Feasibility of Third World Advanced Ballistic & Cruise Missile Threat

Volume 2: Emerging Cruise Missile Threat

By
Systems Assessment Group
NDIA Strike, Land Attack and Air Defense Committee

August 1999

FEASIBILITY OF THIRD WORLD ADVANCED BALLISTIC AND CRUISE MISSILE THREAT
Volume 2: Emerging Cruise Missile Threat

The Systems Assessment Group of the National Defense Industrial Association (NDIA) Strike, Land Attack and Air Defense Committee performed this study as a continuing examination of feasible Third World missile threats. Volume 1 provided an assessment of the feasibility of the long range ballistic missile threats (released by NDIA in October 1998). Volume 2 uses aerospace industry judgments and experience to assess Third World cruise missile acquisition and development that is "emerging" as a real capability now. The analyses performed by industry under the broad title of "Feasibility of Third World Advanced Ballistic & Cruise Missile Threat" incorporate information only from unclassified sources.

Commercial GPS navigation instruments, compact avionics, flight programming software, and powerful, light-weight jet propulsion systems provide the tools needed for a Third World country to upgrade short-range anti-ship cruise missiles or to produce new land-attack cruise missiles (LACMs) today. This study focuses on the question of *feasibility* of likely production methods rather than relying on traditional intelligence based primarily upon observed data. Published evidence of technology and weapons exports bears witness to the failure of international agreements to curtail cruise missile proliferation.

The study recognizes the role LACMs developed by Third World countries will play in conjunction with other new weapons, for regional force projection. LACMs are an "emerging" threat with immediate and dire implications for U.S. freedom of action in many regions . The asymmetrical development of Third World threats favors indirect engagement and unconventional warfare. Unconventional cruise missile acquisition and design methods considered in the study support such asymmetrical threat development as a means Third World countries can significantly reduce the development time, cost, and risk.

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Agenda

Study Objectives

Study Statement of Work:

"As a complement to Volume 1, this Cruise Missile study will examine innovative, low cost approaches to improving and expanding the Third World cruise missile inventory. Modifications of existing systems will be emphasized. A variety of delivery systems will be considered. The primary objective of this study will be to analyze the impact of [Third World] cruise missiles on U.S. ability to advance its national interests worldwide."

- **Describe the history of cruise missiles**
- **Discuss trends of cruise missile technology proliferation**
- **Assess Third World cruise missile acquisition options**
- **Discuss Third World cruise missile applications**
- **Assess implications for Theater Missile Defenses**

This Threat Assessment is compiled from UNCLASSIFIED sources

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Study Approach

- **Review lessons learned from historical cruise missile development programs**
  - **WW II Germany CM evolution**
  - **Development time and motivation**
- **Assess potential technical improvements to cruise missiles available to Third World countries**
- **Assess candidate Land-Attack Cruise Missile alternatives**
- **Analyze of Third World asymmetric threat trends**

Why Cruise Missiles for Third World Forces?

Fundamental regional military requirements explain why cruise missiles are attractive options for Third World countries.

Missions	Objectives
• Threaten/Attack Population Centers • Threaten/Attack U.S. Forward Deployed Forces & Bases • Threaten/Attack Air and Sea Ports • Threaten/Attack Naval & Amphibious Operations	• Prevent Creation & Maintenance of Coalitions • Deny Facillities to U.S. & Allies • Prevent Entry of U.S. & Allied Forces • Raise Risk to Unacceptable Levels

The apparent rise of asymmetrical military forces in Third World countries does not preclude the incorporation of effective technologies which are economical. Cruise missiles of adequate capability can be inexpensively produced in large numbers (as this study will describe). A robust force of cruise and ballistic missiles can significantly contribute to an otherwise low-technology asymmetrical force to dislodge regional enemies, prevent their reinforcement by high-technology allies, or otherwise buy time to create a more favorable political solution.

Why Cruise Missiles for Third World Forces?

- **Cannot Defeat U.S. / Allies on Battlefield: Land, Sea, Air**
  - **Persian Gulf War showed failure of direct confrontation**
- **Development of Hi-tech Conventional Forces Constrained**
  - **Affordability**
  - **Technological Availability**
- **Aggressor Nations Must Develop Asymmetric Strategies & Forces to Counter U.S./Allies**
- **Developed Nations Have Strategic Interest in Constraining U.S. Freedom of Action -- Cooperate with Third World Aggressors**
  - **Cultivate Third World military and commercial markets**
  - **Maintain own defense industries in spite of declining budgets**

Most Cost-Effective Strategy for Deterring or Fighting U.S./Allies is
<u>Acquisition of Ballistic / Cruise Missile Force</u>

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Agenda

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Historical Background

- Overview
- Early Experiments (1907-1939)
- World War II Developments (1939-1945)
- Evolution of the Modern Cruise Missile
- Global Proliferation of Cruise Missile Capabilities
- Lessons Learned

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Overview

- Cruise missiles evolved from multiple origins and through diverse development paths unlike the highly focused German ballistic missile program

- Therefore, a very wide range of approaches can be used to produce a cruise missile system, some of them unconventional and alien to U.S. conventional wisdom

- Virtually all the technologies needed to develop and deploy cruise missile systems are available world wide

- The problem of identifying Third World cruise missile development programs may be significantly more difficult than ballistic missile developments

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Early Experiments
(1907-1939)

- Origins
  - Concept developed by René Lorin, French Artillery Officer -- 1907
  - Early German, U.S., U.K. development -- 1915-1916

- World War I
  - Kettering “Bug” Aerial Torpedo (U.S. Army Signal Corps) -- 1918
  - Sperry Aerial Torpedo - N-9 Biplane (U.S. Navy) -- 1918

- Between the Wars (1919-1939)
  - Larynx (Long-Range Gun with Lynx Engine) (U.K.) -- 1921
  - Argus R/C Target Drone (FZG-43) and Fernfeuer Pilotless Bomber Concept (Germany) -- 1939
  - Argus and Schmidt Pulsejet Developments and the origins of the V-1 (Germany) -- 1939

Kettering Aerial Torpedo "Bug"

The Kettering Aerial torpedo was the first U.S. Purpose-built cruise missile. It was invented by Charles F. Kettering, founder of the Delco Division of General Motors and holder of over 140 patents including the automobile self-starter. Kettering's design was developed and build by the Dayton Wright Airplane Company in 1918 for the Army signal Corps. The unmanned Bug took off from a trolley which ran along a launch track. Target coordinates were preset prior to launch. Heading was maintained by a primitive autopilot and range to target was determined by an engine rev-counter. When the required number of engine revolutions was recorded, a control closed an electrical circuit which shut off the engine. The wings were then released and the Bug dived to earth where its 180 pounds of explosive detonated on impact.

Although the testing of the Bug was successful, World War I ended before the missile could enter combat. System testing continued until 1920 when the project was terminated due to lack of funds.

Kettering Aerial Torpedo "Bug"

U.S. Air force Museum, Wright-Patterson AFB, Internet Home Page.

Specifications
- **Span: 14 ft. 11 1/2 in.**
- **Length: 12 ft. 6 in.**
- **Height: 4 ft. 8 in.**
- **Weight: 530 lbs. loaded**

Performance
- **Armament: 180 lbs. of HE**
- **Engine: One De Palma four-cylinder of 40 hp**
- **Design speed: 120 mph**
- **Range: 75 miles**

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World War II Developments - Germany (1939-1945)

Although Nazi Germany produced the first modern cruise missile, the V-1, both Germany and the United States pursued a number of less-advanced cruise missile concepts where many reached limited operational use throughout the World. The Luftwaffe, in and attempt to solve the problem of killing hard targets in the enemy rear area, developed the bizarre Mistel composite aircraft in which a pilotless converted bomber was connected to a piloted fighter as a recoverable terminal guidance system. The Luftwaffe employed with some success, a number of Air-to-Surface Antiship Missiles which were primarily short range glide or boost-glide vehicles. Although never incorporated into cruise missiles, the Lufwaffe Design Bureau run by the Horten Brothers developed jet-propelled flying wing prototypes which incorporated low observables shaping the primitive radar-absorbing materials.

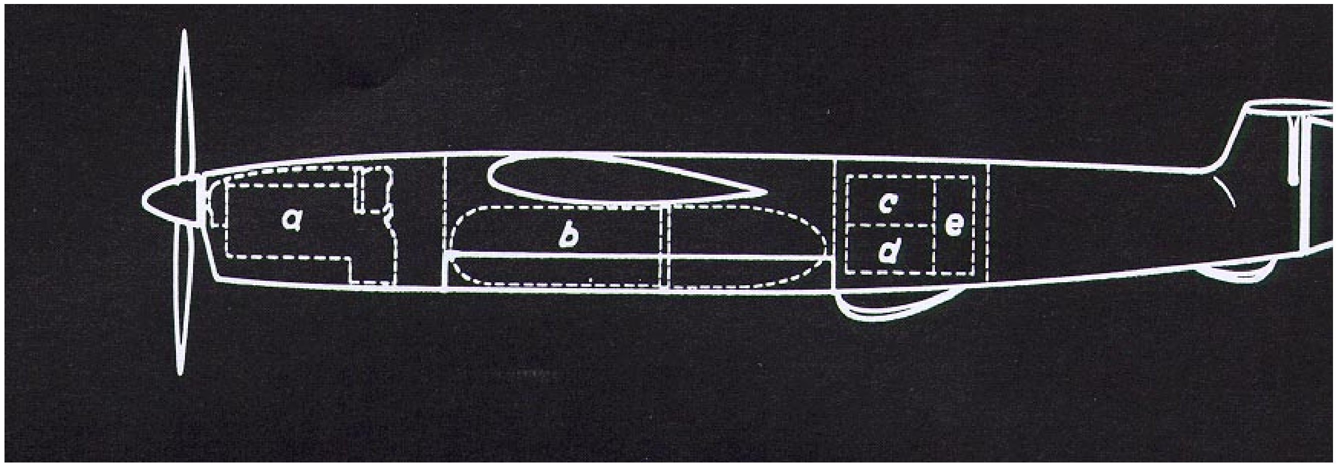
World War II Developments - Germany (1939-1945)

- V-1 (Fiesler F-103) Cruise Missile
  - Ground Launch Version
  - Air Launch Variants
  - Piloted Variants
  - WMD Dispenser
- Mistel Composite Aircraft
- Air-to-Surface Antiship Missiles
- Stealth - 1944

Argus Fernfeuer Pilotless Bomber Concept - 1939

The immediate ancestor of the V-1 Cruise Missile was a pilotless bomber aircraft called the Fernfeuer (Long Range Fire) that was proposed in 1939 by Dr. Fritz Gosslau of the Argus Aero Engine Company. The Fernfeuer was a piston-engined, recoverable pilotless bomber capable of delivering a 1-ton bomb to the target and returning to base. The aircraft was gyro-guided to the target where an accompanying director aircraft provided radio-commanded terminal course correction and issued the bomb release command. The Fernfeuer aircraft would then automatically return to base. The project was abandoned due to urgent priorities for the conduct of the war. Gosslau did not give up and in 1941 Argus proposed a pulse-jet-powered cruise missile which became the V-1.

Argus Fernfeuer Pilotless Bomber Concept - 1939



V-Missiles of the Third Reich The V-1 and V-2, *Dieter Hölsken Monogram Aviation Publications 1994*

Fernbombe.
==========

1000 kg Sprengladung (beleibig aufteilbar). Eindringtiefe 1000 km. Fluggewicht 3 to.
a) Triebwerk 500 PS in 5 km Höhe, b) Sprengladung, c) Drei-Achsen-Kreiselateuerung,
d) Leitstrahlgerät zur funktechnischen stützung des Kurskreisels,
e) Gerät zur Steuerung im Sichtbereich mittels Knüppel vom Boden aus.
Aufteilung in Abwurflast und Tragteil. Letzterer kehrt zu neuem Einsatz zurück.

