INTRO:
This new Land Port of Entry is the busiest border crossing in the world, processing around 50,000 vehicles and 25,000 pedestrians per day. The new border station currently under construction in three phases is designed as the 'port of the future,' addressing goals to update and modernize outdated infrastructure for reduced processing and wait times. Setting a new bar both operationally and in terms of high-performance buildings at international border crossings worldwide, Phase I of this project targeted for completion in 2014 includes security and inspection enhancements for greater safety and efficiency, and is targeted to achieve LEED Platinum certification through energy efficiency and water conservation strategies. Given the complexity and scale of the project, the use of **BIM was a critical component in effective management of a large, far flung project team and in achieving operational efficiencies for a streamlined design process resulting in effective design strategies.**

When completed, the project will accommodate a staggering 34 lanes of traffic with 110,000sf of vehicle inspection canopies, and 200,000sf of administrative and operations facilities. Sustainable water management strategies will reduce water use by an anticipated 28 million gallons+ per year including the use of a rainwater reclamation system treating grey and black water on site. Optimized and efficient mechanical equipment combined with photovoltaic panels and a geoexchange heat pump system support a design goal to become the first 24/7/365 facility to achieve net zero energy in the United States.

To offset the intense operational and regional environment, inspection canopies shelter officers and serve as a visual gateway for millions of people crossing the border each year. The canopies clad in ETFE (Ethylene Tetrafluoroethylene) provide soft filtered natural light and much-needed shade from intense regional sun, a calming presence amidst chaos. The thin, long span profiles are gracefully supported by 120' masts float lighting across the site and offering uninterrupted sight lines for enhanced site surveillance. Artistic elements throughout the site offer a welcoming aspect to the border crossing experience.

Working as an integrated project group, the broader project team was able to review and respond to a large number of options more quickly than if taking a more linear design/delivery approach. The 'over the shoulder' reviews rapidly became a forum to prove out the most innovative ideas and offer the best design solutions. Specific discussion topics were introduced through drawings, sketches, models, material samples, and PowerPoint. **The 'live' Revit/BIM model was used to show critical project views and perspectives.** Overall, BIM technology was crucial to the design process.

An important example of its impact for the project was when it was necessary to confirm views from the Port Headhouse into the unsecure Primary Inspection area at the border of the neighboring country. The initial design met the design mandate, but the owner requested that an alternate design be considered to maximize critical sightline views through a canopy design with a shallower profile. The BIM model enabled seamless work with consultants to produce a solution which not only met the design mandate but which improved views from the Headhouse, maximized solar exposure for PV panels, and reduced the overall weight of the structure – saving money in the process. Remarkably, using the **BIM process enabled the team to present the redesigned solution to the Owner only one week after their initial redesign request.**

The project design lead consistently designs using Revit/BIM and insists that sub-consultant teams also use BIM to streamline coordination efforts, as it has revolutionized cross-disciplinary coordination in the industry and is absolutely essential for complex, large-infrastructure projects.

Recognizing that a truly integrated design comes from excellent team coordination and that BIM is a critical communication tool in the design process, the project design team utilizes Revit as our primary BIM platform and also integrates other software suite's analysis to test and validate design assumptions very early in the process through programs such as Grasshopper, Ecotect, Vasari, and Sefaira for parametric performance simulation and systems. Familiarity with these emerging technologies allowed the team to quickly explore the potential energy and resource strategies of this project, find the ones that best fit this project, and work in tandem with the design and production teams to integrate them into the design.

This analysis often encompasses passive and active mechanical, structural, and envelope systems, making it possible to manipulate building design elements on the fly, with close to instant data feedback. With Grasshopper, for example, the efficiency of differing exterior skin panelization arrangements or reduction and honing of structural systems was quickly assimilated with the Design Team Structural Engineers' TAP model.

When combined with Ecotect, Grasshopper provided quick analysis of daylighting impacts from changes in aperture size on the building skin or PV array efficiencies based on panel type, orientation or tilt. Experience with Navisworks enabled the team to overlay BIM models of each building system and run clash detections in order to virtually address physical conflicts before the start of construction.

Well-coordinated and well-developed documents have meant fewer contractor questions on the job site and less complicated review of submittals due to a clearer understanding of the design work and intent. This also ensured that meeting (or beating) the construction schedule was a viable target for the contractor team and that there were fewer errors and omissions during construction.

THE PROCESS: CLIENT
For this project, the client and user group were critical in developing well-coordinated construction documents. The project was on an expedited schedule with the design process totaling 420 calendar days, including 35 days for Master Planning, 41 days for Preliminary Concepts, 74 days for Final Concepts, 116 days for Design Development, and 154 days for Contract Documents. The aggressive schedule required one-on-one coordination with all user groups and tenants to coordinate programming information and special equipment requirements.

The design team worked to develop construction staging diagrams to ensure Land Port operations could be maintained during all phases of construction. Throughout each design phase, the documents were reviewed by stakeholders and users to ensure the correct spaces, equipment, and operational layouts were carried into the 100% contract documents.

THE PROCESS: BIM
The Land Port Project has utilized the interoperability, coordination capabilities, and analysis tools of BIM throughout the design process. During the Preliminary Concept phase, rough BIM models were developed to efficiently describe massing options and allow for changes to be made during a client review session. The BIM models continued to advance through Design Development and were shared with the Owner for their required Spatial Program Validation analysis which confirms program area requirements and rent calculations.

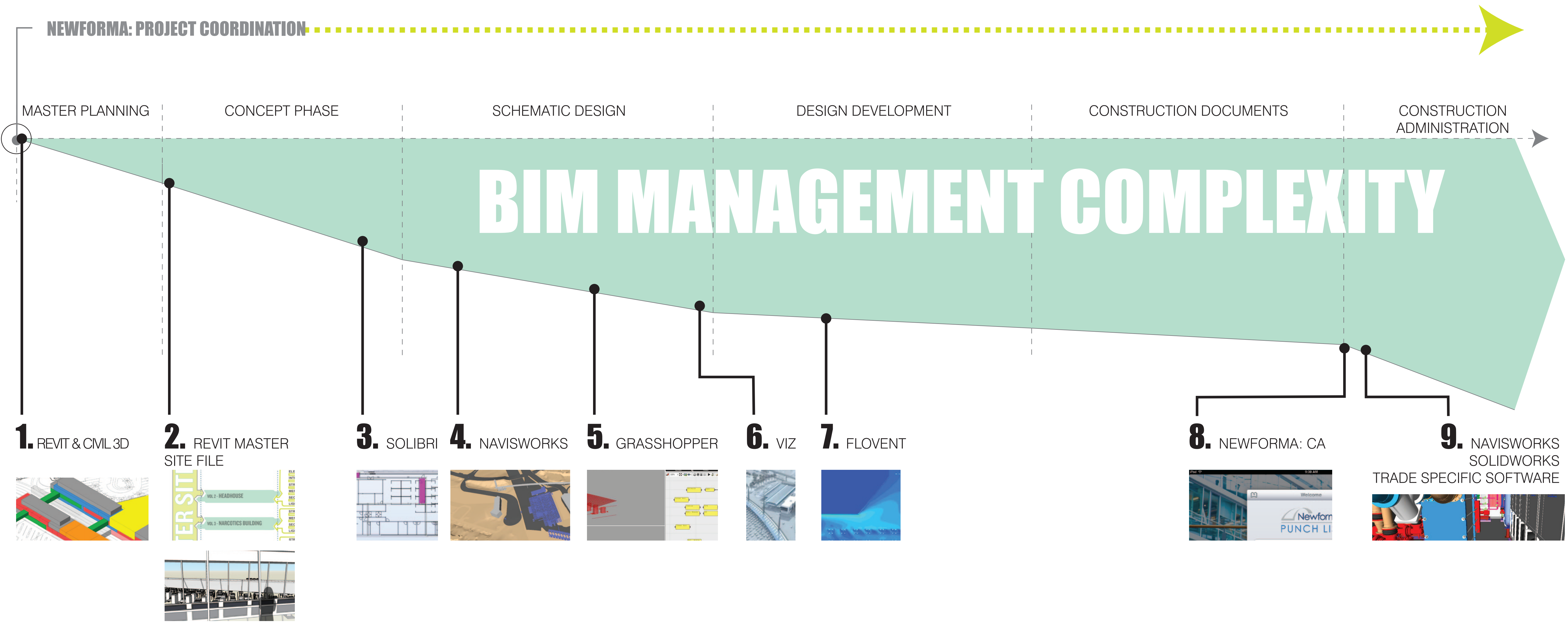
The Owner understood the efficiency of using BIM for validation calculations and has formed their BIM standards to assist A/E teams in identifying and modeling correctly. **The BIM model for the Port project was a unique web of models: Autodesk had never seen such a complex arrangement for a single project.** Due to the size of the project, each project component became an individual model that linked to a "Master Site" model via shared coordinate points. This arrangement allowed for manageable "Site Component" model sizes while still seeing the entire site for coordination. The "Master Site" file has six "Site Component" models linked for phase 1B and will continue to be used in future phases. Within the six "Site Component" models, 22 consultant's information was coordinated; 11 using CAD and four using BIM. All discipline information was collected in each "Site Component" file and checked for conflicts.

The main challenge with this project was constructability and phasing issues, which BIM allowed the team to assess. During the Final Concept phase, the BIM model was taken into Navisworks to animate the construction sequence process. This allowed the User groups and client to fully understand how the proposed design will be constructed without disruption to ongoing Port project operations. Phasing and staging plans were included in the contract documents as a reference for the contractor, who was not yet on the project team but who used these documents to support their work plan. The BIM model provided immediate access to views and building information that could easily and quickly be turned into presentation materials, including watercolor renderings, digital flythrough, and diagrammatic visual aids.

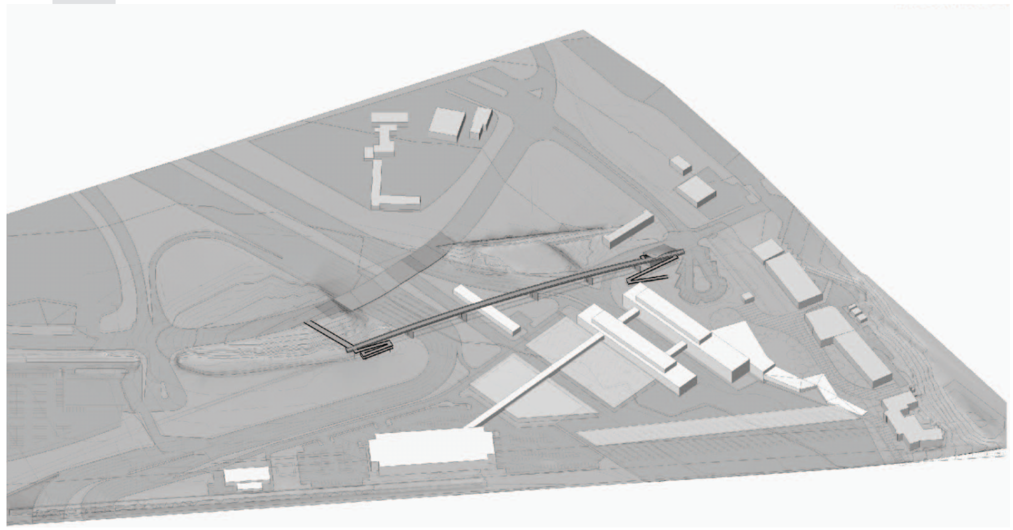
THE OUTCOME: HIGHEST QUALITY CONTRACT DOCUMENTS
Though the design phase was on a fast track, the integrated approach–which included the sharing of BIM models between all team members–allowed for the contract documents to be delivered on time and pushed the project to Net Zero energy for a low premium. Below are the metrics proving that early coordination efforts and BIM management created high quality contract documents.

