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Paper Session III-C - 250 Aerospace Cost Indexes and Escalation

Joseph A. Brown
CCE, Construction Cost Consultant

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Introduction - What is a Construction Cost Index?

It is a tool to measure the cost increases of construction labor and materials. A good cost index can also be used to adjust previous bids and cost estimates to the present time and project their future costs one to ten years, based on past cost increases and experience. An example, the cost of the North/South Shuttle Landing Facility, built in 1974, can be indexed or escalated to 1996. The cost of a new East/West runway could be projected to 1999 to allow for more orbital landing at KSC and more timely shuttle launches. Another example: the cost of the world’s largest building, the VAB, could also be indexed, escalated, and projected to the future. This is a management overview of the unique Aerospace Construction and Ground Support Equipment (GSE) cost escalation since 1974, with cost comparison and analysis of labor and materials costs. This report will show eleven purposes and seven reasons why it is important and a summary of eight reasons how it helped to improve KSC cost estimating accuracy—some surprising and some unanticipated. This graphic presentation will show charts of annual and monthly cost escalation, including twenty-five labor skill rates and fringes, crew rates, and twenty-six material prices, sample aerospace price book index and low and high unit prices for faster conceptual estimating, the real aerospace cost increases since 1974 and one of the largest cost items in estimating, a graphic chart of payroll tax rates, which includes Workman’s Compensation, and a list of seven new exciting estimating tools to improve cost estimating speed and accuracy. It also includes a list of fifty-five of the larger and more accurate estimates since 1974, totaling over $200,000,000, within 6% of low bid estimates. This report discusses the cost index for “Long Term Escalation,” “Short Comings and Analysis.” This report is the twenty-second technical paper published in a one-of-a-kind series on aerospace construction and government cost estimating that started in 1968 with “Construction Bidding Cost of LC-39”—the world’s largest building—and includes “Estimating and Bidding for the Space Station Processing Facility,” completed June 23, 1994. Some other papers are: “Aerospace Construction Cost Estimating,” 1992, “Government Bid Estimate Compared to Contractors’ Estimate,” 1989, and “Government Conceptual Estimating for Aerospace,” 1986, which explains the purpose, use and importance of the system summaries for conceptual estimates and “33 Aerospace Spin-Offs for Construction Cost Estimating,” 1996. These 22 reports should be helpful in understanding some of the complexities of aerospace construction and government estimating. This report is about one of the most basic of over twenty-four aerospace estimating tools being developed at KSC to prove the benefit of the KSC team work efforts. Also included are special prices for aerospace commodities, such as, LH2, GN2, LH2, and HFC 134A costs and a more timely report of fiber optic cable costs. This monthly cost index may well be the only aerospace construction cost index in the world.

BACKGROUND

In the late 1960s and early 1970s, many cost engineers were deeply concerned about the spiraling wage rates and cost escalation and lower productivity, so the Florida section presented its 2nd Annual Symposium on “Cost Escalation and What Can We Do About It?” Subsequently, this author presented a summary of that symposium at the 1st International Cost Engineering Symposium in Montreal, Canada. At these, and additional presentations, a survey was taken as to what we can do about cost escalation. The overall total vote winner was EDUCATION. These surveys, through 1983, have been documented. In 1986, a construction management seminar workbook was presented by Joseph A. Brown, CCE, at the Technical University of Nova Scotia. With this background of cost escalation and lower productivity, the need to measure these increases, the "KSC Monthly Construction & GSE Cost Index" was created and developed by this author with important comments by Howard Gates, PE Aerospace Construction pioneer. This index has been an important educational tool to design engineers, A&E, support contractors, and those involved in aerospace construction and ground support equipment.

The Eleven Purposes of the KSC Cost Index are:

1. To provide current work hours - (Davis Bacon) rates (37) and material prices (24)
2. To show rates of change in labor and material price and a graphic number/month
3. To record and measure past escalation and project future escalation
4. To establish budget/PER conceptual rule of thumb costs and cross check detailed ests,
5. To help establish uniformity for the in-house and A&E cost estimates, etc.

9-9
6. As important communication tools, timely PT&I rates, mark-ups, etc., and new cost items
7. To keep it simple and easy to use
8. To index/unit prices and bid prices in aerospace price books
9. As a timely communication news bulletin on current bid projects, markets, and bids strategy, low bidders, and government estimates
10. Education on cost escalation and labor productivity
11. To escalate the cost of similar bids and estimates from the past to present

Seven Reasons Why Have A KSC Cost Index

Why a KSC Aerospace Cost Index is Important: The two most variable costs in construction are: 1) Location, which may vary from .75 to four times the ideal location, such as, Washington, D. C., or New York City. The major U.S. aerospace launch facilities are located at Kennedy Space Center, Florida and Vandenberg Air Force Base, California, with some overseas locations for landing in Africa, Spain, Guam, etc. Therefore, a cost index based on KSC is a most important factor to increase the accuracy and timeliness of KSC aerospace facilities estimates. Another most important variable cost in construction cost estimates is: 2) in types of industries - from residential to commercial, industrial, petro chemical and aerospace with many special unique costs as noted in technical paper aerospace construction cost estimating presented at the First World Cost Engineering Congress listing over twenty-five of KSC significant cost factors with a cost of 5 to 30 per cent normally and 30 to 200% for special requirements. The major cost indexes do not index a number for KSC or Brevard County. Therefore, these were two of the major reasons for creating and developing the KSC cost index in 1974. Another important variable is in labor payroll taxes, or PT&I, which varied from 12%. in 1961 (Ref. No.19 “How Did the Low Bidder Get Low?”) to 50% or more in January 1995 cost index. It’s importance is also noted in fine tuning PT&I in Ref. No. 18, “33 Aerospace Spin-Offs in Construction Cost Estimating.”

1. For KSC one-of-a-kind projects - Detailed labor and material prices are especially important
2. No published cost data for aerospace/GSE facility costs existed
3. Governments need to budget projects one month to twenty years in advance of their need
4. To take projects/system unit bid prices, bid and build since January 1974 and escalate to now and escalate future costs for faster budget estimates and cross check current project government estimates
5. This index is specific for KSC, Florida
6. This index is specific for aerospace industry
7. This index includes PT&I rates for aerospace

Some special features have been construction cost alerts, in bidding markets with rising and falling prices, a market analysis of low bidder estimates-how the low bidder got low, analysis of the government estimates and differences between bidder estimates. New detailed mechanical cost estimating guideline, NASA Headquarters six year cost escalation guidelines, special prices for aerospace commodities, such as liquid hydrogen, oxygen, and gaseous nitrogen, etc., CAD estimating updates, the Joe Brown “on-the-spot” award for 1992, 1993, and 1994, recent bids and upcoming bid projects and, currently, a list of sixty-five KSC projects recognized for government estimate accuracy—totaling $303,578,791, all within 5.9% of the low successful bid. (Ref. Nos. 2, 3, &7) (See Figure #1.)

