Part One
BIM at SFO

What is BIM?

A Building Information Model (BIM) is a digital representation of the Airport's assets and infrastructure that consists of model elements that represent spaces, infrastructure components, and building systems that comprise the facility. The model elements represent physical geometry and attributes that describe functional and performance characteristics of the infrastructure. An important characteristic of BIM is the ability to automatically associate model elements with their containing spaces (locations) in the virtual environment.

In basic terms: BIM = Virtual Model (3D Geometry + Location) + Data **(see Figure 01).**

The ability to locate model elements in virtual space aligns naturally with Geographic Information System (GIS), which is founded on the association of data and spatial relationships. Finding and querying model elements by location is critical for accessing information by all stakeholders, and is supported by the integration of BIM and GIS at the Airport.

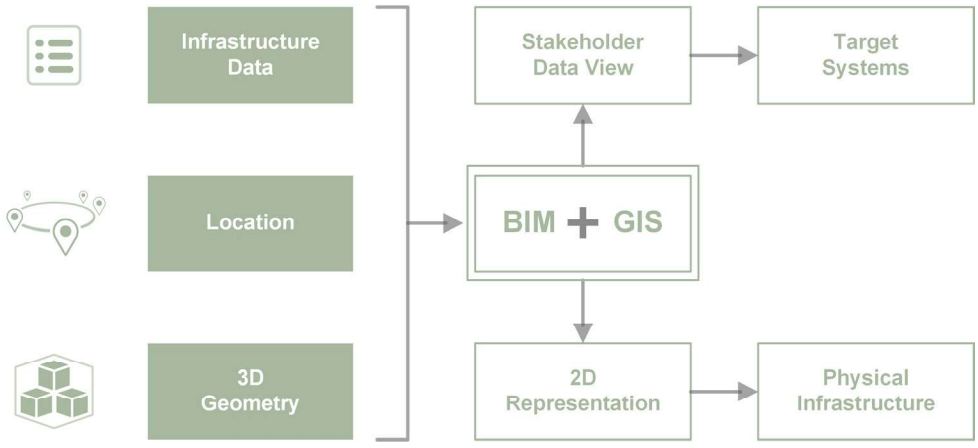


Figure 01. BIM and GIS at the Airport

BIM is an enabler of Virtual Design and Construction (VDC). VDC is the management of integrated multidisciplinary performance models of the Airport's facility and fixed assets, including existing, planned and current infrastructure in development, as well as concurrent and collaborative work processes, and organization of the planning - design - construction - operations team in order to support explicit business objectives. VDC is a collaborative process that aligns with the Airport's methodology for exceptional project delivery through the stakeholder engagement process, partnering and collaborative systems. VDC is facilitated by goal alignment and the shared commitment to partnering and by technologies such as GIS and BIM. The Airport is establishing a centralized integrated infrastructure information platform for the collection of data associated with design and construction projects. This will enable the Airport to deliver sustainable and resilient infrastructures with optimized life cycle values, streamlined operational processes, and minimized cost of operations and maintenance.

BIM, VDC, and GIS are concepts that are synonymous with successful design and construction projects. The wide-ranging definitions of BIM create different perceptions of what BIM encompasses. In the Architecture, Engineering, and Construction community, BIM is commonly referred to as Building Information *Modeling*, when a process is described, and a Building Information *Model* when a product is described.

For the purposes of the Airport, BIM is a digital representation of the product and VDC is the collection of processes and methods that support integrated and concurrent, planning, design, construction, operations and maintenance of its infrastructure.

Why the Airport uses BIM

The Airport believes in the benefit of BIM for the facility life cycle because it supports the approach to project delivery, improved quality of data and streamlining the communication of building information. The Airport is actively involved in collaborating with project teams for goal setting and implementation in terms of BIM uses, best practices, standards, and tools. This ensures that projects develop consistent content that the Airport can use throughout the infrastructure's life cycle.

The following goals highlight the Airport's top priorities of BIM use. They are complementary to the BIM uses defined by project teams for design and construction.

