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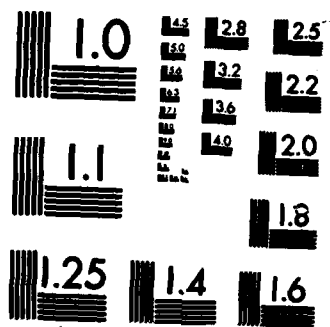
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NAVAL POSTGRADUATE SCHOOL

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THESIS

ANALYSIS OF LOW BIDDING AND CHANGE
ORDER RATES FOR NAVY FACILITIES
CONSTRUCTION CONTRACTS

by

James R. Rosmond

June 1984

Thesis Advisor:

D. C. Roger

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**Analysis of Low Bidding and Change Order Rates for
Navy Facilities Construction Contracts**

by

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Lieutenant Commander, United States Navy
B.S., University of Washington, 1974

Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

One of the principal concerns of Government contract administration is the proper control of change orders. They are useful in resolving problems that would otherwise inhibit the satisfactory completion of contracts, but their overuse is an unnecessary drain on public funds. The purpose of this thesis is to evaluate what effects bidders of fixed-price Government construction contracts have on contract prices when the level of competition intensity increases. It is suggested that in a climate of intense competition, the winners of bid awards are usually not only willing to assume the risk of losing profits, but also are willing to improve their financial positions through excessive use of contract change orders. This premise is tested against a sample of actual construction contract data from the Western Division, U. S. Naval Facilities Engineering Command. Several conventional measures of the level of competition intensity are applied in regression and variance analyses.

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I. INTRODUCTION

The U. S. Government enters into a large number of contracts with the private sector because it has an interest in encouraging private action to accomplish its goals. Contracts are written, agreed to, and executed with the purpose of fulfilling the needs of Government agencies. In doing so, however, many contracts experience cost overruns because of imperfect wording of contract provisions, technical difficulties experienced by contractors, changes in Government mission requirements, or other reasons.

One cause of cost overruns is the change order--a modification issued unilaterally by a Government contracting officer directing the contractor to make changes within certain regulatory limits. The change order is issued during the life of the contract and usually directs certain actions in exchange for compensation to the contractor. The intent of the change order is to benefit both the Government and the private contractor in seeking equitable solutions to otherwise untenable situations. The change order is considered a tool of the Government to provide flexibility during contract administration, but its value is fully realized only when used with restraint. Contract managers sometimes permit change order to be used excessively, especially when they make liberal or lenient interpretations of change order regulations and policies.

The contractor is motivated by the need to survive and to make profits. It is understandable that changes to a contract would be priced at a premium if the prices were solely determined by the contractor, so payments for changes are negotiated at what is considered to be "equitable

adjustment."¹ Critics of Government overspending cite instances of wasteful overruns on Government contracts as testimony to the mismanagement of funds. It is the Government's duty to use these funds strictly for the public good. Since private concerns are subordinate to the public good, the Government has an equal interest in assuring that private individuals do not benefit at its expense.

The process of cost overruns may be exemplified in Government construction contracting by significant numbers of change orders. Construction contracting is unique because virtually every facility differs from others in terms of function and description. Whenever a new and creative architectural concept is expressed in a set of drawings and specifications, it is difficult to insure that all the details are flawlessly coordinated.

This thesis will analyze problems associated with change orders for construction contracts and attempt to identify variables that significantly affect change order occurrences. The motivation of contractors is of primary concern in determining whether they have been successful in attaining profits and in improving their positions as a result of overreliance on changes to contracts.

Chapter II provides a background for the concepts of competitive bidding and contract change orders. A perspective of the bidding contractor is taken to examine his motives and strategies prior to bidding. Several measures of "level of competitiveness" are introduced from bidding theory literature that will be employed in the analysis chapter of this thesis. The means by which change orders

¹The determinant of what constitutes an "equitable adjustment" has never been objectively qualified or quantified. It is construed in the ordinary meaning to connote a "fair," "reasonable," "just," or "right" arrangement or settlement.

can be made are examined. The general hypothesis of this thesis is then presented after the reader is introduced to these concepts.

Chapter III is the presentation and analysis of a model constructed of actual data from one of the Naval Facilities Engineering Command's (NAVFAC) Engineering Field Divisions (EFD). Recently awarded construction contracts of Western Division, Naval Facilities Engineering Command (WESTDIV) are analyzed using the concepts introduced in Chapter II. Appendices A and B provide a description and listing of the variables used for the analysis.

Chapter IV summarizes the thesis and the findings discovered in analysis. In addition, some general conclusions are made which are either supported by the findings or which attempt to explain inconclusive results. Finally, recommendations for future, related research are made.

II. BACKGROUND

A. GENERAL

1. Competitive Bidding

The Department of Defense (DOD) is the largest contracting agency in the federal government, with annual awards running well over \$100 billion in the early 1980's. By the end of the decade this figure is likely to double. Congress and others concerned with federal spending and accountability have paid particularly close attention to DOD because most of this money is spent noncompetitively. In Fiscal Year 1981, of \$105.2 billion worth of prime contracts, only 7.6 percent of this money was involved in competitively-awarded contracts [Ref. 1: p. 106].

This concern generated the creation of the Office of Federal Procurement Policy as an agency to prescribe regulations and policies for federal procurement that would foster more competitive pricing [Ref. 1: pp. 241-245]. The Federal Budget in 1982 projected total government outlays for shore facility construction and rehabilitation in excess of \$30 billion [Ref. 2: p. 1]. The Navy Department's share of this amount was approximately \$830 million.² The Naval Facilities Engineering Command (NAVFAC), which administers most of this money, traditionally awards its construction contracts on a competitive, lump-sum basis. Competitive procurement then, is a consistent practice among the few.

²The Federal Budget projected this amount for Fiscal Year 1982 Navy Department Military Construction outlays. This included money for for active and reserve Navy and Marine Corps components. It did not include construction funded from other sources, such as Non-Appropriated Funds, Defense Family Housing, and Operations and Maintenance appropriations.

Competitive bidding, however has not escaped criticism. Former General Counsel for the Department of the Navy F. Trowbridge Vom Baur once argued during a Senate hearing that fierce competition is not in DOD's interest because it forces contractors to offer "bare bones" prices that could cause them to go out of business. As a result the contractor, Vom Baur stated, is forced to find a way to recover any foregone contingency for claims after the contract is awarded. This could be done he claimed, as a result of changes desired by the Government during the performance of the contract work. Furthermore, he contended that competitive procurement attracts only "marginal producers" interested in low profit business. Referring to complex systems procurement, he explained that claims would occur more often when contracts are competed than when they are negotiated. [Ref. 3: pp. 120-121]

A supporting argument is that the competitive bidding process carries with it a heavy financial burden on the Government and spawns some ridiculous practices. "Competitive bidding causes government to be a bad customer and, therefore, get bad treatment from the vendor." The contractor is obliged to cut services where possible and act particularly stingy and uncooperative when the contractor learns that some significant feature or requirement was left out of the original contract documents. [Ref. 4]

Ample testimony has been given to refute the criticisms of competitive bidding [Ref. 5]. Senator Proxmire challenged Vom Baur's statements with convincing counterargument. Nevertheless, a competitively bid, fixed price contract imparts more risk upon a contractor than any other common form of contractual agreement. The "Changes" clause in Government contracts was therefore adopted for the mutual benefit of the contracting officer and the contractor [Ref. 6: p. 38].

2. The "Changes" Clause

The concept that the Government should have the right to order changes to the work under a contract has been a part of the Government contracting process for years. The "Changes" clause (see Figure 2.1) gives the Government the flexibility to purchase work or effort directly from an existing contractor without the necessity of following the statutes which require procurement pursuant to the formal advertising method. Provided a change is "within the general scope of the contract," a Contracting Officer may bypass a great deal of administrative effort by negotiating the cost of a work change directly with the original contractor.³

The "Changes" clause also serves a useful purpose in allowing contractors a means of initiating changes when errors in the drawings and specifications or special problems in site conditions are encountered. Some Government officials have been concerned that a contractor can utilize this clause as a vehicle for improving his position under a contract where a loss is being incurred either because of a substantial underbid or a variety of other reasons. The contractor is in a strong bargaining position knowing that there will be no price competition. [Ref. 6: pp. 38-39]

A "Changed Conditions" clause was originally incorporated into the Armed Services Procurement Regulation (ASPR)⁴ to discourage construction contractors from

³A change order will be defined herein as a means of ordering variations, changes, and additions to the work under contract within the normal authority of the NAVFAC Engineering Field Division. Therefore Supplemental Agreements and change orders that, when added to existing change orders on a contract, exceed one hundred percent of the original contract price shall not be included. Field ROICC's are not authorized by NAVFAC to exceed this percentage.

⁴The ASPR, adopted in 1947, was replaced by the Defense

**STANDARD FORM 23-A CONSTRUCTION CONTRACT
CHANGES CLAUSE**

CHANGES (1968 FEB)

(a) The Contracting Officer may, at any time, without notice to the sureties, by written order designated or indicated to be a change order, make any change in the work within the general scope of the contract, including but not limited to changes:

- (i) in the specifications (including drawings and designs);
- (ii) in the method or manner of performance of the work;
- (iii) in the Government-furnished facilities, equipment, materials, services, or site; or
- (iv) directing acceleration in the performance of the work.

(b) Any other written order or an oral order (which terms as used in this paragraph (b) shall include direction, instruction, interpretation or determination) from the Contracting Officer, which causes any such change, shall be treated as a change order under this clause, *provided* that the Contractor gives the Contracting Officer written notice stating the date, circumstances, and source of the order and that the Contractor regards the order as a change order.

(c) Except as herein provided, no order, statement, or conduct of the Contracting Officer shall be treated as a change under this clause or entitle the Contractor to an equitable adjustment hereunder.

(d) If any change under this clause causes an increase or decrease in the Contractor's cost of, or the time required for, the performance of any part of the work under this contract, whether or not changed by any order, an equitable adjustment shall be made and the contract modified in writing accordingly: *Provided, however,* That except for claims based on defective specifications, no claim for any change under (b) above shall be allowed for any costs incurred more than 20 days before the Contractor gives written notice as therein required: *And provided further,* That in the case of defective specifications for which the Government is responsible, the equitable adjustment shall include any increased cost reasonably incurred by the Contractor in attempting to comply with such defective specifications.

(e) If the Contractor intends to assert a claim for an equitable adjustment under this clause, he must, within 30 days after receipt of a written change order under (a) above or the furnishing of a written notice under (b) above, submit to the Contracting Officer a written statement setting forth the general nature and monetary extent of such claim, unless this period is extended by the Government. The statement of claim hereunder may be included in the notice under (b) above.

(f) No claim by the Contractor for an equitable adjustment hereunder shall be allowed if asserted after final payment under this contract.

Figure 2.1 Construction Contract Changes Clause.

including contingency allowances in bids for additional work possibly experienced in handling subsurface materials. It promised an equitable adjustment in contract price for additional work necessary to deal with unforeseen conditions. It could be employed only where both contractor and Government parties labor under a "mutual mistake of fact" concerning estimates or beliefs involved. Therefore, it was not the purpose of the Changed Conditions Clause to protect a contractor from his own errors of judgment or calculations. [Ref. 7: p. 19]

In 1968, a slightly revised clause was adopted dealing with "differing site conditions." This clause is incorporated into the General Provisions for Construction Contracts. In effect, this clause removes some risk from the Government by providing for an adjustment decreasing the price if the conditions are found to be better than expected. "Differing Site Conditions" replaced the former title "Changed Conditions" in the Standard Form 23-A (Contract Provisions for Construction Contracts) to describe more accurately the subject matter of the clause. [Ref. 8: p. 205]

There is no question that the "Changes" clause has been used for the purpose of improving the contractor's position. The Government has several ways to protect itself in this situation. The most common is to require adequate proof of claimed increased costs [Ref. 6: p. 39]. In general, the Government is insulated from contract price growth by explicit federal regulations binding contracting parties and policies that discourage excessive change orders.

Acquisition Regulation (DAR), which has since been consolidated into and replaced by the Federal Acquisition Regulation (FAR). The provisions for Changed Conditions, stated within, are still applicable as 10 U.S.C. 2301.

3. Change Order Rate

The change order rate is simply the percentage increase (or decrease) in contract price over the original award amount due to change orders. It is used specifically in this research to assess the impact of price changes irrespective of contract size. It has the advantage of placing all contracts under a normalized measure of performance. The corresponding disadvantage is that a given change order rate may have very different impacts on contracts of contrasting size. This raises the question whether the change order rate is a useful measure for assessing the performance of contract administration. For example, a ten percent increase in contract price for a small contract may be the result of one rather mundane change. A ten percent increase for a large contract, however, probably is the result of more complex problems for the contractor. The amount for these changes could involve complex construction methods that affect other portions of work, or the amount could be an accumulation of many minor changes. A number of small changes as opposed to a single larger one, has the tendency to spread disruptive effects throughout many phases of construction. This problem has been the subject of claims made by contractors for "impact" costs created by a "ripple effect," where a change disrupts the remainder of the contract work [Ref. 9: p. 46].

Keeping contract change orders within controlled minimums is one of NAVFAC's goals [Ref. 10: p. C-109]. Any realistic limit to change orders must be expressed as a goal, not an absolute. Many change orders are valid and prudent tools for accomplishing mission objectives. They are issued for various reasons, including correcting any errors or omissions in plans and specifications. They give the Government the flexibility to make convenient adjustments as

a result of inevitable errors, oversights, and changes in conditions or requirements. Yet Government agencies have been accused of using change orders excessively [Ref. 11: p. 8]. Criticism has been focused on proper or sufficient actions by Government Contracting Officers to:

- Ensure the correctness of contract documents prior to the solicitation of the invitation for bids.
- Screen nonessential customer-requested change orders.
- Settle contract change order prices within reasonable amounts during negotiations with contractors [Ref. 2: pp. 9-14].

