RETRO-COMMISSIONING: AN OWNER'S LOOK AT THE TRUE COSTS AND RETURN ON INVESTMENT

Adam Renzi, PE

NC STATE UNIVERSITY

AIA Quality Assurance

The Building Commissioning Association is a Registered Provider with The American Institute of Architects Continuing Education Systems (AIA/CES). Credit(s) earned on completion of this program will be reported to AIA/CES for AIA members. Certificates of the Completion for both AIA members and non-AIA members are available upon request.

This program is registered with AIA/CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Learning Objectives

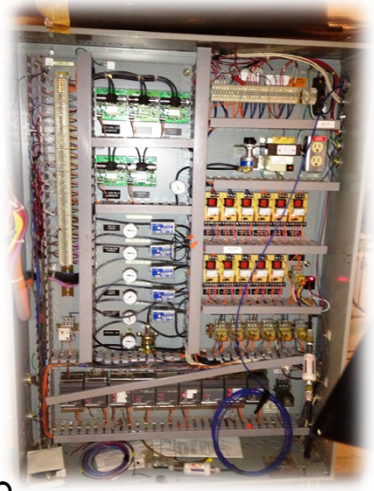
1. Develop an understanding of the true costs of commissioning.
2. Recognize the role of the owner in the commissioning process when the owner acts as the commissioning provider.
3. Identify the additional services necessary to complete the existing building commissioning process.
4. Utilize the data being developed to provide more accurate cost numbers on future jobs.

Reminders

PLEASE INTERRUPT ME! (REALLY!)

Benefits of Retro-Commissioning

- **Improved Occupant Comfort**
  - Indoor air quality concerns alleviated / reduction in employee absenteeism
  - Improved employee productivity & thermal comfort



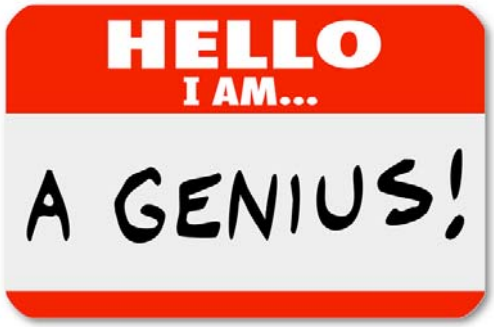
- **Improved Building Operation**
  - Reduced maintenance calls
  - Create benchmarks to facilitate efficient system monitoring

- **Reduced Operating Costs & Decreased Energy Consumption**
  - Corrections to problems never identified during initial building start-up
  - Solutions to systematic problems in building operation
  - Elimination of excessive equipment run times due to changes in occupancy or space usage
  - Replacement of malfunctioning equipment or sensors
  - Optimization of controls sequences
  - Extended equipment life

Where are the Retro-Commissioning Opportunities?

- **Design**
  - Incorrect cooling load calculations
  - Poor equipment access
  - Incorrect head pressure control
- **Construction**
  - Electric duct heaters with incorrect wiring
  - Incorrect air damper sequencing
- **Maintenance**
  - Corroded condenser coils
  - Chilled water bypasses & leaks
- **Operations**
  - Simultaneous heating and cooling
  - Control sequence not operating correctly
  - Temperature and humidity sensors out of calibration
  - Equipment not responding to control system
  - BAS programming vs. actual operation

Outside air dampers found to be non-functional and using cardboard to hold outside air back.



Completed Projects at NCSU

- **Leazar Hall** **(complete November 2013)**
  - Classroom and Office Space – 57,027 SF

- **Withers Hall** **(complete November 2013)**
  - Classroom and Office Space – 71,144 SF

- **Mary Anne Fox Teaching Laboratory** **(complete December 2013)**
  - Teaching Laboratories and Classrooms – 70,700 SF

- **Partners II** **(complete November 2014)**
  - Research Laboratories and Offices – 78,500 SF

- **David Clark Labs** **(complete April 2015)**
  - Teaching Laboratories and Classrooms – 50,953 SF

- **Engineering Building I** **(presently on-going)**
  - Research Laboratories, Classrooms, and Offices – 161,217 SF

Costs to Re-Commission – Direct Costs

- **In industry today, the average cost for retro-commissioning is between <u>$0.05 and $0.50 per square foot</u>.**
  - Dependent on scope, size and age of building, and complexity of building systems.

- **Retro-Cx Cost Allocation**
  - **Planning & Investigation** **69%**
  - **Implementation** **27%**
  - **Verification and Tracking** **4%**

- **Simple Payback Time** **0.2 to 2.1 years**

Information for this slide taken from: *The Cost-Effectiveness of Commercial Buildings Commissioning, Lawrence Berkeley National Laboratory, Mills, E., H. Friedman, T. Powell, N. Bourassa, D. Claridge, T. Haasl, and M.A. Piette. 2004*

Costs to Re-Commission – Direct Costs

- **In industry today, the average cost for retro-commissioning is <u>$0.05 and $0.50 per square foot</u>.**
  - Dependent on scope, size and age of building, and complexity of building systems.