1. Improved documentation and review
2. Data consistency through all lifecycle phases
3. Verified information exchange and handover

Improved Documentation and Review

BIM use in the planning, design, construction and operations phases facilitates design, analysis, documentation, review, pre-construction and construction coordination. These activities are primarily executed by designers, builders and trade partners. The SFO BIM Guide specifies performance requirements for such uses, while allowing builders the flexibility to meet the project specific goals and requirements. The Airport has established design documentation requirements for the use of Autodesk Revit, as described in the attachment "SFO Revit Standard". **Figure 02** conceptually illustrates the use of BIM at the Airport for documentation and review.

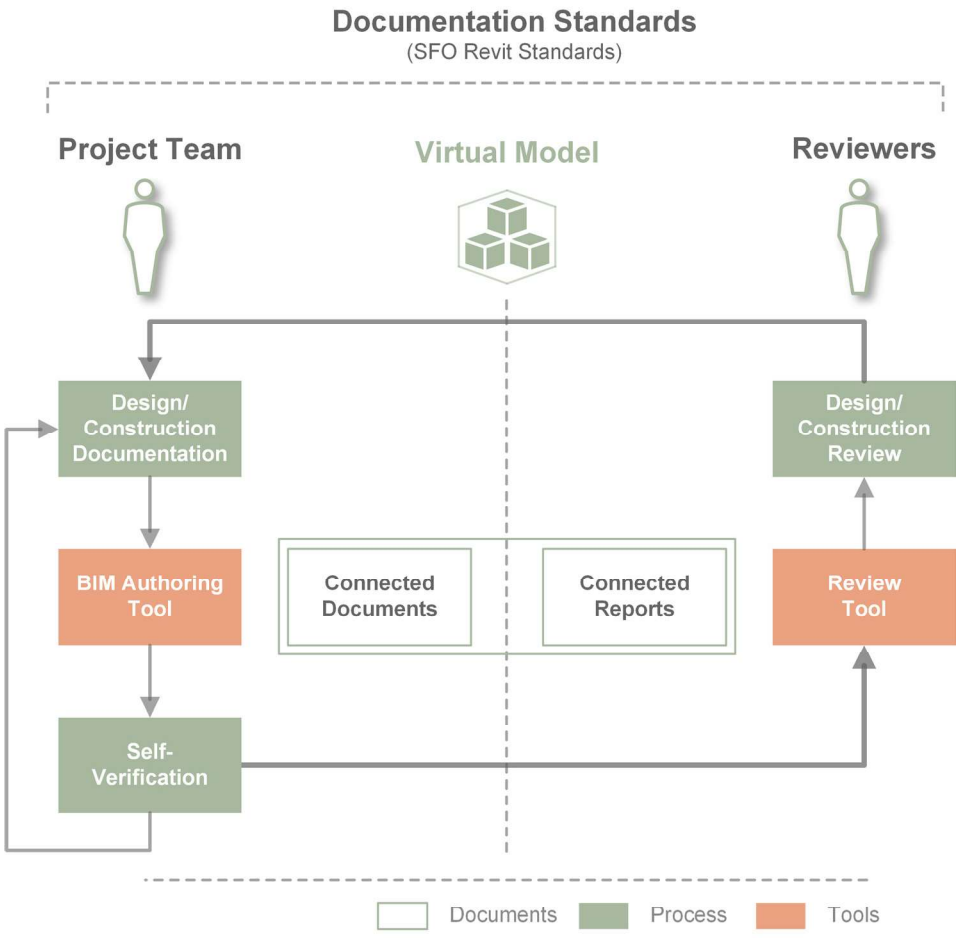


Figure 02. Documentation Standards at the Airport

Data Consistency through all Life Cycle Phases

Model-based data can be used during all phases of an infrastructure's life cycle. Some of this data is created by project teams during one phase and used during another. The SFO BIM Guide promotes continuous and consistent data authoring and verification through data standards, i.e., it specifies what data must be delivered, the data format and the verification criteria. The SFO BIM Guide also encourages project teams to determine how they develop data, by suggesting best practices, given specific project needs and project delivery methods. **Figure 03** illustrates the concept of the incremental collection of infrastructure data through design and construction and the transition to As-Managed Data.