The “Basic Cost Index” Consists of Five Major Graphic Charts and Tables:

1. The “Monthly Graphic Chart Cost Index” shows the escalation from January 1994 to December 1995. (Ref#2)
   for labor, from 2883 to 3181
   for materials, from 2329 to 2606
   total labor and materials, from 5212 to 5747 or +10.3% change

<table>
<thead>
<tr>
<th>KSC Monthly Construction Cost Index - Monthly</th>
</tr>
</thead>
<tbody>
<tr>
<td>JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC</td>
</tr>
<tr>
<td>JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC</td>
</tr>
<tr>
<td>L arg 2883 2893 2893 2913 2913 2933 2933 2943 2943 2960 2960 2960</td>
</tr>
<tr>
<td>Mater i al 2329 2295 2295 2279 2279 2306 2306 2327 2327 2362 2362 2362</td>
</tr>
<tr>
<td>T otal $ 5212 5150 5165 5165 5229 5236 5260 5307 5307 5347 5347 5347</td>
</tr>
</tbody>
</table>

(Ref. Nos. 2, 3, &7) (See Figure #1.)
"Monthly Graphic Chart of Labor and Material Cost," December 1995 is 5747. Note: Orbital Landing Facility (OLF), bid in early 1974, could be escalated by dividing  

\[ \frac{5747}{2000} = 2.8735 \times \$21,812,737 = \$62,678,900 \]

original bid price to budget cost of $62,678,900 in December 1995, the same way any one of 1055 projects bid since 1974 could be escalated. If the VAB was built in 1974 at $117,000,000, what would the budget cost be today? 

\[ \frac{5747}{2000} = 2.8735 \times \$117,000,000 = \$336,199,500 \]

in December 1995

2. The “KSC Annual Construction Cost Index Chart” shows the labor, material and composite labor and material escalation with an erratic high climb since January 1974: (Ref #2)

![KSC Annual Construction Cost Index Chart](image)

<table>
<thead>
<tr>
<th>Year</th>
<th>Labor</th>
<th>Material</th>
<th>Total</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1974</td>
<td>1000</td>
<td>1200</td>
<td>2200</td>
<td>0.00</td>
</tr>
<tr>
<td>1975</td>
<td>1200</td>
<td>1300</td>
<td>2500</td>
<td>0.91</td>
</tr>
<tr>
<td>1976</td>
<td>1500</td>
<td>1400</td>
<td>2900</td>
<td>1.82</td>
</tr>
<tr>
<td>1977</td>
<td>1800</td>
<td>1500</td>
<td>3300</td>
<td>2.73</td>
</tr>
<tr>
<td>1978</td>
<td>2100</td>
<td>1800</td>
<td>3900</td>
<td>3.64</td>
</tr>
<tr>
<td>1979</td>
<td>2400</td>
<td>2000</td>
<td>4400</td>
<td>4.55</td>
</tr>
</tbody>
</table>

Note: The flat materials line 1989-1993 which confirms the “number of bidders” concept, which notes the number of bidders had average 5.5 bids increased to an average of 11.14 bids per KSC project during building recessions October 1989 to September 1994. Recent number of bidders has dropped to 6.3 bids and may be the reason for the
increase in bid cost of 5 to 17%—a new estimating tool—number of bidder concept—as detailed in case study at the 33rd AACE annual meeting “Estimating and Bidding Space Station Processing Facility,” Dearborn, Michigan.

3. The “Department of Labor Wage Rates for NASA Construction Projects” shows the current wage rate for 25 skill trades, such as, plumbers, electricians, iron workers, asbestos workers, cable splicing, crane operations, etc. It also shows fringe benefits and allowances for foremen. (Ref. #2)

4. “KSC Labor Cost Index for December 1994 Chart” shows suggested crew work hour rates for nineteen typical specification sections with a total of 100 work hours. Example: electrical, $30.66/hr x 10 work hours = $306.60. Also note electrical rate in January 1974 was $9.38, and in January 1979 was $15.27, or the average cost for 100 work hours would be $2,687.28 for December 1994 or an average of $26.87 per work hours.

5. “KSC Material Cost Index for December 1995 Chart” shows material prices with estimated typical quantities example 8 x 8 x 16 concrete block at $.78 ea x 339 = $264.42 of material/equipment total material price of $5280.27.

Special Feature of the KSC Cost Index

A special feature of the KSC Cost Index is that it is also an index of the “Aerospace Price Book” with current unit bid prices (Ref #6). In the “KSC Cost Index” is a 30-page index of the 1992-1994 “Aerospace Price Book” for Volume I, II, and III. (Ref#6)

Volume I - “Introduction and Sample - How to Make a Budget Estimate,” “Architectural Structure - Civil and General,” and “Equipment Unit Prices and Rental Rates”
Volume II - Mechanical and Electrical, Unit Prices and Elements/System Prices"
Volume III - “System Summary of Over 340 Bid Projects with Matrix Cross Index” (see Figure VII - sample summary for restoring C5 sub-station).

Note: Volume IV is an over 110 page case study of the detailed government estimate for the space station processing facility, see “Estimating and Bidding SSPF,” references No. 3 and 4- technical paper for government estimates summary and detailed cost data breakdowns.

Some Other Special Features and Comments

Our KSC Cost Index has helped us get other important for cost data, such as, Navy CES and the “Florida Department of Transportation Unit Bid Prices Quarterly,” which we summarized and published as part of our index. This is especially important for civil road projects, earthwork, paving, steel rebar, etc.

One of the largest cost items in construction estimation is the cost of payroll taxes and insurance which varies from 14.6% to 100% of labor cost. These are shown as backup data for the PT&I rate we use in our crew rates (see Figure VIII). Also included in the index is graphic chart 1979-1994 for Workman’s Compensation and PT&I (see Figure III).

Several technical papers have been written about the KSC cost index starting in 1975. “KSC Cost Index for Construction Management” - presented at the 19th Annual AACE Meeting. Also, “Conceptional Cost Estimating Using KSC Cost Index” for CM, presented at the 24th Annual Meeting, July 1980, in Washington, D. C., “Aerospace Construction Cost Estimating” at the 1st World Cost Engineering Congress where the “KSC Cost Index” was featured as one of the 21 unique aerospace estimating tools for more accurate government estimating and also, in the “Space Station Processing Facility Government Estimating and Analysis” as a case study documenting the use of these tools to increase the accuracy of the government estimates.

New Exciting Estimating Tools - Special Feature of Cost Index

As a part of DE cost engineering continuous improvements, some new exciting aerospace construction and GSE cost estimating tools are being developed and tested at KSC:

1. Fiber Optics Cable - A) Cost per fiber foot - John Shramko and Bob Lupo/DF-FED-22, J. A. Brown/NASA, team leader, Austin Durette/EG&G; B) Fiber Meter Graph. (Ref #2)
2. Cost per Panel Component Chart - Labor, Material & Fabrication - For Budget and Cross Checking - Etheroy Jones/EG&G, J. A. Brown/NASA, team leader. (Ref #2)
4. Work Hours Per Panel Component Chart and Summary Analysis - J. A. Brown/NASA, E. Jones/EG&G.
5. Fine tuning labor Payroll Taxes & Insurance (PT&I) since rates vary from 15.8% to 150% or an average of 45%. We are now re-evaluating each project and using appropriate taxes.
6. Avoid sole source/limited competition by making an additional or double design and bidding as an alt. .

● Unique Cost Estimating Incentive Awards - “on-the-spot,” publication, positive and negative,

● Available now - Four basic to advanced cost estimating seminars -
  1. “How to Read Blueprints, Plans, and Specifications Faster and Better,” and “Introduction to Cost Estimating” - a 12 to 20 hours, 3 to 6 days seminar -"# Speeds, 14 Methods, 5 Reasons for Faster and Better Plan Reading."

