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AMERICAN CRUISE MISSILES

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Mankind's striving to establish a superior potential for extermination of antagonistic fellow beings, as a deterrent to those whom he feels threaten his way of life or even existence, has motivated the development of successive generations of 'super weapons' and counter weapons. Thus it is that we now hear the acclaimation for what supposes to be the newest brainchild of this human fear and insecurity, the American cruise missiles. Much has been written about this new American 'wonder weapon' and its capabilities which will argueably give America an advantage over the Soviet Union in the event of an 'ultimate conflict'.

But just what is a cruise missile? The term is somewhat vulnerable to ambiguous interpretation as the weapon is actually a hybrid of features from other specific weapon categories. A working definition used by the United State's Navy and Air Force describes the cruise missile as an unmanned weapon system which:

> *Has a warhead (either conventional or nuclear).*
> *Is propelled by an air-breathing engine.*
> *Operates in sustained aerodynamic flight (that is, uses wings for lift like an airplane).*

Considering the concept in the light of this definition we may conclude that the cruise missile is not a new phenomena. Cruise missiles were then first used operationally from June 1944; this pace-setter was then the German *V-1* flying bomb of the Second World War. This was the introduction of a new dimension to warfare. Weighing 5 000 pounds, 27 feet long and 33 inches in diameter, this ramjet-powered cruise missile carried a 2 000 lb warhead over distances of up to 500 miles. Despite inspiring initial dread probably comparable to Hannibal's use of elephants, the *V-1* was not very effective as a weapon, plagued by the problem that was to prove to be the most marked weakness of cruise missiles – guidance! The accuracy of the *V-1* could hardly be called deadly at the best of times, and total guidance failures of the present autopilot were not uncommon.

After the Second World War the development of cruise missiles was pursued mostly however taking a back seat to the development of manned aircraft and rockets.

In America however, before the advent of the 'ultimate weapon' – the Inter-Continental Ballistic Missile (ICBM) overshadowed all else, some cruise missiles were taken into service by both the United State's Air Force and Navy.

The first cruise missile to enter service with the United State's Air Force was the *TM-61 Martin Matador.* This missile in arming Pilotless Bomber Squadrons in Germany in 1954 became the first cruise missile to serve after the *V-1.* Powered by an Allison turbojet the *Matador* is described as a swept-wing pilotless aircraft, which had a cruising speed of some 600 mph and a range quoted as 500 miles. The *Matador* was, however, subject to guidance limitations. The system of command radio guidance they employed, required the missile to be constantly in view of a network of ground radars. Positive control was therefore only possible to the line of sight limits of the last ground station.

An improved version of the Matador, the *TM-76 Mace,* followed into the United State's Air Force inventory, being deployed in Germany in 1959. *Mace,* using an uprated version of the Allison J33 turbojet engine used on *Matador,* could cruise faster and had a greater range. Its greatest advantage was, however, the improved guidance system. Early models of the *Mace TM-76A* were equipped with the Goodyear Atran guidance system, overcoming the line-of-sight limitations of the *Matador.* The Atran system was a terrain-recognition guidance system which compared the terrain below the missile with the pre-programmed flight path plotted over a strip map. This system is however considered to have been ahead of its time and on later, longer range versions of *Mace,* the *TM-76B,* were guided by an Achiever internal guidance system.

The United State's Air Force also accepted into service an intercontinental-range cruise missile;

this was the *SM-62 Northrop* developed *Snark*. This was a subsonic weapon powered by a Pratt and Whitney turbojet engine and said to have a 5 000 mile range. The guidance system was an unusual hybrid, combining celestial (star-tracking) and internal functions; after initial problems with this navigational system had been ironed out *Snark* entered service with the United State's Air Force in 1958.

The United State's Navy's answer to *Matador* and *Mace* was the *SSNM8 Vought Regulus. Regulus* was a subsonic cruise missile of tailless swept-wing aircraft appearance powered by an Allison turbojet engine, boost launched from the deck of a surfaced submarine by twin rockets; its range was 500 miles. Guidance was by a radio command system whose unreliability and inaccuracy limited the effectiveness of the weapon.

Finally in this 'first generation' of United State's cruise missiles was *Rockwell Hound Dog* air-to-ground. This was a supersonic cruise missile powered by a Pratt and Whitney turbojet engine to speeds of slightly over *Mach 2* and a range of some 600 miles. *Hound Dog* used an internal navigation system. This missile entered service in 1961 and survived well into the seventies, and although manufacturer activity on *Hound Dog* has ceased the operational status of missiles in the United State's Air Force inventory is uncertain.