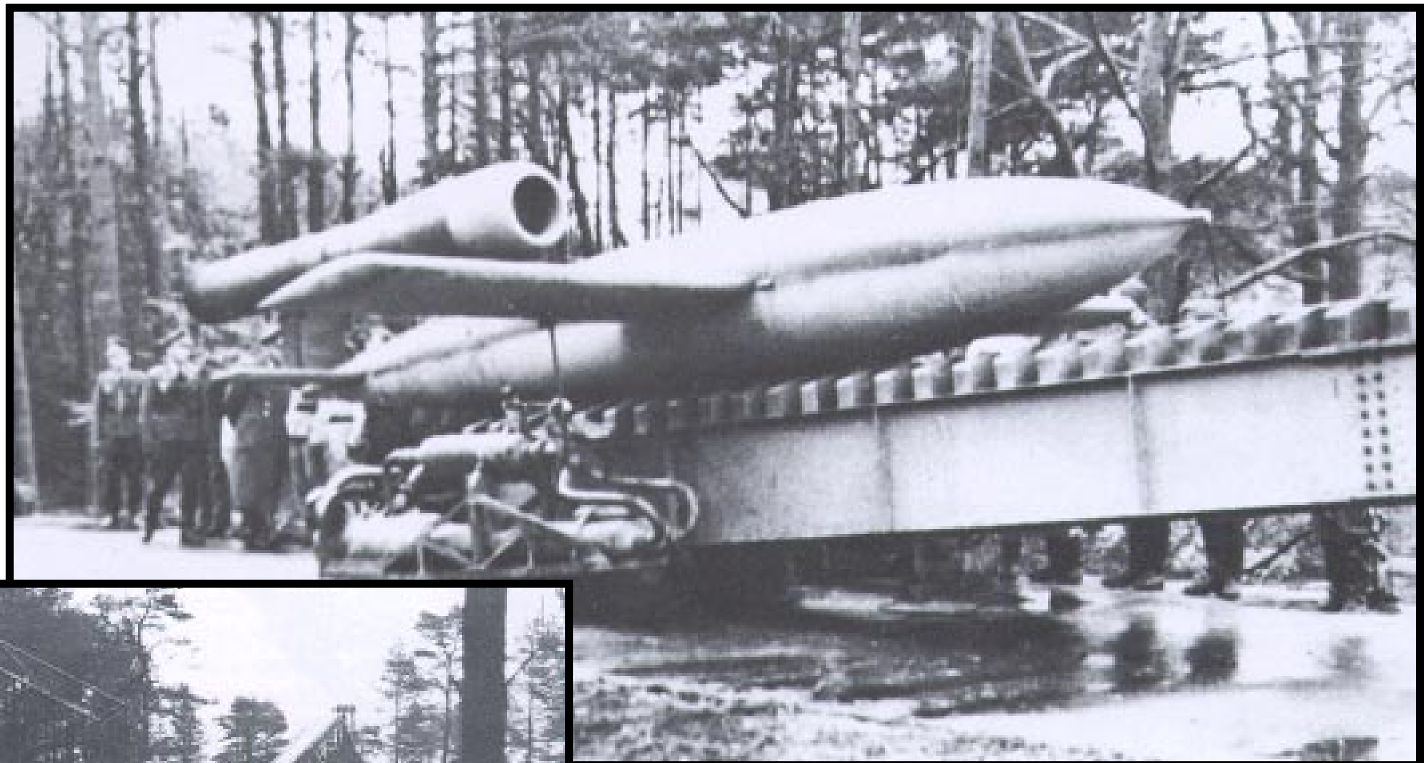
Cutaway drawing of the *Fernfeuer* project. The Argus engine (a) should provide 500 hp at an altitude of 16,400 feet. The 2,200-pound explosive charge was stored in the bomb bay (b). Control of the pilotless aircraft was provided by a three-axis gyroscope (c), a radio beacon (d) for course tracking, and a receiver for wireless guidance (e). At a gross weight of 3 tons, penetration range should have been 621 miles.

Ground Launch V-1 on Ski Site Catapult

The Fiesler F-103 (V-1) was the first modern cruise missile. The key technology for the V-1 was the development of the Argus Pulse-jet engine, a relatively simple propulsion system which could be mass-produced at low cost and which provided the V-1 with a top speed equal to or higher than most of the allied propeller-driven fighters of the day. The V-1 was a relatively simple design which could be produced in large quantities by low skill slave labor. Guidance was provided by a magnetic compass for azimuth and a propeller-based rev counter which resulted in a very large CEP at the target.

The basic V-1 was ground-launched from a gas or steam catapult from a fixed rail launcher. Allied Intelligence analysts dubbed these launch facilities "ski sites"because of the ski jump shape of the launch rail in overhead reconnaissance photography.

Ground Launch V-1 on Ski Site Catapult

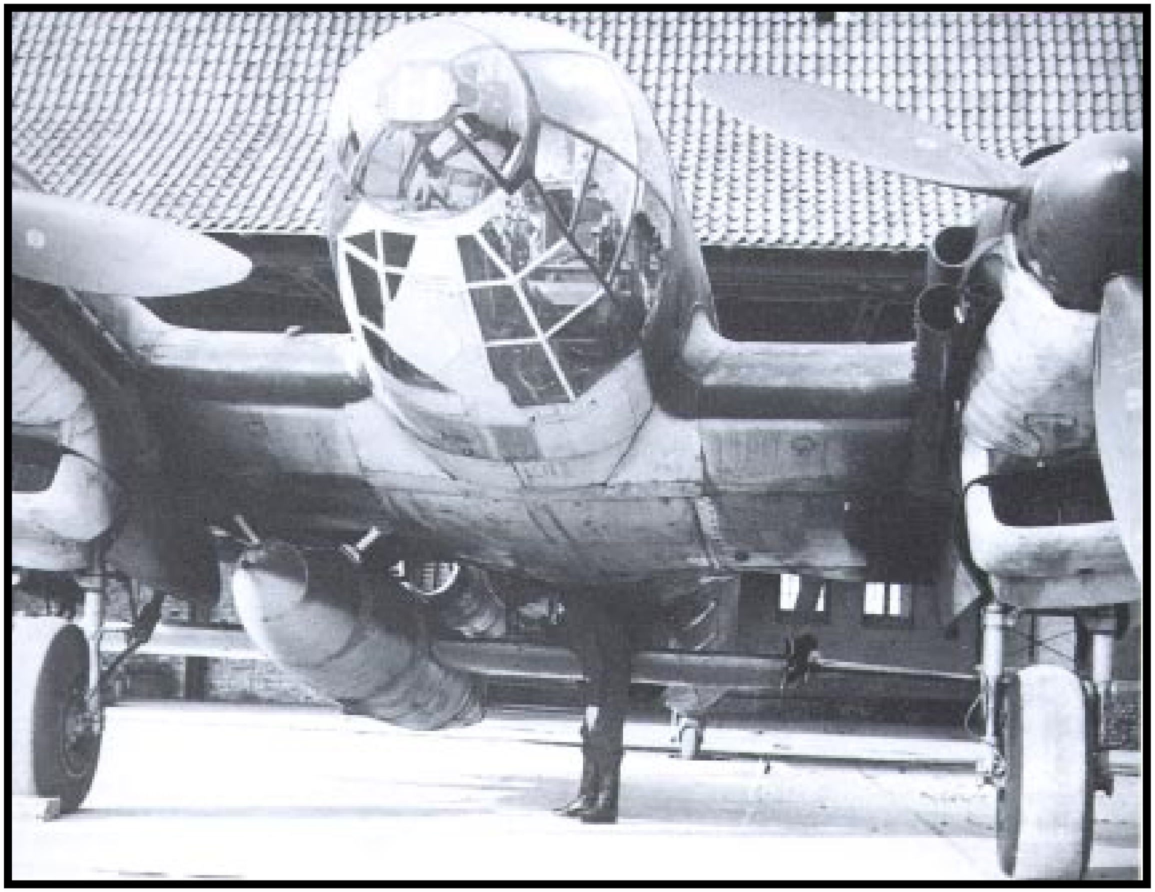


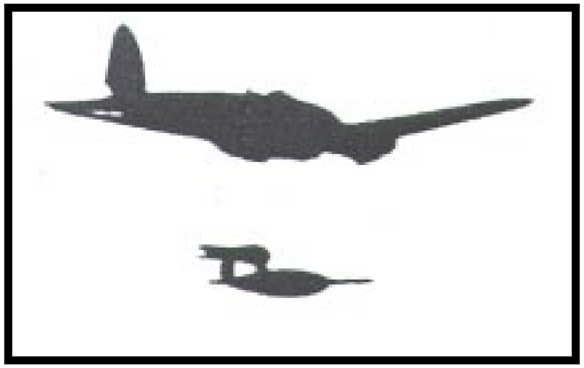
<u>V-Missiles of the Third Reich The V-1 and V-2</u>, Dieter Hölsken
Monogram Aviation Publications, 1994

Heinkel He-111H as Operational Air Launch Platform (1944)

The inherently low survivability of the fixed V-1 ground launchers and the increasingly poor target access with the Allied advances after D-Day led to the operational deployment of a previously-developed air-launched V-1 and a modified Heinkel He-111H bomber as the initial launch platform. The air-launched V-1 partially improved the survivability and range problems of the ground-launched version but further worsened the missile's CEP.

Heinkel He-111H as Operational Air Launch Platform (1944)



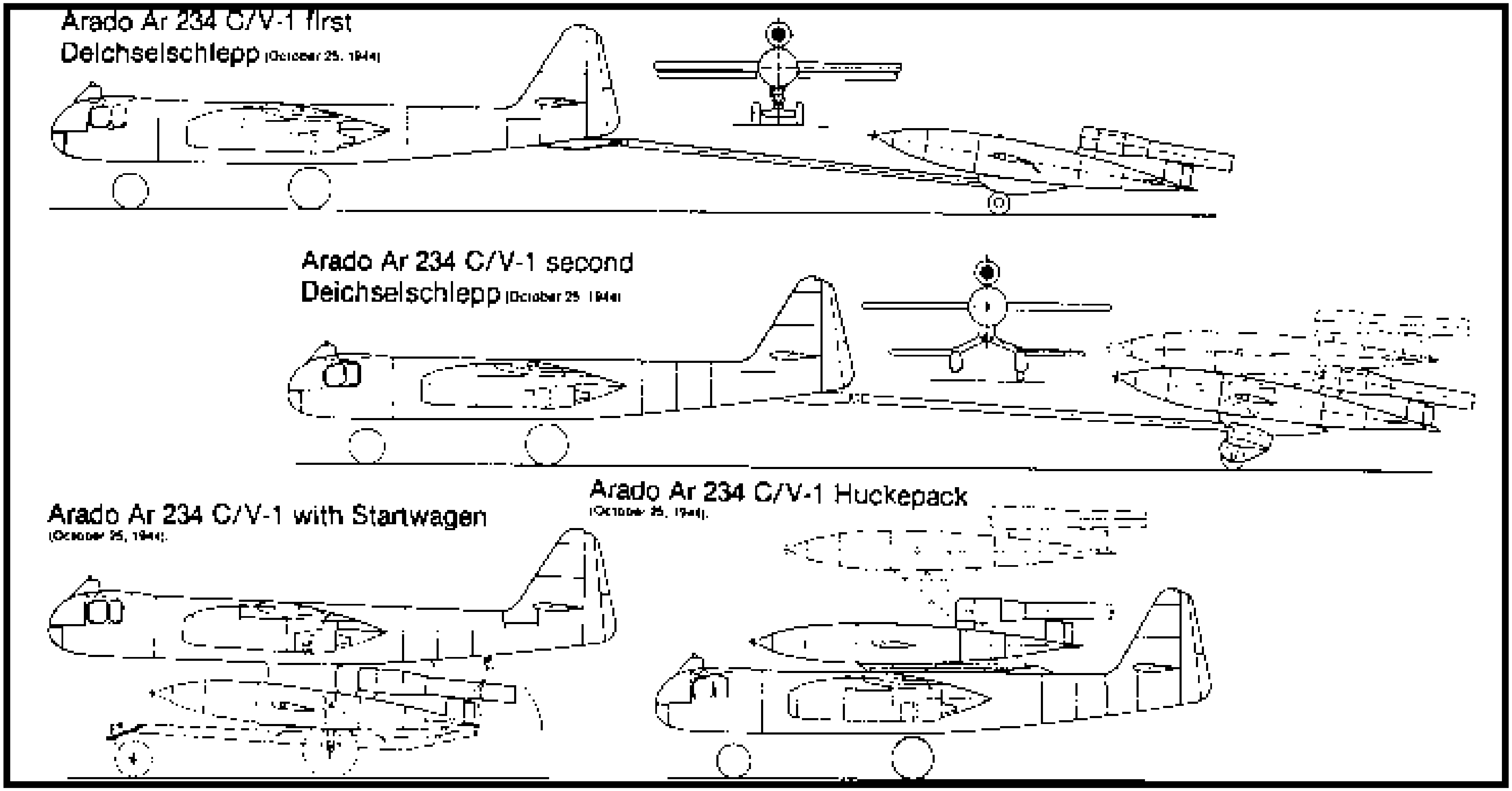


***V-Missiles of the Third Reich The V-1 and V-2,* Dieter Hölsken Monogram Aviation Publications, 1994**

Jet Bomber Air Launch V-1 Options

The rapid development and operational deployment of the Arado Ar 234 Blitz jet bomber in 1944 provided another potential platform for the air-launched V-1. The high speed and resulting high survivability of the Ar 234 provided the potential for deeper penetration of Allied air space which enabled V-1 attacks on rear area targets. Several launch configurations were developed for the Ar 234/V-1, including towbars, vertical carriage with controllable dolly system and the definitive dorsal-launched configuration (the Huckepack) which was ready for operation in the final days of the war.

