Silver BULLET

BY JEFF URDAN

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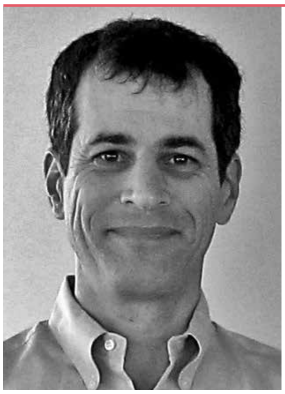
The Washington Metro's long-awaited Silver Line will connect one of the nation's busiest airports to one of its busiest transit systems.



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CONNECTING WASHINGTON DULLES International Airport to the Washington Metro has been an idea even before the Metro itself was built.

In the 1960s, when Dulles was connected to Washington, D.C., via Interstate 66, the median of the adjacent access road was reserved for some sort of rail transit. And even the original Metro plan from 1968 called for the system to eventually extend to Dulles.

Nearly four decades after the first Metro lines began operating in 1976, the first phase of the $6.8 billion Silver Line extension opened this past summer. The new line is nearly 30 miles long, including the portion where it runs parallel to the Orange and Blue Lines. Phase 1 adds an 11.6-mile route from where the Silver Line splits from the Orange line and includes five new stations; Crystal Steel fabricated approximately 3,200 tons for this phase. Phase 2, currently under construction, is scheduled to open in 2018 and will expand the line another 11.5 miles to Dulles and add six more stations.


S & R Enterprises


Crystal Steel

An arch, ready for transport.

Each steel canopy is a unique maze of difficult angles.

Canopy components to be erected.

The Silver Line will be 30 miles long when completed.

Trailers were modified to safely ship atypical assemblies from the shop.


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S & R Enterprises

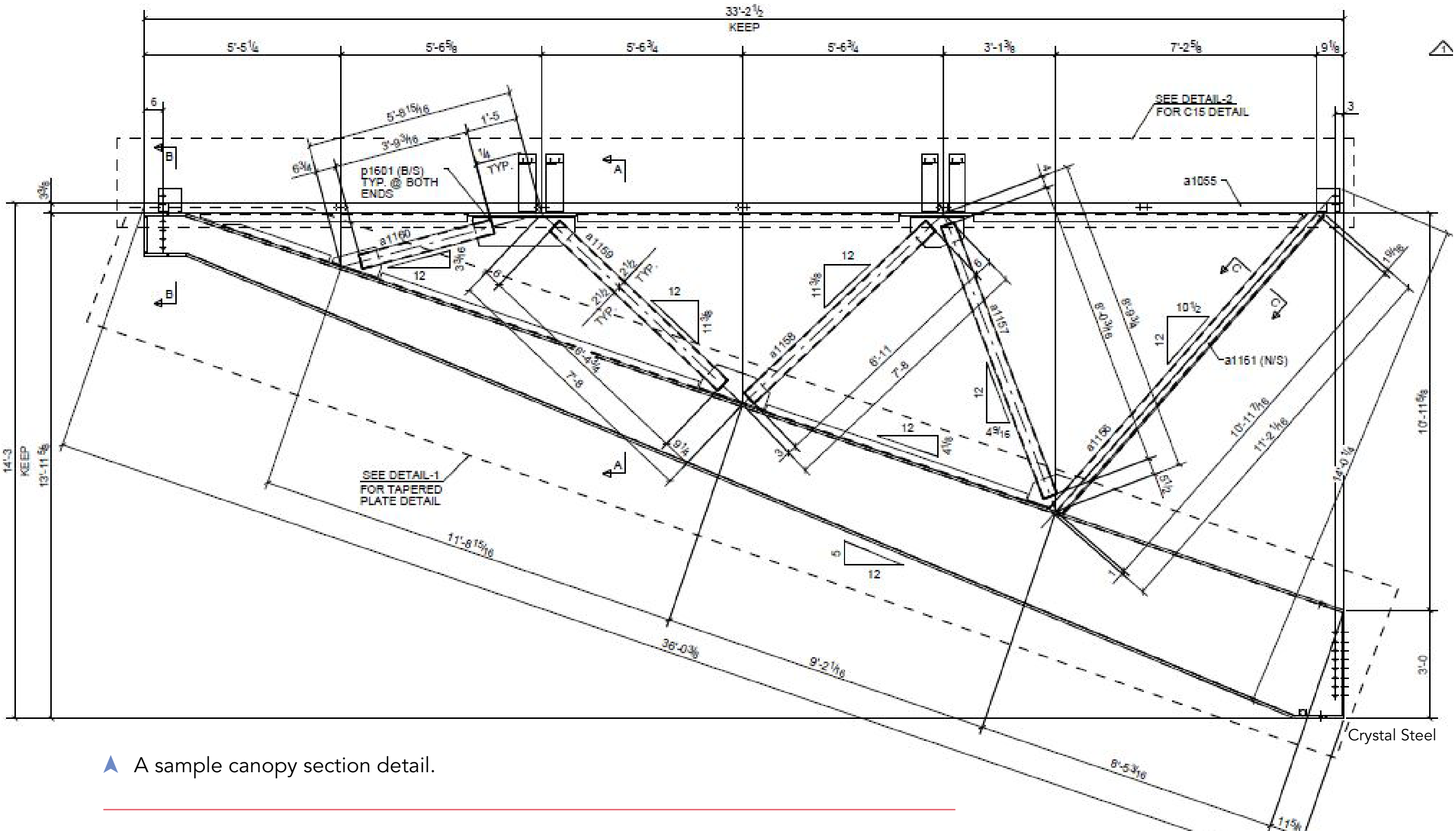
Phase 1 of the project adds an 11.6-mile route from where the Silver Line splits from the Orange Line and includes five new stations.

