Microseismic Data Flow Digitalization at the Quest CCS Facility

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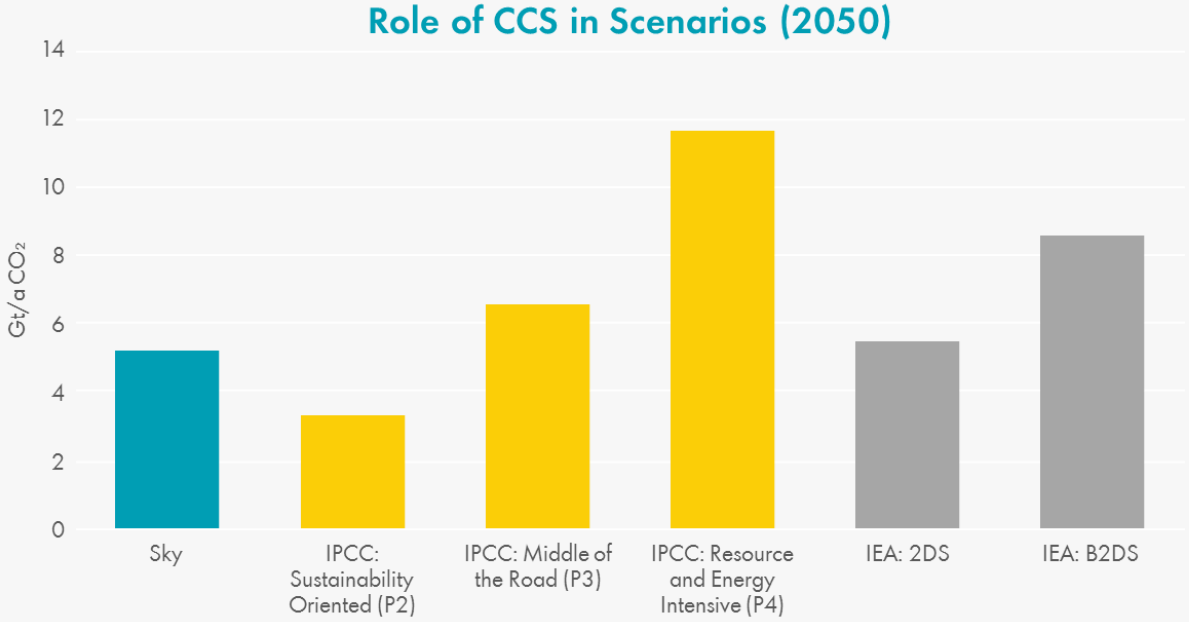
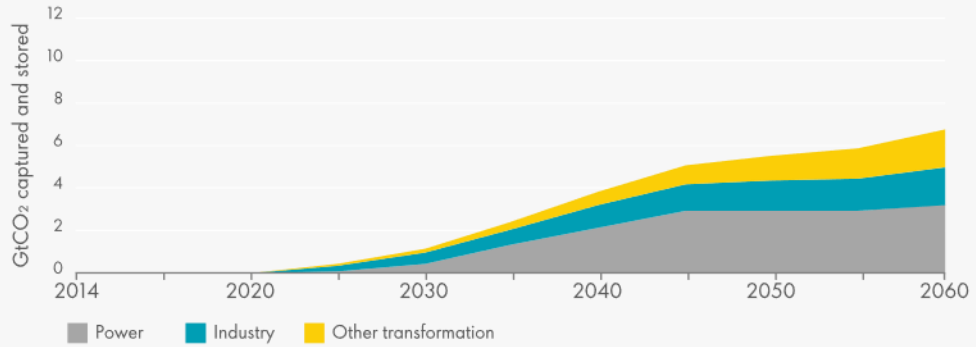
Outline

- **Carbon Capture & Storage**
  - GHG Reduction
- **Risk-based Measurement, Monitoring & Verification (MMV)**
  - Ensure safe CO_2 storage
- **Quest Facility**
  - Operating a 1Mta CCS facility
- **Microseismic Data Flow**
  - Sensor to Assessment
- **Digitalization and AppDesigner**
  - Value add

Scenarios to meet Paris agreement and limit average global temperature rise to below 2°C include CCS





18 large scale projects are in operation
5 in construction
~40 million tons were stored in 2017

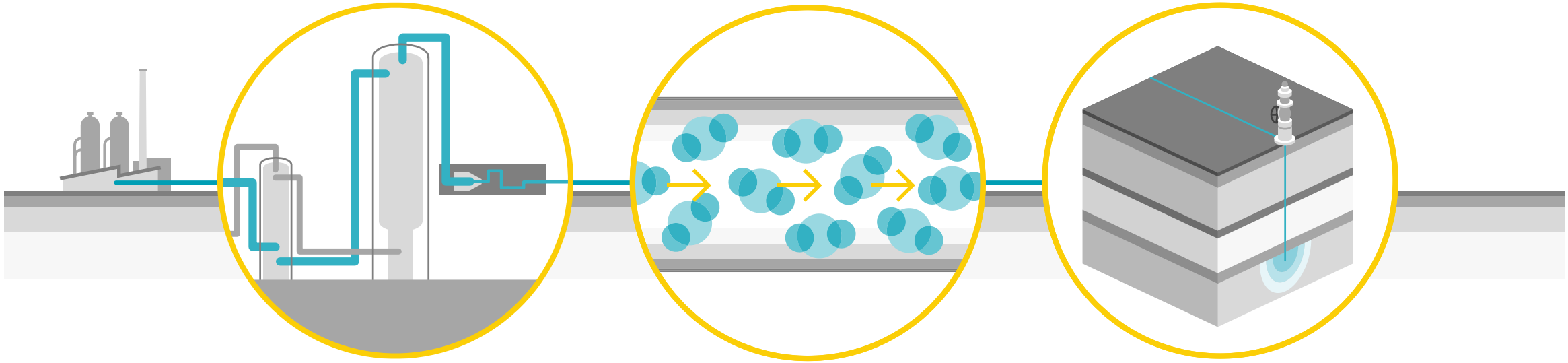
Source: data from Shell (2018), IPCC (2018), IEA (2017), GCCSI (2018)

"CCS is vital for reducing emissions across the energy system in both the Energy Technology Perspectives 2°C Scenario (2DS) and the Beyond 2°C Scenario (B2DS)"
IEA Energy Technology Perspectives (2017)

"CCS is essential to reach net-zero emissions, committed to under the Paris Agreement"
UK Committee on Climate Change (2018)

"Early scale-up of industry-sector CCS is essential to achieving the stringent temperature target (below 2°C)"
IPCC SR15 (2018)

Carbon Capture & Storage (CCS) is based on proven technologies that have been in operation for decades



CAPTURE

- Solvents used for CO_2 capture since 1930s
- Multiple units in operation

TRANSPORT

- CO_2 pipelines in operation since the 1970s
- Over 6,000 km of existing CO_2 pipelines

STORAGE

- Injection of CO_2 for oil recovery since the 1970s
- Storage capacity is not a limiting factor

Source: data from TCM DA (2014), GCCSI (2017), IPCC (2018)

Five performance requirements for geological CO_2 storage

How can an operator ensure safety and long-term effectiveness of CO_2 storage?

Storage Site Feasibility

1. Capacity

Does the storage site have the storage capacity required?

2. Containment

Can it contain the CO_2 indefinitely?

3. Transport & Injectivity

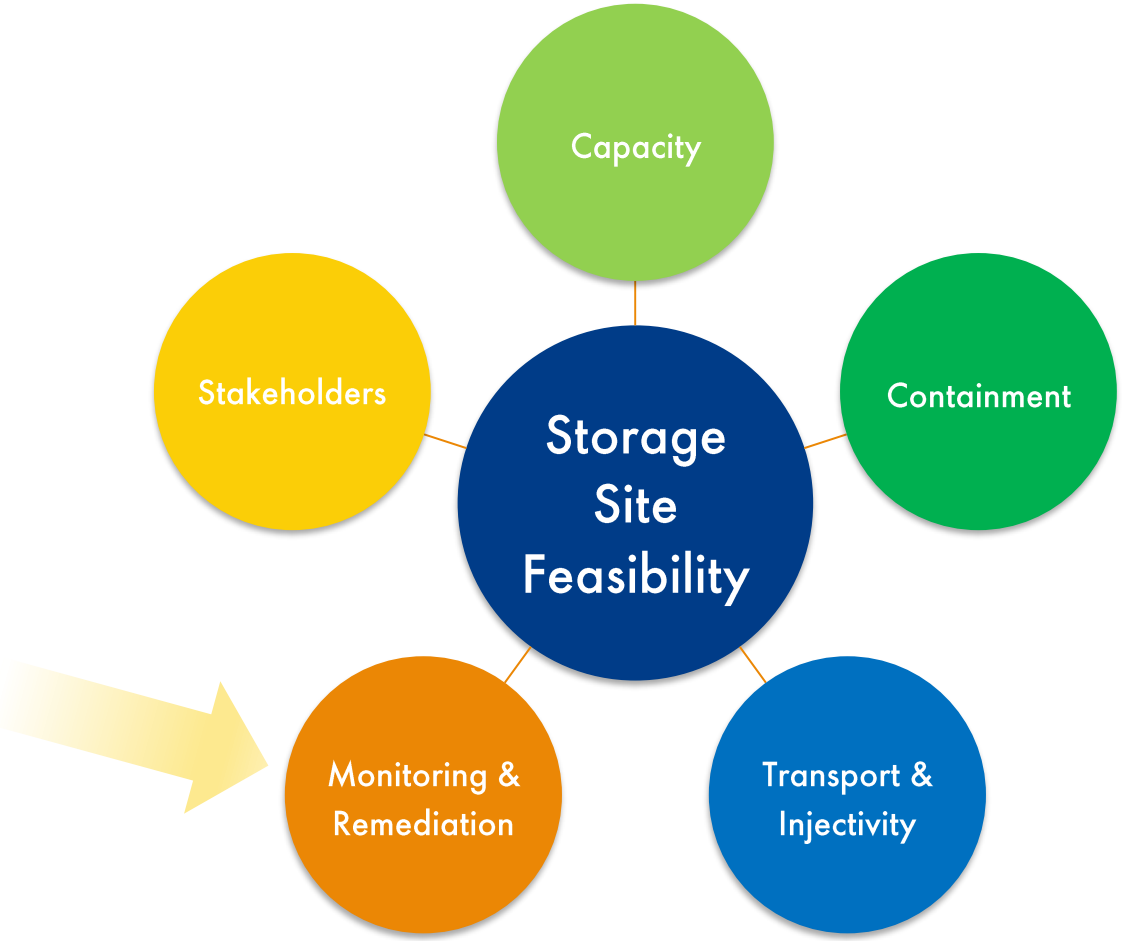
Can CO_2 be transported to the site, and sustained injection maintained, at required rates economically?

