Facility Cost Modeling: Examples from the U.S. experience

DOE Facility Cost Planning Workshop

May 25, 2011
Sheraton Fisherman's Wharf Hotel
San Francisco, CA

Peter Lufkin
Whitestone Research Corporation

- The need for objective estimates
- Evolution of U.S. facility cost modeling
- Recent enhancements
- Cost modeling in the future

The needs for objective facility cost estimates

- Under funding in later decades of the last century left many assets in dire condition; but what is the right cost?
- Justify and prioritize investments
- Identify opportunities for service providers
- Shift production to lower cost sites

Evolution of cost modeling in the U.S.

- Alarm of the 1980's translated to policies in 2000's
  - FASAB standards, Executive Orders, Defense Guidance, NRC[1]
- Old M&R cost forecasting methods found to be insufficient
  - Incremental budgeting
  - Condition assessments / M&R backlog
  - Industry surveys (BOMA, APPA, BCI)
  - Delphic PRV-based rates (FFC 2-4 %)
  - System Replacement Cycles (Stanford model)
- Recent shift (2000+) to detailed parametric cost models of full facilities life cycle

1. "The committee recommends that DOE [U.S. Department of Energy] establish departmental sustainment targets and recapitalization rates."— National Research Council (2004)

Alarmists were right…

Total U.S. M&R Services Market Value = $210 billion ($03)

Uniformat Categories	Total Cost *
B20 Exterior Enclosure	$14,693,612,554
B30 Roofing	$31,038,944,165
C10 Interior Construction	$9,781,225,804
C20 Stairs	$182,820,401
C30 Interior Finishes	$34,152,749,136
D10 Conveying	$3,310,714,225
D20 Plumbing	$25,507,645,515
D30 HVAC **	$68,019,655,972
D40 Fire Protection	$3,854,989,094
D50 Electrical	$19,584,937,393
E10 Equipment	$36,979,281
Total Market	$210,164,273,540

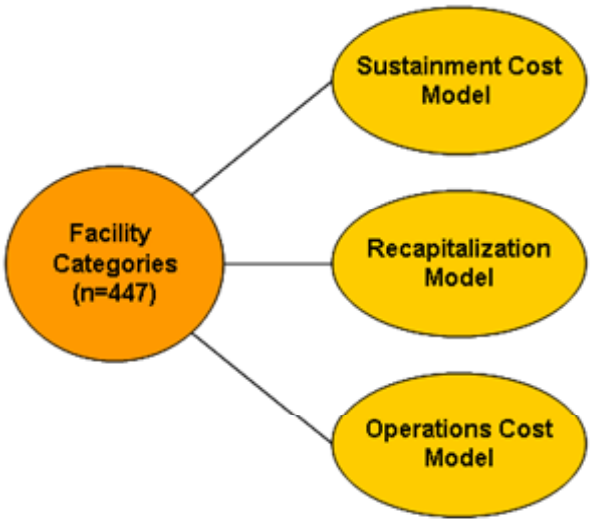
* Total cost for all verticals, including non-targeted.
** D30 HVAC includes BAS Controls

Source: JCI, Controls Group Services Marketing; Whitestone Research; McGraw-Hill Construction, Dodge.

U.S. facility M&R expenditures were 20 percent less than required (est.) in 2003.

Three useful models from the U.S. Defense Department

Three parametric models are used for estimating long term sustainment, restoration & modernization, and operations requirements for specific facility types.

