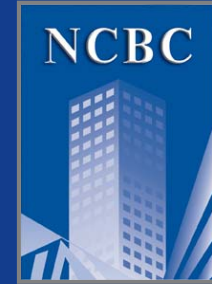


NCBC 2007



An AE/CxA Team Approach Specifying Control Systems Logic and Integration Kent Barber & Doug Chamberlin



Keithly Barber Associates

Solutions for Better Buildings



Presentation Overview

- What do we mean by Control Logic & Integration
- Advantages of AE/CxA Team Based Approach
- Simple examples



Introduction

- What do we mean by Control Logic & Integration



Introduction

- Control Logic – definition relative to this process
 - The cause and effect logic used in the control system programming to implement the sequences of operation.



Introduction

- Control Integration – definition relative to this process
 - The interaction between two control systems required to implement the sequences of operation.
 - What needs to be communicated and how



Introduction

- Control Logic & Integration (CLI) process is a process for precisely identifying the details of how components and systems are to work together in order to achieve the intended systems performance (the desired control strategies).



Introduction

- When are control logic & integration issues typically resolved?
- If we're lucky – during contractor's software programming, startup, debugging or QC
- Often, unfortunately – during Cx functional testing



Introduction

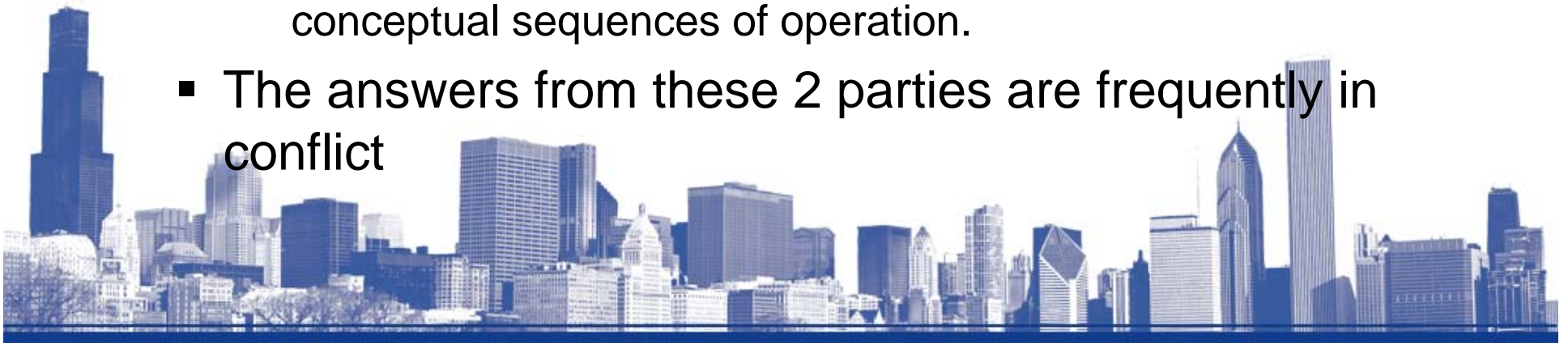
- When should control logic & integration issues be resolved?
- Preferably
 - Prior or during to FPT writing
 - Before BAS programming



Introduction

➤ History:

- In the absence of clearly communicated CLI, repeatable FPT writing requires that the CxA convert the sequences of operation into logic diagrams or statements:
- Inevitably this leads to questions regarding:
 1. Intent of the engineer's design
 2. How the contractor interpreted and implemented the the conceptual sequences of operation.
- The answers from these 2 parties are frequently in conflict



Introduction

- Solution: CLI discussions with the design engineers, contractors, owner's representative, & CxA such that logic & integration, procedures and responsibilities are clearly defined



Introduction

➤ Construction Phase CLI

- Control logic & integration processes have been discussed for a number of years as a construction phase activity
- Advantage - Installing contractors and suppliers available



Introduction

Why do it during design?



