



Envisaged as a beacon to artists across Canada with 50'-high LED video displays over the NAC's new main entrance welcoming the city, the Kipnes Lantern is the largest transparent media facade in North America.

The Rejuvenation

Canada's National Arts Centre is made new again

By: Alan Hardiman

Shining like a beacon and with a refreshing immediacy to its sound, Canada's National Arts Centre has emerged from a comprehensive four-year renovation of its edifice and production infrastructure. Split into two phases—architectural rejuvenation and production renewal—for financial and scheduling reasons, the project was completed within the \$225.4 million budget allocated by the Government of Canada, which was apportioned almost equally between the two phases. Architectural rejuvenation of the Ottawa, Ontario building, was completed in time for the commencement of Canada's 150th anniversary celebration on July 1, 2017, while the renovation of production facilities and infrastructure was postponed until the summer of 2018, when the building was shut down for three months to facilitate work within its four performance venues.

During the overhaul of the 50-year-old performing arts center, an outdoor terrace that saw little use in winter was enclosed within a new glass envelope and developed into four new interior spaces and an atrium. A new front door was set into the base of a three-story transparent video “lantern” on the major downtown thoroughfare Elgin Street, a simple stroke of genius that effectively turned the building around to face and welcome the city. Under the guidance of project architect Jennifer Mallard, principal at Toronto-based Diamond Schmitt Architects, the overall effect of Donald Schmitt's design achieves the complete transmutation of a dark, hulking concrete bunker into a lighter, brighter structure offering views of Canada's Parliament Buildings that were not possible in the original design.

The new spaces have been equipped with full theatrical lighting and performance sound systems; the 2,065-seat Southam Hall has been given a new orchestra shell and seating that improves its acoustics and the engagement of performers with audiences.

Much of the aging electrical and theatrical production equipment has also been replaced in Southam Hall as well as in the 797-seat Babs Asper Theatre and 300-seat black

box Azrieli Studio, while the 150-seat Fourth Stage was completely rebuilt from the ground up.

Architectural rejuvenation

The NAC's five-year strategic plan for 2015-2020 described the shortcomings of the original facility: “People struggle to find the entrance. The lobbies can't accommodate large crowds, are difficult for those with mobility issues, and the lack of washrooms means that women in the audience often spend most of the intermission in line. The building is daunting. Its biggest problem, arguably, is that the main entrance faces the Rideau Canal, meaning that the NAC literally turns its back on the city. All this is compounded by low ceilings and few windows, creating a dark, bunker-like atmosphere.”

The canal, a navigable waterway bisecting the city, is a UNESCO World Heritage Site that, in winter months, becomes the world's largest skating rink. “In the 1960s, Ottawa's Greber urban design plan located some federal institutions, such as museums, on a planned new lagoon and public plaza on the canal side,” Mallard says. “In this ‘town and crown’ arrangement, the federal government was up on the hill and the public institutions, including museums and the arts center, would be built down around this lagoon. However, with the exception of the National Arts Centre, none of it was built, not even the lagoon.”

“When we were originally hired in 2012 to conduct a feasibility study, we were given three mandates: one, to make a new front door; two, to increase patron comfort, encompassing accessibility and washrooms; and three, to engage the NAC in the greater community of Ottawa, while respecting the heritage character of the building, which is quite significant.”

When the NAC opened in 1969 (at a cost of \$46 million), the building was celebrated for its Brutalist style, for its reflection of the landscape evoking the Canadian Shield, and for the hexagon—a shape repeated in virtually every part of the building. “That hexagonal grid informs everything,” Mallard says. “To work with a building that has



Constructed over a former outdoor terrace that had seen little use, the 60,000-sq.-ft. glazed addition houses four new performance spaces and an atrium that dramatically enhance the NAC's engagement with the greater community of Ottawa.

such a strong original character, you either counter that character or you work with it.

"We dove into that hexagonal grid," Mallard continues. "Everything we did originates from that logic, but we reinterpret it in a contemporary way. Whereas the original building was heavy, concrete, and opaque, the new building is glass and steel and warm wood. While that's a contemporary palette, the geometrical architectural language is akin to the original intent."

Several new spaces within the glazed addition add some 60,000 sq. ft. to the facility's original 1.2 million: The Glass Thorsteinson Staircase links the O'Brien Atrium and Peter A. Herrndorf Place at the Elgin Street level to the O'Born Room, Lantern Room, and Rossy Pavilion on the new Terrace level above.

"The foundation line of the former exterior terrace was based on the layout of the hexagonal structural grid, so the new walls emerge from those foundation lines," Mallard says. "They're right on the grid. The only foundation work we did was build a new elevator pit, so the footprint of the addition emerges from the former foundation

line. The wood coffer ceiling structure that we put in is of a heavy timber construction; the wood triangulation visible in the ceiling is the roof structure—prefabricated Douglas fir triangulated glue-lam coffers ganged in linear swaths up to 65' long. They were prefabricated off-site in order to save time, and the whole roof structure was installed in under three weeks.

"Each of the long swaths arrived assembled and prewired and was hoisted on-site by crane. There's a chase in the construction that accommodates all the AV wiring, electrical wiring, sprinkler lines, roof drain plumbing lines, and rigging where needed for the various De Sisti Spider lifts servicing the lighting and AV systems. Each lift fits inside one triangular space in the ceiling. All that infrastructure was installed in the shop; it saved us about six months in construction, since it was all finished material hoisted into place. There was no need to pull cables or install plumbing lines. Connectors for coupling the ceiling pieces were pre-installed, so they just had to be plugged into one another to complete the infrastructure in the ceiling."

Kipnes Lantern

Bridging the original building and addition is the Kipnes Lantern, a three-story glazed hexagon with the Centre's front door in its base on the ground floor, and the 1,300-sq.-ft. high-ceilinged Lantern Room occupying its upper two-thirds. The Lantern, constructed over a single-story hexagonal entrance to the parking garage from the rear of the building, features the largest transparent media façade in North America. An array of LED screens, mounted inside the glazing on four of its six sides, is capable of livestreaming performances from inside the building or anywhere else in Canada, in addition to providing digital signage.

Fabricated as 428 transparent modular LED panels in 13 customized panel types by Vancouver-based ClearLED, the 50'-high, 16mm-pixel-pitch LED displays cover 3,440 sq. ft. at 8,000 nits (about 25,000 lux) with up to 93% transparency—not a single screw is visible. "It is emergent technology that has been used for retail and traveling rock shows," Mallard says. "This is a different interpretation of that technology, and a vehicle to link the arts across the country in more of a national communication."

Martin Van Dijk, senior consultant and partner with Engineering Harmonics and the primary audio-visual designer for the project, says, "The types of video walls typically used in large concert tours present too much visibility-reducing structure for this application. We came up with the see-through idea first, developed that into a design, and found a company to fabricate it to our specifications."

The transparent media façade is linked to 4 two-story-high video displays spaced along the sidewalk on the Elgin Street side, such that images can be moved across the front of the building to and from the Lantern. Because they are viewable at closer range, each of these 150-sq.-ft. displays features a tighter 6mm LED pixel pitch.

"You can see through the Lantern into the building, especially at night," Van Dijk says. "One driving question behind the design was, How to make the Centre more open to the public? It has always been closed off; this used to be the rear entrance to the building. We didn't want to create a barrier with a giant video wall—hence the transparent façade. You can see into the building and simultaneously have a video image. It's really spectacular sometimes. You can do tricks, too: One night, they had a rotating cube on the display. From outside, it looked like the cube was just floating in space, because you didn't see the video wall on account of the interior lighting."

