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GOVERNMENT CONCEPTUAL ESTIMATING
FOR
CONTRACTING & MANAGEMENT

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ABSTRACT

This report explains the use of the Aerospace Price Book and KSC Cost Index for Government Conceptual Cost Estimates for Kennedy Space Center's launch facilities and ground support equipment.

The Aerospace Price Book has been developed since 1974 with over three volumes of cost data based on Government estimates totaling over $500 million. The KSC Cost Index has also been developed since January 1974 with over 140 issues. The Price Book contains over 200 commonly used conceptual elements and almost 100 systems summaries of such projects as launch pads, processing facilities, air locks, and steel/shielded buildings. Some of the over 200 commonly used elements and systems are tower steel for service structures, steel/aluminum access platforms, mating devices, Payload Changeout Room (PCR) special doors, pneumatic remote control panels, PCR bridge hinged column bearing assembly, Halon systems, stainless steel pipe runs, uninterruptible power systems, Orbiter access platforms, and fiber optic cable system.

One of the best methods for making ROMs (rough order of magnitude) conceptual estimates is to find similar items, buildings, systems, elements, and assemblies already designed, built, and costed and to adjust that cost for time, location, and current design requirements. With the aid of these unit bid prices, KSC conceptual budget estimates are more accurate and timely. The prices also serve as a rule-of-thumb and cross-check feedback for detail evaluating designed priced-out project cost estimates. A simple example using the Cost Index and Price Book to make three different types of conceptual estimates for a $10 million project will be shown along with a case study of a conceptually designed $5 million project.

INTRODUCTION

Cost data is published by many organizations, and it is used for budget, funding, cost estimates, and preliminary engineering reports. What is important is the decision to collect such cost data in a completely new industry (the Space industry) right from the beginning of the Space Shuttle era. This report is meant to encourage engineers engaged in research and development projects to recognize the similarity of the repetitive elements and to collect and organize cost data for use in estimating future projects.

SPACE SHUTTLE CONCEPTUAL ESTIMATING - COST MANAGEMENT BACKGROUND

The successful construction of the KSC Shuttle facilities under budget on schedule is attributed to the remarkable KSC Design Engineering and construction management team. This is especially noteworthy for a research and development project. Many R&D projects during the 1970's were costing two to three times budgeted costs due to the (1) energy crisis, (2) social, environmental, and economic regulations, (3) environmental requirements and concerns, and (4) erratic (volatile) economy.

These and many special and unique problems were solved by fast tracking, detail planning and scheduling, cost engineering, and design engineering solutions through an unusual efficient dedicated construction management program. The use of KSC estimating specifications to standardize cost estimating formats, the KSC Cost Index, and the KSC Price Book to provide more accurate cost data served as an important cost engineering tool in this unusual, challenging effort.

Aerospace construction is similar to building, civil, petro-chemical process industry, construction in that it uses concrete, steel, form work, and more conventional materials; but it is different and more costly due to its higher reliability requirements, tolerances, and safety requirements because of the hazardous operations, remote controlled fuels and gases, and some exotic materials, etc.

The concept for the KSC Shuttle facilities was developed in the late 1960's and early 1970's based on limited criteria, horizontal concept, reuse of Apollo facilities (as much as possible), and two simultaneous Shuttle-Orbiter flows (conceptually costed by KSC's Design Engineering between March - October 1970.

The conceptual construction cost estimate of facilities was $147,573,000 which included 10% contingencies and 7% supervision and administration during
The construction of facilities was budgeted in the early 1970's at $150 million of 1970 dollars. The actual in-place cost through April 1980 was $225.3 million which is about 2% less than the original escalated budgeted amount. Quite a remarkable achievement. Some important scope changes that made this cost management more critical was the added Sound Suppression System and the redesign of the Rotary Service Structure for extra Air Force requirements after bidding LC-39 Pad A (during construction of the foundation).

BACKGROUND OF THE AEROSPACE PRICE BOOK

The KSC Price Book was created by the author as KSC Lead Cost Engineer in late 1974 as part of TR-1511, "KSC Monthly Facility and GSE Cost Index" to provide rule-of-thumb cost of aerospace facility construction costs since no such information was available. The October 10, 1974 Cost Index had 21 systems unit costs. On April 21, 1976, the compilation of the development of 54 budget unit costs were first printed. It was published every six months until October 1980 when it became an annual publication. A recent compilation (February 4, 1983) contained over 300 pages of cost data. The 1984 and 1985 editions were in three volumes. The 1985 edition has 485 pages.

