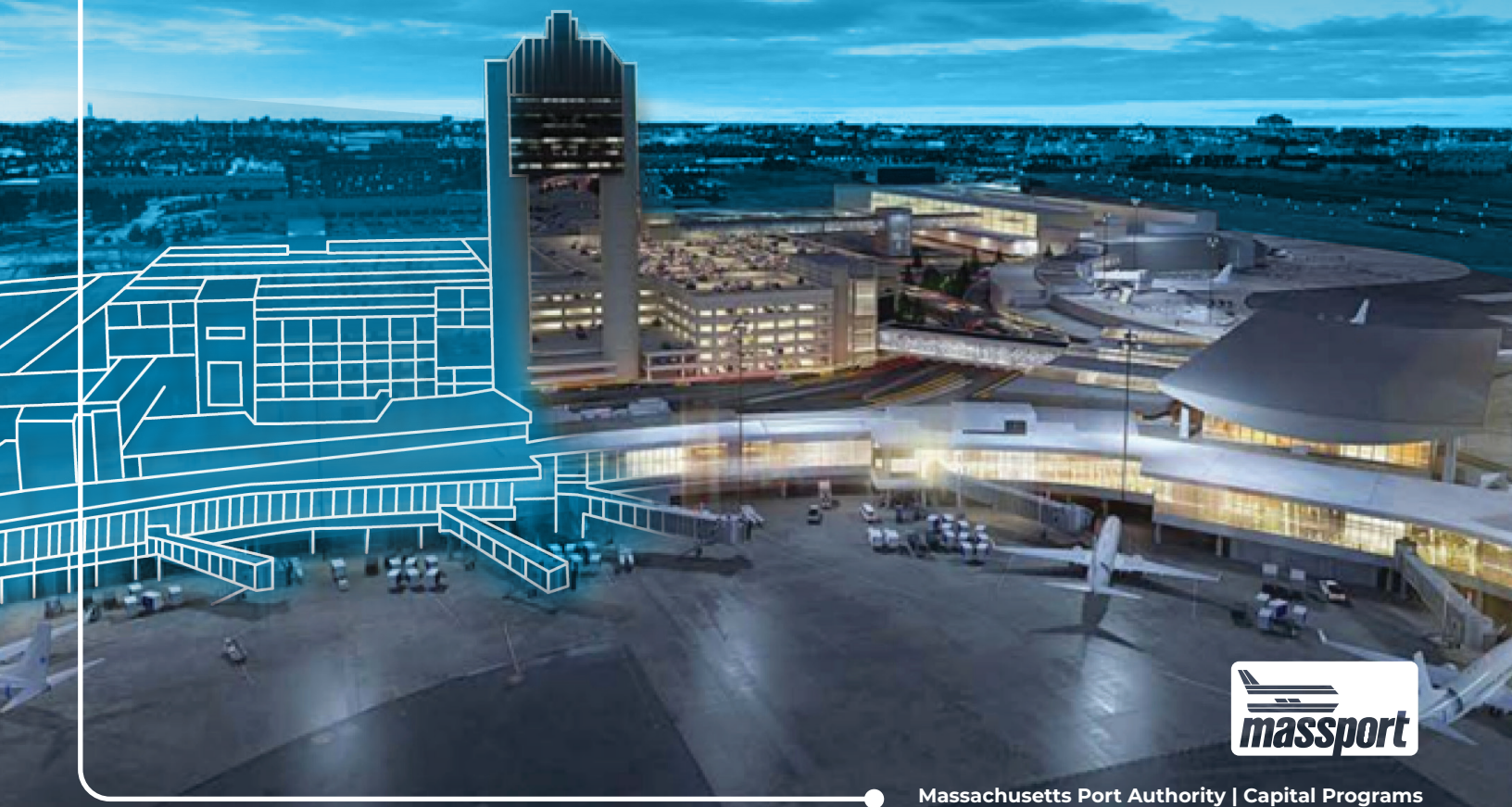


MASSPORT

Virtual Design & Construction

VDC GUIDE





**THE MASSACHUSETTS
PORT AUTHORITY (MASSPORT)
VIRTUAL DESIGN AND CONSTRUCTION
(VDC) GUIDE**

2025

MASSPORT CAPITAL PROGRAMS

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MASSPORT VDC VISION

As the Chief Infrastructure Officer at Massachusetts Port Authority, I am proud to lead Massport's efforts in shaping the future of our built environment. Our mission is to deliver state-of-the-art facilities prioritizing innovation, customer value, safety, and sustainability. By embracing cutting-edge digital technologies, we are setting new industry standards and redefining project delivery.

At the heart of this transformation is the Digital Technologies Integration Group (DTIG). Through collaboration with exceptional design and construction partners, both locally and nationally, we are pushing the boundaries of what's possible in project management and execution. My vision is clear: to drive innovation, foster teamwork, and ensure that our projects not only add value for our customers but also make a lasting, positive impact on the communities we serve.

Our commitment to digital excellence is reflected in the introduction of our VDC Guide and new BIM Standard—essential tools that enhance collaboration and maximize the potential of emerging technologies. From digital twins and AI-driven generative design to robotic construction and AI-powered facilities management, we are confidently embracing the future.

Together, we have the opportunity to lead the industry, leverage technology to its fullest potential, and create a smarter, more resilient built environment.

Let's build the future—innovatively, collaboratively, and with purpose!



**Luciana Burdi,
Intl. Assoc. AIA, CCM,
MCPPO, NAC, FCMMA**

Chief Infrastructure Officer

**"DO NOT GO WHERE THE PATH MAY LEAD,
GO INSTEAD WHERE THERE IS NO PATH AND
LEAVE A TRAIL."**

— Ralph Waldo Emerson

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INTRODUCTION

The Massachusetts Port Authority (Massport) Virtual Design and Construction (VDC) Guide, VDC Roadmap, and the BIM Standard replace the 2013 BIM Guidelines and BIM Roadmap as the required documents for project delivery. The intended audience includes project stakeholders, clients, design and construction service providers, subcontractors, and suppliers.

The VDC Guide explains the rationale, team roles, collaboration strategies, Lean tools, and integrated BIM process requirements for delivering innovative VDC projects. The VDC Guide includes current and aspirational goals for teams to work toward. Primary goals for VDC adoption include process consistency across the supply chain, best-in-class Model-first design and construction, standardized models, and data deliverables supporting Massport's lifecycle asset business objectives. The BIM Standard provides updated modeling processes, data standards, and collaboration requirements. The Guide includes:

VDC GUIDE SECTIONS

Section One The BIM Roadmap Journey 2012-2025

Section Two The VDC Roadmap 2025-2030

Section Three VDC Project Requirements

Section Four VDC Project Execution

Section Five Project Resources

APPENDICES

Glossary Terms and Definitions

Appendix 1 Technology Innovations

Appendix 2 VDC and Lean Tools List

Reference Project References & List of Figures

ADDITIONAL REQUIRED DOCUMENTS

- **BIM Standard** - The companion document providing the prescriptive and technical BIM Stage Two standards and requirements for executing a Model-first strategy on VDC projects.
- **VDC Roadmap** - Goals for VDC adoption and project delivery within Massport's enterprise asset lifecycle. Resources and documents - [Digital Technologies Integration Group \(DTIG\)](#)

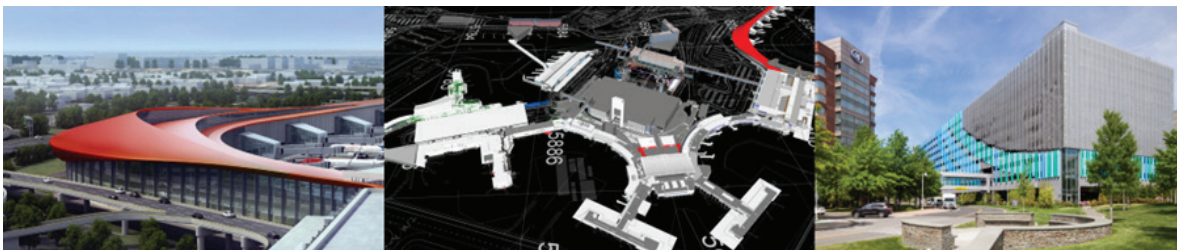
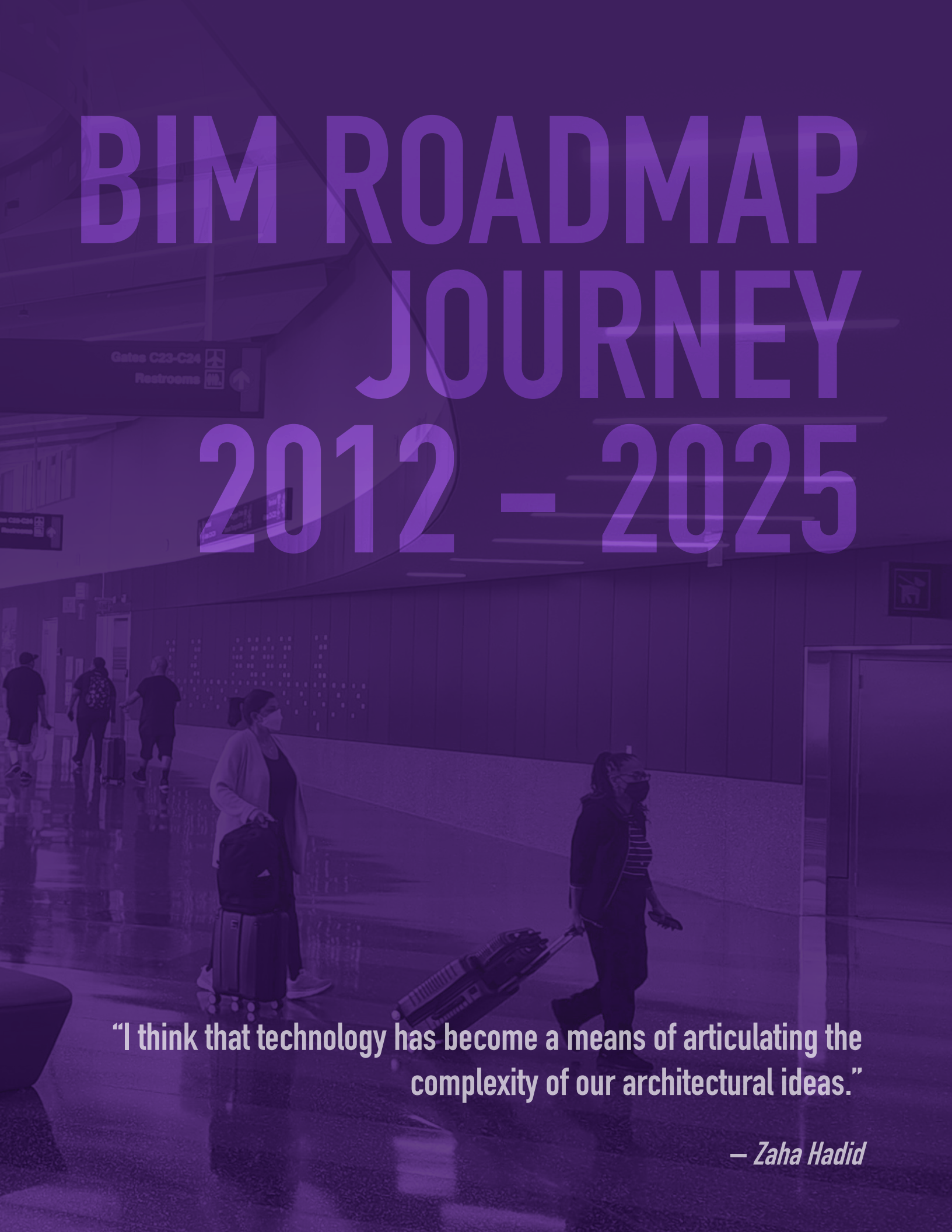


FIGURE 1 — Massport Model Projects

BIM ROADMAP JOURNEY 2012 – 2025

A purple-tinted photograph of an airport terminal. In the foreground, two women are walking towards the right, each pulling a suitcase. The woman on the left is wearing a light-colored cardigan and a face mask. The woman on the right is wearing a dark jacket and a face mask. In the background, other people are walking, and a large digital display board is visible. Above the display board, a sign reads "Gates C23-C24" and "Restrooms". The overall scene is a busy airport terminal.

"I think that technology has become a means of articulating the complexity of our architectural ideas."

— Zaha Hadid

1. BIM ROADMAP JOURNEY 2012 – 2025

In 2012, Massport established its BIM and Lean standards, enhancing processes, adding value to projects, minimizing waste, and mitigating construction risks. The Massport BIM Guidelines were the first owner-driven BIM requirements to integrate Lean management for project delivery. The design and construction teams at Massport reviewed the BIM Guidelines, assisting in the prioritization of BIM and Lean strategies for upcoming projects.



FIGURE 2 — Massport BIM Journey

The 2012 BIM Guidelines provided Massport with higher-quality information for decision support. Lean management tools enhanced the organization's ability to manage projects, and BIM in construction reduced production waste and field changed orders. BIM supplied additional data for facilities asset management.

Massport developed additional resources to support BIM implementation in capital projects. For example, they reviewed various project delivery systems, including Design-Bid-Build (DBB) and Construction Management at Risk (CM@Risk) for building and design-build for infrastructure projects. Subsequently, the team developed legal and contractual addenda related to BIM requirements to be included in project contracts.

In addition, Massport utilized a Lean Deployment Plan (LDP) to manage additional project requirements. The LDP workflows aimed to establish a framework for team collaboration, commitment-based planning, and more efficient project delivery.

1.1. MASSPORT BIM PROJECTS - LESSONS LEARNED

Massport successfully executed projects using the BIM Guidelines through 2025. These projects piloted the integration of BIM technologies and Lean collaboration processes. Lean/BIM integration is transformative, and the benefits include:

- Reality Capture laser scanning provides accurate existing conditions as a foundation for projects.
- Models and virtual mock-ups resolve design and construction issues, saving time and costs.
- BIM is used as a strategic asset database, enabling Massport to achieve higher data quality for asset management.
- BIM visualizations inform project decisions, reducing design and construction issues, errors, and risks.
- Lean management tools, including the Last Planner® System, Choosing by Advantage (CBA), Target Value Delivery, and Plus/Delta, provide a structure for promoting “good behavior” by project teams.

Massport’s lessons learned showed the value of early design options modeling, virtual planning, and using BIM as a robust design and construction tool. The projects helped Massport improve future project delivery.

Terminal E Crescent

New Large Aircraft Wing (NLA)



FIGURE 3 — Terminal E Crescent

Key Project Data

- 96, 000-square foot addition and renovation.
- Reconfigure three existing gates to accommodate A380 Group VI aircraft.

Project BIM Uses

- Multi-trade BIM coordination during design and construction.
- 4D BIM visualization.
- Scan to BIM of existing conditions.

Lessons Learned

- Geolocation of existing conditions scan to model.
- CM, Trades, and Sub-Contractors use of BIM workflows in construction.
- Develop VDC workflow and Lean tools.

B-C Roadway Projects

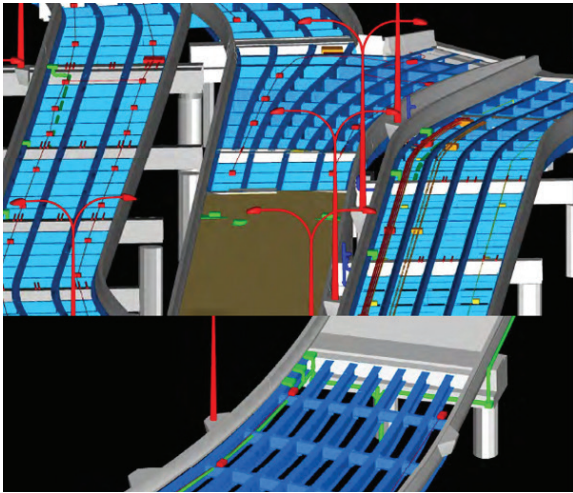
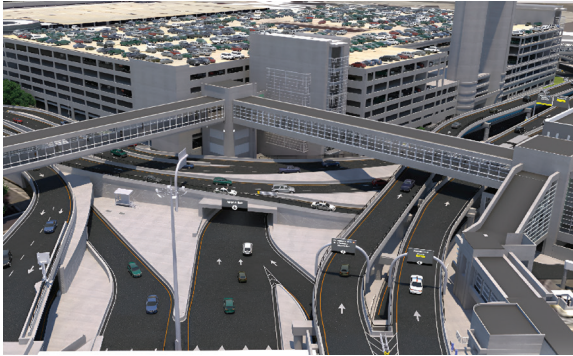


FIGURE 4 — B-C Roadway Project

Key Project Data

- Deconflict B-C roadways - develop dedicated roadways.
- Bridge utility tie-ins.

Project BIM Uses

- BIM 4D construction phasing
- Traffic and schedule simulations.
- Scan to BIM of existing conditions.
- Construction coordination digital workflows.

Lessons Learned

- Reduced variability and risk.
- Reduced logistics issues during construction.
- Scenario planning to manage facility access during construction.

West Garage Extension



FIGURE 5 — West Garage Extension

Key Project Data

- 10-story garage expansion, pre-cast concrete prestressed double tee beams
- Dynamic wall panels

Project BIM Uses

- Scan to BIM of existing conditions.
- BIM-based reviews.
- Conditions of Satisfaction.

Lessons Learned

- BIM-based signage location reviews.
- A-3 landscape design alternatives
- Virtual Mock-ups and detailing for stakeholder participation.

1.2. SUMMARY OF THE VDC ADOPTION CHANGES

Massport has used its BIM projects and industry advancements to develop an outcome-driven approach to VDC project delivery. VDC maximizes BIM use and Lean management within an integrated design and construction framework, enhancing the quality and reliability of project models and data throughout the project lifecycle. The project deliverables add significant value to the asset management program.

VDC “MODEL-FIRST” APPROACH

The Model-first approach uses BIM to enable a project’s virtual design and construction simulation. BIM Stage 2 (BIM-S2), and when contractually possible, a design-assist process ensures that a constructible model is followed during construction. This approach:

- Establishes trust in the design model’s constructability
- Requires collaboration between the design and construction teams
- Increases issue resolution during design and design assist
- Reduces construction errors and field changes
- The Record, As-Built models, and asset data meeting Massport’s BIM standards are required deliverables that are managed throughout the project with support and reviews from the Digital Technologies Integration Group.

ISO BIM MATURITY STAGES

BIM Maturity Stages, as outlined in ISO 19650-1, encompass modeling processes, data management, and cloud-based collaboration, all of which are essential for effective project execution. Massport’s BIM has aligned with BIM Stage 1 (BIM-S1), some 3D modeling, 2D CAD, file-based model federation, and limited data standards.

VDC projects require BIM Stage 2 (BIM-S2), which includes process and data requirements, a cloud-based common data platform, a collaborative modeling environment, standardized data exchanges, and project-specific BIM Uses. Such advancements facilitate data-driven decision-making throughout the asset lifecycle, encompassing design, construction, and operational phases.

Massport aims to reach BIM Stage 3 (BIM-S3) by 2030. BIM-S3 maturity is distinguished by superior integration and interoperability across diverse systems. This stage prioritizes the adoption of open standards, the utilization of shared databases, real-time collaboration, and the seamless integration of enterprise systems.

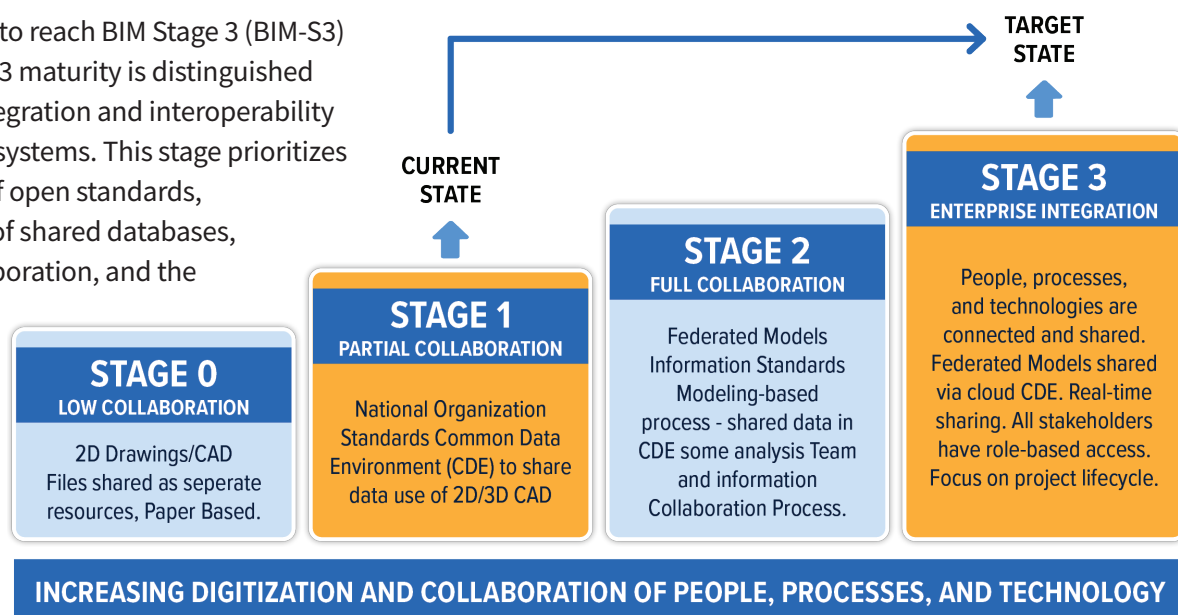


FIGURE 6 — BIM Maturity Stages

PROJECT MANAGEMENT FRAMEWORK

The project management framework is a set of principles, tools, and processes governing project activities, team responsibilities, schedules, and performance metrics. This framework is developed during the Project Success Plan, where teams define the project's Conditions of Satisfaction, project milestones, Lean Collaboration, and project tools, as well as BIM Uses, roles, and responsibilities.

HIGH-PERFORMING TEAMS

Companies typically have different cultures, capabilities, and work methods. It is in Massport's interest that teams establish trust, unify, and collaborate effectively. VDC projects rely upon teams to coordinate their efforts and utilize collaborative technologies to develop project information effectively, reducing risk and waste.

DATA STANDARDS AND COLLABORATION INFRASTRUCTURE

Massport has embraced both national and international standards for effective information management. To ensure that the right information reaches the right individuals at the right time, it is essential to establish a common data environment, clarify information responsibilities, and implement a process for the efficient exchange of standardized models and data. The BIM Standard provides Massport's BIM and data requirements.

PROJECT CONTRACTING AND DELIVERY SYSTEMS

Massport has increased its use of CM@Risk for facility and Design/Build for its infrastructure projects. Project Teams utilizing all project contracts and delivery systems, such as Design-Bid-Build (DBB), CM@R, and Design-Build (DB), are expected to leverage BIM tools and Lean principles in their projects whenever possible.

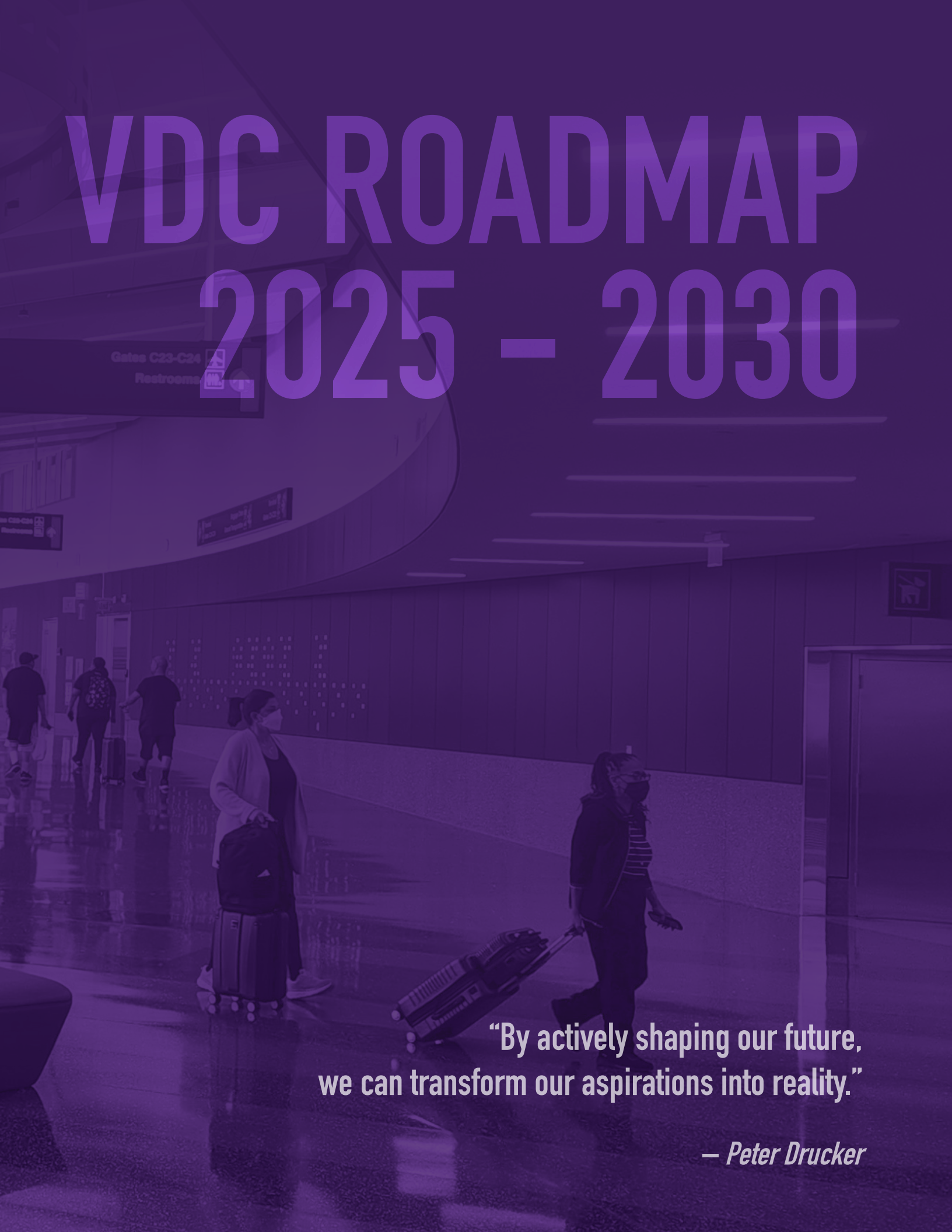
- The DTIG, project PM, and design teams utilize the BIM Decision Matrix to determine the level of BIM implementation on projects for all contract types and sizes. (large capital projects, smaller renovation projects, TAA)
- In collaboration with Massport, the Project Team will set expectations for BIM implementation in a project and make adjustments based on the project's specific goals and requirements.

1.3. DIGITAL TECHNOLOGIES INTEGRATION GROUP (DTIG)

The DTIG's integrated capabilities provide robust support for Massport's VDC project delivery and the Digital Twin/Virtual Campus vision outlined in the VDC Roadmap. By integrating trusted and standardized data from various project sources, the DTIG manages reliable information management, ensuring a holistic view of assets and informed decision-making throughout the asset lifecycle. The DTIG will support project teams in their move to VDC project execution. The DTIG responsibilities include:

- Managing Roadmap projects, new technologies, and asset management initiatives,
- Operating as a unified resource for CAD/BIM, CMMS, GIS, and Enterprise Data Management
- Supporting project BIM use - Managing the BIM process reviews and standards and approval of digital deliverables
- Managing the project Autodesk Construction Cloud – Massport's Common Data Environment
- Integrating organizational workflows in the enterprise Common Data Environment (CDE).

