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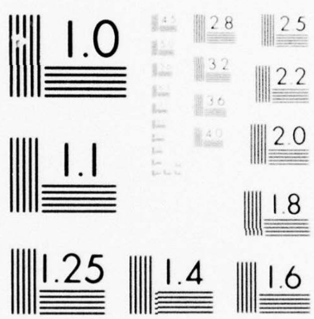

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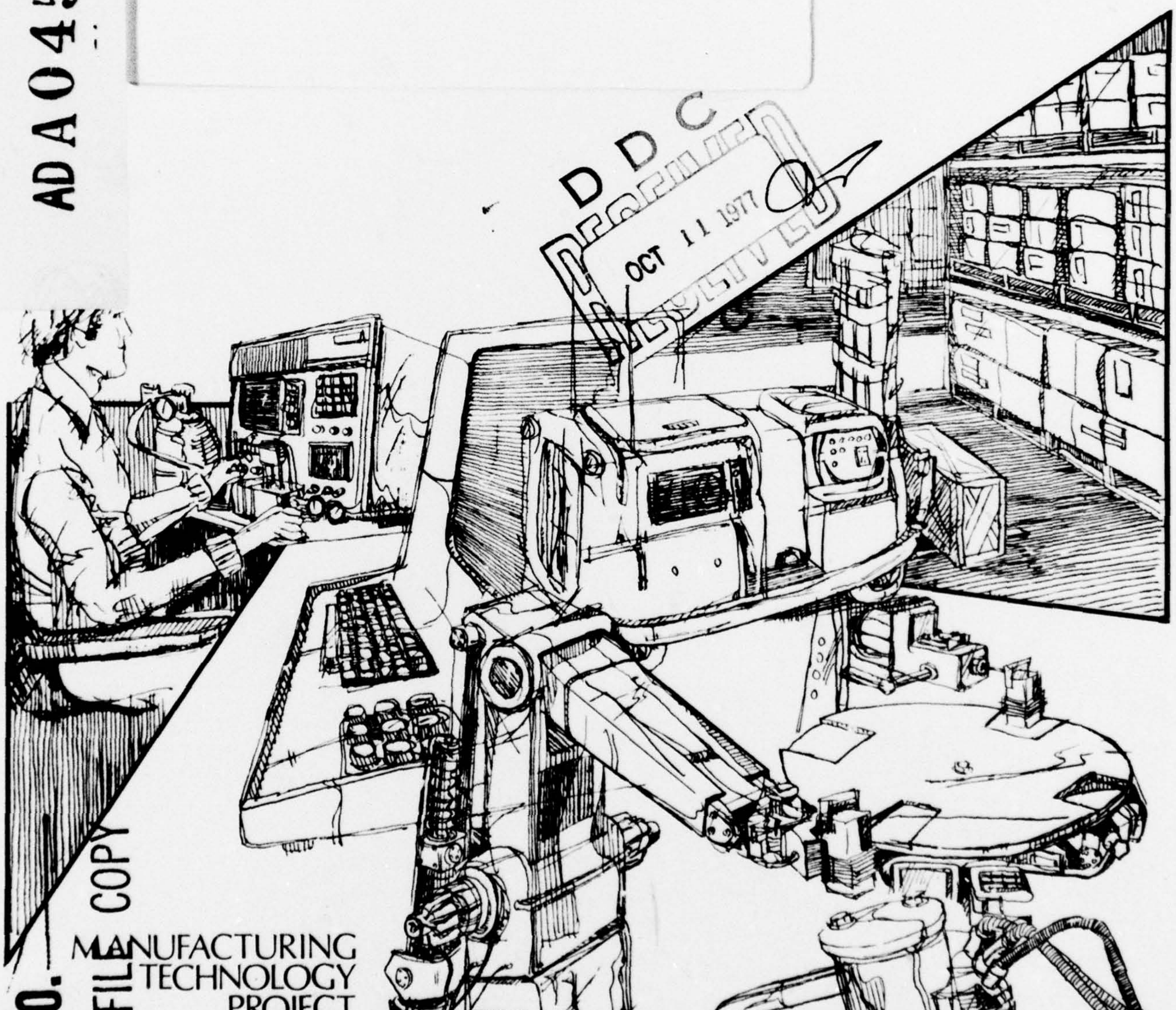

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MANUFACTURING
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THE NAVY MANUFACTURING TECHNOLOGY ELECTRONICS STUDY. - A PLAN FOR COST EFFECTIVE ELECTRONICS IN THE NAVY.

Volume III.
APPENDICES.

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This report was prepared for internal Navy planning purposes only. The data contained herein, while accurate at the time of publication (June 1977), may be subject to frequent revision. It is expected that the program described will be further developed prior to Fiscal Year 1980 due to further review, new technological inputs, and changing procurement priorities. The U.S. Navy is not presently committed or obligated in any way to carry out or follow all or any of the specific projects or recommendations described herein.

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Washington, D.C. 20360
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Volume III

VOLUME III

INTRODUCTION

This volume of the Navy Manufacturing Technology Electronics Study is a series of appendices relating to specific tasks performed during the project. Appendix A contains data summary sheets on 103 candidate MT projects suggested by industry and screened by the study team for entry into the analysis program, NEMTA. These projects form the base of the recommended Navy Electronics MT program. Appendix B describes incentives that industrial firms discussed with the study team. It has been recognized that only with the cooperation of industry will the goals of the Navy MT program be realized. The objectives and procedures of the industrial contacts are outlined in Appendix C. Lists of personnel contacted at Navy Contractors are given in addition. During the course of the study members of the team attended the Army ECOM Electronics Manufacturing Technology Conference. This proved to be a valuable forum for the interchange of ideas, and peer review of MT projects. As a result of this meeting about 50 additional MT project suggestions were introduced for analysis. Appendix D contains a brief analysis of the Conference itself.

A top-down analysis of Navy Weapons Systems costs was performed to facilitate the evaluation of MT projects. This is detailed in Appendix E. The economic analysis and computer program description (NEMTA program) are given in Appendix F. Descriptions of the equipment and systems investigated in the study are included as Appendix G. A bibliography of useful references is summarized in Appendix H.

Appendix A
ELECTRONICS MT PROJECT DESCRIPTIONS

FORMAT EXPLANATION

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. *Sequential*

TITLE: (*Descriptive Title of Proposed Project*)

COSTS: (*In thousands of dollars for each fiscal year*)

AREA OF COST SAVINGS: *Material or labor cost category where hardware cost savings occur; cross reference product related factors from Table A-1.*

METHOD OF COST SAVINGS: *Method of instituting cost savings; cross reference process related factors from Table A-2.*

APPLICABLE NAVY SYSTEMS: *Specific weapon/support system affected; cross reference systems and identifying numbers from Table A-3.*

TECHNICAL OBJECTIVES: (*Key areas to be addressed*)

BACKGROUND: (*Previous methods used*)

APPROACH: (*Basic way of conducting project*)

BENEFITS: (*Estimate including percentage of cost reduction in savings area indicated above*)

IMPLEMENTATION: (*Special features involved in carrying out this project*)

RELATED EFFORTS: (*Other Projects*)

RISK FACTOR: (*Quantitative evaluation of potential risks*)

Table 4a. Product Related Cost Factors*

PRIME CONTRACTOR

	Item	Percent
Hardware Costs (Total=100%)	**Materials, components (often subcontracted)**	
	1. Cabinets, cables, interconnects	13.3%
	2. Sensors, antennas, special tubes	13.3%
	3. Integrated circuits	8.0%
	4. Small hardware, PCB, connectors	8.0%
	5. Discrete semiconductors	4.0%
	6. Hybrid circuits	2.4%
	7. Passive components	2.0%
	Subtotal	51%
	Labor	
	8. Assembly	15%
	9. Fabrication	11%
	10. Support	13%
	11. Test	10%
	Subtotal	49%

TYPICAL SUBCONTRACTOR DISTRIBUTION

1. Raw material	50%
2. Labor	
a. fab/assembly	24%
b. test/support	26%
Total	100%

Non-hardware costs

Item	Percent	
Software	5-15%	22-50% over & above hardware costs
Systems integration	5-10%	
Shipping containers	2-10%	
Documentation	10-15%	

*cf Vol. III, Appendix E for analysis of cost breakdown. All percents refer to total Hardware Costs.

Table 4b. Process Related Cost Factors

PROCESS*

1. Production, i.e., volume and continuity
2. Capital Expenditure, i.e., machinery for fabrication, assembly and test
3. Manufacturing Methods, i.e., design, fabrication, assembly and test
4. Institutional, i.e., depreciation and pricing policies

*Ranked in order of decreasing impact on reducing procurement costs (cf. Vol. III, Appendix E for further discussion)

Table A-3. Navy Weapon/Support Systems

NEMTA Model ID #	NEMTA Model Nomenclature
S01	DDG-47 AEGIS
S02	FFG-7 FRIGATE
S03	SSN 688 CLASS
S04	SSBN TRIDENT
S05	CSGN CRUISER
L10	BQQ-5 SONAR
L11	BQQ-6 SONAR
L12	SQQ-23 SONAR
L13	BQR-21 SONAR
L14	SSQ-41 SONOBUOY
L15	SSQ-53 SONOBUOY
L16	SSQ-62 SONOBUOY
L17	SATCOM SHIP TERMINAL
L18	PRC-104 RADIO
L19	IRR COMMO
L20	ESG NAVIG
L21	TPS-59 RADAR
L22	TPS-63 RADAR
L23	DTP EW SUITE
L24	AN/UYK-7 COMPUTER
L25	AN/UYK-20 COMPUTER
L26	AYK-14 COMPUTER
L27	NTDS
L28	AWG-9 WPN CNTR SYST
L29	TRAM
L30	SPS-49 SHIP RADAR
L31	SPS-58 SHIP RADAR
L32	ALQ-78 ECM SET
L33	ALR-59 EW SET
L34	AIMS
L35	APS 115 RADAR
A40	F14 A TOMCAT
A41	A7E CORSAIR
A42	P3C ORION
A43	E2C HAWKEYE
A44	A6E INTRUDER
A45	EA6B PROWLER
A46	LAMPS
A47	F18

continued on next page

Table A-3. Navy Weapon/Support Systems (continued)

NEMTA Model ID #	NEMTA Model Nomenclature
M60	HARPOON
M61	STANDARD ER
M62	STANDARD MR
M63	PHOENIX
M64	SPARROW
M65	SIDEWINDER
M66	HARM
M67	TOMAHAWK
M68	TRIDENT
080	MK-48 TORPEDO
081	MK15 PHALANX CIWS

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 1

TITLE: Metal Core PCB

COSTS: $85K FY80; $100K FY81

AREA OF COST SAVINGS: Hardware, PCB, #4

METHOD OF COST SAVINGS: Manufacturing Methods, #3

APPLICABLE NAVY SYSTEMS: Harpoon #M60
Standard Missile (ER) #M61
Standard Missile (MR) #M62
Sparrow #M64
HARM #M66
Tomahawk #M67
All Missiles #90

TECHNICAL OBJECTIVES: To develop lamination techniques for normal copper clad epoxy or polyimide PCB materials as a cost effective competitor to aluminum backed glass/epoxy multilayer PCB.

BACKGROUND: Heat rejection problems in missile electronics cause expensive custom PCB board for adequate dissipation at present.

APPROACH: Standard copper clad PCB materials, laminated in multilayer, capable of adequate heat rejection and exibiting thermal stress resistance.

BENEFITS: 50% savings in missile heat sink PCB. This amounts to a savings of 3% in category #4.

IMPLEMENTATION: Over two years

RELATED EFFORTS: IRD work has been completed at one firm; two separate proposals received.

RISK FACTOR: Medium to high

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 2

TITLE: *Conformal Coating - Moisture Seals*

COSTS: *$115K FY80; $100K FY81*

AREA OF COST SAVINGS: *Small hardware PCB, #4*

METHOD OF COST SAVINGS: *Manufacturing Methods, #3*

APPLICABLE NAVY SYSTEMS: *Harpoon #60*
Standard Missile (ER) #M61
Standard Missile (MR) #M62
Sparrow #64
Harm #M66
Tomahawk #M67
All Missiles #90

TECHNICAL OBJECTIVES: *To reduce manufacturing rework on PC boards due to inadequate coating. Make a thorough study of various coating materials, and new coating methods.*

BACKGROUND: *Coating imperfections require rework of PCB's.*

APPROACH: *Investigation of wide range of alternatives, measure cost effectiveness.*

BENEFITS: *Industrial sources estimate improved coating of PCB would be $100 savings/missile; savings range from .2% to one 2% of category 4 for various missiles.*

IMPLEMENTATION: *At about 100K per additional plant for coating deposition equipment.*

RELATED EFFORTS: *Need to be ascertained - First part might relate to review of other firm's efforts. Two separate proposals received.*

RISK FACTOR: *Low to medium.*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 3

TITLE: Group Technology/Parts Classification

COSTS: $180K FY80; $160K FY81; $285K FY82; $125K FY83

AREA OF COST SAVINGS: Support labor, #10

METHOD OF COST SAVINGS: Capital expenditure, #2

APPLICABLE NAVY SYSTEMS: All Missiles #90
All Aircraft #91
All Ships #92
All electronics #93

TECHNICAL OBJECTIVES: Define and study the application of group technology to electronics assembly

BACKGROUND: Group Technology is starting to be applied to heavy industry where parts and manufacturing methods are well defined.

APPROACH: Define electronic parts and manufacturing operations as an initial phase.

BENEFITS: Difficult to quantify. Manufacturing firm suggests 2% of category 10 can be impacted

IMPLEMENTATION: Will need additional funding at each new firm; order of 250K

RELATED EFFORTS: In heavy industry

RISK FACTOR: High - needs to be standardized to be successful in wide spread implementation.

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ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 4

TITLE: Cost Savings via Standardized Soldering Specifications

COSTS: $350K FY80; $350K FY81

AREA OF COST SAVINGS: Assembly labor, #8

METHOD OF COST SAVINGS: Institutional, #4

APPLICABLE NAVY SYSTEMS: All Missiles #90
All Aircraft #91
All Ships #92
All electronics #93

TECHNICAL OBJECTIVES: To lower soldering costs by developing a simpler, more applicable standard based on newer soldering techniques

BACKGROUND: Redundant, conflicting, obsolete, unsupported or unproven specifications for soldering are claimed to exist

APPROACH: Streamline - and modernize the specification via firms inputs

BENEFITS: Lower cost of assembly - higher reliability. Industrial estimates 1.6% improvement in assembly labor category.

IMPLEMENTATION: First phase study of problem, test of alternate soldering techniques.

RELATED EFFORTS: Vapor soldering, etc.

RISK FACTOR: Initially High - must have cooperation of all specification issuing activities - Tri-service coordination needed - technical risk is fairly low overall however, and this is used in project rating

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 5

TITLE: *Smear Free Interconnect Holes - PCB*

COSTS: *$90K FY80; $60K FY81*

AREA OF COST SAVINGS: *Small hardware PCB, #4*

METHOD OF COST SAVINGS: *Manufacturing Methods, #3*

APPLICABLE NAVY SYSTEMS: *Harpoon #M60*
Standard Missile (ER) #M61
Standard Missile (MR) #M62
Sparrow #M64
Harm #M66
Tomahawk #M67
Phalanx CIWS #081
All Missiles #90
All Electronics #93

TECHNICAL OBJECTIVES: *Develop modified techniques - lower drilling speed, and faster feed to reduce smear. Emphasis is on the transfer of this to all firms*

BACKGROUND: *This is a long standing problem area in PCB assembly*

APPROACH: *Procedural*

BENEFITS: *Industry estimates fabrication labor savings of 10% (on PCB) and yield of +20% for 2500/typical missile. Together these economies result in a savings of 5% of category #4.*

IMPLEMENTATION: *Through demonstration and documentation of the problem and solutions determined*

RELATED EFFORTS: *Many - control of drill bit temperature by adaptive techniques is also possible, laser drilling could be tried.*

RISK FACTOR: *May be supplanted by more advanced technology, medium to high.*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 6

TITLE: *Computer Controlled Pattern Printing*

COSTS: *$70K FY80*

AREA OF COST SAVINGS: *Small hardware PCB, #4*

METHOD OF COST SAVINGS: *Manufacturing Methods, #3*

APPLICABLE NAVY SYSTEMS: *Harpoon #M60*
Standard Missile (ER) #M61
Standard Missile (MR) #M62
Sparrow #M64
Harm #M66
Tomahawk #M67
All Missiles #90

TECHNICAL OBJECTIVES: *CAD/CAM development of an "intelligent" plating system - one that allows for tank size - piece position, etc.*

BACKGROUND: *Plating yields for five line (~0.005") PCB applications could be improved if the details of the plating system were known before hand*

APPROACH: *Develop a CAD/CAM approach to take the basic design - compute necessary parameters, correct for manufacturing variables such as tank position*

BENEFITS: *Estimated at 5% yield increase or about 1-2% for category 4*

IMPLEMENTATION: *Through development of technology of controlled plating*

RELATED EFFORTS: *Possible - adaptive plating is an alternative*

RISK FACTOR: *Fairly high - no R and D done yet.*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 7

TITLE: *Automatic Gang Probing of Multilayer Thick Film Substrates*

COSTS: *$20K FY80; $20K FY81*

AREA OF COST SAVINGS: *Hybrid Circuits, #6*

METHOD OF COST SAVINGS: *Capital, #2*

APPLICABLE NAVY SYSTEMS: *Harpoon #M60*
Standard Missile (ER) #M61
Standard Missile (MR) #M62
Sparrow #M64
Harm #M66
Tomahawk #M67
All Missiles #90

TECHNICAL OBJECTIVES: *Construct a continuity check device for thick film hybrid application*

BACKGROUND: *Firm claims all thick film test is now done manually*

APPROACH: *Automated probing*

BENEFITS: *Reduce cost of hybrids about $10.00 each or about 5 to 10% of category 6. Savings range from about 1.5% to 6% from various missiles.*

IMPLEMENTATION: *20K per firm. Procedure is to build and test first unit - replicate for other applications*

RELATED EFFORTS:

RISK FACTOR: *Low*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 8

TITLE: *Revision of Rework Standards - Hybrid Circuits*

COSTS: *$200K FY80; $200K FY81; $200K FY82*

AREA OF COST SAVINGS: *Hybrid Circuits, #6*

METHOD OF COST SAVINGS: *Institutional, #4*

APPLICABLE NAVY SYSTEMS: *Standard Missile (ER) #M61*
Standard Missile (MR) #M62
Tomahawk #67
All Missiles #90

TECHNICAL OBJECTIVES: *To determine how much rework a hybrid can tolerate before reliability is degraded*

BACKGROUND: *Present hybrid rework specifications are claimed to be too restrictive and out of date since more tolerant materials are now used.*

APPROACH: *Develop basis for new standards - guidelines*

BENEFITS: *Claimed up to 10% of category 6 by new rework standards*

IMPLEMENTATION: *By manufacturer guidelines*

RELATED EFFORTS:

RISK FACTOR: *Medium*

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ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 9

TITLE: *Vapor Soldering - Automated Assembly*

COSTS: *$60K FY80; $50K FY81*

AREA OF COST SAVINGS: *Cabling #1, also PCB, Small hardware #4, and Assembly #8*
Assembly #8

METHOD OF COST SAVINGS: *Manufacturing Methods #3, Capital Equipment #2 (second year)*

APPLICABLE NAVY SYSTEMS: *AYK-14 #L26*
Harpoon #M60
Standard Missile (ER) #M61
Standard Missile (MR) #M62
Sparrow #M64
Harm #M66
Tomahawk #M67
All Missiles #90

TECHNICAL OBJECTIVES: *Establish vapor soldering as an automatic technique on a production line for military equipment.*

BACKGROUND: *Automated soldering via wave soldering is preferred but does not apply to some areas. PCB surface mounted capacitor chip, microstrips, etc., hand soldering is costly*

APPROACH: *Adapt a vapor - reflow soldering technique used in telephone industry*

BENEFITS: *30% reduction in solder assembly work in cabling or 2.0% in Category 1.*

IMPLEMENTATION: *License process from Western Electric*

RELATED EFFORTS: *Many - may be done without government intervention*

RISK FACTOR: *Risk in technique is very low*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 10

TITLE: *Interactive Fault Isolation Software*

COSTS: *$50K FY80*

AREA OF COST SAVINGS: *Test Labor, #11*

METHOD OF COST SAVINGS: *Capital, #2*

APPLICABLE NAVY SYSTEMS: *Standard Missile (ER) #M61*
Standard Missile (MR) #62
Sparrow #M64
Phalanx #081
All Missiles #90

TECHNICAL OBJECTIVES: *Fault location prompting assistance to operator via software*

BACKGROUND: *Identification of problem area in testing due to complexity - fully automatic system is out-of-the-question. Semi-automatic one seems feasible*

APPROACH: *Software generated prompting of operator*

BENEFITS: *Industrial estimate is that 2% of test labor will be saved.*

IMPLEMENTATION: *Via software development*

RELATED EFFORTS: *Automatic inspection techniques*

RISK FACTOR: *Medium*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 11

TITLE: Data Link - Supplier/Assembler

COSTS: $50K FY80

AREA OF COST SAVINGS: Support Labor #10, also Purchased Materials #1 through 7

METHOD OF COST SAVINGS: Production Volume #1

APPLICABLE NAVY SYSTEMS: Standard Missile (ER) #M61
Standard Missile (MR) #M62
Sparrow #M64
Phalanx CIWS #081
All Missiles #90
All Electronics #93

TECHNICAL OBJECTIVES: Measure the effect of real time data link between supplier and assembler in inventory control

BACKGROUND: Inventory optimization is difficult when small suppliers are involved, with frequent stopages in production

APPROACH: Develop data links and protocol to allow assembler to be aware of supplier difficulties

BENEFITS: May be vast (see below); initial industry estimates are 0.5 to 1% of support labor

IMPLEMENTATION: Via data link set up - test procedure development - should relate to previous work in auto industry (see below).

RELATED EFFORTS: Many - particularly in auto industry, where supplier - assembler data links are common.

RISK FACTOR: Low to medium

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 12

TITLE: Automated Fault Isolation

COSTS: $100K FY80; $100K FY81

AREA OF COST SAVINGS: Test #11

METHOD OF COST SAVINGS: Capital #2

APPLICABLE NAVY SYSTEMS: Standard Missile (ER) #61
Standard Missile (MR) #M62
Sparrow #M64
All Missiles #90
All Elextronics #93

TECHNICAL OBJECTIVES: Develop software for automatic fault isolation on digital and analog circuits

BACKGROUND: Manual fault isolation is too expensive

APPROACH: Using circuit mode probing fixture, computer guided probe method, with interactive software

BENEFITS: Large - contractor estimates of order of 10% in test labor

IMPLEMENTATION: Via software development, some hardware on hand already

RELATED EFFORTS: Yes - ECOM conference proposals

RISK FACTOR: Medium

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 13

TITLE: Automated Hybrid Circuit Assembly Justification

COSTS: $120K FY80; $250K FY81; $250K FY82

AREA OF COST SAVINGS: Hybrid Circuits, #6

METHOD OF COST SAVINGS: Capital, #2, Volume #1

APPLICABLE NAVY SYSTEMS: All Missiles #90
All Electronics #93

TECHNICAL OBJECTIVES: Develop automated die attach and wire bond for the low volume military hybrid area justification

BACKGROUND: Industry low volume hybrid assembly needs are not being met by the manufacturing equipment industries.

APPROACH: Survey the manufacturing equipment suppliers for alternate solution - purchase equipment and test

BENEFITS: Large savings for hybrid circuits are claimed economies on order of 5 to 10% of category #6.

IMPLEMENTATION: Via phase 1 study and subsequent equipment purchase and test

RELATED EFFORTS: Tape automated bondings - claim is made that this requires a high volume to support

RISK FACTOR: Technically - high due to competing schemes

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 14

TITLE: *Low Cost Hybrid via Redesign for Manufacturability*

COSTS: *$300K FY80; $300K FY81*

AREA OF COST SAVINGS: *Hybrid, #6*

METHOD OF COST SAVINGS: *Capital, #2*

APPLICABLE NAVY SYSTEMS: *F14 #A40*

TECHNICAL OBJECTIVES: *Cost driver analysis will indicate which of several suggestions to lower cost are beneficial.*

BACKGROUND: *F14 hybrids are nearly 10 years old in design - no design for manufacturability has been carried out.*

APPROACH: *Cost driver analysis of hybrid production, evaluation of approaches: eliminate package, more thick film circuitry, automatic seam weld package, laser trimming, automated wire bond, and automated test.*

BENEFITS: *Estimated at 10-20% of hybrid costs, or roughly 1 to 2% of category.*

IMPLEMENTATION: *Specific to F14*

RELATED EFFORTS: *At firm IRD and other programs would benefit this work - in industry extensive efforts*

RISK FACTOR: *Low*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 15

TITLE: Manufacturing Methods for Magnetic Components

COSTS: $150K FY80; $300K FY81

AREA OF COST SAVINGS: Passive Comp #7

METHOD OF COST SAVINGS: Manufacturing Methods #3

APPLICABLE NAVY SYSTEMS: AWG9 #L28

TECHNICAL OBJECTIVES: Develop new manufacturing methods for high voltage transformers

BACKGROUND: Technology of manufacture of magnetic components, e.g., transformer is out-of-date.

APPROACH: A design for manufacturability study: areas of concentration in design for manufacturability study include: core winding, corona-free interconnects, solid encasulation, welded connection, and potting.

BENEFITS: 5 to 10% saving in area of passive component's projected. Approximately 2.5 to 5%

IMPLEMENTATION: Phase 1 evaluation DFM study, phase 2 test

RELATED EFFORTS: None are known

RISK FACTOR: Medium

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ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 16 (DNA 00579)

TITLE: Automated Laser Bonder for Hybrid Microelectronics

COSTS: 250 FY80, 150 FY81

AREA OF COST SAVINGS: Hybrid Circuit #6

METHOD OF COST SAVINGS: Manufacturing Methods #3

APPLICABLE NAVY SYSTEMS: All electronics #93
All Missiles #90
All Aircraft #91

TECHNICAL OBJECTIVES: To save manual assembly costs in Hybrid Circuit Assembly by use of an automated laser bonder for circuit to pad interconnection bonding

BACKGROUND: Other techniques in use presently are ultrasonic, thermocompression, and beam lead bonding

APPROACH: Utilization of fact that die substrate is transparent to CO_2 high power laser radiation allows laser beam to be brought through die to underside of wire to be bonded.

BENEFITS: Estimated at about \$30^{00} per hybrid circuit or about 6% savings in category 6.

IMPLEMENTATION: via a prototype development

RELATED EFFORTS: IRD projects at several firms are referenced

RISK FACTOR: high due to newness of technology and fact that competing methods may be improved.

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ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 17 (DNA 00577)

TITLE: Computerized Ion Beam Resistor Trimming

COSTS: 250 FY80, 180 FY81

AREA OF COST SAVINGS: Hybrid circuits #6

METHOD OF COST SAVINGS: Manufacturing methods #3

APPLICABLE NAVY SYSTEMS: All electronics #93
All Missiles #90
All Aircraft #91

TECHNICAL OBJECTIVES: To lower costs and decrease rejects in resistor trimming for Hybrid circuits.

BACKGROUND: At present high speed laser trimmers or high stability abrasive trim are used. Resistor instability means many passes must be made to achieve final values.

APPROACH: Ion beam milling offers hope of improved trimming rates - resistors are to be trimmed along the lateral thickness.

BENEFITS: Lower cost, faster trims, more stable resistor when complete. Contractor estimates 6% cost savings.

IMPLEMENTATION: Initial study

RELATED EFFORTS: Ion milling techniques are used extensively in other high precision areas

RISK FACTOR: medium

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 18 (DNA 00508)

TITLE: SAW Device Replication

COSTS: 250 FY80

AREA OF COST SAVINGS: Passive Components #7

METHOD OF COST SAVINGS: Manufacturing Methods #3

APPLICABLE NAVY SYSTEMS: APS 115 Radar #L35
Avionics radars, ECM, and ECCM equipment via All Electronics #93

TECHNICAL OBJECTIVES: Reduce the cost of SAW replication by use of E-beam or Xray photo-lithography

BACKGROUND: Line width on state of the art SAW is too fine for conventional photo lithographic techniques.

APPROACH: Investigation of flexible mash generation by Electron beam techniques, and xray photo engraving

BENEFITS: Individual system savings estimated at 1 to 2% of category of costs for rating purposes.

IMPLEMENTATION:

RELATED EFFORTS: several

RISK FACTOR: high

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 19 (DNA 00254)

TITLE: Leadless Inverted Devices

COSTS: 55K FY80; 85K, FY81; 55K, FY82

AREA OF COST SAVINGS: Hybrid circuits #6

METHOD OF COST SAVINGS: Manufacturing methods

APPLICABLE NAVY SYSTEMS: All Aircraft #91
All electronics #93

TECHNICAL OBJECTIVES: To lower costs of hybrid microelectronics by the development of leadless inverted devices (LID's)

BACKGROUND: LID technology is being pursued by industry but not for military applications

APPROACH:

BENEFITS: Higher reliability due to easier test, reduced rework, higher yields. Contractor estimates 1.5% of category.

IMPLEMENTATION: via prototype test, documentation of process.

RELATED EFFORTS: Many

RISK FACTOR: high due to competing projects.

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 20 (DNE 00027)

TITLE: R. F. Packaging Techniques

COSTS: 95K, FY80; 45K, FY81

AREA OF COST SAVINGS: Cabinets #1

METHOD OF COST SAVINGS: Manufacturing methods #3

APPLICABLE NAVY SYSTEMS: TPS-59, #L21, all electronics #93

TECHNICAL OBJECTIVES: To lower costs of cabinets, and r.f. enclosures by use of plastic or fiber glass thermosetting plastics.

BACKGROUND: Dip brazed r.f. packages used at moment.

APPROACH: Plastics have corrosion resistance, strength stiffness and good strength to weight ratios

BENEFITS: Savings estimated at .7% of category #1.

IMPLEMENTATION: via demonstration program

RELATED EFFORTS: several

RISK FACTOR: medium

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 21 (DNA 00415)

TITLE: Electron Beam Imaging System

COSTS: 250K, FY80; 150K, FY81; 200K, FY82

AREA OF COST SAVINGS: integrated circuits #3

METHOD OF COST SAVINGS: capital equipment #2

APPLICABLE NAVY SYSTEMS: all electronics #93

TECHNICAL OBJECTIVES: To lower costs of integrated circuits by developing a "production model" E-beam Projection system.

BACKGROUND: Several labs have R&D projects using E-beam lithography none are available for a production line as yet

APPROACH: Improve throughput of wafers (direct writing mode)

BENEFITS: Lower cost, smaller gates, improve throughput. Contractor estimates 5% savings overall in category 3.

IMPLEMENTATION: Via improved slice handling machinery to improve throughput. Final product is a low cost design for a production system.

RELATED EFFORTS: Many

RISK FACTOR: High.

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 22 (DNE 00042)

TITLE: *Electron Bombarded Device MT*

COSTS: *280K, FY80*

AREA OF COST SAVINGS: *Discrete SC #5*

METHOD OF COST SAVINGS: *Manufacturing methods #3*

APPLICABLE NAVY SYSTEMS: *ALQ-78 ECM Set #L32* *ALR-59 EW Set #L33* *TPS 59 radar #L21* *All electronics #93*

TECHNICAL OBJECTIVES: *To lower costs of electron bombarded Semiconductor (EBS) devices such as amplifiers and switches*

BACKGROUND: *Present EBS costs are high due to poor yield*

APPROACH: *1) EBS gun design for manufacture*
2) high temperature, high speed metallization system development

BENEFITS: *Cost improvement of order of 30% are expected eventually. Initial savings would be smaller, of order of 10%, or 1.6% for the combined category.*

IMPLEMENTATION:

RELATED EFFORTS:

RISK FACTOR: *High*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 23 (DNA 00566)

TITLE: *Thin Silicon Layer Technology*

COSTS: 550K, FY80; 400K, FY81; 150K, FY82

AREA OF COST SAVINGS: *integrated circuits* #3

METHOD OF COST SAVINGS: *Manufacturing methods*

APPLICABLE NAVY SYSTEMS: *All electronics* #93
All Aircraft #91

TECHNICAL OBJECTIVES: *To reduce costs of dielectrically isolated integrated circuits by use of thin layer silicon on insulating substrate*

BACKGROUND: *Many present IC's are not isolated, are fabricated on silicon substrates*

APPROACH: *Fabrication of thin high quality (sufficient for bipolar gates) in an insulating* SiO_2 *layer, which is supported in turn by polycrystaline Si.*

BENEFITS: *Estimated at 25% for high performance circuits when fully operational. Estimated at 6% for category*

IMPLEMENTATION: *Via continuation of RD work to develop a pilot production line*

RELATED EFFORTS: *SOS technology*

RISK FACTOR: *medium to high*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 24 (DNA 00044)

TITLE: High Dose Shallow Profile Ion Implantation Systems

COSTS: 230K, FY80; 100K, FY81; 250K, FY82

AREA OF COST SAVINGS: integrated circuit #3

METHOD OF COST SAVINGS: Capital Equipment #2

APPLICABLE NAVY SYSTEMS: all aircraft #91
F14 #40
F18 #A47

TECHNICAL OBJECTIVES: To lower cost of implantation devices by design of a low cost tabletop device

BACKGROUND: Current implantation devices are large and costly to acquire and run

APPROACH: Develop a "dedicated" small implantation especially for a semiconductor production line

BENEFITS: Contractor estimates at 15 to 20% for high volume linear IC's, or about 3 to 5% in category 3.

IMPLEMENTATION: Design, development of production equipment

RELATED EFFORTS: IRD at contractor is complete and encouraging

RISK FACTOR: medium

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 25 (DNA 00504)

TITLE: *Encoder Improvement Program*

COSTS: *170K, FY80; 100K, FY81; 90K, FY82*

AREA OF COST SAVINGS: *Passive devices #7*

METHOD OF COST SAVINGS: *Manufacturing methods #33*

APPLICABLE NAVY SYSTEMS: *AIMS #L34, UYK 7, #L24, AYK-14 #L26*

TECHNICAL OBJECTIVES: *To lower costs of encoders for avionics altitude reporting devices.*

BACKGROUND:

APPROACH: *1) Automatic ferrite core placement and wiring; 2) Test fixture for hybrid circuit package; 3) Test fixtures for subassemblies*

BENEFITS: *Estimated at 1.5 to 3.0% of category 7 for rating purposes.*

IMPLEMENTATION:

RELATED EFFORTS:

RISK FACTOR: *Medium*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 26 (A832)

TITLE: Evaluation of Electrochemical Etching Process

COSTS: $96K FY80

AREA OF COST SAVINGS: PCB, Small Hardware, #4

METHOD OF COST SAVINGS: Manufacturing Methods, #3

APPLICABLE NAVY SYSTEMS: All Missiles, #90
All Aircraft, #91
All Electronics, #93

TECHNICAL OBJECTIVES:
Manufacture of high reliability multilayer circuit boards through a closed-loop electrochemical etching system

BACKGROUND: High reliability circuit boards are currently manufactured via a subtractive process. This process is costly, productive of chemical pollution, and of limited use in etching precision lines under .01 of an inch wide.

