
Module 2: Asset Management

Section 1: Introduction to Asset Management

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2 Asset Management
Section 1: Introduction to Asset Management

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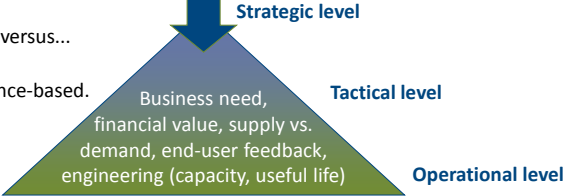
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What Is Asset Management?

- ISO 41011 definitions:
 - Asset management:** “Coordinated activity of an organization to realize value from assets.”
 - Assets:** “Item, thing, or entity that has potential or actual value...”

Undermanaged versus... evidence-based.



Strategic level

Tactical level

Operational level

Business need, financial value, supply vs. demand, end-user feedback, engineering (capacity, useful life)

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Goals of Asset Management

- Enable organization to achieve goals efficiently
- Leverage limited financial and human resources effectively
- Right FM expertise for assets



Utility

<p>Efficiency</p> <p>Is O&M cost-effective?</p> <p>Life-cycle perspective</p>	<p>Effectiveness</p> <p>Flexible uses?</p> <p>Sustainable?</p>
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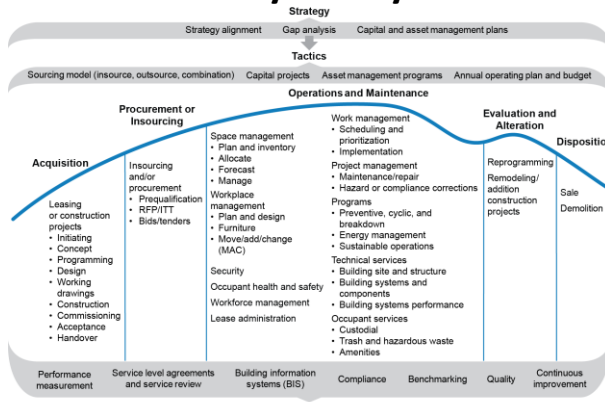
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Facility Life Cycle



The diagram illustrates the Facility Life Cycle as a continuous process. At the top, **Strategy** includes Strategy alignment, Gap analysis, and Capital and asset management plans. **Tactics** include Sourcing model (resource, outsource, combination), Capital projects, Asset management programs, and Annual operating plan and budget. The main cycle is divided into four primary stages: **Acquisition**, **Procurement or Insourcing**, **Operations and Maintenance**, and **Evaluation and Alteration**, leading to **Disposition**. **Monitoring and Controlling** activities like Performance measurement, Service level agreements, Building information systems (BIS), Compliance, Benchmarking, Quality, and Continuous improvement are shown at the bottom.

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Discussion Question

How should depreciation of “permanent” facility systems affect life-cycle cost decisions?

- a) Keep fully depreciated system assets on the books as long as the facility is on the books.
- b) Estimate the number of full depreciation cycles for the system when assessing cost.

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How Asset Management Fits into FM

Facility Management			
<p>Asset management</p> <ul style="list-style-type: none"> ▪ Strategic and capital planning <ul style="list-style-type: none"> • Justify assets • Align to strategy ▪ Project management <ul style="list-style-type: none"> • Unique needs • Temporary teams 	<p>Risk management</p> <ul style="list-style-type: none"> ▪ Compliance and standards ▪ Environmental health and safety ▪ Security ▪ Emergency management 	<p>Business management</p> <ul style="list-style-type: none"> ▪ Manage and lead people ▪ Manage finances ▪ Manage procurement and contracts 	<p>Operations and maintenance</p> <ul style="list-style-type: none"> ▪ Technical services ▪ Occupant services ▪ Manage work, utilities, and spaces

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Section 2: Project Management



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Section 2 Topic Preview

- **Topic 1:** Project Management Overview
- **Topic 2:** FM Projects and Project Selection
- **Topic 3:** Programming and Initiation
- **Topic 4:** Planning
- **Topic 5:** Execution
- **Topic 6:** Monitoring and Controlling
- **Topic 7:** Project Closeout and Continuous Improvement

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Why Use Project Management?

- Using daily work to get complex or unique things done runs into trouble (interruptions, hard to define success).
- Can build custom teams, even from other areas.
- Get agreement up front on success criteria; use as proof.
- Break complex objectives into manageable chunks.
- Create a budget and schedule just for deliverables.
- Monitor and control progress and satisfy stakeholders.
- Prevent scope creep.

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Projects, Project Management, and Scope Creep

Scope creep	<ul style="list-style-type: none"> • Stakeholders add requirements with unintended consequences and/or no extra time or budget. • Say no with respect and authority.
Projects	<ul style="list-style-type: none"> • Clearly defined objectives and start/end. • Unique deliverables (i.e., not on regular basis). • Limited in time, separate budget, custom team.
Project management	<ul style="list-style-type: none"> • Initiate, plan, execute, and close, always monitoring, controlling, and communicating. • Integrate work and direct temporary team.


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Successful Project Manager



- Selects right team and manages dynamics.
- Clearly defines goals and outcomes.
- Mitigates risk and resolves issues promptly.
- Manages against budget and schedule.
- Reviews and approves/rejects changes.
- Integrates team's work to produce cohesive result.

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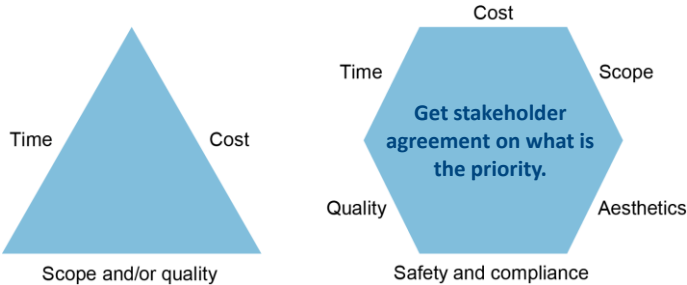
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Project Triangle and Multiple Constraints

- Constraints affect one another; must accept tradeoffs.
- Project manager must keep project feasible.



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Project Sponsorship and Oversight

- Initiator(s)
 - Facility manager
 - Client
 - Executive
 - Functional area manager
 - Project management office (PMO)
- Becomes project sponsor (key stakeholder)
 - Heavily involved in initiating, including releasing funds.
 - Champion, problem solver, and change controller.
 - If customer, will accept/reject deliverables.

Project Budget*	Approval Required
Up to \$10,000	Facility manager
\$10,000 to \$250,000	Upper management
Over \$250,000	Top executive/board

*Amounts are examples only.

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Project Manager and Team Roles

Project manager

- Lead/manage people.
 - Promptly communicate.
 - Agreement on goals.
 - Work gets done.
- Plan/organize tasks.
 - Task breakdown.
 - Budget/schedule.
 - Track variances and correct course.
- Technical savvy (credible).

Team members

- Technical, social, and organizational skills.
- Project management exposure.
- Organizational chart.
- Task, quality, results, and resource clarity.
- Consultants/contractors roll on/off as needed.


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Stakeholders



- Identify early to communicate well and avoid surprise requirements.
- Over-invite and let them self-select out.
- Favored means of communication?
- Meet with manager and team members on time allocation and performance reporting.
- Stakeholder power/interest matrix, areas of interest.
- Acknowledge and address conflicting priorities.

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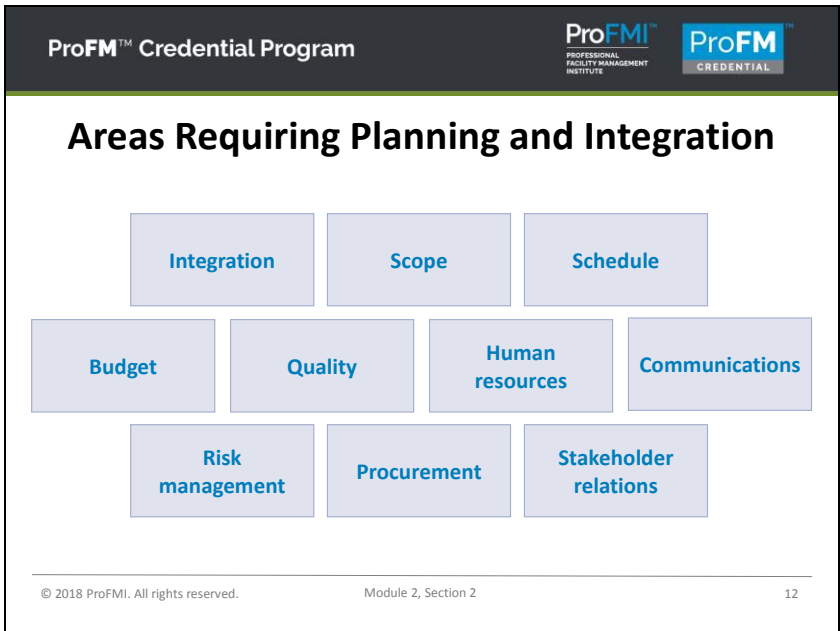
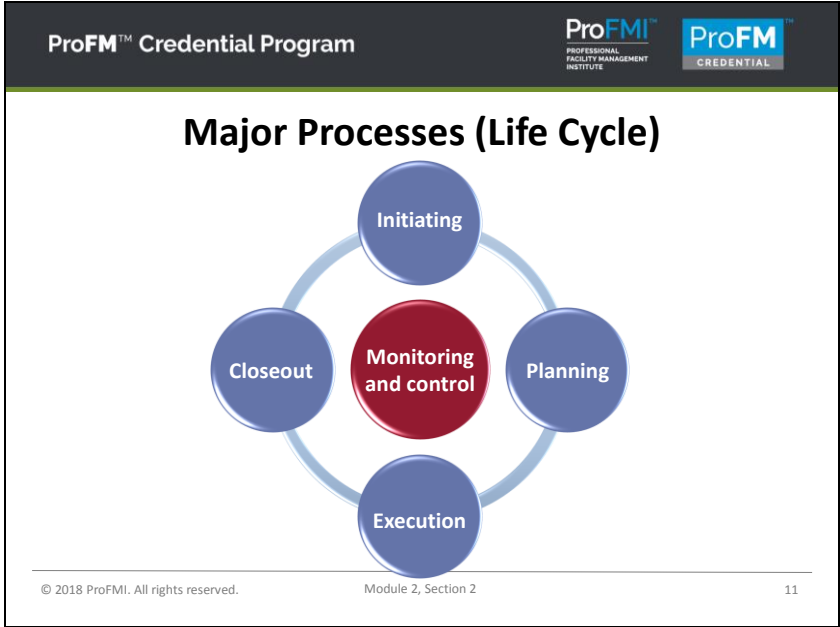
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Example: Lighting Retrofit Project

- Mandate to improve sustainability
- Present to COO (sponsor): New lighting that can reduce energy and maintenance costs from status quo
- FM staff to do installations (or contractors, maybe)
- FM staff on maintenance requirements
- Custodial staff on cleaning requirements
- Finance manager and finance professional
- Purchasing manager and purchasing professional
- End users on lighting needs

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Inputs, Processes, and Outputs

- **Inputs:** What you need to get started
- **Processes:** Task itself
- **Outputs:** What you hand off to another task or to customer (final deliverables)

Important Project Inputs

- FM plans and approved business cases
- FM policies, procedures, and relevant regulations
- Quality, sustainability standards, etc., to save planning time
- Specific measurement tools and KPIs

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Tools and Resources

- Up-to-date databases of costs
- Approved contractors and vendors
- As-built drawings and documents
- Prior project schedules, budgets, lessons learned
- Hand and power tools, material inventories, vehicles
- Project management and technical training
 - Front-end analysis of team needs
- Project management software (must still plan first)
- Project database

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Industry and Environmental Factors, Assumptions

Factors outside control

- Culture
- Regulations
- Political
- Industry
- Economy
- Technology

Assumptions to discuss

- HR availability, skills, rates
- Procurement cost, timing
- Equipment available
- Regulations stable
- Financing stable
- End-user needs correct
- Demand as forecasted

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Common FM Projects

- Cost savings
- Sustainability
- Security upgrades
- Aesthetics, image
- Relocation of staff/ equipment
- Build-outs
- Renovation
- New construction

- Many small- to medium-size projects
- Organize to leverage existing relationships
- Review and reprioritize project order
- Repairs, renovation: technical competence
- Processes, IS: interpersonal skills

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 **Discussion Question**

How should facility managers ensure that small and medium-size projects benefit the customer while still keeping planning time reasonable?

- a) Prioritize interpersonal skills over technical skills on all projects.
- b) Use strategic and annual FM plans as the project plan.
- c) Have project plans link to feasibility and cost-benefit analysis done for strategic and annual FM plans.
- d) Defer or reject any project arising on an ad hoc basis.

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Programming and Initiation: Project Charter

- Consensus up front on end results, success measures.
- Don't start work until you get signatures.
- Work backward from end result.
- Leave how to get there open.
- Project manager: Voice of reason; set expectations.
- SMART goals to avoid moving definition of success:
 - What does fast, cost-effective, or low error rates mean?
 - Scope: What will and will NOT do.
 - Which organizational goals project will fulfill.