VDC ROADMAP 2025 – 2030

The background of the slide is a photograph of an airport terminal, overlaid with a semi-transparent purple filter. In the foreground, two women wearing face masks are walking with rolling suitcases. The woman on the left is looking towards the camera, while the woman on the right is looking down. In the background, other travelers are visible, and a large flight information display board is mounted on the wall. Signs for "Gates C23-C24" and "Restrooms" are visible in the upper left. The overall atmosphere is one of a busy, modern travel hub.

**“By actively shaping our future,
we can transform our aspirations into reality.”**

— Peter Drucker

2. VDC ROADMAP 2025 - 2030

The lessons learned from BIM projects informed the VDC Roadmap's five goals, aligning VDC project delivery with the organization's enterprise asset lifecycle needs. As Massport's technology and lifecycle data management division within Capital Programs, DTIG is responsible for implementing the Massport VDC Roadmap.

The VDC Roadmap (Figure 8) outlines DTIG's vision, initiatives, and services, and illustrates how they contribute to Massport's digital transformation. It includes a summary of DTIG's strategic plan for delivering best-in-class VDC services in capital projects as part of an enterprise-level asset lifecycle program. The roadmap also provides an overview of BIM implementation, emphasizing the connection between people, processes, and technology. Finally, it presents a timeline of DTIG's major activities required to achieve the targeted BIM stages, as outlined in this guide (refer to section 3.4).

“Begin with the end in mind”

-Steven R. Covey



FIGURE 7 — Massport Roadmap Review

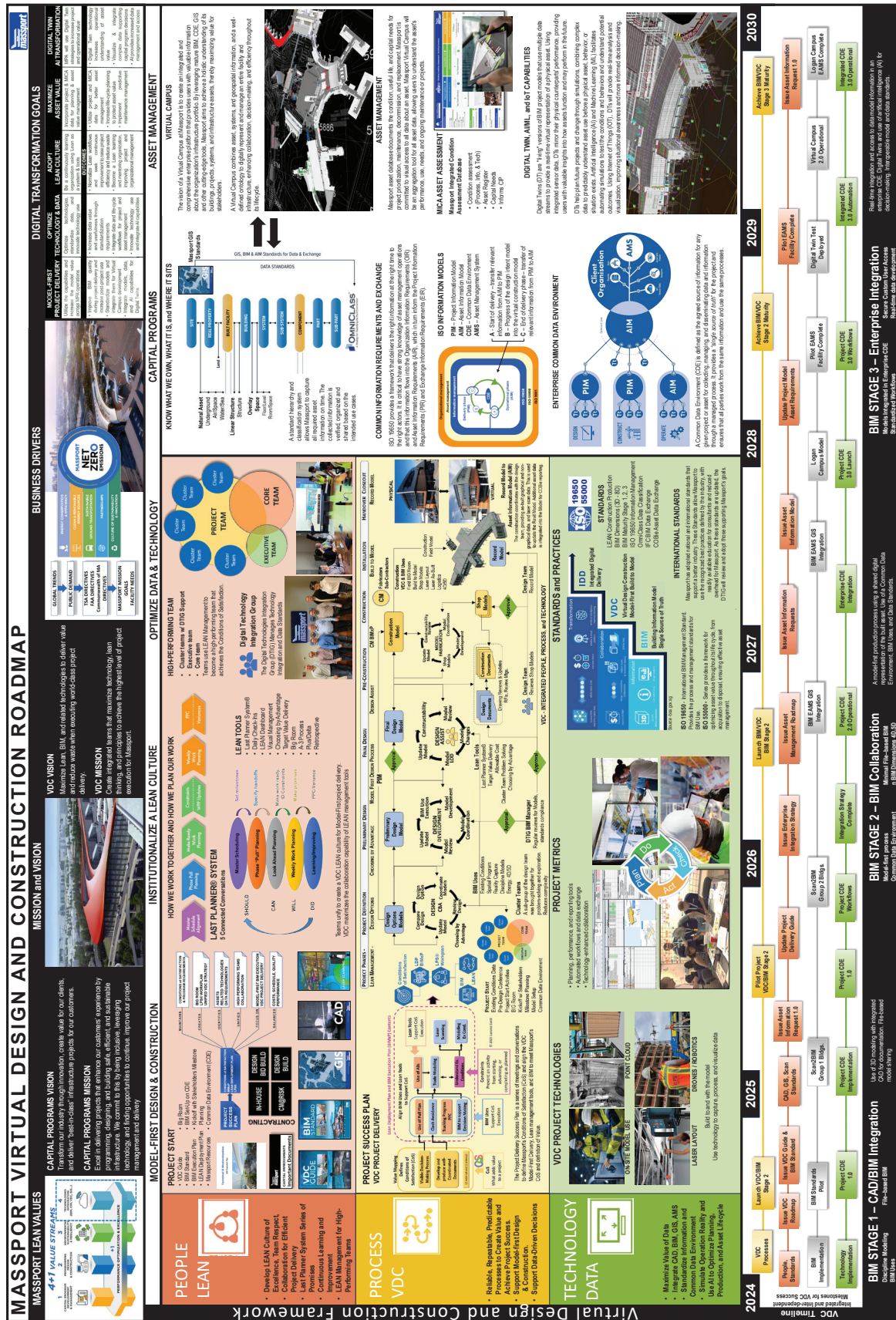


FIGURE 8 — Massport Roadmap Review

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2.1. MASSPORT DIGITAL TRANSFORMATION GOALS

The VDC Roadmap outlines five key objectives: establishing a strategic direction for VDC project delivery, prioritizing model-first design, enhancing information value, cultivating a Lean and sustainable culture, and implementing innovative asset lifecycle management through BIM Digital Twins within a multi-building virtual campus.



FIGURE 9 — Massport Roadmap Goals

MODEL-FIRST PROJECT DELIVERY

The VDC framework uses Lean management tools and model-first design and construction to bridge the gaps between the design intent model, the built project, and the envisioned project outcomes.

Virtual Design and Construction (VDC) employs a ‘model-first’ strategy. “Model-first” uses BIM to prototype “what to build virtually” and then simulates construction to understand “how to build.” BIM-Stage 2 (BIM-S2) is required for these projects.

BIM-S2 maximizes BIM’s potential to simulate design and construction, resolving issues across the project lifecycle. Design options are modeled early, and the best option is selected using Lean tools, including Choosing by Advantage, Target Value Delivery, A3, 4D, and 5D, enabling teams to address significant design, production, and construction issues before purchasing, fabrication, and installation begins.

Design Assist facilitates collaboration between the design, construction assist, and subcontractor teams for constructability reviews during the final design and document creation phases. The design is “constructed” digitally, and the construction team builds the project according to the model. Fabricators take ownership of the model for pre-fabrication opportunities, assembly, coordination, installation, and construction sequencing simulations.

BIM-S2 models, cloud-based model sharing, modeling, and data standards are outlined in the BIM Standard. Teams utilize Lean management tools, establish a common language, and foster a culture of continuous learning and improvement to maximize the value of project delivery.

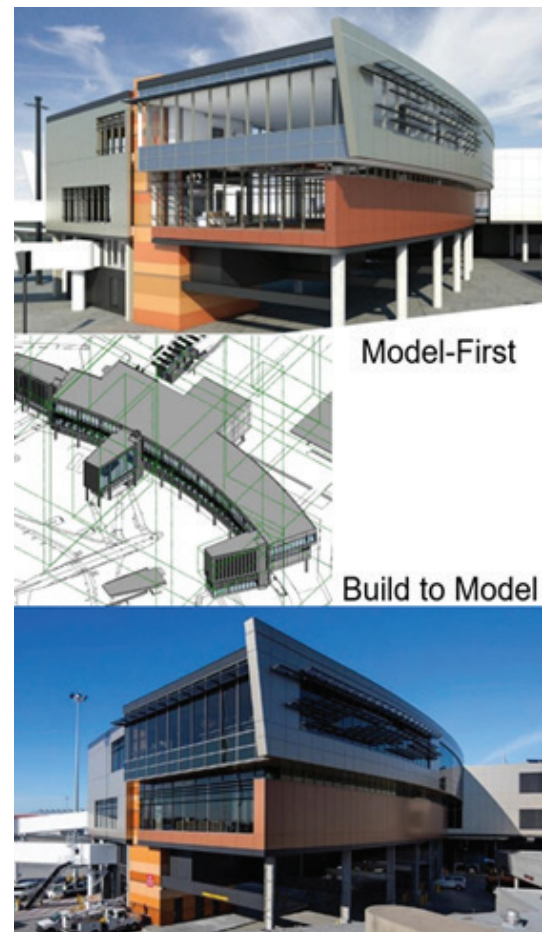


FIGURE 10 — Massport Model First

CREATE A LEAN CULTURE

A lean culture embraces principles and practices that maximize value while minimizing waste in all aspects of an organization. Lean principles foster collaboration, establish trust, reduce waste, and optimize operational resources.

Cultural change encompasses learning and improving how a team behaves, interacts with others, executes its work, responds to problem-solving, and manages risk. Training and cultural change are the primary challenges to adoption.

Massport has adopted a Lean culture as an organizational goal, defining operational value streams to optimize performance and drive continuous improvement across its projects, operations, and asset management.



FIGURE 11 — Lean Value Streams

Adopted Lean Principles:

- **Understand Value from the Customer's Perspective**
 - » Prioritize what matters most to the end-users and stakeholders.
- **Understand the Value Stream**
 - » Analyze the entire process flow to identify areas for improvement.
- **Make the Value Stream Flow**
 - » Eliminate bottlenecks and streamline processes for smoother operations.
- **Create Pull**
 - » Align work with the demand, avoiding overproduction.
- **Continuously Improve**
 - » Foster a culture of ongoing learning and growth.

Massport's leadership and stakeholders actively support the organization's Lean initiatives. They have identified core values that set measurable quality standards throughout the organization. This Guide, BIM standards, and internal resources aim to develop and manage a digital environment for enterprise asset management.

Massport conducts internal Lean and VDC education sessions and participates in workshops to establish a culture of Lean projects. These empower Massport to improve and expand the Lean culture across the organization.

In VDC project delivery, the same Lean principles apply, requiring team collaboration and knowledge to maximize stakeholder value and minimize waste. Teams ensure a seamless flow of information, supporting a data-driven decision process and risk-managed execution.



FIGURE 12 — Lean Culture

INCREASE DATA VALUE AND TECHNOLOGY USE

The data held by Massport represents a vital strategic asset with considerable economic significance. Managing and protecting this data effectively is essential to unlock its full potential. Critical asset information should be systematically identified, collected, organized, and structured following Massport standards. This approach ensures that the data remains accessible and verifiable, fostering stakeholder trust.

Having the *right* information about an asset can profoundly affect an organization's ability to maintain its functional life, operational performance, predictive maintenance, and mission capability.

When stakeholders have confidence in data, they are empowered to make informed, data-driven decisions that enhance the value of Massport's operational activities.

Massport has implemented an ISO 19650 information management framework for project and asset model management. This international BIM standard governs comprehensive data and model management throughout the asset lifecycle, emphasizing the importance of interoperability standards and robust data governance to guarantee consistency and usability.

Massport DTIG collaborates with project teams to develop asset data during the design and construction phases, ensuring adherence to Massport standards to deliver valued asset data for operations.

OPTIMIZE PROJECT DATA AND ASSET INFORMATION

ISO 55000 defines asset management as a coordinated effort that enables organizations to maximize the value derived from their assets. It supports achieving business objectives through informed asset-related decisions, strategic planning, and actions, all within a comprehensive data management framework bolstered by robust processes and tools. The primary aim is to optimize asset costs, risks, and performance across individual, system, and portfolio levels. A structured methodology is crucial for effectively capturing and managing information throughout the asset lifecycle.

The Owner Information Requirements (OIR) are a company's high-level requirements concerning its assets, business operations, and departments. The OIR is important because it influences the subsequent information requirements for a project and supports the organization's objectives. They define inputs and drive every process, leading to better quality delivery and project success.

Standardized Asset Information Requirements (AIR) at each lifecycle stage guarantee the availability of model-based geometric, geospatial, documentation, and alphanumeric data, which are critical for effective business processes and decision-making. Massport emphasizes the importance of data standards and process enhancements to ensure the timely sharing and utilization of trustworthy information within the organization.

The Exchange Information Requirement (EIR) in a project refers to the information that must be exchanged between parties involved in the design and construction process. This includes the sharing of discipline models using a cloud-based common data environment.

The OIR, AIR, and EIR provide the requirements for developing and managing the Project Information Model (PIM). The PIM is developed during the design and construction phases, while the Asset Information Model (AIM) consolidates the necessary data and information to support asset management. It serves as a singular source of validated and approved information regarding a built asset during its operational phase. Elements from the PIM are transitioned to the AIM after the project, facilitating a seamless operational handover.

The AIM functions as the central repository for all requisite asset data during its operational lifecycle, with data being developed incrementally during projects, guided by Massport's Information Requirements (OIR) and Asset Information Requirements (AIR). The AIM ensures alignment with Massport's AIR by capturing essential data attributes and metadata for each asset, ensuring completeness, consistency, and reliability.

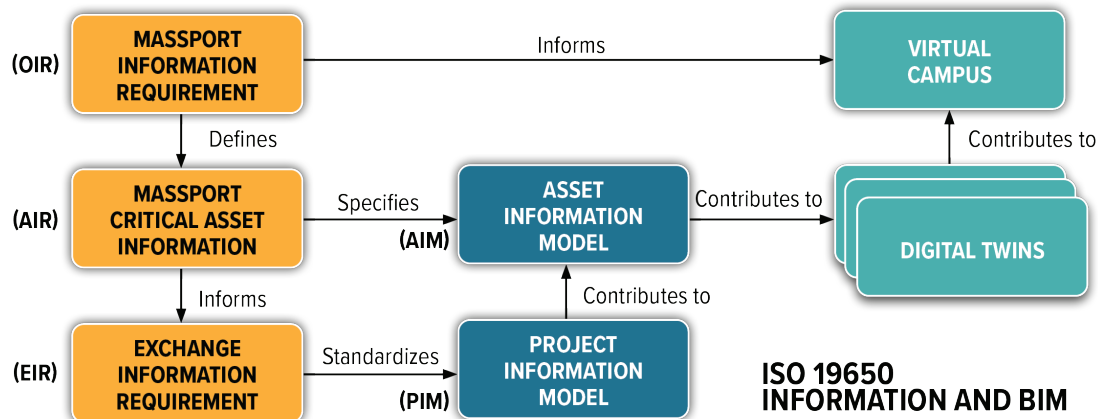


FIGURE 13 — ISO BIM Framework

DATA CLASSIFICATIONS

Adopting consistent and meaningful naming conventions, including codes or alphanumeric identifiers, significantly enhances asset identification. Massport has identified critical assets using OmniClass asset classification and asset data reporting, utilizing the Construction Owners Building Information Exchange (COBie) or other approved methods for transferring asset data from the project model to facility information management programs. These tools and processes guarantee an efficient and reliable information flow to the asset information record utilized in facility management software.

A standardized naming convention ensures that all asset data is uniformly labeled and easily searchable within the Common Data Environment (CDE), supporting the AIM and PIM. Physical tags enable asset identification in the field, which is vital for ongoing operations and maintenance. The established naming conventions ensure coherence between physical assets and their corresponding digital records, with all asset tags adhering to the specifications outlined in the AIR.

Critical assets utilized in a project are addressed in the BIM Standard and the BIM Execution Plan (BIMxP). Additional documentation regarding project standards is available on the Digital Technologies Integration Group (DTIG) website. Link - [Digital Technologies Integration Group \(DTIG\)](#)

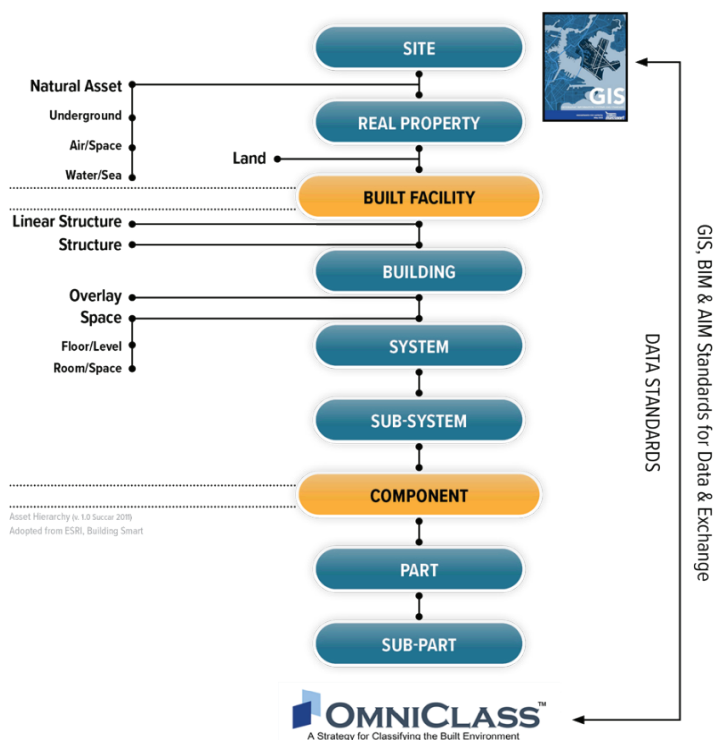


FIGURE 14 — Asset Hierarchy

ASSET HIERARCHY

Ensuring consistency in asset taxonomy, hierarchy, and attributes is essential for maintaining structured, accurate, verifiable, and reliable asset information across various asset management domains. A well-defined asset hierarchy illustrates asset dependencies through parent-child relationships. Massport is adopting an industry-standard asset taxonomy to improve asset management information and guarantee uniform asset classification across its facilities.

This framework, along with the naming conventions outlined in the BIM Standard, enhances model management and facilitates easier access to and search for elements (systems, components) and associated data.

COMMON DATA ENVIRONMENT (CDE)

The Common Data Environment (CDE) has emerged as an optimal platform for collaborative project execution. The CDE is a cloud-based “single source of truth,” providing a centralized repository for teams to collect, manage, and distribute model and non-graphical data to all stakeholders. Data is managed consistently and accurately to support defined use cases and exchange workflows. Massport has adopted Autodesk Construction Cloud (ACC).

FUNDAMENTAL OBJECTIVES OF THE CDE

The CDE enables role-based access to current, reliable information presented in a structured and navigable format. At the enterprise level, it underpins the management, collection, creation, assurance, sharing, dissemination, and coordination of information generated throughout all asset lifecycle activities.

The CDE is the central conduit through which all project participants can access relevant and up-to-date data. Certain information within the CDE repositories is dynamic, allowing for recognizing, modifying, or updating non-standard data when outdated information is identified.

CDE INFORMATION WORKFLOW PROCESS

The CDE also enables the automation of specific workflows, promoting team collaboration within its framework. Notable examples of these workflows include model coordination and reviews, reporting, data verification, issue tracking, scheduling, versioning, bridging, and model federation processes, as well as backup for enhanced resiliency.

Massport’s ACC incorporates standardized processes for team collaboration, effective model and data management, communication, and project execution. The structures established by the CDE are most effective when teams comprehend and adhere to the prescribed workflow and data standards. Massport uses the ISO information workflows for model management.

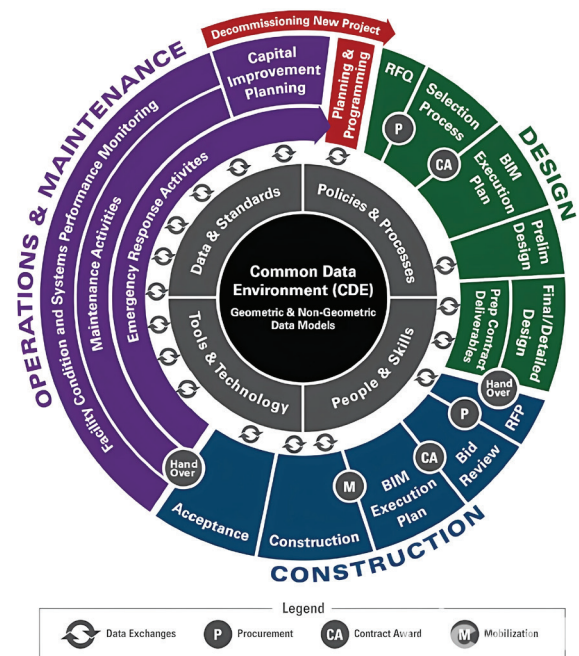


FIGURE 15 — CDE Diagram

THE ISO 19650-1 COMMON DATA ENVIRONMENT WORKFLOW

ISO 19650-1 is an international BIM standard, and the Common Data Environment (CDE) is a key part of the framework. The CDE workflow is a structured process for managing and sharing information throughout the project lifecycle. Massport CDE workflow for project information.

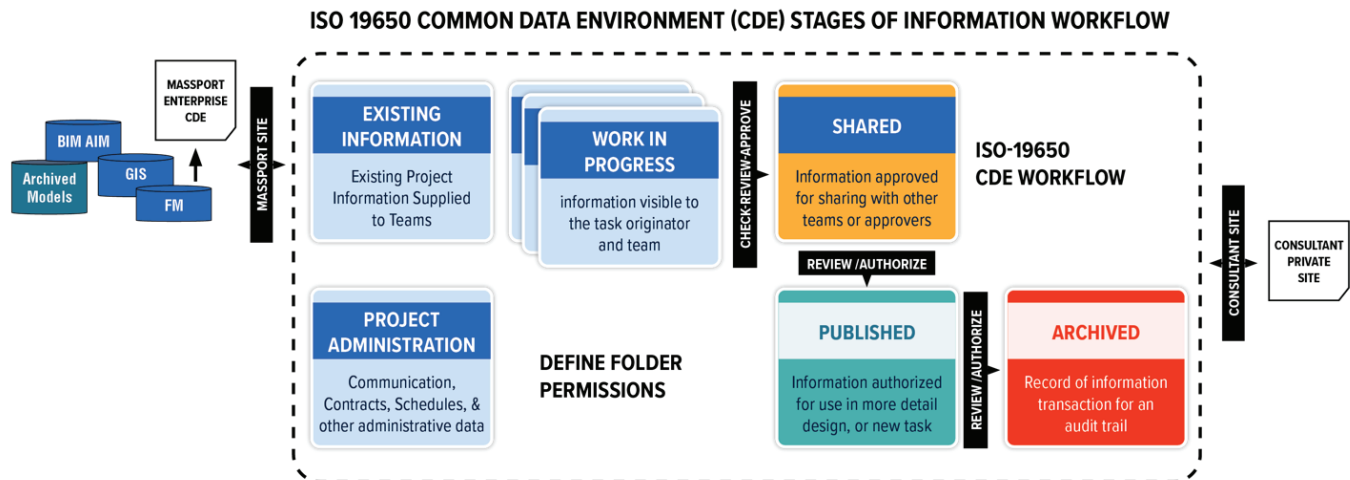


FIGURE 16 — ISO CDE Workflow

- **Work in Progress:** CDE folder where the team executes their work. Non-verified design data should be used only by the in-house design team and verified for standard and quality control purposes before being shared with others.
- **Shared:** CDE folder where the teams share verified design data with other project team members, enabling coordination between different disciplines/ teams.
- **Published:** CDE folder validated for validated design with the output for use by the total project team.
- **Archived:** The CDE folder for project history is maintained for knowledge, resiliency, and regulatory and legal compliance requirements. It is also a repository of metadata and non-asset-type project information, including drawings, renderings, and documents that are part of the project but not intended for future asset management.

The integration of data sources from multiple business silos enables the creation of digital twins, increasing data accessibility for informed decision-making.

PROJECT AND ASSET DATA WORKFLOWS

A project and enterprise CDE offers stakeholders centralized access to information from diverse sources, thereby enhancing asset planning and decision-making for management. The BIM standards are required to maintain the value of project models and data. The enterprise information environment accommodates models, reducing the amount of additional work required to re-purpose the models and data for asset management systems and Digital Twins.

BY-DIRECTIONAL DATA INTEGRATION for VIRTUAL CAMPUS

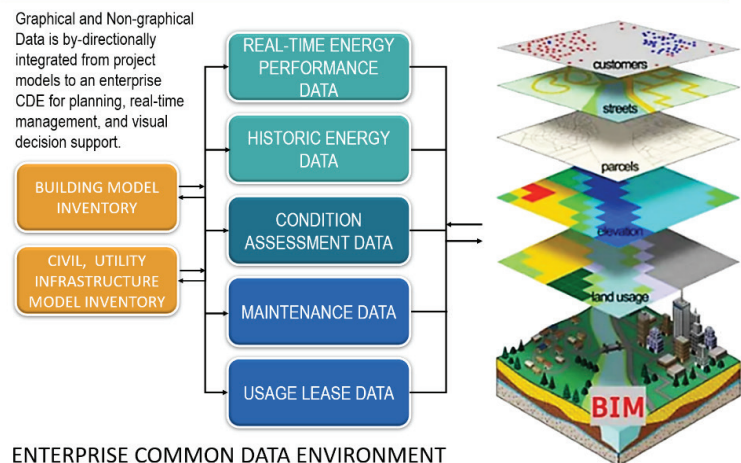


FIGURE 17 — Enterprise CDE

Massport is committed to integrating BIM and asset data with GIS, Enterprise Asset Management Systems (EAMS), and Enterprise Resource Planning (ERP) systems. This initiative will enable the exchange of information in a fully digital and interoperable manner, supporting data-driven decision-making throughout the asset lifecycle, encompassing design, construction, and operations. The enterprise-level CDE facilitates strategic planning, sustainability initiatives, and efficient operational processes using digital twins and the virtual campus.

Massport emphasizes the necessity of interoperability across ESRI (GIS), Autodesk (BIM), and IBM products (AMS). An enterprise CDE will manage federated models, data, and documents. Effective management of standardized data formats, protocols, and interfaces is crucial for ensuring seamless interoperability and data exchange among integrated systems within the enterprise data management framework.

DIGITAL TWINS AND ARTIFICIAL INTELLIGENCE (AI)

Digital Twins serve as sophisticated, data-driven digital representations of physical assets, utilizing advanced processes and technologies to enhance decision-making, optimize priorities, and manage assets throughout their lifecycle. High-quality digital twins, developed from project models, are integrated with asset data within a CDE, allowing for a comprehensive view of Massport's infrastructure as an interconnected, dynamic visual system.

Digital Twins consolidate diverse data sources to facilitate integrated data workflows. Massport can adopt a proactive maintenance strategy, establish long-term priorities, optimize airport space utilization, and enhance safety measures to improve overall operational efficiency. The data may encompass long-term condition assessments, element attributes, and real-time data from sensors. By leveraging BIM Stages Two and Three, Massport can maximize the value and return on its BIM investments.



FIGURE 18 — Digital Twins

Artificial Intelligence (AI) significantly enhances the predictive and decision-support capabilities of Digital Twins for operational planning and enterprise asset management. Integrating validated digital twins with AI technologies lays the groundwork for planning simulations related to facility operations, traffic and passenger movement, wayfinding, security, and emergency response scenarios. The CDE supports the growing volume of data and serves as a training set for ongoing AI development.

