A. Title: Systems Integration on a Light Rail Project: A Tale of Two Agencies

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D. Abstract

Subject Track: Passenger & Transit

As Transit Agencies progress to build new Light Rail Transit (LRT) Projects or extend existing Starter lines, one of the newer elements has been Interface Management or Design Integration between the Civil design and the Systems design. In the Seattle area, Sound Transit has incorporated some of the Design Integration processes utilized by the Aerospace Industry in the Puget Sound region as it extends the initial Central Link LRT line east to Bellevue and Redmond, WA. In Hawaii, the Honolulu Authority for Rapid Transit (HART) accomplishes the same integration of the Design/Build Systems contract elements into their Aerial Station Final Design construction contracts through an Interface Management approach.

As the benefits of a Systems Integration or Design Interface approach become more widely known in the Rail Transit Industry, the pros and cons of how and when to use these tools in the various design and construction contracts becomes more apparent. Supporting the integration process, Sound Transit has been increasing the use of clash detection on the 3-D models for the stations in each stage of the design process. To document the design decisions or respond to design questions, Sound Transit uses a centralized ICD Database. Similarly, in Honolulu, HART utilizes an Interface Management approach with the progress on each design decision or direction tracked through a contract management system database.
In summary, Interface Management/Design or Systems Integration may use different tools or have a different role depending on the type of the rail transit construction contract.

E. Body of paper, including an introduction and conclusion (tables, graphics and figures may be included in the body of the text)

INTRODUCTION

As Transit Agencies progress to build new Light Rail Transit (LRT) Projects or extend existing Starter lines, one of the newer elements has been Interface Management or Design Integration between the Civil design and the Systems design. In the Seattle area, Sound Transit has incorporated some of the Design Integration processes utilized by the Aerospace Industry in the Puget Sound region as it extends the initial Central Link LRT line east to Bellevue and Redmond, WA. In Hawaii, the Honolulu Authority for Rapid Transit (HART) accomplishes the same integration of the Design/Build Aerial Guideway and Systems contract elements into their Aerial Station Final Design contracts through an Interface Management approach.

As the benefits of a Systems Integration or Design Integration approach become more widely known in the Rail Transit Industry, the pros and cons of how and when to use these tools in the various design and construction contracts becomes more apparent. Supporting the integration process, Sound Transit has been increasing the use of clash detection or identification of physical conflicts between disciplines on the 3-D models for the stations in each stage of the design process. To document the design decisions or respond to design questions, Sound Transit uses a centralized Interface Control Document (ICD) Database. Similarly, in Honolulu, HART utilizes an Interface Management approach with each design decision or direction tracked through an ICD database.

This paper outlines the Sound Transit Interface Management and Integration Process (ICIP) and how the H-J-H Final Design team has implemented it on the East Link LRT extension for traditional Design-Bid-Build and Design-Build procurements. In addition, the HART Interface Control Manual and its implementation by the HDR team on the Final Design of the Farrington Highway Station Group contract and its interfaces with the adjacent Design/Build contracts are reviewed.

BACKGROUND

Sound Transit, the long range transit agency for Seattle and the central Puget Sound region, plans, builds and operates express bus, light rail and commuter rail train services. In 2009 Sound Transit (Agency) formalized the requirements for an integration process to be used on all Agency capital projects. The board approved process is the Link Light Rail Interface Coordination and Integration Plan (ICIP) (1). This plan provides both project management and technical requirements fundamental to the integration of light rail projects. In addition, the plan outlines how best practices and lessons learned can be incorporated into the design, delivery, and operation of each project. This plan is designed to be a comprehensive and practical guide to the requirements and
processes that direct and guide internal agency and consultant design activities. The plan is based upon existing procedures, other transit agency plans, as well as non-transit interface control plans.

