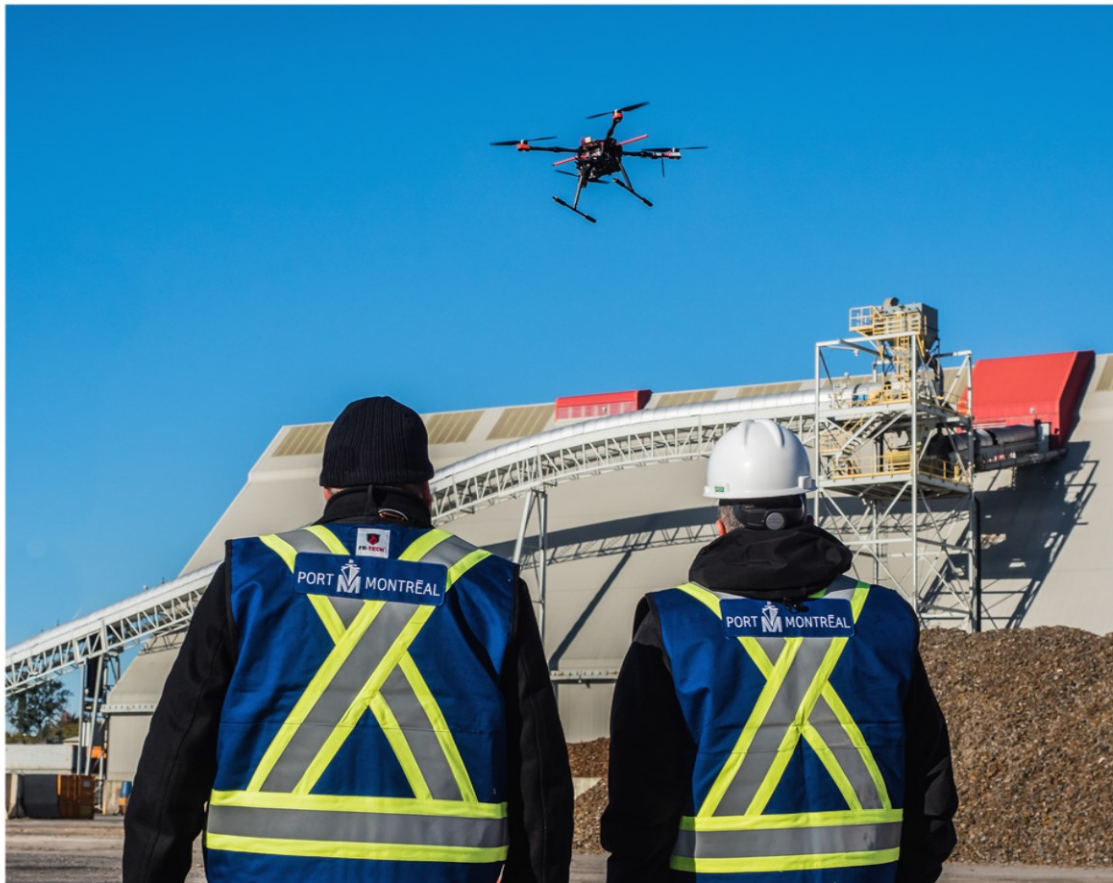


2020 AAPA INFORMATION TECHNOLOGY AWARDS

PORT OPERATIONS AND MANAGEMENT SYSTEMS

PORT OF MONTREAL DIGITAL TWIN PROJECT



INTRODUCTION AND PROJECT SUMMARY

For the Montreal Port Authority (MPA), open innovation is a differentiator and a competitive advantage in the maritime sector. The MPA, which administers the Port of Montreal, has produced a Digital Twin of the port's territory and infrastructures as part of its development strategy focused on innovation and visionary technologies. The Digital Twin is an information technology tool used for infrastructure planning and optimization, training of security and fire prevention staff, and enhanced communications with the community, clients and potential clients.

PORT DESCRIPTION

The Port of Montreal is a major international port and a diversified transshipment centre that handles each year more than 2,000 ships carrying some 40.6 million tonnes of all types of cargo to and from all parts of the world. It also welcomes international cruise vessels and their guests.

Montreal is the second-largest port in Canada, the only container port in Quebec, and a destination port served by the largest shipping lines in the world. It is an intermodal hub with a service offering that is unique in North America, featuring its own railway network directly dockside connected to Canada's two national rail networks. The MPA also operates a Cruise Terminal and a Port Centre.

Port activity in Montreal supports 19,000 jobs and generates \$2.6 billion in economic benefits annually.

