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THESIS

PRODUCTIVITY IMPROVEMENT OPPORTUNITIES
AT
NAVY PUBLIC WORKS ACTIVITIES

by

Richard Jacob Dieffenbach

June 1992

Thesis Advisor: Dan Trietsch
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Productivity Improvement Opportunities at Navy Public Works Activities

by

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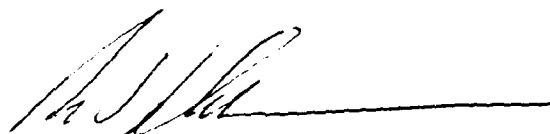
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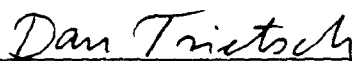
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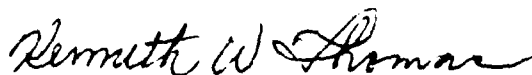


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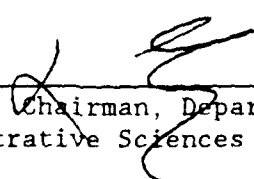
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ABSTRACT

The study identifies six principal opportunities for productivity improvement at Navy Public Works in-house maintenance activities: improving work assignment, increasing shop supervisor effectiveness, reducing long lunches and early quits (through understanding of work impediments as demotivational contributors), improving service order management, improving job order quality and miscellaneous opportunities. Activity "productivity opportunity" self-evaluation questions and methods are provided for each.

Opportunities for productivity improvement are developed from a review of twenty-six completed Public Works productivity studies. Contributors to poor productivity are summarized and cross-referenced to their corresponding effects on the craft-person's time. Intrinsic task motivational theory is used to explain the widespread problem of craft-person returns for lunch to the shop. Key actions and results at specific Navy Public Works activities having documented productivity improvement are summarized.

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DEDICATION

To Kathleen Dianne
.
and Charlotte Edith

The waste of time is the worst kind of all
because it doesn't litter the floor.

-- Henry Ford

I. INTRODUCTION

A. PROBLEM

In the face of severely declining resources there exists a need to improve productivity in Navy Real Property Maintenance Activities (RPMA) with in-house work forces.

B. BACKGROUND AND GOAL

I read my first "E.L. Hamm" productivity study of a Navy Public Works activity in early 1988, shortly after reporting aboard NAS Key West as Assistant Public Works Officer.¹ Several months later, after receiving Hamm's initial report for Key West, I was struck with the similarity of problems at both activities. Naturally suspicious, my first reaction was that the similarity had more to do with the contractor's word processor than reality. I was wrong.

Most E.L. Hamm identified problems about Key West were not surprises to us.² Some were explicitly known while others were more gut level. Many had been internalized in the organization over the years as "just the way it is." The ravages of Commercial Activities ("CA"), the most

¹E.L. Hamm and Associates has done the majority of Navy Public Works productivity studies since the early eighties.

²The Public Works Officer was CDR Jim Corbett, presently Commanding Officer NMCB-FOUR and Captain select.

dehumanizing program in the federal government, had seen to it that workers and supervisors lacked trust in a system that treated them as a commodity. Shop supervisors were available by phone most of the time. Craft-persons seemed to take a long time to leave the parking lot in the morning despite a maze of activity. They returned, however, well before lunch "for supplies" and while back, ate. Shop supervisors negatively conditioned the Planners & Estimator's (P&E's); the first time the two spoke was *after* the job was issued to the shops and usually when the shop supervisor discovered a problem. Only after reading the E.L. Hamm report, however, did we appreciate how ill the organization was. Until then it had been difficult seeing the forest through the trees.

The Key West success in pulling itself up by the bootstraps is described by the E.L. Hamm report of Appendix F (page 100.) If there was any "secret" to this success it was our strategy to harness the collective intelligence of the workforce. By involving everyone and acting on their ideas and criticisms productivity improvement became not just possible but *inevitable*.

This is not to say the improvement process was always pleasant. During our initial round of shop "blitzes", craft-persons expressed *anger* at the sorry condition of our vehicles and at management's failure to do anything about it.³ I responded with "its not our fault, vehicle procurement is centrally controlled and funded, and bla bla bla..." One

³The Production Officer, Maintenance General Foreman and I met with each shop (less shop supervisor) quarterly for about two hours to brief them on what we were doing to improve productivity... and hear their comments on how we were doing.

craft-person spoke up: "look, if you want us to do the job, then give us what we need to do it, or let's just forget about this whole #\$\$! thing." He was right.⁴

Even before E.L. Hamm returned to remeasure productivity 18 months later, we knew it had improved. The shop parking lot seemed to empty quickly in the morning and only partially refill just before lunch. We (amazingly) started to hear craft-persons compliment the service provided by Supply. Shop supervisors, particularly the Building Trades supervisor (lead on most jobs), became difficult to get on the phone. Supervisors were routinely observed in the field with the P&E's. When certain "diehard nothing will ever change" civilians began outwardly recognizing improvement, we knew real progress had been made.

The point is this: productivity can be improved, the status quo doesn't have to be and the Public Works Officer can achieve visible results *well within the span of a tour*. However, to improve productivity one needs to know what the opportunities for improvement are. Key West and a number of other activities were fortunate to have their's identified through work sampling and process analysis, performed by a contractor or an engineering field division. Unfortunately the current implosion of DoD resources may preclude future productivity studies. Therefore, the goal of this thesis is to help activities identify their own opportunities by showing them where to look and what questions to ask.

⁴Postscript: we subsequently found a way to fill all our vehicle needs quickly, at minimal cost. See "2(b)" of Appendix E, page 93.

C. DEFINITIONS AND ASSUMPTIONS

Here are definitions for some key terms used in this thesis:

- * "Craft-person" is the degenderized term for craftsmen.⁵ Craft-persons in Public Works are typically (but not limited to) plumbers, carpenters, electricians, painters, pipefitters, welders, maintenance mechanics, helpers, masons, air conditioning mechanics and high voltage electricians.
- * "Productivity" is the percentage of time the craft-person spends doing work that directly adds value to materials.⁶
- * A "poor productivity cause" is anything which tends to restrict or reduce productivity. Examples are incorrect materials ordered by others, lack of vehicles and lunch breaks beyond the allotted time.
- * "Productivity impediments" or "work impediments" (synonymous) are *poor productivity causes* controlled by and the responsibility of management. They cannot be changed directly by the craft-person. Thus, in the example above, incorrect materials and lack of vehicles are productivity impediments. Extending lunch beyond the allotted time is not.⁷
- * A "poor productivity effect" is a change in how craft-persons spend time as a result of a *poor productivity cause*. For example, a

⁵In many tables and figures "craft-person" is abbreviated "cp."

⁶This will be discussed in greater detail in Chapter II.

⁷However it will be demonstrated in the thesis that productivity impediments may contribute to the craft-person decision to take extended lunches, breaks and quit early.

plumber who discovers on-site that the wrong size PVC was ordered ("the cause") will spend additional time (the "effect") taking corrective action. He/she may return to the shop, confer with the shop supervisor, search for replacement materials and return to the job site etc.

The following assumptions are inherent in this thesis:

- * The reader has some familiarity with terms used in the Public Works environment, such as shop, job order, service order, shop load plan, maintenance management system etc. If not, the reader is referred to Navy Publication MO-321 Maintenance Management of Shore Facilities.
- * Public Works labor resources are scarce. Certain maintenance practices make sense only when this is true. For example, batching service orders (logically grouping them for sequential execution by the craft-person) would make no sense in the situation of plentiful labor and low work demand.

D. PURPOSE OF THESIS

The purpose of this thesis is to identify opportunities for productivity improvement at Navy in-house Public Works Activities. An opportunity for productivity improvement, as used in this thesis, is any management controlled or influenced component of the RPMA system that

limits or impedes the craft-person from doing productive work.⁸

Productive work will be defined in Chapter II as work that adds value to materials.

To determine these opportunities, I will:

- * Identify the most frequent causes of poor productivity.
- * Determine how each cause affects the craft-person, i.e., increased travel time, idle time etc.
- * Examine the relationship between poor productivity causes and craft-person motivation.
- * Investigate productivity improvement at NAS Key West, NAS Dallas and NAB Little Creek to determine:
 - How much productivity improved, and how this compares with the Navy status quo.
 - What changed in the distribution of craft-person time.
 - What changes in modus operandi were suggested of the activity.
 - What changes, in the view of the activity, were key to their overall success.

E. SCOPE OF RESEARCH

The principal data for this research comes from twenty-six Naval Public Works Real Property Management Activities (RPMA) Productivity

⁸The focus of this work is on opportunities for improvement within the sphere of influence of the activity Commanding Officer or preferably, the Public Works Officer.

Studies. The studies were done between the early eighties and 1990. The reports provide insight into activity productivity (and quality) problems. They generally focus on in-house shop forces normally found within the bounds of Maintenance and Utilities Divisions of Public Works Departments and Centers. Consequently, so does this thesis.

Taken together, the reports offer a comprehensive view of productivity opportunities inherent at many Navy Public Works activities.

F. THESIS STRUCTURE

Chapter II, Theory, reviews several concepts for subsequent use in Chapter IV and beyond: productivity theory, the relation between quality and productivity, first and last productive effort and intrinsic motivation theory.

Chapter III, NAVY RPMA Productivity studies, provides an overview of the studies, their background, content, merit and approach. The chapter concludes by summarizing the results of two previous productivity study reviews.

Chapter IV, Methodology and Preliminary Analysis, presents the methodology, results and preliminary analysis on several key questions:

- * What are the most frequent causes of poor productivity?
- * What are the effects of poor productivity causes?
- * How are poor productivity causes and effects related?

- * What were the changes in craft-person time at three activities with documented productivity improvement?
- * What changes in modus operandi were suggested to these three activities in their productivity studies?
- * What changes in modus operandi are considered key by the three activities.⁹

Chapter V, Opportunities for Productivity Improvement, attempts to forge the results of Chapters II through IV into the thesis goal depicted by the chapter title. It is the key chapter and the purpose of this thesis.

Chapter VI, Right Brain Thoughts and Recommendations, concludes the thesis with my insights on productivity improvement and two recommendations.

⁹The goal was three activities. However, pertinent information was available for just two.

II. THEORY

A. PRODUCTIVITY AND QUALITY

The purpose of Chapter II is to review three concepts used later in the analysis:

- * Productivity: theory, relationship to quality, and measurement in the context of Public Works productivity studies.
- * The relation between "first and last" productive effort and productivity.
- * Intrinsic motivation theory and the impact of productivity impediments on craft-person motivation.

1. Productivity

Productivity is most commonly defined as the ratio of outputs to inputs. Applied to an organization, productivity is the ratio of goods or services provided and resources consumed. (Lawlor, 1985, p.33)
Resources are labor, materials, capital and services.

(Juran, 1988, p.8.20)

Lawlor(1985, pp.36-42) suggests that productivity is a "comprehensive measure of how efficiently and effectively organizations satisfy five aims":

- * Objectives. The degree that organizational objectives are being achieved.
- * Efficiency. The efficiency of input to output conversion.

- * Effectiveness. What is being achieved compared to what is possible.
- * Comparability. How productivity compares with other companies, industries and countries.
- * Trends. Productivity performance over time.

Edosomwan(1987,pp.3-6) after cataloging some 18 definitions of productivity proposed since 1776, lists three definitions generally accepted by most researchers and practitioners:

- * Total productivity. The ratio of total output to all input factors.
- * Total factor productivity. The ratio of total output to the sum of labor and capital (factor) inputs.
- * Partial productivity. The ratio of total output to one class of input.

Total factor productivity excludes input (cost) contribution of materials, parts and supplies; its usefulness depends on the nature of the organization applied. Total productivity is the most comprehensive of the three, attempting to relate total input to total output (Edosomwan,1987,p.55) The diversity of inputs and outputs (labor, machines, material, capital etc.) make practical application of total productivity complex.(Sudit,1984,p.3) One method of computing total productivity is to determine input and output costs (making costs the common measure) during some specified period, then adjusting to a base period for comparability.(Kendrick,1984,pp.37-47) Partial productivity is the easiest of the three to calculate and probably the most commonly

used. Its simplicity is not without drawback:

The trouble with single-factor productivity measures (whether output per labor hour, output per machine, output per ton of material) is that it is easy to increase the productivity of one factor by replacing it with another. Labor, capital and materials are all potential substitutes for each other. (Chew, 1988, p. 111)

Utilization productivity, a *partial productivity measurement*, is used in Public Works productivity studies. It is the percentage of time a worker [craft-person] spends doing work that directly adds value to materials. (Lawlor, 1985, pp. 78-82) It may be more formally defined as the ratio of utilized resources (C_d or C_e) to total costs (C).

(Lawlor, 1985, pp. 78-81) The relationships between C_d , C_e and C are shown in Figure 1, page 77 (note: Appendix A contains all figures and tables.) If costs are for hourly labor, utilization may be calculated using labor hours. Lawlor defines *productive work* (C_e) as work that directly adds value to materials. He credits Martin (1966) with the following manufacturing definition of productive work:

Productive work is work which changes the shape, physical characteristics or appearance of materials, or which joins (assembles) one material to another, or separates one material from another during the process of converting production materials into (saleable or usable) products.

Utilization is a measure of effectiveness. Higher utilization implies lower idle time, lower ancillary (indirect productive) time or both. Public Works productivity study application of utilization productivity is discussed further in "A(3)" of this Chapter (page 12) and in "A(2)" of Chapter III (page 21.)

2. Relation Between Quality and Productivity

Deming (1986,p.1) says that productivity increases when quality improves because there is less rework and waste. He cites a "chain reaction" which "was on the blackboard of every meeting with top management in Japan from 1950 onward.":

Improve quality -> Costs decrease because of less rework, fewer mistakes, fewer delays, snags; better use of machine time and materials -> Productivity improves-> Capture the market with better quality and lower price-> Stay in business-> Provide jobs and more jobs. (Deming,1986,p.3) [emphasis added]

According to Juran(1988,p.8.20), reductions in poor quality "almost invariably" result in productivity improvement.

Viewing productivity improvement as a *natural outcome* of reducing poor quality provides management with a powerful and *essential* framework for tremendous productivity improvement. Productivity is primarily concerned with *numbers* of objects produced, implicitly assuming quality (and poor quality costs) a "given." Paradoxically, this inhibits potentially huge productivity increases "locked up" in poor quality.

3. Productivity Measurement in Public Works Productivity Studies

Public Works productivity studies measure utilization productivity using the "High Frequency" work sampling method described in NAVFAC P-700.0 Engineer's Manual. Work sampling may be defined as:

. . .the process of making sufficient random observations of an operator's activities in order to determine the relative amount of time the operator spends on the various activities associated with the job. . . the major goal of work sampling, however, is to determine how long, or how much of the work day, is spent on specific types of work. (Aft,1973,pp.270-271)

or

A technique for making a large number of instantaneous observations over random periods of time of equipment, materials and people. Each observation records what is happening at the instant of the observation. The total of observations for each activity studied can then be expressed as a percentage of all observations, thus giving a picture of the proportions of time on each activity. (Swain, 1973 as quoted by Lawlor, 1985, p. 160)

Statistical principles may be used to estimate error in work sampling. Error is dependent on the number of observations and the percentage occurrence of the task measured using the normal probability distribution as an approximation to a multinomial. In the studies reviewed statistical confidence for productivity varies between one and two percent. However, error is also dependent on the length of time devoted to a particular task, becoming relatively greater as this time decreases. (Aft, 1973, p. 272)

B. FIRST AND LAST PRODUCTIVE EFFORT

Productivity studies performed by E.L. Hamm include a *first and last productive effort analysis*. The Consultant hypothesizes that the average craft-person experiences four bands of time daily during which *no productive work* takes place. These bands are called "start/stop" times and are defined as:

- * morning start- the average time for the first productive effort to begin in the morning.
- * morning stop- the average time between the last morning productive effort and the start of the (official) lunch break.

* afternoon start- the average time between the end of the official lunch break and next productive effort.

* afternoon stop- the average time between the last afternoon productive effort and (official) quitting time.

E.L. Hamm suggests start/stop times have a direct effect on productivity. In theory, the relationship between total start/stop time and productivity for a standard 480 minute day is given by:

$$P = P_0(480-T)/(480-T_0) \quad \text{equation 1}$$

where:

- P is the predicated productivity resulting from decreased start/stop times
- T is the new total average start/stop time (minutes)
- T₀ is the original average start/stop time (minutes)
- P₀ is the original productivity

The equation assumes productivity improvement due solely to decreased start/stop times.¹⁰ Appendix C (page 80) provides the derivation.

The equation will be used in Chapter IV to estimate the contribution of decreased start/stop totals to improved productivity at Key West, Dallas and Little Creek.

¹⁰This can only occur if management support systems improve and/or craft-persons do not extend lunches, breaks and quit early.

C. IMPACT OF WORK IMPEDIMENTS ON MOTIVATION

Can work impediments, such as incorrect materials, poor work descriptions, poor scheduling and lack of planning adversely impact worker motivation? I'll look at this in three subsections. The first examines several behavioral science theories. The second applies this theory to the Public Works craft-person. Finally, I examine documented examples from the field.

1. Intrinsic Motivation Theory

Behavioral scientists label motivation derived *from work itself* as intrinsic task motivation. People are intrinsically task motivated through "positively valued experiences that individuals derive directly from the task." Intrinsically motivated workers are not dependent on close supervision nor upon extrinsic rewards. They exhibit increased flexibility, initiative and possess greater resiliency to obstacles. (Thomas and Velthouse, 1990, p.666)

Hackman and Oldham's job characteristics model predicts intrinsic motivation as a product of three critical psychological states: "experienced meaningfulness", "experienced responsibility" and a "knowledge of results." "Experienced meaningfulness" means the worker believes his/her work is worthwhile. In "experienced responsibility", the worker believes he/she is accountable for the work outcomes *and has the ability to affect those outcomes*. In "knowledge of results", the worker is able to determine if outcomes are satisfactory on some regular basis. If any one of these states is missing motivation is significantly reduced. (Hackman and others, 1975, pp.314-332) Hackman

notes, however, that the theory is valid only for "high growth potential" people. The five job characteristics which Hackman and Oldham believe determine these psychological states are presented in Table 1, page 69.

In the Thomas/Velthouse "Interpretive" model people draw four conclusions (assessments) about their task which contribute to their intrinsic task motivation. (Thomas and Velthouse, 1990, p. 666-681) These conclusions are choice, competence, meaningfulness and impact:

- * "Choice" involves the perceived degree of activity self-determination.
- * "Competence" relates to how well one performs these activities.
- * "Meaningfulness" is the self assigned value of a desired goal.
- * "Impact" refers to the degree to which one is moving towards the goal.

Thomas/Velthouse consider these motivational additive. (A contrast to the multiplicative nature of Hackman and Oldham's model.)

In "expectancy theory", motivation is the product of three factors: (Nadler and Lawlor, 1991, pp. 99-110)

- * "Expectancy", or [Effort->Performance]. This is an individual's perceived probability of successful task performance, given the effort.
- * "Instrumentality", or [Performance->Outcome]. This is an individual's perceived probability of receiving some desired outcome, given the performance of a task. For intrinsic outcomes this instrumentality is usually considered to be 1.00, since

individuals can give this to themselves.

* "Valence". This is an individuals perceived value of the outcome.

For intrinsic motivation, valence has to do specifically with the intrinsic value of an outcome. (Expectancy theory may also be used for extrinsic outcomes (e.g., pay.)

In algebraic form expectancy theory may be expressed as:

$$\text{Motivation} = [\text{Effort} \rightarrow \text{Performance}] \times [\text{Performance} \rightarrow \text{Outcome}] \times [\text{Valence}]$$
$$= [E \rightarrow P] \quad \times \quad [P \rightarrow O] \quad \times \quad [V]$$

Since the relationship is multiplicative, a decrease in any single factor will proportionally decrease motivation.