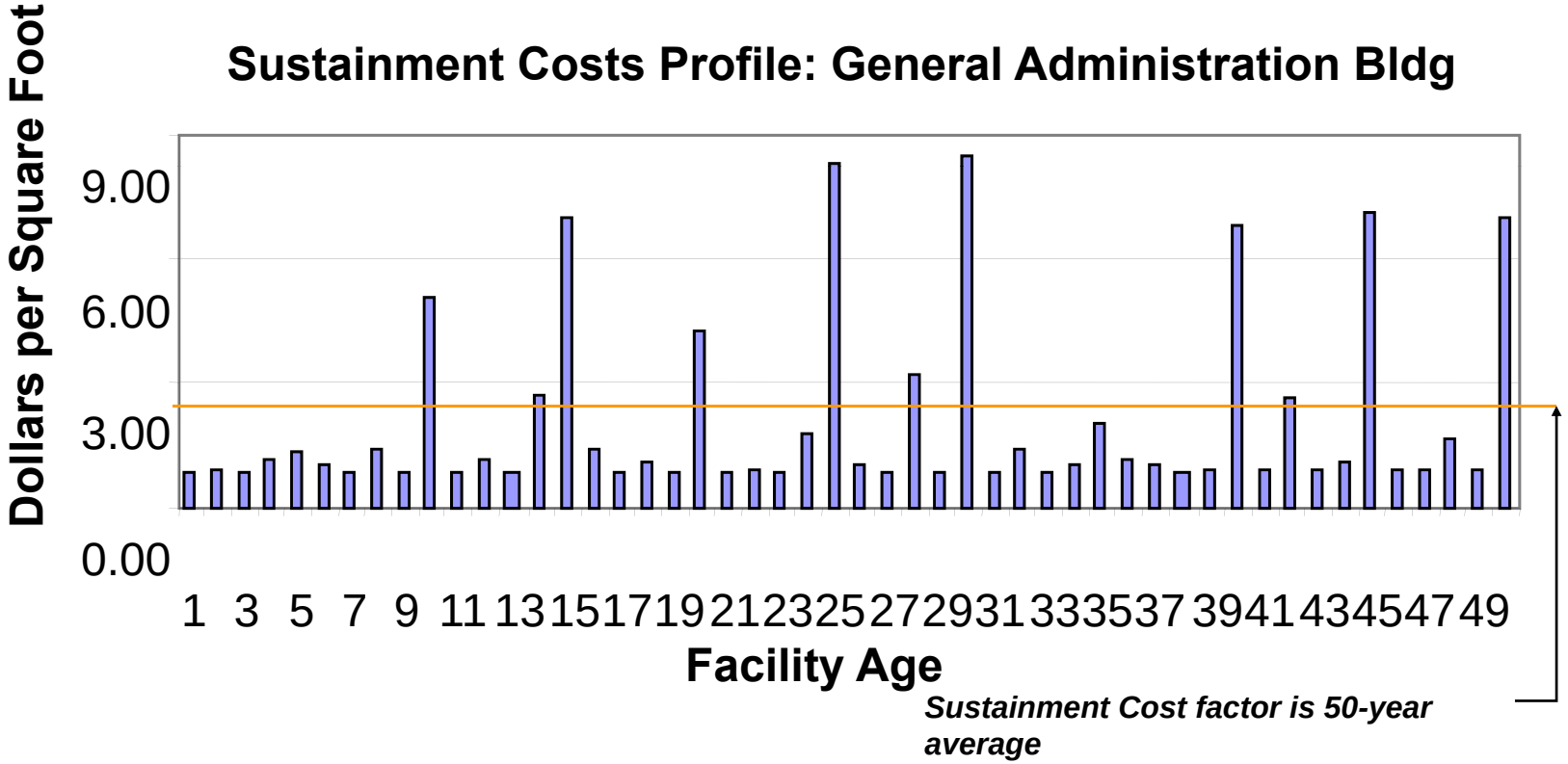


Source: Jay Janke, Peter Lufkin, Facility cost models in *The Military Engineer* (September-October 2005)

Whitestone established explicit definitions aligned with GSA and commercial (BOMA/IREM) charts of accounts.

Sustainment	Preventive Maintenance & Minor Repair Unscheduled Maintenance Renewal & Replacement
Recapitalization	Replacement due to Obsolescence Change in Use Modifications Policy-mandated Modernization Acts of War & Nature Restoration from Neglect Long-lived Component Replacement
Operations	Custodial Energy Grounds Management Pest Control Refuse Road Clearance Security Telecom Water/Sewer

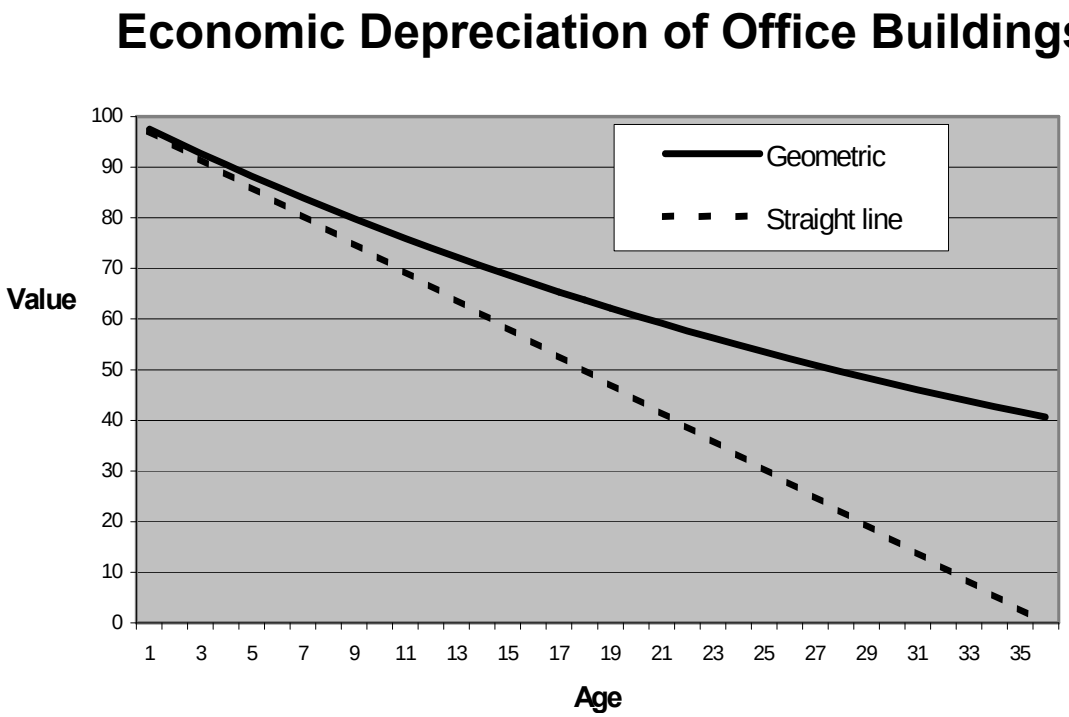
2001: Sustainment Model (Maintenance and repair costs) for 454 asset types



Source: Whitestone Research and Jacobs Engineering, Implementation of the Department of Defense Sustainment Model: Final Report, January 2001

2005: Recapitalization Model

Restoration & modernization costs are based on the economic depreciation known for individual facility types