Massport envisions a virtual campus as a cohesive and comprehensive enterprise platform providing visual and geospatially aligned data regarding the organization's infrastructure assets. Massport seeks a holistic understanding of its buildings, systems, infrastructure assets, and associated data by leveraging BIM Stages 2 and 3, GIS, and other applications.

VIRTUAL CAMPUS

Massport plans to establish a virtual campus as a comprehensive enterprise platform, providing visual and geospatially aligned critical information regarding the organization's infrastructure assets. By leveraging BIM Stages 2 and 3, GIS, and other advanced tools, Massport aims to gain a comprehensive understanding of its buildings, systems, infrastructure assets, and associated data.

The development of cross-functional communication and the reduction of data silos through the virtual campus facilitate sustainable and informed decision-making. Stakeholders are empowered to visualize and interact with various assets, gaining insights into their relationships, functions, and interdependencies that may not be readily apparent. This enhanced understanding improves project planning, prioritization, and effective asset management.

INNOVATIVE TECHNOLOGIES

Massport is committed to exploring cutting-edge technologies to enhance its organizational capabilities, including advanced laser scanning, automated workflows, Digital Twins, and the Virtual Campus, to meet operational requirements. Additionally, the organization is investigating augmented reality tools, robotics, generative design, and Artificial Intelligence (AI). Appendix 1. includes Massport-reviewed technologies.

VDC PROJECT REQUIREMENTS



 Berklee *boston* 



“The future is not about technology itself; it is about how we use technology to improve our lives and the world around us.”

— *Peter Thiel*

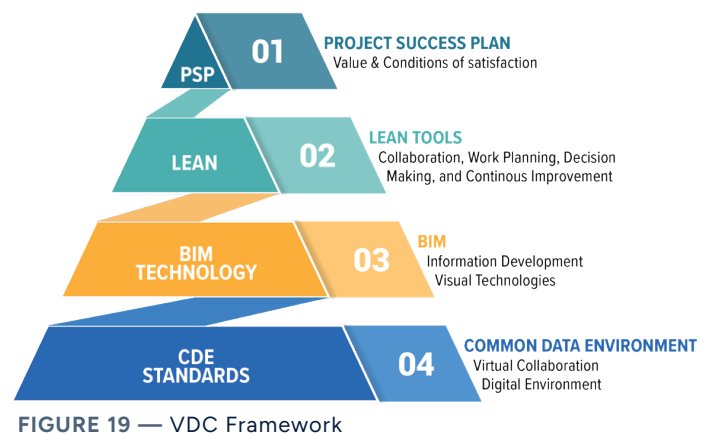
3. VDC PROJECT REQUIREMENTS

One of Massport's goals is to standardize project execution, BIM production, and submissions across all projects. However, design and construction teams bring different understandings of how projects are managed and executed. For teams to arrive at a unified strategy through effective Lean collaboration and efficient BIM production, Massport recognized that its contracts and manuals, project structure, and the roles and skills of the Massport and the design and construction teams needed to be adjusted.

By standardizing VDC approaches, BIM, and Lean tools, Massport is adopting a repeatable project management system that works within the various MPA project procurement and project delivery options.

This section outlines the project requirements for design and construction teams implementing VDC, Model-first project delivery, Lean thinking, and tools at the project's inception. It defines project setup, team roles and responsibilities, VDC processes, and BIM and Lean tools managed in the project ACC environment.

Project management focuses on client satisfaction, team trust, collaboration, efficient production, and project delivery. Lean tools improve work planning, coordination, and continuous improvement. The VDC Project Tools List (Appendix 3) identifies the Lean tools, their purpose, recommended use, and the responsible parties.



VDC manages BIM workflows and project information in a cloud-based common data environment (CDE)¹. BIM prioritizes visual decision support to develop optimal designs and highly constructible models that align with the project's critical success factors (CoS). This approach ensures that the models are confidently used during construction. BIM visualizes design and construction challenges, identifies possible issues, and develops solutions in a virtual space before construction starts.

Rather than relying on the traditional handover between design and construction teams, VDC and design assist methodologies promote early collaboration during the final design phase. This integrated approach helps identify and resolve potential issues before they escalate, fostering alignment among stakeholders. By leveraging digital models and shared platforms, teams can coordinate more effectively, reducing the risk of miscommunication and rework.

The Model-first design and Build-to-Model construction strategies aim to empower stakeholders to evaluate design options proactively, stay within budget constraints, and manage risks with greater precision. These methods encourage continuous refinement of the project, working to eliminate ambiguities, waste, and schedule delays before construction begins. Ultimately, this leads to more predictable outcomes, improved efficiency, and a higher quality work product.

¹ CDE- CDE is a collaborative environment where all stakeholders on a project or asset work on and share information. ISO 19650

3.1. VDC PROJECT TEAM REQUIREMENTS

Massport requires teams from different company cultures and stakeholders with varying agendas to reach a common understanding of the project scope, client value, and success factors for a unified project delivery strategy. Project teams and Massport work collaboratively to ensure a project meets and exceeds expectations. This section provides the required team roles and responsibilities for Massport projects.

VDC project delivery requires teams to:

- Define the processes and deliverables that achieve the desired outcome as outlined in the Project Success Plan and the Conditions of Satisfaction.
- Develop high-performing and continuously improving teams. Stakeholders commit to working collaboratively towards project goals, establishing trust through promises and delivery.
- Maximize BIM visual information for decision support throughout the project.
- Constantly measure and narrow the differences between what is specified, what is designed, and what is built.



The Digital Technologies Integration Group (DTIG) manages Massport’s digital transformation. The DTIG reviews and adopts the best industry initiatives, partnering with design and construction teams to develop innovative VDC approaches that drive project success.

The DTIG oversees project resources and updates Massport VDC and BIM information standards. The DTIG BIM Manager participates in VDC project setup, project success planning, and model reviews for standards compliance. The DTIG BIM Manager reviews the project’s BIMxP models and construction documentation for content and standards compliance.

HIGH-PERFORMING PROJECT TEAMS

Design and construction teams develop high-performing behavior as early as possible in the project. Collaboration and cooperation between the design and construction teams are part of high performance.

Strong leadership is essential for guiding and supporting H-P teams. Leaders should inspire trust, provide direction, and remove obstacles that hinder team collaboration and progress. Leaders prioritizing their team members’ needs can be particularly effective in fostering a positive team culture.

PRINCIPLES OF A HIGH-PERFORMING (H-P) TEAM

All team members are familiar with and adhere to the H-P principles. All team members are responsible for VDC execution, making and keeping promises, supporting the project CoS, and practicing continuous improvement. These principles include:

- **Have a Clear Purpose and Goals:** Every team member understands the project’s CoS and the goals they are collectively working towards. The CoS and team goals are specific, measurable, achievable, relevant, and time-bound (SMART).²

² **SMART-** Specific, Measurable, Attainable, Relevant, Time Bound

- **Shared Values and Culture:** The team operates on shared values and a cohesive culture that fosters trust, collaboration, and respect among team members. Team members are empowered to make decisions and take ownership of their work. They are accountable for their actions and the outcomes they deliver.
- **Continuous Improvement:** The team constantly seeks ways to improve processes, reduce waste, and enhance productivity.
- **Effective Collaboration Based on Trust:** Team members collaborate in a trusting environment across different functions or disciplines. Teams leverage diverse perspectives and expertise in solving problems and achieving objectives.
- **Efficient Decision-Making:** When possible, decisions are streamlined based on reliable data, analysis, and consensus.
- **Be Results-Oriented:** The team is driven by results and committed to delivering high-quality outcomes with agreed-upon timelines and resource constraints.



STEPS TO ACHIEVING THE HIGH-PERFORMING TEAM

- Understand and assign the roles and responsibilities to skilled team members.
- Establish each member's time commitment and availability to the project.
- Define a communication and decision-making structure for the entire project team, including its operation within the Core and Cluster Teams.
- Agree on collaboration tools, such as the Weekly Dashboard and Big Room.
- Provide new members with onboarding project CoS, team governance, roles, and tools.
- Be open to learning and refining the process throughout the project's lifecycle; use retrospectives for continuous improvement.
- Listen, log, and resolve constraints and concerns project team members express.

DEVELOPING HIGH-PERFORMING TEAMS

The Core Team, VDC Managers, and BIM Coordinators are responsible for developing a lean culture that enables high-performing teams to achieve the project CoS, execute the required processes, and meet project performance metrics. Each team member must be willing to adapt to new tools, methods of collaboration, and better processes to achieve success.

- Show respect for all team members and strive for excellence.
- Prioritize customer needs to drive work, deliver value, and eliminate non-value-added tasks.
- Establish purposeful goals for behavior and tasks.
- Practice cross-functional and cross-organizational collaboration, building a broader team perspective, promoting knowledge-sharing and problem-solving.
- Utilize Visual Management tools for transparency, clarity, and understanding between teams and stakeholders.
- Use BIM and Cluster Teams to develop the right data to drive a more informed visual decision process.

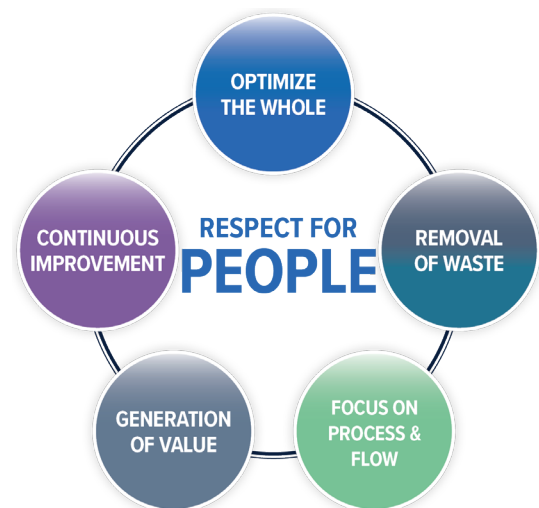


FIGURE 20 — Lean Teaming

- Establish a culture of continuous improvement and autonomy to make positive change. Use standard tools to manage issue resolution.
- Identify and eliminate waste in all areas of project delivery, people, processes, and technology.

HIGH PERFORMING (H-P) TEAM MEMBERS

- Massport Stakeholders
- Project PMs – Massport, Design and Construction
- DTIG BIM Manager
- VDC Managers
- Design and Construction BIM Coordinators
- Technology Specialist
- BIM Discipline Modelers
- Construction Subs and Fabricators

THE H-P EXECUTIVE MANAGEMENT TEAM (EMT)³

The EMT includes appropriate Massport representatives and all core project team leaders (ex., design and construction leads). This team meets as needed to manage contractual, administrative, and project decisions requiring this level of review and intervention. It maintains project focus and ensures that team actions meet the project requirements and achieve the CoS in a collaborative and efficient environment.

- Meet regularly (monthly minimum)
- Facilitate the Project Success Plan
- Drive and confirm CoS
- Drive project vision, schedule, budget, quality

THE H-P CORE TEAM

The core team is the project management team. The team directs the planning, execution, decision milestones, and issue resolution to keep the project on schedule, achieve the CoS, and meet project requirements.

- The Core team consists of the Massport project/program manager and principal members of each essential firm.
- Participates in the Project Success Plan (PSP)
- Assign roles and responsibilities to Cluster teams.
- Responsible for coordinating and resolving project issues
- Drive integration across the entire project team.

The VDC Managers and BIM Coordinators provide coaching and training as needed to help teams achieve the high-performance levels required for success.

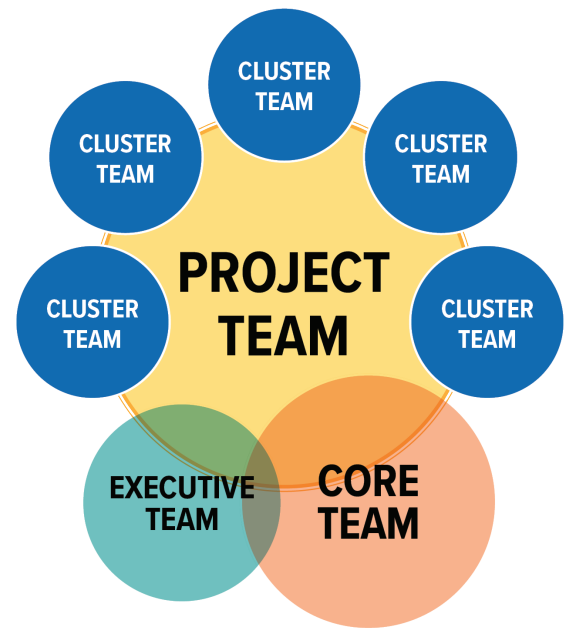


FIGURE 21 — VDC Teaming

³ LCI - <https://leanconstruction.org/lean-topics/work-clusters/#:~:text=Introduction%20to%20Work%20Clusters&text=The%20goal%20of%20Target%20Value,time%2C%20money%2C%20and%20resources.>

THE H-P CLUSTER TEAM

Spontaneously created Cluster teams address a specific issue and reduce project complexity through rapid prototyping, analysis, or learning. Teams may be organized by expertise and disciplines, programmatically or operationally, rather than remaining in company silos. Additional personnel with the necessary expertise may be added to the team or collaborate virtually through the CDE.

The DTIG supports cluster teams by addressing any necessary changes to data access, providing additional Massport-specific data, participating in BIM reviews, and supporting the decision-making process. Cluster teams may utilize VDC tools, including Target Value Delivery, A3 Thinking, Choosing by Advantages (CBA), and Set-based Design, to enhance the decision-making process.

CLUSTER TEAM SCENARIO

A roof cluster team is created to redesign an over-budget roof. While the client likes the roof design, it does not conform to the priorities set by the CoS. The design must change materials and reduce costs, or a new roof must be designed at the allowable cost that satisfies the project's CoS.

The Cluster team includes designers, structural engineers, constructors, roofing sub-contractors, estimators, the DTIG BIM Manager, and client stakeholders. The team focuses on the project's CoS and structural constraints. The team uses Choosing by Advantages and includes a BIM team member for option modeling and an estimator to help with costing.

The DTIG provides CDE support for CDE bridging and participates in the design option modeling reviews. Once an option is designed and approved, the team disbands, and the selected modeling data is incorporated into the design model by the BIM Coordinator.

3.2. VDC ROLES AND RESPONSIBILITIES

Massport has outlined the roles and responsibilities essential for high-performing VDC teams. Each team PM must clearly understand their roles, ensuring the most qualified individuals are chosen for each task. Teams should identify the skills and experience required to achieve project outcomes and receive training to execute their roles effectively.

PROJECT MANAGER RESPONSIBILITIES

Project Managers (PMs) of all teams become integral members of the Core Management team, responsible for steering high-quality, model-first project delivery to achieve the Conditions of Satisfaction (CoS). They collaborate closely with VDC Managers and BIM Coordinators to foster a model-first, lean, collaborative culture. PMs play a crucial role in identifying and selecting decision-makers as necessary. These team members actively participate in project meetings, maintain the schedule, promote continuous improvement, and strive to deliver project value while minimizing waste.

MASSPORT PM

The Massport Project Manager (PM) serves as the primary representative, fostering a culture of collaboration, focusing on project requirements, and ensuring the project progresses smoothly per the established work plan. They collaborate closely with the DTIG BIM Manager to guarantee that all deliverables align with Massport's BIM Standard. Additionally, the PM is crucial in identifying key stakeholders to support decision-making.

The table below provides a framework for collaboration between the Massport PM and project managers from the design and construction teams.

PM Design Team	PM Construction Team	PM Massport
Receive, review, and distribute existing project data and Massport documents- guides, SOPs, and current standards.	Review received project models and data, including design intent model, construction docs, existing data, Massport guides, SOPs, and current standards.	Provide current Massport project data and access to Knowledge Owl if required.
Participate in the Project Success Plan (PSP) meeting/s to establish project Value and the Conditions of Satisfaction (CoS), BIM Uses, constraints, and tools.	Manage the company ACC for construction, bridge to Massport, and design team's ACC.	Support Model-first approach used throughout project execution.
Manage BIM Uses execution schedule to align with the larger project schedule.	Facilitate the Project Success Plan for construction CoS and BIM use.	Oversee Autodesk Construction Cloud. Works with DTIG BIM Manager.
Lead a high-performing team and manage continuous improvement reviews.	Implement Lean production and coordinate Build-to-Model requirements with the BIM Coordinator.	Facilitate Project Success Plan meetings and the creation of the Conditions of Satisfaction (CoS).
Implement a Model-First process oversight on the BIM process.	Support the BIM Coordinator, Subs, and Fabrication production for assembly and installation	Collaborate with the VDC Managers on utilizing the Lean tool and review the Lean Development Plan.
Coordinate company CDE bridge to Massport ACC. Manage ACC collaboration procedures and tools.	Implement the LPS, utilizing look-ahead and pull planning methods for construction. Align the CPM.	Manage project execution schedules and review deliverables.
Execute project Lean tools, ex. Target Value Delivery.	Foster a lean culture in the field using Big-Room, virtual collaboration.	Review the use of human resources and the right person for the right job.
Support Cluster teams.	Review fabrication and construction execution and report progress through the project dashboard.	Drive continuous improvement
Coordinate management activities with the MPA PM, VDC Lean Manager, and BIM Coordinator.	Review and manage information handover, Record Model activities, and project closeout.	Review asset data requirements for compliance
Facilitate, with the Lean Manager, the use of the Last Planner System, including looking ahead and holding pull planning meetings.	Oversees the asset requirements during construction for compliance and accuracy of the AIM data	

PM Design Team	PM Construction Team	PM Massport
Review project execution and report progress in the project dashboards.		
Facilitate BIM coordination, clash detection, constructability reviews, and standards compliance reviews.		
Manage handovers- Record Model, asset data, and activities for construction.		

VDC MANAGER RESPONSIBILITIES

VDC Managers for design and construction are required roles on Massport projects. The responsibilities include:

VDC Manager, Design	VDC Manager, Construction
Participate in the Project Success Plan and develop the Lean Deployment Plan. Advise the BIM Coordinator on VDC for the BIM Execution Plan (BIMxP)	Participate in the Project Success Plan and develop the Lean Deployment Plan.
Facilitate the Model-First process, foster a Lean culture, develop high-performing teams, and drive continuous improvement. Choose project team Lean Champions.	Foster a Lean culture and develop high-performing teams in the shop and field for efficient fabrication and installation. Support BIM use in the field.
Apply Lean principles, thinking, and tools for project execution and Target Value Delivery. Review Lean execution and tool use. Coach as needed.	Identify lean thinking and tools to use with the PM and BIM Coordinator.
Facilitate Last Planner System®, conversations, look-ahead, and pull planning meetings. Identify LPS facilitators from the project team.	Facilitate Last Planner System use, look-ahead, and pull planning sessions. Align CPM.
Document project dashboard and review project metrics and CoS execution.	Support Cluster teams and decision processes
Support and facilitate Cluster teams and decision processes	Train and coach teams as necessary
Drive continuous improvement and train teams	

PROJECT BIM COORDINATORS

The design and construction team BIM Coordinators are responsible for BIM Use development, BIM execution, discipline team management, and fabricators management for construction. They coordinate with other project managers to maximize BIM execution throughout the project lifecycle.

BIM COORDINATOR ROLE AND RESPONSIBILITIES – DESIGN AND CONSTRUCTION

The BIM Coordinators are responsible for BIM management and execution, including BIMxP, modeling schedules, and BIM Use execution, as well as creating deliverables that meet the project's CoS, model standards, and asset data requirements. In a Model-first process, the BIM Coordinator facilitates and manages the use of BIM throughout the project lifecycle to create a constructible model. The BIM Coordinator manages the Discipline Modelers, supports the Cluster teams, and coordinates the model on ACC. The BIM Coordinator may also be a modeler on the project.

The BIM Coordinators in design and construction ensure that asset details are accurately recorded and tagged, if required, in the model and verify the accuracy of as-built data for future use in the Asset Information Model.

THE MASSPORT BIM MANAGER

The DTIG BIM Manager coordinates with the project's PM and consultant BIM Coordinators to provide existing project information and ACC BIM setup and management. The BIM Manager regularly holds quarterly model review meetings to discuss modeling requirements and progression, data standards compliance, and BIM Usage. The BIM Manager approves the BIMxP, project models, and design documentation deliverables.

BIM Coordinator Design	BIM Coordinator Construction	DTIG BIM Manager
Participate in the Project Success Plan meetings- create and manage BIMxP.	Meet to review received project information- design intent models, construction docs, existing data, and current standards review.	Provide existing models, BIM templates, and data for the project.
Receive and review Massport's existing information and current standards.	Setup Construction ACC and bridge to Massport ACC	Manage Massport ACC for BIM management and deliverables.
Coordinate with reality capture teams	Manage model review (clash and issue reviews)	Periodically review project model/s for standards compliance.
Test ACC bridging for BIM setup and collaboration.	Review any project scope questions.	Review and approve the BIMxP
Execute the project BIM Uses.	Facilitate meetings and develop the Construction BIMxP.	Define Lean tools supporting BIM execution

BIM Coordinator Design	BIM Coordinator Construction	DTIG BIM Manager
Support project definition, design options, cluster teams, target value delivery, and optional design assist.	Coordinate Lean tool use with VDC Lean Manager for BIM fabrication	Participate in the Project Success Planning activities
Foster a Lean/BIM culture for continuous improvement and cooperation.	Manage Subs and Fabrication modeling and reviews	Participate in the Project Success Planning activities.
Use lean tools to support BIM process management.	Collaborate with the VDC Lean Manager to utilize the Last Planner System, including look-ahead and pull planning.	Hold BIM progress review meetings for quality, content, BIM Uses, and standards compliance.
Manage model federation process, model reviews, and coordination	Review execution and report progress through the project dashboard.	Provide support to project BIM Coordinators as requested.
Attend Quarterly or As-needed DTIG BIM Manager meetings for BIM Standard compliance. Model quality and Q/C	Participate in the Record Model handover activities and manage project closeout	Review model quality, critical asset data integration
Participate in the Last Planner System® use, look-ahead, and pull planning meetings.	Model quality and Q/C	Participate, review, and approve the Record Model.
Review BIMxP project execution and report progress through the project dashboards.	Asset data-model integration and review	
Manage Record Model and information handover, as well as project closeout activities.		
Asset data-model integration and review		

BIM DISCIPLINE AND FABRICATION MODELERS

BIM Discipline modelers are skilled in the required discipline, modeling, model coordination, and federation to meet the MPA requirements. They collaborate with the BIM Coordinator and VDC Manager to support model quality and innovative practices, thereby enhancing BIM execution.

The fabricators adapt or develop fabrication models used for assembly and installation. They work with the construction BIM Manager to support as-built data collection and handover. The fabricators adapt or develop fabrication models used for assembly and installation. They work closely with the construction BIM manager to support as-built data collection and handover, ensuring alignment with Massport project goals.

Discipline Modelers – Design Team	Trade/Fabrication Modelers Construction Team
Participate in discipline model development to meet the project Conditions of Satisfaction (CoS).	Participate in the design data review process before fabrication modeling. Work with Designers to clarify fabrication and construction needs.
Support Cluster team model needs	Foster a Lean culture for continuous improvement in the shop and field for efficient assembly and installation.
Participate in Target Value Delivery and Choosing by Advantage for the discipline.	Support BIM use in the field.
Manage quality control review and model federation	Identify Lean tool use with PM and BIM Coordinator.
Participate in planning sessions for BIM management	Participate in Last Planner System® use for fabrication and installation.
Develop model-derived construction documentation appropriate to the discipline of the project	Develop As-Built information

ESTIMATORS DURING DESIGN

Teams design to the cost. Estimators collaborate with the BIM Coordinator to utilize BIM quantities and data for accurate estimating. Estimators are integral to the VDC High-performing teams, helping meet the allowable cost requirements of Target Value Delivery. Continuous costing updates utilize models rather than traditional design, costing, and value engineering, which can alter the design and potentially reduce value to cut costs.

COMMISSIONING

Commissioning is an ongoing process of ensuring an asset's safe operation through compliance, performance, and testing. MPA requires specific asset and utility data to be supplied to Massport through the project's Common Data Environment (CDE) whenever possible. COBie or other approved asset templates collect data periodically during the project lifecycle. Commissioning Agents may use project models to support the process.

Commissioning data, including all tagged and documented assets, are defined in Massport's Asset Information Requirements (AIR) and meet Massport's operational and maintenance needs for its Asset Information Model (AIM). This data is integrated with as-built asset data supporting Massport's Enterprise Asset Management System (EAMS). The process and schedule are documented in the commissioning plan.

3.3. VDC PROCESS AND TOOLS REQUIREMENTS

A successful Massport project delivers a high-quality, sustainable, and constructible design aligned to the defined scope, requirements, and Conditions of Satisfaction (CoS).

Specific VDC, Lean, and BIM tools foster a production system that meets Massport requirements and maximizes value while minimizing risk and waste. This section explains regularly used VDC tools

VDC and Lean Process Tools	
Project Success Plan	Last Planner System®
BIMxP	Big Room
Lean Deployment Plan	Choosing by Advantage
Target Value Delivery	A-3 Problem Statement
Risk Management Template	Project Dashboard

THE PROJECT SUCCESS PLAN (PSP)

The PSP is a project kickoff activity defining WHY the project is important to Massport, HOW the project is delivered, WHAT BIM Uses will be executed, and any constraints that may impact processes and project delivery. As a Lean organization, Massport requires the PSP activities to achieve the best possible project outcomes. A culture of collaboration begins with the PSP and establishes a unified understanding between the project delivery team and stakeholders.

The PSP uses the Massport Conditions of Satisfaction, VDC processes, Lean tools, and BIM Uses to develop a project delivery strategy. Value is determined by what Massport considers essential for a project rather than

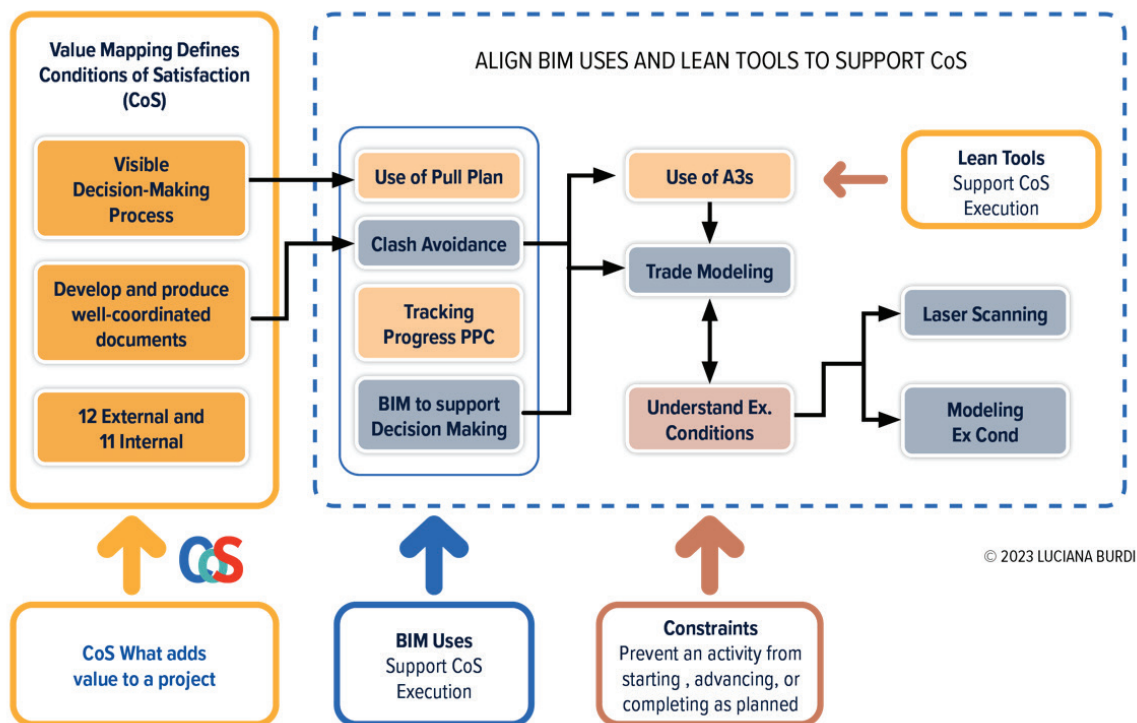


FIGURE 22 — Project Success Plan

what the providers consider necessary. The CoS are measurable statements that tell the project delivery team what test a project must pass to succeed. During the PSP, the teams unify around success factors, the utilization of technologies, and the tools they select to manage production effectively..

