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Establishing Commissioning Fees

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Commissioning is a systematic, documented and collaborative process including inspection, testing and training conducted to confirm that a building and its component systems meet the requirements of the occupants and conform to the design intent. It is a quality assurance procedure applied to building construction. *Integrated* commissioning is a form of the procedure that takes place during the entire project, through planning, design, construction and operation.

The creation of a market in commissioning services and the progressive establishment of fees for those services is vital to making commissioning a part of the standard, accepted construction process. Commissioning cost is more than an academic question and the ability to estimate those costs is more than an administrative tool. The creation of a uniform market in commissioning services is part of the acceptance and inclusion of commissioning as part of the standard construction process.

An understanding of commissioning costs is the first step in justifying commissioning services. Even more important is that the ability to estimate commissioning costs allows these costs to be included early in the project. The bottom line is this: *if commissioning is to be a part of the project, its cost must be included at the planning stage.*

This is not to say that a project will not benefit from commissioning if it is added during the later stages of design, or even during construction. This is not the best method, but some benefits will result. Rather, the problem is that if commissioning costs are not included from

the start, it may be difficult or impossible to inject this extra cost into the project at some midway point.

If the owner waits until construction to begin selecting the commissioning team and establishing fees, it is often too late. Not only are the services of the commissioning authority (CA) compromised by the lack of integration, but the quality assurance process will inevitably be weighed against additional building square footage, ancillary equipment, parking lots, landscaping or other physical improvements. The inertia of selling a new idea sets in and the battle is lost.

Therefore, a database of costs is a vital part of achieving construction quality by planning for commissioning. The database provides a reliable method of estimating commissioning costs so they can be included in the planning budget. Once in the planning budget, it is much easier to defend the inclusion of these costs than it is to add them as new costs later on.

M/E Commissioning

This article will review costs associated with the commissioning of new building mechanical and electrical systems. This

is not “whole building” commissioning, which includes architectural elements in its scope, such as the building envelope, structural components, elevators and more. Although the practice of commissioning is still developing, many feel that mechanical and electrical commissioning yields the largest benefit for the dollar. The information in this article is based on the experience of that scope of work.

The database for this review consists of 19 facilities, 15 of which are examples of comprehensive mechanical/electrical commissioning. This is a modest database and includes only projects in the states of Montana, Missouri and Washington. However, even a large database would fail to provide an absolute means of dictating commissioning costs. This article does not attempt to define exact costs, but only to provide a means for their estimation and justification.

The actual costs presented here are based on detailed proposals by CAs. All owners who include commissioning in their projects should request fee proposals broken down into line item costs for each mechanical and electrical system and for each major piece of equipment. Even better, these line item costs can be developed into a matrix showing static inspection, start-up, and functional tests for each system.

For example, fee proposals should include line item costs for each air-handling unit (AHU), each major return or exhaust fan, chillers, boilers, emergency generators and elevators. Multiple items such as fume hoods and terminal units should

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be listed singly, but may be repetitive. Finally, tasks associated with inspection, start-up, testing and closeout should be in separate tables as well.

This procedure assures an accurate description of the scope of work and shows the owner that the consultant has thoroughly considered the project scope.

3 Components of Commissioning

The overall cost of commissioning consists of three components: 1) the cost of retaining the CA, 2) the costs incurred by the owner's staff and 3) the costs incurred by the general contractor and sub-contractors (the *contractor*).

Experience of others has shown that the cost of retaining an independent CA is the largest of these three components,^{1,2} being approximately 50% to 80% of the total cost. If the owner provides the "CA" as part of an in-house staff, this should not substantially affect the overall cost of commissioning. In either case, the owner will pay the majority of the cost.

The case histories in this article are projects that used third party CAs. Other methods of commissioning exist, such as having the contractor or design team do the work. Although opinions vary as to the best method, one advantage of retaining the CA directly is that this cost is well defined and documented, whereas other methods allow this cost to be buried in a larger contract. If the owner is concerned about CA costs, at least the largest component of the commissioning process is known.

The other two components of overall commissioning cost are less well documented. Nonetheless, limited data on owner and contractor cost is included here.

The Commissioning Authority

Because commissioning is still developing, the CA might take on different responsibilities during different projects. The data includes consistent CA services for the process known as *integrated commissioning*. The principle parts of these services are listed in the sidebar.

