ALBERTA INNOVATES

CLEAN RESOURCES FINAL REPORT PACKAGE

Project proponents are required to submit a Final Report Package, consisting of a Final Public Report and a Final Financial Report. These reports are to be provided under separate cover at the conclusion of projects for review and approval by Alberta Innovates (AI) Clean Resources Division. Proponents will use the two templates that follow to report key results and outcomes achieved during the project and financial details. The information requested in the templates should be considered the minimum necessary to meet AI reporting requirements; proponents are highly encouraged to include other information that may provide additional value, including more detailed appendices. Proponents must work with the AI Project Advisor during preparation of the Final Report Package to ensure submissions are of the highest possible quality and thus reduce the time and effort necessary to address issues that may emerge through the review and approval process.

Final Public Report

The Final Public Report shall outline what the project achieved and provide conclusions and recommendations for further research inquiry or technology development, together with an overview of the performance of the project in terms of process, output, outcomes and impact measures. The report must delineate all project knowledge and/or technology developed and must be in sufficient detail to permit readers to use or adapt the results for research and analysis purposes and to understand how conclusions were arrived at. It is incumbent upon the proponent to ensure that the Final Public Report **is free of any confidential information or intellectual property requiring protection**. The Final Public Report will be released by Alberta Innovates after the confidentiality period has expired as described in the Investment Agreement.

Final Financial Report

The Final Financial Report shall provide complete and accurate accounting of all project expenditures and contributions over the life of the project pertaining to Alberta Innovates, the proponent, and any project partners. The Final Financial Report will not be publicly released.

CLEAN RESOURCES FINAL PUBLIC REPORT TEMPLATE

1. PROJECT INFORMATION:

Project Title:	**Dynamic VR (D-VR) Training Model**
Alberta Innovates Project Number:	G2020000139
Submission Date:	August 25th 2021
Total Project Cost:	$618,000
Alberta Innovates Funding:	$300,000
AI Project Advisor:	Bryan Helfenbaum

2. APPLICANT INFORMATION:

Applicant (Organization):	**Exergy Solutions**
Address:	202 6th Ave SW #800 BVS 1, Calgary Alberta T2P 2R9
Applicant Representative Name:	Scott Hunter
Title:	Digital Solutions Manager
Phone Number:	403-830-0755
Email:	shunter@exergysolutions.com

3. PROJECT PARTNERS

Please provide an acknowledgement statement for project partners, if appropriate.

RESPOND BELOW

- Suncor Energy
- Alberta Innovates
- Innotech Alberta

A. EXECUTIVE SUMMARY

Provide a high-level description of the project, including the objective, key results, learnings, outcomes and benefits.

RESPOND BELOW

Objective

A Dynamic VR (D-VR) prototype model was created by combining a VR environment with a dynamic process simulation, which allowed for the pilot operator to interact with the model. The model can respond in real-time to operator decisions, which are continuously backed up by the dynamic process simulation engine's thermodynamic calculations. The field pilot operators quickly became familiar with operation of the facility, which greatly accelerated the start-up and commissioning phases from months to weeks. The test prototype model will be modular, so that it can be easily adapted to different processes in the future.

Key Results

Key results began with successfully building a stable VR Environment in Unity. 3D CAD models were created based on a facility 3D laser scan which allowed us to accurately as-build the 3D model. A highly optimized low poly count CAD file was converted into the Unity scene which allowed for a stable user experience. Process animations were created that showed the journey of the oil sand throughout the pilot plant.

Next was creating the data bridge connection between MatLab and Unity. The data bridge was able to represent MatLab values and live operating conditions in the Unity scene by accessing bitumen color, solid weights, liquid heights and flowrates from the MatLab model. The MatLab model also displays in Unity a 10 hour journey of how solids behave in the tanks on SK-300.

We then created emergency response narratives that allowed trainees to experience scenarios when things don't go according to plan. Our process engineer, Suncor and Innotech operators were able to collaborate and create 9 emergency response narratives that will be used to train current and future plant operators.

