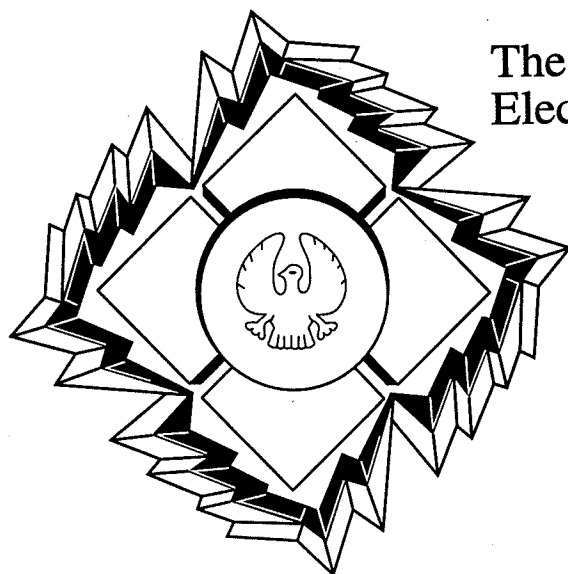


THE ACADEMY OF ELECTRICAL CONTRACTING

**Paper Presented by
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**Job Completion Analysis
May 1994**

JOB COMPLETION ANALYSIS



The Academy of
Electrical Contracting

JCA

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MAY 23, 1994

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WORK SMARTER - NOT HARDER!

Yeah! Yeah! Yeah! Easy to say, **HARD** to do! As Booker T. Washington said, "An ounce of application is worth a ton of abstraction." Saying that we should "work smarter" is a "ton of abstraction" and it doesn't mean a thing until someone finds a way to make it happen.

MEASURE UP!

WE CAN'T KNOW
WHERE WE ARE
UNTIL WE HAVE
LEARNED HOW TO
MEASURE OUR
PROGRESS.

What does it mean to "work smarter?" Perhaps it means **taking the time to measure the progress in completing a job so that the most cost effective method of completing the job can be identified and utilized and so that factors that increase cost can be identified and minimized.**

Some exceptionally gifted individuals have an ability to observe a job and intuitively work smarter. But, for most of us, the goal of "working smarter - not harder" can only be accomplished through a systematic, deliberate, organized effort. Job Completion Analysis is such an effort.

CONSTRUCTION JOB CHALLENGES

BUSINESS IS NOT
GOOD....

IT'S GREAT!

In the construction business, management faces the increasingly difficult task of increasing profits in an ever more competitive marketplace.

The focus of the effort to impact profitability ultimately concentrates on the labor part of the job. The greatest fluctuations from the estimate occur here and provide the greatest opportunity for controlling cost and increasing profit.

The typical contractor's backlog of work consists of a number of individual contracts that vary significantly in content, scope and duration.

LARGE JOBS
PRESENT THE
GREATEST
OPPORTUNITY
TO INCREASE
PROFITABILITY.

It is on medium and large jobs that the opportunity to control costs and increase profitability is greatest. Because of their scope and duration, there are more things that can go wrong and more problems that can degrade performance. It is frequently difficult to determine who is responsible when hours are lost as compared to the estimate.

On the larger jobs, the most important responsibility of job supervision is **"to manage and measure"**. Unfortunately, most supervisors have had little formal training in supervision and most contractors are unable to provide information required to measure job progress.

SMALL JOBS
SEEM TO TAKE
CARE OF
THEMSELVES.

On a small job, the prime responsibility of a foreman is more **"to do"** than it is **"to manage"**. One or two supervisors and a small number of tradesmen clearly have responsibility for performance on small jobs. Since most foremen were promoted because of their ability to perform, small jobs tend to be less troublesome and more consistent than large jobs.

OBJECTIVES OF JOB COMPLETION ANALYSIS

The objective of **JOB COMPLETION ANALYSIS** is to make it possible for Supervision on a large or medium size job to improve job profitability by **working smarter - not harder**. Job Completion Analysis (JCA) achieves this objective by the following means:

PEOPLE DO WHAT
YOU INSPECT...
NOT WHAT YOU
EXPECT

- [1] **Organize job data to facilitate measurement.**
- [2] **Measure and evaluate job progress.**
- [3] **Provide timely feedback on progress.**

UNIT OF MEASUREMENT

The man hour was selected as the unit of measurement in determining job progress because:

[1] Man hours are recorded on the job site for payroll Purposes and tradesmen understand the concept.

[2] Man hours are generally the unit of measure used by most estimating systems in the Electrical Industry.

USE ONLY
WHOLE MAN
HOURS WITH
JCA TO SIMPLIFY
BOOKKEEPING

Since the challenge to field supervision is to install the electrical work for less than the estimated number of man hours, the JCA unit of measurement for field performance was defined as the **HOURS SAVED** when the hours actually used are compared with the corresponding estimated hours.

To determine the number of **HOURS SAVED** or **HOURS LOST**, It is necessary to be able to accurately determine the job's percentage of completion:

$$HS = HE * OPC * 100 - HUTD$$

where HS = **HOURS SAVED**,

HE = Hours estimated,

OPC = Observed percent completion,

HUTD = Hours Used To Date.

The number of **HOURS SAVED** or **HOURS LOST** in each JCA CODE makes excellent feedback to job supervision so that problems can be identified and corrections initiated.

Assuming productivity does not change dramatically and assuming the estimate has no significant errors, it is also possible to predict the total labor hours that will be expended at the conclusion of the job:

$$PFH = LHTD / OPC * 100$$

where PFH = Projected Final Hours,
LHTD = Labor Hours To Date,
OPC = Observed Percent Completion.

Comparing the values of Predicted Final Labor Hours as the job progresses can provide valuable insight on the ultimate profitability of the job!

WHAT ACCURACY IS REQUIRED FOR JCA ?

JCA IS DESIGNED
TO CALCULATE
JOB COMPLETION
TO WITHIN 2 %

Any effort to measure JOB COMPLETION must rely on data and estimates that are far from perfect. It is important to understand how much error can be tolerated in the calculated value of the percentage of job completion and still have useful information.

The JCA is designed and organized so that with maximum observation error the contractor would sacrifice his profit on the job while still covering his overhead, general and administrative expenses.

Historically, NECA contractors have averaged 3 to 4 percent profit before taxes. Assuming that all our profit exposure is concentrated on the labor of the job and assuming that the labor cost is approximately 50% of the total cost, a six percent overrun on labor could be tolerated before the profit was wiped out.

To provide some margin for safety, a range of 4 percent (plus or minus 2%) was selected as the desired limits of error in prediction of job completion with the JCA.

THE LOGIC BEHIND JCA CODES

JCA uses five techniques to improve the accuracy of measurement:

KEEP THE
NUMBER OF JCA
CODES TO A
MANAGEABLE
NUMBER...
MORE THAN 20,
LESS THAN 50.

[1] The job is divided into 20 TO 50 easily identifiable component parts, each with a unique JCA CODE name. Smaller more easily visualized JCA CODES make it possible to estimate completion percentages more accurately. Sub dividing a job further into many more parts will theoretically increase accuracy. Practically, however, as the number of component parts is increased, it becomes more and more difficult to identify and measure each CODE accurately and process the volume of data.

POSITIVE AND
NEGATIVE ERRORS
MAY CANCEL
EACH OTHER OUT
IN SUMMATION.

