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A Cost-Benefit Analysis of Shipboard Telemedicine

Federico Garcia • Peter H. Stoloff

Center for Naval Analyses
4401 Ford Avenue • Alexandria, Virginia 22302-1498

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Laurie J. May, Director
Medical Team
Support Planning and Management

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Federico Garcia, Peter H. Stoloff

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In this study, we estimate the peacetime demand for telemedicine (TM) for ships at sea. We estimate the savings that would accrue if telemedicine technology were available to the entire fleet. These savings would result from avoiding medical evacuations (MEDEVACs) and sick-in-quarters (SIQ) days. We consider several implementations of telemedicine and measure the monetary costs and benefits of each. Where we are unable to attach a monetary value to a particular benefit, we quantify it in other ways. Telecommunications is a central component of telemedicine. We estimated the bandwidth requirement for different shop types based on the demand for telemedicine consulting.

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A Cost-Benefit Analysis of Shipboard Telemedicine

Federico Garcia
Peter Stoloff

CNA

Issues

- ❑ What is the potential TM workload?
- ❑ What are the potential savings from TM?
  - MEDEVACs
  - SIQ days
- ❑ What configurations of telemedicine are cost-effective?
- ❑ What is TM's bandwidth requirement?

In this study, we estimate the peacetime demand for telemedicine (TM) for ships at sea. We estimate the savings that would accrue if telemedicine technology were available to the entire fleet. These savings would result from avoiding medical evacuations (MEDEVACs) and sick-in-quarters (SIQ) days.

We consider several implementations of telemedicine and measure the monetary costs and benefits of each. Where we are unable to attach a monetary value to a particular benefit, we quantify it in other ways.

Telecommunications is a central component of telemedicine. We estimated the bandwidth requirement for different ship types based on the demand for telemedicine consulting.

Overview

- Scope
- Method and data
- TM workload
- Impact on MEDEVACs
- Cost-effectiveness
- Bandwidth requirement

This slide shows an overview of the topics we covered in our analysis. As a preamble, let's define telemedicine and the scope of the study.

Defining Telemedicine

- Uses technologies for communicating health services information when distance separates participants
- Allows transfer of information between platforms at sea and medical facilities ashore
- Combines
  - Health services
  - Telecommunications and computer technology

Telemedicine (TM) is the use of communication technologies to support health care when distance separates the participants. It allows the transfer of medical information between platforms at sea and medical facilities ashore. TM is an umbrella of technologies, not a specific technology.

Telemedicine makes it possible for physicians and other health care providers to see patients and share diagnostic information in geographically dispersed areas. Performing consultations in this manner increases ships' access to specialized medical resources. It has the potential to improve the quality of care for deployed sailors and Marines.

Some Uses for Telemedicine at Sea
(in peacetime)

- Consultation with specialists
  - "See" patients
  - Share diagnostic information
- Health promotion
- Distance learning
- Access to medical data
  - Reference material
  - Electronic patient records

Telemedicine technology has the following uses:

•**Consulting**. The greatest potential for telemedicine is in medical consulting.

•**Health promotion**. Land-based specialists could track a rise in the incidence of a disease aboard a ship or disseminate preventive health care literature. Telemedicine could ease the sense of isolation of at-sea medical providers from the rest of the medical community.

•**Distance learning**. Onboard medical staff could download instructional and reference materials.

Although not part of the scope of our study, providers at sea could use telemedicine technology to access databases containing electronic patient records. Providers at sea could have access to patients' medical records with digital images of X-rays and other diagnostic data.

Scope of Study

- Modalities of telemedicine
  - Telephone and fax
  - E-mail and Internet connectivity
  - Video teleconferencing (VTC)
  - Teleradiology
- Digital diagnostic equipment

We analyzed four telemedicine technologies.

E-mail provides the ability to send and receive E-mail with attachments, such as digitized medical images. Used in conjunction with a digital camera, E-mail allows the transmission of pictures and videos in store-and-forward mode.

Internet connectivity allows for posting and retrieving pictures and videos and searches of medical resource materials on the World Wide Web.

VTC refers to real-time, full-motion, audio and video teleconferencing.

Teleradiology consists of adding a digitizing scanner to existing X-ray equipment. We did *not* analyze computed radiology, which uses filmless X-ray technology.

A variety of digital diagnostic instruments can enhance TM consultations. We analyzed the cost-effectiveness of the following **instruments**: dermascope, ophthalmoscope, otoscope, stethoscope, endoscope, EKG/defibrillator, and ultrasound.

We did *not* include administrative automation systems (such as CHCS) in our analysis.

Overview

- Scope
- ⇨ Method and data
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Next, we discuss our method for estimating the demand for telemedicine. We also discuss the data and how we determined the costs and benefits of implementing the technology.

