



Facilitating a Successful UFAD Project through Commissioning

Presented By

Scott Nelson, P.E.
CH2M HILL

Karl Stum, P.E.
Summit Building Engineering

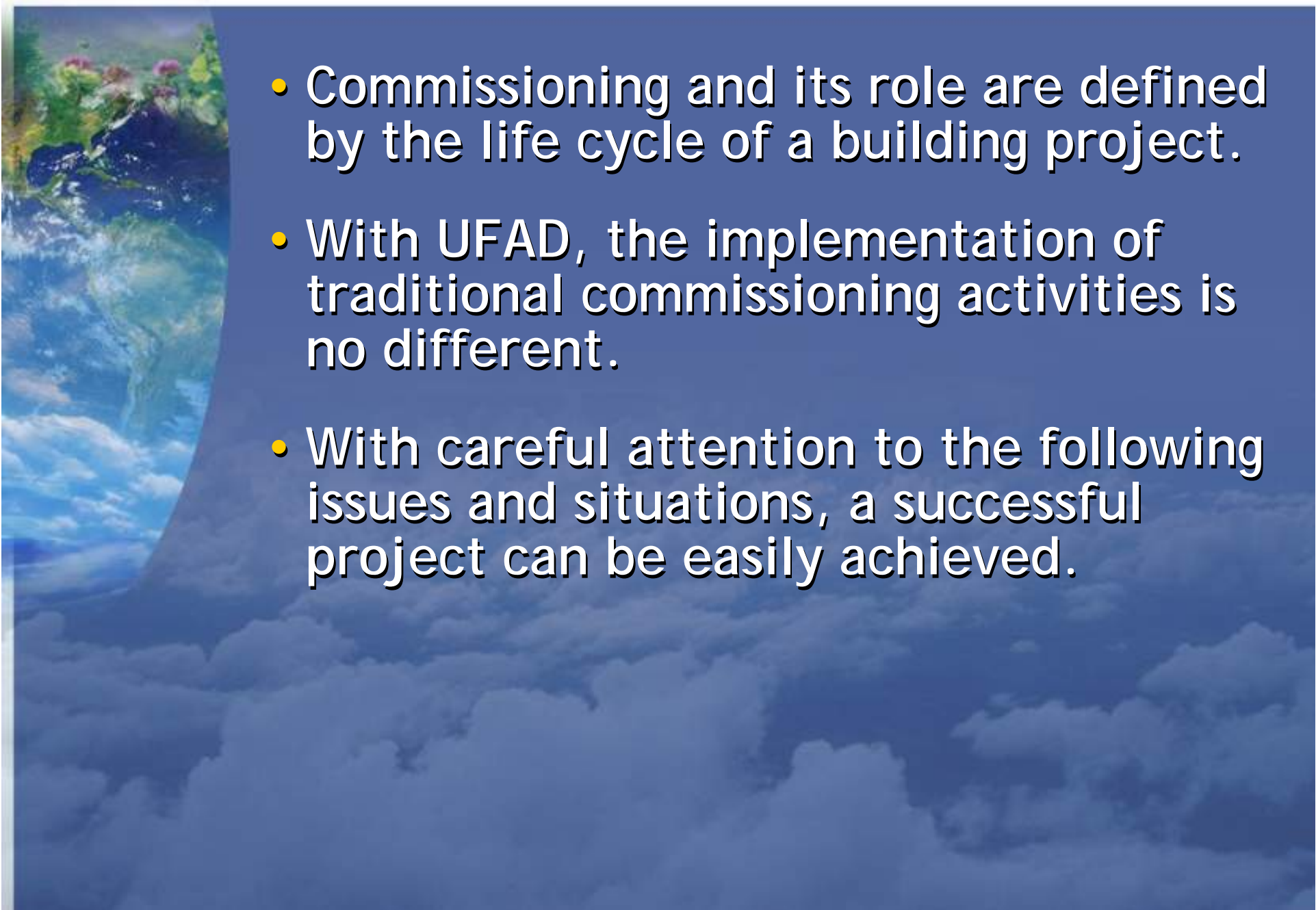
April 20, 2006

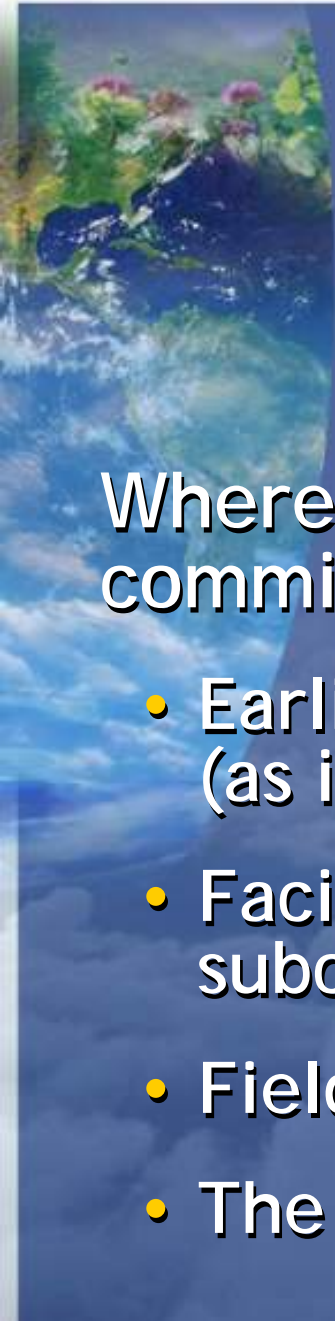
CH2MHILL



THE WHOLE PICTURE

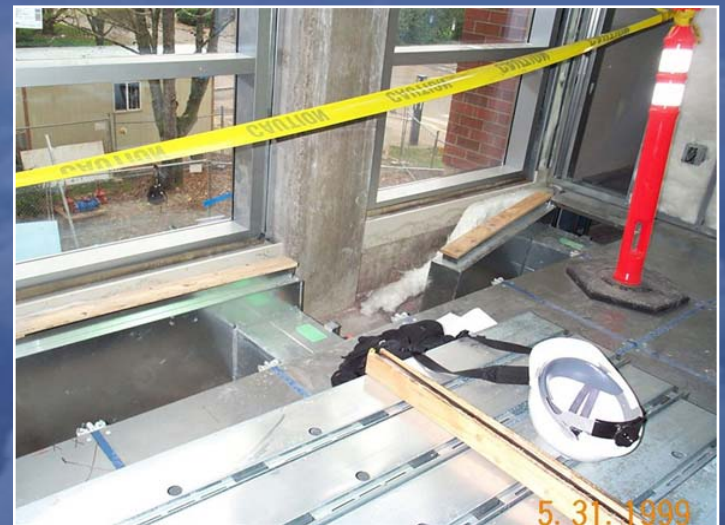
COMMISSIONING UFAD SYSTEMS PER PROJECT PHASES

- 
- Commissioning and its role are defined by the life cycle of a building project.
 - With UFAD, the implementation of traditional commissioning activities is no different.
 - With careful attention to the following issues and situations, a successful project can be easily achieved.



