

Digitalization Implementation Decision Support Tool

Canada Research Chair
in Fuzzy Hybrid Decision Support Systems for Construction

Cenovus Energy

Construction Owners Association of Alberta



Workshop Outline

- **Welcome and safety+productivity moment**
- **Digitalization defined**
- **Digitalization implementation in action** – Mark Sombach/Cenovus Energy
- **Decision support tool** – Larry Staples/ COAA
- **Fuzzy logic decision support tools for digitalization implementation** –
Mohammad Raoufi/UofA
- **Community of Practice**
- **Workshop participation**



Safety+Productivity Moment

AF

Augmented Fitness (AF) is the augmentation of human fitness by machines, especially computer systems. These processes include auto-correction (fat fingers), interpolation (lethargic late afternoon keystrokes) and auto-generation of creative ideas (glazed-over screen stare).



Safety+Productivity Moment

Bene-Fit (to humans)

- Improved concentration
- Sharper memory
- Faster learning
- Mental stamina
- Enhanced creativity
- Lower stress
- Wellness
- Longevity

Hogan CL, Mata J, Carstensen LL.

in Psychol Aging. 2013 Jun;28(2):587-94.

Desk Fit

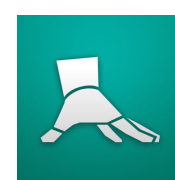
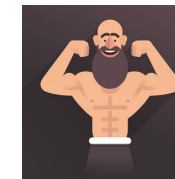
Standing desk

Exercise ball seat

4 in 40

- 150 m stroll
- Shoulder roll
- Arms-up stretch
- Torso flex (four directions)
- Leg flex

Life Fit



Digitalization

International Energy Agency

**“the increasing convergence between
the digital and the physical worlds”**

The digital world has three foundational elements:

- **Data:** digital data
- **Analytics:** use of data to create useful information and insights
- **Connectivity:** the exchange of data and information between humans, devices and machines (including machine-to-machine), through digital communications networks



Digitalization

COAA

People + Processes + Technology

Better information ... better decisions ... better productivity

Another pathway to

improving

heavy industrial construction

productivity



Digitalization Context

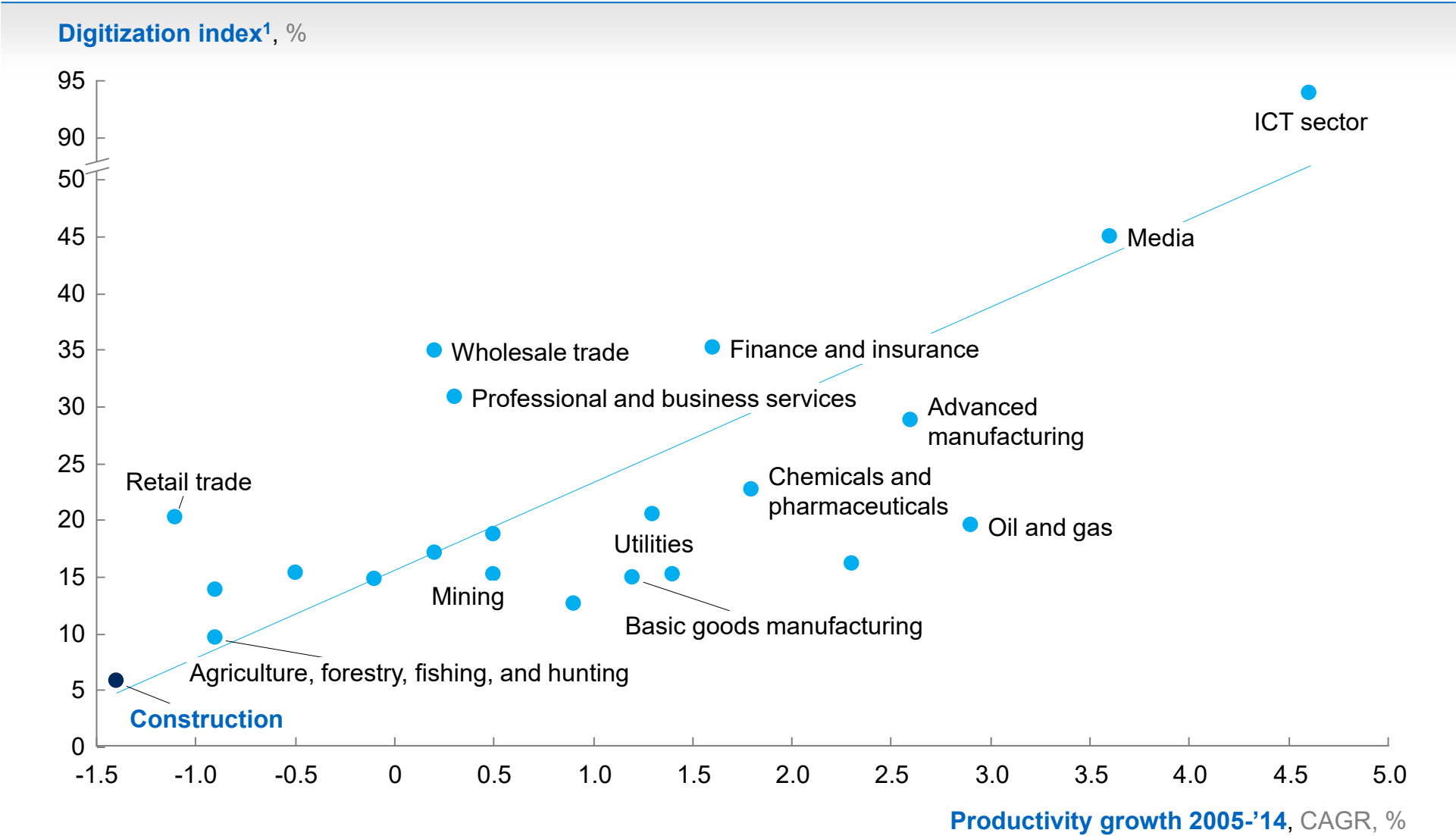
REINVENTING CONSTRUCTION: A ROUTE TO HIGHER PRODUCTIVITY

McKinsey & Company
2017

Briefing by Jason Green
COAA Strategy Offsite, June 2017



Technology - lower digitization in construction relative to other industries has contributed to the productivity decline



¹ Based on a set of metrics to assess digitization of assets (eight metrics), usage (11 metrics), and labor (eight metrics).

SOURCE: BEA; BLS; US Census; IDC; Gartner; McKinsey social technology survey; McKinsey Payments Map; LiveChat customer satisfaction report; Appbrain; US contact center decision-makers guide; eMarketer; Bluewolf; Computer Economics; industry expert interviews; McKinsey Global Institute analysis

Technology - infuse digital technology, new materials and advanced automation to achieve significant productivity improvements

Universally shape the basics...

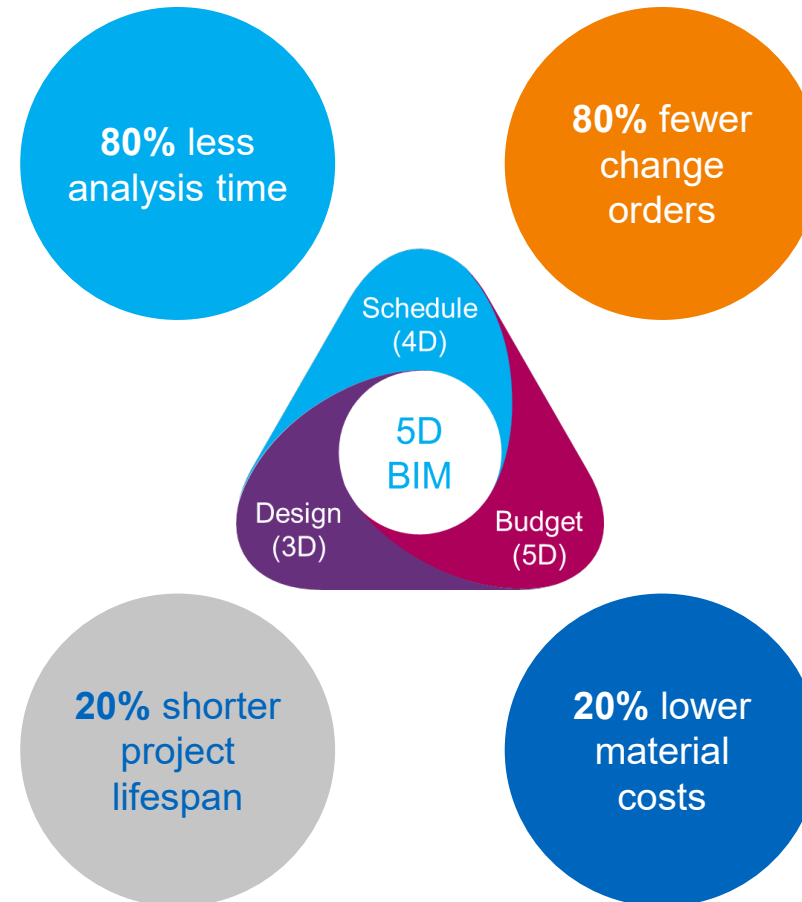
- Invest in a **chief digital/tech/innovation office** and team
- Make **3D BIM** universal
- Introduce **drones** and **UAVs** for scanning, monitoring, and mapping
- Use **digital collaboration** and **mobility tools** on portable devices



... and then push for advanced solutions

- Mobilize **5D BIM** across the project lifecycle, with augmented/mixed reality interfaces
- Leverage the **Internet of Things** enabled fully connected sites (NFC, sensors, wearables)
- Implement **advanced analytics** on project and firm wide data
- Develop **alternative** and **innovative materials**
- Implement **automation equipment** on sites

Example: BIM has four main benefits¹

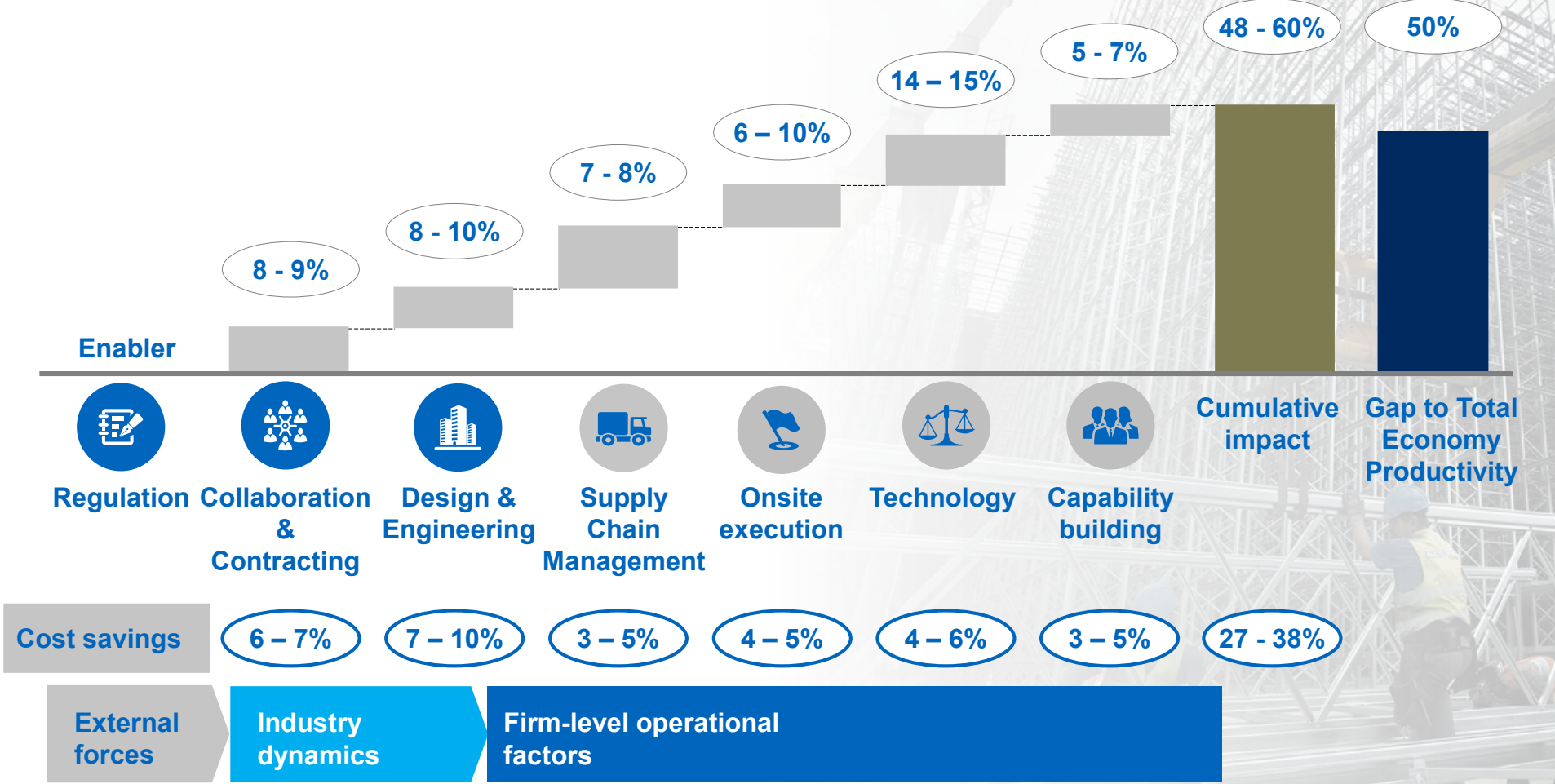


¹ According to a survey of 2,228 construction professionals working on multiple sites and academic research

