De stand van zaken van data management software in het laboratorium

Peter Boogaard

Industrial Lab Automation

17 November 2017 – Wageningen – Nederland

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Industrial Lab Automation

Industrial Lab Automation

Peter Boogaard

- Independent consulting to address harmonization, integration and consolidation in science based processes
- Degree in Analytical Chemistry
- Introduced to Lab automation since 1981
- 30+ years @ international companies
- Founder of the annual Paperless Lab Academy
- International publications
- Active ISPE member (GAMP DI SIG & QbD/PAT)
- After work… Sailing & Music

QbD & PAT
The Scientist Is No Longer In The Laboratory, But Integrated In The Overall Quality Process

Considerations for Software Expansions and Upgrades

Informatics: The Glue to Build Enterprise Knowledge

Is less more in a paperless laboratory?

JOINING UP THE LABORATORY

BioPharma Asia

WHEN DATA COMES TOGETHER

Facing Cross-Industry Challenges in the Food and Pharma Industries

HOW TO IMPROVE DATA INTEGRITY

LABORATORY INFORMATICS GUIDE 2017

ROADMAP TO DIGITAL CONVERGENCE

Paperless Lab Academy® 2018
Milan, March 20-21

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GMP Journal

ENGINEERING PHARMACEUTICAL INNOVATION ISPE
GAMP® Data Integrity Special Interest Group

Empowering the eData Life Cycle

Delivering scientific evidence to data consumers

"eConnect, eManage, eDecide, eArchive"

Paperless Lab Academy® 2018
Milan, March 20-21

"eConnect"

- Effective workflow based self-documenting **data capture strategies**
- New data capture approaches to embrace **Internet of Lab Things** IoLT
- Models to embed intelligent software in instrumentation and sensors
- Integrating external collaborators and scientific literature knowledge

"eManage"

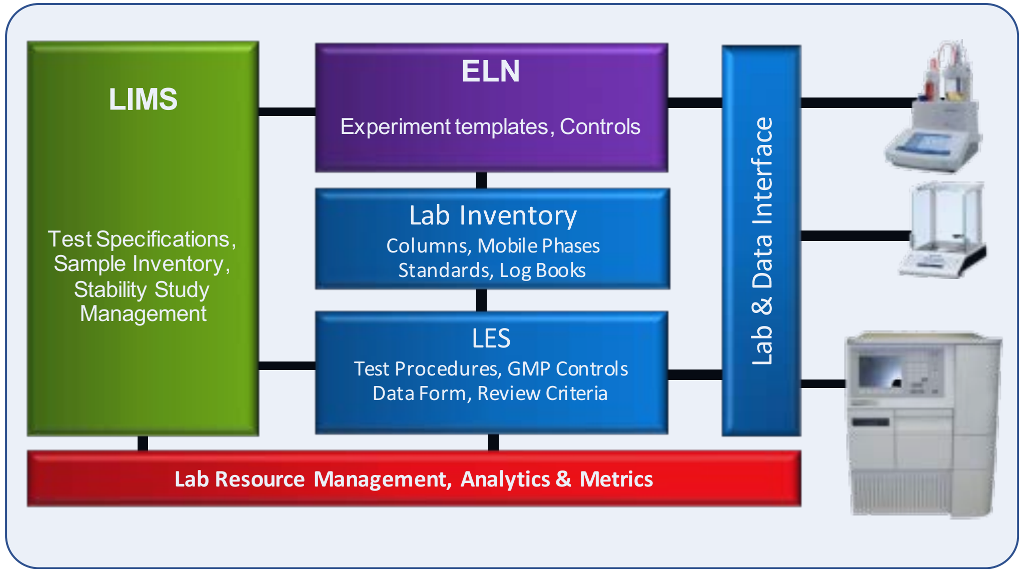
- Innovative methodologies to manage scientific master and meta data
- Concepts to prepare for new regulatory and data integrity challenges
- Strategy to harmonize / reconcile taxonomies and ontologies to boost insight

"eDecide"

- Adopting data analytics and visualization tools to materialize scientific knowledge
- Strategies to ease access and reduce complexity to non-scientific data consumers
- Enabling the power of Industry 4.0 to the laboratory

"eArchive"

- How to reduce the struggle finding the right data in the growing digital universe
- Essentials to secure long-term multi-departmental archiving
- Approaches to manage cost, sustainability and infrastructure processes



www.paperlesslabacademy.com

Industrial Lab Automation

PUBLICATIONS Peter Boogaard - Industrial Lab Automation

Free Download @ www.industriallabautomation.com/Publications.php

ROADMAP TO DIGITAL CONVERGENCE

Data intensive science is becoming mainstream, and new technology will change the dynamics of how scientists will work together. Many cross-industry best practices can be used to enable cross-functional collaboration between internal information silos to transform scientific information into actionable insights. What will the Internet of Lab Things (IoLT) bring in the fguture?

GMP Journal

Trends In Laboratory Informatics. Just like almost anywhere else, informatics is the normality in lab operations. Data intensive analytics create gap-less knowledge management systems also facilitating the cross-sectoral collaboration.

Electronic Laboratory Notebooks

ELN Means Many Things to Many People

ELN means many things to many People. ELNs mean many things to many people. This article starts with the end user in mind and look at the application from a user centric perspective. What is an Electronic Laboratory Notebook (ELN)? What function does it serve? Where does it fit within my laboratory informatics strategy? Do we need an ELN, and if so what would be best for my company's needs? When should I use an ELN, or a LIMS or both?

HOW TO IMPROVE DATA INTEGRITY

Data integrity is currently one of the highest cited areas in regulatory observations. Yet, data integrity is not a new requirement. In this article I will highlight the how can reduce data integrity inconsistencies

Linking an Instrument to a Tablet

Still a bridge too far?

For how long do we need to be professor to link an instrument to a tablet in the laboratory? Why can we connect almost any smartphone using Bluetooth in our personal lives ourselves and why do we need a professor to transfer simple results in the laboratory to our ELN, LES or LIMS

In this article, I will share experiences and observations how the scientific high-tech community, can benefit from adopting paperless processes in the laboratory. Is it because paper doesn't require any significant investment budget, or is it the low barrier to access, since paper even works without power or the need to have access to an information infrastructure, or is it just simply that the "what's in it for me" question hasn't been answered satisfactorily for the scientists?

MANAGING CHANGE IN THE LABORATORY TO DELIVER MORE VALUE

New **scientific data consumers** are increasing the value of laboratory. Research, manufacturing and regulatory procedures have been unchanged for years. There is an urgency to revisit these. The need to integrate the legacy silo based departments is becoming a top priority agenda item in many boardrooms.

JOINING UP THE LABORATORY

It is **pure waste** to perform labour-intensive hunting for information across multi-vendor, multi-technique databases, manual transcription checking and to manually create reports. What are these challenges to create value for the consumers of the laboratory data?

WHEN DATA COMES TOGETHER

When considering data integration, we must first **stop thinking 'technology'**. Integration is not just about instruments or other software platforms. Instead, it is about integrating processes, accelerating ideas and facilitating mandatory compliance requirements more economically.

Less is More: Adopting a Self-documenting Paperless Mindset

The power of a Paperless Laboratory is the ability to enable organizations to implement **self-documenting processes** that produces GxP-compliant documentation to support corporate Cost of Goods Sold (COGS) optimization

Considerations for Software Expansions and Upgrades

Headaches about **upgrading** your software? Considerations for software expansions and upgrades. Before you decide to rock the boat, several key decision-making steps can help to ensure a smooth and successful upgrade. The last thing to do is to start is a project to change a working enterprise application

Informatics: The Glue to Build Enterprise Knowledge

It is time to put more emphasis on the preventing facet and re-order the sequence of the **CAPA** abbreviation **into PACA**. It is proven that his theory to adopt continuous improvement strategies to decrease variability resulted in significantly better products and financial performance.

Facing Cross-Industry Challenges in the Food and Pharma Industries

Food companies are becoming pharma companies. In this publication several overlaps and differences are discussed to spur a discussion on how both pharma and food industries may benefit from adopting the best practices.

Publication Download pages

www.industriallabautomation.com/publications

What general technology needs to be **improved significantly**, to accelerate the acceptance to work electronic?

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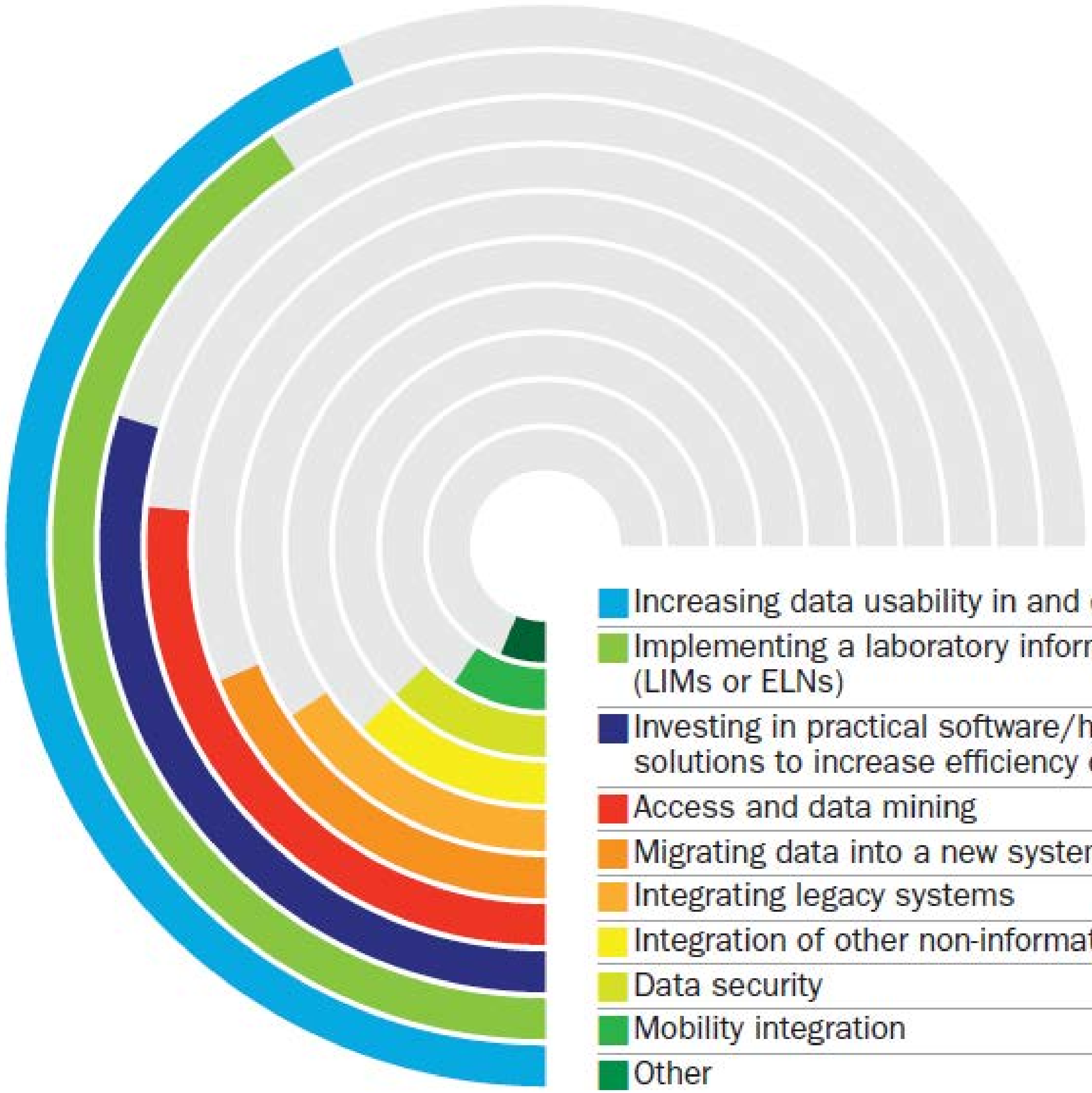
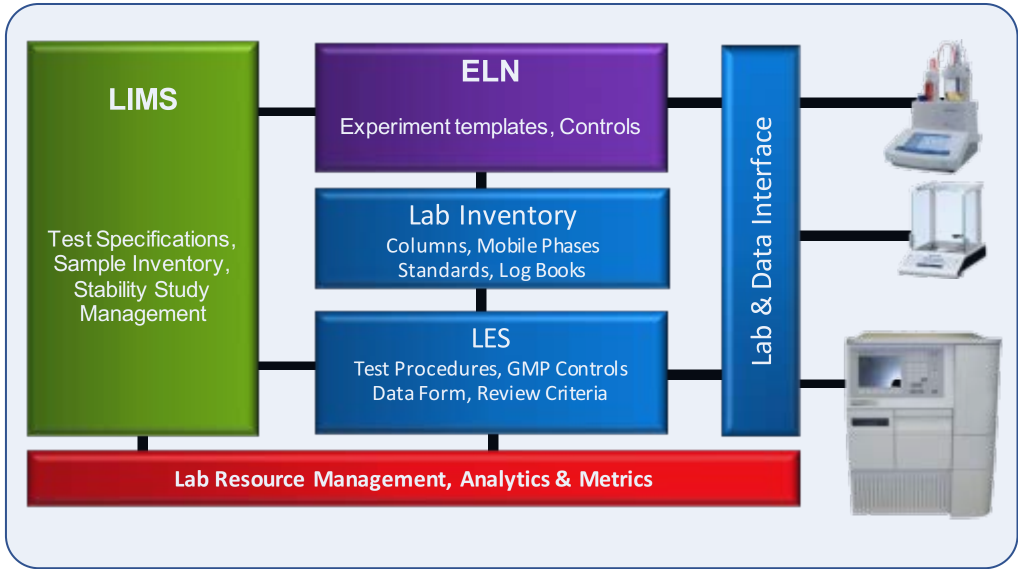
Batt%

Lab informatics expectations (2016)



Increasing data usability in and out of the laboratory	58.3%
Implementing a laboratory informatics system (LIMs or ELNs)	54.2%
Investing in practical software/hardware solutions to increase efficiency of the workflow	39.6%
Access and data mining	35.4%
Migrating data into a new system	25%
Integrating legacy systems	20.8%
Integration of other non-informatics software systems	16.7%
Data security	16.7%
Mobility integration	12.5%
Other	8.3%

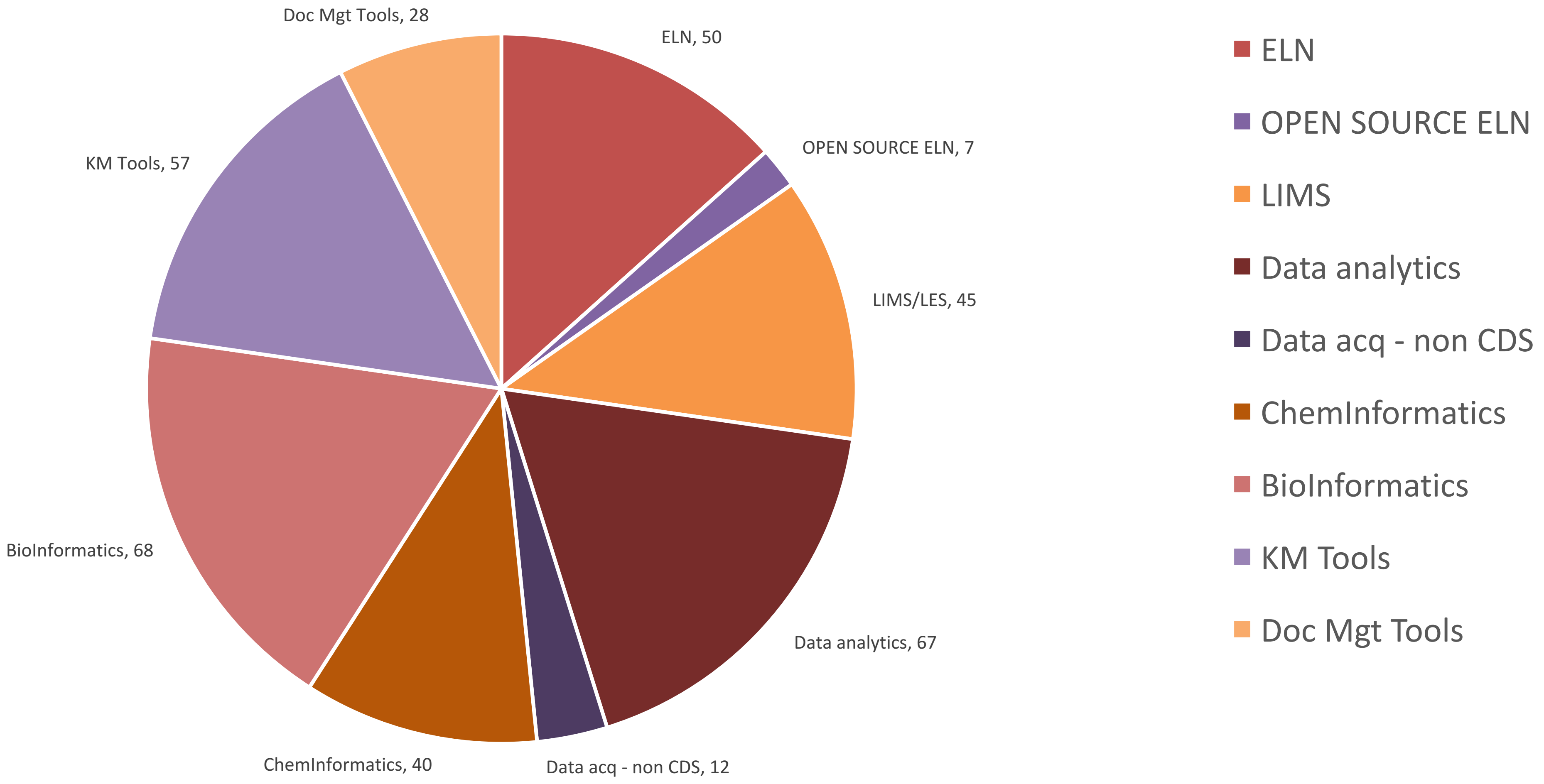


Source: IQPC & SLE 2016

Data-intensive science is becoming mainstream

Where to Start?

Scientific Application Landscape (total 374)



Source Atrium Research website 2017

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Scientific Software landscape