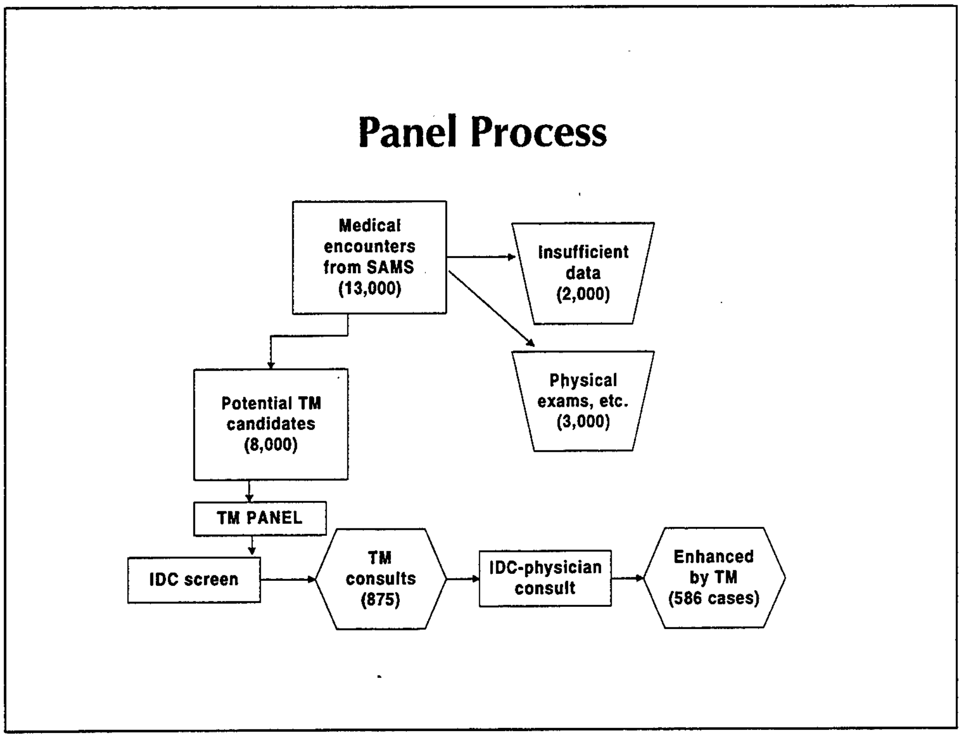
Methodology

- Senior Medical Department Representatives (SMDRs) in LANT and PAC reconstructed Sep 95-Aug 96 MEDEVACs
  - Response rate was 52% (62 of 120 ships sampled)
- Panel of experts (physicians and IDCs) estimated
  - Applicability of TM from about 13,000 individual medical encounters from SAMS
  - Potential reduction in SIQ days
  - Potential enhancement in quality of care
  - Need for add-on digital instruments

We developed a self-administering survey mainly for the purpose of reconstructing MEDEVACs. Fleet Surgeons from the different TYCOMs distributed the survey to ships' medical departments. We asked for ships that had deployed at least 90 days during the analysis period. MEDEVAC information consisted of patient diagnosis, destination, means of transportation, and potential effect of TM in avoiding the MEDEVAC.

Fleet Surgeons also asked ships to submit Snap Automated Medical System (SAMS) data. We looked at the medical encounter information on SAMS. SAMS reports sick bay visits on an individual basis. Our SAMS data included ICD-9, patient symptoms and relevant medical history, prescribed treatment, light- or no-duty days recommended, and referral for follow-up treatment. We used this information to determine the need for consulting with a specialist, and the potential benefits arising from the consultation.

Because some of the telemedicine technology is new, few fleet medical personnel have actually used it. We convened a panel of physicians and Independent Duty Corpsmen (IDCs) familiar with the technology to review the SAMS data and estimate some of the benefits of telemedicine.



Our SAMS data consisted of 13,000 medical encounters from a representative sample of ships. We screened out 2,000 encounters with too little detail and 3,000 encounters with no applicability of TM, such as physical exams and common colds.

We passed on the remaining 8,000 cases to a group of IDCs. The IDCs selected the cases for which they thought a consult with a specialist would help establish or confirm a diagnosis or treatment path (regardless of which TM modality). The IDCs considered the ship type and its available medical resources in determining the need for a consult. The IDCs then presented 875 cases requiring a consult to Navy physicians (by specialty) to determine the possible role of TM.

TM Panel of Experts

	Background/Specialty	Rank	Command
Physicians	Fleet Medical Officer	CAPT	SURFPAC
	Professor, Dermatology	CAPT	USUHS
	SMO (CVA)	CDR	USS George Washington
	Former SMO (CVA)	CDR	BUMED
	Director, MIDN Project	CDR	NNMC
	GMO, SW	LT	BUMED
	Internal Medicine	Civilian	NNMC
IDCs	Analyst, MIDN Project	HMC	NNMC
	Corpsman, SW	HMC	BMC Arlex
	Corpsman, SW	HM1	BMC Arlex
	Corpsman, SS	HM1	Washington Navy Yard

This slide lists the members of the panel of experts. The panel included seven physicians and four IDCs. The panel had Fleet and BuMed representation. All panel members had experience with TM as either providers or "consumers" of telemedicine consulting.

Other Data

- MEDEVACs
  - Aircraft flying costs (fuel, repairs, and maintenance)
  - Ship steaming costs
  - Personnel costs
  - Aircraft hazards
- TM equipment costs
  - Off-the-shelf prices
  - NMIMC factors for installation, maintenance, training, and supplies
- Communication costs (INMARSAT)

We complemented the survey and SAMS data with the following information.

Aircraft. We collected other data to support the analysis, including hourly flight cost of aircraft that typically conduct MEDEVACs attributable to the following:

- Fuel
- Depot-level repairables
- Maintenance.

Ships. We also obtained data to estimate the cost of ship diversions and returns to port, including the following:

- Petroleum, oil, and lubricants
- Repair parts
- Direct depot maintenance
- Nonscheduled repair.

TM equipment. We used off-the-shelf prices for TM equipment. Prices varied widely, but we chose products in the lower end that are currently in use by the military. We added the cost of installation, maintenance, training, and supplies from information supplied by the Navy Medical Information Management Center (NMIMC).

INMARSAT. In the event that ships' communications would not be available for telemedicine, we considered the alternative of a commercial satellite. International Maritime Satellites (INMARSAT), a commercial satellite system, provides relay of voice and data communication. INMARSAT costs $4.00/minute for 9.6-kbps voice transmission and $10.00/minute for 64-kbps data transmissions.

