National BIM Standard - United States™ Version 2

5 PRACTICE DOCUMENT

Chapter 5.6 Planning, Executing and Managing Information Handover – 2007, Revised June 2011

The following is an excerpt from the 2007 National Institute of Standards and Technology publication, NISTIR 7417, *General Buildings Information Handover Guide: Principles, Methodology and Case Studies (An Industry Sector Guide of the Information Handover Guide Series*) by Kristine K. Fallon and Mark E. Palmer. Chapter 5: Planning, Executing and Managing Information Handovers was updated in June 2011, specifically for inclusion in the best practices guidance of NBIMS-US V2.

Overview

The following is a summary description of each step.

- **Information Strategy:** Every organization involved in the design, procurement, construction or operation of capital facilities should develop an information strategy. The strategy will be driven by business purpose. The information strategy should prioritize information and assign a business value to various information packages. The strategy should also be consistent with the organization's data security policies.

- **Information Handover Requirements:** The organization must define the contents as well as the appropriate information form and format for each information package required and also consider the associated metadata. This step will inform the Project Information Handover Plan.

- **Project Information Handover Plan:** This plan not only covers the information handover

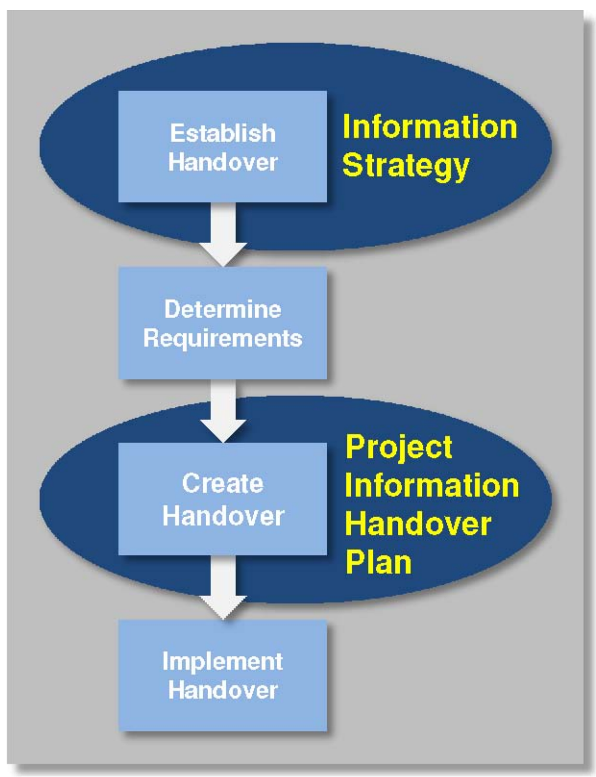

Figure 5.6 -1 – Successful Information Handover Step

requirements, but also covers responsibilities and implementation methods. In particular, the originator of each information package must be identified. Conflicting handover requirements of the various team members, particularly format preferences, must be resolved.

- **Implementation:** This step includes technical implementation as well as establishment of project procedures, contractual responsibilities and training programs.

Information Strategies

The organization's information strategy should cover the following topics:

1. What facility information is important
2. When this information is created and by whom
3. Contractual, legal and regulatory issues related to this information
4. Who within the organization will be responsible for capturing, checking and maintaining the information
5. How the organization's data management and security policies will be applied to this information

Information Strategies for the General Buildings Sector

The *Capital Facilities Information Handover Guide* (CFIHG) *Part 1* suggests that an information handover approach must derive from a facility life cycle information strategy defined by the owner. In the general buildings sector, however, there appear to be at least four different and effective information strategies:

1. **Owner Strategy to Optimize Facility Life Cycle Value**: The first is the strategy envisioned by the CFIHG *Part 1*. Owners endeavor to improve facility life cycle operations and reduce total life cycle costs by first identifying the information packages critical to both project and long-term facility management and then defining information handover requirements. In the general buildings sector, major owners taking this approach include U.S. federal government agencies, particularly the U.S. National Aeronautics and Space Administration (NASA) and the Department of Defense (DoD). The Construction Operations Building Information Exchange (COBIE) project, which is funded by NASA and executed by the Engineer Research and Development Center at the Construction Engineering Research Laboratory (CERL), is an example.

