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ENGINEERING CRITERIA FOR COST EFFECTIVE CONSTRUCTION INSPECTION OF NAVAL SHORE FACILITIES

By

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ABSTRACT

This report describes the construction quality control system that was being followed during most of the period covered by the study effort, discusses some problems observed in the functioning of that system, and then lists several conceivable alternatives to it. Some ideas for future development, which recognize the current modifications provided for by the innovation entitled Contractor Quality Control (CQC), are presented.

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I. INTRODUCTION

A. An Overview

The Navy Construction Inspection System (NCIS)* is charged with the task of coordinating a very diverse and complex set of technical efforts which result in completed facilities. These efforts cover a very broad scope of the current body of engineering knowledge. The sheer number of disciplines and technologies is so great, in fact, that there does not seem to be much hope that the manner in which the Navy manages the construction effort can be reduced from an art to a science. In addition, the essentially autonomous nature of the ROICC offices results in a considerable variation in practice from activity to activity; i.e., what is a serious problem in one location is not at another and vice versa.

B. The Construction Inspector as a Knowledge Worker

One of the great (and as yet unsolved) problems of the Twentieth Century has been how to manage "knowledge-workers" effectively so that they will produce more efficiently. The distinction here is between people whose output is generally easy to measure: The hardware or physical systems output by production workers as contrasted to the staff advice or control function exercised by the knowledge worker. In construction work the architects, engineers, and inspectors working for the owner are knowledge workers whereas the skilled and unskilled construction workers are the production personnel. The civil engineers and construction superintendents working for the contractor do belong in a somewhat grey area, but ultimately their work can be measured in terms of an output rate of apparently satisfactory work. For the architect working for the owners we can ask the question: Is the result esthetically pleasing and structurally sound? . . . and get an answer, more or less. For the engineers working for the owner we attempt to determine if the mechanical and electrical systems operate satisfactorily.

Where matters get difficult is when the time comes to evaluate the output of the inspection staff. The questions to ask would seem to be something like this: How long did the building stand? or How expensive is it to repair and maintain? The difficulty here becomes even greater when we note that the Knowledge worker whose output is the most difficult to measure and appraise is also the <u>only</u> one who is not generally considered a professional. This observation would

*The construction inspection method together with its operational and technical knowledge. The U. S. Navy's primary field organization utilizing inspectors is known as the ROICC (Resident Officer in Charge of Construction) Office.

seem to make part of the solution self-evident: To improve the inspection system we must first upgrade the inspectors. To quote Peter Drucker from page 5 of reference (1):

> "Every knowledge worker in modern organization is an 'executive' if, by virtue of his position or knowledge, he is responsible for a contribution that materially affects the capacity of the organization to perform and to obtain results."

Furthermore, the key to quality in knowledge workers is training or education together with sufficient compensation and status to motivate the acquisition of the required knowledge.

That change must take place is clear. To some degree it already has: The Naval Facilities Engineering Command has instituted a program designed to get the inspector out of the business of contract superintendent, namely: Contractor Quality Control (CQC)[2].

C. Study Objectives

The formal objective for this study was:

> "To develop criteria that will aid Resident Officers in Charge of Construction (ROICC's) in the planning and programming of inspection on construction, and that can be used by the Engineering Field Divisions (EFD's) of the Naval Facilities Engineering Command for the same purpose."[3]

As implied by the title of this study, these criteria are to be "engineering criteria". Cost effective construction inspection is interpreted to be the efficient use of construction inspection personnel which results in savings either in the NCIS or in the entire Shore Facilities Acquisition effort. By implication, a look at the scheduling and staffing of inspectors is a part of this study.

After visiting many ROICC operations, five of the six EFD's and reviewing past efforts, it is clear that criteria for these tasks are not easily reduceable to a computer program or formula. The best procedure for the scheduler is to think; think and function as an engineering manager; think about the goals: what is yet to be done, what facilities and manpower are now available to do this, and so to schedule it; and when the schedule written this week is revised next week, to reinitiate this thinking process.

At most places visited the schedulers are doing an excellent job, considering the boundary conditions under which they operate; therefore, it is the purpose of this report to:

1. Look at some of the conditions which are causing current inefficiencies,
2. Report on the results of an anonymous questionnaire sent to CONUS ROICC's, some allocation methods, and a multiple regression analysis,
3. List alternative control methods which could be considered for the future and,
4. Make evaluations on the basis of 120 field interviews and the questionnaire.

II. STATUS OF THE NCIS (PRE-CQC)

A. General Observations

The most striking characteristic of the ROICC Office staffs is their small size. In FY-63, 70% of the ROICC's had 4 inspectors or less and about 52% had a total staff of 5 people or less.* Data from the 40 ROICC's responding to the anonymous questionnaire indicate that these percentages were 55% and 40%, respectively, at the end of FY-71. See the Appendix, page 43. Two factors could account for this change: a tendency to consolidate ROICC Offices and a possible bias in questionnaire data due to the composition of responses and non-responses to the questionnaire (implying that the real value in FY-71 was closer to that of FY-63).

The group of people available to do direct inspection meets the definition of a small staff (one to five people for the purposes of this report) at a very substantial majority of the ROICC Offices; and for about one half of those offices, one to five people constitute the total staff. It is not unusual for one inspector to carry 5 tasks in slack seasons and 10 or more during the peak of the construction year.

There is a considerable fluctuation, at the Naval Activity level, of construction expenditures annually and over a longer period. The annual fluctuation is largely due to the appropriation cycle of the U. S. Congress.

Consideration should be given to an attempt to level seasonal variations, particularly where the climate permits this easily. Such an effort might have another advantage, also. Contractors would like to level out their variations, too.

In the course of interviewing and observing 120 ROICC personnel in 6 large and 4 medium-sized ROICC offices in the five CONUS EFD's, the importance of effecting better communication between the Construction and Design phases became evident in a number of ways. This

*Obtained from data given in reference 19 and other sources.

information was supplemented and confirmed by an anonymous questionnaire. Typical duties of the ROICC Office are given in reference 4.

B. The Anonymous Questionnaire

It was considered not possible to proceed directly to the formal objective of this study without first making an analysis of the status of the NCIS. The questionnaire was devised to provide information on the status of the NCIS <u>prior to implementation of CQC</u>.

The response to the questionnaire was unusually good. From a mailing list of 96 ROICC Offices in CONUS, compiled at NCEL, exactly ½ or 48 were selected randomly for the initial mailing. The largest ROICC Office studied, with a total staff of 40 (20 of them GS-8 and 9 inspectors), requested and received 12 additional questionnaires. Forty of the 48 ROICC Offices responded with completed questionnaires for an 83% response. Three additional responses which were unsolicited came from two of these 40 ROICC Offices. Eleven of the requested twelve additional questionnaires were received back from the large Area ROICC Office, canvassing the technical staff from Assistant Area ROICC through Engineering Technician (in addition to the Area ROICC Officer who was included in the 40 other responses above). Four responses, not intentionally solicited, came from an EFD. One of these four was from an Area ROICC Supervisory Civil Engineer who had just taken a position in the EFD, so his return was counted as a ROICC Office response. In all, 57 completed questionnaires were analyzed. For some questions the analysis of results was restricted to the 40 unique ROICC Offices responding according to the relevance of the question.

Even more striking than the outstanding percent response was the quality of commentary from about half of the completed questionnaires: Two hundred fifty six of the 615 comments received were abstracted and communicated to the sponsor, NAVFAC, informally. Only 6 respondents were not represented among these quotes. It was clear from the self-consistency, careful wording of comments, and obvious thoughtfulness of many of the completed questionnaires that a good deal of time was spent in their preparation. About a dozen of the questionnaires used every available space provided on the form for comment and at least half of those could be described as fluent essays.

The forwarding letter left the choice of the person to answer the questionnaire to the action addressee, but recommended that he be ". . . the most experienced or best qualified among the staff of CEC officers, civil engineers, or supervisors of inspectors." In the desire to obtain frank answers, anonymity of the respondents has been preserved.

The statistical results of the questionnaire have been summarized on the questionnaire form itself. Because of the striking similarity of distribution of job category of respondents between the large Area ROICC and the other 45 respondents (Table 1) it was decided to include

Table 1

Job Assignment (duty) Category	Respondents From the Large Area ROICC		All Other Respondents	
	No.	%	No.	%
CEC Officers	6	50	25	56
Engineers (Civilian)	3	25	14	31
Supv. Constr. Rep.'s	2	17	4	9
Engr'g. Technicians	1	8	1	2
Unknown	-	-	1	2
Totals	12	100	45	100

them as well as the six unsolicited responses directly in the statistical summary for many questions.

