NUCLEAR RAMJET PROPULSION

3/25/2018

INTRODUCTION

The Supersonic Low Altitude Missile (SLAM), also dubbed "The Big Stick," was conceived around 1964 as a third weapon system in addition to the Inter Continental Ballistic Missiles (ICBMs) and strategic bombers for delivering retaliatory strikes in the event of nuclear war. The SLAM, a nuclear-powered cruise missile would have an unlimited range that could loiter following the terrain at low altitude, hence evading long-range radar, for weeks on end before dropping multiple payloads behind enemy lines.

The USA efforts to build the nuclear-powered SLAM, was named project Pluto. From 1957-1964 the USA worked on a nuclear powered cruise missile, which would carry 16 nuclear munitions to targets in the USSR. The reactor would be unshielded and was colossal in size using a moderator in a thermal neutron spectrum. A fast neutron spectrum reactor would be more compact in size. For testing purposes, an electrical heating system can model the reactor heat input.

The large amount of radiation it generated in flight was considered a feature at the time. However, even though a full scale reactor and engine were built, the project was canceled because the system was considered both highly problematic from an engineering standpoint and also provocative. The SLAM was nixed in 1964. Some believed it would motivate the Soviet Union to build a similar device, and all in all ballistic missiles were far less problematic.

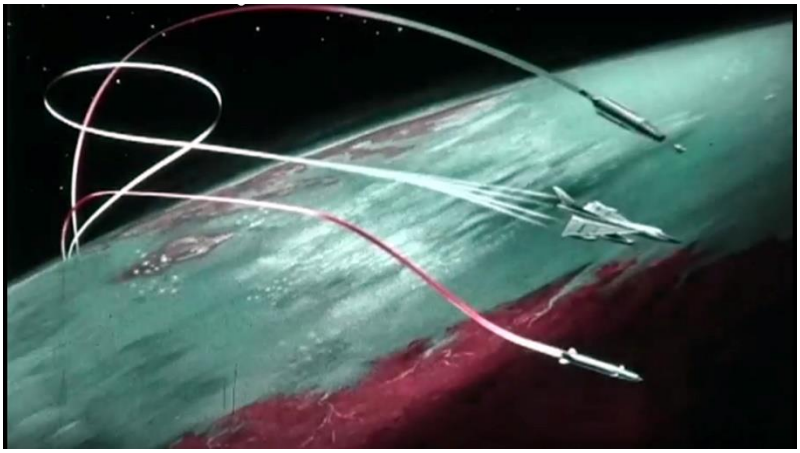


Figure 1. Triad of Supersonic Low Altitude Missile (SLAM), Inter Continental Ballistic Missiles (ICBMs) and strategic bombers.

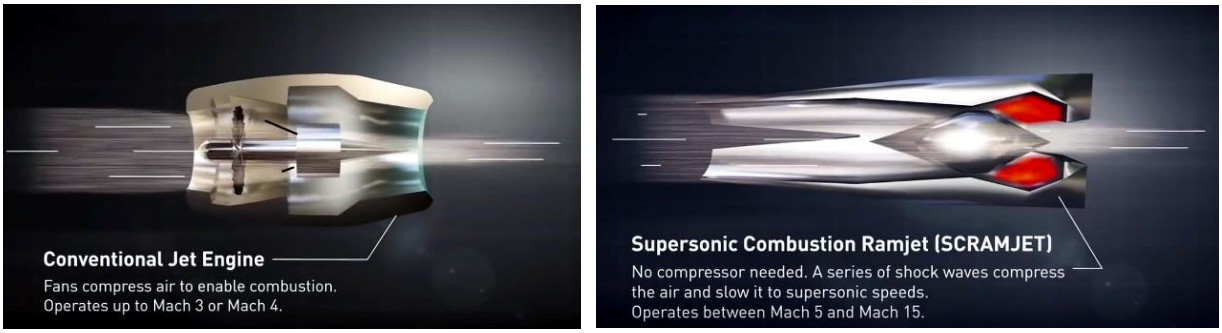


Figure 2. Operation of Supersonic Combustion Ramjet.