And finally bug testing was conducted to ensure a smooth user experience. Diligent testing was conducted over the past month of the project and took several passes to complete. Although at times tedious the project team did not deviate from the schedule and the bugs where identified and eradicated.

Learnings:

Process Model Communication (MatLab → DB → Unity): Embracing open standards / common patterns. A concrete example was when we moved away from specific TCP based communication from MATLAB to the data bridge and instead proceeded with standard web requests (HTTP calls to the data bridge, and subsequently to the VR Scene). This simplified dramatically the nature of the MATLAB code that needed to be crafted, as well as the Unity VR code.

Fully as-built and optimized models are paramount: Cleaner and leaner models with low poly counts allow for larger, smoother and more interactive scenes. We were dealing with a couple models that were created from a very detailed mechanical design program (Inventor). These detailed files are the opposite of what you would want in a VR scene.

Modular Implementation and API Calls: Historically, buttons on the controllers were only mapped to one function in the environment. Using a modular implementation, we were able to change button assignments anytime during runtime in a scene.

Multicore API Calls: A multicore application strategy was implemented where we used the main application on 1 core and the background threads for API calls on the other 3 cores. This ensured maximum core usage and allowed for a more interactive dynamic environment.

Azure Container Instances: We were able to leverage cloud serverless technologies, such as Azure Container Instances, to be able to run our data bridge service without having to maintain VMs or hardware, thus allowing the data bridge to scale elastically when load / traffic demands increases.

Outcomes:

With the successful creation of the data bridge we have ushered in a new era of interactive training simulators. Although they still have their place, static training simulators will start to become less prevalent. Users are now able to interact with the virtual world and are able to relate operational actions or decisions to physical results. In order to provide effective operations and commissioning training, the D-VR allows valves to turn, vessels to fill, emergency situations to be mitigated, and data displays to change in real time.

Benefits:

With this project we were able to accelerate bringing NAE to market via a compressed training schedule. We also created new product or service for Exergy and internally for Suncor. We were able to create new jobs as well as concurrently re-train out of work industry professionals.

B. INTRODUCTION

Please provide a narrative introducing the project using the following sub-headings.

- **Sector introduction:** Include a high-level discussion of the sector or area that the project contributes to and provide any relevant background information or context for the project.
- **Knowledge or Technology Gaps:** Explain the knowledge or technology gap that is being addressed along with the context and scope of the technical problem.

RESPOND BELOW

Sector Introduction: The primary sector the project contributes to is oils sands processing, specifically around research and development. As previously mentioned, we have focused on a pilot plant that will accelerate operator training through a dynamic VR model.

Knowledge or Technology Gaps: The main gap with current Static VR models is that although multiple users can walk through the virtual plant, the model remains static; users cannot interact with the virtual world and are unable to relate operational actions or decisions to physical results. To provide effective operations and commissioning training, the VR Digital Twin needs to allow valves to turn, vessels to fill, stream properties to vary, and data displays to change in real time. This project will allow for a two-way communication between the VR model and the dynamic process model.

C. PROJECT DESCRIPTION

Please provide a narrative describing the project using the following sub-headings.

- **Knowledge or Technology Description:** Include a discussion of the project objectives.
- **Updates to Project Objectives:** Describe any changes that have occurred compared to the original objectives of the project.
- **Performance Metrics:** Discuss the project specific metrics that will be used to measure the success of the project.

RESPOND BELOW

Knowledge or Technology Description: The objective was to "gamify" an operator training simulator. By doing so operators will become fully engaged in the training process therefor becoming more educated operators faster. By providing a realistic VR environment operators will be able to practice real world operating procedures as if they were in the real facility.

Updates to Project Objectives: There have been no changes to the initial project objectives. Initial attempts to have MatLab communicate relevant calculated data to the Unity scene were a success. Various techniques were considered, however successful communication was established by leveraging the Web Access capabilities provided by the Data Import and Export set of functions. With this, MatLab was able to transmit all data sets, on demand, to the data bridge service. Once received by the Data

Bridge, the data is then persisted and shaped for optimal transmission to the Unity scene, either via pull (Unity scene requests the data on demand), or by push (data bridge transmits the data to the Unity Scene in near real time). The latter technique was proven to be able to communicate to multiple Unity scenes concurrently.

