CLEAN RESOURCES FINAL PUBLIC REPORT

Energy UTM Trials

Alberta Innovates Project Number: 201910696

Prepared for Alberta Innovates (Bruce Duong)

Prepared by AIRmarket (Lindsay Mohr) and PTAC (Marc Godin)

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2. EXECUTIVE SUMMARY

In the short term, Energy UTM will allow BVLOS in specific sites in the oil sands / remote region(s) and, in the longer term, contribute to the development of the BVLOS regulatory framework and create Alberta jobs in this emerging sector of the digital economy. The UTM technology is based on software in service in Dubai (United Arab Emirates) / New Zealand / Finland, which has passed the proof-of-concept stage in trials at the Foremost range in Alberta. To provide highly reliable telecommunications coverage, TELUS and AIRmarket initially built a solution for remote and rural areas.

The Project has demonstrated Cellular UTM services using the existing TELUS fixed telecommunications infrastructure to conduct trials between Edmonton and Fort McMurray and in the oil sands region.

The outcome will be reduced environmental impact (reduced GHG emissions and land disturbance), substantial operating cost reductions, improved worker safety, and the progression of a technology and service that could be deployed in other industries and other regions, and open the door to automation, machine learning and artificial intelligence application in resource industries.

3. INTRODUCTION

Drones are a very advantageous technology with countless applications. However, in Canada, as in most countries, regulations are not yet in place for full deployment. Robust and reliable technologies are required to permit, approve, monitor, and regulate drone flights to ensure public safety and the safety of piloted aircrafts. Energy UTM (Unmanned Traffic Management, also referred to as RTM in Canada) demonstrated a TSRL 7 technology to allow safe and regulated drone flights beyond visual line of sight (BVLOS). AIRmarket and PTAC member energy companies are collaborating on the UTM technology in the context of national trials supervised by Transport Canada and NAV Canada.

4. PROJECT DESCRIPTION

Knowledge and Technology Gaps

Drones are Remotely Piloted Aircraft Systems (RPAS), and their use can only be permitted if public safety and the safety of piloted aircrafts can be assured. While the basic technology elements exist, they need to be integrated into a robust and reliable system that will be proven to deliver to the required safety standards. Canadian regulators have undertaken a consultation and regulatory development process to this end. The proposed Project aims to conduct real-world trials of the UTM system in Alberta's oil sands region to understand any remaining technological challenges and provide relevant information to Canadian regulators.

Transport Canada and NAV Canada have undertaken a multiyear process to gather relevant technical information to develop robust regulations. The Energy UTM project is collaborating closely and intends to inform this process.

Technology Description

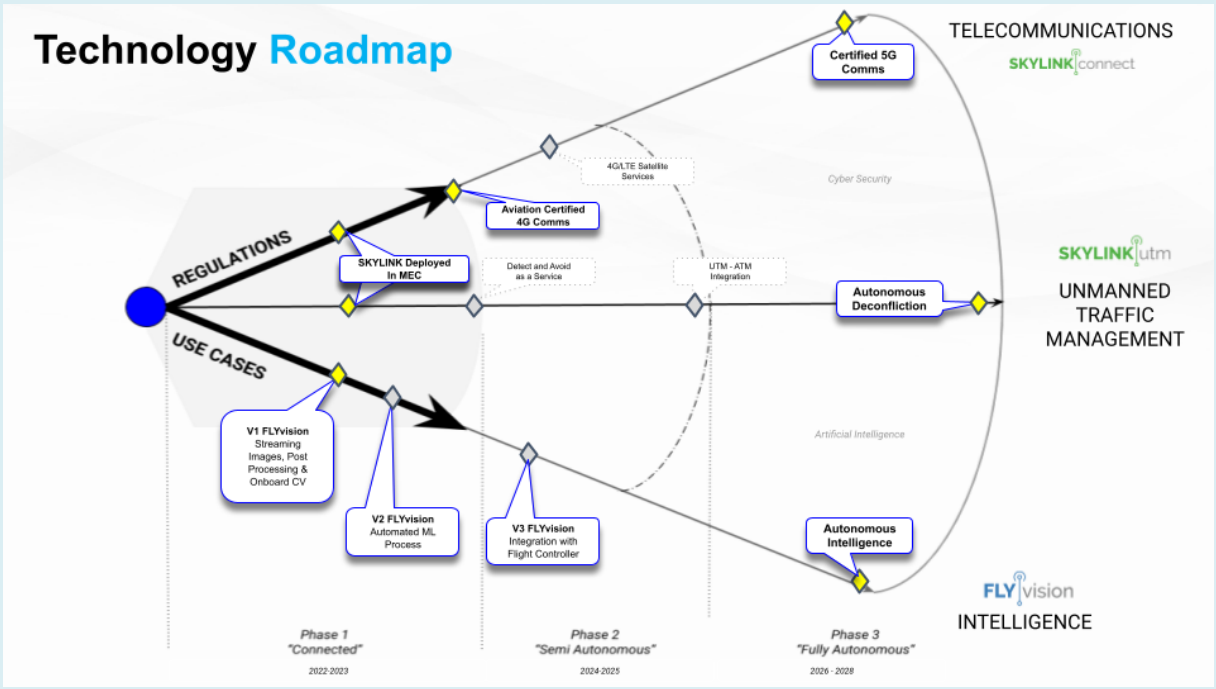
The purpose of UTM is to manage the traffic of remotely piloted aircrafts in a complementary way integrated with the Aircraft Traffic Management (ATM) system for piloted aircrafts. In Canada, ATM regulations are developed by Transport Canada, and airspace management is provided by NAV Canada. AIRmarket is collaborating closely with the regulatory development process in Ottawa for BVLOS drone flights and includes relevant safety, security, and performance standards.