The results of the Questionnaire constitute in themselves a pretty good record of the status of the NCIS prior to the implementation of CQC. Many aspects of problems of this status, some of which profoundly affect the efficiency and vital functioning of the NCIS, are most clearly expressed in the words of the respondents themselves.

Question number 7 treats one of these problems by asking if known "bad" contractors become the low bidder in the respondent's activity. A good definition of "bad" in this context is provided by one of the respondents:

"We are constantly faced with a contractor being the low bidder who is a known marginal performer and who requires a maximum of inspection and prodding to insure adherance to the specifications and time requirements of the contract."*

*Respondent number 9, a Supervisory Civil Engineer. See pages 29 and 30 for a list of facts pertinent to each respondent.

Two of the respondents spelled out the consequences of this situation with directness and clarity:

"Although no 'problem' exists, some cases of 'bad' contractors getting a contract have arisen. One is enough! One 'bad' contractor . . . can destroy the relations a procurement office may have with 'good' contractors."

"We have no trouble identifying a 'bad' contractor with whom we have had experience. The problem is in denying him the contract . . .. Most 'bad' contractors fall into the 'grey' area--not the absolutely 100% 'black' category where he is obviously non-responsible."*

Another problem situation was revealed by the comments stimulated by this question:

"'Bad' as used in the above context includes the problems of inexperienced management in construction firms and poor field supervision. These firms rely on low-bid subcontractors and provide no surveillance over their operations."

". . . a method to prevent contractors from 'shopping' after award would be most beneficial. This could be done by requiring the contractor to submit a list of his sub-contractors with his bid."**

This problem might be controlled by specifying the percentage of the total effort which must be provided by the general contractor. Unfortunately, the following type of situation afflicts the NCIS frequently if the field visits were a proper sample:

"Our biggest problem is that the contractors look for change orders and know that liquidated damages will not be assessed if they finish late. It is my experience that contractors use smaller crews on government jobs. No big rush in 95% of the cases."***

The burden of proper interpretation of the plans and specifications falls on the inspection staff. Question 9 introduced the subject but question 12 brought the problem into focus. The first paragraph (c) in each quote was in response to a question about the present method of feedback of information to Design and the second paragraph (d) is an opinion on how this practice could be improved:

"(c.) Limited guides: 'Constructibility' reviews of P&S just prior to Bid Opening and occasional design deficiency reports which only point out major problems. Memos and telephone conversations during pre-award period. Generally there is no positive feedback of validity or action taken (even) if the responsible designer gets the feedback.

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* Respondents 11, an AROICC and 24, a PWO/OICC, respectively. All underlines within quotes are those of the respondent.

** Respondents 30, a Quality Assurance Officer and 46, a Supervisory Civil Engineer.

***Respondent 39, an AROICC.

"(d.) Adequate time for field personnel to review plans and specifications prior to award. A post-award system could be initiated for positive feedback but generally the field interest and momentum becomes dulled and diluted once the problems are solved."*

"(c.) Inspector tells the Supervisor

Supervisor tells the Engineer or the AROICC

Engineer or AROICC tells the EFD

EFD forgets the whole thing

"(d.) As above, then EFD (to) require Design people to pay attention."**

"(c.) We have an ideal situation at this activity. Design is done in-house. Construction personnel are physically located next to the Engineering Division and there is a constant interchange of information and assistance.

"(d.) With in-house capability. The problem gets much more complex when the job is A&E designed under an EFD. The principal obstacle to good feedback is too few people in the field who have the time to write up the deficiency and transmit it to the EFD and A&E. To answer the question -- give the field enough people to do the job properly."***

A careful study of the other responses to question 12 indicates that a wide variation in conditions exists and that what is one ROICC's solution might be another ROICC's problem.

Question 15 asked about the criteria used in assignment of inspectors. The ROICC at a large Area ROICC Office, who experimented about 2 years with a fairly involved system for assignment, commented:

"Generally it boils down to who is available and who can hack it. Total workload of each man determines the first and his own experience or qualifications the second."

and one of his AROICC's:

"With a fixed number of inspectors available, the geographical location of job and no. of contracts per inspector often control

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* Respondent 47, an OICC/ROICC/PWO

** Respondent 43, a Supervisory Construction Representative

***Respondent 24, a PWO/OICC

other factors."*

Seasonal fluctuation and EFD assignment policies produced another comment:

"The Inspection Staff fluctuates with the workload and is controlled by $WIP. It seems that when the workload is up there are not enough inspectors. By the time the staff builds up then the workload starts down. This is a continuous hardship faced by the ROICC."**

Twenty-six factors possibly affecting quality of construction were dealt with directly in question 18. Some comments were:

"Most detrimental to quality construction is the lack of local control of the assignment of personnel to the field office. Drop in workload at neighboring activity frequently results in reassignment of inspectors to activity with high workload without any regard to (the nature of the) workload or qualifications."

"Quality of construction seems (to) depend primarily on the best set of plans and specifications available. . ."***

Respondents were requested to add to the list and rank their additions with the 26 factors given. Some additions, with their author's ranking in parenthesis, were:

"The system must be revised to function in much the same way as the civilian industry. This will lure the good contractors, who at present steer clear of Government work, into military building." (rated 1st)****

"(Revise) specs to utilize new and modern techniques as soon as possible." (rated 1st)*****

"Coordinate structural, electrical, and mechanical plans considering space requirements, supplying power to all mechanical equipment, etc." (rated 2nd)******

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* Respondents 34 and 39, respectively.

** Respondent 46, a Supervisory Civil Engineer.

*** Respondent 47, an OICC/ROICC/PWO, and 50, a Supervisory Civil Engineer.

**** Respondent 8, an AROICC.

***** Respondent 12, an AROICC

******Respondent 21, an AROICC

C. Some Specific Problems

1. Too many change orders boost construction costs and overburden the Inspection System. The most frequently occurring causes are:

a. The contracting agency revises requirements.

b. The designer overlooked some detail or there is a conflict between the plans (drawings) and the specifications (words).

c. The inspector is unaware that the plans or specifications actually require the proposed change order. This usually occurs when the documentation is so bulky and complex that he didn't actually read it or remember it.

The second cause is simply human error and the first happens to the best laid plans, so the change order system exists to make the necessary changes. Perhaps something could be done about the third cause.

2. The low bid system sometimes leads to poor buildings. It is especially likely to do so when the low bid is accepted from a marginally reliable contractor. Indications are that this happens between 15% and 20% of the time.* A disproportionate amount of the ROICC's and inspector's time is spent with these problem contractors (up to half of the available inspection staff time).

3. Particularly annoying in field practice are the small contracts of all types. Informals and minor repair projects require much more of the inspector's time per dollar of work put in place ($WIP) than other inspection items. Of necessity, the inspector becomes more of a construction superintendent than anything else. Whenever a small contract contractor breaks a utility line or has some other mishap he is generally not competent to handle the problem himself and must obtain help from the inspector. The nature of such an occurrence usually requires that an inspector must give <u>highest</u> priority (immediate action) to the problem at hand. Since, typically, an inspector has one large MILCON line item and several smaller projects, he is continually being diverted at critical times from his main task, the large line item.

4. The existing percent completion payment is a policy which provides no incentive to the prime contractor to remain on the site whenever he has opportunities elsewhere and the completion date is sufficiently late to enable him to take advantage of these opportunities. Excess length of contract time granted often leads to an absence of the prime contractor, for periods of time of his choosing, resulting in a situation where the government inspector is sometimes placed in the position of being the superintendent for any subcontractor working during these absences. NAVFAC might develop better

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*From the questionnaire (Appendix, question 7, page 34) control by requiring the contractor to make and adhere to PERT Critical Path Method (CPM) charting, particularly for major or unusual line items. Training NAVFAC construction management personnel in the use of PERT control methods should certainly be considered as a partial answer to this problem. CPM ought to be feasible for contracts above $500,000.

III. RESOURCE ALLOCATION

A. Methods

Each fiscal year represents a new set of "boundary conditions" for the allocation of inspection personnel among the ROICC Offices by the responsible EFD. The situation is something like the following: Congress authorizes a certain number of construction "line items". The total amount of new construction money available to the U. S. Navy is different than the previous year's total. A fixed percentage of the line item total is available to NAVFAC to administer the construction, not only of line items, but of several other (non-paying) categories of construction. Meanwhile there is a different total of money remaining on the books from last year's construction which has not yet been disbursed, and not all of these remaining funds will necessarily be used during the current year. Location and concentration of the new construction may change significantly among the existing ROICC Offices and may require the creation of new ROICC Offices and the closing of existing ones.

