**A guidance on digital data and information delivery**

**during the life-cycle of transportation assets**

**1. Problem statement**

There has been an emerging trend of adopting intelligent or computer-related technologies to assist in highway project delivery and asset management. The adoption of various advanced computerized technologies such as 3D modeling and Geographic Information System (GIS) is making a transformative change in how project information is produced, exchanged, and managed throughout the life cycle of a transportation project from analog to digital data based system. With ample evidence and success stories from the vertical construction industry and some promising case study results from the highway industry, the significant improvement of data and information sharing between project participants and across various project development stages is possible with a model based project delivery process, and electronic and digital data transfer systems, which will in turn translate into increased productivity, efficiency in project delivery, accountability, and asset management.

However, in current practices, digital data and information are being used and managed independently in proprietary formats by separate project participants, and the data exchange processes are still relying on paper or electronic paper based formats rather than digital dataset. Proper development, manipulation and transfer of digital data, effective and correct extraction of information from them can enable information to be sharable and reliable for decision making and minimize efforts in re-gathering or reformatting data (GSA). Several efforts made by the FHWA to provide guidance and assistance for digital modeling implementation for highway projects, but there is not yet guidance on how to use and transfer digital data and information across highway project life phases. A research is needed for understanding current state of practices in digital data sharing throughout the life cycle of highway projects and develop a guidance on data flows, data sharing requirements, and supporting software applications and techniques to allow fully reuse of digital information models for particular use scenarios in particular projects.

2. **Research purpose**

This research aligns with MTC’s them which envisions a data driven project delivery. As an effort to allow the civil infrastructure reach to that vision, the purpose of this research is to develop a guidance for DOT professionals so that they can use to understand the digital data flow during the project life-cycle for various type of transportation assets including pavements, bridges, culverts, signs, guardrails, etc. The guidebook will include but not limit to the following topics:

* The general data flow and workflow which clearly define sequences of the various work processes to be performed and specify under what circumstances the data and information should be collected in which way through project life cycle;
* Data requirements, data sources, levels of detail, software applications and tools involved in a specific data exchange use case.
* Guidance along with templates on implementation of neutral data standards (e.g., LandXML, TransXML, IFC for infrastructure) for exchanging digital data between project stakeholders.
* Set of software tools that assist efficient digital data transferring.

**3. Related research and prior work by the research team**

Digital data and information sharing throughout the project life cycle has been undertaken well in the building sector. Information Delivery Manual (IDM) by buildingSMART is a guide that specifies use cases where data exchange is required, what and specification for data to be exchanged, data sharing processes and what actors get involved in the processes. The methodology for develop this IDM has been documented by the National Institute of Building Science (NIBS) standard. There are several IDM available, for instance IDM for exchanging within the building programming phase, precast concrete, the use case of geographical referencing, and construction to operation (Cobie). IDM for other user cases of the building project also have been proposed. For example, a research conducted by Berard et al. (2012) included industry experts, manufactures and software vendors to develop an guide for data exchange between the designer and supplier. Another example is the data transferring for environmental and energy performance assessment (Pinheiro et al. 2015).

Our research team have long experience and been successful with the effort to enhance the efficiency in data sharing through the life cycle of the civil projects. For example, to analyze the relationships between data actors and data we developed a social network based framework to assess the importance of each data items (e.g., roadway inventory, pavement cracks) to each use cases and data actors (Woldescenbet et al. 2015). In addition, we also developed a framework for interlinking isolated life cycle data spaces for pavement asset (Le and Jeong 2016). Also, we proposed a methodology for addressing the issue of inconsistency of data attributes name which arises when integrating data from multiple sources. The success of our prior research provides strong foundation for us to continue into the further stage of implementation to provide not only academic outcomes but a practical guidance and tools to assist DOT staffs in manipulating, searching data and sharing data.

**4. Proposed research**

Figure 1 below presents the overview of the research framework. The proposed research is designed to include three main tasks which would result in three deliverables.

Task 3. Develop final guide

**Work Tasks**

**Deliverables**

Task 1. Literature review

Task 2. Process map development and data exchange requirements

Synthesis of current practices

Process map and data map

Final guidebook

Figure 1 Research framework

**4.1 Task 1: literature review**

For this task, the research team will collect, review, synthesize and document domestic and international publications relevant to digital model implementation. Since the implementation of digital models is still in the early stage in the highway industry, there are not many publications directly addressing digital business processes, methods and tools for highway projects.

