

FEB 2020 APPA INSTITUTE



Building Commissioning Elective #596

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San Diego, CA

AIA
Continuing
Education
Provider

Credit(s) earned on completion of this course will be reported to American Institute of Architects (AIA) Continuing Education Session (CES) for AIA members.

Certificates of Completion for both AIA members and non-AIA members are available upon request.

This course 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.

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Course Description

This course will provide an overview of a Building Automation System (BAS) utilized to monitor and control typical building HVAC systems. The course will cover typical architecture for web-based systems, industry terms, types of systems, system components, and communication protocols. Discussions will include the benefits and effective uses of BAS systems for facilities managers related to energy conservation and customer service as well as future trends in the industry.

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Learning Outcomes

Learning Objective 1:
Get an overview of Building Automation System (BAS) to monitor and control HVAC systems.

Learning Objective 2:
Learn about typical architecture for web-based systems.

Learning Objective 3:
Learn about industry terms, types of systems, components and communication protocols.

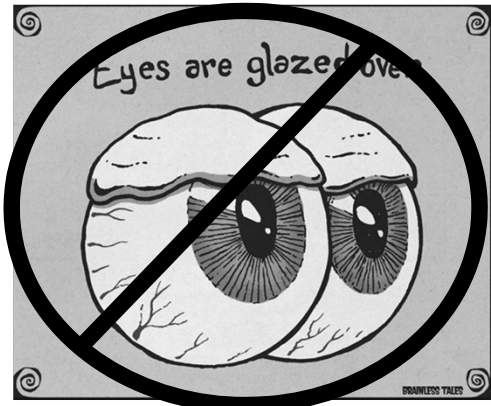
Learning Objective 4:
Learn about the benefits and effective use of BAS systems for facility managers.

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FIRST THINGS FIRST

1. Sign in
2. Fill out the evaluations
3. Candy "Hander Outer"
4. Time-Keeper
5. Flip Charter
6. Ask Questions

5



AGENDA

1. Putting it into Perspective
2. Building Commissioning "101"
 - What?
 - Why?
 - Who?
 - How?
 - \$'s?
 - Keys to Success
 - A Word about "FDD"
3. "Re" and "Retro" Commissioning
4. "Planning for Building Turnover
5. Q/A

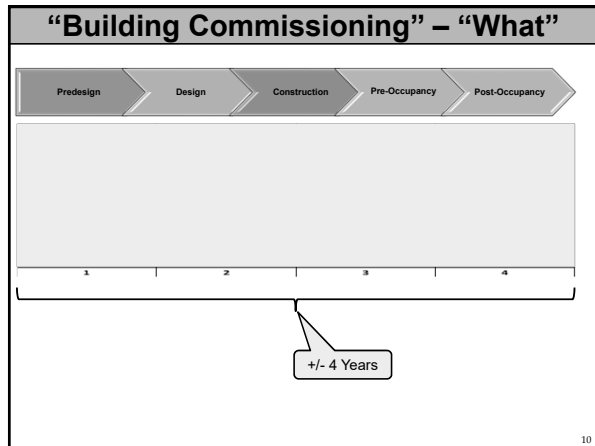
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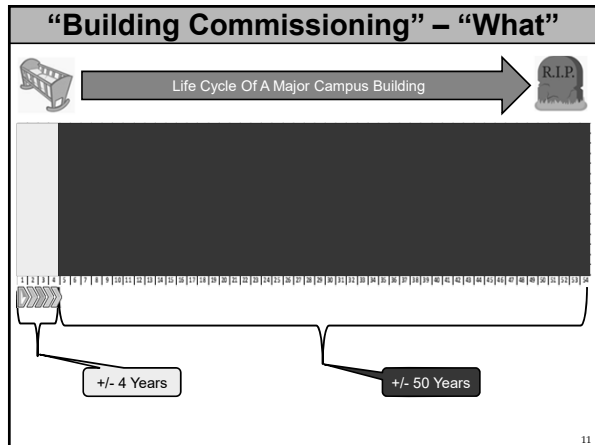


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PUTTING IT INTO PERSPECTIVE

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**BUILDING
COMMISSIONING
-
WHAT?**

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Building Commissioning – “What”



It is a quality assurance process to determine we got what we paid for!

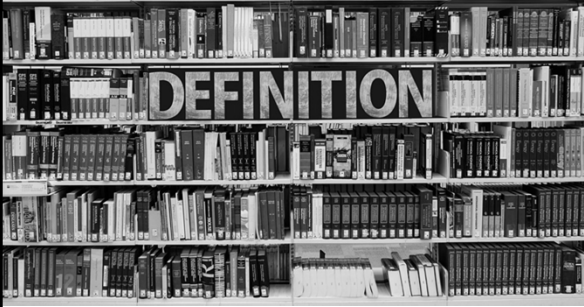
A building that:

- Meets the requirements of the Owner
- Has been tested & verified
- Is comfortable
- Is reliable
- Economical to operate and maintain
- Is efficient
- Safe

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“Building Commissioning” – What

Two definitions...



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Building Commissioning – “What”

Definition #1

A quality-focused process for enhancing the delivery of a project. The process focuses upon verifying and documenting that all the commissioned systems and assemblies are:

- Planned
- Designed
- Installed
- Tested
- Operated and maintained

to meet the Owner's Project Requirements (more to come on the OPR).

Reference #16: The Building Commissioning Handbook (BPA/Building Commissioning Association)

Building Commissioning – “What”

Definition #2

A systematic process of assuring by verification and documentation, from the Design Phase to a minimum of one year after the construction, that all facility systems perform interactively in accordance with:

- The design documentation and intent,
- The Owner’s operational needs, including preparation of operations personnel.

