

# Applying GIS Technology to Arc Flash Study at BWI Thurgood Marshall Airport

David Lin, PE, LC, LEED AP

Ken Lepera

October 25, 2017

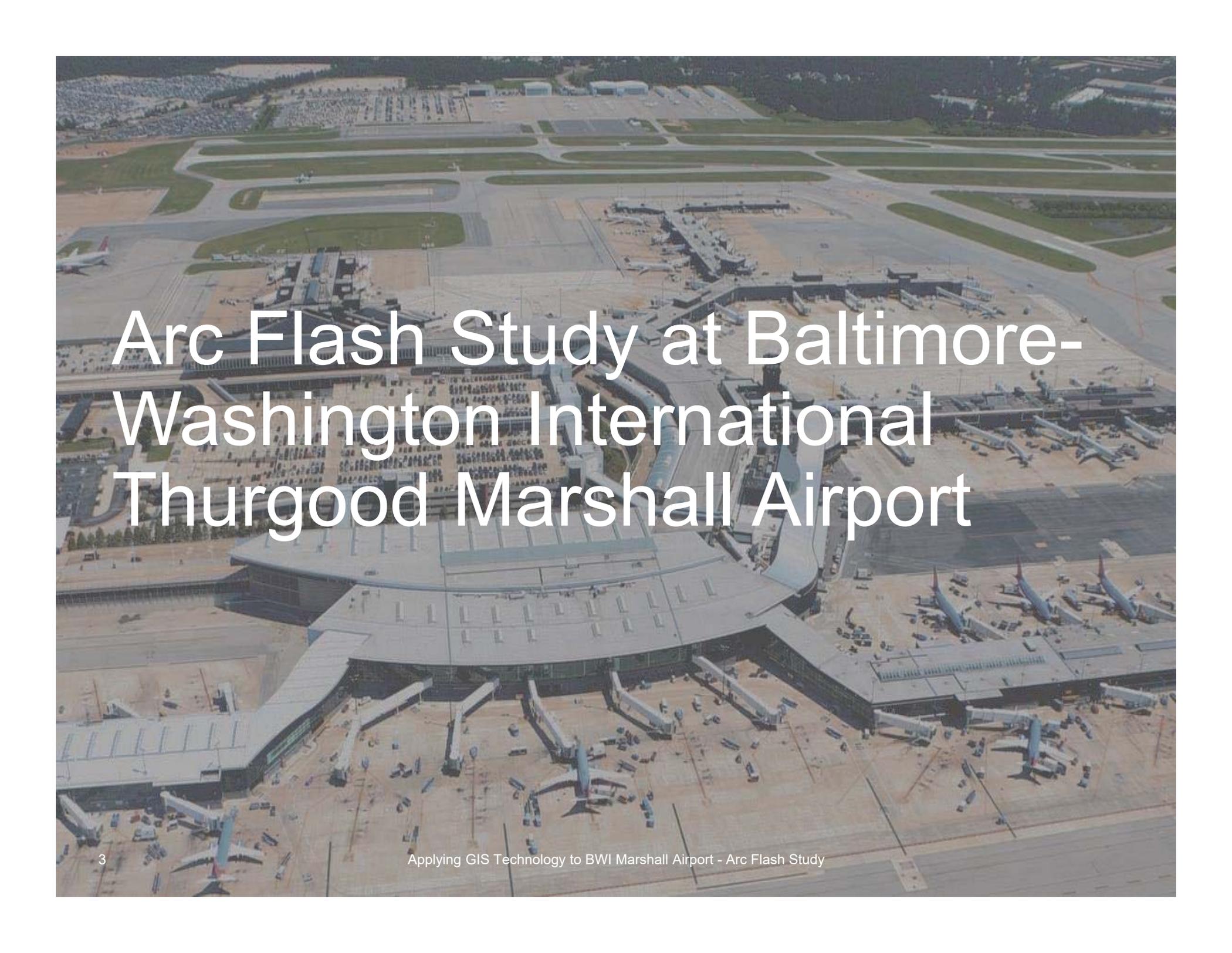
# Presentation Overview

## – Arc Flash Study at BWI Thurgood Marshall Airport

- Arc Flash
- Arc Flash Labelling

## – GIS

## – GIS application for our study

An aerial photograph of the Baltimore-Washington International Thurgood Marshall Airport. The central focus is the large, modern terminal building with a curved, grey roof. Numerous aircraft are parked at gates along the terminal's perimeter. The surrounding area includes taxiways, runways, and parking lots. The text 'Arc Flash Study at Baltimore-Washington International Thurgood Marshall Airport' is overlaid in white, sans-serif font across the middle of the image.

# Arc Flash Study at Baltimore-Washington International Thurgood Marshall Airport

# Arc Flash Study at Baltimore-Washington International Thurgood Marshall Airport

– Maryland Aviation Administration (MAA)



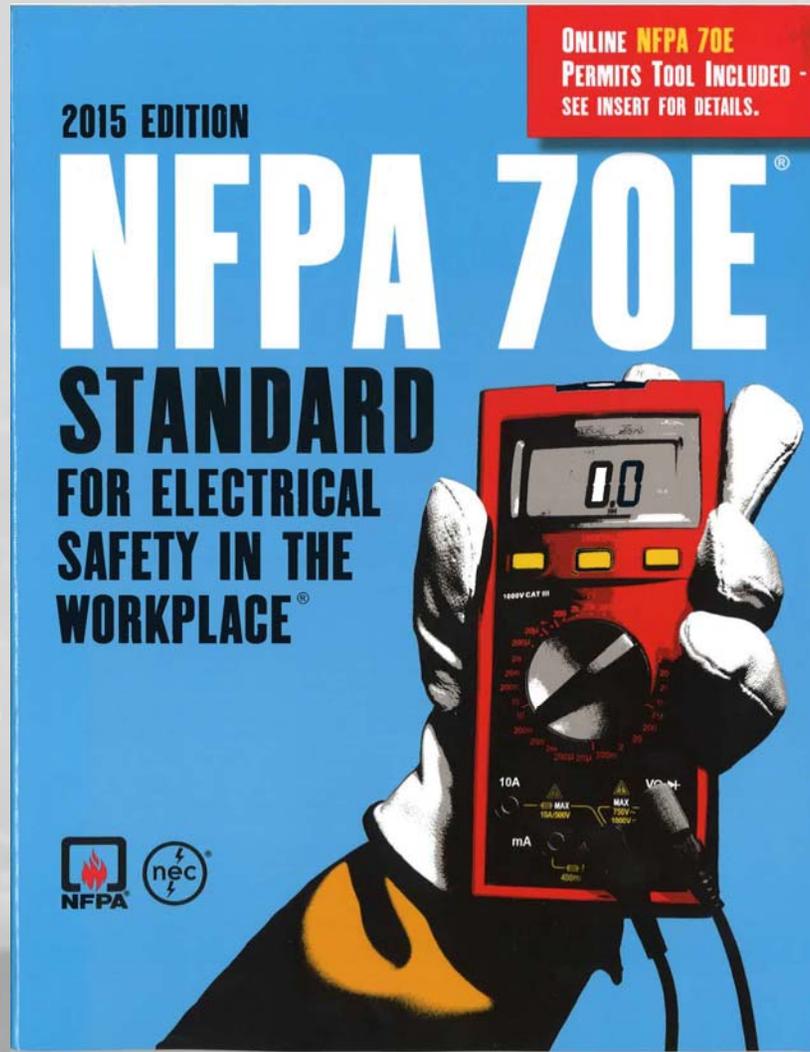
– AECOM



– Baltimore-Washington International  
Thurgood Marshall Airport

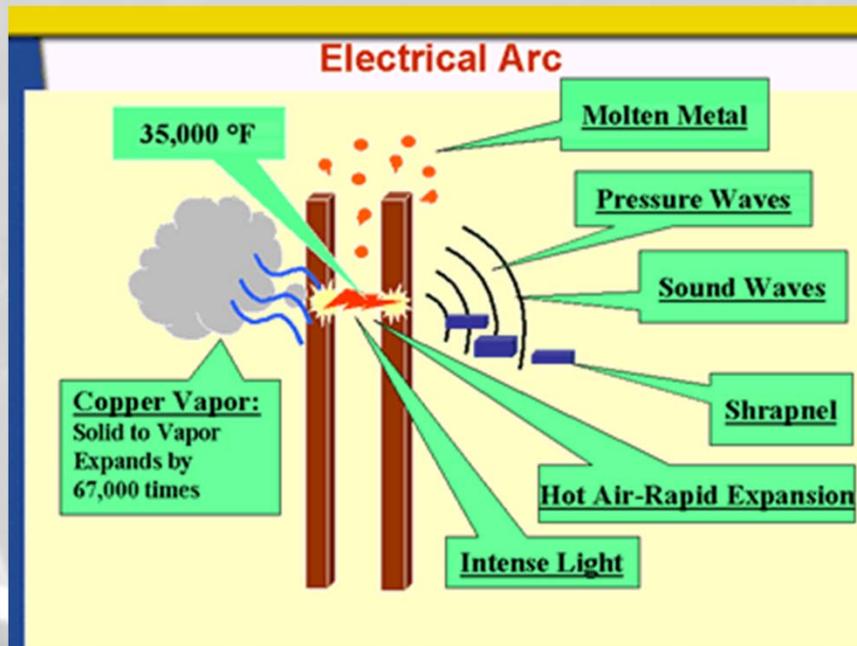


# What is Arc Flash?



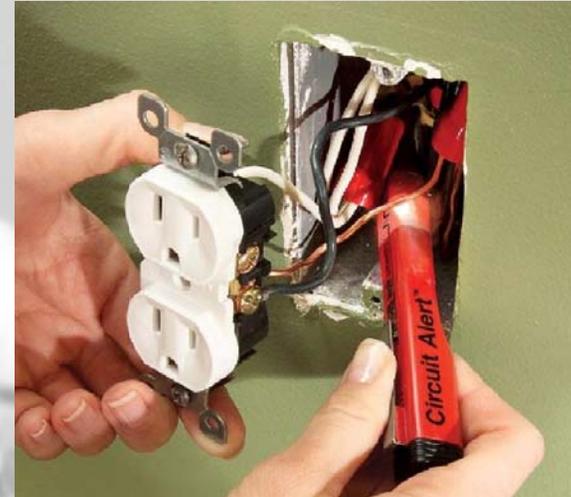
# What is Arc Flash?

- NFPA 70E-2015 Article 100. Arc Flash Hazard
  - A dangerous condition associated with the possible release of energy caused by an electric arc



# What electrical tasks at an airport may cause Arc Flash?

- Per NFPA 70E Table 130.7(C)(15)(A)(a)
- Work on energized electrical conductors and circuit parts, including voltage testing
- Removal or installation of circuit breakers or switches



## What tasks at an airport may cause Arc Flash?

- Removal of bolted covers (to expose bare energized electrical conductors and circuit parts)
- Open hinged doors or covers (to expose bare energized electrical conductors and circuit parts)
- Insertion or removal of individual starter buckets from motor control center (MCC)



## What tasks at an airport may cause Arc Flash?

- Insertion or removal of plug-in devices into or from busways



- In general, electrical tasks involve any exposed energized electrical component.

# Standards Covering Arc Flash

NFPA 70E Standard For Electrical Safety in the Workplace

Occupational Safety and Health Administration (OSHA)

- OSHA 29 CFR Part 1910

Institute of Electrical and Electronics Engineers (IEEE)

- IEEE standard 1584

NFPA 70 National Electrical Code (NEC)

- NEC 110.16 Flash Protection

## U.S. Bureau of Labor Statistics

- 2,000 fatal and 24,000 non-fatal electrical injuries from an arc flash in the last 10 years.
- Over 2,000 people admitted to burn centers yearly with severe arc flash burns
- 80% of electrically related accidents, incidents and fatalities among qualified workers are caused by arc flash



## De-energized Equipment

- The most effective way to eliminate the risk of electrical shock or arc flash is to simply de-energize the equipment

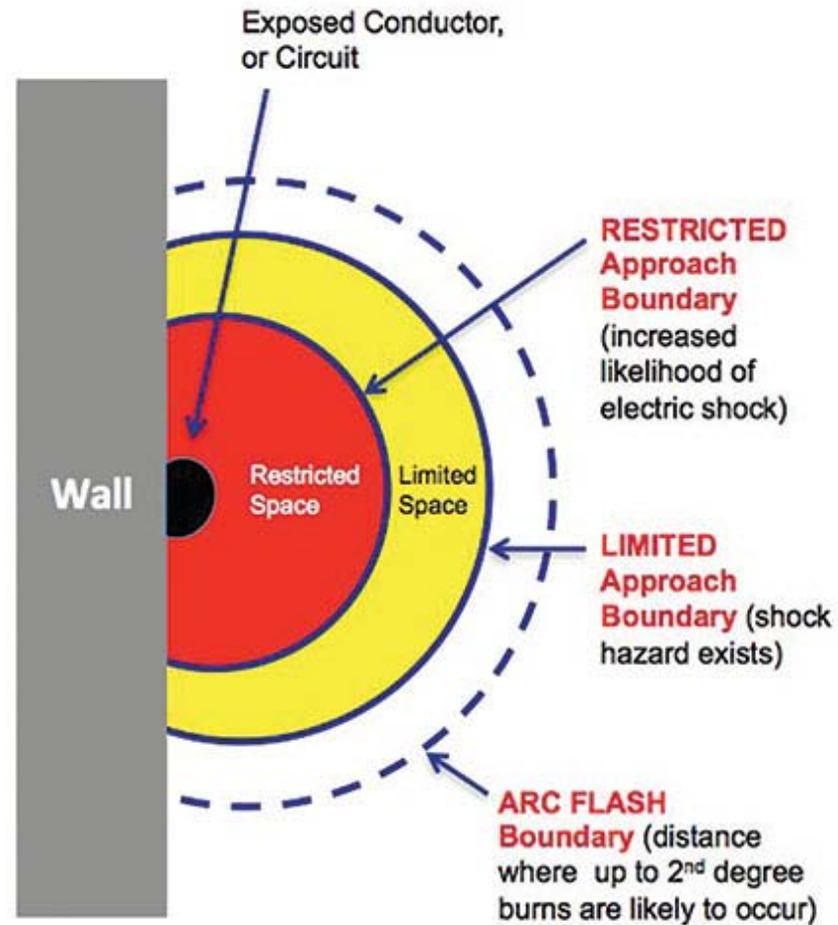


## Arc flash released incident energy

- Incident energy expressed in  $\text{cal}/\text{cm}^2$
- $1 \text{ cal}/\text{cm}^2$  energy approximately equal to hottest part of lighter in 1 sec
- **$1.2 \text{ cal}/\text{cm}^2$**  exposure will cause **second degree burns** on human skin



# Arc flash Boundary Definitions in NFPA 70E - 2015



**2015 Arc Flash Boundaries**

# Selection of PPE

- Arc Flash PPE Categories Method
- Incident Energy Analysis Method

# Selection of PPE

## Arc Flash PPE Categories Method

– NFPA Tables: NFPA 70E – 2015

- Tables 130.7(C)(15)(A) and (B)
- Table 130.7(C)(16)
- Voltage rating
- Maximum available short-circuit current

– Pro: Easiest and quickest

– Con: Provides the least amount of accuracy. Limited equipment are listed in tables.