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Budget, Schedule, Constraints, Assumptions, Risk

- Time-bound: Start and end; milestones.
- Schedule or budget wants versus needs.
- Prioritize real business need, keeping lower priority requirements flexible.
- Clarify management reserve.
- Discuss and get consensus on assumptions, risks, and opportunities (consistent plans, estimates).
- Signatures of named sponsor(s) authorize named project manager to use funds and acquire/direct team.

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Project Number: 1000 Name: Northern Regional Headquarters Lighting Retrofit

Replace the lighting systems in all drop ceiling portions of the Northern Regional Headquarters' three floors to reduce long-term maintenance and energy costs and help the facility comply with the organization's sustainability strategy. The project will be considered a success when all of the following are true:

- Financial criteria: Project costs shall have a discounted payback period of 3.5 years or less and a net present value of \$20,000 or more based on annual maintenance plus energy cost savings from the status quo.
- A not-to-exceed budget of \$60,000 is adhered to. An additional management reserve of \$20,000 is set aside for a new drop ceiling if needed or to address other issues.
- The new lighting system shall have an expected life of at least 8 years.
- The lighting systems shall be fully installed and operational no later than February 15, 2019.
- The new lighting systems shall have luminosity levels of between 400 and 500 lux as measured using a lux meter at workstation desk surface level.
- Light distribution and diffusion shall be optimized to minimize distracting glare while retaining at least 80 percent of the light being produced.
- Color rendition will mimic natural light to the degree possible as measured by at least 75 percent customer satisfaction with the new lighting color in questionnaire results.
- Project work will be conducted with minimal end user disruption. No work is done during normal business hours, and drop cloths are used to protect areas from dust.

Assumptions, Risks, and Opportunities:

- The cost of capital will be 6.5 percent over the project analysis period.
- Net present value calculations are based on an 8-year analysis period.
- Internal staff are available for evening or weekend installation work, and overtime pay is authorized.
- The drop ceiling will not need to be replaced.

The project manager for this project is Pat Smith, Northern Regional Facility Manager. The sponsor for this project is Chris Morris, COO.

I, Chris Morris, hereby authorize this project to proceed.

Signature _____
Date _____

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Programming

- Systematic needs analysis including future needs.
- Validated using end-user surveys, etc.
- Builds a strong support network for project.
- Helps set expectations and guide perceptions.
- Source of innovative solutions.



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Planning: Making Project Plan

- Scale to project size
- Living document
- Baselines for control
- Iterative
- Validate charter assumptions, etc.
- Review of statement of work


Revisit earlier parts planned.



Refine estimates, details.

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 **Discussion Question**

What is a best practice for planning scope?

- a) Brainstorm the tasks first, from start to end.
- b) The smallest possible task chunks are best.
- c) Work backward from deliverables to be produced.
- d) Avoid referring to similar project task lists.

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Work Breakdown Structure (WBS)

- Parent-child hierarchy (Child can have only one parent.)
- Categories for subbudgeting
- Complete only when 100% of tasks are listed
- Unique code per task
- Description, assumptions, constraints, assignments, resources, deadline, cost, and acceptance criteria
- Action verb for tasks (activity not deliverable)
- Experts validate that nothing omitted

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Project Number: 1000 Name: Northern Regional Headquarters Lighting Retrofit

Task ID	Description	Assumptions	Assigned to	Resources	Deadline	Cost	Quality/Acceptance
1100	Manage project		Pat Smith				
1110	Plan project		Pat Smith		9/1/2018		
1111	Develop scope		Pat Smith				
1112	Develop schedule		Pat Smith	MS Project			
1113	Develop budget		Pat Smith	Cost database			
1120	Control variances		Pat Smith				Cost/time <20% over
1200	Set requirements		Pat Smith				
1210	Select engineer	Approved list	Pat Smith				
1211	Contract engineer	Local licence	Pat Smith	Std. contract		\$80/hr	
1300	Procure materials		Henry Ngo				
1310	Set RFP criteria		Henry Ngo	Sustainability plan			
1320	Research vendors		Henry Ngo				
1330	Issue RFPs		Henry Ngo		10/1/2018		
1340	Select short list		Henry Ngo				
1350	Hold presentations		Henry Ngo				
1360	Negotiate contract		Henry Ngo	Std. PO			
1370	Order materials		Henry Ngo		11/20/2018		
1400	Prepare area		Dawn Black				Cubicles protected
1500	Uninstall old fixtures		Dawn Black		1/25/2019		Minimal tile damage
1600	Install fixtures		Dawn Black		2/3/2019		Per manual
1700	Alter ceiling tiles		Dawn Black		1/27/2019		Visual review
1800	Install electrical	Lic. electrician	Jim Macher		1/27/2019		Pass inspection
1900	Test system	Peak load	Dave Hu		1/28/2019		See energy criteria
2000	Clean up area		Dawn Black				
2100	Do postoccupancy	Likert survey	Pat Smith		6/1/2019		75%+ satisfaction

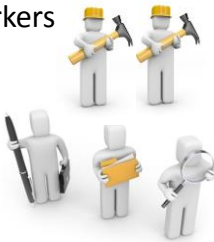
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Resource Requirements and Constraints

- First what you need, then what you have
- Type and quantity of resources per lowest-level task
- Minimal or optimal skills, number of workers
- Facilities, equipment, tools, materials
- Lock in by roll-on and roll-off dates
- Constraints
 - Regular duties or other projects
 - Vacation schedules
 - Lower skill than required (or add time for learning curves)



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Project Schedule

- Baseline for when things should be done
- Timely correction
- Milestones: go/no go
- Time reserves
 - Pad all estimates or overall reserve
 - Estimated vs. “drop dead”
- Bottom-up estimate, top-down reality check



- Task duration estimate
 - Person-hours/workers
 - By analogy
 - Parametric (standard rate × volume)
 - Expert advice averaging estimates in some way

Weighted Estimate (PERT) =

$$\frac{\text{Optimistic} + (4 \times \text{Expected}) + \text{Pessimistic}}{6}$$

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Sequencing Tasks

- Required sequence
- Required predecessors (mandatory or best practice)
- If just best practice, risk of rework
- Software automates logic, but you are responsible for errors, so learn how it works

Critical Path Method

- Schedule network diagram (flowchart)
- Early start (ES)
- Early finish (EF)
- Late start (LS)
- Late finish (LF)
- Next-day scheduling
- Same-day scheduling

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CPM Step 1: Network Diagram and Durations

- Create a diagram with tasks in their sequences.
- What is done in parallel? B and C
- Lines show predecessors.
- Add durations.

Key

Forward pass

Early start → Early finish

ES	Duration (Dur)	EF
Activity name		
LS	Total float	LF

← Late start ← Late finish

Backward pass

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CPM Step 2: Forward Pass for ES and EF

- Forward pass starts at first task: Day 1 in first ES box.
- $EF = ES + (\text{Duration} - 1)$
- Next task ES is highest LF predecessor + 1.

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CPM Step 3: Backward Pass for LS and LF

- Backward pass starts at last task, making EF = LF.
- $LS = LF - (\text{Duration} - 1)$
- Predecessor LF is smallest or earliest LS - 1.

The diagram shows a network of four tasks: A, B, C, and D. Each task is represented by a box divided into three rows and three columns. Arrows indicate the sequence: A to B, A to C, B to D, and C to D.

1	5	5
A		
1		5

6	3	8
B		
9		11

6	6	11
C		
6		11

12	4	15
D		
12		15

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CPM Step 4: Calculate Total Float

- Total float = $LF - EF$ or $LS - ES$ (bottom minus top box)
- Critical path: Highest sum of durations of possible paths
 - A-C-D ($5 + 6 + 4 = 15$ days) has 0 float for all: critical path
 - A-B-D ($5 + 3 + 4 = 12$ days)

The diagram is identical to slide 31, but the scheduling data boxes for tasks B and C are updated to show total float values in the bottom-left cell.

1	5	5
A		
1	0	5

6	3	8
B		
9	3	11



6	6	11
C		
6	0	11

12	4	15
D		
12	0	15

Critical path can change if actual durations longer/shorter.


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Scheduling

- Project management software: Enter tasks, durations, and predecessors by ID or drag and drop
- Milestone: Duration of 0 (event)
 - Obtain permit, pass regulatory inspection, customer accepts
- Enter team members and assign to tasks
- Resource conflicts or schedule compression:
 - Resource smoothing: Only if total slack > 0
 - Resource leveling: Critical path on table
 - Crashing: Add people (incremental cost)
 - Fast tracking: Parallel tasks, but adds risk

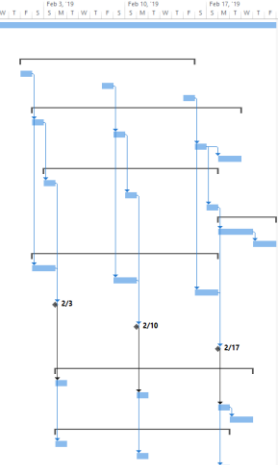


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Task	Task Name	Duration	Start	Finish	Predecessor
7	Control Variances	121 days	Mon 9/17/18	Fri 2/22/19	
8	Set Requirements	13 days	Mon 10/1/18	Wed 10/17/18	
12	Procure Materials	48 days	Thu 10/18/18	Mon 12/24/18	
20	Prepare Area	55 days?	Fri 2/1/19	Fri 2/15/19	
21	Prep F11	1 day	Fri 2/1/19	Fri 2/1/19	
22	Prep F12	1 day?	Fri 2/8/19	Fri 2/8/19	
23	Prep F13	1 day?	Fri 2/15/19	Fri 2/15/19	
24	Uninstall Old Fixtures	18 days	Sat 2/2/19	Tue 2/19/19	
25	Uninstall Old F11	1 day	Sat 2/2/19	Sat 2/2/19	21
26	Uninstall Old F12	1 day	Sat 2/9/19	Sat 2/9/19	22
27	Uninstall Old F13	1 day	Sat 2/16/19	Sat 2/16/19	23
28	Arrange for Recycling	2 days	Mon 2/18/19	Tue 2/19/19	27
29	Install Fixtures	35 days	Sun 2/1/19	Sun 2/17/19	
30	Install Fixtures F11	1 day	Sun 2/3/19	Sun 2/3/19	25
31	Install Fixtures F12	1 day	Sun 2/10/19	Sun 2/10/19	26
32	Install Fixtures F13	1 day	Sun 2/17/19	Sun 2/17/19	27
33	Alter Ceiling Tiles	5 days	Mon 2/18/19	Fri 2/22/19	
34	Alter Ceiling Tiles	3 days	Mon 2/18/19	Wed 2/20/19	32
35	Replace Damaged	2 days	Thu 2/21/19	Fri 2/22/19	34
36	Install Electrical	18 days	Sat 2/2/19	Sun 2/17/19	
37	Run Conduits F11	2 days	Sat 2/2/19	Sun 2/3/19	21
38	Run Conduits F12	2 days	Sat 2/9/19	Sun 2/10/19	22
39	Run Conduits F13	2 days	Sat 2/16/19	Sun 2/17/19	23
40	Do Tagout/Wire Breakers F11	0 days	Sun 2/3/19	Sun 2/3/19	30,37
41	Do Tagout/Wire Breakers F12	0 days	Sun 2/10/19	Sun 2/10/19	31,38
42	Do Tagout/Wire Breakers F13	0 days	Sun 2/17/19	Sun 2/17/19	32,39
43	Test System	17 days	Mon 2/4/19	Wed 2/20/19	
44	Do Unit Test F11	1 day	Mon 2/4/19	Mon 2/4/19	40
45	Do Unit Test F12	1 day	Mon 2/11/19	Mon 2/11/19	41
46	Do Unit Test F13	1 day	Mon 2/18/19	Mon 2/18/19	42
47	Do Peak Load Test	2 days	Tue 2/19/19	Wed 2/20/19	46
48	Clean Up Area	15 days?	Mon 2/4/19	Mon 2/18/19	
49	Clean Up F11	1 day?	Mon 2/4/19	Mon 2/4/19	30,37
50	Clean Up F12	1 day?	Mon 2/11/19	Mon 2/11/19	31,38
51	Clean Up F13	1 day?	Mon 2/18/19	Mon 2/18/19	32,39



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Project Budget

- Schedule and budget are inextricably intertwined.
- Bottom-up budget:
 - Enter cost estimate per task in WBS.
 - In software, these automatically sum up to higher levels.
 - This plus management reserve is master project budget.
- Costs per milestone, per control account.
- Also budget for any administrative expenses, travel, etc.
- Reconcile with top-down budget from project charter.
- If too high, reconsider project assumptions or bring up.

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Other Plans, Revisions, and Plan Approval

Quality	Risk	Procurement	Other
<ul style="list-style-type: none"> Tools to use Acceptance targets 	<ul style="list-style-type: none"> Regular agenda item Late Over budget Functionality 	<ul style="list-style-type: none"> List all materials when needed Work backward, including lead time 	<ul style="list-style-type: none"> HR Communications Change control Stakeholder relations
Circle back and update earlier parts; then set realistic expectations with sponsor.			

