Multi-Modal Modelling: BIM Template for Hub Connectivity and Networks

Danelle Briscoe
Associate Professor

November 2019

A publication of the USDOT Tier 1 Center:
Cooperative Mobility for Competitive Megaregions
At The University of Texas at Austin
DISCLAIMER: The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the information presented herein. This document is disseminated in the interest of information exchange. The report is funded, partially or entirely, by a grant from the U.S. Department of Transportation’s University Transportation Centers Program. However, the U.S. Government assumes no liability for the contents or use thereof.
# Technical Report Documentation Page

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4. Title and Subtitle</td>
<td>5. Report Date</td>
</tr>
<tr>
<td></td>
<td>Multi-Modal Modelling: BIM Template for Hub</td>
<td>November 2019</td>
</tr>
<tr>
<td></td>
<td>Connectivity and Networks</td>
<td>6. Performing Organization Code</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Author(s)</td>
<td>8. Performing Organization Report No. CM2-19,CM2-40</td>
<td></td>
</tr>
<tr>
<td>Danelle Briscoe</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Performing Organization Name and Address</td>
<td></td>
</tr>
<tr>
<td>The University of Texas at Austin</td>
<td>School of Architecture</td>
<td></td>
</tr>
<tr>
<td>310 Inner Campus Drive, B7500</td>
<td>Austin, TX 78712</td>
<td></td>
</tr>
<tr>
<td>Center for Cooperative Mobility for Competitive Megaregions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The University of Texas at Austin</td>
<td>310 Inner Campus Drive, Goldsmith Hall, 2.308</td>
<td></td>
</tr>
<tr>
<td>Austin, TX 78712</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. Work Unit No. (TRAIS)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11. Contract or Grant No. USDOT 69A3551747135</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12. Sponsoring Agency Name and Address</td>
<td></td>
</tr>
<tr>
<td>U.S. Department of Transportation</td>
<td>Federal Transit Administration</td>
<td></td>
</tr>
<tr>
<td>Office of the Assistant Secretary for Research and Technology, UTC Program</td>
<td>12. Type of Report and Period Covered</td>
<td>Technical Report conducted 9/2017 - 11/2019</td>
</tr>
<tr>
<td>1200 New Jersey Avenue, SE Washington, DC 20590</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Abstract</td>
<td>15. Supplementary Notes</td>
<td></td>
</tr>
<tr>
<td>A multimodal, transportation-oriented approach to a Building Information Model (BIM) template advances the application of this technology to a new typology. Furthermore, the directive of the template explores equity diverse populations and communities through the development of user based BIM component assemblies ranging from air travel 3D model objects to high-speed rail hub components to slow-moving transportation circulation studies. Dissemination journal publication, studio book publication proposal and conference presentation would then sustain these metrics and methodology for future transportation development beyond the proposed research period. This proposal aims to deliver impactful output and technological transfer for the development of specialized research into the application of BIM technology for megaregion mobility.</td>
<td>Project performed under a grant from the U.S. Department of Transportation’s University Transportation Center’s Program.</td>
<td></td>
</tr>
<tr>
<td>17. Key Words</td>
<td>18. Distribution Statement No restrictions.</td>
<td></td>
</tr>
<tr>
<td>Building Information Modeling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21. No. of pages 30</td>
<td>22. Price</td>
<td></td>
</tr>
</tbody>
</table>

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized
Acknowledgements

Graduate Research Assistants: The research development is greatly in debt to the performance and diligence of all Graduate Research: Claude Terral (2017-18), Sarah Rousey (Fall 2018), Chetan Kulkarni (Spring 2019). I would also like to thank Inessa Ach for her help as the UTC Assistant Director with organizing and delivering the research.
# Table of Contents

Chapter 1. Introduction: Building Information Modeling .......................................................... 1
  1.1. Relevance and Contribution to CM2 Mission/Themes ....................................................... 2

Chapter 2. Research Methods .................................................................................................. 3
  2.1. Case Studies: Significant Multimodal Transportation Hub .............................................. 2
    2.1.1. National .......................................................................................................................... 3
    2.1.2. International ................................................................................................................ 5
  2.2. BIM Object Library .......................................................................................................... 9
    2.2.1. User Based Scenarios (UBS 1-3) ................................................................................ 9
    2.2.2. Work Objects .............................................................................................................. 13
  2.3. Template Development ................................................................................................... 19
    2.3.1. Re-Categorization ...................................................................................................... 15
  2.4. Assemblies ...................................................................................................................... 17
    2.4.1. Airport ...................................................................................................................... 21
    2.4.2. Freight hub containerization ................................................................................... 21
    2.4.3. Port terminal for passengers ................................................................................... 22
    2.4.4. Autonomous vehicles (no private vehicles) ............................................................ 23