Why Design Phase Cx

- Improved bidding ability and enforceability of the bid documents



Why Design Phase Cx

- Contractors know exactly what is require to implement the sequences of operation
- CxA can specify greater detail regarding functional testing



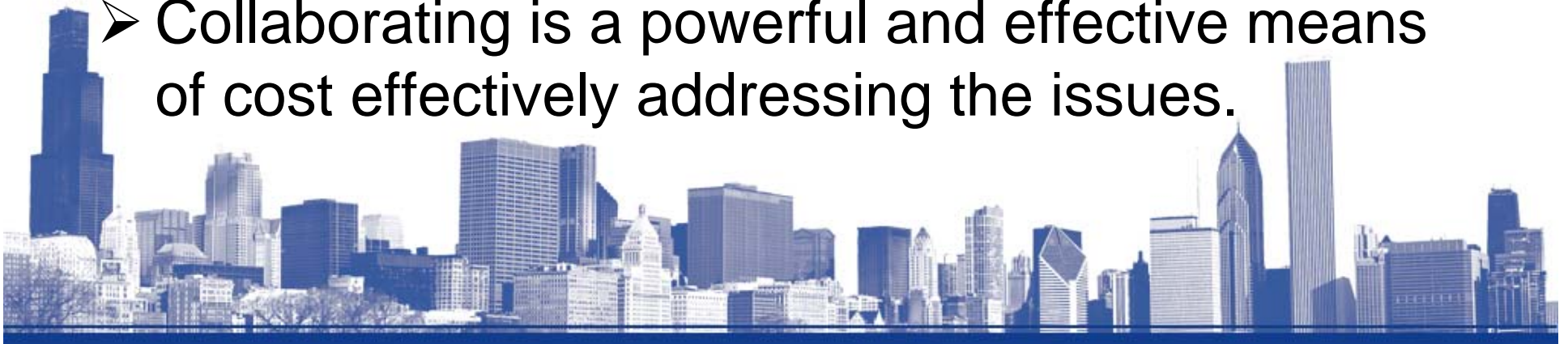
Why Design Phase Cx

- AE/CxA collaboration offers additional advantages



Why Design Phase Cx (cont.)

- CxA can provide:
 - Detailed information regarding issues that repeatedly delay successful Cx efforts
 - Insight into how these issues are typically resolved.
- Design engineer can provide:
 - Design tools and expertise to address the issues in the construction documents
- Collaborating is a powerful and effective means of cost effectively addressing the issues.



Resistance to Design Phase CLI

We frequently encountered two common objections to design phase CLI.



Resistance to Design Phase CLI

- Concern that process will require increased AE time; therefore project expense:
- *The construction phase benefits outweigh the design phase efforts for the AE, as well as the Owner, CxA & contractors.*
- The paper includes an endorsement from an initially skeptical design engineer:



Resistance to Design Phase CLI

- Control logic is proprietary, and that specifying precise control logic and integration might eliminate some suppliers from being able to bid the project:
- *View not shared with major control providers*



Applying the Process

➤ What

- We've discussed what a CLI process is

➤ When

- We've said there are benefits to doing it during design

➤ How

- How do you apply the process?



Applying the Process

Key elements of
An AE / CxA Approach
That we find effective



Effective Application 1

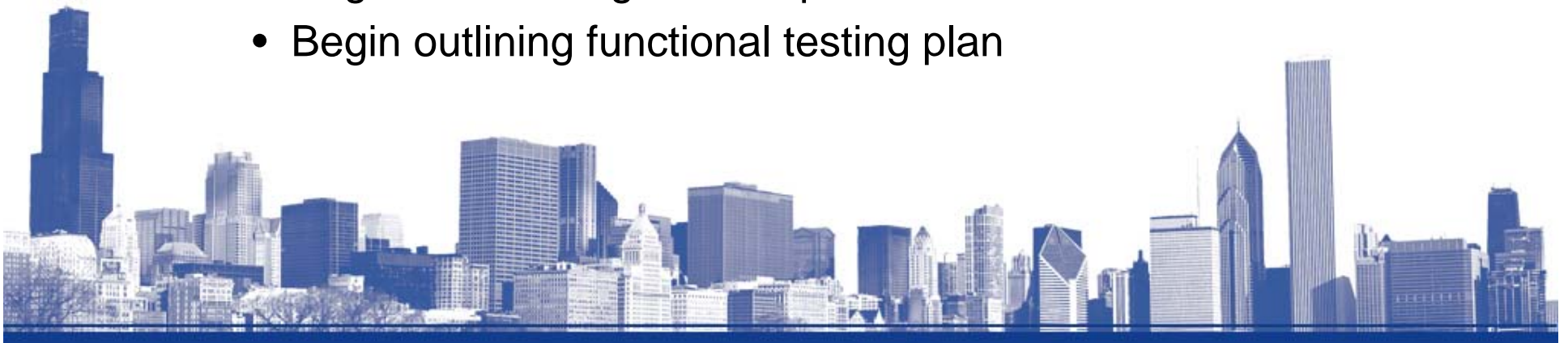
➤ Designers:

