MILITARY INFRASTRUCTURE: IS IT AS BAD AS THE NATION'S INFRASTRUCTURE?

A thesis presented to the Faculty of the U. S. Army Command and General Staff College in partial fulfillment of the requirement for the degree

MASTER OF MILITARY ART AND SCIENCE

by

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This study discusses the infrastructure by contrasting the challenges faced by our national and military leaders in three crisis areas; NEEDS, FUNDING, and MANAGEMENT. NEED is the gap between current conditions and required/desired conditions. Desired conditions include; state-of-the-art, like new, public expectation, actual use, and physically safe. Competition between FUNDING for social programs and capital investment mirror balancing Mission, BASOPS, and RPMA. FUNDING targets are improperly expressed as a percentage of the Plant Replacement Value and not on NEED. The short tenure of leaders is detrimental to long range revitalization programs. MANAGEMENT decisions are now made with institutional knowledge and the "squeaky wheel" method. This study recommends a detailed facility inspection to determine current condition versus desired condition. Funds to close this gap using maintenance, repair and replacement options is the NEED. An accurate PRV must be calculated to assist in obtaining funds. Army level leadership must develop long range goals that can be applied to 18-24 month commanders and reintroduce mandatory RPMA FUNDING levels. Recommend procurement of MANAGEMENT Information Systems with state-of-the-art software supported by high speed condition assessment equipment.

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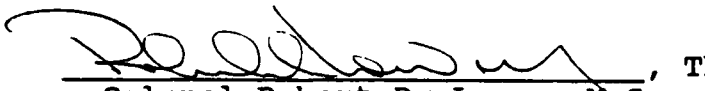

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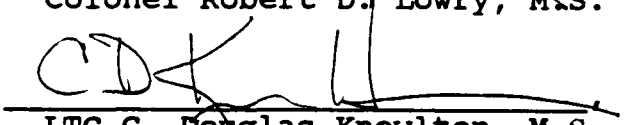

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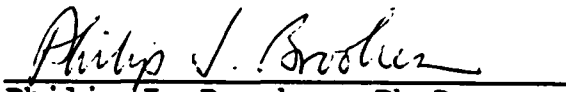

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The opinion and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U. S. Army Command and General Staff College or any other government agency. (References to this study should include the foregoing statement.)

ABSTRACT

MILITARY INFRASTRUCTURE: IS IT AS BAD AS THE NATION'S INFRASTRUCTURE?, by Major Robert R. Derrick, PE, USA Corps of Engineers, 110 pages.

This study discusses the infrastructure by contrasting the challenges faced by our national and military leaders in three crisis areas; NEEDS, FUNDING, and MANAGEMENT. NEED is the gap between current conditions and required/desired conditions. Desired conditions include; state-of-the-art, like new, public expectation, actual use, and physically safe. Competition between FUNDING for social programs and capital investment mirror balancing Mission, BASOPS, and RPMA. FUNDING targets are improperly expressed as a percentage of the Plant Replacement Value and not on NEED. The short tenure of leaders is detrimental to long range revitalization programs. MANAGEMENT decisions are now made with institutional knowledge and the "squeaky wheel" method.

This study recommends a detailed facility inspection to determine current condition versus desired condition. Funds to close this gap using maintenance, repair and replacement options is the NEED. An accurate PRV must be calculated to assist in obtaining funds. Army level leadership must develop long range goals that can be applied to 18-24 month commanders and reintroduce mandatory RPMA FUNDING levels. Recommend procurement of MANAGEMENT Information Systems with state-of-the-art software supported by high speed condition assessment equipment.

Keywords: Management information systems; Value engineering; Management planning/control; Federal budgets; Preventive maintenance; Military budgets; Military facilities; Life cycle costs; Planning programming budgeting; Distribution/economics; Theses.

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Robert R. Derrick, PE

Major, Corps of Engineers

Fort Leavenworth, Kansas

1 June 1990

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CHAPTER 1

INTRODUCTION

GENERAL

Six people die when New York State Thruway bridge collapses without warning into a heap of twisted steel and concrete.[1] Half a town disappears, killing 2 and injuring 5, forty miles south-west of Albany, when a gas cloud explodes after leaking from an eight-inch diameter trans-continental propane line.[2]

Catastrophic failures that cause serious injury and death cause shock waves and draw public attention to the problems of our aging infrastructure. Incidents of failure in systems that we take for granted are shaking the public faith.

Infrastructure, the physical plant of our nation, has not been properly maintained and is failing faster than it is being replaced. The public no longer believes that our government officials are taking care of the basics.[3] About 40 percent of the nation's 576,000 public bridges is considered "structurally" or "functionally" deficient. Many require load restrictions or limited use.[4] The

average age of the private sector is 10 - 20 years, the public sector, 20 - 70 years.[5] With the military outposts often preceding settlement of the country they are, on the average, older than the public sector.[6]

The U.S. Government owns some 83,000 entities ranging from the smallest hamlet and school district to our megalopolises. There are 1,264 military installations world-wide.[7] At the end of FY 87 the DOD had over 435,000 buildings, covering over 2.7 billion sq. ft., with a present value of $500 billion. These facilities support 4.5 million government employees, 3.3 million military (counting selected Guard and Reserve), and 1.2 million civilians. The average age of the DOD facilities is 35 years old, with family housing averaging at 30 years old and administrative facilities at 45 years old. Table 1 presents the DoD infrastructure conditions.

Table 1. DOD FACILITY STATISTICS YEAR END FY87[8]

SIZE:	
Plant Replacement Value	$500 Billion
Number of Buildings	435K
Total Square Footage of Buildings	2.7B
Total Government Employees	4.5M
Military	3.3M
Civilian	1.2M
AGE:	
Average Age	35 yr
Youngest Category (Family Housing)	30 yr
Oldest Category (Administrative Fac)	45 yr
Percent of Facilities (SF) over 30 years old	60%

(Table 1. cont)

CONDITION:	
% of (SF) Labeled by Services as Substandard or Inadequate	30%
Percent of Facilities (SF) Semi-Permanent or Temporary Const	20%
INVESTMENTS:	
Total Annual Facilities Investment (All Sources)	$15B
Construction	$ 8B
M&R	$ 7B
Percent of PRV	3.0%
RPM	$ 8B
Construction	
Replacement, Modernization, Improvements	30%
New Construction	70%
Percent of M&R Projects Less Than $500K	45%
M&R Dollars Invested in Service Call & Preventive Maint	60%
M&R Dollars Invested in Non-Recurring Work and Projects	40%

These conditions and the recent catastrophic failures have caused government officials, construction contractors and economic analyst to focus on the crumbling foundation of our nation. Published estimates report that $3.03 trillion must be spent to maintain our standard of living and world position.[9] The Joint Economic Committee in 1983 estimated that we must invest $1.157 trillion in our

nation's foundation to the year 2000.[10] Numerous reports by leading economists relate the health of our physical plant to our productivity and potential for growth.[11]

Despite these warnings it still takes a catastrophe to resurface the issue. No one wants to hear about a slowly decaying system when it is "functional." Out-of-sight, out-of-mind. Scarce funds go for the visible projects.

The only way a facility, utility or service gets funding and attention is when it malfunctions. Managers find it difficult to guess when failure will occur and get backing to spend money on "functional" systems.

The manager/engineer must be able to articulate clearly the condition of the infrastructure and how failure could impact the public/mission. Only the most farsighted of individuals can see the validity of spending money on a functional system just because it is beyond its design life.

To support spending money on unseen or currently functional systems both art and science must be used. Determining a way to evaluate the system is the science of physical inspection. Estimating the life left in a functional system that has exceeded its design life is an art which has been approximated by computer models. Used together to create valid justifications they will convince

the leadership that "functional" systems need significant funding.

The nation has commissioned several investigations, the largest and most comprehensive being the National Council of Public Works in 1984. Three reports, done between 1986 and 1988, give a national average of the health of our foundation. The final report even gives school grade letters to 7 different subsystems.[12]

Even if the nation's "grade" in one subsystem is a B or B+ all it takes is one part of one subsystem in one city to cause a fatality. The broad study cannot be used exclusively to address repair and replacement efforts. Such a generalized study is misleading as it may lure managers into assuming the general national average reflects local conditions.

Every city planner, Director of Engineering and Housing (DEH), and Base Civil Engineer (BCE) must be responsible for determining and maintaining accurate data on the condition of their facilities. The Defense Guidance states the reason for investment in the infrastructure is to "sustain full mission capability and provide quality facilities for our people to work and live in," and to insure "compliance with OSHA and environmental laws."[13] Unfortunately the Department of Defense (DoD)

invests in infrastructure at a rate of 1/2 of the better private corporations. "Ultimately, competing priorities preclude desired increases."[14]

The current method of identifying items needing repair is "the squeaky wheel gets the grease" method. As the number of work orders increases beyond some norm someone begins to think of total replacement. This can be too late with the time required to design, procure and construct.

To eliminate this catch up process managers must:

1. Know the current condition of every system.
2. Direct money toward the most mission essential first.
3. Increase the funding for repair and maintenance.

Studies show proper repair and maintenance significantly slows the aging process, and then have even proven the economy of choosing large maintenance budgets in lieu of saving maintenance funds and opting for more frequent total replacement.[15] In fact, with aggressive maintenance it is possible to extend service life almost indefinitely.[16] The benefit of maintenance costs versus lump sum replacement is being adopted across the country as a way to preserve infrastructure well beyond original design life estimates.

Civilian and military infrastructure systems are in use today which are far beyond their original design lives.[17] Current replacement rates are not sufficient to stay ahead of the complete failure, offset decay or improve congested facilities. Continuing to use these facilities is obviously exposing us to potential catastrophic failures and mission impact.

BACKGROUND

I was the project manager for the Fort Worth District Engineers on Lackland AFB, San Antonio, Texas when a dining facility sewer line unexpectedly collapsed creating an immediate mission impact. Lackland AFB is the Air Forces' basic training base and as such has a vital mission that cannot be stopped. Within hours an alternate dining facility had to be identified and food, equipment, and personnel moved to support the increased load. The trainees had to be bussed to this new location. The training schedules had to be adjusted to reflect this longer feeding time, threatening to delay replacements scheduled for assignments world-wide.

The catastrophic failure of a utility can have immediate and devastating effect on the mission. Due to the nature of the infrastructure, repair or replacement

often cannot be done within hours or even days. The correction requires an evaluation of the condition of the system. For example, in the Lackland AFB case, we could not just replace one section of pipe to the badly decayed line. Various corrective measures must be evaluated requiring inspection of what is left of the system, the replacement or repair must be designed, funds must be obtained, and then contracting or work order initiation must all take place prior to the physical work to correct the failure.

From this experience and reading about the increase in catastrophic failures across the nation, I challenged myself to investigate how the military is caring for its infrastructure.

RESEARCH QUESTION

My basic research question became; "Does the national infrastructure decay crisis reflect the condition on our military bases?" For this I asked; "What are the major issues in the National crisis?" And then; "Does the military have a crisis in these areas?"

DEFINITIONS

Army Family Housing (AFH) - Appropriation to maintain individual family housing units.[18]

Backlog of Maintenance and Repair (BMAR) - The total maintenance and repair which remains as a verified firm requirement that was not started during the fiscal year due to lack of resources.[19]

Base Civil Engineer (BCE)- The "city engineer" for Air Force installations with almost identical duties as the DEH.

Baseline - The minimum safe and socially acceptable level of performance and condition for an infrastructure system.

Base Operations' Accounts (Activities) - BASOPS(-)

A. Real Estate Leases
B. Supply Operations
C. DS/GS Maintenance of Materiel
D. Transportation Services
E. Laundry and Dry Cleaning Services
F. The Army Food Service Program
G. Personnel Support
H. Unaccomp Pers Housing Opns, Admin and Furnishings
N. Command Element, Special Staff, HQ Commandant
P. Automation Activities
Q. Reserve Component Support
R. Unapplied Program Adjustments
S. Community and Morale Support Activities
T. Preservation of Order
U. Resource Management Operations
V. Plans Training and Mobilization
W. Contracting Operations
X. Security and Counter-Intelligence Operations
Y. Records Management, Publications

RPMA
J. Operation of Utilities
K. Repair and Maintenance of Real Property
L. Minor Construction
M. Engineer Support [20]

Commercial Activities (CA) - Contracting activities designed to augment DEH in-house capabilities.[21]

Construction - The installation or assembly of a facility; the addition, extension, alteration, conversion, or replacement of an existing facility; or the relocation of an existing facility. The term includes installed equipment as well as related site preparation, excavation, filling and landscaping, and other land improvements.[22]

Director of Engineering and Housing (DEH)- The "city engineer" for Army installations whose responsibilities are to:

-Program and budget for real property maintenance activity (RPMA) resources.

-Provide utilities, including operation of installation utilities plants.

-Maintain and repair utility systems, buildings, roads, and grounds.

-Perform minor construction or "new work" funded with Operations and Maintenance (OMA) funds.

-Furnish services including fire prevention and protection, refuse collection and disposal, entomology, custodial service, packing and crating, and engineer-related functions such as design and contract specification.

-Provide master planning and analysis of stationing and utilization as part of the identification of RPMS requirements.

-Define Military Construction Army (MCA) projects and establish land requirements as part of RPMS programming.

-Review designs for MCA projects, acceptance of new facilities, and justification of land acquisition as part of the RPMS acquisition function.

-Determine facilities and land disposal needs and mothball standby facilities as part of the RPMS disposal function.[23]

Facility - A building, structure, or other improvement to real property.[24]

Infrastructure - The physical framework for much of the nation's social and economic development.[25]

- The physical framework that supports and sustains virtually all economic activity, Facilities with ... high fixed cost, strong links to economic development, long service life, interaction with other parts of the system, and public ownership... may be termed public works infrastructure."[26]

- Public works infrastructure - highways, streets, roads and bridges; airports and airways; public transit; intermodal transportation (focusing on the interfaces between individual modes); water supply; wastewater treatment; water resources; solid

waste; and hazardous waste services. Others include communications, power production facilities, railroads (which are largely private), schools, public housing, sidewalks, lighting, hospitals, public buildings, parks, and prisons.[27]

-America's capitol stock- a set of structures which provide mobility, shelter, services and utilities to a population of 230 million people.[28]

Maintenance - The recurrent, day-to-day, periodic, or scheduled work required to preserve real property in such condition that it may be used for its designated purpose.[29]

Maintenance and Repair (M&R) - A subset of RPM which includes only maintenance and repair of facilities.[30]

Major Construction - Construction projects having a funded cost in excess of the statutory cost limitations on minor construction projects.[31]

Military Construction, Army (MCA) - Appropriations for construction, administratively controlled by district Corps of Engineers for major construction and by DEH for minor construction.[32]

Maintenance of Real Property Facilities (MRPF) Maintenance and repair efforts primarily concentrated on utility systems, buildings, grounds and surface areas.[33]

Minor Construction - Projects which cost $1,000,000 or less for the Active Army and $400,000 or less for Reserve Component forces.[34]

Need - Capital investment and maintenance requirements for upgrading structurally deficient systems/facilities.[35]

Nonappropriated Funds (NAF) - Funds collected from sales in Army-Air Force Exchange Service (AAFES) and AAFES sponsored facilities such as bowling alleys.

