Successful Control Projects

Why so Hard?

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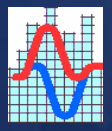

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We Will Discuss...

- Non-example and current practice
- Improved Process
  - Master Planning
  - Defining/Planning DDC Systems for Projects
  - Owner
  - Engineer - Specification, Sequences & Details
  - Contractor Responsibilities
  - Commissioning?
  - Issue in Cx
  - Documentation, O&M…….*Persistence*
- Five Principles of Controls Design/Specification

Classic Non-example…
How "Not" to Design a Control System

- Don't Design it - Delegate the control design responsibility to someone else in the process.
- Make it as complex as possible. Confuse the maximum number of people.
- Forget about documentation or document it in a language not understood by the operators. (Use a foreign language with metrics)
- Ignore maintainability features.
- Assume all we go according to plan (Trust the contractor totally)

DDC Changes over the Years

- 25 years ago, we had Open Protocol, Interoperability, Plug & Play
- Early DDC/EMS - proprietary and expensive
- Move to distributed DDC
- Today
  - Networked Systems, Internet
  - More power at lower levels
  - Open Protocol……Interoperability *#1,3,5
- We haven't kept up….. (who's we?)

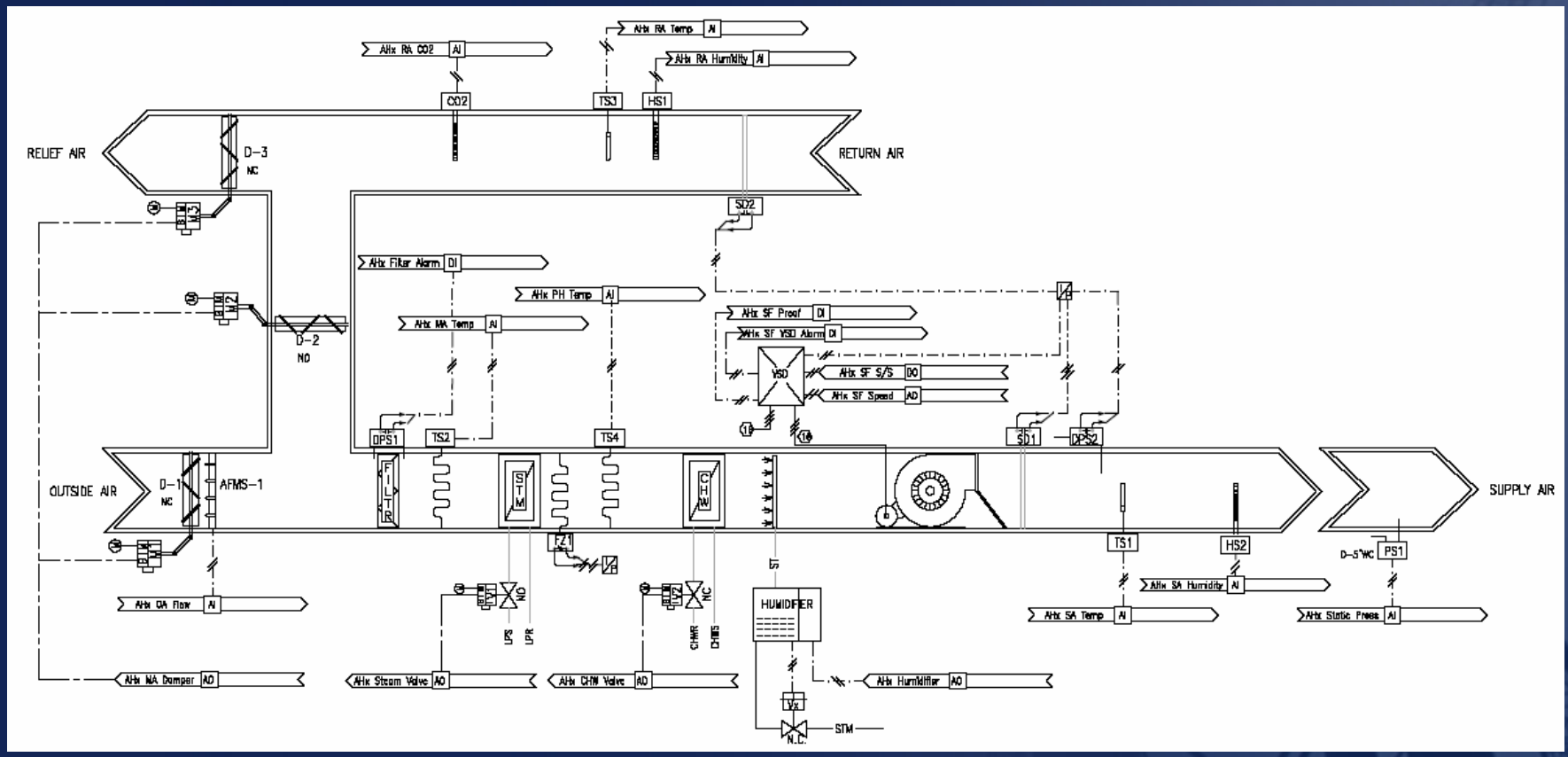
Current Practice

- **HVAC Controls are Performance Specified**
- Specifications aren't very specific
- Controls are typically "Design/Built" by 3rd tier subcontractor
- Application Engineer for vendor is key
- Documentation quality varies
- **Resources are limited,** enforcing good specs are a challenge
- Training is critical
- Difficult to get a system to work as planned
- Commissioning becomes necessary

Essence of a Control System

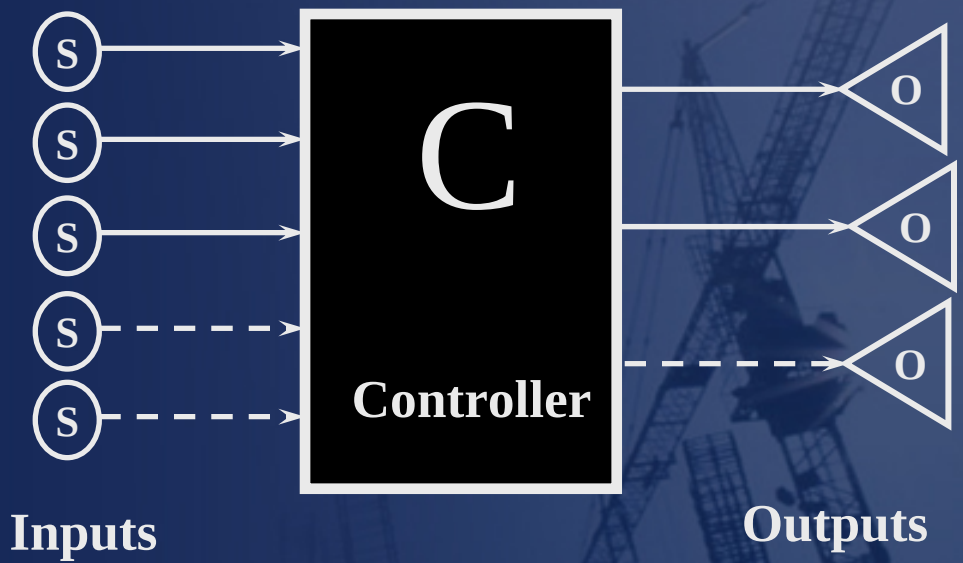
- Stuff
  - Sensors
  - Controlled Devices
  - Controllers
  - Interface Devices
  - Networks
- People
  - Programming
  - Installation
  - Quality Control
- Tools
  - Software
  - Documentation
  - Training