- Develop concept sequences of operation in the early drafts of the BOD.
- When it is clear which concepts of operation best address the OPR, develop accompanying system schematics – prior to DD
- Select components and equipment types that best support the sequences of operation.
- By CD, the CLI process should enable detailed CLI specs



Effective Application 2

- CxA begin the FPTs early to enhance the design review:
 - If the CxA can't figure out how to test the operation of a system the contractor probably can't figure out how to program the controls or integrate the operation of interactive systems.
 - During design submittal review the CxA should
 - Begin considering the test procedures
 - Begin outlining functional testing plan



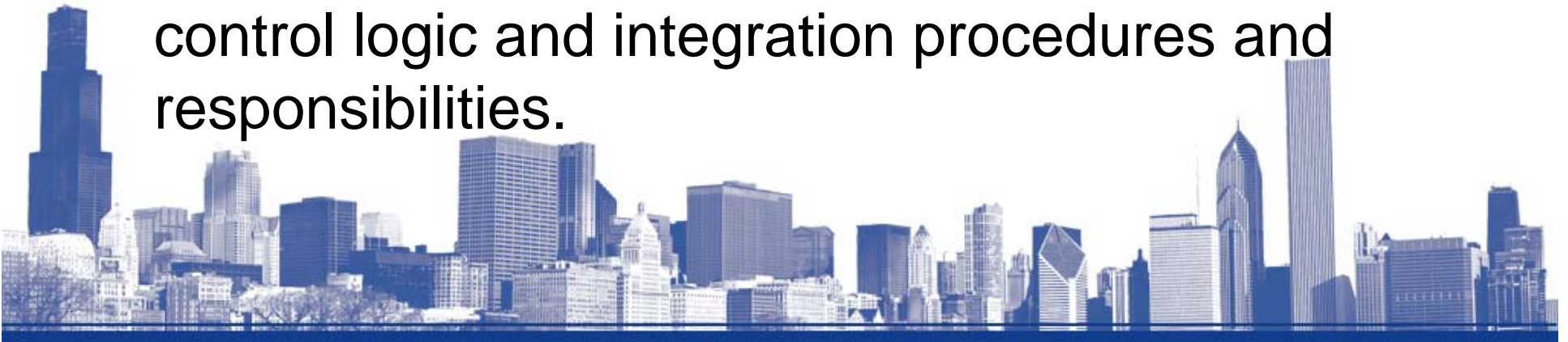
Effective Application 2 (cont.)

- Outline includes the following information:
 - A list of all the FPTs anticipated by the CxA
 - For each FPT, a list of the objectives, the acceptance criteria, and the minimum participants (typically contractors and suppliers)
 - An outline of the various steps of the procedure required to confirm the acceptance criteria
- Use the outline as a working document that evolves into the completed Functional Testing Plan.