Where/when can commissioning help?

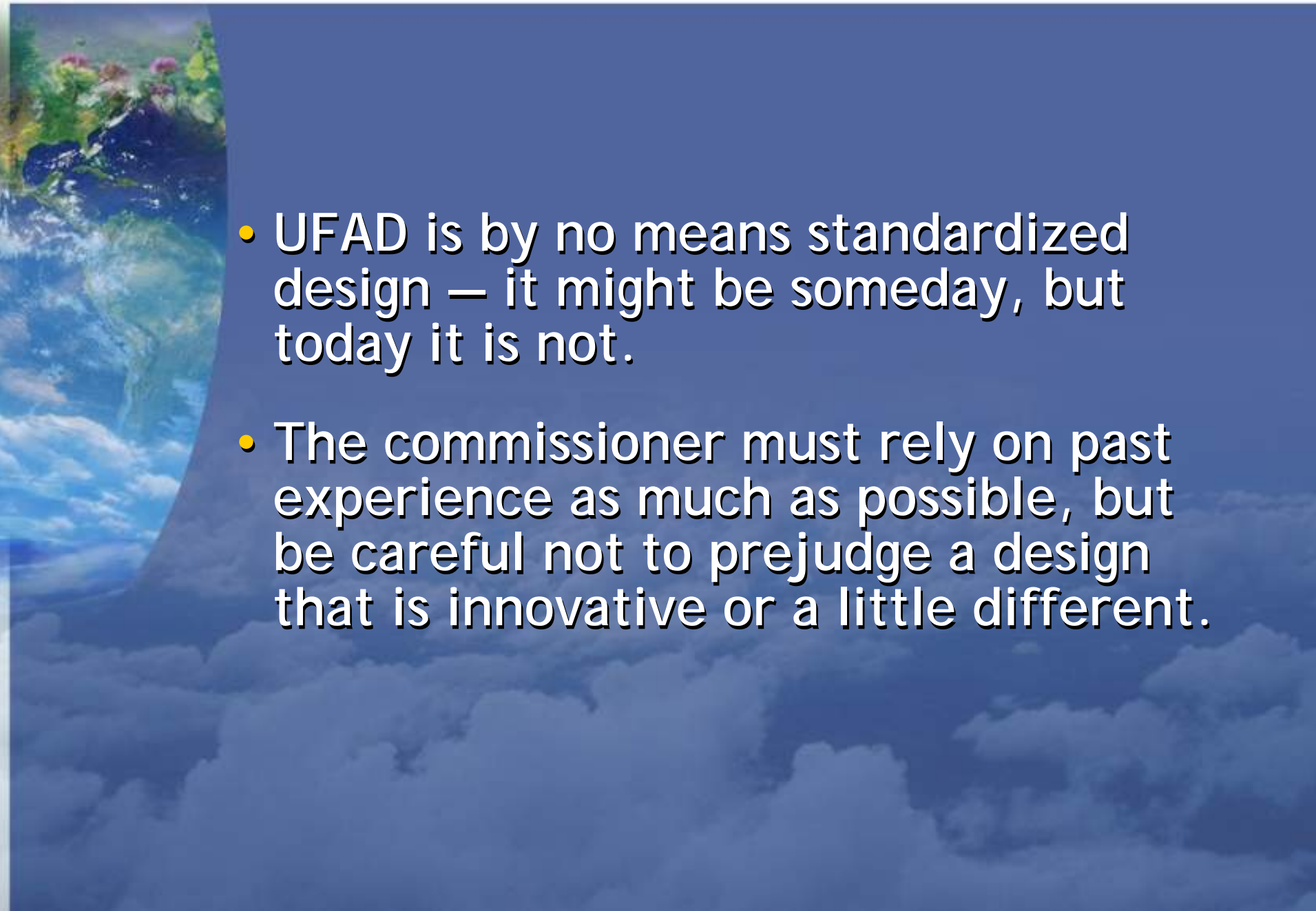
- Earlier the better (as in contract documents)
- Facilitating subcontractor interaction
- Field observation
- The Checklist



DESIGN PHASE COMMISSIONING

- Starting the commissioning process as early as possible during design documentation tends to add value to the project without necessarily adding a large cost.
- A focused review of traditional energy-consuming systems *PLUS* architectural and structural details (such as stem walls, window glazing, stairwells, floors, wall penetrations and other potential leakage areas) allows simple yet invaluable changes to be made during the design.
- This will facilitate the construction of the architectural “plenum” by the contractor.

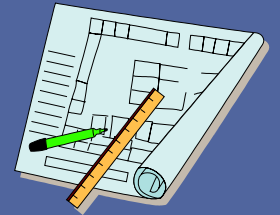
DESIGN REVIEW

- 
- UFAD is by no means standardized design — it might be someday, but today it is not.
 - The commissioner must rely on past experience as much as possible, but be careful not to prejudge a design that is innovative or a little different.

DESIGN REVIEW

Ensure:

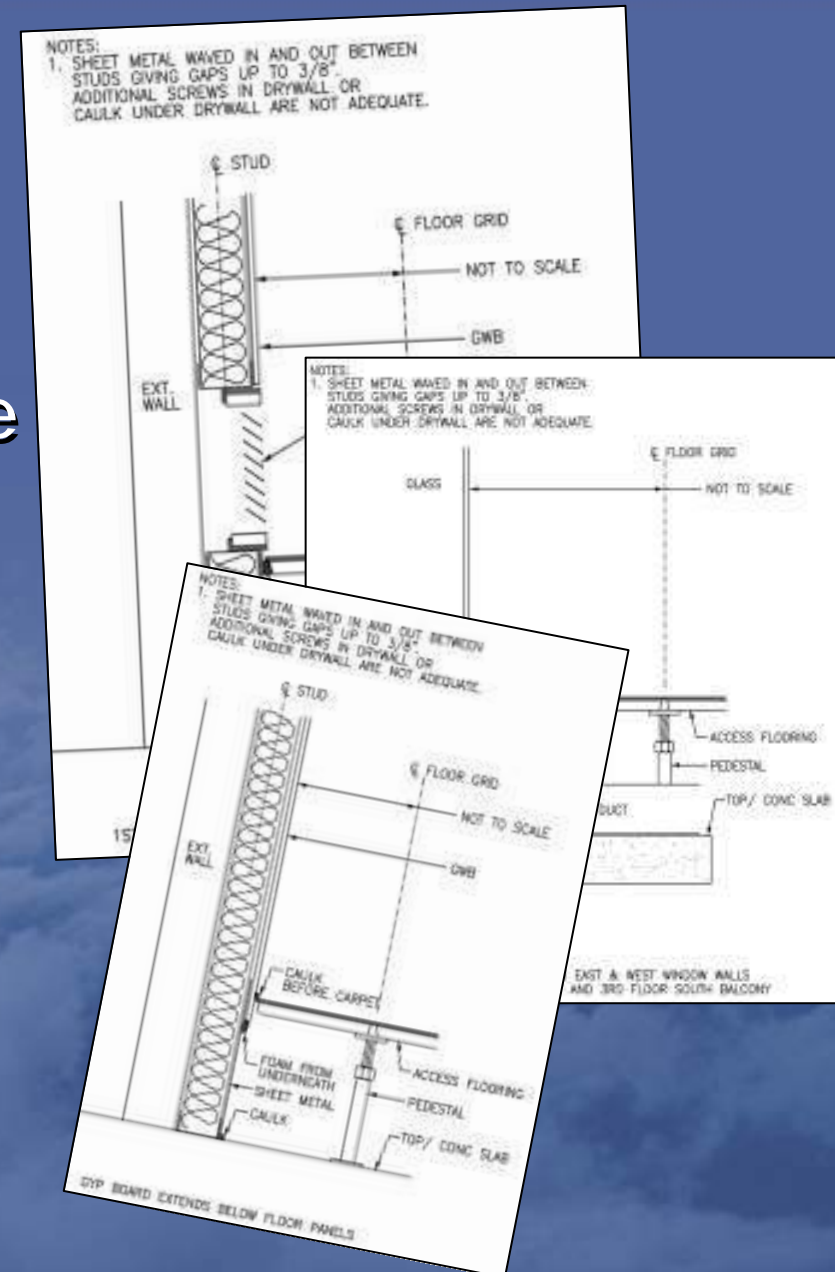
- Design rationale is documented
- Clear specifications
- Performance criteria
- Commissioning is specified
- 1 controlling sensor reading per zone
- Sensor locations
- Accuracy and range of sensors
- Air highways
- Potential sources of noise



DRAWING DETAILS

Drawing details should:

- Specifically point out critical issues
- Draw on your experience and that of others
- Addendums to contract documents?
- Seal with the pressure (like patching a boat or a radiator, use the pressure to enhance the seal, not work against it)



SPECIFICATIONS

DIVISION 1, 10, 15, 16...

- Cx review of the specifications
- “Related Documents” in all specifications
- Bring them together using Cx specifications (01810)

01810 GENERAL COMMISSIONING REQUIREMENTS

GENERAL
SUMMARY
It is of primary concern that all systems and assemblies in the project perform in accordance with design intent and the Owner's operational needs. The process of assuring that such performance is achieved is referred to as "commissioning". Successful commissioning requires cooperation between the Contractor and the Owner. The Contractor shall only comply with contract documents and shall provide full cooperation in the commissioning process.

ACCESS FLOORING SECTION 10270 - 1

RELATED DOCUMENTS
The following documents and general provisions of the Contract, including General and Supplementary Conditions and Specification Sections, apply to this Section.

It includes the following:

15890 AIR DISTRIBUTION

PART 1 - GENERAL

1.1 PROJECT INCLUDES

- A. Air distribution systems including underfloor separation walls, duct systems, HVAC casings, duct accessories, air outlets and inlets, and air terminals.
- B. Refer to LEED specifications for additional information.

1.2 COMMISSIONING AND QUALITY ASSURANCE

- A. Quality Assurance. Quality assurance for automatic controls systems shall be accomplished through the commissioning process consisting of submittal review of system engineering work, documented prefunctional testing and initial checkout, documented functional performance testing, operation and O&M documentation. In addition there will be a qualification testing process.

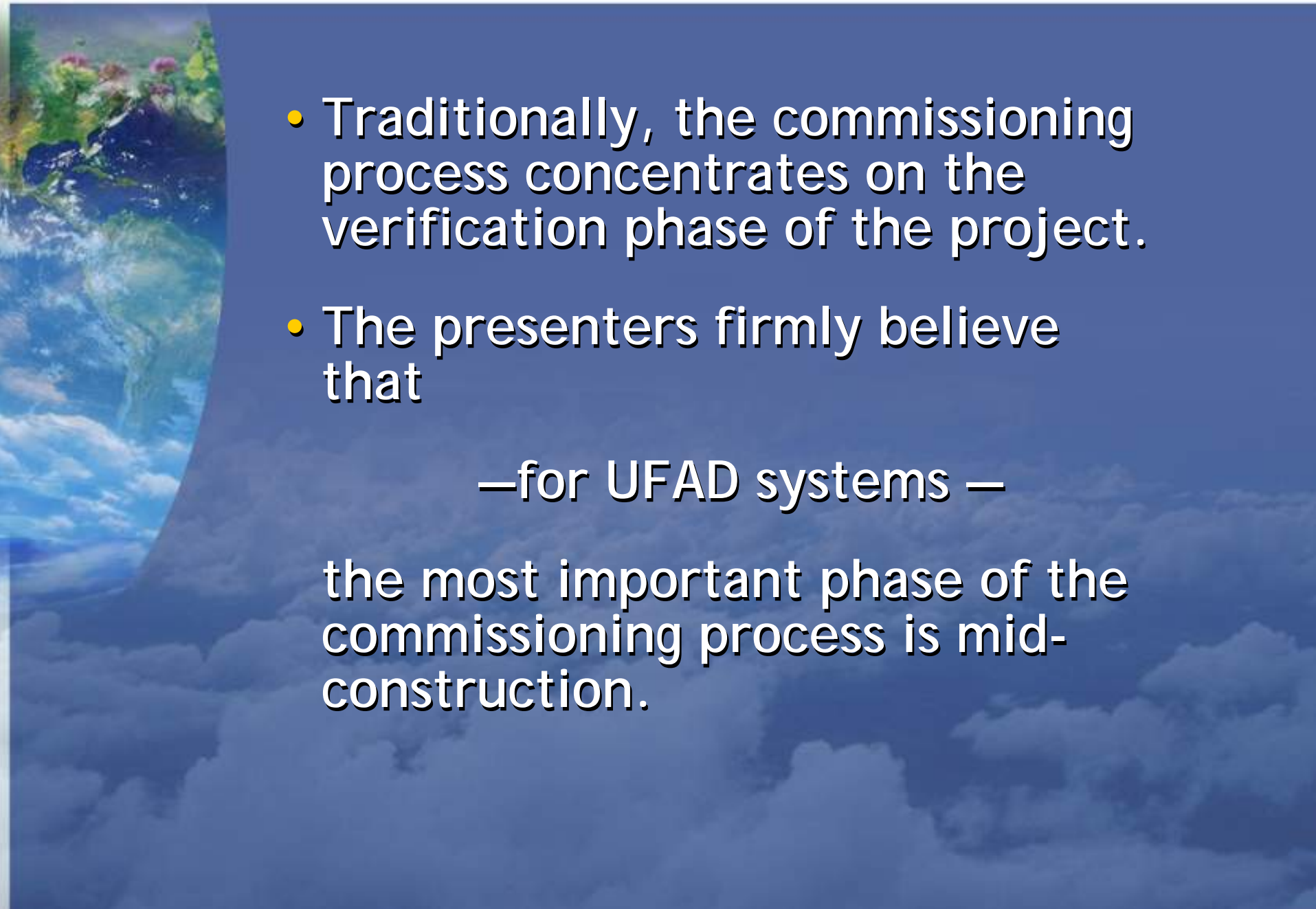
COORDINATING AND SCHEDULING

A. Coordination of Work: Coordinate location of mechanical, electrical and telecommunications work in underfloor cavity to prevent interference with access flooring pedestals.