Normally 6% of the line item budget allowed by the Congress is budgeted for Supervision, Inspection and Overhead (SIOH). Within CONUS, the breakdown of the allocation of these funds is, roughly speaking, into thirds. One third is retained for use outside the EFD structure, about one third for EFD Construction Administration and support personnel assigned to either the EFD or the ROICC Offices and about one-third applied directly to the salaries of the inspectors and their supervisors. Thus, about 2/3 of these SIOH funds are overhead. Two realities modify this situation somewhat: ROICC and AROICC salaries are not paid out of these funds and it was observed that a substantial percentage of the time of these CEC Officers is spent in professional engineering support activity of direct benefit to the Navy's prime interest of useful, high quality, expeditious construction. Some junior officers with mechanical and electrical engineering backgrounds have been especially valuable where technicians were not readily available or were needed elsewhere. The other reality is that, whereas the Military Construction Line Items provide the funds to pay the inspection staff salaries, the many time consuming, generally small, contracts such as O&MN and informals do not contribute to the expense but, altogether, require a substantial percentage of the inspector's time (See IIC above).

The allocation of resources (primarily the civilian inspection staff) among the ROICC Offices by the EFD is actually quite a different problem from that of their efficient utilization (specific contract assignments), once the personnel have been assigned to the ROICC. The ROICC problem is dealt with first.

The problem of the efficient utilization of the existing (assigned) civilian staff is one which is traditionally and in fact solved by each ROICC officer according to his appraisal of the unique local situation. This has, of course, led to many different approaches to similar problems. At the large Area ROICC whose entire supervisory and technical staff was surveyed by the questionnaire, a quantitative approach to the assignment of Inspectors to new work has been used. Six factors are considered formally when the supervisor is faced with the problem of choosing among two or more inspectors in the assignment of new work. These factors are weighted somewhat differently relative to each other:

<u>Factor 1</u>: (relative weight 3) Availability.

Considering his other assignments, is the inspector available for assignment to the contract in question?

<u>Factor 2:</u> (relative weight 4) Grade level compatibility.

If assigned to this job would the resulting workload be in harmony with the grade level of this inspector? Rank higher to the degree to which either an under or overload is avoided.

<u>Factor 3</u>: (relative weight 1) Compatibility with project.

Consider his past or potential relationship with the contractor. Does his previous experience in or out of government service make him a particularly good choice for this assignment?

<u>Factor 4</u>: (relative weight 1) Job-site knowledge.

Is the proposed inspector familiar with the location? Does he know the Navy people he must contact? Is he familiar with subsurface conditions?

<u>Factor 5</u>: (relative weight 1) Proximity to present work.

How much new travel time is involved?

<u>Factor 6</u>: (relative weight 2) Personal preference.

Are there any qualified volunteers?

The originating (Area) ROICC Office added 2 factors (5 and 6) and one unit each to relative weight factors 1 and 2, during a one year period. The technique for use of these factors in practice is illustrated by Table 2. Factor 2, grade level, is no longer used there

Table 2. Assignment of Inspection Personnel to New Work*

	Factors	Low	Average	High**
1.	Availability	3	6	9
2.	Grade Level Compatibility	4	8	12
3.	Compatibility with Project	1	2	3
4.	Job-site Knowledge	1	2	3
5.	Proximity to Present Work	1	2	3
6.	Personal Preference	2	4	6
		12	24	36

Poor Choice:	12 - 18
Satisfactory Choice:	19 - 28
Best Choice:	29 - 36

* All assignments to jobs over $500,000 are subject to approval by the ROICC, upon recommendation of the supervisor.

**Low, Average and High are obtained by multiplying the factor weightings (see text) by 1, 2 and 3, respectively. This choice is purely arbitrary and may be changed in practice.

since all inspectors are now GS-9's. The ROICC Officer who originated this plan is the one quoted in the previous section as saying that assignment depends upon who's available and who can hack it (for an inspection staff of 20). Such a comment could be abbreviated to "who's available" for an inspection staff of 5 to 10 or perhaps "how many reassignments is this new job going to require" if there are less than 5 people on the inspection staff. To quote reference 5 regarding the purpose of the system described above: "This system is intended to assist supervisors in assigning new work to the existing inspection force in an equitable and reasonable manner."

Further information on individual inspection assignments is provided by the questionnaire, page 38.

For the allocation of resources among the ROICC Offices by the EFD, one might wish to minimize the cost of construction management or maximize the efficiency of utilization of resources, subject to quantifiable factors which affect either the cost or the efficiency.* Since allocations must be made in advance, they should be of a predictable nature. In Table 3, modified from reference 6, is a list of ROICC resources with some of the affecting factors divided according to their predictability for the purpose of allocation among ROICC Offices. Note that the process implied by this table is iterative: namely, an approximate change in allocation must first be made in order to obtain the "predictable" factors which in turn determine the resource column, following which another correction is made, etc.

Most items in Table 3 should be self-explanatory. Geographical dispersion is used in several senses:

1. Territory covered by an individual inspector,
2. Total dispersion of the ROICC Office jurisdiction,
3. Travel required of Engineers in Charge (EIC), technicians and Supervisory Engineers out of the EFD.

*The choice to be made here largely depends upon the nature of the data available.

Table 3. Factors Affecting Significant Resources at ROICC Offices

Resource	Predictable Factors*	Unpredictable Factors
Construction Managers	Size of Construction Program** Complexity of Construction Work Contract Duration and Subsequent Construction Year Overlap Degree of Engineering Support Geographical Dispersion of Work Efficiency of Administrative Support Competency of Inspection Staff As a Whole	Quality of Constructor's Management Quality of Contract Documents Competency of Individual Inspector(s) to be Assigned to New Line Items
Construction Engineers	Size of Construction Program** Complexity of Construction Work Contract Duration, etc. Number of Construction Managers Geographical Dispersion of Work	Quality of Contractor's Management Quality of Contract Documents Competency of Individual Inspector(s) to be Assigned, etc.
Procurement Personnel	Size and Complexity of Local Program	Competence of Incumbents
Clerical Personnel	Size of Construction Program** Complexity of Program Program Duration and Subsequent Year Overlap Geographical Dispersion of Work	Quality of Contractor's Management Quality of Contract Documents
Construction Inspection or Surveillance Personnel	Size of Construction Program** Geographical Dispersion of Work Size of O&MN Program** Program Duration and Subsequent Year Overlap	Quality of Contractor's Management Quality of Contract Documents Competency of Individual Incumbents
Class III, Minor	Quantity of Clerical Personnel	
Property	Geographical Dispersion of Work Qualifications of Clerical Personnel	
Transportation Equipment	Quantity of Construction Managers Construction Engineers, Construction Surveillance Personnel Geographical Dispersion of Work	
Operating Budget for Material	Quantity of Clerical Personnel Quantity of Construction Managers (Telephone usage) Quantity of Transportation Equipment/Usage	

* Predictable by the Allocating Authority (EFD)
**Dollars and numbers of contracts

B. A Multiple Regression Analysis

A regression analysis, fitted to FY-71 data from 10 ROICC Offices in CONUS*, resulted in the following:

$$\tilde{N}_{I_1} = 0.75 + 0.81\,(WIP) + 0.02N, \qquad (1)$$

where the N_I is the number of construction inspection and surveillance personnel at the ROICC Office which managed N contracts and had WIP millions of dollars of work-(put)in-place during FY-71.**

A regression line, not using N, and fitted to the same data (less N, of course) yields the following:

$$\tilde{N}_{I_2} = 1.68 + 0.87\,(WIP)^{**} \qquad (2)$$

* See Table 4.

**$\tilde{N}_{I_j}$, j = 1 or 2, symbolizes the <u>estimate</u> of N_I which is made whenever (1) or (2) are applied to FY-71 WIP and N (or just WIP) for any NAVFAC (CONUS) ROICC Office (including the ones used to derive (1) and (2)).

Table 4. Regression Analysis Data

ROICC Office	WIP*	N*	N_I*	$\tilde{N}_{I_1}$***	$\tilde{N}_{I_2}$***	Estimated Quality of Data**
Wash., D. C. Area	11.7	96	14	12	12	G
Naval Academy	7.4	46	10	8	8	G
NATC, Pax. R., MD	6.2	17	4	6	7	G
San Diego Area	23.	115	22	22	22	F
Charleston Area	24.	115	21	22	23	F
Phila. NAVSHIPYD	11.	113	9	12	11	F
NADC, Johnsville, PA	1.2	75	3	3	3	P
Sewell's Pt. Area	11.	104	16	12	11	F
Little Creek, VA	3.5	21	4	4	5	P
Point Mugu, CA	6.5	104	6	8	7	G
TOTALS	105.5	806	109	109	109	

* See text for definitions (Section IIIB).
** G = Good, F = Fair, P = Poor. A grading of the NCEL effort (no reflection on the ROICC).
***Rounded to nearest whole number (of inspectors).