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Execution/Assembling Teams

- Execution: Where work gets done (bulk of project).
 - Project managers direct and control work.
 - Coordinate team activities by seeing big picture.
 - Process audits if process to follow is important.
- Assembling the right team reduces risk.
 - Acquire and train (both add time); then manage.
 - Scarce resources, especially at right skill level.
 - Early team for planning, rest roll on/off as needed.
 - Good relations with functional area managers and HR.
 - Less staffing control (e.g., PM contractor, unions).

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Organizing and Managing Teams/Individuals

Prepare for success	Orienting contractors	Interpersonal skills	Leadership/management
Information locations	Culture, structure	Team building	Monitor, analyze gaps, solve problems
Ground rules	Goals, scope	Recognition, feedback	
	Stakeholders		

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RACI Matrix Chart

Task	Pat Smith (Project Manager)	Chris Morris (Sponsor)	Dawn Black (FM Crew Chief)
Identify end-user requirements.	R	I	R
Specify engineering requirements.	I	I	C
Validate requirements.	R	A	C
Create WBS.	R	I	C
Identify resources.	R	C	C
Determine resource constraints.	R	I	C
Review and approve scope.	C	R, A	I

R = Responsible (worker) A = Accountable (oversight)
C = Consulted (subject matter expert) I = Informed (gets reports)

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Discussion Question

Which is the best example of a project manager exercising integration and communication activities correctly?

- a) Keeping problems at top of people’s minds
- b) Waiting to put pieces together until end
- c) Taking over some failing work to get it done

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Meetings

Kickoff meetings

- One or more.
- Processes and ground rules.
- Milestones.
- Assumptions, risks, constraints.
- Individual and team responsibilities, inputs.

Regular meetings

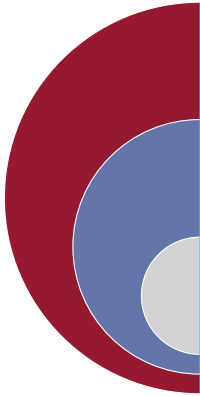
- Right-size people and length.
- Advance agenda.
- Control discussion.
- Be prepared.
- Summarize.
- Follow up.



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Progress Reporting




	<i>Examples</i>
Audience need	<ul style="list-style-type: none"> • Change control board: Effectiveness, risk • Customer: Scope, delivery date, remaining budget
Report type	<ul style="list-style-type: none"> • Work performance • Status report • Dashboards
Level of detail	<ul style="list-style-type: none"> • Root cause: Productivity vs. late delivery • Current condition, trends

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Configuration Management and Control

- Documentation or process version control
- Deliverables with multiple versions to track and label
- Who is accountable?
- Change control for versions
- Forthcoming change notice
- All using current version
- Verification and audit
 - Changes made
 - Effective new version or process




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Monitoring and Controlling

- Overarching process.
- Analyze progress and performance data.
- Required changes to project plan.
- Initiate needed and approved changes; verify done.
- Deliverables conform to scope and requirements?
- Correct course early.
- Process audits more efficient than inspections after.
- Influence factors to prevent changes being needed.




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 **Discussion Question**

How do projects get off schedule or budget?

- a) Casual check-in or self-reporting systems are used.
- b) It happens one day or one dollar at a time.
- c) Data is placed in context and compared to a baseline before making decisions.
- d) There are major problems that can be detected only late in the process.

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Scope Verification

- Identify and manage elements that could alter scope.
- Avoid needless change.
- Scope creep
 - Insist on realistic plans.
 - Don't abdicate power.
 - Proactively consider integration.
 - Explicit acceptance criteria.
- Gold plating
 - Project team member.
 - Good intentions.
 - Integration issues.
 - Not seen as adding value.
 - Manage suggestions and expectations early.



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Schedule and Budget Analysis: Variances

- **Variance analysis:** Plan (baseline) vs. actual
- **Earned value measurement (EVM):** Schedule and cost variances both measured in terms of monetary impact
 - **Planned value (PV):** Cost of work that should be done per project plan (e.g., plan says should be 50% done of \$50k project, then PV = \$25k).
 - **Actual cost (AC):** Actual money spent to date (e.g., AC = \$30k).
 - **Earned value (EV):** Value produced. Budget x Actual Percent Complete (e.g., EV= \$50k x 40% = \$20k).

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Schedule and Cost Variance and Indexes

<p>Variance measures</p> <ul style="list-style-type: none"> ▪ Schedule variance (SV) = EV - PV = \$20k - \$25k = -\$5k ▪ Cost variance (CV) = EV - AC = \$20k - \$30k = -\$10k ▪ Off schedule but over budget even more 	<p>Indexes (above 1.0 is good)</p> <ul style="list-style-type: none"> ▪ Schedule performance index (SPI) $\frac{EV}{PV} = \frac{\\$20k}{\\$25k} = \mathbf{0.8 \text{ or } 80\%}$ ▪ Cost performance index (CPI) $\frac{EV}{AC} = \frac{\\$20k}{\\$30k} = \mathbf{0.67 \text{ or } 67\%}$
--	---

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Quality and Other Metrics

- Validate project requirements/ acceptance criteria
 - Quality
 - Functionality
 - Performance levels
 - Capacity
 - Reliability
 - Operating costs
 - Project schedule dates



- FM project metrics
 - Quantity versus rate cost variances
 - Activity time saved
 - Kilowatt-hours
 - Water usage variance
 - Number of complaints

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Keeping Project on Scope: Change Control

- Change request review and approval/rejection process.
 - Unintended side effects?
 - Necessary change?
 - Schedule and/or budget still achievable?
- Minimize need for change.
 - Involve stakeholders early.
 - Familiar with baselines and interdependencies.
 - Communicate true cost of change to change control board.
- Prepare options and recommendation.
- Communicate reasons for change to team.

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Keeping Project on Schedule and Budget

- Proactively manage to minimize project risk.
- Effective and efficient projects show professionalism.
- Action-oriented: Lead and manage to correct course.
- Look for root causes and prevention:
 - Repeatedly ask why.
 - Avoid treating just symptoms.

ROOT CAUSE
PREVENTION
RISK

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Project Closeout/Continuous Improvement

<ul style="list-style-type: none"> ▪ Importance often underestimated. ▪ Close contracts. ▪ Document and celebrate success. ▪ Lessons learned. ▪ Release resources. ▪ Update cost database. ▪ Archive documents. 	<ul style="list-style-type: none"> ▪ Handoff and transition: <ul style="list-style-type: none"> – System testing and quality control – Customer acceptance – Knowledge, document, and physical transfer – How to operate and maintain – Commissioning
--	--

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Team Debriefing

- Open presentation of problems and successes to get feedback and provide closure.
- Involve many.
- What were we trying to do?
- Did we achieve our objective?
- What caused our results?
- What should we do differently next time?
- Focus on making a plan to fix top five to ten problems.



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Lessons Learned and Final Reports

<h3>Lessons learned</h3> <ul style="list-style-type: none">▪ Briefly address problem and impact▪ How to get more information▪ Corrective action taken▪ Results	<h3>Final reports</h3> <ul style="list-style-type: none">▪ For customer, sponsor, executive presentations▪ Final variances▪ Root causes of success or failure▪ Chance for feedback▪ Organizational learning
---	---



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Disband Team and Administrative Closure

- Get team back to resource pool promptly.
- Report to manager on individual performance.
- Review scope to verify objectives and all deliverables.
- Archive all project documents (WBS, schedule, budget, risks, change log, drawings).
- Financial closure: Work done, no disputes, then pay.
- Contract closeout (completed or terminated):
 - Options exercised/expired, work done, or termination notice.
 - Archive contracts and documents for retention period.

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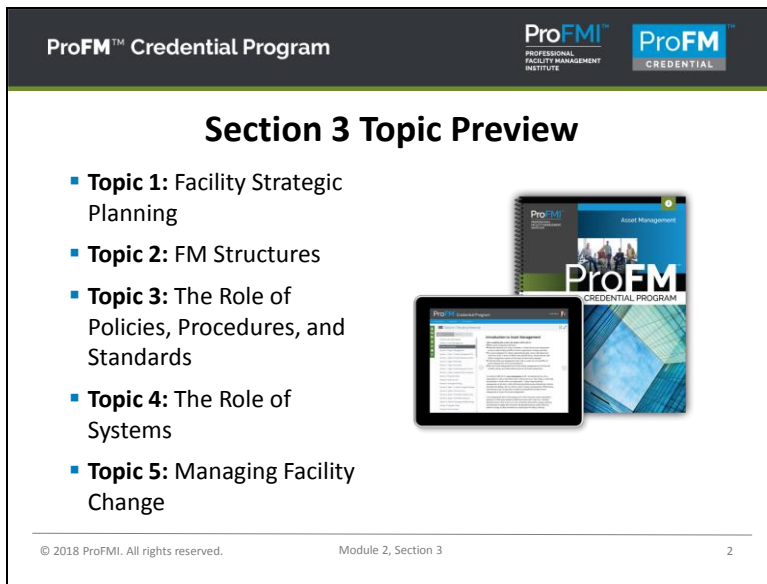
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Continuous Improvement Efforts

- Internalize lessons and put into actual use.
- 6- to 12-month post-implementation review (called postoccupancy analysis for spaces):
 - Actual cost to operate and maintain versus planned costs?
 - How well solved business problem?
 - User acceptance and satisfaction?
 - Performance?
 - Impact on core business?
 - Did it require other organizational changes?
 - Plan versus actual ROI or other financial impact?

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Section 3: Strategic Planning



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Strategy Terminology

- **Strategy:** Plan to create long-term value (and possibly competitive advantage) for stakeholders
- **Strategic planning:**
 - Gathering and analyzing information
 - Setting goals
 - Developing plans
 - Defining performance objectives

```

    graph TD
      SP[Strategic Planning] --> I[Implementing]
      I --> MM[Monitoring and measuring]
      MM --> RI[Revising and improving]
      RI --> SP
    
```

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Strategic Alignment

```

    graph TD
      L((Leaders)) --> F((Function))
      F --> S((Staff))
      S --> L
    
```

- Strategy is communicated to the organization.
- Each layer aligns with that strategy through its own plans and objectives.
- All members know their strategic contributions.

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Benefits of Facility Strategic Planning

- Ability to leverage strategic alignment to win support for programs
- Better understanding of customer needs and staff roles
- Opportunity to plan and consider options
- Improved flexibility and resilience
- Greater transparency about use of resources

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Facility Strategic Planning and ISO 41012

1 Understand the business environment.

2 Align with strategy.

3 Conduct a needs analysis/programming.

4 Specify requirements.

5 Identify service quality and measurable results.

6 Assess the risk and cost of options.

7 Make a business case.

8 Choose a sourcing method.

and/or

9 Provide internal services.

10 Procure external services.

11 Set performance criteria.

12 Monitor, control, and continuously improve services.

Use a feedback loop.

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FM Functions and Service Providers

Same goal:
Align facility strategy with organizational strategy.

The diagram consists of three blue rounded rectangular boxes. The top box contains the text 'Parent Organization' above a double-headed vertical arrow, which is above the text 'FM Function'. The bottom box contains the text 'Client Organization' on the left and 'FM Services Provider' on the right, connected by a double-headed horizontal arrow.

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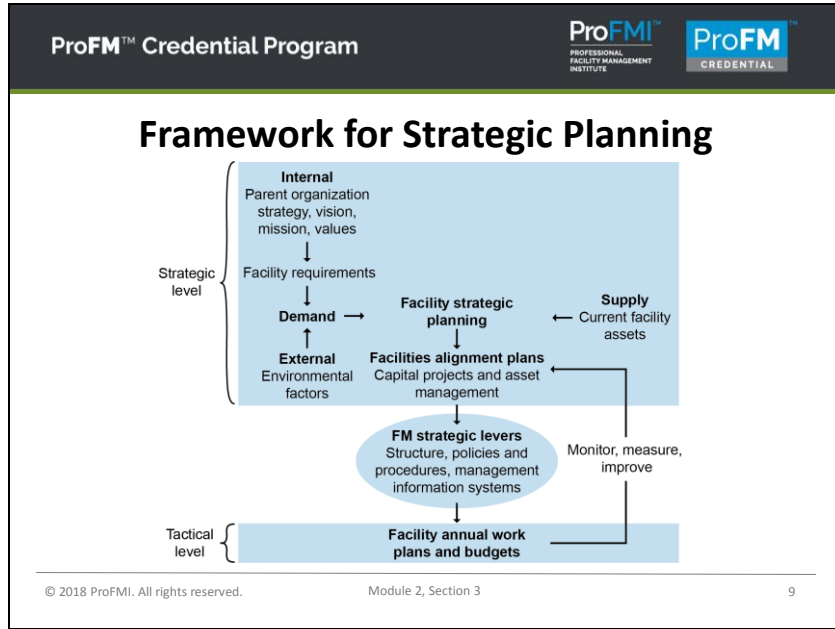
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Facility Strategic Planning Skills

- Understand how organization creates value.
- Present FM solutions in compelling way.
- Speak in financial terms.
- Demonstrate commitment to business control and continuous improvement.

An illustration of a group of stylized human figures. There are five grey figures in a line, and one red figure stands to the right of the line, with its arms raised in a 'V' shape, suggesting leadership or a standout member.