Drone technology is effective and is already deployed in some applications internationally. However, the scale of deployment is set to multiply in the future if robust and reliable UTM technologies are deployed in Canada. A national UTM system will provide the safety framework to monitor, track, and deconflict both manned and unmanned aircraft in real-time in integrated airspace. This capability will empower Canadian regulators to approve BVLOS drone operations at scale. This is the economic and employment opportunity that Energy UTM will contribute to Alberta's benefit.

Figure 1 (AIRmarket Technology Roadmap) describes the overall technology roadmap for AIRmarket. The vision is to fuse telecommunications and unmanned traffic management services to provide business intelligence by leveraging autonomous unmanned aircraft. The proposed Project for Energy UTM Trials only covers Phase 1 of the technology vision. The Project will demonstrate a 4G UTM architecture, software for integrated airspace surveillance, and real-time data feeds for value-added oil and gas use

cases. The Energy UTM project will thus lay the groundwork for follow-on Phase 2 and Phase 3, which will be undertaken and funded separately.

Figure 1. AIRmarket Technology Roadmap

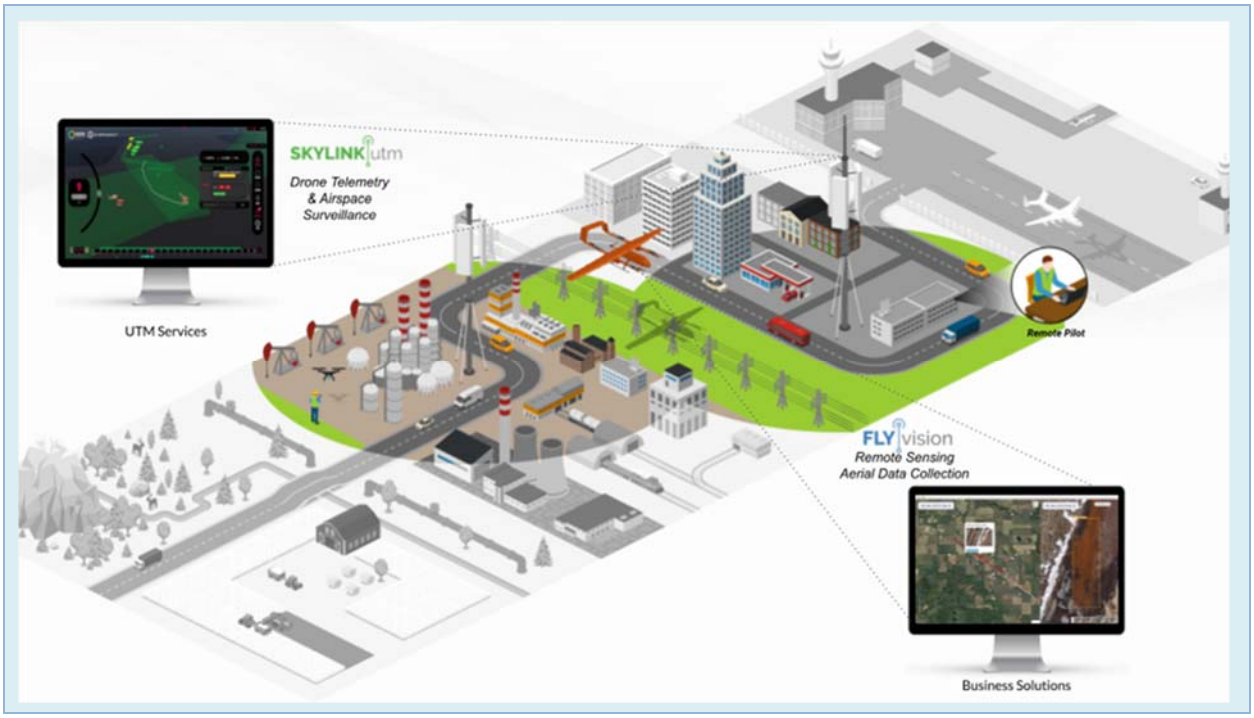