Equation (1) is the plane in 3 dimensional space (WIP, N, N_I), analogous to the familiar (x, y, z) rectangular cartesian space, which best fits the data in the sense of least squares. Equation (2) is plotted in Figure 1. The estimate of the population standard deviation, $\hat{\sigma}$, was 2.6 Inspectors for equation (1) and 2.5 Inspectors for equation (2).

No advantage is to be gained, in a statistical sense, by using equation (1) in preference to equation (2).* A possible reason for this is that WIP is the only factor universally considered by the 5 different (CONUS) EFD's when making assignments of inspection personnel to ROICC Offices, and since the data fit was history, history (FY71) is what equations (1) and (2) describe; thus, equations (1) and (2) are, strictly speaking, usable only with respect to the FY71 (pre-CQC) ROICC environment. The meaning of the word "prediction" on the curves indicated by the .95 (95%) Prediction Interval on Figure 1, may be interpreted as predicting that the FY71 data from the next ROICC Office to be visited (not one of the 10 for which data was collected) has a 19 to 1 chance of falling between the prediction curves drawn. Vertical lines have been drawn to indicate the limits imposed by the range of the data used and a short horizontal line has been drawn in the lower left corner because a "negative" number of inspectors is without meaning.

If this sample of 10 ROICC Offices is regarded as a random sample from an infinite number of hypothetical ROICC Offices that might conceivably have been operating under the same environment (NAVFAC, FY71), then the set of the two "inside" curves is merely the locus of all end points for a 95% confidence interval about an average N_I corresponding to any WIP. This does not mean all WIP taken simultaneously: It does mean that for any WIP one cares to choose, within the permissible range of WIP, the odds are 19 to 1 that the "true" regression line** will intersect the chosen value of WIP within the interval indicated by the end points of the 95% confidence interval. If one chooses any other WIP, then the odds are again 19 to 1, for a separate bet, that the confidence interval defined by the two new end points will describe the interval within which the intersection of the WIP line with the true line will occur. These odds do not apply to the probability that the true line might intersect the curves described by the locus of all confidence interval end points. Had there been time to visit all 100 CONUS ROICC Offices, to obtain the needed data,*** then the 95% confidence intervals would probably have been shorter and centered about a different line. The calculation of the "prediction" intervals for that case would not have been necessary since there would not have been a "next" ROICC Office to visit.

An unexpected result of equation (1) is its apparent applicability to small ROICC functions. For example, for a ROICC with 5 contracts and $250,000 WIP for FY71, equation (1) results in 1.05 or one inspector, whereas equation (2) yields 1.90 implying the need for two inspectors, which the EFD's would recognize as rather unlikely, in most cases.

Such equations as (1) and (2) can be used as rule-of-thumb or rough predictors for a short time into the future whenever basic conditions (salaries, duties, personnel, workload, ROICC Offices (their number, location and policy)), do not change very much. It should be noted, though, that the existence of CQC has very likely precluded such an application.

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* See Table 4.

** Unknowable, since it's existence is inferred from the existence of an infinite hypothetical ROICC Office population.

***Uniformity of definition of WIP and N was found to be very difficult in practice, thus requiring personal visits by the investigator.

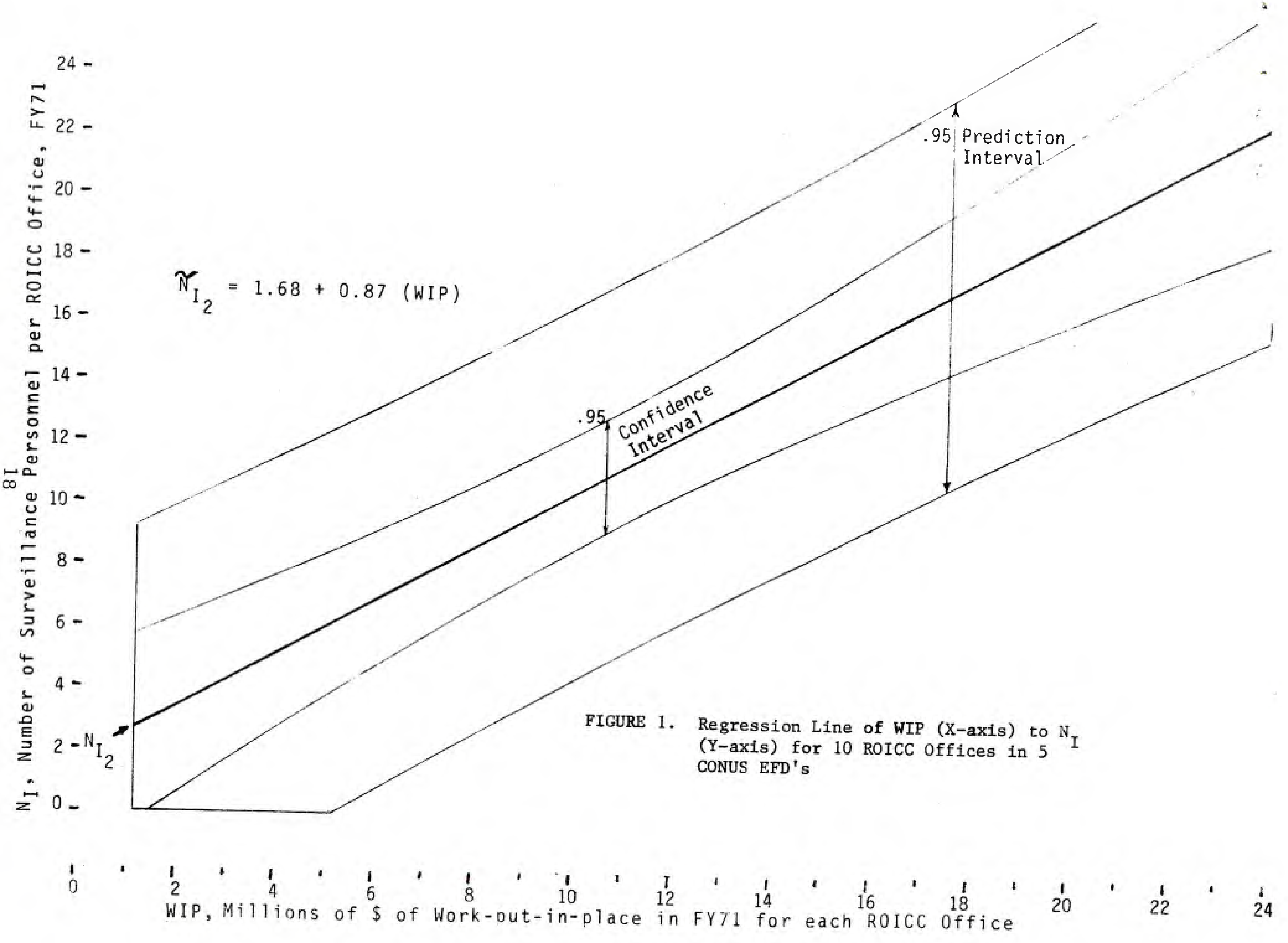

FIGURE 1. Regression Line of WIP (X-axis) to N_I (Y-axis) for 10 ROICC Offices in 5 CONUS EFD's

IV. ALTERNATIVE SYSTEMS

To obtain buildings suitable for the purposes of the Navy the government has available a wide choice of methods. The purpose of this section is to present a few alternatives from this spectrum of choices. Some of these alternatives are practical only for the distant future.

A. A Partial List of Alternatives

1. Contract with a single company which plans, designs and constructs; the turn-key approach, applied more extensively than at present. The arguments for this system are that:

    a. In case of dissatisfaction there is only one company with which to deal. The A&E cannot blame the constructor, nor can the constructor blame faulty design since both are part of the same company. This eliminates part of a three-person, negative sum adversary game.*

    b. Coordination between designer and builder, rather than adversary roles, should reduce overall cost.

    A different, and more sophisticated system of inspection would be needed because inspection would include an attempt to estimate total utility value of the structure. This would require a balanced judgment on the combined results of planning, design, construction and maintainability. There is no formal training for this, so the difficulty of the thinking required might be considered a valid argument against this system.

2. Combine under a single head all those current government offices now separately in charge of planning, contracting, architecture, construction, inspection, legal suits and maintenance. The advantages are:

    a. Efficient coordination with a common purpose from inception through actual utilization and ultimate demolition of the building. For example, in lieu of unenforceable contracts being written now by engineers, careful coordination between lawyer and engineer during negotiation would result in a stronger position for the government should suit be initiated.

    b. A significant overall reduction in direct administrative costs or a very substantial reduction by including many costs that do not now show per se in present accounting.

    c. Shortening feedback loops and establishing important lateral relationships not currently in existence.