Innovation

Process Efficiency

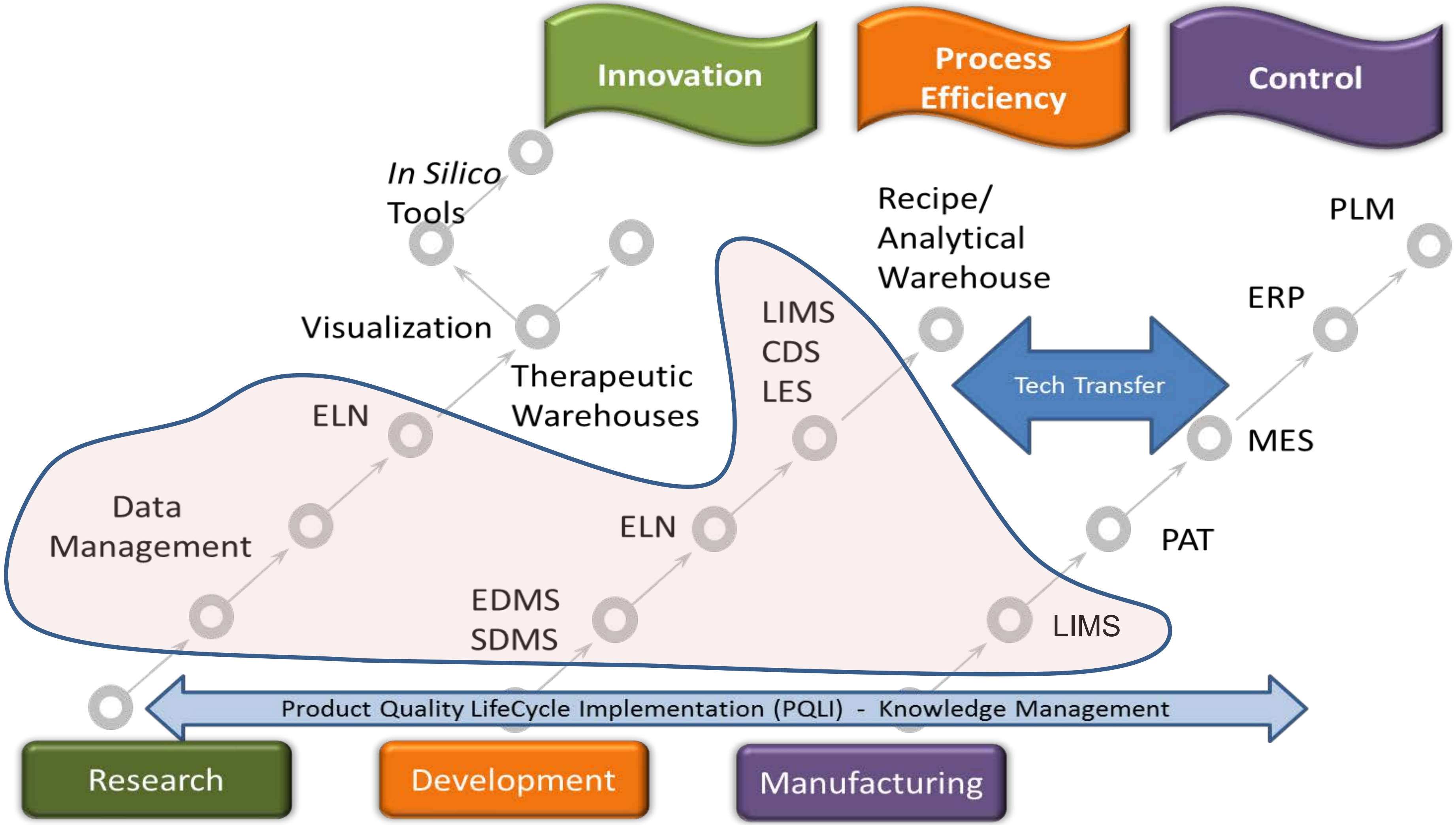
Control

Research

Development

Manufacturing

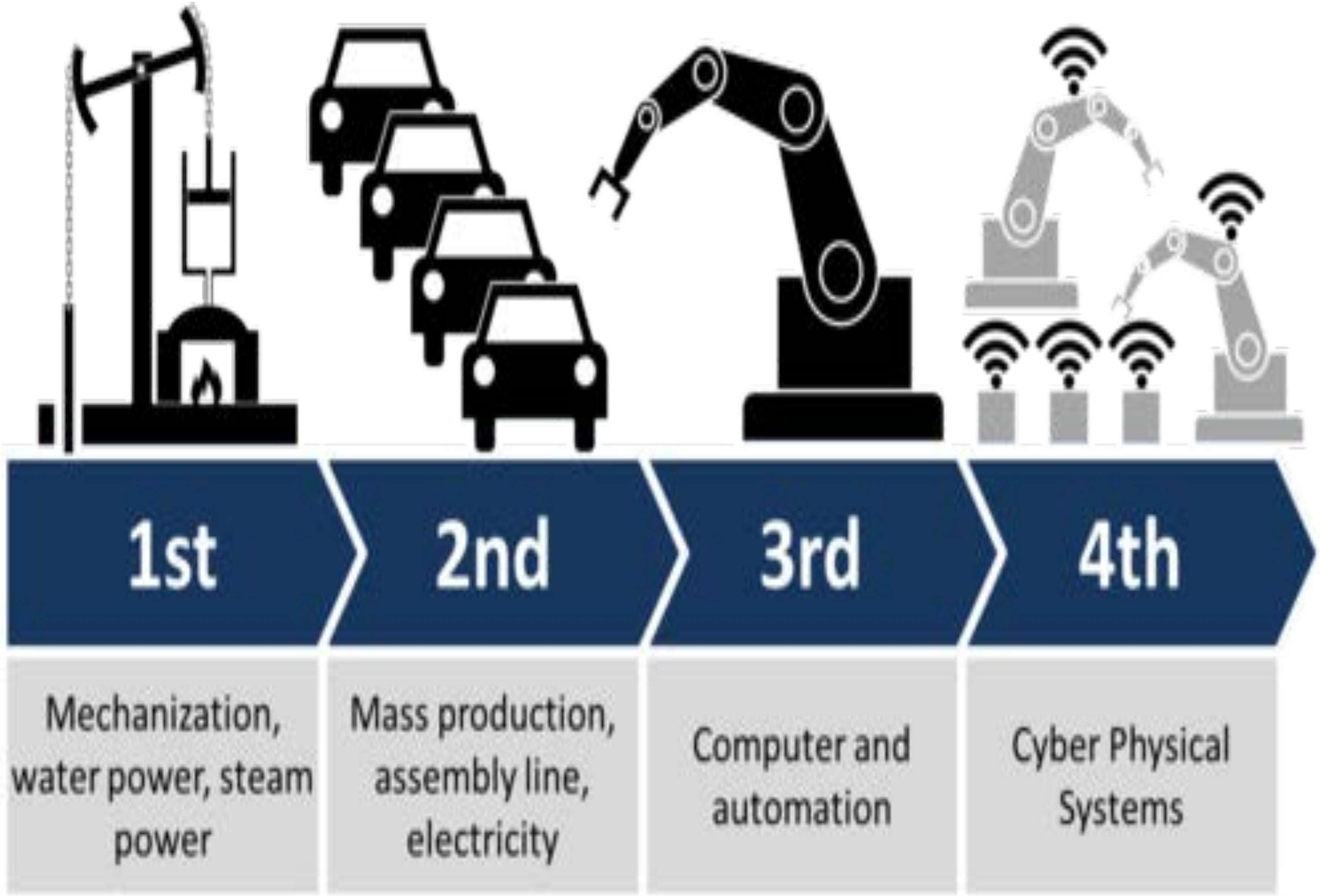
Scientific Software landscape



Source: Accelrys

Industrial Lab Automation

Industry 4.0
The Digital Revolution in Manufacturing



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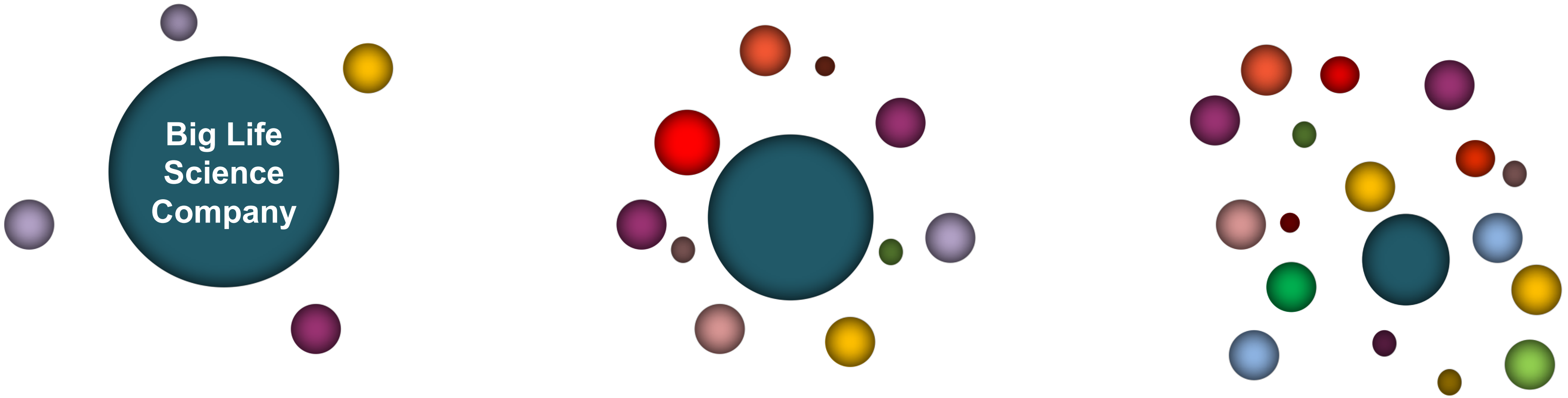
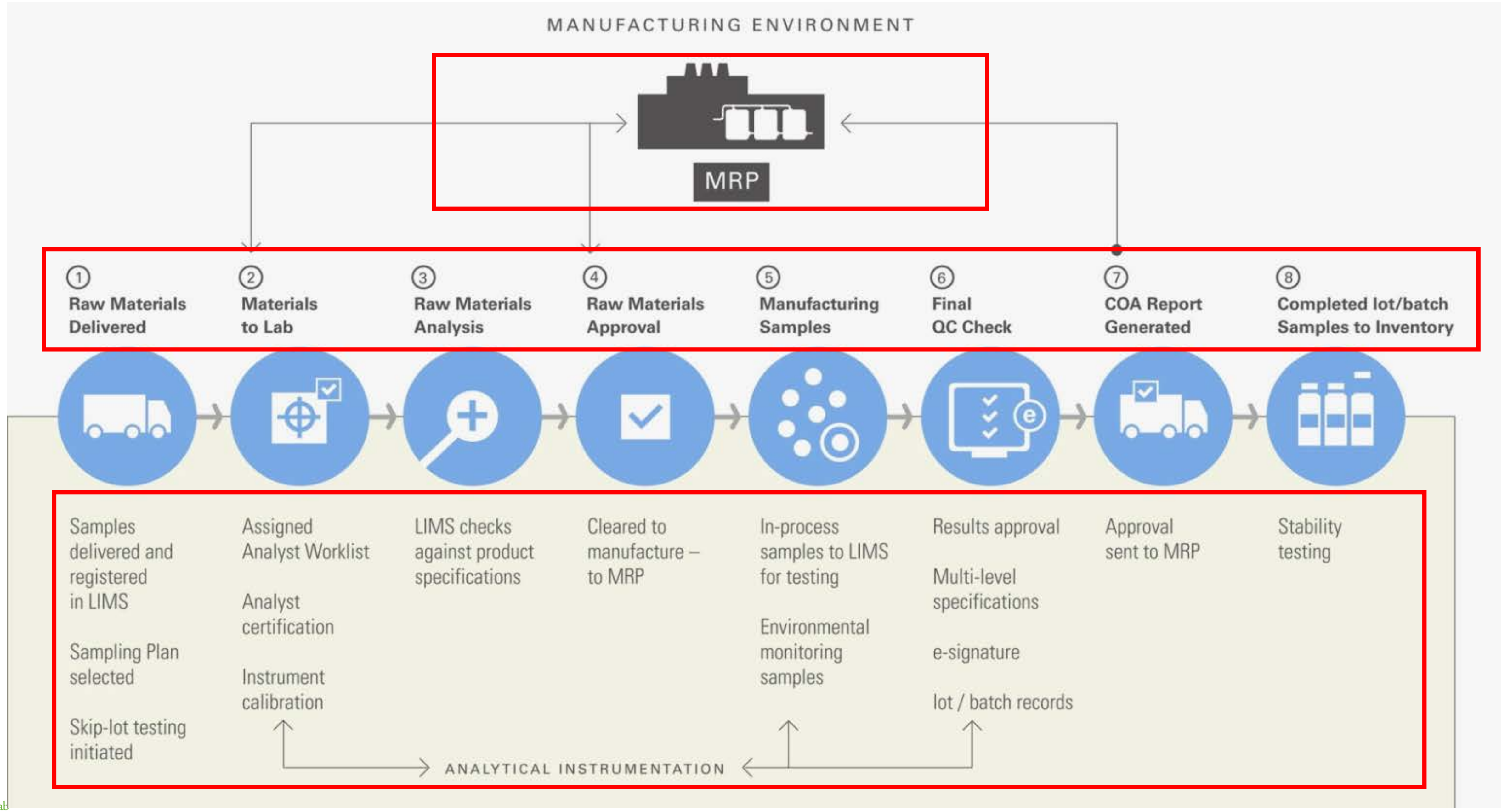
Scientific Information Landscape

A rapidly evolving ecosystem



	Yesterday	Today	Tomorrow
Innovation Model	Innovation inside	Searching for Innovation	Heterogeneity of collaborations. Part of the wider ecosystem
IT	Internal apps & data	Struggling with change Security and Trust	Cloud/Services
Data	Mostly inside	In and Out	Distributed
Portfolio	Internally driven and owned	Partially shared	Shared portfolio

Typical LIMS manufacturing workflow process



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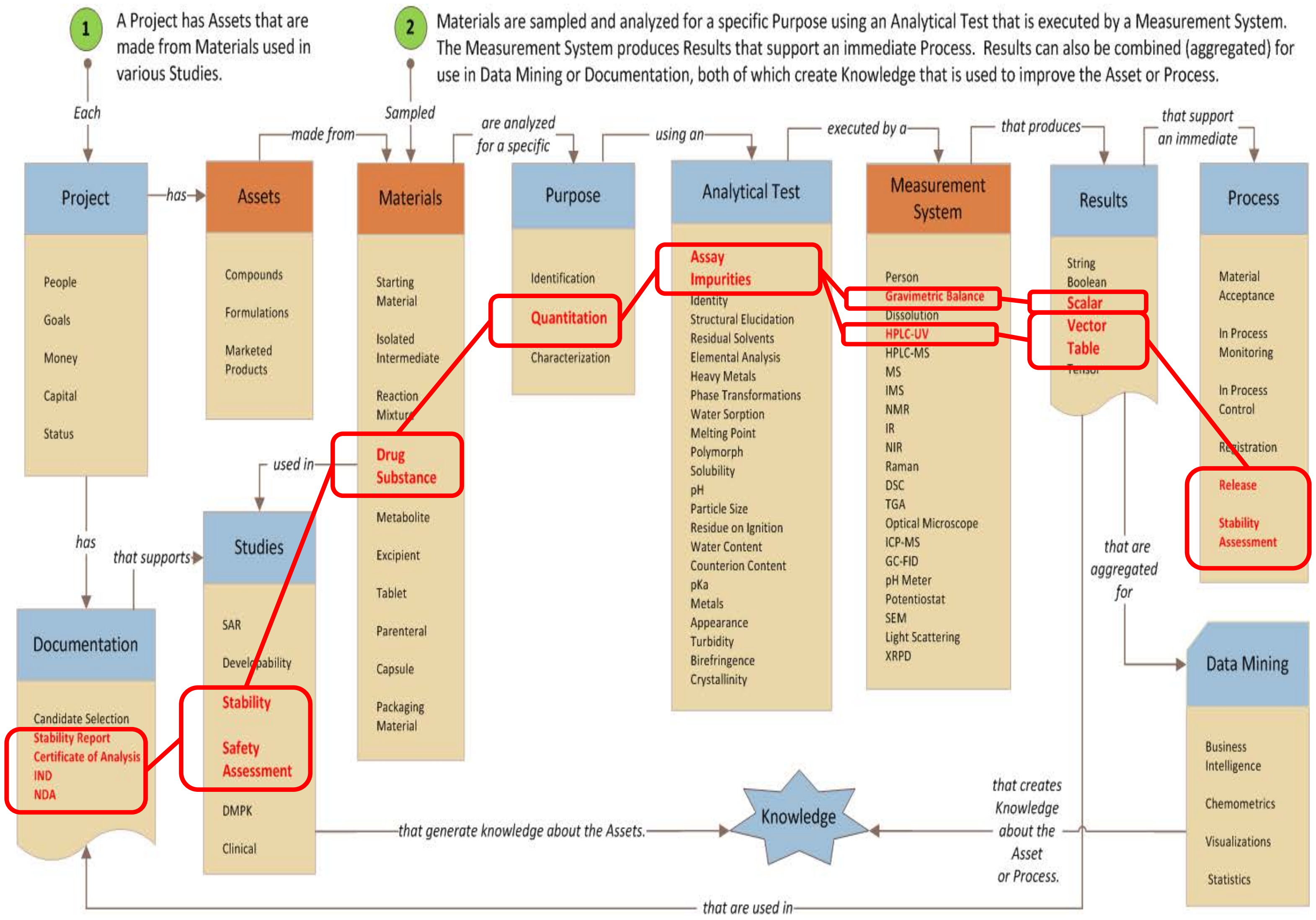
Example of Laboratory Data Life Cycle model



Industrial Lab Automation

#1 CHALLENGE

UNDERSTAND DATA
CONSUMER NEEDS
& THEIR OBJECTIVES

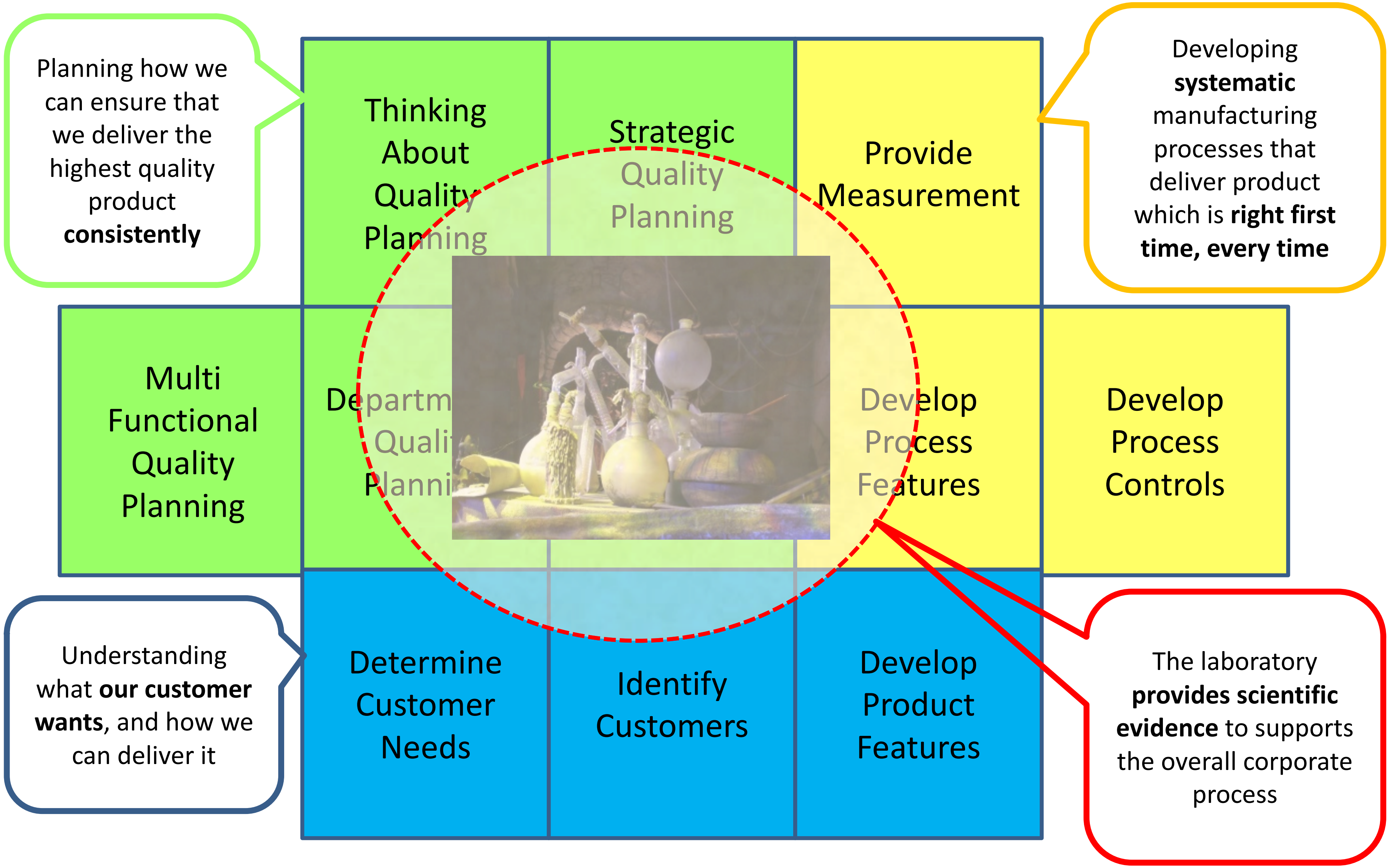
“We believe that the largest drug is the food that you eat three times a day, every day of your life”

Luis Cantarell, President and CEO of Nestlé Health Science - Brett Gundlock for The Globe and Mail Sept 6, 2012

Read full article

Source: Facing Cross Industry Challenges in the Food and pharma Industries Scientific Computing by Peter Boogaard

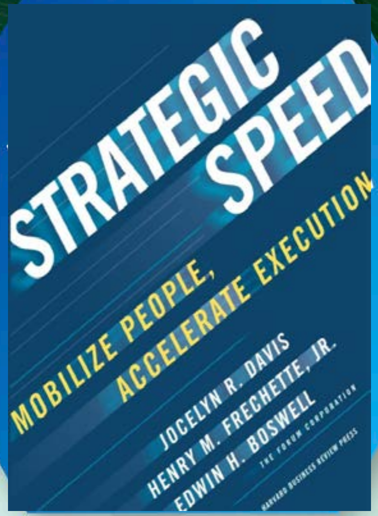
Defining the holistic process



Source: Gawayne M. Jones & P.J. Boogaard

Paperless Lab Academy

Gran Hotel Rey Don Jaime



FINDING the SPEED to INNOVATE

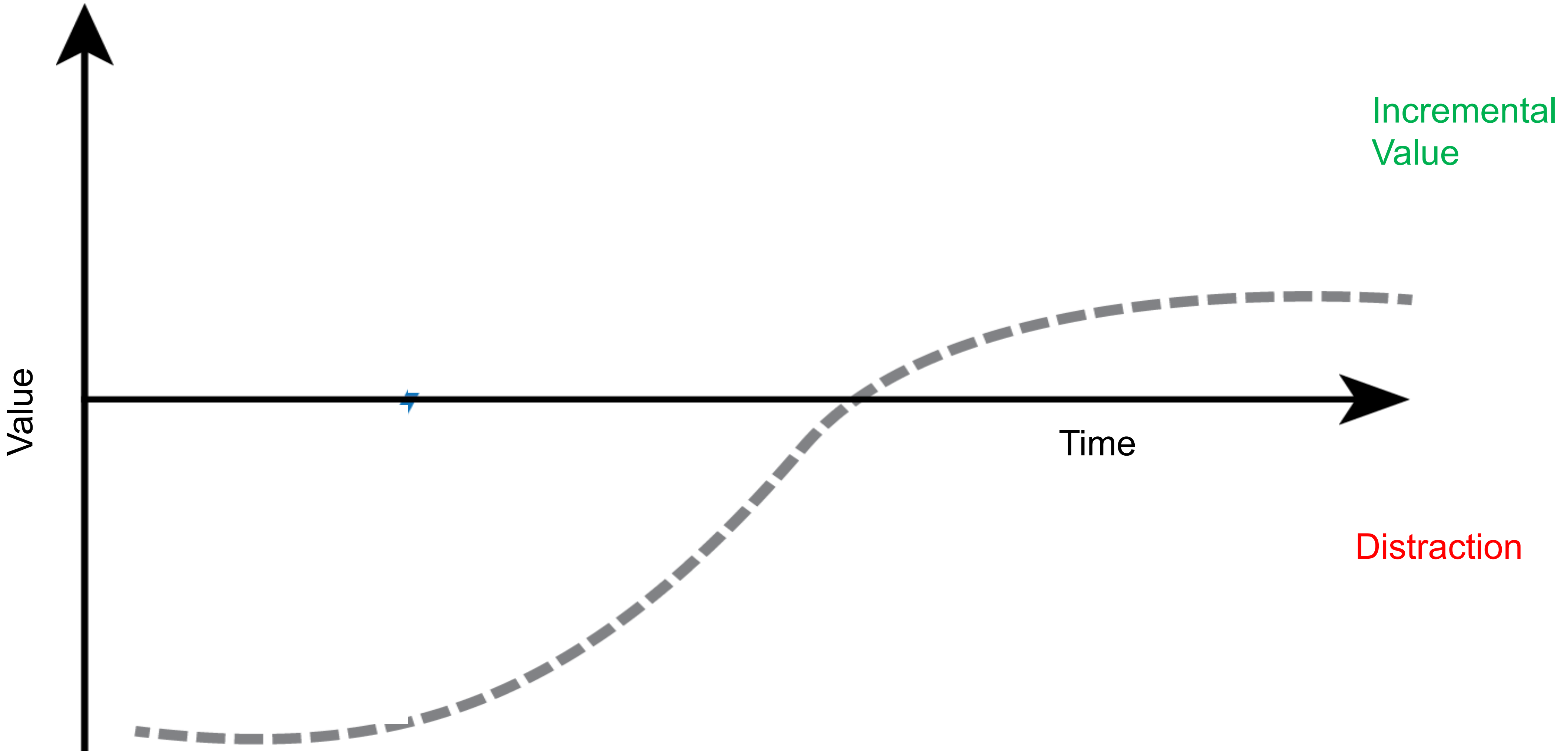
Strategies to effective materialize laboratory knowledge