Jet Bomber Air Launch V-1 Options

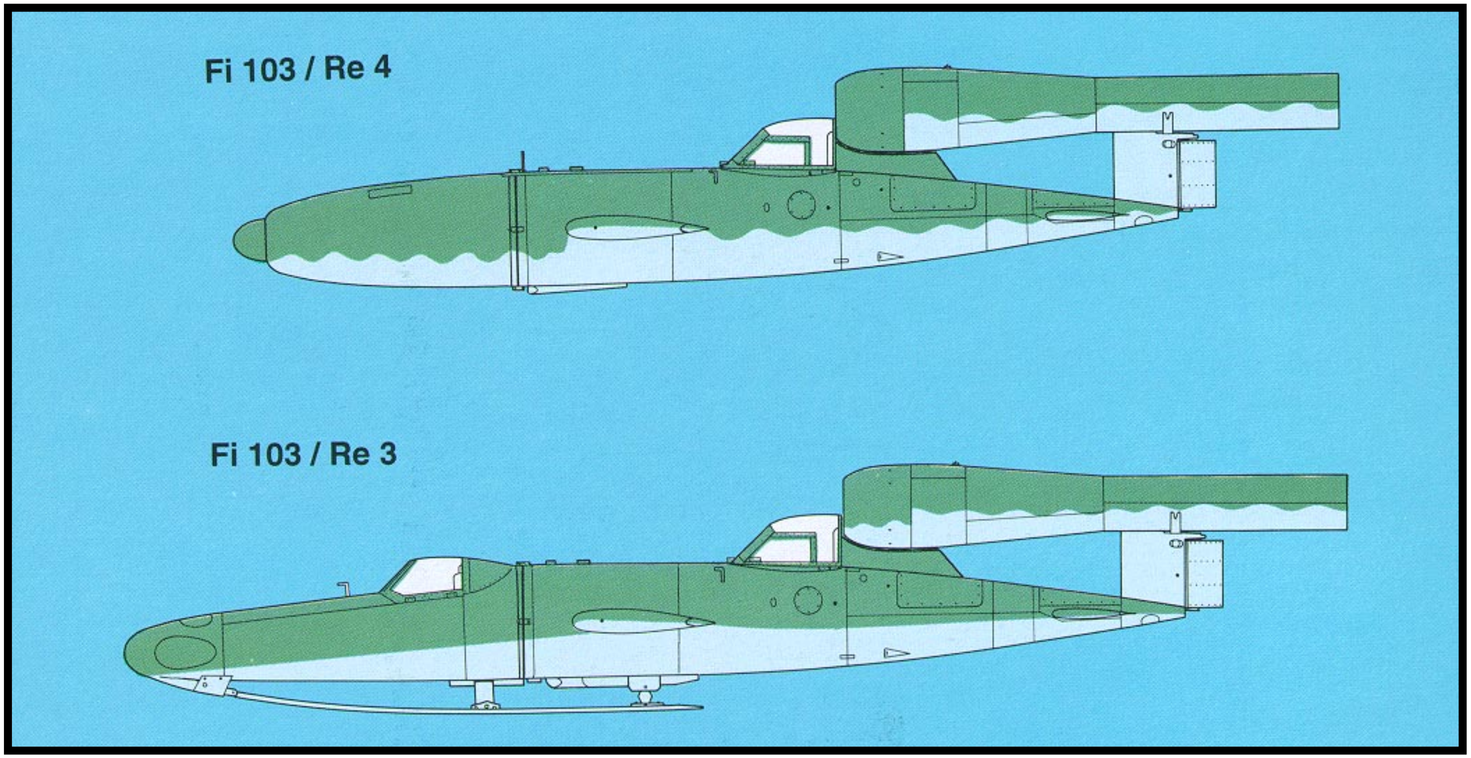


__V-Missiles of the Third Reich The V-1 and V-2__, Dieter Hölsken Monogram Aviation Publications 1994

Piloted V-1 Variants

A radical approach to the solution of the poor accuracy of the V-1 was the development of a piloted version called the Reichenberg (Fi -103 Re 4) to provide a human terminal guidance system. Although not strictly a suicide mission since the pilots were provided with parachutes, the probability of crew survival would not have been very high. Although the Reichenberg project was eventually terminated due to the strong objections of the Luffwaffe Command Structure (Supported by Albert Speer) against near-suicide piloted missions, Reichenberg continued to develop flight test engineering data for the basic V-1.

Piloted V-1 Variants

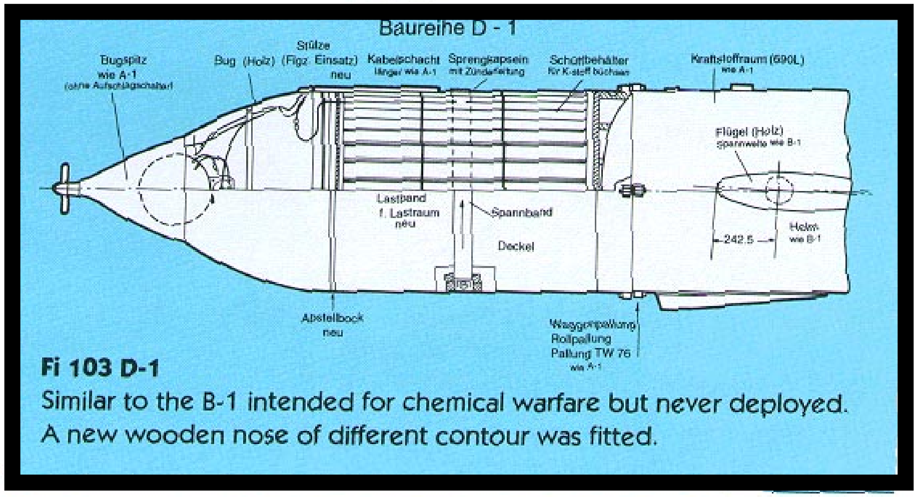


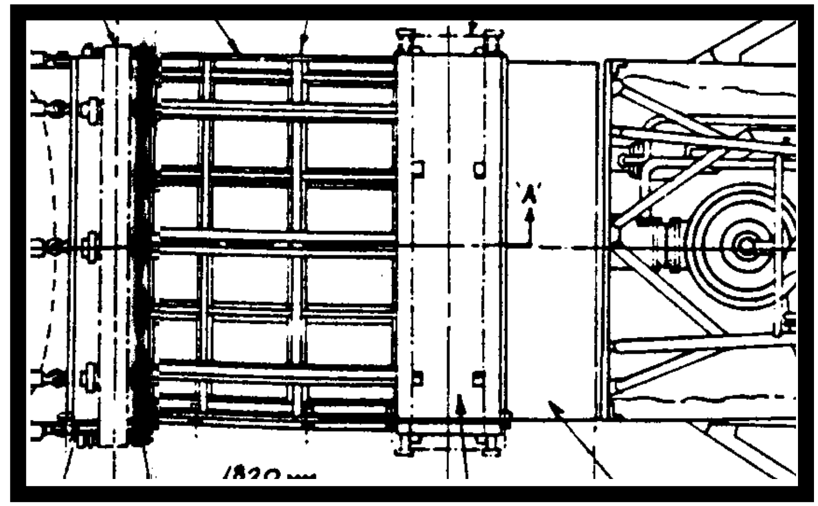
V-Missiles of the Third Reich The V-1 and V-2, ***Dieter Hölsken Monogram Aviation Publications 1994***

WMD Dispensers

Although the Germans produced large quantities of nerve agents (principally Tabun), their use was never authorized by Hitler even during the final collapse of the Reich. Nonetheless, a chemical warfare payload version was designed for the V-1 but never deployed. The V-1 WMD dispenser design with its heavy ribbed reinforcing structure bears a remarkable resemblance to a recently discovered V-2 WMD dispenser design that may have been connected to a potential German Radiological Weapon Program.

WMD Dispensers





V-1

V-2

V-Missiles of the Third Reich The V-1 and V-2 Dieter Hölsken Monogram Aviation Publications 1994

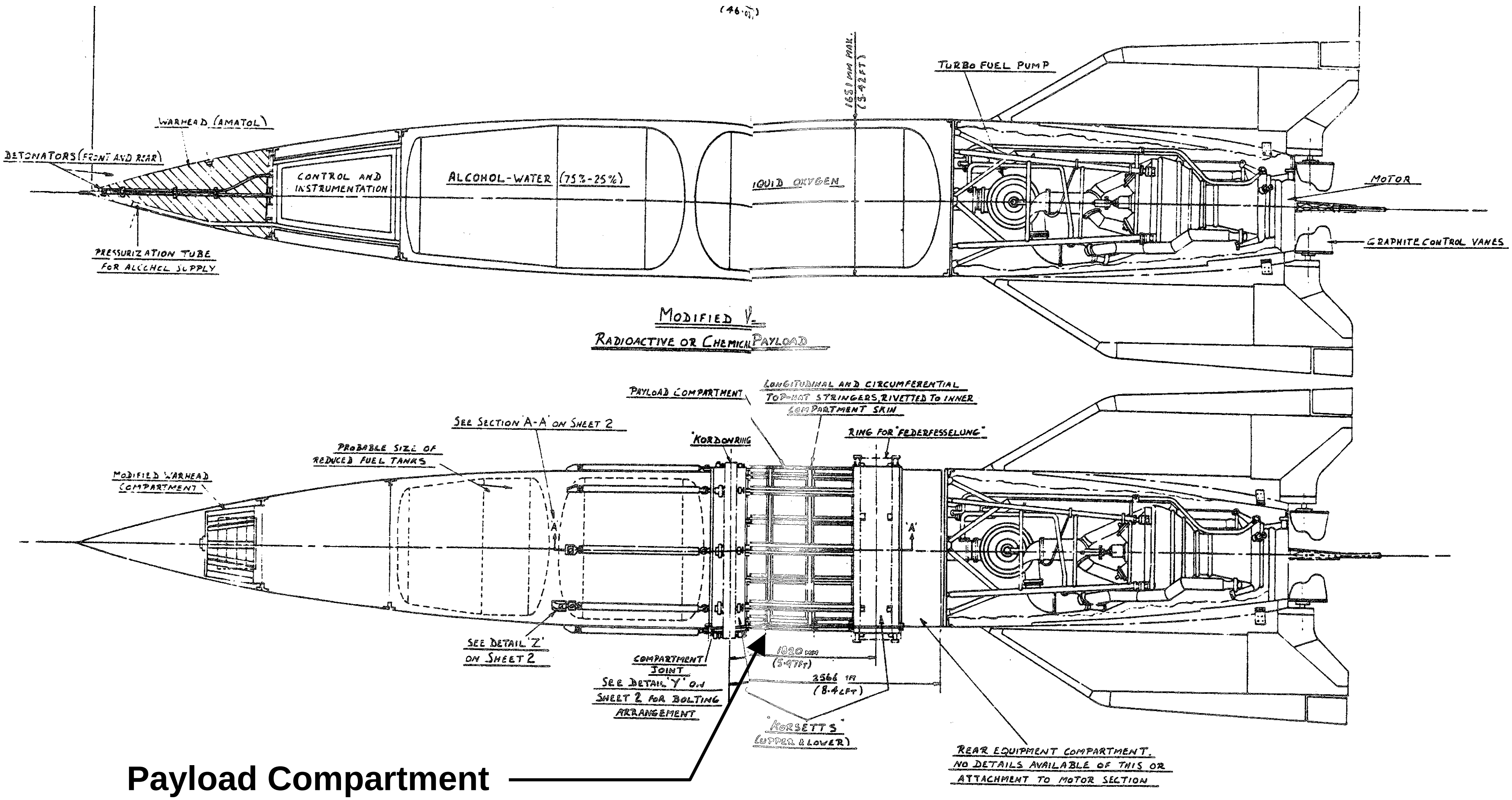
Vengeance. Hitler's Nuclear Weapon. Fact or Fiction? Phillip Henshall, Alan Sutton Publishing Ltd.., 1995

V-2 Design for Use of Chemical/Radiological Payloads

Germany recognized the value of employing warheads of mass destruction on the V-2 rocket. However, they also came to believe that a nuclear bomb was probably not feasible (they believed that an entire reactor would have to be dropped on the target and sent critical). They did recognize however, the potential utility of a radiological weapon of mass destruction which could be delivered to London using the V-2. The above design shows a modified V-2 containing a mid-section payload compartment designed to break and roll away from the rocket intact if the missile were to explode on launch. A large facility was apparently under construction at Watten for the production of radioactive isotope to be mixed with sand and packaged in the payload canister.

Recent investigations by the British military historian Philip Henshall have unearthed a previously classified engineering drawing of a hither to unknown A-4 variant which includes provision for chemical or radiological payloads. In this configuration the nose-mounted conventional high explosive warhead was deleted and replaced by ballast. The payload section was moved to a highly reinforced ribbed cylindrical module which apparently was designed to contain the chemical or radiological payloads in the event of an A-4 launch failure. German Army Ordnance had sponsored studies of the effect of nuclear radiation on biological systems. One concept was to produce tailored radioisotopes (possibly in a reactor in a large hardened launch facility such as Watten) and mix them with a sand dispersal mechanism. Although the German nuclear program failed to provide an atomic bomb, the crude nuclear reactors under development for this program could have been a source of radioisotopes.

V-2 Design for Use of Chemical/Radiological Payloads



<u>Vengeance. Hitler's Nuclear Weapon. Fact or Fiction?,</u> **Phillip Henshall,Alan Sutton Publishing Ltd., 1995**

Mistel 1

During World War II, the Luftwaffe was faced with the problem of destroying high-value hard targets (such as bunkers or other fortifications) in enemy rear areas. This required high accuracy delivery of a large special purpose warhead -- something that was not possible with the early small cruise missile designs. The Luftwaffe produced an innovative approach called the Mistel in which a converted pilotless bomber or purpose-built bomber derivative was equipped with a large (4300 kg) shaped charge warhead whose metal jet could easily penetrate most hardened structures. High accuracy terminal guidance was provided by carrying a piloted fighter aircraft on the back of the bomber which would separate shortly before impact and return to base. The Mistel depicted in the chart is a converted Ju-88 with a Messerschmitt Bf-109F fighter on top.