Reference #16: The Building Commissioning Handbook (APPA/Building Commissioning Association)

THE “OPR”

A written document that details the requirements of a project and the expectations of how it will be used and operated including:

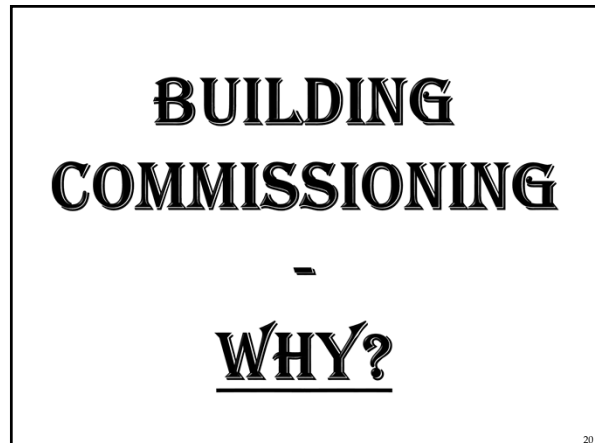
- Project goals,
- Measurable performance criteria,
- Cost considerations,
- Benchmarks,
- Success criteria,
- Supporting information.

THE “BOD”

The BOD (Basis of Design) definition per ASHRAE Guideline 0-2005:

A document that records the concepts, calculations, decisions, and product selections used to meet the OPR and to satisfy regulatory requirements, standards and guidelines. Also includes descriptions and lists of individual items that support the design process.

Building Commissioning – “What”					
Systems and Equipment Typically Included					
HVAC	Plumbing	Electrical	Fire Protection	Building Envelope	Other Systems
Air Handling Units	Potable Water (Hot/ Cold)	Transformers	Fire Pumps	Doors	Building Automation System
Roof Top Units	High Purity Water	Switchgear	Sprinkler Systems	Windows	Piping
Fan Coil Units	Sanitary Sewer	Emergency Power Systems	Kitchen Hood Suppression Systems	Exterior Walls (above & below grade)	Laboratory Exhaust System
VAV Boxes	Storm Water	UPS	IT Room Systems	Roof	Card Access
Chillers	Water Treatment	Breaker Panels	Fire Alarm System	Foundations	CCTV, Voice, Data
Boilers	Restroom Fixtures	Motor Control Centers			IT & Communication Infrastructure
Pumps		Lighting			Elevators
Building Controls		Renewable Energy			




Building Commissioning – “Why”
<ol style="list-style-type: none"> 1. The building meets the requirements of the Owner. 2. The building systems and equipment on the design documents have been installed and tested and they WORK! 3. The building <u>control</u> systems and components have been installed, they work, and the programming works as designed. 4. The building occupants will be: <ul style="list-style-type: none"> ➤ More comfortable ➤ More secure/safer ➤ More satisfied.

THE “SYSTEMS MANUAL”

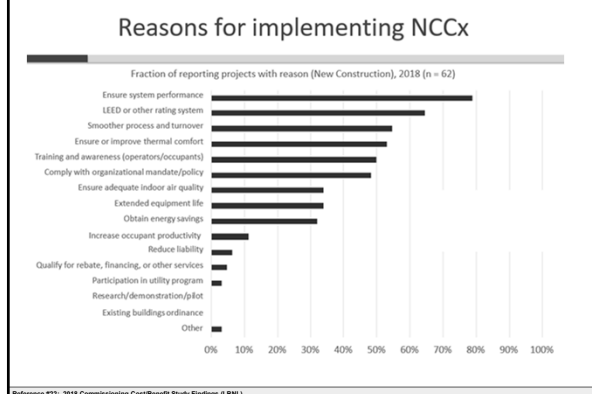
The “Systems Manual” is the main repository of building information, to be used by facilities and operations team members, which is needed to understand, operate, and maintain the building.

It will typically include information like ...

Building Commissioning – “Why”		
Executive Summary	OPR	BOD
System Narratives	General Operating Procedures	Recommended Operational Record-keeping Procedures
Maintenance Procedures, Schedules, etc.	Operations and Maintenance Manuals	Testing and Balancing Reports
Specifications	Approved Submittals	Warranties
Issues/Resolution Logs	Commissioning Plans	

Building Commissioning – “Why”		
Executive Summary		BOD
System Narratives	ASHRAE Guideline 1.4P Advisory Public Review Draft The Systems Manual for Facilities	Recommended Operational Record-keeping Procedures
Maintenance Procedures, Schedules, etc.	First Public Review (May 2015) Guidance Draft for Full Review	Testing and Balancing Reports
Specifications		Warranties
Issues/Resolution Logs		

Building Commissioning – “Why”



BUILDING COMMISSIONING - WHO?

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Building Commissioning – “Who”

		Predesign	Design	Construction	Occupancy
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Building Commissioning – “Who”					
		Predesign	Design	Construction	Occupancy
Owner	Project/Construction Managers	X	X	X	
	Asset Manager	X	X		X
	Building Operations	X	X	X	X
	Energy Manager	X	X	X	X
	Occupant Rep	X	X	X	X
<p>Reference #16: The Building Commissioning Handbook (APPABuilding Commissioning Association)</p>					

Building Commissioning – “Who”					
<p>1. QUALITY OF COMMISSIONING SERVICES</p> <p>Downside Conclusion: Owners are often confused about the role of Providers, and can be frustrated by the quality of work they expect commissioning to provide, while Providers are often hampered by Owners’ lack of participation or commitment to the commissioning process.</p> <p>Reference #21: What Owners & Providers Should Know About Building Commissioning & Each (APPA’s Facilities Manager Magazine – Jan/Feb 2015)</p>					

Building Commissioning – “Who”					
		Predesign	Design	Construction	Occupancy
Owner	Project/Construction Managers	X	X	X	
	Asset Manager	X	X		X
	Building Operations	X	X	X	X
	Energy Manager	X	X	X	X
	Occupant Rep	X	X	X	X
Design Team	Architect PM	X	X	X	X
	Mech, Elect, Plumbing, Etc.	X	X	X	X
<p>Reference #16: The Building Commissioning Handbook (APPABuilding Commissioning Association)</p>					