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Internal Demand Factors: Business Strategies

How to compete?

Low cost

Differentiation


FOCUS

Where to compete?

- Acquire competitors?
- Acquire supply chain partners?
- Expand into new industries?
- Expand into new markets?

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 **Discussion Question**

A large law firm decides to open three new offices in different parts of the country. Leaders intend to leverage the firm's well-known brand and reputation, but the budget will be limited until the strategy proves successful. How might this affect the firm's FM manager?

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**Internal Demand Factors:
Mission, Vision, Values**

Mission	Vision	Values
Scope of services organization intends to deliver	Future that organization wants to create	Principles that shape organization's relationship with stakeholders

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External Demand Factors: PESTLE Analysis

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Discussion Question

Provide examples of PESTLE factors that may affect your work.

Possible answers:

Political	Inefficient permitting process slows facility projects.
Economic	Low interest rates favor capital projects.
Sociological	Focus on fitness hits workplaces.
Technological	Ransomware attacks on the increase.
Legal	Courts favor dispute arbitration.
Environmental	Water shortages predicted.


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Internal Supply Factors



- Facility utilization information
- Real estate costs
- Operation and maintenance costs
- Cost indexes for labor, materials
- Asset condition and useful life
- Space standards
- Occupancy analysis
- Utilities
- Leases and terms
- Workforce supply and costs
- Vendor and procurement costs

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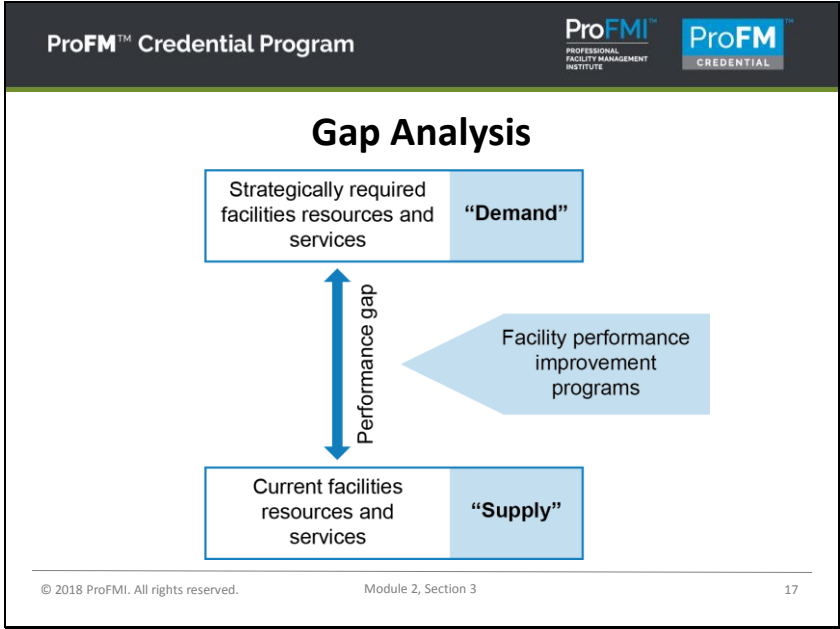
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Master Plan

- Focus on physical assets in facilities with multiple buildings and locations
- Orderly, long-term development plan based on future business requirements and local requirements and conditions



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Gap Analysis Tools

Business directions analysis	Shows business strategy impact on facilities
Facilities portfolio analysis	Aggregates current facility information across portfolio
Capability analysis	Describes current capacity of facility resources and FM staff/vendor capabilities
Performance improvement analysis	Identifies gaps and proposes solutions
Scenario projections analysis	Tests solutions under different business conditions to improve resilience

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SWOT Analysis

Internal	Strengths	Weaknesses
	<p>Strategic impact: Exploit</p> <p><i>Example:</i> Flexible facility space can accommodate changing occupant needs.</p>	<p>Strategic impact: Correct or avoid</p> <p><i>Example:</i> High proportion of building equipment is in late phases of life cycle.</p>
External	Opportunities	Threats
	<p>Strategic impact: Exploit and enhance (improve)</p> <p><i>Example:</i> Favorable real estate market in most locations provides flexibility in adding space.</p>	<p>Strategic impact: Avoid or mitigate effect</p> <p><i>Example:</i> Increasing utility costs will raise operation costs in primary locations.</p>


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Business Case Components

```

graph LR
    A[State purpose.] --> B[Describe assumptions and constraints.]
    B --> C[Describe criteria for success.]
    C --> D[Describe alternatives.]
    D --> E[Describe recommendation.]
    
```




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Making Compelling Business Cases

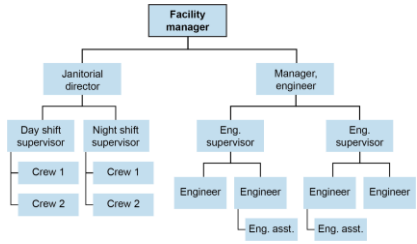
- Know what the decision makers’ objectives are.
- Know possible competing requests for funding.
- Frame the proposal as a solution to an urgent need.
- Follow the format of presentations in your organization.
- Work the organization and your network of allies to review and improve the proposal.



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FM Structures



```

graph TD
    FM[Facility manager] --> JD[Janitorial director]
    FM --> ME[Manager, engineer]
    JD --> DSS[Day shift supervisor]
    JD --> NSS[Night shift supervisor]
    DSS --> C1_1[Crew 1]
    DSS --> C1_2[Crew 2]
    NSS --> C2_1[Crew 1]
    NSS --> C2_2[Crew 2]
    ME --> ES1[Eng. supervisor]
    ME --> ES2[Eng. supervisor]
    ES1 --> E1_1[Engineer]
    ES1 --> E1_2[Engineer]
    ES2 --> E2_1[Engineer]
    ES2 --> E2_2[Engineer]
    E1_1 --> EA1_1[Eng. asst.]
    E1_2 --> EA1_2[Eng. asst.]
    E2_1 --> EA2_1[Eng. asst.]
    E2_2 --> EA2_2[Eng. asst.]
    
```

Structure includes:


- Organization’s components.
- Their relationship and hierarchy.
- Location of formal power and authority.

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Benefits of Strategy-Structure Alignment

- Efficient decision making and communication of actions
- Appropriate level of managerial authority
- Clarity in staff roles and responsibilities
- Integration of processes across functional walls—better collaboration and synergy



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Principles of Organization

Chain of command	Line of reporting relationships
Centralization	Way decision-making authority is located or distributed
Span of control	Number of direct reports a manager has
Differentiation	Way work is assigned to distinguish groups and individuals

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Types of Differentiation


- **Spatial:** Facility location
 - + Allows local adaptation
 - May entail redundancy

- **Horizontal/vertical:**
Layers of management
 - +/- Horizontal structures communicate quickly but take time to develop.
 - +/- Vertical structures offer greater control but can be expensive and rigid.

- **Functional:** Shared tasks
 - + Efficient
 - More prone to silos

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Discussion Question

A large university has four campuses. Reporting into the chief facilities officer are six directors in charge of building maintenance, finance and administration, grounds and building services, data and property, design and construction, and transportation. Reporting into these directors are foremen, supervisors, and project managers. The directors tightly control staff through required meetings and reports and spending limits. How would you characterize this structure?

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Suggested answer:

```

    graph TD
      CFO[Chief facility officer] --- Asst[Assistant]
      CFO --- M[Maintenance]
      CFO --- F[Finance]
      CFO --- G[Grounds]
      CFO --- DP[Data and property]
      CFO --- DC[Design/construction]
      CFO --- T[Transportation]
      M --- M1[ ]
      M --- M2[ ]
      M --- M3[ ]
      M --- M4[ ]
      M --- M5[ ]
      F --- F1[ ]
      F --- F2[ ]
      G --- G1[ ]
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      G --- G95[ ]
      G --- G96[ ]
      G --- G97[ ]
      G --- G98[ ]
      G --- G99[ ]
      G --- G100[ ]
      DC --- DC1[ ]
      DC --- DC2[ ]
      T --- T1[ ]
  
```

Note:

- Centralized
- Functional differentiation
- Vertical (with large span of control in some areas)

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Matrix Structure

- Commonly used in project-driven organizations.
- Team members report to both function and project leader.

```

    graph LR
      VP1[VP, general services] --- PMO[Project management office]
      VP1 --- OandM[O & M]
      VP1 --- Construction[Construction]
      VP1 --- Design[Design]
      VP1 --- Procurement[Procurement]
      VP1 --- Leasing[Leasing]
      VP1 --- Occupant[Occupant Services]
      VP1 --- Finance[Finance]
      VP2[VP, facility management] --- PMO
      VP2 --- OandM
      VP2 --- Construction
      VP2 --- Design
      VP2 --- Procurement
      VP2 --- Leasing
      VP2 --- Occupant
      VP2 --- Finance
      PMO --- PM[Project manager]
      OandM --- TM1[Team member]
      Construction --- TM2[Team member]
      Design --- TM3[Team member]
      Procurement --- TM4[Team member]
      Leasing --- TM5[Team member]
      Occupant --- TM6[Team member]
      Finance --- TM7[Team member]
  
```

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FM Structures: Office Manager Model

Officer (e.g., chief operating officer)
or VP (e.g., VP finance) level

Office manager

<p>Consultants</p> <ul style="list-style-type: none"> • Real estate • Architecture/engineering 	<p>Service contractors</p> <ul style="list-style-type: none"> • Food & beverage • Interior design/decorating • Voice and data systems • Security 	<p>Building manager/lessor</p> <ul style="list-style-type: none"> • Operations, maintenance, repair
---	---	---

Reliance on lessor or landlord, contractors and consultants as service providers.

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FM Structure: One Location, One Site

VP level
(e.g., VP administration)

<p>Facilities director</p> <ul style="list-style-type: none"> • Staff • Strategic planning • Real estate • Work desk • Project management • Finance 	<p>Other director levels: e.g., purchasing, IT, HR</p> <p>Leads</p> <ul style="list-style-type: none"> • O&M • Engineering • Space planning and management • Workplace design • Workplace management • Capital projects
--	---

FM uses staff, department leads, and contractors/consultants.

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FM Structures: One Location, Multiple Sites

```

graph TD
    VP[VP level] --> DofF[Director of facilities]
    VP --> Other[Other director levels:  
e.g., purchasing, IT, HR]
    DofF --> HQ[Departments located at HQ]
    DofF --> Sites[Sites]
    HQ --> Admin[• Administration]
    HQ --> Strategy[• Strategy]
    HQ --> RealEstate[• Real estate]
    HQ --> WorkCenter[• Work center]
    HQ --> Finance[• Finance]
    HQ --> Planning[• Planning & design]
    HQ --> OandM[• O&M]
    Sites --> HQFacility[• HQ facility]
    Sites --> Remote[• Remote sites  
(Leased sites use office manager model.)]
    
```

Headquarters with remote sites that may be owned or leased.

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FM Structures: Public Works Model

```

graph TD
    Electorate[Electorate] --> Mayor[Mayor/City council]
    Mayor --> CityManager[City manager]
    CityManager --> PWD[Public works director]
    CityManager --> Other[Other directors: e.g., finance,  
police, environmental management, parks]
    PWD --> Admin[Administration]
    PWD --> Eng[Engineering and maintenance services]
    PWD --> Trans[Transportation]
    Eng --> EngList["• Capital projects design  
• Construction management  
• Streets maintenance  
• Parks maintenance  
• Facilities maintenance"]
    Trans --> TransList["• Planning & engineering  
• Public transit services  
• Public parking services"]
    
```

Services defined by mission and public expectations.

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FM Structures: Multiple Locations, Strong HQ

Headquarters FM performs organization-wide services and directs regional FM.



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FM Structures: Fully International Model

Headquarters may set broad policies and provide services, allowing regions to act independently, or implement detailed policies and procedures for greater control.



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Policies, Procedures, and Standards

Policy	Set of principles that direct members how to act
Procedure	How policy will be achieved
Standard	What service FM does or does not support and how occupants are expected to behave

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Benefits of Having Policies and Procedures

- Uniformity of purpose and action across organization
- Uniform facility “brands”
- Alignment of internal and external perceptions with organization’s goals (“We are seen as we want to be seen.”)
- Risk management tool (better compliance, sign of good-faith effort)
- Improved efficiency

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Systems Thinking

Recognizing the interconnectedness of things

Systems are designed to:

- Align work with strategy.
- Share information.
- Provide data for better control.
- Support decision making.

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Managing Facility Change

Change

Effective change is aligned with the organization's directions and needs.

Effect


It changes occupant behavior and eventually becomes part of the organization.

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 **Discussion Question**

Why would occupants and staff resist changes introduced by FM?

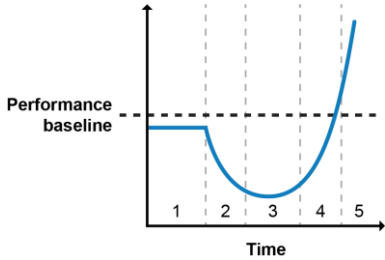
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Impact of Change on Productivity



- Productivity declines at first but gradually recovers and eventually achieves desired improvement.
- FM action can speed the recovery and time to goal.