Incremental data collection and verification focuses on the point of data authorship for project stakeholders e.g., designer, builder, trade partners, commissioning agent, etc. This has the effect of breaking a large effort into smaller and more manageable ones and leveraging the project specific and professional knowledge of original data authors who are most familiar with the work product.

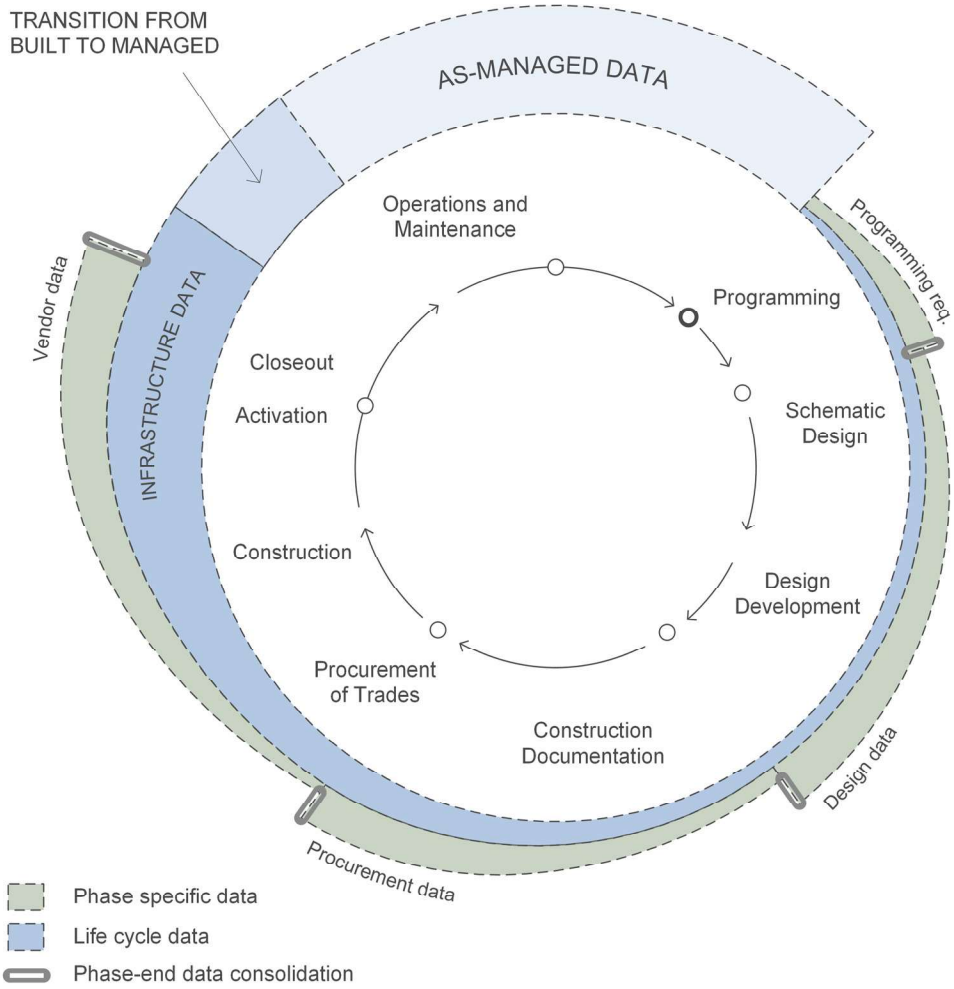


Figure 03. Data Through Life Cycle

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.