Measuring Benefits and Costs

- Net present value of investments
  - Five-year life cycle, discounted
- Some benefits do not have measurable monetary value
- Includes lost productivity of personnel
- Excludes sunk costs (for example, MEDEVACs on non-dedicated transport)
- Projection of estimates to entire Navy based on ships' employment and manning

We discounted future benefits and costs to transform gains and losses occurring in different time periods to a common unit of measurement. In general, investments with a positive net present value are desirable because the benefits outweigh the costs.

We assigned monetary values to benefits and costs—whenever possible. For benefits with no direct monetary value, such as quality-of-care enhancements, we provided measures of their effect.

We ignored sunk costs, such as MEDEVACs:

- Conducted on the mail run
- Logged as training hours.

These airlifts would have occurred in the absence of the medical emergency and, therefore, do not represent potential savings due to telemedicine.

Because our data are based on a sample of ships, we scaled up the savings estimates to the entire Navy. We used scale factors based on ship employment and manning.

Assumptions

- Fleet initiatives (IT-21) will provide computers and software
- Access to ships' communications may be problematical
  - Two scenarios: With and without INMARSAT
- Shore infrastructure cost *not* included

We assumed that IT-21 would provide for local area networks afloat, as well as off-the-shelf personal computers with communications software. IT-21 would also extend the satellite communications capabilities to provide each ship with sufficient computing capacity to support the TM equipment we investigated.

In the absence of the necessary bandwidth, medical departments may have to buy satellite time. Many ships are currently using INMARSAT for some of their transmissions.

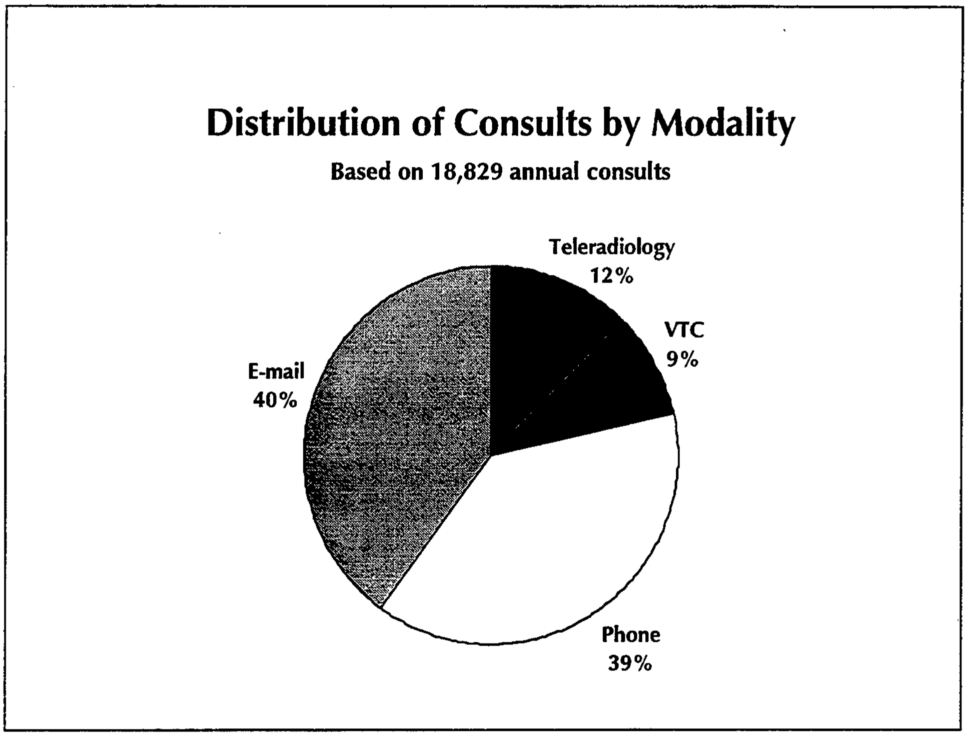
We did not consider the cost of developing a shore infrastructure, or "catcher's mitt," to support telemedicine consults. Members of the medical panel had some insights as to the general process for telemedicine consulting. They envisioned consults going to a centralized point and then being electronically relayed to a medical duty officer of the appropriate specialty.

A prototype for this setup is the Telemedicine Multimedia Integrated Distributed Network (MIDN). This network currently supports remote clinical consultations with ships at sea and the Naval Academy. MIDN channels TM consulting, drawing from existing medical resources.

