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The Copernic Pull
Jerry O. Tuttle

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The Copernican Pull

Jerry O. Tuttle

Vice Admiral Jerry O. Tuttle has been the Director of Space and Electronic Warfare since May 1989. His previous positions include: Director of Command, Control and Communications Systems, Joint Staff; Deputy and Chief of Staff for the Commander in Chief, U.S. Atlantic Fleet; Naval Inspector General; Deputy Director for Intelligence and External Affairs at the Defense Intelligence Agency; Special Assistant to the Chief of Naval Operations; Commander of Carrier Group EIGHT and Carrier Group TWO/Battle Force SIXTH Fleet; commanded the aircraft carrier USS John F. Kennedy *(CV-67); and several other commands. Vice Admiral Tuttle received a Communications Engineering degree from the Naval Postgraduate School, graduated with honors from the Naval War College, and received a master's degree in International Relations from George Washington University. Vice Admiral Tuttle has received many decorations including: the Defense Distinguished Service Medal; Distinguished Service Medal; Defense Superior Service Medal; Legion of Merit; and Distinguished Flying Cross. He also received AFCEAN of the year for his contributions to the Armed Forces Communications and Electronics Association, and was chosen as one of 1991 and 1992 Federal 100 by Federal Computer Week for his impact on government computer systems.*

Preface

Good afternoon. Thank you for that kind introduction and thank you — Tony — for inviting me. Tony is one of the few who has invited me back for a return engagement — an act that might bring into question his judgment. I'm excited and honored to be here at our nation's intellectual locus. And to be perfectly frank, a day's reprieve from the five-sided adult care center on the Potomac is always welcomed. I have about 25 minutes of prepared remarks, after which I will entertain your questions. I confidently predict and look forward to a stimulating and vigorous dialogue.

Since I last had the privilege of addressing this seminar — the world has changed in ways that were unfathomable to even the most prescient Harvard scholar. It is difficult even now to put these changes in perspective. Whether you look at it in terms of hurricanes and volcanoes or in terms of war and peace, the five years since I last spoke here have been remarkably turbulent and the world's landscape changed dramatically.

We have transitioned from the cold war to a new world *disorder*. Though the waters are choppy — we in Navy find these exciting times. We are steaming at flank speed — in white water — in a new domain — in a new universe. Naval leadership has provided us with a new vision of where the Navy/Marine Corps team is headed and how we will be employed. To borrow from an old nautical expression, "You can't change the direction of the wind, but you can change the set of your sails."

Our Navy/Marine Corps team is grappling with the reality that peace has broken out and that national priorities have changed. Economic security is *now* foremost in our national objectives and a military "build down" is manifested. A key element of this "build down" is the *joint consolidation* of *roles* and *missions.*

We have reforged our maritime strategy — crafted — and published our white paper "From the Sea." It is our new *pharos* — our new Navy/Marine Corps strategy.

This new strategy signals a striking change in our focus. We are migrating from a global threat — an open ocean paradigm to one centered on *regional challenges* and *opportunities* — concentrating on warfare near land and maneuver from the sea. This littoral focus aligns our forces with *low-intensity conflict — strategic deterrence* and *defense — forward presence — crisis response* — and *rapid reconstitution.*

There is no guarantee we will not soon feel the heat of adversarial competition in an ever increasing variety of conflict scenarios — *as challenging to our imaginations as to our resources.*

What has emerged from *all three* recent *technologies initiatives games* (TIGs) is the realization that *offensive space and electronic warfare* — which is one of the most important components of information or "cybernetic" warfare — has the potential to revolutionize warfare for the *information age* as profoundly as the inventions of the *rifled barrel* and the *machine gun* transformed warfare during the *industrial age.*

Offensive SEW constitutes an *attack* on the enemy's entire *information infrastructure* — civil as well as military. This concept attempts to separate hostile leaders from their followers and information resources even before hostilities begin. Decisions as to what enemy information resources to destroy and what to keep and exploit become tactical decisions that are part of the battle set.

Space and electronic warfare (*SEW*) is the ark that Navy has chosen to embark as we steam into the future. Join me now for a vista of *SEW* and a look into the future. Our focus is on the future of the Navy and on the Navy of the future.

The vision for space and electronic warfare is encapsulated and articulated in our slick "*SONATA*" — a sure cure for insomnia.

Like Beethoven, *SONATA* is a movement in three parts with recurring themes. Part one: "*WELTANSCHAUUNG*" — a German term for "global perspective" — is concerned with *surveillance* and *electronic combat.*

Part two is "Copernicus" — the C^4I architecture essential for *SEW*; and part three, "Croesus" is our programmatic strategy for fielding information systems — which we named after the *ancient Lydian king* — whose invention of money was a critical enabler for the rise of the Greek city states. *Croesus* is our investment strategy for providing the infrastructure to the architecture necessary for us to conduct *SEW.*

All four pillars of *Copernicus*: global information exchange systems (GLOBIXS), CINC command centers, tactical data information exchange systems (TADIXS), and tactical command centers, depend upon common: *communications, computer processing, displays,* and multilevel security technologies.

The strategic objective of *SEW* is to separate the enemy leader from his forces — to render him remote from his people, and to control his use of the electromagnetic spectra.

This objective dominates when our quarrel is not with the people but the enemy leadership — when it is highly desirable to limit damage — contain the conflict — and terminate quickly.

The despotic regimes likely to be our adversaries are characterized by centralized leadership — hierarchical command and control structure — and *control of the press and information infrastructure.* In the face of new technologies, these features — however modern and redundant — are vulnerable.

At sea, *SEW* is a dramatic new approach to warfare — combining *space, information management,* and *electronic warfare* under a single commander. It ensures maximum effective use of these assets by our forces while denying their use to adversaries.

To realize the potential of *SEW* we must field enabling technology. The following *potpourri* of enabling technologies are a few that we are currently concerned with.

In the early part of this century a technology expert announced that it was absurd to expect anything to come of the horseless carriage movement — *sixty years* later the *one millionth Ford* rolled off the assembly line.

The transistor was invented in 1948 — but was not used commercially for another 10 years. Yet — this year 10 million of them — hosted on chips — will be sold for each and every one of the 5.4 billion people on earth. The transistor is the most important development since man first chipped flint. If the automobile industry had progressed at the same pace as the microprocessor industry, you would be able to drive across country in three minutes — the car would cost two dollars and you would be able to fold it up and put it in your pocket when you got there.

We have ushered in a new era with the technology we have implemented — and continuously *stoke the coals of change* by technology insertion daily.

The amount of information in the world is *doubling every two years — 90 percent* of the international trade today is *information.* Ninety percent of the information a child born today will need to know when he/she enters college is unknown today.

Future information systems will reside far beyond the obvious — and be clearly unlike the common variety. We are thirsty for technology — because we hunger for knowledge.

We are in the information age — some say *information warfare.*

Clearly, we must have a vision — and a clearly defined path for achieving that vision. The question, "How can we implement technology to improve our warfighting capability?" — must determine our vision.

As we apply and insert new technology, we must be cautious not to place ourselves in a *technological cul-de-sac* that will preclude growth.

We must *understand the utility* of new technologies — and *understand* and *exploit* their improvement cycle. Our vision can *not* be based upon today's technology — but sagaciously *predict — lead* and *inspire* new technologies — continuously raising the crossbar of technology expectations.

We in space and electronic warfare find ourselves in an enviable position. We can save significant money by modernizing our C^4I systems — and simultaneously provide orders of magnitude improvements to information processing and transfer. We are surrounded with fascinating opportunities brilliantly disguised as unsolvable problems.

Navy's foremost communications technology requirement is for a wideband — multi-beam — electronically steerable — phased array antenna — that can access both commercial and *DOD* satellites in the C, Ku, *X*, UHF, SHF, and EHF bands — simultaneously — in different sectors of the sky.

Today we have an antenna forest on our ships — with more requirements abounding — e.g., video teleconferencing — high definition television, etc.

We introduced SHF SATCOM — *demand assigned, multiple access — DAMA* — with resounding success. It exceeded our most optimistic expectations and will result in an accelerated introduction of this exciting capability. It will effectively increase channel capacity by a factor of four. We are now busy getting our waveform accepted as the international standard.

We are making operational use of the EHF packages already in orbit and posturing for immediate exploitation of Milstar when it is launched — hopefully by September. Our UHF follow-on (UFO) satellite program will surge us toward a SATCOM *triumvirate.* Starting with the *fourth of ten UHF satellite* follow-on satellites — a parasite EHF package will be included — that uses the Milstar waveform. Our Milstar terminals met all requirements during opeval — then *wowed* observers during interoperability testing with the first Milstar bird. We have accelerated their purchase and will have all of them bought in four years.

As a precursor to future joint Milstar networks, we're using a developmental EHF package on FLTSAT 7 — and an *EHF* shore terminal at the Navy Research and Development Center (NRAD) to provide the third fleet commander *EHF SATCOM* connectivity with the integrated services digital network from SEA.

By December, we'll have *EHF* operational in 14 surface ships — three submarines — and Navy computer and telecommunications area master stations — LANT and EASTPAC — accessing the one up-and-operating Milstar bird.

Video teleconferencing between shore sites and carrier using a commercial satellite has been demonstrated. We will make ever increasing use of commercial satellites, particularly those that no longer have commercial value because of fuel exhaustion — they move but we can track them.

We intend to take *high definition television* to sea this year. For *high definition television,* we will need *14 times* the bandwidth necessary for video teleconferencing — or 20 Mbps. As high definition television is digital, we can compress it and conserve bandwidth. We are posturing to take advantage of its high resolution and high definition for bomb damage assessment. Also, I want to field HDTV in *this* country — create 100,000 jobs — establish the international standard, and *export* something for a change.

We will accelerate the flow of sanitized — tactically useful information to the warfighter and craft a *space architecture* for *Navy global environmental data system* that will:

- Fully integrate the *Tactical Environmental Support System — TESS* — into our every planning enterprise.
- And develop an integrated tactical environmental system that, one — can access ashore databases and "pull" desired information — and, two — can fuse oceanographic/weather data overlaid on desired topography.

We will put radio rooms and even master communications stations into a 19 inch rack. Our *automation net control center* (ANCC) that resides in two 19 inch racks has replaced a tech control facility that occupied a 37 by 95 foot space — took 130 people to operate and is the first one in DOD.

We will field other ANCCs around the world — so their dynamic and automatic circuit loading amongst adjacent communications stations can occur and *Navy computer* and *telecommunication's headquarters* can maintain a continual awareness of its global telecommunications network health and welfare.

We have flank speed rung up to introduce omnipurpose — common power supply and common bus systems to allow the reduction of stand-alone radios — modems, multiplexers, crypto-devices, etc., down to a single card. These cards will be installed in a chassis that provides power, cooling, input/output interfaces and controls.

A two-foot high 19 inch *VME* chassis will host up to 18 cards, enabling it to replace racks of equipment with the attendant big savings in weight, heat generation, and power consumption.

This approach will permit simpler and far more cost effective technology insertion and will soon be fielded in *high speed fleet broadcast — tactical receive equipment (TRE)* — and *improved Link-11 systems*. Today, a VME-scalable chassis — tomorrow one with a *futurebus-plus* backplane that will be backward compatible and interoperable — next week *ATM* protocols residing on single mode *SONET* fiber optics.

