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Submarine Launched ICBM Trident II D5 and Conventional Trident Modification

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Abstract.

This work concerns the submarine launched Intercontinental Ballistic Missiles (ICBM) and especially the Trident II D5. The first ballistic missile developed during the 2nd world war from German and is known as V2 or A4, its creator was Walter Dornberger. It's first succeed launch was on 3rd October 1942 and its mass production began in 1944. Ballistic missiles can be launched from fixed sites or mobile launchers, including vehicles (transporter erector launchers, TELs), aircraft, ships and submarines. The first practical design of a submarine-based launch platform was developed by the Germans near the end of World War II. Ballistic missile submarines have been of great strategic importance for the USA and Russia and other nuclear powers since the start of the Cold War, as they can hide from reconnaissance satellites and fire their nuclear weapons with virtual impunity. This makes them immune to a first strike directed against nuclear forces, allowing each side to maintain the capability to launch a devastating retaliatory strike, even if all land-based missiles have been destroyed. UGM-133 Trident II, or Trident D5 is a submarine-launched ballistic missile, built by Lockheed Martin Space Systems in Sunnyvale, California, and deployed with the US and Royal Navies. It was first deployed in 1990, and is still in service. It carries four nuclear warheads up to 475 kt each one. The US program would have converted existing TridentII missiles (presumably two missiles per submarine) into conventional weapons. The U.S. Navy in August plans to conduct a flight test of Trident submarine-launched ballistic missile technologies modified for conventional strike operations. A second related flight test is scheduled for late 2012 or early 2013.

Keywords: Missile, launch, trajectory, conventional modification

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1 Introduction

This paper concerns the submarine launched Intercontinental Ballistic Missiles (ICBM) and especially the Trident II D5. The first ballistic missile developed during the 2nd world war from German and is known as V2 or A4, its creator was Walter Dornberger. It’s first succeed launch was on 3rd October 1942 and its mass production began in 1944 and was the principal weapon during the fight of Paris in 6th September 1944. Until the end of the 2nd world war more than 3000 V2 had been launched. A total of 30 nations have deployed operational ballistic missiles. Development continues, with around 100 ballistic missile flight tests in 2007, mostly by China, Iran and the Russian Federation. In 2010 the US and Russian governments signed a treaty to reduce their inventory of intercontinental ballistic missiles (ICBMs) over a seven-year period (to 2017) to 1550 units each.

A ballistic missile trajectory consists of three parts:

- the powered flight portion,
- the free-flight portion which constitutes most of the flight time and
- the re-entry phase where the missile re-enters the Earth's atmosphere

Ballistic missiles can be launched from fixed sites or mobile launchers, including vehicles (transporter erector launchers, TELs), aircraft, ships and submarines. The powered flight portion can last from a few tens of seconds to several minutes and can consist of multiple rocket stages.

When in space and no more thrust is provided, the missile enters free-flight. In order to cover large distances, ballistic missiles are usually launched into a high sub-orbital spaceflight, for intercontinental missiles the highest altitude (apogee) reached during free-flight is about 1200 km. The re-entry stage begins at an altitude where atmospheric drag plays a significant part in missile trajectory, and lasts until missile impact.

Ballistic missiles can vary widely in range and use, and are often divided into categories based on range. Various schemes are used by different countries to categorize the ranges of ballistic missiles:

- Tactical ballistic missile: Range between about 150 km and 300 km
    - Battlefield range ballistic missile (BRBM): Range less than 100 km

- Theatre ballistic missile (TBM): Range between 300 km and 3,500 km
    - Short-range ballistic missile (SRBM): Range 1,000 km or less
    - Medium-range ballistic missile (MRBM): Range between 1,000 km and 3,500 km
- Intermediate-range ballistic missile (IRBM) or long-range ballistic missile (LRBM): Range between 3,500 km and 5,500 km
- Intercontinental ballistic missile (ICBM): Range greater than 5500 km
- Submarine-launched ballistic missile (SLBM): Launched from ballistic missile submarines (SSBNs), all current designs have intercontinental range.

Short- and medium-range missiles are often collectively referred to as theater or tactical ballistic missiles (TBMs). Long and medium-range ballistic missiles are generally designed to deliver nuclear weapons because their payload is too limited for conventional explosives to be cost-effective (though the U.S. is evaluating the idea of a conventionally-armed ICBM for near-instant global air strike capability despite the high costs).