Presently Sound Transit is concurrently designing and building three major capital improvement projects: 4.3 mile Northgate Link and 14 mile East Link extensions from downtown Seattle, and the 1.6 mile South Link extensions from the SeaTac Airport, see Figure 1. All three major capital projects are using the ICIP as the basis for the interface coordination and integration process. These projects rely on the expertise of consultants all across the United States, all with competing projects, differing requirements and challenging schedules. As such the importance of a structured approach is paramount to the Sound Transit’s ability to successfully oversee the interface management and integration of the designs.
Figure 1. Sound Transit’s Link LRT Expansion Plans – Funded Segments
In addition to the formalized approach, Sound Transit also employs internal staff to monitor progress, coordinate with other Agency departments and ensure multiple contracts can benefit from each other. The Agency internal staff personnel responsible for the integration process are engineers with mechanical/electrical specialties and transit/facility design experience.

A similar approach is used at HART with their Interface Control Manual (ICM) (2), which describes the role of HART in managing and oversight of the Contractors interfaces and the resolution of conflicts. HART is a relatively new agency, established in 2011, when it assumed the duties and responsibilities of the Rapid Transit Division of the City & County of Honolulu Department of Transportation Services. The ICM addresses the design interfaces of adjacent contracts, systems-civil contracts and other interdisciplinary design. It is a tool to maintain the visibility and control of the construction contract configuration.

Presently, HART is constructing their initial light rail line, see Figure 2. The Honolulu Rail Transit Project (HRTP or Project) is a 20.1-mile rail transit system in Honolulu extending from East Kapolei in the west to Ala Moana Center in the east via the Honolulu International Airport. As stated in their Project Management Plan (3), Interface Management is process which determines and manages the design and construction interfaces by which separate elements of the Project which have been designed and constructed by different organizations all fit and work together in a harmonious fashion.
SOUND TRANSIT INTEGRATION PROCESS

At Sound Transit, the basis of interface coordination and systems integration is the identification of all individual civil and systems elements and their relationship to: each other; the specific facilities and/or components related to the project; and the existing operating light rail system. With the determination of these attributes, interfaces are identified and the integration relationships between them are coordinated and conflicts resolved. This requires the establishment of a structured document control process to monitor the communication and expedite the review and resolution process.

By using the Interface Coordination and Integration Plan (ICIP), civil and systems integration is component oriented, thus the design/component engineers must not only identify and incorporate the appropriate design criteria but also communicate interface requirements between disciplines. In addition, civil and systems interface coordination and systems integration must be thorough and comprehensive in that it must also consider; construction methods and sequencing; testing and commissioning; pre-revenue service testing; and revenue service. Civil and systems integration must be conducted in a logical and precise manner in order to completely and accurately identify and trace the upward and downward relationships between design aspects and components.

Interface management includes a set of activities integrated into the systems engineering process where the benefits include:

- All facility and system interfaces are identified.
• Necessary interface requirements are clearly and completely defined.
• Interfacing systems are designed to the same requirements.
• Incompatibility issues are identified and resolved.
• Changes made in one area of the system are checked for compatibility with other associated areas.

The standard Agency design contract language summarizes the interface management and integration requirements and provides reference to the ICIP such that the competing consultant teams are aware and properly estimate the effort associated with a formalized integration process.

The Sound Transit ICIP places emphasis on the roles and responsibilities of both Agency staff and the design consultants throughout each project’s life cycle and includes significant discussion geared towards supporting communication, consistent planning, system architecture development, detailed design development, and strong design control practices. The plan has six main facets:

(1) Defining **roles and responsibilities** is important to the success of any project and is critical to the integration process. This includes the assignment of an integration manager with experience in this or a similar role.

(2) The lead design consultant on the project is required to submit a **Project Integration Implementation Plan (PIIP)**. The PIIP will tailor the ICIP requirements to suit the scope and contracting methods of the project, establish schedules, define deliverables and establish a comprehensive change control process. The ability to modify the approach while meeting the Agency requirements is critical to ensuring the consultant teams understand the requirements, are committing to the requirements and are approaching the project with efficiency in mind. This plan also allows the consultant teams to include methods and approaches that they have found to work on past projects. Agency acceptance of the implementation plan is required which provides assurance that the project integration process will meet the expectations of the Agency. The plan is revisited as the design progresses to update schedules, personnel, and include any change to the methods being used for the design process. Revisions also require Agency acceptance.

