



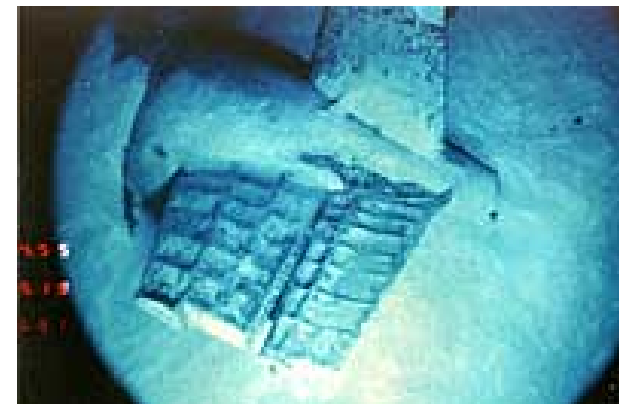
Photo # NH 97557 Upper rudder of the sunken USS Thresher, photographed by USNS Mizar, 1964



Submarine Safety

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Disclaimer

**This presentation does not
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Submarine Losses

United States

Combat Losses (WWII)	41 submarines, 3044 crew lost
Accidents/Perils of the Sea	18 submarines, 765 crew lost
Accidents without loss of boat	16 submarines, 101 crew lost

US Submarine Force had the highest casualty rate of any branch of the US Military in WWII. 33% death rate

The German Navy, by comparison

Combat Losses	753 submarines
Sunk along side piers	350 submarines

75% of all WWII German submariners died in the conflict. Of the German submarine officers on duty at the beginning of WWII, 97% were dead by the end of the war.

The United Kingdom has lost 171 submarines since 1904.

Russia has lost 5 – 10 nuclear and at least 3 conventional submarines from 1960 to the present, with at least 12 others having major casualties.

Basic Precepts

The nuclear submarine program and the Naval Reactors/Naval Nuclear Propulsion Program (NR/NNPP) (hereafter collectively referred to as NR) are inseparable. The way that NR/NNPP looks at safety is driven throughout all aspects of the submarine program.

Two major factors have influenced the unique approach to engineering in the submarine program:

- 1. Admiral Rickover's approach to using nuclear power as a way to propel ships – with personal accountability given to Congress and no program legacy.**
- 2. Only five people in charge of NR since 1947**
 - Admiral Hyman Rickover**
 - Admiral Kinnaird McKee**
 - Admiral Bruce DeMars**
 - Admiral Frank Bowman**
 - Admiral Kirk Donald**

Great information – www.nasa.gov then search for NNBE (NASA/Navy Benchmarking Exchange, Vols. 1, 2, 3.

Basic Rules of Submarine Safety

“In the submarine environment . . . There is only one way to ensure safety: it must be embedded from the start in the equipment, the procedures, and most importantly, the people associated with the work.”

“The only way to operate a nuclear power plant and indeed a nuclear industry – the only way to ensure safe operation, generation after generation, as we have – is to establish a system that ingrains in each person a total commitment to safety: a pervasive, enduring devotion to a culture of safety and environmental stewardship.”

ADM Bowman

“One must create the ability in his staff to generate clear, forceful arguments for opposing viewpoints as well as for their own.”

ADM Rickover

Failures and the Duties of Engineers

Failures – “the phantasmagoria that haunts the engineer’s nights and dogs his days.”

“The great liability of the engineer compared to men of other professions is that his works are out in the open where all can see them. His acts, step by step, are in hard substance. He cannot bury his mistakes in the grave like the doctors. He cannot argue them into thin air or blame the judge like the lawyers. He cannot, like the architects, cover his failures with trees and vines. He cannot, like the politicians, screen his shortcomings by blaming his opponents and hope the people will forget. The engineer simply cannot deny he did it. If his works do not work, he is damned.”



Herbert Hoover, President of the United States

(The only engineer who has been President)

The Gospel According to HGR

Responsibility is a Unique Concept

**It can only reside and inhere in a single individual.
You may share it with others, but your portion is
not diminished.**

You may delegate it, but it is still with you.