Despite the advent of Inter-Continental Ballistic Missile technology which has stifled any operational cruise missiles, a considerable amount of development work was carried out during the 1960s and early 1970s on missiles which never entered service.

Now the forerunner of a resurgent generation of cruise missiles is undergoing Operational test and Evaluation and can be considered as virtually accepted into service with the United State's Navy. This is MacDonnell Douglas' *Harpoon* anti-ship missile. Described as a high-subsonic anti-ship tactical cruise missile *Harpoon* is designed for launch from surface ships, maritime patrol and attack aircraft, and attack submarines. Guidance of the missile will be by pre-programmed altitude reference plus radar altimeter during the cruise with active homing radar being used for the terminal phase, with propulsion by a Teledyne CAE turbojet cruise engine the *Harpoon's* range is over 50 nautical miles.

So on to what has been attracting so much attention to cruise missiles of late, America's development of a new generation of strategic cruise missiles. The cruise missile owes this new found strategic value largely to improved guidance techniques, although also to the development of small lightweight turbofan engines with low fuel consumption plus the miniaturisation of warhead technology.

The guidance system which plays such a big part is the Terrain Contour Matching (Tercom) system. This sytem operates by comparing the measured terrain being flown over with a digital map of the area derived from intelligence gathering sources, should the missile have deviated from course the control surfaces are activated to put it back on its programmed track. Target and route data are read into the missile guidance system, prior to launch. Even with modern computer miniaturisation it is not possible to store mappings of the entire route to a target. Terrain contour matching is therefore used at certain 'mapping areas' en route to update an internal navigation system. This combination of Tercom and internal navigation is known as TAINS (Tercom-aided Internal Navigation System). Accuracy using this system is claimed to be very high, achieving Circular Error Probability (CEP) of only tens of feet.

As to the missiles themselves, two development programs are being run concurrently. The Boeing *AGM-86* Air-Launched Cruise Missile (ALCM) and the General Dynamics *BGM-109 Tomahawk* Sea-Launched Cruise Missile (SLCM). The two missiles have a significant number of features in common.

With Tomahawk the original concept was to provide a naval cruise missile capable of launch from a submerged submarine or surface ship, with air and land-launches as further possibilities. The resultant missile has two variants, a 'land-attack' strategic version and an 'anti-ship' tactical version. Both versions are suitable for launch from standard torpedo tubes and indeed the missile resembles a flying torpedo with small 'pop-out' wings, air-intake and Zeppelin-like tail surfaces. Both versions share a common cruise engine, a Williams Research turbofan, and have the same cruise speed, some 880 km/h, flight *will* be at low level for optimum penetration capability. The *Anti-Ship Tomahawk* will have a probable range of some 300 nm and will be fitted with a conventional warhead, while the land attack version has a range target of 1 500 – 2 000 nm and will have a nuclear warhead option. The anti-ship version will

use many subsystems of Harpoon including the guidance package. The land attack version will utilize a *TAINS* system with a possible means of improving accuracy being the United State's Navy-developed SMAC (Scene Matching Area Correlation) terminal homing system, which utilizes photographic techniques to refine the final Tercom update and direct the missile to its target.

The air-launched cruise missile is very similar in concept to Tomahawk although differing in shape. It was designed to be launched from the *SRAM* missile launcher now to be utilized with the *B-52* following the scrapping of the *B-1*. The air-launched cruise missile has a fuselage of triangular cross-section against which and into which the wings, rudder, tailplane and air-intake fit when the missile is stowed on the launcher. The same Williams Research turbofan used on air-launched cruise missile is used on *Tomahawk* and a Tercom, internal navigation system combination also serves to guide the air-launched cruise missile. The constraint of compatibility with the *SRAM* launcher resulted in a comparatively small missile with a subsequent range of some 1 300 km, however a longer-range version *(AGM-86B)* with extended fuselage and larger win span is expected to have about twice the range of the original air-launched cruise missile, but will need to be carried externally on the aircraft.

Thus while the prospects seem bright for America's new weapon system there are some cautionary points to be considered. Firstly, other countries have not neglected cruise missiles, indeed the Soviet Union has deployed a variety of cruise missiles ever since the very late 1950s and has an estimated 5 000 odd in service primarily with its naval forces. Then critics of the American reliance on cruise missiles point out some weakness in the system. The missiles must be pre-programmed and so once launched cannot be re-directed to new targets, also they can avoid only previously known fixed defensive sites. Further due to their small size the missiles carry no electronic countermeasures and are also vulnerable to supersonic interceptor missiles because of their subsonic speeds. So all in all however promising the concept and encouraging the early trials the missiles are still far from operational and may suffer some inherent disadvantages.

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