# Selection of PPE Incident Energy Analysis Method

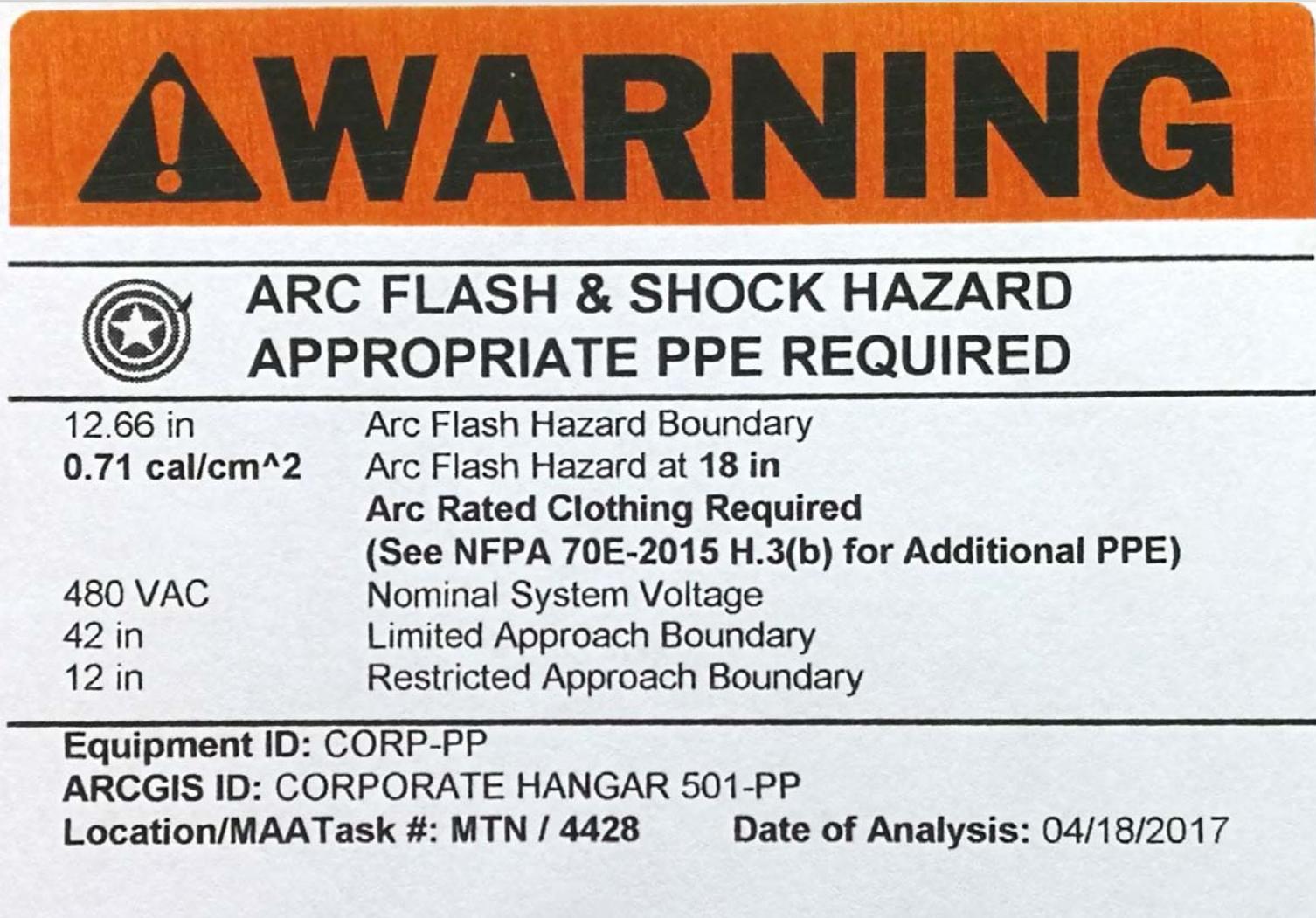
- Electrical modeling
- Pro: More accurate result
- Con: Cost and time



## Arc Flash Label

- Equipment ID (name)
- Nominal system voltage
- Arc flash boundary
- One of the following (**Not Both**):
  1. Available incident energy and the corresponding working distance (Minimum arc rating of clothing required)
  2. Arc flash PPE category from NFPA -70E Tables

# Arc Flash Protection Label



**! WARNING**

---

 **ARC FLASH & SHOCK HAZARD  
APPROPRIATE PPE REQUIRED**

---

12.66 in	Arc Flash Hazard Boundary
<b>0.71 cal/cm<sup>2</sup></b>	Arc Flash Hazard at <b>18 in</b> <b>Arc Rated Clothing Required</b> <b>(See NFPA 70E-2015 H.3(b) for Additional PPE)</b>
480 VAC	Nominal System Voltage
42 in	Limited Approach Boundary
12 in	Restricted Approach Boundary

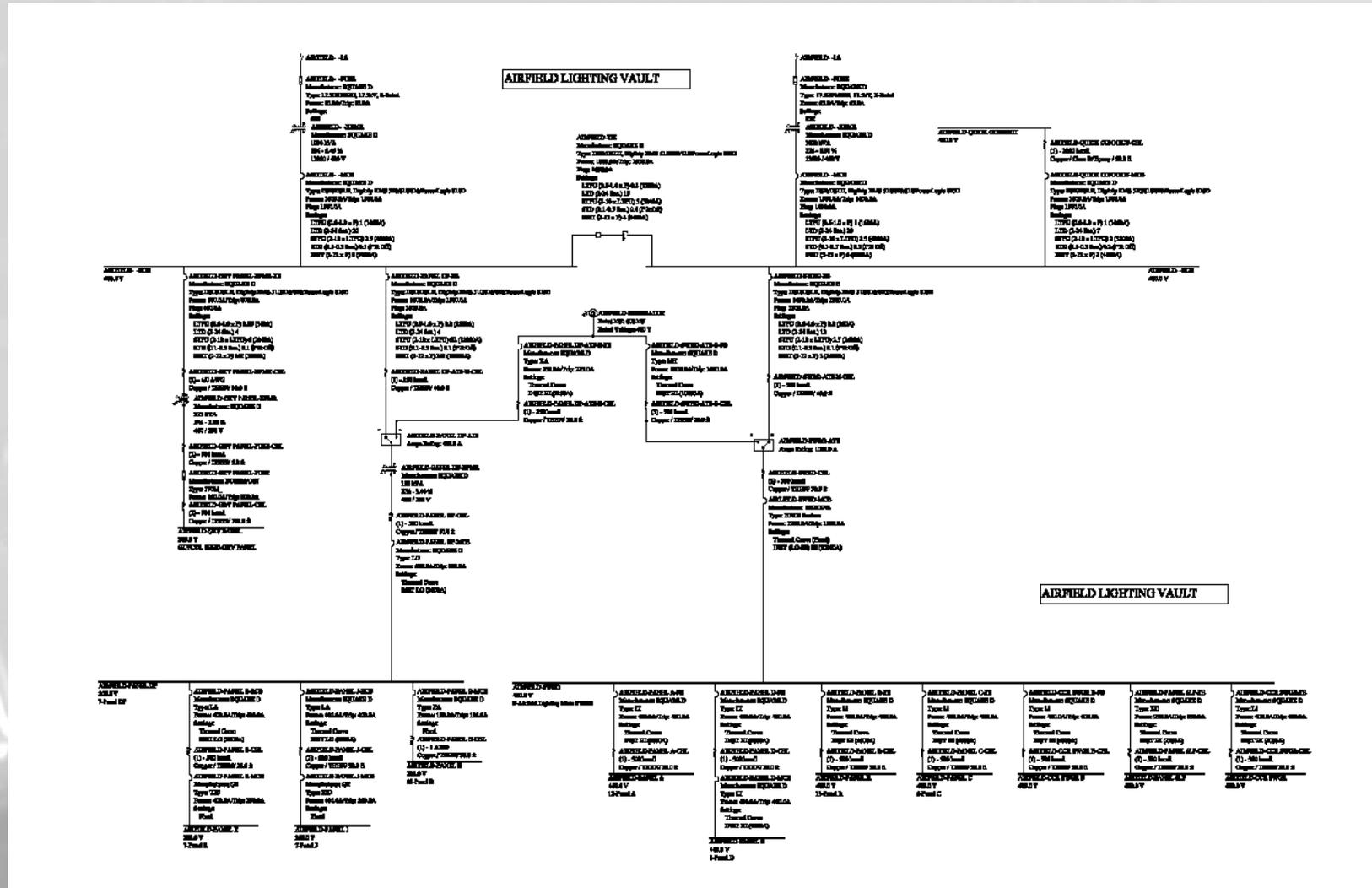
---

**Equipment ID: CORP-PP**  
**ARCGIS ID: CORPORATE HANGAR 501-PP**  
**Location/MAATask #: MTN / 4428**      **Date of Analysis: 04/18/2017**

# Arc Flash Study at BWI Thurgood Marshall Airport

- Incident Energy Analysis Method
- Electrical Modeling Software: SKM

# SKM Single Line Model – Airfield Lighting Substation



## Information needed for SKM Modeling

- Available fault current of power source from utility company



- switchgear/switchboard information



## Information needed for SKM Modeling

– transformer information



– panelboard information

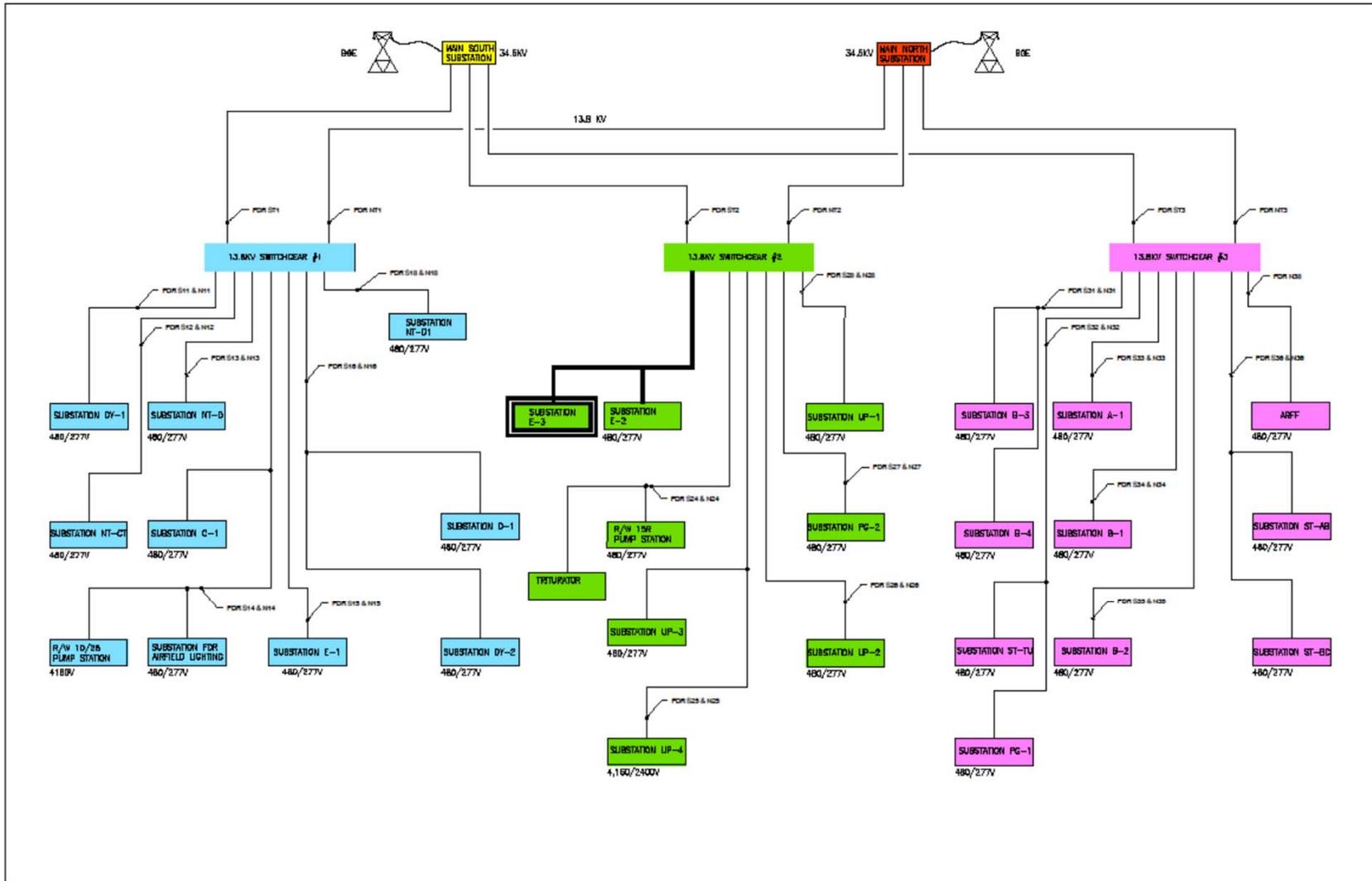


– feeder information

– Connection between electrical equipment.

– (The most difficult task)

