AD-A142 784 PROCEEDINGS PAPERS OF THE AFSC (AIR FORCE SYSTEMS COMMAND) AVIONICS STAND..(U) AERONAUTICAL SYSTEMS DIV WRIGHT-PATTERSON AFB OH DIRECTORATE O.. 1/2

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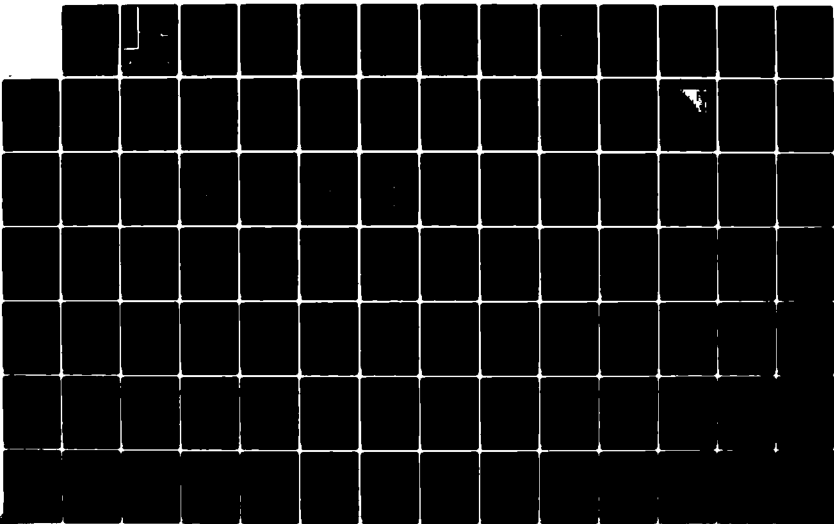

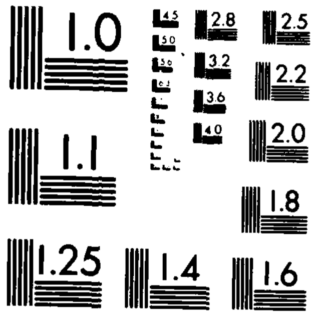

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

ASD(ENA)-TR-82-5031
VOLUME IX

(2)

AD-A142 784

2nd AFSC STANDARDIZATION CONFERENCE

COMBINED PARTICIPATION BY:
DOD-ARMY-NAVY-AIR FORCE-NATO

30 NOVEMBER - 2 DECEMBER 1982
TUTORIALS: 29 NOVEMBER 1982

DAYTON CONVENTION CENTER
DAYTON, OHIO

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TUTORIAL

NAVY CASE STUDY
IMPLEMENTATION OF MILITARY STANDARDS

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This report has been reviewed by the Office of Public Affairs (ASD/PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

Jeffery L Pesler
JEFFERY L. PESLER
Vice Chairman
2nd AFSC Standardization Conference

ERWIN C. GANGL
Chief, Avionics Systems Division
Directorate of Avionics Engineering

FOR THE COMMANDER

Robert P. Lavoie
ROBERT P. LAVOIE, COL, USAF
Director of Avionics Engineering
Deputy for Engineering

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This is a collection of UNCLASSIFIED papers to be distributed to the attendees of the Second AFSC Avionics Standardization Conference at the Convention Center, Dayton, Ohio. The scope of the Conference includes the complete range of DoD approved embedded computer hardware/software and related interface standards as well as standard subsystems used within the Tri-Service community and NATO. The theme of the conference is "Rational Standardization". Lessons learned as well as the pros and cons of standardization are highlighted.

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UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

This is Volume 9

PROCEEDINGS OF THE

2nd AFSC STANDARDIZATION CONFERENCE

30 NOVEMBER - 2 DECEMBER 1982

DAYTON CONVENTION CENTER
DAYTON, OHIO

Sponsored by:

Air Force Systems Command

Hosted by:

Aeronautical Systems Division

FOREWORD

THE UNITED STATES AIR FORCE HAS COMMITTED ITSELF TO "STANDARDIZATION." THE THEME OF THIS YEAR'S CONFERENCE IS "RATIONAL STANDARDIZATION," AND WE HAVE EXPANDED THE SCOPE TO INCLUDE US ARMY, US NAVY AND NATO PERSPECTIVES ON ONGOING DOD INITIATIVES IN THIS IMPORTANT AREA.

WHY DOES THE AIR FORCE SYSTEMS COMMAND SPONSOR THESE CONFERENCES? BECAUSE WE BELIEVE THAT THE COMMUNICATIONS GENERATED BY THESE GET-TOGETHERS IMPROVE THE ACCEPTANCE OF OUR NEW STANDARDS AND FOSTERS EARLIER, SUCCESSFUL IMPLEMENTATION IN NUMEROUS APPLICATIONS. WE WANT ALL PARTIES AFFECTED BY THESE STANDARDS TO KNOW JUST WHAT IS AVAILABLE TO SUPPORT THEM: THE HARDWARE; THE COMPLIANCE TESTING; THE TOOLS NECESSARY TO FACILITATE DESIGN, ETC. WE ALSO BELIEVE THAT FEEDBACK FROM PEOPLE WHO HAVE USED THEM IS ESSENTIAL TO OUR CONTINUED EFFORTS TO IMPROVE OUR STANDARDIZATION PROCESS. WE HOPE TO LEARN FROM OUR SUCCESSES AND OUR FAILURES; BUT FIRST, WE MUST KNOW WHAT THESE ARE AND WE COUNT ON YOU TO TELL US.

AS WE DID IN 1980, WE ARE FOCUSING OUR PRESENTATIONS ON GOVERNMENT AND INDUSTRY EXECUTIVES, MANAGERS, AND ENGINEERS AND OUR GOAL IS TO EDUCATE RATHER THAN PRESENT DETAILED TECHNICAL MATERIAL. WE ARE STRIVING TO PRESENT, IN A SINGLE FORUM, THE TOTAL AFSC STANDARDIZATION PICTURE FROM POLICY TO IMPLEMENTATION. WE HOPE THIS INSIGHT WILL ENABLE ALL OF YOU TO BETTER UNDERSTAND THE "WHY'S AND WHEREFORE'S" OF OUR CURRENT EMPHASIS ON THIS SUBJECT.

MANY THANKS TO A DEDICATED TEAM FROM THE DIRECTORATE OF AVIONICS ENGINEERING FOR ORGANIZING THIS CONFERENCE; FROM THE OUTSTANDING TECHNICAL PROGRAM TO THE UNGLAMOROUS DETAILS NEEDED TO MAKE YOUR VISIT TO DAYTON, OHIO A PLEASANT ONE. THANKS ALSO TO ALL THE MODERATORS, SPEAKERS AND EXHIBITORS WHO RESPONDED IN SUCH A TIMELY MANNER TO ALL OF OUR PLEAS FOR ASSISTANCE.

ROBERT P. LAVOIE, COL, USAF
DIRECTOR OF AVIONICS ENGINEERING
DEPUTY FOR ENGINEERING

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE SYSTEMS COMMAND
ANDREWS AIR FORCE BASE DC 20334

29 AUG 1982

REPLY TO ATTN OF: CV

SUBJECT: Second AFSC Standardization Conference

TO: ASD/CC

1. Since the highly successful standardization conference hosted by ASD in 1980, significant technological advancements have occurred. Integration of the standards into weapon systems has become a reality. As a result, we have many "lessons learned" and cost/benefit analyses that should be shared within the tri-service community. Also, this would be a good opportunity to update current and potential "users." Therefore, I endorse the organization of the Second AFSC Standardization Conference.

2. This conference should cover the current accepted standards, results of recent congressional actions, and standards planned for the future. We should provide the latest information on policy, system applications, and lessons learned. The agenda should accommodate both government and industry inputs that criticize as well as support our efforts. Experts from the tri-service arena should be invited to present papers on the various topics. Our AFSC project officer, Maj David Hammond, HQ AFSC/ALR, AUTOVON 858-5731, is prepared to assist.

ROBERT M. BOND, Lt Gen, USAF
Vice Commander

NAVY CASE STUDY

IMPLEMENTATION OF MILITARY STANDARDS

Instructor: Marshall R. Potter
Naval Electronics System Command

ABSTRACT

A brief overview of the Navy approach to the life cycle management of embedded computer resources will be provided. The role of software engineering as a problem solving discipline involving engineering, computer science and management will be applied to all phases of the life cycle as defined in DODD 5000.1. A case study of a major Navy acquisition initiated in 1974, subsequently deployed and currently under maintenance, will be covered and analyzed. The purpose of the case study is to investigate a system acquisition that utilized the most up-to-date technology practical, including recommended software development tools, techniques, and methodologies. The usefulness and shortfall of good tools and techniques, employed during the acquisition of a complex system, will be discussed illustrating that things dont always turn out right, even when prosecuted in accordance with the best expertise and guidance available.

BIOGRAPHY

Marshall Potter
Head, Software Engineering Branch
Naval Electronics System Command
Washington D. C. 20360

BSEE	University of Maryland	1971
MSEE	University of Maryland	1974
MSCS	University of Maryland	1979

<u>Experience</u>

15 years with the Department of Defense, including the following assignments:
- Naval Ship Research and Development Center
- Defense Communications Engineering Center
- Naval Electronics System Command

<u>Current Assignment:</u> Head, Software Engineering Branch, Computer Resources Division, Naval Electronics System Command

Responsible for developing procedures and policy for the design and implementation of systems that use embedded computer resources.

TUTORIAL

NAVY LIFE-CYCLE MANAGEMENT OF SYSTEMS USING EMBEDDED COMPUTER RESOURCES

MARSHALL R. POTTER
NAVAL ELECTRONIC SYSTEMS COMMAND
WASHINGTON, D.C. 20363

OUTLINE

- BACKGROUND
- THE DOD LIFE CYCLE
- THE SOFTWARE LIFE CYCLE
- SOFTWARE STANDARDS
- SOFTWARE ENGINEERING: A NAVY APPROACH
- CASE STUDY
-

BACKGROUND

EMBEDDED COMPUTER RESOURCES

- OPERATIONAL SOFTWARE/FIRMWARE
- SUPPORT SOFTWARE/FIRMWARE
- EMBEDDED COMPUTERS
- DATA STORAGE DEVICES
- DISPLAYS
- INTERFACES

- PROGRAMMING LANGUAGES
- SOFTWARE SUPPORT FACILITIES
- TRAINING FACILITIES
- PERSONNEL

SOFTWARE

- COMPUTER PROGRAMS
- DATA
- DOCUMENTATION

HARDWARE-SOFTWARE-FIRMWARE

	SPEED	ALTERATION	IMPLEMENTATION
HARDWARE	FASTEST	MOST DIFFICULT	PARALLEL
FIRMWARE	FAST	MODERATE DIFFICULTY	SERIAL OR PARALLEL
SOFTWARE	SLOWEST	EASIEST	SERIAL

SOFTWARE PROBLEMS

- EXCEEDS COST ESTIMATES
- DELIVERED LATE
- DOES NOT MEET REQUIREMENTS
- UNRELIABLE
- INADEQUATELY DOCUMENTED
- DOES NOT INTERFACE

EXPERIENCE WITH INADEQUATE PLANNING

BROOKS — OS 360

- PROBLEMS
  - MANAGEMENT/ESTIMATION
  - DOCUMENTATION
  - ORGANIZATION
  - CONTROL
- STANDARD MANAGEMENT SOLUTIONS
  - ADD MORE PEOPLE
  - SKIMP ON TESTING INTEGRATION AND DOCUMENTATION
  - SCRAP THE NEW SYSTEM AND MAKE DO WITH THE OLD ONE
  - REDUCE THE FUNCTION OF THE SYSTEM

