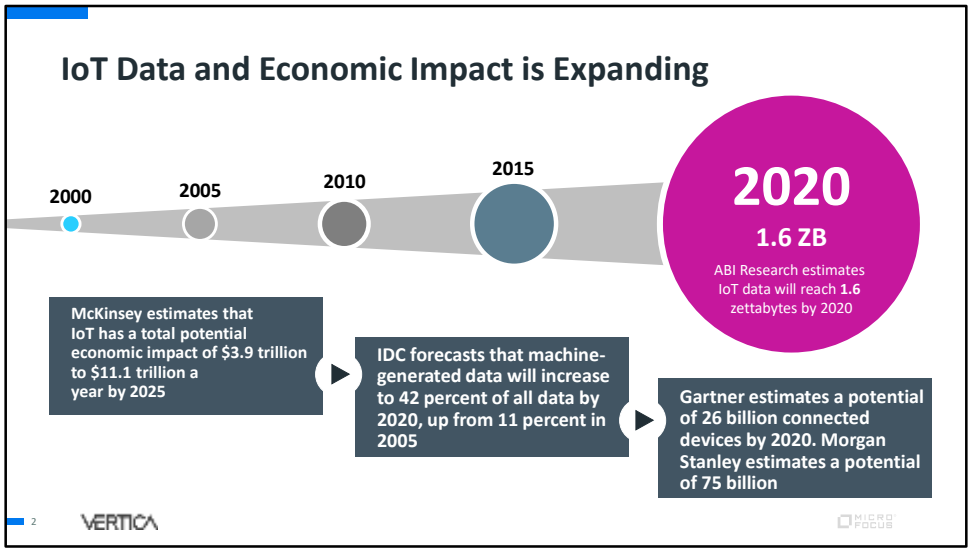
Business Value is all forms of value that determine the health and well-being of the organization over time. It must be, has to be in your tool kit as the most important, critical component of IoT.

There are 5 ways IoT delivers value:
Increase revenue
Decrease cost (often by decreasing latency)
Improve productivity (often by improving interoperability)
Differentiate the organization
Improve customer satisfaction

How do we make sensors, IIoT, a fascinating topic in itself – how can we make it 'shiny' for the business who is increasingly demanding 'revenue and profit' from the expense of sensors, big data, integration, and interoperability costs? Gartner reported last year that just 0.5% of all the data in data lakes was returning value. Ooops. That's not helping our story.

I am going to tell you a few stories, all of which happened over the past 4 years. The stories, I think, are applicable to IoT, IIoT…. aerospace, asset management, consumer manufacturing, shipping, oil and gas, etc. Look for the patterns.



http://www.mckinsey.com/insights/business_technology/The_Internet_of_Things_The_value_of_digitizing_the_physical_world
https://www.gartner.com/doc/2625419/forecast-internet-things-worldwide-
http://www.businessinsider.com/75-billion-devices-will-be-connected-to-the-internet-by-2020-2013-10
"**The Digital Universe in 2020: Big Data, Bigger Digital Shadows, and Biggest Growth in the Far East—United States**," IDC, December 2012

What is the Internet of Things?

"The Internet of Things is the network of physical objects that contains embedded technology to communicate and sense or interact with the objects' internal state or the external environment…

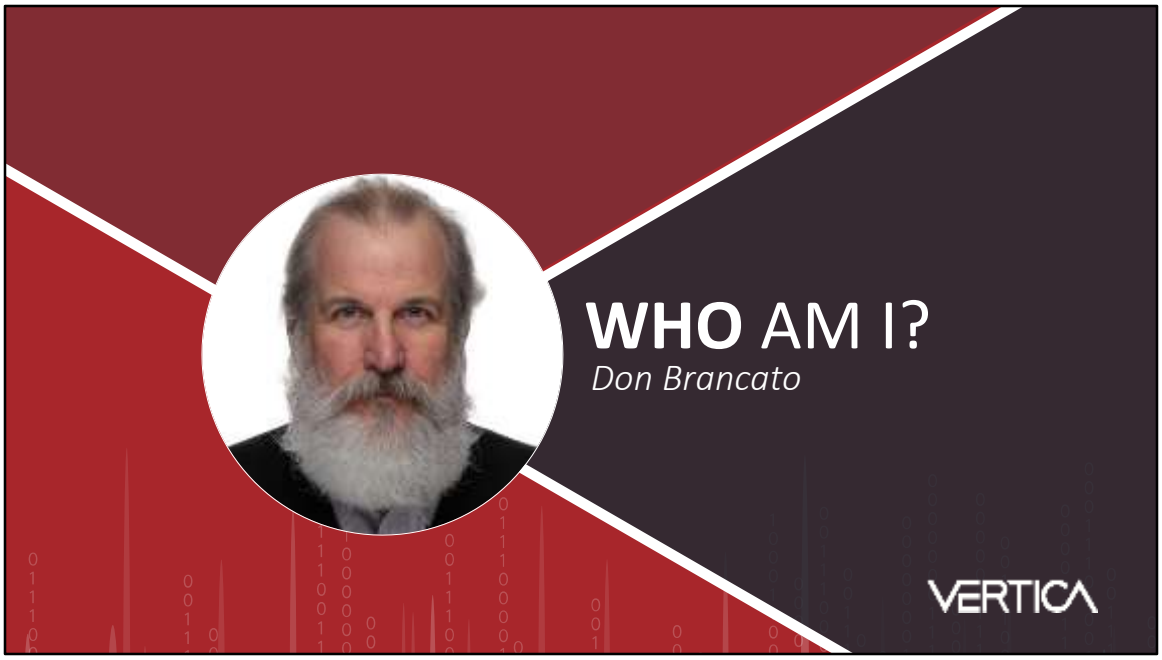
- *with capabilities increasingly seen as independent, **autonomous**.*
- *with an increasing demand for interoperability with other 'things,' often heterogeneous in nature."*

