Change in Submarine Sonar
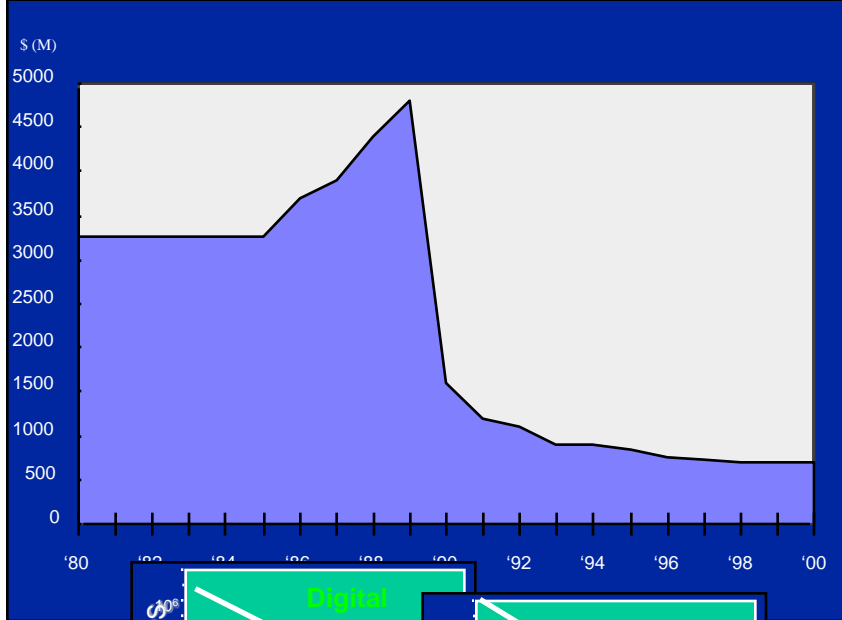
Bill Johnson

WMJ Associates LLC

wmj23@comcast.net
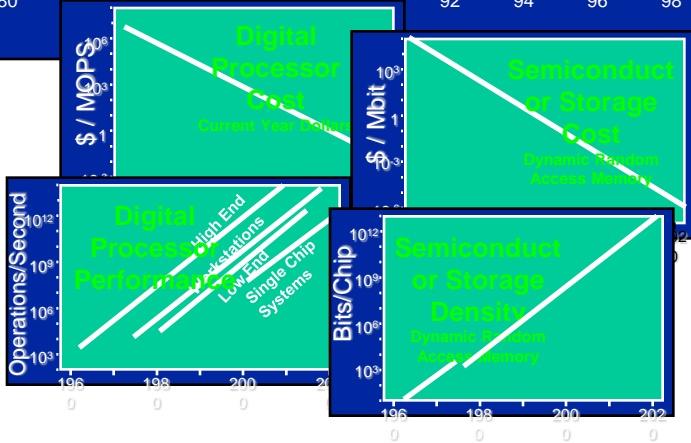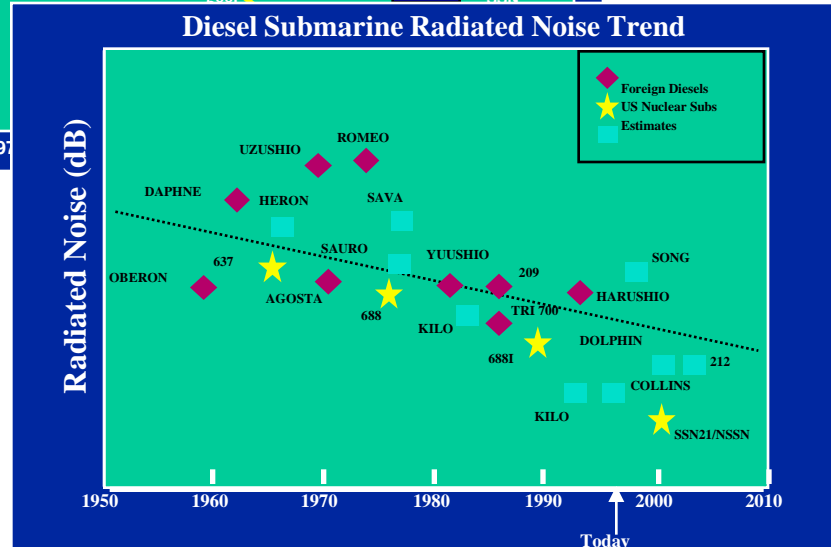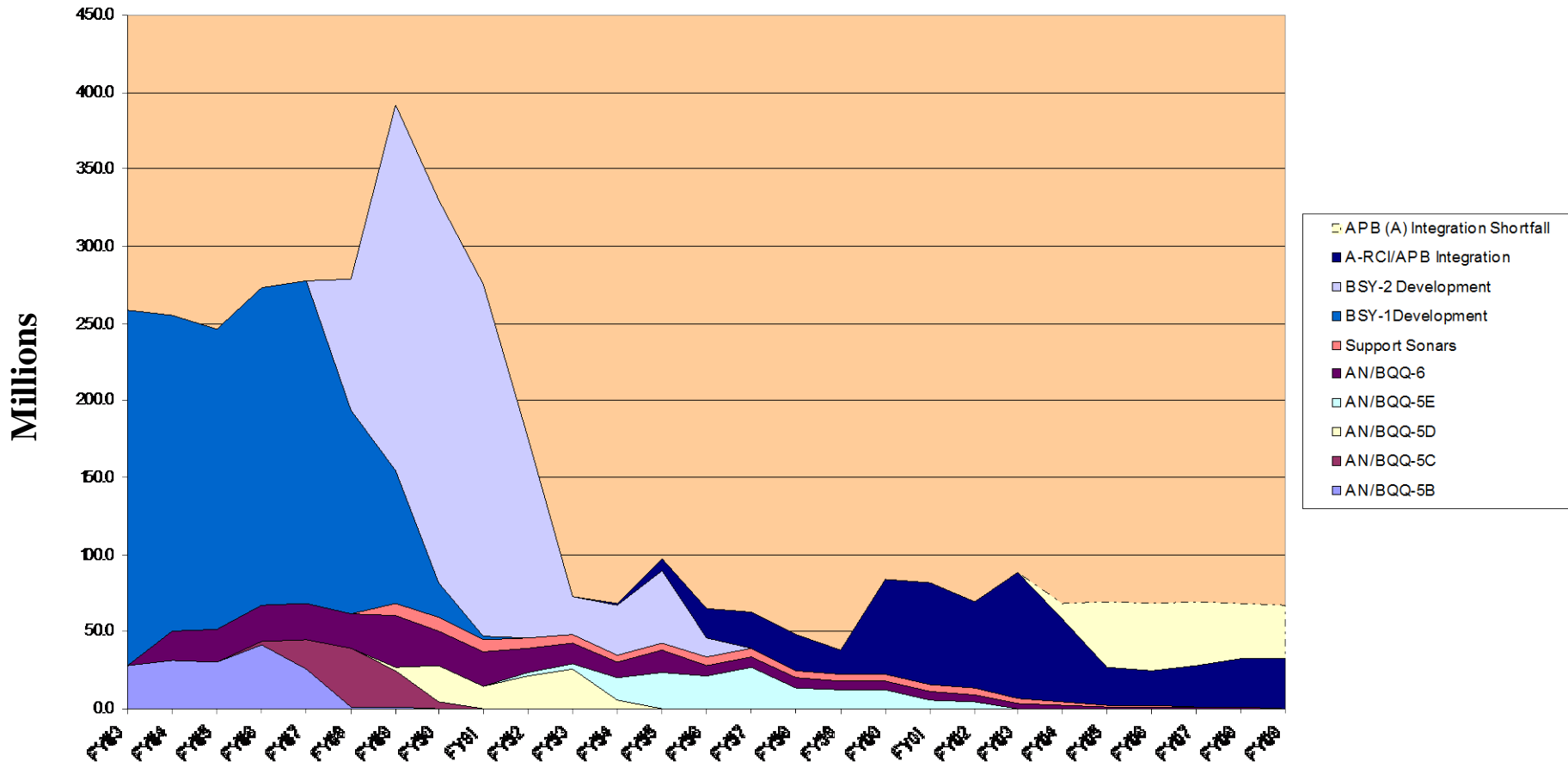
Fact of Life Challenges

SUBMARINE R&D

FSU/US Nuclear Stealth

Diesel Submarine Radiated Noise Trend

Sonar Development Funding

Less Funding – a Reality!

Findings: Systemic

- There is no "quick-fix" to the sonar problem.

- There is no focused technical management with detailed knowledge of (i.e. to the IUSS community) and responsibilities across submarine sonar system boundaries.

- Priorities in submarine sonar programs have been driven by a target rich environment toward highly integrated combat systems capable of handling multiple targets.

- There is a lack of innovative progress, which is always the result of experimentation and iteration (i.e. build-test-build)

  - Yet, in 18 months SURTASS built and fielded in operational prototype a complete twin-line array system and began testing in operationally significant littoral waters.