New, significant improvements to our new tactical information exchange system will provide — OTH-T information via TADIXs to cruise missile ships and submarines — an added OTCIXs DAMA capability — increased gateway message storage — and satellite loading reduction.

However, the real revolution in Navy communications is its change from an "inert" support technology — dedicated to a specific user — to a *dynamic, adaptive, shared asset* — capable of supporting a wide range of users.

SHF modems used in exercise tandem thrust 92 permitted limited dynamic bandwidth reallocation and provided a glimpse into the future of what our *communications support system* will bring to the altar — *CSS* will provide *virtual networks* with variable bandwidth over the full *SATCOM* frequency spectra.

Exercise *TANDEM THRUST* 92 demonstrated for the first time that the *Joint Task Force* commander can be embarked. Some of the services that enabled him to do so include:

- Connectivity at four times the previous rate.
- The ability to "pull" the *air tasking order* (ATO) direct from Air Force computer ashore — make modifications to the *ATO* on-line and interact with its building and dissemination.
- STU-III telephones permitting global secure voice. We had three in the flag ship last year. We will soon have 100 — eventually 1,000.
- Secondary imagery distribution with *Joint Intelligence Centers.*
- A *prototype imagery exchange system* (PIXS) that permitted the *operator* to *review available imagery* — determine what imagery he needed — and then to request only that imagery he wanted to be transmitted — truly Copernican — user pull.
- And *voice, video, fax,* and *data* (VVFD) terminals that provided a multi-media command coordination and conferencing capability.

We have completed a global *CNO defense data network* for all flag officers, whereby the *CNO* and his entire wardroom can exchange communications. This capability will be expanded to include all officers — and eventually to every Navy member.

We have revolutionized how we acquire microprocessors — or engines — that serve as our personal computers — workstations — communications and data file servers. Our computing engine — the TAC-3 — has enabled us to perform feats that we once could only dream.

The TAC-3 contract was let a year ago and delivers an "engine" with 37,000 hours *MTBF, embedded crypto, B1 thrust protection,* and *100 mps* performance — a four-year contract, but we will exceed the monetary cap in less than half that time.

Not to worry — the *TAC-4* will be available in April 1994 — be unbridled by bus-width constraints — have speeds of 600 mps — reliability of 80,000 hours MTBF — that's nearly 10 years — and have a *B3 level of thrust.*

We have hosted the entire *Naval financial database* in the *TAC-3* resulting in a *400 percent reduction in cost* and a *1,200 percent increase in system performance*. The number of personnel hours saved will stagger one's imagination and now the CINCs can access this database instantaneously and at their pleasure.

TAC-3 is 35 percent cheaper than its ancestor the DTC-2 — and has seven times the performance. Its successor, the *TAC-4*, will cost 30–35 percent less and have *six times* the performance — the cost of ADP is *going down six percent per month.*

We will source select the *TAC-4* in January 1996. It will have massive parallel processing — probably have flash or ferroelectric memory — will have an *A1 level of trust* — one million hours *MTBF* and host a fourth generation language. We have literally put our electronic technicians out of a job. They have become like the Maytag repairman — the systems that we are fielding just don't break.

Security, integrity, and *trust* must be our priority; *TAC-4* multilevel *security* will permit unclassified and classified data to run on the same workstation. We'll embed computer security — a KG-84 crypto board — inside the workstation and provide over half a *billion bytes of memory.* Applications that now take hours to execute will run in minutes.

TAC-4 will fundamentally change the way we do business — because it will make the impossible a reality — with maximum utility. It will give us the *speed* to present tactical and logistics data using an array of multimedia options: graphically, in color, and real time. If mathematics is queen of the sciences, then color graphics is the royal interpreter.

So, whether we are pitching missiles and tactics — pay and health — beans and butter — or lube oil and bearings — TAC-4, our common "*engine*," will provide the wings of transport.

The colossal technology advancement in computing power has expanded our capabilities for a modest increase in costs — and scintillated the train wreck of software engineering. As the computing "engine" power surges forward — the expenditures for applications — coding, debugging and testing — spiral upwards to 90 percent of the total computer budgets.

Sadly, these costs are driven by the *process to correct errors* during the coding or testing phases — 85 percent of the errors are induced in the *specification and design phases* — before the first line of code is written. We are attacking the symptoms, rather than identifying and eradicating the causes. The problem begs for a software engineering discipline that models the process — designs the tools to articulate the specifications — and provides for rapid technology insertion. Embracing the higher order languages (fourth generation) — with *problem-oriented programming* — and shifting to parallel computing, we gain efficiency in coding — but it demands we *correct the process* — especially defining the functions during the specifications phase. To do otherwise would be akin to taping the aspirin to your forehead.

For the next year, I intend to put an inordinate amount of energy, time and effort into multilevel security. I have on my staff the foremost expert in *MLS*. I confidently predict quantum progress in trusted systems and *MLS* this next year.

Three years ago we commenced a journey to field *38 Navy tactical command systems — afloat.* We were $168 million short. Last week we fielded over 190 first system.

Flushed with our *Navy Tactical Command System-Afloat* (NTCS-A) success, we have taken on a multitude of *perfumed ADP acronyms*, i.e., *SNAP, MRMS, NALCOMIS*, etc., and have made considerable progress.

Basically, we are porting ancient *COBOL* language programs from nonsupportable equipment to a *UNIX* operating environment — and then updating the software programs off-line. We have the technical solution — it is just a matter of executing our fielding plan.

We have embarked on an adventure to integrate all strike planning. First we will concentrate on *Tomahawk mission planning — Tactical Advanced Mission Planning System (TAMPS) — TEAMS — Tactical Environment Support System (TESS)* and seamless integration of databases, enabling us to construct a composite *air tasking order* on a workstation — and then monitor its execution on the same workstation through the use of national and organic sensors.

NAVSTAR global positioning system (GPS) will greatly improve our ability to target by providing precise positional data and ensuring a coherent force situational gridlock.

Weapons delivery will be defined by *GPS* as it is ever increasingly integrated into our weapons systems. Many of our new precision guided munitions will be *GPS* aided — others guided.

All weather navigation will become a reality and a relatively simple matter. Using *GPS*, a non-precision landing capability will be available worldwide. At sea, a low probability of detection precision carrier landing capability will greatly improve our emission control (EMCON) posture.

We are at flank speed to reduce the *GPS spherical area of uncertainty* from 16 to first 5 then 2 meter accuracy.

The more accurate ground stations and satellite clocks are, the more accurate the system. A clock error of 1/100th of a second for example would cause a positional inaccuracy of 1,860 miles!

We will install at ground monitoring stations *updated atomic clocks* connected to the *UTC* standard at the Naval Observatory.

We have a passive prototype laser reflector array ready for a shuttle flight to provide further improved *GPS* accuracy.

We will continue to identify, isolate, categorize, and assault the *GPS* error budget to reduce accuracy variance. I confidently predict *3 meter accuracy within four years* — some day we will measure *GPS* accuracies in centimeters.

Through advanced technology and *sagacious doctrine* we will exploit sensors — hyperspectral imagery — bistatic radar — GPS-based tracking — and lightning-fast theater ballistic missile indication and warning. We will leverage new technologies like automated imagery interpretation, advanced surveillance technologies, and laser radar, to name a few.

Our most exciting space program is SEALAR — for "sea launch and recovery." Christmas Eve we consummated a "cooperative research and development agreement" (CRDA) with the private sector.

SEALAR will launch rockets from the sea — recovering the first two booster stages for repeated use — hopefully up to 20 times. Anyone with an Atlas can see that 70 percent of the world is a potential gantry with a built-in cooling system.

Launches can be made at the equator conserving on-orbit fuel — and enjoy vast omnidirectional safety zones. Fuel can be metered by the engine controller for minor course corrections, or shut off — whereby the rockets and payload can be recovered by the launch vehicles organic recovery system. Insurance costs should plummet.

Sealar Corporation predicts that it will place a *350 pound payload* in low earth orbit by 1995 at a cost of $2 million per launch — and a 6,000 pound payload in low earth orbit at a cost of $17 million per launch by 1996. This represents approximately an 8 to 1 reduction in launch cost over current methods. I confidently predict far greater savings as the technology and our procedures mature.

SEALAR to me is the most attractive and exciting technology venture that I am aware of. It could revolutionize DOD — this country — actually the world — by drastically reducing the cost of putting payloads in orbit.

I hope that I have intoxicated you with the fantastic opportunities and exciting challenges ahead in space and electronic warfare and provided you *sufficient good cholesterol to combat any arterial plaque that you might have accrued.*

Navy's *SEW focus* will be on providing high capacity satellite communications — multilevel security — providing a new common "engine" for all processing applications every 18 months to two years — moving toward a "lights out" operation in our communication facilities — consistently, but measurably, moving toward *LPI/LPD* communications — fielding a wideband, multi-beam electronically steerable antenna — making it possible for all ships to "pull" environmental data from the *Navy Global Environmental Data System* — and the combining of all shipboard information systems on a common LAN and common "engine."

[End of Admiral Tuttle's prepared remarks. What follows is his informal presentation, plus questions and answers. *Ed. Note*]

Tuttle: It is hard to grasp what it takes to get the next generation of microprocessors fielded until you have dealt with the antiquity of our procurement system and then go through its glacial procedures. I just did this. It took us 30 months to birth the Tactical Advanced Computer 3 (TAC-3), which has enabled us to perform functions that heretofore would not have been possible (figure 1). The TAC-3 has 37,000 hours mean time between failures. It is an 86 SPECmarker* — a 100 million instructions per second "engine." This is what we bought. It has already grown in performance by a factor of two. When we did the source selection for the TAC-3, on 31 March 1993, we submitted immediately the requirements for the TAC-4 which will have as a minimum twice the performance of the TAC-3. I confidently predict that it will be on the order of 6 to 10 times more powerful in performance. It will have a mean time between failures of 80,000 hours. That's 10 years.

I have literally put my electronic technicians (ET) in our ashore stations out of business. The systems that they are responsible for simply do not break anymore. The ETs logged only seven hours last week, in something like a 200-man division at NCTMSLANT (Navy Computer Telecommunication Master Station — Atlantic Fleet), devoted to electronic technician work. They are now available to repair radars and other less reliable electronic systems.