THE PROJECT SUCCESS PLAN:

- Aligns the team and stakeholders' understanding of value. The team uses a value stream mapping activity to help identify topics and values.
- The team and stakeholders develop the CoS as clear statements of value. Ensures that Conditions of Satisfaction (CoS) are SMART. Project requirements are not CoS.
- Includes the needs of the design and construction teams and Massport.
- Identifies BIM Uses, work plans, and processes supporting the CoS. All work drives toward CoS, reducing waste and ensuring continuous improvement.
- The CoS drives decision-making across project teams. (at every level)
- Use Lean management tools to optimize BIM production throughout the project and support visual decision-making.
- Establish and understand constraints to be eliminated or managed. Project constraints prevent activity from starting, advancing, or completing as planned.
- Define VDC and Lean metrics to measure success.
- Update CoS with stakeholder feedback during each project phase.

PROJECT SUCCESS PLAN SESSIONS

PSP sessions are scheduled across the project lifecycle. The structure and allotted time for the session depend upon the number of stakeholders, project complexity, and whether the project scope is defined during the session. First or large sessions should be structured. Typically, Value Stream Mapping captures stakeholder agendas, desired project outcomes, and constraints. These are grouped into topics and then developed as CoS statements that all participants approve of.

The project Executive Team, PMs, and the VDC Managers facilitate the sessions. They identify the stakeholders, the people who can define project value, and the team responsible for the work as participants. BIM Coordinators align BIM Uses with CoS.

CoS WORKSHEET

CoS are documented using the Massport CoS worksheet. It identifies the CoS, the champion or responsible party, the metrics, and the actions necessary to succeed.

METRICS FOR CoS PROGRESS

A weekly project dashboard showing VDC progress and metrics is developed and maintained with input from the project team. The PM and VDC Manager typically manage the dashboard. One section of the dashboard documents the progress made on CoS.

MASSPORT LEAN DESIGN AND CONSTRUCTION EXHIBIT

Teams may receive additional instructions requiring a supplement to the Consultant agreement for preconstruction services. The Massport Lean Design and Construction Exhibit is a Contract Document supplementing the Consultant Agreement between Massport and the Prime Design Consultant ("Consultant"),

CoS	Champion	Performance Metrics	Action Items/Status
<i>Measurable statements that tell the project delivery team what test a project must pass to be accepted as a success</i>		<i>How do we measure it?</i>	
Maintain access to Terminal B during construction	Phasing Team	Sequence work to ensure ongoing access	Study sequencing and phasing
Maintain vehicular traffic and emergency access on departures level during construction (except for short durations)	Phasing Team	Sequence work to ensure ongoing access	Study sequencing and phasing
Maintain bus, vehicular, and emergency access on arrivals level during construction	Phasing Team	Sequence work to ensure ongoing access	Study sequencing and phasing
Return buses to Department Level through garage or on the plaza	Structural and Plaza	Select an alternative that returns buses to departures level	Study roadway structure and bus plaza

FIGURE 23 — CoS Example

the Preconstruction Services Agreement, and the Construction Services Agreement between the Authority and its Construction Manager (“CM”). This Lean Design and Construction Exhibit provides the basis for the Project Team to develop the Project Lean Deployment Plan (“LDP”).

BIM EXECUTION PLAN (BIMXP)

Teams develop several documents for project delivery. The BIMxP documents:

- Project and Contact Information
- BIM Uses and CoS
- BIM Modeling Requirements
- BIM Data Requirements
- BIM Deliverables Requirements
- Collaboration and Communication Procedures

Since teams come from different companies, documenting the collaboration strategies and BIM information reduces the project unknowns. The document assists new team members with their onboarding process, the constructor’s understanding of the models for the design assistance process, and the handover of the Record and As-built models to Massport.

The BIMxP is a “living” document that is developed and updated throughout the project lifecycle. The responsible party submits the BIMxP during specific project stages:

Stage 1- Pre-project response to the Massport Request for Proposal

Stage 2- Project Start, Design BIM Coordinator- BIMxP

Stage 3- Construction Phase, BIMxP update

Stage 4- Handover Phase, Final BIMxP Deliverable Massport’s BIMxP is available on the DTIG website.

<https://www.massport.com/business/capital-improvements/capital-programs-and-environmental-affairs/dtig>

ISO-19650-2 PROCESSES - BIM EXECUTION PLAN STAGES

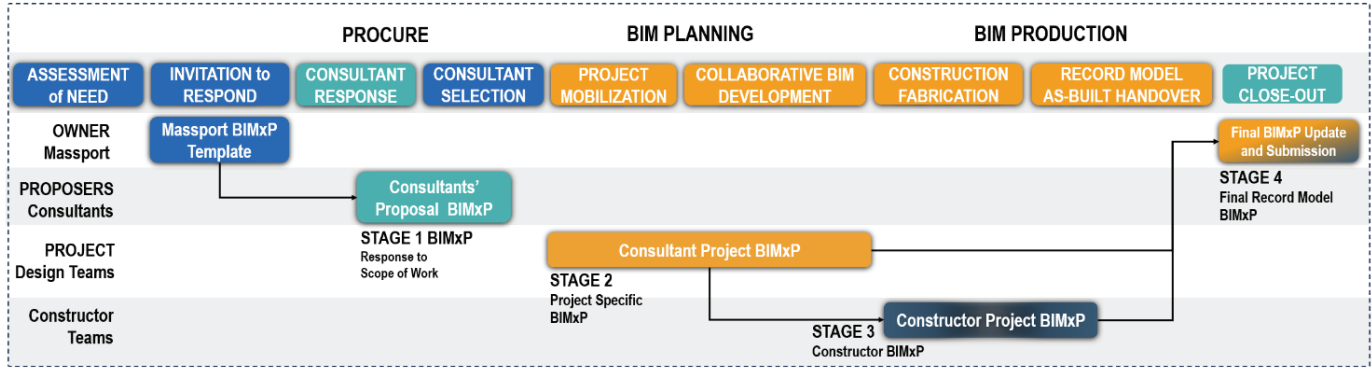


FIGURE 24 — BIMxP Stages

RISK MANAGEMENT

The Massport PM and project team identify and assess project risks. Once identified, the team develops and implements response strategies to ensure the project goals are met, and risks are mitigated.

The Massport PM facilitates a risk workshop with the project team to identify and assess project-specific risks and opportunities. (This workshop generally takes place before the finalization and issuance of the RFP package). If a risk assessment or identification exercise is performed as part of the Project Definition Phase, any previously developed risk register can serve as a starting point for the workshop. The Massport PM documents the identification of risks using the Risk Register-Sample.

Category	Typical Risk	Quantitative				Impact		Risk Owner	Action Response
		Likelihood (L)	Severity (S)	Risk Priority P = L*S	Action	Cost Impact	Time Impact (Weeks)		
Airline	Schedules	1	2	2		3,300	2		
Airline	Requirements	1	2	2		3,300	4		
Labor	Strikes	2	2	4		51,500	5		

FIGURE 25 — Risk Management Example

DESIGN AND CONSTRUCTION TEAM ACTIVITIES:

- Act upon risks (opportunities) that can be mitigated (exploited) through additional investigation and design.
- Identify specific technical issues and challenges that competing CM firms should be aware of in the RFP Package.
- Update the project schedule as needed to incorporate mitigation and schedule contingencies.
- Update the construction cost estimate to include risk-based contingencies.

LEAN DEPLOYMENT PLAN

The Lean Deployment Plan outlines the work methods to achieve each CoS. The LDP defines how teams utilize the right Lean tools and approaches at the right time to add value and meet project requirements within a collaborative VDC environment.

The VDC Manager ensures team members can use the tools successfully, providing training and coaching throughout the project lifecycle. The VDC Manager collaborates with the design, construction, and Massport project managers, as well as the BIM Coordinators, to develop the LDP. Teams may use the Massport LPD template.

THE LAST PLANNER SYSTEM® (LPS)

The Last Planner System® (LPS) is the production planning system that manages a predictable workflow. The LPS is a required Lean planning process for Massport projects. Individuals are responsible for their work, fostering trust in a collaborative environment. The linked Guide defines the minimum requirements for LPS use, planning meetings, and documentation. The BIM Coordinator participates in these conversations to ensure BIM supports the project. The result is a production plan (not a schedule) that provides a predictable workflow, reducing waste.

MASSPORT LAST PLANNER SYSTEM® GUIDE ⁴

Massport has developed a Guide document for project teams. The Guide provides the instructions for Last Planner System® use.

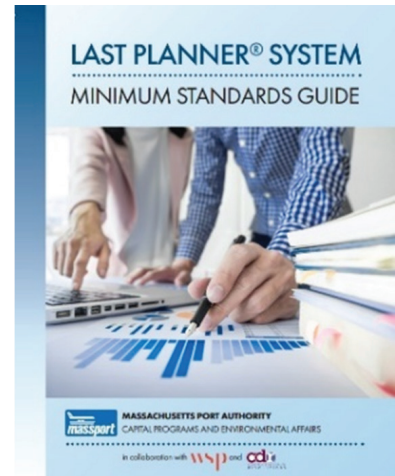


FIGURE 26 — Last Planner System Guide

REASONS FOR LPS:

- Control how information is shared.
- Identify key decision points.
- Keep the owner on track with making decisions.
- Align the team and the owner regarding the necessary information and its timing.

LAST PLANNER CONVERSATIONS

Teams use the Last Planner System® for multiple planning activities and conversations. .

- Improves communication & reliability.
- Fosters an enjoyable environment, trust, and collaboration.
- Promotes early stakeholder engagement.
- Improves project plan transparency
- Creates team alignment.
- Rapid learning through metrics reveals areas for improvement.
- Improves planning in both design & construction phases.

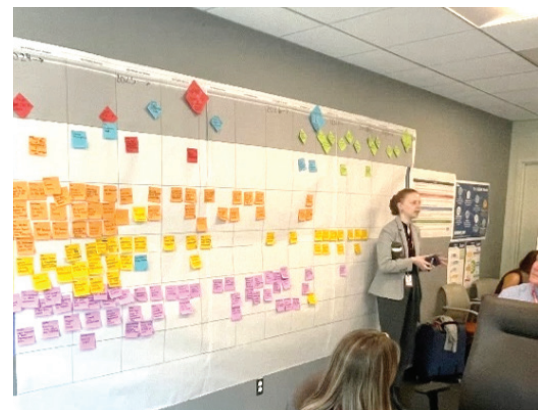


FIGURE 27 — - Pull Planning

LPS – A SERIES OF CONVERSATIONS

The LPS is collaborative and commitment-based, integrating SHOULD-CAN-WILL-DID planning by Last Planners—the people who do the work. It includes:

- Master Schedule Alignment;
- Phase pull planning (SHOULD);
- Make-ready (look-ahead) planning with Constraint analysis (CAN)
- Weekly work planning based upon reliable promises (WILL)
- Continuous improvement (Plan-Do-Check-Act) based upon analysis of Percent Plan Complete and Variances (DID).

⁴ LPS Guide - last_planner_system_guide_final-2019.pdf (massport.com)

MASTER SCHEDULE ALIGNMENT

- **Collaborative Scheduling** - For all team member activities. Align the LPS work plan and the project's Critical Path schedule (CPM). Each is regularly updated and aligned.
- **Master Schedule Alignment** - The project team reviews a high-level schedule that identifies significant events and milestones in a project, including project definition, design development, long lead delivery components, phasing, procurement, bid packages, field mobilization, and construction start and finish.
- **Phase Production Planning** - Collaborative development of a milestone schedule, phase, or production plan emphasizing the relationship between tasks and handoffs between disciplines and team members. Identifies conflicts and constraints.
- **Weekly Work Pull Planning** - 6-12 week pull plan defining the near-term work and schedule
- **Make-Ready/Look-Ahead** - Identify the next steps to ensure the activity is executed effectively.
- **Commissioning and Turnover to Client** - An MSA session fosters team alignment and establishes the basic approach to the work, identifies significant gaps, risks, and constraints, and confirms, based on the best available knowledge, that the plan is achievable. It should be used to develop a plan and timing for future phase pull sessions.
- **Team Management** - Learning and improving by maintaining variance and constraint logs. Recording, measuring, and improving the reliability of project planning and production.

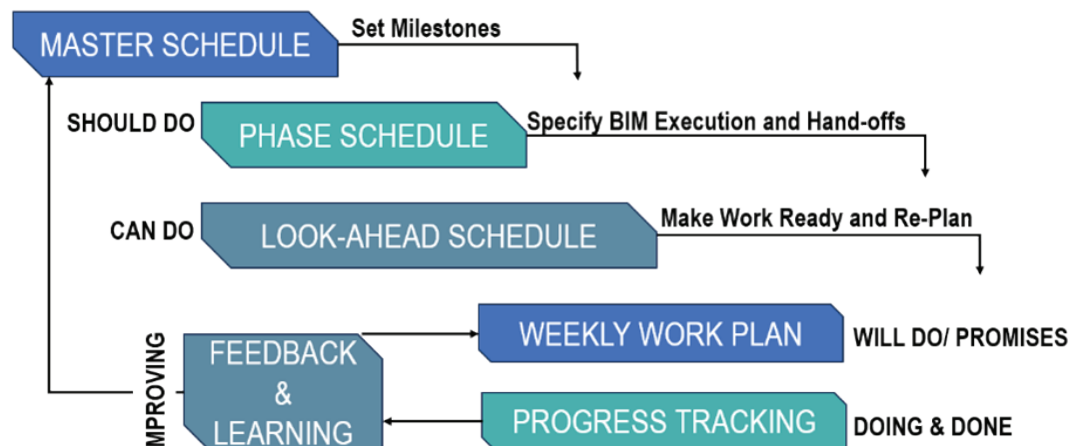


FIGURE 28 — Master Schedule Diagram

ALIGNING LPS AND SCHEDULING⁵

The design team is responsible for meeting the submittal schedule and the Authority's Contract and specification requirements. The design team remains responsible for the proposed design, schedule, and any/all applicable deliverables. When the construction manager comes on board, the CM must ensure that the submittal schedule meets the Authority's Contract and specification requirements. The construction team remains responsible for the project scope of work, the means and methods, and the planned sequence of work. It's worth mentioning that the LPS approach is not a replacement for traditional project scheduling during design and construction. Rather, it aims to enhance collaboration among project teams and prevent potential delays caused by a lack of communication and coordination.

⁵ Massport Primavera Scheduling Guide Massport Capital Programs (dyzz9obi78pm5.cloudfront.net)

BIG ROOM

“Right people, with the right information, are together at the right time.”

Project teams adopt a collaborative, cross-functional, and cross-organizational approach to organizing their project execution activities, as opposed to the typical “siloe” work production cycles.

Massport requires a Big Room team co-location, a physical meeting, and workplace enhanced by virtual communication and collaboration technologies.

Teams co-locate to break down company barriers and maximize all team member’s skills and capabilities. The Massport PM works with the project team on potential physical locations.



FIGURE 29 — Big Room

“Big Rooms” can be hybrid (combining periodic in-person and virtual sessions), recurring (where the project delivery team convenes in a facilitated half- or full-day session once a week), or co-located (where the entire team is located in one shared space for a project phase or project term). Big Room sessions, however, are organized and typically include owners, users, design and construction teams, consultants, trade partners, and suppliers, as needed to advance work production in the session. Participation varies by project phase.

A BIG ROOM PROVIDES:

- A physical co-location workspace enables companies to unite, fostering the development of a high-performing project team. It enables break-out space for cross-functional Cluster team collaboration.
- A Big Room includes equipment for virtual meeting participation, projection capability for BIM and project data review, digital collaboration tools, Whiteboards, and Lean tool materials.
- Focuses teams on work, innovation, and knowledge sharing. At or around the time the CM is retained, this responsibility transfers to the Contractor and its BIM Coordinator.
- Teams combine Lean 5S with “Big Room” for workplace organization, which involves sorting, setting in order, shining, standardizing, and sustaining. 5S improves workplace efficiency and safety by organizing and eliminating unnecessary items.

Big Room sessions are *production work sessions* where the project team makes decisions, produces work, and advances deliverables.

“BIG ROOM” BENEFITS:

- Improve communication, collaboration, and information flow between team members.
- ‘Focus on what matters.’ Focus attention and direct resources to appropriate design decisions at hand.
- Reduce paper-based or email-based communication.
- Engage all relevant stakeholders in the decision-making process.

BIG ROOM GOALS:

- **Facilitate Collaboration:** The Big Room, virtual and physical, is a shared environment where stakeholders collaborate, communicate openly, and work together toward project goals. It encourages integrated planning and immediate communication, reducing miscommunication and delay.
- **Maximize Flexibility:** Teams quickly produce alternatives that continually drive toward project value and allowable cost. Cluster teams allow rapid prototyping and problem-solving. Teams can group and regroup as needed using the Big Room capabilities.
- **Optimize the Whole:** Cluster teams optimize the team and the process. Teams integrate with the estimators for continuous costing during Target Value Delivery, and other knowledge experts not readily available on a team.
- **Visual Management:** Visual aids such as whiteboards, charts, and pull plans display projection systems, wallboard information, progress, and metrics. These tools and the Common Data Environment promote transparency and facilitate discussions.



FIGURE 30 — Target Value Delivery

TARGET VALUE DELIVERY

Massport requires a Target Value Delivery (TVD) process during the Project Definition, Design Development, and Final Design Phases. TVD efficiently designs to a defined “allowable cost” while maintaining or increasing the quality, value, schedule, and MPA Conditions of Satisfaction (CoS).

Cost is an outcome of the traditional design-estimate-rework cycles. TVD defines a target cost⁶ and uses the project values defined in the Project Success Plan to direct the design activities toward the prioritized values, making cost, value, schedule, quality, and constructability project drivers. TVD engages the project estimators with the Cluster teams throughout the design development process, not after.

Target Value Delivery Process

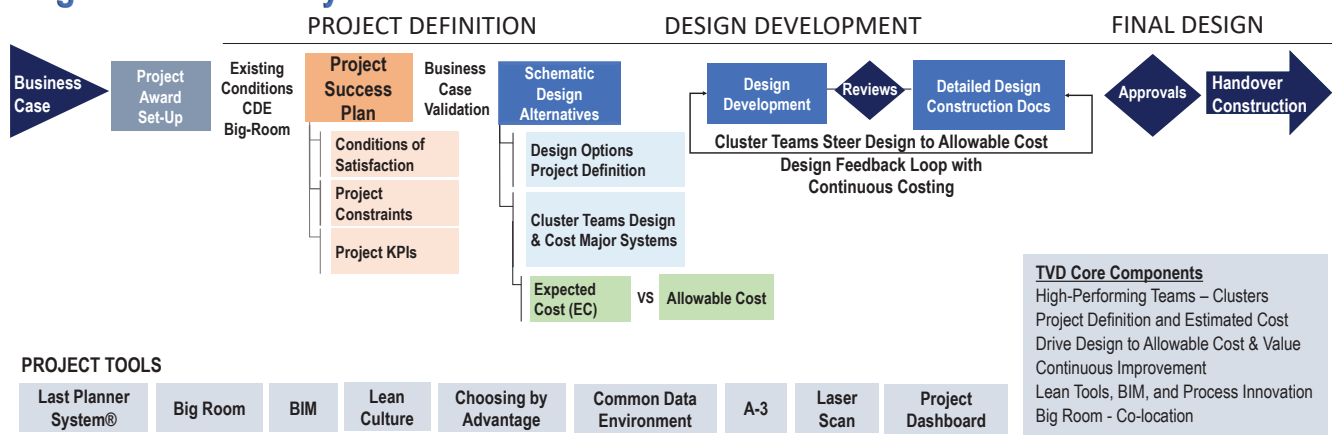


FIGURE 31 — Target Value Delivery

⁶ Target Cost, what the customer is willing to pay. Lean Construction Institute

This change in the estimators' engagement drives process efficiency, managing the design and cost. Sub-budgets may be allocated to Cluster teams to innovate, maintain, or increase value as they design project subsystems; however, the cardinal rule in TVD is that the target cost can never be exceeded, and only Massport can change the target scope, cost, schedule, or quality.

TVD REQUIREMENTS

- **Customer-centric focus**– Teams satisfy the Massport Project Success Plan, delivering value that aligns with project target cost, Conditions of Satisfaction, and other project requirements.
- **Collaboration**– Coordination and communication help teams collectively create value across the project. The teams must drive the project toward the allowable cost and decisions that create value. Estimators and Schedulers support the teams in managing the drive toward cost and schedule.
- **Flexibility**–Teams embrace flexibility and adapt to changing circumstances, issues to resolve, and needed decisions. The team and Massport may adjust project scope and priorities to help achieve the best project outcomes.
- **Continuous Feedback and Improvement**– Regular feedback from Massport decision-makers ensures that the project meets the CoS. Teams use Plus/Delta, A-3, and retrospectives to improve processes and projects.
- **Lean Tools/Principles**– Teams incorporate required Lean principles and tools to maximize innovation efficiency, minimize waste, and deliver value. The Lean Manager supports the Lean culture and tools.
- **Outcome-oriented Metrics** – Progress is measured by achieving specific outcomes or target values vs. tracking task completion or schedule adherence. Teams use the Massport Project Dashboard to document progress.
- **Risk Management**–TVD recognizes uncertainties and risks in a project. Teams manage risks while delivering maximum value.
- **Iterative and Incremental Development** – Teams employ incremental development cycles and continuous improvement, allowing frequent assessments to maximize value. TVD helps teams move from their practice of optimizing their scope of work towards holistically developing the best project.
- **Meet Project KPIs** – Key Performance Indicators are the measurable values the team defines to quantify their success. These are defined as part of the Project Success Plan and documented in the execution strategy and the BIMxP.

CHOOSING BY ADVANTAGE

When multiple parties are involved in making a critical decision or sets of decisions in a project, it's common for each party to become focused on what will most benefit their group. Choosing By Advantage enables the team to focus on the required outcome, the needs of stakeholders, and the CoS as the key decision factors.

“Choosing by Advantage” is a decision-making process that objectively evaluates project options based on delivering the “best value” for the project. The CBA goal is to make the best-informed choices that optimize project value and minimize waste. As CBA is objective, decisions can be respected and acted upon confidently. CBA helps support individual and group

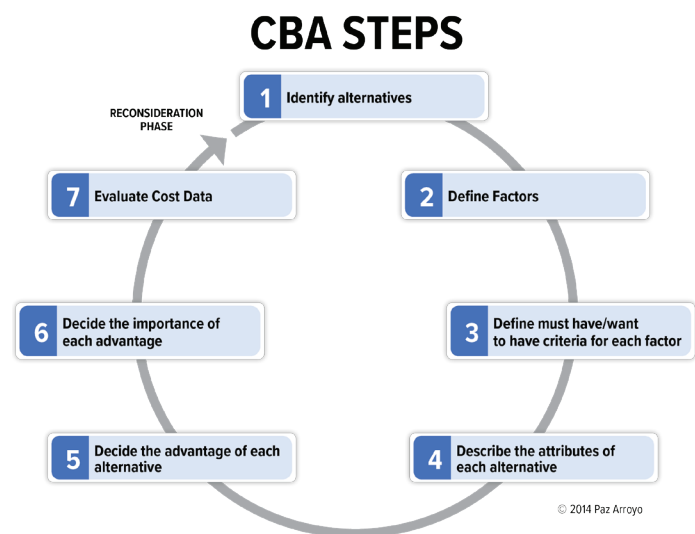


FIGURE 32 — Choosing By Advantage

decision-making, providing a clear rationale for documenting a decision. These have several implications for project management and improving the design and construction processes.

CBA is fact-based and data-driven, so teams do not work to justify a predetermined outcome; instead, the team considers alternatives and assesses the advantages based on Conditions of Satisfaction (CoS) and project factors that affect value, including cost, schedule, quality, safety, and sustainability.

THE STAGES OF CBA⁷ INCLUDE:

- **Stage-setting** – Establish the purpose and context for the decision – WHAT and WHY do we need a decision?
- **Innovation** – Identify alternatives likely to yield essential advantages over other alternatives. Formulate an adequate set of alternatives.
- **Decision-making** – Define factors to differentiate between alternatives. Choose the alternative with the most advantages. Define what must be included.
- **Evaluate Cost** – Cost is a decision factor made after considering the advantages. It helps to assess all factors, not just cost.
- **Reconsideration** – Change the decision to see if it should be revised or can be improved.
- **Implementation** – Execute the decision, adjust as needed, and evaluate the process and results. CBA can help decision-makers avoid late changes and negative iterations due to poor decision-making.

CBA COLLABORATION

Cluster teams working on specific project systems or components may use CBA to determine the best alternative for that system or component. At a collaborative level, multiple Cluster teams and stakeholders use CBA, objective measures, and Massport priorities to inform choices and develop project value holistically. The Massport PM and VDC Manager determine which stakeholders should be part of the process.

CHOOSING BY ADVANTAGES STUDY OF: HEATING HOT WATER SYSTEM					
		ALTERNATIVE 1		ALTERNATIVE 2	
		Central Plant Heating Hot Water System		Distributed Heating Hot Water	
Factor: Square feet of Mechanical Space Required					
Criteria	Attribute	3200 square fee		5100 sq ft required / 17 rooms	
	Advantage	1300 Sq Ft.	2		
Factor: Access for Maintenance					
Criteria	Attribute	Outside secure Perimeter		Inside Secure Perimeter	
	Advantage	Outside rather than in	4		

FIGURE 33 — CBA Example

The CBA Tabular Method can be used for moderately complex to very complex decisions, allowing for transparent documentation of these decisions.

⁷ Dr. Paz Arroyo – CBA instructor Lean Construction Institute

A-3 DECISION TEMPLATE FOR PROBLEM SOLVING

An A3 Report is a Toyota-pioneered practice that documents the problem, analysis, corrective actions, and implementation plan on a single A3 sheet of paper (11 ¾" x 16 ½").

The A3 process identifies a problem to be solved, assesses the root cause, sets the target state, proposes actions to achieve the target state, and identifies means of judging performance. It can facilitate or document a decision. Teams use A-3s for Massport decision support. Massport has developed a template for this process.