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Change Management Process

The diagram illustrates the Change Management Process through three sequential stages, each represented by a blue arrow pointing right:

- Unfreeze**
 - Assess readiness for change:
 - Right leaders
 - Right structures, resources, skills
- Move**
 - Create awareness of need.
 - Develop support.
 - Equip with tools.
 - Reinforce change.
- Refreeze**
 - Use gains to create more change.
 - Anchor change in culture.

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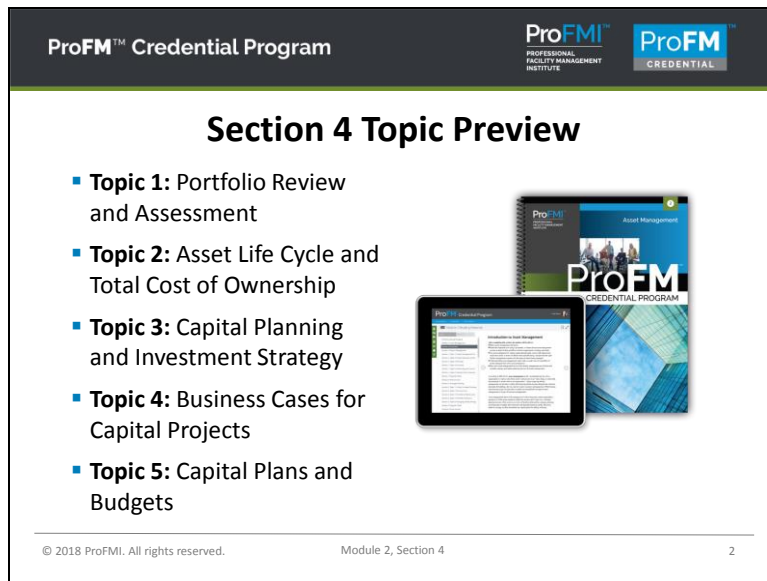
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Discussion Question

FM has a strategic goal to improve physical and digital security. This will require changes in policies and procedures. Facility access protocols and occupant behaviors must change. How can FM introduce this change effectively?

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Section 4: Capital Planning




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Capital Investment Categories

- Obsolescence
- Operational
- New construction



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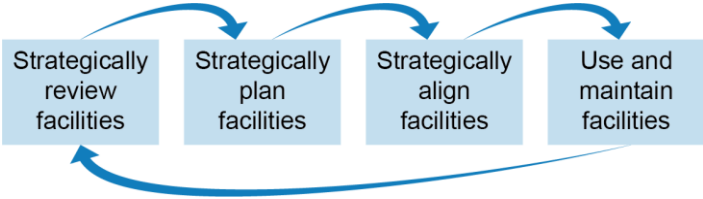
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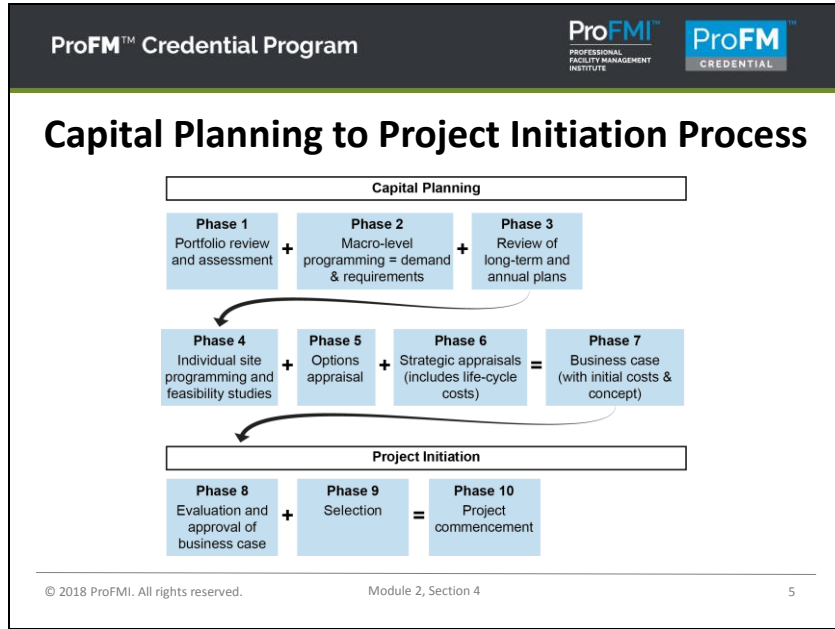
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Portfolio

A portfolio is the entire set of facilities or other capital assets owned or leased and operated by the organization.



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Portfolio Review and Assessment

Portfolio review and assessment steps:

1. Data gathering
2. Database preparation
3. Facility condition assessments
4. Portfolio review and analysis

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Data Gathering and Database Preparation

- Required information is usually spread across computer systems.
- Possible required steps:
 - Access multiple systems.
 - Transfer data to common database.
 - Prepare data for comparison.



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Facility Condition Assessments or Surveys

- Known as:
 - Facility condition assessments (FCAs).
 - Property condition assessments (PCAs).
 - Property condition surveys (PCs).
- Use consultants with expertise to perform assessments.



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Discussion Question

Why are FM staff not ideal to conduct FCAs?

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Facility Condition Index

A **facility condition index (FCI)** is a ratio that compares the current outstanding maintenance, replacement, and repair costs for a facility to the current cost of replacing it with a new facility.

Guideline Scores

Good—Under 0.5

Fair—0.5 to 0.10

Poor—Over 0.10

$$FCI = \frac{\text{Current Maintenance, Replacement, and Repair Deficiencies}}{\text{Current Replacement Value}}$$

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Portfolio Review and Analysis

Includes:

- Facilities portfolio
- Capability
- Performance improvement
- Scenario projections

Elements in Portfolio Review and Analysis	
• Time in service	• Space
• Cost to operate	• Capacity for production
• Capital value	• Functional fitness
• Flexibility	• Quality
• Condition	
• Footprint	

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Total Cost of Ownership

The **total cost of ownership (TCO)** is all the expenditures an owner can expect to make during the service life of a structure/asset.

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TCO Components

TCO comprises several parts:

- Initial design and construction price
- Annual capital renewal costs
- Operations and maintenance (O&M) costs
- Sale or demolition costs

Component	Percentage
Design and construction	20%
Capital renewal	25%
O&M	55%

Improved energy efficiency: savings of 10% in O&M cost

More durable materials: savings of 5% in capital renewal cost

Legend: Design and construction (dark blue), Capital renewal (white), O&M (light blue)

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Influencing TCO

Methods that can decrease TCO:

- Maintain systems and the facility with the goal of optimizing their expected lives.
- Reduce the need for space expansion or change.
- Design and construct or select new and replacement systems that minimize disposal costs and/or maximize sale or salvage value.

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System Disposal Costs

- Disassembly or demolition
- Removal of salvageable parts
- Removal and recycling of non-salvageable parts
- Environmental charges for hazardous material mitigation or site clean-up




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Discussion Question

What are some examples of system disposal costs?

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Asset Life Cycle

Facility layers:

- Site
- Structure
- Skin
- Services
- Space plan
- Stuff

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Life-Cycle Assessment

A **life-cycle assessment (LCA)** takes an inventory of the inputs and outputs of materials, systems, or entire facilities and analyzes the environmental and resource use impacts of asset choices over their expected life cycles.

```

    graph TD
      A[Define goals and scope.] --> B[Analyze input/output inventory.]
      B --> C[Assess impact.]
      C --> D[Interpret results.]
      D --> A
      D --> B
      D --> C
  
```

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Define Goals and Scope

- No single attribute or phase in a product's life cycle dictates overall, long-term environmental impact.
- LCA software is available to assist with environmental impact determination.



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Analyze Input/Output Inventory

- Data confined to specific systems
- Data composite of same types of systems
- Multi-process aggregation
- Industry-average benchmarking
- Generic qualitative descriptions

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Assess Impact

- Classifies outputs of systems or facilities into categories, often by emissions
- Other problem areas that may be assessed:
 - Wildlife habitat alteration or destruction
 - Ozone layer depletion
 - Smog production
 - Use of fossil fuels and other nonrenewable energy sources
 - Influence on climate change
 - Water use
 - Water pollution
 - Addition of acids to air, land, or water
 - Toxic releases into air, ground, or water



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Interpret Results

- Creating an artificial standard unit for comparison may make results more easily comparable.
- Once impact of proposed or current systems is understood, FMs may use the information to make choices on systems and facilities.



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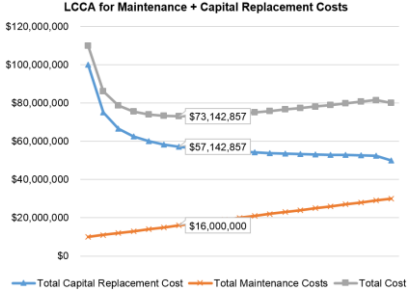
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Life-Cycle Cost Analysis

Life-cycle cost analysis (LCCA) allows for comparison of feasible alternatives and justification for capital expenditures.



LCCA for Maintenance + Capital Replacement Costs



Time Period	Total Capital Replacement Cost	Total Maintenance Costs	Total Cost
Initial	~\$100,000,000	~\$10,000,000	~\$110,000,000
Mid-Point	\$57,142,857	~\$16,000,000	~\$73,142,857
End-Point	~\$50,000,000	~\$30,000,000	~\$80,000,000


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LCCA Terminology

- Time value of money
- Present value
- Discount rate
 - Constant dollars and real discount rate
 - Inflation-adjusted dollars and nominal discount rate
- Net present value
 - One-time costs
 - Recurring costs
- Salvage value



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LCCA Process

Basic process for LCCA:

1. Create feasible alternatives.
2. Set all relevant assumptions and parameters.
3. Project benefits and costs.
4. Estimate when benefits and costs begin.
5. Apply discount rate and future year to convert each year's future costs to initial value.
6. Compare net present values of all alternatives and choose one with lowest total life-cycle cost.

The diagram illustrates the LCCA process. It shows a horizontal flow of stages: 'Site choice & prep', 'Construction & commissioning', 'Continuous use & operation', and 'Renewal or disposal'. Below 'Construction & commissioning' are 'Parts manufacturing' and 'Harvesting raw materials'. A blue arrow labeled 'Use Period' spans from the start of 'Construction & commissioning' to the end of 'Continuous use & operation'. A larger blue arrow labeled 'Facility life cycle' spans the entire duration from 'Site choice & prep' to 'Renewal or disposal'. A box above the 'Use Period' arrow indicates an 'Economic impact study period 50 years'.

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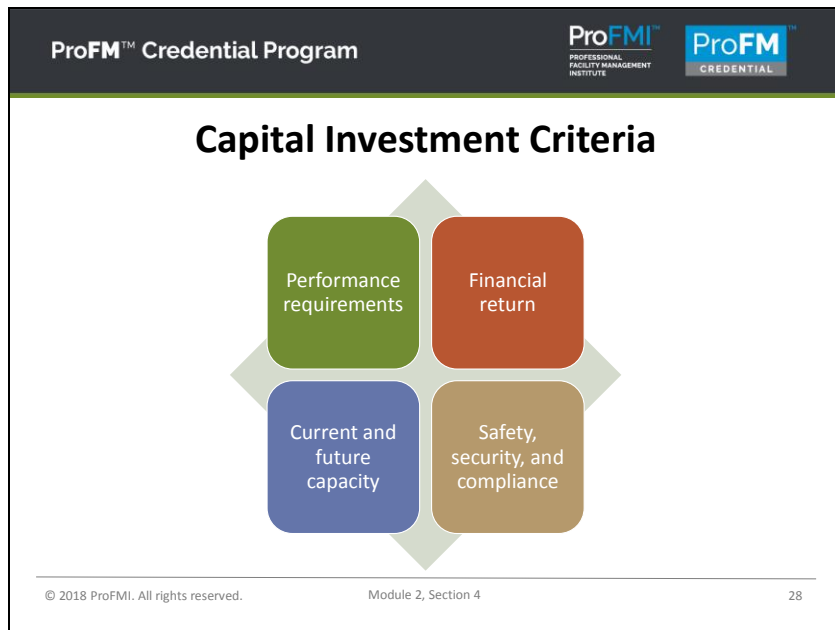
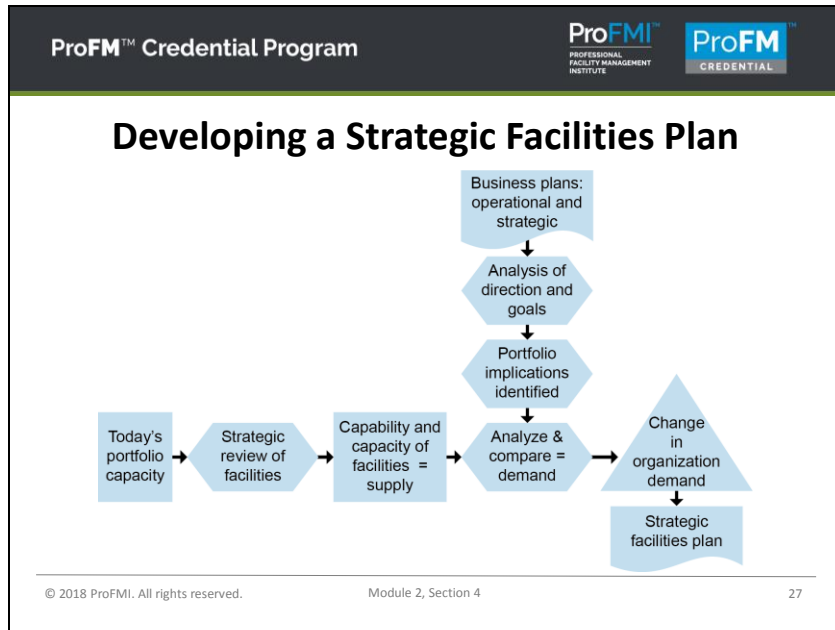
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Combining LCA and LCCA Analyses

- Provides extremely detailed look into environmental and economic impacts of capital investments

The diagram features two large, stylized arrows pointing towards each other. The left arrow is orange and labeled 'LCA'. The right arrow is blue and labeled 'LCCA'. They are positioned such that their tips meet in the center, symbolizing the combination of the two analyses.