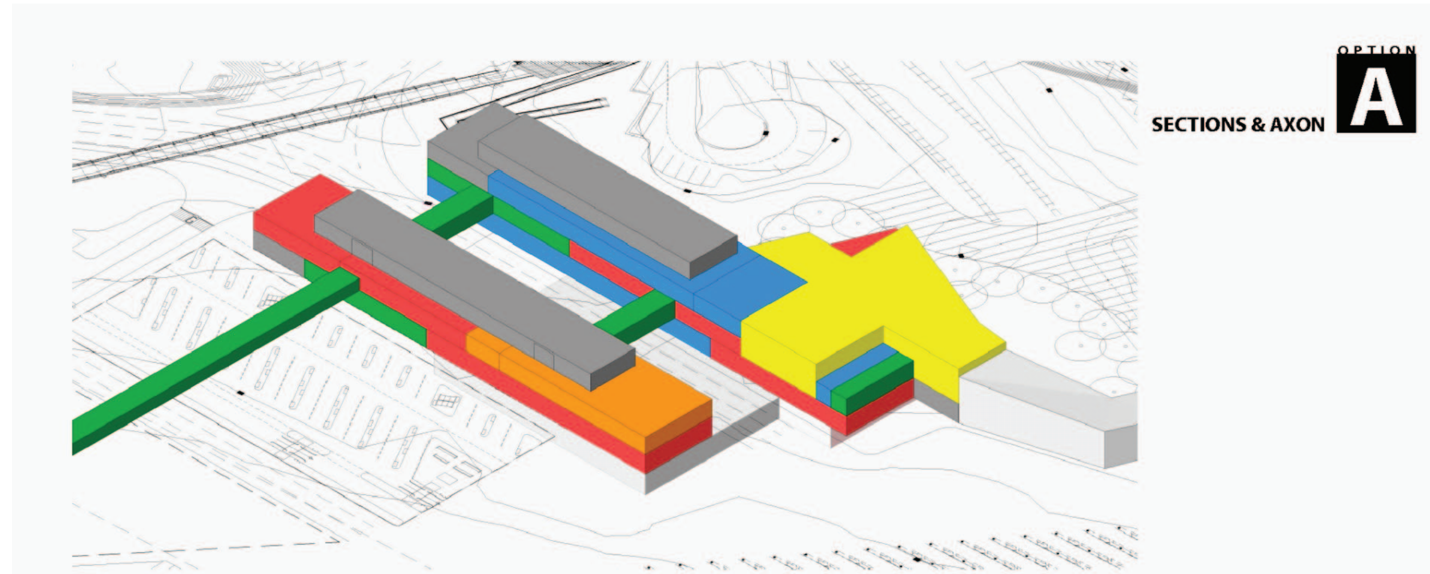
Of note, **the Land Port project is tracking at a 1.4% Change Order rate, far below the industry standard of 5% for errors and omissions.** Historically, the average Architect Project generates 32 RFI's per million dollars of contract cost. Currently, the Land Port project is 50% complete and with the projected average RFI rate, at this point an expected 2,500 RFIs would have been processed. To date, the team has processed 1,240 RFI's - a 49% reduction from historical numbers.

The BIM process and complexity progressed with the progression of the project. Each phase of Design incorporated or utilized a new program, all necessary to meet the stringent deadline and high architectural expectations.



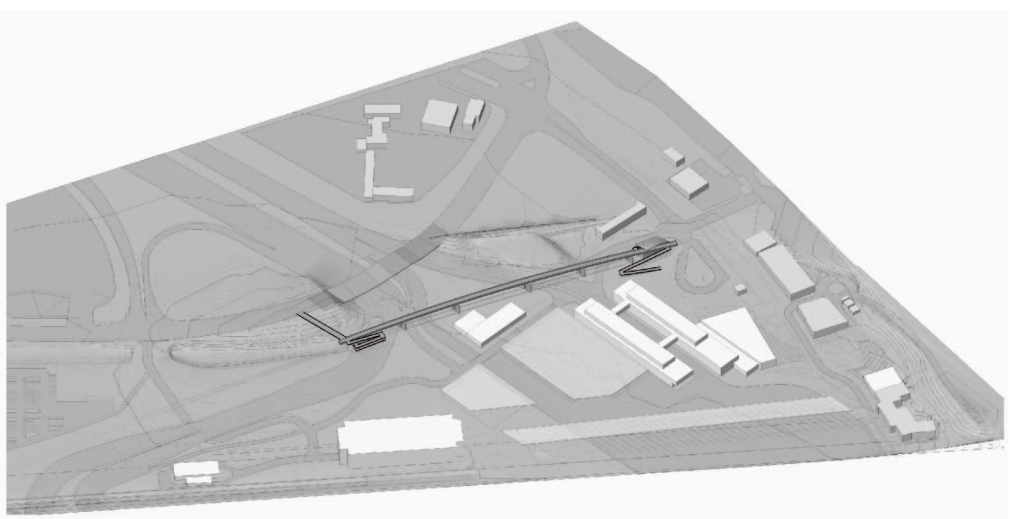
1 REVIT & CIVIL 3D

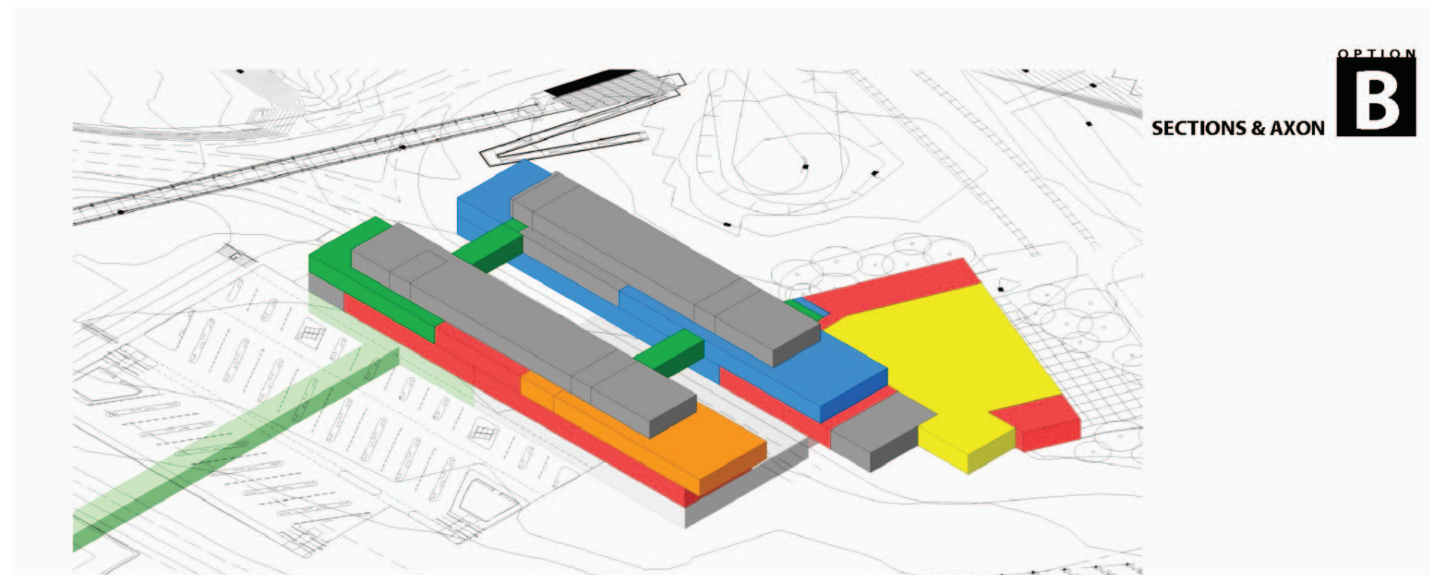


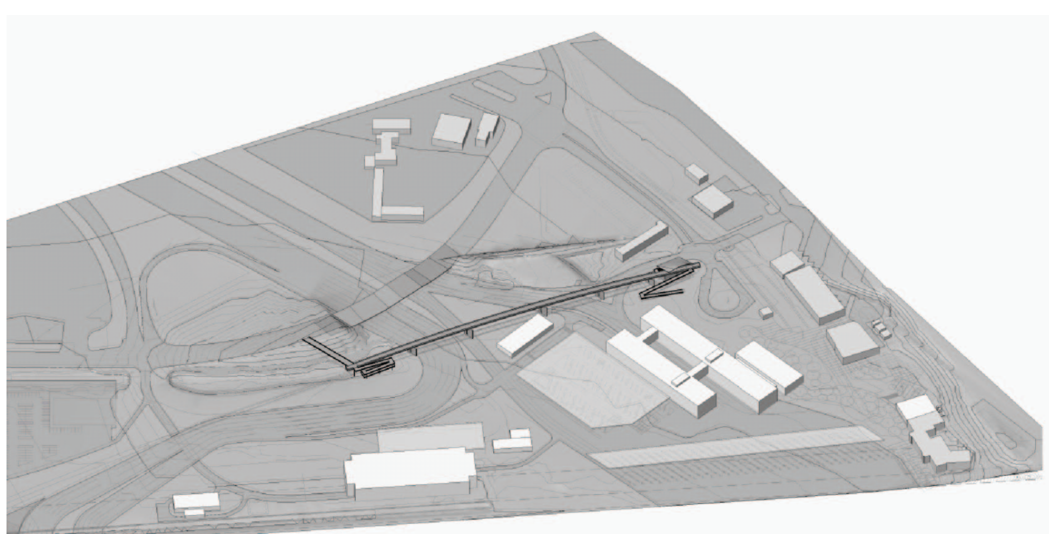


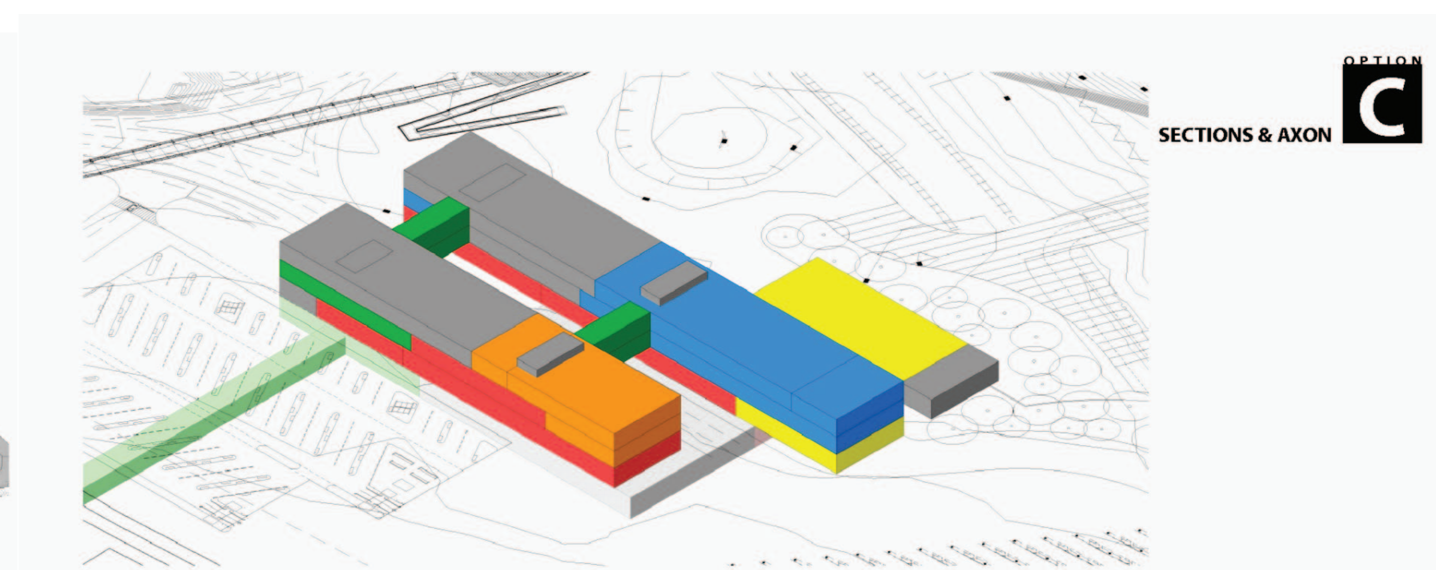
Revit and Civil 3D was essential to the project starting on day 1 in order to manage the expedited timeline of the project. The early use of these programs assisted the programming and site planning efforts, allowing the team to present several iterations with associated area information in real time.

Within Revit and Civil 3D, coordinate points were identified and used as a tool for accurately locating all structures, utilities, fences and bollards on the site.