[2] The completion of each JCA CODE is evaluated individually and then summed mathematically for the whole job. **Errors of evaluation may then fall on either side of the true value and cancel out during summation.**

JCA CODES ARE
TIME PHASED
WITH ONLY A
SMALL NUMBER
OF CODES ACTIVE
AT ANY GIVEN
TIME

[3] JCA CODES are so designed that they are **TIME PHASED** and at any given point in the job, only a small number of CODES are actually being worked on. There is no OBSERVATION ERROR on the remaining codes since they are either NOT STARTED (completion = 0%) or DONE (completion = 100%). In this way, errors of observation are confined to a small part of the total job thus improving the overall accuracy.

JCA CODES ARE
IDENTIFIED BOTH
BY AREA AND
ACTIVITY FOR
EASY FIELD
IDENTIFICATION.

[4] JCA CODES are AREA & ACTIVITY divisions of the work to be done. Consequently, labor hours tend to be accurately assigned to their correct CODE. Journeymen tend to work on the same CODE all day thereby reducing the number of decisions that have to be made in assigning labor hours to the CODE.

[5] As work progresses, the drawings are colored in to show what material has been installed. The determination of the Percent of Completion becomes a VISUAL ASSESSMENT of the amount of colored materials. This determination is made by supervisors who typically have excellent visualization and comparative skills.

There is a direct relationship between the percentage of a job that is under active construction and the amount of error that can be tolerated and still produce an overall 2% error range on the job. The following table summarizes that relationship:

THE SMALLER THE PORTION OF THE JOB CURRENTLY UNDER ACTIVE CONSTRUCTION, THE GREATER THE ALLOWABLE ERROR OF OBSERVATION.

Percent of Job under Construction	Allowable Error in Observed Completion
100%	2.0%
80%	2.5%
60%	3.3%
50%	4.0%
40%	5.0%
30%	6.7%
25%	8.0%
20%	10.0%
15%	13.3%
10%	20.0%

JCA CAN ACCURATELY PREDICT JOB COMPLETION EVEN WHEN ESTIMATES OF JCA CODE COMPLETION ARE ACCURATE TO ONLY PLUS OR MINUS 10%

These values assume that errors of observation are worst case (consistently on the same side of the true value) and do not cancel out.

Experience has shown that it is reasonable to expect that Field Supervision can estimate completion on JCA codes to within $\pm 10\%$. (see appendix D) If only 20% of the job is under construction at any time, JCA will achieve 2% overall accuracy.

REQUIREMENTS FOR JCA CODES

The manner in which the estimated hours of a job are divided into identifiable parts is critical to the success of accurately estimating job completion. Even though jobs differ, JCA will give satisfactory results if the CODES selected conform to the following requirements:

KEEP JCA CODES
VERY EASY TO
UNDERSTAND

[1] The breakdown of the labor hours of the estimate should be into **INSTALLATION RELATED ACTIVITIES** that are easily identifiable by field personnel.

USE THE SAME
CODES FROM
JOB TO JOB
IF POSSIBLE.

[2] Second, CODES should be **semi-standardized** from job to job so that the estimator can minimize the effort required to break the estimate into coded labor hours and simplify the task of keeping the estimate and coded labor updated.

AVOID CODES
WHICH ARE OF
LONG DURATION.

[3] CODES should be "**TIME-PHASED**" so that *at any specific time only a small percentage of the total CODES are being worked on*. And, when work is started on a code, it should progress quickly to completion. Codes that stretch out over a long period of time should be avoided.

JUST 20 CODES
CAN COVER THE
TYPICAL JOB...

[4] To *reduce the impact of an observation error* on a single CODE, the job should be divided into a *minimum of twenty CODES, no one of which is greater than 10% of the total*. The maximum number of CODES should be limited to about fifty and no CODE should be much smaller than 1% of the total.

EXAMINING NECA LABOR CODES

NECA LABOR
CODES ARE
GREAT FOR
ESTIMATING,
BUT...

LEAVE
SOMETHING
TO BE DESIRED
FOR JCA.

In their publication "*Labor Cost Analysis for Electrical Contractors*", which is now out of print, NECA recommended work codes which reflected the way the manual of estimating units was organized:

- (A) Branch Circuit Wiring
- (B) Service & Feeder Wiring
- (C) Panel Board & Switchboard Equipment
- (D) Special Raceway Systems
- (E) Schedule Material (Wiring Devices)
- (F) Lighting Fixtures and Lamps
- (G) Communication and Signal Systems
- (H) Special Power Equipment
- (I) Special Incidental Equipment and Appliances
- (J) Underground Ducts, Trenching and Concrete
- (K) Grounding Systems
- (L) Overhead Systems
- (M) Motors and Controls

The current NECA Manual of Estimating Units does not provide a recommendation for labor codes be used in recording labor hours expended at job site. While the older practice of selecting codes that corresponded to the estimating units was logical, these work codes do not conform well with the suggested requirements for JCA CODES.

A JCA CODE
SHOULD BE
OBVIOUS...
WITHOUT
LOOKING AT
THE DRAWINGS.

For example; a journeyman roughing in a deck for a concrete slab may be installing both branch circuit and service and feeder conduits at the same time. There is also an overlap in these two codes in the 1-1/4" through 2" raceway sizes and the lack of a clear demarcation point between these CODES is inconsistent with the first requirement.

More than 50% of the labor on a typical job is covered by branch circuit wiring and service and feeder wiring - in conflict with the fourth recommendation that no code be greater than 10% of the total labor.

In addition, these same codes cover the installation of raceways and the subsequent pulling wire into them. These activities take place at widely different stages of the construction process and thereby violates the third recommendation for JCA CODES.

In summary, NECA LABOR CODES could be utilized for JCA, but better accuracy in predicting overall job completion can be achieved with some modifications.

DEVISING JCA CODES

JCA CODES were devised by considering, first, the problem of collecting accurate field data, second, the difficulties of breaking the estimate down into corresponding reporting category, and third, the structure and composition of the code as related to the requirements for JCA CODES.

From the job foreman's point of view, a natural breakdown of the job includes :

KEEP CODES AS
LOGICAL AND
UNDERSTAND-
ABLE AS
POSSIBLE!

- (1) installing raceways,
- (2) pulling wire,
- (3) installing fixtures and
- (4) installing other electrical equipment and devices.

If these were the only divisions of a job, the labor hour data would be accurate because relatively few decisions have to be made to collect the data. However, to improve overall JCA accuracy, a larger number of individual CODES is required.

The following steps were taken:

[1] Raceway was separated into two codes with the division occurring at 2" conduit where different threaders and benders are required.

[2] Wire was separated into two codes with the division generally determined by the requirement of mechanical assistance to accomplish the pull.

[3] The interiors of lighting and power panels, transformers, and switchgear were identified as a separate code from devices and equipment connections.

[4] Temporary electrical service, extra work not part of contract, engineering for shop drawings, and an allowance for punch list clean up were also identified as significant areas of work which may deserve an individual JCA code.

LABOR COMPOSITION OF A TYPICAL JOB

WITH 35% OF JOB
LABOR IN SMALL
RACEWAY, IT IS
TOO LARGE FOR
A SINGLE WORK
CODE.