2. Theory Applied To Craft-Persons

The typical craft-person works alone or in fairly independent groups without continuous supervision. Having a high level of intrinsic motivation is essential if productivity is to be maximized.

a. *Job Characteristics Theory*

In the Hackman and Oldham theory intrinsic motivation depends on the worker's belief that they affect outcomes. Craft-persons tasked to complete jobs without substantially functioning support systems (e.g., adequate material, tools and clear directions) would tend to experience weakened "responsibility" and negative (self) feedback. Both result in decreased motivation in the Hackman and Oldham theory.

b. *Thomas/Velthouse Model*

Here "competence" by definition is how well one performs their task activities. If one cannot perform well due to obstacles provided by others then intrinsic motivation suffers. Likewise, if

obstacles interfere with accomplishing task goals, then one's sense of "impact" is reduced.

c. *Expectancy Theory*

Imagine a self-motivated craft-person who is unable to get the materials, supplies and support needed to do the job (to some *self set* standard.) The worker normally places a high value ("valence" [V]) on the satisfaction received from completing the job in a professional manner. Likewise the instrumentality [P->O probability] is high for the individual to feel satisfaction for performing well. However, if the worker experiences productivity impediments, he/she sees that despite best efforts, *the probability of successful performance is now less than before*. In expectancy theory terms, the [E->P] factor will decrease, causing a decrease in motivation.

d. *Motivation Diagnosis Difficulties*

The combination of execution deficiencies (impediments) and motivational problems makes proper diagnoses difficult (Baker,1988,10.32) Productivity improvement efforts that focus on motivation may be treating the symptom instead of the cause. Worse, it places the burden of improvement on workers, when many causes of poor productivity [quality] are out of their control (Deming,1986). From E.M. Baker:

It is common experience to hear of a quality [productivity] problem diagnosed as worker 'laziness', 'carelessness' or 'lack of concern'. Resolution is sought through pleas for better performance, e.g. through the use of motivational posters, or by fixing blame and warning of dire consequences if things do not improve. It automatically puts the burden of responsibility for improvements on the subordinates without diagnosing the higher

management-controllable causes. It forces people into a no-win situation because they do not have the means to change the system. This can be said of all employees, at every level of the hierarchy. (Baker, 1988, p.10.32)

2. Examples from the Field

The relationship between impediments and motivation has not gone unnoticed in the Navy. In 1980 the Naval Personnel Research and Development Center (NPRDC) examined productivity impediments at five Naval industrial facilities, including one Public Works Center. They observed:

All participating field activities noted that negative work attitudes affected productivity to some degree. . . In many instances, employees attributed negative attitudes to the impediments previously discussed [e.g., material support, equipment problems, aged vehicles, etc]. In other words, employees are tired of encountering the same obstacles over and over again, especially when they see no efforts being made to remove the obstacles. (NPRDC, 1980, p.28)

In a separate investigation at six Navy Public Works centers, investigators:

. . . found that employees are motivated by work occurrences that reflect personal concerns (e.g., feelings of accomplishment) and demotivated by those that reflect negative task-related concerns (e.g., equipment problems). This finding suggests that impediments to productivity, as well as decreased motivation, may result when employees do not have the basic tools and supplies needed to accomplish their work. (NPRDC, 1980)

These examples together with the theoretical basis previously discussed suggest that productivity impediments are potentially powerful demotivational forces. Demotivated workers may make decisions that are contrary to the goals of the organization (long lunches, returning to the shops for lunch, early quits etc.) "C" in Chapter V (page 46) returns to this issue.

III. NAVY RPMA PRODUCTIVITY STUDIES

A. BACKGROUND

1. Data Source and History

Naval Public Works Real Property Maintenance Activities (RPMA) Productivity Studies provide the principal data for this research.

Twenty six reports were *provided* to the writer by four Naval Facilities Engineering Command Field Activities:

- * Atlantic Division 12
- * Northern Division 8
- * Southern Division 5
- * Chesapeake Division 1

Most RPMA productivity studies focus on traditional Public Works maintenance and utilities divisions. (i.e., plumbers, carpenters, electricians etc.) At least 38 studies have been done; of these at least six have been follow-up evaluations of the same activity. The three organizations *performing* studies used in this research are E.L. Hamm and Associates¹¹ (18 reports), Northern Division Naval Facilities Engineering Command ("NORTHNAVFACENGCOM" -8 reports) and Southern Division Naval Facilities Engineering Command ("SOUTHNAVFACENGCOM" -part

¹¹E.L. Hamm & Associates, Inc., 4801 Columbus Street, Suite 300, Virginia Beach, VA 23462-6757.

II of an E.L. Hamm report.)¹² In this thesis "Consultant" refers to the organization that *performed* the study.

2. What Do Productivity Studies Provide?

Productivity studies consist of one or more periods of on-site observation of craft-persons by an independent Consultant. They may last a few days to several weeks, depending on the size of the Consultant's team, the size and complexity of the organization to be studied, the statistical accuracy sought and any additional process analysis desired by the activity. Using work sampling techniques, observation, and process analysis, the Consultant furnishes a report consisting of:

- * An estimate of craft-person productivity;
- * A comparison of measured productivity with historical averages;
- * A discussion of the *causes* of poor productivity;
- * Suggestions for improving productivity; and
- * A proposed productivity goal established by the Consultant.

In the productivity studies reviewed, "Productive Work" is defined as:

Time spent in the actual performance of the work. Examples include such observations as threading a pipe, hammering a nail, etc.
(NORTHNAVFACENGCOM, 1987, pp.1-2)

or

. . .work which contributes directly to altering the composition, condition, conformation, or construction of the item or area being

¹²SOUTHNAVFACENGCOM performed the follow-on productivity measurement of NAS Dallas. For the purpose of this research, the SOUTHNAVFACENGCOM report will be considered as an E.L. Hamm study.

repaired or altered. (SOUTHNAVFACENGGCOM [E.L. Hamm and Associates], 1988, p.E-1)

Work sampling was discussed in "A(3)" of Chapter II, page 12.

3. Productivity Study Merit

Productivity studies focus primarily how much time the craft-person spends performing productive work. They are less concerned about the appropriateness of the task or the efficiency of the craft-person. Despite these limitations productivity studies have merit as a first step to improvement.

RPMA as a system combines people, materials, tools and equipment to produce a desired output (enhanced fleet readiness through safe/economical/functional buildings and utility systems.) In the relatively low-tech, labor intensive environment of facilities maintenance, craft-persons are the primary "value adders."¹³ To "add value" they need fully functioning management provided support systems- a maintenance management system that properly prioritizes and schedules the work, good prior planning and quality designs, the right tools, equipment and materials, clear instructions, effective job coordination, and a means to get to and do the job, to name a few. If *something* gets in the way of a functioning support system- call this a productivity impediment- the craft person will inevitably spend disproportionate time performing non-value adding activities. Therefore: the purpose of Navy productivity studies is identifying productivity impediments by examining how the craft-person spends time. Before we can remove

¹³As used in this thesis, "adding value" refers to performing productive work. Productive work is generically defined in "A(1)" of Chapter II, page 9.

productivity impediments we must understand what they are. This is why productivity studies have merit.

4. E.L. Hamm and NORTHNAVFACENGCOM Work Sampling Definitions

Both E.L. Hamm and NORTHNAVFACENGCOM measure the craft-person's time in three principal work sampling categories: productive, indirect productive, and non-productive. The definition of productive work was previously given. The remaining two categories are defined as:

* Indirect productive:

. . . work that renders service for the productive portion of the job. It is necessary work that does not alter the composition, condition, conformation, or construction of the product. (SOUTHNAVFACENGCOM [E.L. Hamm and Associates],1988,p.E-1)

or

. . . Time spent in direct support of the productive portion of the job. It is necessary work and includes job preparation, receiving instructions, getting tools and materials for job, travel to and from the job site, etc. (NORTHNAVFACENGCOM,1987,p.2)

* Non-Productive time:

. . . [the time] each [craft-person] is idle and not engaged in work that contributes directly or indirectly to altering the composition, condition, conformation, or construction of the item or area being repaired or altered. (SOUTHNAVFACENGCOM [E.L. Hamm and Associates], 1988,p.E-1)

or

Idle or personal time which does not contribute to the job. This includes coffee breaks, personal, idle, awaiting assignment, attend safety meetings etc. (NORTHNAVFACENGCOM,1987,p.2)

Both E.L. Hamm and NORTHNAVFACENGCOM definitions are essentially the same.

5. Differences in Approach

E.L. Hamm and NORTHNAVFACENGCOM's general approach to Productivity Studies are basically similar, with differences mainly in report format and level of detail.

a. *E.L. Hamm and Associates Productivity Studies*

E.L. Hamm productivity reports typically provide a *work sampling analysis* and a *process analysis* as separate sections. Each will be discussed in turn.

Work sampling analysis provides measurement results and opinion of poor productivity causes based on field observations. E.L. Hamm divides the craft-persons time into some 30 categories; these are provided in Table 2, page 70. Work sampling reports on the observed and field measured.

Process analysis seeks to substantiate field observations using a quantifiable historical record analysis. Process analysis may analyze (for example) the scheduling and report systems for service orders, supply support or the effectiveness of the shop load plan. It goes beyond reporting the observed into what is "hidden" within the system.

b. *NORTHNAVFACENGCOM Productivity Studies*

NORTHNAVFACENGCOM studies combine elements of work sampling and process analysis in the same section and use only the three principal work sampling categories to report results.

6. Limits of Present Study

The present study focuses on the results of work sampling-field observations and measurements. It does not attempt to analyze the deeper, underlying causes of support system failure. There are two reasons for this.

First, the craft-person is the last link in the RPMA "chain" before the external customer. Generally, it is the support systems that affect them, not the other way around. Understanding impediments faced by the craft-person each day may help management see the world through the craft-person's eyes. . . a necessary step toward improvement. Secondly, analyzing the deep, underlying problems within each support system at 26 activities is beyond the capability of one person within reasonable time constraints.

7. Activity Pseudo Names

Activities in this study are given a single letter pseudo name a-z for the purposes of anonymity. Exceptions are Key West(n), Dallas(1) and Little Creek(u). These activities successfully increased their productivity approximately 15% each. A portion of this study looks at them in greater detail.

B. PREVIOUS REVIEWS

Based on contact with Code 16 personnel from each NAVFAC Engineering Field Command and Naval Facilities Engineering Command Headquarters (NAVFACENCOM), there have been only limited cross-reviews of completed productivity studies.

Western Division Naval Facilities Engineering Command published a summary of productivity problems and recommendations based on a review of six studies in 1988(WESTNAVFACENGCOM,1988). They concluded the most common and significant problems were:

- * Craft-person idleness caused by lack of employee discipline
- * Poor preventative maintenance
- * Not assigning craft-persons a full days work
- * Craft-person return to shops for lunch or breaks
- * ". . . jobs were often overstated which results in extensive idle time"
- * "Maintenance workers were noted to return to the shop for materials which were not identified prior to starting work"
- * Crews are overloaded due to excessive backlogs
- * Craft-persons are pulled from job-in-progress to do non-emergency work
- * Work receptionist's improper diagnosing of problems
- * EPS standards not used correctly resulting in work underscheduling
- * Lack of variance analysis

E.L. Hamm and Associates did a comparative analysis of Army and Navy Real Property Maintenance Activities 1982 through 1986 (E.L. Hamm Associates,1986) E.L. Hamm performed the majority of productivity studies for the Navy and most, if not all, of the Army's (equivalent) studies. They found that the following eight areas have the most direct

impact on productivity:

- * Vehicle support. Each E/S craft-person needs an adequately equipped and stocked vehicle.
- * EPS Application. EPS consistently used (including E/S work).
Variance analysis done.
- * Supply Support. Timely receipt of ordered material and availability of shop stores material.
- * Job Planning. Overall quality of job planning.
- * Automated systems. Work control and stock control systems have automated, meaningful reports used by management.
- * Work priority system. A command approved, consistently used work priority system.
- * Work scheduling. Assign a full day's [valid] work to the craft-person.
- * Supervision. Frequency of [shop supervisor] job site visits and interaction with craft-persons each day.

IV. METHODOLOGY AND PRELIMINARY ANALYSIS

The purpose of Chapter IV is to present the methodology and "answers" to the following preliminary questions, based on a cross-review of 26 Public Works productivity studies:

- * What are the causes of poor productivity? Who controls them?
- * What are the effects of poor productivity?
- * How are poor productivity causes and effects related?
- * What can be learned by examining actual productivity improvement at three Navy Public Works activities?

The last question, involving a review of productivity improvement at NAS Key West, NAS Dallas and NAB Little Creek, yields the following sub-questions:

- * Was there a change in how the average craft-person spends time?
(what got better?)
- * What changes in methods of business were recommended to the activity by the consultant performing the studies?
- * What changes in methods of business does the activity credit as key to overall improvement?

In Chapter V, I use these results to develop a list of opportunities for productivity improvement at Navy Public Works activities.

A. WHAT ARE THE MOST FREQUENT CAUSES OF POOR PRODUCTIVITY?

1. Methodology

The Consultant reports in each study what he/she believes to be significant poor productivity causes. This information was extracted along with Consultant observations (i.e. what the Consultant observed on-site) and effect on the craft-persons time. Table 3 (page 71) is a sample of data extracted from one study. Each productivity effect (e.g., travel), observation (e.g., craft-person driving crisscross through the base) and cause (e.g., ineffective batching of service orders) is recorded. Only E.L. Hamm studies include detailed work category effects. (Note: All tables and figures are located in Appendix A, starting on page 68.)

2. Results

* Table 4 (page 72) poor productivity causes across 26 activities.

* Figure 2 (page 78), (the 15) *most frequent poor productivity causes*. (A subset of Table 4.)

Appendix B (page 83) expands on the meaning of each poor productivity causes listed in Table 4 and Figure 2.

One additional note. The distribution of poor productivity causes (as depicted in Table 4), appears consistent for both E.L. Hamm and LANTNAVFACENCOM performed studies. Thus, at face value *causes are independent of the Consultant performing the study.*

B. WHAT ARE THE EFFECTS OF POOR PRODUCTIVITY?

1. Methodology

For each work sampling category, the difference between the current (measured) percentage time and the Consultant's suggested goal were calculated and summarized.

For each category of work, the Consultant suggests a numerical goal for productivity improvement. This is done by (1) comparing activity performance with (other) activity historical data and (2) considering any unique activity circumstances (e.g., a geographically dispersed activity probably would require a high amount of category 230 Travel time.) The Consultant's suggested overall productivity goal approaches the organization's "productive potential" (Lawlor, 1985, p.81). For this reason I will refer to the difference between current (measured) percentage time and the Consultant's goal as the "Productivity Improvement Potential."

E.L. Hamm performs the comparison on a category by category basis; NORTHNAVFACENCOM takes an overall approach. Their starting assumptions are slightly different; E.L. Hamm believes an average activity can reach 65% productivity while NORTHNAVFACENCOM suggests 60%. The different assumptions are unimportant (since the numbers are somewhat subjective to begin with) unless one is doing activity to activity comparisons performed by the different Consultants.

Such comparisons call attention to work categories that deviate from the norm, which is useful in identifying areas for improvement.¹⁴

2. Results

Table 5 (page 73) summarizes the effects of poor productivity on craft-person time across 18 E.L. Hamm studied activities.

3. Analysis

The major effect of poor productivity is clearly in the areas of increased travel, planning at the job site and craft-person idle time.

C. HOW ARE POOR PRODUCTIVITY CAUSE AND EFFECTS RELATED?

1. Methodology and Results

The data extraction process described in "A" explicitly yields the relationship between each cause and effect for E.L. Hamm studies. These were grouped to produce Table 6 on page 74.

2. Analysis

The interesting observation from Table 6 is the impact of *insufficient work, poor shop supervisor planning/coordination and lack of site visits* on most work categories. Improve these, and improvements across numerous work categories are likely.

¹⁴However, a note of caution. Productivity goals should not be "final targets." Just because a particular work category is equal (or even better) than historical average (even with activity specific influences considered) it *does not follow that the process is optimal*. Since improvement is a never-ending effort, such goals should be viewed as a milestone and not an end.

Another observation is that nearly every (frequent) cause of poor productivity impacts travel. This suggests that analysis of travel reasons (i.e., what caused the craft-person to travel from point 1 to point 2) may provide the Public Works Officer facts on the source and effect of poor productivity causes. Chapter VI section "A(2)(b)" (page 41) presents a procedure for analyzing work impediments based on this observation. The procedure should be helpful for activities that have not undergone a formal productivity study, or as a tool for continuous improvement.

E. PRODUCTIVITY IMPROVEMENT AT THREE NAVY PW ACTIVITIES

What can be learned by examining actual productivity improvement at Key West, Little Creek and Dallas? As depicted in Figure 3 (page 79), these activities began near the lower tier of the "productivity ladder" compared to other activities. After 18-23 months, their productivity was remeasured; productivity improvement averaged 15%. This moved them to the top of the productivity ladder, also depicted by Figure 3. With a relative diversity in shop size and configuration (Table 7 page 75), each activity achieved significant improvement resulting in six and seven digit annual savings. A natural question is: "how did they do it?" This leads to several others:

- * Was there a change in how an average craft-person "spends" time?
- * What changes in modus operandi did the Consultant recommend?
- * What changes did each activity credit as key?
- * How much money can be saved if other activities match the

improvement at Key West, Dallas and Little Creek?

The purpose of "E" is to answer these questions.

1. Changes in Craft-Person's Time

Was there a change in how an average craft-person "spends" time?

a. *Changes by Work Category*

(1) Methodology. For all three activities, the difference between initial and final productivity measurements were computed for each work activity. This number represents improvement (in some instances, negative improvement.) All three activities were E.L. Hamm Studies with SOUTHNAVFACENCOM performing the final measurement of Dallas.

Improvement was significant if the absolute value of the change exceeded three standard deviations assuming a binomial distribution for each work category. The relevant equation is $[np(1-p)]^{1/2}$, where n is the number of observations and p is the work category percentage expressed as a decimal. (Gitlow and others, 1989, p.116)

(2) Results. Figure 4 depicts *changes* in how craft-persons spend time. *Improvements (decreases in indirect and non-productive time) are plotted to the right.*

(3) Analysis. Clearly the largest work category decreases occurred in travel, planning at the job site, and idle time. A review of Table 6 (Cause versus Effects, page 74) and the data extracted from the studies reveals the following:

* *Travel*, as mentioned earlier, is affected by most causes.

- * *Planning at the job site* is most affected by the quality of job orders, the availability of vehicles (so shop supervisors and P&E's can visit the job site), clear/complete service order descriptions, and assigning sufficient work (otherwise, craft-persons must search for work, increasing the planning time.)
- * *Idle time* depends on sufficient vehicles, the effectiveness of the service order scheduling system and assigning sufficient work. It is also affected by craft-person controllable early quits and return for lunch. As discussed later in "V(C)" of Chapter V (page 46), there is probably a relationship between most productivity causes and early quits, long breaks/lunches and returns to the shop.

b. *Changes in Morning/Afternoon Start/Stop Times*

(1) *Methodology and Results.* Equation 1 (discussed in "B(2)" Chapter II page 13) was used to predict productivity due solely to decreased start/stop times. The difference between the predicted productivity and the original productivity represents the contribution due to decreased start/stop times. The results are shown in Figure 5, page 81. As indicated by the dark portion of the bars, only a minority portion of the total improvement stemmed from decreased start/stop times.

(2) *Analysis.* Interestingly, though both Key West and Little Creek achieved approximately the same overall productivity improvement, the start/stop contribution for Key West was more than Dallas and Little Creek combined. Logically, the (total) length of

start/stop time depends on both the effectiveness of craft-person support systems (i.e. vehicles, materials, planning by the shop supervisor etc.) and the choice of the craft-person (when to quit for lunch, whether to return to the shop, and when to return at the end of the day.) I would argue the following is true, on the average:

- * The morning start time, that band between shift start and 1st productive effort, depends primarily on the effectiveness of the support systems, especially previous day preplanning on the part of the shop supervisor.
- * The morning stop, afternoon start and afternoon quit time depends primarily on the decision of the craft-person, as long as sufficient work is available.¹⁵

One probable explanation for the disparity between Key West and Little Creek start/stop times is Key West's emphasis on worker involvement and empowerment, contrasted to Little Creek's structural approach. (The basis of this comment is discussed in "E(3)" page 36.) Energized workers are more likely to work longer and push harder, resulting in greatly improved start/stop times. By characterizing Little Creek's approach as more structural in nature, I mean changes in the methods of business with relatively less emphasis on worker involvement and empowerment. Interestingly, Little Creek *mandated*

¹⁵Sufficient work, as discussed in "A" of Chapter V (page 39), is dependent on the support systems.

eating at the job site while Key West encouraged it.¹⁶

Insufficient information is available to generalize on the Dallas approach.

2. Consultant Recommended Modus Operandi Changes

Table 8 (page 76) provides a summary of Consultant recommended changes in the activities' modus operandi proposed after initial measurement. Data was extracted from the work sampling section of the reports. Categorization (improve design, improve work assignment etc.) was done by the writer to facilitate presentation.

3. Activity Actions Contributing to Success

E.L. Hamm performed a cross review of Key West and Little Creek actions to improve productivity. (LANTNAVFACENGCOM[E.L. Hamm],1991) The (briefing) report examined some of the problems at both locations at the start of their productivity studies and the specific efforts made to improve them. Relevant excerpts are included as Appendix F, starting on page 100.

The report concludes that Little Creek and Key West took two different approaches while essentially achieving the same productivity improvement. Little Creek focused on the maintenance management system while Key West focused on communications, morale and Supply support.

From an activity viewpoint, several actions were key to achieving significant overall improvement. Some are transferrable to other

¹⁶This is discussed in "d" of Appendix D (page 89) and "i" of Appendix E (page 97), respectively.

activities. Appendices D (page 89) and E (page 91) contain descriptions of these key actions.

Information on NAS Dallas' key actions was not available.

4. *How Much Money Can Be Saved?*

Using Key West as an example, increasing labor productivity from 38.7 to 54.6% results in a 40+% increase in productive time $((54.6 - 38.7)/38.7)$. Each craft-person is *adding value to a maintenance product 40% more each day*. In other words, the Public Works Officer is getting 11.2 hours of work a day $(8 + 8 * 0.40)$ at the old productivity level from each craft-person. Saying it another way, Key West increased their work force by 40% without hiring an additional person. Numbers at Dallas and Little Creek are similar. Assuming a *direct* wage rate of \$14/hour and a department of 50 craft-persons, the additional labor value added annually is about \$500K. The "savings" should translate into decreased maintenance backlog, increased customer service, or some mix of both. \$500K is a conservative figure and excludes other, less easily quantifiable but potentially more important benefits. An example is an increase in the customer's ability to perform *their* mission as a result of Public Works doing ours better and faster. Though difficult to quantify, it would be wrong to ignore such "savings."