APPROACH: Develop a closed-loop electrochemical etching system, which will not need electrolyte replenishment, to replace the subtractive manufacturing process.

BENEFITS: Estimated at 1% of category for rating purposes.

IMPLEMENTATION: Installation and use of a pilot operating system to produce qualification test boards, monitor efficient pollution levels, and develop operating procedures.

RELATED EFFORTS:

RISK FACTOR: Medium

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 27

TITLE: Adaptive Control of Drill Temp - PCB Board Application

COSTS: $80K FY80

AREA OF COST SAVINGS: PCB, Small hardware, #4

METHOD OF COST SAVINGS: Manufacturing Methods, #3

APPLICABLE NAVY SYSTEMS: All Missiles #90
All Electronics #93

TECHNICAL OBJECTIVES: Develop adaptive drilling to control smear in PCB board holes.

BACKGROUND: Normal procedure is to use a chemical smear removal technique; however Teflon and Polyimide (high performance) boards are not able to be treated in this way. All smear problems relate to excessive drill temperatures.

APPROACH: Measure and control drill bit temperature

BENEFITS: Many - in reduced need for chemical treatment equipment, in lower rejects etc. Contractor estimates at 1% of category

IMPLEMENTATION: IRD work by contractor would be tested in pilot production

RELATED EFFORTS: IRD by contractor

RISK FACTOR: Low to medium

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 28 (A608A)

TITLE: *Coaxial Magnetron-Design for Manufacture*

COSTS: *$100K FY80*

AREA OF COST SAVINGS: *Special tubes, #2*

METHOD OF COST SAVINGS: *Manufacturing Methods, #3*

APPLICABLE NAVY SYSTEMS: *TPD-59 Radar #L21, APS 115 Radar, #L35 Harpoon #M60, Phoenix #M63*

TECHNICAL OBJECTIVES: *Develop new hobbing techniques to manufacture cathodes*

BACKGROUND: *Old technology used in magnetron manufacturing currently.*

APPROACH: *Not specified by contractor*

BENEFITS: *Contractor estimates of 20% savings relates to about 5 to 10% of category in selected units*

IMPLEMENTATION:

RELATED EFFORTS: *Yes, several proposed Army projects at ECOM Conference, e.g., A609A and A610A*

RISK FACTOR: *Medium*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 29 (A609A, 637A)

TITLE: *Manufacturing Methods - Frequency Agile Magnetrons*

COSTS: *$150K FY80; $100K FY81*

AREA OF COST SAVINGS: *Special tubes, #2*

METHOD OF COST SAVINGS: *Manufacturing Methods, #3*

APPLICABLE NAVY SYSTEMS: *Harpoon Missile #M60*
Phoenix #M63
TPS 59 Radar #L21
APS 115 Radar #L35

TECHNICAL OBJECTIVES: *Develop improved frequency agility mechanisms. Develop positive phased magnetrons, develop replaceable vacuum chambers.*

BACKGROUND: *Frequency agility mechanism is a cost driver in magnetron tube costs.*

APPROACH: *Review advanced materials, lubricants, etc., for improved selection.*

BENEFITS: *Contractor estimates at 5% for tubes which is 2 to 3% of category*

IMPLEMENTATION: *Via development program*

RELATED EFFORTS: *Commercial tubes of positive phase type areavailable at cost savings.*

RISK FACTOR: *Medium*

ELECTRONICS MT PROJECT DESCRIPTION   PROJECT NO. 30 (A501)

TITLE: "Nasglow" Plating on Connectors

COSTS: $100K FY80; $50K FY81

AREA OF COST SAVINGS: Cables, #1

METHOD OF COST SAVINGS: Manufacturing Methods, #3

APPLICABLE NAVY SYSTEMS: All electronics #93

TECHNICAL OBJECTIVES: Verify the suitability of the "Nasglow" plating procedure as a gold substitute.

BACKGROUND: Gold plates interconnects are now standard, but expensive; cost x 2

APPROACH: Substitute materials of equal or better reliability.

BENEFITS: Cost savings in interconnects of nearly a factor of 2. Relates to a savings in cables of up to 5%.

IMPLEMENTATION: Via an extensive environmental test serving to assure reliability.

RELATED EFFORTS: Yes, fiber optics competer. Also see Project 52.

RISK FACTOR: Medium.

MANUFACTURING TECHNOLOGY STUDY

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 31 (A503)

TITLE: *Low Cost Machine Insertable Tantalum Capacitors*

COSTS: *$100K FY80; $50K FY81*

AREA OF COST SAVINGS: *Passive Components, #7*

METHOD OF COST SAVINGS: *Production Volume, #1*

APPLICABLE NAVY SYSTEMS: *All electronics #93*

TECHNICAL OBJECTIVES: *Develop improved plastic coating method to make capacitors meet mil-spec on humidity*

BACKGROUND: *Hermitically sealed capacitors are inappropriate for machine insertion; plastic capacitors are suitable and are superior in most specifications except humidity*

APPROACH: *Develop a moisture resistant plastic case for capacitors*

BENEFITS: *Contractor estimates a 10% savings in capacitors or a 3% savings in category*

IMPLEMENTATION:

RELATED EFFORTS: *Unknown*

RISK FACTOR: *Low to medium*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 32 (A, 314, 317)

TITLE: *Fibre Optics Signal Cables*

COSTS: $250K FY80; $250K FY81; $150K FY82

AREA OF COST SAVINGS: *Cables, #1*

METHOD OF COST SAVINGS: *Volume, #1*

APPLICABLE NAVY SYSTEMS: *All aircraft #91*
All electronics #93

TECHNICAL OBJECTIVES: *Produce a standard design and length cable suitable for many applications.*

BACKGROUND: *Fibre optics costs now are high due to low volume*

APPROACH: *Conglomerate market*

BENEFITS: *Lower cost cables - factor of two or better, project 10% savings in category*

IMPLEMENTATION: *Via design competition for standards - pilot production and test*

RELATED EFFORTS: *Yes, two firms are interested at least*

RISK FACTOR: *Low*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 33 (A 621B)

TITLE: GaAs FET/Replacement for TWT

COSTS: $250K FY80; $250K FY81

AREA OF COST SAVINGS: Discrete Semiconductors, #5

METHOD OF COST SAVINGS: Manufacturing Methods, #3

APPLICABLE NAVY SYSTEMS: Radar and EW @ 10% of all Electronics #93
Aegis #S01 via AN/SPY-1 Radar
TPS 59 #21
PRC 104 Radio #L18, DFP EW #L23
ALQ-78 #L32, ALR-59 #L33

TECHNICAL OBJECTIVES: Develop technical improvements in crystal growth, photolithography, etc., for GaAs FET

BACKGROUND: Current costs are too high, yields too low

APPROACH: Via detailed technology improvements

BENEFITS: Lower cost power amplifiers. Estimate a 1% savings in category #5 as the result of this work

IMPLEMENTATION:

RELATED EFFORTS: Yes at several firms

RISK FACTOR: Medium

MANUFACTURING TECHNOLOGY STUDY

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 34(A630B)

TITLE: *Patterned Polyimide-Siloxane Coatings*

COSTS: *$100K FY80*

AREA OF COST SAVINGS: *Discrete Semiconductors, #5*

METHOD OF COST SAVINGS: *Manufacturing Methods, #3*

APPLICABLE NAVY SYSTEMS: *All electronics #93*

TECHNICAL OBJECTIVES: *Apply Polyimide-Siloxane coatings to high power interdigitated semiconductors.*

BACKGROUND: *Isolation of gate and base fingers from main electrode plate containing cathode or emitter*

APPROACH: *Use of polyimide siloxane in production process as a type of "resist" in lithographic production*

BENEFITS: *Contractor estimates at 10% for these devices - or about 1% of category*

IMPLEMENTATION: *In several types of power circuits including thyristors, power transistors etc.*

RELATED EFFORTS: *None Known*

RISK FACTOR: *High*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 35 (A727)

TITLE: *Ultra Thin Copper Clad Laminates*

COSTS: *$220K FY80; $160K FY81*

AREA OF COST SAVINGS: *Integrated Circuits, #3*

METHOD OF COST SAVINGS: *Volume #1, Manufacturing Methods #3*

APPLICABLE NAVY SYSTEMS: *All Missiles #90*
All Aircraft #91
All Electronics #93

TECHNICAL OBJECTIVES: *Produce low cost mass production methods using ultra thin (5μ) metallic clad dielectric laminates - Develop print and etch techniques for these*

BACKGROUND: *Conventional ceramic substrates are high cost and contribute to low yield*

APPROACH: *Substitution of substrates*

BENEFITS: *Contractor claims vast improvements plus increase of production base - impossible to quantify at this time. Assume a cost savings of 2% in this category for rating purposes*

IMPLEMENTATION: *Via a pilot production program*

RELATED EFFORTS: *Yes Many*

RISK FACTOR: *High*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 36

TITLE: *Lightweight R.F. Stripline Assembly*

COSTS: *$120K, FY80*

AREA OF COST SAVINGS: *Cables and Cabinets #1*

METHOD OF COST SAVINGS: *Manufacturing Methods #3*

APPLICABLE NAVY SYSTEMS: AN/TPS-59 *Radar, L21*
ALQ-78 ECM *Set, L32*
ALR-59 EW *Set, L33*

TECHNICAL OBJECTIVES: *To lower the cost (and weight) of row feed R.F. assemblies by an improved manufacturing technique.*

BACKGROUND: *Present design is a sandwich of flexible foam, aluminum clad Balsa, and honeycomb material. An integral design would lower costs, reduce parts count, and lower weight.*

APPROACH: *Integrated mechanical and electrical design has led to several possible manufacturing techniques. At present a structural foam plastic method appears promising.*

BENEFITS: *Contractor estimates that a dramatic lowering of row feed costs, this translates into a eventual 20% savings in this category.*

IMPLEMENTATION: *Via a study of, and pilot production with, the two or three leading manufacturing methods already identified.*

RELATED EFFORTS: *In house contractor R and D accomplished.*

RISK FACTOR: *Medium*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 37 (A324)

TITLE: *Low Cost Microchannel Plates*

COSTS: *$250K FY80*

AREA OF COST SAVINGS: *Sensors, #2*

METHOD OF COST SAVINGS: *Manufacturing Methods, #3*

APPLICABLE NAVY SYSTEMS: *Night Vision (see project 95) devices which are approximately 1% of all Electronics #93*

TECHNICAL OBJECTIVES: *Develop low cost manufacturing methods for microchannel plates - include a design for manufacturability analysis*

BACKGROUND: *Current costs are high; yield is very low; project will address these cost drivers.*

APPROACH: *Chemical etch techniques will be improved*

BENEFITS: *Great for the item, which is about 10% of sensor category in selected item. Net savings are of the order of 0.1% of category in all electronics*

IMPLEMENTATION: *IRD complete*

RELATED EFFORTS: *Yes*

RISK FACTOR: *Medium*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 38 (A 121B, 122B)

TITLE: GaAs Microwave Circuits - Manufacturability

COSTS: $500K FY80; $500K FY81

AREA OF COST SAVINGS: Discrete Semiconductors, #5

METHOD OF COST SAVINGS: Manufacturing Methods, #3

APPLICABLE NAVY SYSTEMS: Aegis #S01, via AN SPY-1 Radar
TPS-59 #L21 DTP EW #L23
ALW-78 #L32 ALR-59 #33
Radar and EW @ 10% of All Electronics #93

TECHNICAL OBJECTIVES: Improve manufacturing yield and lower cost of GaAs devices

BACKGROUND: GaAs devices have potential to replace many systems in HF devices

APPROACH: CAD techniques, automated manufacturing control and process monitoring

BENEFITS: Greatly reduced costs - estimate at savings of 2 to 3% of category #5

IMPLEMENTATION:

RELATED EFFORTS: Yes Several

RISK FACTOR: Medium

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 39 (A129B)

TITLE: *MNOS Memory-Tri Metal ROM*

COSTS: *$200K FY80; $200K FY81*

AREA OF COST SAVINGS: *Integrated Circuits, #3*

METHOD OF COST SAVINGS: *Manufacturing Methods, #3*

APPLICABLE NAVY SYSTEMS: *PRC-104 #L18*
Communications Equipment @ 7% of All Electronics #93

TECHNICAL OBJECTIVES: *Replace mechanical tuning arrangement with electronic memory*

BACKGROUND: *There is a need for channel memory to exist in a field radio*

APPROACH: *Adapt a commercial EROM-use a special hermeticlly sealed plastic package*

BENEFITS: *Lower cost, field programmability. Savings are in the order of 2 to 4% of category.*

IMPLEMENTATION: *Through adaptation of commercial development*

RELATED EFFORTS: *None Known*

RISK FACTOR: *Medium*

MANUFACTURING TECHNOLOGY STUDY

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 40 (A743, 746)

TITLE: *Low Cost Polyimide MW-PWB's*

COSTS: *$200K FY80, $50K FY81*

AREA OF COST SAVINGS: *Small Hardware PCB, #4*

METHOD OF COST SAVINGS: *Manufacturing Methods, #3*

APPLICABLE NAVY SYSTEMS: *All missiles #90*

TECHNICAL OBJECTIVES: *Develop Polyimide, and epoxy modified polyimide high temperature resistant board material*

BACKGROUND: *Present epoxy-glass boards fail in manufacture because of inadequate high temperature resistance*

APPROACH: *Define material properties, and fabrication procedure that withstand the high processing temperatures*

BENEFITS: *Savings of 10% on PCB or 1 to 2% for category 4 are estimated by the contractor*

IMPLEMENTATION: *Another contractor would like to improve the basic epoxy production control - lack of which at present causes loss of yield. Large benefits are claimed*

RELATED EFFORTS: *Several*

RISK FACTOR: *Medium*

MANUFACTURING TECHNOLOGY STUDY

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 41 (A 603A)

TITLE: Semi-Automated Miniature TWT Assembly

COSTS: $150K FY80; $225K FY81

AREA OF COST SAVINGS: Sensors, Special Tubes, #2

METHOD OF COST SAVINGS: Volume #1

APPLICABLE NAVY SYSTEMS: Aegis #S01, via AN/SPY-1 Radar
DTPEW #L23, TPS-59 #L21
ALQ-59 #L33 ALQ-78 #L32
Radar and EW @ 10% of All Electronics #93

TECHNICAL OBJECTIVES: Establish production techniques for volume manufacturing of TWT's

BACKGROUND: Present TWT manufacturing is in small batch production

APPROACH: Common elements such as collector assembly, gun assembly for 2 to 18 GHz range, also RF structure could be modularized

BENEFITS: Greatly improved TWT cost, reliability increased, manufacturing yield improvement also. Contractor estimates 10% savings in TWT relates to 5 to 10% in category for systems tested.

IMPLEMENTATION:

RELATED EFFORTS: Several

RISK FACTOR: Low to medium

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 43 (A116A)

TITLE: *Large Scale Hybrid Assembly and Test-Automation*

COSTS: *$150K FY80; $150K FY81*

AREA OF COST SAVINGS: *Hybrid circuits, #6*

METHOD OF COST SAVINGS: *Manufacturing Methods, #3*

APPLICABLE NAVY SYSTEMS: *All electronics #93*

TECHNICAL OBJECTIVES: *Certify and demonstrate improved hybrid processing techniques.*

BACKGROUND: *Many contractors assemble hybrid circuits and currently much hand labor is involved.*

APPROACH: *Certify mechanization techniques including the use of leadless inverted devices*

BENEFITS: *Eventually a 30% reduction in category is estimated by the contractor*

IMPLEMENTATION: *Via certification of procedure pilot demonstration, and handbook*

RELATED EFFORTS: *Yes, Many*

RISK FACTOR: *Medium*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 43 (A116A)

TITLE: *Large Scale Hybrid Assembly and Test-Automation*

COSTS: *$150K FY80; $150K FY81*

AREA OF COST SAVINGS: *Hybrid circuits, #6*

METHOD OF COST SAVINGS: *Manufacturing Methods, #3*

APPLICABLE NAVY SYSTEMS: *All electronics #93*

TECHNICAL OBJECTIVES: *Certify and demonstrate improved hybrid processing techniques.*

BACKGROUND: *Many contractors assemble hybrid circuits and currently much hand labor is involved.*

APPROACH: *Certify mechanization techniques including the use of leadless inverted devices*

BENEFITS: *Eventually a 30% reduction in category is estimated by the contractor*

IMPLEMENTATION: *Via certification of procedure pilot demonstration, and handbook*

RELATED EFFORTS: *Yes, Many*

RISK FACTOR: *Medium*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 44

TITLE: Computer Controlled Machine Tools

COSTS: $375K FY80

AREA OF COST SAVINGS: Support labor, #10

METHOD OF COST SAVINGS: Capital, #2

APPLICABLE NAVY SYSTEMS: BQR-21 #L13 AYK-14 #L26
BQQ-5 #L10
SQQ-23 #L12
UYK-7 #L24

TECHNICAL OBJECTIVES: Input of basic engineering data to computer - controls machine tools

BACKGROUND: Current practice is not integrated

APPROACH: Computer based data, transfer, implementation

BENEFITS: $50 to 100K/year on a 30M/year project or 1 to 2% of category

IMPLEMENTATION:

RELATED EFFORTS: Many - USAF ICAM, for example

RISK FACTOR: Medium

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 45

TITLE: *Improved/Automated Standard Machining Processes*

COSTS: *$250K FY80; $250K FY81*

AREA OF COST SAVINGS: *Fabrication labor, #9*

METHOD OF COST SAVINGS: *Capital, #2*

APPLICABLE NAVY SYSTEMS: *BQR21 #L13; BQQ-5 #L10; SQQ-23 #L12*
All electronics #93
UYK-7 #L24; AYK-14 #L26

TECHNICAL OBJECTIVES: *Acquire new N/C machine tools-emphasis on modification to include built in diagnostics to monitor progress in plan - to measure effect and cost effectiveness of tool.*

BACKGROUND:

APPROACH: *Verify cost effectiveness of N/C tools.*

BENEFITS: *Contractor estimates at 2% of category.*

IMPLEMENTATION: *Largely via purchase of new tools, and to study their effect on production.*

RELATED EFFORTS: *Many*

RISK FACTOR: *Low*

MANUFACTURING TECHNOLOGY STUDY

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 46

TITLE: *Automated PCB Insertion*

COSTS: *$50K FY80*

AREA OF COST SAVINGS: *Assembly labor, #8*

METHOD OF COST SAVINGS: *Capital, #2*

APPLICABLE NAVY SYSTEMS: *BQR-21 #L13*
All electronics #93
SQQ-23 #L12
BQQ-5 #L10

TECHNICAL OBJECTIVES: *Verify the performance of automatic component insertion; quantify cost effectiveness.*

BACKGROUND:

APPROACH:

BENEFITS: *About 0.2 to 0.4% of category 8.*

IMPLEMENTATION:

RELATED EFFORTS:

RISK FACTOR: *Low*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 47

TITLE: *Flat Wire Interconnects*

COSTS: $75K FY80

AREA OF COST SAVINGS: *Cabling, #1*

METHOD OF COST SAVINGS: *Manufacturing Methods, #3*

APPLICABLE NAVY SYSTEMS: BQR-21 #L13
All electronics #93
BQQ-5 #L10
SQQ-23 #L12

TECHNICAL OBJECTIVES: *Replace standard wire cabling with flat wire. Investigate the methods of connecting to terminals etc., cable construction, and harnessing.*

BACKGROUND:

APPROACH:

BENEFITS: *Contractor estimated at 1.0% of category 1*

IMPLEMENTATION:

RELATED EFFORTS: *Yes, fiber optic cables, for example.*

RISK FACTOR: *Medium*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 48

TITLE: Automatic Sonar Test Equipment

COSTS: $600K FY80; $800K FY81; $600K FY82

AREA OF COST SAVINGS: Test Labor, #11

METHOD OF COST SAVINGS: Capital, #2

APPLICABLE NAVY SYSTEMS: BQR-21 #L13; SQQ23 #L12; BQQ-5 #L10

TECHNICAL OBJECTIVES: Construct and evaluate the performance of a large automatic test system for a digital sonar system.

BACKGROUND:

APPROACH:

BENEFITS: Estimates by contractor at 10 to 15% of test labor.

IMPLEMENTATION:

RELATED EFFORTS: Many

RISK FACTOR: Medium

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 49

TITLE: *Microprocessor Replacement in Digital Sonars*

COSTS: *$250K FY80; $250K FY81*

AREA OF COST SAVINGS: *Integrated Circuits, #3*

METHOD OF COST SAVINGS: *Manufacturing Methods, #3*

APPLICABLE NAVY SYSTEMS: *BQR-21 #L13*
BQQ-5 #L10
BQQ-23 #L12

TECHNICAL OBJECTIVES: *Demonstrate the cost effectiveness of microprocessor technology in large scale digital sonar systems*

BACKGROUND: *Replacement of costly special purpose IC's with general-low cost microprocessors*

APPROACH: *Via design for manufacture*

BENEFITS: *Contractor estimates 4 to 8% of IC's - category #3*

IMPLEMENTATION: *Study phase to determine feasibility test and validation phase*

RELATED EFFORTS: *Many*

RISK FACTOR: *Low to medium procedure has worked in commercial area*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 50

TITLE: *Automated Wiring System*

COSTS: *$500K FY80; $1000K FY81; $1000K FY82*

AREA OF COST SAVINGS: *Assembly labor, #8; Test labor, #11*

METHOD OF COST SAVINGS: *Capital eq, #2; Manufacturing Methods, #3*

APPLICABLE NAVY SYSTEMS: *BQR-21 #L13*
All electronics #93
BQQ-5 #L10
SQQ-23 #L12

TECHNICAL OBJECTIVES: *Develop a complete CAM system for wiring back panels, including testing.*

BACKGROUND:

APPROACH: *Establish a dedicated computer with software system to generate wire lists from wiring schematic, program wire wrap made directly; tests for continuity performed automatically*

BENEFITS: *5 to 15% of assembly labor (category #8) estimate by contractor*

IMPLEMENTATION:

RELATED EFFORTS: *Many*

RISK FACTOR: *Medium*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 51

TITLE: *Computer Processed Shop Instructions*

COSTS: $200K FY80

AREA OF COST SAVINGS: *Support labor, #10*

METHOD OF COST SAVINGS: *Capital, #2*

APPLICABLE NAVY SYSTEMS: BQR-21 #L13
All electronics #93
BQQ-5 #L10
SQQ-23 #L12

TECHNICAL OBJECTIVES: *Evaluate the cost-effectiveness of a computer based shop instruction system*

BACKGROUND:

APPROACH:

BENEFITS: *Contractor estimates at 2 to 3% of category 10*

IMPLEMENTATION:

RELATED EFFORTS: *Yes*

RISK FACTOR: *Low to medium*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 52 (A 502, 507)

TITLE: *Substitution of Gold Plating - Interconnections*

COSTS: *$150K FY80; $200K FY81*

AREA OF COST SAVINGS: *Cables, #1*

METHOD OF COST SAVINGS: *Manufacturing Methods, #3*

APPLICABLE NAVY SYSTEMS: *All electronics #93*

TECHNICAL OBJECTIVES: *Develop and test reliable low cost interconnects*

BACKGROUND: *Gold plated interconnects are now standard, but expensive; cost x 2*

APPROACH: *Substitute materials of equal or better reliability*

BENEFITS: *Cost savings in interconnects of nearly a factor of 2. Relates to a savings in cables of up to 5%*

IMPLEMENTATION: *Via an extensive environmental test series to assure reliability*

RELATED EFFORTS: *Yes, fiber optics competes. Also, see Project 30.*

RISK FACTOR: *Medium*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 53 (A 840, 842)

TITLE: Mechanized Fabrication-Flexible Multilayer PCB

COSTS: $100K FY80; $200K FY81; $250K FY82

AREA OF COST SAVINGS: Small hardware PCB, #4

METHOD OF COST SAVINGS: Manufacturing Methods, #3

APPLICABLE NAVY SYSTEMS: All Aircraft #91
All Electronics #93

TECHNICAL OBJECTIVES: Develop a continuous process method for flexible printed wiring

BACKGROUND: Present batch techniques are limited to 18", and labor intensive in addition

APPROACH: Select automated equipment, solve problems such as stress in roll laminated copper - clad material, develop tooling that allows layer registration

BENEFITS: Contractor estimates savings at 25 to 30% for item or about 2.5 to 3% for category

IMPLEMENTATION: Firm equipment survey through pilot line operation

RELATED EFFORTS: None known to be working on continuous processes; many in general area however (this write up is based on 2 contractor proposals)

RISK FACTOR: Medium

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 54 (A862)

TITLE: *Water-Soluble Organic Flux Flow Soldering*

COSTS: *$300K FY80; $150K FY81*

AREA OF COST SAVINGS: *Small hardware PCB, #4*

METHOD OF COST SAVINGS: *Manufacturing Methods, #3*

APPLICABLE NAVY SYSTEMS: *All electronics #93*

TECHNICAL OBJECTIVES: *Develop use of water-soluble organic flux*

BACKGROUND: *Although water soluble organic fluxes are known to have excellent solderability properties they are not currently being applied*

APPROACH: *Demonstrate applicability in a military production line*

BENEFITS: *Contractor estimates 10% in PCB or about 3% in this cost category*

IMPLEMENTATION: *Demonstration and documentation definition for new mil spec*

RELATED EFFORTS: *Unknown*

RISK FACTOR: *Low to medium*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 55 (A 836)

TITLE: *HF Removal Technique-Drill Smear PCB*

COSTS: *$150K FY80; $100K FY81*

AREA OF COST SAVINGS: *Small hardware PCB, #4*

METHOD OF COST SAVINGS: *Manufacturing Methods, #3*

APPLICABLE NAVY SYSTEMS: *All electronics #93*

TECHNICAL OBJECTIVES: *Demonstrate high frequency vibration method of cleaning PCB board holes*

BACKGROUND: *Drill smear has been identified as a problem in a number of projects directed toward lower cost PCB*

APPROACH: *Using high frequency vibration in combination with chemical and mechanical techniques*

BENEFITS: *Contractor estimates 10% of PCB cost or ~3% for category*

IMPLEMENTATION: *Pilot production line*

RELATED EFFORTS: *Yes, very many*

RISK FACTOR: *Low to medium - technique has been demonstrated already*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 56 (A S 30)

TITLE: Automated Cable Harness Manufacture

COSTS: $350K FY80; $200K FY81

AREA OF COST SAVINGS: Cable #1, Assembly labor, #8

METHOD OF COST SAVINGS: Manufacturing Method, #3; Capital, #2

APPLICABLE NAVY SYSTEMS: All electronics #93

TECHNICAL OBJECTIVES: Develop a fully automated wire harness manufacturing center

BACKGROUND: Current practice is to cut and strip wires by hand initially, then lay into harness. Loss of wire and labor due to too short wire-nicked conductor etc., and tedious labor are encountered.

APPROACH: Reel wire and route prior to cut and terminate laser insulation stripping by N/C controlled routing

BENEFITS: Large-contractor estimates ROI of 20 but unclear what production base. Estimate a 1 to 2% saving in category

IMPLEMENTATION: Manufacture pilot production

RELATED EFFORTS: Yes several - including fibre optic substitution. Also see Project 57.

RISK FACTOR: Medium

MANUFACTURING TECHNOLOGY STUDY

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 57 (A 809; SS1)

TITLE: N/C Cable Harness Assembly Machine

COSTS: $200K FY80; $500K FY81; $200K FY82

AREA OF COST SAVINGS: Cable, #1; Assembly labor, #8

METHOD OF COST SAVINGS: Manufacturing Method, #3; Capital, #2

APPLICABLE NAVY SYSTEMS: All electronics #93

TECHNICAL OBJECTIVES: Develop an automated wiring machine

BACKGROUND: Production methods for harness assembly have not changed apprecibly during the last decade. The assembly is largely manual.

APPROACH: Design a machine incorporating automatic techniques presently available in the areas of marking, cutting, strapping, and lugging (commercial) with cable forming and filing.

BENEFITS: A 1% to 2% savings in Category 1 is used for rating purposes.

IMPLEMENTATION: Manufacture pilot production

RELATED EFFORTS: Yes many, project 56 for example. Two contractor's efforts reported in this write up

RISK FACTOR: Medium

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 58

TITLE: Environmental Test Automation

COSTS: $300K FY80; $400K FY81; $400K FY82

AREA OF COST SAVINGS: Test labor, #11

METHOD OF COST SAVINGS: Capital equipment, #2

APPLICABLE NAVY SYSTEMS: SSQ-53 #L15; SSQ-62 #L16; SSQ-41 #L14

TECHNICAL OBJECTIVES: Demonstrate automatic environmental test chamber operation

BACKGROUND: Current techniques use cycling - this is expensive in energy cost and is lengthy

APPROACH: Use constant environment chambers and cycle test equipment from one environment to another

BENEFITS: Savings in labor and energy - manufacture estimates 0.5% of category 11

IMPLEMENTATION: Via design and construction of a new test chamber area

RELATED EFFORTS: None Known

RISK FACTOR: Medium

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 59 (A 266, 267, 268)

TITLE: *Automated Optical Inspection PCB*

COSTS: *$200K FY80; $300K FY81; $300K FY82*

AREA OF COST SAVINGS: *Testing labor, #11*

METHOD OF COST SAVINGS: *Manufacturing Methods, #3; Capital, #2*

APPLICABLE NAVY SYSTEMS: UYK-7 #L24
All Missiles #90
All Aircraft #91
All electronics #93

TECHNICAL OBJECTIVES: *Develop automatic "optical" inspection equipment for PCB testing*

BACKGROUND: *Current test costs are labor intensive and difficult. This project addresses one variety of test - for correct assembly, and for certain kinds of flaws, that are evident to IR or holographic techniques.*

APPROACH: *Optical character recognition, IR scanning - active or passive, holographic techniques (pulsed). Self learning system will be investigated.*

BENEFITS: *Contractors estimate at 10% of category also impacts rework*

IMPLEMENTATION: *Via equipment performance verification and pilot demonstration*

RELATED EFFORTS: *This write-up from 3 contractor presentations; many other firms are active in this area.*

RISK FACTOR: *Low*

MANUFACTURING TECHNOLOGY STUDY

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 60 (A 224)

TITLE: Near Field Antenna Measurement

COSTS: $250K FY80; $250K FY81

AREA OF COST SAVINGS: Test labor, #11

METHOD OF COST SAVINGS: Capital equipment, #2

APPLICABLE NAVY SYSTEMS: Aegis System #S01 via AN/SPY-1; ALQ-78 #L32
EW DTP #L23; TPS-59 #L21;
ALR-59 #L33

TECHNICAL OBJECTIVES: Demonstrate near field test of phased array antenna

BACKGROUND: Present far field tests are lengthy and depend on range availability, weather etc.

APPROACH: Map near field measurements into measure for field performance

BENEFITS: Less labor estimated at 10% savings for systems using antennas

IMPLEMENTATION: Production equipment is available from one supplier

RELATED EFFORTS: Yes, two firms are interested at least

RISK FACTOR: Medium

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 61 (A 213, 259, 212)

TITLE: *Production Test Modeling*

COSTS: *$150K FY80; $200K FY81*

AREA OF COST SAVINGS: *Test labor, #11*

METHOD OF COST SAVINGS: *Manufacturing Methods, #3*

APPLICABLE NAVY SYSTEMS: *All Missiles #90*
All Aircraft #91
All Electronics #93

TECHNICAL OBJECTIVES: *Develop optimal test strategies for level and completeness of testing during manufacturing.*

BACKGROUND: *Present test strategy varies from one contractor to another and is rarely studied for optimum approaches*

APPROACH: *Model of manufacturing/test steps will be formulated and studied. Study of optimum manufacturing burn-in for best value.*

BENEFITS: *Decreased labor, less scrap value lost. Contractor estimates range from 5 to 30% improvement. A conservative estimate of 10% savings has been applied to the category.*

IMPLEMENTATION: *Software and data development*

RELATED EFFORTS: *Yes, three contractors presentations used to develop write-up.*

RISK FACTOR: *Medium*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 62 (A 251)

TITLE: Improved Analog Circuit Automated Fault Isolation Software

COSTS: $60K FY80; $40K FY81

AREA OF COST SAVINGS: Test labor, #11

METHOD OF COST SAVINGS: Manufacturing Method, #3

APPLICABLE NAVY SYSTEMS: All electronics #93

TECHNICAL OBJECTIVES:

BACKGROUND: Little work on improving analog circuits in contrast to digital circuits.

APPROACH: Develop software

BENEFITS: Not quantified by contractor, but 1% is assumed for rating purposes.

IMPLEMENTATION: Software development

RELATED EFFORTS: Many

RISK FACTOR: Medium to high

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 63 (A 231)

TITLE: *Improved Test Methods - MOS-Rad Hard IC's*

COSTS: *$200K FY80; $100K FY81*

AREA OF COST SAVINGS: *Integrated circuits, #3*

METHOD OF COST SAVINGS: *Institutional, #4*

APPLICABLE NAVY SYSTEMS: *All electronics #93*

TECHNICAL OBJECTIVES: *Develop, document standard test procedures*

BACKGROUND: *No standards exist now*

APPROACH: *Develop protocol for test, results presentation etc.*

BENEFITS: *Contractor estimates at 50% of IC's category #3. This seems way out of line - since not all IC's need to be rad-hard. Estimate at 1 to 2% savings in category 3.*

IMPLEMENTATION:

RELATED EFFORTS: *None Known*

RISK FACTOR: *Low*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 64 (A 265)

TITLE: Automated PCB Board Test Equipment Development

COSTS: $150K FY80

AREA OF COST SAVINGS: Test labor, #11

METHOD OF COST SAVINGS: Manufacturing Method, #3

APPLICABLE NAVY SYSTEMS: All electronics #93

TECHNICAL OBJECTIVES: Develop a "bed of nails" adaptor to test components on PCB at low cost

BACKGROUND: Units that are available now are too costly

APPROACH: Not specified

BENEFITS: Lower cost test equipment. Assume that this relates to a saving of 0.5 to 1% in test labor category.

IMPLEMENTATION: By equipment development

RELATED EFFORTS: None known in specific topical area - many in general area.

RISK FACTOR: High as method is yet to be specified

MANUFACTURING TECHNOLOGY STUDY

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 65

TITLE: *Ribbon Sapphire*

COSTS: *$250K FY80; $250K FY81; $250K FY82*

AREA OF COST SAVINGS: *Integrated Circuits, #3*

METHOD OF COST SAVINGS: *Manufacturing Method, #3*

APPLICABLE NAVY SYSTEMS: *All electronics #93*

TECHNICAL OBJECTIVES: *Adapt ribbon crystal growth to sapphire-for IC substrates*

BACKGROUND: *Present sapphire growing techniques are costly.*

APPROACH: *Utilize success in silicon ribbon growth and adapt to sapphire.*

BENEFITS: *Faster IC's; greater radiation resistance; higher heat rejection - project eventual savings of 1/2 to 1/3 of cost of high performance military IC's or 10% of category.*

IMPLEMENTATION: *IRD work at contractor is promising - implement via studies of parameters - manufacture of IC's for tests.*

RELATED EFFORTS: *None in sapphire are known.*

RISK FACTOR: *High*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 66 (A124)

TITLE: CMOS Custom Library

COSTS: $250K FY80; $250K FY81; $250K FY82

AREA OF COST SAVINGS: Integrated Circuits, #3

METHOD OF COST SAVINGS: Volume #1

APPLICABLE NAVY SYSTEMS: All electronics #93

TECHNICAL OBJECTIVES: Obtain the economy of scale for custom IC's by using an existing library of designs - and CAD.