Evolutionary Sonar Improvement Program

- Establish and maintain a process to rapidly improve sonar system effectiveness with the following characteristics:
  - Evolutionary improvements through iteratively exploiting the lessons learned in a "build-test-build" program
  - Focus on at-sea experimentation and data analysis
  - Utilization of encounter data recorded in existing systems
  - Signal Processing Innovations
    - *Implementation via COTS insertion in open architecture*
    - *Developing and testing prototype systems in parallel to BSY-1/2 systems*
  - Fleet involvement in testing and improvement of prototypes
    - *Fielding limited numbers of prototypes in forward deployed submarines*
- Primary thrusts of this sonar improvement program are contained in the recommendations to follow

Acoustics Rapid COTS Insertion
A-RCI Objectives

- Achieve dB Gains Faster
- Deliver Additional Acoustic Improvements
- Make Improvements Applicable to all SSN 688, 688I, and SSBN 726 Class Submarines (and Not All Linked to TB-29)
- Implement COTS Based Open System
  - Increased Processing Capacity
  - Growth Potential
  - Reduced Cycle Time for Future Upgrades
  - Better return on Development Dollars
  - Space/Weight Reduction

Design to Meet these Objectives

Acoustics Rapid COTS Insertion Acquisition Strategy

- **Leverage, Leverage, Leverage**

- **Maximum use of COTS/NDI**

- **Institutionalize software Re-Use**

- **Pooled several standalone legacy system upgrades into single COTS-based development program**

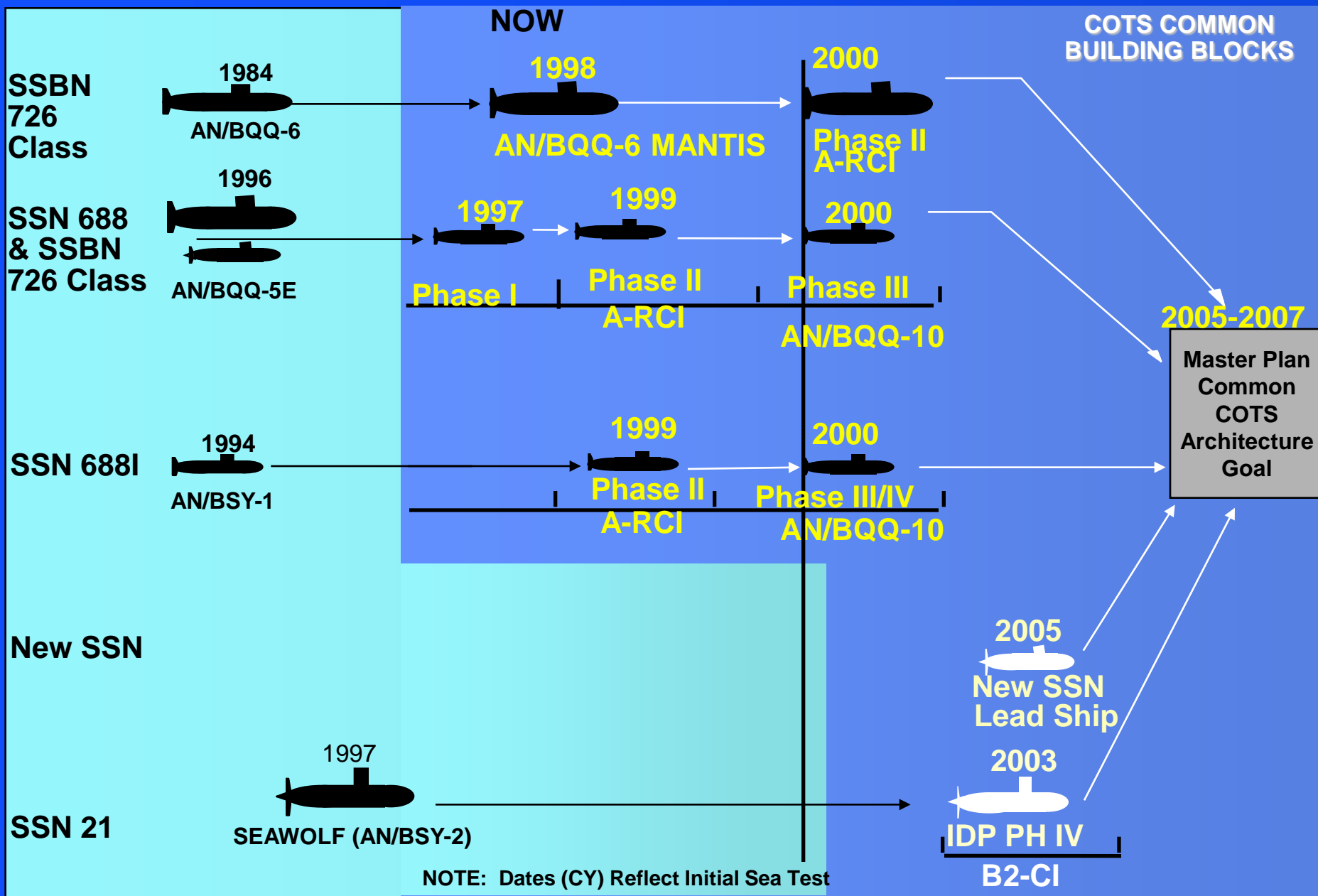- **Share talents and resources between Program Offices**

AN/BSY-1 ECP 1000 DEVELOPMENT SCHEDULE

	FY94	FY95	FY96	FY97	FY98	FY99	FY00	FY01	FY02	FY03
	O N D J F M A M J J A S	O N D J F M A M J J A S	O N D J F M A M J J A S	O N D J F M A M J J A S	O N D J F M A M J J A S	O N D J F M A M J J A S	O N D J F M A M J J A S	O N D J F M A M J J A S	O N D J F M A M J J A S	O N D J F M A M J J A S

ENGINEERING AND MANUFACTURING DEVELOPMENT

- 12 1 — MII AWARD (FY95)
- 7 — CDR (FY96)
- 5, 8 — MPP SYS INT TEST (FY96)
- 10 — PROG REVIEW; 2 — GFE (FY97)
- LRIP (FY00)
- 7, 12 2 — M-DEMO; SDCT/FCA (FY00)
- 10, 12 — GOVT CERT/PCA (FY00)
- 8, 2 — TECHEVAL; 5 6 — OPE VAL (FY01)
- 12 — MII (FY02)

PRODUCTION

- 2 — PROD AWARD (FY00)
- 2 — OPTION (FY01)
- 4 — OPTION (FY02)
- 4 — PROD AWARD; 12 — TO COMPLETE (FY03)

INSTALLATION

- 3, 7 — 4 MO INSTALL (SSN 755) (FY00)

AN/BSY-1 ECP 1000 DEVELOPMENT SCHEDULE WITH RCI

	FY94	FY95	FY96	FY97	FY98	FY99	FY00	FY01	FY02	FY03
	O N D J F M A M J J A S	O N D J F M A M J J A S	O N D J F M A M J J A S	O N D J F M A M J J A S	O N D J F M A M J J A S	O N D J F M A M J J A S	O N D J F M A M J J A S	O N D J F M A M J J A S	O N D J F M A M J J A S	O N D J F M A M J J A S

ENGINEERING AND MANUFACTURING DEVELOPMENT

- 12 1 — MII AWARD (FY95)
- 7 — CDR (FY96)
- 5, 8 — MPP SYS INT TEST (FY96)
- 10 — PROG REVIEW; 2 — GFE (FY97)
- RCI CERT START; 10 — RCI Int Test (FY97/FY98)
- LRIP (FY00)
- 7, 12 2 — M-DEMO; SDCT/FCA (FY00)
- 10, 12 — GOVT CERT/PCA (FY00)
- 8, 2 — TECHEVAL; 5 6 — OPE VAL (FY01)
- 12 — MII (FY02)

PRODUCTION

- 2 — RCI MPP Del (FY97)
- 2 — PROD AWARD (FY00)
- 2 — OPTION (FY01)
- 4 — OPTION (FY02)
- 4 — PROD AWARD; 12 — TO COMPLETE (FY03)

INSTALLATION

- 11 — RCI INSTALL TEST PLATFORM (FY98)
- 3, 7 — 4 MO INSTALL (SSN 755) (FY00)

Acoustic Master Plan

NOW

SSBN 726 Class

1984

AN/BQQ-6

1998

AN/BQQ-6 MANTIS

2000

**Phase II
A-RCI**

SSN 688 & SSBN 726 Class

1996

AN/BQQ-5E

1997

1999

2000

Phase I | **Phase II
A-RCI** | **Phase III
AN/BQQ-10**

2005-2007

Master Plan Common COTS Architecture Goal

SSN 688I

1994

AN/BSY-1

1999

**Phase II
A-RCI**

2000

**Phase III/IV
AN/BQQ-10**

New SSN

2005

**New SSN
Lead Ship**

2003

IDP PH IV

B2-CI

SSN 21

1997

SEAWOLF (AN/BSY-2)