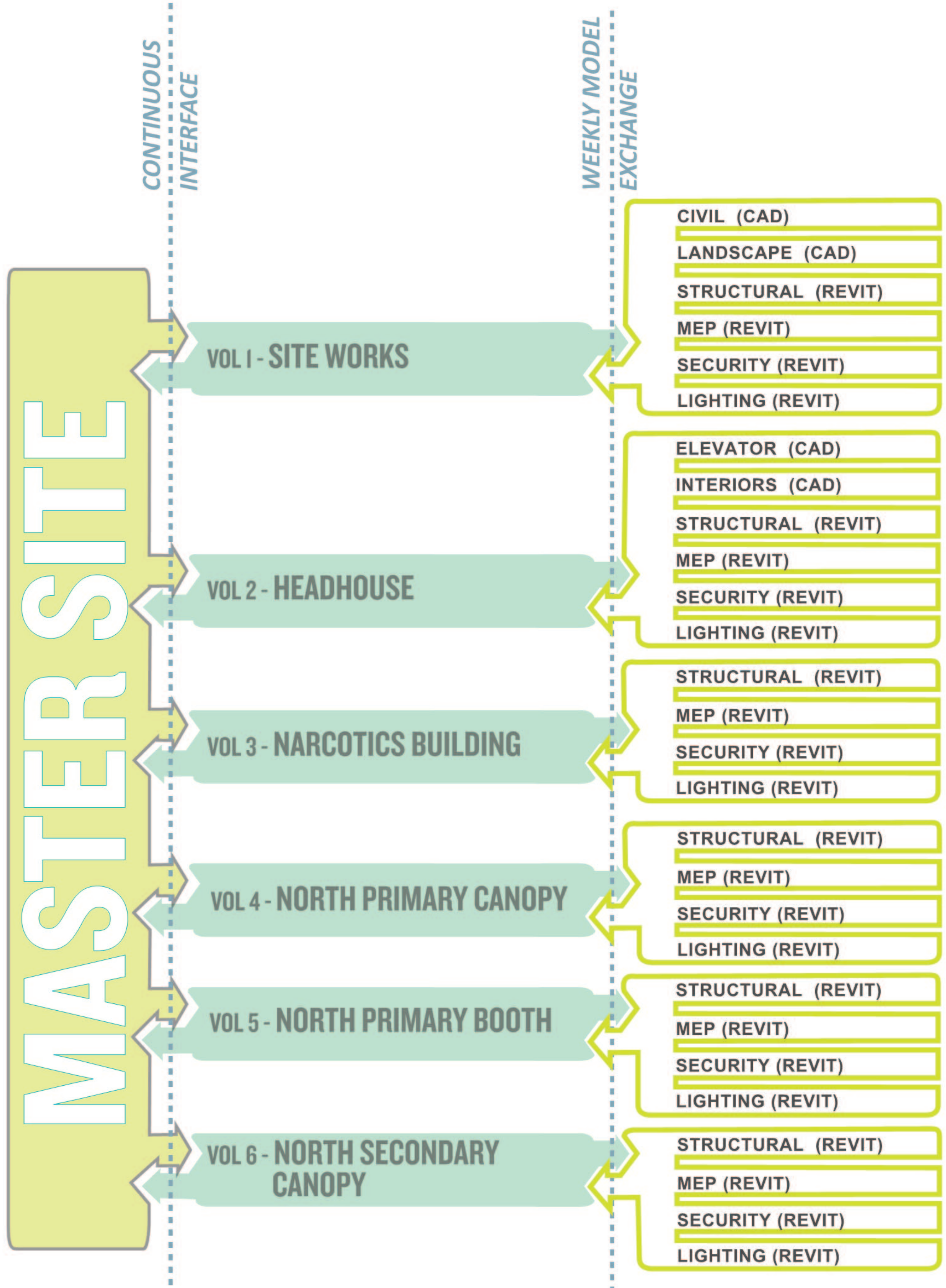




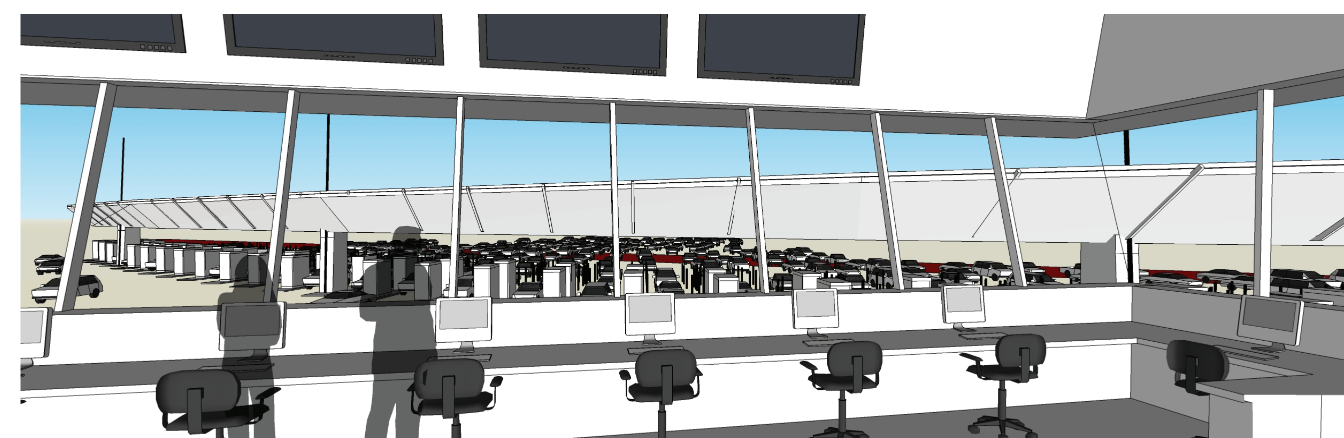


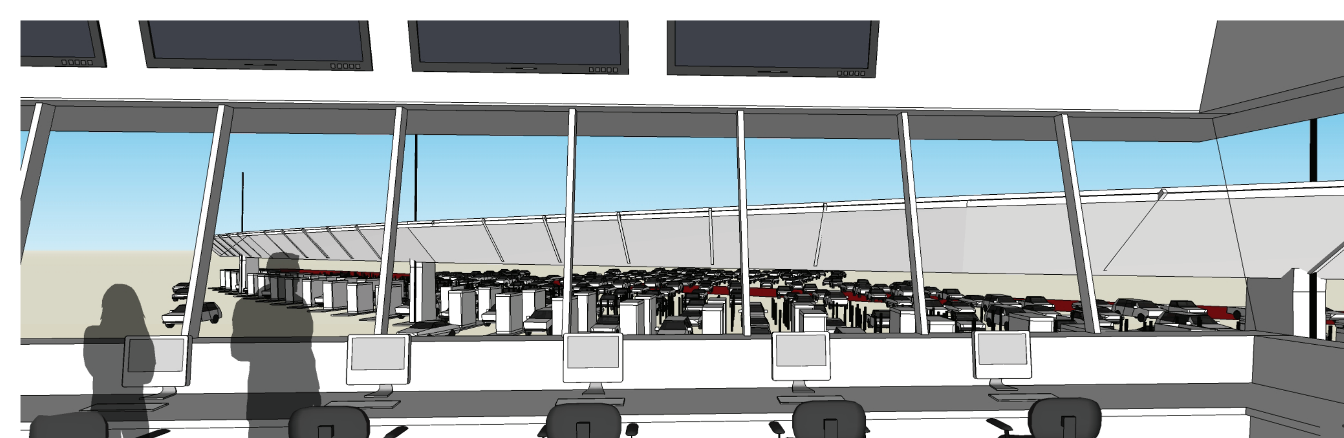
- OFFICE
- PORT OPERATIONS
- DETENTION
- PEDESTRIAN INSPECTION
- MECHANICAL
- CIRCULATION

2 REVIT MASTER SITE FILE

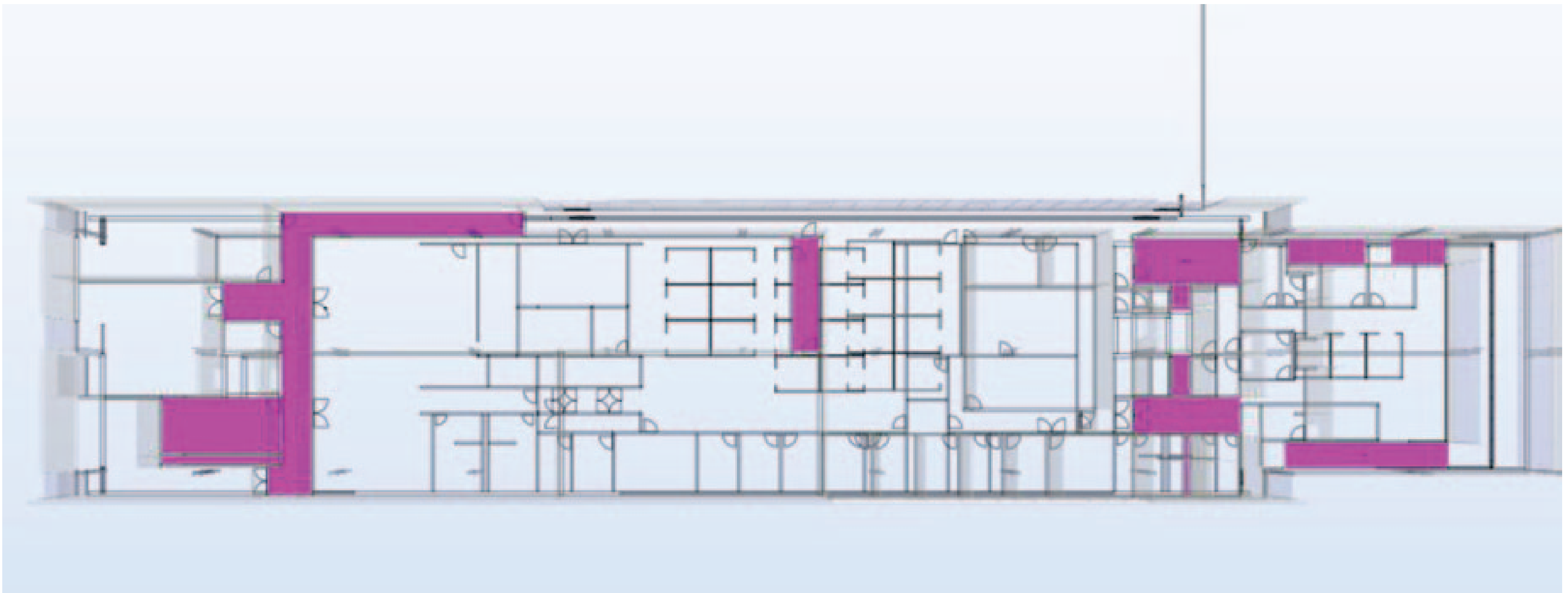


The “Master Site” file has six “Site Component” models currently linked for phase 1B and will include more in future phases. Within the six “Site Component” models, 22 consultant’s information was coordinated; 11 using CAD and four using BIM. All discipline information was collected in each “Site Component” file and checked for conflicts. The “Master Site File” allowed for several key studies to be quickly executed including looking at critical site lines across the border from the Command Center and construction phasing.