Operations and Maintenance, Army funds (OMA) appropriation that essentially provides the funding to maintain the installation and the operating costs of units assigned there.[36]

Plant Replacement Value - The total cost to replace an entire facility,installation, college, factory, city, etc. Variations are: acquisition costs, acquisition costs escalated for inflation, acquisition costs depreciated over time for tax purposes, book value, current value, and plant replacement value.[37]

Preventive Maintenance - Activities done prior to failure to extend life, improve efficiency or slow aging process.

Real Property - Land and all facilities added to the land for which the U. S. Government has right, title or interest.[38]

Real Property Facility - a separate and individual building, structure, or other real property improvement.[39]

Real Property Maintenance (RPM) - A subset of RPMA which includes only maintenance and repair of facilities and minor construction.[40]

Repair - The restoration of real property to such condition that it may be used for its designated purposes.[41]

Real Property Maintenance Activities (RPMA) - The various functions for the maintenance and repair of facilities, the accomplishment of minor construction, the operation or purchase of utilities, and the provision of operating services and other engineering support.[42]

Utility - A public service or a commodity provided by a public utility, or equipment (as plumbing) to provide such or a similar service.[43]

LIMITATIONS AND DELIMITATIONS

I will limit this report to the study of the nation from an over view, the results of the National Council studies, and then narrow in on the DA and MACOM support of the infrastructure at Fort Leavenworth.

SIGNIFICANCE OF THE STUDY

This thesis will provide information to support increased command emphasis on the funding for the replacement and continued maintenance of the infrastructure on our military bases. It will also encourage DEH's to gather the data base and management software necessary to determine their infrastructures' health.

ASSUMPTIONS

The infrastructure situation at Ft. Leavenworth is representative of the infrastructure of other Army Posts in CONUS.

The national infrastructure problem issues are three inter-related areas: need, funding, and management.

RESEARCH METHODOLOGY

Using literature search and interviews with Fort Leavenworth's Garrison Commander, several DEH personnel and the City Engineer for the town of Leavenworth, Kansas, I have found differences and similarities between the military and the public sector. The literature consists mainly of newspaper and magazine articles about national and local catastrophic failures. The national

infrastructure investigations and comments on these studies provide insight on the national problem.

The military has not conducted "needs" studies like the national level studies, but one recent report on the DoD Backlog of Maintenance and Repair (BMAR) gives insight to Army initiatives. The national reports on the nation's problems will be compared to the Army. The problems will be discussed with the Director of Engineering and Housing (DEH) and his staff to determine what programs they have in place. To determine if the military is in any better or worse shape than the nation, this report will compare the maintenance and repair funding for Fort Leavenworth as a percent of PRV to the percent funded by public and private entities.

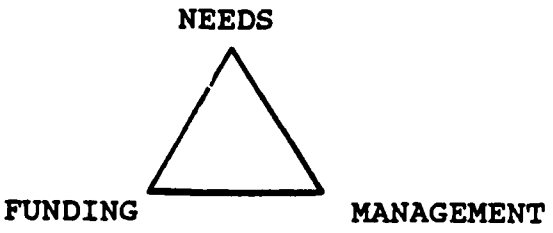
Using the literature search method to answer the thesis question is limited because the only reports are the results of the national studies made between 1986 and 1988 and military facilities were not specifically addressed in the Council's report. The military's infrastructure needs are estimated by analyzing BMAR and funding levels for maintenance and repair.

Interviews have a limitation due to the bias of the interviewer and interviewee. An engineer officer interviewing another engineer about an engineer problem

can lead to slanted reporting. To help balance this, interviews were conducted with engineers who are no longer in the business and can candidly discuss the issues.

ROAD MAP FOR THE PAPER

To answer the question - Does the current civilian infrastructure crisis reflect a similar crisis in the military?, the crisis was broken down into three parts. First a NEEDS crisis, or the physical condition of the subsystems which make up the infrastructure; secondly a FUNDING crisis - shrinking budgets, changing tax laws and pressures to spend on social programs in lieu of capital investment; and finally a MANAGEMENT crisis - the inability to make good decisions due to a lack of information and/or organizational structures which are inefficient at best and detrimental, in some cases, to good infrastructure management.



After the review of the literature (chapter 2), a chapter is devoted to each of the three crisis areas. The needs crisis, chapter 3, will show why there is such a variation in the "bottom lines" of the various needs studies. The national studies have shocked the public with their "bottom lines;" $1.157 trillion, $3.03 billion and $820 billion to fix the problem.[44]

There are hidden differences beyond the obvious variation due to different definitions of infrastructure. Others include different base year dollars and parameters or time periods (from 1983 to the year 2000) and the vague term "to meet all our needs."[45] The chapter ends with an analysis of how this term need can be standardized to a baseline.

Chapter 4, the funding crisis, compares the budgeting difficulties of the civilian sector with those of the military. Federal budget cuts are restricting funds for both state and local governments and the Department of Defense.

The 1986 Tax Reform Act compounded the problem for the state and local governments. Economists have suggested innovative ways to address this funding crisis with only a few applicable to the military.

The chapter ends with a comparison of the pressures felt by the federal government and the Department of Defense to spend more of social programs over capital investment and some unique organizational differences which influence the funding process.

The management crisis, chapter 5, explores the difficulties civilian and military managers experience managing their infrastructure systems. The chapter discusses why preventive maintenance funds are cut to the point where only what is broken can be fixed, and why the short-term solution is so attractive.

Additionally, this chapter emphasizes the need to correct the current information shortage that detracts from the efficient use of funds. With the numerous data base systems and non-intrusive inspection equipment available the military need no longer rely solely on physical inspection and institutional knowledge.

The final chapter reaches a conclusion of whether the current civilian infrastructure crisis reflects a similar crisis in the military. Recommendations, applicable to both civilian and military, on how to react to the needs, funding and management crisis' are also offered. Areas

for continued study close the report and are suggested to allow future scholars to stand on the shoulders of those that have gone before.

END NOTES FOR CHAPTER 1 - INTRODUCTION

1. The Associated Press, Albany, New York, by Jeff Donn, A Crisis of Confidence in New York After Bridge Falls, April 20, 1987, Monday PM Cycle.

2. The New York Times. Explosion in Rural Hamlet Raises Troubling Questions, Sec. B, Pg. 1, Col. 4, March 16, 1990.

3. Rutledge, Nancy C., "Assessing the Nation's Infrastructure," Military Engineer, Vol. 79, No. 518, Nov/Dec, 1987; pg. 566.

4. AP Donn. April 20, 1987.

5. Department of the Defense, Renewing the Built Environment, RPMA Study, DOD Report to Congress, March 1989; pg. 13.

6. Partin, John W. Dr., editor, A Brief History of Fort Leavenworth 1827-1983, Combat Studies Institute, U.S. Army Command and General Staff College, Ft. Leavenworth, Kansas, 66077, 1983; pg. 11.

7. Thornton, William J., "Our Nation's Infrastructure: Not Making the Grade," Military Engineer, Vol. 79, No. 518, Nov/Dec, 1987; pg. 581.

8. DoD. RPMA Study, pg. 35.

9. Association of General Contractors. Infrastructure: The Aftermath and the Realization. A Call For Action, pg. 383.

10. Congress. Joint Economic Committee. Hard Choices - A Report on the Increasing Gap Between America's Infrastructure Needs and Our Ability To Pay for Them, February 1984; pg. 5.

11. Choate, Pat and Walter, Susan; America in Ruins - The Decaying Infrastructure. Durham, N.C.; Duke Press Paperbacks, 1983; pg. 23.

12. Hard Choices. pg. 5.

13. DoD. RPMA Study, pg. 17.

14. Ibid.

15. Robison, Rita, "Preventive Maintenance: Fixing What Ain't Broke," Civil Engineer - ASCE, September 1989, Vol. 59, No. 9; pg. 69.

16. Ibid.

17. Walker, Jack E., Deputy Garrison Commander, Fort Leavenworth, Kansas, January 1990.

18. US Army War College, Army Command and Management: Theory and Practice, Reference Text for Department of Command, Leadership and Management, 1988-89; pg. 16-23.

19. DoD. RPMA Study, pg. C-1.

20. USAWC. Army Command, pg. 16-23.

21. Ibid., pg. 16-37.

22. DoD. RPMA Study, pg. C-1.

23. USAWC. Army Command, pg. 16-16.

24. DoD. RPMA Study, pg. C-1.

25. Rutledge, Nancy C., "Assessing the Nation's Infrastructure," Military Engineer, Vol. 79, No. 518, Nov/Dec, 1987; pg. 566.

26. Congress. House. Committee on Public Works and Transportation, National Council on Public Works Improvement, The Nation's Public Works - Defining the Issues Hearing, Report to the President and the Congress. Waqshington DC, GPO. September 1986, pg. 41.

27. National Council on Public Works Improvement, Fragile Foundations: A Report on America's Public Works, Final Report to the President and the Congress. Washington, DC; GPO; February 1988; pg. 233.

28. Call For Action. pg. 363.

29. DoD. RPMA Study, pg. C-1.

30. Ibid.

31. U. S. Army, AR 415-35, Construction, Minor Construction, Washington D. C.: Department of the Army, 1 February 1979; pg. 1-2.

32. USAWC, Army Command,; pg. 16-25.

33. Ibid.

34. Ibid.

35. Defining the Issues; pg. 7.

36. USAWC, Army Command; pg. 16-23.

37. DoD. RPMA Study; pg. 4.

38. Ibid. pg. C-1.

39. AR 415-35; pg. 1-2.

40. DoD. RPMA Study; pg. C-1.

41. Ibid.

42. Ibid.

43. Webster's New Deal Dictionary, TIME, 1968. 591

44. Thornton, William J., "Our Nation's Infrastructure: Not Making the Grade," Military Engineer, Vol. 79, No. 518, Nov/Dec, 1987; pg. 580-1.

45. Ibid., pg. 580.

CHAPTER 2

REVIEW OF THE LITERATURE

GENERAL

Much of the literature revolves around work done by Pat Choate, four major needs studies, and the National Council on Public Works Improvement reports. The Association of General Contractors, the Joint Economic Committee, the Congressional Budget Office and the Labor-Management Group all attempted to define the national need in terms of a total dollar amount. The council produced three reports to the President and Congress.

NATIONAL LEVEL

America in Ruins, 1981, by Pat Choate was the first major comprehensive and statistically supported review of the deteriorating condition of America's basic public facilities. In this book Mr. Choate discussed the:

- -Downward trend in public works investment over last 20 years.
- -Quantified effect of public works spending on the economy.
- -Recommended methods for improving public works financing.
- -Relationship showing failure to correct this decay will be a bottleneck to national economic revival.[1]

Much of the national attention has been achieved through television, radio and newspaper stories on major catastrophic failures such as gas leak explosions and bridge collapses. Time, Business Week, Newsweek and U.S. News and World Report picked up many of the catastrophic failures which riveted the nation on the decay problem back in the early 80's. One article was entitled, "To rebuild America - a $2,500,000,000,000 Job."[2] The nightly news brought the decay into the home by showing video of the dilapidation with news commentary that was alarming. Due to these highly visible failures, several public and private organizations issued reports documenting the needs with suggestions on how to fund and reverse the decay.

Four major studies inventoried and projected national infrastructure needs. The extent of the needs in total dollars varies from report to report due to the different definitions of infrastructure, the selection of basic resource material used and the time frame addressed. Needs estimates have also been criticized as being not so much a statement of baseline requirements for satisfying objective criteria but more of a "wish list."[3]

All reports agreed that the decaying infrastructure posed an increasingly serious health, safety and economic

growth problems. The studies also agreed that a significant shortfall in infrastructure funding exists.

The public concern coupled with the results of these early needs studies prompted the Congress to conduct hearings and submit some 40 bills in addition to the traditional public works funding bills. Throughout 1983 and 84 most of these bills failed to achieve approval of the majority of Congress and only 4 passed into law.[4]

There was a growing realization that the federal government would no longer be able to shoulder the funding burden, and that state and local agencies must provide significant additional funding. The Government Finance Research Center estimated that out of the $95.9 billion needed, state and local governments must fund $70 billion.[5]

If the reports of the infrastructure decay had a common theme it was the failure of the nation to translate these needs assessments into specific plans of action with the necessary financing. A series of papers and reports was published on creative financing strategies when the funding crisis was made worse by the Tax Reform Act of 1986 which ended the tax free status of numerous capital raising bonds.

To show the economic impact of the decay, the U.S. Department of Transportation in conjunction with the Transportation Systems Center conducted a study in 1983 on the deteriorating highway system. This study clearly showed that the deteriorating highway performance is having a negative impact on the Gross National Product (GNP), productivity and other economic indicators.[6]

The first major national level study was done by the Association of General Contractors of America (AGC) in May of 1983. "America's Infrastructure - A Plan to Rebuild" stated that the task would take $3.03 trillion.[7] The categories are shown in Table 2.

