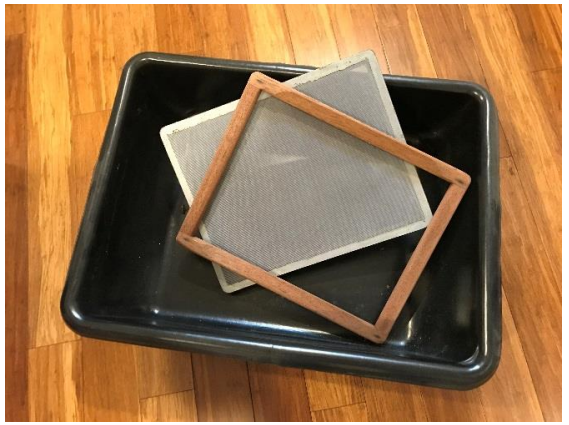
INDUSTRY GUIDANCE WORKSHOP - 30-10-2019

A Framework for IIoT Analytics

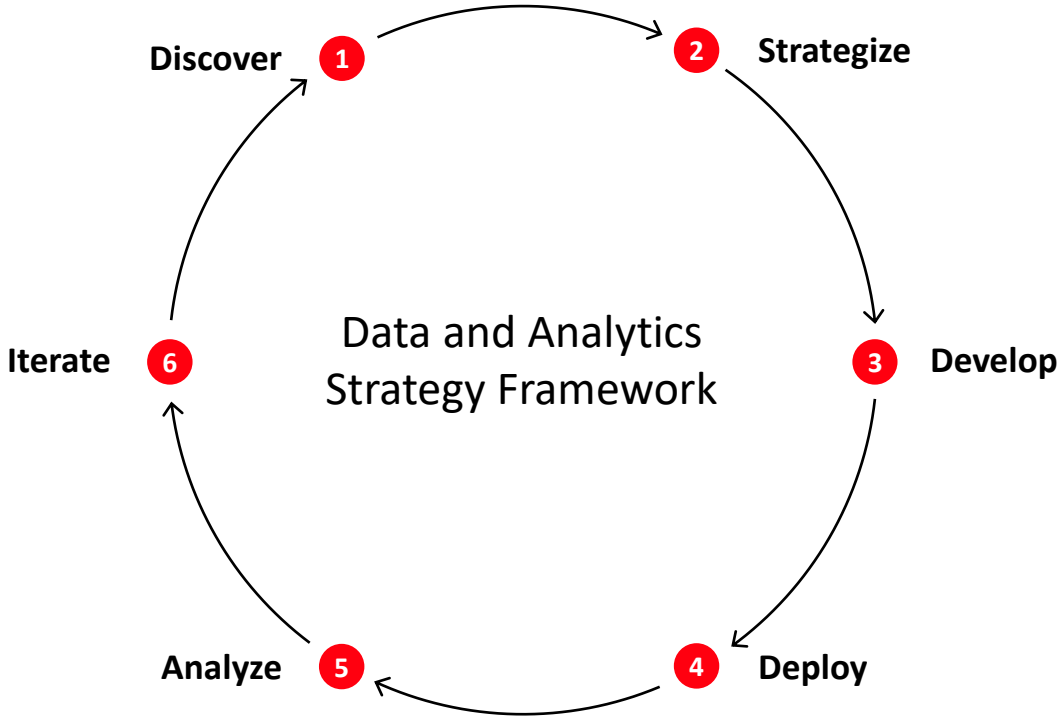
Eric Harper

Papermaking has been a human endeavor for 3,000 years



IT Analytics

An iterative process



Knowlton, B., “Data and Analytics Strategy Framework for Credit Unions and Banks” (2016)

Industrial Internet Consortium

Things are coming together

INDUSTRIAL
INTERNET OF THINGS ANALYTICS FRAMEWORK

We are pleased to announce the **Industrial Internet of Things Analytics Framework (Industrial IoT Analytics Framework)**
for system architects, technology leaders and business leaders looking to successfully deploy industrial analytics systems

Advanced analytics is at the core of the Industrial Internet of Things (IIoT). When analytics are applied to machine and process data, they help optimize decision-making and enable intelligent operations. These new insights and intelligence
can be applied across any level of any industry if the appropriate data can be collected and analytics are applied correctly. If data
is the new oil, data analytics is the new engine that propels the IIoT transformation

Agenda

IIoT Analytics

Business Viewpoint

Usage Viewpoint

Functional Viewpoint

Implementation Viewpoint

Crosscutting Concerns

Questions and Answers

"Analytics Framework", Industrial Internet Consortium (2017)

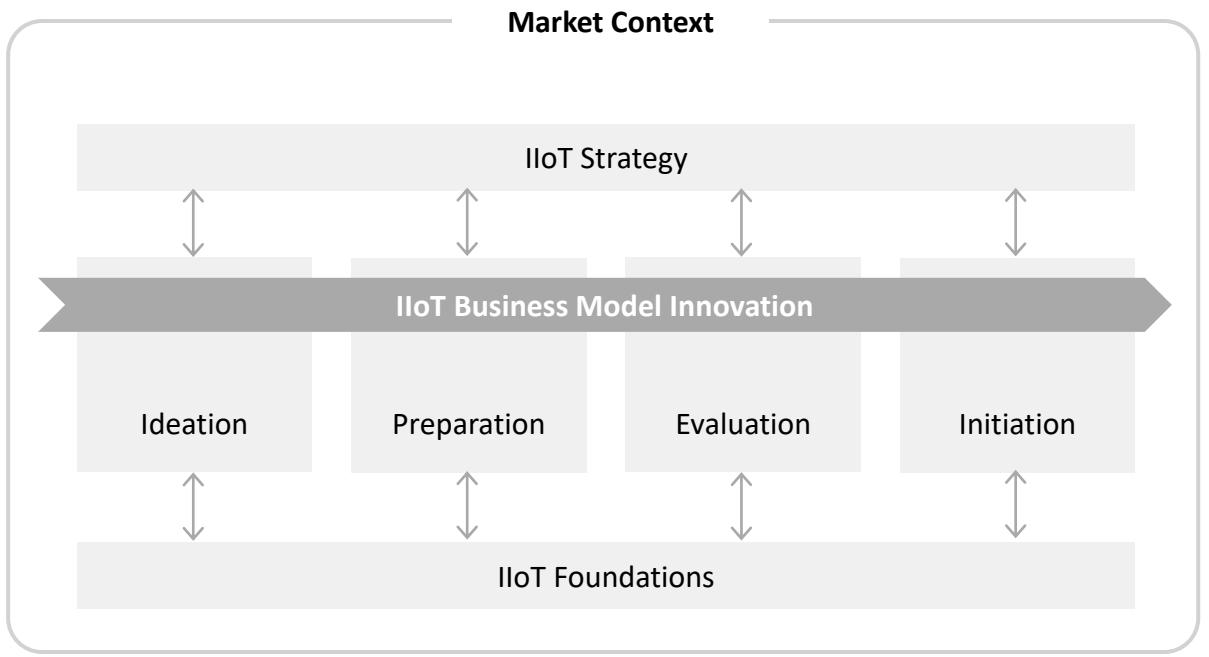
Creating Business Value

Who: Business and technology leaders

What: Increase throughput, reduce expenses and inventory

Why: Generate higher margins to create business value

How: Identify performance bottlenecks in overall operations continuously and remove them one-by-one



"Business Strategy and Innovation Framework", Industrial Internet Consortium (2016)

