

INTRODUCTORY PRESENTATION

FEBRUARY 2023



KEY TO A SUSTAINABLE AIRPORT DIGITAL TWIN

Presentation Overview

- x-Spatial Introduction
- What is an Airport Digital Twin
- Use Cases, components
- Examples of leveraging DT & integration with other airport data
- Case Study
 - Using LiDAR to create a 3D DT at Charlotte Douglas International Airport
- Sustaining DT - Updating the master LiDAR model
- Q & A

Introductions

- Founding member of Airports Digital Twin Consortium (<https://airportdigitaltwin.org/>)
- x-Spatial was formed in 2006 to better focus our application development for our clients
- Formally the application development division of Kelar Corporation (established in 1982)
- Our current focus are airports, assisting them with managing their assets as well as financial information (lease & concession mgmt.) leveraging GIS
- We have over 25 years of direct experience of application development including CAD / GIS / IT in an airport environment, at major European & US airports

What is an Airport Digital Twin



AAAE Digital Twin Working Group



AMERICAN ASSOCIATION OF AIRPORT EXECUTIVES (AAAE) DIGITAL TWIN WORKING GROUP

Explanation of Airport Owner's Digital Twin Final Draft 3/17/22

The purpose of the following explanation is to help airport owners better understand what is a **Digital Twin**, in the context of their airport enterprise management. An airport owner's Digital Twin may be developed incrementally over time, increasing in capabilities gradually on an as needed basis per each airport's individual priorities.

An airport owner's Digital Twin encompasses transportation (e.g., aircraft, vehicle), including but not limited to:

- Air Transportation
- Ground Transportation
- Terminal Buildings

An airport owner's digital twin provides optimal decision-making, and efficient and simulate predicted futures, data, guided by domain knowledge.

An integration of airport information includes:

- **Data** (including spatial, temporal)
- **Software** (including cloud, on-premise)
- **Hardware** (including sensors, cameras, etc.)
- **Network devices** (including routers, switches, etc.)
- **Cloud services** (including storage, compute, etc.)
- **Staff** supporting non-airport activities
- **Governance** (including policies, standards, etc.)

That may provide:

- **Visual multi-dimensional** infrastructure, facilities, resources, workflows, etc.
- **Integrated display of** data, analytics, etc.

AAAE Airport Digital Twin Maturity Model						
	Lowest	>	>	>	>	Highest
	Entry Level					Utopia
Level	1	2	3	4	5	6
Staffing	Self motivated individual division staff conducting analysis	Division designated dedicated analyst	Proactive centralized Business Intelligence (BI) organizational function			
			Understaffed	Adequately staffed	Some machine learning automation reducing needed staff levels	Full machine learning automation
Business Processes	Not documented	Few documented	Few mapped with some workflow automation	Mostly mapped with some workflow automation	Completely mapped with full workflow automation	Completely mapped with full workflow automation
Data Housing	Siloed	Combination of siloed and centralized	Mostly centralized data hub/warehouse	Centralized & integrated data warehouse	Mostly aligned data	Full accessibility & alignment
			Defining DT Vision & Path Forward			
Metrics & Analytics	Measuring available data	Developing division metrics for key priorities	Developing centralized universal metrics	Build alignment of organizational measures into employee work tasks	Calibrate alignment of metrics to improve performance	Fully aligned enterprise with on-demand metrics
Data Flow	No automated data sharing flow (i.e., manual batch loading, not real time via API)	Manual and automated data sharing flow	Manual and automated data sharing flow	Priority external and all internal data flows automated	All data feeds automated with self reported validated	All data feeds automated (no self reporting)
	Some IoT device data flow within proprietary disparate systems	Some internal airport systems with automated data sharing	External partners data is partially manual (e.g., airlines, concessions, etc.)	Automated PAX demographics, POS, concessions data, airline activity overlay		
			Common basemap automated web services			
	Aerial/ALP (aster floor plan maps some georegistered)	Georegistered	Georeferenced with metadata / some surveyed	Some georeferenced LIDAR survey verified	Most georeferenced LIDAR survey verified	All georeferenced LIDAR survey verified
	Real-time sensor/analytics feeds		Interactive analytics	Real-time sensor/analytics feeds		

➔ Roadmap for Airport Owners

➔ Definition / Explanation

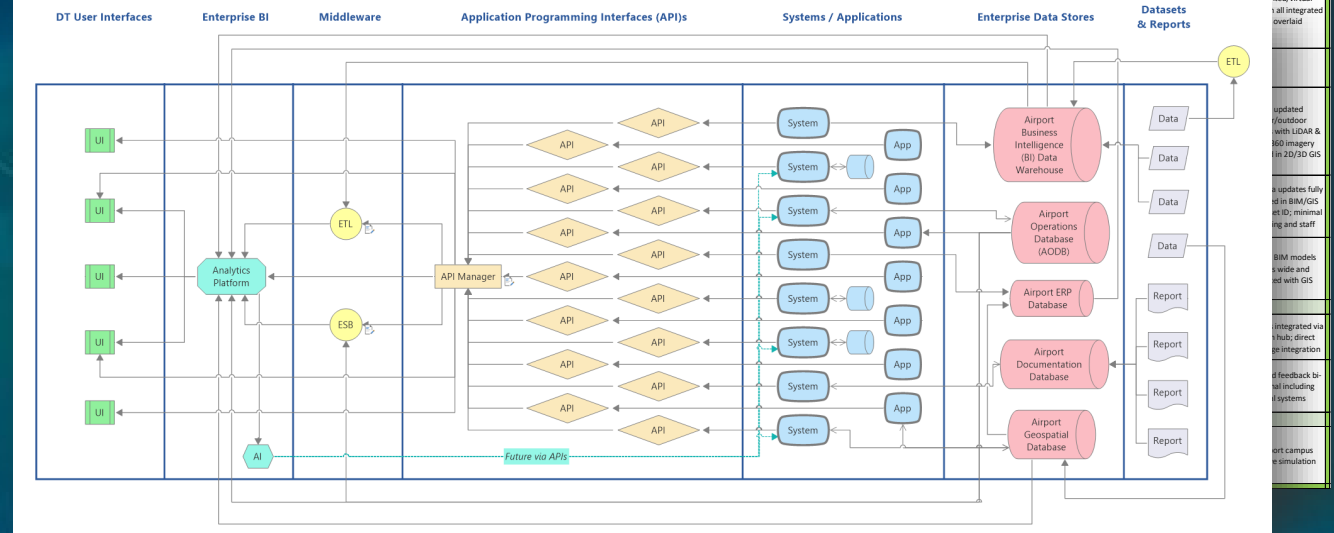
➔ Top Use Cases / Examples

➔ System Architecture

➔ Implementation Approach

➔ Governance to Sustain

➔ Industry Resources



What's an Airport Digital Twin



An airport owner's Digital Twin is a virtual digital representation of the airport's real-world assets, intermodal transportation (e.g., aircraft, vehicles, passengers, cargo), and processes which may span the entire aerodrome ecosystem, including but not limited to:

- Air Transportation
- Ground Transportation
- Terminal Buildings
- Other Buildings
- Infrastructure
- Properties & Environment

An airport owner's digital twin transforms the airport business enterprise by accelerating holistic understanding, optimal decision-making, and effective action. It uses real-time and historical data to represent the past and present and simulate predicted futures. It is motivated by outcomes, tailored to use cases, powered by integration, built on data, guided by domain knowledge, and implemented in IT/OT systems.ⁱ

Source:

AAAE Airport Owner's Digital Twin Working Group Roadmap
(based on Digital Twin Consortium's Definition)



What's an Airport Digital Twin cont'



An integration of airport information systems (including processes, data, and technologies)

- **Data** (including spatialⁱⁱ, non-spatial, real-time, historic, forecast, and simulated)
- **Software** (including configurable COTS solutions, data maintenance, and business intelligence & analytics)
- **Hardware** (including servers, desktops, laptops, tablets, smartphones, and sensors)
- **Network** devices (including switches, routers, and hotspots)
- **Cloud** services (including software, data, databases, and infrastructure “as a service”)
- **Staff** supporting non-automated data updates (such as airport configuration changes)
- **Governance** (including policies, standards, compliance, processes, and procedures)



That may provide

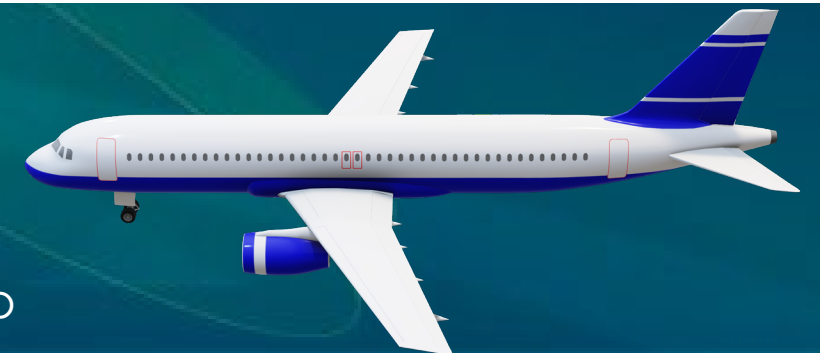
- **Visual multi-dimensional representation** of the airport's ecosystem including its airspace, surroundings, infrastructure, facilities, assets, systems, flux (e.g., aircraft, vehicles, passengers, meeter greeters), staff resources, workflows, etc.
- **Integrated display of correlated information** from multiple systems/sources (aka business intelligence) in the form of analytic graphs, tables, and maps
- **Temporal analysis** of past, current, real-time, forecast, and/or simulated data

What's an Airport Digital Twin cont'



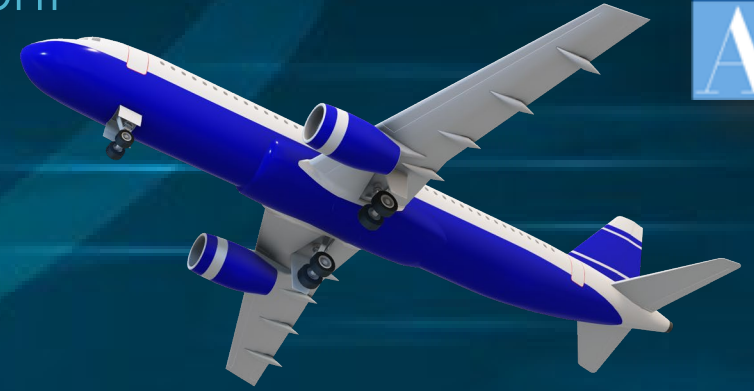
To enable

- **Efficient collection, access, correlation, and understanding of qualityⁱⁱⁱ data** from multiple airport systems/sources to support faster and more confident decisions to improve airport:
 - Level of Service
 - Safety & Security
 - Operations & Maintenance
 - Planning & Development
 - Costs & Revenue
 - Compliance & Risk Management
- **Autonomous** operations and decision making



Source: AAAE Airport Owner's Digital Twin Working Group Roadmap

What's an Airport Digital Twin cont'



In support of all airport management disciplines

- Planning & Environmental
- Engineering & Construction
- Facilities & Asset Maintenance
- Operations (Landside, Terminal, Airside, Security, Fire, Police)
- Property Leasing & Concessions
- Business Development
- Public & Governmental Affairs
- Information Technology & Communications
- Finance & Procurement
- Legal & Administration

Addressing informational needs of various airport stakeholders

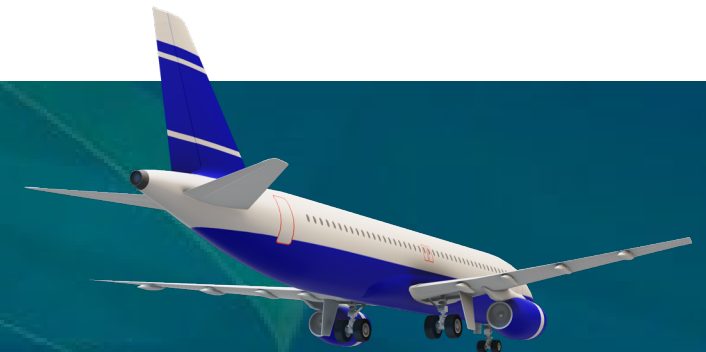
- Board members
- Management
- Staff
- Vendors / Consultants / Contractors / Service providers
- Tenants
- Passengers
- Meeters & Greeters
- Governing agencies (e.g., local, state, federal)
- Surrounding Community

What's an Airport Digital Twin



An airport owner's digital twin is

- NOT a single system, but rather an integration of systems/data, which are assembled into a Digital Twin head-end system
- NOT replacing existing airport systems, but rather expanding their utility; some existing systems may become obsolete or consolidated as a result of a Digital Twin
- NOT the Architectural-Engineering-Construction (AEC) Digital Twin used to design-build-activate new facilities; however, the AEC's Digital Twin data may be leveraged by the airport owner's Digital Twin
- NOT a Building Information Modeling (BIM) nor a Geospatial Information System (GIS), although BIM and GIS are parts of a digital twin



Use Cases & Components



Airport DT Business Needs



- Internet of Things (IoT) with analytics have become common place (e.g., **CCTV cameras, sensors, alarms, elevators, escalators, etc.**)
- Different IoT types overlayed on disparate system maps/floorplans **need to be updated more efficiently with constant airport changes**
- **Need to correlate interdependencies** of various IoT types across large and complex airport facilities that are constantly evolving
- **Need** various IoTs with analytics **on same “page”** via shared up-to-date airport maps/floorplans

Top Use Cases

- Landside Arrivals
- Shuttle Bus Frequency
- Security Checkpoints
- Digital Content
- APM Frequency
- Concessions
- Connecting Flights/PAX Loads
- Terminal Resources
- Terminal Energy Management
- Terminal Cleaning
- Predictive Maintenance
- Work Scheduling
- Airfield Safety
- PAX Safety & Health
- Emergency Situational Awareness

Path to Achieving Airport Digital Twin



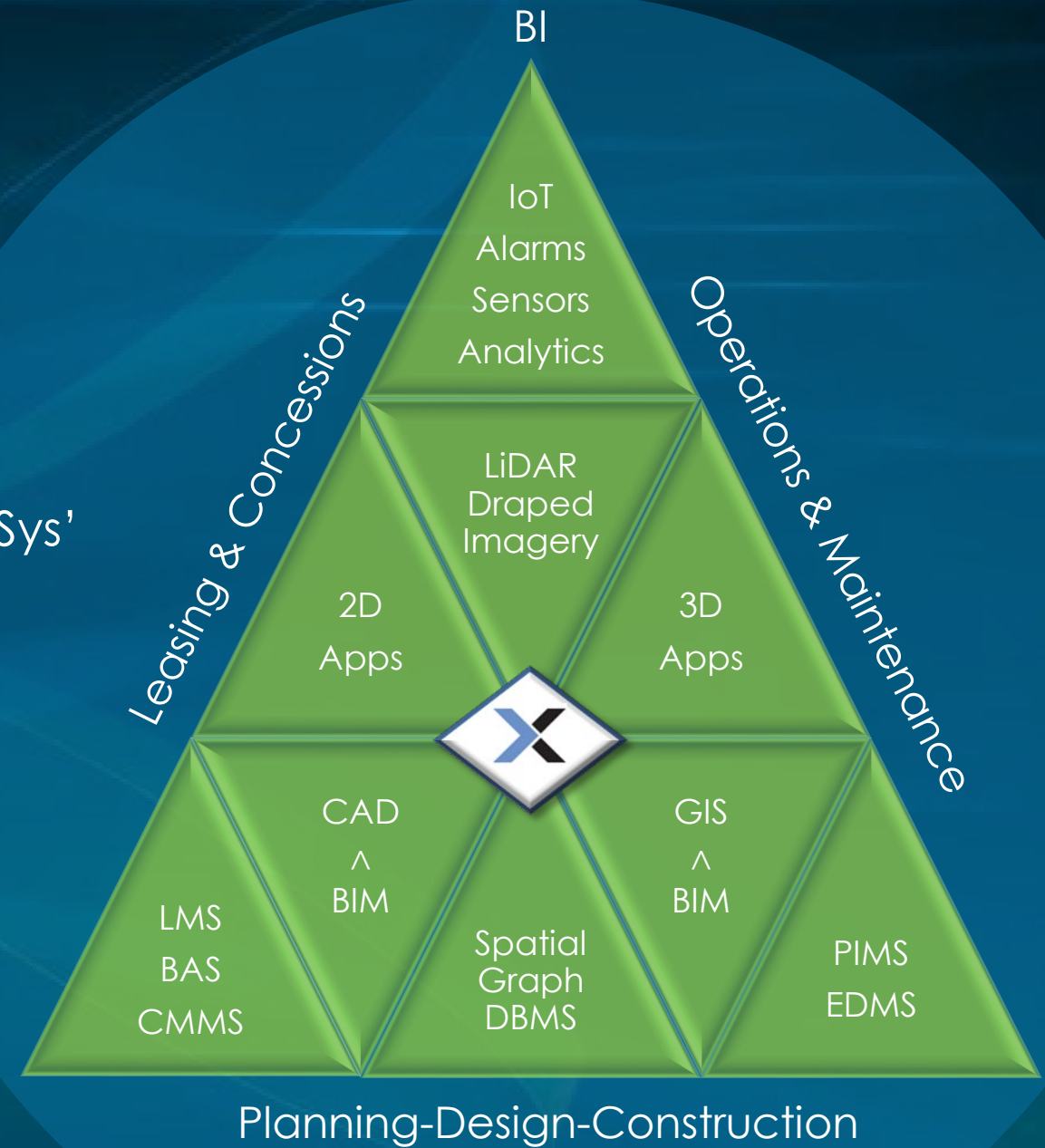
Maturity Model

- ➔ Staffing
- ➔ Business Processes
- ➔ Data Housing
- ➔ Metrics & Analytics
- ➔ Data Flow
- ➔ Spatial Correlation
- ➔ Systems Integration
- ➔ Predictive Simulation

AAAE Airport Digital Twin Maturity Model						
	Lowest	>	>	>	>	Highest
	Entry Level					Utopia
Level	1	2	3	4	5	6
Staffing	Self motivated individual division staff conducting analysis	Division designated dedicated analyst	Proactive centralized Business Intelligence (BI) organizational function			
			Understaffed	Adequately staffed	Some machine learning automation reducing needed staff levels	Full machine learning automation
Business Processes	Not documented	Few documented	Few mapped with some workflow automation	Mostly mapped with some workflow automation	Completely mapped with some workflow automation	Completely mapped with full workflow automation
Data Housing	Siloed	Combination of siloed and centralized	Mostly centralized data hub/warehouse	Centralized & integrated data warehouse	Mostly aligned data	Full accessibility & alignment
Metrics & Analytics	Defining DT Vision & Path Forward					
	Measuring available data	Developing division metrics for key priorities	Developing centralized universal metrics	Build alignment of organizational measures into employee work tasks	Calibrate alignment of metrics to improve performance	Fully aligned enterprise with on-demand metrics
Data Flow	No automated data sharing flow (i.e., manual batch loading, not real time via API)	Manual and automated data sharing flow	Manual and automated data sharing flow	Priority external and all internal data flows automated	All data feeds automated with self reported validated	All data feeds automated (no self reporting)
	Some IoT device data flow within proprietary disparate systems	Some internal airport systems with automated data sharing	External partners data is partially manual (e.g., airlines, concessions, etc.)	Automated PAX demographics, POS, concessions data, airline activity overlay		
		Manual shared CAD/GIS maps	Common basemap automated web services			

Airport DT Components

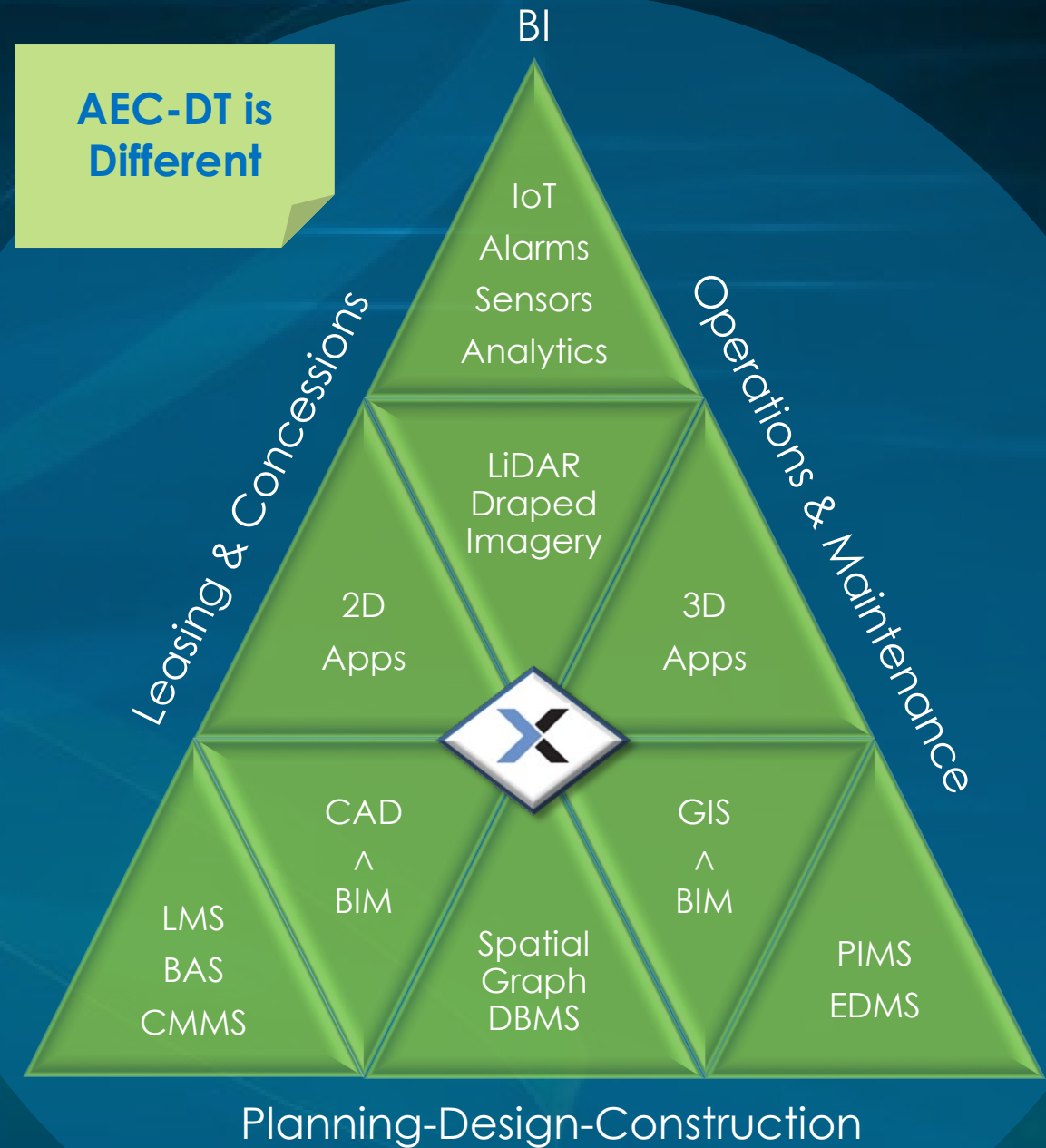
- **BAS** – Building Automation System
- **BI** – Business Intelligence
- **BIM** – Building Information Modeling
- **CAD** – Computer Aided Design
- **CMMS** – Computerized Maintenance Mgm't Sys'
- **DBMS** – Database Mgm't System
- **EDMS** – Electronic Doc's Mgm't System
- **GIS** – Geospatial Information System
- **IoT** – Internet of Things
- **LiDAR** – Light Detection and Ranging
- **LMS** – Lease Management System
- **PIMS** – Project Info' Mgm't System



Holistic DT Stakeholders on Airport Owner-Side ----->

- Planning & Environmental
- Engineering & Construction
- Operations & Security
- Facilities Maintenance
- IT Systems & Infrastructure
- Leasing & Concessions (Revenues)
- Finance & Procurement
- Legal & Administration

