Verified Information Exchange and Handover

The Airport seeks to bridge the gap between how building information is delivered and how stakeholders use it for their business processes. Relevant information from multiple documents and sources should not be manually pieced together for infrastructure operations and management uses. The Airport recognizes that a standard structure and incremental collection and verification of infrastructure data through planning, design and construction make it possible to directly transfer verified information into the Airport's target systems (GIS, CMMS, financial and space management databases, etc.). The Element Attribute Dictionary (EAD) specifies a standard nomenclature for the Airport's BIM elements and attributes to ensure the development and verification of information are consistent across all projects. This makes facility data collection and handover more efficient and scalable. **Figure 04** is a conceptual illustration of how BIM is used at the Airport for authoring, verifying and handing over Infrastructure Data.

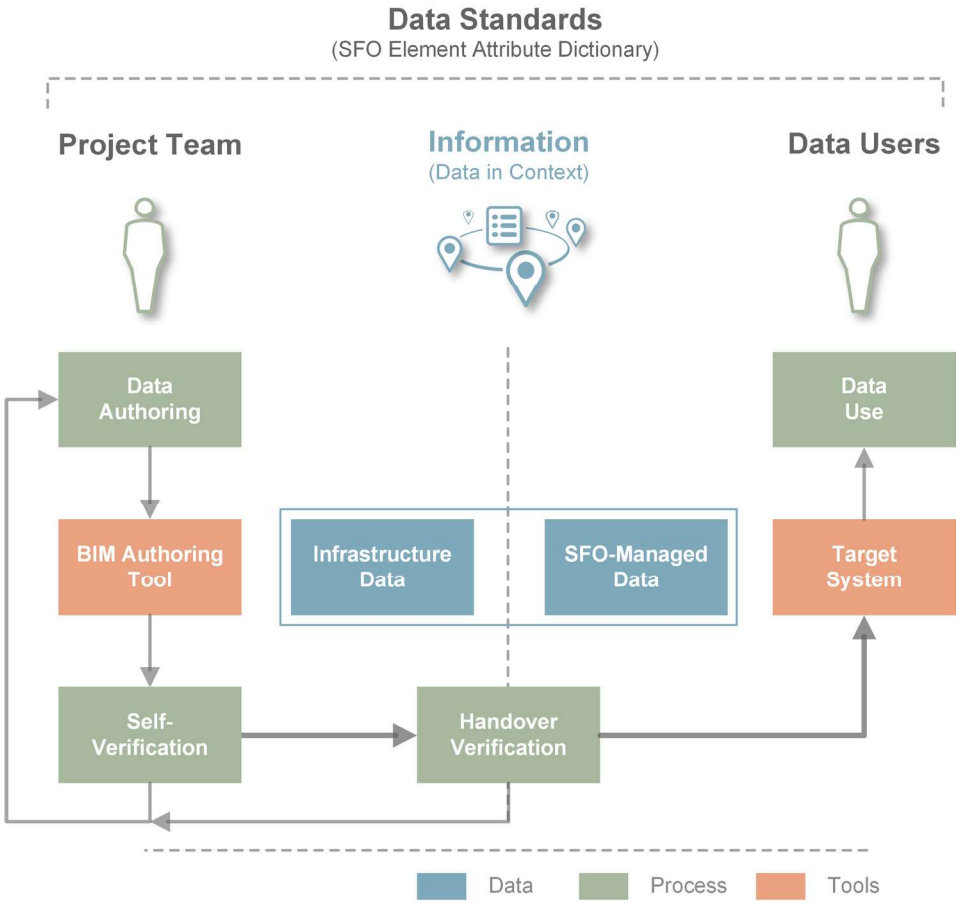


Figure 04. Handover of Infrastructure Data

BIM helps project teams align the facility and fixed asset data they develop with the Airport's strategic vision, operations and maintenance procedures. It also has uses that project teams can leverage to aid the efficiency and effectiveness of planning, design and construction work. These uses are described in the section titled "BIM Uses".