NOTE: Dates (CY) Reflect Initial Sea Test

Submarine Sonar Axioms

1. Rapid COTS Insertion Means Just That.
2. Deliver Each Sensor's Full Theoretical Gain to the Operator:
   All Bearings, All Frequencies, All the Time.
3. Avoid Modifying Successful Commercial Products.
4. Use the Lessons Learned.
5. Use State of the Practice, not State of the Art; Tactical Sonar Systems are not a Beta Test Site.
6. Configuration Management, vice Configuration Control.
7. Software Reuse Is Key to Affordability!
8. No One Organization Has the Full Story.
9. Submarine Acoustic Superiority Depends on the Successful use of these axioms.
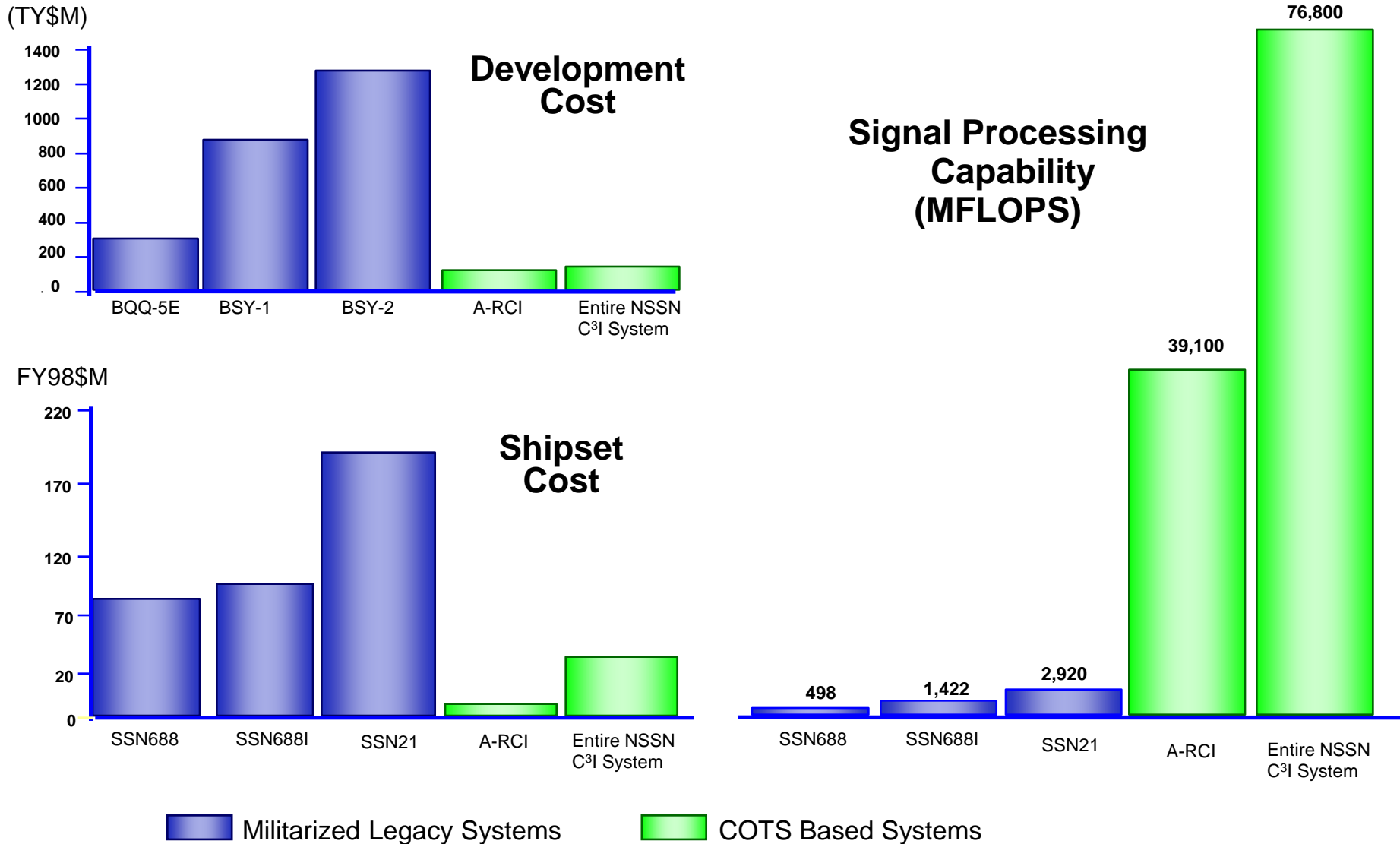
CAPT J. P. Jarabak, USN

CAPT G. L. Sieve, USN

Acoustics Rapid COTS Insertion Acquisition Reform Accomplishments

- **Increased early involvement of OPTEVFOR to Streamline Operational Testing**
- **Minimized Use of MIL-STDs**
  - » **Original ECP 1000 SOW contained 81 Military Unique Standards/Specifications**
    - ↻ **44 Eliminated**
    - ↻ **16 Replaced with Commercial Specifications**
    - ↻ **21 Retained as Guidance**
    - ↻ **A-RCI Eliminated 5 Additional, Added 3 as Guidance**
  - » **Original ECP 1000 PIDS contained 68 Military Unique Specifications**
    - ↻ **58 Eliminated**
    - ↻ **2 Replaced with Commercial Specifications**
    - ↻ **4 Retained as Guidance**
    - ↻ **4 Retained Mandatory (Waiver Granted)**
      - ↻ **Primarily Interface/Shock and Vibration**
    - ↻ **A-RCI added 12 as Guidance and added 8 Commercial Standards**
- **Formalized Integrated Product Teams**

Leverage the commercial sector
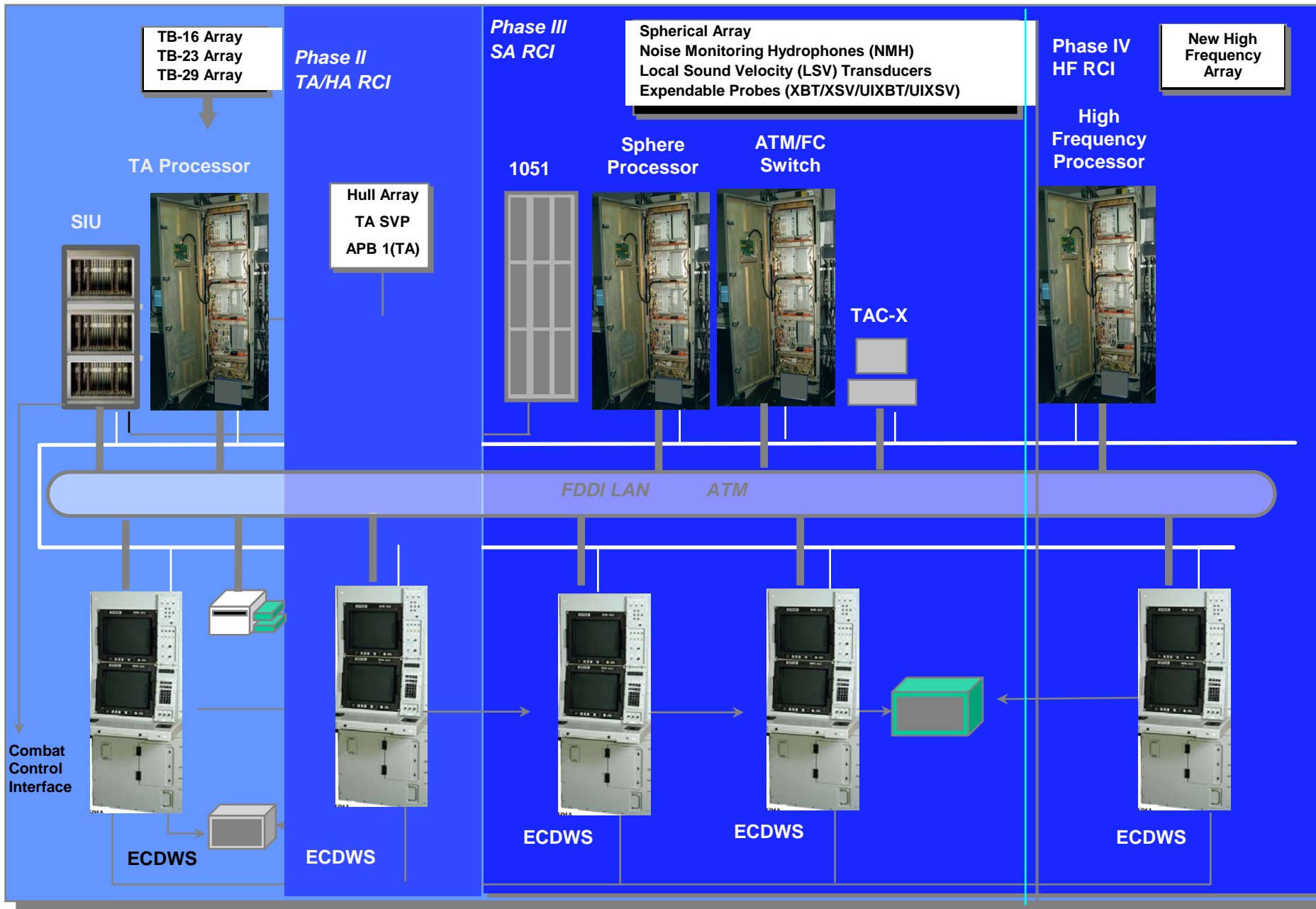
….make a place for small business