(3) The ICIP contains specific technical **requirements** for a disciplined approach for ensuring and documenting that as the design progresses the proper inter-discipline communication is being performed. Early design requirements include the development of **Point to Point Responsibility Block Diagrams; Equipment Circulation and Access Drawings; System Schematic Diagrams; Composite Drawings; and Interface Coordination and Systems Integration Checklists**, all of which require Agency acceptance. These early design submittals define the detailed design responsibilities and the physical requirements for the facility equipment to ensure the system is well understood by all disciplines prior to finalizing the contract drawings and specifications. A few examples of interfaces that are defined during the early stages include; equipment sizes and working envelope; air...
conditioning/ventilation system needs; electrical system sizing; and floor loads are accommodated. These interfaces are also established for equipment that is brought in after the facility is constructed by a follow-on Systems contractor or the Agency.

Once the design of the facilities begins to mature and the necessary equipment is understood the ICIP requires the more detailed functional interfaces be defined through Interface Block Diagrams and Interface Coordination and Systems Integration Checklists. These requirements are intended to ensure that all interfacing equipment is designed to the same requirements and the supervisory and control work can be easily integrated and constructed.

Interface Block Diagrams are used to provide a graphical representation of the system boundary, the interfaces with other systems, and the input and outputs flowing between the systems. This diagram, in conjunction with text descriptions, can provide an adequate functional definition of the system interfaces.

Figure 3 provides the relative timeline for the submittals required by the ICIP. This is an example as the consultants implementation plan generally will tailor this based on the scope of the design project.

Figure 3. Sound Transit ICIP Process Submittal Schedule - Example
The requirement to obtain Sound Transit agency acceptance for these submittals allows Sound Transit to be involved in the design development process and provide meaningful more focused feedback prior to the large design progress submittals. These submittals can also be routed through multiple Sound Transit agency organizations for a detailed review.

(4) ICIP required submittals as well as detailed interface coordination aspects are documented using **Interface Control Documents (ICD)**. ICDs are generated, tracked, and their final disposition recorded using the Systems Integration Database. While the process requires the ICIP submittals to be provided to Sound Transit via the ICD it is also encouraged that the ICD provide a communication mechanism to facilitate resolution of interface issues and conflicts. As interface questions and issues arise the ICD will be developed to identify and detail the interface issue or question and will provide a mechanism for direct communication between affected engineering disciplines with the Sound Transit Systems Integration Team oversight. The ICDs will include interface issues between engineering disciplines within a contract, between contracts, or between Agency and third parties.

(5) The **System Integration Database** is a web-based SharePoint tool that must be used by each design consultant to collect, manage, collate, report, and archive ICD information. The database is managed by Sound Transit and contains the workflow logic that formalizes the review and acceptance of each ICD. The information within each ICD can be easily retrieved and sorted and is often used for understanding what was agreed to as the design is finalized or new personnel are introduced to the project. By keeping the historical ICD records, design and Agency personnel can revisit closed issues in an easily retrievable fashion.

(6) Recent advances with **3D design and modelling** are also being incorporated into the Sound Transit projects as a means to ensure the designs are coordinated and integrated. Based on the contract scope and budget the Agency will modify the 3D modelling requirements to achieve the maximum benefit to the project. Modelling efforts are concentrated on the more complex portions of the designs including Stations, Tunnel Cross-passages, and areas containing complex interfaces with the operating light rail system may exist. Deliverables include Clash Detection Studies that identify the outstanding physical conflicts between disciplines at each design submittal and the final 3D model. The Clash Detection Studies require that all the design disciplines (Architecture, Structures, Electrical Mechanical, and Systems) 3D models are consolidated and an in-depth review is performed by the design team. A report outlining each clash and the resolution is provided to the Agency. The goal of the multiple iterations of clash detection is a final report with zero clashes. This process was formerly very difficult to perform using overlays of 2D drawings and the light table studies.