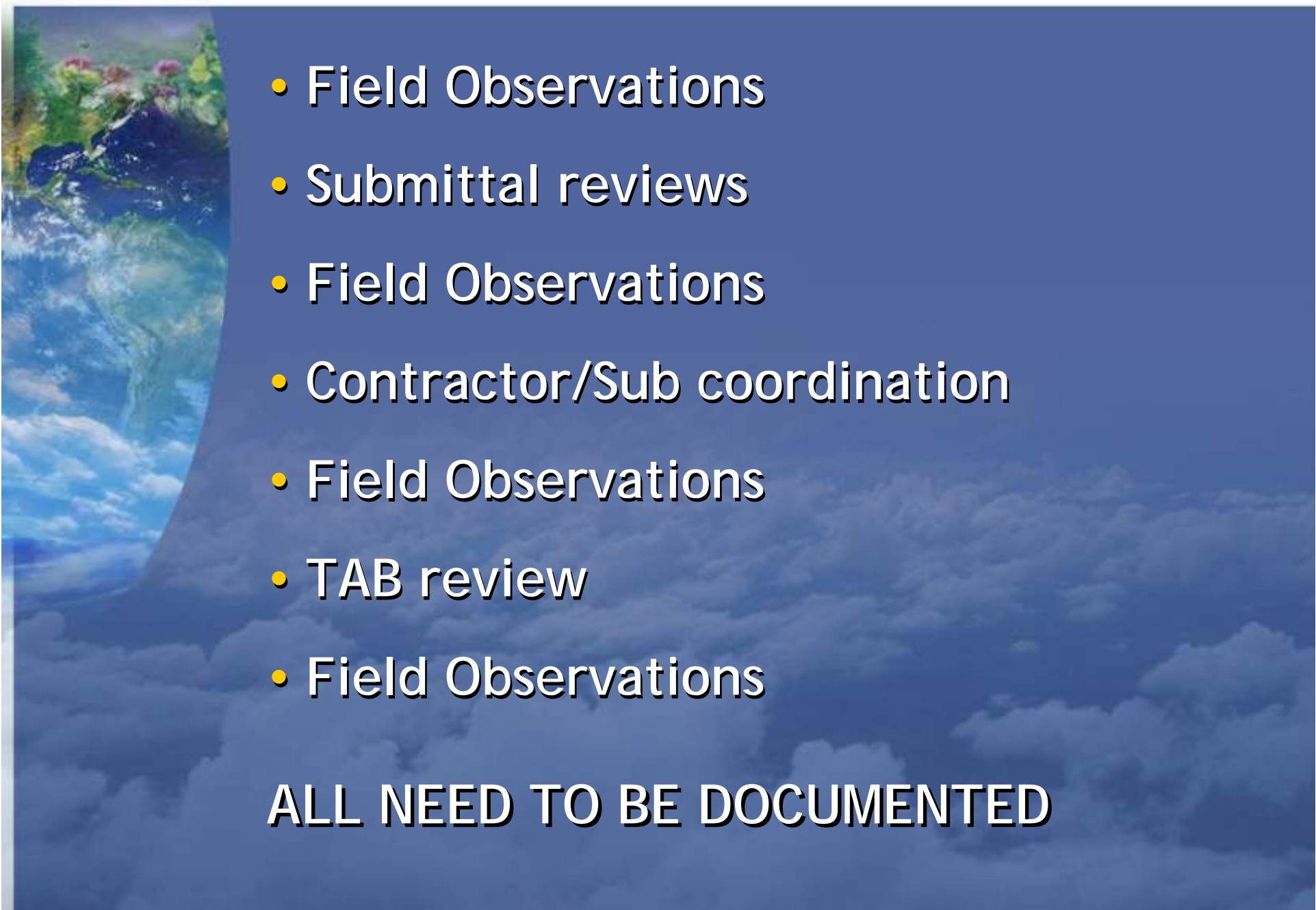
1. Seal all penetrations of spaces under access floors to prevent entry or exit of air. Seal open ends of conduits, openings in junction boxes, and similar items.

