Exocet Anti-Ship Missile

I. Overview:

The Exocet is a family of French anti-ship missiles that can be launched from several platforms like aircrafts, helicopters, high or low tonnage warships and submarines. All missiles have a common layout being all-weather, sea-skimming, fire-and-forget, radar guided and propelled by a dual thrust solid rocket motor at transonic speed. It is intended to attack large as well as small warships at medium range, though later development allow firing at target well over the horizon.

II. Development:

First development began in 1967 the ship launched version, called MM-38 (Mer-Mer 38 for 38 kilometers). French Navy indeed awarded the Aerospatiale company (now MBDA France) to produce a stand-off guided weapon able to destroy large warships. The MM-38 entered service on French navy in 1975, being the world first anti-ship missile with the sea-skimming capability. Study on a airborne variant began in 1972, with tests conducted on a modified MM-38 to allow them to be carried under pylons of helicopters and jets. Since the concept proved itself to be successful, a new missile using a modified rocket motor with longer burn time, greater thrust and adapted airframe for travelling at supersonic speed, was born, the AM-39. It entered service in the French naval air forces in 1979.

Development on an improved ship-launched version, the MM-40, started in 1976. It has a more accurate radar seeker, range increase to 40 nm and lightweight launch container. It entered service in the French navy in 1981.

The last member of the family is the submarine launched one. Work on it began in 1979 with a modified AM-39 and the new missile, SM-39, entered service in 1985 on French attack subs.

Coastal defence version have been constructed, reported as BC-39 or BC-40 depending on the missile used.

Several upgrades took place in the mid-80's, with the replacement of the radar seeker, on board computer and control system by digital computing ones. Then the ability to manoeuvre in the terminal attack phase has been added with the introduction of an improved altitude control system. A new seeker and inertial navigation unit are the last upgrades that lead to the Exocet AM-39 and MM-40 Block 2 Mod 1 standard, currently used by the French navy.

Further development:

MBDA France is working on the MM-40 Block 3 missile with range increased to 100 nm (~180 km) thanks to a turbojet replacing the old solid-propellant sustainer motor, and electronic improvement with a fully digital computing system. The new missile is intended to enter service with the new air defence destroyers, the Horizon class, planned for 2007.

III. Technical description:

Layout is classic with a cylindrical shaped airframe, cruciform wings and tail control surfaces.
The missile is divided into four modular parts:

-The forward section houses the radar seeker, associated guidance computer and autopilot, inertial system with gyros and accelerometers, radio altimeter and radio proximity fuze. This is so the section where the “intelligence” of the missile is located.

-Section 2 contains the warhead which is common to all versions. It is a 165-kg shaped charge with fragmentation and incendiary effects. The explosive employed is Hexolite. It is initiated by a delay fuse which allow the missile to penetrate the outer hull of the ship before blowing up. A proximity fused is fitted as a back-up fuse if the missile overfly its target, then causing extensive damage to the bridge, antennas and potentially aircrafts on deck.

-Section 3 is the power plant. It houses the sustainer motor which is a solid propellant rocket motor with a constant thrust and burn time of 2 minutes with a speed of 310 m/s for MM 38. Burn time is increased with a new motor casing for AM-39 and SM-39 allowing the missile to reach 50km. MM-40 has twice the range of MM-38, with an improved AM-39 rocket motor which sustain a speed of 310 m/s during approximately 4 minutes. Behind the sustainer motor is the booster rocket which accelerates the missile from 0 to Mach 0.93 when launched from ships or submarines, and is also fitted on the airborne AM-39 so that the missile can achieve greater range (up to 70 km) when release at high altitudes and great speeds. Thermal batteries are used to generate the current needed by the seeker, navigation system and actuators.

-Section 4 surrounds the exhaust of the power plant, and contains the actuators that control the missile flight through the tail fins.

Ship-launched versions are contained in water-tight assemblies that are used to protect the missile from the delivery up to the firing, required little to no maintenance work. MM-38 uses a caracteristic launch container while MM-40 has a lighter and smaller one enabling the replacement of 6 MM-38s by 8 MM-40s using the same space. Below, the container of MM-38 missiles:
And the one used by the MM-40:

![Image of MM-40 being launched]

SM-39 use a special container that can be fire from a standard 533mm torpedo tube, it is called VSM (Véhicule Sous Marin) and allow firing without revealing the sub position thanks to a underwater propulsion system (using a low thrust rocket motor).

IV. Engagement:

- **With MM-38 and MM-40:**
  
  Targeting data can be gathered not only by the ship carrying the missile but also from others platforms like helicopters, AWACS, etc. Those data includes targeting ship distance and bearing and are fed into the navigational computer of the missile. Seeker's activation range and search parameters can be modified with both versions as well as shut down range. With MM-40 it is now possible to co-ordinate a salvo of missiles to converge at the target from multiple bearings with a same arrival time on target using waypoints, moreover MM-40 is able to make terminal manoeuvre in order to saturate and avoid defences.