2. **Owner Strategy to Improve Project Delivery**: Another owner-initiated strategy focuses on improving construction project delivery. In 2004, the Construction Users Roundtable (CURT) released a white paper (**WP-1202**), *Collaboration, Integrated Information and the Project Lifecycle in Building Design, Construction and Operation*. This paper was produced by CURT's Architectural/ Engineering (AE) Productivity Committee, which was convened to address the perception of inadequate, poorly coordinated AE drawings that result in difficulties in the field, leading to cost and

schedule overruns. CURT directed this committee to evaluate how alternative processes, particularly the use of information technology combined with changes in project structure and delivery methods, might address these issues. Starting in 2004, General Motors (GM) Corporation, a CURT member, undertook a series of capital projects that have moved progressively toward full virtual design and construction before any activity begins on-site. They progressively eliminated 2D drawing submissions in favor of direct electronic data exchanges and 3D reviews. GM's goal was to reduce waste, non value-added work and rework on the construction site, thereby achieving lower cost, higher quality, improved schedule and greater safety.

3. **Consultant or Contractor Strategy to Improve Project Delivery**: A very different strategy, often with similar results, is a designer- or contractor-led effort to optimize building design and/or construction in one or more performance dimensions (building performance, systems coordination, cost, schedule, quality) and thus create a competitive advantage for the company or team. Many design firms have embarked on path toward increased building performance simulation and design validation in areas such as lighting, thermal performance and sustainability. In addition, some firms now develop design models that can be handed over to contractors for purposes such as cost estimating, interference checking, constructability reviews and 4D simulations. Also, construction companies seek to work with design firms to achieve bidirectional transfers of building and systems geometry and assemblies.

4. **Supply Chain Strategy**: Perhaps the most well-developed information strategy in the general building segment is a supply chain strategy. Supply chain strategies seek to streamline information flow from design through analysis, detailing, fabrication and erection to eliminate lag time and redundancies. The goal is to deliver product better, faster and at a lower cost, creating competitive advantage for the entire supply chain. The American Institute of Steel Construction (AISC) began an Electronic Data Interchange (EDI) initiative in 1999. Very quickly, users of the CIMSteel Integration Standards Release 2 (CIS/2) data exchange standard were able to reduce the time it takes to design, procure and erect a steel structure, at the same time reducing field interferences and waste, and thus cost. In an early case study, structural engineers engaged in bidirectional data exchange with steel detailers and fabricators for the Soldiers Field project and succeeded in shortening the construction schedule by 4 months. The steel supply chain initiative was quickly followed by a precast concrete effort led by an ad hoc organization, the Precast Concrete Software Consortium.

In establishing an information strategy, each organization examines its facility-related business regulations, decisions and processes and defines the information required by each, known as an "information package." It prioritizes information packages based on business value. For example, a comprehensive inventory of light fixtures might be helpful, but that information may have lower business value than knowing the rentable area of the building. If a certain information package is used in many business processes, its value increases. Another way to identify high-priority information packages is by looking at businesses processes that are inefficient and/or costly due to lack of information.

Once the organization has identified its high-priority information packages, it then determines when in the facility life cycle those information packages are created and by whom. Some information packages may be created across multiple life cycle phases and by several different organizations. This is typically the case with commissioning information, for example.

Information developed in one project phase may not be used at all in the next sequential phase, but may have great value in downstream processes. For example, although it may not be important for the contractor to know the reserve capacity of a facility's cooling system, that information will be important if the facility is ever expanded or converted to another use. Therefore, that information should be required at the handover point from design to construction. It will be critical to identify the next user of each information package as well as the party responsible for receiving each information package, ensuring its completeness and maintaining its integrity until its next use.

By defining the contents of high-value information packages, as well as when, how and by whom those packages are utilized, and when and by whom the information is created, the strategy provides guidance to all participants in capital facility projects on appropriate information handover requirements and also informs the issue of appropriate data forms and formats

Contents of the Information Strategy

It is critical that those making day-to-day decisions on capital projects understand the high-level purpose of information handover. By communicating the ultimate use and relative importance of various information packages, the information strategy permits designers, project managers and contractors to make appropriate decisions about handovers on their projects. In addition, the information strategy serves as the source document for detailed handover requirements and project-specific handover plans and for integration with enterprise applications.

The major sections of the facility life cycle information strategy should include, at a minimum:

- Management policy statement, stressing the business importance of successful information handover
- Identification of major information packages with:
    - Explanation of their business purpose and importance
    - Life cycle phases in which they are created
    - Who creates each information package, in terms of project or facility role? Is this an internal or external role? The precise individual and external organization will be identified in the project information handover plan.
    - Business processes in which they are used
- Conformance of information handovers with company policies regarding:

- Contracts and procurement policies
- Legal and regulatory compliance
- Security
- Allocation and management of information technology resources

* Assigning responsibilities for:

  - Establishing appropriate contractual and procurement terms to ensure that required information packages are handed over
  - Ensuring that security policies are enforced during information handovers
  - Seeing that information handovers occur on a specific project
  - Establishing the system infrastructure for receiving information handovers
  - Assuring the quality of information handed over
  - Maintaining and managing handover information over time

Information Handover Requirements

The purpose of an information strategy is to communicate the ultimate use and relative importance of key information packages from the perspective of the organization creating the strategy. The next step is to define the contents of those key information packages, select an appropriate form and format for their handover and determine metadata requirements.