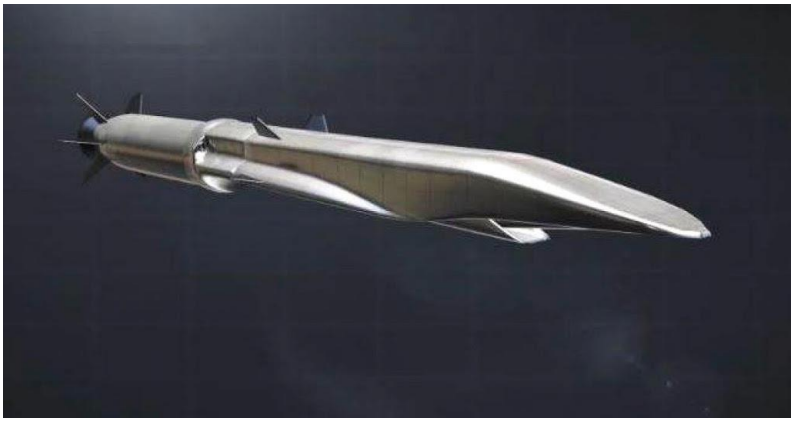


Figure 3. Hypersonic ramjet cruise missile.

Figure 4. Supersonic Low Altitude Missile (SLAM).

A subsidiary of General Dynamics, Convair at San Diego, California envisioned it as an air-breathing, unshielded nuclear reactor-powered cruise missile that would penetrate enemy airspace at low altitude, drop nuclear payloads on enemy targets, and make a suicidal plunge into a final target.

Figure 5. Convair, General Dynamics Pluto 2 nuclear ramjet was conceived to reach a Mach 3.5 speed. Reactor is situated in the back, the payload in the middle and the control and guidance system in front.

Figure 6. Pluto 2 launch using booster rockets.

Launched by a single-stage booster rocket the nuclear-powered ramjet engine would kick in once the missile reached sufficient speed. The cruise missile could then loiter for days at an altitude of 1,000 feet or less at a Mach 3.5 speed. It could carry a single large yield thermonuclear warhead or up to 26 multiple smaller devices.

HYPERSONIC STEALTH, RAMJET AND SCRAMJET

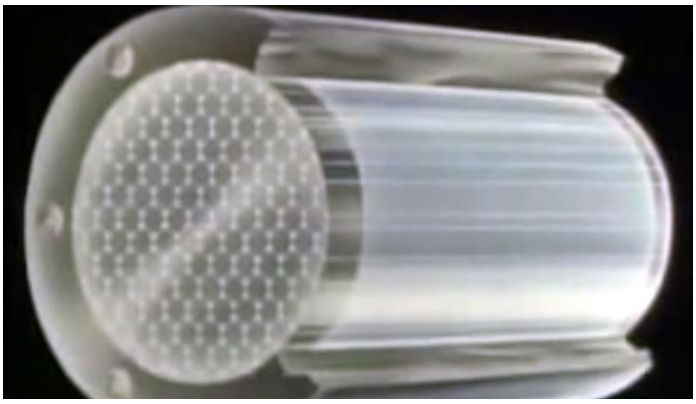
Speed is the new stealth. A hypersonic weapon is a missile that travels at Mach 5 or higher, which is about 1 mile per second. Commercial airliners fly at subsonic sped below Mach 1, whereas modern supersonic fighter jets can travel at Mach 2 - 4.

A traditional turbo-jet engine could operate at up to Mach 3 – 4, but traveling faster would need a completely different design to unclutter the flow path and sustain combustion of the supersonic airflow inside the engine using a Supersonic Combustion Ramjet "SCRAMJET", which can operate between Mach 5 - 15.