He adds, "Peter Herrndorf, the Centre's former president and CEO, believed the National Arts Centre should be more inclusive of the entire country, and he envisioned this as a beacon for the performing arts in Canada. The Lantern has the potential to become a digital canvas that allows the NAC to collaborate with other arts organizations to create digital media artworks for curation and presentation here.

With that in mind, the back end became a big concern, particularly selecting the type of server farm and database, because once you start doing that, the amount of data that must be managed is enormous."

Given its shape and extensive glazing, Van Dijk initially questioned how well the Lantern might function in its secondary role as a meeting room with a capacity of 72-120, sitting or standing. "It's a coffee can," he says. "I thought it was going to be an absolute nightmare from an acoustics point of view, but Threshold Acoustics has done a great job—you can hear the results. This room has got some life, but it's not the terrible echo chamber that it should be, given its geometry." He notes that absorptive acoustic panels and angular diffusors line two of the lower walls. "Visually, that gives a texture to the room—plus it sounds great."

New spaces

Adjacent to the Lantern Room at the top of the grand staircase is the 1,600-sq.-ft. Alan & Roula Rossy Pavilion, a new programming space furnished with theatrical lighting and sound connectivity and an impressive view, through its floor-to-ceiling windows, of the Parliament Buildings a quarter of a mile away. Floor pockets for audio-visual, data and power lines are generously distributed around the room's perimeter.

Across the Terrace level to the north, the 2,700-sq.-ft. Janice & Earle O'Born room is fully glazed on all sides and boasts fabulous views of the Rideau Canal, Chateau Laurier Hotel, and Parliament Buildings. Intended primarily for entertaining, rentals, and hospitality purposes, it accommodates 144-250 guests.

Linking the Terrace level with the Gail & David O'Brien Atrium below is the Susan Glass & Arni Thorsteinson Staircase, with a capacity of 60 for daytime concerts, lectures, and morning workout classes. Modeled on the Bradshaw Auditorium in Toronto's Four Seasons Centre for the Performing Arts, an earlier Diamond Schmitt project, the staircase was included at the client's request.

"On opening day, when Prince Charles was in attendance," Mallard says, "a gospel choir performed on the staircase, with the conductor standing on the floor, surrounded by the audience and looking up at the choir. That was fabulous. We've had audiences seated on that staircase, with dancers on the ground level. If the mandate is public engagement, then that stair is doing its job."

To the eye, the staircase is clearly a production space: The Spider lifts resting in the ceiling coffers are visible to anyone looking up; a black pipe rail affixed to the wall around the upper level of stairs is populated with lighting fixtures much of the time; a Renkus-Heinz Iconyx loud-speaker array is mounted on the wall between a pair of atrium windows near the foot of the stairs.

"The Iconyx digitally steerable array, comprised of three

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IC8 modules, covers this area beautifully,” Van Dijk says. “We have installed infrastructure for additional loudspeakers, and also for up pop-up screens any time they want to do a presentation. There are a lot of theatrical fixtures on the pipe, as well as moving lights up on De Sisti lifts that [Fisher Dachs Associates, the theatre consulting firm] designed in, and that can come all the way down for service, so we can light this like a true production space.”

Beyond the staircase, the atrium flows seamlessly into Peter A. Herrndorf Place, which lies directly beneath the O’Born Room, sharing its footprint. Herrndorf Place “takes many cues from the city room that we created with Diamond Schmitt at the Four Seasons Centre,” says Peter Rosenbaum, of Fisher Dachs Associates. These include “a public gathering space for the community at the center of the new lobby, and public spaces that become part of what is essentially a campus living room, where people can pull out their laptops, enjoy a cup of coffee, and just watch the world go by along the Rideau Canal.”

Pipes and electrical infrastructure are in place to light free public performances on a removable performance platform. “We have the ability to add sound reinforcement

to the modest built-in sound system,” Van Dijk says. “It’s a beautiful space for a noon-hour presentation, especially with the great views of the skyline in the background. It was quite a challenge, in view of the architectural infrastructure, where we could run conduit for the production infrastructure and where we could locate our floor boxes. Some are not as close to the wall as we might like, but it all worked out in the end.”

It was the designers’ intent that there be no walls to contain sound between Herrndorf Place, grand staircase, and atrium. “We were tasked with creating an acoustic dynamic that works for the room acoustics in these situations where there’s a little less sound isolation,” says Robin Glosemeyer Petrone, principal of Threshold Acoustics. “We had different criteria guiding our work, in terms of ‘found performance’ compared with performance that’s isolated in a hall.

“As you’re walking through the atrium with the Glass Thorsteinson Staircase and Herrndorf Place, it may not be immediately apparent that those are individual performance spaces as well,” she says. “The NAC can program any of those spaces at any time. One driving concept





Above: With ample seating for daytime concerts and lectures, the Glass Thorsteinson Staircase was modeled on the Bradshaw Auditorium in Toronto's Four Seasons Centre for the Performing Arts, an earlier Diamond Schmitt project, and was included at the client's request. Opposite: Lobby space adjacent to the grand staircase is fully equipped with theatrical lighting and performance sound equipment. Between the windows, bronze fins perforated with a triangular pattern extend the hexagonal structural motif to the exterior.

behind the architectural rejuvenation was to remove the idea of a performing arts center as a bunker or castle on the hill. We wanted to pull the building into the city and the city into the building, and we worked with Diamond Schmitt to create spaces that allowed sound to bleed from one into the other, so that you would know that activity was happening.”

Adjacent to Herrndorf Place but in the original building, the new 7,000-sq.-ft. Canada Room has been fully furnished with audio-visual and data connectivity. With a capacity of 650 for a sit-down meal or 1,500 for a reception, it can be split into three rooms for smaller functions. Retractable projection screens have been mounted in each of the three areas.

“We have installed 36 manually retractable RPV posts in a grid pattern in the ceiling,” Van Dijk says. “When they are lowered below the decorative hexagonal ceiling grid, we can mount a schedule 40 pipe between them to hang lights or projectors, or even lift a truss if we have to, given that each post can support up to 1,000lb. And, of course, we’ve installed audio-visual and data connectivity throughout, along with loudspeakers in the ceiling, all under Crestron control.”

An in-house media production facility was constructed during the renovation. With double-wall isolation between

the studio and control room, the Hexagon Studio is intended for production of podcasts, interviews, features, and other streaming content.

“One massive challenge of the project was that the building stayed open, which meant that construction managers and contractors were constantly shuffling where people entered and exited the building, where the bathrooms were, and where the vertical circulation through the parking garage was,” Rosenbaum says. “It was a game of Tetris, a constant shuffle of circulation, but at no point did they have to shut down operations in the main part of the building. That shuffle involved temporary walls, hoarding, temporary doors, and scaffolding, all of it well-hidden to ensure that the audiences were not impacted by the work going on.”