Applying an Existing Standard

Most organizations are able to describe the information they need at a summary level. Defining the exact contents of each information package is more challenging. The best approach is to apply a model view or use case that has already been defined, if one exists. Examples are the U.S. General Services Administration's (GSA) Spatial Program view of the Industry Foundation Classes (IFC) model (www.gsa.gov/bim) and the use cases defined for CIS/2 information exchanges in the steel supply chain. In these cases, multiple software vendors have already developed implementations. The COBIE specification discussed earlier and the Early Design Information Exchange specification originally initiated under the International Alliance for Interoperability (IAI) and now continuing under the U.S. National BIM Standard (NBIMS) both detail the contents and format for certain information packages. Both are included in the NBIMS (www.nbims.org).

There is no single standard that currently addresses all of the general building industry's handover requirements. In fact, there are gaps where no standards exist and other solutions must be used. However, not every information package has the same level of interoperability requirements. It is important to focus on the highest priority packages and those for which a standard format is most critical. Begin by understanding the uses of each prioritized information package.

Uses of Information Packages

Information packages have different uses. Understanding the uses of your organization's prioritized information packages allows you to maximize the utility of the information while minimizing the complexity and cost of its capture and management.

Questions that should be answered include:

- Who and what system(s) will use the information and where will it need to be accessed? Which users and systems will view only and which, if any, will update? Obviously, the information package needs to be in a consumable format for its intended downstream users.

- Will this information be updated? Some percentage of the information packages will be static; i.e., they will be "frozen" at a specific point in time. An example would be an occupancy permit or a test report. Static information can be captured in a standard archival format such as PDF/A (ISO 19005-1:2005*, Document management - Electronic document file format for long-term preservation - Part 1: Use of PDF 1.4)* and should be protected from alteration. Good metadata will be required to permit the searching and retrieval of static information in unstructured form.

- Which and how many versions of the information package need to be handed over? For example, does the owner need both the as-designed and the as-constructed information? A common owner mistake is requesting so many handovers of evolving information that it is unclear, after the project is complete, which information package is the final, accurate one. If multiple versions are to be handed over, then data management and configuration control (i.e., tracking which analysis run produced which handover package and which changes within the model) will be critical.

- Is this information handover iterative? An example would be information handed over for design review and coordination. This type of handover must be executed quickly and efficiently. Often it is preferable to use proprietary formats for this type of handover.

- Is this information handover two-way? In other words, will the recipient be revising or adding to the information package and sending it back? A two-way information exchange is technically more difficult and also requires the ability to distinguish what has changed and to maintain an audit trail of which party created and/or changed which information when. Some proprietary solutions work better for this.

- How long will the information be retained? There are multiple factors that contribute to this assessment, including:

    - Regulatory and legal requirements
    - Importance of the information to business functions
    - When in the facility life cycle the information will be needed

  - Intended life span of the facility

- How frequently will the information be accessed or updated? Data that are in constant use can be expected to be converted to new formats as the organization's IT environment evolves. Data that are seldom used, however, risk being forgotten. Monitoring should be put in place to flag any data in proprietary formats threatened with obsolescence. These are the information packages for which a standard format is most desirable.

There are four major categories of information forms and formats. Figure 5.6-2 identifies their comparative longevity and reusability. The terms structured, unstructured, standard and proprietary are defined and discussed in detail in Section 3.