The cost to improve productivity at Key West, Dallas and Little creek were not calculated in this study. However, the "key actions" Appendices (D and E) and the Consultant's recommended changes (Table 8, page 76) suggest the majority of management actions involve little or no

expenditures. Probably the largest initial investment is the cost of the study itself, especially if done by contract. However the "payback" period appears to be short. In the case of Key West, the study cost was equivalent to the (gross) savings achieved in less than two months of operations at the higher level of productivity.

V. OPPORTUNITIES FOR PRODUCTIVITY IMPROVEMENT

Chapter V develops a list of opportunities for productivity improvement.

Each *poor productivity cause* listed in Table 4 (page 72) is an opportunity for productivity improvement. I begin by identifying a particular area for improvement, perhaps grouping several related Table 4 items together (e.g., "ineffective service order batching" and "poor service order descriptions" under the heading of "service order management.") Next, I discuss the nature of the problem, providing background when appropriate and a summary of productivity study findings. I will often call on previously discussed theory (Chapter II) and preliminary findings (Chapter IV.) Finally, I propose questions to help an activity determine if the opportunity exists for them.

A. ASSIGN EACH CRAFT-PERSON A FULL DAYS WORK (THE PARADOX OF INSUFFICIENT WORK)

Interestingly, "insufficient work assigned" was the most frequent poor productivity cause. This seems paradoxical; with the substantial backlog of maintenance and repairs at most activities, how can there be a shortage of assigned work?

Productivity studies completed by E.L. Hamm and NORTHNAVFACENGCOM clearly show that the paradox is, in fact, often true. Worse, Table 6 (page 74) shows that "insufficient work" impacts more work categories (e.g., travel, job preparation) than any other poor productivity cause. The studies revealed two prominent reasons for "insufficient work":

- * Shop supervisors purposely issuing less than a full (or half) days work.
- * Unanticipated work delays and snags caused by most reasons included in Table 4 (page 72): poor quality job orders (wrong materials, unclear work descriptions), poor scheduling, dispatch to completed work sites etc.

1. Purposeful Issuing of Insufficient Work

a. *Nature of Problem*

I can only speculate on the reason for purposely issuing insufficient work. Perhaps (1) shop supervisors are not aware of the wastefulness of the practice, (2) frequent shop supervisor/craft-person contact is warranted by the nature of the work (although there was no hint of this in the studies) or (3) the practice is used as a "control mechanism" to monitor craft-person whereabouts.

In some instances shop supervisors were not issuing the work at all, leaving the task to craft-persons.

b. *Evaluation Questions*

- * Do shop supervisors "subscribe" to issuing a full days work? Are shop supervisors aware of the inefficiencies of craft-persons returning to the shop for their next assignment?

- * Does senior management emphasize the practice?
- * Is work assigned to or selected by the craft-person? (i.e., service orders)

2. Unanticipated Delays and Snags

a. *Nature of Problem*

Unanticipated delays and snags are caused by errors in work planning and/or execution. Errors add complexity to the work process. Complexity is defined as the extra steps required to recover from errors in the process, or errors ahead of the process. (Fuller, 1985, p. 333) Complexity causes delays, snags and wasted effort.

Most Table 4 (page 72) "poor productivity causes" (e.g. poor quality job orders, poor scheduling and poor service order descriptions) are "defects" that add complexity to the work. Reduce Table 4 items and delays and snags should be reduced correspondingly.

b. *Evaluation Questions*

Subsequent sections will address evaluation of most Table 4 poor productivity causes. Here I propose a simple tool to help the Public Works Officer identify the magnitude and distribution of most causes.

Table 6 (page 74) shows *most poor productivity causes impact travel time*. Therefore an analysis of craft-person travel should yield information on poor productivity causes. Once they are identified, efforts can be targeted at their elimination.

One method to do this might be having randomly selected craft-persons maintain travel logs. The logs would document the *cause and*

result of each travel leg. They could subsequently be analyzed to identify effects of work impediments- such as how often:

- * customers are not available.
- * craft-persons must return for assignment (and why).
- * materials were not anticipated and why (poor s/o description, error on job order etc.)
- * craft-persons are dispatched to completed work sites.
- * craft-persons compensate for errors in management planning and coordination.

Accurate completion of logs depend on the craft-person's belief that management will take prompt positive action on findings, and that said action will not adversely affect self or shops. The analysis should be performed with the direct involvement of craft-persons and the shop supervisor. Ideally, analysis would be done by craft-persons and shop supervisor.

B. IMPROVE SHOP SUPERVISOR PLANNING, COORDINATION AND INCREASE SITE VISITS

A lack of effective shop supervisor planning, coordination and frequent site visits is evident in most productivity studies. Like "insufficient work" discussed previously, Table 6 (page 74) shows most work categories adversely impacted by poor performance in this area.

1. Ineffective Job Orders Scoping

a. *Nature of Problem*

A prevalent *complexity adder* is lack of shop supervisor job order scoping (pre-planning/becoming familiar with the work/insuring material is ready and equipment advance coordinated before issue to craft-persons) by the shop supervisor.

b. *Evaluation Questions*

In the studies five conditions seemed essential for shop supervisors to effectively scope out job orders. Absent any, craft-persons will be issued work that can not be smoothly executed. This results in work delays and returns to the shop for more work. Here are the conditions phrased in the form of evaluation questions:

- * Are *complete* job packages available for shop supervisor review? Is sufficient lead time provided?
- * Are job materials easily accessible, preferably centrally staged? How hard must shop supervisors work to physically review staged materials? How long does it take? [How can this time be reduced?]
- * Does a relationship exist between shop supervisors and Planners and Estimators that *encourages identification of errors*?¹⁷
- * Does each shop supervisor have their own vehicle?¹⁸

¹⁷"2(g)" of Appendix E (page 95) describes the Key West approach to this problem: a combination of communications/conflict resolution training and a formal requirement to make contact during the job writing phrase.

¹⁸To be effective, vehicles should be readily available. At Key West, shop supervisors found it difficult to visit job sites because they had given their vehicles up to craft-persons due to an overall vehicle shortage.

* Does the shop supervisor give job order scoping sufficient priority above competing tasks? [Many of these are controlled or influenced by senior management. What demands on the shop supervisor (placed by senior management) can be discarded? (e.g., meetings, reports and constant calls for "job status.")]

The last question deserves two additional comments. First, formal instruction in time management skills may increase shop supervisor effectiveness. Second, senior (Public Works) management needs to objectively examine their influence of the shop supervisor behavior. Scoping out job orders (and visiting job sites) removes the shop supervisor from the office. When in the field, the supervisor is unavailable to answer the phone, complete paperwork, respond to higher level job status questions and attend meetings. It is likely that shop supervisors will choose to spend maximum time in the office *if the system rewards them for being there*. Senior management should ascertain if the demands placed on the shop supervisor encourage or discourage time in the field.

2. Insufficient Job Site Visits

a. *Nature of Problem*

In the majority of studies the Consultant suggests the need for more presence of the supervisor at job sites. A review of eight studies revealed that the average shop supervisor spends 1.5 hours checking jobs daily (includes travel time).¹⁹ Time ranged from 0.4

¹⁹Only eight of the studies had data of this type.

hours to 3. Supervisors should be spending 50% and 40% of their time out in the field, according to E.L. Hamm and NORTHNAVFACENGCOCM respectively. The optimal value would probably depend on the nature of the work and geography. Exactly what percentage is optimal is unclear; what does make sense is the need for on-going work facilitation of which regular on-site visits are an essential element.

The value of site visits goes beyond mere technical aspects such as problem solving and decision making. Frequent interactions between supervisors and craft-persons help reduce misconceptions and build trust. This is supported by a Naval Personal Research and Development Center study on 1st line supervisory effectiveness at three Navy Public Works Centers:

Several conclusions run through this discussion... Supervisors who interact more with their bosses and workers have a better understanding of their expectations... Worker trust, strongly associated with supervisory effectiveness, was also related to supervisors' tendency toward supportive behavior and interaction with others... inaccurate perceptions of expectations by supervisors and conflicting demands from workers and bosses are associated with a variety of negative outcomes for the supervisor.

...All of these conclusions focus on positive interactions and their outcomes. Accurate and frequent communication between levels, supervisory availability, trusting relationships, supportive supervisory behaviors, job satisfaction among workers and supervisors and supervisory effectiveness seem to occur at the same time. Their importance seems obvious, but it became apparent in the interviews with workers and supervisors that not everyone has the same "common sense." *The importance of these factors should not be ignored or assumed as common knowledge in future attempts to improve supervisory effectiveness and overall organizational functioning.* (NPRDC, 1985, p.17) [emphasis added]

b. *Evaluation Questions*

In the studies two conditions seemed essential for job site visits. Both were essentially included in the "job scoping" section of "1" above, page 43. In the form of questions they are:

- * Does each shop supervisor have their own vehicle?
- * Does the shop supervisor give job order scoping [visiting job sites] sufficient priority?

3. *Lack of Coordination*

The principle problem identified in the studies was a tendency to (intentionally or not) delegate work coordination to the craft-persons. When crews coordinate their own digging permits, heavy equipment support, and work phasing with other shops, increased idle time is inevitable. The only evaluation question is "who makes the contacts to coordinate equipment, interface with other shops and gain approvals (such as digging permits.²⁰) If the answer is craft-persons, one should evaluate the purpose of employing a skilled wage grade shop supervisor.

C. *REDUCE LONG LUNCHES AND EARLY QUILTS*

Long lunches and early quits comprise the majority of total morning/afternoon start/stop times, discussed in "E(1)(b)" of Chapter IV (page 34.) Figure 5 (page 81) shows that reducing total start/stop at Key West, Dallas and Little Creek resulted in significant productivity

²⁰Preferably, approvals such as digging permits are received before crews are given the job to execute.

improvement. At Key West, the 6.2% improvement attributable to reduced start/stop times equates to an annual savings of nearly \$500K/year.²¹ Certainly this is an area rich in opportunity at many activities. The (complex) question is, how?

1. Nature of Problem

Why would craft-persons drive to the shop for lunch (outside the designated lunch break), take extended breaks or quit early when there is still available work? Is idle time caused by "deficiencies in employee discipline" as concluded in a 1988 WESTNAVFACENGCOM study or are there other reasons common to most activities? The precise cause at each activity is probably complex and unique, yet the commonality of work impediments (Table 4) suggests a possible common thread.

In Chapter II part "C" (page 15) I reviewed three behavioral science motivation theories: Job Characteristics, Thomas/Velthouse and Expectancy. I showed that without the means to do the job in an effective, quality manner, workers will become discouraged and lose motivation. I cited two Naval Personnel Research and Development Center reports (both involving Public Works Centers) which supported this conclusion. It is suggested, therefore, that poor productivity causes (Table 4 page 72) contribute to reduced motivation and a "it doesn't matter" attitude. When craft-persons develop such an attitude, long lunches, breaks, early quits and driving to the shop for lunch should be

²¹Based on an overall productivity improvement of 15.9% and \$1.2M additional work gained at the lower level of productivity. (LANTNAVFACENGCOM [E.L. Hamm], 1990)

expected. In the words of E.M. Baker:

When workers, for example, do not have the necessary information, proper equipment, and discretion to act, they can become frustrated and discouraged to the point that they no longer want to contribute beyond the minimum required, if that. Even highly motivated individuals eventually will be demotivated by the failures which an incapable process forces them to experience. (Baker, 1988, 10.32)

Another view:

All participating field activities [Navy Industrial Activities, including a Public Works Center] noted that negative work attitudes affected productivity to some degree. . . In many instances, employees attributed negative attitudes to the impediments previously discussed [e.g., material support, equipment problems, aged vehicles, etc]. In other words, employees are tired of encountering the same obstacles over and over again, especially when they see no efforts being made to remove the obstacles. (NPRDC, 1980, p.28) [emphasis added]

The conclusion is this: The craft-persons' decision on lunch, breaks and quits is influenced (perhaps greatly) by the failure of management to remove impediments in the work process. For example, when workers experience frequent and on-going shortages of (executable) work (witness Table 4 page 72), how serious can they take management's interest in productivity and getting the job done?²²

2. Evaluation Questions

There are two questions:

- * Are craft-persons eating lunch and taking (authorized) breaks at the job site?
- * How much idle time is created by long lunches, breaks and early quits?

²²An analogous situation for managers involves the expenditure of expiring funds. What is the message when the manager who returns funds is judged ineffective?

The first question is simple to answer; the second is not. Without the benefit of formal work sampling a precise estimate is not possible. However, based on my experience in Key West the shop parking lot can reveal quite a lot about start/stop times. If productivity improvement efforts are successful, the lot will empty quicker in the morning, fill less and later before lunch, empty quickly after lunch and fill late in the afternoon.

D. IMPROVE SERVICE ORDER MANAGEMENT

There were a number of contributors to poor service order management identified in the studies:

- * Ineffective service order batching.
- * Scheduling/coordination problems.
 - Customer unavailable.
 - Dispatch of craft-persons to completed work sites.
 - Escort delays.
- * Poor quality service order descriptions.
- * Tool and material problems.
 - Routine tools and materials not carried to the work site.
 - Lack of adequate truck stock, or in the extreme, trucks.

1. Ineffective Service Order Batching

a. *Nature of Problem*

Service order batching is simply the grouping of service orders in some logical order so that craft-person travel time is minimized. Batching seeks to insure enough work is assigned to preclude

the need for returning to the shop for assignment. At some activities craft-persons were zig-zagging from one side of the base and back for service orders of a routine nature. Batching also implies the issuance of sufficient work so that the craft-person need not return to the shop for their next assignment. (This is part of the "insufficient work" problem, see discussion in "A" on page 39.)

b. Evaluation Questions

Ineffective batching should be detectable from a review of completed service orders (including partially completed work.) Did the order of accomplishment make sense? Was a full days' work assigned? *Ideally, this review would be performed jointly by the craft-person and shop supervisor as part of an on-going improvement method.*

See also page 40, "A(1)" on the problem of purposely issuing less than a full days work.

2. Scheduling and Coordination Problems

a. Nature of Problem

Service order scheduling and coordination problems were prevalent in approximately half the studies. There were three problems identified. First, the craft-person arrives at his/her next job site but the customer is absent. Due to the nature of the call (e.g., interior housing work) the craft-person must return at some future time. This wastes all or a portion of the travel time expended to go to the job. Second, craft-persons arrive at a job site only to find the work previously done (by another craft-person.) Again, all or most travel time is lost. Lastly, the craft-person arrives at the work site and

must wait for a customer escort, as in a secure area. Escort problems show up in (E.L. Hamm) work category 341. As evidenced by Table 5 (page 73), over half of the E.L. Hamm studied activities experienced escort delays of up to approaching 2% with an average of 1%. This last figure may seem like a small number, but remember it is spread across the entire workforce. If that workforce has 100 craft-persons, *one of them is full time escort waiter.*

The studies suggest a number of ways to mitigate these problems:

- * The craft-person can call ahead to the next job location before preceding.²³
- * Some activities (especially those with housing maintenance) utilize an appointment system to reduce customer absenteeism.²⁴
- * Effective batching of service orders helps mitigate the *customer not at home* and *completed work* problems. By batching, travel time is minimize and therefore so is the loss if a job can not be done or has been done.
- * The *completed work problem* was often caused by multiple customer call-ins for the same service order. It was worse when Public

²³Figure 6 (page 82) provides an easy method to determine when it makes sense to call ahead. Under some conditions it may not. The "savings" from calling ahead depends on the time expended by the craft-person to find a phone and call, the travel time potentially saved by detecting an absent customer, and the average percentage of customers absent.

²⁴An adjunct to appointments in Navy Housing is the "permission to enter" technique used at the PWD, Naval Postgraduate School. Here, the occupant may give permission for the craft-person to enter the house when the occupant is absent. Appointments are possible, but (in my experience) significantly increase response time.

Works placed no or ineffective restrictions on who can submit a service request.

- * Finally, gaining the cooperation and support of customers may lead to significantly reduced escort times.²⁵

b. *Evaluation Questions*

- * How often are craft-persons dispatched to completed E/S sites? How often must they reschedule a service order because the customer was not at home? (SPCC)²⁶
- * Does Public Works accept (routine) service requests from anyone, or are there designated points of contact for each major customer? Which customers seem to habitually place repeat calls? Can Public Works help these customers organize their system to preclude most recalls?
- * How often do craft-persons have to wait for an escort? For how long? (SPCC)
- * Is service order batching practiced? (See "D(1)" page 49 for a more complete discussion on this topic)

²⁵The Fall/Winter 1992 "Navy Civil Engineer" magazine (page 27) described an escort delay situation where customer cooperation yielded much improved escort time. Craft-persons kept track of lost time waiting for an escort. This information was presented to the customer; the customer reacted by improving his/her escort process, benefiting both parties.

²⁶"SPCC" stands for statistical process control charting. Items identified with SPCC could benefit from SPCC techniques. Control charting is a simple statistically based technique for graphically describing the stability of the process. Control chart techniques are covered in statistical process control texts.

3. Poor Service Order Descriptions

a. *Nature of Problem*

Poor service order descriptions fail to clearly describe the nature of the work, its location and two points of contact. They impact the following work categories: job preparation and material (the craft-person may bring the wrong tools or materials), travel time and planning at the job site (witness Table 6, page 74.) The studies identified the following contributors to the problem:

- * Frequent turnover of service desk personnel.
- * Lack of standard operating procedure to obtain two points of contact.
- * Customers placing the service call who are not familiar with the problem directly.
- * Little or no familiarity of service desk personnel with typical problems encountered by the craft-person.
- * Limited feedback to service desk personnel on service order description errors (no mechanism for constant improvement.)
- * Little contact between craft-persons and service desk personnel due to remote or isolated service desk location.

The Consultants' usually suggest the following actions to counter these:

- * Provide (lots of) training to new service order clerks on obtaining clear work descriptions, work locations and at least two points of contact.

- * Encourage the service order clerk to gain first hand familiarity with the job of the craft-persons, the problems they face, and their need for good work descriptions. One way to do this by having the service clerk "ride with the craft-person" on a regular basis (e.g., monthly.)
- * Increase service clerk and craft-person interactions: If the service desk location isolates the clerk from craft-persons consider relocation to a more accessible location, preferably in a common shop area.
- * Take extraordinary measures to "hold onto" good service order clerks; their performance greatly affects the outcome of the entire service order operation.

b. *Evaluation Questions*

Evaluating the "quality" of service order descriptions is somewhat subjective. One method is to ask craft-persons how often poor work descriptions cause them to (1) spend extraordinary time searching for the location or a knowledgeable point of contact and (2) anticipate the wrong tools/materials or not anticipate them at all. Better yet, craft-persons should keep track of when these problems occurred. Keeping track could be done by noting the problem experienced on the service order before turn in.²⁷ Ideally, craft-persons, shop supervisors, the service order clerk and customers would work as a team to continually improve work descriptions. However, to be effective on an

²⁷Statistical process control charting is recommended for analysis.

on-going basis the craft-person must believe that management intends do something positive with the information.

4. Tool and Material Problems

a. **Nature of Problem**

There are two somewhat related material and tool problems here. The first occurs when craft-persons do not or can not predict what tools and materials to bring to the job site. It is highly likely that additional time returning to the truck and/or the shop will result. The second, inadequate truck stock, also results in increased travel.²⁸ Additionally, both problems increase work categories *material handling and laying out and stowing tools at the job site* (witness Table 6, page 74.) Table 4 (page 72) shows that these problems occurred in about half of all activities.

The studies revealed a number of possible causes:

- * Poor work descriptions cause the craft-person to incorrectly anticipate needed items or, worse, encourage a habit of "checking out" the job first then returning to the truck (or shop) for whatever is needed.
- * Poor craft-person work habits, i.e., not realizing how much extra time and human energy it takes to make multiple trips.
- * Non-use of accessories to encourage convenient tool carrying, e.g., tool belts and small tool boxes.

²⁸Truck stock is the inventory of parts and materials carried on the craft-persons truck. Ideally, truck stock concentrates on frequently used items.

- * Lack of an effective system to maintain truck stock levels and make continual improvement on what to carry. A partnership between the Supply Department, Public Works Management and craft-persons is essential for such a system to succeed.²⁹
- * Poor craft-person organization and work habits, i.e., craft-persons not realizing how much extra time and human energy is expended due to poor truck stock.
- * Lack of an appropriate vehicle type or the vehicle not properly outfitted (without securement or without good storage arrangements.) An extreme case is lack of a vehicle at all, which occurred in 10 out of 25 activities, witness Table 4, page 72.
- * At one activity, management placed an explicit cap on truck stock levels.

b. *Evaluation Questions*

- * What is the impact of poor service order descriptions? See evaluation questions on poor work descriptions in "D(3)(b)" on page 54.
- * The travel analysis procedure suggested in "A(2)(b)" on page 41 should help determine the frequency of return trips caused by poor truck stock.
- * A similar analysis could be performed by selected craft-persons, to help them become more aware of the overall extra effort needed when

²⁹NAB Little Creek formed such a partnership and credits better truck stock as one key reason for their overall improvement. See Appendix D, page 89.

tools and materials are not anticipated or carried on-board the truck. Encourage craft-persons to keep a log, noting every reason for returning to the truck throughout the day. At the end of a two week period the craft-person and supervisor could probably scan the log and find multiple trips for the same items and other reoccurring causes. Again, however, problems detected outside the craft-persons control must be acted on quickly and positively by management or the craft-person will become discouraged.

