AABC Commissioning Group

AIA Provider Number 50111116

Case Study: Cx of South Airport APM/ITF Complex at Orlando International Airport

Course Number: CXENERGY1801

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Greater Orlando Aviation Authority

April 25, 2018

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GREATER ORLANDO AVIATION AUTHORITY

CONTINUING EDUCATION AIA

Course Description

When the new South Airport Automated People Mover / Intermodal Transportation Facility Complex (SAC) at Orlando International Airport was commissioned, the massive project produced invaluable lessons and best practices in coordination.

Commissioned systems include all major building envelope, mechanical (HVAC), plumbing, electrical and life safety systems. The session provides a real world example of how to approach the Cx of an approximately $650 million project with multiple CMARs, subcontractors and stakeholders.

Learning Objectives

At the end of the this course, participants will be able to:

1. Importance of designated Cx coordinators for both CMAR firms; acting as liaisons with the CxA and BECxA, as well as coordinating with the multiple subcontractors on site. This ensures that construction systems, products, fixtures, and equipment are consistent across respective areas of responsibility.

2. Importance of regular Tag-Up, Readiness and Pull Planning meetings to monitor system progress and adjust critical schedule activities for testing preparation. This is essential to the integrity of preparation activities to deploy structural, mechanical, electrical, plumbing, communications, security, fire protection systems.

3. Use of cloud-based Cx web application to track and manage the large amount of commissioning data, both envelope and M/E/P/FP, associated with the project (issues, checklists, tests, drawings, specifications, delivery methods, etc.)

4. Employing Lessons Learned from this South Airport Complex project for the next project: South Terminal C – Phase 1 (1.5 million SF).

Overview

Project Description & Scope

Owner's Team and Expectations

Challenges

Documentation

Lessons Learned

Next …

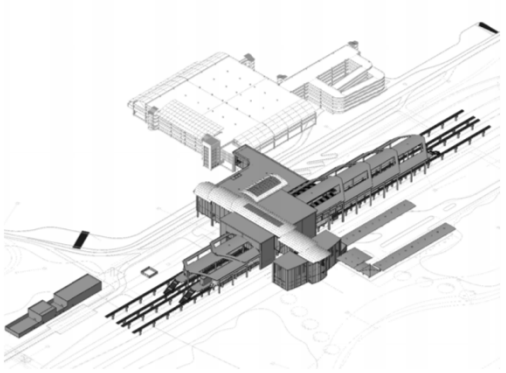
Project Description and Scope

Cx ENERGY 2018

Orlando International Airport (MCO)

- Formerly McCoy Air Force Base (closed 1975)
- Busiest airport in Florida – 44.6 million passengers (2017)
- Nation's 14th largest airport (in traffic)
- Fourth largest airport by area (20.8 sq. miles)
- Operated and managed by Greater Orlando Aviation Authority (GOAA)

South Airport APM Complex and South Airport Intermodal Terminal (SAC)



- Approximately 335,000 SF, excluding Parking Deck
- Automated People Mover (APM) Facility – 4 story with mezzanine, integrated with ITF (approximately 200,000 SF conditioned area)
- Passenger Drop-Off Lobby (PDL)
- Parking Garage – Six level with 2,400 spaces
- Central Energy Plant (CEP) – initially 1,400 tons, sized to accommodate expansion to 8,100 tons

Commissioning Scope

- Building Envelope – (subconsultant CMC)
- HVAC Systems and Controls
- Plumbing Systems
- Fire Protection Systems - including multiple Fire Pumps
- Electrical Systems - including multiple generators and paralleling switchgear
- Electronic Safety and Security – including fire detection and alarm, security / access control, and video surveillance

ORLANDO INTERNATIONAL AIRPORT | MCO

Owner's Team and Expectations

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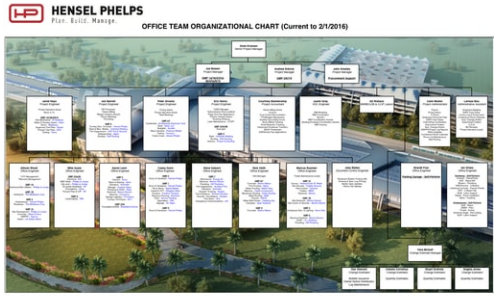
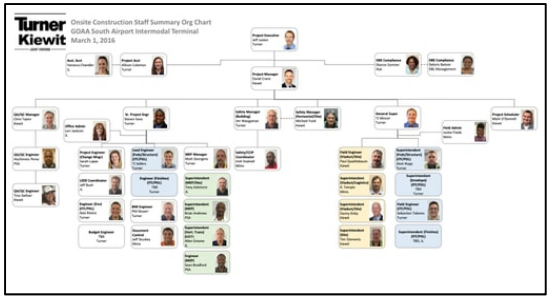
Owner and Project Team

- GOAA, AECOM, GCI and their OARs
- A/E Team
- CMARs and Subcontractors
- CxA and BECxA
- Special Inspectors and Third Party Testing Agencies