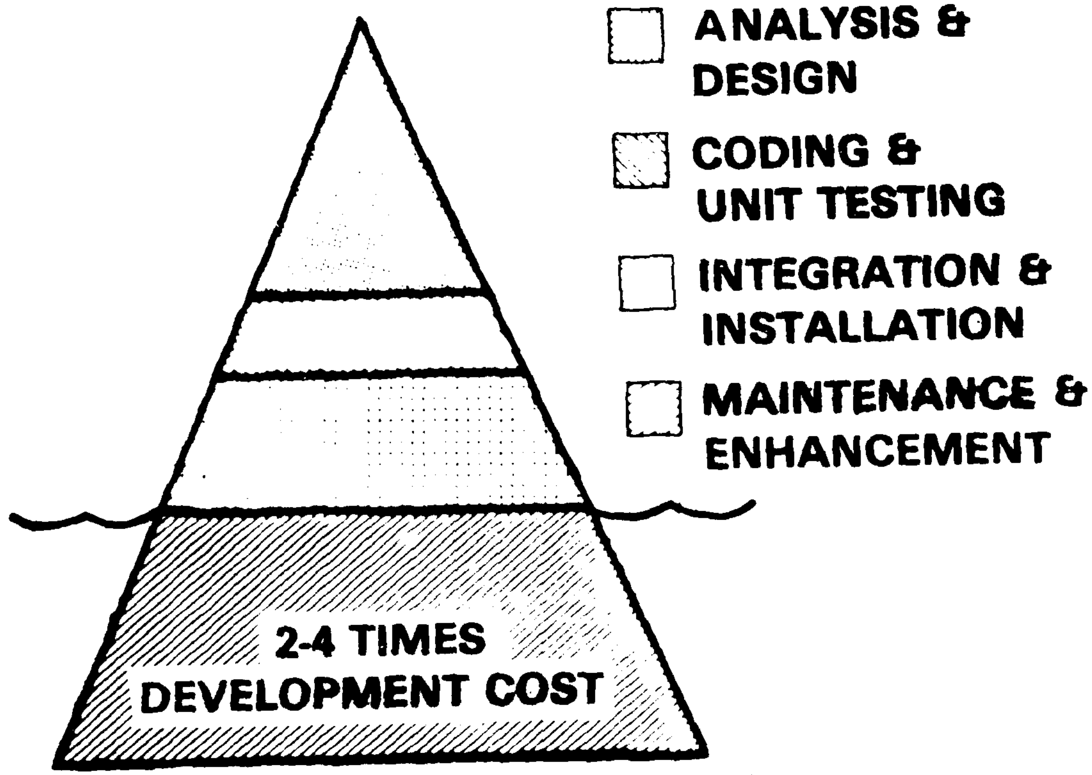
EXPERIENCE WITH INADEQUATE PLANNING

- SEVERAL DISASTERS

  DIAGNOSIS: POOR MANAGEMENT

- NEEDED APPROACH
  - IMPROVE PROJECT ORGANIZATION AND MANAGEMENT
  - INCREASE INDIVIDUAL'S SOFTWARE PRODUCTIVITY (TWO SIDES OF THE SAME COIN)
  - INITIATE SOFTWARE DEVELOPMENT EARLIER IN THE SYSTEM DEVELOPMENT CYCLE

DEVELOPMENT COST IS ONLY A SMALL PART OF THE LIFE CYCLE COST

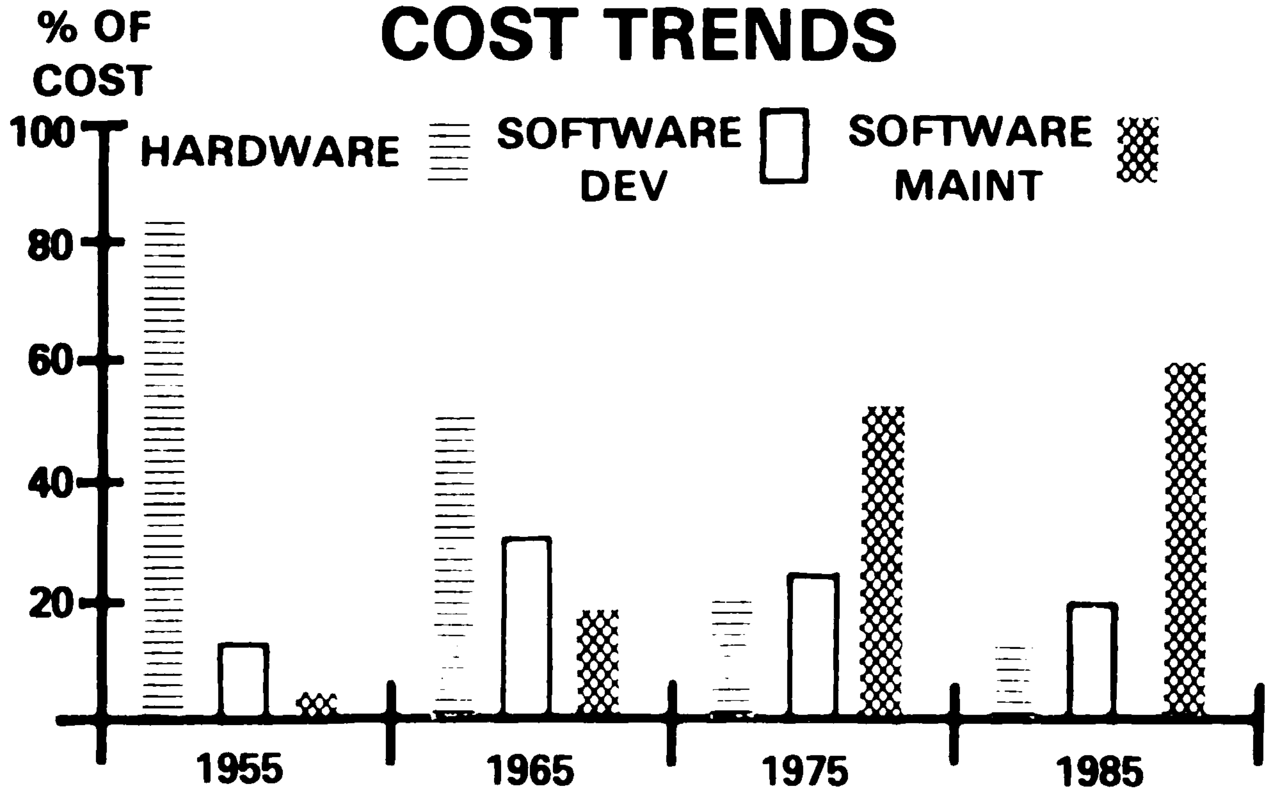


WHY THE HIGH LIFE CYCLE COST?

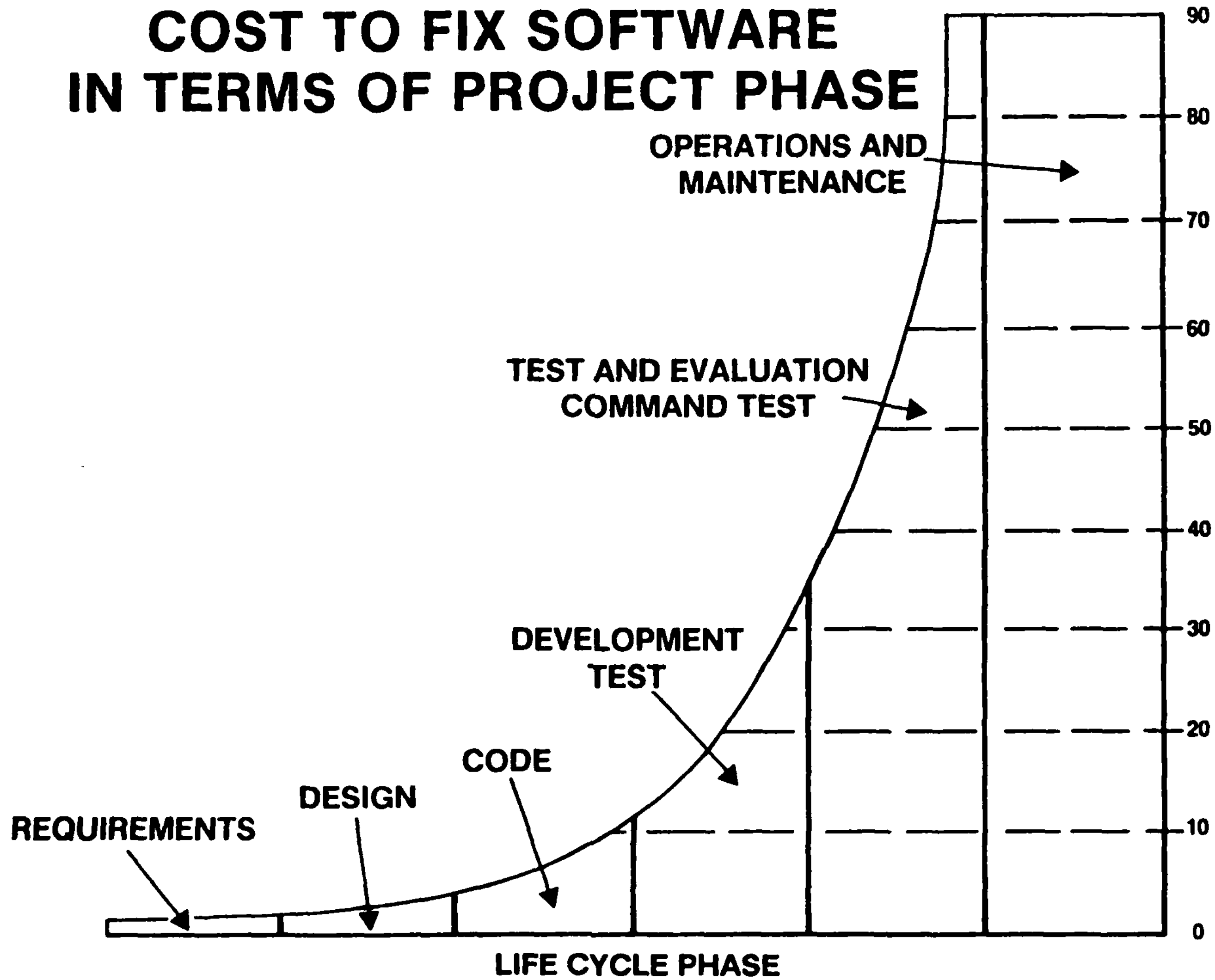
WHERE DOES THE SOFTWARE EFFORT GO?

	ANALYSIS AND DESIGN	CODING AND AUDITING	CHECKOUT AND TEST
SAGE	39%	14%	47%
NTDS	30	20	50
GEMINI	36	17	47
SATURN V	32	24	44
OS/360	33	17	50
TRW SURVEY	46	20	34