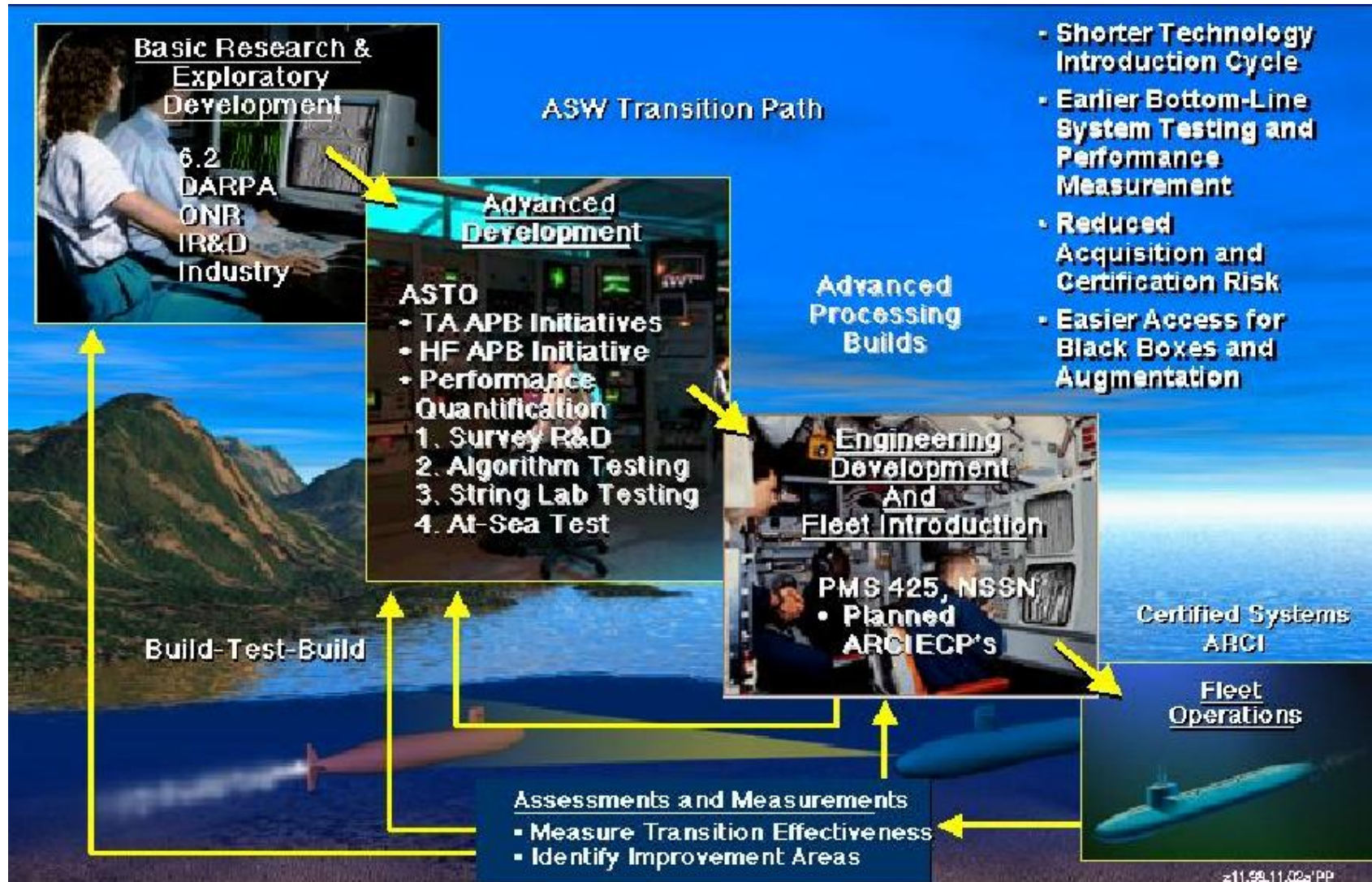# Submarine Combat System Cost - Reversing the Trend

Development Cost

(TY$M)

| 1400, 1200, 1000, 800, 600, 400, 200, 0 | BQQ-5E | BSY-1 | BSY-2 | A-RCI | Entire NSSN C^{3}I System |

Signal Processing Capability (MFLOPS)

76,800

39,100

498   1,422   2,920

SSN688   SSN688I   SSN21   A-RCI   Entire NSSN C^{3}I System

Shipset Cost

FY98$M

| 220, 170, 120, 70, 20, 0 | SSN688 | SSN688I | SSN21 | A-RCI | Entire NSSN C^{3}I System |

Militarized Legacy Systems   COTS Based Systems

Eat the Elephant

… just not in one Bite

A-RCI = AN/BQQ-10 IMPLEMENTATION + APB's

TB-16 Array
TB-23 Array
TB-29 Array

Phase II
TA/HA RCI

Phase III
SA RCI

Spherical Array
Noise Monitoring Hydrophones (NMH)
Local Sound Velocity (LSV) Transducers
Expendable Probes (XBT/XSV/UIXBT/UIXSV)

Phase IV
HF RCI

New High Frequency Array

TA Processor

Sphere Processor

ATM/FC Switch

High Frequency Processor

SIU

1051

Hull Array
TA SVP
APB 1(TA)

TAC-X

FDDI LAN   ATM

Combat Control Interface

ECDWS

ECDWS

ECDWS

ECDWS

ECDWS

Develop an Inclusive

… and Networked Community

Rapid Technology Transition Process

Stay in Synche!

Innovation is a team sport

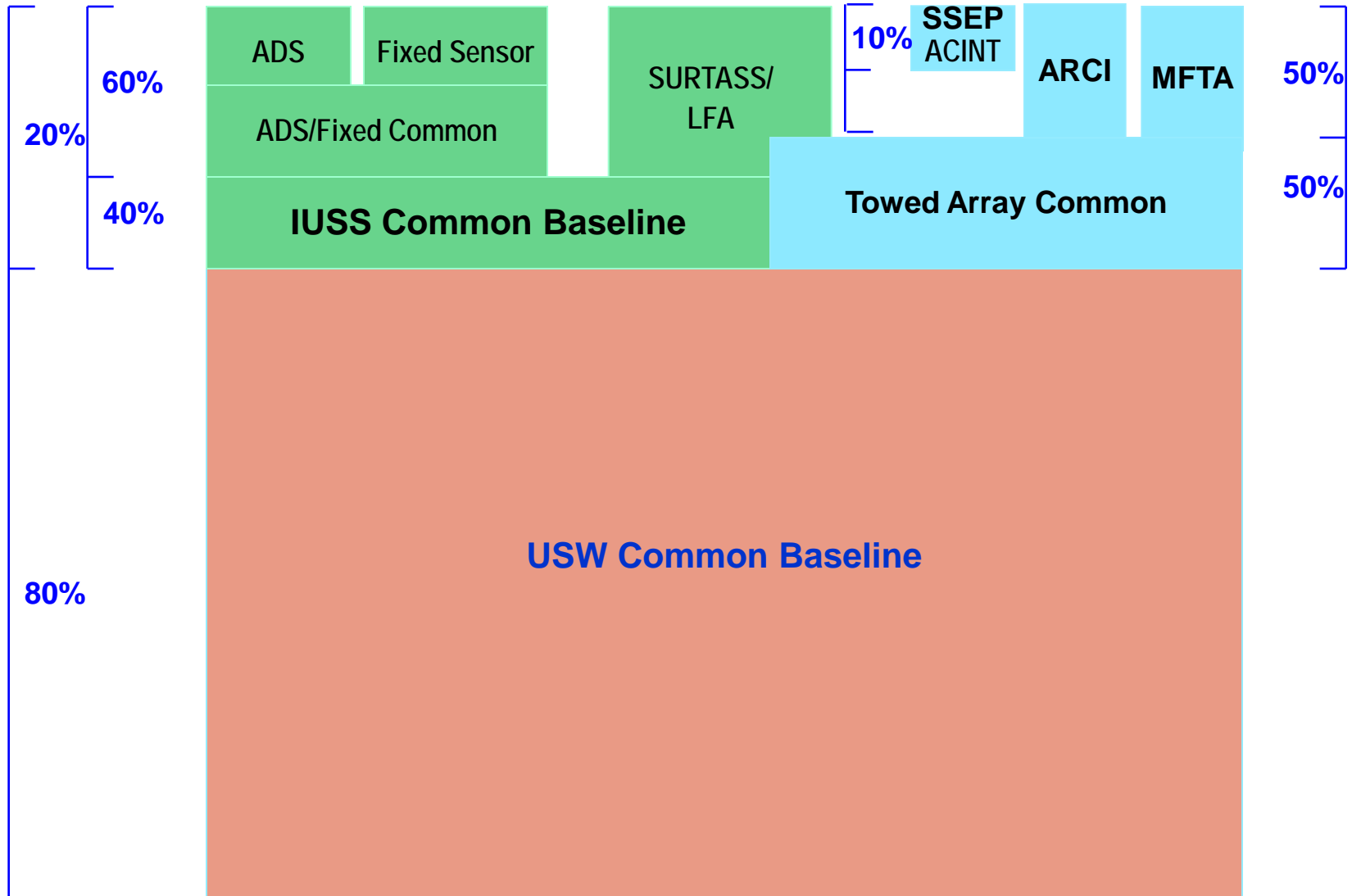# Strong User - Government/Lab - Contractor IPTs

SDWG

TAG/Fleet

DEVELOPMENT MANAGEMENT

- Sensor Optimization IPT (SOIPT)
- Near Term Working Group (NTWG)
- Tactical Integration Advisory Group (TIAG)

Significant User Involvement

Cooperative Support

FUNCTIONAL SUPPORT GROUPS

- Data Support Group (DataSG)
- Development Support Group (DevSG)
- Test, Evaluation, and Assessment Support Group (TEASG)
- Modeling and Prediction Support Group (MPSG)
- CONOPS and OMI Support Group (COSG)
- Training IPT

EXECUTION IPTs

- Towed Array APB-1/2
- Sphere Array
- Towed Array Wet-End
- High Frequency
- Active Classification
- SQQ-89 IPT
- IUSS
- Post Event Analysis Working Group

PEER REVIEW GROUPS

- Automation
- Signal Processing
- Parameter Estimation
- High Frequency
- Operator Feedback

Be an Enterprise!
…Collaborate & Share

A-RCI Software Commonality

Deliver Results

… Early and Often!