Performance Metrics:

1. Job creation. 6 full time and part people were hired and worked on the project. We are in talks with other partners to execute similar VR training projects using the modularized data bridge. When successful this will spawn other project teams and subsequently create more jobs.

2. TRL advancement. Now that the D-VR data bridge is proven and functional we are confident it can advance from TRL 4-6 to TRL 8-9. It's now an actual system that is "flight proven" through successful use case operations.

3. New products/services created. The data bridge pilot has been designed in a way to future proof it. We will be able to modularize the core engine and apply it to other front end and backend applications like MatLab and Unity. A strong foundation has been established.

Project Success Metrics:

A completed, working and tested data bridge between the VR environment and the dynamic process model (simulation), utilizing both platform's APIs. The completed simulator is showing no lags, glitches or bugs after testing was completed. The user experience is smooth due to the stability of the data bridge and the optimization of the 3D models prior to importing them into the Unity environment and scene.

The successful operation and deployment of the first data bridge has progressively reduce the cost and schedule to produce future Dynamic VR (D-VR) Digital Twins for training. The early success with the data bridge has shown that we will be able to leverage a vast amount of early work and apply it to future D-VR training modules.

D. METHODOLOGY

Please provide a narrative describing the methodology and facilities that were used to execute and complete the project. Use subheadings as appropriate.

RESPOND BELOW

Agile Methodology: Given that this was a very dynamic and unproven project from a technology development standpoint, we felt it was a perfect candidate to utilize an agile project execution and project management approach. One key project goal was the development of the data bridge so a proven methodology with a software bent was a great fit. The agile methodology was an effective way to manage this project by breaking it up into several phases or sprints. It involved a daily scrum at 1pm

with team members, and the client, with a focus on continuous improvement at every stage. Once a sprint would begin we go through a process of planning, executing, and evaluating.

Facilities: The majority of the project team worked remotely for the duration of the project due to the global pandemic and Covid-19 restrictions. Our two developers and project manager had the appropriate hardware in their home office's so the team was able execute with no issues.

E. PROJECT RESULTS

Please provide a narrative describing the key results using the project's milestones as sub-headings.

- Describe the importance of the key results.
- Include a discussion of the project specific metrics and variances between expected and actual performance.

RESPOND BELOW

MatLab Data Model: An early milestone was to get the data from one vessel from SK-300 prepared for export so we could begin the early development of the data bridge. Subsequent data models were exported as the project progressed, but future success was contingent on having the MatLab data model far enough along to begin initial exports.

Metrics & Variances: Initial project execution plans indicated that we had to have the MatLab model fully completed by early March 2021. In reality we continued to work with Suncor on the model well into May because we realized that we could continue to upload data sets as the project progressed as long as our programmers had time to parse and organize the data. Furthermore, Suncor continued to do the bulk of the development work on the model which allowed us more time to contribute to the narrative development.

Building VR Environment in Unity: The 3D CAD models were created based on a facility 3D laser scan which allowed us to accurately as-built the 3D model. A highly optimized low poly count CAD file was converted into the Unity scene which allowed for a stable user experience.

Metrics & Variances: We identified by early January 2021, after working with the team at Innotech, that the initial 3D model created by Exergy prior to this project did not sufficiently match what had been constructed in the pilot. We identified the need to 3D laser scan the facility by mid January but due to Covid restrictions was forced to delay that scan until March.

MatLab to Data Bridge to Unity: A major milestone, if not the largest, was successfully getting the data bridge to represent MatLab values and live operating conditions in the Unity scene by accessing bitumen color, solid weights, liquid heights and flowrates from the MatLab model. The MatLab model was also able to display, in Unity, a 10 hour journey of how solids behave in the tanks on SK-300.