HARDWARE SOFTWARE COST TRENDS



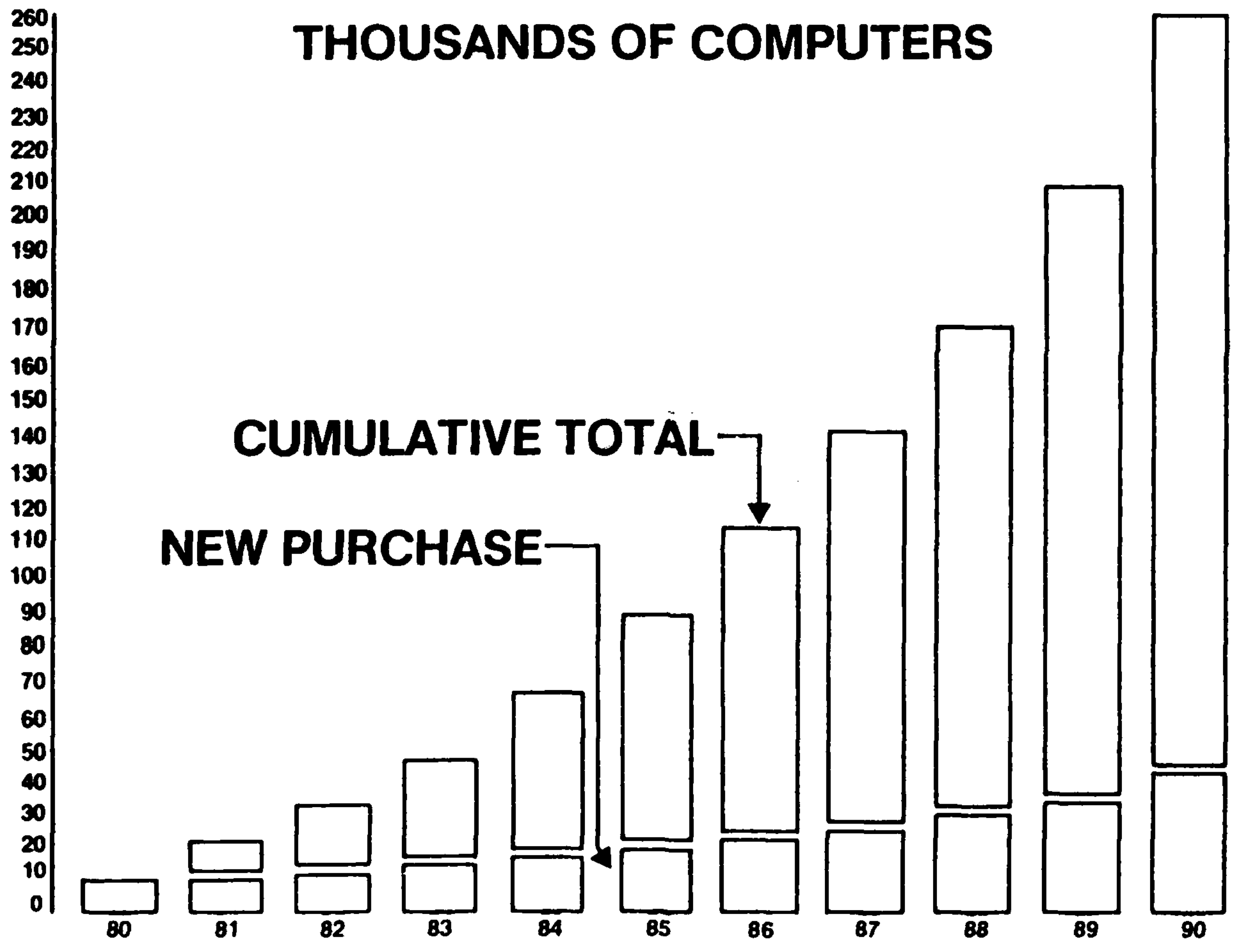
COST TO FIX SOFTWARE IN TERMS OF PROJECT PHASE



DURING THE '80's

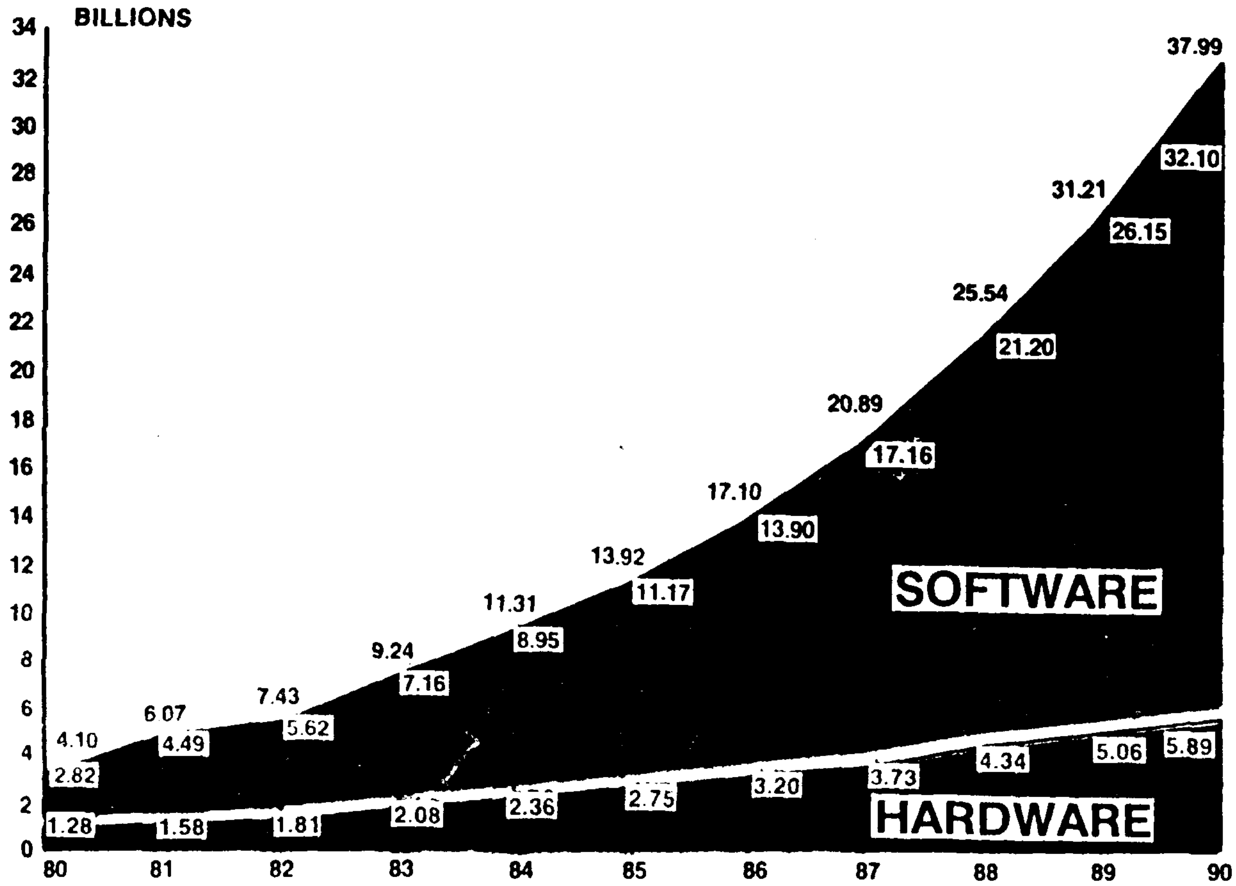
- DOD BUDGET INCREASES 2.8 TIMES
- DOD ELECTRONICS INCREASE 3.8 TIMES
- DOD COMPUTERS INCREASE 6.8 TIMES
- DOD SOFTWARE INCREASES 8.1 TIMES

DOD EMBEDDED COMPUTERS

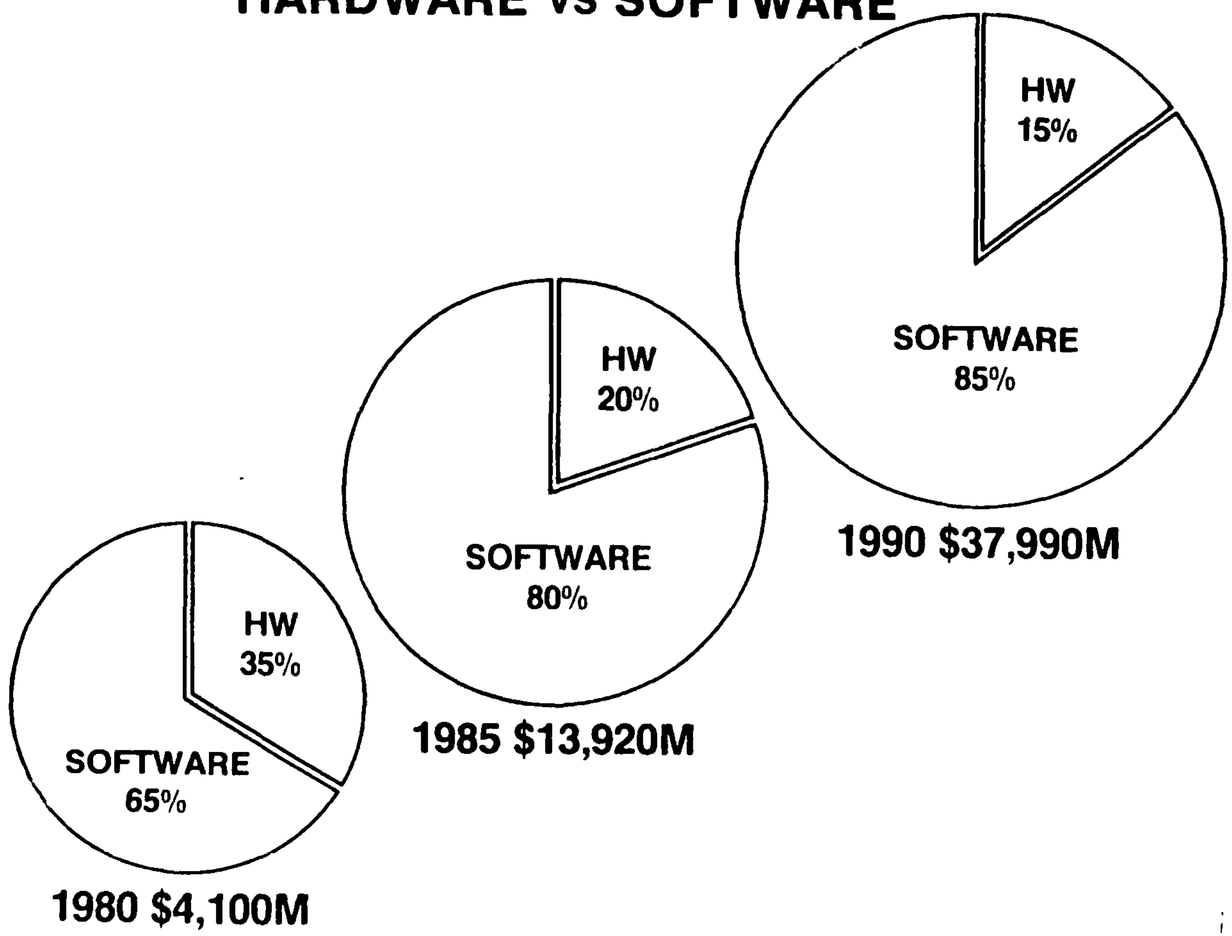


DOD EMBEDDED COMPUTER MARKET

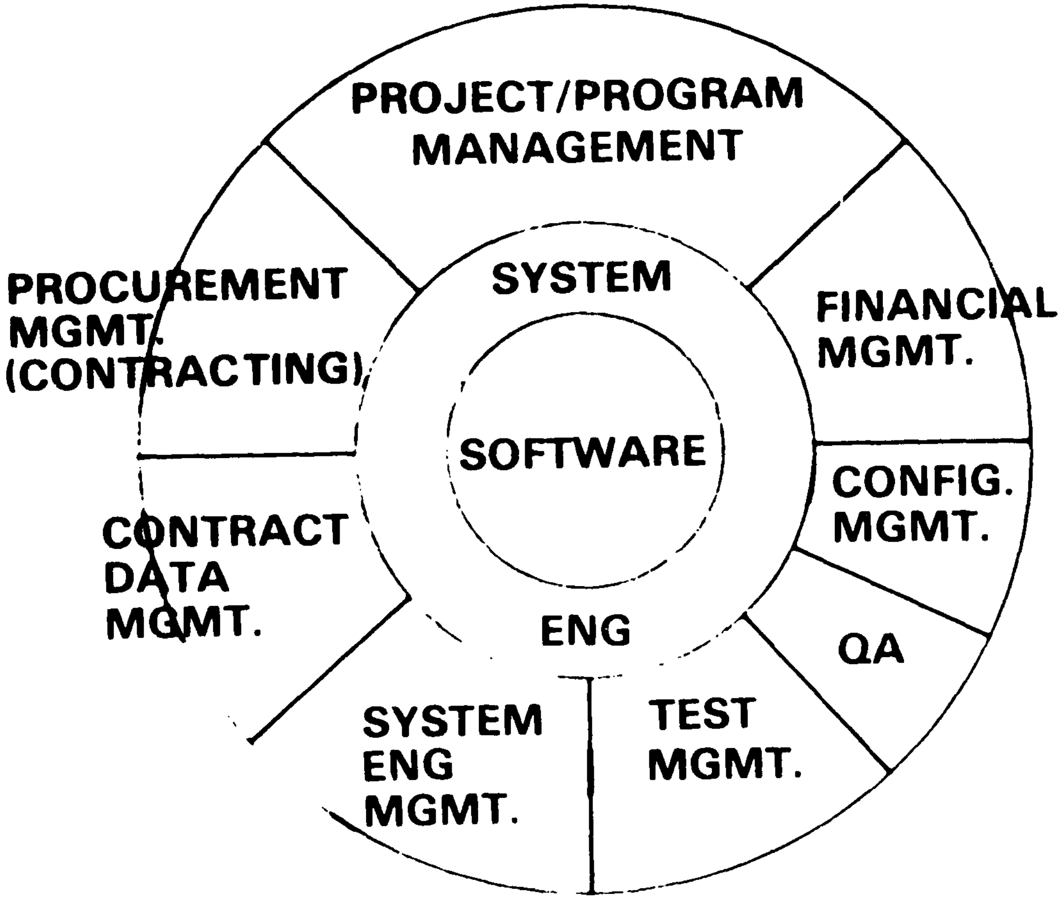
SOFTWARE/HARDWARE



EMBEDDED COMPUTERS
HARDWARE VS SOFTWARE



SOFTWARE SYSTEM MANAGEMENT



INCREASED PRODUCTIVITY

PRESCRIPTIONS

- DESIGN, DEVELOP AND USE THOUGHTFUL TEST PLANS — STARTING IN THE EARLIEST ANALYSIS PHASE
- CHOOSE GOOD PROGRAMMING LANGUAGES WITH ERROR FINDING COMPILERS
- PROVIDE TOOLS AND TECHNIQUES WHICH GET VALIDATION DONE MORE EFFICIENTLY DURING THE EARLY PHASES OF THE PROJECT

  e.g., STRUCTURED PROGRAMMING, TOP DOWN APPROACHES

IMPROVING SOFTWARE MANAGEMENT

PROBLEMS OF MEDIUM AND LARGE-SCALE PROJECTS ARE LARGELY PROBLEMS OF MANAGEMENT NEED:

- THOROUGH ORGANIZATION
- GOOD CONTINGENCY PLANS
- THOUGHTFUL ESTABLISHMENT OF MEASURABLE PROJECT MILESTONES
- CONTINUOUS MONITORING ON WHETHER THE MILESTONES ARE PROPERLY PASSED
- PROMPT INVESTIGATION AND CORRECTIVE ACTION IN CASE THEY ARE NOT
- ORGANIZATION TO TRANSFER EXPERIENCE FROM ONE PROJECT TO THE NEXT

STANDARDIZATION

- IMPORTANT AND NECESSARY ACTIVITY
- MAKES SOFTWARE MORE REUSABLE
- CAN FREEZE US INTO OBSOLETE SOFTWARE PRACTICES
- MAINTAINING SOFTWARE PRACTICES AT LOWEST COMMON DENOMINATOR IS CAUSING A CREEPING PARALYSIS IN OUR SOFTWARE INDUSTRY
- NEED TO MOVE NEW METHODOLOGY INTO PRACTICE IN A REALISTIC WAY
- IF CURRENT PRACTICES CONTINUE — IN 20 YEARS WE WILL HAVE A NATIONAL INVENTORY OF UNSTRUCTURED, HARD TO MAINTAIN, IMPOSSIBLE TO REPLACE PROGRAMS

CRITICAL ISSUE: NEED FOR IMPROVED METHODOLOGY AND THE CRITICAL SELECTION AND TRAINING OF PROGRAMMING PERSONNEL

LIFECYCLE

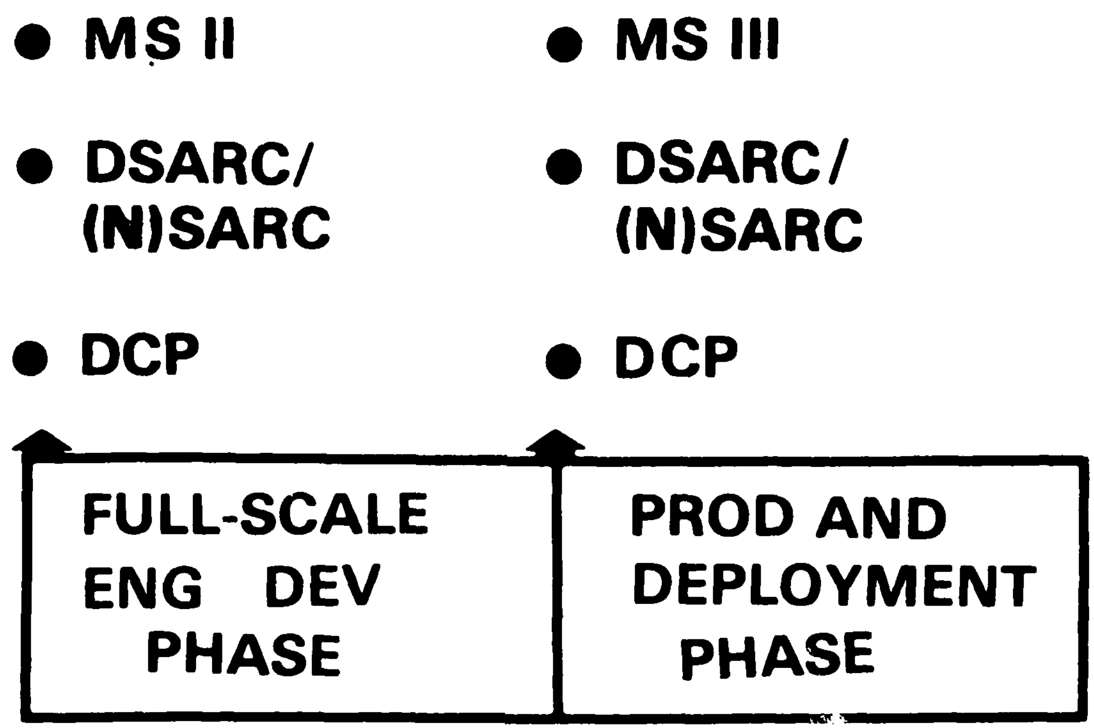
WHY LIFE CYCLE PHASES

- INHERENT SYSTEM ENGINEERING SEQUENCE
- CONTRACTING
- MAJOR DECISION POINTS FOR CONTROL AND OPTIONS
- FUNDING

DOD SYSTEM LIFE CYCLE

• MS 0	• MS I	• MS II
• MENS	• DSARC/ (N) SARC	
	• DCP	

PROGRAM INITIATION PHASE	DEMONSTRATION AND VALIDATION PHASE


MS II
DSARC/
(N)SARC
DCP
MS III
DSARC/
(N)SARC
DCP
FULL-SCALE
ENG DEV
PHASE
PROD AND
DEPLOYMENT
PHASE

SOFTWARE
LIFE CYCLE

LIFE CYCLES

MAJOR DEFENSE SYSTEMS:

PROGRAM INITIATION	DEM AND VALIDATION	FULL-SCALE ENG DEV	PRODUCTION AND DEPLOYMENT

COMPUTER PROGRAM SYSTEMS:

FULL SYSTEM

RQMTS ANALYSIS, DEFINITION, PLANNING	DESIGN	CODE & DEBUG	TEST	INT	OPERATE AND MAINTAIN

SOFTWARE LIFE CYCLE DATA REQUIREMENTS

DEMONSTRATION & VALIDATION PHASE

- SW DEVELOPMENT MGMT
- SW CONFIGURATION MGMT
- SW QUALITY ASSURANCE

DEMONSTRATION & VALIDATION PHASE

- SW SYS ENGINEERING REVIEWS
- CP DEVELOPMENT SPECS
- CP TEST PLANS
- MISCELLANEOUS

FULL-SCALE ENGINEERING DEVELOPMENT PHASE

- SW PROJECT STATUS/PROGRESS
- SW CONFIGURATION MGMT
- SW QUALITY ASSURANCE
- DESIGN REVIEWS & CONFIG AUDITS

FULL-SCALE ENGINEERING DEVELOPMENT PHASE

- CP PRODUCT SPECS
- CP TEST SPECS, PROCEDURES & REPTS
- MANUALS
- MISCELLANEOUS

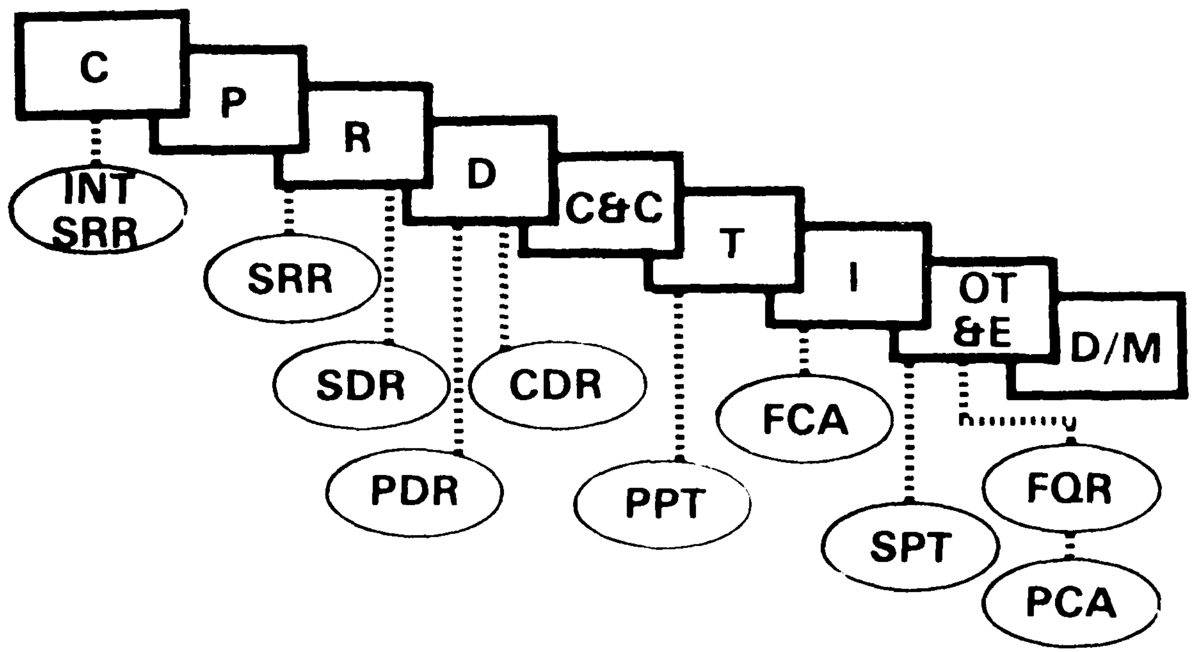
PRODUCTION & DEPLOYMENT PHASE

- MAINTENANCE/MODIFICATION MGMT
- SW CONFIGURATION MGMT
- SW QUALITY ASSURANCE
- DESIGN REVIEWS & CONFIGURATION AUDITS

PRODUCTION & DEPLOYMENT PHASE

- CP PRODUCT SPECS
- CP TEST SPECS, PROCEDURES & REPTS
- MANUALS

MAJOR ACTIVITIES WITHIN SOFTWARE LIFE CYCLE



OTHER LIFE CYCLE MODELS

- PROTOTYPE
- LOOPY LINEAR

SOFTWARE STANDARDS

NAVY POLICY DIRECTION

- SOFTWARE DEVELOPMENT
- SOFTWARE TESTING AND EVALUATION
- SOFTWARE MAINTENANCE

DOD SOFTWARE DEVELOPMENT POLICY

• DODD 5000.1	MAJOR SYSTEM ACQUISITIONS
• DODD 5000.2	MAJOR SYSTEM ACQUISITION PROCEDURES
• DODD 5000.29	MANAGEMENT OF COMPUTER RESOURCES
• DODD 5000.31	HIGH ORDER PROGRAMMING LANGUAGE (HOL) STANDARDIZATION POLICY
• DODD 5010.19	CONFIGURATION MANAGEMENT
• DODD 5000.5X	INSTRUCTION SET ARCHITECTURE
• DODI 7000.11	CONTRACTOR COST DATA REPORTING
• MIL-S-83490	SPECIFICATIONS, TYPES AND FORMS
• MIL-S-52779A	SOFTWARE QUALITY ASSURANCE PROGRAM REQUIREMENTS

NAVY/NAVELEX SOFTWARE DEVELOPMENT POLICY

• SECNAVINST 3560.1	TACTICAL DIGITAL SYSTEM DOCUMENTATION STANDARDS
• SECNAVINST 5200.32	MANAGEMENT OF EMBEDDED COMPUTER RESOURCES
• OPNAVINST 4130.1	CONFIGURATION MANAGEMENT
• NAVMATINST 4130.2A	CONFIGURATION MANAGEMENT OF COMPUTER SOFTWARE
• NAVMATINST 5200.27A	POLICY AND PROCEDURE FOR TRANSFER OF COMPUTER PROGRAMS FROM A DEVELOPMENT ACTIVITY TO A COMPUTER PROGRAM MAINTENANCE ACTIVITY
• TADSTANDS	

NAVY/NAVELEX SOFTWARE DEVELOPMENT POLICY

- NAVELEXINST 5200.22 — NAVELEX ACQUISITION RESOURCE MANAGEMENT
- NAVELEXINST 5200.23 — NAVELEX COMPUTER SOFTWARE LIFE-CYCLE MANAGEMENT GUIDE

TACTICAL DIGITAL STANDARDS

TADSTAND A :	STANDARD DEFINITIONS FOR EMBEDDED COMPUTER RESOURCES (2 JULY 1980)
TADSTAND B : (REVISION 1)	STANDARD EMBEDDED COMPUTERS, COMPUTER PERIPHERALS, AND INPUT/OUTPUT INTERFACES (21 JUNE 1982)
TADSTAND C :	COMPUTER PROGRAMMING LANGUAGE STANDARDIZATION POLICY (2 JULY 1980)
TADSTAND D :	RESERVE CAPACITY REQUIREMENTS (2 JULY 1980)
TADSTAND E :	SOFTWARE DEVELOPMENT, DOCUMENTATION, AND TESTING POLICY FOR NAVY MISSION CRITICAL SYSTEMS (25 MAY 1982)

TADSTAND B

(REVISION 1)

NAVY STANDARD EMBEDDED COMPUTER RESOURCES WILL BE UTILIZED IN SYSTEMS, EXCEPT IN THOSE CASES WHERE STANDARDS ARE DEMONSTRATED TO BE NOT COST EFFECTIVE OR NOT TECHNICALLY PRACTICABLE OVER THE LIFE OF THE SYSTEM.