Table 2. Associated General Contractor's Summary of Total Identified Need[8]

NEED	COST (billions)
Potable Water (Urban)	$138.6
Wastewater Treatment	507.8
Drainage, Minor Flood Control	169.4
Locks	15.0
Ports	3.7
Waterways	32.5
Dams/Reservoirs	83.5
Railroads	60.1
Mass Transit	37.2
Highways	1,570.3
Airports	60.3
Bridges	57.1
Housing (Multi-Fam + Low-Income)	112.0
Hospitals	130.0
Educational Facilities	49.0
Prisons	7.0
Post Offices	3.0
TOTAL	$3,031

The second of the four watershed studies was the Joint Economic Committee's (JEC) report, "Hard Choices - A Summary Report of the National Infrastructure Study" which brought to the federal conscience that the catastrophic failures had caused people to be uneasy and it would take $1.157 trillion to correct the problem from 1983 to the year 2000.[9]

A third study done by the Congressional Budget Committee (CBO) targeted 7 systems and the funding dilemma in a report entitled, "Public Works Infrastructure: Policy Consideration for the 1980's." This report covered some of the same systems as the previous studies and documented an $820 billion need from 1987 to 2000.[10]

The private sector also became involved in the issue and in October of 1983 published the fourth major study - "Rebuilding America's Vital Public Facilities." The Labor-Management Group, a private non-governmental collection of labor and business leaders established six trends.

1. The coincidence of life cycle - Many parts of the infrastructure are reaching the end of their useful life at approximately the same time.
2. Shifts in population - Old regions which are losing people are serviced by obsolete and deteriorating structures and new regions are over taxed by the rapid influx. It was reported that

the town of Houston, Texas was receiving 1000 families a day during the flight to the sun belt in the early 1980's.

3. High inflation and high interest rate - as was the case in 1983 when the report was published.

4. Declining share of GNP devoted to infrastructure and capital investment - the % of GNP put towards infrastructure in 1961 was 2.2 as compared to 1.1 in 1981.

5. Federal programs emphasize capital costs rather than repair and maintenance - local managers could get federal funds for total replacement but not maintenance of existing systems. This was the significant factor which reinforced the attractiveness of total replacement of a facility over life extending maintenance and repair practices. This practice is just now being reversed with New York City taking the lead with the "revelation" that the life span of their bridges, when maintained in a zero defect state, could be extended almost indefinitely.[11]

6. There is a growth in social programs relative to investments in public facilities - a reversible trend if we continue to show the relationship of infrastructure care to public health and welfare.[12]

As each report was published the media fueled public debate and concern that prompted Congress to pass the National Public Works Improvement Act in late 1984 (P.L. 98-501). The act created the National Council on Public Works Improvement (the Council) to provide an objective and broad based view of the condition and adequacy of the U.S. infrastructure. The five-member council was mandated to report on the age and condition of public works,

finance methods and trends, the capacity of public works to sustain our economy, maintenance needs, and the development of appropriate criteria for conducting needs assessments at all government levels.[13]

The legislation also created a 12-member Advisory Group to the Council, chaired by Secretary of the Army, John O. Marsh, Jr., five Cabinet members, who were responsible for national public works programs, and the presidents or chairmen of six major public interest groups. The National Governor's Association and the National League of Cities were among those represented.[14]

The research effort which began in the spring of 1986 produced three reports. The first "The Nation's Public Works: Defining the Issues" was released in September 1986. The second was a nine volume series on individual categories of public works released in June of 1987 and the final report in 1988 entitled, "Fragile Foundations: A Report on America's Public Works," "graded" the nation.

The first report from the Council was essentially a comparison of the three national reports done by the AGC the CBO and the JEC. The report said that we must prioritize our efforts using the following five categories:

1. Safety defects
2. Structural defects
3. Capacity shortages
4. Upgrading old infrastructure to current standards
5. Current and future capacity requirements[15]

The second report consisted of studies by non-governmental research institutes of nine different categories of public works.

1. Airports and Airways
2. Highways, Streets, Roads and Bridges
3. Mass Transit
4. Intermodal Transportation
5. Wastewater Management
6. Water Resources
7. Water Supply
8. Hazardous Waste Management
9. Solid Waste[16]

They constitute the body of the investigation into the condition of the nation, and for these the Council dictated four measurements to be used to determine the "health" of the infrastructure:

1. Physical assets
2. Product Delivery
3. Quality of Service
4. Cost-effectiveness [17]

It was from these nine reports using these four condition measurements that the Council produced its last report, "Fragile Foundations: A Report on America's Public

Works." This report consolidated the existing literature and made five policy recommendations.

1. The level of infrastructure investment needed to ensure continued economic growth.
2. Methods of financing infrastructure.
3. The roles of federal, state, and local governments in providing infrastructure services.
4. Improving the efficiency of infrastructure services.
5. Promoting research and development in public works.[18]

The final report provided a "report card" on the nation's public works in these eight categories:

HIGHWAYS	C+
MASS TRANSIT	C-
AVIATION	B-
WATER RESOURCES	B
WATER SUPPLY	B-
WASTEWATER	C
SOLID WASTE	C-
HAZARDOUS WASTE	D[19]

In 1986 Pat Choate, the author of "America in Ruins" (1981), again sounded the alarm with "America in Ruins - An Update: A Public Works Financing Strategy," which provided a four-part public works financing strategy. In an attempt to show that the country had not taken Mr.

Choate's first warning to heart he showed that public works investments had actually gone down.[20]

Figure 1[21] shows the 40% decline in a per capita basis for the dollars spent on infrastructure and the 52% decrease as a percent of Gross National Product. Due to this apparent disregard for Mr. Choate's warning in 1983, as evidenced by the DECLINE in infrastructure investment, Mr. Choate recommended:

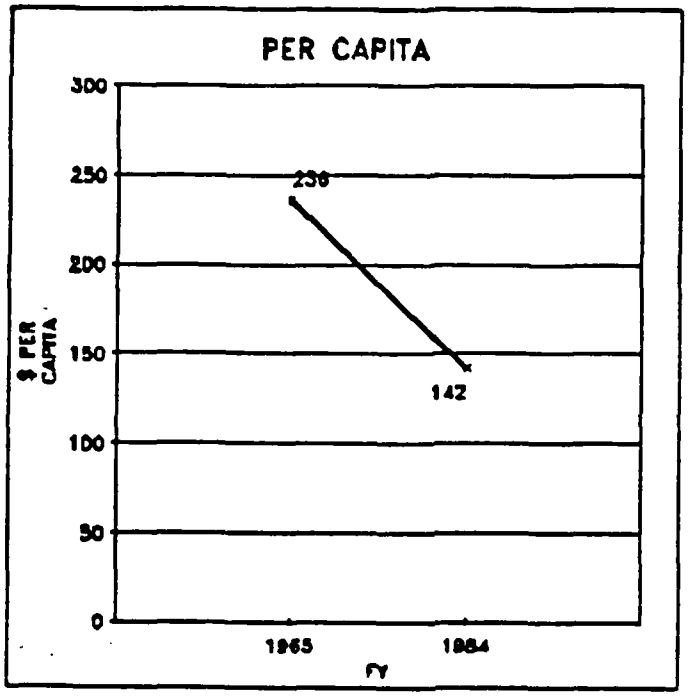
1. That we limit the federal public works budget cuts.

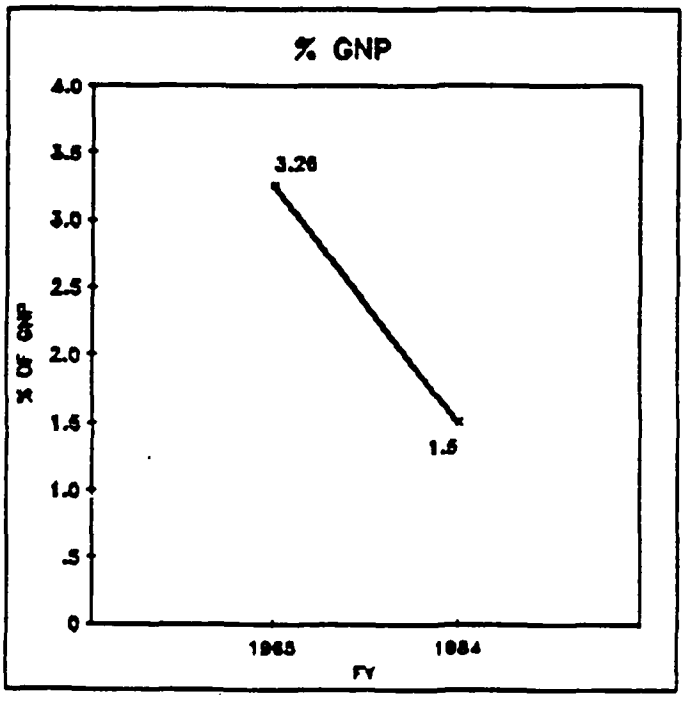
2. We make aggressive use of available funds by reducing government regulations and administrative procedures which slow the concept to commissioning process which drives up the total cost.

3. Apply user fees wherever possible in an attempt to establish a relationship between prices and consumption. Those who use public works services pay, while non-users do not shoulder the burden.

4. Create a new public works financing mechanism like a National Public Works Bank which would issue low interest loans to projects with guaranteed flow from user fees at amounts justified by that same user fee.[22]

Figure 1. Federal Expenditure on Infrastructure (per Capita and % of GNP)[21]





MILITARY LEVEL

The Secretary of Defense recently completed an extensive evaluation of the Real Property Maintenance Activity (RPMA) and reported the results to Congress. The report entitled, Renewing the Built Environment looked at ways to produce a verifiable backlog DoD wide. This standardization would help to increase the credibility in DoD and Congress concerning the RPMA program.[23]

This report compared DoD facility management with 55 non-DoD organizations. The non-DoD organizations included cities and towns (referred to as the public sector), commercial businesses, (referred to as the private sector), and major universities and colleges.

The report compared the percent of total Plant Replacement Value (PRV) invested in infrastructure maintenance and repair (M&R) for the study groups. As Table 3 shows DoD is the lowest at 3% with the rest of the public sector investing on the average of 4.5% and private companies leading the fight with 8.9%. This study shows that if we can increase our investment in facilities, increased productivity will be the direct result."[24]

Table 3. ANNUAL FACILITIES CONSTRUCTION VS MAINTENANCE & REPAIR INVESTMENT[25] (CONSTANT FY87 DOLLARS)

	% OF PLANT REPLACEMENT VALUE		
	CONSTR	M&R	TOTAL
DoD	1.6%	1.4%	3.0%
DECAYING PUBLIC INFRA*			4.5%
MAJOR COLLEGES & UNIV **	6.1%	2.0%	8.1%
MAJOR COLLEGES & UNIV ***	6.9%	1.5%	8.4%
16 MAJOR PRIVATE CORP	5.4%	3.5%	8.9%
23 NON-DOD GOVT ENTITIES	8.2%	1.4%	9.6%

* National Council on Public Works Improvement Report, Feb., 1988.

** Coopers & Lybrand Survey October, 1988 sponsored by the Association of Physical Plant Administrators of Colleges and Universities and the National Association of College and UNIVERSITY Business Offices.

*** DoD Report to Congress, March 1989 "Renewing the Built Environment"

The importance of PRV and the percent spent on infrastucture upgrade is discussed in the funding chapter.

DISCUSSION

A significant shortfall in these studies was the trend to exclude needs that are ineligible for federal funds, such as maintenance. Again we see the mechanism to reward neglect of maintenance and repair in favor of total replacement. No comparison to meeting need with increased levels of maintenance was done in the reports, just total

replacement. Therefore, the cost of closing the gap between the perceived needs, based on total replacement, and the available resources is artificially inflated.

To report the actual gap, needs must be accurately assessed using all available means to improve the infrastructure, not just the means available using federal dollars. A greater degree of the burden is being shifted to state and local governments as the federal government realizes that it cannot fund the staggering amount of repair/replacement work required.

Another concept which was not evaluated in the early studies was the idea that total replacement to bring the service up to current standards may not be necessary. The return to a level of quality that "ought" to be provided may be far beyond what is necessary. The reference point for calculating investment needs may be too high. A significant reduction can be realized if services were provided based on the users' willingness to pay for their actual cost. The baseline discussion in Chapter 3 expands on this idea.

With this we get into the definition of public service and the traditional feeling that Americans should be able to expect a certain level of public (free) service. Much like the argument over how much should be charged to allow

the public to use national parks. Charging an entrance fee commensurate with the cost to maintain the parks and recreations facilities would not be politically possible nor socially palatable.

Suffice to say that the amount of service may be reduced to some safe level without a significant decline in public satisfaction and a slight increase in user fees would do much to close the gap between needs and funding.

There must be a "floor level," standard, or baseline defined by engineering standards that would separate the safe from the unsafe, for all systems. It would be this level that the needs studies would use to assess the funding requirements. The funding required to maintain the systems at this level could also be established. The base evaluation could then be based on output or level of service not just the physical condition of the systems.

The current studies therefore are of only marginal use as they report the financially unconstrained need. Future studies must show need from a set baseline using the best mix of maintenance and repair as well as total replacement. They should recommend capital generating initiatives to fund the gap and convince management that tough decisions must be made immediately. The

infrastructure crisis appears to be one of poorly defined need, lack of funds and improper management.

END NOTES FOR CHAPTER 2 - REVIEW OF THE LITERATURE

1. Call For Action; pg. 380.

2. Ibid.

3. Defining the Issues; pg. 70.

4. Call For Action; pg. 359.

5. Ibid., pg. 382.

6. Ibid., pg. 381.

7. Ibid.

8. Thornton, Military Engineer; pg. 580.

9. Call For Action; pg. 381.

10. Ibid., pg. 382.

11. Robison, Civil Engineer; pg. 68.

12. Call For Action; pg. 381.

13. Rutledge, Military Engineer; pg. 566.

14. Ibid.

15. Defining the Issues; pg. 75.

16. National Council on Public Works Improvement, Fragile Foundations: A Report on America's Public Works, Final Report to the President and the Congress, Washington DC: GPO, February 1988; pg. 423.

17. Ibid.

18. Ibid.

19. Ibid.

20. Choate, Pat. America in Ruins - An Update: A Public Works Financing Strategy, Washington DC: GPO, pg. 2.

21. Ibid., pg. 6.

22. Ibid., pg. 7-8.

23. DoD. RPMA Study, pg. 3.

24. Ibid.

25. Ibid.

CHAPTER 3

NEEDS CRISIS

GENERAL

The national reports contain headline making dollar amounts, $3.03 trillion from now to year 2002, and doomsayers statistics, 23% of 575,600 bridges are structurally deficient as they are either closed or restricted to light traffic.[1]

The shock effect may be beneficial for raising the conscience of the budget and decision makers and the voting constituents, but, they may be misleading. The various reports use different standards for estimating cost. Some used total replacement based on physical condition while some used reduced output of services. The needs were not related to any baseline requirement.[2]

The measurements taken for the various estimates failed to provide a convincing picture of the state of the nation's infrastructure because they measured certain aspects of either demand or supply or a combination of both. It is the interaction of these two that must be used to establish the state of the nation's public works.[3]

Due to the way federal dollars are disbursed, total replacement was used in lieu of estimating the cost to return the system to an acceptable level by using the maintenance and repair option. This drastically inflates the total need dollar figure.