The flight phases are like those for ICBMs, except with no exoatmospheric phase for missiles with ranges less than about 350 km

Now we are going to analyse the history of submarine launched ballistic missiles. The first practical design of a submarine-based launch platform was developed by the Germans near the end of World War II involving a launch tube which contained a ballistic missile and was towed behind a submarine. The war ended before it could be tested, but the engineers who had worked on it went on to work for the USA and USSR on their SLBM programs. These and other early SLBM systems required vessels to be surfaced when they fired missiles, but launch systems eventually were adapted to allow underwater launching in the 1950-1960s. The United States made the first successful underwater launch of a Polaris A1 on 20 July 1960. Forty days later, the Soviet Union made its first successful underwater launch of a submarine ballistic missile in the White Sea on 10 September 1960 from the same converted Project 611 (Zulu Class) submarine that first launched the R-11FM (SS-N-1 Scud-A, naval modification of SS-1 Scud) on 16 September 1955. However, the Soviet Union was able to beat the U.S. in launching and testing the first armed SLBM, an R-13 that detonated in the Novaya Zemlya Test Range in the Arctic Ocean, doing so on October 20, 1961, just ten days before the gigantic 50 MT Tsar Bomba's detonation in the same general area.

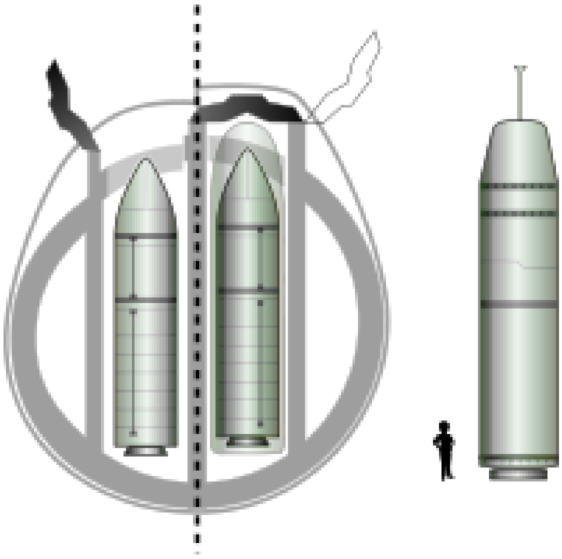

Figure 1. French M45 SLBM and M51 SLBM

2 Strategic Importance

Ballistic missile submarines have been of great strategic importance for the USA and Russia and other nuclear powers since the start of the Cold War, as they can hide from reconnaissance satellites and fire their nuclear weapons with virtual impunity. This makes them immune to a first strike directed against nuclear forces, allowing each side to maintain the capability to launch a devastating retaliatory strike, even if all land-based missiles have been destroyed. This relieves each side of the necessity to adopt a launch on warning posture, with its grave attendant risk of accidental nuclear war. Additionally, the deployment of highly accurate missiles on ultra-quiet submarines allows an attacker to sneak up close to the enemy coast and launch a missile on a depressed trajectory (a non-optimal ballistic trajectory which trades off reduced throw-weight for a faster and lower path, effectively reducing the time between launch and impact), thus opening the possibility of a decapitation strike. The US navy has developed the UGM 133 Trident II D5 as its principal submarine launched ICBM while the Russian has developed the RSM-56 R-30 "Bulava", NATO name SS-NX-32.

3 TRIDENT II D5

UGM-133 Trident II, or Trident D5 is a submarine-launched ballistic missile, built by Lockheed Martin Space Systems in Sunnyvale, California, and deployed with the US and Royal Navies. It was first deployed in 1990, and is still in service.

Trident II was designed to be more sophisticated than Trident I, and have a greater payload capacity. It is accurate enough to be used as a first strike weapon. All three stages of the Trident II are made of graphite epoxy, making the missile much lighter than its predecessor. Trident II missiles are carried by US *Ohio*- and British *Vanguard*-class submarines. USS *Tennessee* (SSBN-734) was the first submarine to be armed with Trident IIs. Trident II missiles are currently carried by fourteen *Ohio*-class, and four *Vanguard*-class SSBNs. There have been 135 consecutive successful test flights of the D5 missile since 1989, with the most recent being from HMS *Vigilant* in October 2012.

The development contract for Trident II was issued in October 1983. The first Trident II launch occurred in January 1987, and the first submarine launch was attempted by *Tennessee*, the first D-5 ship of the *Ohio* class, in March 1989. The launch attempt failed because the plume of water following the missile rose to greater height than expected, resulting in water being in the nozzle when the motor ignited. Once the problem was understood relatively simple changes were very quickly made but the problem delayed the Initial Operational Capability (IOC) of Trident II until March 1990. It is estimated that some 540 missiles will be built by 2013. The Trident D5LE (life-extended) version will remain in service until 2042.

3.1 Specifications of TRIDENT II D5

- Purpose: strategic nuclear deterrence
- Unit Cost: US$30.9 million
- Range: > 11,300 kilometres (7,000 mi)
- Maximum speed: > 6,000 metres per second (22,000 km/h; 13,000 mph).
- Guidance system: inertial, with Star-Sighting; GPS experiments done but not deployed.
- CEP: Requirement: 90–120 metres (300–390 ft). That demonstrated by flight tests is significantly better.

- Warhead (in USA usage only): nuclear MIRV up to four W88 (475 kt) warheads (Mark 5) or eight W76 (100 kt) warheads (Mark 4). The Trident II can carry 12 MIRV warheads but START I reduces this to eight and SORT reduces this yet further to four or five.