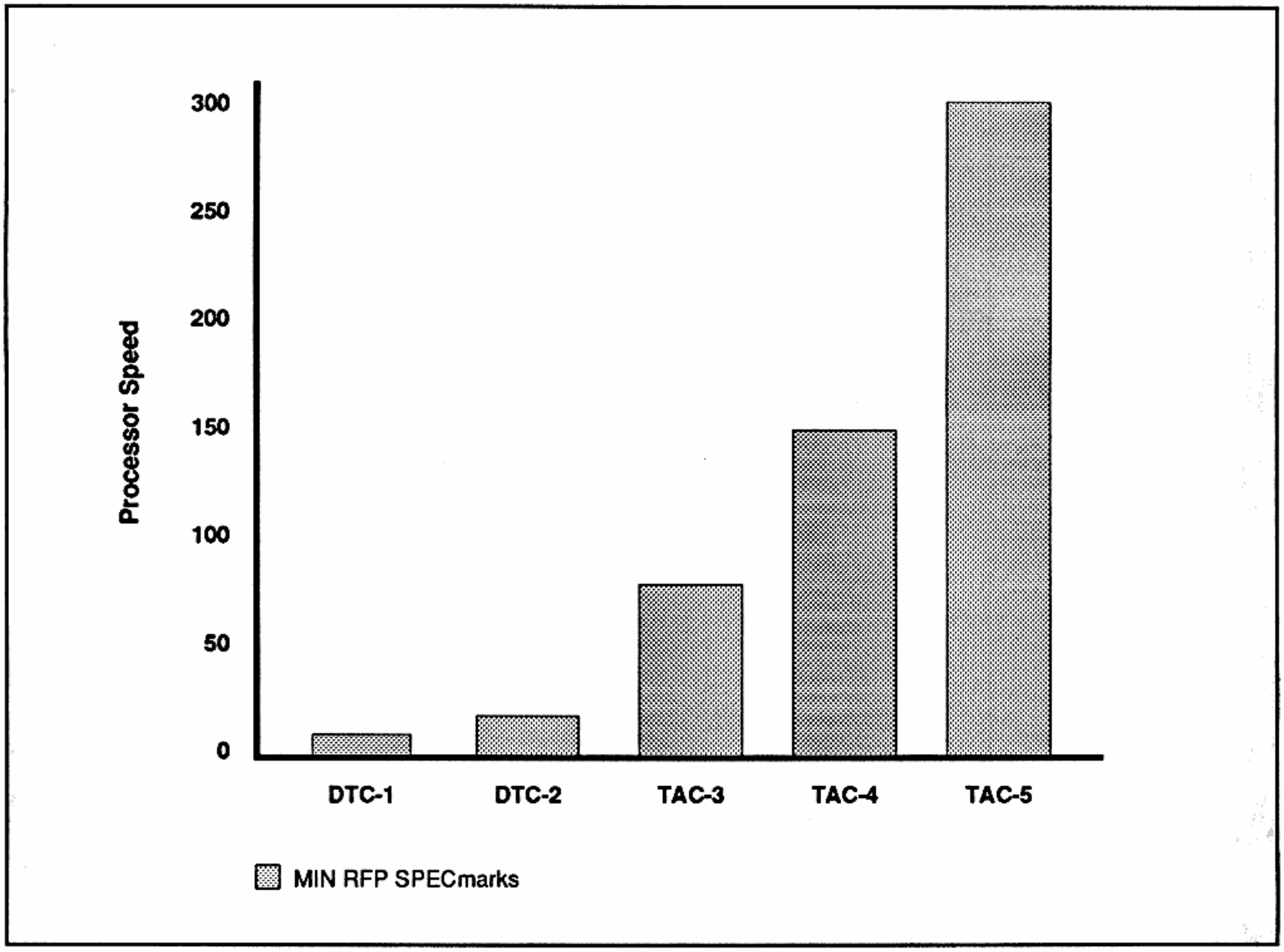


Figure 1
Processor Speed

*A benchmark of SPEC, the Standard Performance Evaluation Corporation.

The TAC-5 is very important to me. That source selection will be done in January 1996. I thought that because we might not be able to get things smaller and more dense on a chip we were going to run out of real estate on the chip and options in sequential processing power. If we were forced to go to massive parallel processing, we would have to rewrite all of our source code algorithms, which has migrated, I might add, without one penny of the appropriated monies from Rocky Mountain BASIC to C, to C++, to Ada. If we were going to have to rewrite all of this source code, whether you are looking at tracking ships at sea or target motion analyses, etc., we would have to write it in another code. I'll come back to code later. I'm only talking about hardware now.

Figure 2: This $65,000 is for our desktop computer one (DTC-1) — grossly overpriced. Remember that we bought the HP-9020C version for $29,500 from off-the-shelf! Incidentally, these were criticized as being "Tuttle's Toys"; if you didn't want them at sea, you argued that they wouldn't stand up. The DTC-1 was the only thing that kept ticking in USS *Princeton* after the mine damage. Having said that, the mean times between failures of the systems up here are infinitely higher than those of any other systems in Navy. The $32,000 here got you the DTC-2; $18,000 the TAC-3.

But this is not where we're going to mine the costs. The cost is going down six percent a month in hardware, 35 percent between processors, but the rate will diminish. Where is the money to be made?

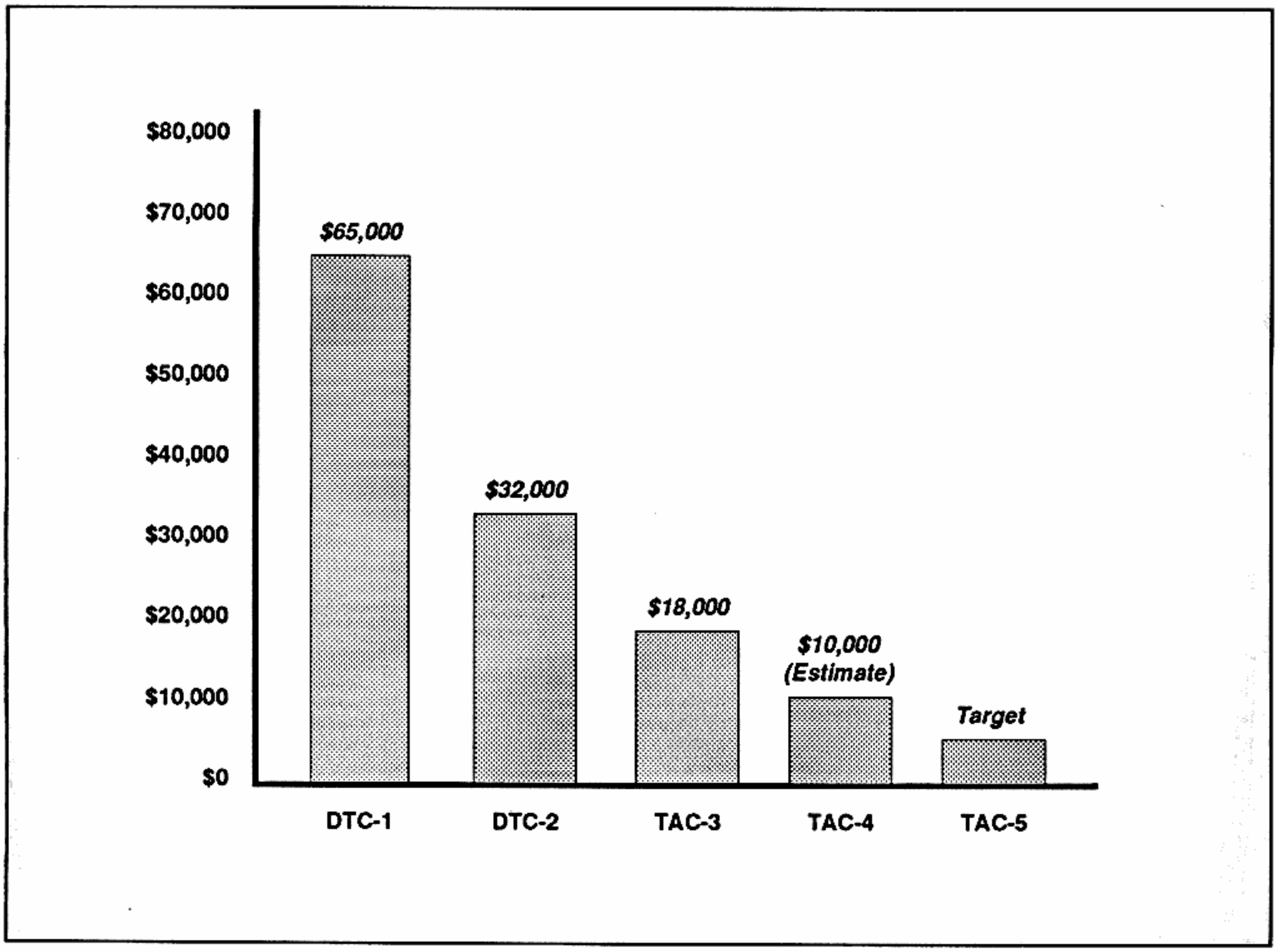
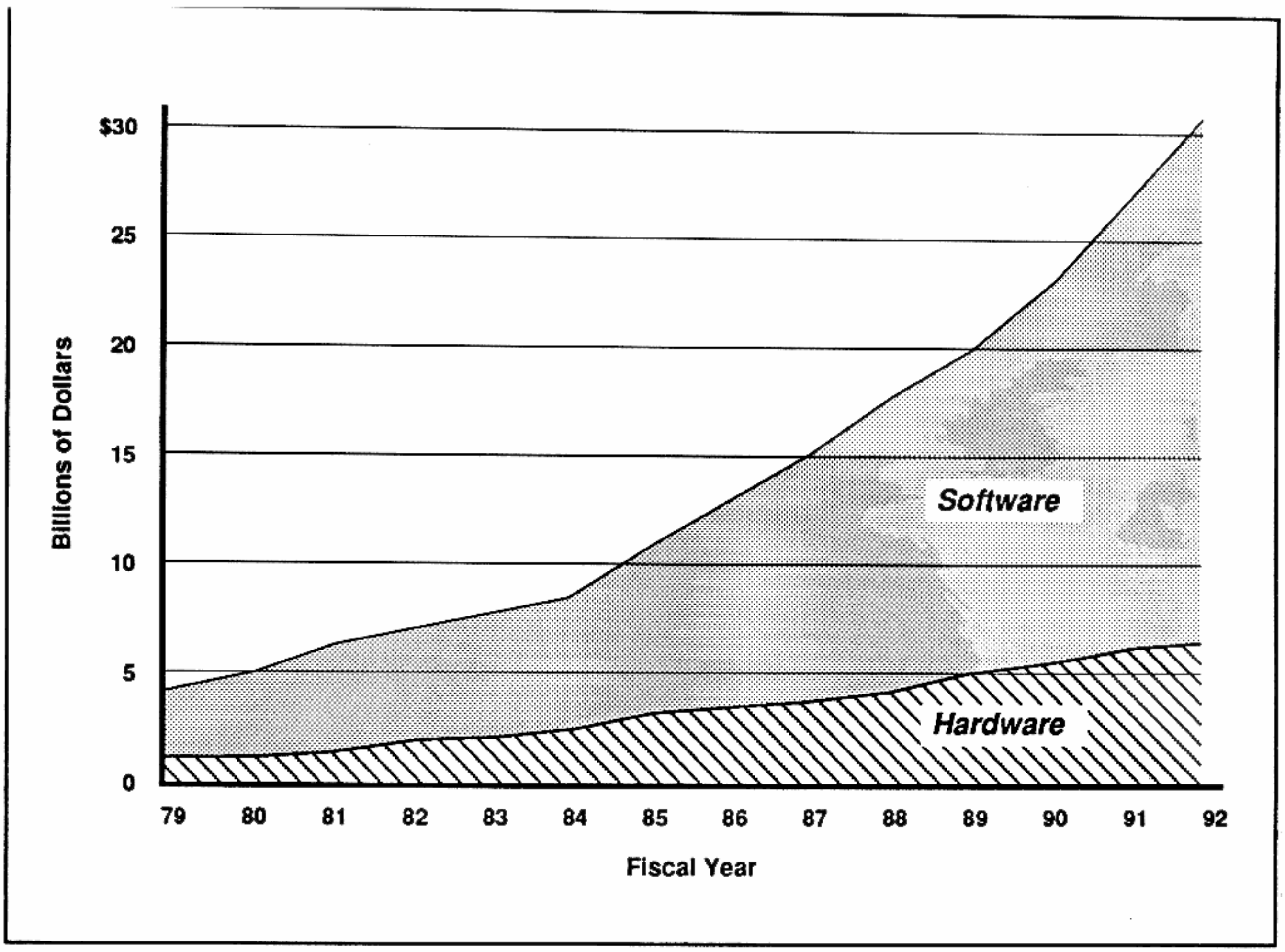


Figure 2
Costs

The other one-third of my domain: that is, software. Figure 3 is dated FY79–92. Your software is going up at an exponential rate. This peaks at FY92. It's actually going up higher than that. Ninety-nine percent of your code in Navy today is over five years old. When you're over five years old, every time you make an engineering change proposal, you have to change about 80 percent of that code. So, using the Willie Sutton theory — he robbed banks because that's where the money was — we went to the software to achieve savings.