Create "Strategic Speed"

Minimize Time to Value; Maximize Value Over Time

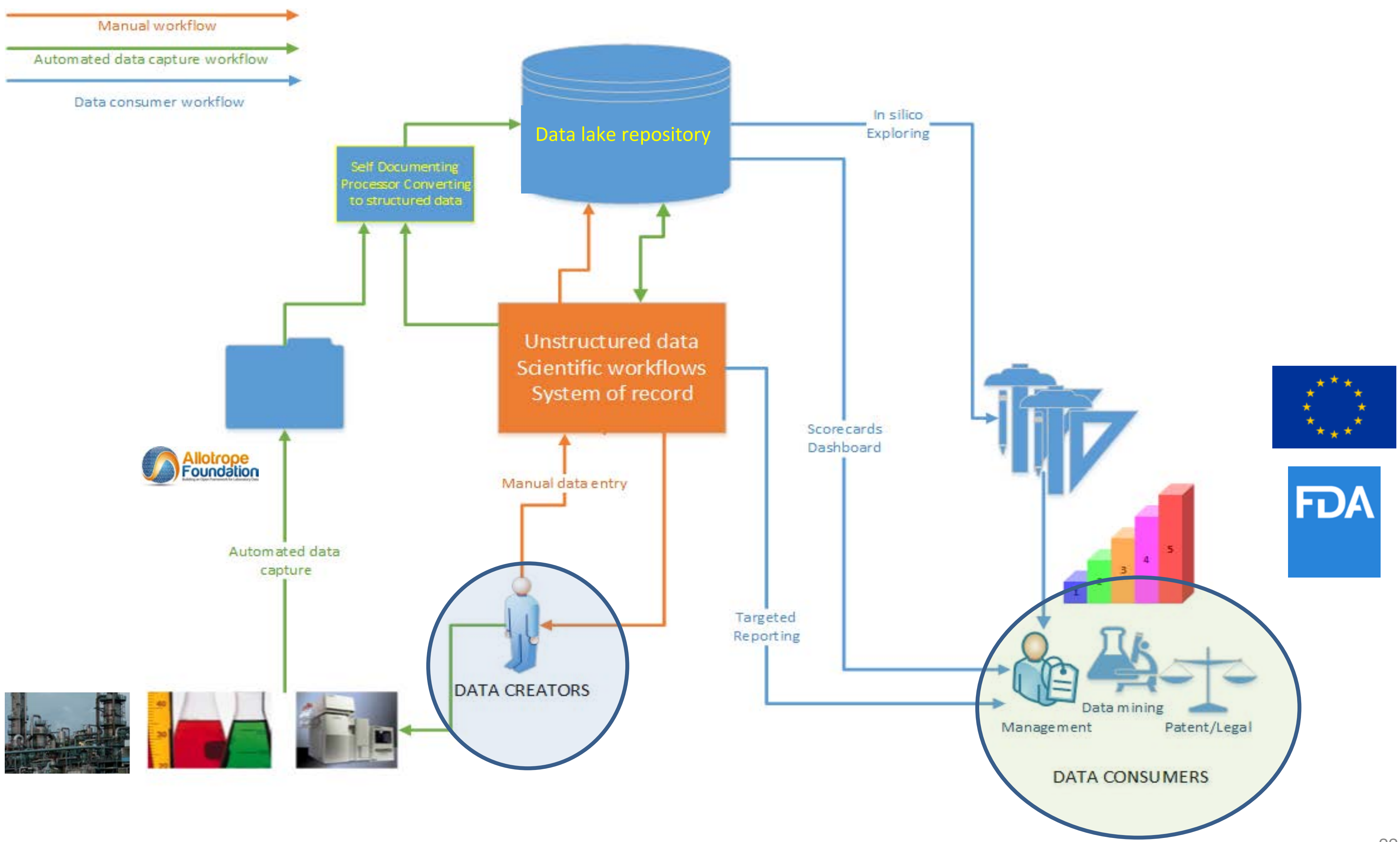
Create “Strategic Speed”

Minimize Time to Value; Maximize Value Over Time



Strategic Speed: Mobilize People, Accelerate Execution by Jocelyn R. Davis, Henry M. Frechette, Edwin H. Boswell

Value of lab data will be expanded by understanding the data consumer need



#2 CHALLENGE

USING THE RIGHT TOOLS

Non regulated ELN LES Regulated LIMS

Chemistry
General chemistry and reactions
Medicinal chemistry
Synthetic chemistry
Cheminformatics
Process chemistry
Analytical chemistry

Engineering
Design engineering
Test engineering
Materials simulation
Process engineering
Process manufacturing

Procedural Execution
Paper-on-glass execution
QA/QC SOP execution
Quality GxP studies
R&D analytical support
Analytical formulation
Self-documenting data capture

QC Manufacturing
Analytical instrument capture
Quality manufacturing
Repeatable analytical processes
Lab resource planning

Core ELN capabilities
Documentation of Experiments
Non procedural / free form
Robotic Automation
Electronic Record Keeping
Patent Evidence Creation
Security and external data access

R&D analytical support
Paper-on-glass execution
R&D analytical support
Data analytics
Structures & unstructured support

Core LES/LIMS capabilities
Compliance
Secured Lab Information hub
Enterprise content feeder
Electronic SOP’s Paper-on-glass
Self documenting Paperless lab
Simplifies repeated operations

Biology
R&D assays
Computational biology
Bioinformatics
Omics research
Pathway exploration
Protein modeling

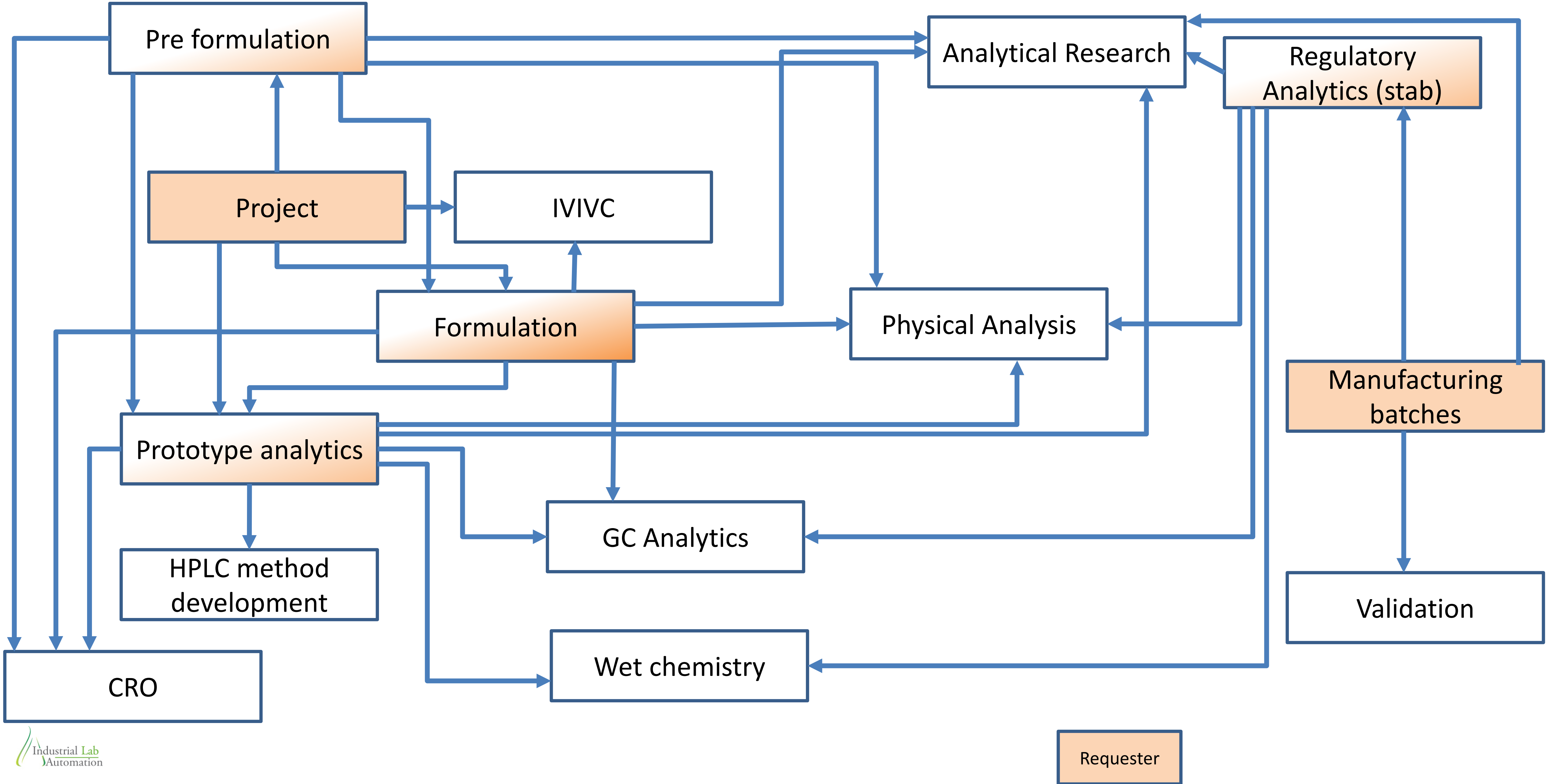
Formulation
Formulation development
Design transfer
Pilot production
Materials blending

Translational Medicine
Healthcare informatics
Clinical trial analytics

Analytical services
Method development
Stability studies
Environmental monitoring
Inventory management
Instrument maintenance

Enterprise integration
Empower/CDS integration
CAPA processes
ERP integration
MES integration
CRM integration

Requester workflow



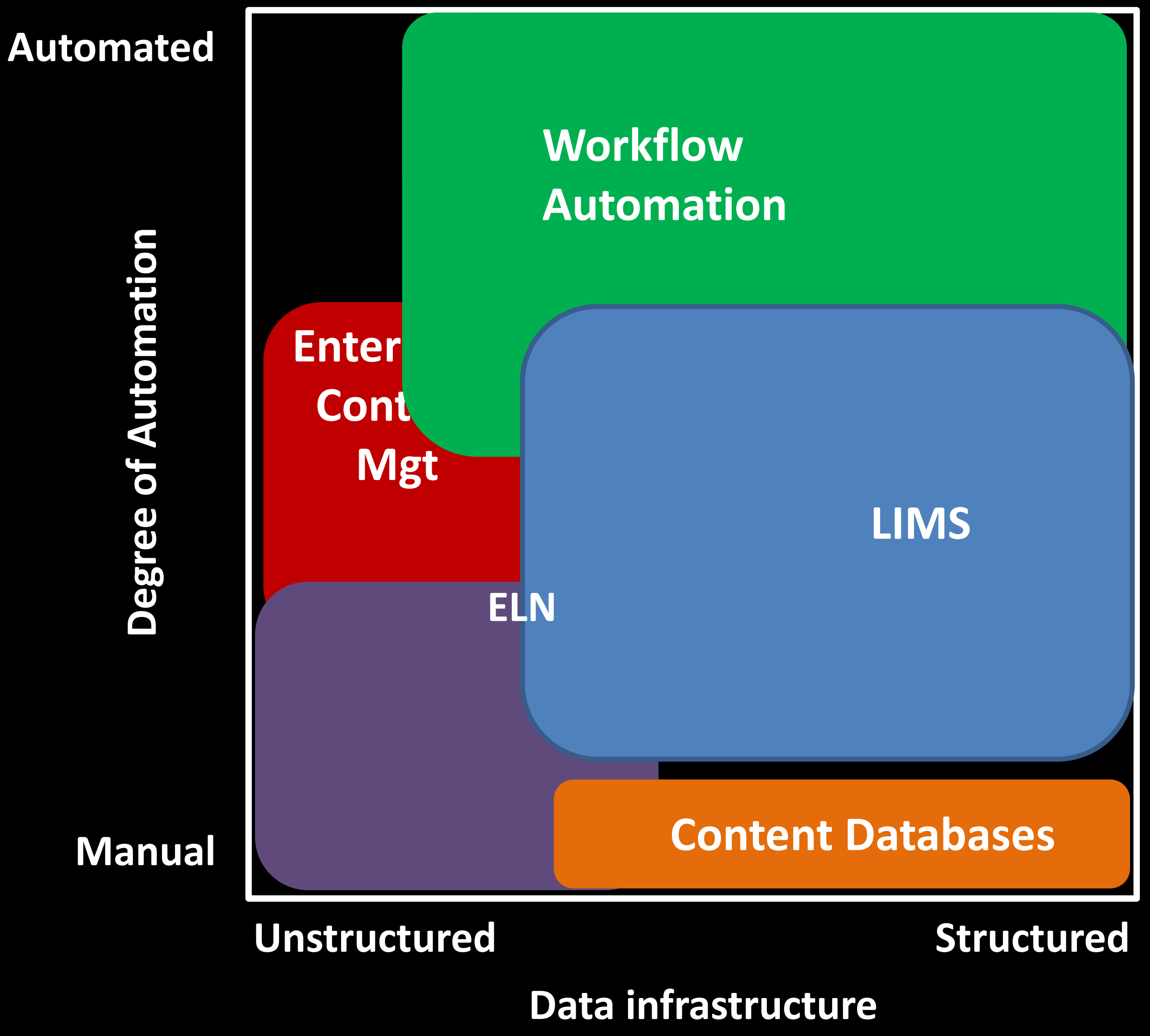
Industrial Lab Automation

In its simplest form, an Electronic Laboratory Notebook can be thought of as for an electronic embodiment of what is currently being done in a paper laboratory notebook.

It is a tool that facilitates workflows that play out in laboratories.

Having said that, Laboratory Information Management System (**LIMS**), Electronic Laboratory Notebook (**ELN**) and Lab Execution System (**LES**) applications **all support this basic definition**, to a greater or lesser extent.

So why bother?



Courtesy Atrium Research

The role of Lab Data management software

eScience

Chemistry
Biology
Formulations

- IP Protection
- Knowledge re-use
- Research Efficiency
- Collaboration

ELN

Procedural
Execution

- Electronic SOP's
- Compliance
- Self documenting Paperless lab
- Simplifies repeated operations

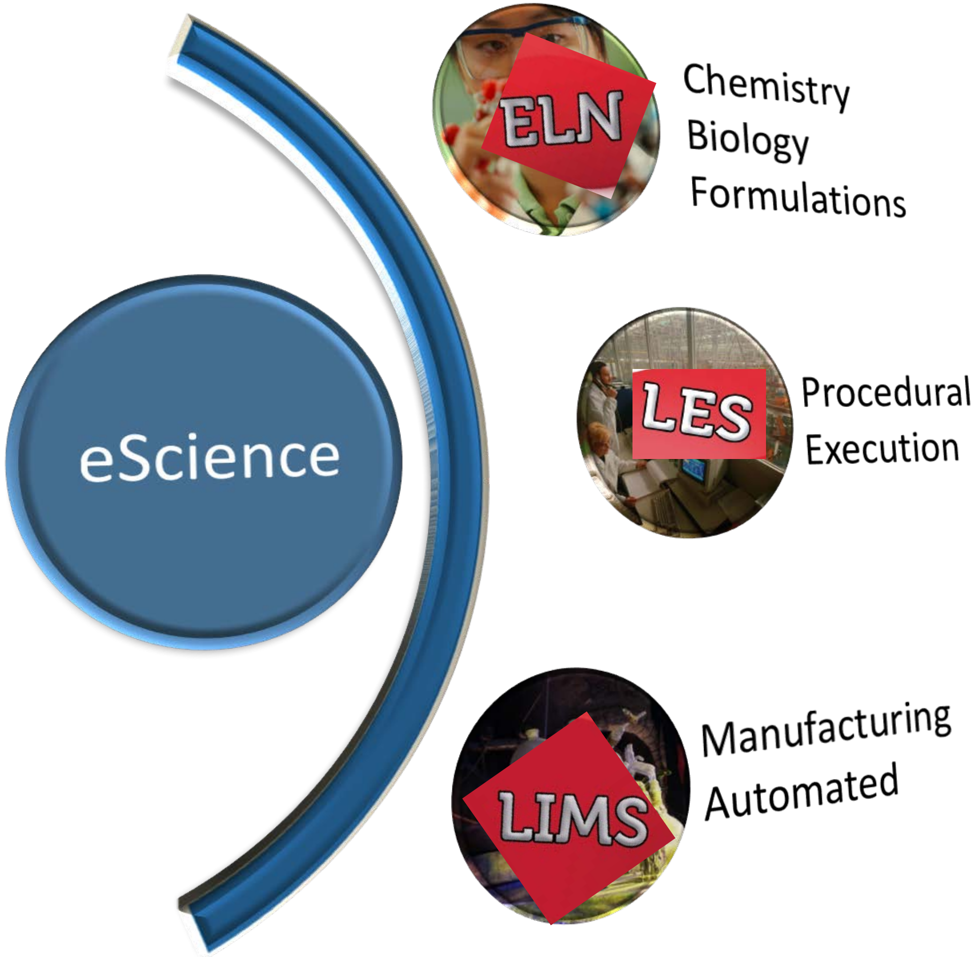
LES

Manufacturing
Automated

- Secured Lab Information hub
- Compliance
- Enterprise content feeder
- Scalable

LIMS

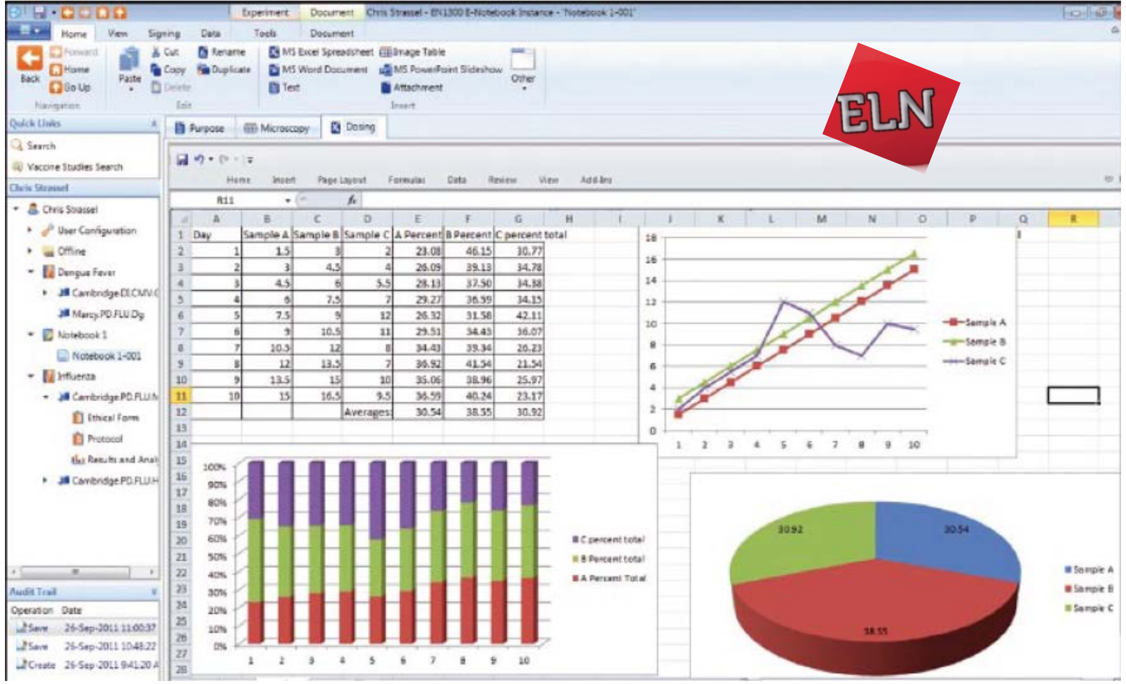
Summary - Behavior of Lab Data management software

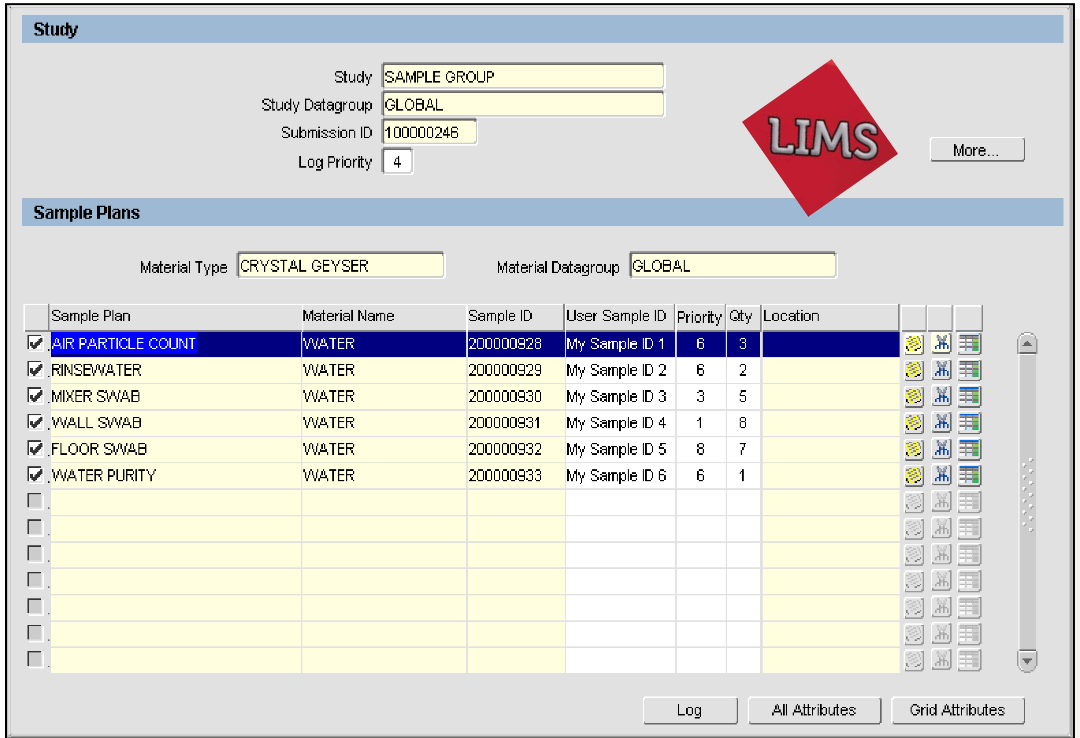


- Experiment centric
- User centric / Adaptable free form
- Scientific databases, Instruments
- Legal & Scientific communities

- SOP workflow centric
- User centric / Natural Language
- Act as paper-on-glass application
- Strong Quality Assurance aspect

- Sample centric
- Organization centric / System defined
- Repeatable standard process workflow
- Regulated manufacturing





LES

Titration Worksheet

Product:	PROPOFOL	Lot Code:	

SOP	20070219_rev05	Current?	
Balance ID		Calibrated?	
pH Meter ID		Calibrated?	