Mistel 1

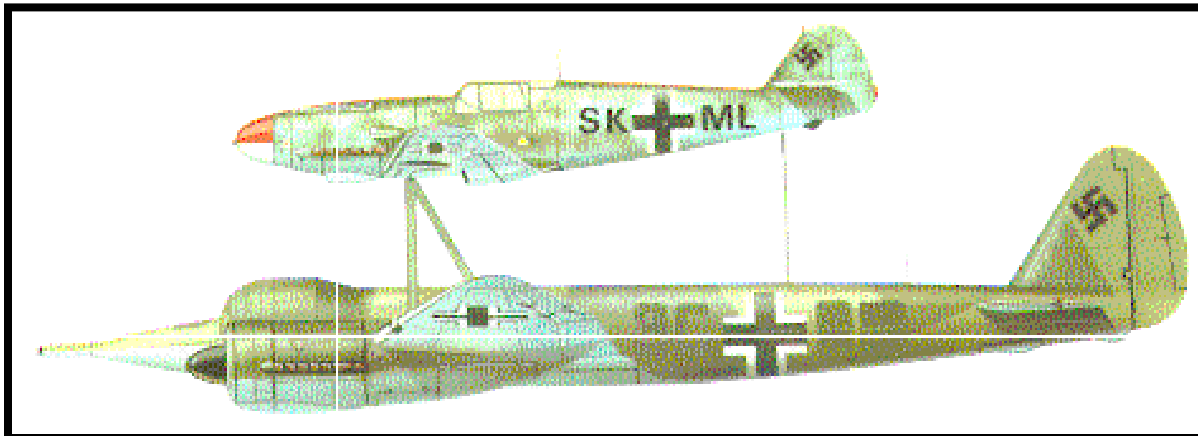
Junkers Ju-88 In Action **(Part 1), Squadron Signal Publications**

Mistel Composite Aircraft

A number of Mistel configurations were developed using both piston-engined and jet bomber and fighter conversions and derivatives. The initial Mistel configuration consisted of a pilotless Junkers Ju-88 combined with a piloted Messerschmitt Bf-109 which provided a human recoverable terminal guidance system. Later variants employed the Focke-Wulf FW-190 fighter as the piloted component. The slow attack speed and limited maneuverability of the early piston-engined Mistels made them highly vulnerable to Allied fighters. Jet Mistels thus were developed. The Mistel 5 used a purpose-built pilotless cruise missile, the Arado E-377a, which was derived from the Ar-234 jet bomber. The piloted component was a Heinkel He-162 Salamander jet fighter. The jet Mistels with their 400-knot attack speeds would have been more survivable but the war ended before they became operational.

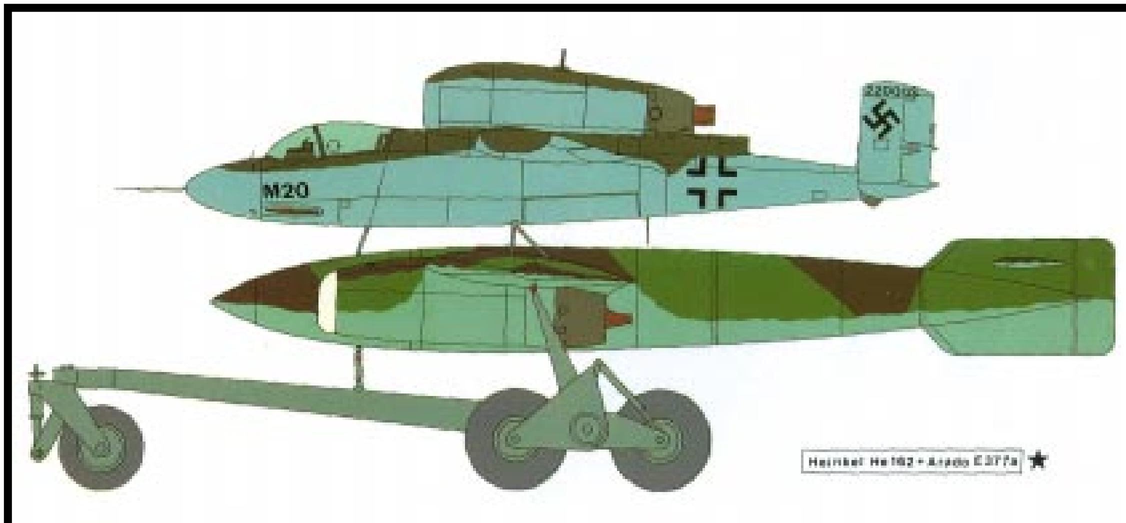
Mistel Composite Aircraft

Mistel 1
Bf-109F
+
JU-88



***<u>Warplanes of the Luftwaffe</u>*, David Donald, Aerospace Publishing London AIRtime Publishing USA, 1994 page 176**

Mistel 5
He-162
+
E-377a



***<u>Secret Wonder Weapons of The Third Reich</u>*, J. Miranda, P. Mercado, A Schiffer Military History Book, 1996 page 106**

Stealth - 1944

The Horten brothers (Reimar and Walter) pioneered a series of advanced flying wing designs in Germany in the 1930's and 40's which paralleled the better know flying wing developments by Jack Northrop in the United States and Alexander Lippisch in Germany. The Hortens, who were both highly qualified engineers and Luftwaffe officers, attained the pinnacle of flying wing technology during World War II -- the twin jet HO-IX flying wing fighter prototype. The HO IX was to demonstrate technologies to be incorporated into HO-229 (a.k.a. GO-229) jet fighter and in the proposed six-jet flying wing Amerika bombers, a long range strategic bomber similar in concept to the post war Northrop YB-49 which was the direct ancestor of the B-2.

The HO-229 design was notable for the fact that it was the first aircraft consciously intended to incorporate stealth technology. The true flying wing configuration with no vertical surfaces and with engine exhausts on top of the wing was combined with a wood/plastic laminate structure with a radar-absorbing core composed of a sawdust, charcoal and glue (a primitive form of RAM) would have been difficult to detect and track by radars deployed during World War II.

Although this stealth technology was applied only to piloted aircraft at the time, it could have eventually been deployed in cruise missiles.

Stealth - 1944

<u>*The Horten Flying Wing in World War II*</u>*, H.P. Dabrowski, Schiffer Military History, Vol.. 47, 1991.*

- **Horten IX twin-jet flying wing prototype for HO-229 fighter and six-jet *Amerika* bomber (1944)**
- **HO-229 design deliberately incorporated stealth features**
  - **Flying wing configuration with jet engine tail pipes on upper wing surface**
  - **Wood/plastic laminate structure with charcoal/sawdust/glue matrix core (early RAM)**

<u>*Northrop B-2 Stealth Bomber*</u>*, Jay Miller, Aerofax, Inc.., 1991.*

World War II Developments - United States 1939-1945

The United States developed several pilotless strike drones during World War II which saw limited operational use for special mission operations in both the European and Pacific Theaters. Project Aphrodite used converted pilotless B-24 Liberator bombers to attack hard targets such as the Watten V-2 launch facility. A radio command guidance system and a 22,000 lb torpex warhead were incorporated and an open cockpit for the safety pilot who flew the aircraft to the English coastline where he turned command of the aircraft to a director aircraft and bailed out. Lt. Commander Joseph P. Kennedy Jr. was killed in 1944 when the Aphrodite B-24 he was piloting exploded prematurely over Sussex England.

Additionally, the U.S. Navy developed a purpose-built piston engined strike drone which employed TV/Radio command guidance and could be launched from aircraft carriers or land bases. Towards the end of the war the U.S. reverse-engineered captured German V-1's into the JB-2 LOON cruise missile

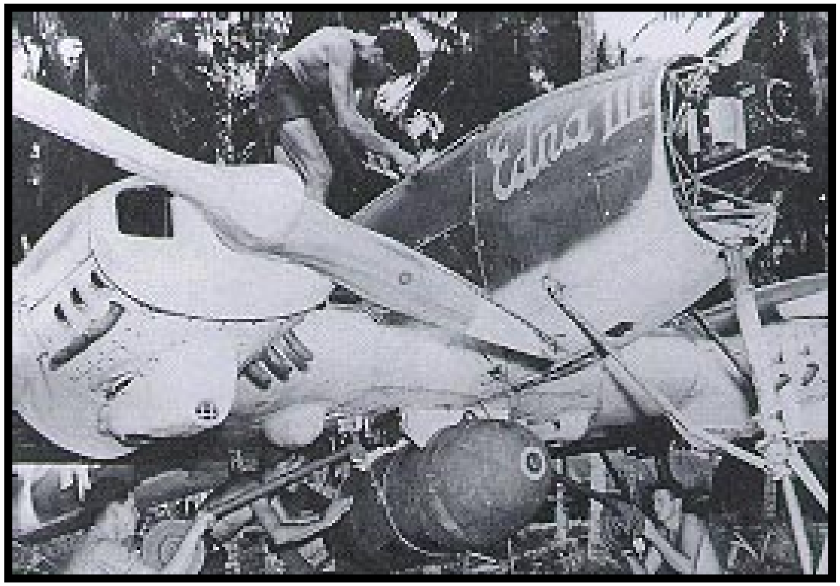
World War II Developments - United States 1939-1945

- Aphrodite (Pilotless B-24)
- U.S. Navy Assault Drone
- U.S. V-1 Variants
  - Army JB-2
  - Navy LOON (Surface and Sub-Launch)

U.S. Navy Assault Drone - 1944

In February 1940 the U.S. Navy Bureau of Aeronautics issued a contract for a television system for use in transmitting instrument readings obtained from radar-controlled flight tests and in providing target and guidance data to enable conversion of radio-controlled aircraft into guided missiles. Technology developed in this program evolved into a television/radio command guidance system which was used on a navy TG-2 drone to conduct torpedo attacks and other demonstrations against many surface targets. An operational version of this system was deployed on a single twin-engined Navy Assault Drone in 1944. The Assault Drones were operated from aircraft carriers or land bases and were commanded to their targets by a director aircraft. Payload was typically a 500 lb bomb.

U.S. Navy Assault Drone - 1944



***The Navaho Missile Project*, James N. Gibson, A Schiffer Military History Book 1996, page 7**

- **Simple twin-engined Assault Drone used to attack heavily defended Japanese targets**
- **Land or carrier based**
- **TV/Radio command guidance from controller aircraft**
- **Could drop single 500 lb bomb or dive into target**

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JB-2 “Loon” (V-1 Buzz Bomb)

In the summer of 1944 the U.S. Army Air Force obtained several examples of the German V-1 cruise missile which partially survived impact in England. Army Air Force Technical Intelligence at Wright Field exploited these specimens to produce a complete set of reverse-engineered construction drawings. These were used to develop a U.S. version of the V-1, designated the JB-2. Radio command guidance was incorporated in the design which significantly improved the large CEP of the V-1. The plan was to produce 10,000 JB-2’s most of which were intended for use in the Pacific to support an anticipated invasion of Japan. Although the full scale production plan for the JB-2 was never executed, the JB-2 was in production by early 1940, and 1400 + missiles were produced by V-J Day. This adaptation illustrates how rapidly a new foreign technology can be transferred and incorporated in weapons if national survival is at stake and unconventional development processes are employed. The JB-2 was also adopted by the U.S. Navy and named the “Loon.” The JB-2/Loon was launched from a number of land and ship platforms and formed the basis for many U.S. post war cruise missile developments.

JB-2 “Loon” (V-1 Buzz Bomb)

U.S. Air force Museum, Wright-Patterson AFB, Internet Home Page.

Specifications
- Span: 17 ft. 8 in.
- Length: 27 ft. 1 in.
- Height: 4 ft. 8 in.
- Weight: 5,023 lbs. loaded

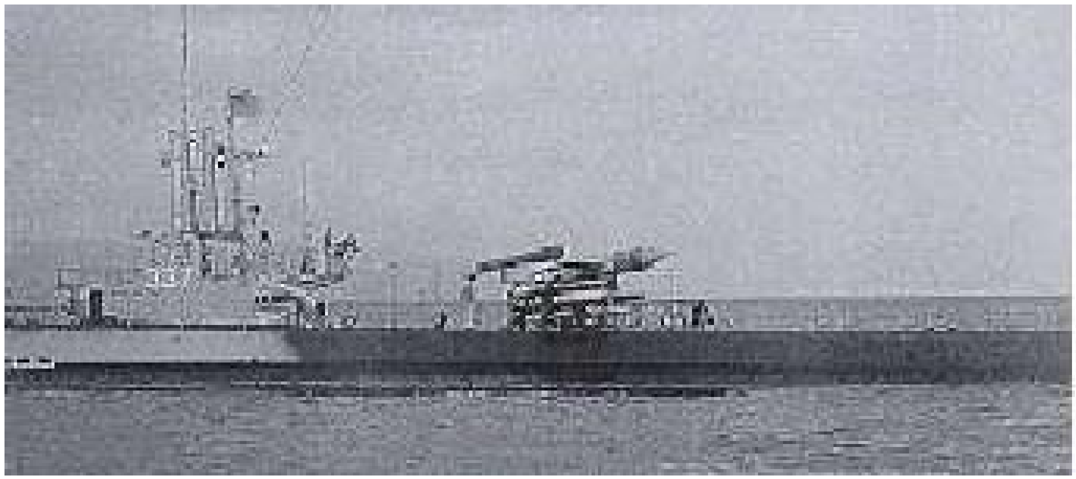
Performance
- Armament: 2,100 lb. HE Warhead
- Engine: Ford PJ-31-F-1 (900 lbs. Thrust)
- Operating speed: 375-400 mph (220 mph launch)
- Range: 150 miles

Center for Defense and International Security Studies, Internet Home Page, Cruise Missile Threats - A Brief History 1907-1945

U.S. Navy Sub-Launched Loon - 1949

Starting in 1949 the U.S. Navy deployed the Loon cruise missile on the modified U.S. submarine Carbonnero. A number of Loons were launched from the Carbonnero until 1950 when it was modified for the Vought Regulus I cruise missile test program.