JCA CODE	PERCENT OF JOB LABOR
RS - Small Raceway	35%
RL - Large Raceway	15%
WS - Wire Small	10%
WL - Wire Large	15%
FX - Fixtures	10%
PS - Panels & Switchboard Equipment	5%
DE - Devices & Equipment Connections	4%
TE - Temporary Electric Service	4%
X - Extras, Not In Contract	varies
EN - Engineering Charged to Job	1%
PL - Punch List Allowance	1%

This provides a possible breakdown that is consistent with most of the JCA code requirements. The exceptions are [1] the total number of Codes is less than 20 and [2] three codes are greater than 10% of the total estimated labor.

The obvious solution was to further sub-divide the large codes and the best means to accomplish this and minimize field decisions was to divide the codes by the area in which they were installed. Most jobs have separate floors or buildings which are easily recognized. If not, Engineer's drawings frequently identify separate building areas for the electrical work and the work can be identified by the drawing number.

To break small raceway into manageable sizes, four or more areas must be identified. It then seems logical to carry the same breakdown through on wire and fixtures with the resulting recommendation :

RECOMMENDED JCA LABOR CODES

SMALL RACEWAY
COVERS CONDUIT
UP TO AND
INCLUDING 1 1/2"

RS-1 Raceway, Small - Area 1
RS-2 Raceway, Small - Area 2
RS-3 Raceway, Small - Area 3
RS-4 Raceway, Small - Area 4

LARGE RACEWAY
COVERS 2" AND
LARGER CONDUIT.

RL-A Raceway, Large - Substation A
RL-B Raceway, Large - Substation B

FX-1 Fixture Labor - Area 1
FX-2 Fixture Labor - Area 2
FX-3 Fixture Labor - Area 3
FX-4 Fixture Labor - Area 4

WS-1 Wire, Small - Area 1
WS-2 Wire, Small - Area 2
WS-3 Wire, Small - Area 3
WS-4 Wire, Small - Area 4

LARGE WIRE
REQUIRES
MECHANICAL
PULLING
EQUIPMENT

WL-A Wire, Large - distribution A
WL-B Wire, Large - distribution B

PS Panel interiors & Switchboard Equipment
DE Devices & Equipment Connections
TE Temporary Electrical Service
X Bulletins & Extra Work

ORGANIZING THE ESTIMATE FOR JCA

Before the estimate of a job is started, thought should be given to how JOB COMPLETION ANALYSIS may be implemented. The drawings should be examined to determine how the job can be divided into at least 4 approximately equal areas that will be very easy to identify during the construction process. This might be by floor, by building bays, by drawing number, or any other convenient means.

PREPLANNING
THE TAKEOFF CAN
SAVE ESTIMATOR
TIME AND MAKE
THE JCA EASIER
TO IMPLEMENT.

Having accomplished this, the estimator is in a better position to organize his estimated take off work sheets so that the time required later to break a job down into JCA AREA CODES will be minimized.

After the contract has been received, the actual AREA CODES to be used on the job should be determined by the estimator, contract manager and the foreman designated to run the job. From the original take off worksheets, the contract manager should break the estimated hours down into the appropriate JCA AREA CODES.

UTILIZING A PERSONAL COMPUTER

JCA IS EASIER
FOR THE FIELD
AND THE OFFICE
IF A PERSONAL
COMPUTER IS
UTILIZED.

Originally JCA was implemented for the manual entry and display of the data. Now, however, the availability of personal computers and computer spreadsheet programs makes it possible to simplify the process of preparing JCA reports.

The reader can prepare his own spreadsheet program by examining the sample reports. A spreadsheet program which automates the data setup and entry process with macro programs is also available.

THE SELECTION OF AN OBSERVER

THE JOB
FOREMAN IS THE
BEST CHOICE TO
OBSERVE AND
REPORT HOURS
AND PERCENT
COMPLETION.

The process of JOB COMPLETION ANALYSIS involves making a series of compromises with a resultant reduction in the quality of the information obtained.

The best possible choice of observer would be to have the original estimator collect and resolve information using his detailed estimate as a source document. On some highly critical jobs, this might be a reasonable course - but for most jobs, contractors have neither the depth of estimating talent, nor the profit to support this practice.

The logical first compromise is to select the job foreman or superintendent, who has responsibility to actually install the job, to observe and record information needed to measure job progress toward completion.

This compromise is a significant one because, first, field personnel are not estimating oriented and accomplished at "paper work" and second, because the accuracy of field reported data seems to be inversely proportional to the number of decisions that have to be made as to where the job labor hours used should be distributed for record keeping purposes.

UPDATING JCA FOR SCOPE CHANGES

As the job increases in scope, it is important that the estimated hours for changes be incorporated in the JCA area CODES. This ensures the greatest possible accuracy in predicting the Job Completion.

If it is not possible to up date the JCA on a timely basis, the JCA report will project a more conservative (smaller) value for percent of completion and hours saved.

THE WORLD WILL
END....
WHEN ALL THE
PAPERWORK IS
DONE!

THE JCA REPORT & PAPERWORK

Every effort has been made to keep the JOB COMPLETION ANALYSIS as simple as possible. In particular, the paperwork to be processed on the job is kept to a minimum.

The supervisor at job site is responsible for recording and summarizing the man hours used on the job for the corresponding JCA CODE. This function can usually be combined with the timekeeping process on the job. The supervisor has the responsibility to provide his best opinion of a value of the percent completion for work done under each CODE.

When JCA is properly implemented on a job, a report would have 10 or so "active" JCA CODES and should not be a major paperwork burden.

OFFICE PROCESSING OF JCA

When the available JCA SPREADSHEET PROGRAM is loaded at the office and the JOB DATA FILE is accessed, The first display is the HELP SCREEN :

JOB COMPLETION ANALYSIS

THIS QUATTRO PRO PROGRAM HAS BEEN DESIGNED TO EASE THE CREATION AND UPKEEP OF JOB COST ANALYSIS INFO USING THE FOLLOWING MACRO KEY COMMANDS:

PREPARE FOR NEXT REPORT..... ALT-A

CALCULATE % ESTM SPENT..... ALT-B

SAVE NEW DATA & PRINT REPORT.... ALT-C

Processing the JCA is as simple as ALT-A, ALT-B, ALT-C.

SIMPLE AS ALT-A, ALT-B, ALT-C

THE JCA DATA FORM FROM THE JOB PROVIDES THE SOURCE DATA TO INPUT INTO THE JCA REPORT.

ALT-A

First key in ALT-A by depressing the "ALT" KEY and the "A" key at the same time. A "macro" program will cause the data in the spreadsheet to be readied for the next report by clearing the HOURS ADDED column and shifting the data in the SAVED columns one column to the right.

The operator enters the date shown on the lower right hand column of the JCA DATA FORM and then moves the cursor to the top of the Hours added column. The hours from the JCA DATA FORM are then entered in the cell corresponding to the corresponding JCA CODE.

If there are any changes to be made to the HOURS ESTD values as a result of changes in the job scope, now is the time to make those changes to the values displayed in the spreadsheet.

ALT-B

Next, key in ALT-B. The "macro" program will then add the HOURS ADDED values to the values which were previously left in the HOURS T/D column. The new values in the HOURS T/D column are the updated values as of this new report.

Next, the %ESTM SPENT column will be recalculated to show the impact of new HOURS ADDED data. Finally, the OBSVD COMPLN column will also be recalculated.

IT'S OK TO USE A CALCULATED VALUE FOR A JCA CODE WHEN THE COMPLETION IS LESS THAN 20%.