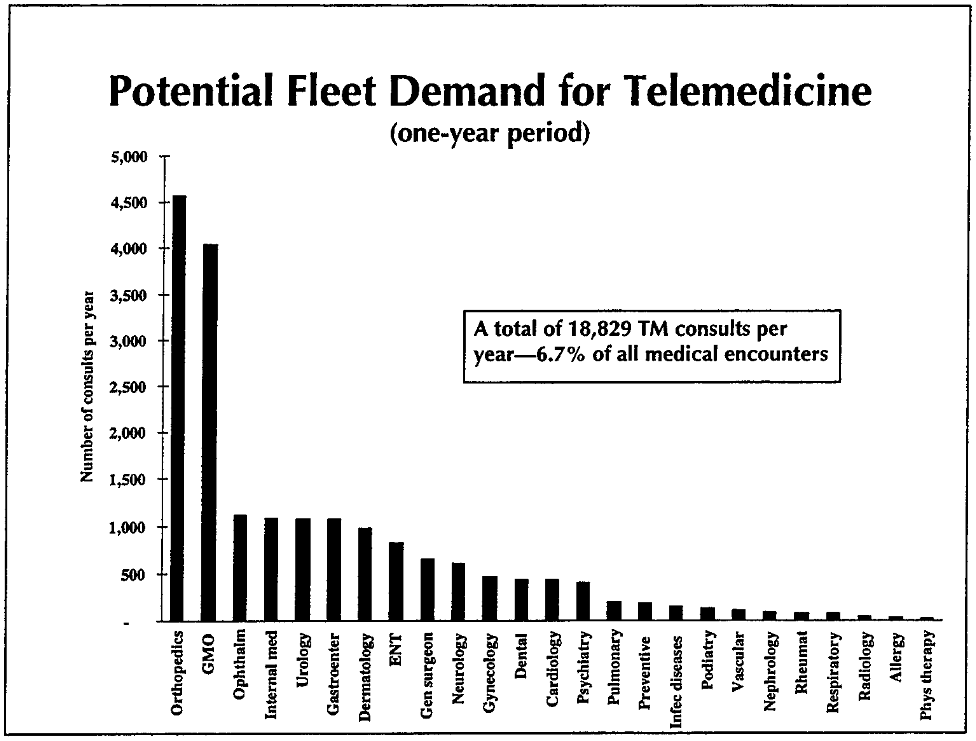
Overview

- Scope
- Method and data
- ⇨ TM workload
- Impact on MEDEVACs
- Cost-effectiveness
- Bandwidth requirement

We now present our findings. First, let's look at our estimates of the demand for telemedicine.



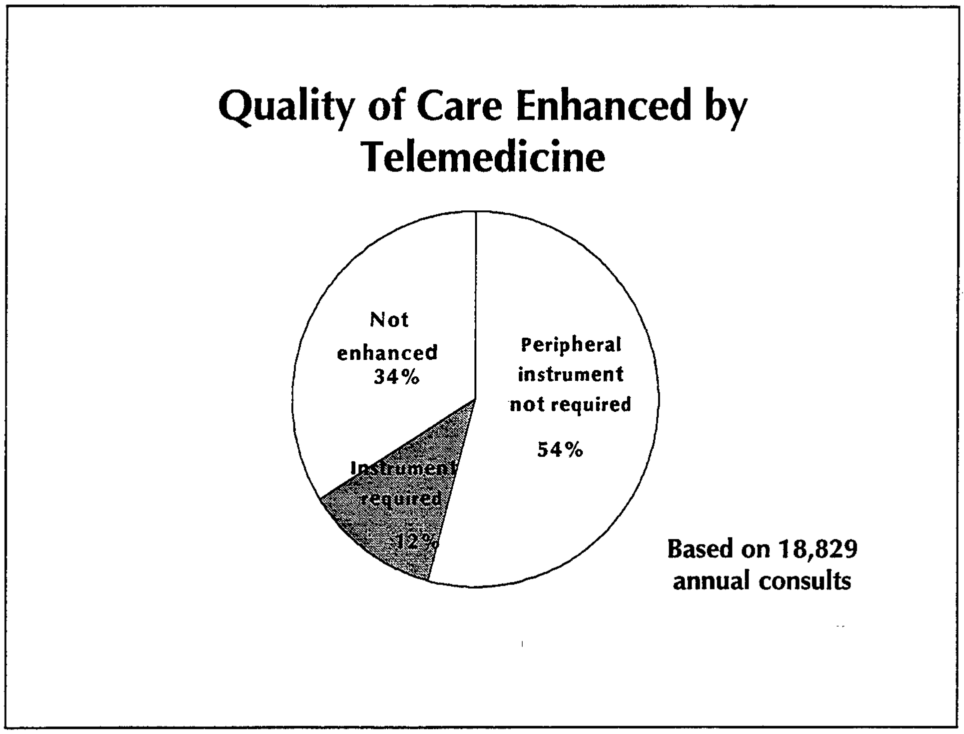
We estimate that, if the technology were available to the entire fleet, there would be over 18,500 telemedicine consults per year. The majority of these consults (79 percent) would use the less technologically sophisticated TM modalities of E-mail and telephone.



This slide shows the estimated annual number of consults for particular medical specialties. Not all consults require a specialist. Twenty-one percent of the consults would be with a GMO—physicians aboard large ships could handle these consults.

Orthopedic consults account for the largest group of referrals requiring a specialist (24 percent). Ophthalmology accounts for the second largest group of referrals to a specialist (6 percent).

We estimate that 6.7 percent of all sick bay visits could potentially result in a TM consult.



We estimated that two-thirds of TM consults would result in improved quality of care. Of those, over 80 percent do not require any add-on digital instrument. For the rest, the consultants felt that a diagnostic instrument (such as a digital dermascope for magnified views of skin tissue) would be required. Nonetheless, the lack of such instruments aboard ship would not necessarily reduce the demand for TM consults.