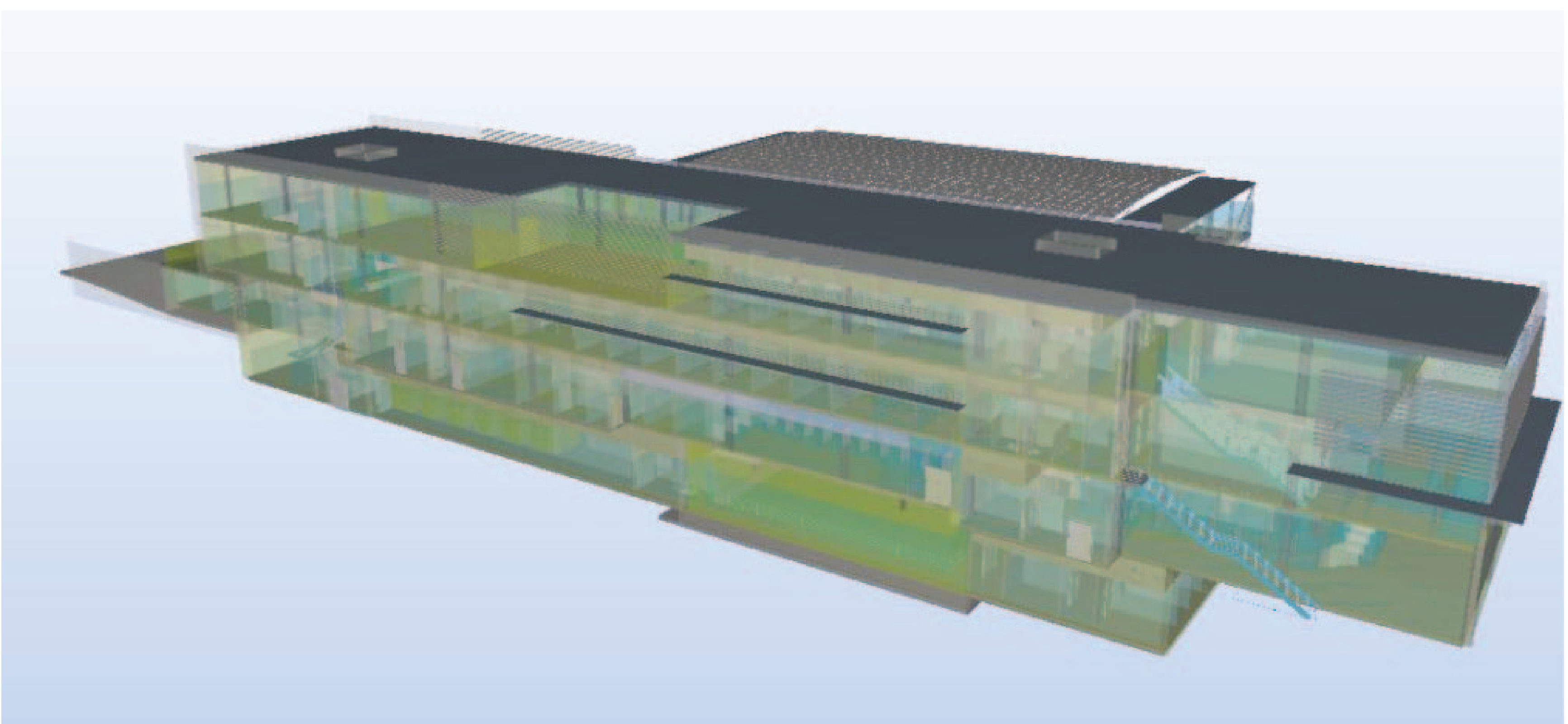

sight line study - option 1


sight line study - option 2

3 SOLIBRI



visual output of Solibri - detection of undefined spaces

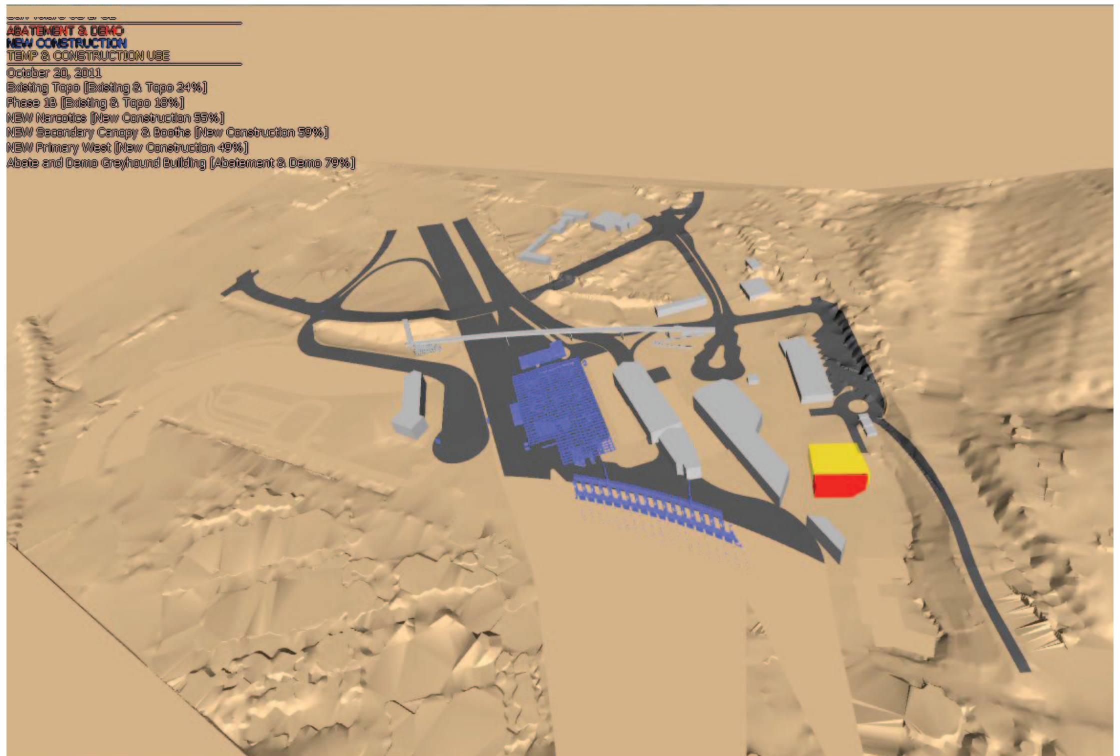


The “Master Site File” was used by GSA in Solibri, a program that verifies room areas. GSA will utilize this information for calculating rent rates for tenants. BIM was critical for quickly generating iterations of room configurations to confirm space classifications and to achieve the desired tenant areas.

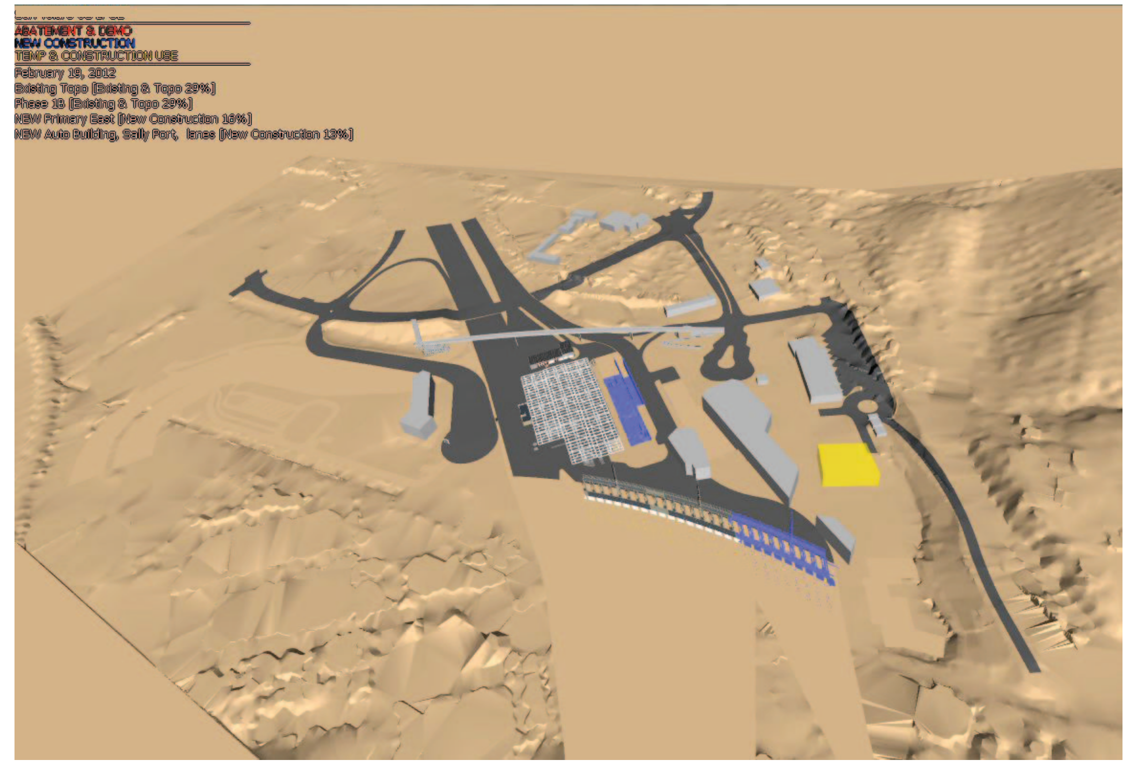
PHASE	GSA BLDG Number	AE BLDG ABBR (from RDC)	MH Suggested Abbreviation		STAR name	MILESTONE USED FOR AREA CALCUATIONS	AE BUILDING Name (from RDC)	MH Suggested Name	Combination of GSA and U.S. Land Port Of Entry Design Guide Supplement name to use	GROSS AREA - FROM AB CODE PDF'S
1B	CA0340	AN	HH	NB HeadHouse	NB HEADHOUSE	35% CD	NB AUTO INSPECTION BUILDING	NORTHBOUND HEADHOUSE	NORTHBOUND HEADHOUSE	83,191
	CA0341	LB	NP	Northbound Primary Inspection Canopy	NB PRIMARY INSPECTION CANOPY	35% CD	NB PRIMARY LANE/BOOTH ARRAY	CANOPY OVER NB VEHICLE PRIMARY	NB PRIMARY VEHICLE INSPECTION BOOTHS AND	41,247
	NR		-	Northbound Primary Booths				NB VEHICLE PRIMARY INSPECTION BOOTHS		
	CA0343	CN	NS	Northbound Secondary Inspection Canopy	NB SECONDARY INSPECTION CANOPY	35% CD	CANOPY OVER AUTO SECONDARY	CANOPY OVER NB VEHICLE SECONDARY	NB SECONDARY VEHICLE INSPECTION	78,865
	NR		-	Northbound Secondary Booths				SB AUTO SECONDARY INSPECTION BOOTHS		
	CA0342	NR	NB	Narcotics/Seizure Building	NARCOTICS / SEIZURE BUILDING	35% CD	NARCOTICS/SEIZURE S BUILDING		NARCOTICS / SEIZURE BUILDING	5,841
	NR		-	Employee Tunnel			SECURE EMPLOYEE TUNNEL			
	NR		-	Field station East				SB BORDER CROSSING - EAST FIELD STATION		
2	CA0337	PN	MB	Main Building	MAIN BUILDING	100% FC	NB PEDESTRIAN INSPECTION BUILDING		MAIN BUILDING	109,683
3	CA0335	AS	SP	Southbound Primary Inspection Canopy	SB PRIMARY INSPECTION CANOPY	100% FC	SB PRIMARY LANE/BOOTH ARRAY	CANOPY OVER SB AUTO PRIMARY INSPECTION	SB PRIMARY INSPECTION BOOTHS AND CANOPY	14,551
	NR		-	Southbound Primary Booths				SB AUTO PRIMARY INSPECTION BOOTHS		
	CA0380		SS	Southbound Secondary Inspection Canopy	SB SECONDARY INSPECTION CANOPY	100% FC		CANOPY OVER SB AUTO SECONDARY INSPECTION	SB SECONDARY INSPECTION	19,514
	NR		-	Southbound Secondary Booths				SB AUTO SECONDARY INSPECTION BOOTHS		
	CA0344	RB	BP	West Side Border Patrol/ Pedestrian Building	WS BORDER PATROL / PEDESTRIAN BUILDING	100% FC	BORDER PATROL BUILDING		WS BORDER PATROL/PEDESTRIAN BUILDING	11,760
	NR		-	Pedestrian South			SB PEDESTRIAN INSPECTION BUILDING			
	NR		-	Pedestrian Canopy			NB PEDESTRIAN CANOPY			
	CA0581		HC	Historic Customs House	HISTORIC CUSTOMS HOUSE	100% FC	HISTORIC CUSTOMS HOUSE		HISTORICAL MAIN BUILDING	24,224
	CA0345	SP	PS	LPOE Parking Structure	LPOE PARKING STRUCTURE	100% FC	SECURE EMPLOYEE PARKING GARAGE	EMPLOYEE PARKING STRUCTURE	LPOE PARKING STRUCTURE	210,980
	NR		-	Field station West				SB BORDER CROSSING - WEST FIELD STATION		
	CA0381	AS	SH	Southbound Headhouse	SB HEADHOUSE	100% FC	SB AUTO INSPECTION BUILDING		SB HEADHOUSE	7,484
EXISTING	need #?		??				EXIST NB PEDESTRIAN			
	CA0588		AB	Administration Building			ADMINISTRATION BUILDING			
	need #?		??				EXIST BORDER PATROL STATION			
	CA0588		AH	Aviary Holding			AVIARY HOLDING FACILITY			
	NA		PL	PayLess			PAYLESS BUILDING			
	CA0588		CU	Central Utility			CENTRAL UTILITY PLANT			
	CA0581		IC	InCinerator			INCINERATOR ??			
	NA		DF	Duty Free			DUTY FREE SHOP ??			
										607,340