NAVFAC communicates specific management goals for its subordinate Engineering Field Divisions (EFD's) through annual Command Management Plans (CMP). In many cases, goals are specifically tailored for each EFD. Under the Fiscal Year 1984 Construction Program of the CMP, all EFD's are subject to the same criteria for change orders:

- Keep all construction type change orders within six (6) percent of their cumulative current year contract Work in Place⁵ (WIP) while maintaining Military Construction change order activity at five (5) percent.
- Keep unforeseen conditions orders⁶ within two percent of the cumulative current year construction contract WIP.
- Keep design change orders⁷ within 1.5 percent of the cumulative current year construction contract WIP. [Ref. 10: p. C-109]

⁵Work in Place refers to the dollar value of work considered to be constructed in place by a contractor. Progress payments are entitled to the contractor based upon the determination of this value by the ROICC.

⁶CMS-coded (see Chapter III.A.1) change orders caused as a result of underground obstructions, changed soil conditions, unobserved site conditions and misstated underground utility locations.

⁷Change orders coded for design errors and omissions.

Internal controls to stem the abuses criticized above are incorporated into NAVFAC directives. Preprocurement actions are carefully delineated in NAVFAC's Contracting Manual (P-68) to assure comprehensive review of contract documents prior to award. The negotiation of change order prices requires an independent Government estimate to be used as the basis for determining a reasonable settlement. Customer-requested change orders must be limited to "in scope" changes with the stipulation that "desirability of the change and the fact that funds may be available do not enter into determinations of scope" [Ref. 12: p. 7-3.1.]. Before the construction plans and specifications are disseminated to prospective contractors, there are three stages of design review. The first two stages are reviews by NAVFAC managers to insure that designs and specifications are adequate for the intended construction. The last of these is a customer review to ensure that a facility will meet the stated functional and mission requirements [Ref. 13: p. 6].

B. CONTRACTOR PERSPECTIVE

1. Bidding Strategy

Contractors, over the long run, are forced to bid low enough to win, yet high enough to cover cost and make a profit. Successful strategy then, as depicted in bid theory, is to bid at a rate above cost that will yield the greatest expected value, that is, the net of probability of winning multiplied by profit margin. As profit margins are increased, the probability of winning is decreased. As a contractor successively increments his profit margin in a bid, he increases the probability that he will exceed the bid of one of his competitors--and therefore lose the award. Presumably, an optimal profit margin exists where the

corresponding probability of winning an award yields the greatest expected profit [Ref. 14: pp. 488-490].

The contractor's first prerequisite for making profits is to win a bid. In the short run, a contractor may be compelled to use a low bid strategy that virtually assures his chances of winning. The amount of his winning bid can seem quite illogical to other competitors. A common occurrence that has frustrated many contractors is that many of the bids submitted on all types of projects appear to be below reasonable costs. In one particular observance, nearly 80 percent of the bids on all major jobs were at less than the engineer's estimate,⁸ some even at less than half the engineer's estimate [Ref. 15: p. 127]. In Government contracting, the mandatory independent estimate of project costs is an average cost only. In contrast, bids of rival firms on contracts represent opportunity costs for their resources. Each rival firm has the option to choose those contracts that are the most advantageous to them in terms of their special qualifications. These low bids are indicative of marginal costs. A Government estimate cannot be contractor specific, that is, representing the cost of performing a particular project or job for one specific firm [Ref. 16: p. 214].

It is advantageous for the contractor to consider the following in choosing a job so that he will have a likely chance of winning:

- a. Size. Usually the larger the job, the fewer will be the number of competitors. This increases the probability of winning. Adversely, the larger the estimate, the greater the risk that the estimate will be

⁸The independent estimate made by the architect-engineer as an agent of the owner. For Government contracting the parallel is the Government estimate.

inaccurate. Larger construction projects tend to involve more unconventional construction methods and have many interrelated activities. Estimators are more prone to errors and oversights in determining the costs for these methods or activities. Smaller jobs may be more attractive to contractors as they can be the foundation for invaluable contacts and reputation for later, more profitable eventualities--a form of advertising.

- b. Care and attention required. A smaller organization may be more successful in performing work on a job that requires more attention to detail than could be provided by a large, high-overhead company.
- c. Profit advantage. Several jobs concentrated in one locality offer inherent advantages. Economies of scale can be realized for labor, materials, and supervision. Improved labor relations and productivity, price discounts for bulk purchases, and improved time-saving and coverage of supervision and management result.
- d. Continuity of employment. Steady employees earn their pay more productively. Once the maximum yearly contribution to the Social Security tax (FICA) has been made by the contractor, the balance stays with the contractor as a distinct accrual to his job return.
- e. Labor conditions. Jurisdictional disputes may involve a contractor's workforce and result in wage increases.
- f. Subcontracting. The reaction and bid of the subcontractor can be important. If the contractor can be assured of obtaining low subbids from reliable subcontractors, he will have a good chance of getting profitable work.

- g. Financial solvency. The competitive edge may be determined by the ability to finance construction between progress payments, procure construction and payment bonds, and take advantage of trade discounts for prompt payment.
- h. Competition. The greater the number of competitors, the lower the contract price must be to win the award. A decrease in price below a certain point makes opportunities elsewhere more favorable. [Ref. 17: pp. 81-86]
- i. Seasonal considerations. Some contractors disregard overhead and equipment costs and bid low upon reaching a certain volume of work during an operating year.
- j. Desperation. When a contractor is in a financial position where money is urgently needed to pay bills, any source, including jobs at a loss, can prolong survival in business [Ref. 15: pp. 187-188]. When faced with a choice of giving up his capital to avoid going deeply into debt, a contractor will assume a great amount of risk just to stay in business. [Ref. 18: p. 154]

There is an intuitive reason to suspect that a winning bid is occasionally submitted by a poorly-informed, irresponsible bidder. The poorly-informed bidder cannot expect to make a positive profit since his bid must undercut an amount very close to the project's "true value" in order to win. The "true value" is a theoretical estimate of what the project should cost, after all biases for misjudgment of costs, unreasonable contingency amounts, and greed are removed. The poorly-informed bidder, in order to make any profit at all, must bid within a very narrow interval between this "true value" and the maximum-informed bidder's amount. More likely, his winning bid will be below the

"true value." This phenomenon is referred to as the "winner's curse;" the individual to whom a contract is awarded tends to be the one who most underestimated the true value of the work [Ref. 19: p. 133]. In higher-risk contracts, the Government might award the contract to a contractor of questionable financial stability, but who cannot be classed as irresponsible.⁹ Reputable contractors would avoid such high-risk, lump-sum contracts, because they would expect to be underbid by contractors who fail to see risk or who desire such risk [Ref. 18: p. 154].

All contractors must face risk. Risk includes all exposures to loss brought about by nature, organizational shortcomings or outside influences. Some of these are: (1) weather, (2) unexpected job conditions, (3) personnel problems, (4) delays in material deliveries, (5) labor strikes, (6) faulty materials, (7) faulty workmanship, (8) operating problems (additional expenditures for increased supervision, damage to equipment through overloading or poor maintenance), and (9) natural disaster.

Successful bidding strategy would seem to involve a careful synergism between assumption of risk and assessment of competition. A misjudgment of the former is likely to result in a disastrous financial consequence. Misjudgment of the latter will likely result in loss of the award.

2. Measuring the Intensity of Competition

A sharp increase in construction industry unemployment occurred in the spring of 1980 (see Figure 2.2). The industry recession prompted contractors to be much more competitive as demonstrated by contractor practices in soliciting business on a national rather than strictly local

⁹If considered a "responsible" bidder, a contractor is entitled to award provided he is also a responsive bidder.

scale, bidding on new types of work, and bidding more projects. Officers of several reputable firms lamented that in order to win, profit margins in bid estimates had to be cut between 25 and 50 percent. [Ref. 20: p. 70]

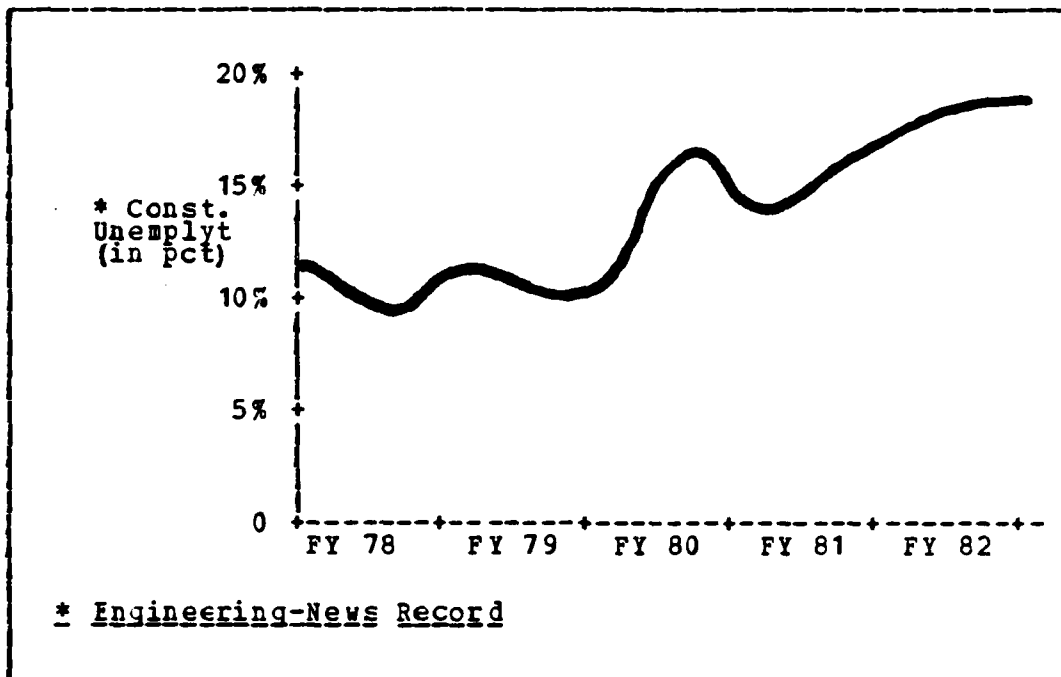


Figure 2.2 Construction Unemployment Fiscal Years 77-82.

The level of competition for a particular contract can be measured in at least three ways. First, the spread, or difference between the low bid and the second low bid, measures the amount of money "left on the table" and indicates how much higher the low bidder could have been and still taken the award. As the number of bidders increases, the percentage spread decreases [Ref. 21: p. 1382]. Second, the ratio of the winning bid to the Government estimate can be used. A ratio near one would indicate firms bidding near average costs while a lower ratio would indicate more

competitive opportunity costs [Ref. 16: p. 214]. The third measure, the expected number of bidders, can be applied where it is necessary to decrement one's markup margin (in order to win) as more competitors respond to the invitation for bids [Ref. 16: p. 213].

The spread can be normalized for contracts of varying sizes by expressing it as a percentage of difference between the lowest and second lowest bids. The bid-to-Government estimate ratio is already normalized and the number of bidders does not appear to be significantly related to the size of a contract. [Ref. 16: p. 217]

An analysis conducted for a large general contractor illustrates that winning bids are based on opportunity costs. Over a two year period, 35 percent of all competitors' bids were below this contractor's estimated direct "out of pocket" costs of performing the work. This contractor was still able to compete successfully among other reputable firms, and his estimates closely reflected his actual costs of operation. Two-thirds of all bids submitted by his competitors fell between 91 and 120 percent of his direct job cost. To be assured a 50 percent probability of winning each award, the contractor would have had to bid below construction cost, or at a negative profit. [Ref. 15: pp. 127-128]

3. Contractor Dislikes for Change Orders

Many contractors contend that change orders are unprofitable [Ref. 22: p. 314]. They complain that they require great effort to price and then take considerable time to get approved and processed [Ref. 23: p. 8]. The implementation of changes results in a dilution of top supervision on original contract work. Too much time of key individuals is spent arranging for changes and pricing and negotiating them [Ref. 9: p. 46].

This sentiment may partially explain why complaints arise from the Government that change orders are priced too highly by contractors. The contractor attempts to account for unknown costs which he fears may occur, while Government estimators may have an unrealistic understanding of actual costs involved in certain operations, particularly the low productivity of direct labor as a result of changes, delays, and uncertainties [Ref. 9: p. 47]. Those contractors averse to change orders should be logically in favor of contracts that limit the amount of damages entitled to the contractor, some contract administrators argue [Ref. 24: pp. 97-98]. If the Government is lenient in permitting compensation to contractors for disputed matters where liability is questionable, then disreputable contractors will benefit. The disreputable contractor, who relies on these compensations, will underbid honest contractors. Limitation of liability clauses in a contract would stem the practice of bidding low and seeking to recoup losses at a later date [Ref. 24: pp. 97-98].

The additional financial burden of performing change orders may be unaffordable to the contractor who is in a low cash position. The contractor also must deal frequently with "constructive"¹⁰ change orders, which are informal but have the effect of eroding profits. A contractor may incur losses on a contract unknowingly, suspecting that there are deficiencies in his accounting system. The real problem may be unidentified constructive change orders [Ref. 25: pp. 5-6].

¹⁰An oral or written act or omission by the Contracting Officer or other authorized Government official which is of such a nature that it is construed or inferred to have the same effect as a formal written change order under the "Changes" clause.

4. Contractor Preferences for Change Orders

Since the Government reserves the right to issue "in-scope" changes to the provisions of a contract, the contractor is within his rights to demand equitable adjustments for additional costs anticipated in associated extra work. If a change reduces the amount of work under contract, the Government, too, is usually entitled to consideration through a reduction of contract price. U. S. Navy contracts ordinarily permit a limit of six percent profit for changes negotiated pursuant to the "Changes" clause [Ref. 12: p. 7.3.4]. The claim that Government estimators of change order prices have been too reliant upon contractor estimates during negotiations [Ref. 11: p. 28], raises the question whether this profit limit has been frequently circumvented. Furthermore, the profit that might have been realized through these changes may have been of sufficient amount to improve many contractors' faltering financial positions.