TADSTAND B
(REVISION 1)

COMPUTERS

AN/UYK-7	AN/AYK-14	AN/UYK-44
AN/UYK-20	AN/UYK-43	AN/UYS-1
AN/UYS-2 (EMSP)		

DISPLAYS

AN/UYA-4(V)	AN/USQ-69(V)	OJ-326(V)/UYK
IP-1181	AN/UYQ-21(V)	

TAPE UNITS

RD-358(V)/UYK	AN/USH-26(V)

DISK UNITS

AN/UYH-2	AN/UYH-3

TADSTAND B
(REVISION 1)

RATIONALE FOR STANDARD ECR

1. MUST STEM ECR PROLIFERATION
2. MUST ACHIEVE ACCEPTABLE LEVEL OF SUPPORTABILITY
3. MUST REDUCE LIFE CYCLE COSTS
4. MUST IMPROVE RELIABILITY AND MAINTAINABILITY OF SYSTEMS WHILE MINIMIZING ECR RELATED COSTS
5. REDUCE BOTH COST AND SCHEDULE RISKS

TADSTAND C

PROGRAMMING LANGUAGES

CMS-2Y

CMS-2M

SPL-I

ADA

FORTRAN ANS FORTRAN ANSI X3.9-1978

TADSTAND D

RESERVE CAPACITY ARE FOR FUTURE GROWTH REQUIREMENTS THAT ARE NOT KNOWN AT THE TIME OF ACQUISITION COMMITMENT AND FIRST PRODUCTION DELIVERY

MAIN MEMORY	20%
SECONDARY STORAGE	20%
THROUGHPUT	20%
NUMBER I/O CHANNEL	18.75%
I/O CHANNEL THROUGHPUT	20%

TAD STAND E

(A) ALL SW SHALL BE DEVELOPED, DOCUMENTED, TESTED, AND SUPPORTED IAW THE PROVISIONS OF MIL-STD 1679

(B) MIL-STD 1679 AND ITS COMPANION DIDs SHALL BE INVOKED IN ALL NEW

- CONTRACTS
- TASKS
- AGREEMENTS
- ETC.

MIL-STD 1679 SHALL ALSO BE INVOKED FOR NEW CONTRACTS, TASKS, AGREEMENTS, ETC. FOR MODIFICATION OR REVISION OF EXISTING SOFTWARE

SOFTWARE DEVELOPMENT STANDARDS

- MIL-STD-1679 — WEAPON SYSTEM SOFTWARE DEVELOPMENT
- MIL-STD-1521A — TECHNICAL REVIEWS AND AUDITS
- MIL-STD-483 — CONFIGURATION MANAGEMENT PRACTICES
- MIL-STD-881A — WORK BREAKDOWN STRUCTURES
- DOD-STD-480A — CONFIGURATION CONTROL
- MIL-STD-490 — SPECIFICATION PRACTICES

SOFTWARE T&E POLICY

- DODD 5000.3 — TEST AND EVALUATION
- OPTNAVINST 3960.10A — TEST AND EVALUATION
- NAVMATINST 3960.6B — TEST AND EVALUATION
- NAVMATINST 3960.8 — LAND-BASED TEST SITE (LBTS)
- NAVELEX INST 3960.3A — TEST AND EVALUATION
- MIL-S-52779A — SOFTWARE QUALITY ASSURANCE
- TADSTAND E

STANDARDS

- MIL-STD 1679
- MIL-STD 1521A

SOFTWARE MAINTENANCE POLICY

• DODD 5000.29	MANAGEMENT OF COMPUTER RESOURCES
• NAVMATINST 5200.27	POLICY AND PROCEDURE FOR TRANSFER OF COMPUTER PROGRAMS FROM A DA TO A PMA
• NAVELEXINST 5200.23	NAVELEX COMPUTER SOFTWARE LIFE-CYCLE MANAGEMENT GUIDE

STANDARDS

MIL-STD-1679

SOFTWARE ENGINEERING
A NAVY APPROACH

AN APPROACH FOR SOFTWARE DEVELOPMENT

- ADEQUATE PLANNING AND ESTIMATING
- DESIGN METHODOLOGY
- SOFTWARE MONITORING
- ADEQUATE DOCUMENTATION
- SUFFICIENT TESTING
- QUALITY ASSURANCE
- CONFIGURATION MANAGEMENT
- POST DEVELOPMENT SUPPORT

ADEQUATE PLANNING AND ESTIMATING

RESOURCE ESTIMATION AND ALLOCATION

- PROBLEMS
  - ESTIMATING SIZE
  - ESTIMATING COMPLEXITY
  - KNOWING ENVIRONMENTAL FACTORS
  - STATE-OF-THE-ART
  - STATE-OF-TECHNOLOGY
- SOLUTIONS
  - RESOURCE ESTIMATION MODELS
    - ONE-FORMULA MODELS
      DOTY, BOEHM/WOLVERTON
    - BASIC RELATIONSHIPS
      WALSTON/FELIX
    - TIME-SENSITIVE/MAN-LOADING MODELS
      PUTNAM, PARR

FACTORS THAT AFFECT SOFTWARE DEVELOPMENT

- COMPUTER SYSTEM RESPONSE TIME
- BATCH VS. ON-LINE (20% IMPROVEMENT POSSIBLE)
- VARIATIONS BETWEEN INDIVIDUALS — UP TO 26:1
- PROGRAMMING LANGUAGES — UP TO 4:1
- SOFTWARE DEVELOPMENT CRITERIA — EFFICIENCY, READABILITY, ETC.

FACTORS THAT AFFECT SOFTWARE DEVELOPMENT

- LEARNING CURVE — UP TO 2 TO 1
- STABILITY OF PROGRAM DESIGN — UP TO 3:1
- PERCENT OF MATHEMATICAL INSTRUCTIONS — UP TO 9:1
- NUMBER OF SUBPROGRAMS
- CONCURRENT HARDWARE DEVELOPMENT
- NUMBER OF MAN-TRIPS etc.

MIL-STD 881A

- WORK BREAKDOWN STRUCTURE
  - IS A PRODUCT ORIENTED FAMILY TREE COMPOSED OF HARDWARE SERVICES AND DATA WHICH RESULT FROM PROJECT ENGINEERING EFFORTS DURING THE DEVELOPMENT AND PRODUCTION OF A DEFENSE MATERIEL ITEM, AND WHICH COMPLETELY DEFINES THE PROJECT PROGRAM. A WBS DISPLAYS AND DEFINES THE PRODUCT(s) TO BE DEVELOPED OR PRODUCED AND RELATES THE ELEMENTS OF WORK TO BE ACCOMPLISHED TO EACH OTHER AND TO THE END PRODUCT

MIL-STD 881A

- WORK BREAKDOWN STRUCTURES
  - SUMMARY WBS
  - PROJECT SUMMARY WBS
  - CONTRACT WBS

DESIGN METHODOLOGY

MIL-STD-1679

- PERFORMANCE & DESIGN REQUIREMENTS
- CODING & LOGIC CONVENTIONS
- PROGRAMMING STANDARDS & CONVENTIONS
- PROGRAM PROD & GENERATION
- QUALITY ASSURANCE

- CONFIGURATION MANAGEMENT
- MANAGEMENT SYSTEM
- RELIABILITY & MAINTAINABILITY
- CONTRACT DATA

LIFE CYCLES

MAJOR DEFENSE SYSTEMS:

PROGRAM INITIATION	DEM AND VALIDATION	FULL-SCALE ENG DEV	PRODUCTION AND DEPLOYMENT

COMPUTER PROGRAM SYSTEMS:

FULL SYSTEM

RQMTS ANALYSIS, DEFINITION, PLANNING	DESIGN	CODE & DEBUG	TEST	INT	OPERATE AND MAINTAIN

REQUIREMENTS DEFINITION

REQUIREMENTS ARE THE SPECIFICATION OF THE PROBLEM FROM THE USER'S POINT OF VIEW

SPECIFICATION IS THE DESCRIPTION OF THE PROBLEM FROM THE DESIGNER'S POINT OF VIEW

REQUIREMENTS DEFINITION

A REQUIREMENTS DEFINITION SHOULD CONTAIN:

- FUNCTIONAL SPECIFICATION — A DESCRIPTION OF WHAT THE SYSTEM IS TO BE IN TERMS OF THE FUNCTIONS IT MUST ACCOMPLISH
- CONTEXT DEFINITION — THE REASON THE SYSTEM IS TO BE CREATED AND THE CONTEXT IN WHICH IT IS TO PERFORM
- DESIGN CONSTRAINTS — A SUMMARY OF CONDITIONS SPECIFYING HOW THE REQUIRED SYSTEM IS TO BE CONSTRUCTED AND IMPLEMENTED

SPECIFICATIONS

- WHAT IS A SPECIFICATION?
  — A DESCRIPTION OF THE REQUIREMENTS WHICH A SOFTWARE PRODUCT SHOULD SATISFY

- EFFECTIVE SPECIFICATION SHOULD:
  — REPRESENT A PRECISE EXPRESSION OF ALL THE THINGS IMPORTANT FOR THE PRODUCT
  — BE UNDERSTANDABLE AND UNAMBIGUOUS IN THINGS THAT MATTER
  — COVER ITEMS CONSIDERED TO BE IMPORTANT:
    - THE FUNCTION IT PERFORMS
    - THE PERFORMANCE EXPECTED
    - THE MAINTAINABILITY, *e.g.*, LANGUAGE USED
    - THE CONFIGURABILITY, e.g., ENVIRONMENTAL PARAMETERS
    -
    -
    -

SPECIFICATIONS

- SPECIFICATIONS ASSUME SOME BACKGROUND CONTEXT BETWEEN THE WRITER AND READER
- THEY SERVE AS A BRIDGE OR INTERFACE BETWEEN THE REAL WORLD SITUATION IN WHICH THE USER OF THE PRODUCT WILL BE INVOLVED AND THE LOGICAL DESCRIPTION WHICH THE PRODUCT WILL SATISFY
- THEY ARE THE POINT OF DEPARTURE FOR THE DESIGN AND DEVELOPMENT OF PROGRAMS