Where the Observed Completion value is below 20%, it is permissible to use the calculated value obtained from HOURS T/D and HOURS ESTD. For those JCA CODES where the calculated value is greater than 20%, the word "ENTER" will be displayed in the spreadsheet cell. From the JCA DATA SHEET, the operator enters the OBSVD % COMPLETE value.

REPORTS ARE PRINTED AT THE END OF THE ALT-C STEP.

ALT-C

Finally, the operator keys in ALT-C. This macro caused the OBSERVED JOB COMPLETION to be calculated and placed in the spreadsheet cell to the right of the "=="> arrow at the bottom of the form.

If a printer is on line and selected at this time, the program will cause a **JCA REPORT** and **JCA DATA SHEET** to be printed.

FLOW OF REPORTS TO JOB & BACK

**EXPECT
EXCELLENCE...**

One copy of the JCA REPORT and Two copies of the JCA DATA SHEET are transmitted to the job foreman usually at the same time payroll checks are delivered.

**INSPECT WHAT
YOU EXPECT...**

The left half of the JCA DATA SHEET provides job supervision with a concise summary of the results of his last report and covers hours used; hours to date; the last value reported of observed completion, the percent of the estimated hours spent, and the hours saved or lost.

**PROVIDE
FEEDBACK!**

The right half of the JCA data sheet provides blank spaces for supervision to record their hours expended and observed completion at the end of the current week.

After collecting and recording the appropriate data, one copy of the JOB DATA SHEET is returned with the payroll time and the other retained for job records.

It is essential that job supervision recognize the importance of providing accurate information on where hours were used and well considered opinions on each code's OBSERVED PERCENTAGE OF COMPLETION. The task of keeping coded labor, while tedious, is not complicated and has been adequately covered in other publications.

"TNQ", a personal computer program is available which enables Supervision on job site to capture Time and Quantity information of job progress and generate payroll and JCA reports which cross-foot and provide audit trail. This greatly simplifies the "bookkeeping burden".

THE JCA REPORTS

=====

The next three pages contain examples of the reports which are generated by the JCA program :

- [1] Sample **JCA REPORT** for the weekending 10/26
- [2] Sample **JCA DATA SHEET** for the weekending 11/2
- [3] Sample **JCA REPORT** for the weekending 11/2

JCA REPORT : The basic purpose of **JCA REPORT** shown on pages 18 and 20 is to predict the job's percentage of completion at the date of the report. The value is displayed at the bottom right hand corner of the report.

With normal care, the value of PERCENT COMPLETION is accurate within a range of plus or minus 2% and will probably be better than that.

The right half of the JCA REPORT contains five (5) columns with the heading "SAVED XX/XX". These columns contain COMPARATIVE HISTORICAL DATA of a reasonably accurate evaluation of the number of hours that have been "saved" as compared to the estimate. Because of the difficulty of obtaining precise values, it is **VERY IMPORTANT** to **LOOK AT TRENDS IN THE DATA** - that is, whether they are increasing, holding steady or decreasing. Consistency of data can also be an indicator of the accuracy of data.

TRENDS IN THE
COMPARATIVE
DATA VALUES ARE
SOMETIMES MORE
MEANINGFUL
THAN THE DATA
ITSELF

The left half of the JCA REPORT contains the information required to calculate the HOURS SAVED for each of the JCA AREA CODES LISTED. Each column is provided totals for HOURS ADDED, HOURS TO DATE, PERCENT OF ESTM SPENT, AND HOURS ESTD.

JCA DATA SHEET : The basic purpose of the JCA DATA SHEET shown on page 19 is to serve as a preprinted form that the supervisor on the job can use to report where labor hours were used on the job and his best evaluation of the PERCENTAGE OF COMPLETION for each AREA CODE.

JOB COMPLETION ANALYSIS

JOB NBR : 1833

REPORT FOR DATA TAKEN: 10/26/76

SAMPLE JCA REPORT

FOR WEEK 10/26

HOURS ADDED	AREA CODE	HOURS T/D	OBSVD COMPLN	%ESTM SPEND	HOURS ESTD	SAVED 10/26/	SAVED 10/19/	SAVED 10/12/	SAVED 10/5/	SAVED 9/28/	PCT COMP
93	RS-E4	258	9.8%	14.2%	1,811	-81	-2	-16	47	47	.8%
25	RS-E5	166	8.7%	9.2%	1,811	-8	-14	-11	-9	-2	.7%
61	RS-E6	740	58.0%	33.3%	2,219	547	548	524	524	524	5.6%
	RS-E7	516	39.0%	26.2%	1,966	251	254	254	263	274	3.3%
	RS-E8	141	16.0%	16.1%	875	-1	-1	-1	-1	-1	.6%
	RS-E9		.0%	.0%	367	0	0	0	0	0	.0%
42	RL-E2	865	63.0%	51.1%	1,693	202	201	216	229	273	4.7%
56	RL-E3	639	54.0%	42.1%	1,518	181	191	108	108	103	3.6%
	RL-E9	7	3.5%	3.5%	200	0	0	0	0	0	.0%
	FX-E4	7	.7%	.7%	988	0	0	0	0	0	.0%
65	FX-E5	147	10.0%	18.7%	786	-68	-2	-2	-3	0	.3%
	FX-E9	7	7.3%	7.3%	96	0	0	0	0	0	.0%
	WS-E4	7	2.0%	2.0%	350	0	0	0	0	0	.0%
	WS-E5	77	12.0%	22.0%	350	-35	-35	-35	0	0	.2%
	WS-E6	7	1.8%	1.8%	380	0	0	0	0	0	.0%
	WS-E7	7	1.8%	1.8%	380	0	0	0	0	0	.0%
	WS-E8	7	.9%	.9%	770	0	0	0	0	0	.0%
	WS-E9	7	6.9%	6.9%	101	0	0	0	0	0	.0%
	WL-E2	7	.4%	.4%	1,575	0	0	0	0	0	.0%
	WL-E3	7	.6%	.6%	1,245	0	0	0	0	0	.0%
	PS-E2	7	1.0%	1.0%	728	0	0	0	0	0	.0%
	PS-E3	7	1.1%	1.1%	639	0	0	0	0	0	.0%
	DE	23	3.1%	3.1%	739	0	0	0	0	0	.0%
32	TE-E4	621	81.0%	85.4%	727	-32	-157	-152	-158	-150	2.6%
32	TE-E5	485	76.0%	80.2%	605	-25	-127	-156	-156	-156	2.0%
406	TOTALS	4,762	20.8%	22,919	929	856	729	844	912	24.8%	

