SUFFOLK

Better Medicine Through Movement

How Suffolk is installing an innovative trolley MRI system at Boston Children's Hospital, making it possible for surgeons to scan patients without leaving the operating room

WHITEPAPER

Challenge

Boston Children's Hospital's new Hale Family Building, scheduled for certificate of occupancy in December 2021, will feature an innovative IMRIS hybrid operating suite. That suite involves a trolley MRI, which rides a massive steel rail on the ceiling to travel between operating rooms and imaging spaces. The result? Surgeons can scan patients during operations, without having to close or transport. The challenge? Installing the steel that carries the MRI and outfitting three rooms with both surgical and imaging capabilities.

The Team

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IMRIS, hybrid operating suite vendor

ETS-Lindgren shielding vendor

Cives Steel Company, gantry steel supplier

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New Hampshire Steel Fabricators, boom support furnisher and installer

Background

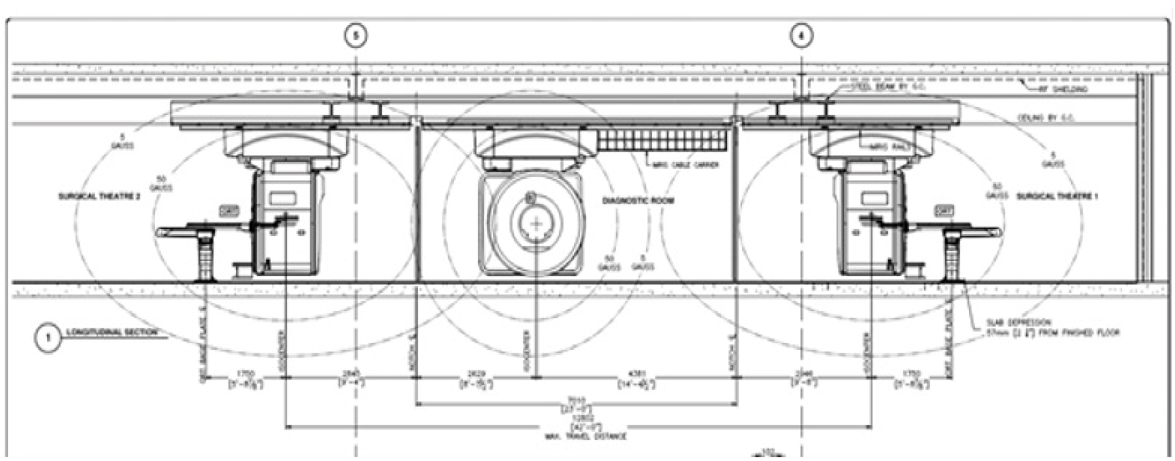
Suffolk is managing construction of the Boston Children's Hospital Hale Family Building, an extension of the hospital's Longwood Medical Area campus. When complete, the building will stand 11 stories high with a two-story mechanical penthouse and four additional stories below grade. The building's mechanical systems will also occupy a floor at the base of the building and a double-story mechanical space in the middle of the structure. The new building will expand the hospital's current bed capacity to support its continuing growth in domestic and international patient volume and its delivery of high-level tertiary and quaternary care. The facility will also provide space for a five-floor comprehensive and integrated heart center; a state-of-the-art neonatal intensive care unit; single inpatient rooms for privacy, quality, and safety; larger and more efficient space for pharmacy, central processing and pathology; and 25 percent more green and open space, both indoor and outdoor in the form of a rooftop healing garden.

The building, scheduled to receive certificate of occupancy in December 2021 for the No. 1 pediatric hospital in the country, will have numerous leading-edge clinical features: info-sharing hubs that enhance clinical collaboration, an open-floor concept clinical lab, and expanded high-tech healing environments within the surgical floors. Those spaces include an enhanced interventional radiology suite and new hybrid operating rooms that incorporate IMRIS systems. IMRIS is the only company in the world with the technology to transport a MR scanner on a ceiling-mounted rail system between an operating room and a diagnostic room. Using patented technology, surgeons can obtain diagnostic-quality images without moving the patient.

The IMRIS hybrid operating suite consists of one or more operating rooms adjacent to a diagnostic room, with an MRI that travels on a ceiling-mounted rail system between the diagnostic room and operating rooms, bringing the magnet directly to the patient. This intraoperative magnetic resonance imaging technology makes it possible for surgeons to complete diagnostics for neurological disorders during operations.

To make this trailblazing medical technology possible, Suffolk needed to build a massive steel system to support the MRI magnet and prepare the rooms for double duty as both imaging and operating suites.