Construction can catch up with total economy productivity by taking action in seven areas

Potential global productivity improvement¹ from implementation of best practice

% impact on productivity²


























¹ The impact numbers have been scaled down from a best case project number to reflect current levels of adoption and applicability across projects, based on respondents to the McKinsey & Co Global Construction Industry Productivity survey who responded agree or strongly agree to the questions around implementation of the solutions
² Range reflects expected difference in impact between emerging and developed markets

Technology - lack of internal processes is the largest barrier to digital technology

Most important barriers to adoption by technology type (n=141)

Frequency of ranking in three most important barriers

 = primary barrier (most often ranked)
 = secondary barrier (second most often ranked)

		No internal process to quantify or communicate business case and benefits	No clear industry standard yet, sub-contractors and customers need to adopt	Management not interested, no budget at project level	Frontline workers insufficiently trained or unwilling to use	Lower-cost options available
Digital	Real-time collaboration					
	Collaborative mobility solutions					
	Digitized project workflows					
	Real-time workforce production tools					
	Sensor and NFC ¹ technology					
	Pattern-/trend-based advanced analytics					
Materials	Surveying and inspection tools					
	Modular construction					
Automation	Durable and lightweight materials					
	Advanced automation					

¹ Near-field communication.

Beyond Best Practices

COAA strategies

- **Grand vision – Twice as Safe, Twice as Productive by 2020**
- **Best Practices – e.g. Advanced Work Packaging, Collaborative Contracting (more emphasis on improving culture, less on improving processes)**
- **Increase rate of technology adoption – specifically digitalization**

Meanwhile ...

- **Cenovus (and others) are “just doing it”**





Mark Sombach

Digital Innovation Specialist

May 8th, 2019

COAA

Digital Innovation at Cenovus
And

PTAC Digital Innovation Consortium



cenovus
ENERGY

Agenda

Overview of our Digital Innovation department

4th Industrial Revolution (AI)

Digital Innovation Research Projects

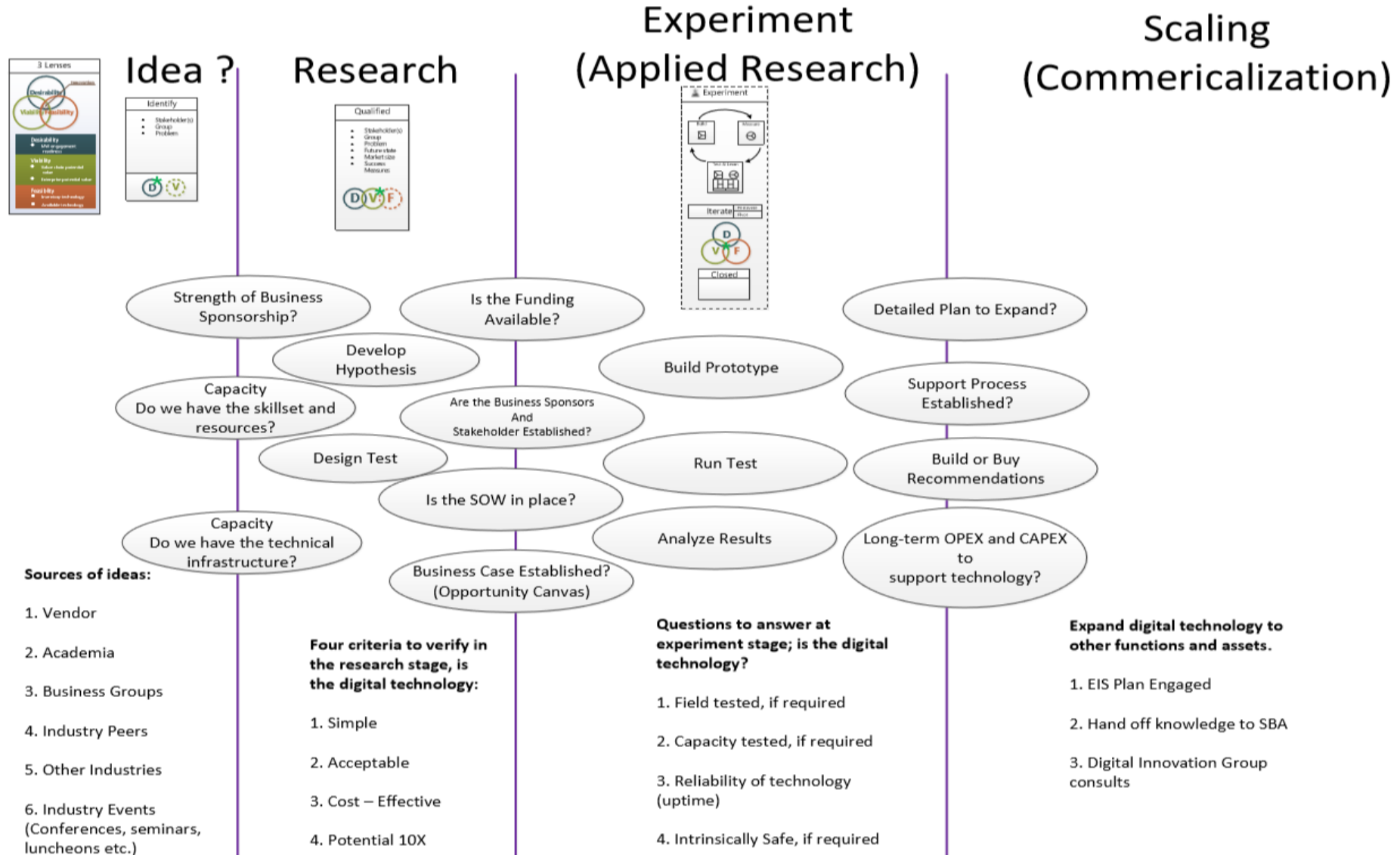
Cenovus

PTAC Digital Innovation Consortium

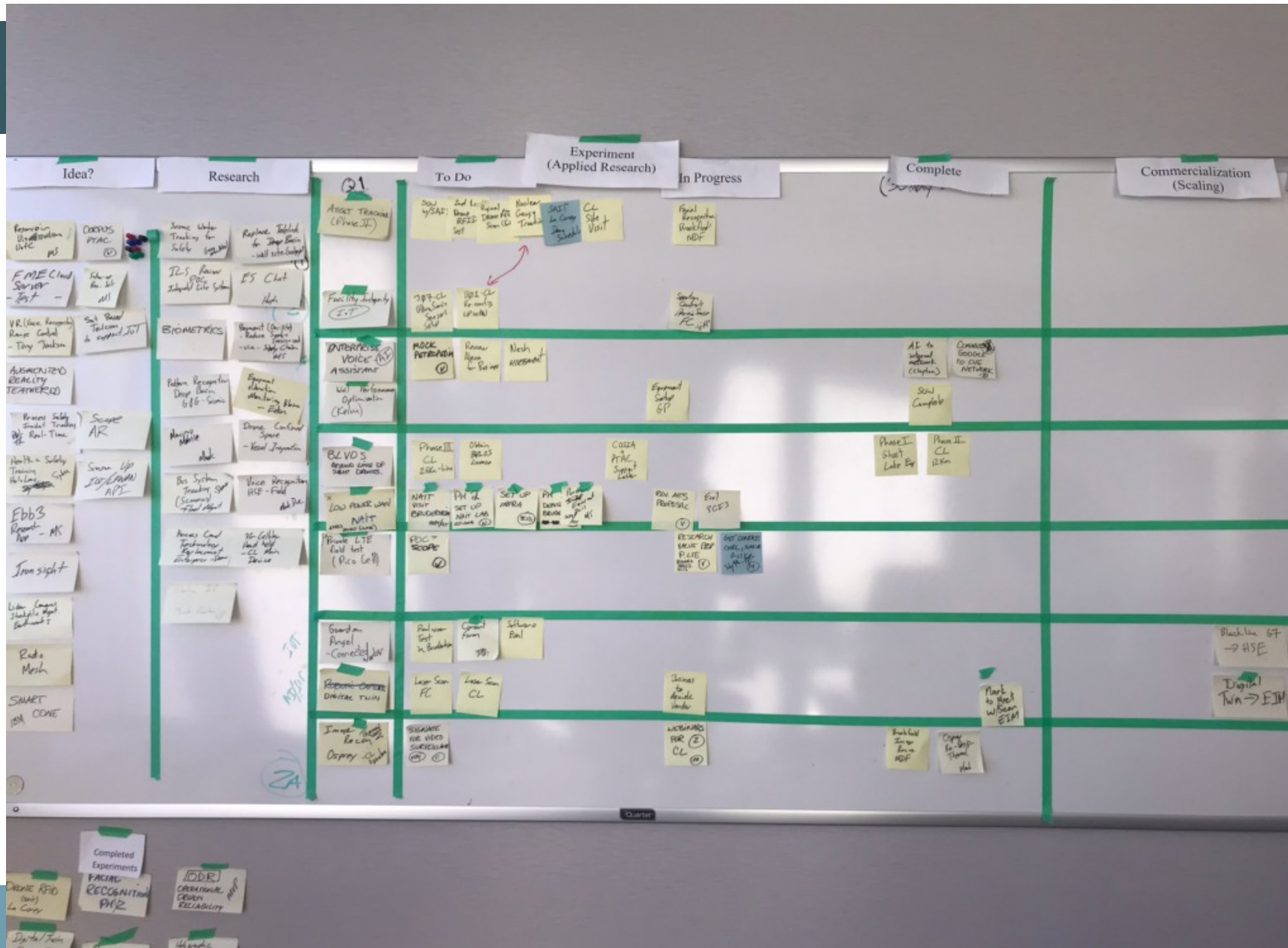


Digital Innovation at Cenovus

Digital Innovation Life Cycle



Agile SCRUM (Kan-Ban)



Evolution

Industrial Revolution

Year 1900: One Motor Vehicle



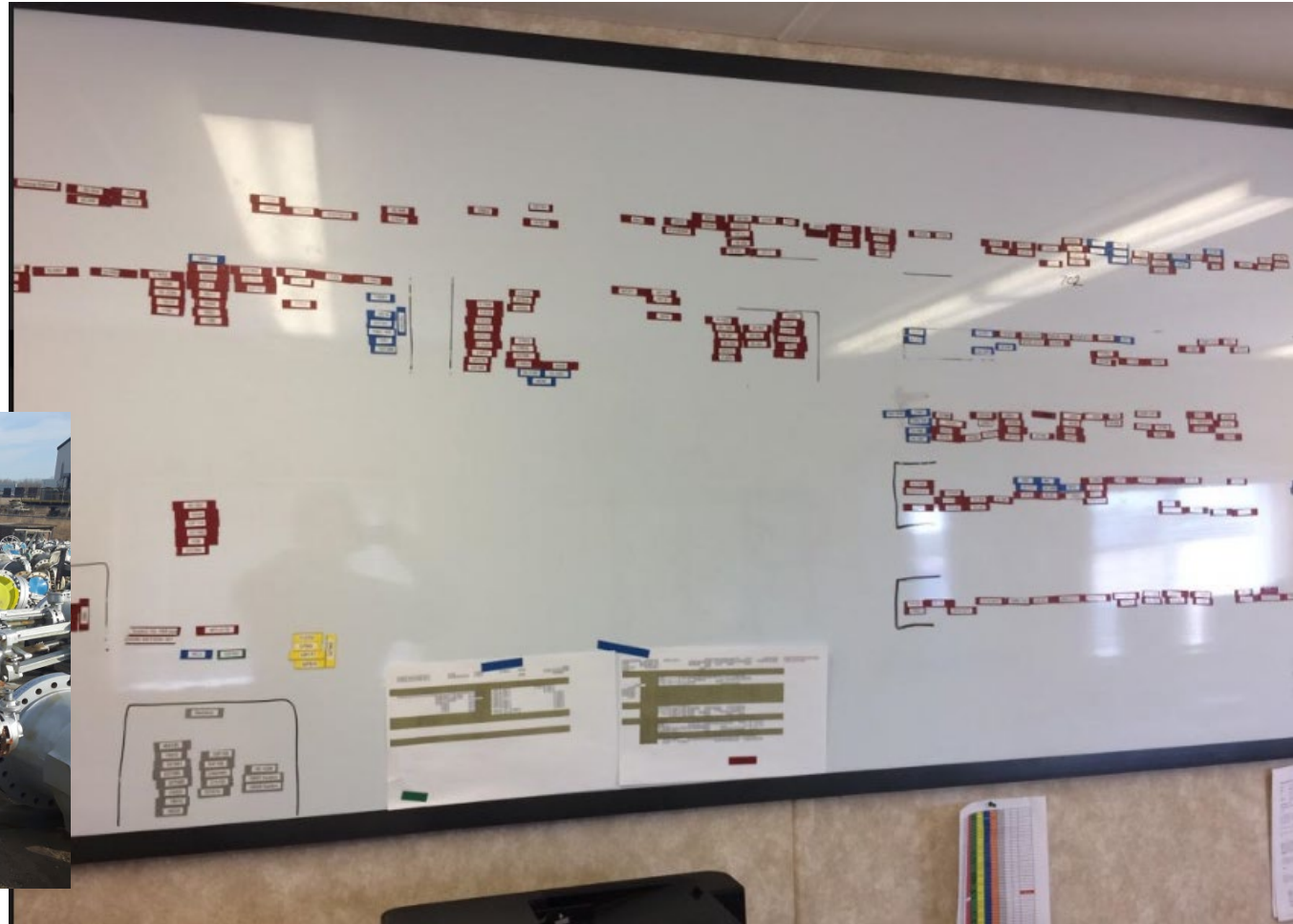
Year 1913: One Horse & Carriage



Asset Tracking

Where is everything?