For example, an upgrade of the Williamsburg Bridge in New York City was estimated to be $250 million in 1987 versus a new bridge at twice the price.[4]

BASELINE

The condition of a public works must be based on a baseline to allow rational discussion and proper budget decisions. The disparity between this baseline and the current condition/output of a public utility would then be the nation's need.

This establishes the requirement for us to determine the baseline and the current levels of performance. The baseline, standard or what the public demands must be consistently defined. Baseline options, as shown in Table 4, vary over a wide range of standards.

Table 4. Baseline Options

STATE-OF-THE-ART	COSTLY BUT WHY NOT USE NEWEST TECHNOLOGY?
RETURN TO LIKE NEW	IS THE DEMAND IDENTICAL TO WHEN BUILT? MORE? LESS?
PUBLIC EXPECTATION	WHAT "OUGHT" TO BE PROVIDED. IS THIS CONSISTENT WITH ACTUAL DEMAND OR REQUIREMENTS?
JUST ENOUGH TO MEET DEMAND	PROVIDE LEVEL COMMENSURATE WITH WILLINGNESS TO PAY. MOST ECONOMICALLY CORRECT BUT MAY BE POLITICAL SUICIDE.
PHYSICALLY SAFE	MINIMUM REQUIREMENT, BUT MAY BE AESTHETICALLY UNDESIRABLE, FAR LOWER THAN PUBLIC EXPECTATIONS AND MISLEADING AS TO TRUE CONDITION.

Do we bring a public works up to the latest state-of-the-art standards or bring it to a "as new" state? Is there some minimum state for safety or a minimum level of service that must be maintained? Does the public feel there is a level of service that "ought" to be provided and is this minimum level of service tied to the public willingness to pay for the service? It may be foolhardy not to take advantage of the improvement in technology when replacing a wastewater plant rather than just return it to its original "like new" condition.

With the infrastructure systems covering a wide range of products and services the standard or baseline must be established using one or more of the above considerations. Baselines, therefore must be tailored for each facility, utility or service.

Society will demand that the government/public works agencies provide "safe" facilities. Engineering standards can establish a minimum safe condition but this may be drastically less than the "expected" level of service the public is used to enjoying. Is this the level the public feels "ought" to be provided? The condition of public services is a very politically sensitive issue which may render a "just safe" condition as inadequate.

Improvements must be made with some general priority in mind. One such as the following is suggested:

1. Life/Safety/Environmental hazards.
2. Structural/Electrical/Mechanical deficiencies.
3. Facility environs (i.e., heating, vent & air cond).
4. Cosmetics/Aesthetics[5]

The civilian sector, for the most part, does not have any goal or baseline for investment in facilities upkeep or new construction. The one exception is "major colleges & universities who use a formula based on age, replacement

cost & type of construction to determine their facilities maintenance and repair budgets."[6]

The "willingness to pay" measure of demand for baseline development is the most politically sensitive. Free and low cost public services have become almost a birth right of this nation. Access to public lands via our U.S. Parks and Recreations services for $1.00 a day appears to be every Americans' right - "after all it's public land." The paltry entrance fee does little to offset the millions required to maintain the federal state and local parks. Is the public willing to pay an entrance fee commensurate with the cost to the government? Not likely, so willingness to pay may not be an indicator of demand for some systems.

Some facilities/utilities and services may use increased user fees to determine need and offset the deficit created by reduced federal funds. This provides for a more efficient use of funds, as services provided come in line with public desires and willingness to pay. Services produced/offered which are beyond the public desires or needs represent waste and inefficient use of scarce funds. A more detailed analysis of user fees is discussed in chapter 4 - the Funding Crisis.

NEED

It appears that the baseline must be established by a combination of minimum engineering standards for safety and the politically sensitive level of service expected by the public. From this baseline the second task, assessing the need, is necessarily a combination of four performance measures:

1. Physical assets
2. Product delivery
3. Quality of service
4. Cost effectiveness[7]

The first measurement of the infrastructure is simply the availability of physical assets. The total numbers of buildings, capacity, rolling stock, miles of pipes and plants while relatively easy to collect does not in of itself provide any information as to the need.[8]

The product or service delivery measures the infrastructures' ability to perform at certain service levels. Service delivery depends on three elements: the systems capacity, the quality of its operation and maintenance, and the level of demand for its service.[9]

The quality of service, reflecting the physical size and condition of public works, the product being delivered and investment and operating priorities. This information

is the most critical for determining need and the most difficult to collect. The quality of service measures accessibility, reliability, safety, health effects and congestion. These three measurements provide many quantitative figures which can be compared to the baseline to create need.[10]

The last measure, economic performance is divided into cost effectiveness and economic efficiency. The economic efficiency of a project measured by the excess of its benefits over costs (cost benefit analysis) is not used to evaluate governmental investments (except by COE).[11]

This rate of return analysis is not used because of the difficulty in defining and measuring future public benefits. The required data collection for the analysis would exceed what is used now to support program decisions, and there are special factors which influence governmental spending. For example, when considering the efficiency of the Interstate Highway System, the national defense concerns negate delicate cost-benefit analysis balances.[12]

The cost effectiveness of a public works is a much better indication of economic performance. The simple measure of service delivered per dollar spent can be used to compare a variety of options. On the contrary though,

the very nature of some public works projects causes efficiency to be ignored altogether. For example the 1972 Clean Water Act (P.L. 92-500) recognized that certain levels of pollution control are - de facto - worth their cost (Joan Kovalic, The Clean Water Act of 1987. Water Pollution Control Federation. July 9, 1987).[13]

Therefore, a combination of all four measurements of performance must be used to determine the current level of service. The disparity between the baseline, (the safe level that is politically/socially supportable) and the current level will be the NEED (Table 5). This need, expressed in total dollars can then be used by managers to determine realistic budgets and long-range infrastructure upgrade programs.

Table 5. COMMON DEMAND AND SUPPLY MEASUREMENTS

Demand Measurement	Supply Measurement
State of Art vs "As New"	Physical Assets
Min Level for Safety	Product Delivery
Political/Social Level Demanded	Quality of Service
Users Willingness to Pay	Economic Performance

We are in a situation where our ability to supply services is declining due to age and condition while the demand for those services is increasing with population growth.

The military has a similar needs crisis because of the lack of specific demand and supply measurements. Once baselines are established the quality of service and the current condition of the various facilities/utilities, can be compared to develop a true picture of the need. Care must be taken to estimate the funding required to meet the need using maintenance and repair options as well as total replacement. Then, with the total need established a credible funding budget can be requested.

END NOTES FOR CHAPTER 3 - NEEDS CRISIS

1. Perry, Nancy J., "The Economy: Good News about Infrastructure," Fortune, April 10, 1989; pg. 94.

2. Defining the Issues; pg. 70.

3. Fragile Foundations; pg. 239.

4. The New York Times, "Taking the Pulse of the Aging Williamsburg Bridge," Sec. 1, Part 1, Pg. 52, Col. 1, November 22, 1987.

5. DoD. RPMA Study, pg. 9.

6. Ibid.

7. Fragile Foundations; pg. 239.

8. Ibid., pg. 241.

9. Ibid.

10. Ibid., pg. 241-2.

11. Ibid., pg. 242.

12. Ibid.

13. Ibid.

CHAPTER 4

FUNDING CRISIS

GENERAL

One point all the needs studies do agree on is the need for capital investment -- large capital investment. It may not be near the staggering amounts initially reported, but it will still require a major shift of priorities and associated funds. Even after proper definition of the level of need and detailed estimating (the dollars to get to that point through total replacement or proper preventive maintenance), the funds will not be readily available. The huge funding requirement is getting larger as decay continues, and funds are getting more scarce.

What are the funding issues which make it difficult to correct the infrastructure decay, and how are these issues handled in the military? The issues include spending on popular social programs versus unglamorous capital investment; the exasperating effect of the 1986 Tax Reform Act; preventive maintenance versus total replacement; the availability of federal funds for total replacement while local funds must be used for operations, maintenance and

repair; stove-piping versus shifting funds at various management levels; and the general tightening of funds due to Gramm-Rudman. All of these are forcing managers to develop new policies and create innovative capital raising initiatives.

GENERAL REDUCTION IN FEDERAL FUNDS

Federal funds for both public and military budgets have been effected by the concerns over the growing federal deficit. These manifest themselves as military budget cuts in Congress and the increased cost sharing requirements for states and townships.

As funds become more scarce, managers must justify the expenditure of every penny. The private sector's investment in infrastructure upgrade is driven by the profit motive and tax considerations. Only some of which are applicable to the military:

1. Make Money
2. Minimization of taxes
3. Government mandated requirements
   (i.e., OSHA, environmental laws)
4. Plant operations driven facility investments
5. Growth needs
6. Corporate image
7. Attracting and retaining customers (soldiers)
8. Service reliability[1]

Without attempting to comment on who is affected most by these cuts, let it be enough to say both civilian and military are experiencing a drawdown in available funds to the point where the old ways of maintaining the infrastructure cannot continue.

1986 TAX REFORM ACT

While federal funds are becoming scarce and management is faced with an ever increasing risk of catastrophic failure, local governments need more ways to raise funds. The 1986 Tax Reform Act made raising local funds for maintenance and repair just that much more difficult.

With this reform many of the local governments bonds lost their tax exempt status. This has exacerbated the problem just when federal funds are drying up due to the requirement for more cost sharing. Cities want to perform preventive maintenance due to the realization that this will extend design life, but, now the Tax Reform has eliminated one of their revenue generating tools. The timing could not have been worse.

SOCIAL vs CAPITAL INVESTMENTS

With the true level of need established and the associated capital requirements estimated leaders must

have the political backing to redirect funds to these unglamorous projects from popular, visible social programs. The choice between the immediate gratification of social programs and the long-term benefits of capital investment appear to be in direct conflict. This mutually exclusive relationship is because the programs are on the same level. For example they can be different line items of the same budget proposal. This means they directly compete for funds. This puts the decision makers in the position of shifting funds from social programs to capital investment at the risk of committing political suicide. The next chapter, Management Crisis, expands on this management problem, while this chapter focuses on just the funding issues.

The appearance of social and capital programs on the same budget is common at all levels of the government for both civilian and military organizations. The Federal government makes decisions between Social Security and Civil Works projects; the State government decides between shelters for the homeless and bridge construction; just as the Major Commands (MACOMs) and installation commanders decide between day-care centers and fixing leaking water systems. One way of eliminating or reducing this direct competition for funds is to allocate directly to

infrastructure revitalization projects through "stove-piping."

STOVE-PIPING OF FUNDS

The basic tenet of the Army's system for distribution and control of funds is to "pass funds through command channels and make the commander responsible for their control."[2] This allows commanders to shift funds within certain limitations.

One way the Congress helps alleviate this pressure on managers, both civilian and military, is to "stove-pipe" funds to specific programs. This is where the funds are specifically directed to a program eliminating any shifting or reprogramming without approval from Congress.

Funds can be approved, appropriated and allocated for specific programs and depending on the "stove-piping" the money may not be shifted at lower management levels. In the military, funds are requested by major appropriation categories (Table 6) and, in general, cannot be shifted without Congressional permission.[3]

Table 6. MAJOR APPROPRIATION CATEGORIES

-Military Personnel (MPA, RPA, NGPA)
-Operations and Maintenance (OMA, OMAR, OMNG)
-Procurement (Aircraft, missiles, weapons & tracked vehicles, ammunition, and other)
-Research, Development, Test & Evaluation, (RDTE)

(Table 6. cont)

-Military Construction (MCA, MCAR, MCNG)
-Family Housing (Construction and Operation) (AFH)
-Army Stock Fund (ASF)[4]

Within these major appropriation categories there still exists a competition not only between social and infrastructure projects but between mission funds and all other activities.

SHIFTING vs STOVE-PIPING

Budget flexibility to move money from other accounts to take care of facilities in the public sector appears to run the gamut from total to none.[5] In the military, although shifting dollars from one major appropriation to another is difficult, shifting below these levels is quite easy.

In these major categories there are both social programs and capital investment programs. The Army gets funds for both programs in the OMA (Operations and Maintenance - Army) and gets capital investments in the MCA (Major Construction - Army) appropriations. The OMA funds go to the Major Commands (MACOM's) who further divide the funds for the subordinate installations for Mission and Base Operations (BASOPS). The MACOM's may

shift funds from installation to installation only within appropriations categories (i.e., OMA and AFH).

The MCA funds go for major construction projects normally administered by the District Corps of Engineers and are restricted to specific projects. Shifting of funds between projects is not allowed. The MCA funds are "stove-piped" from Congress directly to a capital investment on a military facility.

Once the installation commander receives the OMA funds he has the authority to shift funds not only between the two categories, Mission and BASOPS, but between the subcategories within BASOPs. Subcategories of BASOPS, are BASOPS(-), for operations and "social" programs, such as the S. account- Community and Morale Support, and Real Property Maintenance Activity (RPMA) representing capital investments and utility purchases.

The commanders' priorities and associated funding reflect the commands best judgment for allocating funds between Mission (training), BASOPS(-), (social programs), and RPMA, (capital investment). Table 7 shows the funding history for Ft. Leavenworth, Kansas, while Figure 2 shows the relationship of Mission and the K. account (Repair and

Maintenance of Real Property) to the total OMA over 10 years. It is interesting to note that the percent of the OMA for Mission has grown while the investment in real property has shrunk.