- * Are craft-persons provided the means (e.g., tool belts and boxes) to carry their tools to the job site? Are they aware of the potential savings in time and human energy?
- * Do service vehicles have the means to hold truck stock in an organized and secure manner? Observing the parking lot at the end of the day may yield interesting information; how much time is spent unloading trucks?
- * Are Shop Stores "open for business" at the end of the day so craft-persons can restock their trucks?³⁰
- * Does every craft-person who should work independently have their own vehicle?^{31,32}

³⁰At one activity, for example, Shop Stores would close 30 minutes before the end of normal craft-person shift time. Craft-persons had to arrive early to secure materials for the next day.

³¹One key the productivity improvement success at NAS Dallas, according to its Public Works Officer, was (finally) getting additional vehicles.

- * Is there an effective and synergistic relationship between Supply, Public Works Management and craft-persons? This, though difficult to quantify, is absolutely essential. See "2(a)" in Appendix E, page 91 for an example of what is possible.

E. IMPROVE JOB ORDER QUALITY

By "job order quality", I am referring to jobs that are planned and estimated by the P&E's. Unclear work descriptions, errors in design and wrong or missing materials specified added significant complexity to the job of the craft-person. This adversely impacted travel, material handling, planning at the job site and job preparation work categories (witness Table 6, page 74.)

The studies offered several factors contributing to the problem. Here they are, phrased in the form of evaluation questions:

- * Do P&E's routinely discuss the nature of an upcoming job with shop supervisors *before* writing the job?
- * Do P&E's have the means to visit the job site before writing the job? During? Do they visit the job site?
- * Do P&E's have radios so they are accessible to the shop supervisor in the field?
- * Is there a positive feedback mechanism whereby P&E's learn from their mistakes? Do they accept or discourage such feedback?

³²NAS Key West received a vehicle "shot in the arm" by recycling discarded trucks from Air Force disposal sites. (See "2(b) of Appendix E, page 93.) With current fiscal reductions in DoD, opportunities for recycled vehicles should increase greatly.

- * What is the error rate from poor design? How often are materials incorrect? How frequent are design changes? Are errors becoming more frequent, staying the same or getting worse? (SPCC)
- * Does the physical distance/location between the shops and P&E's office encourage frequent communications?
- * How would attendees honestly rate variance meetings? Are the number of variances exceeding tolerances decreasing, staying the same, or increasing over time?³³ (SPCC)

F. MISCELLANEOUS OPPORTUNITIES FOR IMPROVEMENT

The remaining opportunities in Table 4 (page 72) involved fewer activities than those previous, but are still worth considering. Here are a few of the more likely possibilities:

- * Craft-persons returning to the shop for additional instructions rather than calling in on the telephone or radio. There were two causes for this: insufficient radios/lack of a convenient phone or poor craft-person work habits. Again, the travel analysis procedure suggested in "A(2)(b)" on page 41 may also be used to evaluate this problem.
- * Sufficient and appropriate vehicles; one vehicle for each craft-person who should work independently; one vehicle for each shop supervisor and sufficient vehicles for P&E's to visit job sites.

³³I recently heard of one activity using principles of statistical control to determine variance tolerances, rather than an arbitrary use of a fixed percentage, such as +/-10%.

- * "Flexitime" conflicts.³⁴ Craft-persons waited for their partners (or other supporting craft-persons) who worked different flexitime shifts.
- * Must craft-persons wait in lines for shop store materials? Or on line at the tool room? How much time is lost?

³⁴"Flexitime" permits workers to select their own work shift or schedule within certain management defined limitations.

VI. RIGHT BRAIN THOUGHTS AND RECOMMENDATIONS

In the previous chapter I attempted to logically derive a list of common productivity improvement opportunities based on my review of the 26 productivity studies. The purpose of this chapter is to bring the right brain into play by offering some collective thoughts on productivity improvement. Here I provide no analysis and rely, instead, on thoughts assimilated during this study and from past experience.

A. TEN THINGS ANY PUBLIC WORKS OFFICER CAN DO TO IMPROVE PRODUCTIVITY

- * Decide that the craft-person is inherently productive- given the proper tools, materials, equipment, planning and support, they will be maximum productive. Then,
- * Turn the organizational pyramid upside down. In the mind of everyone at all levels all efforts are directed at supporting the craft-person.
- * Treat productivity impediments like the Japanese treat quality defects.³⁵ Complacency with the status quo is unacceptable.
- * Treat productivity impediments like lost funds. They are.
- * Create an atmosphere where shop supervisors cease to be administrators and become leaders and work facilitators. Scoping of job orders, frequent site visits, coordination and work planning

³⁵Actually, productivity impediments are quality defects.

needs to be their job.

- * Foster positive relationships between shop supervisors and Planners and Estimators. They must work consistently and proactively together especially *before* the job is written and materials ordered.
- * Drive out fear of honesty, rejection and effort lost. Treat every idea and criticism from any organization level as a potential money maker. Reward both.
- * Recognize people based on effort not outcome... frequently.
Corollary: Don't allow the annual performance rating system to devastate morale and motivation. Of all the variables in the work place, the worker can only control effort.
- * Join forces with the Supply Officer to optimize the Commanding Officer's operation.
- * Ask craft-persons what they need to do their job then get it.

B. RECOMMENDATIONS

1. Integrate Quality Improvement Concepts into Future Productivity Studies.

There is a clear (but not so well known) relationship between quality and productivity. This was briefly discussed in Chapter II (page 12.) In my experience, productivity improvement without consideration of quality is generally dismissed by "quality advocates" as self-defeating and for the most part, ineffective. I am one of them. Then why do I think productivity studies are potentially good management

tools?

The answer is simple: productivity studies may be used as quality improvement tools. How? They identify quality defects in the work process, such as incorrect materials, poor planning, poor service order descriptions and dispatching craft-persons to completed job sites. Again from the Key West experience, our productivity study helped guide our *Quality Management Board* equivalent. It also provided independent analysis for our *Process Action Teams* equivalent.

But quality improvement (e.g., TQL) is more than just identifying quality defects. TQL seeks to tap the collective intelligence of the workforce to develop improvements in the process leading to the reduction of quality defects. It is probably here that productivity studies may or may not be used as quality improvement tools. At Key West, by conscious management decision, workforce involvement pervaded *everything*. The result was improved quality in the work process, empowered workers and higher productivity.

We therefore, in fact, implemented parts of TQL at Key West as a result of two *independent* reasons: (1) the productivity study identified quality defects in the work process and (2) by *happenstance*, constant worker involvement was in the collective minds of Public Works senior management (PWO, APWO, Production Officer and Maintenance/Utilities Division Director.) Perhaps the (winning) combination of *productivity*

studies and quality improvement through people could be facilitated by:

- * Making the connection between quality and productivity explicit and the centerpiece of the "message" in future productivity studies.³⁶ This will help focus activities on quality improvement as the way to productivity improvement.
- * Writing future productivity studies to "glove fit" the Navy Quality Management Board and Process Action Team structure.
- * Using productivity studies (especially if modified as suggested) as a powerful "kick start" tool for activities trying to gather TQL momentum- recall the relatively short time frames at Key West, Dallas and Little Creek of 18-23 months for visible results.
- * *Marrying TQL management training with productivity studies.*

One final comment. As good as the results were at Key West, Dallas and Little Creek, their improved productivity may not be sustained as new management comes and goes. An important advantage of institutionalized (and internalized) TQL is that *management by personality* is replaced by management by facts and, generally, by the workforce itself. In effect, the "new management" roller coaster is made smooth by the TQL flywheel. With the frequency of military transfers (recall Deming's seven "diseases"), such a mechanism is essential.

³⁶There is another reason for this recommendation: ignorance. As an example, at least one Navy activity did not embrace their productivity study results because they were "waiting for TQL." TQL is not a package that comes in the mail!

2. NAVFACENGCOM Transfer the Knowledge

The "poor productivity causes" identified in this study are not too different than those identified in both the WESTNAVFACENGCOM review and E.L. Hamm analysis (See "B" page 25 of Chapter III for a synopsis of both).³⁷ So, we know the problems, and we know many of the solutions.

The real problem is in the implementation. In the words of L.A.

Broedling:

...We know relatively little about how to implement these [productivity improvement] solutions, that is, how to gain acceptance, to implement, to gain support, and, most importantly, to change corporate culture so that permanent institutional change will occur. (Broedling, 1983, p. 62)

The documented success at Key West, Dallas and Little Creek demonstrate that, at least in the short run, cost effective productivity improvement is possible using the "productivity study" technique.³⁸ *It may be possible to move productivity solutions (almost) directly to the implementation phase.* It makes sense to build on what we've learned from the 38+ Navy studies completed. We've learned what "buttons" to push for good productivity. We do not need to reinvent the wheel at each activity.

To do this, NAVFACENGCOM needs to take the leadership role. We need to gather a team of people who possess productivity improvement *implementation* experience. Armed with knowledge gained from a multitude

³⁷One major disagreement is WESTNAVFACENGCOM's conclusion concerning worker discipline as the cause of worker idleness.

³⁸Public Works Center, North Island also improved productivity in a similar manner.

of past productivity studies, the team would help activities by a three step process:

a. **Step 1: Evaluation Assistance**

The team would *assist and guide* selected activities in *identifying their own* poor productivity causes. The evaluation would be based on:

- Expert observation (much, for example, can be learned by just observing craft-persons in the warehouse.)
- Existing RPMA management information system indicators (e.g., various Base Engineering Support Technical (BEST) system reports.)
- The transportation travel log analysis idea in "A(2)(b)" of Chapter V (page 41.)
- Other evaluation questions such as those presented in Chapter V of this thesis.

b. **Step 2: Development of a Strategic Implementation Plan**

To date, productivity study reports generally list *what to do* but make no suggestions on *how to do or in what order and when*. In Step 2, the team would *work with* the activity to help them *think out* a strategic implementation plan. The strategic implementation plan will broadly outline the general strategies to affect changes in operations and gain work force support. The team, having the knowledge of past implementation plans (both successful and not) should be valuable as a source of ideas, insight and "pitfall avoidance" advice. The activity would then transform this strategic plan into an operational

implementation plan, i.e., the nuts and bolts.

c. *Step 3: Periodic "Second Opinions"*

During the actual implementation phase, the team would periodically revisit and offer management a second opinion on progress, provide mid-course suggestions and perhaps focus on any sticky problems.³⁹

Whether there is "market" for this service is unknown to the writer. Certainly, created demand is likely if customers are made aware of previous productivity improvement successes and feel the pressure of dwindling budgets.

Obviously E.L. Hamm and NORTHNAVFACENGCOM could do the job, or NAVFAC Industrial Engineering Center, or perhaps SOUTHNAVFACENGCOM. With NAVFACENGCOM downsizing the most practical way to go may be contract.

³⁹CINCLANTFLT used this approach in the Little Creek and Key West studies; E.L. Hamm returned several times between productivity measurements.

APPENDIX A

TABLES AND FIGURES

Note: "CP" is often used as an abbreviation for craft-person in the various tables and figures.

TABLE 1: JOB CHARACTERISTICS MODEL (THEORY)

Critical "Psychological States" For Intrinsic Motivation and
The Five "Core" Job Characteristics Needed to Sustain Them

Experienced Meaningfulness:

- Skill variety Degree to which workers skills and abilities are challenged.
- Task identity Degree to which the job requires completion of the "whole".
- Task Significance Degree to which the job has a substantial & perceivable impact on the lives of other people.

Experienced responsibility:

- Autonomy Degree to which the job gives the worker freedom, independence and discretion in scheduling work and determining how it will be carried out.

Knowledge of results:

- Feedback Degree to which a worker gets information on performance effectiveness. (Most powerful when the feedback comes from the work itself)

Extracted from Hackman, Oldham, Janson & Purdy: A New Strategy
For Job Enrichment. According to this model, motivation is determined
as the product of meaningfulness, responsibility & knowledge of results:

$(\text{Skill variety} + \text{Task Identity} + \text{Task Significance}) \times \text{Autonomy} \times \text{Feedback}$

3

TABLE 2: WORK SAMPLING CATEGORIES USED BY E.L. HAMM

PRODUCTIVE	100
INDIRECT PRODUCTIVE	200
job preparation	210
recieve instr. from supv.	211
get/put away tools	212
layout/stow tools at job	213
clean up job site	214
personal clean up at site	215
safety precautions	216
material handling	220
travel	230
planning on the job site	240
balancing delay	250
maint. of shop tools	260
housing keeping	270
paperwork	280
NON-PRODUCTIVE	300
personal	310
head	311
idle	312
cleanup & dressing	313
breaks/rest periods	314
official	320
idle- PWD controllable	330
await transportation	331
await assignment	332
await tools, mat, equip	333
2 per. on one per. job	334
poor scheduling	335
idle- not PWD controlled	340
await other dept/div	341
power failure	342
inclement weather	343

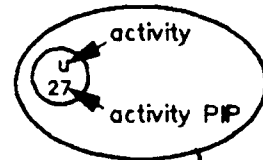
TABLE 3: SAMPLE ACTIVITY EXTRACTION OF CAUSES, OBSERVATIONS & EFFECTS

cp decision	effect	Category
* return to shop for lunch or breaks.	layaway tools eq&mat @job	213
* trips to truck/carts for tools.	layaway tools eq&mat @job	213
* cp return to shop for lunch or breaks.	travel	230
lack of shop supervisor planning, coordination site visits		
* j/o not screened before issue.	layaway tools eq&mat @job	213
* customer not on-site.	travel	230
* added complexity to cp tasks.	planning at the job site	240
* two cp in 1 cp job.	balancing delay	250
* customer not on-site or other.	awt other dept	341
Ineffective s/o batching		
* cp criss-cross base/x-tra travel.	Travel	230
s/o descriptions (poor)		
* incorrect selection of tools/materials.	layaway tools eq&mat @job	213
* added complexity to cp tasks.	planning at the job site	240
supply (no or poor staging of mat)		
* cp search for materials.	material handling	220
* shop sup.unable to check mat.	material handling	220
truck stock (poor)		
* return to shop for materials/tools.	layaway tools eq&mat @job	213
* frequent return to shop for materials.	travel	230
work (insufficient assigned)		
* cp out of work.	travel	230
* return to shop for lunch.	idle (work avail)	312

TABLE 5: POOR PRODUCTIVITY EFFECTS AT 18 NAVY PW ACTIVITIES

LEGEND
 productivity improvement potential (percentages)

- $-2 \leq x < 0$
- ◐ $-5 \leq x < -2$
- $0 < x \leq 2$
- ⊙ $2 < x \leq 5$
- ⦿ $5 < x \leq 10$
- $10 < x \leq 13.2$



		Activities & Productivity Improvement Potential																		
INDIRECT PRODUCTIVE		Work Cat.	y 4	p 16	z 17	v 18	s 18	m 19	w 19	q 19	r 19	k 21	i 21	t 24	x 24	o 24	l 25	j 25	n 25	u 27
job preparation																				
recieve instr. from supv.	211			●				●	⊙						●	●	●			
get/put away tools	212							●							●	●				●
layout/stow tools at job	213	●	●	●	●	●		⊙			●	●		●		⊙		●	●	●
clean up job site	214			●																
personal clean up at site	215																			
safety precautions	216			○																
material handling	220		●	●			●	●	●							●	●			●
travel	230	●	●	●	●	●	●	●	●	⊙	⊙	●	●	●	●	●	●	■	■	●
planning on the job site	240			⊙	⊙	⊙	⊙	●	●	●	●	●	●	●	●	●	●	●	●	●
balancing delay	250		⊙			●					●				●	●	●	●	●	●
maint. of shop tools	260				○															
housing keeping	270													●						
paperwork	280		○	●							○									●

NON-PRODUCTIVE

personal																				
head	311																			●
idle	312	●	⊙	●	●	⊙	⊙	⊙	⊙	■	⊙	⊙	●	●	⊙	⊙	⊙	●	●	●
cleanup & dressing	313															○				
breaks/rest periods	314		●			○				⊙				○	○	○	●	⊙		
official	320		⊙	○	○											●				
idle- PWD controllable																				
await transportation	331														⊙					
await assignment	332			●			●	●		⊙	⊙	●			●	●	●	●	●	●
await tools, mat. equip	333									●	●				●	●				
2 per. on one per. job	334		●				●			⊙	●	⊙	●	●	●	●				
poor scheduling	335													●	●	⊙	●			●
idle- not PWD controlled	341		●	●				●		●	●	●	●		●	●			●	●

TABLE 6: CAUSE VS EFFECTS FOR 15 MOST FREQUENT CAUSES AT 18 NAVY PW ACTIVITIES

increasing frequency
→
CAUSE

EFFECT

INDIRECT PRODUCTIVE		Work Cat.	one job at a time SOP	s/o scheduling system poor	Poor quality job orders	too many cp's assigned	dispatch of cp assigned	not enough vehicles	Job not coordinated w/ customer	Poor s/o descriptions	early quits, long lunches/breaks	cp maintains poor truck stock	Poor shop sup. Plan., coord., site visits	insufficient work assigned
job preparation														
recieve instr. from supv.	211	●	●											
get/put away tools	212					●								
layout/stow tools at job	213	●	●					●	●		●	●	●	●
clean up job site	214													
personal clean up at site	215													
safety precautions	216													
material handling	220		●					●		●				●
travel	230	●	●	●	●	●	●	●	●	●	●	●	●	●
planning on the job site	240		●		●			●					●	●
balancing delay	250			●	●								●	
maint. of shop tools	260													
housekeeping	270													●
paperwork	280													

NON-PRODUCTIVE

personal														
head	311										●	●	●	●
idle	312		●		●					●	●	●	●	●
cleanup & dressing	313													
breaks/rest periods	314									●	●			●
official	320													
idle- PWD controllable														
await transportation	331				●									
await assignment	332													●
await tools, mat, equip	333					●							●	
2 per. on one per. job	334			●	●								●	
poor scheduling	335	●	●		●								●	
idle- not PWD controlled	341						●						●	

TABLE 7: STAFFING AT KEY WEST, DALLAS AND LITTLE CREEK

		<u>Little Creek</u> (work centers)			
		electric	8		
		high voltage	2		
		air conditioning	1		
		utility system rpr	9		
		welder	2		
		sheetmetal	2	<u>Key West</u>	
		machine	4	electrical-a/c	18
		insulation	12	utilities	9
		emergency/service	14	metal trades	18
		carpentry	7	building trades	20
		paint	3	general services	9
<u>Dallas</u>		masonry	2	Sigsbee*	14
pipefitting/boiler	11	pipefitter	8	Trumen*	8
carpentry/paint	5	boiler plant	8	Trumbo*	8
<u>electric-a/c</u>	<u>8</u>	<u>TOTAL:</u>	<u>72</u>	<u>TOTAL:</u>	<u>104</u>
<u>TOTAL:</u>	<u>24</u>				

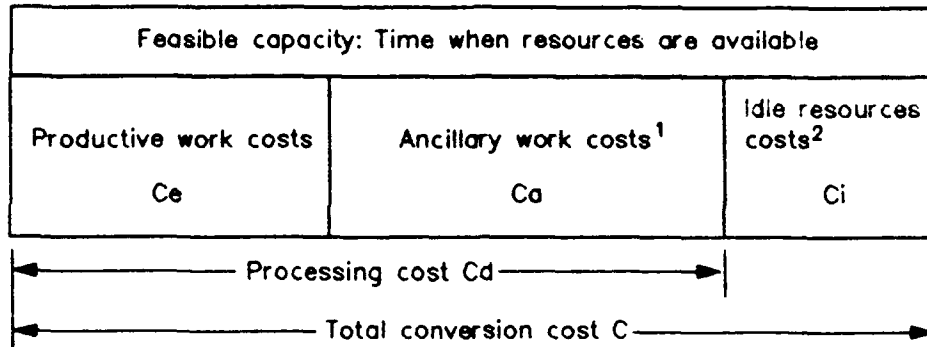
Note: Staffing based on productivity study report information. Dallas & Key West data from initial study; Little Creek data from final measurement report.

* Sigsbee, Trumen and Trumbo are geographically distant sites. They are primarily service order centers for housing, and have a broad trades mix.

TABLE 8: CONSULTANT RECOMMENDED CHANGES IN MODUS OPERANDI

Dallas	Little Creek	Key West	
			<u>IMPROVE DESIGN/INCREASE PRE-PLANNING</u>
●			Management update utility drawings.
●			P&E's visit job sites before writing job. Provide them vehicles.
●	●		Shop supervisor/P&E's discuss job before writing it or before assignment.
●	●		Shop supervisor scope out jobs (and visit job sites) prior to CP dispatch.
			<u>IMPROVE WORK ASSIGNMENT</u>
●			Schedule enough work to insure cp's don't run out.
●			(Insure) high skilled workers are not performing low skilled work.
●	●		Discontinue two [person] crews for most service calls and pm tasks.
			Provide additional vehicles so this can occur.
●	●		Shop supervisor logically batch and issue service orders.
●	●		Assign a full days work to each craft person.
●	●		Provide E/S clerk training so he/she asks the right questions & obtains complete work descriptions, location & POC information.
			<u>IMPROVE COORDINATION/FACILITATION</u>
●			Shop supervisor schedule work with other shops prior to CP dispatch.
●	●		Shop supervisor <i>coordinate</i> heavy equipment.
●	●		Lead shop supervisor manage the jobs for which they have lead shop responsibilities.
●	●		Insure shop supervisor visit the job sites.
			<u>IMPROVE MATERIAL QUALITY/DECREASE COMPLEXITY</u>
	●		Relocate Metal Trades storage area.
●	●		Supply stage specific job materials.
●			Consolidate tool room material into shop stores.
●	●		Shop supervisor check material before dispatching CP's.
●	●		CP's develop truck stock lists then use them.
			<u>DECREASE TRAVEL</u>
●			CP's telephone or radio shop for next assignment.
●	●		E/S CP's call the next customer after completing each job.
			<u>OTHER</u>
●	●		CP's document job completion times and materials used.
●	●		Discourage CP's from returning to shop early for lunch or at the end of day [if there is still feasible work to be done]. If return makes sense, CP's should use the time to prepare for the next day's work.
●	●		Perform a shop-by-shop vehicle analysis based on workload.
●	●		Encourage CP's to eat at the job site.