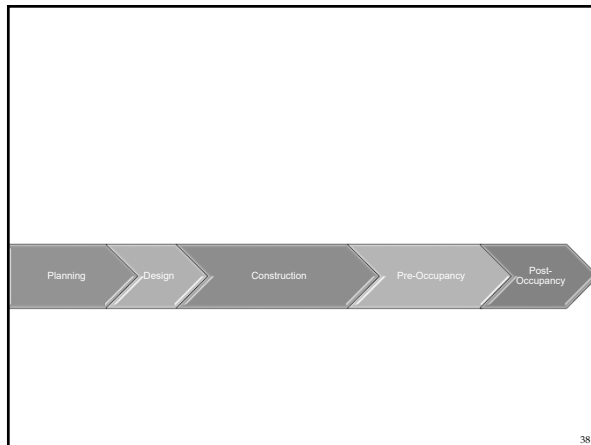
Building Commissioning – “Who”					
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Owner	Project/Construction Managers	X	X	X	
	Asset Manager	X	X		X
	Building Operations	X	X	X	X
	Energy Manager	X	X	X	X
	Occupant Rep	X	X	X	X
Design Team	Architect PM	X	X	X	X
	Mech, Elect, Plumbing, Etc.	X	X	X	X
Contractor	General Contractor, PM, Cx Coordinator, Superintendent			X	X
	Mech, Elect, Controls, Plumb, Fire Protection, etc.			X	X
Reference #16: The Building Commissioning Handbook (APPA/Building Commissioning Association)					

Building Commissioning – “Who”					
		Predesign	Design	Construction	Occupancy
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	Energy Manager	X	X	X	X
	Occupant Rep	X	X	X	X
Design Team	Architect PM	X	X	X	X
	Mech, Elect, Plumbing, Etc.	X	X	X	X
Contractor	General Contractor, PM, Cx Coordinator, Superintendent			X	X
	Mech, Elect, Controls, Plumb, Fire Protection, etc.			X	X
Cx Provider		X	X	X	X
Reference #16: The Building Commissioning Handbook (APPA/Building Commissioning Association)					

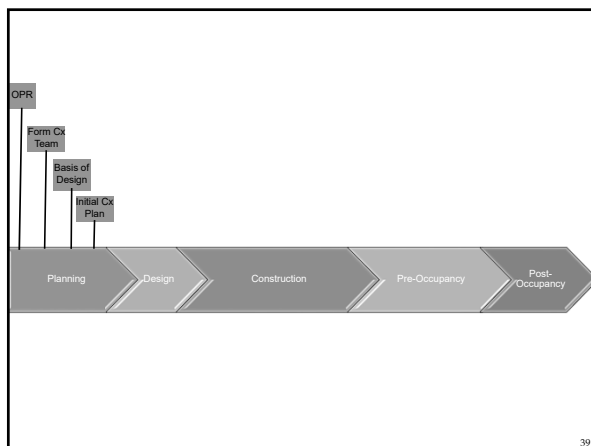
Building Commissioning – “Who”					
		Predesign	Design	Construction	Occupancy
Owner	Project/Construction Managers	X	X	X	
	Asset Manager	X	X		X
	Building Operations	X	X	X	X
	Energy Manager	X	X	X	X
	Occupant Rep	X	X	X	X
Design Team	Architect PM	X	X	X	X
	Mech, Elect, Plumbing, Etc.	X	X	X	X
Contractor	General Contractor, PM, Cx Coordinator, Superintendent			X	X
	Mech, Elect, Controls, Plumb, Fire Protection, etc.			X	X
Cx Provider		X	X	X	X
Suppliers				X	X
Reference #16: The Building Commissioning Handbook (APPA/Building Commissioning Association)					

BUILDING COMMISSIONING - HOW?

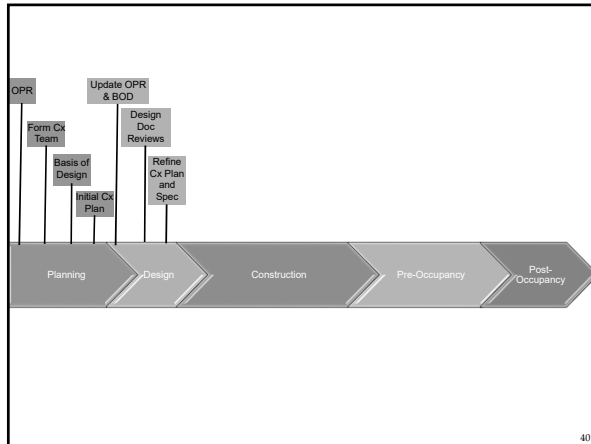
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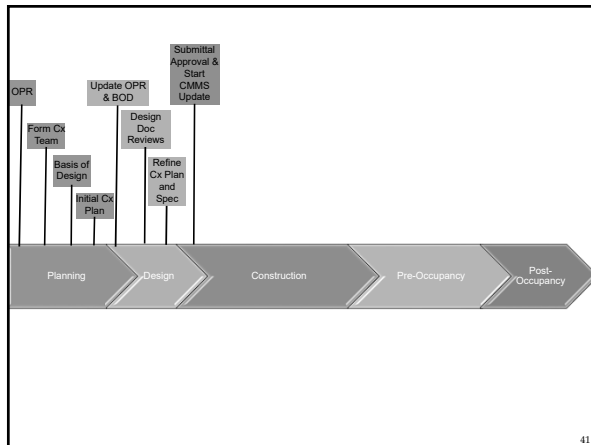


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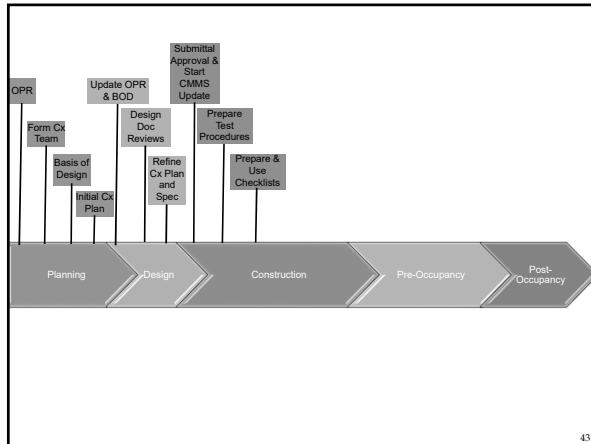