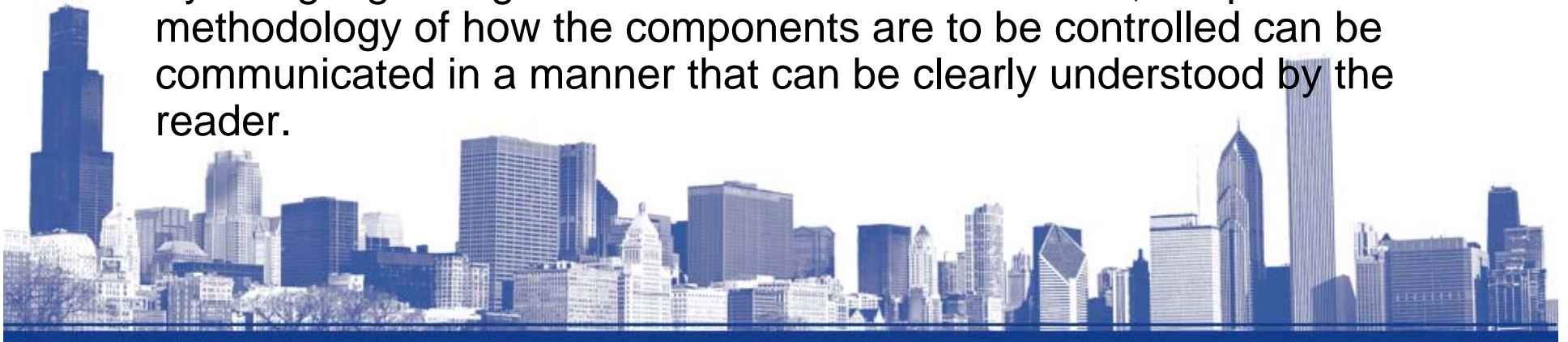
Resolution of CLI Issues

- CxA generates a list of issues for clarification, which effect the functional performance of the systems.
- The Design Team and owner's representatives respond to the comments in writing.
- These parties meet and discuss the written responses in order to clearly document the control logic and integration procedures and responsibilities.



Control Logic – Key Concepts

- Systems are most likely to operate as the designer intended when the designer's sequences of operation are presented in a series of logic diagrams or statements.
- Success of a systems' design depends on specific cause and effect relationships, which may not be fully apparent to readers of narrative sequences of operation, or even to the designer, until the logic is fully developed.
- Control system programmers must translate narrative sequences of operation into a programming language that is understood by a binary-based processor.
- By using logic diagrams or If-Then-Else statements, the precise methodology of how the components are to be controlled can be communicated in a manner that can be clearly understood by the reader.



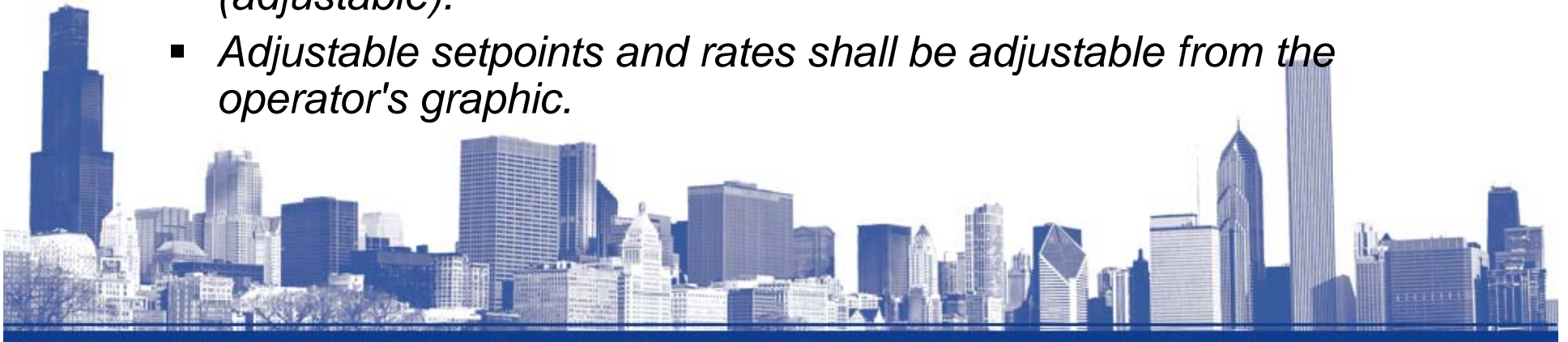
Control Logic Example

- *Consider the following Sequence:*
 - *“The discharge air temperature shall be reset based on cooling demand”*
- The sequence interpreted in many ways, such as:
 - Resetting DAT setpoint based on outside air
 - Resetting DAT based on the average of the VAV terminal unit (TU) cooling outputs
 - Resetting DAT based on the TU with the greatest cooling output.