Over a dozen laydown yards
and Billions (\$) in assets!



Experiment Sites

La Corey Laydown Yard

Christina Lake Tool Crib and Rigmats



Cabinets: LaCorey001, LaCorey002
 Direction: out
 Start Time: October 16, 2018, 1:41 p.m.
 Duration: 0:00:20
 Videos:



Tags Read: 2

Search:

Tag ID	Cabinet	Scanned	Latitude	Longitude
AB99EE0A	LaCorey001	October 16, 2018, 1:41 p.m.	54.441872	-110.768419
AB99EE05	LaCorey002	October 16, 2018, 1:41 p.m.	54.441872	-110.768419

Asset Detail

Location: LaCorey
 Status: IN

Name: Pipe Spools 2
 Cenovus ID: PipeSpools-2
 Group label: Pipe Spools

Image:



Tags:

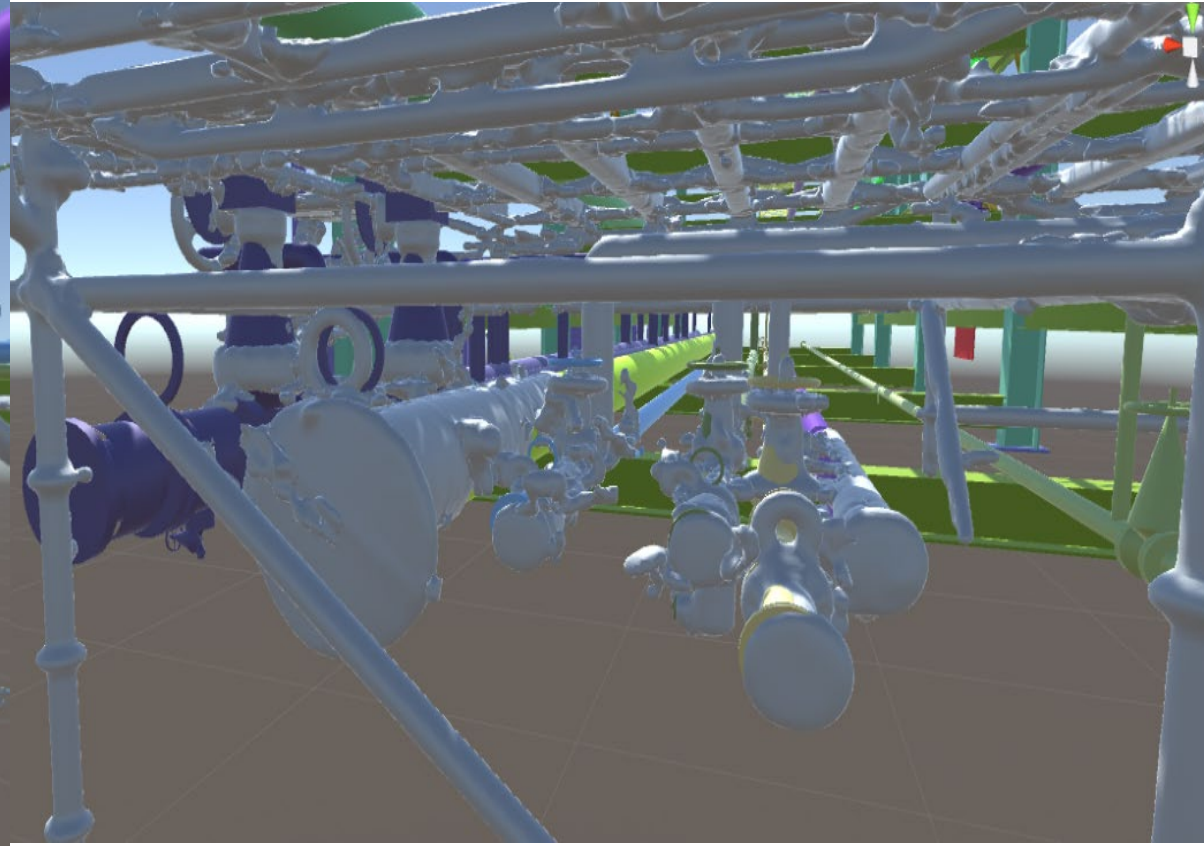
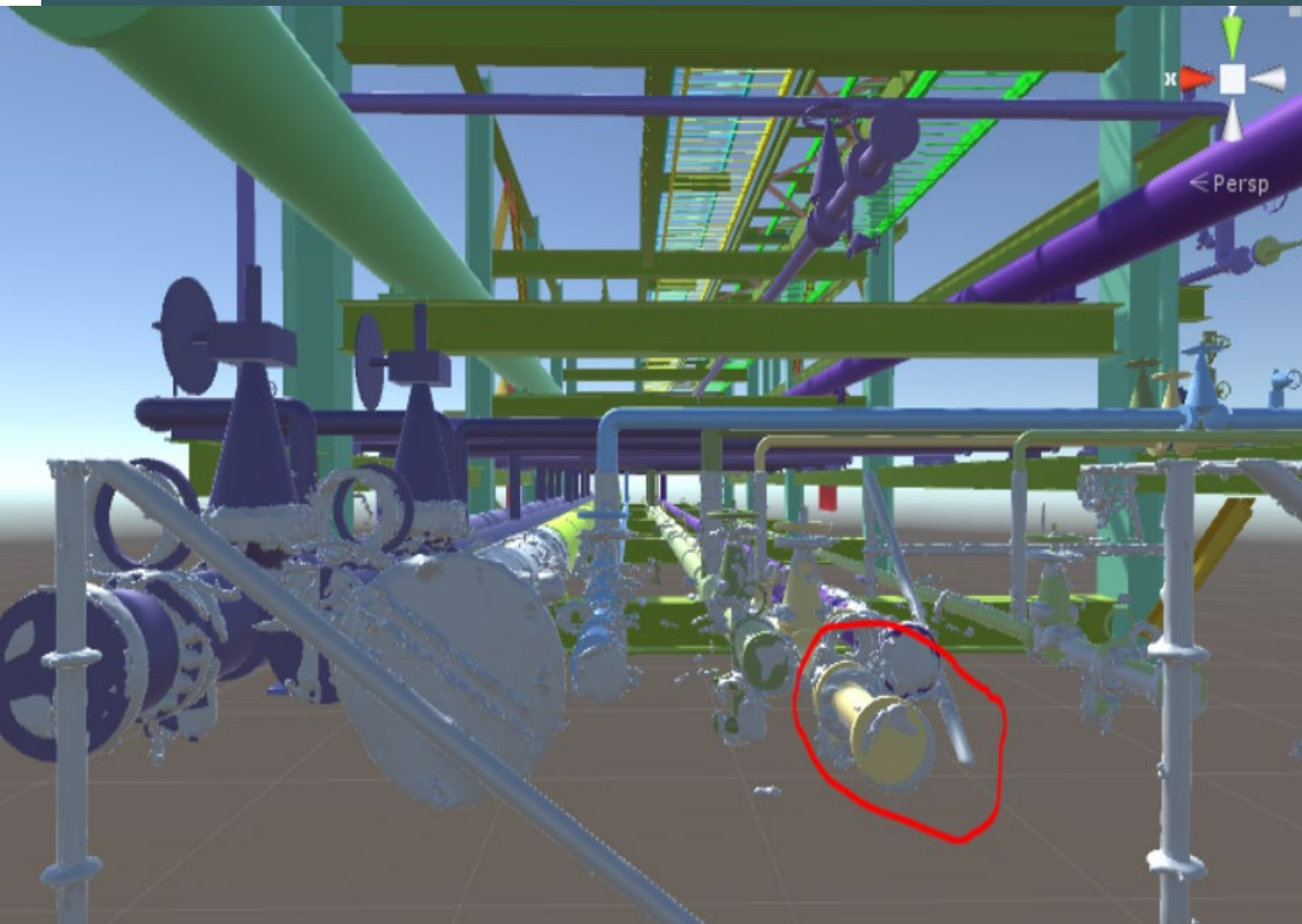
Search:

Tag ID	Last Read	Event Type	Latitude	Longitude
AB99CC3B	October 15, 2018, 1:58 p.m.	PrfidEvent	54.43866685	-110.77386815
AB99CC48	October 15, 2018, 1:58 p.m.	PrfidEvent	54.43866685	-110.77386815