AEC-DT is Different





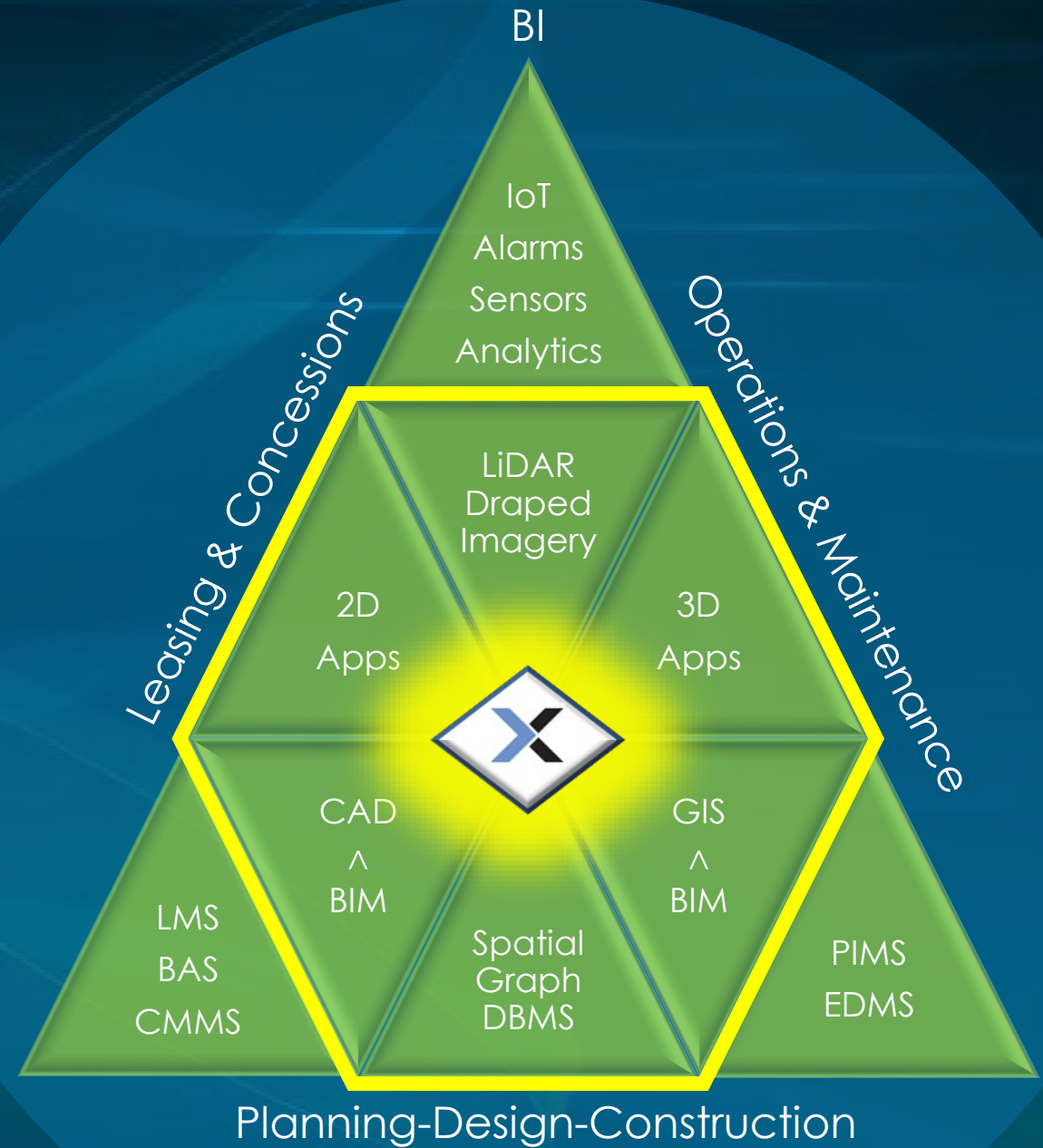
DT Foundation

“Skeleton”
correlates DT
components
together
via common
denominator

Spatial Database

key

to achieving DT



DT & integration with other airport data





Spatial Data
is Common
Denominator

Enabling Spatial
Correlation for
Digital Twin

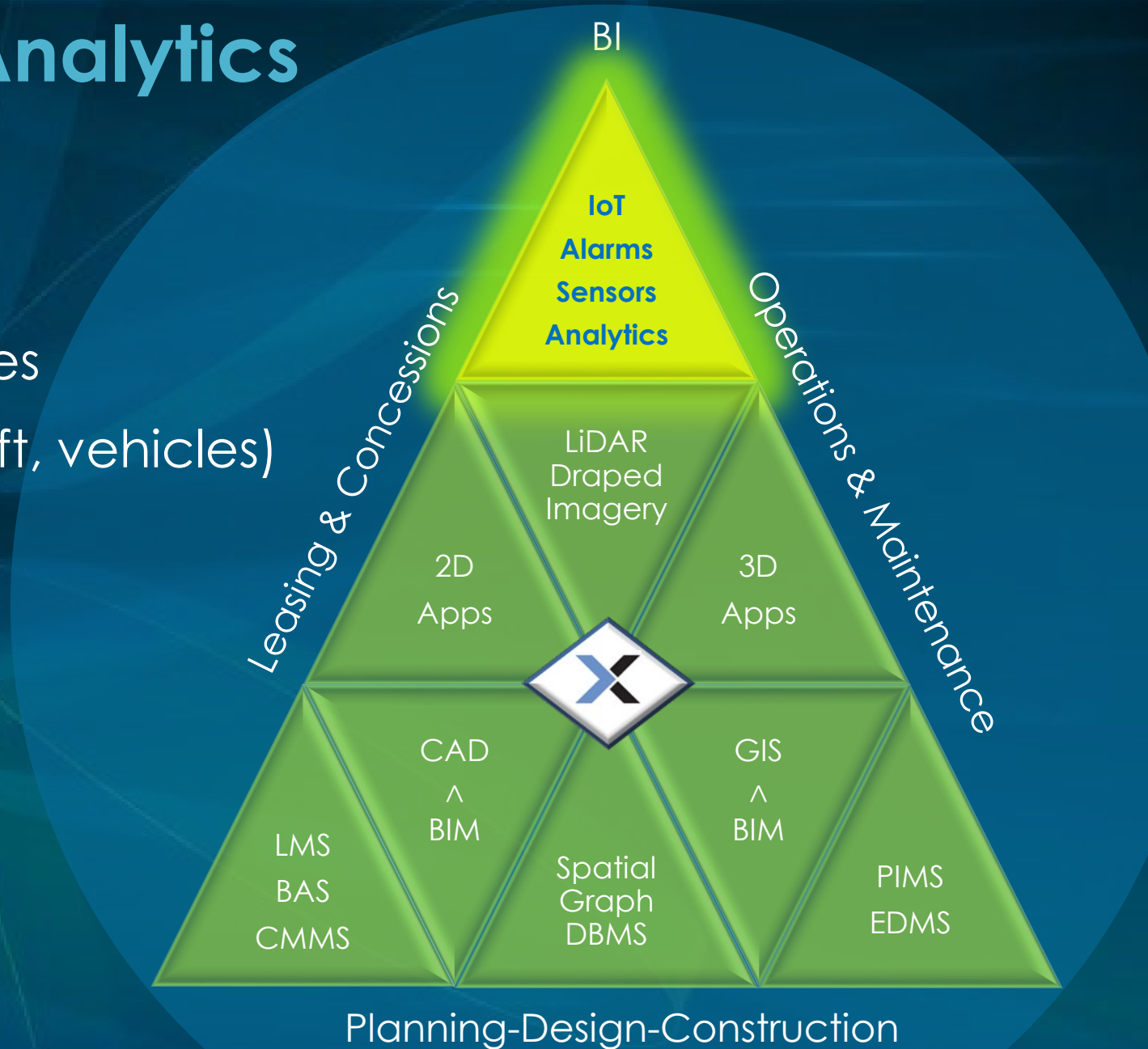
Examples of DT Data Fusion



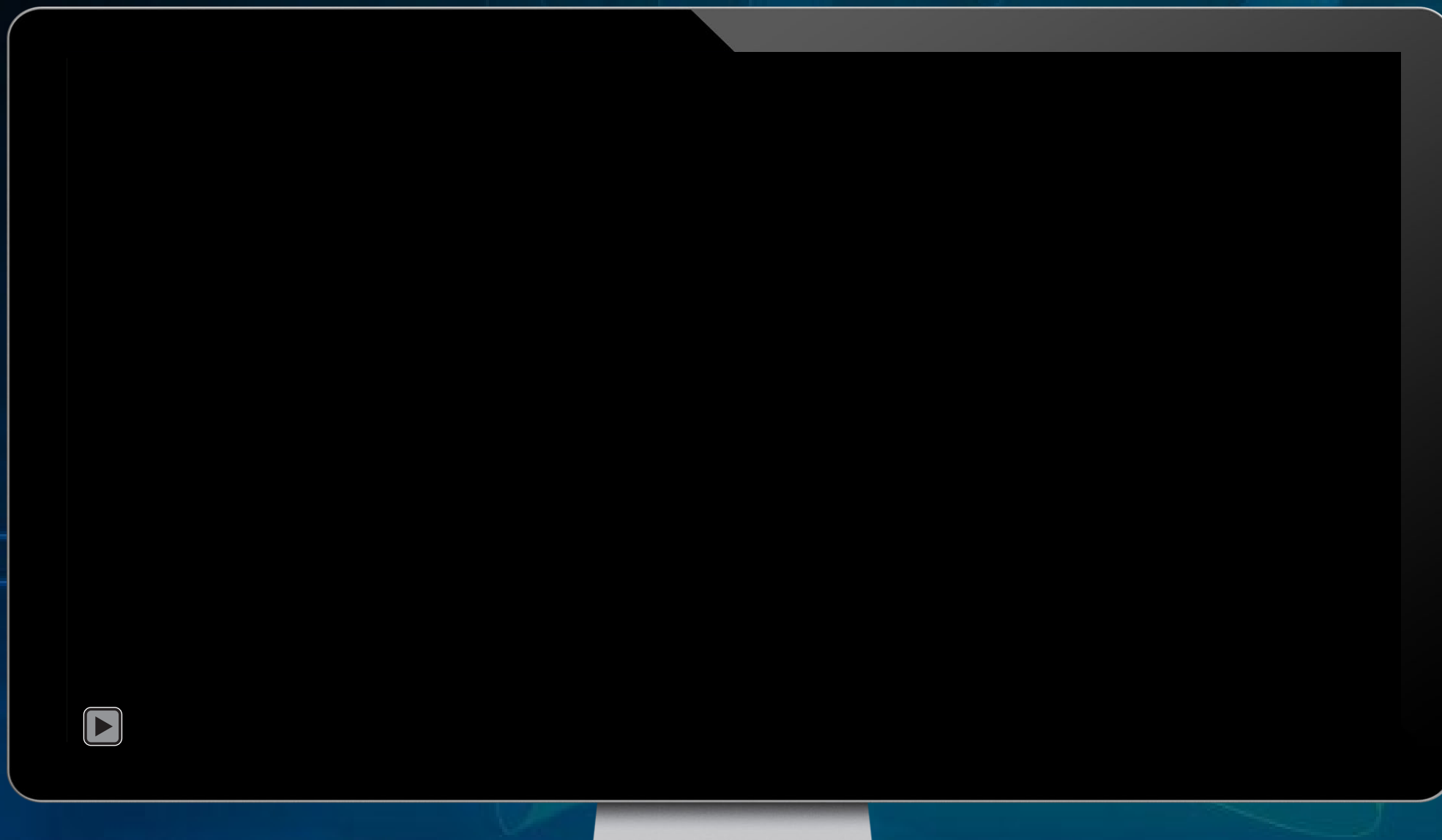
- ALP & Floor Plans
- 3D LiDAR with Draped Imagery
Outdoors & Indoors
- Airspace / AOA Traffic & NOTAMS
- Aircraft Gate Turn-Around Status
- On-Airport Roadways / Curbs
- Parking Garages / Lots Status
- People Movers Status
- Elevators / Escalators Status
- Ticket Counters Status
- Security Checkpoints Status
- PAX Congestion / Queues
- Bathrooms Status
- Alarms / Sensors / CCTV
- Incidents / Complaints
- Inspections / Issues / Weather
- Projects, Work Orders, Outages...

IoT Alarms - Sensors - Analytics

- Roadway Traffic
- Curb to Gate PAX Flux
- Security Checkpoint Wait Times
- AOA Movements (e.g., aircraft, vehicles)
- Aircraft Gate Turnaround
- Access Control Alarms
- Fire Alarms
- Restrooms Level of Service
- Trash-bins capacity
- etc...



Leveraging CCTV Machine Vision & Analytics

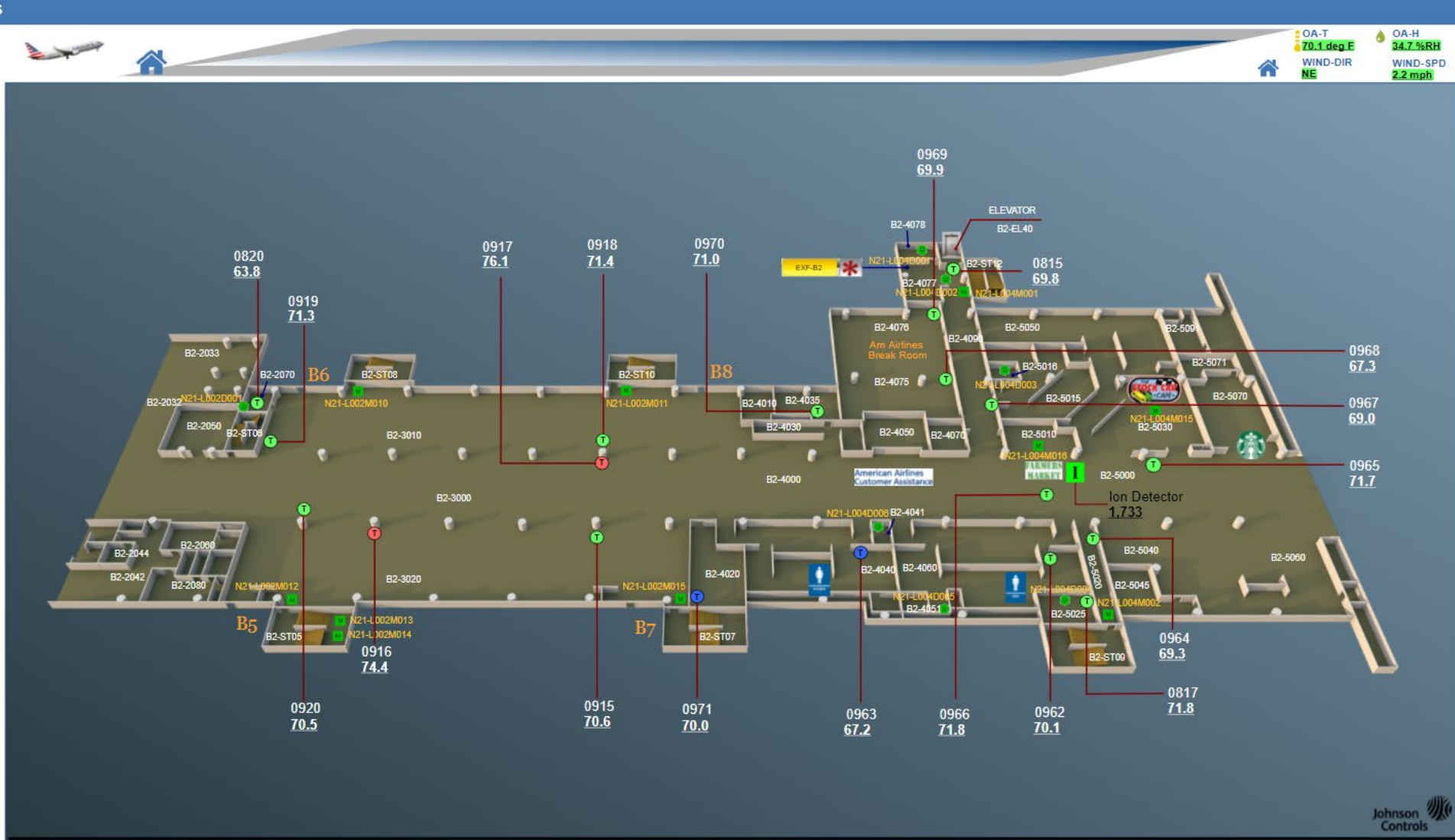


Courtesy
of Intell Act

Leveraging Building Sensors & Alarms

Courtesy of CLT & Johnson Controls (Metasys)

GRAPHICS

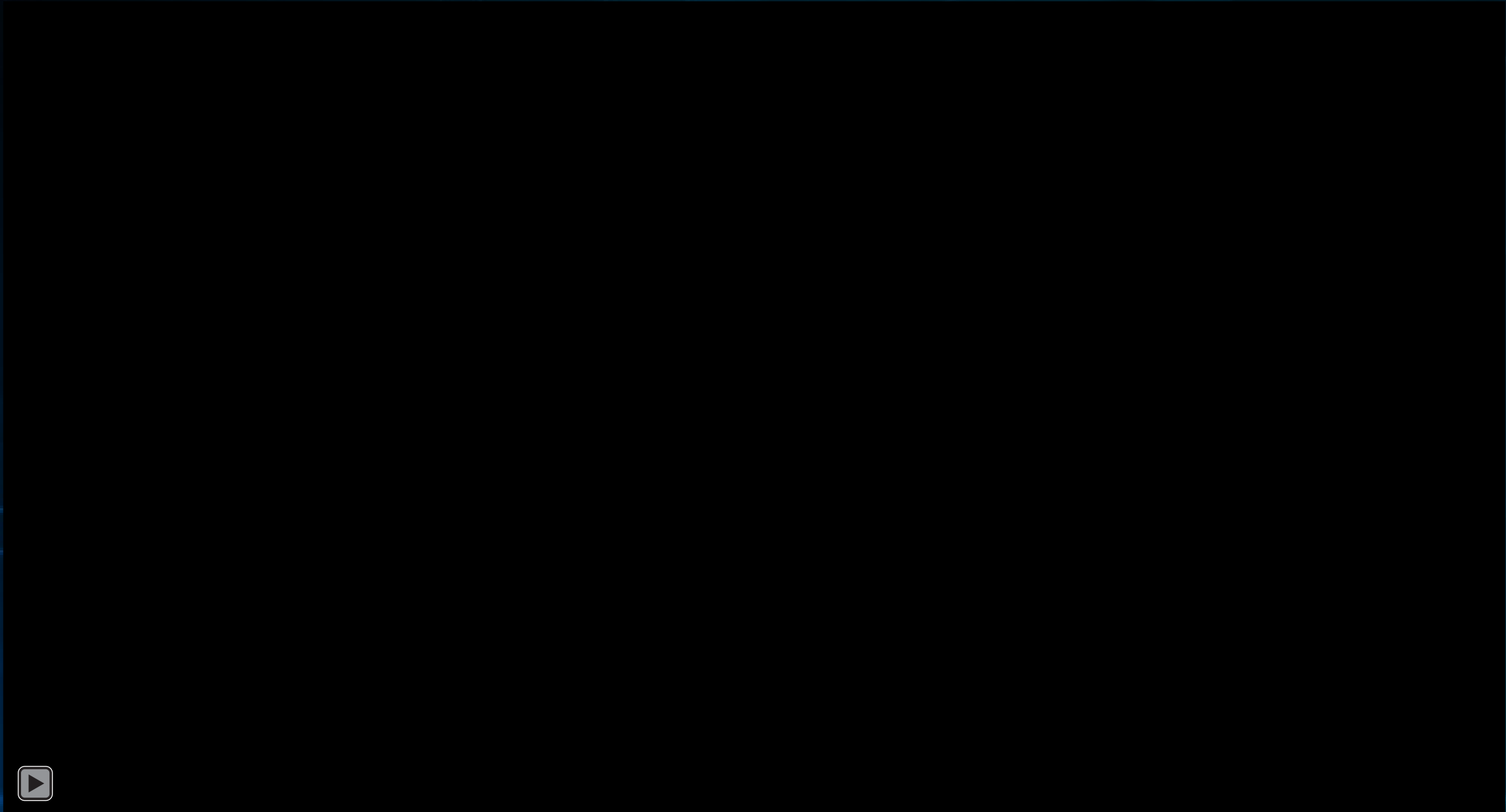


OA-T
70.1 deg F
WIND-DIR
NE

OA-H
34.7 %RH
WIND-SPD
2.2 mph



Real-Time Sensor Overlay



Real-Time Sensor Overlay



Security Checkpoint Wait Time Status

Min Checkpoint Wait Time for all Checkpoints

A semi-circular gauge with a scale from 0 to 30 in increments of 6. The needle points to the number 3.

Average Checkpoint Wait Time for all Checkpoints

A semi-circular gauge with a scale from 0 to 30 in increments of 6. The needle points to the number 5.

Max Checkpoint Wait Time for all Checkpoints

A semi-circular gauge with a scale from 0 to 30 in increments of 6. The needle points to the number 14.

Zoom to Pen ... 1 of 3

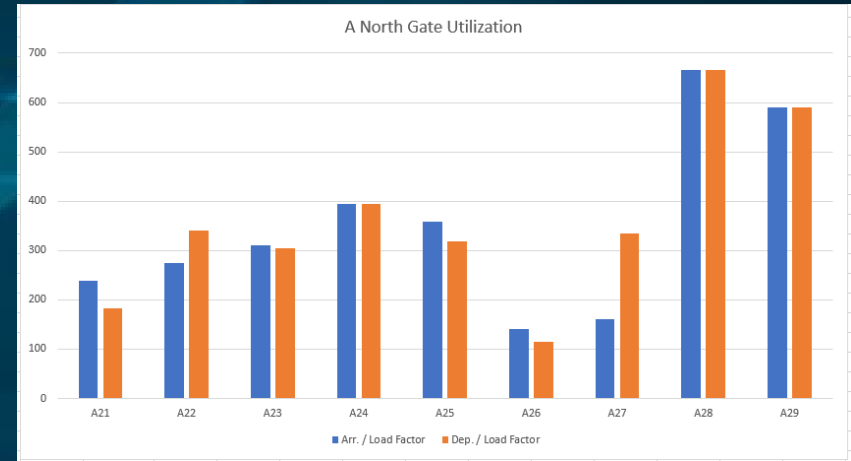
BUILDING_SPACE_AREA: 3140

AEGIS Room No	0355
Interior Space Identifier	1002M2-2220
Floor ID	911.00
Short Name	M2-2220
Full Name	100-M2-2220
Description	Open Space
Concourse	M
Room Type	Open Space
CommRoom	
Tenant	HMS Host
Status	Active
Accessibility	Public
Area	5,807.20
Exhibit J	Rentable Other-C
Exhibit J Area	8590
Exhibit K Join	330
Old Short Name	M2222
Older Short Name	
New Short Name	M2-2500

A map of a building layout with various rooms colored in shades of blue, green, yellow, and purple. Three orange diamond markers indicate wait times: 3 min, 4 min, and 14 min. A scale bar at the bottom left shows 0 to 100 ft. A zoom control at the bottom right shows a plus sign and a minus sign.

Powered by Esri

AODB Integration – Passenger flow modeling



CLT AODB Interface

Layers: Floor Features, building_room_area, Food and Beverage, Other Values, Doors, Floorplan_STD, Floorplan_moving_side, Safety, Building Equipment, Cadastre, Grids, Aerial.

Map Position: X: 1418530 890096, Y: 541458 264175 (FOOT)

Search: Charlotte Douglas International A, AdminOnly) CLT

Facility Level: Level 01

Terminal: Building, Concourse A North

Floor: Floor 2 - CLT_TERM000402

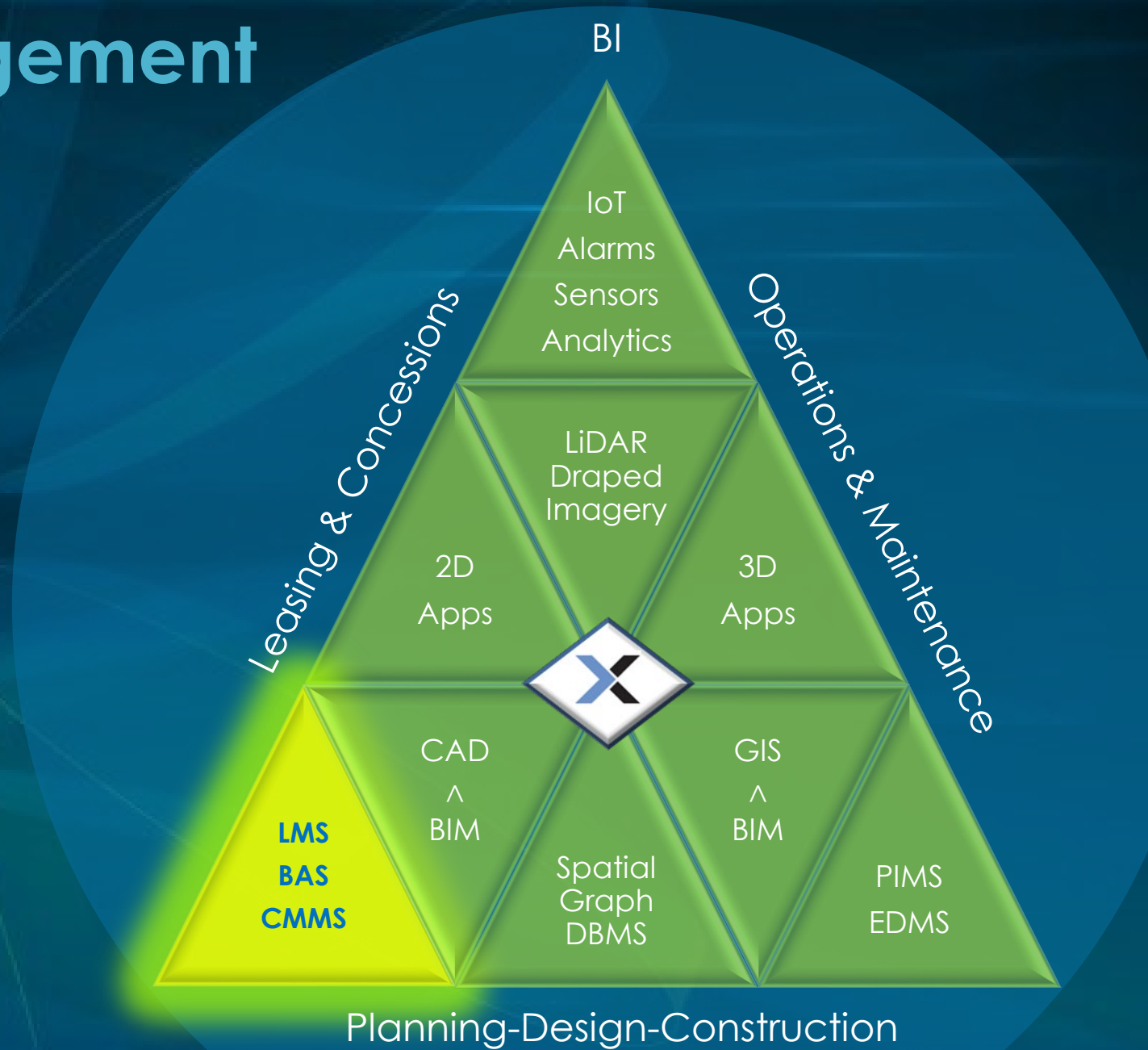
Space Area Table:

Location Code	AEGIS Room No	Interior Space Identifier	Short Name	Full Name	Description	Concourse	Room Type	CommRoom	Tenant	Status	Accessibility	Area	Exhibit J	Exhibit J Area	Exhibit K Join	Old Short Name	New Short Name	Cleaning Responsibility
CLT_TERM000302030061	0061	1002A2-0110	A2-0110	100-A2-0110	Corridor	A	Corridor		CLT		Public	11,843.30		0				

A North	
Number of gates	9
Arrival	
Total Available Seats	3914
Load Factor	80%
Number of passengers	3131
Departure	
Total Available Seats	4056
Load Factor	80%
Number of passengers	3245

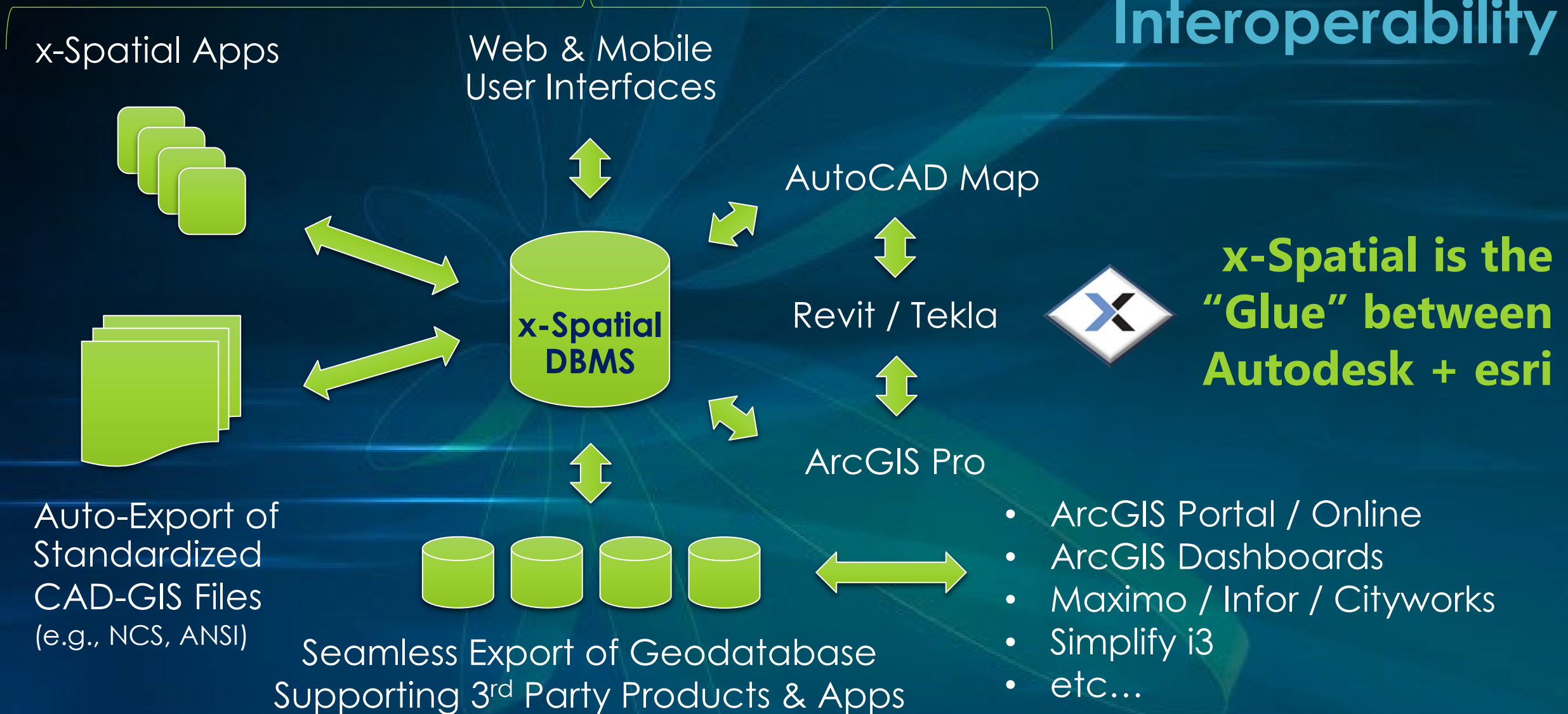
Enterprise Asset Management

- Leases & Concessions
- Building Automation
 - SCADA (HVAC/Electrical)
 - HVAC
 - Electrical & Lighting
 - People Movers
 - Escalators
 - Elevators
 - Moving Sidewalks
 - APMS
 - Jet Bridges
- Work Orders
- Condition Assessments