Typical Documentation - Schematic

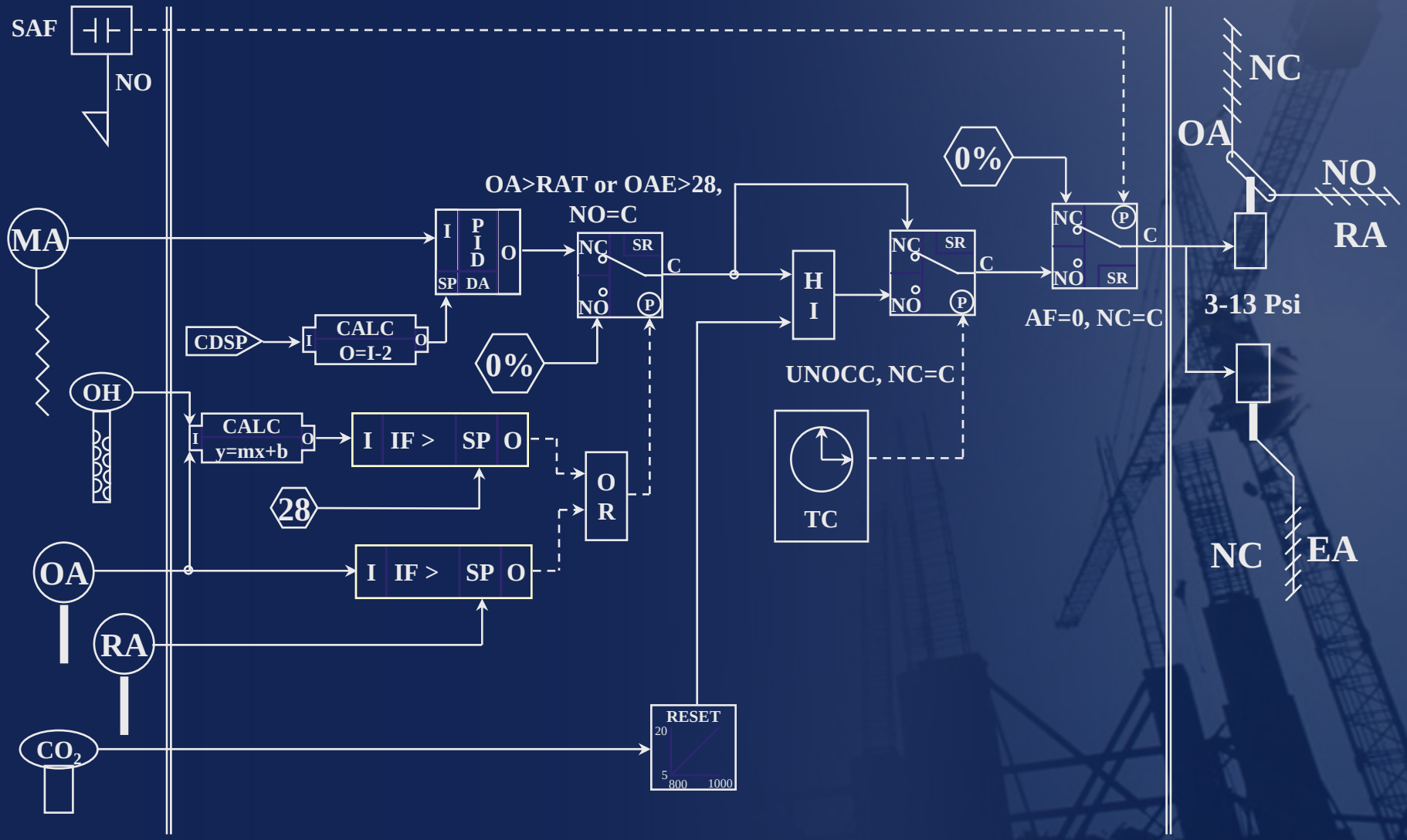


Typical Documentation

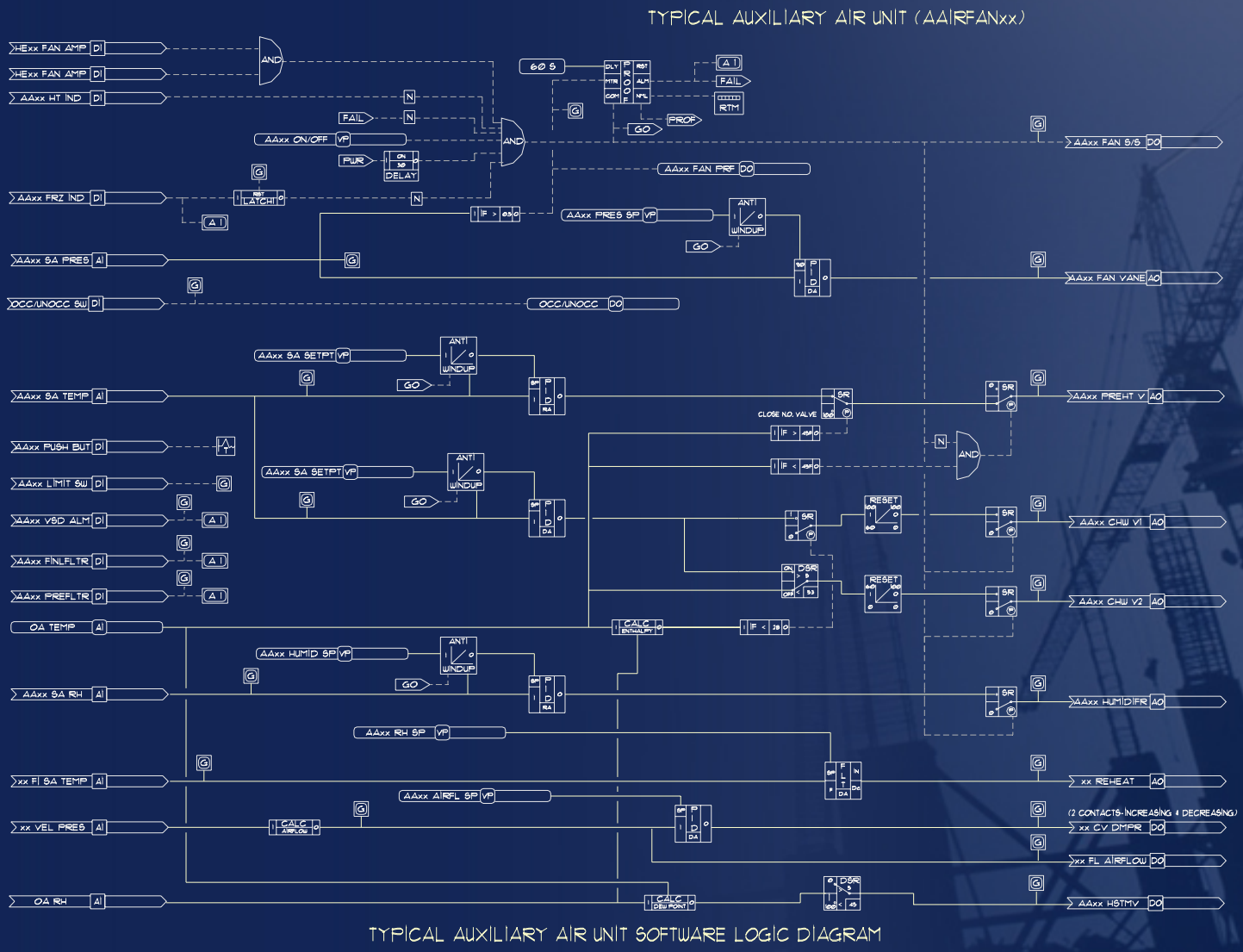
- Shop Drawing
- Sequence of Operation
  - Original
  - Control Engineer
  - Operator Version
  - Current Operation
- Points List



Logic Diagram (mixed air)