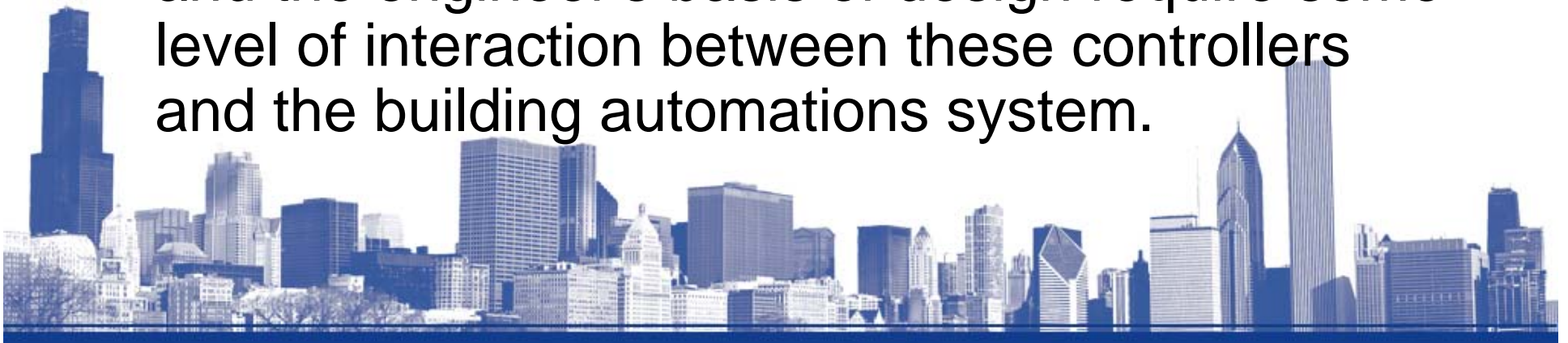
Control Logic Example (cont.)

- Improved Sequence might read:
 - *Reset the DAT setpoint as follows:*
 - *Every 30 minutes (adjustable) poll the cooling output for the terminal units serving each of the labs.*
 - *If the greatest cooling output is greater than 95% (adjustable), and the DAT setpoint is greater than the lower limit of the DAT reset range (adjustable); then decrease the DAT setpoint by 1F (adjustable).*
 - *If the greatest cooling output is less than 85% (adjustable), and the DAT setpoint is less than the upper limit of the DAT reset range (adjustable); then increase the DAT setpoint by 1F (adjustable).*
 - *Adjustable setpoints and rates shall be adjustable from the operator's graphic.*



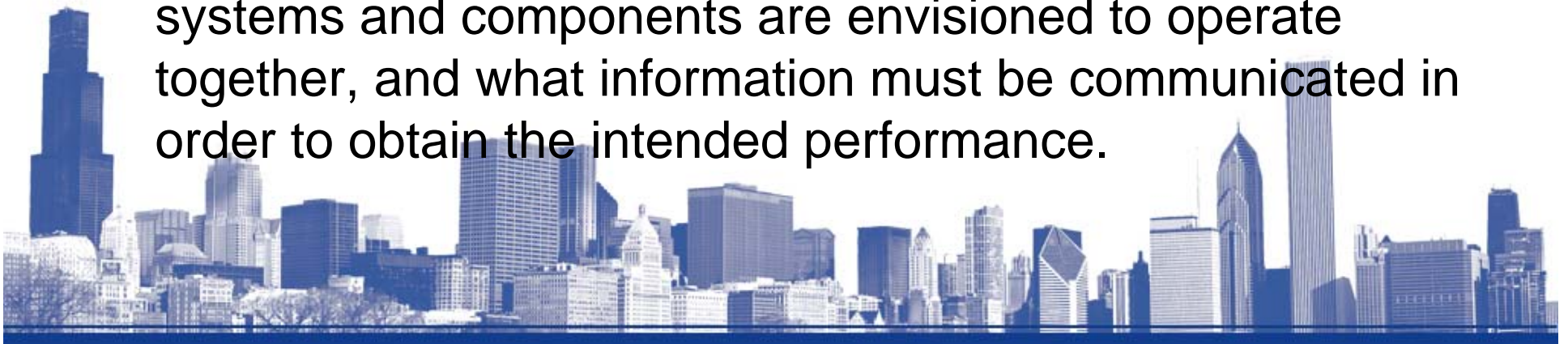
Integration

- Integration issues pertain to the interaction between controls, equipment, systems and disciplines.
- For example, major equipment, such as chillers and boilers, may be provided with sophisticated programmable logic controllers.
- Typically the owner's functional requirements and the engineer's basis of design require some level of interaction between these controllers and the building automations system.



