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The Challenges in Development of Automatic CAD for Government and Aerospace Construction Cost Estimating Systems

OR

Challenges Developing CAD/ACE

OR

Challenges Developing Mini-Computer CAD/Estimating for Government Aerospace Construction

By

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(NASA-TM-103319) THE CHALLENGES IN DEVELOPMENT OF AUTOMATIC CAD FOR GOVERNMENT AND AEROSPACE CONSTRUCTION COST ESTIMATING SYSTEMS OR CHALLENGES DEVELOPING CAD/ACE OR CHALLENGES DEVELOPING MINI-COMPUTER

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Challenges in Computer Aided Design/Automatic Cost Estimating for Government and Aerospace Construction

by

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INTRODUCTION

The purpose of this presentation is to summarize the many years of effort in development of Computer Aided Design/Automatic Cost Estimating using a VAX mini computer (CAD/ACE) by explaining the reasons, the purpose, goals, possible productivity improvements, problems, challenges and some solutions; thereby helping those computer professionals in industry and government to learn from our accomplishments and difficulties. This will help the construction industry to understand why and how to use this futuristic cost estimating system. By listing the 24 problems, difficulties and challenges, the next generation of CAD/estimating will be better, faster and cheaper. Computerization of ACE will benefit the Government, aerospace and construction industries, and our society. Our main purpose is to improve estimating accuracy, save time in estimating by making it faster and more automatic, thereby saving money. It will also provide time for more cost engineering and ultimately more cost effective and efficient construction.

The present manual and computer estimating methods require time consuming quantity takeoffs, looking up, pricing out and marking up of cost estimates. A CAD/computer system can do this faster and be more accurate, using the CAD drawing file for quantities extraction. Three of our goals; to keep it simple, easy to use, and do as much as possible automatically; are probably our biggest challenges. An operational analysis and efficiency analysis of manual versus computer estimating will be shown with projection for CAD/ACE, with the impact of customization of CAD estimating software for Government and aerospace. Flow charts, graphics and estimating steps necessary for the CAD Estimating System being tested will be shown along with a sample computer estimate, bids, CAD estimate and menu. By explaining some of these problems and solutions, it is hoped that with many other engineering computer professionals involved in the development of different concepts, productivity improvements may move successfully to overcome problems faster and more effectively.

HISTORY - BACKGROUND
COMPUTERS, CONSTRUCTION COMPUTER ESTIMATION

In the mid-sixties (1963-1967), computers were successfully used in design, planning, scheduling and construction of the Vertical Assembly Building (VAB), the world's largest building at the time of construction. The 57,000 tons of structural steel were computer coded. This 120 million dollar building was successfully completed and was an important milestone for the successful Apollo Lunar Program, with man's first moon landing in July 1969.

Computer Symposium

On November 7-8, 1969, the Florida Section of the American Association of Cost Engineers (AACE) held its first symposium, "Computers Are Working In Construction," at Cape Canaveral, Florida, featuring some creators, developers and pioneers of Computer Estimating, Cost Control, Accounting, and Planning Systems.

<u>Symposium Program</u>

COST ACCOUNTING - Carl Brown of Wellam Lord

(Computerized) PIPING EFFICIENCY PROGRAM - T. G. Papavero of Catalytic Construction Company

COMPUTER PLANNING AND SCHEDULING - Jessie Taylor of Wellam Lord

IBM PRESENTATION - Computer Control of Apollo Using 360 Model 40

TELEPROCESSING - Paul Spindel of McKee, Berger and Mansuetto

COMPUTERIZED ESTIMATING - Bill Orr of Cost Systems Engineers, Inc.

PROVES/COST OF MAJOR EQUIPMENT SCOPE/PDQS - AACE President, Gus Enedy of Diamond Shamrock Corp.

On February 29, 1972, J. A. Brown sent a 5-page memo to KSC management on the potential benefits, etc., of Computer Estimating to KSC aerospace construction. In 1974 a new design engineering support contract was let to PRC, who operated a new Computer Aided Drafting (CAD) System, Applicon, which provided a limited bill of materials and proved that the real value of CAD was in revision; new and

similar projects could be used over again, saving the initial data entry, which took nearly the same time as manual drafting. In 1978-79 Mr. Ed Rich, Navy Cost Engineering, reported on development on computer aided cost engineering with computer cost database. On June 4-8, 1979, Cost System Engineering, Inc., (CSEI) had a training seminar at KSC on Automated Construction Estimating Using the Orr System of Construction Management which resulted in the following:

TRIAL USE OF COMPUTER ESTIMATING SYSTEMS

Problems Encountered June 1979 - August 1980

The following are typical problems an estimating section had with the computer estimating system using a main frame on a time-sharing basis:

1. Frustration with equipment, telephone instruments, interface, terminals, service bureau, computers, etc.

2. Resistance to new ways of doing things.

3. Inability to fully comprehend complex computer system with all it's flexibility.

4. Lack of desire to devote adequate effort to develop and use system.

5. Inadequate manpower capability in Estimating/Cost Engineering.

6. Expected computer system to automatically estimate accurately with little or no extra input or adjustments. Did not use labor and material difficulty factors to adjust estimate to job conditions.

7. Fear of loss of job.

8. Stress - eyes (bifocal glasses), fatigue.

Comments and Recommendations of Cost Engineer Observer, August 1980 - December 1981

1. Computer system <u>must</u> be made simpler and easier to use.

2. If possible, eliminate need to look up cost codes and have data more easily entered in computer.

3. In CAD have quantity survey done by computer eliminating need for costly time-consuming task and cost codes and ready to input into computer estimating system.

4. Develop program for standard format to simplify computer use initially. Later as experience develops, this flexibility can be explored.

5. Get another company (estimating section) that is more receptive to modern technology.

6. When owner/A&E/contractor goes to extensive computer estimating, a computer terminal operator and computer program (software/hardware/data base) manager may be needed for six months to three years to keep system working properly and to develop additional capabilities until owner personnel are ready to take over total system responsibility. (Confirmed by other cost engineers during specialized/R&D work.)

7. An extensive training/incentive program will be required to insure a successful cost-effective computer estimating system.

8. Provisions need to be made for eyeglass users reading CRT's to prevent frustrations; i.e., bifocals, etc. Better CRT's - resolution, adjustability, becoming more available in 1983.

AN IDEAL COMPUTERIZED
COST ESTIMATING SYSTEM

Based on comments of Cost Engineer Observer and ideal computer Estimating System with 16 Features/Requirements/Capabilities were developed, some of which included:

<u>Simplicity</u> - The system should be simple, easy to use, understand, learn and maintain.

<u>Interactivity</u> - Allow quantity inputs, cost codes from computer design drafting system to provide Automatic Computer Cost Estimates thru CAD/ACCE/CADD. This would have five-way interactivity through CAD, design, cost, construction, plan and schedule, and management. Note: July 1989, ACCE changed to ACE by author.

<u>Judgment Factor</u> - Allow for estimator/cost engineer (E/CE) judgment factors.

<u>Maintenance</u> - Ensure the labor and materials prices, data base, etc., are properly maintained to give complete, current, accurate cost information. Have a large, accurate up-to-date and complete data base.

<u>Review and Updating Capability</u> - Have quantities, labor and materials, unit prices, and totals in all detail printouts for easier review and updating.

Have mechanical and electrical labor costs in manhours for easier review and updating.

<u>Detail Breakdown</u> - Provide labor and materials breakdown with total manhours, per task and craft, and crew days for planning and scheduling; for CPM and construction duration; and for procurement and subcontractor information.

Provide Metric-American conversions.

<u>Automatic Adjustment</u> - Have prices automatically adjusted to the local construction environment with minor input.

Computer Quantities - Have the ability to compute quantities. For example: for concrete LxWxHx No. of rows to give cubic yards (CY) of concrete and square foot contact area (SFCA) of form work. Not as necessary if it had CAD capability.

Summaries and Organized Systems - Have the ability to summarize in many different ways -- bid, trades, labor and materials, 16 CSI divisions, buildings, parameters, budget, systems, etc.

Organized for cost engineers, estimators, accounting, cost control, plan, schedule, etc.

All Types of Estimates - Have capability to do budget/conceptual, preliminary, detail labor and materials, bid, etc.

Other Capabilities - These features, with emphasis on CAD/Estimating for Quantities, were the basis for the author advocating the CAD/ACCE simple concept since 1980 and projecting a state of the art Project Integrated Computerization (PIC) concept to integrate design, specifications, cost, construction, plan and schedule, management and occupancy - interactive integrated systems. See Chart (1983-1989), Figure 3. This simple concept was to get the quantities from computer aided design system and use a linkage program to hook it to an CSEI Orr type system which was the most complete and flexible computer estimating system to make cost estimates automatically, especially since the Orr system had been set up with cost codes for budget, preliminary and detail estimating.

Impact of CAD, June 29, 1982 "The Impact of Computer Aided Design on Cost Engineering," by Ed Zamoski and B. E. Seals, at the AACE 1982 Annual Meeting in Houston, TX, reinforces the author's commitment to CAD estimating with excellent technical and slide presentation.

Goddard CAD System Study Frank O. Grady of Goddard Space Flight Center presentation, "Computer Use in Facilities", December 8-10, 1982, Cocoa Beach, FL. Serves as an excellent overview in selection of CAD systems, capabilities and costs and limited CAD/Estimating.

First CAD Estimates - 1983 - 1986

CAD Estimating by Owens Corning Fiberglass, Administrative Engineering Service. Using Computervision and Orr by Robert Shaffer, 1981-1986; had mechanical electrical up and running in 1983. Had total CAD/Estimating, using Computervision/Orr Estimating/Apollo/AutoTrol/Focus on IBM mainframe as of August 1986, with over 800 projects on file. System makes ROM's with plus or minus 25% in $10 to $20 million projects in 80% less time than manual estimating. Master code of accounts for all cost codes cost $2.5 million for development. Estimates by: Standard Process Function, Unit Costs, and Standard Sets.

Other Comments - Using Orr city to city is good. Needs graphics to give engineers better overview and also serves as a good check sheet.

August 29, 1985 - NASA KSC signs contract for $1,350,059 for eight Intergraph work stations, VAX processing and integrating 39 design packages and estimating software ($31,500), etc. Estimate package proposed was using a Means Cost Data Base. Orr system was not proposed as he was not low sub bidder (wanted more because of extensive development time (15 years) and costs and royalty on future licenses.) Also, Orr data base not updated for two years (October 7, 1985, CAD Estimating Memo). Also did not have a deliverable product for VAX/VMS.

Early 1986 - Intergraph selects IBIS-CALC European Estimating Software Package in Lieu of Means. IBIS-CALC had no cost data base but had ability thru correlation table to get more usable construction estimating quantities, such as cubic yards of concrete, form work, rebar, etc.

March 11, 1986 - Manual vs. Computer Estimating vs. CAD/ACCE. The following is an operational and efficiency analysis for manual estimating and computer assisted estimating as shown in "Cost Engineering," Volume 25/A3, June 1983, in an article by Lawrence C. Bacher of Gilbane Building Company, 7 Jackson Walkway, Providence, RI 02940. The original charts have been extended by J. A. Brown, 3/11/86 (indicated by *), to include Projected Computer Aided Drafting and Design/Automatic Computer Cost Estimating CAD/ACCE* and revised 7/20/89, based on experience from developing CAD/ACE prototype project Propellent System Component Lab) PSCL.

Figure 1 Operation Analysis

Activity	Manual	Computer	CADD/ACCE*
Administrative Work	7%	-	-
Quantity Survey Doc. Review	8%	-	20% Improvement
Quantity Survey Measurement	24%	10% Improvement	90% Improvement
Quantity Survey Mathematics	20%	100% Improvement	100% Improvement
Pricing Man-Hour Study	8%	10% Improvement	10% Improvement
Pricing Market Survey	17%	5% Improvement	5% Improvement
Pricing Mathematics	5%	100% Improvement	100% Improvement
Checking Mathematics	7%	100% Improvement	100% Improvement
Summarization Presentation	4%	80% Improvement	80% Improvement
	100%		

Figure 2 Efficiency Analysis

Assuming 500 Man-Hour Estimating Efficiency

Activity	Normal MH Expended	Computer Aided MH	Est. Imp.	CADD/ACCE* MH Expend.	Improvement	7/24/89 CADD/ACE MH
CADD Intelligence						25**
Administrative Work	35	35	0	35	0%	35
Quan. Surv. Doc. Rev.	40	40	0	32	20%	32
Quan. Surv. Measurement	100	108	10%	12	90%	12
Quan. Surv Mathematics	100	0	100%	0	100%	25**
Pricing Man-Hour Study	40	36	10%	36	10%	36
Pricing Market Survey	85	81	5%	81	5%	81
Pricing Mathematics	25	0	100%	0	100%	0
Checking Mathematics	35	0	100%	0	100%	0
Summary Presentation	20	4	80%	4	80%	4
	500	306	39%	200	60%	250
Cost at $30 per MH	$15,000	$9,120	$5,880	$6,000	$9,000	$7500

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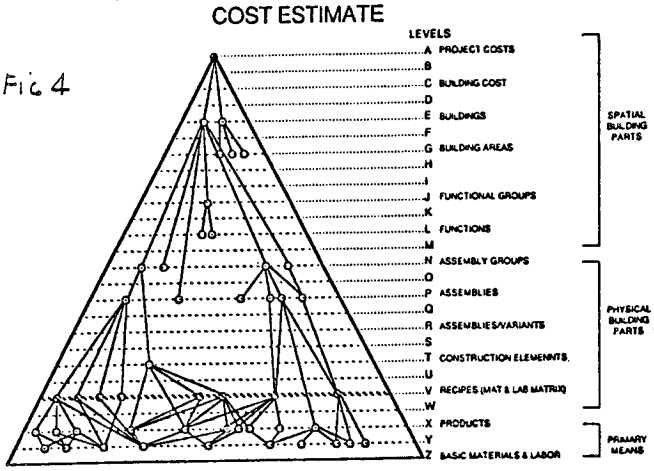
** A new item has been added for CAD/ACE which may require 10-20% more time for customizing for CAD projects and for special intelligence input to CAD design to develop correlation tables, etc.

August 15, 1986 - Hank Perkins and J. A. Brown go to Huntsville, AL, for IBIS-CALC demonstration, Pyramid Assembly Program (See Chart, Figure 4), with 26 levels of detail budget to detail labor and material unit prices. IBIS-CALC developed by Integrated Building Information System, developed by Tricht and Brink and European Co. Headquarters in Leidschendam, Holland, making this an International Computer Estimating System.

CONSTRUCTION DOCUMENTS PHASE
COST ESTIMATE

Fig 4



January 12, 1987 - DL-NED/DF-FED LCE contacted Navy Facilities Engineering Command, A. Sadler, II, Head of Cost Engineering Branch, concerning our use of Navy computerized cost data base with IBIS-CALC System Estimating Package because of their current and most complete data base with Alpha numeric Cost Code System linked to SPECSINTACT system with good work description. Formal request by J. Phillips, DE, Director of Engineering Development, March 2, 1987. Formal approval given on April 17, 1987, by Harry M. Zimmerman, Navy Engineering and Design.

January 21, 1988 - EG&G establishes IBIS-CALC Project Preliminary Requirement, by Carlos Ablanedo.

March 2, 1988 - DE support contractor hires an engineer, Pat Tannner, to aid in development of CAD/Estimating.

March 22, 1988 - Memo. April 5-8, 1988, Brinks - Intergraph install Architectural Quantity and demo IBIS-CALC introduction and training given to KSC/DF-FED/EG&G, C. A. Swinkel, D. Mueller. Flow chart with Architectural Production Design Product (APDP) and Data View Development. (See Figure 5)

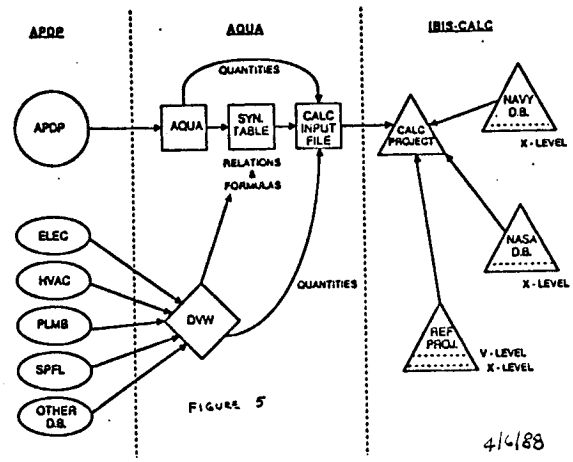


FIGURE 5

April 1988 - Management presentation to Jim Towles, Director, Facilities Engineering, by DF Lead Cost Engineer, on CAD Estimating goals, purpose, need for training and projects designed on CAD to make estimating for electrical design projects. T3-T4 power feeder CAD design - go ahead given. Other projects:

Pre- Engineered Metal Building (PEMB) and concrete masonry building (PSCL).

KSC CAD/ESTIMATING MILESTONES

EG&G delivered a draft Intergraph/IBIS-CALC/Navy Data Base Cost Estimate for the pilot project to KSC Lead Cost Engineer on July 7, 1988. After fine tuning the IBIS-CALC/Navy Estimating, the next step is to put the pilot project in Intergraph/CAD-APDP to get class codes for preliminary quantities.

October 11, 12, 1988 - Summary Briefing to Computer Engineering Software Developer (Brinks Group representative)

Goals - To make CAD/Estimates automatically; to save time and money; to improve accuracy of quantity take-off, prices out and mark-up; to allow more time for value engineering, cost engineering, etc.; and to reduce turn-around time on critical projects from weeks to days.

Possible Solutions to Estimating Problems

A. When Design on CAD - Bill of Materials from CAD to AQUA (architectural quantities) to IBIS-CALC (European estimating software package) - pull from Navy cost database to price out and mark-up to reduce estimating time 40-70%.

Allow estimator/cost engineer to:

1. Add line items missing from estimate, such as testing, equipment, cranes, etc.

2. Adjust prices for a particular project by experience, vendor quotes and major cost items, cost analysis of items such as steel, fill barrow, form work, duct work, etc.

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3. Make reports and summaries for different situations - cost engineering, cost reduction, plan and schedule, etc.

4. Have minimum cost engineering computer data entry input - 10 line items of commands to get estimate.

See Flow charts - Computer flow chart of software programs/interface: CAD/APDP - Architectural Production Data Package; AQUA - Architectural Quantities; IBIS-CALC; Project File;

Databases - Navy, NASA KSC, CACES, Reference Project.

B. When the Design is Not on CAD - The Navy is developing a sonic digitizer system to speed up estimating take-off and make computer aided estimating faster and easier, but not as fast or as accurate as CAD/ACCE.

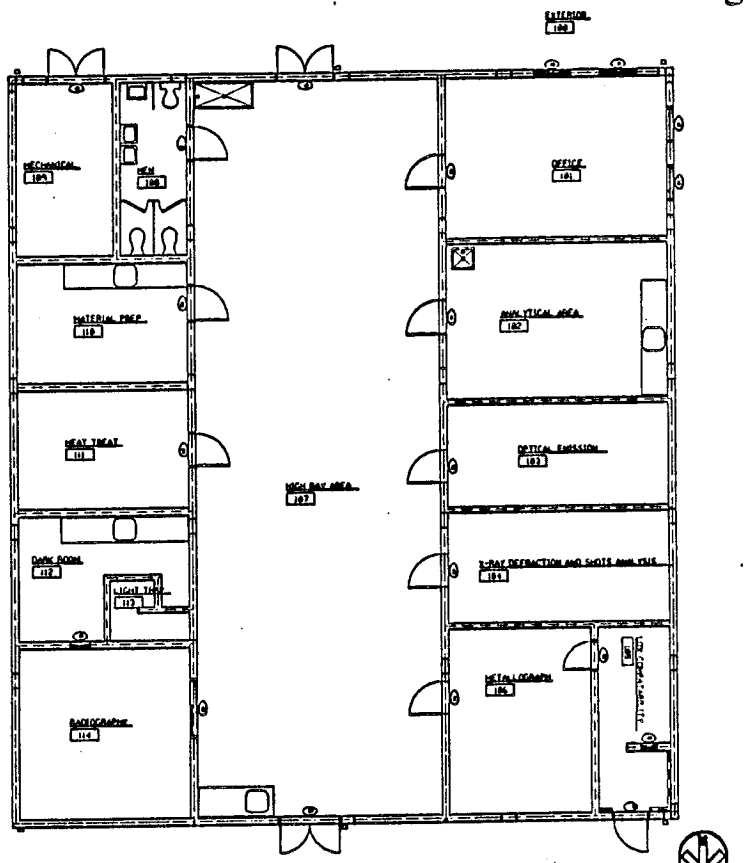
C. Prototype -

1. Electrical Design Project - T3-T4, Figure 6.

2. Concrete, masonry, office, lab, 4100 SF CMU - PSCL, Figure 7

3. Pre-engineered metal building (PEMB)

D. Work to be Done - Correlation Table of Relations and Formulas (link class code to cost code) by Pat Tanner/Joe Brown/System Engineer.