Demonstrated Performance Gains
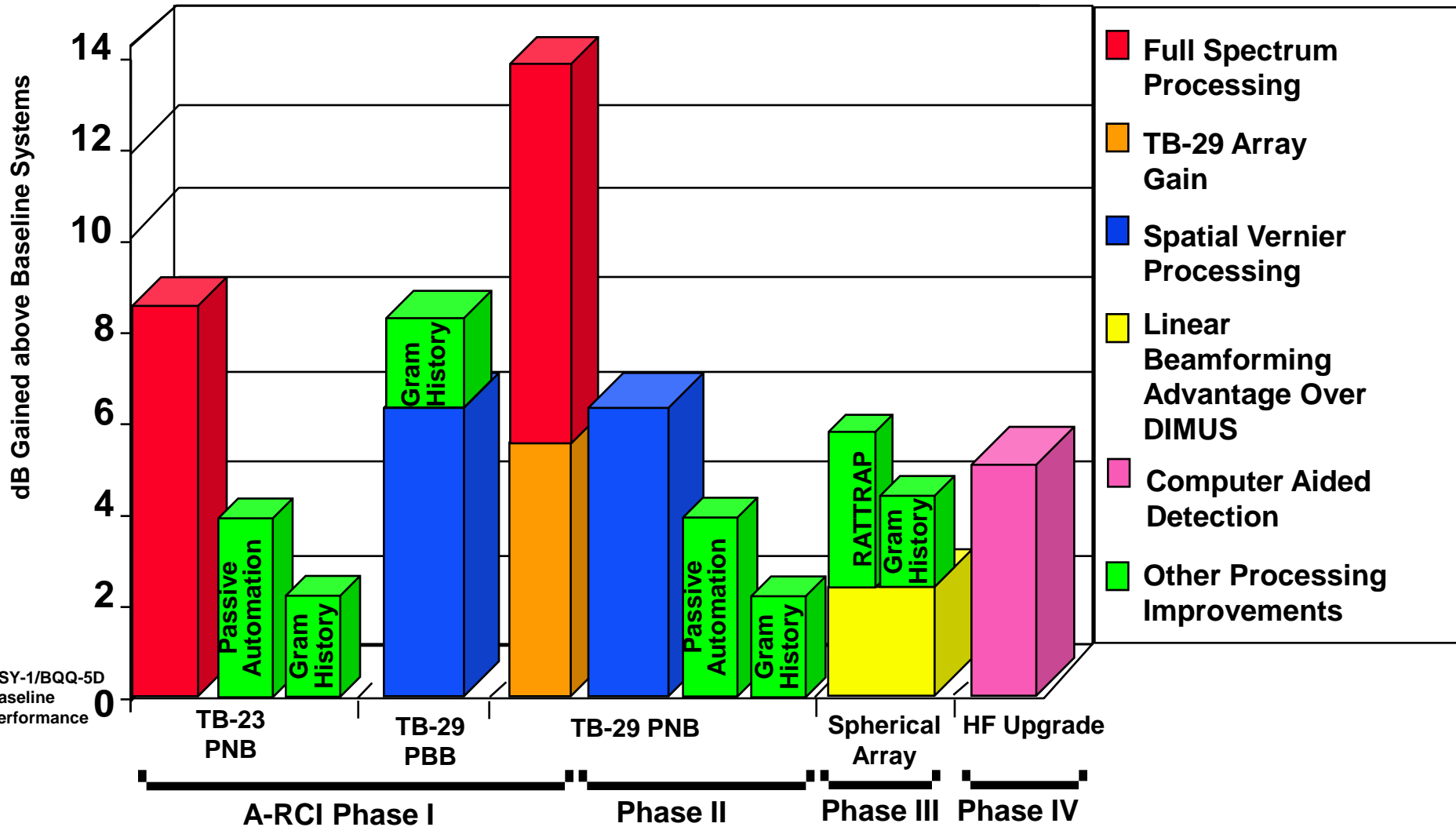
A-RCI Installation Profile (PR-03)

Legend:
- ■ Phase IV SSN 688I
- ■ Phase III SSN 688
- ■ Phase II SSBN
- ■ Phase II SSN
- ■ Phase I SSN
- ■ Phase III SSBN
- ■ SSGN Phase IV

Y-axis: # of Hulls (0 to 70)

X-axis quarters: 1st, 2nd, 3rd, 4th across fiscal years FY99, FY00, FY01, FY02, FY03, FY04, FY05, FY06, FY07, FY08, FY09, FY10

Riding Moore's Law

Processor Speed In MHz

- TI-02 : 2.4 GHz SMP APB 01-03
- TI-00 : 700MHz SMP APB 00-01
- TI-98 : 300Mhz VME APB 99-00
- TI-97 : 200Mhz VME APB 98

▲ Commercially Available
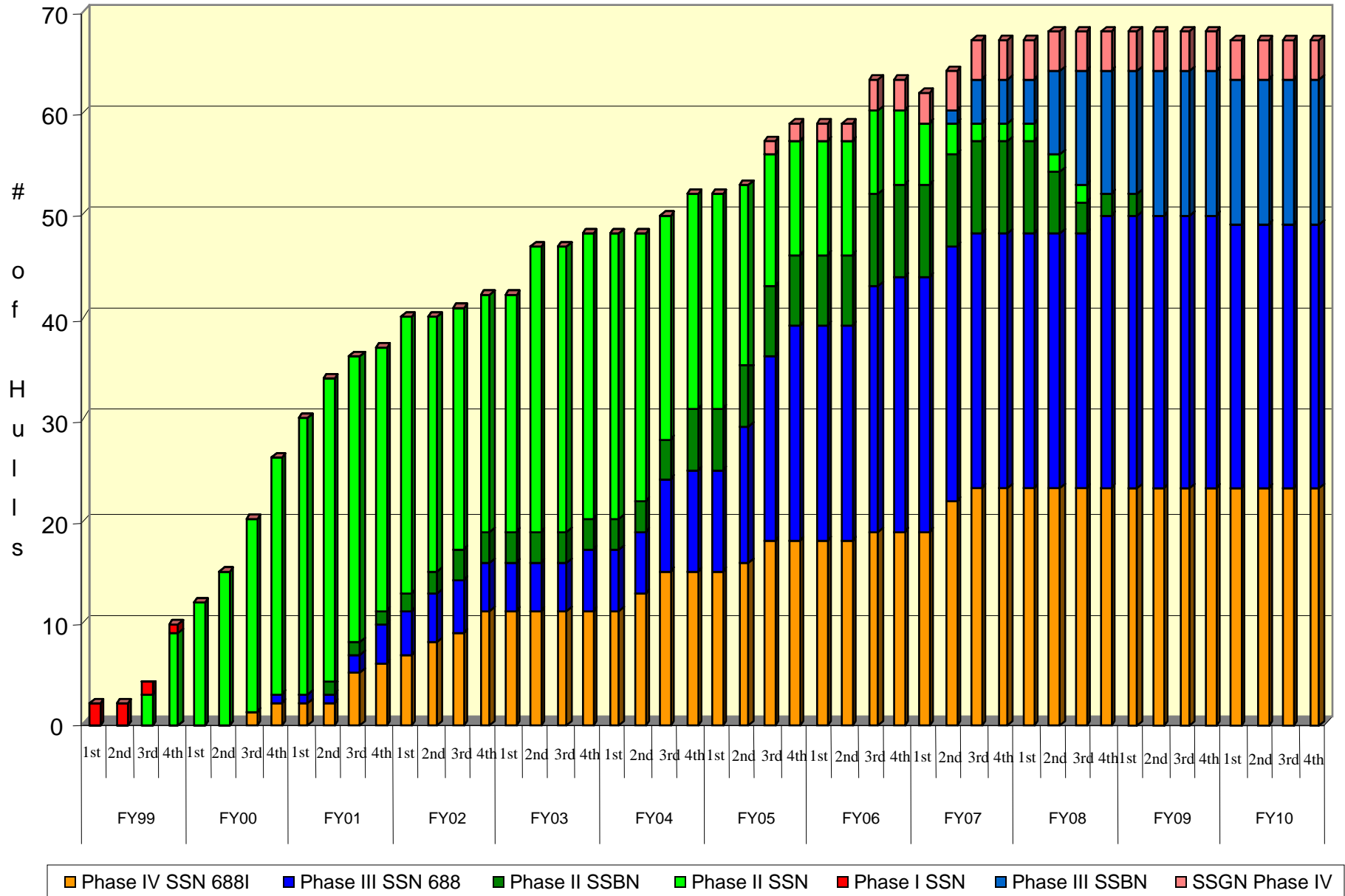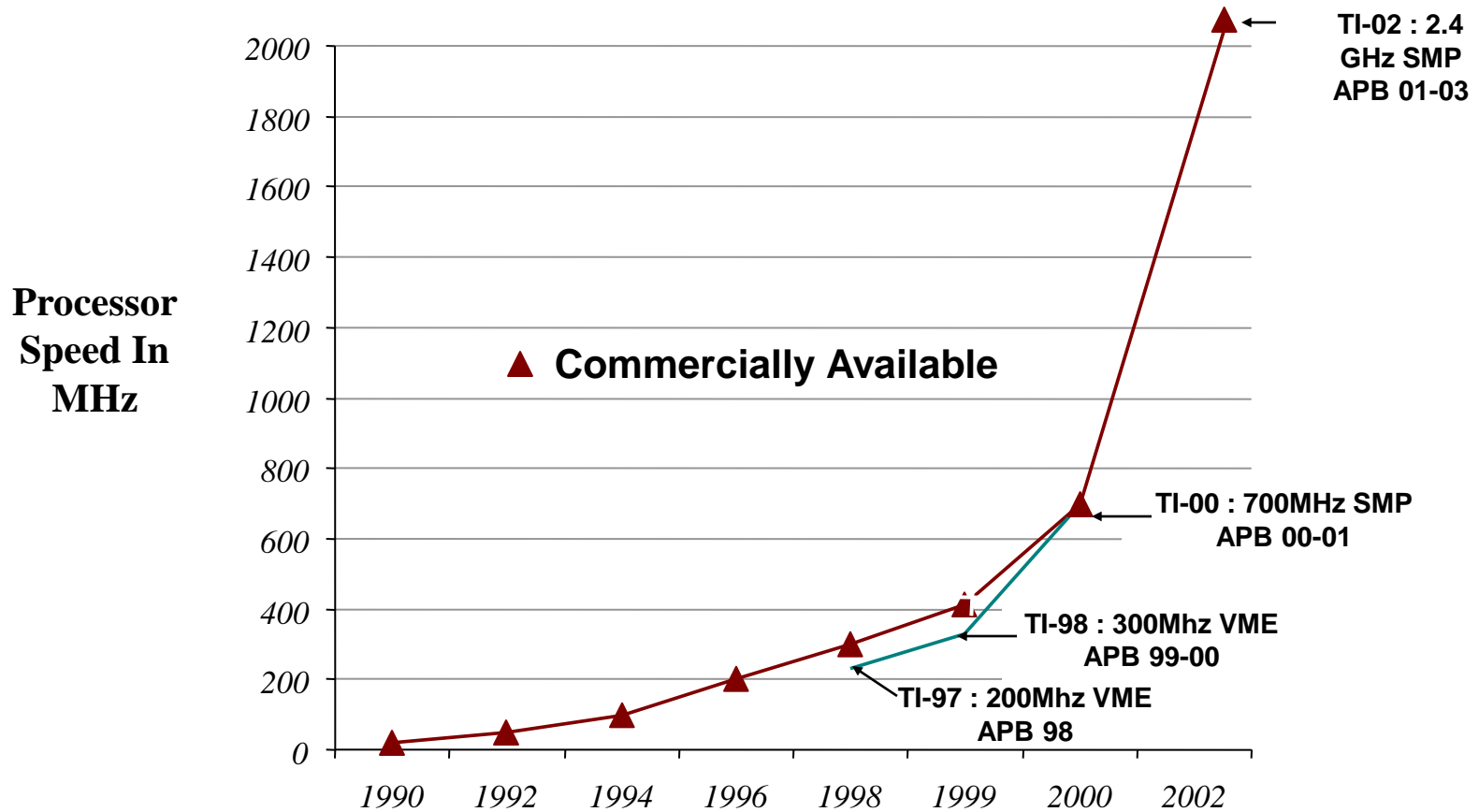
ARCI Pushing the Application of Commercial Technology Envelope