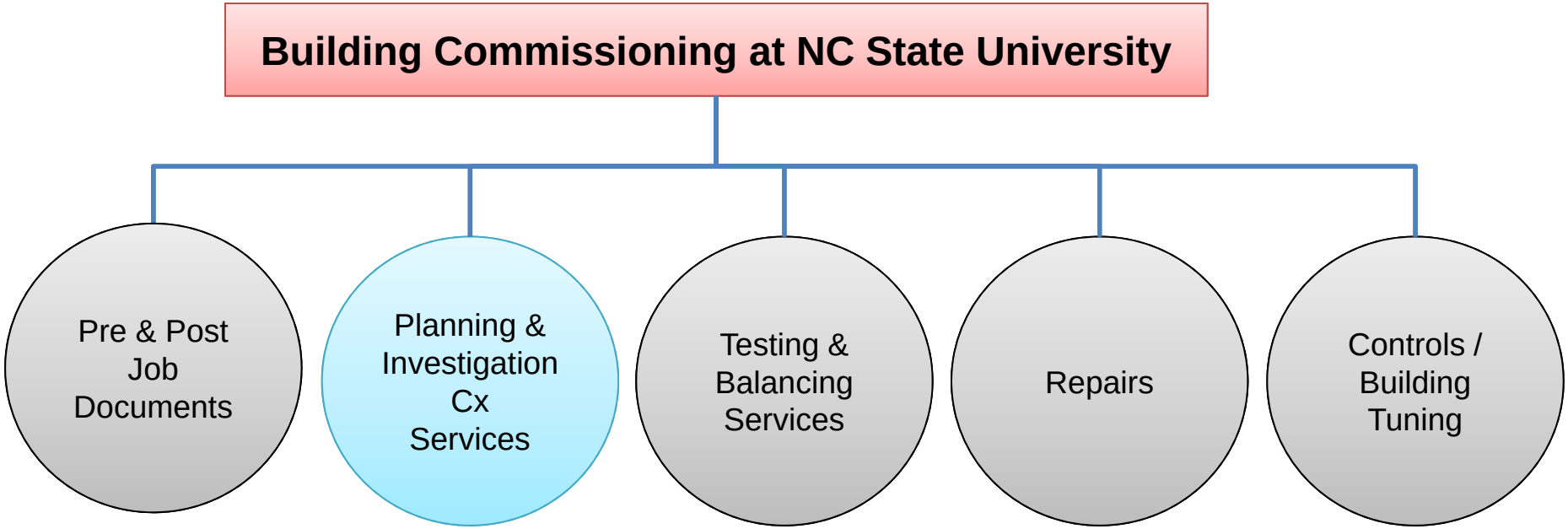
- **Retro-Cx Cost Allocation**
  - **Planning & Investigation** **69%**
  - **Implementation** **27%**
  - **Verification and Tracking** **4%**

- **Simple Payback Time** **0.2 to 2.1 years**

Information for this slide taken from: *The Cost-Effectiveness of Commercial Buildings Commissioning, Lawrence Berkeley National Laboratory, Mills, E., H. Friedman, T. Powell, N. Bourassa, D. Claridge, T. Haasl, and M.A. Piette. 2004*

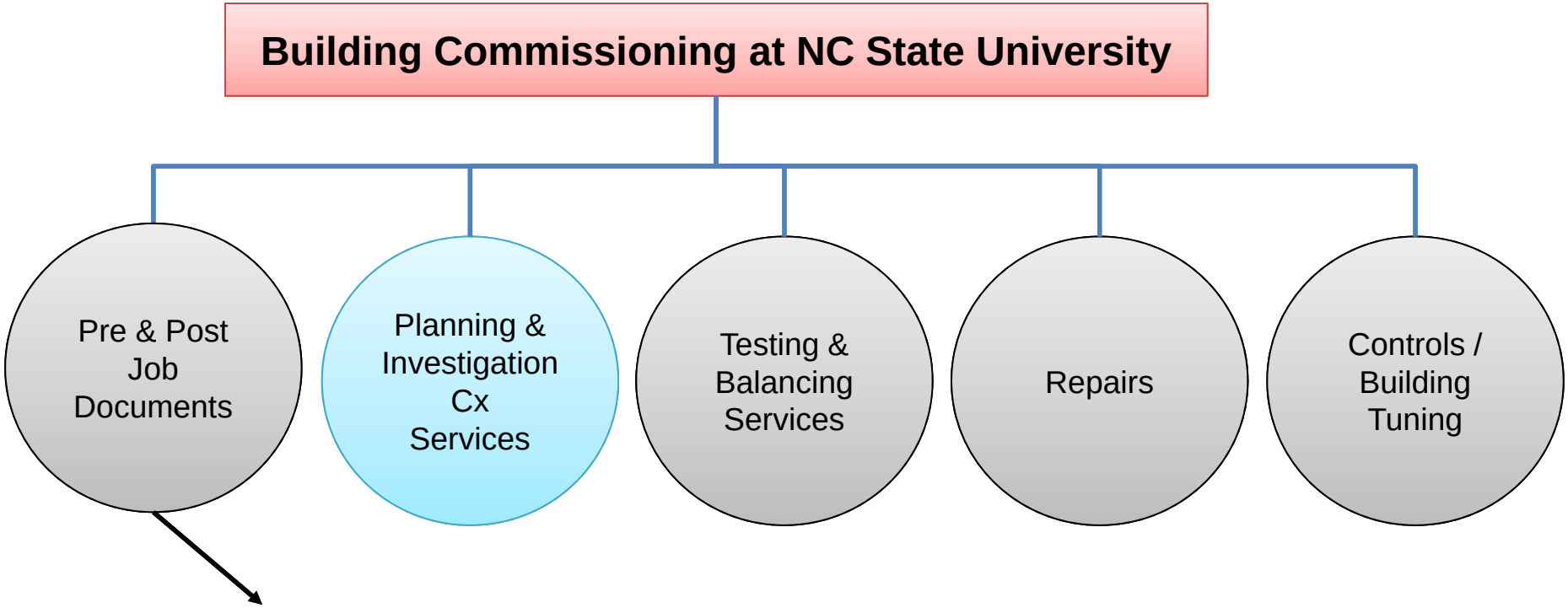
Costs to Re-Commission – Associated Costs