Consumer "Things" - IoT

Personal sensing with remote monitoring and control – Fitbit, Nest, smart refrigerators, etc.

Industrial "Things" (IIoT)

From individual sensors to entire power plants – the world of Operational Technology (OT)



WHO AM I?

I am a bigData and knowledge domain engineer who helps build smart solutions globally - Smart Cities, Safe Cities, Smart Cars and Factories, and Smart Space projects are a few of what I help support.

Standards contributor (Open Platform 3.0, Business Data Lake, IoT, Open Message Interface, Open Data Format, and Data Element Framework); Industrial Internet Consortium (Vocabulary) and its parent org, the OMG.

25 years applied aerospace, manufacturing, business modelling/simulation.

Chief Enterprise Architect for Vertica, a Big Data platform, supporting enterprise and IoT data aggregation and analytics - part of the Microfocus portfolio.

Live in Seattle, USA, on a boat, married and raised 7 kids – all Millennials.

This is the story of Value.
Industry 4.0 relates four design scenarios.
Interoperability. The ability of machines, devices, sensors, and carbon-based entities (e.g., humans) to connect and communicate with each other via the Internet of Things (IoT) or Internet of People (IoP).
Information transparency. The ability of information systems to create a virtual copy, or digital twin of the physical world by enriching digital plant models with sensor data. This requires the aggregation of raw sensor data to higher-value context information – its hard, as we know, due to data interoperability constraints.
Technical assistance. First, the ability of assistance systems to support humans by aggregating and visualizing information comprehensibly for making informed decisions and solving urgent problems on short notice. Second, the ability of cyber-physical systems to physically support humans by conducting a range of tasks that are unpleasant, too exhausting, or unsafe for their human co-workers.
Decentralized decisions. The ability of cyber-physical systems to make decisions on their own and to perform their tasks as autonomously as possible. IIoT is increasingly becoming autonomous. Only in the case of exceptions, interferences, or conflicting goals, are tasks delegated to a higher level like a human agent.

Tunnel Boring Machines (TBMs) and IoT

I have seven children, and my oldest son is a Civil Engineer, 31, works for a tunnel boring machine, TBM, company.

He designs machines that drill holes robotically - with some human assistance.
Sensors over the cutting surface provide a wealth of 3D detail of the material be excavated. Data is passed to datastores, where processing and algorithms deploy metrics to show progress and prediction, improve machine maintenance, design.

Last month, he called and said Dad, we have all the data. Many companies can drill a hole with a robot - the civil/mechanical engineering skills we have down.

"I wish I had been a data scientist. How do we correlate this data to value and repurpose, containerize it, and make it searchable, extendable, reusable, and even integrate it into other systems? Can we have Tunnel Boring Machine Data as a Service?"

Why yes, Son, you can.

It's difficult to deliver value if you are missing people.

First, we just don't have enough people to fill the roles… specifically, applied data engineering and science – machine learning and AI.

IIoT value is about its cost, latency (time-to-value), and interoperability – we need software and trade-knowledgeable engineers to assure setup, installation and govern data collection and context.

Often, machine and sensor data is not interoperable, and open standards are not having the effect we imagined – yet. Industry 4.0 and Industrial Internet Consortium test beds are showing this challenge – and working!

Consider this about data interoperability: when a data system recovers the word 'car,' it should know that semantically, it is the same as the word 'automobile.'