Source: Lufkin, Desai, and Janke, Estimating the restoration and modernization costs of infrastructure and facilities in *Public Works Management & Policy* (July 2005)

2006: Facilities Operations Model

- Individual requirement models for 10 services: custodial, refuse, fire, energy, water & sewer pavement clearance, leases, grounds, management, pest control
- Worldwide location indices defined for each service

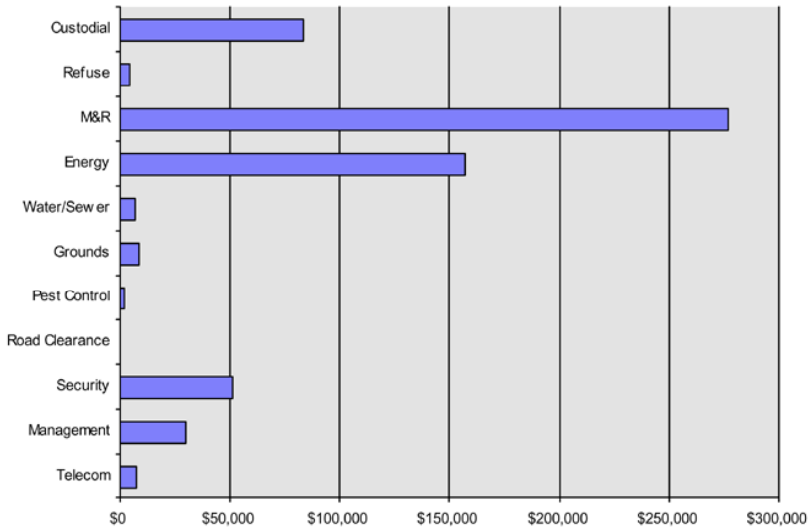
Reference: MARS Facility Cost Forecast System, Version 8.5

Operation Costs Summary — Whitestone Research

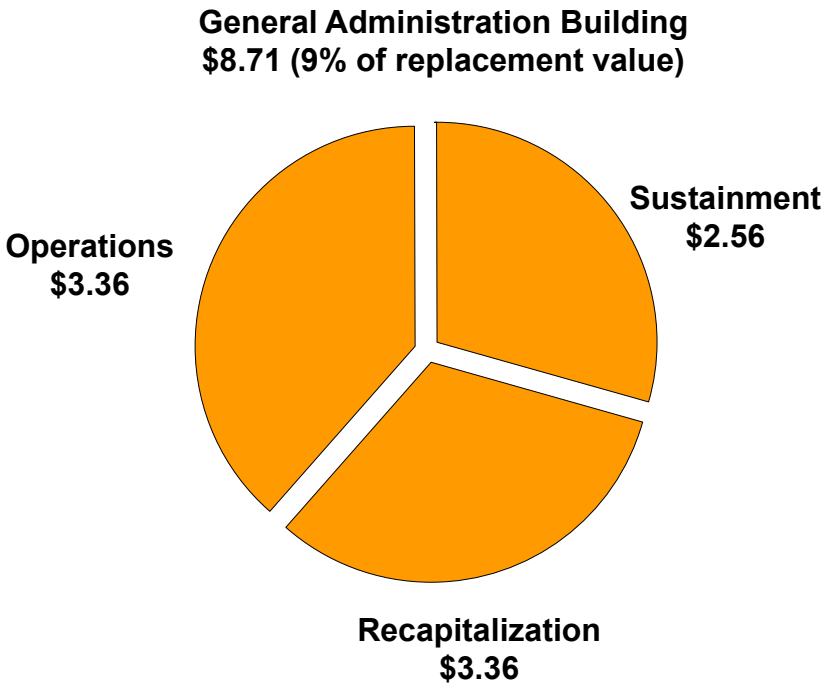
Building: Library
Building Number: 4011
Facility: SPL1
City: Seattle, WA
Built Date: 1950

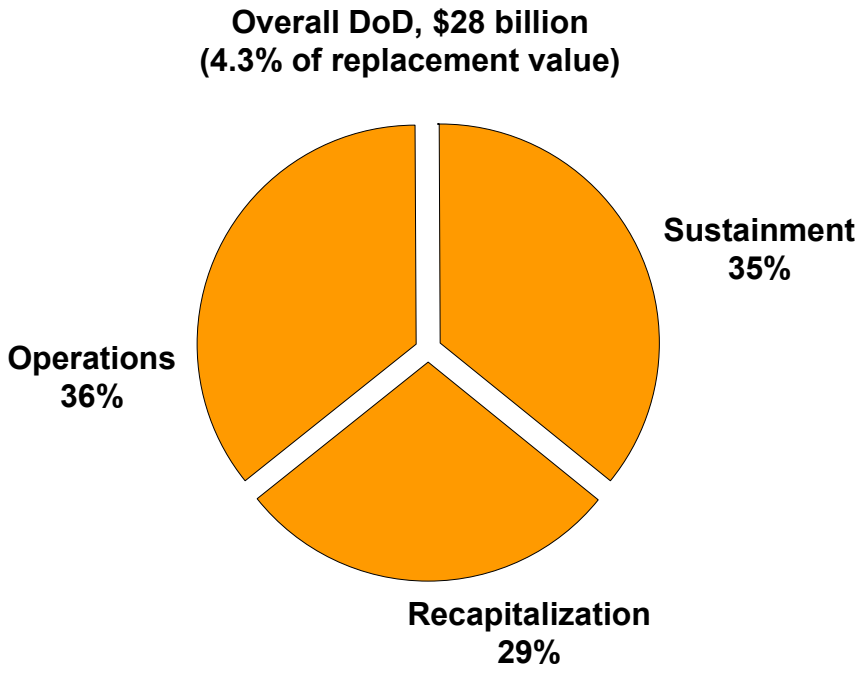
GSFT: 60,000
Replacement Value: $12,397,427
Building Use: Public Assembly
Building Type: Library/Museum