SPECIFICATIONS

- BASIC PROPERTIES OF A GOOD SPECIFICATION:
  - PROVIDE ENOUGH INFORMATION ABOUT THE PRODUCT TO ALLOW IT TO BE USED WELL
  - PROVIDE ONLY INFORMATION THAT IS RELEVANT TO THE USER PROGRAM
  - EXPRESSED ENTIRELY IN TERMS OF USER VISIBLE PROPERTIES OF THE PROGRAM
- SPECIFICATION = CORRECTNESS + PERFORMANCE CHARACTERISTICS
- OFTEN THESE ASPECTS CAN BE TREATED INDEPENDENTLY. CORRECTNESS CAN BE FIXED AND PERFORMANCE CHARACTERISTICS CAN BE IMPROVED AS THE NEED REQUIRES

DESIGN

- DESIGN MEANS “TO FASHION ACCORDING TO PLAN”
- DESIGN ACTIVITY CONTINUES FROM EARLY SPECIFICATION TO THE FINAL IMPLEMENTATION OF THE LOWEST LEVEL MODULE IN THE SYSTEM
- THE BASIC IDEA OF GOOD DESIGN IS TO DEVELOP THE DESIGN USING FUNCTIONAL MODULES, KEEPING THE MODULES AS INDEPENDENT AS POSSIBLE

DESIGN

- PROGRAM DESIGN: THE DEFINITION OF THE STRUCTURE, THE DATA, THE FUNCTIONS AND THE LOGICAL RELATIONSHIPS OF THE FUNCTIONS IN ABSTRACT TERMINOLOGY THAT CORRESPONDS TO A GIVEN SPECIFICATION
- GOOD DESIGN REQUIRES CONTROL, STRUCTURE, VISIBILITY, TRACEABILITY
- IT REQUIRES A HIERARCHY OF TOOLS AND TECHNIQUES WHICH ARE INTERRELATED AND CONSTITUTE A SOFTWARE DEVELOPMENT METHODOLOGY AND INCLUDE STRUCTURED OR COMPOSITE DESIGN, PROCESS DESIGN LANGUAGE, STEPWISE REFINEMENT, CORRECTNESS DEMONSTRATIONS, STEPWISE REORGANIZATION, WALK-THROUGHS

POPULAR DESIGN TECHNIQUES

- TOP DOWN DESIGN
- STRUCTURED PROGRAMMING
- STRUCTURED DESIGN
  - YOURDON/CONSTANTNE/MEYERS/DEMARCO
  - WARNIER-ORR
  - HIPO
  - JACKSON
  - SADT

WHY MODULAR DESIGN?

- CONTROL COMPLEXITY
- MAINTAIN INTELLECTUAL MANAGEABILITY
- MAINTAIN INTEGRITY OF DATA
- ENSURE COMPLETENESS OF DESIGN

PROGRAM DESIGN LANGUAGE

- PDL
- PSEUDO-CODE
- STRUCTURED ENGLISH

THE ABILITY TO PRODUCE EFFECTIVE SOFTWARE DESIGNS BEGINS WITH GOOD COMMUNICATION BETWEEN USERS AND DESIGNERS

WITHOUT IT DESIGNERS CANNOT BE CERTAIN ABOUT INTENDED FUNCTIONS AND USERS CAN END UP WITH ELEGANT SOLUTIONS TO THE WRONG PROBLEMS

NEED A LANGUAGE FOR INVENTING AND COMMUNICATING LANGUAGE DESIGNS, IN LOGICAL TERMS, FOR USE BY A WIDE AUDIENCE

PDL IS AN OPEN ENDED SPECIALIZATION OF NATURAL LANGUAGE

ITS OBJECTIVE IS TO

- PERMIT PRECISION IN DESIGNING LOGICAL PROCESSES
  - FOR HUMAN COMMUNICATIONS
  - FOR NEARLY DIRECT HUMAN TRANSLATION INTO THE TYPICAL PROCEDURAL PROGRAMMING LANGUAGES OF TODAY AS WELL AS INTO USERS GUIDES AND MORE GENERAL HUMAN NEEDS

PDL

- VIEWS DESIGN FROM A LOGICAL POINT OF VIEW WITHOUT INVOLVING THE PHYSICAL STORAGE AND OPERATIONS OF ANY SPECIFIC COMPUTING SYSTEM

SOFTWARE MONITORING

SOFTWARE MONITORING

- MIL-STD 1521A REVIEWS AND AUDITS
- SPECIAL SOFTWARE REVIEWS
- ICWG
- CRWG

MIL-STD 1521A

- SRR
  - — REQUIREMENTS ANALYSIS
  - — FUNCTIONAL FLOW ANALYSIS
  - — ILS ANALYSIS
  - — SYSTEM INTERFACE STUDIES
  - — LIFE CYCLE COST ANALYSIS
  - — IDENTIFY COMPUTER PROGRAM SEGMENTS

MIL-STD 1521A

- SDR
  - MISSION AND REQUIREMENTS ANALYSIS
  - FUNCTIONAL ANALYSIS
  - REQUIREMENTS ALLOCATION
  - SYSTEM/COST EFFECTIVENESS
  - RELIABILITY/MAINTAINABILITY
  - ILS (INCLUDING MAINTENANCE CONCEPT AND SOFTWARE SUPPORT CONCEPT)

MIL-STD 1521A

- SDR (CONT'D)
  - — SYSTEM GROWTH CAPABILITY
  - — PROGRAM RISK ANALYSIS
  - — PRODUCIBILITY (PROCESSES, FACILITIES, SKILLS, ETC.)
  - — LIFE CYCLE COSTING
  - — TRADE STUDIES
    - PROGRAMMING LANGUAGE COSTS
    - HARDWARE/SOFTWARE/FIRMWARE

MIL-STD 1521A

- SDR (CONT'D)
  - — COMPUTER PROGRAM DEVELOPMENT PLAN
    - IDENTIFY ALL CPCIs
    - DEVELOPMENT SCHEDULE FOR EACH CPCI
    - MONITORING AND REPORTING PROCEDURES
    - PROGRAMMING CONVENTIONS AND STANDARDS
    - DEVELOPMENT METHODOLOGIES
    - MAINTENANCE PROCEDURES AND REQUIRED FACILITIES
    - SIZE AND COST ANALYSIS

MIL-STD 1521A

- PDR
  - SW FUNCTIONAL FLOW
  - FUNCTIONAL INTERFACES
  - STORAGE ALLOCATION FOR EACH CPCI
  - CONTROL FUNCTION DESCRIPTION
  - PROGRAM STRUCTURE
  - SECURITY
  - REENTRANCY
  - SOFTWARE DEVELOPMENT FACILITY
  - DEVELOPMENT TOOLS
  - DESCRIPTIONS OF “OFF-THE-SHELF” EQUIPMENT
  - DETERMINE COMPLIANCE TO TADSTAND REQUIREMENTS

MIL-STD 1521A

- CDR
  - DRAFT COMPLETE PART II PRODUCT CPCI SPECIFICATION
    - PDS (FINAL)
    - PDD
    - IDS (FINAL)
    - DBD
  - SUPPORT/DEVELOPMENT SOFTWARE
  - SW/SW AND SW/HW INTERFACES
  - ESTABLISH COMPATIBILITY BETWEEN DEVELOPMENT DOCUMENTATION

MIL-STD 1521A

- CDR (CONT'D)
  - REVIEW TEST DOCUMENTATION
  - DETERMINE CONFORMANCE TO TAD STAND REQUIREMENTS

"SINCE COMPUTER PROGRAM DEVELOPMENT IS AN INTERACTIVE PROCESS, THE COMPLETION OF A CDR IS NOT NECESSARILY SUFFICIENT FOR MAINTAINING ADEQUATE VISIBILITY INTO THE DEVELOPMENT EFFORT THROUGH TESTING. ADDITIONAL IN-PROGRESS REVIEW MAY BE REQUIRED."

ADDITIONAL MECHANISMS

- INTERFACE CONTROL WORKING GROUP (ICWG)
- COMPUTER RESOURCES WORKING GROUP (CRWG)
  - — AFR 800-14 VOL. II SECTION 3-10

ADEQUATE DOCUMENTATION

MID-STD 1679 DOCUMENTATION

- DEVELOPMENT
- DEVELOPMENT MANAGEMENT
- TEST
- USER MANUALS

DEVELOPMENT DOCUMENTATION

- SYSTEM SPECIFICATION "TYPE A"
- INTERFACE DESIGN SPECIFICATION (IDS)
- PROGRAM PERFORMANCE SPECIFICATION (PPS)
- PROGRAM DESIGN SPECIFICATION (PDS)

- PROGRAM DESCRIPTION DOCUMENT (PDD)
- DATA BASE DESIGN (DBD)
- PROGRAM PACKAGES (PP)

DEVELOPMENT MANAGEMENT DOCUMENTATION

- SOFTWARE QUALITY ASSURANCE PLAN
- SOFTWARE CONFIGURATION MANAGEMENT PLAN
- SOFTWARE DEVELOPMENT PLAN

AD-A142 784 PROCEEDINGS PAPERS OF THE AFSC (AIR FORCE SYSTEMS COMMAND) AVIONICS STAND..(U) AERONAUTICAL SYSTEMS DIV WRIGHT-PATTERSON AFB OH DIRECTORATE O..

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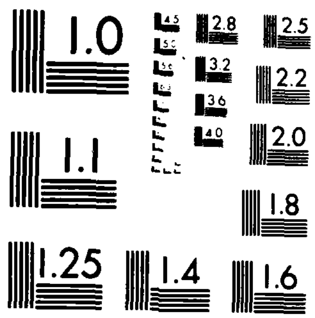


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TEST DOCUMENTATION

- TEST PLAN
- TEST SPECIFICATION
- TEST PROCEDURES
- TEST REPORT

USER MANUALS

- OPERATOR'S MANUAL
- SYSTEM OPERATOR'S MANUAL

SOFTWARE SUPPORT ISSUES

- EARLY SELECTION OF A SOFTWARE SUPPORT ACTIVITY (SSA)
- COORDINATION BETWEEN SSA, PM, DEVELOPER

SOFTWARE SUPPORT PLANNING

- CRLCMP
- ILSP

SUFFICIENT TESTING

MORE THAN 85% OF THE ERRORS FOUND DURING T&E COME FROM REQUIREMENT DEFICIENCIES

1. PERFORMANCE CRITERIA INADEQUATE
2. REQUIREMENTS INCOMPATABILITY
3. ENVIRONMENTAL DATA INCOMPLETE
4. MISSION INFORMATION INCOMPLETE
5. OPERATING RULES INADEQUATE OR MISSING

MODIFICATION OF 27 LINES OF CODE REQUIRED

MAJOR ERROR CATEGORIES

*	LOGIC	26%
*	DATA HANDLING	18%
**	INTERFACE	16%
**	I/O	14%
*	COMPUTATIONAL	9%
**	DATA BASE	7%
	OTHER	10%

* USUALLY DETECTED IN EARLY STAGES OF TESTING

** USUALLY DETECTED IN LATER STAGES OF TESTING

- **SOFTWARE TESTING**

— DOCUMENTATION	FORMAL
— FORMAL REVIEWS	FORMAL
— WALK-THROUGH	INFORMAL
— UNIT	INFORMAL
— MODULE	INFORMAL
— SUBPROGRAM	INFORMAL
— PROGRAM PERFORMANCE	FORMAL
— SYSTEM INTEGRATION	INFORMAL
— SYSTEM PERFORMANCE/ SOFTWARE QUALITY ASSURANCE	FORMAL