Three short stories.

30k kids die a year in Horn of African from viral drinking water
Some big consulting/banks had designed a large drill network that would solve the problem in 3-5 years
Kenyan debt will be significant
We were asked if we knew of a way to support a less costly infrastructure, improving time-to-value, something fast – I was part of a focus group.
A 28-year old engineer stated it rains most in the Spring, 'long rains,' 200-600mm
"Why don't we just pick up the water"
The solution was credited with starting a wave of startups (EMR, data, telecom, and saving thousands of lives in year one.

Finding Water Differently with Data
SAR (Satellite Aperture Radar) strip maps were purchased from an aerospace firm – 450nm up, 10m grid squares of data was produced
Data was downloaded to containerized PODs (portable data centers) and applied to a GIS overlay.
Now, we knew where the water was.
Trucks with 3-sizes of solar-powered water purification units that remove bacteria/materials were deployed to pick up the water
Electronic medical record (EMR) rally points were established with NGOs in the area – shots, health checks
Water rally points and expanded telecom services followed. Water collection volumes and human travel to water rally points were mapped.

Accurate data models for population health, movement, and water recovery were prepared for education/industry and for city planners who used the data to prepare for human migrations that are active in Kenya to coastal cities.

We were the lead for a large telecom project with IoT and big data collection + forecasting – 1.2M customers.
Modeled, extracted, collected, prepped, and delivered data and answers to IT and OT questions
Integrated many IoT APIs, requiring 10-12 data engineers for each data scientist, a team of 60 – note the ratio due to heterogeneous data sources
Our challenge was time required to deal with many IoT datastreams with same context, but different units and measures – unlabeled.
We created prediction reports for facility and OT health, performance, and capacity.
Lastly, for a number of infrastructure scenarios, we used machine learning to develop prescriptive reports for what the provider might do in the future – given those scenarios.

And the CEO said…

'You answered questions that operations/IT teams and data scientists had, but none of the questions linked to capabilities that the business deemed as requirements to solve and assure our business strategy.'

We went back to work….

There were sensors everywhere – facilities, telecom cabinets, transformers, gensets, servers, etc. We needed to show how the data informed business services and how the telecom infrastructure should change, supporting that growth. Every sensor is a service to support operational and business value.

Fixed: DevOps in the Data-Driven Era, and Emerging Data Ops

IT/OT teams were not contributing to business strategy in a traceable, governable manner.

Sadly, another event affected our progress. 27 April 2015. 1832 people killed by 7.8 mag earthquake in Nepal. Millions covered in ruble. Rescuers sifted by hand to find victims – many rescuers were killed looking for victims.

A Swiss volunteer team provided dataOps to our solution, using machine learning algorithms to enable rescuers to use mobile phone location data to save disaster victims and rescuers – the solution required saving 30-days of location patterns.

If an earthquake happens, whether a mobile device is powered or not, the location is likely known based on individual, monthly location patterns.

Data informed strategy – a new capability for saving lives with mobile phones.

A CCTV system was designed to interoperate with city traffic signals. The solution started with 700 fixed and pan-tilt-zoom cameras. We ran into a problem – camera data was not interoperable. We had to bring on device and embedded logic specialists to support custom integration for some 42 different camera models. The cost and client happiness were in jeopardy - we investigated and used a single video standard to deliver content, simplifying integration costs and assuring value.

We fixed the first problem….
Traffic light and camera data were stored for lengthy periods, bringing no value, and high storage costs.

We created a solution to consume the data. Have an accident? Self-service 'digital film' capture of accident is available for 10-days to download via the web for insurance purposes at no cost. Taxpayer satisfaction rose, and we heard about it.

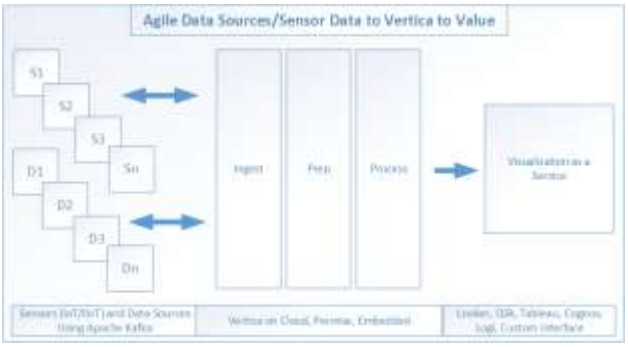
We built a data mesh of city traffic sensors, enabling 'prescriptive' interfaces for citizens to ask when, how, and under what conditions could/should they take public transportation – I'll show you a picture of that in a moment. Camera health (uptime) reported every minute.