    Possible disadvantages are those usually encountered in reorganization toward a smaller and more economical administrative staff.

3. Decrease drastically the amount of business done with contractors by allowing the government to become the <u>prime contractor</u> for planning,

---

*This terminology simply means that the owner, designer, and builder, combined, lose money to the adversary system in court actions.

designing and building the needed structures. This would eliminate the adversary system, but would require a considerably different type of staffing, and, most importantly, a new congressional philosophy of doing business. The Port of New York Authority has gone this route for the construction of their World Trade Center. The Defense Office Building project for replacement of the Main Navy and Munitions buildings is possibly the appropriate place for the Navy to do this.

4. Write an entirely different type of incentive contract wherein the designer and builder are paid an agreed amount upon completion and, additionally, yearly payments until the end of the serviceable life,* so that the total payment will be roughly proportional to the total usefulness of the building. The appropriate longevity would be built into the structures without the need for any government inspectors. There would be difficulty in finding construction corporations sufficiently financially sound to enter such an agreement unless a brokerage system for sale of rights upon completion developed rapidly. Additional implications of such a system would be multiple use, flexibly designed structures built according to performance criteria.[7]

5. Keep the present system, but bring the quality level of inspectors above that of the building trades by upgrading the pay and dignity of the inspectors. It does not seem to make sense to have a ten to thirteen-thousand-dollar-per-year man passing on the work of fifteen to twenty-five-thousand-dollar-per-year people. This system would increase inspection quality but retain the present adversary system.

6. Write contracts with earlier finishing dates and smaller percent completion payment schedules, leaving a much larger percentage for completion payment. This would tend to reward continuity of construction and unburden the inspector of the role of construction superintendent during lengthy periods of absence of the superintendent.

7. Eliminate the present inspection system, substitute a trained Engineer-Inspector or an inspection team whose role it is to help maximize the profit** to the government. The immediate task of such a policy change is to concentrate on scientific acceptance testing methods. Scientific Acceptance Testing is now recommended for highway construction by the Bureau of Public Roads.*** Cost of training and complexity of implementations are arguments against adoption of this approach.

8. A logical or feasible combination of some of the above.

---

* Preferably defined in the contract.

** Excess of cumulative value to the government throughout useful life over total costs from inception through disposal.

***See References 16, 17 and 18.

V. EVALUATION

Creative innovations are needed for NCIS. One thing which clearly needs to be done is develop new performance standards, possibly Engineered Performance Standards for construction inspection. However, before opening the Pandora's Box on performance standards it might be wise to try to get a perspective on the relationships among the management concepts pertinent to this study. Attention is invited to Figure 2.

A. The Management Cycle

Management processes have a cyclic structure which tends to follow the sequence illustrated in Figure 2. At some point in time, on some scale (from a five-man section to the several-million-man DOD), the need to (re-) initiate the management cycle is perceived. Just about every management effort directed to a task follows the steps illustrated either implicitly or explicitly. For routine matters every detail of the entire procedure is usually defined by fixed guidelines and policies of which the elements are more or less recognizable as similar to the 14 sequential steps of Figure 2. They may not always be in the same order and some may either be understood (established policy or common knowledge) or missing. The time required to complete an abbreviated planning, directing and control action could be very short.* On the other hand, the DOD reinitiated its attempt to measure output (step 12) after some 2 or 3 years.[8] Some cycles in Industry may take 5 to 10 years; and in some political or social institutions a generation or so.**

It should be understood that the exact formulation used in Figure 2 is not sacred but has been selected as descriptive of the author's five year acquaintance with the NAVFAC management environment and was strongly influenced by references 9 and 10. Table 5 provides some definitions and clarification of terminology. Note that a Management Cycle is effective roughly to the degree that it is a closed loop - a system aware of its own performance through feedback.[9]

B. Performance Standards

Applying these concepts to the problems at hand, we quickly, but not easily, come to the conclusion that our critical problem is to develop performance standards, following which accomplishment we can think about measuring the results (output) in a constructive and confident manner.

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* Perhaps only minutes on the first (lowest) level of management.

**The time scale for recycling on the top level of any large organization is probably related to the average tenure of top management.

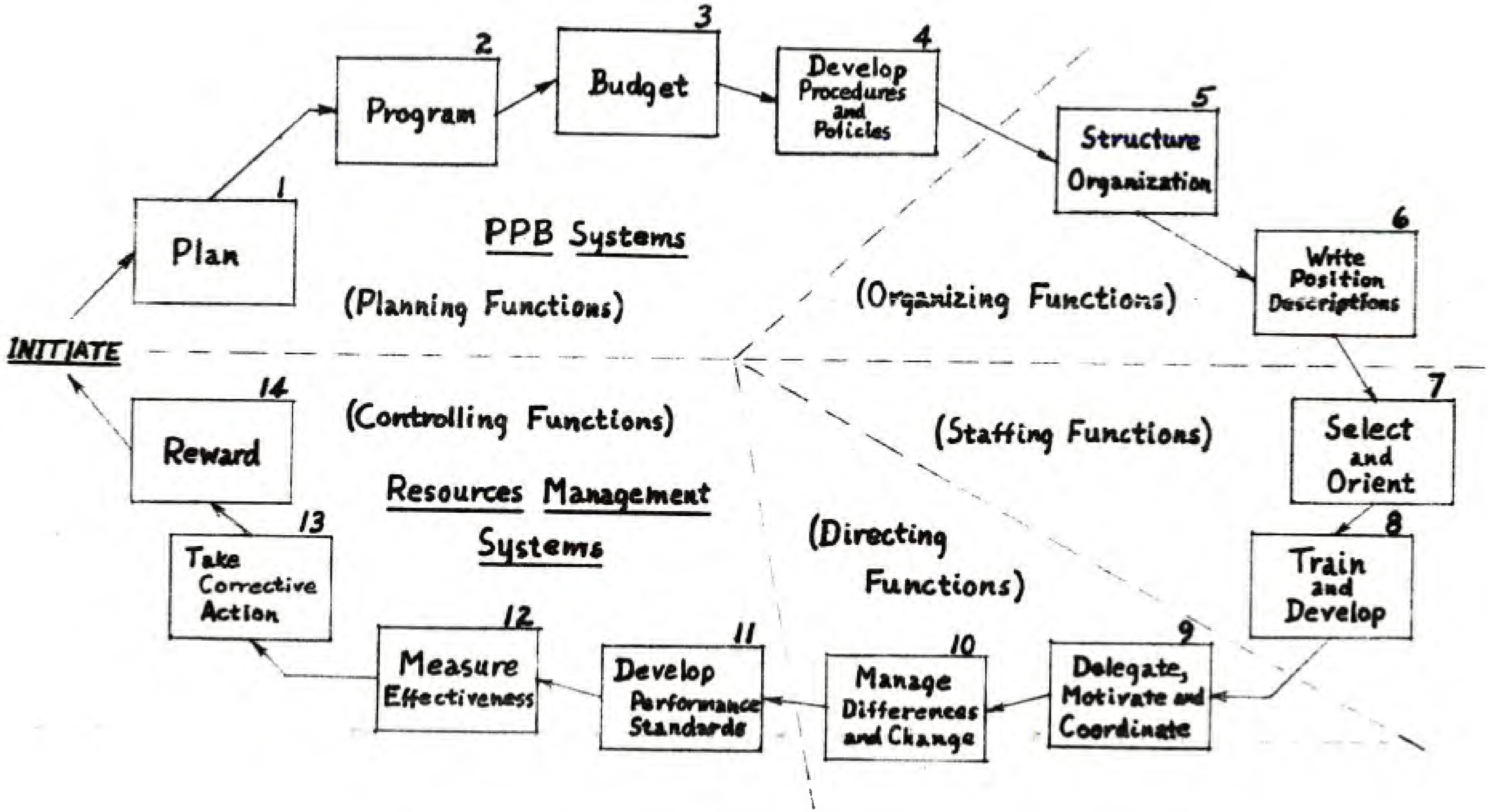

FIGURE 2. The Management Cycle.

Table 5.*

PLANNING FUNCTIONS

1. Plan. This function consists of 3 parts:
   a. Forecasting - where will the present course lead?
   b. Define Objectives, Goals - what does the mission require?
   c. The development of Strategies - how and occasionally when to achieve goals. Strategic planning is of the utmost importance.[11]
2. Program. The priorities, sequences and timing of the steps necessary to the achievement of the goals defined.**
3. Budget. A comprehensive look at all relevant differences in demands upon the available or anticipated resources must now be made to see what changes in allocation are needed.
4. Develop Procedures and Policies. Do new standards need to be devised and what are the required changes in the decision guidelines for important recurring matters. Will there be any new recurring matters?