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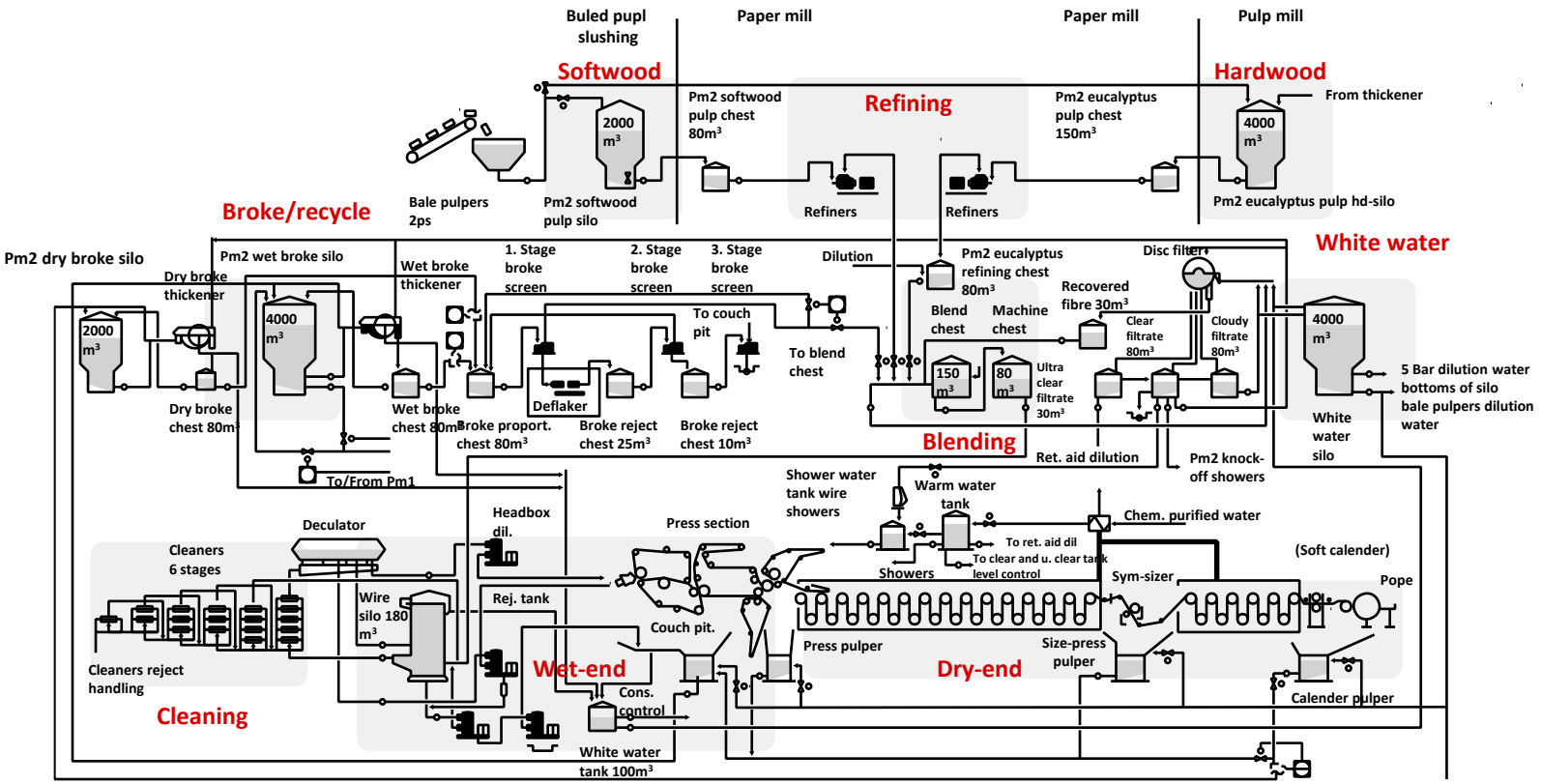
"Analytics Framework", Industrial Internet Consortium (2017)

Papermaking Process



Analytics Framework

Getting started

Descriptive Analytics

Gain insight from historical or current data streams including for status and usage monitoring, reporting, anomaly detection and diagnosis, model building or training

Predictive Analytics

Identify expected behaviors or outcomes based on predictive modeling using statistical and machine-learning techniques, e.g. capacity demand
and usage prediction, material and energy consumption prediction, and component and system wear and fault predictions

Prescriptive Analytics

Uses the results from predictive analytics as guidance to recommend operating changes to optimize processes
and to avoid failures and the associated downtime. An example of prescriptive analytics is on-demand production from
a solid geometric assembly model to find the optimal set of manufacturing processes to achieve the final product

"Analytics Framework", Industrial Internet Consortium (2017)

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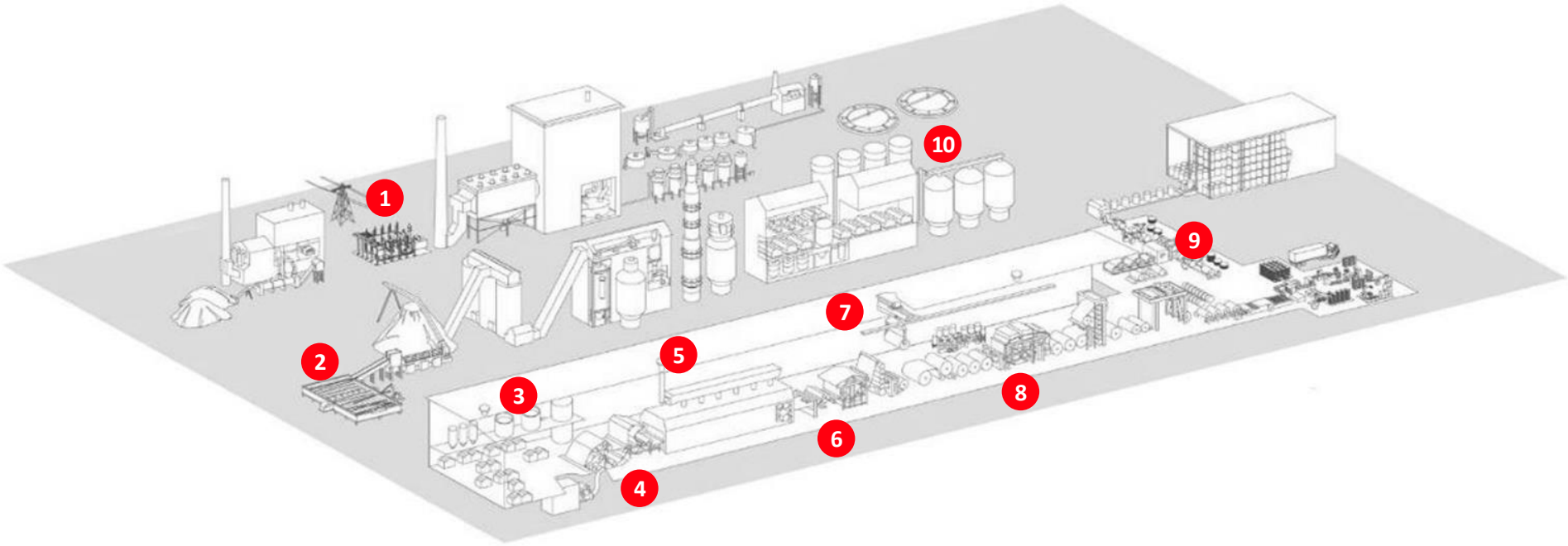
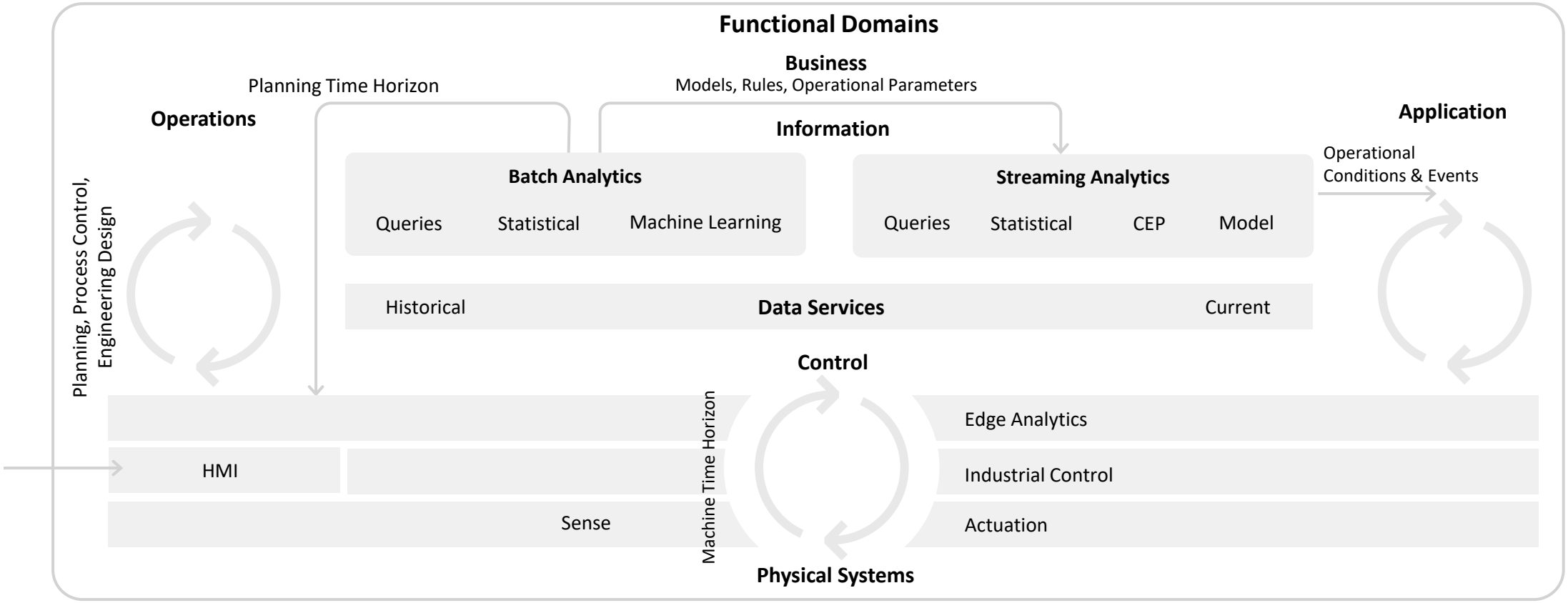
Pulp and Paper Plant