# Existing Electrical Power Distribution System at BWI Thurgood Marshall Airport



# Friendship International Airport 1950



# Baltimore Washington International Airport 1972

## Substations ST-AB, NT-CT, NT-D



# Terminal D Extension 1983

## Substation D-1

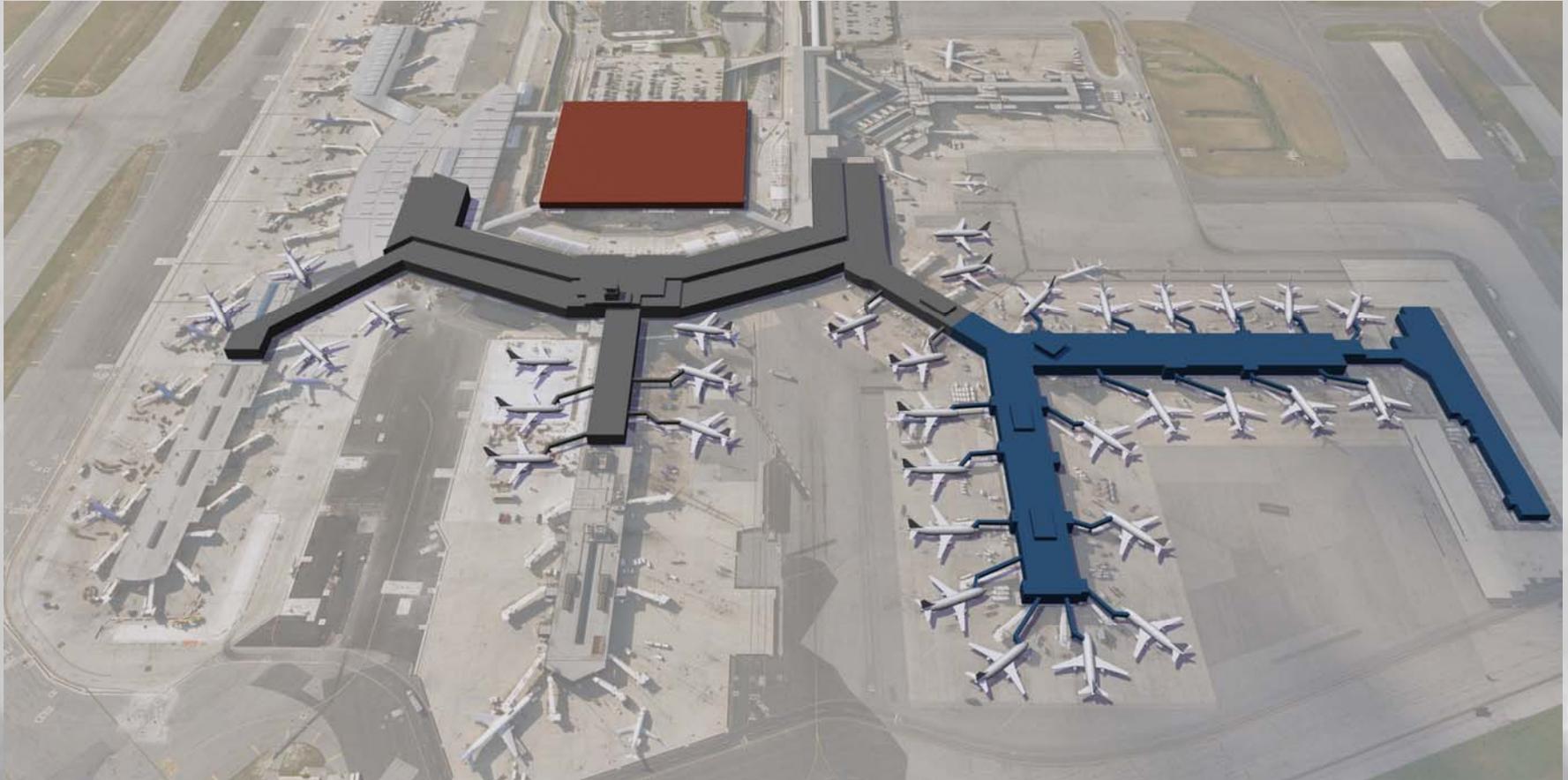


# Terminal DY Extension 1988

## Substations DY-1 and DY-2



# Hourly Garage 1991 Substation PG-1



# Terminal C Extension 1994

## Substation C-1



# Terminal B Extension/Parking Garage Addition 1998 Substations B-3, B-4, PG-1 (Expansion)

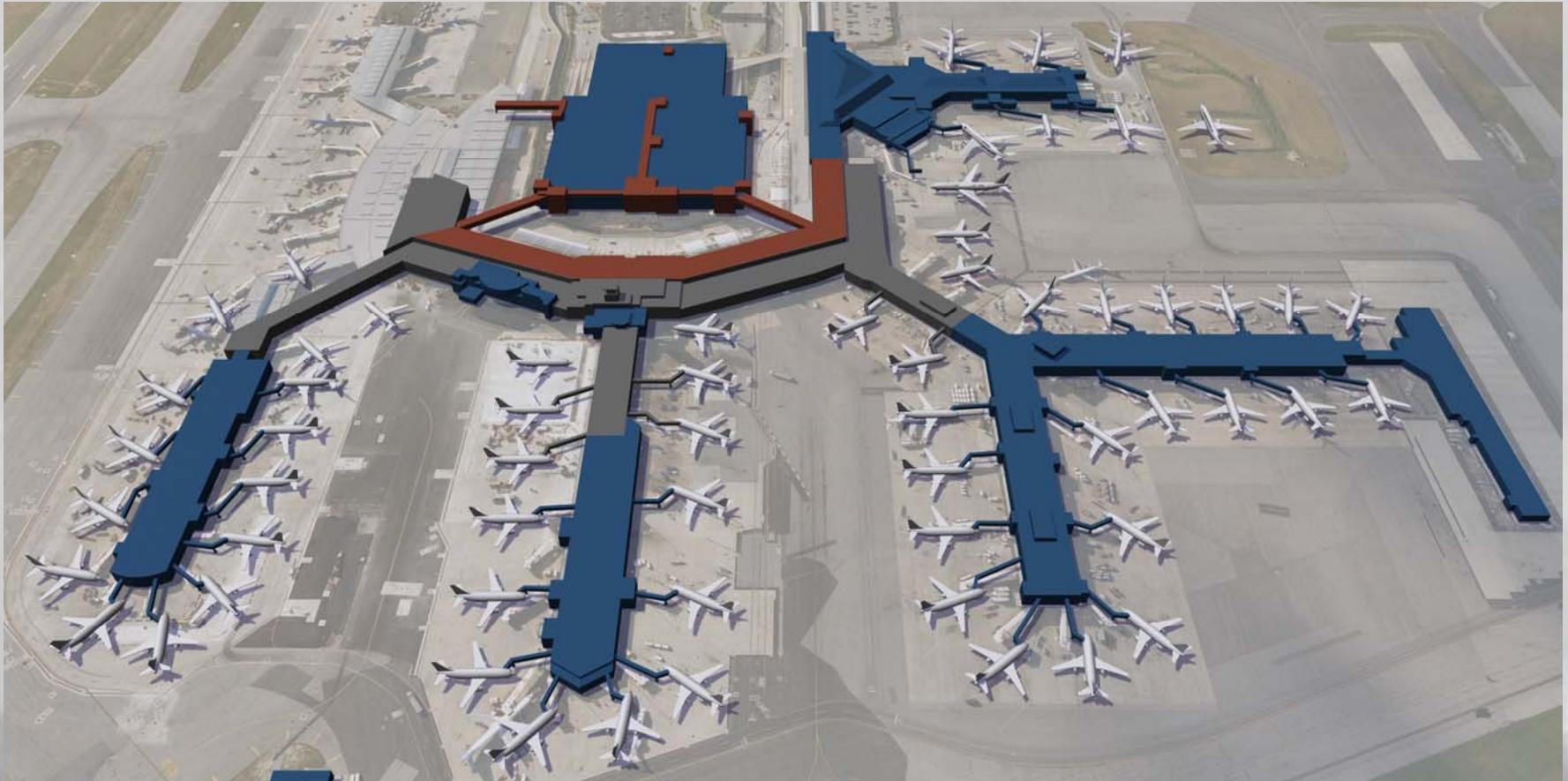


# International Terminal (Pier E) 1999

## Substations E-1, E-2

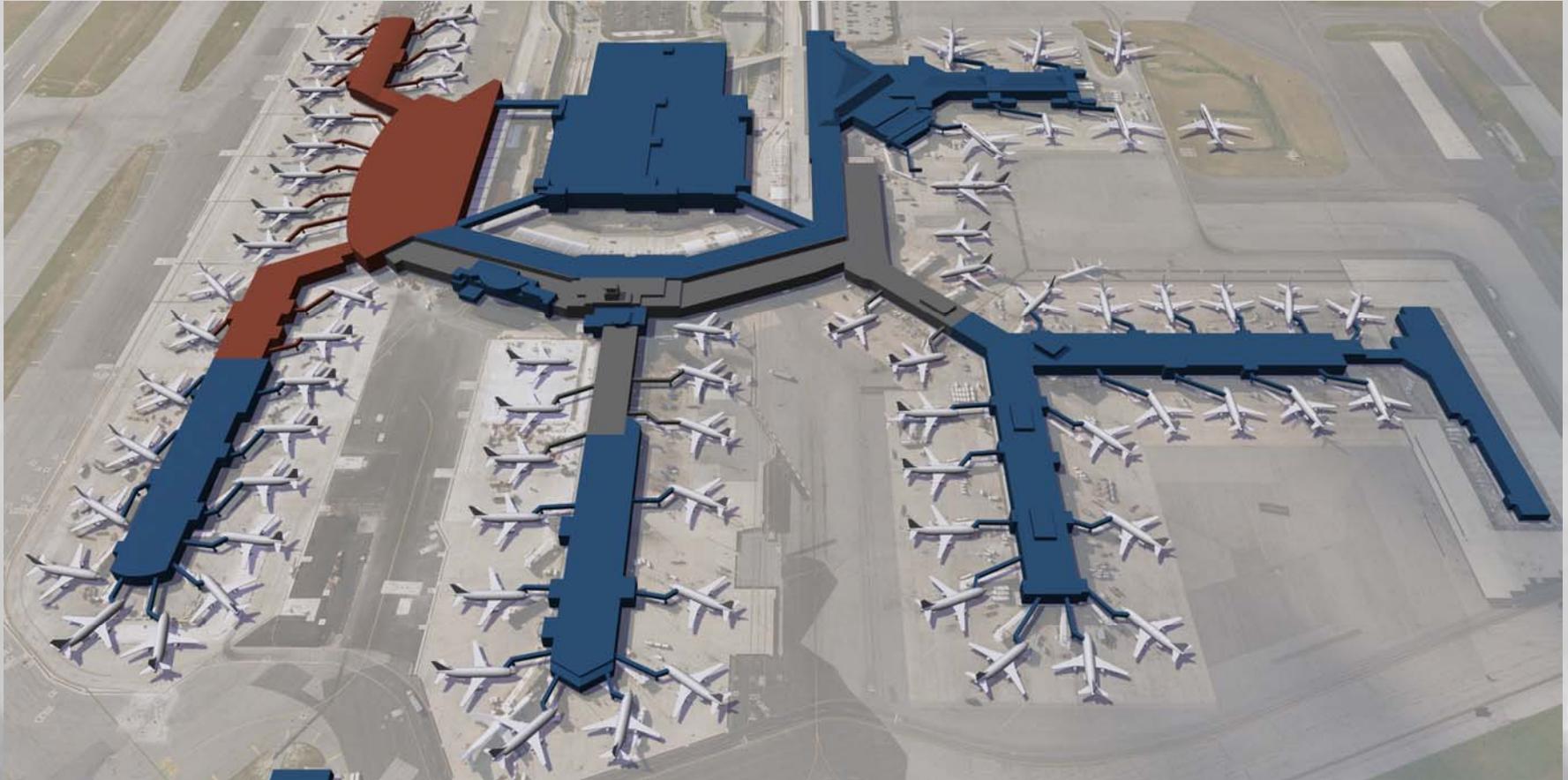