To maintain sustained hypersonic flight, a vehicle must endure the extreme temperatures of flying at such speeds. The faster a vehicle flies, the pressure-temperature rises exponentially needing materials that can withstand high temperatures over a long period of time.

Two types of weapons are emerging: hypersonic cruise missiles and hypersonic glide vehicles:

1. Hypersonic cruise missiles are powered all the way to their targets using a SCRAMJET. It takes 6 minutes from the time they are launched until the time they reach their target. They can fly at altitudes up to 100,000 feet whereas hypersonic glide vehicles can fly above 100,000 feet.
2. Hypersonic glide vehicles are placed on top of rockets, launched, and then glide on top of the atmosphere like a plane with no engine on it. They use aerodynamic forces to maintain stability to fly along and to maneuver. Because they are maneuverable they can keep their target as a secret up until the last few seconds of their flight.



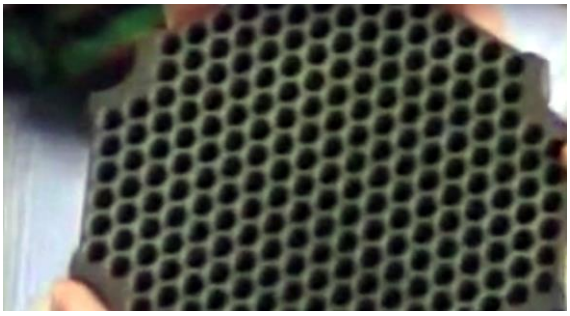


Figure 7. Reactor configuration using a hexagonal BeO moderator configuration.

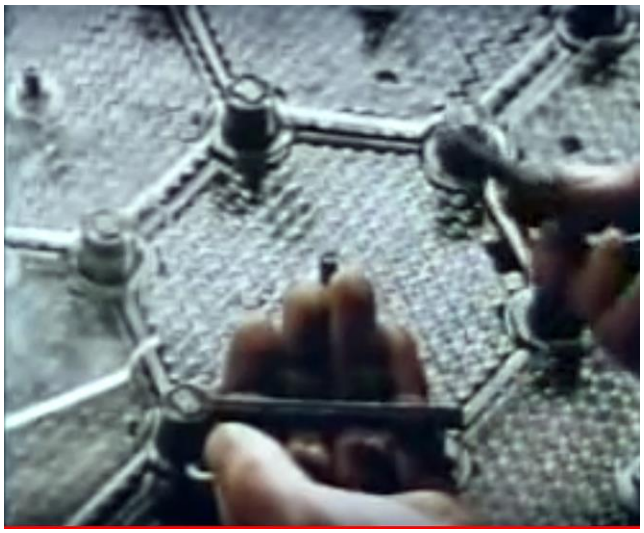


Figure 8. Tubular fuel element connected with tie rods.

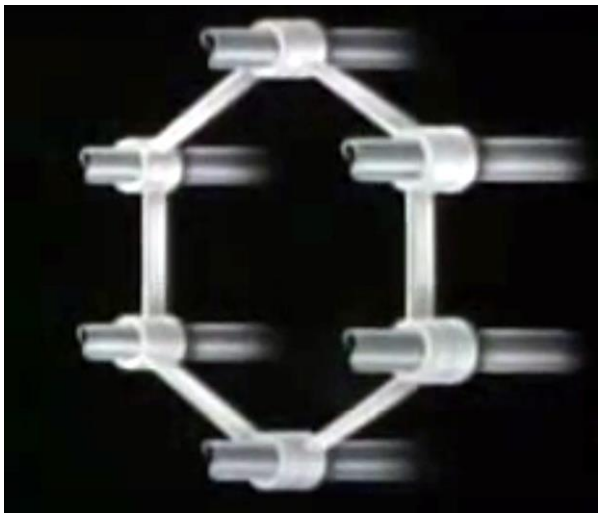


Figure 9. The generated pressures required the use of tie rods.