4. Monitoring & Remediation

Can the injected CO_2 be monitored, and remedial activities deployed within economic limits?

5. Stakeholders

Are all stakeholders in agreement?



Risk-based Measurement, Monitoring and Verification (MMV or MVA)

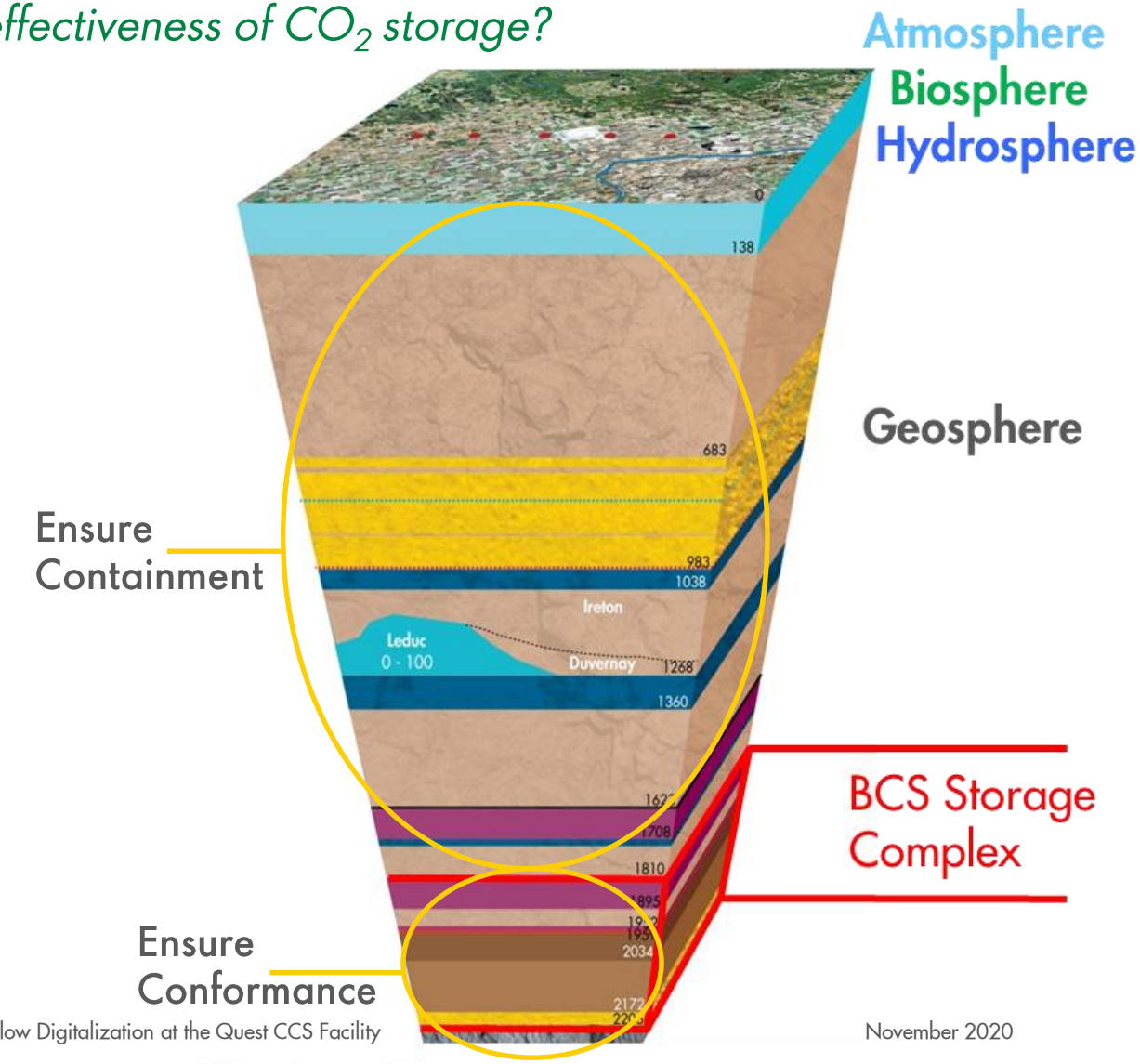
How can an operator ensure safety and long-term effectiveness of CO_2 storage?

Fit-for-purpose MMV plans

- Base monitoring plan: Baseline and selective monitoring focused on key risks
- Contingency monitoring plan
- Corrective measures plan

MMV approach

- Risk-based: Bowtie risk framework, mitigating threats and monitoring active barriers
- Comprehensive: Covering all domains and phases of storage operation
- Adaptable: The plan is updated to respond to changing or updated risk assessments

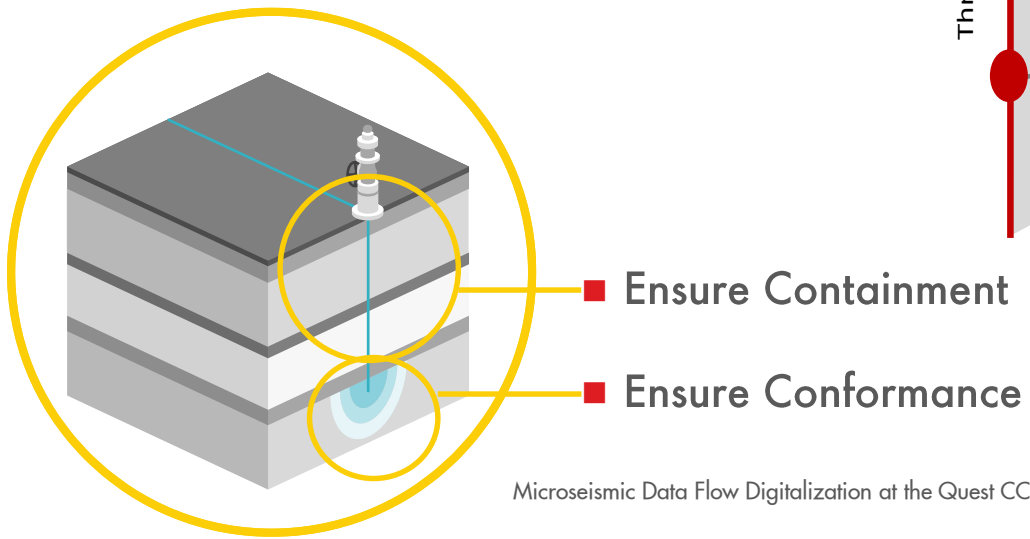


Risk-based Measurement, Monitoring and Verification (MMV)

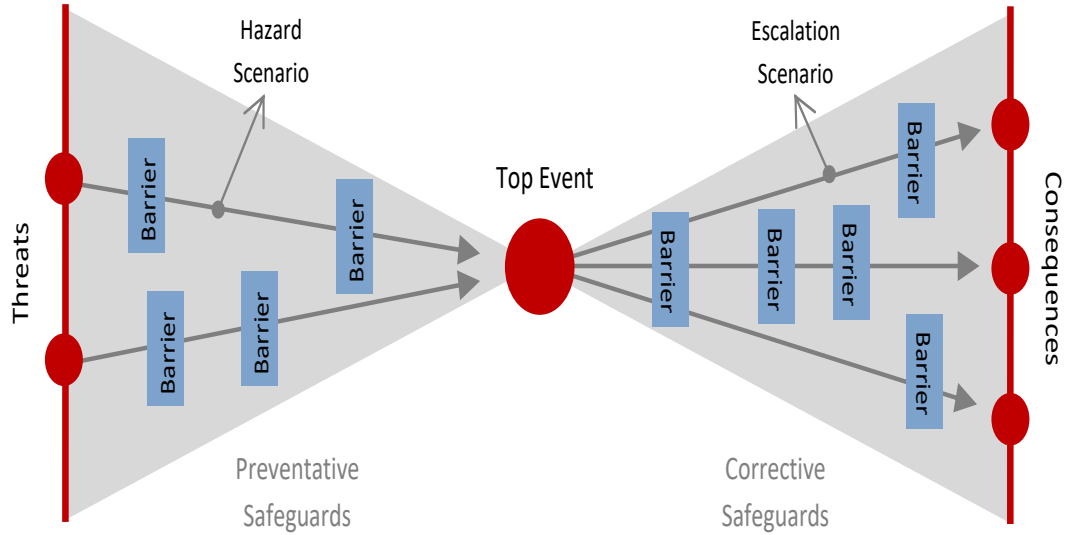
The Bowtie is the central mechanism for risk management within the Measurement, Monitoring and Verification (MMV) plan