JOB NBR : 1833 PCT COMPLETE ==> 24.8% 22.4% 20.8% 19.9% 19.2%

JOB 1833

SAMPLE JCA DATA SHEET

11/2/76

HOURS ADDED	AREA CODE	HOURS T/D	OBSVD COMPLN	%ESTM SPENT	HOURS ESTD	SAVED 10/26/	HRS THIS REPORT	OBSVD % COMPLETE
93	RS-E4	258	9.8%	14.2%	1,811	-81	77	16
25	RS-E5	166	8.7%	9.2%	1,811	-8	62	12
	RS-E6	740	58.0%	33.3%	2,219	547	43	60
61	RS-E7	516	39.0%	26.2%	1,966	251	33	40
	RS-E8	141	16.0%	16.1%	875	-1		
	RS-E9		.0%	.0%	367	0		
42	RL-E2	865	63.0%	51.1%	1,693	202	74	66
56	RL-E3	639	54.0%	42.1%	1,518	181	69	60
	RL-E9	7	3.5%	3.5%	200	0		
	FX-E4	7	.7%	.7%	988	0		
65	FX-E5	147	10.0%	18.7%	786	-68		
	FX-E9	7	7.3%	7.3%	96	0		
	WS-E4	7	2.0%	2.0%	350	0		
	WS-E5	77	12.0%	22.0%	350	-35		
	WS-E6	7	1.8%	1.8%	380	0		
	WS-E7	7	1.8%	1.8%	380	0		
	WS-E8	7	.9%	.9%	770	0		
	WS-E9	7	6.9%	6.9%	101	0		
	WL-E2	7	.4%	.4%	1,575	0		
	WL-E3	7	.6%	.6%	1,245	0		
	PS-E2	7	1.0%	1.0%	728	0		
	PS-E3	7	1.1%	1.1%	639	0		
	DE	23	3.1%	3.1%	739	0		
32	TE-E4	621	81.0%	85.4%	727	-32	27	82
32	TE-E5	485	76.0%	80.2%	605	-25	-	77

DATA IN
THESE 2
COLUMNS
ENTERED
MANUALLY BY
JOB SUPER...

JOB COMPLETION ANALYSIS
 JOB NBR : 1833
 REPORT FOR DATA TAKEN: 11/ 2/76

SAMPLE JCA REPORT FOR NEXT WEEK

HOURS ADDED	AREA CODE	HOURS T/D	OBSVD COMPLN	%ESTM SPEND	HOURS ESTD	SAVED 11/ 2/	SAVED 10/26/	SAVED 10/19/	SAVED 10/12/	SAVED 10/5/	PCT COMP
77	RS-E4	335	16.0%	18.5%	1,811	-45	-81	-2	-16	47	.8%
62	RS-E5	228	12.0%	12.6%	1,811	-11	-8	-14	-11	-9	.7%
43	RS-E6	783	60.0%	35.3%	2,219	548	547	548	524	524	5.8%
33	RS-E7	549	40.0%	27.9%	1,966	237	251	254	254	263	3.3%
	RS-E8	141	16.1%	16.1%	875	0	-1	-1	-1	-1	.6%
	RS-E9		.0%	.0%	367	0	0	0	0	0	.0%
74	RL-E2	935	66.0%	55.5%	1,693	178	202	201	216	229	4.7%
69	RL-E3	708	60.0%	46.6%	1,518	203	181	191	108	108	3.6%
	RL-E9	7	3.5%	3.5%	200	0	0	0	0	0	.0%
	FX-E4	7	.7%	.7%	988	0	0	0	0	0	.0%
	FX-E5	147	18.7%	18.7%	786	0	-68	-2	-2	-3	.3%
	FX-E9	7	7.3%	7.3%	96	0	0	0	0	0	.0%
	WS-E4	7	2.0%	2.0%	350	0	0	0	0	0	.0%
	WS-E5	77	12.0%	22.0%	350	-35	-35	-35	-35	0	.2%
	WS-E6	7	1.8%	1.8%	380	0	0	0	0	0	.0%
	WS-E7	7	1.8%	1.8%	380	0	0	0	0	0	.0%
	WS-E8	7	.9%	.9%	770	0	0	0	0	0	.0%
	WS-E9	7	6.9%	6.9%	101	0	0	0	0	0	.0%
	WL-E2	7	.4%	.4%	1,575	0	0	0	0	0	.0%
	WL-E3	7	.6%	.6%	728	0	0	0	0	0	.0%
	PS-E2	7	1.0%	1.0%	639	0	0	0	0	0	.0%
	PS-E3	7	1.1%	1.1%	739	0	0	0	0	0	.0%
	DE	23	3.1%	3.1%	727	-52	-32	-157	-152	-158	2.6%
27	TE-E4	648	82.0%	89.1%	727	-52	-32	-157	-152	-158	2.6%
	TE-E5	485	77.0%	80.2%	605	-19	-25	-127	-156	-156	2.0%
406	TOTALS	5,147	22.5%	22,919	1005	929	856	729	844	26.8%	

JOB NBR : 1833 PCT COMPLETE ==> 26.8% 24.8% 22.4% 20.8% 19.9%

ANALYSIS OF 10/26 JCA REPORT

JOB PCT COMPLETE = 24.8% WITH 20.8% OF ESTM SPENT.
HOURS SAVED = 929 WITH TREND UP

HOURS SAVED for JOB are 929, up from 729 two weeks ago.
However, only up slightly from 912 on 9/28.
Most of hours saved in Small and Large Raceway
codes. The UPWARD TREND is a good sign.

RS-E4 HOURS LOST went from -2 to -81 with 93 hours
expended. Should review accuracy of 9.8% OBSVD
COMPLN.

FX-E5 HOURS LOST went from -2 to -68 with 65 new hours
expended. Not possible, should review percent
OBSVD COMPLN.

TE-E4 HOURS LOST decreased from -157 to -32 with 31 new
hours expended. Need to review 81% OBSVD COMPLN.
Since the AREA CODE is 81% done, future losses are
limited.

TE-E5 HOURS LOST decreased from -127 to -32 with 32 new
hours expended. Need to review 76% OBSVD COMPLN.

This very brief analysis of the JCA REPORT demonstrates
how much information the Job Superintendent and the
Project Manager can derive from the COMPARATIVE HISTORICAL
DISPLAY of HOURS SAVED / LOST.

The Job Superintendent is now in an excellent position to
MANAGE his job properly. Perhaps for the first time, he
can truly **WORK SMARTER, NOT HARDER!**

ANALYSIS OF 11/2 JCA REPORT

JOB PCT COMPLETE = 26.8% WITH 22.5% OF ESTM SPENT.
HOURS SAVED = 1005 WITH TREND UP

HOURS SAVED for JOB are 1005, up from 729 on 10/12.
Most of hours saved in Small and Large Raceway
codes. The STEADY TREND is a good sign.

RS-E4 HOURS LOST dropped from -81 to -45. Overall
trend is still negative and needs checking.

RL-E2 HOURS SAVED dropped slightly, Trend is down.

FX-E5 Bad estimate of OBSVD COMPLN from previous week
corrected. Accepted calculated value. Watch next
report.

TE-E4 27 hours expended and HOURS LOST went up 20 hours.
Still better than projected loss of 158
hours four weeks ago.

TE-E5 OBSVD COMPLN value changed from 76% to 77% even
though no man hours were expended in this AREA
CODE. Job Super revised his previous opinion.

This JCA REPORT is generated from the previous JCA REPORT
with the addition of the data provided by the Job
Superintendent on the JCA DATA SHEET.

When the Job Superintendent realizes the value of the JCA
REPORTS as a management tool, resistance to doing the
necessary paperwork is greatly reduced.