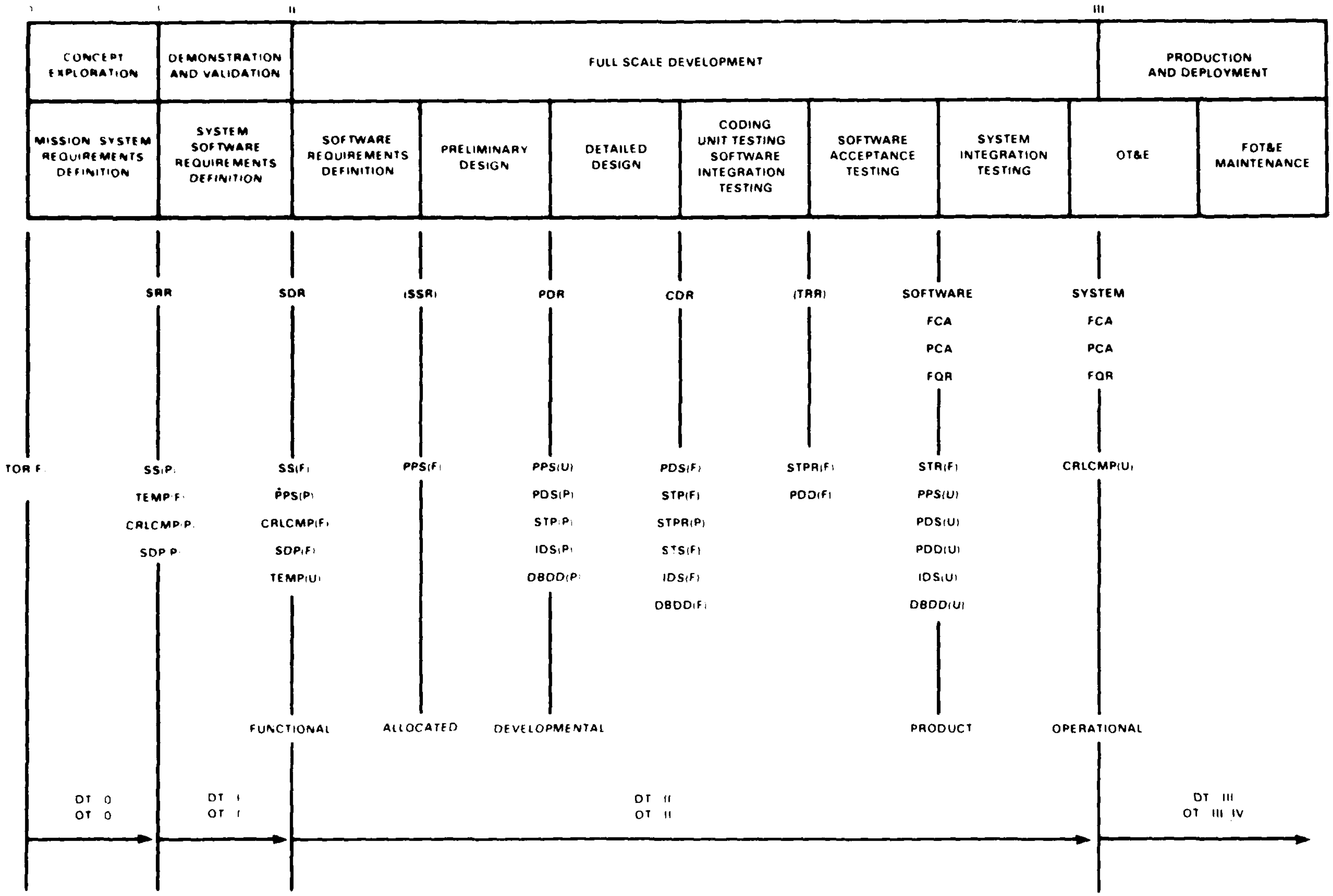
DOD - 5000.3 POLICIES

- EARLY T&E INVOLVEMENT
- T&E RESULTS DICTATE MILESTONE DECISIONS
- <u>SUBJECTIVE</u> T&E TO BE MINIMIZED
- DT&E AND OT&E DEFINED AND MANDATED
- SOFTWARE T&E IS REQUIRED

- TYPES OF T&E PRESCRIBED
  - DT&E
  - OT&E
  - PAT&E
- T&E THROUGHOUT THE ACQUISITION LIFE CYCLE

SOFTWARE ACQUISITION LIFECYCLE

(P) DENOTES PRELIMINARY
(F) DENOTES FINAL
(U) DENOTES UPDATED



GOVERNMENT SOFTWARE TESTING

- LBTS SELECTION
- TEST AGENT SELECTION
- IV & V CONTRACTOR

TESTING TECHNIQUES

- DESK CHECK
- PEER REVIEW
- UNIT TEST
- STRUCTURE ANALYZER
- TEST DATA GENERATOR
- EXECUTION MONITOR
- TEST COVERAGE ANALYZER
- SIMULATIONS

SOFTWARE T&E INPUTS TO THE TEMP

- IDENTIFICATION AND CATEGORIZATION OF REQUIRED SOFTWARE
- EXPECTED LEVEL OF TESTING
- SOFTWARE TESTING STANDARDS
- DT&E TEST RESPONSIBILITIES
- SIMULATION/TEST SUPPORT SOFTWARE
- SOFTWARE MILESTONES
- SOFTWARE IV & V REQUIREMENTS

QUALITY ASSURANCE

SOFTWARE QUALITY ASSURANCE

PURPOSE:

ASSURE THAT SOFTWARE DEVELOPED, ACQUIRED, OR OTHERWISE PROVIDED UNDER THE CONTRACT COMPLIES WITH THE REQUIREMENTS OF THE CONTRACT

SOFTWARE QA's INVOLVEMENT

- PLANNING
- SELECTION OF TOOLS, TECHNIQUES AND METHODOLOGIES
- DOCUMENTATION REQUIREMENTS
- COMPUTER PROGRAM LIBRARY CONTROLS
- REVIEWS AND AUDITS
- CM
- TESTING

SOFTWARE QA's INVOLVEMENT

- CORRECTIVE ACTIONS
- WORK CERTIFICATION
- SUBCONTRACTOR CONTROL

CONFIGURATION MANAGEMENT

SOFTWARE CONFIGURATION MANAGEMENT

- CONFIGURATION IDENTIFICATION
- CONFIGURATION CONTROL
- CONFIGURATION STATUS ACCOUNTING
- CONFIGURATION AUDITS
- CONFIGURATION AUTHENTICATION

POST DEVELOPMENT SUPPORT

SOFTWARE SUPPORT ACTIVITY

- FACILITIES
- SUPPORT HARDWARE RESOURCES
- SUPPORT SOFTWARE RESOURCES
- PERSONNEL RESOURCES

FACILITIES

- ORGANIZATION
- PHYSICAL
  - LAND
  - BUILDINGS
  - SUPPORT EQUIPMENT

SUPPORT HARDWARE RESOURCES

- SYSTEM HARDWARE/TESTBED
- EMULATED/SIMULATED SYSTEM HARDWARE
- PERIPHERAL DEVICES
- FIRMWARE PROGRAMMING EQUIPMENT
- COMPUTER/ ANALYZERS

SUPPORT SOFTWARE RESOURCES

- COMPILER/CROSS-COMPILER
- ASSEMBLER/CROSS-ASSEMBLER
- LINK EDITOR
- OPERATING SYSTEMS
- LIBRARY/FILE -HANDLING SOFTWARE
- SIMULATION SOFTWARE

- REQUIREMENTS ANALYZER
- PROGRAM SPECIFICATION LANGUAGE
- PROGRAM DESIGN LANGUAGE (PDL)
- PROGRAMMING DEBUGGING TOOLS

PERSONNEL RESOURCES

- DESIGN/REDESIGN
- CONFIGURATION MANAGEMENT
- QUALITY ASSURANCE
- CODING
- TESTING/INTEGRATION
- TRAINING

CASE STUDY

NAVAL ELECTRONIC SYSTEM CASE STUDY

OBJECTIVES:

- PROVIDE AN EXERCISE IN ANALYZING EMBEDDED COMPUTER SOFTWARE MANAGEMENT ACTIVITIES
- PROVIDE AN OPPORTUNITY TO THE PARTICIPANT TO APPLY HIS OWN SKILLS AND EXPERIENCE TO A SET OF TYPICAL PROBLEMS
- PROVIDE THE OPPORTUNITY FOR PARTICIPANTS TO TRACE THROUGH THE ENTIRE DEVELOPMENT CYCLE OF A SOFTWARE DEVELOPMENT

NAVAL ELECTRONIC SYSTEM CASE STUDY

SYSTEM ACQUISITION CONSIDERATIONS:

- MAJOR SYSTEM ACQUISITION
- VERY HIGH PRIORITY
- OVERLAPPING DEVELOPMENT AND PRODUCTION
- VERY ADVANCED SYSTEM
- DISTRIBUTED SYSTEM
- SIMULTANEOUS SOFTWARE AND HARDWARE DEVELOPMENT
- HARDWARE AND SYSTEM PRIME CONTRACTOR WITH SOFTWARE SUB-CONTRACTOR

NAVAL ELECTRONIC SYSTEM CASE STUDY

- HISTORY
  - RFP RELEASED (10/74)
  - PRELIMINARY PPS (4/75)
  - CONTRACTOR SELECTED (8/75)
  - CONTRACT FOR FSD (3/76)
  - NOSC AND NESEC APPOINTED SW AGENTS (3/76)
  - PRELIMINARY PPS (6/76)
  - CODING HAD COMMENCED (7/76)
  - MISSED 2'ND SW INCREMENT (11/76)
  - NEW PPS (2/77)

NAVAL ELECTRONIC SYSTEM CASE STUDY

- **HISTORY CON'T**
  - PARTIAL DELIVERY OF 2'ND SW INCREMENT (2/77)
  - INITIATED SW/HW INTEGRATION (2/77)
  - EXPECTED DELIVERY OF INTEGRATED TESTED SYSTEM (9/77)
  - SW DEVELOPMENT RELOCATED TO TEST SITE (12/77)
  - FIRST SYSTEM FIELDED (3/79)
  - UNDER GOVT CONFIGURATION CONTROL (6/79)
  - OPEVAL (9/80)
  - TRAINING SITE FULLY OPERATIONAL (6/81)

NAVAL ELECTRONIC SYSTEM CASE STUDY

- **SOFTWARE DEVELOPMENT APPROACH**
  - TOP DOWN DESIGN (MIL-STD-1679)
  - STRUCTURED CODE (MIL-STD-1679)
  - NAVY STANDARD COMPUTERS AND HOL (TADSTANDS)
  - DOCUMENTATION (MIL-STD-1679)
  - REVIEWS AND AUDITS (MIL-STD 1521A)
  - INDEPENDENT VALIDATION AND VERIFICATION (IV + V)
  - INCREMENTAL DEVELOPMENT AND DELIVERY
  - WORK BREAKDOWN STRUCTURE (MIL-STD-881A)
  - COST/SCHEDULE CONTROL SYSTEM (DODI 7000.2)
  - PROVIDED FOR BOTH SOFTWARE SUPPORT AND SOFTWARE MAINTENANCE AGENTS.

NAVAL ELECTRONIC SYSTEM CASE STUDY

SOFTWARE ACQUISITION PROBLEMS:

- UNREALISTIC COST AND SCHEDULE ESTIMATES
- INTEGRATION OF HARDWARE AND SOFTWARE
- LIMITATIONS OF NAVY STANDARD HARDWARE
- PROBLEMS CAUSED BY LATE DELIVERY
- NEITHER COST OR SCHEDULE WERE REEVALUATED
- INCOMPLETE TESTING CRITERIA

A NAVAL ELECTRONIC SYSTEM DEVELOPMENT (Cont'd)

- CONCLUSIONS
  - INITIAL PLANNING WAS GOOD
    - STATE-OF-THE-ART TECHNOLOGY
    - DEVELOPMENT OF SOFTWARE SUPPORT AGENCY
    - TRAINING REQUIREMENTS
    - THIRD PARTY MONITOR
    - USE OF USER COMMUNITY PERSONNEL
    - USE OF REVIEWS AND AUDITS
  - UNDERESTIMATION OF EFFORT
  - MANY INTEGRATION PROBLEMS COULD HAVE BEEN PRECLUDED BY PLANNING AND THE DEVELOPMENT OF GOOD INTERFACE SPECS
  - LACK OF TEST CRITERIA IMPACTED DEVELOPMENT
  - VALUE OF AN INDEPENDENT TEST CENTER BEING THE SAME AS THE V&V AGENT
  - IT IS NOT SUFFICIENT TO SPECIFY GOOD SOFTWARE DEVELOPMENT CRITERIA

SPECIFICATION SHEET

NAVAL ELECTRONICS SYSTEM CASE STUDY

TOPIC:

Management problems and solutions associated with a Naval electronics embedded computer software system throughout its development history.

TYPE: Case Discussion, 1 1/2 Hrs.

OBJECTIVES:

. To provide the participant with an exercise in analyzing embedded computer software management activities.

. To provide the participant with an opportunity to apply his own skills and experience to a set of typical problems associated with virtually every complex software intensive system.