Chapter 3. Industry Collaboration: PAGE ............................................................................. 24

Chapter 4. UTSOA Advanced Studio ..................................................................................... 24

Chapter 5. Conclusion and Recommendations .................................................................... 26

Appendix A: Additional Matters .......................................................................................... 27

References ............................................................................................................................ 28
Chapter 1. Introduction: Building Information Modelling (BIM)

A Building Information Model platform supports the ability to coordinate, update, and share design data collaboratively throughout the design construction and management phases of a building’s life. A key component in managing the BIM process is to establish a foundation for different types of projects by creating standard templates and custom 3D modelled elements. Having this in place makes the process of new (or renovated) project potentially smoother and with guided efficiency. For USDOT or private service providers involved in multi-modal services, BIM technology in general and a loaded template for multi-modal integration would advance and organize this effort.

Proprietary BIM software contains standard templates specific to an Architecture, Structural or Construction stakeholders. BIM content libraries exist with examples specific to certain typologies, like education or small scale residential, but are not however transportation specific, much less focused on multi-modal integration in transit hubs. Furthermore, the National BIM Standard-United States® (NBIMS-USTM) provides consensus based standards through referencing existing standards, documenting information exchanges and delivering best business practices for the entire built environment. From both forms of open BIM standards, a template for transportation hubs can expand upon the detailed models that exist, create new custom ones and give stakeholders accurate BIM models to optimize this network. This template could then be used at all stages of project development to ensure functionality throughout the life of the facility and to deliver high performance (and potentially net zero energy) based 3D modelled objects. In summation, a content library exists, but needs to be filtered and edited for transportation multi-modal hub design and more importantly supplemented.

Projects, especially broad network-based ones like a transportation hub, need standards and consistent object files. Although many standards and templates exist, there is no one reliable source. These standards cannot just be explicit and written standards, but also in drawing (template format) for common use and distribution. Standards will begin to be established by the content in

---

the template. Workflow redundancy of gathering basic 3D models can be alleviated for a new project. Without such basic template guidelines, project information can become difficult to interpret and responsibilities begin to blur. Important sustainability measures can also be forgotten.

Lastly, this proposal extends research with innovative design methodologies using Building Information Modelling (BIM) through the development, evaluation and definition of multi-modal networks which currently does not exist. This occurred through library development, collaboration with a national architecture firm and with students in an Advanced Design Studio. The research opens up the potential to use BIM in novel ways and to capture not only quantification of parts placed in the transportation User Based context but give rise to theoretical positioning of the software platform for the industry and academic realm.

1.1. Relevance and Contribution to CM2 Mission/Themes

CM2 has outlined six research themes that highlight the goals of the UTC. The research demonstrates the promotion of a Megaregional approach to equity. More specifically, the research contributes to the optimization of inter-modality through research on the applications of Building Information Modeling (BIM). In general, the project and its dissemination aims to improve multi-modal integration in transit hub network diagrams and design. Dissemination has occurred through conference presentation and publication. Collaboration and or discussion with industry has also occurred both formally and informally.
Chapter 2. Research Methods

2.1. Case Studies: Significant Multimodal Transportation Hub

The research modelled ten significant multi-modal transportation projects (and their surrounding urban context) in both the national and international cities. This procedure amplified the template collection of major 3D objects, like the network of rail lines, at a schematic understanding. The basic models further the CM2 agenda to promote BIM technology through diagram and design. Comparable items are: Location, Size, and Passenger footfall, Type, Modes served. This study is an attempt to provide a better definition of the BIM comparisons in public transport and to develop a framework for measuring perception of accessibility and equity, one of the most important determinants of public transport convenience. Developing these models also confirmed the basic object library necessary to define a multi-modal hub in terms of its Indicators of Multimodal Transport as Parameters for BIM Families: Sustainability and Equity, Accessibility, Convergence, Integration.