What about use of cost indexes for long term escalation? What are the short comings or disadvantages? Answer: This was discussed at the December 20, 1994, Design Facility, “Cost Estimating Briefing” (reference #1), where the following chart was presented and the analysis matrix was later developed by the author based on his use of the “KSC Cost Index” for conceptual/budget, estimating with over 20 years’ experience. These concerns were also noted at the lecture presentation to the University of Florida, Building Construction 5625 (reference #15). But first, what are the short comings of the cost index system?

Short Comings of Cost Index System

1. Doesn’t account for construction bid market, such as, contractor markups. These bids may vary from 25% to 90% of labor material prices. (Ref #9)
2. Doesn’t account for types and number of bidders - union/open shop, number of bidders’ concept 1-30. (Ref #10, 3, & 4)
3. Doesn’t account for Design Environment - cost effective to gold plated. (Ref #5)
4. Doesn’t account for New Design Requirements or obsolete requirements - environment, asbestos, lead, freon, storm water, wind loading, ADA, energy conservation, etc. (Ref #5)
5. Doesn’t account for labor productivity - then and now. (Ref #11, 13, & 16)
6. Doesn’t account for location factors. (Ref #5, 11, & 16)

However, KSC Cost Indexing is a most fast and easy system that can be more accurate when major cost considerations are used. These considerations and cost analysis are documented in the case study of “SSPF Government Estimating” presented at the AACE International Meeting at Society of Cost Estimating and Cost Analysis Workshop, October 8, 1993, (Ref #3 & 4).

Note: Since most of the experience using the KSC Cost Index has been for KSC projects, the six short comings are easier to evaluate. When this index is used around the world, as KSC has developed many alternate landing sites, such as, Spain, Africa, Guam, and South America, California, and New Mexico, the location factors are the most variable factors in using the following analysis matrix, therefore, more time needs to be devoted to that portion. See Reference
EXAMPLE OF ANALYSIS MATRIX

<table>
<thead>
<tr>
<th></th>
<th>When Original Bid Date</th>
<th>Today's Bid Date</th>
<th>When Expected to Bid</th>
<th>Adjustment %</th>
<th>Range %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mark-ups</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. No. of Bidders</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ref. #10, 3, &amp; 4</td>
<td></td>
<td></td>
<td></td>
<td>-5% to +27%</td>
<td></td>
</tr>
<tr>
<td>3. Design Environment</td>
<td></td>
<td></td>
<td></td>
<td>± 20%</td>
<td></td>
</tr>
<tr>
<td>4. New Design Requirement, Wind, Flood Levels, Earthquakes</td>
<td></td>
<td></td>
<td></td>
<td>± 20%</td>
<td></td>
</tr>
<tr>
<td>5. Labor Productivity</td>
<td></td>
<td></td>
<td></td>
<td>38% to 90%, 70% norm</td>
<td></td>
</tr>
<tr>
<td>Ref. #11 &amp; 13</td>
<td></td>
<td></td>
<td></td>
<td>Location Factors</td>
<td>.75 to 3.0 Ref. #5</td>
</tr>
<tr>
<td>6. Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total</td>
<td>.75</td>
</tr>
</tbody>
</table>

Therefore, this project may cost ________% more or less than the escalated totals

Shared Cost Data

Since this is probably the first report on many of these exciting new tools, the author would appreciate sharing your cost data, comments, feed back, and successes, etc. Also, note that many of the important details, cost data, limitations, etc., could not be listed and explained in this brief report because of time, space, and their wide potential application in saving estimating time and improving estimating accuracy (AC 407-452-4909). As a successfully retired NASA/KSC Lead Cost Engineer, this paper will help document these spin-offs, tools, and usefulness to estimators, contractors, and other local, state, and federal government organizations. These tools, particularly the KSC Cost Index, have been and are being used throughout the USA by the Air Force, U.S. Navy, U. S. Coast Guard, and other NASA field centers, over 30 architects, engineers, firms, and over 1,000 individuals. The usefulness has been documented by almost 1,000 responses to five NASA Technical Briefs from 1983 to 1995, and based on personal feed back, telecon, over 100 letters, and comments and over 23 published and presented professional technical papers to over 650 professionals on aerospace government estimating. These tools are an important part of over 25 continuing education cost estimating seminars presented to over 500 construction students throughout North America from San Francisco to Nova Scotia, Miami to Toronto. These students are from 17 countries in 6 Continents. (Ref. #2, 11, 13, 18, & 20)

In Summary

1. It has been used successfully for 20 years with over 250 monthly cost indexes.
2. It has accurately recorded and documented KSC construction and GSE escalation.
3. List of top 65 projects for $179,231,000 where a low responsive bid was within 6% of government estimate.
4. It has helped improve our cost estimating accuracy.
5. It has made the lead cost engineer’s job a lot easier by saving time proving and justifying our many cost estimates and negotiations - an especially nice surprise.
6. As one of KSC’S important cost engineering teamwork tools, it is responsible for saving time, money, and improving performance.
7. It has been an important part of our development of our new exciting cost estimating tools, such as fiber optics on the information superhighway, cost on special aerospace control panels for space program, fine tuning PT&I, number of bidder concept—most pleasant and rewarding surprises.
8. It has provided a means of exchanging and sharing important, cost data and team work with others, Florida DOT, Navy CES, and A&E firm, and consultants-an important unanticipated benefit.
9. Has been an important means of proving KSC cost engineering cost data integrity with facts and figures to backup cost estimates in negotiations, low bidders, and non-responsive bidders, to help avoid protests---one of the pleasant surprises and major benefits, saving lots of time.

10. The “KSC Monthly Index” has helped make it possible to publish the current and projected Workman’s Compensation Rates and PT&I Rates-9 to 18 months early improving estimating accuracy---one of the most beneficial and surprising benefits.

This report is about one of the most basic of our over 30 aerospace estimating tools and spin-offs being developed at KSC to prove the benefits of the KSC team work efforts which are contributing to our goals of continuing space exploration and development.

J. A. Brown, CCE
Construction Cost Consultant
1695 Vega Avenue AC 407-452-4909
Merritt Island, Florida 32953-3175

References


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### Figure II - KSC Material Cost Index for December 15, 1995

