idea of Internet of things for maintenance

step two

the Internet of Things

complete a process flow with the new streaming data

The IBM idea of Internet of things for maintenance

The need for analytics and sensemaking Big Data

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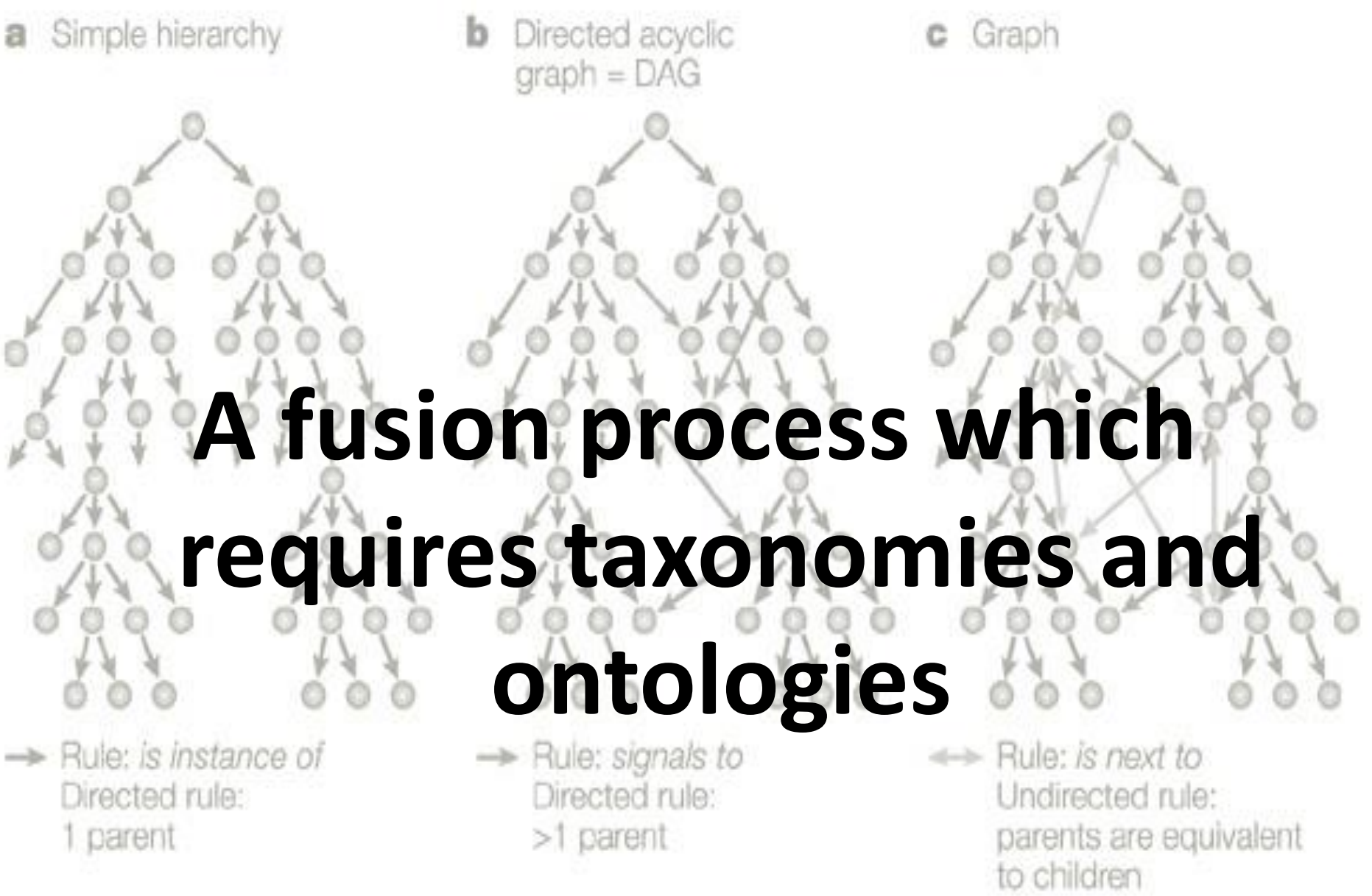
Data must be prepared…



A fusion process which requires taxonomies and ontologies

Taxonomy vs. Ontology

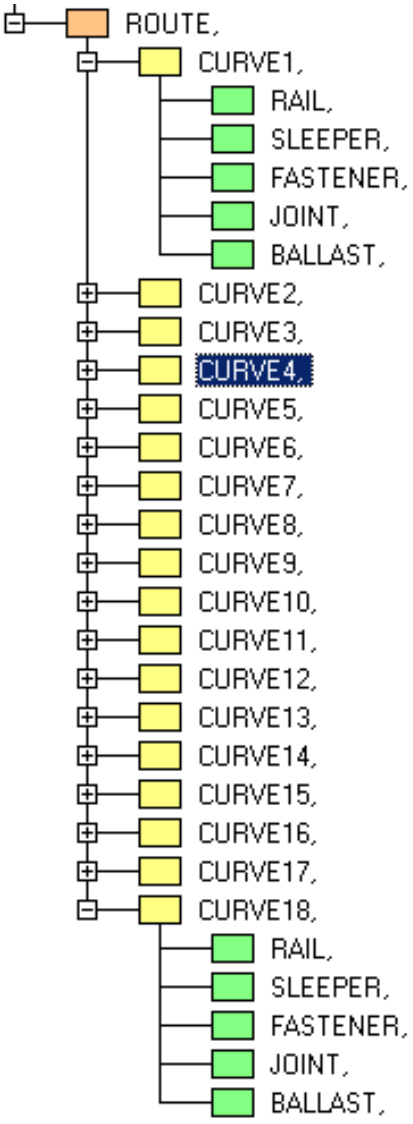
Taxonomies:

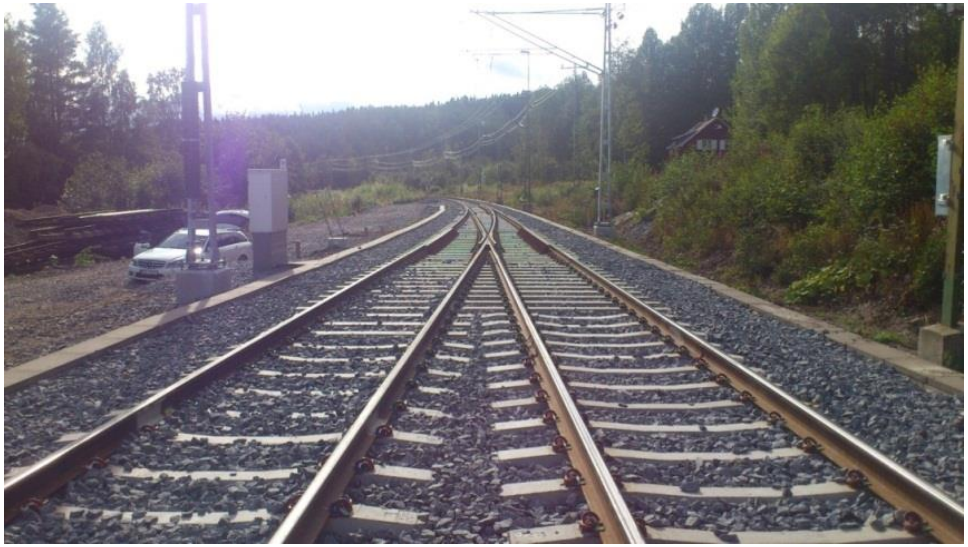
- Usually are a single, hierarchical classification within a subject
- Primarily focused on "is-a" relationships between classes
- Limited in inferencing potential due to lack of relational expressiveness.

Ontologies:

- Subsume taxonomies.
- Include attributes with cardinality and restricted values.
- Unlimited relationships between entities.
- Superior inferencing support due to relational expressiveness.