2.1.1. National

1. 30th St Station, Philadelphia, PA
   
   9 island platforms (3 upper level, 6 lower level)
   Tracks 15 (6 upper level, 9 lower level)
   Connections
   Market–Frankford Line at 30th Street
   Subway–surface trolley lines at 30th Street
   City Bus SEPTA City Bus: 9, 12, 21, 30, 31, 42, 44, 62, LUCY
   Suburban Bus SEPTA Suburban Bus: 124, 125
   JFK Boulevard & 30th Street
   NJT Bus NJT Bus: 316, 414, 417, 555
   Intercity Bus Megabus: M21, M23, M29, M30, M31, M32, M34
   Intercity Bus BoltBus
   Intercity bus Martz Trailways
   Passengers (FY 2017) 4,411,662

2. Union Station, Washington D.C.

Platforms 18
Tracks 22
Connections Washington Metro
WMATA Red.svg at Union Station
Tram interchange DC Streetcar
Bike transport Metropolitan Branch Trail
Passengers (2017) 5,225,460 annually
3. Denver Union Station

Platforms  2 side platforms, 3 island platforms (commuter rail and Amtrak)
1 side platform, 1 island platform (light rail)
Tracks   8 (commuter rail and Amtrak)/ 3 (light rail)
Bus stands  22
Passengers (2017)   154,706

![Figure 2.1.3. Denver Union Station](image)

2.1.2. International

4. Vancouver, BC

Passengers (2017[1])   37,500
Platforms   3 separate sets of center platforms
Tracks   6
Connections  Translinkbus.svg 95 B-Line
Translink–Expo Line, Canada Line, SeaBus, West Coast Express

![Figure 2.1.4 Waterfront Station, Vancouver](image)
5. King’s Cross, London, UK

2017–18  33.905 million
Platforms  12
Hull High Speed Trains, Inter-city railways, Suburban, Semi-fast trains
Lists of stations
DLR Underground National Rail Tram link

Figure 2.1.5. King’s Cross Station

6. Alexanderplatz, Berlin, GE

Lines– S-Bahn U-Bahn Tram
Regional-Express services RE
Local services RegionalBahn 14
S-Bahn services over ground S3, S5, S7, and S9
U-Bahn services underground U 2, U 5 and U9
The station is also served by four tram lines, two of which run continuously, as well as five bus lines during the day, one of which runs continuously and three night bus lines.

Figure 2.1.6. Alexanderplatz Station
7. Amsterdam, NE

Platforms 11
Tracks 15 total
Passengers 162,000 passenger daily (2013–2014 statistics)
Connections Mainline rail interchange GVB Amsterdam Metro
Mainline rail interchange GVB Amsterdam Tram
Ferry GVB Amsterdam
Bus transport Connexxion, Bus transport EBS, Bus transport GVB

8. Florence, IT

Distance 314.077 kilometres (195.158 mi) from Roma Termini
Platforms 19
Line(s): Bologna–Florence (high speed), Bologna–Florence (traditional), Florence–Rome (high speed), Florence–Rome (traditional)
9. Gare du Nord, Paris, FR
   Platforms 36 (two not in service)
   Passengers 214 million
   High Speed Rail, Inter-city, Regional Rail, Commuter Rail, Subway Metro

10. St. Lazare, Paris, FR
    Line(s) Paris–Le Havre railway
    Platforms 27
    Passengers 100 million
    Inter-city, Suburban
2.2. BIM Object Library

Development of (what the research notes as) “User Based Scenarios” (UBS) also helps predict relevant circumstances of multi-modal transit integration, for example analyzing the experience of a suburban commuter to an urban workplace. The user based BIM component assemblies range from air travel 3D model objects to high-speed rail hub components to slow-moving transportation circulation studies. The components facilitate modeled experiences and potential predicaments to develop further a multitude of necessary 3D BIM components for multimodal transport system, 4D assemblies necessary for transfer nodes, 5D cost implications, 6D robust multi-modal time factor elements, and 7D operational control of line-bound public transport services. These UBS are understood graphically, like reading a map of experienced networks. Through the development of a BIM 3D database template, this study becomes a critical reference to USDOT or private service providers in their future efforts to multi-modal services, ultimately effecting informed policy-making. A multi-modal approach to the template includes diverse populations and communities. The BIM template would also include the facilitation of public-private partnerships for freight mobility planning and operation efficiency, along with advanced thinking of the future of self-driving transportation networks. By cataloguing such information model specificity, the future city can benefit from a knowledge base of advanced and alternative transportation design elements, which promote safety, diversity, and environmental efficiency.