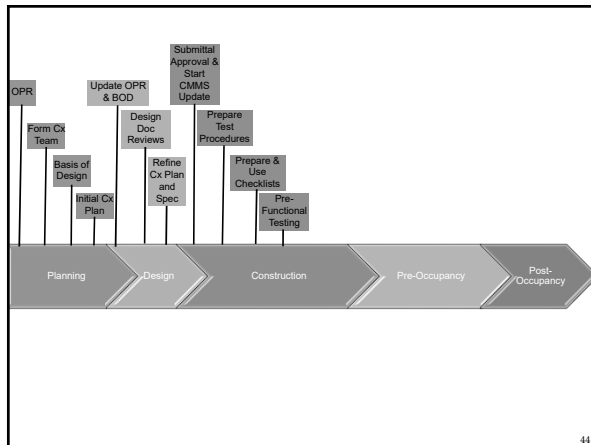
“PREPARE FOR CMMS”

CAUTION!

Do not overlook the importance of having the asset management program in place **BEFORE** the day the building is turned over.

Start planning NOW!



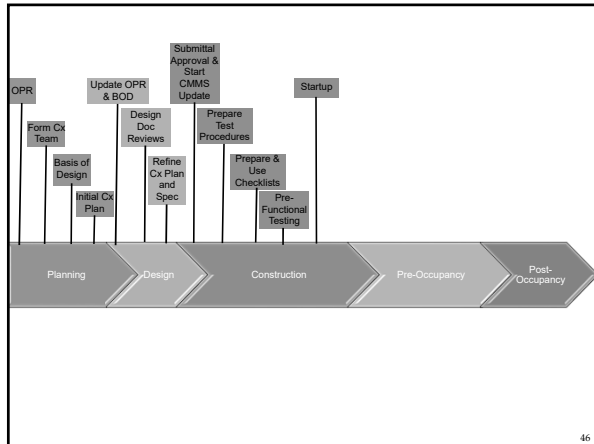


"PRE-FUNCTIONAL TESTING"

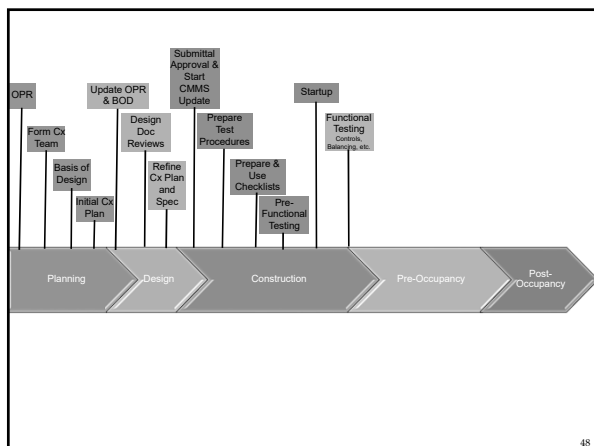
Issues are identified and corrected during equipment installation. Catching them at this phase , the issues are:

- Resolved faster;
- Cheaper to resolve;

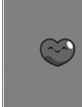
compared to correcting them after construction is complete. The focus is on the "components" not the operating systems.







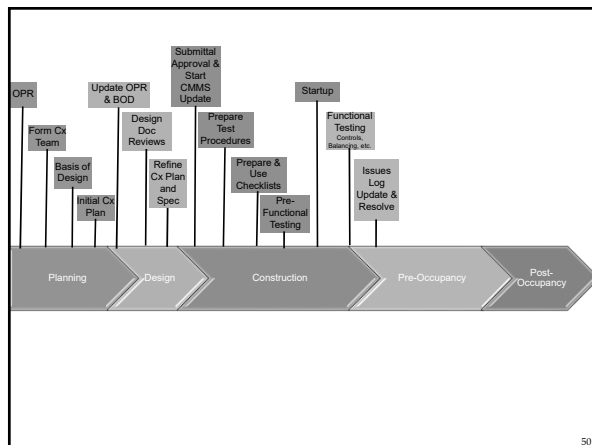
"FUNCTIONAL TESTING"



The

Of The Commissioning Process!

Functional testing is the "dynamic" testing of a functioning "system" rather than only the components.

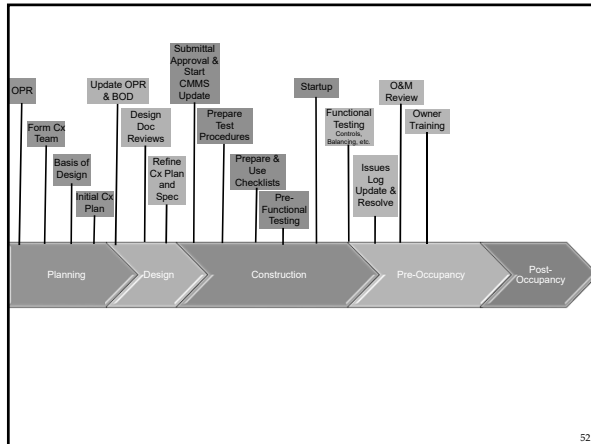


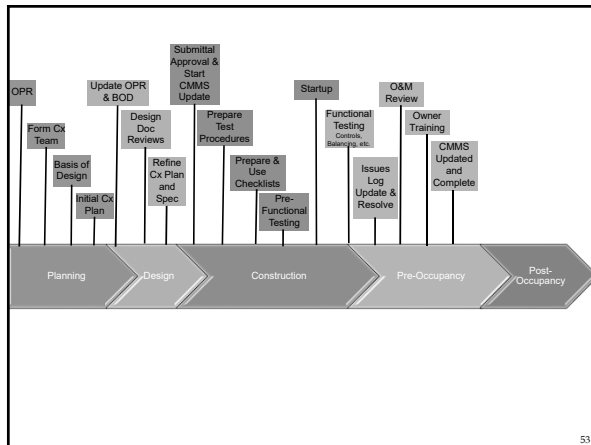
"ISSUES LOG"

A document maintained by the CxP used to identify and track describes system deficiencies found and what action was taken by who to correct them.