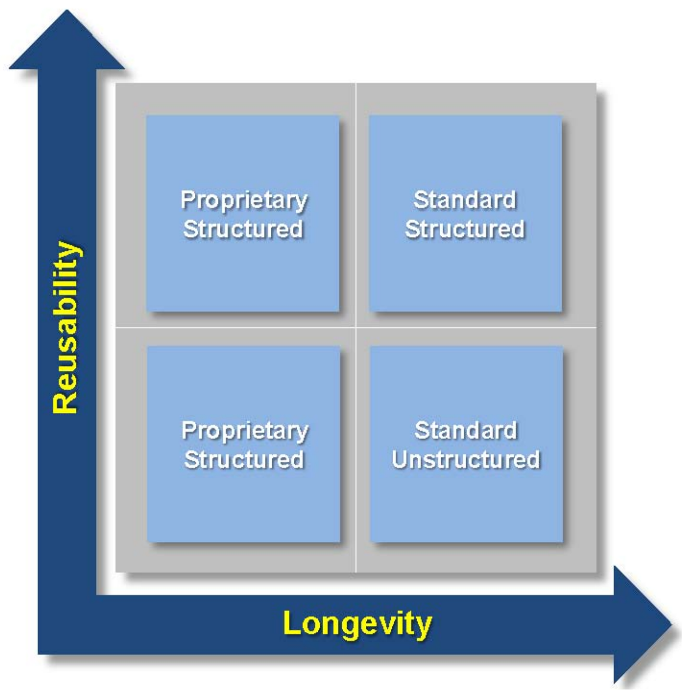

Figure 5.6-2 – Longevity and Reusability of Information Forms and Formats

In deciding on a standard format one must assess the level of adoption, the availability of reliable implementations and the cost of using the standard. Also, who will be the downstream users of the data? Will these users have access at a reasonable cost to software that supports the standard? It is also critical to consider the level of technological expertise of the potential information providers. Assuming that a standard format is available and well-supported by commercial application software, are the potential consultants, contractors and suppliers capable of creating a complete and accurate information package in that format? If it is unlikely that the level of technological expertise in the marketplace will support the optimal information handover approach, the facility owner must either provide training or modify the information strategy. Careful thought should be given to whether the short-term cost of providing training outweighs the long-term benefits of having the facility information in structured form and standard format.

Project Information Handover Plan

The information strategy:

- Specifies information required for decision-making, work processes and regulatory compliance (information packages)

- Prioritizes these information packages
- Identifies by whom and when in the facility life cycle these information packages are created, and
- Identifies by whom or what process and when in the facility life cycle these information packages are used.

The handover requirements define, for each information package:

- Content
- Uses
- Preferred form and format
- Metadata requirements, and
- Retention.

The project information handover plan brings together the information handover content, format and metadata requirements and the project-specific conditions to ensure that the required information handovers can be executed.

Developing the Project Information Handover Plan

The information strategy and the handover requirements are generalized for any number of locations, facility types, project scopes and delivery methods. The challenge of the project information handover plan is to apply these general requirements to the specific project so that high-priority, correct and properly formatted information packages are dependably, timely and cost-effectively handed over by the originating members of the project team.

From General to Specific

Important considerations in tailoring the general guidance to the specific project include:

- Jurisdiction-specific requirements. Since the built environment is typically regulated at the local level, pay attention to requirements that vary based on locale, including:
  - Retention
  - Hard copy
  - Wet signatures or physical stamps
  - Digital signatures/ transmission, and
  - Information handover(s) to the jurisdiction.
- Each team member’s responsibility for work processes that create priority information packages.

This is an area of great variability, since many companies play multiple roles on some projects and entirely different roles on others. For example, some owners may self-perform some construction work and a firm that is the design engineer on one project may be the construction manager on another. Whether key information handovers are occurring within a single organization or across multiple companies affects the legal complexity and the need for data management at the overall project level. Typically, a firm will manage its own data and data exchanges until that data is released to outside companies.

- Specific software products in use by team members. Until the general building industry achieves much better software interoperability, this will be a constant question, exacerbated by the increasing prevalence of the use of multiple analysis programs for design optimization. What capabilities do the software packages have for reading/writing data in formats compatible with applications used by other project team members? These data exchanges will require testing and documentation of required user practices to ensure that non-exchangeable data types are not used.

- Requirements for information sharing among team members within the project, as well as for handoff to downstream processes. The concept of information handover seems to imply relinquishing ownership and management of that data, similar to the handing over of as-built drawings at project closeout. However, many data handovers during project planning, design and construction are iterative, with information added, reviewed, updated and then further developed. Iterative exchanges are perhaps the most difficult to manage inasmuch as they require tracking versions of data sets. They are particularly challenging when a model developed by one team member is handed off to an analysis application that modifies the model and the modified model is then returned to the original author. In this circumstance, tracking who is responsible for each change is critical.

- Each organization’s experience and capacity to work with data standards and structured data forms. The teams most successfully using BIM consider BIM expertise in selecting project team members. Many organizations launching a BIM project are frustrated by a key team member’s inability or refusal to participate in the electronic process.

Balancing Costs and Benefits

There will be some cost associated with both the project information planning process and the project team members’ compliance with the plan. Based on the case studies documented in this guide, these costs are more than offset by benefits. Benefits do not accrue evenly to all stakeholders, however, and are not necessarily proportionate to costs incurred. The compensation model for the project participants should recognize this fact and create appropriate incentives for all team members.

Handover Plan Contents

The project information handover plan should define a comprehensive approach to the consistent creation, management, use and exchange of all information related to both the execution of the project and the priority information packages identified as deliverables at project closeout. The plan should document:

- Project-specific information package sources and when produced
- All uses of priority information packages generated during the project in subsequent life cycle phases
- Format for each information package
- Required metadata
- Handover method, and
- Clear assignment of responsibility for all information creation, handover, quality and compliance monitoring activities

The following topics should be considered when developing the project information handover plan.