U.S. Navy Sub-Launched Loon - 1949



***The Navaho Missile Project*, James N. Gibson, A Schiffer Military History Book 1996, page 8**

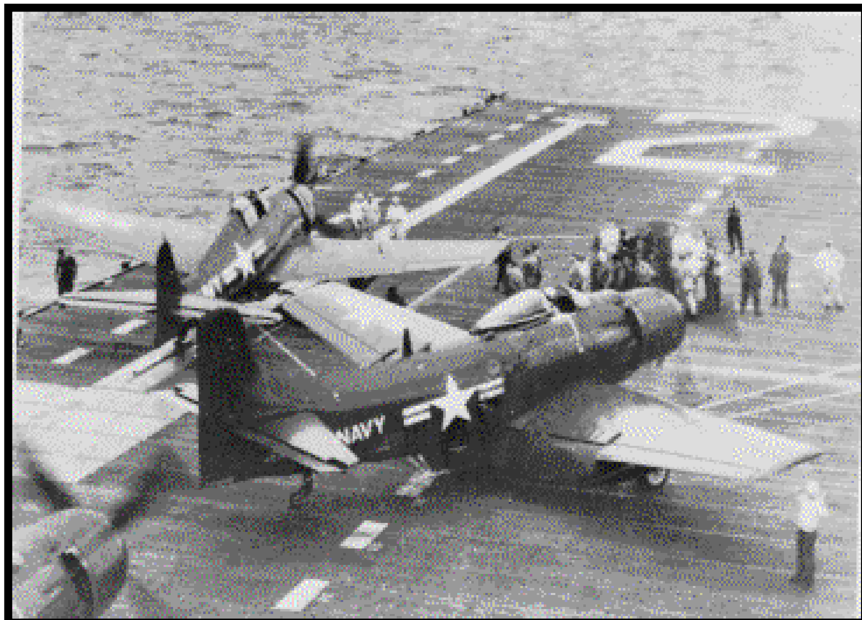
- **Loon cruise missiles launched from U.S. Submarine Carbonnero 1949-1950**
- **Experiments laid groundwork for Regulus I cruise missile**

Hellcat Strike RPV - 1952

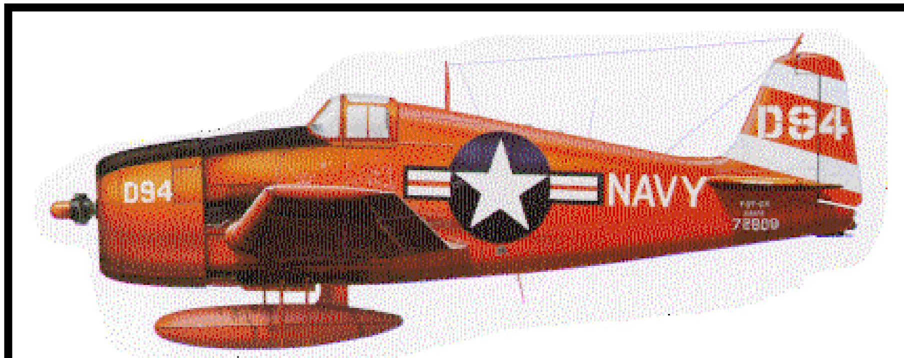
The Grumman F6F Hellcat was the premier U.S. Navy carrier-based fighter in the Pacific War. After V-J Day a small number of Hellcats were converted to the F6F-5k multi-mission drone configuration. The modification included the addition of a radio command link, mission-specific instrumentation and wing tip fuel tanks to extend the aircraft's endurance.

Hellcat drones were used for nuclear cloud sampling for the Operation Cross Roads atomic weapon testing at Bikini Atoll. During the Korean War Hellcat strike drones operated by Guided Missile Unit 90 from the USS Boxer were used to attack heavily defended targets such as the bridge at Hungnam, Korea. The Hellcats typically carried a 2000-lb bomb and were controlled by a Douglas AD-4Q Skyraider director aircraft.

Hellcat Strike RPV - 1952



- F6F-5K Hellcat Multimission drone used during Korean War to attack heavily - defended bridges and other targets (1952)
- Employed AD-4Q Skyraider as director aircraft
- Typical payload - 2000lb bomb



<u>F6F Hellcat in Action</u>, Squadron/Signal Publications, 1979

MACE Land-Attack Cruise Missile
US Air Force CGM-13 (1955-1969)

The Mace development program is an illustration of how a nation can convert an existing cruise missile design into a long range system -- using technology available over 40 years ago!

The US Air Force provided Goodyear Aircraft (Akron) with 25 obsolete Matadors to modify for long range low altitude flight. These old missiles were gutted, disassembled, and structurally redesigned for the rigors of low altitude high-subsonic flight with aerodynamic controls to permit rapid response to onboard terrain following commands during mid-course flight. Airframe and propulsion changes included: new wings with ailerons, new engine inlet, completely new structure for the tail section, enlarged body section to house and control added fuel, and a completely new nose section for the ATRAN terrain guidance system. ATRAN system located in the nose comprised a mission control computer, and a radar altimeter autopilot based on a new Goodyear missile X-band terrain avoidance radar. Mission planning systems determined a selection of survivable flight paths, including tactics to mislead enemy intelligence and detection devices. The desired flight path was loaded into the missile navigator equipment on the day of the mission. After a successful series of development flight tests at White Sands Missile Test Range, the Air Force awarded production to two “associate prime” contractors: Goodyear for guidance, control, mission planning, mobile ground systems, and training; and the Glenn L Martin Company for the airframe, assembly and integration of guidance, control, warhead, and propulsion.

The first Mace (CGM-13A) surface-to-surface missiles became operational in 1959 and used a guidance system permitting a low-level attack by matching a radar return with radar terrain maps. The "B" series, in service from 1961 to early 1970s, offered the option of high or low attack using an unjammable inertial guidance system. Mace "As" were phased out in the late 1960s, but some were used later as target drones.

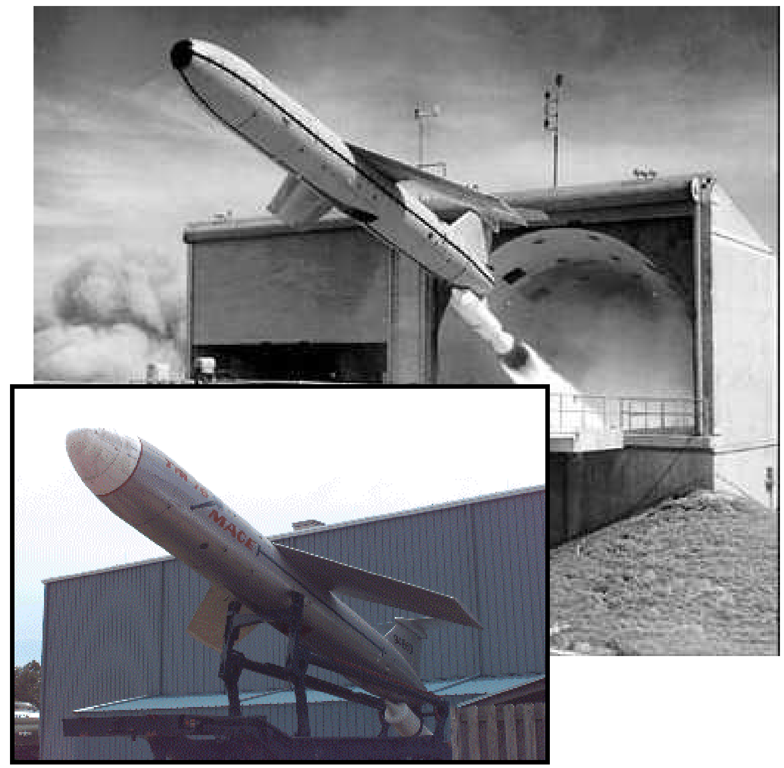
While Mace squadrons were deployed in Germany and Taiwan during the 1960s, some operational testing was conducted in the north African desert near Tripoli. It is unknown if all test units were recovered.*(Historical facts recounted by Mr. Hal Flowers, Director of Advanced Systems, Goodyear Aircraft, during the Mace Program)*

MACE Land-Attack Cruise Missile

US Air Force CGM-13 (1955-1969)

- Upgraded from obsolete Martin Matador airframes
- Operationally deployed at US bases in Europe and Asia until 1969
- SPECIFICATIONS
  - Span: 22 ft. 11 in.
  - Length: 44 ft. 6 in.
  - Height: 9 ft. 7 in.
  - Weight: 18,000 lb. at launch
  - Warhead: 3,000 lb. conventional or nuclear
  - Engine: Allison J33 of 5,200 lb. thrust; Thiokol solid-propellant booster rocket of 100,000 lb. Thrust
- PERFORMANCE
  - Max. speed: 565 knots in level flight; supersonic in final dive
  - Range: 1,217 nautical miles
  - Operating altitude: from under 1,000 ft. To 40,000 ft.

Third World CM facilities could include hardened launchers like this Mace site.



Source: Air Force Armament Museum, Eglin AFB,, Florida.

XSM-64 Navaho

Supersonic Intercontinental Cruise Missile (1950-1958)

The Navaho intercontinental cruise missile has been called the ultimate development of the German A-9/A-10 concept. When the program was canceled in July 1957, missiles were in fabrication for flight test. The Navaho and its comparable Soviet strategic cruise missile programs were being rapidly eclipsed by the shift of development resources to faster long range ballistic missile with shorter times of flight and hence higher accuracy and survivability. The Navaho program was terminated due to the success of ballistic missiles that were relatively unstoppable in light of the increasing air defense missile threat of the time.

Despite cancellation, the engines developed for the Navaho were used, with minor modifications, for all the first generation of American orbital rockets -- the Jupiter, Thor, Atlas, Titan I and Saturn I. Versions of Navaho engines continue in use today in the Atlas II and Delta III.
(Encyclopedia Aeronautica)

XSM-64 Navaho

Supersonic Intercontinental Cruise Missile (1950-1958)

North American
G-26 Navaho Test Vehicle

- **Navaho resulted from early study of high speed long range missile (1945-1947)**
- **Evolved from German WW II A-9/A-10 ICBM concept**
- **10,000 km range (G-38 Production Version)**
- **Mach 3.25 average velocity**
- **Nuclear warhead (G-38)**
- **Inertial guidance**
- **Liquid rocket boost/ramjet cruise**
- **Never achieved a full duration test flight**
- **Canceled July 13, 1957 - flight test continued through 1960**
- **Provided key technologies (guidance, propulsion, etc.) for the U.S. ICBM program**

Source: "The Navaho missile project", James N. Gibson, page 64

La-350 Burya

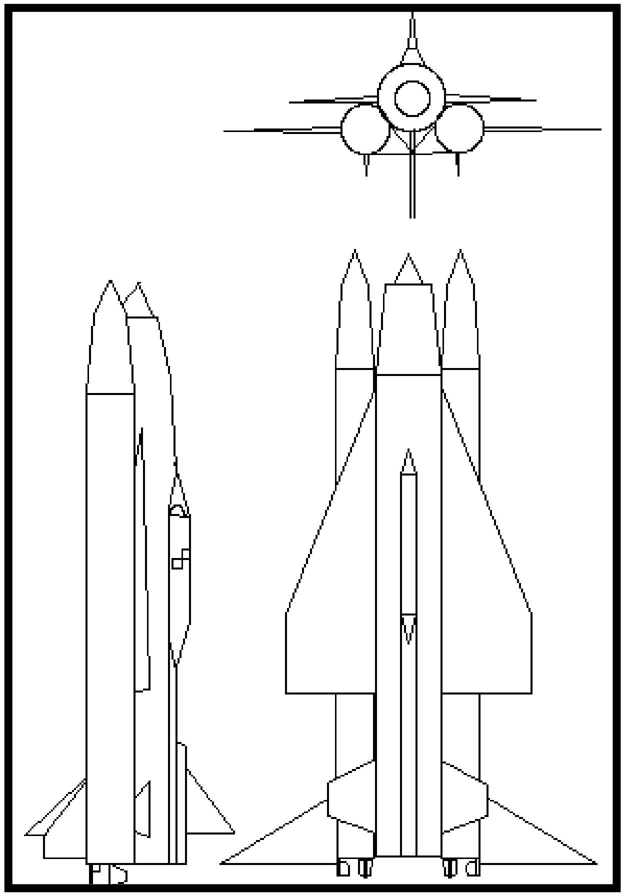
Supersonic Intercontinental Cruise Missile - (1954-1960)

Soviet government decree on 20 May 1954 authorized two parallel development programs by two aircraft design bureaus: Lavochkin (Burya program) and Myasishchev (Buran program) -- commissioned to develop intercontinental range supersonic cruise missiles. Both missile designs were to use ramjet engines and astronavigation-aided inertial navigation. The Lavochkin-designed Burya used liquid rocket boosters developed by Glushko whose engines were used in space launchers and military ICBMs for the next thirty years.