# Terminal Curbside Expansion & Skywalks 2004 Substation ST-TU



# Terminal A/B Expansion 2005

## Substations A-1, B-1, B-2

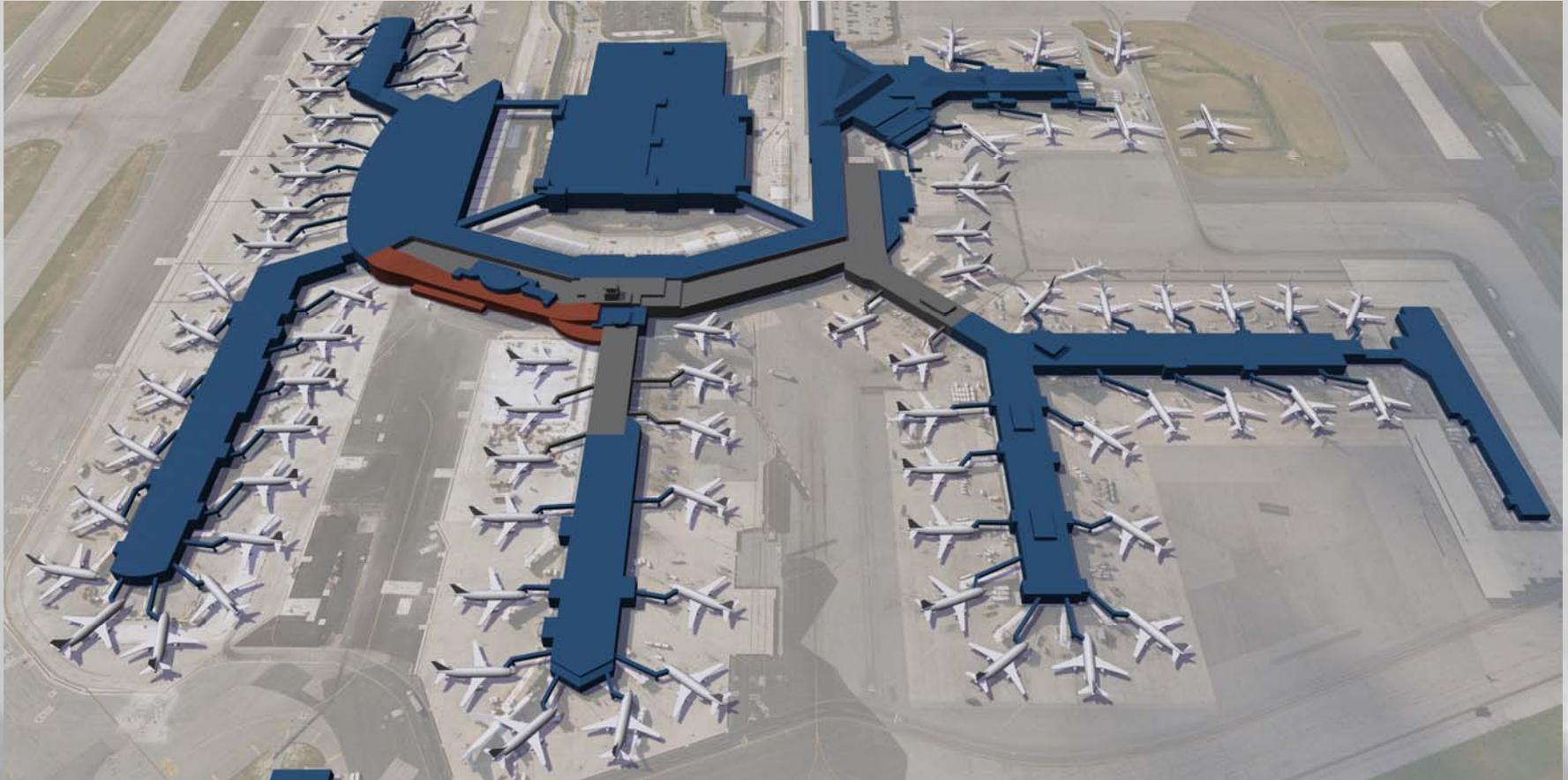


# DE Baggage System Claim Improvement (DEBSCI) 2010

## Major Modification to Substation E-1

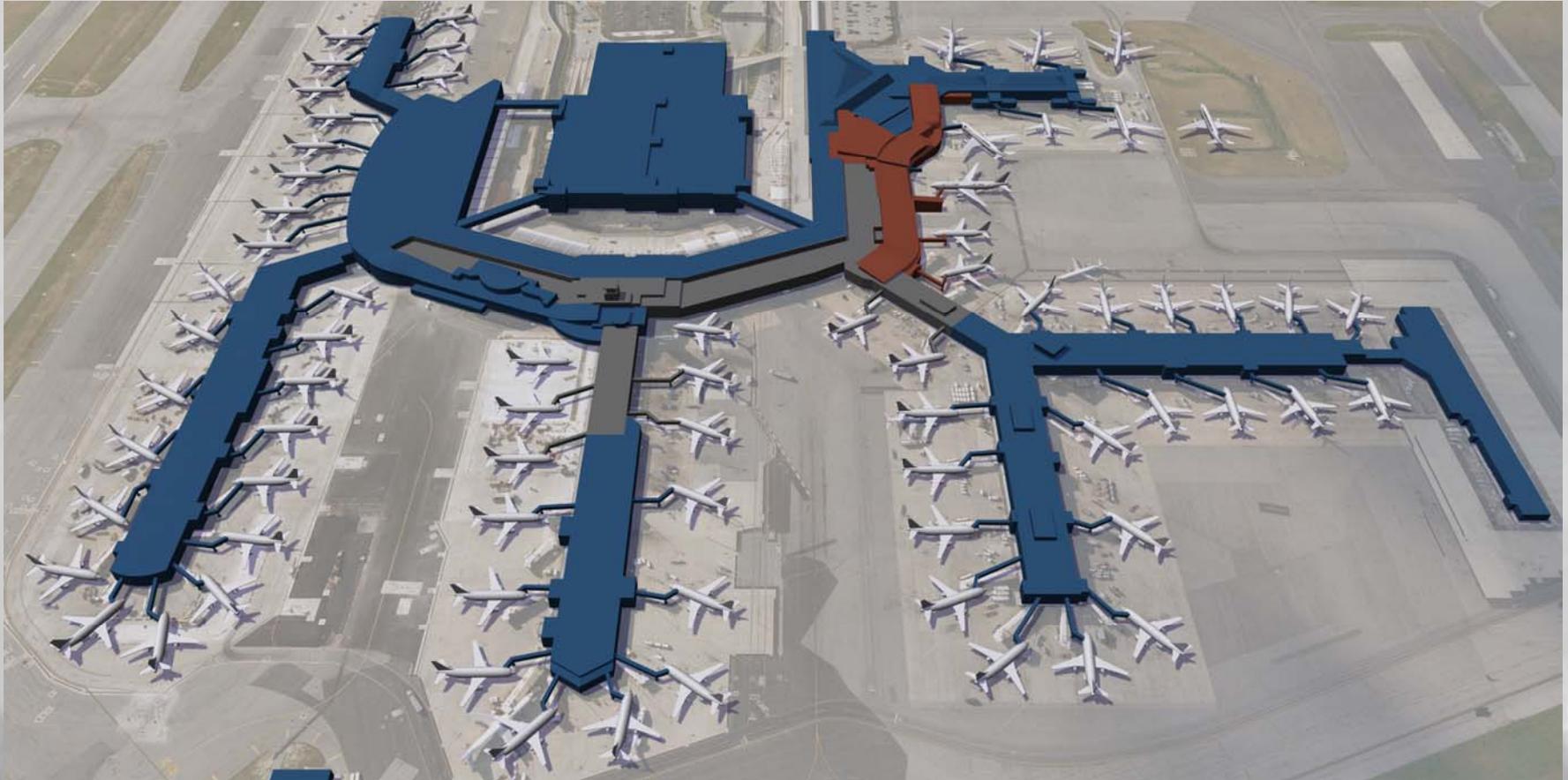


# B/C Connector 2013 Substation ST-BC



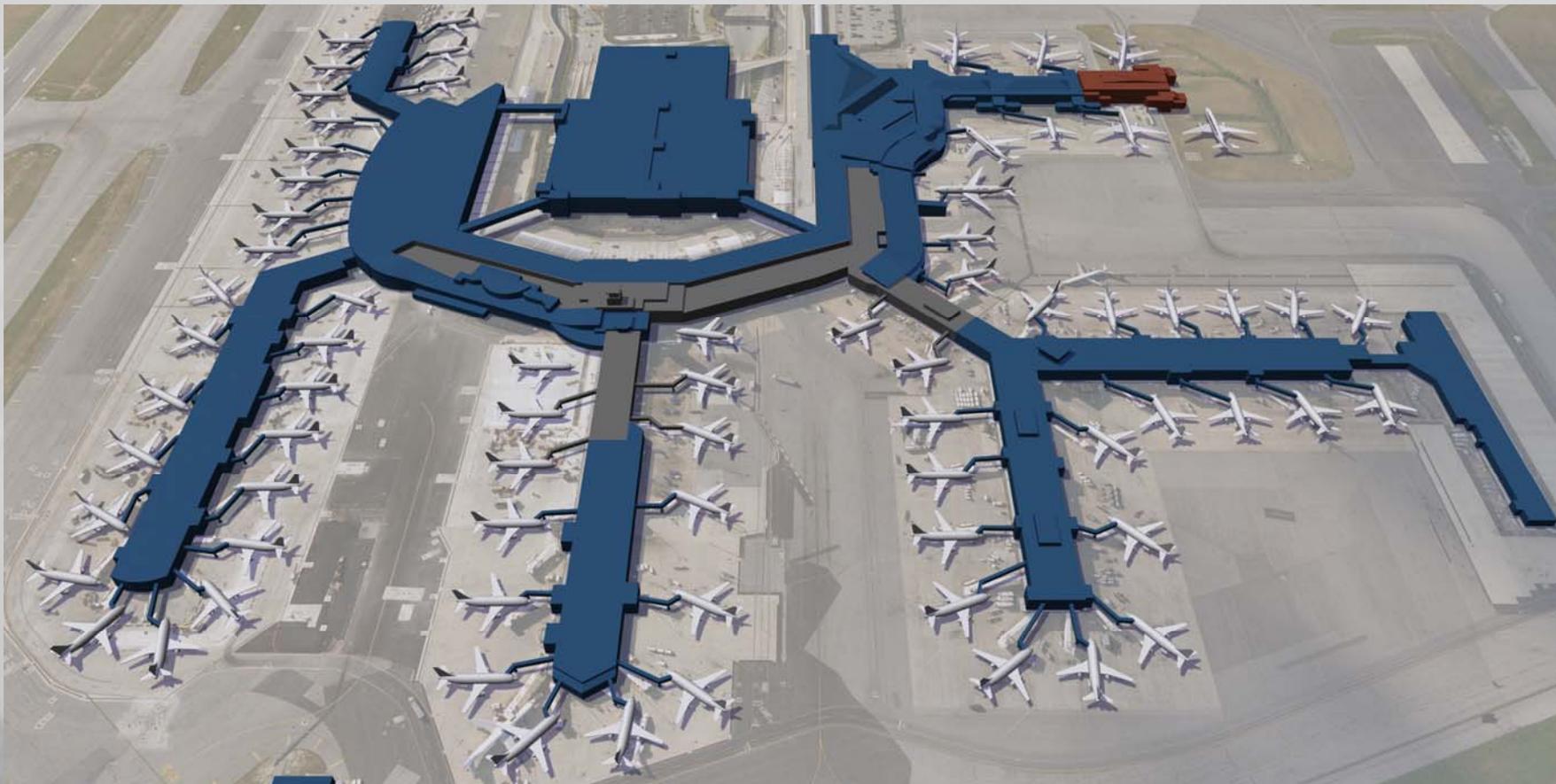
# D/E Connector 2016

## Substation NT-D1



# Concourse E Extension 2017

## Substation E-3



# Baltimore Washington International Airport 1972

## Substations ST-AB, NT-CT, NT-D



# Terminal D Extension 1983

## Substation D-1

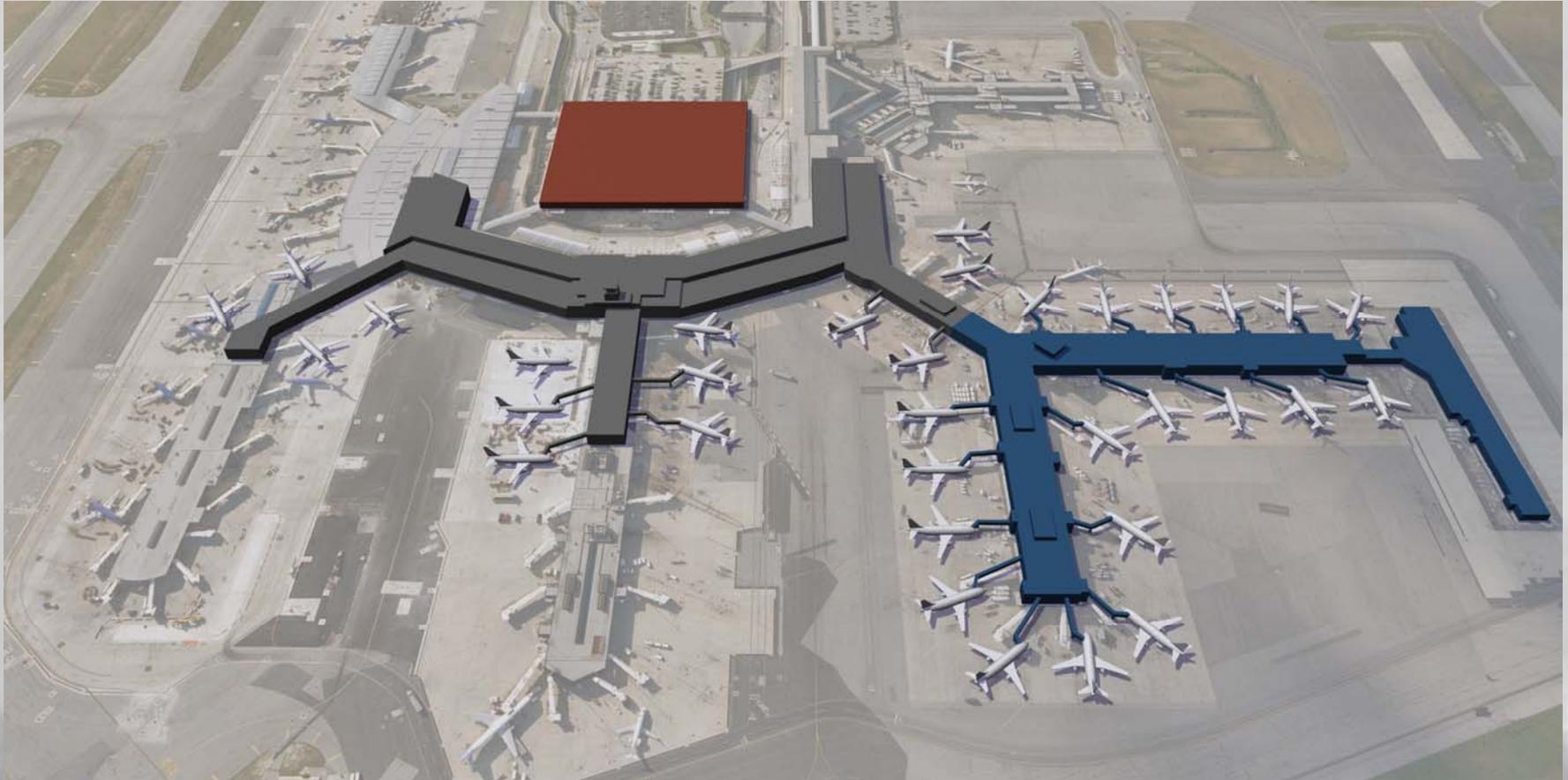