PSCL FLOORPLAN

OCT 1988

REV. MAR 1989

FIGURE 7.

SYSTEM SUMMARY OF GOVERNMENT ESTIMATE FOR SYSTEMS

PAGE 49 OF

DRAWING NO: 79K32623 | BUDGETS: 3 | PCN: 94051 | LOCATION: KSC, LC-39, OLF | PROJECT: OLF 60 HZ POWER T3 & T4 FEEDER

PRIME BUDGET CONTRACT: NAS 10-11582 | ARCHITECT ENGINEER: NASA - R. CASON | ESTIMATOR: TANNER/BROWN-NASA | CHECKED: S.S. VARNDELL/EGG, T. FITZGEROUS/NASA | CODE: C-100 | SUBMITTED: 11/3/88 S.S.7/3/89

CONSTRUCTION COSTS

A & E TRADES / DIV. TITLE	QTY	UNIT	COSTS $ UNIT	$/LF	TOTAL	DIV. TOTAL
1. GNL COND.						
10 %					33,528	
2. SITE	33,000	LF	1.31	1.31		43,138
CLD-GOUD						
GROUTING						
EXTRACTING TRENCH	33,000	LF	1.28	1.08	42,270	
HAND EXCAV.	50	CY	1736	.02	868	
PAVING						
UTILITIES						
OTHER						
3. CONCRETE	65	EA	5.12	.01		376
MARKERS	65	EA	5.12	.01	376	
REBAR						
CONCRETE						
4. MASONRY						
5. METALS						
STRUCT STL						
PLYWOOD						
OTHE						

SYSTEM TRADES / DIV. TITLE	PIPING & ELECTRIC CABLING CONDUIT SIZES	MATL	QTY	UNIT	$ UNIT	TOTAL	COSTS OTHER	$ LF	TOTAL	DIV. TOTAL
15 MECHANICAL										
A. PLUMBING										
B. HVAC										
C. FIRE PROTECT										
D										
E. HYDRO										
F. CATV										
G. PNEU										
H. ECS										
I. HYDRAULICS										
16. ELECTRICAL	1/0	CU	119,000	LF	2.84			911		355,098
REMOVE CABLES	2-3/0	AL	92	EA	21.70			.05	1,996	
#1 AWG I/C 15KVA	1/0	CU	119,000	LF	2.84			866	337,925	
SPLICES	2-3/0	CU	30	EA	115.68			.15	5,786	
TERMINATIONS	2-3/0	CU	92	EA	102.10			.26	9,393	
A. OUTER SYCS										
B. POWER										
PROJECT TOTALS				LF				10.21		398,312

SCOPE: 1 FAIR, 2 AVERAGE, 3 GOOD, 4 EXCELLENT, 5 SUPERIOR

BASIC PLAN: A NEWARE, B RESTORATION, C MODERNIZATION, D REPAIRS, E

CONCEPTS: FIRST KSC CAD IBIS CALC COMPUTER ESTIMATE - ERATIC PRICE OF COPPER CAUSED PROBLEM.

DESIGN DATA: TYPE FAC 60 HZ POWER; CAPACITY 39,000 LF; SP AREA; HEIGHT; STORIES; STRUCT. FOUND; VOLUME; PT.; CU

SPECIAL FEATURES: #1 AWG - CU X LPIC 15KVA $2.84 LF GOVT. EST. WAS RAISED DUE TO VENDOR REQUIREMENT FOR 5% ADD. MATERIAL. MARKUP ADJ. TO 10% ON 7% PROFIT.

CONSTRUCTION BID DATA INFO 10-0009-9

MECH. LP:			
ELEC LP:	39,000	9.11	355,098
MASONRY LP:			
OTHER			43,214
SUBTOTAL:	39,000	10.21	398,312

SPECIAL COST FEATURES: HAZARDS; PAD TEST ELM CERT.; GFE; OTHER; SUBTOTAL; TOT. PODAJ; BID DATE 3/23/88; AWARDED TO GF&L $396,000; CONSTRUCT TIME SPAN 180 CAL DAYS; NO OF BIDS 13; GOVT EST PCT 1 OF 13; PCT BID AWARDED BID & GOVT EST 2.83

BIDDERS

GOVT. EST.	$ 385,242	9.88
GF&L	$ 396,000	10.15
GOVT. EST. REV.	$ 398,312	10.21
EAST BAY ELEC.	$ 397,227	10.19
MILITARY CONST.	$ 398,770	10.23
SOUTHERN ELEC.	$ 400,425	10.27
STRUMCRAFT	$ 413,134	10.59
CONSOLIDATED ELEC.	$ 421,762	10.81
HEDGECOCK ELEC.	$ 422,000	10.82
FLA. INDUST.	$ 444,000	11.38
SOUTHEASTERN	$ 480,432	12.32
CHROME ELEC.	$ 494,603	12.68
OLSON ELEC.	$ 497,535	12.76
ACME ELEC.	$ 513,200	13.16

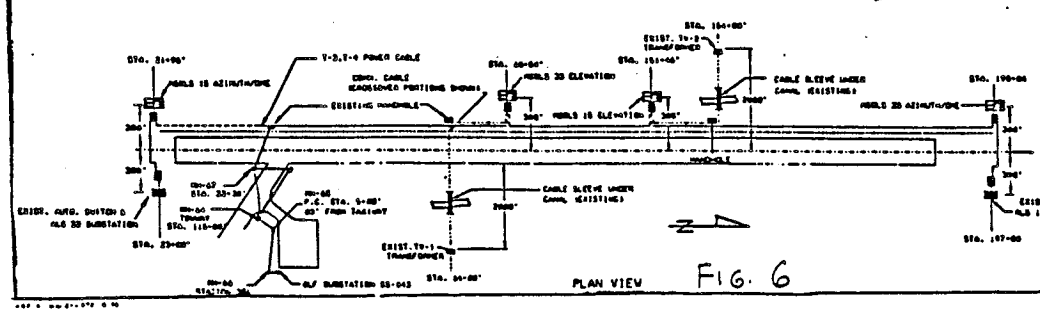


FIG. 6

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E. CAD/ACCE Problems, Difficulties and Challenges

1. APDP drawing not complete for PSCL: graphics, concrete and block; dimension; descriptions, finish schedule.

2. IBIS-CALC Format - Summary of labor and material, units quantities and unit prices; separate labor and material mark-ups are not available in Version 2.37 (IBIS-CALC Version 3.0 to solve these problems, Kees said)

3. Present Intergraph CAD, IBIS-CALC Navy System, relationship not complete - civil, mechanical and electrical not integrated. (Some mechanical and electrical fixtures can be incorporated by noting them as components in APDP.)

4. Many quantities missing from APDP/AQUA - foundations, structural, etc.

5. Excessive training time required to understand and use the system. (May require six to eight weeks of training time and hands-on to become proficient; after system up and running - I think 10-24 weeks, for formal classes, supplemental training and practice.)

6. Keeping computerized cost data up to date for local areas.

7. Limited budget to ideally customize CAD/ACCE System.

8. Limited priority, resources.

9. Difficulty making CAD/ACCE faster, simple and easy to use.

10. Difficulty in getting A&E's to use Intergraph CAD, APDP (Auto CAD - Cheaper and easier to learn and use).

11. Intergraph efforts are being concentrated on microstration for auto CAD competition.

12. Low priority allocated to processing causes the slow VAX computer software/cost database loading time of 27 hours. (Kees said individual stand alone work station coming in two years will solve some of this.)

13. Lack of user (cost engineering) input in software program development. (Intergraph may be hiring a cost engineering consultant by early 1989.)

14. Difficulty in putting together off-the-shelf programs (APDP, AQUA, IBIS-CALC) for customized Government application.

15. Negative finishes problem due to corrupt drawing file - October 1988/memo, 3/2/89

16. IBIS-CALC Computer Aided Design/Automatic Cost Estimating using a VAX mini computer Estimating Program cut itself off (built-in timer) 7/1/89

Note: New compact disk CD-ROM disk with October 1988 cost database due January 1, 1989 (which includes Navy CES, NASA, Army and Navy specification system).

Comments, Discussion and Summary

More experienced personnel dedicated to Architectural/Structural APDP are required.

Additional Intergraph APDP projects are needed.

Doing the review of the AQUA report file, it is most important that the designer, computer technician, estimator and LCE, especially, evaluate error messages for intentional errors or mistakes, and check quantities for correctness or reasonableness. (1) Close open spaces to get better quantities, (2) Floor area = finish floor quantities, (3) Wall area = 2 x finish areas; single walls have two sides.

Doing the review of the IBIS-CALC report, which is used to generate the correlation table, the designer, estimator, computer technician and LCE work together to standardize the correlation table for future projects. (It took Brinks 15-20 projects to get most of their (90%) class codes/correlation tables. They are also using their CAD estimates to generate their specification sections.)

After we get the APDP drawing corrected and completed, it may take 1-7 days (?) for a correlation table to get a more complete estimate.

COMPUTER ESTIMATING

The computer 90% design estimate for Orbiter Landing Faciliy (OLF) 60 Hertz (cycles) Power T-3 and T-4 feeder was delivered to J. King, DF-FED-21, by J. Brown on November 3, 1988. This project was designed on Intergraph 2D Generic CAD by Tay Fitzgerald and R. Cason. This is an important milestone in our goal toward CAD/Automatic Computer Cost Estimating (CAD/ACCE). EGG/BOC-139 computer technician, Pat Tanner, inputted Tay's estimate into IBIS-CALC stand-alone estimating program on VAX. The Navy database was used as a reference file for cost and supplemented with vendor quote and KSC unique cost data, Figure 6.

KSC CAD ESTIMATING MILESTONE

A CAD Estimate for the PSCL Building was delivered to DF-FED Lead Cost Engineer on November 17, 1988, by Pat Tanner, based on PSCL drawing for APDP class codes for quantity. See Figure 8, A, B, & C.

February 23, 1989

The apparent low bidder for replacement of power feeders at the Shuttle Landing Facility is GF&L Construction of Columbia, SC. This project was bid February 23, 1989, as shown:

Project : PLOT4 PILOT WITH PLOT DRAWING
Indexdate: 03-17-89
Estimate : J-A1.1 .1

Printdate: 03-20-89
Printtime: 12:49:18
Page: 2

Codenumber	Description	Amount Quant.	Unit	Mh/cost per unit	Man-hours	Amounts Labour	Materials	Equipment	Sub-contr.	Totals
03	DIVISION III									
03.10										
03.10.0										
X-1EBBRC	FORM COL PLYWD 3-USE	1023.74	SF	2.15	2201.05	2201 05				
X-1EBFRA	FORM ELEVATED SLAB PLYWD	98 21	SF	1.61	158.11	158 11				
X-1EBKRA	FORM BEAMS UNSUPPORTED	1615 28	SF	3.21	5185.05	5185 05				
X-1EBYRA	FORM WALLS TO 16' PLYWD	1528.53	SF	2 58	3943.60	3943.60				
X-1ECFPH.D	EDGE FORMS SLAB ON GRADE	1016.99	LF	1.09	1108 52	1108 52				
X-2EBBRC	FORM COL PLYWD 3-USE	1023.74	SF	0.81			829 23			
X-2EBFRA	FORM ELEVATED SLAB PLYWD	98 21	SF	1.98			194.45			
X-2EBKRA	FORM BEAMS UNSUPPORTED	1615.28	SF	2.26			3650.53			
X-2EBYRA	FORM WALLS TO 16' PLYWD	1528.53	SF	1.52			2323 36			
X-2ECFPH.D	EDGE FORMS SLAB ON GRADE	1016.99	LF	0.28			284 76			
X-3EBBRC	FORM COL PLYWD 3-USE	1023.74	SF	0.09				92.14		
X-3EBFRA	FORM ELEVATED SLAB PLYWD	98 21	SF	0.05				4.91		
X-3EBKRA	FORM BEAMS UNSUPPORTED	1615.28	SF	0.09				145.38		
X-3EBYRA	FORM WALLS TO 16' PLYWD	1528.53	SF	0.08				122.28		
X-3ECFPH.D	EDGE FORMS SLAB ON GRADE	1016.99	LF	0.05				50 85		
03.10.0		total		*******		12596 33	7282 34	415.55		20294.22
03.10		total		*******		12596 33	8852 62	415.55		21864.51
03.20										
03.20.0										
X-1EFAA	REBARS AVG PLACE & SIZE	3.78	TN	330.87	1250.03	1250 03				
X-1EGFU	PLACE WIRE MESH SLABS	45.36	SQ	10.73	486 72	486 72				
X-2EFAA	REBARS AVG PLACE & SIZE	3.78	TN	559.52			2113 87			
X-2EGFU	PLACE WIRE MESH SLABS	45.36	SQ	16.32			740 29			
03.20.0		total				1736.75	1736 75	2854 16		4590.91
03.20		total				1736.75	1736 75	11706 78		13443 53
03.30										
03.30.1										
X-1EKDMG	PLACE CONC 2500 OR 3000#	1.08	CY	13.03	14.10	14 10				
X-1EKBMN	PLACE CONC 2500 OR 3000#	13.27	CY	11.18	148 40	148 40				
X-1EKIMN	PLACE CONC 2500 OR 3000#	22.31	CY	6.71	149.71	149.71				
X-1EKKMG	PLACE CONC 2500 OR 3000#	20.94	CY	13.03	272.82	272 82				
X-1EKSMN	PLACE CONC 2500 OR 3000#	89.87	CY	4.79	430.49	430 49				
X-1EKYMN	PLACE CONC 2500 OR 3000#	29 72	CY	9.87	293 35	293 35				
X-1EPKS	FINISHING CONC SLAB	4100 32	SF	0.17	697.05	697 05				
X-1ERIJ	CURING CONC SLAB SPRAYED	4100 32	SF	0.02	82.01	82 01				
X-2EKBMG	PLACE CONC 2500 OR 3000#	1.08	CY	52.73			57.05			
X-2EKBMN	PLACE CONC 2500 OR 3000#	13.27	CY	52.73			699.94			
X-2EKIMN	PLACE CONC 2500 OR 3000#	22.31	CY	52.73			1176 51			

FIGURE 8A

Project : PLOT4 PILOT WITH PLOT DRAWING
Indexdate: 03-17-89
Estimate : J-A1.1 .1

FIGURE 8B

Printdate: 03-20-89
Printtime: 12:49:18
Page: 13

Codenumber	Description	Amount Quant.	Unit	Mh/cost per unit	Man-hours	Amounts Labour	Materials	Equipment	Sub-contr.	Totals
16	DIVISION XVI									
16.51										
16.51.0										
X-1ZA12D	2'X4' STL. SIDED SUR.	12.00	EA	13.98	167.76	167.76				
X-1ZA12E	2'X4' STL. SIDED SUR.	30.00	EA	13.98	419.40	419.40				
X-1ZA40A	INCAN. STEP LIGHT W/POLY	18.00	EA	13.98	251.64	251.64				
X-2ZA12D	2'X4' STL. SIDED SUR.	12.00	EA	71.21			854.52			
X-2ZA12E	2'X4' STL. SIDED SUR.	30.00	EA	56.77			1703.10			
X-2ZA40A	INCAN. STEP LIGHT W/POLY	18.00	EA	82.16			1478.88			
X-2ZA91C	LAMP 40W MED. BIPIN BASE	29.00	EA	4.54			131.66			
16.51.0		total				838.80	838 80	4168 16		5006.96
16 51		total				838.80	838.80	80080 44		80919.24
16	DIVISION XVI	total				838.80	838 80	4168.16		5006.96
	TOTAL OF CHAPTERS					*******	54228.09	80080.44	5103.87	139412.40

Project : PLOT4 PILOT WITH PLOT DRAWING
Indexdate: 03-17-89
Estimate : J-A1.1 .1

FIGURE 8C

Printdate: 03-20-89
Printtime: 12:49:18
Page: 14

Codenumber	Description	Amount Quant.	Unit	Mh/cost per unit	Man-hours	Amounts Labour	Materials	Equipment	Sub-contr.	Totals
	LABOR & MATERIAL COST		$							139412 40
	TAXES & INSURANCE	20.00	%							27882.48
	SUB TOTAL L&M T&I COST		$							167294 88
	OVERHEAD	15.00	%							25094.23
	SUB TOTAL		$							192389.12
	PROFIT	10.00	%							19238 91
	SUB TOTAL		$							
	BOND	1.00	%							1923.89
	ESTIMATED CONSTRUCT. BID COST		$							213551.92
	ESCALATION & SPECIAL COND.	10.00	%							21355.19
	SUB TOTAL		$							234907.11
	S & A	10.00	%							23490.71
	CONTIGENCY	10.00	%							23490.71
	C.C.E.		$							281888.53

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1.	Government Estimate	$385,282	
2.	GF&L	$396,000	+2.8%
3.	East Bay Elect.	$397,227	+3.1%
4.	Military Const Inc.	$398,770	+3.5%
13.	High Bidder	$513,220	

See Figure 6

Due to the erratic price of copper, etc., cable suppliers may be requiring contractors to buy an extra 5% of cable length. This would add $13,000 to the Government Estimate. This project was designed on Intergraph CAD and estimating, using Intergraph/IBIS-CALC/Navy Database Computer Estimating System. The Navy Database was used as a reference file for cost and supplemented with vendor quotes and KSC unique cost data. This was the first CAD design computer estimated project for KSC. This computer estimating system also allowed worse case scenario, as well as updated government estimates, quickly, as the price of copper kept changing during design and bidding. May 23, 1989 KSC LCE gives CAD ACE briefing for Development of Microstation CAD Estimating.

June 1989 - Where are We?

PRESENT AND FUTURE TYPES OF ESTIMATES

Manual estimating has been used by Government and general contractors' estimators for over 75 years and will continue to be used by both the Government and contractors' estimators for those many applications where computer estimating is not practical or cost effective, such as unique, one-of-a-kind, and complex projects with too many variables to justify extra training and customized computerization, etc. A recent survey of manual vs. computer estimating of 113 shows 71% making manual estimates and only 29% making computer estimates. This is after 20 years of computer estimating. However, 70% of those surveyed <u>want to make and use computer estimating successfully</u>. The trend toward more computer estimating should continue as computer estimating becomes faster, cheaper, more accurate, and easier to use; especially with digitized estimating, voice recognition, artificial intelligence and CAD/ACCE (Automatic Computer Cost Estimating). Computer estimating can be justified on repetitive type projects or when two or more estimates are required. Therefore, the following four types/methods of estimating for the Government and contractors.

<u>Present and Future Types of Estimates</u>

1. Manual estimate, KSC Spec G-0002, TR 5-800

2. Computer estimates, CES/CACES/DOE

3. Digitized estimating, being developed by the Navy.

4. CAD/ACCE being developed and tested by NASA/Intergraph/IBIS-CALC

<u>Accomplishments</u> The PSCL estimates were delivered on 11/17/88 and 3/89 and proved that:

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 (see type element chart) and components can be used instead of a detail database management system requiring cost/item for each and every item in a building, thus saving 10-50% of date line items in CAD drawings quantities.

3. This accomplishment is now forcing the developing of the next generation workstation concept with integrated civil, structural, architectural, mechanical and electrical design packages to get a totally integrated cost estimating system more automatically. There is still a need for a simpler, faster and more automatic computer estimating system that is also IBM PC compatible.

THE 39 STEPS FOR DEVELOPING CAD ESTIMATES

<u>APDP</u>

1. Create (or copy) project (see figure 15)
2. Create (or copy) DDL (Data Definition Language)
3. Add "AQUA" attributes
4. Add Code list #4 - finishes
5. Create (or copy) class code table
6. "Plan" which drawings are on which floors
7. Create (or copy) drawings
8. Place/manipulate graphics
9. "Trace" room perimeters
10. Compile database - can be done anytime after Step 4
11. Load design file
12. Insert floor to drawing relations. See Figure 9, Class Code Guide

<u>AQUA</u>

13. Manipulate finishes using the Tutorial
14. Establish relations
15. Label elements and graphic groups
16. Run AQUA report option
17. Review quantities and cross check

<u>IBIS</u>

18. Generate correlation table. See Figure 10, Sample Correlation Table.
19. Edit correlation table
20. Create IBIS-CALC input file
21. Edit IBIS-CALC input file
22. Create the new project
23. Process input file into project
24. Activate reference project (Navy database or KSC unique historical database)
25. From top level of project, save triangle to get prices and substructures
26. Calculate and print estimate by spec code
27. Add civil, mechanical, electrical codes and quantities

COST ENGINEERING

28. Add new prices for missing priced items, adjust prices for each unique project (quantities and height)
29. Review cost estimates for accurate quantities and prices
30. Add missing cost line items not an drawing, in specs, etc., such as testing, scaffolding, construction, cranes, hoists, trusses, etc.
31. Do cost analysis of all major cost items, vendor quotes, etc.
32. Summarize mark-up; do other summaries, etc.
33. Review overall estimate
34. Apply bid/market strategy - special conditions, joint occupancy, down time costs, etc.
35. Final mark-up (percentages)
36. Adjust for late vendor quotes, amendments
37. Final check
38. Approve bid estimate and get signatures
39. Get bid in on time

SUMMARY LIST OF PROBLEMS, DIFFICULTIES AND CHALLENGES

1. The need for industry standardization, architectural, structural,. mechanical and electrical CAD input data so pricing can be more accurate. An answer may be that CAD/Industry is now moving in this direction. (ENR 8/10/89, Corps seeks unity through CADD.)