UGM-133 Trident II

A Trident II launch from a submerged submarine.

Type	SLBM
Place of origin	USA
Service history	
In service	1990
Used by	United States Navy Royal Navy
Production history	
Manufacturer	Lockheed Martin Space Systems
Unit cost	$30,900,000
Produced	1983

Specifications	
Weight	129,000 lb (59,000 kg)
Length	44 ft (13 m)
Diameter	6 ft 2 in (1.88 m) (1st stage)
Warhead	Multiple W88 or W76 nuclear warheads
Detonation mechanism	Air Burst
Engine	Three solid-propellant rocket motors; first & second stage - Thiokol/Hercules solid-fueled rocket; third stage - United Technologies Corp. solid-fueled rocket
Operational range	7,000 mi (11,000 km) (exact is classified)
Speed	Approximately 13,000 mph (21,000 km/h) (Mach 17)(terminal phase)
Guidance system	Inertial
Accuracy	90–120 m (300–390 ft) CEP
Launch platform	Submarine-launched ballistic missile(SLBM)

3.2 Warheads

Figure 2. Artist's impression of an incoming generic re-entry vehicle

The British government maintains that the warheads used in the UK Trident system were "designed and manufactured in the UK at the Atomic Weapons Establishment (AWE), Aldermaston". However, declassified US Department of Energy documents indicate that development of the non-nuclear elements of the warhead may have taken place alongside those of the US W76 nuclear warhead fitted in some US Navy Trident missiles. The National Audit Office noted that most of the warhead development and production expenditure was incurred in the US. The US President authorised the transfer of nuclear warhead components to the UK between 1991 and 1996. This has led the Federation of American Scientists to speculate that the UK warhead may share design information from the W76, a practice encouraged by the 1958 US-UK Mutual Defence Agreement. Nine joint US/UK underground nuclear tests were carried out at the Nevada Test Site between 1983 and 1991,[with many or all of these believed to be tests of the British-variant Trident physics package. The final warheads have been assembled at the AWE facilities near Aldermaston and Burghfield since 1992, and are transported to storage facilities in Scotland by heavily-guarded overland conveys.

4 Description of Launch

The launch from the submarine occurs below the ocean surface. The missiles are ejected from their tubes by igniting an explosive charge in a separate container which is separated by two titanium alloy pinnacles activated by a triple alloy steam system. The energy from the blast is directed to a water tank, which is flash-vaporized to steam. The subsequent pressure spike is strong enough to eject the missile out of the tube and give it enough momentum to reach and clear the surface of the water. However, should this fail, there are several safety mechanisms that can either deactivate the missile before launch or proceed missile through an additional phase of launch. Inertial motion sensors are activated upon launch, and when the sensors detect downward acceleration after being blown out of the water, the first stage engine ignites, the aerospike extends, and the boost phase begins. The missile is pressurized with nitrogen to prevent the intrusion of water into any internal spaces, which could damage the missile or add weight which would destabilize the missile. When the third stage motor fires, within two minutes of launch, the missile is travelling faster than 20,000 ft/s (6,000 m/s), or 13,600 mph.

The missile attains a temporary low altitude orbit only a few minutes after launch. The Guidance System for the missile is an Inertial Guidance System with an additional Star-Sighting system, which is used to correct small positional errors that have accrued during the flight. GPS has been used on some test flights but is assumed not to be available for a real mission.

Once the Star-sighting system has been completed, the missile deploys the multiple independent re-entry vehicles as their individual targets come within range. The lateral area coverage of the targets remains classified. The warheads enter the atmosphere at hypersonic speeds.

The Trident was built in two variants: the I (C4) UGM-96A and II (D5) UGM-133A. The C4 and D5 designations put the missiles within the "family" that started in 1960 with Polaris (A1, A2 and A3) and continued with the 1971 Poseidon (C3). Both Trident versions are three-stage, solid-propellant, inertially guided missiles whose range is increased by an aerospike, a telescoping outward extension that halves aerodynamic drag. In the post-boost phase, the Trident missile uses stellar sighting to update its position and reduce the drift error inherent in all inertial reference systems.