ORGANIZING FUNCTIONS

5. Structure Organization. Will any change be necessary in the existing organizational structure? What changes might be anticipated for liaison?
6. Write Position Descriptions. For new qualifications or revise old relationships, responsibilities and authorities as required.

STAFFING FUNCTIONS

7. Select and Orient. Recruit if necessary, and inform the new people about their duties and environment.
8. Train and Develop. Proficiency is, of course, obtained most effeciently from instruction and practice through the inculcation of knowledge, attitudes and skills.

DIRECTION FUNCTIONS

9. Delegate, Motivate and Coordinate. Persuade and inspire but don't forget to relate efforts and demand accountability for results.
10. Manage Differences and Change. Resolve conflicts but not to the detriment of the creative environment.

CONTROLLING FUNCTIONS

11. Develop Performance Standards. What conditions will exist when essential duties are done well? What are the proper measures of effectiveness?
12. Measure Effectiveness. Determine variation from the standards.
13. Take Corrective Action. At this point the feedback to the planners must take place, and if necessary, the cycle repeated.
14. Reward. Can be negative as well as positive and is intimately connected to the whole cycle.

---

* Synthesized from references 9, 10 and 11.

** In PPBS this means dividing the mission into "programs" and thence "management by program"; a possible source of confusion, since these "programs" become accounting type controls. (a noun instead of a verb).

One of the pressing existing problems at NAVFAC is to develop these new performance standards so that a new cycle can be intiated by the planners. Additionally, the planners need these standards as guidelines for necessary changes in the allocation of resources (budgeting). The relationship among these needs is clarified, again, by reference to Figure 2.

The development of performance standards in the constructive sense* is not an operations research task but one requiring the somewhat different skills and training of industrial engineering.[12] Reference 13 represents an actual attempt to do something like this for the NCIS. Mr. McClellan, a consulting industrial engineer, chose three construction sites and spent 90 actual working days collecting the data required. Reference 14 was a letter to NAVFAC enclosing a revised Laboratory Program Summary (LPS) which changed the approach for the NCIS study. This LPS required that an analysis, more detailed than Mr. McClellan's, be done for ten times as many construction projects, requiring at least 900 mandays or more than four manyears of effort to gather just the data. The need for such a comprehensive, thorough study is clear, but equally clear is the necessity of committing a considerable amount of resources to such a project; therefore, it seems reasonable that the development of this type of approach beyond the stage reached in reference 13 be considered for the future.

C. Operational Improvements

The following is a simple listing of possible areas for NCIS operational improvements which developed out of the many interviews conducted. It is a rough consensus and is pre-CQC.

1. Weed out and discourage low performance contractors. The contractor selection and debarment process needs review.
2. Minimize administrative paper work especially for the inspectors. The inspector might keep a notebook or journal in lieu of the present reporting system.
3. Upgrade civilian personnel and the field organization itself.
4. Make improvements in electrical and mechanical systems as have been made in structural and architectural systems.
5. Improve the quality of technical supervision of inspectors, possibly through more technical training.

---

* A detailed breakdown of a task or job into its component parts (operations) with careful attention to the synchronization of those operations and the consumption of time in performing them. There are some 6000 of these for construction.

6. Make contract time extensions less liberal.

7. Provide stricter accountability of the designer for errors, omissions and changes. Feedback from the field should be increased.

8. Reduce involvement of inspectors in supervision of work on small contracts. Reduce number of small projects per inspector during seasonal peaks.

9. Level out seasonal workload variations where possible.

10. Improve claim administration.

11. Re-emphasize the ultimate responsibility of field personnel for finished product quality.

D. Conclusions and Recommendations

The results of Chapter III satisfy the intent of the original objectives to the greatest degree possible at this time and, somewhat more specifically, the final objective placed upon this study. The rest of this report contains ideas which might lead to fruitful results in future studies.*

It is recommended that further study not be initiated in this area until:

1. The new NCIS, namely CQC, has had sufficient time to "settle down" to routine practice.

2. A careful review of this report and its references has been made.**

The way to gather the data needed for a more meaningful analysis is to perform an experiment which systematically varies input parameters of interest, such as:

1. Inspection man hours,
2. Contract dollar value,
3. Type of construction,
4. Duration of the contract,
5. Contractor performance.
6. Number of contracts being managed at the same time by the ROICC offices, and
7. The geographic location of the offices.

Simultaneously, observe output parameters of interest such as:

1. Total cost of structures completed,
2. Yearly maintenance cost, and
3. Number of years of useful service.

---

* Some could be considered for application.

**Reference 20 is especially important in this context. Statistics applied to construction inspection is discussed in references 16, 17 and 18.

The reason such an approach must be used is that we have to know more than just simple correlation. We have to know cause and effect in order to determine which variations are cause (independent variables) and which are effect (dependent variables). Such a study would require a great deal of careful thought; that is, we would need to design the experiment with great care within the constraints determined by what is possible. But having decided (designed and performed the experiment) we would then be in a position to determine whether or not a greater number of man hours of inspection is buying less yearly maintenance cost and/or less total cost of completed structures and/or more years of useful service. We might find that fewer inspection man hours would result in less total cost of structure plus yearly maintenance, but fewer useful years of service. In plain language, it might be possible to learn something about the "trade-offs" involved in utilizing more (or less) inspection man hours.

The following is based on Section VA, above.

PPBS for ROICC Inspection Assignments

1. Plan the Desired Objectives.

The objective is given: See that the structure is completed according to the Plans and Specifications.

2. Program.

Establish the priority sequence and timing of steps to achieve these objectives. Unfortunately, these are determined largely by the timing of the contractor's PPBS steps. Programming is currently accomplished by bar charts and occasionally by PERT/CPM (increase CPM use).

3. Allocate (Budget) Resources. (Inspection Staff Assignments, primarily)

a. Who is available? and/or

b. Who is best qualified for the type of construction planned (and can he be reassigned)?

4. For the Measure of Performance or Effectiveness:

a. What degree of quality was obtained?

b. Did the structure meet Plans and Specifications criteria?

c. Later: What is the O&MN cost?

d. Much later: What was the useful life of the structure with regard to mission and/or intended design?

ACKNOWLEDGMENTS

Considerable factual and philosophical help was obtained from Mr. M. L. Eaton and Mr. J. A. South of the Naval Civil Engineering Laboratory, and the more than 120 CEC officers and civilians of the Naval Construction Inspection System who were contacted at 5 Engineering Field Divisions and 10 ROICC offices.

Special appreciation is due to those respondents to the questionnaire who took it upon themselves to compose comments which virtually amounted to essays on their problems and point of view.

Special thanks are due to Captain M. T. Mooney, Executive Officer, USNCBC, Port Hueneme, California (formerly ROICC, San Diego area), Commander T. Yoshihara, recently PWO, USNCBC, Port Hueneme, Commander R. B. Reeves, ROICC, Charleston Naval Base, South Carolina, Commander D. A. Morton, Executive Officer, USNCBC, Davisville, Rhode Island, Lieutenant Commander E. W. Thomas, Code 09AX, NORDIVNAVFAC, and Lieutenant (JG) W. J. Overton formerly AROICC, Point Mugu, California. Creative efforts of these CEC officers were borrowed in the eclectic sense, and published in a modified form in this report.

Acknowledgement should be made, also, of the exceptional interest and cooperation of the Division Directors for Construction at the five EFD's visited.*

The author also wishes to thank Professor Henry W. Parker, Civil Engineering Department, Stanford University, for information about the adversary structure built into construction inspection systems.

*PACDIV was not visited.

APPENDIX

RESULTS OF "QUESTIONNAIRE ON THE NAVY CONSTRUCTION INSPECTION SYSTEM"

(Summaries of responses are shown on a copy of the questionnaire)

Table 6. Responses in Order of Receipt

Order Received	Age (Bracket)	Yrs. Exp. (Bracket)	Number Of Quotes*	Respondent's Title (as given)
1	40-44	10-19	5	CDR, CEC
2	31	1	6	PWO
3	45-49	20-29	0	PWO
4	50-54	10-19	2	Constr. Engr.
5	25-29	0-9	4	UNK (CEC)
6	55-59	0-9	3	UNK (former contractor)
7	25-29	0-9	3	ROICC
8	20-24	0-9	5	AROICC
9	40-44	0-9	5	Supv. Civil Engr.
10	25-29	0-9	7	ROICC/AROICC
11	20-24	0-9	3	AROICC
12	25-29	0-9	9	AROICC
13	55-59	Over 30	4	Supv. Gen. Engr.
14	34	11	6	PWO/ROICC
15	20-24	0-9	7	AROICC
16	45-49	10-19	1	Engr. Tech.
17	55-59	20-29	5	OICC/ROICC
18	40-44	10-19	6	PWO/OICC/ROICC
19	Over 60	20-29	0	Supv. Constr. Rep.
20	30-34	10-19	3	LCDR, CEC
21	20-24	2	3	AROICC
22	25-29	0-9	5	APWO
23	45-49	10-19	6	Supv. Constr. Rep.
24	40-44	10-19	14	PWO/OICC
25	35-39	10-19	5	ROICC
26	25-29	0-9	3	AROICC
27	55-59	0-9	1	Resident Engr.
28	40-44	10-19	4	Supv. Civil Engr.
29	45-49	20-29	1	Supv. Civil Engr.
30	35-39	0-9	6	Qual. Assurance Officer

*Number of comments quoted in the summary communicated informally to the sponsor at NAVFAC. The order received number is used to identify the respondents.