Operation	Annual Cost/GSFT	Annual Total	Percent
Custodial	$1.388	$83,280	13.3%
Refuse	$0.075	$4,488	0.7%
M&R	$4.611	$276,672	44.1%
Energy	$2.619	$157,128	25.0%
Water/Sewer	$0.112	$6,690	1.1%
Grounds	$0.145	$8,718	1.4%
Pest Control	$0.032	$1,902	0.3%
Road Clearance	$0.012	$690	0.1%
Security	$0.048	$50,904	8.1%
Management	$0.496	$29,754	4.7%
Telecom	$0.126	$7,578	1.2%
Building Total	**$10.46**	**$627,804**	**100.0%**



Applying these models to the facility inventory provides a full view of annual costs for specific facility types or an aggregation of organization-wide requirements





Total facility costs compared to a common benchmark

Table 9. Total Annual Building Costs, Selected ARS Buildings[A]

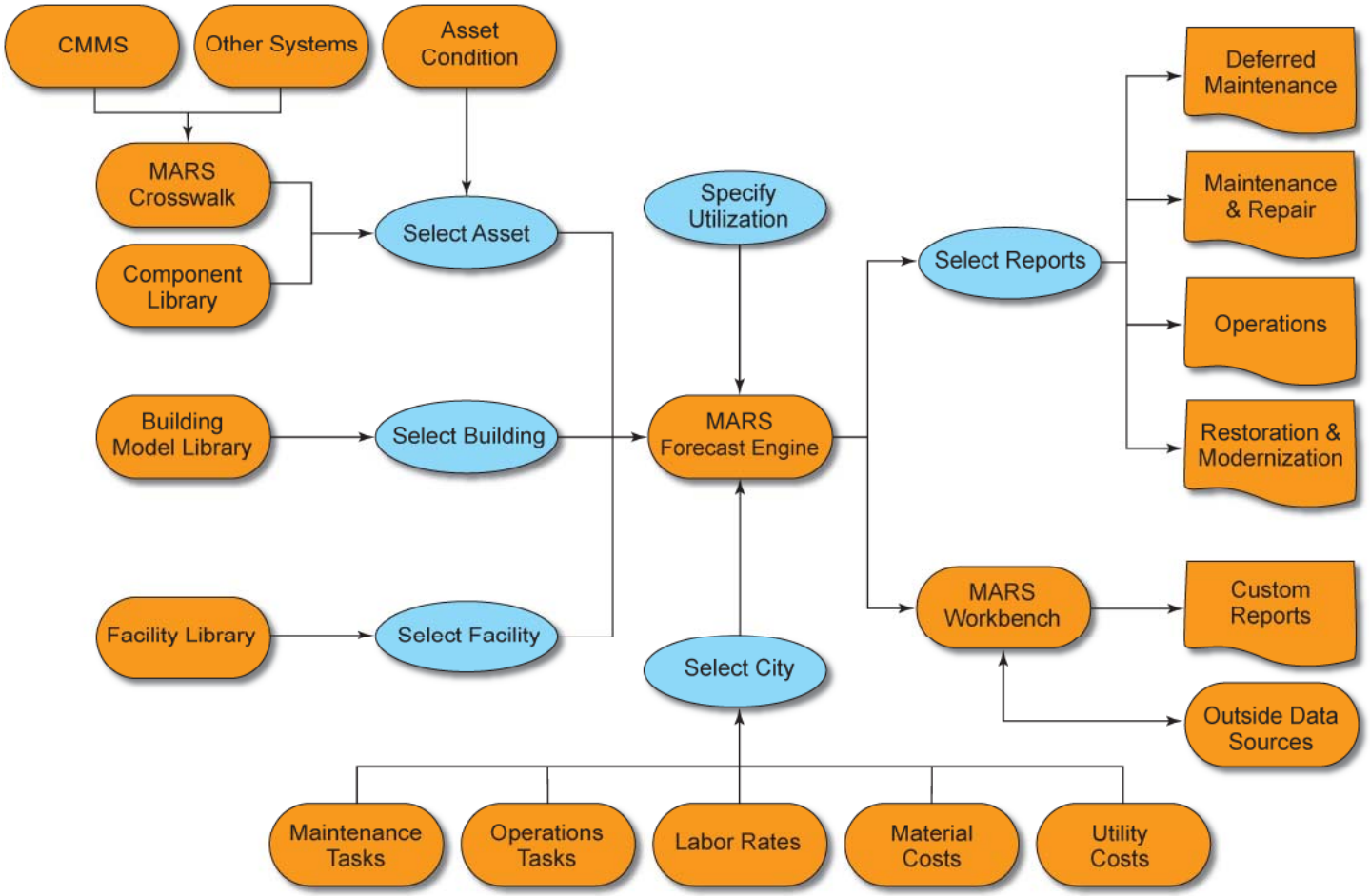
			Estimated Costs					
Predominant Usage	**PRV**	**GSFT**	**Sustainment**	**Operations**	**Recapitalization**	**Total Facility Costs**	**Per GSFT**	**Percent PRV**
All Other	$834,225,670	3,807,716	$26,553,835	$15,103,816	$7,755,595	$49,413,246	$12.98	5.9%
Dormitories/Barracks	$1,685,819	9,093	$94,144	$13,615	$6,987	$114,746	$12.62	6.8%
Family Housing	$24,278,029	129,733	$798,632	$377,007	$114,106	$1,289,744	$9.94	5.3%
Laboratories	$2,285,074,743	6,439,933	$66,097,728	$71,877,470	$21,511,109	$159,486,308	$24.77	7.0%
Office	$139,530,092	526,698	$3,353,216	$2,613,005	$1,062,136	$7,028,357	$13.34	5.0%
Service	$169,439,752	901,960	$4,737,091	$3,791,530	$1,527,357	$10,055,978	$11.15	5.9%
Warehouses	$188,897,417	1,550,373	$4,178,910	$3,735,648	$1,826,710	$9,741,268	$6.28	5.2%
Total[B]	**$3,643,131,522**	**13,365,506**	**$105,813,556**	**$97,512,090**	**$33,804,001**	**$237,129,647**	**$17.74**	**6.5%**