Data sources and systems

1. Energy Management
2. Order Management
3. In Line Measurement
4. Paper Controls & Optimization
5. Lab Measurement System
6. Quality Controls System
7. PM Drives System
8. Web Inspection System
9. Production Planning & Measurement
10. Pulp Mill Controls & Optimization



Analytics Architecture



"Analytics Framework", Industrial Internet Consortium (2017)

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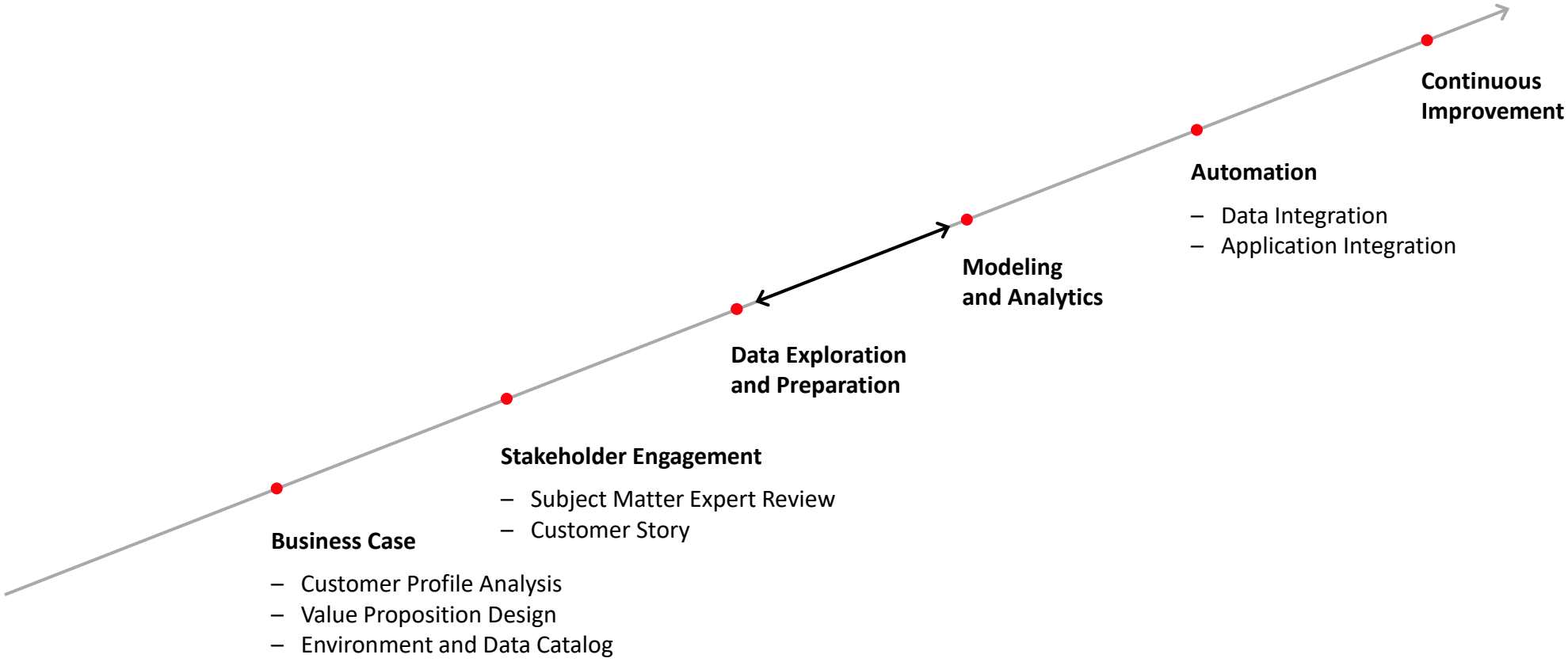
Analytics Deployment Considerations

Evaluation Criteria	Analytics Location		
	Plant	Enterprise	Cloud
Analysis Scope			
Single Site	✓	✓	✓
Multi-Site		✓	✓
Multi-Customer			✓
Response Time			
Control Loop	✓		
Human Decision	✓	✓	
Planning Horizon	✓	✓	✓
…			