Overview

- Scope
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- ⇨ Impact on MEDEVACs
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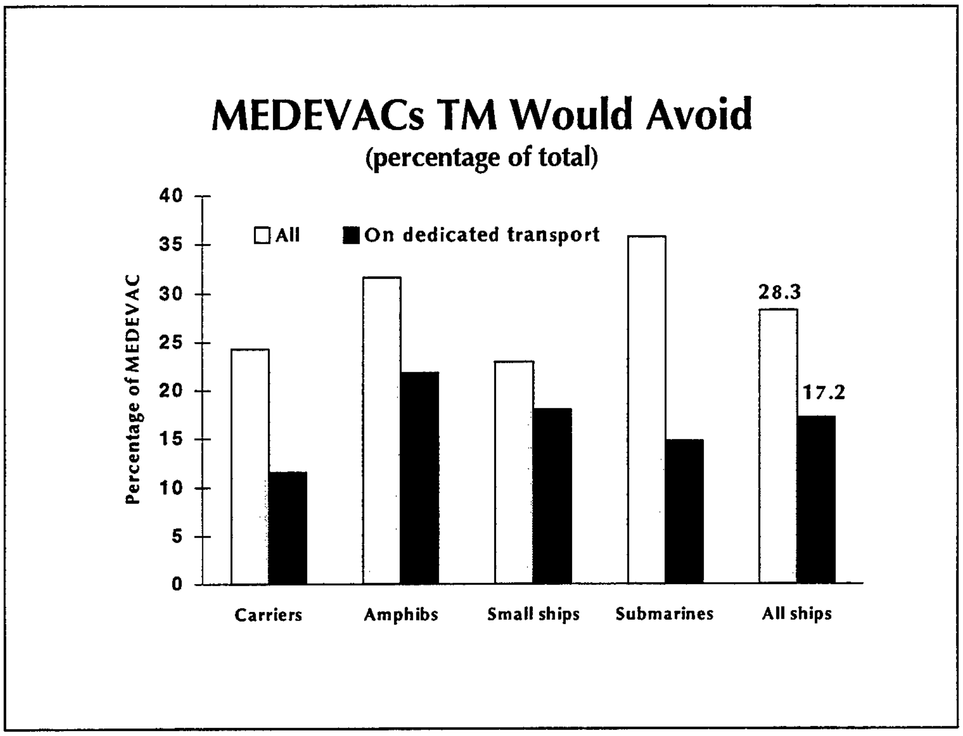
- Bandwidth requirement

Now, we look at the role of telemedicine in MEDEVACs.



Based on our survey of ship medical departments, we estimated that Navy ships evacuated 911 patients during the 12-month period from 1 September 1995 to 1 September 1996. Not all MEDEVACs are avoidable. Many are related to orthopedic injuries (such as broken bones) and psychiatric illnesses (such as attempted suicides). Fleet policy is to evacuate personnel with these conditions. Intervention with TM would not avoid these MEDEVACs. On the other hand, many MEDEVACs result when a ship's medical department does not have the resources for a proper diagnosis.

This figure shows the MEDEVACs that, according to the SMDRs, could have been avoided if TM had been available to aid in the diagnosis and treatment of patients. We highlight avoidable MEDEVACs conducted on *dedicated* transport (17.2 percent) because these generate savings.

Potential MEDEVAC Travel Avoided

(one-year period)

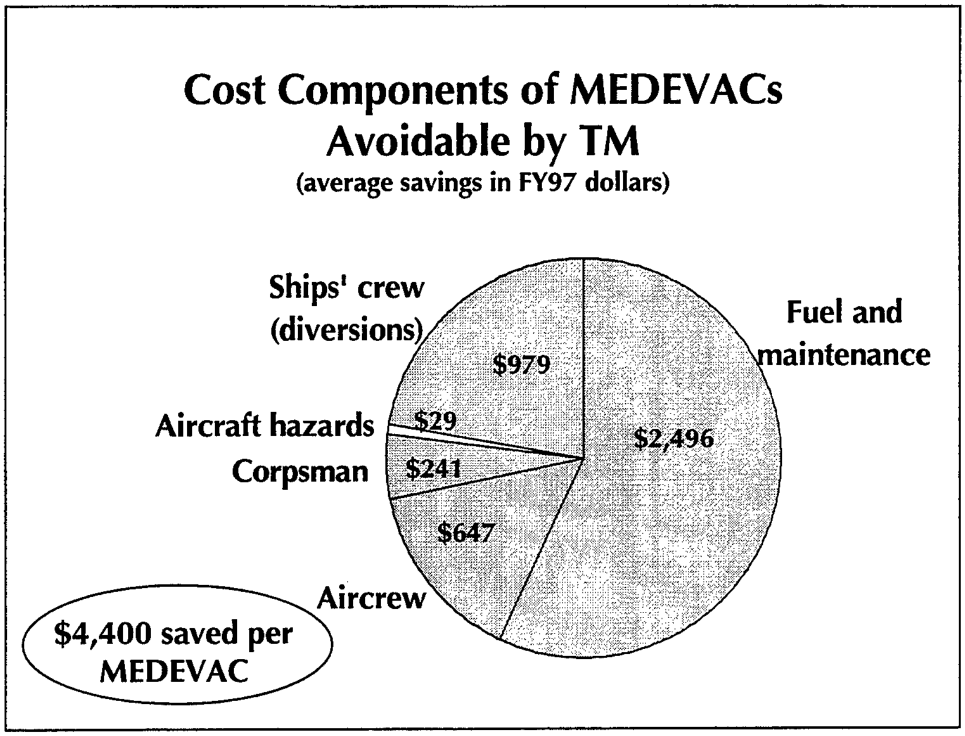
Mode of transport	Miles
Fixed wing	147,217
Helo	8,154
Ship	905

Avoiding MEDEVACs also eliminates a considerable amount of travel. The mode of transport to the immediate destination is distributed as follows:

- Fixed wing: 64 percent
- Helicopter: 29 percent
- Ship diversions: 6 percent
- Returns to port: 1 percent.

Based on data for seven helicopter and three fixed-wing airframes, the average one-way distance of a MEDEVAC was:

- Fixed-wing: 466 miles
- Helicopter: 68 miles.



We divided the cost components of avoidable MEDEVACs into the following categories:

- **Fuel and maintenance** account for more than half of the costs.
- **Corpsman** refers to medical staff escorting evacuated patient.
- **Ship diversions** refer to pay of ship personnel diverted or returned to port.
- **Aircrew** refers to pilot and aircrew pay.