Digital Twin

x-Spatial DBMS Interoperability



CLT Lease...
Operations Dashboard

Tenant:

Description:

Concourse:

Floor:

Lease Termination:



Leases To Expire

21

This Quarter

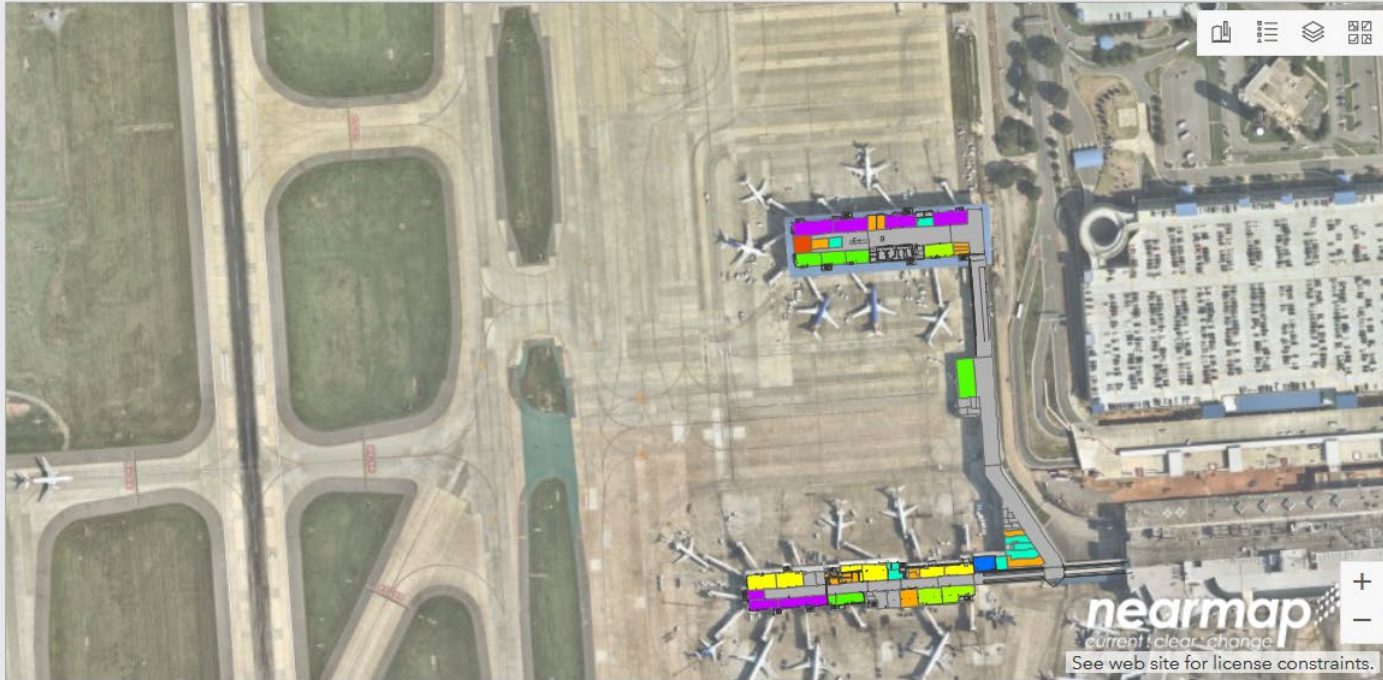
Last update: a few seconds ago

Leases To Expire

53

Next Quarter

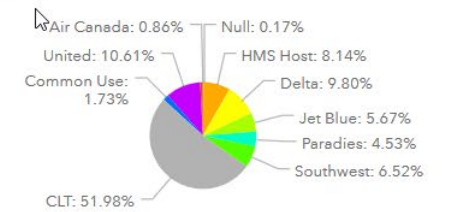
Last update: a few seconds ago



Total Lease Area:
230,554.4 ft²

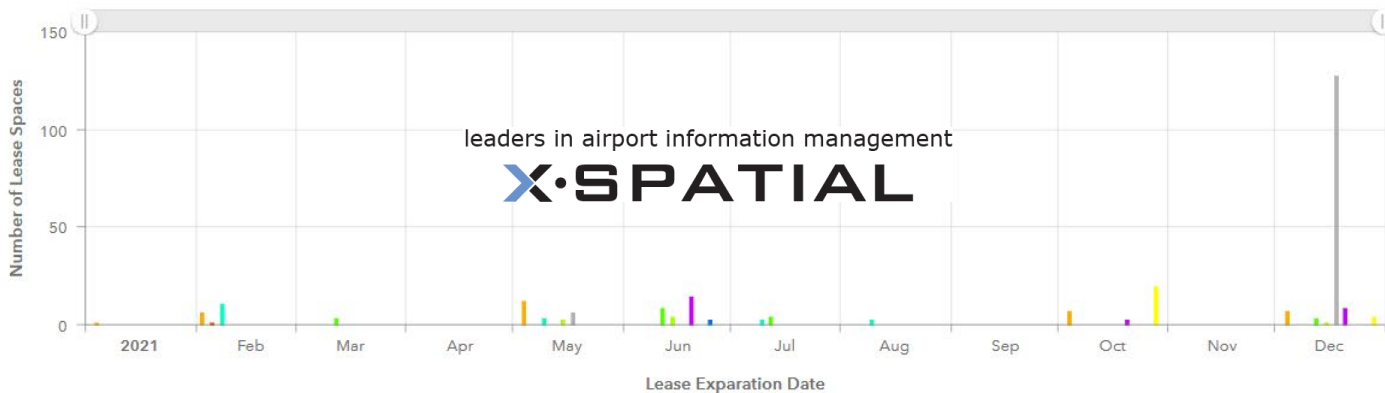
Last update: a few seconds ago

Total Lease Area



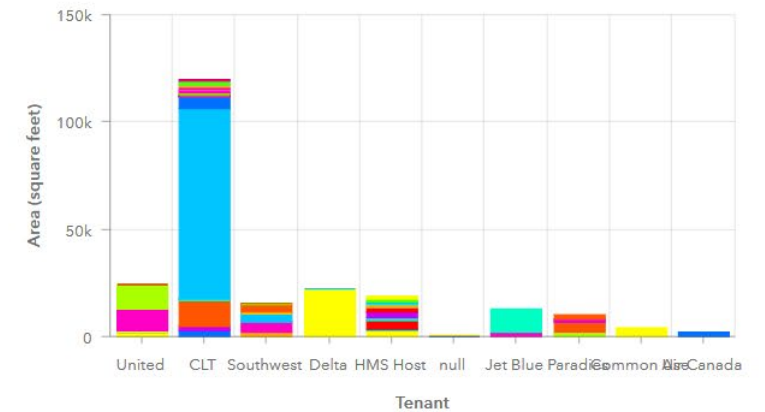
Last update: a few seconds ago

Lease Expiration Timeline



Last update: a few seconds ago

Total Lease Space Area by Tenant



Last update: a few seconds ago

Space & Lease Mgm't ArcGIS Dashboard

Rooms at CLT Operations Das...

X-Spatial

Tenant:

Description:

Concourse:

Expire:



Total Room Area:
230,554.4 ft²

Last update: a minute ago



Leases to Expire

This Quarter:

21

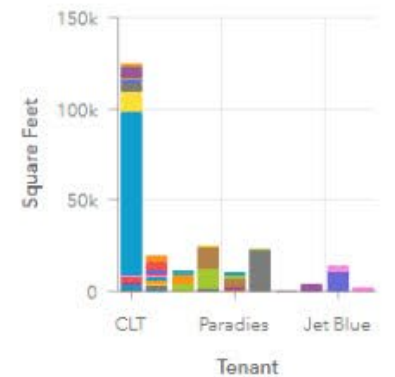
Next Quarter: 53

Last update: a minute ago

1/4

Year

Area by Tenant and Room Description



Last update: a minute ago

Bar

Pie

Lease Expiration Timeline



Last update: a minute ago

leaders in airport information management

X·SPATIAL

Map Legend

FloorPlan

Rooms

<Null>

Air Canada

CLT

Common Use

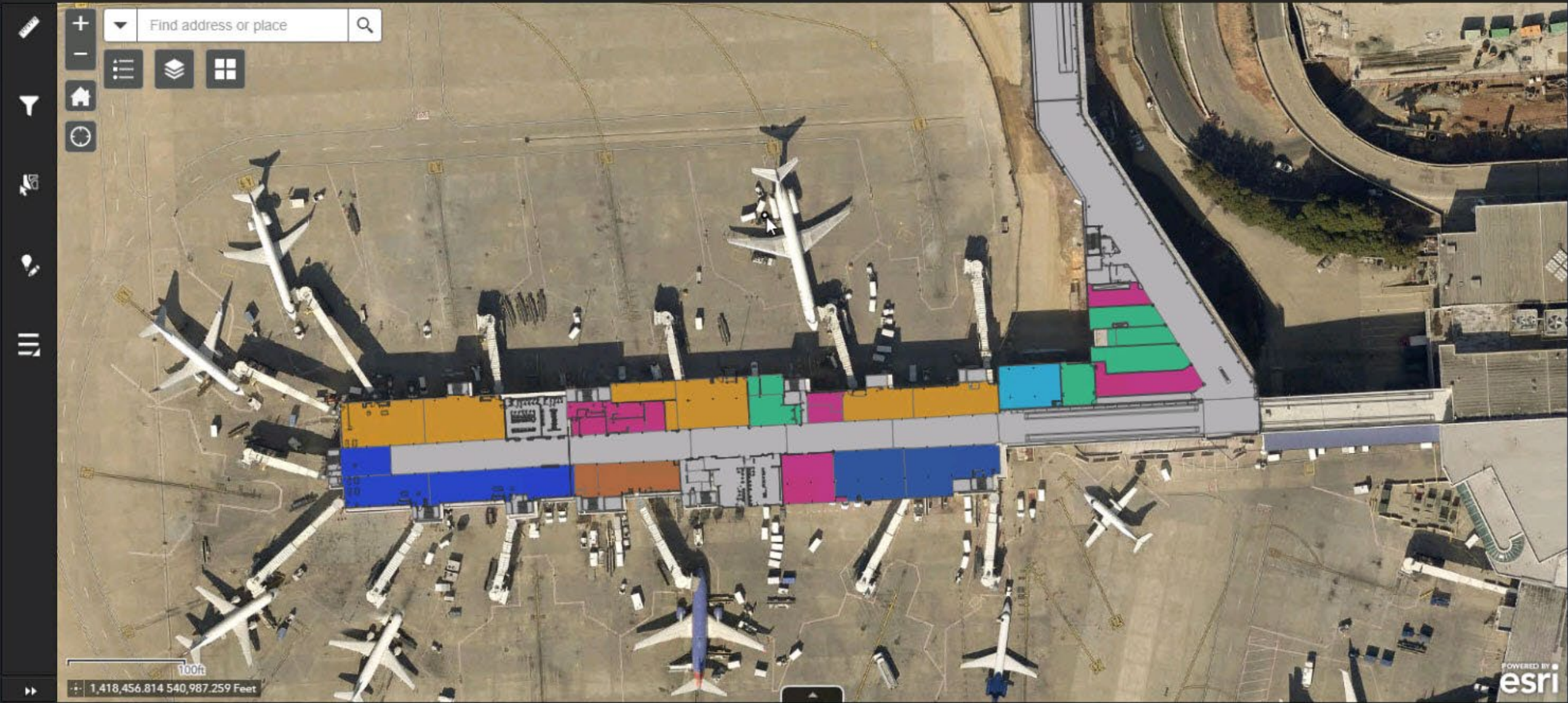
Delta

ArcGIS On-Line Web Lease Management

leaders in airport information management

X·SPATIAL

Terminal and Concourses Web Application X-Spatial



ArcGIS On-Line Web Lease Management

leaders in airport information management

X·SPATIAL

Terminal and Concourses Web Application X-Spatial

Find address or place

20ft
1,418,211.946 540,874.195 Feet

POWERED BY esri

FloorPlan Rooms

Options Filter by map extent Zoom to Clear selection Refresh

LeaseTermination	Tenant	Description	OBJECTID_1	A_LOC_ID	Location Code	AEGIS Room No	Interior Space Identifier	Short Name	Full Name	Concourse	Room Type	CommRoom	Status	Access
December 31, 2021	CLT	Mechanical Chase	96	CLT_TERM00030	CLT_TERM00030	2.000000	1002A2-MC07	A2-MC07	100-A2-MC07	A	Mechanical Chase	A1483	Active	Private
October 1, 2021	HMS Host	Common Use Hold Room	104	CLT_TERM00030	CLT_TERM00030	10.000000	1002A2-0420	A2-0420	100-A2-0420	A	Hold Room	A1483	Active	Private

48 features 0 selected

ArcGIS On-Line Web Lease Management

leaders in airport information management

X·SPATIAL

Terminal and Concourses Web Application X-Spatial

Find address or place

Room Editor

Clear Save

(1 of 4)

tenant
Delta

Description
Common Use Hold Room

Room Type
Hold Room

Status
Active


Accessibility
Public

Cleaning Responsibility

Comment

Location Code
CLT_TERM000302030015

AEGIS Room No
15



Terminal and Concourses Web Application

Filter

Rooms

Room by Tennent

Tenant is
- empty -

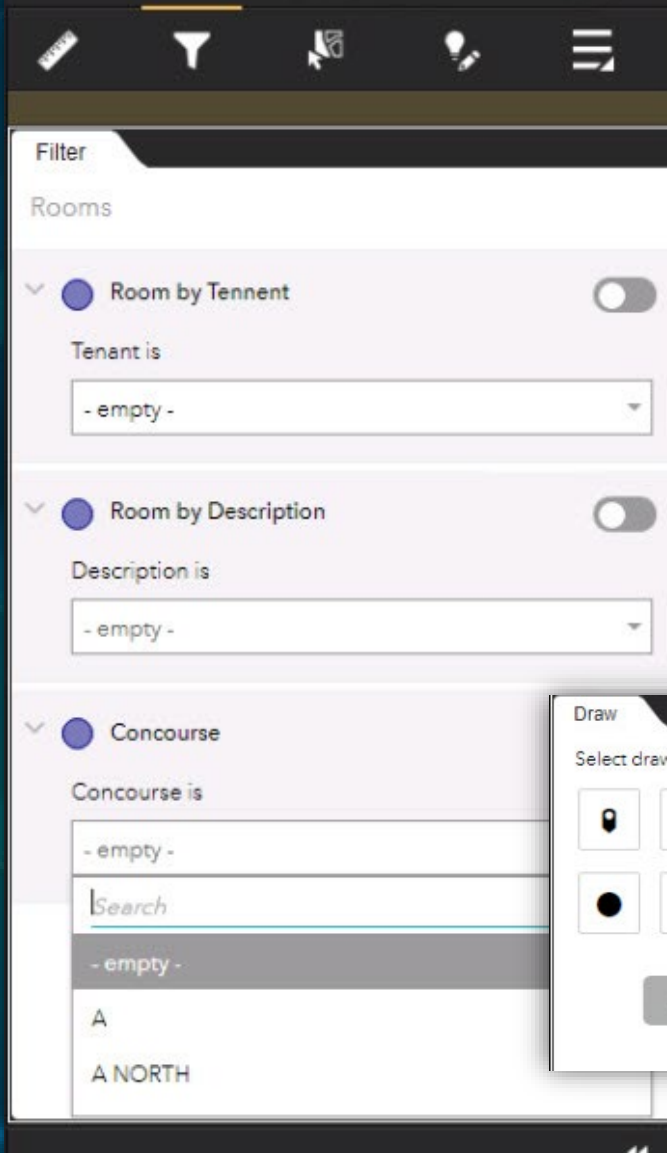
Room by Description

Description is
- empty -

Concourse

Concourse is
- empty -

Search
- empty -
A
A NORTH



Other panels

Draw

Bookmark

Print

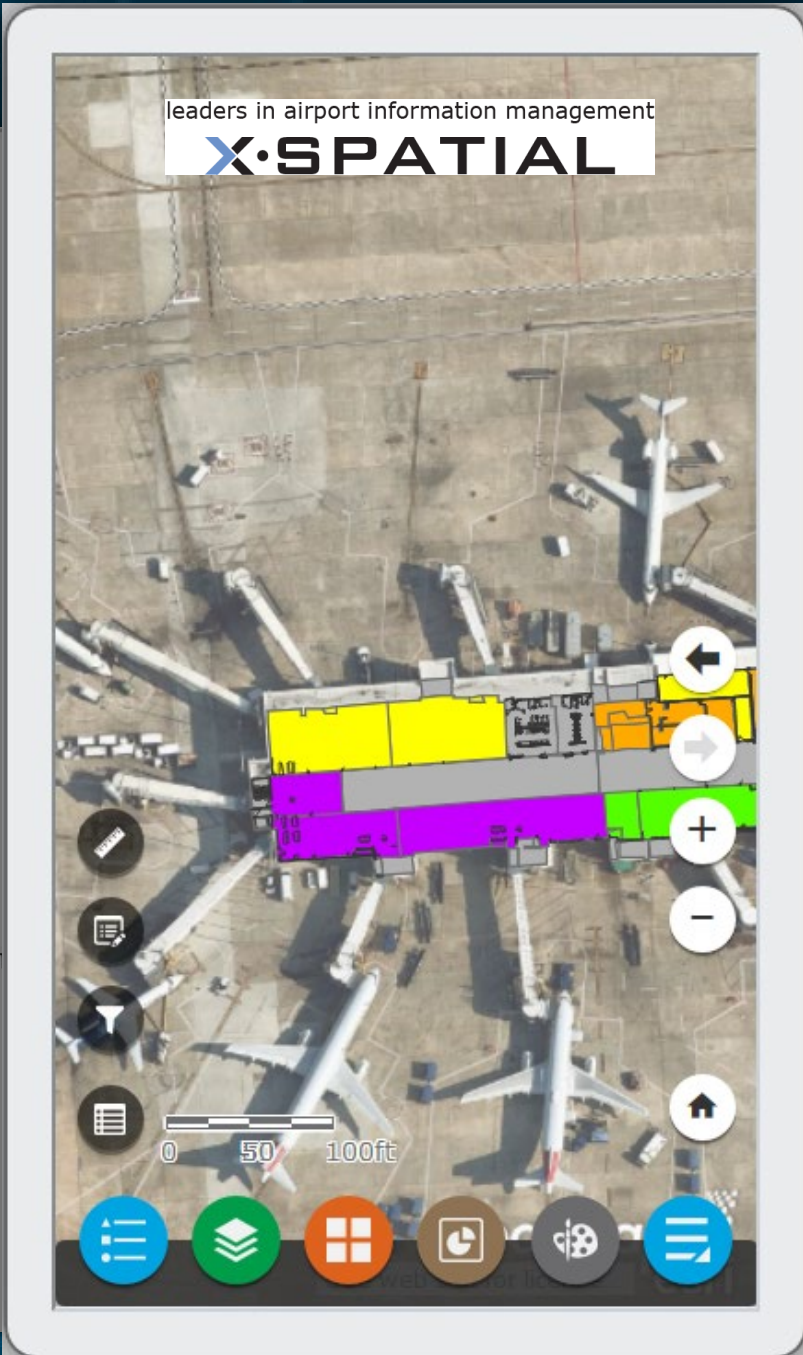
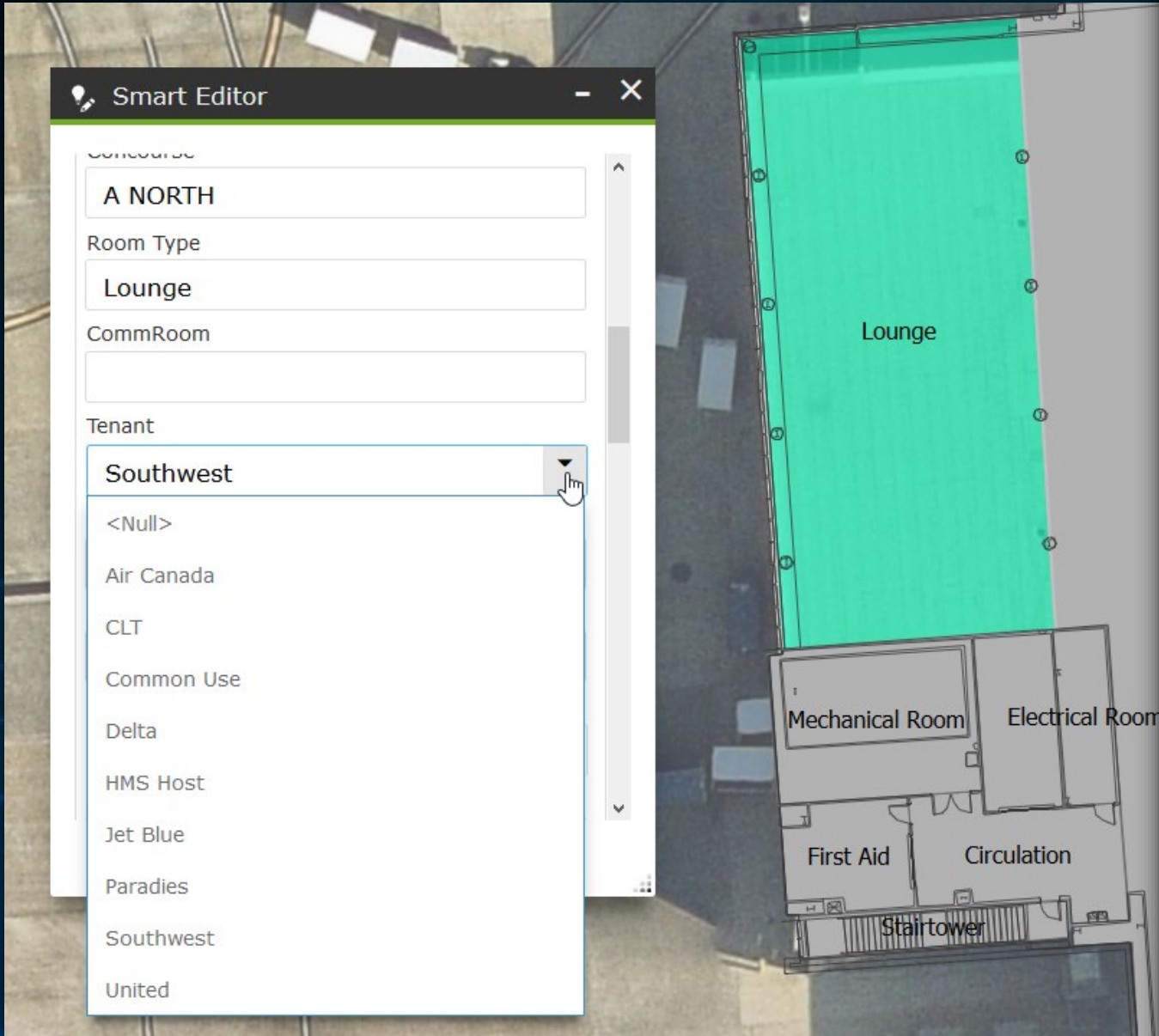
Draw

Select draw mode

Point, Line, Polygon, Polyline, Polygon (area), Polygon (ring), Circle, Ellipse, Rectangle, Star, Text

Undo Redo Clear

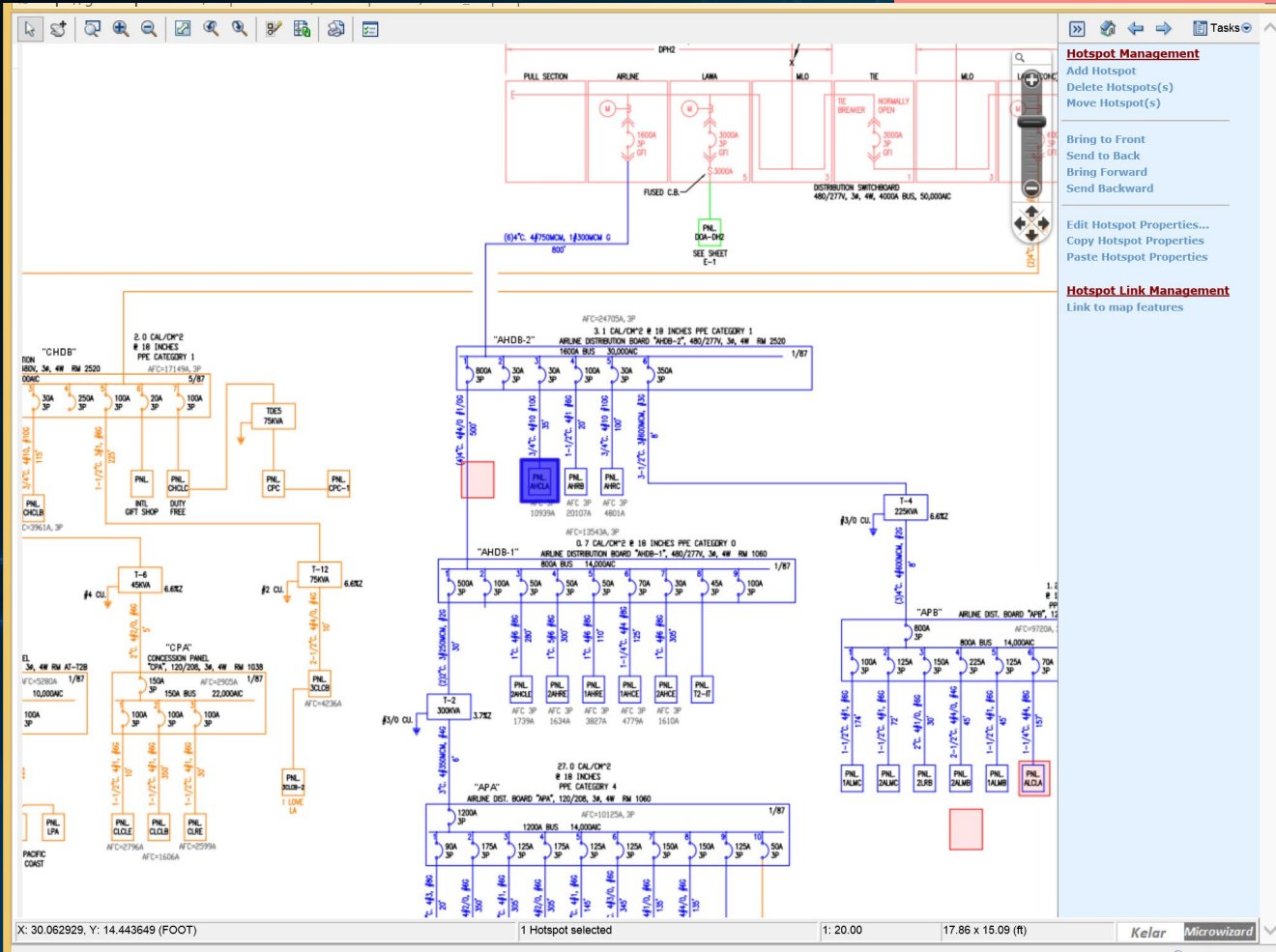
Mobile View & Edit



Asset Linked Drawings & Documents

Mapped Electrical Panels with 2-Way
Hyperlinked One-Line Diagrams

1



Datalink ID: 11954082
Entity Type Name: electrical_panel_area
Type Discriminator: NORMAL_PWR
DDMS Source: [2021515](#)
Comment: AHCLA
Panel Name: AHCLA
Related Documents (first 20):
: [2021511 AHCLA_1_T2 Equip Assessment Report 2009-11-01 342.pdf](#)
Hyperlinked Drawings:
[20060029A-11-E03 - Panel AHCLA \(4\)](#)
[20060029A-12-E04 - Panel Sch AHDB - AHCLA \(3\)](#)