High Traffic

Architects and structural engineers often balance characteristics and costs in order to make a choice between steel and concrete as the fundamental structural material for their job. For the Silver Line, they chose both. While much of the track support that will be visible along the route is concrete, steel plays a key role as both a structural and a design element at the points where people interact with the system: the stations and pedestrian walkways that span the traffic-choked roadways below.

There are two key steel elements per station: the mezzanine, where people get on and off trains, and the canopy, which serves as a focal point. Each mezzanine uses sizeable steel elements—W36×395—that can support over 500 kips in several locations. Imagine a train platform, suspended by steel, with a train zooming in and slowing to a stop every three minutes (sometimes it's two trains, going in opposite directions, arriving on either end of a beam), and you can appreciate the forces that the framing needs to withstand. When a train arrives on the end of a beam, as each wheel passes a point it adds a new load, so both the initial and the "cyclical" loads were important to consider in the design. Vibrations were dampened at the concrete bearing interface by the use of Teflon pads mounted to Masticord.

By contrast, steel for the canopies is a maze of difficult angles, each one unique. Due to its high visibility, canopy steel was fabricated to architecturally exposed structural steel (AESS) finish standards. All steel was blasted and coated with two shop coats of high-performance paint prior to shipping to the site. After coat-



Crystal Steel

A sample canopy section detail.

ing the steel for the initial station, for subsequent stations it was decided that the third and final coat should be applied in the field to better deal with erection blemishes and handling scars—plus applying the final coat in the field was determined to be more cost-effective.

When it came to steel detailing and BIM, coordination with fire suppression, electrical and interior finishes were monitored and reviewed on a weekly basis throughout the steel detailing process. Due to the complex geometry, connection design was far from typical, which resulted in weekly meetings with the structural engineer to review issues. This open forum for communication streamlined the detailing and connection design process to a level of partnership in design far removed from "normal" projects, where the RFI process can become a bottleneck instead of a facilitator.

Heavy Traffic

To address the complicated geometry and assemblies, special jigs were fabricated in the shop to standardize the fitting and layout and to better manage the fabrication quality tolerances. The jigs were customized for each Metro station, then disassembled and reconfigured for the next station (the jigs took up thousands of square feet of shop space, making it virtually impossible to fabricate any other projects concurrently while a station was moving through the shop). In addition, the erector signed up for extra handling and "hook time," with the goal of minimizing the individual pieces needing to be erected, bolted or welded.