Metrics & Variances: This was a more iterative process than initially thought. The team continuously aimed to improve the efficiency of the data transfer as the model grew with complexity. Early execution plans did not entirely account for this.

Emergency Response Narratives: Our process engineer, Suncor and Innotech operators were able to collaborate and create 9 emergency response narratives that will be used to train current and future plant operators.

Metrics & Variances: This milestone required more effort than originally required because of the time it took for our process engineer to identify and script the narratives while getting approval from Suncor. This was mitigated because we had budget left over from the process engineering scope which was also handled by our process engineer. Suncor in the end approved these narratives although Exergy was required to create them.

Bug Testing: Diligent bug testing was conducted over the past month of the project and took several passes to complete. Although at times tedious the project team did not deviate from the schedule and the bugs where identified and eradicated.

Metrics & Variances: This pretty much went as planned.

F. KEY LEARNINGS

Please provide a narrative that discusses the key learnings from the project.

- Describe the project learnings and importance of those learnings within the project scope. Use milestones as headings, if appropriate.
- Discuss the broader impacts of the learnings to the industry and beyond; this may include changes to regulations, policies, and approval and permitting processes

RESPOND BELOW

Process Model Communication (MatLab → DB → Unity): Embracing open standards / common patterns. A concrete example was when we moved away from specific TCP based communication from MATLAB to the data bridge and instead proceeded with standard web requests (HTTP calls to the data bridge, and subsequently to the VR Scene). This simplified dramatically the nature of the MATLAB code that needed to be crafted, as well as the Unity VR code.

Broader Impacts: Larger data sets are now being handled which will increase the size and efficiency of not only the modules but also the environments that will be build.

Fully as-built and optimized models are paramount: Cleaner and leaner models with low poly counts allow for larger, smoother and more interactive scenes. We were dealing with a couple models that

were created from a very detailed mechanical design program (Inventor). These detailed files are the opposite of what you would want in a VR scene.

Broader Impacts: As mixed reality solutions become more of a regular day occurrence in training and maintenance modules we as an engineering and design community must always be aware of the total life cycle of the CAD files. If you are lucky enough to know from day one of design that a CAD file is destined for a mixed reality environment, take the proper precautions and implement the proper practices to ensure low poly counts.

Modular Implementation and API Calls: Historically, buttons on the controllers were only mapped to one function in the environment. Using a modular implementation, we were able to change button assignments anytime during runtime in a scene.

Broader Impacts: Although mainstream in the gaming community, there has been very little development with this modular implementation in training modules for the energy industry. If we want to continue to grow mixed reality solutions in this sector we must continue to evolve and innovate even at a granular level. In the end each small step towards efficiency breeds broader improvements.

Multicore API Calls: A multicore application strategy was implemented where we used the main application on 1 core and the background threads for API calls on the other 3 cores. This ensured maximum core usage and allowed for a more interactive dynamic environment.

Broader Impacts: If we as an industry can start to apply these types of computing application strategies, our training platforms and products will be industry leading.

Azure Container Instances: We were able to leverage cloud serverless technologies, such as Azure Container Instances, to be able to run our data bridge service without having to maintain VMs or hardware, thus allowing the data bridge to scale elastically when load / traffic demands increases.

Broader Impacts: Cloud is King! Get on board or be left in the dust. This is another core technology that must become mainstream if we want to compete on a global platform. There is simply no comparison to what cloud technologies can offer versus conventional on site server solutions.

G. OUTCOMES AND IMPACTS

Please provide a narrative outlining the project's outcomes. Please use sub-headings as appropriate.

- **Project Outcomes and Impacts:** Describe how the outcomes of the project have impacted the technology or knowledge gap identified.
- **Clean Energy Metrics:** Describe how the project outcomes impact the Clean Energy Metrics as described in the *Work Plan, Budget and Metrics* workbook. Discuss any changes or updates to these metrics and the driving forces behind the change. Include any mitigation strategies that might be needed if the changes result in negative impacts.
- **Program Specific Metrics:** Describe how the project outcomes impact the Program Metrics as described in the *Work Plan, Budget and Metrics* workbook. Discuss any changes or updates to these metrics and the driving forces behind the change. Include any mitigation strategies that might be needed if the changes result in negative impacts.
- **Project Outputs:** List of all obtained patents, published books, journal articles, conference presentations, student theses, etc., based on work conducted during the project. As appropriate, include attachments.