We applied the probability of occurrence of an aircraft safety **hazard** to the fixed-wing and helicopter travel miles potentially avoided by TM. Hazards cost up to $10,000 and include localized fires and electromagnetic interference causing loss of a signal. We obtained aircraft hazard data from the Navy Safety Center.

MEDEVACs That TM Would Expedite and Facilitate

(percentage of total)

Platform	Expedite (%)	Facilitate decision (%)
Carriers	20	38
Amphibs	14	37
Small ships	36	57
Submarines	9	50

Arranging for a MEDEVAC requires planning and coordination between the ship's medical staff and the receiving facility. TM expedites MEDEVACs by routing patients to appropriate sources of care and forwarding data to the receiving facility. Consulting by TM reduces uncertainty, making the decision to MEDEVAC less arbitrary.

Overview

- Scope
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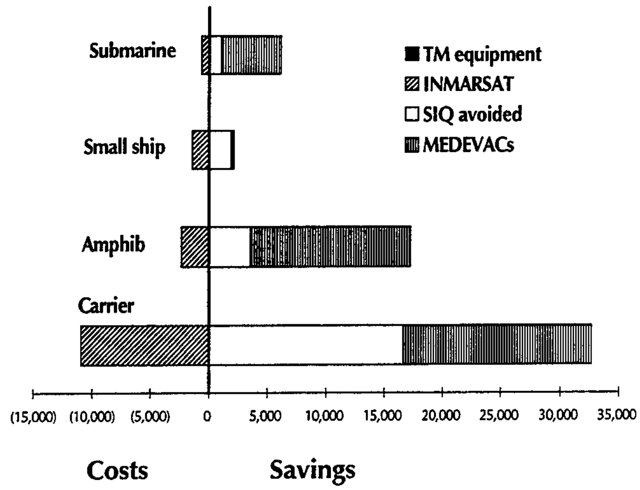
- Impact on MEDEVACs
- ⇨ Cost-effectiveness
- Bandwidth requirement

Now, let's look at the cost-effectiveness of each of the TM modalities.

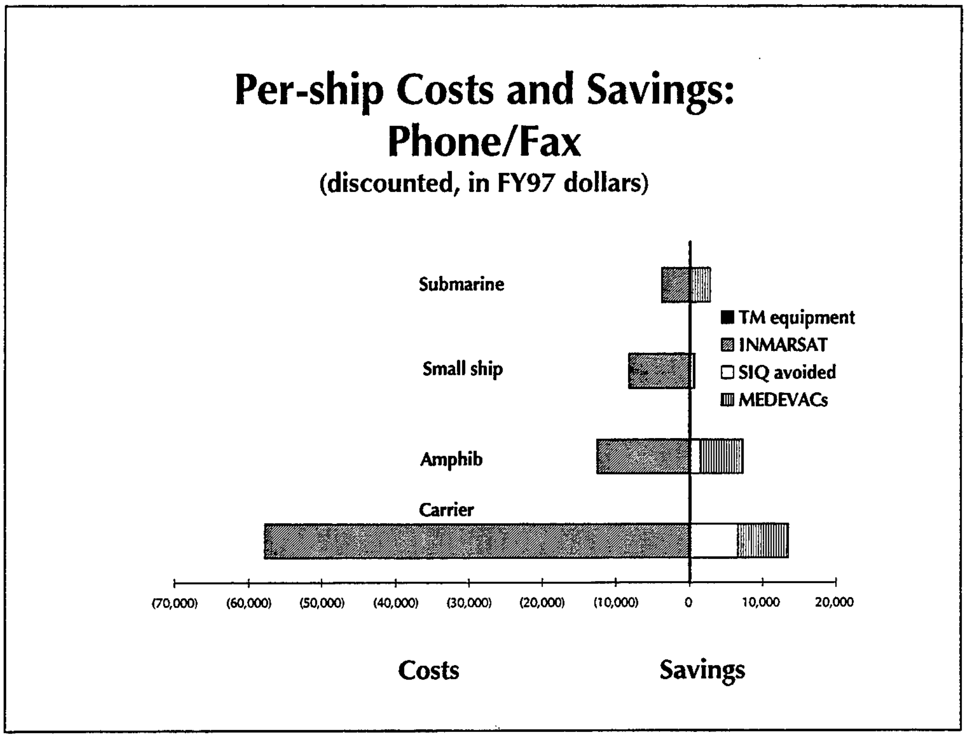
Per-ship Costs and Savings: E-mail/Internet

(discounted, in FY97 dollars)