How the Airport uses BIM

The Airport uses BIM as part of VDC to support Stakeholder Engagement and Collaborative Partnering processes, and to ensure that design and construction information can flow into the Airport's target systems, through the implementation of an Element Attribute Dictionary, Data View Definitions and verification methods.

Furthermore, the Airport has adapted its organization to include a dedicated group of subject matter experts, the BIM Integration Team (BIT), to provide leadership for BIM implementation through each project's life cycle. The BIT functions as a bridge for the in-house stakeholders, design reviewers and project teams to ensure the correct implementation of the SFO BIM Guide. The BIT serves in-house architects and engineers to support their BIM goals. They also engage with capital project teams to develop standards and processes for data collection and verification, and enable Airport stakeholders to collect design and construction information.

Technology changes rapidly and solutions must be aligned with each project's scope. Project teams and the BIT collaboratively overcome challenges and develop solutions related to implementing software solutions to meet the Airport's goal.

BIM Uses

The Airport has identified and organized the following BIM uses during design, construction and operations into five categories. Project teams should use their knowledge and expertise to assess and align the use of BIM with their project specific scope and requirements, and address their plan for achieving the Airport's vision in the BIMx Plan. Their project specific BIMx Plans supports the definition of responsibilities across the entire team and provides a benchmark for how teams work together to execute BIM and deliver integrated infrastructure information.

Authoring

- Design Documentation
- Shop Drawings
- Digital Fabrication

Analysis

- Design Review
- Engineering Analysis
- Clash Coordination
- Virtual Mockups

Execution

- Logistics Modeling
- Supply Chain Management

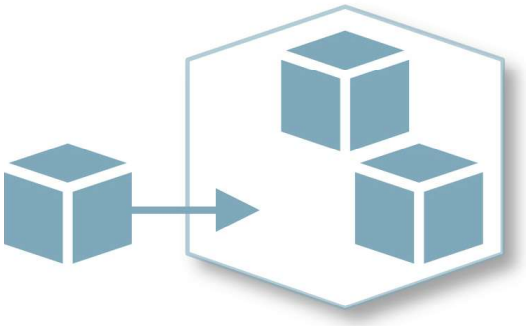
Verification

- Laser Scanning
- Model Data Verification
- Robotic Layout

Operations

- Facility Management
- Geographic Information System (GIS) Integration
- Space Management

Authoring



BIM replaces traditional CAD-based workflows with a more efficient content creation and documentation process. The models also enable processes such as digital fabrication by serving as the source files for machining technologies.