FIGURE 1: UTILIZATION PRODUCTIVITY RELATIONSHIPS (THEORY)



Lawlor offers two definitions of utilization productivity:

$$\frac{Cd}{C} \text{ or } \frac{Ce}{C}$$

Public Works productivity studies measure utilization as the later, $\frac{Ce}{C}$

Notes:

- (1) Called "indirect productive" in Public Works productivity studies
- (2) Called "non-productive" in Public Works productivity studies

FIGURE 2: MOST FREQUENT POOR PRODUCTIVITY CAUSES ACROSS 26 NAVY PW ACTIVITIES

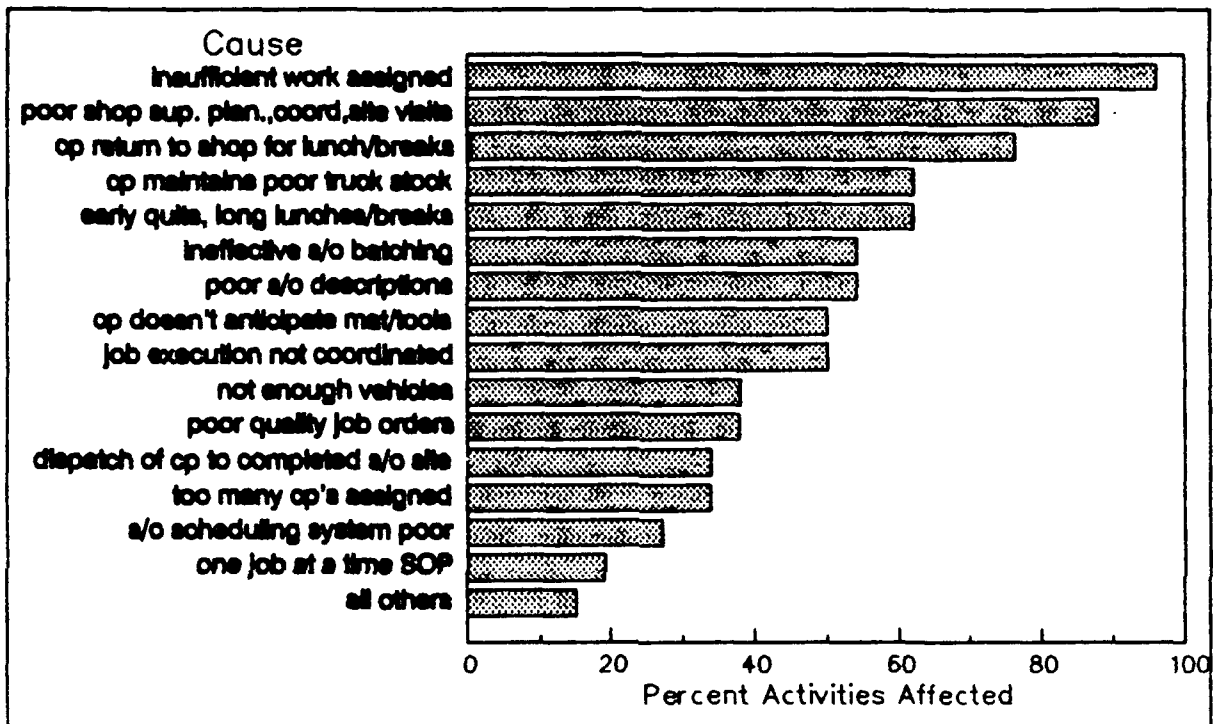


FIGURE 3: OVERALL PRODUCTIVITY IMPROVEMENT AT KEY WEST, DALLAS AND LITTLE CREEK

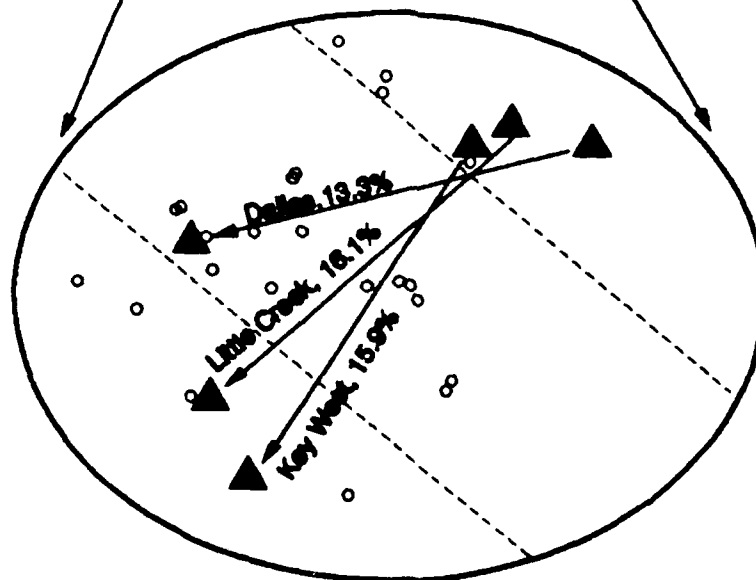
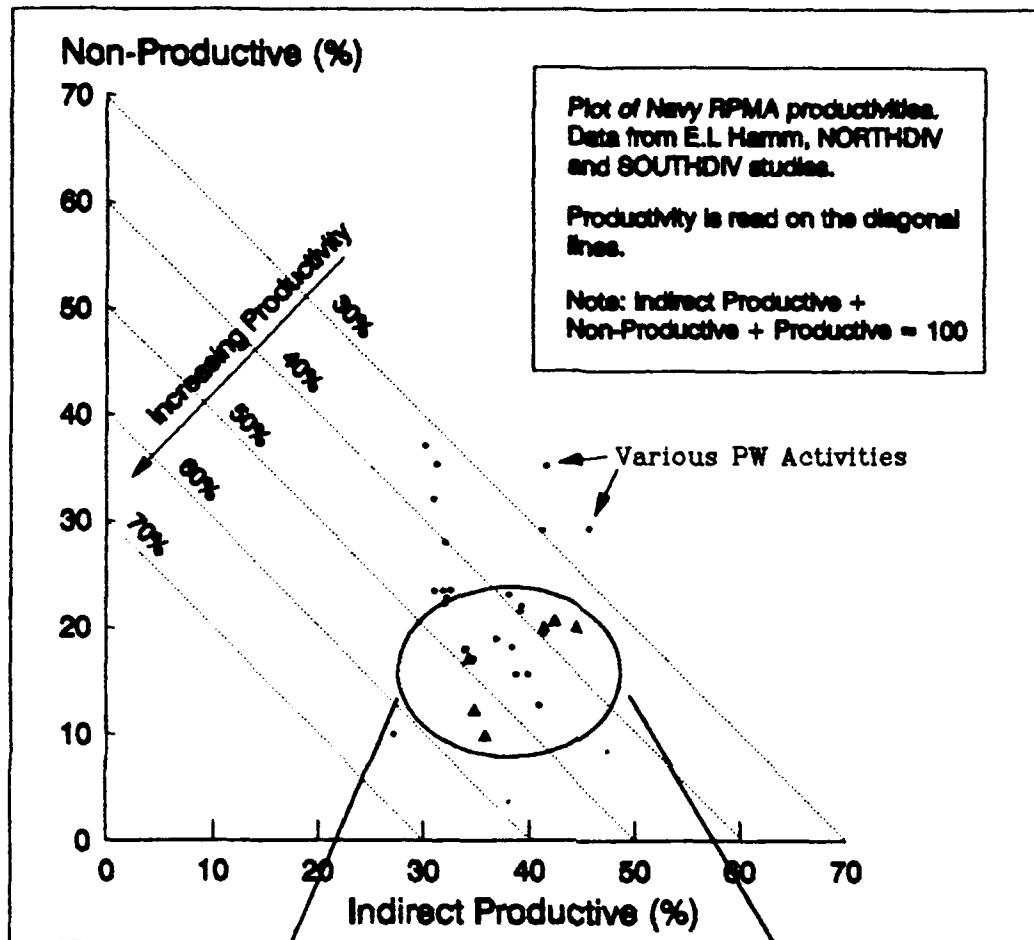
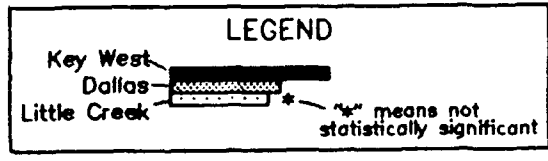
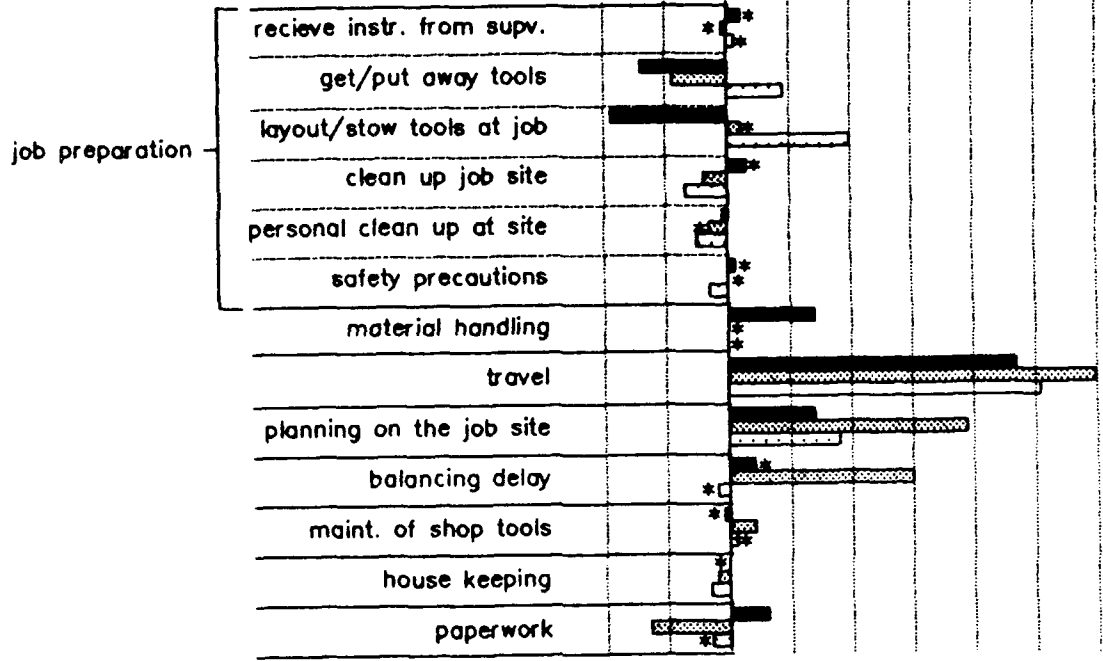


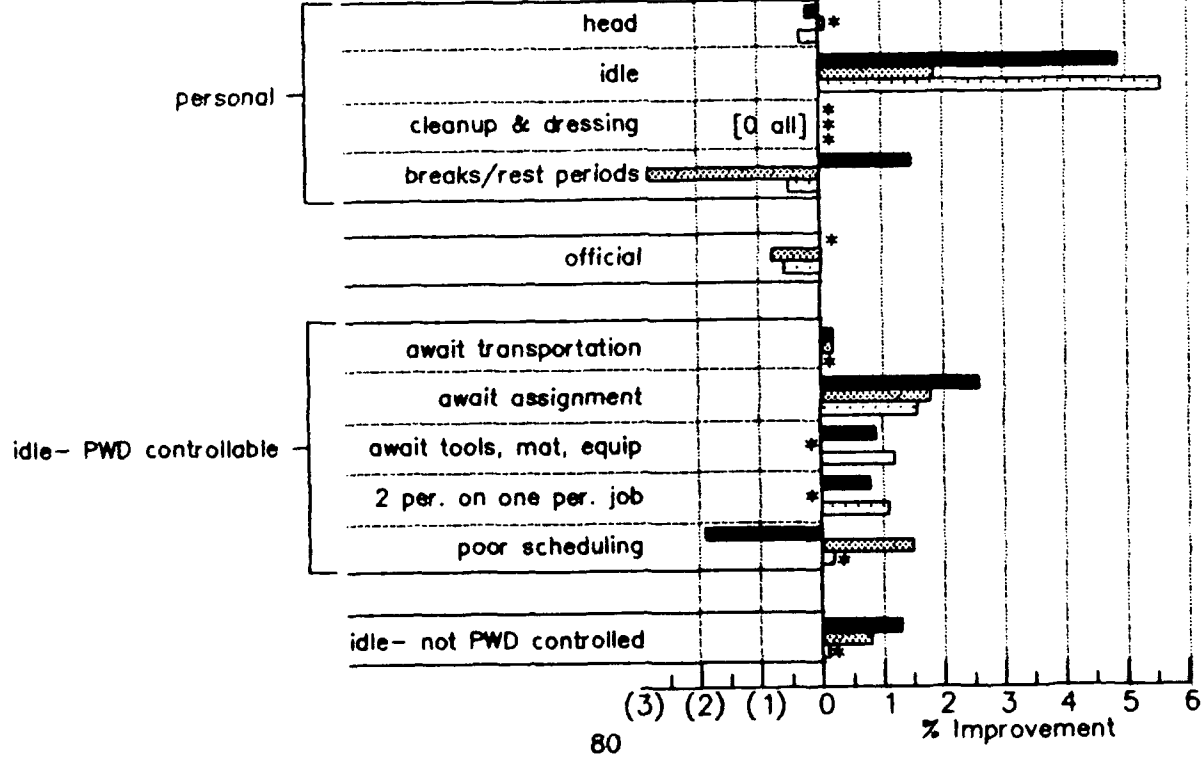
FIGURE 4: WORK CATEGORY CHANGES AT KEY WEST, DALLAS AND LITTLE CREEK



INDIRECT PRODUCTIVE:



NON-PRODUCTIVE:



(3) (2) (1) 0 1 2 3 4 5 6
 80 % Improvement

FIGURE 5: CONTRIBUTION OF REDUCED START/STOP TIMES TO IMPROVED PRODUCTIVITY AT KEY WEST, DALLAS AND LITTLE CREEK

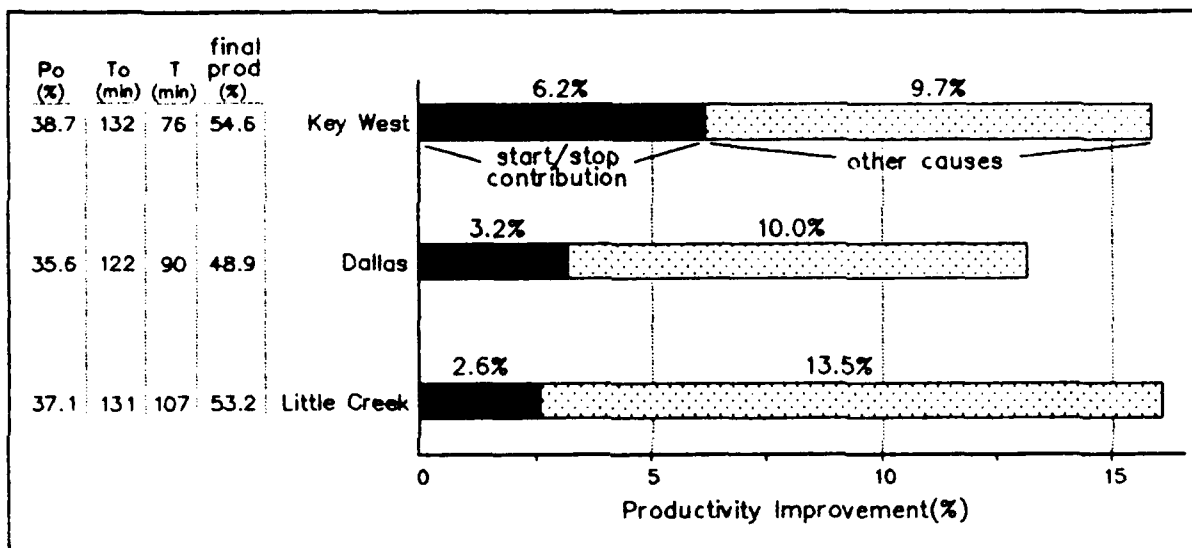
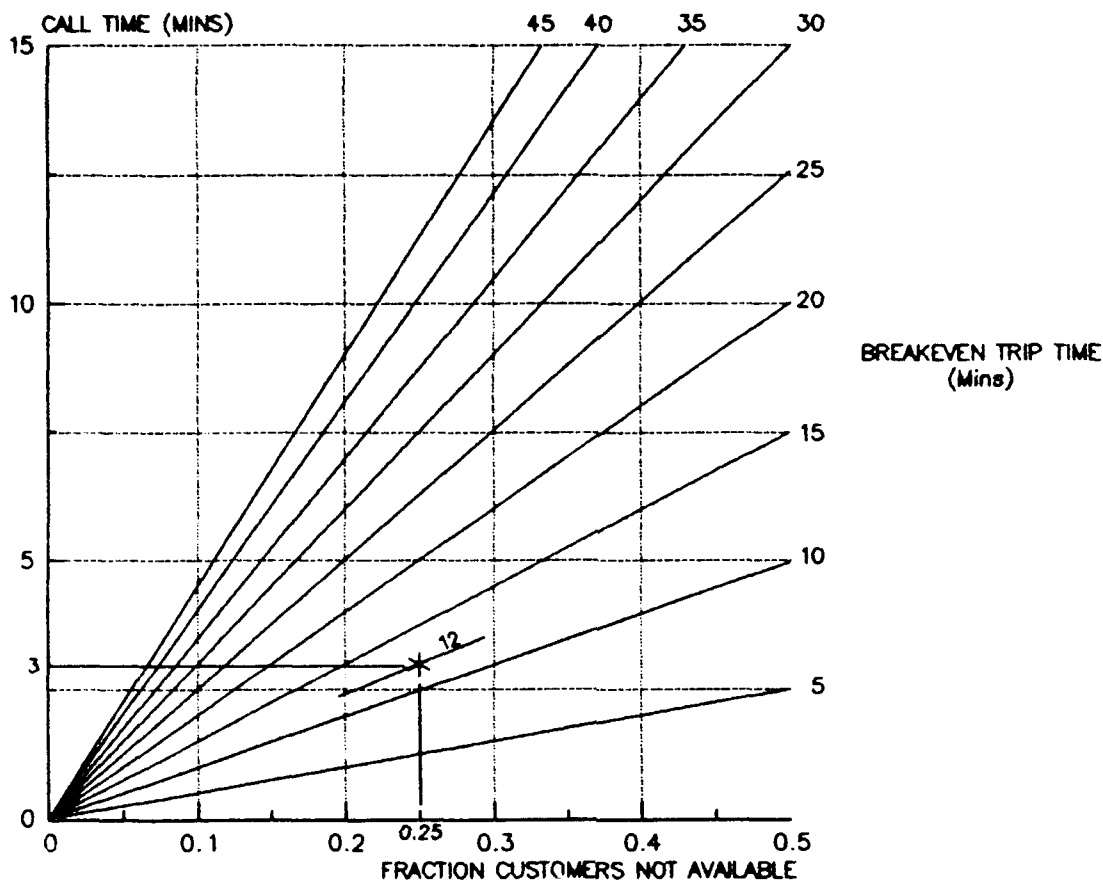


FIGURE 6: CALLING AHEAD POLICY GUIDE



Application of Deming's "kp" rule. (Gitlow, 1989, pp. 516-518) Answers "under what conditions should craft-persons call ahead?" Enter with average "CALL TIME" on the vertical axis and the average fraction of customers not available on the horizontal axis. Find the intersection. Read the BREAKEVEN TRIP TIME, interpolating as needed between the diagonal lines. If the expected TRIP TIME is more than the BREAKEVEN TRIP TIME, then expending the time to call ahead makes dollar sense.

The guide assumes (1) work can not commence without the customer on-site and (2) other costs (gas, vehicle wear, etc.) are insignificant.

DEFINITIONS:

KP RULE- The "kp" rule is to call if $k_1/k_2 < p$

CALL TIME- The total extra time invested to contact the next customer. This is k_1 in the kp rule.

BREAKEVEN TRIP TIME- The total time lost when physical contact with an unavailable customer is attempted (includes any wasted travel time.) This is k_2 in the kp rule.

FRACTION CUSTOMERS NOT AVAILABLE- The proportion of customers who, if not contacted ahead by phone, would probably be unavailable once the craft-person arrives on-site. This is p in the kp rule.