The Agency has found that the construction industry has fully embraced the value and power of 3D modelling for coordinating the installation process.
While the 2D engineered drawings remain the controlled design and construction documentation the models created by the design team are also provided to the construction team as a tool for estimating, coordinating, and evaluating changes during installation.

H-J-H FINAL DESIGN FOR EAST LINK LRT IMPLEMENTATION

For the easternmost 7 miles of the East Link LRT extension from South Bellevue to Microsoft’s Headquarters Campus in Redmond at Overlake Transit Center, see Figure 4, Sound Transit has retained the final design team of H-J-H Final Design Joint Venture (H-J-H), of which Hatch Mott MacDonald is providing the Design Integration. The Systems Integration, which is a subset of the overall Design Integration, focuses on coordinating H-J-H’s 5 civil design contracts (E320 – E360) and Sound Transit’s separately designed and bid E750 Systems contract. For the East Link extension, Sound Transit has retained LTK Engineering (LTK) as the systems engineering designer. Both design teams are co-located in a project office at the Sound Transit offices.

Figure 4. Sound Transit’s East Link LRT Project Map.

While three of the five East Link contracts are traditional design-bid-build (d-b-b), one is Design/Build (D/B) and another is a General Contractor/Construction Manager (GCCM). For Design Interface or Systems Integration, there is little difference between GCCM and the traditional contracting method. However, for Design/Build, the Systems Integration starts with the Final Design team who prepares the DB procurement documents and then transfers to the Design/Builder. For DB projects where the
systems design is included, such as Sound Transit’s South 200th Extension, the Systems Integration is all internal to the D/B team.

H-J-H has developed an East Link-specific Project Integration Implementation Plan (PIIP) (4) for the 7 mile South Bellevue to Redmond H-J-H design segment. Some of the elements used by the H-J-H PIIP to respond to the Sound Transit requirements in the ICIP are:

- **Pt-to-Pt Responsibility Diagrams** High level Point-to-Point Responsibility Diagrams are used during 60% design development for such elements as power feeds, utility services, traction power substations, etc. whereas more detailed Point-to-Point Responsibility Diagrams are completed later in the project. An example of a more detailed Point-to-Point Responsibility Diagram is shown in Figure 5.

![Figure 5. E330 Downtown Bellevue Tunnel Point-to-Point Responsibility Diagram](image)
• **Equipment Circulation Drawings** The intent of these drawings is to ensure that initial installation and future maintenance or replacement can be performed without structural shoring or modifications.

• **Interface Block Diagram** The system-to-system or –civil interface functions and requirements are established as early in the project as possible and detailed in the Interface Block Diagrams. Use of the Interface Block Diagrams at Sound Transit, such as in Figure 6 for the below-grade 120th Station’s Sanitary Pump, has resulted in significant improvement in coordination between design teams.

![Figure 6. East Link’s 120th Ave Station Interface Block Diagram](image)
• **Composite Drawings/Clash Detection** All 6 of the traditional final design stations are modelled in Revit with a series of clash detection efforts in 60% and 90% design. By the 90% submittal, there should be zero clashes remaining. An example of a systems-civil clash (since resolved) is shown in Figure 7.

![Image](image-url)

Figure 7. E340 Bel-Red contract's 130th Station Clash Detection at mid-90% design. Clash shown between the white Communications Systems conduits and blue Electrical handholes.

• **Equipment Matrix** For equipment within the Stations, a detailed Equipment Matrix is developed as a tool to perform the final verification of the Interface Block Diagrams.

• **Interface Coordination and Systems Integration Checklist** These checklist serve as the final verification that integration is complete, correct and included in the contract drawings and specifications.