Pulling this work into the shop and planning with the erector resulted in enormous time savings in the field. Assemblies of this type would typically be stick-built in the field, but we elected to build large portions in the shop, which allowed the erector to simply pick a frame and place it rather than put two header beams and 10 cross members into place and then bolt them up. Trailers were modified to safely ship atypical assemblies from the shop. One example was modifying a truck to ship the frames vertically instead of as an escorted wide load, which reduced the per-load cost from $3,000 to $1,000.

Loads were built and timed to get as close to "in a perfect world" scenarios as possible to feed the site and reduce the amount of laydown area required.

And laydown area was already at a premium. The typical expectation of "reasonable crane access" had to be altered a bit when installing steel in the middle of the Dulles Airport Toll Road, one of Washington's busiest freeways. For example, when it came time to bring steel on-site for the Wiehle-Reston East station, there was only a 25-ft space from the jersey barrier at the edge of the freeway traffic lanes to the face of the 20-ft-tall concrete station wall. Steel erector S & R Enterprises used a Link-belt 75-ton crawler crane, wedged between the walls with zero additional room for tail swing, and also accommodated oversized permit loads coming in with next to no laydown area. (This scenario occurred with the Spring Hill and Greensboro stations as well, though the Wiehle-Reston East station is in the middle of the Dulles Toll Road while these other two are on heavily trafficked secondary roads.)

Such a situation called for a little practice. After laying out assemblies and simulating the job in a mocked-up "site" in its shop, S & R needed to find a way to make the physical limitations and the site logistics work so that the freeway was never closed and the steel was safely swung into place from carefully staged trucks. Steel was delivered along the "flow of traffic" side. Trucks were staged off-site, within a 30-minute drive, and were called in by the S & R, typically every two hours or so. A typical delivery day consisted of four deliveries, but this varied from station to station based on assembly size and truck access.

The barrel roof assemblies were particularly challenging to erect. The arch frames first needed to be set, and then the shop-

▲▼ Crystal Steel fabricated approximately 3,200 tons for Phase 1 of the Silver Line project.

▲ Framing for a window in the Wiehle-Reston East station canopy.

▼ Steel "V's" at the McLean station.

assembled panels were laid into them. There are four separate panels per bay, so each shop-built panel turned 11 picks into one. Because the ridge beam is shared by two panels, only three of the four could be shop assembled; the fourth had to be stick-built in the field. And the practice paid off; the barrel roof assemblies were erected in less than half the time that was originally planned.

Several of the new stations shared geometric roof designs. All steel was delivered to the "median" or job site using standard trucking; nothing was hoisted over active travel lanes. Once in the construction area, the crane would unload and erect steel as normal.

To apply decking, S & R developed an angle jig in its shop that made sliding sheets of deck into place easy and safe, given the tight workspace in the middle of a busy highway. In addition, the AESS and special finish paint system meant that no holes could be made and no welding could be used to attach the sheets of steel deck. Hilti pins were used to secure them, affording an almost invisible yet extremely durable connection.

The most rewarding part of the project was the close collaboration with the design team during the detailing and connection design process. Being able to sit with the engineers and architects, have them listen to and incorporate our ideas and see the shared plan emerge in drawings that incorporate elements of current industry standards, as well as our particular fabrication practices, was refreshing. This level of design-build partnership with the fabricator is rare, but the benefit—when done well—is significant: a constructable design that is produced and erected more quickly (estimated time savings was 25% to 35%) and avoids the clutter of RFIs, design changes and unexpected cost increases during the course of the project. When the documents were released, they included the best thinking from all parties. This is a project that is already changing the face of Washington both in terms tangible, high-visibility infrastructure improvement as well as how people think about future projects of this type—including the ongoing Phase 2 of this project. ■

Owner

Metro Washington Area Transit Authority

Design-Build Developer

Dulles Transit Partners (a Joint Venture of Bechtel and URS)

General Contractor

Turner Construction

Steel Team

Fabricator and Detailer

Crystal Steel Fabricators, Delmar, Del.
(AISC Member/AISC Certified Fabricator)

Erector

S & R Enterprises, LLC, Harrisburg, Pa.
(AISC Member)