Track model





- Failure data
- PM data
- Deployment locations
- Logistic parameter
- Cost data

Wagon model

- WAGON, Freight wagon
  - WHEELSET,
    - AXLE,
    - MONO-BLOCK WHEEL,
  - AXLE BOX,
    - AXLE BOX HOUSING,
    - BEARINGS,
    - SEALINGS,
  - PRIMARY SUSPENSION,
    - COIL SPRINGS,
    - BRACKETS, DAMPERS LENOI
    - SPRING CAPS,
    - DAMPER,
    - RADIAL ARM,
  - BOGIE FRAME,
    - LOWER BOLSTER,
    - AXLE GUIDES,
    - BOGIE FRAME BUSHINGS,
  - DISC BRAKE,
    - BUSHINGS AND BOLTS,
    - LEVERS, RODS AND CONNECTIONS,
    - BRAKE PADS,
    - SLACK ADJUSTER,
    - BRAKE BEAM -TRIANGLE,
    - BROMSSKIVOR MM.,
    - BRAKE UNIT,
    - DYRARE AXLAR,
    - INBYGGNAD UPPHÄNGNING,
  - PNEUMATIC BRAKE,
    - DISTRIBUTOR (TRIPLE-) VALVE,
    - PIPES, TANKS,
    - CHANGE OVER DEVICES,
    - LOAD PROPORTIONAL BRAKING,
  - DRAW GEAR,
    - DRAW HOOK,
    - DRAWBAR,
    - SPRING ELEMENTS,
  - COUPLING,
  - BUFFING GEAR,
    - BUFFER PLATE AND HOUSING,
    - BUFFER SPRING ELEMENTS,
  - UNDERFRAME,
  - SUPERSTRUCTURE,
  - SPECIAL MECHANISMS,
  - HANDLES AND STEPS,
  - PAINTING AND LETTERING,
  - FASTBROMSNINGSSKYDD,
  - KES CONTROL SYSTEM,

SUSTRAIL wagon

- WAGON, Freight wagon
  - WHEELSET,
    - AXLE,
    - MONO-BLOCK WHEEL,
  - AXLE BOX,
    - AXLE BOX HOUSING,
    - BEARINGS,
    - SEALINGS,
  - PRIMARY SUSPENSION,
    - COIL SPRINGS,
    - BRACKETS, DAMPERS LENOIR,
    - SPRING CAPS,
  - BOGIE FRAME,
    - LOWER BOLSTER,
    - AXLE GUIDES,
    - BOGIE FRAME BUSHINGS,
  - MECHANICAL BRAKE GEAR,
    - BUSHINGS AND BOLTS,
    - LEVERS, RODS AND CONNECTIONS,
    - BRAKE BLOCK SHOES,
    - BRAKE BLOCKS
    - SLACK ADJUSTER,
    - BRAKE BEAM -TRIANGLE,
  - PNEUMATIC BRAKE,
    - DISTRIBUTOR (TRIPLE-) VALVE,
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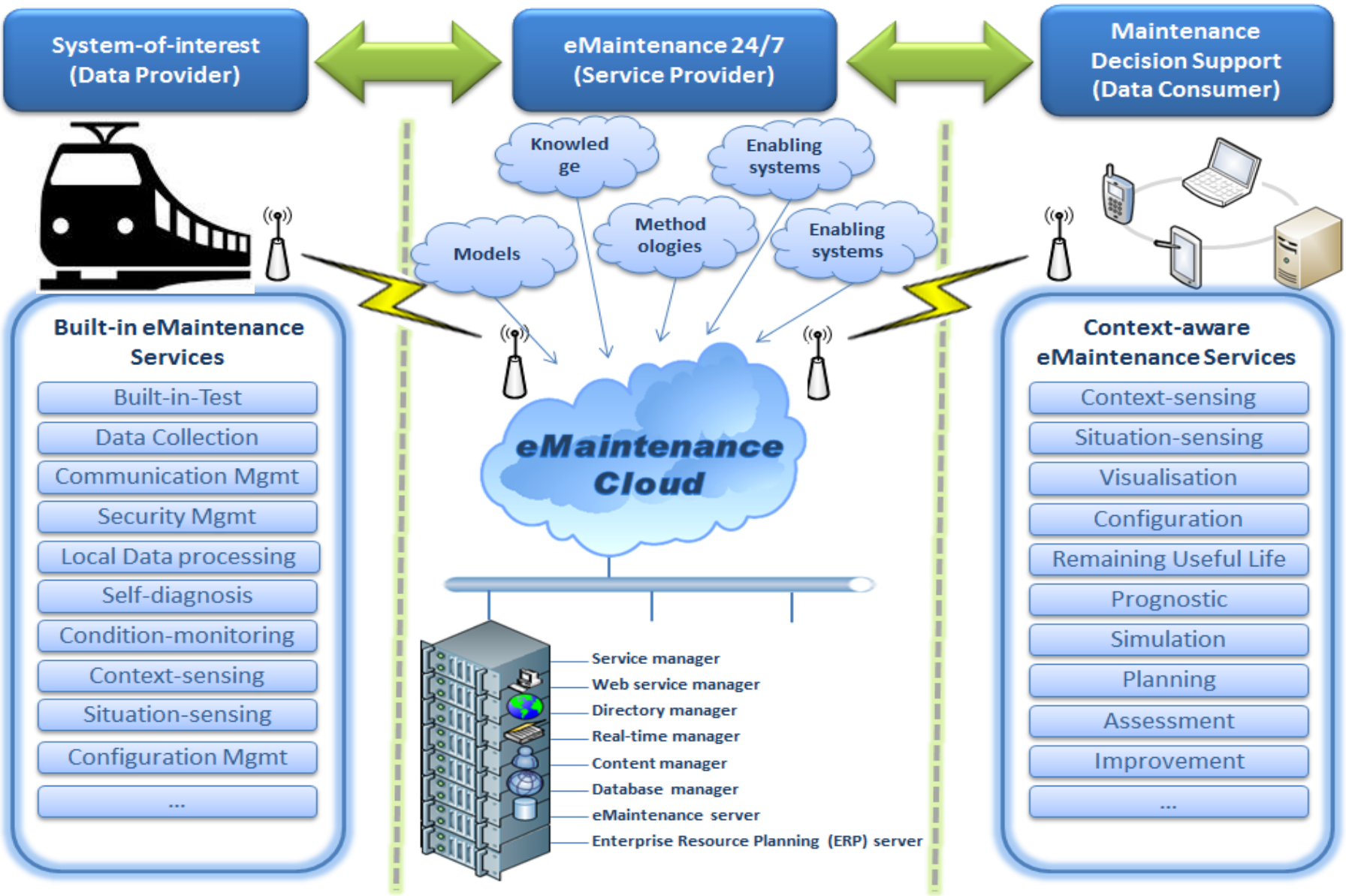
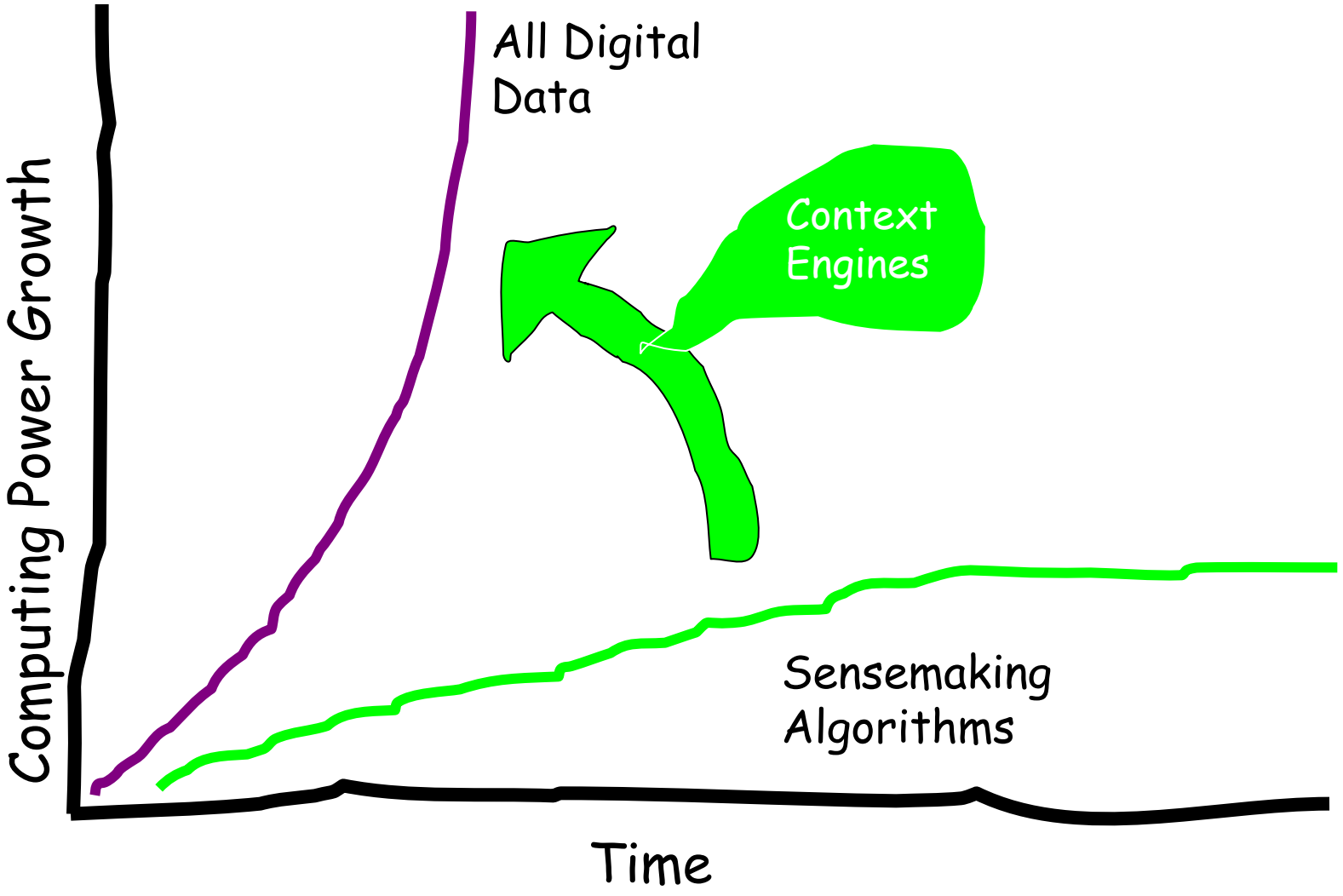
  - HANDLES AND STEPS,
  - PAINTING AND LETTERING,