Here is how glacial the software industry growth has been (figure 4). Back here on the bottom line, in 1945, we started in machine language; five years later we went up to Symbolic, it simmered, and then within 9 to 10 years, we had already gone up to third generation languages (figure 5). We started off with FORTRAN, then grew into C, and then progressed to Ada. Ada was the first time that a standard was specified for a language that had been widely in use. It was noble initiative but the language's use and acceptance were so glacial that before Ada was made a standard and an edict in DOD, the commercial world had leaped forward to C++. C++ is not as disciplined a system, but it certainly was an enabler. It was the one of choice and we're still here in Ada. None of these codes are optimum for parallel processing. C++ will do massive parallel processing but not too efficiently.

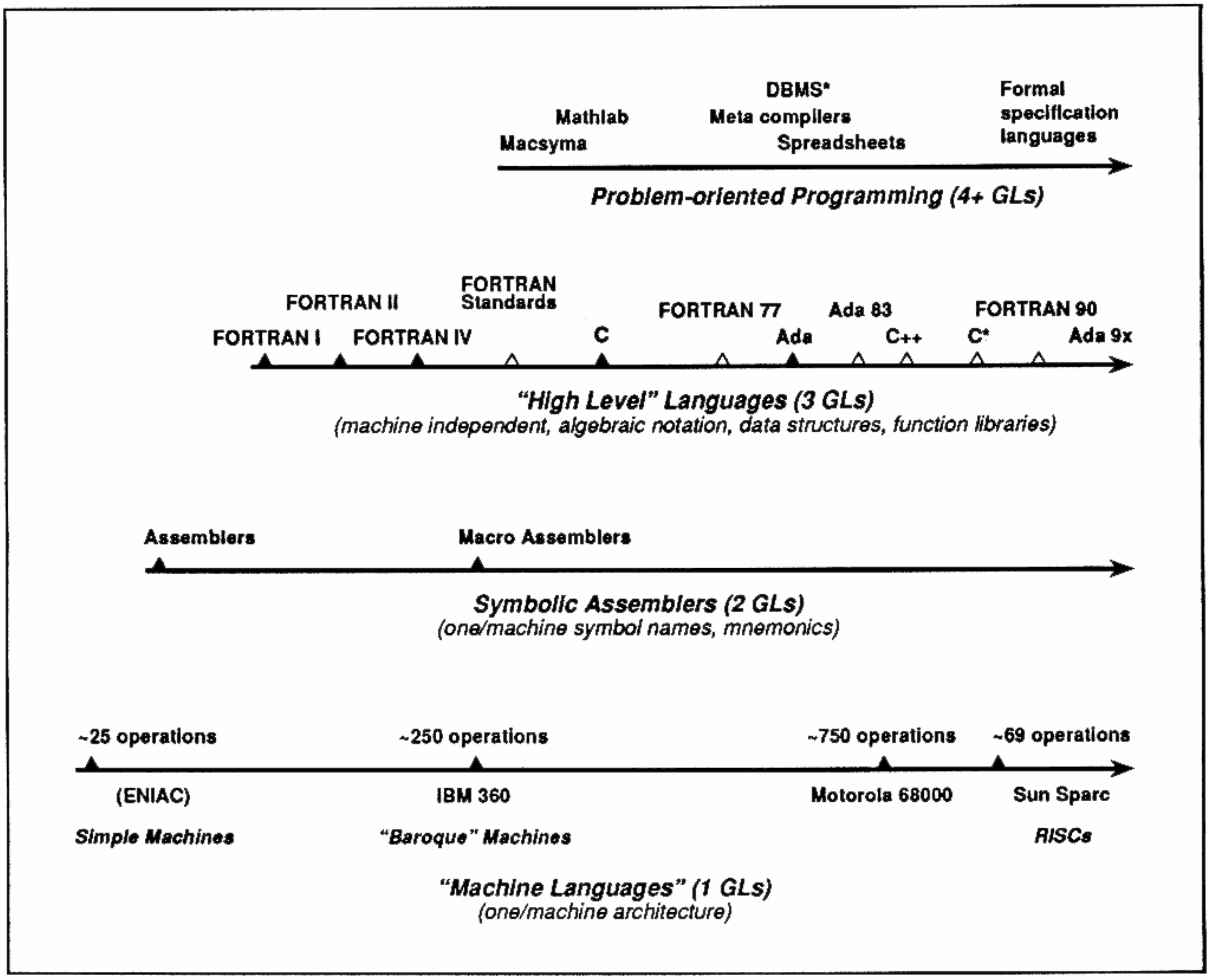
In software systems, 53 percent of the errors are introduced in the requirements and specification phase — 53 percent. To remove an error in that



Sources: *Aviation Week & Space Technology*, 20 March 1989, FY 79–89; JDL Computing Panel, DARPA FY 90–92.

Figure 3

DOD Hardware and Software—Estimated Procurement Costs: Fiscal Years 1979–1992



*Database Management Systems
GL = Generation language
▲ = Code introduced
△ = Approved as a standard

Figure 4
Programming Language Evolution: Some Examples

phase is minuscule in money. When you get to the stage where you start writing your code, it costs double the amount to remove errors. Some of the error rates in software have a latency of 5,000 years, but when you get into the test phase, which is where 45 percent of our errors are debugged today, it costs a factor of 75 times that of what it would have cost if we had removed the errors in the requirements and specification phase.

We should go to an object-oriented, problem-oriented generation of computer languages (figure 6). In this figure the software productivity is a logarithmic scale. To achieve acceptable productivity, keep costs down and bring systems in on time, we should operate in the region where the arrow is pointing — about 15,000 equivalent machine instructions/man-month.

The third element of my approach to improved C^3I systems was to increase throughput to ships. We have demonstrated all of these capabilities at sea (figure 7). Four years ago, the baby was halfway to the morgue. We were on a 100-word-per-minute

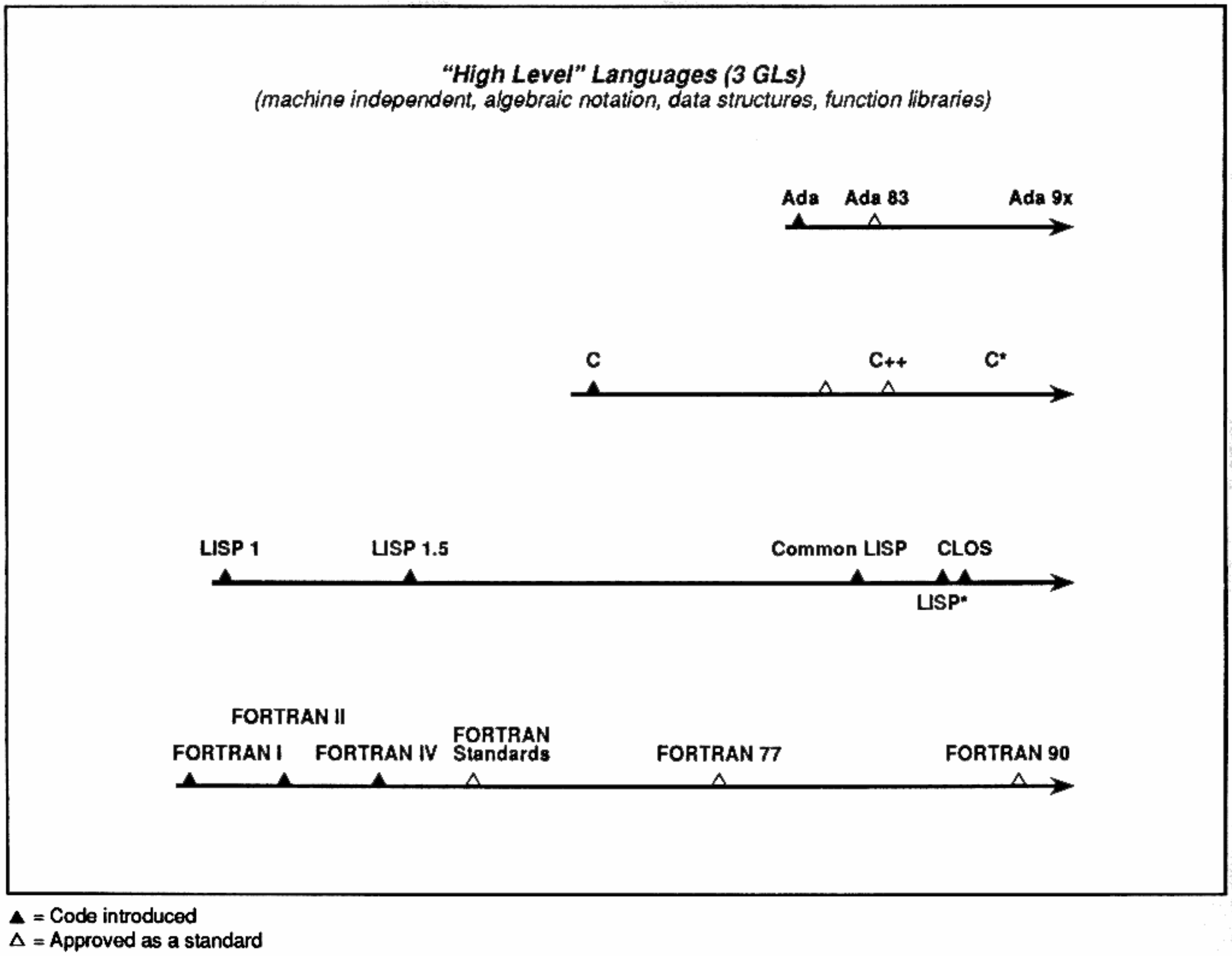
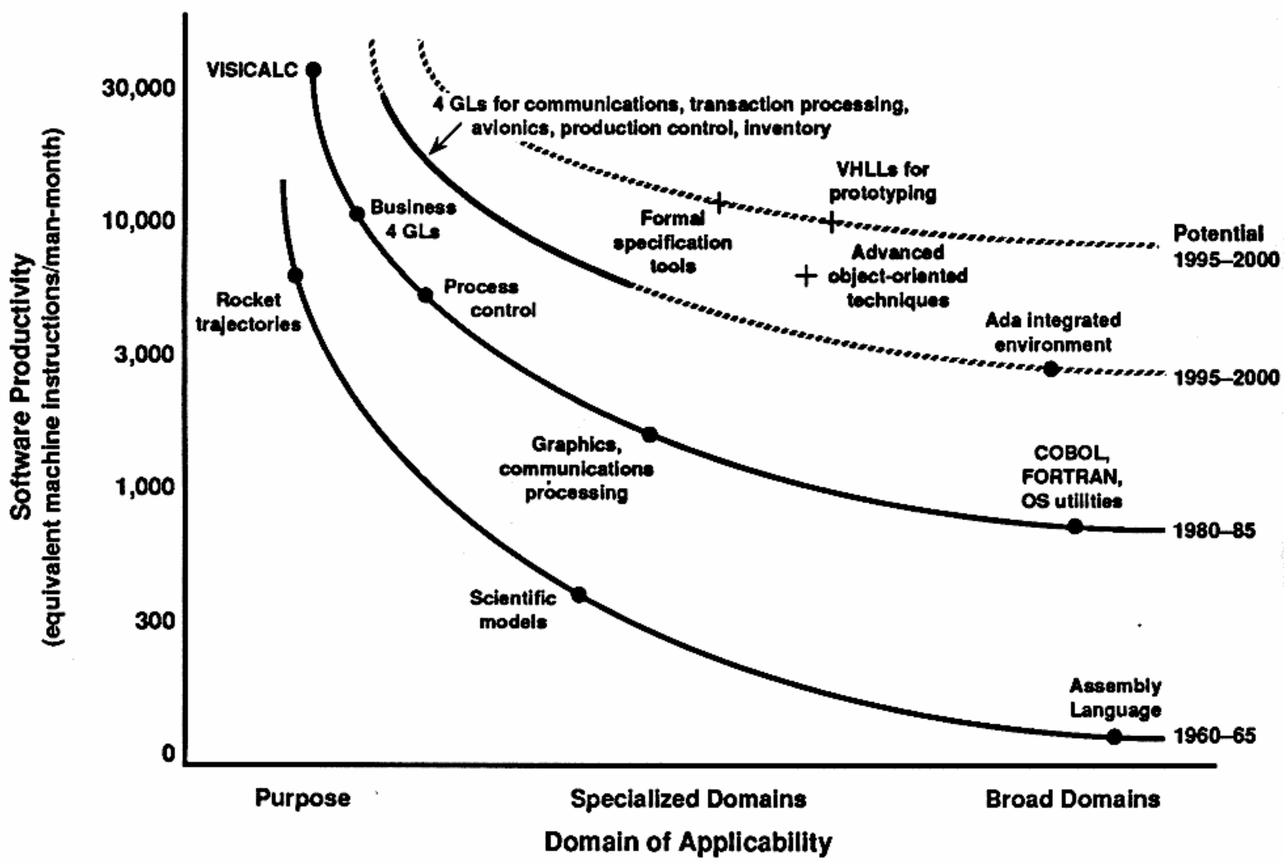