# Terminal DY Extension 1988

## Substations DY-1 and DY-2



# Hourly Garage 1991 Substation PG-1

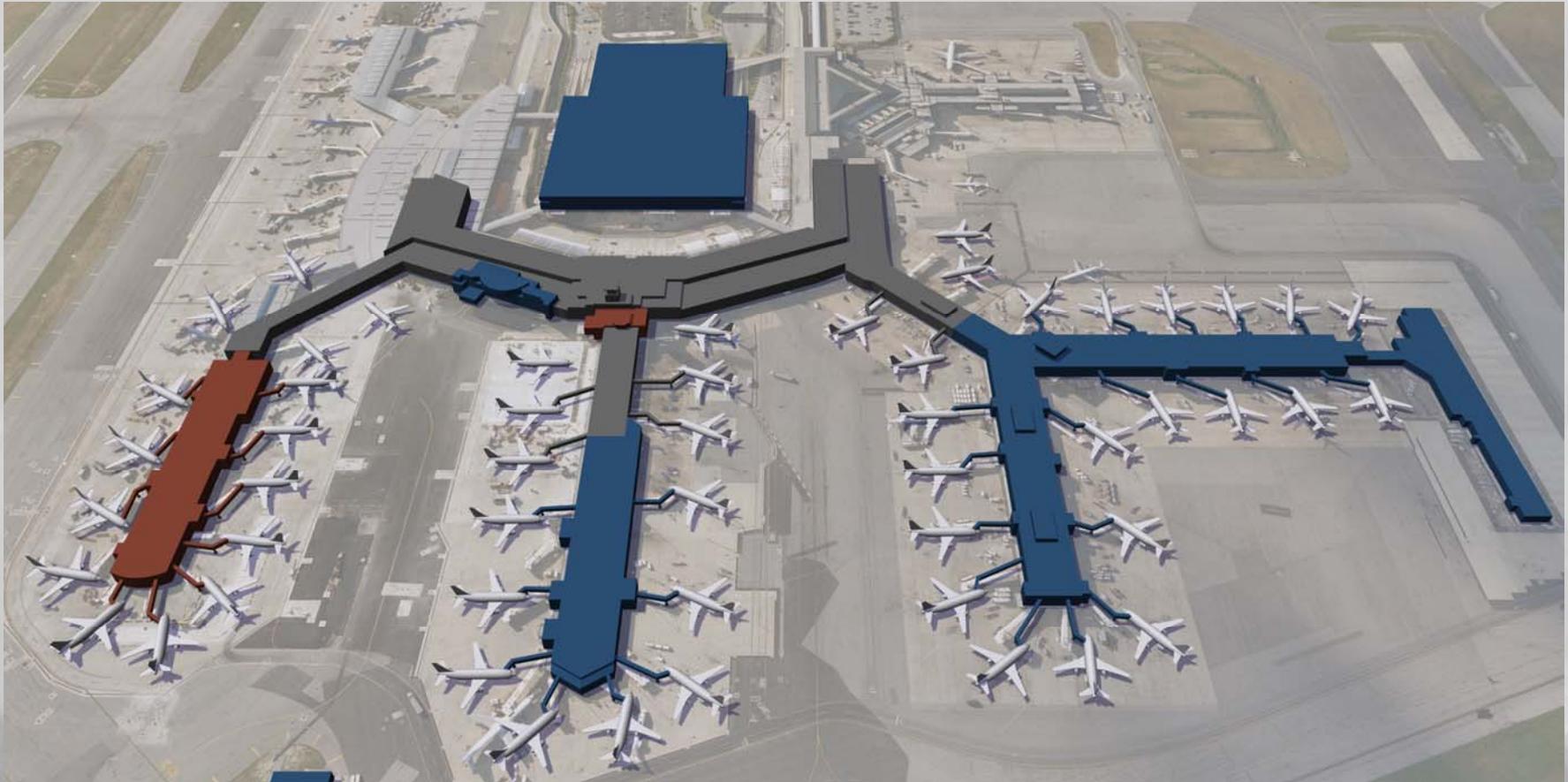


# Terminal C Extension 1994

## Substation C-1



# Terminal B Extension/Parking Garage Addition 1998 Substations B-3, B-4, PG-1 (Expansion)

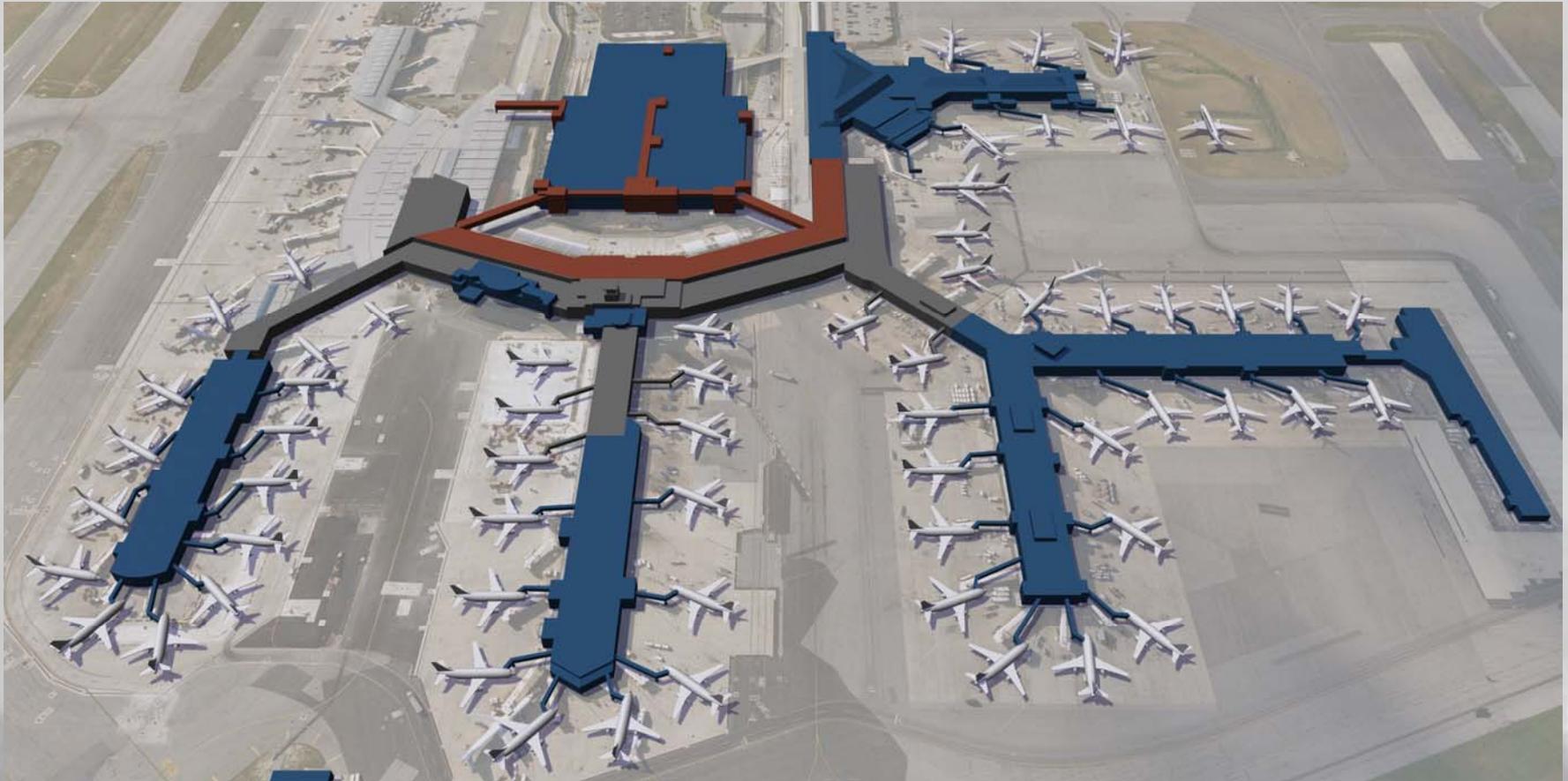


# International Terminal (Pier E) 1999

## Substations E-1, E-2

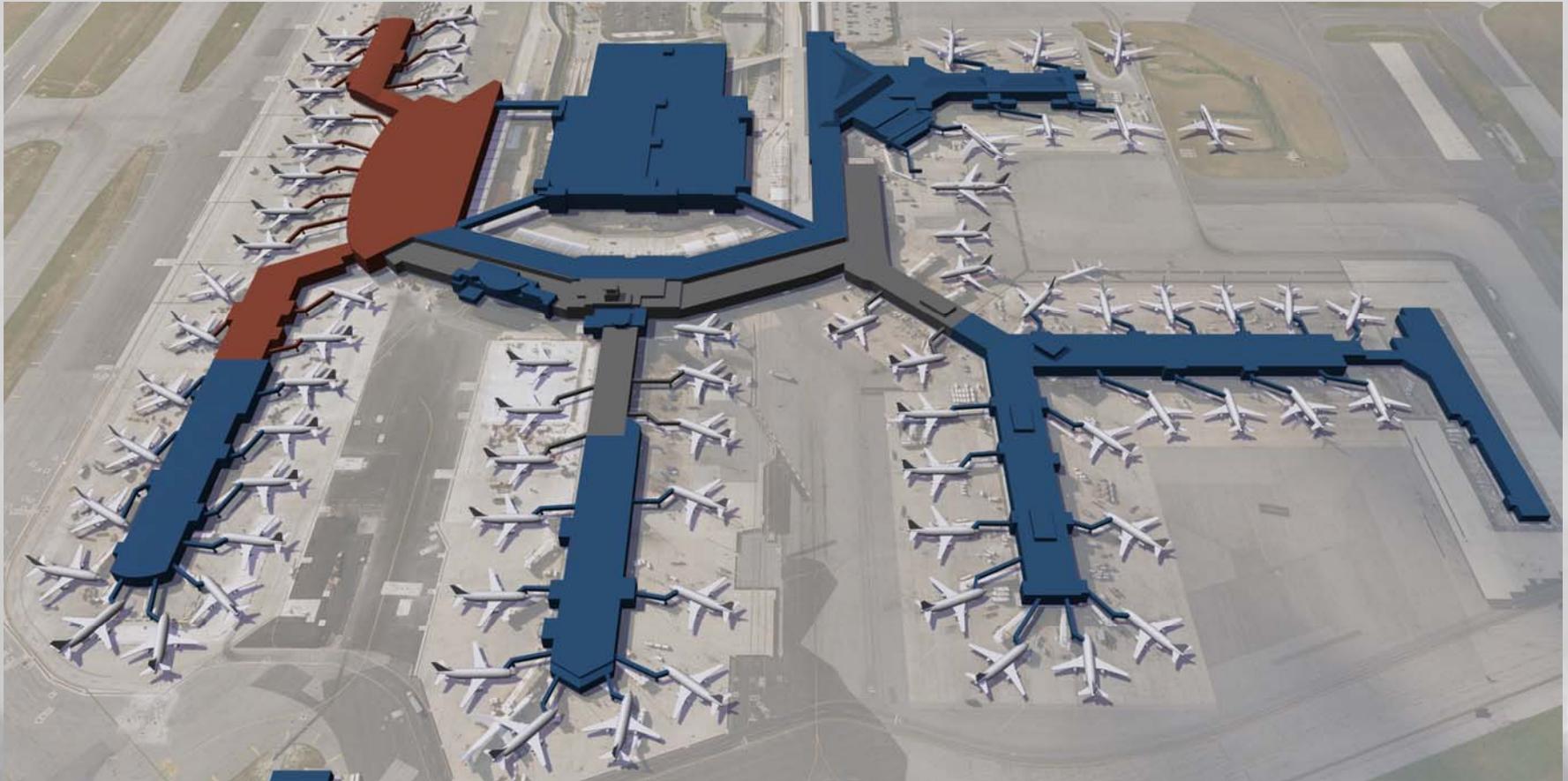


# Terminal Curbside Expansion & Skywalks 2004 Substation ST-TU



# Terminal A/B Expansion 2005

## Substations A-1, B-1, B-2



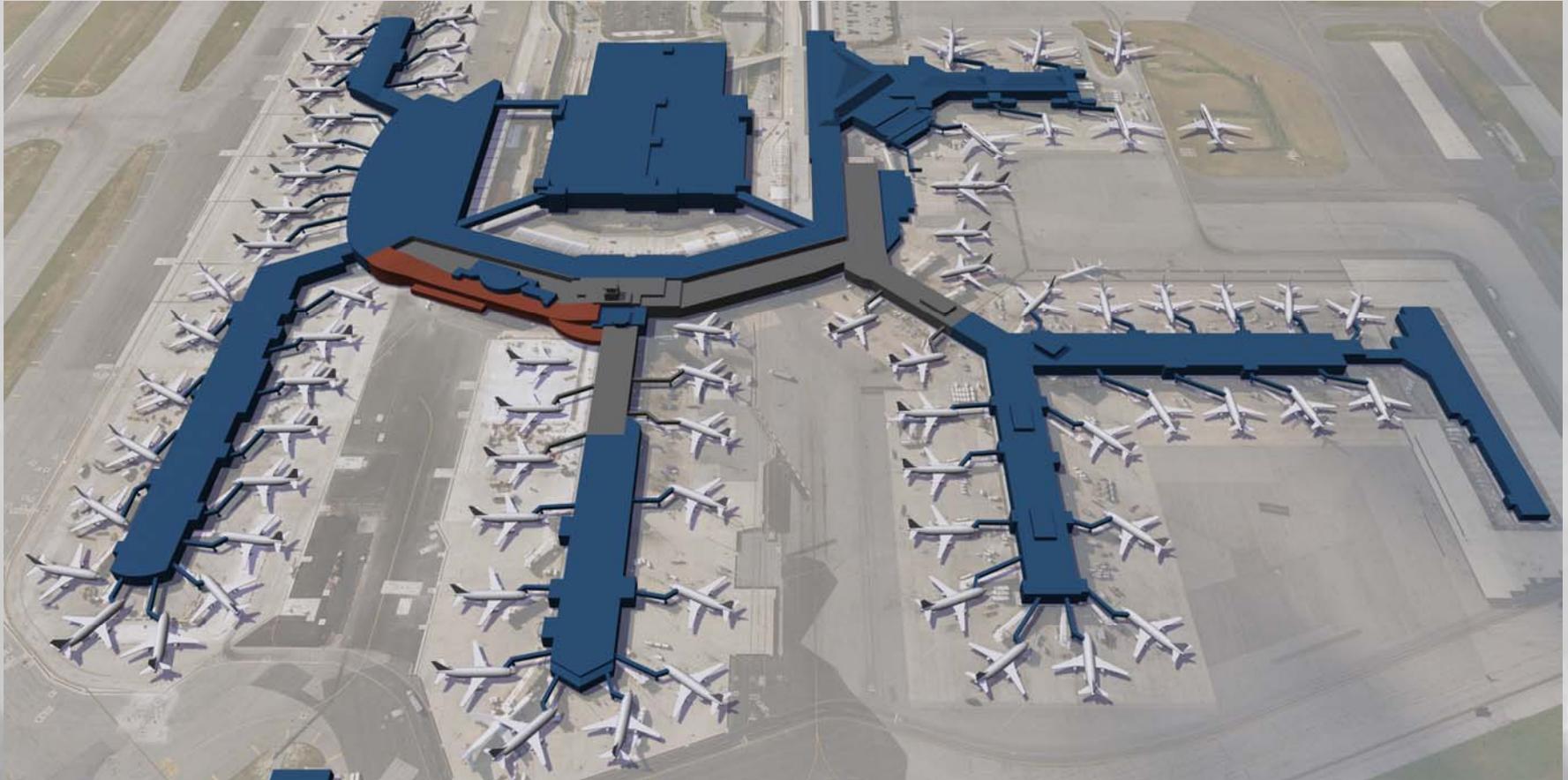
# DE Baggage System Claim Improvement (DEBSCI) 2010