The way in which we at NCSU provide commissioning services adds some costs <u>not always fully calculated</u> in 'standard' industry:



Costs to Re-Commission – Associated Costs

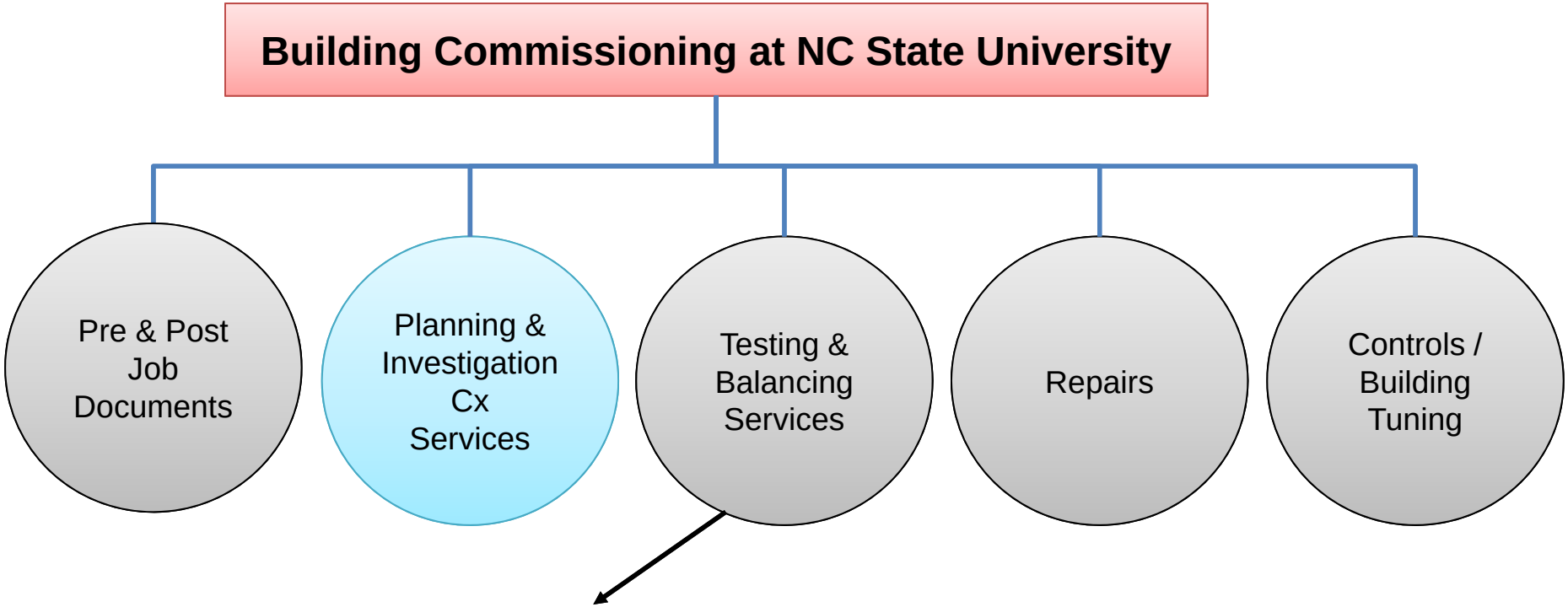
The way in which we at NCSU provide commissioning services adds some costs <u>not always fully calculated</u> in 'standard' industry:



- **We must gather building documentation <u>prior to starting</u> a commissioning job. May or may not include design drawings, TAB reports, etc.**

Costs to Re-Commission – Associated Costs

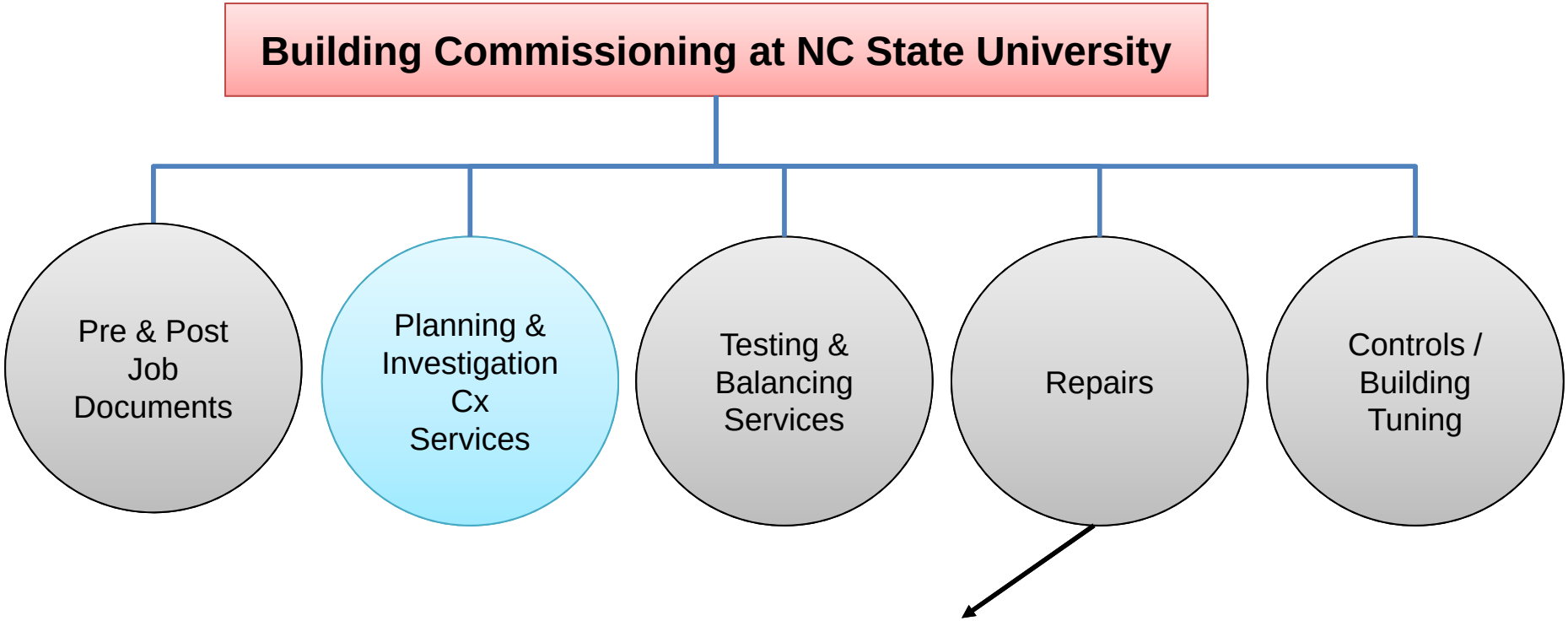
The way in which we at NCSU provide commissioning services adds some costs <u>not always fully calculated</u> in 'standard' industry:



- **We test and balance nearly 100% of the building we are commissioning.**

Costs to Re-Commission – Associated Costs

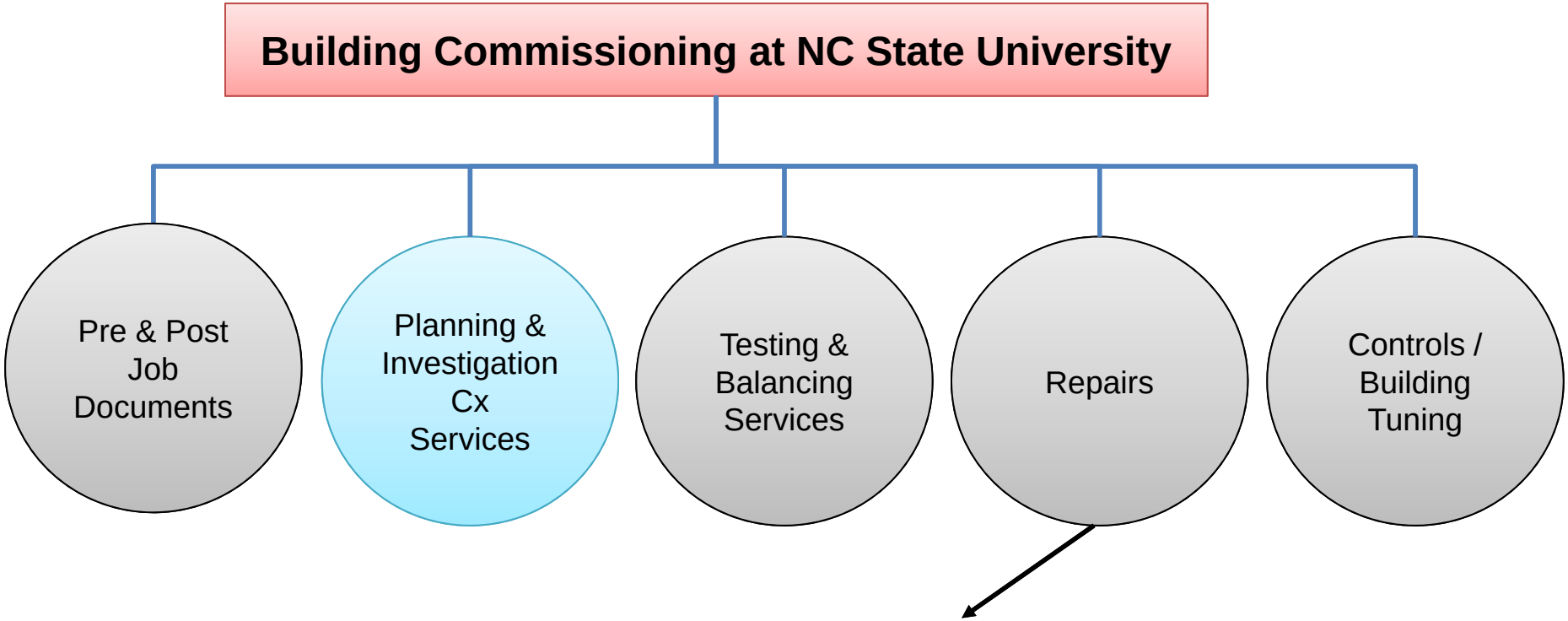
The way in which we at NCSU provide commissioning services adds some costs <u>not always fully calculated</u> in 'standard' industry:



- **When we encounter a broken or defective component or sensor, we buy a new one and replace the part.**

Costs to Re-Commission – Associated Costs

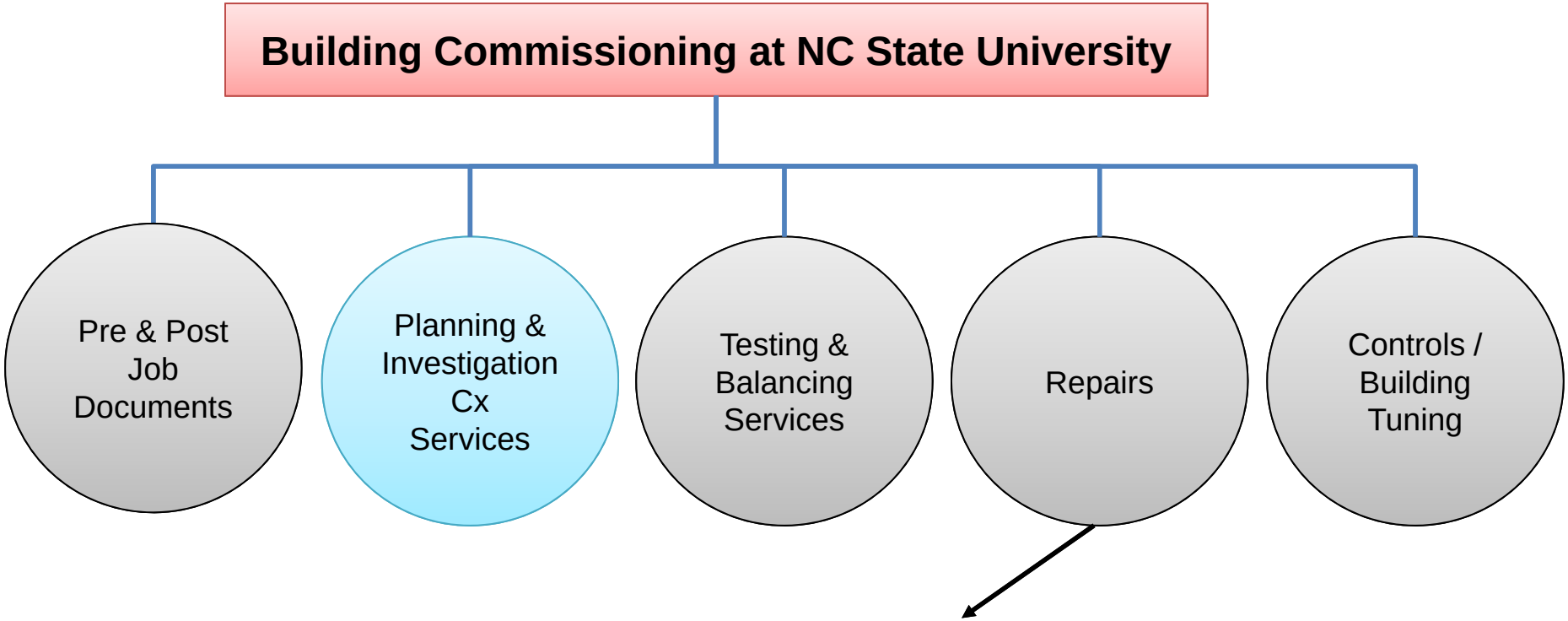
The way in which we at NCSU provide commissioning services adds some costs <u>not always fully calculated</u> in 'standard' industry:



- **When we aren't able to make the repair on our own, the maintenance shop assigned to the building will assist.**

Costs to Re-Commission – Associated Costs

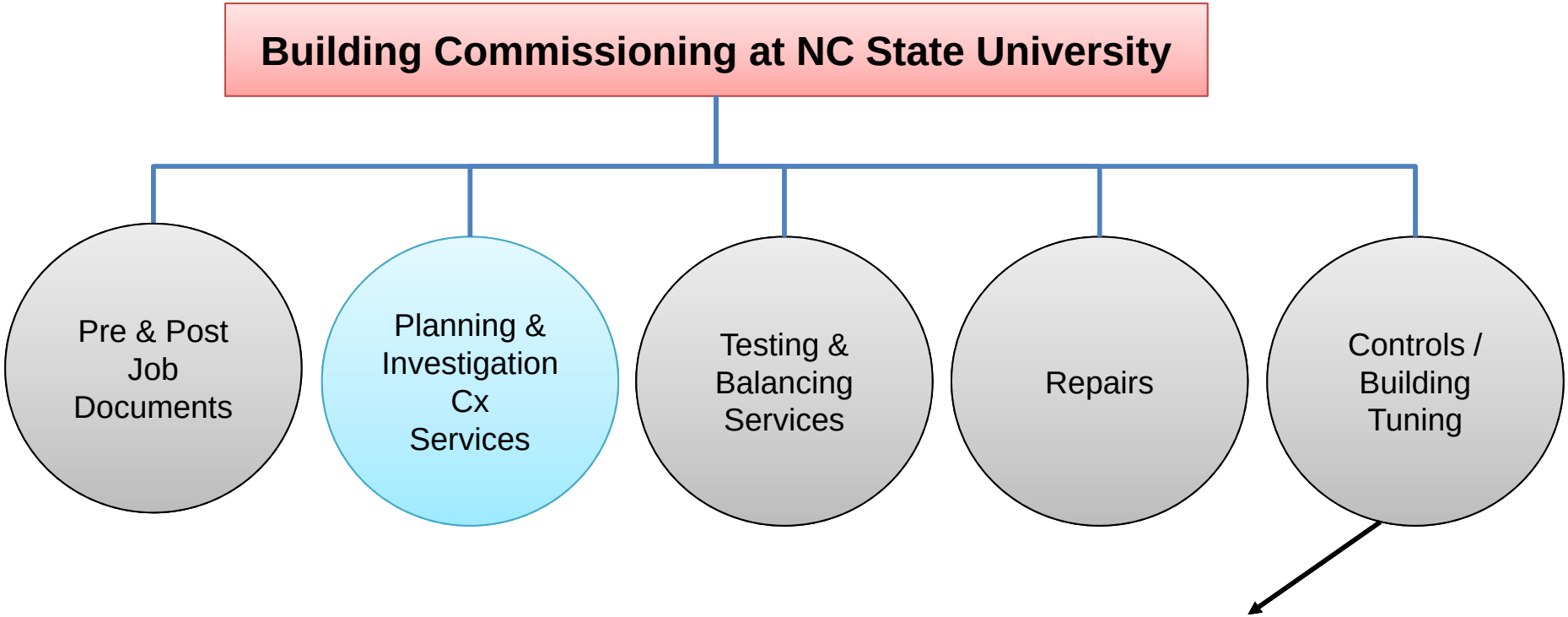
The way in which we at NCSU provide commissioning services adds some costs <u>not always fully calculated</u> in 'standard' industry:



- **When there is a systematic failure, we will enlist the help of a project engineer and outside contractors to make the repair**.