BACKGROUND: Custom IC's are used extensively in the military but are expensive.

APPROACH: Amortize non recurring costs of many custom orders together

BENEFITS: Could lower costs of custom IC's by 1/2; better efficiency in production etc., is also beneficial. 10% used for rating purposed in category

IMPLEMENTATION: Software development to link contractor CAD programs needed.

RELATED EFFORTS: Other firms have similar libraries

RISK FACTOR: Low - IRD work well in hand - used by commercial world extensively.

Reference: A-S20

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 67

TITLE: N/C Machine Calibration

COSTS: $30K FY80

AREA OF COST SAVINGS: Support labor, #10

METHOD OF COST SAVINGS: Manufacturing Method, #3

APPLICABLE NAVY SYSTEMS: Standard Missile (ER) #M61
Standard Missile (MR) #M62
Sparrow #M64
Phalanx CIWS #081
All Missiles #90

TECHNICAL OBJECTIVES: Establish procedures to calibrate N/C machines - test and verify with time share computer

BACKGROUND: Present practice is lengthy

APPROACH: Interconnected transducers with computer for improved speed. Sensors could be built into machine with cables to a shared computer

BENEFITS: Estimated at 1.0% of category by firm

IMPLEMENTATION: Via a program of instrumentation of machine with computer connection as a shake down test.

RELATED EFFORTS: None Known

RISK FACTOR: Medium

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. *68*

TITLE: *Thick Film Printed Hybrid Seals*

COSTS: *$70K FY80*

AREA OF COST SAVINGS: *Hybrids, #6*

METHOD OF COST SAVINGS: *Manufacturing Method, #3*

APPLICABLE NAVY SYSTEMS: *Standard Missile (ER) #M61 All Missiles #90*
Standard Missile (MR) #M62
Sharrow M64

TECHNICAL OBJECTIVES: *To eliminate sealing problem, reduce costs for large hybrids*

BACKGROUND: *Present techniques use non-hermetic epoxy or metallic rings for mermetic seal (expensive)*

APPROACH: *Extend the thick film technology to the seal*

BENEFITS: *Up to $50.00 per large hybrid - or a potential savings of 5 to 10%*

IMPLEMENTATION: *Via a test program using already developed techniques*

RELATED EFFORTS: *IR and D at contractor has been encouraging*

RISK FACTOR: *Low to medium*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 69

TITLE: *Plastic Molded Microwave Components*

COSTS: *$140K FY80*

AREA OF COST SAVINGS: *Sensors, Antenna #2*

METHOD OF COST SAVINGS: *Manufacturing Methods, #3*

APPLICABLE NAVY SYSTEMS: *Standard Missile (ER) #M61*
Standard Missile (MR) #M62
Sparrow #M64
All Missiles #90

TECHNICAL OBJECTIVES: *Replace expensive metal parts with low cost plastic parts in waveguides, antennas, filters.*

BACKGROUND: *Commercial quality parts now available, contractor IR and D gives encouraging results.*

APPROACH: *Develop tooling techniques for injection molding, relate the military needs (dimensional tolerance, etc.) to manufacturing processing*

BENEFITS: *Contractor estimates at 1 to 3% of category.*

IMPLEMENTATION: *Via a careful study of requirements - test program, etc.*

RELATED EFFORTS: *None known for military - see above*

RISK FACTOR: *Low*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 70

TITLE: Laser Welding of Cabinets

COSTS: $300K FY80; $200K FY81

AREA OF COST SAVINGS:

METHOD OF COST SAVINGS: Manufacturing Methods, #3

APPLICABLE NAVY SYSTEMS: All electronics #93
SQQ-5 #L10
UYK-7 #L24
AYK-14 #L26

TECHNICAL OBJECTIVES: Develop improved fastening techniques for electronics enclosures.

BACKGROUND: Cabinets are often a high cost area - fastening procedures are important cost elements

APPROACH: Investigate the possibility of laser welding - speed, reaching inaccessible areas, etc.

BENEFITS: Could lower cabinet costs up to 20% - or from 1 to 5% of the category

IMPLEMENTATION: Via a pilot production demonstration

RELATED EFFORTS: Epoxy fastening, molded cabinents etc.

RISK FACTOR: Medium

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 71

TITLE: *Projection Printing SAW Device Manufacturing*

COSTS: *$60K FY80; $60K FY81*

AREA OF COST SAVINGS: *Discrete Semiconductors, #5*

METHOD OF COST SAVINGS: *Manufacturing Methods, #3*

APPLICABLE NAVY SYSTEMS: *F14 #A40 (TID in radar)*
All aircraft #91
F18 #A47

TECHNICAL OBJECTIVES: *Apply projection printing to the manufacturing of SAW devices - improve resolution and yield.*

BACKGROUND: *Present technique uses contact printing and is difficult to apply and has low yield*

APPROACH: *Projection system*

BENEFITS: *Manufacturer estimates SAW device cost reductions of 75%! However this relates to 0.2% of category 5 due to limited present SAW usage.*

IMPLEMENTATION:

RELATED EFFORTS: *IRD work by contractor*

RISK FACTOR: *Medium*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 72

TITLE: *Increased Median Technology Level via Contractor Short Courses*

COSTS: *$600K FY81; $1000K FY82*

AREA OF COST SAVINGS: *Assembly labor, #8*

METHOD OF COST SAVINGS: *Institutional, #4*

APPLICABLE NAVY SYSTEMS: *All missiles #90*

TECHNICAL OBJECTIVES: *Increase the median level via technology transfer from leading firm*

BACKGROUND: *Firms need to be motivated to share service sponsored project information.*

APPROACH: *Short course with hands-on training at leading contractor firms.*

BENEFITS: *Could be wide spread - rough estimate is 2 to 3% of assembly labor cost*

IMPLEMENTATION: *At a wide variety of firms*

RELATED EFFORTS: *None of this type*

RISK FACTOR: *Not quantifiable - initial work would have to justify savings - measure if possible*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 73

TITLE: N/C Placement of Components and Reflow Solder

COSTS: $150K FY80

AREA OF COST SAVINGS: Assembly labor, #8

METHOD OF COST SAVINGS: Manufacturing Methods, #3

APPLICABLE NAVY SYSTEMS: AYK-14 #L26
UYK-7 #L24

TECHNICAL OBJECTIVES: Achieve N/C placement of surface mounted components with reflow solder inserts

BACKGROUND: Presently done by hand.

APPROACH: Need more contractor data

BENEFITS: Not quantified. 2% of category #8 is assumed for comparison purposes.

IMPLEMENTATION:

RELATED EFFORTS:

RISK FACTOR: Medium

MANUFACTURING TECHNOLOGY STUDY

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 74

TITLE: Semi-Automated Core Stringing

COSTS: $150K FY80; $250K FY81

AREA OF COST SAVINGS: Assembly labor, #8

METHOD OF COST SAVINGS: Capital, #2

APPLICABLE NAVY SYSTEMS: AYK-14 #L26

TECHNICAL OBJECTIVES: Adapt a commercial high precision XY positioner to a core stringing task, or to refine existing manual techniques

BACKGROUND: Current practice is labor intensive

APPROACH: Use of existing equipment design - adapt only

BENEFITS: Not specified by contractor - 2% for comparison purposes is assumed

IMPLEMENTATION: By purchase of equipment and engineering adaptation

RELATED EFFORTS: Cable routing tasks have already been automated by this approach. Two separate proposals received in this area

RISK FACTOR: Medium

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 75

TITLE: *Improved Hole Etching/Striplines*

COSTS: *$45K FY80*

AREA OF COST SAVINGS: *Small hardware PCB, #4*

METHOD OF COST SAVINGS: *Manufacturing Methods, #3*

APPLICABLE NAVY SYSTEMS: *Standard Missile #M61*
Standard Missile (MR) #M62
Sparrow #M64

TECHNICAL OBJECTIVES: *Remove dangerous chemical (cost driving) step from etching process*

BACKGROUND: *Ancient practices used sodium vapor etch.*

APPROACH: *Test various reactive gases, in conjunction with rf discharge to condition hole surfaces*

BENEFITS: *Manufacturing estimates $50.00 per circuit board. Economies vary from about 1% to 5% of category #4 depending on missile type and number of boards. Benefits may b2 higher in other areas.*

IMPLEMENTATION: *Via controlled study*

RELATED EFFORTS: *None known in this method. Holes on PCB's are receiving much attention in other projects*

RISK FACTOR: *High*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 76

TITLE: *CAD for Wire Harness - Software*

COSTS: *$120K FY80*

AREA OF COST SAVINGS: *Support labor, #10*

METHOD OF COST SAVINGS: *Capital equipment, #2*

APPLICABLE NAVY SYSTEMS: *All Missiles #90*

TECHNICAL OBJECTIVES: *Develop software that allows CAD on 3D basis for cable harnessing in missiles*

BACKGROUND: *Hand designed at present*

APPROACH: *Software development*

BENEFITS: *Not easy to quantify/applies to tooling stage of manufacturing; assume 1% of category for comparison.*

IMPLEMENTATION:

RELATED EFFORTS: *Several*

RISK FACTOR: *Medium*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 77

TITLE: Advanced N/C Machine Controller

COSTS: $200K FY80; $200K FY81

AREA OF COST SAVINGS: Fabrication labor, #9

METHOD OF COST SAVINGS: Manufacturing Methods, #3

APPLICABLE NAVY SYSTEMS: All Missiles #90

TECHNICAL OBJECTIVES: Demonstrate an advanced N/C machine control that can be plugged into existing interface, and cause adaptive control of machine (i.e., vary speed, feed rates)

BACKGROUND: This is the next generation of N/C machines

APPROACH: Via common data base, and language

BENEFITS: 5 to 10% increase in machine time utilization is claimed. Relates to 2 to 4% of category

IMPLEMENTATION:

RELATED EFFORTS: Yes

RISK FACTOR: Medium

MANUFACTURING TECHNOLOGY STUDY

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 78

TITLE: Laser Welding - Core Memories

COSTS: $75K FY80; $75K FY81

AREA OF COST SAVINGS: Special functions, #2

METHOD OF COST SAVINGS: Manufacturing Methods, #3

APPLICABLE NAVY SYSTEMS: UYK-7 #L24
UYK-20 #L25
AYK-14 #L26

TECHNICAL OBJECTIVES: Determine potential cost saving via laser welding in memory manufacture

BACKGROUND: Present technique uses parallel gap welding

APPROACH: Controlled positioning of laser welder

BENEFITS: Reduction of labor content of memory may save 10 to 15% of category, manufacturer estimates

IMPLEMENTATION: Four phases: #1 survey of available equipment, #2 cost study, #3 verification onsite, #4 tooling for production

RELATED EFFORTS: None Known

RISK FACTOR: Medium to high

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 79

TITLE: "Silk Screen" Printing for PCB's

COSTS: $150K FY80

AREA OF COST SAVINGS: Small hardware PCB, #4

METHOD OF COST SAVINGS: Manufacturing Methods, #3

APPLICABLE NAVY SYSTEMS: UYK-7, #L24
UYK-20, #L25
AYK-14, #L26
All electronics #93

TECHNICAL OBJECTIVES: Develop stainless steel screen fabric technique for an automatic printing machine.

BACKGROUND: Automatic silk screen is not practical for high density multilayer PCB due to poor resolution

APPROACH: Develop stainless steel screen and fixture that allows automatic printing

BENEFITS: May save 10% in PCB or about 1 to 3% in category #4. Has wide applicability

IMPLEMENTATION: Via IRD developed fixture component

RELATED EFFORTS: IRD at contractor on fixture

RISK FACTOR: Medium

MANUFACTURING TECHNOLOGY STUDY

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 80

TITLE: *Quick Reaction - Change Capability*

COSTS: *$500K FY80; $600K FY81; $1000K FY82*

AREA OF COST SAVINGS: *Support labor, #10*

METHOD OF COST SAVINGS: *Capital, #2*

APPLICABLE NAVY SYSTEMS: *Phoenix #M63*
All missiles #90

TECHNICAL OBJECTIVES: *CAD/CAM approach as a quick reaction to changing missile engineering requirements*

BACKGROUND: *Support labor costs an high due to frequent engineering changes*

APPROACH: *Computerized data/search techniques, etc.*

BENEFITS: *Manufacturer estimates saving on the order of 500 to 600K per year on production base of 20 to 40M. This relates to about a 10% cost savings in category #10*

IMPLEMENTATION: *In phases beginning with system definition*

RELATED EFFORTS: *Yes many*

RISK FACTOR: *High if not well thoughtout, phased approach will reduce risk.*

MANUFACTURING TECHNOLOGY STUDY

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 81

TITLE: Effective Utilization of Automation Interfaces

COSTS: $50K FY80; $50K FY81; $50K FY82

AREA OF COST SAVINGS: Assembly labor, #8

METHOD OF COST SAVINGS: Institutional, #4

APPLICABLE NAVY SYSTEMS: All electronics #93

TECHNICAL OBJECTIVES: Determine the standard for interfaces used in automated equipment, to allow for the widespread use of automation.

BACKGROUND: Current practice is often stand-alone; need for standard is recognized.

APPROACH: Involvement of NBS and other outside consultants to determine standards

BENEFITS: Not quantifiable. Consider 1% for evaluation purposes

IMPLEMENTATION:

RELATED EFFORTS: None

RISK FACTOR: Low

Science Applications, Inc.

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 82

TITLE: Hierarchical Control Program/Robotics

COSTS: $50K FY80; $50K FY81

AREA OF COST SAVINGS: Assembly labor, #8

METHOD OF COST SAVINGS: Manufacturing Methods, #3

APPLICABLE NAVY SYSTEMS: All electronics #93

TECHNICAL OBJECTIVES: Further development of already demonstrated Robotic control program language

BACKGROUND: Current robotic control language is cumbersome

APPROACH: Refine an elegant computer language structure, develop and demonstrate

BENEFITS: Not possible to accurately quantify. For rating purposes assume 0.2% of category

IMPLEMENTATION: Via demonstration/development program

RELATED EFFORTS: None Known

RISK FACTOR: Low; IRD has been accomplished

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 83

TITLE: *Tactile/Visual Sensors on Robotic Arms*

COSTS: *$150K FY80; $200K FY81; $200K FY82*

AREA OF COST SAVINGS: *Assembly labor, #8*

METHOD OF COST SAVINGS: *Manufacturing Methods, #3*

APPLICABLE NAVY SYSTEMS: *All electronics #93*

TECHNICAL OBJECTIVES: *Develop and refine tactile and visual sensors on robotic arms - used in adaptive control of manipulation*

BACKGROUND: *Present robotic arms have no adaptive control - may hit wrongly positioned work piece in moving*

APPROACH: *Develop sensor for arms - reflected light sensors or other pressure sensors are possibilities*

BENEFITS: *Not possible to quantify. Assume 0.2% of category for rating purposes*

IMPLEMENTATION: *Needs to be demonstrated in an actual factory environment*

RELATED EFFORTS: *Now largely in University research area*

RISK FACTOR: *High*

MANUFACTURING TECHNOLOGY STUDY

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 84

TITLE: Reembodiment of Semi Conductors in LSI

COSTS: $200K FY80; $250K FY81; $500K FY82

AREA OF COST SAVINGS: Integrated Circuits, #3

METHOD OF COST SAVINGS: Volume #1

APPLICABLE NAVY SYSTEMS: All electronics #93

TECHNICAL OBJECTIVES: Study the potential to reembody current SSI and MSI IC's as LSI with identical functions so that a replacement at the SEM level could be made

BACKGROUND: Services currently have too low volume to take advantage of commercial LSI development

APPROACH: Through a "blue ribbon" panel of industrial experts. The problem is outlined and cost savings estimates are developed. Further stages are performed as warranted.

BENEFITS: Commercial practice find savings of 1/3 or 1/2 by this technique, LSI circuits are more reliable also. (Use 10 to 20% savings for rating purposes)

IMPLEMENTATION: In phased steps

RELATED EFFORTS: None

RISK FACTOR: Low, commercial experience is promising

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 85 (A 311)

TITLE: Fibre Optics Integrated Structure - Airframe

COSTS: $250K FY80; $250K FY81

AREA OF COST SAVINGS: Cables, #1

METHOD OF COST SAVINGS: Manufacturing Method, #3

APPLICABLE NAVY SYSTEMS: All aircraft #91
All missiles #90

TECHNICAL OBJECTIVES: Develop a composite aircraft structure with embedded fibre optic cables

BACKGROUND: IRD work at contractor has validated approach on small sample size.

APPROACH: Replacement of structural fibre with optical fibre at selected locations

BENEFITS: Lower weight, cost could be dramatic, although contractor believes gain is higher. Let us assume a 10% reduction in category #1 for rating purposes (agrees with estimate on project 32)

IMPLEMENTATION: Via development of larger panels and test program

RELATED EFFORTS: None exactly like this - competes with other fibre optic programs such as ALOF

RISK FACTOR: High

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 86 (A 802)

TITLE: *Glue Process Avionics Chassis*

COSTS: *$100K FY80*

AREA OF COST SAVINGS: *Cables, Cabinents, #1*

METHOD OF COST SAVINGS: *Manufacturing Methods, #3; Volume #1*

APPLICABLE NAVY SYSTEMS: *All aircraft #91*

TECHNICAL OBJECTIVES: *Develop a glue process for a cabinent capable of meeting avionics standards*

BACKGROUND: *Present cabinent cost is too high - weight reduction also is desirable*

APPROACH: *Develop a glue process - also standardize cabinent, chassis, etc.*

BENEFITS: *Cost and weight reduction. Estimate 5% of category*

IMPLEMENTATION: *IRD work in process at contractor*

RELATED EFFORTS: *None Known*

RISK FACTOR: *Low*

AD-A045 164 SCIENCE APPLICATIONS INC MCLEAN VA MANUFACTURING TEC--ETC F/G 13/8
THE NAVY MANUFACTURING TECHNOLOGY ELECTRONICS STUDY. A PLAN FOR--ETC(U)
JUN 77 N00039-77-C-0095

UNCLASSIFIED SAI-MT-2010-VOL-3 NL

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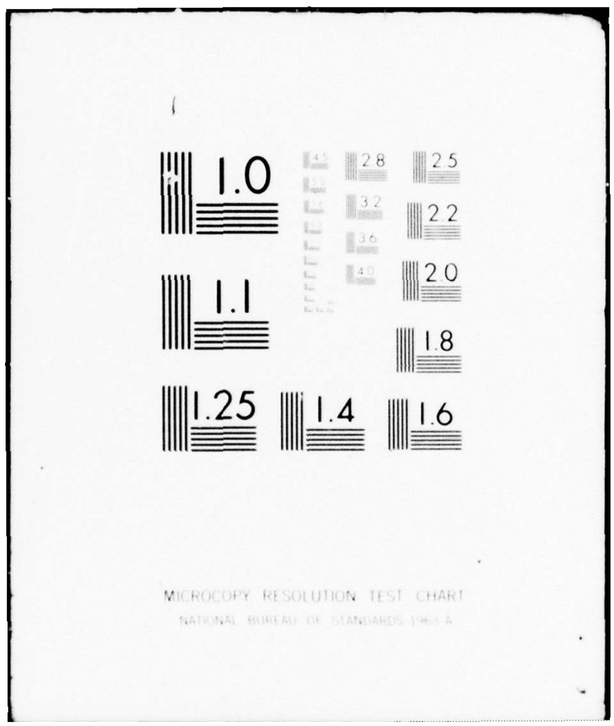
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

MANUFACTURING TECHNOLOGY STUDY

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 87 (A 773)

TITLE: Plastic H.V. Power Sup. Cabinets

COSTS: $150K FY80; $150K FY81

AREA OF COST SAVINGS: Cabinets, #1

METHOD OF COST SAVINGS: Manufacturing Methods, #3

APPLICABLE NAVY SYSTEMS: All electronics #93

TECHNICAL OBJECTIVES: Develop a low cost, low EMI plastic H.V. cabinet

BACKGROUND: Current technology uses aluminum - arcing problem, and cost dictate an alternate

APPROACH: Plastic molded (high volume) or standard plastic members assembled (low volume) will be investigated

BENEFITS: Low cost, no arcing. Estimate 10% savings in category can be achieved.

IMPLEMENTATION: Via study program, development of two chassis design

RELATED EFFORTS: None Known

RISK FACTOR: Low, EMI shield must be provided

MANUFACTURING TECHNOLOGY STUDY

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 88

TITLE: III, V Compound Crystal Growth

COSTS: $250K FY80; $250K FY81

AREA OF COST SAVINGS: Integrated circuits, #3

METHOD OF COST SAVINGS: Manufacturing Methods, #3

APPLICABLE NAVY SYSTEMS: All electronics #93

TECHNICAL OBJECTIVES: Improve the present techniques for III, V compound crystal growth

BACKGROUND: III, V compounds are used in high speed logic circuits, in EO devices, and in photo-multiplier tubes

APPROACH: Investigate techniques, including chemical vapor deposition

BENEFITS: Lower cost, reduced defects etc.; assume a 1% lower cost for IC's category 3

IMPLEMENTATION:

RELATED EFFORTS: Many in industry

RISK FACTOR: High

MANUFACTURING TECHNOLOGY STUDY

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 89 (A 618B)

TITLE: GaAs FET Yield Improvement

COSTS: $650K FY80; $650K FY81

AREA OF COST SAVINGS: Discrete semiconductors, #5

METHOD OF COST SAVINGS: Manufacturing Methods, #3

APPLICABLE NAVY SYSTEMS: Radar and EW @ 10% of
All Electronics #93
Aegis #S01 (via AN-SPY Radar)
PRC-104 #L18; TPS 59 #L21; DTPEW #L27
ALW-78 #L32; ALR-59; #L33

TECHNICAL OBJECTIVES: Improve yield, especially in interconnect on GaAs FET

BACKGROUND: Present chip interconnect is done by hand operation

APPROACH: Investigate epitaxial material preparation, metal definition, interconnect and metalization schemes

BENEFITS: Claims of factor of 10 reduction in power devices; relates to 1 to 2% reduction in category. Also can replace TWT's for greater benefit.

IMPLEMENTATION: IRD is well under way at contractor

RELATED EFFORTS: Other firms are active in area

RISK FACTOR: High

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 90 (A 508)

TITLE: Epitaxial YIG Microwave Filters

COSTS: $250K FY80; $350K FY81

AREA OF COST SAVINGS: Passive components, #7

METHOD OF COST SAVINGS: Manufacturing Methods, #3

APPLICABLE NAVY SYSTEMS: All electronics #93 (radar components)

TECHNICAL OBJECTIVES: Replace down conversion of microwaves for processing with direct processing (filtering) at microwave frequency.

BACKGROUND: Use of YIG material for filters has been proposed to solve this need

APPROACH: Develop procedures, in photolithograph epitaxial growth techniques etc.

BENEFITS: Improved microwave circuit design savings estimated at 1% of category

IMPLEMENTATION: Via development work up through the pilot line stage

RELATED EFFORTS: None Known

RISK FACTOR: High

MANUFACTURING TECHNOLOGY STUDY

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 91 (A 601B)

TITLE: Piezoelectric Polymer Films

COSTS: $200K FY80; $175K FY81; $75K 82

AREA OF COST SAVINGS: Sensors, #2

METHOD OF COST SAVINGS: Manufacturing Methods, #3

APPLICABLE NAVY SYSTEMS: Sonars and Sonobuoys
BQR-21 #L13; SSQ-41 #L14
SSQ-53 #L15
BQQ-5 #L10; SSQ-23 #L12; SSQ-62 #L16

TECHNICAL OBJECTIVES: Develop PVF (polyvinyl flouride) film stretching techniques to make acoustic and ultrasonic sensors

BACKGROUND: Ceramic sensor costs are high - this is an innovative approach that may cut costs, especially for small hydrophones such as in sonobuoys

APPROACH: Continuation of IRD program

BENEFITS: Not specific at this time - assume a 1% savings in category 2 for ranking purposes

IMPLEMENTATION:

RELATED EFFORTS: None Known

RISK FACTOR: High

MANUFACTURING TECHNOLOGY STUDY

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 92 (A 301)

TITLE: *Composite Materials in Optical Assemblies*

COSTS: *$250K FY80; $200K FY81*

AREA OF COST SAVINGS: *Sensors, #2*

METHOD OF COST SAVINGS: *Manufacturing Methods, #3*

APPLICABLE NAVY SYSTEMS: *IR guided missiles such as Sidewinder #M65*

TECHNICAL OBJECTIVES: *Demonstrate composite materials for support structures, and for reflecting optical elements.*

BACKGROUND: *Current costs of manufacturing optical components are very high. Weight must be reduced.*

APPROACH: *Use of composite materials, innovative pressing and forming techniques for the reflecting surfaces.*

BENEFITS: *Contractor estimates reduction of $2000.00 per missile or 10% of category #2*

IMPLEMENTATION: *IRD work is complete - could start on development*

RELATED EFFORTS: *Yes in other firms*

RISK FACTOR: *Medium*

MANUFACTURING TECHNOLOGY STUDY

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 93 (A 331)

TITLE: *Diamond Turned Plastic Lenses*

COSTS: *$250K FY80; $200K FY81*

AREA OF COST SAVINGS: *Sensors, #2*

METHOD OF COST SAVINGS: *Manufacturing Methods, #3; Capital, #2*

APPLICABLE NAVY SYSTEMS: *IR missiles such as Sidewinder #M65*

TECHNICAL OBJECTIVES: *Develop diamond turning as a production technique*

BACKGROUND: *IR missiles often use convex aspheric plastic lenses. At present there is no low cost manufacturing technique.*

APPROACH: *Laboratory and small scale work on diamond turning appears suitable for development as a mass production method.*

BENEFITS: *Greatly improved costs on lenses - estimated at 2 to 5% of category 2.*

IMPLEMENTATION: *Need for a 300K diamond turning machine is projected (cost included)*

RELATED EFFORTS: *Several*

RISK FACTOR: *Medium*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 94 (A 332)

TITLE: Vacuum Lock Coating System

COSTS: $200K FY80; $150K FY81

AREA OF COST SAVINGS: Sensors, #2

METHOD OF COST SAVINGS: Volume #1, Capital #2

APPLICABLE NAVY SYSTEMS: All Missiles #90

TECHNICAL OBJECTIVES: Apply mass production vacuum lock coating systems to military hardware

BACKGROUND: Present military systems use batch type coating - at great expense.

APPROACH: Verify the economics of vacuum lock system, purchase and test

BENEFITS: Cost: factor of two in coating costs - estimated at 0.5 to 1.0% of category. Also higher quality, less contamination, etc.

IMPLEMENTATION:

RELATED EFFORTS: Used commercially

RISK FACTOR: Medium to low

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 95 (A 322, 631A)

TITLE: *Automated Photo-Cathode System*

COSTS: *$200K FY80; $150K FY81*

AREA OF COST SAVINGS: *Sensors #2*

METHOD OF COST SAVINGS: *Manufacturing Method #3*

APPLICABLE NAVY SYSTEMS: *Night Vision Equipment*
Estimate at 1% of all electronics #93

TECHNICAL OBJECTIVES: *Develop an adaptive system to quantify photo cathode response while it is being formed.*

BACKGROUND: *Low yield of good photo multiplier and image enhancement devices due to poor photo cathode response is found.*

APPROACH: *Automate and allow adaptive control of key manufacturing step that of cathode deposition*

BENEFITS: *High for selected equipment;*
benefit is 10% of sensor (but x1% for all electrons);
net is 0.1% benefit category 2 for #93 systems.

IMPLEMENTATION: *Via computer controlled equipment*

RELATED EFFORTS: *Two firms are active in area*

RISK FACTOR: *Low to medium*

MANUFACTURING TECHNOLOGY STUDY

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 97 (A 302, 607A)

TITLE: *Monolithic Focal Plane Detector - Manufacturability*

COSTS: *$300K FY80; $250K FY81*

AREA OF COST SAVINGS: *Sensors #2*

METHOD OF COST SAVINGS: *Manufacturing Methods #3*

APPLICABLE NAVY SYSTEMS: *IR Missiles (Sidewinder) #M65*
A-6E #A44
EA-6B #A45

TECHNICAL OBJECTIVES: *Develop manufacturing techniques to improve yield and lower cost of monolithic focal plane detector.*

BACKGROUND: *Monolithic focal plane detectors are candidates to replace discrete detector systems in airlight and IR seeking missiles. Costs must be reduced however.*

APPROACH: *Investigate backside thinning techniques and other ways to enhance yield.*

BENEFITS: *Manufacturer claims an economic savings relating to a factor of 10 reduction in detector costs. Relates to 10% improvement in Category 2.*

IMPLEMENTATION: *May need additional RD work; schedule may slip one or two years.*

RELATED EFFORTS: *Yes at several firms*

RISK FACTOR: *High*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 98 (A 125B)

TITLE: CMOS/SOS Manufacturability Study

COSTS: $300K FY80; $300K FY81

AREA OF COST SAVINGS: Integrated circuits #3

METHOD OF COST SAVINGS: Manufacturing Methods #3

APPLICABLE NAVY SYSTEMS: All electronics #93

TECHNICAL OBJECTIVES: Study the potential for newly applied manufacturing techniques to Silicon on Sapphire (SOS) circuitry.

BACKGROUND: SOS circuitry is desirable from the point of view of high speed, radiation resistance, and heat dissipation. However manufacturing methods for mass production have not been used up to now.

APPROACH: Investigate use of ion implantation, vapor phase deposition of polysilicon, sputtering of aluminum etc.

BENEFITS: Contractor estimates savings of 10% in all IC's for military market. Use 3 to 5% of category #3 as a conservative estimate.

IMPLEMENTATION:

RELATED EFFORTS: Several

RISK FACTOR: Medium

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 99

TITLE: *Laser Inspection of Hybrid Circuits*

COSTS: *$150K FY80; $150K FY81*

AREA OF COST SAVINGS: *Hybrid circuit #6*

METHOD OF COST SAVINGS: *Capital #2*

APPLICABLE NAVY SYSTEMS: *All electronics #93*

TECHNICAL OBJECTIVES: *Develop a laser based inspection system for hybrid circuits*

BACKGROUND: *Yield problem continually plague military users of hybrids*

APPROACH: *Developed an automatic laser scanning system to detect flaw - may be used in conjunction with IR imaging.*

BENEFITS: *Could result in a 1 to 2% savings in hybrid costs (test) and in improved yield (up to 10%); assume 2 to 5% for rating purposes*

IMPLEMENTATION:

RELATED EFFORTS: *Many*

RISK FACTOR: *Low to medium*

MANUFACTURING TECHNOLOGY STUDY

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 100

TITLE: Low Cost Monolithic Ceramic Capacitors

COSTS: $80K FY80; $190K FY81

AREA OF COST SAVINGS: Passive components #7

METHOD OF COST SAVINGS: Manufacturing Methods #3

APPLICABLE NAVY SYSTEMS: All electronics #93

TECHNICAL OBJECTIVES: Develop manufacturing methods for handling the thinner dielectric sheets needed for lower cost units.

BACKGROUND: Metal electrode thickness has already been reduced. This is one cost driver as metal is costly. The second cost driver is the dielectric.

APPROACH: Reduced dielectric layer thickness would be practical if machinery were available to handle thin sheets.

BENEFITS: Contractor estimates that 8% of capacitor costs or 3% of passive costs would be saved.

IMPLEMENTATION:

RELATED EFFORTS: Unknown

RISK FACTOR: Low to medium

MANUFACTURING TECHNOLOGY STUDY

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. *101 (A 847, 848)*

TITLE: *Closed Circuit Cleaning of PCB's*

COSTS: *$95K FY80*

AREA OF COST SAVINGS: *Small hardware PCB #4*

METHOD OF COST SAVINGS: *Manufacturing Methods #3*

APPLICABLE NAVY SYSTEMS: *All Aircraft #91*
All Electronics #93

TECHNICAL OBJECTIVES: *Demonstrate a closed circuit PCB cleaning process. Develop ionic contamination monitors.*

BACKGROUND: *IRD work at contractor has resulted in an operational lab unit. Cleaning costs can be dramatically lowered.*

APPROACH: *Filtration and ionic exchange beds are used to recycle cleaning fluid.*

BENEFITS: *Savings on materials, improved cleaning capability, better yield and less rework. Contractor estimates savings at 3 to 5% rate for category.*

IMPLEMENTATION: *Via pilot production facility.*

RELATED EFFORTS: *IRD at firms (two contractors suggestions are combined in this write-up).*

RISK FACTOR: *Low to medium*

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 102 (A 805, 807)

TITLE: Component Assembly - Automated Operator Assistance

COSTS: $70K FY80

AREA OF COST SAVINGS: Assembly labor #8

METHOD OF COST SAVINGS: Capital #2

APPLICABLE NAVY SYSTEMS: All electronics #93

TECHNICAL OBJECTIVES: Demonstrate a system which allows automatic prompting of an assembly operator

BACKGROUND: Need to reducelabor in assembly is well recognized.

APPROACH: Use machine readable card for each component - kit the parts and then provide visual clues and prompting to the operator as to component insertion.

BENEFITS: Claims for great savings are made but not substantiated. Assume a 2% savings in assembly labor for ranking purposes.

IMPLEMENTATION: Via demonstration of system.

RELATED EFFORTS: Contractor has a system such as this working partially - two different firm's information went into this project write-up.

RISK FACTOR: Medium - may be superceded by other fully automated procedures.

ELECTRONICS MT PROJECT DESCRIPTION PROJECT NO. 103 (A-SS2)

TITLE: *Ink Jet Wire Marking System*

COSTS: *$400K FY80; $400K FY81; $200K FY82*

AREA OF COST SAVINGS: *Cabling #1*

METHOD OF COST SAVINGS: *Manufacturing Methods #3*

APPLICABLE NAVY SYSTEMS: *All aircraft #91*

TECHNICAL OBJECTIVES: *Demonstrate an ink jet system to mark wires to mil-spec reliability and quality levels.*

BACKGROUND: *Present wire marking techniques include hot stamp, color stripe, color band, ID sleeve, or tape.*

APPROACH: *Develop an ink jet system - IRD work at contractor has one developed which needs to be shown on pilot level and that wires meet specs.*

BENEFITS: *Five times faster than conventional, less damage to wire insulation, more information in marking, can mark wires that cannot be marked by present methods. Estimate at 1% cost savings for category.*

IMPLEMENTATION: *Via a pilot production set up, work on smaller diameter than presently demonstrated.*

RELATED EFFORTS: *None Known*

RISK FACTOR: *Medium*

Appendix B

MT INCENTIVES FOR INDUSTRIES

Papers and Letters by David R. Heebner
G. D. Goldshine
N. R. Hangen
William E. Bradley

OVERVIEW AND SUMMARY

INTRODUCTION

The goals of the Navy Manufacturing Technology program - that of procurement cost reduction - can be met in two ways: Specific funded MT projects will, when successfully executed, bring cost savings. Equally effective may be the development of a broad class of incentives for industry. During the study the issue of incentives surfaced regularly and several general areas of incentives were identified: A Navy offered incentive can cause a firm to direct its manufacturing activities in a way jointly beneficial to the Navy and its own interest. However, the specific costs or benefit of the potential leverage were not addressed during the main part of the study. In order to amplify the feeling in industry the study team requested "white papers" on the specific area of industrial incentives.