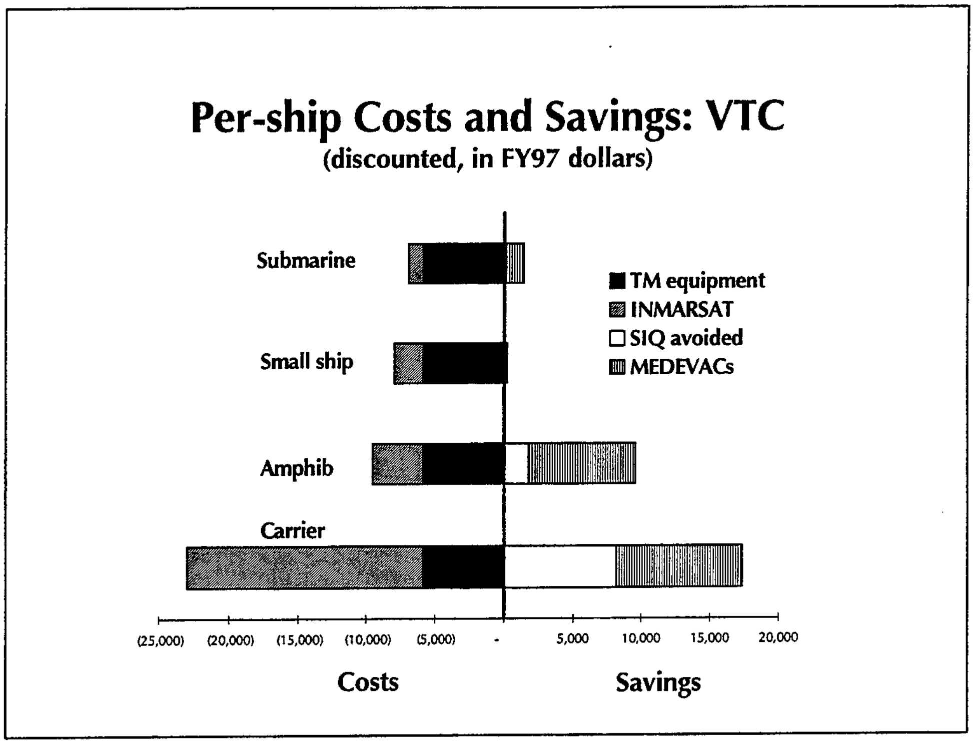


This slide and the next three show the costs and savings associated with implementing each TM modality. On each chart, we show the costs as bars to the left of the horizontal axis. The costs have two components: equipment (solid black portion) and communications (INMARSAT) (striped portion). The savings are to the right of the horizontal axis. The solid white part of the bar represents the recouped pay of sailors avoiding SIQ due to the intervention by TM. The striped part represents the avoided MEDEVACs. We estimated the costs and savings in FY 1997 dollars over the 5-year life cycle of the technology. We show estimates for each of the four ship types.

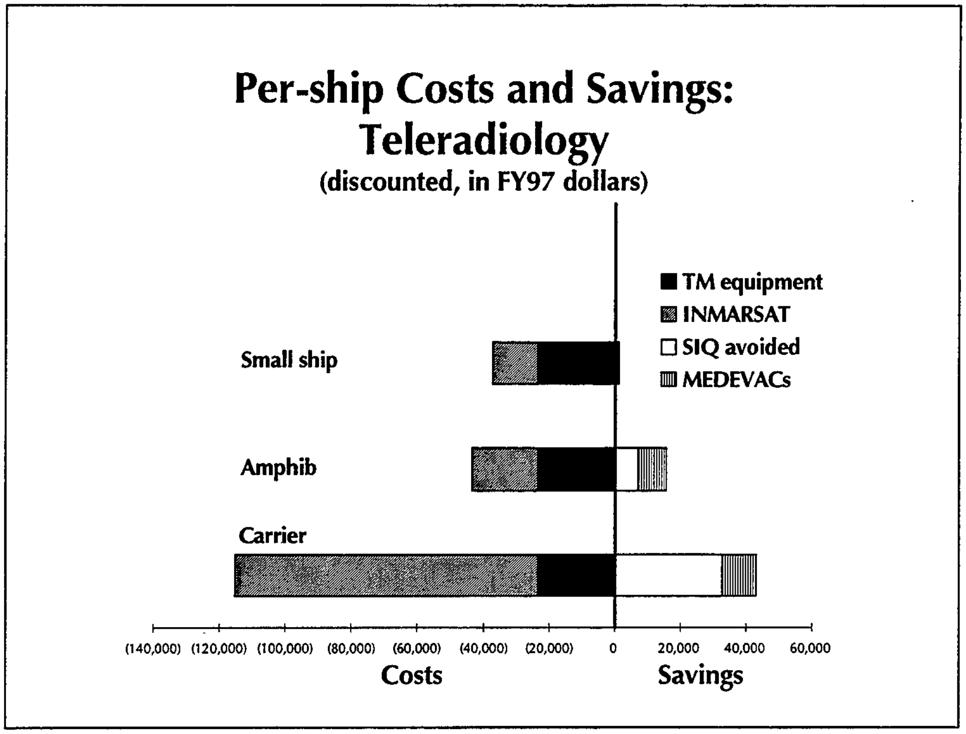
E-mail and Internet connectivity would be cost-effective on all platforms, even if ship's communication were unavailable (and INMARSAT were used). Note that the cost of equipment for E-mail/Internet is negligible.



This slide shows the costs and savings associated with providing ship medical departments with a telephone and a fax. We assumed that each consult would require a 30-minute call. If a commercial satellite is used, this modality would not be cost-effective on any ship platform. If the ships' communications resources are used, phone and fax would be cost-effective on all platforms.



Video teleconferencing is not cost-effective on any platform if a commercial satellite is used. If own ship's communication were available, VTC would be cost-effective on the large platforms (carriers and amphibious ships) only.



When ship's communications are used, teleradiology is cost-effective on aircraft carriers only. When INMARSAT is used, teleradiology is not cost-effective on any platform.

This slide shows estimates of savings through the use of teleradiology on small ships, although these ships currently do not have the required film X-ray equipment. The potential teleradiology savings are limited on small platforms, and would not justify the investment of an X-ray machine solely to support teleradiology. We did not consider teleradiology for submarines because of their space limitations.

Per-ship Net Present Value of Instruments

(5-year period, in FY97 dollars)

	Stetho-scope	Ophthal-moscope	Derma-scope	Ultra-sound	Defibr./ EKG	Oto-scope	Endo-scope
Carrier	6,788	5,621	2,513	(1,300)	(2,987)	(3,965)	(5,874)
Amphibious	2,317	232	(226)	(1,971)	(4,601)	(3,965)	(5,874)
Small ship	(1,309)	(2,938)	(1,021)	(2,758)	(6,478)	(3,305)	(5,628)
Submarine	(2,041)	(2,281)	(732)	(2,937)	(6,608)	(2,648)	(5,874)

Here, we look at the cost-effectiveness of digital diagnostic instruments. The numbers in parentheses are *negative* savings (that is, the costs exceed the savings). The demand for these digital instruments is relatively small. Only the stethoscope, ophthalmoscope, and dermascope are cost-effective on the large platforms. The other instruments are *not* cost-effective on any platform.