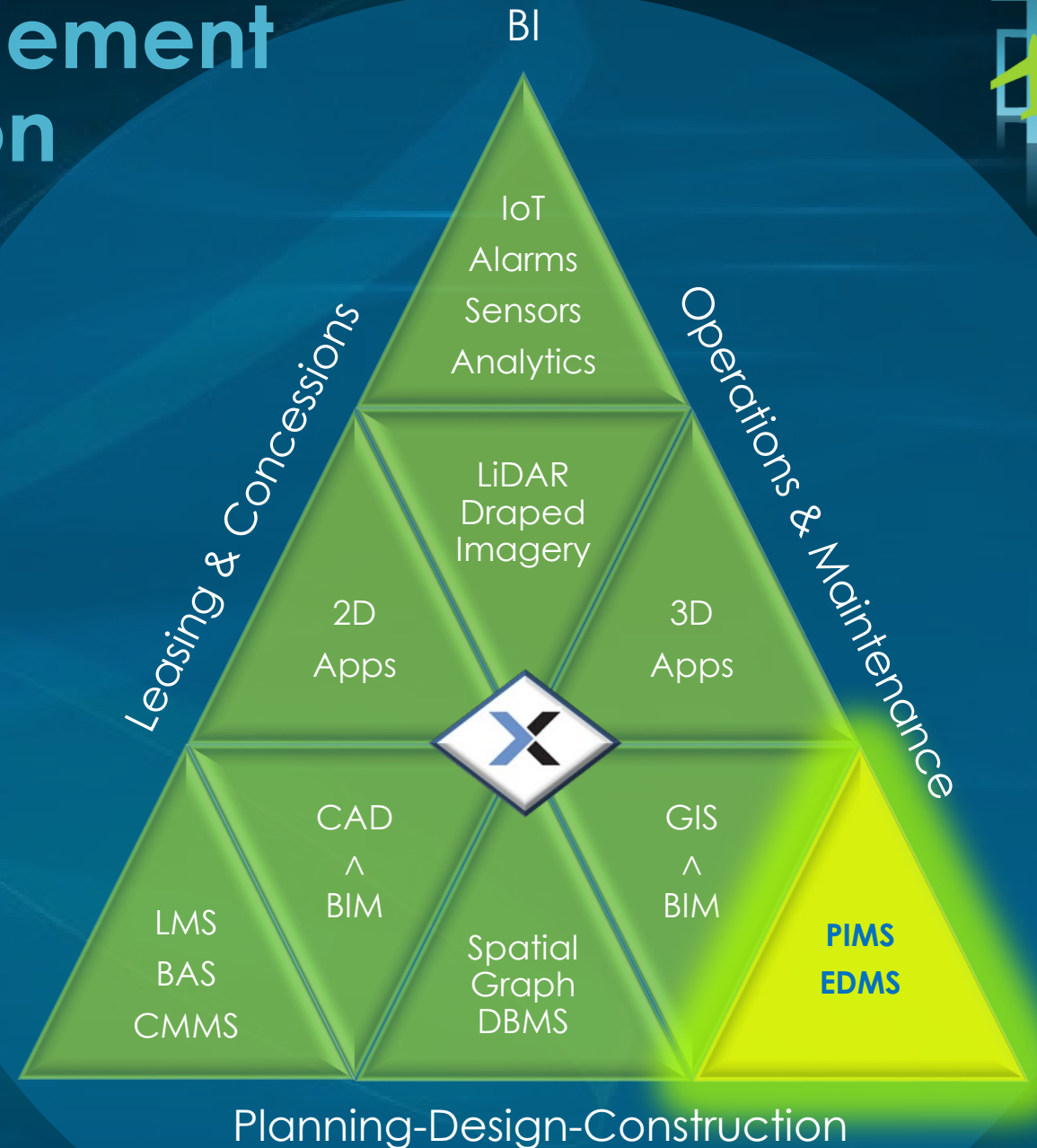
2



Project Information Management & Electronic Documentation



- ALP Change Requests / 7460s
- Construction/O&M Logistics
Outage Coordination
- Construction Photos
- LiDAR Scans & Survey Data
- ORAT
- As-Builts / O&M Manuals
- etc...



Integrated BIM Deliverables



Spatial Admin **DDMS Admin**

Hello Ahmad Maghbol
Logout

Home

Open Map

Facility
Los Angeles International Airport

LAX

Facility Level
Basement

Default Facility Map

Sector
Central Terminal Area

Building
Terminal 2

Floor
Departures - LAX000CTA00T203

Default Floor Map

Search

Data Explorer

Pavement Management

ELSEE

Mobile Data

Reports

Document Administration

Media Log Administration

Spatial Data Administration

Geodatabase Administration

System Administration

Layers

- Buildings
- Boundaries
- Property Mgmt
- Transportation
 - Aircraft
 - Vehicle
 - Rail
 - Pedestrian
 - Parking
 - Thomas Brothers
- Utilities
- Fences Gates and Walls
- Environmental
- Survey Control
- Geology and Soils
- Grounds
- Wells
- Contours and Coastline
- Parks and Recreation
- Grids
- Planned Construction
 - Airfield
 - Transport
 - Utilities
 - Bridges
 - Structures
 - Fences/Gates/Walls
 - Parking
 - Removed
 - Aerial
 - Raster Archive

Datalink ID: 36963442
 Entity Type Name: structure_existing_site
 DDMS Source: 2025309
 Disposition: IN_CONSTRUCTION
 Type Discriminator: STRUCTURE
 Building Name: Police Headquarters
 FM - Name: O0903
 Use Code: Security
 Type Code: Police
 Status Code: PERMANENT
 Address 1: 9160 S Loyola Blvd
 Revit Model: <https://autode.sk/35XJhexd>

Map Position

Create Point Data

Quickview

- LAMP Area
- MSC Area
- Mid Field
- North Park
- Northeast
- Pershing and Westchester
- Police Headquarter
- Remote Gates

Go! Update Add Remove

Private quickview

(+) Admin. quickview

Layer Set

Re-Load Update Add Remove

(*) Private layer set

(+) Admin. layer set

Map Tools

Markup Tools

X: 6436768.906330, Y: 1804937.869837 (FOOT)

0 features selected

1: 7327.18

8262.16 x 4108.82 (ft)

Powered by MapGuide

Sectors

	Location Code	Sector No.	Sector Name	Sector Name Code	Zoning	Actual Area	Datalink ID	Location	Date Created	Date Last Edited	DDMS Source	Comment	Disposition	Is Published	Type Discriminator
<input type="checkbox"/>	LAX000APM	000APM	APM Area	PM	NON-AIRPORT	13,517,434.00	38131143	LAX	2019/02/12@12:07:15	2019/02/12@12:09:24				Y	AIRPORT
<input type="checkbox"/>	LAX000CTA	01000CTA	Central Terminal Area	CT	TERMINAL	7,503,987.00	30366930	LAX	2018/03/08@06:49:22	2019/06/21@09:18:35				Y	AIRPORT
<input type="checkbox"/>	LAX00APMN	0300APMN	APM Maintenance	PN	MAINTENANCE	880,219.00	23469937	LAX	2016/09/28@14:43:23	2019/06/21@09:22:41				Y	AIRPORT
<input type="checkbox"/>	LAX00ASDN	0500ASDN	Airside North	AN	AIRPORT	1,708,040.00	24025522	LAX	2018/08/20@14:21:46	2019/06/21@09:22:41				Y	AIRPORT

(1-25 of 27 Records) First Previous Next Show ALL Records Show 25 Rows per page

Web-enabled BIM Viewing



AUTODESK VIEWER > DA5288_A_APF.rvt

Help Apps

Views Model browser Properties Settings

Comments Print Screenshot Share

Views

- Views
 - 3D
- Sheets
 - (UNKNOWN)A6-901 -
 - 00 - Starting Sheet
 - A1-101 - SITE PLAN - OVERALL
 - A10-100 - FF&E SCHEDULES
 - A10-101 - OVERALL FF&E
 - A10-102 - OVERALL FF&E
 - A10-103 - OVERALL FF&E
 - A10-201-G5 - FF&E PLAN -
 - A10-201-G6 - FF&E PLAN -
 - A10-201-G7 - FF&E PLAN -
 - A10-201-H1 - FF&E PLAN - HQ
 - A10-201-H2 - FF&E PLAN - HQ
 - A10-201-H3 - FF&E PLAN - HQ
 - A10-202-G4 - FF&E PLAN -
 - A10-202-G5 - FF&E PLAN -
 - A10-202-G6 - FF&E PLAN -

Web-enabled BIM Viewing



AUTODESK VIEWER > DA5288_A_APP.rvt

Views | Model browser | Properties | Settings

Help | Apps | Comments | Print | Screenshot | Share

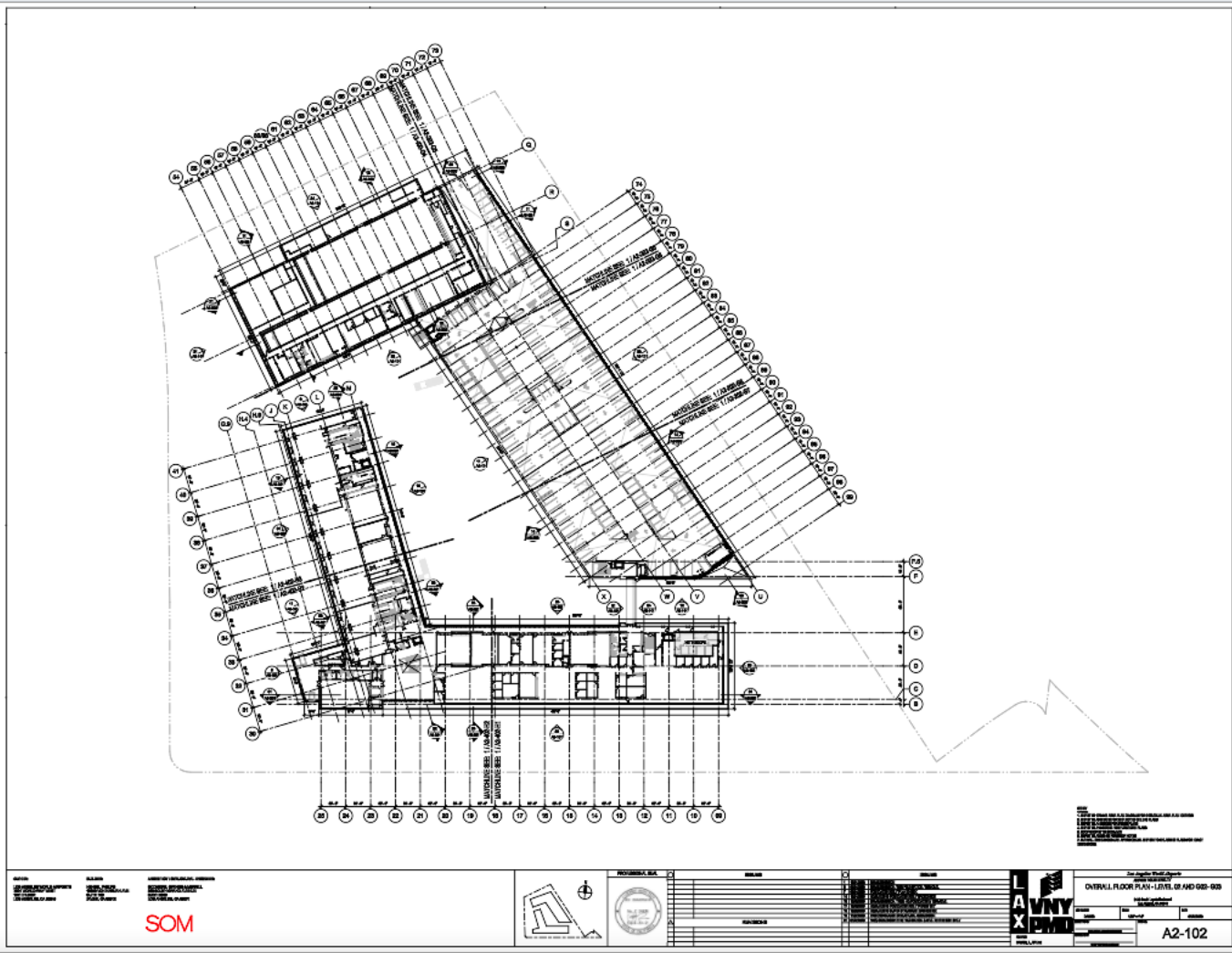
Views

- 3D
- Sheets
 - (UNKNOWN)A6-901 -
 - 00 - Starting Sheet
 - A1-101 - SITE PLAN - OVERALL
 - A10-100 - FF&E SCHEDULES
 - A10-101 - OVERALL FF&E
 - A10-102 - OVERALL FF&E
 - A10-103 - OVERALL FF&E
 - A10-201-G5 - FF&E PLAN -
 - A10-201-G6 - FF&E PLAN -
 - A10-201-G7 - FF&E PLAN -
 - A10-201-H1 - FF&E PLAN - HQ
 - A10-201-H2 - FF&E PLAN - HQ
 - A10-201-H3 - FF&E PLAN - HQ
 - A10-202-G4 - FF&E PLAN -
 - A10-202-G5 - FF&E PLAN -
 - A10-202-G6 - FF&E PLAN -
 - A10-202-G7 - FF&E PLAN -
 - A10-202-H1 - FF&E PLAN - HQ

BIM Exported Drawing Sheet Viewing

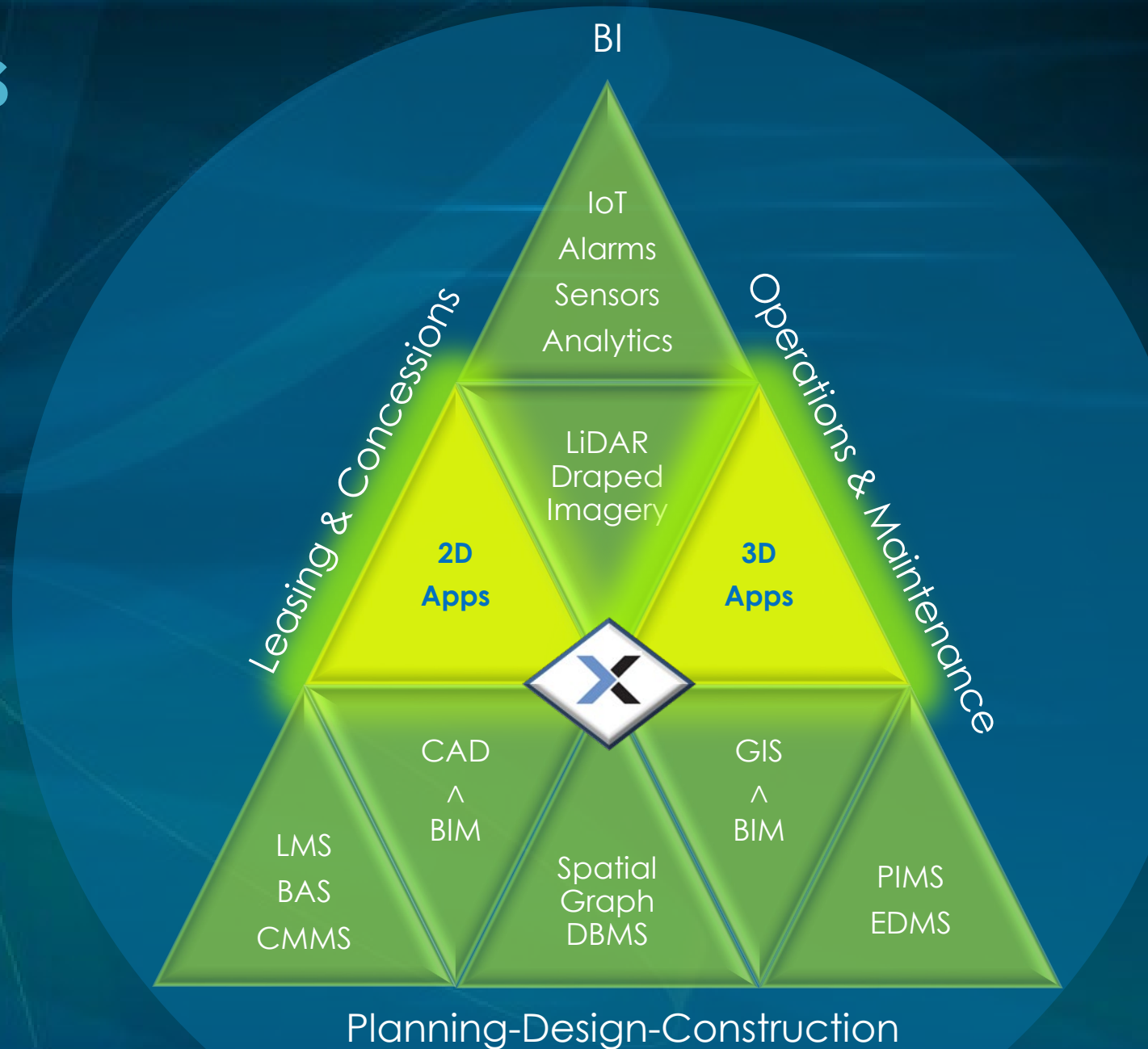


- Views ☰ ☱ ✕
- A2-044 - ENCLOSURE TYPE
 - A2-045 - ENCLOSURE TYPE
 - A2-051 - OPEN GARAGE
 - A2-061 - HQ BUILDING AREA
 - A2-062 - GARAGE AREA
 - A2-063 - HQ BUILDING AREA
 - A2-064 - GARAGE AREA
 - A2-065 - HQ BUILDING AREA
 - A2-066 - GARAGE AREA
 - A2-067 - HQ BUILDING AREA
 - A2-068 - GARAGE AREA
 - A2-101 - OVERALL FLOOR
 - A2-102 - OVERALL FLOOR**
 - A2-103 - OVERALL FLOOR
 - A2-104 - OVERALL FLOOR
 - A2-201-G4 - FLOOR PLAN -
 - A2-201-G5 - FLOOR PLAN -
 - A2-201-G6 - FLOOR PLAN -
 - A2-201-G7 - FLOOR PLAN -
 - A2-201-H1 - FLOOR PLAN - HQ
 - A2-201-H2 - FLOOR PLAN - HQ
 - A2-201-H3 - FLOOR PLAN -



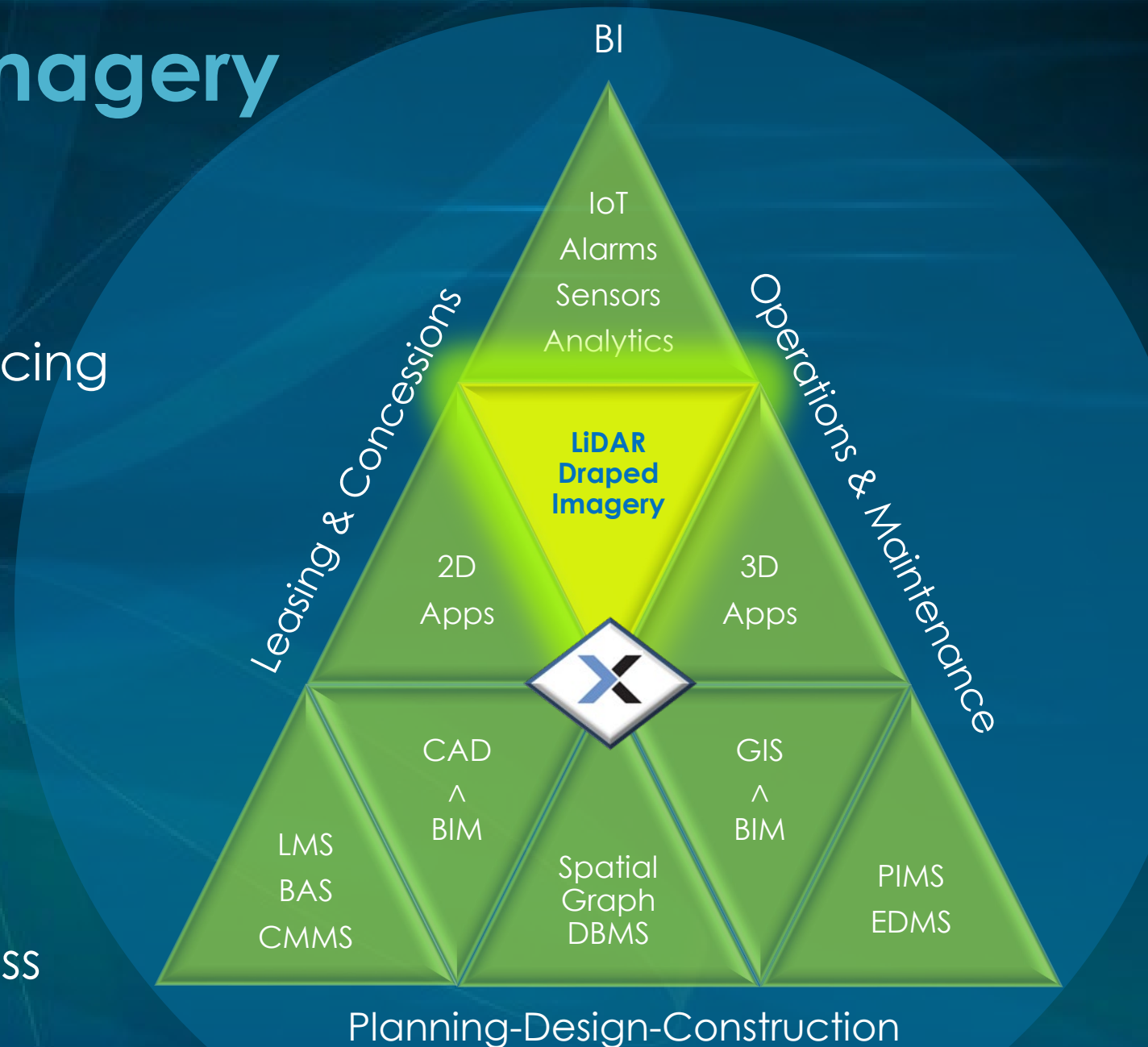
2D & 3D Applications

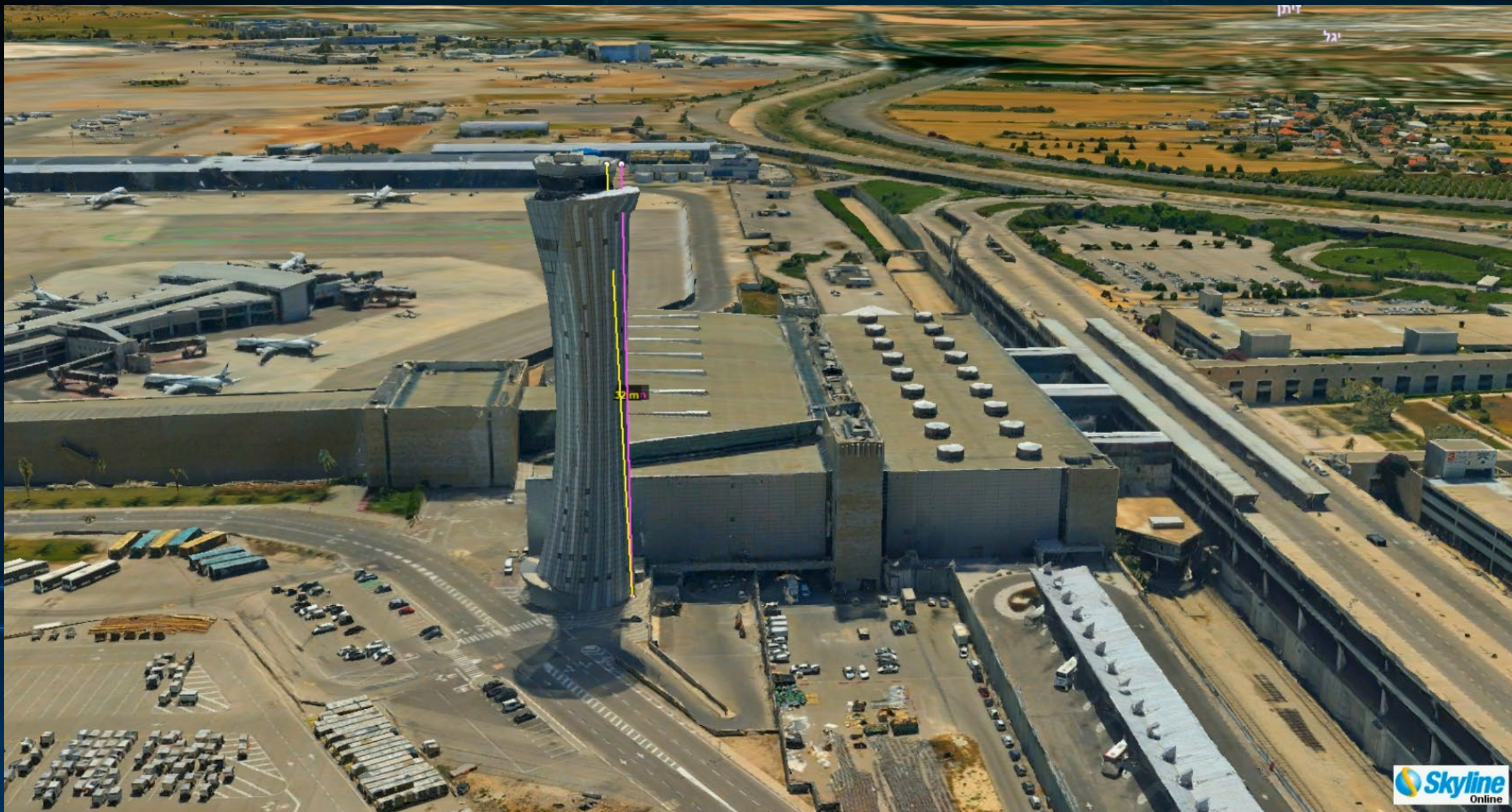
- ➔ Most map-based applications used by airport owner are 2D; easier to understand
- ➔ 3D mostly used by airport owner for:
 - Height constraints analysis related to airspace
 - Line of site analysis for ATCT and CCTV camera placement
 - Subsurface utilities depth analysis



LiDAR with Draped Imagery

- Survey Automation Tools
- Ground Control Points (GCP)s
Enable On-Going Updates Splicing
 - Outdoor
 - Indoor
- GIS Integration
 - 2D/3D Linked Views
 - 2D/3D Linked Assets
- 3D Measurement Tools
- Improved Situational Awareness





3D Aerial Imagery Leveraging LiDAR & PhotoMesh

Courtesy of Skyline Software Systems

3D LiDAR with Draped Imagery



The screenshot displays the IMTG (Infrastructure Map Cover) software interface, which is used for managing and visualizing 3D LiDAR data. The interface is divided into several sections:

- Left Panel (Navigation and Search):** Contains a search bar, a data explorer, and various management tools like 'Pavement Management', 'Reports', and 'Document Administration'. It also shows a 'Hello Ahmad Maghoub' message and a 'Logout' button.
- Layers Panel:** Lists various data layers such as 'AED, Fire Ex', 'Equipment', 'Interior Features', 'Floorplan', 'Access Points', 'Room Information', 'Leasehold Information', 'Cleaning Resp', 'Leaseholder', 'Space Class', 'Space Descript', 'Space Numbers', 'Base Map', and 'Aerial'. Each layer has a checkbox to toggle its visibility.
- Main View:** Shows a 3D perspective view of an airport terminal interior. A Trimble LiDAR scanner is visible in the foreground, and the terminal's layout is overlaid with 3D models. The view is draped with imagery, showing the terminal's floor and walls. A 'Paging Position' tool is visible on the right side of the view.
- Right Panel (Map Position and Tools):** Includes a 'Map Position' section with 'Popup' and 'Docked' options. Below it is a 'Create Point Data' section with 'Add Point(s)', 'Multi-Point Mode', and 'Point Classification' options. The 'Point Classification' section lists categories like 'buildings_access', 'passngr_board_point', and 'BOARDING_CHECK'. There are also 'Auto-Generate Attributes' and 'Auto-Gen Suffix' options. The bottom right corner shows 'Quickview', 'Layer Set', 'Map Tools', and 'Markup Tools'.
- Bottom Panel (3D View):** Shows a 3D perspective view of the terminal interior. A red vertical line indicates a point height measurement of 2.655 m. A yellow cube is visible in the upper left corner of the view. A 'Measure Preferences' dialog box is open in the bottom right corner, showing the following data:

Point height to horizontal reference plane			
Point	X	6438160.844	
Distance	Y	1802759.563	
Line	Z	-1.047	
Catenary	Distance	2.655 m	
Area			
Volume			

Buttons for 'Copy to Clipboard', 'Clear', and 'Copy to Feature' are visible at the bottom of the dialog box. The bottom right corner of the interface shows 'Powered by Infrastructure Map Cover' and 'orbit' logo.