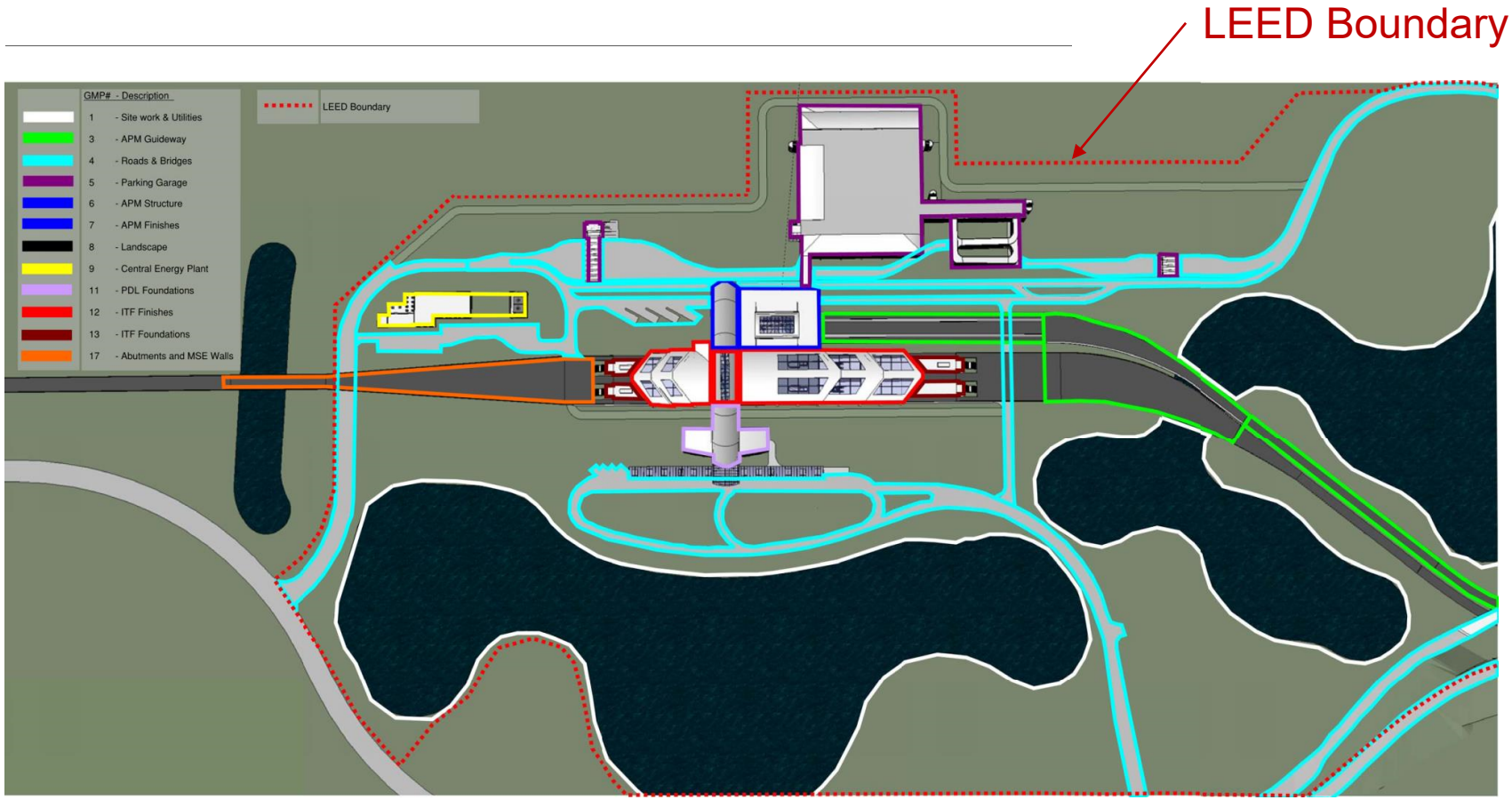


Cx ENERGY 2018

Contracting Arrangement – CMARs / GMPs

- Two Construction Managers at Risk (CMARs) – Hensel-Phelps and Turner Kiewit JV
- Multiple GMPs – examples: GMP-5 – Garage and Toll Booth, GMP-6 – APM, GMP-9 – CEP, GMP-11 – ITF, GMP-12 - PDL
- Multiple Subcontractors (by GMP)
- Defined lines of demarcation between GMPs
- Some systems divided between GMPs and CMARs; e.g. central chilled water loop and atrium smoke evacuation

Contracting Arrangement – Multiple GMPs



Owner's Requirements / Expectations

- Comply with GOAA's Sustainability Management Plan
- LEED v4 Campus Certification
- 16% improvement over baseline energy model (90.1-2010) & 20% water reduction using EPA Water Sense Tool
- First phase of a multi-phase master plan – design needs to be flexible and accommodate growth
- Coordinate with outside transportation groups

Owner's Requirements / Expectations

- Environmental Quality is critical – Space temperature and humidity, lighting and acoustics
- Continuity of airport operations, without interruptions, is critical
- Security and Life Safety systems to meet all State, local and Federal (FAA & DHS) requirements
- Ensure integration with North Terminal systems
- Interior design to emphasize the "Orlando Experience"