[A] Does not include land, structures, or deactivated or excessed assets. Total Building Operations & Maintenance Cost is the average annual sum of operations, recapitalization, and 5-Year sustainment costs. Only sustainment costs have been adjusted for building utilization factors.

[B] All costs expressed in $2008.

	Sustainment	**Overage (Loss)**
2%	$72,862,630	($32,950,926)
4%	$145,725,261	$39,911,705

Models have been consolidated into a system (MARS v 8.5) applicable to individual buildings



Recent enhancements:

- Calibration for utilization
- Levels of service
- Condition assessment
- Estimate staff requirements
- Identify market opportunities
- Estimate costs of non-building assets
- Evaluation of energy savings

Table 3 Utilization Multipliers[A]

	Hours of Operation[B]	Security[C]	Safety & Permitting[D]
Low	0.80	1.00	1.00
Moderate	1.00	1.01	1.07
Medium	N/A	N/A	1.75
High	1.37	1.15	3.00

[A] Multipliers are applied to MARS estimates to account for varying utilization factors common with technical facilities.

[B] Hours of Operation rates building use on a weekly basis and is defined as follows: Low = 40 hours, Moderate = 41 to 80 hours, High = 80+ hours.

[C] Security is defined as follows: Low = free access, Moderate = contractor training & daily check-in, high = full contractor accompanyment.

[D] Safety & Permitting is defined as follows: Low = typical commercial & service activity, Moderate = non-specific laboratory, Medium = radiological or life science research, High = nuclear facility

Note: In combination the multipliers are additive such that the total multiplier = $1 + \sum (\beta - 1)$ where β = the multiplier value

Sources: DOE laboratories, Air Force Space Command, OSD Draft report on Utilization & Sustainment

WHITESTONE

Alternative levels of service can significantly affect projected costs

Office Building, 2 Story

Gross Square Feet (GSFT):	83,000
Replacement Value (PRV):	$16,255,022
Capacity:	N/A
Occupancy:	740
Pavement Sqft:	66,400
Grounds Sqft:	49,800
Floors:	2
Use Type:	Office

Service Levels

Custodial	Office Area: Clean floors 3 times per week, remove trash 3 times per week; clean, dust and polish surfaces and window coverings once per week. Dust and polish furniture once per week. Common Areas: Clean floors and remove trash 3 times per week, clean furniture and seating areas once every 2 weeks. Complete restroom service 3 times per week.
	54.2 kBtu per square foot per year.
	Mow once per week, fertilize every 13 weeks, clean and trim walks every 2 weeks.
	50-year average annual cost, utilization rate between 41 and 80 hours per week.
	Commercial management, facility data, real estate, and engineering services.
	Rodent control and insect abatement procedures performed every 18 weeks, and inspections every 52 weeks.
	Average annual refuse production of 0.6 lbs per square foot.
	Sweeping of paved areas once every 2 weeks, and snowclearing once per snowday.
Security	Access control, system monitoring, and intrusion detection systems. Daily patrol.
Telecom	Local phone and data subscriptions.
Water/Sewer	59 gallons of water per square foot per year.

5. Level of Service Alternatives — Custodial Services

Model	Level of Service	Description	Cost per GSFT	Cost per Occupant
Office Building, 2 Story	High	Office Area: Clean floors and remove trash 5 times per week; clean, dust and polish surfaces and window coverings 6 times per month. Dust and polish furniture 2 times per week. Common Areas: Clean floors and remove trash 5 times per week, clean furniture and seating areas once every week. Complete restroom service 5 times per week.	$4.10	$460
	Medium	Office Area: Clean floors 3 times per week, remove trash 3 times per week; clean, dust and polish surfaces and window coverings once per week. Dust and polish furniture once per week. Common Areas: Clean floors and remove trash 3 times per week, clean furniture and seating areas once every 2 weeks. Complete restroom service 3 times per week.	$2.40	$270
	Low	Office Area: Clean floors every week, remove trash 2 times per week. clean, dust and polish surfaces and window coverings once every 2 weeks. Dust and polish furniture every 2 weeks. Common Areas: Clean floors and remove trash 2 times per week, clean furniture and seating areas once every 4 weeks. Complete restroom service 2 times per week.	$1.10	$123

Reference: Romani et. al., The Whitestone Building Operations Cost Reference 2009-2010, Whitestone Research: Santa Barbara. October 2009.