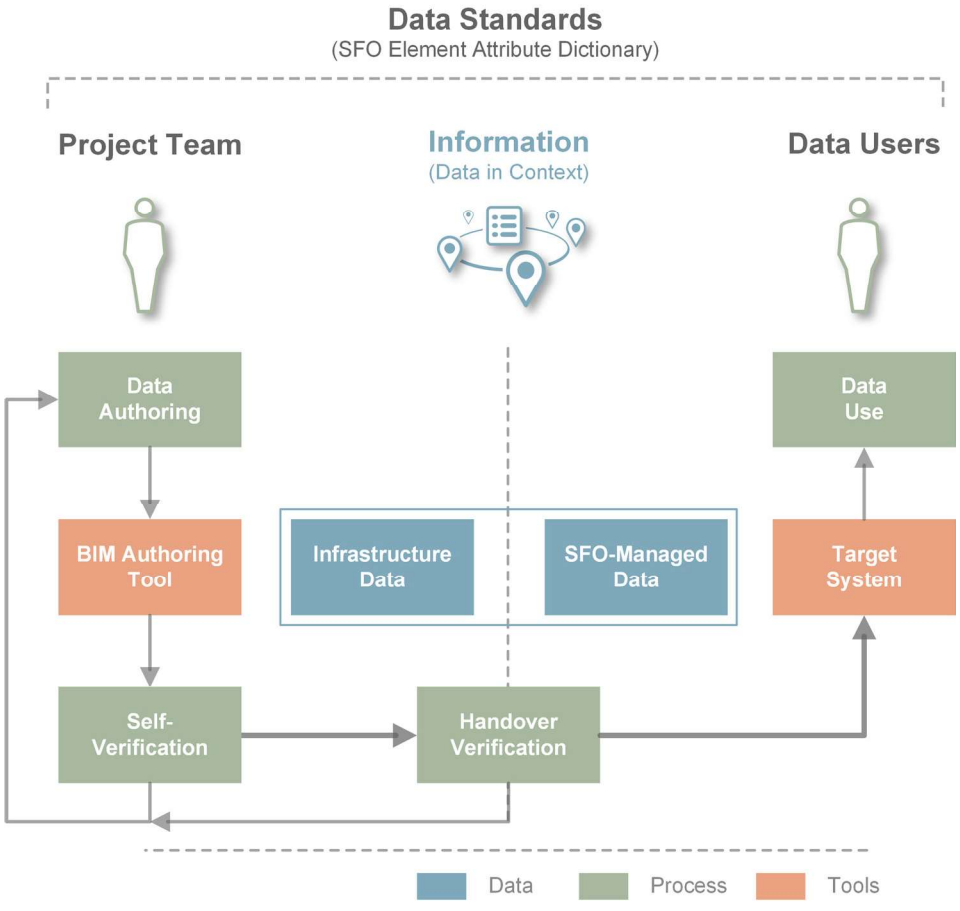


Figure 04. Handover of Infrastructure Data

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

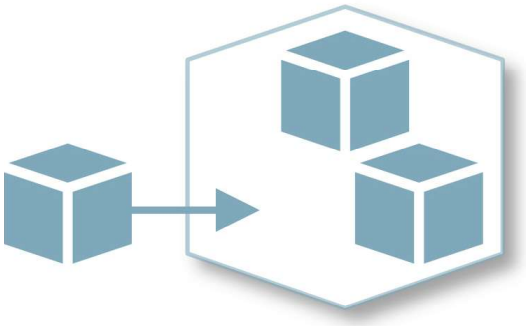
Verification

- 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.