• **Interface Control Documents (ICDs)** An example of the outstanding ICDs for the E330 Downtown Bellevue Tunnel contract at 90% is shown in Figure 8.
Additional H-J-H Design tools include:

- **Bi-weekly Systems Integration Meetings.**
- **Interface Matrix** – Design Interface matrices are used to identify and establish links between the interfacing parties, and track the overall progress towards full design integration. This is an initial step in implementing the H-J-H PIIP.
- **Systems Design Integration Matrix (DICM)** For each contract, a customized DICM is developed focusing on systems elements for systems integration level coordination and verification in final drawings and specifications. As items are verified, they are shaded green with coordination with future or NIC contracts in blue, as shown in Figure 9 (5). Yellow boxes are items for ongoing coordination that will need resolution during 100% design.
<table>
<thead>
<tr>
<th>Physical interface (right)</th>
<th>Locations (Stationing) of Systems Elements</th>
<th>Cut &amp; Cover Structure</th>
<th>SEM Tunnel Structure</th>
<th>Headhouse/Access Shaft/Adit Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systemwide ductbank</td>
<td>Sta. - All</td>
<td>Verified embedded in concrete under walkway (SCXX) and in invert (TEXX)</td>
<td>Structural drawings show 3-3 conduits in the walkways but some systems drawings show 3-2-1 arrangement; need to resolve detail in 100% design.</td>
<td>Verified no conflict between comm. Conduits and electrical conduits, standpipe or drainage cuts.</td>
</tr>
<tr>
<td>12</td>
<td>Comm. conduits</td>
<td>Coordinated</td>
<td>Structural drawings show 3-3 conduits in the walkways but some systems drawings show 3-2-1 arrangement; need to resolve detail in 100% design.</td>
<td>Verified no conflict between comm. Conduits and electrical conduits, standpipe or drainage cuts.</td>
</tr>
<tr>
<td>Traction Electrification Conduits</td>
<td>Sta. - S. Portal S. C &amp; C SEM Tunnel</td>
<td>Need field coordination for sweeping conduits / rebars, but appears doable.</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>13</td>
<td>12.7 kV Tie Line Conduit</td>
<td>Verified Coordinated</td>
<td>Verified Coordinated</td>
<td>N/A</td>
</tr>
<tr>
<td>14</td>
<td>480 V Power to S. Cut &amp; Cover Fans (4) Conduits</td>
<td>Sta. - S. Portal to S. C &amp; C Fan Niche</td>
<td>Need field coordination for sweeping conduits / rebars, but appears doable.</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Figure 9. E330 Systems Design Integration Control Matrix (DICM) at 90% design.

- **General Arrangement Drawings (GZK)** With a focus on space proofing or verifying each element does not adversely impact an adjacent element, a series of general arrangement drawings to coordinate between the various contracts is developed as part of the PIIP, see Figure 10 (6). No new design is shown in these drawings, it is all imported (cross referenced) from other design drawings.
All of the required H-J-H PIIP products are produced and submitted to Sound Transit. For the traditional d-b-b and GCCM contracts, they will be developed using all the elements identified in the H-J-H PIIP plus the 3 supplemental H-J-H items of the General Arrangement/Space Proofing drawings and the DICM and SI EQ matrices.

Since there is only a limited design effort by the Agency for the E360 Design-Build contract beyond the 2010 Preliminary Engineering, only the General Arrangement/Space Proofing drawings are created as part of the PIIP. The Systems Integration responsibility transfers to the E360 Design/Build team to coordinate with Sound Transit's Systems Engineering consultant as they complete the civil design.

In contrast, Sound Transit’s other Design/Build contract, South 200\textsuperscript{th} (S440), has the systems elements included in the Design/Build aerial guideway and station contract due to the limited size of the 1.6 miles LRT extension. With the regular Systems Integration meetings and the resulting improved communications, the South 200\textsuperscript{th} extension has used only half as many ICD per mile as Sound Transit's previous North Link project.
For East Link, the H-J-H Final Design Team has made good use of the existing ICD database to capitalize on the existing Lessons Learned and to hold regular Systems Integration meetings to improve communication, thus reducing the number of the ICDs per mile on their design segment to half of that of the South Link extension. Much of this can be attributed to the higher level of experience of agency staff with implementing Sound Transit’s ICIP and the experienced design and systems integration team on the consultant side. The H-J-H lead for Design Integration, Hugh MacGillivray with Hatch Mott MacDonald, is leading the AREMA Committee 12 Rail Transit effort to draft the C-4-04: Systems integration issues for rail transit section. Systems integration is useful and valuable for all complex multidisciplinary projects such as Light Rail Transit.