5 UK Renewal

On 14th March 2007, the government of the United Kingdom won Commons support for plans to renew the UK's nuclear submarine system. Between £15bn and £20bn will be spent on new submarines to carry the Trident missiles. The fleet will take an estimated 17 years to develop and build, and will last until 2050. More than 90 Labour members of the Commons voted against the proposed upgrade to the missile system, and the vote was only won with the support of the Opposition, although with the substantial support of 63% of MPs. *[http://news.bbc.co.uk/2/hi/uk_news/politics/6448173.stm Trident plan wins Commons support] . BBC News. March 15, 2007*]

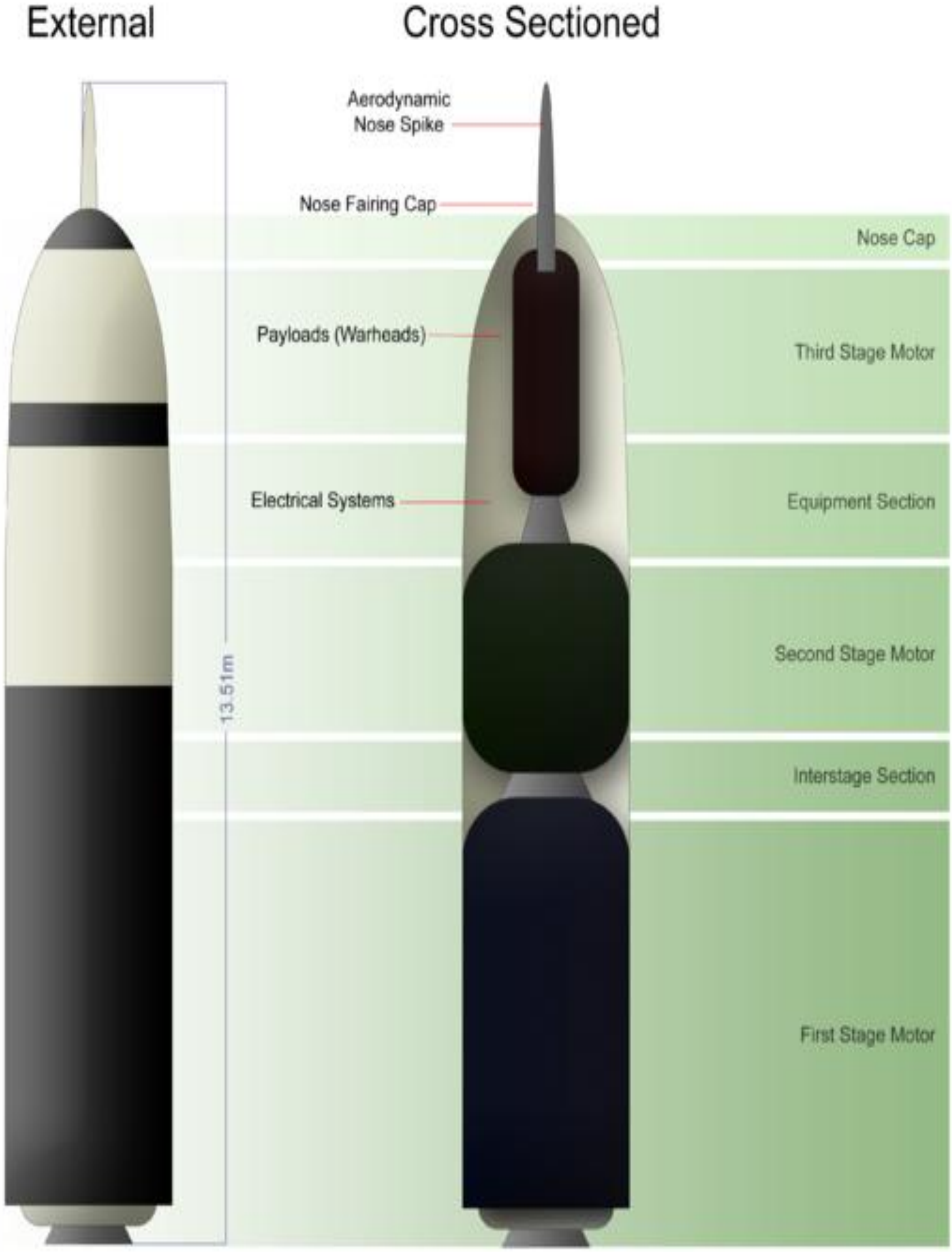
External
Cross Sectioned
Aerodynamic
Nose Spike
Nose Fairing Cap
Nose Cap
Payloads (Warheads)
Third Stage Motor
Electrical Systems
Equipment Section
Second Stage Motor
13.51m
Interstage Section
First Stage Motor

Figure 3.