2. The need for cost engineering standards of cost codes (spec description). We used Navy cost codes database but some are changing again in 1989. (Good hope for the future with MOU; Army, Navy and Air Force, October 1988, Tri-Service Automated Cost Engineering System.)

3. The Bill of Materials from CAD programs are not necessarily the construction estimating quantities needed to make a Detail Construction cost estimate. The AQUA/IBIS-CALC Estimating Program helped solve this problem with a correlation table which also allowed adding additional estimate quantities such as, formwork, rebar, finishing, waste factor, etc.

4. The excessive training time required to understand and used the system (10-24 weeks). It is hoped that with the workstation concept and evolution of CAD estimating, this may be reduced to 1-2 weeks.

5. The CAD drawings must be complete (with intelligent information) to obtain accurate quantities. A special estimation/cost engineering review step will be required.

6. The government estimating system requires a detail description, quantity, unit labor, total labor, unit material, total material and total line item cost column for each line item, for review and evaluation. This is not yet possible with the IBIS-CALC product. This is also necessary for proper markups for labor, payroll, taxes, insurance and material and equipment taxes. This government format may be coming on the next IBIS-CALC version, via the workstation with CES.

7. It is most important that these estimating programs can update the cost database easily for local areas, etc. This is another enhancement needed. We plan on working on this with the Navy (CES).

8. The difficulties in getting A&E's and design engineers to use the CAD, with intelligent drawing concept. It is still more expensive initially; but with workstation CAD and industry standardization; a more cost effective hardware and software; simpler systems; and education; this problem will be gradually solved as the benefits outweigh initial cost and extra learning etc.

9. The hardware/software program developer failure to have adequate end user (cost engineer) input, requirements and responsibilities in total system development is a common problem in computer program development. By emphasizing this problem here and now, it is hoped that the next generation will be wiser, resulting in a faster, cheaper, easier to use and more cost effective product.

10. The excessive amount of customization for each user is an expensive hidden cost consideration. With industry standardization, workstation CAD, linked to generic computer cost estimating systems such as CES, MC^2, Bautec/Access, and Timberline, this problem should be reduced to an acceptable level; keeping in mind that each user will have unique requirements, most of which should be solved with a more flexible CAD/ACE.

11. The need for a totally integrated design and estimating program is necessary so a complete cost estimate can be derived more automatically. This is now being planned for the workstation being developed for release in July 1990. The new system is planned to have integrated architectural, structural, civil, space planning, HVAC, electric wiring, plumbing and piping. The quantities captured from unintelligent (dumb) drawings (see Figure 12) will be a new feature.

12. The problem of keeping CAD/ACE simple is probably one of the most difficult and yet the most necessary for acceptance by A&E's, owners, government management, and primarily the estimators/cost engineers. If it is to be readily accepted and implemented as soon as possible for more cost effective construction,

it is hoped the simplistic workstation concept as compared to the mini computer system will be a major step to make CAD/ACE more simple. We will continue working on this with future enhancements. See Figure 11. Note 21 steps for manual estimating vs. 39 steps for CAD estimating. CAD/ACE needs to reduce this to 10 steps. This should be accomplished after the 15-20 projects are estimated and many of the user variables can be identified, evaluated and automated.

13. Making the CAD/ACE easier to use has been one of the biggest challenges since estimating/cost engineers require years of education and experience, and estimating may vary with each project, each estimator and cost engineer. Our work has been mainly centered on detail labor and material government estimates as required by TM 5-800, KSC Spec G0002, and the Navy CES. Due to limited R&D, funding our efforts have been trying to customize and integrate many different hardware and software programs which required many separate and distinct operations. This can be noted by the 39 steps shown previously to make CAD/ACE linking up (39) separate/different programs to make a complete estimate. The new workstation CAD/ACE should be easier to use since it is being designed and integrated for the workstation with 11 software packages in mind--see sketch 4/12/89, Figure 12. It is being designed for some of the more popular third party computer estimating programs so the estimator can use the program with which he is most familiar and experienced, that also fits his needs best. An example is KSC and Navy using CES which is best suited for government work. The Q-capture with unintelligent drawings also could make it easier to add the unique items not in CAD/ACE. It is hoped that in developing the stand-alone system (See Figure 13), it will be used by A&E/Estimators/Cost Engineers without access to CAD ACE to start using computer estimating tools. This way, they will be ready when their firms start using intelligent CAD and CAD/ACE.

14. Do as much as possible automatically, try to limit the CAD/ACE to little data entry since most estimators apparently dislike this requirement of present computer estimating system. This requirement will have to be developed as more projects are implemented into this system. It is hoped that many steps can be automated through advanced programing, artificial intelligence, voice recognition, etc. The basic concept is to use CAD for quantities and to use quantity extraction software and correlation tables for cost codes, specifications, description, and other tools such as a data base management system for listing and pricing out, a spread sheet type program for pricing out and marking-up the cost estimate. Also a report writing program for formatting of reports and and to give it the automatic flexibility not thought possible nine years ago when the CAD/ACE concept was first advocated.

COST ESTIMATION FLOW DIAGRAM

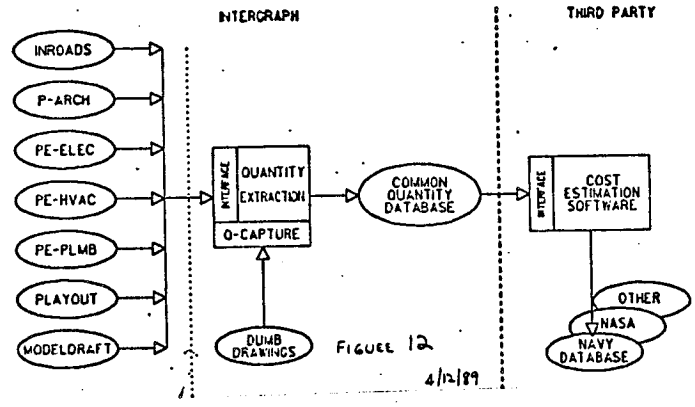
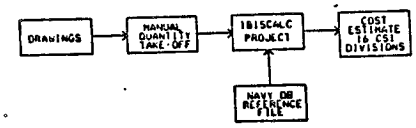


FIGURE 12

STANDALONE



AUTOMATED - CAD

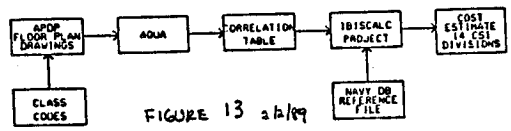


FIGURE 13 4/12/89

In summary, we are continuing to develop the mini-computer/CAD/estimating with the stand-along version and requesting more CAD/APDP design projects while advocating and cooperating in the development of the next version of CAD/ACE which we hope and pray will be the futuristic cost estimating system (Figure 14) that will provide time for even more cost engineering and ultimately more cost effective and efficient construction for government and aerospace and ultimately for you, the consumer and taxpayer. Such a cost estimating package would assist in the continuation of our ambitious space program to ensure the United States of continued preeminence in space exploration of development and attaining our new goals for Space Station, to the Moon, and to Mars.

COMPUTERS & COMPUTER ESTIMATING REFERENCES

1. Frank O. Grady, Goddard Space Flight Center, Greenbelt, MD, "Computer Use in Facilities," at NASA Facility Conference, December 8-10, 1982, Cocoa Beach, FL.

2. "Personal Computer," Design News, Electronix Special Issue, February 7, 1983; also, June 6, 1983 and August 22, 1983.

3. H. P. Conner, "What's the Hang-Up With Computers in Construction Estimating," at AACE 1981 Annual Meeting, Toronto, Canada.

4. "Ten Pitfalls You Can Avoid When Buying a Computer," Computers For Design Construction Handbook, 1982/83.

5. Construction Cost Engineering and Computation, State of the Art, 1973. Edgar S. Neely, Jr., Interim Report, "Improve Accuracy of Cost Estimating Budget Data," Construction Engineering Laboratory, p. 10, December 1973.

6. "Information System For Small/Medium Sized Contractors," Arthur Anderson and Company, Nov., 1982.

7. "Microcomputers in Construction," Arthur Anderson and Company, Nov., 1982.

8. Lawrence C. Bacher, "Computer-Assisted Estimating, Analyzing the Options," Cost Engineering, p. 39, June 1983.

9. "Micro, Mini, Maxi, and Super Computers," Computer Basics #390, Information Plus, 1165 Long Hill Road, Stirling, NJ 07980, Copyright September 1983.

10. "ORR System Estimating by Systems," Management Time Sharing, The Service Bureau Company, 65-2721-2.

11. "How to Buy a Computer for Your Business," Construction Contracting, pp. 37-39, Apr 1979.

12. "Computerization - A Technology Comes of Age," Building Design and Construction, October 1981.

13. "Low Cost Microcomputers in Construction," Contractor Estimator,. Jan/Feb 1981.

14. Edward Zamojski and Bernard E. Seals, "The Impact of Computer-Aided Design on Cost Engineering," at 1982 AACE Annual Meeting.

15. "Computers in Construction", Walkers Estimating and Construction Journal, Jan 1983.

16. Lee D. Peters, PE, "Performance Specifications for Computerized Estimating - How Real is the Computer Cure?" Cost Engineering, Aug 1983.

17. Engineering News Record, 12/3/81, 1/5/84, 10/84, 2/13/86, 8/10/89.

18. AACE Computer Application Committee, "31 Micro Computer Software Listings", June 1984.

19. "Computerized Scheduling," By Edward D. Hamm, PE, to Florida Section AACE, Nov. 16, 1985, Tampa, FL.

20. "Computer Estimating," By Dr. Zohar Herbsman to Florida Section AACE, Feb. 8, 1986 (at BCN School).

21. "Cost Estimating Programs for Micro Computers," By Thomas Ponder, Jr., Florida Section AACE, March 8, 1986, Lake Buena Vista, FL.

22. "Automated Estimating Systems, Army, Navy, Air Force," By John W. Williams, Florida Section AACE, 17th Annual Symposium, Lake Buena Vista, FL.

23. Brown, J. A., 1989, AACE 33rd Annual Meeting, June 25-28, San Diego, CA, Construction Government Bid Estimates Compared to General Construction Bid Estimates.

24. Brown, J. A., 1980, AACE Annual Meeting, Washington, DC, July 6-9, Seminar Workbook, "Estimation of Construction Cost".

25. 1986, Compiling Construction Cost Estimates, Specification KSC SPEC-G_0002, Rev. B, NASA/KSC.

26. 1960, 1985, TM 5-800, U. S. Army tech Manual U.S.A.

27. 1989, "KSC Monthly Facility Construction, GSE Cost Index," TR-1511, July, NASA/KSC.

28. Brown, J. A., 1986, "Technical University of Nova Scotia Seminar Work Books," Vol. I, Introduction to Cost Estimating; Vol II, Construction Cost Estimating; Vol. III, Cost Engineering and Construction Management; Vol IV, Computerized Cost Estimating.

29. 1986, "Escaping the Computer Debt Spiral - PSMJ, Design Service Fee Structure Survey," ENR p. 30.

30. 1987, "U.S. Navy Computer Estimating System Data Base," USN.

31. Brown, J. A., 1988, "Government Contract and Computer Estimating Seminar Work Book for 19th Annual Cost Engineer Symposium on Computerized Cost Engineering Applied Work Seminar," North Florida Section AACE.

32. 1988, "AACE's Skills and Knowledge of Cost Engineering," 2nd Edition, 17th Session Workshop.

33. Brown, J. A. 1988, "Manual and Computer Estimating Trends," Florida Section, 19th Annual Cost Engineering Symposium, Orlando, FL.

34. "CED Users Guide for Micro Estimating," NARDAC, Version 4.0, Jul, Aug 1989; Version 3.0, May, Jul 1987.

35. "IBIS-CALC - Integrated Building Information System Software Manual," 1987.

36. "Composer Plus - PC Cost Estimating Companion to CACES," Building System Design, Inc.

37. Brown, J. A., 1982 - BCC, Cocoa, FL Seminar Workbook Construction Estimating Cost Engineering & Construction Management

38. Brown, J. A., 1982 Aerospace Construction Price Book for Construction Management of Aerospace Facilities 7th International Cost Engineering Congress, London, England, Oct. 3-6

Figure 2 Efficiency Analysis

Assuming 500 Man-Hour Estimating Efficiency

Activity	Normal MH Expended	Computer Aided MH	Est. Imp.	CADD/ACCE* MH Expend.	Improve-ment	7/24/89 CADD/ACE MH
CADD Intelligence						25**
Administrative Work	35	35	0	35	0%	35
Quan. Surv. Doc. Rev.	40	40	0	32	20%	32
Quan. Surv. Measurement	100	108	10%	12	90%	12
Quan. Surv Mathematics	100	0	100%	0	100%	25**
Pricing Man-Hour Study	40	36	10%	36	10%	36
Pricing Market Survey	85	81	5%	81	5%	81
Pricing Mathematics	25	0	100%	0	100%	0
Checking Mathematics	35	0	100%	0	100%	0
Summary Presentation	20	4	80%	4	80%	4
	500	304	39%	200	60%	250
Cost at $30 per MH	$15,000	$9,120	$5,880	$6,000	$9,000	$7500

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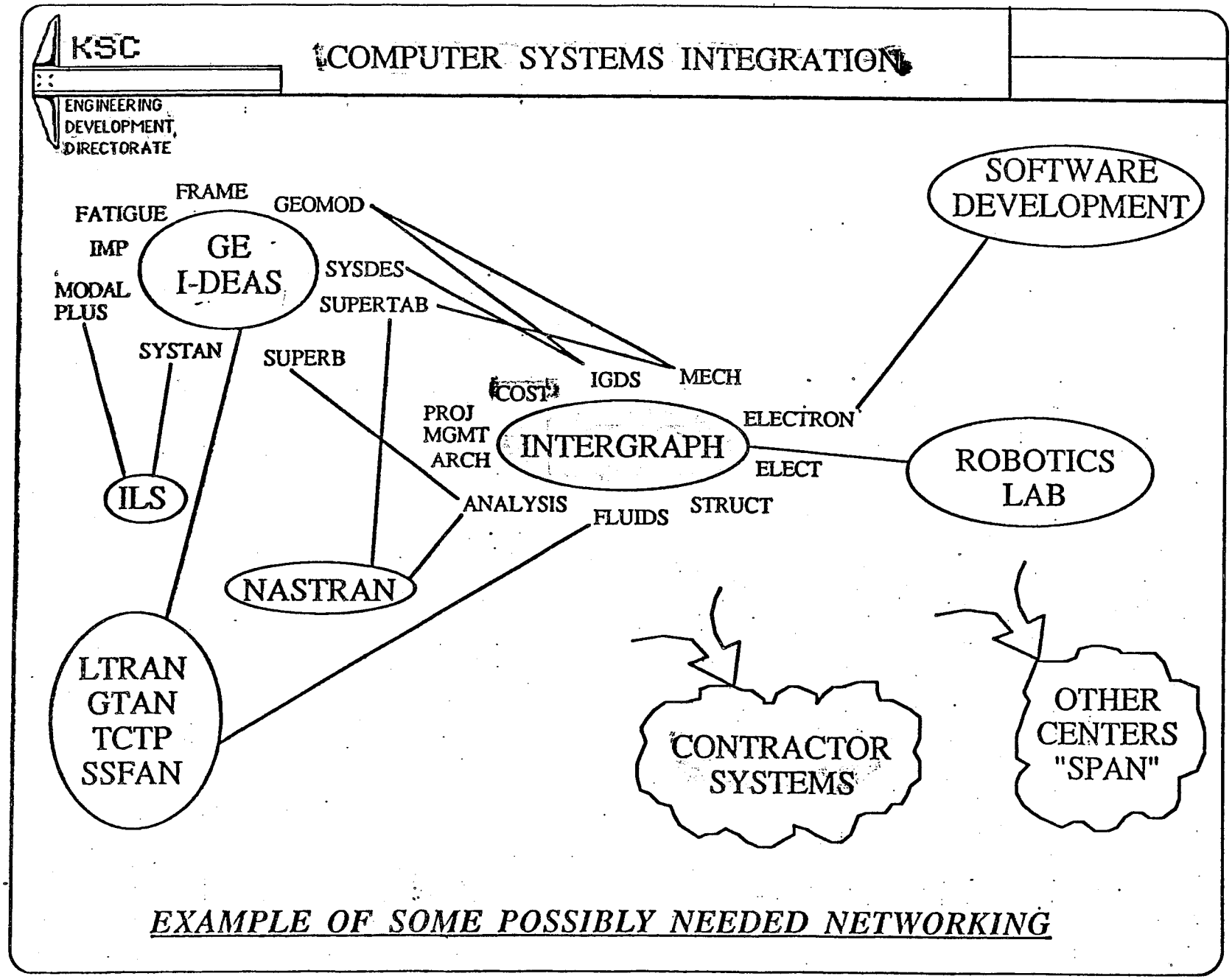