## Major Modification to Substation E-2



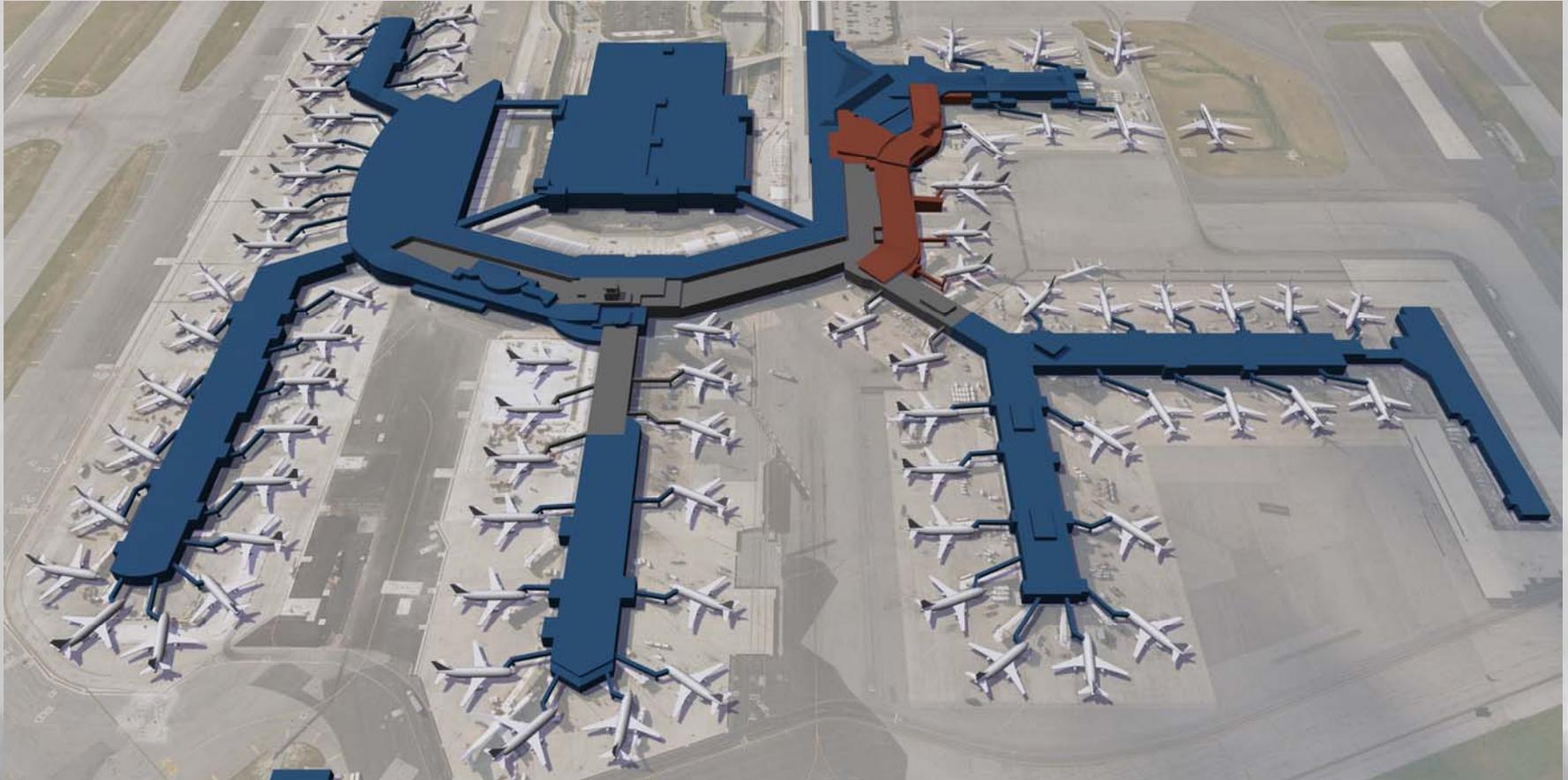
# B/C Connector 2013

## Substation ST-BC



# D/E Connector 2016

## Substation NT-D1



# Concourse E Extension 2017

## Substation E-3

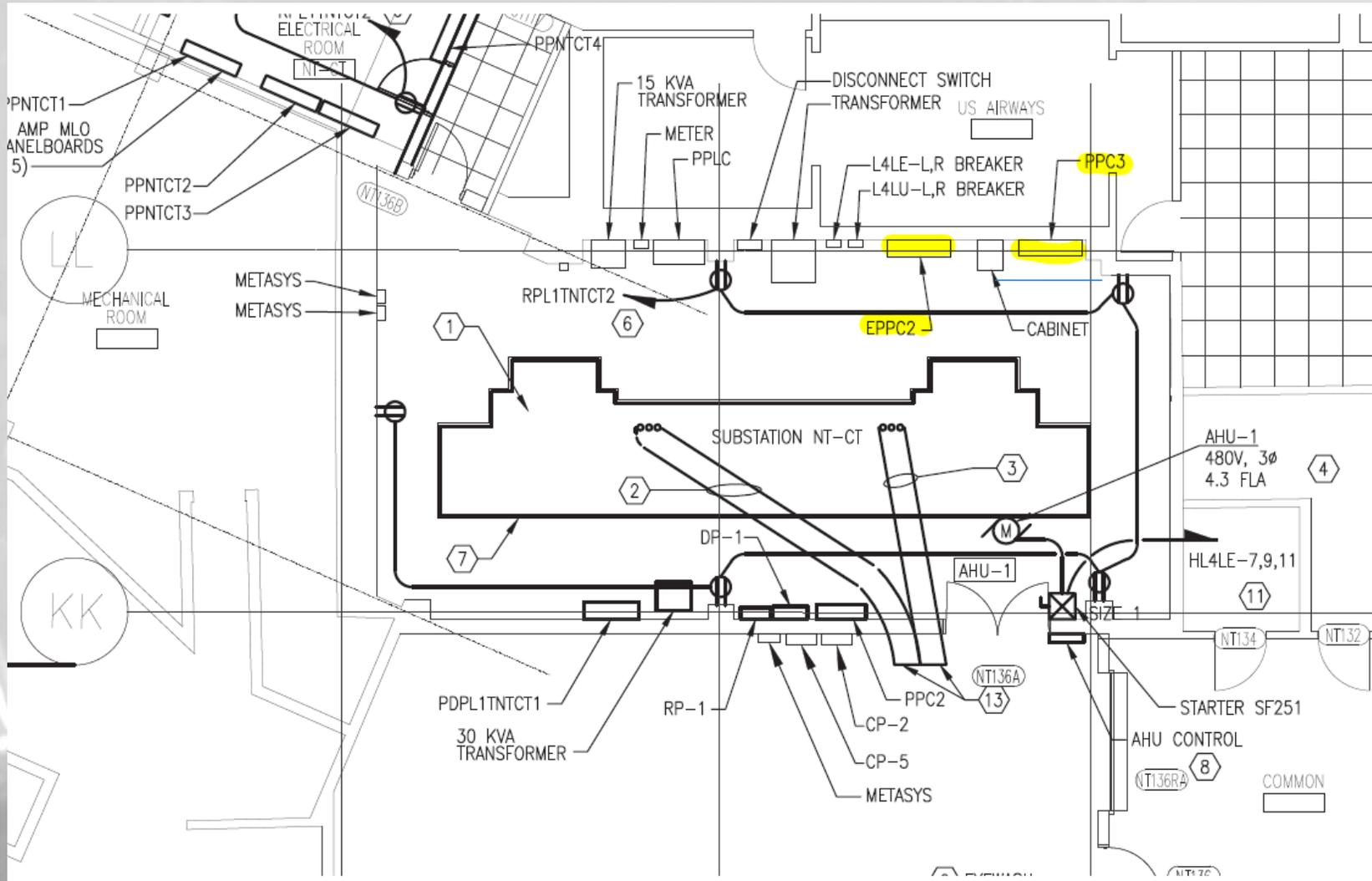


## Complexity of Electrical Distribution System

The electrical system was constructed, modified, replaced through the growth of the airport over more than 60 years.

- Service area of different substations are overlapping with each other.
- Some of the electrical equipment was fed from one substation before. Now they are fed from different substation.
- Electrical equipment in the same electrical room are fed from different substations.

# Complexity of Electrical Distribution System





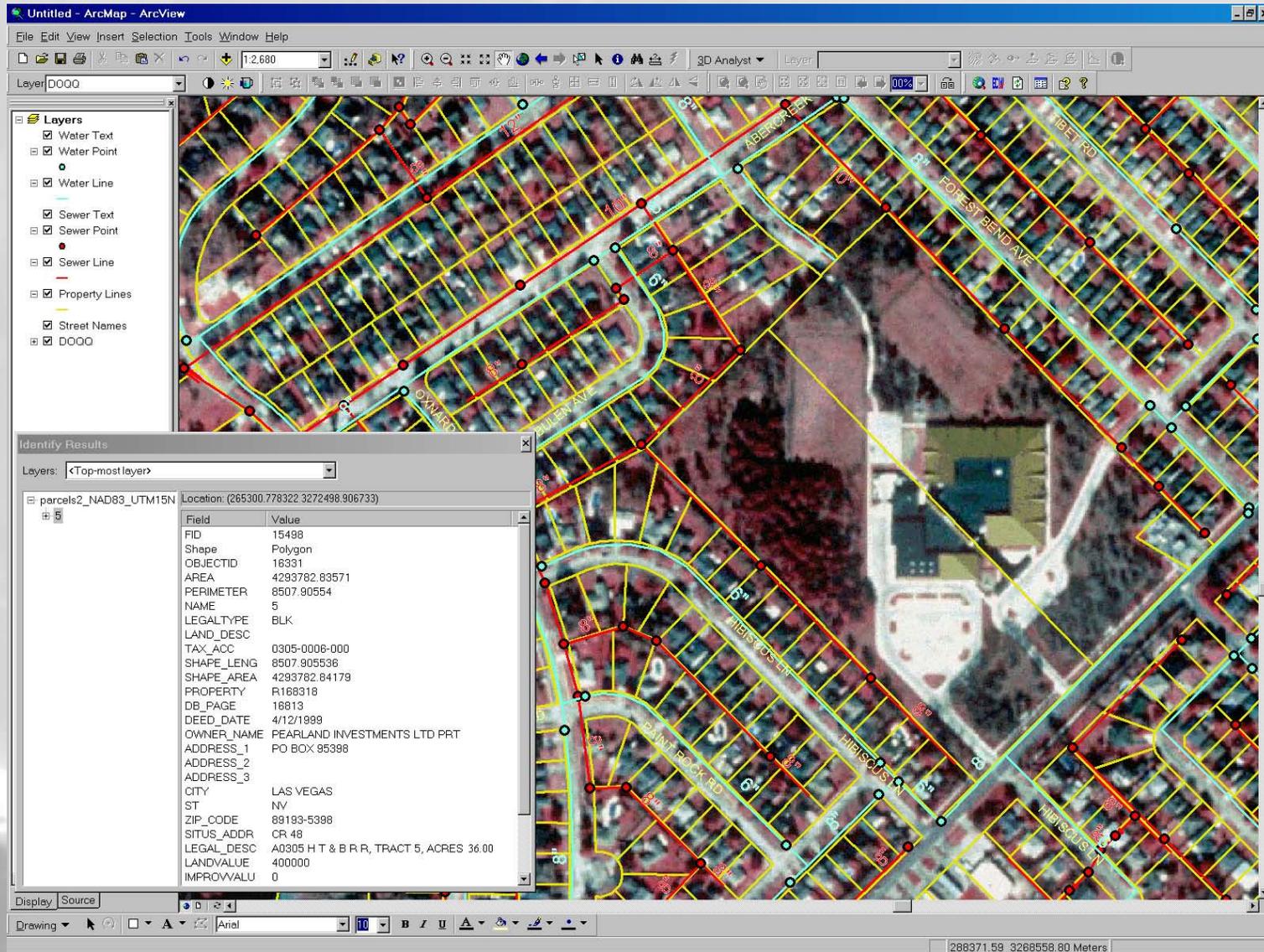
# What is GIS?

GIS stands for Geographic Information System.

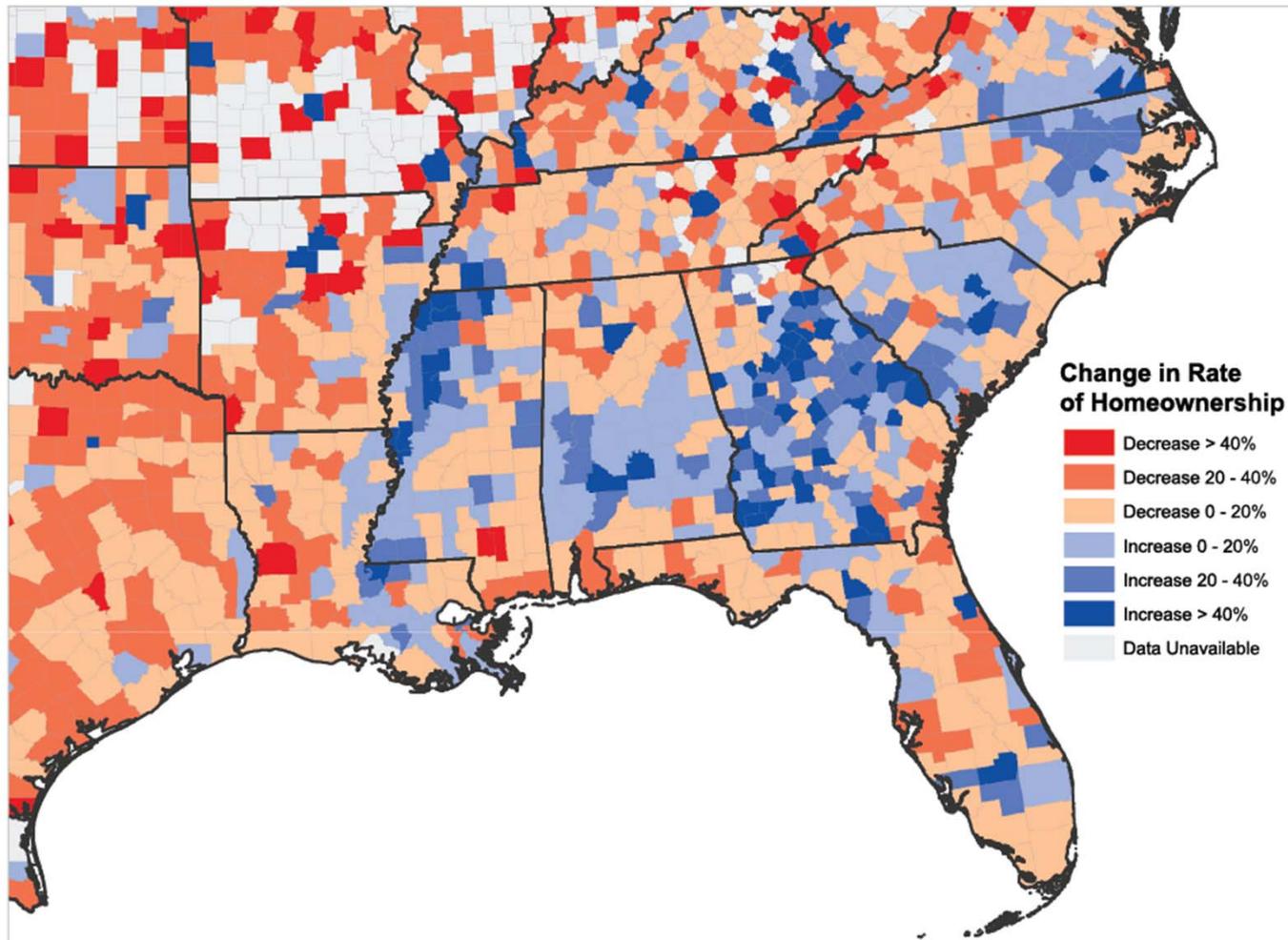
A geographic information system (GIS) is a computer system for capturing, storing, checking, analyze, and displaying data related to positions on Earth's surface. (National Geographic Society)

**G**eographic → Maps  
**I**nformation → Data  
**S**ystem → Computers

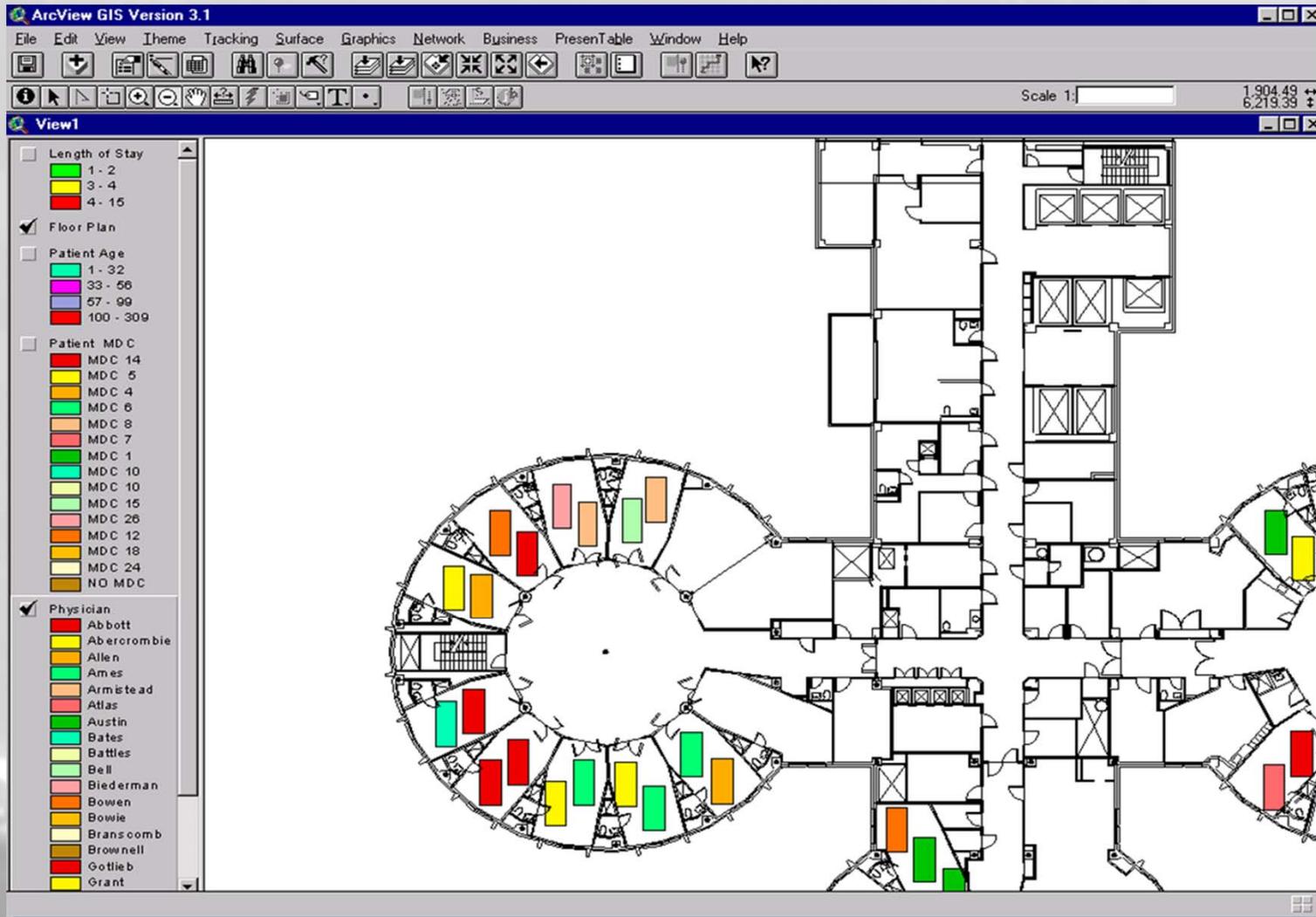
# Typical GIS Application –water and sewer piping management