<table>
<thead>
<tr>
<th>SEC</th>
<th>DIV NAME</th>
<th>MATERIAL</th>
<th>JAN 74</th>
<th>JAN 79</th>
<th>QUANTITY DEC. 1995</th>
<th>JOB $</th>
</tr>
</thead>
<tbody>
<tr>
<td>1D</td>
<td>GEN REQ</td>
<td>3/4&quot; A/C PLYWOOD</td>
<td>0.41</td>
<td>0.55</td>
<td>200 SF</td>
<td>0.99</td>
</tr>
<tr>
<td>2P</td>
<td>SITE WORK</td>
<td>ASPH PAVING 1-1/2&quot; FINE</td>
<td>0.80</td>
<td>1.20</td>
<td>30 SY</td>
<td>2.43</td>
</tr>
<tr>
<td>3A</td>
<td>CONCRETE</td>
<td>2000# REDI-MIX (QUOTATIONS RANGE FROM $1.41 TO $700 CY)</td>
<td>23.25</td>
<td>35.00</td>
<td>15 CY</td>
<td>59.00</td>
</tr>
<tr>
<td>3B</td>
<td>CONCRETE</td>
<td>REBAR 2&quot;</td>
<td>0.18</td>
<td>0.22</td>
<td>500 LB</td>
<td>0.45</td>
</tr>
<tr>
<td>4A</td>
<td>MASONRY</td>
<td>CONC. BLOCK 8X8X16 300 SF</td>
<td>0.07</td>
<td>0.44</td>
<td>339 EA</td>
<td>0.78</td>
</tr>
<tr>
<td>5B</td>
<td>SHOP FAB AT INSTALLED AT</td>
<td>1&quot; X 1&quot; 100 LB</td>
<td>1.09</td>
<td>1.12</td>
<td>100 LB</td>
<td>1.65</td>
</tr>
<tr>
<td>6A</td>
<td>CARPENTRY</td>
<td>WAREHOUSE SHAPES DELIVER BUSINESS WEEK</td>
<td>0.23</td>
<td>0.26</td>
<td>1000 LB</td>
<td>0.45</td>
</tr>
<tr>
<td>7M</td>
<td>MOIST PROT</td>
<td>9# ROLL ROOFING</td>
<td>6.90</td>
<td>9.80</td>
<td>10 SQ</td>
<td>13.07</td>
</tr>
<tr>
<td>7J</td>
<td>MOIST PROT</td>
<td>FIBER INSUL 3-1/2&quot;</td>
<td>0.09</td>
<td>0.21</td>
<td>1000 SF</td>
<td>0.22</td>
</tr>
<tr>
<td>8G</td>
<td>DOORS</td>
<td>3&quot; X 7&quot; ALLOCT &amp; FR</td>
<td>11.43</td>
<td>20.95</td>
<td>10 SF</td>
<td>45.90</td>
</tr>
<tr>
<td>8J</td>
<td>WINDOWS</td>
<td>VINYL COMPOSITION TILE</td>
<td>0.33</td>
<td>0.42</td>
<td>100 SF</td>
<td>0.82</td>
</tr>
<tr>
<td>9B</td>
<td>FINISHES</td>
<td>1/2&quot; GYPSUM BDR, FIRE COCOED</td>
<td>0.06</td>
<td>0.09</td>
<td>1000 LB</td>
<td>0.26</td>
</tr>
<tr>
<td>9C</td>
<td>FINISHES</td>
<td>PVC ACOUSTICAL TILE W/SUSP SYS</td>
<td>0.33</td>
<td>0.39</td>
<td>100 SF</td>
<td>0.58</td>
</tr>
<tr>
<td>10</td>
<td>SPECIALTIES</td>
<td>VENETIAN BLINDS - ALUM. 2&quot;</td>
<td>1.46</td>
<td>2.55</td>
<td>10.5 SF</td>
<td>5.05</td>
</tr>
<tr>
<td>11</td>
<td>EQUIPMENT</td>
<td>ELEVATED FLOOR SYS - STEEL</td>
<td>4.34</td>
<td>7.25</td>
<td>10 SF</td>
<td>12.50</td>
</tr>
<tr>
<td>14H</td>
<td>CONVEY SYS</td>
<td>PANEL WITH CARPET, SM. QUANTITY - MATERIAL ONLY</td>
<td>0.37</td>
<td>1.10</td>
<td>100 LB</td>
<td>1.45</td>
</tr>
<tr>
<td>15A</td>
<td>MECHANICAL</td>
<td>6&quot; SLIP JOINT CLASS 50 DIP</td>
<td>3.60</td>
<td>5.93</td>
<td>25 LF</td>
<td>6.38</td>
</tr>
<tr>
<td>16</td>
<td>ELECTRICAL</td>
<td>1/2&quot; CU TUBING ($2.58 LB)</td>
<td>0.26</td>
<td>0.32</td>
<td>500 LF</td>
<td>0.51</td>
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<tr>
<td>17</td>
<td>WELDING</td>
<td>BUSINESS WEEK 12/13/95 142.7 CENTS/LB (12/25)</td>
<td>4.92</td>
<td>246.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>HVY CONSTR</td>
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<td>SHEET METAL</td>
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### Figure IV - KSC Labor Cost Index for December 15, 1995

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5280.27 X ADJUSTMENT FACTOR OF .493628 KSC MATERIAL COST INDEX FOR DEC. 1995 IS AN INCREASE OF 160.6% OVER JANUARY 1974 AND AN INCREASE OF 9.91% FROM JANUARY 1995.

* TO BE USED IN DETAILED ESTIMATES. CONFIRMED BY QUOTES WHEN COST EXCEEDS $1,000.

$2,845.84 X ADJUSTMENT FACTOR OF 1.10355 KSC LABOR COST INDEX FOR DEC. 1995 IS AN INCREASE OF 214.1% OVER JANUARY 1974, AND A CHANGE OF 0.9% FROM JANUARY 1995.
Introduction

As a successful, retired NASA/KSC Lead Cost Engineer, this paper will help document these spin-offs and/or tools and their usefulness to estimators, contractors, and other local, state, and federal government organizations. These tools have been and are being used throughout the USA by the Air Force, U.S. Navy, U.S. Coast Guard, and other NASA field centers, over 30 architects, engineers, firms, and over 1,000 individuals. The usefulness has been documented by almost 1,000 responses to five NASA Technical Briefs from 1983 to 1995, and based on personal feedback, telecon, over 100 letters, and comments and over 23 published and presented professional technical papers to over 650 professionals on aerospace government estimating. Some of these spin-off tools and the government estimating technical papers are an important part of over 25 continuing education cost estimating seminars presented to over 500 construction students throughout North America from San Francisco to Nova Scotia, Miami to Toronto. These students are from 17 countries in 6 continents. (Ref. #24.) This report is about over 33 construction cost estimating tools, some especially exciting. They have been useful in improving accuracy and helpful in reducing estimating time in keeping with better, faster, and cheaper methods of estimating costs. At the 1st World Cost Engineering Congress in 1992, the first 21 tools were listed and described. These 12 additional spin-offs are for general bidding, mechanical, and electrical estimating. The most surprising and exciting tool may be a cost engineering contribution to the communications super highway by estimating the cost of installed fiber optic cable faster and more accurately. Another is one the author and others have been searching for for many years in mechanical estimating involving total bid costs, work hours, and materials costs per component or three tools in one. Other tools include analysis for adjusting cost indexes for long term escalation, number of bidders concept, PT&I rates, O. F. E., and GSE estimating, CAD automatic cost estimating, duel design, work hours, and material cost charts for pneumatic and hydraulic panels and tubing, work hours for welding SS tubing, etc. These 33 spin-offs were developed, tested, and used by government and A&E estimators for cost engineering for Total Cost Management (TCM).

Background

The background for developing new tools goes back to early 1960s, working for a general contractor - professional engineer (PE) during design, design-build, and construction management (CM) projects and learning to be the successful low bidder and analysis of what other bids would be before the bid opening by analysis of prime and sub-bids. Later on, teaching four college credit courses: Cost Estimating and Blue Print Reading; Construction Methods - Planning Scheduling - CPM; Contract Law and Specifications for Engineers, Contractor’s License Review Course, while working for Corps of Engineers as a structural engineer and NASA as KSC Lead Cost Engineer, more recently, in 1992, at the 1st World Cost Engineering and Project Management Congress where 21 mostly unique government contractor estimating tools were listed in “Aerospace Construction Cost Estimating.” The following is an updated list of these tools with some comments and additions. This paper will concentrate on the newest spin-offs.