Augment tracking with Facial Recognition

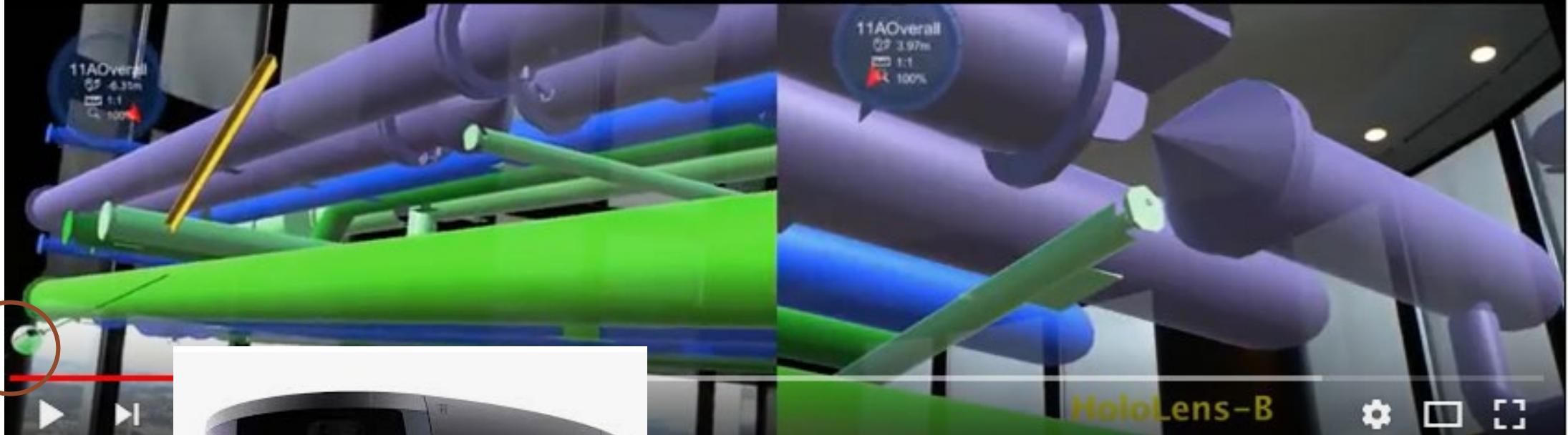


As-built laser scan augmented on 3D CAD Model



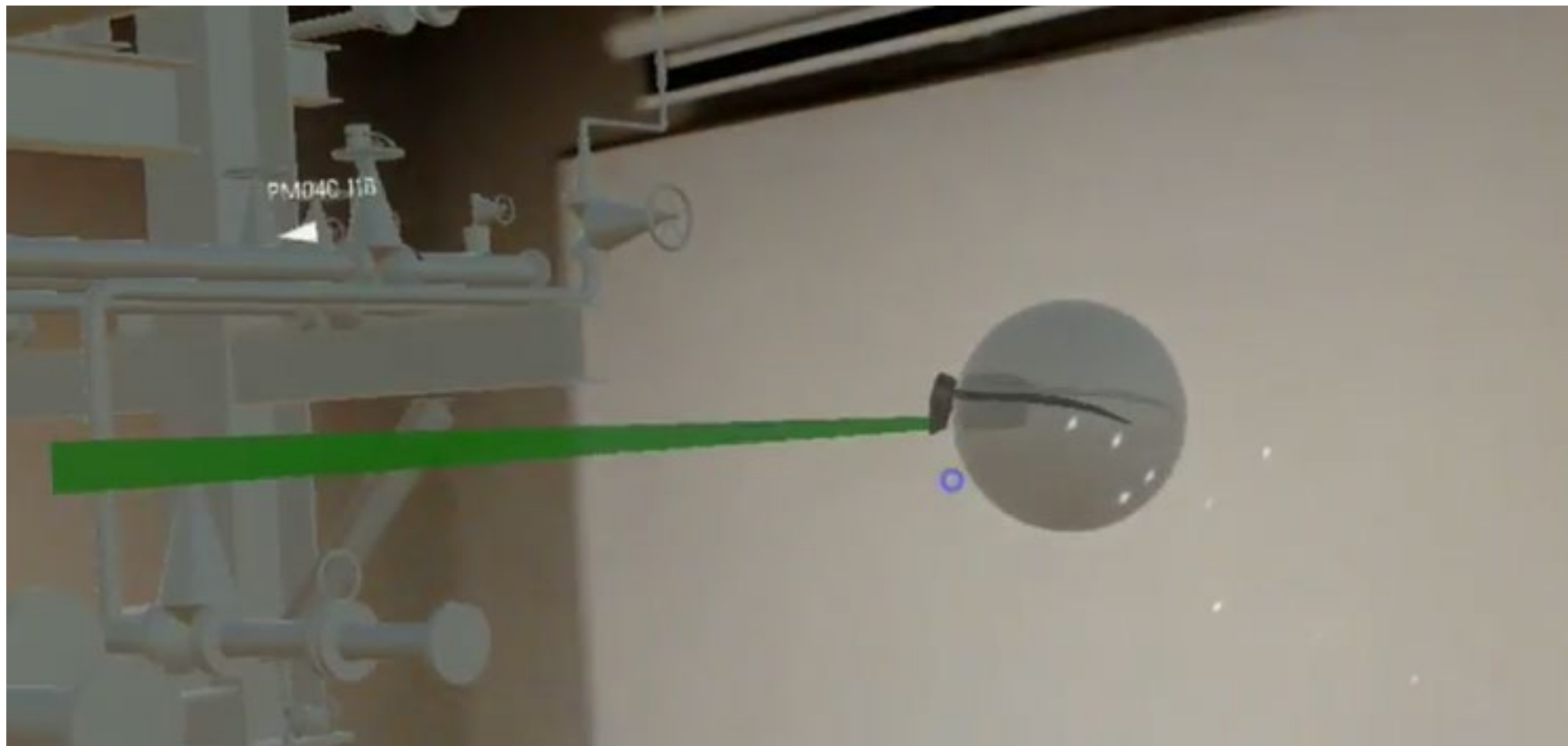
Digital Twin and Augmented Reality

Collaborative Design Reviews



https://www.youtube.com/watch?v=eqZCSD8m_7g&feature=youtu.be

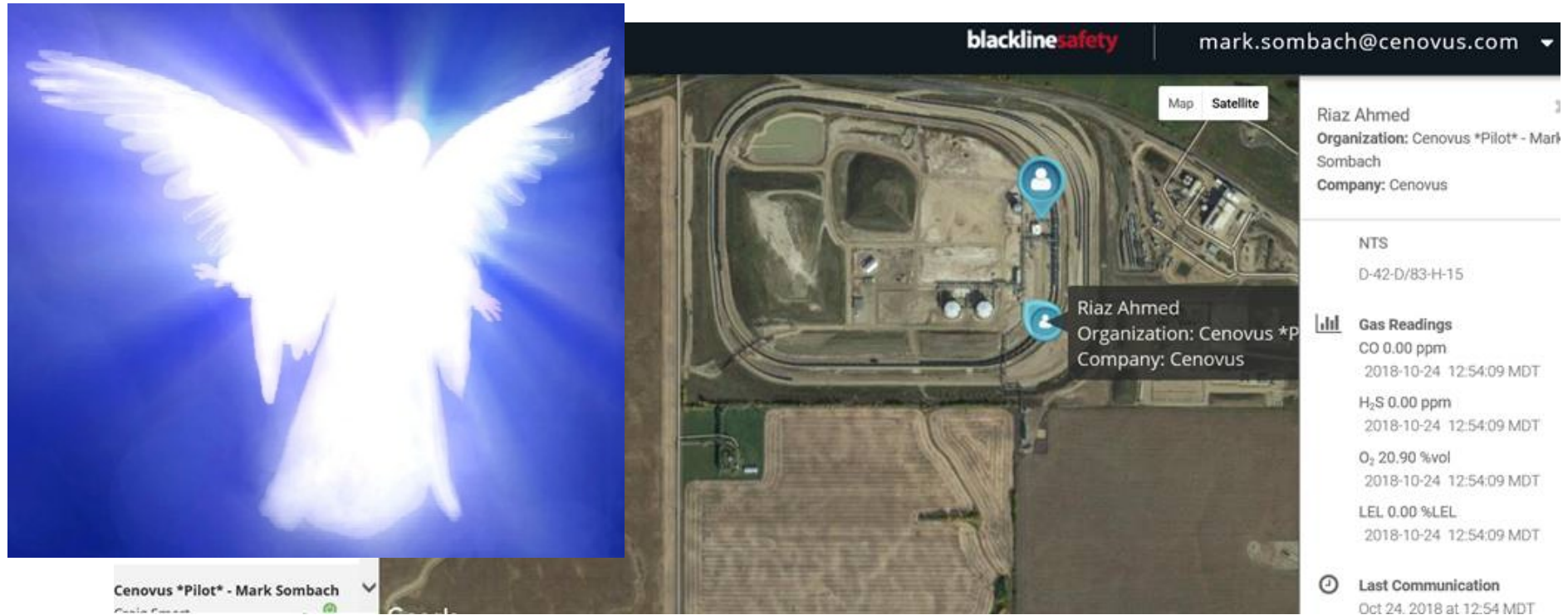
Avatar



Robotic Data Capture



Connected Worker



blacklinesafety | mark.sombach@cenovus.com

Map Satellite

Riaz Ahmed
Organization: Cenovus *Pilot* - Mark Sombach
Company: Cenovus

NTS
D-42-D/83-H-15

Gas Readings
CO 0.00 ppm
2018-10-24 12:54:09 MDT
H₂S 0.00 ppm
2018-10-24 12:54:09 MDT
O₂ 20.90 %vol
2018-10-24 12:54:09 MDT
LEL 0.00 %LEL
2018-10-24 12:54:09 MDT

Last Communication
Oct 24, 2018 at 12:54 MDT

Cenovus *Pilot* - Mark Sombach

Tracking devices



Cenovus *Pilot* - Mark Som

Live View History View

Riaz Ahmed

Date Range:
Oct 24, 2018 12:00 am - Oct 25, 2018

Oct-24-2018 11:09:09 MDT

History Feed

Cenovus *Pilot* - Mark Sombach
Erica Macpherson: Location

Oct-24-2018 11:04:09 MDT

Cenovus *Pilot* - Mark Sombach

Heat Maps created from data captured by the Devices

Reports

- Events
- [Events map](#)
- Alerts report
- Incident report
- Usage and compliance
- Bump tests and calibrations
- Location beacons
- Devices and cartridges
- Docks
- Device logs

Events map

Use this report to explore the locations of your data events. Multiple occurrences of the same type of event might indicate a recurring issue that may require investigation.