Benchmark wagon


System-of-interest (Data Provider)
eMaintenance 24/7 (Service Provider)
Maintenance Decision Support (Data Consumer)
Knowled ge
Enabling systems
Models
Method ologies
Enabling systems
eMaintenance Cloud
Built-in eMaintenance Services
Built-in-Test
Data Collection
Communication Mgmt
Security Mgmt
Local Data processing
Self-diagnosis
Condition-monitoring
Context-sensing
Situation-sensing
Configuration Mgmt
...
Service manager
Web service manager
Directory manager
Real-time manager
Content manager
Database manager
eMaintenance server
Enterprise Resource Planning (ERP) server
Context-aware eMaintenance Services
Context-sensing
Situation-sensing
Visualisation
Configuration
Remaining Useful Life
Prognostic
Simulation
Planning
Assessment
Improvement
...

The need of the context for sensemaking



Context-aware & CBM based Decision Support Solutions for maintenance actions

Condition Data

Maintenance Data

Business Data

Information models

Knowledge models

Context models

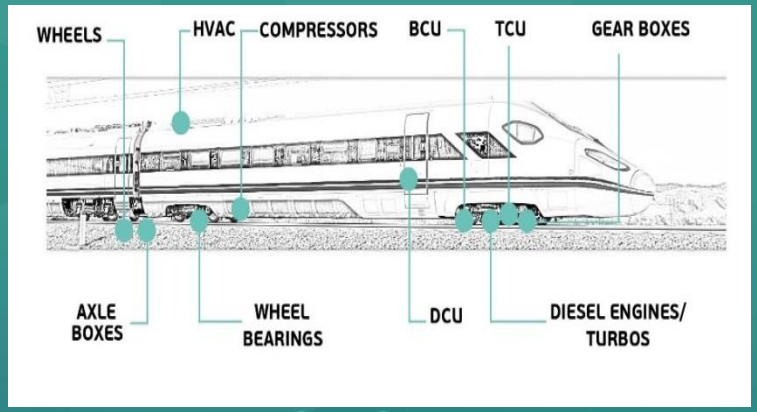
Data Fusion & Integration

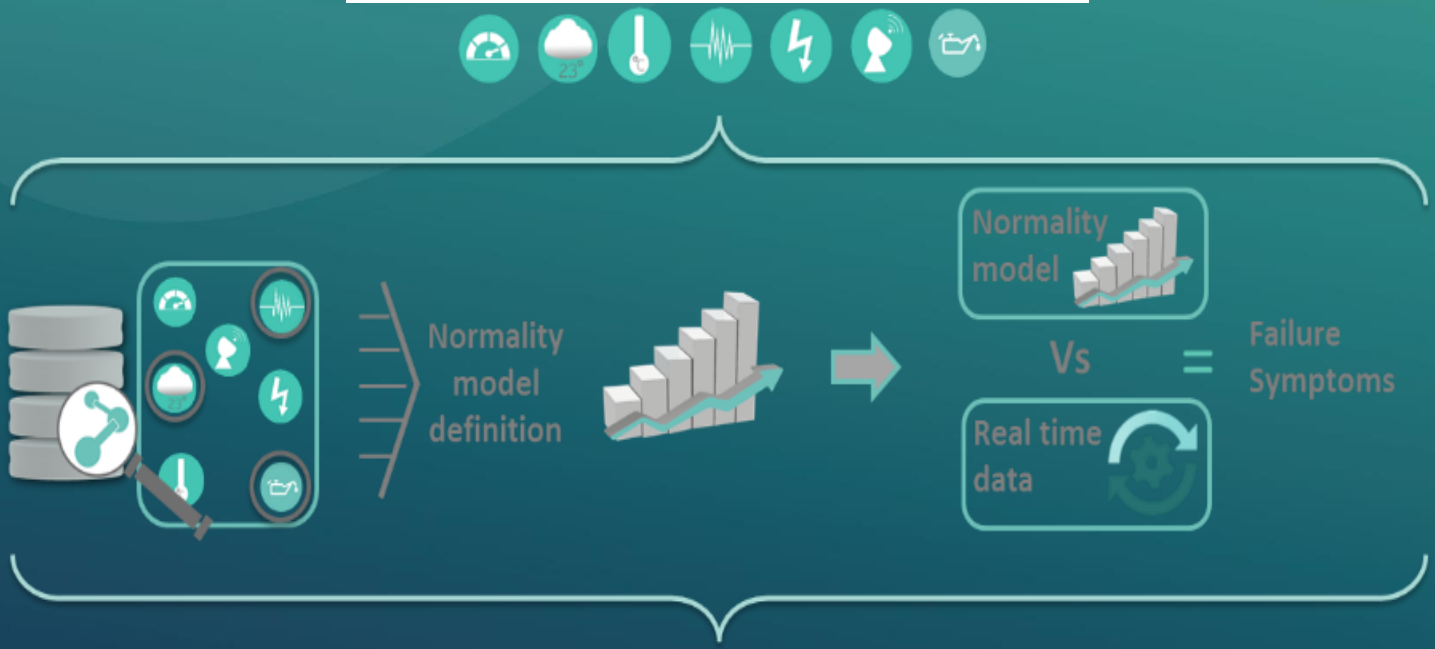
Big Data Modelling & Analysis

Context sensing & adaptation

Link, Think & Reconfigure


Success
Stories





DATA FORECASTING

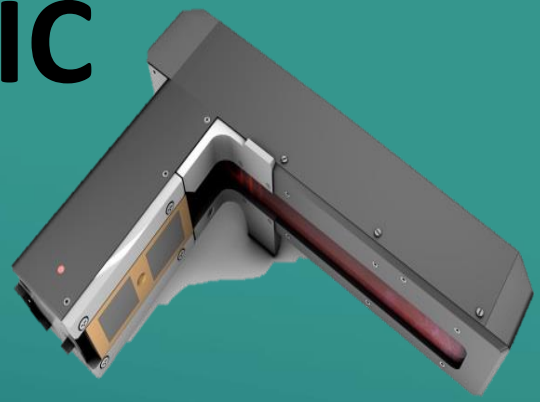
GENERATION OF KNOWLEDGE

diagnostic

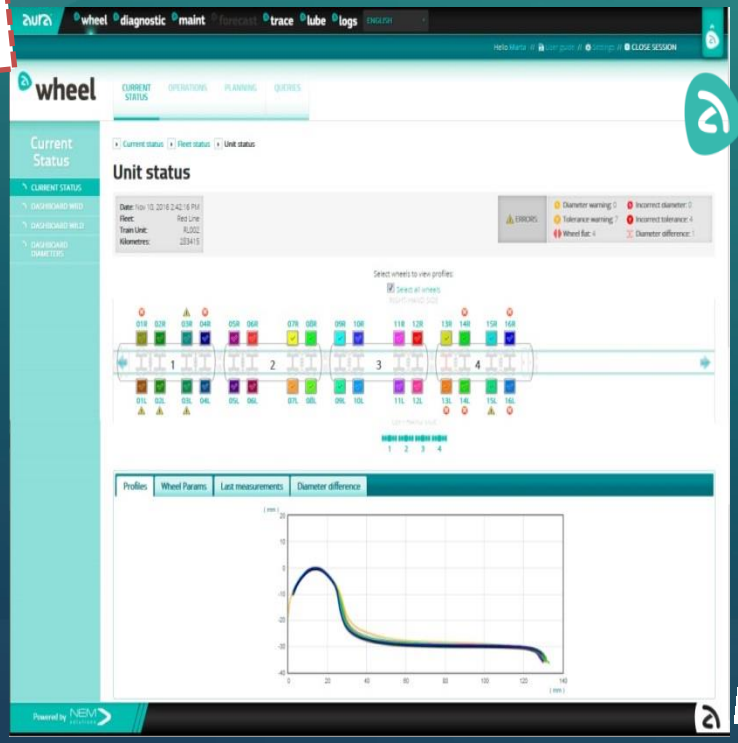
1 2 3 4 5 6

NEM solutions

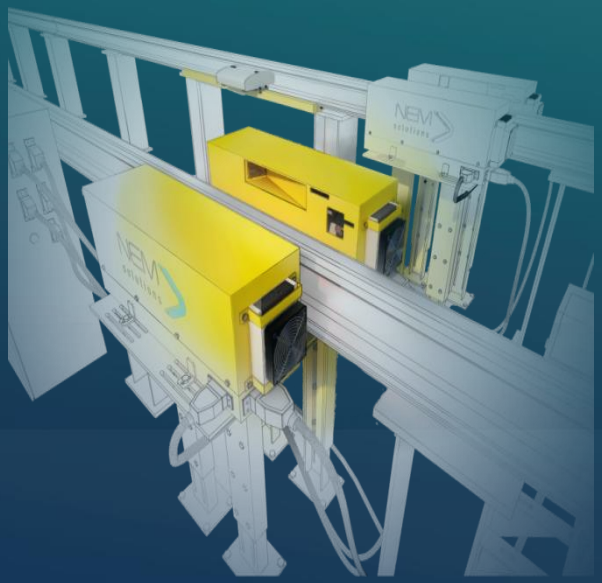
A.U.R.A DIAGNOSTIC



All depot technologies integrated into
ONE STOP SOLUTION



wheel



solutions

ePilot

To achieve a more effective way to conduct railway operation and maintenance

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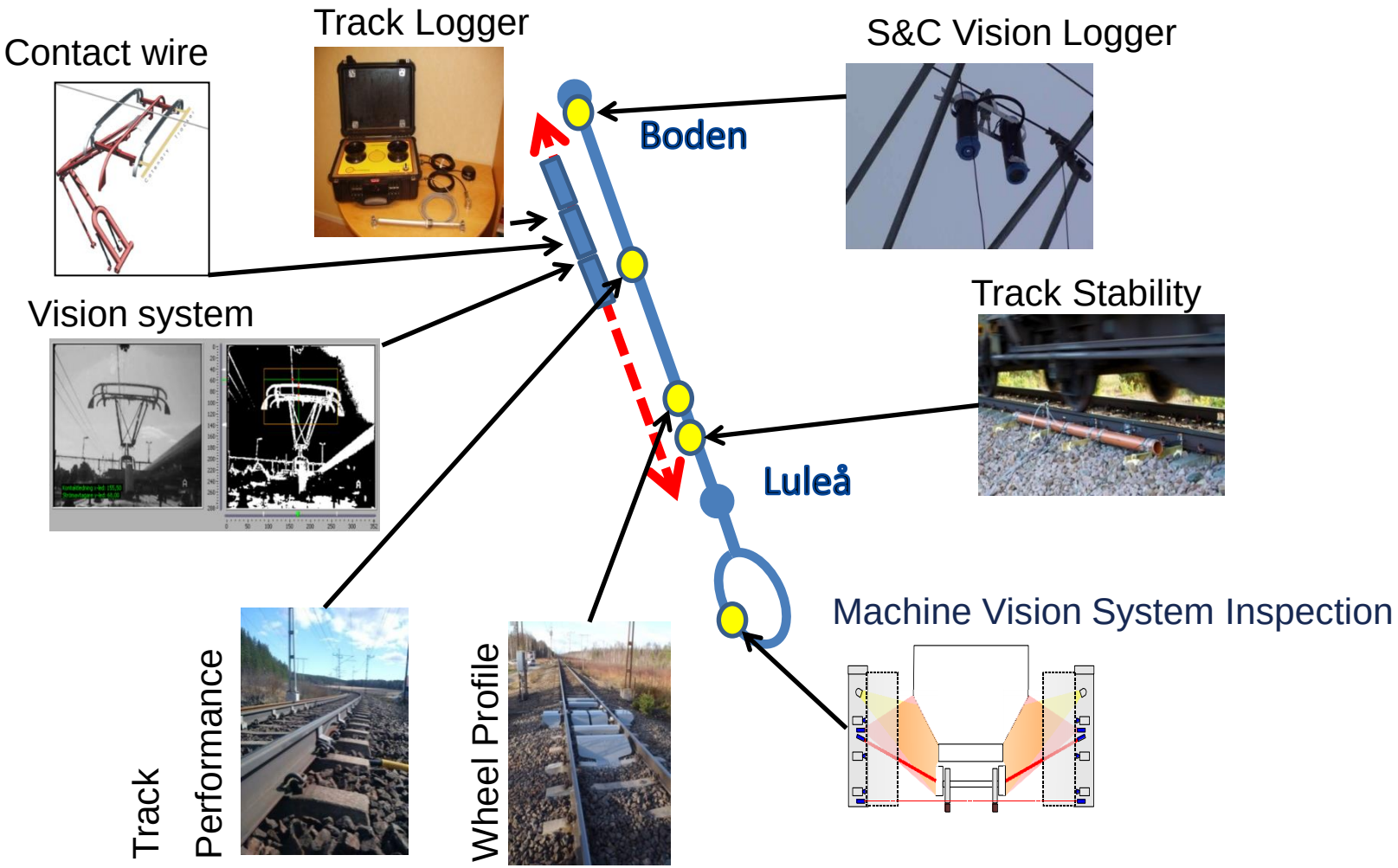
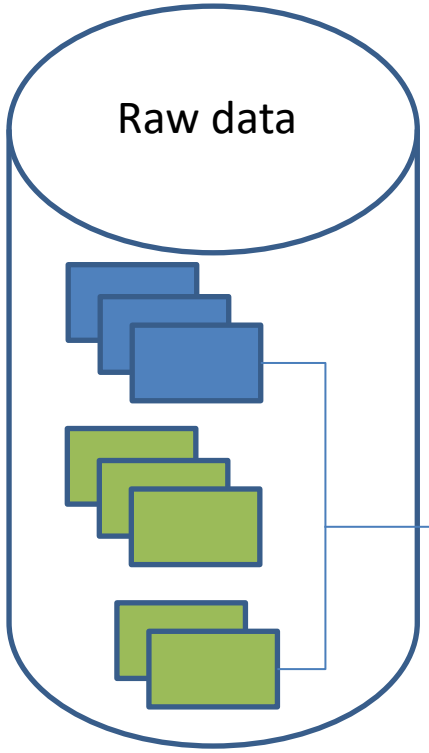
Measurement systems



Railway Research Data Cloud at eMaintenanceLAB

Data providers and data owners

- TRV
- JBV
- Measurement and other data from contractors
- LKAB
- Etc.