This appendix focusses first on the general goals of manufacturing technology and on their need to relate to industrial incentives. The second part of this appendix is a first step at allowing cognizant industrial representatives to provide input dealing with the economic questions they face when considering funding MT projects.

GENERAL GOALS AND PRACTICES OF MANUFACTURING TECHNOLOGY (MT)

During the course of this study the task team reviewed the delineation of specific MT terminology and general MT goals in industry, in the three service programs, and in the DoD. It was increasingly obvious that manufacturing technology meant different things to different people depending upon their background, orientation, and objectives. MT goals will not be easily met unless there is a common basis for understanding. Although this study focussed on electronics and procurement costs, the principles, problems, and potential applications fit equally well in the broader framework of a general definition for MT.

Manufacturing technology involves the application of advanced ideas and methods to reduce manufacturing costs. After a cost area is identified and quantified, then the feasibility of an innovative technique must be demonstrated, developed and implemented. Manufacturing technology is translated into practical production processes that can reduce production time, decrease material costs, and shorten inspection and testing time. Often improved reliability, yield, and quality are side effects. The study showed that ideas and methods can be applied across the manufacturing process cycle of a system: in production scale, capital expenditures, manufacturing process cycle or institutional policy (i.e., government-management relations). The effect in product-related cost reductions appears in subcontracted materials, improved fabrication techniques, more efficient assembly and subassembly, better material flow and inventory control, and automatic measuring, inspecting and testing processes.

Deputy Secretary of Defense, William P. Clements, Jr., in April 1975, directed the services to identify and aggressively exploit opportunities to reduce weapon-systems costs through advanced manufacturing technology. Mr. Clements stressed creating incentives for defense contractors.[1)] In response to this directive the Navy is now engaged in defining and implementing "an integrated MT plan for investments selection that offers attractive incentives for industry while lowering overall equipment production and support costs."[2)]

The SAI study team, in support of the Navy Project, received a number of specific technical proposals from industry addressing the improvement of their manufacturing base to benefit the Navy. The following general areas of incentives were identified:

- The need for improved industrial knowledge of the MT program goals and practices
- The opportunity for more frequent discussions with and more rapid response of the Navy to contractors
- Improved contract procedural matters.

The incentive related suggestions were recorded and analyzed in a similar format to those of specific MT innovations. The summary findings are discussed in Volume I and the specific details are found in Appendix A. They depend in part on such things as reexamining the feasibility of multi-year contracting and value engineering clauses as suggested in Mr. Clements' memo.[2)]

The following specific suggestions that deal with industrial incentives were identified during the course of the study. The Navy should take an active role in a continual communications exchange with its key industrial contractors. Central MT points of contact in the Navy Project Offices should be established and coordinated with counterparts in the various firms. Many firms are establishing central points of contact for MT, and this trend ought to be encouraged. An informal written journal should be established to inform both Navy and industry of program and technological goals and progress. Both the Army and the Air Force have such a journal and the Navy already disseminates Technical Notes from NAVMIRO, Philadelphia which is a step toward this desired goal.[3)] Frequent working sessions with industry ought to be established and directed along the technological lines of the MT program, i.e., micro-electronics.

The study interviews continually reinforced the view that electronics is a manufacturing microcosm and uses a multitude of manufacturing techniques. In addition, since revolutionary changes are taking place in major branches of electronics technology the Navy program should include allowances for rapid changes in methods and technology in response to changing military requirements and threats. It should, therefore, also provide a dynamic rather than a static MT plan. Summary recommendations concerning how this might be accomplished are included in the study synopsis, Volume I.

INDUSTRIAL VIEWPOINT

Industrial cooperation in achieving both short term cost savings and long range MT goals depends in large part upon industry's perception of the scope of potential Navy MT program plans and in particular on the incentives to be provided. During the course of the study it became apparent that the recurring theme of incentives needed to be investigated further. Summary essays from industry were therefore requested to address more directly the question of industrial incentives.

Industrial response to a request for comments about the types of incentives that would encourage them to fund MT projects that would ultimately lower electronics cost to the Navy was candid and specific.

The need and desire for open communication and clearly defined guidelines was an implied and underriding concern of each respondent to the incentive question. The overriding concern was succinctly stated by Mr. N. R. Hangen, Manager of R&D Market Development for RCA, Electronic Components. To encourage industrial participation in a cost reduction program through manufacturing technology the company must be offered a ..."carrot, not merely a picture of a carrot."... "If industry is to make the investment in manpower, space and in most cases production facilitation, then they require that a payback be permitted to recover the investment."

Specific suggestions included:

- Successful implementation of a Navy MT program should have the attendant advantage of improving chances for a follow-on procurement.
- Assuring a contractor reimbursement for MT expenses based on quality of work and the extent to which it complies with firmly established guidelines.
- An increase in B & P funding allocations for contractors bidding on MT programs to compensate for substantial expense and utilization of limited resources.

Discussion on three other topical areas relating to industrial incentives was stimulated by SAI's letter requesting incentive information from industry. These topics dealt with sharing of data rights after a successful MT project, industry's contribution to improving manufacturing and procurement costs peculiar to defense systems.

Mr. G. P. Goldshine, Director of Manufacturing Engineering for General Dynamics identified as a basic purpose of MT projects the sharing of results, and elsewhere in his essay devotes major concern and encompassing suggestions for providing better techniques for technology transfer. The consensus of all respondents indicates that proprietary concerns do not represent a major problem to industry.

Mr. Patrick J. Campbell, Business Director of Staff Engineering cited specific incidences where Sperry Univac has contributed to improving manufacturing techniques. Industrywide, however, additional work can be done to improve technology and to increase use of existing technology.

The specific items that drive component costs for defense systems evolve around special tooling, documentation and control requirements, and quality and reliability impositions on small quantities of cost effective production of special components requires an accelerated development sequence which must be well coordinated, planned, and budgeted for.

The following essays offer a number of additional suggestions dealing directly with ways to encourage industry to actively participate in the MT Program.

REFERENCES

1) MT Program Electronics Study, Memo 042/LCD, from the Chief of Naval Material, 11 January 1977.

2) This view is confirmed in a recent conference (see Proceedings 1976 Manufacturing Management Conference, American Institute of Industrial Engineers, 1976).

3) Authority to do so is contained in NAVMATINST 4800.36C.

ECONOMIC ISSUES RELATED TO
MANUFACTURING TECHNOLOGY

MT Incentives by David R. Heebner, Science Applications, Inc.

Letter from G. D. Goldshine, General Dynamics

Letter from N. R. Hangen, RCA

Letter from Patrick J. Campbell, Sperry-Univac

Industry Incentives for Manufacturing Technology Improvement and a Suggested Procedure for Navy Procurement of Such MT Developments by William E. Bradley, Consultant

MT Incentives

by David R. Heebner
Senior Vice President
Science Applications, Inc.

On the Navy side of the MT program the incentives are clear, direct and simple, viz., reduction in the producement costs of weapons systems without degrading systems performance or value. On the industry side, the incentive picture is more complex. Cost saving manufacturing methods enhance competitive posture. Methods developed under Government contract will be available to the competition. Some methods developed for military systems may have a larger payoff in applications to civilian market products. The Government may start development of MT projects but not follow through with implementation, thus making investment planning in production equipment uncertain. Maybe the result of the work will be used in a negotiation to reduce allowable costs and fee in a cost type procurement.

All of these conflicting forces - and many more - make the industrial community wary of the MT program; this wariness revealed itself in the industrial interview process. Interestingly, the interview process itself, combined with other MT activities has communicated a seriousness and dedication to the MT program that have been helpful in dispelling some industrial worries. Additional institutional efforts, conferences, etc. will help but the key problems will remain. Industry must be convinced that it will be fully compensated for MT work that it shares and will not be expected to self-finance part of the work on IR&D and other overhead accounts. They must be convinced that profit incentives will in fact be applied, not undermined, by contract negotiations.

Service program managers, curiously, are in the position between the industry and the service. Their problem is that while strongly motivated to keep procurement costs low and to optimize cost effectiveness of their systems, they must maintain program schedules and avoid all unnecessary risks. Thus, efforts of influences that they do not control directly are viewed with caution. They must be especially wary of planning on specific kinds of support that fail to materialize. There is some evidence that the past experience of some PM's with MT proposals has been bad in this regard.

The design of incentives for MT then, while having some unavoidable conflicts, should emphasize full funding, clear decision milestones, a presumption of implementation of all successful projects, guidelines to contracting officers that reinforce MT oriented efforts and profitability increases under weighted guidelines for innovation in cost reducing manufacturing methods.

GENERAL DYNAMICS
Pomona Division
P. O. Box 2507, Pomona, California 91766 • 714-629-5111

April 12, 1977

Mr. T. Michael Knasel
Director, Manufacturing Technology Project
Science Applications, Inc.
8400 West Park Drive
McLean, Virginia 22101

Dear Mr. Knasel:

We received your request for our comments on the economic issues related to manufacturing technology with considerable interest. We appreciate the opportunity to comment on these issues.

Topic 1. What are the proper incentives needed by your company, by the industry, to participate in a cost reduction program through manufacturing technology?

We are basically a Weapon Systems firm in the Aerospace industry. We will address the question from that standpoint although avionics or aircraft personnel might have a different point of view.

Our position as a company is that we will work on manufacturing technology projects which are likely to provide cost savings to our current or anticipated product lines. Basically we have limited resources of development personnel and the application of these resources is key to our future.

For the last several years our primary in-house manufacturing technology efforts have been supported by - %*of the Division's IRAD budget. Additional small amounts have been received from product contracts and from manufacturing, to work on specific problems. Since these efforts are spread roughly equally between cost reduction efforts and efforts aimed at specific technical goals, we can summarize by saying that an amount roughly equal to - %*of the Division IRAD (~ - K)*is spent yearly on manufacturing technology cost reduction projects. Additionally, - K to - K*is spent from the capital budget to acquire facilities for these projects. We have received one contracted manufacturing technology project from NAVSEA which we recently completed.

During the last year we bid on four manufacturing technology projects from MICOM which were related to the Hilton Head Conference. We did not win any of these four. Our investment in bidding on these projects was primarily 8 man months of time from our development personnel.

*Figures have been deleted by SAI for publication.

The result of this experience is that we feel bidding on manufacturing technology projects is very questionable economically. If we win an average number of contracts, approximately 1 in 7 based on the number of bidders for the MICOM projects, we won't do much better than break even on our bidding expenses. Also we do not get as much value from contracted R&D as from the same amount of in-house funding because of the higher reporting and demonstration requirements of the contract and because the contracted R&D requires the addition of some work to establish a general industry application.

Another difficulty with the current approach to contracting manufacturing technology is that it takes too long and frequently interjects a period of formal competition which delays the project and increases costs without much probability of cost advantage to the government. There should be a more efficient and direct way to contract with an organization which has originated a proposed project, and demonstrated feasibility with its own money. The prospect of competing in the open market for a project that we have conceived and demonstrated and then waiting the attendant 1 to 3 year delay before funds may actually be received is a major discouragement. On the really critical technology projects it is unacceptable.

Pursuing the problems of the current approach for a minute longer, the idea of getting technology transfer from the current system is somewhat too optimistic. In theory the company which is furthest advanced in a technology field will win a project. At the end of the project a report is issued and a one day demonstration is held. That is a totally inadequate method to transfer technology to other companies which can be from 1 to 5 years behind.

Proposals

From our point of view the manufacturing technology projects need to better meet the following objectives:

1. Be responsive to general industry needs.
2. Provide some level of flexibility to handle unexpected opportunities.
3. Require less expense from bidding and proposal.
4. Provide better techniques for technology transfer.

To meet these requirements we propose that the manufacturing technology effort be divided into 3 segments:

Segment 1: This effort would be run in the same general manner as current contracted manufacturing technology programs. It would be utilized for contracting technology efforts which are specialized to small segment of the industry. An example could be the development of better methods to form/machine Laser Gyro materials. The technology transfer effort would be a two week short course and the attendees would be required to pay a substantial course fee to preclude attendance by casual observers.

GENERAL DYNAMICS
Pomona Division

Segment 2: This effort would be directed toward technology projects with a very broad interest. Examples would be automated planning systems, additive plating of printed circuit boards, adaptive control of machining systems, etc. The project would be run in a manner similar to a CAM-I (Computer Aided Manufacturing-International) project. Interested companies would be invited to attend a requirements definition meeting, at their own expense. At the 2 or 3 day meeting, chaired by a government representative, the scope of the project would be defined and a skeleton RFP/Specification would be developed. Subsequent to the meeting, the government would take one to three months to create a draft RFP/Specification. The government might utilize contract assistance in this effort, but the contractor would be excluded from responding to the RFP. A finalization meeting similar to the first meeting would be held to get industry inputs to finalize the RFP/Specification. The government would then send the RFP out for quote to any interested firms. The details of the technology transfer effort would be included in the RFP/Specification.

In both Segment 1 and 2, there should be informal procedures for submitting proposals and performing the work. The emphasis should be on technical results and technology transfer. One way to achieve this would be to create incentive contracts which induce the contractor to use his prime personnel resources.

Segment 3: This effort would be an extension of the current IRAD effort. It would allow a contractor to be reimbursed for a limited amount of manufacturing technology effort beyond the general IRAD budget ceiling. The limit would be related to the average amount of government production contracts over a several year period. The percentage reimbursement would be determined by a government decision on the quality of the work and the extent to which it complied with the Manufacturing Technology IRAD guidelines. The purpose of this segment would be to provide Manufacturing Technology money to exploit emerging cost reduction possibilities and company peculiar opportunities and needs. The primary judgment on the quality of the work should be: "Does it provide for current or future production cost savings for the government?"

Topic 2. What is your position on sharing data rights after a successful Manufacturing Technology project?

A basic purpose of Manufacturing Technology projects is the sharing of results. If we felt we would be unable to do this because of the attendant loss of proprietary data we would not respond to the RFP or we would respond with a notification that we reserved rights to specific proprietary data.

On our recently completed contracted Manufacturing Technology project on Acrylic Flex Harness materials we supplied voluminous amounts of specs, procedures and test results.

GENERAL DYNAMICS
Pomona Division

In those cases where we have proprietary rights to some of the data or we are sharing costs with the government, we would usually be willing to negotiate a period of time, perhaps 12 to 18 months, after which public release of the data would be acceptable.

Topic 3. Do you feel that sufficient work is being done in improved manufacturing in your company, in the industry?

No. Not in improving manufacturing technology or even using existing technology

- In machinery and equipment
- In processing
- In Computer Aided Design and Manufacture
- In Quality Assurance
- In testing.

Topic 4. What are the largest single items which drive defense system procurement costs in your opinion?

1. Separate documentation and control of common items for each individual program. If our own experience is a guide, there must be many dozens of spec control documents for the 2N2222 transistor. Each document controls the parameters and test procedures for a specific program.

2. The application of strict change control procedures before a design matures.

3. The heedless application of mil specs, with endless tiering, and confusing and conflicting requirements to all products. Contracting for measurable performance and reliability requirements should be preferred over specifying endless details of how the product is to be designed and manufactured. The morass is so great that no one can clearly assess the total impact of mil specmanship on cost. We think that costs outweigh any benefits.

4. Low quantity is a driving factor used in assessing a Return on Investment situation in program planning by a manufacturer. Non-recurring costs during product manufacturing development could be contract supplemented to enhance early phases of production.

5. The involvement of various government procurement agencies and their technical subagencies (HDL, NWCCL) into details of hardware, quality, reliability, etc., items contribute heavily to cost, and not necessarily to a better product.

6. Excessive and repetitive testing requirements being imposed by the procuring agency or manufacturer at low levels of fabrication.

7. Spares identification and documentation is often excessive and unnecessary.

GENERAL DYNAMICS
Pomona Division

I hope that we have answered your questions and that our response will be helpful in establishing a more productive manufacturing technology program in the near future. If we can be of more assistance toward this goal, please let me know.

G. D. Goldshine

G. D. Goldshine
Director
Manufacturing Engineering

RCA | Electronic Components | Lancaster, Pennsylvania 17604

Dr. T. Michael Knasel
Science Applications, Inc.
8400 Wespark Drive
McLean, Va. 22101

RCA

Subject: SAI Letter dated 17 March 1977
Item: Navy Electronics Manufacturing Technology
Program Improvement Comments

Dr. Knasel: April 25, 1977

I must preface my following comments to advise that my past experiences have been primarily with MT programs with agencies other than the Navy Electronics Manufacturing Technology activity, but I feel some of the comments in some cases may be directly applicable and informative. The comments represent my personal experiences and observations as directly involved in the development/manufacturing transition and active participation in developing and executing manufacturing technology programs.

Too often, self-proclaimed experts in the services will generate the requirements and specifications, particularly the funding levels, with little or no inputs from cognizant industry representatives. Also, I have personally experienced situations where these "experts" totally disregarded inputs because they would have to redo the paperwork, thereby possibly admitting that they didn't do the correct homework initially.

Another problem which is surfacing more and more, due to R&D funding cutbacks and limitations, is that the Research activities are trying to push for earlier MT starts, really as a mechanism to complete the engineering development with someone else's funding.

For MT's to be meaningful, the services should require, as a qualification to bid, representative samples and data to certify: (a) that the engineering development has been completed, (b) that indeed that the bidder is qualified.

Pre-bid industry group meetings to review specs. have a very limited value if competitors are also present since no company will really level or ask the pertinent questions.

I address the topics per your letter:

Incentives

As to incentives to industry to participate in the achievement of MT program goals, the primary comment is that a follow-on procurement intention, best manifested by an order tied directly to the MT is the best incentive. Most companies the services should be doing MT business with should be profit oriented production houses, not those merely selling engineering manpower.

It must be "carrot," not merely a picture of a carrot.

Too many times, industry does the MT job, only to find: (a) it was a solution looking for a problem; i.e., no direct, timely production follow-on, or (b) additional sources are brought in at the conclusion of the MT without the same constraints as the MT participant, i.e., Auction bidding for the follow-ons and revised specs.

If industry is to make the investment in manpower, space and in most cases, production facilitation, then they require that a payback be permitted to recover the investment.

The other aspect appears equally important; that is, instead of having price auction bids which only drive the price down beyond an acceptable level (encourages buy-ins), to get the most effective and productive MT, the services should officially advise the qualified bidders of the available funds and press for the best technical job bid fitting the funding available. Companies with the best G2 can always find out that is budgeted.

Since MT's are planned in advance, in some cases, up to 5 years ahead, provisions must be taken to update (a) the technical requirements vs. advances in the art to assure the latest methods, materials, etc.; (b) projected funding levels since apparently, in the past very little adequate updating or adjustments for inflation and technical state-of-the-art were made.

<u>Sharing of data rights after a successful MT project</u>.

Understanding the need for and accepting the government preference for multi-sources, RCA continues to agree with the limited rights arrangement of providing the required data on a free licensee basis for government end-use. Any application for other than government end use must be arranged and negotiated outside of the government

<u>Industry Improvements in Manufacturing</u>.

Suffice to say, from certain aspects, no company does the best job they would like to do with respect to improving manufacturing. It is a balance of priorities of manpower and funding directed towards optimizing selected markets.

The government MT programs certainly assist in accelerating and/or emphasizing improved manufacturing methods for producing specific items. Also, MT's are necessary since they include items of concern and data requirements which are peculiar to specific government requirements, which would be emphasized or handled in a different way to satisfy industrial/commercial needs.

Defense System Procurement Costs

In my opinion, the largest single item which drives defense system or components costs up is the excessive specifications, certification put on the contractor. Many times the government technical personnel impose excessive, best laboratory sample specs. into a MT and/or require excessive, self-serving engineering data requirements into an MT. An MT must be production oriented.

This, again, is brought about by attempts to shorten the basic cycle of development thru production. The engineering development phase prior to an MT should have included life test/field evaluations.

The following is a sample component oriented Product Development Sequence.

Product Development Sequence

Need/concept
Feasibility
Practicality
Prototype dev.
Engineering samples
System breadboard
Manufacturing methods - pilot production
Production samples
System brassboard
System prototype
Standard product
System production

Difficulties arise when one or more of these steps are eliminated rather than accelerated.

If the cycle of 6.1 thru 6.6 development and planning is followed by the government, instead of each activity trying to push their budget and time problems into the next succeeding activity, then more cost effective components and systems will result. There is no substitute for good, effective, coordinated planning and budgeting within the agencies.

I hope these comments are helpful in developing meaningful MT programs.

Please contact me for any additional assistance I can provide.

Very truly yours,

N. R. Hangen, Manager
R&D Marketing

mm
cc: C.W.Bizal, T.T.Lewis, R.E.Simon

SPERRY UNIVAC
COMPUTER SYSTEMS

UNIVAC PARK, P.O. BOX 3525
ST. PAUL, MINNESOTA 55165
TELEPHONE (612) 456-2222

April 26, 1977

Mr. T. Michael Knasel
Director
Manufacturing Technology Project Office
Science Applications Incorporated
8400 Westpark Drive
McLean, Virginia 22101

Dear Mr. Knasel:

Sperry Univac is pleased to submit the following responses to the topical questions submitted by Science Applications Incorporated (SAI). As a major supplier of electronic equipment to the Navy as well as other government agencies we appreciate this opportunity to contribute in this planning phase. We at Sperry Univac feel that industry acceptance of the Navy Manufacturing Technology program is essential for its success and that the MT program must contain sufficient incentives to be acceptable to industry.

The issues raised by your questions, traverse a broad range of professional disciplines such as legal, contracts, engineering, manufacturing and the like. Our responses reflect Sperry Univac's position on the specific issues raised by SAI's topical questions and our active experience with the Navy MT program to date. However, until the Navy has published a well organized and clearly defined plan for their MT program(s), it is virtually impossible to provide clear, analytical, and concise answers. Accordingly, the following subparagraphs consists of the topical issues and Sperry Univac's responses.

Question: What are proper incentives needed by your company, by the industry, to participate in a cost reduction program through manufacturing technology?

Answer: Sperry Univac proposes four incentives for consideration and they are as follows:

1. Company funded MT expenditures should be an allowable cost which can be amortized over production units.
2. Successful implementation of a Navy MT program should have the attendent advantage of an assured follow on manufacturing program.
3. Decreased cost on existing products, reduces revenue and profits. Therefore, considerations should be given to offset the decrease in return.

4. Competitive Navy MT programs will require substantial utilization of resources not previously planned. Accordingly, we recommend a corresponding increase in the TRI-Service Bid and Proposal funding allocations for contractors bidding on MT programs. Accordingly, we recommend that the contractors B&P cost expended on competitive Navy MT programs be excluded from the IR&D and B&P ceiling and that the contractor be allowed to recover 100% of these costs.

Question: What is your position on the sharing of the data rights after a successful MT project?

Answer: Where the successful MT project was totally funded by the government; then there is no doubt the government owns the data rights to disperse as they deem appropriate. However, where the successful MT project resulted from a shared funding agreement; then we recommend limited data rights, e.g., Sperry Univac reserves all data rights for proprietary data developed with company sponsored funds.

Question: Do you feel that sufficient work is currently being done in improved manufacturing in your company in the industry?

Answer: In the past five years, Sperry Univac has made substantial investments to automate and modernize our St. Paul, Minnesota and Clearwater, Florida manufacturing facilities. In addition, significant investments have been made to build Photo-lithographic, MOS semiconductor, hybrid, packaging, and test facilities at our Eagan, Minnesota facility. During this fiscal year we are building a bipolar semiconductor facility. These latter facilities were built to protect the low volume military market where there is a diminishing interest on the part of our traditional vendors.

The above are specific incidences where Sperry Univac has improved manufacturing.

Question: What are the largest single items which drive defense system procurement costs in your opinion?

Answer: The largest single costs drivers for Sperry Univac Defense Systems Division are listed as follows:

- Special tooling
- Packaging
- Test
- Design
- Software
- Small quantities
- Documentation and control

Once again we are dedicated to the success of this important program. If you need clarifications to our response or if we can be of further assistance, please don't hesitate to call the undersigned at (612) 456-2920.

Sincerely,

Patrick J. Campbell

Patrick J. Campbell
Business Director of
Staff Engineering

PJC/vlh

INDUSTRY INCENTIVES FOR MANUFACTURING TECHNOLOGY IMPROVEMENT AND A SUGGESTED PROCEDURE FOR NAVY PROCUREMENT OF SUCH MT DEVELOPMENTS

by Wm. E. Bradley

While the intent of the Navy MT program is perfectly clear, it is obviously a complex problem to design procedures by which the desired results can be obtained within the framework of existing Government procurement regulations and prevailing incentives to industry. The advantages and difficulties of the MT improvement process in private industry are instructive in this connection.

MT Projects in Private Industry

The MT improvement procedure in private industry involves investment of private capital of the innovating firm, usually with substantial risk, followed by a period of proprietary use of the innovation which repays the costs and hopefully produces added profits. The success of this process requires skill in estimation of the technical prospects of success and attendant costs, and also is dependent on estimates of the market for the resulting product.

Even for this simple procedure, obstacles appear some of which may be overcome by a Government agency MT procurement program. Some of these are the following:

1. Improved product reliability or longevity can cause a compensating loss of the replacement market so that such an improvement may be of little benefit to the producer, however desirable it might be to the user. In commercial markets there have been many examples of this: a) the Gillette Corp. had no incentive to improve the longevity of its razor blades until forced to do so by a small British company, Wilkinson Sword, which began marketing blades of a corrosion-resistant alloy; b) the positive

plates of an automotive lead-acid storage battery buckle or crumble at a fairly predictable rate, a defect avoided at small additional cost in industrial long-life lead-acid batteries by encasing the positive plate in a suitable "gauntlet." c) A major cause of obsolescence of automobiles in the U.S. is corrosion of the steel body by salt from the roadway, or from airborne salt near the seacoast. It is well known that admixture of a small percentage of copper with the steel reduces the corrosion rate by a factor of approximately ten (this is, in fact, done with steel manhole covers).

2. If an MT project greatly reduces manufacturing cost of a product, by a factor of three or five for example, as occurs when large scale integrated circuits can be directly substituted for printed circuit boards, then the dollar volume of sales may be drastically reduced unless the market has great elasticity or unless new markets are found for the product. Since military markets are often inelastic, cost reduction may actually be injurious to the producer of military equipment even though highly desirable to the user. For this reason, MT developments leading to drastic cost reduction of military equipment are likely to be initiated by an "outsider," a firm not formerly manufacturing that type of product.

The point here is that benefits to the producer do not always parallel benefits to the user unless unimpeded competition allows one producer, usually an outsider like Wilkinson Sword, to introduce a clearly beneficial improvement.

3. An important obstacle is the high cost of capital under the economic conditiong prevailing during the past five years. This has the effect of limiting MT investment to "sure things," usually incremental improvements to familiar processes, with assured but small benefits.

4. The private industry MT activity usually requires a long period of proprietary control in order to assure a profit to the innovator. This delays transfer of the new technology to other producers, delaying the public benefits somewhat (although not long in the case of outstandingly profitable innovations).

5. Engineers and applied scientists of sufficiently broad talents to conceive and implement MT developments are scarce, and when their ability becomes known, are likely to be exposed to seductive offers from competing organizations. Much technology transfer actually takes place by this mechanism.

Advantages of the Private Industry Procedure

One outstanding advantage of the private industry approach to MT is that all aspects of a project are contained within one organization (except for the necessary dependence upon the future market). As a result control of funding can be closely coupled to readily observed progress with excellent communication and a minimum of procedural complexity. The progress and the degree of success of an MT project can usually be gauged without much difficulty within a single firm through its usual cost accounting procedures aided by close technical scrutiny by the peers of the project personnel in the same organization.

Another attractive feature of the private industry approach to MT is that the kind of improvement is not narrowly limited by scope of a contract or other procedural constraint. An MT project often is found to provide other benefits than cost reduction such as improved performance, improved reliability, more convenient packaging, etc. To a private manufacturer all such benefits are joyfully recognized as "selling points" and are used to improve the competitive position of the firm.

Suggestions for a Navy MT Program Procedure

The difficulties confronting any Government Agency in procurement of improved MT have been extensively described by others. It is frequently pointed out that, from the contractor's point of view, decentives often appear to outweigh incentives to undertake such efforts under conventional Government contract rules designed for product procurement.

A fundamental difference between procurement of MT and procurement of a product is that an MT improvement is a process which generates a continuing benefit as long as it is used or until it is rendered obsolete by a better process. Part of this benefit can be the profit to the innovator and can be used to repay the expenditure on MT development. Indeed, if the project is not estimated to be able to repay its cost it is usually not worth undertaking. It would be desirable to provide a flexible means for compensation of the contractor to cover special circumstances existing at the time of completion of the project, as might occur when Government policy may require action which prevents an anticipated profit by the contractor due to no fault of his own, or to reward outstanding success.

In spite of the difficulty of the subject it seems most constructive to attempt to suggest a specific MT procurement procedure which takes account of the foregoing considerations and sidesteps most of the obstacles, while providing strong industry incentives parallel to those of the MT program.

The steps in the procedure might be as follows:

1. Proposals would be invited from industry, with emphasis on estimated benefits, time to complete, and cost. The proposals should list departments and key personnel who would be assigned to the project and the degree and involvement of each specified. These proposals should be evaluated by the Navy MT program office

mainly on the basis of the benefit to the Government which they would provide if they were to be as successful as claimed by the proponent. Detailed <u>technical</u> evaluation should be avoided at this stage.

2. Funding of selected proposals should take the form of a <u>low interest loan</u> to be made available according to a schedule of "progress payments" during the ensuing project. Normally, except as provided below, the loan is to be repaid in its entirety over some suitable time period, such as five or seven years according to an agreed-upon schedule.

3. The contractor is to provide letter reports on project progress indicating the funding expended or committed to date and a brief account of the degree of project completion accomplished.

4. At the completion of the project, a formal report is to be delivered containing all information necessary to gauge the success of the project. In addition, to complete data on project cost, there must be an estimate of the future benefits to the Government in terms of reduced unit cost, improved performance, etc., and conditions required to assure such benefits, such as production volume or continuity, etc. This final report should for the first time in the project disclose fully the technical aspects of the project.

5. The final report is to be evaluated by a special MT advisory panel made up of highly qualified and respected engineers, scientists and economists fully competent to determine the degree of success of the project. This panel may visit the facilities of the contractor and observe the improved process in operation as well as to request additional technical information to be furnished as briefings or supplements to the final report. The panel is required not to disclose to others any proprietary information furnished.

Depending on the result of this inquest the panel is to recommend the contractor's reward. This reward may have several components which may be applied singly or in appropriate combination.

a) The entire amount, or some fraction, of the loan repayment may be waived;

b) The contractor may be allowed to retain proprietary rights in the process for some time period such as eighteen months. This form of reward may be appropriate when assured continuation of Government production appears doubtful while a substantial civilian market profit potential exists.

c) Immediate transfer of essential technical information from the contractor to other invited corporations may be recommended. The transfer should take place in a set of meetings and demonstrations over an adequate time period to assure complete transfer. Recipients should pay a substantial fee to participate, the proceeds being allocated to the innovator as a kind of royalty.

6. The MT program office is to finally determine the contractor reward, based on the Advisory Panel's report and taking into account any other relevant factors and policy considerations.

Discussion

Note that the above recommended procedure differs markedly from present practice in that the award initially takes the form of a loan which in the contractor's worst case would have to be repaid as if he had obtained the money from a bank. In this case the contractor incentive is the low interest rate and availability of capital. To decide whether to take on such a loan, the contractor must perform his own realistic evaluation of the merits of the MT project, which he is presumably best qualified to do.

If the project is found by the Advisory Committee to be outstandingly successful, forgiveness of the loan is in many respects equivalent to the result of a conventional contract which covers the cost of development, except that since it is much easier and more accurate to evaluate a project after completion than in advance, the contractor's reward is directly related to performance, rather than to "brochuremanship" or sales effort.

Evaluation and reward of project success after completion has some additional advantages: a) The proposal effort by the contractor is somewhat simplified in the sense that emphasis in the proposal is on economic rather than complex technological considerations; b) a painstaking evaluation by an outside group of technical aspects of the project in its formative stages is avoided; c) proprietary ideas do not have to be exposed in detail early in the porject; and d) risk to the funding agency is reduced, since the loan is to be repaid anyhow if the success is not outstanding; e) the contractor reward can be based accurately on an objective criterion, applied by the MT program office, namely, the discounted financial benefits to the Government resulting from the project. The exact form of the rule used to relate reward to discounted future estimated benefits is a policy option to be decided by the MT office.

Appendix C
INDUSTRIAL INTERVIEW OBJECTIVES AND PROCEDURES

OVERVIEW

Electronics equipment manufacturers were interviewed to acquire:

- Cost data on currently produced equipment
- MT project recommendations and cost savings estimates
- Identification of industrial incentives for manufacturing technology advances
- Identification of barriers that currently inhibit implementation of cost-reducing technology.

Interview results are incorporated in the recommended MT plan (Vol. 2), in the top-down analysis (Appendix E), and in the form of observations or lessons learned in several portions of the report. Observations related to specific equipment are presented in Appendix G. This appendix addresses the specific objectives of the interviews and the procedural aspects. It also lists the manufacturers and their representatives who participated in the interviews.

OBJECTIVES

Major manufacturers of a representative set of electronics equipment were visited to secure information on production processes and costs. (The selection process is outlined in Appendix E, and will be discussed further below.) It was imperative to assess current production practices in such areas as degree of automation, quality control procedures, and capital investment policies and to secure cost breakdowns into various material and labor categories. This information provided a base for reviewing MT project proposals and including cost savings, where appropriate, in a form useable by the Navy Electronics Manufacturing Technology Analysis (NEMTA) computer model. The plan produced via NEMTA incorporates projects resulting from this industrial survey as well as from other sources.

In addition to the cost and MT data, the manufacturers' were invited to present their views on what sort of incentives were needed to spur manufacturing technology advances in electronics and on what particular characteristics of the military market might be hindering such advances. Examples of the types of questions asked by the interviewers are provided below. Consistency and comparability of results was maintained by having the majority of the interviews conducted by the same 2-member team. No formal questionnaire was employed.

- Production/Cost

  - Can we secure a work breakdown structure?
  - What are the costs or relative costs of each process or step?
  - How labor intensive is each (significant cost) step?
  - Can your manufacturing costs be divided in percentage terms into direct manufacturing labor, direct materials, engineering, tooling, quality control, testing, etc.?
  - Can you provide a contract history (costs, quantities, length, type of contract)?