2.2.1. User Based Scenarios (UBS 1-3)

The UBS list below describe the context with which each one distinguishes itself, followed by the mode with which a user would use to get from one destination to the other, the infrastructure necessary to support that mode, along with nodes that would be necessary to have as a BIM object. The names of the BIM family objects are then listed to follow.

UBS-1: Satellite Home to Perimeter Core Workplace

1. Home \(\rightarrow\) Park and Ride
   a. Mode: Personal Auto
   b. Transit Infrastructures: Surface Roads, Highway, Parking Lot
   c. Intermediate Nodes: Gas Station/Charging Station
   d. Families: Automobile, Road Stripes, Parking Stripes, Gas Pump, Car Charging Station, Ticket Machine, Road Signs, Park and Ride Signs, Traffic Signals,
Station Signage, Station Canopy, Curb, Curb Cut, Tactile Paving, Furniture, Planting, Lighting

2. Park and Ride → Central Transit Hub
   a. Mode: Light Rail
   b. Transit Infrastructures: Light Rail Track
   c. Intermediate Nodes: Rail Stations
   d. Families: Light Rail Train, Light Rail Track, Crossing Signage, Switch Signage

3. Central Transit Hub → Central Bus Stop
   a. Mode: Pedestrian
   b. Transit Infrastructures: Walkway, Sidewalk, Escalator, Elevator
   c. Intermediate Nodes: Bank/ATM, Restroom
   d. Families: Station Signage, Restroom Signage, Plumbing Fixtures, Lighting, Emergency Signage, Stairs, Escalator, Elevator, Doors, Curb, Curb Cut, Tactile Paving, PV Applications, Station Canopy, ATM, Furniture, Planting

4. Central Bus Stop → Perimeter Core Bus Stop
   a. Mode: Public Bus
   b. Transit Infrastructures: Road, Bus Lane
   c. Intermediate Nodes: Bus Stops
   d. Families: Bus, Road Striping, Bus Lane Striping, Bus Stop Shelter, Bus Stop Signage, Furniture

5. Perimeter Core Bus Stop → Perimeter Core Workplace
   a. Mode: Pedestrian
   b. Transit Infrastructures: Sidewalk, Crosswalk
   c. Intermediate Nodes: None
   d. Families: Curb, Crosswalk Striping, Traffic Signals, Planting, Lighting

Figure 2.3.1. Diagram: Park and Ride – Central Transit Hub – Bus Stop (detail view)
UBS-2: Perimeter Core Workplace to Airport

1. Work → Subway Station
   a. Mode: Bicycle
   b. Transit Infrastructure: Roads, Bike Lanes, Bike Storage Tower
   c. Intermediate Nodes: Bicycle Maintenance Station
   d. Families: Bike Storage Tower, Road Stripes, Bike Lane Stripes, Traffic Signals,
      Bicycle Signage, Bicycle Maintenance Station, Bike Pumps, Air Compressor
      Station, Bike Rack, Planting, Lighting

2. Subway Station → Airport Monorail Station
   a. Mode: Subway Train
   b. Transit Infrastructures: Subway Third Rail
   c. Intermediate Nodes: Market/Restaurant/Café
   d. Families: Ticket Machine, Security Station, Security Turnstile, Station Signage,
      Lighting, Emergency Signage, Stairs, Escalator, Elevator, Tactile Paving, Food
      Service Appliances, Electronic Payment Systems, Furniture, Planting

3. Airport Monorail Station → Airport Terminal
   a. Mode: Monorail
   b. Transit Infrastructures: Monorail Track
   c. Intermediate Nodes: Security Station
   d. Families: Security Station, Security Turnstile, Monorail Doors, Monorail Signage,
      Tactile Paving, Lighting

*Figure 2.3.2. Diagram: Bicycle Hub – Subway Station – Airport Monorail Station*
1. Airport → Ferry Port
   a. Mode: Autonomous Ride Share Automobile
   b. Transit Infrastructure: Ride Share Stand, Roads
   c. Intermediate Nodes: Phone Charging Station
   d. Families: Road Stripes, Ride Share Stand, Phone Charging Station, Airport Signage, Bollards, Traffic Signals, Planting, Lighting