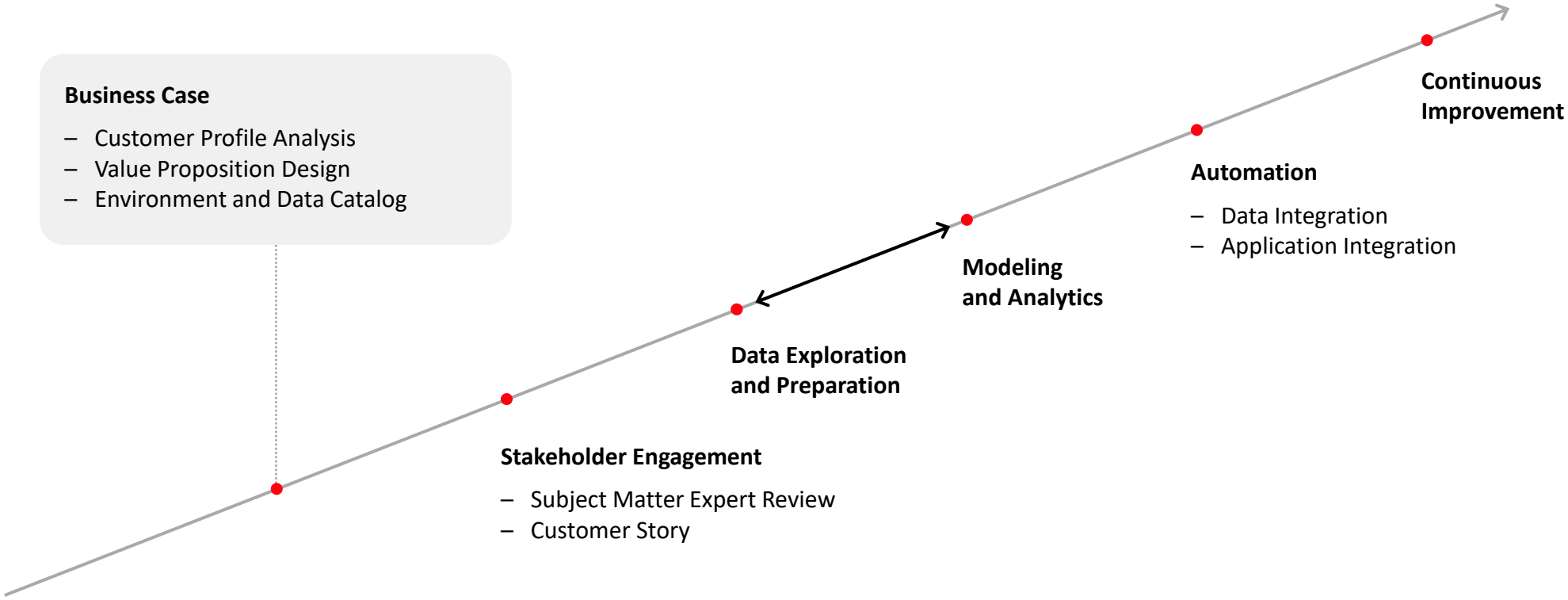
"Analytics Framework", Industrial Internet Consortium (2017)

Analytics Design and Implementation Process



Analytics Design and Implementation Process

Business Case



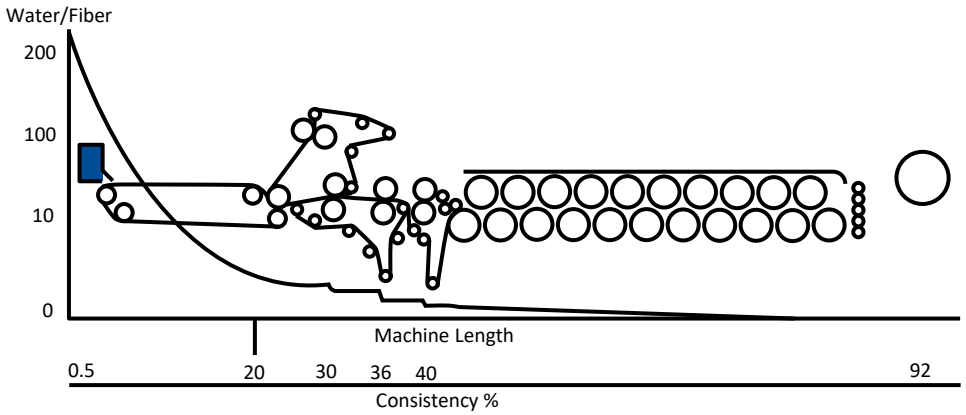
Challenges in Papermaking Process

Measure, Control and Optimize

Papermaking needs to **measure** many process variables and product qualities for monitoring production operations and control automations

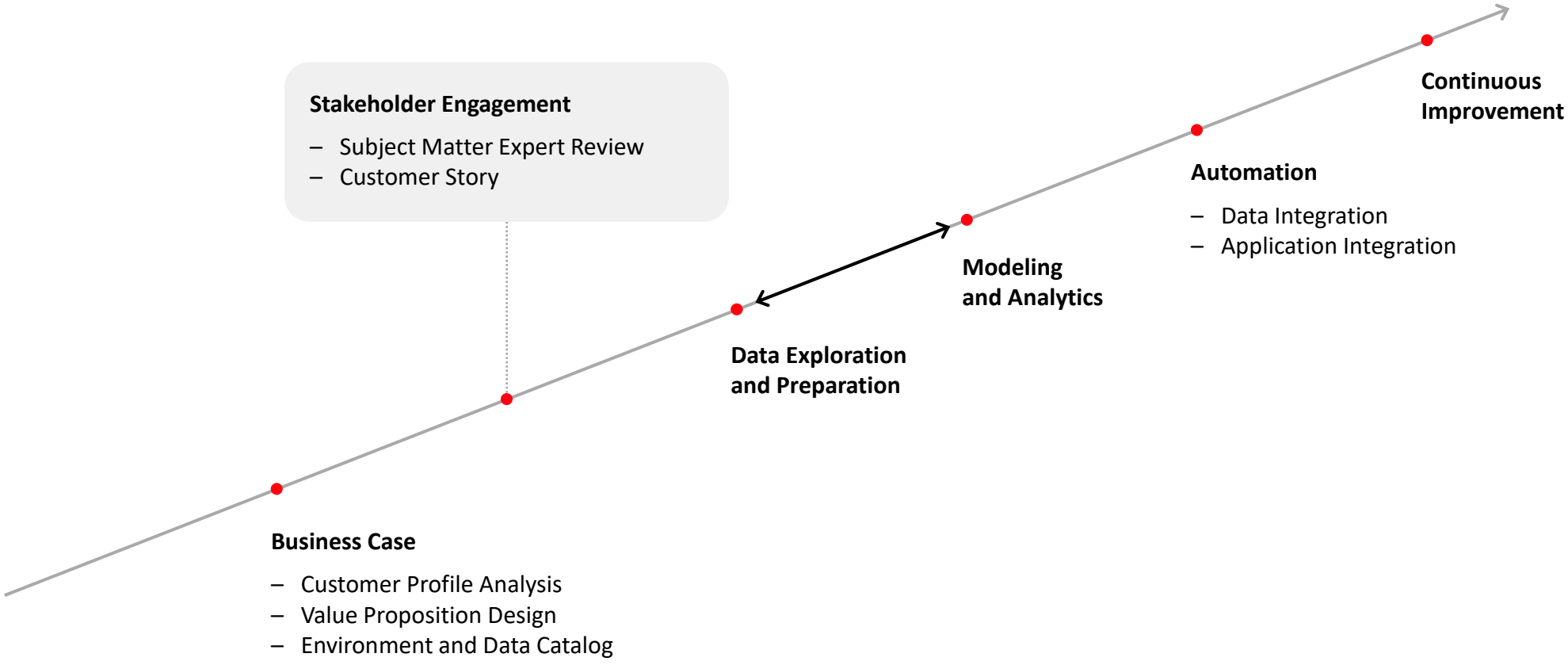
Papermaking consists of many complex processes that require various **control** solutions and techniques to produce high quality products

Papermaking is an energy intensive production process. There are many opportunities to **optimize** consumption of raw materials, utilities, and energy