The practice of trying to obtain a contract award by knowingly offering a price less than anticipated costs, with the expectation of increasing the price during performance through change orders, is referred to as "buying in." This is generally deemed to be irrational bidding behavior for contractors, except for large, multibillion-dollar firms that depend upon traditional growth in defense "state of the art" programs [Ref. 1: p. 106]. But "buying in" may not seem so irrational if viewed as a two-part strategy. Behind the low bid could be a "bail-out," or contingent escape strategy. A "bailout" is a loophole which allows the bidder to recoup losses. The "bail-out" can even be perpetrated with the help of the Government by accepting whatever the contractor can deliver, even if it is a cheaper or substandard product. After all, it is reasoned, the public

disclosure that a very low bid has been accepted could be ultimately embarrassing to Government officials. Either a deductive change order or termination of contract, which would have the effect of minimizing the contractor's losses, could be a satisfactory compromise for both parties [Ref. 26: pp. 84-87].

C. THE QUEST FOR PROFIT THROUGH CHANGE ORDERS

The potential to profit from any change order depends upon many factors. Among the most prominent of these is the type of change order. The Defense Audit Service, in a 1982 audit [Ref. 11: p. 8], attributed 73 percent of DOD change orders to three causes. Slightly over half of the change orders they found were due to deficiencies in designs and specifications; ten percent resulted because specifications and designs had not been completed before the basic contracts were awarded; and about eleven percent of the change orders were the result of user requests for changes. Value engineering changes were not cited as a significant cause of change orders, but they are very attractive for enhancing contractor profitability.

1. Customer Requests

It is difficult to predict customer-requested change orders since they are implemented either in response to unpredicted changes in mission requirements, or in as a result of inadequate planning. They can be generated as a real facility need or as a compromise or exchange for facility features no longer required. It has been an implicit policy of NAVFAC to accommodate the customer's desires for such changes [Ref. 11: p. 19]. If the contractor is bound by a set of explicit specifications and drawings, the customer-requested change order may be one of

the final avenues for opportunity profits. An indicator of contractor motive here would be seen by suggestions for changes made by the contractor directly to the facility user.

2. Ambiguities of Contract Documents

The most overt evidence of contractor motive to benefit through change orders has been seen in the litigation of disputes over contract documents. Considerable legal precedent in establishing the conditions through which a contractor may benefit from contract ambiguities has evolved in the courts. A number of landmark cases clearly shows that both Government and contractor parties cannot use unilateral interpretations of contract language to benefit at the expense of each other. Since the majority of change orders are caused by mistakes in the preparation of contract documents, this is the most fertile ground for seeking extra compensation. Ordinarily the contractor relies on the implied suitability of Government plans and specifications for their intended use [Ref. 27: p. 1076]. But a contractor's interpretation of contract language may differ from that of the Government's due to some degree of ambiguity caused by imperfect wording, conflicting statements or depictions, or connotated meanings. The legal system has tested many cases involving contract ambiguities and has, as a result, produced two counterbalancing, risk allocation principles: the rule of contra proferentum, which adopts the interpretation that favors the non-drafting party (contractor) and the rule of pre-contract clarification, which denies adoption of a contractor's interpretation when he has failed to request clarification of an ambiguity of which he knew or should have known [Ref. 27: pp. 993-994].

a. Legal Precedent Favoring the Contractor

Courts have generally been sympathetic to contractors when inaccurate or incomplete information in bid packages result in unexpected costs. In Peter Kiewit Sons' Company v. United States, 109 Ct. Cl. 390 (1947), the Court of Claims held:

Where one of the parties to a contract draws the document and uses therein language which is susceptible of more than one meaning, and the intention of the parties does not otherwise appear, that meaning will be given the document which is more favorable to the party who did not draw it. This rule is especially applicable to Government contracts when the contractor has nothing to say as to its provisions. [Ref. 6: pp. 231-232]

In WPC Enterprises, Inc. v. United States, 163 Ct. Cl. 1, 323 F.2d 874 (1963), and Blount Brothers Construction Co. v. United States, 171 Ct. Cl. 478, 346 F.2d 962 (1965), the Courts ruled that where an ambiguity was "subtle, not blatant" and where the contractor is genuinely misled and not deliberately seeking to profit from a recognized error by the Government, relief is entitled to the non-drafter [Ref. 28: p. 152]. Furthermore, in Gholson, Byars and Holmes Construction Co. v. United States, 173 Ct. Cl. 374, 351 F.2d 987 (1965), the Court ruled that there is no duty to seek clarification where a contractor innocently construes a subtle ambiguity in his favor. Equally important, if clarification is not provided to an ambiguity sought by a contractor, the Government will be held to have waived its right to complain of the interpretation placed on the contract by the contractor [Ref. 29: pp. 154-155].

Under the rule of pre-contract clarification, the contractor is obligated to inquire about major patent discrepancies, obvious omissions or drastic conflict in

provisions. In a case where the distinction between a patent and latent ambiguity was an issue, the Board of Contract Appeals in Worsham Construction Co., Inc., v. United States, GSBCA 5469, refused the Government invocation of the "patent ambiguity" rule as a means of preventing contractor recovery for a defective specification. [Ref. 30: pp. 9-10]

b. Legal Precedent Favoring the Government

The rule of pre-contract clarification is a rule of fair dealing which protects the Government from a contractor who intentionally submits a low bid with the goal of claiming ambiguities during contract performance to obtain price increases. In Beacon Construction Co. v. United States, 161 Ct. Cl. 1, 314 F.2d 501 (1963), the contractor failed to notify the Government of an ambiguity and interpreted the contract in its own favor. The contractor sought to recover expenses after performing the work where the contract language was vague. The Court denied relief to the contractor, holding that such a claim was made without protest and in absence of direction from the Government [Ref. 6: p. 234]. Where a conflict in contract documents exists and is known to the contractor, relief will be denied the contractor when he assumes the right to disregard the affected portions and apply his own remedy. The Court stated in S.O.G. of Arkansas v. United States, 212 Ct. Cl. 125, 19 G.C. (1976), that this action is taken to avoid post-award disputes of the type which arose here by encouraging contractors to seek clarification before anyone is legally bound [Ref. 31: pp. 3-4].

The pre-contract clarification rule also applies to circumstances where a reasonable or experienced bidder should be capable of recognizing a patent or glaring

discrepancy. In Wickham Contracting Co. v. United States, 212 Ct. Cl. 318, 546 F.2d 395 (1976), a contractor submitted a bid based on an erroneous drawing scale. The court ruled that the use of the erroneous scale was so unusual that it created a patent discrepancy [Ref. 27: pp. 1074-1078]. Similarly, in J. W. Bateson Co., Inc. v. United States, GSBCA 1221; R. M. Hollingshead Corp. v. United States, 124 Ct. Cl. 681, 683, 111 F. Supp. 285, 286 (1953); and others, the Courts generally agreed that:

An experienced contractor cannot rely on government-prepared specifications where, on the basis of the government furnished data, he knows or should have known that the prepared specifications could not produce the desired result for '... he has no right to make a useless thing and charge the customer for it.' [Ref. 27: p. 1079]

c. Misrepresentation

A contractor might receive relief or avoid the commitment to a contract if he is misled by a false representation or nondisclosure of terms in the bidding package. Although such action is usually not indicative of a contractor's motive to gain through changes to a contract, it provides recourse for a low bidder to escape an unprofitable dilemma. A Contracting Officer must be careful that he is not on constructive notice of an error where a mistake in bid is alleged after award of contract. If a low bid is significantly lower than other competing bids or the Government estimate, the contractor may avoid commitment to the terms of the contract ordinarily established under the firm bid rule¹¹ if he can demonstrate that the Contracting

¹¹Under the firm bid rule in Government contracting, the bidder cannot, in the absence of special circumstances, withdraw or revise a bid at the time of bid opening.

Officer had "constructive knowledge" of a mistaken bid.
[Ref. 32: pp. 152-153]

3. Value Engineering

Value Engineering changes are unique in that they tend to maintain the essential function of a facility while creating cost savings for both the Government and the contractor. Provided that a facility's "essential function" is retained intact, a Value Engineering change will deflate the change order rate and increase contractor profitability. In fixed-price NAVFAC contracts, the contractor's share of savings is determined by subtracting Government costs (resulting from developing and implementing the change) from contract savings and multiplying the result by 55 percent. The Value Engineering provision is applicable to contract prices of \$100,000 or more [Ref. 33]. Obviously it is an attractive alternative to consider for the change-minded contractor.

D. GENERAL HYPOTHESIS

It has been stated that contractors are compelled in competitive situations to bid very close to their expected costs of construction. They are motivated in some cases to win as a preferable alternative to having no business at all, even if it means operating at a loss. Winners of competitively-bid contracts are either those who enjoy the relative advantages of economies of scale or proprietary properties, or are willing risk-takers. Risk-takers are those who accept the probability of setbacks in the course of construction. More likely they probably believe that they can recoup profits later. Although there are many reasons that a prudent contractor would choose to avoid change orders, they are nonetheless inevitable. It is the

premise of this paper that there is a link between the cost of change orders to a contract and the degree of competitiveness under which that contract was bid. As bidding competition increases, those bidders who are more amenable to the risk of seemingly unprofitable ventures and are willing to gamble on change order dynamics displace the more conservative and reputable contractors.

The contractor can use a number of different change order types to his benefit. Among these are customer-requested changes, changes to correct mistakes and ambiguities in contract documents, changes to account for differing site conditions, and Value Engineering changes. Value Engineering changes have been shown to be a relatively small proportion of federal construction contract administration effort. If these contractors as described are typically successful bidders, then higher change order rates among contracts that are bid under strong competitive conditions should be systematically evident. Empirical data will be used in a model to test the following conclusions:

- A direct relationship exists between change order rate and degree of competition--measured by number of bidders, the "spread," bid/Government estimate ratio, bid/mean bid ratio, and deviation of winning bid from mean bid.
- Relationships exist among various classifications of construction contract change order rates according to: (1) timing of the contract award, (2) contract size, (3) geographical area, (4) type of facility, and (5) construction industry unemployment rate.

III. METHODOLOGY

A. DEVELOPING THE DATABASE

1. General

The data for the research were collected at the Western Division, Naval Facilities Engineering Command, San Bruno, California (WESTDIV). Only construction contracts that were formally-advertised and fixed-price are included for analysis. These contracts were WESTDIV administered--that is, advertised and awarded through WESTDIV or its authorized agents at WESTDIV-designated geographical locations. Therefore, construction contracts awarded by local Officers-in-Charge of Construction (OICC's) of more limited contracting authority at 20 remote "field" offices are not included.¹² The data were extracted from two sources:

- The Construction Management System (CMS), a subsystem contained in the AMALGAMAN/Integrated Disbursing and Accounting Data Base Master maintained by the Naval Facilities Support Office (FACSO). The information provided was extracted from the CMS system for the author. The data were transcribed from computer print-outs into the statistical computer program to be used for the analysis in this chapter.

¹²Navy Civil Engineer Corps officers assigned as Public Works Officers at Naval activities usually are assigned concurrently (dual authorities are vested in one person) as field OICC's. As a field OICC, contracting authority is more limited than that of the Commander of the Engineering Field Division (WESTDIV). Since field OICC contract bidding data are maintained locally at these remote offices and their collection was considered infeasible within the time constraint for research, they are excluded from analysis.

- Completed Scales of Bid Offers for Construction Contracts (12ND WESTDIV Form 4330/24) maintained by the Head, New Procurement Branch (Code 021) of the Acquisition Department. This information was provided by hardcopy listings of individual contract Government estimate and bid-opening results.

2. Data Set Definition

The model for analysis is established within the following considerations:

- Availability of bidding information.
- Recentness of information.
- Consistency in management policies concerning contract administration.
- Completion (closeout) of contract.
- U.S. Navy funding sources (appropriated and non-appropriated) only.

The major restriction for data analysis is imposed by availability of bidding information. Although CMS affords the opportunity to review award amounts and change order information for contracts of all appropriation sources and Engineering Field Divisions of NAVFAC, the extraction of information for bidding data and government estimates¹³ is cumbersome. Accordingly, only WESTDIV contracts awarded from Fiscal Year 1978 to the present have been included.¹⁴ This does afford relative currency of information. Fiscal Year 1983 data is excluded, however, due to (1) the small

¹³Government estimates for contracts are available in another subsystem of the AMALGAMAN Data Base, but they are not tailored as necessary to reflect the actual estimate for the base bid plus or minus the additive or deductive bid items that actually might have been awarded.

¹⁴Scales of Bid Offers are maintained at WESTDIV for six years until disposal. Coincidentally, data for completed contracts were implemented into CMS at the approximate starting point for this same period (1977).

proportion of completed contracts available and (2) revision of WESTDIV policies in (a) "downloading" many contracts to field OICC's (WESTDIV was authorized increases in manpower levels for field offices, so many contracts, especially CMW-funded, were delegated in 1983 to OICC's to administer), (b) accelerating the execution of WESTDIV contracts award phase and (c) encouraging other forms of modifications to contracts, such as Supplemental Agreements. Items (b) and (c) above were internalized in Fiscal Year 1983 WESTDIV management objective plans.

All considered contracts must have been "closed out" or completed, so that the change order rate is reflected as a final, static figure, rather than a dynamic one as under a contract-in-progress. This constraint is imposed so that all influences of contract price expansion during the life cycle of the contracts have matured.

Funding sources are limited to Military Construction, Navy (MCON) and Non-Appropriated Funds (NAF) contracts in excess of \$200,000, and Operations and Maintenance, Navy (OMN) contracts in excess of \$2500. This constraint is arbitrary. The intent is to view the incidence of construction change orders under one service branch (Navy), so that as much consistency in the attitudes and policies of making change orders could be ensured. This would avoid any possible biases by NAVFAC managers. The \$200,000 floor on MCON and NAF contracts reduces the size of this study's data base to a workable¹⁵ number and eliminates many mixed-funding source contracts.¹⁶ These contracts

¹⁵Initially it was estimated that inclusion of many smaller MCON contracts would overload the storage capacity of the MINITAB computing system used for statistical analysis.