2. Ferry Port → Gondola Platform
   a. Mode: Autonomous Marine Vessel
   b. Transit Infrastructures: Dock, Water
   c. Intermediate Nodes: Ticket Machine

3. Gondola Platform → Dining with a view
   a. Mode: Gondola
   b. Transit Infrastructures: Gondola Cable
   c. Intermediate Nodes: None
   d. Families: Gondola Cable, Gondola Car, Gondola Platform, Sidewalk, Planting, Lighting

*Figure 2.3.3. Diagram of Ferry Port – Gondola Platform*
2.2.2. Work Objects

The “User Based Scenarios” (UBS) facilitate further development of a multitude of 3D BIM components for multimodal transport integration (4). This design methodology proposes a data structure based on a focus and context approach (5) in which information is mapped from diverse demographics in order to imagine the multi-modal transportation transfers they would potentially encounter. Particular necessary objects in these design scenarios would become content for the template. To further advance this BIM modelling technique, 4D time based assemblies necessary for transfer nodes could start to include 5D cost implications and 6D schedule design of robust multi-modal time-tables. Laying down metro rail tracks or other BIM object models becomes a scheduled endeavor, whereby every part and piece can be accounted for early on the schematic phases of design. One specific model could serve as the pilot for what a 7D (operational control) could mean for a line-bound public transport service.

As proof of concept, the direction of custom components for use in multi-modal transportation networks took on the idea of “work” as directed by the theme of the current issue of Journal of Architectural Education, Volume 73, Issue 2. Novel examples were explored to work through the 3D-7D research proposal (described above), specifically (for this report explanation) the Freeway Wind Turbines⁴-- a prototype/ invention by Capture Mobility. The turbine proposal has been recognized by Shell and awarded by the United Nations. The turbine stands two-and-a-half meters tall, weighs just nine kilograms and is made of recyclable carbon fiber. The fully-charged battery can hold a kilowatt of electricity, enough to run two lamps and a fan for around 40 hours. The idea is that this could be a source of electricity for rural communities in developing countries, or could power traffic lights or road signs in urban areas. Such projects would be able to reduce the Carbon particles from the environment 450 grams per year per turbine by our integrated filtering sheets. Working with a BIM model, such items such as the cost of each turbine (around $200) demonstrates the work able to be produced to be around 300 Watt. This would be 90% efficient and much more competitive than the typical solar or wind products.⁵

⁴ https://www.shell.com/inside-energy/turbine-turns-traffic-into-energy.html
http://www.bestclimatepractices.org/practices/capture-mobility/
https://www.facebook.com/CaptureMobility/videos/1174143536021440/.
⁵ https://weather.com/science/video/highway-traffic-powers-wind-turbine
http://devecitech.com/
Proprietary BIM software contains standard templates specific to an Architecture, Structural or Construction stakeholders. BIM content libraries exist with examples specific to certain typologies, like education or small scale residential, but are not however transportation specific, much less focused on multi-modal integration in transit hubs (2). Furthermore, the National BIM Standard-United States® (NBIMS-US™) provides consensus based standards through referencing existing standards, documenting information exchanges and delivering best business practices for the entire built environment. From both forms of open BIM standards, a template for transportation hubs can expand upon the detailed models that exist, create new custom ones and give stakeholders accurate BIM models to optimize this network. This template could then be used at all stages of project development to ensure functionality throughout the life of the facility and to deliver high performance (and potentially net zero energy) based 3D modelled

objects. In summation, a content library exists, but further filtering and editing for transportation multi-modal hub design proves necessary.

In the fall of 2018, the BIM template development focused on the graphic capability and modifications that could improve the User Based Scenarios with so many objects. A workflow was tested with rendering through Enscape and also a method for transferring BIM object insertion to these urban scenes of transportation complexity.