Goals

- Ensure Conformance to indicate long-term effectiveness of CO_2 storage
- Ensure Containment to demonstrate the safety of CO_2 storage
- Transfer of long-term liability Enables timely handover to the government after site closure



Bowtie risk assessment



Operating MMV Technologies with Proactive Technical Monitoring

The GOAL of PTM is to detect threats and realize opportunities early through structured monitoring of process and equipment

The FOCUS of PTM is to monitor and interpret deviations from specified limits

Reduces

- **cost/time** to maintain equipment
- **cost/time** to assess containment risks
- **manual oversight** allowing for focus on key issues and opportunities
- **down time** by preventing corrective maintenance

Builds

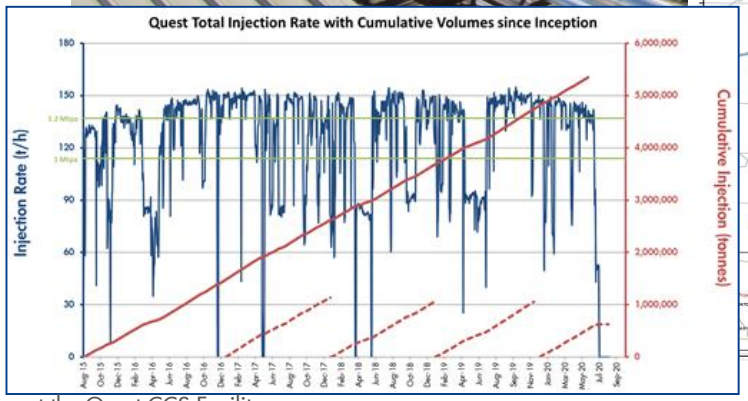
- **consistent datasets** which are key for enabling automated PTM
- **consistent documentation** which allows for quick review and effective handovers
- **knowledge** for future operations of this facility and future facilities
- **Ease of access to data** allowing experts to review data quickly

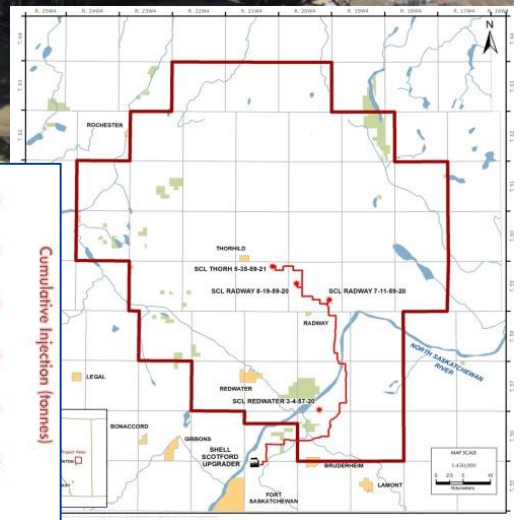
DIGITALIZATION OF MICROSEISMIC TECHNOLOGY

Enabling automated surveillance is a step towards implementing PTM and running an efficient MMV plan

Quest CCS Facility

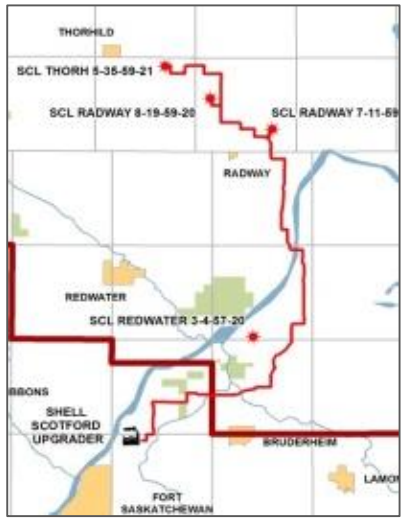
- **What** – fully integrated, commercial scale CCS facility at an industrial complex
- **Where** – capture at Scotford Upgrader; storage in a deep saline aquifer: the Basal Cambrian Sands (BCS) at a depth of 2000m
- **Who** – Shell operated joint venture between Canadian Natural Resources, Chevron and Shell
- **Impact** – 25 million tonnes of CO_2 captured over a 25-year period (1/3 of CO_2 from the Upgrader) – equivalent to the emissions of about 250,000 cars
- **Volume** – 5.4 Mt since August 2015

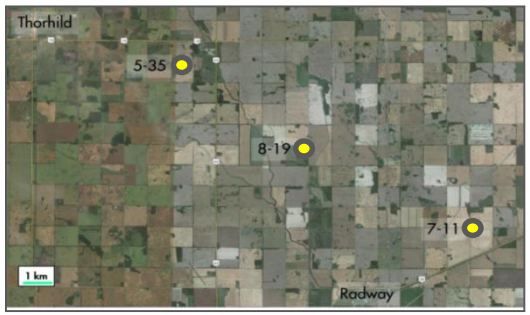


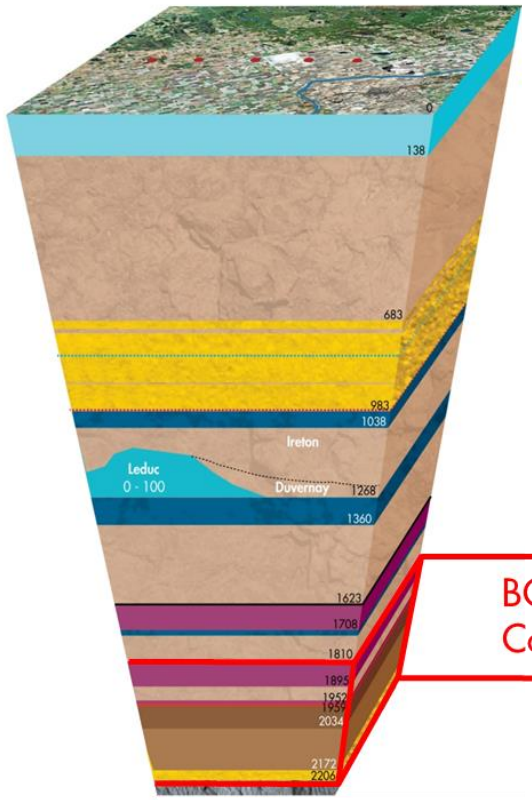


Quest CCS Facility – Fully Integrated

Capture → Transport → Inject → Storage







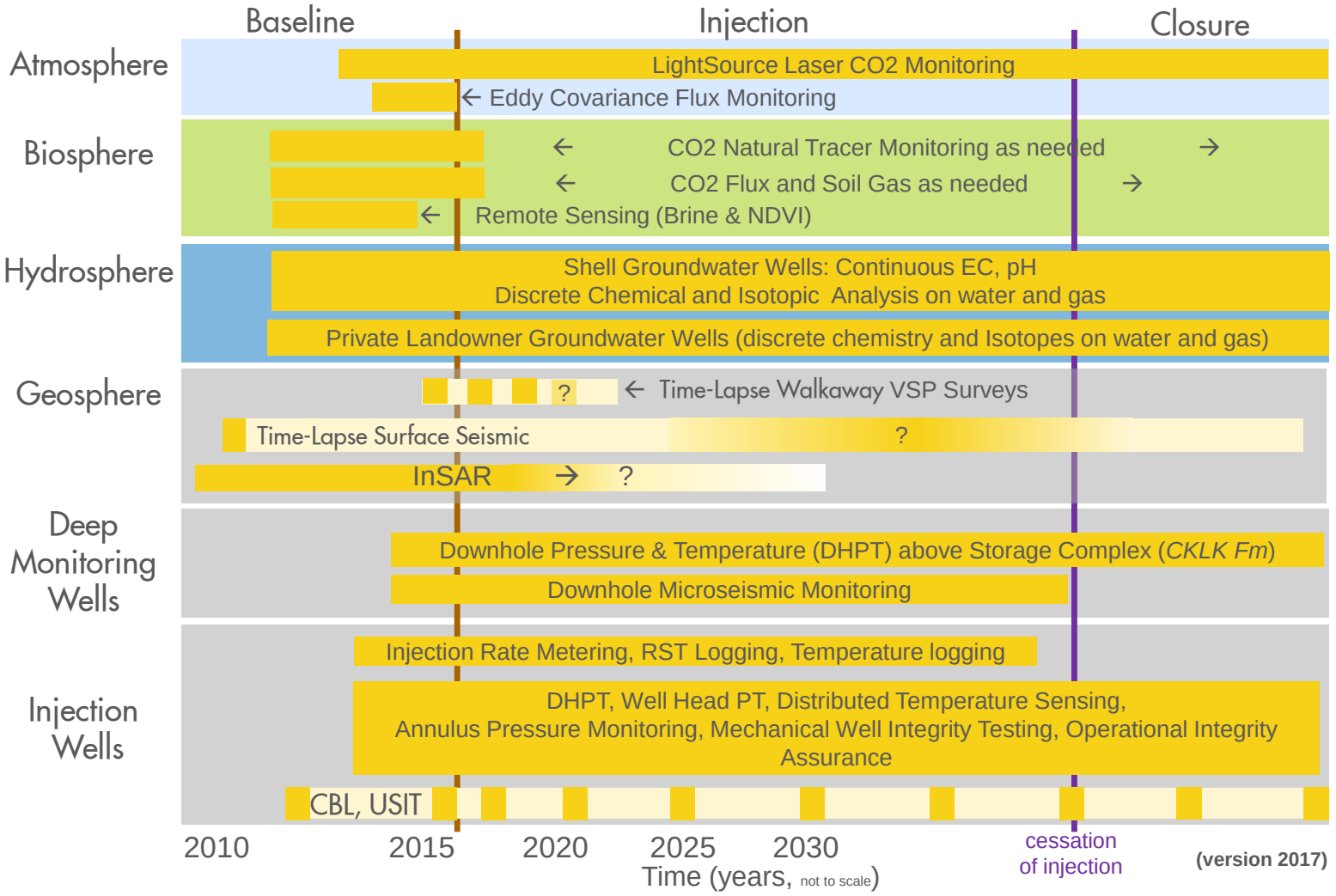
- 1 Million tonnes per year
- 1/3 of CO2 from the Upgrader