Titrants

NaOH		Normality		Expiration	
H2SO4		Normality		Expiration	

Blank

Blank	mL	Titrant	mL
NaOH		H2SO4	

Sample + 20 mL 1 N NaOH	Weight (mg)	Titrant 1 N H2SO4 in mL
Sample 1		
Sample 2		
Sample 3		

Calculation: ((Blank – Sample)(180.2)(N H2SO4/ N NaOH) = mg Product

%RSD = (SD/average)*100

Sample	mg
Sample 1	
Sample 2	
Sample 3	
Average	
%RSD	

Performed by: ____________________ Date: ______________

SOP: 20070219_rev05

Industrial Lab Automation

Typical Objectives for LIMS/LES

- Validated source for regulatory compliance
- Automate manufacturing workflows
- Electronic Batch Record (EBR) support
- Facilitates self Documenting processes
- Enables cross functional KPIs
- CAPA / PACA evidence
- Complement manufacturing/ERP processes
- Achieve data integrity quality data consistency
- Stability studies
- Environmental monitoring
- Complements CDS systems
- Resource to enabling workflow optimization

Industrial Lab Automation

Typical Objectives for ELN

- Enables to re-use scientific insight
- Facilitates prior knowledge sharing
- Resource for data analytics and formulation optimization
- Self Documenting data acquisition processes
- Exposing KPIs
- Integrates external partner collaboration
- Achieve sustainability goals - reduce paper volume
- Support migration from hybrid (paper) legacy processes
- Achieve data integrity quality data consistency
- IP protection (legal)
- Simplifies tech transfer processes
- To attract new scientists

Industrial Lab Automation

Data Integrity starts @ the source

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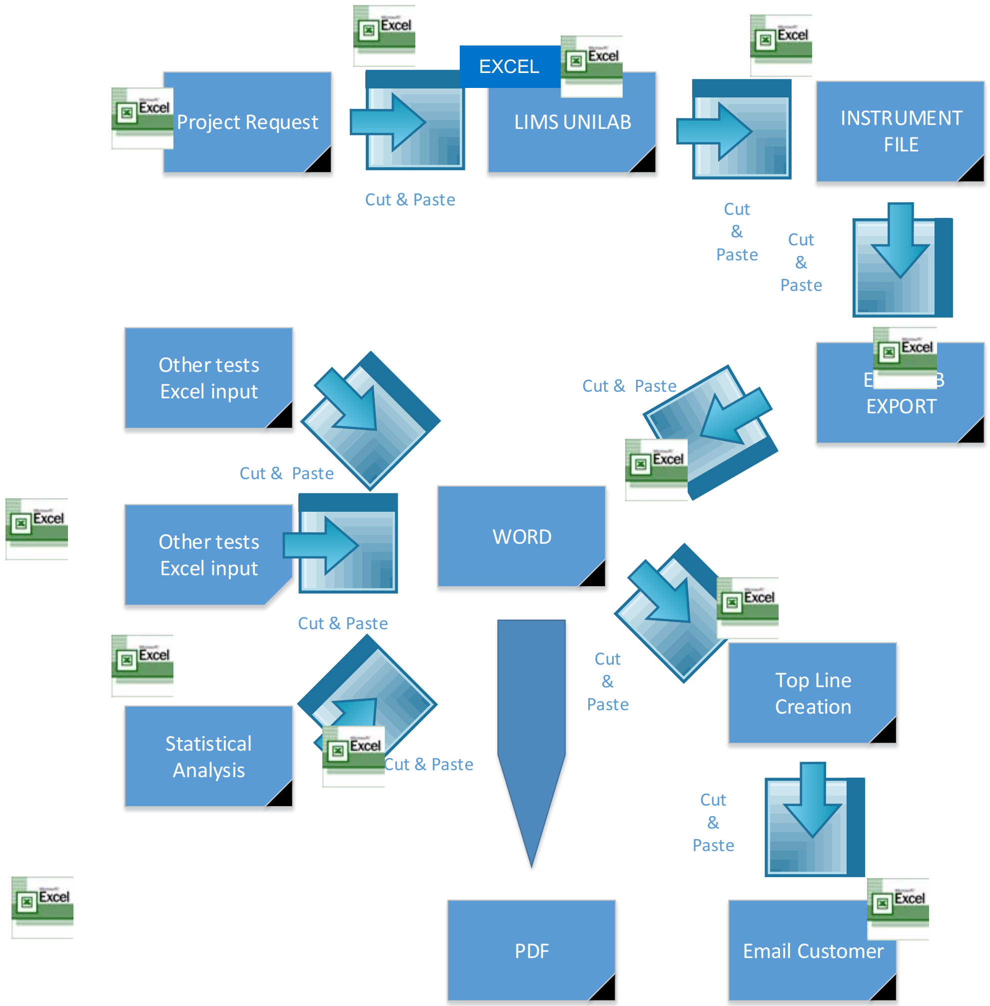
Source: How to Improve Data Integrity
Laboratory Informatics Guide (LIG 2016) / Scientific Computing World

Data Integrity nightmare

COPY/PASTE Madness



Metadata, why important?

- Without Meta data this is just a photo.

Meta data:
Speed, when, where, photo ID, last calibration, …

Courtesy Mettler Toledo PLA2016

Self-documenting processes

Reduces the value of data integrity at the source

Industrial Lab Automation

Source: How to Improve Data Integrity
Laboratory Informatics Guide (LIG 2016) / Scientific Computing World

Self-documenting processes

Reduces the value of data integrity at the source

Courtesy Mettler Toledo

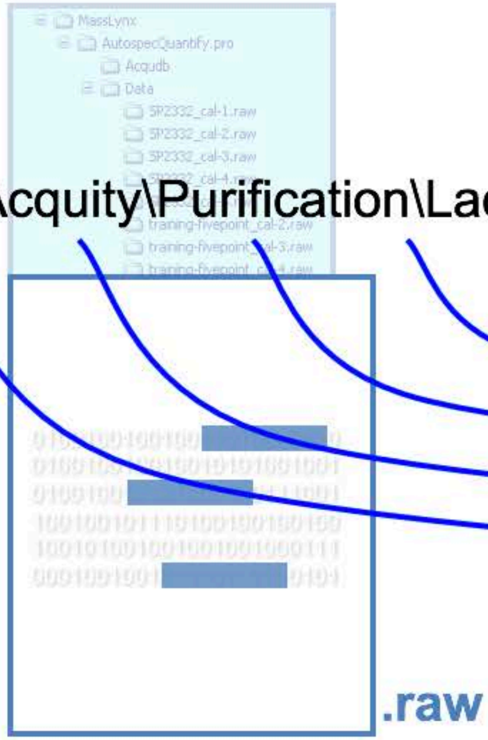
Example of Self documenting processes in the laboratory

SDMS automated acquisition extracts system and fixed metadata

plus metadata from file name and folder structure

and metadata from file content

C:\QC\Acquity\Purification\Lactose_50_7476.raw



File	Lactose_50_7476.raw
Unique ID	236F 2536 4509 …
Date/Time	01.01.2006/18:25:47
Source	PC2222
Batch	7476
Dosage	50
Compound	Lactose
Project	Purification
Instrument	Acquity
Department	QC
Channel	1143
Vial	B04
Method	3/116

Source: WATERS Corp

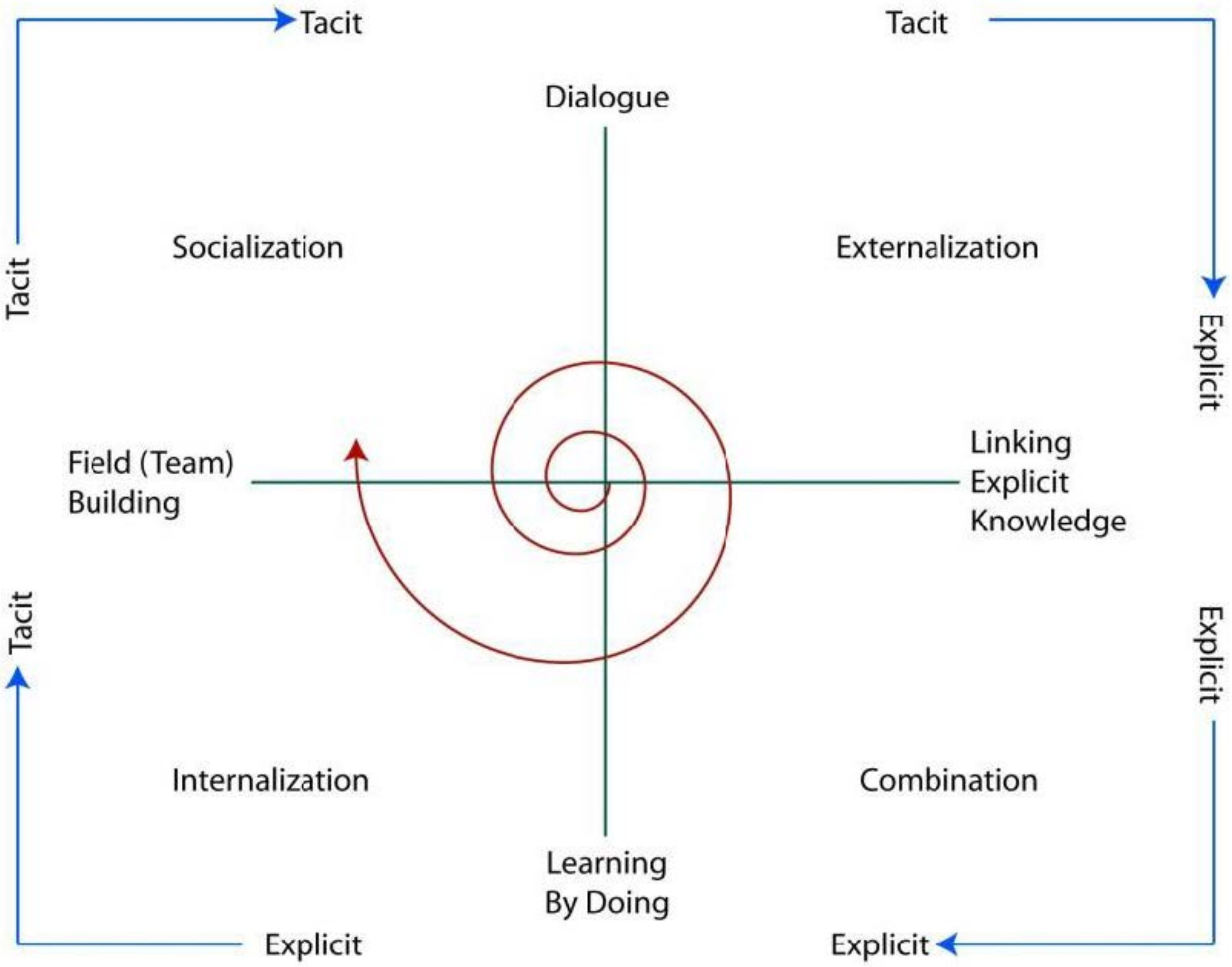
#3 CHALLENGE

CREATING THE RIGHT CONTENT

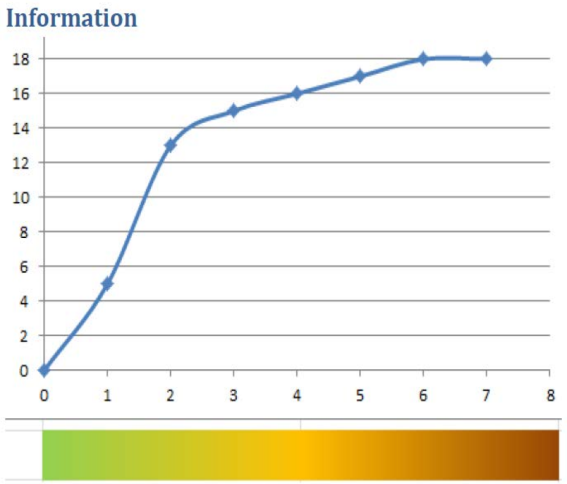
Knowledge is of no value unless you put it into practice

Anton Chekhov- writer

Nonaka's *Spiral of Knowledge* framework for learning



Do we speak the same language?



<u>DATA</u>

To tell the color
To tell what object represents

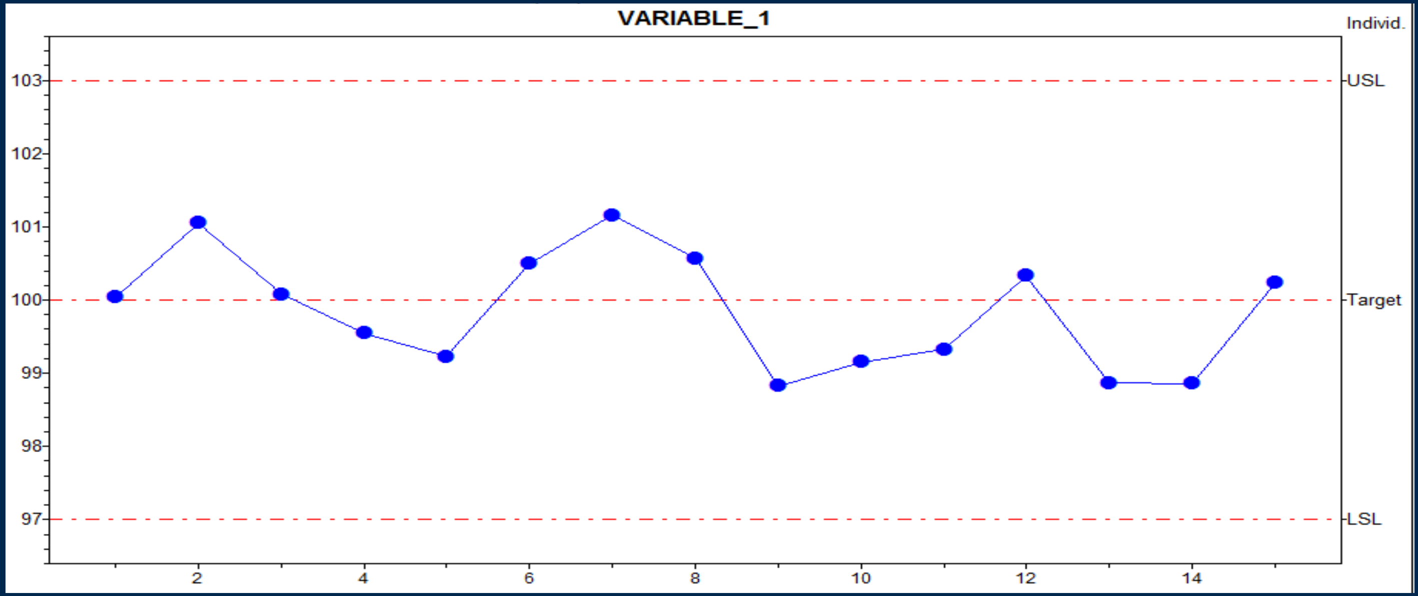
<u>INFORMATION</u>

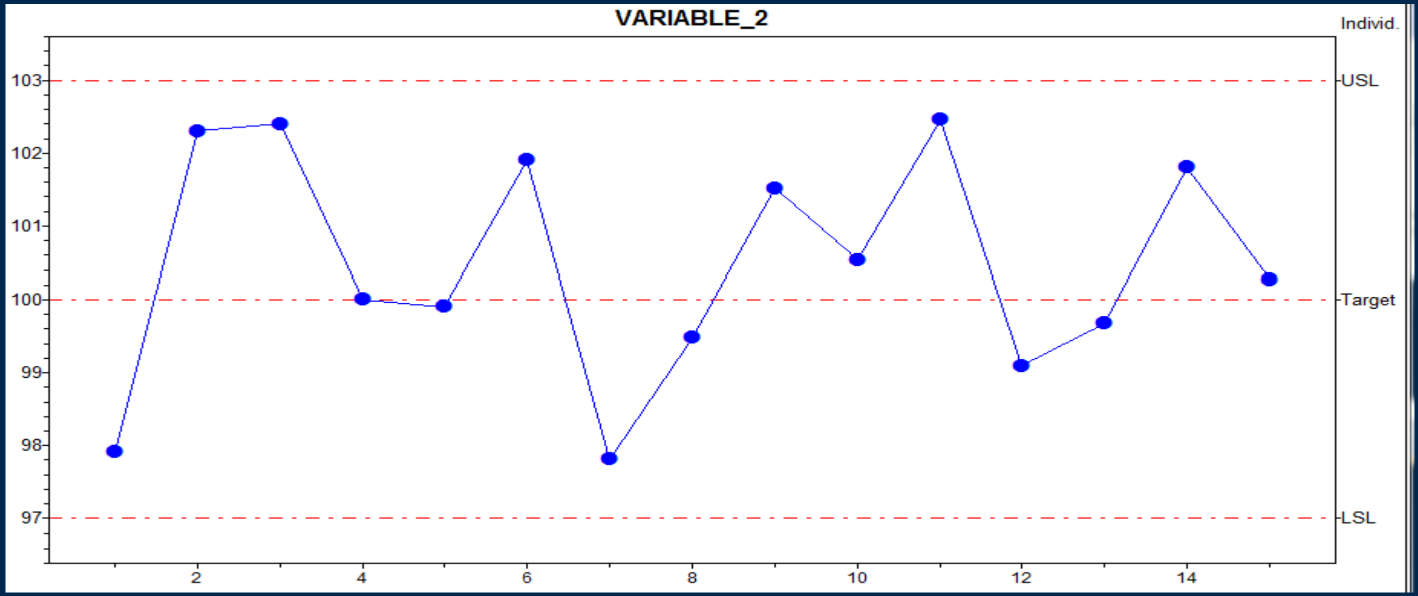
From color
Physical attribute
establish
sugar content
Chemical attribute

<u>KNOWLEDGE / INSIGHT</u>

What to buy
Make decision by linking Information
to the objective

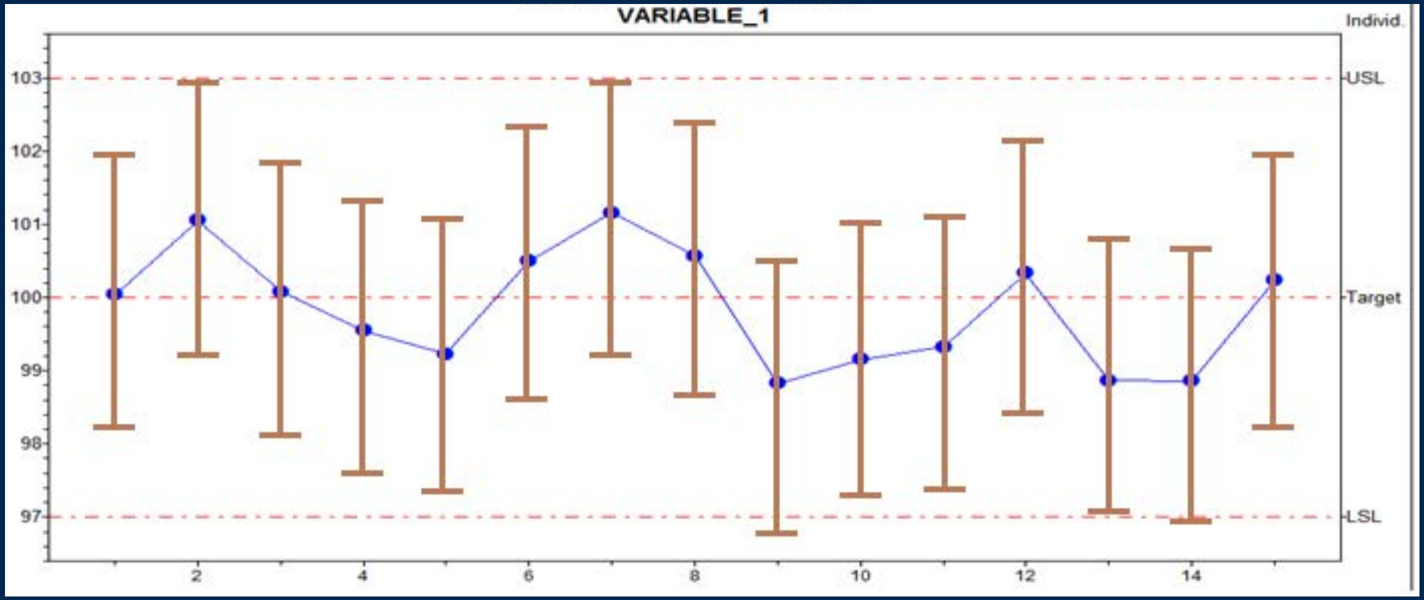
Measurement Uncertainty – which results do you like?