Cost-effective Condition Assessment

Recent NNSA (2005, 2008) studies demonstrate the utility of the models model for large scale large-scale assessments:

- Initial study validated DM for 31 million SF in six months
- Definition of deferred maintenance carefully aligned with assessment tool
- Combine engineering judgment w/parametric estimates
- Multi-tiered statistical sampling provided estimates at costs much lower ($.07 SF) than full inspection
- Model also provided forecast of future M&R requirements

Competitive trial before actual assessment: MARS parametric model estimates within 6% of traditional inspection

Determine Staffing Requirements

Lifecycle models calculate direct labor requirements by trade for individual components.

- Summed by year, these create a schedule of annual labor needs.
- Averaged over time, they approximate long-term staffing requirements.

Table 7. M&R Staff Labor Requirements[A]
5 million square foot campus

Trade	Annual Labor hours[B]	Full time equivalent[C]
Painter	539,939	14
Plumber	440,538	5
Electrician	502,322	6
Gen Maintenance Worker	321,771	4
HVAC Technician	1,661,013	19
Total	**3,465,583**	**47**

[A] Includes only routine M&R; does not include major repair or replacements.

[B] Includes only labor directly related to maintenance tasks. Does not include indirect requirements, such as supervision and support and non-productive time. Averaged over 50 years.

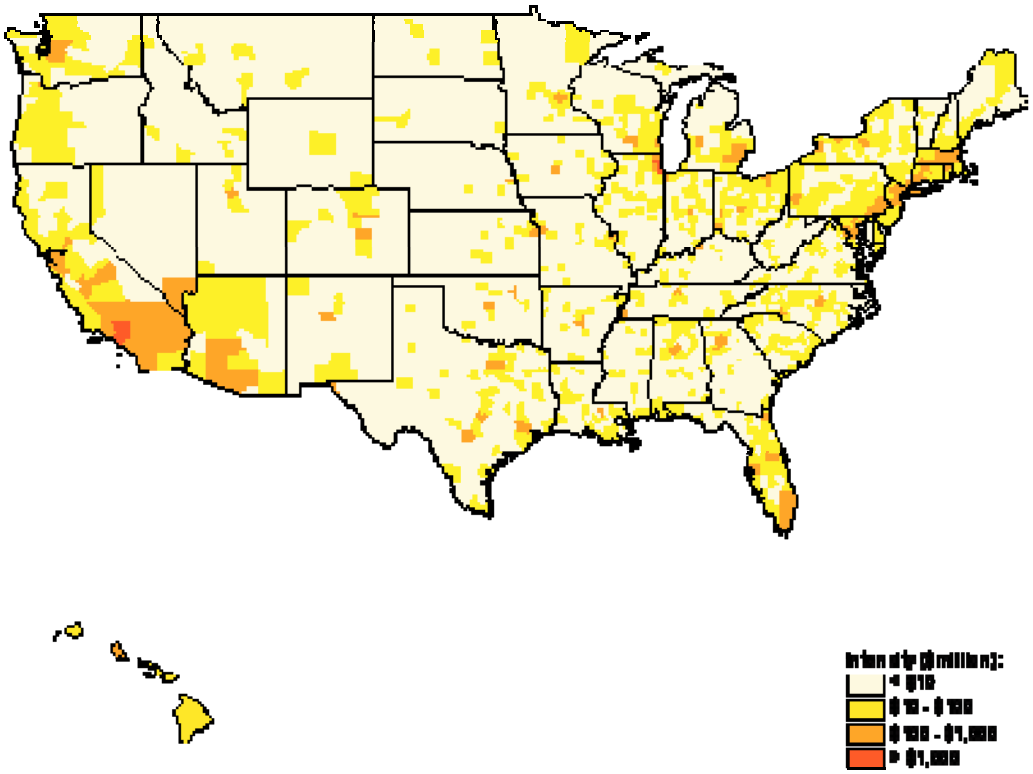
[C] Full-time equivalent (FTE) is the total direct labor hours divided by 1776, the assumed productive hours per year.

Source: Whitestone Research.

Identify Marketing Opportunities

With knowledge of the geographic distribution of the facility inventory and representative lifecycle models by use type, broad analyses of market opportunities are possible

A demand intensity map generated for selected HVAC services.



Estimate Costs of Non-building Assets

Lifecycle cost models have been developed for non-building assets as varied as launch facilities, piers, and utilities

A recent study (2011) found for the U.S. Coast Guard that M&R costs for marine piers were almost twice estimates based on a single case study.

Measure the return on energy-saving investments

Case study evaluates the life cycle cost effectiveness of alternative combinations of energy-saving components for a laboratory at the U.S. Department of Energy's Pacific Northwest National Laboratory (PNNL).