THE MASSPORT A-3 TEMPLATE INCLUDES:

- Background – Define the context of the problem
- Problem Statement/Current State-What is the problem
- Target State/Conditions of Satisfaction
- Investigations and Analyses
- Proposed Options Considered
- Impact Summary and Recommended Actions
- Follow Up
- May include graphics

Name _____ Title _____ Author _____ Manager _____ Date _____ Version _____ Decision Maker/Implementer/Communicator _____	
Section 1 - Background	Section 5 - Proposal/Options Considered
Section 2 - Problem Statement/Current State	Section 6 - Impact Summary/Recommended Actions
Section 3 - Target State/Conditions of Satisfaction	Section 7 - Follow Up
Section 4 - Investigations and Analyses	

FIGURE 34 — A-3 Framework

Team members may issue A-3s to address potential issues, process improvements, activities, design solutions, or project documentation. The A3 clarifies responsibility by placing ownership squarely on the shoulders of the author-owner of the A3, the individual whose initials appear in the upper right-hand corner of the document. This person may not have direct authority over every aspect of the proposal. The A3 owner is the person who has taken or accepted responsibility for making decisions and implementing them.

A3 REPORT

An A3 report guides the dialogue and analysis. It identifies the current situation, the nature of the issue, the range of possible countermeasures, the most effective countermeasure, the means (i.e., who does what and when) to implement it, and the evidence that the issue has been addressed.

ROOT CAUSE ANALYSIS (RCA)

Root Cause Analysis is a problem-solving technique that identifies the underlying causes of issues or defects in processes and systems, enabling organizations to address the root causes rather than just the symptoms. Teams may create a predefined list of root causes for more consistent and holistic identification and categorization of issue causes.

A3 RESPONSE

The A3 is a component of continuous improvement. The A3 must receive an appropriate and timely response to resolve issues, change procedures, and make improvements.

A3 No	Title	Revision	Champion	Date Started	Collaborators	Reviewer	Approved by:	Approved date:	Status
4	L1428 FAA NEXGEN ATCT Tower	2	R. Couto, WSP	08/16/2019	D. Ericson, WSP	R. Couto	S. Harris-Long, MPA	08/16/2019	☒ Development ☒ Collaborative review ☒ Implementation

Section 1 – Background

The Massport-operated and FAA-leased Control Tower at Logan International Airport plans to upgrade the existing air traffic control equipment to NEXGEN equipment. In order to accommodate the NEXGEN equipment, the study team assessed the feasibility of meeting the following:

Baseline Condition of Satisfaction

- 600 SF of additional equipment space

Additional Considerations for Future Value

- Expand administrative and training spaces
- Relocate the existing simulator space
- Consolidate employee spaces from adjacent buildings to the vicinity of the Control Tower

Section 2 – Problem Statement/Current State

WSP | PB's team performed the following:

- Review of all available existing documentation of the Control Tower Structure and the adjacent Central Garage Structure, including all renovations and additions
- Several field visits to the Control Tower, the Central Garage, the FAA Equipment Rooms, and the FAA Office Space
- Internal meetings on a regular basis to produce viable options to meet Massport's goals and to coordinate our investigation and analysis efforts
- Weekly meetings with the Massport Project Manager

Section 3 – Target State/Conditions of Satisfaction

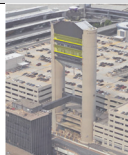
- Cost:** Cost excluded from initial advantage assessment. Included in analysis for reference only.
- Schedule:** Shorter schedule duration is more desirable.
- Construction Logistics/Phasing:** Less construction phasing complexity is more desirable.
- Permitting/Code:** Less code complexity is more desirable.
- Feasibility & Technical Complexity:** Less technical complexity is more desirable.
- Impacts to Tenants:** Less impact to tenants is more desirable.
- Potential for Program Growth:** (beyond Baseline Conditions of Satisfaction) Higher square footage is more desirable.
- Unknowns/Risk:** Less risk/unknowns is more desirable.

Section 4 – Investigations and Analyses

WSP | PB's team performed the following:

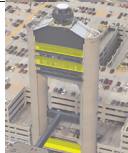
- Review of all available existing documentation of the Control Tower Structure and the adjacent Central Garage Structure, including all renovations and additions
- Several field visits to the Control Tower, the Central Garage, the FAA Equipment Rooms, and the FAA Office Space
- Internal meetings on a regular basis to produce viable options to meet Massport's goals and to coordinate our investigation and analysis efforts
- Weekly meetings with the Massport Project Manager

Section 5 – Proposal/Options Considered



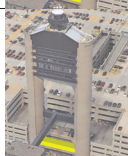
OPTION 1

- Interior Renovation Only
- Reallocates Tower Space at Levels 17 & 19
- Meets Baseline Condition of Satisfaction



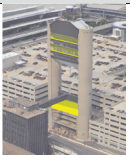
OPTION 2A

- Buildout of Tower Walkways
- Reallocates Tower Space at Levels 17 & 19
- Exceeds Baseline Condition of Satisfaction by ~350 SF Equipment Space at Level 3 and ~1000 SF Office Space at Level 2
- Add Alternate: Potential for additional ~750 SF Equipment Space at Level 1 & 4



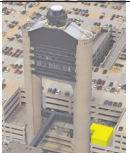
OPTION 2B

- Buildout of Tower Walkways
- Exceeds Baseline Condition of Satisfaction by ~750 SF Equipment Space at Levels 2 & 3
- Add Alternate: Potential for additional ~750 SF Equipment Space at Level 1 & 4



OPTION 3

- Constructs New Elevated Level Between the Pylons
- Reallocates Tower Space at Levels 17 & 19
- Exceeds Baseline Condition of Satisfaction by ~2900 SF Programmable Space at New Elevated Level



OPTION 4A

- Exceeds Baseline Condition of Satisfaction by ~2900 SF Programmable Space at Garage Level 4



OPTION 4B

- Exceeds Baseline Condition of Satisfaction by ~7400 SF Programmable Space above Garage Level 4

Section 6 – Impact Summary and/or Recommended Actions

ARCHITECTURAL IMPACT SUMMARY										CODE IMPACT SUMMARY					
Approximate Square Footage & Program-Added Second Baseline															
Options	TOWER 1	TOWER 2	TOWER 3	TOWER 4	TOWER 5	TOWER 6	TOWER 7	TOWER 8	TOWER 9	RELOCATED SPACE	NEW SPACE	TOTAL DELTA	System	Upgrade Level 1 & 2 to Comply to ADA	Res Rooms
1										600 SF EQUIP	0 SF	600 SF	1	☒	☒
2A										600 SF EQUIP	1300 SF	1300 SF	2A	☒	☒
2B										0 SF	1300 SF	750 SF	2B	☒	☒
3										600 SF EQUIP	2000 SF	2000 SF	3	☒	☒
4A										0 SF	3000 SF	2000 SF	4A	☒	☒
4B										0 SF	8000 SF	7400 SF	4B	☒	☒

Recommended Option: OPTION 2B

STRUCTURAL IMPACT SUMMARY				LATERAL IMPACT SUMMARY			
Options	Classification of Work	Gravity	WIND	Gravity	WIND	Gravity	WIND
		Existing Structure Requirements	Existing Structure Requirements			Existing Structure Requirements	Existing Structure Requirements
1	Alteration Level 2	☒	NO	Alteration Level 2	☒	NO	NO
2A	Alteration Level 2	☒	NO	Alteration Level 2	☒	NO	NO
2B	Alteration Level 2	☒	NO	Alteration Level 2	☒	NO	NO
3	Addition	☒	NO	Addition	☒	NO	NO
4A	Addition	☒	NO	Addition	☒	NO	NO
4B	Addition	☒	NO	Addition	☒	NO	NO

Section 7 – Follow Up

- Publish A3 Decision Summary internally to Project Team and to Massport
- Coordinate with Architecture, Structural, MEP, Scheduling, Estimating, and Code disciplines to incorporate appropriate changes into design.

FIGURE 35 — A-3 Example

3.4. VDC/BIM MANAGEMENT

Massport has used BIM since 2014. All teams must be experienced in creating and managing project BIM. Massport requires ISO 19650-1 BIM Stage Two model deliverables and the appropriate level of effort to deliver the quality and uniformity required to create this virtual project deliverable.

The BIM Standard updates the prescriptive modeling requirements for Massport projects. The BIM Standard includes a prescriptive model structure, adopted model standards, naming conventions, object and element standards, critical assets, the file folder structure for the CDE, BIM Uses, and model review procedures. The goal is to provide baseline models for projects, bidding activities, and handover to the construction team.

Models for existing facilities come from several sources and project types. Assessment, survey, and scanning are related technologies to collect source data for BIM. Feasibility studies, planning, retro-commissioning, renovation, and sustainability projects all utilize BIM.

A shared digital representation of physical and functional characteristics of a built environment asset.

National BIM Standard

SITE CIVIL INFRASTRUCTURE CAD STANDARD

Massport's portfolio includes land assets, airfields, marine facilities, utilities, horizontal structures, other infrastructure, and non-building assets. Infrastructure modeling emphasizes surface and subsurface elements, as well as topology projects. BIM applies to vertical and infrastructure construction projects. MPA has already completed projects combining building, site, roadway, land use, and infrastructure modeling. Massport resources include the *Site and Civil CAD Standard*.⁸

VDC/BIM REQUIREMENT CHANGES

The primary changes in Massport's BIM requirements:

- ISO 19650-1 BIM Stage 2 requirements for Model development, information management and responsibility, content standards, processes, and delivery
- Fully integrate BIM, VDC, and Lean tools to manage and maximize BIM value
- Model-First Design and Design Assist processes
- Design and Construction Collaboration process using Autodesk Construction Cloud (ACC)
- Use BIM dimension tools (4D, 5D, and simulation) to support Conditions of Satisfaction (CoS), Cluster team exploration, scheduling, production planning, and visual decision support.

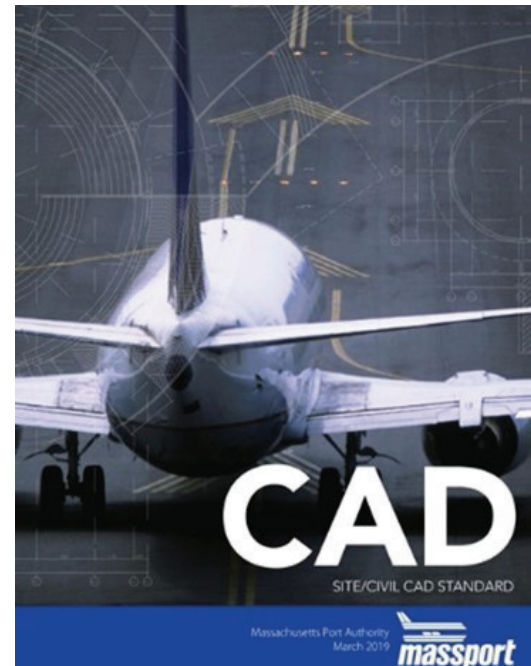


FIGURE 36 — Massport Site & Civil CAD Standard

BIM STAGE 2 (BIM-S2) MODEL MANAGEMENT

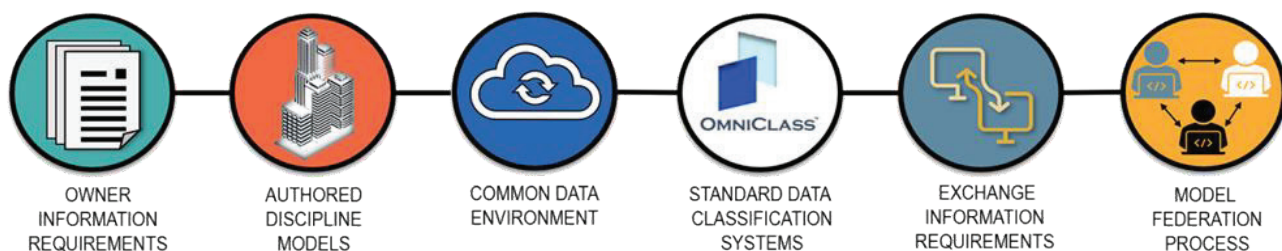


FIGURE 37 — BIM-S2 Model Structure

VDC projects move Massport from BIM-S1⁹ to BIM-S2 maturity. BIM-S2 is a more prescriptive modeling and information development effort that relies on a collaborative CDE-based and model-first process, requiring experienced design and fabrication modelers, design and construction-assisted collaboration, and compliance with Massport's critical asset data standards.

Massport's VDC strategy and standards comply with ISO 19650-1, an international standard for managing the asset lifecycle using BIM¹⁰. ISO standards are international and general. The project-specific requirements are defined based on Massport's model standards and data requirements.

⁸ Massport Site and Civil CAD Standard Digital Technologies Integration Group (DTIG) | Massport

⁹ Refer to Section 1.2.2 in this document for BIM Stage Maturity Levels

¹⁰ ISO "Organization and digitization of information about buildings and civil engineering works."

Information is defined across three sub-divisions:

- Geometrical and geospatial information requirements,
- Asset information requirements,
- Modeling, documentation, and visualization requirements as illustrated in ISO 19650-1, US NBIMS v.4, National CAD Standard, and the Massport BIM Standard.

BIM-S2 facilitates the integration of models, alphanumeric data, and documentation to support projects and Massport's long-term asset management objectives. The 19650-1 standard introduces a framework for appointing and delegating the information management function, underlining the need for clear accountability and responsibility across the project hierarchy. The US National BIM Standard v4 (US NBIMS v4) aligns with ISO 19650-1 and incorporates the BIMForum Level of Development (LOD) and the Construction Specification Institute (CSI) OmniClass classification system. The Massport BIM Standard references the U.S.-NBIMS v.4, the OmniClass classification system, and the National CAD Standard, and it is expected that project teams possess a comprehensive understanding of these standards and their application in Massport VDC projects. Specific data requirements are outlined in the Massport BIM Standard and the BIMxP template.

The responsibility for BIM-S2 discipline models throughout the project lifecycle rests with the respective discipline modeler. These models are federated, allowing for a comprehensive view of the design to enhance collaboration, visual decision support, and construction documentation. BIM-S2 emphasizes the importance of information exchange standards for facilitating effective model and data sharing within a project-level collaborative environment. Massport employs Autodesk Construction Cloud (ACC) as its CDE.

BIM-S2 maturity focuses on creating and exchanging structured data in standardized formats with interoperable systems, fostering collaboration among discipline models. Each discipline is accountable for its model, with models and data being federated and shared via the cloud-based Common Data Environment—Autodesk Construction Cloud.

Massport aims to progress from BIM-S1 to BIM-S2 by 2026 and to BIM-S3 by 2030, leveraging international standards and best practices. BIM stages encompass modeling processes and content. The Massport standards for BIM-S2 are defined in the BIM Standard. Massport aspires to achieve a highly advanced BIM-S3 maturity with enhanced integration and interoperability across various systems. BIM-S3 prioritizes structured data, open standards, shared databases, real-time collaboration, and the integration of enterprise systems, facilitating the exchange of information in a fully digital and interoperable manner for data-driven decision-making throughout the asset lifecycle, encompassing design, construction, and operations.

BIM USES

Project BIM Uses are identified during the Project Success Plan to achieve the Conditions of Satisfaction (CoS).

A BIM Use maximizes BIM capability by adding additional data and computational capability to automate information development.

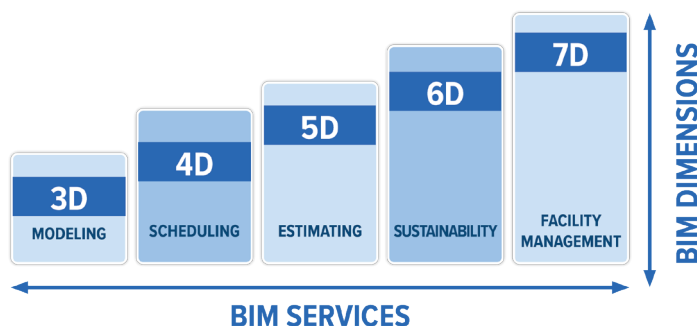


FIGURE 38 — BIM Uses

- 4D BIM is the 3D model combined with time for visual scheduling and coordination.
- 5D is the Model and Estimating.
- 6D is sustainability and energy simulation
- 7D is facility management.

The team defines what BIM Uses and services are appropriate for the project. These are documented in the BIMxP.

MODEL-FIRST PROJECT DELIVERY

Model-first requires collaborative and trusted communication between the design and construction teams early in the design assist process. The design team creates a constructible model, and the construction team builds the project based on the model and synchronized documents.

The model is used in planning, rapid prototyping, design detailing, and construction optimization, culminating in a more efficient project with fewer field errors.

Model-first informs design decision-making and supports constructability reviews as the project models evolve. The teams utilize Lean tools to facilitate efficient information flow and robust problem-solving before initiating physical construction.

The design and construction teams concurrently address constructability issues, including cost-saving design-to-budget analysis, virtual mock-ups, scheduling, and coordination simulations. These activities build the project virtually. Teams can see and manage assembly sequencing, layouts, coordination, and work scheduling.

The model also supports safety, off-site fabrication, laser layout, material laydown, equipment coordination, utilities, and as-built capture during the construction phase.

Massport promotes information sharing, open communication, and collaborative processes to ensure the quality and constructibility of the project models. This can be achieved by cultivating a culture of collaboration and dismantling digital communication barriers among planners, designers, builders, operators, and maintainers.

DESIGN ASSIST

Traditionally, the final design model and documentation were released to the construction team for review and to address requests for information. The identified changes required additional time during construction and necessitated rework by the design team. During construction, documentation ambiguities caused change orders and additional costs.

Design Assist is a proactive approach that leverages BIM and construction expertise during the final design phases to enhance the model and documentation constructability before construction. This approach develops a virtual prototype of “what to build,” rehearses through model simulation “how to build,” and then the construction team builds to the model during construction.

Design Assist serves as a facilitator for the further adoption of BIM during the construction phase. For example, options for construction layout and machine guidance use the model to increase efficiency in the field. These activities are planned early so that model files can be completed for the task. Project managers may enable Design Assist through collaboration in CM@Risk or separate service contracts during the final design phases.

The design and construction teams, in collaboration with the fabricators, minimize constructability issues and design uncertainties that can cause delays during construction. Construction team fabricators add model detail for off-site fabrication, reducing material handling, waste, and rework.

BIM MANAGEMENT

BIM is a primary means of developing project information, exploring options, and analyzing the performance and constructability of designs for use in construction. In VDC projects, Lean tools help teams maximize the value of BIM.

Project-specific BIM requirements are developed in the Project Success Plan. The VDC Model-First process, BIM Uses, and progress are managed with the Last Planner System®. BIM is integrated into the project process mapping, LPS pull planning, look-ahead, and weekly planning to ensure BIM supports team activities.

Collaborative modeling involves model tasks (BIM Uses) carried out in a specific order that benefits the project's workflow and supports the CoS. The BIM Coordinator and discipline modelers participate in LPS activities to ensure that BIM fully supports the design process and aligns with the team's information development needs.

VDC & BIM MINIMUM PROCESS REQUIREMENTS

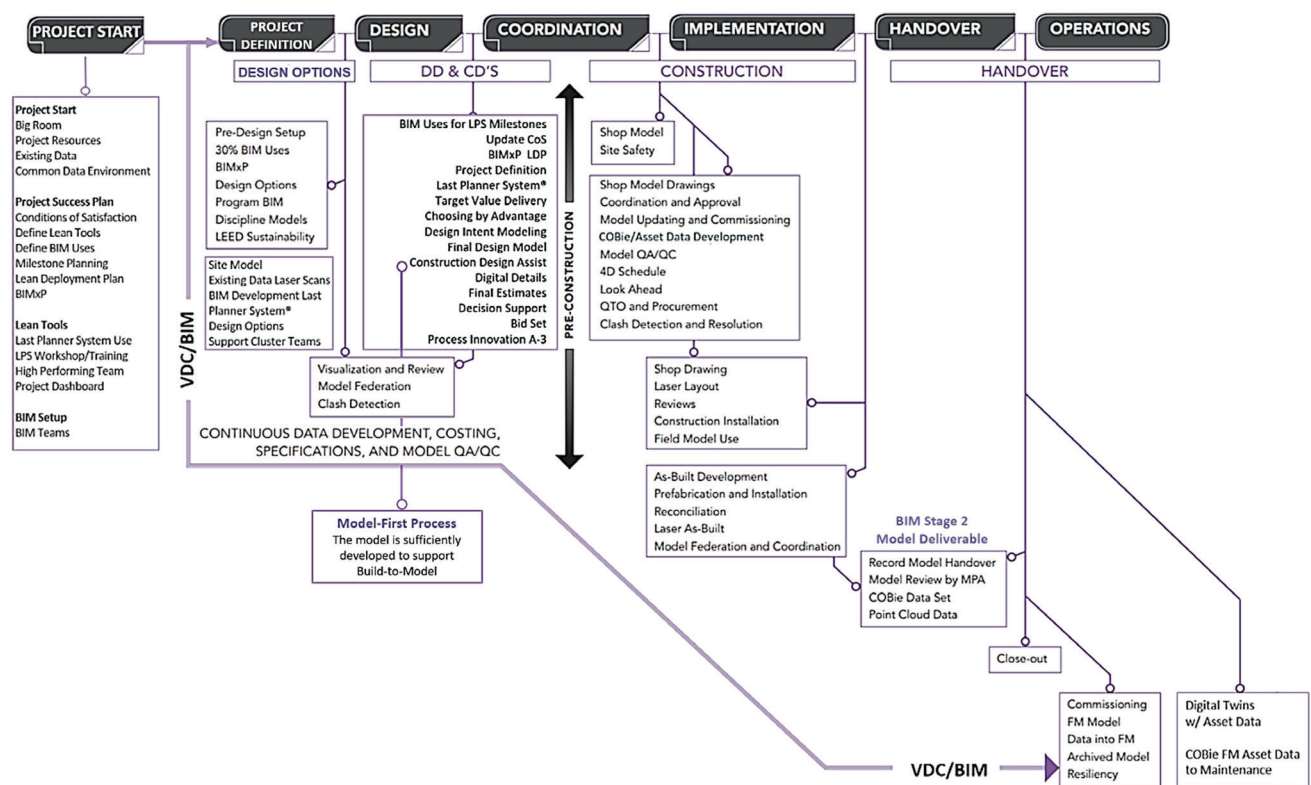


FIGURE 39 — VDC BIM Process Diagram

Examples of BIM integration include these items:

- Big Room project review
- Last Planner participation
- A-3 Reporting
- Cluster Team rapid prototyping for problem-solving
- Choosing by Advantage visual review for identifying advantages and reporting
- Target Value Delivery quantity takeoff
- Bill of Materials (BOM) for allowable cost estimating

The BIM Coordinator transitions from one value-adding BIM Use to the next, maintaining project development, information flow, and the visual decision process across the project lifecycle. This model progression is identified in the BIMxP, defined in the Project Success Plan, and the changing Conditions of Satisfaction (CoS).

MODEL QUALITY REVIEWS

Models are developed per the BIMxP model progression schedule, BIM Use execution, Cluster team support, and required standards compliance.

- Each Discipline team holds regular model reviews for content, modeling progress, and standards compliance before a weekly model federation.
- Project teams conduct federated model reviews and conflict resolution meetings before Massport submissions. The Federated models are reviewed for conflicts, and once resolved, the model may be submitted to the DTIG BIM Manager through the ACC bridge. The coordination review identifies model element conflicts, their resolution, model structure, and compliance with standards.

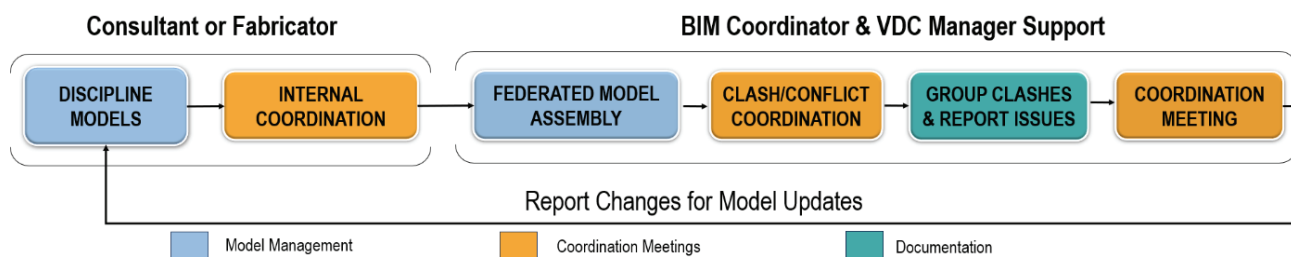


FIGURE 40 — Internal Model Reviews

The DTIG BIM Manager holds monthly or as-needed review meetings with the BIM Coordinator to review the current state and quality of the models. The DTIG may participate in Coordination meetings throughout the project.

MODEL-BASED ESTIMATING, SCHEDULING, AND REPORTING

Teams add and extract data from elements, areas, and volumes and report the data in an organized form to support project processes. SqFt cost by material/labor or spaces by function/quality helps design teams compare the costs of different configurations during the schematic design phase. Volume calculations support MEP requirements.

Quantity takeoff and estimating are required for VDC Target Value Delivery. BIM teams provide quantity data to estimators for quantity takeoff and estimating purposes. Model-reported quantities can be used in estimating software for more detailed estimates. This capability is underutilized on most projects. New AI-enabled tools support faster design options estimating.

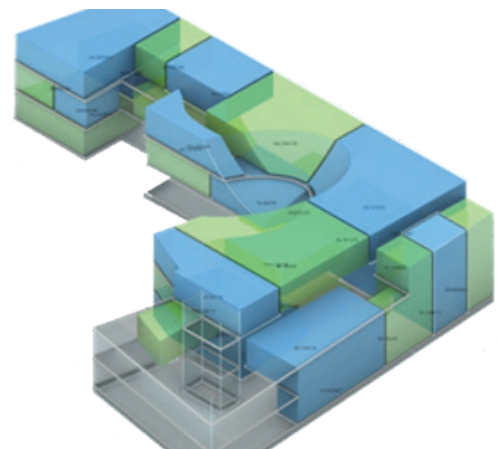


FIGURE 41 — Schematic Model Estimate

ARTIFICIAL INTELLIGENCE (AI) ENHANCED SCHEDULING

4D scheduling can be time-consuming, so teams must determine whether it is cost-effective for a project. AI is making a positive impact on project construction scheduling. The AI component¹¹ of scheduling enables teams to apply AI-based scenarios to optimize scheduling options, manage risk, and allocate resources. These parametric tools support multiple what-if options to determine the maximum balance of resources, time, and cost. These tools support current scheduling software and BIM.

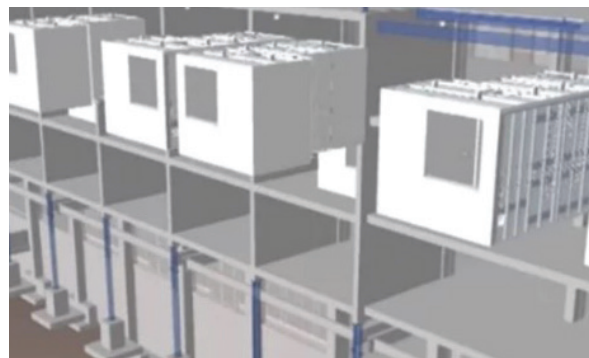


FIGURE 42 — Pre-fabrication

MODEL TO FABRICATION

The construction fabricators use the Model to produce building system components for installation. They further develop the Model for fabrication and construction installation. This increases the model components' Level of Development (LOD)¹² The team shall identify the model changes and software used for fabrication in the Construction Phase BIMxP. Off-site fabrication reduces assembly time, increases safety, and minimizes site coordination and material handling.