GOALS AND OBJECTIVES / BUSINESS PROBLEM

The Port of Montreal is a 965-hectare territory where cargo terminals, silos, hangars, rail tracks and thousands of trucks and ships co-exist. Its cargo-handling operations stretch along 26 kilometres of waterfront on the island of Montreal between the city and the St. Lawrence River.

As part of our efforts to continuously enhance our operational and business processes, we wanted to create a tool that would fully document and provide a better understanding of port



spaces and infrastructures. In turn, we would further develop this tool to help plan port developments and optimize space, train

staff and enhance communications. We determined and understood that the creation of a dynamic, accessible and practical three-dimensional tool that geographically represents the port's structural layout would best serve our needs.

DISCUSSION

Background

The MPA partnered with the Centre for Technological Entrepreneurship (Centech) in 2018 to create the first port innovation accelerator in North America. The unit, which is helping the port accelerate its innovation cycle, provides us with access to high-tech start-up companies and is a basic lever for the advancement of technological solutions in the marine transportation sector.

One year after its launch, the innovation unit generated a strategic open innovation project with two promising Montreal high-tech start-ups. With PreVu3D and ARA Robotics, the MPA carried out an extensive three-dimensional modelling of port locations and facilities... a Digital Twin.

Objectives and Methodology

ARA Robotics used a drone to take high-quality overhead photographs of all of our installations, along a distance of 26 kilometres. The photos were transformed into 3D using photogrammetry technology.



PreVu3D took the data-heavy 3D models, smoothed out the textures to make the files easier to read, and created an interactive environment to navigate the model from an overhead, first- or third-person perspective.

A third-party consultant created an application that presents the model of port installations in augmented reality. A tablet with the application and a 2D map of the port are all that users need to move around the port and learn about our operations and ecosystem in a more interactive way as if they were in a video game. They can visit all of our spaces, down to the closest millimetre, without ever having to actually travel to them.

By means of this photographic scan by drone, the port now has a huge interactive model of its facilities that can be used for various purposes.

Hardware/Software

The capture of the Port of Montreal was done using ARA Robotics proprietary software and hardware. Initial data processing of the imagery was carried out using the professional suite of Bentley ContextCapture at the highest level-of-detail possible, reaching billions of triangles and thousands of textures per section of the port.

The PreVu3D automated cloud-processing solution was used to process the massive datasets to generate multiple optimization to allow for various outputs and level-of-details based on the project's scope and hardware limitations (augmented reality, virtual reality, Viewer and Desktop Editor).

Data sharing

PreVu3D proprietary advanced level-of-detail and collision systems are used to generate both the desktop-based applications and web-based viewer. They are hosted on AWS (Amazon Web Services) servers in Canada, the U.S. or Europe, depending on clients' requirements.

PreVu3D Desktop applications provide further functionalities as they leverage the full access to GPUs (Graphics Processing Units) and CPUs (Central Processing Units) for heavy computing functionalities such as its patent-pending mesh-cutting tool.

The PreVu3D web-based viewer allows for very large datasets to be explored in first-person with collision, a feature that has yet to be reproduced on the market at such level of details (50+M polygons and textures).

Coding

The end-to-end pipeline requires more than 25 steps and algorithms all optimized for various operating systems and constraints. The solution is coded with several languages that aim to combine efficiency, precision and realistic rendering.

Project Cost

PreVu3D developed and led the solution over one year and at a cost of \$112,000. It includes:

- Project management for three start-ups
- Coordination of port scans
 - Alignment with security teams
 - Alignment with Transport Canada and the City of Montreal for flight approvals
 - Alignment with all of the port's tenants
- Scanning operations
 - Flight plans
 - Data collection
 - Data optimization
- Software development (augmented reality software)
 - Integration of existing 3D models by a third-party consultant
 - Programming of the interactive interface

- Integration of 3D data to homemade custom-made software (PreVu3D)
 - Data transformation
 - Data cleaning
 - Reduction of weight of textures
- Delivery of a turnkey solution, executable on desktop or accessible via Cloud.

Performance Measures

The project was completed on schedule and within budget. It has been operational since September 2019.

We have used the tool widely to document all of our spaces and infrastructures. It is being used to help plan and develop our new Contrecoeur container terminal, train the 21 staff members in our security and fire prevention departments, and enhance communications with the general public. Up to 37,000 people visiting our Port Centre have had the opportunity to experience an interactive map, created from the Digital Twin, at our new *All Aboard!* exhibition. (The exhibition opened December 21, 2019, and, unfortunately, temporarily closed on March 13, 2020, due to the Covid-19 pandemic.) Visitors have told us that the interactive map helps them better understand the importance of port activity and the benefits it brings to the community.

The feedback and reaction from users on the PreVu3D software has been very positive. In particular, they appreciate its ease of use, its compact format that can be easily shared with collaborators, and the lightweight computer program that allows them to move around as if they were in a video game.