Event map report

Last Updated: 10/31/2018 7:00:14 AM MDT

Event Type ● High Gas Alert



Reset page



Data status: ?
All data available

Total events
29

Date

7/10/2018 10/31/2018

Organization

All

Group

All

User

All

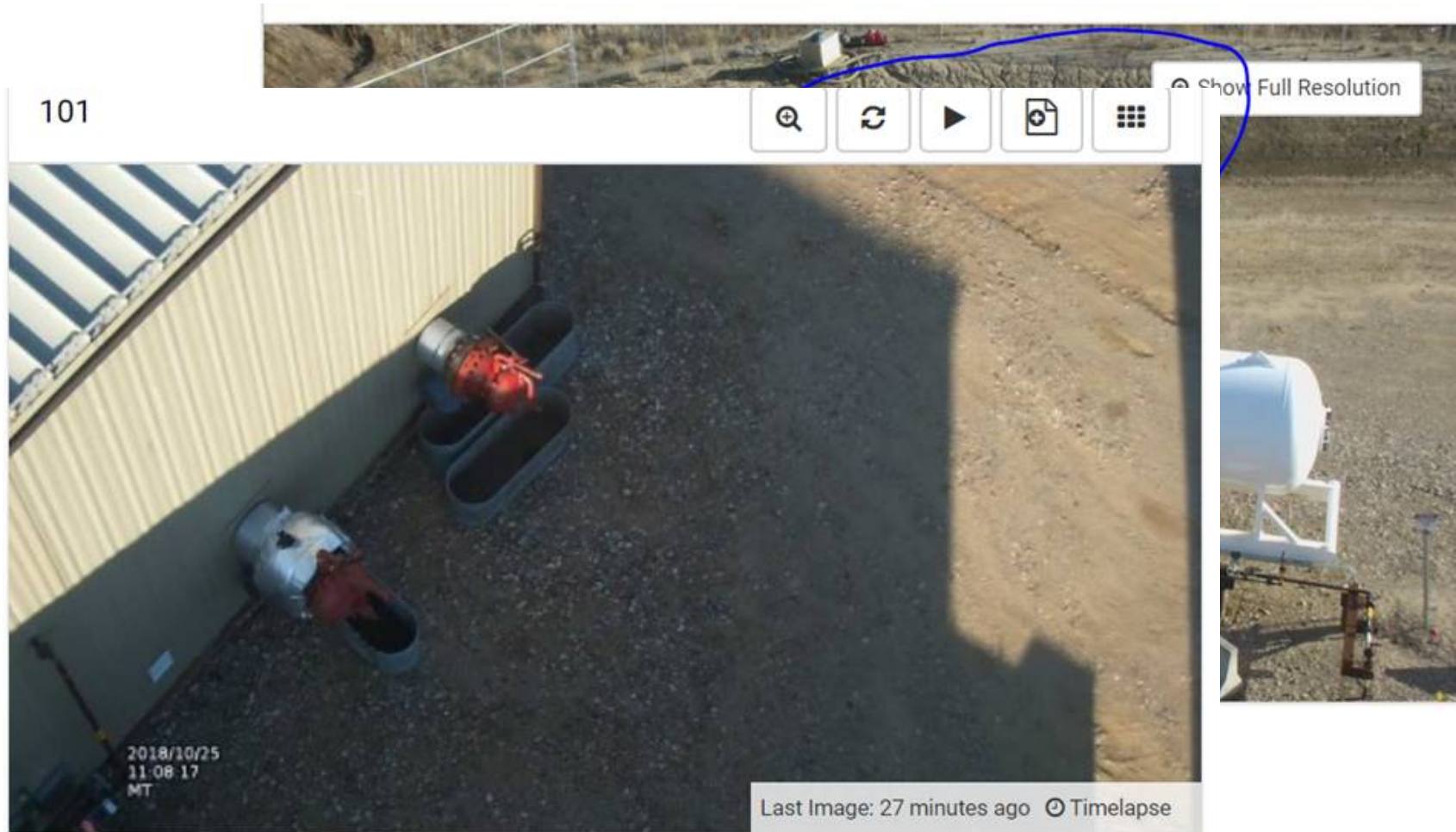
Event type

High Gas Alert

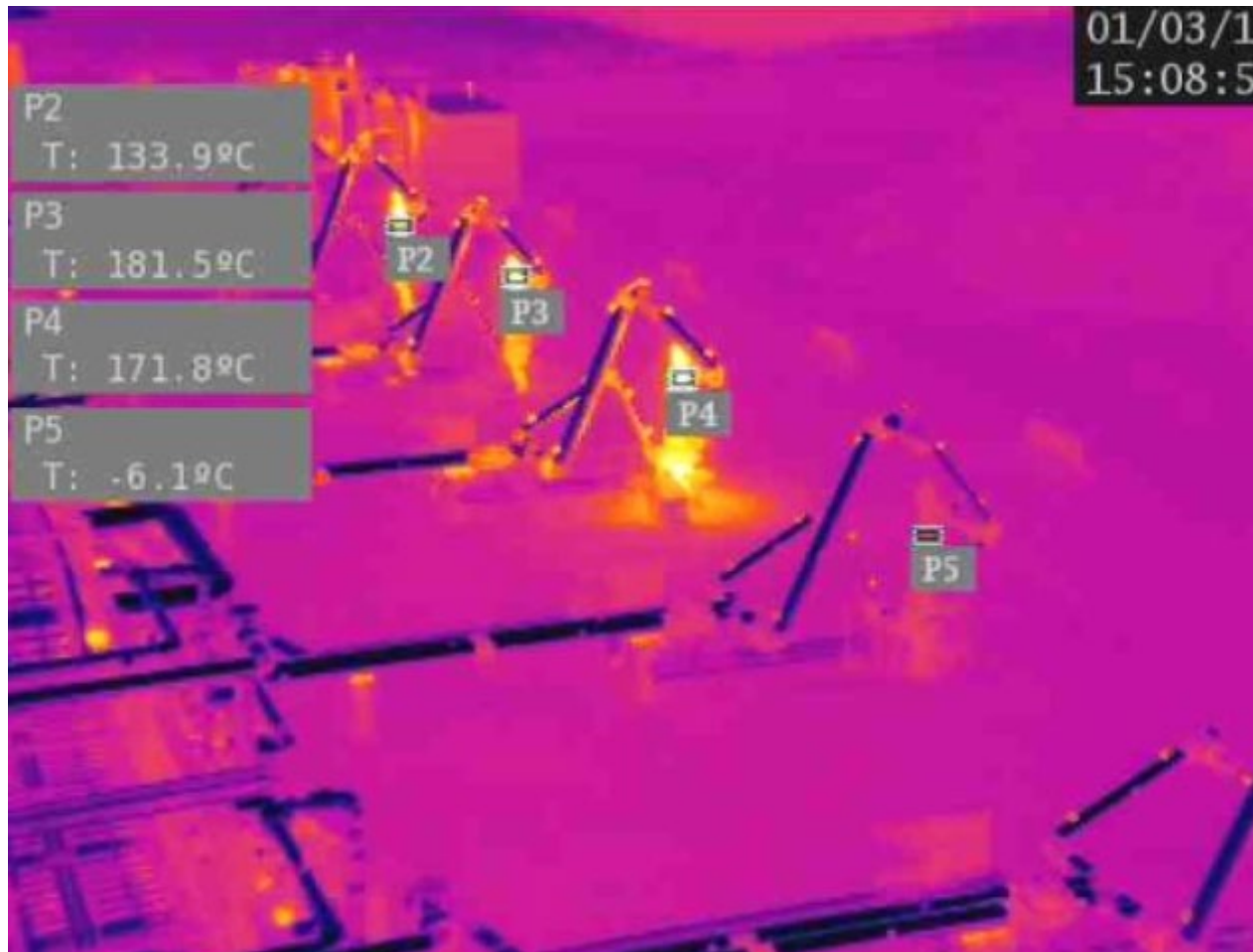
Connected Worker



Image Recognition



Thermal (FLIR Cameras)



IIoT Initiatives

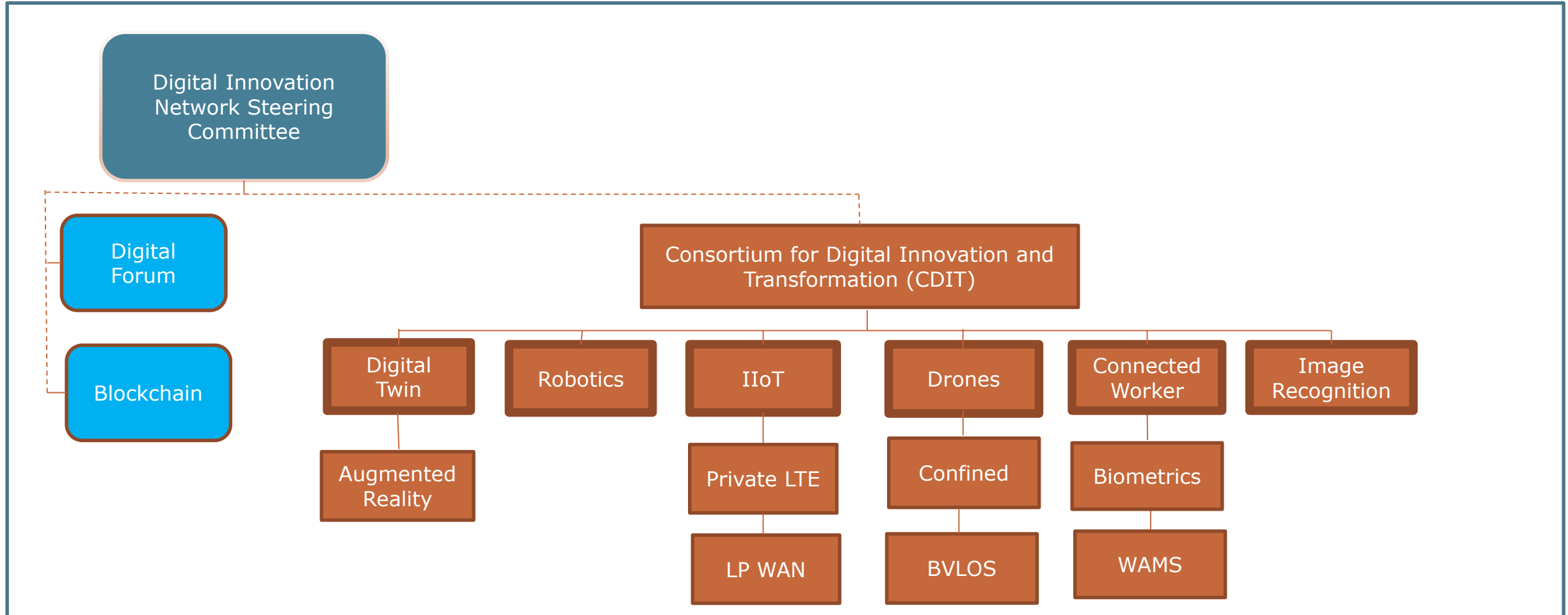




PTAC

**PETROLEUM
TECHNOLOGY
ALLIANCE
CANADA**

Organizational Structure



Current Members

Cenovus

Suncor

CNRL

Husky

Enbridge

TCPL

ATCO Gas

Chevron

Imperial

Encana

COSIA Rep

CRIN rep

Drones (Beyond Visual Line of Sight) - BVLOS

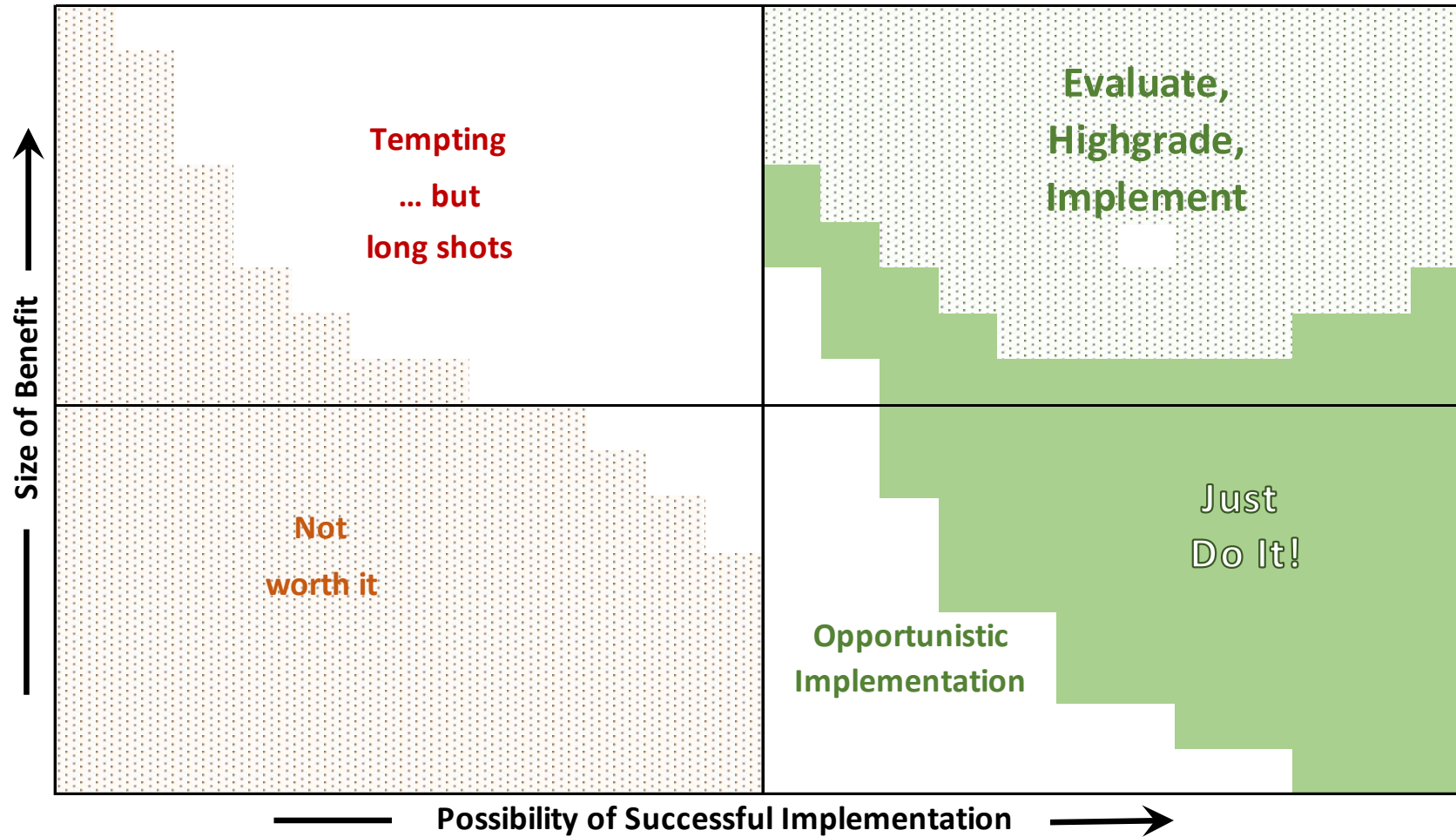


Question and Answer

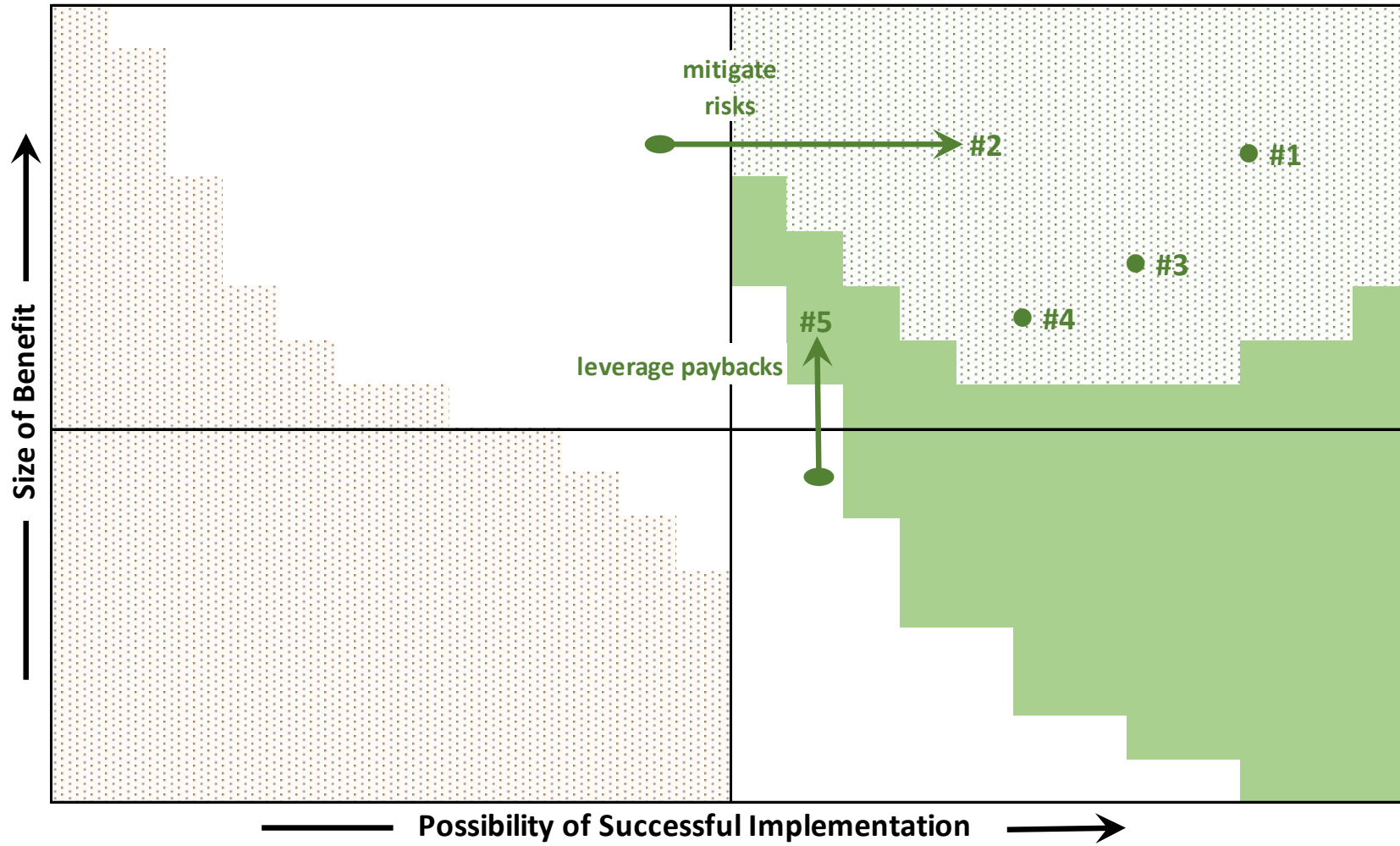


Mark Sombach

Digitalization Opportunities



Identifying the Best Opportunities



Possibilities >>> Practical Plans

Technology

- State of the art possibilities
- Industry trends
- Customer/partner trends
- Practical options ... likely benefits