Purpose

The purpose of this Price Book is to:

a. Show the compilation of KSC labor and materials prices with typical markups.
b. Show the development of rule-of-thumb (ROT) unit prices for aerospace elements and systems.
c. Record major projects costs and KSC-unique cost engineering experience for conceptual estimates now and for future computer database.
d. Aid in the development of automated conceptual estimating system for aerospace construction and ground support equipment.
e. Aid in cross-checking detail labor and material Government estimate for current prices and serve as a checklist of necessary items to prevent omissions.
f. Provide better, more accurate consistency and uniform cost estimates in a timely manner now and in the future.

TR-1508 - What Is It?

TR-1508, "Budget Cost Data for Construction and GSE Elements" is a 485-page price book for KSC construction and GSE. It is divided into three basic parts - the first is bid abstracts of major Shuttle projects; the second part is the budget cost data divided into 16 CSI/SPECSINTACT divisions, and the third part is the system summary of 105 typical projects.

Part I - Summary of Bids

Part one lists over 350 major Shuttle projects with the bid date, successful low bid, bidder, and the Government estimate for comparison. The total Government estimates of these projects is $413,372,330 which averages 8.4% above the low bidders. The position of the Government estimate is 3.6% of the 7.3 average bids. Exhibit A is a bid summary and sample format.

The low bidder averaged 7% under the Government estimate.

The position of the Government estimate average is 3.8 of 7.1 bids for 152 projects.

Part II

In part two, the budget cost data sheets are divided into the 16 Construction Specification Institute SPECSINTACT divisions with a typical example cost data description for each division.

Division 1: Overhead General Conditions - Payroll Tax and Insurance

Division 2: Earthwork - Piling and Road Paving System - Demolition

Division 3: Concrete - Concrete Wall Trench System - Floor Slab

Division 4: Masonry - Concrete Block Wall System

Division 5: Metals - Structural Steel Service Structure

Division 6: Wood and Plastic - Wood Stud Drywall System

Division 7: Thermal and Moisture Protection - Insulated Roof Decks

Division 8: Doors and Windows - Special Hinged Insulated Door

Division 9: Finishes - Suspended Acoustical Tile System

Division 10: Specialties - Mesh Partitions

Division 11: Equipment - Laboratory

Division 12: Furnishing - Carpeting

Division 13: Special Construction - Elevated Floor System - Metal Building

Division 14: Conveying System - 125-Ton Bridge Crane - RSS Drive Trucks

Division 15: Mechanical - KSS Bridge Hinge Column - FSC A/C

Division 16: Electrical - Emergency Light System - Fiber Optics Cable

The cost data sheet shows quantities, detail labor and materials breakdown for the major cost items for each system. It includes the normal contractor markups for PT&I, sales tax, overhead, profit, and bond.

For other sample breakdowns, see Conceptual Cost Estimating using KSC Budget Cost Data for Construction Management of Space Shuttle Facilities.

The unit prices shown above in rectangles cost/linear foot $267, cost per cubic yard $752, cost per square foot $124, are published in the KSC Monthly Cost Index. See Figure D for sample summary.

Figure D (below) from TR-1511 is a sample of a Unit Summary from KSC Cost Index dated March 17, 1983.

Part III - Cost Management Summaries

Part three consists of sample cost management summaries for (1) budget line items which show the budget 30%, 60%, and 90% design estimates compared to
the final Government estimate, (2) a projects labor and materials summary showing a detail breakdown of the architectural/structural, mechanical and electrical costs with the contractor's markups shown separately, and (3) systems summaries broken down into 16 CSI/SPECISINTACT divisions with major quantities and unit prices. This summary also includes project descriptions, design data, scope special features, bidders and bids, and estimating comment. Some of the facilities systems' summaries are for LC-39 Pad B and RSS, Orbiter Valve Devices, HB-2 OFF Platforms, Shuttle Payload Vertical Processing Facility, Crawler-Transporter Maintenance Facility, Life Science Support Facility, etc.

Figure E is a sample system for the Solid Rocket Booster Rotation and Processing Facility. This project was bid on 3/23/82 and consisted of four separate buildings. The buildings are: (1) the 18,628 square foot Rotation and Processing Building, (2) a 5,000 square foot Office Support Building, and (3) and (4) two Rocket Booster Storage Buildings 65 x 90' long x 47' to 62' high for a total square footage of 11,700 square feet.

The Government Estimate without Special Conditions was $7,690,060 which compares very favorably with the two tied low bids of $7,247,000 (a minus 5.8% of the Government estimate) The Special Conditions were not needed due to the recession and the large number of bidders.