**You may disclaim it, but you cannot divest yourself
of it.**

**Even if you do not recognize it or admit its presence, you cannot
escape it.**

**If responsibility is rightly yours, no evasion, or ignorance, or
passing the blame can shift the burden to someone else.**

**Unless you can point your finger at the man who is responsible
when something goes wrong, then you have never had anyone
really responsible.**



**Admiral Rickover
Inspecting USS Nautilus (SSN 571)**

More of the Gospel



“My program is unique in the military service in this respect: You know the expression ‘from the womb to the tomb’ My organization is responsible for initiating the idea for a project; for doing the research, and the development; designing and building the equipment that goes into the ships; for the operations of the ship; for the selection of the officers and men who man the ship; for their education and training. In short, I am responsible for the ship throughout its life – from the very beginning to the very end.”

Even More of the Gospel

“In accepting responsibility for a job, a person must get directly involved. Every manager has a personal responsibility not only to find problems but to correct them. This responsibility comes before all other obligations, before personal ambition or comfort.



When important decisions are not documented, one becomes dependent on individual memory, which is quickly lost as people leave or move to other jobs. In my work, it is important to be able to go back a number of years to determine the facts that were considered in arriving at a decision. This makes it easier to resolve new problems by putting them into proper perspective. It also minimizes the risk of repeating past mistakes. Moreover, if important communications and actions are not documented clearly, one can never be sure they were understood or even executed. “

The Submarine Environment



As complex as space
ADM Bruce DeMars

The Submarine Environment

- **Los Angeles Class Attack Submarine**
 - Steel tube 365 feet long, 33 feet in diameter
 - Doesn't float very well – 90% of ship is submerged when on the surface
 - Atrocious sea - keeping on the surface
 - Can't walk in a straight line more than about 15 feet
 - Up to 165 people on board
 - 112 bunks, including 6 temporary bunks – each bunk slightly larger than a coffin. >100 people “hot bunk”
 - 2/3 of the internal volume is the nuclear propulsion plant
 - All personnel except 11 at any time are in 90 feet of the hull length
 - Submerged for months in a corrosive ocean
 - Makes its own atmosphere and water
 - **EVERYTHING MOVES!!!**
 - One of only five programs in the military from which women are excluded.
- **All in a fundamentally hostile environment**

The Submarine Environment

- **Consider the hazards and resultant safety issues**
 - Nuclear propulsion plant
 - High pressure steam
 - Numerous sea-connected systems
 - 25,000 valves
 - 150 miles of pipes
 - 1500 miles of electrical cables
 - High voltage, high current electrical systems
 - A lead-acid battery the size of a tractor-trailer
 - Electrolytic oxygen generators
 - 4500 psig air systems
 - 3000 psig oxygen, nitrogen, and hydraulic systems
 - Many weapons containing high explosives and propellants
 - Potential to carry nuclear weapons **(currently not deployed)**
 - Sonar systems that can produce up to very high db levels
 - High power RF systems
 - **Drive your car with the windows covered, listening to the traffic**

Implementation of HGR's Gospel

- Conservatism in design
- Quality in construction, maintenance, and repair
- Appropriate funding for R&D, construction, O&M
- Selection of personnel
- Processes and procedures
- **Verbatim compliance with procedure**
- Education, training, and qualification – **with thorough knowledge for those instances when there are no procedures**
- Personal accountability – “You bet your crow”
- The highest standards for integrity (example)
- Performance - AND compliance - based inspections
- **The standards are the same for senior officers and junior enlisted people**

Recent Examples

USS Thresher (SSN 593) Loss – 10 April 1963

USS Scorpion (SSN 589) Loss – 2 June 1968

USS Guitarro (SSN 665) Sinking - 15 May 1969

USS Baton Rouge (SSN 689) Collision – 11 February 1992

USS Thomas Edison (SSN 610) Collision – 29 November 1992

USS Greenville (SSN 772) Collision – 9 February 2001

USS San Francisco (SSN 711) Grounding – 16 May 2005

Komsomolets K278 Loss – 07 April 1989

Kursk K141 Loss – 13 August 2000

Related Problems

Loss of Challenger – 28 January 1986

Loss of Columbia – 01 February 2003

USS Thresher (SSN 593)

Thresher sank on sea trials from Portsmouth Naval Shipyard, 220 miles off Cape Cod, MA, 10 April 1963. 129 perished. Cause was flooding followed by inability to blow main ballast due to freezing of the lines. It took 8.5 minutes for the ship to slowly descend to collapse depth. Thresher rests in 8,800 feet of water.