Figure 5

Programming Language Evolution: "High Level" Languages (3 GLs)

broadcast, HF. We put in SHF QUICKSAT (figure 8). We went to INMARSAT (the International Maritime Satellite Organization), just to get on another band because we couldn't get the SHF systems fast enough. We begged and borrowed SHF from the Air Force and the Marines, and put it on our carriers. We're putting it on the cruisers now going into the Indian Ocean with a four-foot dish.

We are going to a seven-foot dish in our carriers and flagships that will provide two T-1 pipes. Milstar will add more. We have employed a commercial satellite to provide a four megs path to sea. We have video teleconferencing between USS *George Washington*, CINCLANTFLT, and Washington — the Pentagon. On the fourth of May we'll do the same thing with the USS *Mount Whitney*, video teleconferencing, running 128 bits at sea to the headquarters. We'll be running on a T-1 elsewhere. By the 15th of August, we'll be able to go video teleconferencing from the USS *America* at sea off the coast of Yugoslavia to Naples, Italy, to London, England, to Norfolk, to the Pentagon, to Hawaii — both the fleet commander and the TYCOM, or the specified commander — on out to Seoul, and COMSEVENTH Fleet in USS *Blue Ridge*. About six months later we will put this capability in Bahrain. So we will have achieved a follow-the-sun OPINTEL (operational and intelligence) brief like CNN today, where you can prepare an OPINTEL brief and refurbish and nourish it



Source: DARPA software technology roadmap, 1990.

Figure 6
Software Technology: Technology and Productivity

electronically to suit your local commander requirements as you circle the earth following the sun.

Here is where we've got to go (figure 9). SHF DAMA (demand assignment multiple access) already has provided greater than T-1 capacity. We're up to two megs, which is over 3,500 times the capacity that we had when USS *Princeton* was struck by a mine at sea. We need 14 T-1s capacity for high definition video teleconferencing. The reason that we need high definition video teleconferencing to sea is to provide the capability for greatly improved bomb damage assessment. We will also be in a fine position to establish the standards for high definiton television for this country. But, I am afraid that we are going to rehearse the play so long that we fail to put on the play. We should have our standards accepted now as the international standards and create 100,000 jobs in this country and start exporting HDTVs soonest.

How do we pay for the large amounts of infrastructure that we are buying? Long before it was the fashionable thing to do, Navy was on a 25 percent down glide slope reducing people. We in Space and Electronic Warfare were actually on a 44 percent decline in personnel. The only reason that we are not going faster is not because we need the people, but because we owe our people loyalty and career transition opportunities. We have put our electronic technicians out of work. I want to train them as warfare information specialists. That is what automation and technology will do. There are four Navy Computer Telecommunication Master Stations (NCTMSs) around the world, and all kinds of other communications stations. They are overpopulated. NCTMS were run by 1,200 people. We have reduced to 900 people now in Guam. We have replaced a technical control center at Wahiwa, Hawaii, that occupied a space 37 feet by 95 feet with two 19-inch racks and provided 100 percent redundancy. This automatic network control will automatically, dynamically control and be able to monitor the capacity of any one of 8,000 hard lines or RF transmitters.

We are migrating to "virtual bandwidth" RF channels and we will have a communications support system within six months, which will be just like the ISDN (Integrated Services Digital Network) now ashore residing on wire and fiber. It will be in the RF spectrum. The receiver will not know whether he's getting traffic via UHF, SHF or EHF satellite, nor will he care. Eventually we'll get into the commercial spectrum, i.e., INMARSAT,

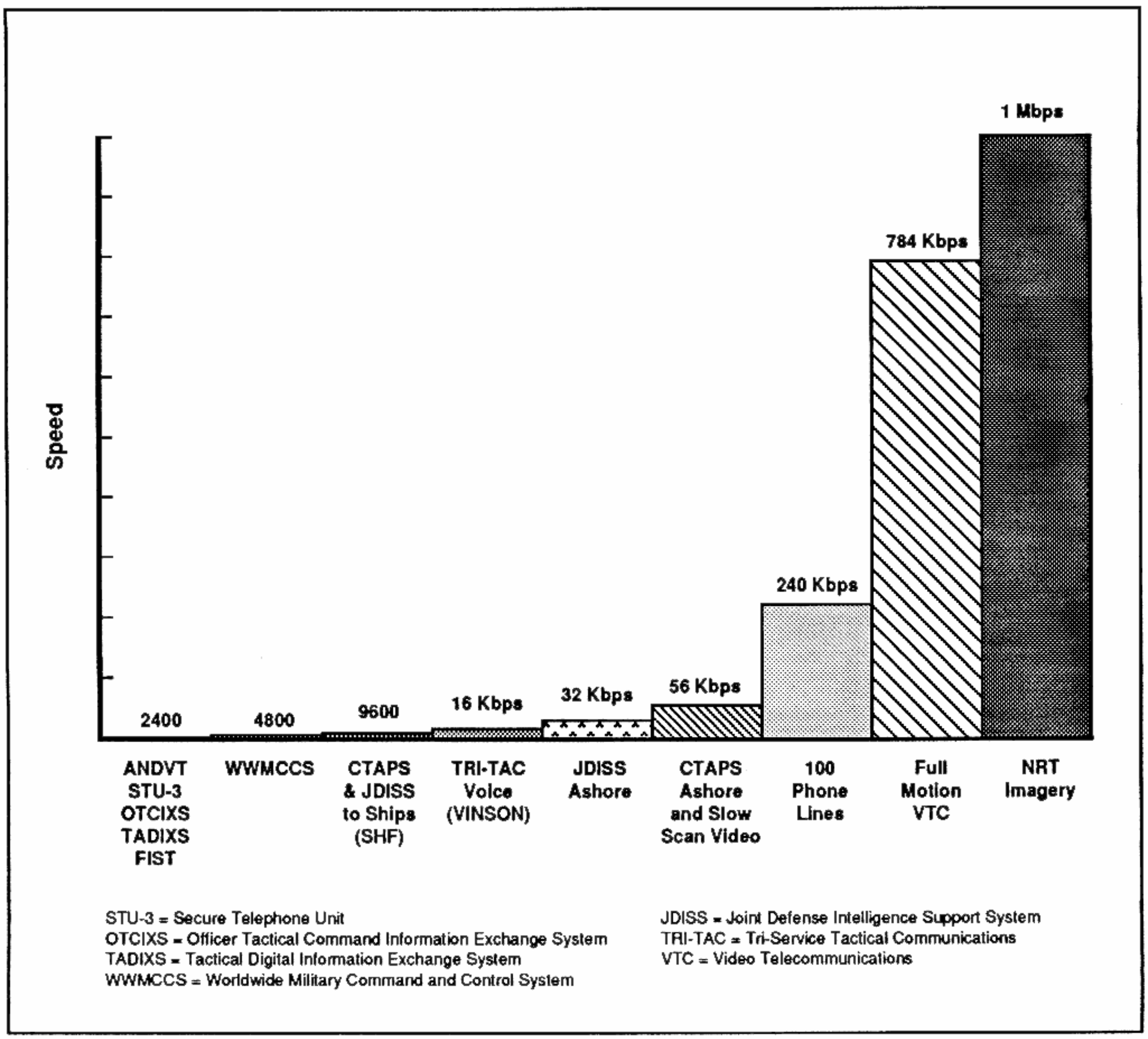
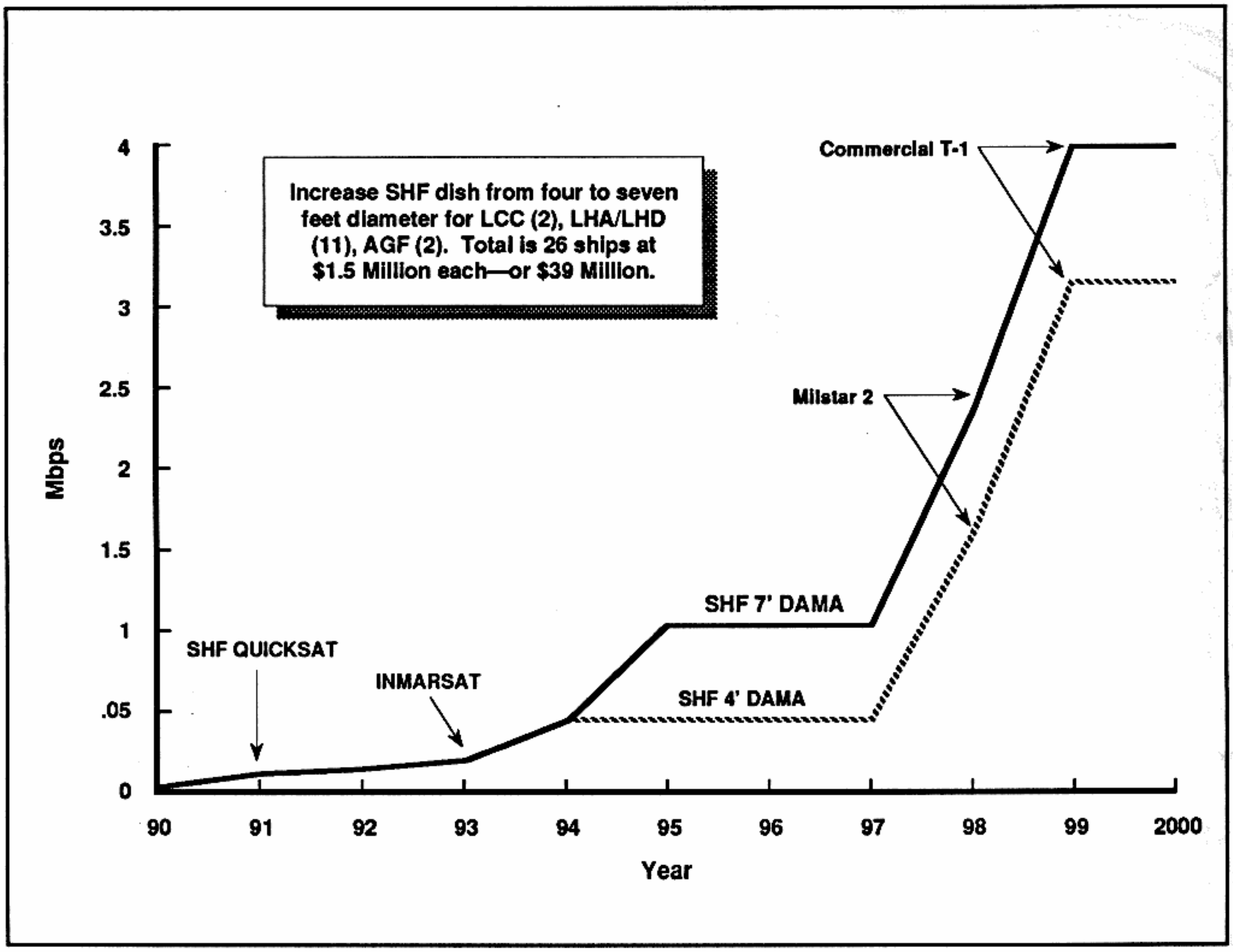