The Digital Twin was also the subject of a CTV Montreal news report:

<https://montreal.ctvnews.ca/robotics-company-creates-3d-model-of-montreal-port-using-vr-and-drone-technology-1.4241776>

How the Project Fulfills the Award Criteria

i) Level and nature of the benefits

The Digital Twin is a powerful and modern tool that is useful at the decision-making and communications levels. It responds to three main operational and business needs and brings added value in terms of infrastructure planning and optimization, training, communications and marketing.

Infrastructure planning/optimization



The Digital Twin is a cutting-edge tool used to plan, develop and optimize space and improve fluidity throughout port territory (i.e. remodel entire container yards, move/modify truck and rail accesses). The digitized infrastructures of the port also serve as a basis for the design and development (provide geographic information system data, plan infrastructure work, etc.) of our new Contrecoeur container terminal, scheduled to open in 2024. The tool will help facilitate more efficient and rapid decision-making.

Emergency response training

The Digital Twin allowed for the creation of an immersive and interactive 3D/virtual reality training tool for the Port of Montreal's 21 security and fire prevention staff. Using the software, instructors can create “real-time” response scenarios (i.e. fire, gas or liquid bulk leak, accident) at different locations, with varying degrees of difficulty.



Actions must be taken within a specific timeframe to control the situation. The instructor can time, record and evaluate the response. Rather than training on the ground, trainees are given a type of video

game controller. With a virtual toolbox, they go through checklists as if the incident were occurring in real time, giving them a safer way to practise port security; staff members come into contact with typical accidents or disturbances before ever having to face them in real life. The tool optimizes training time, provides access to port territory at all times in a virtual manner, and ensures uniformity of the evaluation process.

Communications/marketing/education



The Digital Twin helps facilitate internal and external communications at the port. It enabled the creation of a huge interactive map that allows the general public to tour the port

in augmented reality as part of the *All Aboard!* exhibition at our Port Centre. The application presents port activities and helps communicate the added value that a port brings to its community. This immersive experience allows the port to better connect with its neighbours and the general public.

The Digital Twin also allows us to market the port internationally. It is a tool that our representatives in Europe, Asia and the U.S. can use to present the port and its advantages to clients and potential clients in an interactive fashion without having to be physically present.

ii) Creativity of the solutions or programs

The production of the Digital Twin is part of the MPA's vision to be a supplier of digital solutions to our logistics chain in addition to being a supplier of traditional infrastructures.

The project is unique in many ways. The Centech accelerator provides us with access to start-up companies that have targeted experience and offer us an ad-hoc labour force that responds to real port issues.

The opportunities extend beyond modelling. The software lets us plan spatial redevelopment, as if we were playing Minecraft: move a machine here, push back walls or move a pipe there, all in a space constructed down to the closest millimetre.

Depending on the training needs for the port's security and fire prevention departments, factors such as the degree of difficulty, the wind direction and on-site components can be varied. And

just like in a video game, the difficulty of the simulation can be increased as the trainees gain more skill and experience.

As its cargo-handling operations are, for the most part, hidden from public view, the port is generally unknown to the public. Touring the port in augmented reality at the Port Centre allows visitors to enjoy unprecedented views of port facilities and residents to rediscover this area in a brand-new way.

The project challenges were considerable, considering the huge surface area of the port, not to mention that it is 26 kilometres long and located in the middle of an urban area, the scale of port operations, the number of people on site and the type of equipment required for the data capture, i.e. a drone that can take 42 MP quality images. Operating the drones in this setting was particularly challenging in itself.

iii) Whether the project results are apparent

The results of developing and implementing the Digital Twin are indicated in the Performance Measures section.

iv) Cost effectiveness

The MPA has invested \$112,000 to develop the Digital Twin (see the Project Cost section above).

The actual cost came within budget. It is a significant investment but an exceptional value considering the many benefits and added value it will bring to develop and optimize port operations, train staff, enhance communications and grow the port's business.

v) Transferability of the technology to the port industry

The Digital Twin technology is transferrable to and can be applied to other ports.

CONCLUSION

The Port of Montreal's Digital Twin is an information technology innovation that is already paying dividends. It will improve port operations and the safety of port operations, assist with infrastructure planning and optimization, and enhance internal and external communications. It will revolutionize the way we make decisions and allow us to make smarter and safer decisions.

FURTHER INFORMATION

Article in the Port of Montreal's *Logbook* community e-magazine:

www.port-montreal.com/en/the-port-of-montreal/news/news/logbook/prevu3d-rethinking-port-space

Video of the Port of Montreal's Digital Twin project:

<https://youtu.be/JM7wCR-37VI>