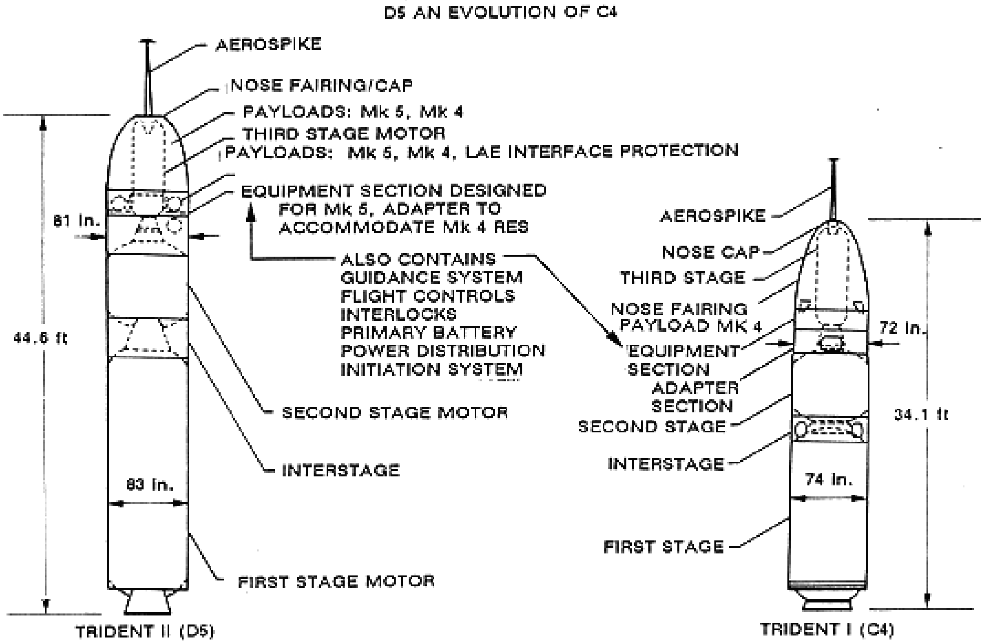

Figure 4. TRIDENT II (D5) Baseline Missile

The *Trident II D-5* is a three-stage, solid propellant, inertially guided FBM with a range of more than 4,000 nautical miles (4,600 statute miles or 7,360 km) *Trident II* is more sophisticated with a significantly greater payload capability. All three stages of the *Trident II* are made of lighter, stronger, stiffer graphite epoxy, whose integrated structure mean considerable weight savings. The missile's range is increased by the aerospike, a telescoping outward extension that reduces frontal drag by about 50 percent. *Trident II* is fired by the pressure of expanding gas in the launch tube. When the missile attains sufficient distance from the submarine, the first stage motor ignites, the aerospike extends and the boost stage begins. Within about two minutes, after the third stage motor kicks in, the missile is travelling in excess of 20,000 feet (6,096 meters) per second.

The missile consists of a first stage section, an interstage [IS] section, a second stage section, an Equipment Section [ES], a Nose Fairing [NF] section, and a nose cap section with an aerospike. The D5 ES, along with containing all the guidance and electronics, (e.g., structural support between the aft end of the NF and the forward end of the second stage motor).

The first stage and second stage motors are also primary structural components of the missile, connected by an Interstage (IS). Forward of the second stage motor, the adapter section structure of the C4 has been eliminated in D5, and the equipment section (ES) has been extended to serve as the adapter section plus ES. The third stage motor is mounted within and to the ES similar to C4. Structural bracketry on the forward part of the ES is modified from C4, in order to accommodate the bigger Mk 5 reentry vehicle or, with added fixtures, a payload of Mk 4 RBs.

The first stage section includes the first stage rocket motor, TVC system, and the components to initiate first stage ignition. The IS section connects the first stage and second stage sections and contains electrical and ordnance equipment. The second stage section includes the second stage rocket motor, TVC system, and components to initiate second stage ignition.

In order to achieve the longer range with its larger, heavier payload, improvements in rocket motor performance would be required plus reductions in the weight of the missile's components. To improve rocket motor performance, there was a solid-propellant change. The C4 propellant carried the name of XLDB-70, translated to, cross-link double-base70 percent solid fuels. The solids consisted of HMX (His Majesty's Explosive), aluminium, and ammonium perchlorate. The binder of these solids was Polyglycol Adipate (PGA), Nitrocellulose (NC), Nitro-glycerine (NO), and Hexadiisocryanate (HDI). This propellant could have been called PGA/NG, when we consider that D5 propellant is called Polyethylene Glycol (PEG)/NG. D5 is called this because the major innovation was the usage of PEG in place of the PGA in the binder. It was still a cross-link, double-base propellant. The use of PEG made the mixture more flexible, more rheological than the C4 mixture with PGA. Thus, the D5 mixture being more flexible, an increase could be made in the amount of solid fuels; increased to 75 percent solids resulting in improved performance. Thus, D5 propellant's is PEG/NG75. The Joint Venture (the propulsion subcontractors, Hercules and Thiokol) have given a trade name to the propellant NEPE-75.

The motor case material on the D5's first stage and second stage became graphite/epoxy versus the Kevlar epoxy of C4, an inert weight saver. The TS motor was to be Kevlar epoxy but, midway through the development program (1988), it was changed to graphite/epoxy. The change was a range gainer (reduced inert weight) plus eliminated any electrical static potential associated with Kevlar and graphite. There was also a change in all D5 rocket motor nozzles' throat material from segmented rings of pyrolytic graphite in the entrance and throat of the C4 nozzle to a one-piece integral throat and entrance (ITE) of carbon-carbon on D5. This change was for reliability purposes.