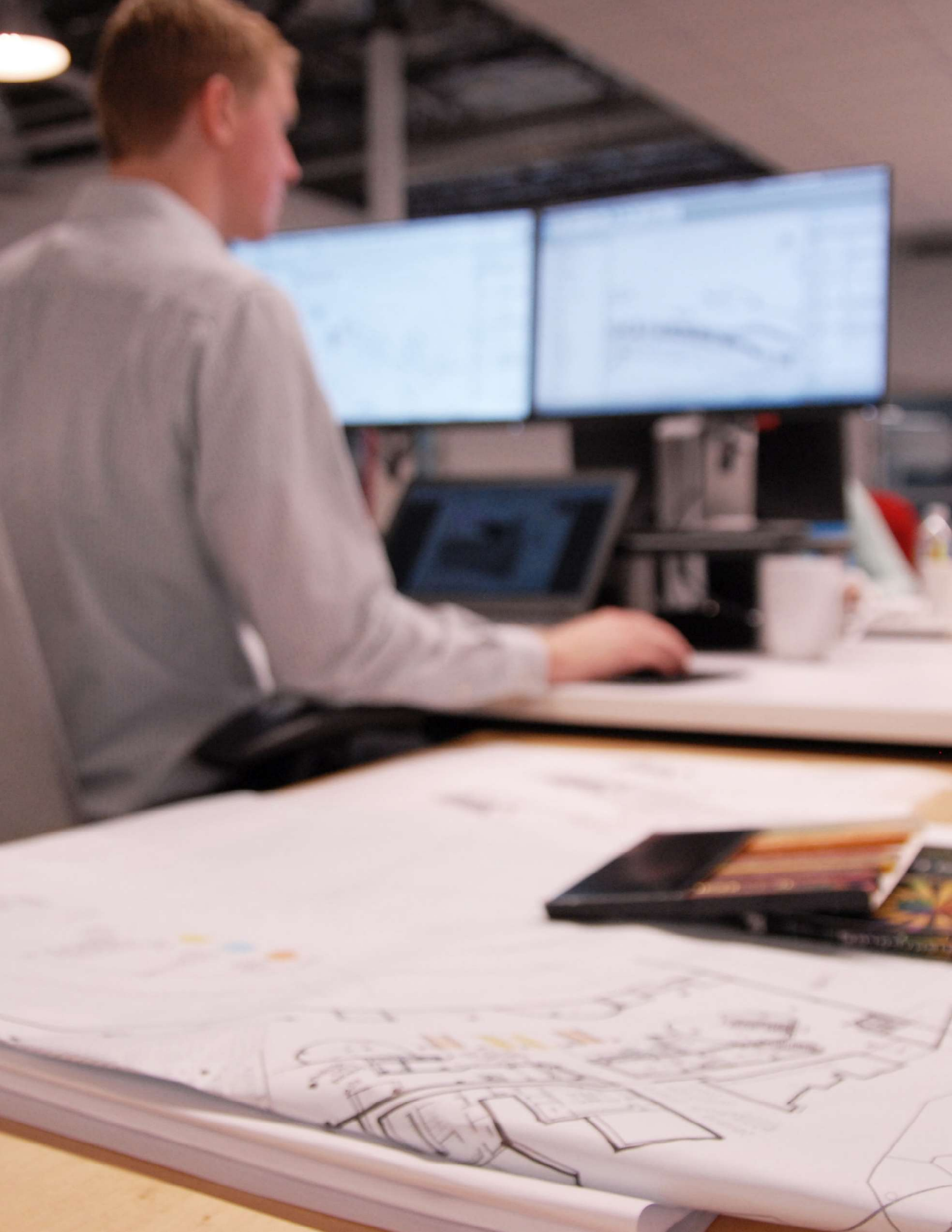
Design Documentation

What is it?

Design documentation is the process of translating the design intent for a building to a realistic virtual representation using a BIM authoring tool (i.e., modeling software). BIM authoring tools utilize a library of explicit 3D elements (also known as, objects or components) with embedded data, represented in the form of attributes or properties. The spatial location of the elements is automatically recorded and tracked in BIM. The relationship between these elements are governed by implicit rules and constraints that can be modified parametrically. Design documentation using BIM replaces individual static drawings with views generated from a virtual model. Therefore, changes made in one place are automatically propagated throughout the model. The primary BIM authoring tool used at the Airport for Architecture and Engineering is Autodesk Revit and Autodesk Civil 3D®. For detailed requirements see the SFO Revit Standard.

How does it benefit stakeholders at the Airport?

- Efficient design documentation, changes and review
- Supplementary uses of design models (e.g. analysis, visualization, coordination)
- Availability of uniform updated design models for re-design after handover