Information Quality Considerations

Processes must be agreed upon and put in place at project startup to ensure the quality of the information to be handed over. These should be part of the project's overall quality plan.

Properties of information for which quality requirements should be assessed include:

- **Clarity/ Consistency**: Clear and shared definitions: do creators and users of information use the same codes and terms with the same meaning? Is information received from different sources consistent in terms of naming, units and relationships? Be thorough about developing and enforcing standard terminology.
- **Accessibility**: Where, how and to whom the information is or is not available: is the information easily accessible? Adequately secured? This will, at a minimum, require the designation of a team member to be responsible for managing information handovers. Hopefully, automated systems can be used to assist team members in delivering and logging their handovers and accessing the information they require.
- **Usability**: Can the information be organized and presented differently for different users? For example, a cost estimator or specification writer views facility information much differently than the design engineer who created it. Are there multiple copies or versions of this information? If so, is there a master copy from which the others are derived? With BIM, there is frequently a

considerable difference in the way the design team models the building compared to how the construction team models it. For example, the designers may model a large slab as a single object. The contractor may model it as a number of smaller slabs, defined by his pours. One way to handle these differences is to have the contractor, assuming he is involved during design, provide his objects for the design team to incorporate into the model. The second approach is to create a second construction model. This would then require some way of referencing the design model to ensure maintenance of design intent.

- **Completeness**: How much of the required information is available: is the full content of each information package supplied? Is all the required information routinely created by the project team in their normal course of activities, or do they need to do something special? Another issue here is that an information package may be generated by multiple organizations and/or in multiple phases. Thus the handover is not a single deliverable, but two or more deliverables that must be merged in some fashion to create the required information package.

- **Timeliness**: The availability of the information at the time required: is the current version of the information team members require available, and is it available when they need it? The project schedule should accurately reflect when information handovers are required. However, the transfer of data, particularly if it must be translated or checked, may add time that is not reflected in the schedule. A second issue is when in-progress information should be communicated to other team members. Sharing in-progress work too transparently may result in other team members' scrambling to accommodate a change that really is not a change; it is just a "what-if" study.

- **Accuracy**: How close to the truth the information is: is the accuracy of the information known and does it meet requirements? It is important to determine both the level of detail and the level of precision expected at various points in the project process. Clearly the "build it first digitally" approach requires a very complete and very precise model for all systems included before the project enters physical construction. However, this is not the level of accuracy required in conceptual design. Some organizations, such as the U.S. Coast Guard, have defined levels of model detail required at project milestones based on the UniFormat levels.

- **Cost**: The cost incurred in obtaining the information and making it available for use: is the information supplied in a form and format that means the cost of maintaining it throughout the life of the asset has been minimized? What about the costs of managing and quality assuring the information handovers during the project process? Information management may be a new cost item for many organizations. It is important that business managers understand that there is a cost to this activity when they determine project staffing and fees.

Information Quality Management

The project information handover plan should provide an information quality management framework that describes the information handover in terms of scope, contents, constraints, coding, timing and procedures.

The information quality management framework should address:

- What is to be handed over and in what format
- Required metadata
- How the information is to be handed over and receipt acknowledged
- Time period allowed for verification of transfer and checking
- Quality metrics for the information and the process to ensure that the information is of the required quality, and
- The procedure to be followed if and when incorrect or incomplete data is found.

Logistics

The project information handover plan should make clear:

- Who will produce each required information package
- When they will deliver the information package
- How they will deliver the information package
- Who will receive the information handover
- Where the handover information be stored, and
- Who will be responsible for its management and integrity.

New Project Roles

Managing data exchanges during the project process is typically the responsibility of the project team. As the AISC suggested in the *2005 Code of Standard Practice,* the responsibility for managing the model and the data exchanges should be assigned to a specific organization on the team. The owner should also designate responsibility within its IT group for receiving the appropriate information handovers at project closeout, archiving and maintaining the data and making it accessible to downstream users.

Handover Methods

The method of handover will depend to a certain extent on the form of the information to be handed over. Owners may continue to require information to be handed over as paper records, most often in conjunction with digital surrogates. Where this is required, it should be clearly noted in the project information handover plan.

For electronic handover, there are a number of approaches that can be adopted. Efforts should be made to provide the entire project team controlled access to a shared repository of accurate project information and to minimize redundancy, data re-entry and the effort required to conform multiple versions of the same information. There are a number of possible approaches to doing this and these are somewhat dependent on the information strategy:

- **Owner System**: The owner implements an information system and provides controlled access to all project participants, internal and external. Based on project role, the various participants upload deliverables to the information system at the required handover points and/or retrieve the information required for their activities. This approach is designed for an owner-driven strategy of optimizing facility life cycle costs and operations. The challenge with this type of system is that it may not support all information exchanges necessary between project team members.