B. Layout: Mark pedestal locations on concrete subfloor so that mechanical, electrical and

CONSTRUCTION PHASE COMMISSIONING

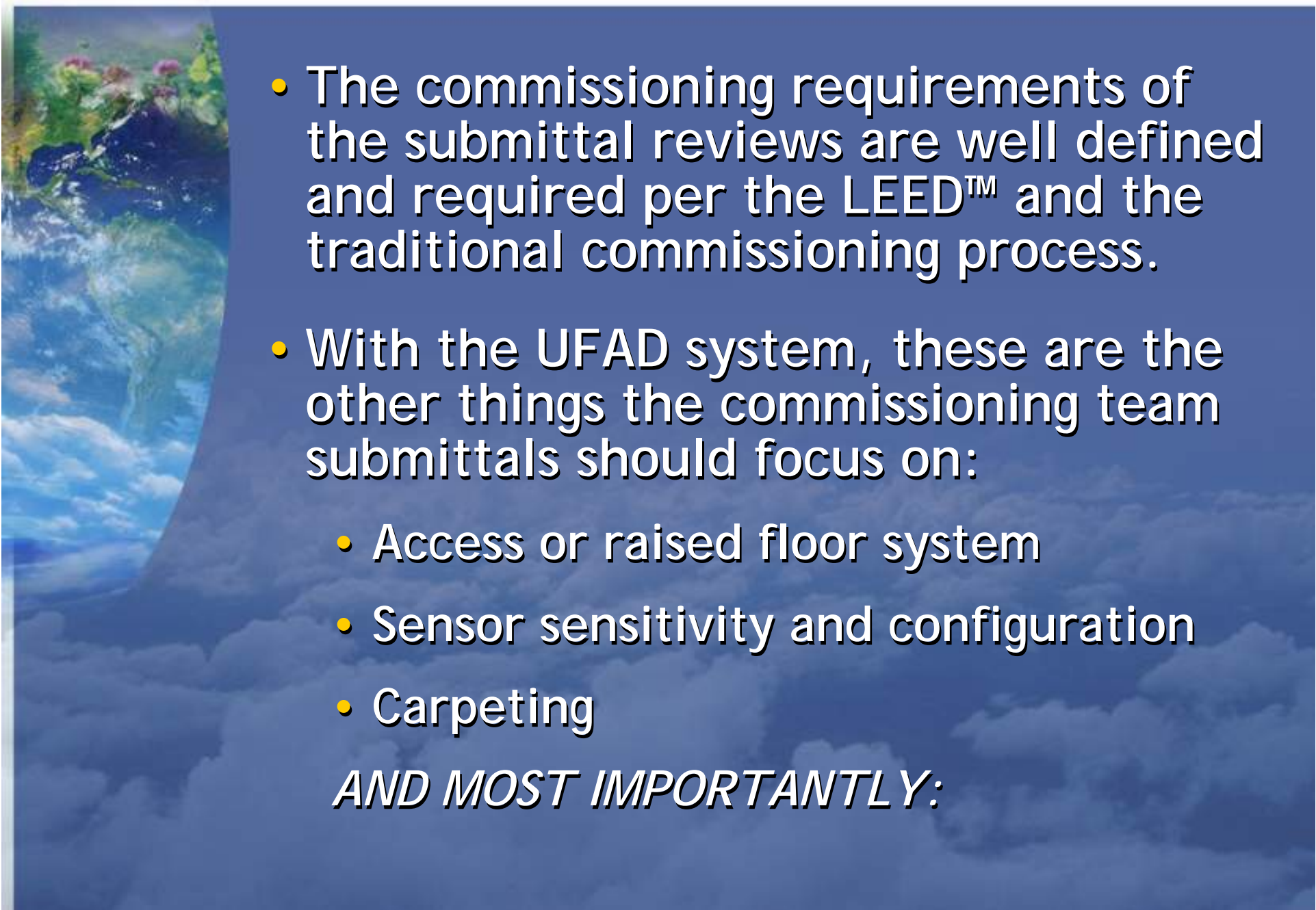
- 
- Traditionally, the commissioning process concentrates on the verification phase of the project.
 - The presenters firmly believe that
 - for UFAD systems –
 - the most important phase of the commissioning process is mid-construction.

CONSTRUCTION PHASE

- 
- Field Observations
 - Submittal reviews
 - Field Observations
 - Contractor/Sub coordination
 - Field Observations
 - TAB review
 - Field Observations

ALL NEED TO BE DOCUMENTED

SUBMITTAL REVIEW

- 
- The commissioning requirements of the submittal reviews are well defined and required per the LEED™ and the traditional commissioning process.
 - With the UFAD system, these are the other things the commissioning team submittals should focus on:
 - Access or raised floor system
 - Sensor sensitivity and configuration
 - Carpeting

AND MOST IMPORTANTLY:

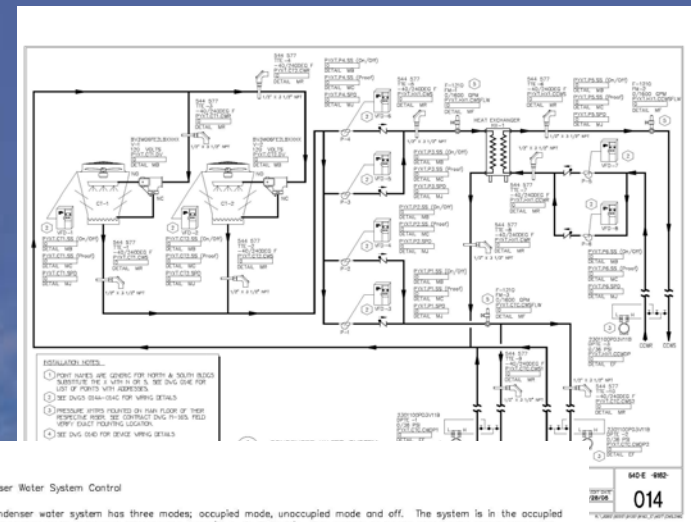
THE CONTROLS SUBMITTAL REVIEW

- Multi-disciplined
 - ME, EE, CxA, Ops staff
- Thorough comments
 - Written, common format, adjudicated

| STATUS | Global Issue ID | Sheet or Page ID | Sheet Issue ID | System (dropdown) | Equip Tag (dropdown) | Description | Need Owner Input | Need Design Input | Date Entered | Entered By | Contractor / Designer Response and Final Action Taken (with dates and initials) |
|--------|-----------------|---------------------|----------------|----------------------|-------------------------|--|------------------|-------------------|--------------|------------|--|
| IP | 3 | All sequence sheets | | Other | | General Note 3. Per specifications (15975 1.07,B.6.m.12 & 13)) sequences shall include Effects of power or equipment failure with all standby component functions and Sequences for all alarms and emergency shutdowns. Some of this is in the sequences, but some is missing. This issue is noted here for reference. Further detail from the contractor will be required by assisting in filling in the Emergency Power and Fire Alarm Response Matrices. | | | 9/17/04 | san | (40) Item noted. 1-7-05 CH2M HILL, san: Emergency shutdowns are to be tested during functional testing. These are not "s" What happens when a piece of equipment shuts down subsequently restarts needs to be defined and will be RFI's if not. This issue will remain open unless each 2-18-05 JCI: Need more time to research the power sequences and specification requirements. 2-23-05 CH2M HILL, ks: We will bring an e-power meeting and get it partly filled out there. 3/14/05. CH2M HILL ks: Karl and Rick B worked on Karl will finish the draft and send to JCI, Gayner and goes to LBNL staff for more fill in and review. Unresolved in a final meeting. Then JCI can use it for p 5-20-05. ks: The Standby power and fire alarm matrices and forwarded to the contractor for their use. |
| IP | 4 | General | | Other | | The naming conventions used are not consistent with the lab's. Examples: Zone air temp is ZAT, not ZA-T. Analog VFD output is SPD-CTL not, CT1VFD-O. | | | 9/19/04 | JLF | (41) Please clarify. 1-7-05 CH2M HILL, ks: This needs a meeting with L programming. 3-14-05. CH2M HILL ks: Steve G, LBNL will send n JCI. 5-20-05: JCI: Will incorporate Steve Greenberg's 3/ |

SUBMITTAL REVIEW

- Compare to specs, drawings, narratives and owner requirements
- Control theory
- Energy efficiency
- Commissionability
- Enough sensors
- Too many sensors
- Operational issues
- Capacity staging



Condenser Water System Control

The condenser water system has three modes; occupied mode, unoccupied mode and off. The system is in the occupied mode when any main condenser water pump runs (P-1, 2, 3, or 4). The system is in the unoccupied mode when both main condenser water pumps are off and either commercial system closed loop pump runs. The system is in the off mode when both main condenser water pumps and both commercial system closed loop pumps are off.