  Then the missile is launched from its container, accelerates to Mach 0.93 using its booster rocket motor and sustains its speed with its sustainer motor. In a first phase, the missile use inertial navigation and flies at 9-15 meters above sea. Arriving at the activating point, the radar seeker turn on and begin searching for targets. Improved seeker with frequency-agile capability and counter-counter measure algorithms make the MM-40 more resistant to jamming and deception.

  Achieving a lock on its target, the missile flies now as low as 2-3m to avoid being intercept by anti-missile systems and, for the MM-40, make some terminal manoeuvres before hitting the targeting ship, penetrating the hull before exploding its warhead which starts massive fires inside the ship.

  Below the photo of an MM-40 being launched:

- **With AM-39:**

  The missile can be launched from several airborne platforms like helicopters, fighter jets or patrol aircrafts. The engagement occurs in the same way as for ship launched missiles, however,
when releasing the missile from high altitudes and speeds, the range can be greatly enhanced, up to 72 km while 50 km is the “standard” one. The latest versions, AM-39 block 2, are able like MM-40 to follow pre-determined waypoints to co-ordinate saturation strikes, evolved seeker and ECCM algorithms, and terminal manoeuvres capabilities.

- With SM-39:
  The procedure of a submarine launch is a bit different. Targeting data can come from multiple sources like sonar, electronic interception, periscope and data links while the sub is at periscope depth. The missile can be fired in bearing only mode, since the range is more difficult to know with sonar and EW intercept. When the firing computer has fed a solution into the navigational computer on board the missile, the launch can occur. Limitation on speed and depth are not known, but the course of the sub has no incidence on the path followed by the missile after launch. Contained in its VSM (Véhicule Sous Marin -Underwater Vehicle-), the missile is launched through an standard 533mm torpedo tube, then the VSM travels underwater in order not to reveal the sub position, then it breaks the surface and explosive bolts release the missile which clears the surface with its booster rocket. The engagement occurs then in the same way as AM-39, and using the block 2 missile, it is possible to launch co-ordinated salvo in saturation strikes.

Below a Sm-39 taking off from its VSM:

V. Operational status:

Whereas MM-40 are fitted on more modern unit such as F-70 ASW destroyers and F-70 anti-air (AAW) destroyers, on Lafayette class stealth frigates and on remaining D'Estiennes d'Orves frigates.
The navy air force uses AM-39 on Atlantic 2 patrol aircraft (which has very close capabilities to the P-3C Orion), on Super Etendard Modernisés (SEM) aboard the Charles de Gaulle aircraft carrier and the new batch of Rafale Marine are able to carry it.
The 6 Amethyste class SSNs carry SM-39 as well as ballistic submarines, Triomphant and Inflexible class SSBNs, in order to self-defend against a surface threat.
Exportation of the Exocet family has been an enormous success with over 3200 missiles sold.

They have been used first during the Falkland war in 1982 when a couple of Argentina's Super Etendard fired AM-39 missiles on the British Type 42 anti-air destroyer HMS Sheffield. One
missile misses its target, being jammed, whereas the other hit the warship, starting a massive fire which sank the ship within 24 hours. Another Exocet strike sank the cargo *Atlantic Conveyor*, causing heavy materials losses in the British side. Because the Argentine military were short of air-launched Exocets, they dismounted an MM-38 firing ramp from one of their warships in order to make it a coastal battery to defend the island. They managed to sink another British destroyer with this improvised system using MM-38 missiles.

The Iraqi air forces extensively used AM-39 during the Iran/Iraq war in the 80's against Iranian warships and Oil platform, with more than 100 missiles fired. Then two missile launched by Iraqi Mirage F1 damaged the *USS Starke* in 1987 in the Persian Gulf, but didn't sunk.

Exocets have been exported to a lot of countries, including among others Argentina, Brazil, Egypt, Germany, Iraq, Greece, India and Pakistan.

General characteristics:

**Primary Function:** Anti-ship missile

- **Contractor:** MBDA France
- **Power Plant:** Dual thrust solid propellant rocket motor
- **Thrust:** not available
- **Speed:** 310 m/s
- **Range:** 38 km for MM-38, 50 km for AM/SM-39, 70 km for MM-40
- **Length:** 4.7m for AM39/SM39, 5.2 m for MM-38 and 5.8 m for MM-40
- **Diameter:** 0.35 m for all versions
- **Finspan:** ~1.1 m
- **Warhead:** 165 kg shaped charge with fragmentation and incendiary effects
- **Launch Weight:** 735 kg for MM-38, 670 kg for AM/SM-39 and 870 kg for MM-40
- **Guidance System:** inertial navigation, terminal guidance by radar seeker.
- **Unit Cost:** unknown.
- **Inventory:** more than 3200 missiles sold

**Sources:**
- French Navy, photo of MM-38 casing taken on the *Duquesne* DDGM, photo of the MM-40 taken on a F-70 class destroyer. Thanks to the crew of the *Amethyste* SSN and the *De Grasse.*