Control Logic Diagram



Practical Issues

- Resource Limitation
  - Education/Training Required
  - Experience Based Learning
- Numerous Proprietary DDC Systems
- Open Protocol Issues – new complication
- Other Design Issues
  - Specifications not specific (trend is for less detail)
    - Especially true relative to sequences
  - System Architectures are quite different
    - Many specifications do not cover this well

Master Planning of DDC Systems

- System Architecture
  - What is the size of the requirement?
  - Is there a requirement for remote communications?
  - What is already installed?
  - What are the growth plans?
  - What are the priorities?
- Controllers
  - What type of systems are to be controlled?
  - What are the requirements for each system?

Master Planning of DDC Systems

- Operator interfaces
- Equipment interfaces
- EMS interfaces
- Remote communication details
- Integration
- Backward compatibility

Master Planning of DDC Systems

- Personnel
  - Project Managers
  - Procurement Issues
  - Inheritor's
    - Level of Independence
    - Training

Owner's Input

- Be realistic
- Good controls projects just don't *happen*
- Consider developing a controls master plan
- Demand (and pay for) better (more prescriptive) controls designs
- Technical career track for control techs
- Develop control standards

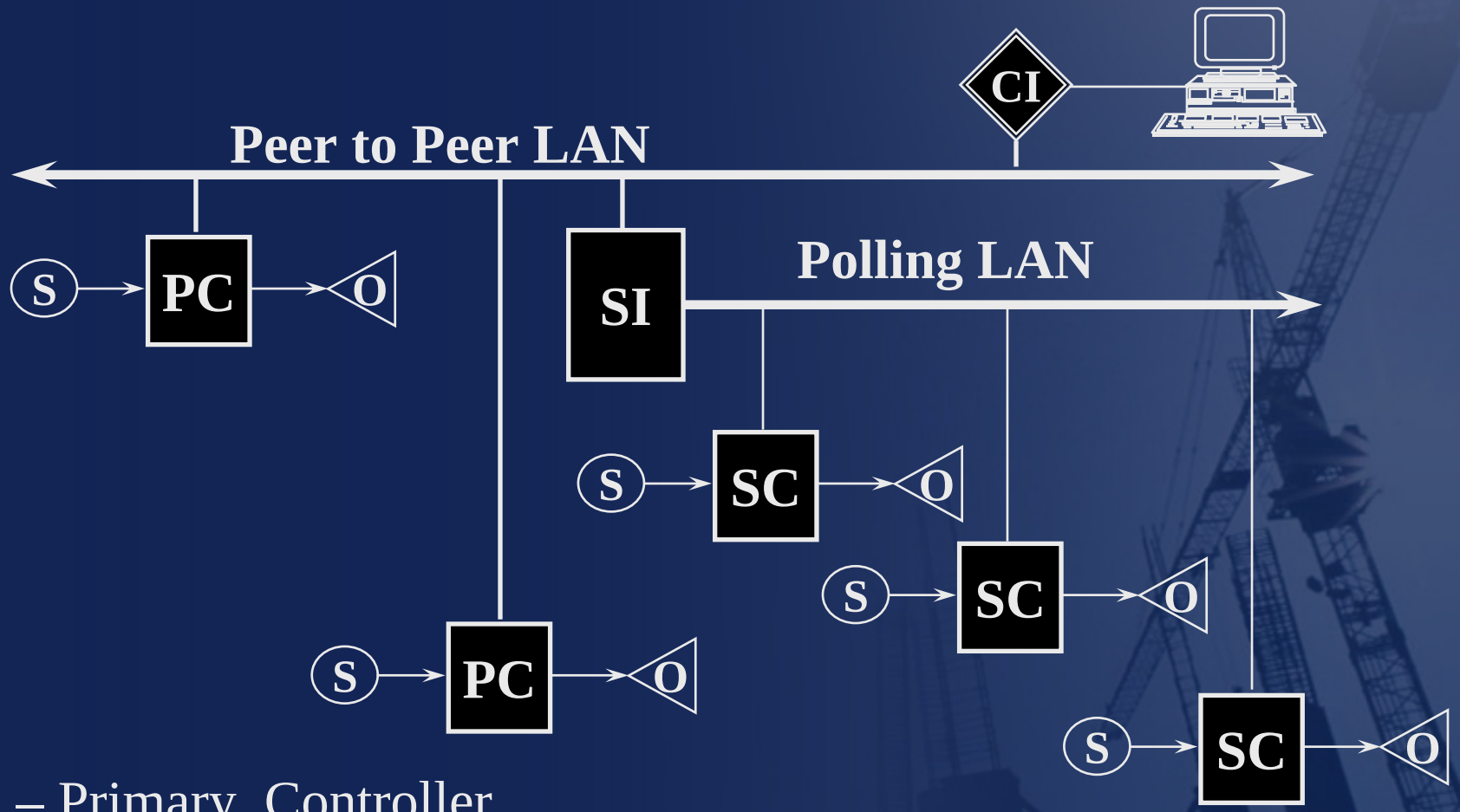
Criteria for Quality Specifications

- Prescriptive, Prescriptive, Prescriptive
  - The more well defined the specification, the easier (in theory) the commissioning
  - More functional testing, less refereeing
  - Enforcement
    - Design Phase
    - Submittals
    - Installation
- DEFINITIONS

Key Specification Issues

- System Architecture
- Control Hardware
- Interoperability/Integration
- Software
- System Setup

Typical DDC Architecture



PC – Primary Controller
SC – Secondary Controller
SI – Supervisory Interface
CI – Communication Interface