Net Allocatable Processing Capacity

Net System GFlops

$/Net GFlop
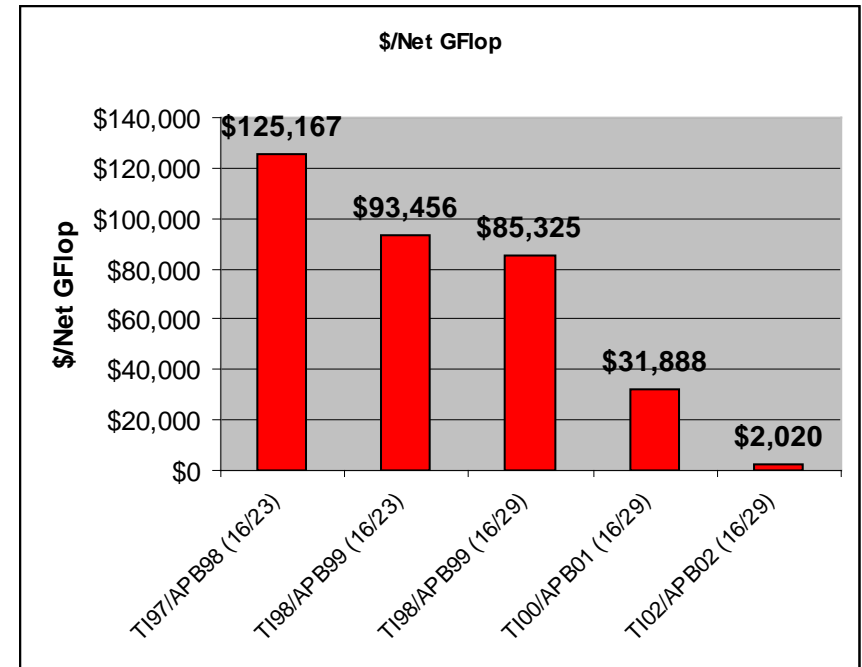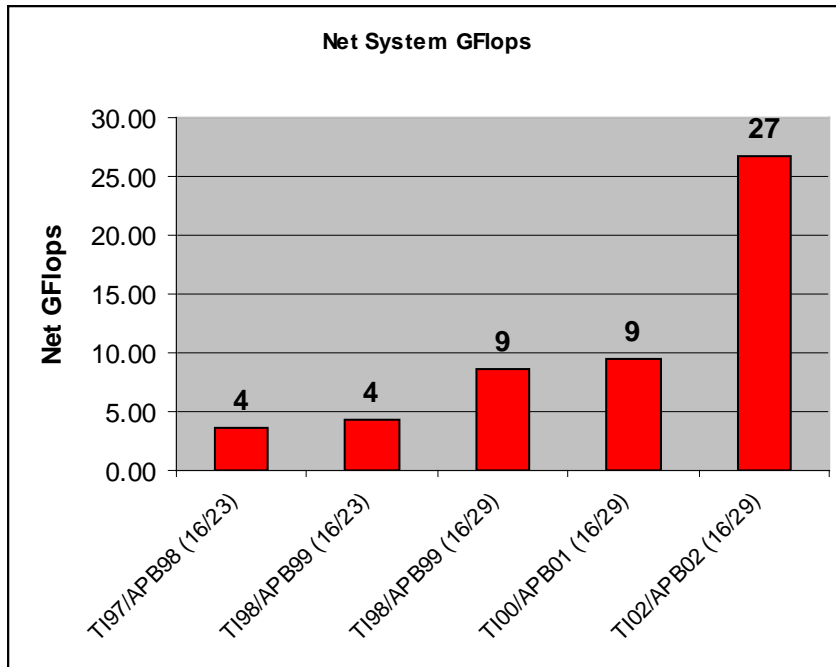
7x Increase In Real Processing From TI 97 to TI 02
60x Decrease In Real Processing Cost From TI 97 to TI 02