- **Third Party System Based on Owner Requirements**: A consultant, construction manager or contractor establishes a system to capture the information packages required by the owner and then hands over the populated system to the owner at the end of the project. This approach can be used where the outside organization already has a well-established infrastructure, but the owner does not. It is useful in providing a framework within which the owner will be able to manage key information packages over the long term. It is consistent with an owner-driven strategy to optimize facility life cycle costs and operations but, again, may not support information handovers between team members during design and construction.

- **Cross-Organizational System**: A consultant, application service provider, construction manager or contractor implements and manages a shared information system that is populated with information throughout the project by all participants. This approach is consistent with a supply chain or project delivery optimization strategy and is the approach recommended by AISC. In this approach, the information to be handed over to the owner will likely be a subset of all information accumulated. The current lack of robust data management tools means that the selection and transfer of the owner-required handover data to the owner's system may require additional effort.

- **Information Handover as Discrete Project Closeout Task**: Each organization participating in the project uses its own in-house systems to assemble the information and then exchanges information periodically on a one-to-one basis with other team members or the owner. At project closeout, some team member is designated to go back and assemble the owner-required information packages. Experience with Operations and Maintenance Support Information (OMSI), which is an example of this approach, indicates that the information gathering and formatting (not in structured form) effort to produce a modest group of information packages costs US $40,000 for a typical Naval Facilities Engineering Command (NAVFAC) facility. In addition, this approach fails to support a high level of project collaboration and integration. This unmanaged type of data exchange with an add-on task of assembling information packages after the fact is undesirable under any strategy.

Data Transfer Methods

In the past, data were usually transferred on magnetic or optical media, such as 3.5-inch floppy disks, magnetic tapes or CD-ROMs. Today, such transfers are usually accomplished by electronic transfer across a public or private data network.

The method of data transfer should be agreed by the parties prior to the exchange of any information. Security issues must be addressed. It may be necessary to hand over certain design or contractual information on paper to meet with legal requirements. The requirements for paper documents need to be carefully considered in relation to the ability to create verifiable copies of information from electronic storage and the legal admissibility of such information.

Timing

The frequency and timing of information handovers must be settled. Issues to be covered include:

- Will there be a specific milestone at which various players deliver information packages, or will the information be built up throughout the project?
- Will trial handovers be required? It is advisable to test the handover technique and participants' understanding of the requirements early on to avoid reworking large quantities of data.
- If data conversion is required, how long will that take?

Responsibilities

Once the required handover information has been specified and documented, the participants in the project need to agree responsibilities for:

- Creation of information
- Security of information
- Quality assurance of information
- Gathering third party information (e.g., equipment vendor documentation)
- Getting information into the right format

- Assigning metadata
- Implementation of the information management systems
- Managing the information through the project duration, and
- Assuming responsibility for the information upon project closeout.

Storing and Preserving Handover Information

Data preservation is a highly complex issue. Paper-based preservation focuses on preserving the physical entity. With digital data, preserving the physical media on which the data is stored solves only part of the problem. Digital preservation requires not only refreshing the physical media and ensuring that it can be read, but also ensuring that the digital data is not changed or corrupted and that programmatic access to the data is maintained.

Media refreshing ensures that data will not be lost due to deterioration of the media on which it is stored. An example of this would be copying data archived on one storage media to new storage media on a scheduled basis. Ensuring that the file is not changed or corrupted can be handled by techniques such as a checksum or digital signatures. This is called "bit preservation." With the rapid turnover of devices, processes and software, the more difficult issues are the availability of hardware that can read the media and of software that can display the content.

Archiving the data in active, online storage rather than on external media best solves the media problem. Requiring information to be handed over in formats that are defined by *de jure* standards organizations such as the International Organization for Standardization (ISO) is the best protection against format obsolescence.

Implementation of the Project Information Handover

Implementation requires the alignment of work processes and software tools to produce and deliver the required handover information. The greatest efficiency will be achieved if the handover process is integrated with the information creation process. This will provide a streamlined flow of information.

Handover requirements (content, format and metadata) should be defined in the contract between parties. Unless the information is originally created in the desired form, it may be difficult and expensive to convert. Therefore, it is essential that the information strategy and the handover requirements be established before project initiation so that contractual requirements for information handover can be defined. It is also advisable to clarify the minimum hardware, software and communications requirements for each team member.

Business Considerations

Over the last ten years, many businesses in the design and construction industry have developed two separate IT groups. The first is more traditionally focused, addressing issues of system capacity planning, uptime and performance, communications infrastructure, data security and internal systems management. The second group merges domain expertise with IT savvy to assist the firm in evaluating and deploying client-facing systems such as Building Information Modelling (BIM), project management and collaboration. This second group typically has at least two tiers: project-focused individuals who provide front-line expertise, technology training and support to the teams working on projects and the more strategically focused technology visionaries responsible for proposing, evaluating and deploying new technologies and products. Large firms may have an additional tier of experts in specific products or technologies. This tier is typically involved in customizing solutions for specific markets, clients or projects to create competitive advantage. Many businesses are finding it valuable to include this second, domain-focused IT group in proposal/ bid preparation to help business managers assess the staffing, training and hard cost impacts of client electronic collaboration and information handover requirements.