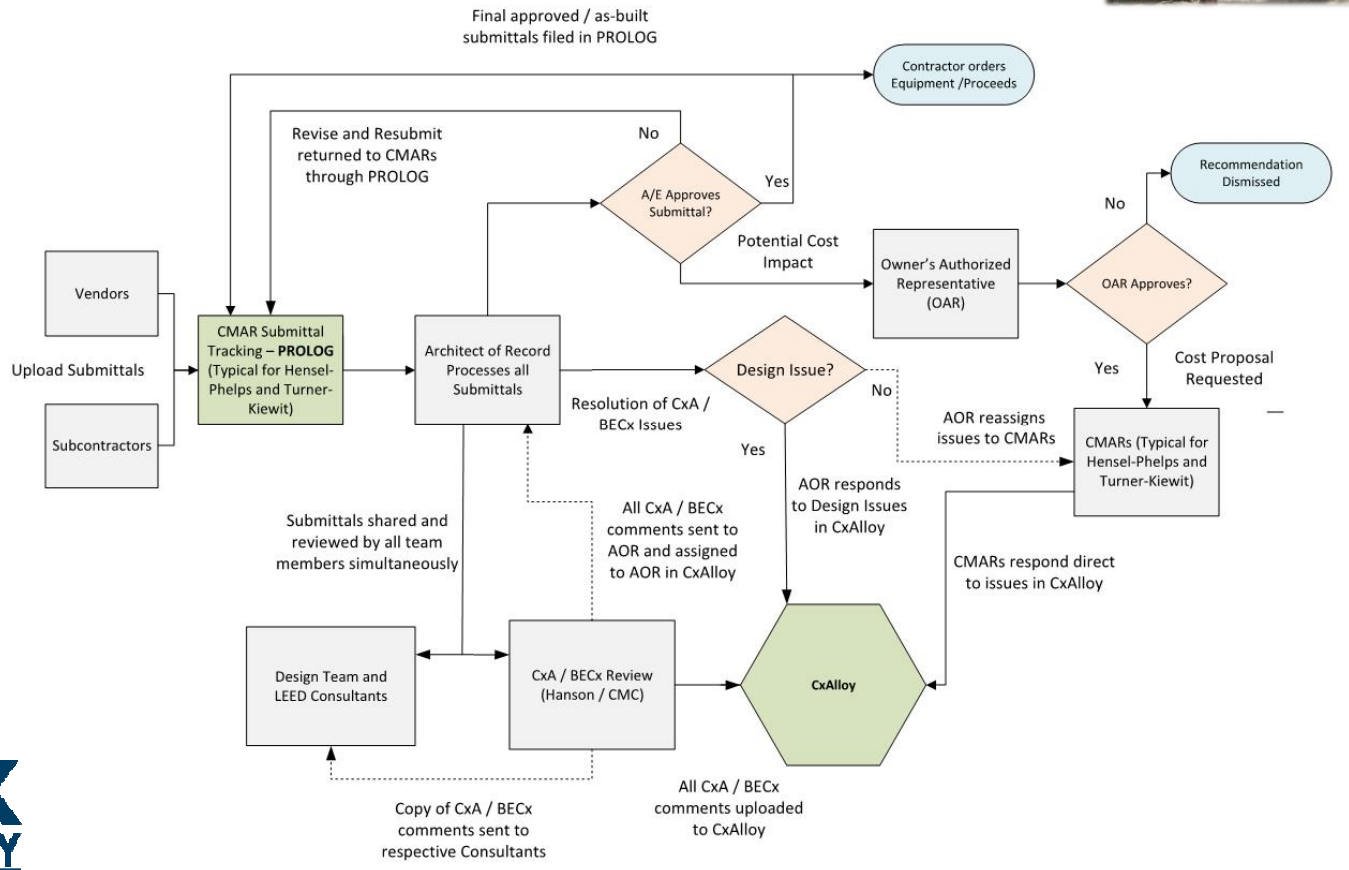
Challenges

Cx ENERGY 2018

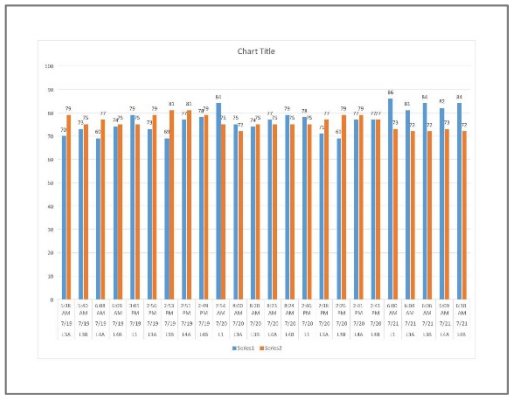
Large Project Team - Multiple Parties

- Multiple Bid Packages
- Multiple A/E firms requiring more challenging inter-disciplinary coordination efforts
- Multiple installing contractors / subcontractors and vendors
- Multiple submittal reviews
- Multiple 3rd party inspections and testing agencies
- Multiple coordination meetings (eventually leading to Tag-up, Readiness and Pull Planning meetings)

SAC Submittal Review Process



Staggered Progress of Construction



- GMPs awarded at different times, resulting in various levels of progress throughout site
- Delayed completion and activation of chilled water loop
- Multiple data loggers employed, tracking temperature and humidity in areas seeking to start finish work
- IEQ critical - monitored by EOR, CxA and LEED administrator (use of filter logs)