- 65 km pipeline

- 3 injection wells

- 2km underground

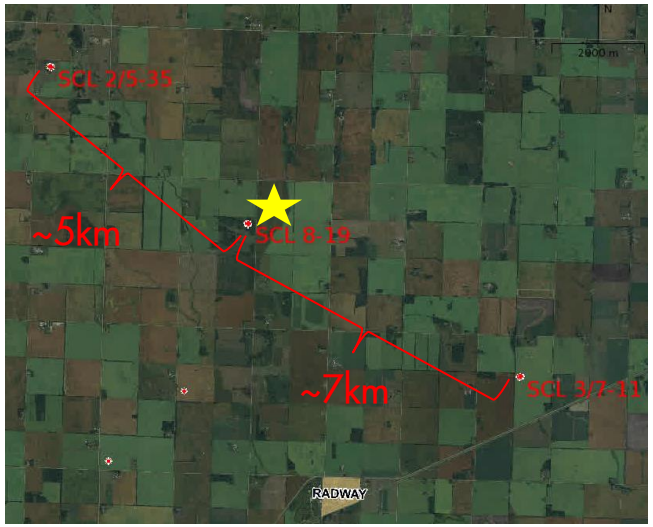
MMV (Measure, Monitor and Verify) Plan

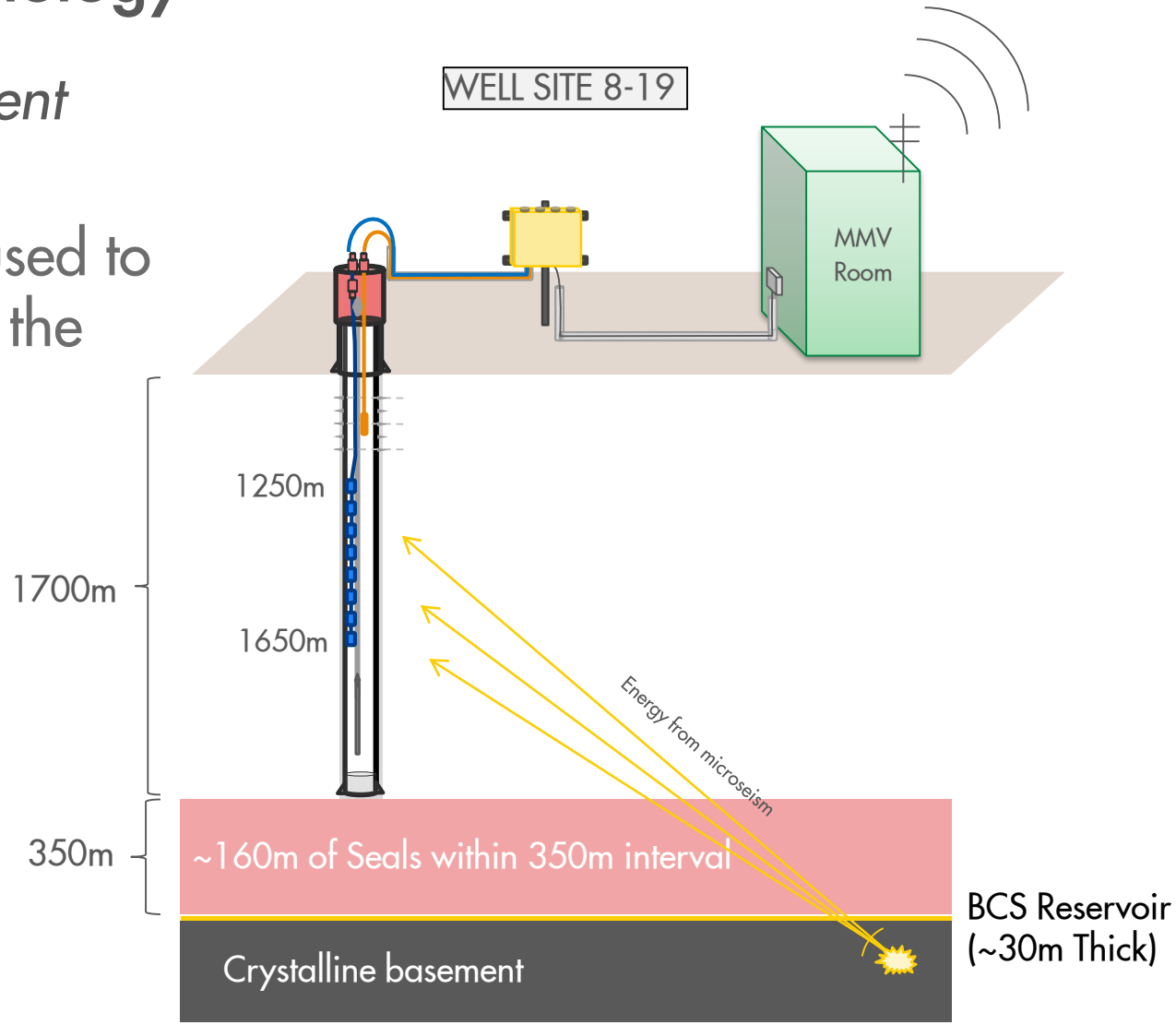


- First of a kind – conservative approach
- Comprehensive: from atmosphere to geosphere
- Risk-based
- Site-specific
- Independently reviewed
- Combination of new and traditional technologies
- Baseline data collected before start-up

Microseismic as a Containment Technology

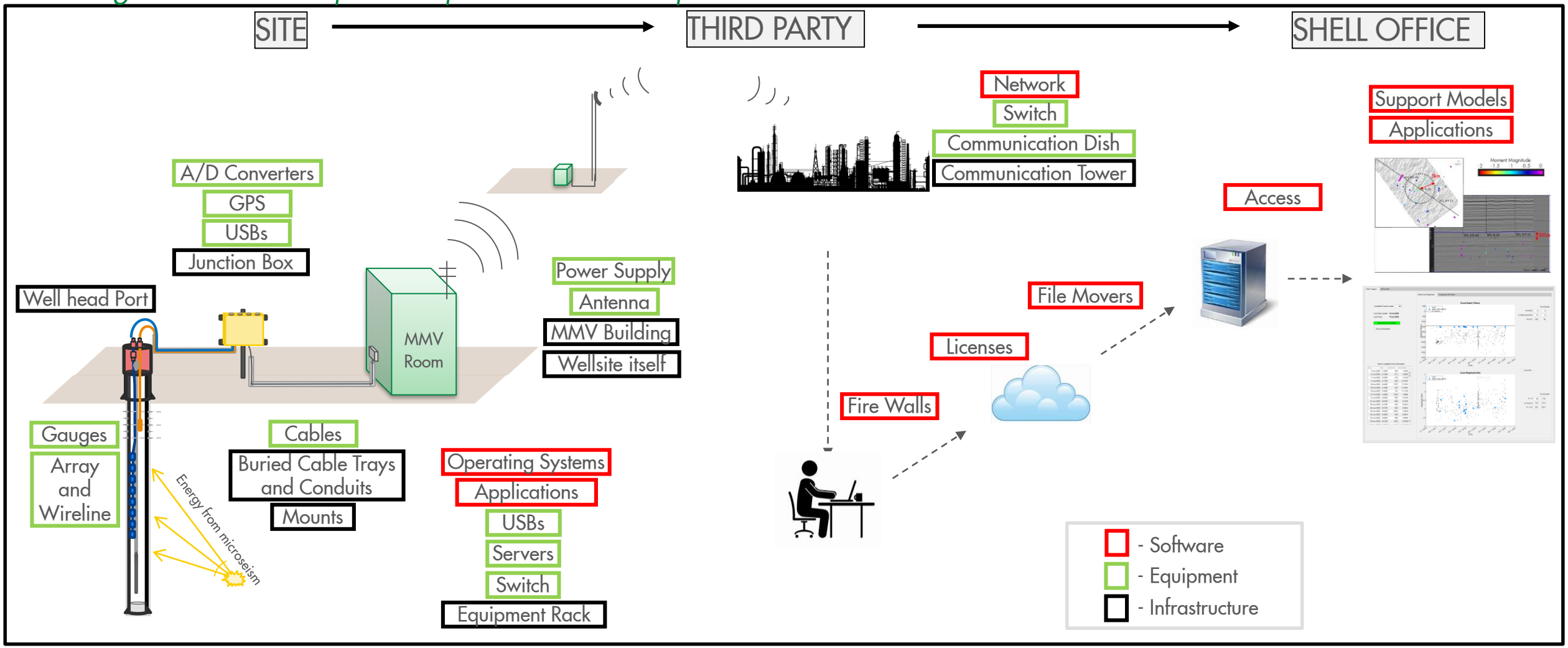
- Ensure Containment *to demonstrate current security of storage*
  - A downhole microseismic array is used to monitor microseismic activity within the storage complex
  - TD of well above Seals