AIRmarket UTM technology includes two forms for tracking and monitoring drones. The basic tracker is a wholly encapsulated and independent hardware that provides the 4D positioning of the drone. The 58-gram tracker includes a built-in IMU accelerometer, barometric altimeter, and GPS and GSM modules with an independent power source. The advanced tracker integrates with the drone autopilot and provides advanced telecommunications connectivity functionality for streaming: command and control, telemetry, sensor data. These trackers provide near real-time situational awareness of drone operations via a secured cloud-based internet platform and existing cellular networks.

Establishing 4G-enabled UTM services will provide the foundations to serve the commercial demands through Mission Control Centers. Certification of 4G services will provide the foundation of aviation communications services. The AIRmarket software portal will approve, track, and monitor flights. BVLOS flight operations will enable drones to be utilized over a wider area than current methods. With BVLOS, drones will be operated from a central location instead of within line of sight. These drones' data can then be transmitted directly to the end-user in real-time.

An effective UTM system can consume multiple data from cooperative and non-cooperative surveillance solution frameworks. This empowers solution diversity to ensure deconfliction events.

Figure 2. AIRmarket Energy UTM Solution



5. METHODOLOGY

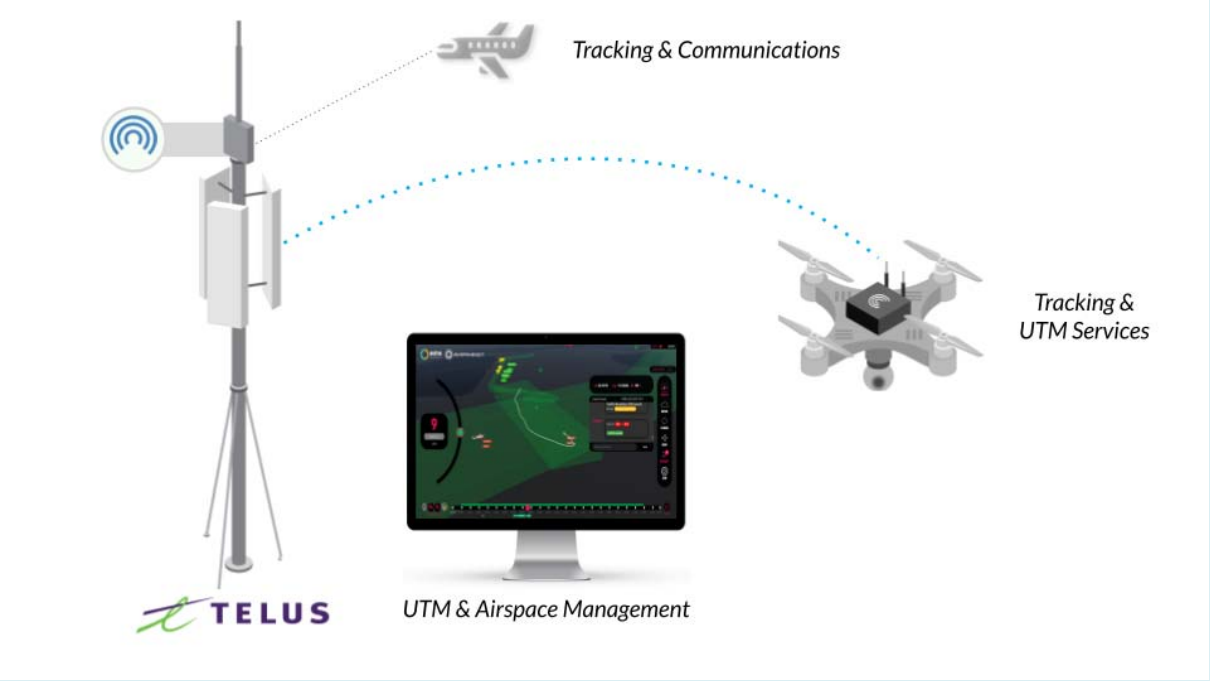
The AIRmarket UTM technology supported this deployment approach, providing three telecommunication channels between the drone and the control room over the 4G telecommunication infrastructure (see Figure 3):