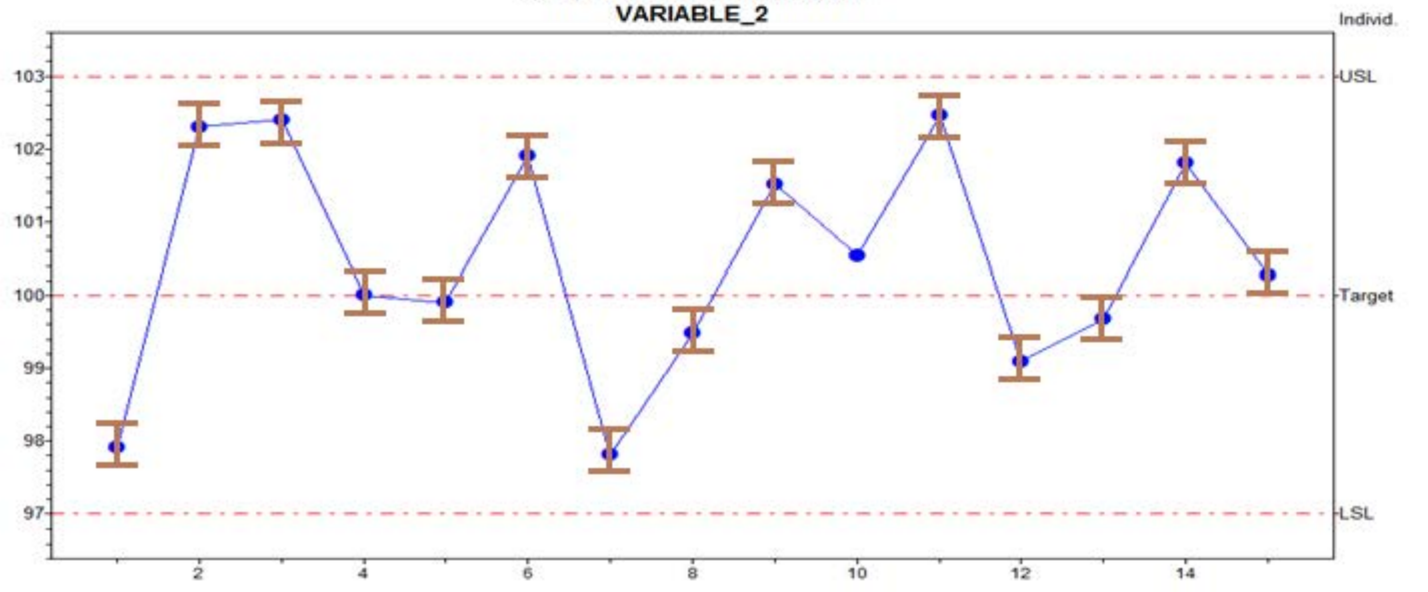




Source: Northwest Analytics

Measurement Uncertainty – which results do you like!





Source: Northwest Analytics

Graph Technology gains traction

Numbers

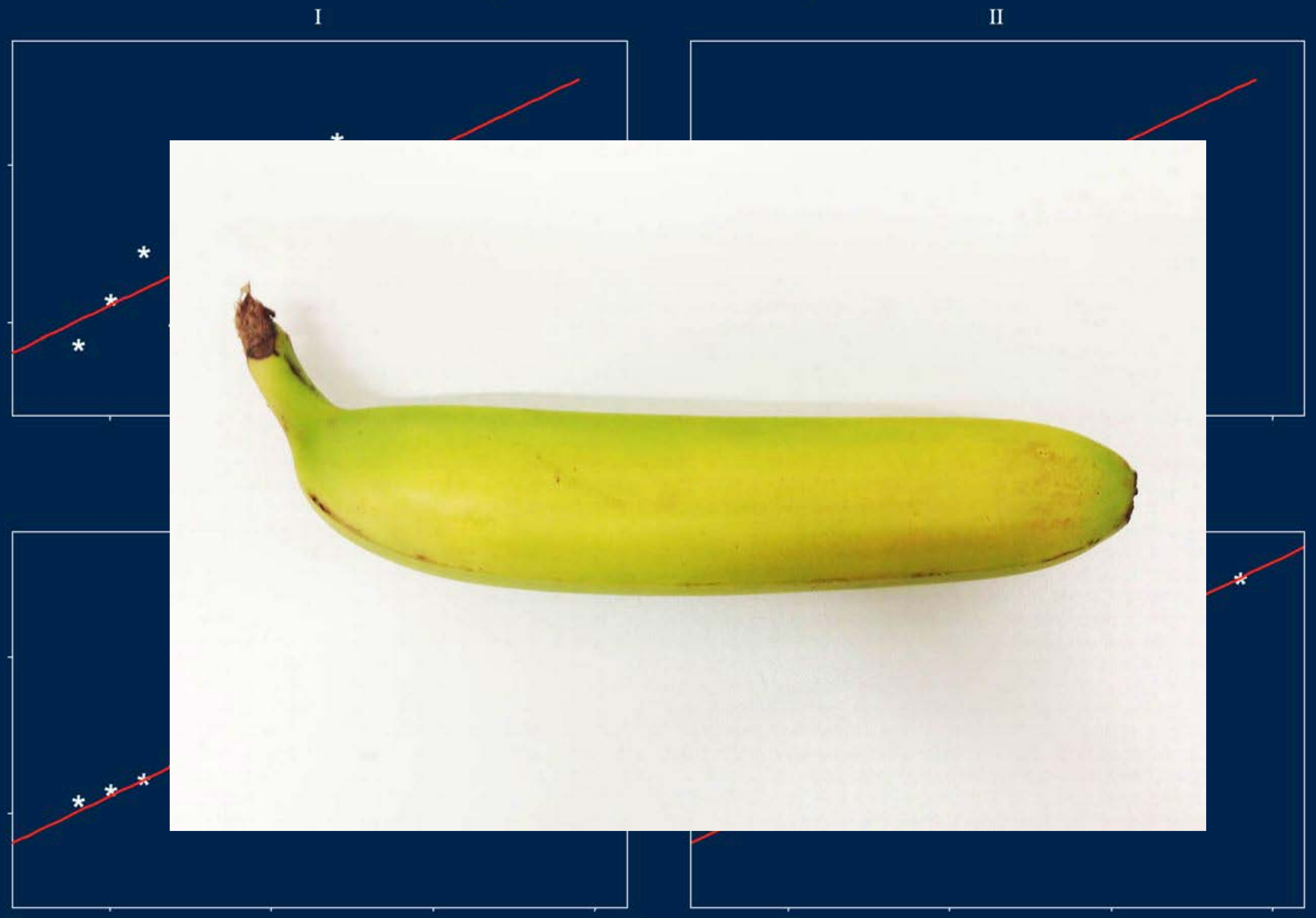
I		II		III		IV	
X	Y	X	Y	X	Y	X	Y
10	8.04	10	9.14	10	7.46	8	6.58
8	6.95	8	8.14	8	6.77	8	5.76
13	7.58	13	8.74	13	12.74	8	7.71
9	8.81	9	8.77	9	7.11	8	8.84
11	8.33	11	9.26	11	7.81	8	8.47
14	9.96	14	8.1	14	8.84	8	7.04
6	7.24	6	6.13	6	6.08	8	5.25
4	4.26	4	3.1	4	5.39	19	12.5
12	10.84	12	9.13	12	8.15	8	5.56
7	4.82	7	7.26	7	6.42	8	7.91
5	5.68	5	4.74	5	5.73	8	6.89

F. J. Anscombe "Graphs in Statistical Analysis", American Statistician, 27 (February 1973), 17-21

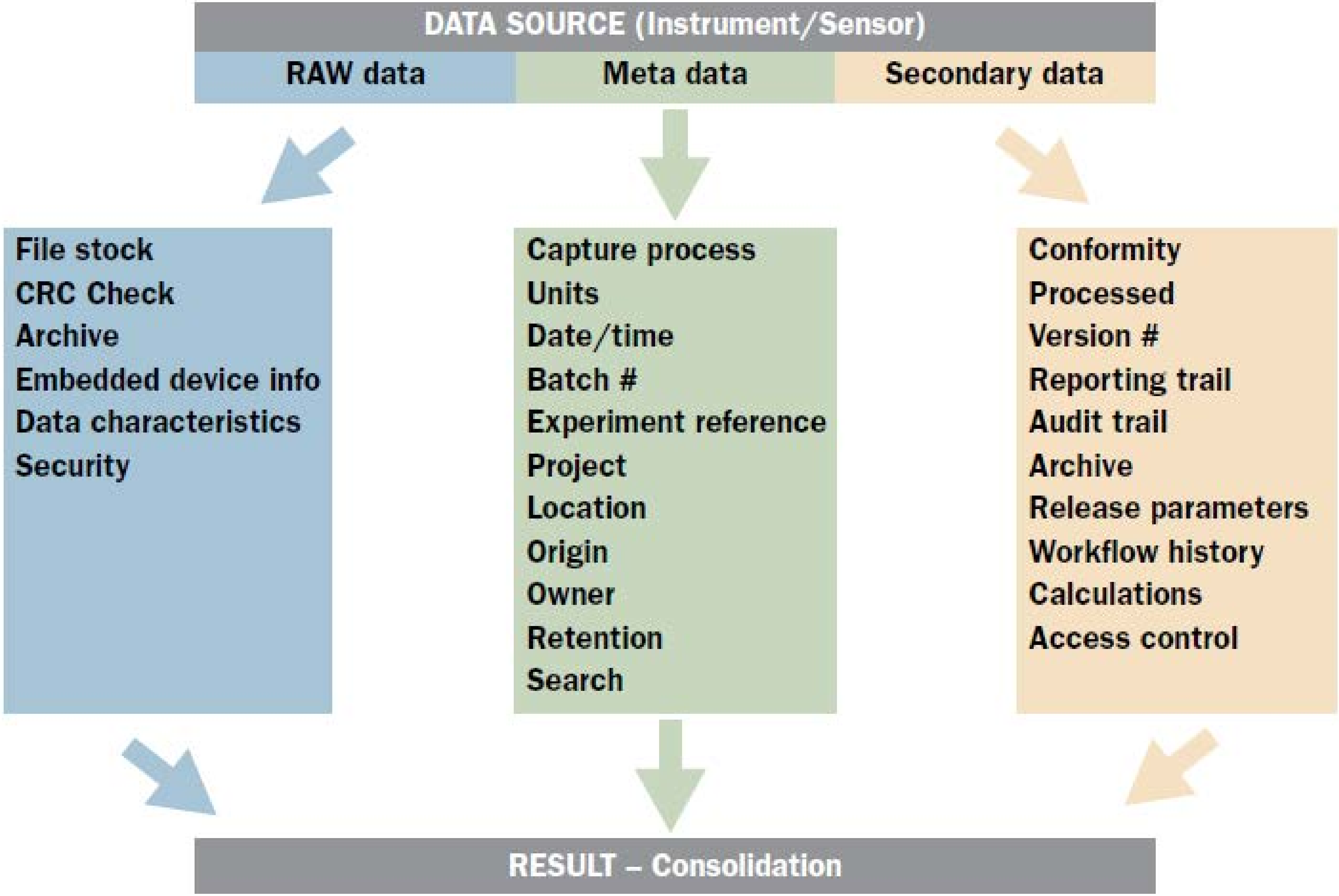
Statistics

Data pairs = 11
mean of X's = 9.0
mean of Y's = 7.5
standard deviation of X's = 3.32
standard deviation of Y's = 2.03
correlation = .82
regression line: Y = 3 + 0.5 X
r-squared = .67
slope t-statistic = 4.24
standard error of regression = 1.24

Graphical Analysis



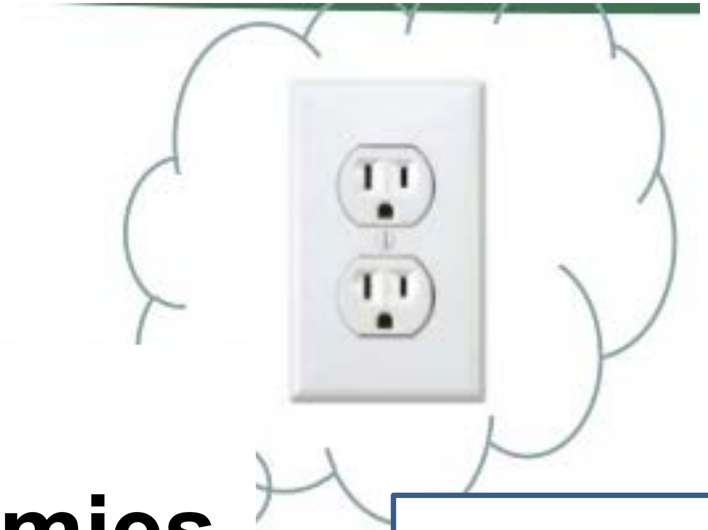
Scientific Data Sources



Source: How to Improve Data Integrity Laboratory Informatics Guide / Scientific Computing World by Peter Boogaard

Importance of standards

Yes I have power.....



Apply consistent **ontologies** and **taxonomies** to assure **finding** the right data

Pistoia Alliance
HELM
Hierarchical Editing Language for Macromolecules

Allotrope Foundation

#4 CHALLENGE

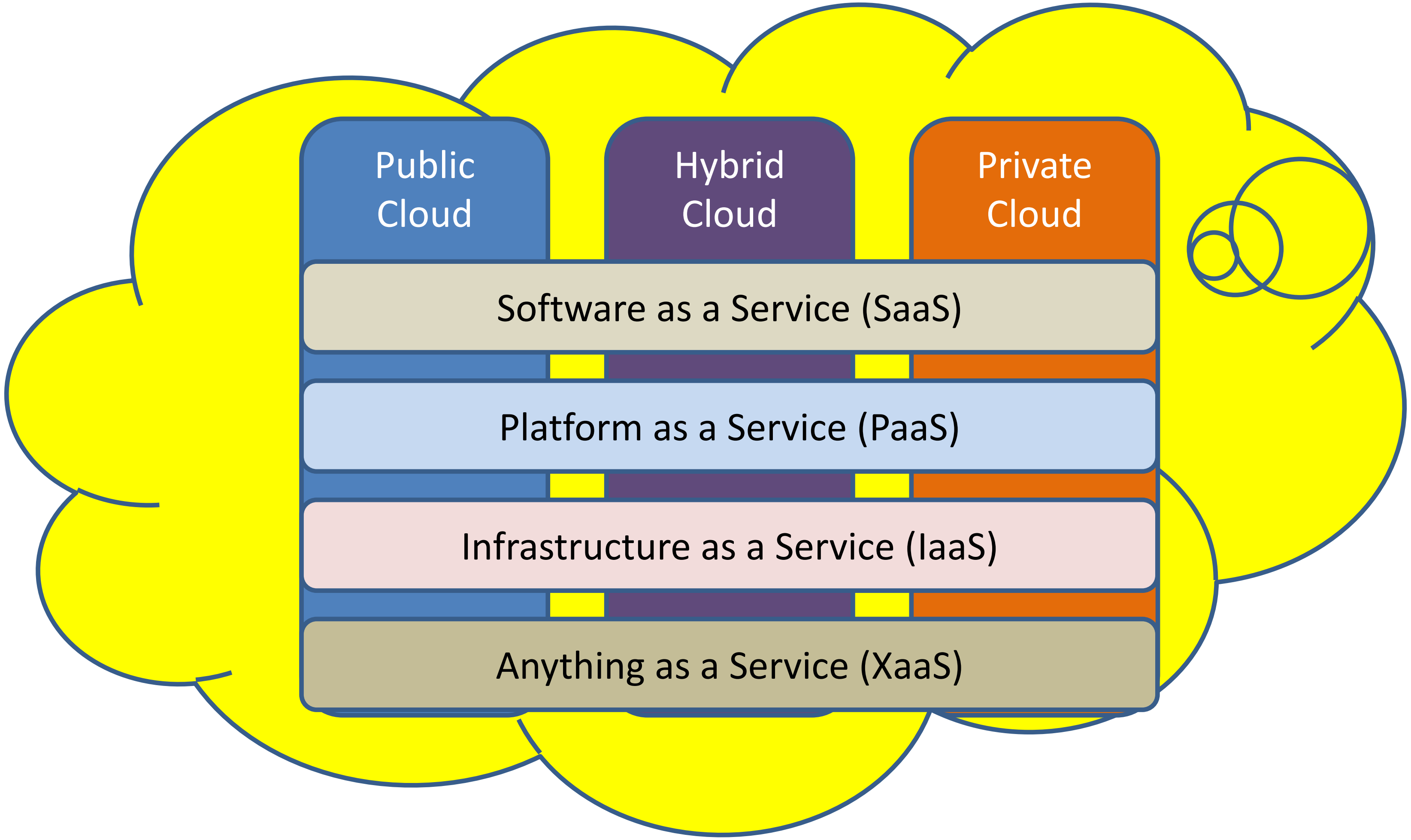
EXPLORE NEW CAPABILITIES


8.500.000.000 IoT (2016)

Internet of Things (IoT)

Zeilen - April 2017

Cloud related acronyms



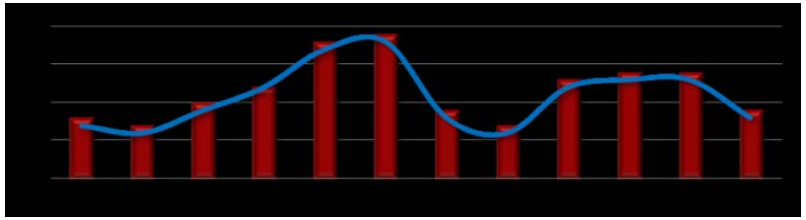
SaaS ≠ Cloud

Cloud

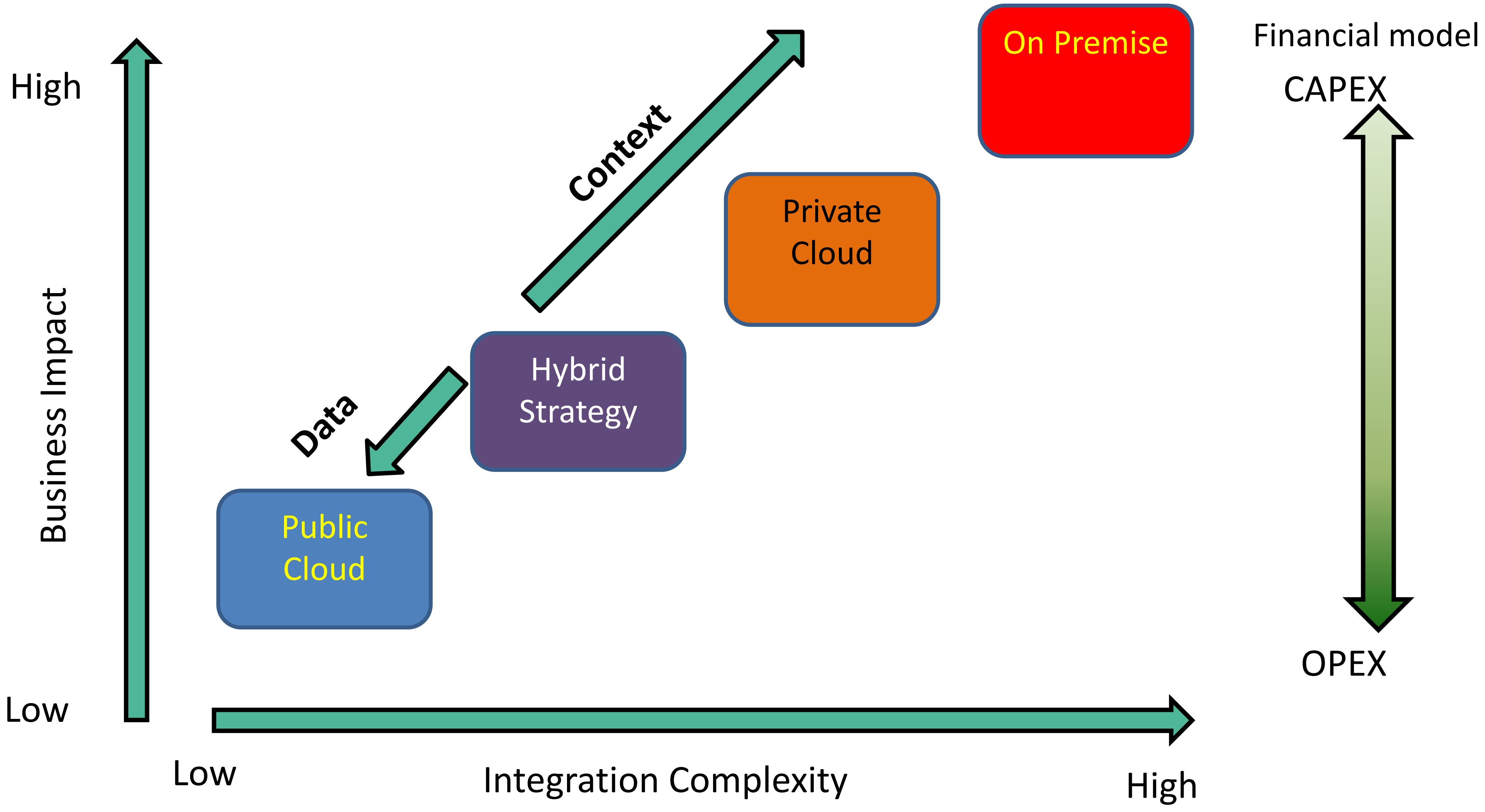
- Service Level Agreement
- Where is my data?
- Emergency & escalation plan
- Back-up services
- On-demand scalability
- On-demand capacity
- Ownership