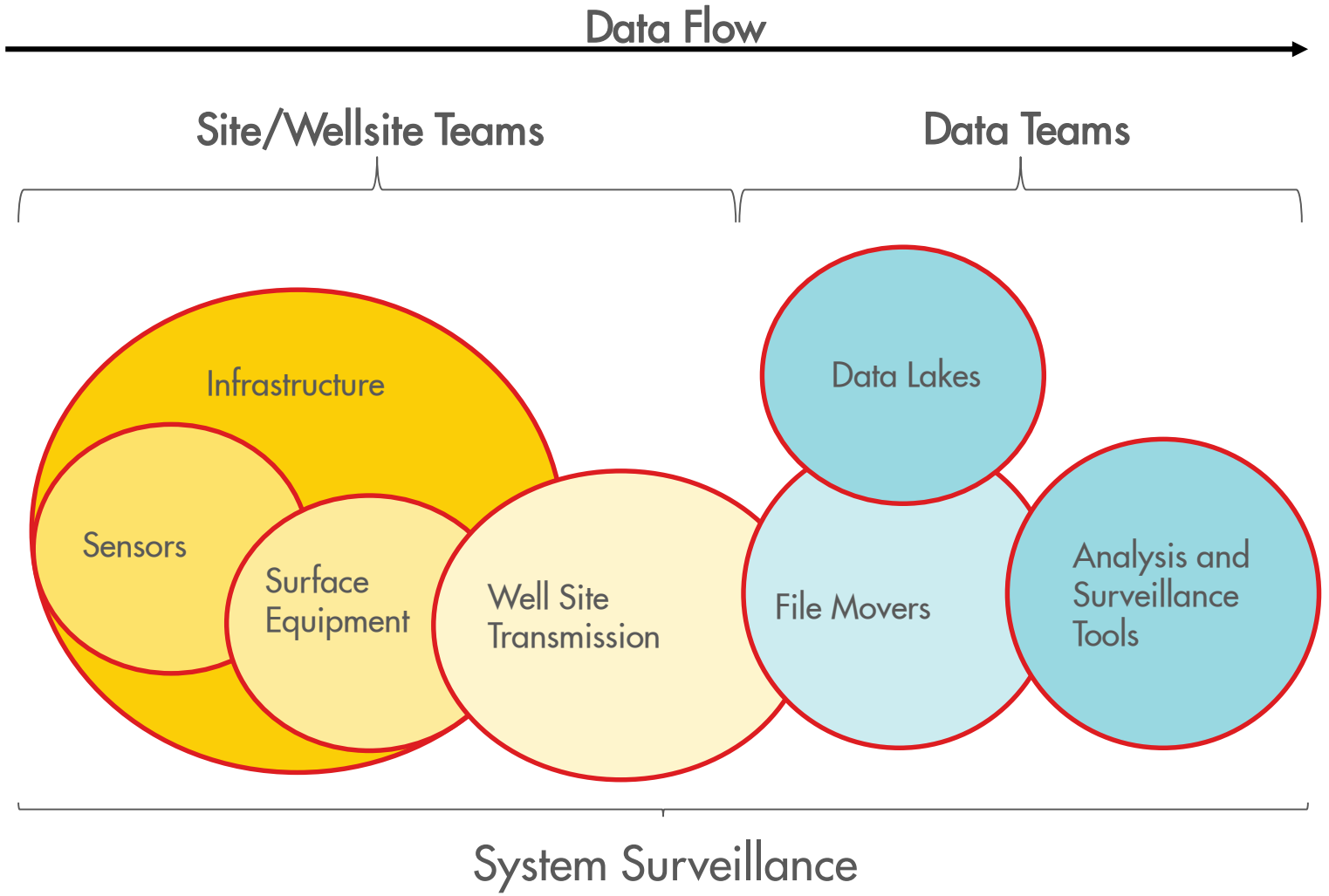
Microseismic Data flow – Detailed

Diving into the details paints a picture of the complete data flow

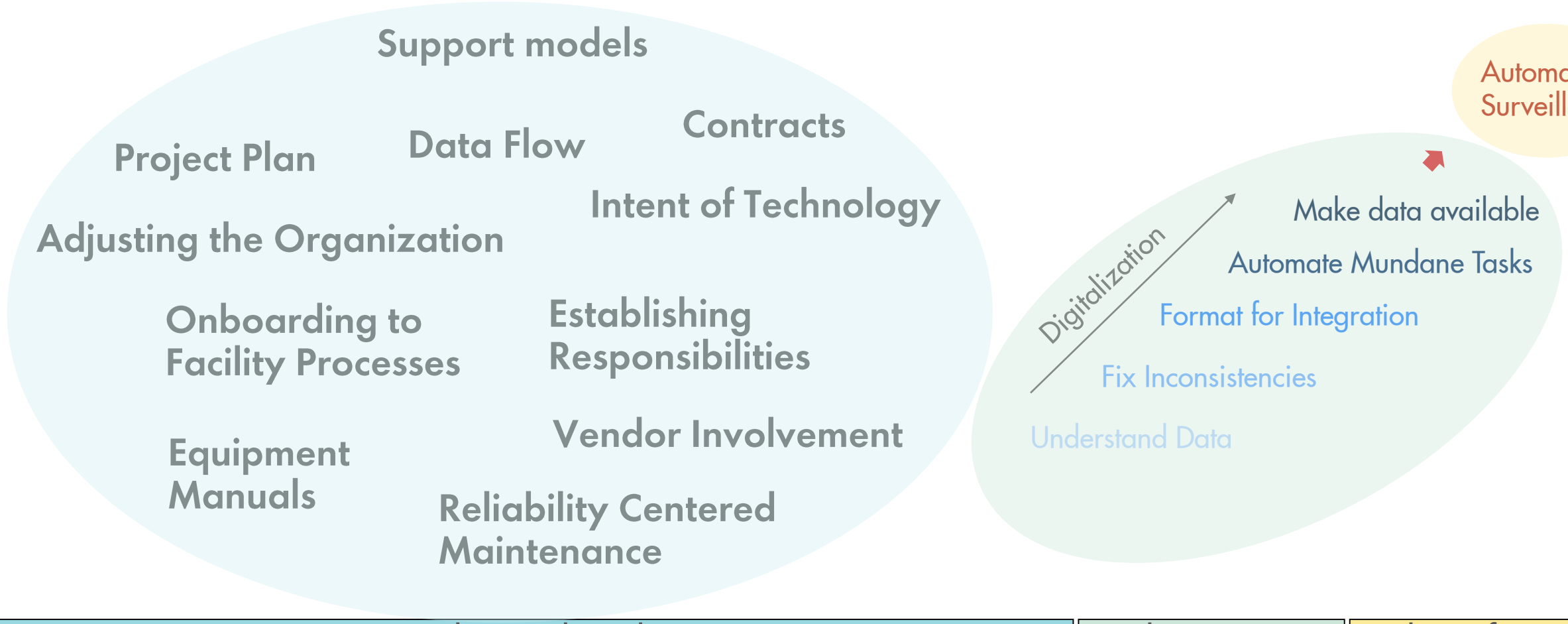


Microseismic Data flow – Categories

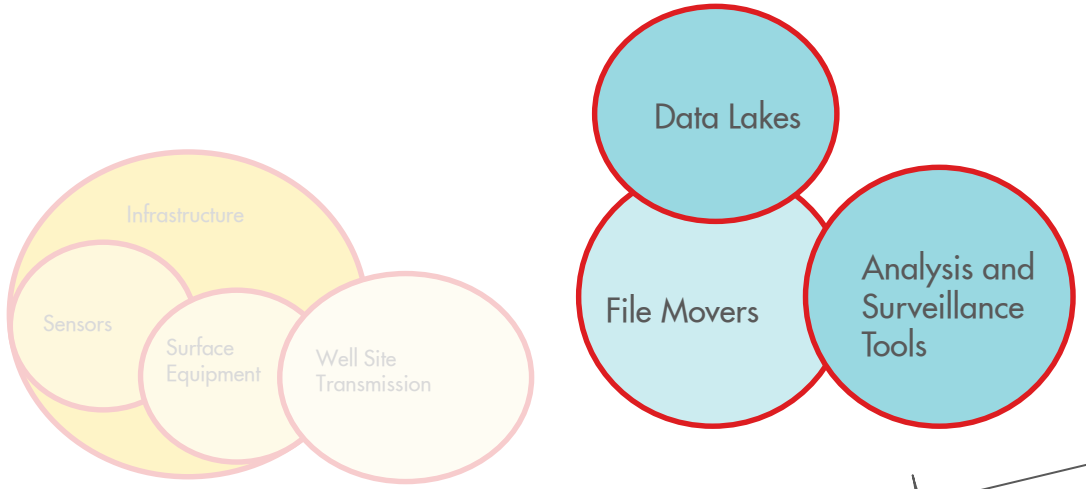
- Create a plan to **Implement PTM** by **Enabling Automated Surveillance** which has a system with the architecture and organization in place for:
  - **Systematic visualization of Triggers**
  - **Surveillance of System Health**