data output of Solibri

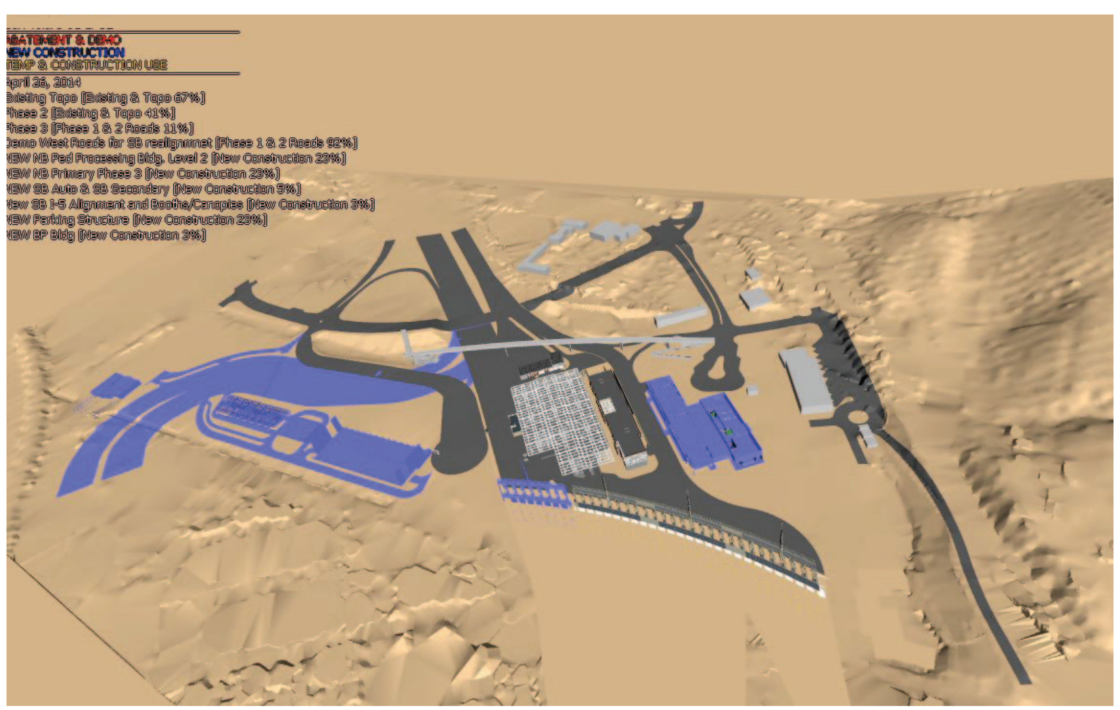
4 NAVISWORKS

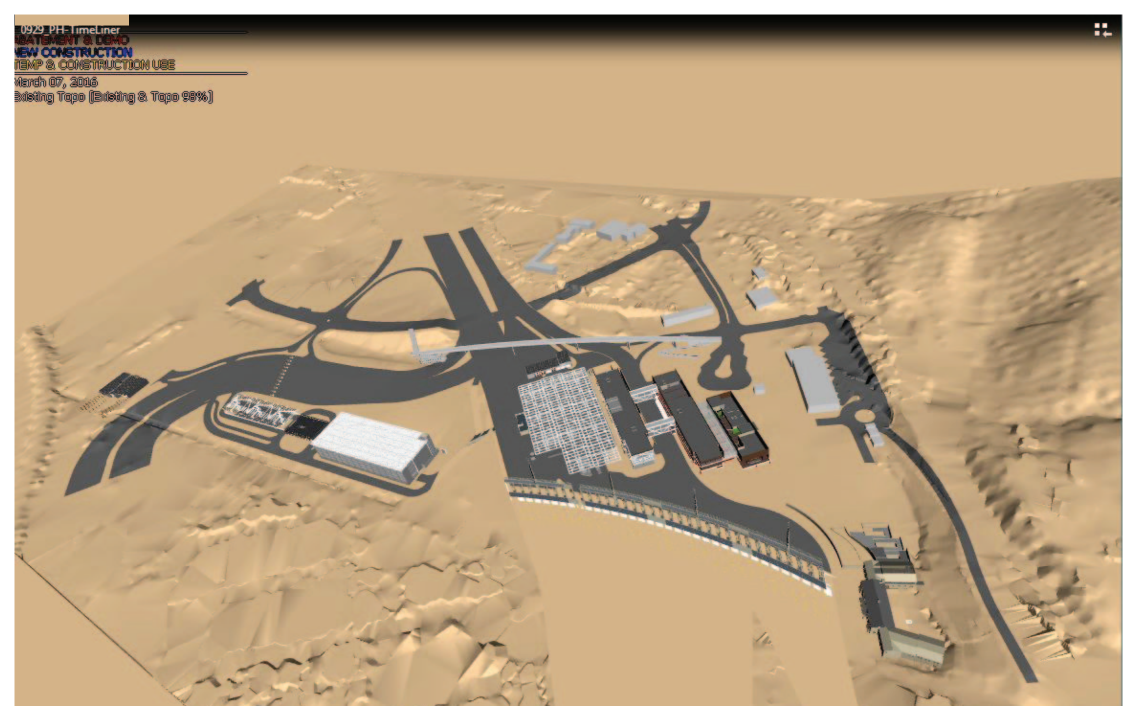


snapshot of phasing animation

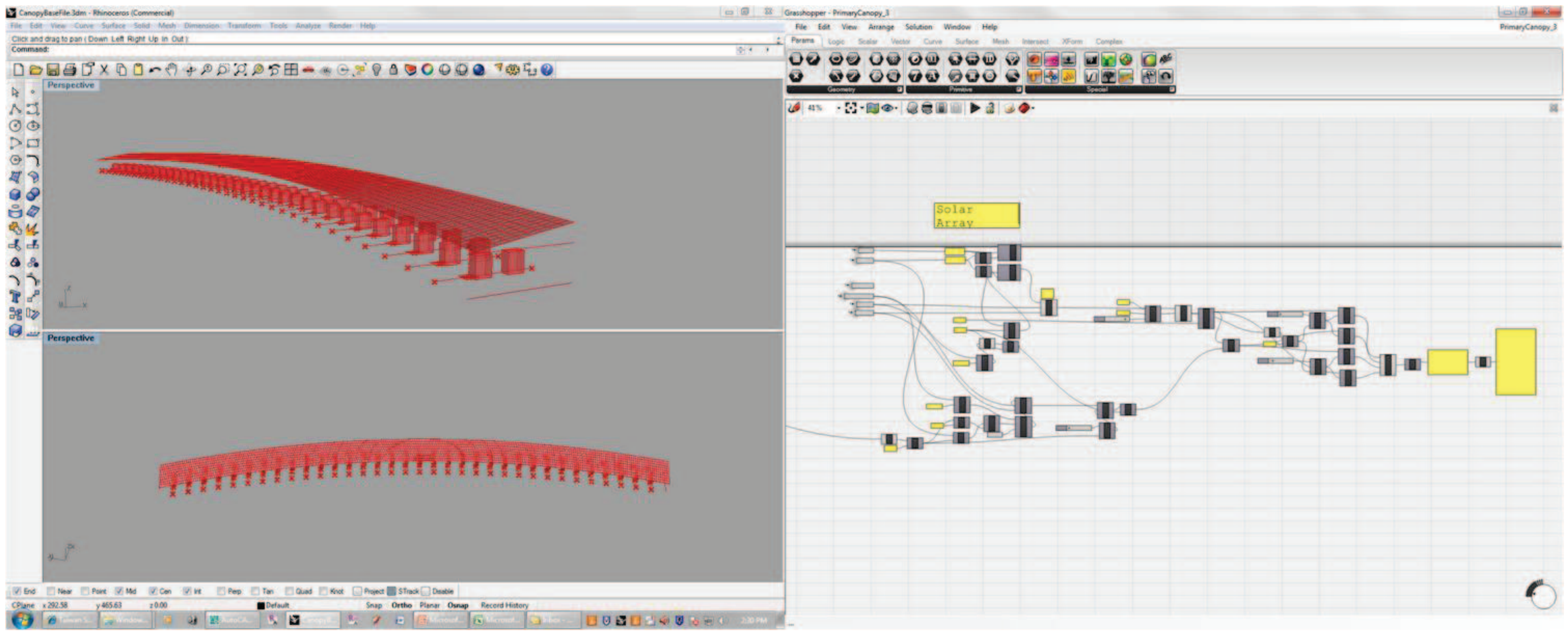


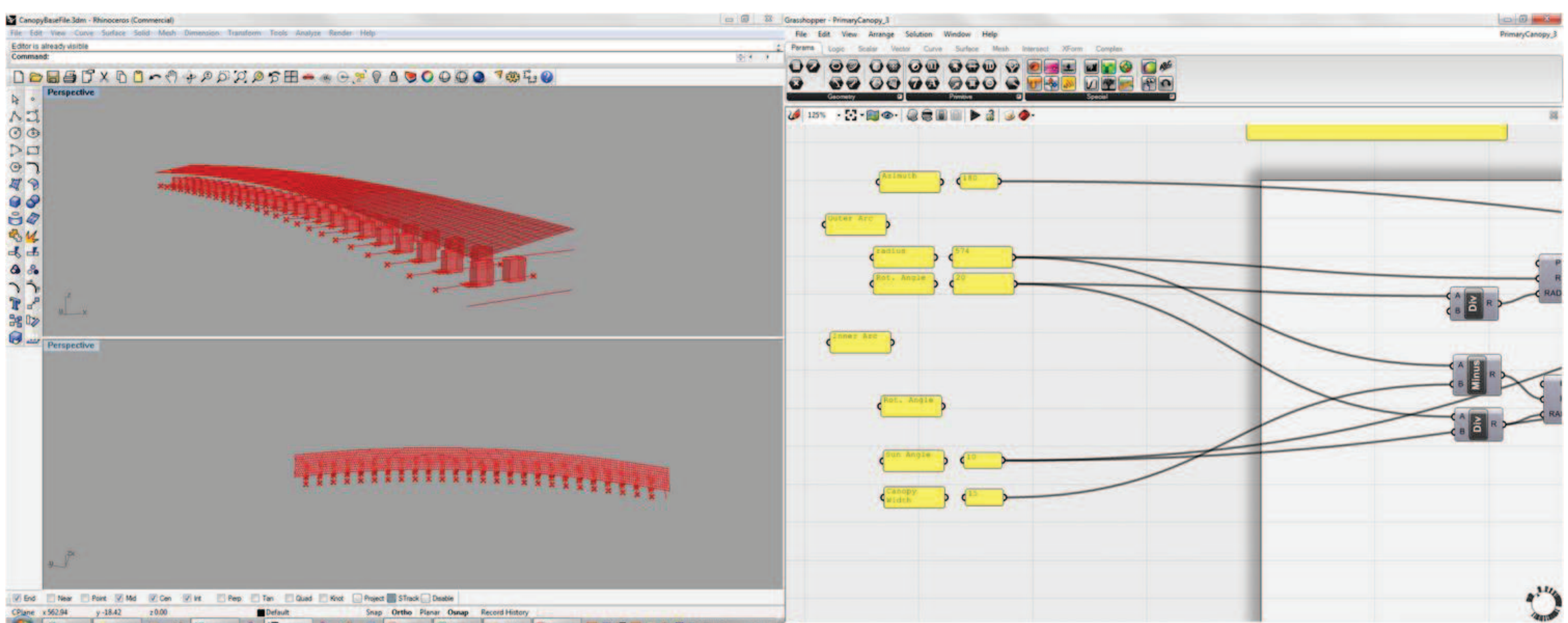
The team used Navisworks, which utilized the "Master Site File", to generate a phasing animation to identify the potential construction sequence of this complicated project. The Navisworks animation was critical in determining the constructability of the proposed design while keeping Port operations open 24/7 during construction.