The USA, Russia, and China are developing hypersonic weapons, as well as France, India, and Australia. Japan and various European countries are working on civilian uses of the technology, such as space launch vehicles or civilian airliners.

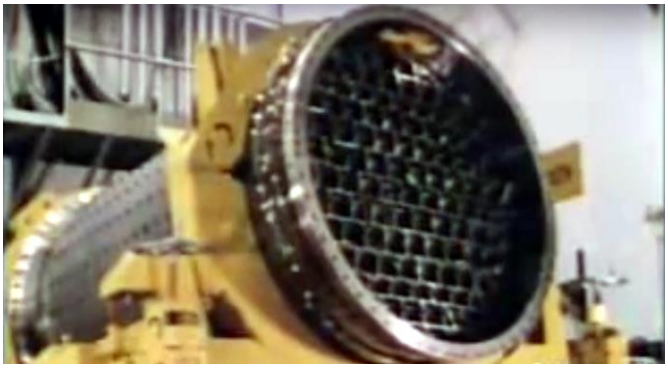


Figure 10. Torre IIC air-cooled reactor core.

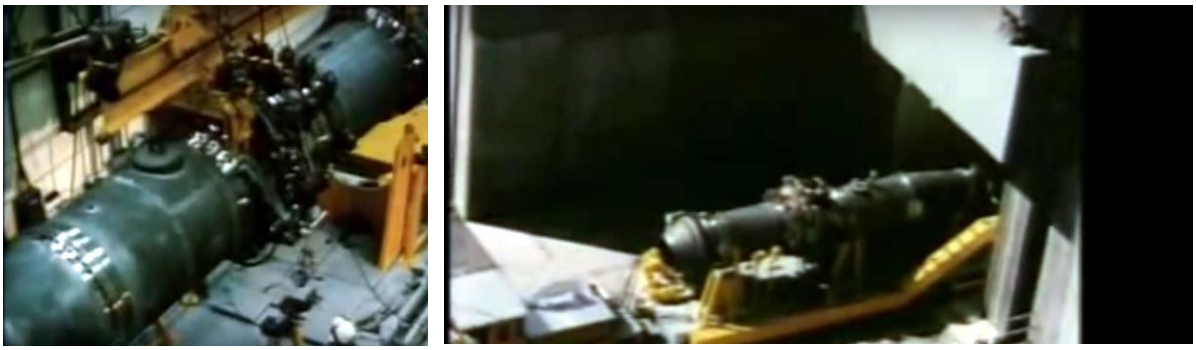


Figure 11. Torre IIC attached to exhaust nozzle.

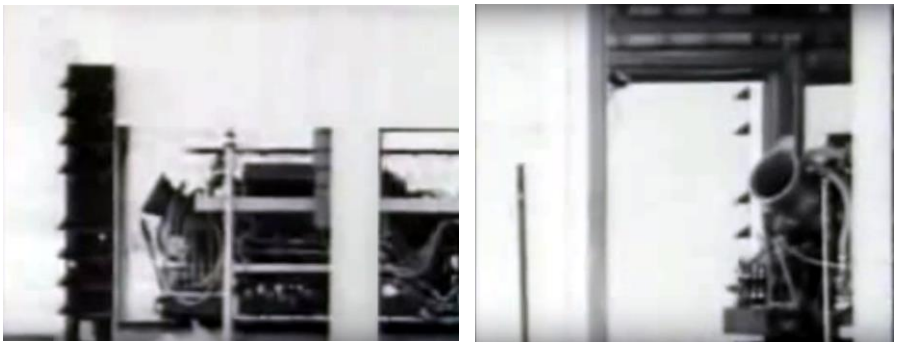


Figure 12. Testing of nuclear ramjet engine.

Figure 13. Torre IIC on way to testing.

Figure 14. Tore IIC after testing.