6 Missile Function

The Equipment Section [ES] houses the major guidance and flight control electronics packages. The TS rocket motor and its TVC system are mounted to an eject cylinder at the centre of the ES and extends forward of the ES. A small TS eject motor is recessed in a cavity on the TS motor forward dome. When the TS motor is expended, the eject motor pushes the TS motor aft, out of the ES to effect TS separation. The Equipment Section was integrated with the adapter section, using graphite/epoxy versus the aluminium composite structures on C4. This was a weight saver, providing a range gainer. The IS did not change, conventional aluminium. The ES mounting for the third stage rocket motor is similar for both the C4 and D5 with an explosive zip tube used for separation, and the third stage motor has a similar eject rocket motor on the forward end of the rocket motor.

The NF section covers the re-entry subsystem components and the forward portion of the TS motor. The NF section consists of a primary structure with provisions for two jettison rocket motors and a locking mechanism. The nose cap assembly at the forward end of the NF houses an extendable aerodynamic spike.

The D5 missile has the capability of carrying either Mk 4 or Mk 5 re-entry vehicles as its payload. The D5 re-entry subsystem consists of either Mk 4 or Mk 5 re-entry vehicle assemblies attached by four captive bolts to their release assembly and mounted on the ES. STAS and pre arming signals are transferred to each re-entry vehicle shortly before deployment through the separation sequencer unit. When released, the re-entry vehicle follows a ballistic trajectory to the target where detonation occurs in accordance with the fuse option selected by fire control through the preset subsystem.

The re-entry vehicle contains an AF&F assembly, a nuclear assembly, and electronics. The AF&F provides a safeguard to prevent detonation of the warhead during storage and inhibits re-entry vehicle detonation until all qualifying arming inputs have been received. The nuclear assembly is a Department of Energy (DoE) supplied physics package.

In the case of D5, the ES uses its PBCS to manoeuvre for stellar sighting; this enables the guidance system to update the original inertial guidance as received from the SSBN. The flight control system responding to guidance reorientates the D5 ES and enters a high-thrust mode. However, in the D5 case, the ES flies forward. (RBs are basically down the line of the trajectory.) As in C4, the D5 ES (when it reaches the proper altitude, velocity and attitude) enters the vernier mode to deploy RVs. However, to eliminate the PBCS plume from impacting the re-entry vehicle upon release, the ES undergoes a Plume Avoidance Manoeuvre (PAM). If the re-entry vehicle to be released will be disturbed by a PBCS nozzle's plume, that nozzle will be shut off until the re-entry vehicle is away from the nozzle's plume area. With a nozzle off, the ES will react to the other three nozzles automatically. This causes the ES to rotate as it backs away from the re-entry vehicle just released. In a very short time, the re-entry vehicle will be beyond the influence of the plume and the nozzle is returned to normal operation. PAM is used only when a nozzle's plume will disturb the area around an RV. This PAM was one of the design changes to the D5 to provide improved accuracy.

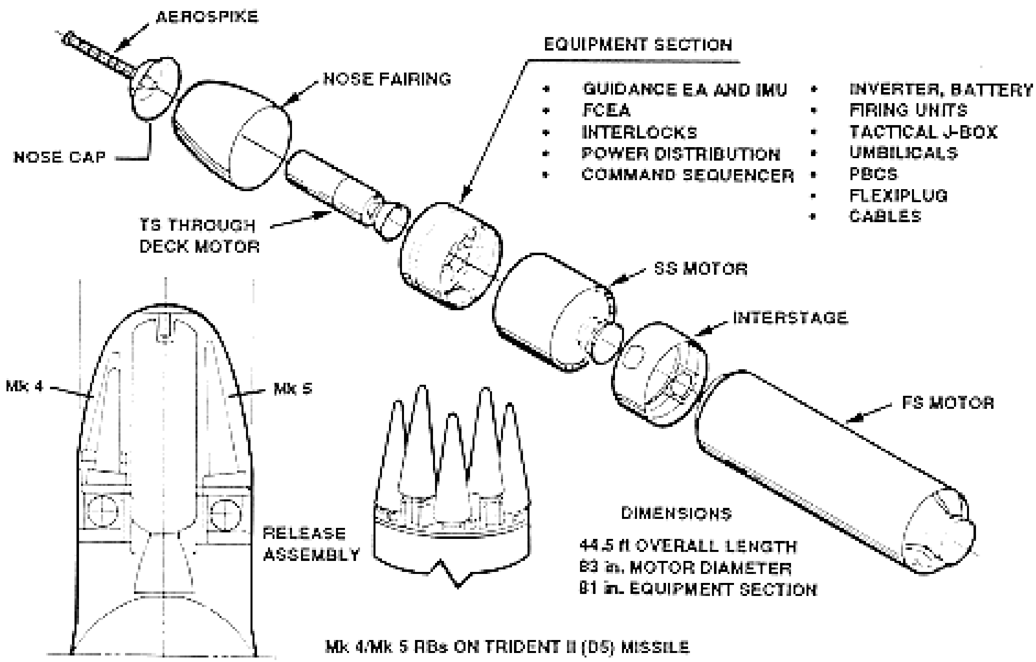

Figure 5.