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Discussion Question

What are the key performance requirements at the strategic FM level to include in financial return analyses?

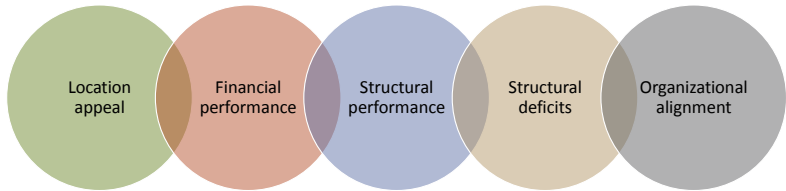
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Demand and Supply Gap Analysis




Location appeal Financial performance Structural performance Structural deficits Organizational alignment

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Performance Improvement Analysis

- Focuses on steps needed to adjust existing capacity to fit future needs
- Should include list with timing and priorities identified



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Scenario Analyses

- Involve the creation of a financial model.
- Organization management can use the analysis to get an idea of how well their future plans match their current portfolio's capacity.

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Facility Alignment Strategy and Investment Strategy

Recapitalization plan key to capital budgeting

```
graph TD; A[FM investment strategy should have a clear model that.] --- B[Ensures optimal use of facility across all time frames.]; A --- C[Plans to proactively renovate/rehabilitate or replace structures.]; A --- D[Validates that the total amount of fixed assets is in line with organizational guidelines.]; A --- E[Makes capital plans in advance.]
```

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Facility Requirements and Goals

Questions That Must Be Asked:

- What organizational function will the space facilitate?
- How many people must be housed?
- What public and site infrastructure must be in place?
- What internal and external site obstacles currently exist?
- What specialized equipment, machinery, storage, or workspace is required?
- What sustainability, organizational image, or cultural specifications must be included?
- What other special business or personal accommodations must be considered?
- What are the mandatory requirements?

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Lease, Buy, Build Out, or Construct Analysis

Important questions that impact the decision:

- How much expertise is there in house?
- What guidance is provided in organizational and FM strategic plans?
- What is the organization's financial position?
- Is the organization ready to take on the burdens and risks of ownership?
- Can the organization generate the sustained cash flow required for profitable ownership?
- What is the market or industry trend for owning versus leasing?
- Are interest rates attractive?

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Site Selection

Market Survey

Site costs	Geographic locations
Zoning restrictions	Opportunities
Risks	Benefits


▲

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Discussion Question

What are some examples of environmental and sustainability principles to pay attention to when selecting a site if the organization is interested in LEED certification?

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Feasibility Analysis

- Evaluate whether the site or capital project can fulfill requirements.
- Predict and list project development and implementation tasks.
- Estimate project timeline and schedule, milestones, budget, human resources, and equipment needs.
- Compare technological, utility, and transportation requirements against site capabilities.
- Explore environmental impacts and remediation, compliance requirements, and other necessary costs.

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Macro-Level Cost Estimation

Types of macro-level cost estimates:

- Informal estimate
- Generic or analogous estimate
- Comprehensive estimate

Cost categories:

People	Utilities	Maintenance
Space	Build-outs	Furniture
Site surroundings	Access roads	

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Due Diligence Analysis

Works to avoid potential pitfalls due to issues in the following areas:

- Political
- Economic
- Sociological
- Technological
- Legal
- Environmental



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Single-Site Facility Plan

Contains:

- Customer or demand organization requirements.
- Occupant demographics and needed organizational functions.
- Project context in the form of detail from prior analyses.
- Design priorities and attributes needed to begin the design visualization process.



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Elements of a Business Case

Elements of a business case should:

- Explain the drivers behind and impacts of the project.
- Discuss major stakeholder needs, wants, and issues.
- State any opportunities and risks related to the project or of the status quo.
- Provide supporting examples and information, including data and information from previous analyses.
- Ensure that all organizational data and processes used as source material are up to date.

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Elements of a Business Case

Problem or opportunity

Strategic fit

Financial and nonfinancial analysis results

Risk and opportunity analysis results

Project management and delivery strategy

Alternative solutions

Recommendation

Business case approval

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Statement of Work

- **Statement of work (SOW)** is a narrative description of the work that needs to be done to fulfill project objectives.
- **Specifications** are alternative methods of setting requirements for the quantity and quality of work to be done, services to provide, standards to use, results to achieve, or materials, systems, or equipment to provide.

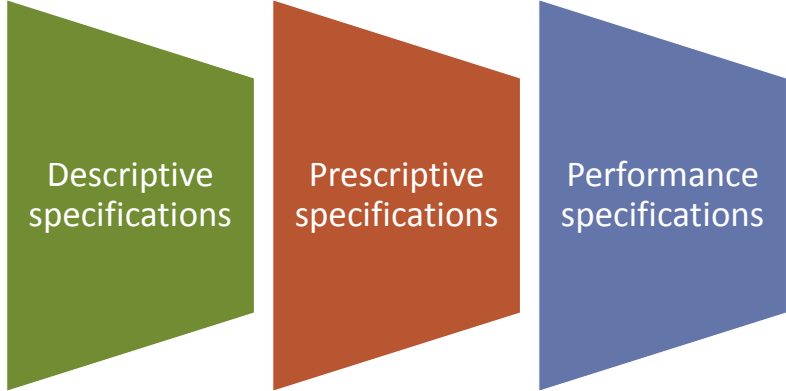
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Specification Types



Descriptive specifications

Prescriptive specifications

Performance specifications

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Capital Planning and Budgeting Policy and Strategy

Two primary rules must be followed:

- Current tax code
- Organizational policy



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Inputs

Requirements gathering should include:

- Business case.
- Statement of work.
- Conceptual representation, mock-up, or drawing.
- Other inputs from appropriate stakeholders or technical experts.

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Ranking/Prioritizing Capital Project Requests

- Gather requirements for each project and summarize in one document.
- Compare capital evaluation metrics, requirements, strategic fit, and rationale for each project.
- Categorize and rank projects in priority based on the primary decision criteria.
- Refine project ranking using other criteria.
- Submit the ranked list of projects for consideration as part of a capital budget request.
- Prepare a summary argument that justifies the overall funding request.

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Long-Range Capital Plan

Must include:

- Projects by name, identification number, and planned start and end dates.
- Capital expenditure breakdown.

Included in Capital Expenditure Breakdown

- Actual costs/expenses incurred
- Any carryover capital costs
- New expenses planned for the next fiscal year
- Total capital expenditures for the planning time horizon
- Total capital expenditures by fiscal year


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Facilities Portfolio Rationalization

Ensures that organization's ROI is maximized

Surplus owned property disposal methods:



- Selling after improvement
- Selling it as is
- Leasing it as rental property
- Donating it to get tax deductions
- Allowing it to enter foreclosure
- Offering it as part of a business deal
- Offering it in a tax-deferred exchange

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Capital Replacement Plan

- Focuses on the replacement of facility systems at appropriate times.
- **Alterations** change the space from what it was originally designed for.
- **Improvements** increase a space's capability for efficiency or productivity.

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Program Management

- Contains schedule of projects for multiple years
- May span multiple fiscal years, countries, and business units
- Used to prevent cash flow issues

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Annual Capital Plan/Budget

- Must be kept up to date with new projects, priority changes, and cancelled projects.
- Managing timing of capital expenditures is critical.




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Questions?



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Section5: Construction



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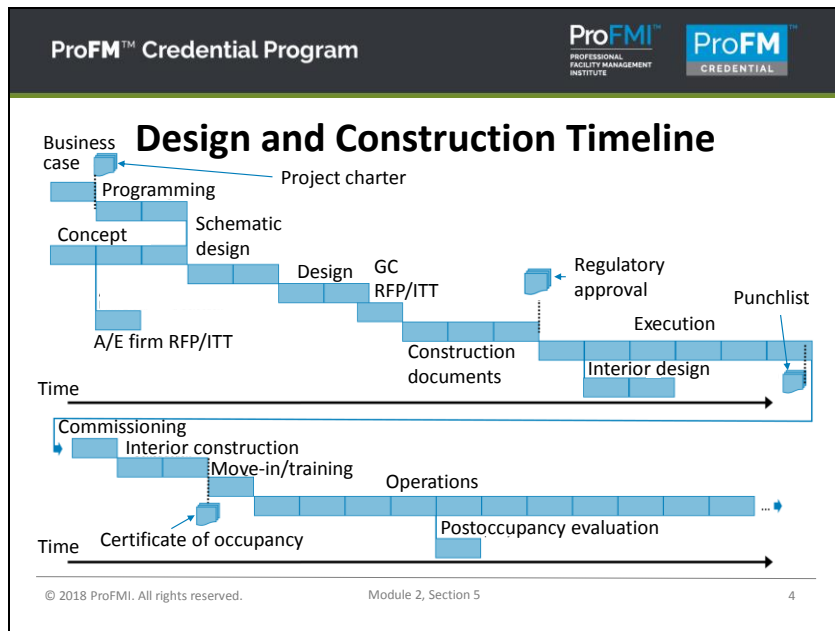
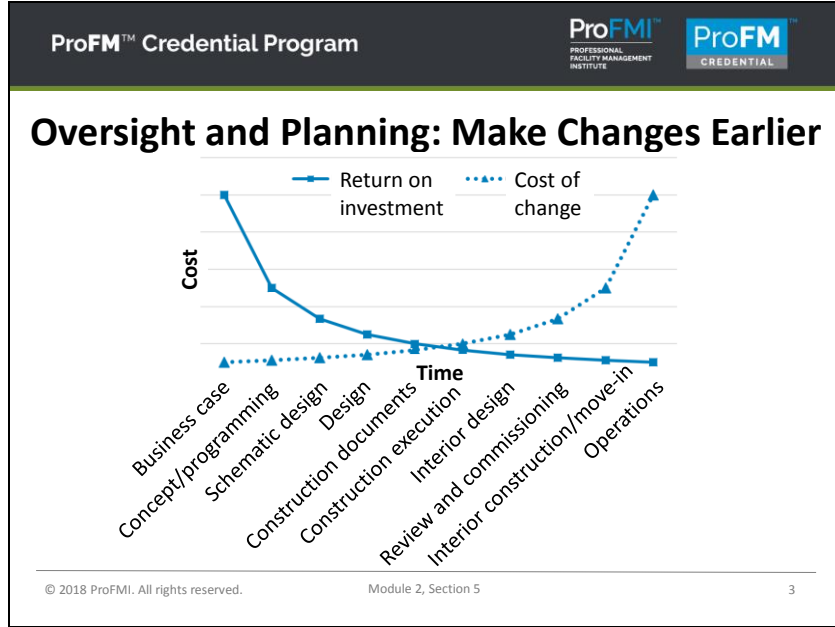
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Section 5 Topic Preview

- **Topic 1:** Initiation for Construction
- **Topic 2:** Design and Construction Planning
- **Topic 3:** Programming
- **Topic 4:** Facility Concept and Schematic Design
- **Topic 5:** Design and Construction Documentation
- **Topic 6:** Construction Execution and Monitoring and Control
- **Topic 7:** Construction Project Closeout

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 **Discussion Question**

What can facility managers do to get general contractors (GCs) to make quality facilities?

- a) Require the GC to make all construction documents rather than having subcontractors do portions.
- b) Specify minimum GC experience in similar facilities of similar numbers of square feet/meters.
- c) Review the punchlist with the GC at the kickoff.

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Construction Project Oversight

<p>Governance committee</p> <ul style="list-style-type: none">▪ Sets goals and measurable objectives▪ Specifies requirements and quality▪ Change control board final decider▪ Sets expert agenda and reviews their submittals▪ Reports to CEO/board	<p>Experts committee</p> <ul style="list-style-type: none">▪ Decides on daily design and construction issues▪ Adjusts course to stay on schedule/budget▪ First assessor of change order requests▪ Reviews alternatives, progress, and risks
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Project Management Office or Other Support

- Portfolio management/program management
- FM leadership and influence over multiple projects
- Aligns with organizational strategy and policies
- Keeps sustainability and life-cycle cost focus
- Avoids FM pain points like unnecessary confined spaces
- Corrects record keeping, IS, and as-built drawings
- Follows commissioning/decommissioning standards
- Benefits more from postoccupancy evaluations

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Project Charter: End Results and Scope

- Concise, easy-to-read statement of end results.
- Phases and milestones clear, e.g., demolition phase.
 - “The new facility shall be open for business and fully operational no later than June 1, 20XX.”
- Total square feet or meters, plus expansion options.
- Document should never need to change.
 - More than one path to success (e.g., LEED GOLD or LEED SILVER certification for health care, version xx.xx)?
 - High-level site requirements and concept.
 - Processes, methodologies, metrics, and controls to use.