Project Information Manager

Although each company participating in the project is responsible for the content, timely delivery and management of the information it creates, there is a need to integrate, check, coordinate and manage the information received from all parties. Beyond understanding the issues of coordinating building systems, this model management activity requires expertise in data structures, configuration control and information management. A single entity should be designated to serve this function. This entity can be dedicated exclusively to this activity or be a team member that is providing other services. The following is a commentary from the AISC's 2005 *Code of Standard Practice for Steel Buildings and Bridges, Appendix A: Digital Building Product Models:*

> *When a project is designed and constructed using EDI, it is imperative that an individual entity on the team be responsible for maintaining the LPM [Logical Product Model]. This is to assure protection of data through proper backup, storage and security and to provide coordination of the flow of information to all team members when information is added to the model. Team members exchange information to revise the model with this Administrator. The Administrator will validate all changes to the LPM. This is to assure proper tracking and control of revisions. This Administrator can be one of the design team members such as an Architect, Structural Engineer or a separate entity on the design team serving this purpose. The Administrator can also be the Fabricator's detailer or a separate entity on the construction team serving this purpose.*

As an example, for the Hamilton Building of the Denver Art Museum, the contractor, Mortensen Construction, acted as the project information manager. Mortensen executed model sharing agreements with other team members. In addition to the 3D architectural model, all major shop drawings were submitted in 3D form. Throughout the pre-construction period, many different software products were used to create system-specific models that were shared through a project website.

Mortensen staff linked the design model and the manufacturing (shop drawing) models used to build the project. The BIM models became the catalyst for collaboration. They conducted interference checks and 4D construction sequence simulations. They used the model data to ensure proper placement and tolerance during construction.

Contractual Terms

Integrated practice and the replacement of physical documents by information handovers raise questions about standard contracts, liability, risk management and insurability. Although there is little litigation case history, the emerging consensus is that these changes in when and how information is communicated do not alter the basic roles and responsibilities of the team. The AE is responsible for the design; the contractor is responsible for constructability issues, construction means and methods and shop drawings. What is important is that all parties understand, at each handover, the accuracy of the model and its intended uses.

Commonly used standard contracts do present an obstacle to a collaborative information sharing environment. These contracts are based on a legal differentiation between design, a professional service, and construction, a contractual and warranty obligation. Design information is conveyed via "instruments of professional service" to be used by the contractor. Even when information is exchanged electronically, most contracts denote the hard copy as the controlling design information. When the project delivery approach eliminates drawings and requires the development and use of a shared model, such contractual terms must be changed. Organizations such as the American Institute of Architects (AIA) and the Associated General Contractors of America (AGC) are currently working on revised language for standard contracts, but these updated standard contracts are not yet available. Businesses must therefore work with legal counsel to develop and negotiate special contract clauses that include:

- Allocation of responsibility for creating information
- Appropriate access to, reliance on and use of electronic information handed over
- Responsibility for the updating and security of the data
- Ownership and downstream uses of the information, and
- Compensation for team members that recognize the costs and risks they incur and the value they deliver.

The presence of a proposed project information handover plan will greatly facilitate the negotiation of these terms.

Liability and Insurance

Although the AE's professional liability coverage does not extend to technology-based risks such as lost data, virus corruption, or software malfunctions, it does cover broadly defined design services, regardless of the means of communication or the form of the instruments of service. A new development may be the incorporation of elements designed by team members other than the AE. These team members will be legally responsible for their own design negligence and should consider insuring themselves appropriately. The model manager plays a critical role in tracking the source of each design element and incurs some special liability for data mismanagement, corruption or loss.

Technical Implementation

The technical implementation must align the hardware, software, data communications and IT operations to ensure timely creation and delivery of quality information in the proper form and format. It must also establish the proper access controls, data backup and security provisions.

Configuration Management

For all dynamic information, both standard and proprietary formats, configuration management will be very important. The information content of a given model or document will evolve over the course of the project, and many will continue to evolve through operations and maintenance. However, there may be a need to preserve and access "snapshots" at key points along the facility life cycle timeline and know who was responsible for each change. During design and construction, configuration management will be the responsibility of the model manager.

Testing

Initial testing should be performed to ensure that all software selected correctly reads and writes the preferred format. Time required for translations and data transfers should be measured. Additional testing is required for the software or technique that will be used to maintain an audit trail of changes to the model.