¹⁶Many construction contracts are funded by a mix of more than one source-- for example, MCON and OMN dollars are commonly used under one contract for building alterations

represent a relatively small proportion of the total amount of MCCN and OMN funds administered by NAVFAC and therefore should not significantly bias the results of analysis.

3. Refining the Data

The data considered within the above constraints possess a number of clear outliers that, if included in the analysis, would distort overall values for change order pricing and bid averages. The following types of WESTDIV contracts are further excluded:

- Contracts terminated early, where the majority of construction dollars are not consumed or "in place." Otherwise the change order rate would appear as a large deductive (negative) one. A small number of contracts are terminated for convenience of the Government if the facility or some of its features are no longer required. A contract may also be terminated for default when the contractor fails to make satisfactory progress in construction or breaches the terms of the contract.
- Contracts for which costs listed in CMS do not account for the majority of the award amount. Presumably, other phases of construction had not yet been reported as completed or consisted of work funded under a separate, unreported source.
- Construction contracts for Adak, Alaska, under WESTDIV's cognizance; these contracts suffer from restrictive competition and unique logistics at an isolated location.

A total of 473 completed MCON, NAF, and CMN construction contracts awarded from October 1977 through September 1982 were listed on the CMS printouts as of 15

(MCON) and repairs (CMN) when the construction features for each funding source are clearly separated.

February 1984. Of these 47 were deleted for the reasons stated above. Another 126 contracts for Fiscal Years 1980 and 1981 were excluded because their corresponding Scales of Bids were not available. There remained 300 contracts for analysis. Table I summarizes the distribution of these contracts.

TABLE I
Summary of Distribution for Database Contracts

<u>FISCAL</u> <u>YEAR</u>	<u>NUMBER OF</u> <u>CONTRACTS</u>			<u>TOTAL DOLLAR AMT</u> <u>(in \$1000)</u>			<u>YEAR TOTAL</u> <u>(in \$1000)</u>
	CMN	MCON	NAF	OMN	MCON	NAF	
1978	6	43	4	\$ 868	72111	2453	\$ 75432
1979	28	76	6	6295	142980	5008	154283
1980	14	14	2	5741	31817	688	38246
1981	1	12	2	255	17645	569	18469
1982	60	28	4	14932	30279	1713	46924
	---	---	---	---	---	---	---
TOTAL	109	173	18	28091	294832	10431	\$ 333354

4. Summarization and Assumptions

Appendix A describes the variables provided for each WESTDIV contract by the Construction Management System and the Scales of Bids. Appendix B tabulates these data.

a. Assumptions

(1) Geographical Categorization.. To isolate the effects of geographical differences in climate, economy, employment rate, and other factors, the contracts are classified among eight general categories. Four of these pertain to major U. S. Naval activity concentrations, while the other four are classified as "rural" areas in the outlying vicinity of these concentrations. Generally these "rural" activities lie more than 50 miles or convenient commuting distance from San Diego, Los Angeles, San Francisco or Seattle/Emmerton.

(2) Number of Bids. It is apparent that some bids appearing on the Scales of Bids were disproportionately high as compared to either other competitors or the Government estimate. These bids would only distort values (such as standard deviation and mean bid) calculated for analysis [Ref. 21: pp. 1377-1378]. These are considered nonserious or "noise" bids and are typically excluded in studies of auctions and bidding models [Ref. 19: p. 126]. An appropriate algorithm for identifying these bids depends upon the model, and there appears to be no definite rule for determining them. Therefore, any bid greater than 150 percent of the competitive mean bid was arbitrarily considered a "noise" bid by the author and was extracted. This adjustment was made to 54 bids on 43 contracts. It was observed that some bidders consistently submitted "noise" bids. Common reasons for unreasonably high bid prices may fall into one or more of the following categories [Ref. 34: p. 127] :

- Complementary bidding. The bidder is not interested in performing the subject work, yet does not want to be otherwise prevented from bidding on future projects or to be deleted from future Bidder's Lists. The proposed

price is inflated to a range that will prevent likely award.

- Bidder error. Mistakes simply may be made when calculating bid prices.
- Bidder misunderstanding of the scope of the work.
- Perceived risk on the part of the bidder. Any number of factors may cause the bidder to perceive real or imaginary areas of risk and to raise his bid price to provide for this risk.
- The bidder may be quite uncertain about the proposed work, the Government's particular requirements of the contractor, or his ability to perform as expected.

(3) Next Lowest Bidder's Price and Spread.

The next lowest bidder's price and the spread are included for analysis to examine any significant relationships between change order rate and intensity of competition. Chapter II.P.2. cites the significance of these data in bid analysis.

(4) The Number of Change Orders. The number per contract of dollar-valued change orders is analyzed to determine the effect it has on the change order rate. Some change orders are "no-cost" and do not directly affect the change order rate. Among the dollar-valued change orders are amounts either added to, or deducted from, the contract price. This variable is of no value for predictive purposes, it is noted, since it cannot be known at the time of bid opening.

(5) Low Bid/Mean Bid Deviation. The deviation of the low bid from the mean bid can be expressed as a measure of the number of standard deviations that lie between the low bid and mean bid on a given contract. It conveniently normalizes all contracts regardless of award amount. A comparatively high value here is an indication of

an unusually deviant bid. But the value of a standard deviation is diminished for very small population sizes, so this measure is used only on contracts where there were at least four bidders. Analysis is focused on the determination of any relationships between this value and the change order rate.

(6) "Equivalent" Change Order Rate. A contract change order is frequently intended as a means of correcting a deficiency or mistake or making an "in scope" change that is more accommodating to the facility user. Frequently, a specific feature of a final facility after change orders is not that which was originally intended at the award of contract. In many cases, some facility features are no longer needed or are substituted by an equivalent "in-scope" alternative. These changes do not alter the function of the facility, but they do alter the contract price, and usually at a lower cost. Adding the amount of deductive change orders back into the contract price reflects more accurately what the contract would have cost if the original features were left intact. While this is not necessarily an accurate assumption for all deductive change order situations, it is believed to provide a more conservative comparison of contracts in the context of "dollar's worth" of construction. Value engineering change orders are not added back into the contract price, because this kind of change order actually reduces the contract price without "impairing essential functions or characteristics." The basic criterion for deducting the "equivalent" change order, as contrasted with leaving the Value Engineering change order intact, is in the consideration given to the Government. In the "equivalent" change order, the Government gets a reduction in the contract price, because it is buying something less in value than originally intended.

(7) Winning Bid to Average Bid Ratio. This value, usually less than unity (unless there is only one bidder), compares the relative difference between the winning bid and the competitive average. The "competitive average" excludes the winning bid in its computation and is assumed to be a more realistic approximation of a construction project's "true" or market price. Therefore, a low ratio would imply that a winning bid is priced far below expected costs, and is prone to being a "buy-in" or a potentially losing venture for the contractor.

(8) Winning Bid to Government Estimate Ratio. The use of this ratio for analysis assumes that the independent Government estimate, also referred to as the "engineer's estimate," is a fair price for the contract. The relationship of change order rates to this ratio is another focus of analysis.

b. Research Limitations

The availability of Scales of Bids and a source for reliable Government estimates is clearly the most limiting factor of this research. A reliable classification code for the type of construction performed under each contract was extremely limited. It is acknowledged that certain types of construction, such as placement of underground utilities, are inherently risky. Many projects involve an aggregation of various construction trade disciplines, so it is difficult to make a single, inclusive classification for a contract. NAVFAC Facility Category Codes [Ref. 35] are available in CMS for Military Construction contracts only. However, Facility Category Codes categorize contracts according to facility type rather than construction type. Table II summarizes the distribution of Military Construction contracts contained in the database according to Category Code.

TABLE II
MCOM Contracts by Category Code

<u>Facility Category</u>	<u>Number of Contracts</u>
Operational (excl. Waterfront)	21
Waterfront	10
Training	19
Maintenance	33
Production	1
Supply	12
Hospital, Medical and Dental	7
Administration	8
Unaccompanied Personnel Housing	9
Community	3
Utilities and Ground Improvements	43
Total Military Construction Contracts in Database	173

c. Other Data

For informational purposes, Figures 2.2 and 3.1 show the trends in various measures of construction industry inflation and unemployment over Fiscal Years 1977 to 1982. This information is extracted from periodical issues of Engineering-News Record (ENR).

(1) Construction Industry Inflation. Figure 3.1 plots ENR's Construction Cost Index (CCI) for three major geographical areas pertinent to the database contracts. The CCI is a measure of the combined effect of wage and material price changes on the value of the construction dollar. The year 1967 was established as the base for an index value of 100. This index is computed monthly by ENR for twenty major U.S. metropolitan areas.

(2) Unemployment Rate. This rate is determined quarterly by ENR and is expressed as a national average; no geographical distinctions are made.

(3) Small Business Set-Asides. NAVFAC requires that all construction procurement in excess of \$2500 and under \$1,000,000 shall be considered for Small Business Administration (SBA) set-asides [Ref. 12: p. 4.2.13]. A small business set-aside is a procurement that is eligible only for award to an SBA-certified contractor. Set-asides were created to encourage more commerce among small, entrepreneurial firms. Approximately 95 percent of the database contracts are set-asides. The awarding of set-asides has drawn some concern:

A dilemma to the Government posed by set-asides is that in the short run, prices may be higher and competition restricted as small businesses incur high start-up costs and are unable to take advantage of economies of scale to lessen costs. In the long run, however, the set-aside program enlarges the total number of contractors available to compete, and it should thereby contribute to lower contract bids. [Ref. 37: p. 21]

B. ANALYTICAL COMPUTATIONS

The data were compiled for analysis on the IBM 3033AP Computer at the Naval Postgraduate School, Monterey, California. The general purpose statistical computing system, Minitab [Ref. 36], was used to perform various computational functions for data organization and analysis. The functions included:

- Sorting, rank-ordering, and recoding of data.
- Mathematical calculations (averages, totals, standard deviations, etc.).
- Histogram and plot construction.
- Regression analysis.
- Analysis of variance.

1. Sorting, Rank-ordering, and Recoding of Data

These features of Minitab are useful in examining ranges of values, breaking data into cells for variance analysis, and isolating selected independent variables for more detailed analysis. Variance and regression analyses can be performed conveniently for selected geographical areas, time frames, dollar ranges, facility types, and many other desired classifications.

2. Mathematical Calculations

Minitab enables simple calculations of averages, totals and standard deviations of various data diversifications. Much of the summary data represented in this study are the result of these calculations.

3. Histogram and Plot Construction

This feature provides convenient display of data distributions. Figure 3.2 displays the skewed distributions of change order rates for the database contracts. Plots afford graphical displays of relationships among variables. They are used, if necessary, in analysis of regression residuals to check the validity of the assumptions of normality and constant variance of the residuals. Plots are useful in visually displaying the degree of correlation between two variables.

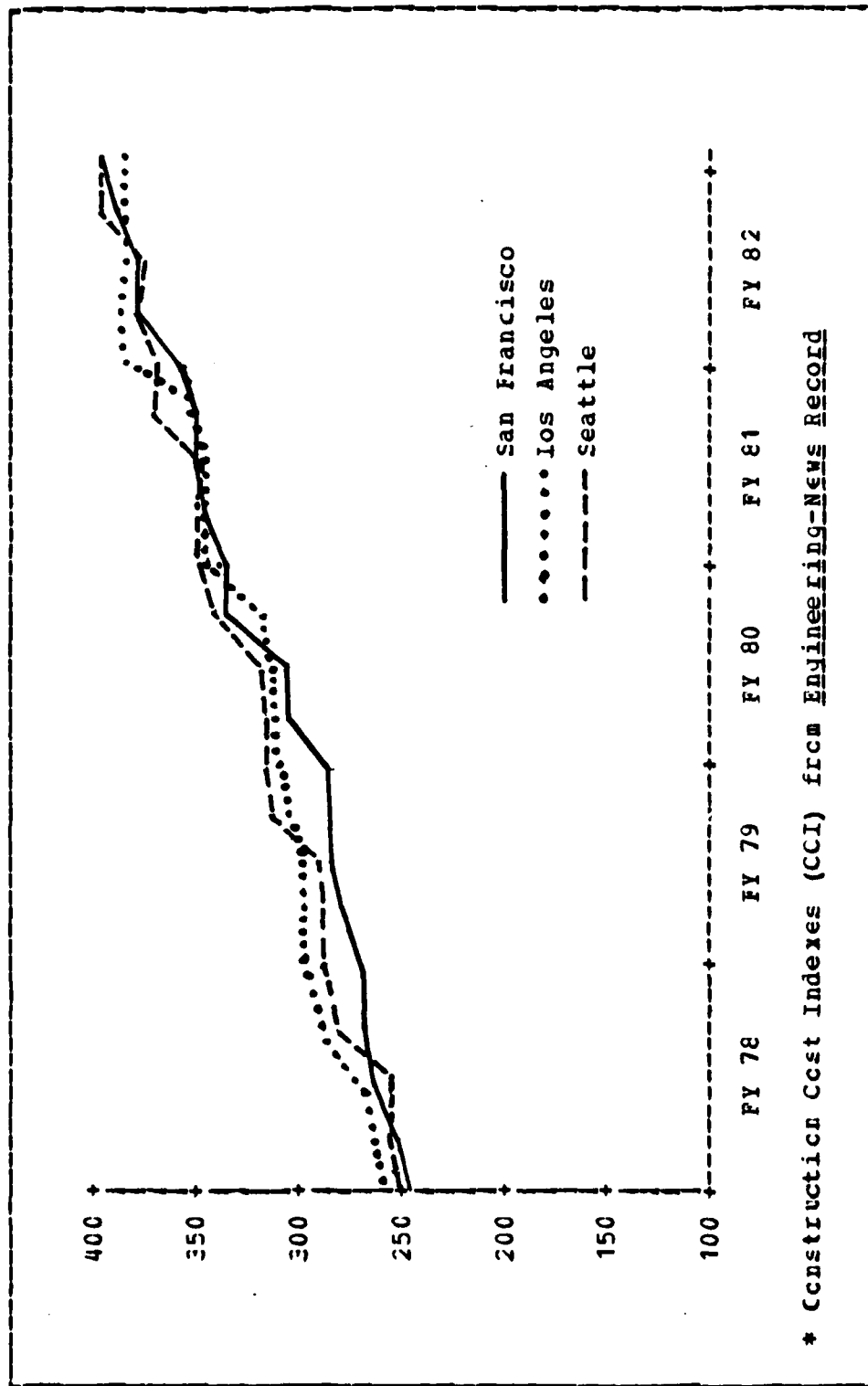


Figure 3.1 Construction Industry Inflation, Fiscal Years 1977-1982.