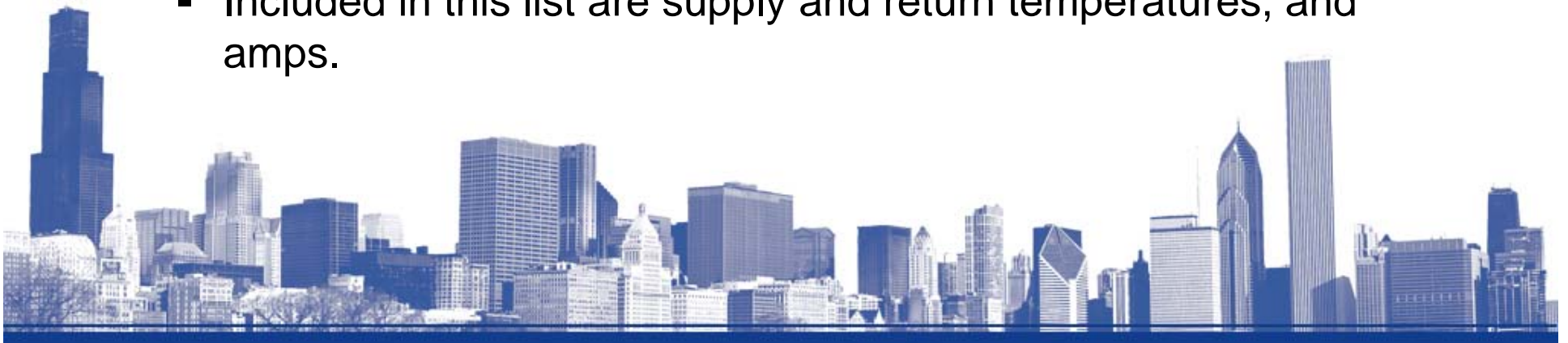
Integration (Cont.)

- As the need for increased interoperability has become more prevalent, manufacturers have responded with products that claim the ability to operate per public or proprietary protocols.
- Often, project team does not fully understand the type or level of interaction between control systems, and the capabilities of the controllers and interface devices.
- The design phase CLI process focuses on how various systems and components are envisioned to operate together, and what information must be communicated in order to obtain the intended performance.