Documentation of Best Practices and Project Procedures

Following the testing, it is important to document any specific user practices necessary to achieve the desired outcome. A good example for BIMs is to advise users not to delete a model element and add a new one, which will also delete that element's unique ID, but rather modify the element. This will permit the maintenance of the element's unique ID and allow the tracking of changes to that element.

Documenting project procedures related to information handovers will help clarify new roles and responsibilities. The best approach is to write step-by-step work instructions specific to the software products(s) in use. The *GSA BIM Guide for Spatial Validation,* available at www.gsa.gov/bim, provides an excellent example of such documentation.

Staffing and Training

It is advisable to request a contact person on each company's project team responsible for communications concerning information handovers, changes to the system or procedures and user training and support. This individual should also be responsible for initiating new users.

Whether or not all project team members have experience with the software to be used, they all require training in the project information handover plan, associated procedures and best practices. All persons involved in information generation and handover should understand the following:

- Purpose and use of the information involved
- Life cycle aspect of information (in particular, the need for information to satisfy future life cycle requirements as well as its immediate use)
- Quality assurance issues (how to verify information)
- How to create and use the information, and
- Security issues such as confidentiality, virus checking and backup.

Project staffing is never static; people will come and go. Provide mechanisms for identifying and training new users.

Compliance Checking

There is a natural reluctance to change the way one works. In order to ensure the stated project procedures are followed, compliance checks should be performed periodically.

Continuous Improvement Program

A Lessons Learned or other continuous improvement program that periodically solicits feedback from users will be very effective both in encouraging compliance with project procedures as well as in identifying better ways to work.

Handover Lessons Learned By Early Adopters

The advisory panel for this guide contributed a number of insights concerning the potential pitfalls and keys to success.

Challenges

There were challenges encountered in a number of areas, including: commercial issues, entrenched expectations, resistance to change, immature technology and inadequate technology infrastructure.

Commercial Issues

Commercial issues encountered included conflicting business models of different project team members. This led to an individual company's attempting to optimize its own outcome rather than the project outcome.

Another issue that arose was model ownership. A related issue was the expectation on the part of some clients that, because a model existed, it could be readily reused for other, not necessarily intended, purposes. This raises the need for clarification of the specific information packages to be handed over.

Expectations

Aligning expectations in general was an issue. Persistence of a 2D mentality and insistence on traditional project process, phasing and deliverables reduced the effectiveness of streamlined computer-based workflows and electronic information handovers. There were problems defining deliverables appropriate for the new project approach.

Change Management

There was also active resistance within project teams to change. A number of advisors reported that key project team members promised but failed to work in 3D or simply refused to believe the information handed over. In one case, the construction manager insisted on doing a manual quantity take-off even though they were supplied with a detailed take-off from the structural model by the engineers. Even where there was no active resistance, it was still challenging to find staff who could work and problem-solve in new ways. Project team members had different levels of IT capability and understanding. There was often a need for continuous training that was not always budgeted for or met. The consensus was that these issues are best resolved when the client assumes a leadership role and project team members are selected partially based on their 3D/ BIM capability.

Immature Technology

Early adopters encountered a number of challenges that were related to the immaturity of the technology. These included:

- Lack of standard model views
- Software incompatibility
- Limited data re-usability and machine interpretability, and
- High level of effort required to make the electronic information usable by others. This was particularly pronounced in two-way exchanges of information (e.g., the results of the analysis update the model).

The root causes of these issues are discussed in Section 3. There is still much work needed to develop use cases and model views and develop standard terminology so that advanced software systems can fully interoperate. There is also the need for test cases that will permit both software vendors and end users to know whether specific products can interoperate effectively. This is the area that is being investigated by the IAI buildingSMART initiative internationally and the NBIMS project committee in the United States.

Inadequate Technology Infrastructure

In addition, advisors cited inadequate technology infrastructure in several areas:

- Wireless access and speed (processing time, bandwidth)
- Appropriate viewing devices
- Collaborative tools, and
- Model repository/model management software.

Keys to Success

Advisors were also able to identify common factors that led to success. These focused more on human factors and the quality of collaboration.

Human Factors

Perhaps the greatest success factor was strong leadership, either by the client or executive leadership within their own company. Also important were grassroots leadership and buy-in by the team. The availability of personnel with process flexibility and skills with the technology tools was also a factor.

Quality of Collaboration

The greater the number of team members who can share project information with confidence, the greater the level of efficiency and automation and the more successful the approach. Thus, key success factors also included:

- Transparency and accessibility of electronic information for more people
- Ability to use the information across the design/ construction team
- Appropriate quality assurance methods and procedures
- Collaboration that includes the trades
- Mutual trust, and
- Recognition of new project roles, such as information manager.

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