Another design change to help improve accuracy was to the nosetip of the Mk 5 RV. In the TRIDENT I (C4) missile, an error condition existed in some cases upon re-entry into the atmosphere when the nosetip ablated at an uneven rate. This caused the re-entry vehicle to drift. As the design of the Mk 5 re-entry was developed, the change to a shape stable nosetip (SSNT) was established. The nose of the Mk 4 re-entry vehicle was boron carbide-coated graphite material. The Mk 5 nose has a metallated center core with carbon/carbon material, forming the rest of the nosetip ("plug"). The metallated center core will ablate at a faster rate than the carbon/carbon parent material on the outer portion of the nosetip. This will result in a blunt, more-symmetrical shape change with less of a tendency to drift and, consequently, a more-accurate and more-reliable system. Prior testing of SSNTs on some C4 missile flights had verified the design concept.

In TRIDENT II (D5), the rate gyro package was eliminated. The D5 flight control computer receives these missile response rates from the guidance system inertial measuring unit (IMU) as transmitted through the guidance electronic assembly (EA).

The more-extensive use of composites in D5's structure provided inert weight savings. Redesign of ordnance system D5-versus-C4, although functionally the same, in particular the separation ordnance to "cut" structure, contributed to weight savings.

7 Flight Tests

Figure 6.

The flight test program of the missile and the guidance subsystems of the weapon system began in January 1987, and the overall performance results from the tests indicated that the missile was achieving its objectives for this phase of the program. Of the 15 tests conducted as of September 30, 1988, 11 were successful, 1 was partially successful, 2 were failures, and one was a "no-test" [the 15th flight test was destroyed by command destruct early in its flight while the missile was performing normally at the time the decision was made to destruct: therefore, the flight was a "no-test". Although the majority of the tests were successful, each of the failures involved different problems and occurred at different stages of the missile flight. A problem encountered during the seventh flight requires a redesign of the Post Boost Control System.

During the deployment phase of the seventh flight, one of the valves in the system, which controls the flow of hot gases through the system, remained closed and limited the system's steering capability. Engineering evaluations indicate there was overheating or contamination in the valve, causing it to stay closed. The redesign was incorporated during the 1989 testing program.

During the ninth flight test, the missile lost control and went off course about 14 seconds into third stage flight and self-destructed. Engineering verification of the failure indicated that a short in one of the power supplies, which control the flight control computer, prevented the computer from providing the proper steering commands for the missile's third stage. The problem was solved through minor changes in the flight control computer. Also, there has been no reoccurrence of the problem in subsequent flight tests.

During the 13th flight, the missile encountered a problem with the thrust vector control subsystem on its first stage, causing it to lose control and go off course about 55 seconds into flight. The missile was destroyed by the range safety officer for safety reasons. During the 15th flight, the missile was destroyed by command destruct early in its flight. The missile wars performing normally at the time the decision was made to destruct, thus resulting in a no test. A combination of events prompted the destruct action, including the specific trajectory selected to be flown, the prelaunch weather conditions, and the missile dynamics along the flight path, which resulted in the missile looking to the range safety officer as though it would cross the boundaries of the safety corridor.

8 Recent Developments

USS LOUISIANA (SSBN 743), the last of the 18 Trident submarines to be constructed, successfully launched one unarmed Trident II (D-5) ballistic Missile on 18 December 1997. The launch from the submerged submarine took place on the United States' Eastern Range, off the coast of Florida, as part of LOUISIANA's Demonstration and Shakedown Operation (DASO). The purpose of the DASO is to demonstrate the submarine crew's ability to meet the stringent safety requirements for handling, maintaining and operating the strategic weapons system. The DASO also confirms the submarine's ability to correctly target and launch a Trident missile. This was the 77th consecutive successful launch of the Trident II (D-5) missile since 1989; the longest string of successes in the history of United States' ballistic missiles

The US Navy's Trident II Submarine-Launched Ballistic Missile system routinely conducts joint DOE/Department of Defense flight tests on instrumented Mk5 Re-entry Bodies known as Joint Test Assemblies (JTAs). During a past flight, the JTA telemetry experienced a single-event upset occurrence as it flew through the Van Allen Belt and the South Atlantic Anomaly (an intense, low-altitude high-energy proton belt). A multidisciplinary effort by Sandia Lab scientists and engineers assembled to determine the causal elements and to assist in devising a solution. To correct for this event, the W88-0/JTA telemetry system was redesigned by incorporating into the signal processor design four high-energy-proton-resistant integrated circuits.

Figure 7.