JCA WORK CODES DETAIL DEFINITIONS

RS	RS	Raceway, Small Conduit 1-1/2" & smaller (All Types) Boxes & Covers Wiremold	Supports, Fittings, Bushings, Locknuts, Connectors, Couplings Ells, Templates, Layout Handling & Storage
RL	RL	Raceway, Large Conduit 2" and larger Cans for panels & Sys Equip Large Cabinets Pull Boxes	Supports, Fittings, Locknuts, Bushings, Connectors, Couplings Fastenings, Knockouts Handling & Storage
	RD	Raceway, Duct Underfloor Duct Trench Duct Header Duct	Supports, Junction Box Leveling, Handling and Storage
	RT	Raceway, Tray Tray or Ladder	Supports, Ells, Tees Coupling, Handling and Storage
	BD	Bus Duct Plug in Bus Feeder Bus	Supports, Tap Boxes, Ells, Tees, Feeder, Boxes, Swing plugs Handling & Storage
	RU	Raceway, Underground Fiber Duct, Plastic Duct Installed Under Grade	Supports, Spacers Bends, End Bells Adapters, Handling and Storage
WS		Wire Small Wire Nbr. _____ and smaller	Pulling, Splicing Handling, Storage (Terminations are not included).
WL	WL	Wire, Large Wire Nbr. _____ and larger	Rigging, Handling, Pulling, Splicing, Sealing, Testing Fireproofing, Storage
	WP	Wire, Primary	Ditto
FX		Fixtures Lamps Stems & Canopies Plaster Frames Poles Luminous Ceilings	Supports, Terminations of Wire and Connection of Flex at Fixture Handling, Assembly & Storage

DE	DE	Devices & Equipment Switches, Receptacles & Plates, Pilot Lights Relays, Service Fittings Underfloor Duct, Pressure Switches, Motors, Motor Starters, Control Panels, M-G Sets, Capacitors, Etc.	Equipment and Wire Terminations Required for Operation Handling & Storage
	MC	Motor Control Centers	Handling, Setting Connecting, Connection of Starters, Testing
	SS	Special Systems: Fire Alarm Clock, Public Address, Intercom Nurse Call	Equipment and Wire Terminations, Handling & Storage (Back Boxes Conduit & Wire Pull Not Included.)
	PS	Panels, Switchboards Panelboards (Interiors Only), Switchgear Unit Substations Transformers Circuit Breakers Safety Switches (Term Only) Gutters Fuses	Receiving, Handling Installation, Rigging, Supports, Fasteners, Wire Terminations, Testing (Conduit, Blackboxes Knockouts not included)
	TE	Temporary Electric Service	Distribution Equip. Switches, Meters, Conduits, Wire, Fixtures, Lamps Switches, Receptacles That do Not Become Part of Final Installation
	X	Extra Work that is not Part of Contract.	
	PL	Punch List: An allowance to clean up misc. items at the conclusion of a job.	
	EN	Engineering and Shop Drawing Hours Charged To the Job	
	NP	Not Directly Productive: Hours for Job Personnel Not Physically Engaged In Installing Job. Includes Non Working Supervision, Job Clerk, Timekeeper, Etc.	

APPENDIX B

THE ACCURACY OF
THE ESTIMATE OF
OVERALL JOB
COMPLETION CAN
BE IMPROVED BY
FOLLOWING
THESE
SUGGESTIONS...

WHEN YOU
FAIL TO PLAN...
YOU PLAN
TO FAIL!

IMPROVING THE ACCURACY OF JOB COMPLETION ANALYSIS

The task of developing "well considered" opinion on observed percentage of completion deserves a great deal of attention. The following recommendations for field supervisors responsible for JCAs should be used to improve impromptu evaluations:

[1] Know your job: know each code's physical boundaries; know its material components and their quantities; know the estimated labor hours; know the scope of work as defined by the specifications.

[2] Involve other experienced tradesmen in making a judgment on degree of completion.

[3] Be conservative in your evaluations - the last 10% of any job seems to take 20% of the labor.

[4] Manage your job so as to start and complete any given area code within the shortest time span consistent with efficient production. The fewer codes that must be evaluated between zero and one hundred percent, the greater is the probability of overall accuracy.

[5] Color your drawings to indicate materials installed. Providing drawings are to scale, the degree of colored in materials is indicative of your percent of completion.

[6] Start from a known point. Usually, the estimate is the most accurate measure available. If the observed percent completion varies significantly from the "% Estimate Spent" value, its time to begin to determine why. A spot check of how fast materials are installed will confirm whether the estimated labor unit is reasonable. Assuming it is, begin to check for differences in scope of what has to be done by checking material purchases and specifications.

[7] Walk the job and try to visualize your evaluation. If what you see doesn't agree with other evaluations, proceed to the next steps.

WHENEVER
MANAGEMENT
WANTS
SOMETHING
REAL BAD...
THAT'S THE WAY
THEY GET IT!

[8] Count and measure what you have installed and compare that with estimated quantities. This is time-consuming - but it is accurate. If you are at the end of a code, estimate what you have to do to complete and use this to determine what completion is.

Last, when all else fails, *ask the Estimator or Contract Manager for help.*

If job supervision follows these recommendations, the observed percentage of completion reported should fall well within the degree of variation that produces acceptable end results.

APPENDIX C

APPENDIX C
SHOWS THE
VALUE OF USING
COMPARATIVE
DATA DISPLAYS
IN REPORTS.

TO GET MAXIMUM
ATTENTION...
IT'S HARD TO
BEAT A GOOD,
BIG MISTAKE !

USE OF COMPARATIVE DATA & OBSERVED COMPLETION IN JCA

The JCA REPORT utilizes COMPARATIVE DATA DISPLAY to increase the information content of the data.

Examine the following case history on a sample job to see how COMPARATIVE DATA and use of OBSERVED COMPLETION can improve insight into how the job is progressing.

Four monthly profit & loss statements on a SAMPLE JOB are shown below :

A SAMPLE JOB, MONTH 1

MONTH	JAN
CONTRACT AMT	\$1,000
BILLINGS APVD BY OWNER	\$40
- LABOR COSTS	\$20
- MATERIAL COSTS	\$20
- JOB COSTS	\$2
JOB PROFIT	\$-2

A SAMPLE JOB, MONTH 2

MONTH	FEB
CONTRACT AMT	\$1,000
BILLINGS APVD BY OWNER	\$104
- LABOR COSTS	\$50
- MATERIAL COSTS	\$50
- JOB COSTS	\$3
JOB PROFIT	\$1

MONTHLY BILLINGS OF A SAMPLE JOB, CONTD.

A SAMPLE JOB, MONTH 3

MONTH	MAR
CONTRACT AMT	\$1,000
BILLINGS APVD BY OWNER	\$160
- LABOR COSTS	\$75
- MATERIAL COSTS	\$75
- JOB COSTS	\$5
JOB PROFIT	\$5

A SAMPLE JOB, MONTH 4

MONTH	APR
CONTRACT AMT	\$1,000
BILLINGS APVD BY OWNER	\$214
- LABOR COSTS	\$100
- MATERIAL COSTS	\$100
- JOB COSTS	\$7
JOB PROFIT	\$7

THE PROBLEMS
THAT HURT YOU
THE MOST...
ARE THE ONES
YOU DON'T KNOW
YOU HAVE!

Isn't this a nice little job? Good cash flow, increasing profits after the first month! Time to pat the Contract Manager and Job Super on the back!

The individual monthly reports, like the ones most contractors are familiar with, make it difficult to make comparisons. Even here, you have to flip back and forth between pages to see how billings and job costs have changed from month to month.

To make life easier, lets rearrange the monthly statements into a COMPARATIVE DISPLAY...