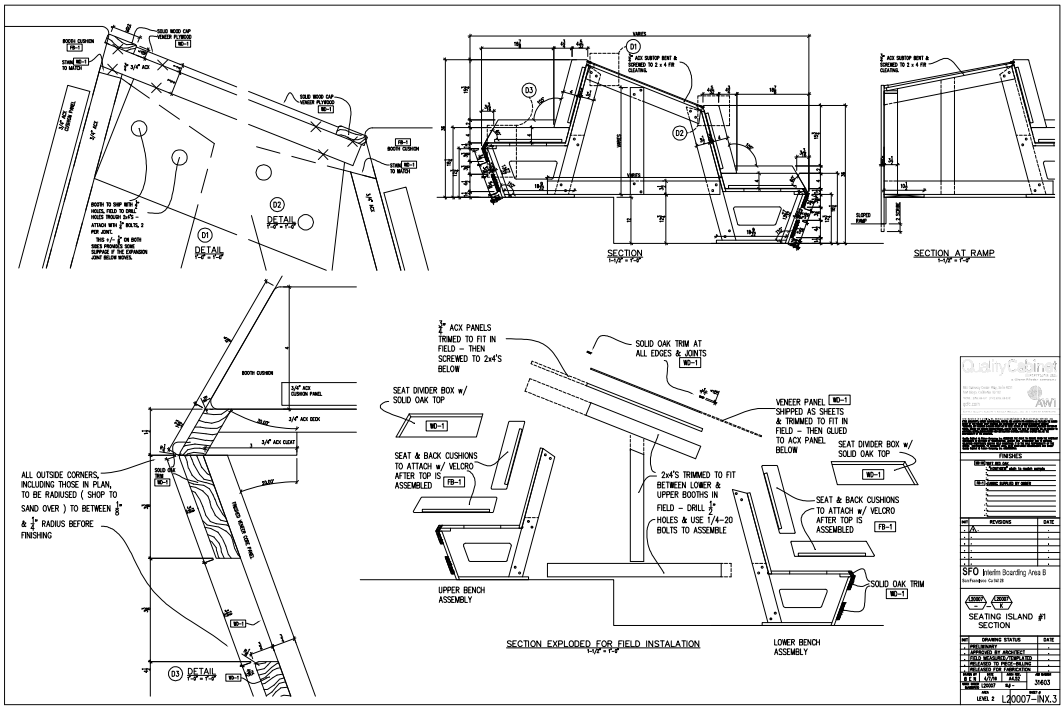
Shop Drawing Authoring

What is it?

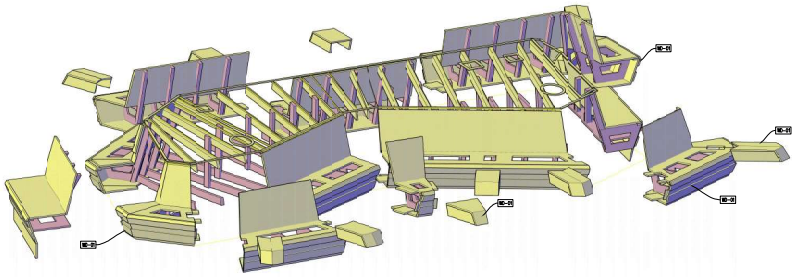
Trade partners create shop drawings, which include drawings, diagrams and schedules. These documents serve as a submittal for designers to demonstrate the approach to executing the work in accordance with the intent of the approved design documents. Shop drawings also communicate the fabrication and installation procedure to the fabricator and field installer. The trade partner can generate discipline specific shop drawings directly from a *fabrication model*, if created using a BIM authoring tool. As a best practice, trade partners manage a custom library of elements to streamline the production process. The practice of clash coordination ensures that the trade partners' models are coordinated, accurate and contain all the elements required by the approved design documents. Further detailing the coordinated model for shop drawings translates to quality fabrication and efficient installation in the field.

How does it benefit stakeholders at the Airport?