Southam Hall

The production renewal phase of the project required a complete shutdown for about three months in the summer of 2018. Much of the NAC's decades-old theatrical lighting, sound, and other production equipment was nearing obsolescence, and a good deal of the electrical infrastructure hadn't been touched since opening day in 1969. In addition, poor acoustics and a lack of sound and light locks had plagued Southam Hall from the beginning; the original

orchestra shell had never worked as intended, while the seating and interior appointments contributed to less-than-optimum acoustics. In 2000, management made a last-ditch effort to circumvent a complete acoustical overhaul by installing an ACS artificial reverberation system.

“This room is truly an iconic venue,” says the NAC’s president and CEO Christopher Deacon. “It’s a place where Canadian artists dream of performing, but it was not actually designed for orchestra concerts. This is essentially an opera and ballet hall. This new shell will fundamentally change that. It was designed over the course of 18 months by the brilliant Canadian architecture firm Diamond Schmitt Associates in partnership with Fisher Dachs Associates,

Threshold Acoustics, and Engineering Harmonics, and it was built by the renowned theatre firm Wenger and JR Clancy.”

“Threshold Acoustics was brought in to do an analysis of the room at the beginning of this project,” Rosenbaum says. “It became very clear that the original shell, designed into the building 50 years ago, was not supporting the orchestra or the room in a way that it needed to for the size

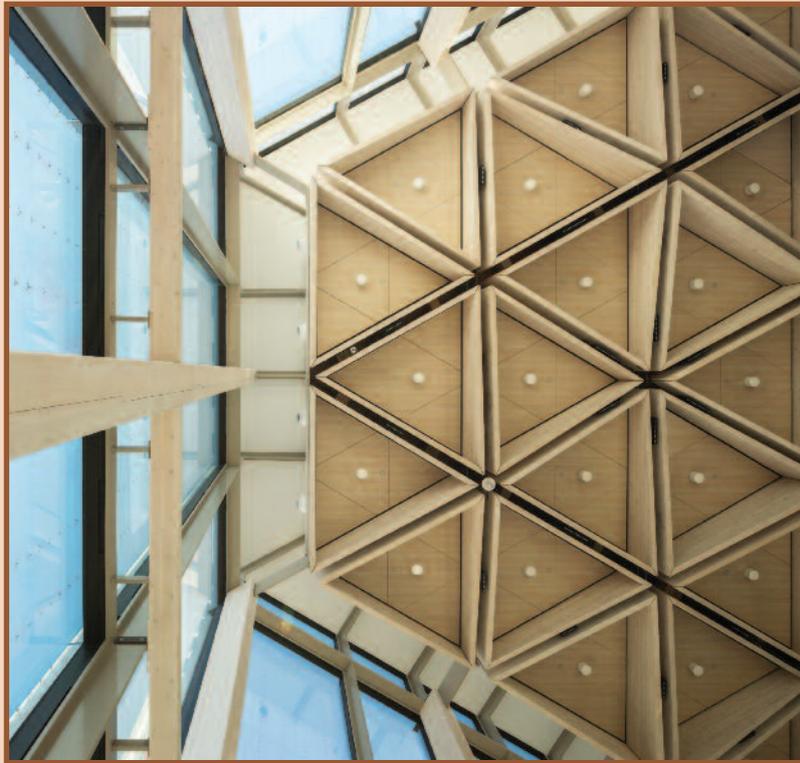
of the orchestra. Musicians were not hearing each other. The sound coming out of the shell was not reflecting properly out to the audience. The walls didn’t have the right mass or the right diffusion and reflection properties, and they were too far apart. The ceiling didn’t have the appropriate shaping. Together with the architects, we had to come up with a way to create a shell that was flexible enough to support not only the orchestra, but also all the events that happen inside Southam Hall. It is the home of the National Arts Centre Orchestra, to be sure, but it is also the home of an extensive Broadway series, a dance program, a theatre program, and quite a few other events.”

Orchestra shell

The shell consists of an upstage wall and overhead forestage reflector, together with five movable towers on each side of the stage, four of which are visible in the orchestra configuration. Finished on one side in white oak, the panels can be manually flipped and rearranged with their opposite dark sides toward the stage and audience for other types of performances.

“The panels are made out of a honeycomb system laminated with Masonite on either side and finished with a wood veneer,” says Glosemeyer Petrone. “The honeycomb system provides a structural stability through its stiffness, which allows the shell to reflect the sound of

the orchestra across a broad range of frequencies, down to the low frequencies for the basses sitting in front of it on stage left. The benefit of the honeycomb material lies in its relatively low weight: It allows us to achieve increased stiffness without having to work with something so heavy it can’t move. These are tall systems, over 40’-high in front of the proscenium. The ones just behind the proscenium are a bit lower—39’- or 40’-high—because they have to be able to



A motif embedded in the original construction, the hexagon shape is repeated in virtually every part of the building. Here, the wood triangulation visible in the ceiling is the roof structure. Prefabricated Douglas fir triangulated glue-lam coffered ganged in linear swaths up to 65’ long were prefabricated off-site to save time.

tuck away under the side stage.

“The towers in the forestage zone are in a much different position now than before the renovation. They are several feet farther in, making the room in the forestage zone narrower than before, when those panels flanked the pit lift and audience seating. Because the old panels couldn’t track in or be set to an optimum angle, they gave the musicians very late reflections that weren’t useful and sent sound into places that it didn’t need to go.

“The new shell corrects that. We’ve pulled the panels in and made the stage aperture smaller for orchestral performances. Now that the orchestra sits closer to the audi-



A multipurpose venue accommodating up to 250 guests, the 2,700-sq.-ft. Janice & Earle O'Born Room boasts fabulous views of the Rideau Canal, Château Laurier Hotel, and Parliament Buildings.

ence, with the bulk of the pit lift up and the panels tracked in, the acoustic volume of the room is engaged together with the acoustic volume of the stage; for the audience, it feels more like a one-room setting rather than peering through a picture box into a remote jewel on the stage.

"However, the aperture isn't necessarily required to be that size for other performance uses, so the panels have to track back out, to retain the sightlines and the right lighting angles. The first of the towers on each side of the stage tracks back out. The second also tracks out, flips around, and rotates to show its black side, and another panel, with a darker wood color matching the ceiling panels, flips out and tracks in to make the appropriately sized proscenium

opening. The large forestage ceiling reflector tips from nearly horizontal to vertical and is flown to a position where its bottom edge completes the frame. The maximum proscenium opening is now on the order of 65' or 67'-wide, which is as big as we would ever want for an orchestra, but much bigger than you would want for Broadway or dance."

The upstage sidewall towers can also pivot to create lighting positions. "They rotate and track on a trolley beam and sit on tricasters on the floor," Rosenbaum says. "They incorporate folding panels that open up to reveal lighting truss positions in one configuration, and then rotate to create a reflective surface for the orchestra in a different configuration.



Southam Hall's new orchestra shell consists of an upstage wall, overhead forestage reflector, and five movable towers on each side of the stage, four of which are visible in the orchestra configuration. Finished on one side in white oak, the panels can be manually flipped and rearranged with their opposite dark sides toward the stage and audience for other types of performances.

Downstage towers also incorporate doors for orchestra entry and exit, and apertures for moving pianos onto the stage.”

The honeycomb in the interior of the panels is made of a cardboard material. “It’s about 2” thick at the top part of the shell, and lower down, say 12’ from the deck, it’s about 4” thick,” Glosemeyer Petrone says. “The thicker it is, the stiffer it is, and, of course, there’s a little bit more weight, but even with all the air space, it’s the stiffness of the honeycomb that gets us the acoustic reflection patterns that we need.”