The main condenser water pump (P-1) is interlocked to start when any floor (tenant area) AC unit runs in the occupied mode and be off when all tenant area AC units are not running in the occupied mode (P-2 is a standby pump for P-1). When pumps run, differential pressure sensor at the base of the risers controls pump VFD's in parallel to maintain set point (15 psig diff), adjustable through the EMCS. AC units running in the night set-back or morning warm-up mode shall not start the main condenser water pumps.

The commercial system closed loop pumps are each controlled by the EMCS. When pump P-5 runs, differential pressure sensor at the base of the risers controls pump VFD's in parallel to maintain set point (15 psig diff), adjustable through the EMCS (P-6 is a standby pump for P-5). Interlock commercial water system controls to be de-energized when both closed loop pumps are off.

Occupied Mode:

Main condenser water system pumps run and condenser water temperature reset controls are energized. Reset controls index condenser water supply control to 80 degrees F when outside air temperature raises above 55 degrees F and to 45 degrees F when outside air temperature drops below 50 degrees F.

Immersion thermostats in CW supply pipe control cooling tower fan speed in parallel to maintain set point.

Immersion thermostat in commercial system closed loop return pipe cycles commercial system condenser water pumps P-3 (P-4 standby) in sequence to maintain set point (90 degrees F).

Unoccupied Mode:

Main condenser water pumps are off.

SUBMITTAL REVIEW

- No submittal approval until all issues are resolved and reflected on submitted drawings and Sequence of Operations

Will reflect in as-builts

Condenser Water System Control

The condenser water system has three modes; occupied mode, unoccupied mode and off. The system is in the occupied mode when any main condenser water pump runs (P-1, 2, 3, or 4). The system is in the unoccupied mode when both main condenser water pumps are off and either commercial system closed loop pump runs. The system is in the off mode when both main condenser water pumps and both commercial system closed loop pumps are off.

The main condenser water pump (P-1) is interlocked to start when any floor (tenant area) AC unit runs in the occupied mode and be off when all tenant area AC units are not running in the occupied mode (P-2 is a standby pump for P-1). When pumps run, differential pressure sensor at the base of the risers controls pump VFD's in parallel to maintain set point (15 psig diff), adjustable through the EMCS. AC units running in the night set-back or morning warm-up mode shall not start the main condenser water pumps.

The commercial system closed loop pumps are each controlled by the EMCS. When pump P-5 runs, differential pressure sensor at the base of the risers controls pump VFD's in parallel to maintain set point (15 psig diff), adjustable through the EMCS (P-6 is a standby pump for P-5). Interlock commercial water system controls to be de-energized when both closed loop pumps are off.

Occupied Mode:

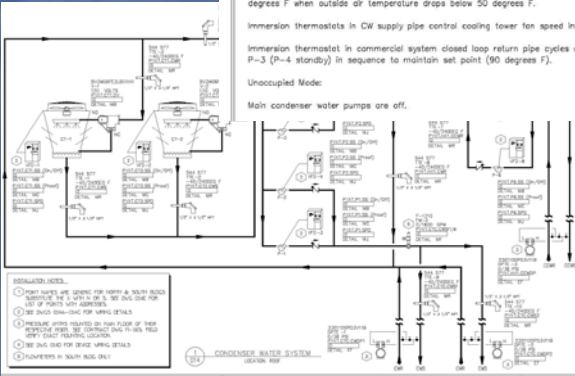
Main condenser water system pumps run and condenser water temperature reset controls are energized. Reset controls index condenser water supply control to 80 degrees F when outside air temperature raises above 55 degrees F and to 45 degrees F when outside air temperature drops below 50 degrees F.

Immersion thermostats in CW supply pipe control cooling tower fan speed in parallel to maintain set point.

Immersion thermostats in commercial system closed loop return pipe cycles commercial system condenser water pumps P-3 (P-4 standby) in sequence to maintain set point (90 degrees F).

Unoccupied Mode:

Main condenser water pumps are off.



FIELD OBSERVATIONS

- Who gets there first?
- Altering someone else's work.



***"Sheet rockers,
'lectricians, and
framers...OH MY!"***

FIELD OBSERVATIONS

Field observation by the commissioner needs to be more than an exercise in documentation.

- Frequent
- Representative
- And documented

View from 30,000 feet



FIELD OBSERVATIONS



SEALING

- The difference between success and failure

FIELD OBSERVATIONS



CLEANLINESS

- Save it to the end?
- Everyone's task, but one person's responsibility

CONSTRUCTION CHECKLIST

UNDER FLOOR AIR DISTRIBUTION

2. Requested documentation submitted Check if Okay

| Check | Floor-> | «Tag1» |
|--|---------|--------|
| Panel Mfr's cut sheet and air leakage performance data | | |
| Installation manual for panels | | |
| O&M manual | | |

• Documentation complete as per contract documents

3. Installation Checks Check if Okay

| Check | Floor-> | «Tag1» |
|---|---------|--------|
| PRIOR TO SETTING PEDESTALS: | | |
| Meeting held with drywall, electrical, controls, cabling, mechanical, sheetmetal and general contractors, architect and commissioning authority to go over raised floor protocols and sealing details. | | |
| Concrete floor sealer applied to subfloor, IF specified | | |
| Pre-installation adhesive field test completed per specifications (set 3 pedestals in adhesive, let cure for 30 days under 25 lbf, apply lateral load at top of pedestal, measure force to fail adhesive bond). | | |
| PRIOR TO SETTING FLOOR PANELS: | | |
| -MISC. | | |
| All under floor utilities and work complete (HVAC, plumbing, electrical, data, etc.) | | |
| Carpet glue type and method of application relative to how much it seals panel joints is mocked up and approved. | | |
| Under floor air plenum dividers located and installed as designed. | | |
| Zone and fire separations installed. Perimeter of every air handler zone is walked to verify it is in place and sealed. | | |
| Shut off valves, sensors, dampers, actuators, fan coil units, filters booster fans will be located so they can be accessed later for service and replacement. | | |
| Record drawings submitted showing location of shut off valves, sensors, dampers, fan coil units, filters booster fans, controllers and other equipment requiring future maintenance or replacement. Submittal required before any panels cover these devices. | | |
| Under floor temperature sensors in good representative locations away from piping that may affect readings. | | |
| Under floor zone thermostats installed in location to avoid drafts and allow the best available representation of the zone temperature for control. | | |
| Leak and moisture sensors in place, as specified | | |
| Insulation installed, as specified. | | |
| Notes: | | |