- Incentives/Technology

  - What are a manufacturer's major inducements to reduce costs - e.g., follow-ons, cost reduction saving, value engineering, etc.?
  - What changes in government procurement practices would stimulate electronic manufacturers to increase productivity at a faster rate through additional capital expenditures?
  - What are the impediments to introducing new manufacturing methods?
  - Are the impediments to introduction of new manufacturing methods the same for commercial and military markets?
  - What is your assessment of the state and level of technology in the electronics industry in general and at your plant in particular?
  - What financial arrangement would you want with DoD for new MT equipment and processes - own it? operate it? other?
  - What ROI do you require before making capital commitments?

- Other

  - Do you have an MT department? If so, how is it organized?
  - Do you think it would be advantageous to you and to the Navy to have an IMT program along the lines of the IRD program?

- How do you rate the degree of competition in your industry? Too much? Too little?
- Would more competition stimulate productivity or could it be counterproductive?
- What is your opinion of form, fit and function specifications at the card level as opposed to the module level?

PROCEDURES

Figure C-1 depicts the flow of activities associated with the industrial interviews. The succeeding paragraphs describe the various activities.

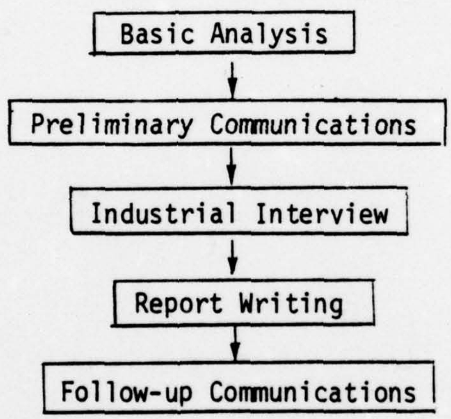

Figure C-1. Industrial Interview Activities

Basic Analysis

This task was a part of the overall top-down analysis used in developing the Navy 5-Year Electronics MT Plan. Systems and their manufacturers were identified for potential detailed analysis. Systems were limited to those currently in or nearing production with a high electronics content and procurement cost.

Specific actions included:

- Review of budget and program data for high cost electronics items

- Review of Defense Marketing Service (DMS) Electronics Systems Reports for Navy equipment and their manufacturers
- Discussions with cognizant Navy representatives regarding particular systems and their manufacturers
- Telephone calls to panel chairmen for the US Army Electronics Conference (held February 28-March 4, 1977) to identify industrial contacts.

Preliminary Communications

Each industrial interview was preceded by a personal visit to the Navy Program Manager. This was done to facilitate establishment of the "need-to-know" and to collect information. Basic cost, technical, and schedule data provided by the PMs were analyzed before the visit to minimize the need for asking for general background at the plant.

In general, the cognizant DoD plant representative was called following the visit approval by the PM. The purpose of the visit was explained in detail and names and telephone numbers of the appropriate industrial personnel were requested. The plant representative either set up the meeting himself or provided the necessary contact information.

A letter from the Navy Director of Manufacturing was mailed to the Manufacturing Vice President of the Corporation or appropriate Division and to the DoD plant representative. A copy of this letter is included as Annex C-1.

After an appropriate lead time, a telephone call was placed to the Manufacturing Vice President to make arrangements for the interview. Wherever possible, a lead time of from 7 to 10 days was given to encourage effective industrial response.

Industrial Interviews

Most of the industrial interviews were completed in one day by a 2-member interviewing team. Table C-1 lists the major industry representatives interviewed and the associated Navy system.

Table C-1. Industrial Interviews

Electronics System	Manufacturer	Representatives
Ship Electronics		
DDG-47 Aegis	RCA, Moorestown, N.J., Aegis target acquisition and weapons control system	Mr. Howard Grossman, RCA Production Manager Mr. Howard Mercer, RCA Production Planning
	Raytheon, Wayland, Mass., Fire control system and major subcontractor for elements of the acquisition radar	Mr. Hal Soderberg, Aegis Program Manager Mr. Dick Schwartz, Fire Control Systems Mr. Grant St. John, High Powered Radar Transmitters
SSBN Electro-Static Gyro Navigation System	Rockwell, International, Autonetics Division, Anaheim, California	Mr. James Driver, Director Operations
Sonar		
AN/BQQ-5	IBM, Manassas, Virginia	Mr. James C. Sharp, Contracts Mr. Donald J. Buckley, Manager of Manufacturing Mr. R. C. Jonsson, Proteus Production Program Office Mr. A. H. Toman, Military Disk Files/Storage Mr. Larry Ii, Planning Mr. A. J. Elias, Finance Mr. C. R. Bogan, Finance Mr. Robert L. Volp, Cost Engineering
AN/BQR-21	Honeywell, West Covina, California	Mr. Gerald Vander Voort, Manager of Operations Mr. Gerald Hollman, BQR-21 Program Manager Mr. Hugh Tulloch, Marketing Mr. Steve Goldwater, Production Eng. Supervisor
Avionics		
Phoenix airborne weapon control system (AWG-9)	Hughes Aircraft Company, Conoga Park, Ca.	Mr. L. B. Wallace, AWG-9 Operations Manager Mr. W. L. Allen, AWG-9 Production Programs Mr. Howard Edwards, Phoenix Planning Mr. Dick Clapp, Cost Analysis Mr. Lee Elrod, AWG-9 Systems Manager Mr. Donald Matteis, Components & Process Engineer

Table C-1. Industrial Interviews, Continued

Electronics System	Manufacturer	Representatives
Missile Electronics		
Harpoon	Texas Instruments, Dallas, Tex. (Seeker Assembly Manufacturer)	Mr. Michael Johns Mr. Gary Koster, Manufacturing, Harpoon
Standard Extended Range (ER) Standard Medium Range (MR)	General Dynamics, Pomona, Ca.	Dr. Marvin Abrams, Chief Advanced Mfg. Technology Mr. William M. Leonard, Chief Mfg. Development Mr. G. D. Goldshine, Director of Mfg. Engineering
Phoenix	See entry for Phoenix airborne weapon control system (AWG-9)	
HARM	Texas Instruments, Dallas, Tex.	Mr. Harold Wombel, Production Planning, Design-to-Cost Mr. Bill Mitchel, Missile Development Mr. Don McGuire, Manufacturing Mr. Gary Koster, Manufacturing, Harpoon
Sonobuoys		
AN/SSQ-41 AN/SSQ-53 AN/SSQ-62	Sparton Electronics, Jackson, Mich. (interview held at Arlington, Va.)	Mr. C. W. Skillas, Director of Marketing
Computers		
AN/UYK-7	Sperry Univac, St. Paul, Minn.	Mr. Don Dunn, Director of Operations Mr. John Knaak, Director of Mfg. Engineering Mr. Tom Bush, Schedule and Cost for UYK-7 Mr. Dave Duncan, UYK-7 Program Manager Mr. Paul Welshingor, Director of Quality Control Mr. Earl Verra, MT Department Engineer Mr. Marc Shoquist, Representative of Vice President for Manufacturing
AN/AYK-14	Control Data Corporation, Minneapolis, Minn.	Mr. Jerry Silverman, Program Manager Mr. Jerry Johnson, Business Management Mr. Ken Mulholland, Manufacturing Engineering

Table C-1. Industrial Interviews, Continued

Electronics System	Manufacturer	Representatives
Radios		
AN/PRC 104 Manpack Transceiver	Hughes Aircraft Company, Fullerton, Ca.	Mr. Lou Kurkjian Mr. Dave Andert
Gun System Electronics		
Phalanx Close-In Weapons Systems (CIWS)	General Dynamics, Pomona, Ca.	Mr. Bernie Chambers, Program Manager Mr. Bill Leonard, Chief, Manufacturing Development Mr. G. D. Goldshine, Director, Mfg. Engineering
General		
Semiconductors and Integrated Circuits	Intel Corporation, Santa Clara, Ca.	Mr. Gordon Moore, President

Report Writing

Each of the industrial interviews was documented as appropriate. Much of the information contained in Appendix G has been taken directly from the interview reports. Appendix G contains a combined summary of industrial and Navy Project Office visits. Documentation collected during the interviews in the form of MT project proposals and estimated cost savings have been used as sources of input to the NEMTA computer model.

Follow-Up Communications

Follow-up communications were made as necessary via telephone for clarification in the various documents provided by the manufacturer or in the interview notes. No plant was revisited.

SUMMARY OF INDUSTRIAL VISITS

Table C-2 summarizes the interview task statistics up to and including data received 120 days after the study started. Despite the tight time schedule considerable cooperation was evident. This was stimulated in part by the NAVMAT 042 letter of introduction from Capt. Dittmar, Director of Manufacturing Technology, which delineated the importance of this task to the Navy MT 5-year plan. The number of responses could have been increased and the quality of those achieved could have been enhanced if there had been more time for interviews, especially follow-up interviews.

Table C-2. Statistics On Industrial Response
(Up to 120 days after study started)

Preliminary Interviews With Navy Project Offices	32
Industrial Plant Visits	16
System Cost Breakdown Data Obtained	8
Percent	50%
Manufacturing Technology Projects Received	55
Average Number Per Firm	~ 4
Firms Suggesting MT Incentives and Barriers	10
Percent	~ 70%
Total Number of Firms Responding With MT Projects	8
Percent	50%
Total Number of Firms Responding With Either Cost Breakdown or MT Projects	14
Percent	~90%
Firms That Did Not Desire to Cooperate	1
Percent	8%

DEPARTMENT OF THE NAVY
HEADQUARTERS NAVAL MATERIAL COMMAND
WASHINGTON, D. C. 20360

IN REPLY REFER TO

ANNEX C-1

Sample Navy MT Letter to Industry

Dear Sir:

As a part of the Department of Defense's Manufacturing Technology initiative, I would like to bring to your attention opportunities that will enhance the productivity of the electronics industry. It is the intention of the US Navy to define and implement an integrated Manufacturing Technology (MT) plan for investment selection that offers attractive incentives for the industry. Benefits will accrue to the cooperating electronics manufacturing firms by assisting them to obtain technological advances, to the Navy in the form of enhanced buying power, and to the national economy through the productivity increments. References (a) and (b) outline these activities in greater detail.

The degree of success in such a joint government/industry venture depends crucially upon the level of mutual participation. To aid the Navy Electronic Systems Command (NAVELEX) in carrying out these plans, and to form an appropriate liaison for the cooperative effort, we have contracted with Science Applications, Inc. (SAI), of McLean, Virginia. Their work in performing a study of leading MT opportunities will enhance the responsiveness of NAVELEX to the Navy MT objectives. The contract called for completion of data collection by interviewing appropriate personnel at many manufacturing facilities during January. Due to the importance of this work, and the need for additional follow-up data, SAI will continue this task in February.

We wish to express gratitude for the high level of cooperation extended by your firm thus far, and to encourage you to provide the necessary data the contractor is required to obtain to complete this study.

These data include percentage cost breakdowns of electronics equipment material and labor, and your suggestions for improved electronics manufacturing technology. This information will be reflected in the Navy 5-year MT plan. SAI will maintain as proprietary any data or information as you desire.

An attachment to this letter provides further background and information concerning the Navy MT program, as well as suggestions for structuring the type of information that the representatives from SAI will be looking for during their visit. You should feel free to contact either the Navy representative for this program, Carl A. Rigdon at (202) 692-7575, or the senior Science Applications, Inc. representative, Dr. T. Michael Knasel at (703) 821-4499. Kindly contact these persons for additional information concerning the US Navy program. Your cooperation and assistance in this matter of national importance are greatly appreciated.

Sincerely,

Capt. L. C. Dittmar
Director of Manufacturing Technology

Ref:
(a) DoD Memo of 11 Apr. '75 to the Secretaries of the Military Departments
(b) Chief of Naval Material Memo 11 Jan. '77 to the Naval Program Managers

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Attachments:
References (a) and (b)
Industrial Data Package

Appendix D

ECOM CONFERENCE
SPECIFIC FINDINGS

ELECTRONIC SYSTEMS MANUFACTURING TECHNOLOGY CONFERENCE
(ECOM)

Cherry Hill, New Jersey
28 February-4 March 1977

The Navy MT electronics study conducted by SAI had similar general goals to that of the Army ECOM Conference:

> The objectives of the conference are to define potential projects which would provide new or improved manufacturing technology, and assess the potential payback of these projects. The results of the conference will be used as a basis for formulating future programs in this area.

The study team attended all of the panel workshops and presentations, reviewed over 300 proposals, sifted out over 30 specific proposals that had Navy application, and assessed a number of positive and negative results from the conference method of exploiting manufacturing technology.

The conference method, as exemplified by ECOM:

- generates a substantial number of proposals
- motivates and stimulates active participation from industry
- provides an opportunity for candid peer review in widespread and specialized areas
- sets up a made-to-order forum for a dialogue of requests and responses between top level DoD and industrial representatives
- encourages immediate attention to the problem by imposing a deadline that has to be met
- allows a free interchange of ideas which improves overall education concerning state of the art, throughout the industry.

Areas which need to be improved represent a challenge for future conferences.

- It is important that a framework be developed which encompasses more than simply industrial interests. All areas impacted by MT must be addressed.
- Each succeeding conference should build upon all former ones, extrapolating both generalities and specifics. This conference did

not set goals for industry, did not attempt to balance the projects proposed based on previously identified cost drivers, nor even use cost generating mechanisms that had proven useful at earlier conferences.

- To weed out irrelevant proposals and to assure that quality projects are presented and debated, the framework must be specific, well defined, and include a basis for determining cost drivers.
- Coordination of rating systems among panels is critical so that overall rating is obvious. Does #1 project from micro-electronics have more or less potential return than #1 project recommended by testing panel? What about #12? Even within each panel it was difficult to objectively assess payback potential from one area to the next.
- There was an obvious lack of relationship to the Army procurement. The framework should also identify important Army systems so that industry would be able to address them specifically.

Appendix E

TOP-DOWN ANALYSIS OF NAVY WEAPONS SYSTEMS ELECTRONICS COSTS

INTRODUCTION

The top-down analysis of Navy weapon system electronics costs identifies the costs of electronics manufacturing in a series of categories including material (with seven sub-categories), touch labor (assembly and fabrication) support labor and test labor. The analysis begins with the "top-figure," the Navy procurement budget, and proceeds with a logical breakout of the total into platform (ship, air, missile or multiplatform electronics). Platform costs are then broken out into electronics and non-electronics costs. The analysis continues with a breakout of platform electronics into equipment type (radar, sonar, E/O, etc.). Finally, the equipment costs are distributed among the material and labor subcategories mentioned above.

At the study outset it was decided that a completely thorough analysis of all equipments and every level of breakdown was not required as long as the systems covered were representative of typical manufacturing practice. This followed from the fact that the sole purpose of the cost analysis was to provide a basis for estimating benefit and thus contribute to rating the candidate manufacturing technology (MT) projects. For example, a project might claim a 10 percent cost savings in integrated circuits used in infrared seeking missiles. In order to calculate the dollar savings, the percent breakout of IR missiles into integrated circuits (among other things) would be required. The fact learned early in the study that manufacturing technology projects would always address cost savings in material or labor for a specific system, whereas budget data would relate to total weapons systems necessitated adoption of the top-down analysis approach. In retrospect, it is apparent that the top-down analysis coupled with a sampling type method using representative systems has proved to be adequate in assessing MT project benefits.

Definitions

Within the Department of Defense certain standard definitions of equipment costs have evolved as outlined below:

- Unit Cost (also called flyaway or sailaway or rollaway cost as appropriate) - The cost of procuring one complete unit fully equiped for its mission. This cost will include recurring costs and profit as well as a portion of non-recurring cost. Unit cost will vary with phase of the production contract.

- Weapon System Cost - This includes the above and ground support, training of personnel, publications, or other additional technical assistance from the manufacturer as may be provided in the contract.

- Procurement Cost - This cost includes the above manufacturers contract costs, initial spares, and service management costs.

- Program Acquisiton Costs - The above costs plus RDT&E and MILCON costs (if required)*

- Life Cycle Costs - The entire cost of ownership which includes the acquisition costs, operating costs, repair, logistics and disposal costs.

In this study the change in unit (or flyaway) cost has been isolated as the key measure upon which manufacturing technology project benefits are estimated. The potential impacts of increases in quantity due to lowered costs have not been incorporated into the analysis.

Within the unit cost are the following breakout categories were utilized:

- Material - Purchased or subcontracted electronic components, and sub-assemblies which are assembled into an electronics system. The key examples are:
  - Enclosures, larger hardware and cabling between enclosures
  - Sensors, antennas, and special electron tubes
  - Printed circuit boards (PCB), without components, inter-connection cables between PCB's and miscellaneous small hardware associated with PCB's.
  - Discrete semiconductors, rectifiers, microwave power amplifiers, etc.
  - Hybrid circuits
  - Passive components - generally mounted on PCB's

Material costs reflect overhead loading for storage, order administrative costs, and profit or fee.

*Research, Development, Test and Engineering, and Military Construction.

- Touch Labor - Labor actually associated with the putting together of a complete electronics system consisting of
  - Assembly Labor - component insertion, soldering, etc.
  - Fabrication Labor - manufacture of enclosures, PCB's, metalworking, painting, etc.
- Support Labor - Engineering and management tasks both recurring and an allocated proportion of non-recurring, depending on the production phase and contract details.
- Test Labor - Labor associated with the testing of the final assembly in process testing, and test of components if not included in component costs.

Labor costs reflect allowable overhead, profit, etc. Note that the purchased or subcontracted materials themselves can be broken out into a similar set of costs, and this breakout process may be possible at still a finer level of detail. For example, manufacturer A purchases integrated circuits from manufacturer B, who in turn has purchased purified silicon from manufacturer C. An example of how a breakout might look is given by the following table:

Manufacturer	Material	Typical Labor Steps
A	Integrated Circuit (IC)	Assembly on PCB Test of completed equipment
B	Refined Crystaline Silicon	Fabrication of IC device Assembly of IC into hermetic package Test of IC
C	Raw (amorphous) Silicon	Fabrication of silicon crystals Test of crystals

Hence the cost breakout must reflect the proper level of manufacturer-correlated to the candidate manufacturing technology project. As a final example, a new process suggested for MT funding may claim to give a 15 percent improvement in the cost of fabrication of silicon crystals. In rating this project the analyst must know the following:

- Percent <u>fabrication</u> cost to total cost Refined Silicon
- Percent <u>material</u> cost of Refined Silicon to total cost integrated circuits

- Percent material cost of integrated circuits to total electronics system unit costs.

Thus the need to rate projects determines the number of breakout steps and the precision required.

SOURCES OF DATA

During the top-down analysis the following general data sources were reviewed:

- Documentation developed from specific interviews with Navy offices or industrial firms as part of other phases of this study. Results are summarized in Appendix G.
- Congressional budget submissions and DoD budget documents, such as the Congressional Data Sheets maintained by OP-92C, the Five Year Defense Plan (FYDP) and the Extended Planning Annex (EPA).
- Conferences on Manufacturing Technology, and previous electronics cost analysis studies. Examples include:
  - Seventh and Eighth Manufacturing Technology Advisory Group Annual Meeting Reports
  - Three Tri Service MT meetings on TWT and Hybrid Circuits
  - The Army ECOM MT meeting at Cherry Hill, N.J., March 1977
  - The Army MICOM Missile MT meeting
  - The USAF Electronics MT meeting
  - Various service publications and reports
  - Summaries of SAI cost analysis reports on previous projects (if not proprietary)
- Industrial and Trade Association Statistics on Electronics Manufacture; for example, data from the Electronic Industries Association
- Government statistics on the electronics industry, such as Department of Commerce publication
- Trade magazines and electronics marketing publications - examples are: Aviation Week, Electronics Times and Laser Focus.

The above sources proved helpful in several ways: basic data, suggested approaches, formats, rough order of magnitude relationships, etc. In some instances, important cross checks were provided by use of multiple sources. At the study conclusion the compiled sources formed a valuable library of documents related to Manufacturing Technology, in general, and to electronics MT, in particular. Sources are documented throughout the three volumes, with Appendix H listing those most readily available in published form.

ANALYSIS TECHNIQUE

The general philosophy of the top-down analysis has been described in the Introduction. In this section the details of how the analysis was accomplished are presented. Figure E-1 shows the general analysis schematic diagram. Beginning in the far left at "the top," or at the level of overall procurement figures, the weapons systems are broken out into electronics systems costs and non-electronics costs. The electronics systems costs included in ships, aircraft, and weapons are then reordered into equipment type; for example; underwater acoustical equipment and radar and EW equipment for aggregation under functional electronics systems (center of figure). The breakout of the functional electronic system into material and labor and the final synthesis in a cost analysis and report follow to the right.

A more detailed version of the top-down approach is shown in Figure E-2. This figure follows the format of E-1 but contains more specific factors. At each stage the review of the data was performed for details as to the cost breakout to the next lower level. The results of the analysis are given in the next section. The specific description of the analysis follows.

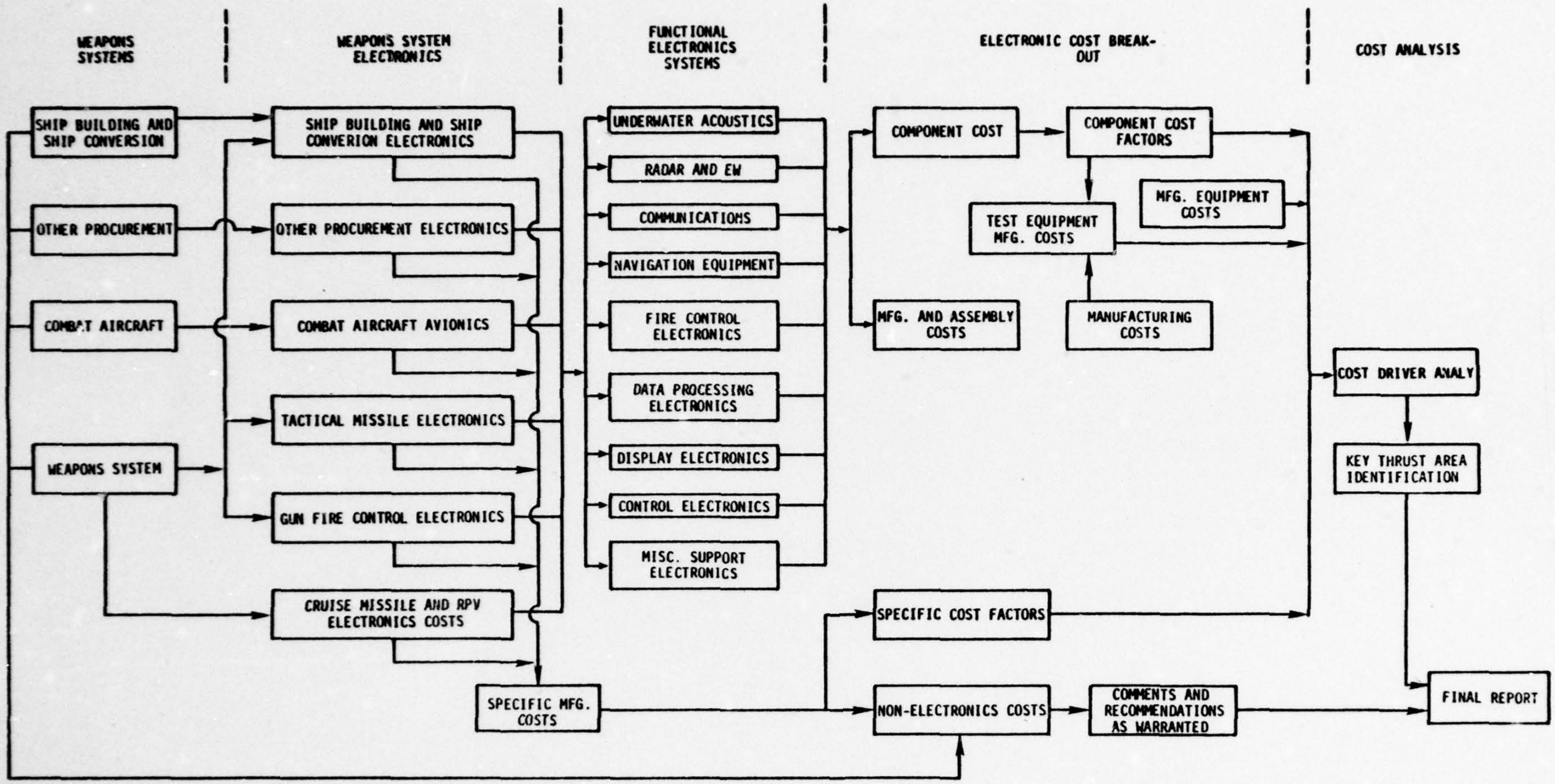

Figure E-1. Electronics Cost Analysis, Schematic

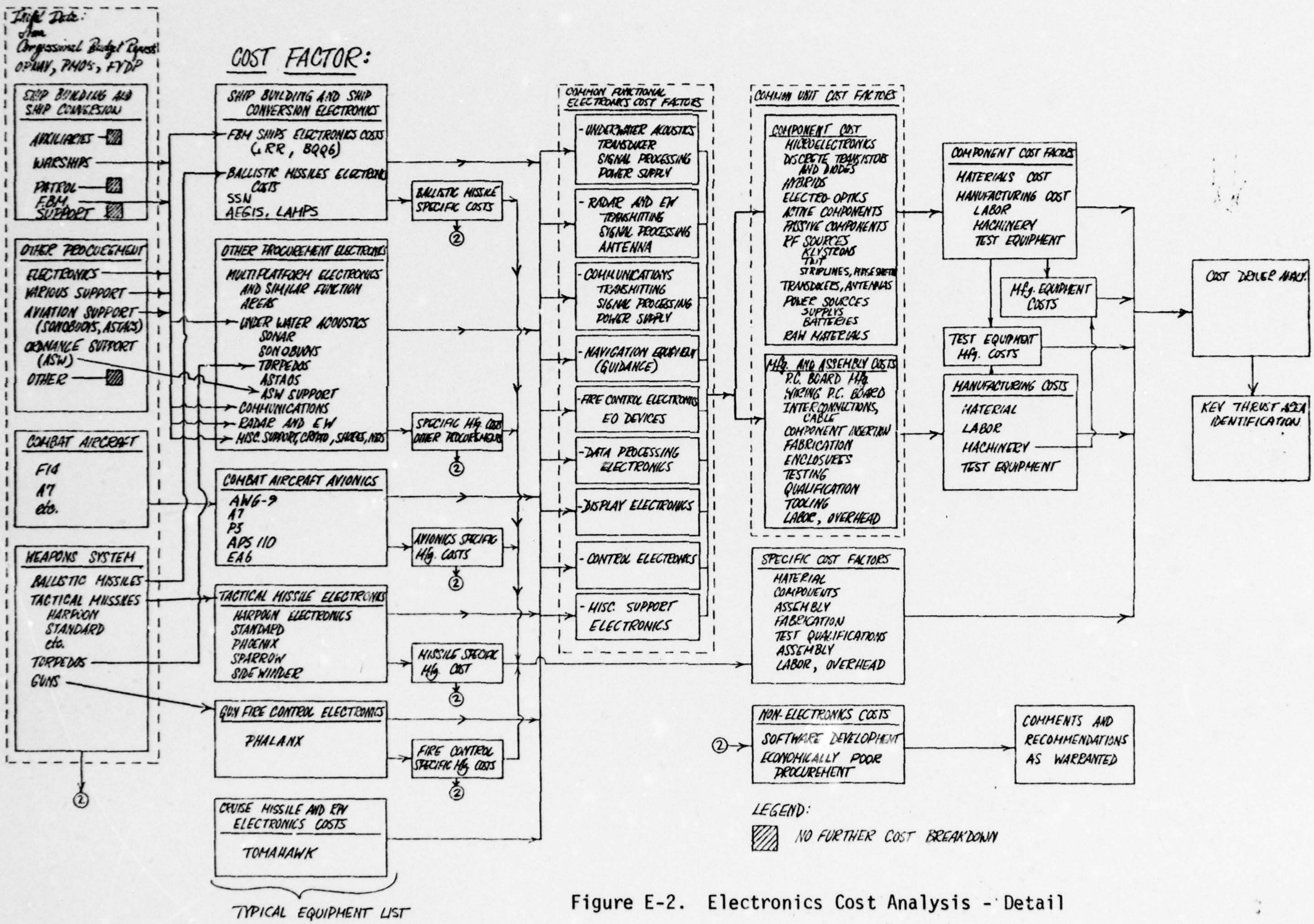

Figure E-2. Electronics Cost Analysis - Detail

UNIT COST DATA

The unit cost input data were generally derived from weapon system cost data. These were taken from Navy program/budget data obtained from documents in the Program/Budget Coordination Branch (NOP-92C), Fiscal Management Division, Program Planning Office of the CNO.

The basic data sources (for FY82 and earlier) were the Back-up Data documents for the APN, OPN, SCN, and WPN FY78 Budget Submission and the "Congressional Data Sheets." Costs were projected for the period FY83-87 inclusive based on information in the "Extended Planning Annex" document obtained from NOP 965B.

The Procurement Back-up Data documents gave detailed program cost information for line-item projects through FY79. For example, for particular aircraft in the APN Back-up Data, costs were shown by year, FY76-FY79, for airframe/CFE, several GFE categories including electronics, flyaway costs, support costs, and several other less important categories of cost. For missiles, costs were shown for several components of missile hardware, procurement support, flyaway, fleet support, amd modifications and spares. The data for SCN and OPN were much less detailed, in some instances only total quantity and program costs by year were shown. In addition, the OPN, SCN, and WPN documents showed the overall program costs projected to FY82 for most line items. The APN document did not include these data. The SCN Back-up data did not show data for complete ship systems, only for certain subsystems such as ship radars.

The Congressional Data Sheets provided information compiled for congressional committees. These were used for cost data on ship systems and for extending the aircraft data to FY82. The cost categories shown on the Data Sheets were procurement, advance procurement prior years, advance procurement FY, Weapon System Cost, Initial Spares, RDT&E, and Military Construction.

The Extended Planning Annex showed program data for the period FY83-FY92. It was used to project program cost data beyond FY82 for ship systems and missiles. The data included quantities and costs for ships, but for missiles only inventory levels were shown and procurement quantities had to be estimated from average consumption rates calculated for years prior to FY83. Also, the EPA showed all cost data in constant FY77 dollars, whereas procurement costs in the budget data are in then-year dollars. An escalation rate of 4 percent was used to convert to then-year dollars.

It was assumed that the impact of MT projects would be almost wholly on system flyaway costs; that is, hardware cost plus procurement support. These costs were readily available for aircraft and missile systems for periods up through FY82. The most comparable line of procurement data for ship systems in the Congressional Data Sheets appears to contain support costs not included for missiles and aircraft. In general, the data on OPN systems is total program cost. All these data were adjusted to unit costs by subtraction of the non-unit costs if available, or by using estimated percentages of unit costs to weapon system costs.

Exceptions to the above generalizations follow:

- LAMPS: Only FYDP data were available. The APN costs from Program Element 24243N was added to the RDT&E costs in Program Element 64212N to get yearly program costs through FY82.
- *TRIDENT missile and TOMAHAWK SLCM:* ERDA costs (warhead) were included in the procurement costs in Congressional Data Sheets; these were then reduced to allow for the warhead portion.
- PHALANX: WPN Back-up data showed costs and quantities through FY82, but the system was not included in the EPA. Information from General Dynamics was that the total inventory objective was 359; therefore, 124 systems would be required after FY82. It was assumed 68 (the FY82 buy) would be procured in FY83 and 56 in FY84.
- SONOBUOYS: These systems were not included in the EPA, but information from industry and Navy project offices indicated that the trend is toward increasingly large annual buys and that major design changes are not frequent. Therefore, the FY82 funding, escalated by 4 percent yearly was projected through FY87.
- Some systems, such as BQQ-5, are procured with both OPN and SCN funds but are line items only OPN. When it was known that new ship construction would include such an item, appropriate additions were made to the OPN cost data.
- In some instances, AWG-9, ALQ-78, ALR-59, procurement programs were estimated from project office unit cost data and related aircraft procurement programs.
- Post-FY82 procurement costs for the P-3C and the E-2C were calculated based on "cost to complete" statements in the Congressional Data Sheets.

COST BREAKOUT DATA

The breakout of unit costs into material and labor costs was accomplished by applying percentage distributions developed from or provided through the various data sources. These were analyzed for trends and summarized, and cross-compared. Breakouts of labor and material costs were prepared following:

- Analysis of manufacturers' percent cost breakout data for eight specific types of equipments secured via interviews
- Analysis of Army study data of missile electronics cost breakouts[1)]
- Analysis of Air Force study data on avionics cost breakouts[2)]

Excellent agreement in formal percentages was obtained.

The initial step was a four-component breakout as a function of equipment type into material, assembly and fabrication labor, support labor, and test labor. These proved to be remarkably insensitive to type of weapon system. Material was then broken out into seven sub categories, and assembly and fabrication labor were separated. Some non-hardware costs such as software and documentation were assessed in addition. The next section reports the results of the analysis.

RESULTS

The top-down analysis produced a series of results relating to the costs of Navy electronics that are summarized here. These costs were then used to assist in the ranking of Manufacturing Technology projects. This section reports costs associated with major weapons systems, their breakout into functional equipment, and the further breakout to several material and labor categories.

The need for cost-effective weapons systems has been recognized on a Department-of-Defense-wide basis for many years. The Navy's Manufacturing Technology Program exemplifies an approach to quantify costs and promote economies in weapon systems expenditure. This study addressed a particular segment of the life cycle cost (LCC) of Navy weapons - that of procurement (which generally amounts to about 40 percent of the LCC). It is further specialized to the costs of electronic systems in these weapons (usually one-third of the procurement cost). Finally, it considers only those methods of cost reduction related to the manufacturing aspects. Even within this narrowing selection, considerable scope remains. For example, the annual procurement costs for Navy weapon systems are approximately $15 billion. The following table (Table E-1) illustrates the pervasive nature of electronic systems costs throughout this budget in all weapons systems. Note that the percentage of electronics costs varies widely from one weapons system to another. A procurement weighted average of 30 percent was obtained for the total procurement. Thus the Navy is spending on the order of $4 to $5 billion on the procurement of electronics annually. Considering the importance of electronics costs to weapons systems costs and the historical trend toward more electronics, it is well justified to examine how electronics costs might be decreased.