The Burya was designed to carry a 2,350 kg payload over a 8,500 km range. Despite cancellation of its U.S.-equivalent Navaho and competing Myasishchev Buran, Burya testing was continued through 1960, finally demonstrating cruise at Mach 3.2 over a range of 6,500 km with a 2,350 kg payload. With development of Korolev's R-7 ICBM going well, the Soviet government canceled Lavochkin's Burya due to its cost and vulnerability. Nonetheless, the key technologies for an intercontinental-range cruise missile were proven.
(from Encyclopedia Aeronautica)

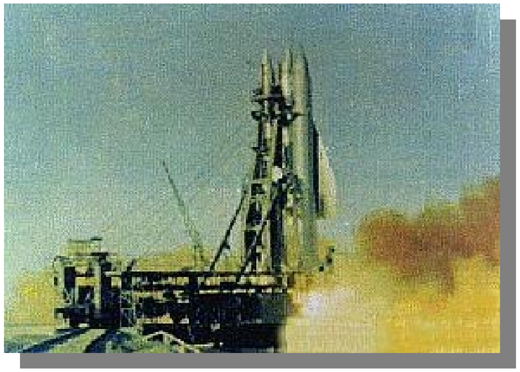
La-350 Burya

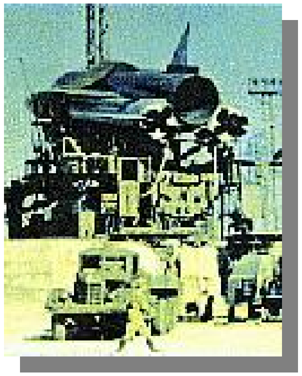
Supersonic Intercontinental Cruise Missile - (1954-1960)



Lavochkin
La-350 Burya ICCM

Source: Mark Wade's Encyclopedia Astronautica Home Page





- Development initiated 1954
- 8,500 km (4600 NM) range
- Mach 3.2 cruise
- 2,350 kg (5,170 lb) nuclear warhead
- Astro-aided inertial guidance
- Liquid rocket boost / ramjet cruise
- Seventeen test flights (1957-1960)
- Final test flight 6,500 km at Mach 3.2
- Program canceled 1960

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Significance of Historical Design Approaches

Fundamental Cruise Missile concepts were proven...

- **Conversion of fighter/bomber/transport airframes**
  - **Provides large internal volume for warhead or extra range fuel**
  - **Rapid conversion of proven aircraft, known flight characteristics**
  - **More suitable than typical Western cruise missiles for delivery of large, unsophisticated WMD or explosive payloads (political/ terrorism mission)**

- **Mass production of large numbers of low-cost cruise missiles**
  - **Simple materials (home-built aircraft technology)**
  - **Defenses may be saturated with large numbers**
  - **Primitive stealth is achievable**

Agenda
Third World Cruise Missile Technology/Proliferation

Key aerospace technologies necessary to build cruise missiles for the land-attack mission are becoming readily available in most parts of the world. Cruise missile production is a natural extension of aircraft manufacture, maintenance, and commercial subsystems design. The ubiquity of the technology enables many countries to join the missile owners club relatively inexpensively. Cruise missiles provide a complementary element to a regional offensive weapons inventory. Cruise missile operations integrate easily with conventional forces, yet demonstrate modern technological achievement; like ballistic missiles elevating the stature of countries which possess them.

Among major arms-producing nations, most produce cruise missiles for internal use and export. Second tier producers and importers in turn produce cruise missiles for themselves and other nations. Third World nations purchasing older, export cruise missiles or other air vehicles from a producer nation can upgrade them with modern off-the-shelf technology. Such indigenous modifications may be used to improve the range of a short range anti-ship missile, arm a reconnaissance vehicle or simply reduce guidance inaccuracy to attain a land-attack cruise missile capability.

Agenda

Expanding Cruise Missile Production

Shown on this map, countries around the world have realized the value of cruise missile production technology as an important element of their military forces. They all recognize the versatility of cruise missiles for attacking a variety of targets.

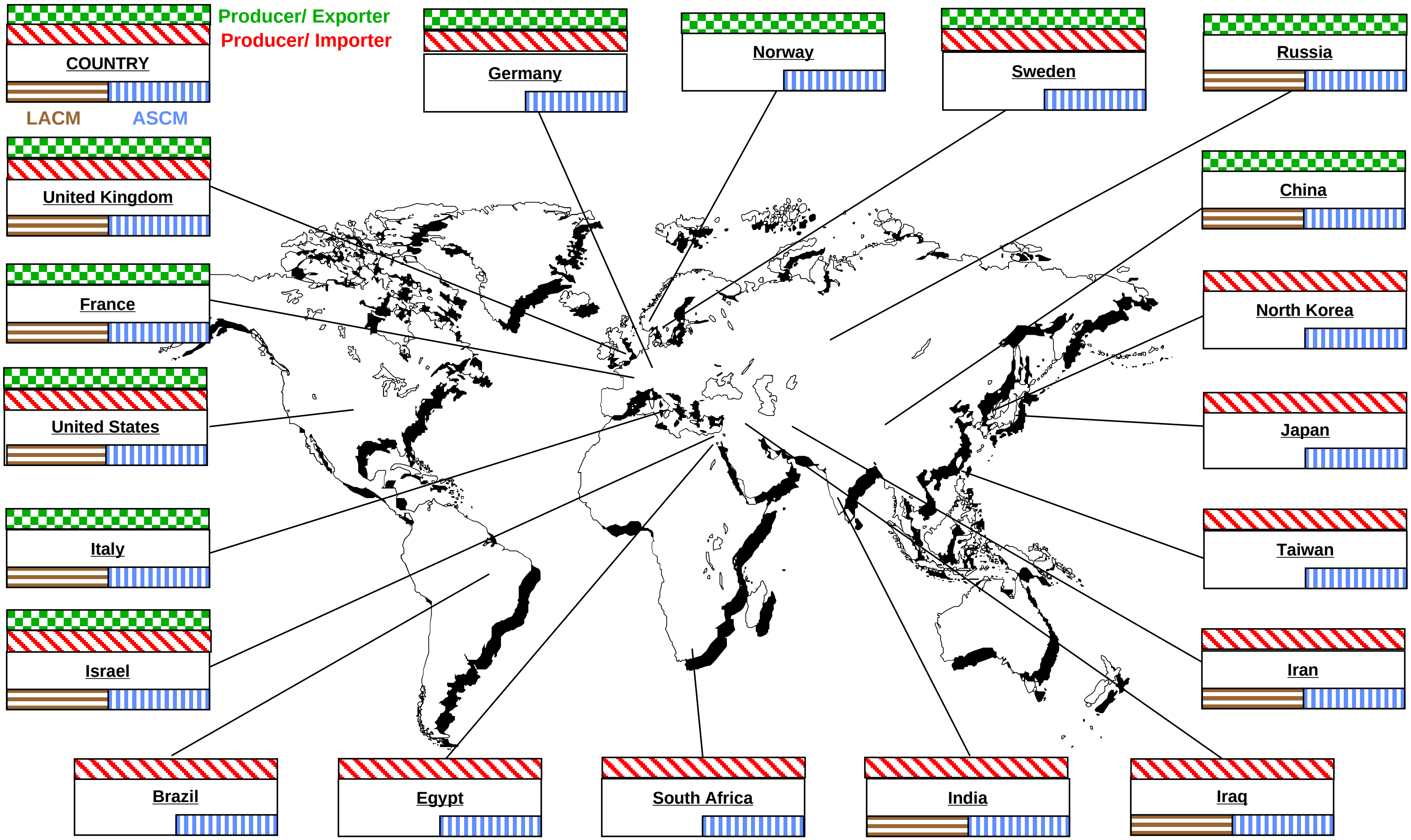
Distinctions between major producers and importing countries are being blurred as indigenous CM development and licensed production is undertaken by Third World nations. As aerospace technology spreads, more countries are able to acquire large numbers of "adequate" cruise missiles to engage regional targets. Several feasible development options are discussed in the following sections.

Contrary to the assumption that international non-proliferation agreements such as MTCR can stop arms proliferation, there is ample evidence of the trend for developed nations to act out of national self-interest rather than supporting cooperative restraint.

Tables identifying cruise missile producers, exporters and importers and their cruise missile inventories are found in the Appendix.

Expanding Cruise Missile Production

• 1998 Status



* Under development

Source: Boeing open source ROW compilation, April 1999

Key Cruise Missile Techniques & Technologies

Certain key subsystems are essential for developing or improving Land-Attack Cruise Missiles. The world marketplace enables access to CM technologies based largely national military priorities and intent of the buyer. Trade restrictions or international guidelines like Missile Technology Control Regime (MTCR) present only minor obstacles to acquiring the desired level of performance to meet mission requirements. Three key enabling technologies are discussed in detail.

Third World CM designers can choose from a commercial list of key components to satisfy the specific performance parameters dictated by mission requirements and economic constraints:

- **Propulsion determines range and speed for the altitude and maneuver profile to the target**
- **Lightweight avionics save power and weight that can be used for fuel and warhead. Directly related to lighter weight electronic components is higher cost that may be deemed worthwhile for faster processing, flexible memory, and programmability.**
- **Integrated Mid-course Guidance largely determines the accuracy of payload delivery, but also determines survivability by enabling terrain following, deceptive routing, or pre-programmed maneuvers for threat avoidance. Here, the ready availability of commercial GPS navigation receivers for mid-course updates enables the use of inexpensive inertial components reducing cost.**
- **Targeting Weapon accuracy may be enhanced by reducing the uncertainty of aimpoint position with commercial imagery annotated with precise GPS or GLONASS coordinates. If higher precision is required, a terminal seeker may be used (with added processing costs).**
- **Increased fuel and therefore range can be achieved by the simple but logical lengthening of the fuselage of an existing CM without significantly affecting flight characteristics.**
- **Structural changes may require additional flight stability verification, but the payoff may yield a more efficient aerodynamic shape, stealth characteristics, or added payload with no change in propulsion or other systems of an existing CM.**

Key Cruise Missile Techniques &Technologies

- **Fuel Efficient Gas Turbine Engine**
- **Lightweight & Integrated Avionics**
- **Integrated Mid-Course Guidance**
  - **Inertial + Global Positioning System**
- **Targeting -- Aimpoint Definition**
  - **Commercially Available Geographic Information Systems**
  - **High Resolution Satellite Imagery of Target Area**
- **Additional Fuel Loading for Greater Range Capability**
- **Structural Changes to Accommodate New Capabilities**
  - **WMD payloads**
  - **Stealth shaping**

Current aerospace technology offers the capability to convert an existing anti-ship cruise missile or modify other air vehicles into a long-range land-attack weapon system.

Third World Threat: Built on Hi-Tech Proliferation

Of the numerous examples of weapons technology proliferation, the examples here show how available aerospace technologies may become key elements of a Third World country's cruise missile improvement program. The aircraft technologies applicable to cruise missiles are far easier to acquire than ballistic missile technologies (which may also be acquired for a price).

A big step in improving Third World cruise missile accuracy and autonomy can be expected with the incorporation of terminal seekers. While Western nations have spent considerable time and resources developing the underlying technologies for seekers, the commercially available spin-offs from those military developments are now readily available. Integration of seeker components can be performed using skills taught at good engineering schools worldwide.

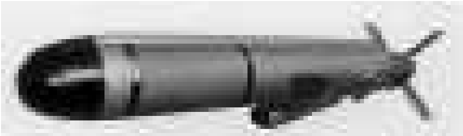
For each of the identified key technologies, there is more than one developed nation willing to sell components or manufacturing technology to lesser developed nations. These improvement technologies have been addressed in several recent land-attack cruise missile studies such as "Controlling the Spread of Land-Attack Cruise Missiles", Scott McMahon and Dennis Gormley, American Institute for Strategic Cooperation, January 1995.

Third World Threat: Built on Hi-tech Proliferation

- CM Migration Paths
  - Chinese YJ-2 ASM to **IRAN (C-802)**
  - Russian SS-N-2 Styx ASCM

C-802 Export Model

  - Israeli Delilah 2 ASM to **TAIWAN (HF-2)**
  - US Seeker technology



Delilah CM

- Systems, Components and Fabrication Technology
  - Evidence French ‘Microturbo, S.A.’ exported TRI-60 engines
  - China sold missiles and manufacturing technology to Iran
  - Russian technical integration assistance also suspected in Iran
- Next Step: EO-IR Terminal Seekers
  - Improve simple man-in-loop terminal guidance (TV data link)
  - EO/IR technology widely available
  - Precision targeting imagery from satellites

Exported Cruise Missile Technology

Aircraft manufacturing technology available throughout the world in aircraft plants, maintenance facilities, parts suppliers, and in local machine shops is adequate to manufacture cruise missiles. Capable land-attack cruise missiles can be acquired by converting existing airframes or by indigenous fabrication without relying on cutting edge technologies that may be politically difficult or expensive to obtain.

However, despite international non-proliferation agreements and the threats of sanctions, several countries continue to build systems for the "export market" and are willing to lend technical assistance to emerging aerospace industries. The French angered the US Government in 1998 when they decided to export the Apache cruise missile to the United Arab Emirates.