- Clear conformance between construction and approved design documents
- Accuracy and reliability of shop fabrication models (representing as-built conditions)
- Clear communication of design requirements to field installers

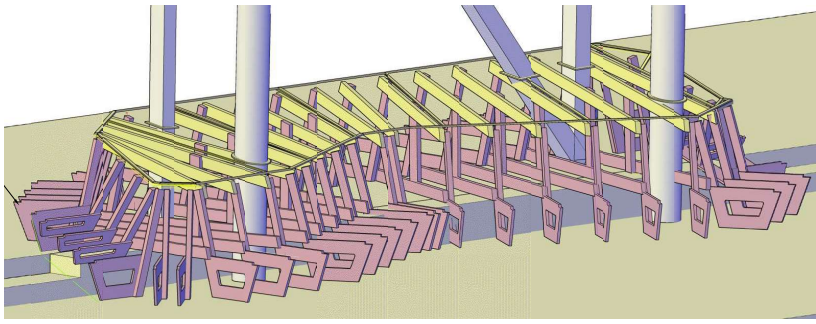


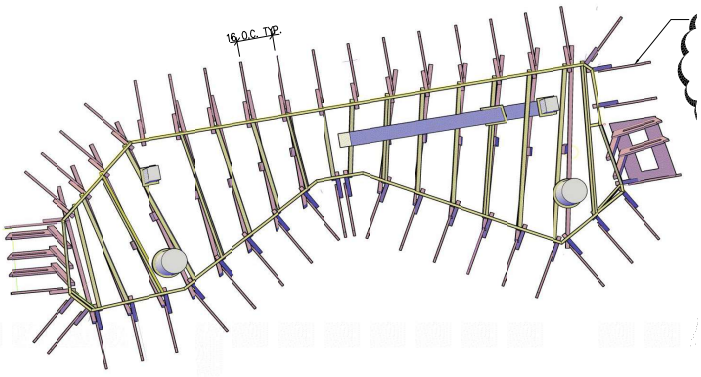
Digital Fabrication



What is it?

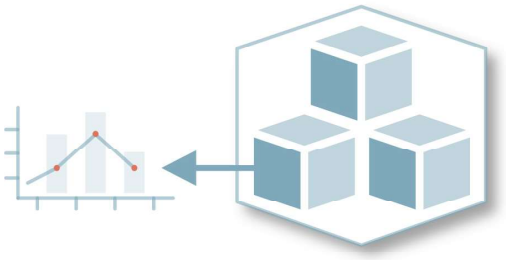
Digital fabrication is a computer-aided design and manufacturing process based on technologies such as Computer Numeric Control (CNC), laser cutting and 3D printing. Trade partners use this process to fabricate components from a source 2D or 3D model. Trade partners create highly detailed fabrication models that accurately capture all the components to be installed. This process is highly dependent on properly resolving conflicts during clash coordination to ensure accuracy of the fabricated components. Shop drawings are then generated from a 3D model, which can be set up such that the components are prefabricated off site using fabrication and machining technologies, pre-assembled as a kit of parts and shipped to the site ready to be installed.





How does it benefit stakeholders at the Airport?

- Clear conformance between construction and design intent
- Reduction of waste (material, labor, staging area etc.)
- Lean construction process
- Improves construction productivity
- Improves on-site safety



Analysis

BIM facilitates iterative design review at any stage of model development, providing the ability for stakeholders to visualize decisions made during the design process. Accurate geometry in 3D models enables clash coordination and virtual mockups by enabling collaboration, communication and decision making in a virtual environment prior to building on site.

3D Design Review

What is it?

The Airport reviews building designs at project milestones to ensure alignment with project requirements and to confirm the outcome of design decisions. The design review also serves as a platform for the project team to highlight design related issues and discuss potential solutions in upcoming project phases.

BIM supports design review by Airport stakeholders, who are not experienced designers and engineers, but are active users of building information. It allows comprehensive feedback from these stakeholders by offering the ability to view and navigate assets and related information in 3D space. BIM also enhances the review process with an additional perspective that traditionally was not possible because of the significant time to generate, but now is inherent to the design process. In addition, BIM allows design teams to perform iterative design review on multiple design options as part of schematic design and development, which leads to exceptional project outcomes.

How does it benefit stakeholders at the Airport?