This was a watershed event in US submarining.

Photo # NH 91424-KN Insignia of USS Thresher (SSN-593), adopted in 1960



Photo # NH 97562 Sonar dome wreckage from USS Thresher, seen from bathyscaph Trieste, 1963



Photo # NH 97560 Mosaic of sail and other debris of sunken USS Thresher



USS Scorpion (SSN 589)

Scorpion, returning home from deployment, sank 2 June 1968 400 miles from the Azores, in 10,000 feet of water. 99 perished. The cause is believed to be a torpedo hot run from inadvertent battery activation. Much later, it was revealed that Naval Undersea Warfare Engineering Station was aware of the problem, which could lead to inadvertent battery activation.

Photo # NH 97221-KN Stern section of sunken USS Scorpion, 1986

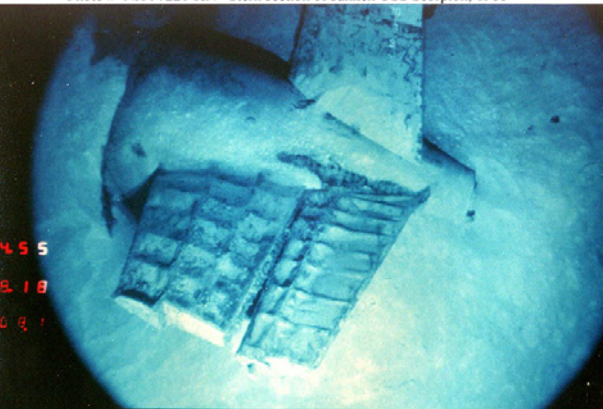


Photo # NH 97222-KN Distorted hull section of sunken USS Scorpion, 1986

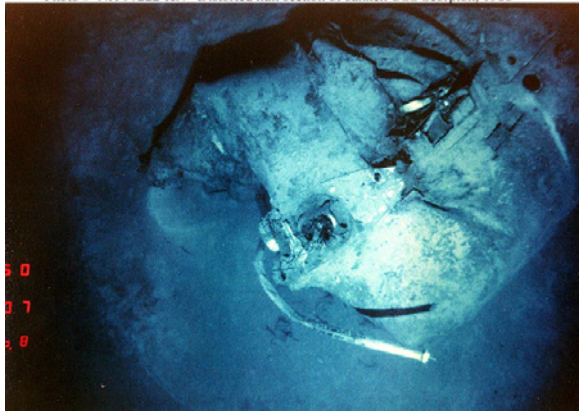


Photo # NH 97215 USS Scorpion on trials, 27 June 1960



Photo # NH 70305 USS Scorpion comes alongside USS Tallahatchie County, April 1968



USS Guitarro (SSN 665)



Guitarro sank alongside the pier in new construction at Mare Island Naval Shipyard, Vallejo, CA 15 May 1969. This was a watershed event in the shipyard business.



USS Thomas Edison vs. USS Leftwich



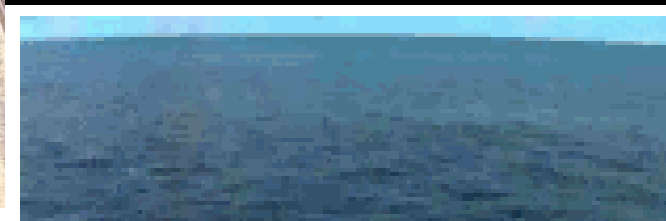
29 November 1982, Thomas A. Edison collided with USS Leftwich (DD 984) when coming to periscope depth. She was decommissioned thereafter. This emphasized the perils of treating all submarines as alike, regardless of the sophistication of their sensor suites.