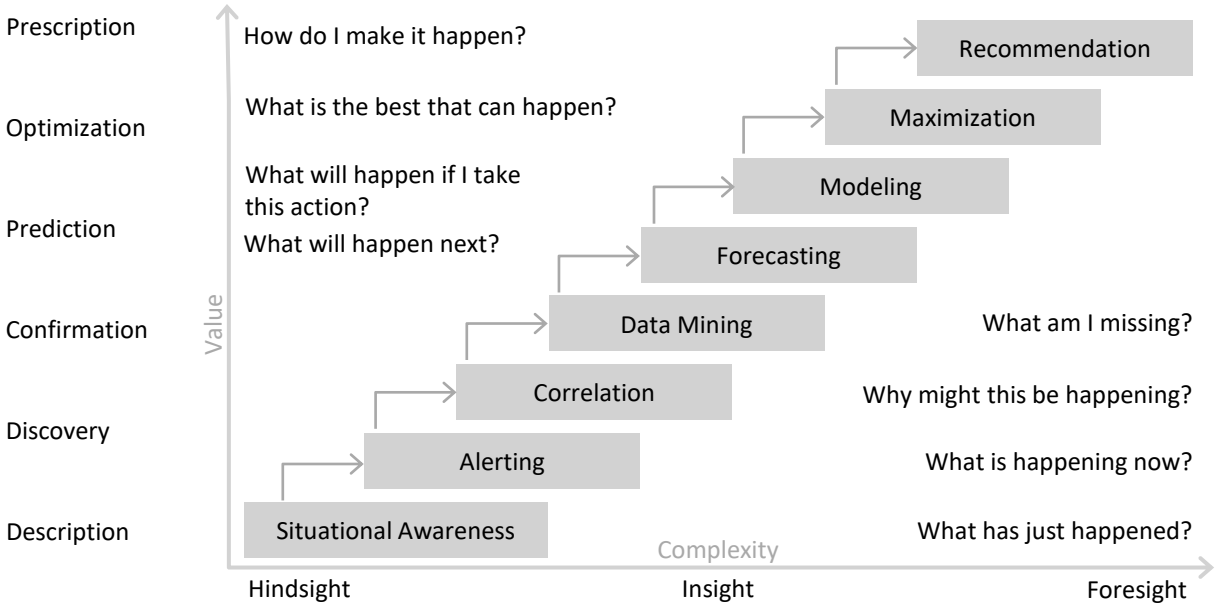


Analytics Design and Implementation Process

Stakeholder Engagement



Data Science vs. Model-Based Analytics



Extract knowledge from data, using scientific discipline

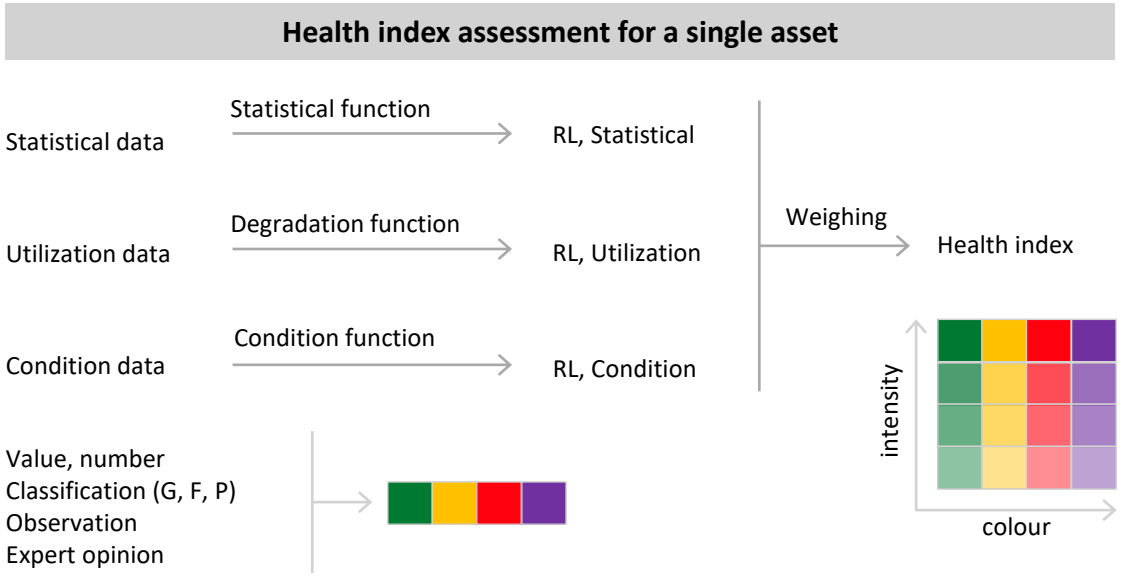
Collect and clean raw data, explore relationships, develop models and algorithms, uncover patterns and predict outcomes

Effective with large amounts of data

System models using subject matter expertise, physics, mechanics and dynamics of component interactions

Approximations using linear simplification of non-linear behavior

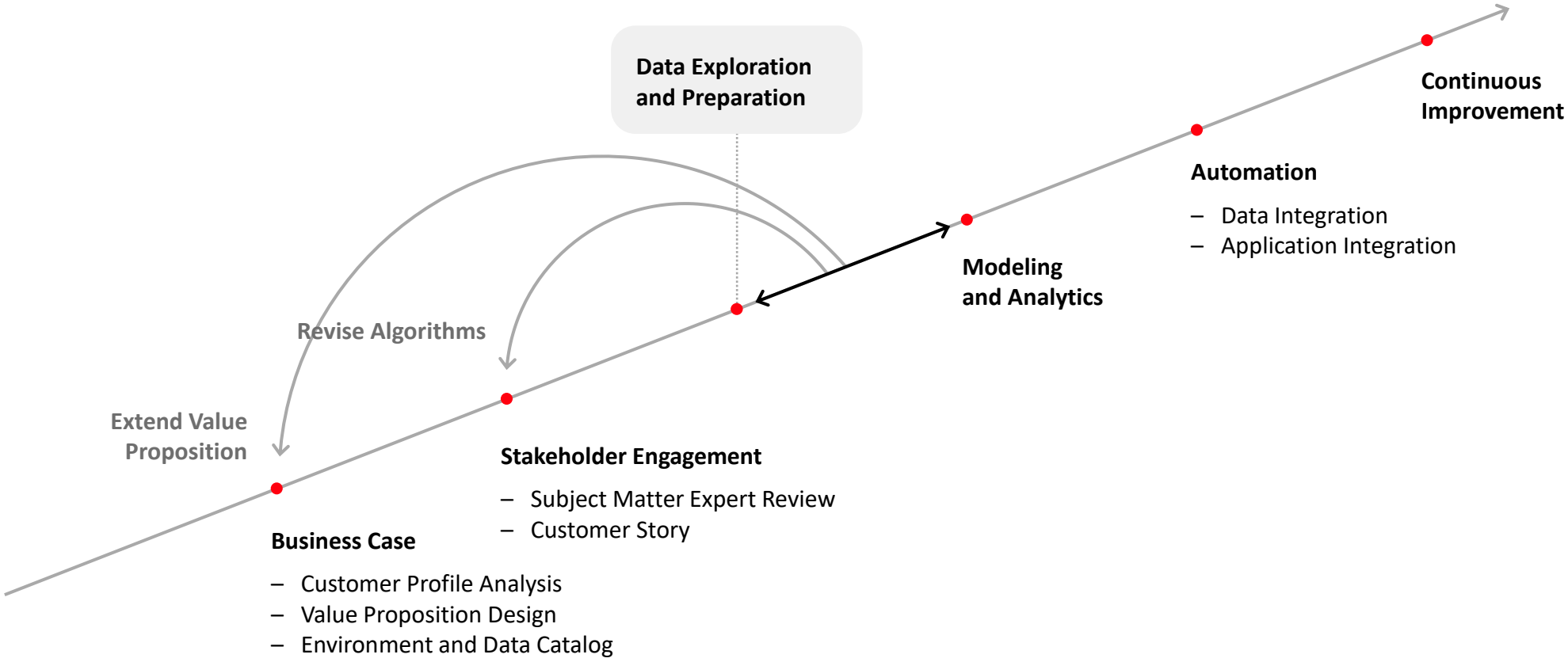
Effective with small amounts of data



Harper, E., Zheng, J., Jacobs, S., Dagnino, A., Jansen, A., Goldschmidt, T., Marinakis, A., "Industrial Analytics Pipelines", IEEE BigDataService (2015)