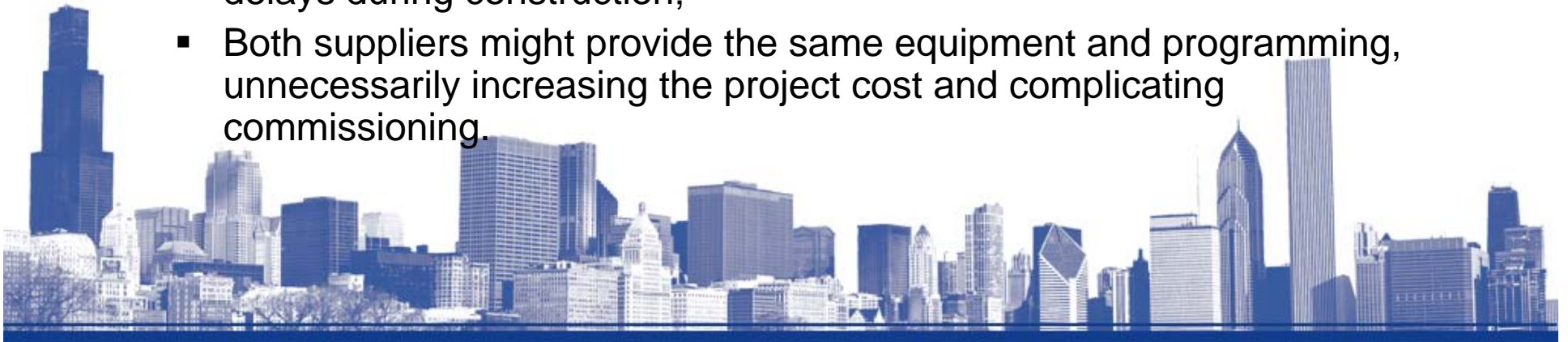
Integration Example

- Consider as an example:
 - Central plant with two chillers
 - Primary-secondary pumping
 - Chilled water flow is not monitored.
 - The chiller specification requires the chillers to be provided with a programmable logic controller.
 - The specification does not include a controller model
 - The specification does include an exhaustive list of information required to be available at the PLC display. Including:
 - Included in this list are supply and return temperatures, and amps.



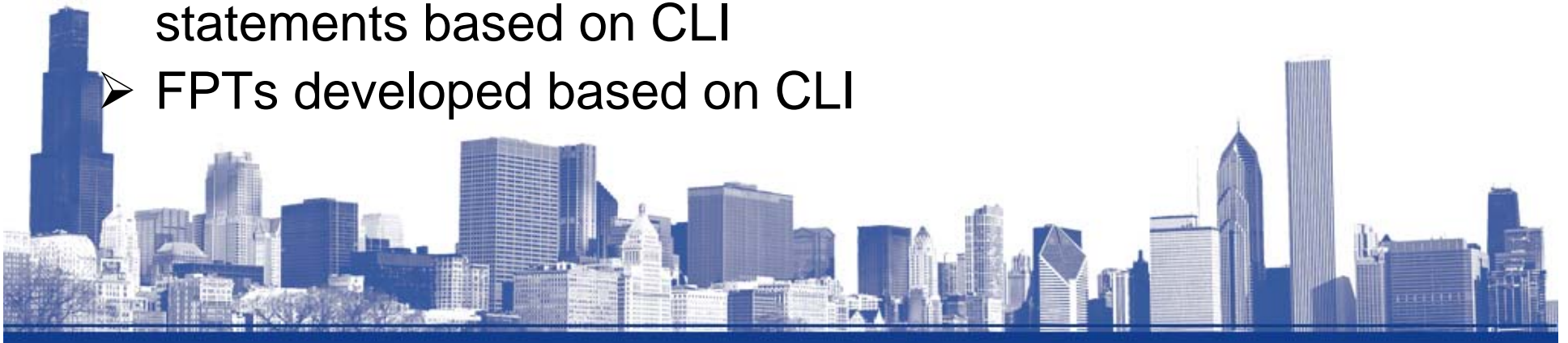
Integration Example (cont.)

- The following sequence of operation is included in the chiller and building automation system (BAS) specifications.
 - *"Upon a call for cooling the chiller plant shall be enabled. A PID loop shall modulate chiller output to maintain the chilled water temperature setpoint, which shall be determined by the BAS. The chillers and their associated pumps shall be staged based on the cooling load of the building".*
- This sequence of operation could be interpreted and implemented in a variety of ways by the providers of the chiller and the BAS:
 - Each supplier might assume the other is providing critical equipment and programming, which could result in change orders and scheduling delays during construction;
 - Both suppliers might provide the same equipment and programming, unnecessarily increasing the project cost and complicating commissioning.



Effective CLI Process Elements

- Well documented OPR developed at project conception and maintained throughout the project
- BOD developed early in schematic design including:
 - Concept sequences of operation
 - System schematics based on the sequences of operation
 - Systems and equipment types chosen to best support the schematic design and implementation of the sequences
- CLI process performed as prescribed
- Sequences of operation developed into logic diagrams or statements based on CLI
- FPTs developed based on CLI