9 Conventional TRIDENT Modification (CTM)

The US program would have converted existing Trident II missiles (presumably two missiles per submarine) into conventional weapons, by fitting them with modified Mk4 re-entry vehicles equipped with GPS for navigation update and a re-entry guidance and control (trajectory correction) segment to perform 10 m class impact accuracy. No explosive is said to be used since the re-entry vehicle's mass and hypersonic impact velocity provide sufficient mechanical energy and "effect". It offered the promise of accurate conventional strikes with little warning and flight time.

The Conventional Strike Missile is a manoeuvrable hypersonic boost-glide weapon system capability is to deliver precision conventional effects with global reach (~9000nm) within one hour. The weapon system could be boosted by excess and/or commercial motors, or perhaps via future responsive space lift platforms. In either case, the majority of the flight trajectory would be endoatmospheric and have sufficient manoeuvrability to avoid overflight of restricted airspace (600-3000nm cross-range capability). Delivered payload is on the order of 1000-2000lbs, with flexible kinetic and non-kinetic configurations including multiple precision guided sub-munitions, unitary penetrating munitions, and/or sensor packages. Physical characteristics of the hypersonic vehicle are 12 feet length, 4 feet width, and up to 3500lb weight. The vehicle speeds are nominally Mach ~24 re-entry, a Mach 10-15 glide, and Mach 4 terminal impact. Conventional Strike Missile (CSM) would conduct flight demonstrations of an advanced boost-glide weapon system. Includes Minotaur rocket boost, biconic hypersonic glide vehicle, advanced GPS guidance, and conventional payload integration. Flight demonstrations will prove manoeuvrable long range endoatmospheric glide with advanced TPS and precision terminal accuracy. Three demonstration flights are planned for 2012-1015.

This initial prompt Global Strike capability will be achieved by arming a small number of long-range Trident missiles them with accurate, non-nuclear warheads. The rationale for focusing on ballistic missiles, in general, and on a non-nuclear Trident missile in particular, is that Conventional Trident represents a near-term, affordable, low-risk option for providing the President of the United States with an important, new capability. By deploying SSBNs armed with Conventional Trident missiles we will close a long-standing gap in our strike capability for engaging an adversary promptly and precisely, anywhere in the world, and without having to resort to nuclear weapons. The goal of this new strategy was to produce a force capable of assuring allies, dissuading competitors, deterring adversaries, and if necessary defeating enemies. The conventional missile program will help achieve this goal by providing the capability to defeat threats on short notice without crossing the nuclear threshold. Additional benefits of the Conventional Trident Modification are that it requires no forward-deployed or visible presence, has few if any requirements for allied overflight permission, and gives the enemy little or no warning before a strike

The Navy CPGS Technology Refinement and Demonstration sub-project supports Navy Conventional Prompt Global Strike (CPGS) technology development and will assess the feasibility of producing an affordable solution (i.e., ballistic missiles from an underwater environment) to fill the CPGS capability gap. It will assess CPGS technologies that could lead to a weapon system with the stealth, availability, accuracy and rapid response of today's ballistic missiles. The technologies developed will have cross-service and cross-concept applicability and will be developed through close coordination among DoD components. In FY09, a CPGS Flight Experiment (FE1) using a Life Extension Test Bed (LETB-2) re-entry body (RB) will be conducted using a currently planned TRIDENT II (D5) missile flight to demonstrate communication and telemetry link overhead for future experiments.

In preparation for the FY09 FE1, FY08 activities will involve: test completion and delivery of flight software, assembly and integration of components into LETB-2, fabrication and delivery of heatshield, nosetips and flaps, and, assembly and delivery of power distribution unit and telemetry systems. In addition, two other CPGS technology efforts will be pursued/developed in FY09 to support a future (FY11 timeframe) Flight Experiment (FE2) utilizing a Sandia STARS A3 launch vehicle: the Medium Lift Re-Entry Body (MLRB), and; Warhead and Fuze (WF). For MLRB, deliverables in FY09 include: completion of detailed design, and; an 80% completion of RB software modules. For WF, deliverables include completion of the following items: Kinetic Energy Projectile (KEP) warhead static test; KEP and penetrator lethality modelling; full-scale penetrator gun test; KEP/aeroshell interaction test; KEP warhead arena test, and, KEP warhead sled test number one.

10 Conventional TRIDENT Flight Tests

The U.S. Navy in August plans to conduct a flight test of Trident submarine-launched ballistic missile technologies modified for conventional strike operations.

The experiment could help the Pentagon assess the feasibility of equipping the Trident with a conventionally armed and manoeuvrable re-entry body. The D-5 missile's re-entry body, which normally carries nuclear warheads, would receive a precision guidance system and modified control surfaces to help boost its accuracy.

A second related flight test is scheduled for late 2012 or early 2013, according to the Pentagon's "Research, Development and Testing Plan for Conventional Prompt Global Strike, FY 2008-2013."

From a technical perspective, such accuracy modifications could be made regardless of whether the re-entry body carried a nuclear or conventional payload, but in recent years Pentagon discussion has focused on the conventional mission.

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