Table 6. Responses in Order of Receipt (Cont'd)

Order Received	Age (Bracket)	Yrs. Exp. (Bracket)	Number of Quotes*	Respondent's Title (as given)
31	45-49	9	1	Supv. Civil Engr.
32	30-34	0-9	4	PWO/OICC/ROICC
33	40-44	10-19	5	OICC/ROICC
34	40-44	10-19	14	Area ROICC
35	25-29	0-9	4	Assist. Area ROICC
36	25-29	0-9	2	LT, CEC
37	25	2	2	AROICC
38	25-29	0-9	1	AROICC
39	25-29	0-9	11	AROICC
40	55-59	Over 30	1	Supv. Civil Engr.
41	25-29	0-9	5	Supv. Civil Engr.
42	25-29	0-9	2	Civil Engr.
43	58	14	3	Supv. Constr. Rep
44	Over 60	Over 30	1	Supv. Constr. Rep.
45	50-54	0-9	0	Engr. Tech.
46	40-44	10-19	13	Supv. Civil Engr.
47	45-49	20-29	9	PWO/OICC/ROICC
48	20-24	0-9	3	AROICC
49	Over 60	Over 30	0	Supv. Civil Engr.
50	50-54	10-19	5	Supv. Civil Engr.
51	40-44	0-9	2	PWO/OICC/ROICC
52	45-49	0-9	5	Supv. Civil Engr.
53	50-54	20-29	7	REICC
54	35-39	9	12	OICC
55	58	20-29	12	Constr. Rep. (Gen.)
56	40-44	20-29	0	Supv. Constr. Rep.
57	Over 60	20-29	0	Civil Engr.

*Number of comments quoted in the summary communicated informally to the sponsor at NAVFAC. The order received number is used to identify the respondents.

Naval Civil Engineering Laboratory
Port Hueneme, California 93043

QUESTIONNAIRE ON THE NAVY CONSTRUCTION INSPECTION SYSTEM

Date: June 1971 (date of survey)

In answering the following questions please keep in mind that they are to be evaluated in the context of improving the Navy's Construction Inspection System. You are under no obligation to make comments, but space has been provided and you are encouraged to do so if you wish.

Respondents: 31 CEC Officers: 17 Engineers; 6 Supervisory Construction Representatives; 2 Engineering Technicians; 1 Unknown/Total: 57

Number of years experience in present type of assignment or employment:

0-9	29
10-19	15
20-29	9
Over 30	4
TOTAL	57

Your Title: ____________

Your Age:

20-24	5
25-29	13
30-34	4
35-39	3
40-44	10
45-49	7
50-54	4
55-59	7
Over 60	4
TOTAL	57

GLOSSARY

1. Turn-Key Project: Where one organization, based upon the user's requirements, handles the total project including planning, design and construction.

2. Proprietary Specification: Specific items are identified by manufacturer and identification number.

3. Performance Specification: Operational and component characteristics are identified but no manufacturer is specified.

4. Submittal Checking Procedure: A procedure through which the contractor submits to the ROICC office, prior to purchase, and/or installation, a detailed listing of major contractual elements which are covered in the plans and specifications.

5. CQC (Contractor Quality Control): A new procedure in U. S. Navy Shore Facility construction which places more responsibility for control of quality on the contractor. Currently being implemented for projects in excess of $1 million.

1. Some A & E firms have indicated that they would like to be required to participate in the supervision of construction of a facility. The general feeling is that they could:

(a) Prevent and/or resolve problems quickly

(b) Improve the quality of the end product

At your location, have A & E's expressed the same view?

Yes 13 Blank/Don't know 2
No 25 (total of 40 ROICC Offices)

Do you feel A & E participation would be beneficial?

Yes 32 Blank/Don't know 1
No 22 Yes and No (Depending) 2

Comment:

Actual experience with this was indicated by only 4 of the 40 different ROICC Offices returning at least one questionnaire. These 40, all in CONUS, represent about 40% of all CONUS ROICC's.

2. Could the construction industry produce superior facilities in terms of lower cost and more functional effectiveness if the Navy were to make wide use of "Performance Specifications" for facility requirements?

Yes 31 Blank/Don't know 3
No 22 Yes and No (Depending) 1

Comment:

Do you feel that a proprietary specification would be better?

Yes 42 Blank/Don't know 1
No 13 Yes and No (Depending) 1

Comment:

3. Have construction contractors initiated and maintained any quality control programs in your area, prior to CQC?

Yes 8 (Misunderstood Question 1
No 31 (40 different ROICC Offices)

Comment:

4. What training programs are regularly available and utilized by the government inspection personnel?

Of the 40 ROICC Offices:
33 had from 1 to 4 training programs
4 claimed no training program
3 gave no information

(9 different types of programs were described, including On-the-Job-Training)

5. What are the comparative advantage of a turn-key project?

Of the 40 ROICC offices only 10 had had any turn-key projects within the experience of the respondent.

Do the owners find the finished turn-key product acceptable?

4 of 10 said "yes"

If not what % don't? 50%: 2; 20%: 2; Some: 1; "too early to tell": 1

Comment on the monitoring system used:

6. With the goal of achieving the highest quality in construction project, do you consistently have problems in one or more of the following areas? Rank (1, 2, 3, etc.) starting with area of greatest problems. Only 2 of 57 returns left this blank.

	Rank	1	2	3	4	Comment		
Design	1st	41	5	6	2	77/54	=	1.43
Construction	2nd	8	24	15	3	113/50	=	2.26
Inspection	4th	4	17	24	6	134/51	=	2.63
Other (specify)	3rd	1	8	3	2	34/14	=	2.43

7. Does the problem of known "bad" contractors being the low bidder exist in your area?

Yes 41 Blank/Don't know 3
No 13

a. If yes about what percent of the time does this happen?

18% (17.95% from 39 giving numbers)

b. If yes, do you have difficulty in awarding to a more responsible contractor (above low bid)?

Yes 32 Can't be done 4
No 0 Blank/Don't know 5

c. Would a simple procedure to identify a "bad" contractor improve the overall class of contractors?

Yes 36 Blank/Don't know 1
No 7 (3 yes answers were given to 7c. by those otherwise claiming "no problem"

Comment: See pages 5 and 6 of this report for a sample of comments on this question.

8. Do you feel the present system of construction inspection justifies its cost?

Yes 41   Blank/Don't know 3
No 12   Yes and No (Depending) 1

Comment:

9. Are the specifications generally easy to coordinate with the plans?

Yes 44   Sometimes 1
No 12

Comment:

10. Should inspectors be engineers or subprofessionals or a mixed team?

Engineer 2

Subprofessional 16

Mix (specify) 38

One respondent recommended a mix of Engineers and Technicians and another a mixed team of specialists.

Comment:
Nine of 38 checking mix specified the % of Engineers in the team. This worked out to be 30% Engineers, or about 1 Engineer to every 3 or 4 inspectors....range was from 10% to 50% Engineers.

11. Would a different number of inspectors at the current grade level result in substantially better construction quality?

Yes 27   Blank/Don't know 2
No 25   Depends 3

Would this number be

more? 27

or less? 0

What are the current grade levels for inspection personnel?

Comment:

Only 5 ROICC offices responding have any inspectors below the GS-9 level.

12. It is generally recognized that "feedback" of information from construction personnel to design personnel is desirable.

a. Is it being accomplished in your locality?

Yes 50 Blank/Don't know 3
No 4

If yes,

b. Should there be a greater volume of feedback?

Yes 43 Blank/Don't know 7
No 7

c. Describe, briefly, how it is being done currently.

(See text, pages 6 and 7)

d. How do you think that this feedback process is best accomplished?

(See text, pages 6 and 7)

13. Have you had any experience with CQC?

Yes 16

No 24

# of contracts	?	1	2	3	4	total
# of responses	2	5	6	1	2	16

If yes,

a. How many contracts to date? (above)

b. Check effect CQC has had on the present inspector workload.