1. Telemetry: the drone autopilot will send the drone GPS coordinates in real-time, enabling the system to have accurate drone positioning information.

2. Control: Control commands are sent over the telecommunication infrastructure by pilots in a central control room in real-time.

3. Data: The onboard sensors will collect data in real-time and send it to a cloud-based repository for analysis by the end user.

Figure 3. Energy UTM Services



The Project was performed in 11 tasks, as shown below:

Task 1: Project launch and Kick-off meeting

Task 2: 4G UTM Integration Testing at Edmonton

Task 3: 4G UTM TECH Demo Day with test inspections successfully performed using the existing TELUS infrastructure.

Task 4: 4G UTM Field Testing of the Concept of Operations and required procedures for using 4G UTM services to conduct BVLOS flight operations

Task 5: Energy UTM Trial Proposal to RTMAT / Transport Canada

Task 6: Energy UTM Trials Approval for BVLOS Flight Operations

Task 7: Pipeline inspection trial for existing pipeline corridor from Edmonton north to monitor corridor health and potential intrusions.

Task 8: Oil sands mine site trial to monitor production attributes.

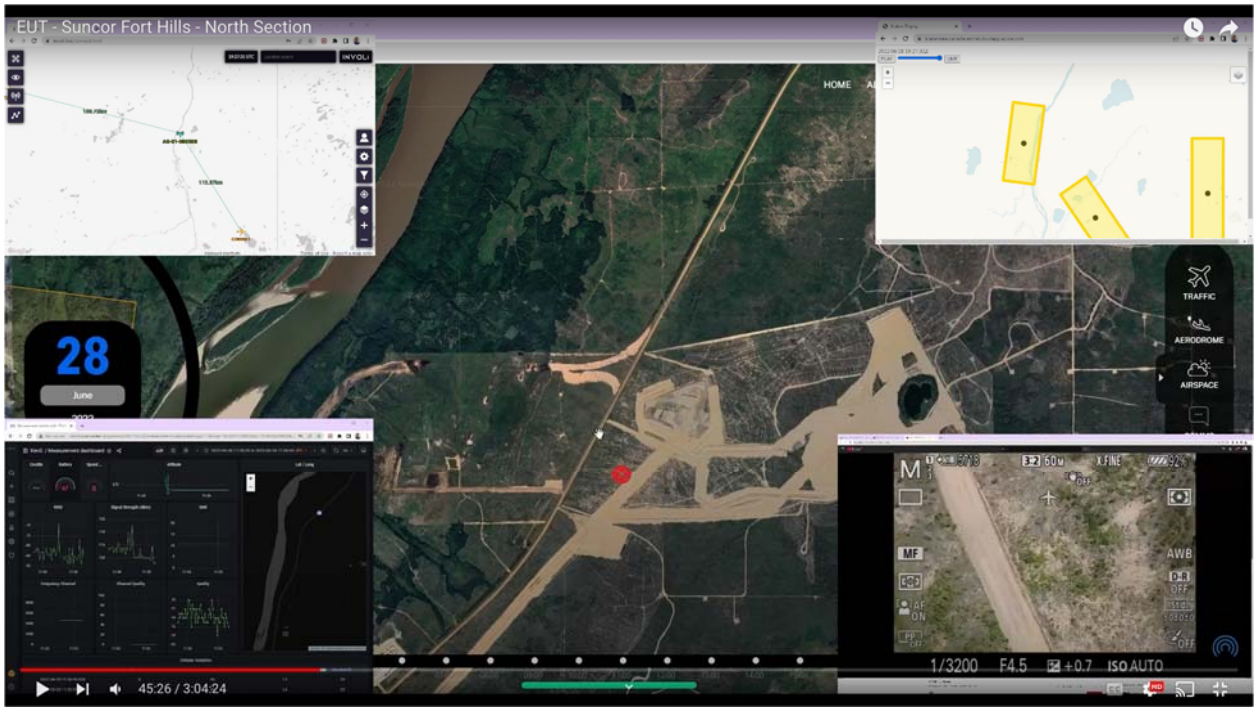
Task 9: Well site inspection trial to perform regulatory required inspection and monitoring of assets.