HONOLULU AREA RAPID TRANSIT (HART) INTERFACE CONTROL PROCESS

The HART Interface Control Manual (ICM) (2) is intended to assist the Honolulu High Capacity Transit Corridor Project (HHCTCP) Contractors, and the City and County of Honolulu (City) in maintaining the visibility and control of construction contract configuration. Its intent is to document and identify as much detail as possible at the time of contract proposals. As the Project advances through design and construction, all final designers, design-build contractors, and contractors are responsible to identify interface points and requirements, develop an Interface Control Manual for their Work, and support the City in maintaining the Project Interface Control Manual (PICM). Figure 11 depicts HART’s anticipated flow of interface data among contractors for tracking the resolution process for each identified interface including manual updates and the preparation of interface control documents.

Figure 11. HART Project Interface Control Manual Information Flow Chart
As the contracting approach for the various contracts was defined early in the project, the HHCTCP Interface Control Manual delineates the various systems-fixed facility (civil), systems-systems, fixed facility (civil) – fixed facility (civil) interfaces and also third party interfaces (utilities, etc.). The focus is on both interface and configuration control for the Core Systems Contractor (Systems and Vehicles) and the Fixed Facility Contractors (Guideway, Stations and Maintenance Facility).

**HDR IMPLEMENTATION FOR HRTP FARRINGTON HIGHWAY STATION GROUP**

For the final design of the three elevated stations along Farrington Highway, HDR Engineering developed a Passenger Station Interface Control Manual (PSICM) (7) that provided the tools that the Farrington Highway Station Group (FHSG) used to systematically identify and document design interfaces and illustrated how the PSICM was used as a management tool for the resolution of design interfaces. The PSICM was used to:

- Establish the policies and procedures by which the design interfaces were identified, assigned, monitored, resolved and documented.
- Facilitate collaborative resolution of design interfaces through Biweekly meetings
- Provide documentation for any configuration changes.

The Interface Management process focused on identifying interfaces, creating Requests for Interface Data (RFID) for which the resolution of is documented in the Interface Control Document (ICD). HART tracks the status of the completion of the RFID through a Contract Management System (CMS) module and documents the resolution of the RFID or group of RFIDs in an ICD for the project files.

One tool that the HDR design team used to identify and verify coordination had occurred by the various design interfaces was a Design Interface Control Matrix, similar to the one shown in Figure 9.

**CONCLUSION**

Interface control and integration is and has been a hot topic in all facets of large design projects, transit is no exception. Transit projects generally introduce a new set of requirements that are not typically found within large commercial type projects including the requirements to integrate with existing infrastructure, equipment and control systems.

Sound Transit has found success through the use of a formalized integration process that is clearly referenced within the design contracts. As a result, the expectations of the Agency are much more closely coupled with the cost and schedule estimates provided by the design teams. Allowing the consultant teams to tailor the requirements also allows for the right fit for the project without becoming overly burdensome and decreasing the cost effectiveness of the efforts. The predominant principal of the process is to provide tools and process for the exchange of information and communication between engineering
disciplines and the Agency. A quick search for the word ‘communication’ finds twelve occurrences in the ICIP and in this report.

From the consultants’ viewpoint, as familiarity with the Interface control and integration process spreads the number of formal interface data request is reduced by resolving issues in the weekly focus meetings and bi-weekly systems integration meetings. The H-J-H PIIP and the Point-to-Point Responsibility Diagrams have been useful design tools on the East Link project. Contracting method must also be considered when implementing an interface/integration plan as is the case when a contract is design build that may or may not have the Systems work under the same contract.