Note arrows in right border. See comments at Arrow #1. Arrow #2 points to special features such as two 200-ton electric bridge cranes bid at $1,798,000 at "Note in Contract". Arrow #3 gives the estimated cost per square foot for the Rotation Building at $203.72 for the architectural/structural portion. Arrow #4 notes the tie bid. NASA Procurement required labor surplus evaluation. After a thorough review of the contractor's bid breakdown for both low bidders showing less than 50% of work in labor surplus areas, the award was made to the Small Business Firm. Arrow #5 shows the actual bids and bidders' names.

The left-hand and center portion of Figure E shows the Unit Costs for the 16 CSI Divisions per building square foot, tons of steel, and cubic yards of concrete, etc. Some especially interesting items and costs are: Division B8: Vertical Lift Doors at $131.89 per door square foot; Division 14: a 90-foot high passenger elevator at $164,395; railroad at $295.16 per linear foot; Division 16: electrical, electronic security $3.79 building square foot, and cathodic protection at $0.76 building square foot.

See attached Figure E - System Summary Sample.

CONCEPTUAL ESTIMATING

Why Conceptual Estimates?

Conceptual estimates of KSC facilities and ground support equipment are required to provide the most probable project cost for budget, funding, and project approval purpose. The conceptual estimate is continuously used throughout the project development cycle to compare the further defined cost estimate with the approved estimate with detail quantities. The labor and materials are evaluated against the budget to assure costs are within budget dollars and can be awarded to the successful bidder.

How to Make Conceptual Estimates

One of the best methods for making ROM conceptual estimates is to find similar items, buildings, systems, and elements already designed, built, and costed and adjust that cost for time, location, and current design requirements. With the aid of these unit bid prices, KSC conceptual budget estimates are more accurate and timely. The prices also serve as a rule-of-thumb and cross-check feedback for detail designed priced-out project cost estimates.

In making conceptual estimates, it is important to first determine the purpose of the estimate. Next, find a similar project and adjust for time, location, and design or conceptual design and conceptual estimate using conceptual unit prices such as developed in this price book. Next, add for escalation to the estimated mid-point of construction, contingencies, supervision, and administration during construction. The cost of design and/or construction management is usually estimated separately since it is funded separately.

Simple Example of Conceptual Estimate

A simple example for conceptual estimate for a new Solid Rocket Booster Facility for rotation, processing, and storage of additional boosters with a new 1,000-foot pipe trench and a new Orbiter contamination control system would be:

1. New SRB Building and Sitework: The Government estimate for SRB Facility t-id March 1982 was $7,960,000 (see Figure E, page 10). KSC Cost Index dated March 1983 - Index Factor #3916 divided by KSC Cost Index March 1982 - Index Factor #3674 = #1.0659 x $7,690,000 (bid price) = $8,196,771

   or

   3916 = 1.0659 x $7,690,000
   3674 = $8,196,771

2. Exterior Site Work - New Pipe Trench: New pipe trench 1,000 feet at $267 per linear foot (Figures G and D, pages 7 and 8. KSC Cost Index March 1983 - Index Factor #3916 divided by KSC Cost Index October 1982 - Index Factor #3770 = #1.0387 x Budget Unit Price of $267 per linear foot = $277.33/adjusted linear foot. 1,000 feet at new escalated unit price of $277.33 per linear foot = $277,330

   or

   3916 = 1.0387 x $267/LF = $277.33/LF x 1,000' = $277,300
   3770

3. New Specialized Construction System: Add for new Orbiter Contamination Control System similar to one bid 10/7/82. The Government estimate was $1,289,278 (see Exhibit A, page 6). KSC Cost Index March 1983 - Index Factor #3916 divided by KSC Cost Index October 1982 - Index Factor #3770 = #1.0387 x Bid Price $1,289,278 = $1,339,183

   or
Total estimated construction bid cost March 1983 for a new SRB Facility with 1,000-foot pipe trench and new Orbiter contamination control system = $9,813,274. Round to say $9,813,300. Escalation from March 1983 to August 1985:

Aug '85 Index Factor 4217 = 1.08 x 9,813,274
Mar '83 Index Factor 3917 = $10,567,562
Round to say $10,568,000. Total as of August 1985: $10,568,000

Estimate Notes

Note 1: Add for future escalation, contingencies, supervisory, administration and design as required.

Note 2: Bridge Cranes: Two 200-ton electric bridge cranes are not included. These are assumed to be R&D funded and not in construction contract.

Note 3: Confidence factor plus or minus 10% due to excellent Government estimates and bid data.