COMPARATIVE DATA DISPLAY ON A SAMPLE JOB

COMPARATIVE
DATA DISPLAY
INCREASED THE
"INFORMATION"
IN THE DATA

A SAMPLE JOB		FOUR MONTHS COMPARATIVE DATA			
=====					
MONTH		JAN	FEB	MAR	APR
=====					
CONTRACT AMT		\$1,000	\$1,000	\$1,000	\$1,000
BILLINGS APVD BY OWNER		\$40	\$104	\$160	\$214
- LABOR COSTS		\$20	\$50	\$75	\$100
- MATERIAL COSTS		\$20	\$50	\$75	\$100
- JOB COSTS		\$2	\$3	\$5	\$7
		-----	-----	-----	-----
JOB PROFIT		\$-2	\$1	\$5	\$7

That's better. Now we can easily see that the Contract Amount has not changed. Hmmm, wonder if there have been changes and the bulletins have not been quoted or processed? Nice jump in billings from the 1st month to the next. And after the startup costs in JAN, the JOB PROFIT has been increasing each month. Wonder how long that can go on?

Now, take a look at the same job with the addition of **OBSERVED COMPLETION** data from JOB COMPLETION ANALYSIS.

ADDING THE
OBSERVED
COMPLETION
REVEALS THE
TRUE NATURE
OF THE JOB...

IT'S IN TROUBLE!

WITH 80% OF THE
JOB TO GO,
THERE IS STILL
TIME TO TURN IT
AROUND. AND
THAT IS THE REAL
VALUE OF JCAI

SAMPLE JOB WITH OBSERVED COMPLETION DATA

MONTH	JAN	FEB	MAR	APR
CONTRACT AMT	1,000	\$1,000	\$1,000	\$1,000
OBSERVED COMPLETION	4.0%	10.0%	15.0%	20.0%
BILLABLE AMOUNT	\$40	\$100	\$150	\$200
BILLING, 1ST EXAMPLE	\$40	\$104	\$160	\$214
CHANGE IN BILLING	\$0	\$4	\$10	\$14
- LABOR COSTS	\$20	\$50	\$75	\$100
- MATERIAL COSTS	\$20	\$50	\$75	\$100
- JOB COSTS	\$2	\$3	\$5	\$7
JOB PROFIT	\$-2	\$-3	\$-5	\$-7

WHOOOPS! What is quickly revealed is a job that has been overbilled (with the owner's acquiescence) to provide a positive cash flow. However, the job's real performance has resulted in an actual and increasing LOSS every month.

PROJECTED FINAL PROFIT

It can be seen that COMPARATIVE DATA DISPLAY utilizing JCA OBSERVED COMPLETION data obtained from JCA has real value.

There is one final technique that can be used to help gain confidence in the accuracy of the data and that is to PROJECT THE FINAL PROFIT each month and incorporate it into the COMPARATIVE DATA DISPLAY:

JCA EXAMPLE WITH PROJECTED FINAL PROFIT

MONTH	JAN	FEB	MAR	APR
CONTRACT AMT	1,000	\$1,000	\$1,000	\$1,000
OBSERVED COMPLETION	4.0%	10.0%	15.0%	20.0%
BILLABLE AMOUNT	\$40	\$100	\$150	\$200
BILLING, 1ST EXAMPLE	\$40	\$104	\$160	\$214
CHANGE IN BILLING	\$0	\$4	\$10	\$14
- LABOR COSTS	\$20	\$50	\$75	\$100
- MATERIAL COSTS	\$20	\$50	\$75	\$100
- JOB COSTS	\$2	\$3	\$5	\$7
JOB PROFIT	\$-2	\$-3	\$-5	\$-7
PROJECTED FINAL PROFIT	\$-50	\$-30	\$-33	\$-35

CONSISTENCY IN
THE VALUES OF
PROJECTED FINAL
PROFIT INCREASE
THE LEVEL OF
CONFIDENCE IN
THE JCA'S
ACCURACY

It is useful to include PROJECTED VALUES in a comparative display. Examining the JOB PROFIT values above provides little information because the values change each month in proportion to the percentage of completion. If, however, the JOB PROFIT is divided by the OBSERVED COMPLETION to generate the PROJECTED FINAL PROFIT VALUES, additional insight to the true nature of the job may be obtained.

Since the PROJECTED FINAL PROFIT should be the same value, it should be expected to find that one value in each column. If the value varies greatly, it is an indication that the job needs further close examination.

PROJECTED FINAL PROFIT \$-50 \$-30 \$-33 \$-35

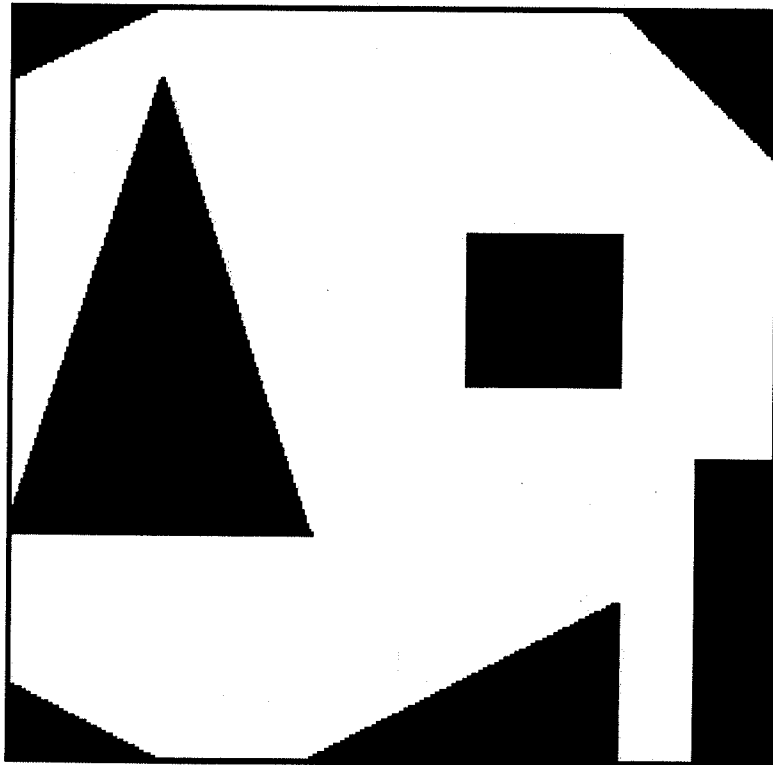
Neglecting the first month, the PROJECTED FINAL PROFIT value varies from -30 to -35. Not too much of a change... giving us more confidence in the overall JCA analysis!

APPENDIX D

AN EXERCISE IN ESTIMATION

Examine the box below and estimate the percent of the box that is black.

IF YOU THINK THE
PROBLEM IS BAD
NOW...
JUST WAIT UNTIL
WE HAVE SOLVED
IT!



On the job, the process of estimating the percentage of completion in any JCA code is very similar to the visual skills to estimate what percent of the square above is black.

You might walk the job and see what has been installed and then try to visualize what has to be installed to complete the work code. Then, when you have a feel for the relationship, you come up with a value...