Figure 2. PERCENT MISSION AND K ACCOUNT TO TOTAL OMA

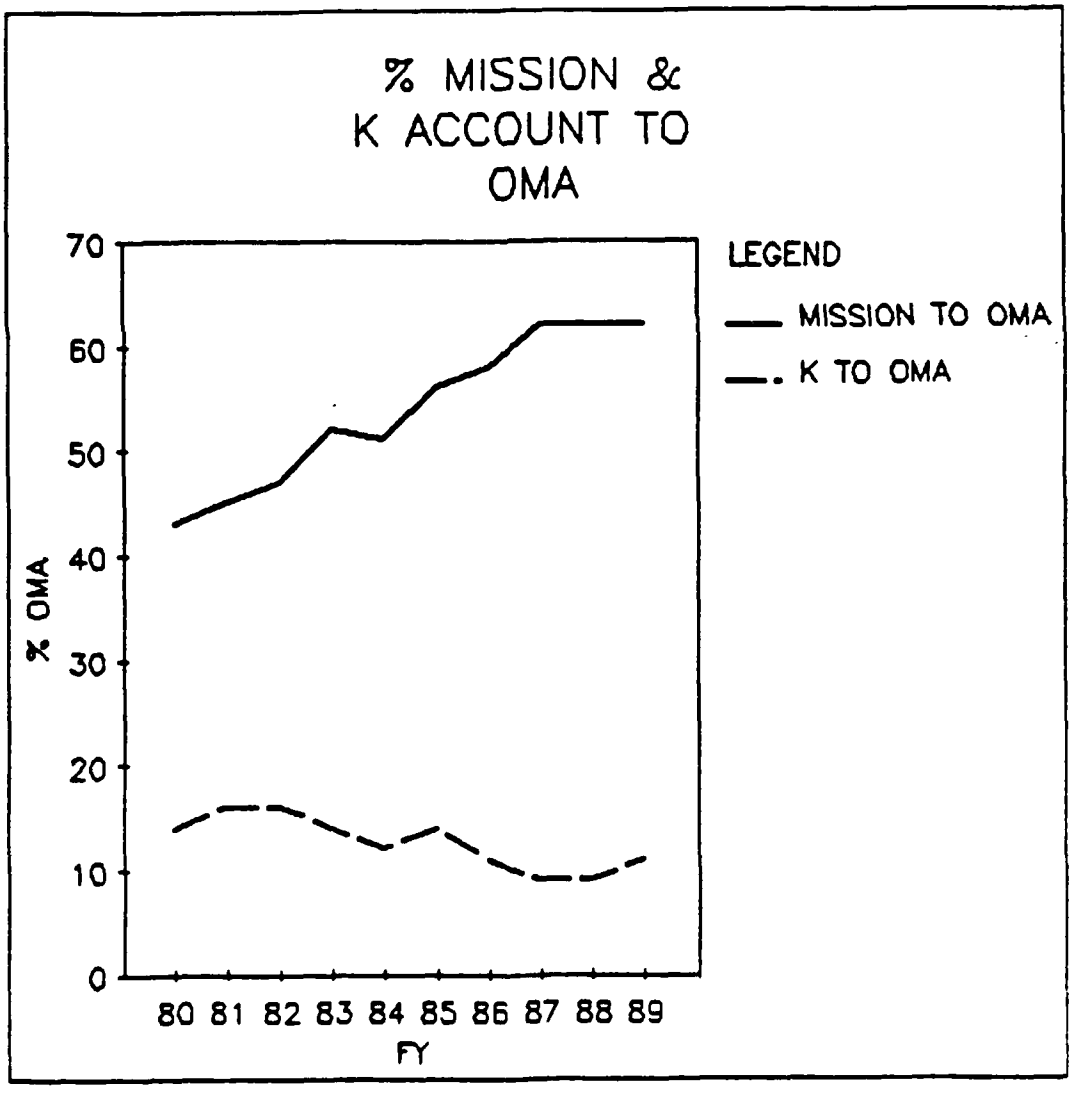


Table 7. Ft. Leavenworth OMA/BASOPS Budget Data[6]

FY	OMA	BASOPS-	RPMA	.J	.K	.L	.M	MISSION
80	39030	11667	10395	2220	5423	369	2383	16967
81	50354	13681	13846	2240	7946	687	2972	22826
82	59354	14762	16497	2815	9440	938	3302	28094
83	69379	16146	17297	3273	9887	1126	3010	35935
84	70833	17713	16858	3663	8413	1449	3332	36261
85	92815	20283	20728	2741	12587	1536	3862	51804
86	89964	19570	17823	3449	9747	951	3676	52571
87	121316	24137	21945	3211	11307	2480	4945	75234
88	108952	22626	18831	3093	10291	1023	4422	67495
89	131408	24721	25208	3131	14312	2284	5479	81478

To make the "right" decisions the manager with the authority to shift funds must have political and social support for these decisions. The commander must understand and have the backing to pursue the value of long term capital investment over quick fix. The unglamorous projects and mundane preventive maintenance activities often appear to be lucrative targets when budget cuts have to be made. The challenge is to:

1. Publicize the effects on the social welfare of the decaying infrastructure,

2. Understand and articulate the drain on mission funds when the infrastructure suffers reduced capacity and failure and,

3. Realize the long term savings achieved by higher Preventive Maintenance (PM) expenditures. (An example of the benefits of preventive maintenance versus total replacement is New York City's bridge maintenance policy discussed below.)

FEDERAL FUNDS vs LOCAL FUNDS

The funding idiosyncrasy of using federal funds to replace while local funds must be used to maintain has for years negated the benefits of life-cycle comparisons of various preventive maintenance policies. It was never "prudent", from the local governments point of view, to spend local funds to maintain when federal funds would be available for total replacement. Decision makers were lulled into a policy of minimal funding for quick fix of the infrastructure while shifting funds to more popular social programs. Once the federal government started requiring more cost sharing for total replacement the policy of neglect became indefensible. In fact, New York City is proving the axiom "an ounce of prevention is worth a pound of cure".[7]

PREVENTIVE MAINTENANCE vs TOTAL REPLACEMENT

New York City has taken this philosophy to heart by instituting a comprehensive program to bring its bridges up to the zero defects level by the year 2000. The City's new Bureau of Bridges estimates this will cost $3 billion in capital funds and nearly $60 million in maintenance funds for the next 10 years.[8]

The closure of the Williamsburg Bridge in 1987 provided the public support necessary to allow funds for serious investigation of the city's bridges. Of the 1,424 bridges, the city owns 526, the state owns 573 and there are 325 railroad overpasses. From the Bureau's investigation it was reported to the Mayor that "a crisis threatens to disrupt the city's transportation system and the health of its economy." The report listed 46% of the bridges as needing extensive reconstruction, 29 bridges as closed entirely or partially, and subway lines as disrupted because of problems on the Williamsburg Bridge.[9]

The report stressed the importance of preventive maintenance by stating, "The current situation is unnecessary. If bridges are consistently maintained, they will not deteriorate to the point where they must be rebuilt. If we create a world-class bridge program, all of our bridges will remain in good condition."[10]

The Bureau used local talent from five universities to recommend the particulars of the program. The ultimate result of the study was the establishment of a goal to have all 1,424 bridges in "zero defect condition" by the end of the next decade. This would take a serious commitment of serious amounts of money.[11]

The next comment was most significant to the problem faced by mangers of funds. "Rather than continually compete for funds in the city's general budget (bridges vs. hospitals vs. shelters for the homeless vs. police, vs. you-name-it), the Department of Transportation should operate the Bureau of Bridges with dedicated funds."[12] Public support during a "crisis" allows shifting of funds but once the problem becomes "old news" the mood changes. To conduct long term spending a system to shelter funds or stove-pipe them must be instituted. As the New York City Bureau of Bridges realized the social and capital programs must be de-conflicted.

As an example where spending funds now on preventive maintenance SAVES money New York City reports: "Our conclusion is that we can save the city and public hundreds of millions of dollars per year if we change either way we handle our projects. By the year 2000, we can reduce expenditures by a quarter of billion a year, including state and federal funds."[13] The City has worked out the long-term annual cost of a bridge at various levels of maintenance and is attempting to educate the voters that after saving a total of $20 million over the years by reducing maintenance on a bridge, the taxpayers must eventually spend $300 million to replace it."[14]

It must be noted that the maintenance plans do not require sophisticated maintenance. All that is needed is the mops, buckets and paint brushes used to keep the bridges clean, drained properly and painted. Even the bridges in the worst condition are being maintained, with the result of extended life, until replacement funds become available. The Bureau reports that if you stop maintenance for a couple of years the rate of corrosion increases rapidly.

New York City has proven the vicious cycle of build-neglect-rebuild is just not defensible anymore. When the federal government funded the total amount for replacement it was not necessary to use local funds to maintain bridges above a very minimal level. Intensive preventive maintenance to the point where the bridges are maintained with zero defects is proving to extend bridge life almost indefinitely.[15]

The conclusion of the NY City bridge study is that preventive maintenance can save hundreds of millions of dollars a year. This savings means more money for the other services, other public works, expanding capacity, social programs or lowering taxes.

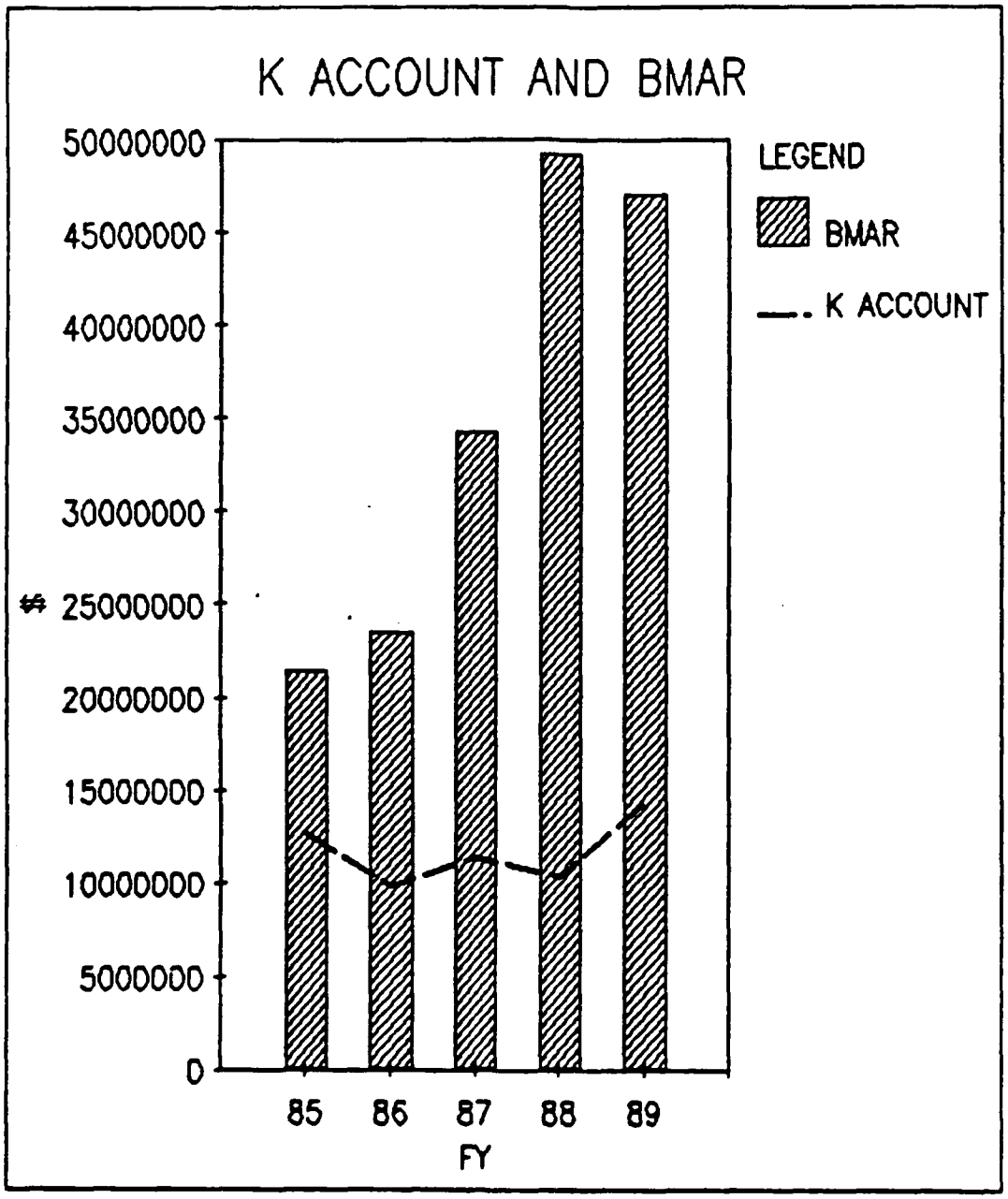
MILITARY FUNDING

The military must draw from this a similar lesson that properly funded PM will produce savings allowing more money for mission/training. One indicator of how the military handles preventive maintenance is the amount spent on the K account (Repair and Maintenance of Real Property) and the amount of deferred maintenance carried on the Backlog Maintenance And Repair (BMAR) list. The preventive maintenance funding history from 1985 to 1989 for the K. account and BMAR for Ft. Leavenworth is listed in Table 8 and visualized in Figure 3.

TABLE 8. K. ACCOUNT AND BMAR FOR FT. LEAVENWORTH, KS.