Author's Note

The bid prices were escalated using the KSC Cost Index Factors to March 1983 and August 1985.

This simple example of conceptual estimating for a new SRB Facility shows how all three parts of the Aerospace Price Book can be used for making conceptual cost estimates in a timely manner. Section 1 above was taken from the Price Book, Part Three, the Detail System Summary; Section 2, Part Two of the Budget Cost Data Sheets; and Section 3, from Part One, the Summary of the Abstract of Bids.

CONCLUSION

The Aerospace Price Book, KSC Cost Index and Conceptual Cost Estimating are some of the tools used by KSC Design Engineering to provide cost effective design and construction of KSC Space Shuttle facilities. These facilities are being used successfully to process, checkout, launch and recover elements of the Space Transportation System which assures the United States' continued pre-eminence in space exploration and development.

REFERENCES


8. Space Transportation System - Facilities and Operations, KSC-KSTS-MO-1, Appendix A.


The low bidder averaged 7% under the government estimate.

The position of the government estimate average of 3.8 of 7.1 bids for 152 projects

Exhibit A

The low bidder averaged 7% under the government estimate.

The position of the government estimate average of 3.8 of 7.1 bids for 152 projects.
### Figure D. Unit Price Summary

**INDEX**

**SUMMARY OF UNIT PRICES FROM AEROSPACE CONSTRUCTION PRICE BOOK BASED ON BIDS AND GOVERNMENT ESTIMATES**

The following engineering costs include labor, material, tax, insurance, overhead and profit. They do not include design, special conditions, government contingencies or SRA. Back-up data is available from TR-70-1 and TR-73-6.

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<th>DESCRIPTION</th>
<th>SPEC.</th>
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<td>Overhead &amp; General Condition - Avg. 15%</td>
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<td>Relocation of building from LC-39 to LC-39B</td>
<td>5,000 EA</td>
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<td>24-25 2A Demolition</td>
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<td>Move and alteration cost estimate guide (FC64)</td>
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<td>Demolition of slab (no rehab of area)</td>
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<td>Demolition of slab and rehab area</td>
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<td>28 2A Demolition</td>
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<td>Demolition - Conc. masonry walls (cavity)</td>
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<td>Demolition - Drywall/steel stud</td>
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<td>Fill - Unclassified borrow pit, Orbiter Landing</td>
<td>40,000 LF</td>
<td>4,40 LF</td>
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<td>35 2HK Piling Off</td>
<td>02354</td>
<td>Off piling wood, conc. st. 6&quot; to 14&quot; (18,330 Ft.)</td>
<td>11,17 LF</td>
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<td>36 2HK Piling Pad &quot;B&quot;</td>
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<td>23,00 LF</td>
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</table>

**53 3A Concrete**

- Sewage Treatment Plant 1000 GPD
  - 23150 EA
  - 23.15 GALL

**55 3A Concrete**

- Slab 6" on grade w/thickened edge
  - 191.15 CY
  - 3.22 LF

**56 3A Concrete**

- Concrete walled trench with support blocks and grating
  - 157.49 CY
  - 2.52 LF