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Selecting Project Manager (PM)

Contractor or employee with:


- Design-build expertise.
- Knowledge of local codes, regulations, and licensing for type of facility.
- Soft skills.

Construction management:

- Coordinate multiple construction projects.
- Oversee progress and payments.

General contractor as PM:

- May require different PM during design or GC design-build firm.



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Role of Facility Manager on Construction Projects

Facility manager as PM?

- Right skill set needed.
- No general contractor fee.
- No volume discounts from subcontractors.
- Opportunity cost:
 - Backlog
 - Additional FM staff cost

Facility manager oversight

- Get the right PM.
- Administer contracts.
- Inspect and accept completed work at site.
- Design review expertise (have or get).
- Represent end users.

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Project Team

Contractors

Architect: Design for function, looks, sustainability, and organization's vision.

Engineer: Calculate specialized area's requirements (M, E, S, C, A).

General contractor: Marshal forces, timing. Knows local and industry-specific codes?


Interior designer

Commissioning agent

External

Plan examiner

Building inspector



Proven team or custom but new?

Internal or contractor

Project manager

Scheduler

Inspectors

Cost estimator

Modeling analyst

Project accountant

Contracting officer

Safety and compliance officer

Construction procurement officer



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Range of Architectural-Engineering Services

- Feasibility analysis and cost estimation
- Conceptual design
- Programming
- Schematic design
- Construction documentation
- Commissioning support (criteria, system integration)
- Construction review (fabricated materials, changes)



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Charter: Budget, Schedule, Constraints, Approvals

- Macro-level budget and schedule from business case
 - Adjust indexes like *Engineering News Record's* ENR index or *RSMean's Construction Cost Data* for local market costs.
- Parametric estimates: volume (square feet/meters) × rate (cost per square foot/meter for space type)
- General contractor estimate
- Constraints: Site entry, orientation, parking, trees, noise
- Signatures for accountability
- Partnering charters for collaboration

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Commissioning

- Systematic process that goes beyond punchlist.
- Verify and document facility and systems function per:
 - Specifications at average and peak loads and in failure modes.
 - Owner's operational requirements.
- Starts in design: system and subsystem requirements.
- Who is liable for rework and if change orders allowed:
 - Owner risk if prescriptive or descriptive specification.
 - Contractor risk if performance specification (end results).
- Document testing plan and schedule.

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Commissioning

- Factory witness testing.
- Inspect on arrival.
- Installed with utilities:
 - Start-up: Manufacturer recommendations and codes.
 - Document results.
- Independent commissioning authority.
- Benefits > costs?

The diagram illustrates four levels of commissioning: **Individual** (a single yellow unit), **Subsystem** (a group of units connected together), **System** (multiple subsystems connected), and **Integrated** (the entire facility with a central red sphere and blue spheres). A plus sign (+) is shown between the 'Integrated' level and a box labeled 'CMMS facility analysis'.



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Project Delivery Systems

<p>Design-bid-build</p> <ul style="list-style-type: none"> ▪ RFP/ITT to AE firms ▪ AE subcontractor alignment ▪ Dimensional accuracy disclaimer ▪ Substantially complete design: RFP/ITT to GCs ▪ Low/high bid comparison ▪ Change orders a risk if low bid missing things ▪ Long lead-time items delay 	<p>Design-build</p> <ul style="list-style-type: none"> ▪ AEC firm liable for errors and omissions ▪ Owner changes add cost ▪ Earlier, cheaper changes, but design frozen earlier ▪ Earlier cost estimates ▪ Shorter duration ▪ Programming reflects multi-project goals? ▪ Best value, sustainability, and life-cycle cost kept in?
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Project Delivery Systems

- Construction management at risk
 - AE firm and construction manager at initiation
 - Guaranteed maximum price (GMP) limits cost overrun liability
- Fast tracking
 - Start parts of construction early, making cost estimates hard
- Turnkey
 - Hands-off reduces owner tasks, risks less-than-ideal solution
- Integrated project delivery (IPD)
 - Collaborative from start with risk/reward contracts
 - Building information modeling (BIM)
 - Integrate to meet multiple requirements at low cost, less rework

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Building Information Modeling (BIM)

- Collaboration methodology
- Whole life cycle: concept, design, construct, operate, maintain, alter, dispose
- Open, standards-based, machine-readable format
- Any compatible software can interface (verify)
- Meet holistic goals such as for sustainability
- Less rework between design and construction documents
- More profitable for AE and GC due to faster and more accurate changes and better procurement timing
- No data reentry at handover and revision history available

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BIM Rules: Parametric Objects

Feature	Description	Example
Objects with parameters	Rules or data governs objects (e.g., an I-beam, a chiller).	I-beam engineering properties and maximum variable length.
Non-redundant objects	Same object used for two- and three-dimensional plans for consistency.	I-beam is same length in two- and three-dimensional renderings.
Automatic alignment	Placing object in model automatically adjusts variable components to fit space.	I-beam snaps to attaching I-beams, setting the length so no gaps exist.
Rule violation warnings	Validate manufacturability, size, weight, power load, capacity, pressure, etc., given any changes.	I-beam insufficient for load after different subcontractor's BIM upgrades an HVAC system.
Data aggregation	Total aggregated weight, etc.	Total weight of I-beam structure.

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Discussion Question

An executive lists software, training, change management, and consulting fees as big cost increases of BIM. What can offset these costs?

- a) All contractors using BIM
- b) Fewer errors and omissions
- c) Truly seamless transition from design to construction documents

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Methods of Design and Construction Contracting

Lump sum	Cost-plus-fixed-fee	Guaranteed maximum price	Custom
<ul style="list-style-type: none"> • Design-bid-build or turnkey. • Fixed price is risk for AE or GC, so build in higher profit. • Change order risk. 	<ul style="list-style-type: none"> • Design-build, construction management, or fast tracking. • Total cost not known until plans complete. • Independent estimates needed. • Design change costs passed on. 	<ul style="list-style-type: none"> • Construction management at risk. • Only owner changes increase price. • Construction manager losses from errors and omissions. • Adversarial. • High profit. 	<ul style="list-style-type: none"> • Integrated project delivery. • Incentives for collaboration. • Share risks and rewards. • All motivated to find ways to cut costs.

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Design and Construction Firm Bidding/Selection

<ul style="list-style-type: none"> ▪ Reasonable time for preparation and response. ▪ Customize questions to draw out answers that are differentiators. ▪ Project management and key staff expertise. ▪ Local code knowledge. ▪ Innovation in bids. ▪ Able to collaborate. 	<ul style="list-style-type: none"> ▪ Bid price, best value, and/or life-cycle cost. ▪ View plans at site (field conditions). ▪ Experts committee sets criteria weighting: <ul style="list-style-type: none"> ▪ Members should read all bids and may vote. ▪ Government organizations should document why choice differs from highest weighted score or vote.
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Scope and Schedule Planning

Scope

- Statement of need or work from approved business case
- Detailed line-item work breakdown structure

Schedule

- Milestones
 - Success risk
 - Share with all parties
- Architect decides % completion?

Granular level
High level
Business case
Innovate on scope

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Budget Planning

Order-of-magnitude budget	Occupant unit budget	Parametric estimate budget	Systems or assembly estimate budget	Unit price estimate
<ul style="list-style-type: none"> ▪ Similar facilities ▪ For feasibility studies 	<ul style="list-style-type: none"> ▪ Occupants and historical cost per occupant ▪ For project charter 	<ul style="list-style-type: none"> ▪ Square feet/meters times cost per square foot/meter ▪ From programming 	<ul style="list-style-type: none"> ▪ Market price for selected systems ▪ From schematic design 	<ul style="list-style-type: none"> ▪ Detailed line-item budget at 65% complete design, with final at 100% ▪ From GC

Iteration	Accuracy Range
Order-of-magnitude	+50% to -30%
Occupant unit	+40% to -25%
Parametric estimate	+30% to -20%
Systems or assembly estimate	+20% to -10%
Unit price estimate	+10% to -5%

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Parametric Estimate Budget Example

Total project cost per square foot (or meter) useful for comparisons

Project: Headquarters data center			
Project number: 120384			
Date: 11/1/2017		Budget version: 1.4	
Current milestone: Design RFPs issued			
Direct construction costs	Volume (ft²)	Rate (\$/ft²)	Cost
Demolish existing facility	3,200	\$200	\$640,000
Grade and prepare site	6,000	\$30	\$180,000
Set up site safety and security	6,000	\$5	\$30,000
Data center construction			
Common areas	1,200	\$90	\$108,000
Facility systems area	1,000	\$110	\$110,000
Data center area	1,500	\$120	\$180,000
	3,700		\$1,248,000
Other construction costs		% of direct costs	
Off-site utility connections (flat fee)	N/A		\$50,000
Fixed equipment (security and facility systems)		30%	\$374,400
Movable equipment (includes IT hardware)		13%	\$162,240
			\$112,320
Management reserve		9%	\$112,320
Total construction cost			\$1,946,960
Services costs		% of total costs	
Architectural-engineering designs and consulting		9%	\$175,226
Project management and cost estimating		2%	\$38,939
Programming (internal)			\$0
Property survey (flat fee)	N/A		\$20,000
Environmental assessment (flat fee)	N/A		\$50,000
Plan reviews and permitting (flat fee)	N/A		\$15,000
Land acquisition	(already paid)	N/A	\$1,200,000
Total project cost			\$3,446,126
Total project cost per square foot			\$931

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Initial Occupancy Planning

- Relocations are separate projects needing planning.
- Long-term or project-specific contractors: Equipment and furniture installers, signage vendors, art installers, movers.
- Keys for vendors and security.
- Bottlenecks such as freight elevators.
- Storage and special dumpsters.
- Change management and communication (e.g., newsletter).
 - Milestones and how to get to work, how to pack, how to track, etc.
- Move day
 - Cater lunch?
 - Vendors on site for finding items or touch-ups.

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Operations and Maintenance Planning

- Staff training
- System documentation and facility handbook
- Actual cost database and benchmarking
- Design issues that may affect O&M

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Programming

- Project's/program's requirements for period of time
- Performance expectations of organization and end users
- Mandatory (e.g., code) requirements

Steps:

1. Identify business functions/programs by type and volume.
2. Forecast number of workers for planning horizon.
3. Perform technical analysis per worker plus support space.
4. Gather end-user input to validate technical analysis.
5. Develop quantity, quality, and custom feature specifications.
6. Compile relevant design, AE, regulatory, policy standards.
7. Set space standards and reevaluate feasibility.
8. Calculate minimum space requirements per function, program, building core, site.

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Identify Business Functions to Accommodate

- Activities to be performed over planning horizon
- Strategic plans, business cases
- Adjacency diagram

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Forecast Occupants/Perform Technical Analysis

<p>Forecast workers and guests</p> <ul style="list-style-type: none"> ▪ Needed workers: Revenue forecasts and forecasts of productivity per worker ▪ Guests ▪ Long-term horizon for facility ▪ Lead or lag expected growth? 	<p>Perform technical analysis</p> <ul style="list-style-type: none"> ▪ Workspace per worker ▪ Shared support services ▪ Common spaces ▪ Building core ▪ Security or special design ▪ Site access
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Gather End-User Input

- Technical analysis gives end users something to react to.
- Validate results, and help end users feel heard.
- Questionnaires to representative set.
- Requirements for security, accessibility, specialized areas.
- Review new requirements for applicability and feasibility.
 - For example, ranking optional additions or benefit-cost analysis
- From business requirements to facility requirements:
 - Total, average, peak?
 - Remote workers or second shift?
 - IT, copiers, printing, security, cleaning, catering, equipment...

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Specifications and Design Standards

<p>Develop specifications</p> <ul style="list-style-type: none"> ▪ Translate validated requirements into specifications for: <ul style="list-style-type: none"> ▪ Quantity of each type of space. ▪ Quality needed. ▪ Special features. 	<p>Compile design standards</p> <ul style="list-style-type: none"> ▪ AE manuals and standards ▪ Optional standards like LEED ▪ National, regional, local regulations ▪ Organizational policies ▪ Modify specifications
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Set Space Standards and Reevaluate Feasibility

- Square foot/meter requirements per worker and per support space.
 - Cubic dimensions for some spaces like warehouses.
 - Square meters/feet for other areas like shop floor.
- Review feasibility initially conducted for business case.
 - Engineering requirements understated?
 - O&M feasibility?
 - Communications dynamics between functions optimal?
 - Fine-tuned cuts to meet not-to-exceed budget.
 - Redo financial metrics for ROI, etc.