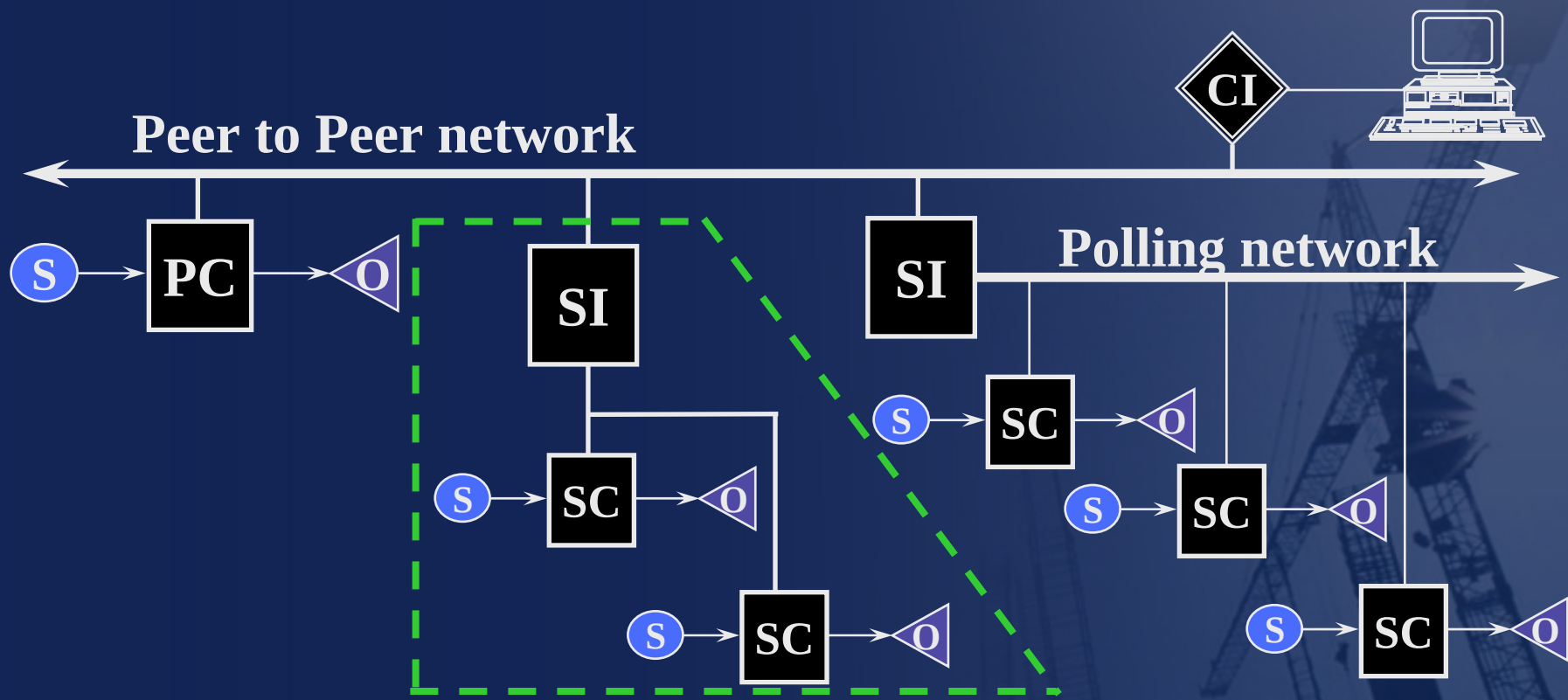
Key Specification Issues

- System Architecture
  - Robustness for project
    - Maximum Configurations
      - Especially on lower level networks
    - Peer to Peer versus Polling networks
    - Performance specify event criteria
      - Speed of alarm, command, status, graphic update, etc.
  - Capability of trending
    - Long term
    - Commissioning related
    - Impact on normal control functions

Key Specification Issues

- Control Hardware
  - Specify controllers for applications
  - Know potential bidders limitations
  - Design system around that reality
  - Consider 4 application categories
    - Peer to Peer only
    - Secondary controller on very limited polling network
    - Secondary controller on limited polling network
    - Terminal controller on limited polling network

Controllers Types



- PC – Primary Controllers
- SC – Secondary Controllers
- SI – Supervisory Interface

Key Specification Issues

- Interoperability, interface to existing systems and procurement limitations, criteria
  - Define terms
  - Make sure interoperability goals are realistic
  - Procurement issues
  - Define level of integration to existing
  - If interoperability is desired to a high degree, research capabilities of vendors further
  - If interoperability is being used as a procurement solution, reconsider
  - If all these interoperability criteria are met, review one more time

Key Specification Issues

- Software
  - Numerous software programs are needed for full functionality of DDC system
  - Vendors package these differently
  - Difficult to keep up
  - Specify vendor provide all software to perform common functions
    - Add hardware, edit database
    - Alarming, trending, reporting
    - Graphics, programming, upload/download, etc.

Key Specification Issues

- System Setup
  - Capabilities are one thing…
  - Setup is another
  - Details of the capabilities of trending, scheduling, alarming, password protection, graphic software are typically not discriminators
  - Focus on setup of these features
  - Easier to enforce if defined

Contractor/Vendor

- Stop overselling the benefits of open protocol
- Be realistic in meeting specifications
- Hire, train, reward and retain good control installers
- Develop more user-friendly products
- Develop better training and documentation tools
- Be realistic about schedules

Why Commissioning?

- Theoretically, shouldn't be necessary
  - If Controls were well designed…
  - Well installed
  - Well operated
  - Not sure Commissioning would be where it is
- How much is new work?
- Know Controls

Tool & Cx Requirement

- The DDC system is the most important tool available to the Commissioning provider.
  - The DDC system can provide the means for analysis, measurement and verification of commissioning activities.
  - Use in functional testing
  - “Readiness assessment”
- Is is also the most significant system to be commissioned.
  - It contains the sequence of operation that must be validated during commissioning.