On the HART project, as the contracting approach for the various contracts was defined early in the project, the Interface Control Manual delineates the various interfaces rather than identifying the interface tools as recommended by Sound Transit in their ICIP. The clarity of HART’s contract interfaces and operations & maintenance interfaces early in the design process was a helpful element.

As the benefits of a Systems Integration or Design Interface approach become more widely known in the Rail Transit Industry, the pros and cons of how and when to use these tools in the various design and construction contracts becomes more apparent. Supporting the integration process, Sound Transit has been increasing the use of clash detection on the 3-D models for the stations in each stage of the design process. To document the design decisions or respond to design questions, Sound Transit uses a centralized ICD Database. Similarly, in Honolulu, HART utilizes an Interface Management approach with the progress on each design decision or direction tracked through a contract management system database.

In summary, Interface Management/Design or Systems Integration may use different tools or have different roles depending on the type of the rail transit construction contract.

F. Acknowledgements

Kevin Collins, PE, HNTB (formerly with HDR Engineering, Inc. as the Interface Manager on the 2011 Final Design contract for HART’s Farrington Highway Stations Group) for Consultant experience with HART Interface Control Process

G. References

1. Sound Transit Link Light Rail Interface Coordination and Integration Plan (ICIP), Rev 0, October 2009


3. Honolulu Rail Transit Project’s Project Management Plan, Rev. 5.0, July 2012


H. Figures

Figure 1. Sound Transit Link LRT Expansion Plan - Funded Segments

Figure 2. Honolulu Rail Transit Project (HRTP) Map

Figure 3. Sound Transit ICIP Process Submittal Schedule - Example

Figure 4. Sound Transit’s East Link LRT Project Map

Figure 5. E330 Downtown Bellevue Tunnel Point-to-Point Responsibility Diagram

Figure 6. East Link’s 120th Ave Station Interface Block Diagram

Figure 7. E340 Bel-Red contract’s 130th Station Clash Detection at mid-90% design. Clash shown between the white Communications Systems conduits and blue Electrical handholes.

Figure 8. Open Interface Control Documents (ICDs) for Sound Transit’s E330 Contract Final Design (Database screenshot).

Figure 9. E330 Systems Design Integration Control Matrix (DICM) at 90% design.

Figure 10. E330 South Cut and Cover General Arrangement Drawing with items called out by contract.

Figure 11. HART Project Interface Control Manual Information Flow Chart
System Integration on a Light Rail Project: A Tale of Two Agencies

Evaluation of Seattle’s Sound Transit and Honolulu’s HART Integration Programs

By Jennifer Ryan, PE  Hatch Mott MacDonald
Craig DeLalla, PE  Sound Transit
Overview

• What is System Integration and/or Design Interface Control
• How two agencies, Sound Transit and HART, utilize integration/interface control with different contracting approaches
• How the various consultants design teams approach integration/interface control on the agencies LRT projects

Interface Coordination and Integration is:

• Identification of all individual civil and systems elements and their relationship to specific facilities and/or components related to the project
• Establishment of systems interfaces with all engineering disciplines
• Establishment of structured document control process to monitor and expedite the review and resolution process (ICDs)

Sound Transit

Initial Central Link LRT: 15.6 miles to Airport opened 2009

Proposed Link Extensions
– University: 3.1 miles opening 2016
– South 200th: 1.6 miles opening 2016
– North: 4.3 miles opening 2021
– Lynnwood: 8.5 miles opening 2023
– East: 14 miles opening 2023

Sound Transit’s ICIP

Link Light Rail Interface Coordination and Integration Plan (ICIP)
• Created in 2009
• Supports flexible contracting methods used and proposed (Design-Bid-Build, Design/Build, GCCM, etc.)
• Formal process referenced by ST’s Design Contracts
– Establishes Roles and Responsibilities
– Supported by Agency staff
– Uses ICD process

Goal is frequent design communications between disciplines

Sound Transit’s ICIP, cont.