Learning – Time spent to ENABLE Automated Surveillance



Original System

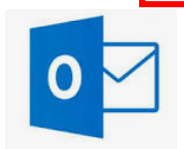


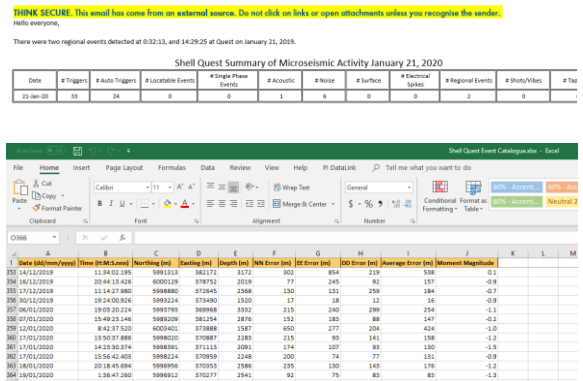
- Manual data flow from Vendor to User Analysis
- ~30min/day required for surveillance

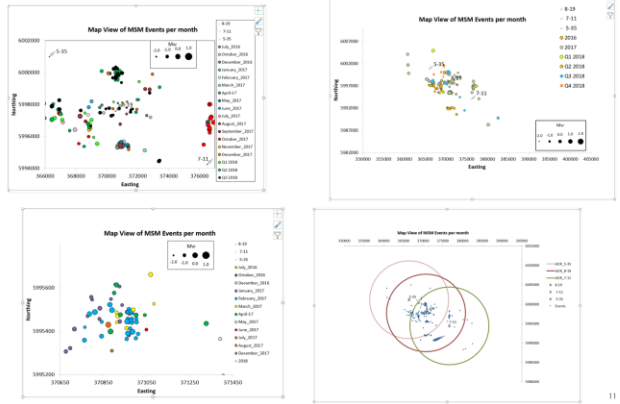
Attachments

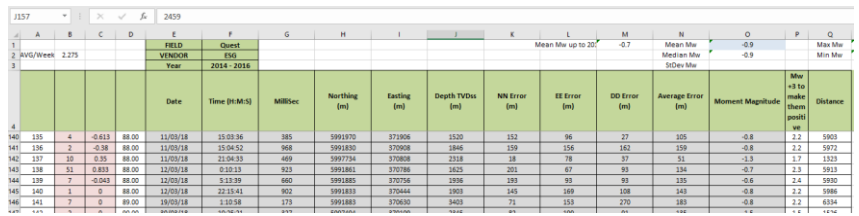
Manual Copy

Manual Figure Update

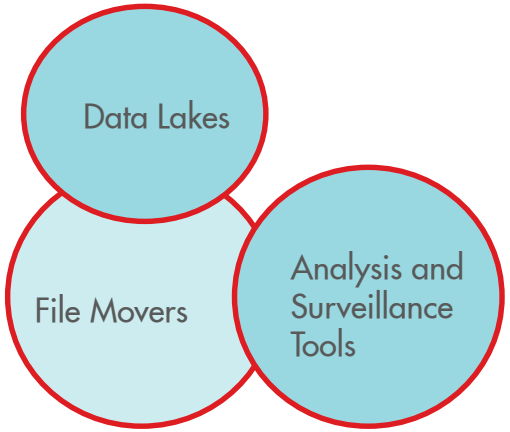






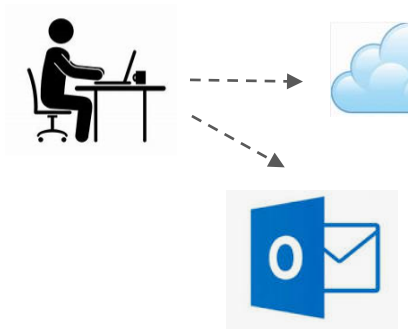


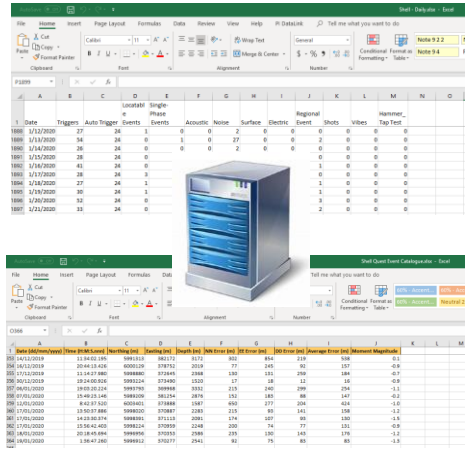
Current System



- Automated data flow from Vendor to User Analysis
- <1min/day required for surveillance

