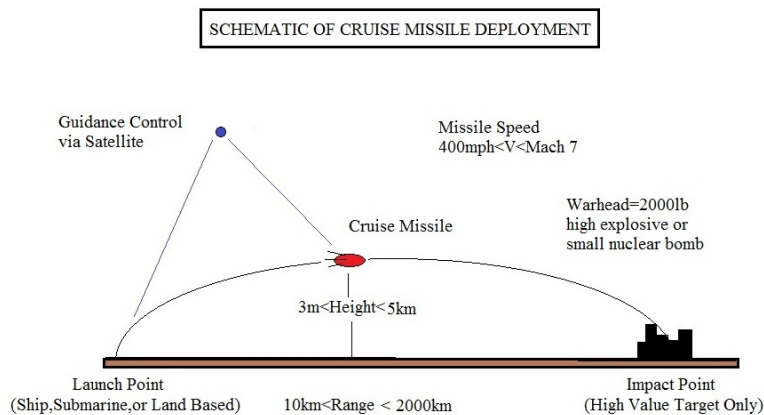


HISTORY OF CRUISE MISSILES

The recent successful deployment of 26 Russian cruise missiles (SSN-30A-KALIBRE) launched from small ships in the Caspian sea to impact on selected targets some 1500km away in Syria and to do so with an accuracy of 8ft came as a complete shock to the United States Defense Department. To partially overcome the embarrassment, the CIA planted the story the following day that some of these missiles hit cows in Iran. They could not admit that Russia has far outdistanced the US in cruise missiles technology. Indeed, the only cruise missile with comparable characteristics in the US arsenal is the Tomahawk missile which is capable of delivering a 1000lb warhead over distances of up to 1500 miles. Unfortunately it is driven by a turbo-fan jet and thus is limited to a top speed of only 550mph . Also it has limited evasive capability when dealing with a sophisticated opponent. The Russian cruise missile can reach supersonic speeds during its final approach to a target and is capable of out maneuvering defense installations. It is high time the US undertake a crash program to develop its own long range supersonic or even hypersonic cruise missiles since clearly cruise missiles, be they nuclear or not , promise to play an ever increasing role in any future expected but limited conflicts with Russia, China , and other advanced countries.

It is our purpose here to briefly discuss the history of cruise missiles, give more details concerning their capabilities, and distinguish them from other delivery systems such as the Predator drones, SAM and Exocet missiles, and ICBMs.

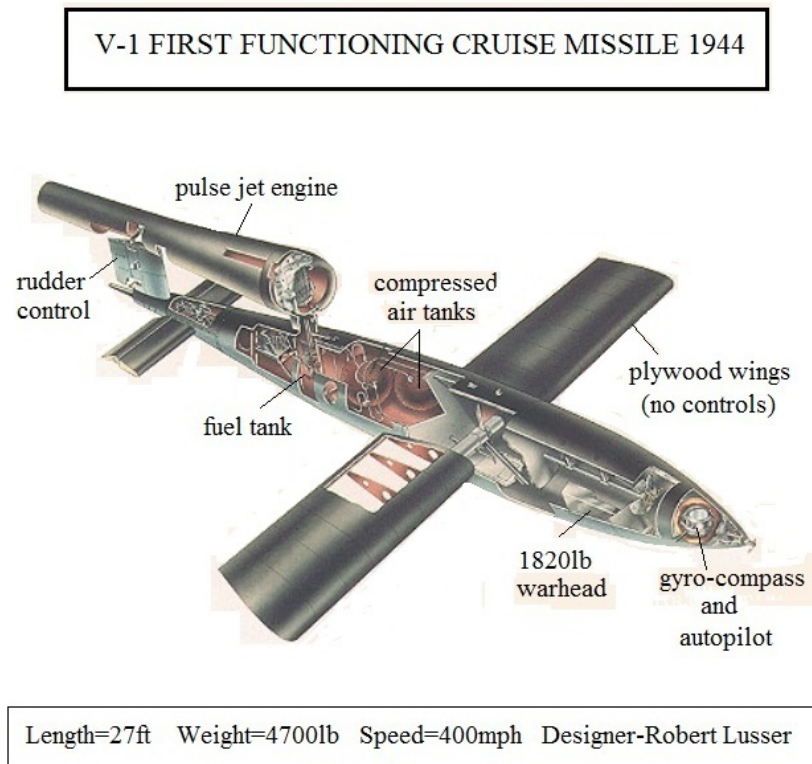
A cruise missile is any unmanned aerial propulsion system capable of carrying an explosive warhead over long distances and hitting a target with high precision. The propulsion systems range from pulse jets, to turbojets, to solid propellants, rocket propulsion, and ramjets. Guidance is inertial with some aerodynamic controls using fins and/or thrust controls. The latest guidance methods include use of satellites in addition to carried radar and infrared detectors. A schematic of a cruise missiles flight looks like this-



For land based cruise missiles one typically wants to have a range of about 1000km, if possible have supersonic speed capability, and fly close to the ground to avoid radar detection. Some type of stealth design would also come in handy. A one ton warhead would be ideal for taking out any hardened site when the accuracy at the impact point is 20 ft or less.