Mallard adds, “While the texture of the shell is derived heavily from input from the acousticians in order to get diffusion and sound reflection, it’s also architecturally designed to continue the line of the cascading loges that hug the sides of the room. Large horizontal bands in the face of the shell are directly aligned to pick up that cascading geometry. We wanted to repeat that and extend that hug around the stage; when you’re sitting as a patron, you feel like you’re in one unified room instead of the two rooms that there used to be.”

Ceiling reflector

The ceiling reflector is constructed in four sections, not all of which are deployed for every orchestral performance; the rearmost section is used only “when there’s the largest orchestra onstage plus a choral loft,” Mallard says. The large downstage section of the reflector has a cove built into it to incorporate concert lighting. Rosenbaum says, “We also added an inventory of flexible apertures in the reflector to allow for chain motor rigging to pass through it to fly, for example, an entire lighting truss full of moving lights for a big pops concert.”

Bomb bay doors in the center of the forestage section of the ceiling reflector allow for the center loudspeaker cluster to pass through for pops concerts and vocal reinforcement. Two pairs of upstage loudspeakers—one for voice lift and one for sound reinforcement—are tightly coordinated with the reflector, ensuring that they can be deployed independently or in concert with each other. Small apertures at the edges of the reflector accommodate lift lines for the main left and right loudspeaker line arrays,



Large horizontal bands in the face of the orchestra shell are directly aligned to pick up the cascading geometry of the loges that hug the sides of the auditorium. Beyond the glazed walls, a new lobby with light and sound locks on all four audience levels permits scheduling simultaneous performances in adjacent spaces for the first time.

which are lowered to the deck for removal. “They come and go much more frequently than the center cluster, which is permanently rigged,” Rosenbaum says, “Additional offstage left and right loudspeaker pairs bypass the reflector entirely.

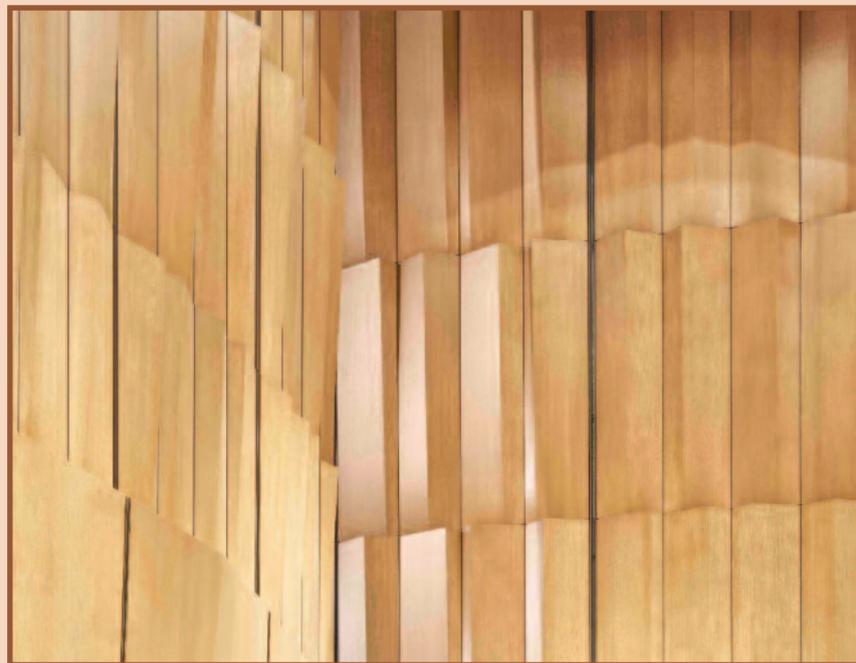
“The original ceiling consisted of a series of horseshoe-shaped catwalks and a central chandelier,” he continues. “Under the catwalks, a series of architectural battens and flags are part of the historic fabric of the room. As we were designing the forestage reflector, there was a lot of push and pull between the need for getting the reflector as deep into the room as it could possibly go, at the same time avoiding contact with the overhead existing catwalk and chandelier system. We all came to the conclusion that we had to do some minor surgery. In some places, we trimmed back as little as a foot or two off the ceiling; at 60’ in the air, we had to trim the catwalks to install the forestage reflector so that, as it tipped into its vertical orientation to go up and down, it could bypass the catwalks without scraping them.”

“That aspect of the work was coordinated down to the millimeter,” Mallard adds. “The original ceiling sculpture is archived as an artwork. We wanted to put a crisper, contemporary edge on the room without feeling like that ceiling sculpture is a foreign object in the room.”

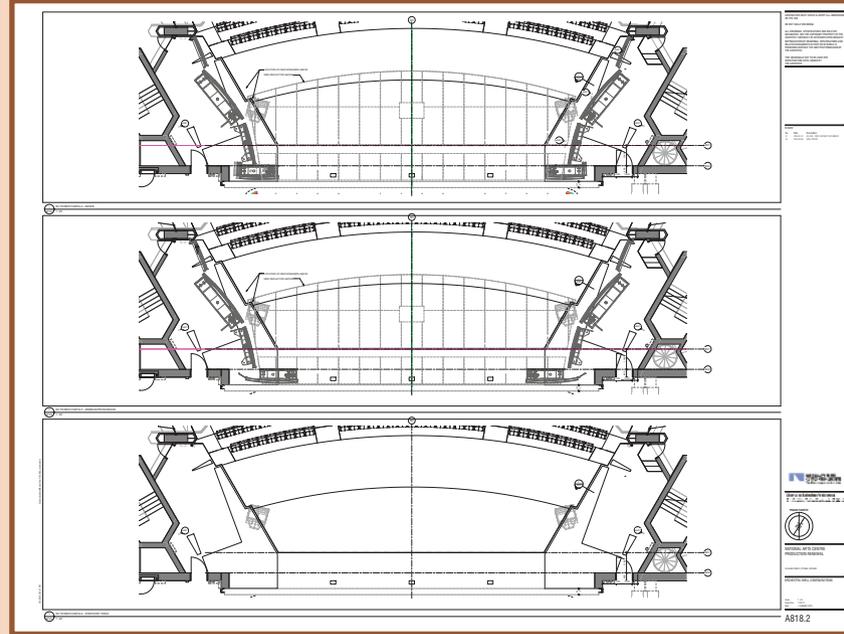
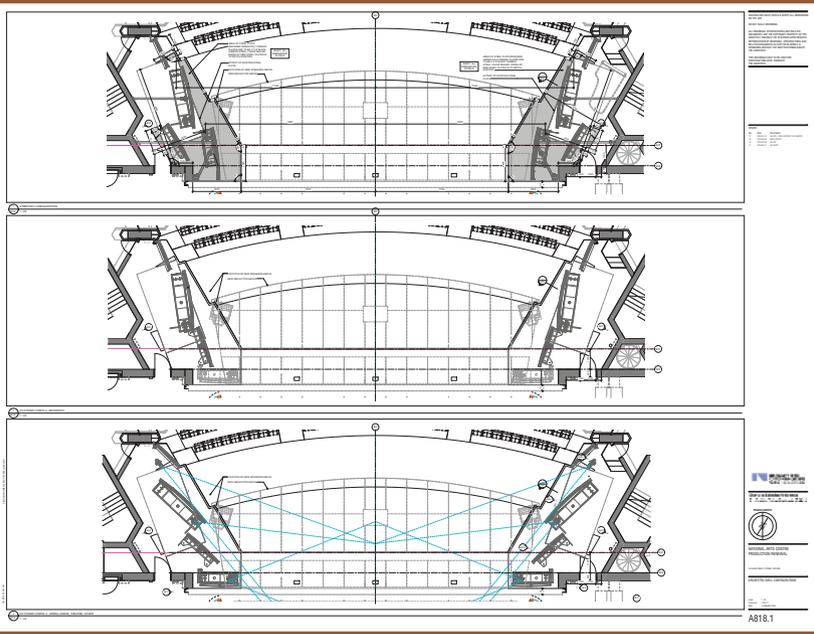
“A great deal of coordination was required because as you go vertically above the reflector, you hit a variety of pieces of the building that can’t move,” Rosenbaum says. “You first hit the catwalk that held up the previous loudspeaker clusters. That steel bridge is still there and some of the lifting lines have to pass through that. We had to coordinate all the holes that go through the plaster ceiling 65’ — 70’ up in the air. Then you pass through the ductwork zone, so we had to trim back a number of ducts that fed the forestage area, clearing out the diffusers and ductwork to provide adequate clearance for the lifting lines.