Example: Assume craft-persons expend 3 minutes to locate a phone, use it and return to a point adjacent to the last completed job. Also assume that 25% of customers on the average are unavailable. Read the breakeven visit time as 12 minutes. The kp rule is satisfied that:

$$k_1/k_2 = 3/12 = p = 0.25$$

If the ACTUAL trip time (all time that will be lost if the customer is absent) is greater than 12 minutes then calling ahead makes sense.

APPENDIX B

POOR PRODUCTIVITY CAUSE DESCRIPTIONS

* Poor truck stock. Truck stock is the inventory of parts and materials carried on the craft-persons truck. Failure to carry materials routinely needed by the craft-person generally increases travel, layout tools and materials and material handling time. Three categories of poor truck stock were identified:

- "limited by management." Management placed limitations on the amount of truck stock that could be carried.
- "Incorrect vehicle type/not outfitted." Either the wrong type vehicle was assigned (such as a pick up truck for a housing service order plumber) or trucks lacked appropriate shelving/compartments to carry parts/materials in an organized manner.
- "cp (craft-person) maintains." The craft-person has not stocked the truck sufficiently, but the reason may be any one or combination of the following: craft-person work and organization habits, Supply support and/or management support.

* Customer classifies service orders. At one activity, customers explicitly assign the priority of service orders. Often, otherwise routine calls are classified as emergencies.

* Cp (craft-person) joyriding. At one activity craft-persons were observed joy riding around the base while work was available.

* Cp travels to remotely located Supply. At one location, Supply materials were located a considerable distance from the principal work locations.

- * Work SOP's (Standard Operating Procedures). "SOP's" are work procedures official or unofficial which govern the operation of the shops. There were two:
 - "Don't start what can't be finished before lunch." Craft-persons will return to the shops early instead of beginning a new job.
 - "one job at a time." Craft-persons were issued only one job (either service order or other) at a time. It was understood they would return for the next job upon completion.
- * Cp perform Supply research function. At one activity, craft-persons spent time researching materials (e.g. stock numbers) with the (probably incorrect) belief that this would speed the material procurement process.
- * Cp search in large shop stock (poor material support). At one activity, the shops had "grown" large shop stocks to increase material availability. The work samplers observed craft-persons spending consider time trying to *find* those materials.
- * Authorized fitness time. Command approved physical fitness time. (one activity)
- * Cp drives to shop vice job site. At one activity personnel were required to drive directly to the jobs sites. Few did.
- * Management directed short service order turn around time. At one activity, all routine service orders of less than five hours duration were to be completed as soon as possible (resulting in an average completion time of two to three days). This decreased the opportunity to batch service orders.
- * Cp awaiting military return from muster. Craft-person idle time while waiting for military craft-persons to complete muster.

- * Cp delays in shop store lines. At one activity craft-persons have to wait in line to sign out small parts.
- * Cp must P&E job orders. Craft-person essentially did job order planning and estimating.
- * Tool room not always available. Tool room operating hours were not commensurate with the craft-person or unpredictable.
- * Lack of radios. A shortage of radios causing delay in communications and additional travel.
- * Cp idle during flex time. Several activities have authorized flexible schedules for shops personnel. Differences in craft-person schedules resulted in idle time while craft-persons waited for their partners to arrive before beginning work.
- * Cp drive to shop vice call for instructions. Craft-persons would return to the shop to confer with the shop supervisor rather than call in.
- * Material not centralized by Supply. The shop supervisor is unable to efficiently "check out" materials during the job order screening process because materials are not centrally staged.
- * S/O (service order scheduling system poor- customer not home). Time lost because the customer was not contacted by phone ahead of arrival or not coordinated in advance.
- * Poor quality job orders. Poor descriptions and/or incorrect material selections.
- * Too many craft-persons assigned to the job. Self explanatory.
- * Dispatch of cp's to completed s/o sites. Craft-persons were issued service orders for work that had already been completed by another craft-person. The problem was caused by a 2nd customer call or an error in closeout.
- * Not enough vehicles. Insufficient vehicles to support the shops.

- * Job execution not coordinated with customers. Lack of coordination with the customer before and during work execution. An extreme example is workers showing up on-site with tools and materials to begin a job that the customer no longer desires.
- * Cp can anticipate some tools and materials but does not. This refers to jobs that are somewhat routine in nature for which certain materials or tools (e.g., screw drivers) could be anticipated with a high degree of success. Craft-persons arrive at a job site, check out the job, and then return to the truck (or shop) to gather tools and materials.
- * Poor service order descriptions. Service order descriptions that fail to clearly describe the nature, location, and two points of contact for the work.
- * Ineffective S/O (service order) batching. Service orders are not grouped in logical sequence. Either service orders are issued on an as-received basis or the craft-person chooses their own based on personal preference.
- * Cp early quits, long lunches, or extended breaks. Self explanatory.
- * Cp return to shop for lunch or breaks. Craft-persons drive (or walk) back to the shop for lunch.
- * Lack of shop supervisor planning, coordination, and site visits. Shop supervisors fail to screen job orders, check out the job site conditions prior to assigning workers and/or visit the work sites once the job has commenced. Coordination (e.g., scheduling equipment or other shop support) is the responsibility of the craft-persons.
- * Insufficient work assigned to the craft-persons. Workers run out of work during the day and must contact the shop supervisor for

additional instructions.

APPENDIX C

DERIVATION OF EQUATION TO PREDICT START/STOP TIME CONTRIBUTION TO PRODUCTIVITY IMPROVEMENT

The following relationship was presented in Chapter II:

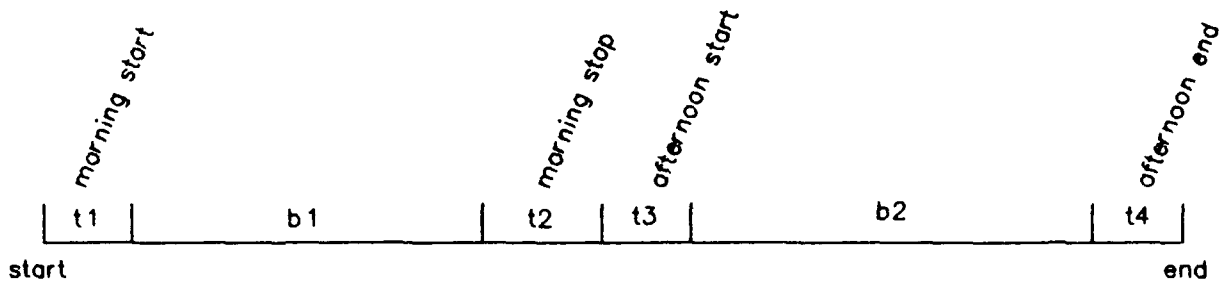
$$P = P_o (1 + (T_o - T)/(480 - T_o))$$

Where P_o = initial productivity, T_o = initial start/stop time total

P = new productivity level and T = new start/stop time total

This appendix presents the derivation.

Given a typical craft persons' eight hour day (excluding official lunch break):



Productive work occurs during b_1 and b_2 . Actual productivity during b_1 & b_2 is somewhat higher than measured productivity, and may be calculated by:

$$P' = 8P_o / (b_1 + b_2) \quad (\text{time in hours})$$

The sum of b_1 & b_2 may be computed from $[8 - (t_1 + t_2 + t_3 + t_4)]$, or $(8 - T_o)$ for short:

$$P' = 8P_o / (8 - T_o)$$

For each hour of start/stop time converted to "b", $P' \Delta T$ additional productive work is gained. The total daily productive work is then:

$$8P_o + 8P_o \Delta T / (8 - T_o) \quad \Delta T = \text{change in total start/stop time.}$$

The new productivity P becomes:

$$P = \frac{8P_o + 8P_o \Delta T / (8 - T_o)}{8} = P_o (1 + \Delta T / (8 - T_o))$$

substituting $\Delta T = T - T_o$:

$$P = P_o (1 + (T_o - T) / (8 - T_o))$$

Using minutes instead of hours:

$$P = P_o (1 + (T_o - T) / (480 - T_o))$$

Which is linear in T .

APPENDIX D

KEY ACTIONS- NAB LITTLE CREEK

1. Background

Just prior to their first productivity study, NAB Little Creek had implemented their Most Efficient Organization under the A-76 Commercial Activities program. According to an E.L. Hamm, at the time of initial study the "entire organization was in turmoil." (LANTNAVFACENGCOM [E.L. Hamm], 1990, p.VI-4) E.L. Hamm also cited a "major morale problem" surfacing as a direct consequence of "Most Efficient Organization" implementation. A major reorganization occurred with the elimination of the Assistant Public Works Officer billet and later, its reinstallation.

Unlike most other Public Works productivity studies, the NAB study included four work groups: the shops, shop supervisors, P&E's and the production controllers.

2. Key Actions

The following actions were key to their overall productivity improvement success: (Hanes, 1992)

a. **After-Hours Vehicle Fueling**

Previously, craft-persons fueled their trucks at the fuel station, located several miles from the shops. Little Creek decided to bring the fuel to the vehicles by fueling after-hours in the Public Works compound. This idea saves both craft-person travel and idle time.

b. **Created a Formal Truck Stock Inventory System**

Targeted at service order vehicles, truck bins are stocked from shop stores "truck stock" inventory. Craft-persons normally restock on

a weekly basis.

c. On-The-Spot Preventive Maintenance Repairs

Previously, any problem identified during Preventive Maintenance was referred to Maintenance Control for job issuing. Now, craft-persons are authorized to make on-the-spot repairs within certain limits.

d. Eating at the Job Site Emphasis

Returning to the shops for lunch had been a significant productivity killer at NAB Little Creek (as it is at most activities.) Little Creek management made a decision that this practice would cease, negotiated impact with the union, and issued new "marching orders" to the shop supervisors.⁴⁰

⁴⁰The reader is referred to "C" of Chapter V (page 46) for additional discussion on this subject.

APPENDIX E

KEY ACTIONS- NAS KEY WEST

1. Background

The start of the productivity improvement initiative at Key West and the winning of their A-76 (Commercial Activities) study occurred nearly simultaneously. The win was not clean; a GAO protest had delayed an uncertain final outcome well over a year. Doubts throughout the work force were strong, the general feeling being that the government wanted the function to "go contract." Morale was understandably poor and trust of senior leadership (in the government) almost non-existent.

CDR J.T. Corbett (NMCB-FOUR) was PWO Key West during the time frame of interest. He and I agree that the following actions were key to productivity improvement.⁴¹ (Corbett, 1992)

2. Key Actions

a. Restructured Material Support

E.L. Hamm has said of Supply support at NAS Key West:

NAS Key West Supply and PWD have developed an outstanding working relationship that has allowed both organizations to develop some innovative procedures that enhance both operations productivity. . . . Their efforts should be documented and provided to Supply and PWD organizations at other activities throughout the Navy so that these innovative techniques can be adopted. (LANTNAVFACENGCOM [E.L. Hamm], 1991)

This compliment, made subsequent to the final productivity measurement, illustrates the benefits breaking down barriers between departments.

Public Works had for some time done their own "1348" preparation, material tracking, receipt, warehousing and "shop store" (i.e., large pre-expanded bin) functions. Public Works wanted "control" over

⁴¹I was Key West APWO during the 18 month study period.

materials, believing that Supply could not (or would not) fully support their needs. However the (Public Works operated) system wasn't working either. Bins were too often empty and material disorganized.

The solution was found by approaching Supply using Deming's (1986,p.43) perspective:

This is what I can do for you.
Here is what you might do for me.

One important outcome of these discussions was a realization that our respective roles often reverse: Public Works becomes the supplier and Supply our customer. Supply's ability to provide Public Works timely material depends on Public Works ability to tell Supply what we need and when we need it.

Supply and Public Works developed a new system for material operations. Supply would take over all material management functions within Public Works. Our goals were (1) eliminate manual processing of form 1348's (2) provide stocked, accessible bins (3) organize, centralize and stage job order materials (4) Act on the knowledge that changes in our work schedules had downstream implications for our other jobs/Supply and (5) remove barriers between our respective organizations by co-locating a buyer and material management personnel within Public Works. By "co-location", I mean in the *same office area* as the Maintenance/Utilities Division Director... there were no walls or counters isolating Supply clerks from contact with the craft-persons. The material manager essentially became part of the Public Works team; attended meetings, made suggestions and solved problems. *Most notably, the material manager and her staff seemed to internalize their role of providing key and essential support to Public Works for the benefit of the Station.*

If I had write down a single line recipe for successful Supply/Public Works synergism based on Key West it would be this: key

leadership in both departments need to decide that it is more important to optimize the Commanding Officer's operation than their own. Paradoxically, once we made this decision all were optimized.

b. Getting More Vehicles, Quickly

Key West needed more vehicles. The problem was insufficient physical assets; the fleet was well within CINCLANTFLT allowance. A Public Works transportation inspector suggested looking at Air Force disposal yards for serviceable vehicles. He was sent to visit three activities and identified fifty vehicles for "recycling." Most were younger and in better shape than our Navy fleet. The vehicles were shipped, repaired as required and pressed into service.

Although Air Force recycles were not a permanent solution, they did provide much immediate relief.

c. Increase Craft-Person Participation

Traditional hierarchial organizational structures in the United States impede the flow of worker ideas. Good ideas are too often filtered or (worse) discouraged by management.

NAS Key West took a two prong approach to "listening." The first was establishment of a "Productivity Quality Circle" headed by the Public Works Officer and made up of craft-person representatives from each shop. The key to the success of the PQC was the determination on the part of the PWO to be a listener and take action on ideas. Today, three years and one PWO later, the group continues. (McNamara,1992)

The second approach was the creation of "shop blitzes." Each quarter, the Assistant Public Works Officer and Production Officer met with each shop for one to two hours. The shop supervisor was not in attendance. The meetings had two purposes. One, to brief the craft-persons on what management is doing to improve the craft-person support systems. Two, to gather craft-person thoughts and ideas. The meetings

initially produced a torrent of criticisms: we don't have enough work, my vehicle is always in the shop, we need more vehicles, why do we have to do this/that dumb thing, I can't get materials/tools/equipment/whatever and you (management) said you'd do this and that and- you haven't. At first suspicious, even angry, the craft-persons' tone seemed to change for the positive as the months went by and they noticed improvement. All the time, though, management was collecting and acting on many good ideas generated by the meetings.

There were probably a hundred or more good specific suggestions made by craft-persons during the 18 months between productivity measurements. Most were acted on. Some samples:

- * Provide specific tools/equipment (generally inexpensive.)
- * Provide a class for new housing tenants on proper care of appliances.
- * Provide classroom training to helpers from experienced journeyman.
- * Have transportation perform preventative maintenance/work on vehicles after-hours so downtime is minimized.
- * Provide oil and spare tires to the satellite shops (geographically remote) to decrease travel.
- * Obtain a small trailer to house job materials on-site.
- * Involve more craft-persons in ROICC acceptance inspections

d. Increase Shop Supervisor Site Visitations

How could shop supervisors facilitate work they were not familiar with? We asked the building trades shop supervisor, a person known for a high energy level and innate leadership qualities, why the lack of site visits. His answer: he had given his vehicle to his people, since there was a vehicle shortage in his shop. Borrowing a vehicle from another shop supervisor was both discouraging and practically useless, since several others were in the same position as he. In this case shop

supervisors lacked the tools to do their job, a responsibility of senior management.

Several vehicles were immediately short term rented for shop supervisor use. Routine site visits commenced thereafter for most shop supervisors.

e. Improve Radio Communications

Poor radio communications with craft-persons was another impediment to shop supervisor productivity. First, there was a radio shortage. Some craft-persons had none. Second, due to the Key West geography, craft-persons frequently could not be received at the base station located at the main shops. Additional radios and a relatively inexpensive radio system upgrade solved this problem.

f. Increase Shop Supervisor Job Order Scoping

Shop supervisors increased job order pre-planning. Formally, jobs for the next month were held from the shop supervisor to prevent "digging", the supposed practice of starting jobs before authorized because they are in some way attractive. In many instances shop supervisors were given jobs late Friday for execution beginning Monday. The policy was changed 180 degrees; shop supervisors were purposely given complete job packages from the long term shop load plan to permit early review and pre-planning. Most of the "digging" occurred because the shops needed executable work.

g. Increase Shop Supervisor/P&E Communications

Communications between Shop Supervisors and P&E's had historically been poor. Finger pointing and poor relations, mostly resulting from differences of opinion in job design were the norm. The goal of management was to get the shop supervisors and P&E's on the same team. This was never achieved in full, for behaviors rooted in habits are often difficult to change. However enough small success was

achieved to show significant improvement.

A new Facilities Management and Engineering Director (FMED, formally Maintenance Control Director) helped set a tone of cooperation within his division. However, some P&E's had to be directed to discuss upcoming jobs with shop supervisors. They, in my opinion, felt threatened by the prospect of cooperation with shop supervisors. Fortunately key P&E's and shop supervisors welcomed the new modus operandi as a way to improve the system they had known needed improvement.

To aid the transformation, human relations (communications and conflict resolution) training for shop supervisors and P&E's was arranged. Senior and line management participated. Additionally, radios were issued to the P&E's.

To help shop supervisors better understand the Planning and Estimating process, on-site Engineering Performance Training was conducted by SOUTHNAVFACENCOM.

h. Field Service Orders

Previously, a problem discovered in the field had to be called into the trouble desk before work could commence. For example, a plumber responding to a problem in the mens head is told by the barracks manager that the women's head also has a plumbing problem. The craft-person lacked the formal authority to commence work until issued a service order number. The result? Extra time spent by the craft-person obtaining authority to proceed.

"Field Service Orders" provide an easy means for craft-persons to perform such repairs on the spot without spending time on the phone or radio. The craft-person completes a "Field Service Order" form documenting the work accomplished. At the end of the day these forms are turned into the service desk (through the shop supervisor.) The service

desk enters the work into the database and creates a formal service order. If the work was completed, the data base is so entered. If work is on-going, the field service order is returned attached to a formal service order.

Craft-persons were provided training on proper use and limitations of field service orders.⁴²

i. Lunch Policy

The geography of Key West made the "returning to the shop for lunch" problem worse than most activities. NAS Key West is geographically split over several islands. During peak tourist season, it may take 30 minutes to drive from the most distant island area to Boca Chica, site of most "parent" shops. E.L. Hamm work samplers observed returns to the shop for lunch that essentially caused two hours of dead time.

How does one go about changing such (time honed) behavior? Edict? Encouragement? Ignoring it?

Management did not presume that returns were strictly the result of a craft-persons decision to do so. Obviously the shop supervisors and higher management on through the Public Works Officer had tacitly approved the practice over time. Less obviously were the reasons given by the craft-persons when we asked "why?":

- * We never know where we will wind up for lunch. It seems like planning "around here" is non-existent.
- * On one island, there is no place to eat.
- * "Cultural" relationships between craft-persons and shop supervisors on different islands make eating at a location other than the craft-person's own shop unattractive.

⁴²In my opinion, this particular action had a significant worker empowerment impact.

- * "You" try working outside in 95 degree Key West weather and then eat at the job site.

- * It doesn't seem to matter since we have to come back for tools, supplies and assignment (so often) anyway.

Obviously the issue was more complex than suggested at face value.

Management's decision was to take both a "hard" and "soft" approach:

- * Our goal would be to achieve no more than 45 minutes of "dead time" around and including lunch. This included the 30 minute lunch break itself and 15 minutes to wash up, secure tools and materials and their subsequent unsecurment. We expressed this goal to the craft-persons.
- * Soft: Craft-persons were encouraged to eat at the job site. We installed ice machines at various shop locations and issued "igloo" like coolers. If work was outside and the weather hot, craft-persons could drive (within the 45 minute bracket) to the nearest lunch facility.
- * Soft: We gave craft-persons (and supervisors) the flexibility to start lunch at the most appropriate time, based on the work. Previously it was "understood" that the official lunch break began at 12 and ended at 12:30. We removed the time clocks (used in a.m. and p.m.), which seemed to result in a positive psychological effect on the workers.
- * We made sure supervisors at remote island sites welcomed "visiting" craft-persons. At the island that lacked food facilities, a sandwich truck was enticed to stop at noon.
- * Management praised craft-persons found eating at the job site.
- * Implicitly, management knew we needed to do our part (remove productivity impediments) or craft-persons would not take the lunch policy seriously. Failure to do this would also insure that craft-

persons continue to frequently return for parts, supplies and additional work assignments.

- * Hard: Driving from one island to another to eat lunch was unacceptable.

The result? Total dead time before and after lunch was halved from 57 minutes to 28 minutes (determined from "start/stop" data.)

APPENDIX F

EXCERPTS FROM E.L. HAMM PRODUCTIVITY ENHANCEMENT TEAM (PET) BRIEFING

In January 1991 E.L. Hamm and Associates developed a briefing for CINCLANTFLT on the progress of work sampling (productivity) studies. (LANTNAVFACENCOM, 1991) The heart of the brief was a side-by-side comparison of productivity improvement initiatives at NAS Key West and NAB Little Creek. The purpose of this Appendix is to highlight the contrasting approaches of these activities to productivity improvement by providing excerpts from the briefing.⁴³

Excerpts are provided for the following areas:

<u>Page</u>	<u>Subject</u>
101	Communication and Employee Morale
105	Emergency Service Work
108	Supply Support
112	Planning/Estimating
115	Automated Systems
118	Backlog Management
120	Shop Loading and Scheduling
124	Preventive Maintenance
126	(Interim) Conclusions

Each subject area consists of an overview chart followed by text.