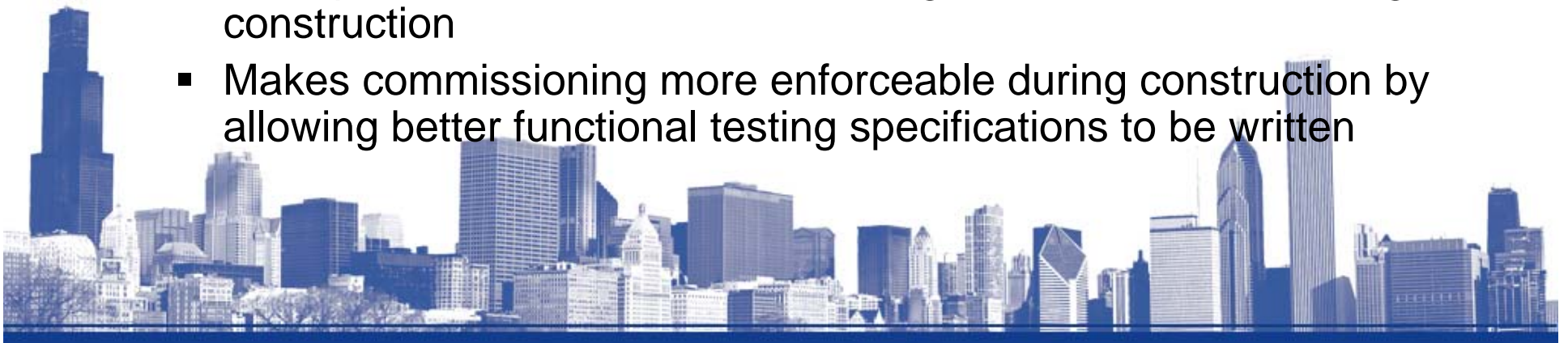
Advantages of CL&I

➤ **For AE Team:**

- Project is more likely to be installed in accordance with the AE's original BOD.
- Minimizes time consuming involvement in potentially contentious resolution during construction
- Minimizes the potential for having to reverse engineer solutions for the wrong equipment of control systems.

➤ **For CxA**

- Makes it easier to determine CxA fees by reducing the potential for unpredictable and time consuming issues resolution during construction
- Makes commissioning more enforceable during construction by allowing better functional testing specifications to be written



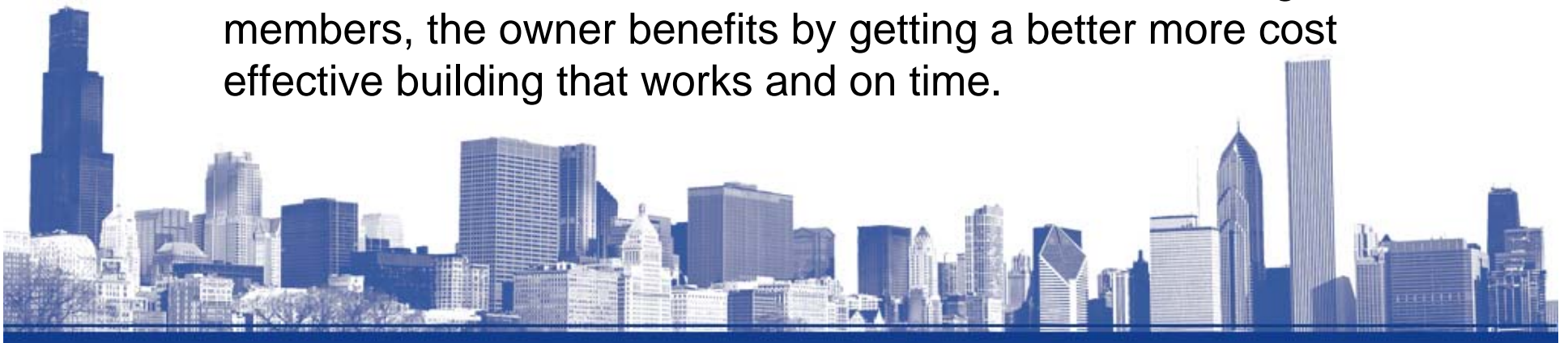
Advantages of CL&I

➤ ***For Contractors***

- Levels the bidding field by minimizing the number of ways that critical portions of the CDs can be interpreted.
- Makes commissioning more biddable by knowing what the FPTs are in advance
- Minimizes the potential project delays caused by discovering complex issues near project closeout

➤ ***For Owner***

- For all of the reasons described for other commissioning team members, the owner benefits by getting a better more cost effective building that works and on time.



Questions?



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