There are currently no effective defenses against hypersonic weapons because of the way their maneuverability. They can hug the ground at 500 feet below long range radars beams and hence escape detection. This is in contrast to ballistic missiles which possess predictable trajectories determined by momentum and gravity.

Deterrence with other systems such as existing nuclear triad of land-based intercontinental ballistic missiles, strategic bombers and submarine-launched ballistic missiles is an available counterweight. To defend against them, a space-based sensor system that would be able to track Hypersonic Glide Vehicles globally would be needed with some additional system to down them.

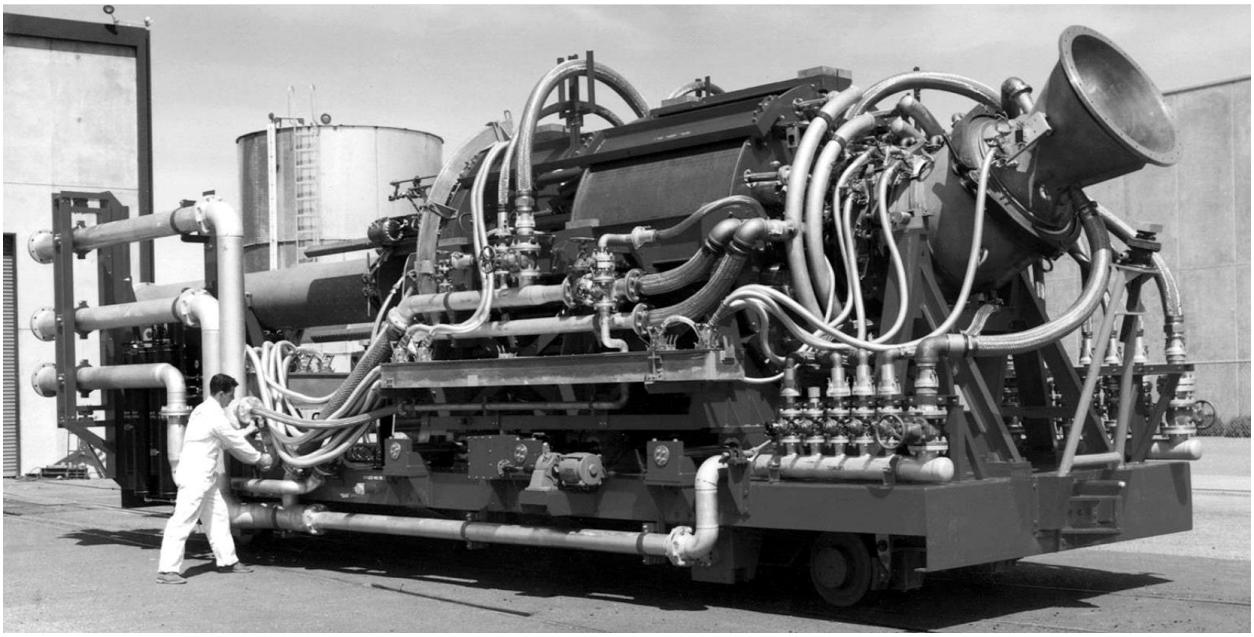


Figure 15. Nuclear reactor and nozzle Torre IIA.