YEAR(FY)	K.[16]	BMAR (yrly avg)[17]
85	12,587,000	21,506,000
86	9,747,000	23,590,000
87	11,307,000	34,332,000
88	10,291,000	49,295,000
89	14,312,000	47,210,000

FIGURE 3. K ACCOUNT AND BMAR FOR FT. LEAVENWORTH, KS

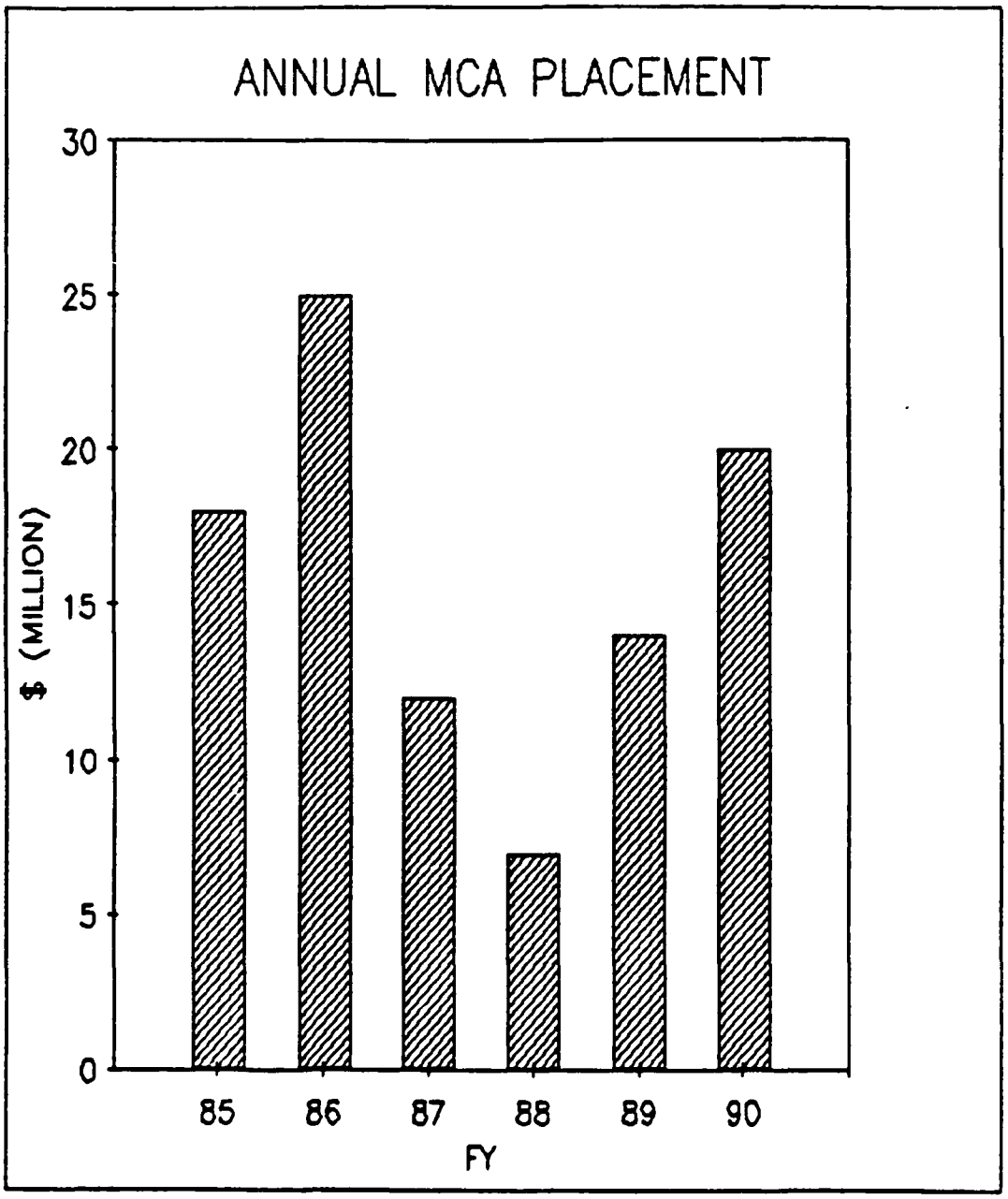


RPMA is just one program that provides capital investment in DoD real property. Another major effort is the Military Construction (MilCon) Program. Figure 4 shows MCA for Ft. Leavenworth from 1985 to 1990 and to some degree this capital investment contributed to the upgrade of the infrastructure.[18]

In the DoD report on RPMA the MCA program is included as infrastructure upgrade even though this new work is often for new equipment and missions rather than upgrade and/or replacement of existing facilities.

At the DoD level total investment in its $500 billion worth of facilities in FY87 was $15 billion, $8 billion for construction and $7 billion for maintenance and repair. The total investment of $15 billion represents 3% the total net worth, or PRV, is misleading. From FY85-87 only 40% of DoD construction was for replacement, modernization, or improvements, while 60% was for new construction to meet new mission/weapon systems requirements or to meet facility deficits.[19]

FIGURE 4. ANNUAL MCA PLACEMENT FOR FT. LEAVENWORTH, KS[18]



Additionally, the DoD RPMA report warns that Congress wants verifiable backlogs rather that "paper" backlogs that are adjusted each year based on funding, rather than actual inventory.[20] Methods used in the past to determine investment levels include ramping, backlog (BMAR), and 3% real growth.

Ramping is proposing a budget which is the same as the current year plus some percentage, usually inflation. This is not related to need and it becomes difficult to convince Congress that our ramp is not too steep.[21]

Backlog of Maintenance and Repair, while it appears to be a list of concrete needs, upon historical inspection shows itself to be a function of expectations. If dollars go up the BMAR goes up because the field spends more resources identifying requirements. When the available dollars go down the list goes down.[22]

The 3% real growth is estimated by adding our inventory growth of 1% per year, 1% for aging (even with new construction the net result is still an average increase in age every year), and 1% because maintenance of our sophisticated systems is more complex and costly. Funding at this 3% of PRV level has never been met.[23]

An easy target when funds are needed elsewhere, the repair and maintenance activities reflect a capital

investment in the future and a dedication to the philosophy of "an ounce of prevention being worth a pound of cure."

By increasing the K. account to the point where we approach zero defects commanders should enjoy capital savings by delaying total replacement and mission savings by eliminating impacts due to failures and reduced capacities. Power, HVAC and water distribution failures cause immediate mission impacts which drain mission funds as well as BASOPS funds.

PLANT REPLACEMENT VALUE

To determine what percent of the total net worth or Plant Replacement Value (PRV) Ft. Leavenworth is investing in maintenance and repair, the PRV had to be calculated. The 1989 Installation Utilization Survey for the Combined Arms Center and Ft. Leavenworth provided the total square-foot estimates for buildings in the following categories:

100- Operations and Training Facilities
200- Maintenance and Production Facilities
300- Research, Development and Test Facilities
400- Supply Facilities
500- Hospital and Medical Facilities
600- Administrative Facilities
700- Housing and Community Facilities
800- Utilities and Ground Improvements

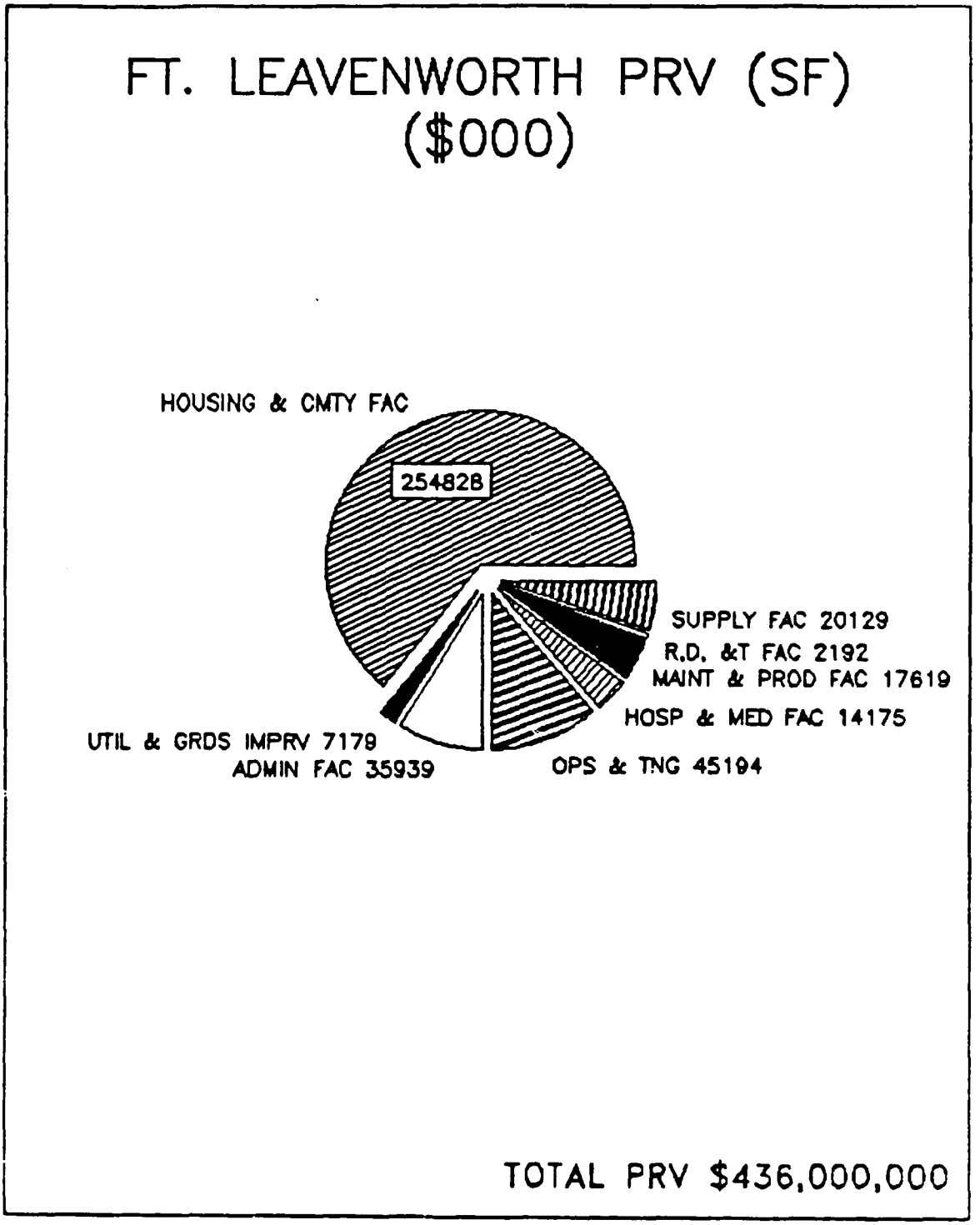
Using the 1988 Means, adjusting for inflation and for region, Ft. Leavenworth's PRV for buildings is roughly $436 Million as shown in Figure 5.

The K and L accounts plus MCA is considered by the Army as their "revitalization" program and has published a goal of spending 1.75% of PRV on "revitalization". TPADOC's estimate of Ft. Leavenworth's PRV which includes everything but land acquisition, is $962,098,000. As shown in Table 9, Ft. Leavenworth's revitalization effort is 3.18% of PRV. This indicates a very positive attitude towards the fight against infrastructure decay on Ft. Leavenworth.

TABLE 9. FT. LEAVENWORTH, KS REVITALIZATION PROGRAM (89).

FORT LEAVENWORTH PRV	$962,098,000
1.75% of PRV	16,836,715
RPMA (K+L accounts)	16,596,900
MCA	14,000,000
TOTAL	30,596,900
% OF PRV	3.18%
ARMY GUIDANCE	1.75%

FIGURE 5. PRV FOR FT. LEAVENWORTH, KS USING SQUARE FOOTAGE FOR BUILDINGS ONLY.



SUMMARY - FUNDING PROBLEMS REFLECT MANAGEMENT PROBLEMS

More accurate PRV's must be developed and the actual amount spent on just maintenance, repair and true replacement must be collected. Only with these figures will the average % of PRV spent on revitalization be factual. Additionally, using a single % of PRV for all the different types of infrastructure systems is unrealistic. A separate % should be developed for each subsystem based on historical data and computer modeling.

If the NY study is any indication, more funding for preventive maintenance of military facilities is an absolute must. This requires long-term vision, which is difficult unless supported by the installation and higher commanders. Managers are often not able to pick the long-term good over the quick fix high visibility project. When management is not "allowed" to make the right choices due to voters or to superiors we have a management crisis.

The funding crisis can be solved by forward thinking managers and leaders. Innovative funding ideas which include spending more now for large future savings must be adopted by the facility managers and their bosses. In the next chapter: Is there a management crisis that precludes solving our funding crisis?

END NOTES FOR CHAPTER 4 - FUNDING CRISIS

1. DoD. RPMA Study, pg. 12.

2. USAWC. Army Command, pg. 15-10.

3. Ibid., pg. 14-7.

4. Ibid.

5. DoD. RPMA Study, pg. 10.

6. Ft. Leavenworth, Garrison Commander's Office.

7. Robison, Civil Engineer, pg. 67.

8. Ibid.

9. Ibid., pg. 67-8.

10. Ibid., pg. 68.

11. Ibid.

12. Ibid.

13. Ibid., pg. 69.

14. Ibid.

15. Ibid.

16. Ft. Leavenworth, Garrison Commander's Office.

17. Oberforcher, Tony, BMAR, DEH, 2 March 1990.

18. Captain Jack Matthews, Resident Office, Ft. Leavenworth, Ks, Kansas District Corps of Engineers.

19. DoD. RPMA Study, pg. Executive Summary, unnumbered page.

20. Ibid., pg. 3.

21. Ibid., pg. 6.

22. Ibid.

23. Ibid., pg. 7.

CHAPTER 5

MANAGEMENT CRISIS

GENERAL

Because all decisions about need and funding are made by "managers," the most important aspect of the three crisis areas appears to be its management. Guidance on the baseline or minimum level of service (or condition) and the appropriate funding to meet this level is formulated by managers at multiple levels. Decisions on the shifting of funds and the actual execution of the RPMA programs are also made at numerous levels. For the purposes of this discussion the term manager will be divided into two general categories: leader-managers who determine level of service by assigning priorities, making funding decisions; and executor-managers who must operate within budgets and make the day-to-day decisions on maintenance and repair of preventive maintenance work based on their interpretation of dictated guidance and priorities.

Leaders will include elected officials (ie. City Mayors) and military commanders (ie. DA, MACOM, Installation Commanders) while executors include political appointees (i.e., City Engineers) and military "city

managers" (i.e., DEH and BCE's). The DEH is on the critical path of nearly everything that happens on today's Army installations. Readiness, recruitment, retention, force structure and modernization, training, mobilization, the Army Family, Quality of Life - all these elements depend to an important degree upon efficient facilities engineering and housing support.[1]

The last chapter pointed out that managers (both leaders and executors) agreed that during the years of readily accessible federal funds it was prudent management to use local funds for social programs while doing total replacement with federal funds. Management was operating responsibly in light of this federal funding concept. Now that the local governments must take more responsibility for total replacement the maintenance and repair funding levels must increase. More managers are bringing their funding and execution decisions in line with current budget realities.

The over reaching issue which influences both types of managers and the quality of their decisions is tenure. A second issue related to management, the quality of their decisions, is tied to the quality of the information available to them.

TENURE

Both leaders and executors are influenced by their short tenure. It is American to expect immediate results and instant gratification. Elected officials, appointed commanders and city managers all operate in an extremely high pressure environment which demands fast response and quick fixes.