Id

Data system for information logistic:

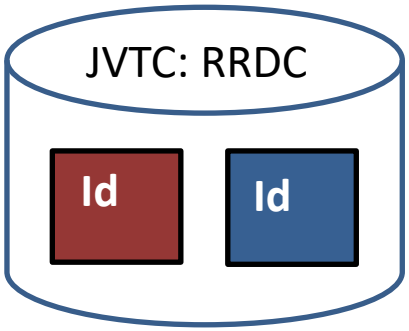
- Data quality check and cleaning, etc..
- Connecting data sets ,from different data providers, related to the same asset with the same **Id**.
  - **Rolling stock** and its components
  - **Infrastructure** and its components
- Relate data to other parameters like contextual information

Project Data request → JVTC Management: Grants access to the data?

Manual

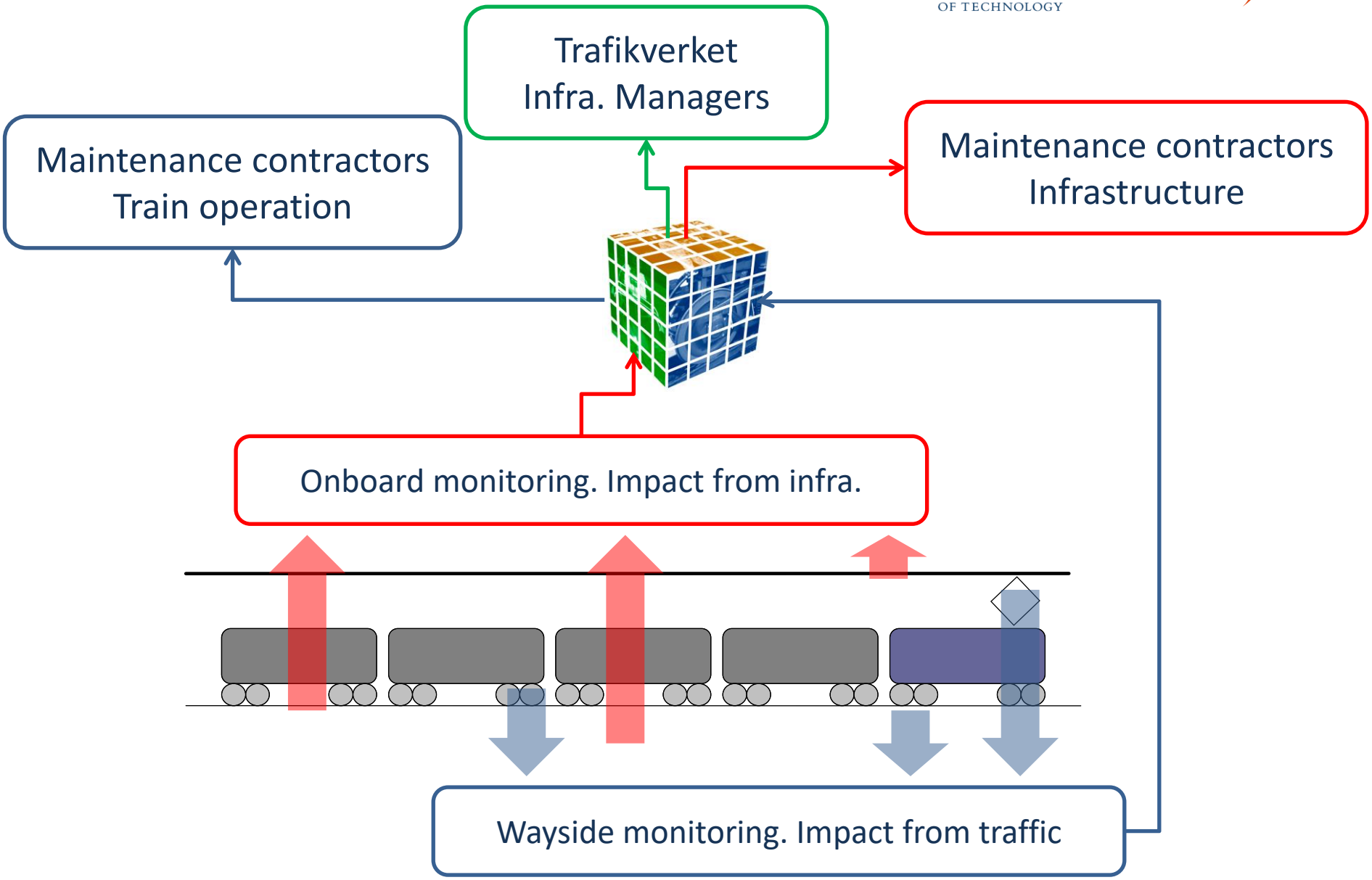
Automatic

New algorithms for analysis



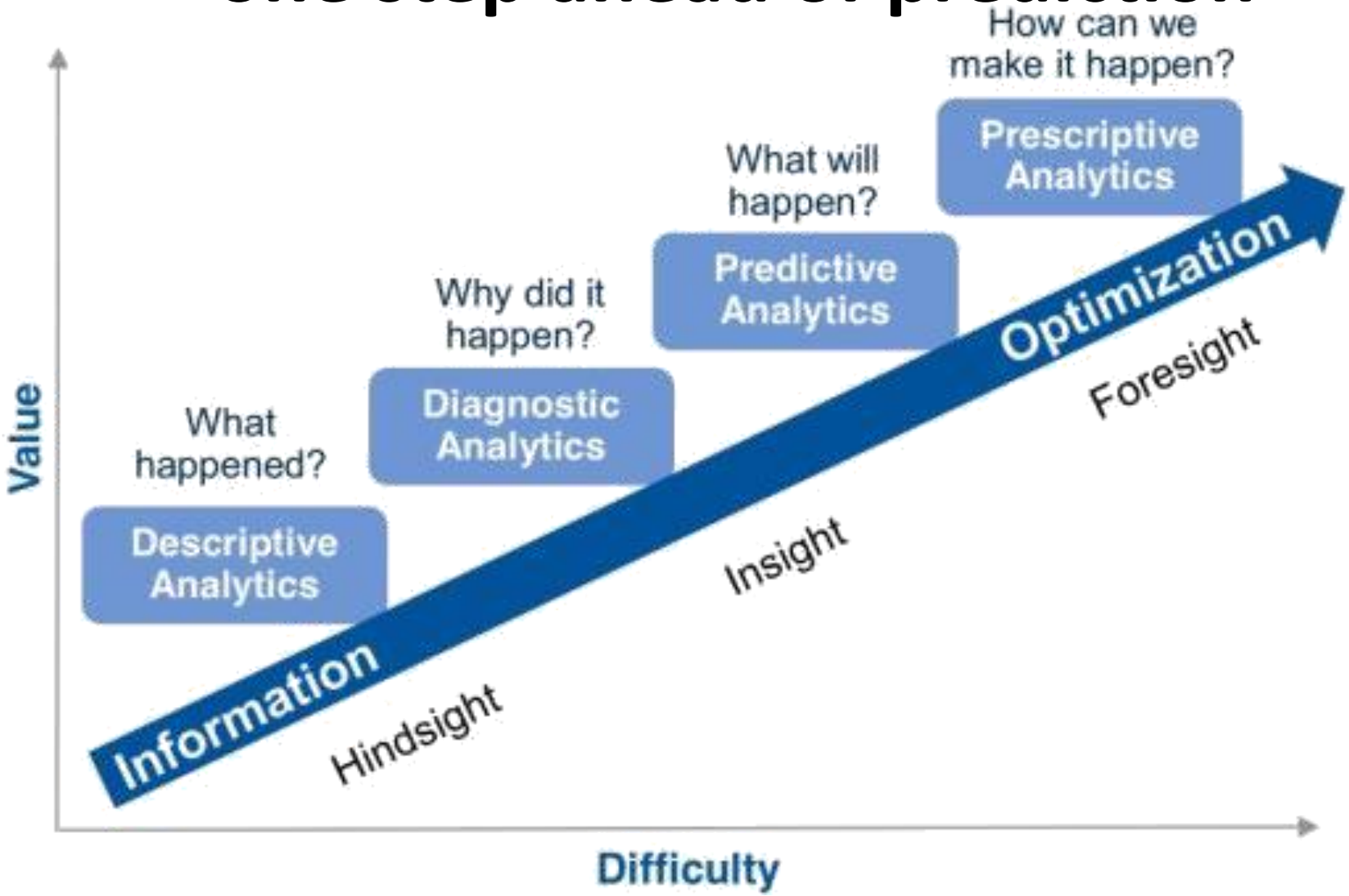
Generates a new set of sorted data which will grant new possibilities for research and innovation