- More efficient design review by Airport stakeholders
- Improve accessibility and facilitate design review for non-practitioners
- More efficient design review with multiple design options

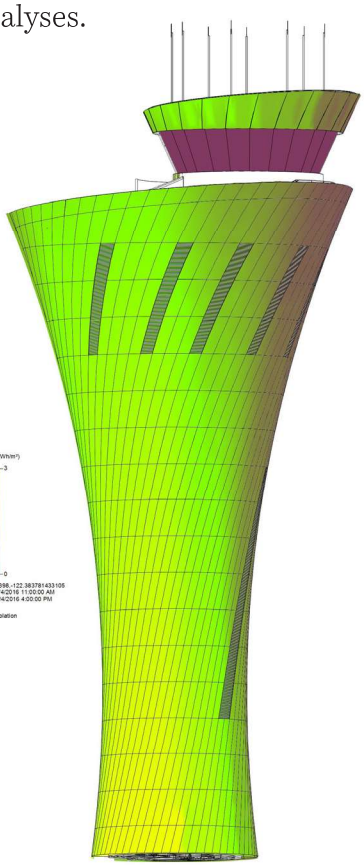
Engineering Analysis

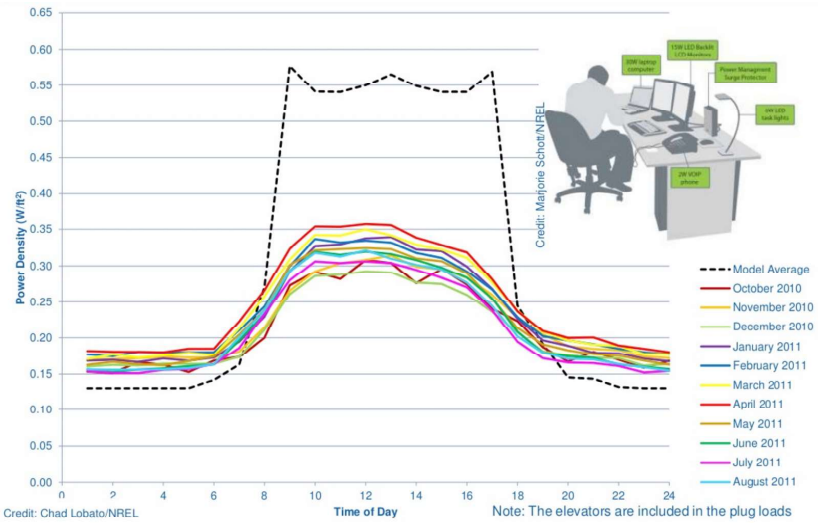
What is it?