USS Baton Rouge (SSN 689) vs. Tula (K239)



11 February 1992, Baton Rouge collided with the Russian Sierra (Barrakuda) Class nuclear submarine Tula (K-239) in the Barents Sea near Severomorsk. Baton Rouge suffered only minor damage and was decommissioned in 1995 as scheduled. Tula has remained in a drydock to this date. When details became known, this precipitated a major diplomatic confrontation between newly inaugurated President Clinton and the Russian Government.

USS Greenville (SSN 772) vs. MV Ehime Maru



USS Greenville collided with Ehime Maru 9 Feb 2001 off Diamond Head, HI, during an emergency surfacing evolution conducted for VIP riders. Nine Japanese students died and the Ehime Maru was sunk. The US and the CO of the Greenville issued formal apologies to the Japanese government and the families of the deceased.

USS San Francisco (SSN 711)



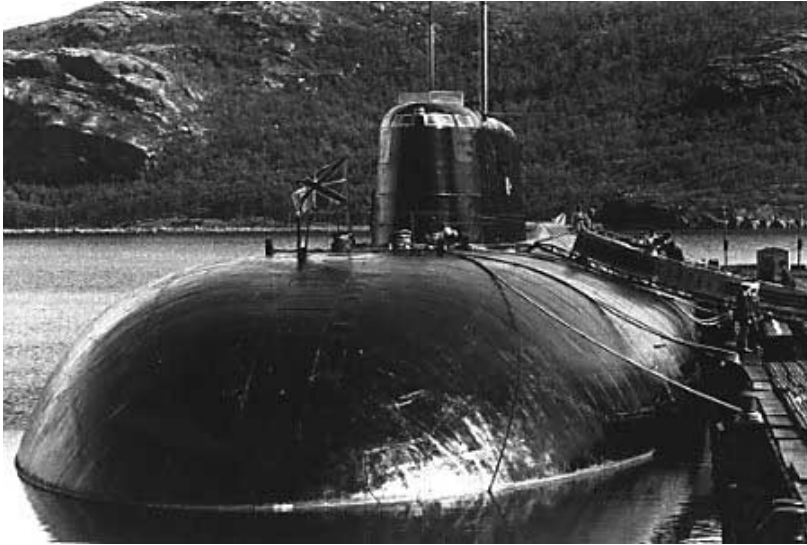
16 May 2005 USS San Francisco grounded on a sea mount about 400 miles from Guam. Weaknesses in track preparation and failure to understand the fathometer readings were the proximate causes. The ship decelerated from maximum speed to stopped in 4 seconds. One crewman died and several were injured. The ship is so heavily damaged that it will be decommissioned.

Komsomolets K-278



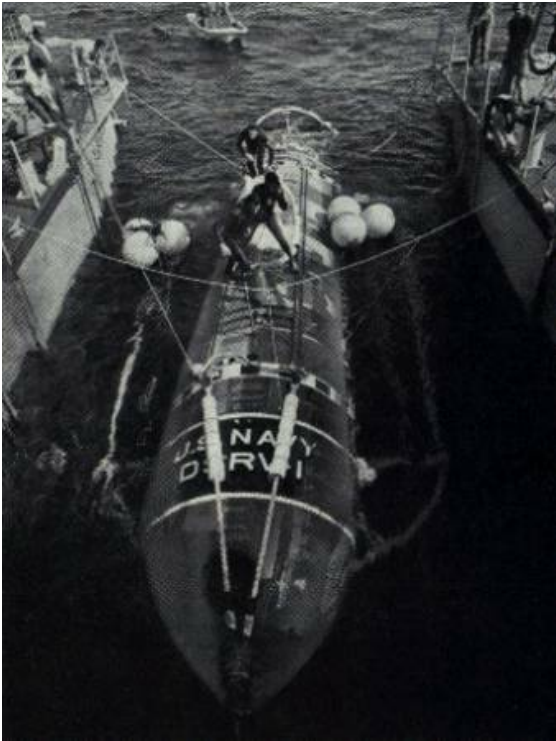
Komsomolets K-278, Project 685 (Mike Class) sank 07 April 1989 after a fire. The ship surfaced after 11 minutes but the crew was unable to stop the fires after several hours of effort. 42 of 69 crew members perished, most of hypothermia in the 36 degree water. The ship is in water a mile deep.