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Calculate Minimum Space Requirements

$$\left(\begin{array}{l} \text{Worker} \\ \text{Forecast} \\ \text{(Volume)} \end{array} \right) \times \begin{array}{l} \text{Area's Space} \\ \text{Standards in} \\ \text{Square Feet/} \\ \text{Meters per} \\ \text{Worker (Rate)} \end{array} \left. \right) + \begin{array}{l} \text{Area's} \\ \text{Common} \\ \text{Space in} \\ \text{Square Feet/} \\ \text{Meters} \end{array} = \text{Minimum Space} \\ \text{Requirements}$$

- Similar calculations for building core, etc.
- Convert net floor area (usable) to gross floor area (+ walls, envelope, core).
- Feasibility: Ratio of facility footprint to total site area.
- Allows new budget estimate.
- Architects—Detailed site plan validating:
 - Footprint
 - Daylighting
 - Views from and of facility
 - Circulation
 - Parking and delivery access

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Design Review Process

- Virtual meetings may visualize, edit design.
- Design charrette:
 - Shared goals, priorities.
 - Explore design ideas.
 - Collective wisdom.
- Internal design team reviews (review, assign):
 - Short iterative cycles.
 - Intense bursts of effort.
- Formal owner reviews:
 - True to goals, life-cycle cost, maintainability, sustainability?
- Criteria to move beyond each milestone:
 - Redo energy, water, peak demand simulations.
 - Meets sustainability, user needs, and other goals?
 - Added costs in one area offset by other savings?

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Discussion Question

According to Roper and Payant, when is the best time to do a constructability review?

- a) Design concept complete
- b) Design 25% to 35% complete
- c) After checking for errors and omissions
- d) Design 80% to 85% complete

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Design Concept

- Written requirements and constraints
- Visualizations and models
- Multifaceted design goals
 - Operations effectiveness
 - Sustainability and energy efficiency
- High-level cost estimate based on design features
- Concept review
 - Meets strategic goals and specific requirements? Feasible?
 - Initial price as well as O&M cost estimates




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Design Concept Areas

 <p>Site</p> <ul style="list-style-type: none">• Drainage and storm water• Parking, traffic, and public transport• Customize to climate and terrain	 <p>Facility</p> <ul style="list-style-type: none">• Mission and vision• Functional area square feet/meters• Special (e.g., delivery doors)• Structural (e.g., earthquake)• Circulation	 <p>Systems, utilities, equipment</p> <ul style="list-style-type: none">• Mechanical• Electrical• Orientation• Energy model by month• General capacities and space needs, not specific systems
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Schematic Design

- Validate regulations compiled in programming.
 - Plumbing code, HVAC code, gas code, life safety code...
 - Testing to determine capacities of potential systems
- Systems, materials, and equipment type selection.
 - From foundations to finishes
 - Landlords
 - $$\frac{\text{Rentable square feet/meters}}{\text{Gross Internal Area}} = \text{Net Internal Area} = \begin{matrix} 80\% \text{ minimum,} \\ 84\% \text{--}87\% \text{ ideal} \end{matrix}$$
 - $$\frac{\text{Inside dimensions of exterior walls}}{\text{Gross Internal Area}} = \text{Net Usable Area} = \begin{matrix} 75\% \text{ minimum,} \\ 80\% \text{--}84\% \text{ good} \end{matrix}$$
 - Occupiers
 - $$\frac{\text{Includes building core}}{\text{Net Usable Area}} = \text{Net Usable Area} = \begin{matrix} 75\% \text{ minimum,} \\ 80\% \text{--}84\% \text{ good} \end{matrix}$$

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Schematic Design

- System capacity and type enable better cost estimates.
 - May use actual quantities and prices for standardized items
 - Parametric estimates for custom areas
 - Remaining design costs accurately known
 - Estimates of lost productivity, relocations, real estate, fees
- Constructability and cost feasibility reviews.
- Schedule versus deadlines.
- Go/no go point.
- Passing final schematic design review releases designers.

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Design and Engineering

- Full schematics and detailed engineering specifications.
- Mandatory and non-mandatory design criteria.
- Facility managers should be able to interpret two-dimensional design drawings and provide feedback.
- Other stakeholders strongly benefit from three-dimensional virtual or physical models, snapshots, and walkthroughs.
- Documents on circulation and access, systems, structure, walls, roofs...
- Modeling software for acoustics, energy, structural properties, thermodynamics, earthquakes...

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Building Information Modeling (BIM) Designs

- BIM model can produce both two- and three-dimensional documents.
- Color-coded spaces by function.
 - Meeting rooms, etc., appropriately sized?
- Three-dimensional visualizations and walkthroughs.
 - Faster but labor-intensive
 - May require added software, expertise
- More accurate and able to show alternatives.
- Simultaneous reviews reduce duration.
- Negotiate in advance degree of precision.


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Value Engineering

Goals: All items to meet success criteria; no unnecessary or wasteful items **Risks:** Too much focus on initial cost; worse life-cycle cost/maintainability; failure to get sustainability certification

“This alternative can save money with little impact on quality, maintainability, or aesthetics.”



Design/construction consultant

“Eliminating these sustainability features and materials will get us to our cost target.”

“This is a good balance between needs and nice-to-have items.”

“Those high-efficiency systems take us over our budget.”

“These finishes cost a lot less.”

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Construction Documents and Models

- Even with completed design, construction can't begin.
- Sequential versus parallel tasks.
- Independently produced (designs show just intent)?
 - Limits liability
 - Rework
- Collaborative (BIM, integrated project delivery)?
 - Less rework (unlikely to be none)
- Demolition plan by sequence.
- Base plan at common scale with detail layers.

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Documents for Interior Construction and Finishes

-  Installation and components plans
-  IT and telecommunications plans
-  Reflected ceiling plan
-  Floor plans and floor covering plans
-  Wall finishes plan
-  Details and joinery plans

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Construction Permitting

- Utility, building, use permits
- Zoning restrictions
- Water, sewer, and other major utility development projects done
- Early review sessions of local building code and zoning
 - May reduce project duration
 - Early correction of code violations
- Public review period and community meetings
 - Allow time
 - Communications plan and spokesperson

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Preconstruction Meeting Agenda

- Attendees: Owner representative, facility manager, AE, consultants, GC, new subcontractors since last kickoff
- Schedule in detail
 - Key milestones, including certificate of occupancy
 - Critical path tasks
 - Long-lead time and fabricated materials
- Communications
 - Project risks/assumptions
 - Change order process and authorized approvers
 - Prompt notification policy
- Payment requests and timing
- Commissioning and punchlist processes
- Job site safety, policies, and administration

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Construction and Interior Design Meetings

Construction meetings

- On-site weekly meeting.
- Review progress.
- Cost and schedule variances.
- Status of:
 - Change order requests.
 - Progress payments.
 - Risks and responses.
- Resolved issues.
- Task assignments.

Interior design meetings

- Separate project if:
 - Shell finish.
 - Shell and core finish.
- Facility manager helps owner or tenant find interior designer or GC.

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Construction Inspections

- After permits issued, construction begins.
- Government inspectors:
 - Inspections before features covered up or buried.
 - Finished work.
 - Materials and work processes.
- Owner representative inspectors (area specialists):
 - Accept or reject work as owner's representative.
 - GC meeting all terms and conditions.
 - Data for performance reviews.
 - Decide on necessary modifications.
 - Validate progress payment vouchers sent to GC or subcontractors.



Too lenient?




Too stringent?

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Discussion Question

A subcontractor is refusing to remove an invoice for removal and replacement of water heaters, claiming that the owner verbally requested a change to an on-demand system. The kickoff meeting clearly specified that the governance committee was the only approval authority. What should the facility manager do?


- a) Document the issue and forward it to legal.
- b) Indicate that the subcontractor is in breach of contract.

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Procurement and Fabrication

- Procurement schedule at design end
- Paperwork on items with long lead times
 - Especially if form critical path
- Tradeoffs: Cost, insulation, durability, sustainability, weight, maintainability...
- Factory-made fabrication
 - Cheaper labor
 - Sustainability
 - Less toxicity
- On-site fabrication
 - Logistics
 - Schedule compression



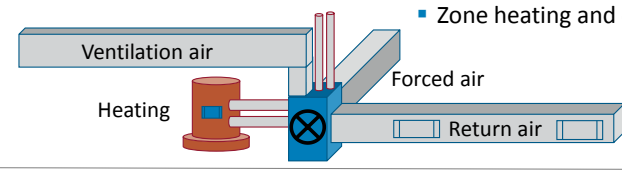
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Commissioning and Quality Control

- Precommissioning at factory or on arrival
- Barcode scanners
- Installation supervision
- With utilities
- Later at peak load

- HVAC commissioning
 - Start-up tests
 - Test and balancing
 - Ventilation/return air mix
 - Heated or chilled water rate to air volume
 - Humidity
 - Zone heating and cooling



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Sustainability on Construction Sites

- Storm water and erosion protection are mandatory.
- During construction:
 - Reduce construction waste and runoff.
 - Indoor air quality:
 - Seal off ductwork and openings.
 - Keep materials dry.
 - “Roads” for construction equipment.
 - Tree or nature preservation.
 - On-site recycling and material reclamation (e.g., concrete).
 - Salvage materials from demolition, if cost-effective.



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Cost and Schedule Monitoring and Control

<h3>Cost and schedule</h3> <ul style="list-style-type: none">▪ Keep focus on schedule to reduce budget risk.▪ Timely decisions.▪ Inspector relations.▪ Communicate bottlenecks.▪ Life-cycle cost champion.▪ Remaining funds sufficient for balance of payments?▪ Change orders add to budget?	<h3>Allowances</h3> <ul style="list-style-type: none">▪ Allowance per square foot/meter for interior design/construction.▪ Owner vs. tenant:<ul style="list-style-type: none">▪ Who pays?▪ Who does project management, permitting...?▪ Facility manager ensures maximum allowance benefit.▪ Unused allowances in cash or as rent abatement.
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Performance Monitoring and Control


- Change order review and acceptance or rejection.
- Inspection to validate that plan specifications are met.
- Experts committee checks if above or below scope.
- Legal review.
- Facility manager provides facts, acts as voice of reason.
- Facility staff performance monitoring:
 - Correct mix of time on project and on O&M
 - Deferred maintenance tracking
 - Catch-up plan

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Turnover: Substantial Completion and Punchlists

- Punchlist only after “substantial completion.”
 - Brief walkthrough to verify, so as not to waste time
- If doing commissioning, focus on things it doesn’t cover:
 - Paint coverage
 - Door functionality
 - Outlets, light switches, and thermostats
 - Ceiling tiles
 - Locks and keys
 - Ductwork (no covers or blockoffs)
 - Filters and lighting units
 - Balanced and tested airflow diffusers
 - As-built drawings, owner manuals, paint samples
- Cleanup period and final walkthrough.



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Turnover: Documents, Payments

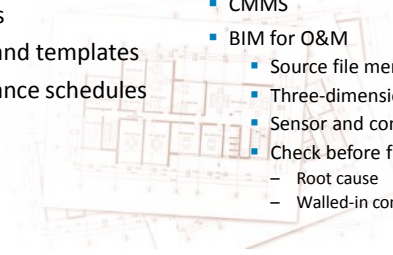
- Commissioning report
 - Changes from plan
 - Actual energy efficiency
 - HVAC zone capabilities
 - Indoor air quality levels
- Final payments
 - No outstanding lien waivers from GC or subcontractors
 - Lien insurance
- Certificate of occupancy
 - Enables occupation and use
 - Relocation only after
 - Warranty initiation date
- As-built drawings
 - What was actually built
 - Site conditions
 - Faster or fewer materials
 - Variances approved before work done
 - Still to code
 - No conflicts
 - Red-line drawings
 - CADD or BIM files
 - Cabling and wiring

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Training, FM Database

- O&M training**
 - Procedures (test some)
 - System baseline standards
 - Job aids and templates
 - Maintenance schedules
- FM database**
 - Print or digital manuals and as-built documents
 - CMMS
 - BIM for O&M
 - Source file merging
 - Three-dimensional color-coded views
 - Sensor and control feed
 - Check before field work
 - Root cause
 - Walled-in components





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Interior Construction and Relocation

<p>Interior construction</p> <ul style="list-style-type: none">▪ Overlap with general construction as feasible▪ Facility manager as GC and project manager? <p>Relocation projects</p> <ul style="list-style-type: none">▪ Facility manager project▪ Complete by deadline	<p>Owner-furnished items</p> <ul style="list-style-type: none">▪ Security and locks▪ IT/telecommunications▪ Manufacturing equipment▪ Window blinds▪ Copiers▪ Cubicles and furniture▪ Kitchen equipment▪ Signage and art▪ Carpeting▪ Walls
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Postoccupancy Evaluation (POE)

- Evaluation three months to one year after occupation
 - Annual or seasonal repetition
- Effectiveness
 - Right facility for end users' needs
- Efficiency
 - Energy use, waste generation, sustainability, program delivery, meeting program goals
- Likert surveys (subjective 1 to 5) with some open-ended questions
 - Pilot survey to ensure that right questions are asked
- Drive actual corrections and continuous improvement
 - Inform end users

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