Commissioning Responsibilities

To gain a better perspective on CA responsibilities, it is useful to review what

Integrated Commissioning Responsibilities	
<p>The Commissioning Authority</p> <p>During Early Design and Planning:</p> <ul style="list-style-type: none"> • Verify owner intent and confirm the design team's <i>Design Intent Narrative</i>. • Discuss commissioning with the design team and confirm the <i>Basis of Design</i>. • Verify cost estimates for commissioning. • Begin the process of teambuilding for quality. <p>During Building Design:</p> <ul style="list-style-type: none"> • Review design documents for "commissionability," maintenance and testing access. • Develop "Division 17" or other specification sections defining commissioning activities. <p>During the Bidding Process:</p> <ul style="list-style-type: none"> • Attend the pre-bid inspection (walkthrough) and explain the commissioning process to contractors. • Participate in bid award negotiations and document design changes. <p>During Construction:</p> <ul style="list-style-type: none"> • Attend the pre-construction meeting. • Develop the commissioning plan and the commissioning schedule. • Write and inspect static inspection checklists. • Write and inspect startup checklists. • Develop functional performance tests. • Collect and organize contractor data for the commissioning report. <p>During the Acceptance Phase:</p> <ul style="list-style-type: none"> • Perform functional performance testing. • Review and comment on O&M manuals. • Participate in and augment training sessions. • Submit the commissioning report. • Provide alternate season testing. 	<p>The Owner</p> <ul style="list-style-type: none"> • Coordinate and confirm the inclusion of an estimated commissioning cost in preliminary planning for the project. The inclusion of this budget line item is the first step in having the project commissioned. • Develop the commissioning scope of work, conduct the CA selection process and negotiate the CA fee. • Check the inclusion of commissioning language in the construction documents and expedite responses to questions about commissioning. • Defend the inclusion of commissioning if the project bids come in above budget. • Attend the pre-bid and pre-construction conferences to further explain the commissioning process. • Check the content of static inspections and functional tests. • Monitor training sessions coordinated by the CA and review O&M documentation in conjunction with the CA. • Review and approve the final commissioning report.
	<p>The Contractor</p> <ul style="list-style-type: none"> • Provide for commissioning in the cost estimate for the bid. This author, for projects under his direction, includes commissioning information in Divisions 1, 15 and 16 for commissioning mechanical and electrical systems • Integrate commissioning in the project schedule and the schedule of values • Allow for tradesmen to work with the CA through commissioning. This time ranges from brief intervals during early inspection to extended periods for large equipment start-up and energy management systems • Allow time for additional review of O&M manuals and expanded training

the owner and contractor provide for the commissioning process (see sidebar).

The majority of commissioning work falls on four sub-contractors: plumbing, mechanical (sheet metal), electrical and controls. The contractor's part of the commissioning process starts with the award of the bid and continues through final completion. There is often some "off-season" commissioning, but this can sometimes be avoided and, in any event, is minor.

The general contractor or mechanical

subcontractor might hire or appoint a *test engineer* to take responsibility for the duties listed in the sidebar. In this case, the overall cost to the contractor should stay about the same. However, if the test engineer also develops and documents the actual test and inspection procedures (instead of the CA), the cost to the contractor will increase and the cost to the CA will decrease. In this article, it is assumed that inspection and test documentation is developed and organized by the CA, not the contractor.