JVTC LULEÅ RAILWAY RESEARCH CENTER at Luleå University of Technology

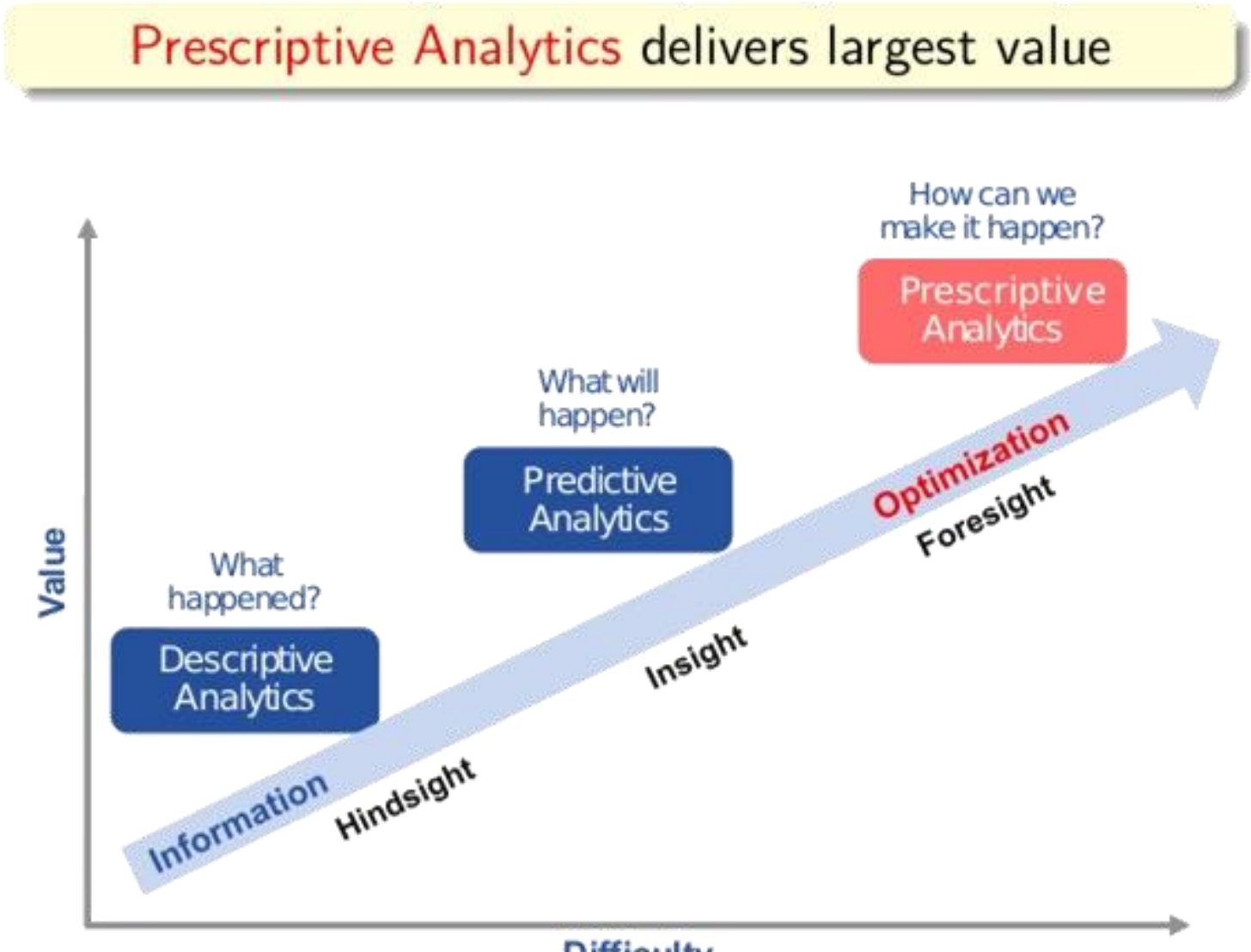

Trafikverket
Infra. Managers
Maintenance contractors
Train operation
Maintenance contractors
Infrastructure
Onboard monitoring. Impact from infra.
Wayside monitoring. Impact from traffic

What do we expect from the analytics?

Prescriptive maintenance, one step ahead of prediction



Let us perform O&M according to our wishes and do not be passive watchers



CBM++

- Sensing
- Measurement
- Diagnostics of Faults-Failures
- Prognostics
- Context aware RUL
- Decision Support Models

SCADA Supervisory Control And Data Acquisition
ERP Enterprise Resource Planning
CMMS Computer Maintenance Management Software

Data Collection

Contactor Raw Data

Signal Processing

Transformed Data

Feature Extraction

Condition Indicators

DATA FUSION

Fault Classification

Diagnostic Modellting

Failure Detection and Evaluation

Sensors

Managerial data

Historical data

CMMS ERP SCADA

DATA FUSION

Required functions

Work Order

Contractual Condition Evaluation

Train/Track Contractor

Decision support system

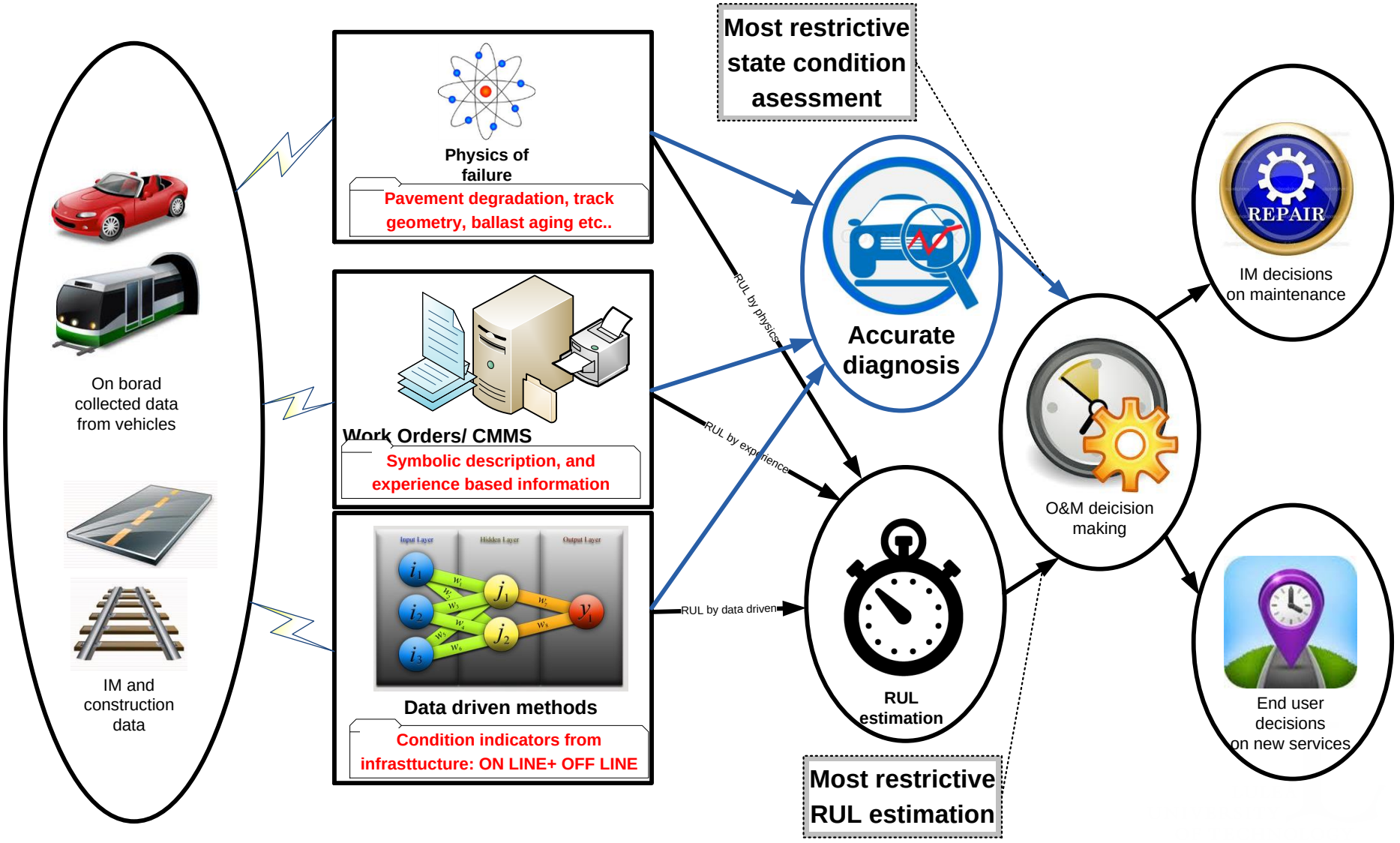
Remaining useful life Reliability prediction Risk assessment