Government Estimating Tools/Spin-Offs

- The cost estimate - Codes A, B, C-30, 60, 90, 95, and 100; D, E, &G; (GSE Cost Estimates)
- KSC estimating specifications G-0002, Construction
- KSC estimating specifications G-0003 for ground support equipment fabrication. The development of this specification was requested by Jim Hart, NASA Project Manager, because NASA/KSC received no bids, or only one or two bids and/or inflated bids. This specification helped solve this problem and saved the government millions of dollars
- KSC Monthly Cost Index (January 1974 to present) (See “240 and 250 Cost Indexes and Escalation”)
- Aerospace Price Books - four volumes
- Volume 1- “introduction and Sample - “How to Make a Budget Estimate,” “Architectural Structure - Civil and General,” and “Equipment Unit Prices and Rental Rates”
- Volume II- Mechanical and Electrical, Unit Prices and Elements/System Prices
- Volume III - “System Summary of Over 340 Bid Projects with Matrix Cross Index”
• Volume IV is an over 110 page case of the detailed government estimate for the space station processing facility, see “Estimating and Bidding SSPF.” (Refs. # 3 and 4- technical paper for government estimates summary and detailed cost data breakdowns.)
• Areas and volumes, square and cubic foot costs, unit cost (studies for unique projects);
• Computers, 3-D Modeling, Micro station, Spreadsheet, etc., for KSC cost data;
• Quotes and sources for major aerospace cost items;
• Special cost engineering summaries - system, L&M, overhead and budget comparison;
• Cost estimates/studies of A&E service; design costs, engineering costs. Design to cost limit in A&E
• Five volume seminar work books (with over 100 estimating secrets);
  • Vol. I - Plan Reading, Faster and Better - three speeds, 14 methods, five reasons;
  • Vol. II - Cost Estimating - faster, better -32 ways, 33 tools, bidding strategies;
  • Vol. III - Cost Engineering/Construction Management - Cost Controls -60 ways, CPM;
  • Vol. IV - Computerized Estimating -14 programs, present and future;
  • Vol. V - Aerospace/GSE Cost Estimating -12 new exciting tools -20 other aerospace tools;
• Project source list of potential bidders (prime, subs, vendors) - those who get bid packages (available only to those who ask for it. List name, address, and phone numbers);
• Planning and Scheduling CPM, Primavera Scheduling Program; VAB use of Computerized CPM-
  Aerospace Labor Productivity Surveys (Refs. #.5, 11, and 16)
• 23 Aerospace Government estimating technical papers, services, description and “How to Use Spin-Offs”

The twelve new estimating spin-offs are: (updated from KSC Cost Index, 12/15/94)

4. Work Hours Per Panel Component Chart and Summary Analysis -J. A. Brown/NASA, E. J.
5. Fine tuning labor Payroll Taxes & Insurance (PT&I) since rates vary from 15.8% to 150% or an average of 45%. We are now re-evaluating each project and using appropriate taxes, such as, Office O/H- 15% to 24%, Elec - 26%, Carp/Cone - 45%, Steel - 57%, Civil - 23% to 31%, & Marine - 60% to 100%, J. A. Brown.
6. Avoid sole source/limited competition by making an additional or double design and bidding alt.
12. Fine Tuning “Number of Bidders’ Concept,” J. A. Brown.

Other Spin-Offs

• Educational, historic, video - estimating and bidding strategy showing government construction -17 case studies 40 ways, methods, “How The Low Bidder Got Low,” commercial, industry, Apollo, shuttle, and space station.

• Available now- Four basic to advanced cost estimating seminars - How to use these spin-offs now. “How to Read Blueprints, Plans, and Specifications Faster and Better,” and “Introduction to Cost Estimating” - a 12 to 20 hours, 3 to 6 days seminar -3 Speeds, 14 Methods, 5 Reasons for Faster and Better Plan Reading.”

Number 12- Number of Bidders’ Concept - Introduction - What is the Number of Bidders’ Concept? We have found at KSC:

1. The more bidders over five means lower bid costs. As more prime, subs, vendors, suppliers, etc., give lower, more competitive prices.
2. Using the number of bidders - it can be shown how the local building economy is doing - more bidders doing a building recession.
3. By estimating the expected number of bidders, the owner/government can more accurately determine the best markups to have a fair and reasonable estimate for budgets and detailed bid estimates.

At the KSC construction cost estimating briefing, 12/20/94, it was stated that the number of bidders’ concept showed a KSC building recession from October 1989 to September 1994. It ended as the number of bidders decreased from an average of 11 bids to an average of 6.3 bids per KSC construction building projects which may be reason for increased bid costs of 5 to 18% on some projects. The speaker went on to say, “What does this mean to the bidding and estimating market?” - turbulence, erratic transitional period of very high and low bids which happened during 1995. Tool number 12, “Fine Tuning Number of Bidders’ Concept,” was first discussed at the 1st World Congress presentation of new tools, but was documented in the 1993 Presentation Estimating and Bidding Space Station Processing Facility (SSPF) in Dearborn, MI, and at the Society of Cost Estimating and Analysis, October 8, 1993. These technical papers may be the best documentation of a case study showing the use of the number of bidders’ concept and its applications in improving the accuracy of the government estimate. It must be noted the importance of the research of Dr. R. M. Skitmore, with the aid of KSC Lead Cost Engineer, providing R&D projects cost data which was published in the 10th International Cost Engineering Congress in New York, 1988, entitled “Factors Affecting Accuracy of Engineering Estimates.” The charts published in these three technical papers involved 65 projects with 429 bids---quite a large sampling. The KSC Lead Cost Engineer’s comments were based on his experience and applications of the number of bidders’ chart. It is suggested that increased bid competition lowers the bid cost 7 to 22% as the number of bidders increases over seven bidders. In summary of the SSPF case study, listed:

1. Five ways to help determine the number of bidders for government projects
2. Special studies and analysis of previous government estimates
3. Special studies of low bidders, bids, and estimates
4. Independent analysis of bids - low bid, medium high bids -3 months prior to bidding
5. Special analysis and review of the SSPF government estimates
6. Special data matrix analysis combining five lists to determine the most likely number of bidders

Why Number of Bidders is Important

1. Like detailed planning and scheduling, it forces a detailed bidding analysis
2. Helps fine tune all mark-ups, OH&P, PT&I, which may vary from 25 to 90% of labor and materials costs
3. Can help get more bidders, if necessary
4. Can help get better bidders, if necessary
5. Helps to ensure bids for special or unique materials, installations, service, systems
6. After the bids are in, helps explain what happened - why bids were too high or too low
7. Most helpful in budget estimating and adjusting cost indexes.
8. Adjust your estimates down 25% if over 10 bidders, to up 5% for special conditions escalation, if only two bids are expected.
Steps for Using Number of Bidders' Concept to Adjust Estimating Mark-Up

1. Keep records of your bids - see “Abstract of Bids Summary.” (Ref. #3)
2. Determine number of potential bidders, 1-30, from several sources. The more sources, the better.
3. List them and note types and kinds of bidders, primes/sub types, union/open shop, specialty, etc.
4. Based on bidding experience, analyze, make a numerical number determination, 1-4, 5-7, 7-10, 10-15 or more. If you don’t have enough, try to get more.
5. Review number of bidder charts and ref. #4, 10, 18, and 23
6. Determine percentage effect on your estimates - 5% to 27%, based on normal full mark-ups
7. Review and analyze your estimates for accuracy and completeness, especially labor and material quantity take-offs and unit prices - quotes, volume discounts, etc.
8. Adjust your estimates down 25% if over 10 bidders, to up 5% for special conditions escalation, if only two bids are expected.