Overview

- Scope
- Method and data
- TM workload
- Impact on MEDEVACs
- Cost-effectiveness
- ⇨ Bandwidth requirement

In the next section, we look at the bandwidth requirement for implementing TM on ships at sea.

TM Bandwidth Requirement

(minutes per month)

	Asynchronous	Synchronous	
	S&F (64k)	Phone/Fax (9.6k)	VTC (128k)
Carriers	166	191	160
Amphibious	36	42	35
Small ships	1	50	0
Submarines	1	20	0

- **Nine hours/month on carriers**
- **About 1% of the bandwidth**

Store-and-forward (S&F) transmissions include E-mail messages on all platforms and X-ray transmissions on carriers and amphibious ships. We assumed a 64-kbps pipe for S&F transmissions. Real-time communications include phone on all platforms and VTC on carriers and amphibious ships.

Would providing the medical departments access to the ships' communications capabilities place a burden on the available bandwidth? No. For example, for carriers, where the largest volume of transmissions would take place, telemedicine would require less than 1 percent of a month's time.

Conclusions

- Potential demand of 18,000 TM consults per year
  - 7% of sick-bay visits
- Enhance quality of care in 67% of consults
- Avoidance of 28% of MEDEVACs, 17% dedicated
  - About 155,000 miles per year
  - About $4,400 per MEDEVAC
- Reduction of 0.42 SIQ days per consult
  - Up to 7,900 man-days per year

This slides summarizes our findings. Here, we focus on the demand for and potential benefits of implementing telemedicine in the fleet.

From the sailor's perspective, it would improve the *quality of life* aboard ship.

From the Fleet Commander's perspective, it would improve *readiness* by:

- Increasing availability of aircraft
- Keeping sailors on the job.

Conclusions (Continued)

Modality	Ships' comms	INMARSAT
E-mail/Internet	All platforms	All platforms
Phone/Fax	All platforms	None
VTC	Large platforms	None
Teleradiology	Carriers	None

Work with Fleets to provide access to communications

This slide summarizes the cost-effectiveness of the four modalities of telemedicine on the different platforms. Access to ships' communications is essential for telemedicine to be cost-effective.

The Navy should reevaluate fleet policy for assigning communication priorities aboard ships. Providing ship's medical departments with their "fair share" of the bandwidth to support telemedicine would result in savings from avoided MEDEVACs and reduced SIQ days. It would also improve sailors' quality of life.

Ponderables

- Per-ship net savings relatively small
  - Range from ±$35K (excluding INMARSAT)
  - Does *value* of quality of life make investment cost-effective?
- Costs are highly variable
  - Wide range of equipment costs—Will low-cost alternatives suffice?
  - Availability of ships' communications uncertain
  - We assume Fleet will provide computers (IT-21). If not, will existing computers suffice?

To put the results of the study in context, we need to consider the following issues. Telemedicine's net costs and savings per ship are relatively small. Over the 5-year life cycle of the technology, the net monetary savings on any platform are plus or minus $35,000. (These figures pertain to the scenario in which own ship's communications are used.) This is a relatively small sum of money in a ship's budget.

We observed a wide range of costs associated with any given type of telemedicine equipment. We chose the low end of the spectrum. However, given the declining prices of technology over time, the prices we used may be those of mid-range equipment in a few years.

Access to ship's communications is essential for cost-effective telemedicine. Giving medical its fair share of the bandwidth to support telemedicine would enhance fleet readiness.

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SNDL

Attn: MED-08B CAPT Midas
Attn: MED-82 CAPT Durm

C34F NAVMEDCLINIC LONDON DET LANDSTUHL GE
Attn: Commanding Officer

C52E NAVMEDATASERVCEN DET SAN DIEGO
Attn: Commanding Officer
Attn: Ophthmology Department

FB58 NAVHOSP OKINAWA JA
Attn: Commanding Officer

FC17 NAVHOSP NAPLES IT
Attn: Commanding Officer

FH20 NAVHLTHRSCHCEN SAN DIEGO CA
Attn: Commanding Officer
Attn: Technical Director

FKN3 OICC NAVHOSP PORTSMOUTH VA
Attn: Commanding Officer

FW1 NATNAVMEDCEN BETHESDA MD
Attn: USUHS CAPT Vindmer
Attn: Internal Medicine Department Dr Millman
Attn: Radiology Department CAPT Thomas
Attn: CAPT Dieffenbach
Attn: Commanding Officer
Attn: Telemedicine Department CAPT (Sel) Bakalar
Attn: NMIMC CAPT Tibbits
Attn: NMIMC LT Pettit
Attn: NMIMC LT Cunningham

MISC MISC
Attn: HQ USAF/SG
Attn: US Army Surgeon General
Attn: Director, Telemedicine Project CDR CF Faison
Attn: Tripler Army Medical Center, Commanding Officer
Attn: Commanding Officer/AKAMI Project

OASD OASD (HA/CS)
Attn: Principal Deputy Dr. Martin

V12 CG MCCDC QUANTICO VA
Attn: Code C-392 CAPT Frank

SNDL

OPNAV
N093M
Attn: RADM Diaz
Attn: CAPT Stoddard
N6

N62M
Attn: CDR Ferraro
Attn: LCDR Tillery (N62M4)
N813
Attn: CDR Balistrari
N931
Attn: RADM Phillips