DATA FUSION

Prognostic Modelling

Track/Train Maintenance Contractors

Prognosis, enabler for new business models



Data science… Narrow vision and mistakes

Value when analyzing data at mass scale

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- As observations increase in frequency
  - Each individual observation is worth less
  - …as the set of all observations becomes more valuable

- *Big Data* is the accumulation and analytical processes that uses this data for business value

Value when analyzing data at mass scale

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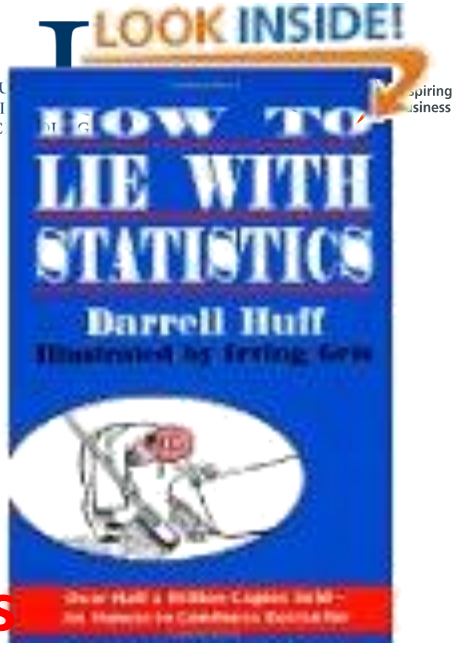
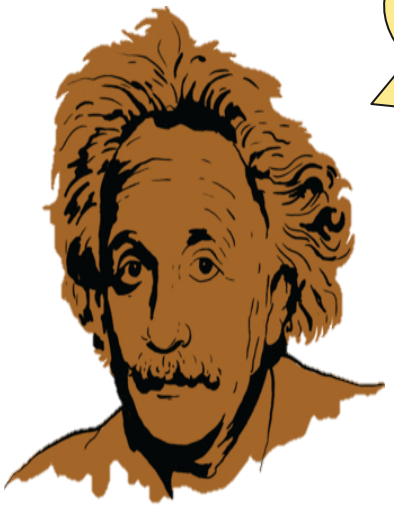
Let us be careful bigger = smarter?



- Yes!
  - tolerate errors
  - **discover the long tail and corner cases**
  - machine learning works much better
- But!
  - more data, more error (e.g., semantic heterogeneity)
  - with enough data you can prove anything
  - still need humans to ask right questions, lack of analytics

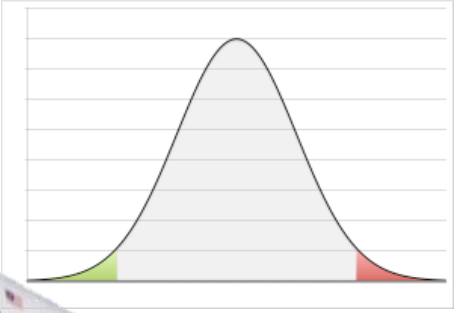
But Remember…



Not everything that can be counted… counts,
Not everything that counts… can be counted

The only thing that interferes with my ability to learn is…

My Education



AND…even with all this data

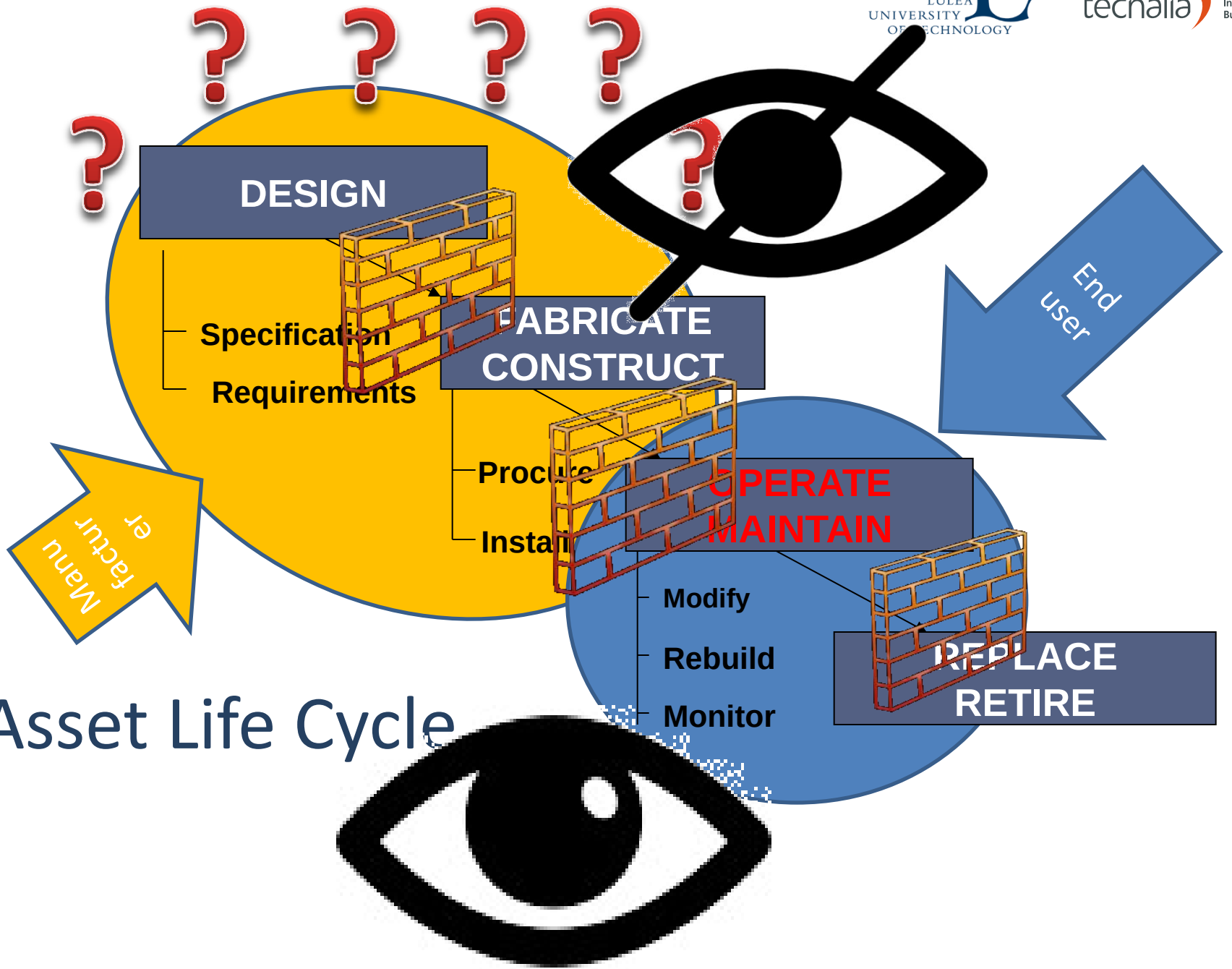
We can't find many answers

Black Swan Losses

- Loss Distribution
  - Tail events are rare – very little data
  - Typically strong model assumptions