The FY76 Procurement Budget Books provided the basic data used to compute the procurement percentage factors in Table E-1. The percentage of electronics costs to total unit costs had been studied previously in the "Electronics-X" effort.[3)] Interviews and analysis of other data were also performed to verify these figures. Based on these, modifications of the Electronics-X values were made and the scope was increased. For example, in Reference 3, 75 percent of missile

Table E-1. The Pervasive Nature of Electronics is Illustrated in an Analysis of Weapons Systems Procurement Costs

Weapons Systems	Percent of Navy Procurement (a)	Percent Electronics In System (b)	Percent Electronics With Respect To Total Procurement (c)	Percent Electronics In System To All Navy Electronics Procurement
Shipbuilding and Ship Conversion	45	20	9.	33
Other Procurement				
Electronics	4.5	100	4.5	16
Ordnance	3.3	6	0.2	0.6
Miscellaneous	8.2	10	0.8	2.7
Combat Aircraft	12	30	3.6	12
Aircraft Support	10	50	5.0	17
Weapons (e.g. Missiles)	17	42	7.2	24
			30.3 (c)	

(a) FY76 Navy Procurement Budget.
(b) Estimated percentages using Study Methodology described in this report.
(c) Weighted average of electronics to total procurement costs.

flyaway costs are considered electronics. The present analysis showed, however, that more accurate percentages are 60 percent for tactical missiles, and 30 percent for ballistic missiles. Further, the Electronics-X value of 30 percent electronics for aircraft was found applicable to fighter aircraft while other combat aircraft (Electronic, Warfare, Anti-Submarine Patrol) tend to be slightly higher (35 to 40 percent). In Table E-1, a procurement weighted average value of about 30 percent was determined for the electronics content of Navy procurement.

FUNCTIONAL BREAKOUT ANALYSIS

Within each major weapons system electronics systems perform unique functions, e.g., ASW, EW, Crypto, etc. On a procurement average basis, the weapons systems were broken into functional electronics areas and these were analyzed as percentages of total electronics procurement. Table E-2 presents these results. The categories are somewhat arbitrary, but have been designed to relate as closely as possible to manufacturing. For example, the category "sonar and ASW" encompasses digital sonars, which include digital data processing modules. The category "Digital data processing" provides for machines which are typically procured as separate entities, often to be integrated into larger systems.

Candidate electronics manufacturing technology project descriptions and economic justifications tend to be expressed in terms readily relatable to the functional categories of Table E-2. A typical project proposal will claim a certain percentage cost reduction in a sonar system, or in a computer. The interview process uncovered distinct differences in the manufacturing practice in the functional areas. Projects that purported to achieve economies in several functional areas were assessed and rated on this basis.

MATERIAL/LABOR BREAKOUT

The analysis procedures identified 50 systems for initial study. These represented a coverage factor of 67 percent of all Navy procurement. For this initial set unit cost data were determined (over a 10-year cycle beginning in FY78). Further selection of 32 systems was made for detailed interviews.

Table E-2. Approximate Functional Breakout of Naval Electronics Procurement

Area	Percent of Electronics Procurement Value
Sonar and ASW	30
Navigation	14
Analog Controls	13
Radar	7
EW	7
Communications	7
Recon, E-O	4
Crypto	3
Digital data processing	3
Display equipment	2
Miscellaneous	10
Total	100

The interviews ultimately resulted in the attainment of useable breakdowns of cost into labor and material categories for eight systems. The eight provided balance over both type of weapon system and functional area. Previous studies were being reviewed and analyzed concurrently with the weapon system interviews. An Army study on missile costs and an Air Force study on avionics costs were found to contain particularly valuable data,[1,2] and were analyzed for breakout into material and labor categories.

The initial analysis utilized four categories: Material (purchased or subcontracted), assembly and fabrication labor, support labor and test labor. The result of this analysis is shown in Table E-3. Variation of percentage breakout between systems is reasonably large. In the case of Digital Sonar A and B, this relates to the phase of production which will be isolated for analysis later. Interestingly, the averages are fairly stable when compared to similar averages from other studies. Altogether, a total of 82 system breakout data sets were analyzed to form the final overall average. Due to the consistency of the data these values are considered "universal" for all Navy electronics. The industrial investigation provided cost breakout data on a limited number of systems but it did include some Navy specific systems (and ones of high procurement value) for the first time.

Table E-3. Material/Labor Component Breakout For Selected Electronics Systems

System	MATERIAL: Purchased or Subcontracted	LABOR: Touch (Assembly & Fabrication)	Support	Test
Digital Sonar A	46	26	19	9
Digital Sonar B	70	6	18	6
Digital Sonar C	59	10	17	14
Small Sonar Set	40	23	17	10
Digital Computer A	44	37	11	18
Digital Computer B	77	16	4	3
Fire Control Set	27	45	16	10
Air to Air Missile Detector Assembly	62[1)]			
Data Averages	52±17	23±14	15±5	10±5
Avionics Averages[2)]	50±10	24±2.5	17±4	9±5
Missile Electronics Averages[1)]	50±6	32±7	8±5	10±2
Overall Average	51±7	26±5	13±3	10±2

1) Further breakdown unavailable.

2) Data from USAF sponsored study of 62 avionics systems.[2)]

3) Data from Army sponsored study of 12 missile systems.[3)]

MATERIAL BREAKOUT

The breakout of material into seven key categories was made using interview results and the missile and avionics cost data sources referred to previously. The selection of these seven categories was based on achieving a comprehensive set of standard electronic component classes consistent with categories of data found in the sources.

Initially the material was broken into three areas: 1) PCB boards including components, 2) cabinets and cabling between cabinets, and 3) sensors, antennas and special tubes or devices. The results are: 1) 48 ± 8%; 2) 26 ± 5%; 3) 26 ± 5%. The next breakout was of the largest material area assembled, PCB boards. Analysis yielded a breakout as follows: integrated circuits, 33%; discrete transistors, 17%; hybrid circuits, 10%; passive components, 8% (approximately 1/3 resistors, 1/3 capacitors, and 1/3 inductors and crystals), and the PC board itself, its cabling to other boards and various small monitoring hardware, 32%.

LABOR BREAKOUT

The largest labor category, touch labor, was further broken out into fabrication labor, 42 ± 7% and assembly labor 58 ± 8% by methods similar to those described above.

SUMMARY OF BREAKOUT RESULTS

The unit cost breakout analysis has yielded costs in 11 categories for electronics equipment. These percent costs include allocation of nonrecurring costs, overhead and profit as appropriate to the individual categories. The percentages are broad averages over all Navy electronics procurement, thus a specific equipment may vary due to stage of production cycle, type of equipment, or other special features. During the analysis considerable stability and uniformity of the average breakout percentages were observed. Table E-4 summarizes these results.

Table E-4. Average Percentage Cost Breakout For Electronics Equipment

Cost Category	Percentage	Percentage
Material	51	
Enclosures and Cables		13.3
Sensors, Special Tubes		13.3
Integrated Circuits		8
Printed Circuit Boards and Wiring		8
Discrete Semiconductors		4
Hybrid Circuits		2.4
Passive Components		2.0
Touch Labor	26	
Assembly Labor		15
Fabrication Labor		11
Support Labor	13	13
Test Labor	10	10
		100

PRODUCTION PHASE ANALYSIS

The largest single cause of percent breakdown value variation was determined to be differences due to production phase. This stems from variation in manufacturing cost patterns depending on the number of units to be produced during the contract. The variation is reflected in the ratio of labor to material cost, a ratio which changes radically with units produced. The basic reason is attributed to touch labor learning. As the number of units produced increases less material is wasted and economies of scale on material purchase are achieved; however, these are not nearly as dramatic as those associated with labor learning. Figure E-3, which is based on analysis of Standard Electronic Module costs by Wyatt,[4)] graphically depicts the changing percentage contributions of labor and material to total cost with increasing production quantities. An asymptotic value of 43 percent material, 57 percent labor is reached after the production of 1000 copies.

NON-MANUFACTURING COSTS

Some limited additional information was gathered concerning non-manufacturing costs. From these the following factors as percentages of unit costs were developed: software development and maintenance, 5 to 15 percent; documentation, 10 to 15 percent; system integration, 5 to 10 percent; shipping, 2 to 10 percent. These costs are not directly related to manufacturing but are part of the weapons systems costs paid by the Navy, and in some cases are at least partially allocated to unit or flyaway costs. The specifics of this vary with the weapon system and contract details.

ELECTRONICS MARKET DATA ANALYSIS

As a final step in the analysis industrial market data were reviewed. From this the following lessons were learned:

- The electronics industry is atypical in American business because of its rapid product innovation and its creation of mass consumption markets.
- The number and diversity of firms and their historic high level of competition demand that they accept MT innovations more rapidly than firms in more established manufacturing areas.

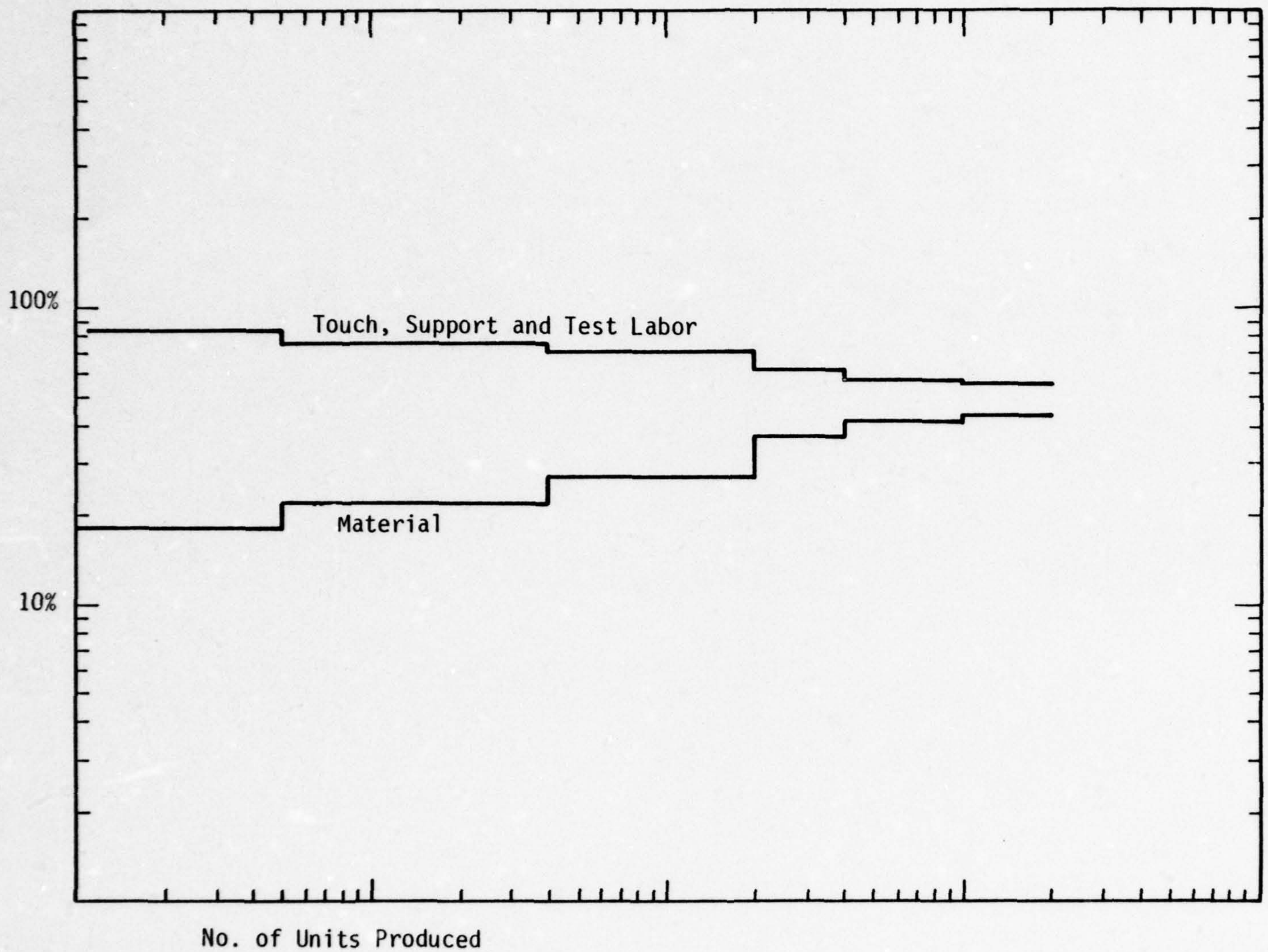

Figure E-3. Percent Labor and Material Breakout as a Function of Units Produced (Results of Cost Modeling in Reference 4)

- In some cases the industrial and commercial market pressures force revolutionary changes as exhibited in the areas of microcomputers, digital watches, personal communications equipment, and home entertainment devices.

- It has become somewhat fashionable to question the viability of the DoD as a market force in the electronics arena.

The remainder of this section reports the results of an examination into the importance of the electronics industry to the DoD and vice versa. A study of the flow of sales dollars from the DoD to US industry (Table E-5) shows the results of an analysis of industrial trends averaged over the period 1969 to 1972. During this period the total "electronics industry" provided about one-third of all procured items to the DoD, and the DoD as a customer did represent a major factor of the sales of several large industrial groups. Use of these groups are identified by the standard industrial classification (SIC) codes in the analysis of industrial data. The SIC code data also show the pervasive nature of electronics since electronic systems are procured from a broad segment of industry, often as part of a larger system, e.g., ships.*

A successful electronics MT program for the Navy must consider this pervasiveness of electronics systems in weapons as well as the large number of firms that can contribute to cost reduction. Defining MT program goals that encompass both expectations of the Navy and of industry will encourage their cooperation and result in a plan that can be used as a pattern for other cost reduction efforts.

CONCLUSION

Analysis of Navy electronic procurements into various cost factors such as

- Unit costs
- Functional breakout
- Cost breakout (material and labor)
- Material cost breakout

*Unfortunately later data on the market were not available during the study. Clearly the commercial markets for electronics have increased in response to availability of new products (e.g., hand held programmable calculators, CB radios, games attached to TV sets). However, the military market has experienced similar new product availability (e.q. FLIR, microprocessors, etc.). The conclusion at this time is that the DoD is an important market factor, but faces the prospect of being "crowded out" due to the potential rapid expansion of the commercial segment.

Table E-5. DoD Electronics Procurement by SIC Code
(Data Average Values 1969-72)

SIC Code	Name	DoD Procurement Value ($ Billion)	Total DoD Procurement Budget (%)	DoD Procurement Value to Total SIC Value (%)	Electronics Value ($ Billion)
37	Transportation	12.2	44	53	3.6
36	Electrical	6.5	24	22	5.7
19	Ordnance and Missiles	6.0	22	72	2.0
3811	Scientific Instruments	0.3	1	30	0.3
3573	Computers	0.2	0.7	3	0.2
35	Machinery	1.0	4	2	0.3
					12.1

- Labor cost breakout
- Production phase differences
- Non manufacturing costs
- Market trends.

has been performed for a variety of electronics systems. Representative systems were chosen, reviewed and analyzed. Relatively uniform cost breakout relationships were formed in most cases; the largest single variation was found to be due to the production phase of manufacture. Certain non-manufacturing costs were also assessed. The results are sufficiently accurate and representative to allow a ranking of candidate Manufacturing Technology projects.

REFERENCES

1) U.S. Army Materiel Command, "U.S. Army Missile Manufacturing Technology Conference," Hilton Head Island, South Carolina, September 22-26, 1975, Special Report RL-7T-L, 2 Volumes.

2) Air Force Systems Command, "Summary Report on the Air Force/Industry Electronics Manufacturing Cost Reduction Study, March 24-29, 1974," AFML-TM-LT-75-2, December 1, 1974.

3) Morris Zusmann, Selmer Gustaves, et al., "Electronics-X: A Study of Military Electronics with Particular Reference to Cost and Reliability," R-195, Institute for Defense Analyses, 2 Volumes, January 1974.

4) John A. Wyatt, "Standard Electronic Modules: Their Impact on Life Cycle Cost," PMC-74-2, Defense Systems Management School.

Appendix F

ECONOMIC ANALYSIS AND COMPUTER PROGRAM DESCRIPTION

INTRODUCTION

To evaluate and rate the candidate MT projects based on their potential economic returns requires a methodology that estimates the 5-year plan cost and benefits. The methodology needs to be flexible enough to allow changes in basic assumptions regarding project timing and probability of success in order to test the robustness of the results and to provide a basis for assessing program risk. The program written during the course of this study, called NEMTA (Navy Electronics Manufacturing Technology Analysis), provides these tools. In its memory storage are procurement costs for over 50 Navy weapons systems, the percentages of electronics costs, and the detailed cost breakout into 11 subcomponents (see Table 4, Volume I for further details). Data read-in on each of over 100 candidate projects include the areas of cost impact, the systems to which the project applies and the timing. A variety of discount and inflation rates may be assumed to verify the sensitivity of results to the nominal values used. Table F-1 outlines the main features of the NEMTA program. Subsequent sections of this appendix cover the method of calculating savings and investment, underlying data, and program outputs. Throughout this appendix hypothetical data are used to illustrate calculations. Volume II presents the candidate Navy 5-year plan produced by the NEMTA program and program listings. Highlights of the results obtained from a study of the program output are summarized in Volume I.

Table F-1 NEMTA Logic (Navy Electronics Manufacturing Technology Analysis)

- OBJECTIVE

    1) Provide Estimates of MT Plan Cost and Procurement Savings for Navy Electronics

    2) Provide Basis for Evaluating Alternative MT Plans

    3) Assess Impact of Plan on Procurement Schedule

- STRUCTURE

    1) Input Projected System Costs (Electronics Only)

    2) Input Cost Breakout into Elements

    3) Input MT Project Data

    4) Determine Savings* for Each Applicable or Chosen System and for Aggregate of Systems (By Year and Total)

    5) Rank Projects by Total Savings and Itemize Cumulative MT Plan Cost

    * Nominal and Lower Bound

- All Cost Data Discounted and Corrected for Inflation

DISCOUNTED REAL SAVINGS

The NEMTA program provides a calculation of discounted real savings for each project; factors included are inflation, discount rate, and project success probability. To illustrate how the program works explicit examples will be shown in detail for three hypothetical projects. Table F-2 summarizes the key assumptions and impacts and describes the systems and elements used as examples. The following sections explain the various input values and equations used.

System Data

Tables F-3 through F-5 display the system cost data that are used in calculating procurement savings. These data become increasingly specific with each table. Table F-3 includes total system fly-away cost by year (the product of unit cost and buy quantity) and the electronics portion of system cost by year. Table F-4 provides the standard element percentage cost distributions for the electronics position of each system by year. Table F-5 relates the yearly percentage cost reduction by element and system attributable to a specific MT project.

Table F-3. System Then-Year Procurement Cost ($100K) and Electronics Percentage of System Cost

	Year																			
	1		2		3		4		5		6		7		8		9		10	
System	Cost	%EL	Cost	%EL	Cost	%EL	Cost	%EL	Cost	%EL	Cost	%EL	Cost	%EL	Cost	%EL	Cost	%EL	Cost	%EL
S10	160	60	170	60	115	60	50	65	50	65	0	65	0	70	0	70	0	70	0	70
S11	137	60	170	60	200	60	250	65	310	65	200	65	170	70	150	70	50	70	50	70

Table F-2

Discounted Real Savings:
Summary of Key Points for Examples

GENERAL ASSUMPTIONS

Weapon System Costs in Then-Year Dollars

Annual Inflation Rate of 6 Percent

Annual Discount Rate of 10 Percent

HYPOTHETICAL MT PROJECTS USED IN EXAMPLES

Project No.	Hypothetical Project Description
P001	PCB Polyimide
P008	Microwave Elements
P010	Flexible Harnesses

SYSTEMS USED IN EXAMPLES

SPARROW (System called #S10 in examples)
HARPOON (System called #S11 in examples)

FUNCTIONAL ELEMENTS CONSIDERED IN EXAMPLES

E02	Active Components
E04	Printed Circuit Boards
E05	Cables

PROJECT IMPACT

The cost reduction implications for the hypothetical projects will consider the two missile systems in terms of the functional elements as follows

Project	System	Element
P001	S10	E04
P001	S11	E04
P008	S11	E02
P010	S10	E05
P010	S11	E05

Table F-4. System Electronics Element Percentage Cost Distribution (Shown only for System/Elements Impacted by MT Projects P001, P008, P010)

System/Element	Year 1	2	3	4	5	6	7	8	9	10
S10/E04	20	20	20	19	19	19	18	17	17	17
S11/E04	20	20	20	20	20	20	20	20	20	20
S11/E02	06	06	06	06	06	06	06	06	06	06
S10/E05	06	06	06	06	06	06	06	07	07	07
S11/E05	06	06	06	06	06	06	06	06	06	06

Table F-5. MT Project System/Element Percentage Cost Reduction

Project/ System/Element	Year 1	2	3	4	5	6	7	8	9	10
P001/S10/E04	00	00	10	10	15	20	20	20	20	20
P001/S11/E04	00	00	00	05	10	20	20	20	20	20
P008/S11/E02	00	00	00	00	15	20	25	25	25	25
P010/S10/E05	00	05	10	10	10	10	10	10	10	10
P010/S11/E05	05	05	10	15	15	15	15	15	15	15

MT Project Uncertainty

Project uncertainty considerations are incorporated into the savings calculations through use of savings achievement probability factors. The factors are specified by MT project and year for all combinations of systems/elements that are anticipated to experience cost reductions from project implementation. The uncertainty factors are a recognition of the inherent differences between projects in terms of risk and are applied as savings percentage reduction factors to provide lower bounds on cost savings estimates. Table F-6 provides the uncertainty factors for the three illustrative projects.

Table F-6. MT Project Uncertainty Factors

Project/ System/Element	Year									
	1	2	3	4	5	6	7	8	9	10
P001/S10/E04	070	070	075	075	080	085	085	090	095	100
P001/S11/E04	080	080	090	095	095	100	100	100	100	100
P008/S11/E02	080	080	080	080	090	100	100	100	100	100
P010/S10/E05	080	080	090	100	100	100	100	100	100	100
P010/S11/E05	080	080	090	100	100	100	100	100	100	100

Calculated Results

The flexibility built into the NEMTA methodology allows for savings to be calculated in thousands of dollars under the following options

- Then-year or constant dollars
- Discounted or undiscounted dollars
- Upper bound or lower bound savings

The succeeding subsection illustrates cost savings calculations in terms of undiscounted, then-year dollars for both the upper and lower bounds. This is followed by illustrations of upper and lower bound cost savings in terms of present value, constant dollars.

Savings $K, Undiscounted, Then-Year Dollars. All NEMTA production runs are of this type, using a 10 percent discount factor and a 4 percent inflation factor. However, savings can be computed in terms of undiscounted, then-year dollars by simply specifying values of 0 percent for the two economic factors.

Upper Bound Savings. Table F-7 provides upper bound savings in terms of undiscounted, then-year dollars. This means that the savings have not been adjusted for either price level changes (presumably inflation) or for the opportunity costs of money measured by an interest rate.

Table F-7. Upper Bound Savings (No Application of Uncertainty Factors)

System/ Project	Year										
	1	2	3	4	5	6	7	8	9	10	Total
S10/P001	0	0	138	62	93	0	0	0	0	0	293
S11/P001	0	0	0	162	403	520	476	420	140	140	2261
S11/P008	0	0	0	0	181	156	178	158	52	52	777
S10/P010	0	31	41	20	20	0	0	0	0	0	112
S11/P010	25	31	72	146	181	117	107	94	32	32	837
Total	25	62	251	390	878	793	761	672	224	224	4280

Upper Bound Savings Equations

$$S_{ikj}{}^{G} = W_{ij} * \delta_{ij} * \left(\sum_{\ell'=1}^{N\ell'} x_{ij\ell'} * R_{ikj\ell'} \right) \qquad \text{(F-1)}$$

where $S_{ijk}{}^{G}$ is upper bound undiscounted, then-year savings ($ thousands) achieved in system i by applying project k advances in year j;

W_{ij} is total fly-away cost for system i in year j ($ hundreds of thousands);

δ_{ij} is (electronics % of system i cost in year j);

$x_{ij\ell'}$ is (element % of electronics cost of system i in year j for subset ℓ' of elements ℓ), with the subset ℓ' reflecting only those elements subject to cost reduction in system i through MT project k);

$R_{ikj\ell'}$ is (element % reduction in system i attributable to project k in year j and element ℓ);

$$S_{ik}{}^{G} = \sum_{j=1}^{10} S_{ikj}{}^{G} \qquad \text{(F-2)}$$

$$S_{kj}{}^{G} = \sum_{i=1}^{Ni} S_{kji}{}^{G} \qquad \text{(F-3)}$$

$$S_{k}{}^{G} = \sum_{i=1}^{Ni} S_{ik}{}^{G} \qquad \text{(F-4)}$$

$$S^{G} = \sum_{k=1}^{Nk} S_{k}{}^{G} \qquad \text{(F-5)}$$

Lower Bound Savings. Table F-8 provides lower bound savings in terms of undiscounted, then-year dollars. The table differs from the immediately preceding one in that the uncertainty factors (Table F-6) have been incorporated into the calculations.

Table F-8. Lower Bound Savings (Application of Uncertainty Factors)

System/ Project	Year										
	1	2	3	4	5	6	7	8	9	10	Total
S10/P001	0	0	104	46	74	0	0	0	0	0	224
S11/P001	0	0	0	154	383	520	476	420	140	140	2233
S11/P008	0	0	0	0	163	156	178	158	52	52	759
S10/P010	0	25	37	20	20	20	0	0	0	0	102
S11/P010	20	24	65	146	181	117	107	94	32	32	818
Total	20	49	206	366	821	793	761	672	224	224	4136

Lower Bound Savings Equations

$$S_{ikj}^{H} = W_{ij} * \delta_{ij} * \sum_{\ell'=1}^{N_{\ell'}} x_{ij\ell'} * R_{ikj\ell'} * U_{ikj\ell'} \qquad \text{(F-6)}$$

where S_{ikj}^{H} is lower bound undiscounted, then-year savings ($ thousands) achieved in system i by applying project k advances in year j;

$U_{ikj\ell'}$ is the probability of achieving savings at least as great as the "upper" bound

All other terms in Equation (F-6) are defined as in Equation (F-1). Equations for lower bound costs parallel Equations (F-2) to (F-5). The superscript "H" simply replaces that of "G."

Savings $K, Present Value 1978 Dollars

Upper Bound Savings. Table F-9 provides upper bound savings in terms of present value 1978 dollars. Annual inflation and interest rates of 6% and 10% respectively have been used in the sample calculations. Both rates are compounded annually and appear as denominator entries in the basic equation (Equation F-7). This places the results in terms of present value constant dollars with FY 1978 as the base year.

The use of the discount rate in the manner described follows conventional financial practice. The placement of the inflation rate in the denominator reflects the basic fact that system costs are most likely to be secured from planning and budgeting documents. These costs include allowances for anticipated inflation.*

Table F-9. Upper Bound Savings (No Application of Uncertainty Factors)

System/ Project	Year										
	1	2	3	4	5	6	7	8	9	10	Total
S10/P001	0	0	87	33	43	0	0	0	0	0	163
S11/P001	0	0	0	88	187	207	162	123	35	30	832
S11/P008	0	0	0	0	84	62	61	46	13	11	277
S10/P010	0	23	26	11	9	0	0	0	0	0	69
S11/P010	21	23	45	79	84	47	37	28	8	7	379
Total	21	48	158	211	407	316	260	197	56	48	1720

Upper Bound Savings Equations

$$S_{ikj}^{G*} = W_{ij} * \delta_{ij} * \sum_{\ell'=1}^{N\ell'} \frac{x_{ij\ell'} * R_{ikj\ell'}}{(1+r)^j \, (1+d)^j} \qquad \text{(F-7)}$$

*In production runs and system costs not already in then-year dollars were suitably adjusted as indicated previously, a 4% inflation rate was used for system costs rather than the sample rate of 6%.

where S_{ikj}^{G*} is upper bound present value 1978 savings ($ thousands) achieved in system i by applying project k advances in year j;

r is annual interest rate;

d is annual inflation rate.

All other terms in Equation (F-7) are defined as in Equation (F-1). Equations for upper bound present value 1978 savings parallel Equations (F-2) to (F-5). The superscript G* simply replaces G.

Lower Bound Savings. Table F-10 provides lower bound savings in terms of present value, FY 1978 dollars. The uncertainty factors included in Table F-6 have been incorporated into the calculations.

Table F-10. Lower Bound (Application of Uncertainty Factors)

System/ Project	Year										Total
	1	2	3	4	5	6	7	8	9	10	
S10/P001	0	0	65	25	34	0	0	0	0	0	124
S11/P001	0	0	0	84	178	207	162	123	35	30	819
S11/P008	0	0	0	0	76	62	61	46	13	11	269
S10/P010	0	18	24	11	9	0	0	0	0	0	62
S11/P010	17	18	41	79	84	47	37	28	8	7	366
Total	17	36	130	199	381	316	260	197	56	48	1640

Upper Bound Savings Equations

$$S_{ikj}^{H*} = W_{ij} * \delta_{ij} * \sum_{\ell'=1}^{N\ell'} \frac{x_{ij\ell'} * R_{ikj\ell'} * U_{ikj\ell'}}{(1+r)^j \ (1+d)^j} \qquad \text{(F-8)}$$

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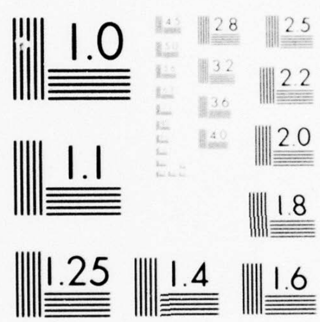

MICROCOPY RESOLUTION TEST CHART
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where S_{ikj}^{H*} is lower bound undiscounted, then-year savings ($ thousands) achieved in system i by applying project k advances in year j;

$U_{ikj\ell}'$ is defined as in Equation (F-1);

r is annual interest rate;

d is annual inflation rate.

All other terms are as defined in Equation (F-1).

Equations for lower bound present value 1978 savings parallel Equations (F-2) to (F-5). The superscript H* simply replaces G.

DISCOUNTED REAL INVESTMENT

The NEMTA program calculates the discounted real investment, and another example will be shown for the same hypothetical projects. Table F-11 shows the assumptions of this example.

CALCULATED RESULTS

Investment $K, Present Value 1978 Dollars

Table F-12 provides the MT project investment costs in terms of present value 1978 dollars. Annual inflation and interest rates of 6% and 10% respectively have been used in the sample calculations.

	Year							
Project No.	1	2	3	4	5	6	7	Total
P001	0	37	158	54	0	0	0	249
P008	0	0	0	54	46	0	0	100
P010	9	7	6	5	0	0	0	27
TOTAL	9	44	164	113	46	0	0	376

Table F-12. MT Project Investment Costs (Present Value 1978 Dollars)

Investment Equations

$$I_{kj}{}^* = I_{kj} \div \left[(1+r)^j \; (1+d)^j\right] \qquad \text{(F-9)}$$

where $I_{kj}{}^*$ is present value, constant dollar investment ($ thousands) for project k in year j;

I_{kj} is then-year investment ($ thousands) for project k in year j;

r is annual interest rate;

d is annual inflation rate.

Table F-11

DISCOUNTED REAL INVESTMENT: EXAMPLE PARAMETERS

GENERAL ASSUMPTIONS

Investment in Then-Year Dollars

Annual Inflation Rate of 6 Percent

Annual Discount Rate of 10 Percent

HYPOTHETICAL MT PROJECTS USED IN EXAMPLE

Project No.	Hypothetical Project Description
P001	PCB Polyimide
P008	Microwave Elements
P010	Flexible Harnesses

PROJECT DATA (THEN-YEAR INVESTMENT $K)

	Year						
Project No.	1	2	3	4	5	6	7
P001	0	50	250	100	0	0	0
P008	0	0	0	100	100	0	0
P010	10	10	10	10	0	0	0

$$I_j^* = \sum_{k=1}^{Nk} I_{kj}^* \qquad \text{(F-10)}$$

$$I_k^* = \sum_{j=1}^{7} I_{kj}^* \qquad \text{(F-11)}$$

$$I^* = \sum_{k=1}^{Nk} \sum_{j=1}^{7} I_{kj}^* = \sum_{j=1}^{7} I_j^* = \sum_{k=1}^{Nk} I_k^* \qquad \text{(F-12)}$$

Calculated Results

The flexibility built into the NEMTA methodology for MT investment parallels that for system cost savings in that output can be generated in thousands of dollars in terms of then-year or constant dollars, discounted or undiscounted. The methodology differs in that no uncertainty factors are applied to investment data. A single output value is provided rather than an upper and lower bound.

Two discount factors may be specified as NEMTA input and applied inseparably to investment and savings calculations. Inflation rates are specified separately for investment and savings. Also this feature allows project costs (generally available from source documents in terms of constant dollars) and weapon system costs in terms of then-year dollars to be used in the same program with no difficulty.

Table F-12 provides the MT project investment costs in terms of present value 1978 dollars. Annual inflation and interest rates of 6% and 10% respectively have been used in the sample calculations. All NEMTA production runs produce present value constant dollar investment output, using a 10% discount factor and a 0% inflation rate. The latter was used since the project costs specified as input to NEMTA were in constant FY1978 dollars.

PROGRAM SUMMARY

Table F-13 produces a summary of the Navy Manufacturing Technology Program for FY78-87 using the hypothetical data introduced in this appendix. The table displays results oriented to MT projects. With its flexible formatting capability, NEMTA is not only able to produce reports of this type but also system-oriented output and various special purpose displays.

Table F-13. Navy Manufacturing Technology Program FY78-87

Case	Project Number	Bound	Project Title	S-I S+I	Fy 78	FY 79	FY 80	FY 81	FY 82	FY 83	FY 84	FY 85	FY 86	FY 87	Total (I) Total (S)
					Project Cost ($ Thousands) Anticipated Savings (S Thousands)										
1	P001	Upper	PCB Polyimide	746 400	0 0	37 0	158 87	54 121	0 230	0 207	0 162	0 123	0 35	0 30	249 995
1	P001	Lower	PCB Polyimide	694 379	0 0	37 0	158 65	54 109	0 212	0 207	0 162	0 123	0 35	0 30	249 943
1	P008	Upper	Microwave Elements	177 277	0 0	0 0	0 0	54 0	46 84	0 62	0 61	0 46	0 13	0 11	100 277
1	P008	Lower	Microwave Elements	169 269	0 0	0 0	0 0	54 0	46 76	0 62	0 61	0 46	0 13	0 11	100 269
1	P010	Upper	Flexible Harnesses	421 1659	9 21	7 46	6 71	5 90	0 93	0 47	0 37	0 28	0 8	0 7	27 448
1	P010	Lower	Flexible Harnesses	401 1585	9 17	7 36	6 65	5 90	0 93	0 47	0 37	0 28	0 8	0 7	27 428
1	—	Upper	Total	1344 457	9 21	44 46	164 153	113 211	46 407	0 316	0 260	0 197	0 56	0 48	376 1720
1	—	Lower	Total	1264 436	9 17	44 36	164 130	113 199	46 381	0 316	0 260	0 197	0 56	0 48	376 1640
2	—	Upper	Total	3640 669	10 25	60 62	260 251	210 390	100 878	0 793	0 761	0 672	0 224	0 224	640 4280
2	—	Lower	Total	3496 6	10 20	60 49	260 206	210 366	100 821	0 793	0 761	0 672	0 224	0 224	640 4136

* Case:

1 - Present Value, Constant $

2 - Undiscounted, Then-Year $

Appendix G

EQUIPMENT LIST AND STUDY RESULTS RELATED TO SPECIFIC EQUIPMENT

APPENDIX G

EQUIPMENT DATA AND LESSONS LEARNED FROM NAVY PROJECT OFFICE AND MANUFACTURER INTERVIEWS

INTERVIEWS

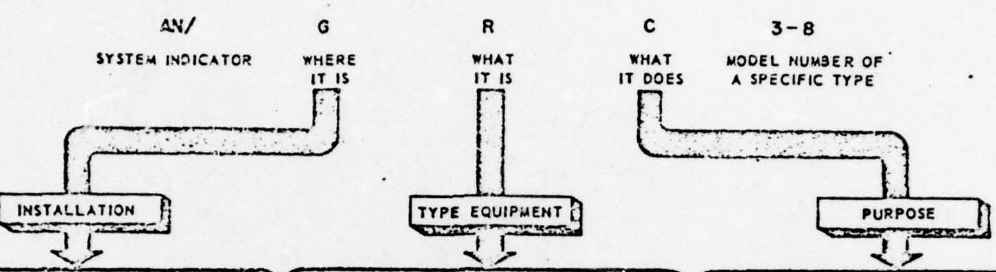
Interviews were conducted with 27 Navy Project Offices in NAVELEX, NAVMAT, NAVSEA, and NAVAIR and with 15 selected manufacturers. Some firms and project offices represented opportunities for more than one interview area. Altogether a total of 58 separate interviews were conducted.