SaaS

- Subscription
- Free and paid services
- Application consultancy
- Application support
- Automatic updates
- No investment in software
- Minimal hardware investment

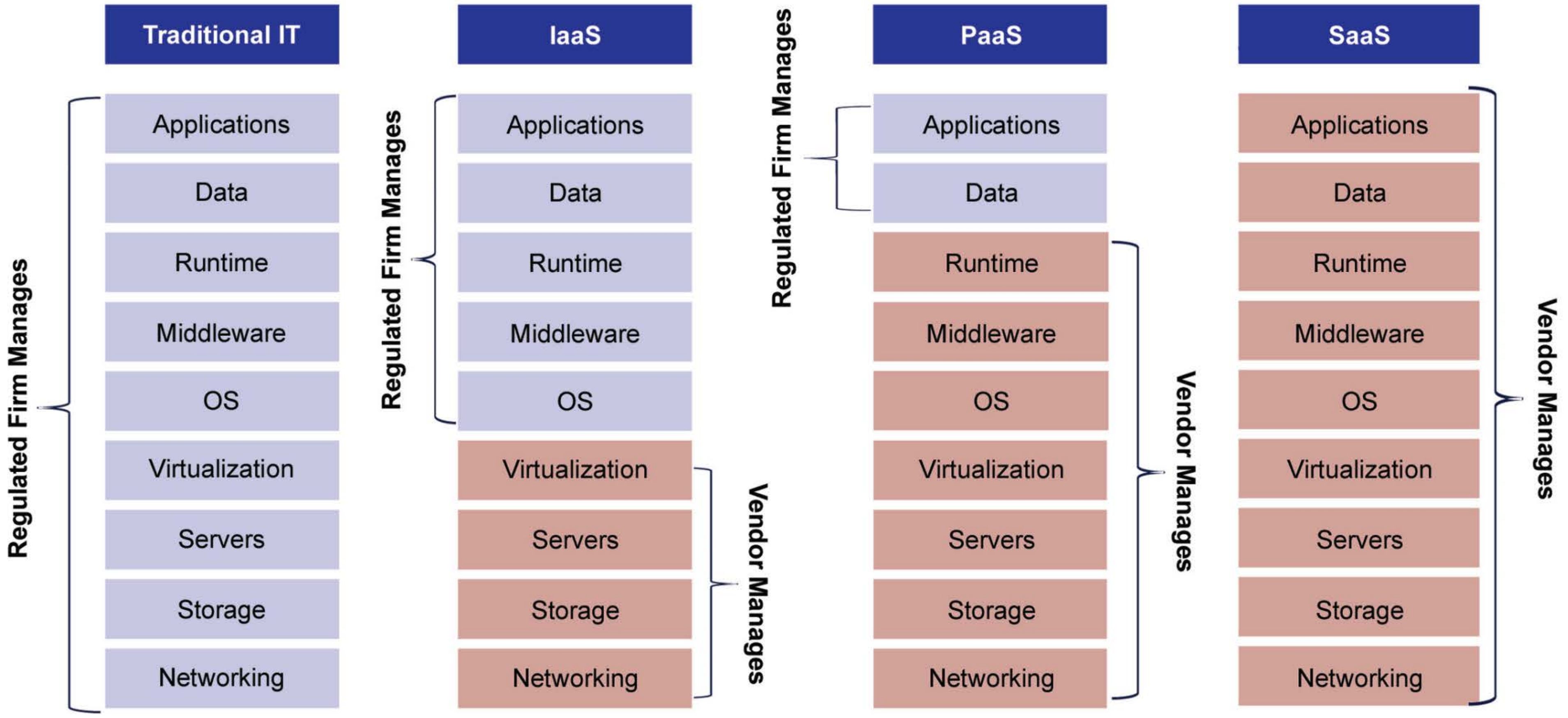


Accepted cloud strategies



The Route to clarity

GAMP Cloud Computing Special Interest Group (SIG)



Industrial Lab Automation

Source: 2016 - PHARMACEUTICAL ENGINEERING

LAB {SaaS + Cloud} candidates for the laboratory

- When prototyping requiring a lot of IT infrastructure
- Applications that require mobile access
- Applications outside of the core business
- Applications that require a high upfront investment (CAPEX vs OPEX)
- Projects requiring intensive (external) collaboration
- When fast access to increased scalability is a required
- Applications where 21CFR is not a direct requirement

Industry 4.0 IoLT Potential for Laboratories

Real-time Data Capture	**Self-documenting** process to include meta data and content in single process
Predictive maintenance	**Predict equipment failures** before they happen, and systematically prevent them
Remote monitoring	Remote monitoring solutions **collect live data from assets**, and use that data to trigger automatic alerts and operational actions based on current conditions, such as remote diagnostics and maintenance requests.
Deep learning data analytics	Ability to **include big-data** in R&D projects
Instrument interaction	**Auto registers material and equipment** that you are using. E.g. predict reagent consumption and initiate action when reagent is low with supplier
Customer/Consumer experience	Will provide contextualized and personalized C2C experience. Focus on customer experience, including physical safety and security
Enables multi technology validation	Ability to automatically **compare real-time test results from multiple technologies** on a large scale
Automate to transform	Integrate with existing Lab applications and explore to re-use existing dead-data silo's
Location tracking	Biometrically knows who you are. **Automates user authentication** process and reduces keystrokes. Simplifies application experience

Source: Roadmap to Digital Convergence - Laboratory Informatics Guide (LIG2017) / Scientific Computing World by Peter Boogaard

New areas of scientific expertise

More QA and less QC

Traditional Release Approach

API Blend

PAT Testing Approach

Manufacturing Floor
NIR Composite Assay
On-line Dosage Uniformity by Weight

Lubricant Blend

Compress

Manufacturing Floor
Disintegration
NIR ID
Appearance

Lab Tests
HPLC
Content Uniformity
Composite Assay
Degrades
ID
Dissolution
Appearance

Film coat

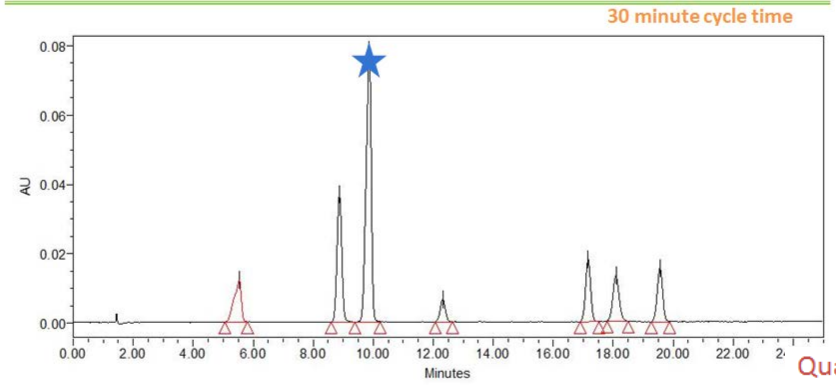
Laboratory

LIMS , ELN , LES

QbD , MES , ERP, LIMS

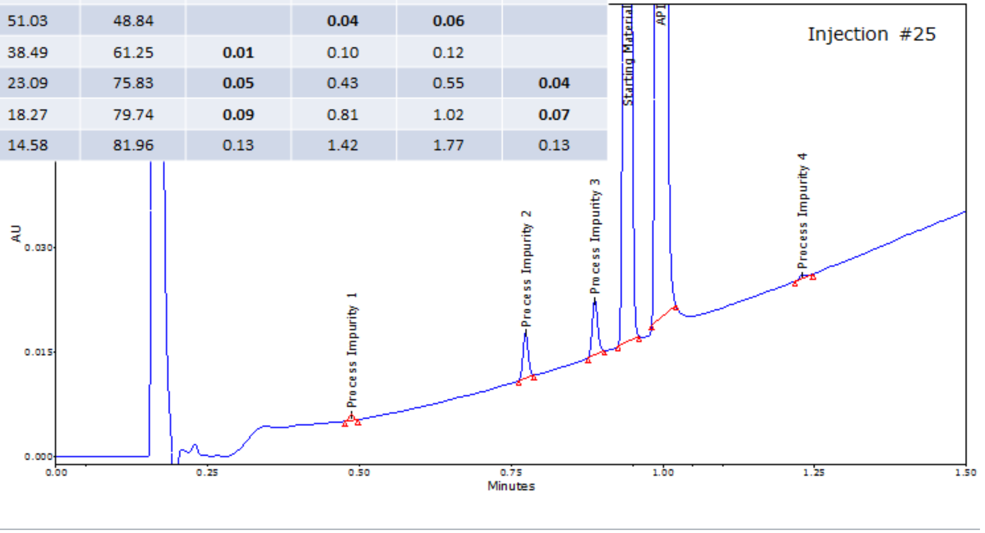
The scientist no longer just in the laboratory

Original HPLC Method
TOO SLOW for Online Analysis



Quantify low level components in the presence of a high concentration API

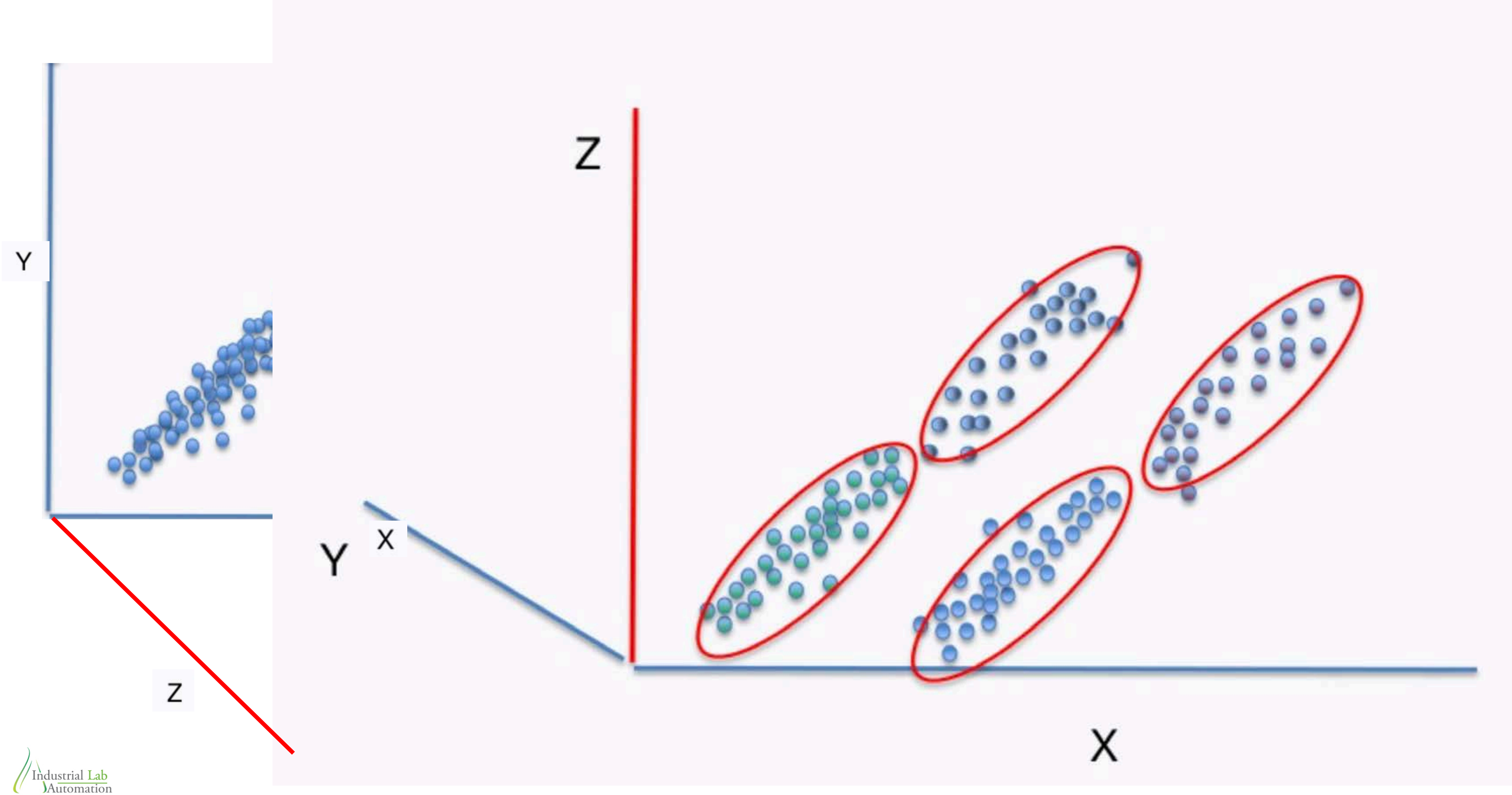
Reaction Aliquot	Starting Material	API	Process Imp#1	Process Imp#2	Process Imp#3	Process Imp#4
1	98.56	1.38				
5	89.54	10.43				
13	51.03	48.84		**0.04**	**0.06**	
17	38.49	61.25	**0.01**	0.10	0.12	
25	23.09	75.83	**0.05**	0.43	0.55	**0.04**
29	18.27	79.74	**0.09**	0.81	1.02	**0.07**
33	14.58	81.96	0.13	1.42	1.77	0.13



Industrial Lab Automation

Courtesy WATERS Corp.

Multivariate analysis can reveal a change in correlation structure not visible with univariate analysis



Courtesy: Festo

XXXL

Big Data

Massive amounts of information derived from dry /wet lab investigations, feasibility studies and clinical trials.

Big Science

Research silos are evaporating with the merging of scientific methods. Traditional hypothesis-testing studies will couple with data-driven research.

Fast Data

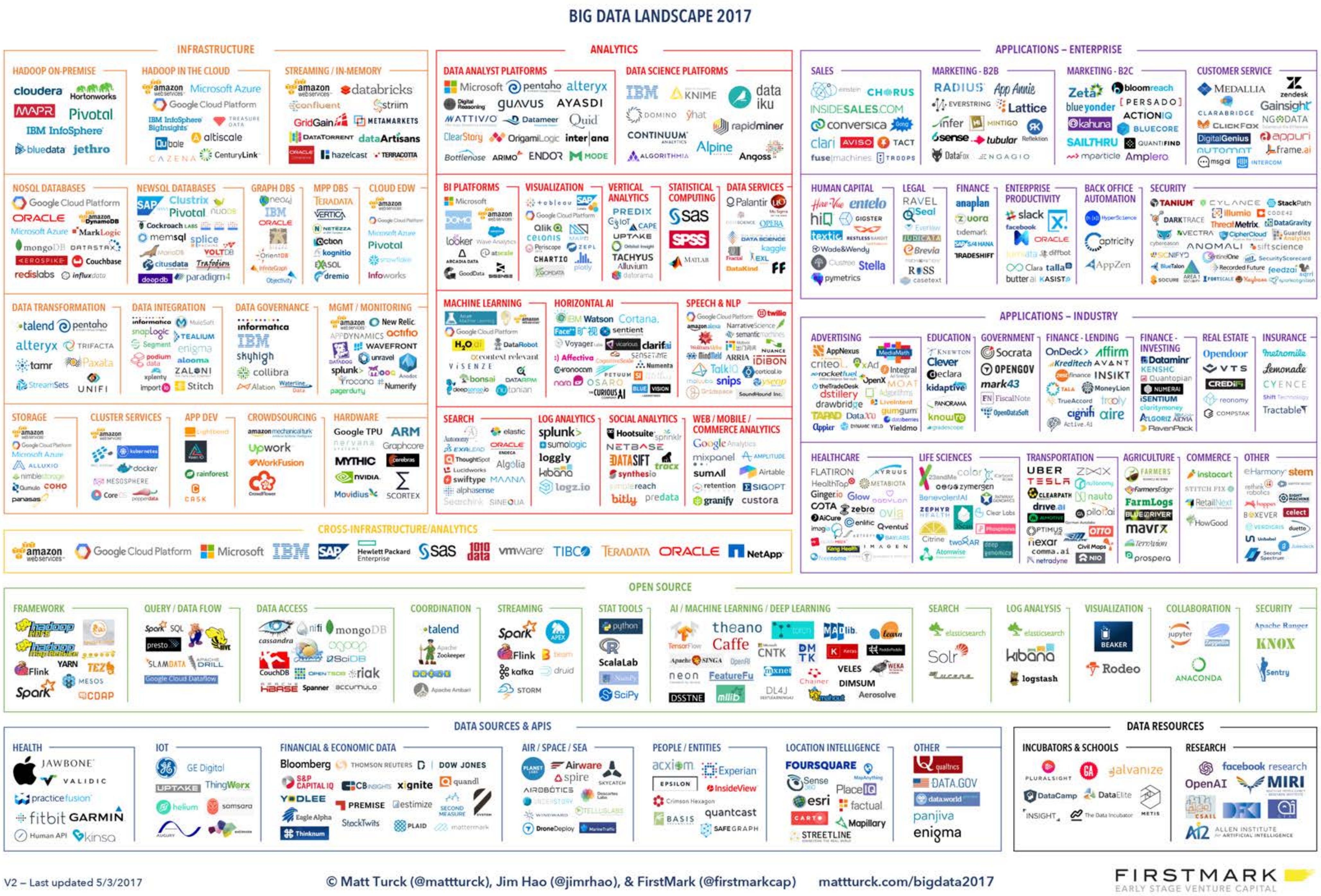
Fast Data is a range of approaches that process data that might or might not be stored.

Big Collaboration

As evidence accumulates, personalized medicine will become a reality, and patient-specific disease interventions will become available. Teams of disease specialists, researchers and bioinformaticians working in concert in a virtual frontier.