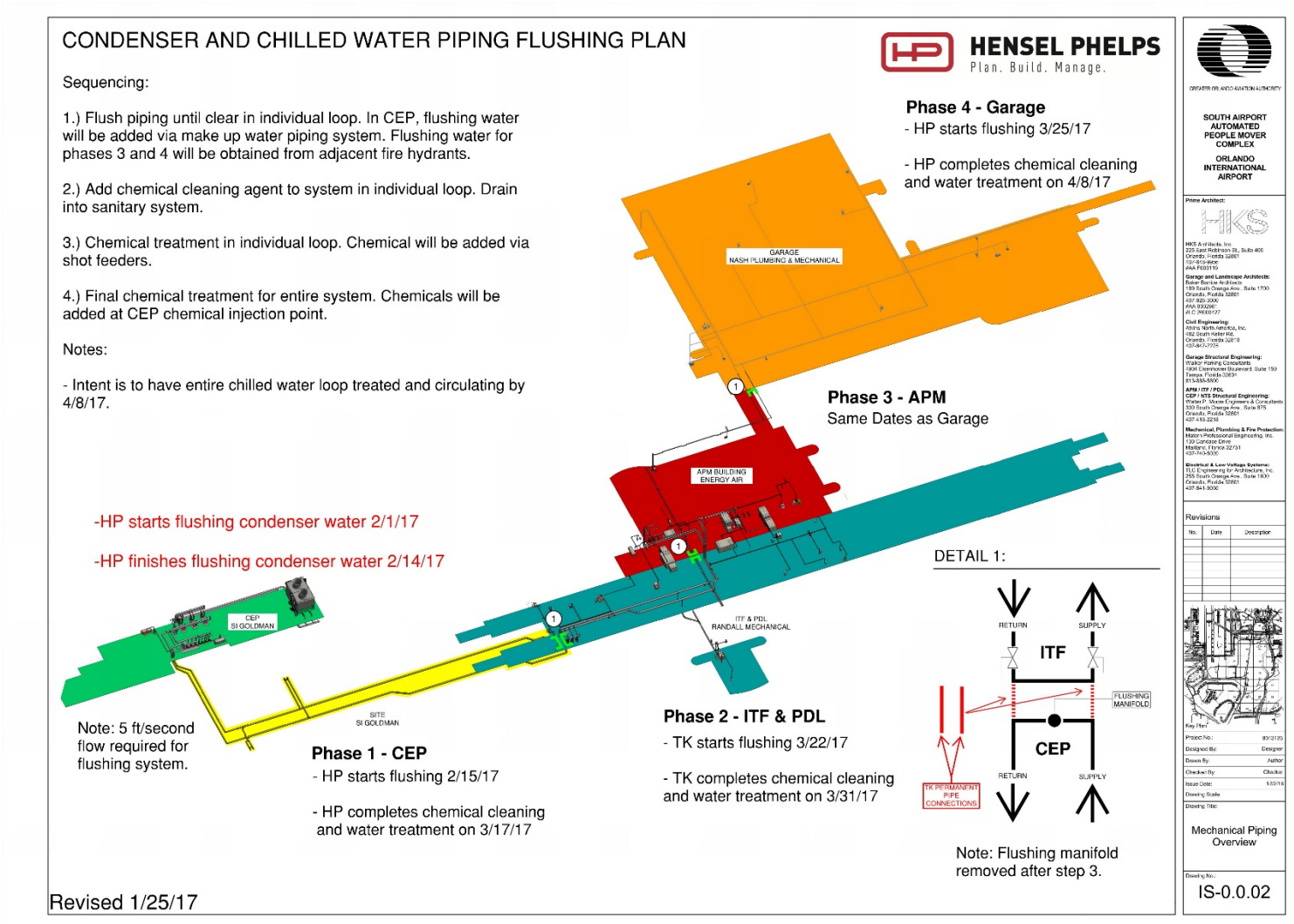
Central Energy Plant

- Three 700 ton chillers utilizing N+1 redundancy
- Variable primary pumping system (Systecon package) with N+1 redundancy
- Variable speed tertiary chilled water pumps at ITF to distribute chilled water throughout complex
- At least 60% cooling capacity provided under emergency power
- CHW piping loop sized for ultimate plant build-out of 8,100 tons

Pipe Flushing and Treatment

- CHW loop constructed by four different mechanical contractors under different GMPs, (completed at different times)
- Each responsible for their flushing and treating their portion of the system
- Challenge to maintain required 5 ft./sec. flow velocity in large 30” underground mains for flushing (supplement pumps required)

Pipe Flushing and Treatment – Four Mechanical Contractors



Chiller Sequence of Operation

- Projected peak cooling load was 1400 tons, with minimal load between 150 and 200 tons
- At start-up, with minimal traffic, winter ambient conditions, actual load between 50 and 100 tons.
- Excessive cycling with potential for surge at low loads
- Enacted a “Winter” sequence of operation, with ability to switch back to normal sequence; supply CHW temperature allowed to vary between 40°F and 52°F

Outdoor / Ventilation Airflow

- Multiple built-up AHUs tied into common gravity OA plenum
- Duct configurations and ERV resulted in excessive pressure drops (negative), some greater than 5 inches
- Constant tripping of duct S.P. safety switches
- Design OA flows required adjustments to R.A. damper ranges, or adjustment to design OA flows
- Insufficient discharge S.P. resulted in supply airflow challenges

Numerous Third Party Inspections (often for Warranties)

- Composite Metal Wall Panels
- Expansion Joints
- Insulated Core Metal Wall Panels
- Membrane Roof
- Metal Roof
- Sealants
- Skylights
- Textured Acrylic Coatings
- Waterproofing
- Windows

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Documentation

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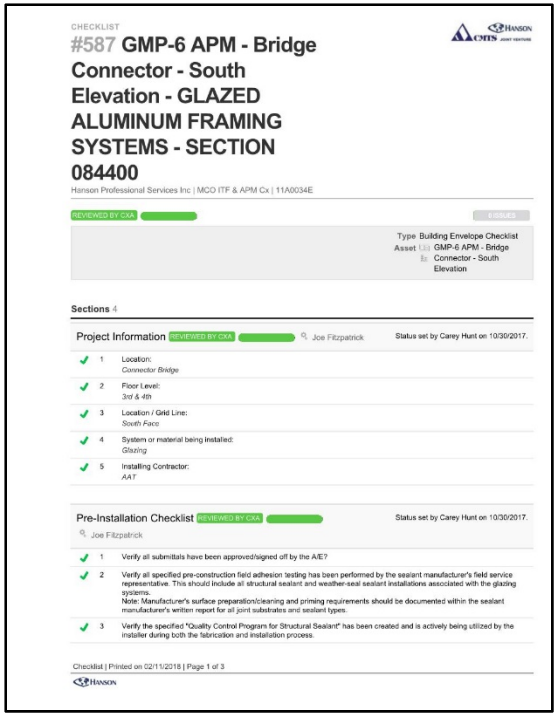
Cx / BECx Documentation

- Project utilized CxAlloy cloud-based web application to maintain all M/E/P/FP and Envelope Cx documentation

- Extensive use of “Files” section, including folders for:
  - AC Temperature / Humidity Logs
  - Contract drawings and specifications
  - Contractor tests (duct leakage, hydrostatic piping, etc.)
  - Cx Plan and Cx specifications
  - Equipment start-up reports
  - LEED documentation
  - Photos
  - Third party envelope inspections and tests

Cx / BECx Checklists


CHECKLIST

#587 GMP-6 APM - Bridge Connector - South Elevation - GLAZED ALUMINUM FRAMING SYSTEMS - SECTION 084400

Hanson Professional Services Inc | MCO ITF & APM Cx | 11A0034E

REVIEWED BY CXA

Type Building Envelope Checklist
Asset GMP-6 APM - Bridge Connector - South Elevation

Sections 4

Project Information REVIEWED BY CXA Joe Fitzpatrick Status set by Carey Hunt on 10/30/2017.