RESPOND BELOW

Project Outcomes and Impacts: With the successful creation of the data bridge we have ushered in a new era of interactive training simulators. Although they still have their place, static training simulators will start to become less prevalent. Users are now able to interact with the virtual world and are able to relate operational actions or decisions to physical results. In order to provide effective operations and commissioning training, the D-VR allows valves to turn, vessels to fill, emergency situations to be mitigated, and data displays to change in real time.

Clean Energy Metrics:

new jobs created from project. 6 full time and part time people were hired and worked on the project. We are in talks with other partners to execute similar VR training projects using the modularized data bridge. When successful, this will spawn other project teams and subsequently create more jobs.

TRL advancement. Now that the D-VR Data Bridge is proven and functional we are confident it can advance from TRL 4-6 to TRL 8-9. It's now an actual system that is "flight proven" through successful use case operations.

New products/services created. The data bridge pilot has been designed in a way to future proof it. We will be able to modularize the core engine and apply it to other front end and backend applications like MATLAB and Unity. A strong foundation has been established.

$ in Clean Technology. NAE technology will result in significant environmental benefits and cost savings in comparison to the currently used processes of hot water extraction and paraffinic froth treatment.

Project Outputs:
Two conference booth presentations have been planned for mid and late September (WMTS & GES). For both, our CEO Billy Rideout also has a keynote address where the project will be referred to.

H. BENEFITS

Please provide a narrative outline the project's benefits. Please use the subheadings of Economic, Environmental, Social and Building Innovation Capacity.

- **Economic:** Describe the project's economic benefits such as job creation, sales, improved efficiencies, development of new commercial opportunities or economic sectors, attraction of new investment, and increased exports.
- **Environmental:** Describe the project's contribution to reducing GHG emissions (direct or indirect) and improving environmental systems (atmospheric, terrestrial, aquatic, biotic, etc.) compared to the industry benchmark. Discuss benefits, impacts and/or trade-offs.
- **Social:** Describe the project's social benefits such as augmentation of recreational value, safeguarded investments, strengthened stakeholder involvement, and entrepreneurship opportunities of value for the province.
- **Building Innovation Capacity:** Describe the project's contribution to the training of highly qualified and skilled personnel (HQSP) in Alberta, their retention, and the attraction of HQSP from outside the province. Discuss the research infrastructure used or developed to complete the project.

RESPOND BELOW

Economic: The project has employed a full time and part time staff of 6. Because of their experience in the development of the technology, these team members have moved on to other D-VR related projects within Exergy. In addition, we have been able to hire additional team members such as designers, trainers, programmers, and IT personnel who have been crossed trained. These new jobs have been filled through a re-training of a technical workforce that have been victims of the economic downturn and new graduates who have been unable to find work post-graduation.

Environmental: Remote training has never been more accessible and available with projects and products like this training simulator. We are now able to ship a $600 headset to multiple team members anywhere in the world fully loaded with the latest module. They can now all be trained more efficiently, in less time and in safer environments. A reduction in travel via planes, trains and automobiles are contributing to less overall environmental impact via a reduction in GHG's.

Social: Now that the D-VR data bridge module has been created it is expected to create approximately 50 new jobs over the next year as other projects kick off. Furthermore, there are related benefits in the field of remote education and training which can potentially offer benefits to rural and indigenous communities through e-learning and increased access to education/educational tools.

Building Innovation Capacity: Based on the success of this project, Exergy plans to continue to expand the use of D-VR training within the province. By demonstrating that the use of Dynamic VR (D-VR) Digital Twins can make training more affordable and effective we expect the technology to be more widely adopted.