IMPORTANT NOTICE: This sample document is provided for informational purposes only. CCC is not rendering advice concerning any commissioning project or practices. This document is neither approved nor intended to serve as a standard form. The use of these documents should comply with qualified advisors with respect to its commissioning and other documentation.

HVAC QA ISSUES LOG										DATE: 12/24/04
Owner's DDC System Installation Project										
ITEM	ID	NOTIFICATION	ISSUES		ACTION REQUIRED	PARTY RESPONSIBLE	DATE REQ.	CHECKED	DATE	
NO.	DATE	DATE	LOG					BY	DATE	
S	1/12/04	1/14/04	General							
S	1/21/04		Owner's first naming convention has not been followed.							
S	3/10/04		QA reviewed Cont.'s handout - more still needs to be done to follow point naming convention - offered to mark it up.							
S	4/14/04		QA to review point names on graphics and provide comment to Cont. once Cont. provides document.							
S	6/17/04		QA documented point name corrections on Cont.'s spreadsheet.							
S	6/22/04		QA edited Cont.'s point name spreadsheet, adding call points for Main Building.							
S	8/13/04		QA to provide the remainder of corrected hard and soft point names. Update provided 7/27/04 based on feedback from Cont.							
S	8/13/04		Point name corrections are still to be completed. QA provided access to program and has begun making revisions to point names and trend names in program per 7/27/04 spreadsheet.							
S	9/1/04		After named two point names are still to be revised and zone controller.							
S	9/1/04		Cachuffeas@% trend view added in FDB. See 9/2/04 spreadsheet.		Cont.	9/1/04	QA	10/5/04		
S	9/1/04		Change set location is, isolation area needs to be corrected out.							
S	9/1/04		QA provided marked up points and description of zone blocks and requirements.							
S	9/2/04		QA provided update to Cont.'s programmer.							

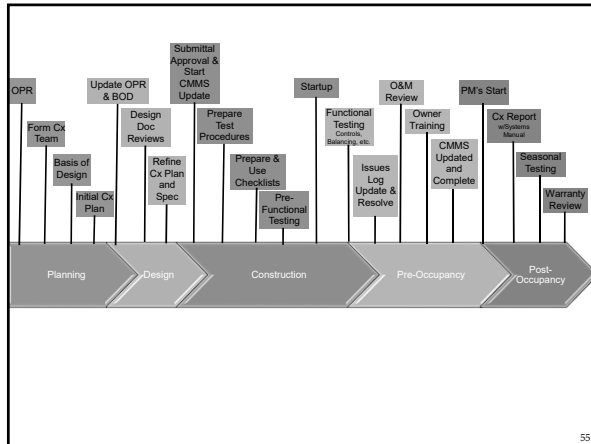




"PREPARE FOR CMMS"

GOAL!

Have the asset management program 100% complete at building turnover so preventive maintenance work orders start coming out immediately and ALL work requests associated with this new building will be logged on DAY 1!



Building Commissioning – “How”

Bldg Envelope Commissioning (BECx)

1. Key standards for BECx:

ASTM E2813-18	Std Practice for Building Enclosure Commissioning
ASTM E2947-16a	Standard Guide for Building Enclosure Commissioning
NIBS Guideline 3-2012	Building Enclosure Commissioning Process BECx
ASTM and AAMA (American Architectural Manufacturers Association) Testing Stds	

The image shows the cover of the NIBS Guideline 3-2012, titled "Building Enclosure Commissioning: The Guideline for Use with ASHRAE Guideline 180". The cover features the NIBS logo, the title, and a photograph of a modern building's glass facade. The text on the cover includes "Standard Practice for Building Enclosure Commissioning" and "The Guideline for Use with ASHRAE Guideline 180".

Building Commissioning – “How”

Bldg Envelope Commissioning (BECx)

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ASTM E2947-16a	Standard Guide for Building Enclosure Commissioning
NIBS Guideline 2-2012	Building Enclosure Commissioning Process BECx
ASTM and AAMA (American Architectural Manufacturers Association) Testing Stds	

2. Integrated into the design process and visually observe the work DURING the construction.

3. Testing Considerations:

- Preconstruction laboratory mockups
- Field-constructed mockups
- Field testing of assemblies at key intervals
- Post-occupancy evaluation

Building Commissioning – “How”

Bldg Envelope Commissioning (BECx)

4. Key elements of the enclosure include:


Roof/Ceilings	Exterior Above-Grade Walls	Exterior Below-Grade Walls and Foundations
Fenestration (windows, curtainwalls, doors, skylights, louvers)	Exposed Floors	Slab-on-Grade
Interior Partitions	Exterior Cladding	Plaza Decks/Gardens over Occupied Spaces
Fall Protection Systems	Expansion Joints	

5. Why BECx?

Mitigate Contractual Risk	Prevent Indoor Air Quality Problems	Optimize Energy Performance
Enhance Security & Resiliency	Improve Operations & Maintenance	Meet Regulatory and Program Requirements

**BUILDING
COMMISSIONING
-
\$'S?**

Building Commissioning – “\$’s”




1. Costs are highly dependent on the nature of the building:
 - Size
 - Function
 - Complexity
2. “Soft,” non-CxP, costs are hard to quantify:
 - Owner
 - Design team
 - Contactors
3. Scope of the commissioning process will have a major impact.