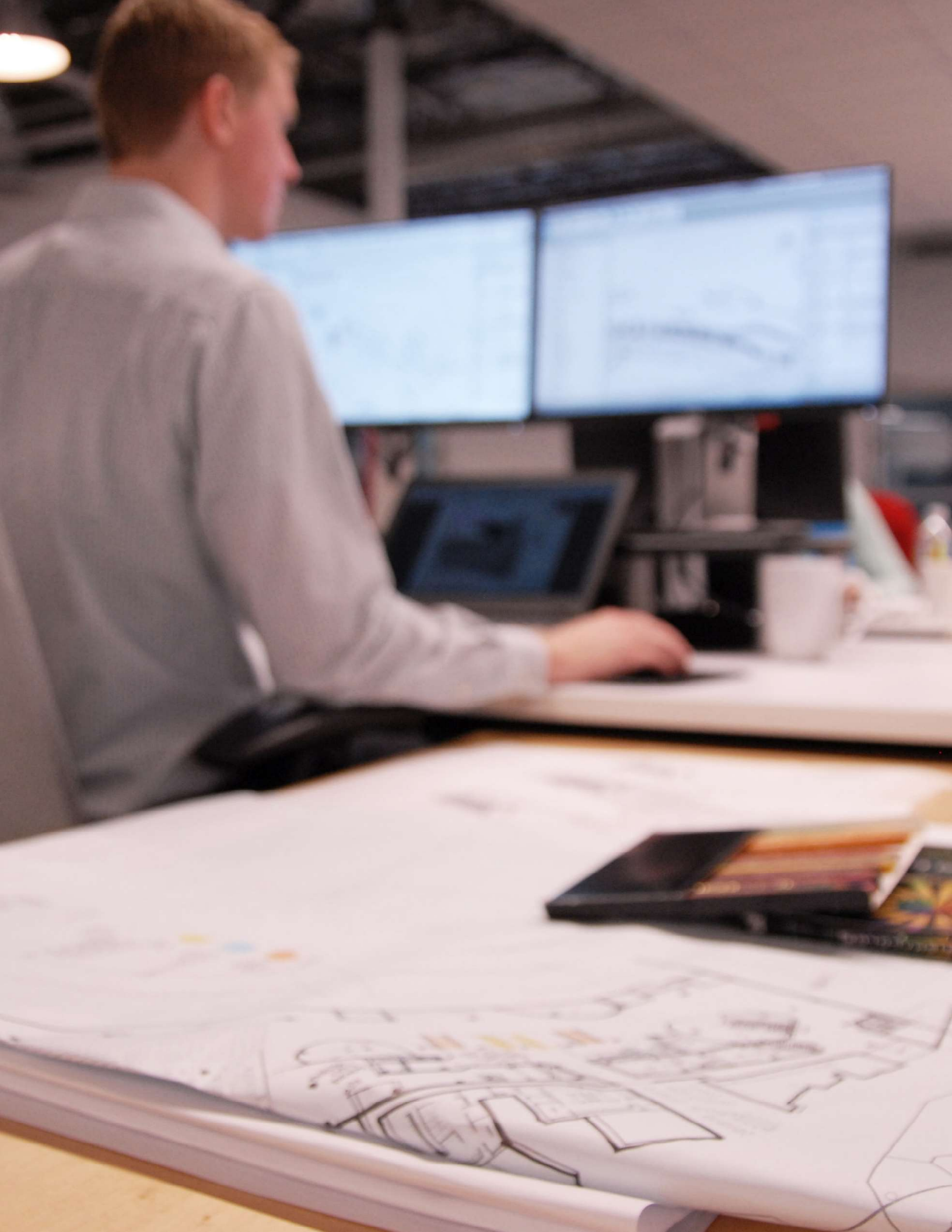
Design Documentation

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



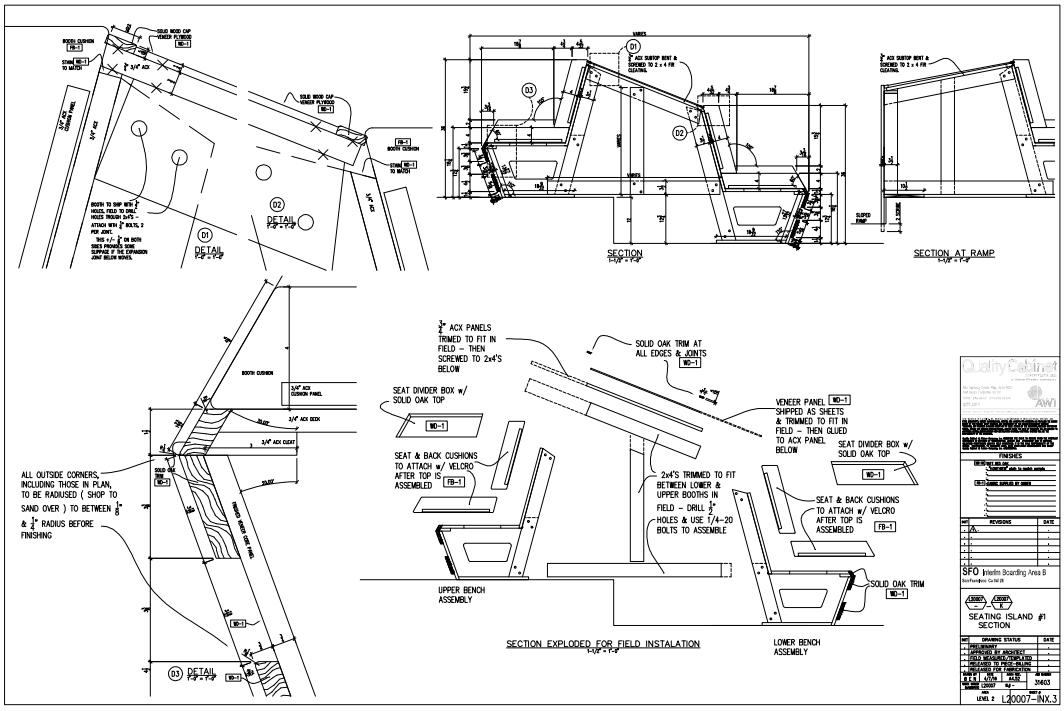
Shop Drawing Authoring

What is it?

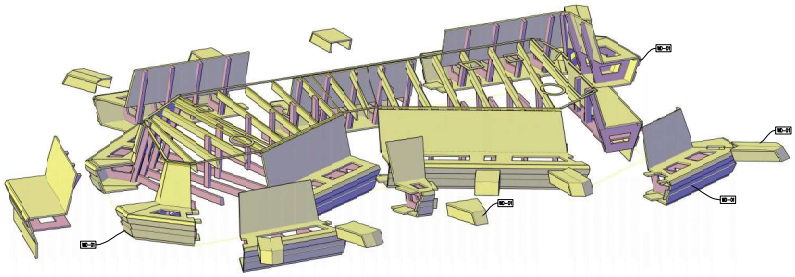
Trade partners create shop drawings, which include drawings, diagrams and schedules. These documents serve as a submittal for designers to