4. Regression Analysis

Regression analysis is a useful tool for determining relationships between a dependent variable and any number of independent variables. The change order rate, as a dependent variable, is examined for any significant relationship to a number of independent variables, such as number of bidders, the "spread," and bid-to-Government estimate ratio.

5. Analysis of Variance

Through the use of analysis of variance, significant differences among two or more populations of data can be tested. A statistical investigation can be made into the comparison of change order rates, for example, among different classifications of geographical areas, award periods, and bid-estimate ratios.

C. FINDINGS OF ANALYSIS

1. Dependent Variables

The objective of this analysis is to determine any significant relationships through regression and variance analyses between change order rates and other variables available in the database. Two independent variables are considered: the actual change order rate and the "equivalent" change order rate--a refined figure with the dampening effect of deductive change orders removed.

2. Independent Variables

The following are used as independent variables for regression analysis:

- Number of Change Orders.
- Number of Bids.

Actual Change Order Rate
Each * represents 2 observations

Middle of Number of
Interval Observations

0.00	minus 2	*
-2.00	7	****
0.00	70	*****
2.00	43	*****
4.00	40	*****
6.00	34	*****
8.00	24	*****
10.00	16	*****
12.00	14	*****
14.00	8	****
16.00	3	**
18.00	4	**
20.00	6	***
22.00	5	***
24.00	3	**
26.00	4	**
28.00	4	**
30.00	0	
32.00	2	*
34.00	1	*
36.00	3	**
38.00	1	*
40.00	plus 5	***

Equivalent Change Order Rate
Each * represents 2 observations

Middle of Number of
Interval Observations

-2.00	minus 1	*
0.00	72	*****
2.00	42	*****
4.00	40	*****
6.00	35	*****
8.00	24	*****
10.00	18	*****
12.00	14	*****
14.00	8	****
16.00	3	**
18.00	4	**
20.00	5	***
22.00	6	***
24.00	4	**
26.00	3	**
28.00	6	***
30.00	1	*
32.00	2	*
34.00	1	*
36.00	3	**
38.00	1	*
40.00	plus 7	****

Figure 3.2 Histograms of Change Order Rates.

- Number of Standard Deviations Between the Low Bid and the Mean Bid.
- Winning Bid to Mean Bid Ratio.
- Winning Bid to Government Estimate Ratio.
- Percent Spread Between the Low Bid and the Next Lowest Bid.

Subpopulations of the following variables were used for examining significant differences among change order rates through variance analysis:

- Award Date Periods, by fiscal year and by fiscal quarter.
- Award Amount, in stepped ranges of various dollar amount intervals.
- Geographical Area, by each of the eight categories, and then into two categories--"metropolitan" versus "rural."
- Funding source, in three cells--Military Construction, Non-appropriated Funds, and Operations and Maintenance.
- Number of Bids, in various cells ranging from one to 24 bids per contract.
- Winning Bid to Mean Bid Ratio, classified into 10 cells of approximate equal size:

0.00 - 0.70	0.88 - 0.91
0.70 - 0.78	0.91 - 0.93
0.78 - 0.82	0.93 - 0.95
0.82 - 0.85	0.95 - 0.97
0.85 - 0.88	0.97 - 1.00.

- Winning Bid to Government Estimate Ratio, classified into ten cells for all 300 contracts; and seven cells for the 173 MCON contracts:

<u>300 Contracts</u>	<u>173 MCON Contracts</u>
0.00 - 0.65	0.00 - 0.80
0.65 - 0.76	0.80 - 0.90
0.76 - 0.84	0.90 - 0.97
0.84 - 0.90	0.97 - 1.03
0.90 - 0.97	1.03 - 1.10
0.97 - 1.03	1.10 - 1.20
1.03 - 1.10	1.20 plus.
1.10 - 1.19	
1.19 - 1.30	
1.30 plus	

- Unemployment Rate, classified into 13 cells representing approximate construction industry unemployment rates ranging from 9.0 to 18.5 percent over 20 quarters.

3. Preliminary Findings

a. Change Order Rates

The change order rates for the data are shown in Table III. These rates are higher than the WESTDIV standards of six percent overall and five percent for Military

TABLE III
Change Order Rate Summary

Average Change Order Rate	Actual (percent)	Equivalent (percent)
MCON	7.83	8.43
CMN	7.53	8.41
NAF	6.19	6.23
OVERALL	7.62	8.29

Construction contracts. The WESTDIV standards are predicated upon the annual Work in Place, however, and do not account necessarily for all change orders to a given contract. The figures above are representative of a slightly different criterion, that is, the total change orders for each contract, including settlements to claims that may have lingered over a substantial period of the contract life. WESTDIV has been more successful in controlling the overall change order rate than it has the MCON change order rate. The Command Management Plan standards mentioned in Chapter II are high. The change order rates in Table III, it is recalled, were adjusted to eliminate deviant values. To make a more fair comparison between the performances of CMP-based change order rates and the change

order rates determined in this analysis, a number of factors would have to be considered in order to put them on an even plane. Such factors include the percentage of Work in Place contracts actually completed, and the average incidence rate of change orders toward the end of the contract life.

1. Number of Bids Affecting the "Spread"

Park [Ref. 15] asserts that the percentage spread decreases as the number of bidders increases. The evidence for this in this analysis is weak. The only significant¹⁷ difference in the spread is between the group of 3 to 5 bidders and the group of 6 or more bidders. The mean spread for the group of 3 to 5 bidders in the data is 13.2 percent, with a confidence interval between 10.1 and 16.3 percent. The mean "spread" for the group of 6 or more bidders is 6.9 percent, with a confidence interval between 4.4 and 9.4 percent. These findings are based on only 169 contract observations, as the "spread" was not calculated for contracts where there were three bidders or less.

4. Findings of Regression Analysis

A series of stepwise regressions were performed on each of the dependent variables against all considered independent variables. No single variable emerged with a correlation that was significant enough to explain the change order rate. The measure of the proportion of total variation in a dependent variable that is explained by a regression line is the coefficient of determination, or "r-squared" value.¹⁸ Each of the independent variables alone failed to yield a coefficient above 6.0 percent. The best

¹⁷Based on a 95 percent confidence level.

¹⁸The coefficient of determination or "r-squared" value can range from zero, which denotes no correlation, to unity, which represents perfect correlation.

fit found was a multiple regression of the bid-to-Government estimate ratio and the number of change orders against the actual change order rate. Only an 8.2 percent coefficient existed here with "t" ratios¹⁹ for the bid-to-Government estimate and number of change orders equal to -4.64 and 2.87 respectively. Since the values of the coefficients of determination are so close to zero, the change order rate explained by the independent variables is insignificant.

Subpopulations of geographical areas, funding sources and time frames failed to isolate any further data that could provide useful regressions. Plots of change order rates against each of the independent variables indicated that little resemblance of a linear relationship existed in any case. Figure 3.3, the plot of actual change order rate versus bid-to-Government estimate ratio, demonstrates this point.

5. Findings of Variance Analysis

In all analyses of variance, 95 percent confidence intervals for level means were assumed in hypothesis testing. One-way analyses of variance were performed for each of the two independent variables (actual and "equivalent" change order rates).

a. Award Date Periods

Two analyses of variance were performed: (1) by fiscal year and (2) by fiscal year quarter. If improvements have resulted in controlling change order rates due to WESTDIV efforts, then significant differences in change order rates should lie among the the five fiscal years. At least a significant difference between 1978 and 1982 should

¹⁹A "t" ratio should be at least plus or minus 2 to be considered significant enough for an independent variable to used in a regression equation.

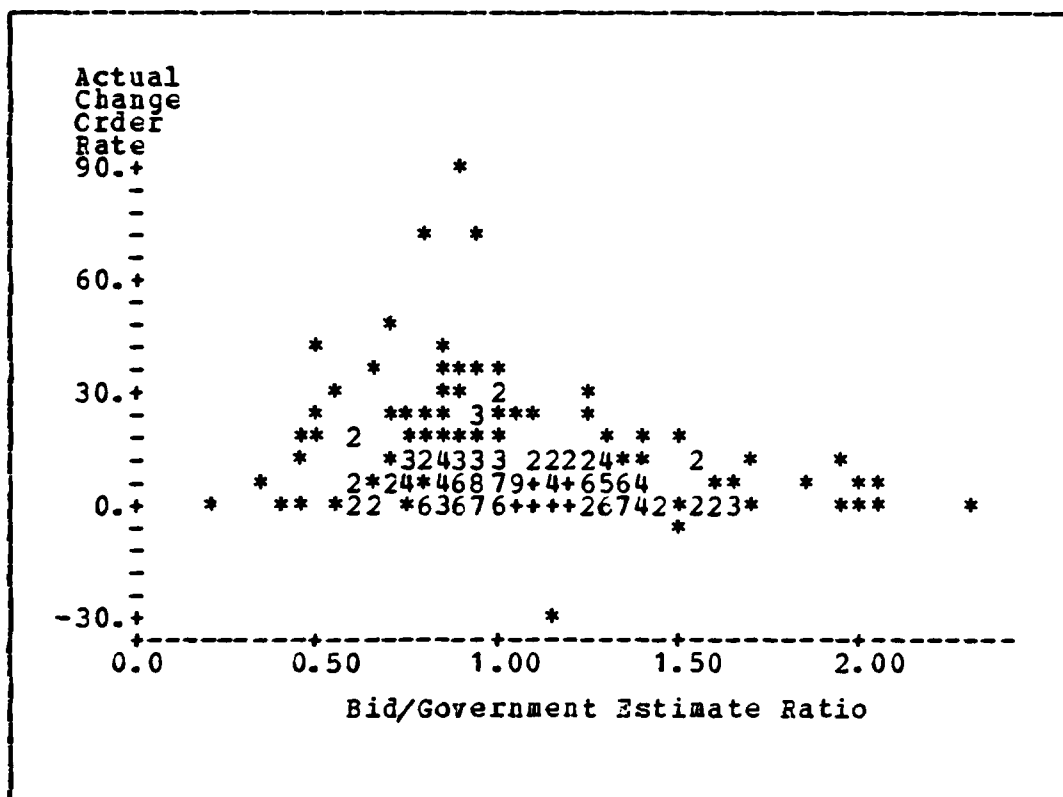


Figure 3.3 Plot of Change Order Rate vs. Bid/Govt Est.

exist. The hypothesis is that there has been significant improvement in reducing change order rates, and that it will be demonstrated by a change order rate confidence interval for 1982 that is below the lower limit of the confidence interval for 1978.

There is a common perception that contracts awarded in the fourth quarter tend to be "rushed" in the attempt to award before the end of the fiscal year and that the quality of specifications and drawings is therefore sacrificed. If this true, then a significantly higher change order rate should be seen for awards made during the fourth quarter in contrast to the other quarters. This

hypothesis will be affirmed if the lower limit of the fourth quarter change order rate confidence interval is greater than the upper confidence interval limits of the other quarters.

Analysis of variance for both cases reveals that no significant differences in change order rates can be found between any of the fiscal years or fiscal year quarters. Therefore, no improvement in reducing the WESTDIV change order rate over the five years was observed. Although there was no statistical difference in the change order rates among the four quarters, it was interesting to note that the mean change order rate (both actual and "equivalent") for contracts awarded during the fourth quarter was the lowest.

b. Other Findings

Analyses of variance for amounts of award, funding sources, number of bids, winning bid-to-mean bid ratios, Category Codes, and unemployment levels revealed no significant differences in change order rates among the various cells.

c. Geographical Areas

Among the eight described geographical areas there were no significant differences in change order rates between any two areas. An analysis of variance clearly shows that there is a significant difference in the change order rate between construction contracts performed in "rural" areas and those performed in the "metropolitan" or high density areas. Rural areas incur lower change order rates than do metropolitan areas. Figure 3.4 shows the 95 percent confidence intervals for each of these two cells. The upper limit of 7.1 percent for actual change order rate

(based on a pooled standard deviation) for rural areas is exceeded by the metropolitan areas' lower limit of 7.3 percent.