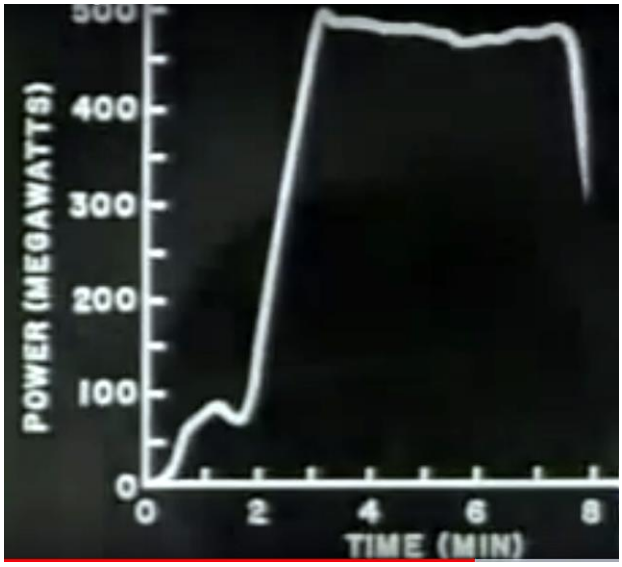


Figure 16. Reactor was tested at a power level of 500 MWth for 5 minutes.

THE "BUREVESTNIK" NUCLEAR-POWERED CRUISE MISSILE

This is claimed to have a virtually unlimited range probably using a ramjet engine powered by a nuclear reactor. A possible 9M730 project, the device, once launched, heats up the inlet shocked-air, which is mostly nitrogen gas, and does not require any more fuel, hence claims an unlimited range. "Russia has completed the trials of miniaturized nuclear power units for cruise missiles of unlimited range and for autonomous submersibles of an oceanic multi-purpose system.

"Russia has created a small-size super-powerful power plant that can be placed inside the hull of a cruise missile and guarantee a range of flight ten times greater than that of other missiles." "A low-flying low-visibility cruise missile armed with a nuclear warhead and possessing a practically unlimited range, unpredictable flight path and the capability to impregnate practically all interception lines is invulnerable to all existing and future missile and air defenses". To date, those technologies have been designed and put into practice only by Russia.

Its main characteristics are:

i) Low-flying and steady,
ii) Nuclear powered,
iii) Unlimited flight range,
iv) Penetrates missile and air defense shields,
v) Unpredictable flight path.

Figure 17. Nuclear-powered earth-hugging, radar-evading cruise missile which is claimed to have a virtually unlimited range probably using a ramjet engine powered by a miniature nuclear reactor. This missile can take an arbitrary path to its target and circumvent any enemy defenses. And the advantage to being nuclear-powered is that it can loiter around for months, due to its almost practically limitless energy supply. The missile has special compartments where air is

heated by a nuclear reactor to several thousand degrees, then thrust is created by ejecting the superheated air. The picture shows four rear nozzles creating thrust for the missile.

KINZHAL, "DAGGER" HYPERSONIC CRUISE MISSILE

The Kinzhal "Dagger" air-launched, precision-guided cruise missile is designed to engage ground-based and seaborne targets. The air-to-ground missile code-named is Kh-47M2 is launched from a modified MiG-31BM supersonic interceptor aircraft. It is based on the 9M723-1F variant of the 9M723-1 missile as used by the 9K720 Iskander-M short-range road-mobile ballistic missile system. It uses a solid propellant motor with a non-separating warhead and a finned truncated tail-cone at the missile's rear to decrease the aerodynamic effects of the missile when carried at high-speed on the aircraft and protects both its control components and motor nozzle from damage when in transit.

No extraneous external components are located on its surface other than its two cable ducts, which run from the control/motor nozzle section, over the motor and into to the guidance section, and the skin of the missile has been covered with a special heat-resistant and radar absorbing coating to minimize the heat effects on it and further lower its Radar Cross Section (RCS) [1].

Figure 18. High precision Kinzhal "Dagger," hypersonic cruise missile launched from the belly of a Mig 31 supersonic interceptor jet in the South Military District in Russia's southwest.

Figure 19. Kinzhal, “Dagger” cruise missile launch from Mig 31BM interceptor has a range of 1,000 kms.

Figure 20. Kinzhal Dagger hypersonic cruise missile in flight.

REFERENCES

1. Neil Gibson and Nikolai Novichkov, “Russian Aerospace Forces take delivery of ‘new’ Kinzhal air-launched ballistic missile,” Jane’s 360, Match 19, 2018.