File: Under Floor Air Distribution Check 11.doc 01/18/2006

UNDER FLOOR

| Check | Floor |
|--|-------|
| Floor drains installed, as specified | |
| FCU and booster fans mounted to avoid vibration. Duct insulation installed. | |
| Transfer ducts and extension ducting installed. | |
| Ducts to terminal devices connected and sealed. | |
| Special dampers installed. | |
| Any piping or other assembly under the floor that is more than 1/4 the floor space depth tall and is more than 1/2 the width of a path to an under floor zone shall be viewed and approved by the designer. | |
| Electrical conduit and junction boxes and water piping is mounted above the concrete floor to allow for water to flow underneath to a floor drain or at least not backup into electrical equipment in the event of a leak. | |
| Piping pressure tested and passed and reports submitted. | |
| Under-floor motorized dampers and valves wired and verified to be functioning properly. | |
| -CLEANING | |
| The area that panels are to be installed in is closed-in from outside (doors, windows installed and no wall breaches). | |
| The area that panels are to be installed in is closed-in from other areas in the building that are not closed-in to the outside. | |
| Prior to applying floor panels, after pedestals are set, sweep the concrete deck, scrape it of mud and vacuum with a pleated filtered vacuum with a brush-ended tool. The area cleaned shall be no more than the area planned to be covered with panels in the following two days. | |
| -AIR SEALING | |
| Floor area inspected and each opening to wall or floor cavities or to other spaces or zones is verified to be appropriate and all openings that should not be communicating to this floor space are sealed. | |
| Under floor perimeter along exterior walls and above unconditioned space sealed absolutely airtight (drywall or sheet metal to concrete deck, vertical and horizontal drywall joints, other penetrations). Overlapping or butting building elements are not acceptable as a seal unless caulked. | |
| Penetrations from under floor space into interior walls sealed reasonably airtight (drywall to concrete deck, vertical and horizontal drywall joints, around duct, pipe, conduit and cabling penetrations). | |
| Open ends of conduits in under floor space sealed. | |
| Penetrations of ducts and piping and other assemblies through the concrete subfloor or through the raised floor are sealed. | |
| Floor panels butting walls are planned to be gasketed and seal tight. | |
| Notes: | |

File: Under Floor Air Distribution Check 11.doc 01/18/2006

Bringing it all together

- Provide help, not hindrance
- Parallel completion

UNDER-FLOOR CONSTRUCTION CHECKLIST

The Construction Checklist as a tool

- IS a contract document
- ALL subs' responsibility
- Done – with a capital "D"

UNDER FLOOR AIR DISTRIBUTION CONSTRUCTION CHECKLIST

Construction Checklist

Project: «ProjectName»

UNDER FLOOR AIR DISTRIBUTION

Floors: «Tag1», «Tag2», «Tag3», «Tag4», «Tag5»

1. Submittal / Approvals

Submittal. The above equipment and systems integral to them are complete and ready for functional testing. This construction checklist is submitted for approval by the parties having direct knowledge of the equipment and systems marked below, respective to each responsible contractor. This construction checklist is submitted for approval upon completion of any outstanding areas. A Statement of Correction will be submitted upon completion of any outstanding areas.

| | | | |
|-----------------------|-------|---------------------|-------|
| _____ | _____ | _____ | _____ |
| Mechanical Contractor | Date | Controls Contractor | Date |
| _____ | _____ | _____ | _____ |
| Electrical Contractor | Date | Cabling Contractor | Date |
| _____ | _____ | _____ | _____ |
| TAB Contractor | Date | General Contractor | Date |

Construction checklist items are to be completed as part of startup & initial checkout, preparatory to functional testing.

- This checklist does not take the place of the manufacturer's recommended checkout and startup procedures.
- Items that do not apply shall be noted with the reasons on this form (N/A = not applicable, BO = by others).
- If this form is not used for documenting, one of similar rigor shall be used.
- Contractors assigned responsibility for sections of the checklist shall be responsible to see that checklist items are completed and checked off.
- "Trade" column or abbreviations in brackets to the right of an item refer to the contractor responsible to the completion of this item. A/E = architect/engineer, All = all contractors, CA = commissioning agent, CC = contractor, EC = electrical contractor, GC = general contractor, MC = mechanical contractor, SC = sheetrock contractor, TAB = test and balance contractor, _____ = _____

Approvals. This filled-out checklist has been reviewed. Its completion is approved with the exception of _____

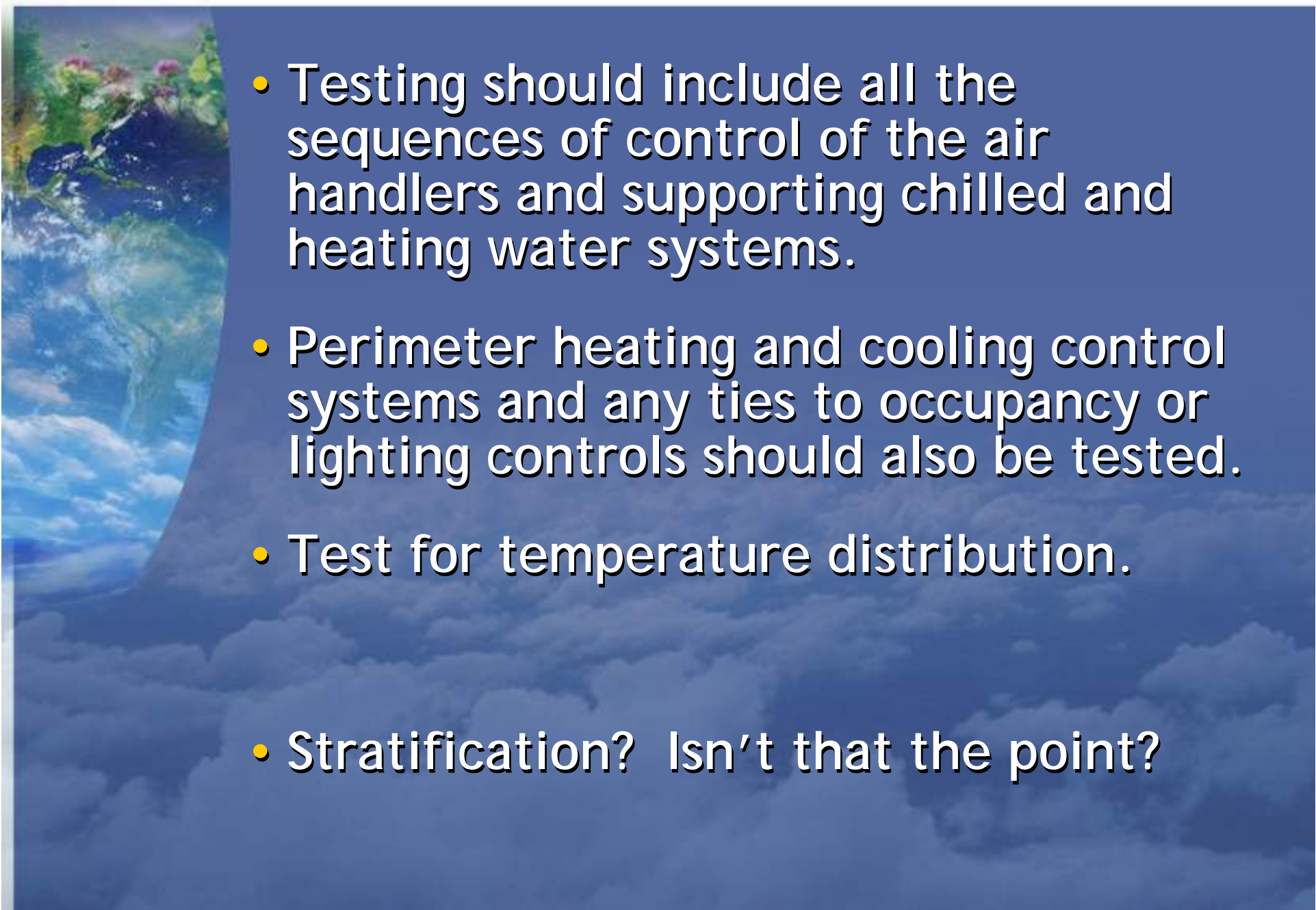
| | | | |
|---------------------|-------|------------------------|-------|
| _____ | _____ | _____ | _____ |
| Commissioning Agent | Date | Owner's Representative | Date |