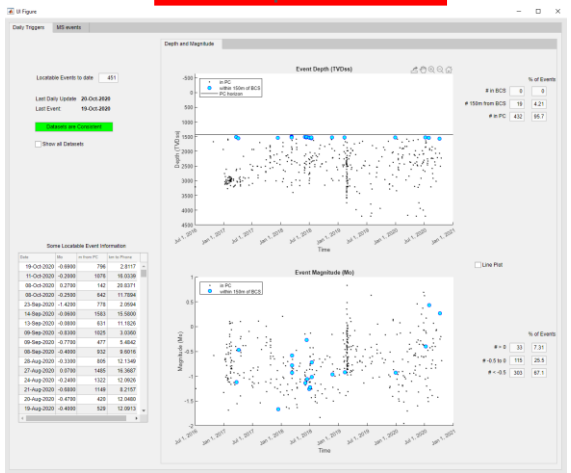
File Movers

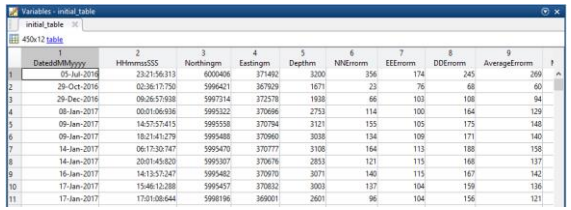




Script

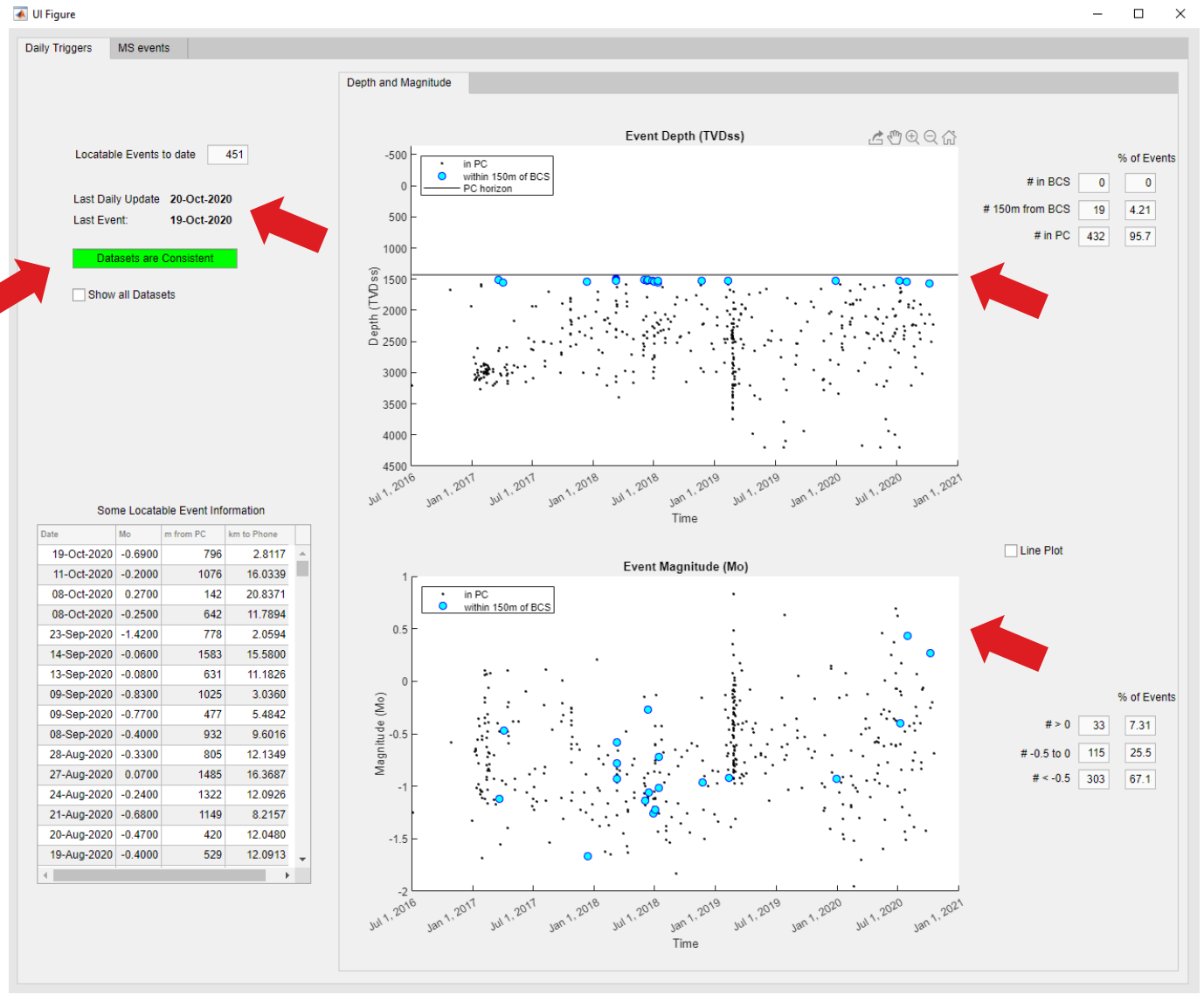
Automated Figure Update





Surveillance Requirements

- Key surveillance requirements:
  - Data has been received from the day before
  - Data is consistent
  - Any immediate response required
  - Any trending indicating change over time



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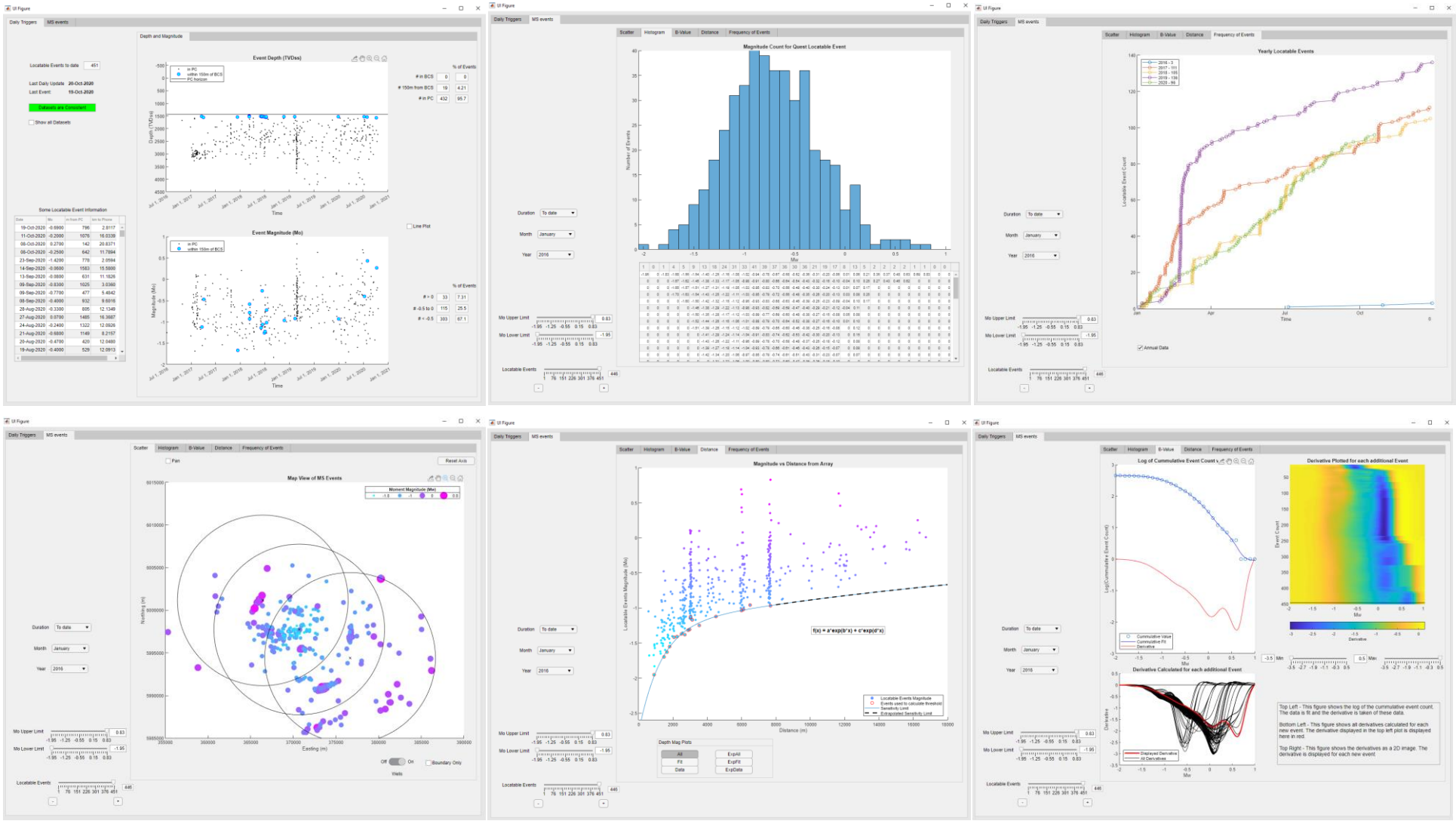
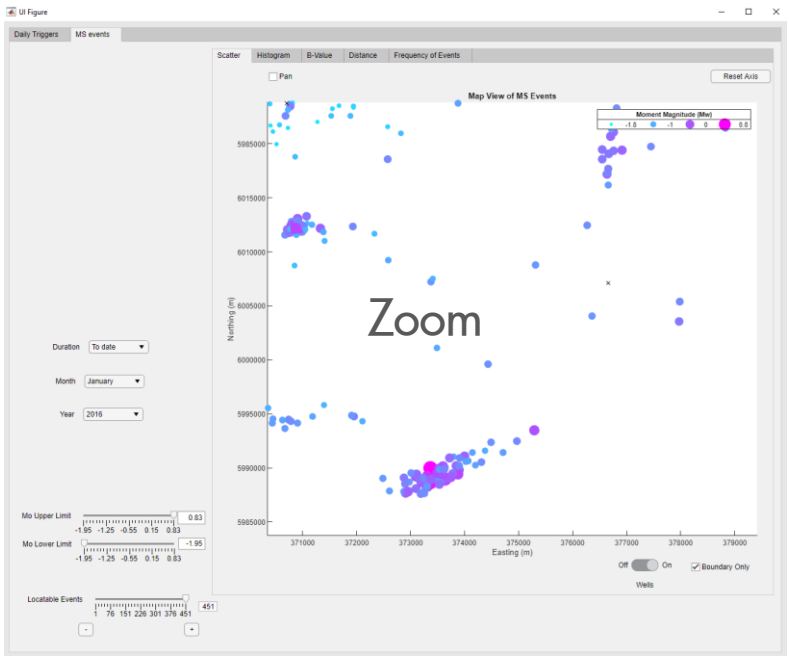
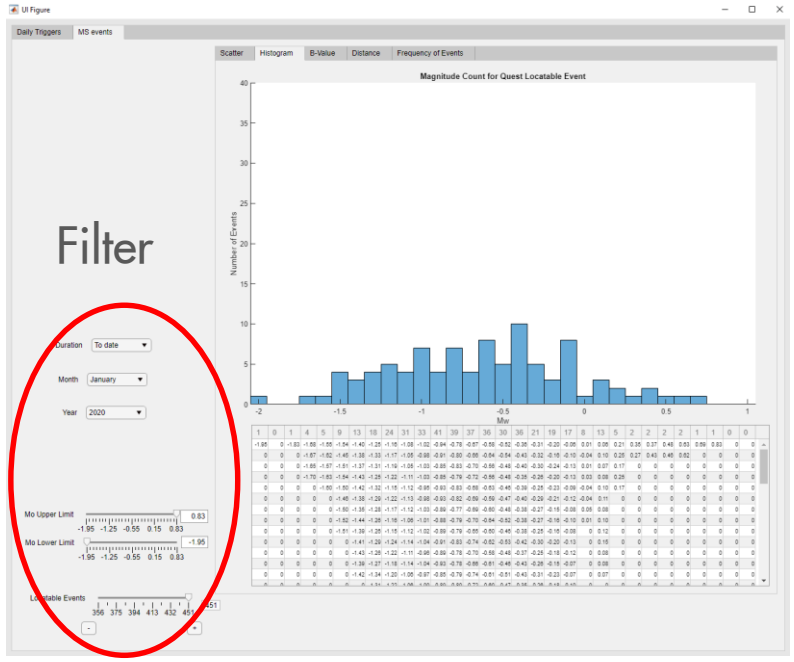
08-Oct-2020	0.2700	142	20.8371
08-Oct-2020	-0.2500	642	11.7894
23-Sep-2020	-1.4200	778	2.0594
14-Sep-2020	-0.0600	1583	15.5800
13-Sep-2020	-0.0800	631	11.1826
09-Sep-2020	-0.8300	1025	3.0360
09-Sep-2020	-0.7700	477	5.4842
08-Sep-2020	-0.4000	932	9.6016
28-Aug-2020	-0.3300	805	12.1349
27-Aug-2020	0.0700	1485	16.3687
24-Aug-2020	-0.2400	1322	12.0926
21-Aug-2020	-0.6800	1149	8.2157
20-Aug-2020	-0.4700	420	12.0480
19-Aug-2020	-0.4000	529	12.0913