Costs to Re-Commission – Associated Costs

The way in which we at NCSU provide commissioning services adds some costs <u>not always fully calculated</u> in 'standard' industry:



- **We employ our own building automation technicians to do BAS loop tuning.**

Individual Project Costs: Fox Labs

- **Example 1: Mary Anne Fox Labs (70,700 SF)**
  - **Commissioning performed by outside contractor**

EXPENSE (BY WHOM)	COST ($)
Re-Commissioning (AEI)	48,500
Facilitate Contractors (NCSU)	14,052
Repair Work (Zone Maintenance)	2,696
Parts & Components	1,300
Lab Airflow Contractor (Hahn Mason)	12,000
Major Projects (NCSU/Contractor)	24,500
TOTAL COST	**103,048**

COST PER SQUARE FOOT: $1.46

- **Retro-Cx Cost Allocation**
  - **Planning & Investigation 61%**
  - **Implementation 35%**
  - **Verification and Tracking 4%**

Facility Improvement Measures – Fox Labs

- **Numerous Phoenix Control Valves had failed and required complete replacement.**
- **Chilled Water Pump Skids found to be running inefficiently – replaced with pumps integrated with VFD**
- **Both hot water system heat exchangers 1/3 control valves were modulating simultaneously. System was re-programmed for a lead/lag configuration.**

Individual Project Savings: Fox Labs

- **Example 1: Mary Anne Fox Labs (70,700 SF)**
  - **Energy savings for Fiscal Year 2014 (as compared Fiscal Year 2013).**

ENERGY CATEGORY	SAVINGS ($)
Electricity	17,854
Steam	23,548
Chilled Water	41,455
Domestic Water	1,230
TOTAL SAVINGS	**84,087**

EUI dropped from 528 to 468 (11%)

Individual Project Costs: Withers Hall

- **Example 2: Withers Hall (71,144 SF)**
  - **Commissioning performed by NCSU Commissioning Team**

EXPENSE (BY WHOM)	COST ($)
Re-Commissioning (NCSU)	29,630
Repair Work (NCSU Cx Team)	16,387
Repair Work (Zone 1)	6,207
Parts & Components	3,956
Major Projects (NCSU/Contractor)	19,008
TOTAL COST	**$75,188**

COST PER SQUARE FOOT: $1.06

- **Retro-Cx Cost Allocation**
  - **Planning & Investigation 39%**
  - **Implementation 57%**
  - **Verification and Tracking 4%**

Facility Improvement Measures – Withers Hall

- **VAV supply box minimum found to be 50% of maximum, reduced to 20%.**
- **OA Intakes Impacted and Inaccessible – Access Door Cut in Place and Mesh Screens Replaced with Bird Screens**
- **Excessive sediment was found clogging the chilled water strainers on the AHU's – New In-Line Strainer Installed**
- **Hot Water System Triple Duty Valves found to have failed. Eliminated from piping system.**

Individual Project Savings: Withers Hall

- **Example 2: Withers Hall (71,144 SF)**
  - **Energy savings for Fiscal Year 2014 (as compared Fiscal Year 2013).**

ENERGY CATEGORY	SAVINGS ($)
Electricity	15,193
Steam	6,262
Chilled Water	20,195
Domestic Water	356
TOTAL SAVINGS	**42,006**

EUI dropped from 110 to 77 (30%)

Individual Project Costs: Leazar Hall

- **Example 3: Leazar Hall (57,027 SF)**
  - **Commissioning performed by outside contractor**

EXPENSE (BY WHOM)	COST ($)
Re-Commissioning (CxWorCx)	34,900
Facilitate Contractors (NCSU)	14,652
Repair Work (Zone 1)	4,900
Parts & Components	483
Major Projects (NCSU/Contractor)	0
TOTAL COST	**54,935**

COST PER SQUARE FOOT: $0.96

- **Retro-Cx Cost Allocation**
  - **Planning & Investigation 90%**
  - **Implementation 8%**
  - **Verification and Tracking 2%**

Facility Improvement Measures – Leazar Hall

- **VAV supply box minimum found to be 50% of maximum, reduced to 20%.**
- **Two air-handling units had excessive supply air (fixed sheave, no VFD), re-sheaved to reduce airflow.**
- **AHU's did not have economizer implemented as was intended in original sequence. Revise sequence to include free cooling.**

Individual Project Savings: Leazar Hall

- **Example 3: Leazar Hall (57,027 SF)**
  - **Energy savings for Fiscal Year 2014 (as compared Fiscal Year 2013).**

ENERGY CATEGORY	SAVINGS ($)
Electricity	7,308
Steam	19,255
Chilled Water	19,045
Domestic Water	333
TOTAL SAVINGS	**45,941**

EUI dropped from 157 to 103 (34%)

Return on Investment (ROI)

ROI - simple economic analysis of the costs against the energy savings.

EXAMPLE PROJECTS	ROI
Mary Anne Fox Labs	0.61 years
Withers Hall	0.89 years
Leazar Hall	0.60 years