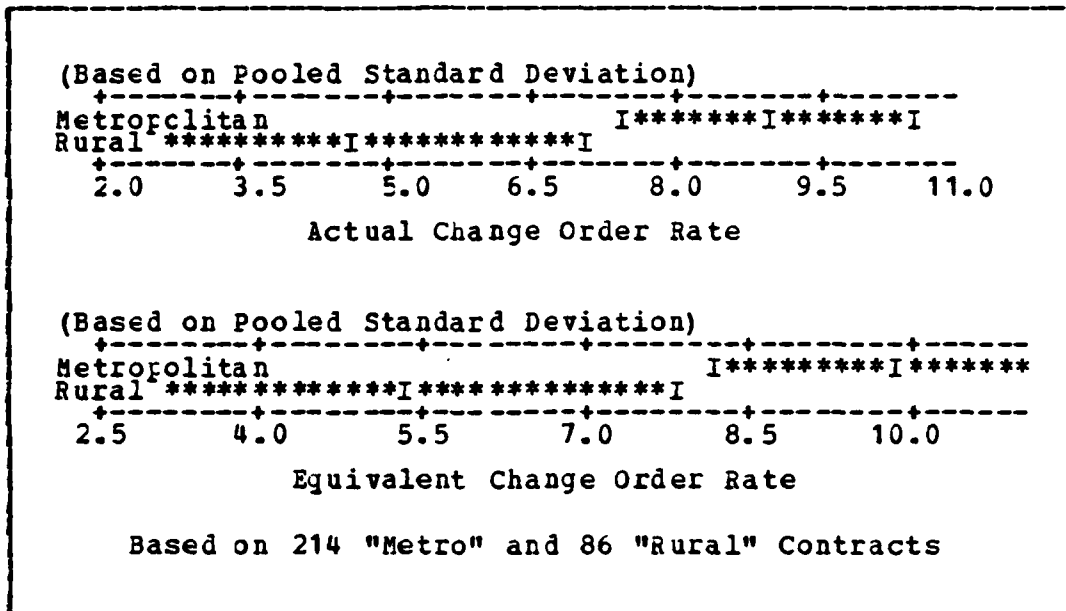


Figure 3.4 Variance Analysis for Geographical Areas.

d. Winning Bid to Government Estimate Ratio

The most significant findings in the difference among change order rates are found in the varying ranges of this ratio. Generally, it is found that change order rates tend to be high when the winning bid is proportionately lower than the Government estimate. Conversely, change order rates are significantly lower where the winning bid is much greater than or very close to the Government estimate. Figure 3.5 shows the 95 percent confidence intervals for change order rates among the cell classifications described

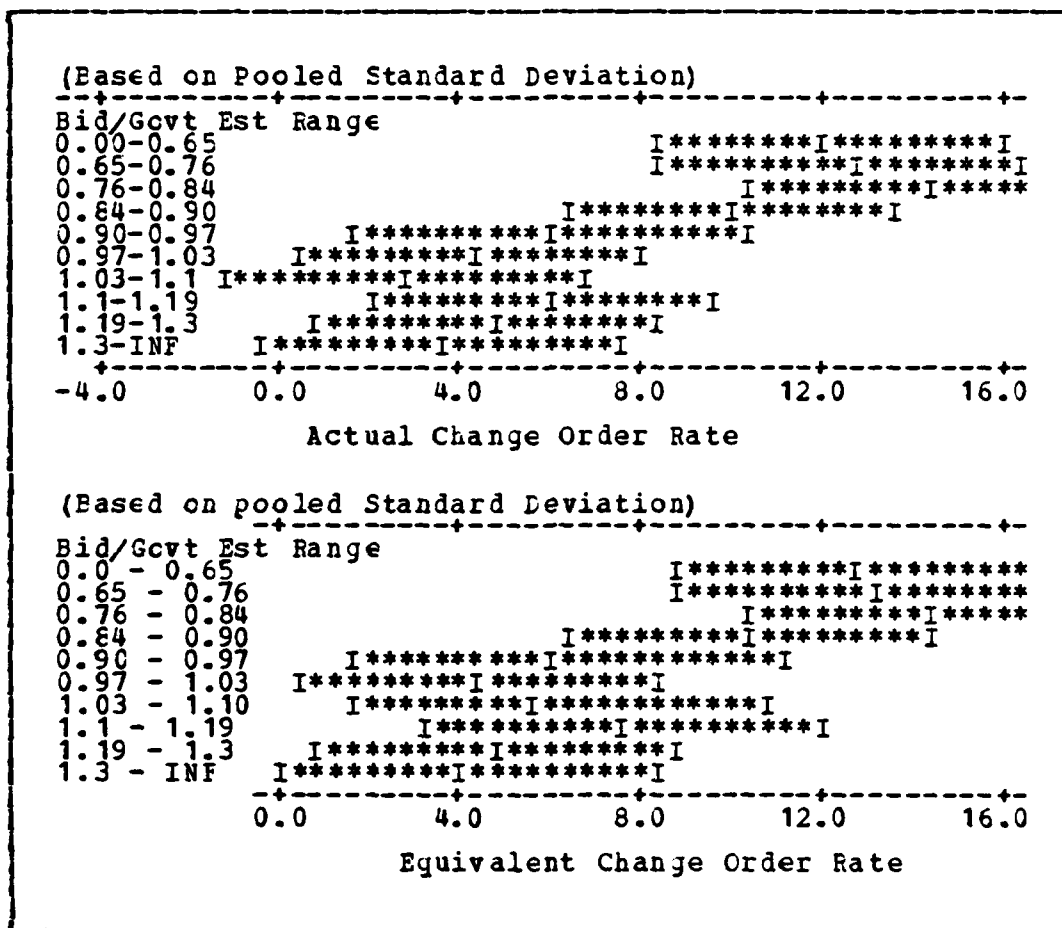


Figure 3.5 Variance Analysis for Bid/Govt Estimate.

in Section C.2. of this chapter. There is a significant difference in change order rates for both the actual and "equivalent" change order rate between the ratio extremes. The difference is significant between contracts where the ratio is 84 percent and lower; and where the ratio is either 119 percent and higher or between 97 and 103 percent. Where the ratio is roughly between 3 and 16 percent on either side of the Government estimate, no significant difference (at a 95 percent confidence level) in change order rates can be detected. One reason explaining why change order rates are

significantly low where the winning bid is within three percent of the Government estimate could be that these are considered "clean," risk-free jobs, and the work and costs involved are clearly discernable by both the Government and the contractor estimators.

This ratio may be of some use to the Contracting Officer in assessing the level of competition for a contract. If a contractor's bid is significantly lower than the Government estimate (approximately 15 percent), the likelihood of high change order rates can be anticipated.

D. SUMMARY OF ANALYSIS

A database with recent construction contract information was developed so that the principles introduced in Chapter II could be challenged for validity. It was necessary to make a number of refinements to the data so that various external influences such as nonserious bids, peculiar geographical characteristics, and terminated contracts that distort any general trends in change order rates could be eliminated.

A general statistical program, Minitab, was used to calculate a number of analytical determinations. Chapter II introduced the notion of competition intensity as a variable that affects the profit margin that contractors apply to bids. It is a general hypothesis of this thesis that as competition intensity increases, winning bidders tend to be contractors who are willing to assume greater risks than their rivals. They apply lean profit margins to their bids and expect change orders to ultimately improve their financial positions. The measures of competition intensity introduced in Chapter II, in addition to two measures introduced by the author, are applied in the database analysis to determine what conclusions can be drawn. Finally, the

incidence of change orders among varying classifications of geographical areas, time periods, price ranges, and unemployment rates was examined.

IV. SUMMARY AND CONCLUSIONS

A. SUMMARY

The excessive use of change orders in Government contracting has been alleged to be the result of improper diligence and care by management. The change order, in its original conception, was intended to be a remedy for the imperfections of contract language and depictions so that Government and contractor parties could proceed in executing the contract to a smooth end. Although change orders are intended primarily as a convenience for the Government so that "in-scope" modifications can be made to contract drawings and specifications, there is some evidence that the contractor has used change orders to his advantage. The intensity under which construction contracts are bid creates a highly competitive environment that demands a careful trade-off between a rational profit margin and a competitive price in order to win and stay in business.

It has been suggested that the winners of competitively-bid contracts are frequently contractors who fall into several categories: (1) they enjoy the advantage of economies of scale over their rivals, (2) they are more willing to assume certain risks, and (3) they see the opportunity to improve their financial positions, once the objective of winning the bid has been attained, by recouping losses through change orders. The limits that govern the extent to which contractors and contracting officers can use contract language to resolve issues of contract ambiguities in their favor have been defined through legal precedent.

Some of the theories and concepts of bidding strategy were applied to a model of representative construction contract data to test for their validities. Chapter II introduced three conventional measures for intensity of competition that were applied in the analyses. Risk-takers and "buy-in" bidders presumably emerge as victors in the bidding game under conditions of intense competition. For this reason, the number of bidders on a contract, the spread between low bidder and next lowest bidder, and the bid-to-Government estimate ratio were used in regression and variance analyses to determine the validity of this statement. Two other measures were introduced by the author for use in analysis: the bid-to-mean bid ratio and the number of standard deviations of the low bidder from the mean bid. Chapter III considered a number of predictive variables that might help to explain the conditions that affect change order rates.

It was necessary in the analysis to make several assumptions and refinements to the data. This was done so that the data could be analyzed without the influence of outliers to distort any general trends.

B. CONCLUSIONS

Change orders do not appear to be influenced by any dominant variable or combination of variables. There are many miscellaneous factors, apparently randomly distributed throughout the contract administration process, that contribute to contract price growth. These factors include, but are not limited to:

- Contracting officer and contractor expertise and competence.
- Availability of construction materials and labor.
- Architect-engineer competency.

- Contractor business windfalls or failures on other concurrent jobs.
- Backlog of contracting officer paperwork.

The results of analysis were conclusive. No direct relationship exists between the change order rate and any simple combination of variables. The most significant findings for the variables that were considered lie in the change order rates among varying bid-to-Government estimate ratios and geographical locations. Change order rates appear to be higher when the contractor bid is at least 15 percent below the Government estimate. When the contractor bid is very close (within three percent) to the Government estimate, or when his bid is approximately twenty percent above the Government estimate, change order rates are significantly lower. This information may be useful to the contracting officer in anticipating the magnitude of change orders for a contract, since it is information readily available at bid opening.

There is a significantly lower change order rate for construction contracts awarded for "rural" Naval activities than there is for contracts awarded in metropolitan areas, such as San Diego, Los Angeles, San Francisco, and Seattle/Bremerton. The explanation for this is speculative, but one may infer that "rural" contracts are "cleaner" or that the intense bidding competition in the metropolitan areas contributes to higher change order rates.

A discovery incident to the aim of this thesis was that the change order rate was remarkably similar to the spread. Of the 169 contracts with 4 or more bidders, the actual change order rate mean was 7.91 percent with a standard deviation of 12.10. The mean spread was 9.36 percent with a standard deviation of 13.06. These figures imply that

statistically, for a 95 percent confidence level, there is no significant difference between the two.

C. FUTURE RESEARCH

The intent of this thesis was to identify variables that significantly influence change order rates. Data was therefore refined so that general trends could be examined. One obvious shortcoming in the analyses was in the consideration given for the type (structural, electrical, mechanical, earthwork, etc.) of construction and the effect it has on the change order rate. Future research could explore this variable for significant relationships in change order occurrences.

There is room for more study on the performance of goal standards established in the NAVFAC Command Management Plan for controlling change orders. Research could not only determine how well the Engineering Field Divisions are performing under these standards, but it could identify where weaknesses exist. Such factors as geographical location, construction type, or type of facility may be selectively examined.

The analysis of bid spreads could determine when a justifiable move should be taken to cancel and rebid for contracts or when it is feasible to remain with a low bidder even if other forms of contracting (for example, negotiated fixed-price) seem desirable.

APPENDIX A
DESCRIPTION OF DATABASE VARIABLES

DATA GROUP 1

Column 1
CONTRACT NUMBER

The number assigned by WESTDIV prior to the Invitation for Bids (6-digit number), identifying the contract.

Column 2
AWARD DATE

The date the contract was awarded by WESTDIV to the contractor. (Year-Month-Day)

Column 3
AWARD AMOUNT

The amount of money originally awarded for a particular portion of work identified by line item in the CMS.

Column 4
GEOGRAPHY CODE

The location of construction, derived from the Unit Identification Codes listed for each contract in the CMS:

- 10 Metropolitan San Francisco area.
- 11 Northern California/Nevada area, excl. San Francisco metropolitan area.
- 20 Metropolitan Seattle/Bremerton area.
- 21 Washington/Oregon area excluding Seattle/Bremerton.
- 30 Metropolitan Los Angeles area.
- 31 Rural Los Angeles area, incl. Ventura County.
- 40 Metropolitan San Diego area.
- 41 Rural San Diego area, including Arizona.

Column 5
NUMBER OF BIDS

The number of responsive and serious bids submitted by contractors in response to the Invitation for Bids.

Column 6
MEAN BID

The average amount bid for each
contract, equal to:

Sum of bid amounts per contract
Number of bids per contract

Column 7
NUMBER OF CHANGE ORDERS

The number of dollar-valued
change orders to a contract.

DATA GROUP 2

**Column 1
GOVERNMENT ESTIMATE**

The independent estimate of construction made by the Government for work corresponding to the base bid and bid additives actually awarded.

**Column 2
WINNING BID**

The winning bid for the contract by the contractor, inclusive of all work segments and funding sources.

**Column 3
WINNING BID TO
MEAN BID RATIO**

The ratio of the winning bid to the mean of bids for a contract. Values close to unity indicate relative closeness of the winning bid to the competition average.

**Column 4
WINNING BID TO GOVERN-
MENT ESTIMATE RATIO**

The ratio of the winning bid to the Government Estimate. Values above unity indicate a winning bid that exceeds the Government Estimate.

**Column 5
ACTUAL CHANGE
ORDER RATE**

The actual change order rate accounting for both additive and deductive change orders, expressed as a percentage:

$$\left(\frac{\text{Final contract price}}{\text{Original award amount}} - 1 \right) \times 100$$

**Column 6
"EQUIVALENT" CHANGE
ORDER RATE**

The change order rate adjusted to dilute the effect of deductive change orders, and to account for the difference in the final product from the original, equal to:

$$\left(\frac{(\text{FCP} - \text{DCO's} + \text{VECO's})}{(\text{Original award amount})} - 1 \right) \times 100$$

FCP = Final contract price
DCO's = Deductive change orders
VECO's = Value Engineering change orders

DATA GROUP 3

Column 1
CONTRACT NUMBER

The number assigned by WESTDIV.
(This number can be used as a
cross-reference for data in the
first two Data Groups.)

Column 2
SECOND LOWEST BID

The amount submitted by the sec-
ond lowest bidder for the con-
tract.