With 80% confidence, bus wait time, number of people on and getting off the bus, was published at hourly intervals by location.

Today, we have 3000 cameras operating, and expect to go to 6000 in the next year.

Smart City Prescription and ML in Auckland

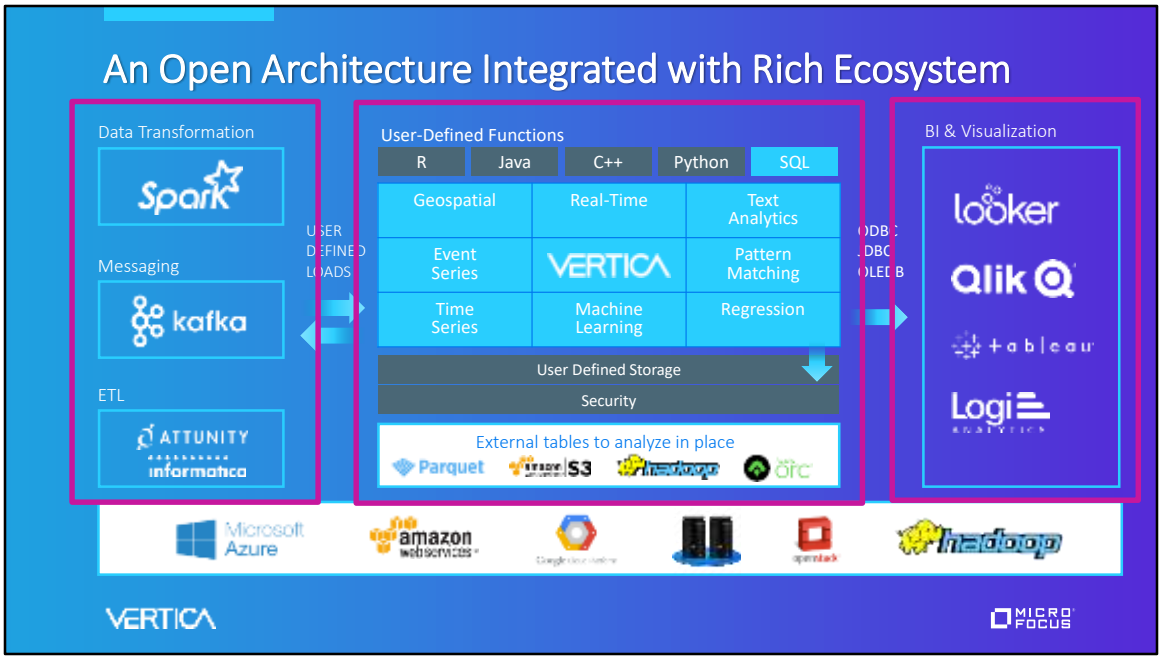
- When is the best time to ride the bus when it's raining or snowing?
- There is a parade next week, will I have trouble riding the bus?
- New data sources and models can be added for new or different events to ensure that value is provided to citizens.



Prescription is 'what should I do, given a number of different forecast trends, in the future'?
When is the best time to ride the bus when it's raining or snowing?
There is a parade next week, will I have trouble riding the bus?

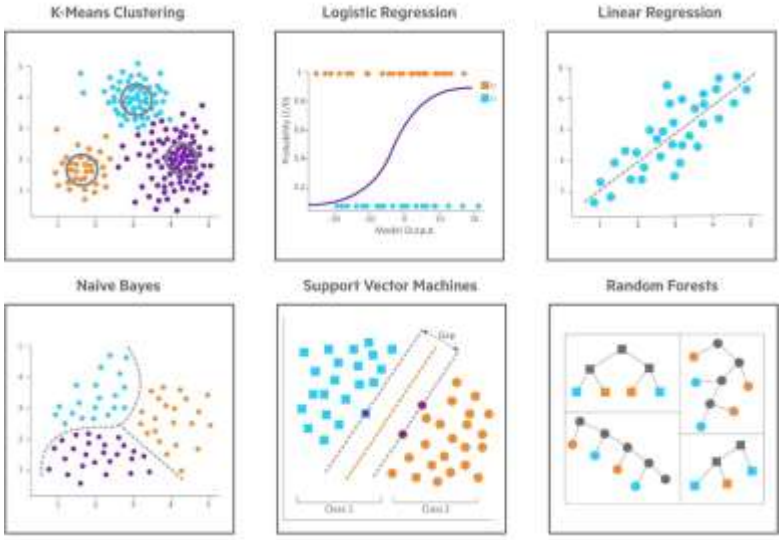
There are three components to a machine learning/AI solution: data collection and streaming, data prep/processing/machine learning/results correlation, and finally, graphical reporting of the result sets.