1 Location: *Connector Bridge*
2 Floor Level: *3rd & 4th*
3 Location / Grid Line: *South Face*
4 System or material being installed: *Glazing*
5 Installing Contractor: *AAT*

Pre-Installation Checklist REVIEWED BY CXA Status set by Carey Hunt on 10/30/2017.
Joe Fitzpatrick

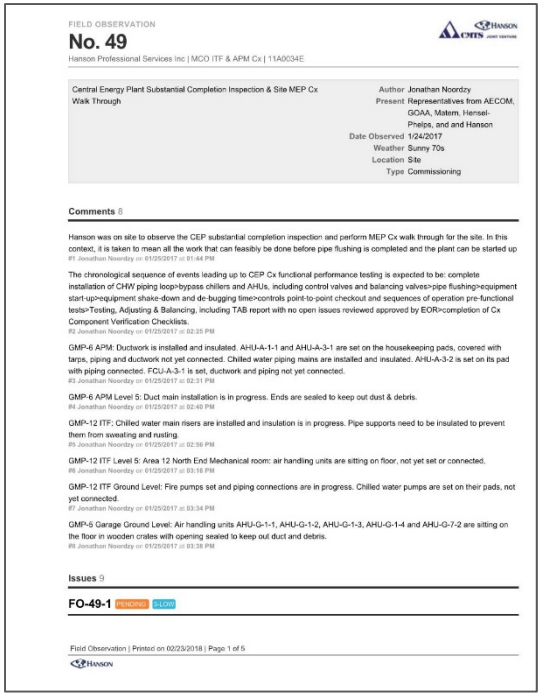
1 Verify all submittals have been approved/signed off by the A/E?
2 Verify all specified pre-construction field adhesion testing has been performed by the sealant manufacturer's field service representative. This should include all structural sealant and weather-seal sealant installations associated with the glazing systems.
Note: Manufacturer's surface preparation/cleaning and priming requirements should be documented within the sealant manufacturer's written report for all joint substrates and sealant types.
3 Verify the specified "Quality Control Program for Structural Sealant" has been created and is actively being utilized by the installer during both the fabrication and installation process.

Checklist | Printed on 02/11/2018 | Page 1 of 3

- 581 checklists – mix of envelope and M/E/P systems
- Identified by GMP and building name
- Envelope checklists included: roof system components, thermal insulation, waterproofing, wall panels, glazed aluminum framing, expansion control, etc.
- M/E/P/FP checklists included: all HVAC equipment, generators, ATS, lighting controls, distribution panels, fire pumps, security and access control, etc.

Cx / BECx Field Observation Reports

- Close to 200 Field Observation Reports with additional meeting minutes and supporting data
- Exclusive of Tag-up, Readiness and Pull Planning meeting spreadsheets, etc. for tracking Contractor's progress with respect to Cx documentation



FIELD OBSERVATION

No. 49

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Central Energy Plant Substantial Completion Inspection & Site MEP Cx Walk Through

Author Jonathan Noordzy
Present Representatives from AECOM, GOAA, Matern, Hensel-Phelps, and and Hanson
Date Observed 1/24/2017
Weather Sunny 70s
Location Site
Type Commissioning

Comments 8

Hanson was on site to observe the CEP substantial completion inspection and perform MEP Cx walk through for the site. In this context, it is taken to mean all the work that can feasibly be done before pipe flushing is completed and the plant can be started up
#1 Jonathan Noordzy on 01/25/2017 at 01:44 PM

The chronological sequence of events leading up to CEP Cx functional performance testing is expected to be: complete installation of CHW piping loop>bypass chillers and AHUs, including control valves and balancing valves>pipe flushing>equipment start-up>equipment shake-down and de-bugging time>controls point-to-point checkout and sequences of operation pre-functional tests>Testing, Adjusting & Balancing, including TAB report with no open issues reviewed approved by EOR>completion of Cx Component Verification Checklists.
#2 Jonathan Noordzy on 01/25/2017 at 02:25 PM

GMP-6 APM: Ductwork is installed and insulated. AHU-A-1-1 and AHU-A-3-1 are set on the housekeeping pads, covered with tarps, piping and ductwork not yet connected. Chilled water piping mains are installed and insulated. AHU-A-3-2 is set on its pad with piping connected. FCU-A-3-1 is set, ductwork and piping not yet connected.
#3 Jonathan Noordzy on 01/25/2017 at 02:31 PM

GMP-6 APM Level 5: Duct main installation is in progress. Ends are sealed to keep out dust & debris.
#4 Jonathan Noordzy on 01/25/2017 at 02:40 PM

GMP-12 ITF: Chilled water main risers are installed and insulation is in progress. Pipe supports need to be insulated to prevent them from sweating and rusting.
#5 Jonathan Noordzy on 01/25/2017 at 02:56 PM

GMP-12 ITF Level 5: Area 12 North End Mechanical room: air handling units are sitting on floor, not yet set or connected.
#6 Jonathan Noordzy on 01/25/2017 at 03:16 PM

GMP-12 ITF Ground Level: Fire pumps set and piping connections are in progress. Chilled water pumps are set on their pads, not yet connected.
#7 Jonathan Noordzy on 01/25/2017 at 03:34 PM

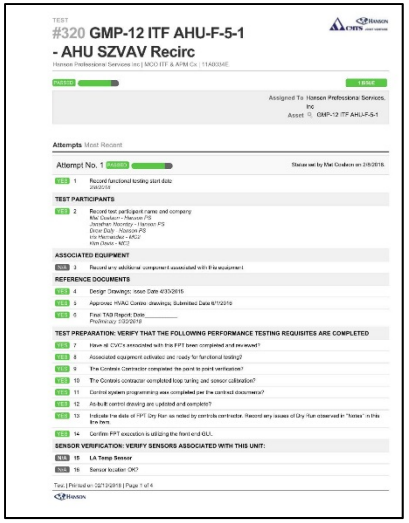
GMP-5 Garage Ground Level: Air handling units AHU-G-1-1, AHU-G-1-2, AHU-G-1-3, AHU-G-1-4 and AHU-G-7-2 are sitting on the floor in wooden crates with opening sealed to keep out duct and debris.
#8 Jonathan Noordzy on 01/25/2017 at 03:38 PM

Issues 9

FO-49-1 PENDING LOW

Field Observation | Printed on 02/23/2018 | Page 1 of 5

Cx / BECx Documentation - Tests



TEST

#320 GMP-12 ITF AHU-F-5-1
- AHU SZVAV Recirc

Hanson Professional Services Inc | MCO ITF & A/M Cx | 11400ME

PASSED 1 ISSUE

Assigned To Hanson Professional Services, Inc
Asset GMP-12 ITF AHU-F-5-1

Attempts Most Recent

Attempt No. 1 PASSED Status set by Mel Graham on 2/8/2018.