In John Naisbitt's book Megatrends (1982) he devotes an entire chapter to Short-Term versus Long Term trends in the United States. His discussion applies equally to military commanders and political leaders. As an example of one company's success in using long term goals, Naisbitt sites the American Standard, Inc., a transportation & building-products maker.[2]

This company made a conscience shift after the 1974 recession, when the board of directors added long-term incentives to the standard annual bonuses for top executives and tied bonuses to increases in earning per share over a four-year period. Since 1975 profits have grown at an annual rate of 30 percent and the company now has 3 concurrent long-term executive bonus plans.[3]

Unfortunately, the American way is to make the current quarter look good in spite of, and sometimes at the

expense of, the future. In contrast Japanese management will sacrifice now in order to have health in the future.[4]

Many rewards systems are structured to support the short term. "All the judgments of Wall Street are short-term-oriented; executive salary and bonus plans are almost all geared that way; chief executive officers' tenure averages only five years, and they all want to make their mark during that short period when they are heading up their company."[5]

Military Commanders, and most assignments for that matter, average 18 months. What happens on "my watch" can be a driving philosophy. Young officers are told to hit the ground running and produce results. Except for the occasional Report of Survey, very little follows an officer to the next assignment. Annual evaluations based on results achieved within one year add to the "my watch" concept.

We use numerical results to evaluate performance because we tend to focus on what we can measure. Numbers are short-term. If we are to get away from this short-term myopia we must develop ways to shelter management (leaders and executors), from these pressures.

Civilian as well as military organizations must develop systems where decisions for the long-term good are

recognized as germane to success and are rewarded. To define what is good for the long-term the organization must have a strategic vision.

NASA had a strategic vision statement to "Put a man on the moon by the end of the decade", not "We are going to be the world leader in space exploration."[6] The vision statement must be clear and specific so decisions at all levels will move the organization in the desired direction. New York City's vision to have zero defects by the year 2000 gives direction to needs assessment, budget formulation and management decisions.[7]

The environmental movement and concern over our nonrenewable resources has assisted the shift to long-term decisions. "We have become much more sensitive to the longer-range implications of our short-term actions. It has become apparent to most people, for example, that the short-term convenience that encouraged us to pollute the air and water was not worth the long-range damage done to the quality of our lives and our environment".[8] Forrest-products companies now have impressive reforesting programs as an additional example of how environmental concerns have helped to raise our collective consciousness.[10]

As the country shifts to longer term vision, Naisbitt observed, we may even see some political changes: all states shifting from two- to four-year terms for their governors and a lengthened term of the presidency from four to six years.

The military may be reaping a side benefit from its decision to extend CONUS tours from three to four years. The message to the young officers may be "you will be around to deal with the result of your short-term (short sighted) decisions."

Now this long-term philosophy must drive the strategic vision statement. Then this must be translated to specific guidance for the executors. As was discussed in the Needs chapter the leadership must dictate what level of service is required (and fund it accordingly) so executors can make the correct management decisions.

DECISION MAKING

Even with proper long-term vision, management decisions are only as good as the information used to support them. A second crisis issue in both civilian and military organizations is the varying abilities to capture and manage information about the infrastructure.

The infrastructure problem is not only overwhelming in size and capital needed but "those in charge do not have tools commensurate with a task of this magnitude".[11] Facility management information systems being used in the rest of the public sector range from none to extensive, with the major colleges and universities having the best systems.[12]

Maintenance and Repair (M & R) budgets are equaling and exceeding construction and operating budgets. There are sophisticated tools for design, construction and operations management but very little exists for M & R management.[13]

The decision support tools and information, whether to repair or replace, defer maintenance, take preemptive measures or select among repair strategies, is just not available in most organizations.[14]

The consequences of making M & R decisions without adequate tools and support information include: an inability to justify M & R strategies to higher management; inefficient use of resources while operating in a costly reactive mode; repetitive repairs at the same site due to improper selection of maintenance alternatives; and costly and embarrassing overruns on M & R projects due to inadequate condition information."[15]

Decision support systems must have two data bases: "1. Inventory data; e.g., describing quantities, types, locations and area; and 2. Condition and performance data; e.g., describing cracking, deterioration, leakage, loss of capacity, performance problems, frequency of repair, etc. Not that the concept of performance, which defines the ability of a facility to perform its expected function, differs from the concept of condition, which is a description of its current physical state and a basis for projecting future performance."[16]

Current information at both municipal and installation level is usually incomplete, inaccessible or nonexistent.[17] Files contain bits of information and old drawings are inconsistently updated when new work is done.[18] DoD has an extensive data base with facility management information such as average age, condition, costs by facility type, physical plant inventory in square feet, plant value (current or replacement) and their average annual investment per square foot or per other common unit of measure depending on facility type. Some civilian entities have the data to compute these statistics but others don't have it at all.[19]

To gather this information with current manual inspections would require an inordinate amount of time and

once gathered, unless entered into an electronic retrieval system, would become quickly outdated and unmanageable.

Before the information is gathered the organization must consider what is the optimal state. Is it optimizing the performance of a facility or unit for a given cost or is it maintaining a desired level of performance at the least cost. This guidance, from the leader-manager to the executor-manager, will need to be utility/facility specific. The guidance for level of service for each subsystem must be a leadership decision due to the political implications of reducing the public's level of expectations.

DATA COLLECTION

There are numerous sensor, data acquisition, and computer interface technologies which could be used for rapid and efficient data collection. High-speed non contact sensory techniques such as video imaging, infrared thermography, optical character and code recognition, ground penetrating radar, laser interferometry, and terrain conductivity are some of the technological advances which have potential in this area. The best application is one that does not interrupt the operation and can cover large areas quickly, due to the economic

impact of outages in utilities and the size of infrastructure systems.

Table 10 lists High Speed Sensing Systems that may be used to collect data on the vast infrastructure systems.

Table 10. Examples of High-Speed Sensing Systems for Inventory and Condition Assessment[20]

Application	Technology	Status	Reference
	CONDITION ASSESSMENT		
Pavement surface condition	Optical Imaging and Image Processing	Under development by several organizations	Maser & Schott (1986)
Bridge deck and parking lot deterioration	Radar; infrared thermography	Partially developed; continuing R&D	Maser(86) Roddis(86) Holt(85)
Pavement Sub-surface eval.	Radar	Developed for void detection	Steinway et al.(81)
Roof moisture surveys	Infrared thermography	Developed and in use	Tobiasson & Korhonnen
Pavement roughness & profile	Laser profile meter; response ridemeters	Developed and in use	National Cooperative Highway Research Program(86)
Leak detection in underground pipes	Infrared, radar and terrain conductivity	Under development	Maser(88)

INVENTORY

Application	Technology	Status	Reference
Building characterization	Video imaging	Under development	Schodek et al. (1984)
Railroad car indentification	Optical charter recognition	Under development	
Highway photologging	Laserdisc	Under development	Better Roads(85)
Pipe location	Radar	Under development	Gas Research Institute (1985)
Inspection data logging	"Electronic clipboard" (using optical bar coding)	Developed and in use	

Why hasn't this technology been used to gather the necessary data to allow managers to make good decisions? One reason is the fact that "technology development is generally motivated by profit" and many public/municipal utilities have no profit based motivation for technological innovation.[21] Similarity, within the military, managers must relate the benefits of these non-intrusive inspection processes and their associated decision support software to improved infrastructure management and performance.

MANAGEMENT INFORMATION SYSTEMS

A second challenge to managers after the right information is collected is how to manage it properly. Numerous computer assisted management models have been developed. RAILER, PAVER and PIPER have been developed by CERL as predictive deterioration models for railroad systems, pavements and pipelines.[22] These have not been widely accepted because without a way to capture current inspection data one must resort almost exclusively to the theoretical failure predictions which, while interesting, often do not describe the "real world".

A management information system fed by the high-speed collection tools could then perform five critical functions:

1. Inventory and condition recording management.
2. Maintenance history/system failure.
3. Maintenance management and control.
4. Capital improvement/maintenance planning.
5. Planning maintenance resources/scheduling. maintenance effort.[23]

With this system the inefficient and costly reactive maintenance operations could be virtually eliminated, as would reliance on the collective memory of the organization or institutional knowledge of the "old timers."

INSTITUTIONAL KNOWLEDGE AND LONG RANGE PLANNING

Both Fort Leavenworth and the City of Leavenworth execution-managers use institutional knowledge, gut feeling and guidance from leadership-managers to prioritize infrastructure actions. Without the high speed condition acquisition equipment and computer based decision support models the executors strive hard to avoid expensive reactionary maintenance by developing capital improvements plans (City of Leavenworth) and 5 year programs (Ft. Leavenworth).[24]

These long range plans should be a result of thorough inspections of subsystems so the actual conditions drive what goes into the revitalization program. They should be an accurate prioritization based on actual need and not on changing political climates.

SUMMARY

The management crisis therefore is threefold: short tenure, contributing to short vision decisions; lack of current information, as manual methods of collection and filing are not applicable to the large complex systems; and lack of management information systems, which are total electronic retrieval/decision support software and

hardware packages. Combined they force managers to rely on institutional knowledge and crisis management.

END NOTES FOR CHAPTER 5 - MANAGEMENT CRISIS

1. U. S. Army Corps of Engineers, "Report of the Green Ribbon Panel on: U. S. Army Corps of Engineers Support to Army Installation Commanders," Office of the Chief of Engineers, March 1985; pg. iii.

2. Naisbitt, John, Megatrends - Ten New Directions Transforming Our Lives, Warner Books, Inc., New York, N.Y., 1982; pg. 79.

3. Ibid., pg. 79,80.

4. Ibid., pg. 81,82.

5. Ibid., pg. 80,81.

6. Ibid., pg. 94.

7. Robison, Civil Engineer; pg. 67.

8. Naisbitt, 1982; pg. 80.

9. Ibid.

10. Ibid., pg. 96.

11. Maser, Kenneth R., "Inventory, Condition, and Performance Assessment in Infrastructure Facilities Management," Journal of Professional Issues In Engineering, Vol. 114, No. 3, July 1988, pg. 271.

12. DoD. RPMA Study; pg. 8.

13. Maser, Journal of Professional Issues In Engineering; pg. 271.

14. Ibid., pg. 272.

15. Ibid.

16. Ibid.

17. McDonald, Michael G., Director Public Works/City Engineer, Leavenworth, Kansas, 8 March 1990.

18. Stricklin, Thomas D., Cpt (P), Operations Officer, DEH July 1989 - May 1990.

19. DoD. RPMA Study; pg. 8.

20. Maser, Journal of Professional Issues In Engineering; pg. 275.

21. Ibid., pg. 276.

22. Kumar, A. et at., "Demonstration of the Pipe Corrosion Management System (PIPER) (U), Army Construction Engineering Research Laboratory, Champaign, Illinois. Report TR - M - 86/08.

23. Karaa, Fadi A., "Infrastructure Maintenance Management System Development," Journal of Professional Issues In Engineering, Vol. 115, No. 4, October 1989, pg. 424-7.

24. McDonald, Michael G., Director Public Works/City Engineer, Leavenworth, Kansas, 8 March 1990.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

GENERAL

The public sector recommends: 1. making the most of what we've got through timely maintenance; 2. reducing demand through increased user fees or "efficient pricing" (lowering demand by raising cost); and 3. using advance technology.[1] The military can and does, for the most part, strive for timely maintenance. It has not started a billing system for utilities to reduce demand, but, it can capitalize on advance technology for the inspection and maintenance of the infrastructure.

NEED

To properly assess the need within the military, a specific baseline for each utility, facility and structure must be established. Then the actual need (the gap between present condition and the minimum acceptable baseline), and it's associated capital requirements, can be estimated and articulated in the budget requests.

The agreed upon required level of service would then allow managers to prioritize and document impacts of

reduced budgets. If DA/MACOM provides less than is necessary to maintain services at the desired level or baseline, everyone's expectations will have to be lowered accordingly. Our managers (both leaders and executors) will know what is expected and can provide the level of service (or condition) commensurate to the level of funding.

FUNDING

Because asking for more funds is a weak option, the funding crisis will not be easily fixed. There has been a two pronged assault on the defense budget, one from the desire to reduce the national debt, and, two from the "peace dividend" from the alleged reduction of the threat, due to events such as the elimination of the Berlin Wall.

The 1986 Tax Reform Act has caused the economists to develop new and innovated ways to finance the capital needed. In light of the Tax Reform Act Pat Choate's suggestions from his 1981 book "America in Ruins" become even more valuable.

Choate recommends:

1. Increasing application of user charges. This is unpopular and may be rejected outright for political survival. The military community would have similar difficulty instituting user charges.

2. Privatization of Public Works. A possible solution for some utilities/facilities but not easily transferable to the military due to our 24 hour, 7 day a week mission and national security reasons.

3. Reduce cost of delay by stream-lining federal red tape. This includes costs from preconstruction delays for documentation and judicial delays and delays during construction. These delays cause diminishing purchasing power, postponed benefits and uncertainty and loss of confidence. Both civilian and military communities would benefit from this streamlining.[2]

Other recommendation have suggested a public works bank just for infrastructure projects loans based on ability to repay using user fees. This is unlikely to include the military as user fees run contrary to the military pay/benefit structure.

The current lack of stove-piping of OMA funds to infrastructure maintenance, repair and replacement and the flexibility at the installation level is not beneficial in most cases. The flexibility means the DEH and/or installation commander will be subject to "command influence" which may sacrifice long term for the short term (eg. paint curbs versus replace leaking water lines).

Stove-piping of funds to the K. account (Real Property Maintenance and Repair) or requiring a specific percentage of the PRV be used for RPM or revitalization is recommended.

The funding crisis can only be addressed by clearly articulating the need in a convincing manner. Credibility of the data is required to justify shifting funds now from mission and social programs to revitalization. This will take management information systems to insure proper justification and utilization of the funds.

The DoD BMAR report recommends level of effort goals be established for facility investment and service calls and recurring work be addressed separately from non-recurring work and minor construction."[3] This study recommendations are listed below with the crisis area each action would address.

1. Collect RPM costs by facility investment category (need & funding)
2. Standardize BMAR reporting (need & funding)
3. Institute five year maintenance planning (management - tenure)
4. Standardize PRV computation (need & funding)
5. Establish a meaningful goal for RPM investment[4] (funding & management)

MANAGEMENT

Our current practice of using institutional knowledge to establish priorities and our "policy" of limited inspection forces the operation into an inefficient and

costly reactive mode. The military must collect condition data to feed decision support software to insure correct prioritization of M,R&R efforts. The military should not avoid the initial capital outlay for the high speed inspection tools and management information systems.