Based on the KSC Lead Cost Engineer's experience, the number of bidders concept may help explain over 60% of estimates that differ greatly from the Government estimate. Therefore, this is the twelfth new exciting government estimating tool fine tuning the number of bidders concept to adjust mark-ups, etc., based on Dr. Skitmore's factors affecting engineering estimate. (Refs. #3, 4, 10, and 17). Since the Technical paper SSPF estimating and bidding was written, an interesting article in Cost Engineering Journal, April 1995, entitled “How to Relate Construction Cost Estimates to the Prevailing Bid Market for Government and Institutional Projects,” was published by Nissim Zelouf with similar findings on bid variation factors with a cost analysis for eight examples - from .785 to 1.3 for one bidder. A parametric computer estimating program by Delta Research Corporation in Niceville, Florida, now uses the number of bidders as a factor in adjusting their ratio estimates for the Air Force budget estimates. So the importance of understanding and using this concept correctly has a direct correlation on the accuracy of their estimates. This number of bidders’ concept has successfully been used at KSC since 1990 and has resulted in increased estimating accuracy, as noted 4/15/94 and in KSC Cost Index, 3/15/95---Joe Brown “On-The-Spot Awards” for twenty-one projects, with GE total near $90,000,000.

Tool Number 11- Cost Analysis for Long Term Escalation

The eleventh tool - “Cost Analysis for Long Term Escalation,” was created in late 1994 and early 1995 by the KSC Lead Cost Engineer and documented in the technical paper, “240 Aerospace Cost Indexes and Escalation,” presented at the AACE International meeting in St. Louis, June 1995. Due to the variation in the six factors, especially the location factor and date of future projects, the analysis can justify or explain a wide variation in the “did cost” - “will cost” budget estimates (see technical paper, “Estimating Labor Productivity,” 30th AACE Meeting Chicago, 1986, and Seminar Work book Volume III, “Cost Engineering, Construction Management, and Computer Estimating, 1986, (see chart revised 4/4/95 from “240 Cost Indexes.” Note item No. 2 on the chart uses the number of bidders to adjust the effect of long term escalation of cost indexes. (Refs. #17, 22, and 23. This Reference includes an updated copy of the Analysis Matrix.)

Tool Number 10- Owner Furnished Equipment (OFE) and Government Furnished EQ GFE Cost Est.

Number 10, OFE/GFE estimating - cost of handling, storage, and insurance 1-10%, - this is a special tool that has been used in electrical estimates for owner furnished transformers and has been updated and analyzed for aerospace application by breaking down the cost of testing - at pickup - hauling, storage, crane, housing and special insurance for damage. In some cases, millions of dollars of OFE/GFE were furnished to the successful low bid contractor because the OFE was needed to speed-up the project - fast tracking or it was not available, otherwise; such as, special vacuum, jacket pipe, remote control panels, specialized existing equipment to be reused. The guideline percentages used are:

| Handling       | - .5-10% % with back-up for hours and equipment costs |
| Storage        | - 0-5% % Days - weeks, place, cost, back-up data   |
| Insurance      | - .5-10% % Quote, backup helpful                   |
|                | .1%-15% The percentage cost is of the value of the GFE per item or total - or new. |
Another estimating method may be to figure cost estimate with total value/cost of OFE/GFE and deduct only its cost/value from total bid. Thus, GSE cost has its normal mark-ups. Many low bidders have lost millions of dollars by not being aware of or appreciating the value and importance of this tool in their bidding estimate, especially a world famous engineering contractor who lost millions on one bid. As a reference, this item was originally listed and describes KSC estimating Spec G-0002 revision July 1986, G-0003 GSE -1976, but the value of the new tool was not appreciated until recently after successful government settlement of a major $5,000,000 contract claim.

**Tool Number 9- Chart for Specialized Aerospace Welding**

Work hours for welding SS tubing using Astro Heliarc Welding Machine (Ref 6 Vol 11, p. 31/32, 12/14/92, varying from 42 X to 2.82 de joint 1/4” - 2” chart was successfully used recently in SSPF estimates includes .40 handling + .02 welding. (Published in APB Vol. 11, page 31 and 32, dated 12/14/92.) (See figure #1.) (Ref. #6) A copy of this chart should be in upcoming paper, “12 New Exciting Tools.”

**Tool Number 8- Charts for Specialized Aerospace Remote Control Panels**

Work hours for pneumatic and hydraulic panels - this chart has been developed since the 1980’s and recently updated 4/25/92. This chart has been used successfully for over $10 million of panels procured and bids from 1980 through 1995. As listed in APB, Vol. 11, dated 12/14/92, page 30, this tool is most important in detailed labor and materials, GSE cost estimates, which led to the exciting new tools numbers 2, 3, and 4. A copy of 2 of these charts should be in technical paper, “12 New Exciting Tools.” (Ref. #23)

**Tool Number 7- CAD/ACCE - Automatic Computer Cost Estimating**

CAD/Automatic Computer Cost Estimating was developed by the author with most important assistance from Hank Perkins, NASA KSC Project Manager, Pat Tanner, Industrial Engineer with NASA KSC Support Contractor, the U.S. Navy, IBISCALC -of the Netherlands, Europe, Intergraph of Huntsville, Alabama. Many of the details of the amazing computer estimating system have been published, presented in phases at PROCIEEM 89, 11th International Cost Engineering Congress, Paris 1990, AACE International Boston 1990, the WATTEC 91, Knoxville, Tennessee, as the challengers developing PC work stations, CAD estimating, and at the 22nd Annual Cost Engineering Symposium on CADD Estimating Systems, March 1991, at Lake Buena Vista, Florida. The 55 page technical paper listed the 39 steps for making the CAD estimate with 24 challenges, computer estimating from CAD and CAD drawings, etc., with the following accomplishments: (NASA Tech Brief, KSC 11578)

1. A project can be estimated from CAD quantities to get a fair and reasonable cost estimate.
2. The architectural assemblies, elements, wall, floor, ceiling and components can be used instead of a detailed database management system requiring cost/item for each and every item in a building, thus saving 10-50% of data line items in CAD drawing quantities.
3. This effort is forcing the development of the next generation work station concept with integrated civil, structural, architectural, mechanical, and electrical design packages to get a totally integrated cost estimating system more automatically.
4. This effort has accelerated CAD estimating development (for mini-computers, work stations, and main frames).
5. A multi-platform/software CAD estimating system has now been integrated on one computer estimating system.
6. This effort shows that useful estimating quantities can be obtained from intelligent CAD systems. More accurate quantities than from digitizing because the quantities can be exact.
7. Showed step by step the details of how to make automatic computer cost estimate from computer aided design.

The development of this tool led to the world’s first CADD estimating symposium in 1991 with updated development of private industry, such as, Rust International Corp., G2 International, Intergraph Corp., ASG (auto desk), U.S. Cost Inc. (success) and Timberline Software and Panel Discussion CADD/estimating past, present, and future chaired by the author, which highlighted the concerns of trust, liability and estimating, and responsibility of CAD designing and estimating. Other topics included total project integrated computerization (cradle to grave); sending bidders the plans, specifications and IFBs electronically, saving time and reproduction
costs; and allowing the bidders to use the data in preparation of their bids; shop drawings, and as-built drawings.