The mini-grid—a forestage rigging zone—had to be penetrated to get to the building’s roof steel, to which all of the cable reels and lifting line winches are mounted. It was a seven-layered cake of steel, concrete, and plaster, and we had to carefully coordinate the work to thread the needle for the pass-throughs in each layer.”

The audience chamber of Southam Hall is wrapped in glass interrupted only by 24 floor-to-ceiling concrete pillars flanking the room. “Southam Hall doesn’t have much reverberation because of the shape of the room and architectural vernacular,” Glosemeyer Petrone says. “In plan



Stiffened internally with a lightweight cardboard honeycomb between layers of Masonite finished with wood veneer, the orchestra shell was designed to increase both diffusion and reflection of sound.



Details of orchestra shell configurations for various kinds of performance. In proscenium mode, the large forestage ceiling reflector tips from nearly horizontal to vertical and is flown to a position where its bottom edge completes the frame.

view, it has a circular shape, with glass glazing, that goes all the way around. The glazing lets sound at the mid and low frequencies bleed out, and the concrete pillars quickly break up reflections on the audience levels. The large volume in the room's upper reaches is broken up with big pyramids on the ceiling that were constructed in an early attempt at creating reverberation chambers. The technique used at the time didn't work out in the way that they were hoping; as a result, there are no useful reflection surfaces. It's difficult to access these chambers, and there's a lot of gack up there. Originally, there were draperies that could be deployed to close off the reverberation chambers, but because it is so diffusive up there and the chambers didn't actually work, the variable acoustic draperies hadn't been used for years.

"Consequently, an ACS [Acoustic Control Systems] artificial reverberation system was installed, and it has been updated as part of this renovation. The ACS system allows us to provide early reflections that mimic what would happen in a natural room. There are several settings that we can use with unamplified program material. Most of the time, the is set around 2.1 – 2.25s, depending on the type of pieces that are playing. ACS loudspeakers in the shell provide a little bit of foldback from the room, so that the orchestra doesn't feel like it's playing into a dead box. The old shell provided very little support, and the ceilings were lightweight, so the string players were sawing away, working hard to project any sound at all, because they felt like nothing was getting into the audience. The ACS system gave them a bit of that feedback so that they could feel some sense of the room.

"We carried that forward into the new shell to get a bit of energy back from the room; however, the orchestra musicians need it much less now because the new shell gives them so much energy, both retaining it onstage and sending it out into the house in a way that they haven't had before. It's nice to get that bit of response back from the room, but the musicians can hear themselves much better and are finding dynamic ranges that they had not been able to experiment with before."

The National Arts Centre Orchestra's assistant principal cellist, Julia MacLaine, concurs, saying, "The string sound was always a little bit brittle, and now I can tell it's warmer and richer. You have a sense of how the sound is carrying out into the hall. Also, we have more dynamic range to play with: We can go really soft and it feels like it's still carrying out there."

"As soon as I gave the first downbeat, I felt the change in the sound," says music director Alexander Shelley. "This space now allows the instruments and the musicians to perform from the softest pianissimo to the loudest fortissimo with every nuance in between, which is not a luxury we have had in this space until now."

Glosemeyer Petrone notes that for amplified performances, such as musical theatre, dance, or rock concerts, the ACS system is not used; the room works well due to the lack of reflections. "Typically, when there's a lot of glazing, reflections bounce around off the hard glass; in this room, most of the glazing is not apparent to the sound-reinforcement loudspeakers due to interference from the big concrete pillars, and the reverberation time is not too long. Because the sound reinforcement system doesn't

have as much impact on the room surfaces as it might in a standard theatre or concert hall, Southam Hall works very well for amplified events.”

Seating

“Two summers ago, we designed a seating replacement strategy for Southam Hall, which up to then had featured entirely continental seating,” Rosenbaum says. “Part of the problem was that people had to cross in front of 50 others to get to their seats if they came in the wrong side. Even though the rows were extremely deep, it was awkward, and wheelchair accessibility was limited. Our brief was to improve comfort, circulation, sightlines in the orchestra, and improve accessibility. We divided the orchestra level into three sections by adding additional mid-aisles and we reraked the rear of the room to create a rear parterre section behind a new cross-aisle with a new sound mix position. Reraking the rear of the room was a delicate operation, in that we were always balancing head height under the balcony versus sightlines.” The new cross-aisle also provides space for patrons in wheelchairs and their companions.

Montreal’s Ducharme Seating provided new seats in three different widths for the orchestra, parterre, three balcony levels, and loges, allowing for fully staggered seating to optimize sightlines. “All-new aisle lights were installed as well,” Rosenbaum says. “We also rebuilt the balcony rail at the front of the mezzanine to create permanent lighting positions and incorporated permanent AV and theatrical

power and data infrastructure into the balcony rail for lighting, audio, and projection.”

The carpet was replaced in order to improve acoustics. “The floor and chairs were incredibly absorptive,” Glosemeyer Petrone says. “We took the opportunity to improve the immediate acoustic environment around the audience member. If the surfaces immediately around you are very dead, you don’t have a sense of other people in the audience; all of their sound is absorbed. In theatre spaces, especially a concert hall, you want a bit of reflection around you. By replacing the flooring material and changing the seat to one with a wood back and wooden seat pan, we’ve provided not only some early reflections that arrive very soon after the immediate sound to the audience member, but also reflections between the audience members. When one person starts clapping, everyone’s hearing it.

“Improving the immediate acoustic environment for the audience member also improved the acoustic response of the room overall,” she says. “The orchestra noticed a marked difference in the room response that they were receiving back up on the stage, similar to what we were doing with the ACS system. They started to feel a response from the room and audience.”