![Image](image.png)

*Figure 2.4.1. Template development through graphic consideration and translation*

### 2.3.1. Re-Categorization

In 2019, the research began by re-categorizing the objects in the BIM template. The general headings of this re-categorization—being Vehicles, Transit Infrastructure, and Other (Landscape and Entourage)—give broader structure to the template allocation. Finding existing BIM family categories within a default template were stated as necessary by Autodesk consultants as the research has come to find that these headings for families cannot change. Families were equally pulled from existing online libraries and well as custom generated as generic models.
<table>
<thead>
<tr>
<th>Vehicles</th>
<th>Land</th>
<th>Water</th>
<th>Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car (Fuel/Electric)</td>
<td>Kayak</td>
<td></td>
<td>Airplane</td>
</tr>
<tr>
<td>Public utilities (Ambulance/Fire truck)</td>
<td>Passenger vessels/Ferry</td>
<td></td>
<td>Helicopter/Jet</td>
</tr>
<tr>
<td>Taxi/Van</td>
<td>High-speed boat</td>
<td></td>
<td>Cableways</td>
</tr>
<tr>
<td>Delivery bot (AV)</td>
<td>Bulk carriers</td>
<td></td>
<td>Unmanned Air Taxi/Hovercraft/Zeppelin</td>
</tr>
<tr>
<td>Bus</td>
<td>General Cargo</td>
<td></td>
<td>Shuttle</td>
</tr>
<tr>
<td>Trucks (Freight)</td>
<td>RO-RO Ships (roll-on roll-off)</td>
<td></td>
<td>Hot-air balloon</td>
</tr>
<tr>
<td>Motorcycle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bicycle (Docked/-less)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tram (sloped)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Railway (passenger)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High-speed Rail, Bullet train TGV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freight trains/Rail tankers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metro/Subway</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transit infrastructure</th>
<th>facilities Construction</th>
<th>Operations and handling</th>
<th>Maintenance and security</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporary equipment</td>
<td>Bike racks</td>
<td>Handicapped access lifts</td>
<td></td>
</tr>
<tr>
<td>Modular cubicles</td>
<td>Containerization equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scaffolding</td>
<td>Conveyor belt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trusses and frames</td>
<td>Logistics /cargo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety netted surface on edges</td>
<td>Ticketing and document processing</td>
<td>Fire truck</td>
<td></td>
</tr>
<tr>
<td>Construction site cabins</td>
<td>Shade Sail Canopy roofs</td>
<td>Street cleaning truck</td>
<td></td>
</tr>
<tr>
<td>Escalators</td>
<td>Turnstiles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parking space lifts</td>
<td>Charging pods</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parking space ADA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KITO</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crosswalk pattern</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utility supply pipelines</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lavatories</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cubbies</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.4. Assemblies

The notion of Assemblies redefines the original User-based Scenarios (UBS) premise from the 2017-2018 grant period. The four spatial scenarios explored conditions for multi-modal transit hub. These scenarios demonstrate the complex networks for transfer and relay of goods and people between points of source and destination. General graphic work to explain the position of context of UBS and Assemblies was done for dissemination.
Figure 2.4.3. Graphic explanation and diagram of accessibility strategy

Figure 2.4.4. Graphic explanation and diagram of accessibility strategy
Figure 2.4.5. Graphic explanation and diagram of accessibility strategy

Figure 2.4.6. Graphic explanation and diagram of User Based Scenario
Figure 2.4.7. Graphic explanation and diagram of User Based Scenario

Figure 2.4.8. Graphic explanation and diagram of User Based Scenario
2.4.1. Airport

The Airport Assembly is depicted with a Centralized terminal with finger piers. An Optimal terminal size is established through precedent case study. The Assembly prioritizes an Express commute to intermediate transfers (domestic-international) with an additional airport express train and rail link to city core. Passenger transport terminal (in urban core dense areas) are the primary means of Public Transit, which include modes, such as: Bus, Light rail/Tram, Subway/Metro/Elevated rail/Commuter rail (Inter-city or Suburb-City). Some alternatives might be: Gap-filler micro-transit (e.g. E-Tuks in Kansas and Seattle), Docked bikes, Private companies such as LYFT. The Assembly also recognizes the need for Taxi, Bus, and Automobiles.

![Figure 2.4.9. Graphic explanation and diagram of Assembly 1](image)

2.4.2. Freight hub containerization

A Port terminal for ships (Hub-and-spoke operations along coasts) is a critical Assembly for understanding the BIM logistics of freight and distribution. Transfer to railway or truck its own layout for Logistics facility operations. Freight rail terminal to road highways (port-hinterland connectivity) must also be considered. BIM quantification and scheduling could be especially useful here.
2.4.3. Port terminal for passengers

A High speed rail network reference graphically\(^6\) assists the production of this assembly. The assembly also takes broad strokes to include the BIMs of Inland waterways transport (see US inland waterways map), Tubing for inter-city transport (Hyperloop) and Tunneling for inter-city transport (The Boring Company).