People + Processes

- Leadership / vision
- Culture / adaptability
- Technology infrastructure
- Practical implementation plans





The Knowledge Leader for Project Success

Owners • Contractors • Academics

Information Integration to Improve Capital Project Performance

2009 CII Annual Conference

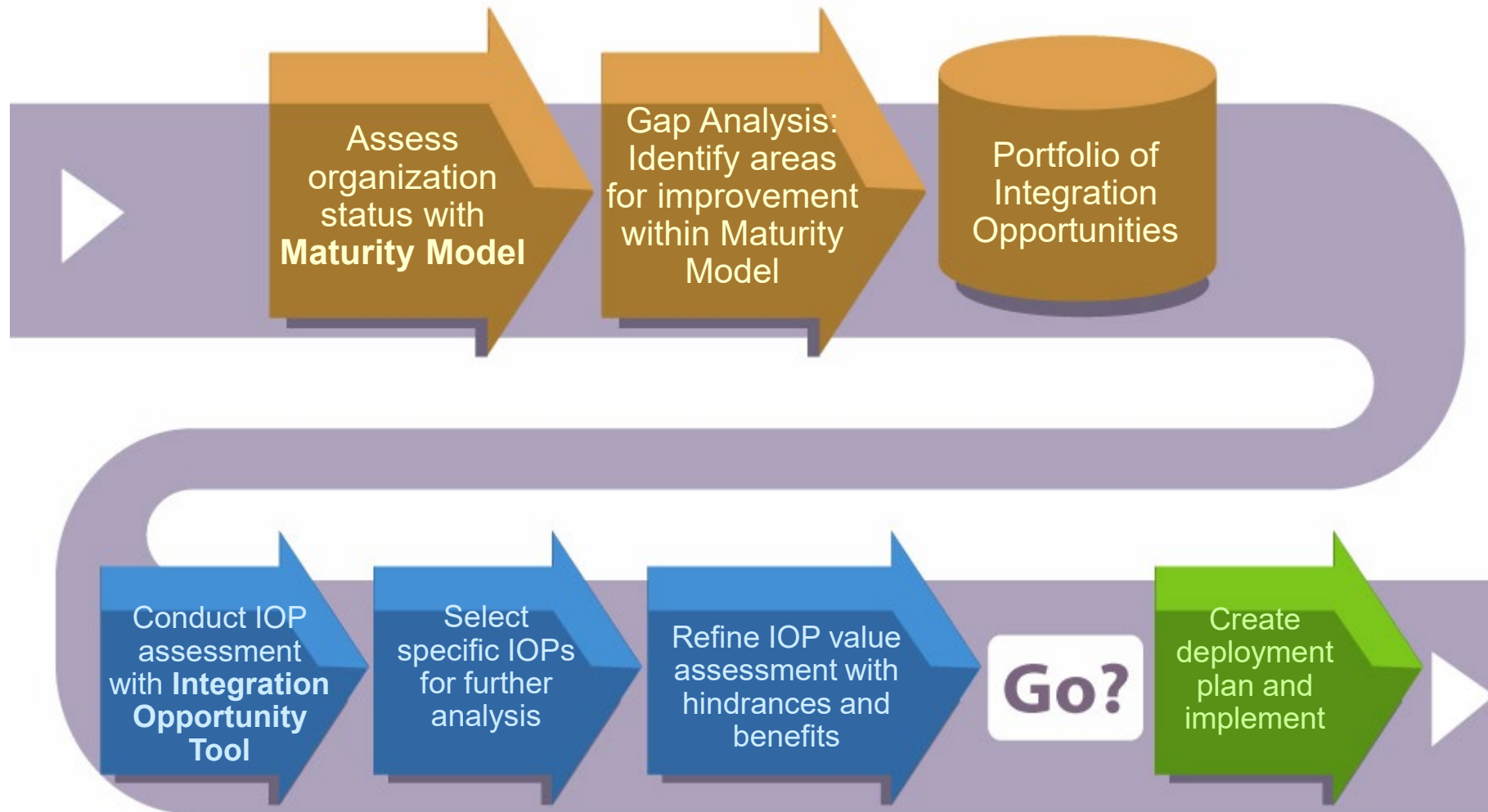
Reno, Nevada

Decision Support Tool

History

RT 258 ... the first structured process
to help companies assess current
efforts and plan a path forward.

Assessment and Selection Process



Integration Opportunity Assessment Tool

<Instruction>

- For each question, please mark your answers with "X" or "x". "V" or "O" will not work.
- Please make sure that you mark only one choice for each question.
- In the current scoring algorithm, "No response" will be regarded as "NA/UNK".
- Once you finish answering the questions, go to "Summary" spreadsheet. You will be able to see the benefit driver score and hindrance score.
- This is a beta version. There will be some changes such as having radio click button instead of "x" mark, having a minimum number of valid answers for analysis, etc.

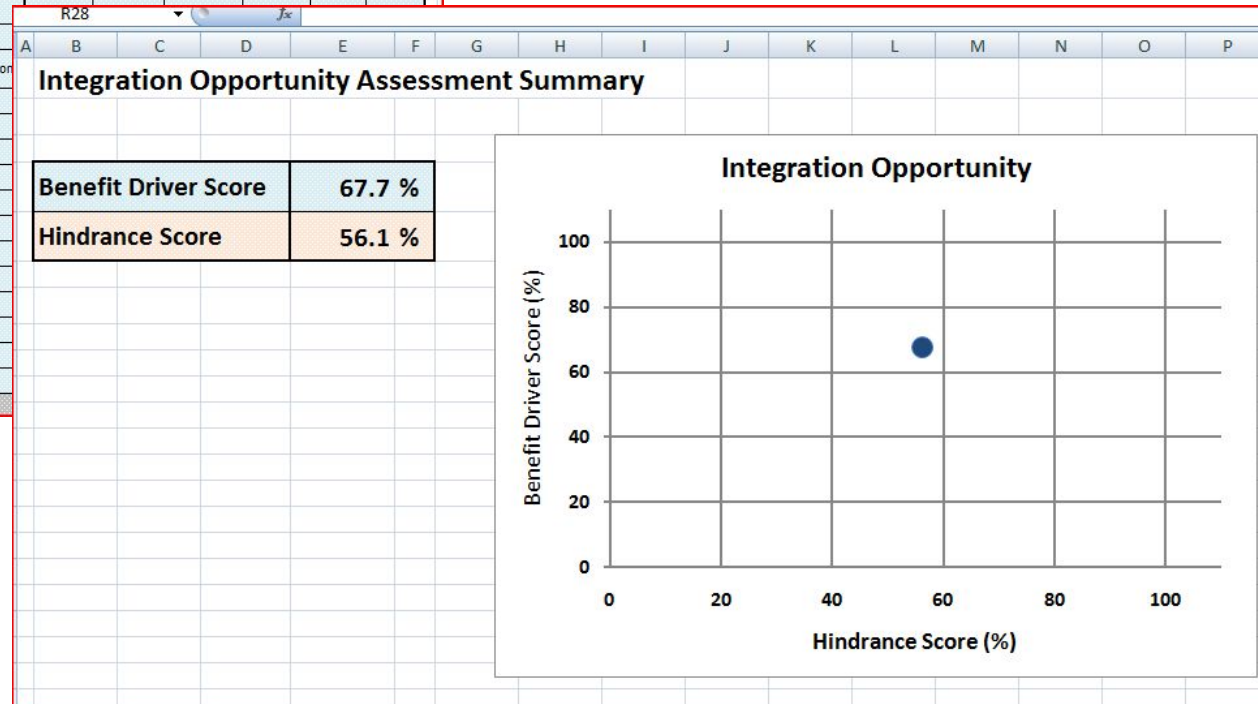
Part I. Benefit Drivers

I. 1. Market/Legal Benefit Drivers

	Yes	No	NA/UNK
1. Would the IO enable entry to new market?	x		
2. Would the IO facilitate or enhance regulatory compliance?			

I. 2. Organizational & Process Benefit Drivers

	High	Med. Hig.	Med. Low	Low	NONE	NA/UNK
3. Please characterize the general extent of benefits likely to result from the IO:						
a. Enhanced Quality						
b. Enhanced Reliability						
c. Enhanced Functionality						
d. Enhanced Adaptability/Flexibility/Robustness in responding to varying conditions						
e. Enhanced Productivity						
f. Enhanced Speed-to-market						
g. Enhanced Project Schedule performance						
h. Enhanced Cost reduction						
i. Enhanced Predictability of cost, schedule, performance, etc.						
j. Enhanced Customer Focus and/or Satisfaction						
k. Enhanced Security of data						
l. Enhanced Access to information						
m1. Enhanced Management of human resources						
m2. Enhanced Management of physical resources						
4. Frequency of IO application to projects						
a. For what portion of projects is this IO applicable?						

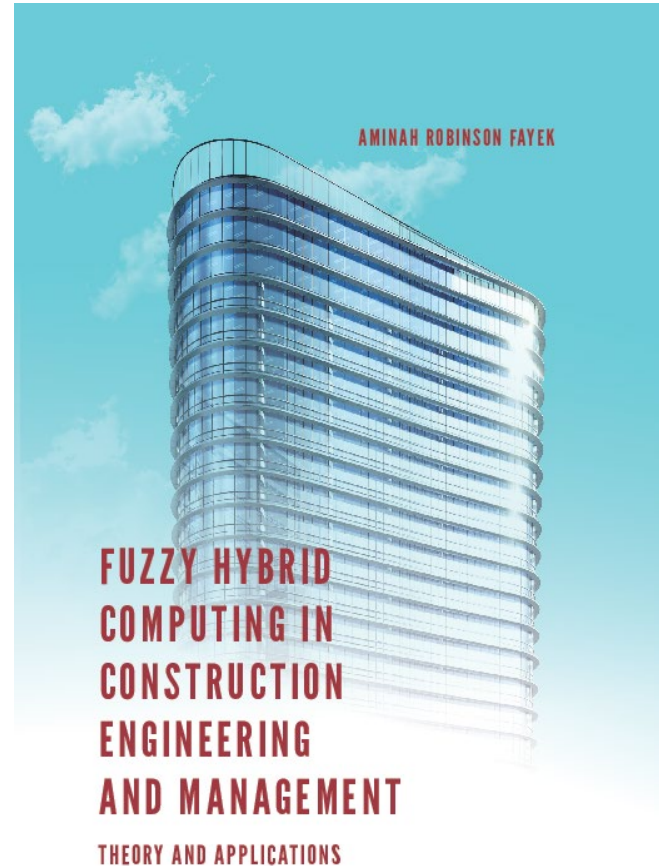


Fuzzy Logic Tools - Advantages

- **Structured process** to consider potential benefits and risks
- Uses natural language (**user friendly**)
- Enables **multi-user inputs** online by stakeholders and experts across the company (eliminates difficult-to-schedule meetings to gather inputs)
- Flexibility to **customize** lists of benefits and risks, customize linguistic terms
- Can **identify opportunities** to leverage high-impact benefits; manage and mitigate high-impact impediments
- **Easily-communicated, defensible recommendations** and ranking of digitalization opportunities