The purpose of these interviews were to:

- Secure information on electronic equipment selected as candidates for this study; in particular 1) procurement cost drivers and 2) manufacturing technology projects or incentive suggestions.
- Obtain experience-based observations for compilation into lessons learned of pertinence to the MT program.

The succeeding section summarizes the lessons learned. This is followed by data on specific Navy equipment. Data sheets are provided, irrespective of whether the particular item was ultimately included or excluded in this study as a possible MT candidate. Cross-referencing to each included item has been facilitated by entering the system identification number used in the computerized cost model (see Volume II and Appendix F, this Volume) in the top left-hand corner of each data sheet.

Many of the equipment items addressed in this study are identified by an "AN" number. Figure G-1 provides a coding dictionary for AN equipment.



INSTALLATION

A-AIRBORNE (INSTALLED AND OPERATED IN AIRCRAFT)
B-UNDERWATER MOBILE, SUBMARINE
C-AIR TRANSPORTABLE (INACTIVATED, DO NOT USE)
D-PILOTLESS CARRIER
F-FIXED
G-GROUND, GENERAL GROUND USE (INCLUDES TWO OR MORE GROUND INSTALLATIONS)
K-AMPHIBIOUS
M-MOBILE (INSTALLED AS OPERATING UNIT IN A VEHICLE WHICH HAS NO FUNCTION OTHER THAN TRANSPORTING THE EQUIPMENT)
P-PACK OR PORTABLE (ANIMAL OR MAN)
S-WATER SURFACE CRAFT
T-GROUND, TRANSPORTABLE
U-GENERAL UTILITY (INCLUDES TWO OR MORE GENERAL INSTALLATION CLASSES, AIRBORNE, SHIPBOARD, AND GROUND)
V-GROUND, VEHICULAR (INSTALLED IN VEHICLE DESIGNED FOR FUNCTIONS OTHER THAN CARRYING ELECTRONIC EQUIPMENT, ETC. SUCH AS TANKS)
W-UNDERWATER, FIXED

TYPE EQUIPMENT

A-INVISIBLE LIGHT, HEAT RADIATION
B-PIGEON
C-CARRIER (WIRE)
D-RADIAC
F-PHOTOGRAPHIC
G-TELEGRAPHIC OR TELETYPE (WIRE)
I-INTERPHONE AND PUBLIC ADDRESS
K-TELEMETERING
L-COUNTERMEASURES (INACTIVATED, DO NOT USE)
M-METEOROLOGICAL
N-SOUND IN AIR
P-RADAR
Q-SONAR AND UNDERWATER SOUND
R-RADIO
S-SPECIAL TYPES, MAGNETIC, ETC., OR COMBINATIONS OF TYPES
T-TELEPHONE (WIRE)
V-VISUAL AND VISIBLE LIGHT
X-FACSIMILE OR TELEVISION

PURPOSE

A-AUXILIARY ASSEMBLIES (NOT COMPLETE OPERATING SETS)
B-BOMBING
C-COMMUNICATIONS (RECEIVING AND TRANSMITTING)
D-DIRECTION FINDER
G-GUN OR SEARCHLIGHT DIRECTING
H-RECORDING (PHOTOGRAPHIC, METEOROLOGICAL, AND SOUND)
J-COUNTERMEASURER, RECEIVING AND TRANSMITTING
L-SEARCHLIGHT CONTROL (INACTIVATED USE "G")
M-MAINTENANCE AND TEST ASSEMBLIES (INCLUDING TOOLS)
N-NAVIGATIONAL AIDS (INCLUDING ALTIMETERS, BEACONS, COMPASSES, RACONS, DEPTH SOUNDING, APPROACH AND LANDING)
P-REPRODUCING (PHOTOGRAPHIC AND SOUND)
Q-SPECIAL OR COMBINATION OF TYPES
R-RECEIVING
S-DETECTING AND/OR RANGE AND BEARING
T-TRANSMITTING
W-REMOTE CONTROL
X-IDENTIFICATION AND RECOGNITION

Figure G-1. Joint Communications-Electronics Type Designation System

LESSONS LEARNED

As a result of the interviews conducted, the following lessons were apparent:

- While interviews in Navy offices did not generate many specific leads for cost drivers or MT projects, they did identify, to a varying degree, details about systems and their components and the related vendors. They were essential in securing the cooperation of the project office and contracting firms, and in making a wide group in the Navy procurement cycle aware of the MT program goals. In any subsequent studies of this nature, considerable effort is suggested at the project office level. The assistance of NAVMAT 042 in providing a letter of introduction to the project offices was a critical first step in this process.

- Neither the contractor firms nor the project offices had much general data about percentage of distribution of costs of electronics components to total system costs, nor cost learning curves available during the initial interviews. An apparent exception to this is NAVSEA-06H, particularly with respect to sonar systems. This office, with its support contractor, EG&G, has also developed many factors and estimating relationships pertaining to electronics costs. The data and cost estimating tools are highly proprietary and for the most part were not made available.

- Most of the manufacturing firms contacted were very cooperative and in many instances were able to provide percentage cost breakdown of electronics devices into subcomponents after some research. Learning curves were much more difficult to obtain and many of the most interesting systems from the MT point of view are not well advanced in production in any case. In subsequent studies it is well to recognize that a time lag between the initial interview and cost data may exist.

- All respondents recognized that military electronic hardware costs more than equivalent commercial equipment because 1) military procurements usually are small in quantity, which results in batch-type production, and 2) the military requirements for testing and for documentation are extremely costly. There was no universal opinion on whether the Navy MT program would be able to overcome these formidable facts of life. All respondents also accepted the general view that U.S. industry was currently lagging in manufacturing productivity and that something ought to be done to correct the problem.

- Specific and detailed proposals for Manufacturing Technology projects were received from several firms subsequent to the interviews. The fact that the Army ECOM Conference was being held in the same timeframe provided additional motivation to many firms. Other firms provided general ideas as to projects or incentives they felt desirable. In total, nearly 400 candidate projects were reviewed. However, in many cases cost benefit data were either missing or difficult to verify. Moreover, many firms did not relate their proposals toward specific military procurements. In some cases it was clear that little initial R&D work had been accomplished. Follow-up interviews with industrial firms to clarify data are required for those proposals rating well in the initial analysis.

The following points also emerged, although not directly related to the scope of the investigation; they are included for completeness.

- The non-hardware costs of procurement programs for large systems have become excessive. These costs include computer programs and also the many aspects of program management, and they can amount to over 70 percent of total production program costs. The cost of developing and maintaining system computer programs is substantial, and these software costs are usually under-estimated by program managers.

- Almost any change that is introduced after the start of production increases costs. This even includes reducing such things as required inspections or reports. This is because of the many agencies that are involved in the procurement process; introducing a change directly affects many of them and has to be coordinated with many others, and this is costly.

- The Navy frequently has a problem maintaining electronic equipment because as technology advances, many firms lose interest in producing old components that the Navy needs for repair parts.

- The opinion in Navy project offices about the Standard Electronic Module (SEM) program is divided. Some stress the opportunities for cost savings in development of follow-on similar systems and for life cycle savings because of multiple vendors and high reliability; others assert that the program inhibits technological advance by restricting design to use of existing components and that it leads to high cost of initially qualifying modules.

COVERAGE

Of the 51 systems selected for inclusion in the initial phase of the study, 32 of these were felt important enough to warrant specific interviews of program offices and industrial firms. The following table, G-2, shows the coverage and indicates whether an equipment data sheet was generated. The subsequent pages represent a summary compilation of the 32 equipments investigated, the data sources and observations. In addition, four other thematic areas were included due to their importance in manufacture or widespread utilization in the fleet. These are: Integrated Circuits, Traveling Wave Tubes, Robotics and High Power Laser usage in Manufacture. Finally, important observations unrelated to any particular system are also summarized.

Table G-2. Equipment Data Sheet Status

NEMTA Model ID #	NEMTA Model Nomenclature	Specific Interview Write-up
S01	DDG-47 AEGIS	Yes
S02	FFG-7 FRIGATE	Excluded
S03	SSN 688 CLASS	Excluded
S04	SSBN TRIDENT	Excluded
S05	CSGN CRUISER	Excluded
L10	BQQ-5 SONAR	Yes
L11	BQQ-6 SONAR	Yes
L12	SQS-56 SONAR	Yes
L13	BQR-21 SONAR	Yes
L14	SSQ-41 SONOBUOY	Yes
L15	SSQ-53 SONOBUOY	Yes
L16	SSQ-62 SONOBUOY	Yes
L17	SATCOM SHIP TERMINAL	Yes
L18	PRC-104 RADIO	Yes
L19	IRR COMMO	Excluded
L20	ESG NAVIG	Yes
L21	TPS-59 RADAR	Yes
L22	TPS-63 RADAR	Yes
L23	DTP EW SUITE	Yes
L24	AN/UYK-7 COMPUTER	Yes
L25	AN/UYK-20 COMPUTER	Yes
L26	AYK-14 COMPUTER	Yes
L27	NTDS	Yes
L28	AWG-9 WPN CNTR SYST	Yes
L29	TRAM	Excluded
L30	SPS-49 SHIP RADAR	Excluded
L31	SPS-58 SHIP RADAR	Excluded
L32	ALQ-78 ECM SET	Excluded
L33	ALR-59 EW SET	Excluded
L34	AIMS	Excluded
L35	APS 115 RADAR	Excluded
A40	F14 A TOMCAT	Excluded
A41	A7E CORSAIR	Excluded
A42	P3C ORION	Yes
A43	E2C HAWKEYE	Yes
A44	A6E INTRUDER	Yes
A45	EA6B PROWLER	Yes
A46	LAMPS	Yes
A47	F18	Excluded

Continued on next page

Table G-2. Equipment Data Sheet Status (Cont'd)

NEMTA Model ID #	NEMTA Model Nomenclature	Specific Interview Write-up
M60	HARPOON	Yes
M61	STANDARD ER	Yes
M62	STANDARD MR	Excluded
M63	PHOENIX	Yes
M64	SPARROW	Excluded
M65	SIDEWINDER	Excluded
M66	HARM	Yes
M67	TOMAHAWK	Yes
M68	TRIDENT	Excluded
080	MK-48 TORPEDO	Yes
081	MK15 PHALANX CIWS	Yes
IC's		Yes
TWT's		Yes
Robotics		Yes
High Power Laser use in Manufacture		Yes
General		Yes

NAVY EQUIPMENT DATA

S01 AEGIS DESTROYER/CRUISER WEAPON SYSTEM

The AEGIS weapon system is designed to counter the aircraft and missile threat to the fleet. The elements of the system are shown in the attached display (Figure G-1). RCA is the prime contractor for the AEGIS system and Raytheon is the subcontractor for the fire control system as well as being a major subcontractor for elements of the acquisition radar. General Dynamics is the contractor for the SM-2 missile. The AN/SPY 1-A multifunction radar system is the major component of the system. It provides hemispherical target acquisition capability using electronically steerable phased-array antennas. In addition, the SPY-1 provides track and mid-course guidance to the SM-2 missile. The AEGIS weapon system has undergone testing at sea in the USS Norton Sound, but a production decision is still pending. Current plans call for installation of the system on 25 ships.

Office Visited	Date	Personnel Contacted	Remarks
NSEA PMS 403 (now designated PMS-400)	2/4/77	Richard Britton William Mercanti Gan Lee	PMS 400 is responsible for the AEGIS system development including SM-2 missile development.

Contractors Visited	Date	Personnel Contacted	Remarks
RCA, Moorestown, N.J. (prime contractor)	2/8/77	Howard Grossman, RCA Production Manager Howard Mercer, RCA Production Planning Leo F. Snyder, Navy On-Site Representative William Mercanti, PMS 403 Representative	
Raytheon, Wayland, Mass. (subcontractor)	2/9/77	Hal Soderberg, Raytheon Aegis Prg. Mgr. Dick Schwartz, Raytheon, Fire Control Sys. Grant St. John, Raytheon, High Powered Radar Transmitters	An informal conference was held at Raytheon. In addition to the personnel identified at the left, about 30 other industry representatives were present. These included representatives from GE and RCA as well as Raytheon.

Observations:

1) PMS 403 in-house analysis has identified cost drivers and developed a list of MT recommendations.

2) RCA is implementing a fully automated AEGIS production Management Control System.

3) All organizations concerned expressed interest in the MT program and suggested areas for improvement including:

- Firmer distinction between MT and redesign efforts
- Demonstration of technology improvements by MT funds through pilot production and qualification
- Avoidance of funding slippage for urgent projects
- Development of better ways of disseminating the results of industrial MT projects to interested military and industrial representatives.

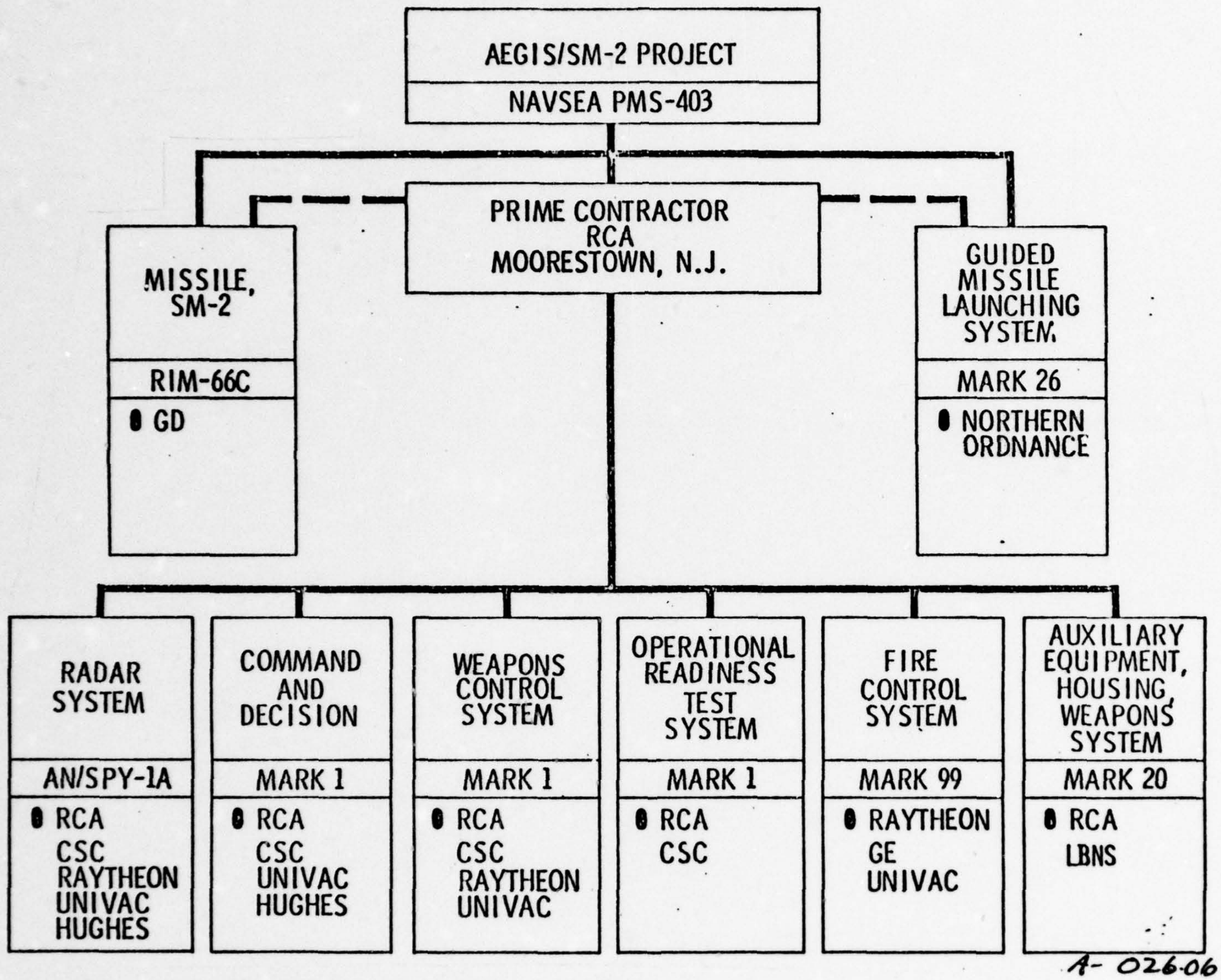


Figure G-1. Aegis Weapon System Mark 7 Mod 2

L10

AN/BQQ-5 SONAR

The AN/BQQ-5 is an active, all digital ASW sonar for SSNs. It will detect, classify and track submarines, surface ships and torpedoes. The unit cost is about $6.8 million for a backfit system. The prime contractor is IBM, Manassas.

Office Visited	Date	Personnel Contacted	Budget
NSEA 660FB	1/20/77	Mr. Don Baird	$170M for R&D $42.6M FY77 SCN funds $517.3M FY77-82 OPN funds
IBM, Manassas, Va.	2/15/77	James C. Sharp, Contracts Donald J. Buckley, Mgr. Mfg. R. C. Jonsson, Proteus Prod. Prog. Office A. H. Toman, Military Disk Files/Storage Larry Ii, Planning A. J. Elias, Finance C. R. Bogan, Finance Robt. L. Volp, Cost Engineering	

Component Engineering	Unit Cost	Vendor	Notes
SEM	-	Circuit Technology Inc. (Largest supplier)	$3M total per system
Cabinets	-	Weston & Langley	16 per system
Power supplies	-	TRIO/IBM	100 per system
Displays console W2 Drums	-	IBM	3 per system
Associated Equipment			
Towed array	-	Gould	
Towed array handling system	-	ITW	
XMTR Kits	-	Raytheon	
Refurbished XMTR	-	Raytheon	
AN/UYK-7 Computer	-	Univac	
Precision Data Recorder	-	Raytheon	

Observations

1) 3 systems are operational, and 15 systems are in various stages of installation. Projected installation rate is 12/year.

2) System consists of 52 cabinets of electronics, including 16 provided as GFE. Each system includes about 18000 SEMs. System includes 3 display cabinets.

3) IBM, Manassas is responsible for final assembly, integration and testing.

4) Manufacturing is done chiefly in the Owego, N.Y., plant where all purchasing is also centrally located.

5) Testing at all levels is highly automated and accounts for only 6% of cost.

L10 AN/BQQ-5 SONAR (Cont'd)

Observations (continued)

6) All cabinets are subcontracted.

7) SEMs provide opportunities for significant cost savings. IBM sees benefit of the current "improved" generation of SEM.

8) IBM believes that the very large memories now available will result in significant reduction in hardware/software costs due to simpler programming.

9) The Environmental testing specifications could result in large increases in cost and time; however, the contractor has apparently an effective testing plan that allows thorough testing for reasonable costs.

L11 AN/BQQ-6 SONAR

The AN/BQQ-6 is a passive, all digital sonar for the TRIDENT submarine. It detects, classifies, and tracks submarines and ships. No BQQ-6 cost data are available. The prime contractor is IBM, Owego.

Office Visited	Date	Personnel Contacted	Budget
NSEA 660G	1/20/77	LCDR. W. N. Moore Mr. Bernard Bernstein	

Component Equipment	Unit Cost	Vendor	Notes
SEM	-	-	AN/BQQ-6 and AN/BQQ-5 sonars employ thousands of common modules
Mass Memory Drums	$60K		
Associated Equipment			
Fire Control System	-	Singer/ Librascope	Uses High density 5x5 modules with high tech. components instead of SEMs
FCS Displays	-	Hughes	

Observations

1) Software costs are about half of total system costs.

2) Wire harnessing is a problem because of variation in manufacturers' cabling techniques. IBM uses flat cabling, whereas Hughes and Singer use bundled cables.

L12 AN/SQS-56 SONAR

The AN/SQS-56 Sonar system provides active/passive sonar capability and track/classify-while-search capability to surface ships. It is being installed on the new FFG-7 class frigrates. The unit cost of the system is (in pilot production) about $2.5 million, of which about $1.5 million is for hardware and $1 million for software, project management, logistics support, and documentation.

Office Visited	Date	Personnel Contacted	Budget
NSEA 661C4	1/6/77	Mr. Robert Einzig	
	6/21/77	Mr. Andy Breece	

Observations

1) Total procurement will be about 70-80 systems.

2) The sonar is based upon 1972-73 technology. It does not include any LSI.

3) About 40% of the electronics are SEM.

L13 AN/BQR-21 SONAR

The AN/BQR-21 DIMUS (Digital Multibeam Sonar), which replaces BQR-2, gives passive sonar capability to SSBNs and some SSNs. Unit cost is approximately $1.7 million. The prime contractor is Honeywell, Marine Systems Division. MSD is located in West Covina, California and in Seattle, Washington. Approximately 80% of their business is with the Navy - 20% is commercial. Honeywell MSD has had the total ASW system integration responsibility for 270 ships.

Office Visited	Date	Personnel Contacted		Budget
NSEA 660C-2	1/7/77	Mr. Fred Brumbaugh		
Contractor Visited				
Honeywell, West Covina, Ca.	1/12/77	Gerald Vandevoort	(AN/BQR-21 Program Mgr.)	
		Jerry Holman	(Mgr. Defense Operations)	
		Hugh Tulloch	(Marketing)	
		Steve Goldwater	(AN/BQR-21 Production Mgr.)	
		John Marsh	(NAVSEA Rep.)	

Component Equipment	Approximate Unit Cost	Vendor	Notes
Electronics	$900K	Honeywell	Consists of pre-amplifier switch assembly, processor, & display
Hydrophones	$42K		Honeywell provides the
Array/Baffle	$150K		baffles only - 41 sets
Delivery Rate 2/month			NAD, Crane monitors program.

Observations

1) The electronics are 85% SEM, of which 90% are unique to the system. SEM's cost $12M for 56 BQR-21 systems.

2) Harnesses are assembled manually.

3) The wire wrap of modules and electronics testing is automated and computer controlled. Test equipment and wire wrap machine are owned by Navy.

4) The procurement contract is fixed price, incentive type.

5) Sylvania and Circuit Technology, Inc. (CTI) are the principal vendors of SEM modules.

6) 27 months lead time for first systems. Production started at 2/month.

7) Payment is not in installments but occurs about one year after delivery so that front end investment by contractor is very high.

8) Of the 56 systems, 2 are refurbished engineering development models and 43 are new; 8 are for trainers; 1 is a configuration control model.

9) Detailed breakdown of percentage costs were obtained.

L14/L15/L16 SONOBUOYS

Sonobuoys are air-dropped expendable devices used for ASW. There are several models and types for different purposes, but they are of a standard size to fit aircraft launch tubes.

Office Visited	Date	Personnel Contacted	Budget
PM4/ASW-11	1/19/77	Mr. H. Magid	$80M FY77
NAIR 5330	1/13/77	G. L. Perseghin	

Contractor Visited			
Sparton Electronics	2/3/77	Mr. C. W. Skillas, Director of Marketing (interview took place in Arlington, Va.)	

Sonobuoys	Unit Cost	Vendor	Notes
SSQ-53 (DIFAR)	$300-500	Magnavox, Sparton Hermes	Passive, $35M FY77
SSQ-41	$170-200	Magnavox, Sparton Hermes	Passive, $21.4M FY77
SSQ-62 (DICASS)	$3K-4K	Raytheon, Sparton	Active, $12.6M FY77
SSQ-50 (CASS)	-		Active, $4.6M FY77
SSQ-57	-		Passive, $3.7M FY77
SSQ-47	-		Active $3.6M FY77
SSQ-36	-		Bathythermograph, $2.0M FY77

Observations

1) All production contracts are fixed price against functional specifications.

2) Dual sources for all sonobuoys maintained.

3) High volume procurement - about 200,000 in FY77.

4) Automated prepared production capability is a possible alternative to stockpiling and continued production, but no action being taken in this direction.

5) High reliability is the overriding requirement for sonobuoys, due to stringent procurement acceptance tests.

6) Specification, through development, to full production for a new sonobuoy usually takes about 9 years.

7) Manufacturers differ in their production methods for the same item, but typically, sell for about the same price.

8) Batteries are a high cost component of active sonobuoys. Batteries account for about 30 to 50% of active sonobuoy cost.

9) Sonobuoy contracts require that there be two suppliers for all critical parts.

10) Sparton has primarily produced its sonobuoys as handmade items. An automated insertion machine has been procured and is being evaluated for production use.

11) Sparton has developed its sonobuoys with corporate funds and subsequently marketed them to the Navy.

12) Detailed cost breakdowns are available.

L17 AN/WSC-3 SATCOM TRANSCEIVER

The AN/WSC-3 UHF SATCOM TRANSCEIVER will provide the Satellite Communications System Terminals for most ships and submarines. The unit cost is $28.5K. The prime contractor is Electronic Communications, Inc. (ECI), St. Petersburg, Fla.

Office Visited	Date	Personnel Contacted	Budget
PME 106	12/29/76	Mr. J. D. Sampson	$5.6M FY77 OPN Funds
			$4.0M FY78 OPN Funds

Component Equipment	Unit Cost	Vendor	Notes
Radio Xmtr.	$2,340	-	From Interim Report Parts List
Voltage Regulator	$1,221	-	" " " " "
FSK Detector	$ 862	-	" " " " "
RF Translator	$ 928	-	" " " " "
Synthesizer	$1,965	-	" " " " "
Data Modulator	$ 817	-	" " " " "
Switch Assembly	$ 740	-	" " " " "

Associated Equipment		
OE-82 Ship Antenna	$47.6K	Datron
Sub.Sat.Info.Exch.Sub-sys	$29.5K	-
Secure Voice Encoders	$28.4K	E Systems

Observations

1) Fixed price contract with ECI.

2) The Submarine Satellite Information Exchange Subsystem (SSIXS) equipments with the AN/WSC-3 submarine SATCOM terminal will provide a high data rate submarine-shore-submarine satellite communications capability.

L18 AN/PRC-104 MANPACK TRANSCEIVER

The AN/PRC-104 Manpack Transceiver is a HF SSB Transceiver for short and long range voice communications. It weighs 12½ pounds and provides channels in 100 KHz increments over the band 2 to 30 MHz. The unit cost is $4.2K. The prime contractor is Hughes, Fullerton, California.

Office Visited	Date	Personnel Contacted	Budget
NELEX 5401	12/29/77	Mr. G.T. Bartnett	$22M
Contractor Visited			
Hughes Aircraft Co. Fullerton, Ca.	2/9/77		

Component Equipment	Unit Cost	Vendor	Notes
5 modules	-	-	-
28 submodules	-	-	-
7 hybrid assemblies	-	-	-
6 LSIs	-	-	-

Associated Equipment			
Receiver/Exciters	$2,725	Hughes	Procured separately but same contract
Mount, TTY Conv., Audio-ampl. for vehicle version	$1,231	Hughes	Procured separately but same contract

Observations

1) 3,740 units of the PRC-104 are to be procured, 2421 for the U.S. Marines and 1,319 for Sweden. The fixed price contract, with escalation clause, also includes 1,067 of the associated equipment for the vehicle mounted version.

2) Production decision is shceduled for July 1977.

3) High-cost components that might be suitable for an MT project are:

- Temperature compensated crystal oscillator
- Synthesizer, including voltage and temperature control oscillators.

L20 SSBN ESG NAVIGATION SYSTEM

Autonetics Division of Rockwell International is producing the high accuracy electro-static gyro (ESG) navigation system for SSBNs.

Office Visited	Date	Personnel Contacted
Air Force Plant Rep.	1/14/77	Col. Talley, USAF Mr. A. A. DiNubiia
Contractor Visited		
Autonetics Div., Rockwell International	1/20/77	Mr. James Driver, Director of Operations

The Air Force Plant representative gave a general rundown of the active contracts of Naval interest at Autonetics. Autonetics is to produce 9 ESG navigation systems at a cost (FFP) of $44M. The Anaheim autonetics facility is used primarily for assembly of operations.

Observations

1) Cabling is considered a major problem. There is a need to investigate all methods of multiplexing to reduce cable runs.

2) Differences in soldering specifications between the Services lead to costly duplication of efforts.

3) Standard Electronic Modules (SEM) result in increases in material costs which probably offset lower logistics costs.

L21 AN/TPS-59 RADAR

The AN/TPS-59 3D, "L" band radar is a long range phased array set used for surveillance of tactical air space and ground control intercept. It is the world's first all solid state tactical radar. Its unit cost is estimated at about $4M. The prime contractor is General Electric, Syracuse, N.Y.

Office Visited	Date	Personnel Contacted	Budget
NELEX 5402	1/3/77	Mr. W.C. Alexion Mr. Ike King	$14M for Development

Contractor Visited			
General Electric Syracuse, N.Y.	5/27/77	Mr. Jon Canolesio Mr. Bernard Geyer Mr. Jim Kalitta	interview took place in McLean, Virginia

Component Equipment	Unit Cost	Vendor	Notes
Antenna	-	-	-
-54 Row Feed Networks			
-Row Electronics			
-Row Transmitter Power Supplies			
Signal Processor	-	-	-
Display Console	-	-	-
Data Processor (UYK-7)	-	-	-

Observations

1) Repair parts list giving vendor code and unit price for hundreds of small parts such as P.W. Boards, transistors, switches, filters, etc., is available.

2) One development model being tested now at Camp Pendleton.

3) Possible MT candidate is the row board.

4) Production decision scheduled for about November 1977.

L22 AN/TPS-63/65 RADAR

The AN/TPS-63/65 Radar is a high performance, 2D, "L" band radar used by the U.S. Marine Corps for air traffic control and airfield surveillance in amphibious areas. The TPS-65 is a dual capability TPS-63 with a single antenna. The unit cost is about $525K for the TPS-63 and $850K for the TPS-65. The prime contractor is Westinghouse, Baltimore, Md.

Office Visited	Date	Personnel Contacted	Budget
NELEX 5402	1/3/77	Mr. W.C. Alexion	$10.4M FY77
		Mr. D. Bicoff	

Component Equipment	Unit Cost	Vendor	Notes
Transmitter	-	-	-
Antenna	-	-	-
Receiver	-	-	-
Signal Processor	-	-	-
System Power	-	-	-

Observations

1) Repair parts list giving manufacturers code and unit price for hundreds of small parts such as ICs, resistors, capacitors, transistors, etc., is available.

2) The Marines are considering acquisition of an additional 10 TPS-63s and 23 TPS-65s.

L23 DESIGN-TO-PRICE EW SUITE (SLQ- 32)

The Design-to-Price EW Suite is a modular EW system intended to provide a varied set of modern low cost EW equipments to about 300 ships. Different vessels will be provided different EW capability from the Design-to-Price EW modules so there is no standard unit cost. However, the total program is estimated to have an acquisition cost of about $240M, 5-year support costs of $60M, and installation costs of about $160M. The prime contractor is Raytheon.

Office Visited	Date	Personnel Contacted	Budget
PME 107-3	1/28/77	Capt. R.A. Hullander	$44.8 FY77

Quantities over four years	Component Equipment	Unit Cost	Vendor	Notes
1,024	Voltage Control Oscillator	$1.3	FSI	These items selected by Capt. Hullander as ones most pertinent for MT
9,000	Miniature TWT	$1.9K	Varian & ITT	
27,598	Crystal Video Receiver	$30	Teledyne MIC	
637	YIG Filters	$1.5K	WJ	
896	High Voltage Power Supply	$8K	KELTEC	

Observations

1) Each of the components listed above will be bought in very large quantities.

2) A good candidate for MT is the miniature TWT due to the volume required.

L24 AN/UYK-7 COMPUTER

The AN/UYK-7 computer is a standard general purpose digital computer for various tactical applications on ship, submarine, and shore bases. It is of modular design, allowing for flexibility in memory capacity. The basic computer uses a single bay. Additional bays are added to provide for memory capacity increases. A single bay is used with the AN/BQQ-5 sonar, two bays with the AN/BQQ-6 sonar, and four bays with such ships as the DLG 38-DLG 41. The prime AN/UYK contractor is Sperry-Univac of St. Paul, Minnesota. The computer has been in production for several years and is expected to continue for several more. Currently, 144 single bay equivalents are being produced per year with an "average" configuration of 1.9 bays.

Contractor Visited	Date	Personnel Contacted	Budget
Sperry-Univac, St. Paul, Minn.	2/2/77	Don Dunn, Director of Operations John Knaak, Director of Mfg. Eng. Tom Bush, Schedule & Cost for UYK-7 Dave Duncan, UYK Pgm. Mgr. Paul Welshinger, Dir. of Quality Control Earl Verra, MT Dept. Engineer Marc Shoquist, Rep. of VP for Mfg.	

Observations

1) The cabinets are all subcontracted and are a major cost item.
2) There is a high degree of automation employed in the plant.
3) There is a centralized Manufacturing Technology Department at Sperry.
4) Interest in the MT program is high.
5) The incentives for industrial modernization to reduce unit production costs can be augmented by changing the procurement regulations to allow for lower risks in capital investment decisions.

L25 AN/UYK-20 COMPUTER

The AN/UYK-20 mini computer is a standard general purpose digital computer for various tactical applications. It is of modular design, allowing many features to be added. The unit cost for the basic set is about $20K. The prime contractor is UNIVAC, Clearwater, Florida.

Office Visited	Date	Personnel Contacted	Budget
NELEX 5701	12/27/76	Mr. A.L. Smeyne	-

Component Equipment	Unit Cost	Vendor	Notes
Memory Array boards			High cost part
Power supplies			" " "

Observations

1) About 800 UYK-20s have been procured under a fixed unit price contract, no quantity specified. A new follow-on contract is now being negotiated.

2) IC's were held to specifications required by the AN/UYK-20 environment only.

3) Fairly steady Navy demand has permitted mass-production line type manufacture.

L26 AN/AYK-14 DIGITAL COMPUTER

The AN/AYK-14 is an airborne computer designed for application in multiple aircraft and weapon systems. Two basic configurations give flexibility in system capability.