Building Commissioning – “\$’s”	
% of Total Construction Cost	Source
~ 1%	Reference #20: The Building Commissioning Handbook (APPA/Building Commissioning Association)
~0.25%	Reference #27: 2018 Commissioning Cost/Benefit Study Findings (Lawrence Berkeley National Lab)
0.5% - 1.5%	Reference #1: United State General Services Administration
0.3% - 1.1%	Reference #4: California Commissioning Collaborative

Building Commissioning – “\$’s”

1. NCCx Cost
 - a. \$0.82 per sq.ft., typical range \$0.40-\$1.35, compared with median \$1.16 in 2009 study
 - b. 0.25% of overall construction cost, compared with median 0.57% in 2009 study
 - c. Difference in 2018 and 2009 sample composition makes it difficult to conclude true shift in market costs for NCCx, though there is anecdotal evidence costs have reduced
 - d. Larger projects tend to have lower cost per sq.ft., and market segment also has an impact on cost
2. Savings and Payback: insufficient data for updating 2009 results
 - a. Survey responses report that only 6% of projects include scope item to evaluate energy savings
3. NCCx Scope of Work
 - a. For projects in 2018 dataset, >90% of Cx Providers were involved at the design review stage
 - b. Engagement of Cx provider for post-occupancy services is still low
4. Non-Energy Benefits
 - a. 10 high-value non-energy benefits reported on over two thirds of projects, impacting construction project first costs and ongoing benefits



Reference #27: 2018 Commissioning Cost/Benefit Study Findings (LBNL)

Building Commissioning – “\$’s”

GSA

U.S. General Services Administration

Commissioning Agent Costs

Total building commissioning costs for commissioning agent services can range from 0.5% to 1.5% of total construction costs (according to U.S. Department of Energy’s Rebuild America Program, written by the Portland Energy Conservation, Inc. (PECI)). The National Association of State Facilities Administrators (NASFA) recommends budgeting 1.25 to 2.25% of the total construction costs for total building commissioning agent services. GSA’s commissioning practice is expected to cost approximately 0.5% of the construction budget for federal buildings and border stations. More complex projects such as courthouses could run 0.8 - 1% of the construction budget, and even more complex facilities such as laboratories can exceed 1%. Factors influencing commissioning costs include facility type, phasing 24/7 operations, the depth and breadth of commissioning services, the level of commissioning desired, and the systems and assemblies chosen to be commissioned.

Reference #1: US GSA Building Commissioning Guide

Building Commissioning – “\$’s”

GSA

U.S. General Services Administration

Industry sources indicate that on average the operating costs of a commissioned building range from 8% to 20% below that of a non-commissioned building. Certain available commissioning implementation tools, such as cost shared USDOE Energy Contractors, may even result in a negative capital investment cost. GSA’s goal in adopting building commissioning is:

Reference #1: US GSA Building Commissioning Guide

Building Commissioning – “\$’s”

California Commissioning Guide:
New Buildings

Cost Savings: The Benefit of an Early Start

When commissioning starts during the design phase of a new construction project, the result is significant cost savings. Errors caught on paper, rather than on the job site, are much less expensive to fix. Because commissioning identifies and helps resolve potential problems, it reduces costly change orders and contractor call-backs. This in turn helps keep the project on schedule and on budget.

Savings from Commissioning¹

Commissioning can produce significant cost savings in a new building project. Cost savings are usually presented as a range, since actual savings vary depending on the building type, its location, and the scope of the commissioning process. A comprehensive study found the following cost savings ranges:

Description	Range of Values
Value of Energy Savings	\$0.02 - \$0.19/sqft
Value of Non-Energy Savings	\$0.23 - \$6.96/sqft

Reference #4: California Commissioning Guide

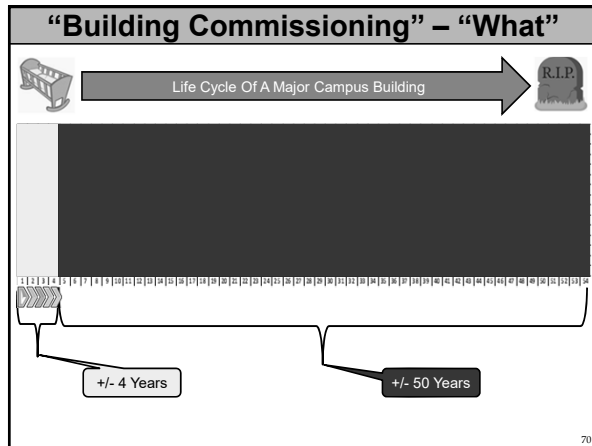
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Building Commissioning – “Keys”

1. Make the decision early.
2. Create the OPR WITH the CxP.
3. Hire the CxA (Commissioning Provider) based on qualifications.
4. The Owner needs to be engaged and supports the CxP.

**Plug key members
of the operations
and maintenance
team in EARLY &
OFTEN!**



- ### Building Commissioning – “Keys”
1. Make the decision early.
 2. Create the OPR WITH the CxP.
 3. Hire the CxP (Commissioning Provider) based on qualifications.
 4. The Owner needs to be engaged and supports the CxP.
 5. Integrated into the design process and visually observe the work DURING the construction.
 6. Contractors “feet are held to the fire.”
 - Honest
 - Proper planning & coordination with others
 - Schedules are met (major impact on the CxP)

- ### Building Commissioning – “Keys”
7. Plan for effective operator training.
 8. Make sure all members of the project team understands and appreciates the roles and responsibility of each team member.
 9. And, finally

**Plug key members
of the operations
and maintenance
team in EARLY &
OFTEN!**

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**A WORD ABOUT
“FDD”**

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Building Commissioning – “FDD”

“FDD” Stands For:

“F” is for “FAULT”



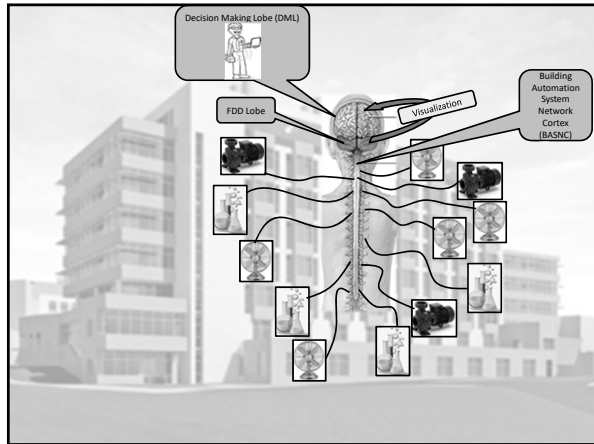
“D” is for “DETECTION”



“D” is for “DIAGNOSTICS”



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Building Commissioning – “FDD”

A “significant” DEVIATION from the ...