Charlotte Douglas International Airport LiDAR Scanning Project

Business Drivers

Create accurate, up-to-date floor plans drawings

- Leasing purposes
- Integration with other systems (sensors, other location-dependent systems, etc.)

Create a digital twin of the Terminal and Concourses

- Asset management (location, extraction, etc.)
 - Signage / HVAC / Fire Extinguishers, etc.
- Door/room renumbering
- Space usage
- Situational awareness
- Wayfinding

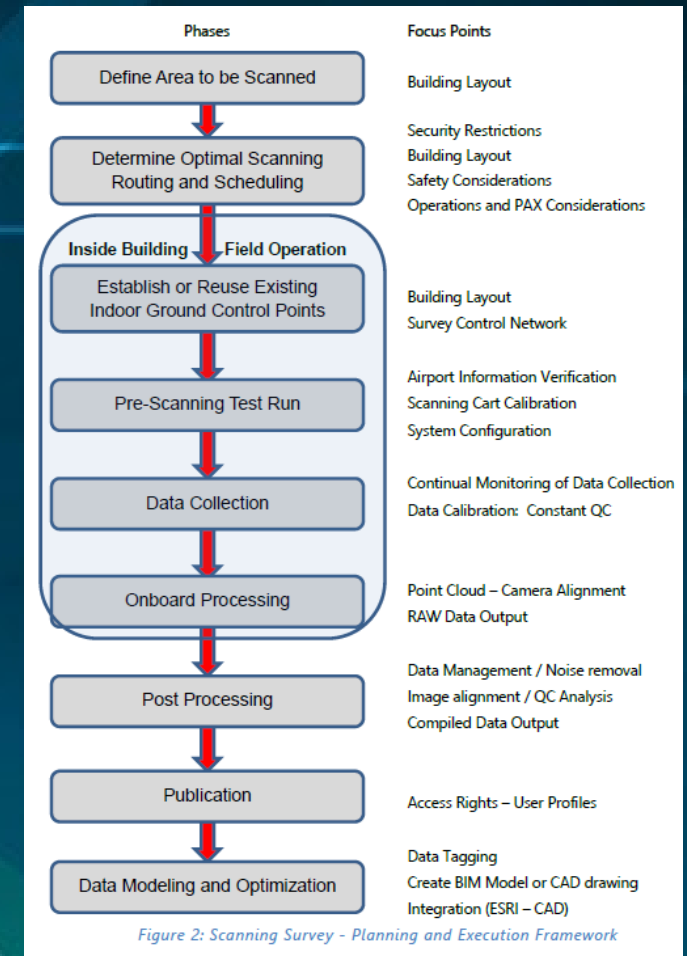
Project Overview

- Approximately 1.8 million SQFT of the terminal area scanned in 7 Days
- 5.16 TB of data (LiDAR & 360d images) delivered
- Over 67000 360d images
- 299 1cm Color LAS files edited & combined to create 17 distinct floors
- 17 CAD floor plans

Mission Planning

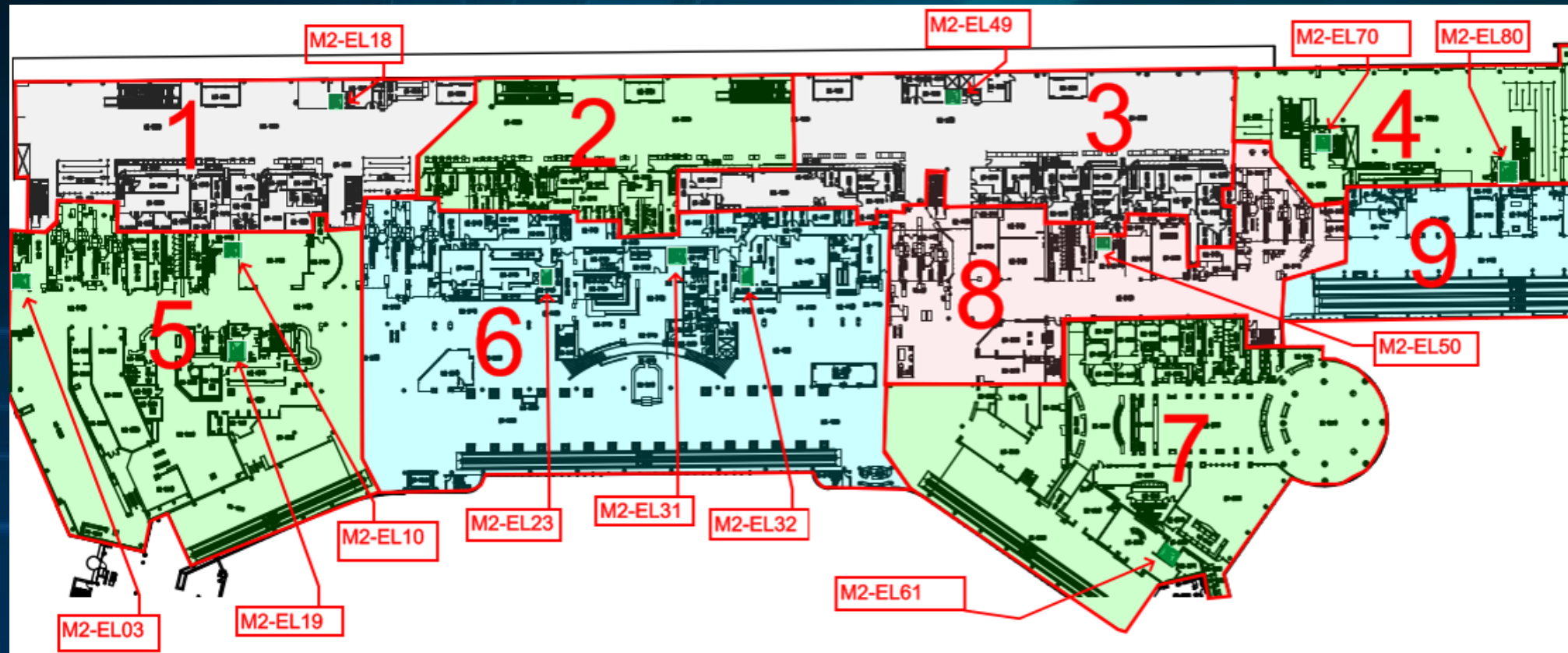
Mission planning was based on the framework established in CLT's Guideline for indoor scanning document.

- The scanning routes for the terminal and concourses were created based on levels, regions and rooms.
- Other considerations for planning included flight ops, inaccessible or out-of-service elevators, secured area's escort requirements, etc.



Mission Planning

Scanning regions were created and elevators were marked to assist in more efficient routing



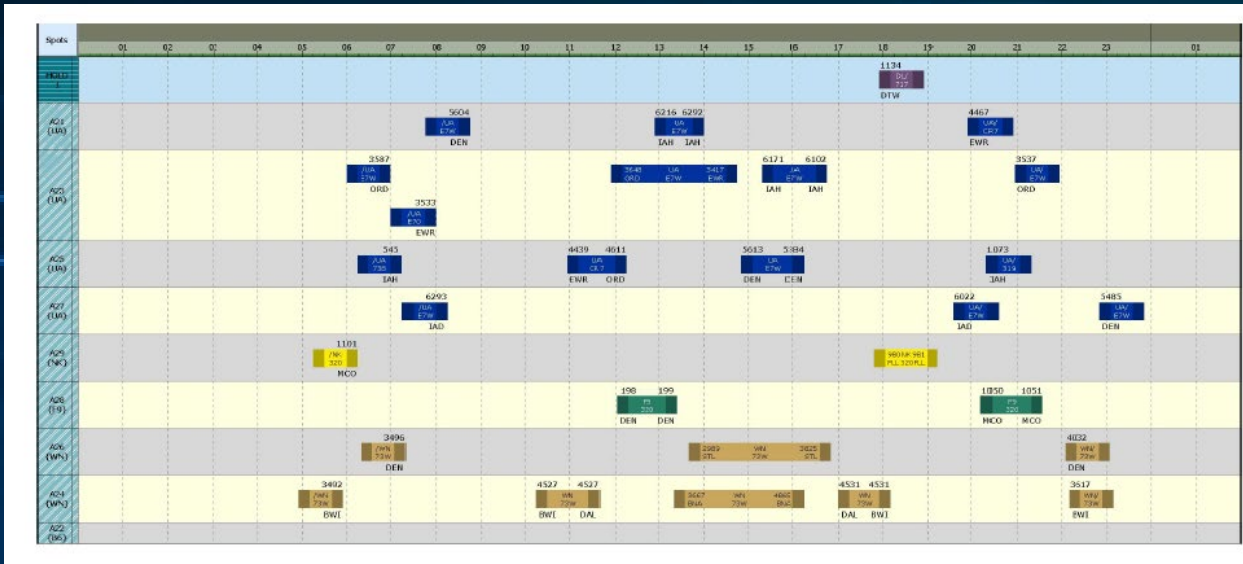
Main Terminal – Ticket Level – Overview of scanning regions

Mission Planning

- A detailed schedule for scanning was created based on the number of rooms within each level and region
- A report was also created to inform the scanning crew of issues that need to be addressed and spaces to avoid
- Aircraft operations per concourse was one of the key drivers for mission planning to avoid a high number of passengers, which affects the quality and increases the post-processing of LiDAR data

Building	Level	Region	Rooms	Time @ 60 rooms per hour	Sunday		Monday					
					10-14am	14-20pm	06-12am	12-18pm	18-24pm	00		
				60								
Terminal	Basement	Region 1	132	2.20								
		Region 2										
		Region 3	6	0.50		0.50						
	Ramp	Region 1	239	3.98	Together with Ticket region 4							
		Region 2										
		Region 3										
		Region 4										
		Region 5										
		Region 6										
	Ticket	Region 1	480	8.00	8.00							
		Region 2										
		Region 3										
		Region 4										
		Region 5										
Region 6												
Region 7												
Region 8												
Region 9												
Office	Region 1	259	4.32									
	Region 2											
	Region 3											
	Region 4											
	Region 5											
Tower 01	Region 1	21	0.35									
	Region 2											

Scanning planning



Aircraft Operations: day-overview
Concourse A

Building	Level	Region	Scanning times	Comments	Comments
Terminal	Office	Region 1	After 19:00	Includes a Mechanical room, roof access only: out-of-scope	ELEV. M3-EL10 inactive last visit
		Region 2			ELEV. M3-EL31 is out-of-service
		Region 3		Includes a Mechanical room, roof access only: out-of-scope	
		Region 4		Mechanical rooms, roof access only: out-of-scope	
		Region 5		TSA Offices – Access via Elevator M2-EL80 on ticket level	Escort required for TSA offices
	Tower 01	Region 1	N/A	No access Covid 19 restrictions	
		Region 2	N/A	Mechanical room, roof access only: out-of-scope	
Tower 02	Region 1	N/A	No access Covid 19 restrictions		

A typical report showing potential scanning issues for a building/level/region

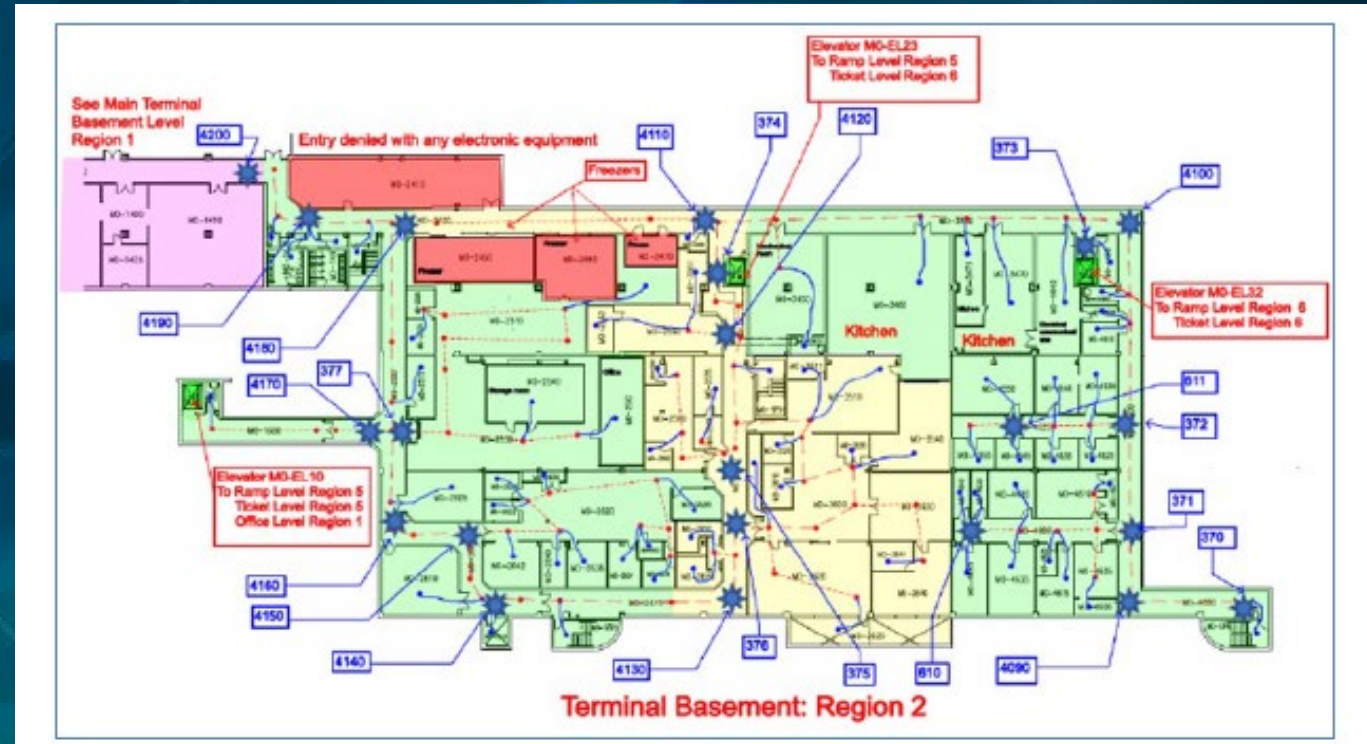
Survey

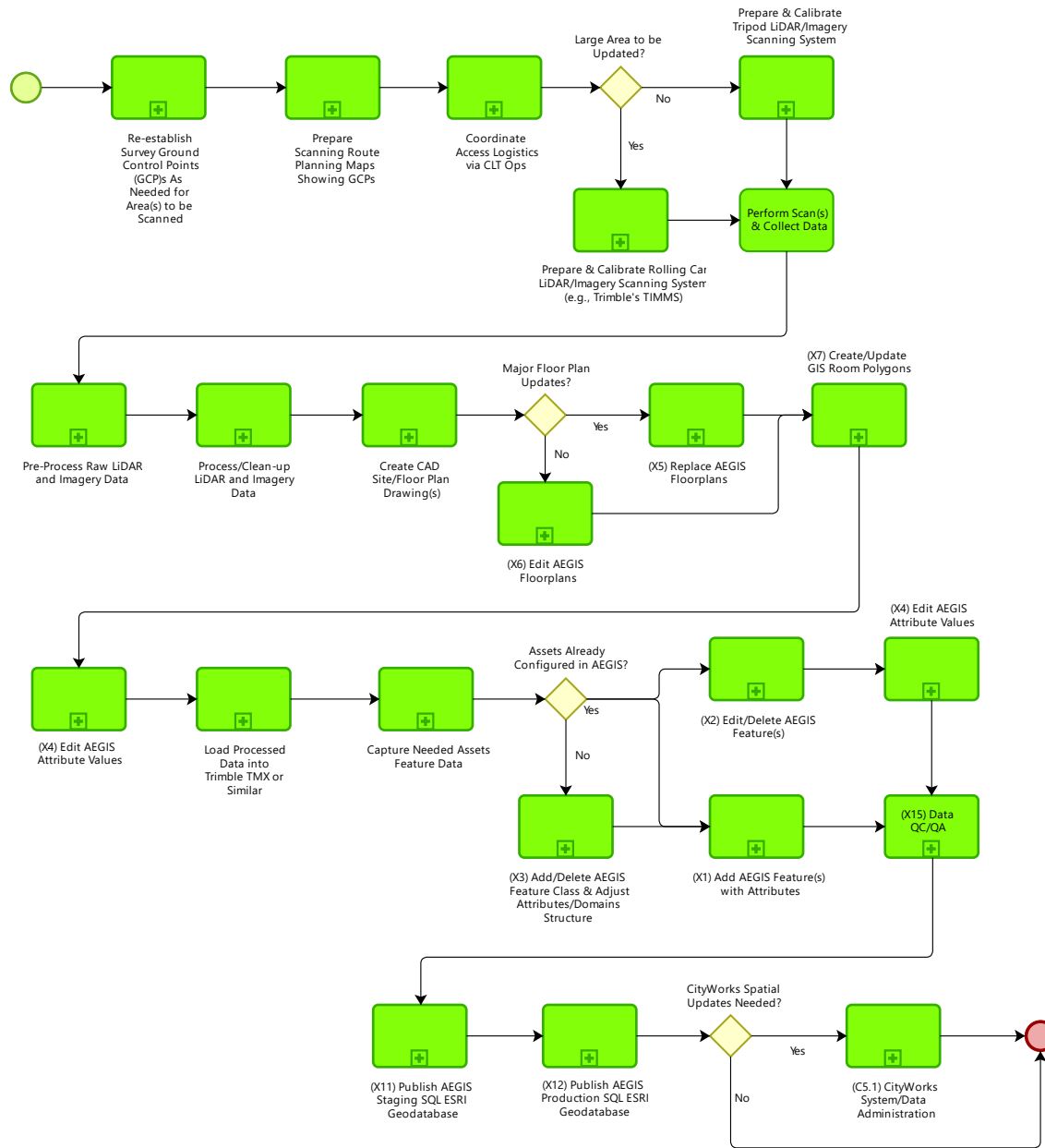
Survey Control Network and Supplemental Indoor Ground Control Points are keys for sustainability & updating the master LiDAR model

- CLT's Control survey network establishes a common, consistent network of physical monuments that are the basis for the horizontal and vertical location of CLT.

Supplemental Indoor-Ground-Control-Points (IGCP)

- CLT Terminals and Buildings are environments where the accuracy, integrity, continuity and consequent suitable availability of GNSS signals cannot be assured.
- Supplemental Indoor-Ground-Control-Points are densification or extension of the survey control network that are required for future scanning projects.





LiDAR Data Update Process


Incremental update of master model (sustainability) is the key benefit of creation of IGCP's.

Survey

The survey deliverables included;


- CAD drawings
- Survey report including photographs of IGCP
- Excel file identifying IGCP point #, type, location, etc.

Name: 263
 Concourse: EXTERIOR TERMINAL BAGGAGE
 Level: RAMP
 Description: PK NAIL SET IN CONCRETE @ DOOR TO M1-0210



NC State Plane 1983 **WGS 1984**

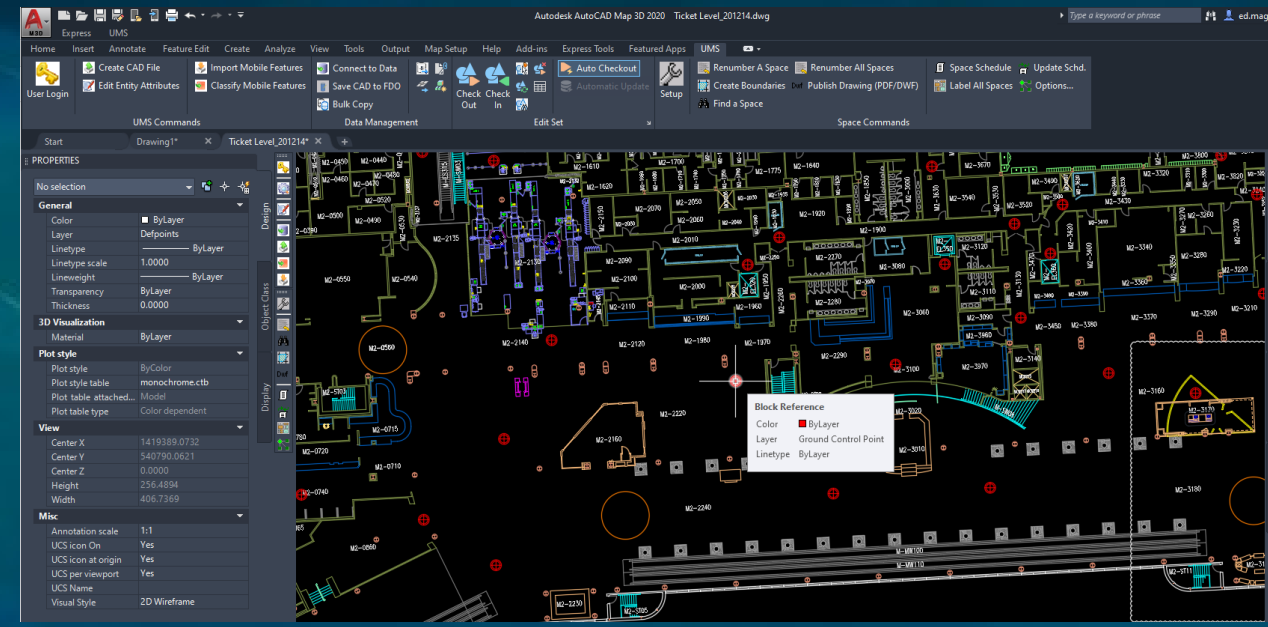
Northing: 540783.02 Longitude: 80° 56' 42.3814" W
 Easting: 1419119.00 Latitude: 35° 13' 12.9543" N
 Elevation: 723.48 Ellipsoid H: 623.13



Sample GCP Report

NAME	LATITUDE	LONGITUDE	Altitude	SD LAT	SD LONG	SD ALT	Building	Floor	Region	Marker
259	3,522,041,044	-8,094,534,287	3,901,006,484	0.02	0.02	0.02	Terminal	Ramp	5	PK NAIL SET IN CONCRETE
263	3,522,026,510	-8,094,509,205	3,899,319	0.02	0.02	0.02	Terminal	Ramp	5	PK NAIL SET IN CONCRETE
264	3,522,010,023	-8,094,496,418	3,896,926,089	0.02	0.02	0.02	Terminal	Ramp	3	PK NAIL SET IN CONCRETE
265	3,521,957,674	-8,094,510,123	3,896,994,361	0.02	0.02	0.02	Concourse B	Ramp	1	PK NAIL SET IN CONCRETE
266	3,521,928,509	-8,094,503,908	3,895,924,826	0.02	0.02	0.02	Concourse B	Ramp	2	PK NAIL SET IN CONCRETE
267	3,521,950,831	-8,094,523,308	3,895,890,475	0.02	0.02	0.02	Concourse B	Ramp	1	PK NAIL SET IN CONCRETE
268	3,521,964,539	-8,094,496,604	3,895,495,625	0.02	0.02	0.02	Concourse B	Ramp	1	PK NAIL SET IN CONCRETE
269	3,521,916,157	-8,094,506,394	3,895,156,039	0.02	0.02	0.02	Concourse B	Ramp	2	PK NAIL SET IN CONCRETE
271	3,521,919,509	-8,094,530,035	3,896,674,679	0.02	0.02	0.02	Concourse B	Ramp	2	PK NAIL SET IN CONCRETE
272	3,521,902,572	-8,094,509,214	3,895,206,638	0.02	0.02	0.02	Concourse B	Ramp	2	PK NAIL SET IN CONCRETE
273	3,521,890,669	-8,094,511,103	3,895,904,252	0.02	0.02	0.02	Concourse B	Ramp	3	PK NAIL SET IN CONCRETE
275	3,521,865,633	-8,094,545,329	3,896,054,864	0.02	0.02	0.02	Concourse B	Ramp	3	PK NAIL SET IN CONCRETE
277	3,521,830,996	-8,094,543,305	3,896,842,286	0.02	0.02	0.02	Concourse B	Ramp	4	PK NAIL SET IN CONCRETE
278	3,521,837,984	-8,094,507,941	3,896,636,608	0.02	0.02	0.02	Concourse B	Ramp	4	PK NAIL SET IN CONCRETE
279	3,521,817,671	-8,094,557,798	3,896,882,499	0.02	0.02	0.02	Concourse B	Ramp	4	PK NAIL SET IN CONCRETE
280	3,521,811,318	-8,094,513,608	3,896,771,857	0.02	0.02	0.02	Concourse B	Ramp	4	PK NAIL SET IN CONCRETE
281	3,521,793,257	-8,094,517,248	3,896,045,974	0.02	0.02	0.02	Concourse B	Ramp	4	PK NAIL SET IN CONCRETE
282	3,521,600,913	-8,094,501,017	3,896,657,201	0.02	0.02	0.02	Concourse B	Ramp	4	PK NAIL SET IN CONCRETE
286	3,522,022,753	-8,094,336,947	3,896,261,367	0.02	0.02	0.02	Terminal	Ramp	6	PK NAIL SET IN CONCRETE
289	3,522,034,969	-8,094,254,035	3,896,741,682	0.02	0.02	0.02	Terminal	Ramp	6	PK NAIL SET IN CONCRETE
290	3,522,014,352	-8,094,278,856	3,897,896,298	0.02	0.02	0.02	Terminal	Ramp	6	PK NAIL SET IN CONCRETE
291	3,522,027,156	-8,094,303,396	3,896,846,835	0.02	0.02	0.02	Terminal	Ramp	6	PK NAIL SET IN CONCRETE
292	3,521,994,696	-8,094,303,002	3,895,881,331	0.02	0.02	0.02	Terminal	Ramp	6	PK NAIL SET IN CONCRETE
293	3,522,001,748	-8,094,276,576	3,896,342,698	0.02	0.02	0.02	Terminal	Ramp	6	PK NAIL SET IN CONCRETE
295	3,521,960,575	-8,094,264,388	3,895,327,813	0.02	0.02	0.02	Concourse C	Ramp	1	PK NAIL SET IN CONCRETE
296	3,521,947,413	-8,094,256,903	3,895,877,399	0.02	0.02	0.02	Concourse C	Ramp	1	PK NAIL SET IN CONCRETE
297	3,521,927,551	-8,094,249,977	3,896,809,347	0.02	0.02	0.02	Concourse C	Ramp	2	PK NAIL SET IN CONCRETE