Task 10. Reporting to AI, Transport Canada, and NAV Canada

Task 11. Project completion

6. PROJECT RESULTS

All project deliverables were accomplished and delivered. UTM services were integrated and demonstrated through the pipeline, oil sands, and trials described below. This video of the activities at Suncor Fort Hills mine demonstrates the integrated results from the project. The video demonstrates the use of cellular UTM & connectivity services and how they will be utilized by the Energy sector to derive business intelligence within integrated airspace.



Pipeline Inspection Trial

A total of 21 days (168 hrs) of mission days were completed, with a total of 43 flights, 893 kms, 20 of actual flight hours in the air and resulted in the following:

- Grand Rapids Pipeline Corridor:
  - #1 Orthomosaic Example - Demo Day
  - #2 Annotation Example
  - #3 Drone Flight & AI Computer Vision Examples
- Pipeline Corridor Scans
  - #1 Orthomosaic & Annotation Example
  - #2 3D Model Example

Oil Sands Mine Inspection Trial

- Planning to support deployment and ongoing operations for BVLOS drone operations.
- Oil sands airport visit
- Site Assessment at mine site to support BVLOS flight operations.
- BVLOS Flight Operations Conducted
- Testing and data collection flights were conducted during and resulted in the following:
    - Imagery processing and resulting data products are produced: Orthomosaic, Digital Surface Model, Contours Map, AI Algorithms: Standing Water, Vegetation
    - #1 Fort Hills Mine Scan Ortho Map
    - #2 Fort Hills Mine Scan AI Examples
    - #3 Fort Hills Mine Scan 3D Models

Remote Well(s) Inspection Trial

- Multiple test flights results were completed with these outputs:
    - Upstream Well Scans #1
    - Upstream Asset Scan #2
- 4 flight hours with thirteen (13) well sites & 3 upstream processing facilities have been inspected over the life of this Project.