Table 1. Energy Reduction of Alternatives

Alternative	Initial Cost	Component Change*	Energy reduction from FY03
Alternative 1	$2.3 mil	Reflective coating to built-up roof, Double glazed windows, Water heater turbocharger, VAV air handlers, Secondary transformers, Variable volume exhaust hoods	16%
Alternative 2	$3.4 mil	Green roof w/ growing medium, Triple glazed windows, Water heater turbocharger, Heat recovery chiller, Variable volume fancoil system, Secondary transformers, Variable volume exhaust hoods w/ occupancy control	35%

* Some component changes not listed

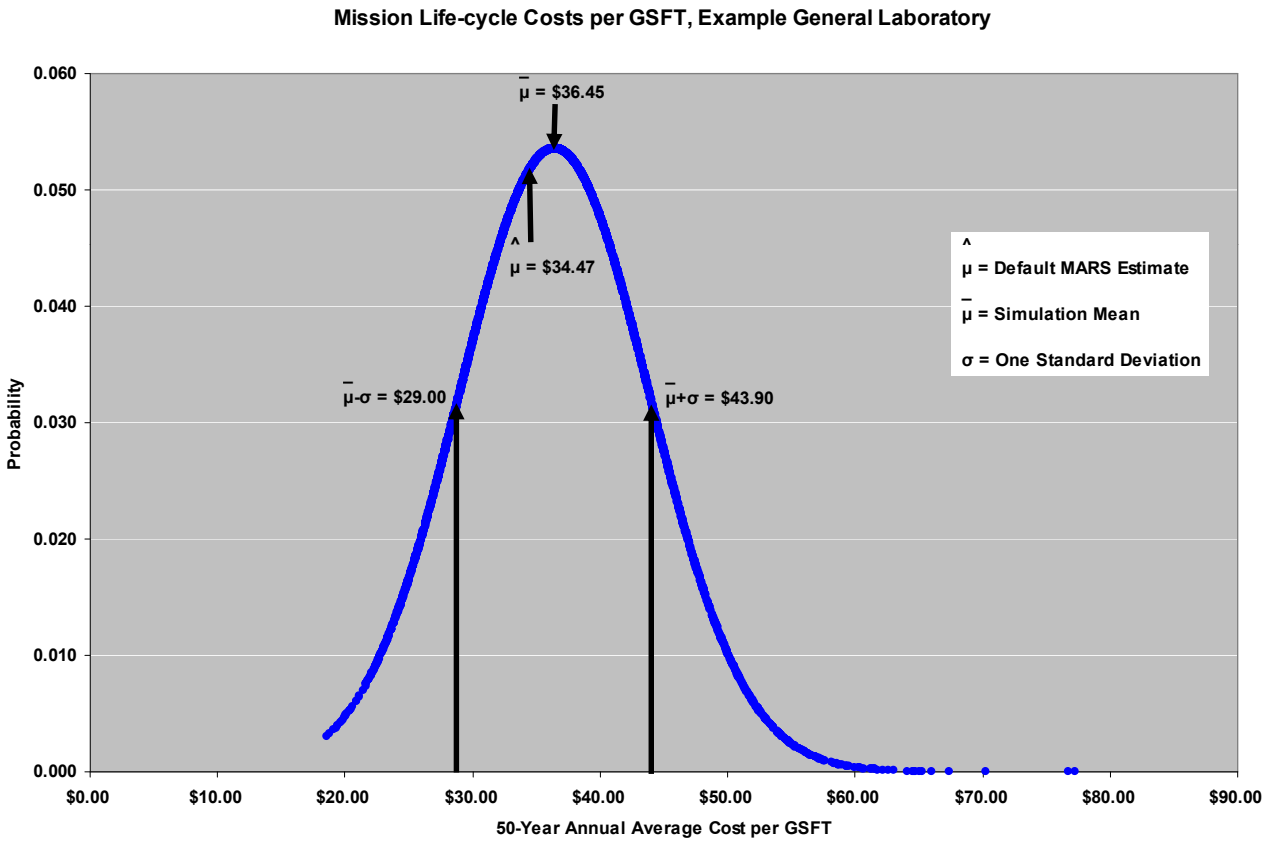
Pacific Northwest National Laboratory Life Science Research Laboratory

Source: Whitestone Report: Study of Energy-Saving Retrofits has Lessons for Other Green Projects, January 2009

Cost modeling in the future: estimates should include formal accuracy and error measures as in other disciplines