\(^6\) http://www.ushsr.com/ushsrmap.html
2.4.4. Autonomous vehicles (no private vehicles)

Autonomous marine transport (freight) mixes with unmanned air-taxis as a statement on the implications for land use due to roof-to-roof, or intermediate pickup. Drop-off scenarios are considered and modeled, as well as development air rights. As delivery drones will increasingly be present as a means of freight transportation, the BIM Assembly acts as an agent of exchange and modeled delivery proposal.

*Figure 2.4.10. Graphic explanation and diagram of Assembly 4*
Chapter 3. Industry Collaboration: PAGE

Through my research with the CM2 grant, I have an opportunity to further research on the Austin State Hospital traffic planning. I have met only once with Ryan Losch of Page Architects and have begun looking through their drawing files. I would be applying one of my User Based Scenario BIM templates (which I showed in the lunchtime presentation) to this project. I feel this would be very beneficial for testing how it applies to a real world project that is essentially master planning a traffic proposal here in central Austin. CM2 Directors have stated this is not in conflict with CM2 to work with industry in such a way. This aspect of the research gave us insight as to how practice might find the template and approach useful. Several studies were done to accompany the UBS drawing file to demonstrate how a traffic APP, such as WAZE, would be sending traffic through the ASH campus. The BIM multi-modal study encouraged transportation currently under-utilized in this area of Austin.

Figure 3.1. User Based Scenario developed for the corner of Guadalupe and 43rd Street, Austin
Chapter 4. UTSOA Advanced Studio Offering

This studio agenda works in conjunction with ongoing research afforded by the USDOT University Transportation Center and Center of Cooperative Mobility for Competitive Megaregions (CM2). Undergraduate and graduate students were prompted to design a 30,000 sf multi-modal transportation hub, an established building typology that is a ripe candidate for redefinition and reinvention. The studio allowed students to complete the conceptual development of a building with consideration of structural, mechanical, electrical, and site integration needs while simultaneously designing an exemplary work of architecture. As a proposed process, the re-scripting of Building Information Modelling allowed students to have a more focused integration of the user base and the discrete object scale within the urban and infrastructural context. The intention was to then understand the whole of the network, devoid of its formal “architecture.” The studio site was located at the designated Houston-to-North Texas High-Speed Railroad Corridor station in the urban context of downtown Dallas.

Lastly, Texas Central named global railway company Renfe as its high-speed train operating partner. Renfe is one of the world’s most significant railways operators, running 5,000 trains daily on 7,500 miles of track. The company is integral to the transport system in Spain, its home base, handling more than 487 million passengers and 19.6 million tons of freight moved in 2017. New York Policy Analyst, Benjamin Villanti, also reminds us that the Madrid subway system is an example that other cities can learn from. For these reasons, the studio will travel and research the rail system in Spain, experiencing first-hand the Renfe HSR system and its architecture and urbanism from Madrid to Barcelona and back. This distance is comparable to the Houston-Dallas Corridor.

Figure 4.1. JAE Article of Studio Research
Chapter 5. Conclusion and Recommendations

RESULTS
This research has created a thorough and complete archive of highly detailed information models to serve the transportation typology with regard to multi-model transit hubs. The innovation of these file lies in the collection of multi-modal database components, for the transportation sector in general, and particularly for the development of a multimodal transportation network. The proposal develops a fundamental BIM component and assembly library via the template format for future use, ultimately resulting in a multi-modal center design guideline of standards for intra-megaregion travel ease, sustainability and metrics. The template identifies and includes networks for private transport, public transport, and other transport services that are part of the multimodal transport system, including sustainable transfer possibilities between these networks. Having this in place makes the process of any new (or renovated) project potentially smoother and with guided efficiency. For USDOT or private service providers involved in multi-modal services, BIM technology in general would advance and optimize multi-modal integration in transit hubs.