. To provide the opportunity for participants to trace, in a single thread fashion through the entire development cycle of a system as it experiences early difficulty, periods of constant reassessment, and finally, success.

NAVAL ELECTRONICS SYSTEM

DISCUSSION:

In the fall of 1974, the Navy Project Management Office - Electronics (PME) solicited an RFP for proposed system designs for a naval electronics system. Of the original 38 contractors who attended the initial briefing, four teams of contractors submitted proposals. Two of these contractor teams were eliminated, primarily due to the fact that their proposals disclosed that the contractors did not understand the depth and complexity of the requirements. The remaining two contractors were selected to submit system specifications by April of 1975. At that time, two contenders were placed under cadre tasking while their proposals were evaluated. Under the cadre tasking, the two contractors were directed to further refine their specifications and to develop preliminary Program Performance Specifications (PPSs). In August of 1975, the PME selected one company as the prime contractor with a separate company as the major software developer. The software subcontractor was directed to continue development of the PPS and the Program Design Specification (PDS). The contract for full scale development was signed in March of 1976.

Under the terms of the contract, the software subcontractor was required to utilize a top-down modular design methodology, the CMS-2 high order language, and structured programming techniques. As top-down implementation of the design proceeded, the software subcontractor would deliver software in four basic increments resulting in a final delivery of an integrated, tested software system by May 1977. System integration of software to hardware was specified for completion, with acceptance testing, by September 1977. This allowed a period of only 18 months from the start of full scale development to completion of acceptance testing for a system composed of 18 hardware racks and associated system software; a very ambitious contract.

The PME, realizing that they had a lack of computer software trained personnel, negotiated with the Naval Ocean Systems Center (NOSC) to provide software support during the development phase of the program. NOSC is a major Navy laboratory that is electronics-oriented. They experiment in microelectronics, radar, and satellite systems. On this program, NOSC was specifically tasked to:

1. Provide support to the PME during the review and evaluation of contractor produced software and documentation.

2. Serve as the single point of contact in the provision of software support to the prime contractor.

3. Provide facilities and instruction to the computer system hardware and software maintenance agent, the Naval Electronic Systems Engineering Center (NESEC).

4. Install Level 2 Support Software (CMS-2M, SDEX120) at the contractor development and test facilities.

5. Perform testing and verification of incremental software deliveries and report results to the PME.

In support of these requirements, NOSC would partake in all design and program reviews, computer program regeneration, and computer program acceptance demonstrations.

NESEC, San Diego was designated as the software maintenance agent. It was recognized that NESEC would have to participate in all phases of development to gain the necessary experience to undertake software support functions upon completion of system development. NESEC personnel were to interface, primarily with NOSC, to gain the needed hands-on experience.

During the eleven-month cadre tasking period, the software subcontractor continued to refine the system specifications and develop the PPS and the PDS. A preliminary PPS was delivered just prior to the signing of the full scale development contract. Within 90 days of the contract signing, a preliminary PDS was delivered. No realistic new cost or schedule reestimation was attempted.

Upon delivery, the PPS and the PDS were submitted to exhaustive design reviews. The PPS document was determined, with minor exceptions, to accurately specify system requirements but was not in the format required by SECNAV Instruction 3560.1. Rewriting of the PPS, in accordance with the instruction, resulted in a six-month delay in delivery and acceptance of the final document with corresponding delay in placing the allocated baseline under configuration management control. The initial version of the PDS constituted well over 1000 pages and was subsequently determined by the software contractor to specify design requirements at too low a level and in too great detail. The final document was on the order of 200-300 pages. A significant shortcoming of the PDS was that it did not provide detailed interface specifications between software and hardware.

The programming phase of software development commenced upon initiation of the development contract. The software subcontractor began coding before either the PPS or the PDS were finalized. In July of 1976, it became apparent that the software subcontractor was not spending funds in accordance with the Cost and Schedule Control Program (as required by DODD 7000.2). This initiated an investigation that indicated that the software developer was not meeting the scheduled requirements for delivered lines of executable code. Although reluctant to admit to development delays, the software subcontractor eventually had to acknowledge that they were experiencing significant software production difficulties when they missed delivery of the second software increment in November of 1976. In December of 1976, a number of actions were recommended to contain cost growth and to schedule a slip in the program. Among the actions taken were replacement of an IBM 370/135 support computer with an IBM 370/145, partial delivery of the second software increment, and significant reorganization of the software subcontractor management. At this time, software development was from three to four months behind schedule.

With the partial delivery of the second increment of software in February of 1977, integration of software to hardware began. It soon became apparent that significant problems existed in accomplishing the integration because of inadequate implementation of interface controls within the software. As integration difficulties expanded, more and more resources were diverted to the test site to contain the problem. In order to allow more time to deal with integration problems, the hardware development began to drive the software.

Even though software development was three to four months behind, the Navy refused to relax the schedule. This resulted in abandoning incremental deliveries in favor of drop deliveries of software modules which would interface with the emerging hardware devices. This required that the software subcontractor reestablish software priorities to support hardware availability. The change from incremental software deliveries to drop deliveries seriously impacted verification and the test center's ability to provide test results in a timely manner.

At the same time, a problem of simple logistics became evident. The 400 mile separation between the test site and the software development personnel was creating additional delays in development. As a result, in December 1977, all software development personnel were relocated to the test site to optimize the integration process.

While the major software development was going on by the software subcontractor, NOSC was expending considerable resources in establishing an independent verification and test center at NESEC, San Diego. A test facility, consisting of operator consoles and AN/UYK-20 computers with supporting peripherals, was set up. Test drivers which simulated the various system hardware devices were written. Software increments were simultaneously delivered by the software subcontractor to NOSC and to the main test site at the prime contractor's facility. Various tests conducted on software delivered by the software subcontractor uncovered errors, especially in modules which interfaced to hardware. There was, however, no correlation performed with errors discovered at the main test site so it could not be determined which proportion of errors discovered at NOSC accurately reflected errors which were caused by improperly coded test modules. Although NOSC's test facility was similar to the system configuration in computer and peripherals, the front-end was software simulated. Errors discovered in the system were often duplicates of errors uncovered by the prime contractor. Front-end errors were often attributed to the software simulation at the San Diego test site.

Although the San Diego test center did perform verification functions, the primary purpose of the center was to provide training to NESEC personnel. Due to the high priority and expedited schedule of the program, there was not the usual three to four year test phase to gain knowledge. Therefore, the test activities at NOSC provided invaluable experience for the software maintenance personnel from NESEC.

At the present time, system deployment is on schedule. The first system was fielded three years following the start of full scale development. The software subcontractor is under a maintenance contract to help clear "bugs" and provide training to NESEC personnel. Although no changes were allowed during the initial production due to the tight schedule, approximately 100 class II changes were presently in work in 1978. Most of these changes are to improve efficiency by revisions to the display format, timing, etc.. In the summer of 1979, the Navy assumed configuration control at the code level. All libraries were removed from the prime contractor and assumed by the Navy.

CONCLUSIONS:

Given the scarcity of formal guidance and the lack of computer software trained personnel, the PME did a commendable job in advance planning and utilization of computer resources for the project. State-of-the-art design and development techniques were demanded of the contractor such as new hardware, new support software, top down structure, and the latest USN standards and specifications. The need for a maintenance support agency for post-development phases of the software life cycle was recognized early. Foresight was evident in insuring that the maintenance agency would receive adequate training and participate in all aspects of development. Acknowledging their lack of software expertise, the PME employed NOSC to assist in providing for quality assurance of the delivered product. The use of a high order language, structured programming, and good program documentation was specified to improve ease of software maintenance. Personnel from the user community were trained and incorporated into the test program. Problems in production were detected early and aggressively attacked by the project management group. Unfortunately, advance planning and close program monitoring by the PME were not sufficient to prevent a significant software cost overrun and schedule slippage.

The two predominant causes of cost overrun and schedule slippage were underestimation of the task complexity by the major software contractor and inadequate planning for the system integration by the prime contractor. Discussions with the software subcontractor disclosed that they themselves felt that the complexity of software requirements was grossly underestimated due to the utilization of a relatively naive engineering team to initially scope the problem and design the system. Specifications resulting from this effort were not adequately reviewed by higher level management within the software subcontractor organization and were not balanced against preliminary cost and time estimations. Software subcontractor management admitted that this could have been accomplished by project management personnel if adequate funds and time had been provided. The assumption that the underestimation of program complexity was a main problem is borne out by growth in source code and by code production figures for the project which show that lines of code produced per manhour were slightly above average for the industry. It can also be shown that the software subcontractor's original budget for cost per executable lines of code called for a production rate well above the norm. In spite of these problems, the delivered code is generally of good quality with the exception of the interface software controls.

The software and hardware developing agencies must both be held accountable for integration of software to hardware. If the interface is designed properly, there is no good reason why hardware and software developers cannot meet specifications which will promote a smooth integration. Much of the delay that was realized in system integration for the project was due to the failure to produce rigid interface design specifications early in the project and plan them under configuration control. Another cause of delay in system integration was the lack of planning for this phase of development. The prime contractor, who was tasked with final responsiblity for system integration, failed to provide a functional integration plan. They allowed only 33 manmonths for the software developer to accomplish its portion of the task. The emergence of various items of hardware to meet Navy schedules even though software was late, was permitted to become the main driving force behind the path of integration thereby pertubating the software development plan and further aggravating the schedule for delivery of software.

Other factors which impacted software cost and delivery includes: failure to finalize the PPS and the PDS before commencement of coding; lack of adequate test plans, specifications, and procedures, and lack of well-defined acceptance criteria; lack of AN/UYK-20 software support diagnostic and debugging aids; and lack of software engineering personnel within the PME. Failure to finalize the PPS and the PDS before the start of programming permitted the incorporation of design errors into the program which proved very costly to eliminate at a later date. In addition, problems were often pushed off for later resolution and often resulted in unforeseen ramifications in other program modules. For the same reasons, inadequate test plans and procedures can prove costly if the program is not tested properly to insure that all requirements are being met. An early definition of good test specifications and acceptance criteria will assist the developer in understanding the requirements and motivate him to deliver a product which meets acceptance goals. The inadequate test plans on this project substantiate the fact. Frequently, the software subcontractor had no concept of an adequate acceptance criteria for their software modules. The quality of documentation between the prime contractor and the subcontractor was poor. Although the software subcontractor requested more definitive procedures, the prime contractor did not. Since this program was one of the first to use the AN/UYK-20 computer, the Navy lacked support software to support structured code. This forced the contractor to direct resources to develop the necessary tools. Although the Navy was driving the use of structured codes, the Navy was not ready to support these types of systems.

Another issue implicit in the study of this project is the lack of land based test sites within this Navy organization. Such sites can provide facilities for software maintenance, independent acceptance testing, and training for both support agency personnel and the user community. The PME had to develop its own maintenance and test site to meet the project requirements.

The desirability of a verification and test center, such as furnished by NOSC, in major software development programs is questionable. The requirement to verify all computer programs as they are delivered levies a significant software development task on the test center that must parallel the efforts of the major developing agency. It is not clear whether the test center might not either substantially delay the whole program or be entirely bypassed if they do not produce on schedule. Moreover, if errors were discovered, it would not be readily apparent that they had not been introduced by the test center through test drivers and simulators. What is clearly needed is an agency to provide support in the areas of software engineering, program monitoring, and test plan and acceptance criteria development. It would be highly desirable if this support could be provided by the designated post-development software maintenance agency who has a vested interest in the final product. Any proposed agency of this type should be under the control of the PME. Both the PME and any post-development software maintenance agency would be highly motivated to insure adequate system configuration and implementation

NAVAL ELECTRONICS SYSTEM CASE STUDY

QUESTIONS

1. Based on the history of this project, discuss the pros and cons of a separate test agency.

2. Discuss the various pitfalls of a project such as this one where development and production run simultaneously in order to meet critical schedules.

3. What steps should a project management office take when a contractor is obviously producing poor or inadequate software estimates?

4. Discuss the problems that occurred and the result of the Navy requesting structured codes before they had the capability to support such systems.

5. Discuss the problems that can occur when hardware and software are developed concurrently.

6. Discuss the steps which you would take, given the mission and role of the PME, to preclude the management problems indicated in the case study.

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