“Don’t just take up space in this life. It is your responsibility to make a difference.”

Dr. Israel Asper (1932-2003)
Visionary of the Canadian Museum for Human Rights
On every plane, whether we’re talking vision, people, or technology, the Canadian Museum for Human Rights (CMHR) is making a difference...because it is different. The CMHR has been recognized as the first large-scale, complex project in Canada to use virtual design and construction universally across all consultant and contractor teams.
Just take one look at this breathtaking, iconic structure and its uniqueness is apparent. This case study will reveal how the CMHR project team used virtual design and construction (VDC) and other supportive technologies to build a project that, frankly, couldn’t have been built to the same standard without it. The team will share with you how being a part of the CMHR story has changed its members and how they manage complex projects of this scale.

DESIGN EXCELLENCE

After 18 months and three levels of increasingly detailed submissions, the contemporary design of internationally renowned architect Antoine Predock was selected over those of 61 other firms from 12 countries, in one of Canada’s largest-ever juried architectural competitions. Visitors will enter through the “tree roots,” travelling through nearly 47,000 square feet of exhibit space and 2,300 feet of ramps. The average floor-to-ceiling height of each level is 17 feet, mirroring the sense of vastness and openness in the Canadian landscape. Central to the experience is the Garden of Contemplation with its still water pools, and the Tower of Hope, a 328-foot-high glass structure overlooking the Winnipeg prairie horizon. All in all, the design is an inspiring showcase for this human rights museum.

The building design is reminiscent of icebergs, tree roots, and the wings of a dove, symbolizing hope for a changed world.
The complex geometries made 2D visualization of interior spaces very challenging. Scheduled model walk through meetings, which occurred at various intervals of design development, assisted in identifying and resolving potential construction design conflicts between the individual disciplines. Without this type of communication, it would have been nearly impossible to convey the design intent to various project stakeholders and may have resulted in never getting the project off the ground.

J. (Joe) Geurts, Owner’s Construction Manager, CMHR
The true power of VDC is its ability to combine information from a multitude of software packages into one bidirectional integrated file. On the CMHR project, active teams from 40 different companies located in eight cities in Canada, the United States, and Germany all contributed to a centralized model database. This database encompassed the project’s 3D model, 2D drawings, 2D details, schedules, and specifications.

**DESIGN VISUALIZATION**

A risk associated with complex projects like the CMHR is that the design can get lost in translation during the progression from a 2D plan to a 3D structure. By optimizing the virtual construction process, the consulting team, led by Smith Carter and Yolles, was able to translate the form into coordinated constructible components that could be analyzed in real time. This perpetuated a design-assist culture between the consulting team, PCL, and the major subcontractors. This joint access improved understanding of the design intent, as all team members were able to view and discuss design elements in the actual model, or with screen shots, while the design team articulated the importance of the various elements.

**CLIENT VISUALIZATION**

Traditionally, project teams require clients to interpret their 3D buildings from our 2D documents (e.g., plans, sections, elevations, renderings, and construction schedules). On the CMHR project, the project team sat with the client to review the museum in 3D, with live walk-throughs and renderings produced from vantage points of their choice. To help the client visualize and evaluate their options, the team even revised major structural components, such as curtain walls, right in front of their eyes.

**CANADIAN PERSPECTIVE**

The CMHR explores the universal subject of human rights, with a special reference to Canada. How fitting then, that this world-class museum should reside on the historic site of The Forks, Manitoba, which is ancestral land of Canada’s First Nations and Métis people. The project team implemented steps to help preserve more than 400,000 artifacts uncovered during excavation. In addition, following consultation with local First Nations elders, a medicine bag was deposited into more than 500 holes for the museum’s driven piles and caissons, out of respect for Mother Earth.
VIRTUAL MODEL AND DOCUMENTATION

The unconventional architectural form of the CMHR meant that hand sketches or traditional 2D AutoCAD could not be rationalized into a 3D model. Instead, the team started with a 3D model, set datum points and planes for the geometry, created hand sketches to determine the construction make-up, and then added the digital information to the model. As the complex geometry evolved and details were impacted, the team was able to continuously adjust the details to ensure the model was correct – and current – from a constructability, aesthetic, and technical perspective.

PRECONSTRUCTION PLANNING

During the preconstruction planning phase, the project team embarked on extensive reviews of the VDC models to identify and address potential design issues, or clash detection, prior to starting construction. Early clash detection presented a business advantage to the client, consultants, and contractors, by saving the time and money associated with unnecessary rework.
Improved collaboration, facilitated through early involvement, led to a more accurate budget and schedule, as well as the development of alternate design approaches from the entire team – from the owner, consultants, and construction manager, to the subcontractors. The project team was fully accountable for all aspects: pricing, design, quality, and schedule.

