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Washington Headquarters Services
Engineering & Technical Support Directorate

Quantifying Costs & Benefits: A 6 Year Check-up on Commissioning at the Pentagon

National Conference on Building Commissioning

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Introduction

Presentation Outline

- Summary of Pentagon Renovation & Commissioning
- Financial Costs & Benefits Approach
- Pentagon Metrics
- Commissioning Process Lessons Learned

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Introduction

Summary of Pentagon Renovation & Commissioning

- 1998 Commissioning Start
- Design-Bid-Build → Design-Build
- 6 Million Square Feet Renovation
- 1 Million Square Feet New Construction
- Systems Commissioned
  - HVAC
  - Electrical Power
  - Lighting Controls
  - Life Safety

Introduction

Project Costs

• 2006 Summary of Pentagon Renovation & Commissioning Costs

Project	Area (Sq. Ft.)	Cx $ vs Const $ (%)
Wedge 1[1]	1,077,000	0.8%
Remote Delivery Facility	215,000	2.7%
Metro Entrance Facility	21,000	1.1%
Phoenix (9-11 Reconstruction)	400,000	0.6%
Wedge 2+ including Basement	1,415,000	1.0%
Pentagon Athletic Center	150,000	1.2%
Pentagon Library and Conference Center[2]	250,000	1.8%
TOTALS		**1.0%**

[1] Wedge 1 was construction phase commissioning only. It was also the only commissioned Design-Bid-Build project. All subsequent projects were Design-Build.

[2] This project is in early construction at the time of this report. Final numbers are likely to be different.

Financial Costs & Benefits Approach

Benefits of Commissioning

• Energy Benefits
  – Easy to quantify
  – Secondary importance to facility owners
• Non-Energy Benefits
  – Not-so-easy to quantify
  – Primary importance to facility owners

Financial Costs & Benefits Approach

Non-Energy Benefits

• Assurance that owners get the building they want and are paying for
• Smoother turn over
• Improved comfort control
• Opportunity to monitor building performance over 1st year of operation
• Improved building performance
• Better communication between project team members
• Reduced construction and warranty issues

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Financial Costs & Benefits Approach

Benefits Quantification Approach

- Establish the Metrics
- Mine the Data
- Derive Conservative Benefit Numbers

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Financial Costs & Benefits Approach

Potential Non-Energy Metrics

- Productivity
  - Maintenance worker hourly rate
  - Maintenance supervisor hourly rate
  - Average tenant hourly rate
  - Value of daily production
- Working Hours
  - Normal work week
  - Production hours
- Analysis Timeframe
  - One time effect
  - Life cycle effect

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Financial Costs & Benefits Approach

Mine the Data

- Potential Project Data Sources
  - Design review comments
  - Prefunctional checklist results
  - Functional test results
  - Commissioning action lists
  - Commissioning meeting minutes
  - "As built" drawings
  - Test and balance reports
  - O&M manuals
- Potential Operations Data Sources
  - Trouble call log
  - Work order log
  - Preventive maintenance records
  - Service contractor reports and invoices

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Financial Costs & Benefits Approach

Derive Conservative Benefit Numbers

- Project Benefits
  - Reduced change orders
  - Reduced requests for information
  - Expedited problem resolution
  - On-time project completion
  - Reduced warranty calls
  - Improved perception of project success
- Tenant Benefits
  - Staff productivity
  - Process productivity
- Facility Benefits
  - Reduced energy consumption
  - Decreased O&M staff time finding and correcting problems
  - Decreased O&M staff budget demand for correcting problems
  - Improved preventive maintenance
  - Improved predictive maintenance
  - Improved trouble call responsiveness

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Financial Costs & Benefits Approach

Derive Conservative Benefit Numbers

- Example Project Benefit Calculation

REDUCED REQUESTS FOR INFORMATION

VARIABLES:

X_o= Labor time to administer one request for information, including reproduction and distribution of the response (hours)

X_c= Labor time to administer one commissioning comment (hours)

Y= Labor cost, fully load ($/hour)

Z= Number of total commissioning comments likely to have eliminated future RFIs

CALCULATION:

$SAVINGS\ (\$) = (X_o - X_c) \times Y \times Z$

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Financial Costs & Benefits Approach

Derive Conservative Benefit Numbers

- Example Facility Benefit Calculation

IMPROVING ACCESSIBILITY & MAINTAINABILITY OF A SPECIFIC SYSTEM

VARIABLES:

X_o= Labor time to perform preventive maintenance procedures without commissioning benefit (hours)

X_c= Labor time to perform preventive maintenance procedures with commissioning benefit (hours)

Y= Labor cost, fully load ($/hour)

Z= Number of affected systems

W= Frequency of procedure (procedures/year)

V= Period of time over which procedure will be performed (years)

CALCULATION:

$SAVINGS\ (\$) = (X_o - X_c) \times Y \times Z \times W \times V$

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Financial Costs & Benefits Approach

Derive Conservative Benefit Numbers

- Example Tenant Benefit Calculation

IMPROVING BUILDING OCCUPANT STAFF PRODUCTIVITY

VARIABLES:

X_o= Productive labor time per person without commissioning benefit (hours/week)
X_c= Productive labor time per person with commissioning benefit (hours)
A= Number of affected tenants (# of people)
B= Tenant labor cost, fully load ($/hour)
C= Work hours per year (hours/year)
D= Period of time over which benefit will be realized (years)

CALCULATION:

SAVINGS ($) = $(X_c - X_o) \times A \times B \times C \times D$

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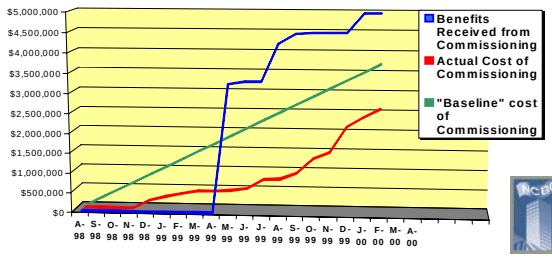
Benefits at the Pentagon Renovation

First 18 Months (2000)

- 68 Benefits Evaluated
- 23 Benefits Quantified
- All Non-Energy Benefits



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Benefits at the Pentagon Renovation

2006 Benefits Analysis Status

- 1,672 Benefits in Database
- 23 Benefits Quantified

Breakdown of Benefits by Project Phase	
Design Phase	54%
Construction Phase	46%

Relative Value of Quantified Design & Construction Benefits	
$$ Total Design Phase Benefits per $$ Total Benefits	55%
$$ Total Const Phase Benefits per $$ Total Benefits	45%

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Benefits at the Pentagon Renovation

2006 Benefits Analysis Status

- 1,672 Benefits in Database
- 23 Benefits Quantified

Breakdown of Benefits by Type	
Project Benefit	18%
Facility Operations	70%
Tenants/Productivity	12%

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Benefits at the Pentagon Renovation

2006 Benefits Analysis Status

- 1,672 Benefits in Database
- 23 Benefits Quantified

Overall Cx Cost per Identified Benefit	
Cx Cost per Identified Benefit	$2,500/Benefit
Benefit Values	
$$ Value per Quantified Benefit (All)	$125,000/Benefit
$$ per Benefit/Square Feet (All)	$0.57/Benefit/Sq Ft
$$ Value per Quantified Design Phase Benefit	$200,000/Benefit
$$ per Design Phase Benefit/Square Feet	$0.85/Benefit/Sq Ft
$$ Value per Quantified Construction Phase Benefit	$80,000/Benefit
$$ per Construction Phase Benefit/Square Feet	$0.35/Benefit/Sq Ft
Identified Benefits per Square Foot	
Square Feet per All identified Benefits	1,900 Sq Ft/Benefit
Square Feet per Identified Design Phase Benefit	3,500 Sq Ft/Benefit
Square Feet per Identified Const Phase Benefit	4,100 Sq Ft/Benefit

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Benefits at the Pentagon Renovation

What Does this Mean to You?

- 1,672 Benefits in Database
- 23 Benefits Quantified

METRICS

	1,900	sq ft per benefit
$	0.57	value per benefit per sq ft
$	2,500	cx cost per benefit

Project Size (Sq Ft)	Const Cost per Sq Ft	Value per Benefit	Total Quantity of Benefits	Total Benefits Value	Cx Cost	Total Const Cost	Cx Cost % of Const
50,000	$ 100	$ 28,500	26	$ 750,000	$ 65,789	$ 5,000,000	1.3%
100,000	$ 150	$ 57,000	53	$ 3,000,000	$ 131,579	$ 15,000,000	0.9%
400,000	$ 250	$ 228,000	211	$ 48,000,000	$ 526,316	$ 100,000,000	0.5%

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Commissioning Process Lessons Learned

Lessons Learned Summary

- Planning & Scheduling Commissioning
- Project Phasing
- System Un-Readiness for Testing
- Failure Definition
- Failure Management
- Best Value Commissioning Documentation
- Test Sampling Strategies
- Best Value Testing Strategies
- Flexibility in Commissioning Approach
- Testing & Verification Techniques in Mission Critical Facilities
- Coordination with other Owner-Contracted Suppliers, Contractors & Vendors
- Training Building Users & Operators

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Commissioning Process Lessons Learned

Lessons Learned

- Planning and Scheduling Commissioning
  - Single master construction schedule
  - Commissioning milestones defined in specification
- Project Phasing
  - Number of phases
  - Size of phases

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Commissioning Process Lessons Learned

Lessons Learned

- System Un-Readiness for Testing
  - System to be tested is not complete or ready
  - Other systems' status impacts ability to conduct scheduled performance test
- Failure Management
  - Tie contractor payment to test metrics
  - Is commissioning complete when testing is complete? Or when testing is successful?

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Commissioning Process Lessons Learned

Lessons Learned

- Best Value Commissioning Documentation
  - Performance requirements and criteria
  - Design intent documents
  - Systems operations and maintenance manuals
  - Master test procedures for Re-commissioning
  - Commissioning and De-commissioning Plans
  - Training plans, materials, and videos
  - Lock-out, Tag-out procedures
  - As built drawings

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QUESTIONS?

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