As a result of the past two decades of growth and capital investment in the energy sector, Alberta now boasts a very technical labour market. Among these are CAD designers who are trained to design and model large oil and gas projects. Due to the similar technical requirements, CAD designers are easily trained to convert 3D models to VR models. We estimate that a fully commercialized Dynamic VR Digital twin market would require more than 50 new highly technical personnel to support the rapid growth and development in Alberta.

In addition, it is expected that as the Dynamic VR (D-VR) Digital Twin technology begins to be more widely adopted, eight to ten student or research associates could be required to map existing processes in detail and to provide related background research.

Recommendations and Next Steps

Please provide a narrative outlining the next steps and recommendations for further development of the technology developed or knowledge generated from this project. If appropriate, include a description of potential follow-up projects. Please consider the following in the narrative:

- Describe the long-term plan for commercialization of the technology developed or implementation of the knowledge generated.
- Based on the project learnings, describe the related actions to be undertaken over the next two years to continue advancing the innovation.
- Describe the potential partnerships being developed to advance the development and learnings from this project.

RESPOND BELOW

The outcomes of this project will be presented at various trade conferences in Alberta and abroad, demonstrating the benefits of implementing D-VR Digital Twins for training. Specifically on September 14th – 16th at the WMTS in Edmonton and on September 21st - 23rd at the GES in Calgary. Exergy has made financial commitments to plan to continue to grow and market this lower cost line of Dynamic VR Digital Twin technology and we plan to work with collaborative technology sharing organizations like Alberta Innovates, COSIA (Canada's Oil Sands Innovation Alliance), and CRIN (Clean Resource Innovation Network). Furthermore, Exergy is planning a social media expansion campaign to let the province, country and world know about the success of the project with the hopes of acquiring new partners and

clients. As previously mentioned, we are in talks with a couple existing and new clients about applying the data bridge module to their systems, for example LabView.

I. KNOWLEDGE DISSEMINATION

Please provide a narrative outlining how the knowledge gained from the project was or will be disseminated and the impact it may have on the industry.

RESPOND BELOW

The source code from the repository will be delivered to Suncor in September along with the Unity scene and data bridge architecture. The theories and scripts behind the narratives have also been shared and discussed throughout the course of the project. All of this can and will be used for future projects. Since Suncor is a long-term partner of Exergy, we have offered continuous support for future development of this or any other mixed reality projects. There have been recent conversations about kicking off another similar project. This is now with their camp and we expect to know if the project will go forward after they look at Q4 budgets.

J. CONCLUSIONS

Please provide a narrative outlining the project conclusions.

- Ensure this summarizes the project objective, key components, results, learnings, outcomes, benefits and next steps.

RESPOND BELOW

Objective

- A Dynamic VR (D-VR) prototype model was created by combining a VR environment with a dynamic process simulation

Key Results:

- Successfully building a stable VR Environment in Unity.
- As-building the plant via 3D laser scanning.
- Low poly count CAD file was converted into the Unity scene.

- Process animations were created that showed the journey of the oil sand throughout the pilot plant.
- Creating the data bridge between MatLab and Unity.
- Creating emergency response narratives.
- Successful bug testing.

Learnings:

- Process Model Communication (MatLab → DB → Unity)
- Fully as-built and optimized models are paramount
- Modular Implementation and API Calls
- Multicore API Calls
- Azure Container Instances

Outcomes:

- Successful creation of the data bridge.
- Stable scene and environment.
- Improved 3D model optimization techniques.
- Usable product and service.

Benefits:

- Accelerate bringing NAE to market via a compressed training schedule.
- Created new product or service for Exergy and internally for Suncor.
- Create new jobs.
- Re-train out of work industry professionals.

Next steps:

- Exergy has made financial commitments and plans to continue to grow and market the product and service created
- Share the project outcomes and benefits at 2 upcoming technology shows on September 14th – 16th at the WMTS in Edmonton and on September 21st - 23rd at the GES in Calgary.
- Social media expansion campaign to let the province, country and world know about the success of the project with the hopes of acquiring new partners and clients.