⁴³Keep in mind the following as you read: both Little Creek and Key West began their productivity improvement quest at nearly the same percentage productivity (37.1 and 38.8%), improved about the same (16.1 and 15.9%) and had many similar problems (activities "u" and "n" in Table 4, page 72) respectively.

COMMUNICATION and EMPLOYEE MORALE

PWD LITTLE CREEK	PWD KEY WEST
UNION ACCEPTED LUNCH POLICY	HIGH NUMBER OF TEMPORARY EMPLOYEES
STAND UP SHOP MEETINGS	SHOP BLITZES
SHOP REORGANIZATION	SUGGESTION BOXES
LOSS OF SOME DISGRUNTLED CRAFTSMEN	TIME CLOCKS REMOVED
MANAGEMENT JOB SITE VISITS	EMPLOYEE AWARDS BEGUN
REORGANIZATION OF PWD MANAGEMENT ORGANIZATION	LOGO CONTEST
	APPRENTICESHIP PROGRAM
	INCREASED INFORMATION DISSEMINATION THROUGHOUT ORG.
	P/E & FOREMEN COM- MUNICATION WORKSHOPS
	PRODUCTIVITY NEWS

SLIDE 33

- P-W-D Little Creek faced a very difficult morale and communication problem at the start of the interim period. The work sampling revealed that lunch hours were being badly abused because the entire P-W-D was operating under the impression that returns to the shop for lunch were a part of the union agreement. A process analysis review of the union agreement showed that returns for lunch were not a part of the agreement. After the PET workshops in which craftsmen were presented with the statistics supporting how returns to the shop negatively impact productivity, the P-W-D managers began making recommendations regarding whether a return to the shop for lunch was warranted when a work assignment was given. The union immediately responded that management could not arbitrarily take away something that had proven to be unwritten policy for a number of years. Negotiations were conducted and the union agreed to go back to the terms of the union agreement. The agreement stated that craftsmen should eat at or near the job site unless conditions at the site were prohibitive. After union concurrence was received, the Production Officer conducted meetings with all shop personnel to present management's position on the matter. During these meetings he stressed that management was not forbidding the craftsmen to return to the shop for lunch, just asking that it be done within the lunch period rather than 15 minutes before and 15 minutes after the lunch break. However, for all his efforts, during the first I-A-R, craftsmen told **HAMM ASSOCIATES** that they were being "made" to eat at the job sites and they could not walk to a neighboring snack bar. The craftsmen's response appeared to be the result of their refusal to hear what was being said.
- The Production Officer also conducted *regular stand up meetings in the shops* at the onset of the PET interim period to provide craftsmen with general P-W-D information. He explained changes that were taking place as a result of the ongoing PET project. In the interest of minimizing the amount of nonproductive official time shop personnel spent in these stand up meetings, he later changed to regular meetings with elected representatives from the shops. These craftsmen were delegated to take the information they received back to the shops and carry to these meetings any concerns voiced within the shops.
- The reduction-in-force or RIF process that accompanies the transition into the M-E-O had caused a number of craftsmen who wanted to stay on board to accept position outside of their primary trade. The Maintenance Director was able to recommend changes in the M-E-O staffing to better suit the work requirements he was receiving. These recommendations adjusted the mix of shop trades within the work centers shortly after I-A-R number 1. In making these changes, he was able to shift a number of very frustrated craftsmen working in positions outside of their primary trade into positions that were in their primary trade area. The changes greatly helped their morale and the morale of the shops in general.

- Through personal decisions on the part of a number of craftsmen, P-W-D Little Creek lost some of their more disgruntled craftsmen. They were able to replace them with individuals who were glad to get the jobs because they had come from far worse situations than P-W-D Little Creek appeared to have. These new employees and their positive attitudes also went a long way in improving the shop morale.
- The Production Officer requested that foremen begin developing a daily schedule of the jobs being worked and listing the craftsmen assigned. He began visiting the job sites and informally meeting with craftsmen. This procedure is still in place in the reorganized structure. The A-P-W-O, General Foreman, and Maintenance Director now go out to the job sites daily.
- With the addition of the A-P-W-O position, the organization was reorganized and the reorganization seemed to enable the organization to take a more comprehensive approach to productivity improvements efforts being made. As the commitment to improve increased through the A-P-W-O's efforts, the innovations seemed to improve communication and boost morale both in the shops and in the management support functions.

At P-W-D Key West an intensive effort was put forth by P-W-D managers to improve productivity through increased communication and efforts to make every employee a part of the productivity team.

- The PET workshops revealed a problem that was negatively affecting morale in the shops. P-W-D craftsmen were very disgruntled because a large number of them were temporary employees and had been temporary for several years. P-W-D managers worked closely with the Civilian Personnel Department to convert the majority of the temporary craftsmen to full time permanent positions. By the time the first I-A-R was conducted, the majority of the temporary craftsmen had become permanent employees.
- P-W-D Managers conducted "shop blitz" meetings on a quarterly basis. These meetings were designed to enable craftsmen to hear directly from the P-W-O, A-P-W-O, and Production Officer plans being developed that would have an effect on the shops. It also enabled the craftsmen to talk to these individuals about ideas that they had for improving operations and productivity within the P-W-D. Whenever possible the P-W-D Managers attempted to implement as many of the good suggestions as possible as soon as possible.
- The Production Officer had locked suggestion boxes built and installed throughout the P-W-D. Each suggestion that she received she responded to in writing. She thanked each individual for submitting an idea and discussed in her letter whether the idea was workable. She implemented as many of the suggestions as possible. At her request, many of the suggestions were also submitted as beneficial suggestions. Several of the individuals who made suggestions received cash awards for their ideas.

- At one of the blitz meetings, a craftsman inquired as to the rationale behind craftsmen having to punch a time clock while the management support staff did not. The P-W-O could only acknowledge that a time clock documented whether the craftsmen were there on time and if they left on time. What went on in between was not accounted for by the time clock. He went to the Base Commander and sought permission to remove the time clocks from the shops. He received approval to do so. When the time clocks were removed, craftsmen began leaving the shop area earlier than the actual work start time and returning to the shop after the final bell. The Production Officer observed that, when the craftsmen had been docked a half hour for being late each time they failed to punch in at or before the start time, they always asked for overtime even if the job they were on only required an additional ten minutes to complete after the appointed departure time. When the time clocks were taken out, the requests for small amounts of overtime stopped. Craftsmen began routinely returning a few minutes late rather than 15 to 30 minutes in advance of quitting time.
- P-W-D managers created an Employee of the Quarter Award Program which went into operation the last quarter of FY-88. It proved so successful that they are presently developing a similar program for managers. They also instituted "on the spot" awards to craftsmen which the Foremen give out for exceptional performance.
- P-W-D managers held a contest to develop logos for the maintenance and utilities and Transportation Divisions. These logos, now proudly painted on the street side of their buildings, make a strong statement regarding the pride the P-W-D employees take in their respective missions.
- P-W-D managers, in conjunction with the Civilian Personnel Department set up an Apprenticeship Program within the shops. This program has been designed to provide lower graded craftsmen with an incentive to improve their skills.
- In an effort to improve communications throughout the organization, the P-W-D managers made a conscious effort to become more visible and communicate more information to their subordinates. In turn, shop foremen were asked to change their management styles to put more emphasis on communicating to craftsmen information they received at their staff meetings. The goal is to build a better relationship of mutual trust and respect throughout the entire organization.
- The Administration Officer, who has a background in employee relations, developed communications workshops which were presented to the Planner/Estimators and foremen in group sessions. These workshops were designed to help the members of each work group to gain a better understanding of one another's role and promote improved working relations and better communications.
- Productivity newsletters were routinely published and made available in a number of locations throughout the P-W-D to assist P-W-D managers in more effectively communicating PET progress information throughout the organization.

EMERGENCY/SERVICE WORK

PWD LITTLE CREEK

WORK RECEPTIONIST
TRAINING

E/S WORK MADE PWD's #1
WORK PRIORITY

NEW E/S OPERATING PRO-
CEDURES IMPLEMENTED

IMPROVED E/S REPORTING
ESTABLISHED

PWD KEY WEST

WORK RECEPTIONIST
TRAINING

SATELLITE SHOP FOREMEN
AS WORK FACILITATORS

IMPROVED TRUCK STOCK

IMPROVED SUPPLY DEPT.
SUPPORT

BOCA CHICA E/S WORK

SLIDE 35

At both installations E-S work was a primary productivity improvement area; however, the approaches were different due to differences in the organization structures of the two P-W-Ds. P-W-D Little Creek has an E-S shop that is responsible for accomplishing between 60 and 75 percent of the E-S tickets. P-W-D Key West has three satellite E-S shops located in the three off base housing areas. Their base tickets are handled by the specific shops at Boca Chica.

- At both installations, the baseline reviews had shown that the work receptionists needed to learn more about maintenance work and about how the calls they were receiving were actually getting accomplished in the field. To train the work receptionists, the F-M-E-Ds arranged for the clerks to ride with the craftsmen so that they could see firsthand the problems being described to them by customers, learn a little more about the various trades, and begin to understand how hard it is for craftsmen to plan ahead when work descriptions are unclear and work locations vague.
- At P-W-D Little Creek, the change in command that took place about midway during the interim had the most dramatic effect on the productivity emphasis on E-S work. The incoming P-W-O made E-S work the number one priority work to be accomplished. He felt it was the most visible work done by the P-W-D and represented the largest percentage of the work accomplished. He also requested that the response time for E-S work be decreased from 14 days to 5 days from receipt of the ticket.
- P-W-D Little Creek managers reviewed the service ticket shops methods for accomplishing work to develop some procedures to minimize craftsman planning time and travel time. A procedure was developed to decrease travel for the housing E-S craftsmen, by assigning them tickets in only one housing area and eliminating the need for them to travel from one housing area to another throughout the day.
- A procedure was developed by P-W-D Little Creek and billeting facility managers to decrease travel and improve service delivery for billeting customers. Where billeting had routinely phoned in calls as they were observed and craftsmen dispatched daily, the new procedure enables P-W-D to hold all billeting work except emergencies until Thursday. On Thursday, all billeting work is now done at one time. P-W-D craftsmen travel less throughout the week and billeting has escorts waiting for the craftsmen at the door which minimizes delays associated with finding escorts.
- The Little Creek E-S shop foreman was encouraged to become the principal manager of work in the E-S shop. He now assigns work daily and manages the service ticket backlog where during the baseline those responsibilities were the craftsmen's.

- The F-M-E-D has been able to improve the information it is able to provide related to service ticket performance. As a result the E-S shop foreman and the specific shop foremen are provided with data about their performance that they never had before and they find it very helpful in managing the E-S work.

At P-W-D Key West the major E-S work changes have occurred in the satellite shops. The satellite shop foremen have become work facilitators. Under the direction of the lead foreman these men have become work managers. Each day they compile the assignments for the next day and at the end of the day all work accomplished and unaccomplished is turned back to them. In that way they know what has been done and can make decisions about who should be assigned the tickets that were not accomplished. It may be that the craftsman who could not get to a job one day is going off in a different direction the next day and someone else is going to the area instead.

Key West Supply Department personnel have worked closely with P-W-D Managers to determine how Supply can better support the E-S craftsmen in the satellite areas. Better truck stock was found to be one way. Craftsmen now have a mini hardware store shop stores warehouse at one of the satellites. The warehouse has been arranged to allow the craftsman to go in unsupervised, select the parts required, annotate the bin cards and leave. It is also anticipated that Supply will begin stocking the satellite shop trucks each day in the near future.

Craftsmen at the satellites now have tool belts or pouches that they were observed routinely carrying with them from the truck when they started out. These belts and pouches contributed to fewer trips back and forth to the truck as they worked on completing a ticket. It was also observed that the tools on the truck were the ones most often required because fewer trips were made back to the shop for tools.

At P-W-D Key West, the Boca Chica shops were not found to be handling E-S work as productively as the satellites were. In part, the problem was directly attributable to a high turnover of work receptionists making it difficult to get good work descriptions and work locations on the tickets. In part it was due to the fact that the specific shops each handle their trade related tickets. As a result, there is no way that a single shop foreman can strategize more effective ways to assign tickets because primarily they are done as filler work.

SUPPLY SUPPORT

PWD LITTLE CREEK

SUPPLY SUPPORT PROVIDED
BY NAB SUPPLY
DEPARTMENT

SUPPLIES NOT LOCATED IN A
SINGLE WAREHOUSE

PWD SHOP STORES A LOW
PRIORITY ON THE NAB
SUPPLY DEPARTMENT
IMPROVEMENT PROGRAM

STOREKEEPERS ARE MORE
FLEXIBLE IN THEIR ATTITUDE
TOWARD WALK IN REQUESTS

SHOP STORES MANAGERS
NOT IN TUNE WITH PWD
WORK CONTROL
IMPROVEMENTS

PWD KEY WEST

SUPPLY SUPPORT PROVIDED
BY NAS SUPPLY
DEPARTMENT

NAS SUPPLY DEPARTMENT
COMMITTED TO HELPING
THE PWD IMPROVE
PRODUCTIVITY

PWD'S SHORT RANGE PLAN-
NING PROBLEM NEGATIVELY
IMPACTS NAB SUPPLY
PRODUCTIVITY

PWD SHOP STORES IS A
MODEL FOR OTHER PWD
ACTIVITIES THROUGHOUT
THE NAVY

SLIDE 38

- Supply Operations for P-W-D Little Creek are handled by N-A-B Supply Department. In the CA review process, the P-W-D managers realized that an engineering function is not trained to run a supply operation efficiently; therefore, after negotiation with N-A-B Supply Department representatives, P-W-D provided them with four billets to operate the Shop Stores, order Job Order materials, and stage them for pickup. At the time of the Phase one study, the Shop Stores operated a manual record keeping inventory control system from which their manual data was input from log sheets into the automated Supply Department system. Interviews with Supply representatives regarding Shop Stores operations at the baseline review showed they were aware of the inventory control problem they had. These problems were documented in a Phase one comparative analysis of actual bin inventory to automated inventory. It was found that accuracy was below 50%. The Supply Department managers stated that and again in the PET workshops that P-W-D Shop Stores was rather low on their list of priorities. In the interim period, they planned to get a number of their more important items accomplished moving P-W-D up on the list. At the conclusion of the PET project, P-W-D Little Creek is still waiting. Everything with regard to Supply inventory control remains as it was when the baseline study was conducted.
- The baseline review showed a serious logistics problem that the craftsmen were facing daily. When Supply took over the P-W-D Shop Stores, items stocked in the P-W-D Tool Room, which included the entire fastener inventory, were not included in the transition. When the M-E-O was adopted, the Tool Room Attendant became a part time position which meant the Tool Room was only open 4 hours each morning from 0800 - 1200 hours. Craftsmen were not able to access either tools or stock items after lunch unless the E-S shop foreman or the Maintenance Director was found and they issued the needed item. In Phase one, it was recommended that the fastener inventory be transferred to Shop Stores to eliminate craftsmen having to go to two locations for materials. This move would also centralize the inventory control in N-A-B Supply. In the Maintenance Director's reorganization of the shops, the Tool Room Attendant was made a full time position. Just prior to I-A-R Number 3, P-W-D Managers approached N-A-B Supply regarding inventory consolidation of the 460 item fastener inventory into Shop Stores inventory. To date, no change has occurred because Supply representatives insist that it will require an additional person to maintain this inventory.
- Shop Stores storekeepers were observed to have become more flexible in Phase three in allowing craftsmen to enter the stock area and "shop" for the particular items they require. However, they do not allow craftsmen to go in unescorted. As the craftsman picks up items, the storekeeper records the data on the item. This procedure, although to the craftsman's advantage, ties up a considerable amount of the storekeeper's time. In I-A-R Number 3 it was recommended that the stock area be opened up like a hardware store in which the craftsmen select the items, annotate the necessary bin information on the bag, and let the storekeeper "check it out" as the craftsman exits.
- At the baseline study, it was observed that Shop Stores storekeepers did not stage

all Job Order materials in the staging area. When questioned they stated that P-W-D was so unpredictable in their job planning and scheduling that many jobs in the staging area were over a year old. If they staged their stock inventory when the ordered materials arrived, it would cause them to reorder more while the staged material sat and deteriorated. For that reason, when the craftsman came to pick up a Job Order, only then did they pull the required item from stock. This process, although cost effective, is definitely a productivity deterrent. While the Storekeeper goes about pulling stock off shelves if ample quantities are available not only the craftsman waits for the Job Order, but many craftsmen at the counter are forced to wait. To P-W-D's credit, their F-M-E-D has improved significantly and they now maintain a 150 day turnaround time for staged jobs, with only 23% falling below that figure. However, N-A-B Supply continues to make craftsmen wait while stock items are pulled.

- At the baseline review, P-W-D Key West operated their own Shop Stores and Job Order staging warehouse. Like P-W-D Little Creek, they realized that N-A-S Key West Supply Department was the resident expert. Shortly after the PET workshops, the entire inventory was turned over to the N-A-S Supply Department along with the billets required to operate the function.
- Supply Department managers committed to P-W-D the resources and time necessary to make the Supply function a productivity enhancement rather than a deterrent. First, they relocated a portion of their Purchasing Department into office spaces built for them in the P-W-D shops. They felt that, in so doing, materials requiring quick turnaround time could be easily acquired and any questions purchasing agents had regarding substitution of parts could be quickly answered by skilled craftsmen to cut down the number of incorrect substitutions that were made.
- Supply has converted its preexpended parts area at Boca Chica into a hardware store in which the craftsmen are permitted to shop (with carts) for what they require and check out the items they have selected when they leave. Although not in place at the final review due to a hiring freeze, N-A-S Supply is ready to take over the Sigsbee Satellite Shop Stores operation and has already converted the bins so that craftsmen only need to go to the bin, take what they need, record it on a card located at the bin, and leave. Supply hopes to get a procedures started in which craftsmen drop off a list of items used during the day and Supply collects and bags the items for truck restocking the next day.
- Key West Supply managers are somewhat frustrated with P-W-D managers because they feel that Supply has done a great deal to enhance P-W-D productivity; yet, P-W-D continues to crash work into the shops. When work crashes the shop, it in essence also crashes work into Supply. They must stop their routine work to order the necessary materials for the crash work and get them to the shops as quickly as possible. This problem is a direct result of the F-M-E-D's failure to be in control of work through long range and short range planning. Now that an F-M-E-D Director has been hired, as soon as he is able to get his shop loading plan finalized, he will be able to work on more long range planning and gain control of the work so that P-W-D can become more proactive and less reactive.

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- N-A-S Key West Supply and P-W-D have developed an outstanding working relationship that has allowed both organizations to develop some innovative procedures that enhance both operations' productivity. Their efforts should be documented and provided to Supply and P-W-D organizations at other activities throughout the Navy so that these innovative techniques can be adopted.

PLANNING/ ESTIMATING

PWD LITTLE CREEK	PWD KEY WEST
FEJE ABANDONED	P/Es AND SHOP FOREMEN REQUIRED TO VISIT JOB SITES TOGETHER WEEKLY
DECREASED DISTANCE BETWEEN P/E AND FOREMEN OFFICES VIEWED AS MEANS OF IMPROVING COMMUNICATION	COMMUNICATION SEMINARS DEVELOPED AND PRESENT- ED TO P/Es AND FOREMEN
SKETCHES AND DRAWINGS MANDATORY PART OF JOB PACKAGES	JOINT EPS CLASSES CONDUCTED P/Es SCHEDULED TO MOVE OFFICES INTO SHOP AREA

SLIDE 40

- As already discussed in relation to interim actions regarding automated systems at P-W-D Little Creek, to increase P-E productivity, P-W-D Managers have opted to have P-Es go back to a manual mode of estimating due to the prolonged scroll time they are experiencing using FEJE in the BEST system. Two problems were observed as a result of this change. The automatic transfer of phase data into a sequential phase summary sheet is somewhat problematic for the shops who now must shift from craft phase summary to craft phase summary to see the job phase sequence. The second problem is that since the job is not estimated in BEST, the data input into WIC from FEJE is not automatically transferred, it must be manually input by Production Controllers. The result is increased P-E productivity but additional work for other work groups within F-M-E-D.
- The Phase one report recommended that the P-Es be moved closer to the shops to improve communication between shop foremen and the P-Es and to break down the barriers that seem to exist between management support staff and the members of the shops. P-W-D Little Creek opted to move the P-Es further from the shops as opposed to closer. The barriers and distrust that existed between the work groups has not diminished as a result. Instead, it has merely taken a different tack. Now, shop managers state they have stopped trying to change what they feel is unchangeable in a Job Package. They now accept the Job Packages they receive and no longer complain when the materials are insufficient or incorrect or they feel that a better approach to the repair is required. They believe that since other problems have diminished, there is no need to create new ones.
- When the Production Officer was changed to the Engineering Officer as a result of the reorganization that took place when the A-P-W-O billet was re-established, the F-M-E-D was moved under his supervision. One of the first changes he instituted was his personal review of completed Job Packages. His initial reviews showed that few Job Packages contained job sketches or drawings including measurements. He asked that each Job Package include a sketch or drawing detailing work locations and specifications. As a result of this change, work samplers observed a 1.8% decrease in the observed on the job planning done by the craftsmen. They also observed in the P-E work sampling an increase in the amount of measurement taking being done when P-Es go out to job sites to determine what work was to be done.
- At P-W-D Key West, the F-M-E-D Director and the Production Officer now require that the P-Es and shop foreman go out and review every job that is being planned and estimated. Both managers realize that this approach is somewhat extreme and that many jobs do not require both men to go out, but they felt it was the only way that they could initially ensure that the two work groups would go out together at least half a day once a week.
- The Key West Administrative Officer was asked to develop a series of communication seminars that she conducted for these two work groups so that they would better understand how communication works, how important it is to their jobs, and how they must listen to one another when they talk to each other.