BURLEIGH HILL, MANITOBA OPERATIONS MANAGER
GRACOM MASONRY A JV

ESTIMATING INNOVATION

Due to its complex building geometry, the CMHR project could not be fully dimensioned in 2D, making it almost unbiddable using standard quantity take-off methods (e.g., digitizers, scales). The increased potential for bidder risk would normally translate into higher project costs; however, by using the fully integrated, up-to-date 3D model to isolate and extract accurate construction-caliber quantities for specific trade scopes, more competitive pricing was achieved. For example, Smith Carter created DWFX (Design Web Format) models for the exterior limestone veneer, allowing bidders to pinpoint their scope of work and quantities, and easily relate the information back to the 2D drawings. Confidence in the accuracy of the quantities was demonstrated by the fact there was a less than two-per-cent difference among the top three bids.

ROYAL BLESSING

On July 3, 2010, thousands gathered to witness the unveiling of the museum cornerstone by Her Majesty Queen Elizabeth II, accompanied by Prince Phillip, the Duke of Edinburgh. Her Majesty selected the stone from Runnymede, where the constitutional Magna Carta was signed 800 years earlier. The stone, which is encased in indigenous Manitoba limestone, is inscribed with her personal message.
The extreme geometric complexity and extensive interfacing of construction materials on the CMHR made virtual design and construction essential to the project’s success. It was an invaluable tool for establishing the building envelope and primary member geometry, and allowed for detailed pre-planning and visualization of erection sequencing and constructability.

Peter Kranendonk, Vice President & General Manager, Walters Inc.

GLOBAL PROCUREMENT

A significant level of preconstruction planning and coordination was required between the consulting and construction teams in North America, and the subcontractor who designed and manufactured the building’s exterior glazed façade in Europe. The project team used the VDC model to clarify information in the 2D drawings, which improved project efficiency by reducing the amount of time spent on data exchange and improving the accuracy of the information being shared.

REAL-TIME COLLABORATION

The project team overcame logistical challenges, such as bandwidth and server storage, by establishing a stable work platform in a virtual domain. By implementing remote desktop protocols during virtual meetings, team members were able to view, mark up, and take control of the model. Among the many benefits of this real-time collaboration were reduced travel time and costs, as well as improved communication and project coordination, thanks to increased meeting efficiency and expedited decision-making.
The virtual design model offered a complete package of the form, materials, structure, systems, and subsystems. It was so comprehensive that, long before final documents were complete, the project team was able to simulate building performance, evaluating the impact of wind and smoke flow, as well as structural loading and construction sequencing. The information was used to test, revise the model, and retest, until the unknowns and concerns were minimized.

**High Tech Tools**

To visualize, manage, and document this project, the project team adopted new technology (e.g., tablets, 3D mice, rapid prototyping or 3D printing, holograms and motion-capture technology) that even a few years ago was largely unknown. The consulting team, which originally supported AutoCAD and three or four other programs as its primary production tools, adopted 24 software platforms to provide the vast range of data and input required for the CMHR. Likewise, PCL expanded its AutoCAD software suite to include a range of 3D modeling platforms by Autodesk. All project stakeholders, including the owner and museum staff, were able to access the model using Navisworks, a free Autodesk download.

**A Canadian First**

On March 14, 2008, Bill C42 was passed by the Parliament of Canada with unanimous consent, making the CMHR a Crown corporation and the first national museum to be located outside the nation’s capital in Ottawa, Ontario. Upon opening in 2014, the Winnipeg-based facility, valued at approximately $350 million, will be Canada’s fifth national museum.
CONSTRUCTION MANAGEMENT

The VDC model provided the project team with an opportunity to break down the building into small components, around which the team could plan construction sequencing and activities. In self-performing the concrete work, PCL needed to install a large quantity of concrete shoring beams, or EFCO super-studs, which diagonally supported the inside of the concrete walls and tied back to the floor slab. The location of these super-studs could not conflict with the structural steel to be installed later. PCL overlaid its 3D concrete wall shoring model on the 3D structural steel model produced by Walters Inc., and then adjusted the super-stud locations in the model to reduce potential conflicts in the field. This process positively impacted the project budget and schedule.

CONSTRUCTION CHALLENGES

Capitalizing on its in-house VDC capabilities, PCL self-performed the CMHR’s cast-in-place structure. The design incorporated exposed-to-view, sloped, battered, and curved concrete walls, as well as a free-standing concrete wall with large openings. PCL developed a fully integrated 3D model for the formwork design and another for the re-shore components, all from the issued-for-construction model provided by the design consulting team, which allowed PCL to fine-tune the scheduling process. In addition, information from the model was used to design formwork and to fabricate panels to meet the CMHR’s specific requirements, geometrically and dimensionally. Using VDC models for construction coordination paid big dividends. PCL was able to schedule the concrete structure work with a high degree of accuracy – and finish this scope of work 11 weeks ahead of schedule.
When the doors open, the space will be filled with exhibits and stories that will make a difference to the understanding of human rights.

Built into every corner of this iconic structure will be the innovative spirit and expertise of the CMHR project team, which has written its own compelling story about the design and construction.

Izzy Asper would approve.