EXAMPLE OF SOME POSSIBLY NEEDED NETWORKING

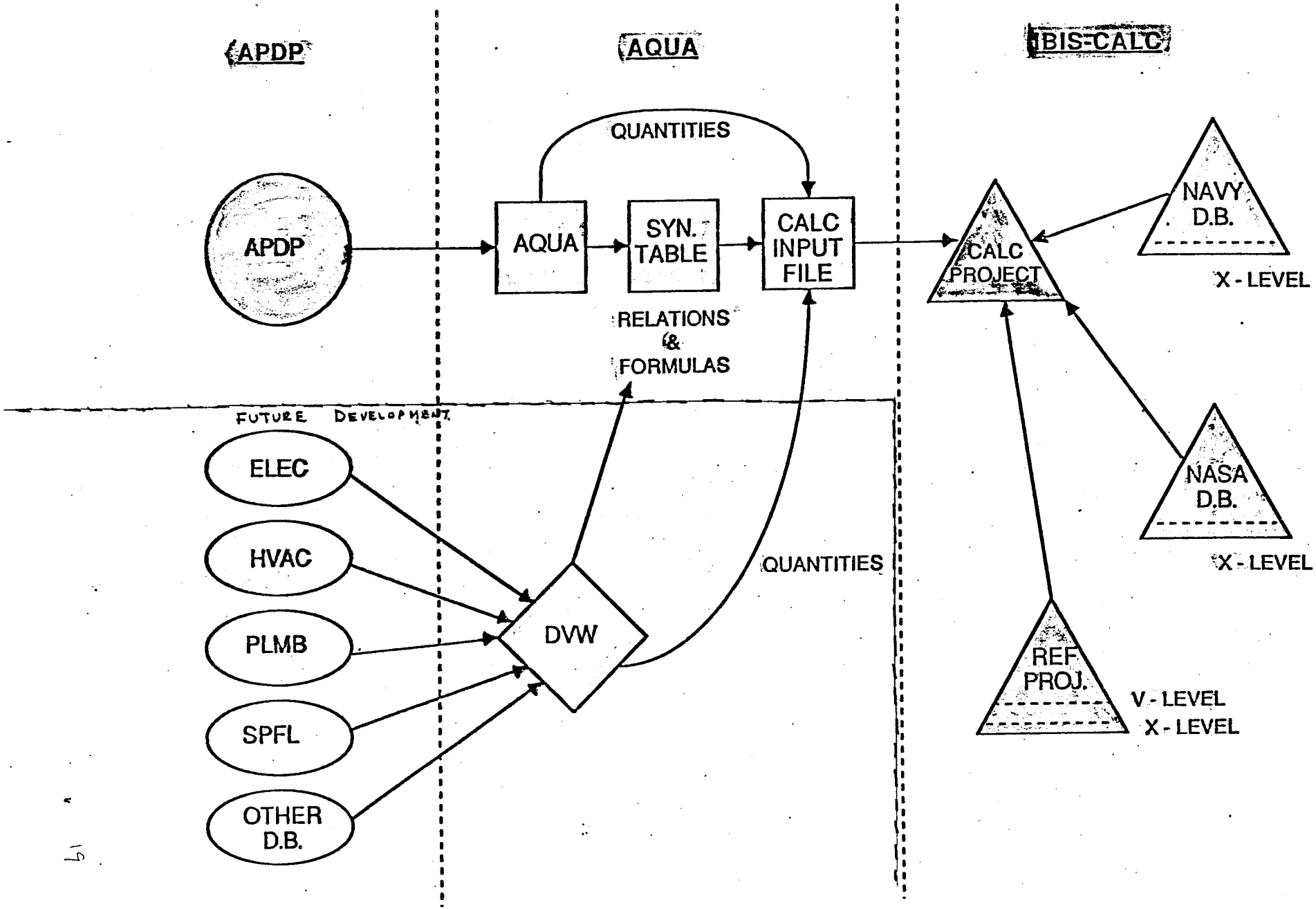
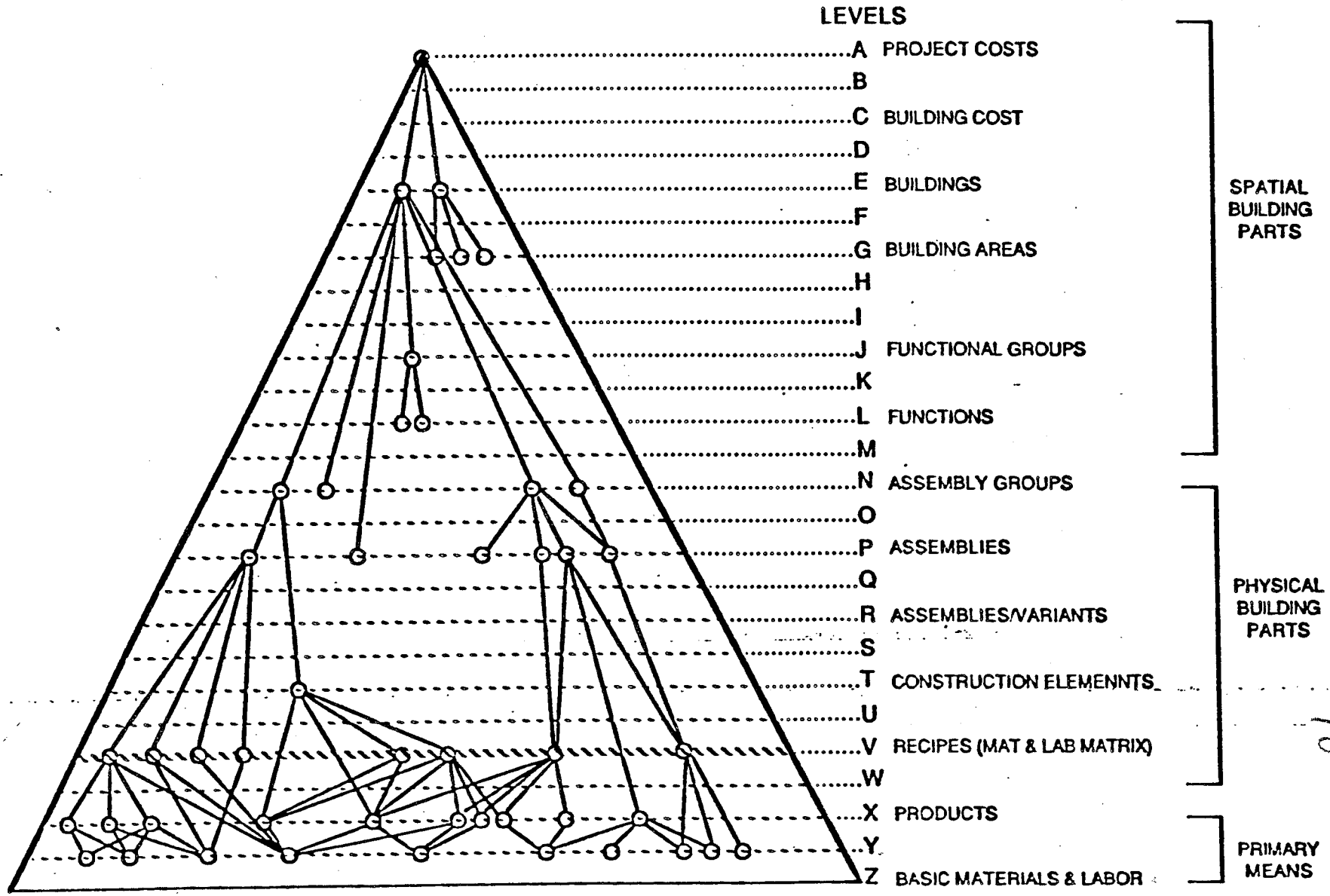

APDP
AQUA
IBIS-CALC
QUANTITIES
APDP
AQUA
SYN. TABLE
CALC INPUT FILE
CALC PROJECT
NAVY D.B.
X - LEVEL
RELATIONS & FORMULAS
FUTURE DEVELOPMENT
ELEC
HVAC
PLMB
SPFL
OTHER D.B.
DVW
QUANTITIES
NASA D.B.
X - LEVEL
REF PROJ.
V - LEVEL
X - LEVEL

FIGURE 4

CONSTRUCTION DOCUMENTS PHASE COST ESTIMATE



materials – to give the user access to accurate cost information throughout the design phases. Accurate budgets can be set, and design and material selections can be made according to the owner's budget priorities. The interactive nature of the package enables the estimator to know the cost impact of each design decision immediately at any level of detail.

IBIS-CALC features include:

- **Computer-Aided Design (CAD) interface for automatic development of element quantities**
- **The capability to use data from multiple sources**
- **Simultaneous cost updating**
- **The display of project costs or incremental costs**
- **A "recipe" concept**
- **Reporting versatility**
- **The generation of specifications**

IBIS-CALC is highly sophisticated yet easily used, designed for operators with varying levels of experience and training. The menu structure lists available options at all points in the program, making it readily functional for the occasional user. An online help facility is also available from any location within the menu. The frequent user can rapidly move through the menu with single-letter commands.

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The estimato
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different parts
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can be copied i
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specifications a

View Update Locks Display Parameters Utilities Interface

View One

08-00-36-AE-1A-00 - VT220

Proj:VILL APARTMENT RENNOVATION
Indx:00-00-86 MAJOR CATEGORIES OF WORK Hrly rate: 0.00 Rele: Ind.: - -

E-3	BUILDING INTERIOR			EA.=	570614.00	570614.00
G-TYPE01.	SAVANNAH	flat	1.000	EA.+	25768.000	25768.00
G-TYPE02.	WILMINGTON	townhouse	2.000	EA.+	34560.000	69120.00
G-TYPE03.	CHARLESTON	flat	2.000	EA.	24000.000	48000.00
G-TYPE04.	BOSTON	flat	1.000	EA.	25735.000	25735.00
G-TYPE05.	BALTIMORE	flat	1.000	EA.	26799.000	26799.00
G-TYPE06.	PROVIDENCE	flat	1.000	EA.	23608.000	23608.00
G-TYPE07.	ADAMS	flat/loft	2.000	EA.+	29888.000	59776.00
G-TYPE08.	JEFFERSON	rowhouse/2story	4.000	EA.	37681.000	150724.00
G-TYPE09.	HENRY	townhouse	2.000	EA.	24544.000	49088.00
G-TYPE10.	REVERE	flat	2.000	EA.	24550.000	49100.00
G-TYPE11.	FRANKLIN	flat	2.000	EA.	21456.000	42912.00

//

PROJECT ?
H??? Analysis Modify Save Remove Disp Level ? 15.000 %
Enter codenumber and skip through means.

578614.00
65592.10
658206.10

IBIS-CALC can run concurrently with an Intergraph APDP process on an

ORIGINAL PAGE IS OF POOR QUALITY

SYSTEM SUMMARY OF GOVERNMENT ESTIMATE FOR SYSTEMS

SHEET 49 OF

DRAWING NO.	SHEETS	PCN	LOCATION	PROJECT
79K32623	3	94051	KSC, LC-39, OLF ORBITER LANDING FAC	OLF 60 HZ POWER T3 & T4 FEEDER

WORK ORDER CONTRACT	ARCHITECT ENGINEER	ESTIMATOR	CHECKER	CODE
NAS 10-11582	NASA - R. CASON	TANNER/BROWN-NASA	S.S. VARNDELL/EGG T. FITZGEROUS/NASA	C-100 SUBMITTED 11/3/88 S.S.7/3/89

CONSTRUCTION COSTS

A 3 TRADES DIV. TITLE	QTY	UNIT	COSTS $ UNIT	$/LF	TOTAL	DIV. TOTAL	SYS. INVOLVED MECH	ELEC
1. GNL. COND.								
10 %					33,528			
2. SITE	33,000	LF	1.31	1.31		43,138		
CLR/GRUB								
DEMOLITION								
EXTRACT/FILL TRENCH	33,000	LF	1.28	1.08	42,270			
HAND EXCAV.	50	CY	1736	.02	868			
PAVING								
UTILITIES								
OTHER								
3. CONCRETE	65	EA	5.12	.01		376		
MARKERS	65	EA	5.12	.01	376			
REBAR								
CONCRETE								
4. MASONRY								
5. METALS								
STRUCT STL								
PLTFMS								
MISC								

SYSTEMS TRADES DIV. TITLE	PIPING DUCTING CABLING CONDUIT SIZES	MATL	QTY	UNIT	COSTS $ UNIT	TOTAL	OTHER $	$ LF	TOTAL	DIV. TOTAL
13. MECHANICAL										
A. PLUMBING										
B. HVAC										
C. FIRE PROTECT										
D										
E. HYDER										
F. CRYO										
G. PNEU										
H. ECS										
I. HYDRAULICS										
16. ELECTRICAL	#1/0	CU	119,000	LF	2.84			.911		355,098
REMOVE CABLES	2-3/0	AL	92	EA	21.70			.05	1.996	
#1 AWG 1/C 15KVA	#1/0	CU	119,000	LF	2.84			.866	337,925	
SPLICES	2-3/0	CU	50	EA	115.68			.15	5.786	
TERMINATIONS	2-3/0	CU	92	EA	102.10			.24	9.393	
A. ENTR SVCS										
B. POWER										
PROJECT TOTALS				LF				$10.21		398,312

DESCRIPTION

SCOPE	BASIC PLAN	COMMENTS
1. FAIR 2. AVERAGE 3. GOOD 4. COMPLEX 5. SOPHIST	A. SQUARE B. RECTANGULAR C. IRREGULAR D. VERY IRREG E	FIRST KSC CAD IBIS CALC COMPUTER ESTIMATE - ERATIC PRICE OF COPPER CAUSED PROBLEM.

DESIGN DATA

TYPE FAC: 60 HZ POWER SF AREA
CAPACITY: 39,000 LF
HEIGHT: - STORIES - - FT.
STRUCT. FRAME
VOLUME: - CF

SPECIAL FEATURES

#1/0AWG - CU X LPIC 15KVA $2.84 LF GOVT. EST. WAS RAISED DUE TO VENDOR REQUIREMENT FOR 5% ADD. MATERIAL. MARKUP ADJ. TO 10% OH 7% PROFIT.

CONSTRUCTION BID DATA SPEC 10-0009-9

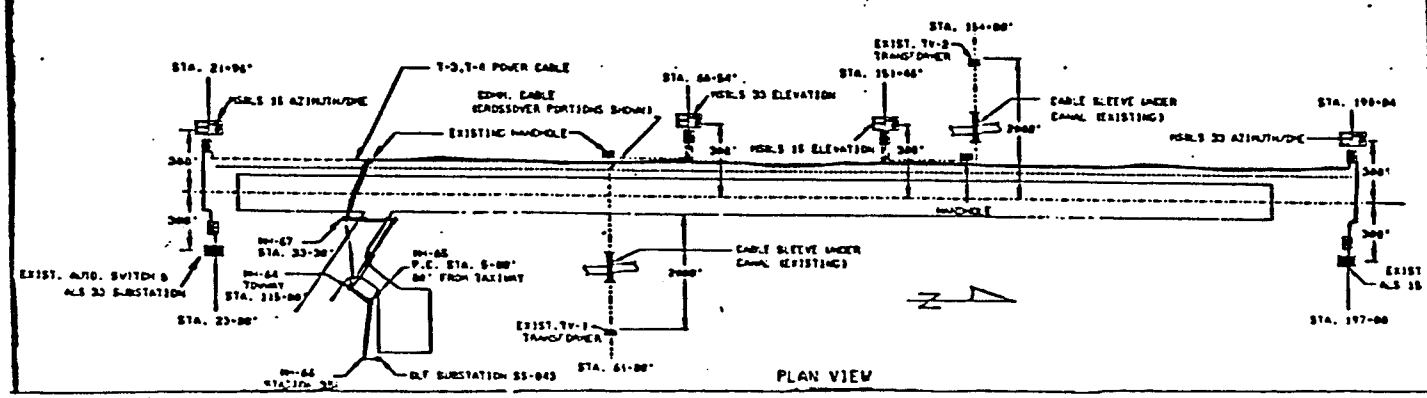
MECH. LF:		$	/LF $
ELEC. LF:	39,000	$ 9.11	/LF $ 355,098
SUBTOT LF.		$	/LF $
OTHER		$ -	/LF $ 43,516
SUBTOTAL	39,000	$ 10.21	/LF $ 398,312

SPECIAL COST FEATURES

HAZARDS.	$	/LF $
FAB TEST CLN CERT.	$	/LF $
GFE	$	/LF $
OTHER	$	/LF $
SUBTOTAL:	$	/LF $
TTL PROJ $	/SF $	/LF $

BID DATE 2/23/89
AWARDED TO GF&L $ 396,000
CONSTRUCT TIME SPAN 180 CAL DAYS
NO OF BIDS 13 GOVT EST POS 1 OF 13
PCT DIF. AWARDED BID & GOVT EST 2.82

BIDDERS		$/LF
GOVT. EST.	$ 385,242	9.88
GF&L	$ 396,000	10.15
GOVT. EST. REV.	$ 398,312	10.21
EAST BAY ELEC.	$ 397,227	10.19
MILITARY CONST.	$ 396,770	10.23
SOUTHERN ELEC.	$ 400,425	10.27
STRUMCRAFT	$ 413,134	10.59
CONSOLIDATED ELEC.	$ 421,767	10.81
HEDGECOCK ELEC.	$ 422,000	10.82
FLA. INDUST.	$ 444,000	11.38
SOUTHEASTERN	$ 480,452	12.32
CHROME ELEC.	$ 494,603	12.68
OLSON ELEC.	$ 497,535	12.76
ACME ELEC.	$ 513,200	13.16



PLAN VIEW

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COST ESTIMATE COVER SHEET

GOVERNMENT ESTIMATES ARE ADMINISTRATIVELY CONFIDENTIAL
ACCESSIBLE TO AUTHORIZED NASA/KSC PERSONNEL OR REPRESENTATIVES ONLY

Project : REPLACE OF POWER FEEDERS AT THE SPACE SHUTTLE LANDING FACILITY, KSC
OLF 60 HZ POWER T3 & T4 FEEDER
99,000 LF OF 1/0 15KV

Location :

IFB No. : IFB10-0009-9 OF 1/14/89

Bid Date : FEBRUARY 23, 1989

Amendment : 1 OF 02/08/89

Estimate Code: C100

PCN : 94051

Contract No. :

Drawing No. 79k32623 Sht 3:

Model No.:

Lead Designer: R. Carson

KSC Cost Engineer: Joe A. Brown

Project Engineer:

Prepared by: Tay Fitzgerald/Pat Tanner/Joe Brown

Firm/Address: DFFED-21

Location: KSC Hqbld Fla

Submittal Date: 02/17/89

Estimated By: Joe Brown/Pat Tanner

Phone No.: 867-3268/867-3447

Reviewed By:

Approved By:

Phone No.:

Cost Estimating for procurement requires special handling in accordance with DE ID-1142.23, KSC SPEC-G-0002 and KSC SPEC-G-0003 for GSE.

Project : T3T4ALT4 ALT END PAGE FOR T3T4 PROJ Printdate: 09-20-89
Indexdate: 03-10-89 Printtime: 09:25:38
Estimate : B-1 LABOR & MATERIAL SUB TOTAL Page: 1

Codenumber	Description	Amount Quant.	Unit	Mh/cost per unit	Man-hours	Amounts Labour	Materials	Equipment	Sub-contr.	Totals
E-1	LABOR & MATERIAL SUB TOTAL	1.00	EA							
P-15	XV - MECHANICAL	1.00	EA	0.00						
P-16	XVI - ELECTRICAL	1.00	EA							
X-2WKJKC	#1/0 AWG CU XLP 1/C 15KV	119011.00	LF	2.11			251113.20			
X-WKJKCL	#1/0 AWG CU XLP 1/C 15KV	113344.00		0.12						13601.28
X-1ZN82	CABLE SPLICE 0-15KV 1/C	50.00	EA	45.00	2250.00	2250.00				
X-2ZN82	CABLE SPLICE 0-15KV 1/C	50.00	EA	35.00			1750.00			
X-1ZN47C	CABLE TERM. SIZE 2 - 3/0	92.00	EA	26.26	2415.92	2415.92				
X-2ZN47C	CABLE TERM. SIZE 2 - 3/0	92.00	EA	44.28			4073.76			
X-1REMCA.B	REMOVE CABLE	92.00	EA	15.00	1380.00	1380.00				
P-16	XVI - ELECTRICAL	1.00	EA	276584.17	6045.92	6045.92	256936.96			276584.16
P-01	I - GENERAL CONDITIONS	1.00	EA	0.00						
P-02	II - EARTHWORK	1.00	EA							
X-1BIFKE	TRENCHING & BACKFILL IN	33000.00	LF	0.67	*******	22110.00				
X-3BIFKE	TRENCHING & BACKFILL IN	33000.00	LF	0.33				10890.00		
X-1BIGEB.KC	EXCAVATION HANDDIG	50.00	CY	12.00	600.00	600.00				
P-02	II - EARTHWORK	1.00	EA	33600.00	*******	22710.00		10890.00		33600.00
P-03	III - CONCRETE	1.00	EA							
X-1CONCK.C	16" CONCRETE CABLE MARKS	65.00	EA	2.00	130.00	130.00				
X-2CONCK.C	16" CONCRETE CABLE MARKS	65.00	EA	2.00			130.00			
P-03	III - CONCRETE	1.00	EA	260.00	130.00	130.00	130.00			260.00
P-04	IV - MASONRY	1.00	EA	0.00						
P-05	V - STRUCTURAL STEEL	1.00	EA	0.00						
P-06	VI - CARPENTRY	1.00	EA	0.00						
P-07	VII - ROOFING	1.00	EA	0.00						
P-08	VIII - DOORS & WINDOWS	1.00	EA	0.00						
P-09	IX - FINISHES	1.00	EA	0.00						
P-10	X - SPECIALTIES	1.00	EA	0.00						
P-11	XI - EQUIPMENT	1.00	EA	0.00						
P-12	XII - FURNISHINGS	1.00	EA	0.00						
P-13	XIII - SPECIAL CONSTRUCTION	1.00	EA	0.00						
P-14	XIV - CONVEYING SYSTEMS	1.00	EA	0.00						
E-1	LABOR & MATERIAL SUB TOTAL	1.00	EA	310444.17	*******	28885.92	257066.96	10890.00		310444.16
B-1	LABOR & MATERIAL SUB TOTAL	total			*******	28885.92	257066.96	10890.00		310444.16

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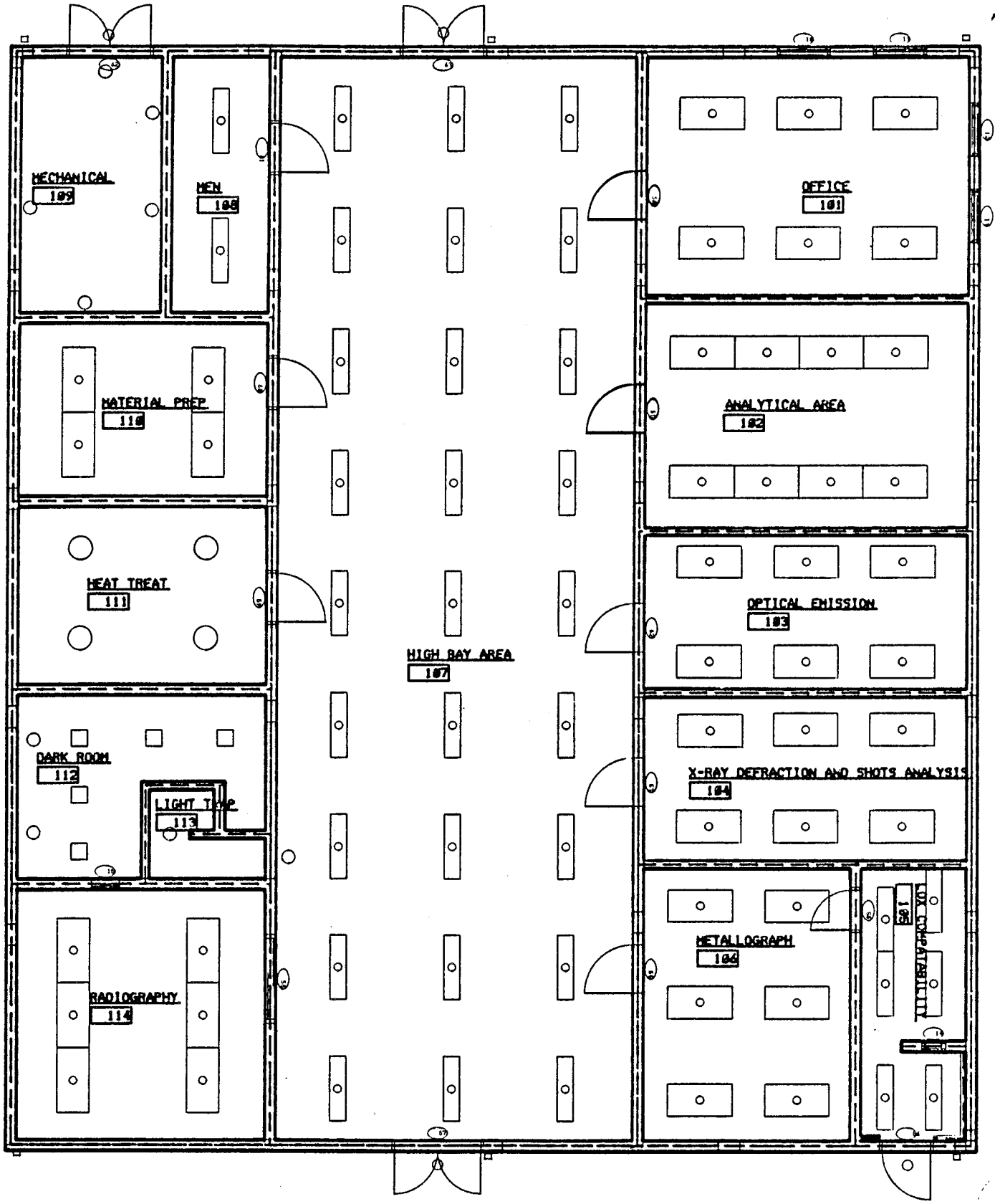
Project : T3T4ALT4
Indexdate: 03-10-89
Estimate : B-1