To minimize the short term tendency of managers the entire chain of command must emphasize efforts which are beneficial in the long term. The definition of success should include a reduction of the fragility of the infrastructure. Estimating this is difficult because the very nature of failure due to decay is uncertain. Science can tell us the condition of the structure but art is used to predict failure. Even sophisticated software cannot explain why structures with 50 year design lives are still operating 100 years later. Specific improvements in infrastructure systems can only be measured using accurate data collected throughout the tenure of the manager.

Additionally, success (eg. the efficiency report) is still written on what happens "on the watch" and can not be changed years or even months after submitted when the whole water system collapses from poor maintenance. With adoption of high technology condition assessment devises and the resulting data base of infrastructure condition,

progress toward specific long range goals could be measured for use in support forms.

The manager's commitment to long range goals could be easily documented. The improved condition of the infrastructure and the number and scope of the projects in design and awaiting funding would show this commitment. Currently superiors are often limited to "gut feeling" on the progress of an installation's fight to reverse the decay of the infrastructure.

In fact all three crisis areas, needs, funding, and management, will be addressed by improving the assessment of the current condition (by adoption of the high technology collection equipment) and using this data with the decision making software (MIS and decision support tools).

The newly acquired condition data as compared to the required level of service will define our need. Funds justified by showing the deference between current condition and the level of service required can be provided for (stove-piped!) to close this gap. Additionally this current condition data will improve management decisions which drive all M,R&R actions.

SUMMARY

The military must do more to determine its true need. As discussed, the BMAR is not a good indicator of true need and will not be credible until reporting is standardized. Only after a detailed infrastructure assessment program using high technology non-intrusive inspection equipment tied to state-of-the-art computer assisted retrieval and decision making software will DEH's know their true need. The funding of this true need may then be documented in a more convincing manner, and, thereby draw more funds for maintenance and repair. Due to the military community concept most of the other civilian initiatives to assist the funding crisis are not applicable. One exception, which will be politically sensitive, will be the establishment of ceilings for AFH utility use as an attempt to reduce demand.

In an effort to stovepipe funds the Army should reestablish the minimum floors for RPMA funding. This would reduce the competition between Mission and RPMA and provide long-range capital improvements through many of the short tenured commanders.

The management of the military infrastructure will improve as the leadership realizes the value of long range infrastructure improvement goals, the money saved by

increasing the levels of maintenance, and the missions made possible by a robust infrastructure. All this would be in addition to the improvement in retention due to quality living and working conditions.

The condition of the military's infrastructure is very similar to the national infrastructure. Exceptions do exist, but, in general the military's need and management activities are better than the national average while the funding situation is better in the national arena where the profit motive rules.

RECOMMENDATIONS FOR FURTHER STUDY

A detailed study of the Needs, Funding, or Management areas would make an interesting thesis. In fact, many of the chapter sub-divisions hold ideas which could easily be expanded into very interesting reports.

I recommend an accurate PRV of Ft. Leavenworth be calculated using square-foot and linear-foot quantities for all structures, utilities and pavements. A more accurate PRV would add credibility to the need and assist in obtaining RPMA funds.

Also, the current BMAR should be evaluated to see if it is a reflection of "where the dollars are" or a true picture of the maintenance & repair projects in need of

funding. Also, recommend a study on the various methods of determining investment levels.

Finally, I recommend a percent of PRV for each subsystem be determined based on type of construction, design life, composition and use.

END NOTES FOR CHAPTER 6 - RECOMMENDATION AND CONCL

1. Perry, Nancy J., "The Economy: Good News about Infrastructure," Fortune, April 10. 1989.

2. Choate, Pat and Walter, Susan; America in Ruins - The Decaying Infrastructure. Durham, N.C.: Duke Press Paperbacks, 1983; pg. 7.

3. DoD. RPMA Study, pg. 27.

4. Ibid., pg. 31.

BIBLIOGRAPHY

BIBLIOGRAPHY

BOOKS

Choate, Pat and Walter, Susan; America in Ruins - The Decaying Infrastructure. Durham, N.C.: Duke Press Paperbacks; 1983.

Naisbitt, John, Megatrends - Ten New Directions Transforming Our Lives. New York: Warner Books, Inc.; 1982.

GOVERNMENT STUDIES and HEARINGS

Association of General Contractors, Infrastructure: The Aftermath and the Realization. A Call For Action. In Congress. House. Committee on Public Works and Transportation, How to Solve the Nation's Infrastructure Problem Hearings. 99th Congress, 1st and 2nd Sess. Washington D.C.: GPO, 1986, pg. 375-405, (CIS 86 H641-19).

Choate, Pat, America in Ruins: An Update. A Public Works Financing Strategy. Prepared for Associated General Contractors. In Congress. House. Committee on Public Works and Transportation, How to Solve the Nation's Infrastructure Problem Hearings. 99th Congress, 1st and 2nd Sess. Washington D.C.: GPO, 1986, pg. 406-413, (CIS 86 H641-19).

Congress. House. Committee on Public Works and Transportation, How to Solve the Nation's Infrastructure Problem Hearings. 99th Congress, 1st and 2nd Sess. Washington D.C.: GPO, 1986, (CIS 86 H641-19).

Congress. House. Committee on Public Works and Transportation. Progress Report of the National Council on Public Works Improvement Hearing. 99th Congress, 2nd Sess. Washington D.C.: GPO, July 1986.

Congress. House. Committee on Public Works and Transportation. To Discuss the Final Report of the National Council on Public Works Improvement Hearings. 100th Congress, 2nd Sess. Washington D.C.: GPO, (CIS 89 H641-10).

Congress. Joint Economic Committee. Hard Choices - A Report on the Increasing Gap Between America's Infrastructure Needs and Our Ability To Pay for Them. Washington D.C.: GPO, February 1984. (CIS 84 J842-7).
Pisarski, Alan E. A Study of Policy Issues in Highway, Streets, and Bridges. Submitted to The National Council of Public Works Improvement, April 1, 1987.

Congressional Budget Office, New Directions for the Nation's Public Works. Washington D.C.: GPO, September 1988, (CIS 88 J932-35).

Government Finance Research Center of the Government Finance Officers Association. Building Prosperity, October 1983.

National Council on Public Works Improvement, Executive Summaries of Nine Studies, studies commissioned by Council on Transportation, Water Resources, and Waste Management, May 1987, In Congress. House. Committee on Public Works and Transportation. To Discuss the Final Report of the National Council on Public Works Improvement Hearings. 100th Congress, 2nd Sess. Washington D.C.: GPO, May 1988. pg. 126-183. (CIS 89 H641-10).

National Council on Public Works Improvement, Fragile Foundations: A Report on America's Public Works, final Report to the President and the Congress, February 1988, In Congress. House. Committee on Public Works and Transportation. To Discuss the Final Report of the National Council on Public Works Improvement Hearings. 100th Congress, 2nd Sess. Washington D.C.: GPO, May 1988. pg. 183-448. (CIS 89 H641-10).

National Council on Public Works Improvement, The Nation's Public Works - Defining the Issues, report to the President and the Congress, September 1986, In Congress. House. Committee on Public Works and Transportation. To Discuss the Final Report of the National Council on Public Works Improvement Hearings. 100th Congress, 2nd Sess. Washington D.C.: GPO, May 1988. pg. 23-1258. (CIS 89 H641-10).

Olinger, Lawrence, Wastewater Management. Apogee Research, Inc., Submitted to The National Council of Public Works Improvement, May 1987.

Wade Miller Associates, Inc; Infrastructure Policy Issues in Water Supply. Submitted to The National Council of Public Works Improvement, May 8, 1987.

MAGAZINES and JOURNALS

Callahan, Frank T., "America Rebuilds," Military Engineer, Vol. 79, No. 518, pp. 560-564, Nov/Dec, 1987.

Karaa, Fadi A., "Infrastructure Maintenance Management System Development," Journal of Professional Issues In Engineering, Vol. 115, No. 4, October 1989, pp. 422-432.

Maser, Kenneth R., "Inventory, Condition, and Performance Assessment in Infrastructure Facilities Management," Journal of Professional Issues In Engineering, Vol. 114, No. 3, July 1988, pp. 271-280.

Perry, Nancy J., "The Economy: Good News about Infrastructure," Fortune, April 10. 1989; pg 94.

Robison, Rita, "Preventive Maintenance: Fixing What Ain't Broke," Civil Engineer - ASCE, September 1989, Vol. 59, No. 9, pp. 67-69.

Rutledge, Nancy C., "Assessing the Nation's Infrastructure," Military Engineer, Vol. 79, No. 518, Nov/Dec, 1987, pp. 566-569.

Thornton, William J., "Our Nation's Infrastructure: Not Making the Grade," Military Engineer, Vol. 79, No 518, Nov/Dec, 1987, pp. 580-583.

NEWSPAPERS

Melloan, George, "Infrastructure Repair Needs More Than Money", The Wall Street Journal, 29 March 1988.

Public Utilities Fortnightly, "Utility Begins Replacing Gas Pipes," Vol. 124, No. 4, Pg 41, Aug 17, 1989,

The Associated Press, Albany, New York, by Jeff Donn, "A Crisis of Confidence in New York After Bridge Falls," April 20, 1987, Monday PM Cycle, Retrieved from LEXIS/NEXIS database.

The Kansas City Star, "County Bridges are Runsting and Rotting - Obsolete system cited as worst in U. S.," Sec. B, Pg. 1, Col. 1, January 21, 1990.

The Kansas City Star, "Safety board blames KPL in fatal blasts," Sec. C, Pg. 1, Col. 4, March 28, 1990.

The New York Times, "Explosion in Rural Hamlet Raises Troubling Questions," Sec. B, Pg. 1, Col. 4, March 16, 1990.

The New York Times, "Taking the Pulse of the Aging Williamsburg Bridge," Sec. 1, Part 1, Pg. 52, Col. 1, November 22, 1987.

The New York Times, "Large Infusion of Funds Urged for Public Work," Pg. A12(L), Col. 5, February 25, 1988.

The Wall Street Journal, "Infrastructure Repair Needs More than Money," Pg. 31(E), Col. 3, March 29, 1988.

Tolchin, Martin, "Large Infusion of Funds Urged for Public Works", New York Times, 25 February 1988.

INTERVIEWS

Knowlton, C. Douglas, LTC, Director of Engineering and Housing, Fort Leavenworth, Kansas, July 1989 - May 1990.

Lowry, Robert D., Col, Garrison Commander, Fort Leavenworth, Kansas. July 1989 - May 1990.

McDonald, Michael G., Director Public Works/City Engineer, Leavenworth, Kansas, 8 March 1990.

Oberforcher, Tony, BMAR, DEH, 2 March 1990.

Stricklin, Thomas, Cpt (P), Operations Officer, DEH July 1989 - May 1990.

Topper, Dennis LTC (Ret), Base Civil Engineer, Lackland Air Force Base, San Antonio, Texas, August 1989.

Walker, Jack E., Deputy Garrison Commander, Fort Leavenworth, Kansas, January 1990.

TECHNICAL REPORTS

Bailey, D. M., et al., Evaluation of Existing Bridge Maintenance Management Practices for Application (U), Army Construction Engineering Research Laboratory, Champaign, Illinois, Report M- 87/18, September 1987, (ADA 187986).

Cowell, J. W., The Effects of Inadequate Component Inspection on Facility Repair Projects (U), Massachusetts Institute of Technology, Cambridge, Department of Civil Engineering, June 1988, (ADA 196637).

Kirby, Jeffery G., Estimating the Life Expectancy of Facilities, Army Construction Engineering Research Laboratory, Champaign, Illinois. April 1974.

Kumar, A.; Riggs, W.; Blyth, M., Corrosion Mitigation and Management System, Army Construction Engineering Research Laboratory, Champaign, Illinois. Report M - 86/08, April 1986.

Kumar, A. et at., Demonstration of the Pipe Corrosion Management System (PIPER) (U), Army Construction Engineering Research Laboratory, Champaign, Illinois. Report TR - M - 86/08, (ADA 166807).

Reighect, E. F. et al., The Relationship of Pavement Maintenance Costs to the Pavement Condition Index (U), Army Construction Engineering Research Laboratory, Champaign, Illinois. Report M - 87/82, February 1987, (ADA 179653).

Torres, Louis, A History of USA - CERL, 1968 - 1986, Army Construction Engineering Research Laboratory, Champaign, Illinois. December 1987.

Walski, Thomas M., Making Water System Rehabilitation Decisions, Reprinted from Water Forum '86: World Water Issues in Evolution Proceedings of ASCE Conferences, Long Beach, CA. August 4-6, 1986.

Whang, Kyu-Seung; Moore, Alan; Perez, Gonzalo; Facility Cost Simulation Models: A Basis for Replacement Policy, Army Construction Engineering Research Laboratory, Champaign, Illinois. Report P - 89/81, October 1988.

Other Reports

City of Leavenworth, Capital Improvements Program, November 14, 1989.

Department of the Defense, Renewing the Built Environment, RPMA Study, DOD Report to Congress, March 1989.

Index of USA - CERL Publications (U), Army Construction Engineering Research Laboratory, Champaign, Illinois, July 1985, (ADA 168928).

Index of USA - CERL Publications for October 1984 - November 1988 (U), Army Construction Engineering Research Laboratory, Champaign, Illinois, February 1989, (ADA 186375).

U. S. Army Corps of Engineers, Report of the Green Ribbon Panel on: U. S. Army Corps of Engineers Support to Army Installation Commanders, Office of the Chief of Engineers, March 1985.

US Army War College, Army Command and Management: Theory and Practice, Reference Text for Department of Command, Leadership and Management, 1988-89.

Partin, John W. Dr., editor, A Brief History of Fort Leavenworth 1827-1983, Combat Studies Institute, U.S. Army Command and General Staff College, Ft. Leavenworth, Kansas, 1983.

Webster's New Deal Dictionary, TIME, 1968.

ARMY REGULATIONS

U. S. Army, AR 10-69, Organizations and Functions, United States Army Corps of Engineers, Washington, D. C.: Department of the Army, 15 September 1980.

U. S. Army, AR 415-10, Construction, General Provisions For Military Construction, Washington D. C.: Department of the Army, 2 February 1972.

U. S. Army, AR 415-35, Construction, Minor Construction, Washington D. C.: Department of the Army, 1 February 1979.

U. S. Army, AR 420-10, Facilities Engineering - General Provisions, Organization, Functions, and Personnel, Washington D. C.: Department of the Army, 20 December 1977.

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