PK Nail set in concrete



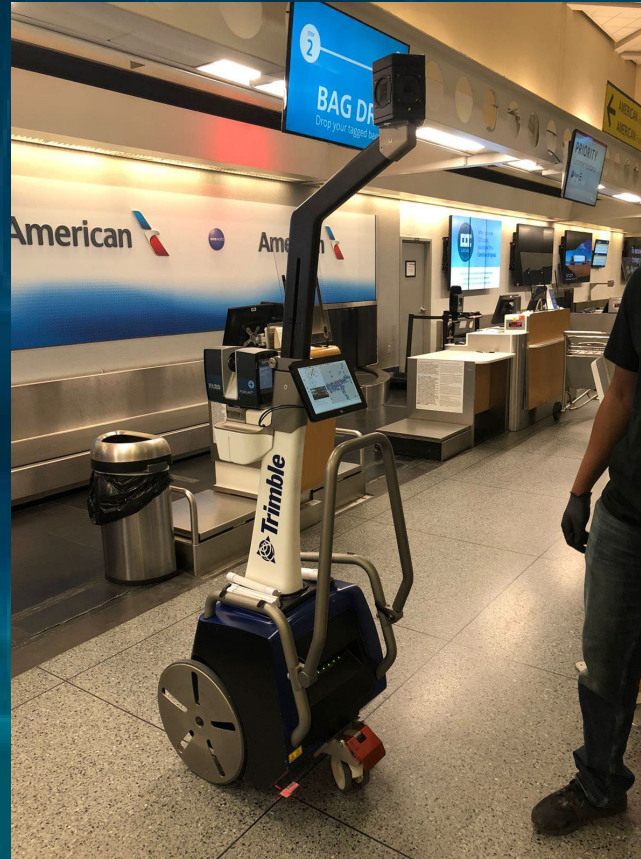
AutoCAD floor plan with marked IGCP's

Scanning

Mission overview

FLOOR	AREA	REGION	SCAN MISSION	HDPics numbering	Total
03_Ticket	Terminal	1	1	0000-3754	3,755
03_Ticket	Terminal	2			
03_Ticket	Terminal	3			
03_Ticket	Terminal	4	2	0000-1176	1,177
03_Ticket	Terminal	8			
03_Ticket	Terminal	9			
03_Ticket	Terminal	5	3	0000-3322	3,323
03_Ticket	Terminal	7			
04_Office	Terminal	1	4	0000-3264	3,265
04_Office	Terminal	2			
04_Office	Terminal	3			
03_Ticket	Concourse C	All	5	2034-1624	2,591
02_Ramp	Terminal	3		4839-6394	1,556
03_Ticket	Terminal	6		0000-2033	2,034
03_Ticket	Concourse A	All	6	2056-4390	2,335
04_Office	Concourse D	All		0000-0661	662
04_Office	Terminal	5		1055-1707	643
03_Ticket	Concourse A North	All	7	0000-2791	2,792
04_Office	Concourse A North	All		2798-3548	751
03_Ticket	Concourse B	All		4003-6644	2,642
00_Basement	Terminal	1	8	0626-3839	3,214
00_Basement	Terminal	2		0013-0327	314
00_Basement	Terminal	3			
02_Ramp	Concourse A North	2	9	0000-3825	3,826
02_Ramp	Concourse A North	3			
02_Ramp	Concourse A North	4			
02_Ramp	Concourse A North	1	10	0001-0593	593
02_Ramp	Terminal	1		0733-2378	1,646
02_Ramp	Terminal	2			
03_Ticket	Concourse D	Time Restrictions	11	0001-0636	636
02_Ramp	Terminal	5		0974-4626	3,653
02_Ramp	Terminal	6			
03_Ticket	Concourse D	All	12	0000-1435	1,428
02_Ramp	Concourse A	All		0000-3428	3,429
02_Ramp	Concourse B	All			
02_Ramp	Concourse C	All	14	0000-4235	4,235
02_Ramp	Concourse E	All		0000-8256	8,257
03_Ticket	Concourse E	All			
03_Ticket	Concourse C	Missing Rooms	16	0485-0662	178
03_Ticket	Concourse D	Missing Rooms		0000-0235	236
02_Ramp	Terminal	1 - Missing Rooms		1191-1218	28
03_Ticket	Terminal	6 - Missing Rooms	0976-1128	153	
					64,140

Mission Planning

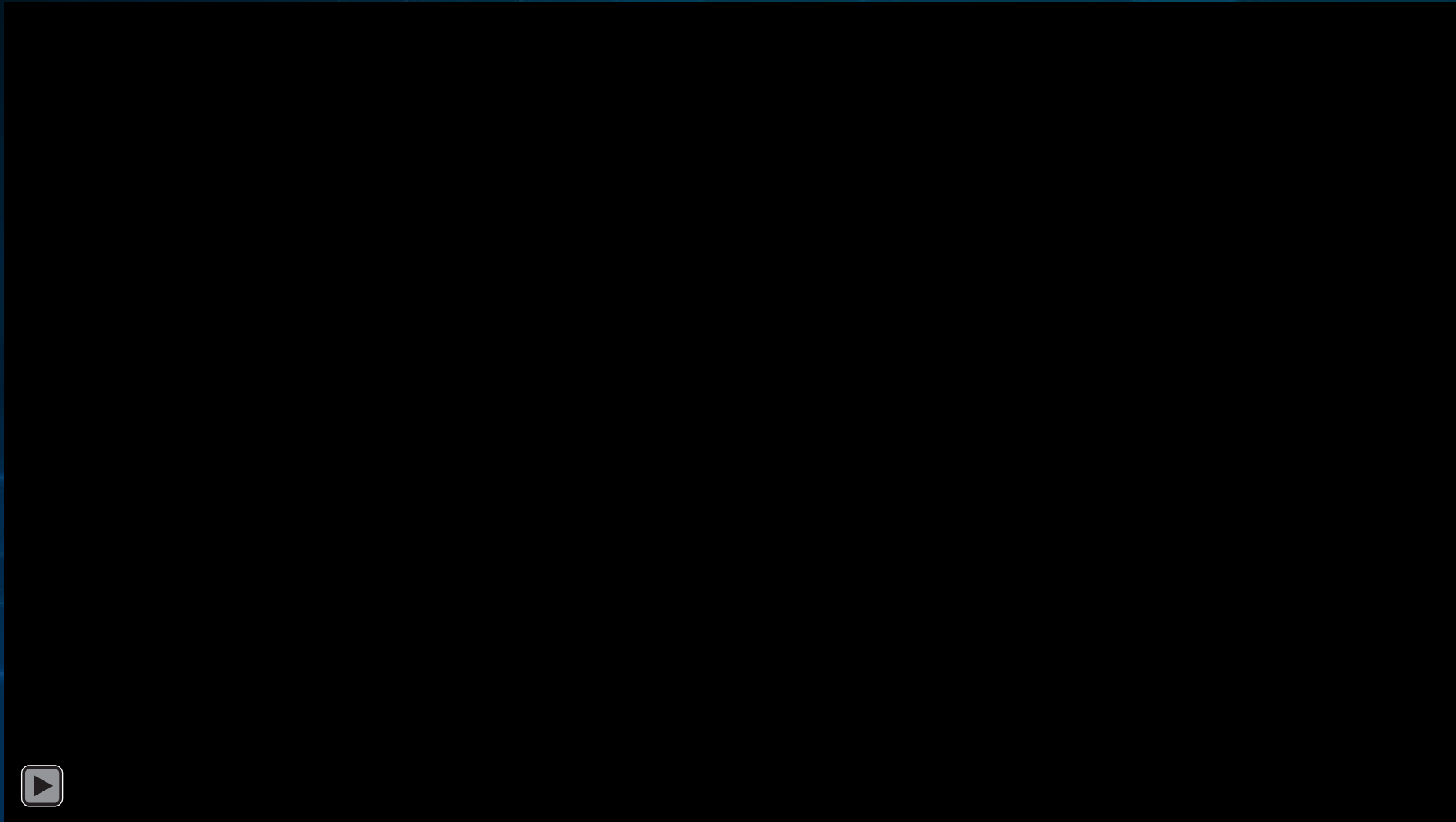


Trimble Indoor Mobile Mapping System (TIMMS)

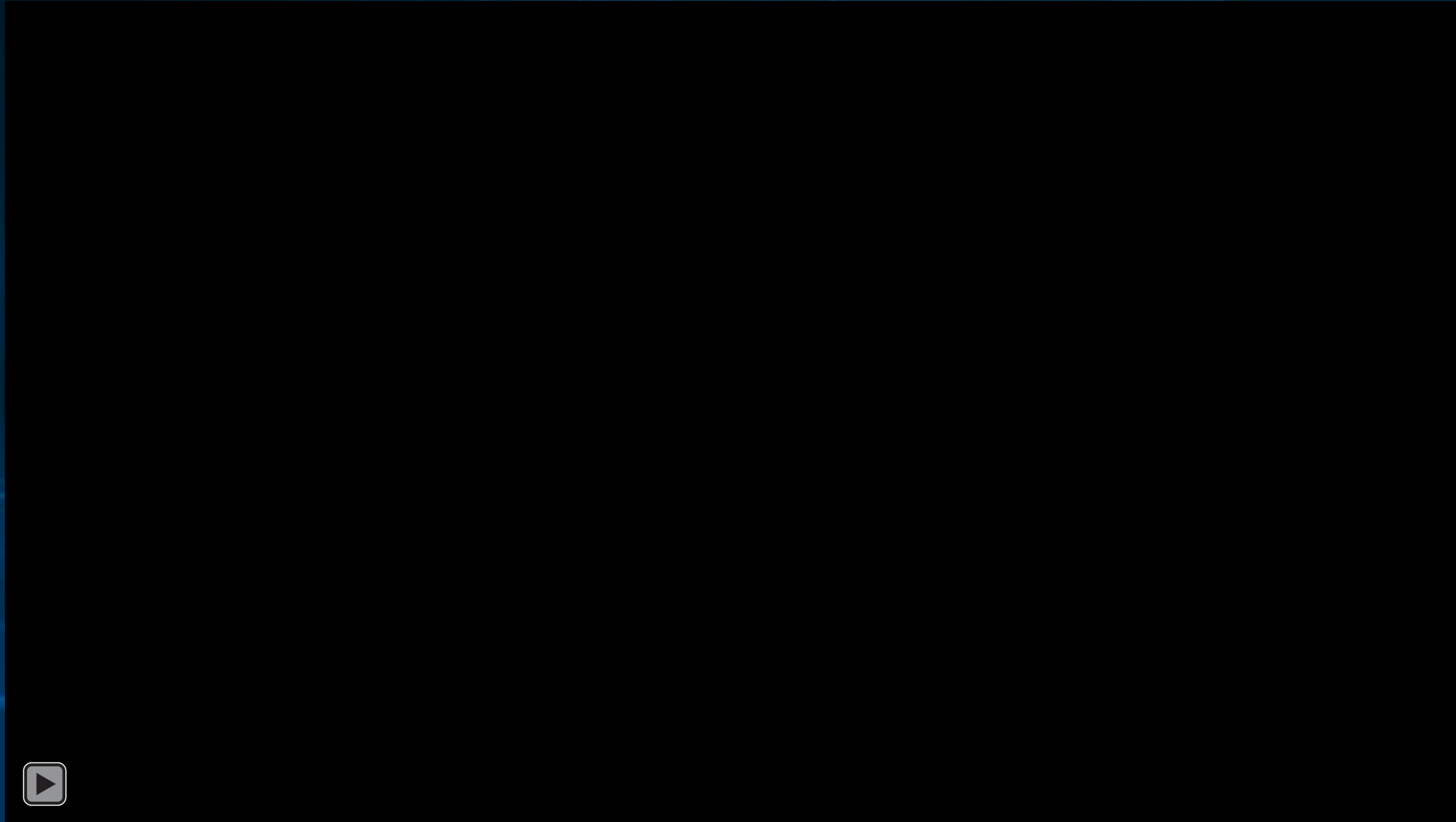


TIMMS interface showing scanned path and 360° image capture locations

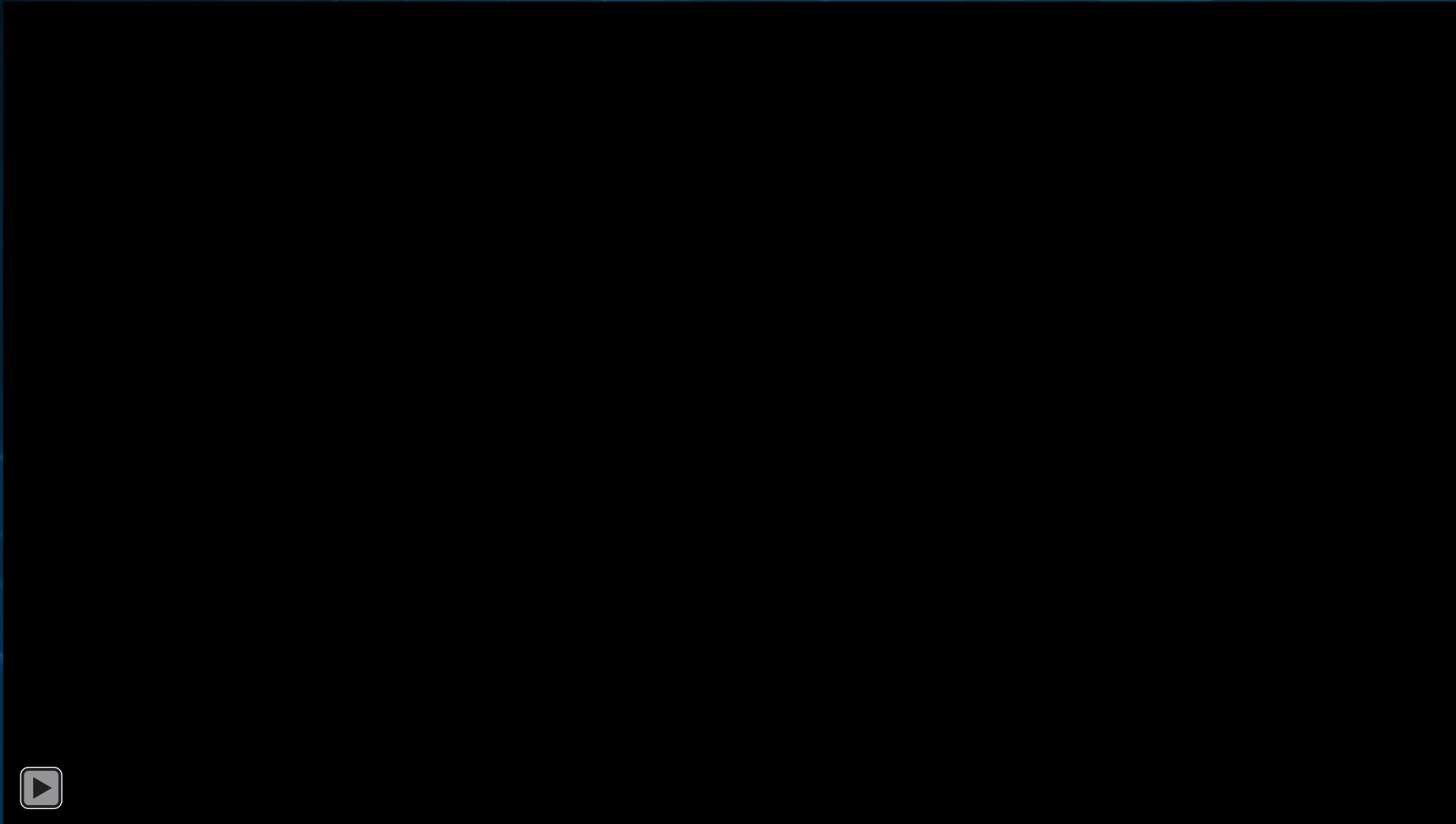
Scanning - Interior



Scanning - Exterior



Scanning - Obstacles



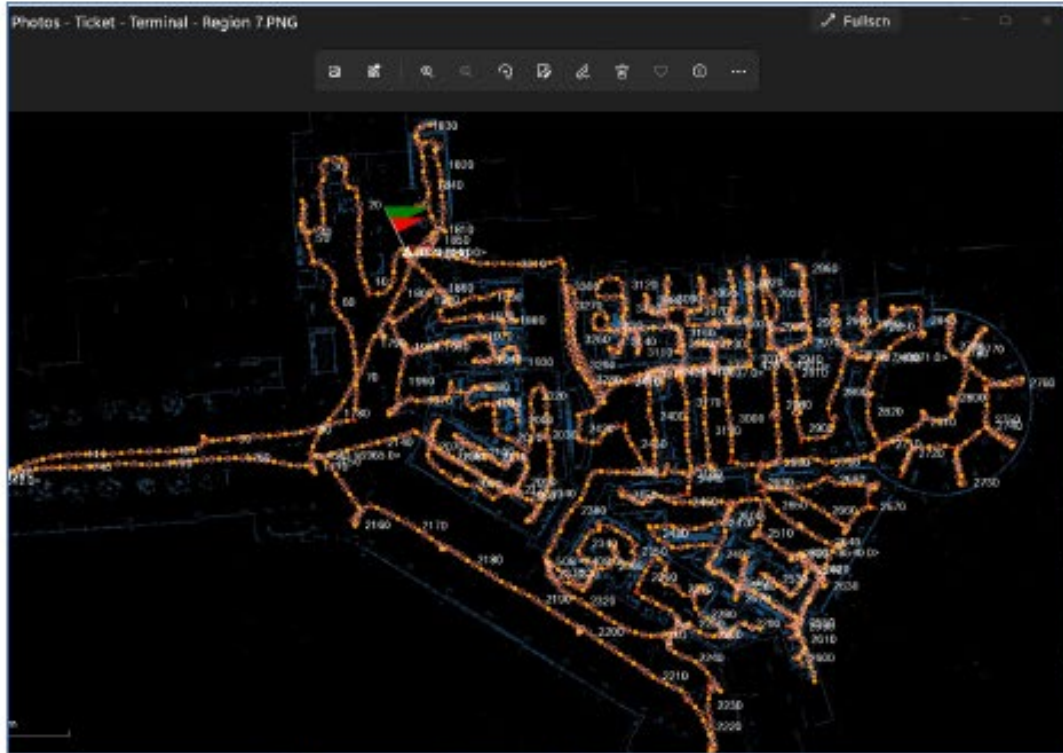
Scanning – Mechanical Rooms



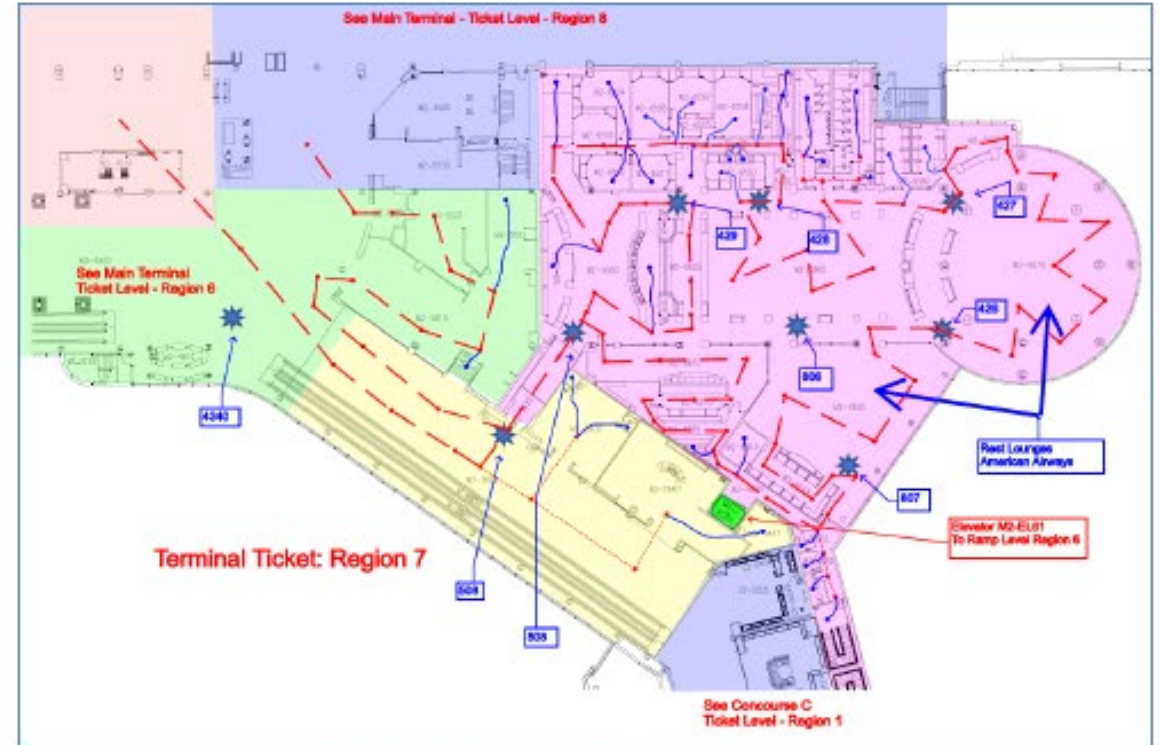
Scanning - Obstacles



Scanning – Planned vs. Actual



The actual route of the scanning cart



Planned route of the scanning cart

Deliverables and Post-processing

Spherical 360° imagery

- RAW images (JPEG images): both high definition and
- standard, along with supporting files, for each part of the scanning project

Point Cloud files

- Color georeferenced point cloud in ASPRS LAS format: (The American Society for Photogrammetry & Remote Sensing – LASer format)
- Mono georeferenced point cloud

area_ftUS_eo_tmX_txt - Notepad

Photo Id	Time	Easting(ft US)	Northing(ft US)	Ellipsoid Height(ft US)	Omega TMX (deg)	Phi TMX (deg)	Kappa TMX (deg)	Lat(deg)	Long(deg)
0	1345.281475	1419643.748	540855.3964	652.7318728	-0.32010944	-0.40921302	78.91644238	35.22049185	-80.94334001
1	1357.158426	1419643.995	540857.9095	652.7175253	0.27124428	1.25154558	-68.07630695	35.22049876	-80.94333935
2	1358.300430	1419640.825	540850.2280	652.7323730	-0.07940222	0.20438841	-34.05800338	35.22049123	-80.94334979
3	1359.36045	1419639.824	540851.6097	652.7341944	-0.01360591	0.52136716	-20.82352698	35.22048123	-80.9433529
4	1360.260515	1419639.656	540848.3113	652.7072702	-0.4273756	0.18950391	-23.2980671	35.22047216	-80.94335325
5	1361.256681	1419639.575	540845.0812	652.7072659	-0.81788277	0.8106318	-36.38993227	35.22046315	-80.9433533
6	1363.255747	1419638.64	540841.9939	652.7636657	-0.27558998	0.71075723	-54.79493598	35.22045475	-80.94335671
7	1364.758661	1419636.919	540839.3265	652.7759	0.35428949	0.69178166	-84.93396334	35.22044733	-80.94336182
8	1365.962786	1419633.962	540838.2415	652.7718848	0.0763524	0.01490632	-105.9656952	35.22044419	-80.94337165
9	1374.762192	1419629.035	540838.3741	652.7509061	0.82965247	-0.54059313	-179.7036767	35.22044594	-80.94338819
10	1376.459356	1419627.945	540842.2703	652.7200144	0.64815648	-0.12229076	-176.8422136	35.22045494	-80.94339206

Image locations .txt file

Name	Date modified	Type	Size
L1_TICKET_color_001_m_to_sft.las	6/15/2021 9:56 PM	AutoCAD Layer State	557,166 KB
L1_TICKET_color_002_m_to_sft.las	6/16/2021 1:43 AM	AutoCAD Layer State	404,197 KB
L1_TICKET_color_003_m_to_sft.las	6/15/2021 10:01 PM	AutoCAD Layer State	426,380 KB
L1_TICKET_color_004_m_to_sft.las	6/16/2021 1:43 AM	AutoCAD Layer State	901,901 KB
L1_TICKET_color_005_m_to_sft.las	6/15/2021 10:12 PM	AutoCAD Layer State	854,251 KB
L1_TICKET_color_006_m_to_sft.las	6/16/2021 12:41 A...	AutoCAD Layer State	870,687 KB
L1_TICKET_color_007_m_to_sft.las	6/16/2021 1:43 AM	AutoCAD Layer State	717,726 KB

Color full: Contains every point from the point cloud data

Name	Date modified	Type	Size
L1_TICKET_refl_001_m_to_sft.las	5/16/2021 9:33 PM	AutoCAD Layer State	520,370 KB
L1_TICKET_refl_002_m_to_sft.las	5/16/2021 9:33 PM	AutoCAD Layer State	360,200 KB
L1_TICKET_refl_003_m_to_sft.las	5/16/2021 9:33 PM	AutoCAD Layer State	376,137 KB
L1_TICKET_refl_004_m_to_sft.las	5/16/2021 9:33 PM	AutoCAD Layer State	766,964 KB
L1_TICKET_refl_005_m_to_sft.las	5/16/2021 9:33 PM	AutoCAD Layer State	727,640 KB
L1_TICKET_refl_006_m_to_sft.las	5/16/2021 9:33 PM	AutoCAD Layer State	739,781 KB
L1_TICKET_refl_007_m_to_sft.las	5/16/2021 9:33 PM	AutoCAD Layer State	614,559 KB

monocolor full: Contains every point from the point cloud data

Deliverables and Post-processing

Cleaned and combined 1cm Point Cloud files

- Combining the several mission files to create one file per building floor
- Removing excess noise from the point cloud
- Publishing the point cloud and imagery to be used for future feature extraction



Example of six scanning crew continually moving within the range of the scanning cart and creating numerous ghost images

FLOOR	AREA	REGION	SCAN MISSION	Pics Name	USR Frame Date is?	HDPics	Total	area_ftUS_eo_tm.txt	Color LAS Files
02_Ramp	Concourse A	All	13	ladybug_panoramic_M13_000000 to _M13_003428	22 May 2021	0-3428	3,429	0-3428	1m - 16m
03 Ticket	Concourse A	All	6	ladybug_panoramic_M06_002056 to _M06_004390	18 May 2021	2056-4390	2,335	2056-4390	1m - 11m
02_Ramp	Concourse A North	1	10	ladybug_panoramic_M10_000001 to _M10_000593	20 May 2021	1-593	595	1-593	1m - 2m
02_Ramp	Concourse A North	2	9	ladybug_panoramic_M09_000000 to _M09_003825	20 May 2021	0-3825	3,826	0-3825	1m - 16m
02_Ramp	Concourse A North	3							
02_Ramp	Concourse A North	4							
05_Ticket	Concourse A North	All	7	ladybug_panoramic_M07_000000 to _M07_002791	18 May 2021	0-2791	2,792	0-2791	1m - 12m
04_Office	Concourse A North	All	7	ladybug_panoramic_M07_002798 to _M07_003548	19 May 2021	2798-3548	751	2798-3548	1m - 4m

LiDAR + 360° Image Integration with GIS

The screenshot shows a GIS application interface for a facility. The main map area displays a 2D floor plan of a terminal building, with rooms and corridors color-coded (e.g., yellow, green, purple, pink). The interface includes a top toolbar with navigation and editing tools, a left sidebar with navigation and search options, and a right sidebar with map tools. A table at the bottom displays data for 'Floor: Floor 2'.