3.5. CONTINUOUS LEARNING AND IMPROVEMENT

Continuous improvement is a lean principle that identifies changes or improvements (deltas) to enhance processes, products, or services. Continuous improvement and problem-solving focus on efficiency, effectiveness, and value creation. Lean tools are used for these activities. Lean Practice: Continuous Improvements SOP¹³

PLAN-DO-CHECK-ACT

The Plan-Do-Check-Act cycle is an iterative process for carrying out change. This four-stage method enables teams to avoid recurring mistakes and improve processes and team behavior.

PLAN—DECIDE ON AN ACTION

This activity often begins with an A-3 problem statement and a root cause statement. Once the problem is identified, the team should ask several questions:

- What is the core problem to solve?
- What resources are needed?
- What resources do we have?
- What is the best solution for fixing the problem with the available resources?
- Are there any constraints delaying our ability to act on the problem?
- In what conditions will the plan be considered successful? What are the goals?
- Set clear SMART goals to guide the team and ensure focus and consistency.

The team should not move forward until there is an agreement on the problem and answers to the above questions.

¹¹ Alice Core – Stanford developed tool <https://reponse.net/4d-bim-cpm-scheduling/>

¹² Level of Development, BIM Forum

¹³ Continuous Improvement SOP - Event Charter Template (d1yzz9obi78pm5.cloudfront.net)

DO—ACT

Once the plan is in place and actions can be taken, the team applies all considerations from the previous stage. The team tasked with solving the problem should understand their role and responsibilities, have access to the necessary resources, and be aware of the metrics for success. If possible and appropriate, the team should do a pilot activity to minimize risk. This allows the team to implement the strategy, check the execution results, and improve the successive iterations until the problem is solved.

CHECK—REVIEW

Audit the action results and analyze the collected data to understand what has been learned. The Check phase activity sets up the team for continuous improvement and learning to solve the problem. Completing an audit enables the team to assess the success of the plan and identify areas for improvement. The team identifies problematic aspects of the current process and eliminates them going forward. If something goes wrong during the process, you need to analyze it and find the root cause of the problems. Another A-3 can be developed to distribute this information.

ACT--USE

The information developed in the Check phase serves as the basis for the next iteration if the problem remains unsolved. If the action solves the problem, the team will deploy the activities, resources, and learning so the entire project benefits from the PDCA activity. The team documents the new process and creates a standard operating procedure (SOP) for the project.

PLUS/DELTA

Lean Plus/Delta” is a feedback technique used in project management, team dynamics, and continuous improvement processes. The meeting facilitator manages the Plus/Delta. At the end of an activity, there are two questions to be asked:

- **Plus** – What produced value during the sessions?
- **Delta** – What could we change to improve the process or outcome in the future?

PLUS/DELTA IMPROVES TEAM ACTIVITIES IN 5 WAYS:

- This process improves productivity
- Encourages open communication
- Increases accountability
- Clarifies priorities
- Boosts team morale

Plus/Delta helps team members be responsible for the activity outcome and hold each other accountable for making changes. The PM is responsible for responding to the Plus/Delta improvements.



FIGURE 43 — Lean Plan, Check, Do, Act

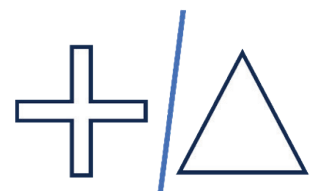


FIGURE 44 — Plus Delta

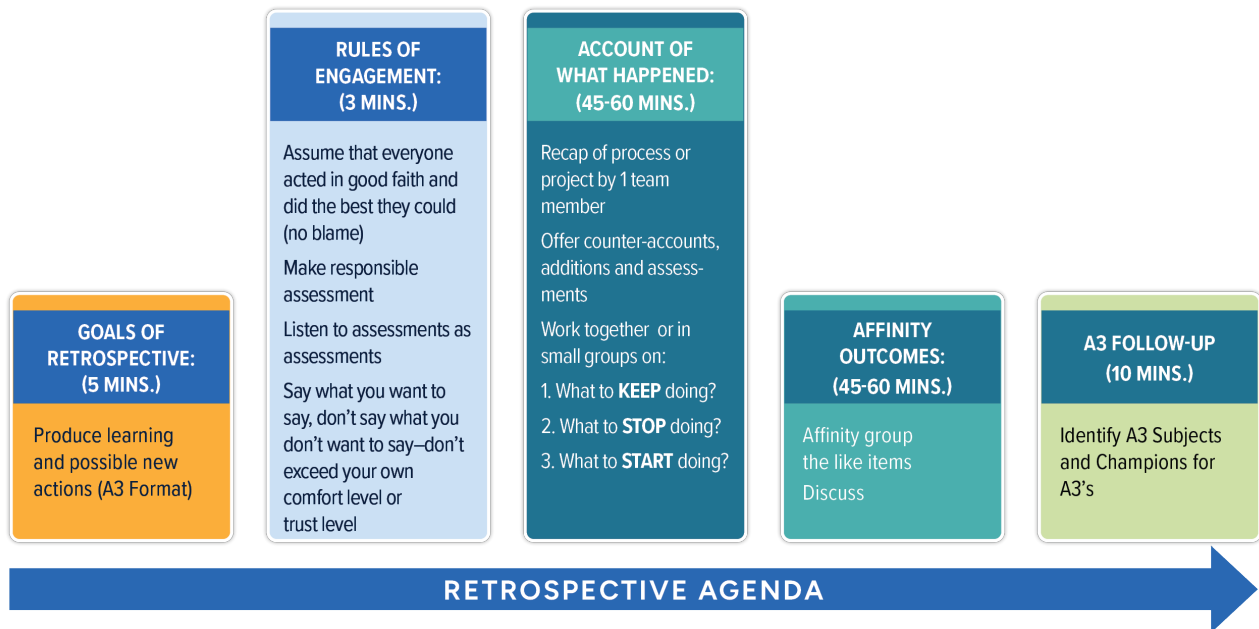


FIGURE 45 — Retrospectives

RETROSPECTIVES

Retrospectives regularly pool team members' collective knowledge, ensuring continuous improvement and eliminating waste caused by a lack of communication. Retrospectives are respectful. It is not a grievance session. It is a meeting focused on process issues and potential improvements to reduce waste, not people..

REGULARLY HELD RETROSPECTIVES:

- These discussions involve a broader analysis than Quick-format Retrospectives
- The team reflects on some facets of the workflow. Three key questions fuel this discussion:
 - » What do we want to keep doing?
 - » What do we want to stop doing?
 - » What do we want to start doing?

EVENT-BASED RETROSPECTIVES

Event-based retrospectives are conducted for the major milestones or the declaration of a significant breakdown. The facilitator distributes a meeting agenda to all members before the Retrospective. Participants come to the Retrospective prepared to engage in constructive conversations.

AGENDA CONTENT

- Goals of Session
- Ground Rules
- What Happened
- Counter-accounts
- Assessments
- Possible Actions

CONSIDERATIONS FOR RETROSPECTIVES¹⁴

- A third party may be secured to facilitate the meeting.
- The facilitator manages the discussion so everyone participates, and a small group does not take over the meeting.
- The discussion stays on topic – process, not people.
- People take the meeting seriously.
- Conditions of Satisfaction serve as a driving force for all discussion.
- Team members are prepared to discuss the agenda topics.

PROJECT		TEAM RETROSPECTIVE				SESSION DATE	
STOP		KEEP		START			
WHAT	HOW	WHAT	WHY	WHAT	HOW	WHY	
TOPIC							
TOPIC							
TOPIC							

FIGURE 46 — Retrospectives Example

VDC PROJECT METRICS - DASHBOARDS

MPA uses a VDC-focused Project Dashboard to document the team's progress and track VDC deliverables during design and construction. The dashboard facilitates discussions between the DTIG VDC Manager, Consultant/Constructor VDC Managers, and other team members during periodic meetings.

At the VDC kick-off meeting, the project team shall discuss the data required to maintain the dashboard based on the selected sections they plan to use. Additionally, they should determine which party will be responsible for updating the dashboard and how the data flow can be automated to ensure all team members have seamless access to an up-to-date dashboard.

The content of the VDC dashboard can be summarized as follows

1. **Project Information:** Summarizes basic information about the project, including the VDC point of contact for each team party.
2. **Project Timeline:** Visualizes the project's start, current, and end dates, as well as specific milestones for which VDC deliverables are expected.
3. **PPC Percentage:** This shows the weekly Percent Plan Complete (PPC) so that project managers can see how well the project follows the production plan.

14 Retrospective Meeting - <https://leanconstruction.org/lean-topics/retrospective-meeting/>

4. **Condition of Satisfaction (CoS):** Documents the identified CoS items and their associated BIM uses. This table, documented in the BIMxP, should be completed by the project team to identify the project-applicable BIM uses. The dashboard enables the team to track the execution of intended BIM uses and update them as needed.
5. **VDC Transmittals:** Displays the transmittals received by MPA on the project data environment, including specific file types (Revit, Point Clouds, etc.)
6. **Decision Log:** Captures decisions and related action items (if applicable) that the project team can create during meetings and share on the dashboard as a reference.
7. **Design Review:** Lists pending and approved reviews for easy status updates during meetings. The project team should decide what types of reviews (constructability, code compliance, safety, etc.) should be included in this table.
8. **Approved & Rejected Documents:** Related to the previous item, this graph summarizes the status of documents submitted for design review.

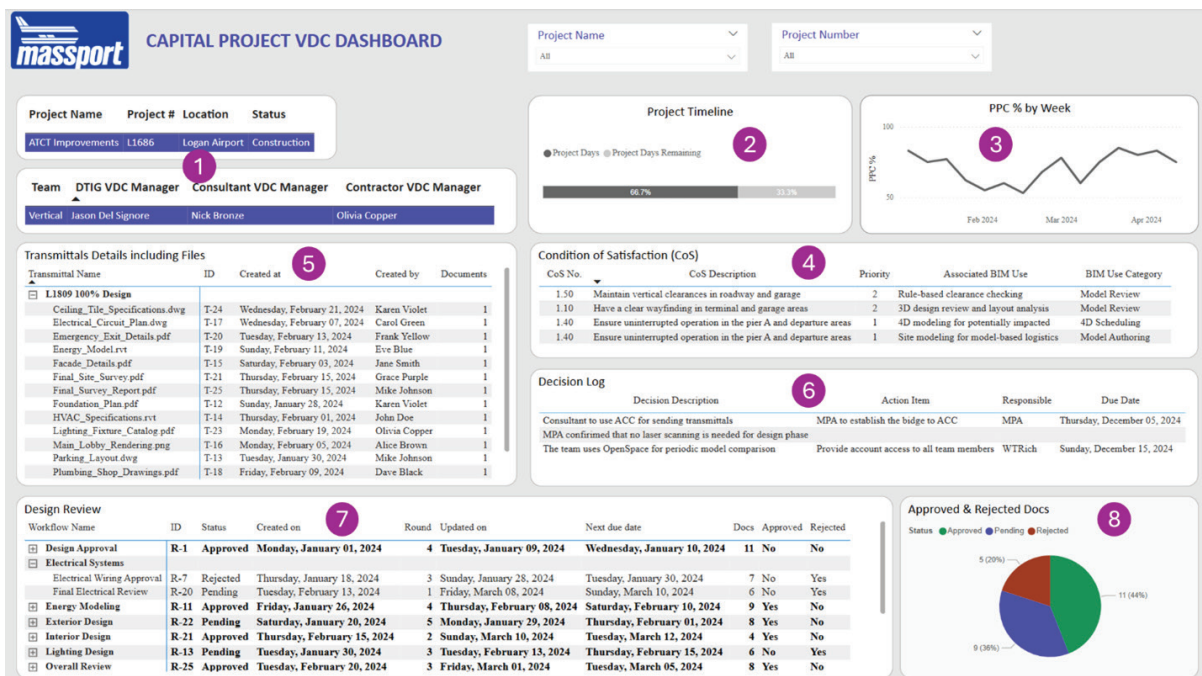
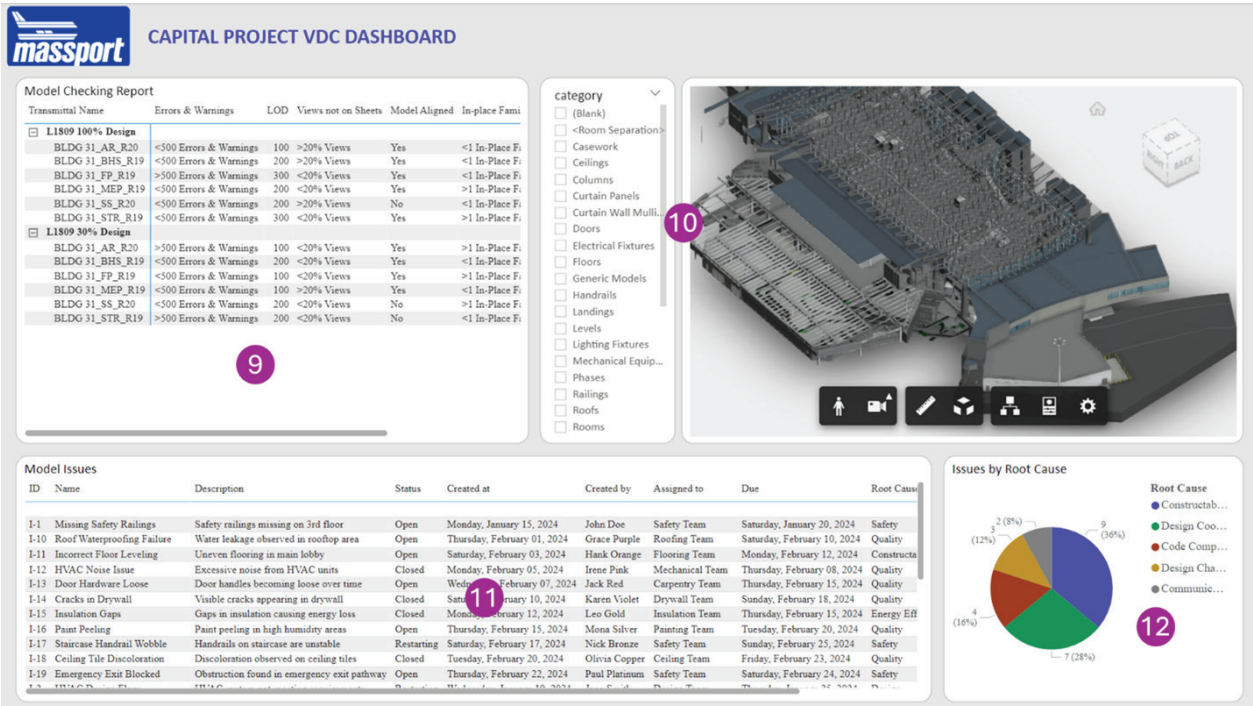


FIGURE 47 — Dashboard Part One

9. **Model Checking Report:** This allows the project team to communicate the results of model quality checks (QC) and address any required actions. Specific QC items are documented in the MPA Model Quality Assurance Standard.
10. **Model Viewer:** Enables quick model navigation during meetings. Model element categories can be used to isolate specific elements and review related data in the dashboard.
11. **Model Issues:** Summarizes issues identified by different team members during model coordination and reviews. It helps the project team prioritize and discuss selected issues during meetings.
12. **Issues by Root Cause:** Related to the previous item, this graph provides more in-depth information about documented issues by categorizing them based on their identified root causes.



VDC PROJECT EXECUTION



Berklee *boston* logan



“Execution is the ability to mesh strategy with reality,
align people with goals, and achieve the promised results.”

— *Mike Gregor*

4. VDC PROJECT EXECUTION

This section details the phase-specific VDC requirements and workflow, as illustrated in Figure 49 and the VDC Roadmap. Each team employs the Project Success Plan to develop a project-specific VDC framework, incorporating Lean principles, tools, and BIM Stage 2 modeling to support a Model-first approach and fulfill the Conditions of Satisfaction.

4.1. PROJECT STARTUP ACTIVITIES

The project start-up includes a Big Room for meetings, team co-location, and a Common Data Environment (CDE) for virtual collaboration and BIM processes.

BIG ROOM, CDE, AND BIM

Massport works with the Consultant to assign a Big Room space and install the required collaboration equipment for project execution. The Big Room allows teams to be located by task, discipline, and problem-solving rather than company.

CDE AND BIM

The DTIG and the project team BIM Coordinator will test the project ACC. This testing and set-up include:

- Review the ACC folder structure to ensure the team understands the environment.
- BIM is set up on the ACC per the BIM Standard.
- Implement ACC permissions and preliminary model setup for Site, Arch, and discipline models and review for standards compliance with DTIG.
- Existing data provided by the DTIG is made available through the ACC.

MINIMUM VDC REQUIREMENTS

- Project Success Plan - Conditions of Satisfaction (CoS)
- Lean Deployment Plan
- BIM Execution Plan
- Last Planner System® major milestones
- BIM Models, including the site and discipline models on the CDE
- Model Setup and model structure review

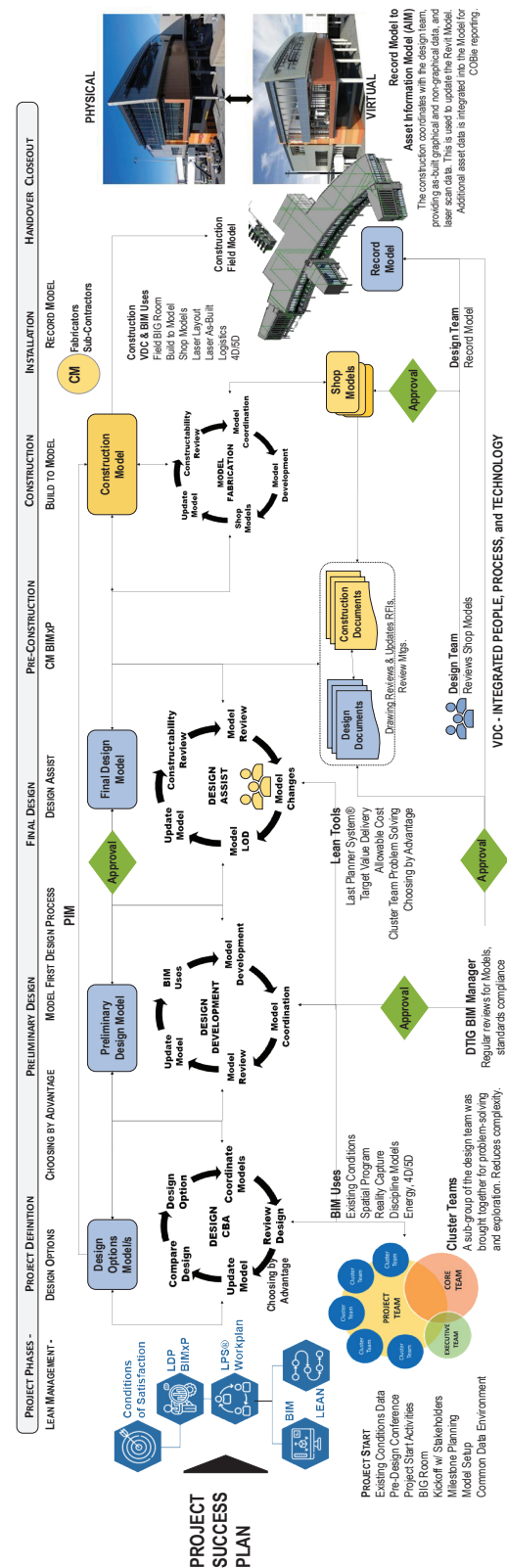


FIGURE 49 — VDC Workflow (from the Massport VDC Roadmap)

VDC COLLABORATION REQUIREMENTS

This section describes required VDC coordination, design assist, shop, fabrication meetings, and project lifecycle activities with the DTIG. A VDC or BIM Coordinator who can plan, lead, maintain the schedule, focus on meeting goals, and hold people accountable is essential for success. The meeting coordinator should possess the technical knowledge to understand and assign issues, ensuring that the right decision-makers are present during the meetings. If the meetings are particularly complex, it may be advisable to consider an outside facilitator.



FIGURE 50 — Model Review Collaboration

DTIG coordination meetings, utilizing BIM and Lean management tools, occur throughout the project lifecycle. These meetings identify model system clashes, explore options, and facilitate visual decision-making. It is essential for project success and must be managed effectively to resolve issues before they impact the field.

The design team's BIM Coordinator and the VDC Manager facilitate the design phase coordination meetings. The construction team's BIM Coordinator and building systems fabricators facilitate during construction.

The design team creates the project's discipline models. The Construction team is responsible for the shop and fabrication models used during the construction process. The design and construction teams hold internal coordination and milestone meetings for models before submission to Massport.

PRE-COORDINATION MEETING SETUP AND ACTIVITIES

Coordination meetings require a physical, virtual, and technological setup. The setup is part of the project kick-off phase. Massport PM and the Consultants jointly manage these activities.

- **Meeting Infrastructure** - Meetings can be held virtually, in person, or as a combination of both. The BIM Coordinator and the PM confirm that the infrastructure meets the meeting requirements.
 - » The CDE and collaboration tools – Massport uses Autodesk Construction Cloud (ACC) for CDE. Meeting tools include Teams or Zoom for virtual team meetings.
 - » Big Room - Physical location with computer and large screen presentation capabilities
 - » Model set-up - Before the meeting, the teams bridge their federated Models into ACC to ensure they work correctly. This activity should be given ample time so that the meeting can start and run efficiently.
 - » Coordination software is defined in the BIMxP as Navisworks Manage, the ACC coordination tools, or other approved software for identifying clashes and conflicts.
- **Agenda** - Teams supply coordination issues to the meeting Coordinator at least 48 hours before the meeting for inclusion in the agenda.
 - » The agenda outlines the CoS, agenda items, time, participants, decision goals, and desired outcomes for the meeting.
 - » Topics are organized by the participants and stakeholders required for the decision-making process.
 - » The project PM or responsible party issues an Expected Outcomes Agenda (EOA) at least 24 hours before the meeting. An example and instructions are provided in the EOA/Standard Operating Procedures (SOP) and the Massport Meeting Minutes Template.

- **Meeting Schedule and Participants**

- » Keep meetings to one hour.
- » A clear agenda and staggering participant start times help manage meeting length and focus on the desired outcomes.
- » Align the participants' start times to the agenda and model groupings. For example, the architectural and structural teams are grouped to address model conflicts, and the MEP and structural teams meet later to resolve their model conflicts. Participant staggering keeps meetings focused on the intended decision process.

- **End of Meeting Activities**

- » Determine the need for Cluster teams or additional meetings
- » Plus-Delta - document the success of the meeting and needed improvements
- » Meeting Minutes are distributed to all participants

DESIGN PHASE COORDINATION MEETINGS

Two coordination meetings are held before a general coordination meeting with Massport. The design teams regularly scheduled internal discipline and federated model coordination meetings. The schedule is documented in the BIMxP.

Teams must decide which disciplines have priority when a conflict arises. Teams should understand their discipline hierarchy and the conflict decision process. This priority decision process is established at the project's outset. Typically, architecture and structure take priority in conflict resolution; however, the right decision requires the right stakeholders to be present in the meeting. Example: MEP Models are typically changed when in conflict with the structural model. Stakeholders from architecture, structure, Massport, and MEP disciplines must be included in the decision-making process.

The decision process and discipline conflict requirements determine the right meeting participants and the most efficient way to resolve a conflict between two or more disciplines.

INTERNAL DISCIPLINE COORDINATION MEETINGS

Discipline teams complete intra-team discipline model reviews, identify and correct errors within their model, and prepare the issues to be resolved for the coordination meeting. These issues are sent to the meeting coordinator for inclusion in the agenda. Issues can be tracked through the ACC issue tracking tool, as set up in the CDE.

- Discipline modeling teams review their models before the weekly federation to ensure they comply with Massport standards.
- Ensure the model is clash-free within the scope of work and in coordination with the base model.
- Remove extraneous elements, duplicates, and other unnecessary notes and details.
- The elements are in the correct location.
- LOD and data conformance with BIMxP.
- Develop issue list for federation Meetings.
- Generate and share clash detection reports (if needed).
- Conduct model QC and submit the report (if required in the BIMxP).

INTERNAL COORDINATION MEETINGS

The BIM Coordinator utilizes the ACC federation process for the discipline models and holds meetings to resolve conflicts between discipline models, ensuring compliance with standards and design feasibility. The DTIG BIM Manager may participate in this meeting.

- Discipline teams review model conflicts and discipline issues, ensuring the resolution supports the CoS and design scope requirements.
- Ensure the model is clash-free and conforms to Massport standards and model structure.
- Check for omissions in the models or elements in the wrong discipline model, LOD check.
- Elements in the wrong location – Use discipline hierarchy decision process

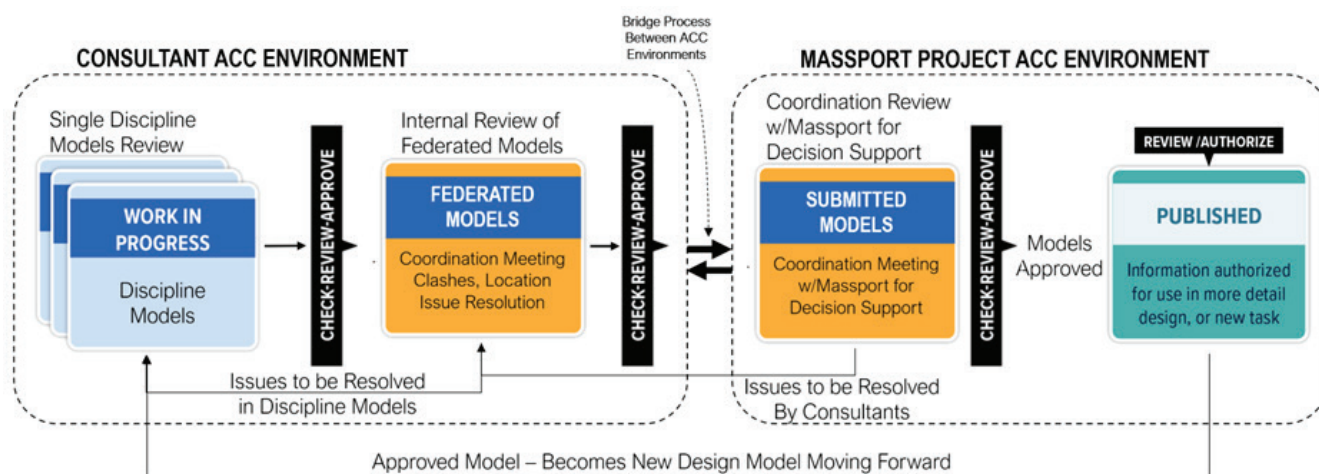


FIGURE 51 — Model/CDE Workflow

MASSPORT REVIEW COORDINATION MEETINGS

These meetings are Massport's opportunity for a model walk-through and provide feedback documented for further discussion or work. The DTIG BIM Manager and appropriate Massport stakeholders participate. Alternatively, the Massport PM and DTIG BIM Manager may participate in the design and construction teams' Internal Coordination Meetings when owner's input is needed for decision making. The agreed plan for model review and 3D coordination shall be documented in the BIMxP.