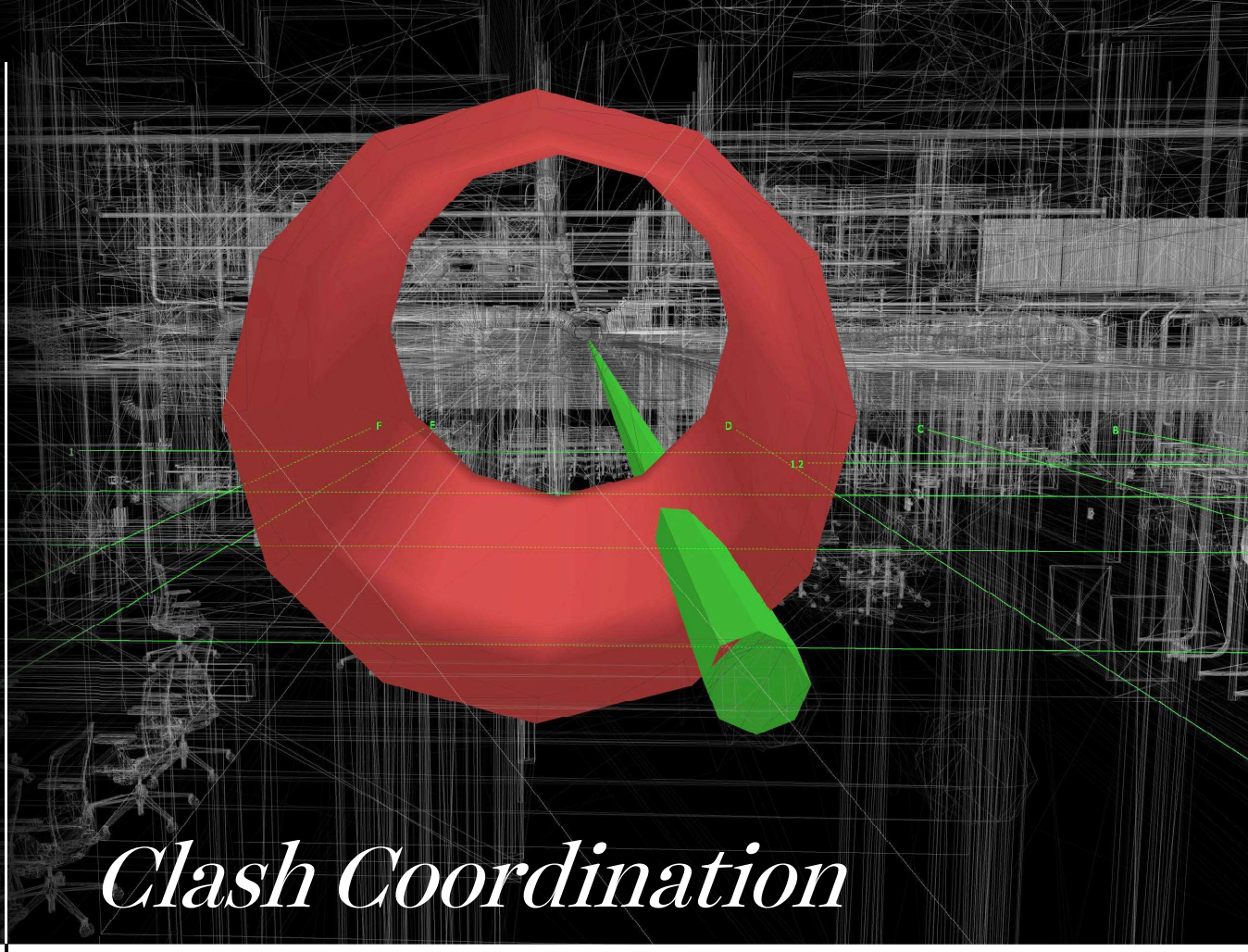
Designers and builders use BIM analysis tools with information rich 3D models to simulate engineering options based on design and performance specifications for mechanical, electrical, structural, lighting and sustainability factors. Examples of these analysis tools include energy modeling, seismic modeling, queing modeling and flexibility modeling. These analysis tools help in better decision-making for project teams, assess the viability of their design, improve the design of the facility, and manage sustainability and resiliency in the facility life cycle. Various software applications require specific modeling standards to perform these analyses.

How does it benefit stakeholders at the Airport?

- Design and engineering efficiency
- Improves decision-making
- Enhances feedback and design review
- Better performing facility







Clash Coordination

What is it?

Clash coordination or clash detection are terms that refer to the process of resolving design conflicts in a federated model using a BIM based coordination software such as Autodesk Navisworks®, with the primary goal of eliminating design and construction conflicts prior to fabrication and/or installation. A federated model is the combination of all distinct discipline and trade models from project teams to create a single representation of the building or facility.

Through the process of clash coordination, each discipline-specific model is compared to another to determine if building components are occupying the same physical space. This is known as a "hard clash". A "soft clash", also known as a "clearance clash", refers to components that violate a minimum clearance requirement, tolerance requirement or are in conflict with components that have not yet been modeled. Project specific clash coordination workflows are documented in the BIMx Plan developed by the project team.

How does it benefit stakeholders at the Airport?

- Resolves issues before anything is fabricated
- Reduces waste, rework and construction delays due to redesign
- Reduces design tolerances due to increased design accuracy
- Increased efficiency and optimization of components