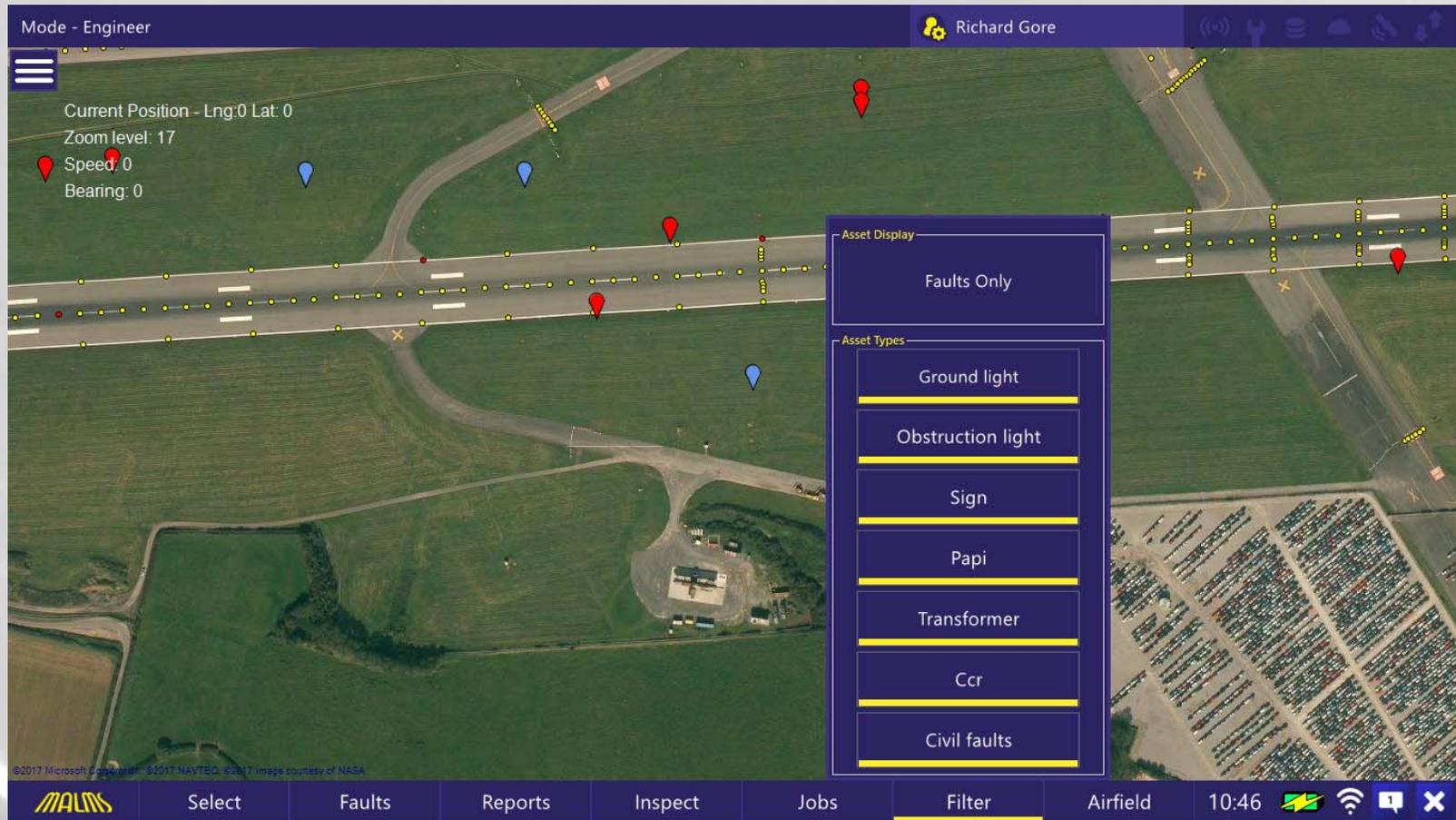
# Typical GIS Application – Areas (Change in Rate of Homeownership)



# Typical GIS Application – Hospital Facilities Management



# Typical GIS Application – Airfield Electrical Equipment Management



## Four basic categories of GIS Applications

- Environmental/natural resource management
- Urban and regional management
- Infrastructure management
- Commercial



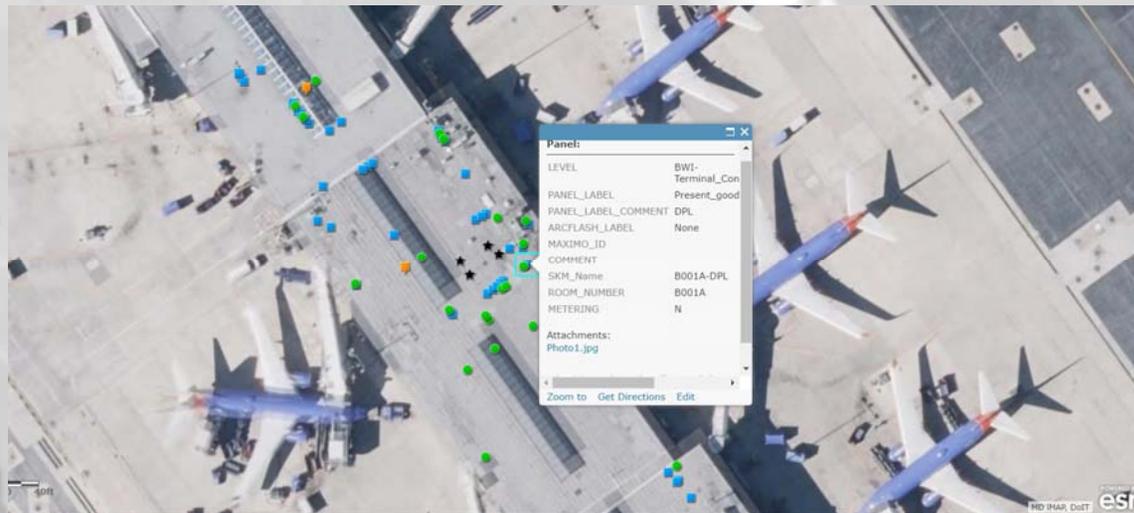
# Components of GIS

- Hardware
- Software
- Data
- People
- Applications



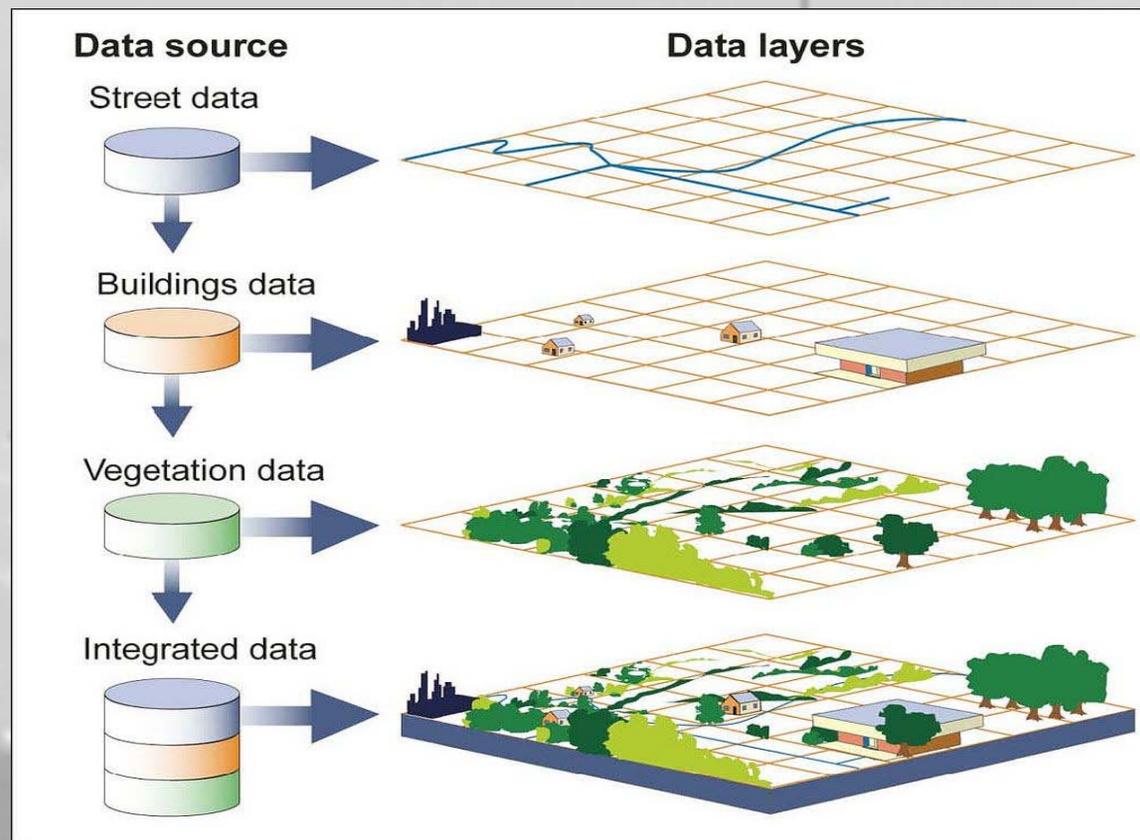
# Spatial Data and Attribute Data

- Spatial data (location of an object)
  - Coordinate system
    - Latitude and Longitude
- Attribute data (information about an object)
  - Specifies characteristics at the location



# GIS Architecture

Spatial data are organized into layers. GIS can show many different kinds of data on one map through different layers, such as streets, buildings, and vegetation.

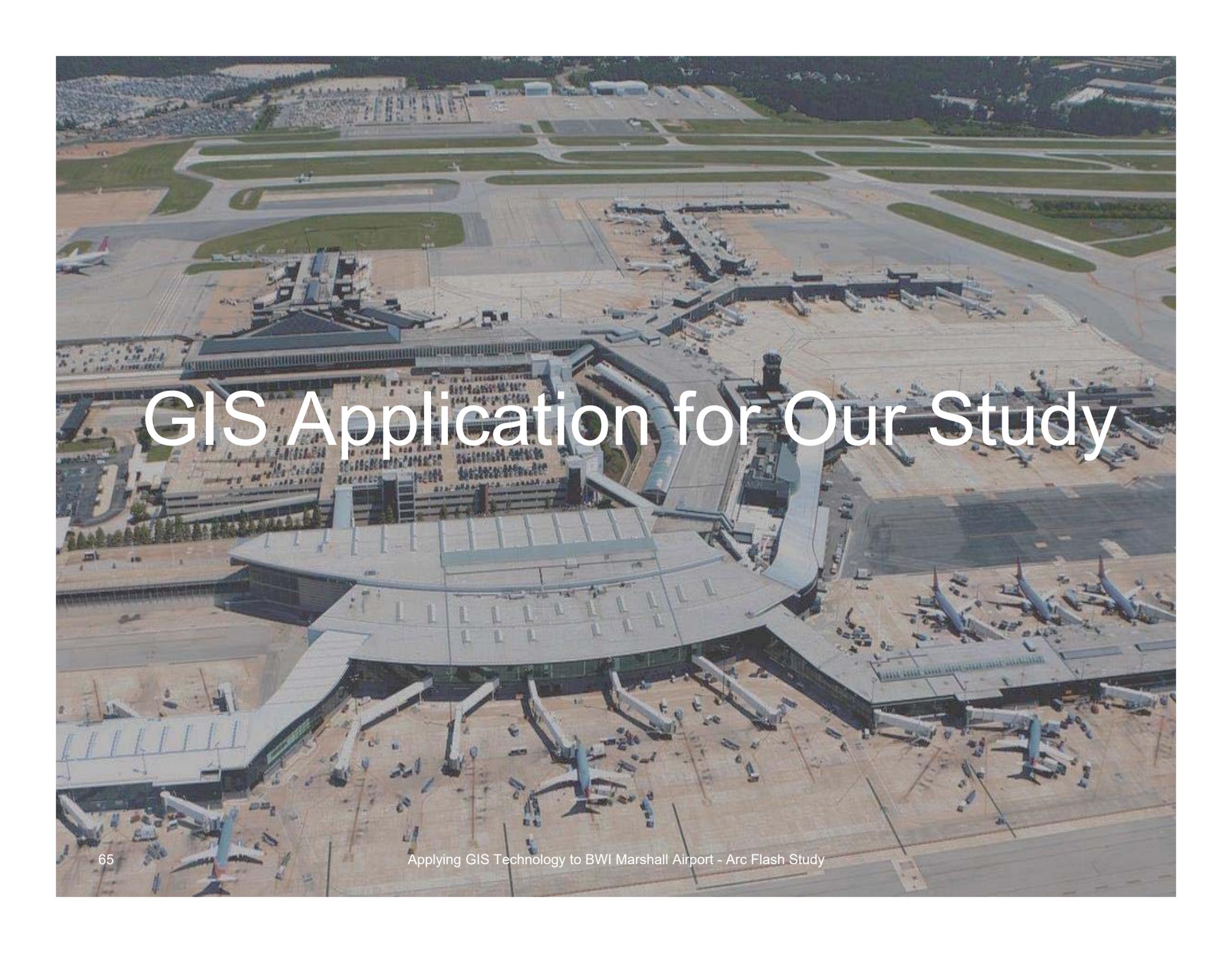


Source: GAO.

## Data Capture – Entering Information into the system

- Map Scan
- Remote sensing
- Field data collector



An aerial photograph of the BWI Marshall Airport terminal and tarmac. The terminal is a large, modern building with a curved roof and multiple concourses. Numerous aircraft are parked at gates, and the surrounding area includes parking lots, roads, and green spaces. The text "GIS Application for Our Study" is overlaid in white on the center of the image.