Column 3
NUMBER OF STANDARD
DEVIATIONS OF LOW
BID FROM THE MEAN

The number of standard devia-
tions that the low bid for a
contract lies from the mean of
bids for that contract, ex-
pressed as:

$$\frac{(\text{Mean bid} - \text{winning bid})}{\text{Standard deviation of bids}}$$

Column 4
BID SPREAD

The percentage of spread between
the winning bid and the second
lowest bidder, expressed as:

$$\left(\frac{\text{Second lowest bid}}{\text{Winning bid}} - 1 \right) \times 100$$

Columns 5 and 6
ACTUAL CHANGE ORDER RATE and (As described in DATA
"EQUIVALENT" CHANGE ORDER RATE GROUP 1)

APPENDIX B
WESTDIV CCNSTRUCTION CONTRACTS DATA

Note: The following data are in three groups. The first two groups include data for all 300 contracts; the third group includes only those contracts with four or more bidders. The row number can be used as a cross-reference between the first two groups, and the Contract Number can be used as the cross-reference between the third group and the first two groups. For the first two groups, rows 1 through 173 are MCON contracts, 174 through 191 are NAF contracts, and 192 through 300 are OMN contracts. For the third group, 1 through 98 are MCON contracts, 99 through 110 are NAF contracts and rows 111 through 169 are OMN contracts.

DATA GROUP 1

Row	Contract Number	Award Date	Award Amount	Geog. Code	No. Bids	Mean Bid	No. C.O.
1	76-7344	77-10-28	708,297	21	5	780,542	6
2	76-7340	77-10-31	216,689	20	3	259,254	2
3	77-2067	77-11-03	389,225	20	3	478,195	13
4	76-7180	77-11-30	224,942	40	5	266,348	4
5	77-2276	77-12-01	367,000	31	6	460,632	2
6	76-7409	77-12-06	3,469,300	31	2	499,650	17
7	73-5370	77-12-06	3,379,000	20	2	3,271,000	11
8	77-2369	77-12-06	3,325,800	10	3	354,557	8
9	77-2454	77-12-09	269,000	40	3	297,333	1
10	76-7178	77-12-30	461,000	41	9	615,088	7
11	75-6305	77-12-30	555,000	31	8	7,001,945	12
12	77-2617	78-01-13	314,725	40	3	326,763	1
13	76-7336	78-01-19	711,868	10	2	958,533	37
14	76-7162	78-01-25	3,416,226	10	6	4,369,262	29
15	78-0224	78-02-06	3,345,430	10	2	3,351,185	3
16	77-2222	78-02-22	335,278	11	4	383,516	27
17	76-7150	78-02-28	5,982,800	40	6	6,175,274	2
18	77-2971	78-03-08	297,671	20	4	347,193	1
19	75-6468	78-03-15	4,031,967	10	5	5,377,916	23

201	71-4364	78-03-17	4599	400	345	1	27	1	25
223	76-7326	78-03-31	4980	430	57		88		3
234	77-2674	78-04-21	4980	350	269		33		2
255	77-2657	78-04-28	4980	400	75		73		3
267	77-2657	78-05-01	4980	400	54		25		3
278	77-2657	78-05-03	4980	400	35		05		5
289	77-2657	78-05-26	4980	400	75		00		1
301	77-2657	78-06-02	4980	400	43		49		6
312	77-2657	78-06-15	4980	400	54		68		8
323	77-2657	78-06-23	4980	400	35		49		1
334	77-2657	78-06-28	4980	400	75		28		6
345	77-2657	78-06-30	4980	400	43		49		1
356	77-2657	78-08-02	4980	400	54		28		3
367	77-2657	78-08-04	4980	400	35		49		1
378	77-2657	78-08-16	4980	400	75		28		6
389	77-2657	78-09-11	4980	400	43		49		1
400	77-2657	78-09-15	4980	400	54		28		3
411	77-2657	78-09-22	4980	400	35		49		1
423	77-2657	78-09-29	4980	400	75		28		6
434	77-2657	78-09-29	4980	400	43		49		1
445	77-2657	78-09-29	4980	400	54		28		3
456	77-2657	78-10-23	4980	400	35		49		1
467	77-2657	78-11-14	4980	400	75		28		6
478	77-2657	78-11-29	4980	400	43		49		1
489	77-2657	78-11-29	4980	400	54		28		3
500	77-2657	78-11-30	4980	400	35		49		1
511	77-2657	78-11-30	4980	400	75		28		6
523	77-2657	78-12-05	4980	400	43		49		1
534	77-2657	78-12-15	4980	400	54		28		3
545	77-2657	78-12-21	4980	400	35		49		1
556	77-2657	78-12-29	4980	400	75		28		6
567	77-2657	78-12-29	4980	400	43		49		1
578	77-2657	78-12-29	4980	400	54		28		3
589	77-2657	78-12-29	4980	400	35		49		1
590	77-2657	78-12-29	4980	400	75		28		6
601	77-2657	78-12-29	4980	400	43		49		1
612	77-2657	78-12-29	4980	400	54		28		3
623	77-2657	78-12-29	4980	400	35		49		1
634	77-2657	78-12-29	4980	400	75		28		6
645	77-2657	78-12-29	4980	400	43		49		1
656	77-2657	78-12-29	4980	400	54		28		3
667	77-2657	78-12-29	4980	400	35		49		1

71

72

73

260	111	002	041	112	210	102	002	041	110	121	212	121	212	152	132	021	1
261	337	325	101	733	622	310	819	251	277	955	755	121	450	233	757	116	206
262	443	443	609	822	769	598	218	618	118	517	844	542	387	167	575	506	711
263	597	897	897	897	897	897	897	897	897	897	897	897	897	897	897	897	897
264	101	897	897	897	897	897	897	897	897	897	897	897	897	897	897	897	897
265	622	822	822	822	822	822	822	822	822	822	822	822	822	822	822	822	822
266	310	822	822	822	822	822	822	822	822	822	822	822	822	822	822	822	822
267	819	769	598	218	618	118	517	844	542	387	167	575	506	711	509	903	920
268	251	218	618	118	517	844	542	387	167	575	506	711	509	903	920	934	574
269	277	118	517	844	542	387	167	575	506	711	509	903	920	934	574	768	138
270	955	517	844	542	387	167	575	506	711	509	903	920	934	574	768	138	234
271	755	844	542	387	167	575	506	711	509	903	920	934	574	768	138	234	574
272	121	542	387	167	575	506	711	509	903	920	934	574	768	138	234	574	768
273	450	387	167	575	506	711	509	903	920	934	574	768	138	234	574	768	138
274	233	167	575	506	711	509	903	920	934	574	768	138	234	574	768	138	234
275	757	575	506	711	509	903	920	934	574	768	138	234	574	768	138	234	574
276	506	711	509	903	920	934	574	768	138	234	574	768	138	234	574	768	138
277	711	509	903	920	934	574	768	138	234	574	768	138	234	574	768	138	234
278	509	903	920	934	574	768	138	234	574	768	138	234	574	768	138	234	574
279	903	920	934	574	768	138	234	574	768	138	234	574	768	138	234	574	768
280	920	934	574	768	138	234	574	768	138	234	574	768	138	234	574	768	138
281	934	574	768	138	234	574	768	138	234	574	768	138	234	574	768	138	234
282	574	768	138	234	574	768	138	234	574	768	138	234	574	768	138	234	574
283	768	138	234	574	768	138	234	574	768	138	234	574	768	138	234	574	768
284	138	234	574	768	138	234	574	768	138	234	574	768	138	234	574	768	138
285	234	574	768	138	234	574	768	138	234	574	768	138	234	574	768	138	234
286	574	768	138	234	574	768	138	234	574	768	138	234	574	768	138	234	574
287	768	138	234	574	768	138	234	574	768	138	234	574	768	138	234	574	768
288	138	234	574	768	138	234	574	768	138	234	574	768	138	234	574	768	138
289	234	574	768	138	234	574	768	138	234	574	768	138	234	574	768	138	234
290	574	768	138	234	574	768	138	234	574	768	138	234	574	768	138	234	574
291	768	138	234	574	768	138	234	574	768	138	234	574	768	138	234	574	768
292	138	234	574	768	138	234	574	768	138	234	574	768	138	234	574	768	138
293	234	574	768	138	234	574	768	138	234	574	768	138	234	574	768	138	234
294	574	768	138	234	574	768	138	234	574	768	138	234	574	768	138	234	574
295	768	138	234	574	768	138	234	574	768	138	234	574	768	138	234	574	768
296	138	234	574	768	138	234	574	768	138	234	574	768	138	234	574	768	138
297	234	574	768	138	234	574	768	138	234	574	768	138	234	574	768	138	234
298	574	768	138	234	574	768	138	234	574	768	138	234	574	768	138	234	574
299	768	138	234	574	768	138	234	574	768	138	234	574	768	138	234	574	768
300	138	234	574	768	138	234	574	768	138	234	574	768	138	234	574	768	138

DATA GROUP 2

Row	Govmnt Estimate	Winning Bid	Win Bid/ Mean Bid	Win Bid/ Govt Est	Act Chg Ord'r Rt	Eguv Chg Ord'r Rt
1	635	708	0.90758	1.11506	2.6869	2.6869
2	222	216	0.85582	0.97377	1.41331	1.6849
3	330	389	0.81395	1.03793	8.55133	17.8467
4	366	224	0.84454	0.97546	6.55123	6.55123
5	443	367	0.79673	1.00273	10.9109	10.9109
6	461	469	0.99133	1.00764	41.5856	41.5856
7	362	379	0.91115	1.07574	12.1421	12.1421
8	344	269	0.91889	0.90000	0.0	0.0
9	626	461	0.90471	0.78039	32.1789	32.1789
10	422	555	0.94947	0.73619	2.4632	2.4632
11	431	314	0.93617	1.02044	0.0	0.0
12	815	711	0.95025	1.16867	23.5941	23.5941
13	366	345	0.93304	1.04237	27.5623	27.5623
14	815	335	0.98316	0.70938	3.51425	3.51425
15	366	382	0.87483	1.02585	26.7703	26.7703
16	557	335	0.87736	1.05650	24.0551	24.0551
17	856	297	0.96577	1.25856	26.7031	26.7031
18	190	231	0.87497	1.03222	26.1606	26.1606
19	525	468	0.88739	0.89227	16.6119	16.6119
20	445	599	0.87588	1.12428	10.5119	10.5119
21	158	605	0.76512	0.97744	3.6890	3.6890
22	541	249	0.86578	1.02438	9.5311	9.5311
23	211	253	0.90899	0.99050	6.4646	6.4646
24	537	294	0.94954	0.95587	13.4165	13.4165
25	387	333	0.84277	0.92371	2.5299	2.5299
26	499	333	0.90899	0.95587	0.0	0.0
27	181	282	0.84277	1.02438	2.0481	2.0481
28	330	282	0.82130	1.21699	0.8424	0.8424
29	555	766	0.85808	0.94267	10.7224	10.7224
30	581	905	0.94310	0.87720	7.5014	7.5014
31	000	631	0.83322	0.98193	1.5529	1.5529
32	000	336	0.93528	1.03803	4.5307	4.5307
33	000	359	0.96915	1.25379	1.5529	1.5529
34	040	351	0.97709	1.06662	6.5385	6.5385
35	400	331	0.90213	1.09166	8.2907	8.2907
36	520	518	0.90213	1.09166	5.6603	5.6603
37	177	079	0.95578	1.03319	8.7408	8.7408
38	799	684	0.95578	1.03319	6.2268	6.2268
39	518	096	0.83198	1.09450	4.4319	4.4319
40	353	109	0.83198	1.09450	11.3199	11.3199
41	160	096	0.83198	1.09450		
42	549	645	0.92381	1.17443		

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91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138					
6	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50		
82	91	74	56	22	22	62	23	43	82	74	42	31	70	62	88	53	45	30	25	39	05	08	17	19	20	28	45	71	20	87	18	26	13	39	20	07	55	50	01	08	00	01	00	00	00	00	00	00	00	00		
04	65	00	00	00	00	00	08	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00		
00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00		
19	36	93	25	38	46	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00			
01	60	40	10	01	07	00	13	19	08	15	58	35	12	55	16	34	59	28	00	30	77	28	00	30	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00		
156	93	79	69	02	41	1	2	3	0	2	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	
-7	2	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0		
0	77	86	72	0	92	41	1	2	3	0	2	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0

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187	2	010	000	43	180	92	000	000	1290	5349	105	5349
188		711	000	421	622	160	000	000	000	8849	050	8849
189		389	500	492	042	622	000	000	000	5372	050	5372
190		605	000	412	132	132	000	000	000	0181	050	0181
191		43	000	387	778	778	000	000	000	0071	050	0071
192		703	000	977	375	375	000	000	000	0953	020	0953
193		499	500	847	775	775	000	000	000	5193	005	5193
194		358	500	311	753	753	000	000	000	881	38	881
195		117	800	977	706	706	000	000	000	1215	38	1215
196		50	400	96	400	400	000	000	000	0064	000	0064
197		577	400	72	330	330	000	000	000	1064	03	1064
198		577	400	72	110	110	000	000	000	1815	1	1815
199		207	723	262	505	505	000	000	000	5858	3	5858
200		107	000	167	305	305	000	000	000	0100	8	0100
201		140	000	580	600	600	000	000	000	9283	23	9283
202		198	000	239	800	800	000	000	000	05820	0	05820
203		232	000	46	220	220	000	000	000	7930	1	7930
204		333	000	54	295	295	000	000	000	7914	4	7914
205		323	000	318	773	773	000	000	000	3925	1	3925
206		276	300	371	900	900	000	000	000	1420	0	1420
207		333	500	34	900	900	000	000	000	000	0	000
208		65	600	87	490	490	000	000	000	000	0	000
209		242	000	23	900	900	000	000	000	000	0	000
210		136	900	170	600	600	000	000	000	000	0	000
211		778	200	144	350	350	000	000	000	3744	1	3744
212		106	000	103	160	160	000	000	000	000	0	000
213		497	000	861	700	700	000	000	000	595	10	595
214		539	000	46	200	200	000	000	000	3989	12	3989
215		45	000	50	800	800	000	000	000	0946	3	0946
216		32	000	46	300	300	000	000	000	000	0	000
217		66	000	50	800	800	000	000	000	000	0	000
218		902	000	87	500	500	000	000	000	9679	4	9679
219		136	000	144	200	200	000	000	000	3827	21	3827
220		106	000	103	160	160	000	000	000	000	0	000
221		497	000	861	700	700	000	000	000	592	4	592
222		539	000	46	200	200	000	000	000	899	23	899
223		45	000	50	800	800	000	000	000	9914	40	9914
224		32	000	46	300	300	000	000	000	22396	2	22396
225		66	000	50	800	800	000	000	000	000	0	000
226		902	000	87	500	500	000	000	000	000	0	000
227		136	000	144	200	200	000	000	000	000	0	000
228		106	000	103	160	160	000	000	000	000	0	000
229		497	000	861	700	700	000	000	000	000	0	000
230		539	000	46	200	200	000	000	000	000	0	000
231		45	000	50	800	800	000	000	000	000	0	000
232		32	000	46	300	300	000	000	000	000	0	000
233		66	000	50	800	800	000	000	000	000	0	000