ALT END PAGE FOR T3T4 PROJ

LABOR & MATERIAL SUB TOTAL

Printdate: 09-20-89
Printtime: 09:25:38
Page: 2

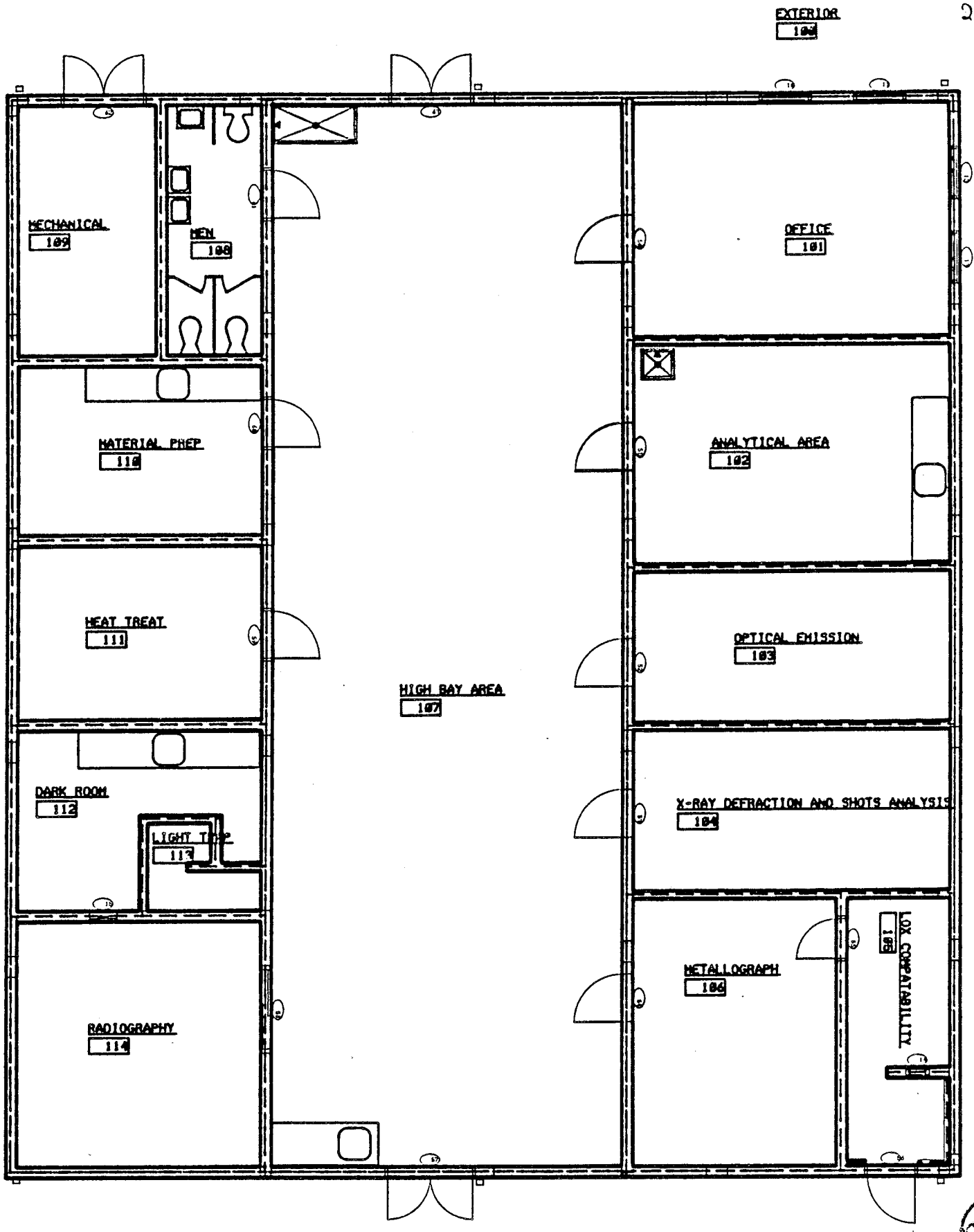
Codenumber	Description	Amount Quant.	Unit	Mh/cost per unit	Man-hours	Amounts Labour	Materials	Equipment	Sub-contr.	Totals
	LABOR & MATERIAL COST		$							310444.16
	TAXES & INSURANCE	8.00	%	MAT. 6% SALES TAX		LABOR 25% PTAX				24835.53
	SUB TOTAL L&M T&I COST		$							335279.70
	OVERHEAD	10.00	%							33527.97
	SUB TOTAL		$							368807.67
	PROFIT	7.00	%							25816.54
	SUB TOTAL		$							
	BOND	1.00	%							3688.08
	ESTIMATED CONSTRUCT. BID COST		$							398312.28



PSCL FLOORPLAN

OCT 1988

REV. MAR 1989

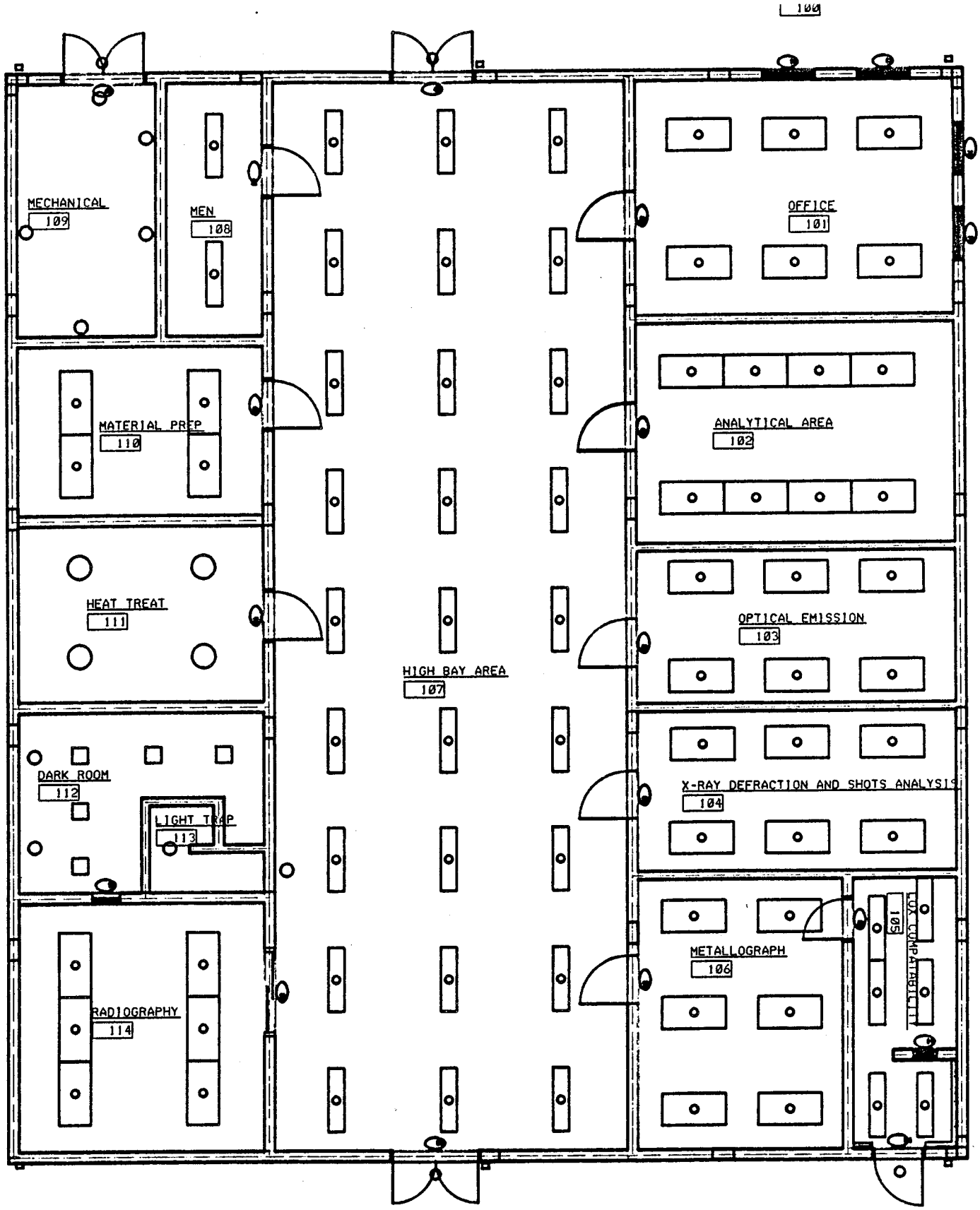


PSCL FLOORPLAN

OCT 1988

REV. MAR 1989

PLUMBING LAYOUT

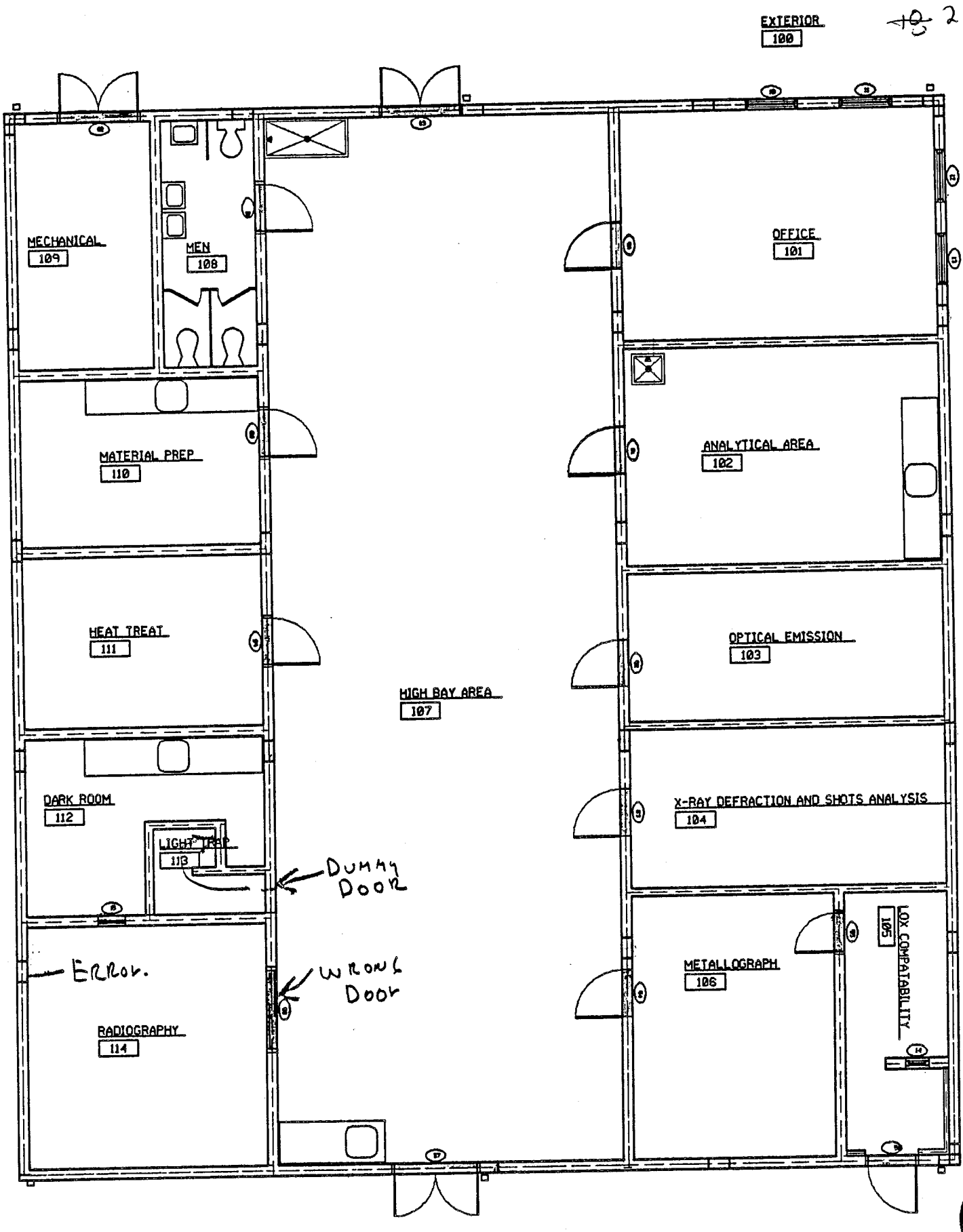


ELECTRICAL PSCL FLOORPLAN

LIGHTING LAYOUT

OCT 1988

REV. MAR 1989



Concrete

Masonry

Door

PSCL FLOORPLAN

OCT 1988

REV. MAR 1989

Project : PLOT4 PILOT WITH PLOT DRAWING Printdate: 03-20-89
Indexdate: 03-17-89 Printtime: 12:49:18
Estimate : J-A1.1 .1 Page: 1-16

Codenumber	Description	Amount Quant.	Unit	Mh/cost per unit	Man-hours	Amounts Labour	Materials	Equipment	Sub-contr.	Totals
02	DIVISION II									
02.20										
02.20.0										
X-1BIGKC.B	FINEGRADING	4100.32	SF	0.10	410.03	410.03				
X-1BIGKC.C	COMPACTION	4100.32	SF	0.10	410.03	410.03				
X-2BIGKC.B	FINEGRADING	4100.32	SF	0.05			205.02			
X-2BIGKC.C	COMPACTION	4100.32	SF	0.06			246.02			
02.20.0		total			820.06	820.06	451.03			1271.10
02.20		total			820.06	820.06	451.03			1271.10
02.21										
02.21.0										
X-1BGAEA.A	CUT, BACKFILL	64.33	CY	1.31	84.28	84.28				
X-3BGAEA.A	CUT, BACKFILL	64.33	CY	2.30				147.97		
02.21.0		total			84.28	84.28		147.97		232.24
02.21.4										
X-1BGCBL	BORROW FILL SAND COMPACT	497.45	CY	1.01	502.42	502.42				
X-2BGCBL	BORROW FILL SAND COMPACT	497.45	CY	2.25			1119.25			
X-3BGCBL	BORROW FILL SAND COMPACT	497.45	CY	2.80				1392.85		
02.21.4		total			502.42	502.42	1119.25	1392.85		3014.52
02.21		total			586.70	586.70	1570.29	1540.81		3697.79
02.22										
02.22.2										
X-1BIGEB	STRUCTURAL EXCAVATION	80.85	CY	6.91	558.65	558.65				
02.22.2		total			558.65	558.65				558.65
02.22		total			558.65	558.65	1570.29			2128.94
02	DIVISION II	total			1965.41	1965.41	1570.29	1540.81		5076.51

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Codenumber	Description	Amount Quant.	Unit	Mh/cost per unit	Man-hours	Amounts Labour	Materials	Equipment	Sub-contr.	Totals
03	DIVISION III									
03.10										
03.10.0										
X-1EBBRC	FORM COL PLYWD 3-USE	1023.74	SF	2.15	2201.05	2201.05				
X-1EBFRA	FORM ELEVATED SLAB PLYWD	98.21	SF	1.61	158.11	158.11				
X-1EBKRA	FORM BEAMS UNSUPPORTED	1615.28	SF	3.21	5185.05	5185.05				
X-1EBYRA	FORM WALLS TO 16' PLYWD	1528.53	SF	2.58	3943.60	3943.60				
X-1ECFPH.D	EDGE FORMS SLAB ON GRADE	1016.99	LF	1.09	1108.52	1108.52				
X-2EBBRC	FORM COL PLYWD 3-USE	1023.74	SF	0.81			829.23			
X-2EBFRA	FORM ELEVATED SLAB PLYWD	98.21	SF	1.98			194.45			
X-2EBKRA	FORM BEAMS UNSUPPORTED	1615.28	SF	2.26			3650.53			
X-2EBYRA	FORM WALLS TO 16' PLYWD	1528.53	SF	1.52			2323.36			
X-2ECFPH.D	EDGE FORMS SLAB ON GRADE	1016.99	LF	0.28			284.76			
X-3EBBRC	FORM COL PLYWD 3-USE	1023.74	SF	0.09				92.14		
X-3EBFRA	FORM ELEVATED SLAB PLYWD	98.21	SF	0.05				4.91		
X-3EBKRA	FORM BEAMS UNSUPPORTED	1615.28	SF	0.09				145.38		
X-3EBYRA	FORM WALLS TO 16' PLYWD	1528.53	SF	0.08				122.28		
X-3ECFPH.D	EDGE FORMS SLAB ON GRADE	1016.99	LF	0.05				50.85		
03.10.0		total			*******	12596.33	7282.34	415.55		20294.22
03.10		total			*******	12596.33	8852.62	415.55		21864.51
03.20										
03.20.0										
X-1EFAA	REBARS AVG PLACE & SIZE	3.78	TN	330.87	1250.03	1250.03				
X-1EGFU	PLACE WIRE MESH SLABS	45.36	SQ	10.73	486.72	486.72				
X-2EFAA	REBARS AVG PLACE & SIZE	3.78	TN	559.52			2113.87			
X-2EGFU	PLACE WIRE MESH SLABS	45.36	SQ	16.32			740.29			
03.20.0		total			1736.75	1736.75	2854.16			4590.91
03.20		total			1736.75	1736.75	11706.78			13443.53
03.30										
03.30.1										
X-1EKBMG	PLACE CONC 2500 OR 3000#	1.08	CY	13.03	14.10	14.10				
X-1EKBMN	PLACE CONC 2500 OR 3000#	13.27	CY	11.18	148.40	148.40				
X-1EKIMN	PLACE CONC 2500 OR 3000#	22.31	CY	6.71	149.71	149.71				
X-1EKKMG	PLACE CONC 2500 OR 3000#	20.94	CY	13.03	272.82	272.82				
X-1EKSMN	PLACE CONC 2500 OR 3000#	89.87	CY	4.79	430.49	430.49				
X-1EKYMN	PLACE CONC 2500 OR 3000#	29.72	CY	9.87	293.35	293.35				
X-1EPKS	FINISHING CONC SLAB	4100.32	SF	0.17	697.05	697.05				
X-1ERIJ	CURING CONC SLAB SPRAYED	4100.32	SF	0.02	82.01	82.01				
X-2EKBMG	PLACE CONC 2500 OR 3000#	1.08	CY	52.73			57.05			
X-2EKBMN	PLACE CONC 2500 OR 3000#	13.27	CY	52.73			699.94			
X-2EKIMN	PLACE CONC 2500 OR 3000#	22.31	CY	52.73			1176.51			

Project : PLOT4 PILOT WITH PLOT DRAWING
Indexdate: 03-17-89
Estimate : J-A1.1 .1

Printdate: 03-20-89
Printtime: 12:49:18
Page: 3

Codenumber	Description	Amount Quant.	Unit	Mh/cost per unit	Man-hours	Amounts Labour	Materials	Equipment	Sub-contr.	Totals
X-2EKKMG	PLACE CONC 2500 OR 3000#	20.94	CY	52.73			1104.06			
X-2EKSMN	PLACE CONC 2500 OR 3000#	89.87	CY	52.73			4739.00			
X-2EKYMN	PLACE CONC 2500 OR 3000#	29.72	CY	52.73			1567.19			
X-2EPKS	FINISHING CONC SLAB	4100.32	SF	0.00						
X-2ERIJ	CURING CONC SLAB SPRAYED	4100.32	SF	0.02			82.01			
X-3EKBMG	PLACE CONC 2500 OR 3000#	1.08	CY	16.44				17.79		
X-3EKBMN	PLACE CONC 2500 OR 3000#	13.27	CY	13.34				177.08		
X-3EKIMN	PLACE CONC 2500 OR 3000#	22.31	CY	8.00				178.50		
X-3EKKMG	PLACE CONC 2500 OR 3000#	20.94	CY	16.44				344.22		
X-3EKSMN	PLACE CONC 2500 OR 3000#	89.87	CY	5.71				513.17		
X-3EKYMN	PLACE CONC 2500 OR 3000#	29.72	CY	11.77				349.82		
X-3EPKS	FINISHING CONC SLAB	4100.32	SF	0.08				328.03		
03.30.1		total			2087.94	2087.94	9425.76	1908.60		13422.29
03.30		total			2087.94	2087.94	21132.54	1908.60		25129.07
03	DIVISION III	total			*******	16421.02	19562.26	2324.15		38307.42