Note, you can apply new data sources, streams, to learning models using AI, delivering enhanced safety, reliability, trust, and maintainability.



No matter what products are employed, aggregation, prep/model/evaluate, and deployment/presentation to value are the three components to the data science platform.

Based on latency and cost, vendors support on premise and cloud solutions. In general, IoT eats cloud in the control plane, but as we well know, many a speaker has been proven lost with the advance of technology.



15

https://analyticsindiamag.com/10-machine-learning-algorithms-every-data-scientist-know/

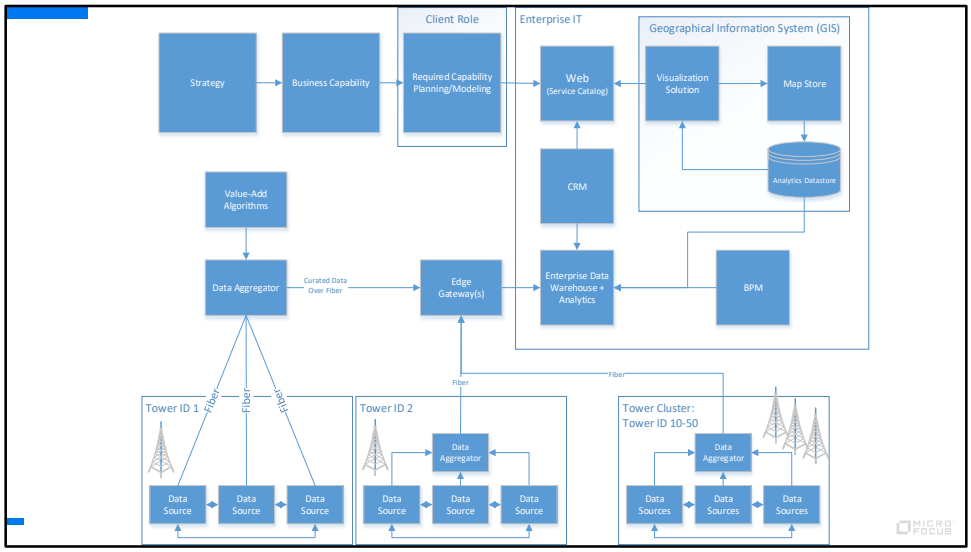
K-Means Clustering
Logistic Regression
Linear Regression
Naïve Bayes
Support Vector Machines
Random Forests…
A few of the dozen or so algos that data scientist will use to exploit data value.

Accurate Prescription: What Should I do Given…?

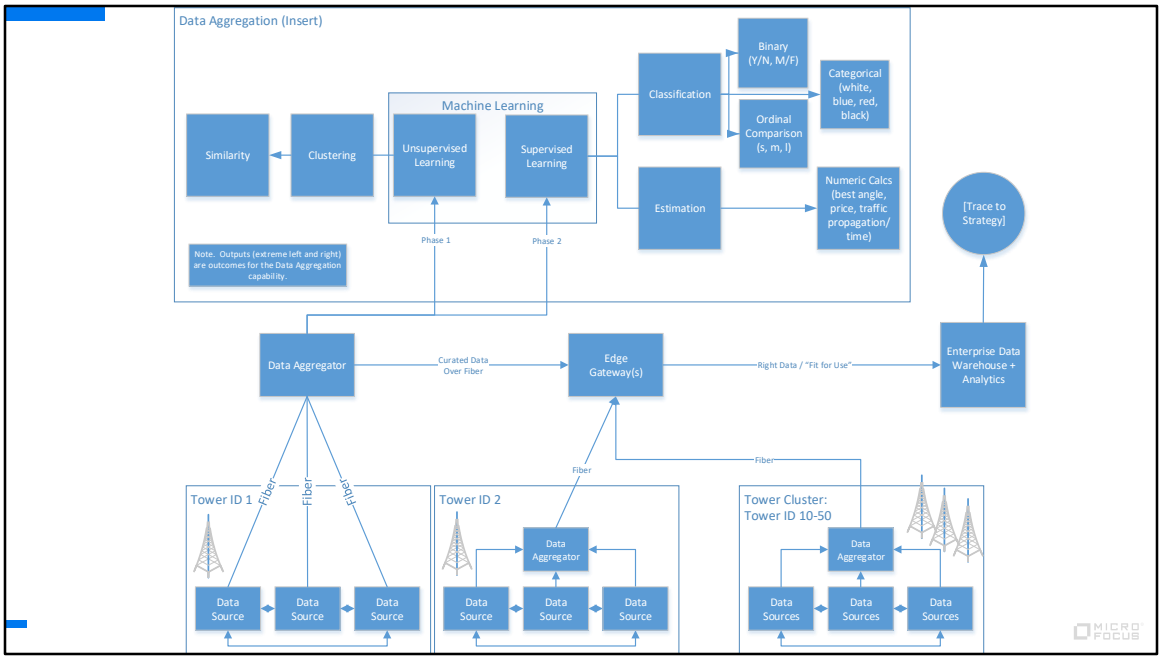
- 80% of cumulative stop-level predictions were within +/- 1 rider of reality.