YES 1 Record functional testing start date
2/6/2018

TEST PARTICIPANTS

YES 2 Record test participant name and company
Mel Graham - Hanson PS
Jonathan Novotny - Hanson PS
Drew Daily - Hanson PS
Iris Hernandez - ARUP
Kim Davis - MCO

ASSOCIATED EQUIPMENT

N/A 3 Record any additional component associated with this equipment

REFERENCE DOCUMENTS

YES 4 Design Drawings: Issue Date 4/30/2015

YES 5 Approved HVAC Control drawings, Submittal Date 8/7/2016

YES 6 Final TAB Report: Date _____
Preliminary 1/30/2018

TEST PREPARATION: VERIFY THAT THE FOLLOWING PERFORMANCE TESTING REQUISITES ARE COMPLETED

YES 7 Have all CWCs associated with this FPT been completed and reviewed?

YES 8 Associated equipment activated and ready for functional testing?

YES 9 The Controls Contractor completed the point to point verification?

YES 10 The Controls contractor completed loop tuning, and sensor calibration?

YES 11 Control system programming was completed per the contract documents?

YES 12 As-Built control drawing are updated and complete?

YES 13 Indicate the date of FPT Dry Run as noted by controls contractor. Record any issues of Dry Run observed in "Notes" in this line item.

YES 14 Confirm FPT execution is utilizing the front end GUI.

SENSOR VERIFICATION: VERIFY SENSORS ASSOCIATED WITH THIS UNIT:

N/A 15 LA Temp Sensor

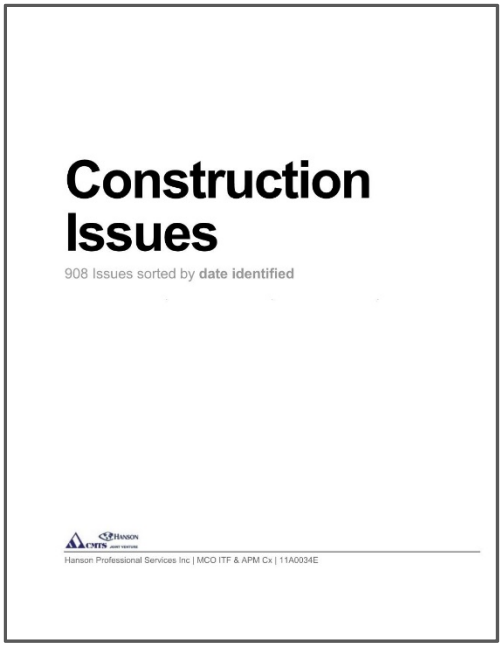
N/A 16 Sensor location OK?

Test | Printed on: 02/12/2018 | Page 1 of 4

Hanson

- 213 M/E/P/FP tests, excluding envelope testing performed by third parties
- Special Inspector oversaw Smoke Evacuation System testing
- Numerous envelope tests, including: water leakage (curtainwall, skylights, gutters), waterproofing tests, sealant adhesion tests, roofing IR testing, etc.

Cx / BECx Documentation



- 1161 Design Issues – commissioned envelope and M/E/P/FP systems
- 908 Construction Issues – from site observation reports and tests
- BECx generated separate punchlist, based upon some site observations and failed envelope tests

LEED v4 Documentation

GREATER ORLANDO AVIATION AUTHORITY

CURRENT FACILITY REQUIREMENTS / OPERATIONS and MAINTENANCE PLAN

South Airport APM Complex & South Airport Intermodal Terminal Facility
Orlando, FL

Hanson No: 11A0034EE

January 12, 2018

HANSON CMTS JOINT VENTURE Building Systems Commissioning Team CMC Construction Moisture Consulting, Inc.

GREATER ORLANDO AVIATION AUTHORITY

ONGOING COMMISISONING PROGRAM

South Airport APM Complex & South Airport Intermodal Terminal Facility
Orlando, FL

Hanson No: 11A0034EE

February 12, 2018

HANSON CMTS JOINT VENTURE Building Systems Commissioning Team CMC Construction Moisture Consulting, Inc.

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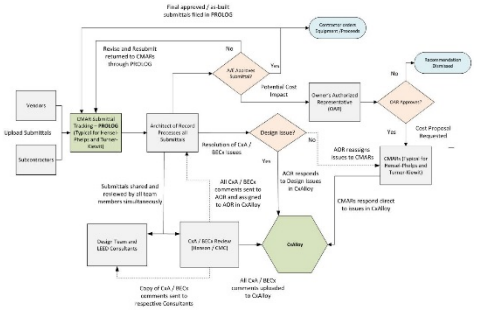
Lessons Learned

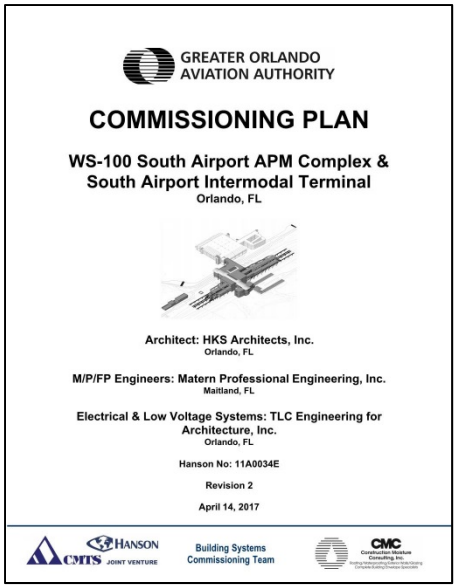
Cx ENERGY 2018

Lessons Learned – Document Handling



- Project utilized PROLOG, BIM 360 Field and CxAlloy
- Need to discuss process for notifications of updated documents, how they will be handled and reviewed, and where documentation will be maintained.
- Massive amount of documentation, reports, etc. – communication is critical

Lessons Learned – Cx Coordination with CMARs


GREATER ORLANDO AVIATION AUTHORITY

COMMISSIONING PLAN

WS-100 South Airport APM Complex & South Airport Intermodal Terminal
Orlando, FL

Architect: HKS Architects, Inc.
Orlando, FL

M/P/FP Engineers: Matern Professional Engineering, Inc.
Maitland, FL

Electrical & Low Voltage Systems: TLC Engineering for Architecture, Inc.
Orlando, FL

Hanson No: 11A0034E

Revision 2

April 14, 2017

CMTS HANSON JOINT VENTURE Building Systems Commissioning Team CMC

- Include CMARs' Cx Coordinators in contract documents – Cx Plan and specifications
- Require separate Cx Coordinators for M/E/P/FP and for envelope commissioning coordination
- Cx Coordinators are liaison between CMARs, CxA, BECxA and all subcontractors
- They need to report on checklists' and issues' status on a weekly basis.