demonstrate the approach to executing the work in accordance with the intent of the approved design documents. Shop drawings also communicate the fabrication and 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

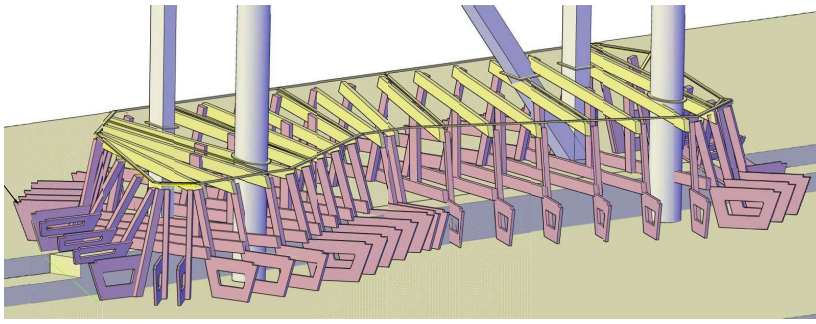


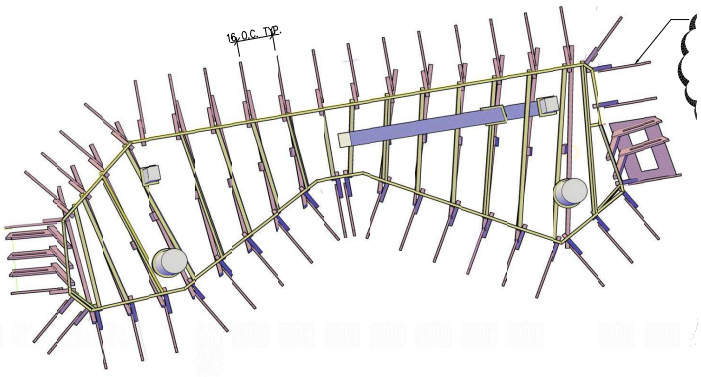
Digital Fabrication



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