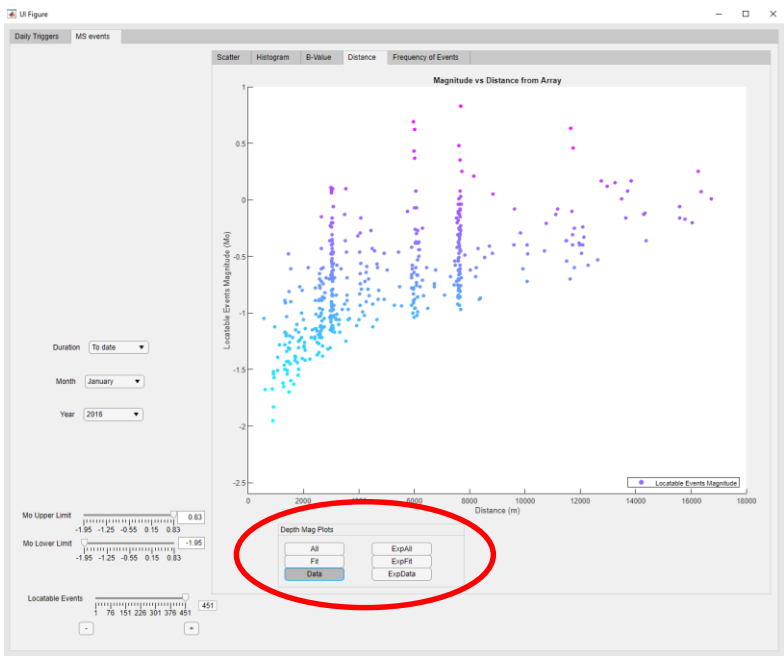
Building using tabs



Zoom, Filtering, Figure Selection





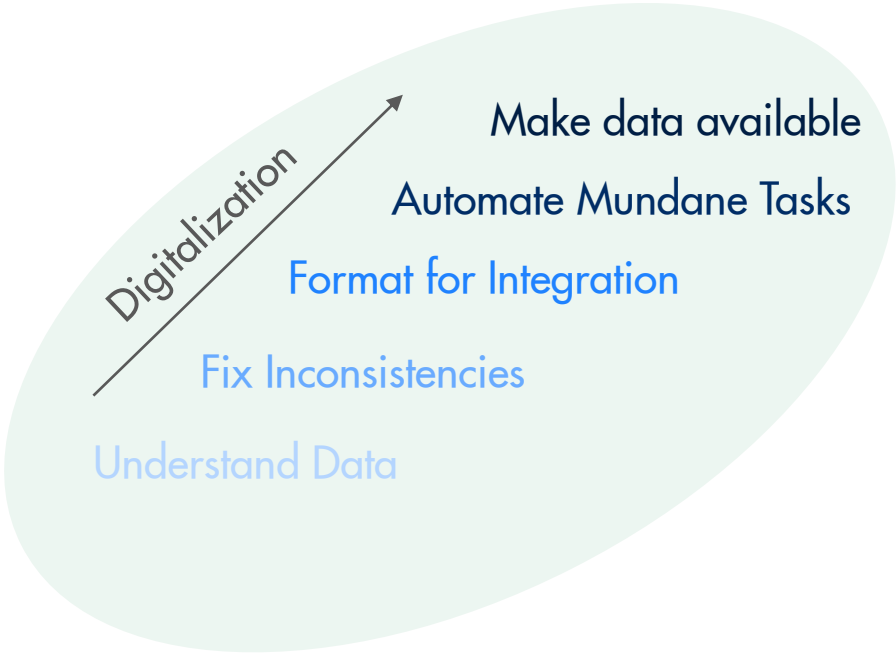


Select Figure

- Ability for user to build customized figures and filters allows for efficient surveillance
- A consistent frame work allows for fast prototyping and continuous improvement

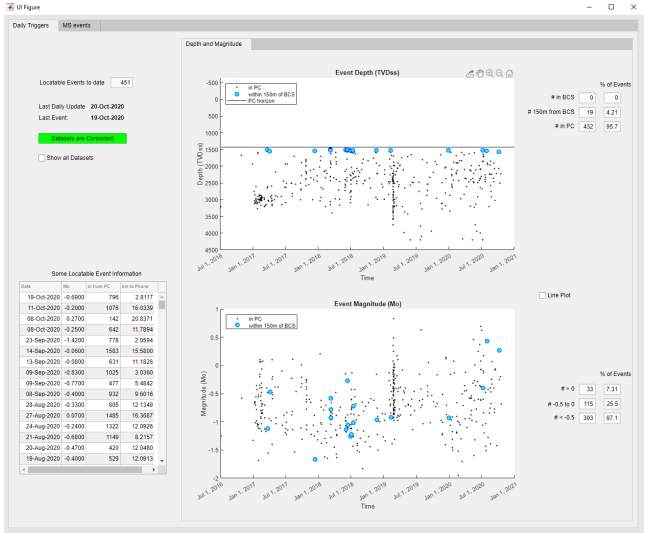
Time Savings

- Key surveillance requirements:
  - Data has been received from the day before
    - Time Saving - We can now quickly establish where the data flow break is and focus there
    - Ex. Email from vendor and data file mover system allows us to eliminate variables
  - Data is consistent
    - Time Saving – We can trust our data is up to date and inconsistencies are flagged
    - Ex. The most recent data file is sent every day, not copied cumulatively. Any formatting or NaNs are flagged and can be immediately fixed rather than compounded
  - Any immediate response required
    - Time Saving – We have established limits for our key surveillance items
    - Ex. Use of traffic light system to monitor allows us to do exception based surveillance for daily checks
  - Any trending indicating change over time
    - Time Saving – We have established templated figures which continue to grow as new data comes in
    - Ex. Using filtering on standard figures, we can quickly check for trends on a longer timescale in the data. The next step is to build limits from these trends

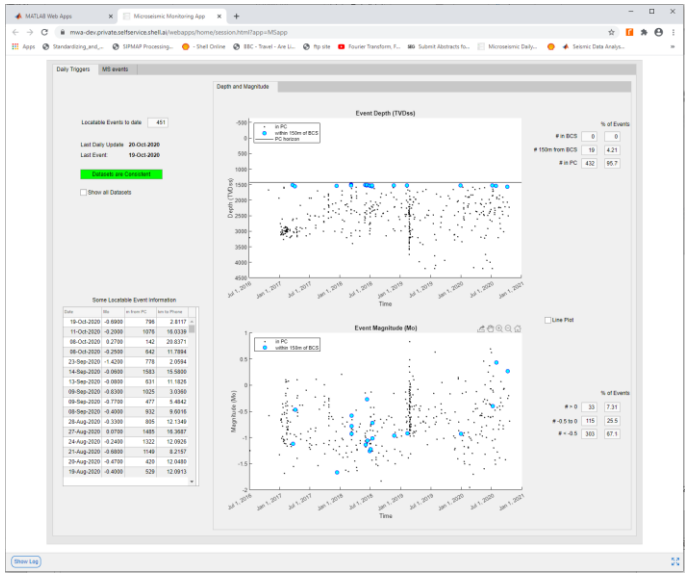


Continuous Improvement

- Appdesigner has been used as an active Surveillance tool for 10 months
- Daily surveillance time has dropped from ~30min/day to <1min/day
- The use of webapp has allowed the desktop application to be made visible to others within Shell, making the data more accessible to experts
- New ideas have formed with internal expert groups on how to integrate data with other technologies as well as get more from these data
- Focus has shifted from maintaining the data flow to generating value from the data
- Ease of access to data and shift of focus away from mundane tasks has stimulated data sharing with multiple external consortiums as well as internal experts



Desktop



WebApp

Summary

- To get CCS to the gigaton scale, we need more projects which are cheaper and efficient
- Implementing PTM is an efficient way to operate the MMV plan by reducing time and cost as well as building knowledge
- Automated surveillance has played a key part in implementing efficient PTM at Quest
- Digitalization of the microseismic data flow and the use of the MATLAB AppDesigner has substantially contributed to time savings in daily surveillance from ~30min/day to <1min/day
- As the dataset grows larger, the need to automate mundane tasks has also grown. The use of a highly flexible graphical interface has allowed for quick verification of data transfer, readily available analysis and user prototyping. Time previously spent on mundane tasks is now spent on continuous improvement which is driving creativity, collaboration and integrated analysis.

Finally, visualization and self-service analytics tools are encouraging greater uptake of data science capabilities within the organization. This is enabling the operation of an efficient MMV plan at Quest and will continue to be a key factor as we scale to Gigaton CCS

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