Here you can see the Auckland Prescriptive solution. What should I do given… a time, day of week… weather conditions, etc.

Accuracy for 1 day in advance is currently 80% confidence +/-1 one rider.



Conceptual architectures are a great tool to show to business and operational leaders, concerned with the future state of an organization, what the capabilities or solutions are that are part of the futurescape. Value will transit over each box or capability from bottom to top, top to bottom.



Here, I have added the conceptual components for Machine Learning… both supervised and unsupervised.

Supervised learning implies that we aren't operating in production, we are testing data population size and algorithms for accuracy

Unsupervised means that data is learning from its results, by classifying and regressing data to understand what kinds of data is revealed and how much or little, it's statistics, is measured and forecast.

BUSINESS-DRIVEN TO DATA-DRIVEN

Design today is often by tradition, by named authority, by academic leaders… historically proven, or past patterns that worked in the Industrial and Information Era, but may not be sustainable in the Digital Era.

Should we collect data, correlate data and answers from humans, systems, and machines to determine 'what to deliver'? YES. Can the factory deliver curated data to IT as a service? YES. Can the business, IT, enrich data with accurate factory metrics and near-realtime market data to assure business-to-factory governance? YES.

For the first time in history, we cannot hide from ***how*** things are used. IIoT fills in the gaps to BigData - data that was missing.

History, culture, and tradition have typically informed Policy or guidelines, how we do things here – “we do it this way,” and now, we will do it a new way, based on the data that we have collected.

IIoT and Data-Driven challenges our factories, businesses, cities, and even community and national cultures.

How do You Prove IoT and BigData are Delivering Value?

It's a requirement – it must be done.

Data prep and its organization can be 60-80% of the data's lifecycle – this problem can be fixed by machine and sensors using open standards, a common taxonomy, and let me dream… a semantic ontology by vertical industry. Note that both Industry 4.0 and Industrial Internet Consortium continue to work together, as shown in the next slide, assuring continued efforts toward data interoperability and exchange.

A traceability model is a simple 2-3 column matrix to assure strategy is traceable down the stack, capability-to-machine-to-sensor and its data, and back up. A traceability model is often used with a capability model for complex organizations to understand work distribution.

Collect what delivers value 'fast' – time-to-value is critical. ID areas where you can show expertise fast.

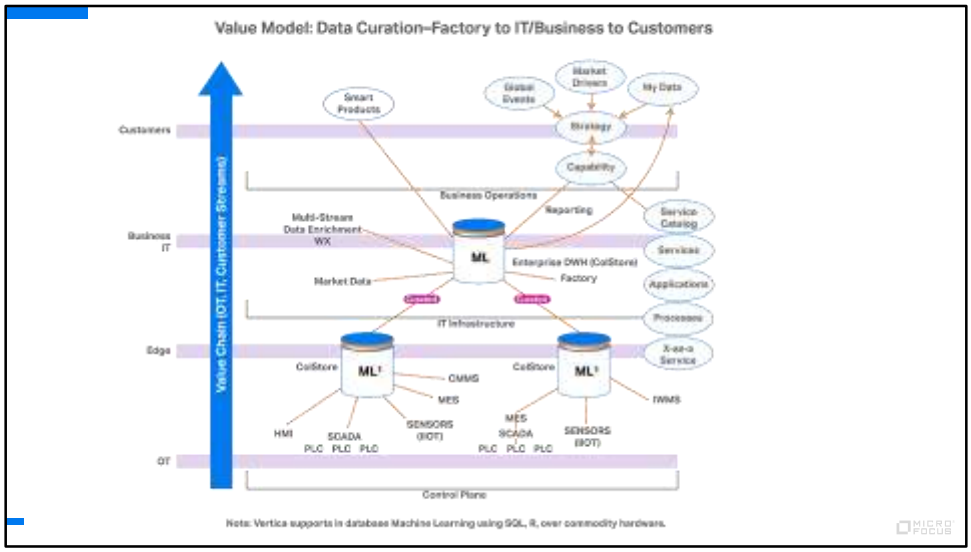
Likely in OT Condition Monitoring, Predictive Maintenance, and Event Correlation.