VERIFICATION PHASE COMMISSIONING

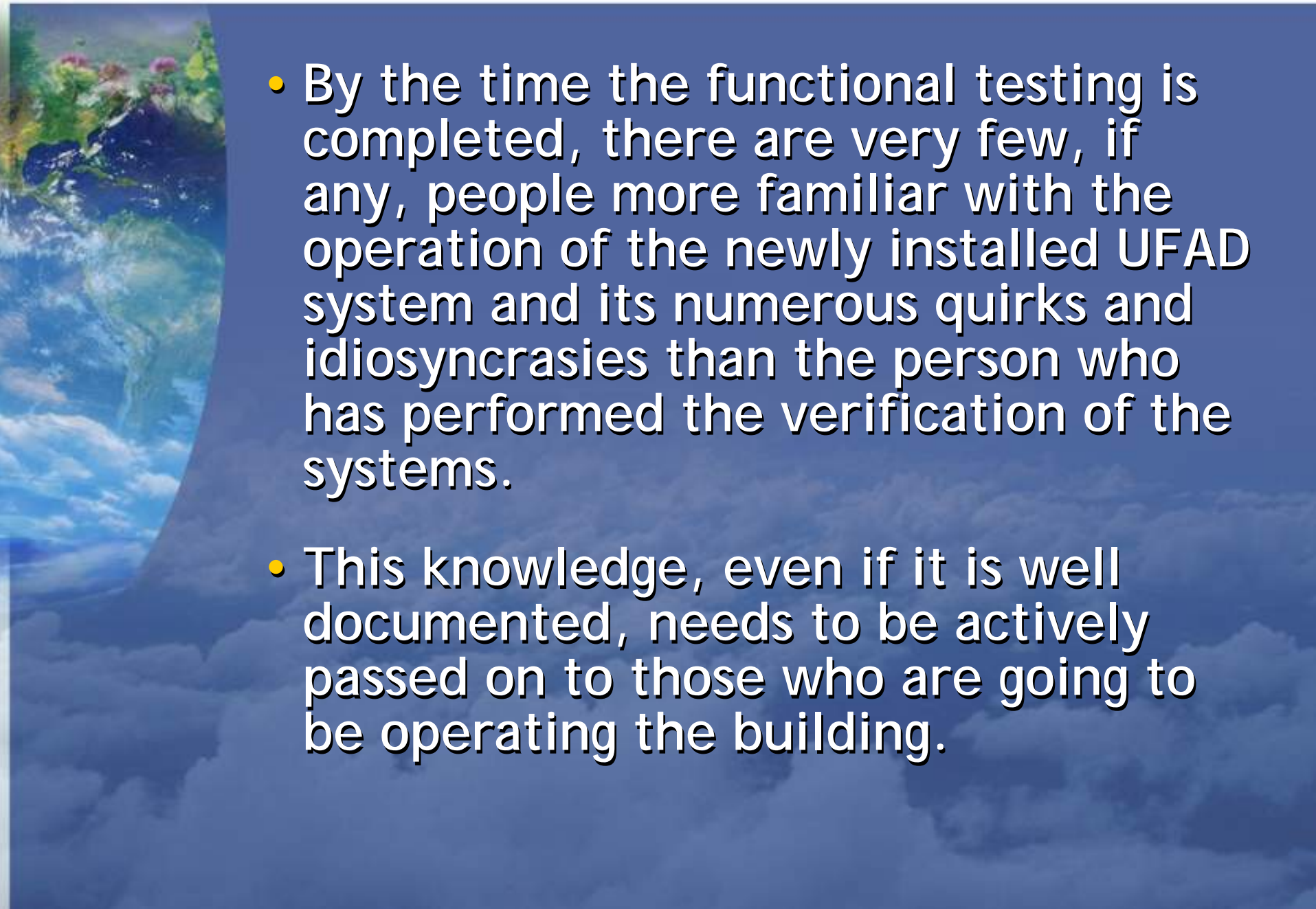
If the construction phase commissioning is performed correctly, the verification phase should be a formality.



FUNCTIONAL TESTING

- 
- Testing should include all the sequences of control of the air handlers and supporting chilled and heating water systems.
 - Perimeter heating and cooling control systems and any ties to occupancy or lighting controls should also be tested.
 - Test for temperature distribution.
 - Stratification? Isn't that the point?

FACILITIES TRAINING

- 
- By the time the functional testing is completed, there are very few, if any, people more familiar with the operation of the newly installed UFAD system and its numerous quirks and idiosyncrasies than the person who has performed the verification of the systems.
 - This knowledge, even if it is well documented, needs to be actively passed on to those who are going to be operating the building.

WARRANTY PHASE COMMISSIONING

UFAD systems are new:

- Occupants of buildings are not used to it and may or may not like it.
- Occupants' opinions often cannot be anticipated until well after the contractors, designers, and original owner project managers are done and gone.
- The commissioning provider needs to be aware that there may need to be additional occupant adjustments that were not anticipated by the owner, architect, or designer.

SEASONAL TESTING

Fine-tuning a UFAD system in one season WILL require (LEED or not) a sanity check during the opposite season.



This not only ensures that the commissioned systems are still functioning as they were designed, but allows for verification of and adjustments for occupants' comfort.

SYSTEMS OPERATIONAL REVIEW

- One year after occupancy, are the fans running at or below design?
- Are the occupants happy?
- Comfortable?
- At least not complaining?



CONCLUSION

- Fewer deficiencies
- Faster testing
- Fewer delays from problems
- Systems work as intended – from the beginning!



Scott Nelson • 503/753-4832 • scott.nelson@ch2m.com

Karl Stum • 360/573-5700 • kstum@summitbe.com