Source: Prof. Yike Guo - Imperial College London

XX XL



Industrial Lab Automation

#5 CHALLENGE

MAKE IT EASY ACCESABLE

Barriers

Technology

Almost disappeared

Globally accessible & available

People

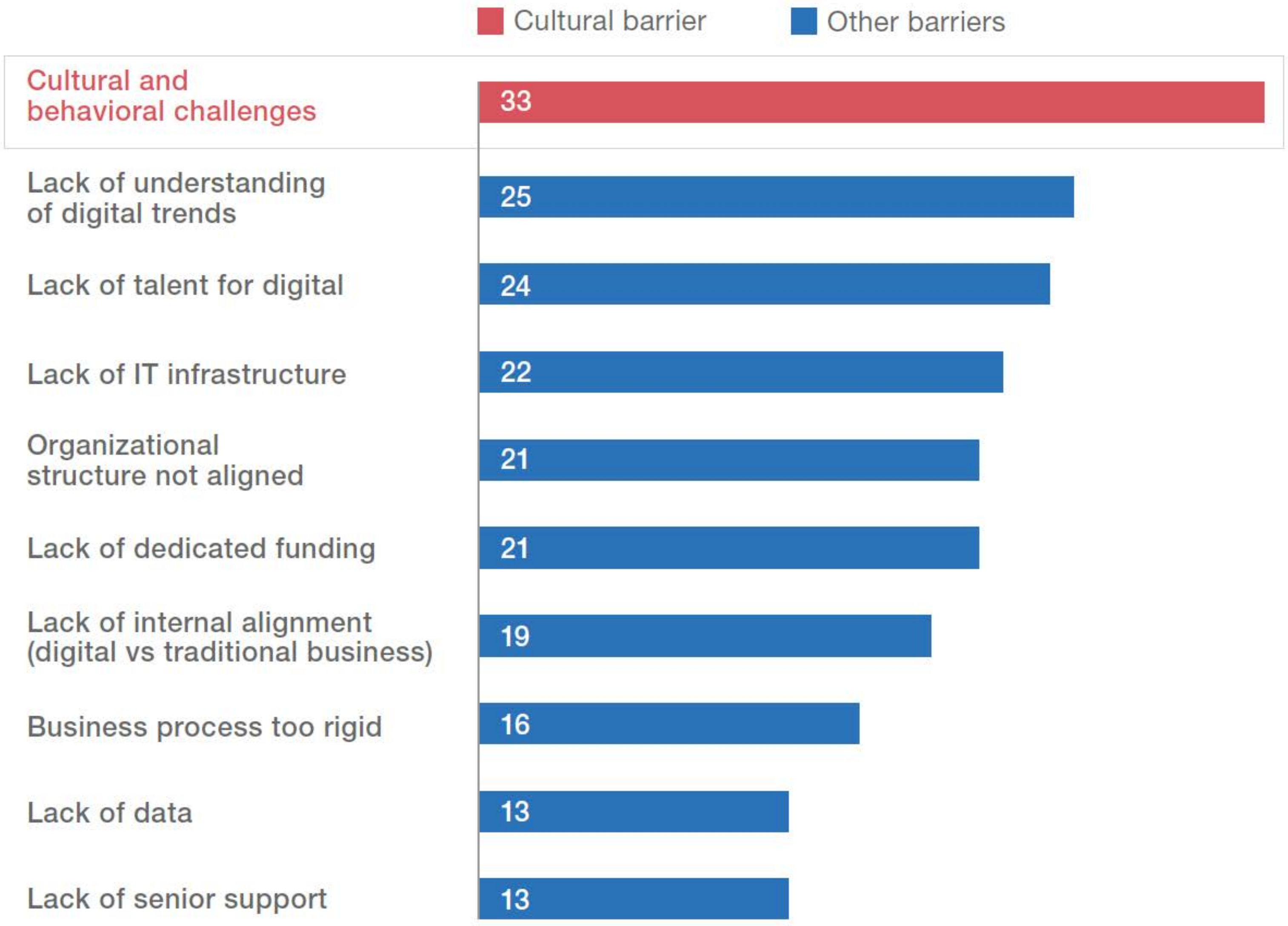
Challenge

Requires a mindset change

COMMENTARY LETTERS

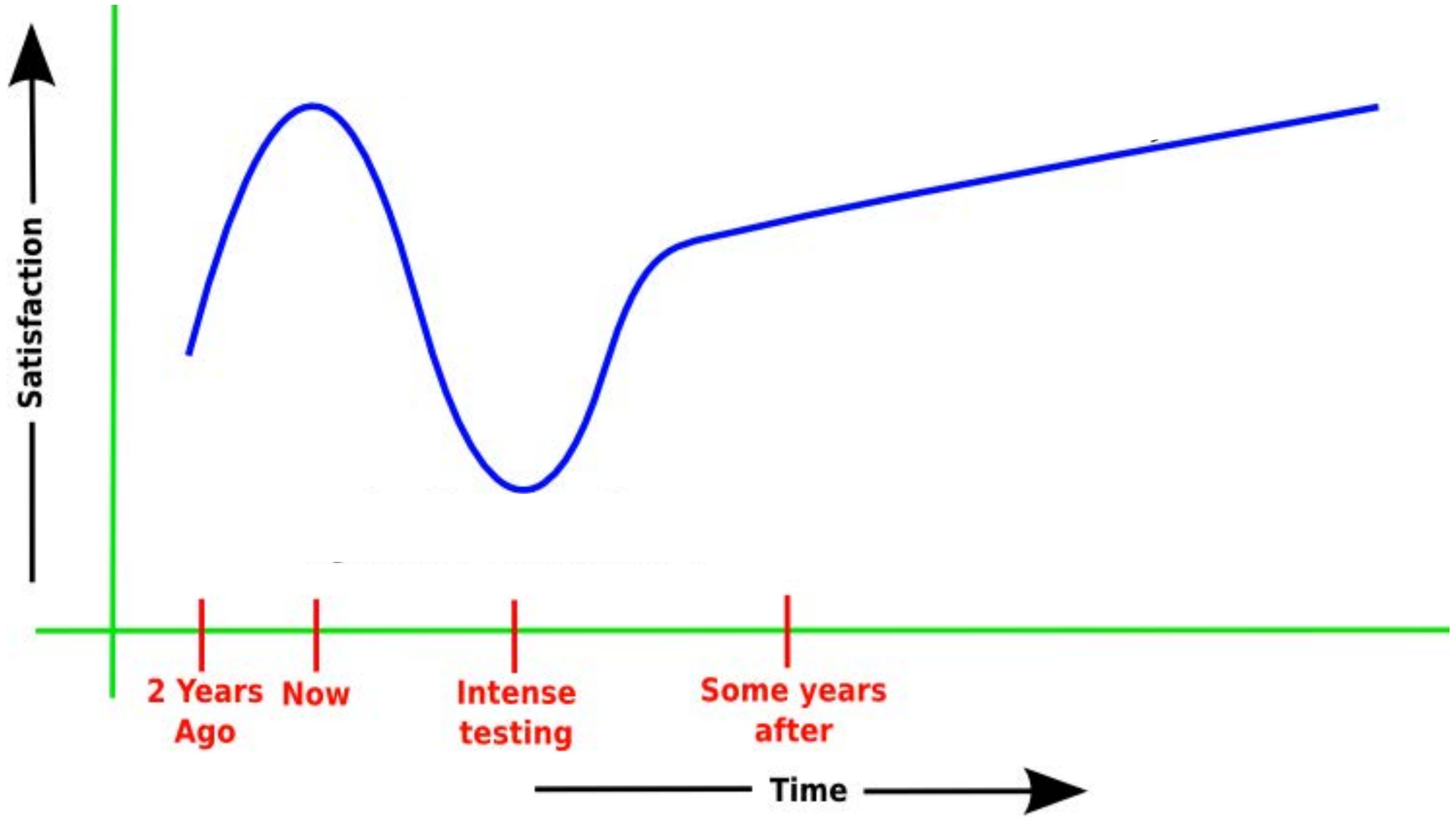
BY HENG IN LIANHE ZAOBAO (SINGAPORE). CWS/CARTOONARTS INTERNATIONAL

Significant challenges to meeting digital priorities



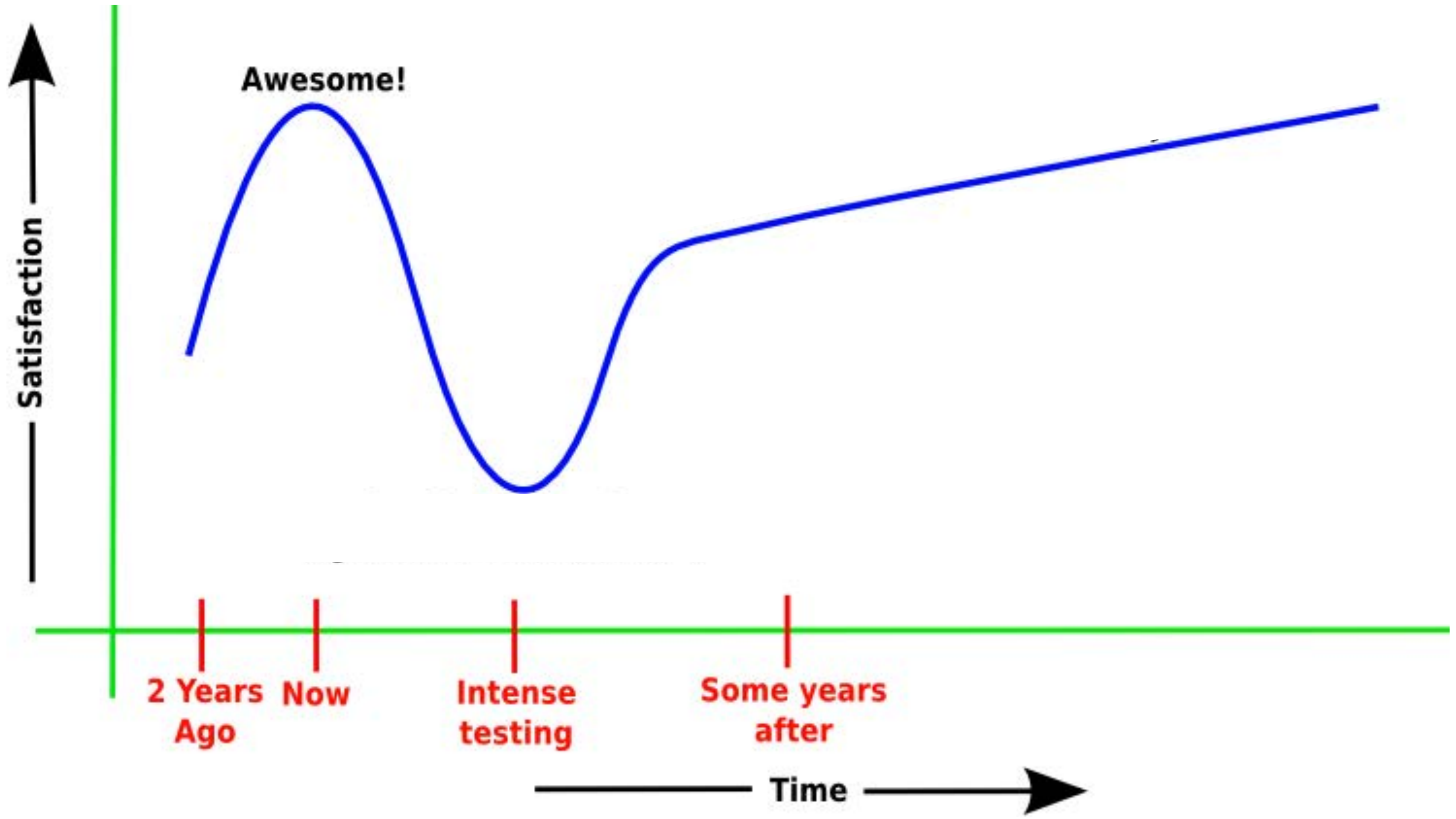
McKinsey&Company | Source: 2016 McKinsey Digital survey of 2,135 respondents