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Project : PLOT4 PILOT WITH PLOT DRAWING
Indexdate: 03-17-89
Estimate : J-A1.1 .1

Printdate: 03-20-89
Printtime: 12:49:18
Page: 4

Codenumber	Description	Amount Quant.	Unit	Mh/cost per unit	Man-hours	Amounts Labour	Materials	Equipment	Sub-contr.	Totals
04	DIVISION IV									
04.20										
04.20.0										
X-1FCIC	REINFORCING-LADDER TYPE	2804.98	LF	0.05	140.25	140.25				
X-1FFJH	CMU HOLLOW 6" RGLR WT	1247.67	SF	1.99	2482.86	2482.86				
X-1FFJJ	CMU HOLLOW 8" RGLR WT	5294.32	SF	2.09	*******	11065.14				
X-1FGBM	ACOUSTICAL SLOTTED BLOCK	237.25	SF	2.33	552.80	552.80				
X-2FAP	MORTAR TYPE M	668.40	CF	2.31			1544.01			
X-2FCIC	REINFORCING-LADDER TYPE	2804.98	LF	0.17			476.85			
X-2FFJH	CMU HOLLOW 6" RGLR WT	1247.67	SF	1.01			1260.14			
X-2FFJJ	CMU HOLLOW 8" RGLR WT	5294.32	SF	1.29			6829.68			
X-2FGBM	ACOUSTICAL SLOTTED BLOCK	237.25	SF	3.31			785.31			
X-3FFJH	CMU HOLLOW 6" RGLR WT	1247.67	SF	0.05				62.38		
X-3FFJJ	CMU HOLLOW 8" RGLR WT	5294.32	SF	0.05				264.72		
04.20.0		total			*******	14241.04	10895.99	327.10		25464.13
04.20.3										
X-1EXIH	PRECAST CONC COPING 10"W	13.33	LF	2.51	33.46	33.46				
X-1EXTR	PRECAST CONC LINTELS	79.33	LF	1.26	99.96	99.96				
X-2EXIH	PRECAST CONC COPING 10"W	13.33	LF	3.03			40.40			
X-2EXTR	PRECAST CONC LINTELS	79.33	LF	5.50			436.32			
04.20.3		total			133.42	133.42	476.71			610.13
04.20		total			*******	14374.46	32505.24	327.10		47206.80
04	DIVISION IV	total			*******	14374.46	11372.70	327.10		26074.26

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Project : PLOT4 PILOT WITH PLOT DRAWING Printdate: 03-20-89
Indexdate: 03-17-89 Printtime: 12:49:18
Estimate : J-A1.1 .1 Page: 5

Codenumber	Description	Amount Quant.	Unit	Mh/cost per unit	Man-hours	Amounts Labour	Materials	Equipment	Sub-contr.	Totals
05	DIVISION V									
05.12										
05.12.0										
X-1GBPC	MISC SHAPES (ANGLES,BARS	488.37	LB	0.23	112.33	112.33				
X-2GBPC	MISC SHAPES (ANGLES,BARS	488.37	LB	0.52			253.95			
05.12.0		total			112.33	112.33	253.95			366.28
05.12		total			112.33	112.33	32759.20			32871.52
05.50										
05.50.0										
X-2GLJLB.D	BOLT HS 3/4"DIA X2" THRU	374.58	EA	2.11			790.36			
05.50.0		total					790.36			790.36
05.50		total					33549.56			33549.56
05	DIVISION V	total			112.33	112.33	1044.31			1156.64

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Codenumber	Description	Amount Quant.	Unit	Mh/cost per unit	Man-hours	Amounts Labour	Materials	Equipment	Sub-contr.	Totals
06	DIVISION VI									
06.10										
06.10.0										
X-1HABVG.Z	BLOCKING & NAILERS	495.21	BF	0.64	316.93	316.93				
X-1HFBGI	STRUCTURAL PLYWD EXT	571.30	SF	0.26	148.54	148.54				
X-2HABVG.Z	BLOCKING & NAILERS	495.21	BF	0.41			203.03			
X-2HFBGI	STRUCTURAL PLYWD EXT	571.30	SF	0.87			497.03			
X-3HABVG.Z	BLOCKING & NAILERS	495.21	BF	0.10				49.52		
X-3HFBGI	STRUCTURAL PLYWD EXT	571.30	SF	0.01				5.71		
06.10.0		total			465.47	465.47	700.07	55.23		1220.77
06.10		total			465.47	465.47	34249.63	55.23		34770.33
06.20										
06.20.0										
X-1HPEPN	EXT TRIM CLEAR CASING	119.41	LF	0.50	59.71	59.71				
X-1HQGOW	BASEBOARD FLAT 1X4	71.41	LF	0.51	36.42	36.42				
X-2HPEPN	EXT TRIM CLEAR CASING	119.41	LF	0.84			100.31			
X-2HQGOW	BASEBOARD FLAT 1X4	71.41	LF	0.84			59.99			
X-3HPEPN	EXT TRIM CLEAR CASING	119.41	LF	0.08				9.55		
X-3HQGOW	BASEBOARD FLAT 1X4	71.41	LF	0.08				5.71		
06.20.0		total			96.13	96.13	160.29	15.27		271.69
06.20		total			96.13	96.13	34409.92	15.27		34521.31
06	DIVISION VI	total			561.60	561.60	860.36	70.50		1492.46

Codenumber	Description	Amount Quant.	Unit	Mh/cost per unit	Man-hours	Amounts Labour	Materials	Equipment	Sub-contr.	Totals
07	DIVISION VII									
07.22										
07.22.0										
X-1IELRD	INSULATION COMPOSITE BD	4100.32	SF	0.17	697.05	697.05				
X-2IELRD	INSULATION COMPOSITE BD	4100.32	SF	0.57			2337.18			
07.22.0		total			697.05	697.05	2337.18			3034.23
07.22		total			697.05	697.05	36747.10			37444.15
07.51										
07.51.1										
X-1IQDIE	BLT-UP ROOFING ASPHALT	41.00	SQ	27.88	1143.16	1143.16				
X-2IQDIE	BLT-UP ROOFING ASPHALT	41.00	SQ	40.85			1674.97			
X-3IQDIE	BLT-UP ROOFING ASPHALT	41.00	SQ	6.00				246.02		
07.51.1		total			1143.16	1143.16	1674.97	246.02		3064.15
07.51.2										
X-1IQDUD	BLT-UP ROOFING ASPH FELT	41.00	SQ	17.43	714.68	714.68				
X-2IQDUD	BLT-UP ROOFING ASPH FELT	41.00	SQ	30.15			1236.24			
X-3IQDUD	BLT-UP ROOFING ASPH FELT	41.00	SQ	3.75				153.76		
07.51.2		total			714.68	714.68	1236.24	153.76		2104.68
07.51		total			1857.85	1857.85	39658.31	399.78		41915.94
07.60										
07.60.0										
X-1IRWAS.J	GRAVEL STOP AL .032" 8IN	256.68	LF	0.98	251.54	251.54				
X-1ISJBS.H	GUTTER BOX AL .032" 5"	118.66	LF	1.02	121.04	121.04				
X-2IRWAS.J	GRAVEL STOP AL .032" 8IN	256.68	LF	4.46			1144.78			
X-2ISJBS.H	GUTTER BOX AL .032" 5"	118.66	LF	1.25			148.33			
07.60.0		total			372.58	372.58	1293.11			1665.69
07.60		total			372.58	372.58	40951.42			41324.00
07	DIVISION VII	total			2927.48	2927.48	6541.50	399.78		9868.76

Codenumber	Description	Amount Quant.	Unit	Mh/cost per unit	Man-hours	Amounts Labour	Materials	Equipment	Sub-contr.	Totals
08	DIVISION VIII									
08.11										
08.11.0										
X-1JA@CA	INT HM DOOR & FRAME W/	11.00	EA	100.46	1105.06	1105.06				
X-2JA@CA	INT HM DOOR & FRAME W/	11.00	EA	492.49			5417.39			
X-3JA@CA	INT HM DOOR & FRAME W/	11.00	EA	0.53				5.83		
		total			1105.06	1105.06	5417.39	5.83		6528.28
08.11.0		total			1105.06	1105.06	46368.81	5.83		47479.70
08.11										
08.12										
08.12.0										
X-1JKSBE	SWING ENTRANCE 3-0/7-0	1.00	EA	149.44	149.44	149.44				
X-1JKSBK	SWING ENTRANCE 6-0X7-0	3.00	EA	182.88	548.64	548.64				
X-2JKSBE	SWING ENTRANCE 3-0/7-0	1.00	EA	330.00			330.00			
X-2JKSBK	SWING ENTRANCE 6-0X7-0	3.00	EA	574.20			1722.60			
		total			698.08	698.08	2052.60			2750.68
08.12.0		total			698.08	698.08	48421.41			49119.49
08.12										
08.52										
08.52.0										
X-1JLHDI.C	WINDOW D/H AL EXTRUDED	4.00	EA	24.00	96.00	96.00				
X-2JLHDI.C	WINDOW D/H AL EXTRUDED	4.00	EA	102.00			408.00			
		total			96.00	96.00	408.00			504.00
08.52.0		total			96.00	96.00	48829.41			48925.41
08.52										
08.71										
08.71.0										
X-1JPBIQ	LOCKSET SERIES 1000 GR 2	11.00	EA	15.20	167.20	167.20				
X-1JQF-I.K	EXIT DEVICE TYPE 1 626	2.00	EA	16.00	32.00	32.00				
X-2JPBIQ	LOCKSET SERIES 1000 GR 2	11.00	EA	95.00			1045.00			
X-2JQF-I.K	EXIT DEVICE TYPE 1 626	2.00	EA	290.00			580.00			
		total			199.20	199.20	1625.00			1824.20
08.71.0		total			199.20	199.20	50454.41			50653.61
08.71										
08	DIVISION VIII	total			2098.34	2098.34	9502.99	5.83		11607.16

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Codenumber	Description	Amount Quant.	Unit	Mh/cost per unit	Man-hours	Amounts Labour	Materials	Equipment	Sub-contr.	Totals
09	DIVISION IX									
09.11										
09.11.0										
X-1KAPWH.E	LATH MET DIAMOND EXPAND	138.88	SY	1.81	251.38	251.38				
X-2KAPWH.E	LATH MET DIAMOND EXPAND	138.88	SY	2.30			319.43			
09.11.0		total			251.38	251.38	319.43			570.81
09.11		total			251.38	251.38	50773.84			51025.22
09.15										
09.15.0										
X-1KBCFC	KEENES CEM PLASTER LIME	138.88	SY	5.73	795.79	795.79				
X-1KBXE	PLASTER SCRATCH COAT FOR	138.88	SY	2.10	291.65	291.65				
X-2KBCFC	KEENES CEM PLASTER LIME	138.88	SY	2.48			344.43			
X-2KBXE	PLASTER SCRATCH COAT FOR	138.88	SY	0.87			120.83			
09.15.0		total			1087.45	1087.45	465.25			1552.70
09.15		total			1087.45	1087.45	51239.10			52326.54
09.31										
09.31.0										
X-1KEMYO	CERAMIC TILE FLOOR	518.93	SF	1.40	726.50	726.50				
X-2KEMYO	CERAMIC TILE FLOOR	518.93	SF	2.01			1043.05			
09.31.0		total			726.50	726.50	1043.05			1769.54
09.31		total			726.50	726.50	52282.14			53008.64
09.50										
09.50.0										
X-1KIJCR.O	ACOUST PANEL FOR EXPOSED	1851.39	SF	0.21	388.79	388.79				
X-1KJEBI.F	SUSP SYS (ACST)CONCEALED	1851.39	SF	0.25	462.85	462.85				
X-2KIJCR.O	ACOUST PANEL FOR EXPOSED	1851.39	SF	0.35			647.99			
X-2KJEBI.F	SUSP SYS (ACST)CONCEALED	1851.39	SF	0.37			685.01			
X-3KIJCR.O	ACOUST PANEL FOR EXPOSED	1851.39	SF	0.04				74.06		
X-3KJEBI.F	SUSP SYS (ACST)CONCEALED	1851.39	SF	0.04				74.06		
09.50.0		total			851.64	851.64	1333.00	148.11		2332.75
09.50		total			851.64	851.64	53615.14	148.11		54614.89
09.65										
09.65.0										

Codenumber	Description	Amount Quant.	Unit	Mh/cost per unit	Man-hours	Amounts Labour	Materials	Equipment	Sub-contr.	Totals
X-1KL1	CLEAN AND WAX FLOORS	1855.59	SF	0.05	92.78	92.78				
X-2KL1	CLEAN AND WAX FLOORS	1855.59	SF	0.10			185.56			
		total			92.78	92.78	185.56			278.34
09.65.0		total			92.78	92.78	53800.70			53893.48
09.65										
09.66										
09.66.1										
X-1KLUR	VINYL COMPOSITION TILE	1855.59	SF	0.27	501.01	501.01				
X-2KLUR	VINYL COMPOSITION TILE	1855.59	SF	0.75			1391.69			
		total			501.01	501.01	1391.69			1892.70
09.66.1		total			501.01	501.01	55192.39			55693.40
09.66										
09.91										
09.91.0										
X-1KU#BB.0	PAINT CEILING STUCCO SF	2041.39	SF	0.03	61.24	61.24				
X-1KU#BB.1	PAINT WALLS CMU	24355.88	SF	0.28	6819.65	6819.65				
X-1KU#E	PAINT DOORS METAL (1)	238.97	SF	0.26	62.13	62.13				
X-2KU#BB.0	PAINT CEILING STUCCO SF	2041.39	SF	0.12			244.97			
X-2KU#BB.1	PAINT WALLS CMU	24355.88	SF	0.20			4871.17			
X-2KU#E	PAINT DOORS METAL (1)	238.97	SF	0.17			40.63			
X-3KU#BB.1	PAINT WALLS CMU	24355.88	SF	0.01				243.56		
X-3KU#E	PAINT DOORS METAL (1)	238.97	SF	0.01				2.39		
		total			6943.02	6943.02	5156.77	245.95		12345.74
09.91.0		total			6943.02	6943.02	60349.16	245.95		67538.13
09.91										
09	DIVISION IX	total			*******	10453.77	9894.75	394.06		20742.58

Codenumber	Description	Amount Quant.	Unit	Mh/cost per unit	Man-hours	Amounts Labour	Materials	Equipment	Sub-contr.	Totals
10	DIVISION X									
10.20										
10.20.1										
X-1LCVIP.J	LOUVERS ALUM. ANODIZED	4.00	SF	4.45	17.80	17.80				
X-1LELII	LOUVERS DOOR FIXED 1" TK	8.00	EA	3.36	26.88	26.88				
X-2LCVIP.J	LOUVERS ALUM. ANODIZED	4.00	SF	19.43			77.72			
X-2LELII	LOUVERS DOOR FIXED 1" TK	8.00	EA	39.33			314.64			
X-3LCVIP.J	LOUVERS ALUM. ANODIZED	4.00	SF	8.25				33.00		
X-3LELII	LOUVERS DOOR FIXED 1" TK	8.00	EA	0.55				4.40		
10.20.1		total			44.68	44.68	392.36	37.40		474.44
10.20		total			44.68	44.68	60741.52	37.40		60823.60
10.40										
10.40.0										
X-1LMZOS	ROOM SIGN 2" HIGH PLAST	1.00	EA	8.48	8.48	8.48				
X-2LMZOS	ROOM SIGN 2" HIGH PLAST	1.00	EA	15.75			15.75			
X-3LMZOS	ROOM SIGN 2" HIGH PLAST	1.00	EA	1.40				1.40		
10.40.0		total			8.48	8.48	15.75	1.40		25.63
10.40		total			8.48	8.48	60757.27	1.40		60767.15
10	DIVISION X	total			53.16	53.16	408.11	38.80		500.07

Codenumber	Description	Amount Quant.	Unit	Mh/cost per unit	Man-hours	Amounts Labour	Materials	Equipment	Sub-contr.	Totals
12	DIVISION XII									
12.51										
12.51.0										
X-1NFY	VENETIAN BLINDS TYPE I	71.11	SF	0.27	19.20	19.20				
X-2NFY	VENETIAN BLINDS TYPE I	71.11	SF	3.78			268.80			
X-3NFY	VENETIAN BLINDS TYPE I	71.11	SF	0.04				2.84		
12.51.0		total			19.20	19.20	268.80	2.84		290.85
12.51		total			19.20	19.20	61026.07	2.84		61048.12
12	DIVISION XII	total			19.20	19.20	268.80	2.84		290.85

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Codenumber	Description	Amount Quant.	Unit	Mh/cost per unit	Man-hours	Amounts Labour	Materials	Equipment	Sub-contr.	Totals
13	DIVISION XIII									
13.40										
13.40.0										
X-1LXXKC.B	LEAD WALL	691.52	SF	4.00	2766.08	2766.08				
X-1LXXKC.C	LEAD DOOR	1.00	SF	6.00	6.00	6.00				
X-1LXXKC.E	LEAD GLASS 12"X12"	1.00	EA	20.00	20.00	20.00				
X-1LXXKC.F	LEAD LOUVER 24"X24"	1.00	EA	80.00	80.00	80.00				
X-2LXXKC.B	LEAD WALL	691.52	SF	16.00			11064.32			
X-2LXXKC.C	LEAD DOOR	1.00	SF	24.00			24.00			
X-2LXXKC.E	LEAD GLASS 24"X24"	1.00	EA	80.00			80.00			
X-2LXXKC.F	LEAD LOUVER 24"X24"	1.00	EA	100.00			100.00			
		total			2872.08	2872.08	11268.32			14140.40
13.40.0		total			2872.08	2872.08	72294.39			75166.47
13.40		total			2872.08	2872.08	11268.32			14140.40
13	DIVISION XIII									

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Codenumber	Description	Amount Quant.	Unit	Mh/cost per unit	Man-hours	Amounts Labour	Materials	Equipment	Sub-contr.	Totals
15	DIVISION XV									
15.06										
15.06.0										
X-1SJ#AB	ROUGH-IN FOR FLOOR MTD	2.00	EA	120.86	241.72	241.72				
X-1SJ#CA	ROUGH-IN FOR WALL MTD	1.00	EA	127.30	127.30	127.30				
X-1SJ#DA	ROUGH-IN FOR SERVICE	3.00	EA	176.76	530.28	530.28				
X-1SJKRA	URINAL CARRIER,SINGLE WA	1.00	EA	23.24	23.24	23.24				
X-2SJ#AB	ROUGH-IN FOR FLOOR MTD	2.00	EA	126.68			253.36			
X-2SJ#CA	ROUGH-IN FOR WALL MTD	1.00	EA	174.40			174.40			
X-2SJ#DA	ROUGH-IN FOR SERVICE	3.00	EA	151.68			455.04			
X-2SJKRA	URINAL CARRIER,SINGLE WA	1.00	EA	42.48			42.48			
15.06.0		total			922.54	922.54	925.28			1847.82
15.06		total			922.54	922.54	73219.67			74142.21
15.44										
15.44.0										
X-1SJB	LAVATORY WALL HUNG 19"	2.00	EA	28.10	56.20	56.20				
X-1SJLK	URINAL, FLUSH VALVE,	1.00	EA	28.10	28.10	28.10				
X-1SJQ	KITCHEN SINK DBL COMP	3.00	EA	21.28	63.84	63.84				
X-1SKWWA	DELVGE SHOWER & EYE WASH	4.00	EA	114.94	459.76	459.76				
X-2SJB	LAVATORY WALL HUNG 19"	2.00	EA	210.72			421.44			
X-2SJLK	URINAL, FLUSH VALVE,	1.00	EA	181.31			181.31			
X-2SJQ	KITCHEN SINK DBL COMP	3.00	EA	176.62			529.86			
X-2SKWWA	DELVGE SHOWER & EYE WASH	4.00	EA	390.00			1560.00			
15.44.0		total			607.90	607.90	2692.61			3300.51
15.44		total			607.90	607.90	75912.28			76520.18
15	DIVISION XV	total			1530.44	1530.44	3617.89			5148.33