# GIS Application for Our Study

# GIS Software – App for iPad



**Legend**

**Transformer**  
●

**Panel**  
■

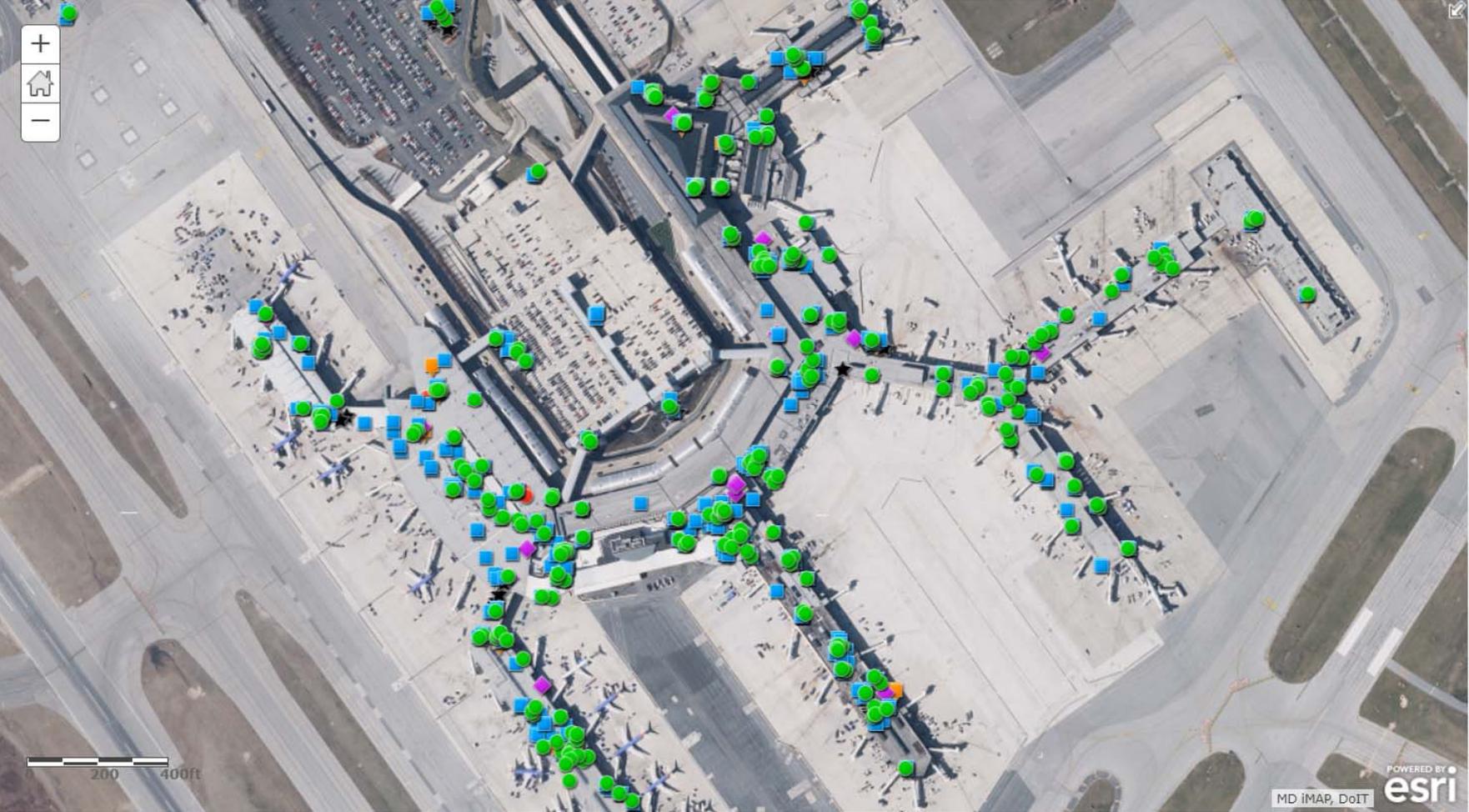
**MCC**  
◆

**Switchboard**  
▮

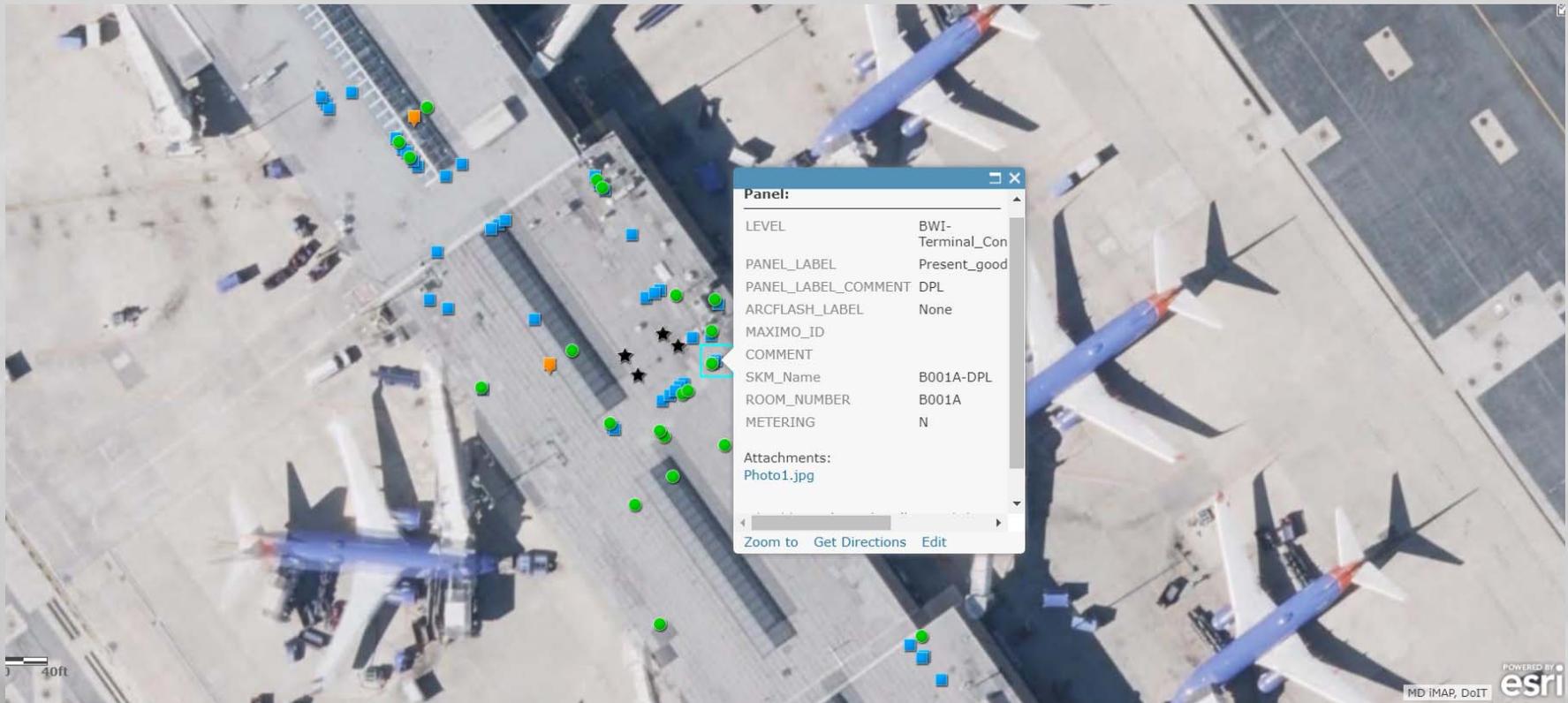
**Switchgear**  
★

**Floorplan Discrepancy**  
●

# BWI GIS Map for Arc Flash Study on Desktop



# Electrical Equipment Attribute Data



# Electrical Equipment Attribute Data

MAA Task 4428 Data Collection

maryland.maps.arcgis.com/home/webmap/viewer.html?webmap=7f11c59eff3348639bdf262bfe06c9a5

Home ▾ MAA Task 4428 Data Collection New Map ▾ David ▾

Details Add ▾ Edit Basemap Save ▾ Share Print ▾ Directions Measure Bookmarks Find address or place

About Content Legend

**Contents**

- Transformer
- Panel
- MCC
- Switchboard
- Switchgear
- Floorplan Discrepancy
- BLDG 001 003 Hangar Lower Level Anno
- BLDG 001 003 Hangar Upper Level Anno
- BLDG 004 006 Hangar Lower Level Anno
- BLDG 009 Maintenance Shop Lower Level Anno
- BLDG 009 Maintenance Shop Upper Level Anno
- BLDG 015 Administration Terminal ATCT 1st Floor Anno
- BLDG 015 Administration Terminal ATCT 2nd Floor Anno

Esri.com ArcGIS Marketplace Help Terms of Use Privacy Contact Esri Report Abuse Contact Us

**Panel (Features: 1259, Selected: 1)**

LEVEL	PANEL_LABEL	PANEL_LABEL_CC	ARCFLASH_LABEL	MAXIMO_ID	COMMENT	SKM_Name	ROOM_NUMBER	METERING	Photos &
BWI-Terminal_Concours_e_AB_Ground_Level_1a	Present_good	RPL2A18	None			A101C-RPL2A18	A101C	N	(1) S
BWI-Terminal_Concours_e_AB_Ground_Level_1a	Present_good	LPL2A17	None			A101C-LPL2A17	A101C	N	(1) S
BWI-Terminal_Concours_e_AB_Ground_Level_1a	Present_good	RPL2A17	None			A101C-RPL2A17	A101C	N	(1) S
BWI-Terminal_Concours_e_AB_Ground_Level_1a	Present_good	LPL2A13	None			A101C-LPL2A13	A101C	N	(1) S
BWI-Terminal_Concours_e_AB_Ground_Level_1a	Present_good	LSRL2A16	None			A101C-LSRL2A16	A101C	N	(1) S
BWI-Terminal_Concours_e_AB_Ground_Level_1a	Present_good	RPL2A15	None			A101C-RPL2A15	A101C	N	(1) S

# Substation ST-TU



# Panel Attribute Data Table

The screenshot shows an ArcGIS web application interface. At the top, the browser address bar displays the URL: `maryland.maps.arcgis.com/home/webmap/viewer.html?webmap=7f11c59eff3348639bdf262bfe06c9a5`. The page title is "MAA Task 4428 Data Collection".

On the left side, there is a "Contents" panel with a list of layers. The "Panel" layer is checked and highlighted. Other layers include Transformer, MCC, Switchboard, Switchgear, Floorplan Discrepancy, and various Hangar and Maintenance Shop annotations.

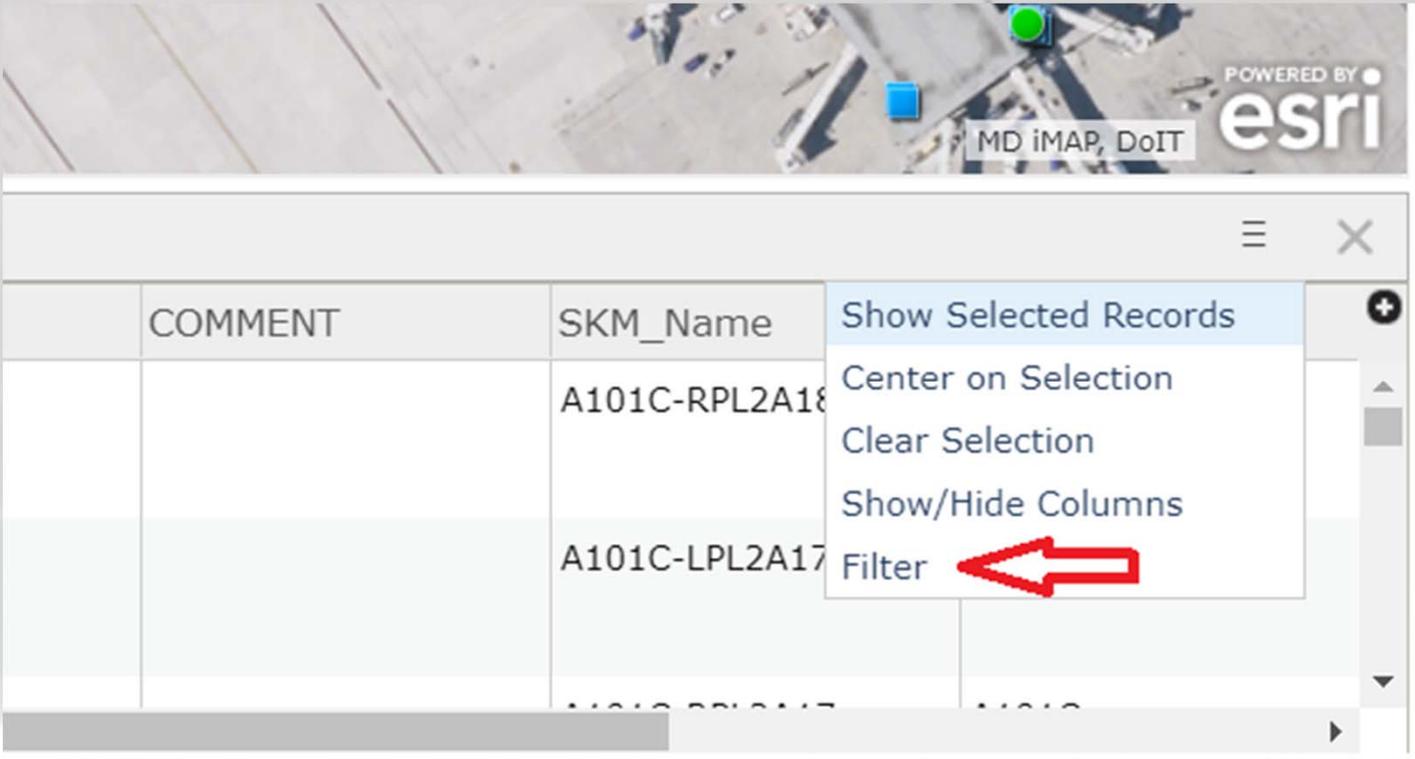
The main map area shows an aerial view of an airport with several green and blue markers. A pop-up window is visible over one of the markers, displaying the following attributes:

- ROOM\_NUMBER: NTEZ70
- METERING: N
- Attachments: (empty list)
- Buttons: Zoom to, Get Directions, Edit

Below the map, a data table titled "Panel (Features: 1259, Selected: 1)" is displayed. A red arrow points to the close button (X) in the top right corner of the table. The table has the following columns and data rows:

LEVEL	PANEL_LABEL	PANEL_LABEL_CC	ARCFLASH_LABEL	MAXIMO_ID	COMMENT	SKM_Name	ROOM_NUMBER	METERING	Photos
BWI-Terminal_Concours e_AB_Ground_Level_1a	Present_good	RPL2A18	None			A101C-RPL2A18	A101C	N	(1) Photos
BWI-Terminal_Concours e_AB_Ground_Level_1a	Present_good	LPL2A17	None			A101C-LPL2A17	A101C	N	(1) Photos
BWI-Terminal_Concours e_AB_Ground_Level_1a	Present_good	RPL2A17	None			A101C-RPL2A17	A101C	N	(1) Photos
BWI-Terminal_Concours e_AB_Ground_Level_1a	Present_good	LPL2A13	None			A101C-LPL2A13	A101C	N	(1) Photos
BWI-Terminal_Concours e_AB_Ground_Level_1a	Present_good	LSRL2A16	None			A101C-LSRL2A16	A101C	N	(1) Photos
BWI-Terminal_Concours e_AB_Ground_Level_1a	Present_good	RPL2A15	None			A101C-RPL2A15	A101C	N	(1) Photos

# Panel Attribute Data Table



The screenshot shows a GIS application window titled "MD iMAP, DoIT" with the Esri logo. Below the map, there is an attribute data table. The table has columns for "COMMENT" and "SKM\_Name". A context menu is open over the table, listing several actions: "Show Selected Records", "Center on Selection", "Clear Selection", "Show/Hide Columns", and "Filter". A red arrow points to the "Filter" option.

COMMENT	SKM_Name
	A101C-RPL2A18
	A101C-LPL2A17
	A101C-RPL2A17
	A101C-RPL2A17

# Panel Attribute Data Table

The screenshot shows a GIS application interface with a 'Filter: Panel' dialog box open. The dialog has a 'Create' tab and options to '+ Add another expression' and '+ Add a set'. Below these, it says 'Display features in the layer that match the following expression'. The filter expression is 'PANEL\_LABEL\_COMM is PPC3'. The 'PANEL\_LABEL\_COMM' field is selected, and 'PPC3' is entered in the value field. The 'Value' radio button is selected. There are three red arrows: one pointing to the field name, one to the value, and one to the 'APPLY FILTER' button. The background shows a map and a data table.

Panel (Fe				
LEVEL				
BWI-Terminal_Concourse_A				
B_Ground_Level_1a				
BWI-	Present_good	LPL2A17	None	

# Panel Attribute Data Table

Panel (Features: 1, Selected: 1)

LEVEL	PANEL_LABEL	PANEL_LABEL_COMM	ARCFLASH_LABEL	MAXIMO_ID	COMMENT	SKM_Name	ROOM_NUMBER
BWI-Terminal_Lower_Level_1	Present_good	PPC3				NT136A-PPC3	NT136A

# BWI Enterprise GIS Application

[« Back to Home Page](#)

## BWI GIS Applications

 <b>SUE Status</b> Status of available Subsurface Utilities data by grids as of the date indicated in the grid	 <b>All Utilities</b> All above- and below-ground utility features and attributes	 <b>Communications</b> Exterior communication systems features & attributes, excluding fiber optic network
 <b>Deicing Collection</b> Airfield deicing collection system features and attributes	 <b>Electrical</b> Exterior electrical system network features and attributes	 <b>FAA Systems</b> Exterior FAA airfield system features and attributes
 <b>Fueling Systems</b> Hydrant fueling and gasoline systems features and attributes	 <b>Heating &amp; Cooling</b> Exterior HVAC hot water heating & cooling pipes features and attributes	 <b>Natural Gas</b> Natural gas exterior network features and attributes
 <b>Stormwater</b> Stormwater network features and attributes	 <b>Wastewater</b> Sanitary sewer/wastewater exterior network features and attributes	 <b>Water</b> Main domestic water exterior network features and attributes

**MOT** MARYLAND DEPARTMENT OF TRANSPORTATION,  
MARYLAND AVIATION ADMINISTRATION

**BWI** BALTIMORE/WASHINGTON INTERNATIONAL  
MARSHALL AIRPORT

**MARTIN** STATE AIRPORT

**AECOM** Imagine it.  
Delivered.