7. KEY LEARNINGS

Artificial intelligence

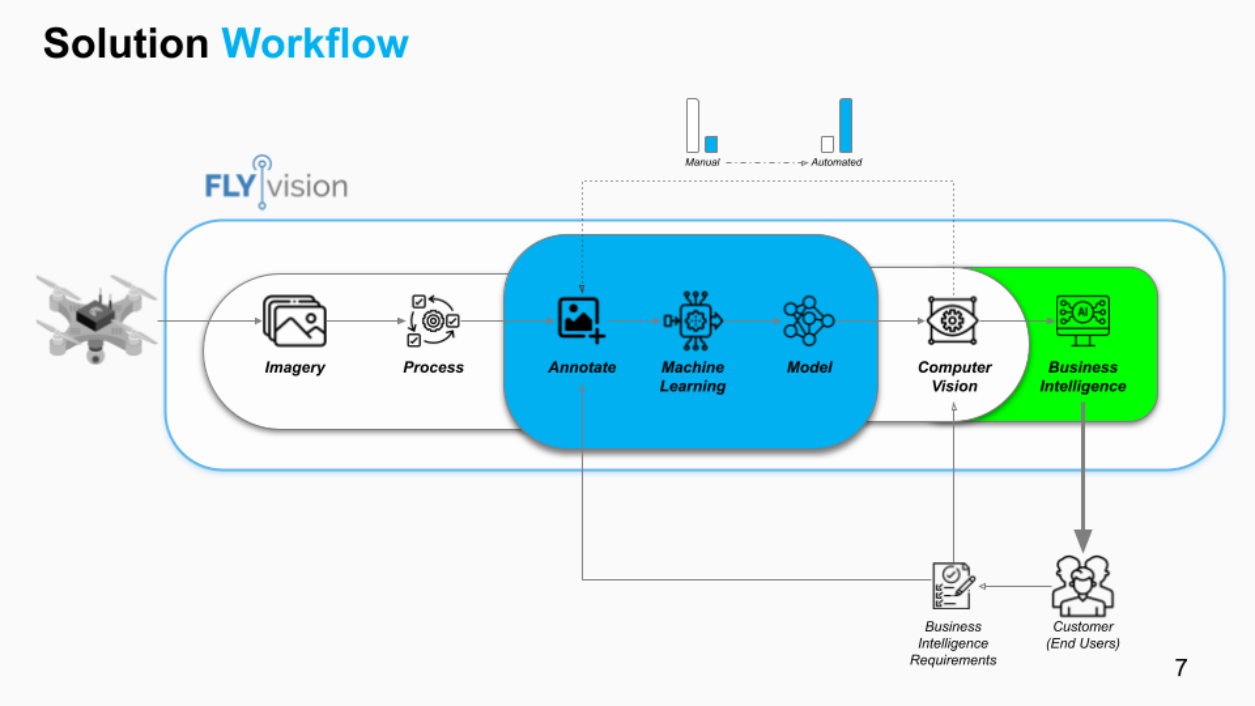
The development of Computer Vision applications using Artificial Intelligence has been delivered on multiple channels.

These videos (video #1 & video #2) demonstrate the internal developments completed as part of the Project to establish onboard airborne computer vision / AI applications. The automated recognition of 90+ common objects has been demonstrated from a 4G/LTE connected drone.

The development of computer vision / AI applications was integrated within the photogrammetry (imagery processing) platform with which we partnered to provide business intelligence to our customers. The FLYvision platform facilitates the processing of imagery and production of related data products: Orthomosaic maps, Digital Surface Model (DSM), and Contour maps. Based upon these fundamental data products, computer vision applications that level Artificial Intelligence (AI) derived through Machine Learning (ML) were used to extract business intelligence, as illustrated in the diagram below. The FLYvision

application demonstrates the "Standing Water" and "Vegetation'' algorithms in the data collected during the Suncor Fort Hills Oil Sands Mine inspection, as illustrated above.

The FLYvision platform can be extended to provide customized business results as requested by our end customers, as the diagram below outlines. The next phase of this work will be to extend a solution



framework to empower customization capabilities as defined above.

8. Outcomes and Impacts

The Alberta energy sector, alongside many other industries, is entering an era of considerable transformation triggered by the availability of new digital technologies. A sector once driven solely by resources is now driven predominantly by technology and innovation. Specifically, the digitization of the energy sector will profoundly affect operational efficiency, capital, operating and G&A cost reduction. The environmental performance will inevitably alter the industrial landscape as it presently exits. For example, in 2018, Blockchain was used to execute an oil royalty contract settlement and payment transaction using a Blockchain Royalty Ledger. Participating oil and gas companies anticipate that Royalty Ledger, along with automation and digitization of volumetric gathering and marketing information, has the potential to save between 30 and 80 percent of the effort it typically takes to get from start to finish when paying out monthly royalties.

Petroleum Technology Alliance Canada (PTAC) has worked in the digital innovation realm for several years with Alberta SMEs and oil and gas companies and has identified an opportunity to test, on a commercial scale, drone flights for the inspection and monitoring of remote oil and gas installation in central and or Northern Alberta. PTAC is uniquely positioned to use its existing network of members and service providers to launch the Energy UTM project.

Energy UTM will provide the following capabilities at a level and pace not presently available and will deliver outcomes that are currently out of reach for the existing digital innovation ecosystem:

- Real-world test of new and innovative air space management technology.
- Use case trial and development for additional applications and deployment of unmanned autonomous vehicles in an industrial setting.
- Develop and establish delivery costs and demand parameters for BVLOS drone flights.
- Test and confirm technical and business viability of BVLOS drone flights and air space management.
- Collect and analyze data related to air space management and drone flight feasibility.
- Provide science and technical information to inform the regulatory development process at Transport Canada and NAV Canada.