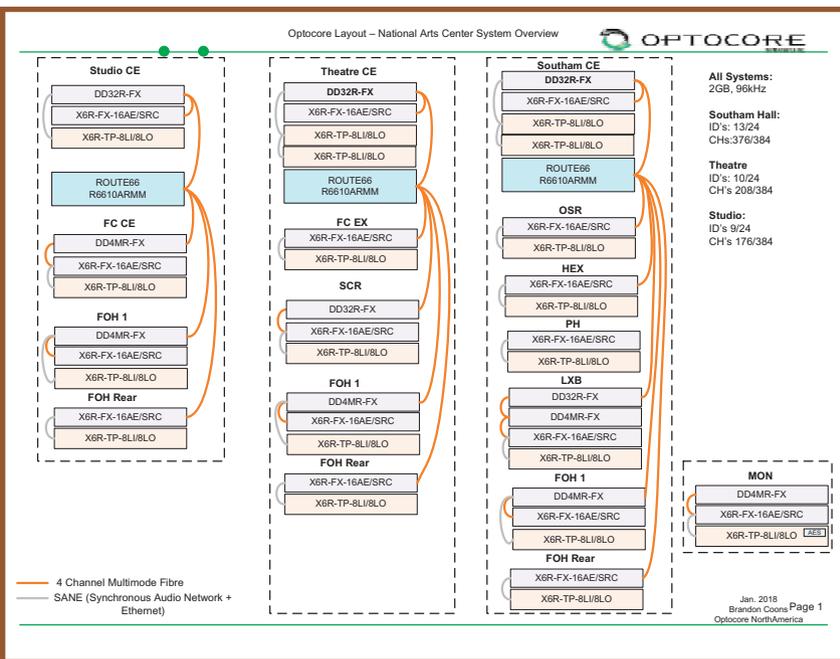
The choice of wood for the seat backs and pans satisfied an architectural objective, too. “We incorporated a touch of the contemporary wood from the atrium coming into the hall,” Mallard says. “It’s all white oak. We knew we wanted to make the orchestra shell white oak, for its warmth and for the continuity of the contemporary palette. We knew we were dealing with an oak veneer and determining the stain color on that was a long discussion that had to satisfy varied artistic needs.”

For additional acoustical isolation, sound and light locks were constructed on all audience levels of Southam Hall. Formerly, the only doors separating the hall from the lobby had been the glazed doors to the hall itself. “That was contentious,” Mallard says, “because the lobbies flowed really nicely into those flanking, glazed, not-sound-and-light locks. The architecture changed a bit with us adding the sound and light locks, but it’s a performance hall, so priority should be for performance.” Now, activity in the lobbies, such as reloading ice trays before intermission, causes no disturbance; during orchestral rehearsals, the Glass Thorsteinson Staircase space can be used for a full-on performance without either interrupting the other.

Electrical infrastructure

Southam Hall also benefited from a full renovation of its entire theatrical infrastructure. “We designed brand-new theatrical lighting power and data distribution throughout the venue,” Rosenbaum says. “There are multiple dimmer and electrical rooms, each one feeding different zones of the hall; finding the right topology for distributing power

Bottom image: Courtesy of Brandon Coons, Optocore North America



Southam Hall, like the Asper Theatre and Azrieli Studio, has its own dedicated Optocore digital audio network that serves as a routing matrix for the sound reinforcement, monitor, and inter-connected signal feeds.

and data throughout the hall became a big challenge, along with housing the new dimmer racks, transformers, and other equipment in the existing rooms.”

In addition, a new facility-wide resiliency was provided for the electrical systems. “Crossey Engineering found ways to replace decades-old transformers and power distribution all the way from the main electrical system into the various substations and the various dimmer rooms throughout the facility,” Rosenbaum says. “This not only guarantees high-quality power at the appropriate voltages without any voltage loss through the system, but also redundancy in the back end of the main electrical room, providing resiliency against power loss throughout the building, especially in the theatrical venues. Over the years, some tight spaces had been systematically augmented with other infrastructure that had to be cleared out to make room for the new systems and we had to coordinate our schedules tightly. As those spaces were being demolished, we were back-filling them with dimmer racks while Crossey Engineering was simultaneously installing new transformers and switch gear.”

While the facility had smaller upgrades, only some of them were documented. “The electrical engineers had a full-time surveyor on-site for several months, going through and redocumenting many cable pathways in order for us to understand where some of the work had been routed, so that we could surgically remove and replace it as needed,” Rosenbaum says. “We replaced all the ETC AVAB dimming with ETC Sensor racks with ThruPower modules, so the NAC can incorporate more LED sources by switching the modules from dimming to relays. At present, there’s not a significant number of LED fixtures in the house. We have completed the theatrical lighting upgrades in Southam Hall and the Babs Asper Theatre, and the data distribution upgrades throughout the entire building. The lighting renovation in the Azrieli Studio Theatre has been deferred; we’re going to be coming back in the summer of 2019 to replace the dimmers.”

He adds, “Many challenges that the team faced in this project arose from dealing with a building made of concrete. Everything is surface-mounted; every hole that you cut has to be acoustically sealed back up. We tried as much as possible to surface-mount conduit, routing it clear of the other systems such that it would be accessible for future cable pulls and cable replacement as needed.”

Theatrical lighting

“The dimmers and control are ETC, and all in the Eos family,” says Alex Gazalé, director of the production renewal project. “Because we are both a presenting and a producing facility, we’re constantly moving equipment around the venues based on show needs.”

Newly specified instruments for the three primary venues include four Robert Juliat Cyrano followspots, two

Robert Juliat Victor followspots, 60 ETC Source Four LED Series 2 Lustr arrays with shutter barrels, 30 ETC Source Four Zooms, 56 Chroma-Q Color Force II 72s, 20 Chroma-Q Color Force II 12s, 40 ETC D60 Lustr+ luminaires, 20 Elation Professional Fuze PAR Z60 IPs, 36 Arri ST Series Fresnels, 48 Martin by Harman MAC Aura XB washlights, 20 Martin MAC Encore Performance CLDs, 12 Martin MAC Encore Wash CLDs, and six Martin MAC Viper Performances, together with a host of lenses, tubes, mounting accessories, and spares, as well as 36 Osram KREIOS FLx90 worklights.

The control console inventory now includes a new ETC Gio @5 and two new ETC Ion XE 20s, each furnished with a pair of external touch-screen displays. A pair of ETC RPUs and three ETC Universal Fader Wings are also available for larger productions. “All of this is in addition to the hundreds of ETC Source Four, Arri, and other fixtures that were retained from our existing inventory,” Gazalé says. The cue light system consists of one portable ETC CueSystem eight-channel desk, one portable CueSystem 12-channel desk, two portable playback units, and 36 CueSpider outstations connected over the data network.

Performance sound

Two line array sound reinforcement loudspeaker systems are available in Southam Hall: a voice-lift system, which is also appropriate for some types of music performance, and a larger concert-level system. All performance sound loudspeakers and amplifiers are from d&b audiotechnik.

“I’m always trying to design for two scenarios: voice lift and music,” Van Dijk says. “Some loudspeakers are part of the voice lift system that helps to project intelligible spoken word out into the room—not at enormous levels, but with quality and articulation, without having a lot of the big speakers in place. For a music show requiring more power, we can deploy deck carts with line-array elements and larger subs in place of the smaller corner fills used for voice lift. With the larger loudspeakers in place, certain components get turned off and others then act as fills.”

The voice-lift system consists of left and right arrays each comprising eight V-Series elements. The lower units in each array are 120°-horizontal dispersion V12 boxes, while 80°-horizontal dispersion V8 elements are arrayed above them for a longer throw. Seven V-series elements comprise the center array. Six additional V-series elements are available for deck mounting as required. The voice-lift system also includes four V-SUB subwoofers.