- **Our payback "goal" was 2.7 years for a lab/classroom.**

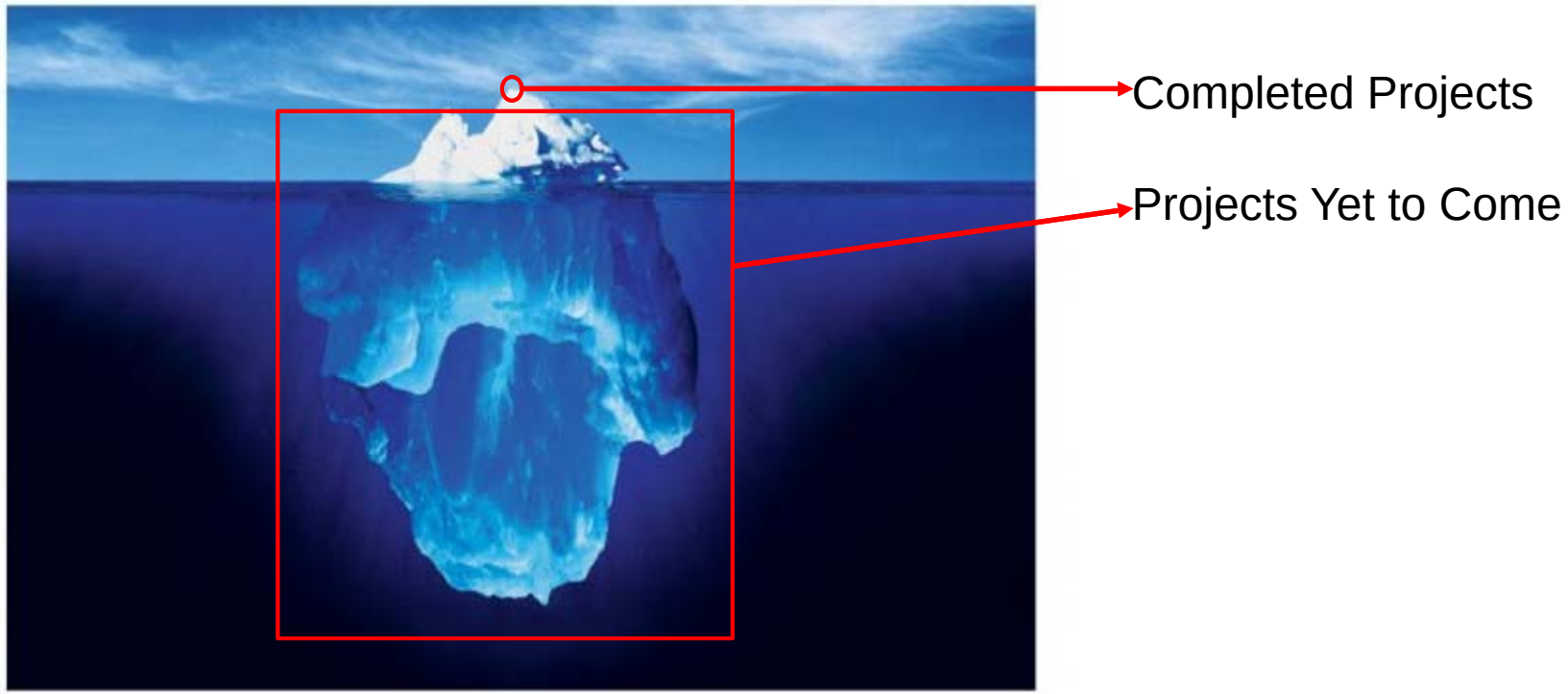
Return on Investment (ROI)

ROI – <u>building tenant safety</u>.

- **FOX LABS.** Found a significant number of failed lab exhaust control valves.
- **WITHERS HALL.** Found the outside air intakes to each of the 8 air handlers to be fully impacted with dirt and debris.
- **LEAZAR HALL.** Found the outside air flow stations to be reading inaccurately, and in need of repair on all air handlers.
- **DAVID CLARK LABS.** Found a significant amount of collapsed exhaust ductwork above ceiling.
- **PARTNERS II.** Found numerous incorrect pressure relationships between labs and offices/classrooms.

Return on Investment (ROI)

ROI – the downside



Lessons Learned

- It **costs more** to Cx and repair items than we estimated
- We are **saving much more** energy than we estimated
- A 0.7 year simple payback means **we need to do more** commissioning to reduce campus energy costs
- Found more issues that expected in a relatively ‘new’ building
  - Up-fits have significantly changed buildings in short time
  - Dampers not functioning
  - Device calibration requirement is high
- Team effort /Communication key to success
  - Users, key constituents, Zone Maintenance Staff, Cx Team, Energy Management

Lessons Learned

- Use of a 3rd part Cx Firm more expensive
  - NC State ‘assist’ so costs higher
- Setup work orders to effectively capture where effort and costs occurred (Cx, Repairs, Projects)
- Correcting the issue saves energy – simply making a list of the issues does not save energy
- Correct potential safety issues in Labs
  - Phoenix Lab exhaust valves are not maintenance free
- Cx Team develops basic scope of work for repairs & projects which helps to facilitate execution
- Need to track energy usage to determine optimum time to re-commission again!

NCBC
May 18-20, 2015 | St. Louis, Missouri

Adam Renzi, PE
Facility Mechanical Engineer / Commissioning Team Leader

NC State University
adrenzi@ncsu.edu
www.ncsu.edu

NC STATE UNIVERSITY

BCA™ Building Commissioning Association