Cost estimates should include formal accuracy and error measures

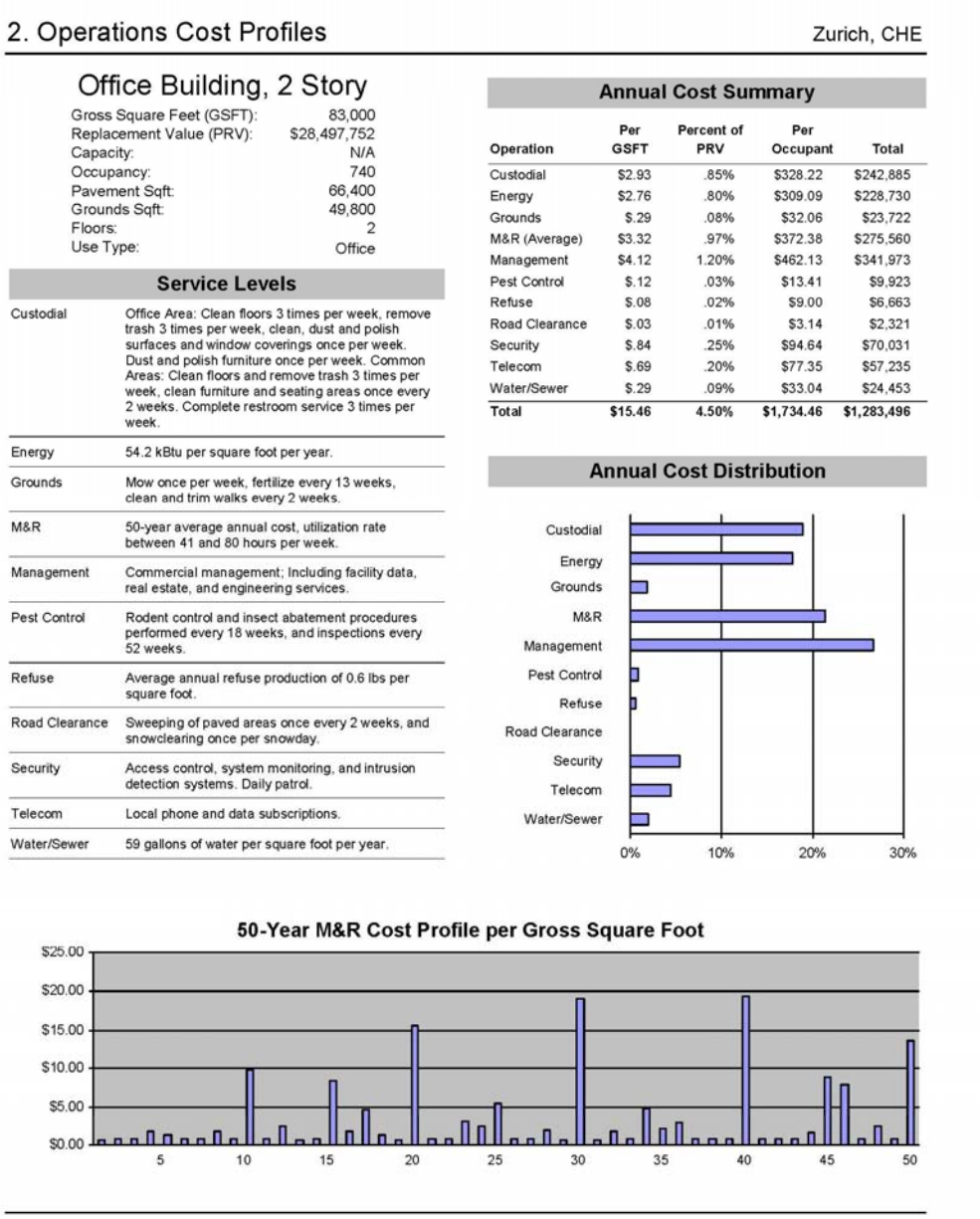
Example: Monte Carlo simulation for a general laboratory model.



Estimates varied by ± $7.45 per GSFT or 20.4% (2 σ interval) around a mean of $36.45 per GSFT

Cost modeling in the future: growth of global facility cost models.

Most of the largest companies in the U.S. have facilities in over 100 foreign locations. Yet the detailed data necessary to make strategic investment decisions is scattered and incomplete.



2. Operations Cost Profiles — Zurich, CHE

Office Building, 2 Story

Gross Square Feet (GSFT):	83,000
Replacement Value (PRV):	$28,497,752
Capacity:	N/A
Occupancy:	740
Pavement Sqft:	66,400
Grounds Sqft:	49,800
Floors:	2
Use Type:	Office

Service Levels

Custodial	Office Area: Clean floors 3 times per week, remove trash 3 times per week, clean, dust and polish surfaces and window coverings once per week. Dust and polish furniture once per week. Common Areas: Clean floors and remove trash 3 times per week, clean furniture and seating areas once every 2 weeks. Complete restroom service 3 times per week.
Energy	54.2 kBtu per square foot per year.
Grounds	Mow once per week, fertilize every 13 weeks, clean and trim walks every 2 weeks.
M&R	50-year average annual cost, utilization rate between 41 and 80 hours per week.
Management	Commercial management; Including facility data, real estate, and engineering services.
Pest Control	Rodent control and insect abatement procedures performed every 18 weeks, and inspections every 52 weeks.
Refuse	Average annual refuse production of 0.6 lbs per square foot.
Road Clearance	Sweeping of paved areas once every 2 weeks, and snowclearing once per snowday.
Security	Access control, system monitoring, and intrusion detection systems. Daily patrol.
Telecom	Local phone and data subscriptions.
Water/Sewer	59 gallons of water per square foot per year.

Annual Cost Summary

Operation	Per GSFT	Percent of PRV	Per Occupant	Total
Custodial	$2.93	.85%	$328.22	$242,885
Energy	$2.76	.80%	$309.09	$228,730
Grounds	$.29	.08%	$32.06	$23,722
M&R (Average)	$3.32	.97%	$372.38	$275,560
Management	$4.12	1.20%	$462.13	$341,973
Pest Control	$.12	.03%	$13.41	$9,923
Refuse	$.08	.02%	$9.00	$6,663
Road Clearance	$.03	.01%	$3.14	$2,321
Security	$.84	.25%	$94.64	$70,031
Telecom	$.69	.20%	$77.35	$57,235
Water/Sewer	$.29	.09%	$33.04	$24,453
Total	**$15.46**	**4.50%**	**$1,734.46**	**$1,283,496**

Annual Cost Distribution

50-Year M&R Cost Profile per Gross Square Foot

For more information contact:

Peter Lufkin
Principal and Senior Analyst
plufkin@whitestoneresearch.com