Fuzzy Logic Tools – COAA Advantage

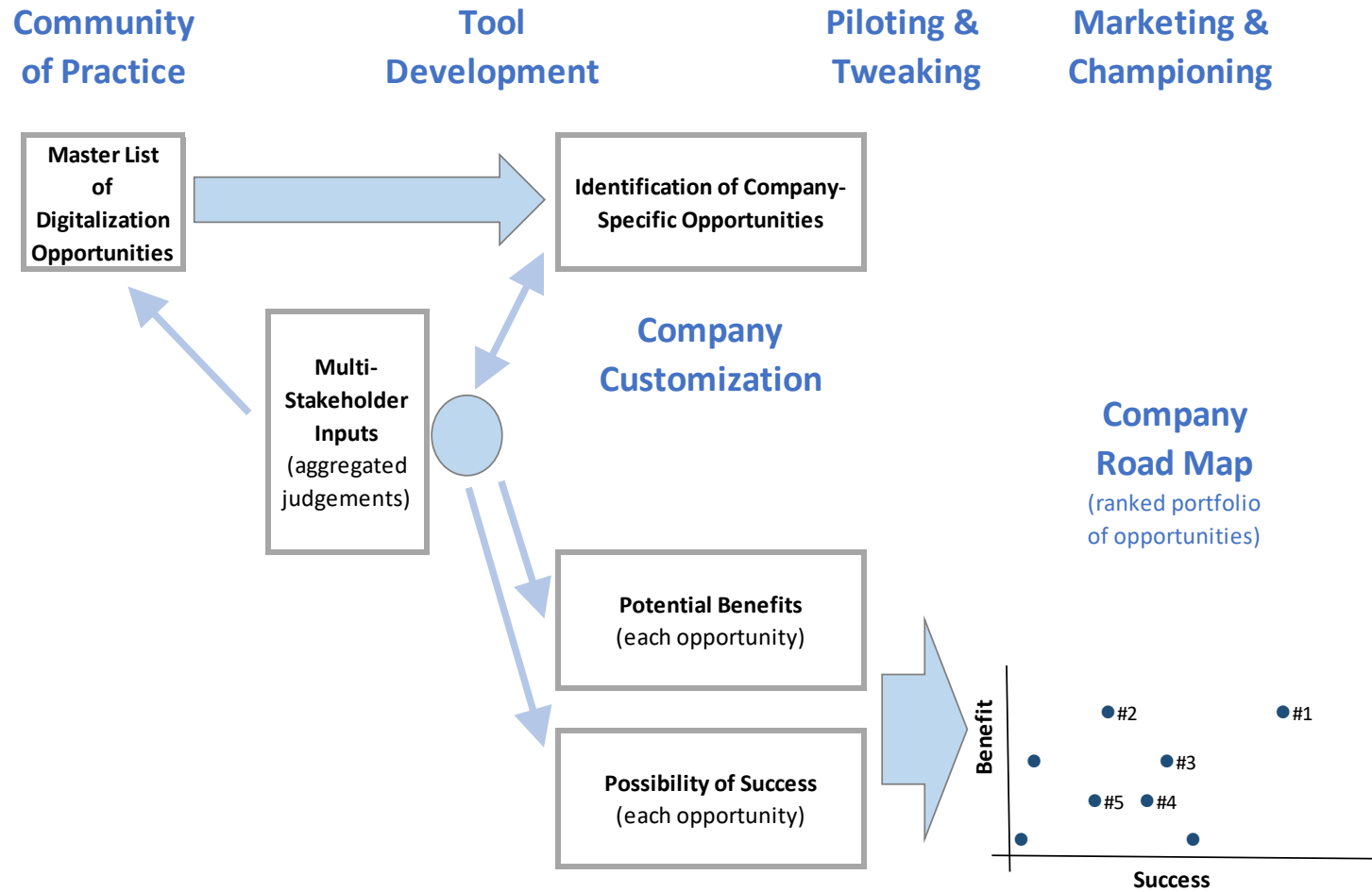


Dr. Aminah &
Students / Post Docs

Assisting companies
to think through
benefits and risks ...



Decision Support Tool



Project Plan

	2018 2019				2019 2020				2020 2021		
	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter		
Establish CoP & web page		BP2019									
Project Workshop II											
Refine question sets											
Spreadsheet mockup of tool											
Alpha version of tool											
Project Workshop III											
Tool demo at BP2020											
Beta version of tool											
Project Workshop IV											



Project Steering Committee

Adamantia Fatsea	Director, Engineering & Construction	Alberta EDT&T
Chris Desaulniers	Project Sponsor	Ledcor
Chris Squires	Project Engineer	Imperial Oil
Jason Collins	Chair	Alberta Steel Manufacturers
Jennifer Collins	Project Manager, Core Projects	Enbridge Pipelines
Mangesh Kumthekar	Project Manager, Digital Projects	Suncor Energy
Matt MacMaster	Group Lead, Construction Project Services	Cenovus Energy
Richard Boodoo	Project Manager, Core Projects, Mainline	Enbridge Pipelines



Community of Practice

- Contribute digitalization opportunities to web portal; learn from submissions of others (one-page template)
 - Potential opportunities (interesting technologies)
 - Case studies: opportunities implemented – successes and lessons learned
- Updates on project progress, invitations to join project workshops



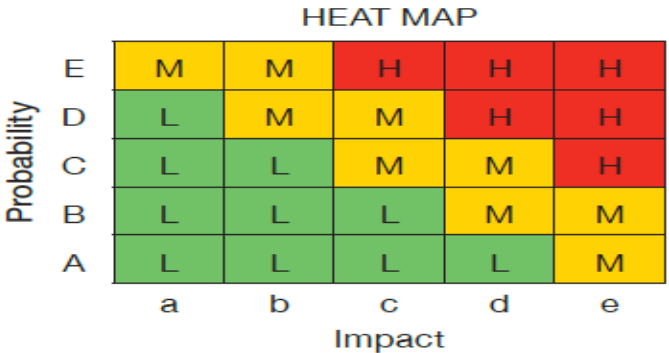


**STRATEGIC CONSTRUCTION
MODELING AND DELIVERY**
INDUSTRIAL RESEARCH CHAIR

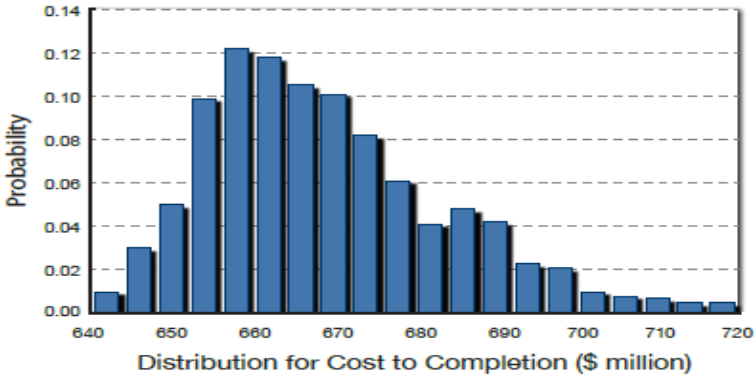
Fuzzy Logic Decision Support Tool for Digitalization Implementation

Digitalization in Assessing Risk and Contingency

Traditional risk analysis approaches fail to capture subjective uncertainties and expert knowledge and rely on historical data. Opportunities are often not captured.



Deterministic risk analysis



Probabilistic risk analysis (Monte Carlo simulation)



Digitalization in Assessing Risk and Contingency

Multi-level risk/opportunity event breakdown structure can be created for each project category or for individual projects.

The screenshot displays a software interface for managing risk and contingency. On the left, a tree view shows a hierarchy of categories: 1. Management, 2. Technical, 3. Construction, and 4. Resources related. Under '4. Resources related', there are three sub-categories: 4.1. Resource related, 4.2. Material related, and 4.3. Equipment related. The '4.1. Resource related' category is expanded, showing a list of specific events: 4.1.1 Unavailability of sufficient amount of skilled labour in project region, 4.1.2 Low labour productivity of local workforce, 4.1.3 Untrained and inexperienced labour force, 4.1.4 Strikes and labor disputes, 4.1.5 Higher workforce attrition rates, and 4.1.6 Workforce absenteeism. On the right, a table titled 'Risk/Opportunity Event List: 4.1. Resource related' displays these events in a structured format.

Event Code	Event Name	Event Type
4.1.1	Unavailability of sufficient amount of skilled labour in project region	Local
4.1.2	Low labour productivity of local workforce	Local
4.1.3	Untrained and inexperienced labour force	Local
4.1.4	Strikes and labor disputes	Local
4.1.5	Higher workforce attrition rates	Local
4.1.6	Workforce absenteeism	Local



Digitalization in Assessing Risk and Contingency

Experts assess the probability and impact of each risk and opportunity event using natural language. Methods have been developed to take into account their levels of expertise when combining their opinions in order to calculate project contingency.

Risk/Opportunity Event List

Local Global

	Risk Probability	Risk Impact	Risk Severity in %	Opportunity Probability	Opportunity Impact	Opportunity Severity in %	Net Severity in %	Cost of Work Package Affected in %	Cost of Work Package Affected in \$	Net Severity in \$
▶	Low	High		N/A	N/A			100	15336600	
	High	Low		N/A	N/A			100	15336600	
	Medium	High		Low	Medium			50	7668300	
	N/A	N/A		Medium	Low			75	11502450	
*										

Work Package Contingency

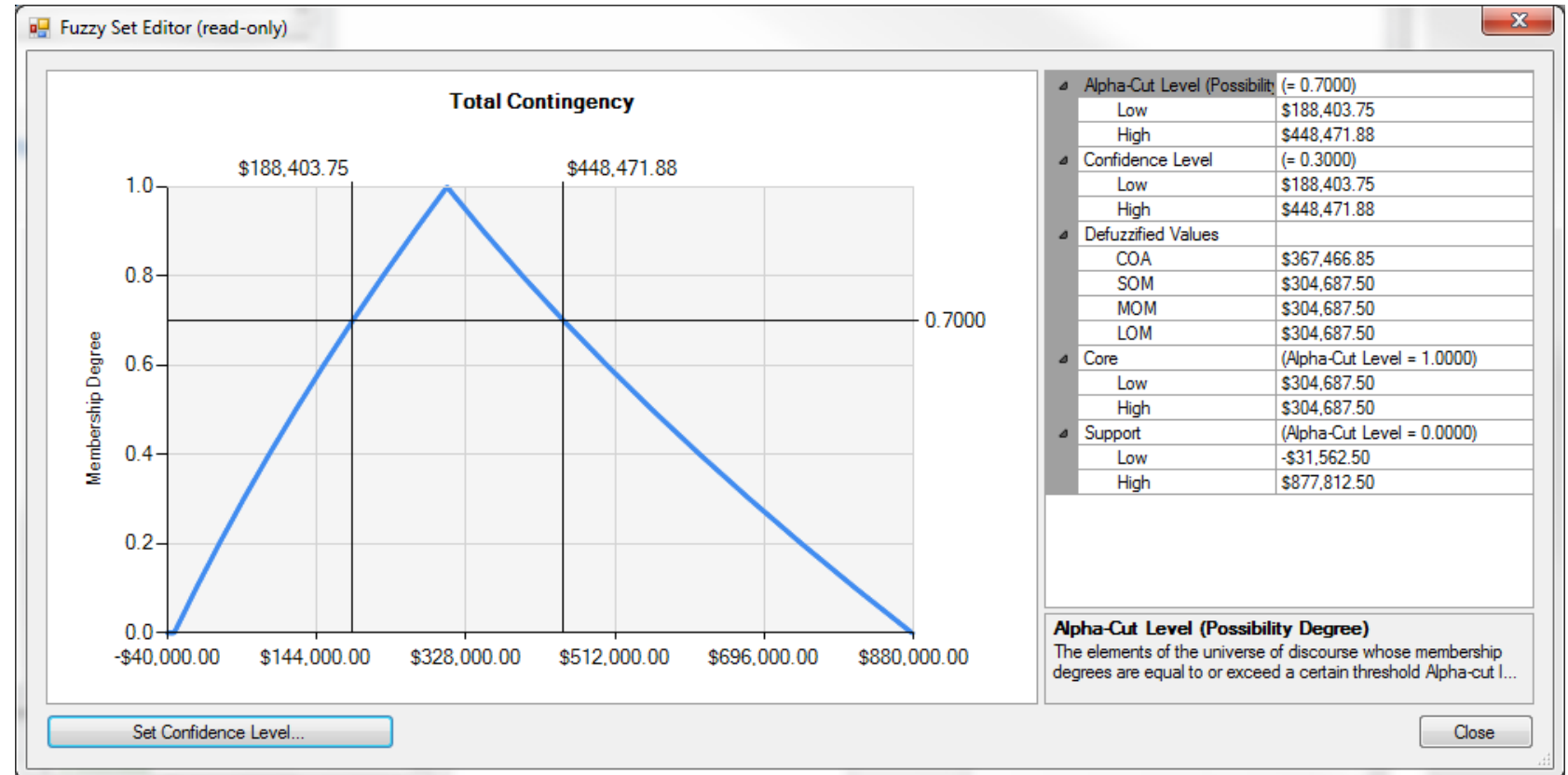
Due To Local Risk: **\$9,836,991.09** Due To Local Opportunity: **\$3,001,420.55** Due To Local Events: **\$6,835,570.55**



Digitalization in Assessing Risk and Contingency: Fuzzy Risk Analyzer[©] (FRA[©])