- The model is clash-free (unless a clash is to be reviewed with Massport) and conforms to the model standards and structure.
- The BIM Coordinator prepares the federated model for design coordination, conflict resolution, design scope, and standards compliance, which require input from Massport decision-makers.
- During the meetings, the BIM Coordinator or a designated Model Manager manipulates the model.
- Each discipline team provides a model reviewer who is familiar with the meeting agenda and discipline-specific issues.
- The agenda provides the issues to be addressed by Massport.

SHOP MODEL FABRICATION COORDINATION MEETINGS

The fabricators hold model coordination reviews.

- Ensure the model is clash-free.
- Remove extraneous elements, duplicates, and other unnecessary notes and details.
- The elements are in the correct location.
- LOD and data conformance with BIMxP
- Develop issue list for Coordination Meetings.
- Models are reviewed by the design team and the DTIG BIM Manager to ensure they meet the design specifications.

4.2. VDC ACTIVITIES - DEFINITION PHASE

These activities begin after the team has been selected and the work order issued. It addresses the project scope, including programming, scheduling, and cost relationships, sets preliminary Conditions of Satisfaction (CoS), and utilizes VDC tools and processes for project execution. Teams should be aware of the project resources available for VDC and BIM activities.

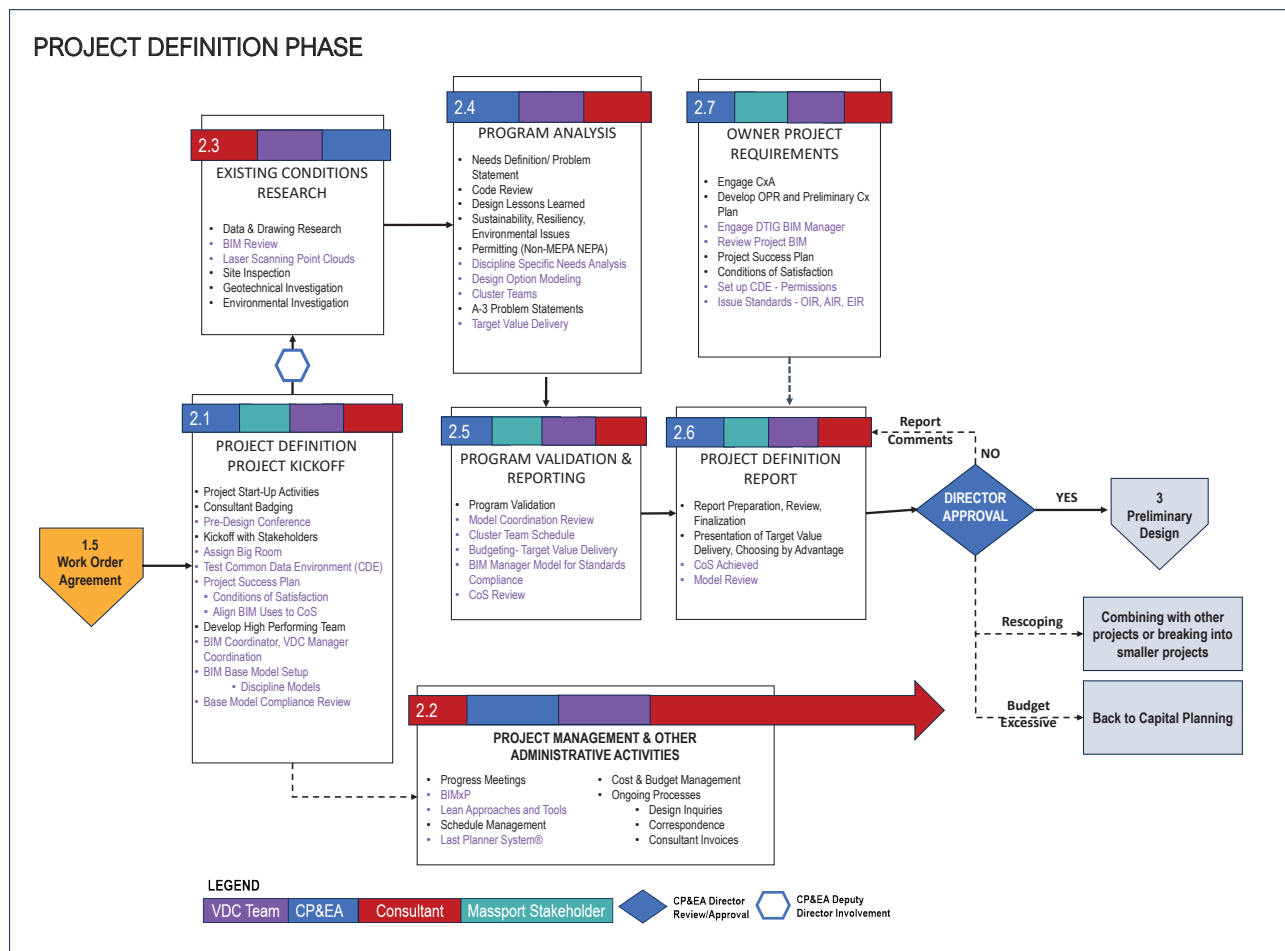


FIGURE 52 — Project Definition Workflow

If not previously conducted, teams perform the following project start-up activities:

- Review the Big Room facility.
- Review the information folder structure on ACC. Work with the DTIG to establish a permission structure for its use.
- Submit requests for additional software needs (excluding PMWeb) per the Massport SOP Software Request Process.
- Assign roles and responsibilities for BIM. Determine discipline teams. The BIM Coordinator develops the base models in the ACC environment.
- Hold an internal BIM set-up review for standards compliance and submit it to the DTIG BIM Manager for review.
- Review critical Asset list in BIMxP for asset data integration in Models.

The project team (PM, VDC Manager, BIM Coordinator, and the DTIG) work in consultation with major stakeholders to define the following:

- The specific problem or needs to be addressed by VDC processes
- The project's preliminary Conditions of Satisfaction (CoS)
- Define how teams achieve the project scope, manage schedules, determine a budget, and reduce costs, inefficiencies, and risks.
- The Project Success Plan aligns the Conditions of Satisfaction (CoS), Lean management tools, and BIM use in a unified VDC framework for project execution.
 - » The team and stakeholders develop the project Conditions of Satisfaction (CoS) and a specific VDC Framework through meetings and conversations.
- Conditions of Satisfaction (CoS) are measurable statements that outline the criteria a project must meet to be considered successful.
 - » Teams may use value stream mapping to define value as part of creating a CoS.
 - » Define Lean Tools – Implement the required Lean tools and determine optional tools. Last Planner System®, Choosing by Advantage, Target Value Delivery, A3, Plus/Delta, Retrospective, Project Dashboard
- Identify Constraints – Define and minimize or eliminate
- Define BIM Uses – The minimum required and optional uses based on project's identified CoS items.
 - » The Massport PM leads the effort of developing CoS in collaboration with design team, and then defining applicable BIM uses by connecting them to the intended CoS items.
 - » The BIM Coordinator works with the BIM team to define the Model-first strategy and BIM Stage 2 requirements. Model-First is the basis of Virtual Design and Construction.
- Milestone Planning – Using Last Planner System®, including BIM modeling milestones.
- Lean Deployment Plan – Document Lean tools for the project – Use the Massport Template
- BIMxP – Define Design BIM Execution Plan – Massport Template
- Align BIM, LDP, and LPS® Requirements

The PMs, VDC Manager, and BIM Coordinator determine how BIM supports the project as defined in the BIMxP and LDP. BIM activities are integrated into the Last Planner System® activities. The BIM modeling schedule aligns with the LPS®.

- Project Definition Report (PDR) - submitted to the Director CP&EA for approval. This report then forms the basis for the subsequent work phases (Preliminary and Final Design Phases)
- Define program requirements
- Define project criteria
- Formulate design approach
- Develop design concepts, including alternative solutions
- The BIM Coordinator oversees Design Options. This can include schematic models and drawings that address design concepts, alternative solutions, and demarcation points between existing and proposed systems and networks.
- Choosing by Advantage can be used to determine the best option based on cost of service (CoS), allowable cost, functional use, and schedule.
 - » Refine the elements defined and information contained in the approved PDR
 - » Coordinate and resolve existing conditions and interdisciplinary issues and conflicts.
 - » Internal reviews for Model coordination and standards compliance
 - » Integrated existing conditions point-cloud data
 - » Develop a Basis of Design - package sufficient for CM RFP (pricing package)
- Site, utility, and floor layouts – Massing and building envelope – One-line diagrams and P&ID for existing systems – Master Building Control System (MBCS) schematics – Node diagrams for existing networks – Survey of existing conditions and report diagrams – Perspective Sketches and Study Models are potential design activities. These materials are used to finalize the Project Definition Report and to support Coordination and Review meetings.

4.3. PRELIMINARY VDC DESIGN PHASE

Based upon the accepted Project Definition Report, the Consultant performs additional existing conditions research, stakeholder outreach, design, and engineering services to produce key deliverables as part of the Preliminary Design Phase:

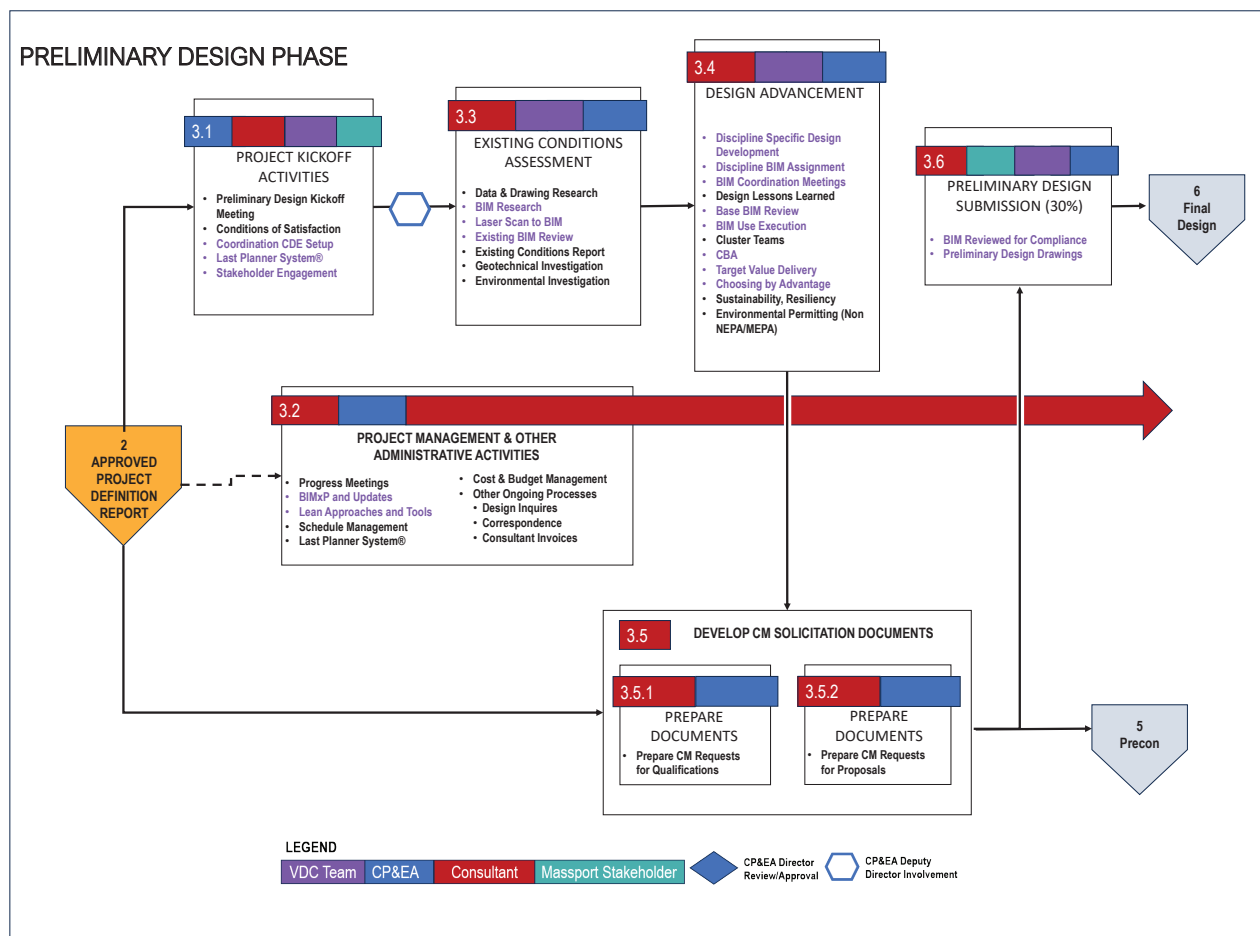


FIGURE 53 — Preliminary Design Phase Diagram

A preliminary design submission is prepared and submitted per the Contract Documents (Models and Construction Documents)

- The Design team assembles the information collected and developed during the Preliminary Design Phase into a complete and coordinated package that further refines the project scope, cost, and schedule.
- The BIM Coordinator participates in Last Planner System® meetings and adds BIM Uses to the pull plans. BIM modelers may be added to Cluster teams based upon project meetings as design issues are addressed.
- Discipline Modelers hold internal reviews in preparation for the weekly model federation review. The DTIG BIM Manager holds quarterly review meetings but may participate in coordination meetings.
- The BIM Coordinator reviews the integration and reporting of asset data.

PRELIMINARY MINIMUM VDC DESIGN SUBMISSIONS

- Design criteria and performance
- Model of each major system
- Model Option, Schematic Plans for review and approval
- Construction sequencing and staging schedules
- Construction cost estimate, including quantities and unit prices

4.4. FINAL VDC DESIGN PHASE

Upon receiving Massport's written approval of the Preliminary Design Submission, the Consultant proceeds with the design development activities needed to prepare the final construction Model and documents (90-100% design) in the sequence agreed to by the project team.

Design Assist begins during the final design phase. The design-assist focus removes model ambiguities to address Model-first construction phase goals. The combined teams review the models and enhance the constructability, if necessary, for use in the field.

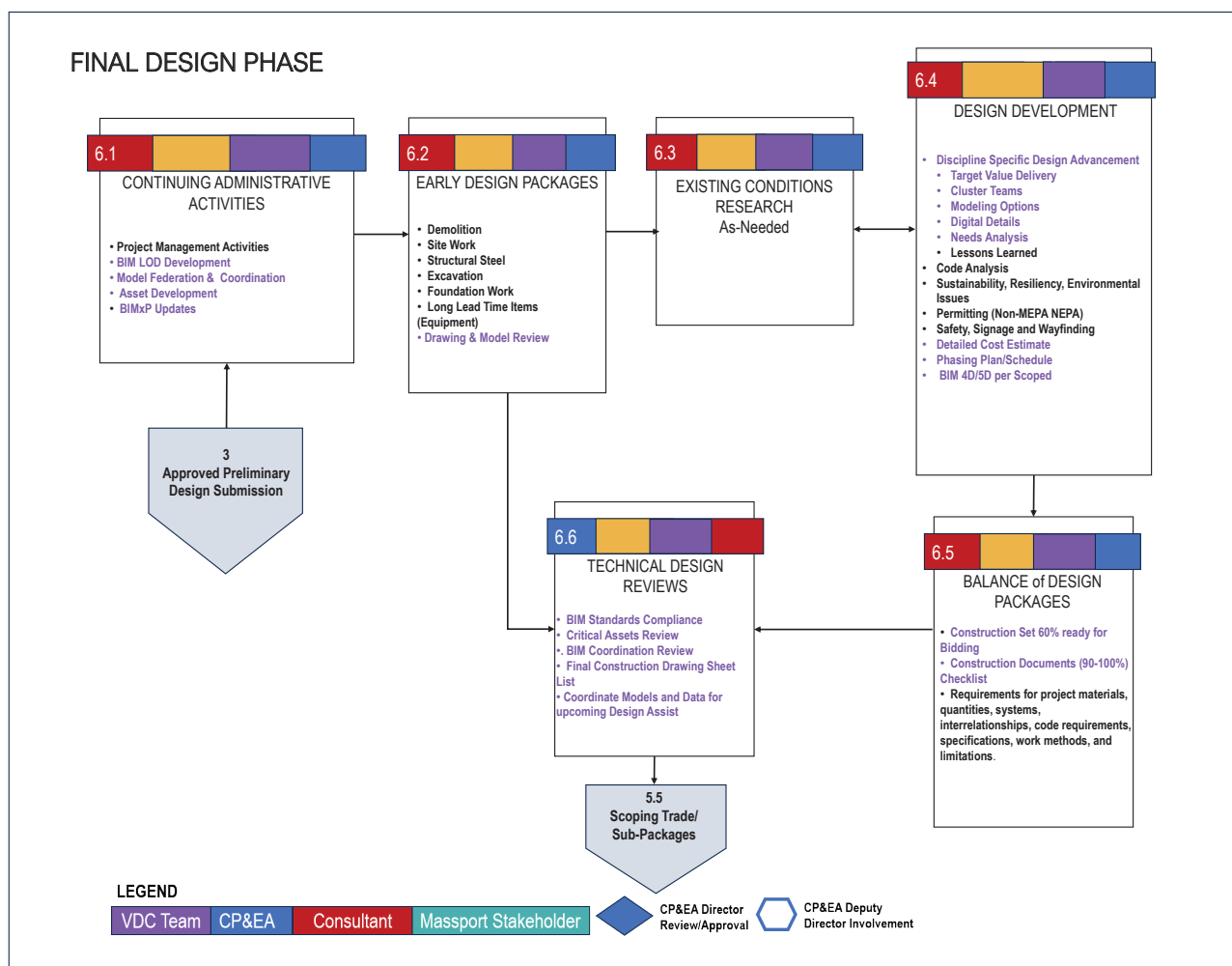


FIGURE 54 — Final Design Phase

Coordination meetings for federated models continue, and support for Cluster teams may increase as more design detail is needed.

- The design packages are prepared for release.
- All Models and documentation complete internal reviews before submission to Massport.
- Preparation and release of early design packages
- Preparation of design development submissions (e.g., at the 60% interim completion level of a particular package) for review by Massport PM, DTIG, the CM, and other stakeholders
- Preparation of balance of design packages
- Asset data review and reporting

EARLY DESIGN PACKAGES

- Preparation and release of early design packages per agreed-upon content:
 - » Demolition
 - » Site work
 - » Structural steel
 - » Excavation
 - » Foundation work
 - » Long lead items (equipment)
 - » Preparation of design development submissions (e.g., at the 60% interim completion level of a particular package) for review by Massport PM, the CM, the DTIG, and other relevant stakeholders
- Preparation of balance of design packages
 - » Develop construction documents suitable for bidding purposes

FINAL DESIGN PACKAGES

Design Team

- Develop final design packages for bidding and construction. Unless otherwise agreed to by the Massport PM, packages should adhere to the format and content described in the Construction Documents (90-100%) Checklist. (Note that the first issued design package is “DP1”.
- Subsequent design packages are issued as bulletins to the original DP1 design package for new design packages or changes.)
- Address comments received from the MPA PM, CM, and other stakeholders:
- Provide written responses to review comments, clearly indicating the recommended action to resolve the comment.
- Meet with other members of the project team as needed to resolve comments.

Construction Team

- Conduct technical design (coordination/clash detection) and constructability reviews of each early package.
- Use packages to develop scopes of work for bidding.

MINIMUM FINAL DESIGN SUBMISSIONS

Design Team submits the following as part of the final design package:

- Define and further develop the design Model to define all project requirements (materials, quantities, systems, interrelationships, code requirements, specifications, work methods.)
- Construction Documents (CD) - Prepare comprehensive and complete final construction contract documents suitable for public bidding and construction—the final coordinated construction drawings are completed to approximately 100%, and Models and Civil 3D files.
- CDs- All required sheets of the final construction drawings defined by the drawing list, each at least to the 60% level of completion, with sufficient information included for the preparation of a detailed cost estimate and phasing plan/schedule
- Calculations and Analysis - Calculations for all disciplines, components, and systems are required to determine the final configuration of all project parts.
- Commissioning Plan updates (as needed) - Draft of the Spare Parts List
- Updated BIMxP (with CM input) • Updated LDP (with CM input) • Draft of the Long Lead Items List (to allow the Airport to consider advance purchases)
- Civil- Site plans • Demolition plans • Layout and grading plan • Drainage and sewer plan • Utility plan • Landscaping plan

Once submittals are received, Massport initiates a review process including model review, to verify compliance with the BIM Standard, and model-based design review, to ensure design constructability and quality (as illustrated in the figure below).

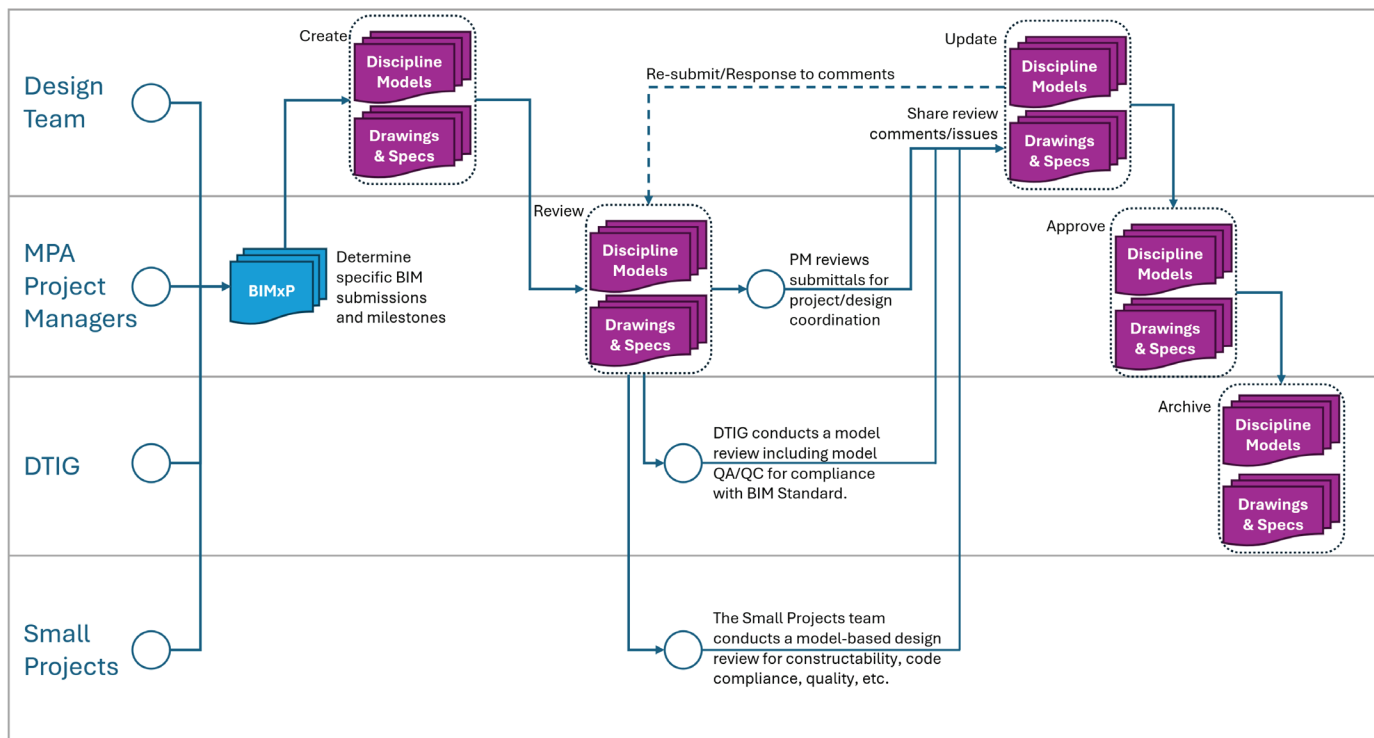


FIGURE 55 — Review Process of Design Submissions

4.5. PRE-CONSTRUCTION, VDC DESIGN ASSIST PHASE

In the Preconstruction Phase, the project team expands to include the construction manager (CM). Focus is placed on collaboration and open communication with the CM to minimize risk, help ensure constructability, meet or improve the project schedule, and maximize scope within the budget.

Minimum Preconstruction Services:

- Budget (including scope verification and estimate reconciliation)
- Schedule/phasing
- Design assistance and constructability inputs – BIM detailing, early fabrication modeling
- Development of scopes of work for Trade Contractors and Subcontractors
- Logistical planning/project management systems start-up
- BIM Services- 4D and 5D as specified, support for Cluster teams
- Mobilization (early packages)

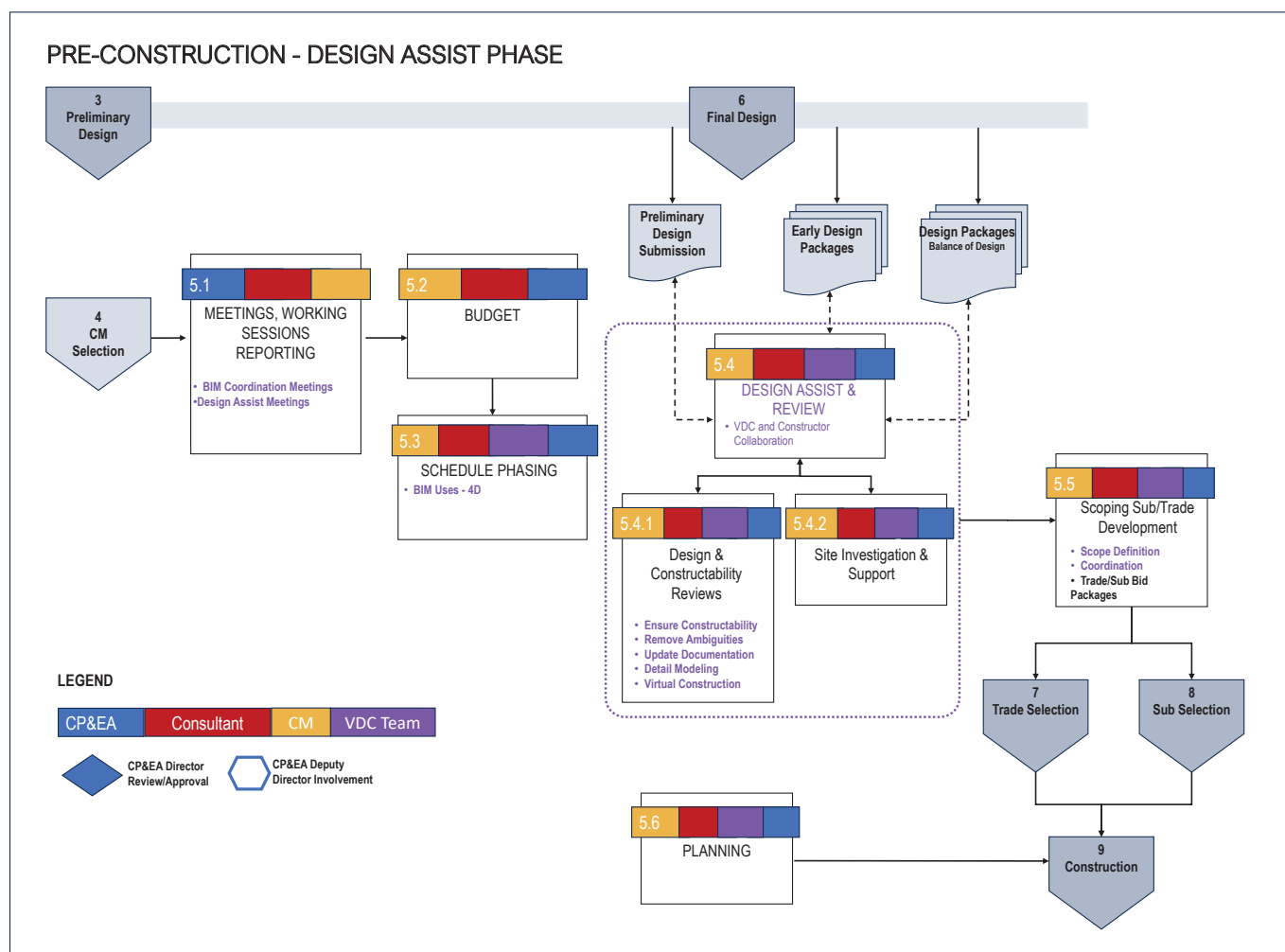


FIGURE 56 — Pre-Construction Design Assist

4.6. VDC CONSTRUCTION PHASE

During the project's Construction Phase, the project team's goal is to construct the project according to the discipline models and construction documents while controlling the risks identified in the pre-construction phase.