Controls Design

- Commissioning Provider role/opportunity in controls design
- Clarify Sequences of Operation
  - Research Control Response Options
- Clarify other gray areas of specifications
  - Open protocol, interoperability requirements
  - Controller “robustness”
  - Performance criteria
  - Areas covered earlier

Issues for Cx

- How well is Cx defined in documents?
- What is the CA's Cx process?
- Certification
- Schedule Impacts
- Cost Impacts

Issues

- How well is Cx Defined
  - Nebulous (i.e. demonstrate all and everything to anyone's satisfaction) -
  - Prescriptive Good – Well defined, reasonable process
  - Prescriptive Bad – Overly complex, unrealistic
  - Everything in Between
  - Serious Cost Consequences

Issue's – What's the CA's Process

- Contractor Perspective to CA's Process
  - Estimating Impact
  - How involved are you in the process
  - Your subs?
  - How much paper?
  - Electronic/IT requirements
  - Who conducts FPT's
  - How "grey" are the requirements?

Issues – Certification

- 5 Certifications currently, more to come
  - Building Commissioning Association
  - NEBB
  - AEE
  - AABC
  - University of Wisconsin
  - ASHRAE
- Certify a Process
- One size does not fit all
- Varied approaches
- Owner's are becoming educated on Commissioning

Issues - Scheduling

- Should not be managed as a single task
  - HVAC Commissioning
  - Electrical Commissioning
- Needs to be broken down into multiple systems
- Controls Contractor manpower
  - To finish job
  - To demonstrate Cx (hands-off process)
  - To react to punch list and Cx deficiencies
- Consequences for missing early milestones
- Can’t have everything ready in parallel

Issues – Cost

- "It depends"……
  - Breadth of Project (HVAC, Controls, Electrical, Specialty…)
  - Project Overhead (Quantity of Meetings)
  - Start-up Attendance
  - Remote access capability
  - Efficiency of Project Management
  - Performance of Contractors
  - Allowance for contingencies & retesting
  - Depth of Cut (Sampling)
  - Scope of Report/Training/O&M Manual Review
  - Who conducts the detailed Functional Testing

Documentation, O&M, Persistence

- Sustainability of a well-commissioned project……..persistence
- Keeping entropy at bay
- People are key
- Systems Manuals
- Training
- Organizations need to identify key individuals to develop…….and retain

Significant Figures

- Flow = 754.24 cfm
- RA Enthalpy = 24.566 Btu/lb
- SP = 1.24 in
- RAH = 54.53%
- Control Response of these measurements
  - Two-position
  - Proportional
  - PI, PID
  - Floating

Principle 1

- The control system must first and foremost provide effective and reliable control, commensurate with the systems it is controlling.
  - Architecture, networking
  - Controllers
  - Stand alone capability
  - Redundancy

Principle 2

- The manufacturer and installer must be highly qualified with extensive experience and must be committed/bound to a thorough Commissioning of the system
  - Qualifications of installer equally important as the product
  - Committed to commissioning process
  - Research into the products and local capabilities of installer is necessary

Principle 3

- The control installation must be fully documented as consistently as practical with nothing required to fully operate and maintain the system withheld from the owner
  - Specifications must cover these issues
  - Details like graphics, point naming conventions, programming logic, network configuration, documentation
  - Owner has all software tools and owns their own sequences

Principle 4

- The system must be interoperable to the appropriate level
  - The control industry has oversold the procurement related benefits of interoperability and open protocol
  - Review reasons for interoperability and make sure they are well founded
  - Specify reality

Principle 5

- The sequence of operation must be clearly and completely communicated for each system.
  - Performance specifications – punting
  - Generic sequences are subject to interpretation
  - FPT's are challenging to write for gray sequences
  - Consider logic diagrams
  - Clarify sequences as soon as possible in the process

Summary

- Opportunities for improvement across the board
- Product is not the problem
- People are the limitation
- Two main goals
  - Getting a well performing building
  - Keeping it that way
- All the existing buildings……..