Analytics Design and Implementation Process

Data Exploration and Modeling



Simulation of Water Papering Process

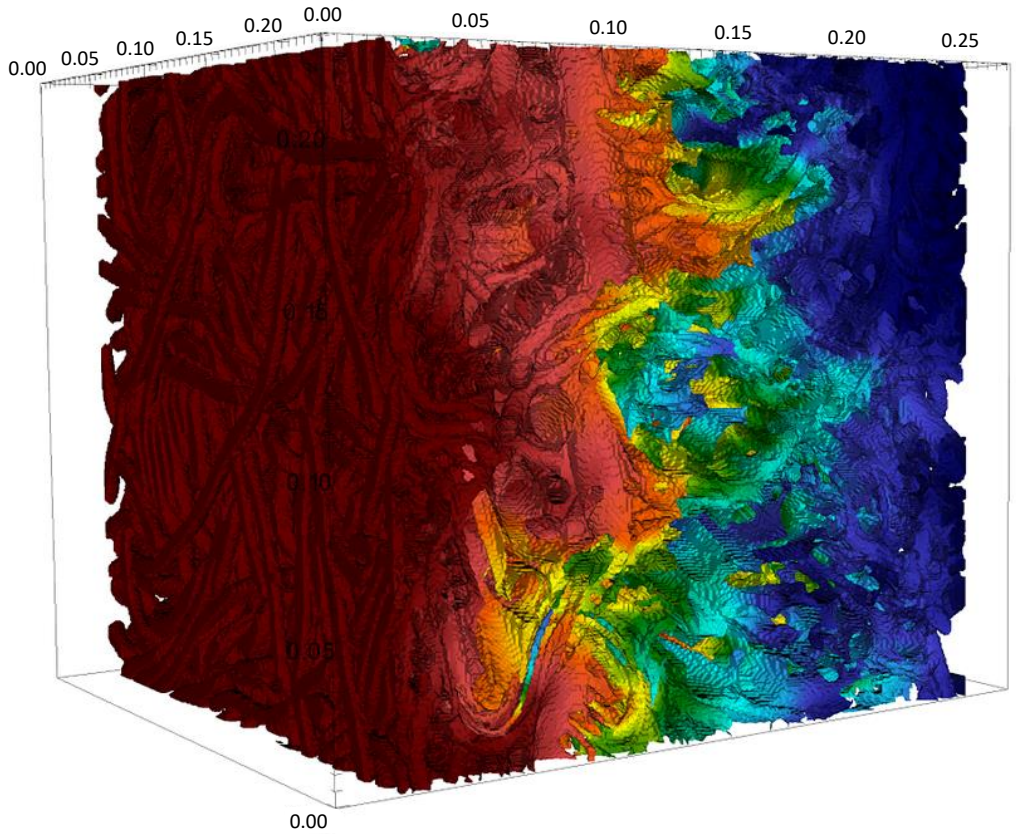
Multi-scale, Multi-physics Modeling

HPC for Manufacturing

Leverage advanced simulation capabilities, high performance computing resources and industry paper press data to help develop integrated models to accurately simulate the water papering process

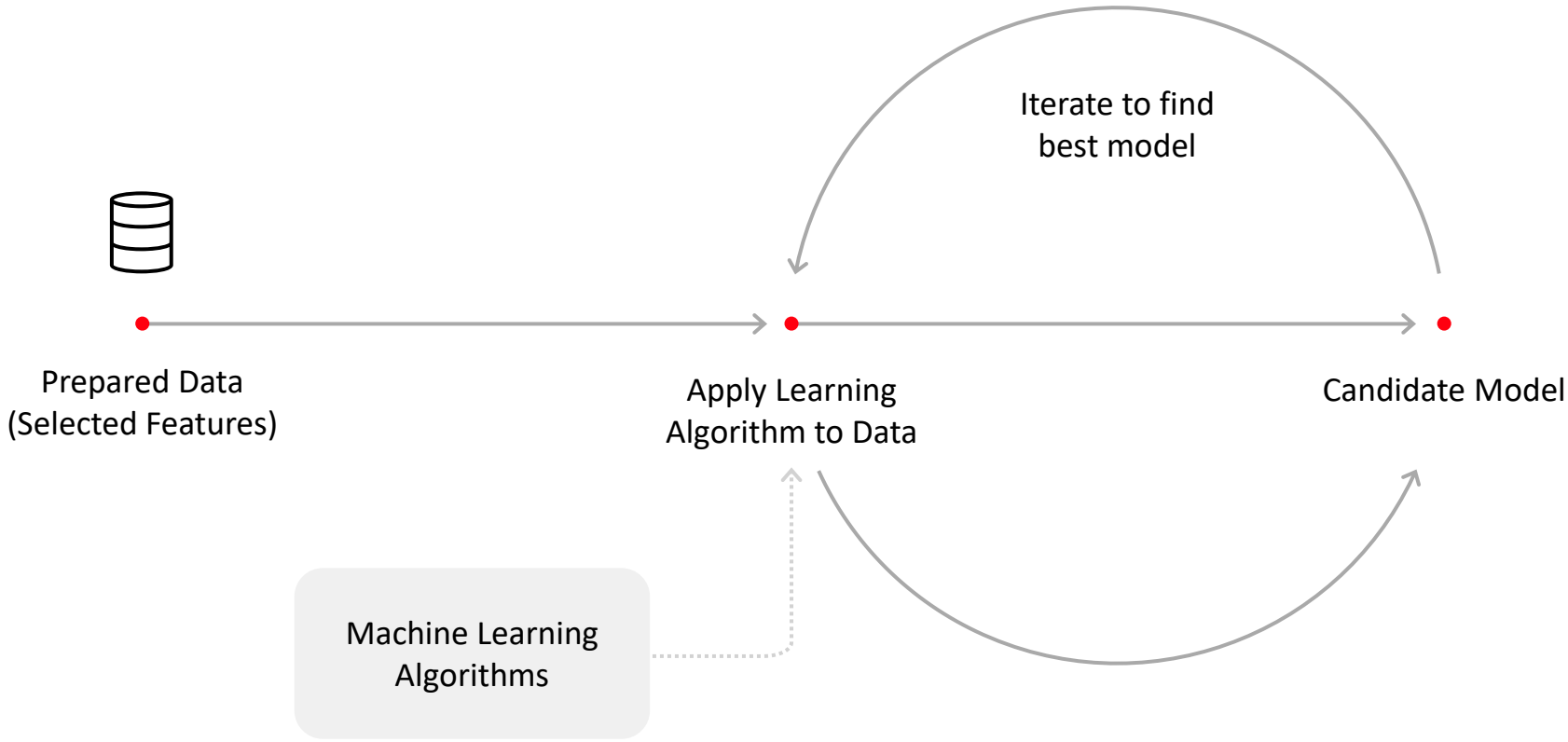
Researchers used a computer simulation framework, developed at LLNL, that integrates mechanical deformation and two-phase flow models, and a full-scale microscale flow model, developed at Berkeley Lab, to model the complex pore structures in the press felts