EXPECTED value of a parameter ...

over particular period of TIME.

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**“RE” AND
“RETRO”
COMMISSIONING**

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“Re” and “Retro” Commissioning

Retrocommissioning

1. “Retrocommissioning” is the application of the commissioning process to existing buildings.
2. RCx is a process that seeks to improve how building equipment and systems function together.
3. RCx often resolve problems that occurred during design or construction, or address problems that have developed throughout the building's life.
4. RCx improves a building's operations and maintenance (O&M) procedures to enhance overall building performance.

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“Re” and “Retro” Commissioning

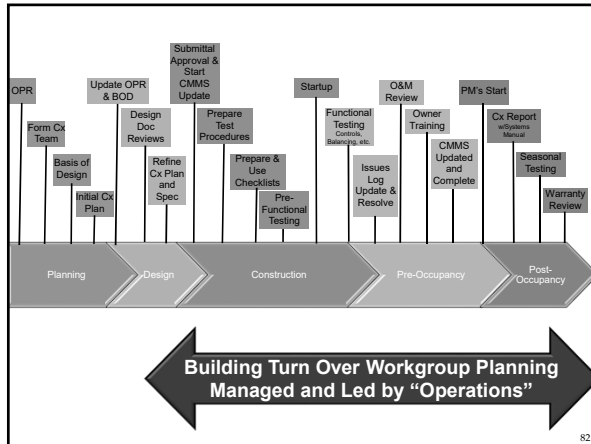
Recommissioning

1. “Recommissioning” is another type of commissioning that occurs when a building that has already been commissioned undergoes another commissioning process.
2. The decision to recommission may be triggered by a change in building use or ownership, the onset of operational problems, or some other need.

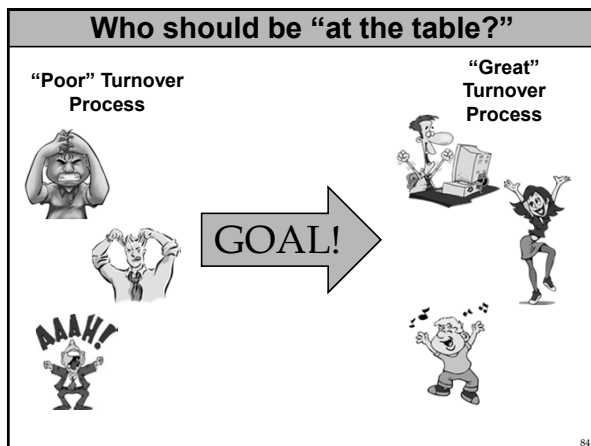
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PREPARING FOR BUILDING TURNOVER

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Who should be "at the table?"		
Building Operations & Maintenance	Custodial	Construction Manager
Fire Protection & Fire Alarm	Building Controls	Key and Access Services
Landscape Services	Environmental Compliance	Environmental Health & Safety
Work Control	Utilities Distribution	Energy Management
IT Services	The "Customer"	TOW Coordinator
FF&E Coordinator	Project Manager	Space Management



Quote #1

"Failure to prepare operationally, prior to moving into a space designed for a set workflow, can upset the financial parameters on which the project was approved. It can also create a negative perception of the project delivery team's performance even if all the building systems are functioning properly."

Patrick Duke
Health Facilities Management Magazine
August 2015

Potential Discussion Items

1. **Opening Statement:**
 - ✓ Becomes less important as individuals know their role. We want conversation and communication!
2. **TOW Membership:**
 - ✓ Confirm we have the right stakeholders with the right information participating at the right time so we can make better decisions!
3. **FM Personnel:**
 - ✓ Who (by name) is going be involved in the building?
 - ✓ What is their role and responsibilities and when do they need to get involved?
 - ✓ When will the new hires be on-board?

Potential Discussion Items

4. **Project Walk-Throughs (PWTs):**
 - ✓ When, who, documented issues, close the loop.
 - ✓ Expectations of PWT participants
 - ✓ "TOW-Initiated Issues Log" vs. "Project Issues Log"
5. **Custodial/Waste/Recycling:**
 - ✓ Containers? Will they fit?
 - ✓ Maintenance of flooring and other finishes
6. **Operations/Maintenance Manuals:**
 - ✓ Who is going to review the manuals by when!
7. **Asset Management Program:**
 - ✓ Physical asset inventory \$ & tagging
 - ✓ Preventive maintenance program development
 - ✓ Who is going to what by when?
 - ✓ Internal or external resources?

Potential Discussion Items

8. Training:

- ✓ What systems will which members of the FM team be trained on?
- ✓ Syllabus review and confirm instructor credentials.
- ✓ Who (by name) will attend which sessions.
- ✓ Training of occupants

9. Tools & Equipment Purchases:

- ✓ Funding
- ✓ Lead time

10. Warranty Management:

- ✓ Documentation
- ✓ Information flow

11. Attic Stock Management:

- ✓ What do we want?
- ✓ Where are we going to put it?