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282	93,000	82,200	0.70554	0.88387	8.8041	8.8041
283	146,000	192,887	0.93560	1.32114	3.5453	3.5453
284	190,100	185,808	0.85202	0.95236	0.04899	0.04899
285	671,000	682,820	0.45227	1.01762	1.9974	1.9974
286	420,000	433,651	0.90927	1.03254	0.8766	0.8766
287	148,000	98,641	0.71007	0.66549	17.8393	17.8393
288	42,300	81,410	0.61407	1.92459	7.8117	7.8117
289	1,010,000	527,916	0.79774	0.52269	1.5979	1.5979
290	66,900	47,750	0.78102	0.71375	12.6962	12.6962
291	740,000	520,101	0.61900	0.70284	10.6056	10.6056
292	88,100	98,576	1.00000	1.11891	0.6056	0.6056
293	5,790,000	3,471,960	0.80143	0.59965	10.8237	10.8237
294	790,000	634,003	0.74721	0.77227	35.7499	35.7499
295	303,000	153,400	0.68424	0.50627	7.2281	7.2281
296	181,900	146,900	0.82760	0.80759	3.8263	3.8263
297	32,900	24,000	0.80429	0.75000	22.2208	22.2208
298	35,400	25,600	0.71478	0.72316	0.01375	0.01375
299	46,600	67,600	0.55868	1.45064	15.0073	15.0073
300	72,500	68,420	0.79266	0.94372		

DATA GROUP 3

Row	Contract Number	2nd Low Bid	No. Bid	Std Dev fm Mean	Bid Spread	Act Chg Ordr Rt	Equiv Chg Ordr Rt
1	76-7344	747,478	1	1.18900	5.516	2.6869	2.6869
2	76-7180	260,700	1	1.58300	15.897	6.5513	6.5513
3	77-2276	438,558	1	1.48500	19.498	6.5123	6.5123
4	76-7178	525,372	1	1.65700	13.964	32.1789	32.1789
5	75-6305	611,778	1	1.62300	0.866	2.4632	2.4632
6	76-7162	673,002	1	1.30500	1.962	27.0629	27.0629
7	77-2222	366,577	0	1.94300	9.335	3.1425	3.1425
8	77-7150	116,443	1	1.77300	2.744	26.0559	26.0559
9	77-2971	341,560	1	1.35400	14.744	4.7031	4.7031
10	75-6468	586,820	1	1.23900	23.682	26.0858	26.0858
11	76-7236	648,971	0	1.86000	3.061	29.0910	29.0910
12	76-7328	653,635	1	1.46400	8.039	15.5119	15.5119
13	77-2674	271,235	1	1.06200	8.856	10.6890	10.6890
14	77-2657	295,314	0	1.82200	0.193	3.4646	3.4646
15	77-2678	219,172	1	1.06700	0.046	13.4165	13.4165
16	78-0455	359,802	1	1.06200	7.854	2.2089	2.2089
17	77-2738	279,432	1	1.17900	22.555	0.5425	0.5425
18	77-2570	339,999	1	1.32300	20.524	2.2048	2.2048
19	78-0243	359,918	1	1.62900	6.034	10.7224	10.7224
20	75-6547	773,867	1	1.06300	5.406	7.5311	7.5311

1	78-0539	14	352	100	105	11	0144	11	0143
2	77-2073	1	194	1	405	2	9306	3	1783
3	77-2079	1	538	1	373	4	3079	6	3853
4	76-2057	1	127	0	229	6	6690	6	7403
5	76-2058	1	173	1	239	4	2268	4	2268
6	78-0684	1	373	1	015	1	0834	1	6294
7	78-0284	1	173	5	506	4	7837	1	7737
8	78-0253	1	173	5	070	2	7881	2	7740
9	77-2750	1	173	9	989	6	5847	5	9570
10	77-2269	1	355	3	989	5	0617	5	0617
11	77-2269	1	797	1	989	0	0	0	0
12	78-0093	1	158	1	292	19	1958	19	2220
13	75-6475	1	726	14	016	6	0733	7	2212
14	78-0423	1	465	26	109	7	2320	7	2320
15	76-7142	1	800	1	877	2	0514	20	0514
16	74-3952	1	693	6	318	6	4807	8	4807
17	75-6315	8	234	10	586	8	1101	3	3488
18	77-2164	7	349	1	873	13	1411	13	1411
19	77-2170	7	874	2	080	13	7537	14	8226
20	77-2889	5	785	1	049	14	8226	14	8226
21	77-2051	9	785	6	778	5	2401	40	7621
22	77-2174	2	487	10	197	3	8452	18	4222
23	78-0880	5	198	10	368	2	9033	5	9422
24	77-2909	2	774	5	834	12	5751	18	5422
25	77-2563	5	711	0	833	5	9925	5	9925
26	79-5279	4	794	0	188	2	1764	5	1764
27	77-2520	2	736	0	504	1	4801	1	4801
28	78-0895	1	144	0	507	3	2197	4	3079
29	78-0698	1	047	5	813	1	1569	5	7786
30	79-5149	1	164	15	052	7	0573	7	0573
31	77-2287	1	585	1	491	0	9241	0	9241
32	79-5287	1	506	3	326	1	2601	1	2601
33	78-0576	1	808	5	752	1	1416	1	1416
34	76-7131	1	037	10	822	2	8237	2	8237
35	78-0731	1	684	16	782	8	8906	8	8906
36	78-0089	2	229	22	277	7	9949	7	9949
37	76-0265	3	180	4	915	1	1522	2	0550
38	75-6679	1	228	9	330	2	3404	2	7094
39	79-5099	1	137	4	073	9	2684	9	2684
40	77-2061	1	137	0	143	5	7149	5	7149
41	79-5165	1	340	53	788	0	1848	0	1848
42	77-2126	1	375	10	513	1	2705	1	2705
43	77-2126	1	375	10	513	1	2705	1	2705
44	77-2126	1	375	10	513	1	2705	1	2705
45	77-2126	1	375	10	513	1	2705	1	2705
46	77-2126	1	375	10	513	1	2705	1	2705
47	77-2126	1	375	10	513	1	2705	1	2705
48	77-2126	1	375	10	513	1	2705	1	2705
49	77-2126	1	375	10	513	1	2705	1	2705
50	77-2126	1	375	10	513	1	2705	1	2705
51	77-2126	1	375	10	513	1	2705	1	2705
52	77-2126	1	375	10	513	1	2705	1	2705
53	77-2126	1	375	10	513	1	2705	1	2705
54	77-2126	1	375	10	513	1	2705	1	2705
55	77-2126	1	375	10	513	1	2705	1	2705
56	77-2126	1	375	10	513	1	2705	1	2705
57	77-2126	1	375	10	513	1	2705	1	2705
58	77-2126	1	375	10	513	1	2705	1	2705
59	77-2126	1	375	10	513	1	2705	1	2705
60	77-2126	1	375	10	513	1	2705	1	2705
61	77-2126	1	375	10	513	1	2705	1	2705
62	77-2126	1	375	10	513	1	2705	1	2705
63	77-2126	1	375	10	513	1	2705	1	2705
64	77-2126	1	375	10	513	1	2705	1	2705
65	77-2126	1	375	10	513	1	2705	1	2705
66	77-2126	1	375	10	513	1	2705	1	2705
67	77-2126	1	375	10	513	1	2705	1	2705
68	77-2126	1	375	10	513	1	2705	1	2705

69	76-7314	904	3	1	46500	0	2	854	3	2214	2214	47
70	77-5751	643	011	1	033000	0	1	1076	5	3501	3501	2396
71	77-5751	424	296	1	033000	0	1	1076	5	3501	3501	2396
72	77-5751	190	575	1	033000	0	1	1076	5	3501	3501	2396
73	80-9481	778	791	1	164600	0	1	034	0	2244	2244	3393
74	80-9626	912	919	0	71800	0	2	037	0	1728	1728	2393
75	80-9627	512	516	1	54600	0	2	399	0	8840	8840	2393
76	80-9627	665	575	1	54600	0	2	399	0	8840	8840	2393
77	80-9173	691	798	1	50300	0	7	033	0	9211	9211	5584
78	80-9161	226	798	1	50300	0	7	033	0	9211	9211	5584
79	80-8607	249	403	1	42100	0	2	163	0	0929	0929	7284
80	80-9830	551	990	1	42100	0	2	163	0	0929	0929	7284
81	80-9749	246	908	1	75500	0	7	610	0	2844	2844	0
82	80-9763	728	932	1	68800	0	21	948	0	2686	2686	0
83	80-9519	302	932	1	83400	0	6	697	0	3954	3954	7
84	80-5488	724	920	1	63800	0	0	614	0	9197	9197	7
85	81-8632	16	658	0	38100	0	1	984	0	0872	0872	4
86	80-9329	470	583	0	80100	0	1	157	0	3910	3910	3
87	80-9548	280	898	1	42500	0	4	391	0	0732	0732	5
88	81-8545	352	876	1	19500	0	5	467	0	9738	9738	0
89	81-8683	378	489	1	35600	0	4	790	0	2096	2096	0
90	81-0572	219	005	0	70500	0	6	065	0	5143	5143	6
91	81-8605	278	084	1	05400	0	1	372	0	9363	9363	1
92	81-8211	416	879	1	14300	0	1	372	0	1261	1261	1
93	79-5476	968	027	0	32700	0	2	024	0	5876	5876	2
94	81-5591	112	076	0	23300	0	2	559	0	1315	1315	1
95	81-8297	937	054	1	09800	0	2	250	0	0284	0284	0
96	82-0674	670	046	1	55800	0	12	182	0	8506	8506	0
97	82-0674	336	844	1	15200	0	6	650	0	5684	5684	8
98	77-2472	787	243	0	90800	0	2	949	0	8952	8952	9
99	77-2472	106	258	1	43900	0	3	921	0	6459	6459	3
100	77-3357	326	958	1	24400	0	1	490	0	4590	4590	3
101	77-3357	370	958	1	24400	0	1	490	0	4590	4590	3
102	78-0223	442	928	1	08800	0	4	762	0	2373	2373	3
103	77-2077	542	970	1	28800	0	6	794	0	8702	8702	1
104	77-2333	229	918	1	23900	0	7	799	0	5349	5349	3
105	77-2378	453	184	1	184300	0	7	527	0	3849	3849	3
106	79-9278	421	346	1	10200	0	2	202	0	1055	1055	1
107	80											

117	79-001	0.97100	21.795	0.3827	0.3827
118	79-009	1.24300	23.073	27.2342	27.2342
119	145.039	1.33300	23.771	47.1124	47.1124
120	516.935	0.92200	15.910	3.2680	3.2680
121	63.777	1.78500	49.106	0.0	0.0
122	24.465	1.60700	2.452	16.5619	16.5619
123	18.399	1.22800	2.241	0.0	0.0
124	452.022	1.54100	8.659	0.8862	0.8862
125	71.303	1.11900	28.757	30.2664	30.2664
126	94.597	1.33100	28.119	5.6222	5.6222
127	028.532	2.00600	15.640	10.4371	10.4371
128	1.028.098	1.71200	16.251	13.1921	13.1921
129	155.986	1.34400	0.677	0.0	0.0
130	186.889	1.52700	4.638	31.0723	31.0723
131	343.841	1.10700	7.984	8.3117	8.3117
132	625.896	1.45000	3.659	0.0	0.0
133	110.007	0.55600	10.560	0.7651	0.7651
134	476.086	1.14300	18.880	21.3115	21.3115
135	253.306	1.05200	36.243	4.7901	4.7901
136	81.481	1.32800	0.622	0.0	0.0
137	289.481	0.96100	14.052	0.3592	0.3592
138	706.392	1.47400	1.303	0.0	0.0
139	199.452	0.47600	14.052	20.6828	20.6828
140	289.063	0.31700	2.303	20.3945	20.3945
141	706.392	0.31700	4.839	23.3345	23.3345
142	223.452	1.22500	32.895	36.3747	36.3747
143	177.990	0.47600	4.283	8.0962	8.0962
144	289.063	1.34500	6.209	0.6358	0.6358
145	115.254	1.27200	18.368	0.0	0.0
146	389.770	1.01700	31.265	0.5351	0.5351
147	224.188	1.33900	19.923	0.0	0.0
148	58.982	0.80800	12.150	5.9071	5.9071
149	194.474	1.10900	4.620	0.0	0.0
150	466.030	1.70100	12.620	0.0	0.0
151	115.982	1.04400	6.097	0.5032	0.5032
152	91.750	1.02200	41.823	0.0	0.0
153	466.030	1.26000	0.923	0.8041	0.8041
154	123.132	1.20200	14.702	3.5453	3.5453
155	560.340	1.30100	6.619	0.0	0.0
156	642.574	1.41200	24.819	1.4899	1.4899
157	3.762.502	1.67000	2.548	0.9974	0.9974
158		1.55500	23.368	17.8766	17.8766
159				13.8117	13.8117
160				1.5979	1.5979
161				12.6962	12.6962
162				10.8237	10.8237

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14-643

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1-10400
1-36700
1-47700

683,637
159,238
169,000
50,790
78,439

82-0700
82-0217
82-0207
82-0276
81-8709

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167
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