Figure 7
Service vs. Throughput



Source: Joint Space and Electronic Warfare/Intelligence Assessment.

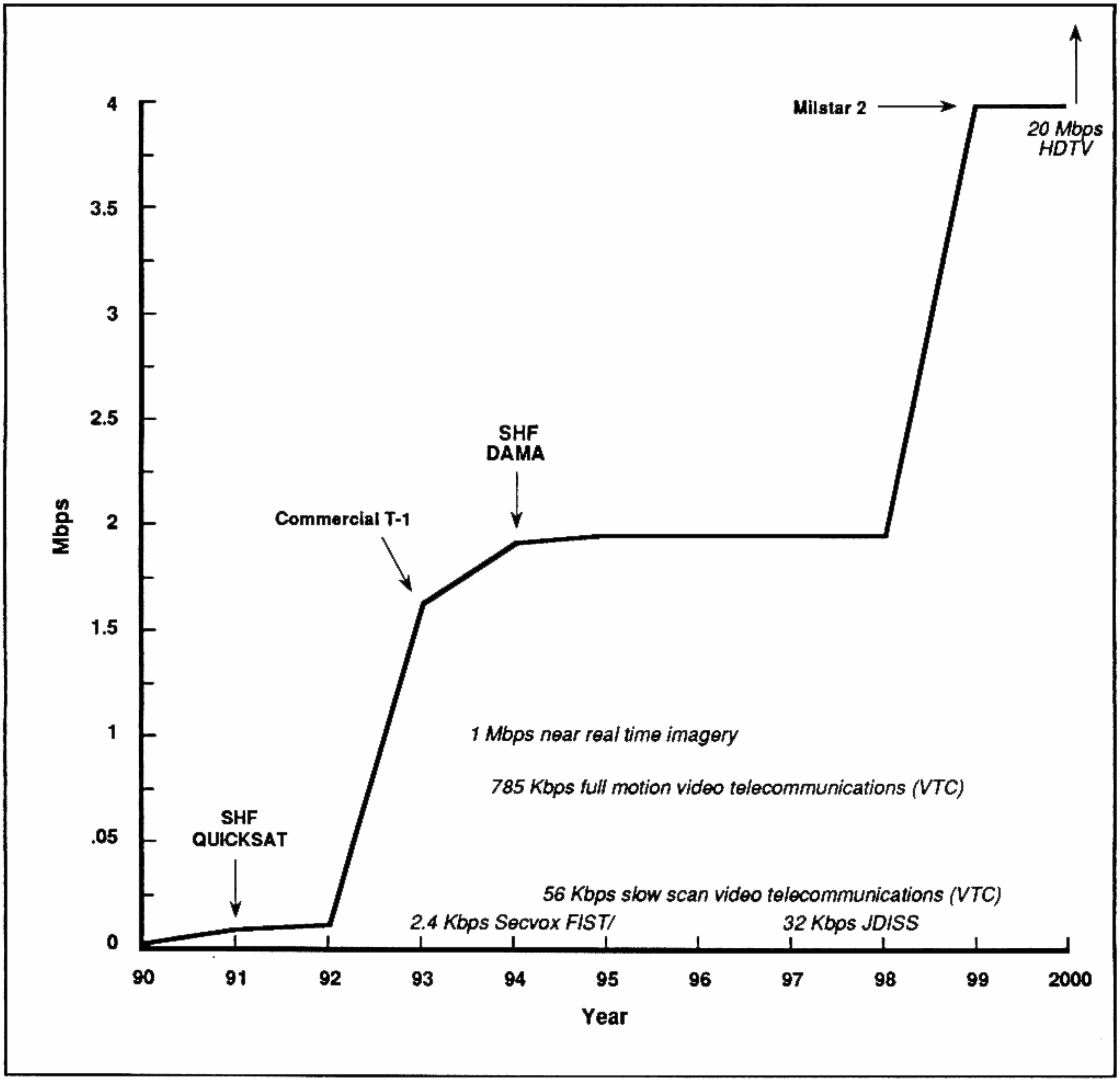
Figure 8
Throughput to Ship vs. Time

C-Band, or Ku-Band. What will enable us to take advantage of multiple satellites in different parts of the sky is a wideband, multiple array, full spectrum, electronically steerable antenna that will be able to access different satellites, in different spectra, and be able to transmit over others simultaneously.

Student: I was going to say that's the most impressive thing I've ever heard, except I don't really understand it. In layman's terms, what does this mean for the commander on-site?

Tuttle: It will give the commander at sea access to an amount of information that would be unimaginable before and his information universe will be expanded greatly. On shore, there will be communications channels that have teraflops (10^{12}) capacity. That means that the people ashore will have the ability to get it on glass (fiber optic cable) that is available now. It will be a national grid that you will be able to subscribe. If we were to take all of the satellite resources, DOD and commercial, available in any footprint on earth we can hardly get 100 million bits. We are at best at a 10 to 1 disadvantage with our brethrens ashore if Navy were to get all of the capacity — which it won't. Access to information depends on bandwidth and I'm severely disadvantaged at sea.

I got away from the topic of personnel. Here I want to show that we have traded personnel cost in my claimancy for procurement dollars. We're coming down 45,000 people in Navy this year, and I want to be able to make a greater than my



JDISS = Joint Defense Intelligence Support System

Figure 9
Cumulative Throughput to Ship vs. Time

proportional share contribution, save the taxpayer's money, and do away with personnel intensive work and let the people we can retain fly airplanes, drive ships, and dive submarines.

The commander at sea, or any other decision maker for that matter, can prescribe his own information domain. He can do so by describing the procedures and boundaries of his information domain administratively, geographically, parametrically, and temporally. This information must be made available in cue for the commander to access and "pull" when he needs or wants it and in the dosage that he prescribes. This doctrine is the centerpiece of our Copernicus architecture.

The NAVCOMPARS, which is a computer base message management system ashore, is where messages for ships at sea are stored and routed. Just as you have a PC on your desk now that has a menu that you can pull up and read only those E-mail messages that you wish, I want the commander to have the same capability at sea to decide what information he wants and when and then be able to "pull" it to his facility at his discretion.

The Copernicus "pull" theory is particularly important for information requiring great bandwidth, like photography. It used to be that for Tomahawk mission planning — all photography that met certain criteria in the library was broadcasted over the Fleet Imagery Support Terminal (FIST). This procedure took a lot of time and used a lot of bandwidth which could and should be used for other operational purposes. We have now about 100:1 data compression and only the satellite photography specifically requested by the commander for mission planning is broadcast.

Student: In saving costs, what is your experience with the method of rapid prototyping, which I know you've been trying to implement? Has that been working and reducing development costs?

Tuttle: We don't *try* to save monies — we *have*. We have saved vast amounts of money by rapid prototyping. All of the systems that I have alluded to are commercial off-the-shelf systems. Technology brings to the altar not only performance but reliability, and you cannot field C³I systems by the book today. If you do, it takes you 15 months to get to milestone 0. That's an entire generation of microprocessors. Another 18 months to milestone 2, and then you're into the second generation. By the time you make the decision to go to limit rate production, you have forfeited three generations of computers. You're penalizing yourself financially.

As you will recall, the cost of microprocessors are going down 6 percent a month, but more importantly is what we're spending on the hardware maintenance. We have Honeywell DSP-6s in the fleet, which are 30 years old, riding on COBOL, a language created by the late Grace Hopper. To get away from the unsupportable mainframe computers and create a cash flow, I ported all those COBOL programs over into a UNIX operating system (i.e., the tactical advanced computer). We make too big a thing of computing: a processor is nothing more than a one-and-zero cruncher, and whether it's painted gray and you can drive a tank over it without failure is somewhat immaterial, the point being it crunches ones and zeros. Now how it does that is a different thing. As we approach the density MOS (metal oxide semiconductors) limits on the chip we will have to turn ever increasingly to massive parallel processing. It matters little whether you use these microprocessors as a PC, a workstation, a data file server, a communications file server, et cetera, et cetera.

To build upon your question, when we started three years ago there were zero Navy Tactical Command Systems-Afloat (NTCS-A). We took the tactical flag command center (TFCC), the afloat correlation system, and electronic warfare coordination module programs and merged them. We concluded that we had a requirement for 38 systems in 38 ships. I was told that we had an unexecutable program because we were $168 million short. Because of rapid prototyping and the use of commercial off-the-shelf equipment, we fielded the 191st NTCS-A two weeks ago. Incidentally, the microprocessor originally planned was a color workstation that cost $450,000. Figure 2 shows one that gives at least 100 times more performance for $18,000. That's striking testimony to the wisdom of rapid prototyping and the use of COTs. We achieved far greater performance and reliability at far less costs. Since 1982, we have progressed from Rocky Mountain BASIC to C, C++, and now a lot of kernels are written in Ada.

Student: Admiral, when you say you field a system in that example, are you fielding a prototype and is that one that the manufacturer gives you as a demo?