Lessons Learned – Division of Work between GMPs and Contractors

- Chilled water loop constructed by multiple contractors; each responsible for testing, flushing and treating their portion of the system.
- Primary building expansion joint (and its adjacent components) – responsibility divided between CMARs and their subcontractors; lack of coordination and quality control
- Keep critical systems under a single CMAR, maintain system subcontractors across GMPs

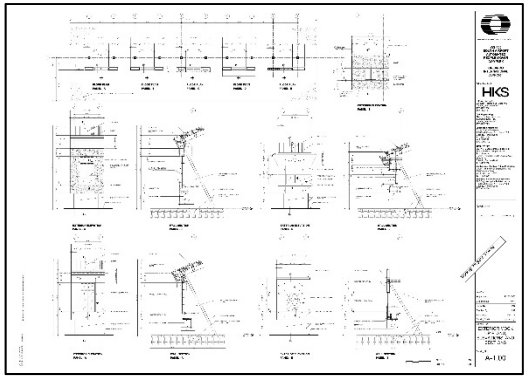
Lessons Learned – Tag-Up, Readiness and Pull Planning

- Be realistic with schedules and times required to complete tasks.
- Ensure all stakeholders (subcontractors, vendors, etc.) attend meetings on a regular basis
- Let subcontractors / vendors identify their key requirements and make sure they are addressed.
- Plan for contingencies

Lessons Learned - Coordination between Mechanical / Electrical and Controls

- HVAC and Electrical design handled by separate consultants
- Number of controllers did not reflect correct / separate power source
- Where power service to controller routed through adjacent disconnect switch, disconnecting equipment would also cut power and communications to BAS
- In some cases BAS not provided with separate input from FA. Could not distinguish failure

Lessons Learned - Mock-up Wall



- Specification section 01 43 39 Visual Mock-up Requirements required CMARs to submit shop drawings, but without details
- After delays, Architect issued drawing with 80’ x 24’ mock-up wall covering all exterior conditions
- CMARs requested $250,000 contract amendment and after rejection, smaller mock-up constructed late
- Need more detailed criteria for mock-up wall including specifications defining testing for same

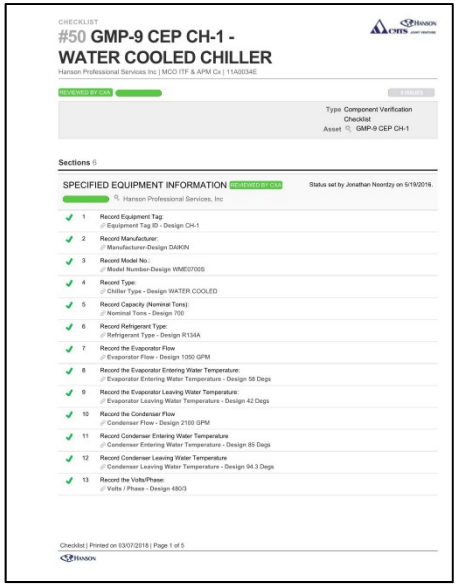
Lessons Learned – Chiller Sizing

- Three 700 ton chillers to accommodate projected cooling load of 1400 tons with N+1 redundancy
- However, at start-up, minimal occupancy and winter ambient conditions resulted in initial load between 50 and 100 tons
- Recommendation had been made to consider a smaller ‘pony’ chiller; however, it was not accepted

Lessons Learned – OA Control

- Multiple built-up AHUs tied into common gravity OA plenum and excessive pressure drops compromised ability to achieve design OA flows
- Examine Dedicated Outdoor air Systems (DOAS), pressurized plenum (supply fan), and/or multiple (segregated) plenums during design
- Ensure pressure drop calculations accommodate field adjustments and duct construction is specified for proper pressure range

Lessons Learned – Checklist Management and QA / QC



CHECKLIST

#50 GMP-9 CEP CH-1 - WATER COOLED CHILLER

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REVIEWED BY CM

Type Component Verification Checklist

Asset GMP-9 CEP CH-1

Sections 6

SPECIFIED EQUIPMENT INFORMATION REVIEWED BY CM

Status set by Jonathan Neondzy on 5/19/2016.

Hanson Professional Services, Inc

✓	1	Record Equipment Tag: Equipment Tag ID - Design CH-1
✓	2	Record Manufacturer: Manufacturer-Design DAIKIN
✓	3	Record Model No.: Model Number-Design WME0700S
✓	4	Record Type: Chiller Type - Design WATER COOLED
✓	5	Record Capacity (Nominal Tons): Nominal Tons - Design 700
✓	6	Record Refrigerant Type: Refrigerant Type - Design R134A
✓	7	Record the Evaporator Flow Evaporator Flow - Design 1050 GPM
✓	8	Record the Evaporator Entering Water Temperature: Evaporator Entering Water Temperature - Design 58 Degs
✓	9	Record the Evaporator Leaving Water Temperature: Evaporator Leaving Water Temperature - Design 42 Degs
✓	10	Record the Condenser Flow Condenser Flow - Design 2100 GPM
✓	11	Record Condenser Entering Water Temperature Condenser Entering Water Temperature - Design 85 Degs
✓	12	Record Condenser Leaving Water Temperature Condenser Leaving Water Temperature - Design 94.3 Degs
✓	13	Record the Volts/Phase: Volts / Phase - Design 480/3