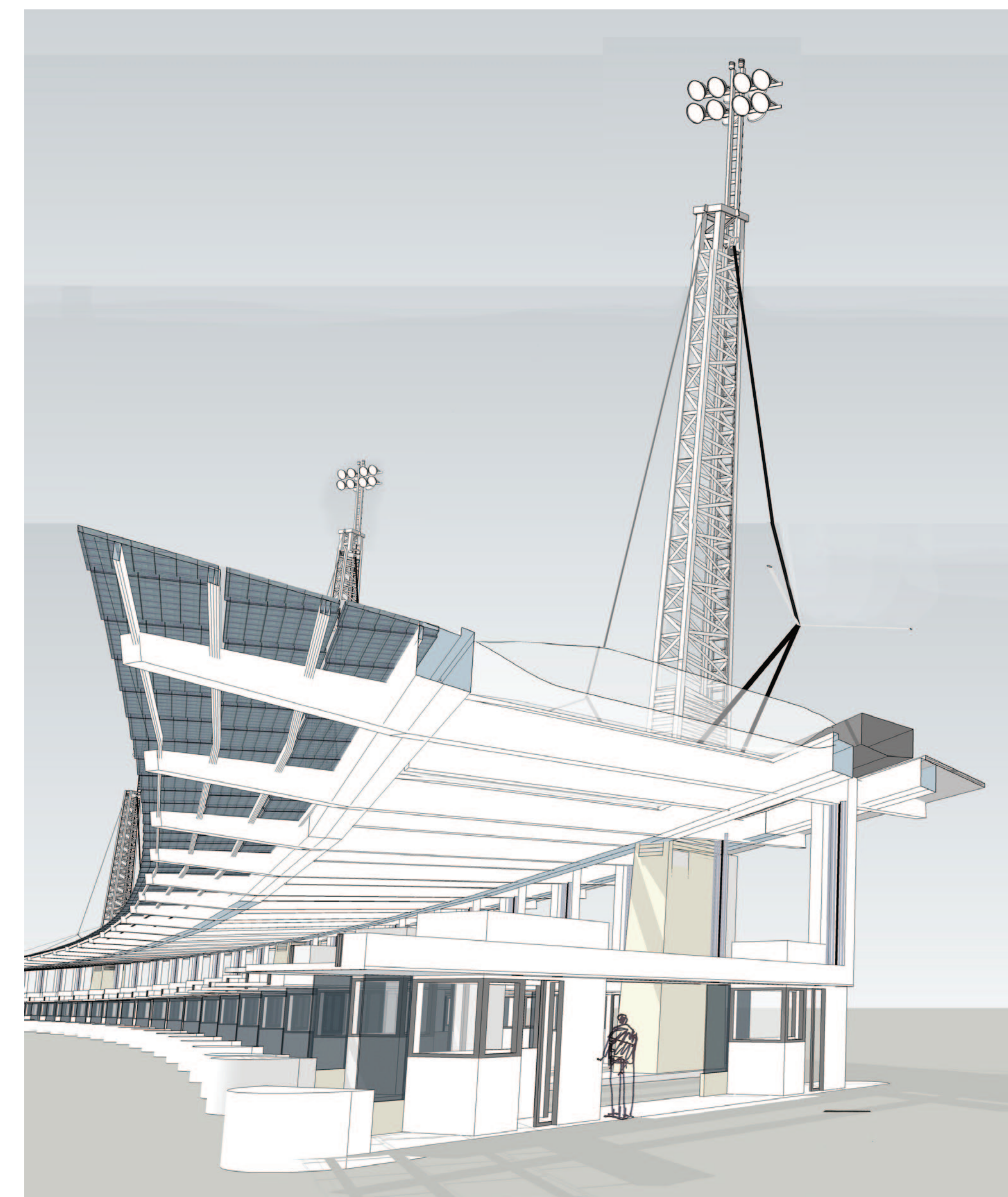
5 GRASSHOPPER





Grasshopper interface - manipulating the design through rules

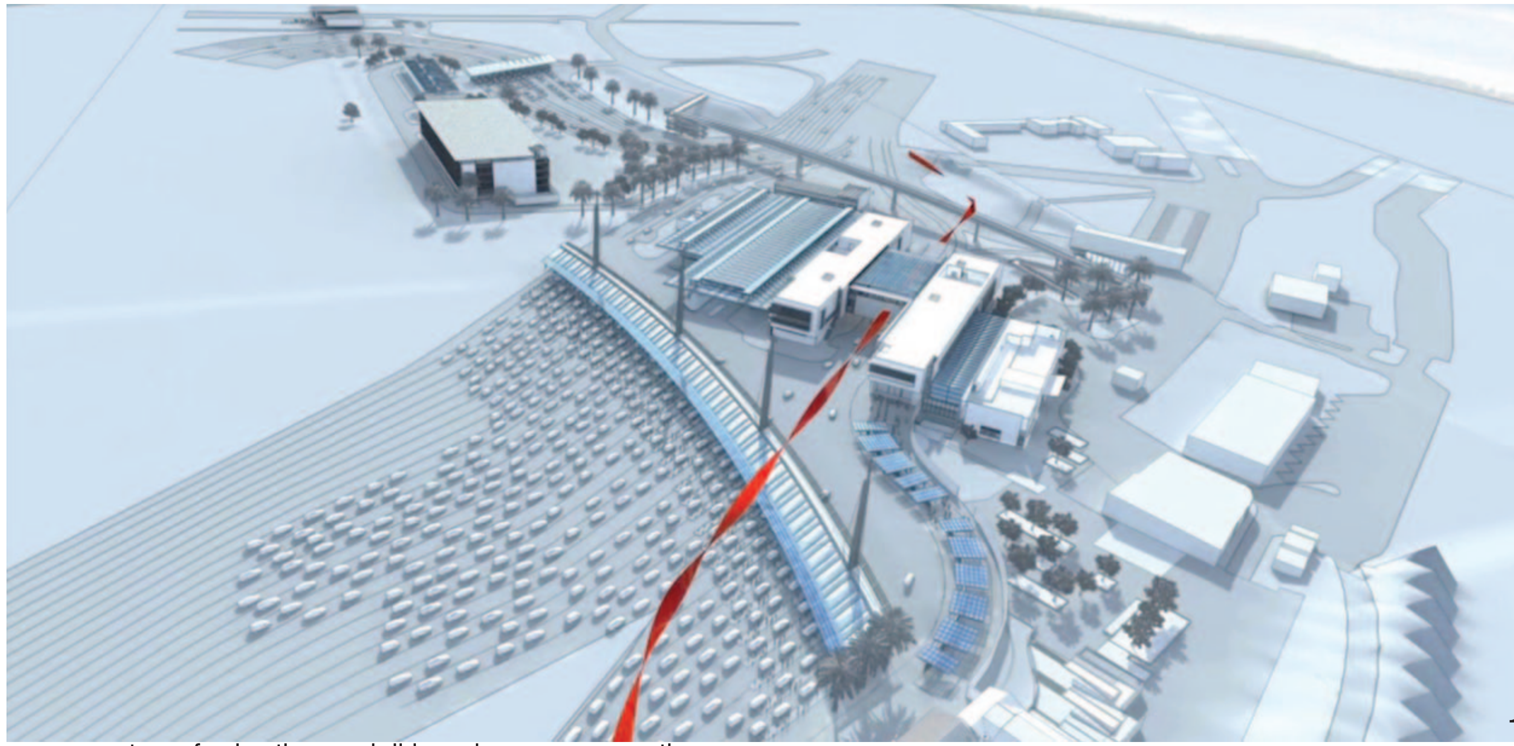
Grasshopper was a design tool which allowed the team to quickly generate several concepts for the Primary Canopy Towers through the use of parametric modeling, each iteration was subsequently provided to the engineer to be analyzed structurally. The geometry generated by Grasshopper allowed for a fluid check and balance between the architectural and structural reviews. Once the design was confirmed in Grasshopper it was transferred into the North Primary Structural Revit Model.



section cut of final canopy design in Revit

6 VIZ

The Project's Master Site Revit file was used in the animation program called Viz to clearly and creatively show the various aspects, views, and traffic flows of the site in a fly through animation. The Viz animation incorporated 2D watercolor renderings at the end of each scene which helped determine each animation sequence. This tool was extremely useful to present the concepts and features of the new design to the general public.

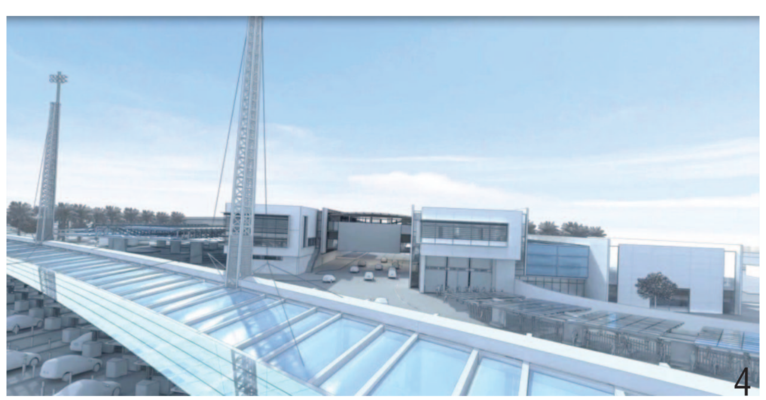


1

screen capture of animation - red ribbon shows camera path

2

3



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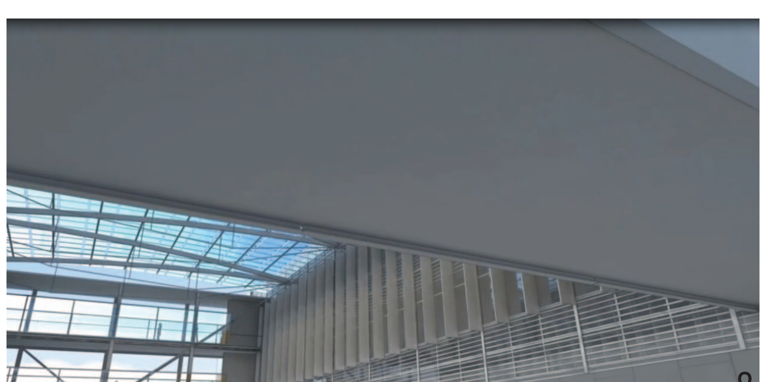

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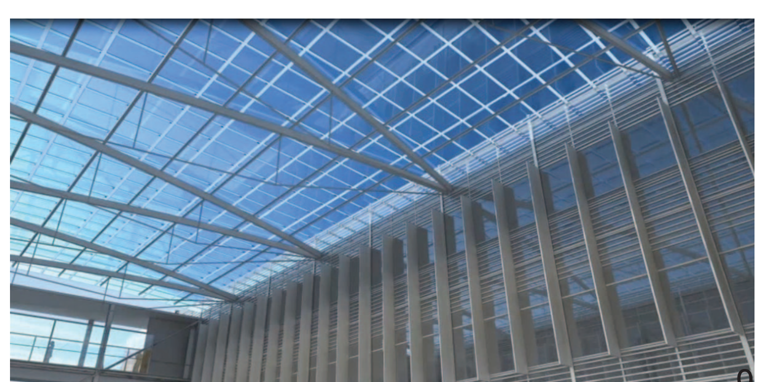

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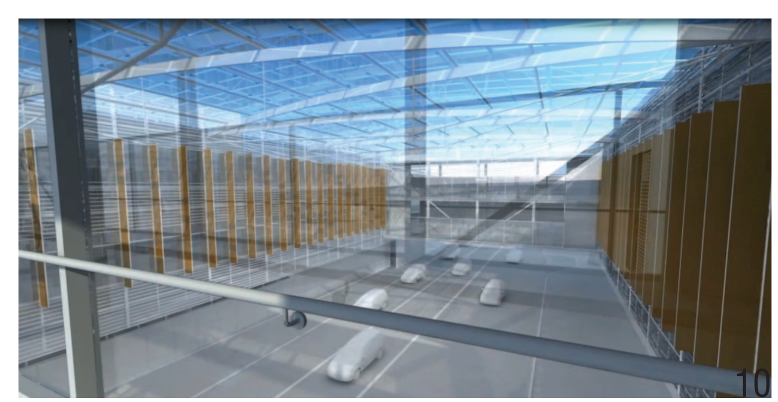
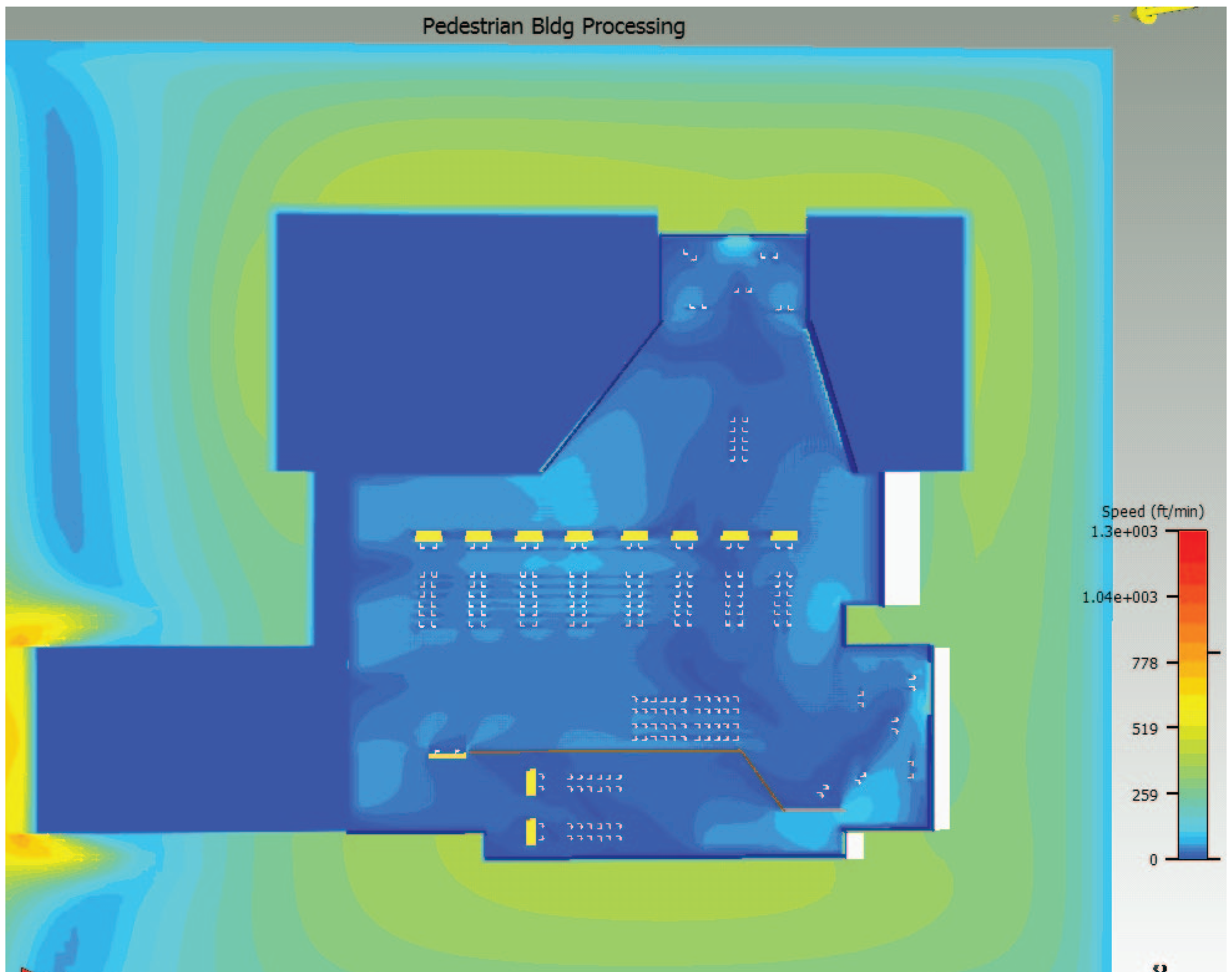