Adoption curve



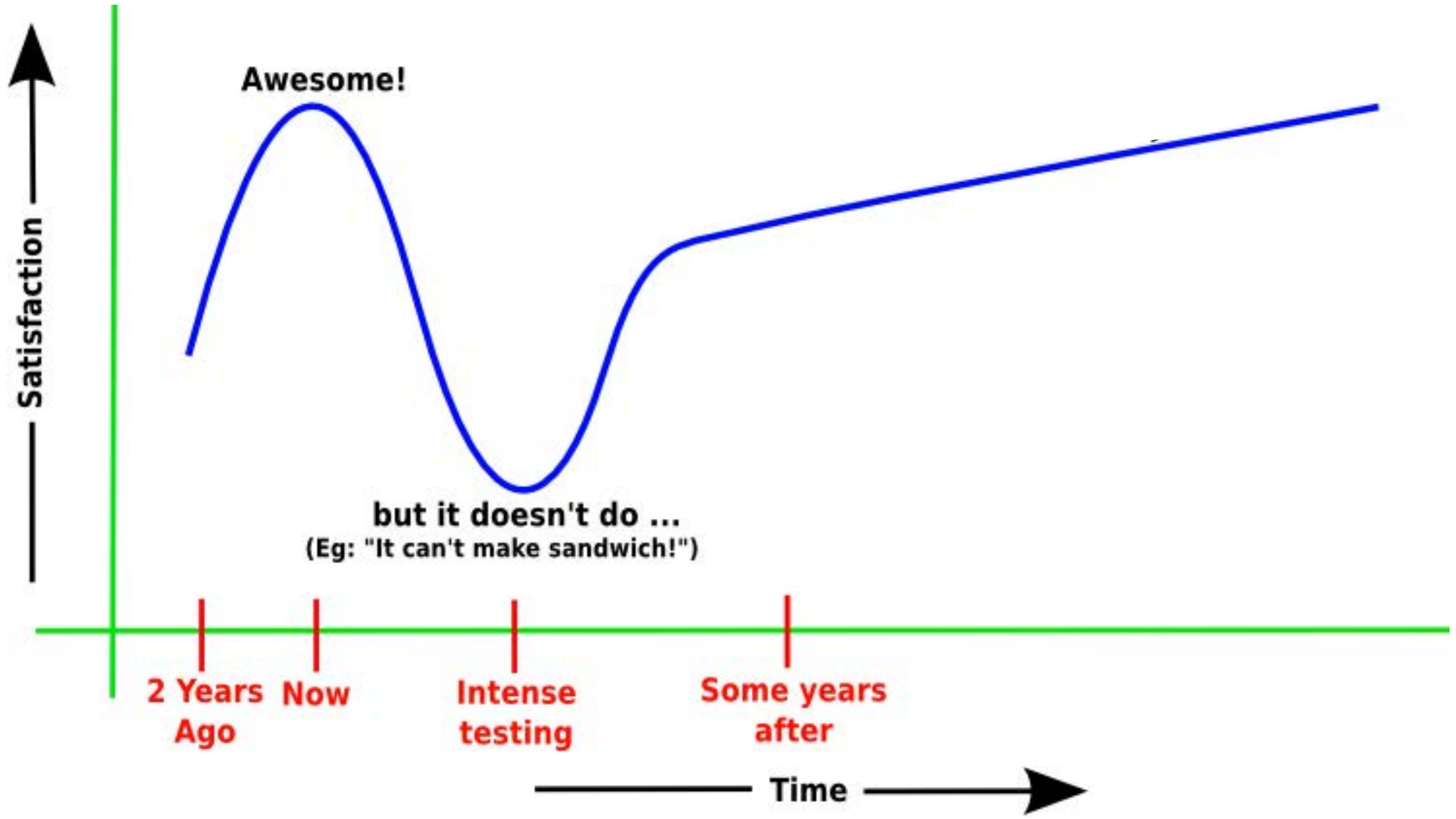
Source: tech.puredanger.com

Adoption curve



Source: tech.puredanger.com

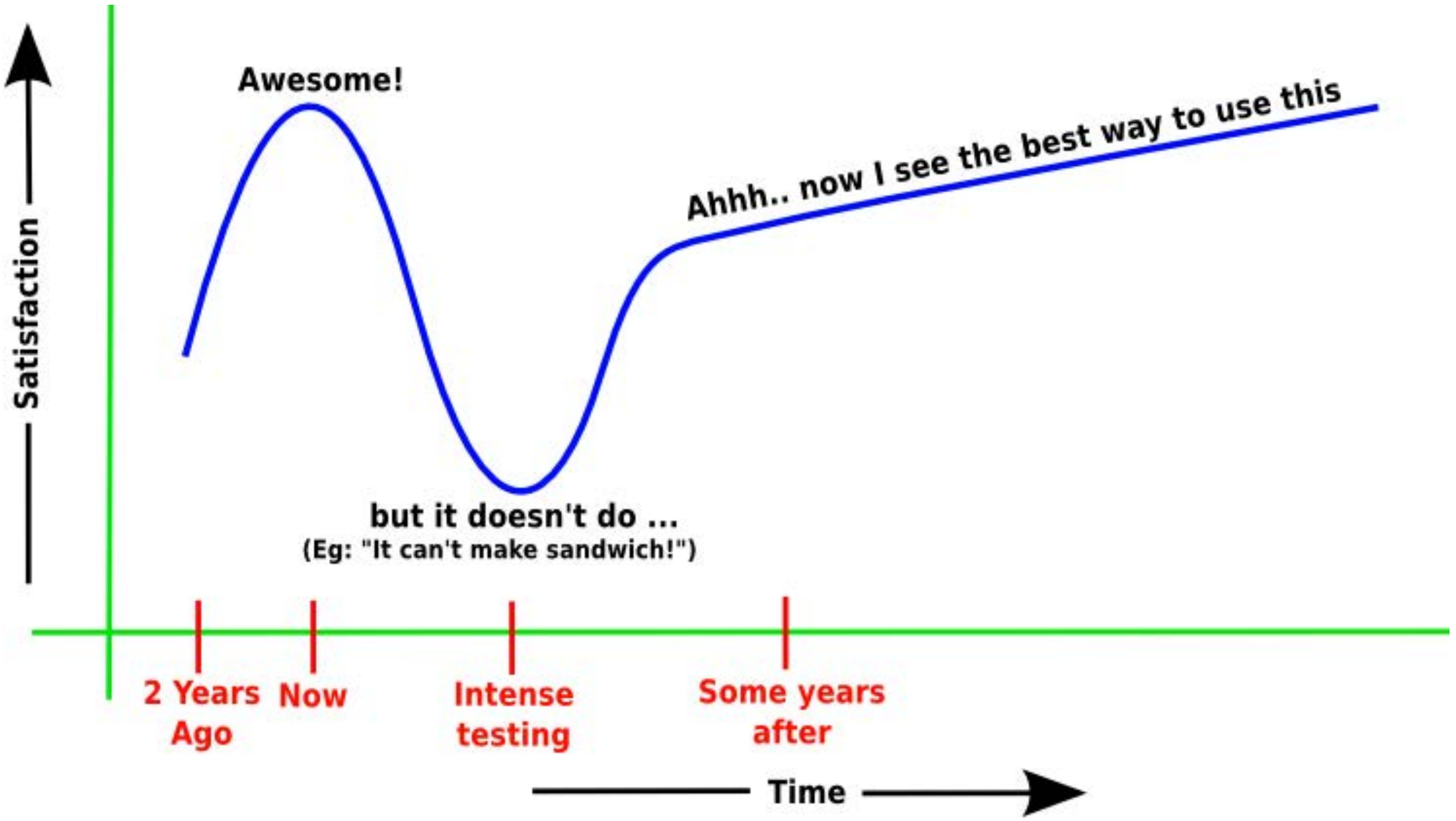
Adoption curve



Source: tech.puredanger.com

Industrial Lab Automation

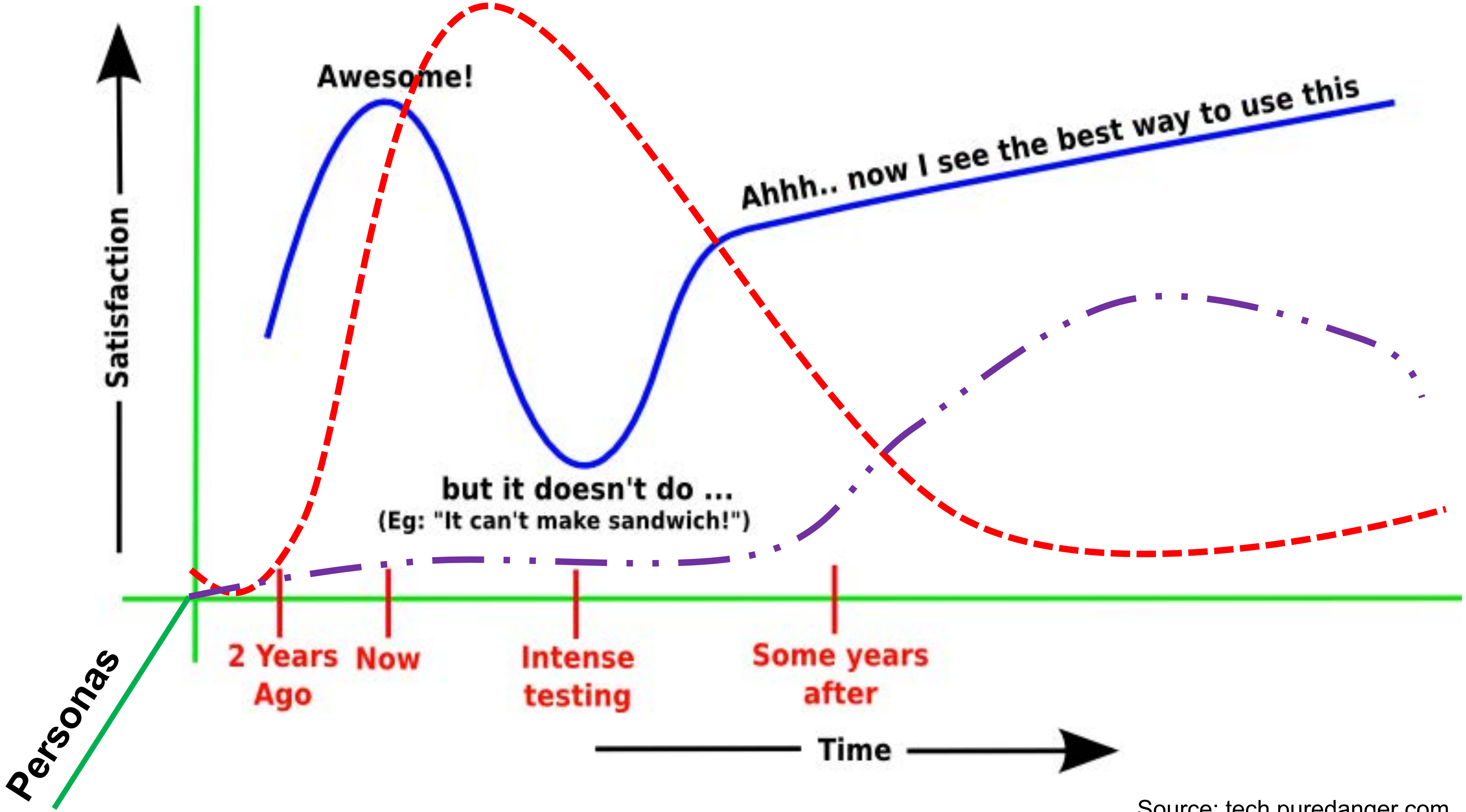
Adoption curve



Source: tech.puredanger.com

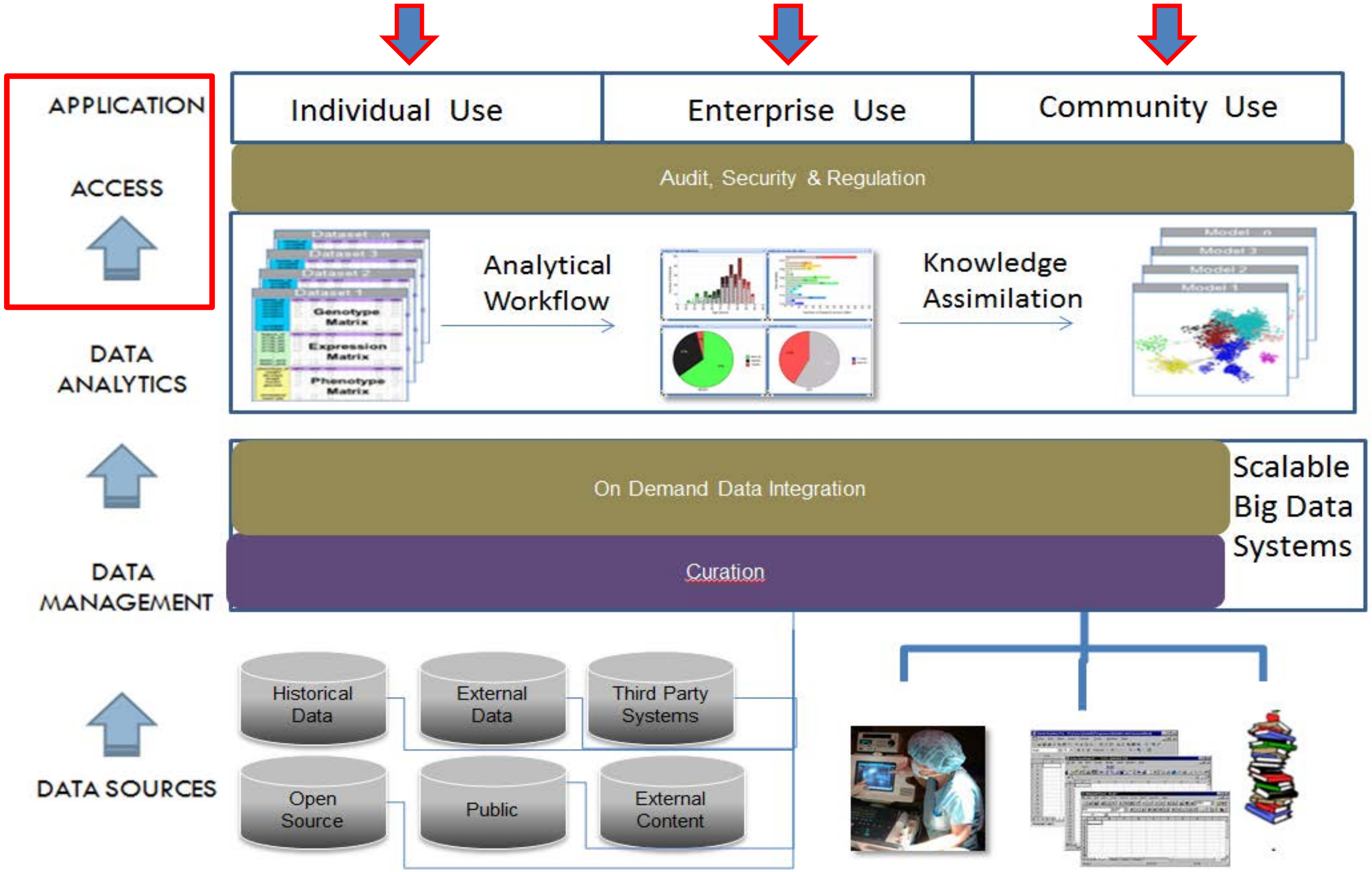
Industrial Lab Automation

Adoption curve



Source: tech.puredanger.com

Models of communication processes

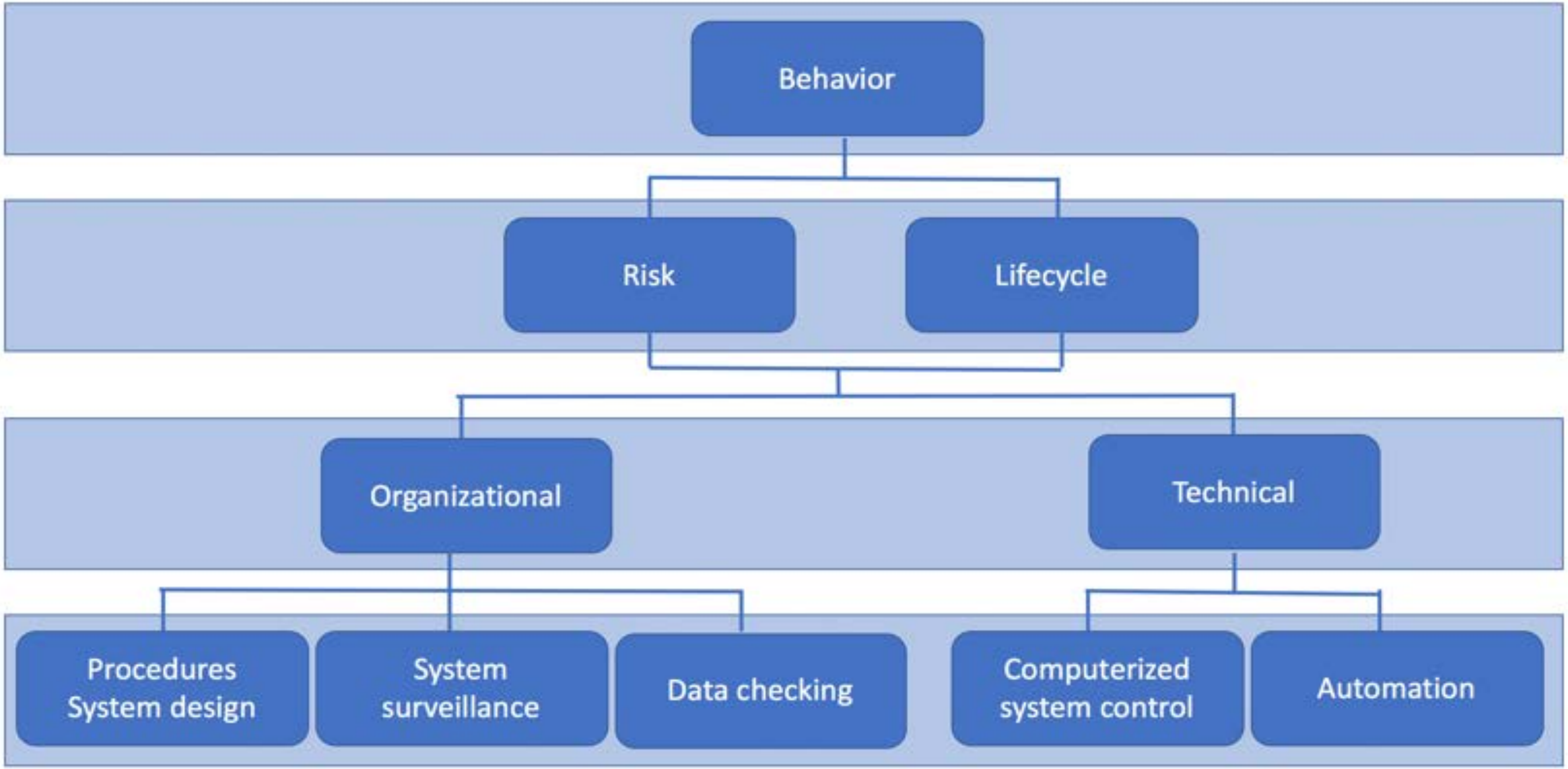


#6 CHALLENGE

ASSURE DATA GOVERNANCE

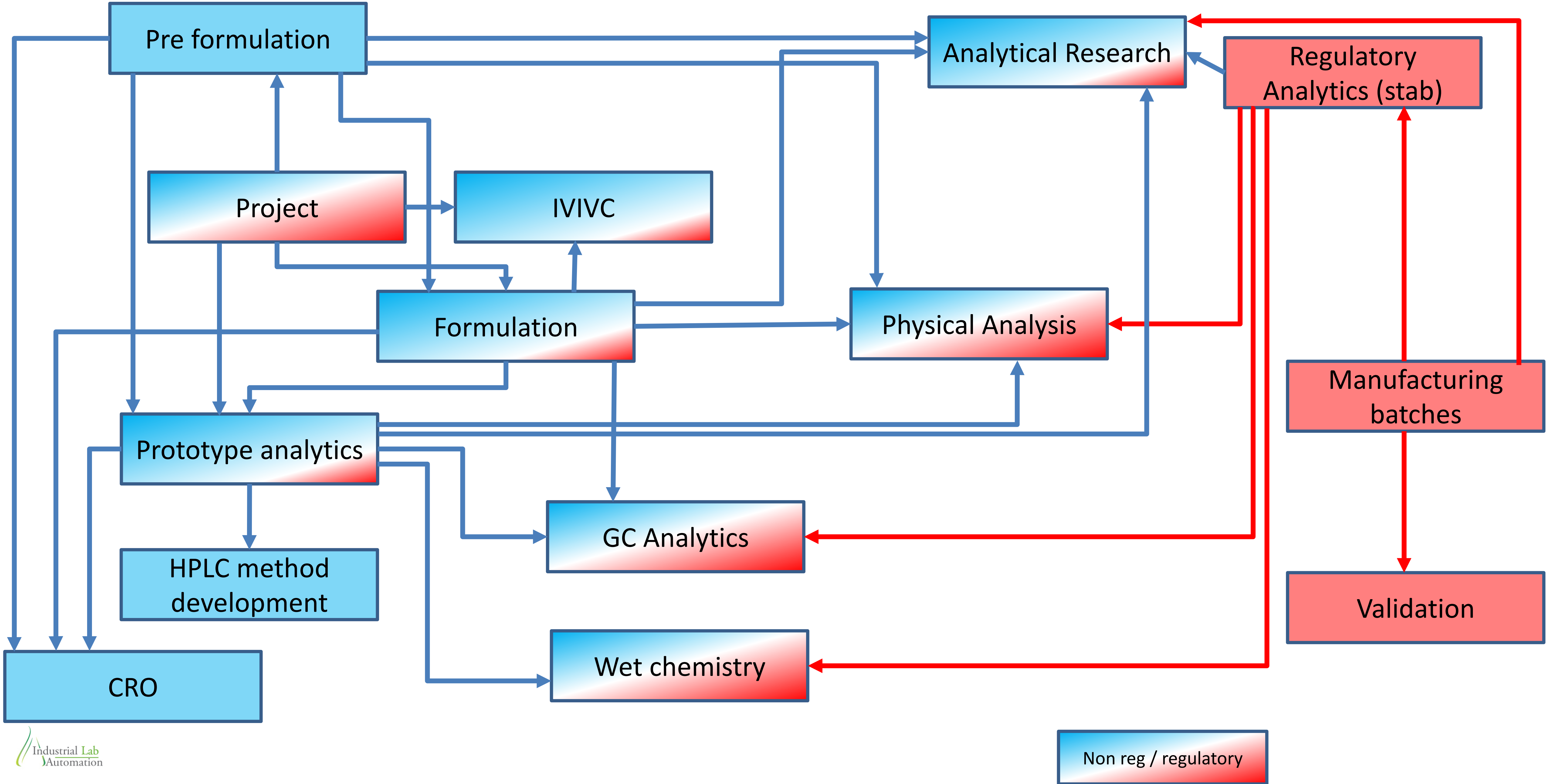
Data integrity refers to maintaining and assuring the accuracy and consistency of data over its entire life-cycle

Change management requires a data lifecycle based approach

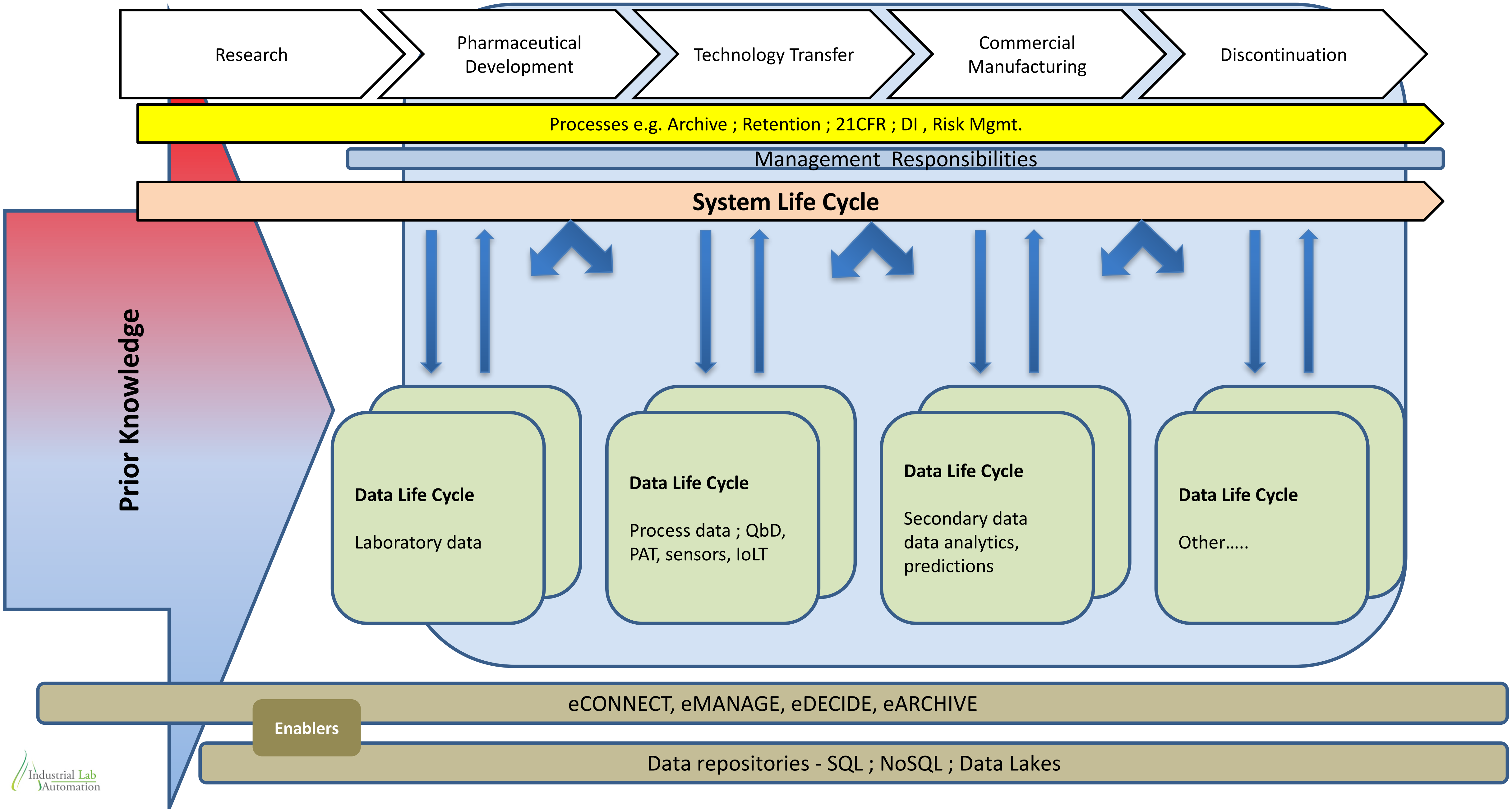


Source: GMP's Data Integrity Guidance Documents

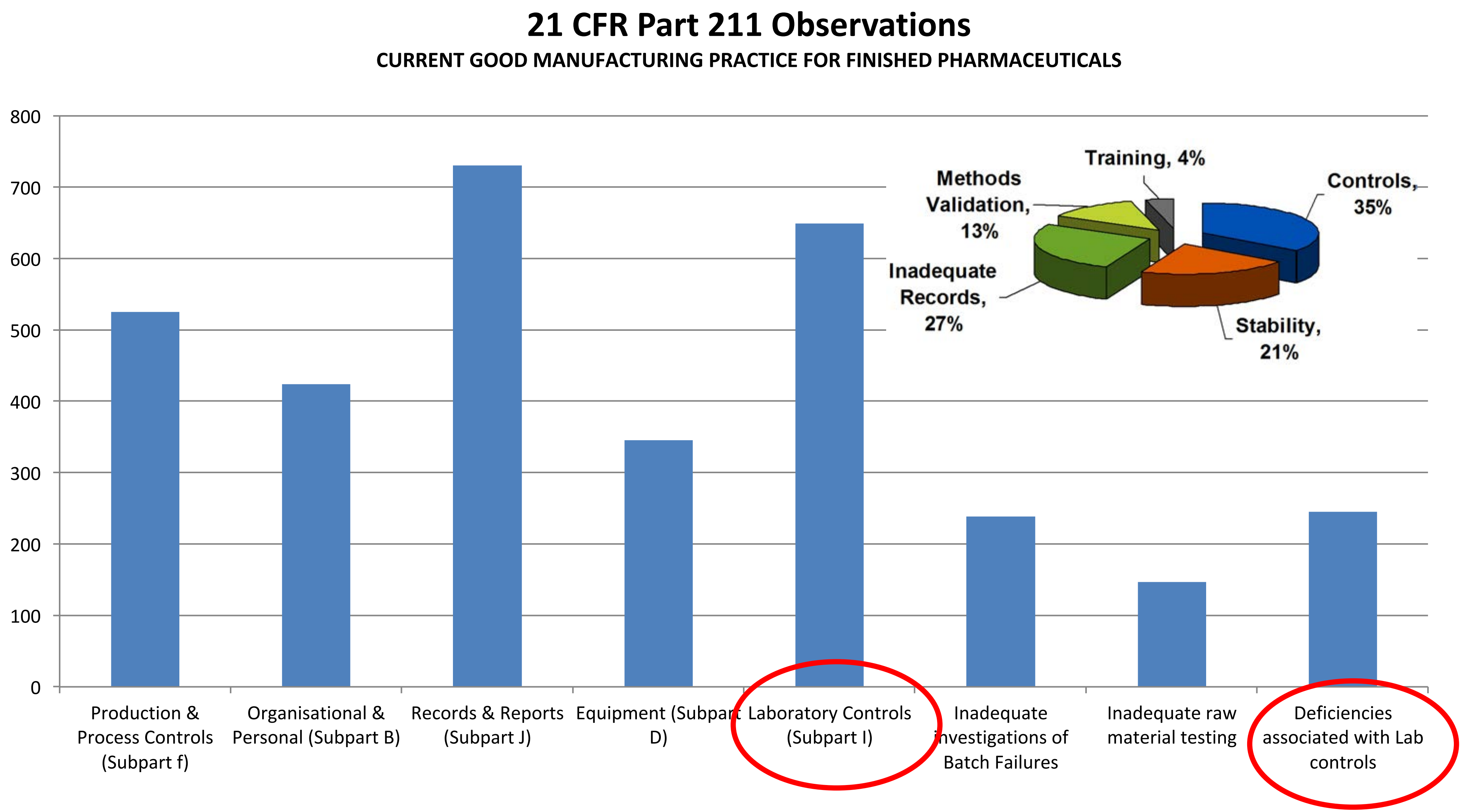
Cross departmental regulatory requirements



Empowering the e-DATA LIFE CYCLE



US FDA Observations Summary



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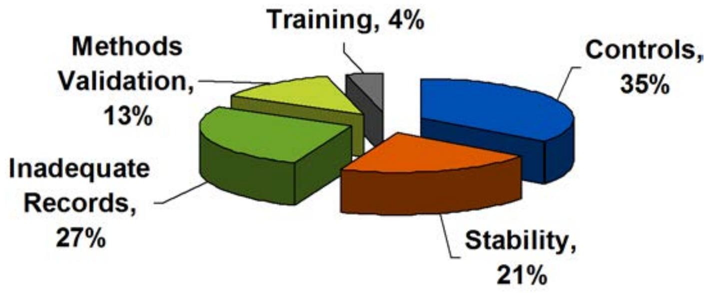
Laboratory data integrity observations

- **Alteration** of raw, original data and records
- Multiple analyses of assay with the same sample **without adequate justification**
- Manipulation of a poorly defined **analytical procedure** and associated data analysis in order to obtain passing results
- **Backdating** stability test results to meet the required commitments
- Creating acceptable test results **without performing** the test
- Using test results from previous batches to **substitute testing** for another batch



Source: FDA

Attention areas: data governance

- Data security protocols
- Master Data management
- Each interface is a potential Data Integrity challenge
- Long-term data access control
- Privacy regulations incl. new European GDPR compliance
- Enforcement of data and ontology standards

Transforming scientific information into actionable insights
Take away message

- People
  - Data consumer vs data creator mindset change
  - Think data lifecycle
  - Think capabilities vs technology first
  - Avoid applying previous excuses
- Technology
  - Apply industry data access & security processes
  - Apply cross industry standard technologies
  - Apply visualization to data analytics
  - Utilize 24x7 global IT technology to reduce TOC
  - Include roadmap to address upcoming technology obsolesce
  - Go mainstream
- Processes
  - Apply as much self documenting context & meta data in all processes
  - Apply consistent standards (incl. ontologies and taxonomies) to assure finding the right data
  - Involve management to assist breaking internal silo barriers to address data life cycle
  - Define long-term ownership of master data

De stand van zaken van data management software in het laboratorium

We expect too much in 1 year

And not enough in 10

Batt%

Peter Boogaard

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17 November 2017 – Wageningen – Nederland

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Industrial Lab Automation