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Codenumber	Description	Amount Quant.	Unit	Mh/cost per unit	Man-hours	Amounts Labour	Materials	Equipment	Sub-contr.	Totals
16	DIVISION XVI									
16.51										
16.51.0										
X-1ZA12D	2'X4' STL. SIDED SUR.	12.00	EA	13.98	167.76	167.76				
X-1ZA12E	2'X4' STL. SIDED SUR.	30.00	EA	13.98	419.40	419.40				
X-1ZA40A	INCAN. STEP LIGHT W/POLY	18.00	EA	13.98	251.64	251.64				
X-2ZA12D	2'X4' STL. SIDED SUR.	12.00	EA	71.21			854.52			
X-2ZA12E	2'X4' STL. SIDED SUR.	30.00	EA	56.77			1703.10			
X-2ZA40A	INCAN. STEP LIGHT W/POLY	18.00	EA	82.16			1478.88			
X-2ZA91C	LAMP 40W MED. BIPIN BASE	29.00	EA	4.54			131.66			
		total			838.80	838.80	4168.16			5006.96
16.51.0										
		total			838.80	838.80	80080.44			80919.24
16.51										
		total			838.80	838.80	4168.16			5006.96
16	DIVISION XVI									
	TOTAL OF CHAPTERS				*******	54228.09	80080.44	5103.87		139412.40

Codenumber	Description	Amount Quant.	Unit	Mh/cost per unit	Man-hours	Amounts Labour	Materials	Equipment	Sub-contr.	Totals
	LABOR & MATERIAL COST		$							139412.40
	TAXES & INSURANCE	20.00	%	MUST BE CALCULATED 6% MAT 39% LABOR PTAI						27882.48
	SUB TOTAL L&M T&I COST		$							167294.88
	OVERHEAD	15.00	%							25094.23
	SUB TOTAL		$							192389.12
	PROFIT	10.00	%							19238.91
	SUB TOTAL		$							
	BOND	1.00	%							1923.89
	ESTIMATED CONSTRUCT. BID COST		$							213551.92
	ESCALATION & SPECIAL COND.	10.00	%							21355.19
	SUB TOTAL		$							234907.11
	S & A	10.00	%							23490.71
	CONTIGENCY	10.00	%							23490.71
	C.C.E.		$							281888.53

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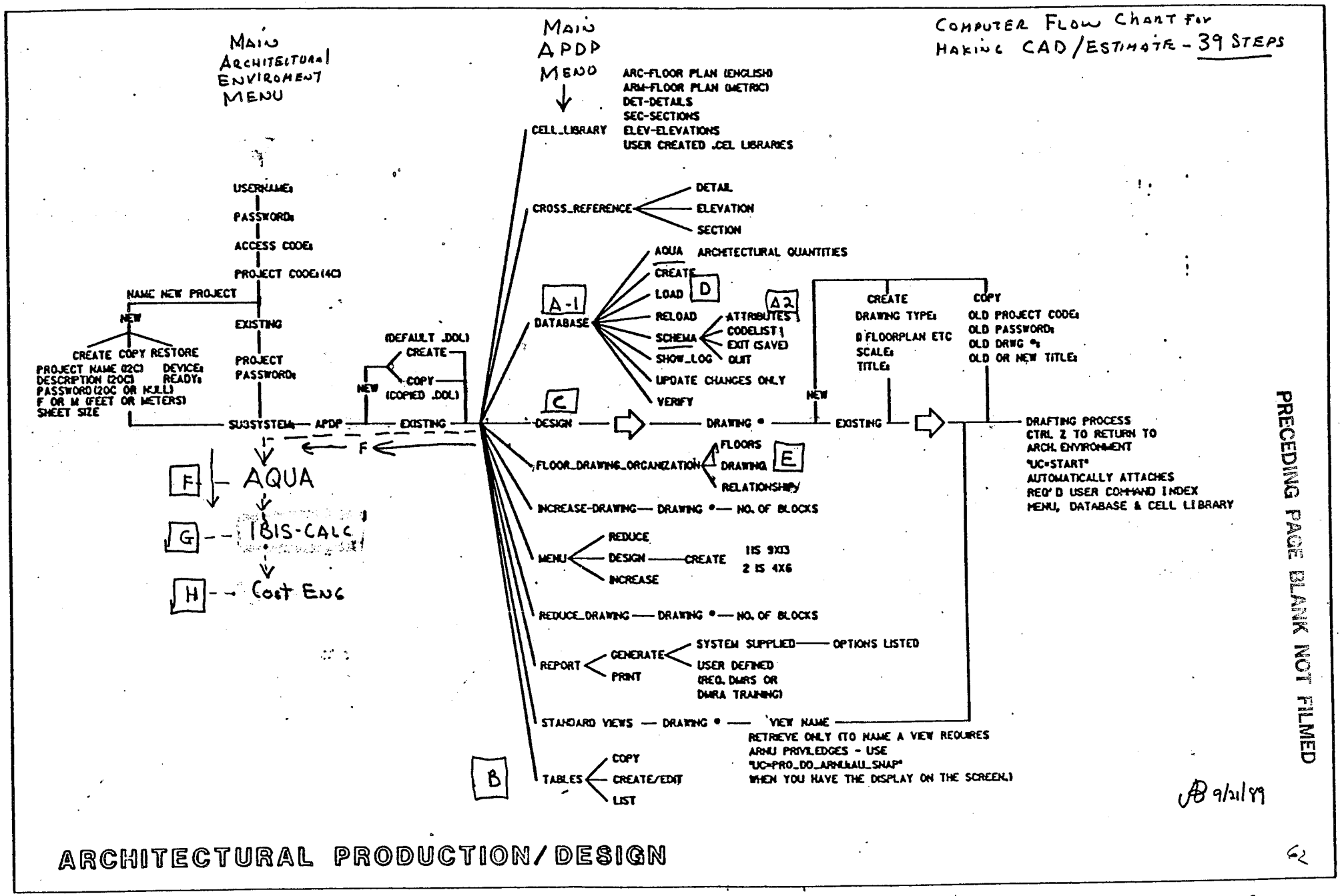

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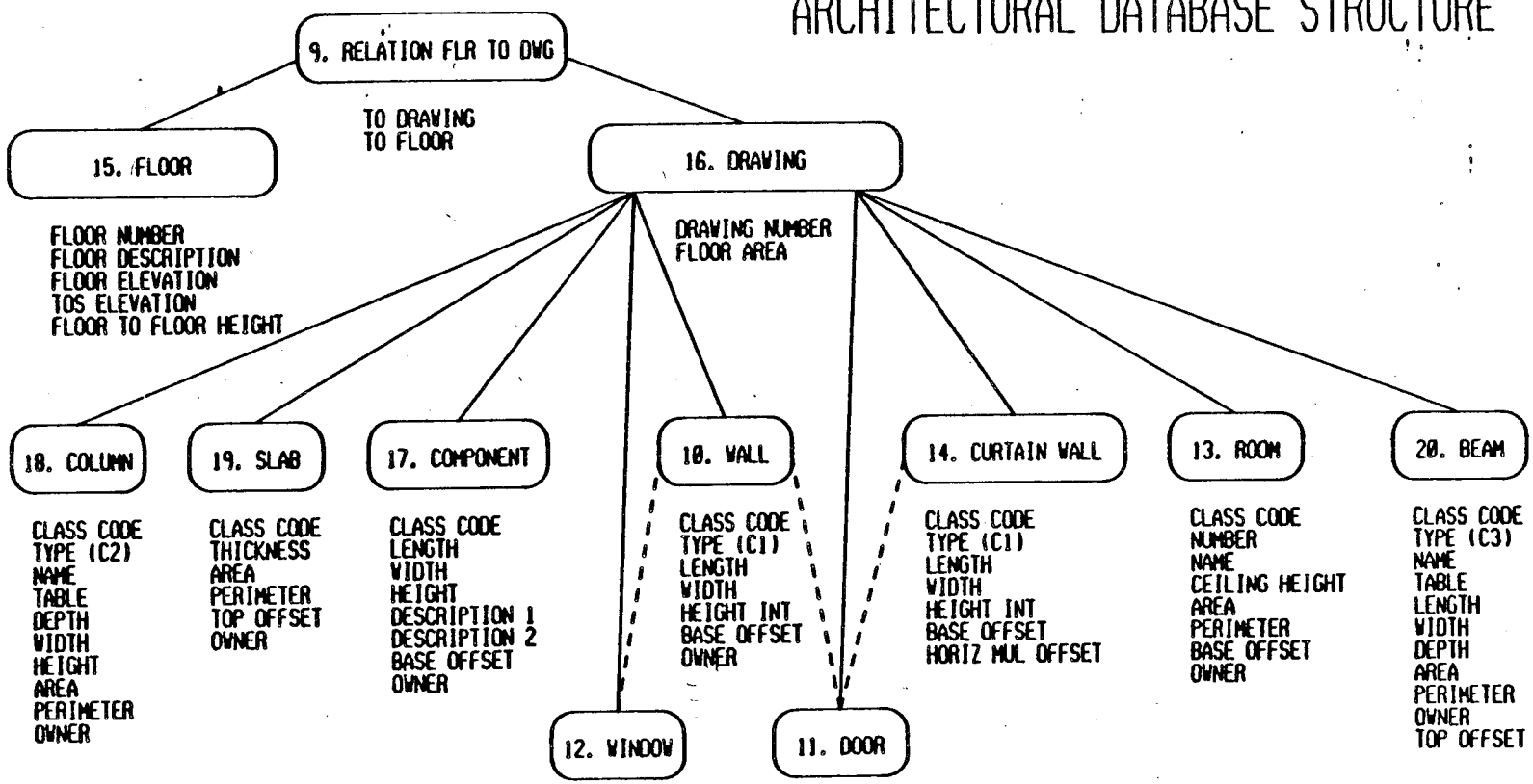
ARCHITECTURAL DATABASE STRUCTURE



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AQUA REFERENCE GUIDE FOR CLASS CODES/CORRELATION TABLE

TYPE	ELEMENT	Q - A	Q - B	Q - C	Q - D	Q - E
A	WALL	GROSS AREA	LENGTH	WIDTH	HEIGHT	---
M	CURTAIN WALL	GROSS AREA	LENGTH	WIDTH	HEIGHT	---
B	COLUMN	VOLUME	LENGTH	WIDTH	HEIGHT	PERIMETER
C	BEAM	VOLUME	LENGTH	WIDTH	HEIGHT	PERIMETER
D	SLAB	GROSS AREA	THICKN	PERIM	---	---
K	SLAB OPENING	--- AREA	THICKN	PERIM	---	---
E/F	DOOR F WINDOW	1	AREA	WIDTH	HEIGHT	SILL HGT
L	COMPONENT	1	LENGTH	WIDTH	AREA	---
G	FLOOR FINISHING	AREA	PERIM	HEIGHT	---	---
H	CEILING FINISH	AREA	PERIM	HEIGHT	---	---
J	WALL FINISHING	GROSS AREA	LENGTH	WIDTH	---	---
N	WALL FIN OPENING	--- AREA	LENGTH	HEIGHT	SILL HGT	TOTAL HGT

ARCHITECTURAL QUANTITIES REPORT FROM AQUA FOR PSCL

LENGTH, WIDTH HEIGHT, AREAS, PERIMETER, EACH.
VARIES WITH EACH CLASS CODE

```
$
$ INTERGRAPH Architectural Quantities report on project :   PLOT
$ Created on : 21-MAR-89 at : 12:45:08 hrs
$
1|4|            |  |1            |  |A1.1  1     |  |           |  |
$|LOC_1 FLOOR_|LOC_2 FLOOR_|NR___|CLASSCODE___|_|AS_NR|AS_CLASSCODE|QUANTITY_A|QUAN_B__|QUAN_C__|QUAN_D__|QUAN_E__|USER_ FLOOR_|
$
$ WALL reporting
$ WALL   372 : invalid quantity A
A|            |            |  84|CONC8"      | | |           |  202.669|  16.000|   0.667|  12.667|        |        |
A|            |            |  84|CONC8"      | | |           |   -3.208|   1.750|   0.667|  -1.833|        |        |
A|            |            | 388|CONC8"      | | |           |  202.628|  15.997|   0.667|  12.667|        |        |
A|            |            | 392|CONC8"      | | |           |  202.667|  16.000|   0.667|  12.667|        |        |
$ WALL   398 : invalid quantity A
A|            |            |  89|MASON8EXT   | | |           |  642.778|  43.333|   0.667|  14.833|        |        |
A|            |            |  89|MASON8EXT   | | |           |  -24.167|   3.333|   0.667|  -7.250|        |        |
A|            |            |  89|MASON8EXT   | | |           |  -40.611|   5.667|   0.667|  -7.167|        |        |
A|            |            |  88|MASON8EXT   | | |           | 1003.722|  67.667|   0.667|  14.833|        |        |
A|            |            |  88|MASON8EXT   | | |           |  -17.778|   3.333|   0.667|  -5.333|        |        |
A|            |            |  88|MASON8EXT   | | |           |  -17.778|   3.333|   0.667|  -5.333|        |        |
A|            |            |  91|MASON8EXT   | | |           |  880.111|  59.333|   0.667|  14.833|        |        |
A|            |            |  91|MASON8EXT   | | |           |  -38.444|   5.333|   0.667|  -7.208|        |        |
A|            |            |  91|MASON8EXT   | | |           |  -38.222|   5.333|   0.667|  -7.167|        |        |
A|            |            |  91|MASON8EXT   | | |           |  -17.778|   3.333|   0.667|  -5.333|        |        |
A|            |            |  91|MASON8EXT   | | |           |  -17.778|   3.333|   0.667|  -5.333|        |        |
A|            |            | 124|MASON8EXT   | | |           |  766.389|  51.667|   0.667|  14.833|        |        |
A|            |            |  58|8"MAS/FOOT  | | |           |  653.625|  48.417|   0.667|  13.500|        |        |
A|            |            |  58|8"MAS/FOOT  | | |           |  -23.889|   3.333|   0.667|  -7.167|        |        |
A|            |            |  58|8"MAS/FOOT  | | |           |  -23.889|   3.333|   0.667|  -7.167|        |        |
A|            |            |  58|8"MAS/FOOT  | | |           |  -23.889|   3.333|   0.667|  -7.167|        |        |
A|            |            | 167|MASON6"     | | |           |  261.775|  20.666|   0.500|  12.667|        |        |
A|            |            | 165|MASON6"     | | |           |  261.775|  20.666|   0.500|  12.667|        |        |
A|            |            | 160|MASON6"     | | |           |  261.775|  20.666|   0.500|  12.667|        |        |
A|            |            | 156|MASON6"     | | |           |  259.664|  20.500|   0.500|  12.667|        |        |
A|            |            | 205|MASON6"     | | |           |   63.336|   5.000|   0.500|  12.667|        |        |
A|            |            | 214|MASON6"     | | |           |   62.275|   4.916|   0.500|  12.667|        |        |
A|            |            | 211|MASON6"     | | |           |   77.066|   6.084|   0.500|  12.667|        |        |
A|            |            | 219|MASON8"     | | |           |   50.667|   4.000|   0.667|  12.667|        |        |
A|            |            | 219|MASON8"     | | |           |   -2.250|   1.500|   0.667|  -1.500|        |        |
A|            |            |  40|MASON8"     | | |           |  202.669|  16.000|   0.667|  12.667|        |        |
A|            |            |  53|MASON8"     | | |           |  202.669|  16.000|   0.667|  12.667|        |        |
A|            |            |  54|MASON8"     | | |           |  202.669|  16.000|   0.667|  12.667|        |        |
A|            |            | 153|MASON8"     | | |           |  208.998|  16.500|   0.667|  12.667|        |        |
A|            |            | 170|8SOUNDBLOX  | | |           |  174.167|  17.417|   0.667|  10.000|        |        |
A|            |            | 170|8SOUNDBLOX  | | |           |  -20.306|   2.833|   0.667|  -7.167|        |        |
A|            |            | 184|SOUNDBLOX   | | |           |   53.393|   5.339|   0.333|  10.000|        |        |
A|            |            | 186|SOUNDBLOX   | | |           |   18.333|   1.833|   0.333|  10.000|        |        |
A|            |            | 402|8"MAS/FOOT  | | |           |  913.500|  67.667|   0.667|  13.500|        |        |
A|            |            | 402|8"MAS/FOOT  | | |           |  -21.000|   3.000|   0.667|  -7.000|        |        |
A|            |            | 402|8"MAS/FOOT  | | |           |  -21.000|   3.000|   0.667|  -7.000|        |        |
A|            |            | 402|8"MAS/FOOT  | | |           |  -21.000|   3.000|   0.667|  -7.000|        |        |
A|            |            | 402|8"MAS/FOOT  | | |           |  -21.000|   3.000|   0.667|  -7.000|        |        |
A|            |            | 402|8"MAS/FOOT  | | |           |  -21.000|   3.000|   0.667|  -7.000|        |        |
A|            |            | 402|8"MAS/FOOT  | | |           |  -21.000|   3.000|   0.667|  -7.000|        |        |
A|            |            | 402|8"MAS/FOOT  | | |           |  -21.000|   3.000|   0.667|  -7.000|        |        |
A|            |            | 201|SOUNDBLOX   | | |           |   11.667|   1.167|   0.333|  10.000|        |        |
A|            |            |  85|CONC8"      | | |           |  204.768|  16.166|   0.667|  12.667|        |        |
A|            |            |  85|CONC8"      | | |           |  -45.260|   5.500|   0.667|  -8.229|        |        |
$
$ CURTAIN WALL reporting
$ CURTAIN WALL            : not located
```