Type of Building	Year Complete	Construction Cost (\$)	Mechanical (\$)	Electrical (\$)	Total M&E (\$)	Actual CA Fee (\$)	Actual CA Fee % of M&E	Comments
1–Mental Hospital (Mont.)	96	8,000,000	2,000,000	NA	2,000,000	15,450	0.8%	Partial Cx Only
2–Univ. Classroom (Mont.)	97	140,000	140,000	0	140,000	12,000	8.6%	VAV retrofit
3–Univ. Classroom (Mont.)	97	14,000,000	2,152,848	1,514,562	3,667,410	45,600	1.2%	Partial Cx Only
4–Univ. Lab/Classroom (Mont.)	97	14,400,000	2,584,300	1,409,100	3,993,400	73,800	1.8%	Partial Cx Only
5–Office (Mont.)	97	505,000	420,000	51,000	471,000	11,370	2.4%	Mechanical Replacement
6–Univ. Lab/Classroom (Mont.)	99	6,500,000	2,400,000	805,000	3,205,000	49,907	1.6%	Mech/Elec Replacement
7–Univ. Lab/Classroom (Mont.)	99	8,700,000	2,763,500	910,000	3,673,500	139,000	3.8%	Major Addition
8–Office (Mont.)	98	600,000	227,000	112,000	339,000	6,700	2.0%	Energy Retrofit
9–Lab/Classroom Addition (Mont.)	99	8,000,000	1,473,797	894,864	2,368,661	56,810	2.4%	In construction
10–Juvenile Detention (Mont.)	99	8,000,000	1,570,241	699,830	2,270,071	49,201	2.2%	In construction
11–Mental Hospital (Mont.)	99	12,000,000	2,131,206	1,440,994	3,572,200	110,600	3.1%	In construction
12–Office (Mont.)	2001	14,000,000	4,965,000	2,400,000	7,365,000	109,000	1.5%	In construction
13–Prison (Mo.)	98	69,000,000	13,800,000	6,058,200	19,858,200	320,000	1.6%	In construction
14–Prison (Mo.)	2001	61,000,000	12,200,000	5,355,800	17,555,800	486,600	2.8%	In construction
15–Prison (Mo.)	2001	68,000,000	13,600,000	5,970,400	19,570,400	390,200	2.0%	In construction
16–Prison (Mo.)	2001	110,324,000	22,064,800	9,686,447	31,751,247	813,588	2.6%	In construction
17–Laboratory (Mo.)	2000	20,000,000	6,500,000	3,500,000	10,000,000	258,000	2.6%	In construction
18–Hospital (Wash.)	2001	6,746,000	1,922,610	785,076	2,707,686	63,000	2.3%	In construction
19–Student Union Building (Wash.)	2001	2,805,000	883,575	179,520	1,063,095	28,000	2.6%	In construction

Table 1: Actual overall CA costs as a percent of construction.

Two Cost Models

This article will analyze a set of case histories and identify patterns in commissioning costs based on two models. The first model correlates commissioning costs with construction cost. The second model is based on building square footage corrected for building complexity. The analysis continues with the comparison of the construction cost model to the square footage model.

The Construction Cost Model

Based on detailed proposals for CA services, the costs in *Table 1* have been recorded. These amounts were tabulated from pro-

posals detailed down to line items on a system-by-system basis. Projects 1 through 4 were early projects and are not representative of standard commissioning processes. These were projects that included partial commissioning of HVAC systems, focusing on energy efficiency items or problem areas. The remaining 15 cases may be considered in three groups:

Projects 5 through 12 are representative of a standardized commissioning process for Montana projects in which the CA is an independent third party retained during the design process (in the future, the Montana A/E Division will be retaining CAs prior to design). For these projects, CA costs vary from a low of 1.5% of combined mechanical and electrical to a high of

Type of Building	Total Construction Cost \$	Mechanical \$	2.5% Mechanical \$	Electrical \$	1.5% Electrical \$	Total Model CA Fees \$	Actual CA Fee \$	Variation
1–Mental Hospital	8,000,000	2,000,000	50,000	0	0	50,000	15,450	–69%
2–Univ. Classroom	140,000	140,000	3,500	0	0	3,500	12,000	243%
3–Univ. Classroom	14,000,000	2,152,848	53,821	1,514,562	22,718	76,540	45,600	–40%
4–Univ. Lab/Classroom	14,400,000	2,584,300	64,608	1,409,100	21,137	85,744	73,800	–14%
5–Office	505,000	420,000	10,500	51,000	765	11,265	11,370	1%
6–Univ. Lab/Classroom	6,500,000	2,400,000	60,000	805,000	12,075	72,075	49,907	–31%
7–Univ. Lab/Classroom	8,700,000	2,763,500	69,088	910,000	13,650	82,738	139,000	68%
8–Office	600,000	227,000	5,675	112,000	1,680	7,355	6,700	–9%
9–Lab/Classroom Addition	8,000,000	1,473,797	36,845	894,864	13,423	50,268	56,810	13%
10–Juvenile Detention	8,000,000	1,570,241	39,256	699,830	10,497	49,753	49,201	–1%
11–Mental Hospital	12,000,000	2,131,206	53,280	1,440,994	21,615	74,895	110,600	48%
12–Office	14,000,000	4,965,000	124,125	2,400,000	36,000	160,125	109,000	–32%
13–Prison	69,000,000	13,800,000	345,000	6,058,200	90,873	435,873	320,000	–27%
14–Prison	61,000,000	12,200,000	305,000	5,355,800	80,337	385,337	486,600	26%
15–Prison	68,000,000	13,600,000	340,000	5,970,400	89,556	429,556	390,200	–9%
16–Prison	110,324,000	22,064,800	551,620	9,686,447	145,297	696,917	773,880	11%
17–Laboratory	20,000,000	6,500,000	162,500	3,500,000	52,500	215,000	258,000	20%
18–Hospital	6,746,000	1,922,610	48,065	785,076	11,776	59,841	63,000	5%
19–Student Union Building	2,805,000	883,575	22,089	179,520	2,693	24,782	28,000	13%

Table 2: Comparison of actual commissioning costs to the 2.5%/1.5% model.