> **"Sources indicate that the UAE version of the Apache missile, dubbed Black Shahine, will have a range in excess of 300km, thereby breaching the MTCR guidelines. Although the MTCR is a voluntary code of conduct and there are no enforcement proceedings, it is expected that signatory nations will abide by the letter and the spirit of the agreement. *(Jane's Defense Weekly, April 8, 1998)*"**

The C-802 cruise missile, according to intelligence community reports publicized in the Washington Post (April 3, 1999), was enhanced with a reverse-engineered French TRI-60 turbojet engine. The engines were subsequently shipped to Iran, which has also learned the French turbine manufacturing technology.

The propulsion system remains the major precision subsystem Third World cruise missile developers would likely buy. As recent reports charge, developed countries aid indigenous cruise missile technology directly with exported engines or by providing specifications that enable the acquiring country to reverse-engineer key design elements of a high-speed precision turbine engine.

Exported Cruise Missile Technology

- **"U.S. intelligence must monitor the spread not only of missiles such as the C-802 but also their components... 'engines are the key technology... the critical choke point'** ***(Washington Post,4/3/99)*** **"**

- **Sale of French Apache/SCALP CMs to the UAE under the name "Black Shahine" also proliferates advanced technology**

Chinese C-802 Air-Launched CM (multi-mission), Jane's Air Lunched Weapons

JET ENGINE TECHNOLOGY

SCALP EG/STORM, Jane's Missiles and Rockets, February 1, 1998

STEALTH & GUIDANCE

Gas Turbine Engine Availability
U.S./International Markets

A Third World country's quest for Land-Attack Cruise Missile capability would most likely begin by upgrading the propulsion of available Anti-Ship Cruise Missiles.

Efficient flight sustaining propulsion such as can be obtained from compact turbojets or turbofan engines enables the longer ranges required for regional land-attack missions. A Third World country's engineers would have a variety of suitable jet engines to select from.

The table identifies a number of gas turbine engines that a Third World country could purchase and install in a land-attack cruise missile weapon system. The selected engines are arranged by maximum available thrust.

The Aviation Week and Space Technology annual Aerospace Source Book, provides a lengthy catalog of gas turbine engines produced (and available for export) by aerospace companies throughout the world. In most cases the Third World country could circumvent MTCR restrictions by purchasing engines under the guise of aircraft replacement parts for a non-military aircraft, UAV, target drone, or other non-weapon application.

Gas Turbine Engine Availability
U.S./ International Markets

Country of Origin	France	U.S.	China	U.S.	U.S.	France	France	Japan	Canada	Canada	Poland
Engine Model	Microturbo TRI-60 (series)	J69-T-41A Turbojet	WP-11 Turbojet	FJ-44-1 Turbofan	FJ-44-2 * Turbofan	Larzac 04 C20	Larzac 04 C6	CFJ-801	JT-15D-1 Turbofan	JT-15D-5 Turbojet	SO-1 Turbojet
Maximum Thrust (lbf)	800-1200	1,920	1,874	1,900	2,300	3,180	2,966	3,000	2,200	2,900	2,205
Length (in)	30-33	44.8	44.8	41.9	47.2	46.4	46.4	52.0	57.0	60.0	84.7
Diameter (in)	13	22.4	22.4	20.9	21.7	23.7	23.7	26.0	27.0	27.0	27.8
Weight (lb)	108-135	350	365 **	445	480 - 510 **	640	640			632	
Specific Fuel Consumption (lb/lbf/hr)	1.1-1.3	1.10	1.145 **	0.467	0.55	0.76	0.71			0.551	
Usage	Sea Eagle RBS-15, C22 Drone	Ryan BQM-34A Target	HY-4, WZ-5	Citation, Dark Star UAV	Primier 1, SJ30-2	Alpha Jet, Mig-AT	Alpha Jet	Busines s Jets	Citation	Citation, T-47, Beachjet	TS-11, Isakara

* Proposed

** Estimated

Integrated Midcourse Guidance

Compact worldwide precision navigation systems are now available "over-the-counter" to any general aviation customer. For a few thousand dollars, a customer can upgrade his navigation system for "the next century":

> **"The GARMIN GNC 250 is a full-featured VFR navcom... On the NAV side, the GNC 250 provides clear, accurate navigation data from takeoff to touchdown, complete with a full Worldwide Jeppesen database, ...1,000 user waypoints, ...one-touch direct-to navigation, and you get a complete package that's an ideal choice for <u>new/experimental installations</u> ... with the technology that's taking aviation into the next century."**
>
> *From Garmin's Internet site describing products: http://www.garmin.com/aviation.html*

When commercial GPS navcom units are used with accompanying "target upload software", precise navigation of a cruise missile can be performed and adjusted with a "386 PC or better."

> **The PCX5 software package allows you to use a personal computer to upload or download data from your GPS unit. The PCX5 program is compatible with most GARMIN ... GPS receivers. Several varieties of PCX5 software packages are available--each with the proper cable connector to match your particular GPS unit."**
>
> *From Trimble's GPS Mission Planning Internet page, http://www.trimble.com/satview/index.htm*

Other GPS navigation companies such as Trimble also provide to the world GPS planning software for flight optimization directly on the internet: http://www.trimble.com/satview/index.htm

> **"... SatView, Trimble's online GPS mission planning program... allows you to increase the accuracy of the GPS positions you collect by scheduling your field sessions during time periods when satellite availability and geometry are optimal. "**
>
> *From Trimble's GPS Mission Planning Internet page, http://www.trimble.com/satview/index.htm*

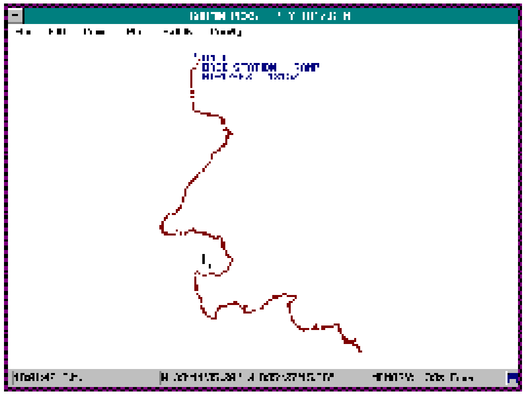
Integrated Midcourse Guidance

Commercial GPS Navigation...

(from Garmin GNC 250 web site)

... suitable for cruise missile precision route planning

"Plot waypoint, route and track log data right on your computer's screen... The built-in waypoint editor allows you to modify existing waypoint or route data files,... files can then be uploaded back into your GPS unit, printed, or saved for later reference."
(PCX5 software description from Garmin web site)



Sample Garmin PCX5 computer display

Improved Targeting Technology

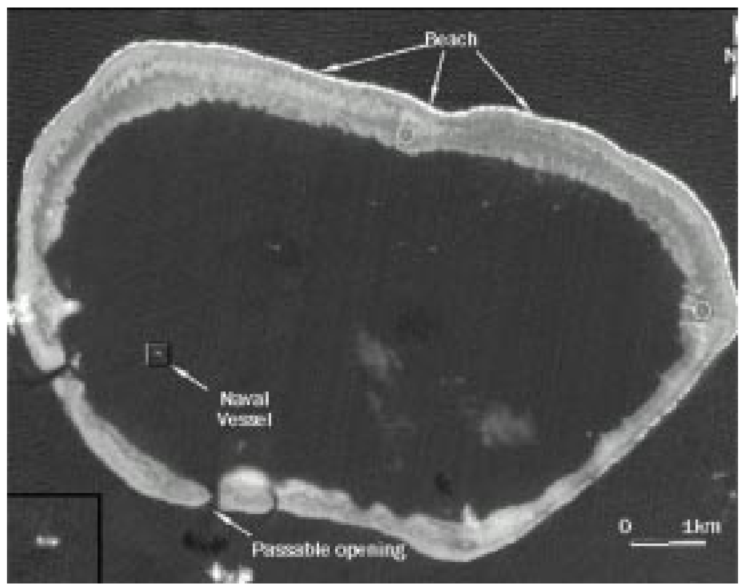
The importance and techniques of using satellite imagery to target precision weapons has been proven by developed countries. Satellite imagery targeting improvements for Third World cruise missiles and other weapons will soon be available even from indigenous satellite systems as indicated by this *Defense News* article from May 10, 1999:

> **"India's military, which makes extensive use of civilian satellite data for identification and mapping of potential enemy targets, expects to bolster its remote sensing capabilities with Cartosat-1, the first of a new series of Earth imaging satellites proposed for launch in 2000. ... high resolution, stereoscopic images will be of greater use to the armed forces than for town planners."**

Additionally, commercial sources of satellite imagery for targeting potential enemies can be purchased and aimpoint data used to program terminal cruise missile seekers or guidance systems.

Improved Targeting Technology

Indian IRS-1C reconnaissance satellite 5.8m-resolution image of Mischief Reef in the Spratly Islands, where significant Chinese construction is currently underway.



JANE'S INTELLIGENCE REVIEW, February 1, 1999

Agenda

Third World Acquisition Options

This list presents the most likely methods a Third World country would employ to acquire a cruise missile force with a land-attack capability. Each country will balance regional national goals against available technology and cost to tailor their specific acquisition approach.

CMs which have mission and payload versatility will become increasingly desirable for Third World CM systems as Weapons of Mass Destruction become more available.

> **"According to a US Defense Department's 1999 nuclear, biological, and chemical report to Congress, chemical and biological weapons will continue to proliferate during the next decade. Proliferation will result from the development of increasingly stealthy chem-bio agents and <u>markedly improved delivery systems</u>. States will be more proficient at incorporating chemical or biological agents into delivery systems and ..., the threshold of some states to consider using these capabilities may be lowered."** ***(DEFENSE NEWS, April 19, 1999)***

Adding stealth features to new or old CMs is another likely trend since "survivability of cruise missile depends on two factors: how easy they are to detect, and how easy they are to intercept once detected.... ***(Rand report RP-463, GPS-Guided Cruise Missiles and Weapons of Mass Destruction, 1995).*****"**

The "poor man's cruise missile" can be a more economical solution than buying or developing CMs, by converting relatively inexpensive airframes of existing civilian or military jet aircraft to armed, unmanned operation. In a similar fashion, light aircraft or kits may also be purchased on the open market. There are virtually no restrictions on acquisition of these capable, long range aircraft options; coupled with available avionics and guidance they have sufficient payload and range to become adequate land-attack cruise missiles.

Third World Acquisition Options

- **Modify Existing Anti-Ship Cruise Missile for Land-Attack Mission**
- **Purchase Advanced Cruise Missiles From Developed Nations**
- **Convert Unarmed UAV to LACM Mission**
- **Develop Improved / Reduced Signature CMs Indigenously**
- **Create “Poor Man’s” Cruise Missiles from Existing Aircraft**
- **Weaponize Civilian and Home-built Kit Aircraft**

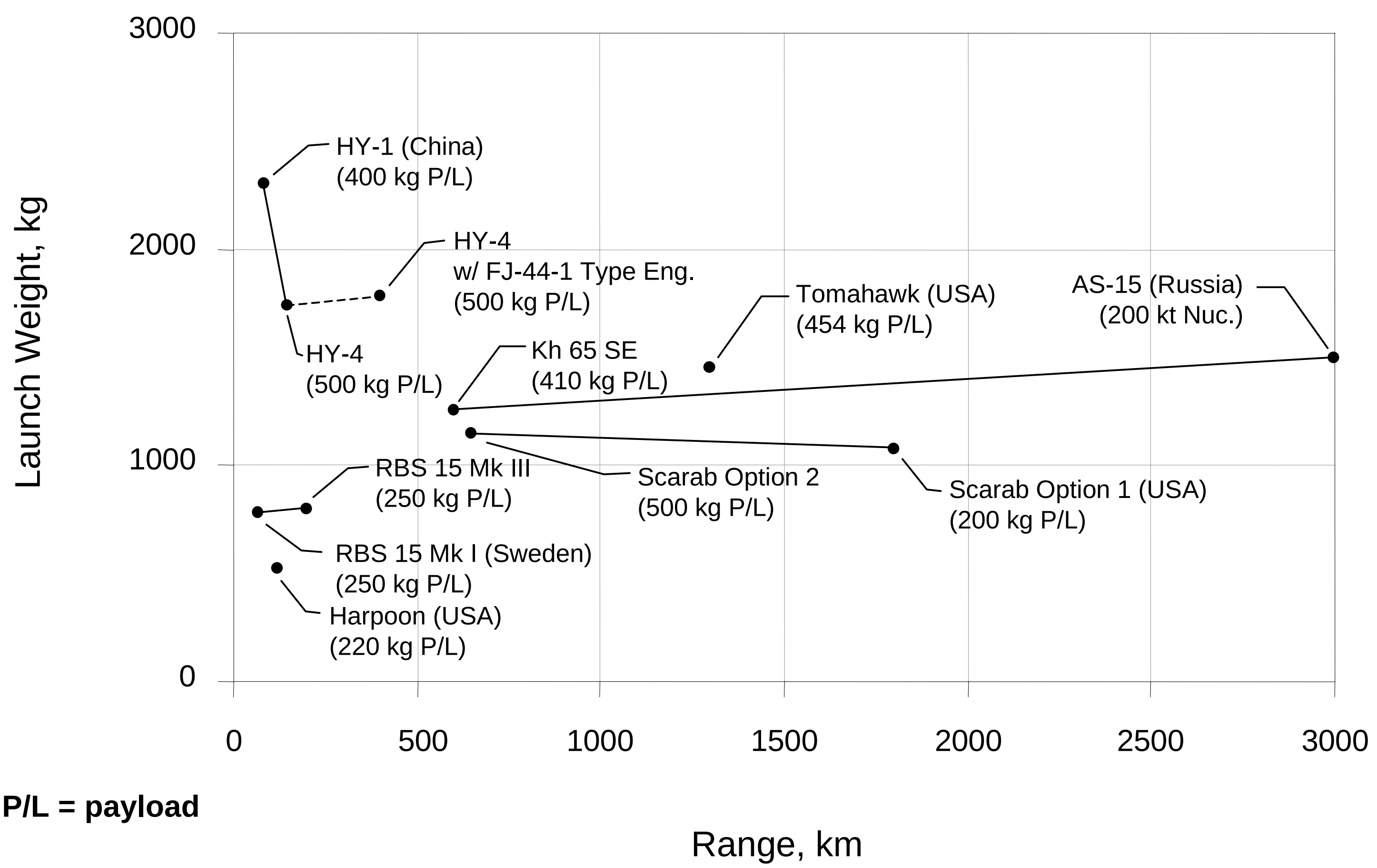
Range Improvement for Land-Attack Mission

This chart depicts the evolution of examples of different classes of cruise missile systems developed by various countries. It serves to show the improvements in missile range that result from applying improved propulsion and fabrication technologies to expanding mission requirements.