Fig 4

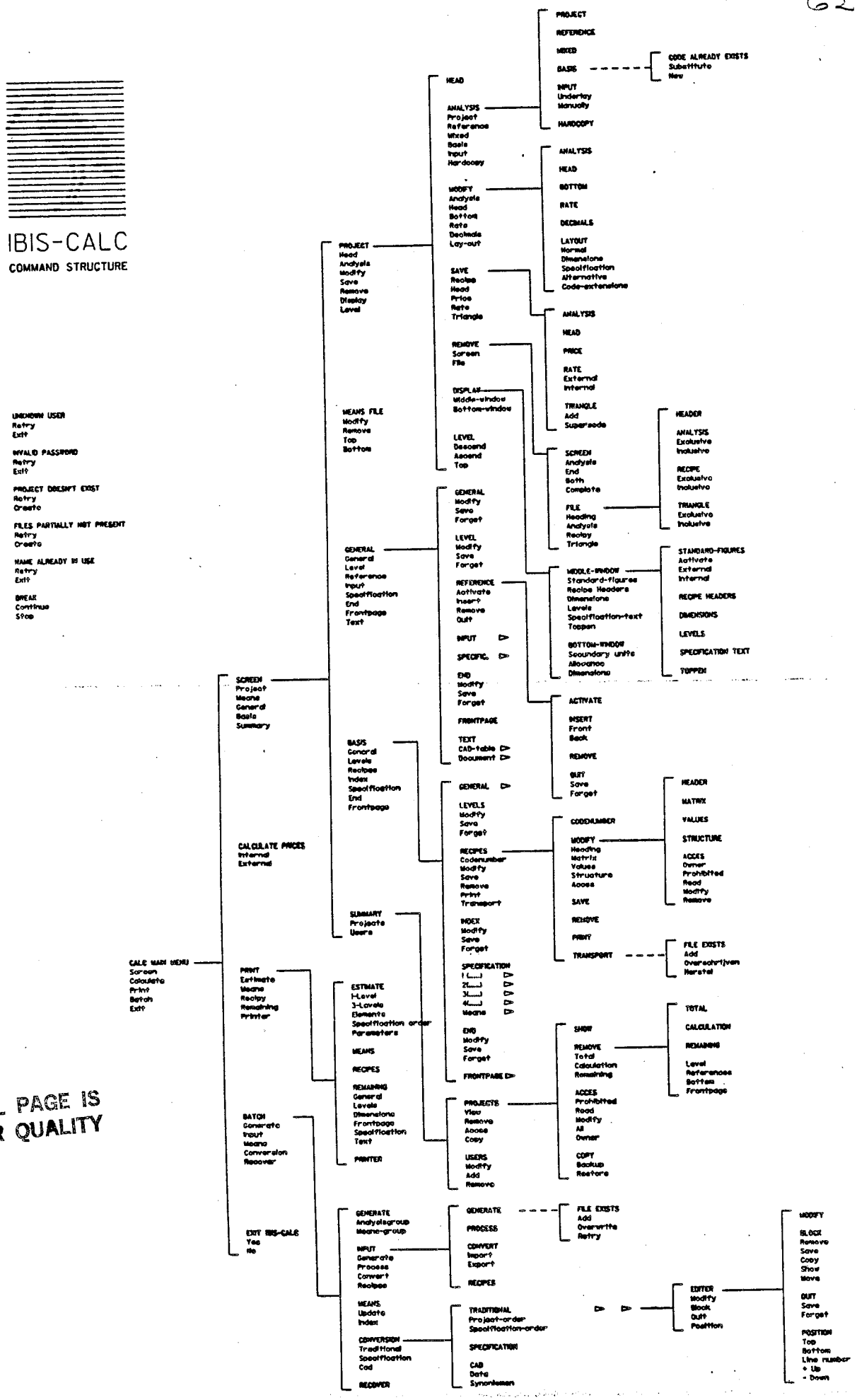
CORRELATION TABLE

* TIMES
/ DEVIDE
\- MINUS
\+ ADD

Class Code		IBISCALC Code*	Quantity Calculation
A8"MAS/FOOT		1 V-FFJJ .	A '8" MASONARY WALLS
A8"MAS/FOOT		7 V-BIGEB .	B*2.33*2.33/27' EXCAVATION
A8"MAS/FOOT		8 V-BGCBL .	B*1.33*.833/27*-1'BUILDING
A8"MAS/FOOT		9 V-BGCBL .	' FILL REDUCTION FOR FOOTINGS
ACONC8"		1 V-EKYMN .	A/27*1.05 '8" CONCRETE WALL
ACONC8"		2 V-EBYRA .	A*2 'FORMWORK WALL
ACONC8"		3 V-EFAA .	(A+B)*.688*1.1/2000'#4REB-V
BA		1 V-EKBMN .	A/27*1.05' CONCRETE COLUMNS
BA		2 V-EBBRC .	B*2*D 'FORMWORK COLUMNS
BA		3 V-EFAA .	4*D*1.1*1.04/2000'#5REBAR
C12J2		1 V-GFS .	B*4.5/2000' BAR JOIST
CA		1 V-EKKMG .	A*1.05/27'CONCRETE BEAM PLACE
CA		2 V-EBKRA .	B*D*2 ' BEAM FORMWORK
CA		3 V-EFAA .	B*4*1.04*1.1/2000'#5 REBAR
DSLAB		0 V-IQDIE .	A/100 'ROOFING
E3X7-1		0 V-JKSBE .	A 'AL DOOR SINGLE
E5-6X7-11	KSC Spec	0 V-LXXKCC.	A ' LEAD DOOR
E5-6X7-11	" "	1 V-LXXKCF.	A ' LEAD LOUVER
E5-6X7-11	" "	2 V-LXXKCE.	A ' LEAD GLASS
EPR2-6X7		1 V-JKSBK .	A' ALUM DOOR-PAIR
FWIN		1 V-JLHDIC.	A 'WINDOW
GVINYL		1 V-KLUR .	A 'VINYL COMPOSTION FINISH
HACOUST TILE		1 V-KJEBIF.	A 'ACOUSTICAL CEILING GRID
HACOUST TILE		2 V-KIJCRO.	A 'ACOUSTICAL TILE
HPLASTER		1 V-KBCFC .	A/9 'PLASTER
JLEAD		1 V-LXXKCB.	A 'LEAD WALL LINING
JMASONARY		1 V-KU#BB1.	A*2'PAINT WALL-2COATS
LF9		1 V-ZA91C .	A '40 W LAMP
LFA340		1 V-ZA12D .	A 'FLOURESCENT 3 LAMP
LSHOWER		1 V-SKWWA .	A 'SHOWER
LTOILET		1 V-SJB .	A 'TOILET
LURINAL		1 V-SJLK .	A 'URINAL
NLEAD		1 V-LXXKCB.	A 'LEAD WALL LINING
NPLASTER		1 V-KU#BB1.	A*2'PAINT PLASTER -2COATS

* A navy database code converted into IBISCALC.

IBIS-CALC
COMMAND STRUCTURE



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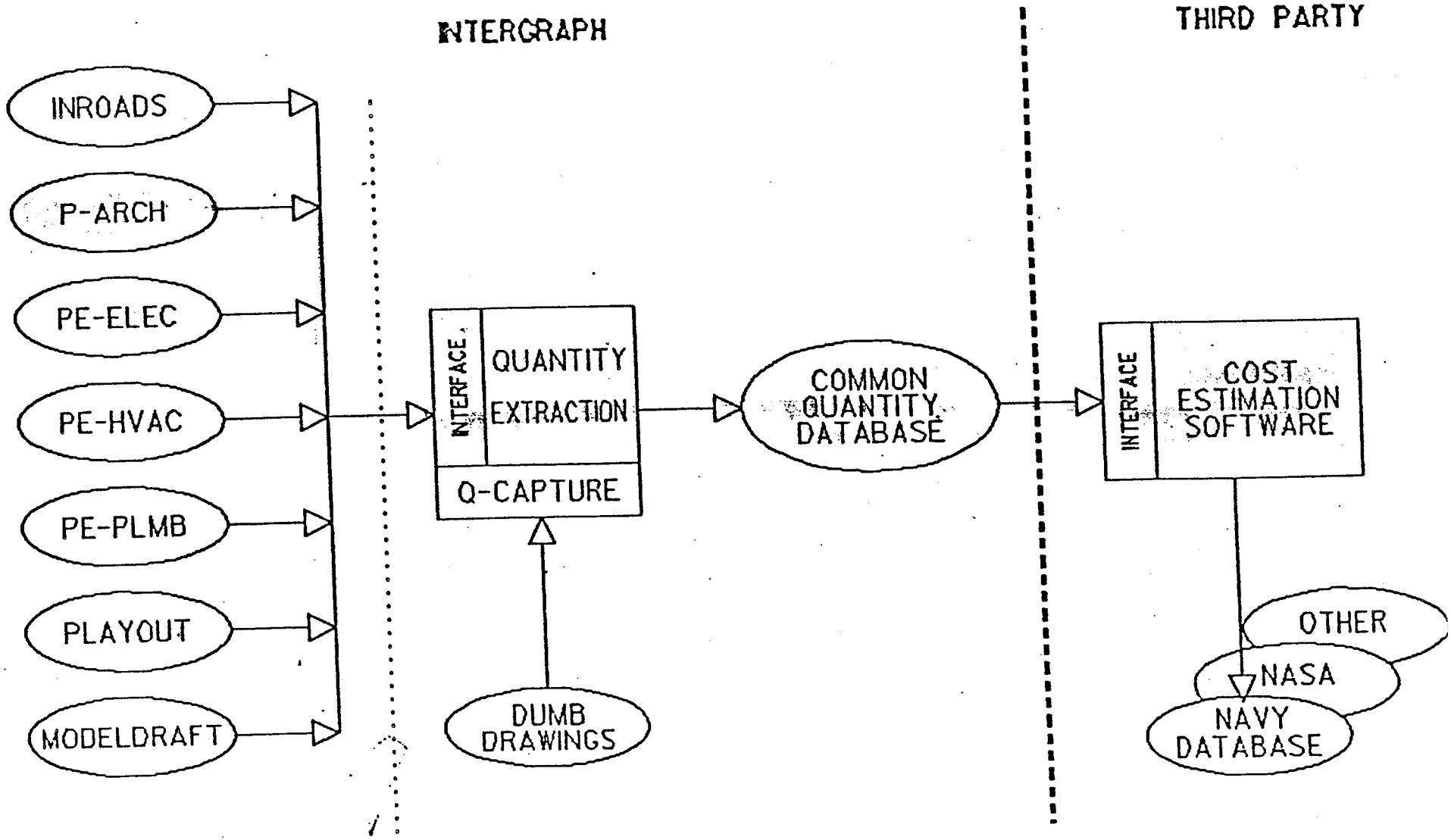
SAMPLE NAVY DATA BASE

Navy Cost/SPEC Code	Unit	SPEC Code	Sub-SPEC Code	Cost Date	Material Price	Labor Unit Price	Equipment Unit Price	Description		
EK@MA	SF	03300	03300	12/28/88	1.2993	0.49		FLOOR SLAB 4" COMPLETE	INCL FORMS WWM CURING	FINISHING PO
EK@MB	SF	03300	03300	12/28/88	1.4681	0.50		FLOOR SLAB 5" COMPLETE	INCL FORMS WWM CURING	FINISHING PO
EK@MC	SF	03300	03300	12/28/88	1.6228	0.52		FLOOR SLAB 6" COMPLETE	INCL FORMS WWM CURING	FINISHING PO
EKB		03300		/ /	0.0000	0.00	0.00	PLACING CONCRETE AND	MASONRY GROUT	
EKB-		03300		/ /	0.0000	0.00	0.00	PLACE CONC 2500 OR 3000#	COLS, ELEV. SLAB, FTG,	PILE CAP, GI
EKBMG	CY	03300	03301	12/28/88	52.7300	0.15	0.15	PLACE CONC 2500 OR 3000#	COLUMNS BY CRANE	
EKBMN	CY	03300	03301	12/28/88	52.7300	0.13	0.13	PLACE CONC 2500 OR 3000#	COLUMNS BY PUMP	
EKFMG	CY	03300	03301	12/28/88	52.7300	0.08	0.08	PLACE CONC 2500 OR 3000#	ELEVATED SLAB BY CRANE	
EKFMN	CY	03300	03301	12/28/88	52.7300	0.07	0.07	PLACE CONC 2500 OR 3000#	ELEVATED SLAB BY PUMP	
EKIMD	CY	03300	03301	12/28/88	52.7300	0.07	0.07	PLACE CONC 2500 OR 3000#	FTG OR PILE CAP BY CHUTE	
EKIMN	CY	03300	03301	12/28/88	52.7300	0.08	0.08	PLACE CONC 2500 OR 3000#	FTG OR PILE CAP BY PUMP	
EKIMP	CY	03300	03301	12/28/88	52.7300	0.08	0.08	PLACE CONC 2500 OR 3000#	FTG OR PILE CAP BY HAND	BUGGY
EKKMG	CY	03300	03301	12/28/88	52.7300	0.15	0.15	PLACE CONC 2500 OR 3000#	GIRDERS & BEAMS BY CRANE	
EKKMN	CY	03300	03301	12/28/88	52.7300	0.16	0.16	PLACE CONC 2500 OR 3000#	GIRDERS & BEAMS BY PUMP	
EKN		03300		/ /	0.0000	0.00	0.00	PLACE CONC 2500 OR 3000#	SLAB ON GRADE, STAIRS,	TOPPING
EKNM	CY	03300	03301	12/28/88	52.7300	0.00	0.00	CONCRETE 2500 OR 3000#	MATERIAL ONLY	
EKNN	CY	03300	03301	12/29/88	5.0903	0.00	0.00	CONCRETE 2500 OR 3000#	MATERIAL ONLY ADD FOR	HIGH EARLY S
EKNU	BAG	03300	03301	12/28/88	4.6700	0.00	0.00	CEMENT TYPE II MATERIAL	ONLY (TRUCKLOAD LOTS)	
EKSMD	CY	03300	03301	12/28/88	52.7300	0.06	0.06	PLACE CONC 2500 OR 3000#	SLAB ON GRADE BY CHUTE	
EKSMG	CY	03300	03301	12/28/88	52.7300	0.06	0.06	PLACE CONC 2500 OR 3000#	SLAB ON GRADE BY CRANE	
EKSMN	CY	03300	03301	12/28/88	52.7300	0.06	0.06	PLACE CONC 2500 OR 3000#	SLAB ON GRADE BY PUMP	
EKSMP	CY	03300	03301	12/28/88	52.7300	0.07	0.07	PLACE CONC 2500 OR 3000#	SLAB ON GRADE BY HAND	BUGGY
EKUMD	CY	03300	03301	12/28/88	52.7300	0.09	0.09	PLACE CONC 2500 OR 3000#	STAIRS BY CHUTE	
EKUMG	CY	03300	03301	12/28/88	52.7300	0.09	0.09	PLACE CONC 2500 OR 3000#	STAIRS BY CRANE	
EKUMN	CY	03300	03301	12/28/88	52.7300	0.08	0.08	PLACE CONC 2500 OR 3000#	STAIRS BY PUMP	
EKUMP	CY	03300	03301	12/28/88	52.7300	0.10	0.00	PLACE CONC 2500 OR 3000#	STAIRS BY HAND BUGGY	
EKVMG	CY	03300	03301	12/28/88	52.7300	0.08	0.08	PLACE CONC 2500 OR 3000#	TOPPING BY CRANE	
EKVMN	CY	03300	03301	12/28/88	52.7300	0.07	0.07	PLACE CONC 2500 OR 3000#	TOPPING BY PUMP	
EKW		03300		/ /	0.0000	0.00	0.00	PLACE CONC 2500 OR 3000#	WALLS	
EKWMD	CY	03300	03301	12/28/88	52.7300	0.05	0.05	PLACE CONC 2500 OR 3000#	WALLS & GRADE BEAMS	TO 4' BY CHU
EKWMN	CY	03300	03301	12/28/88	52.7300	0.06	0.06	PLACE CONC 2500 OR 3000#	WALLS & GRADE BEAMS	TO 4' BY PUM
EKWMP	CY	03300	03301	12/28/88	52.7300	0.07	0.07	PLACE CONC 2500 OR 3000#	WALLS & GRADE BEAMS	TO 4' BY HAN
EKXMG	CY	03300	03301	12/28/88	52.7300	0.10	0.10	PLACE CONC 2500 OR 3000#	WALLS TO 8' BY CRANE	
EKXMN	CY	03300	03301	12/28/88	52.7300	0.09	0.09	PLACE CONC 2500 OR 3000#	WALLS TO 8' BY PUMP	
EKYMG	CY	03300	03301	12/28/88	52.7300	0.13	0.13	PLACE CONC 2500 OR 3000#	WALLS TO 16' BY CRANE	
EKYMN	CY	03300	03301	12/28/88	52.7300	0.12	0.12	PLACE CONC 2500 OR 3000#	WALLS TO 16' BY PUMP	
EKZMG	CY	03300	03301	12/28/88	52.7300	0.14	0.14	PLACE CONC 2500 OR 3000#	WALLS OVER 16' BY CRANE	
EKZMN	CY	03300	03301	12/28/88	52.7300	0.13	0.13	PLACE CONC 2500 OR 3000#	WALLS OVER 16' BY PUMP	

WORKSTATION PRODUCTS

PRODUCT	DESCRIPTION	APPLICATION AVAILABLE	QUANTITY EXTRACTION AVAILABLE
P ARCH	FLOOR PLANS - 2D DATABASE	NOW	NONE
	FLOOR PLANS - 3D DATABASE	4Q 89	1Q 90
	REFLECTED CEILING - 2D DATABASE	NOW	NONE
	REFLECTED CEILING - 3D DATABASE	4Q 89	1Q 90
	SECTIONS/ELEVATIONS - 3D DATABASE	4Q 89	1Q 90
IN-ROADS	CIVIL SITE - 3D DATABASE	NOW	1Q 90
P-LAYOUT	SPACE PLANNING - 2D DATABASE	NOW	NONE
	SPACE PLANNING - 3D DATABASE	4Q 89	1Q 90
MODEL DRAFT	STRUCTURAL MODELING - 3D DATABASE	NOW	1Q 90
PE HVAC	HVAC - 3D DATABASE	4Q 89	2Q 90
PE ELEC	ELECTRICAL WIRING - 3D DATABASE	4Q 89	2Q 90
PE PLUMB	PLUMBING/PIPING - 3D DATABASE	1Q 90	2Q 90
Q CAPTURE	QUANTITY CAPTURE FROM DUMB DRAWING	2Q 90	2Q 90

COST ESTIMATION FLOW DIAGRAM



21 STEPS FOR MAKING BID ESTIMATES

GOVERNMENT	GENERAL CONTRACTOR
1. Get the bid package from owner/A&E/government	Same
2. *Read plans	Same
3. *Read specs	Same
4. *Make check list from specs and plans	Same
5. *Tell civil, mechanical, electrical engineers you need estimates on their portions- ASAP	Different
6. *Make site visit	Same
7. *Make take-off on your portion	Same
8. *Do math extensions	Same
9. *Price out labor and materials	Similar
10. *Get quotes on own items	Similar
11. *Mark-up own - tax, insurance, O.H., profit, bonds	Similar
12. *Check estimate	Same
13. *Add in civil, mechanical and electrical estimates, etc.	Similar
14. *Summarize mark-up. Do other summaries, etc.	Similar
15. **Review overall estimate	Similar
16. **Apply bid/market strategy - special conditions, joint occupancy, down time	Different
17. **Final mark-up	Similar
18. **Adjust for late vendor quotes and amendments	Similar
19. **Final check	Different (get bid bond)
20. Approve bid estimate and get signatures	Same
21. Get bid in on time	Same

*Most government estimates are prepared during the preliminary design phase and finalized during the bid period; sometimes by A&E (architectural and engineering firm), sometimes by consultants or support contractors.

**Sometimes also by A&E firms for government agency.

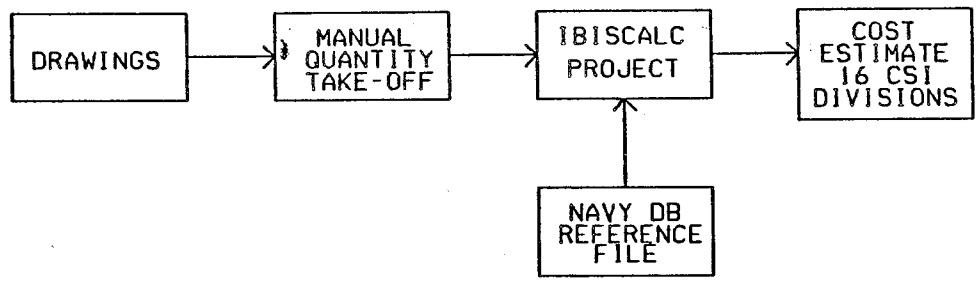
COST ESTIMATION SYSTEM

CREATE/MODIFY KSC COST ITEMS

Item Code	EKBMG
Unit of Measure	CY
Spec Code	3300
Sub Spec Code	3301
Date Revised	01/07/89
Material Costs	57.5000
Labor Costs	12.9793
Equipment Costs	21.4442
Description	PLACE CONC 2500 OR 3000# COLUMNS BY CRANE

BASED ON NAVY DATA BASEN

STANDALONE



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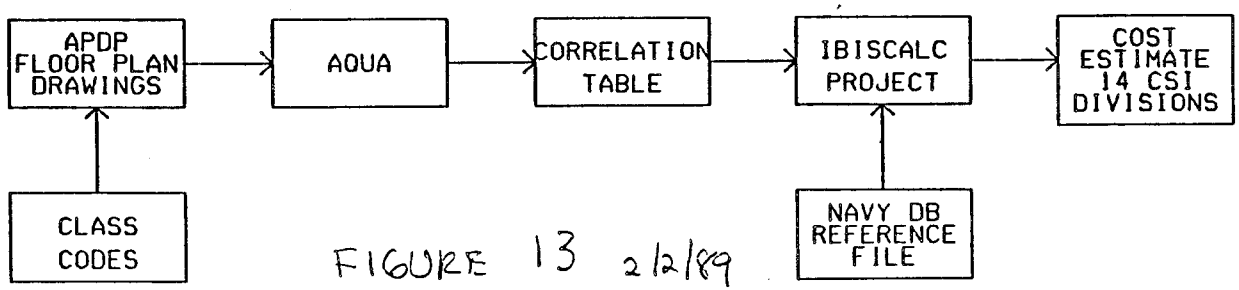

FIGURE 13 2/2/89

<u>ACCOMPLISHMENTS</u> - THE ESTIMATES WERE DELIVERED ON 11/17/88 AND 3/89 AND PROVED THAT:

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 DETAIL DATABASE MANAGEMENT SYSTEM REQUIRING COST/ITEM FOR EACH AND EVERY ITEM IN A BUILDING, THUS SAVING 10-50% OF DATA LINE ITEMS IN CAD DRAWINGS QUANTITIES.

ACCOMPLISHMENTS (CONTINUED)

3. THIS EFFORT IS FORCING THE DEVELOPMENT OF THE NEXT GENERATION WORKSTATION CONCEPT WITH INTEGRATED CIVIL, STRUCT, ARCHITECT, MECH AND ELECT 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.

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Joseph A. Brown, CCE, has prepared and reviewed construction cost estimates amounting to over $7 billion. He is a graduate of the University of Florida with a Bachelor of Building Construction, BBC (1959). He has been a consultant to commercial, industrial and residential complex interests in several states including work for the Walt Disney World Contemporary Resort Hotel. He has received AACE's Fellow Award and the prestigious astronauts "Silver Snoopy" for professional excellence and his contributions to the success of the manned space efforts. He has successfully prepared estimates for the U.S. Army Corps of Engineers and Air Force facilities. Mr. Brown has written an estimating workbook and is writing a text book, "Estimation of Construction Cost and Cost Engineering." He is currently employed by NASA at Kennedy Space Center, where he specializes in construction cost engineering.

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Professional Society Affiliations:
AACE Member Yes X No ____
Other: ~~Same~~ SAME.

Publications, Papers & Patents:
20 Technical Papers on
Cost Engineering, etc.

Honors Received:
AACE "Fellow"
"Silver Snoopy"
DE - Outstanding Performance
Awards, 1987-88

VISUAL AIDS REQUIREMENTS

____ **None**

X **35-mm Projector**

X **Overhead Projector**

X **Other (specify)** Movie Screen, Blackboard or Chart Board, Lapel Mike

NOTE: AACE cannot provide computer equipment and/or data projectors.

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