Layers:

- Floor Features
 - building_room_area
 - Food and Beverage
- Other Values
 - Doors
 - Floorplan_STD
 - building_moving_sides
 - Space
- Safety
 - Building Equipment
- Cadastral
 - Grids
 - Aerial

Map Tools:

- Zoom Scale
- Zoom Selection
- Zoom to Initial View
- Zoom to Previous View
- Zoom to Next View
- Buffer
- Select within
- Clear Selection
- 3D Project View
- Measure Dist
- Measure Area
- Get Length
- Get Area
- Get Coordinates
- Printable Page
- Dwf Plot
- Markup Tools

Table: Floor: Floor 2

Location Code	AEGIS Room No	Interior Space Identifier	Short Name	Full Name	Description	Concourse	Room Type	CommRoom	Tenant	Status	Accessibility	Area	Exhibit J	Exhibit J Area	Exhibit K Join	Old Short Name	Older Short Name	New Short Name	Cleaning Responsibility
CLT_TERM000302030061	0061	1002A2-0110	A2-0110	100-A2-0110	Corridor	A	Corridor		CLT		Public	11,843.30		0					

(1-25 of 94 Records) First Previous Next Show ALL Records

LiDAR + 360° Image Integration with GIS

- 3D AEGIS functions launches a window showing a 360° panoramic image of that location draped over the point cloud
- Image viewer allows
 - Virtual walkthrough
 - Measurement
 - Asset tagging
 - Feature Extraction

The screenshot displays the X-Spatial GIS interface. On the left, a 360-degree panoramic view of an airport terminal is shown, with a compass rose indicating orientation. The main area on the right shows a 2D floor plan map of the terminal, with a red arrow pointing to a specific area. A red circle highlights the '3D Project View' button in the 'Map Tools' panel on the right. Below the map, a data table is visible.

CommRoom	Tenant	Status	Accessibility	Area	Exhibit J	Exhibit J Area	Exhibit K Join	Old Short Name	Older Short Name	New Short Name	Cleaning Responsibility	Es
	CLT		Public	11,843.30			0					

LiDAR + 360° Image Integration with GIS

New tools have been developed which allow tagging of an asset in the 360° image, transferring that point to AEGIS and using the provided AEGIS tools to classify the asset

The screenshot displays the X-Spatial web application interface. The main view is a 360-degree image of an airport terminal interior, showing a corridor with electrical panels. A red location pin is placed on one of the panels. A data popup is visible, containing the following information:

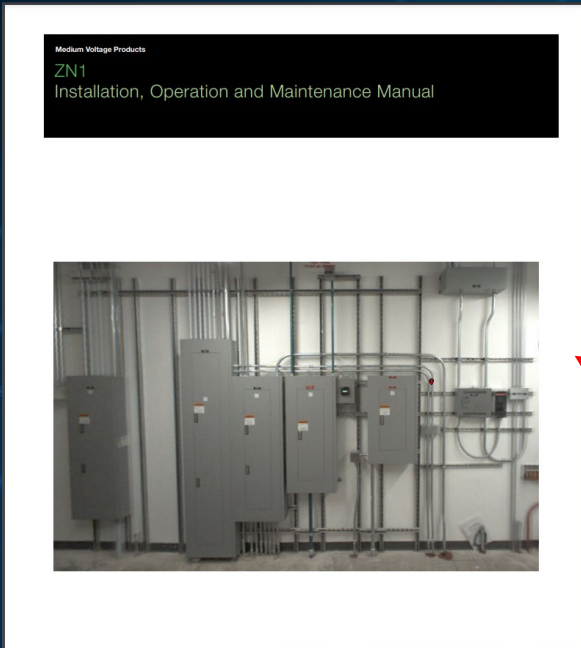
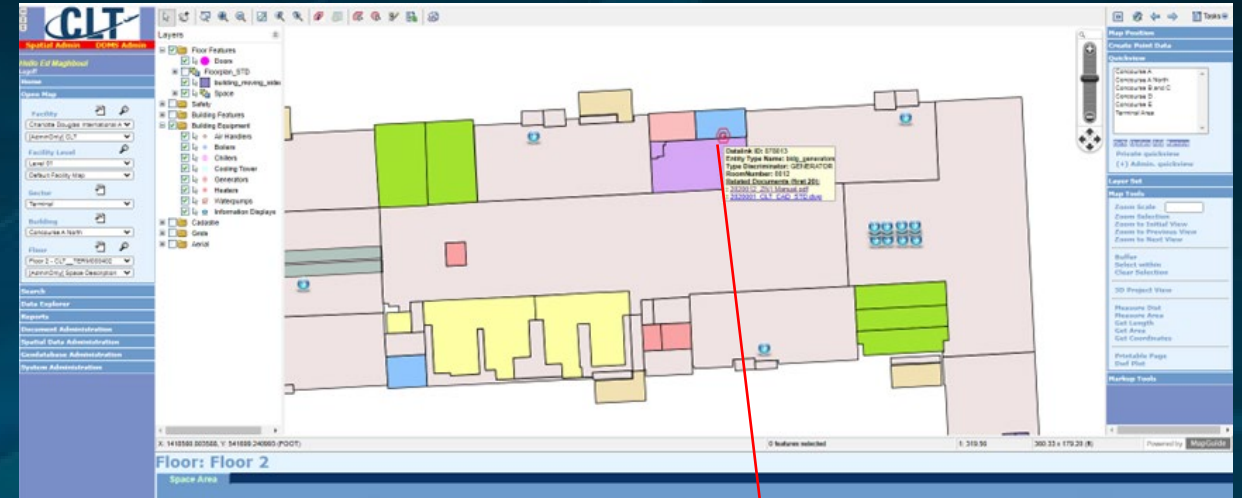
- Datalink ID: 876013
- Entity Type Name: 100_generator
- Type Discriminator: GENERATOR
- Room Number: 0012
- Related Documents (Start 20): 202007-201 Manual.pdf, 202007-201 CLT - 100.dwg

The interface also includes a sidebar with navigation options (Measurements, Layers, Folders, Bookmarks, Data Export, Print Screen, Jump to Location, Management, Settings), a top navigation bar with the user's name (ed.maghboul@x-spatial.com), and a bottom table with columns for Concourse, Room Type, CommRoom, Tenant, Status, Accessibility, Area, Exhibit, and Cleaning Responsibility.

Concourse	Room Type	CommRoom	Tenant	Status	Accessibility	Area	Exhibit	Exhibit J Area	Exhibit K	Old Short Name	New Short Name	Cleaning Responsibility
A	Corridor		CLT	Public		11,843.30			0			

Asset Tagging

Once the asset has been classified and recorded in the dB, users can proceed to attach documents and edit its attributes



Entity Attribute - Google Chrome

airports.x-spatial.com/UMSCLT/cfscrip...forms/EntityType_view.cfm?RecordID=878013...

Location CLT

Created By ed

Date Created 2022/02/10@10:06:10

Last Edited By ed

Date Last Edited 2022/02/11@09:49:35

Asset ID 90001

Quality Level A

DDMS Source

Comment

Disposition

Is Published N

Type Discriminator GENERATOR

Documents (2)							
Bar Code No.	Project Title	Sheet No	Sheet Title	Alias	Document Type	Document Subtype	File Name
2020001	CAD Standard Drawing						
2020012	ABB Elec panel				Manual		

Entity Attribute - Google Chrome

airports.x-spatial.com/UMSCLT/cfscrip...forms/EntityType_view.cfm?RecordID=878013...

Location CLT

Created By ed

Date Created 2022/02/10@10:06:10

Last Edited By ed

Date Last Edited 2022/02/11@09:49:35

Asset ID 90001

Quality Level A

DDMS Source

Comment

Disposition

Is Published N

Type Discriminator GENERATOR

Documents (2)	
ID	RoomNumber
0012	0012
BuildingNumber	CLT
Location	Conc A North
Model	ABB ZN1
Serial	
KW	
Age	
Manufactre_Date	06/2017
Notes	
Fuel_Tank_Types	
Fuel_Tank_Size	
Floor	
Status	ACTIVE
Verified?	YES
MaintainedBy	CLT

LiDAR + 360° Image Integration with GIS



Integrated with GIS



X-Spatial - Google Chrome

x-spatial.solv3d.com/#hash=8b3d9e80&minimap=1&fov=90&cam=1320&x=1418648.858&y=541647.539&z=646.837&ae=0&az=17&lon=-80.946...

leaders in airport information management

X-SPATIAL

Conc_A_North_Ticket_V3

ed.maghboul@x-spatial.com

3D Mapping Cloud | Jira | BeyondTrust Privile... | Adobe Account | CDTFA Online Servi... | Other bookmarks

Measurements

Layers

Folders

Bookmarks

Data Export

Print Screen

Jump to Location

Management

Settings

Map Position

Create Point Data

Quickview

- Concourse A
- Concourse A North
- Concourse B and C
- Concourse D
- Concourse E
- Terminal Area

Go To Update Add Remove

Private quickview

(+) Admin. quickview

Layer Set

Map Tools

- Zoom Scale
- Zoom Selection
- Zoom to Initial View
- Zoom to Previous View
- Zoom to Next View

Buffer

- Select within
- Clear Selection
- 3D Project View**
- Measure Dist
- Measure Area
- Get Length
- Get Area
- Get Coordinates

Printable Page

Dwf Plot

Markup Tools

0 features selected | 1: 363.34 | 409.70 x 203.75 (ft) | Powered by MapGuide

	Location Code	AEGIS Room No	Interior Space Identifier	Short Name	Full Name	Description	Concourse	Room Type	CommRoom	Tenant	Status	Accessibility	Area	Exhibit J	Exhibit J Area	Exhibit K Join	Old Short Name	Older Short Name	New Short Name	Cleaning Responsibility	Ex
<input type="checkbox"/>	CLT_TERM000302030061	0061	1002A2-0110	A2-0110	100-A2-0110	Corridor	A	Corridor		CLT		Public	11,843.30		0						

(1-25 of 94 Records) First Previous Next Show ALL Records

3D LiDAR with Draped Imagery



Multi-Dimensional Data



CLT
Spatial Admin DDMS Admin
Hello Ed Maghoul
Home
Open Map
Facility: Charlotte Douglas International A
Facility Level: [AdminOnly] CLT
Level 01
Sector: Terminal
Building: Concourse A North
Floor: Floor 2 - CLT_TERM000402

Layers

- Floor Features
 - Doors
 - Floorplan_STD
 - building_moving_side
 - Space
- Safety
- Building Features
- Building Equipment
 - Air Handlers
 - Boilers
 - Chillers
 - Cooling Tower
 - Generators
 - Heaters
 - Waterpumps
 - Information Displays
- Cadastr
- Grids
- Aerial

Data Link ID: 878013
Entity Type Name: bldg_generators
Type Discriminator: GENERATOR
Room Number: 0012
Related Documents (first 20):
2020012_ZN1 Manual.pdf
2020001_CLT_CAD_STD.dwg

X·SPATIAL
leaders in airport information management
Conc_A_North_Ticket_V3
ed.maghoul@x-spatial.com

Measurements

Layers

Folders

Bookmarks

Data Export

- Print Screen
- Jump to Location
- Management
- Settings

Title: Electric Panel
Color: ■
Collection: Electric Panels

Entity Attribute - Personal - Microsoft Edge

airports.x-spatial.com/UMSCLT/cfscripts/forms/EntityType_view.cfm?RecordID=87801...

Edit: 878013, buildings, buildings_equipment, bldg_generators, bgutgen

Location: CLT
Created By: ed
Date Created: 2022/02/10@10:06:10
Last Edited By: ed
Date Last Edited: 2022/02/10@10:13:15
Asset ID: 90001
Quality Level: A
DDMS Source:
Comment:
Disposition:
Is Published: N
Type Discriminator: GENERATOR

Attributes		Documents (1)					
ID	RoomNumber	Bar Code No.	Project Title	Sheet No	Sheet Title	Alias	Document Type
		2020001	Elec Panel Documentation				Manual

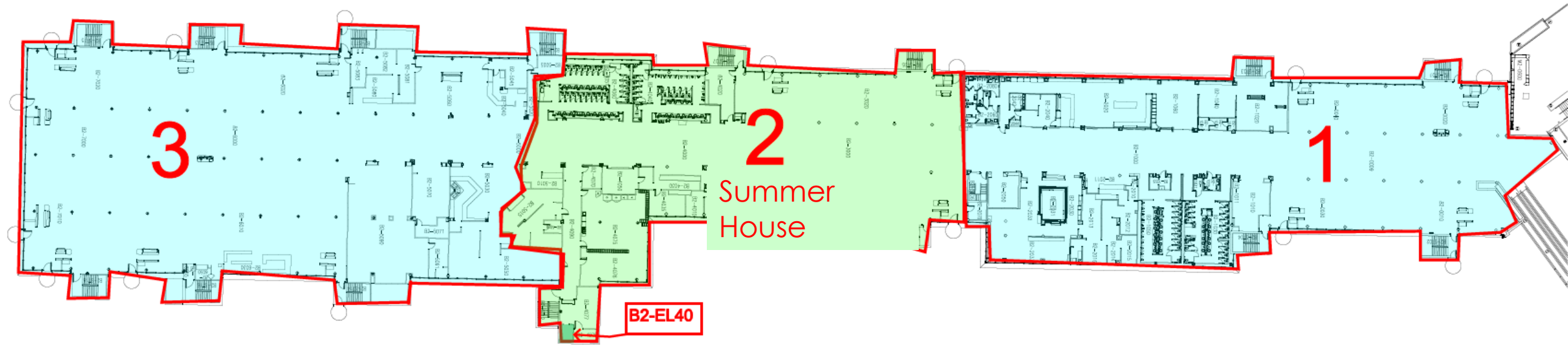
1 / 17 75% +

Medium Voltage Products
ZN1
Installation, Operation and Maintenance Manual

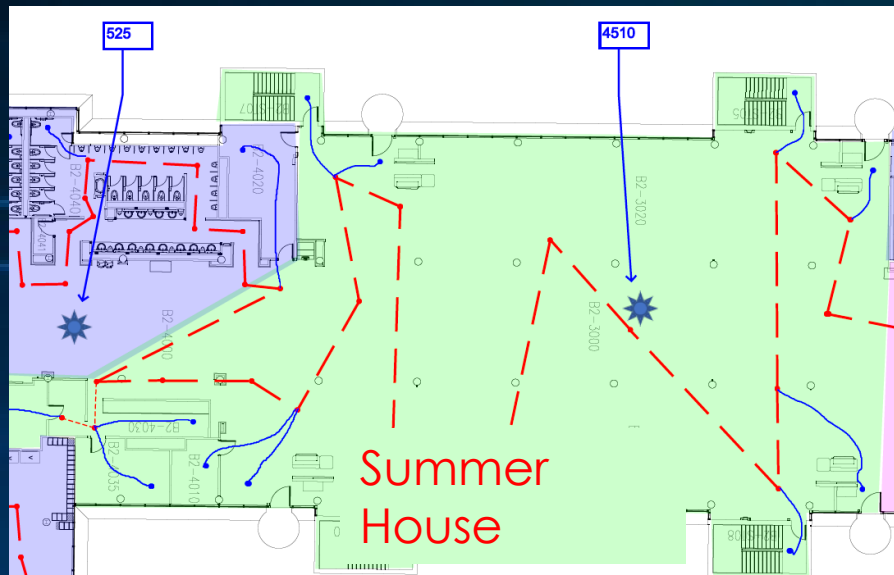
In-door Imagery Draped over LiDAR
Integrated with GIS

The background is a dark blue gradient with several bright, glowing cyan horizontal lines. A faint, semi-transparent 3D model of a hand is visible in the background, rendered in a light blue color. The text is centered and reads:

**Rescanning a renovated region /
Updating the master LiDAR model**



Concourse B – Ticket Level – Overview of scanning regions



Concourse B – Ticket Level – Region 2



Name 4510
Concourse B
Level TICKET
Description TARGET WITH PINK TAG NE CORNER BLUE TILE @ MIDLINE GATES B5 AND B7

wood.

NC State Plane 1983

Northing 540337.95
Easting 1419070.96
Elevation 735.48

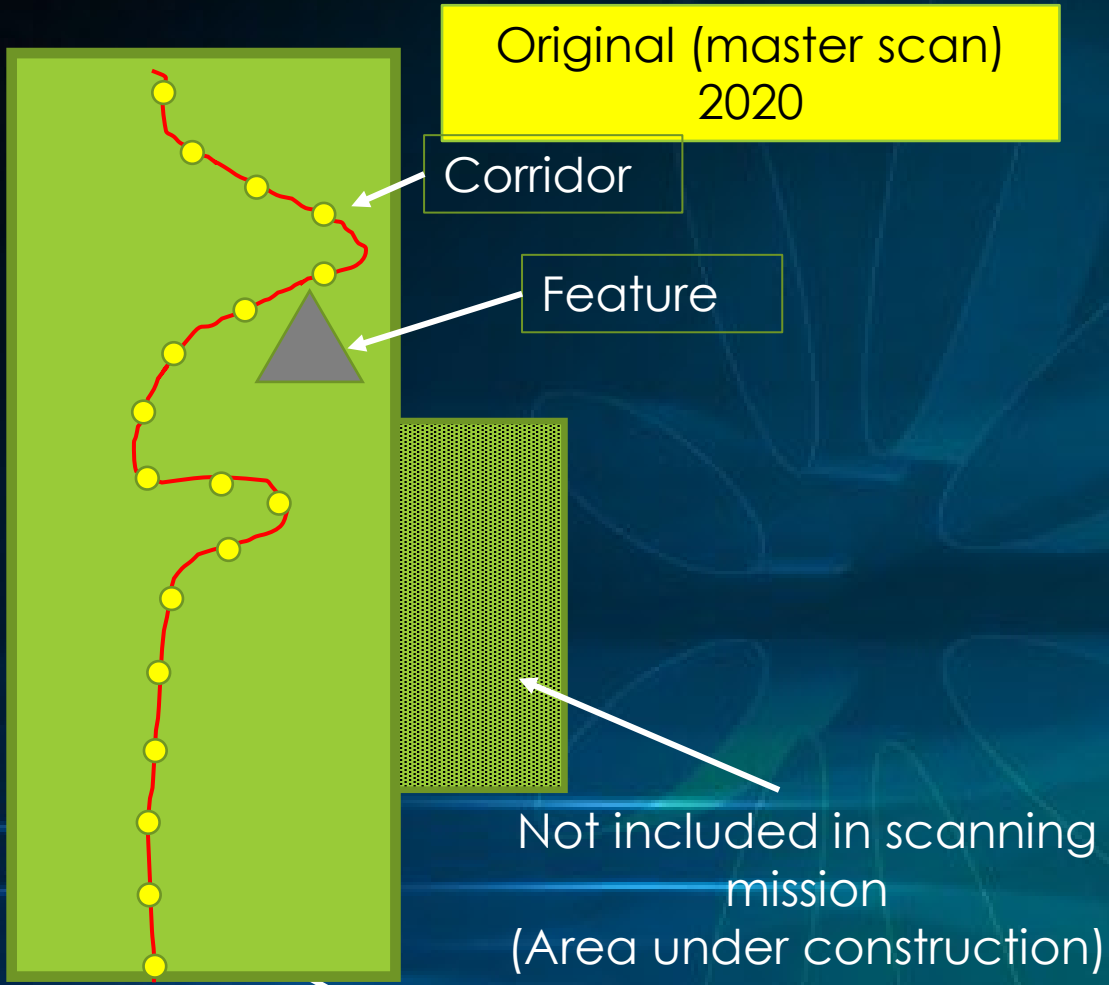
WGS 1984

Longitude 80° 56' 42.8052" W
Latitude 35° 13' 08.5441" N
Ellipsoid H 635.14

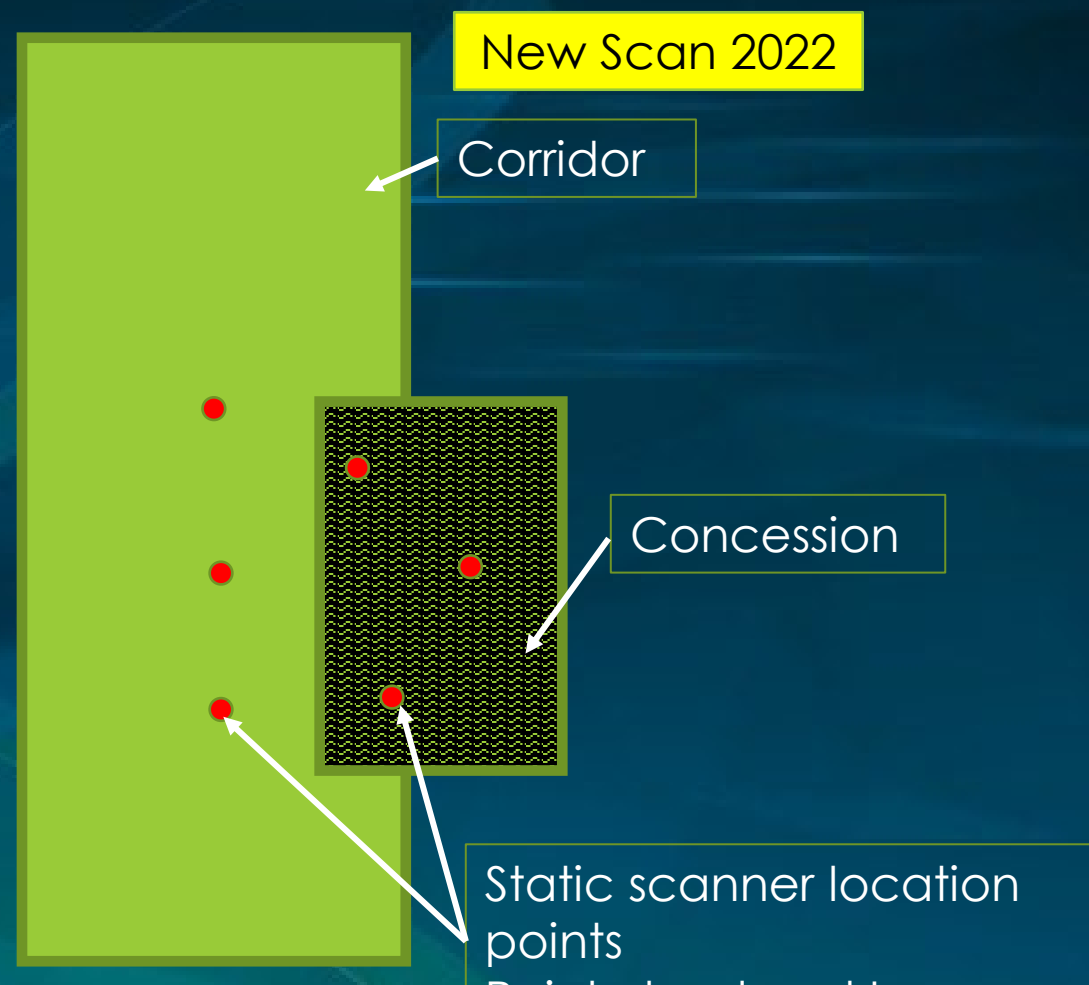


Nearest IGCP

Example showing a similar type of concession project as the summer house



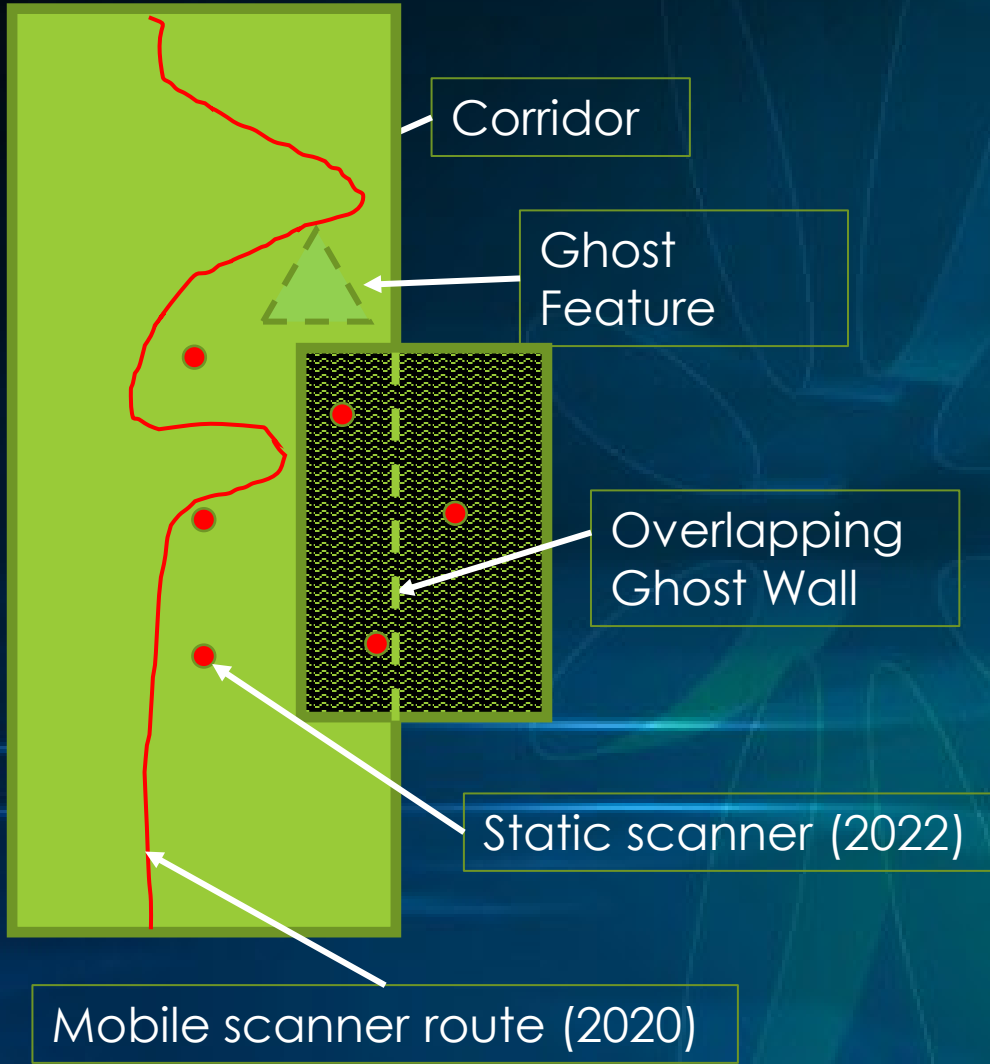
Mobile scanner route:
360° images taken at 1-meter intervals
(2020)