Save paper manufacturers up to 20 percent of the energy used in the drying stage – up to 80 trillion BTUs (thermal energy units) per year – and as much as $400 million for the industry annually



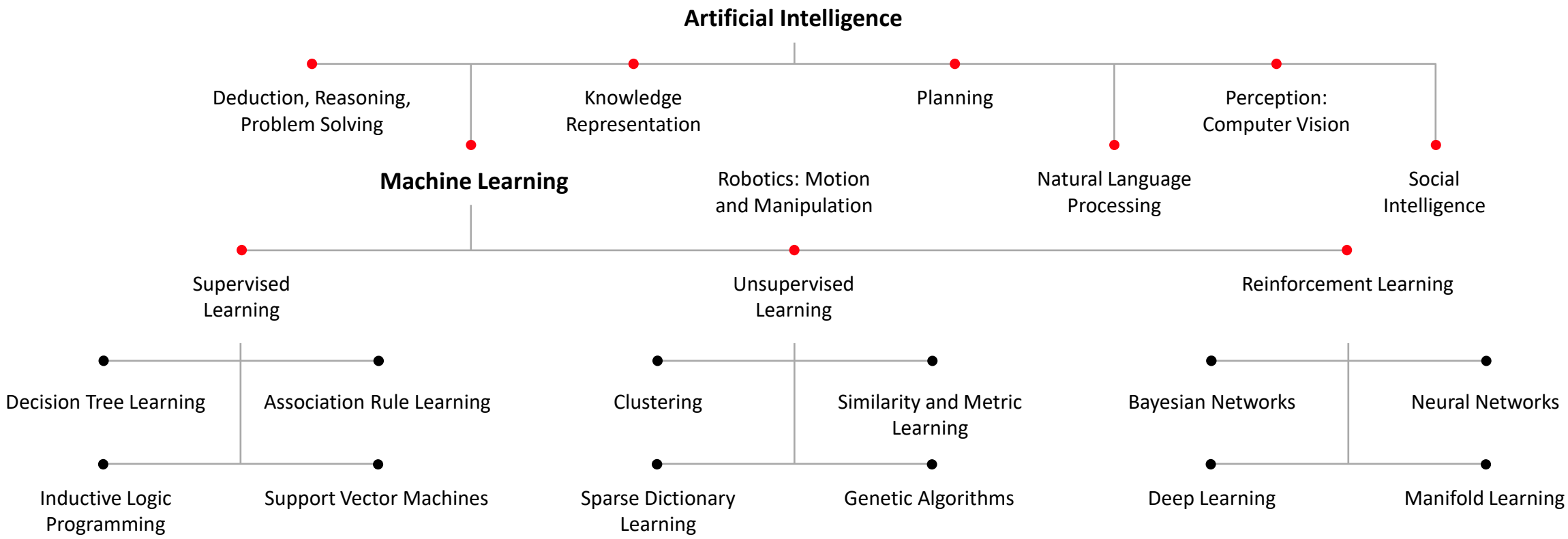
HPC4MfG paper manufacturing project yields first results, https://phys.org/news/2017-05-hpc4mfg-paper-yields-results.html (2017)