CONCLUSIONS
A multi-modal approach to the template itself creates a revamping of the BIM platform. This study becomes a critical reassignment of the role of BIM as active player in the betterment of multi-modality design thinking. With reference to governmental departments of transportation or private service providers, their future efforts to multi-modal services, ultimately effect informed policy-making. The BIM template would then also include the facilitation of public-private partnerships for freight mobility planning and operation efficiency, along with advanced thinking of the future of self-driving transportation networks. By cataloguing such information model specificity, the future city can benefit from a knowledge base of advanced and alternative transportation design elements, which promote cost effective safety, diversity, and environmental efficiency.
### Appendix A: Additional Considerations for BIM Template

#### 1. Table of Contents of BIM Assembly Qualifications

<table>
<thead>
<tr>
<th>Performance Index</th>
<th>Transportation Metrics</th>
<th>BIM Families and Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustainability</td>
<td></td>
<td>Relationship between each other</td>
</tr>
<tr>
<td>□ Environmental impact</td>
<td>□ Spatial structure of the city</td>
<td>Energy</td>
</tr>
<tr>
<td>□ Climate-neutral station operation</td>
<td>□ Land use pattern</td>
<td>□ Emission load (tons/peak-hour)</td>
</tr>
<tr>
<td>□ “GreenHub”</td>
<td>□ Land acquisition</td>
<td>□ Temperature required</td>
</tr>
<tr>
<td>□ Green roofs</td>
<td>□ Built-to-open space ratio</td>
<td>□ Power consumed</td>
</tr>
<tr>
<td>□ Renewable construction material and glass</td>
<td>(Land use vis-à-vis land cover)</td>
<td>□ Area built</td>
</tr>
<tr>
<td>□ Geothermal, photovoltaic, and solar thermal energy</td>
<td>□ Degree of accidents</td>
<td>□ Occupancy load</td>
</tr>
<tr>
<td>□ Rainwater harvesting</td>
<td>□ Speed of commute mode</td>
<td>Cost</td>
</tr>
<tr>
<td>□ Supply chain efficiency</td>
<td>□ Service coverage</td>
<td>□ Level of service</td>
</tr>
<tr>
<td>□ Emission load</td>
<td>□ Service frequency</td>
<td>□ Transportation</td>
</tr>
<tr>
<td>□ Mode share</td>
<td>□ Timeliness</td>
<td>□ Warehousing</td>
</tr>
<tr>
<td>□ Willingness of transportation provider to accept impact on environment</td>
<td>□ Intelligent systems–security and surveillance</td>
<td>□ Administrative</td>
</tr>
<tr>
<td>Equity</td>
<td>Passenger</td>
<td>□ Order processing</td>
</tr>
<tr>
<td>□ Safety</td>
<td>□ Average footfall</td>
<td>□ Inventory carrying</td>
</tr>
<tr>
<td>□ Accessibility</td>
<td>□ Traffic management of passenger and vehicular circulation</td>
<td>Time</td>
</tr>
<tr>
<td>□ Accountability</td>
<td>□ Convenient pass-through for inter-modal transfers</td>
<td>□ Estimated time to reach destinations</td>
</tr>
<tr>
<td>□ Flexibility</td>
<td>□ Average dwell time</td>
<td>□ Truck turnaround time–pickup, delivery and back for pickup</td>
</tr>
<tr>
<td>□ Ease of travel “Digital reception”</td>
<td>Freight</td>
<td>□ Average dwell time</td>
</tr>
<tr>
<td>□ Wayfinding Orientation-friendliness</td>
<td>□ Average time for delivery</td>
<td>Distance</td>
</tr>
<tr>
<td>□ Floor-heated waiting areas</td>
<td>□ On-time loading and departure</td>
<td>□ Trip distance</td>
</tr>
<tr>
<td>□ Affordability</td>
<td>□ Accurate temperature maintenance for goods</td>
<td>□ Modes between start and end destination (measured by number of modes, or percentage by distance/time)</td>
</tr>
<tr>
<td>□ Willingness to pay Diversity of commuters</td>
<td>□ Freight cost per unit shipped</td>
<td>□ Passenger transfer minimum distance</td>
</tr>
<tr>
<td>□ Affordability</td>
<td>□ Human labor</td>
<td>□ Distance between passenger terminals</td>
</tr>
<tr>
<td>□ Willingness to pay Diversity of commuters</td>
<td>Number of ships taking optimal routes, as compared to total number of shipments</td>
<td>□ Turning radius for vehicles</td>
</tr>
<tr>
<td>□ Affordability</td>
<td>□ Egress</td>
<td>□ Egress</td>
</tr>
</tbody>
</table>
References