Tuttle: No. We don't go to manufacturers for systems, we create our own. We craft a C³I architecture and then go to manufacturers to acquire the components to build the infrastructure for that architecture. An example is the microprocessor. The one that we use now is the TAC-3. We have already sold over 100,000 of them. The TAC-4, which I'm targeting next year, is at $1.4 billion now and by the time the contract is let, it will be a $4 billion contract because it will be the best processor available. There are only three principal components of any information management system. There is a processor, there's software, and there's connectivity. And if you go to a particular manufacturer, you get their solution. Navy is making software upgrades and releases every three months. To enable us to do this, we have a complete NTCS-A mockup at NOSC (Naval Ocean Systems Center), where we do the prototyping and perform continuous testing. We took the NTCS-A prototype running on the TAC-3 computer at NOSC in San Diego and let Admiral Larson run his exercises from San Diego on this system. As soon as the exercise was over, we crated and shipped it to the Mediterranean and installed it in USS *Belknap*. The *Belknap* is using that installation today for real world operations.

Oettinger: While you are shuffling through pages, Jerry, let me just make sure that the full impact of the technical stuff is understood. You all kind of nodded about the answer to his question, or he nodded about the answer to his question, but I didn't see all the rest of you nod, so despite the possibility of overkill. . . .

Student: Can you slow down on the acronyms a little, because I am military, but I am not Navy, so many of your acronyms kind of go above my head.

Tuttle: I'm sorry about that. I apologize.

Oettinger: But let me give a quick summary. What the admiral is describing is an enormous degree of improvement in the performance and the simultaneous decrease in cost of computer and communications capability. That essentially amounts to putting any naval ship anywhere in the world right here in this room for all practical purposes as far as communications is concerned. That is something which a hundred years ago was an impossibility. Once the fleet went out of sight, the fleet had one set of traditions, as described to those of you who have read Allard.* So, you have the makings here of the technical infrastructure for an absolutely radical change in what a Navy, as an organization, as a command and control system, looks like. Because, when you have the capacity to ship information, whatever it might be — orders, maps, air tasking orders (ATOs), and so on — as if the guy were at the supercomputer next door, the question of what our naval tactics and strategy and so on is completely up for grabs. Is that a reasonable summary?

Tuttle: That's beautiful, that is an eloquent expression of my message.

Oettinger: That is what you heard. What he described is what the technical substrate was, with the alphabet soup. Help me catch him when he does too much.

Tuttle: He'll attack on and off, I'll try to be careful.

Oettinger: I was the only one to stop him, but don't be ashamed if you don't understand.

Tuttle: No, no. I'm here to impart what little knowledge I may have and give you my perspective.

Oettinger: Yes. Nobody is born with everybody else's alphabet soup in their heads.

Student: Sir, could you talk a little about this information push versus pull and how it might change the kind of job commanders do or the kind of support intelligence would have to give to them?

Tuttle: Certainly! But, just let me make a few other comments. Two big fundamental changes have occurred. Firstly, these systems have great reliability. The TAC-3 has yet to fail. So the practice of sending people to a 47-week school to learn Ohm's Law, so that they can repair these microprocessors that are not going to break and I'll swap it out three times during their enlistment demands a logic transplant.

Oettinger: That is the Maytag repairman sort of reliability.

Tuttle: Maytag repairman scenario, precisely. So now we take that same intelligence individual and teach him how to operate the systems as opposed to repair it. It also precludes obsolescence. It now takes three years to get repair components into our supply system. By that time, we will have turned the microprocessor over twice, and besides, in the microelectronics industry, they no longer make component parts because they don't break and as a result there is no market. You can buy microprocessors cheaper than you can repair them. Microprocessors are rapidly becoming consumables.

Now, Navy's information system: that is, Copernicus.* I didn't even know Copernicus, the

*Kenneth Allard, *Command, Control and the Common Defense*. New Haven, CT: Yale University Press, 1990.

*Copernicus is the new name for a system formerly known as JOTS — the Joint Operational Tactical System or the Jerry O. Tuttle System.

astronomer, but when I was at sea, I tried to command the carrier battle group and every place I went for information there was always an individual — what I call an air-gap, and I had to depend upon him. It might be my intelligence officer. These positions are populated by some of the most intelligent people in the world. They are professionals. I would go to my air-wing commander who was going to lead the strike. But, I was the one with the ultimate responsibility. I wanted to be able to reach out and go into a DODIIS (Department of Defense Intelligence Information System) database, another acronym, but it is an intelligence database ashore, designed in recognition that they had no intention of taking it to sea. I wanted to be able to tap into imagery sources ashore. I wanted to be able to get the tactical environment support system — like weather — directly from satellites overhead or from the weather database ashore. I wanted to pull my information as opposed to permitting someone ashore to determine my information requirements and inundate me with message traffic by broadcasting everything. We have 60,000 of what we call UICs, Unit Identification Codes, in which any number of people, depending on how far you go down the release authority, who can send a message. That is the "push" mode. We should avoid the broadcast mode. You have to be able to access information and "pull" it as necessary to fulfill your information requirements.

Oettinger: May I just add that this is true of the retail world now as well. The big shift in the information business is that from a business dominated by whatever the supplier wanted to sell to what the customer wants, so that out there is a vast reservoir of information. You, as a customer, have to have something that tells you where it is or how to get it, whatever it might be, and you get only that which you want. Now that is a radical shift in thinking all around. It is sort of a hard call to articulate how major a change it is. If you think about mass media and so on . . . all of the current thinking next door in this place, the press and politics folks are still geared to the notion that there are folks out there talking now, sending ATOs, and you get the broadcast and go down. The notion that wherever the hell I am — and this is not here, this guy is talking about ships at sea anywhere — I've got a tactical problem, I've got a strategic problem, I've got whatever I think my problem is, and the information I need to resolve it, to aim my weapons, to locate myself, to do damage assessment after I have had a sortie, is available to me when I bloody well want it as I choose it. I think that is what Admiral Tuttle is saying.

Tuttle: That is exactly it.

Oettinger: That's a complete turning upside down of the world as it is now organized.

Student: Sir, does that require a really educated consumer then to figure out what is available? Do they have to become almost intelligence experts then?

Tuttle: No, no, I said information, not intelligence. And there is a big distinction.

Take Desert Storm/Desert Shield; we almost failed because we didn't have SHF on our ships. We didn't have big enough communications pipes, and when the information came out, they carried it in aircraft in narrative form. There is no way that we could read all of the information "pushed" to us. All we needed was our segment of the ATO that was profiled for us, but that was also in narrative form.

In November 1988, Admiral Trost, the CNO, called me while I was on the Joint Staff. I was Director for Space and C^3 at the time — the top such job in the world. He asked me if I would come back to Navy to solve his biggest problem at that time — that of command and control. I agreed and came back to Navy and relieved a two-star flag officer. That is not a step down in prestige, that is a jump off Pike's Peak. I inherited a bankrupt organization. No one was being promoted. We were thought of as communicators who didn't know what we were doing, and who did not provide the required systems. We had another organization, populated by high salaried individuals who thought that we only existed to be a customer for them.

So, we merged organizationally what had occurred functionally 20 years before and that was to combine the disciplines of automatic data processing and telecommunications. The results have been phenomenal. But what Admiral Trost really wanted me to do was take on what the Soviets called radio electronic battle management. The CNO's executive panel had worked 18 months on formulating the Space and Electronic Warfare concept. They observed us avoid the Soviet's radar ocean reconnaissance/surveillance satellites, with the cover and deception and by staying out of their footprints and avoiding detection by their ELINT sensors by not operating electronically within their collectors parametric windows. What has accrued is Information Warfare, the first new warfare area in 70 years.

Oettinger: It's got no water in it.

Tuttle: Yes, you are correct. You have no idea how I was criticized in 1981 and 1982 for using UHF satellites. Today we have a satellite communication triumvirate of UHF, SHF, and EHF satellites. We first crafted a C³I architecture so that we could identify and acquire the necessary infrastructure, composed of hardware, software, doctrine, and technology. We gave this architecture the sobriquet of *Copernicus*.

Copernicus was only the C⁴I part of the necessary architecture for Space and Electronic Warfare (SEW). We crafted *SONATA* — a SEW architecture in three parts. Under Weltanschauung (Weltanschauung is an umbrella, a German word for global perspective) we included electronic combat and all surveillance systems. Then of course we had *Copernicus*. The third movement was *Croesus*, named after the Grecian king who created money and dominated the eastern Mediterranean back in 500 B.C. with a very small army. *Croesus* is an investment strategy to acquire the necessary competence to build the SEW infrastructure. We concentrated on finding solutions to problems and not concerning ourselves too much with resources. Sonata's three movements are: Weltanschauung, Copernicus, and Croesus.

Oettinger: Let me just emphasize this before you go on, because over lunch we came back to a bit of the discussion there was in the last session over negativism. What you are getting today is an antidote in terms of how to do things. I just want to make sure the importance that Admiral Tuttle put on these things, like Sonata and Croesus, et cetera, et cetera, does not pass by you. What he is saying may sound very whimsical, but let me, at the risk of boring you, underscore the absolute importance of this. He invented words and, more importantly, concepts, but also attached concepts to the words, that no one had in any bureaucratic lexicon, so that no one could tie him to any known set of rules. It may seem like: what is this guy being whimsical about? It's an enormously important part of that. You don't do that in empty stuff, because there are ideas there and you will be getting sense of the scope of the ideas, but there are lots of people with ideas who see the ideas die because they get killed by bureaucrats. One of the key secrets to having ideas not die in the hands of bureaucrats is to use words that do not appear in anybody's lexicon, except that they are important.

Tuttle: That is so true. It also can capture new ideas. Anybody who knows music knows what a sonata is. It also permits you to avoid adversarial relations.

The world is extraordinarily dynamic today. You hear it all from every podium, every dais, from every speaker, how dynamic change is, new issues — the Berlin Wall and all the things that it didn't solve. Technology has been the catalyst in ushering in this change. The transistor was invented in 1948, yet it took 10 years before it was used commercially. This year, there will be 10 million transistors sold for every one of the 5.4 billion people on earth. I recently visited Digital Equipment Corporation (DEC) to witness their new Alpha card. On that little three-eighths by three-eighths chip resides 1.7 million transistors. By 2003 it will be 100 times that. These metal oxide semiconductors (MOS) are packed with great density in clean rooms of .75 microns. Further refinements will permit them to achieve .18 microns or the size of a virus, enacting up to 100 million MOS on this small piece of real estate.

The amount of information in the world is doubling every two years, and when a child born today goes to college, 90 percent of what they will need to know is unknown in the world today. That brings me to a philosophy that has nothing to do with the engineering or organization. I call it IEEE. We have four problems in this world today. One is information management, two is the environment, three is education, and the fourth is economy. We must address these issues.

Oettinger: You left out energy. One second, before I lose that point, and tie it to this inversion that you mentioned earlier. Given the statistics about the amount of information, et cetera, et cetera, you hear a lot of wailing over information explosion, information overload, and the like, that assumes that the stuff just pours out; that is the old paradigm. When you do what Jerry was talking about, an inversion, you pull what you want. That whole lot of nonsense about information overload disappears. So, anytime you hear somebody saying "information overload," it is a guarantee he doesn't understand what the hell is going on. It is an ass-backwards, upside-down look at the world because you don't have to do it that way. It used to be that it was the only way to do it. So, I just wanted to make sure that you again grasp this, because some of these things are going by very fast.

Student: Sir, I guess I'm digressing a little bit. I want to ask you about something you said earlier about the system that you developed that was absolutely maintenance free, or has an incredibly long mean time between failures. I guess I would like you to expand on that because that's totally alien to anything I've ever dealt with in a military context, particularly as you get toward the information technology side. Could you expand on why that is, how that is, and how does that work?