OT control plane data is massive – a successful story, assuring OT uptime. ***Curation*** assures the OT-IT community supports data to business value. Curating OT data allows for IT delivery of summarized content fast – data answers business questions. The critical key to business value is assuring OT/IT context to business capability – proof of value.

Curated OT data crosses the Edge – IT mixes that data with other business data streams, enhancing value (Wx, market data, other factories).

As products and services are sold, a 'call home capability' is tied to the business data warehouse,

continually assuring value.
Reporting. Every capability (human, sys, or machine/sensor) a business adopts has questions that require answers – trace the role to the answers.



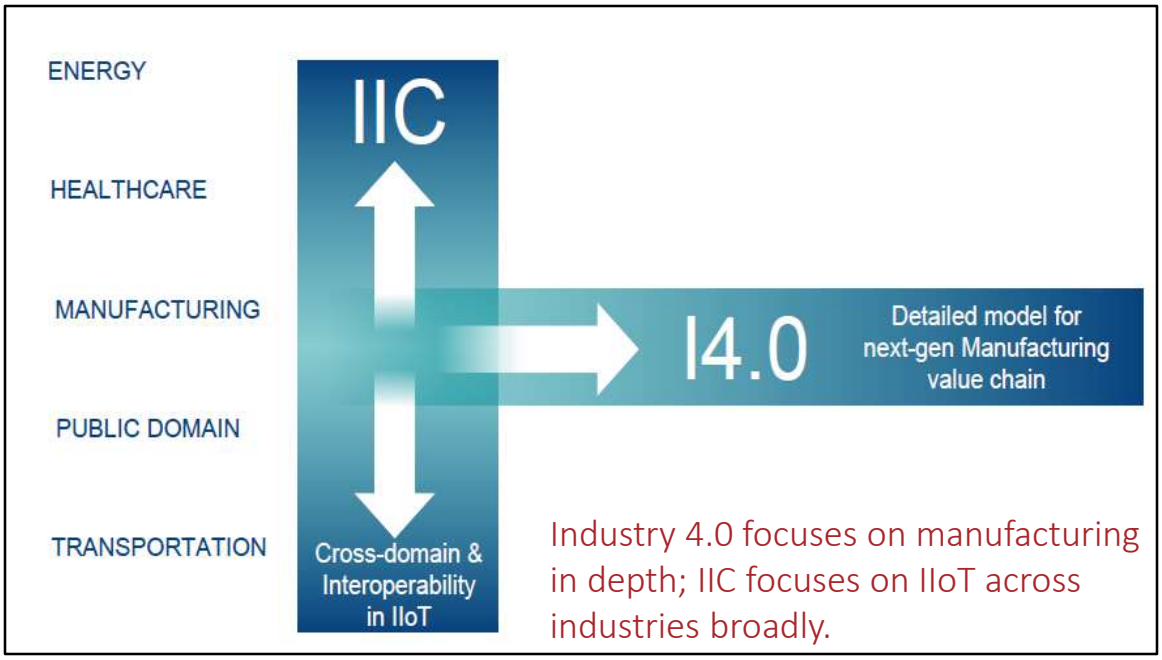
From top down, to bottom up, Value is delivered in three levels.

OT to IT
IT to Business
Business to Customer

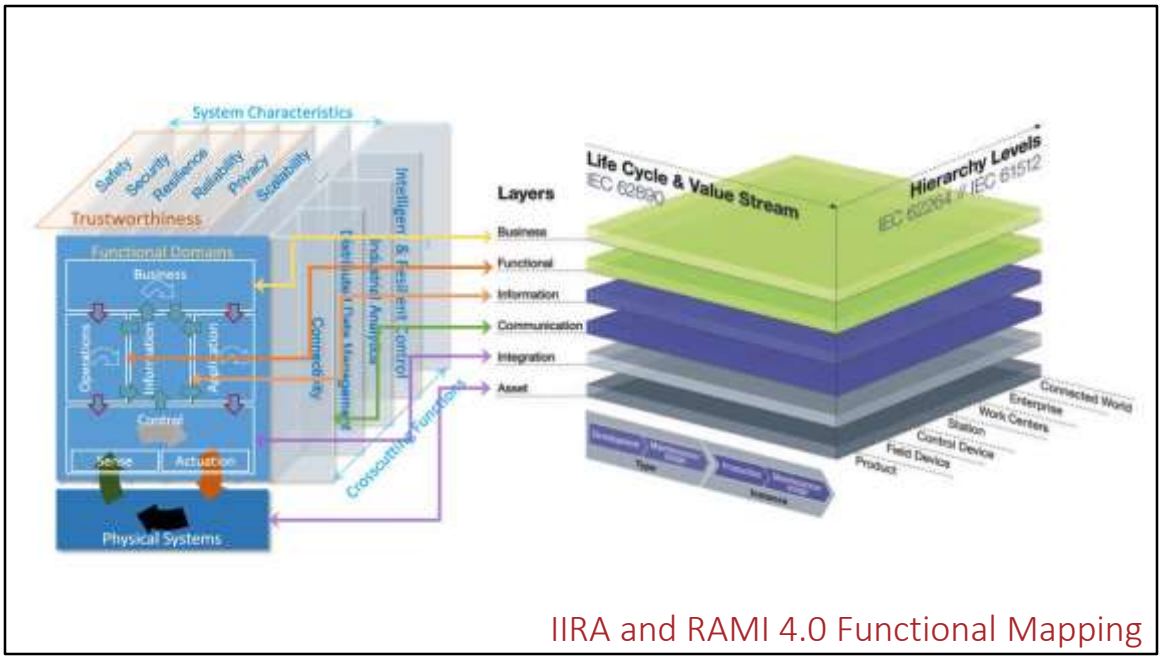
Each of the areas represents a value stream, and together, in total, a value chain.