10

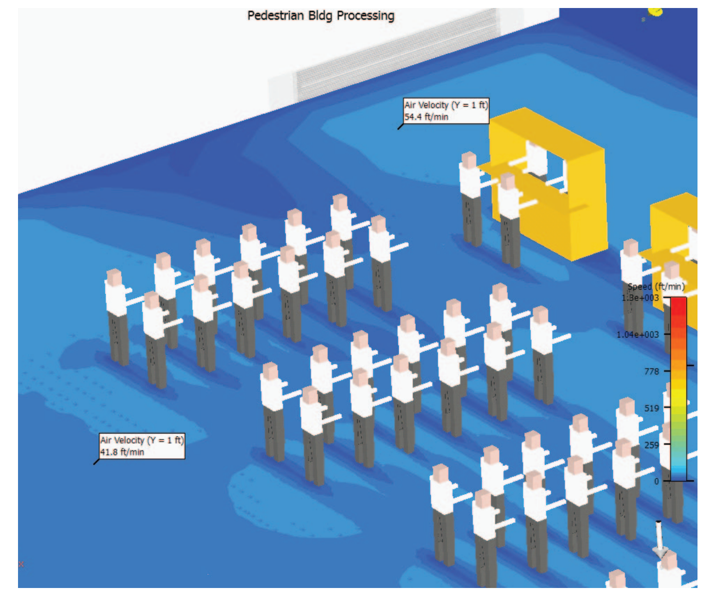
11

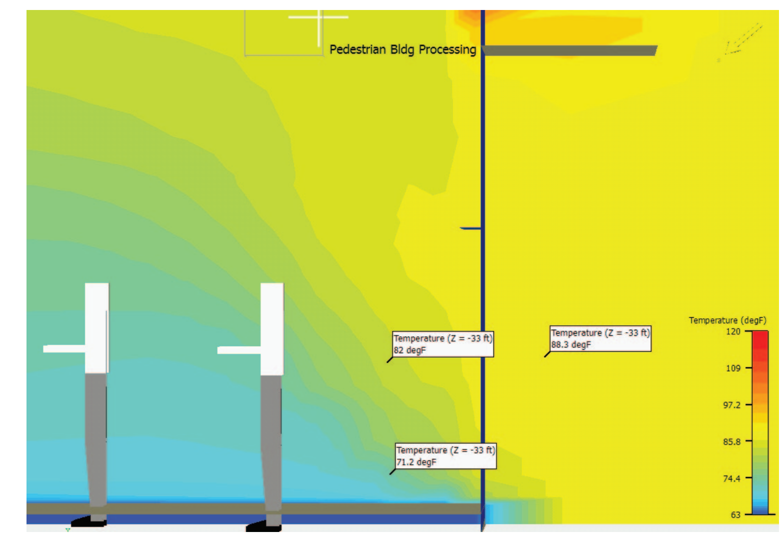
7 FLOVENT

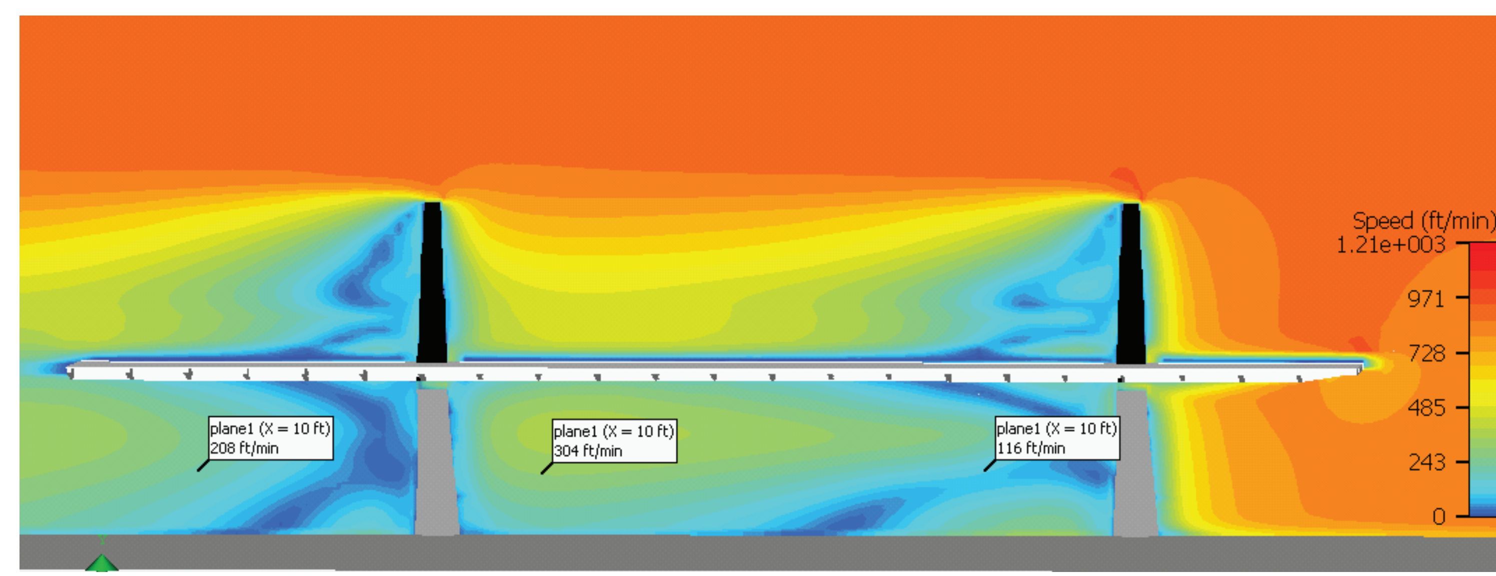
A Computational Fluid Dynamics (CFD) model was created from the Revit Model to analyze natural ventilation inlet and outlet locations and sizes in order to optimize the airflow through the space. The CFD model allowed the design team to simulate iterations of the space with design occupant and thermal loads in order to assess whether natural ventilation could provide effective passive cooling.



Flovent visual output of pedestrain processing airflow quantities

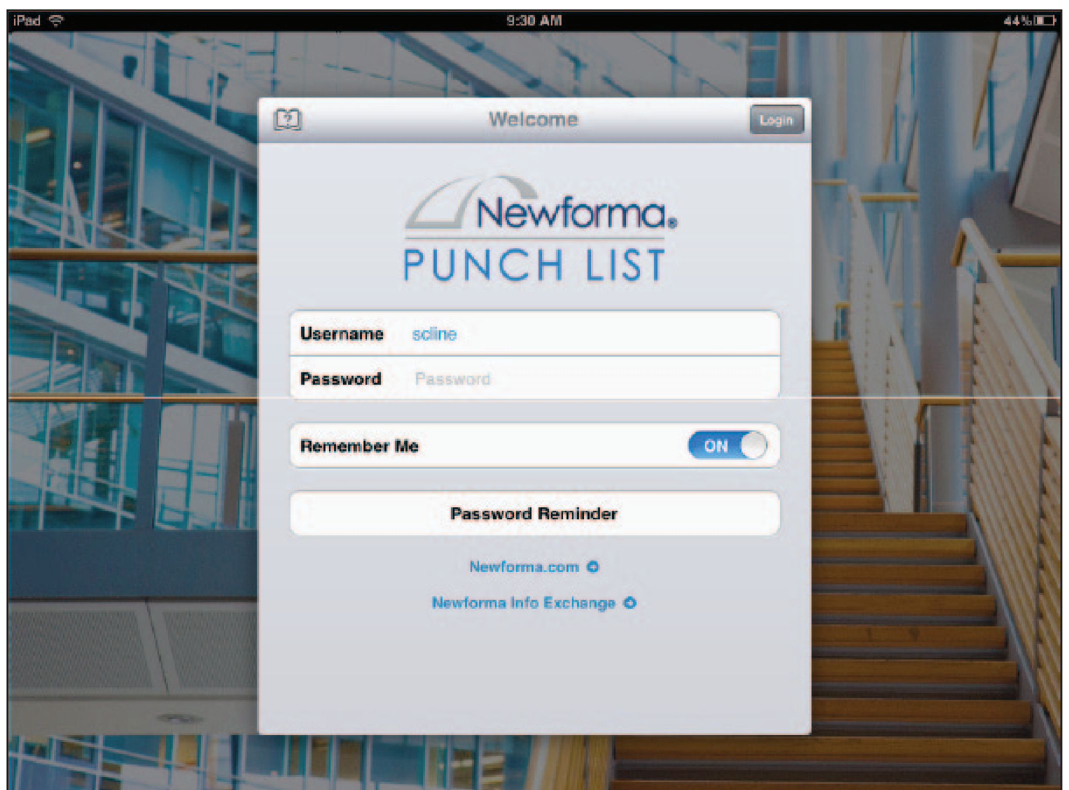




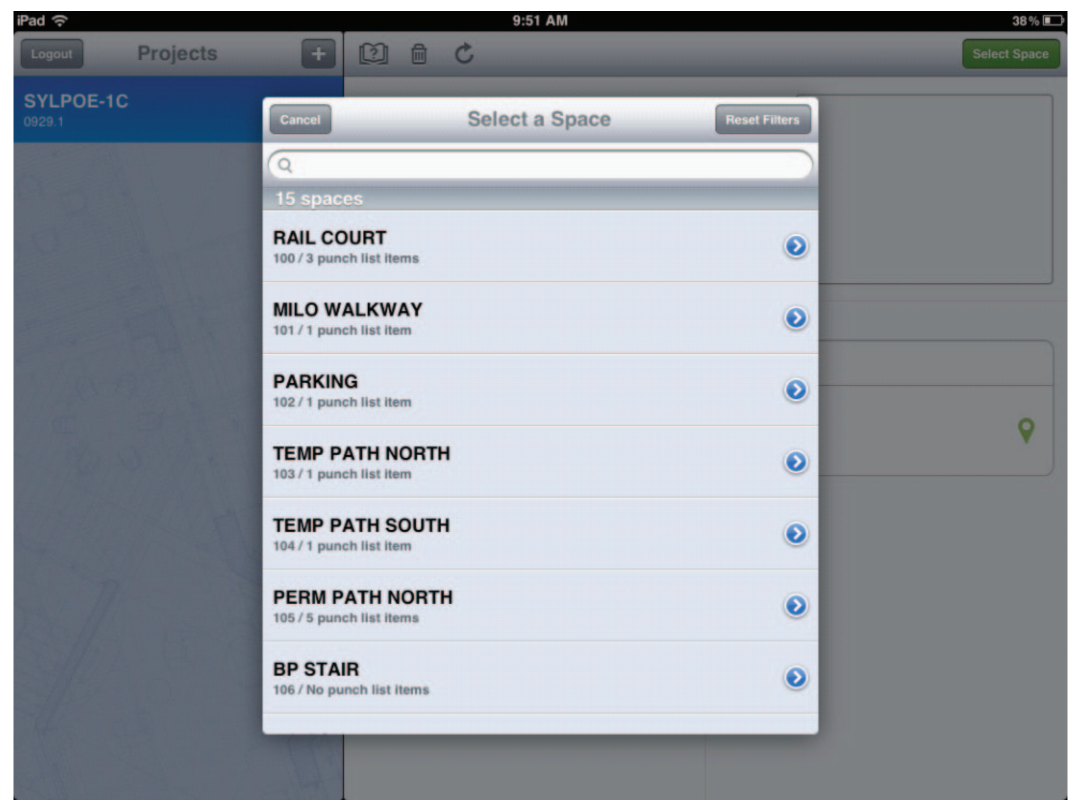


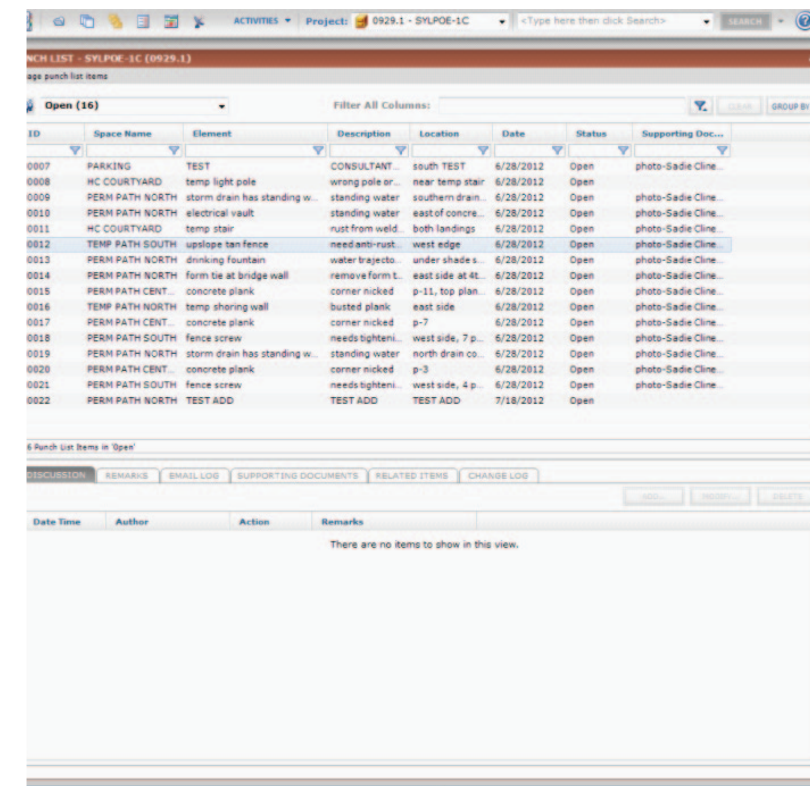
8 NEWFORMA: CA

Once in Construction Administration, the project has utilized the capabilities of Newforma to manage drawing releases, RFI's, submittals, and punchlists. The Punchlist links to the Revit model to generate room data that is transferred to an ipad for use at the job site and then linked to the Newforma Infoexchange site for the team to access.