3.8%, with the average being 2.4%.

Projects 13 through 17 (in Missouri) consist of four large prison complexes and one research laboratory. These projects are more expensive than, but similar in average complexity to, the group described above. For these projects, CA costs vary from a low of 1.6% of combined mechanical and electrical construction cost to a high of 2.8%, with the average being 2.3%.

Projects 18 and 19 (in Washington) are of a similar size and complexity to the first group. The higher percentage CA cost is 2.6% of mechanical and electrical and lower is 2.3%. The average of 2.45% is virtually the same as the previous two groups.

To put these percentages in proportion, other CA cost guidelines include the following:

- 1.3% to 5.1% of mechanical construction cost. Commissioning cost includes total costs incurred by Owner, Contractor and CA.^{1,2}
- 1.7% to 3.8% of HVAC, controls, plumbing and lighting construction costs.³
- 1% to 2% of electrical construction cost plus 2% to 3% of

mechanical construction cost.⁴

- 2% to 5% of HVAC construction cost.⁵

- 1.5% to 4% of mechanical contract cost for HVAC and automated controls and 1% to 1.5% of electrical contract cost.⁶

Based on the reference guidelines, these costs indicate that the documented experiences of Montana, Missouri and Washington appear to be typical of North American averages. However, the reference guidelines span ranges of more than 300%, which demonstrates the developing nature of the commissioning process.

Table 2 shows the same list of projects broken down into mechanical and electrical construction costs. “Model” CA costs were then calculated based on an arbitrary 2.5% mechanical and 1.5% electrical guideline and compared to the actual CA fees. The right-hand column summarizes the variation from the model in percent over or under.

In general, Projects 5 through 12 have a good correlation with the arbitrary guideline. Projects 7 and 11 have higher than expected commissioning costs due, in part, to high travel costs.

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Type of Building	Gross Floor Area (ft ²)	Actual CA Fee	
		Amount (\$)	Cost per SF
1-Mental Hospital	—	15,450	—
2-Univ. Classroom	—	12,000	—
3-Univ. Classroom	110,380	45,600	0.41
4-Univ. Lab/Classroom	—	73,800	—
5-Office	32,268	11,370	0.35
6-Univ. Lab/Classroom	44,966	49,907	1.11
7-Univ. Lab/Classroom	140,700	139,000	0.99
8-Office	—	6,700	—
9-Lab/Classroom Addition	72,165	56,810	0.79
10-Juvenile Detention	45,915	49,201	1.07
11-Mental Hospital	79,130	110,600	1.40
12-Office	202,648	109,000	0.54
13-Prison	245,000	320,000	1.31
14-Prison	381,000	486,600	1.28
15-Prison	380,891	390,200	1.02
16-Prison	685,000	773,880	1.13
17-Laboratory	76,000	258,000	3.39
18-Hospital	51,000	63,000	1.24
19-Student Union Building	30,000	28,000	0.93

Table 3: Actual commissioning contribution per square foot.

Project 7 employed a CA from out of state, and the Project 11 CA incurred approximately 350 miles for each round trip to the construction site. Each CA included approximately \$20,000 to \$30,000 in the overall fee for travel.

Incidentally, the author recommends evaluating basic commissioning cost apart from extras such as travel, videotaping, code reviews and test and balance. Although it may be cost-effective to include some or all of these items in the CA's scope, their inclusion in the commissioning cost needlessly complicates the analysis. Extra services are more easily evaluated separately.

If travel and videotaping are removed

from these fees, all eight projects fall into a range of $\pm 33\%$ of the "2.5%/1.5%" model (incidentally, the two projects with the lowest comparative costs (Projects 6 and 12) employed CAs who were either in the same city or a short distance away). A variation of plus or minus one-third still leaves the sample costs well within all of the guidelines listed earlier.

The remainder of the projects (13 through 19) also are within a range of plus or minus one-third of the model predictions.