Checklist | Printed on 03/07/2018 | Page 1 of 5

- Checklist management was difficult requiring edits and time consuming tracking
- Various tools were employed, tracking percentage complete by disciplines / subcontractors per checklist
- Appeared a number were “pencil whipped” near completion
- Looking at improved logs and better assignment / signature responsibilities for QA / QC

Lessons Learned – IP addresses / BAS Integration

- Even with multiple Controls' Integration and Interoperability meetings, there were delays in completing BAS communication w/ North Terminal
- In addition, there were delays in identifying IP address requirements for several systems, including the Power Xpert system
- These issues: configuring and enabling data communication and identifying and assigning IP addresses for systems to be monitored by the BAS is becoming a common issue we address in our Controls' meetings

Lessons Learned – CMMS Integration

- Checklists collect some of the data required for the Owner's CMMS system, Maximo
- However, extraction of this data was not a requirement of the contract, not considered when building the checklists.
- While data could be downloaded into spreadsheets, it was a more cumbersome process
- This can be solved by re-configuring the data on the checklists, and will be done going forward

Next

Cx ENERGY 2018

Next …. South Terminal C – Phase 1

- Approximately $2.1 billion, (second largest infrastructure project in central Florida)
- Landside Terminal – 5-Level, approx. 630,000 SF
- Airside Terminal – 3-Level, Concourse building, approx. 700,000 SF serving initial 16 gates, with CEP
- Ground Transportation Facility – approx. 240,000 SF
- Parking Garage Expansion – additional 2,400 spaces

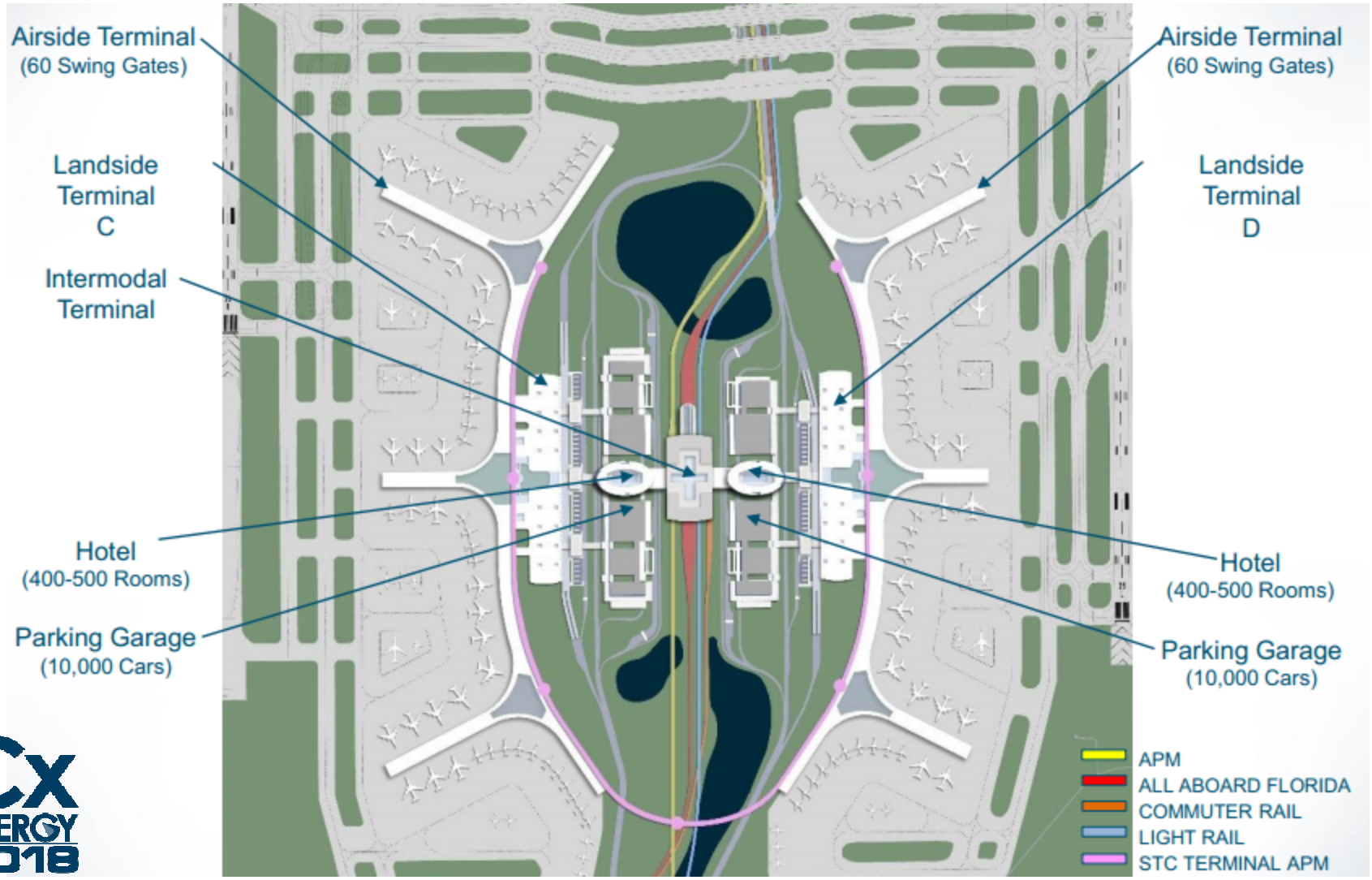
Next …. South Terminal C – Phase 1

https://www.orlandoairports.net/getting-around-mco/south-terminal-complex/

South Terminal C – Phase 2

- Airport Capacity with APM / ITF (currently open) is 45 MAP, which is approximately the current demand!
- Design for STC - Phase 2 already authorized, adds another 16 gates
- Trigger for Phase 2 was to be 50 MAP, with delivery (completion) 2025 – 2026 – Airport capacity 60 MAP
- However, current demand is 45 MAP, and projected capacity when STC – Phase 1 opens is 50 MAP

… and beyond



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Questions

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Thank You!

This concludes The American Institute of Architects
Continuing Education Systems Course

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