Tuttle: Part of it is enabling technology, and the process of building transistors onto chips is drastically refined; that's why they have these clean rooms. They'll let you get down to closer tolerances. You get a greater density of computational power when they lay the layers of the metal and the dielectric components on these chips. Now they're able to make the chips bigger and bigger and get more processing power at the output as opposed to building more chips. These chips will grow in size. Silicon won't permit you to do that because it has a rigidity and it would crack and/or break. We have reduced the number of moving parts and reduced the size of components so that we can afford to build in redundancy. We must make sure however that we never steam into what I call a technology cul-de-sac. On your personal computer today, nothing breaks other than the monitor and the keyboard, or maybe a mouse if you've got one, and maybe if you have a vanilla drive, one of the old types, it will fail.

We are now migrating to "flash memories" with no moving disk parts, and the disks are going from big, to the standard disk now, the 3.5-inch floppy, down to one-inch disks with a density of 100 times that available today. So you can take these disks, if you care, and put them in a matrix form and get the performance out of the machine and have a lattice, where every one of the processors can take on the processing, so you have redundancy. You don't have any moving parts. In the old radio rooms that we used to have, there were 25-year old radios, there were vacuum tubes. Filaments would burn out, arcing would go between the plate and the filament. Semiconductor technology, more than the gee-whizzes and the performance, brings with it reliability.

Now what is going south and what we are attacking is the software. The reliability of software is inversely proportional to where the errors are induced and what stage in the software production and where you identify and remove the errors. The latency of errors in software can be up to 5,000 years.

Student: So, I guess what I'm asking is, it escaped me which system you were specifically speaking of.

Tuttle: The microprocessor, primarily.

Student: . . . that thing just flat out does not break?

Tuttle: It isn't going to break. And if it does, it doesn't make any difference because the Navy Tactical Command Center Afloat (the command and control system), mission planning, personnel accounting, logistics, maintenance, etc., will all operate on the same microprocessor. So in the unlikely event one breaks, you have probably 300 more of them in the carrier to perform any function. They all will be connected by a local area net. If you take an Exocet missile into the side of the command and control spaces, you can proceed to supply and fight the war. What's equally important is that we can have the option of a new, more reliable microprocessor, with far greater performance for every deployment.

Oettinger: You know, I think that part of the problem, if I may be so bold, is that Admiral Tuttle is talking about an environment that's a good deal more benign than your Army ground environment, and so, take his figures and discount them by a factor of 10 or 100.

Student: Sir, I guess I can grasp the no-maintenance idea, but I don't think I quite grasp the battle damage concept because if the processor is damaged in an engagement, it's gone.

Oettinger: Not if you've got 10 in every knapsack, you hear?

Student: You're just talking about the processor that runs the system?

Tuttle: Yes. If I take damage on a processor that's used for command and control, I simultaneously have 200–300 other identical processors residing on a local area net that runs throughout the ship. Thus LAN carries data. It doesn't care if that data is beans, butter, or information on the high speed target coming at me; it's a bit stream as far as it is concerned. If I lose a microprocessor anywhere in the ship, I can on line a workstation with an identical microprocessor in another part of the ship and perform the function of the damaged and lost microprocessor.

Navy's standard microprocessor is the TAC-3 and it is remarkable. During its test, the machine administering the test failed first. You could see the sides of the TAC-3 flex in and out but it kept right on ticking. We put it in a rain forest. It grew mold inside. That system is operational today.

MIL SPEC 16,400 was the criteria used for our C^3I systems. We set out to change these MIL SPECs so that we could afford to buy C^3I systems. We rewrote the entire MIL SPEC manual for C^3I systems with industry resulting in new affordable criteria contained in 2,036.

Student: If this stuff won't break down for 5,000 or however many years . . .

Oettinger: He meant that certain errors in software can't be found for 5,000 years, as opposed to the reliability of the hardware.

Student: Okay, that's good enough. If the software errors cannot be found for 5,000 years, what measures are you taking to insure against the enormous security risks that could result from computer viruses? Is there a threat, or is this just something that is being hyped up about individuals or terrorists or states handcuffing our entire military computer system? Is that a myth?

Tuttle: It's a tremendous threat. Not necessarily to military systems anymore; the real threat is to the country. The sabotage that can be done to your PBX system in this country is astronomical. Look what happened to Wall Street when they cut the telephone wires by mistake. In fact that is a major thesis of Space and Electronic Warfare: you can bring a country to its knees without firing a shot. You can make it decisive, so he doesn't have an appetite for war. The idea is to isolate the head, the leadership, particularly when your argument is with him and not the people. We did it pretty well with Saddam Hussein. We separated him from his economic infrastructure, i.e., his shipping. We tried to separate him from his people. We did not effectively use misinformation, but we did roll his air defense systems back effectively. It was picturesque, [John] Madden would have loved it — I can see him drawing on the screen how we rolled back his air defense systems. It can happen to us as well, clearly, and that's why we have defensive and offensive SEW, Space and Electronic Warfare.

Student: I have a question on what you said before about being able to run the war off the local area network systems. Doesn't that have the detriment of making the session activities more vulnerable?

Tuttle: To what kind of activities?

Student: Some sort of sabotage, if it's on a network system.

Tuttle: When I'm at sea, I don't have a sabotage problem. But incidentally, I'm glad you brought that up because of what has occurred. There are five components necessary for multilevel security and trusted systems. What we really need is the capability to put Top Secret, Secret, Confidential, and privileged information on the same fiber optic LAN and workstation. We have now, a B-1 level trusted system that will demonstrate, for the first time ever, a system (not just one of the components — file server, LAN, processor, etc.), so it will be able to run all those types of information at the same time.

Oettinger: The B-1 is not a bomber in this context; it's a standard for trusted systems promulgated by NSA and NIST.

Student: Fairly weak, but better than commercial.

Tuttle: That's correct. In fact, they are a part of our big team. In fact, NSA gave me a gentleman I have, a lieutenant commander, who has a brilliant mind. He knows more about multilevel security and trusted systems than any other person I know. He has worked with NSA and has written the DOD policy on MLS and trusted systems.

Student: Is this Joe Lubis?

Tuttle: No, Don Hangerling, who knows more about multilevel security and trusted systems than anyone else that I am aware.

Oettinger: You don't say anything about RPVs (remotely piloted vehicles) or the differences they make for personnel deployment and weapons and so on.

Tuttle: I don't because, and I hate to admit it, another organization has responsibility for RPVs and I haven't got involved yet, but I should as we use the sensor data. RPVs, of course, have been an emotional issue forever. The range, sensor package and time on station requirements vary so greatly amongst the various potential users.

One's position depends on where they stand, i.e., where you sit is where you stand. The CINC wants theater coverage: long stay times — eight weeks, a vacuum sweeper. If you ask the guy on the bridge, he just wants to know if he can do gunfire spotting. Then you've got the battle group commander who wants all weather. He wants IR (infrared). He wants the RPVs to be stealthy, the IR to cover both the 3 to 5 microns and the 8 to 12 microns spectra, etc. He wants a low cross section area. He wants it for reconnaissance and for battlefield surveillance. The requirements will determine the aerodynamics, stay time, sensor package, etc. Every time we have a conflict, we go get a Pioneer or something else off-the-shelf that's already been built, and then tailor the sensor package.

Oettinger: The thing that cannot be overemphasized is the degree to which these changes in information technology are opening options. That is, all the received notions about what is good — not so much the basic principles, if you go back to Coakley* and all that, but the basic details of how you do it and with what kind of weapons and what kind of people with what kind of skills — are up for grabs. It all needs thinking through afresh because you've got options that simply did not exist five years ago. What Jerry has shown is increasing capability coupled with a decrease in cost, which is a remarkable thing. You usually get increased capability for increased costs coupled with decreased reliability. It is a very unusual technology where cost goes down while performance and reliability go up, and in some of them do a hell of a lot for you. I mean, it's just a bunch of stuff, which is why people tend to dismiss it as, "ah, another technology trick." The key is that these technology tricks call into question every detail of how one goes about normal military or industrial business.

Tuttle: That's exactly right. And all that I have discussed exists, except for the 20 meg for high definition television, and is going to sea now and being upgraded with each succeeding deploying carrier battle group.

We do not buy 300 of any C^{3}I suite for however many ships we have. We build our C^{3}I suites on a building block strategy. We start with a local area net in the ship, add the latest processors as they become available and make continuous software upgrades in an ongoing iterative fashion. So every time that a carrier battle group deploys, every six months, from either coast, we have increased its C^{3}I capability by a quantum jump.

Student: Admiral, how do you answer critics who say, "What we have now is good enough"?

Tuttle: It is difficult to respond to the uninformed and misguided. If they truly feel that way then let them live with what they have. I have no time to concern myself with naysayers because I have heard naysaying (by the professionals, I might add) for 13 years. You either accept the things as they are or you step forward and accept the responsibility to change it. When I went to sea to command a carrier battle group, I could not command anything. I had some of the most intelligent kids in the world trying to put schedules together. They stayed up all night, their eyes looked like roadmaps, and they still didn't get the job done. I didn't know anything about computers, but knew that I needed automation for nontactical use and a tactical decision aid.

The critics have been there, and they always will be, but I take great satisfaction in the knowledge that I have contributed to the use of satellites and computers in the conduct of Naval Warfare.

Student: I have two questions. Can you talk about interoperability between the Navy and the other services? And also, how does this compare to what exists with the other countries, and what does that do to military situations vis-à-vis us and a potential adversary?

Student: One other question to tag onto that. It's not just interoperability between the services, but if your change in carrier battle group systems doesn't go out, you've got interoperability problems with yourself.

Tuttle: We have made great strides in DOD and in all of the services to achieve interoperability by common standards and a common operating environment.

There is a fantastic forum called the Military Communications and Electronics Board, composed of all the services and agencies and chaired by the J-6-JCS. This body has been primarily responsible for the tremendous progress made in C^{3}I systems interoperability.

Oettinger: I just want to contrast for the class some of the discussion yesterday with the discussion today. Same question: technical standards? If you have turf problems, you use the technical standards as a barrier, as an excuse, as a shield, as a tool for infinite obfuscation. If you want to get something done, use the technical standards as a weapon and get it done. You have now heard concrete examples, over two days, of both approaches.

Student: What does Ada serve? That's a software . . . ?

Tuttle: It's a programming language.

Student: And you are at the point now where you are the only users?

*Thomas P. Coakley, *Command and Control in War and Peace*. Washington, D.C.: National Defense University Press, 1991.

Tuttle: DOD is the principal user of Ada.

Oettinger: It was developed at great expense over a period of years for Defense Department use. A very high-minded, noble, useless set.

Student: Admiral, you mentioned that you were a battle group commander about 10 years ago. Could you describe how you would today be a battle group commander given the kind of equipment that you, yourself, have put out into the fleet? How would this new generation of stuff have modified your command and control spot?

Tuttle: Well, frankly we have invented our future. The battle group commander today resides in a different C^3I universe than I between 1981 and 1985. Almost all the battle group commanders today have a far greater grasp of and an appreciation for C^3I systems. We have created a new community. We have created an entirely new warfare area. We call it Space and Electronic Warfare — the first new warfare area in 70 years. It should more appropriately be called Information Warfare.

Oettinger: Thank you, sir.

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