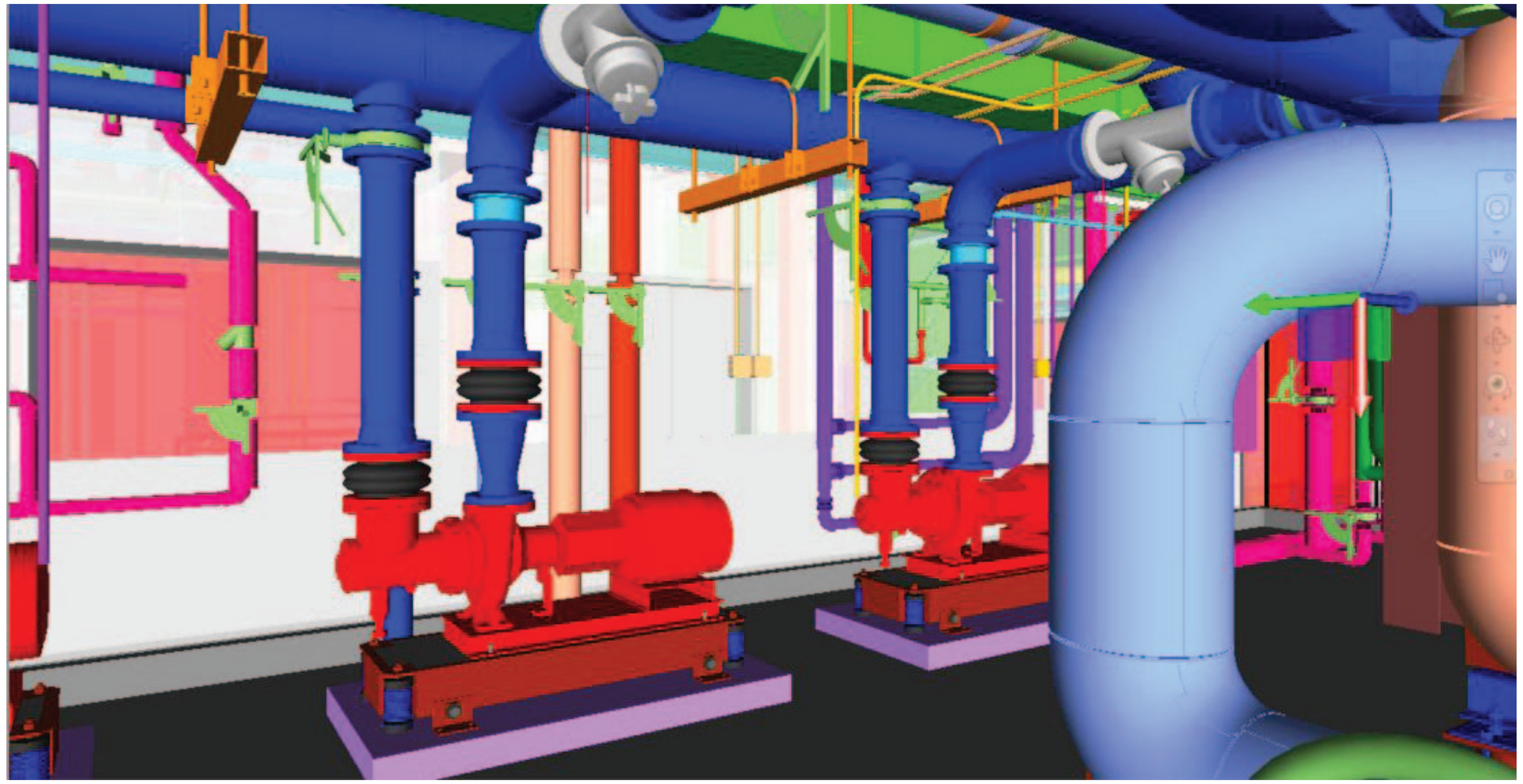


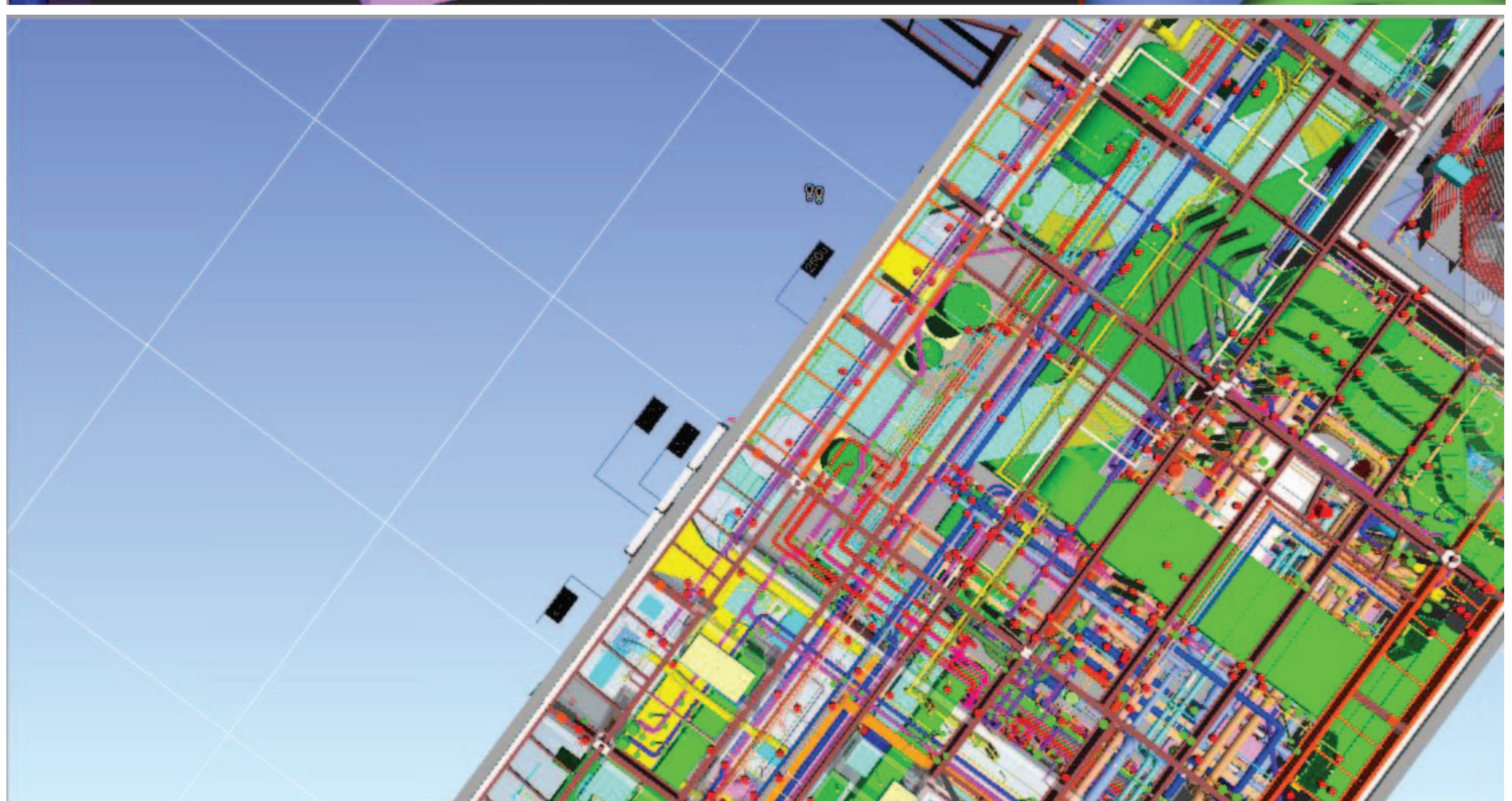
Newforma punchlist app for ipad



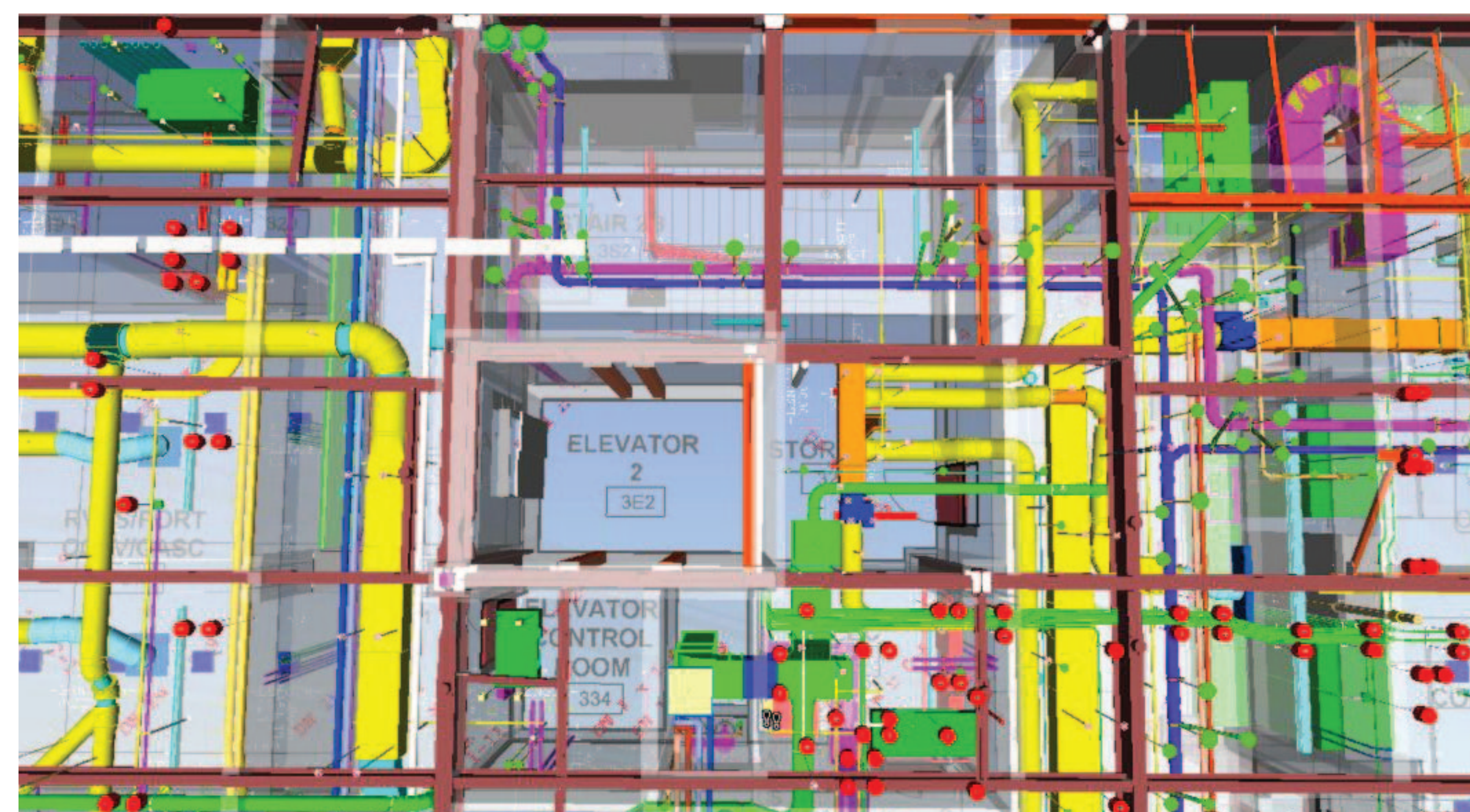


9 NAVISWORKS, SOLIDWORKS, TRADE SPECIFIC SOFTWARE





The design Revit models were issued to the contractor for coordination among various trades using Solidworks and Navisworks. Each subcontractor has their own trade-specific program that models their information while using the Revit model as a template. Early BIM coordination across trades has allowed for an effective and efficient clash-detection process prior to construction.



material from contractor coordination session