Four V10P point-source loudspeakers were specified for deck-fills, and eight V10Ps for proscenium fills. Eight Y7P point-source loudspeakers do duty as front fills, the pit rail is populated with twelve E4 two-way coaxial units, and eighteen E4s service the loges. Over-balcony reinforcement is provided by four V10Ps and the under-balcony by eight E6 point-source loudspeakers. Four-channel

D20 and D80 amplifiers power the systems.

“For voice lift, we can use any of three modes,” Van Dijk says. “The center and fill speakers, together with some small deck speakers, form a really basic system. From there, we can add the two modest left and right line arrays to give it more power. Beyond that, the deck systems can be added to provide a small music system. For full power and impact, however, we augment the center array with larger left and right line arrays and even more loudspeakers on carts on the deck.”

Eleven J-Series line array elements comprise each of the left- and right arrays in this concert-level system, with 120°-horizontal dispersion J12s occupying the lower positions in each array, and 80°-horizontal dispersion J8 elements mounted above them. Four J-Series elements are available for deck mounting, and the bottom end is handled by four J-SUB subwoofers.

“To localize performers accurately, we have programmed various timings into the different components of the system,” Van Dijk says, “which allows for reinforcement of the first arriving wavefronts emanating directly from performers themselves.”

All consoles in the NAC are from the DiGiCo SD series, including the SD7, SD9, and SD10. “The NAC is a DiGiCo house. It’s essentially the same interface, so that ensures interchangeability of hardware and personnel,” Van Dijk says. Floor monitors include the d&b audiotechnik M4 and M6 two-way wedges for all venues, except the Fourth Stage, which is equipped with self-powered Meyer Sound monitors due to the lack of space backstage to accommodate amplifiers.

Audio networking

Each of the three primary venues has its own dedicated network that acts as a routing matrix for the sound reinforcement, monitor, and interconnected signal feeds. In addition to the permanently installed network devices, a number of racks can be moved freely between connection points in a venue or from one venue to another. According to Optocore, the networks are set to run at a 2GB speed at a 96kHz sample rate to optimize audio quality and channel count. The network in Southam Hall provides 376 audio inputs, while the Asper Theatre network offers 208 inputs and the Azrieli Studio/back-of-



A casual, intimate venue with a self-contained bar, the Fourth Stage lends itself to cabaret seating for 150 with a program featuring emerging Canadian artists.

house network provides 176 audio inputs with an unlimited number of outputs.

“At the heart of each network is a Route66 Autorouter, which is configurable with a mix of Multimode and Singlemode transceivers to support any infrastructure, with fiber ports for up to 20 different network access points,” says Brandon Coons, Optocore North America product specialist. “The Autorouter functions like a smart fiber patch bay: When equipment at remote connection points is turned on and starts streaming data into the fiber, the Route66 detects this data and automatically repatches its fiber ports to accommodate this new location. When remote racks are powered down or disconnected, the Route66 adjusts its patching to maintain a closed and redundant network, bypassing the now-unused fibers. This saves having to send a tech to the equipment room to repatch the fiber every time you move a rack around.

“The Route66 is format-agnostic, so it not only functions to create redundant star topologies for Optocore or DiGiCo SD equipment that uses Optocore as their onboard network transport protocol, but it can also be used with Yamaha TwinLane and Avid AVB networks in stand-alone applications,” Coon says. “This is due to the Route66’s ability to detect correctly any incoming data format and output it accordingly. Within each venue, there is a mix of DD32R-FX, X6R-FX, and X6R-TP units configured for AES and analog audio, with additional DD4MR-FX units for MADI distribution. Preprogrammed macros in the Optocore control software allow users to quickly change the network’s routing to feed AES or analog audio from any location to the front-of-house system, monitor ampli-

fiers for wedges onstage, or to installed monitor loudspeakers. This setup allows users to quickly set up the main and monitor feeds with any analog or digital console regardless of whether there is a dedicated monitor console available, and with whatever audio signal format they might wish to use.”

Optocore X6R-FX-16AE network converter units populate the console interface racks, each offering 16 AES digital audio inputs and outputs. Onboard sample rate converters automatically reclock incoming AES signals to the network’s 96kHz sample rate, permitting visiting equipment operating at 48kHz to integrate seamlessly into the network without risk of wordclock errors.

X6R-TP-8LI/8LO devices permit interfacing analog signals with the digital network, each unit providing eight analog inputs that can serve as patches to other locations, feeds for loudspeaker processors and amplifiers, or splits for the local inputs.

“Optocore DD32R-FX network 64-channel AES3 I/O devices serve as the master interfaces for each network, routing outputs from the front of house and monitor consoles to Meyer Galileos for processing and distributing wordclock from the master Nanosync wordclock generator in each venue to all network devices,” Coons says. “The post-Galileo signal is fed back into Optocore and sent to DD32Rs in the central equipment rooms, where signals are routed to amplifiers for the main sound reinforcement system, surround speakers, stage fill speakers, and monitor systems. The high AES channel count of the DD32R gives each venue lots of additional ports for future needs and distribution. The X6R-TP-8LI/8LOs that are attached via SANE [Synchronous Audio and Ethernet protocol] to the DD32Rs give additional 16/16 analog I/O for local inputs and outputs which tie into other systems, such as QSC’s Q-SYS.

“MADI distribution is also available within each system through multiple DD4MR-FXs located in control rooms, at front-of-house locations and in the mobile monitor rack, giving operators the ability to feed the sound reinforcement system via MADI, output the shows for multitrack recording, transport MADI between the stage and front of house for guest consoles that would otherwise need a separate MADI snake, or tie into any production mobiles that might be hired for the performance.”

Asper Theatre

Like Southam Hall, the Babs Asper Theatre benefited from increased isolation from the rest of the facility. “We added new sound and light locks and upgraded the doors right at the entrance to the theatre,” Glosemeyer Petrone says. “This will allow for increased activity out in the Canal Lobby and Fountain Lobby so that those spaces can be rented out or programmed more regularly without fear of interrupting whatever is going on in the theatre. There’s

also a path from the kitchen where carts are rolled right through the theatre sound lock, so we worked on quieting that path.

“When the NAC was originally designed, performing arts centers were spaces that you performed in: the theatre and the concert hall. Now, they want to be active all day. That means spaces that would have been quiet before are now being used for some sort of production; increasing the sound isolation has been a large part of the work, to allow them to be used simultaneously.”

Also, Glosemeyer-Petrone says, “In the theatre, as in Southam Hall, all of the mechanical rooms housing the dimmers, the electrical, the racks for the sound system, and so on are located inside the stage box. Most of the work we did in the theatre was directed at containing sounds emanating from those rooms. There were large holes and other penetrations drilled into the concrete over 50 years to pass cables through. We did a lot to plug up holes in the theatre, and we replaced doors that were flimsy and lightweight, in order to reduce the background noise level in the theatre.”

The Asper Theatre thrust stage is removable; in proscenium mode, 87 additional seats occupy the front orchestra space vacated by the thrust stage. Because the proscenium opening can be widened or narrowed to accommodate various production designs, the left and right loudspeaker line arrays are designed to travel 8' laterally on custom-designed rigging that also lowers them for servicing and removal. “When you’re working with lav mics on a thrust stage, you don’t want the loudspeakers way offstage and aimed inward, because that poses a gain-before-feedback problem,” Van Dijk says, adding that the theatre features fixed acoustics. “We can bring in each array to the edge of the tormentor. Because the rigging is motorized, we can remotely rotate the arrays via a panning mechanism at the top of the bumper to pull our focus.” A new rigging position for the center cluster required cutting a hole in the existing plaster ceiling and tightly coordinating new rigging over the ceiling to raise and lower the cluster. Rigging was provided by Wenger and JR Clancy.