Potential Discussion Items

12. Safety:

- ✓ Arc flash
- ✓ Lockout/tag-out
- ✓ Eyewash stations/safety shower
- ✓ Confined spaces
- ✓ Safety data sheets

13. Others:

- ✓ Access control
- ✓ Building automation system
- ✓ Fire protection
- ✓ IT

Best Practices

1. Start meeting with the team early – no later than 12 to 18 months prior to Substantial Completion.
2. Get the “customers” involved early.
3. Emphasize the team (avoid “we/they”).
4. Continue to meet post-Substantial Completion.
5. Send out agendas
6. Distribute meeting notes within 48 hours.
7. Do not turn it into a “project meeting”.
8. Focus on:
 - What
 - By When
 - By Who

COMMISSIONING RESOURCES

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Commissioning Resources				
Ref #	RESOURCE	SOURCE	URL	
1	The Building Commissioning Guide	U.S. General Services Administration	https://www.gsa.gov/cdnstatic/BCG_3_30_Final_R2-v221_025R02-046.pdf	Free
2	New Construction Building Commissioning Best Practices	Building Commissioning Association	https://www.bcaa.org/wp-content/uploads/2018/11/BCA-New-Const-Best-Practices-2018-09-14-12-0.pdf	Free
3	Best Practices in Commissioning Existing Buildings	Building Commissioning Association	https://www.bcaa.org/wp-content/uploads/BCA-Best-Practices-Commissioning-Existing-Construction.pdf	Free
4	California Commissioning Guide: New Buildings	California Commissioning Collaborative	https://www.cccx.org/resources/documents/CA_Commissioning_Guide-New.pdf	Free
5	Strategic Guide to Commissioning	ASHRAE	https://www.ashrae.org/Files/2016/04/Technical%20Resources/Book%20on%20Commissioning-ASHRAE-Book%20on%20Commissioning-2016-04-14.pdf	Free
6	Building Commissioning	National Institute of Building Sciences	https://www.nibbs.org/building-commissioning	Free
7	Guide to Building Commissioning	U.S. Department of Energy	https://www.eere.energy.gov/buildings/publications/pdfs/tbgs/tbgs.pdf	Free
8	Commissioning Process - A Step-by-Step Guide	Burn and McDonnell	https://www.burnandmcdonnell.com/media/files/insightnews/insights/technical/the-commissioning-process-a-step-by-step-guide/whitapapercommissioning02051.pdf	Free
9	Building Commissioning for New Buildings	Washington State University	http://www.energy.wsu.edu/Documents/BuildingCommissioning.pdf	Free
10	New DOE Research Strengthens Business Case for Bldg Commissioning	U.S. Department of Energy	https://www.energy.gov/news/bldg/articles/new-doe-research-strengthens-business-case-building-commissioning	Free
11	Owner's Role and Responsibilities in the Commissioning Process	National Institute of Building Sciences	https://www.nibbs.org/building-commissioning/owners-role-and-responsibilities-commissioning-process	Free
12	Building Commissioning - Key To Quality Assurance	U.S. Department of Energy	https://www.michigan.gov/documents/CIS_EO_commissioningguide_75698_7.pdf	Free
13	Generic Commissioning Plan	University of Michigan	https://umiac.umich.edu/wp-content/uploads/2013/08/Sample-Cx-Plan-Minute.pdf	Free
14	Commissioning Deliverables	Facility Performance Associates	https://www.bcaa.org/ncbc/2010/documents/presentations/ncbc-2010-cx-deliverables-lettlor.pdf	Free
15	Owner's Project Requirements	University of Florida	http://www.facilities.ufl.edu/grdocs/00001173.pdf	Free

Commissioning Resources				
Ref #	RESOURCE	SOURCE	URL	
16	The Building Commissioning Handbook	APPA/Building Commissioning Association	https://www1.appa.org/bookstore/store_browse.cfm?categoryid=4	\$
17	Enclosure Commissioning NIBS GL03 & ASTM E2189-12	PPT by WDP (Whitlock, Dalrymple, Poston & Associates)	https://www.bcaa.org/ncbc/2017/documents/presentations/10-ncbc-2012-bldg-enclosure-nibbs03.pdf	Free
18	ASTM E2813-18 (Std Practice for Bldg Enclosure Commissioning)	ASTM	https://www.astm.org/Standards/E2813.htm	\$
19	NIBS Guideline 3-2012 (Bldg Enclosure Commissioning Process BECx)	National Institute of Building Sciences	https://www.nibbs.org/Files/NIBS/nibs_g3.pdf	Free
20	ASTM E2847-16a (Std Guide for Building Enclosure Commissioning)	ASTM	https://www.astm.org/Standards/E2847.htm	\$
21	What Owners & Providers Should Know About Building Commissioning & Each Other	APPA's Facilities Manager Magazine (Jan/Feb 2015)	https://www1.appa.org/FacilitiesManager/index.cfm?itemnumber=2703	Free
22	2018 Commissioning Cost/Benefit Study Findings	Lawrence Berkeley National Laboratory	https://drive.google.com/file/d/1d7jpd_1P4HtYqgATAmQnXkXP6hPmHf/view	Free
23	Guideline 0-2019--The Commissioning Process	ASHRAE	https://www.techstreet.com/ashrae/standards/guideline-0-2019-the-commissioning-process/product_id=2076310	\$
24	ASHRAE 202-2018	ASHRAE	https://www.techstreet.com/ashrae/standards/ashrae-202-2018/product_id=2095517	\$
25	Guideline 1.1-2007 HVAC&R Technical Requirements for the Commissioning Process	ASHRAE	https://www.techstreet.com/ashrae/standards/guideline-1.1-2007-hvac-technical-requirements-for-the-commissioning-process/product_id=177396	\$
26	Commissioning Process (online slides)	Applied Energy Solutions	https://www.slideshare.net/d-mackay/the-commissioning-process	Free
27	Building Commissioning 101	Building Commissioning Association	http://www.bcaa.org/wp-content/uploads/2014/09/7Twenty-Minute-Owner-Presentation-Rev-7-Short-Version.pdf	Free
30	Building Systems Commissioning for Project Managers	Facility Commissioning Group	http://www.facmfgroup.com/wp-content/uploads/2014/09/FMG-May-June-Present_2012031.pdf	Free
31	Commissioning the Building 9 (Chapter 9)	U.S. DOE/Los Alamos National Lab	https://www.energy.gov/sites/prod/files/2013/12/15/sustainable_guide_ch9.pdf	Free

This concludes The American
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Systems Course.

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Q & A WRAP-UP

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