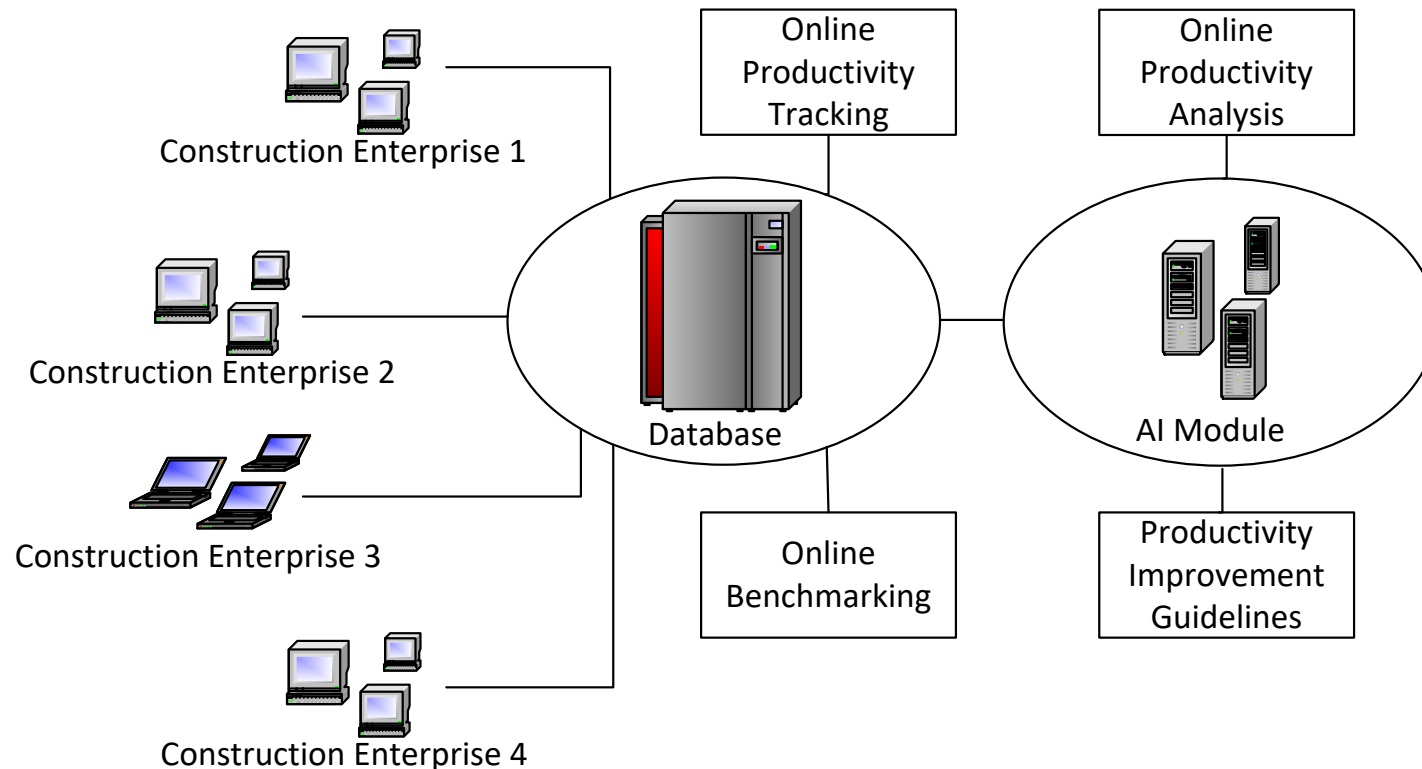
Database-driven software tool for determining construction project contingency:

- **Ease of use**
 - ✓ Efficient and consistent group inputs
- **Robust methodology & reliable results**
 - ✓ Linguistic factors calibrated
- **Proven useful**
 - ✓ Staff efficiencies and corporate benefits



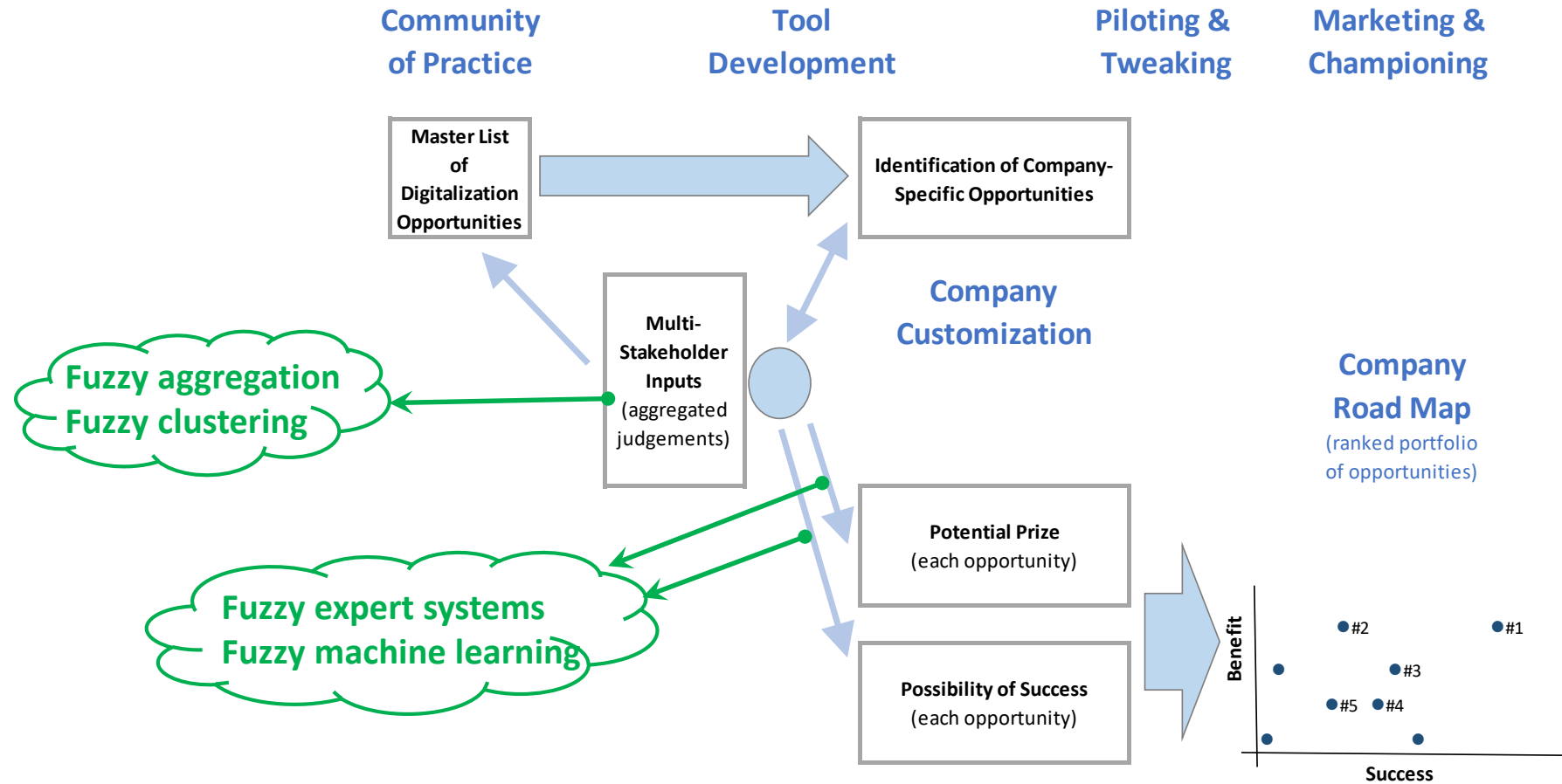
Digitalization in Productivity Tracking And Analysis

Artificial Intelligence (AI) tools and a database to help construction organizations record, measure, track, and improve construction productivity.



Fuzzy Logic in Decision Support Tool

Preliminary Conceptual Model



Workshop Participation

Sli-do “voting buttons”

1. Join WiFi: **Freeman** >>> Prepaid Access Password: **BP2019**
2. Go to www.slido.com Code: **COAA19**
3. Select room: **CPC-8 Digitalization Support Tool ...**



Workshop Participation

Sli-do “voting buttons”

Q1: Do you want that your identity and contact information revealed to others in the Community of Practice?

Q2: How do you prefer to provide your input for the Community of Practice?

1. Online Web Form (online form completed by you)
2. Survey Monkey (online survey emailed to you)
3. Questionnaire (Hard copy delivered to you)
4. Interview (Face-to face interview)



Potential Benefits

of implementing digitalization

To what extent do you consider each of the following as a significant benefit of implementing digitalization in a construction organization?

<p>if successful ... low or localized impact on safety, productivity, effectiveness</p>		<p>if successful ... significant division-wide impact on safety, productivity, effectiveness, customer service</p>		<p>if successful ... significant Alberta-wide impact on safety, effectiveness, customer relationships, strategic prospects</p>
				



Potential Benefits

of implementing digitalization

Q3: To what extent do you consider each of the following items as a significant benefit of implementing digitalization in a construction organization?

1. Enhanced quality, reliability, and functionality
2. Enhanced productivity and cost reduction
3. Enhanced understanding and predictability of work process
4. Enhanced customer focus and/or satisfaction
5. Enhanced security of data and access to information
6. Enhanced adaptability/flexibility/robustness in responding to varying conditions
7. Enhanced product speed-to-market and project schedule performance
8. Enhanced management of human and physical resources
9. High utilization time and applicability to majority of projects in the company
10. Enhanced strategic and tactical decision-making



Potential Benefits

of implementing digitalization

Q3 Cont'd: To what extent do you consider each of the following items as a significant benefit of implementing digitalization in a construction organization?






11. Enhanced inter-company/intra-company efficiency
12. Enhanced concurrent use of data, quality of data, and subsequent leveraging of data
13. Enhanced work sharing
14. Resolving data versioning problems among different users
15. Consolidating and elimination of existing software applications
16. Utilizing/leveraging established and industry-wide data standards
17. Utilizing existing commercially proven applications
18. Enhanced ease of application and training
19. Enhanced employee morale and the work environment
20. Enhanced or encouraged positive behavioural change (e.g., collaboration)



Success Factors

for implementing digitalization

To what extent do you consider that each of the following significantly affects the possibility of success of implementing digitalization in a construction organization?

weak effect (positive or negative) on successful implementation		possible enabler or possible barrier re: successful implementation		strong enabler or strong barrier re: successful implementation
				



Success Factors

for implementing digitalization

Q4: To what extent do you consider that each of the following significantly affects the possibility of success of implementing digitalization in a construction organization?

1. Security and holder-of-data requirements
2. Intellectual property demands and legal ownership of data
3. Contractual agreements and labour agreements
4. Possibility of misuse and mishandling of data
5. International/local law restrictions
6. Internal/external organization culture
7. Business procedures/process
8. Internal /external parties
9. Data availability (timing)
10. Quality of data (i.e., data structure, formats, data sources)



Success Factors

for implementing digitalization

Q4 Cont'd: To what extent do you consider that each of the following significantly affects the possibility of success of implementing digitalization in a construction organization?

11. Upper management support
12. Financial support
13. Geographic dispersion of users
14. Company expertise
15. Basic capabilities of user community
16. Training requirements
17. Sustained support resources (e.g., on-call support)
18. Champions at the user/manager levels
19. Technology ownership
20. Commitment of data providers (to comply data standards/procedures)



Digitalization Resources

- McKinsey Global Institute **Reinventing Construction: A Route to Higher Productivity** 2017 www.mckinsey.com
- The Revay Report **Demystifying Artificial Intelligence (AI) in Construction** March 2019 www.revay.com/index.php/publications/the-revay-report/
- Torroba, Andrea **Digitalization in Oil and Gas Projects** September 2018 (MBA capstone paper) ... contact Larry Staples



Digitalization Resources

- Construction Industry Institute. Information Integration to Improve Capital Project Performance (RR258-1 Research Summary) September 2009.
<https://www.construction-institute.org>
- Construction Industry Institute. Information Integration to Improve Capital Project Performance(IR258-2 Implementation Resource) May 2011.
<https://www.construction-institute.org>
- Construction Industry Institute. Information Integration to Improve Capital Project Performance (RR258-11 Research Report) December 2010.
<https://www.construction-institute.org>



Digitalization Resources

- McKinsey and Company. Imagining Construction's Digital Future, June 2016 <https://www.mckinsey.com>
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- World Economic Forum. Digital Transformation Initiative Oil and Gas Industry (White Paper), January 2017. <https://www.weforum.org>



Thank You

for participating today

- Sign up to join the **Community of Practice** to identify promising new technologies and share implementation experiences:
e-mail coaa.admin@coaa.ab.ca Subject: **Digitalization Implementation**
- Stay in touch via project web page www.coaa.ab.ca/tbd
- Larry Staples larry@coaa.ab.ca





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