Five V-Series line-array elements comprise each of the left and right flown arrays, with three additional V-Series elements in each of the left and right deck-mounted systems. Eight Y-Series elements make up the center array. In addition to four ground-level V-SUB subwoofers, the system also includes 14 point-source Y10Ps (deck, proscenium, and over-balcony fills), six Y7P front-fills, eight E6 under-balcony fills, and eight 8S two-way compact coaxial loudspeakers hidden behind the slatted wall at various heights for effects and surround sound.

Azrieli Studio

“In the Azrieli Studio, we have been working on the same sorts of improvements for sound isolation, and while much



The 797-seat Babs Asper Theatre is convertible from a thrust to a proscenium stage. Because the proscenium opening can be widened or narrowed to accommodate various production designs, the left and right loudspeaker line arrays are designed to travel 8' laterally on custom-designed rigging.

of that work has been completed, there will be more of it with the next phase of the project due for completion in the summer of 2019," Glosemeyer Petrone says. "We have added a double layer of doors to improve the sound lock, because the restaurant, Le Café, has space right in front of the studio that they occasionally use for additional seating. The Fountain Lobby is right there as well, so work was done on upgrading the sound isolation—plugging up holes for ducts that were never run, crawling around above the ceilings and finding holes that we didn't know were there, and remediating structural isolation joints in which material had degraded over the years. It took a lot of digging to determine that part of the problem was, in fact, that the material had degraded."

Performance sound and lighting are easily reconfigurable in Azrieli Studio. Two modest loudspeaker arrays,

each consisting of a pair of d&b audiotechnik V10P three-way passive point-source loudspeakers, are permanently mounted in hanging frames fabricated in the NAC's shop, facilitating installation and removal. "They've got quite a good fabrication facility here, and they did a great job," Van Dijk says. An inventory of d&b audiotechnik Y7P two-way passive loudspeakers is available to supplement the main system, along with four ground-stacked Y10P loudspeakers and two B6 subwoofers, and six E4 two-way compact coaxial loudspeakers for sound effects replay.

The Fourth Stage

The Fourth Stage is a unique room, much more casual than a black-box studio. Its self-contained bar lends it to cabaret seating for about 150 patrons, or 200 in a theatre configuration. Created in 2000 and operated as a general

admission venue, the Fourth Stage typically features emerging Canadian artists; the acclaimed jazz pianist Diana Krall performed there as a rising star long before she was capable of selling out a two-night stand in Southam Hall, a feat she accomplished in 2017.

“The Fourth Stage started life as a bookstore, then it became a catered function room; however, without a proper kitchen it didn’t get used that way very much,” says Peter Kealey, the room’s technical director. “Peter Herrndorf wanted a space for more community-based programming, and we started in that direction by hosting the Ottawa Writers’ Festival. We converted it into a small bar, scrounged equipment from all over the building—including some very old stuff—and created a small cabaret.”

“The intimacy of the Fourth Stage was there when it was just the bookshop renovation, the \$100,000 paint-it-black-and-just-bring-in-some-plywood-tables,” Mallard says. “We wanted to maintain that kind of intimacy. We discussed moving it somewhere else because it’s a long, odd-shaped room; to get any kind of focal energy on a stage in a room that’s really long like that, it’s not ideal. But its location on Elgin Street is important, and Peter Herrndorf said it had to stay right there. He was absolutely right.

“We tore it down to grade and rebuilt it during the architectural rejuvenation. As a bookstore, the ceiling height was adequate, but with the addition of a theatrical grid we made the room about 1m higher. There is a mechanical room above, so we built a floating slab there, with all the mechanical equipment on spring isolators.”

“Here’s the challenge,” Van Dijk says. “You want a nice nightclub, a quiet room, but you’re sticking tractor-trailer-sized air-handling units directly above. We have the slab of this ceiling, and then another floating slab above it that’s the floor of the mechanical room.” He notes that the slabs are isolated by neoprene pucks rather than sand.

“Air is best,” he adds. “In other words, with no conductivity, pucks are best when you’re talking about super-low frequencies, because at certain frequencies sand eventually becomes liquid and transfers energy. Frequencies around 5Hz shake a building and create a harmonic at something like 20Hz or 25 Hz that we can hear. The air is not sealed; it’s an air gap.”

Adding to the venue’s isolation is a new sound and light lock from the lobby, and an STC-rated loading door to the street. Given that the Fourth Stage is very close to Southam Hall, the acousticians took care to ensure the integrity of the walls, adding an additional isolating wall on isolated studs on the Fourth Stage side to mitigate any sound bleed between the venues. Interior acoustic treatment includes several wall-mounted absorptive acoustic

panels and angular diffusers, similar to those in the Kipnes Lantern, and drapes that can be deployed manually to reduce reverberation time and the liveness of the room.

A Meyer Sound reinforcement system consists of three UPJ-1P self-powered loudspeakers per side, with four UP Junior outer fills, six UPM-1P fills, four USW-1P subs, and Galileo loudspeaker processor. Six MJF-208 floor monitors are also available.

The lighting grid covers almost the entire ceiling of the room and is populated exclusively with LED fixtures. The lighting inventory includes six Chroma-Q Color Force II 72s and five Color Force II 48s, 52 Martin RUSH Par2 RGBW Zooms, 24 Martin MAC Aura XBs, 68 ETC Source Four LED Series 2 Lustrs, 15 ETC Desire D22 Studio HDs, eight Martin MAC Quantum Profiles, and 14 Robe DL4S Profiles. The control console in the Fourth Stage is an ETC Gio @5.

“The lighting is great in here,” says the lighting director Jeremy Winnick. “I have a 96-bank ThruPower distro system and a 40-bank ETC Eos lighting console with two touch screens. Initially, I wanted to go with a [MA Lighting] grandMA, but all the other spaces are equipped with Eos, so it wouldn’t make sense to have one room that’s different. Because this is a more static rig with high changeover, I have to make a lot of magic sheets, so I repurposed an X-keys [computer input device] and made a macro matrix out of it.”

A similar console is available for use in the Atrium and Herrndorf Place, while the Canal Lobby is equipped with an ETC Nomad Puck dedicated microcomputer with 1,024 outputs. Wireless handheld remotes are available for inconspicuous real-time lighting control.

Summing up

The authors of the NAC’s five-year strategic plan suggested that the renovation “has the potential to transform everything we do. Like the refreshed Lincoln Center in New York, or the revamped Southbank Centre in London, UK, the reimagined NAC will fundamentally change our relationship with the public, inviting people from all walks of life to enjoy its attractive and transparent public spaces and allowing us to engage with our patrons in a more meaningful and contemporary way.”

As Mallard says, “We wanted to provide increased connection with the National Arts Centre across the country, improve public accessibility and improve the ‘street-to-seat’ experience for patrons.” In the opinion of this writer—and of others chronicling the performing arts in Canada—they have more than ably succeeded, and in the process have wrought perhaps the most luminous and welcoming facility for artists and audiences in the country. 📶