Also discussed was the need for industry and cost engineering standardization for CAD systems and cost data. With the advent of "Windows 95," Intel's "Pentium," better and faster PCs, Auto CAD, the communicative information super highway, computer aided design/automatic computer cost estimating, CAD/AACE concept/tool is ready for the universal use of intelligent CADD to make it possible today to improve estimating accuracy, making it faster, more automatic, saving money and providing time for more cost engineering and, ultimately, more cost effective and efficient construction. (See Refs. #8, 17, and 23)

Tool Number 6 - Avoid Sole Source - Limited Competition

Background

In 1961, I learned first hand as a construction engineer cost estimator, there is a real premium for sole source as noted in technical paper “How Does the Low Bidder Get Low and Make Money.” (Reference #1 9.) The owner paid a 31% plus mark-up premium for sole source and, more recently, 1993, one low bid had a 700% premium for a wall system to match a similar nearby facility but by alternate systems. Listing the name, address, and phone number of equal acceptable systems, etc., or dual design, etc., KSC has saved over $1,480,000 on five recent bids since the KSC Lead Cost Engineer humorist creation of SS-S - Sole Source - Stinks and subsequently SS-SS - Still Stinks, this humor has caused positive results and is easier to remember. It could be updated to PSS - because SSS.

How to prevent sole source and discourage limited bidding:

- **Education** - of design team, procurement personnel, etc.
- **Teamwork** of A&E, design engineers, system engineers, project managers, budget personnel.
- **Documentation** - of case studies, bids, etc., which prove the premiums.
- **Performance** - specification where necessary clean rooms, chiller system.
- **Different systems** - specification example roof systems.
- **Different materials** - specification example walls, concrete, masonry, steel.
- **Dual design** - electrical power supply - this tool has become a real money saver by providing better and more cost effective projects. It is most useful because of more accurate cost estimates.

Tool Number 5 - Payroll Tax and Insurance Rates (PT&I)

Fine tuning PT&I rates - payroll taxes and insurance - in particular, Workman’s Compensation rates. How? By selection of the best PT&I rates as shown in KSC cost index and developed by this author. These rates are also shown annually in weekly engineering publications and other major cost data publications 9 to 18 months later than in KSC cost index). The best PT&I rates can be selected based on a particular trade and the types of bidders expected, such as, an electrical PT&I rate of 24% instead of current average rate of 50% - when mostly electrical work and bidders. (See 240 and 250 Cost Indexes for charts and PT&I rates, Refs. #17 & 22)

Why is this tool important?

1. The PT&I rates which are one of the biggest variables in mark-ups now average 42-50% at KSC of labor cost, but really 22% to 177% for home office overhead to marine construction pile driving. The electrical and mechanical PT&I rates are in the lower range of 24% and 26% to 30%. These trades are an important part of aerospace construction.
2. This process has allowed NASA/KSC to get rates 9 to 18 months before published cost data.
3. Gives NASA/KSC a better negotiating position because of better facts. More current and more knowledgeable than many contractors.
4. Improves accuracy of Government estimate mark-ups as noted in SSPF estimating and bidding case study as presented to AACE and society, of cost estimating and cost analysis.
5. These rates are an important construction cost escalation component as it has risen more than many other cost components (see chart and details in AACE transaction -240 cost indexes and escalation from Ref. #17), from 22% in 1983 to 45% in 1987. (During this time, cost escalation was not as great.)
6. Allows government to understand and use the experience modification factor (EMF) which may vary from .6 to 1.5 of Workman’s Compensation rates as discussed in
Richard J. Coble’s presentation on “Fraudulent Worker’s Compensation Claims in the Construction Industry,” 9/20/95 to Florida Section AACE.

7. The EMF can compound the difference in contractor costs and helps explain the difference in bids especially in bids during boom times when fewer bidders bid and those may have higher PT&I rates because of higher Workman Compensation rates due to a higher EMF (for example, over 1.2).

**Tools Number 2, 3, and 4 - Revolutionary New Estimating Spin-Offs - Introduction and Background**

These tools are particularly exciting as it took twenty years to find the key or secret of making remote control of pneumatic panels in budget estimates. At first, we tried to square foot the panel costs and later linear foot of stainless steel piping, but nothing seemed to work. In the past the rule of thumb for panels was: $10,000 to $360,000—quite a large range for budgets. In order to make detailed estimates, Tool #8 - chart for specialized aerospace remote control panels, was created by S. Thomason in early 1980, further developed and refined by Joe Brown and E. Jones. This was the first formal, standardizing government estimating method. This takes too many hours and too much time and can be used only when a detailed design 60-100% of the panels with list of government furnished equipment. Some of the most experienced engineering estimators would just look at the panel plans and make a scientific wild guess—probably subconsciously counting the controls, gauges, etc., and formulate a number between $10,000-$500,000.

**Tool Number 3- Material Cost per Component**

During 1991 and 1992, the KSC Lead Cost Engineer was discussing computerized CAD automatic cost estimating with Kim Ballard and suggested he use the KSC CAD computer estimating system to develop the material cost or fluid components. In doing this, Kim defined components as valves, filters, gages, switches, transducers, orifices, and silencers. The computerized graft of distribution and cost range should be $216 to $4,100 with a mean of $652.00 standard development or $837.00 with a variance of $693,387 for 283 samples, dated November 19, 1992. It was later determined that this was the big breakthrough or secret in these tools—that or defining the components—this became Tool #3 and was added to the KSC Cost Index.

**Tool Number 4- Work Hours Per Component**

Based on the Kim Ballard definition of a component, E. Jones, of EG&G, was asked by the KSC Lead Cost Engineer to review and summarize the panel cost data in the aerospace price book. This was done for twenty-six panel projects from 1980 to 1992 with a cost range of $6,720 to $201,626. This graphic chart showed twelve work hours to thirty-one work hours per component or an average of 15 work hours per component and thus this became our Tool #4. (See Summary Cost Data Chart for Component Cost.)

**Tool Number 2- Cost Per Panel Component Chart**

The next step was to figure out the average cost per component. Note on Cost Data Chart for Components of contracts, cost and data. It can be summarized to cost from $937 to $1,987 or an average cost of $1,367 per component and when adjusted, test manifold and spaces. The average cost per panel on this sampling was $29,158, but this is based on GFE tubing and fitting and may be low because of mortality and initial spares were included and the average cost may be as high as $65,514. (See Refs. 2, 6, 17, 22, and 23)

**Summary Cost Data Chart for Component Cost**

**SUMMARY - ANALYSIS OF PNEUMATIC PANEL COST**

1. Average cost per component is $937 to $1,987; to be used for budget estimate and cross check detailed estimate or 524,113 DIVIDED by 441 = $1,188 average cost per component.
2. Concerning escalation 1980-1 992; little or no escalation. May have gone down slightly due to learning experience, material cost flat or decreasing.
3. Electrical/Mechanical type panel cost more than mechanical panel only.
4. Be aware of GFE component costs as they affect average panel.
5. Tubing and KC Fittings are assumed GFE in all cases.
6. Increase size of tubing, fittings, and components will cost more; normal size 1/4” to 1”
7. Panels are fabricated, tested, and cleaned in the shop and delivered to KSC; no payment or performance, bond or state sales taxis included in these costs

This method of budget estimating and cross checking detailed estimating was used in KSC bid project construction Hypergol Oxidizer Decontamination Mods bid 4/19/94, with a government estimate of $548,528 between low bidder and second bidder and within 6.1% of low bid, saving the government estimating time and money and a very surprising brand new exciting KSC aerospace estimating tool.