ARCI Processing Projection
With Technology Insertion

Y-axis: Throughput (GOPS), scale from 0 to 1,000

Phase I	Phase II TR96	Phase II Blk 2 TR98	Phase III/IV TR98	HF APB…. TR00	Future APBs TR02
Intel i860	200MHz PPC	300MHz PPC	300MHz PPC, SHARC	ALTIVEC PPC	ALTIVED+ PPC
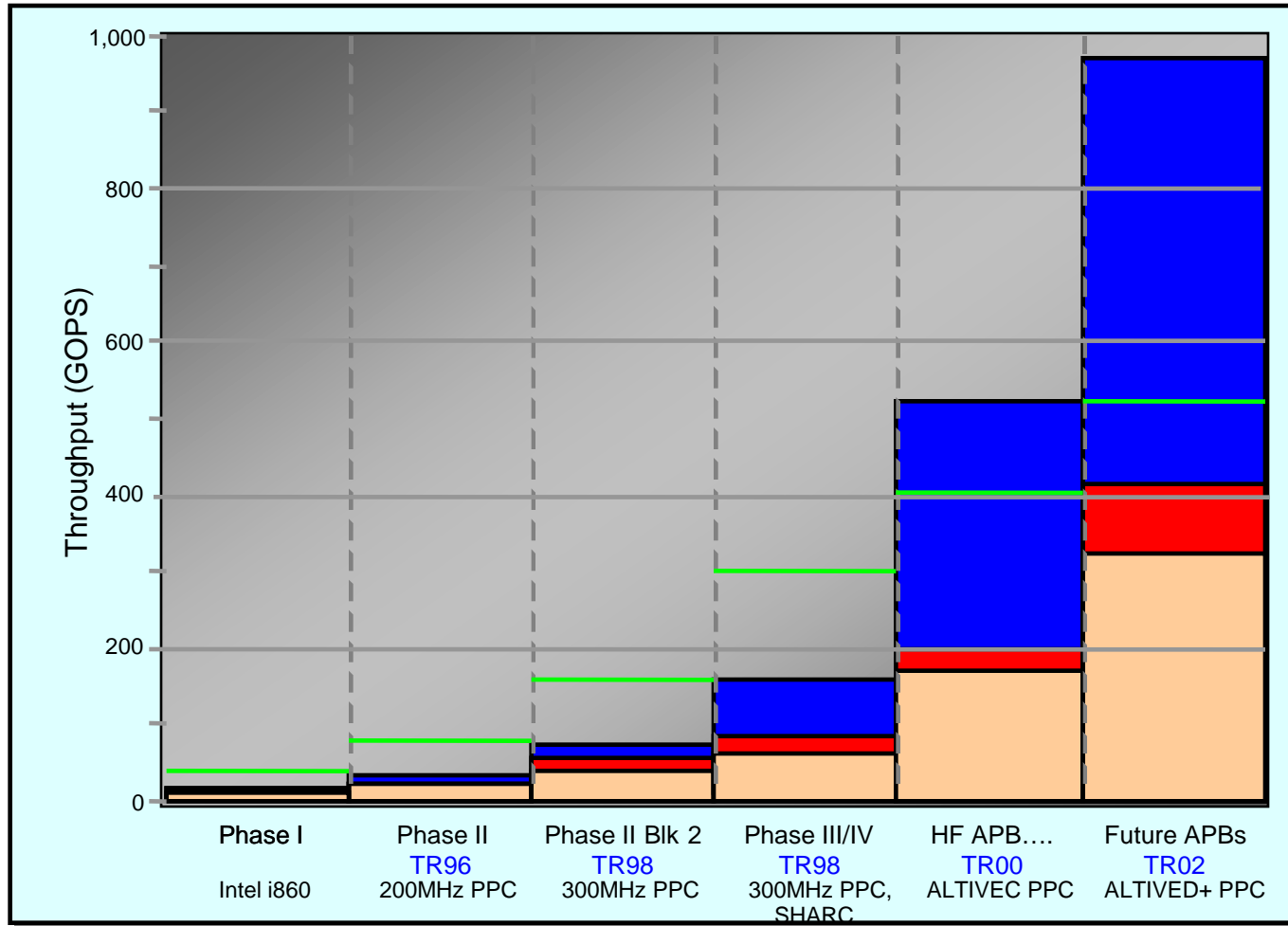
Legend:
- Utilized Processing Capacity
- Installed Capacity
- Fully Populated Capacity (Max drawers & cabinets)
- Latent Demand Estimate
- TRxx Technology Model Year

Towed Array Processing Performance Improvement Trend

	AN/BQQ-5	A-RCI/APB-98	A-RCI/APB-00
Mean Operator Detection Success Rate	**23%**	**49%**	**87%**
	Improved by a Factor of ~ 4		
Mean # of False Alarms Per Run	**1.0**	**0.92**	**0.58**
	False Alarms Reduced by 40%		
Mean Initial Detection & Classification Time (When Detection Occurred)	**Baseline**	**9 Min Earlier**	**27 Min Earlier**
	Improved by 27 Minutes		
Mean Contact Holding Time* (When Detection Occurred)	**Baseline**	**10 Min Longer**	**25 Min Longer**
	Improved by 25 Minutes*		

* Measured holding time limited by the length of recorded tape.

A system is more than

… hardware and software

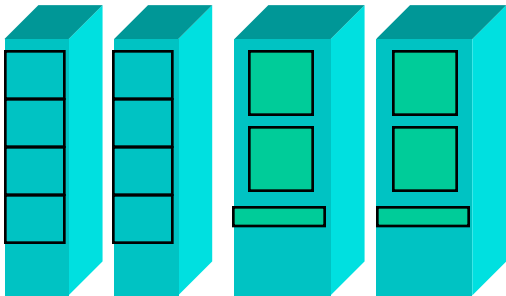# Changes to Logistics Support Products
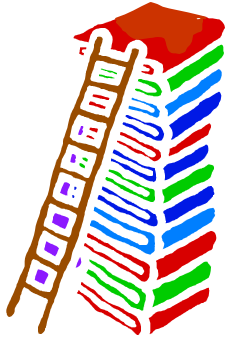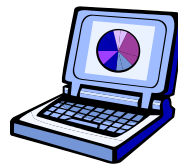
48 Volume
Paper Tech Manual
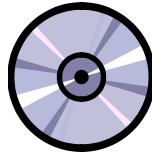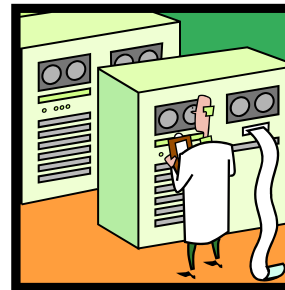
1 CD IETM

$600 Million
BSY-1 Inventory

Just-In-Time
Support

Tactical System
Maintenance Trainer

ICW

Complex
Component Change

A-RCI Component
Integration

New Products Have Smaller Logistics "Tail"

Realized Cost Avoidance for Logistics Support

$1+
Million

IETM
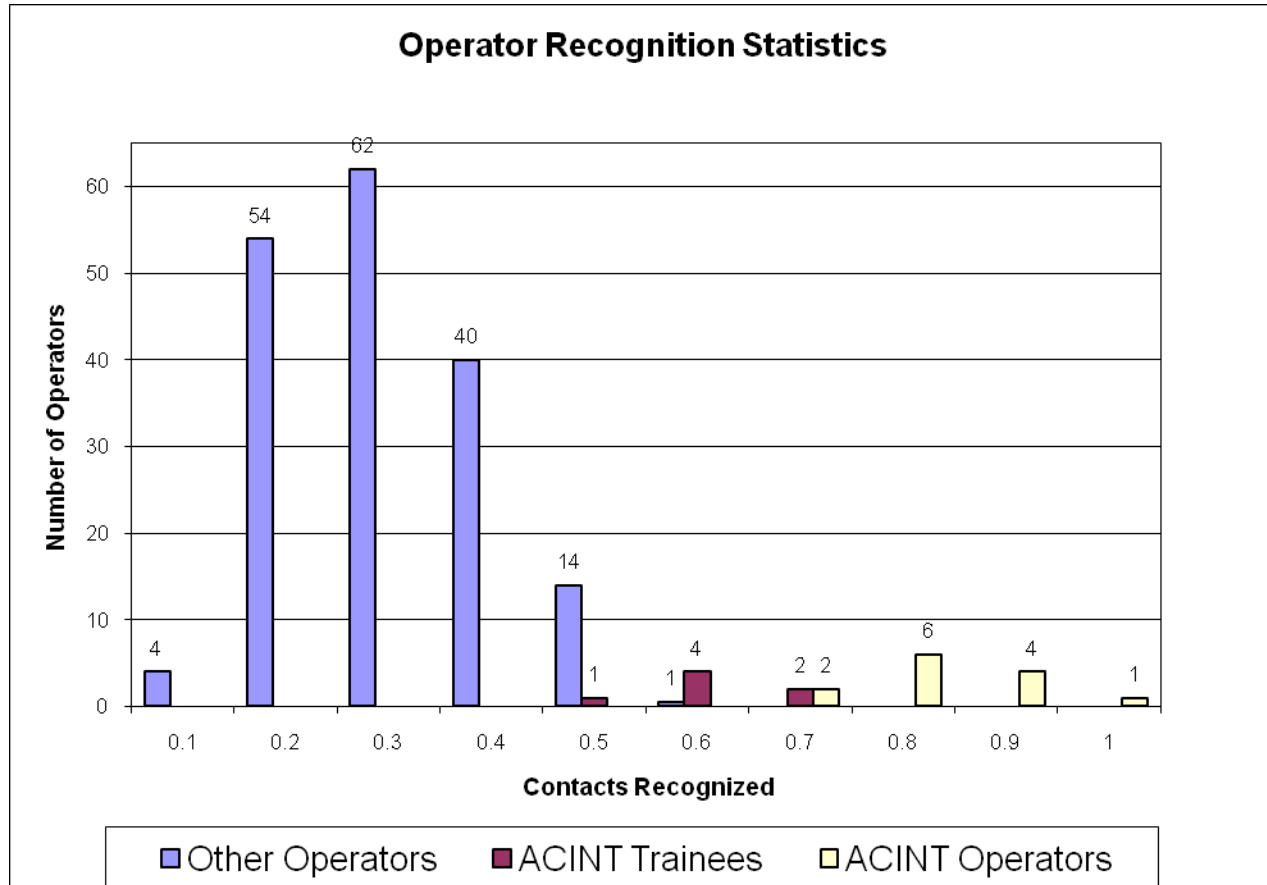
$2+
Million NWCF

Direct Vendor Delivery

$19
Million (est.)

Interactive Multimedia Instruction

$3
Million/Hull

Outfitting Spares Reduction

Don't forget the operator!

The Operator in the Loop

Operator Recognition Statistics

Operator Recognition of Contacts							
OPERATORS	**NUMBER OF OPERATORS**		**PERCENT OF CONTACTS RECOGNIZED**				
ACINT Operators	**13**		76%				
ACINT Trainees	**7**		57%				
Non-ACINT Operators	**174**		25%				

The business of "open acquisition" … is different.