The administration of the construction phase is like a traditional project, except for possible phased completion and handover of specific design packages before the entire project has been completed and accepted.

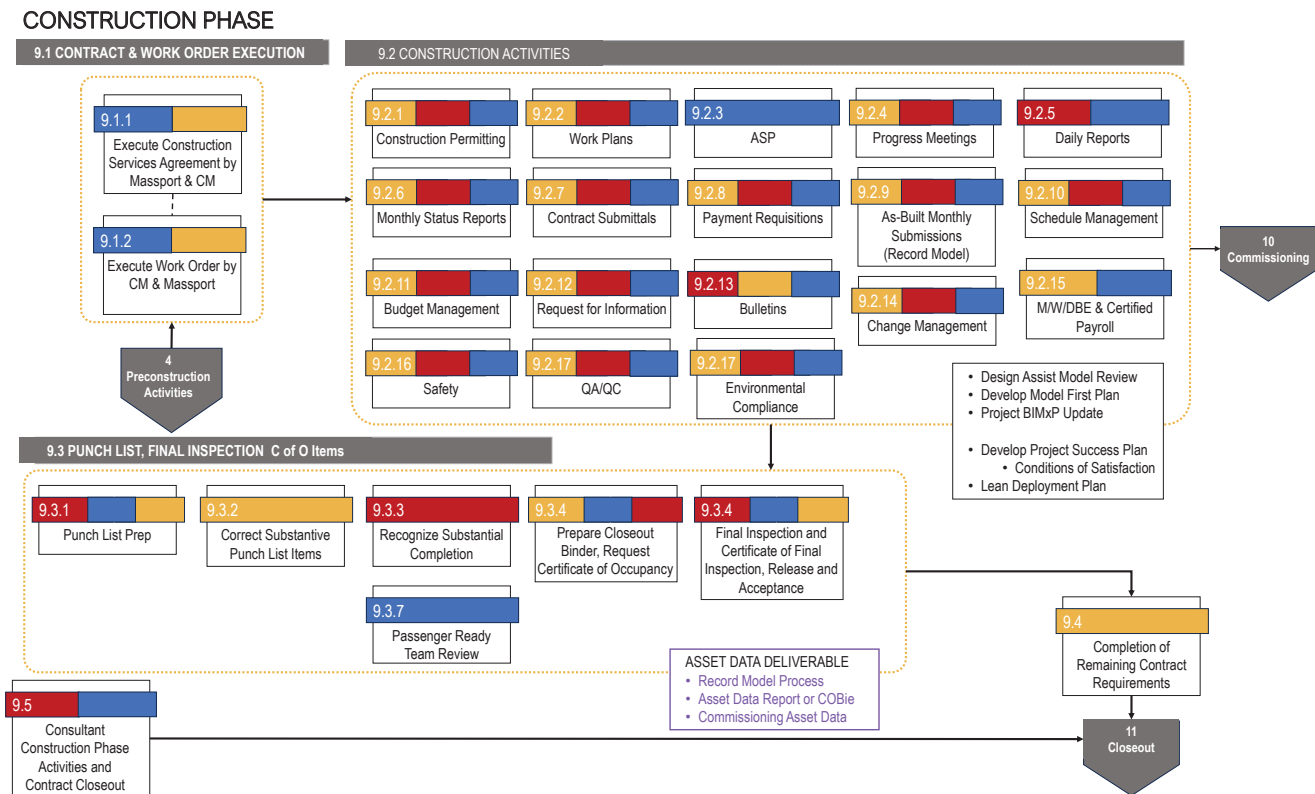


FIGURE 57 — VDC Construction Phase

The process flow illustrates the key activities involved during a project's construction phase. The CM is responsible for driving most construction phase activities. The consultant, however, retains an essential role in advising and representing Massport as construction progresses, determining if the work is completed according to the contract documents.

VDC SUPPORT ACTIVITIES - CONSTRUCTION

Minimum Construction activities utilize the VDC Framework, Lean tools, and BIM.

- Update BIMxP
- Develop construction Conditions of Satisfaction
- Work Plans: Last Planner System®
- Progress Meetings: Continue the regular progress meetings conducted throughout the Design and Preconstruction Phases to coordinate, review, and track the work effort, including RFIs, shop drawing submissions, and schedules; resolve issues; and make decisions to advance the work.

ASSET DATA AND COMMISSIONING

The BIM Coordinator collaborates with the Commissioning Agent to facilitate model use during commissioning, ensuring that the coordination of asset data in the model aligns with field data

4.7. HANDOVER RECORD AND AS-BUILT MODELING PROCESS

The As-Designed Record Model (also known as the Record Model) and the As-Built Record Model (also known as the As-Built Model) are required contract deliverables at the final stages of the construction phase. The Design and Construction teams are responsible for establishing an ongoing collaborative process throughout the project, ensuring the models and data development are completed for handover to Massport. Each model has a specific purpose in supporting Massport's asset, maintenance, and virtual campus needs. This section defines the Models, process, and deliverables for this activity.

Massport requires a model-first process, which allows the constructor to build from the model developed through the design assistance process and the reviewed subcontractor fabrication models. This Model-first process should reduce the changes required in Model geometry; however, the Record Model shall be updated to address any major discrepancies between the designed and actual project conditions.

The teams meet with the DTIG VDC Manager to validate changes and ensure Model coordination throughout the project. These update processes are managed in the ACC environment, and the updated models shall comply with the LOD and LOI for both buildings and infrastructure/utility elements as required by the Massport BIM standard.

THE RECORD MODEL

At a minimum, the Record Model shall accurately represent the project's final design intent and the information related to the architectural, structural, programmatic, and MEPF elements, as well as other required systems. The Record model:

- Reflects the final design intent (reflecting major changes during construction)
- It is based on the Design Revit model and updated with geometry changes and necessary asset data provided by the construction team.
- The typical LOD is 300 for most elements. Elements within the model submittals shall match the LOD defined in the BIMxP and shall comply with the BIM Standard requirements.
- Primarily serves as the formal archived representation of the project.

THE AS-BUILT MODEL

At a minimum, the As-built Model shall accurately represent the project's built conditions. The As-built Model:

- May combine design intent, construction, and subcontractor fabrication models (in multiple file types).
- Reflects the as-built conditions for building systems, critical assets, and discipline models. (e.g., architectural, civil, structural, mechanical, life safety, and electrical systems)
- Includes all changes in the addenda, approved change orders, field orders, clarifications, RFI responses, and other as-built conditions.
- May include reality captures of point clouds conducted during the construction. Laser scanning and photogrammetry files may be integrated into the As-Built Model and/or submitted as a separate deliverable.

- Includes critical asset data reportable from the Record Model and supplemental data files such as the COBie template. Asset data submittals shall match the model element defined in the BIMxP and comply with the BIM Standard requirements.
- Primarily serves as a source of truth for future BIM uses including site/building condition assessment and asset management.

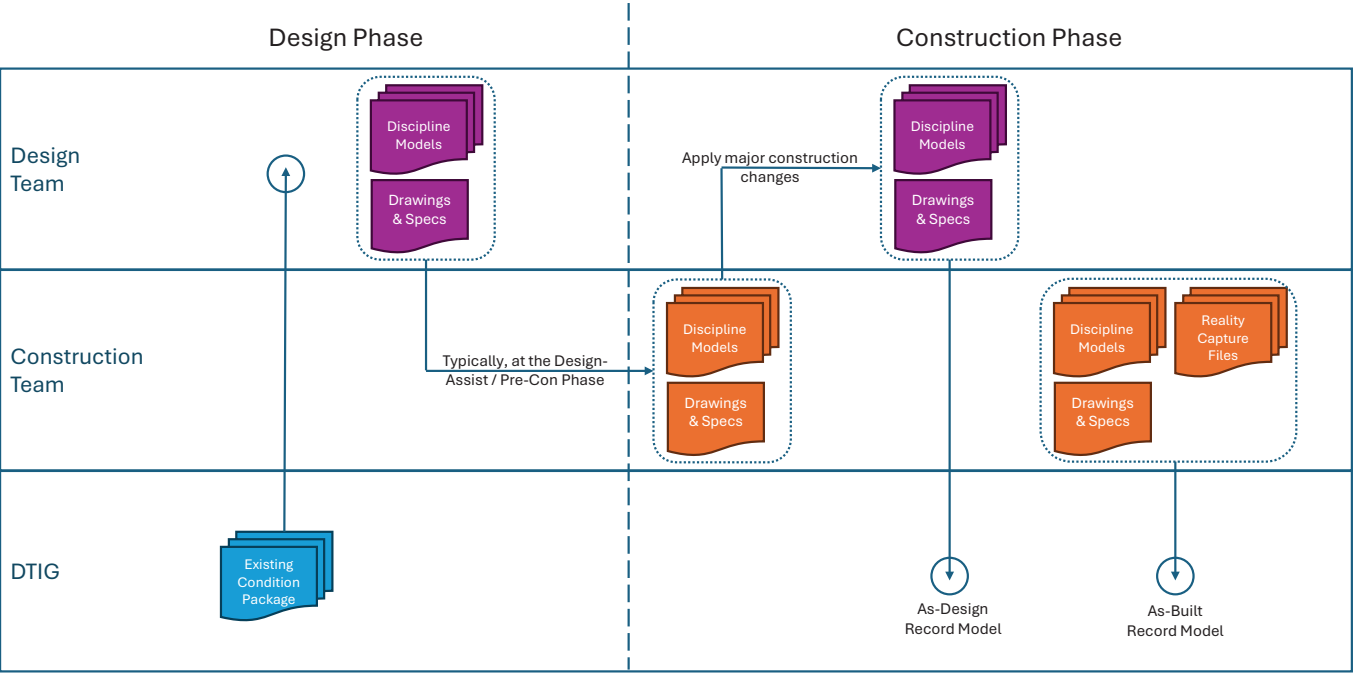
THE RECORD AND AS-BUILT MODELING PROCESS

The Design team creates the Record Model Submittal. The Construction team creates the As-Built Model Submittals. The Design and Construction teams submit to the ACC.

Before submission, the Design team shall run clash detection and remove all extraneous geometry, data, and documentation, such as element duplicates. Additionally, the Design team and the DTIG review the Record Model asset data and model standards. Massport may add additional data requests as needed for asset management purposes.

The Design and Construction teams determine how to collaborate to facilitate information exchanges, including change orders, field orders, clarifications, RFI responses, and as-built conditions, supporting the development of the Record Model.

Massport’s Record Modeling Process



Note: please refer to your project’s BIMxP for specific BIM deliverable requirements.

FIGURE 58 — Record Model Process

RECORD AND AS-BUILT MODELS AND RELATED DELIVERABLES

The record and as-built deliverables include, but are not limited to, the following documents:

DOCUMENTS and MODELS	DELIVERABLES	
	RECORD MODEL	AS-BUILT MODEL
Native models (Revit, Civil 3D, CAD, etc.)	✓	✓
Coordination models (Navisworks, etc.)	✓	✓
Other BIM models (4D, conditioned model, etc.)	✓	✓
Reports (clash detection, quality check, etc.)	✓	✓
Updated BIMxP	✓	✓
Specifications and other design-related PDFs	✓	
Warranty, O&M manuals, and other construction-related PDFs		✓
Reality capture files		✓
Commissioning reports		✓
Other DTIG-requested documents	✓	✓

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PROJECT RESOURCES



5. PROJECT RESOURCES

Please visit the Massport [DTIG Website](https://www.massport.com/business/capital-improvements/capital-programs-and-environmental-affairs/dtig) to access to most recent version of the documents.
(<https://www.massport.com/business/capital-improvements/capital-programs-and-environmental-affairs/dtig>)

PROJECT REFERENCES

STANDARDS AND GUIDELINES

- Massport VDC Guide
- Massport VDC Roadmap
- Massport BIM Standard
- Massport Site/Civil CAD Standard
- Massport GIS Standard
- Massport Room Numbering Standard
- Massport Reality Capture Guide
- Massport ACC Integration Guide

TEMPLATES AND SUPPLEMENTAL FILES

- Massport BIM Exhibits: Contract Language for BIM Implementation
- Massport BIMxP Template
- Massport Revit Template
- Massport Civil 3D Template
- Massport Project Title Block Sheet List

GLOSSARY



GLOSSARY

One of Massport's goals is to standardize project execution, BIM production, and submissions across all projects. However, design and construction teams bring different understandings of how BIM projects are managed and executed. For teams to arrive at a unified strategy with effective collaboration and efficient BIM production, Massport recognized that its contract and manuals, project structure, and the role and skills of the MPA PM and service providers needed to change.

The Project Management team facilitates the use of Lean and BIM on projects. By standardizing Lean Design and Construction approaches and tools, Massport is adopting a repeatable project management system that works within the various MPA project procurement and project delivery options. As an industry initiative, Lean training, approaches, tools, and facilitators are commercially available, and resources continue to expand as universities teach Lean strategies to students. This section contains project requirements for consultant teams implementing VDC, Lean thinking and tools, and BIM at the start of the project.

MASSPORT VDC GUIDE GLOSSARY

TERM	DEFINITION	SOURCE
A		
Allowable Cost (AC.)	The most the client is able and willing to pay for the project in Target Value Delivery.	Lean Construction Institute
As-Built Deliverable	A BIM Deliverable developed by the Constructor and captures the final condition of a project after construction. An As-Built Deliverable includes As-Built Drawings, Model, and other relevant information determined by the BIMxP.	Massport
Asset Information Model (AIM)	The operational model for all the assets in an Employer's portfolio.	ISO 19650
Asset Information Requirements (AIR)	Specified data/ information necessary to manage an organization's physical and digital assets effectively and efficiently.	ISO 19650
Autodesk Construction Cloud	ACC - The cloud-based work space. ACC is the Massport Common Data Environment (CDE)	Autodesk

TERM	DEFINITION	SOURCE
B		
BIM Deliverable	Building information model and/or non-model data to be provided to the Owner in connection with the intended BIM uses in a project.	Massport NBIMS
BIM Dimension	BIM dimensions refer to 3D, 4D (Time), and 5D (Cost) designations used in BIM Uses on projects. It is carried further into 7D for asset management to cover the lifecycle of BIM use.	National BIM Standard NBIMS
BIM Use	Specification of how a Building Information Model is developed and used to progress a project and achieve the identified project's Condition of Satisfaction.	Massport NBIMS
BIM Execution Plan	BIMxP - A plan that explains BIM information created, managed, and delivered	ISO 19650 Modified
C		
Condition of Satisfaction	An explicit description by a customer of all the actual requirements that must be satisfied by the Performer for the Customer to feel they received exactly what was wanted.	LCI
Construction Operations Building Information Exchange (COBie)	Construction Operations Building Information Exchange (COBie) is a data schema delivered in a spreadsheet data format, containing a subset of the information in the building model (all except graphical data, and hence a subset of IFC; see below), for facility management (FM) handover.	NBIMS

TERM	DEFINITION	SOURCE
Constructor	General term for the team responsible for the construction process. Includes CM, DBB, DB	Massport
Common Data Environment (CDE)	Agreed source of information for any given project or asset for collecting, managing, and disseminating each BIM Deliverable through a managed process	ISO 19650 Modified
Contract Document	A set of legally binding documents that outline the roles, responsibilities, and detailed descriptions of the work to be performed on a project.	AIA
D		
Digital Twin	An integrated data-driven virtual representation of real-world entities and processes, with synchronized interaction at a specified frequency and fidelity.	Digital Twin Consortium
Discipline Model	A shared digital representation of physical and functional characteristics of a building and/or infrastructure discipline (architectural, structural, etc.).	Massport NBIMS
E		
Exchange Information Requirements (EIR)	From the BS 19650 framework, define how and when information should be exchanged throughout the project and asset lifecycle. These define what information must be delivered as part of project delivery.	BS 19650

TERM	DEFINITION	SOURCE
F		
Federation Process	In ACC, the discipline models are shared to provide a holistic view of the project BIM. The models remain separate files for development and as deliverables.	Autodesk
G, H, I		
Industry Foundation Class (IFC)	IFC is an object-based format that enables the exchange of information between different software. Developed by 'BuildingSMART,' a global alliance specializing in open standards for BIM, IFC is an official standard and contains geometric and other data.	ISO 19650
Information Exchange	Structured sharing of data between Project Team members throughout the project lifecycle.	Massport AIA
Information Models	Information models combine Graphical information (such as 3D and 2D models of geometry), non-graphical data (such as schedules and specifications), and associated documents.	ISO 19650
K, L, M		
Level of Development	LOD- BIM Forum identification of Geometric granularity	BIMForum
Model-first	Model-first design and construction mean making a digital model the primary source of information for a building project. Model-first focus is to develop a constructible model used as a "blueprint" in the field for construction.	LCI
Model Federation	The act of creating a virtual representation of several linked but distinct Discipline Models to accomplish an intended BIM Use.	Massport Autodesk
Meta Data	A set of data that describes and gives information about other data	ISO 19650-1

TERM	DEFINITION	SOURCE
O		
OmniClass	Building element classification system. Additional tables classify information and project processes.	CSI.org
Organization Information Requirements (OIR)	High-level information on the asset lifecycle - information related to asset management. Objectives, outcomes, and organization policies	ISO 19650
Owner	The entity that holds the contract and receives information concerning works, goods, or services. In the context of this document, the term "Owner" mainly refers to the Massachusetts Port Authority (Massport).	Massport NBIMS
P		
Project Definition	Project Phase in early design. Business planning and business plan validation (done by the client in collaboration with a project team). It concludes with the client deciding to abandon a project or to fund it incrementally or entirely.	Massport
Project Information Model (PIM)	PIM - The model developed for a project.	ISO 19650
Project Information Requirements (PIR)	Include some OIRs, a project business case, a strategic brief, and project stakeholders and tasks.	ISO 19650
Project Participant	Project participants are individuals who actively engage in a project, contributing their skills, knowledge, or decisions to achieve project goals. This includes team members and stakeholders.	Massport

TERM	DEFINITION	SOURCE
Project Success Plan	A series of activities to align Massport Conditions of Satisfaction, Lean Management tools, and BIM Uses to create the VDC project framework	Massport
Q, R		
Quantity Take-off	A BIM Use - artifact reporting the number of objects, square footage, volumes, and other data supporting project analysis.	Massport
Record Model	A BIM Deliverable developed by the Design Team that captures major changes made during the construction phase of a project.	Massport
Responsibility Matrix	The chart that describes the participation of various functions in completing tasks or deliverables	ISO 19650-1
S, T		

TERM	DEFINITION	SOURCE
Target Value Delivery	A disciplined management practice is to be used throughout the project to ensure that the project meets the operational needs and values of the users, is delivered within the allowable budget, and promotes innovation throughout the process to increase value and eliminate waste (time, money, human effort.)	Lean Construction Institute
Trade Model	A Discipline Model developed by trade/sub-contractors during the prefabrication and construction phases of a project.	Massport
V W X Y Z		
Virtual Design & Construction (VDC)	VDC is a framework focused on model-first project delivery, utilizing simulation to design and build projects virtually before physical construction. It integrates with Lean management tools, BIM Stage Two or Three, and other related technologies.	Stanford CIFE
Virtual Campus	A virtual campus combines BIM models, asset and geospatial information, and a well-defined ontology to digitally represent and manage an entire facility and infrastructure, enhancing collaboration, decision-making, and efficiency throughout its lifecycle.	CIFE
Whole Life Cost	Whole Life Cost is the total cost of acquiring, operating, maintaining, and disposing of an asset over its entire life cycle. Whole Life Costing optimizes decision-making across an asset's lifecycle by considering immediate capital expenditure and longer-term operational and maintenance expenses.	ISO 19650-1

APPENDIX 1. TECHNOLOGY INNOVATIONS

A blue-tinted photograph of an airport terminal. In the foreground, there are rows of airport-style seating and a modern, curved ottoman. People are walking through the terminal, some with luggage. In the background, there are signs for "Terminal", "Gates C23-C25", and "Restrooms". The overall atmosphere is busy and modern.

APPENDIX 1. TECHNOLOGY INNOVATIONS

Massport is actively engaged in the exploration and integration of advanced technologies throughout the organization. This section outlines technologies reviewed for application in various projects.

Online Automated Workflows: Several Lean tools offer online software solutions. The Last Planner System® features digital tools designed for pull-planning, while BIM Execution Plans (BIMxP) can be developed online. Furthermore, additional tools for BIM coordination, simulation, visualization, and 4D scheduling can significantly enhance project efficiency. The technologies employed in a project are documented within the BIMxP.

Construction Robotics: Recent advancements in BIM-based Digital Twins have facilitated the integration of mobile robotics, including quadrupeds (robotic dogs), wheeled platforms, and drones. These systems can operate autonomously, guided by pre-established algorithms, or remotely controlled by personnel in different locations. Facility owners gain significant advantages from the ability to service facilities around the clock, leveraging robotics and teleoperators across various time zones. Additionally, robots can continuously monitor and document their activities (e.g., through photography), which demands considerable effort from human operators.

Mobile interfaces for Building Information Modeling (BIM) and Digital Twin applications have become ubiquitous, marking the industry's transition into a new era characterized by the adoption of spatial computing, including Augmented Reality (AR) and Mixed Reality (XR) as the predominant interface paradigm.

Augmented Reality (AR) overlays digital information and 3D graphics onto physical objects, enabling architecture firms to present clients with a clear visualization of the building before construction. Virtual Reality (VR) immerses users in a detailed exploration of designs through VR headsets, allowing for the assessment of various materials before any physical construction occurs.

The Internet of Things (IoT) comprises a network of interconnected devices facilitating communication. In architecture, IoT technology is instrumental in creating smart buildings, which provide enhanced control over energy consumption and system performance. Additionally, IoT enables predictive maintenance for heating, ventilation, and air conditioning (HVAC) systems.



FIGURE 59 — Virtual Design Review



FIGURE 60 — AR MEP Review

Artificial Intelligence (AI) and machine learning automate the creation of facility models from existing CAD files. Developing a Minimum Viable Digital Twin (MVDt), which encompasses Level of Development (LOD) 200 geometry and maintainable assets, significantly enhances the efficiency of building model creation compared to traditional methods. Market-available applications that leverage AI and machine learning can generate MVDts from 2D drawings and unstructured data, further improved by AR-based asset verification workflows. The costs associated with creating an MVDt through these innovative methods are considerably lower than those of conventional manual modeling approaches.

Generative Design, an algorithm-driven process, integrates design objectives, material specifications, cost constraints, and other relevant data into software that evaluates all potential solutions. This automated approach produces design options at a pace that exceeds human capabilities, empowering architects and other stakeholders in the construction process. The stakeholders identify the best design from the many automated options for a project based on real-world data. This rapid machine design helps teams determine the preferred option for further development.

Process Optimization Using Autodesk's Project Refinery (formerly known as Project Fractal), Crane Position Optimization enables builders to select the most effective strategy for assembling structures from precast panels. The algorithm evaluates various positioning scenarios for the delivery truck and the crane responsible for placing the panels, aiming to identify the most efficient operational process based on the specific building design. This sophisticated sequence can be computationally established well before the construction phase.

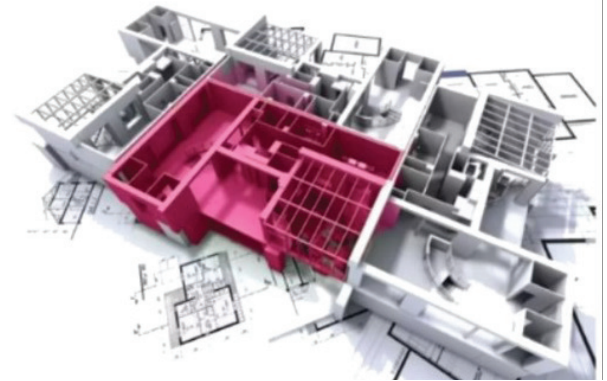


FIGURE 61 — AI and Digital Twins



FIGURE 62 — Generative Design Example



FIGURE 63 — Process Optimization

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APPENDIX 2. VDC AND LEAN TOOLS LIST



APPENDIX 2. VDC AND LEAN TOOLS LIST

VDC PROJECT DELIVERY PROCESSES AND TOOLSET

Lean and VDC tools are execution methods used during project delivery.

Tool	Purpose	When to Use	Responsible Parties
Common Data Environment (Autodesk Construction Cloud)	Virtual Collaboration Environment	Throughout project	DTIG, BIM Coordinator, PMs
Big Room	Physical Collaboration Environment	Throughout project	PMs, VDC Manager, BIM Coordinator
Project Success Plan (PSP)	Develop Condition of Satisfaction (CoS) and supporting VDC activities	Project Start	PMs, VDC Managers, BIM Coordinators
BIM Execution Plan (BIMxP)	Project Management	Throughout project	VDC Managers, PMs, BIM Coordinators
Last Planner System®	Scheduling, Project Management	Throughout project	PMs, VDC Managers
Cluster Teams	Task-oriented Collaboration method	As needed	Based on the Task
Target Value Delivery	Value-based budgeting method	Design Development	PMs VDC Managers, BIM Coordinator, Discipline teams
Choosing by Advantage	Value-based Decision-making tool	As needed	PMs, Activity owner
Risk Management	Project Management	Throughout project	PMs, Activity owner
Design Assist	Constructability, Model-first Process	Final Design Development	Constructor, Design PMs, BIM Coordinators, VDC Managers
A-3 Decision Support	Problem-solving method, decision-making tool	As needed	Based on the issue
Root Cause Analysis	Problem-solving method	As needed	Based on the issue
VDC Dashboard	Project Management	Throughout project	VDC Managers, BIM Coordinators, PMs
Plan-Do-Check-Act (PDCA)	Change Management tool	Throughout project	PMs, Activity owner
Plus-Delta	Change Management tool	Throughout project	Activity owner
Retrospectives	Change Management tool	Throughout project	Activity owner

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PROJECT REFERENCES

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FIGURE 62 — Generative Design Example

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FIGURE 63 — Process Optimization

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