The Square Footage Model

Using building square footage to model commissioning costs appears more com-

Type of Building	Construction Cost \$	Total Cx Costs \$	CA Fee \$	% of Total	Contractor Cost \$	% of Total	Owner Cost (@\$40/hr)	% of Total
1–Mental Hospital	8,000,000	19,450	15,450	79%	2,500	13%	1,500	8%
2–University Classroom	140,000	15,000	12,000	80%	2,000	13%	1,000	7%
3–University Classroom	14,000,000	68,600	45,600	66%	18,200	27%	4,800	7%
4–University Lab/Classroom	14,400,000	86,400	73,800	85%	7,000	8%	5,600	6%
5–Office	505,000	15,370	11,370	74%	2,000	13%	2,000	13%
6–University Lab/Classroom	6,500,000	67,907	49,907	73%	12,000	18%	6,000	9%
7–University Lab/Classroom	8,700,000	183,500	139,000	76%	40,500	22%	4,000	2%
8–Office	600,000	7,600	6,700	88%	500	7%	400	5%

Table 4: CA, contractor, and owner commissioning costs.

plicated than using construction costs. This is due to complexity factors that are inherently included in system cost but are not included in the size of a building's floor area.

Table 3 lists unitary CA costs for the sample buildings. Buildings 1 through 5 and Building 8 were only partially commissioned and therefore are not included in the analysis. Building 8 is included in the earlier construction cost analysis because the complete mechanical system was replaced. Excluding these buildings, the remaining six Montana buildings show commissioning costs varying from \$0.54/ft² to \$1.40/ft².

The highest example, Building 11, which is a mental hospital, incurred high travel costs as described earlier. Without the travel costs, it would be closer to \$1.15/ft².

Of the six buildings, the office is the lowest cost example, at \$0.54/ft². The three lab/classroom buildings and the correctional center are next at \$0.79/ft² to \$1.11/ft². The mental hospital is the highest at \$1.40/ft². Although this is a very small sample of these case histories, the trend shows that cost per unit of floor area does tend to increase with complexity and is in the general range of \$0.50 to \$1.50/ft².

For the Missouri prisons, CA costs ranged from \$1.31/ft² to \$1.02/ft², which is above the cost of the Montana office buildings and slightly above the cost of the Montana lab/classroom and correctional facility (a juvenile facility). The Missouri laboratory is very

high in cost, reflecting a high level of complexity.

The Washington Student Union building is more expensive than the Montana offices and classrooms and less than the hospitals and prisons. The hospital is about the same as Montana's mental hospital, slightly above the average prison, but still well below the research lab.

However, consider that for one particular project on this list, incidental research revealed an actual range of commissioning fee proposals of \$0.50 to \$2.50/ft²! Let the buyer beware: the field is young and opinions on costs vary considerably!

Contributions to Cost

Table 4 lists the first eight projects on the complete list with actual CA costs and estimated contractor and owner costs. The other projects are not completed, and so do not have final contractor and owner costs.

Contractor costs are taken from several sources. On some projects, the contractor is asked to indicate his estimate of commissioning costs. For others, commissioning costs are included as line items in the schedule of values. On other projects, contractor costs are estimated based on the author's knowledge of the project.

One thing is clear—contractors have little experience in commissioning. This data, regardless of the source, is approximate. Contractor costs range from a high of 27% of the total costs to a low of 7% of the total costs.

Owner costs are based on the author's direct experience. However, for each project, the agency staff participated as well, and this component is estimated. Owner costs range from a high of 13% to a low of 2%.

These contributions appear in approximate agreement with the guidelines (Trueman) cited earlier.

Conclusion

In conclusion, this sample of commissioning projects points to the following:

- Most projects appear to follow an approximate cost guideline of 2.5% of mechanical and 1.5% of electrical construction cost, within a range of plus or minus one-third.

- Most projects appear to have commissioning costs in the range of \$0.50 to \$1.50/ft², with classroom and office buildings in the lower one-third of the range, lab/classrooms and correctional facilities in the middle third and hospitals and research labs in the upper third.

- CA costs appear to contribute most of the cost of commissioning, ranging from 66% to 88% of the total.

These costs do not include travel, videotaping, code reviews or testing and balancing, which are sometimes added to the CA's scope of work. Furthermore, they do not include the commissioning of special systems such as prison security systems or audio/video systems.

Both the floor area and construction cost guidelines appear to point to approximately the same cost for the commissioning authority. However, one method may

be more applicable than the other depending on the type of project. For instance, if only part of a new facility is being commissioned, the use of the floor area guideline might work best. If an existing building is being retrofitted with an entirely new HVAC system, the construction cost guideline appears to be the most applicable.

Regardless of the estimation method used, pricing and negotiating the actual commissioning services should only be done with reference to a detailed listing of systems to be commissioned.

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