Historically the first cruise missile introduced into warfare was the German V-1 rocket. The V stands for the first letter in the German word Vergeltungswaffe(vengeance-weapon). It was developed at Peenemuende from 1940 through 1943 and used the first time against London starting June 13, 1944 , a few days after D-day. Living in Peenemuende from 1938 through August of 1943, I remember as a pre-schooler seeing tests of both the V-1 and later V-2 from our beach along the Baltic. A lot of the earlier ones didn't get very far before plunging into the sea.

A schematic of the V-1 looks as follows-



The V-1 was a pulse jet with limited aerodynamic controls and carrying a little less than one ton of explosive. It took off from ramps by booster assist. Once takeoff speed was attained the pulse jet engine took over. It opened and closed its intake shutters about 50 times a second and reached a cruising speed of 400mph. A gasoline cut-off valve was activated when the “buzzbomb” reached its target and then made a rapid descent to explode at ground level. The accuracy of this grand-daddy of all cruise missiles was poor with only about one quarter of the 10,000 or so fired from the Calais area hitting London.

Also the British managed to bomb most of the launch ramps in France and also shot down many of the V-1 by use of their high speed Spitfire fighter.

After WWII most of the allies built their own improved versions of the V-1. These included the Regulus and the Matador. Soon however, interest in cruise missiles waned because of the cold-war between Russia and the United States called for longer range nuclear missiles. This led to the construction of thousands of nuclear armed ICBMs sitting in underground silos and aimed at each others cities. It is interesting that the V-2 was the forerunner of these ICBMs. My father, an aerodynamicist who was also the designer of the V-2 fin system came to the US after the war and worked for the US Navy on their Poseidon Program and later became chief scientist at NASA.

With the end of the cold war in the late 1980s, interest revived in cruise missiles and other short range solid propellant missiles. Vietnam saw the use of SAM missiles (surface to air), the Falkland Island war the French Exocet missile, and most importantly the ship-fired Tomahawk cruise missile during the Iraq war.

The Tomahawk cruise missile was introduced into the US arsenal in 1983 and modernized versions continue to be used to the present day. The missile has a turbo-fan propulsion system, weighs 3500lbs, has a 1000lb warhead, and can travel 1500 miles at a speed of 550mph. Here is a picture of the missile-

TOMAHAWK CRUISE MISSILE



Range=1500miles, Length=18ft, Speed=550mph, Warhead=1000lb
Propulsion-Turbofan Jet, Ship Launched

Except for its relatively slow speed, the Tomahawk is an excellent weapon when fighting an inferior opponent such as in Iraq, Afghanistan, Libya, and Syria. But will not be so when opposing Iran, Russia, or China. These countries have defenses against such

missiles. To overcome such defenses will require that the Tomahawk have higher speeds suggesting a ram-jet design. Speeds in the hypersonic range (Mach>5) would be ideal. This will however come at the expense of shorter range.

The latest and highest performing cruise missile in the world is the BrahMos .(named after an Indian and Russian river). It is the product of a joint Indian-Russian collaboration. It uses a solid propellant booster and then a ram-jet capable of attaining speeds of Mach 3. Here is a schematic of the missile-

SUPERSONIC BRAHMOS CRUISE MISSILE
(joint Russian-Indian development)



Speed-Mach 3 , Warhead=450lb , Propulsion=Solid Booster and Ramjet
Length 25ft , Guidance-Satellite, Autopilot, Control Surfaces , Range=300miles

The range of 300 miles is somewhat limiting but the speed is impressive. It should be able to defeat any countermeasures. With nuclear warhead capability and stealth design it would be a formidable weapon.

Finally, let us say a few words about drones. These are unmanned vehicles whose main function is reconnaissance. They are not cruise missiles. These drones are slow moving propeller driven vehicles which can linger for up to 14 hours at high altitudes over a given area. The most famous of these is the Predator Drone employed very effectively by the US in Afghanistan, Iraq and Syria. The Predator is equipped with two air-to-ground Hellfire missiles each carrying 20lbs of high explosive. The drone is ideally suited for assassinations of individuals on the ground under cloud-free conditions. Such drones can travel some 450 miles without refueling but are vulnerable against ground-based hand-held missiles and fighter jets.