Office Visited	Date	Personnel Contacted
NAIR 533	1/21/77	Henry Mendenhall
Contractor Visited		
Control Data Corp. Minneapolis, Minn.	2/9/77	Jerry Silverman, Program Mgr. Jerry Johnson, Business Mgmt. Ken Mulholland, Mfg. Eng.

Observations :

1) The AN/AYK-14 is being procured in small quantities for programs such as the F-18, LAMPS III and others. There is a potential market for many hundreds of these computers in ten or so programs.

2) CDC will provide a production data package and procurement will be by competitive bid.

E16 NAVY TACTICAL DATA SYSTEM (NTDS)

The NTDS is a system of communications, display and data processing equipments incorporated in varying combinations on all major Navy warships. The purpose is to allow the Tactical Commander to perform his combat function accurately and quickly. Some equipment is old; other equipment is continuously being developed for the system.

Office Visited	Date	Personnel Contacted	Budget
NSEA 612B	1/11/77	Capt. C. C. Drenkard	$14.3M in FY77 (R&D only)

Representative Component Equipment	Unit Cost	Vendor	Notes
Communications: USQ-59		Collins	
SRC-23			
URC-75			
Displays: UYQ-21		Hughes	
UYA-4			
Data Processing: UYK-7 and peripherals	-	Sperry Univac	

Observations

1) NTDS provides (a) combat direction system integrating ship sensor data, communications and weapon control; (b) analysis of operational data, and (c) initiation of response in accordance with doctrine in computer memories.

L28/M63 PHOENIX WEAPON SYSTEM

The PHOENIX missile system is comprised of a long-range airborne weapon control system (AN/AWG-9) with multiple target handling capabilities and a long range missile (AIM-54A) utilizing command mid-course guidance and active terminal guidance. The Hughes Aircraft Co. is the prime contractor for both the weapon control system and the missile. These two elements of the Phoenix weapon system have unit costs, respectively, of about $2M and $310K.

Office Visited	Date	Personnel Contacted	Budget (Missile Only)
PMA 241	1/10/77	Mr. Terry Hannah	$77M FY77 $70M FY78

Contractor Visited		
Hughes Aircraft Co.	1/11/77	L.B. Wallace-AWG-9 Operations Mgr. W.L. Allen-AWG-9 Prod. Programs Howard Edwards-Phoenix Planning Dick Clapp-Cost Analysis Lee Eldrod-AWG-9 Systems Mgr. Donald Matteis, Components & Process Eng.

Component Equipment	Unit Cost	Vendor	Notes
Waveguides	-	Mid-Continent Eng.	-
Computers	-	Control Data Corp.	(10% of total hardware cost of AWG-9)
Semi-Conductors	-	Motorola	-
Microwave Assemblies	-	Microwave Assoc.	
TWT	$25K	Hughes, Torrance Div.	Major problem area

Observations:

1) A chart is available showing all the PHOENIX parts suppliers.

2) In addition to the missile procurement budget shown above, funds for spare parts are $2.2M in FY77 and $1.8M in FY78. Funds for advance procurement for the two years are 4M/year.

3) Other costs as a percentage of missile hardcosts: Procurement support - 36%; Fleet support - 31%; Modifications and spares - 14%.*

4) Hughes is tooled for 8 AWG-9 systems per month, and 55 missiles/month.

5) Contract has option buy requirements and includes a cost escalation relief for material, labor and extraordinary inflation.

*Percentages in notes 5 and 6 derived from budget submission data for FY77.

A42

P-3C AIRCRAFT

The P-3C (ORION) patrol aircraft is a land-based, four engine, turboprop patrol aircraft whose primary mission is anti-submarine warfare (ASW). The unit cost is approximately $16.9 million. The prime contractor is Lockheed.

Office Visited	Date	Personnel Contacted	Budget
PMA 240	1/26/77	Cmdr. J. Kiel	$241.9M FY77 $259.2M FY78

Component Equipment (GFE)	Unit Cost	Vendor	Notes
AQA-7 Acoustic Processor	$350K	Magnavox	2 per A/C
APS-115 Radar	$175K	Texas Inst.	
AAS-36 IR Detecting Set	$300K	Texas Inst.	
AWG-19 HARPOON FCS	$200K	McDonnell-Douglas	
ARS-3 Sonobuoy Reference Syst.	$135K	Cubic	
ALQ-78 ECM Set	$175K	Loral	
ARC-161 HF Radio	$ 90K	Collins	
ASQ-81 Magnetic Anomaly Detector	$ 60K	Texas Inst.	
ASA-70 Displays	$270K	Data Graphics	
ASN-84 Inertial Navigation	$210K	Kearfott	2 per A/C
ASQ-114 Computer	$350K	Univac	

Observations

1) 12 new P-3C aircraft are to be procured in FY77 and in FY78.
2) 50% to 60% of aircraft cost is estimated to be avionics,
3) In addition to the procurement of new P-3C aircraft for FY77 and FY78, there is an extensive modification program as shown below:

Modification	FY77	FY78
P-3B Navigation System Improvement Program	$12.6M	$21.7M
P-3B FLIR POD Modification	7.5M	14.3M
FLTSATCOM Airborne Terminal	3.9M	
TT/581/AG Teletypewriter Display	1.2M	1.9M
HARPOON Airborne Command & Launch System	9.6M	19.5M
Others	3.7M	1.4

A43 E-2C AIRCRAFT

The E-2C is a carrier-based airborne earlv warning/command and control system. Unit flyaway cost is about $24.4M. The prime contractor is Grumman.

Office Visited	Date	Personnel Contacted	Budget
PMA 231	1/20/77	Mr. C.L. Freeman	$157.3M in FY77
		Mr. G.P. Stewart	$194.3M in FY78

Component Equipment	Unit Cost	Vendor	Notes
ASN-92 CAINS		Litton	
APS-120 Radar		G.E.	Prior systems
APS-125 Radar		G.E.	New installations
ALR-59 EW Set		Litton	Passive Detection
ARC-158 UHF Radio		Collins	
ARQ-34 HF Radio		Collins	
APA-172 Control Indicator Group		Hazeltine	

Observations

1) PMA 231 places great emphasis on quality control and contracts for authority to inspect production lines of equipment it buys and to stop production if necessary to correct faulty procedures or workmanship.

2) Life cycle costs could be reduced by imposing rigid quality control and eliminating unrealistic specifications.

3) Modification programs for the E-26 amount to $14.9M in FY77 and $29.3 in FY78 and initial spares will cost $10.4M in FY77 and $2.05 in FY78.

A44/A45

A-6E/EA-6B AIRCRAFT

The A-6E is a carrier-based, all weather attack aircraft. A-6A aircraft are being converted to the A-6E configuration, which includes replacing the computer, weapons release system, and radar and incorporating the Target Recognition and Attack Multisensor (TRAM). The EA-6B is an advanced electronic warfare aircraft which provides protection to Navy strike aircraft by jamming enemy radar-controlled weapons. Unit cost of the EA-6B is about $19.3M. The prime contractor for the A-6 is Grumman.

Office Visited	Date	Personnel Contacted
PMA 234A	1/25/77	Mr. F. J. Boos Mr. J. Nemerow Cdr. R. McDivitt (EA-6B)

Component Equipment	Unit Cost	Vendor	Notes
AAS-33A Detecting & Ranging Set (TRAM)		Hughes	
ASQ-133/ASQ-155 CAINS		-	
APQ-148/APQ-156 Radar		Norden	
ALQ-126 EW Set		-	A-6E
ALQ-99 Tactical Jammer		Cutler-Hammer	EA-6B
EW POD Equipments		Raytheon	EA-6B. Wide Range of cost, 94 WRA's
Digital Display EA-6B		ACA	

Observations:

1) AAS-33A components are FAC Receiver, laser receiver/transmitter/rangefinder/designator, and IR receiver plus others.

2) AAS-33A uses germanium windows, which are high cost and currently not refurbishable.

3) Out of about $11M total A-6E aircraft costs, over $4M is for avionics.

A46 (LAMPS) DATA INFORMATION TRANSFER SYSTEM (DITS)

The DITS is the interface unit for the Light Airborne Multi-purpose System (LAMPS) avionics. Sensor signals and control signals come to the integrated logic unit, which functions not only as a central switching unit but also as the primary source of system tuning, protective interlocks and the main area for all audio processing, amplification and distribution. The estimated unit cost of DITS for the pre-production units is about $261K; it is expected that the production unit cost will be about $187K. The DITS are provided on a subcontract basis from TELEPHONICS, Huntington, N.Y., to the LAMPS prime contractor - IBM, Owego, N.Y.

Office Visited	Date	Personnel Contacted	Budget
PMA 266	1/27/77	Capt. J.K. Thomas	-
NAIR 533		Cmdr. John Hood	
		Mr. E. Stobie	

Component Equipment	Unit Cost	Vendor	Notes
Integrated Control Panel	-	-	
Integrated Logic Unit (ILU)	-	-	
Integrated Comm. Unit	-	-	
AYK-14 Computer (part of ILU)	-	CDC	

Observations:

1) Copies of the contractor specifications for DITS and also for the Navigation Interface Unit were obtained.

2) There will be 11 pre-production units of DITS, and the planned production buy is 200 units.

3) Two pre-production DITS units are now in Operational Test and Evaluation (OT&E).

M60 HARPOON (AGM-84A)

The HARPOON is an air/surface/sub-surface launched anti-ship cruise missile. It uses an active radar seeker, radar altimeter, and altitude reference assembly in conjunction with a small digital computer for missile guidance and control. The unit cost is about $279K. The prime contractor is McDonnell-Douglas, St. Louis, Mo.

Office Visited	Date	Personnel Contacted	Budget
PMA 258	1/20/77	Capt. P.L. Dudley	$178.3M FY77
		Mr. B. Remer	$188.1M FY78
		Mr. A.H. Daitch	

Contractor Visited	Date	Personnel Contacted
Texas Instruments, Dallas, Tex. (Seeker Assembly Manufacturer)	1/26/77	Mr. Michael Johns
		Mr. Gary Koster

Component Equipment	Unit Cost	Vendor	Notes
Seeker Assembly	-	Texas Inst.	
Radar Altimeter	-	Honeywell	
Mid-Course Guidance	-	IBM	
Warhead	-	NWS, China Lake	
J-402 Engine	-	Teledyne	
Booster	-	Aerojet General	
Data Processor	-	Westinghouse	
Shipboard Integration	-	Sperry	

Observations:

1) As part of a directed cost reduction program MCDAC has identified second source suppliers for almost all purchased parts and components, and also, has defined specific cost reduction projects.

2) In addition to the procurement budget shown above, funds for spare parts are $7.7M and $8.5M in FY78.

3) Cost percentage breakdown of missile hardware: Guidance, control, and airframe (GC&A) - 46%; other - 54%.*

4) Other costs as a percentage of missile hardware costs: procurement support - 25%; fleet support - 19%; modifications and spares - 11%.*

5) It uses a high degree of discrete components in manufacturing the HARPOON seeker assembly. This is considered cost effective compared to use of higher levels of integration with custom made chips.

6) Assembly of various seeker components is done manually with the aid of visual devices which identify insertion location. It has not proved feasible thus far to duplicate the dexterity of the operator in component insertion by a machine.

7) To increase yield and improve testing results TI has developed its own trimming machine for lead wires and is using increasingly greater automated testing earlier in the manufacturing process.

*Percentages in notes 3 and 4 derived from budget submission data for FY77.

M62/M61 STANDARD MISSILE MR/ER (RIM-66/67)

The Standard medium range (MR) and extended range (ER) missiles use semi-active homing guidance in destroying anti-aircraft, anti-ship, and anti-missile targets. Both are available in an SM-1 and SM-2 version.

The SM-2 version of the Standard MR is scheduled for use on Aegis destroyers. The SM-1 will be used with smaller ships that lock the uplink/downlink capability of the Aegis destroyers. The differences in the SM-2 version over the SM-1 for the Standard ER include longer range, mid-course guidance capability, strapdown inertial reference system, and ECCM improvements.

The prime contractor for the Standard missile in all configurations is General Dynamics, Pomona, Ca.

Office Visited	Date	Personnel Contacted	Budget
NSEA 6541B	1/7/77		MR \$43.4 FY77
			\$49.3 FY78
			ER \$45.8 FY77
			\$67.8 FY78

Contractor Visited	Date	Personnel Contacted
General Dynamics, Pomona	1/19/77	Dr. Marvin Abrams, Chief Adv. Mfg. Technology Mr. Wm. M. Leonard, Chief Mfg. Development Mr. G. D. Goldshine, Director of Mfg. Engineering

Observations:

1) In addition to the missile procurement data shown above, \$1.5M and \$.7M are budgeted in FY1977, respectively, for Standard MR and Standard ER initial spare parts. Corresponding totals for FY1978 are \$1.7M and \$3.6M.

2) Cost percentage breakdown of missile hardware: Guidance, Control, and Airframe (GC&A) - 88%; other - 12%.*

3) Other costs as a percentage of missile hardware costs: procurement support - 94%; fleet support - 25%; modifications and spares - 4%.*

4) Currently the SM-2 is being procured in small quantities for fleet evaluation.

5) The external configuration from previous generation missiles is virtually unchanged but increases in propulsion and warhead have substantially reduced the weight and volume allowance for electronics which the required capability has increased drastically. This has necessitated the introduction of microcircuitry. Current versions of the SM-2 are using hybrids since the space allocated for the warhead is not needed in test vehicles. New methods for producing microcircuits are being developed.

*Percentages in observations 3 and 4 derived from FY77 budget submission data.

M62/M61 STANDARD MISSILE MR/ER (RIM-66/67) - continued

6) A large-scale effort is underway to substitute plated plastic for metal microwave devices such as wave-guides, horns, antenna, etc. This effort is directed to decreasing cost and weight.

7) General Dynamics maintains an organized and active MT department.

M66 HARM(AGM-88)

The High-Speed Anti-Radiation Missile (HARM) is an air-to-surface missile designed to suppress or destroy land and sea based radars included in enemy air defense systems. HARM is a design evolution of current ARM weapons, SHRIKE and STANDARD ARM.

Office Visited	Date	Personnel Contacted	Budget
PMA242	1/24/77	Mr. Paul Kaschak	

Contractor Visited			
Texas Instruments, Dallas, Texas	1/25/77	Mr. Harold Wombel (Production Planning, Design-To-Cost) Mr. Bill Mitchel (Missile Development) Mr. Don McGuide (Manufacturing) Mr. Gary Kuster (Manufacturing Mgr.)	

Observations

1) Research and Development (R&D) funds are supporting the procurement of missiles for oeprational evaluation and testing (OPEVAL).

2) It is actively pursuing a cost reduction program for HARM. Examples of efforts include moving from discrete components to IC's, redesign of circuitry for streamlined assembly, and automation of testing.

3) It is developing test equipment that will permit each MWPCB to be tested individually rather than within a complete assembly.

4) The packaging density requirements of missile electronics, and most other military electronics, restrict the use of currently available automatic insertion machines. These machines are more suited to developing commercial electronics.

5) Increases in manufacturing costs are sometimes accepted with the view of lowering the overall cost of ownership to the Government. This has been done in the HARM program by using components subjected to rigorous testing (JAN TX) in the guidance head.

M67 TOMAHAWK-CRUISE MISSILE

The TOMAHAWK Cruise Missile Weapon System is designed as a long range cruise missile (nuclear armed land attack and conventionally anti-ship applications) sized to fit torpedo tubes and capable of being deployed from a variety of air, surface ship, submarine, and land platforms. The guidance system of the land attack version utilizes a terrain matching system, whereas the anti-ship version uses a modified HARPOON missile guidance system. The prime contractor for TOMAHAWK is General Dynamics Corporation.

Office Visited	Date	Personnel Contacted	Program Procurement Cost
NOP-92C	3/1/77	B. Protz	1,152.0M

Components	% Estimates of Missile Hardware Cost
Guidance, Control & Airframe	64.9
Propulsion	17.1
Booster	9.0
Warhead	1.1
Integration & Assembly	2.5
Engineering changes	5.4

Observations

A production decision has not yet been made for TOMAHAWK.

080

MK-48 TORPEDO

The MK-48 is a new, wire-guided torpedo for use in both the ASW and anti-ship role. Its unit cost in FY77 is $472K. The prime contractor is Gould.

Office Visited	Date	Personnel Contacted	Budget	
NSEA 662D1	1/6/77	Mr. R.L. Piere	$139.3M	FY77 WPN
		Mr. C. Peterson	$164.4M	FY78 WPN

Component Equipment	Unit Cost	Vendor	Notes
Command Control Unit	-	-	Average cost of
Guidance Control Unit	-	-	component modules
Gyro control	-	-	is about $30K
Power supply	-	-	
Receiver	-	-	
Transducer	-	-	

Observations

1) Homing control logic circuit boards are made by IBM, Owego, by labor intensive methods, and at same plant similar boards for commercial use are being made by advanced techniques.

2) Production rate and process control tolerances are the main determinants of the manufacturing processes used for any particular component.

081 PHALANX CLOSE-IN WEAPON SYSTEM (CIWS)

The Phalanx is a self-contained gun system for use in short range defense against aircraft and missiles which penetrate the area defenses. It provides autonomous search, detection, classification, acquisition, track, fire and target destruction in a unitized modular structure for fast, low-cost installation on a variety of ships. A high speed digital computer system provides for fully automatic operation but with operator override.

Office Visited	Date	Personnel Contacted
PM 20	1/13/77	Frank Wilczch

Contractor Visited		
General Dynamics, Pomona, Ca.	1/19/77	Mr. Bernie Chambers, Prg. Mgr.
		Mr. Bill Leonard, Chief, Mfg. Dev.
		Mr. G. D. Goldshine, Director, Mfg. Eng.
		Mr. Bob Hartley, Navy Plant Rep.

Observations:

1) The Phalanx has been under development for eight years, has undergone initial operational test and evaluation aboard ship. Currently it is in pre-production status. DSARC III is scheduled for 1st Quarter, FY78.

2) A build-up to a production rate of 7/month over 5 years is planned.

3) The projected US Navy buy is for 359. There will also be a NATO market and other Services may require variants.

4) The system is controlled by a local control panel but provision is made for a remote display and for a remote control panel.

5) Cost breakdown and MT recommendations have been provided.

INTEGRATED CIRCUITS

Integrated Circuits play a major role in the functioning of all military electronic equipments. They are also a major cost item. A major cost item in microelectronics is the packaging of integrated circuit chips. The ratio of cost of packaging to the cost of the chip varies inversely with the chip density. Cost to package,a low density chip may be four to five times the cost of the chip itself.

Revolutionary cost reductions for commercial electronics have taken place during the past five years through extensive use of large-scale integrated circuits (LSI) with thousands of active elements on each chip. The cost reductions in commercial electronics compared to those of military applications are largely attributable to the long-continued large volume production for the former as contrasted with the short run, limited quantity production characteristic of most military electronics procurement.

The economic incentives for more extensive use of LSI in military electronics are very strong. At least an order of magnitude reduction in power consumption, volume occupied, number of connectors, number of packages and failure rate can be expected whenever LSI can be substituted for the presently-used combinations of individual components, medium-scale integrated circuits and hybrids.

The following facts emerged concerning LSI chips and their utilization:

a) The high speed requirements of military equipment had led to the extensive use of MSI chips and SSI components mounted on circuit boards, sometimes grouped in hybrid structures.

b) Technology advances, reliability improvements and cost reductions achieved by LSI have appeared relatively recently, after many of today's prime DoD systems had already been designed. It is incumbent upon DoD resource managers to investigate means for adapting the military procurement process to secure the advantages in economy and reliability afforded by present day LSI commercial mass-produced devices.

c) LSI chips with clock speeds in excess of 10 MHZ with several hundred gates per chip have been recently developed by Raytheon for a variety of high speed digital data processing applications. Texas Instruments believes that similar performance with several thousand gates per chip can be achieved using I^2L technology although these are not yet available with clock speeds above 10 MHZ.

d) Manufacturers of MOS LSI chips are convinced that effective clock speeds in excess of 10 MHZ can readily be achieved, and that the high density achievable with that technology makes parallel processing and/or redundancy an attractive option. They foresee in the immediate future MOS memories with 45 manosecond access time and MOS microprocessors with clock speeds above 8 MHZ and with greater ease of manufacture than I^2L bipolars. They also foresee widespread use of ion implantation for precise geometrical control of impurity distribution in MOS devices.

e) Custom LSI chips have traditionally been less reliable and/or more expensive than mass-produced LSI chips.

Integrated Circuits, continued

f) One manufacturer was observed to use automated test equipment to evaluate each chip on a large silicon wafer prior to separation into identical chips, and also to use such equipment to test finished encapsulated devices.

g) The trend toward further miniaturization of circuit elements leading to higher densities on chips of the same area, and also a trend toward use of chips of larger area are both proceeding rapidly at present. Miniaturization confers the added advantage of higher speed without added power density. Electron beam and x-ray lithography for production of masks, and electron imaging of masks for device production lithography, are undergoing rapid development. These technologies permit higher densities than can be achieved with optical lithography. The results of all of these trends is the prospect of an enormous further increase of information processing capability per chip.

h) Bipolar gates tend to be faster than MOS gates because of the large ratio of transconductance to capacitance of bipolar transistors. One of the best technologies, LS TTL (Lowpower Shottky Transistor Transistor Logic) bipolar, is extensively used in present Navy systems, but in SSI,MSI or hybrid packages. The Navy should encourage application of the new techniques of miniaturization to LS TTL bipolar technology so that LSI packages of this technology can be available. Miniaturization is confidently predicted to increase speed even further while reducing power drain per gate in such a way that power dissipation per unit area remains constant, or under practical conditions may actually decrease.

i) The new I^2L technology appears to be a promising candidate for military electronic systems. Those who manufacture it advocate it strongly and confidently expect I^2L LSI chips soon to achieve clock speeds of 10 MHZ or more. Other manufacturers differ, claiming that production of such I^2LLSI chips of high speed has not yet been demonstrated and is much more difficult than MOS production.

j) There appears to be no conflict between the Standard Electronic Module (SEM) concept and the extensive use of LSI in Naval Electronic Systems. The modules become fewer in number and have fewer packages on each board, and require fewer interconnections. For maximum benefit, some new standard modules should be designed utilizing LSI, rather than attempting to subsume existing module internal functions in LSI keeping the module external functions unchanged, since otherwise the number of modules cannot be reduced.

The circuit architecture of LSI chips is a highly specialized and demanding art of which competent practitioners are in short supply.

Two manufacturers (INTEL and TI) offered to lend skilled designers to a Navy Working Group, if one were convened, to assist in appraisal of optimum application of the LSI art to any specific Navy electronic systems.

Integrated Circuits, continued

Visits	Date	Personnel Contacted
National Bureau of Standards, Gaithersburg, Md.	1/21/77	Mr. Martin H. Buehler, Electronic Technology Division Mr. George Harman, Electronics Technology Division Mr. Robert Hocken, Dept. of Automation (several other NBS staff members from the above Department)
Texas Instruments		Mr. Dean Toombs, Texas Instruments, Ft. Worth, Texas (contacted at ECOM meeting, Cherry Hill, N.J.)
INTEL Corporation Santa Clara, Ca.		Mr. Gordon Moore, President

TRAVELING WAVE TUBES

(1) Now and for the foreseeable future the TWT tube fills a unique military system need for broad band, high power microwave amplification. Despite the fact that the TWT is an old design (ca 1946), its manufacture is not mature. The reasons for this situation lie in the following:

a) TWT's have only a military market
b) TWT's are redesigned for each new application
c) No single military application uses a large number of TWT tubes
d) The volume of TWT sales is at the low end of the interest range of the electronics industry; consequently, only a few firms maintain capabilities and these have no motivation to upgrade.

(2) Opportunities for Navy MT funding include

a) Large volume (projected) TWT uses such as the mini-TWT and the disposable TWT
b) Production testing associated with automated assembly
c) Design for manufacture of integrated TWT's (power supply + tube envelopes) and improved packaging

(3) TWT manufacturers indicate the following, among others, as problems in tube manufacture:

a) Interface difficulties between the tube and power supply/modulator
b) Overspecification of tube requirements
c) Inadequate funding for R&D
d) Materials inadequacy

(4) Manufacturing yields of TWT's are low due to the delicacy of the art, the low volume, and the lack of in-process testing.

(5) Manufacturing of TWT's is labor intensive. Off-the-shelf manufacturing equipment is not yet available.

<u>Meetings</u>

Tri-Service Manufacturing Technology Meeting, Naval Electronics Laboratory Center, San Diego, California, January 27, 28, 1977 - See SAI MT 2007 for formal trip report and list of attendees.

Manufacturing Technology Advisory Group - Traveling Wave Tube (MTAG) Workshop, Dayton, Ohio 15-17 March 1977. Chaired by Dr. Larry Yarrington, Air Force Materials Laboratory, Manufacturing Technology Division, Wright-Patterson Air Force Base. Meeting attended by representatives from all three Services and from industry.

ROBOTICS

Robotics is the science of intelligent machine control of a tool or manipulator. Present day commercial industrial robotics are relatively unsophisticated in operation and not capable of easily programmable functions. Work at the National Bureau of Standards is being conducted on hierarchical control of industrial robots. This type of control permits a degree of responsiveness on the part of an automatic machine to its environment. This differs from the conventional mode of robot control wherein the robot functions as programmed, regardless of the consequences to itself or to the materials being handled.

Robots have proved cost effective in applications where they replace expensive operators but do not require a great amount of dexterity. Spot welding is an example of a typical robot application; assembly of small electronic equipment is not.

Visits	Date	Personnel Contacted
National Bureau of Standards Gaithersburg, Md.	1/26/77	Dr. J. Evans Dr. Frank Oettinger Dr. J. Albus Dr. B. Smith

Enclosure: Letter to William E. Bradley, dated March 15, 1977

Enclosure

UNITED STATES DEPARTMENT OF COMMERCE
National Bureau of Standards
Washington, D.C. 20234

March 15, 1977

Mr. William E. Bradley
Willow Hill Farm
P.O. Box 257, Route 2
New Hope Pennsylvania 18938

Dear Bill:

In our recent discussions concerning NBS capabilities in the areas of automation and technology for the manufacture of electronics, several items became clear.

First, there are three kinds of standards that are relevant to the production and use of electronics in DoD systems: standards on individual devices, standards on interfaces between weapons system components, and standards on interfaces between components of computer aided design and computer aided manufacturing systems used in the design and manufacture of electronic devices and systems.

The National Bureau of Standards represents a National resource with an on going program to develop standards, test methods, and performance specifications in those areas in excess of $4 million.

For example, NBS already provides test methods and standards for electronic devices under support from DARPA and all three services. Further, NBS will provide standards support for the new Air Force $75 million Integrated Computer Aided Manufacturing program. This capability can be used as a base for developing specific standards needed by the Navy.

In planning for a comprehensive 5 year program in electronics manufacturing technology, the Navy should evaluate the cost savings from standardization in both product and process technology and where standards, test methods, or performance measures are needed, should draw on the National Bureau of Standards for support.

A formal working arrangement between the Navy and NBS would allow the least cost development of the required standards for Navy use. In addition, the Navy should benefit from the coordination of the contacts that NBS maintains with all standards activities in both Government and the private sector.

Enclosure

Mr. William E. Bradley

We would be glad to review and comment on proposed plans and to provide any further information on NBS programs.

Sincerely,

John M Evans, Jr

John M. Evans, Jr.
Acting Manager
Office of Developmental Automation
and Control Technology, ICST

HIGH POWER LASER APPLICATIONS IN MANUFACTURING OF ELECTRONICS

The high powered laser is playing an increasingly more important role in the fabrication of electronics materials, components and subsystems. This parallels the earlier rise in the use of low power lasers in a wide variety of inspection and test situations.

There does not appear to be substantial psycological or economic resistance to the utilization of automated manufacturing technologies employing laser energy to perform material modification (cutting, trimming, scribing, welding, heat treating, bonding and piercing). Whereas individual instances can be found where apparently irrational judgements removed laser utilizing systems from contention, the opposite is more often the case. Frequently, the laser's mystique together with its potential for versatility and noncontact processing bring it into contention even when contradictory requirements weigh strongly against a laser system. In spite of the agonizing dearth of practical laser applications in the early years, it is possible that the very dramatic applications, successes in recent years have in fact contributed to an oversell.

The case histories of laser applications experiences in electronics and related manufacturing industries fall into the following categories:

(a) Has proven itself superior to other technologies and is now vigorously employed as the standard for the industry. Examples are resistor trimming, tuning of monolithic filters, piercing of wire-drawing dies, welding of electrical contacts, and balancing gyroscopes.

(b) A variation of the above concerns initially successful laser processing applications that quickly saturate the market and find only limited utilization. The laser scribing of ceramic substrates is an important example of this phenomenon.

(c) Cases where initial tests or production demonstrations are unimpressive or problemmatical and implementation is limited, spotty, or nonexistent. Examples are the scribing of semiconductors and the cutting of composites.

(d) Applications that appear to be in the offing in response to successful tests or demonstrations. Hermetically sealing battery welds and tagging mil spec qualified components are examples.

In the context of this review, there is very little to be said of (a) except that it exemplifies desirable responsive situations that are revealing principally in contrast to the less-successful cases. Similarly, (b) is of largely academic interest here in that the technology was successfully implemented, except that the field did not grow to expectations or a still more advanced manufacturing technology supplanted it. In the case of ceramic substrates manufacturing procedures were refined in dimensional control so that scribing was less often required. Hybrid circuit technology has not yet reached a volume requiring a substantial number of scribers.

Cases (c) and (d) are able to provide a revealing focus concerning both pitfalls and opportunities. Upon inspecting several manufacturing systems employing lasers and instances where processing was either proposed or attempted, it is evident that the same generalizations can be advanced.

A survey of the manufacturers of laser processing equipment (CRL, Korad, Apollo, Quantronix, ESI, and some individuals formerly involved with similar companies), was made. The issues of system reliability and laser/ material interaction are intertwined not only with technical and economic factors, but with political questions as well.

Laser processing systems in fact are often four to five times more costly than the systems they replace. However, when one customer switches to laser processing (silicon scribing for example) and obtains a better yield, greater versatility, freedom from tool wear, and less waste, other producers inevitably begin selecting laser equipment as well. The economic facts of life come into play at this point and the customer seeks to minimize his capital investment and new laser equipment producers spring into being to satisfy this desire for economical equipment (and exploit a new market at the same time). One result of this scenario is that people start bolting together the most economical lasers, positioners, optics, and computers without designing a well integrated system. Frequently, the user is disappointed then with reliability or performance or versatility. Events of this sort are inevitable in a free-enterprise society and may rectify themselves periodically with time. Some companies will perish, some will survive, and others will thrive. In the case of silicon scribing 2 firms were never able to penetrate the market despite repeated attempts. Two other firms shared it for awhile and now one is emerging as the principal supplier. At the same time the entry of the laser systems stimulated developments in conventional technologies and new diamond saws are making a strong comeback. It is not obvious whether Navy MT policies can assist with this type of evolutionary process in industry directly.

The other hinderance to the implementation of laser processing systems is concerned with laser effects. It was mentioned often in the survey that a national laboratory for applications research, laser effects studies or simply data collection and dissemination would be helpful to the electronic industry in selecting optimum processes. At present NASA appears to be a significant national resource in this regard. IBM and Western Electric generated substantial amounts of laser effects data internally for their own purposes. Unfortunately, there are two sides to the coin. There is no incentive or logical reason why IBM or Western Electric should give away data or processes that were developed in-house.

One useful and effective measure that could be taken would be to establish an Information Analysis Center for laser effects data that is generated through government contracts or published in the scientific literature. An example is the Nondestructive Testing Information Analysis Center operated for the U.S. Department of Defense by the Southwest Research Institute in San Antonio, Texas. When Navy procurements involve novel or advanced processing technologies it would be desirable to urge or require that the pertinent process data be submitted to such an Information Center.

SUMMARY

NAVY PROJECT OFFICE INTERVIEWS ON GENERAL SUBJECTS

1) The size of military electronic procurements and the uncertainties associated with procurement funding account for the following characteristics:

   a) The state of military technology generally follows rather than leads that of commercial electronics.

   b) Automation in manufacturing for Navy electronics procurement is inhibited.

   c) LSI utilization is often not cost effective.

   d) The procurement environment makes it risky for firms to attempt to modernize their processes (for example, by CAD/CAM). The ASPR has recently been changed to allow up to 1 percent more return for funds invested in capital equipment. Possible means for reducing risk rather than increasing the return on capital include multi-year funding and inclusion of capital indemnification clauses in case of contract termination.

2) Standardization and specification requirements have to be examined closely for cost-effectiveness. Each carries the possibility of cost savings but can also lead to otherwise avoidable costs. Attention has to be focussed on the following tradeoffs:

   a) Introducing standard hardware and modules to allow technological advances without unduly sacrificing interface capability, logistical advantages, etc.

   b) Implementing the standardization program in a way that the cost savings from standardization are not more than offset by restricting system design.

   c) Striking a balance between the amount of documentation required for sophisticated long support items and the documentation requirements and costs.

3) Cost analysis is conducted on an ad hoc basis by most of the offices interviewed in this study. The exception is NAVSEA 06H. EG&G does cost analysis for this office and has an extensive data bank of proprietary data. Examples of other costing activities include:

   a) NAVELEX 604B - cost analysis support to project managers, with primary emphasis on analyzing specific contracts.

   b) NAVELEX 5101 - analysis of acquisitions and value engineering proposals.

4) The program office interviews resulted in a list of management-oriented problems. These are neither unique to the Navy nor to electronics. Some, however, suggest certain obstacles that must be overcome if the objective of reduced electronics acquisition costs is to be achieved:

   a) The solutions to specific procurement problems too often become institutionalized.

   b) Government management offices tend to create counterpart operations in industry and contribute to program overhead.

   c) The number of separate offices which are associated with a major program is sometimes too great for effective control.

   d) The non-hardware cost of procurement programs has grown to the point where it can account for from 50 - 80 percent of total cost.

   e) The software costs associated with modern systems are high and are frequently grossly underestimated by engineers and project managers.

   f) Introduction of competition into procurement programs often does not result in savings to the Government.

Office Visited	Date	Personnel Contacted
NAVELEX 310	1/6/77	Mr. Irwin L. Smietan
NAVSEA 06H2	1/11/77	Mr. E. A. Landers
NAVELEX 5101	1/11/77	Mr. Otis Robinson Mr. Norman Horowitz
EG&G Hydrospace-Challenger, Inc. (contractor for NAVSEA 06H2)	1/12/77	Mr. Perry L. Shuman
NAVSEA 06H3B	1/14/77	Mr. Robert Morss Mr. S. Hienger

Appendix H

BIBLIOGRAPHY

INTRODUCTION

This appendix lists documents reviewed and found useful during this study. The list is limited to reports most readily available in published form. Documentation received during the course of the industrial interviews and various financial publications used as sources for system cost data are excluded. Included are the following:

- Military directives and instructions
- MT conference proceedings and reports
- Cost analysis studies
- Productivity analyses
- Miscellaneous publications pertinent to electronics.

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