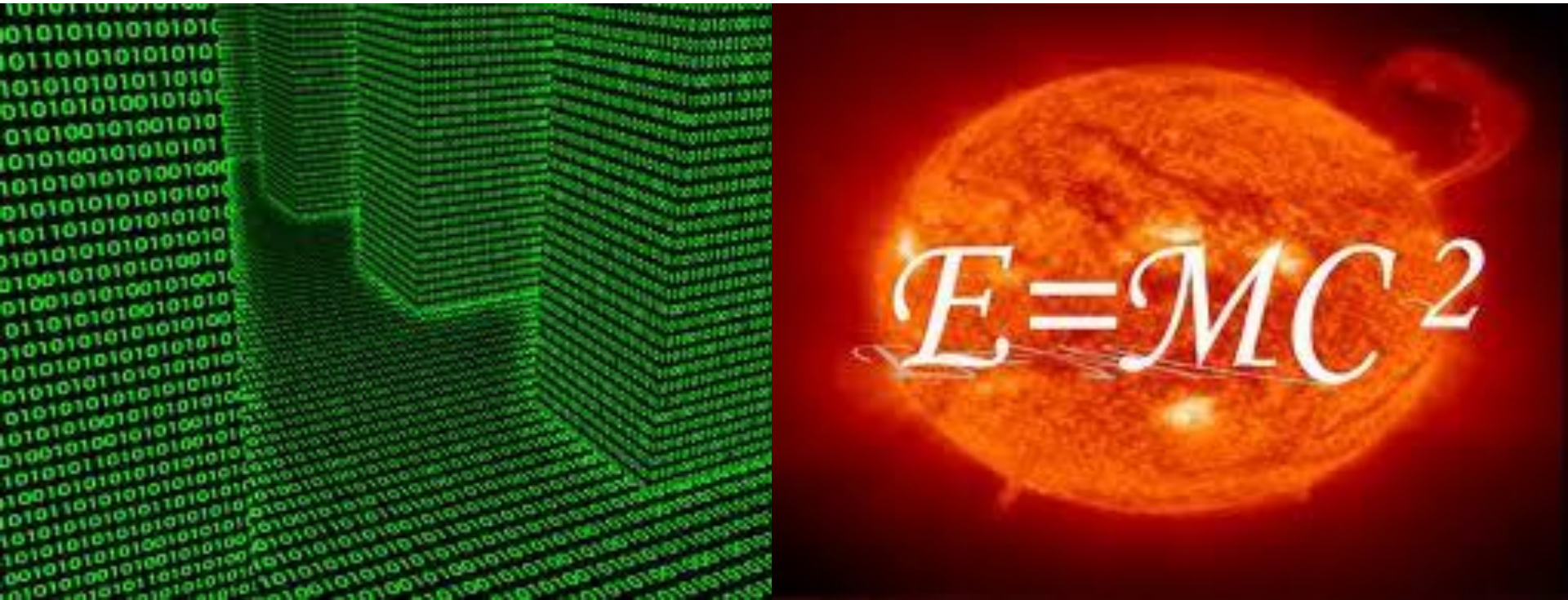

Why

Asset Life Cycle

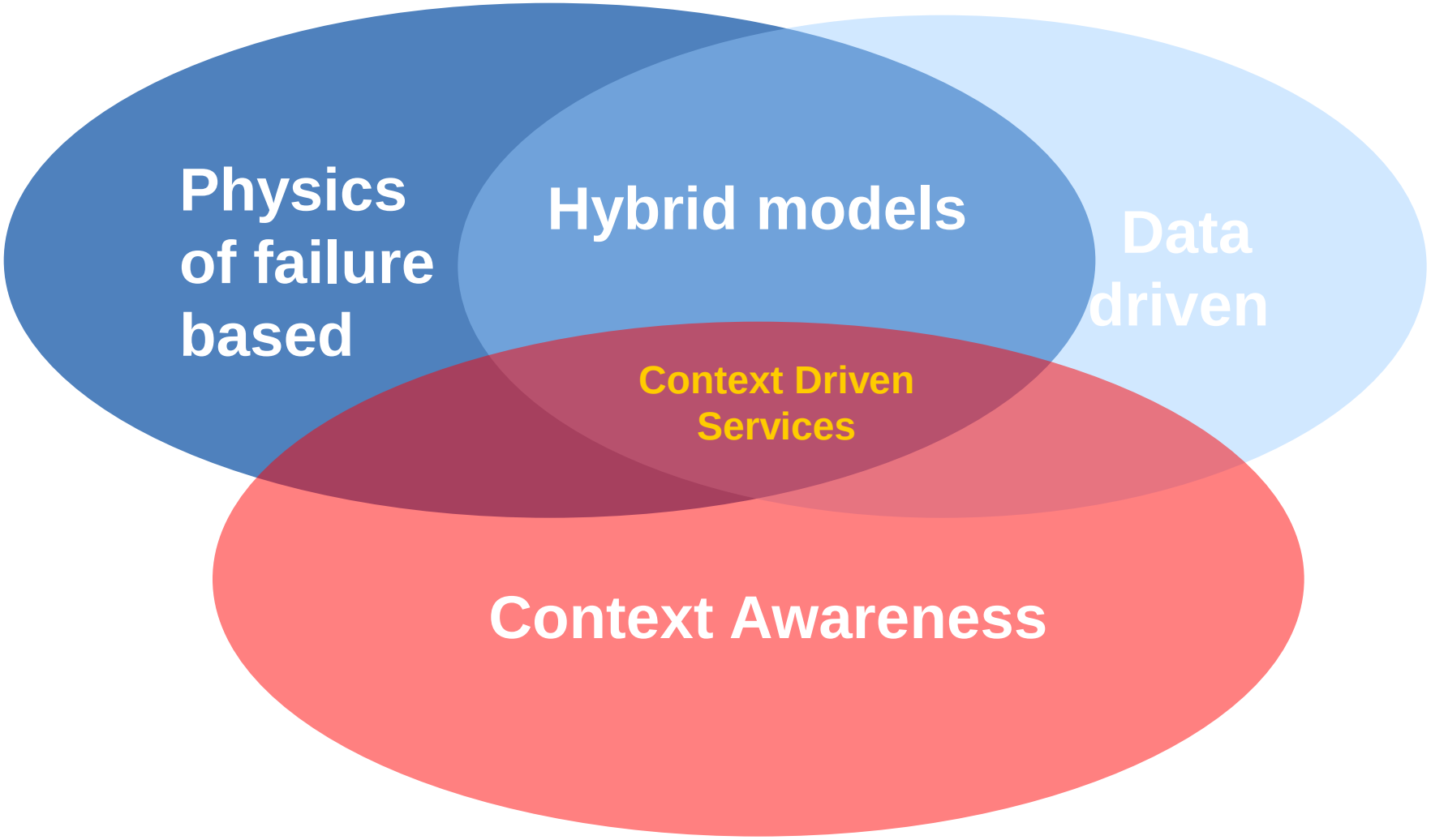


Data driven or model based?

Data-Based or Physics-Based Models? – That is the question!



Hybrid & Context Driven Services



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Synthetic Data Physics of failure

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Concluding remarks

- Transportation data is becoming one of the largest domain for big data analytics and target of data science
- Massive observations of certain processes do not assure the quality of deliveries
- Lack of definition in the services expected by customers

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