Kursk K-141



Kursk K141, Antey Type 919 (Oscar II SSGN) sank on 13 August 2000 in the Barents Sea 100 miles from Murmansk in 300 feet of water due to a torpedo explosion . All 118 crew members died. 23 survived the initial explosion and subsequently perished from cold and CO₂ buildup. The ship was raised and taken to port where it was partially dismantled.

Deep Submergence Rescue Vehicle (DSRV) Program



The DSRV program is based at NAS North Island, CA. It consists of DSRVs Mystic and Avalon and is deployable to any location world-wide within 24 hours by C-5 Aircraft, which are on continuous alert. Successive administrations have proposed terminating the program. The concept of low probability, high consequence accidents is frequently misunderstood.

Some Program Changes From Casualties

- Diesel engines versus gasoline
- Battery ventilation systems with explosion - proof fans
- Messenger buoys to help find submarines lost on sea trials
- Changes in torpedo design after warshot failures in WWII
- Atmosphere monitoring and control systems
- Momsen lung and McCann (really Momsen) submarine rescue bell
- Emergency breathing systems
- Multiple, redundant safety systems
- Deep Submergence Rescue Program (this program has been made available to other countries – only Russia and the PRC declined)
- Submarine Safety Program following loss of USS Thresher (SUBSAFE)
 - A complete redesign and re-engineering of nuclear submarines
 - Entire fleet LID until all SUBSAFE requirements were met
 - Flood control and emergency ballast blow systems
 - Submarine Safety Certification Boundary Book (SSCB)
 - Material Control Standards
 - Nuclear propulsion plant equivalent QA throughout the hull integrity envelope
- Manual for Control of Testing and Ship Conditions and stringent watertight integrity controls following sinking of USS Guitarro
- Changes in weapon design following loss of USS Scorpion

Relationship between NASA and Submarine/Naval Reactors Programs

- Navy study of Challenger disaster revealed significant differences between Navy and NASA safety cultures
- NASA/Navy Benchmarking Exchange (NNBE) study from 2002 – 2004
- NASA identified key attributes of the submarine/NR safety programs
 - Safety requirements documented and achievable with minimum waivers
 - Requirements implemented through controlled processes
 - Compliance is independently verified
 - Strong safety culture with emphasis on understanding and learning from the past
 - Centralized technical authority and large operational experience base
 - NR has total programmatic and safety responsibility for all aspects of naval nuclear propulsion plants (NNPP)
 - NR is a flat organization with wide access to the Director
 - The safety and QA processes are totally embedded so that no separate offices are needed.
 - Critical programmatic decisions require concurrence of all related people
 - The airing of diverse and differing opinions is promoted.
 - An institutionally - embedded Lessons Learned process based on 5400 reactor-years of operational experience
 - NR relies on recruiting, training, and retaining highly qualified people who are held personally accountable and responsible for safety.

Embedding this level of a safety culture into NASA will not be easy.

The Difference between the Army and the Navy



Backup

Why no Women in the Submarine Force?

Inability to meet privacy standards, driven by berthing and heads

Los Angeles Class example

- Up to 165 total crew
- CO/XO share a head with one toilet and one shower
- 13 other officers share a head with one toilet, one sink, and one shower
- 15 Chief Petty Officers share a head with one toilet, one sink, and one shower
- 21 man bunkroom shares a head with one toilet, one sink, and one shower
- The remaining 114 crew, in Crews Berthing, share a head with three toilets, two showers, and four sinks.

Tridents can accommodate women, but career rotation could not be met.

DACOWITS has made an effort to require the Navy to design submarines for mixed - gender crew. Navy to date refuses, for obvious design reasons.

K-159



K141 was being towed from Gremikha Naval Base, Murmansk, to Polyarny shipyard, Kola Peninsula for dismantling and sank about 0300 30 August 2003. Nine of the 10 crew were lost. The ship sank with the core intact in the reactor vessel. Radiation surveys in the vicinity are normal. Reactor accidents have occurred on several other Russian submarines, including K-11, K27, K-140, K329, the K-222, K-123, K-314, K-431, K-192, K-8, K-3 and the Soviet Union's first strategic submarine, K-19.