Trident Targeting and Fire Control

The main centre for US nuclear war planning is Offut Air Force base in Omaha, Nebraska. However for Trident the focus of activity is the Naval Surface Warfare Centre, Dahlgren Division (NSWCDD). K Department of NSWCDD is responsible for support for the Submarine Launched Ballistic Missile (SLBM) program. They carry out work for both the American and British Trident programmes.

There are two processes:

Target Planning is carried out on shore and involves the allocation of specific targets to a series of RVs on a number of missiles on one or more submarines.

Fire Control is the translating these plans into detailed instructions which can be used to launch one or more missiles. Fire Control is carried out onboard the submarine.

Many factors are taken into account in preparing to use Trident missiles. Calculations are carried out in advance within the target planning system. Material is prepared and supplied for the Fire Control System (FCS) on the submarine. These two systems have to be compatible. Britain uses the same FCS as the US. The workings of the British target planning system are not in the public domain, but there may be more dependence on the US than is admitted. The SLBM Retargeting System (SRS) has substantially speeded up the process of retargeting Trident missiles. SRS has resulted in substantial upgrades to the target planning systems and FCSs used by both Britain and America.

The following sections consider key aspects of target planning and fire control:

- Factors in Trident planning
- Development infrastructure
- SLBM Retargeting System
- Fire Control Hardware
- Fire Control Software
- Target Planning (US)
- Tape and message Production (US)
- Software and the independence of Britain's Trident

Factors in Trident planning

Submarine navigation

Unlike a land-based ICBM, a Trident missile is launched from a platform which, prior to launch, is constantly moving. The exact position of the submarine has to be known and the launch calculations have to be adjusted at the last moment to take account of the current position.

US submarines use three systems to calculate their position. There is built in redundancy so that Trident is not dependent on one navigation system.[1]

GPS

From time to time the submarine takes a fix to determine its position using signals from GPS satellites. The signals cannot be received under the water so this requires raising a receiver above the surface. The US Strategic Systems Program anticipates that GPS could be crippled by exoatmospheric nuclear explosions in a strategic nuclear exchange and so does not want to be wholly dependent on GPS.

Inertial

The submarine command system logs instructions given to manoeuvre the vessel, but these are not very accurate. The Ships Inertial Navigation System (SINS) uses gyroscopes and accelerometers to provide more accurate information on the direction and speed of the submarine. SINS monitors the vessel's position between GPS fixes. The velocity data provided from SINS is not considered sufficiently accurate, on its own, for a Trident missile launch. It has to be supplemented with other information.

Navigational Sonar

US Trident submarines use a Navigational Sonar System (NSS). This can measure the speed of the vessel as well as taking depth fixes. NSS is dependent on detailed bathymetric maps. It is used to complement GPS and SINS in order to provide greater accuracy. The navigational sonar system used on Ohio class submarines is the *BNQ 19* produced by Raytheon. This is in addition to other active and passive sonar systems.

British submarines use the same GPS and SINS systems as their US equivalents and are also dependent on geophysical and gravity data. Descriptions of sonar systems on Vanguard submarines do not refer to Navigational Sonar and it is not clear if British submarines have this capability.

Bathymetric data

Bathymetry is the science of measuring the depth of the sea. Only a small proportion of the world's oceans have been mapped in detail. With current ship-based methods it would take 200 years to map the entire ocean bed and even longer to map all coastal areas.[2]

Under the Ocean Survey Program (OSP) the US Navy has surveyed small areas in detail to support Polaris and Trident submarine operations. The information from these surveys is held on the Digital Bathymetric Data Base 0.1 Minute (DBDB 0.1).[3] This contains a depth figure for each 0.1 minute segment, latitude and longitude, of the areas surveyed. Around Britain this is a rectangle of approximately 185 metres by 100 metres. The depth figure for each rectangle is accurate to within 9 metres. Information on which areas have been surveyed in detail is classified secret, as nuclear-armed submarines only patrol within these zones. Extracts from the database can be provided by NSWCDD to submarines in either tape or CD form. These tapes and CDs are all classified at least Secret. Some have the highest classification, Top Secret Special Compartmented Information.

Oceanographers are interested in using satellites to produce maps of the seabed based on variations in surface of the sea. The US Navy is interested in using this new approach to extend the areas where Trident submarines can operate. Northrop Grumman have investigated the possibility of using this satellite data. They are working on a simulation which will measure the effect of using this data on the accuracy of Trident. In 2002 a presentation on this project referred to developing a "Go anywhere and shoot" capability for Trident.[4]

Gravitational data

In addition to SINS, used to fix the submarine's position, inertial systems are also a critical feature of the guidance system on the missile itself. The inertial guidance monitors use accelerometers that are affected by changes in gravity. Gravity anomalies are changes in the strength of the gravitational force. Vertical Deflections are changes in the direction of the force. Accelerometers can interpret gravity anomalies and vertical deflection as changes in velocity. These can produce substantial errors in the accuracy of Trident. To compensate for this, Trident Fire Control System computers hold data on gravity anomalies and vertical deflections in the patrol area.

In addition to the bathymetric data, NWSCDD also supplies gravitational data for submarines.

Gravity Compensation

The trajectory of an RV is affected by variations in the earth's gravitational field. These are caused by mountains and land mass concentrations.[5] Gravitational data is loaded into the DESS from tape for predicted missile trajectories. If the submarine was moved to a new patrol area and the missile were allocated new targets, then additional gravitational data would have to be compiled for the new trajectory.

The gravitational effect of the moon on an RV varies as the moon's position changes. This can introduce an error of around 100 m in Trident accuracy.[6] Astronomical data will be used to adjust for this.

Times of flight

One of the main variables used for each RV is the Time of Flight (TOF).[7] This is used to determine that each RV will reach its allocated target.

Guidance

The Trident D5 missile uses inertial and stellar guidance systems. The gyroscopes in the inertial guidance system monitor the trajectory of the missile. This information is updated by the stellar system which takes a fix on two stars to calculate the position. Guidance requires substantial support from the FCS software.

Plume avoidance

RV are each spun-off from the manoeuvrable bus. Between sending off each RV the bus performs a plume avoidance manoeuvre so that the trajectory of the RV is not distorted.

Penetration aids

A missile may use decoys and penetration aids in order to overcome Anti Ballistic Missile (ABM) defences. Balloon decoys, such as used on Chevaline, are only effective before the RVs re-enter the earth's atmosphere. They are destroyed during re-entry. Substantial dummy RVs can survive re-entry. The software will calculate when the decoys should be released from the bus.

Re-entry

The flight path of a Trident missile takes it outside the earth's atmosphere. The RVs then re-enter the atmosphere. If an RV re-enters at too steep an angle then it will be destroyed by the heat of re-entry. The acceptable limits are described as the survival envelope. The trajectory of each RV is adjusted to keep it within the survival envelope.

Weather

Both air density and wind can affect the RV. Weather factors alone can knock the RV 100 m off-target. To get round this the US Navy produces detailed weather forecasts over the target areas. Communications with submarines are limited, because of the low bandwidth of transmissions. So the weather information is compressed into Ballistic Parameters (BALPARs).[8] BALPARS approximate the total effect which the winds and air density at different altitudes would have over the final stages of an RV's flight path. BALPARs are calculated for fixed points in a grid and are produced by the US Fleet