There are four planes that make up the model: control plane, IT infrastructure, business operations, and customer satisfaction.

Note, the curation engines, dataStores – they pass only a subset of the control detail to IT. IT gathers many streams of data to enrich the data to provide ecosystem value to IT. Lastly, note the customer product calls home and updates data on the health, performance, capacity of a smart product the factory may have built.



Happily, the IIC and Industry 4.0 folks globally work together to support a mesh of understanding on how IIoT and its data is functionally enabled by test beds to prove complex integrations and then, reference architectures to show conceptually and functionally how they can be reproduced by product.



IIRA and RAMI 4.0 Functional Mapping

Shown are how the Industrial Internet Consortium and Industrie 4.0 have built maps to integrate their reference architectures.

The Industrial Internet Consortium works globally to transform business and society by accelerating the Industrial Internet of Things (IIoT). Their mission is to deliver a trustworthy IIoT in which the world's systems and devices are securely connected and controlled to deliver transformational outcomes.

The Reference Architectural Model for Industrie 4.0, RAMI, is a 3D map showing how to approach the issue of Industrie 4.0 in a structured manner. It ensures that all participants involved in Industrie 4.0 discussions understand each other

Continuously, stories are reported on how companies, governments save money on open standards, and yet vendors attempt to produce their own industrial, closed standards, and customers fail to resist buying solutions that are not standard and interoperable. The lack of IIoT interoperability, open standard compliance, is the biggest risk to value we can point to in the economic value of sensors.

Why does this matter to value and data? Common taxonomy, well-defined asset and message models assure data correlation accuracy, metrics, and time-to-value.

There are open IoT standards – check out the Open Data Format, Open Message Interface, and the Open Data Element Framework at OpenGroup.org.

What is a Test Bed?

A test environment to exercise industrial internet solutions, showing vendor and data interoperability, assuring value delivery.

Plus over 500 research/test bed sites within Germany, funded by Industrie 4.0 (https://www.plattform-i40.de/I40/Redaktion/EN/Standardartikel/in-practice-testbeds.html)

Test Beds to Prove Data IIoT Interoperability

Testbeds are where the innovation and opportunities of the Industrial Internet – new tech, new applications, new products, new services, new processes – can be initiated, thought through, and rigorously tested to ascertain their usefulness and viability before coming to market. If data is going to interoperate, be safe, secure, trustworthy, and deliver value – its here.

Global events, market drivers, and 'my data' ->
Strategy - >
Capability -> work that is core or contextual to the organization
Actors (humans, systems, machines, sensors)…
goto a Service Catalogue ->
Services, Processes, Applications, Machines, Sensors -> anything as a service… from accountProcessing-as-a-Service to structuralSteelWelding&Repair-as-a-Service.
Data collected represents the answer to questions one or more levels up.

Technology is the biggest equalizer on Earth. We get results in 3-5 years - benefiting all. It requires a foundation… a country, society to embrace. Don't let our companies and countries resist, build walls and borders, or press for trade embargoes.

World is interconnected by oceans, and we don't need data to separate us. The 4th revolution technologies, data and interoperability, are the mechanisms that enable us all work together to deliver value.

Contextualizing, analyzing data so we can measure and forecast, inform situations with complex solutions that humans could never imagine is where we are going. Delivering value teaches us all – it enables reuse.

IoT is the compass and radar of the 4th revolution – it's value is the direction, future, and prescription for humanity's future discovery.