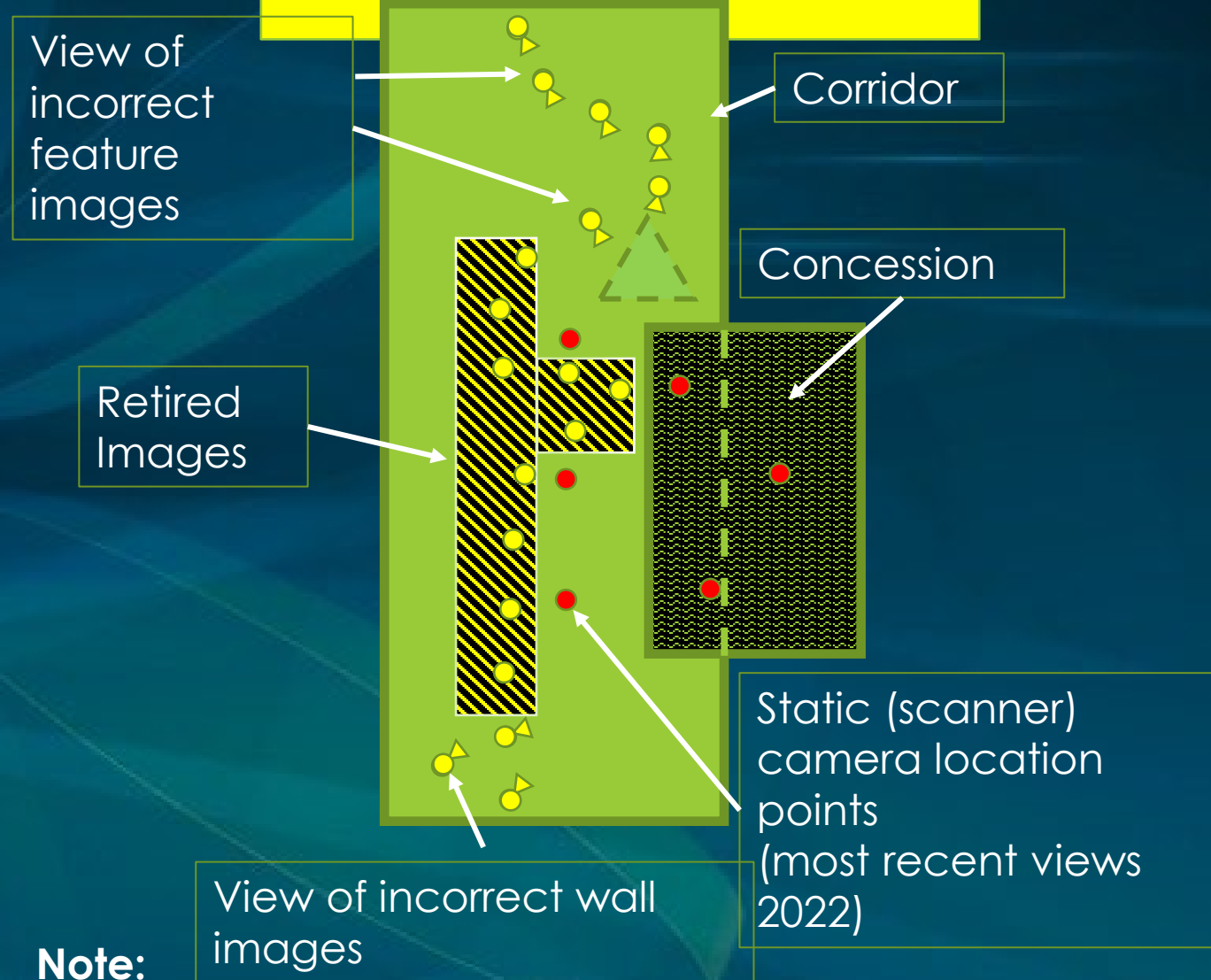
- Note:**
- ❖ There need to be more camera location points (in the corridor) to cover all viewpoints of the changes.
 - ❖ Point cloud requires: Noise removal and Image alignment Solv3D and/or Recap

Example showing a similar type of concession project as the summer house

Combined 2020 and 2022 point clouds



Combined 2020 and 2022



Note:

There are insufficient camera location points (in the corridor) to cover all viewpoints of the changes



Retired photo (date: 2020)



New photo (date: 2022)

Filename	X	Y	Z	Roll	Pitch	Yaw
ladybug_panoramic_M07_004152.jpg	1419094.471	540450.8661	646.309739	-1.05849	-1.35918	35.25035
ladybug_panoramic_M07_004153.jpg	1419093.388	540447.3813	646.313961	-1.68237	-0.41526	28.27305
ladybug_panoramic_M07_004154.jpg	1419092.843	540444.0938	646.27646	-1.76848	-0.36329	29.02638
ladybug_panoramic_M07_004155.jpg	1419092.277	540440.6363	646.257501	-1.83061	-0.34345	28.48124
ladybug_panoramic_M07_004156.jpg	1419091.837	540437.2924	646.227028	-1.71551	-0.77253	31.89983
ladybug_panoramic_M07_004157.jpg	1419091.153	540434.0392	646.204083	-1.97468	-0.90033	34.74238
ladybug_panoramic_M07_004158.jpg	1419090.148	540430.6169	646.179002	-1.73937	-0.57001	35.57959
ladybug_panoramic_M07_004159.jpg	1419089.078	540427.1928	646.165955	-0.98452	-0.59861	29.06799
ladybug_panoramic_M07_004160.jpg	1419088.559	540423.4911	646.17601	-1.41168	-1.02094	23.51646
ladybug_panoramic_M07_004161.jpg	1419088.328	540420.0427	646.185581	-1.6911	-0.97708	20.67407
ladybug_panoramic_M07_004162.jpg	1419088.618	540416.74	646.171334	-0.98237	-0.60995	41.9955
ladybug_panoramic_M07_004163.jpg	1419087.825	540413.4159	646.19573	-0.56149	0.96447	111.76797
ladybug_panoramic_M07_004164.jpg	1419083.979	540413.1044	646.206249	1.76133	0.27515	222.96599
ladybug_panoramic_M07_004165.jpg	1419085.465	540416.4304	646.187232	-0.42544	-1.26066	358.31142
ladybug_panoramic_M07_004166.jpg	1419086.519	540413.1996	646.198019	-0.60503	-1.70661	2.40749
ladybug_panoramic_M07_004167.jpg	1419087.481	540409.861	646.208657	-0.82502	-1.47147	354.30188
ladybug_panoramic_M07_004168.jpg	1419089.227	540406.9977	646.186128	-1.22512	-1.26614	16.13291
ladybug_panoramic_M07_004169.jpg	1419089.107	540404.0314	646.185487	1.40665	-1.34052	295.7288
ladybug_panoramic_M07_004170.jpg	1419092.119	540403.3136	646.193997	-0.10998	1.24217	108.37726

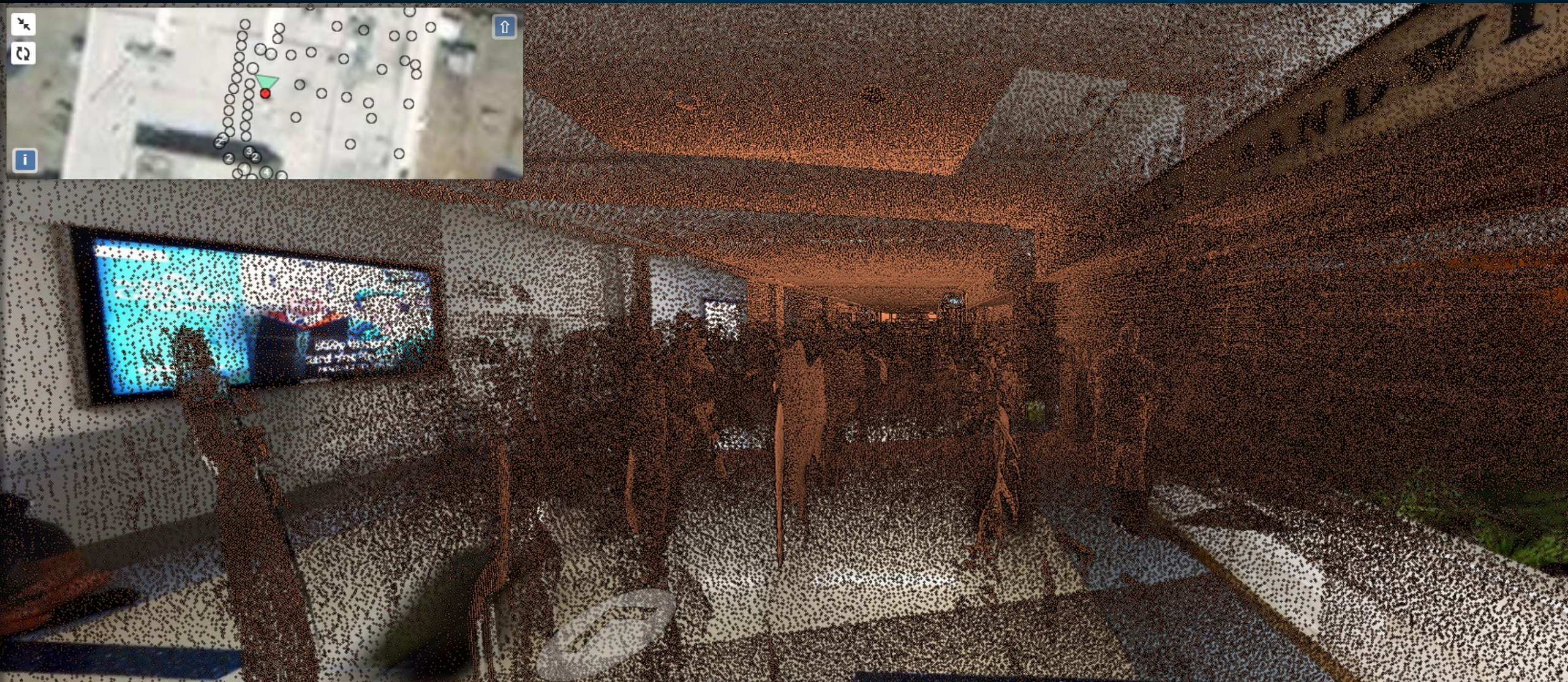
Scanner position 2020 photos.

Filename	X	Y	Z	Roll	Pitch	Yaw
SummerHouseExportXspatial_48	1419073.8	540344.5994	741.1200072	-0.0194	0.08093	17.80163
SummerHouseExportXspatial_47	1419086.035	540352.5427	741.1493807	0.19099	0.24862	-139.81399
SummerHouseExportXspatial_46	1419095.606	540401.1732	741.1465497	-0.3166	0.0054	-77.37746
SummerHouseExportXspatial_45	1419089.012	540374.2901	741.1334785	0.53212	-0.14121	-121.08866
SummerHouseExportXspatial_44	1419094.533	540409.3928	741.0879978	0.3512	0.07719	-136.65786
SummerHouseExportXspatial_43	1419100.162	540428.8373	741.0507545	-1.70914	0.45345	-125.88256
SummerHouseExportXspatial_42	1419108.729	540440.937	741.153359	-0.43209	-0.5792	127.22978
SummerHouseExportXspatial_41	1419153.751	540448.7748	741.4572646	-0.37343	2.04586	-31.06913
SummerHouseExportXspatial_40	1419123.566	540449.6413	741.304119	-6.99929	-5.32167	-58.47966
SummerHouseExportXspatial_39	1419132.284	540448.2211	741.2847409	-3.80676	-4.61394	-80.97263
SummerHouseExportXspatial_38	1419141.873	540446.44	741.2671414	-0.10152	-6.90209	-118.22638
SummerHouseExportXspatial_37	1419111.381	540431.3276	741.382945	-1.58427	-0.6767	15.54796
SummerHouseExportXspatial_36	1419109.943	540421.1119	741.0266678	-1.98454	-0.20591	-57.25499
SummerHouseExportXspatial_35	1419115.106	540441.5415	741.5770861	-0.86377	1.32012	-79.71418
SummerHouseExportXspatial_34	1419125.563	540439.2543	741.5127879	0.52606	2.34132	-48.64062
SummerHouseExportXspatial_33	1419137.657	540435.753	741.2018534	-1.83804	-0.93063	-72.51612
SummerHouseExportXspatial_32	1419118.269	540428.624	741.0411466	-1.55056	0.92828	-25.17691
SummerHouseExportXspatial_31	1419126.196	540427.1094	741.093536	-0.68196	-1.25976	-123.17655
SummerHouseExportXspatial_30	1419133.31	540425.2834	741.2167071	-0.84445	-0.89227	-48.83357
SummerHouseExportXspatial_29	1419134.183	540420.1471	741.1460811	-0.68308	1.55542	-172.40829
SummerHouseExportXspatial_28	1419127.234	540412.1553	741.0677353	-1.37422	-0.31479	87.84318
SummerHouseExportXspatial_27	1419124.898	540398.3701	741.0999109	-1.00777	0.86011	134.16706

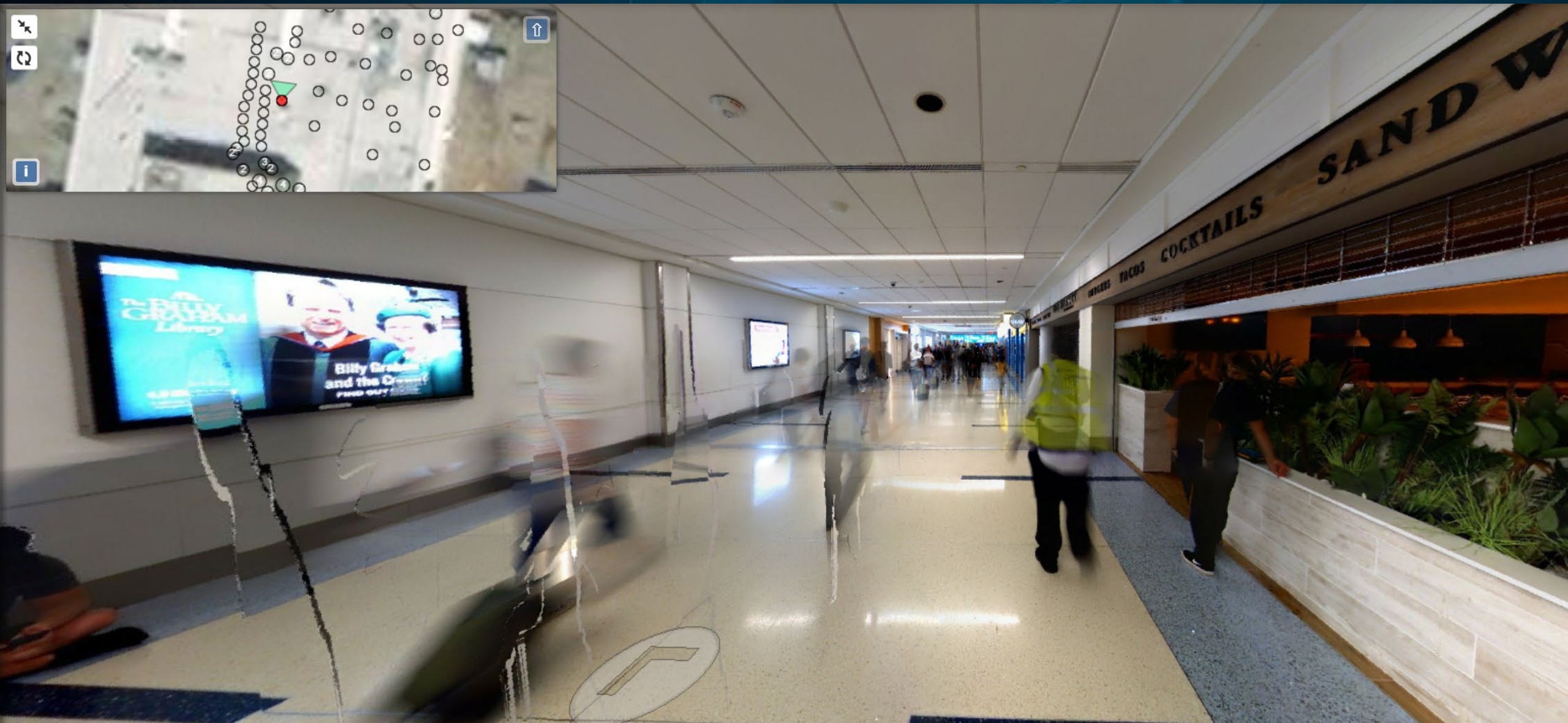
Scanner position 2022 photos.



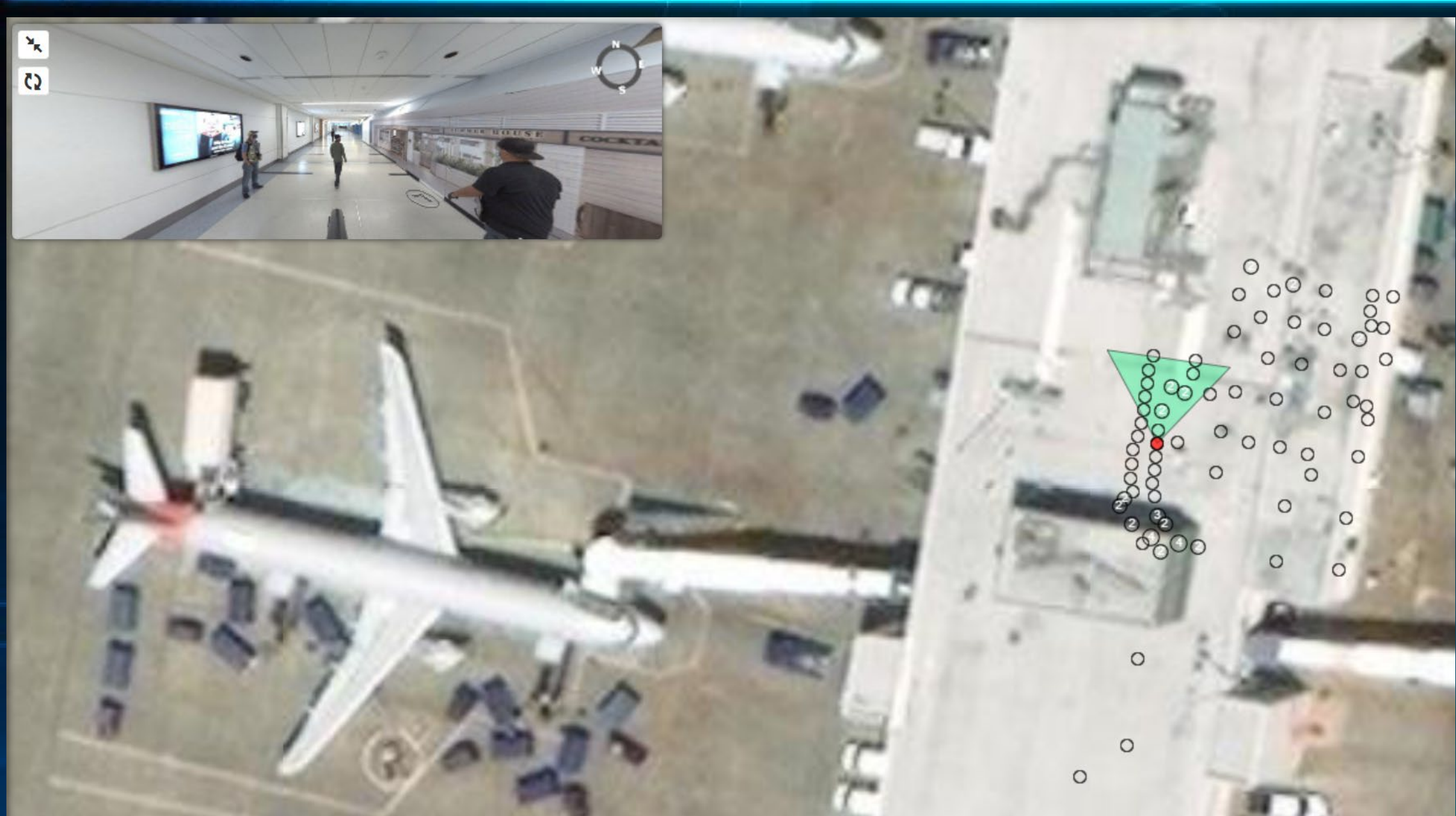
Combined Scanner (TIMMS and TMX) images 2020 and Summerhouse Mission 2022



New Static scanner (X7) Point cloud requires: Noise removal and Image alignment



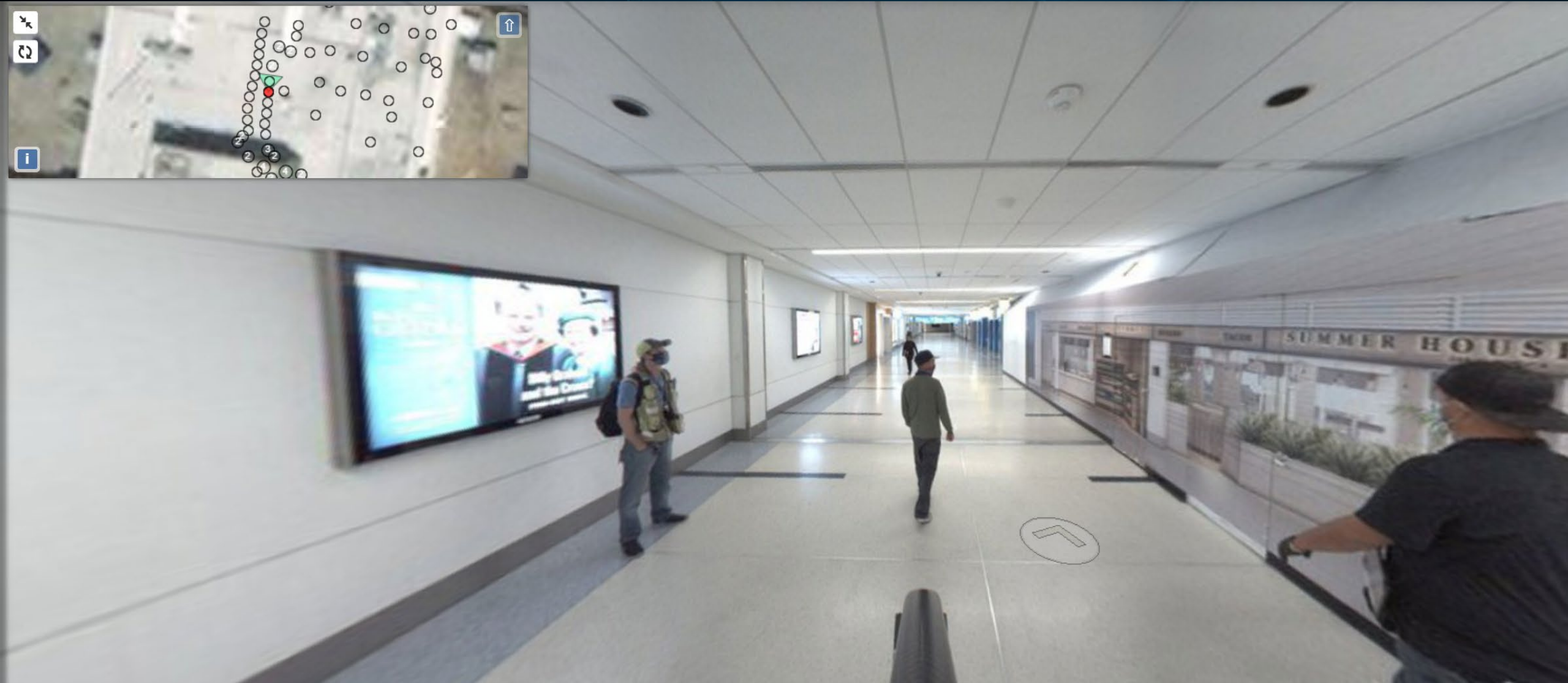
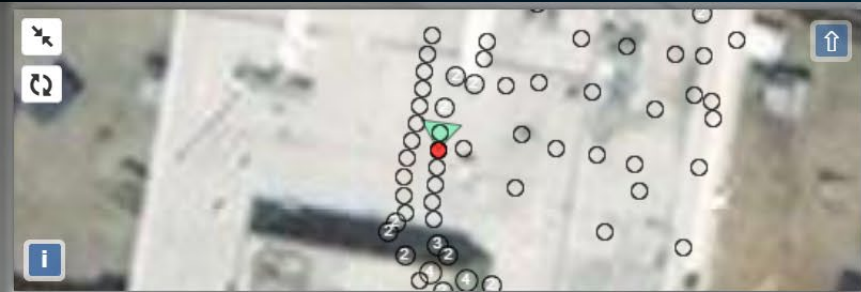
New Static scanner (X7) images showing passenger crowd movements and ghosts images that cannot be removed



Combined Scanner (TIMMS and X7) images 2020 and Summerhouse Mission 2022



TIMMS scanner Mission 7 (sliced): Noise removed and images aligned



TIMMS photo to be retired: Mission 7 2020

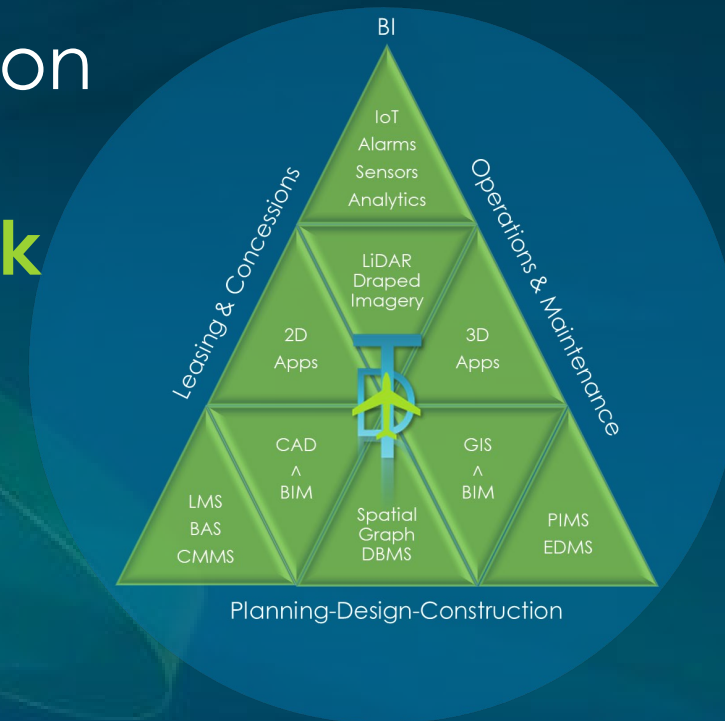
Keys to Sustaining Airport Digital Twin

- Keep it Simple & Sustainable **(KISS) Principle**
- Leverage **IoT sensors with APIs to automate overlay** of real-time (and historical) data
- **Update spatial “skeleton”** with new and/or relocated IoT sensors, assets, etc...; **leverage simple GIS symbolized point features in 2D/3D**
- Leverage **LiDAR draped imagery** with **semi-automated/robotic scanning platforms**



Takeaways

- ➔ Airport Owner's Digital Twin (DT) is not a single software solution; it's an **integration of systems, data, and processes**
- ➔ DT is **not replacing existing airport systems**, but rather expand their utility via DT integration
- ➔ DT **requires sustainable geospatial framework**
- ➔ Airport **CIP builds and renovates** assets physically and should **also virtually via DT**



Q / A

A. Ed Maghboul

Ed.maghboul@x-spatial.com

Tel: 310.293.8268