A layout of the three hybrid IMRIS suites at Boston Children's Hospital



Solution

The Steel

MRI machines are notoriously sensitive to vibration and movement, which Suffolk encountered while installing a gas-fired cogeneration plant under the imaging suite at Brigham and Women's Hospital. That complexity occurred with a stationary machine; now, Suffolk had to tackle the challenge of an MRI that would ride on a 56-foot structural steel rail and needed all of its systems and stability to go along with it. The magnet alone weighed 15,000 pounds, and the level, parallel, and straightness tolerance on the steel had to be 1/16 of an inch from one end of the rail to the other. Typical structural steel in a building is about ¼ to ½ inch.

Suffolk worked with the design and engineering team and a third-party surveying company to create a steel trolley beam system that was supported from the building steel columns, but isolated from the building steel with dielectric isolator sleeves and plates. Those long plate girder members, which spanned column to column, weighed in at about 7,500 pounds. The IMRIS rails then interlocked into the plate girders using a total of 66 clamp blocks. Creating the rails also presented many challenges, including fabricating large cutouts to account for the operable garage doors that allow the MRI to travel from room to room.

To account for the level, parallel, and straightness tolerance over 56 feet, iron workers worked on sections, surveyed what they had accomplished, then welded it all together. The precision demanded for the steel welded connections meant the job took two welders 10 days to complete.

The trolley steel, which supports the 15,000-pound IMRIS magnet

The Systems

Structural steel is crucial for supporting mechanical systems, but that component was completely blocked by the silicon steel shielding support system the team had installed in the ceiling above level 2. Because it was not possible to attach mechanical systems to the remote steel under the MRI travel path, IMRIS installed a separate hanger support system for the mechanicals. The original plan for the hybrid suites called for horizontal hanger supports for all those systems. Once Suffolk completed calculations of the loading of hanger and spacing required per system, Suffolk and IMRIS reviewed those numbers and determined that rotating the supports 90 degrees—making them vertical instead of horizontal—would allow the corridor mechanical systems to be installed accurately.

The success of that change depended on a high degree of 3D modeling, given the many mechanical parts and pieces an MRI required. Suffolk's team worked with vendors and trade partners in BIM 360, Revit, and AutoCAD to properly coordinate the support systems and make sure all the mechanical systems fit properly.

Since the IMRIS MRI would travel across three rooms, the mechanical systems needed to span that space as well. The IMRIS was on level 3, so the team fed the mechanicals down from the level 4 mechanical space and around the trolley beams. The MRI's quench vent also needed to be heavily evaluated to go up and over the trolley beam, and then back under the shielding building steel to exit the room. The quench had connections on the end to transfer it from a hard pipe to a movable quench that travels along with the magnet.

All three rooms were designed as separate operating and MRI rooms, meaning no mechanical system could cross between rooms, which is why they went around the magnet in U-shaped feeds to come into the rooms on each side without crossing. The team also had to place an isolation ceiling for noise travel above level 2, since the MRI was directly above a clinical floor. the mechanicals had to wait to be installed until the remote MRI steel under level 3, the additional hanger support system, and the isolation ceiling was installed, which meant the area needed to be watertight as well.

For the middle unit, the original plan was to have a typical exhaust and supply exchange, but the team found it was not possible to cross the trolley beam in the middle room. The steel was too tight to the deck and too tight to the ceiling that no mechanicals could fit in the 10-inch buffer zone. So, the team decided to split the exhaust and supply into two. With new drop zones, they ran the ductwork up on the floor above and came down in two locations. For example, the quench vent had a window that went up and over to send it over the trolley beam steel, but under the shielding required for the MRI and under the building steel. That piece also required painstaking modeling and collaboration to execute.

Mechanicals fed around the trolley beam.