Uses Interface Control Document (ICD)
• Provide technical interface details and status
• Tracked in the Systems Integration Database
  – Identify interfaces
  – Direct communications between design disciplines
  – Coordination assistance by Agency Systems Integration Team
  – Track issues from identification through closure

Sound Transit’s ICIP, cont.
H-J-H East Link PIIP

Project Integration Implementation Plan (PIIP)
For H-J-H East Link LRT Design (Bellevue to Redmond)

- JV of HNTB-Jacobs-Hatch Mott MacDonald
- Multiple design methods (D-B-B, Design/Build, GCCM)
- 7 miles of elevated, at-grade, depressed and tunnel LRT guideway
- 5 Civil Contract Packages
H-J-H East Link PIIP, cont.
Traditional Design-Bid-Build (D-B-B) and GCCM
– Items required by ICIP
– Limited use of ICDs
– Focus on resolving DICM and SI EQ issues
– Bi-weekly meeting between H-J-H and LTK

Design-Build (D/B)
– Limit on items required by ICIP due to limited design effort
– Greater use of ICD’s to document decisions for D/B
– H-J-H and Systems Designer focus on Project Requirements rather than drawings, DICM or SI EQ
– Project Requirements invoke the ICIP for the D/B team

Honolulu Authority for Rapid Transportation (HART)
Initial line is 20 mile Automated Aerial LRT Guideway using third rail
Phase I opening 2017 to Aloha Stadium
Phase II opening 2019 to Ala Moana Center

HART's Interface Control Manual (ICM)
Focuses on technical project interfaces and configuration control of:
– Contract-level ICMs
– Relationship to concurrent and adjacent contracts, third party constraints (AHJ)
• Contract ICMs support HART’s Project ICM (PICM)

HART's Interface Control Manual, cont.
Implementation requires:
– Preparation of Contract ICM
– Configuration control
– Documentation of interfaces
– Interface Control Doc. (ICD) triggered by Requests for Info. Doc. (RFID)

HART's Interface Control Manual, cont.
ICD Process
• Starts with Request for Information documents (RFID)
• RFID routed to applicable interfacing contracts, AHJs
• Resolution summarized in ICD
• RFID status tracked in HART’s CMS database, but not the ICDs themselves
HDR’s Passenger Station Interface Control Manual (PSICM)
Final Design Consultant prepares PSICM for elevated station designs (HDR for 3 stations along Farrington Hwy)

- Establishes policies and procedures for design interfaces
  - Identification
  - Assignment
  - Monitoring
  - Resolution
  - Documentation

Farrington Hwy Station Group FD Interfaces:
- Adj. Contracts
  - W. Oahu/Farrington Hwy Guideway D/B Contractor
  - Core Systems DBOM Contractor
  - Transit Arts Program Artist
- Third Party
  - Hawaii DOT
  - Univ. of Hawaii, Leeward Community College
- HART/GEC

Conclusions
- Results of Systems Integration / Interface Control
  - Better design interface between contracts & disciplines
  - Database of Lessons Learned
- Translation to LRT from Aerospace/Military requires logic-based sequential approach
- Number of ICDs decreases as communication processes improve
- Integration tools may vary based on contracting methods

Presenters
System Integration on Light Rail Project: A Tale of Two Agencies
By

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H-J-H East Link PIIP, cont.
PIIP responds to ST’s ICIP by:
- Interface Matrix
- Point-to-Point Responsibility Diagram
- Equipment Circulation Drawings
- Interface Block Diagrams
- Composite Drawings/Clash Detection
- Equipment Matrix
- Interface Coordination and Systems Integration Checklists
- Interface Control Documents (ICDs)
- Bi-weekly meetings for H-J-H and LTK (Systems Designer)

H-J-H East Link PIIP, cont.
H-J-H Team builds on prior ST and HART experience
- Systems Design Integration Control Matrix (DICM)
- Systems Equipment Integration Matrix (SI EQ)
- General Arrangement Drawings for spaceproofing of all disciplines