Changed BUSINESS VISIONS

"Traditional" ➡ "Open"

"Traditional"	"Open"
• Deficient GFE	• *System Ownership*
• Meet the Spec	• *Build-Test-Build*
• Follower	• *Leader*
• Yesterday's Technology	• *Today's/Tomorrow's Technology*
• Competing Cost Centers	• *Teaming Cost Centers*
• Overruns	• *On Cost, On Schedule, Exceed Performance*
• Builds Computers	• *Packages/Interfaces Computers*
• Bureaucratic	• *Flat Organization*
• Inflexible	• *"Turn-on-a-Dime"*
• 6-8 Years Development	• *1-2 Years Development*
• Pieces & Stove Pipes	• *"End-to-End" View*
• To-The-Death Competition	• *Team w/Competition Day-to-Day*
• Re-Invent Wheel	• *Improve Wheel*
• Near Team Bottom Line	• *Long Range Success*
• In-Tune w/Spec	• *In-Tune w/Threat*
• Years of Experience	• *New Ideas*
• 6.5 Only	• *6.2 thru 6.5*

TOC Savings are Real!

Total Cost Savings

- Top Down Comparison of the Budget Allocations

  – 1983-1993 (Traditional Model) Budget Allocation Across SCN, OPN, O&MN, RDT&E, MilCon

  – 1996-2006 (A-RCI Model) Budget Allocation Across SCN, OPN, O&MN, RDT&E, MilCon

  - **$ 7,633,638,065** ← **2.1:1** Less Budget Allocated for COTS Based Submarine Acoustics → - **$ 3,613,920,085**

- Bottoms-Up Comparison from Contract Data and VAMOSC Database

  – 1983-1993 (Traditional Model) Development and Production

  – 1996-2006 (A-RCI Model) Development and Production

  - **$7,363,960,752** ← **6:1** Less Contract Dollars for COTS Based Submarine Acoustics → - **$1,243,396,610**

  – 2005 (Traditional Model) Operating and Support Costs

  – 2005 (A-RCI Model) Operating and Support Costs

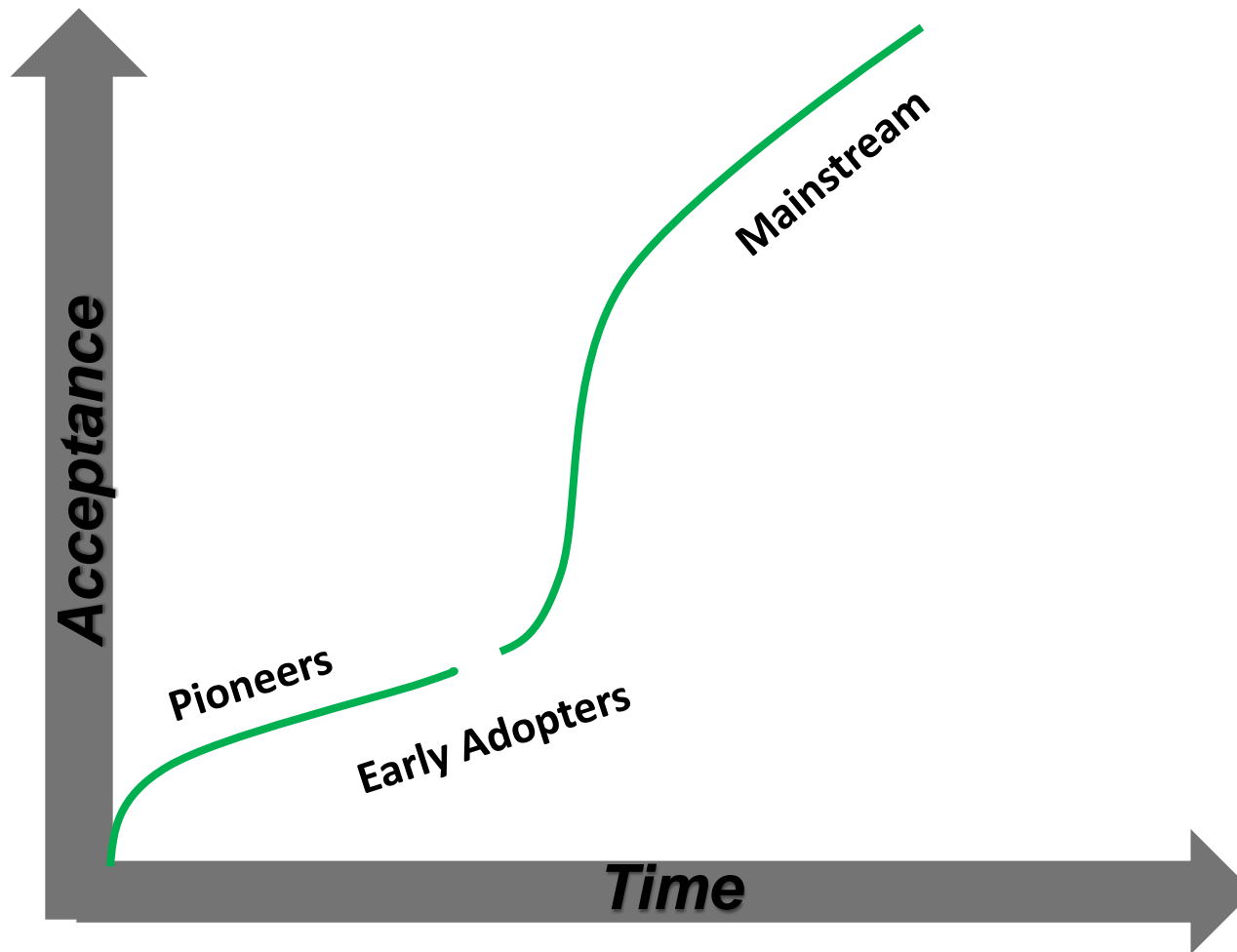 - **$482,779** ← **8:1** Less Operation and Support Dollars per Ship Year for COTS Based Submarine Acoustics → - **$61,177**

How "Open"

... is the Navy Today?

The "Culture Change" Problem

How to span the "Valley of Death"

- **Make the vision relevant to the warfighter.**

- **Establish incremental performance goals based on Fleet needs.**

- **Select leaders at all levels who can deal with uncertainty without losing sight of the vision – reward success**

- **Develop and cultivate allies at all levels – the strongest ally is the Fleet.**

- **Involve industry, especially "non-traditionals", in the formulation of strategies and architectures.**

- **Instill within the "Team" a sense of empowerment and entrepreneurial spirit.**

Commit and Be Accountable!

ARCI Chronology

- DEC 94 - MDA (VADM Sterner) approves plan for the AN/BSY-1 ECP 1000 program. At-sea fielding was planned for mid FY00 (approx 6 years later).

- SEP 95 - The Submarine Sonar Technology Panel "red team" reports their findings indicating serious acoustic superiority issues. Recommendations require radical transformation of SUB's approach to designing and fielding sonars.

- NOV 95 - ARCI concept briefed to SSTP and OPNAV (RADM Jones)

- APR 96 - OPNAV (RADM Jones) directs SUBs to implement ARCI

- JUN 96 - COMNAVSEA /MDA (VADM Sterner) approves ARCI plan

- NOV97 - PMS425 Certifies ARCI (Phase I) which is installed on AUGUSTA in Dec. (eg Q5E performance delivered to 688 in 18 months from MDA decision)

- JUN 2004 - 8 year anniversary of the ARCI MDA decision.   ARCI is installed on over 50 subs with at least 4 generations of hardware and software upgrades

MAN BATTLE STATIONS!
A-RCI HAS DETECTED YOU FOR ACOUSTIC SUPERIORITY.
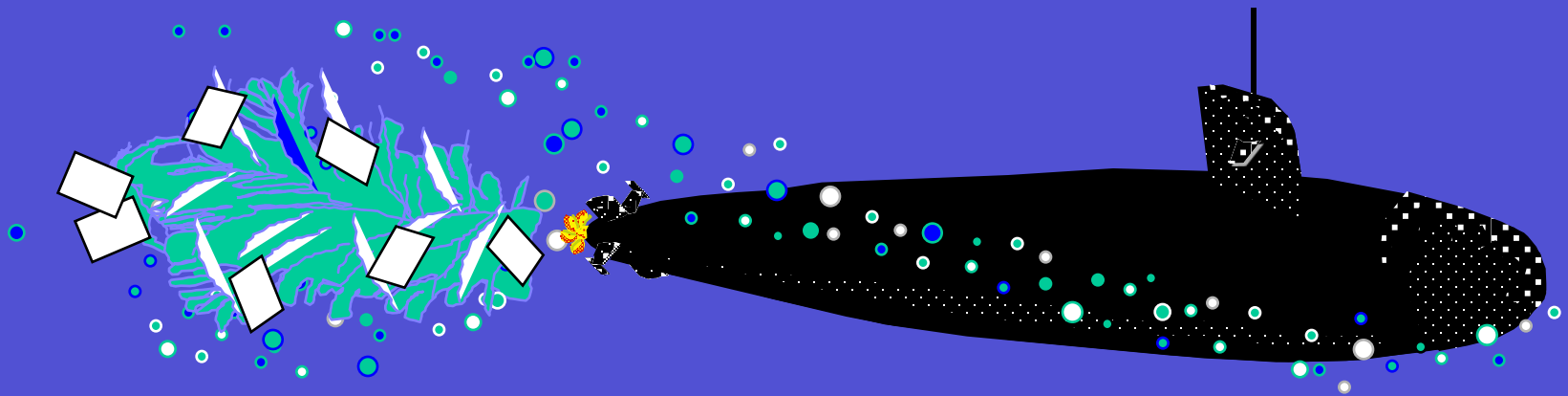
LEAD, FOLLOW OR GET OUT OF THE WAY!!!
A-RCI! EXPEDITE . . . NOW!