Considerable 4

Little 3

None 4

Increase 6

Decrease 0

Left Blank 1

Don't know yet 2

c. Do we get better buildings with CQC?

Yes 0

No 8

Too early to tell yet 8

Comment:

In 13b. 3 respondents checked both considerable and increase,
1 respondent checked both little and increase,

accounting for the total of 20 from 16 respondents.

14. How often have you observed a structure being used for a purpose completely different from its original intent?

Frequently 10

Seldom 33

Never 8

Blank/Don't know 6

How long, after completion, does this occur? 30 responses.
Average
9.3 years (Range from 0 to 30 years)

How many times during its useful life do these changes occur?
18 respondents gave answers ranging from 1 time to "many". The average of the 14 numerical answers was about twice (2 1/7) ranging from 1 to 4.

15. Do you have a system or a policy for assignment of inspectors i.e. planning, programming and scheduling of the inspection of construction?

Yes 45 Blank/Don't know 4
No 8

If yes, please check which of the following are taken into account, in a quantitative sense:

1st	(a)	type of construction,	43
4th	(b)	level of complexity of construction,	34
	(c)	size of contract ($),	25
	(d)	type(s) of materials used,	14
	(e)	materials testing involved,	10
	(f)	level of quality of plans and specifications,	5
	(g)	level of quality of the contractor,	16
3rd	(h)	level of experience of the inspector(s),	38
	(i)	degree of motivation of inspector(s),	24
5th	(j)	degree of responsibility required of inspector(s),	33
	(k)	inspector's travel time to site (geographic dispersal),	22
	(l)	seasonal workload patterns,	13
	(m)	weather,	1
	(n)	climate,	2
	(o)	work in place ($WIP) rate,	15
	(p)	labor share of WIP rate,	2
	(q)	materials share of WIP rate,	2
	(r)	effect of inspector interaction with contractor,	24
	(s)	effect of inspector interaction with owner,	18
	(t)	effect of owner interaction with contractor,	10
2nd	(u)	number of contracts managed by each inspector.	39

Comment: (See text pages 7 and 8)

16. Presently $WIP (rate) is used for determining allocation of $SIOH. If $LABOR or hours labor on each project were used instead of $WIP do you believe that a more accurate allocation of $SIOH might occur?

Yes 28
No 17

Blank/Don't know 10
No effect 2

Comment:

17. The following are considered to be a list of essential Inspection functions which are thought to have a potential effect on quality of construction. About what % of their time do your inspectors spend on each type of action?

		%
(a)	Safety enforcement	3 1/2
(b)	Plans & specifications review	7
(c)	Pre-award surveys	1/2
(d)	Pre-construction conferences	1 1/2
(e)	Job planning	3
(f)	Paper work functions (sub-total: 13)	---
(1)	Inspector's daily report	8
(2)	Material testing reports	2
(3)	Change order logs	1 1/2
(4)	Submittal logs	1 1/2
(g)	Determining partial payments	3
(h)	Monitoring progress schedules (Bar Charts, CPM, etc.)	2 1/2
(i)	Obtaining shop drawings & determining equipment warranties	2 1/2

			%
(j)	Change order negotiations		3
(k)	Acceptance inspections		4
(l)	What % of their time is spent on non-productive and administrative actions (such as labor interviews, other paper work, photographs, tours, etc.)?		6 1/2
		TOTAL	50%

Please go back and check that one action which is most difficult to do.

Comment:

Based on 51 responses. The other 50% of the inspector's time is spent on standard surveillance and other inspection matters.

Safety enforcement, plans and specifications review, paper work functions, change order negotiations and job planning, in that order, were considered to be the most difficult to do. All other items combined received only 9 of the total of 44 check marks.

18. What are the 5 best steps that the U. S. Navy can take to improve the level of quality of construction of its Shore Facilities? Please number them in order, starting with 1 for the best. Your 5 choices do not have to be taken from this list (a to z). Please feel free to include your own ideas at the end of this list, and rank them with the others. (Check-marked rankings are for actions which might lead to a decrease in quality.)

Construction:

		Rank	1	2	3	4	5	✓
10th	(a)	Hire more inspectors	4	2	1	1	4	5
	(b)	Raise the GS level of the inspectors	2	3	2	0	0	5
9th	(c)	Extend the inspector career ladder upward	2	1	2½	4	3	3
	(d)	License inspectors	1	2	2	1	1	1
3rd	(e)	Require more training for inspectors	5	3	4	4	3	0
✓ (3rd)	(f)	Hire younger inspectors	0	2	1	1	1	11
✓ (4th)	(g)	Assign more young CEC officers	1	1	0	2	0	8
8th	(h)	Assign more experienced CEC officers	0	3	2	2	2	0
5th	(i)	Hire more Civil Engineers for ROICC offices	1	3	5	3	2	0
	(j)	Improve the techniques for assignment or scheduling of inspectors	1	1	3	1	1	0
4th	(k)	Feed more information on construction experience back to design personnel	1	2	3	6	7	0
✓ (1st)	(l)	Standardize the ROICC office organization throughout the Navy	0	0	0	1	2	16

Planning:

			Rank 1	2	3	4	5	√
	(m)	Consider the actual utility of the finished structure relative to its purpose and <u>total</u> cost	1	0	1	2	1	1
6th	(n)	Clarify owner's requirements (written and verbal)	1	3	2	7	2	0
	(o)	Consider that use of facilities after completion compared to use planned originally may be different	0	1	0	0	0	4
√(2nd)	(p)	Use A & E's more to resolve conflicts between owner and builder	0	1	0	2	3	13
		● Suggestions by Respondents...	5	2	3	1	1	0
		● Left Blank by Respondents...	0	0	0	1	2	21
Design:		Place more emphasis on:						
	(q)	Appropriateness of design to its intended use	1	1	2	0	1	0
	(r)	Quality of architectural design	0	1	1	1	0	0
	(s)	Quality of structural design	0	1	1	0	1	0
7th	(t)	Quality of mechanical design	2	3	2	2	0	0
	(u)	Quality of electrical design	1	0	3	1	2	0
2nd	(v)	Accuracy of architectural drawings and plans	6	7	3	2	2	0
1st	(w)	Accuracy of specifications and compatibility with plans	12	8	$4\frac{1}{2}$	4	1	0
	(x)	Accuracy of A & E construction cost estimate	0	0	0	0	1	1
	(y)	Functional adequacy of facility design	2	0	0	1	6	1
	(z)	Satisfying owner/user	2	0	3	1	2	4

Rankings are determined by the point system defined below. The points for check marks were selected to cancel a positive choice, on the average. Note the rather striking difference of opinion on items (a), (b), (c) and (z).

Now go back over this list and place a <u>check mark</u> beside every action which, in your opinion, might lead to a <u>decrease of quality</u>.

Comment: 51 useful responses. Ranked according to points obtained from the following scoring system:

Respondent's Ranking	1	2	3	4	5	√
Points	5	4	3	2	1	-3

(See text, page 8, for quoted commentary)

19. In your opinion, is the present Shore Facilities system, from recognition of the need for a structure to its ultimate demolition, a good one?

Yes 27 Blank/Don't know 9
No 21

if not, where would you change the system? (26 responses)

1st	(a)	planning system	18
	(b)	architectural design	4
2nd	(c)	plans and specifications	10
3rd	(d)	bidding practice	8
	(e)	inspection methods	2
	(f)	training of inspectors	2
	(g)	policy for paying contractors	1
	(h)	adversary proceedings	3
	(i)	O&M methods and procedures	3

Please comment on any items you may have checked, or add to the list:

(j)	Funding	1	3 added to list
	"response time too long"	1	
	delays in EFD	1	

(Five people checking "yes" also indicated where they would like to change the system.)

20. Who should provide the funding for the assurance of the adherence to labor laws?

Department of Labor 53 Blank/Don't know 3

Other government department 0 Other (please specify) "Procuring Agency" 1

21. Concerning Quality Control of materials

(a) Is the present material quality control procedure satisfactory in terms of producing reliable results?

Yes 32 Blank/Don't know 12
No 13

(b) Should there be an expanded effort in this area?

Yes 24 Blank/Don't know 17
No 16

If yes, by how much? 45 % (19 responses - range 5 to 100%)

(c) Would increased quality control of materials decrease lifetime maintenance costs?

Yes 34 Blank/Don't know 16
No 7

Comment:

At the 40 ROICC's:

22. Is the number of construction representatives or inspectors on your staff less than 5 people?

Yes 22 (55%)
No 18

Is the clerical staff available for the ROICC function less than 5 people?

Yes 36 None 1
No 3 (8%)

Is your total ROICC function staff, military and civilians, less than 5 people?

Yes 12 Exactly five 4
No 24 [Total staff $\leq$ 5: 16 (40%)]

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