- The A-P-W-O asked the SOUTH-DIV Engineer in Charge of the PET project to conduct E-P-S classes for a combined group of foremen and P-Es during two I-A-R visits . The week of E-P-S training served as a P-E refresher course and a mini E-P-S training course for the Foremen. This introduction to E-P-S enabled the foremen to better understand how estimates are developed and provided another opportunity for the two work groups to interact.

- At the final briefing for Phase three, it was recommended that the P-Es be provided work space in the shop area to facilitate communication between foremen and P-Es and between P-Es and Supply. The P-W-O said that he and the F-M-E-D had already given that idea considerable thought and were planning to do exactly that.

AUTOMATED SYSTEMS

PWD LITTLE CREEK

PURGE BEST OF ALL EX-
TRANEOUS DATA

FEJE ABANDONED

EFFORTS MADE TO LOCATE
A REAL TIME LABOR DATA
COLLECTION SOFTWARE
PROGRAM

AUTOMATED LONG RANGE
PLANNING DOCUMENT
DEVELOPED

AUTOMATED PM PROGRAM
OPERATIVE

PERFORMANCE ORIENTED
MANAGEMENT REPORTS DE-
VELOPED MONTHLY

PERFORMANCE INDICATORS
FOR PWS COLLECTED

PWD KEY WEST

SHOP LOADING USING
CPM

E/S COMPLETED TICKET
BACKLOG

EFFORTS MADE TO LOCATE
A REAL TIME LABOR DATA
COLLECTION SOFTWARE
PROGRAM

SLIDE 34

Where the previous slide showed Key West with a major emphasis having been made to improve communication and morale, this one shows Little Creek's emphasis on their automated systems during the interim period.

- The F-M-E-D Director made a concerted effort at the onset of the interim period to clean out the extraneous data in the BEST system so that it could begin to generate meaningful reports. As an industrial engineer, he was cognizant of the importance of providing managers with reliable performance indicators and reports on which sound management decisions can be made.
- Planner/Estimators were forced to abandon their use of the Facilities Engineering Job Estimating or FEJE module to develop job estimates in BEST. They returned to using the hard copy Engineered Performance Standards or E-P-S handbooks, because the BEST system scroll time had become very slow. So slow, it was seriously impeding their productivity. A high usership demand on the system from other areas of the F-M-E-D is the cause of the scrolling problem.
- The F-M-E-D Director put forth an extensive effort to obtain a real time data collection software program that would minimize the compilation of labor hour data. After a great deal of time was devoted to the adaptation of the Sub Base New London, Connecticut, real time data collection program, only a portion of it was found to be usable and adaptable. The F-M-E-D was able to bring online the data collection of Ship's Tickets for the hookups and detachments of shore support. All the other effort proved for naught. The P-W-D still faces a serious dilemma regarding the validity of the labor data being compiled at a number of places within the P-W-D.

If we look at the Key West column, you will note that they too have taken similar actions to find a field level means of collecting labor data. They also obtained the Sub Base New London program in the hopes that it would provide them with a program that would solve their problems. They do have multiple data collection locations and inaccurate data. Like Little Creek, they were unable to adapt it to their needs and still face the problem that was identified during the baseline study.

- The F-M-E-D Director at P-W-D Little Creek developed an automated dBase program for maintaining and updating his long range resource management plan that incorporates a sophisticated assignment of work classifications, priorities, funding codes, etc. The beauty of his program is that data entries can be checked through a print out of system identified errors.
- The Little Creek F-M-E-D hired a Production Controller to manage the P-M program which eliminated the excessive backlog of completed P-M data that existed at the baseline. F-M-E-D is now able to utilize the information craftsmen annotate on the checklists regarding major repair requirements and checkpoint and inventory discrepancies that exist between the estimate that the P-Es have developed and the actual work being performed.
- The P-W-D Business Officer and the F-M-E-D Director were the driving force in the

efforts to make the data in the automated systems in the P-W-D accurate and usable for decision making purposes. Their diligence yielded a series of performance oriented reports that all P-W-D managers are finding an extremely important tool in their day-to-day management.

- After the A-P-W-O came aboard, the Business Officer became a staff position to the P-W-O. Her first major tasking was to develop a means of monitoring work in accordance with the P-W-S and amend that document to reflect the work actually being performed by the P-W-D workforce. The Business Officer's reassignment has proven to be very valuable to the productivity effort. Her emphasis has been on developing indicators by which performance data can be collected and monitored. Her work is providing all the P-W-D managers with very useful management information on which they are beginning to rely very heavily in making their management decisions.

At P-W-D Key West these three areas related to automated systems were focused on during the interim. The location and implementation of software to collect labor hour data is one we have already discussed.

- The F-M-E-D Director who joined the organization in the later part of the interim period has worked very hard to automate the shop load plan process using Critical Path Method or C-P-M. His goal is to use the C-P-M plan as both a monthly shop loading document and a shop scheduled. At the time of the Phase three visit to Key West, he had made several changes in his approach to using C-P-M, but at that point had not been successful in developing a viable alternative to the master scheduling methodology in M-O-3-21.
- The E-S module in BEST has proven problematic for P-W-D Key West. Two work stations input data simultaneously. One is directly connected to the main frame and one is connected to the mainframe by a telephone modem. As a result, the modem work station is very slow scrolling and processing reports when requested. The modem station is located in the satellite shops, where a high volume of calls is routinely received from family housing. The Work Receptionist is barely able to keep up with the data entry of Service Tickets and is consistently unable to close out all the tickets completed each day. The result is a large backlog of completed E-S Tickets which renders any data in BEST related to service work useless for management decision making purposes.

BACKLOG MANAGEMENT

PWD LITTLE CREEK

STAGED JOBS NOT TO
EXCEED 150 DAYS IN THE
STAGING AREA

HIGH VACANCY RATES
MAKE BACKLOG MANAGEMENT
DIFFICULT

PWD KEY WEST

BACKLOGGED JOBS
DIFFICULT TO REVIEW
DUE TO FILING SYSTEM

A NUMBER OF VERY OLD
JOBS IN THE BACKLOG

SLIDE 36

Backlog management was carefully reviewed at P-W-D Little Creek after the Phase one report was received. A team of P-W-D managers analyzed every job in the backlog to determine if it was workable by the shops, should be contracted, or should be canceled. All the old jobs that could be worked by the shops were scheduled in an effort to clear them out the staging area. In many cases the materials for those jobs were over a year old and some were even over two years old. The management review team established a performance indicator to monitor jobs in the staging area in an effort to prevent keeping them there more than 150 days.

P-W-D Little Creek found that one of the major contributors to backlog management problems was the high vacancy rate that they maintained throughout the interim. For a variety of reasons, the organization has continued to sustain a vacancy rate between 10 and 13 percent. In the smaller work centers, when a position is vacant for any length of time, for whatever the reason, backlog quickly goes out of balance as the smaller work center finds it impossible to keep up with the demand for its craft phases. As a result, planned work gets delayed and larger work centers are forced to go looking for work to fill in the gaps created by the overloaded work centers.

At P-W-D Key West, the method used to file backlogged jobs made backlog management very difficult to accomplish. Instead of filing all jobs awaiting accomplishment in one central file by Job Order Number, the P-W-D filed them in the facility history folders by facility number. As a result, the only way to review the Job Packages of jobs awaiting scheduling or with materials on order was to go into each facility history jacket and pull the job to be reviewed. Based on a recommendation in the early part of the interim, the P-W-D was in the process of installing new filing cabinets so that they could pull out all their backlogged jobs and file them by Job Order Number and status -- awaiting scheduling, awaiting materials, estimated but on hold.

When the backlog at Key West was reviewed, it was found that it contained a number of very old jobs. These jobs that were not workable for a number of reasons were inflating the backlog and giving the organization a false impression of their backlog. At the time of the followup study, they had just begun to send some of the older smaller single phase jobs down to the shops to work as unscheduled minors to fill in when time was available.

SHOP LOADING and SCHEDULING

PWD LITTLE CREEK	PWD KEY WEST
AUTOMATED ANNUAL WORK PLAN	FMED DIRECTOR POSITION VACANT FOR LARGE PART OF INTERIM PERIOD
JOB ORDER REVIEW MEETING	
SHOP LOAD PLAN USED AS THE MONTHLY SCHEDULE	SHOP LOAD PLAN USED AS THE MONTHLY SCHEDULE
AUTOMATED SCHEDULING PROGRAM SOUGHT	FMED DIRECTOR INSTALLING AUTOMATED GPM PROGRAM TO OPERATE AS SHOP LOAD PLAN AND SHOP SCHEDULE
SHOP FOREMEN DEVELOP A DAILY SCHEDULE FOR FOR PWD MANAGERS	JOB CRASHED INTO SHOP LOAD PLAN/SCHEDULE
SCHEDULED CARRY OVER MORE ACCURATE	
FOREMEN REQUIRED TO VISIT JOB SITES TWICE A DAY	
FMED HAS BECOME MORE PROACTIVE	

SLIDE 37

Shop loading and scheduling are two very important components of the maintenance management system. Shop loading representing work planning and shop scheduling being a component in and of itself.

At P-W-D Little Creek, the F-M-E-D Director was hard at work developing an annual work plan for the activity when the baseline study was conducted. During the interim, he completed the task using a dBase III program he developed. The plan has now been implemented into the work control process and forms the basis for the three month shop load plan developed in Production Control.

Although a three month shop load plan had always been developed at P-W-D Little Creek, the changes that occurred during a given month had rendered it virtually useless for planning purposes. With the addition of the new annual work plan, the Production Controller--Scheduling is now able to develop a very firm three month shop load plan and is able to load the second month at 80% by the third week of the current month. As a result, a monthly Job Order Review meeting is conducted during the last week of the month to review upcoming jobs. Jobs that are determined to be unworkable by the review committee are removed from the shop load plan and alternative work substituted. As a result, the shops find that they are working more of the planned jobs each month.

The baseline study recommended that the Little Creek shops adopt master work scheduling as described in M-O-3-21 to ensure that the shops have sufficient work each day to keep each craftsman productively engaged throughout the day. The Maintenance Director at this P-W-D does not feel that the effort required to perform master scheduling will yield the desired results. He contends that the maintenance environment at P-W-D is too unpredictable and that too many variables impact the schedule every day. As a result, he prefers to use the shop load plan as the basis for his schedule and load to the shops with one week of work at a time.

The Maintenance Director's concern with master scheduling is that it is a very time consuming endeavor and the P-W-D Little Creek M-E-O did not provide the shops with the resources to perform that level of scheduling. In addition, master scheduling requires a highly skilled individual to perform this work in the manual mode. He and the Production Officer searched the commercial markets and made inquiries throughout the NAV-FAC community to find an automated master scheduling program that they could adopt to their needs. Their efforts met with no success during the interim.

In an effort to become more visible and more in tune with the workforce, the Production Officer asked the shop foremen to provide him with a daily listing of the jobs being worked and the craftsmen assigned. Using these lists, the Production Officer would randomly visit job sites during the work day and talk with the workers. This document, in serving the Production Officer's purpose of giving him an idea of where the workforce was throughout the day, also forced the shop foremen to do more comprehensive planning of each man's day as the list of jobs to be worked was developed. The only negative observation that is associated with this list is that it does not require the foremen to estimate how long each man will be at the job site. As a result, craftsmen still run out of work toward the end of the workday. When the reorganization took place due to the addition of the A-P-W-O billet being added, the decision

was made to continue the development of these lists which are now used by the A-P-W-O, the Maintenance Director, and the General Foreman who now routinely go out to job sites together during the day.

Carry over work was handled as crash work during the baseline review. This method of carrying it over was because the shop load plan for the month came out about a week in advance of the end of the month and the Maintenance Director and Production Controller-Scheduling were not able to predict with high accuracy exactly which jobs would actually carry over and which would be completed. Through some strategizing on their parts, these individuals have now developed a system in which more accurate carry over figures are incorporated in the shop load plan thus decreasing the amount of unpredicted carry over that was causing it to be virtually impossible for the shops to complete more than half of the work on the shop load plan during the month.

Little Creek foremen are now required to make a minimum of two trips to all the specific job sites in progress each day. This requirement enables them to better manage shop resources by moving craftsmen around more expeditiously throughout the day and eliminating the need for craftsmen to return to the shop for more assignments when they run out of work unexpectedly.

Many of the shop loading and scheduling interim actions taken by the P-W-D have enabled managers to gain a greater deal of control over the work being accomplished. F-M-E-D is much more proactive in its approach to work planning and has managed to minimize the amount of crash work that must be dealt with each month. Although crash work is a fact of life in the maintenance arena, it does not have to be the *modus operandi* of the organization.

P-W-D Key West has had difficulty during the interim implementing many of the recommendations made in the Phase one report related to planning and scheduling. This is due to the fact that the F-M-E-D Director position was vacant for several month during the interim. When the new Director was hired, some immediate changes began to occur.

The new F-M-E-D Director has a strong background in construction management which relies heavily on the Critical Path Method or C-P-M to plan and schedule work. With the P-W-O's permission, he began developing a shop load plan using C-P-M as its basis. Unfortunately, he has encountered a number of problems in the development process related to the computer hardware available in the P-W-D. During the follow-up review, he had not yet been successful in getting the program fully operative, but was in the process of instituting some changes that were believed to be the ones needed to get it fully operational.

As with P-W-D Little Creek, P-W-D Key West has used their shop load plan as a schedule and does not do the detailed master scheduling described in M-O-3-21. It is believed that when the C-P-M method for shop loading is finally operational, it will eliminate the need for a detailed daily schedule since it will be a part of the C-P-M plan itself.

Because of the difficulty F-M-E-D has faced in getting its shop load plan operative, the organization remains in a reactive mode with a high number of jobs crashing into the shops on a routine basis. The F-M-E-D has recently developed a four month plan of the work that will be loaded and scheduled to the shops and is beginning to use this plan as a basis for forcing the P-W-O and A-P-W-O to consider what must be left undone when they decided that a newly identified requirement takes precedence over the planned work.

PREVENTIVE MAINTENANCE

PWD LITTLE CREEK	PWD KEY WEST
SOUND PM PROGRAM WITH INACCURATE INVENTORY AND CHECK POINTS	PM PROGRAM FOUND TO BE DIFFICULT TO REESTABLISH
DIFFICULT TO REPROGRAM CHANGES TO PM JOBS IN SFI MODULE OF BEST	SHOPS ANXIOUS TO REESTABLISH PM PROGRAM
PM PROGRAM NOW OPERATED IN ACCORDANCE WITH PWS	

SLIDE 39

- P-W-D Little Creek Planner/Estimators have developed a sound Preventive Maintenance Program for P-W-D Little Creek. The problem is that the P-W-D P-M Inventory has not been validated in a number of years and many of the items shown in the program are no longer operative. In some cases the piece of equipment has been changed and the checklists no longer match the item to be P-M'd. Efforts are being made to incorporate changes but many inaccuracies still exist. For a long period of time at the start of the interim period, F-M-E-D had a vacancy for the Production Controller position whose responsibility is the management of the Shore Facilities Inspection or S-F-I module of BEST. As a result, completed checklist data entry backlogged and all annotations related to repairs, inventory, and checklist points were not incorporated in the FY-89 P-M program.
- Because the BEST System S-F-I module is not an easily modified module, the incorporation of changes has been limited to an annual basis. To change a P-M Job Order, the job must be downloaded or unscheduled in S-F-I and all other jobs in S-F-I rescheduled. The job can then be modified in FEJE and reloaded or scheduled in S-F-I which necessitates that all jobs be rescheduled to accommodate the job being added. P-W-D managers have decided that the system requirements do not support the gains of continual updating of these P-M jobs. Craftsmen find the situation frustrating in that when they update the checklists each and every month and no changes occur they begin to think their input is not wanted and the communication barriers appear to be raised higher.
- P-W-D managers have recently begun managing the P-M program in accordance with the P-W-S. The P-W-S requires that all repairs up to the level of a sixteen hours and \$500 material requirement or service ticket is included as a part of the P-M. At present, this requirement poses no problem because the P-M estimates are not accurate due to inventory and checklist problems that inflate the estimates and enable craftsmen to make repairs without any negative effects. However, if the P-M estimates are tightened through inventory verification and checklist adjustments, unscheduled or unplanned repairs that extend a P-M from an estimated one hour to sixteen hours may wreak untold havoc on work schedules and shop load plans. The result will be other work centers running out of work as smaller work centers are unable to stay on schedule due to the unexpected P-M delays.
- P-W-D Key West found that they faced a number of problems in reestablishing a P-M program. Basically, the problem is insufficient resources to develop the inventory, determine which items represent critical mission essential pieces of equipment, and subsequently estimate the P-M Job Orders. It has been recommended that P-W-D Key West seek outside assistance from NAV-FAC-ENG-COM SOUTH-DIV.
- The Shop foremen and craftsmen at P-W-D Key West are very critical of the lack of P-M Job Orders. They are confident that if they had scheduled P-M Job Orders that the amount of service ticket work and reactionary repairs associated with emergency work would decrease. They express frustration that P-M work has become filler work rather than scheduled maintenance.

INTERIM CONCLUSIONS

- TREMENDOUS STRIDES MADE BY BOTH PWDs TO ENHANCE PRODUCTIVITY THROUGHOUT THE ORGANIZATIONS
- TWO DIFFERENT FOCUSES ON THE EFFORTS PUT FORTH
 - PWD LITTLE CREEK FOCUSED ON THE MAINTENANCE MANAGEMENT SYSTEM
 - PWD KEY WEST FOCUSED ON COMMUNICATION, MORALE, AND SUPPLY SUPPORT
- WHEN ALL THE MAINTENANCE MANAGEMENT SYSTEM COMPONENTS ARE OPERATIONAL TO SOME EXTENT AND SOME ARE FULLY OPERATIONAL, AN ACTIVITY WILL OPERATE AT APPROXIMATELY 50-55% PRODUCTIVITY
- MO-321 IS THE BIBLE FOR EFFECTIVE, EFFICIENT, PRODUCTIVE, MAINTENANCE OPERATIONS IN A PWD
- PWDs NEED HELP IN LOCATING TOOLS TO MAKE MO-321 MANAGEMENT PRINCIPLES LESS LABOR INTENSIVE AND EASIER TO IMPLEMENT

SLIDE 41

Both activities made a tremendous number of improvements to the maintenance management system within the organizations they operate. It was simply not humanly possible for them to accomplish everything and still maintain the level of service they are required to provide. As many of the actions taken show, a great deal of effort was routinely required to accomplish what initially may have appeared to be small change. The effort required is due to the complexity of the system and the myriad of interfaces the components have within the system.

Of interest are the results that the organizations' efforts netted. P-W-D Little Creek focused on work control components of the maintenance management system. P-W-D Key West operating for several months without an F-M-E-D Director, focused on communications and Supply support. Each organization succeeded in getting all the elements of their maintenance management systems operating to varying degrees where in the Phase one review many of the maintenance management system components were not operative at all.

It appears that as long as every maintenance management system component is operating to some extent and several are operating almost completely, the organizations in which this level of system operation is occurring will function at the productivity levels that P-W-Ds Key West and Little Creek have now reached. As an organization manages to get more and more components operating in accordance with the principles of M-O-3-21, productivity will continue to increase to the recommended goal of approximately 65%.

It has routinely been recommended in productivity reviews that P-W-Ds go back to M-O-3-21 and operate in accordance with its prescribed approach to managing maintenance and repair work. As these two organizations have demonstrated, that recommendation is easier said than done. It appears the NAV-FAC-ENG-COM and major command representatives like CINC-LANT-FLEET need to assist the P-W-Ds. Automated programs need to be developed that automate some of the more arduous manual processes described in M-O-3-21.

As P-W-D Little Creek has done, the Annual Work Plan should be automated to easily add or delete jobs. If the net results can be displayed so that P-W-D Managers can make decisions regarding work requirements being considered for acceptance, much greater control over work is achieved. The concept of master scheduling, a critical element to shop productivity also requires automation so that the changes that occur on a daily basis can be input and factored into the next day's schedule in a minimum amount of time. The reason so few P-W-Ds presently do master scheduling is because manually it is a monumental job that cannot be done in a timely enough manner to put out a schedule each morning. Finally, as these two organizations have attempted to locate, a system for real time labor hour compilation that interfaces with BEST, the master scheduling component, and the Comptroller is needed so that the work appraisal component can become fully operational on a real time basis.

To develop these automated management tools, it is suggested that care be taken to find programmers who understand maintenance management. Systems developed to run programs that do not take into account the dynamics of a P-W-D and the nature of maintenance and utilities repair work will be of no use to the P-W-Ds of the 90s and a waste of valuable dollar resources. The budgetary changes facing engineering functions appear to be staggering, if these organizations are not provided with the management tools they require to

get their jobs done effectively, efficiently, and productively. the dollars lost due to lost productivity will be astronomical and facility deterioration rampant.

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8. Commander, Northern Division, Naval Facilities Engineering Command Attn: Mr. John Wilkinson, Code 16 Philadelphia PA 19112-5094	1