After the Energy UTM project, we have generated the information to support the confirmation of the technical and economic viability and the facilitation of the development of new businesses, jobs, and technical capabilities for Alberta.

This Project enables companies to access drone technology that increases efficiencies of current maintenance and inspection processes. By allowing BVLOS flight, companies can increase revenues by enabling more cost-effective methods to detect anomalies, leaks, emissions, and other labor-intensive processes. Currently, the industry driver for UTM includes costs related to annual inspections for observation wells, production wells, and pipelines. These costs are $30 million, $40 million, and $60 million, respectively. Through BVLOS Flight Ops, as supported by this Project, total costs of inspections can be reduced by $30 to $50 million.

The anticipated business impact yearly would be over $30,000,000 post-project.

9. Benefits

The Project has established 4G UTM services using the existing TELUS fixed telecommunications infrastructure to conduct trials in the oil sands region.

The outcome will be reduced environmental impact (reduced GHG emissions and land disturbance), substantial operating cost reductions, improved worker safety, and the progression of a technology and service that could be deployed in other industries and other regions, and open the door to automation, machine learning and artificial intelligence application in resource industries.

As mentioned above, in addition to the technical capabilities being developed in Alberta, significant regulatory expertise is also being developed. The relevant influence on developing national RTM and BVLOS regulations is also essential.

10. Recommendations and Next Steps

The Project has been completed, but development efforts to reach full commercialization and deployment at scale continue.

One of our anchor clients is interested in using computer vision and anomaly detection to monitor the pipeline rights-of-way. The trials supported by Alberta Innovates have demonstrated command-and-control of the aircraft and integration into the air space, as well as the capability to detect the anomaly of

interest to pipeline companies. Support from Transport Canada and NAV Canada will enable BVLOS at scale.

The Cobalt aircraft is flying frequently and flew seven days in July. It is scheduled to fly an extended 100 km one-way flight to reach Boyle, Alberta. The SOFC for the Cobalt to fly from Bruderheim to Boyle has been received.

AIRmarket is working with Alberta Machine Learning and Artificial Intelligence companies to continue to fly and collect additional data to assess the pipeline right of way and further automate the capabilities. AIRmarket provides BVLOS flight and data capture capabilities, and our Machine Learning partners analyze the data using machine learning to extract actionable information and business intelligence. The energy industry client consumes the data and improves its business operations.

The continuation of the Project is still at the innovation stage. Eventually, it will transition to operations.

AIRmarket will continue collaborating with an oil sands company in the oil sands. The use cases are various inspections at the mine sites. UTM is providing airspace monitoring and feeding remote ID information to NAV Canada. The Telus modeling system provides assurance of coverage. One application is the creation and frequent updates to elevation models that guide production. The oil sands company requires the data products quickly, on a daily or weekly basis. A second key driver is to avoid the presence of staff on-site for safety reasons. Artificial intelligence is used to detect anomalies such as standing water and vegetation. The next step is to prepare a comprehensive proposal to fly, stream data, and provide business intelligence products frequently.

Critical learning from the Project is the amount of data that will need to be handled. During the Project, 3 hours of data over 25 km² required 66 GB. However, the amount of disturbed area in the oil sands is 900 km², and the amount of data to inspect this large area will be several terabytes. These data will need to be managed securely and quickly to provide business intelligence to the client rapidly.

The Project has elevated the performance of BVLOS and UTM to a level that would not have been possible without the support from Alberta Innovates. The Project will deliver the anticipated economic and environmental benefits as the technology is fully deployed.

11. KNOWLEDGE DISSEMINATION

Concerning this Project, the following communications activities were conducted:

1. Trial Executive Steering Committee (TESC) - weekly ongoing basis on Wednesday's
2. Transport Canada BVLOS Railway Inspection - Mar 23, 2022
3. TC Energy Mexico Engagement - Mar 17, 2022
4. PTAC Webinar - Jun 5, 2022
5. TCE Demonstration Day - Jun 22, 2022
6. Suncor Fort Hills Findings Webinar - July 13, 2022
7. Suncor weekly meetings
8. TC Energy bi-weekly meetings

12. CONCLUSION

The Project has elevated the performance of BVLOS and UTM to a level that would not have been possible without the support from Alberta Innovates. The Project will deliver the anticipated economic and environmental benefits as the technology is fully deployed.