**57 3A Concrete**

- Formwork for concrete walled trench
  - 219.33 CY
  - 78.96 LF

**58 3A Concrete**

- Rebar for concrete walled trench
  - 14.17 LF
  - 6.10 LF

**59 3A Concrete**

- Grating for concrete walled trench
  - 707.72 CY
  - 118.7 LF

**60 3A Precast Conc.**

- Tilt panel exterior wall
  - 11,90 LF
  - 11.44 LF

**61 3A Precast Conc.**

- Structural concrete, piers, beams, columns
  - 864.00 LF
  - 32.00 LF

**62 3A Rebar for piers, beams, columns, etc.**

- 682 LF
  - 25.26 LF

**63 3A Rebar for piers, beams, columns, etc.**

- 162 LF
  - 72 LB

**64 3A Concrete**

- Concrete for piers, beams, columns, etc.
  - 106 LF
  - 3.93 LF

**65 3A Lightweight Insulation concrete roof slab**

- 7901 EA
  - 1.58 LF

**66 3A Lightweight Insulation concrete roof slab**

- Prestressed roof system
  - 21,095 EA
  - 4.27 LF

**67 3M Grout**

- Emboce grout
  - 337 LF
  - 3.51 LF

**68 3A Block Masonry**

- Concrete block wall
  - 5,89 LF
  - 4.91 RLK

**69 3A Block Masonry**

- Block & mortar 8 x 8 x 16
  - 3,78 LF
  - 3.15 RLK

**70 3A Insulation 1/2 polystyrene**

- 54 LF
  - 4.5 RLK

**71 3A Drywall 1/2 thick fire resistant**

- 1.44 LF
  - 1.73 RLK

**72 4A Paint (2 sides exterior & interior)**

- 1.25 LF
  - 1.04 RLK

**73 4A Orbiter Processing Facility, Phase I Struct.**

- 1200 TON
  - 152.63

**74 4A OPF Phase I Mech. Summary**

- 1,239,892 EA
  - 390.67 TON

**76 5B Steel Joists**

- Structural steel building
  - 3687 TON

**77 5C Metal Floor**

- Roof Structural steel
  - 9,091.00 EA
  - 7.56 LF

**78 5F Metal Floor**

- O&C Mods, integrated test stands
  - 15,12 LF
  - 1.54 LF

**79 5F Metal Floor**

- Aluminum deck, VAB platform mod.
  - 37,86 LF
  - 8.53 LF

---

(1) Note the engineering cost here is also called the bid cost or more specifically, the estimated construction bid cost.
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*NEENAH FOUNDRY - NEENAH, WISC. 414/725-2041 - MILE BANKSF
2'' SOLID C.I. GRATING 26'' WIDE X 6 - 4900-1-26L-2''-3/4''
108 SF - 30.813 SF

FIGURE C
# Figure E

## Project: Solid Rocket Booster Rotation & Processing Bldg.

### KSC

**Estimator:** G. L. Files, DMAU

**Thompson**

**Code:** C-100

**PRC-1391**

**Submitted:** 5-27-82

### Sheet

#### Description

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<td>3,093</td>
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<td>55.30</td>
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<td>7,876</td>
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<td>SF</td>
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### Scope

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<th>(Circle one)</th>
<th>(Circle one)</th>
<th>Comments</th>
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<tr>
<td>1. Fair</td>
<td>A Square</td>
<td>35,216 TOTAL SQ. FT. (4 BLDGS)</td>
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<td>2. Average</td>
<td>Rectangular</td>
<td>GOVT. EST. DID NOT NEED SPL.</td>
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<tr>
<td>3. Good</td>
<td>Irregular</td>
<td>COND. DUE TO ECONOMIC CONDITIONS.</td>
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<td>4. Complex</td>
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<td>E. DESIGN DATA.</td>
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<td>5. Sophistic</td>
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### Design Data

- **Bldg. Type:** Hangar
- **Capacity:** Steel
- **Exterior Wall:** 20 GA. 3 RB GALV. INSULATED
- **Height:** PLTRMR. STORIES 100 FT.
- **Ground Floor Area:** 18,628 SF
- **Total Floor Area:** 545,365 SF
- **Volume:** 267,704 CF
- **Percent Air Conditioned:** 0%
- **Other:**
  - **special features:**
    - **(NC)** TWO 200 TON ELEC. BRIDGE CRANES
    - **SUP. BLDG. 50'X100'X16'** = $1,798,000
    - **(2) STOR. BLDG. 65'X90'X67'-62'** = $11,700 SF

### Construction BID Data (IFB 10-005-2)

- **Total Bldg. SF:** 18,516 (ROTATE & PRO. BLDG.)
- **Arch/Struct:** $203.72 /BSF $3,772,070
- **Interior Mech:** $8.20 /BSF $151,810
- **Interior Elec:** $22.79 /BSF $421,900
- **Total Interior:** $234.70 /BSF $4,345,780
- **Total Exterior:** $97.33 /BSF $1,802,100
- **Total Constr.:** $332.03 /BSF $1,295,560
- **Additional Bldgs:** $92.35 /BSF $912,762
- **SPL. Cond.:** $6.32 /BSF $222,702
- **Total Project Est.:** $2,912,762

### Awards

- **Awarded to:** W&J Constr. $7,247,000

### Construction Time Span: 540 Calendar Days

- **No. of Bidders:** 9
- **Position of Govt. Est.: 8/9
- **Percent Difference, Awarded Bid and Govt. Est.: 8.4%

### TIE Bid. NASA Procurement Required Labor Surplus Evaluation. It was less than 50%, so award to small business.

### Bidders:

- **W&J Constr.** $7,247,000
- **Great Southwest** $7,247,000
- **NORFLOR Constr** $7,449,880
- **Algeron Blair** $7,777,000
- **Scandia, Inc.** $7,840,000
- **Hobbs Constr.** $7,900,000
- **Gov't. Est.** $7,912,762
- **Gulf Contractors** $7,957,000