The Room

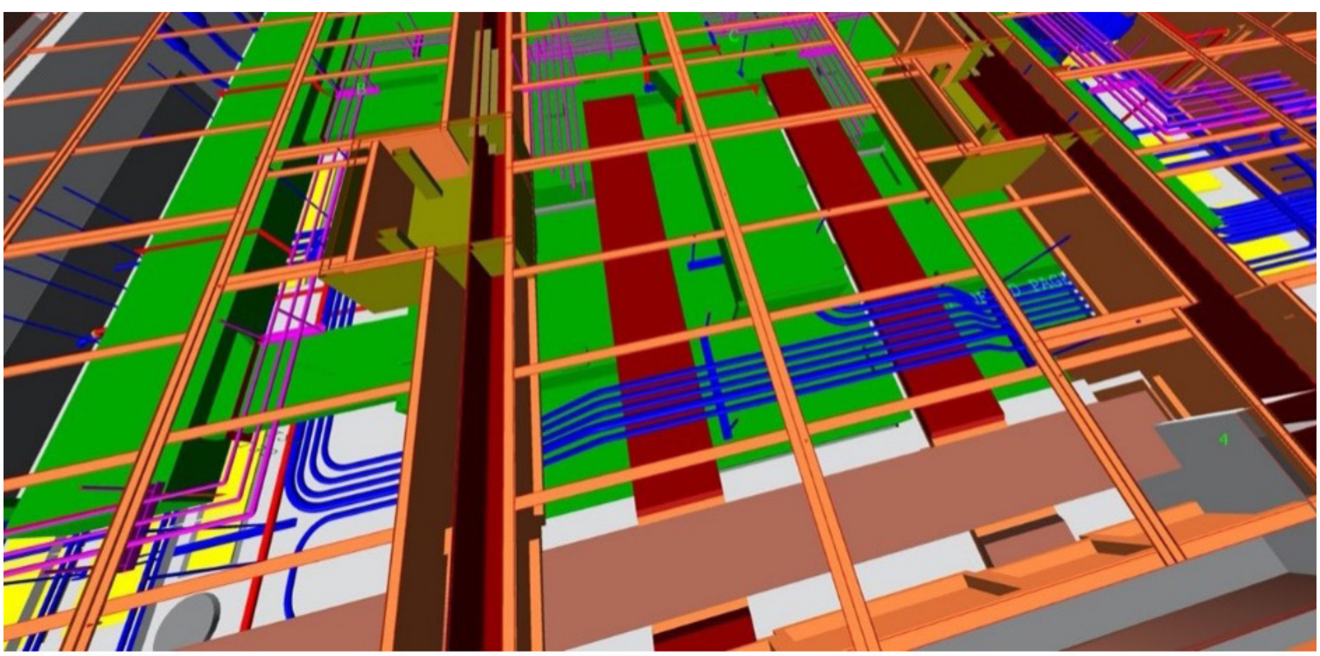
Because the magnet traveled to all three rooms, everything was considered an imaging suite, which meant the walls of those rooms—plus anything entering—needed the enclosure filters, waveguides, and shielding required for MRI machines. Every suite had to act as both an operating and imaging suite, meaning the team essentially built two rooms per suite.

For example, in operating rooms, surgical booms are common and designed to ergonomically centralize all surgical support equipment and utility services for OR staff, but booms are not typically in MRI rooms. All those booms needed to be shielded as separate structures, including on the structural connections, and that shielding had to happen during boom support fabrication. An added complexity: the trolley beam at the ceiling and the extra shielding shrunk the amount of space for HVAC air exchange space and mechanicals that fed the booms. In the suites, the diffuser systems aligned alongside every open space around the boom with one access zone.

Where mechanical connections to the boom needed to happen, Suffolk reviewed and showed the design team where shallower diffusers were necessary—eight inches rather than the typical 12—to allow for boom connections.

The team also installed shielded enclosure filters, which help isolate inside (clean) environments from outside (dirty) electrical noise by attenuating electromagnetic interference from outside sources. Filters ran the entire length of the walls in the three rooms for all the required systems to make an MRI and operating room function correctly. MRI suites typically might have two data ports; in ORs, though, there are usually at least 25. In the Boston Children's operating rooms, there are five data ports for every boom, plus six TV screens that needed data. Suffolk worked closely with the hospital to determine which ports would be "always on," meaning the port would be live even in MRI use and required individual filters.

The shielding integration grid plan for the hybrid suites.



Conclusion

Collaboration, coordination, Suffolk Engineering, and high-tech 3D modeling have been key to successful installation of IMRIS MRI. The IMRIS MRI hadn't been in the original plans for the building when Suffolk mobilized onsite in August 2016, but the whole team quickly pivoted and worked together when the hospital made the decision to convert a planned operating room into the IMRIS suite in spring 2019. Thanks to nimble teamwork, the design team was able to issue a new architectural bulletin, Suffolk properly coordinated the space, and the entire team kept the project on schedule and will complete the IMRIS suite with the rest of the building.

Suffolk and its partners continue to work hand-in-hand to meet the needs of the project's complex mechanical systems, precise structural steel requirements, and expansive shielding. The trolley beam rails, shielding, and structural steel will be on site in mid-April 2021, with construction of this complex build completing at the end of December 2021. Once complete, the IMRIS hybrid operating suite will be an innovative tool for Boston Children's Hospital to continue to deliver care when it matters most.

BY THE NUMBERS

15,000 pounds

The weight of the IMRIS magnet

1/16 of an inch

The straightness tolerance for the magnet's steel rail

10 days

Amount of time dedicated to precise welding connections

Here's how you can connect with our healthcare experts:

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