The research team will document their best practices through extensive literature review and identify and document lessons learned and possible areas of adaptations for the highway industry. As part of Task 1, the Information Delivery Manual (IDM) will also be extensively studied and analyzed. IDM aims to define (1) processes through the life cycle of a project in which information exchange is required, (2) which actors sending and receiving information for each process, and (3) definitions and descriptions for information to be shared (buildingSMART, 2012). There are some IDMs available, for instance, IDM for building programming phase, IDM for Geographical Referencing. This guidance has been widely accepted as an industry standard in the building and facility construction and management sectors.

**4.2 Task 2: Data and information delivery development**

The purpose of this task is to capture industry experts’ knowledge and needs regarding digital data sharing. In order to achieve that goal, we would adopt the methodology to develop Information Delivery Manual in the vertical sector. Focus group discussion will be used. Working group will include domain industry professionals with various expertise, research team, and software vendors. This focus group discussion aims to identify and document the data exchange scenarios, data flows, data requirements, data format, supporting software applications. The outcome of this phase will be a process map and a data map. The process map would show the data exchange processes throughout the project lifecycle; and the data map presents what data required to be shared by whom and to whom and when. The following section presents more detail about specific tasks and anticipated outcome.

**4.2.1. *Task 2a. Project scope identification***

Asset life cycle involves a large number of stakeholder with various disciplines, phases. The life cycle include large number of data exchange scenario. And the sharing scenario also differ between project delivery methods, design bid build or design and building method. It is important to determine the critical data sharing scenario. Research team together with DOTs professionals to discuss and to define scope of the information delivery manual, for example architecture and designer, product suppliers during the programing phase.

**4.2.2. *Task 2b. Workgroup formation***

Industry professionals for expertise related to the data exchange use case will be invited to participate in the focus group. The workgroup will include experts, research teams, and software vendors.

**4.2.3. *Task 2c. Identify business use case narratives***

This is the first deliverable expected to obtain from the workgroup discussion. The group will discuss and identify business use cases in which data sharing between project stakeholders (actors) would occur for the entire throughout the asset life-cycle within the project scope. For example, the “cost estimating” use case would need data sharing between the engineer and cost estimator. Each identified scenario will be described in plain language and include the following information: (1) project phase (e.g., design), actors involved (e.g., designers, estimators), activities (e.g., cost estimation), software platform used, purposes of the activities and anticipated outcome of the activities.

This task, will be conducted by the research team, aims to translate the narratives resulted from the previous task in to a formal process map. A map process would shows the relationships between activities, actors, and input and output. Business Process Modeling Notation (BPMN) standard will be used to draw the process map. This process representation method allows the map to be readable to both human and machine.

**4.2.4. Task 2e. *Identify da exchange requirements***

The workgroup will discuss to identify data exchange requirements based on the developed process map. The data exchange requirements present what specific data to be shared, who is requesting the information and, who will send the data, and the rationale for the data requests. The required data would be described in the level of detail that clearly define what data entities (e.g., pavement layer), attributes (e.g., geometry information such as width, thickness). It is important to clarify the definition for each data term. Specifications describing each data items would be discussed. Based on these specifications, the inconsistency of data names used among the experts can be identified. Also, software applications that creating and receiving those data would also be identified by the workgroup. The data exchange requirements will be documented by the research team.

The data exchange requirements resulted from the prior discussion will be used by the research team to develop visual data map. Table 1 below shows an example of the anticipated map in tabular format.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Phases: design |  |  |  |  |
| Data | data explanation | Data creator | Data receiver | Data attribute |
| Alignment |  |  |  |  |

**4.3 Task 3: Guidance development**

With the successful completion of the task above, the research team will develop a guidance for DOTs on data sharing during the life cycle. The guidebook will include the process map and data map along with plain language description which clearly describe the following items to efficiently transfer and reuse digital and information data: a) business use cases where data sharing is needed, b) data and information requirements, c) detailed specifications for each data and information type, d) actors responsible for creating, receiving, validating, securing and maintaining the data and information, and e) software applications involved during each data transaction.

**5. Research plan**

**6. Research funding**

**7. Research team**