Tool Number 1- Cost of Fiber Optics Cable

Previously, electrical cable has been estimated in linear foot and pounds of copper at the price of copper varying from $.50 to $1.50 per pound. A new method of estimating the cost of fiber optics cable is the cost per fiber foot or per fiber meter. But now, most importantly, by the amount of cable or by the size of the project, such as, small, medium, or large projects defined as follows. The project size was derived from the cost data charts and graphs. The lead cost engineer’s original concept when fiber feet was first suggested by John Shramko was from .50/ff and eventually goes to .10 to .20/ff with a goal to find the bottom price. However, it was Bob Lupo who, after seeing the graphs and charts developed by Austin Durette, came to me with his surprising observation that the projects be evaluated on size—small, medium, and large with separate average unit prices. Where can this unit price cost data be used?

1. In cross checking detailed labor and material cost estimates 30-60-90-95- and 100% final
2. In reviewing chance order proposals
3. In evaluating low bidder or high bid cost estimates prior to award.
4. In study cost estimates
5. In budgets/conceptual cost estimates
6. In per-engineering estimate
7. In negotiation of proposals and change orders

Steps in Making a Fast and Easy Fiber Optics Cable Cost Estimate Using This New Exciting Tool

1. Calculate the total linear fiber feet or meters of fiber cable needed.
2. From the chart/graft select the size of the project - small, medium, or large.
3. Select the appropriate unit price - average unit price for that size project or low or high within that size range. Example, .17/ff or 11 to 15.5/ff for large projects (see average cost summary chart, fiber optic cable costs).
4. Do the math calculations.
5. Review, check, and approve - watch out for unusual design requirements, etc., OFE cable.

Note: These prices are based on projects bid from 1980 through 1995 and may vary with the number of bidders. Current man-hour rates, material costs single-mode of multi-mode or combination of both, in existing duct banks, with inner duct, or direct buried, etc.

CHART - Simple example in fiber feet - How to calculate fiber feet (f. f.)

<table>
<thead>
<tr>
<th>1,000 LF of 72 Fibers</th>
<th>72,000 ff</th>
</tr>
</thead>
<tbody>
<tr>
<td>10,000 LF of 144 Fibers</td>
<td>1,440,000</td>
</tr>
<tr>
<td>20,000 LF of 216 Fibers</td>
<td>4,320,000</td>
</tr>
<tr>
<td>1,000 LF of 36 Fibers</td>
<td>36,000</td>
</tr>
<tr>
<td>10,000 LF of 12 Fibers</td>
<td>120,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5,988,000 ff</strong> (therefore, this is a large project)</td>
</tr>
</tbody>
</table>

Average Cost 1983-1995 = .17 Cents/Fiber foot
5,988,000 ff x .17/ff = $1,017.960- based on overall average cost per fiber foot.

Average cost 1983-1995 for over 5,000,000 LF = .13/LF - based on large projects average cost per fiber foot.
or 5,988,000 ff x .13/ff = $778,440- ECBC (simple answer for budget estimate)
This tool was successfully tested on Phase XIV - KSC fiber optic cable project, to Saturn V, display facility with 5,600,000 fiber feet of 12, 36, 72, and 144 fiber cable, bid 10/31/94 with low bid $916,870. This tool helped adjust the high A&E estimate of $1,274,157 to between the low bid and the second bidder and thus helped discourage a protest by the second bidder and justify the low bid of about .1256/ff and saved the government $200,020.00 if the project was awarded to the second bidder. This new exciting tool may be the most important and cost effective estimating tool KSC teamwork developed on our communication super highway, saving work hours and improving cost estimating accuracy. (See Refs. # 2, 6, and 17)

CAUTION: Please be careful in using the tools. Although they have been successfully used at KSC, many different factors may affect their use at different locations, projects, and industries.

How Successful Have These Tools Been?

Since 1964, over 165 projects totaling over $303,578,000 as listed in the KSC Cost Index, dated 12/1 5/94, have been recognized for government estimating accuracy with names of cost estimator, lead

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### Average Cost Summary Chart

<table>
<thead>
<tr>
<th>FM AVERAGE COST</th>
<th>BY FIBER METER</th>
<th>SIZE OF PROJECT</th>
<th>BY FIBER FOOT</th>
<th>FF AVG. COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>.96</td>
<td>.72 - 1.53/fm</td>
<td>Small less than 500,000M</td>
<td>.30 - .45/FF</td>
<td>.34</td>
</tr>
<tr>
<td>.67</td>
<td>.61 - .72</td>
<td>Medium</td>
<td>.19 - .22</td>
<td>.205</td>
</tr>
<tr>
<td>.46</td>
<td>.36 - .47</td>
<td>Large</td>
<td>.11 - 1.5</td>
<td>.13</td>
</tr>
</tbody>
</table>

Overall Average - .688/FF .17/ff

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### FIBER METER GRAPH

COST BASED ON TOTAL LENGTH

This tool was successfully tested on Phase XIV - KSC fiber optic cable project, to Saturn V, display facility with 5,600,000 fiber feet of 12, 36, 72, and 144 fiber cable, bid 10/31/94 with low bid $916,870. This tool helped adjust the high A&E estimate of $1,274,157 to between the low bid and the second bidder and thus helped discourage a protest by the second bidder and justify the low bid of about .1256/ff and saved the government $200,020.00 if the project was awarded to the second bidder. This new exciting tool may be the most important and cost effective estimating tool KSC teamwork developed on our communication super highway, saving work hours and improving cost estimating accuracy. (See Refs. # 2, 6, and 17)

CAUTION: Please be careful in using the tools. Although they have been successfully used at KSC, many different factors may affect their use at different locations, projects, and industries.
engineer, or team effort with the bid date, amount, different low bid and government estimate position and special thank you for A&E, design team, or other. (See chart ‘250 Cost Indexes) Successful construction of KSC Aerospace Launch facilities under budget and on schedule is a tribute to the remarkable KSC design engineering and construction management teams and A&E and support contractors, construction contractors and their teams of vendors and supplies. There is especially noteworthy for one of a kind research and development projects. Most R&D projects during the 70s were costing two to five times budgeted costs due to the energy crisis, environmental concerns, and erratic (volatile) economy, excessive regulations, etc., These and other problems were solved by fast tracking detailed planning and scheduling, cost and design engineering solutions through an unusually efficient total cost management program (TCM). The use of these thirty-three construction cost estimating tools most conceived, developed, and documented by the KSC Lead Cost Engineer to provide more accurate cost data better and faster, served KSC, NASA, and the U.S. Government in the challenging effort toward space exploration. Note: The KSC Lead Cost Engineer, Joe A. Brown, retired from NASA after over thirty-three years of government service and was responsible for creating and/or developing twenty-four of these tools.

Shared Cost Data

Since this is probably the first report on many of these exciting new tools, the author would appreciate sharing your cost data, comments, feedback, and successes, etc. Also, note that many of the important details, cost data, limitations, etc., could not be listed and explained in this brief report because of time, space, and their wide potential application in saving estimating time and improving estimating accuracy (AC 407-452-4909). Call me with comments.

Summary

These spin-offs tools have worked successfully to increase estimating accuracy, make estimates faster, easier, and simpler as proven by bidding results, analysis, comparisons, project close-out costs and other important cost data. They have been an important part of KSC design engineering teamwork that has helped save hundreds of millions of dollars and thus has helped in our successful efforts of space explorations, Apollo, shuttle, space stations and future possible programs, such as, moon mining of helium 3 to provide the United States with a clean new energy source and a new $75 billion a year industry. (Ref. #20)

References


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Joseph A. Brown, CCE  
Construction Cost Consultant  
1695 Vega Avenue (AC 407) 452-4909  
Merritt Island, FL 32953-3175  
33rd Space Congress  
April 23-26, 1996  
P.O. Box 321333  
Cocoa Beach, FL 32932

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