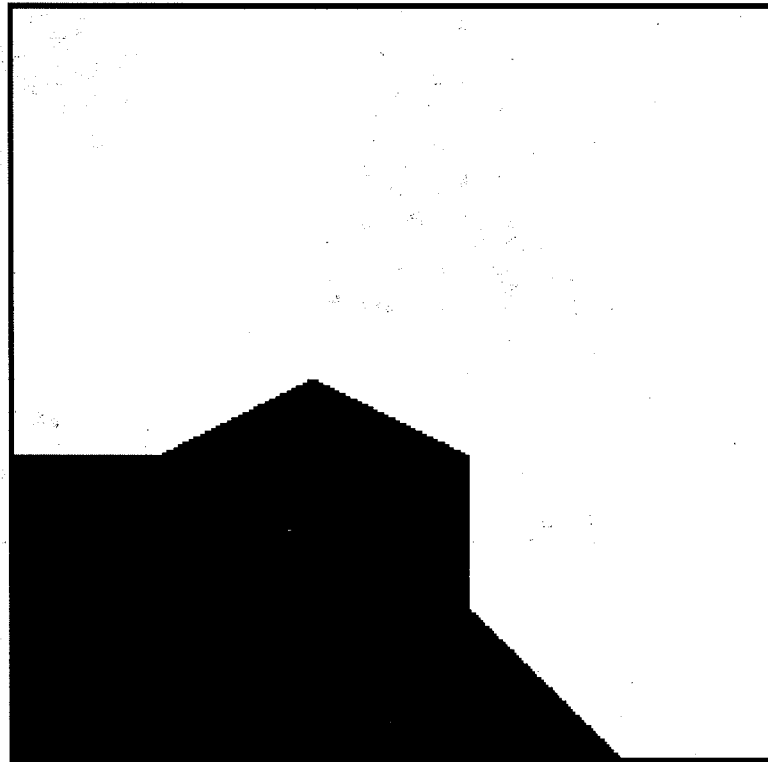
Or you might color in the work that has been completed on the drawings and try to visualize what has been done as compared to what has to be done...

When you have decided what percent of the box is black, write down your answer before you turn the page...

PROBLEMS ARE
ONLY
OPPORTUNITY IN
WORK CLOTHES!

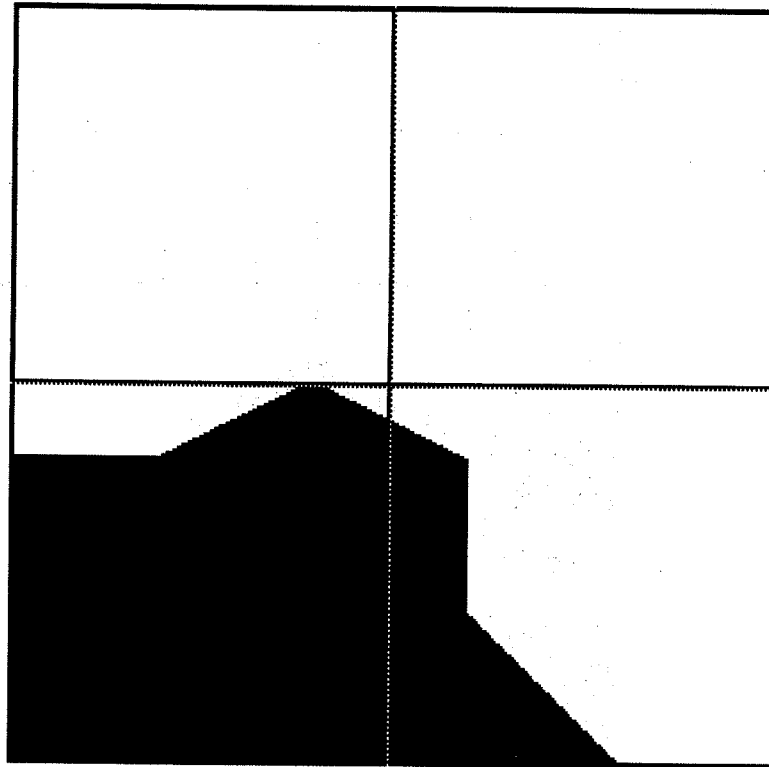
Well, estimating percentages isn't as easy as you might first think! Its easy to see how an estimate, even by an experienced Job Superintendent might be off by a percent or two.

To improve the accuracy of the estimate, you might try to organize things a little better. Let's take the box from the previous page and gather all the black areas together into one larger black spot... as you see in the box below. The total black areas are the same...



Now, look at the box carefully and estimate the percent of the box that is black and then write down your answer so we can learn as we progress...

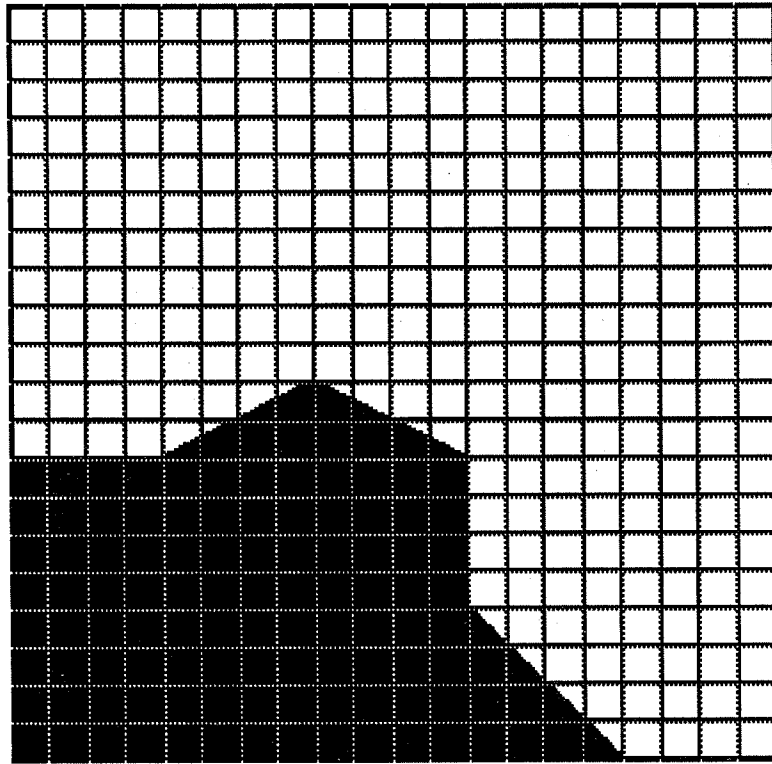
Next, lets provide a little more help by drawing two grid lines in the square which divide it into four equal parts.



Sometimes even simple changes to the way in which you approach the evaluation of percentage of completion can be very helpful. Just dividing the square into four parts provides a basis for comparing the area in black with one of the four parts... resulting in a better evaluation.

For the record, write down your evaluation of what percentage of the square is in black.

If dividing the large square into 25 smaller squares improved the accuracy of the prediction, how about going a little further and see what happens...



We have now divided the large square into 400 smaller squares. We still have the 3 types of small squares:

- [1] Squares that are all black.
- [2] Squares that are all white.
- [3] Squares that are both black and white.

Now, how many small squares are all white? Boy, there are a batch of them! Well, let's count the number of small squares that are black instead... one, two, three, four,...

KEEP JCA AREA
CODES TO A
MANAGEABLE
NUMBER...
MORE THAN 20,
LESS THAN 50.

Well, perhaps you get the message. When you have too many small squares, Area Codes, or anything else, the process of keeping track of individual items becomes a problem. Keep your breakdowns in the range from 20 to 50 items for best results!

John M. Harlan is president of Harlan Electric Company in Southfield, Michigan. Harlan began as an apprentice electrician at Harlan Electric Company in 1951. Harlan Electric Company has been a NECA member for 52 years. John Harlan has served as director of the Southeastern Michigan Chapter since 1968 and as president of the chapter in 1973. He has also served on NECA's Marketing Committee.