Model Building Process



AI / Machine Learning

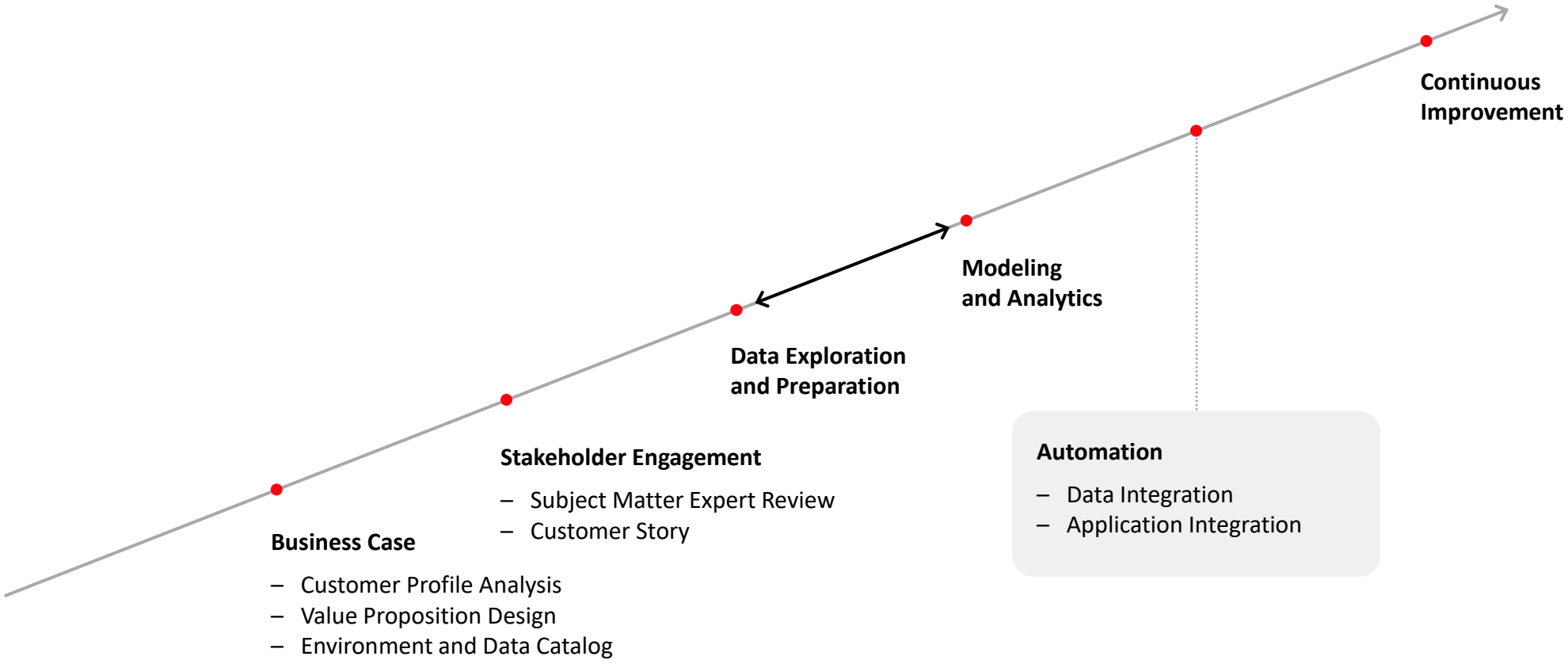
Algorithms



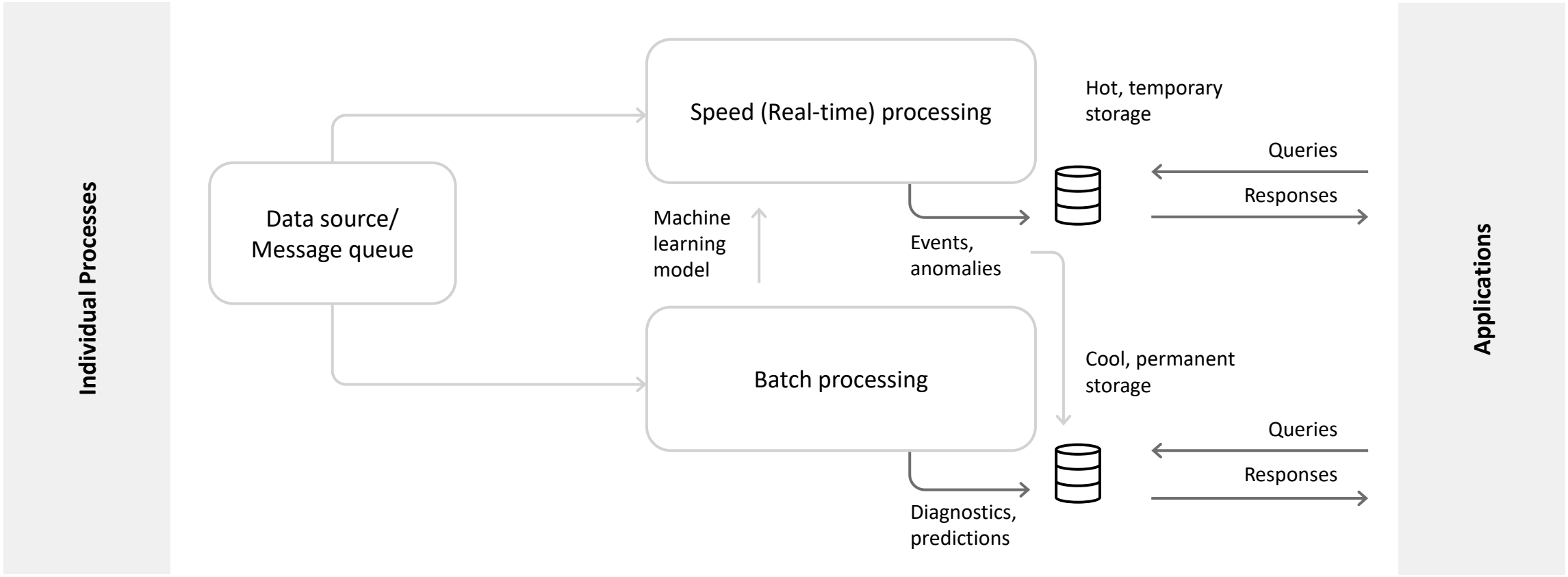
Nazre, A., Garg, R., "A Deep Dive in the Venture Landscape of Artificial Intelligence and Machine Learning" (2015)

Analytics Design and Implementation Process

Automation



Streaming and Batch Integration



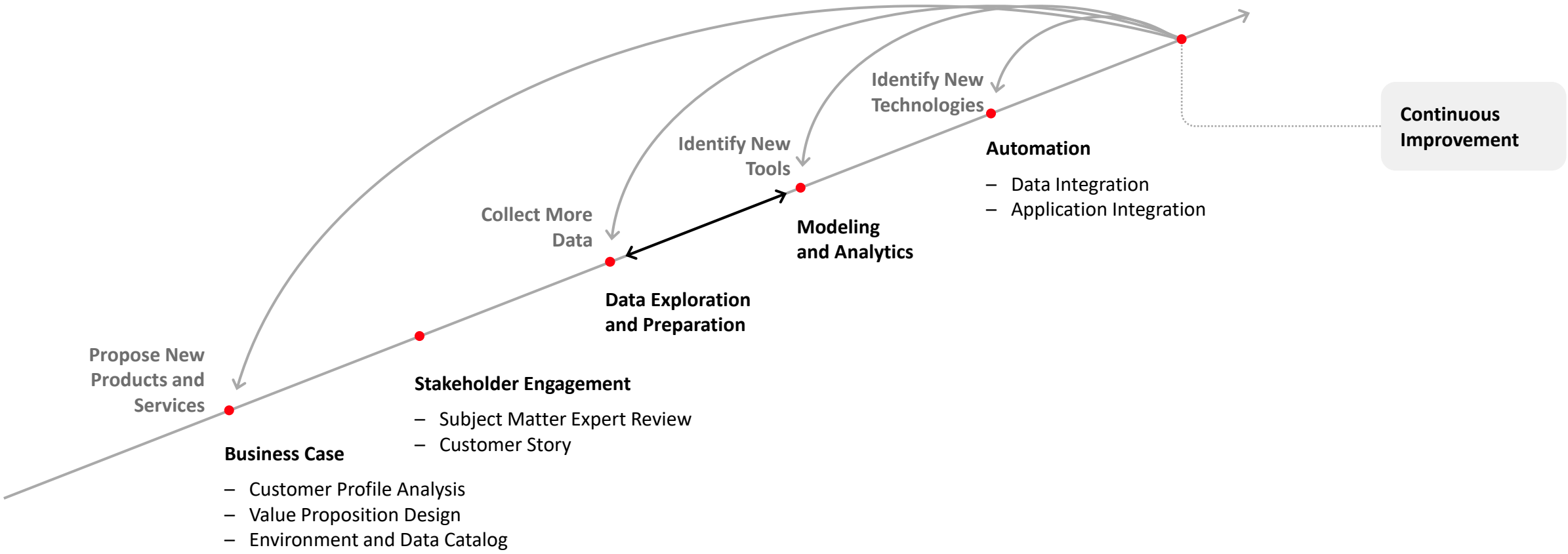
Analytics Technology Choices

Type			Rationale	
	Example Technology	**Development**	**Motivation**	**Constraints**
Hadoop	Hive/Pig	SQL	Large static capacity and fault tolerance through data replication	Computations are disk bound, high latency and response execution times
Indexed	Solr/Lucene	Indexed Query	Real-time, scalable search with support for almost any type of data and file format	Latency to create and maintain indexes
RDBMS	JDBC	SQL	High productivity, legacy data store use requires no retraining. Support for transactions	Scalability, limited to structured data
Key-Value Pair	NoSQL	CQL	Simplicity of design, reliability (fault tolerance), and scalability	Unstructured and schema-less data
Time Series	Time Series	Summary, Aggregates	Efficient storage and processing for high frequency data	Data access as single columns, robustness is of importance given susceptibility to error due to missing data
Streaming	Storm	Java, Topology	Quick insight from streaming and real-time data	Slow recovery from faults
In-Memory	Interactive	SQL, Script	Scalable dynamic capacity, low latency, and low (quick) overall response time	Large main memory (RAM) requirements
Single Node	R / Python	Script and Packages	High productivity, quick prototyping and proof of concept; rich data science libraries	Limited in terms of scalability
Graph	GraphX / GraphLab	Spark, TensorFlow	Intuitive and visual representations of computational problems, represent arbitrary data and systems as nodes and connections	Not all algorithms can be represented as graphs
Custom	Custom	Java	High level of data and algorithm flexibility	Custom programming, lower productivity

Harper, E., Zheng, J., Jacobs, S., Dagnino, A., Jansen, A., Goldschmidt, T., Marinakis, A., “Industrial Analytics Pipelines”, IEEE BigDataService (2015)

Analytics Design and Implementation Process

Continuous Improvement



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System Characteristics Related to Analytics

Industrial analytics requires many services from IIoT

Safety

Design industrial analytics processes and computations to prevent unintended operation and independently validate that the resulting actions do not harm life or property

Security

Provide defense in depth so that if a malicious or un-intended action compromises one security or accountability measure then another measure still guards the assets

Data Management

Common across tiers and accessible using a federated information model that supports search, classification and markup to enable rapid industrial analytics application development

Connectivity

Distributed architecture requires connectivity between components, not only between collocated processes but also across wide-area and global networks

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ABB