Hypothetical range extensions are displayed on the chart for a re-engined HY-4 and a modified SCARAB reconnaissance drone specially adapted for a land-attack attack capability discussed later.

Several countries' CM improvement programs exhibit similar range improvement trends. It is noteworthy how different military requirements have yielded different systems optimized to perform specific cruise missile missions.

Range Improvement for Land-Attack Mission



P/L = payload

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Transforming Chinese Anti-Ship Cruise Missiles into Land-Attack Weapon Systems

- **Large Inventory of Existing Chinese Silkworm and Derivative Cruise Missiles**
  - **70 Nations have Produced/Purchased Missiles**
  - **Currently Deployed in 40 Developing World Countries**
- **Chinese Cruise Missiles have Simple Design and Large Volume**
  - **Permits Ease of Transformation**
  - **New Subsystems can be added**
- **Significant Performance Improvements Possible**

Chinese Anti-Ship Cruise Missiles

In the late 1950's the former USSR supplied China with a number of P-15 cruise missiles. The Chinese designated these Russian built cruise missiles as SY-1 (CSS-N-1 Scrubbrush is the NATO designation). They formed the basic design for the major part of the Chinese cruise missile development from the 1960's through the 1980's. During the late 1960's the Chinese built their own version of the Russian "Styx", designated the HY-1, which was deployed as a ship-launched and coastal defense anti-ship cruise missile. Since that time the Chinese have developed, tested and produced numerous variations or improvements of anti-ship cruise missiles. This table summarizes the basic characteristics and status of Chinese anti-ship cruise missiles. Several of these Chinese designs have been exported to Third World countries, and China is still actively pursuing export sales. China is the currently most prolific exporter of cruise missiles after the United States.

Chinese Anti-Ship Cruise Missiles (U)

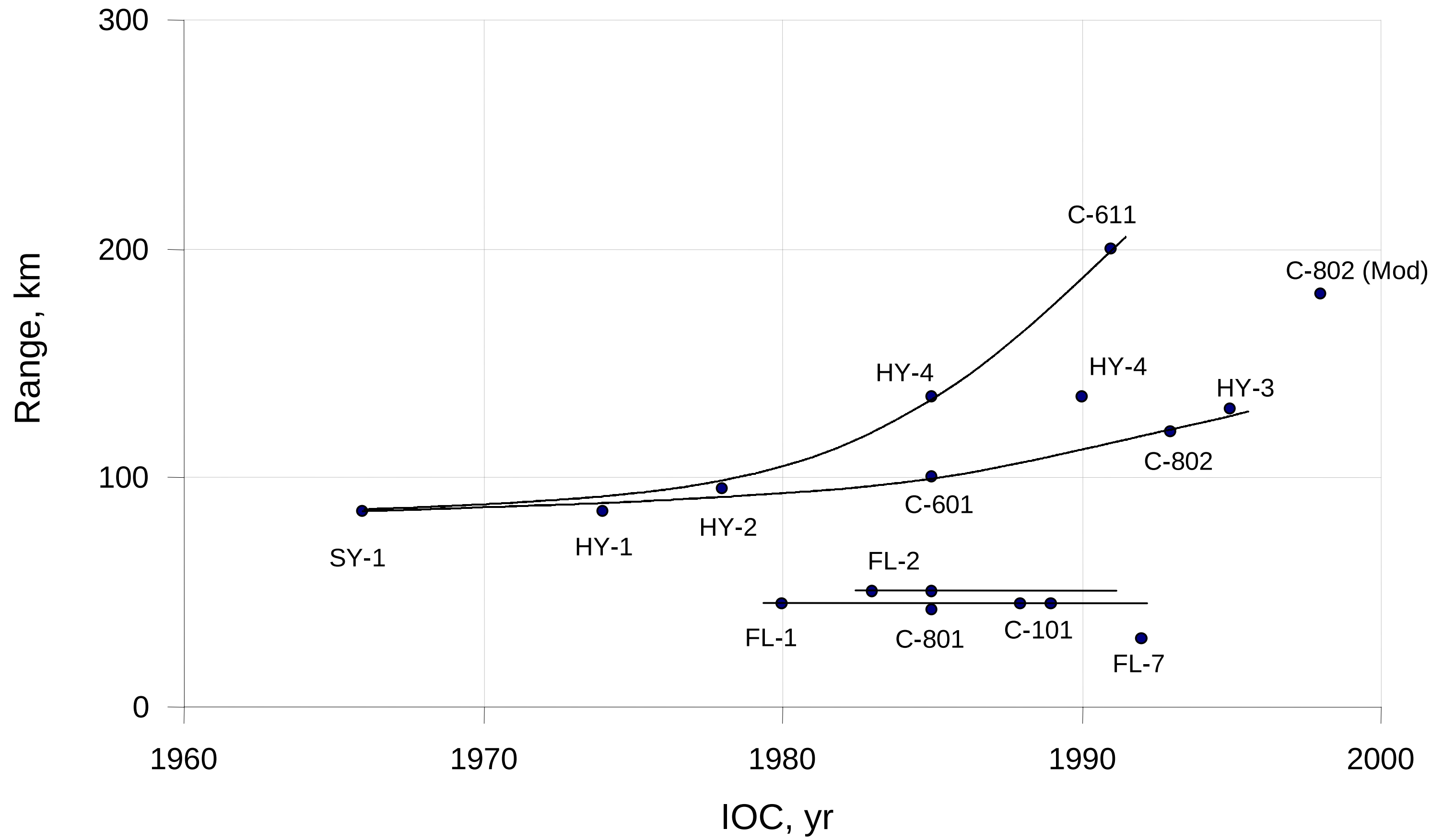
Designation		NATO Name	IOC	Type	Launch Platform	Cruise Speed (Ma)	Cruise Altitude (m)	Range (km)
CSS-N-1	**(SY-1)**	Scrubbrush	1966	Surf-Surf	FAC	0.8	100-350	85
	(SY-1A)	Scrubbrush	1983	Surf-Surf	FAC	0.8	100-350	85
CSS-N-2	**(HY-1)**	Safflower	1974	Surf-Surf	FAC	0.8	100-350	85
	(HY-1A)	Safflower	1988	Surf-Surf	FAC	0.8	100-350	85
CSSC-2	**(HY-1)**	Silkworm	1974	Surf-Surf	CDU	0.8	100-350	85
CSSC-3	**(HY-2/C-201)**	Seersucker	1978	Surf-Surf	CDU	0.9	30-50	95
	(HY-2A)	Seersucker		Surf-Surf	CDU	0.9	30-50	95
	(HY-2B)	Seersucker		Surf-Surf	CDU	0.9	30-50	95
CSS-N-4	**(YJ-1/C-801)**	Sardine	1984	Surf-Surf	SS/SUB	0.9	20-30	45
	(YJ-8/C-801)	Sardine	1989	Air-Surf	AC	0.9	20-30	45
CSSC-4	**(YJ-1/C-801)**	Sardine	1984	Surf-Surf	CDU	0.9	20-30	45
		FL-3A				0.9	30-50	100
CSS-N-8	**(YJ-2/C-802)**	Saccade	1993	Surf-Surf	SS	0.9	20-30	120
CSSC-8	**(YJ-2/C-802)**	Saccade	1993	Surf-Surf	CDU	0.9	20-30	120
		Saccade	1996	Air-Surf	AC	0.80-0.85	20-30	120
CSSC-X-5	**(YJ-16/C-201))**	Saples	1989	Surf-Surf	CDU	2.0	50	45
		Saples	1988	Air-Surf	AC	2.0	50	45
CSSC-X-6	**(HY-3/C-301)**	Sawhorse	1995	Surf-Surf	CDU	2.0	100-300	130
CSSC-7	**(HY-4/C-201)**	Sadsack	1985	Surf-Surf	SS/CDU	0.8-0.9	70-200	135
		Sadsack	1991	Air-Surf	AC	0.8-0.9	70-200	135
CSS-N-1	**(FL-1)**	Scrubbrush Mod 2	1980	Surf-Surf	FAC	0.9	30	45
CSS-NX-5	**(SY-2/FL-2)**	Sabbot	1983	Surf-Surf	FAC	0.9	30	50
	(SY-2/FL-7)	Sabbot	1992	Surf-Surf	FAC/CDU	1.4	30	30
CAS-1	**(C-601)**	Kraken	1985	Air-Surf	BAC	0.9	50, 70 or 100	100
	(C-611)	Kraken	1991	Air-Surf	BAC	0.82-0.87	50, 70 or 100	200

AC Aircraft
BAC Bomber Aircraft
CDU Coastal Defense Units
FAC Fast Attack Craft
SS Surface Ships
SUB Surfaced Submarines
C-XXX Export Variants

Chinese Anti-Ship Cruise Evolution

The Chinese have made improvements in almost all cruise missile subsystems since the advent of the SY-1 and HY-1. These improvements include turbo-jet engines instead of liquid propellant rocket motors, inertial guidance instead of pre-programmed auto-pilot guidance and more capable terminal sensors. The figure portrays Chinese anti-ship cruise missile evolution in terms of range performance as a function of initial operating capability (IOC) date. The Chinese were primarily pursuing other weapon system improvements (mid-course and terminal guidance) in the 1970's and early to mid 1980's (e.g., HY-2 terminal seeker evolved through four upgrades beginning in the early 1980's). Only the newest cruise missiles (since mid 1980's IOC) provide significant range (>100 km) capabilities.

Chinese Anti-Ship Cruise Missile Evolution



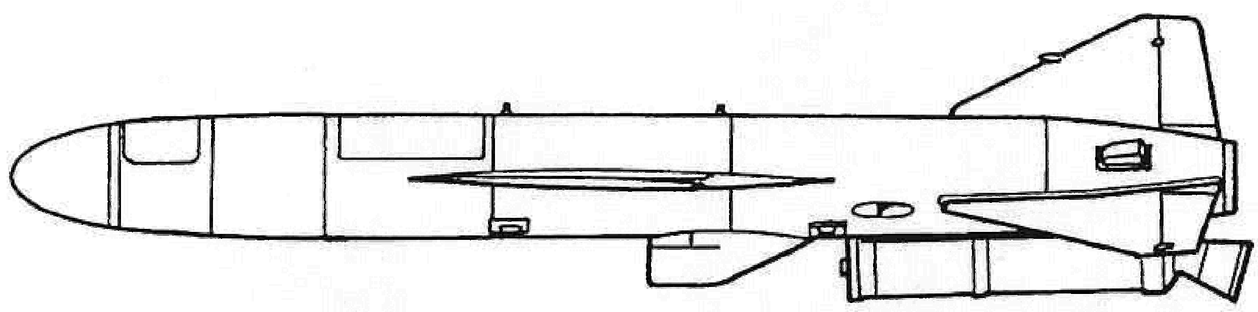
HY-4 Sadsack

A Third World country could acquire land-attack weapon systems by modifying existing anti-ship cruise missiles. The most direct development path would be to modify existing Chinese "Silkworm" derivative cruise missiles. The Chinese have produced, sold directly to Third World countries, and offered for export a whole family of anti-ship cruise missiles based upon the original Russian P-15 Styx cruise missile. The Chinese HY-4 Sadsack cruise missile is a very likely candidate for conversion into a longer-range land-attack weapon system.

The Silkworm family of missiles can be ground- or air-launched and the HY-4 is currently capable of delivering a 500 kg payload to a maximum range of 150 km. The Chinese cruise missiles are inherently easier to modify than other anti-ship weapon systems, such as the French Exocet family, and require less sophisticated manufacturing skills because of their sheer size and simplicity of design. The Chinese HY-1 and HY-2 cruise missiles could also be modified into land-attack cruise missiles, but would benefit from a more efficient turbojet engine and accuracy improvements such as a terminal seeker.

The Chinese HY-4 anti-ship cruise missile currently employs a relatively inefficient WP-11 turbojet engine. Its physical size (7.36 m overall length, 0.76 m body diameter) would provide space for adding fuel, changing engines, rearranging avionics, replacing existing guidance subsystems, or modifying payloads. In addition, structural modification can be made by adding bulkheads or partitions between compartments and adding simple shaped plates to increase the missile's length slightly. These modifications can all be accomplished with existing Third World expertise.

HY-4 Sadsack



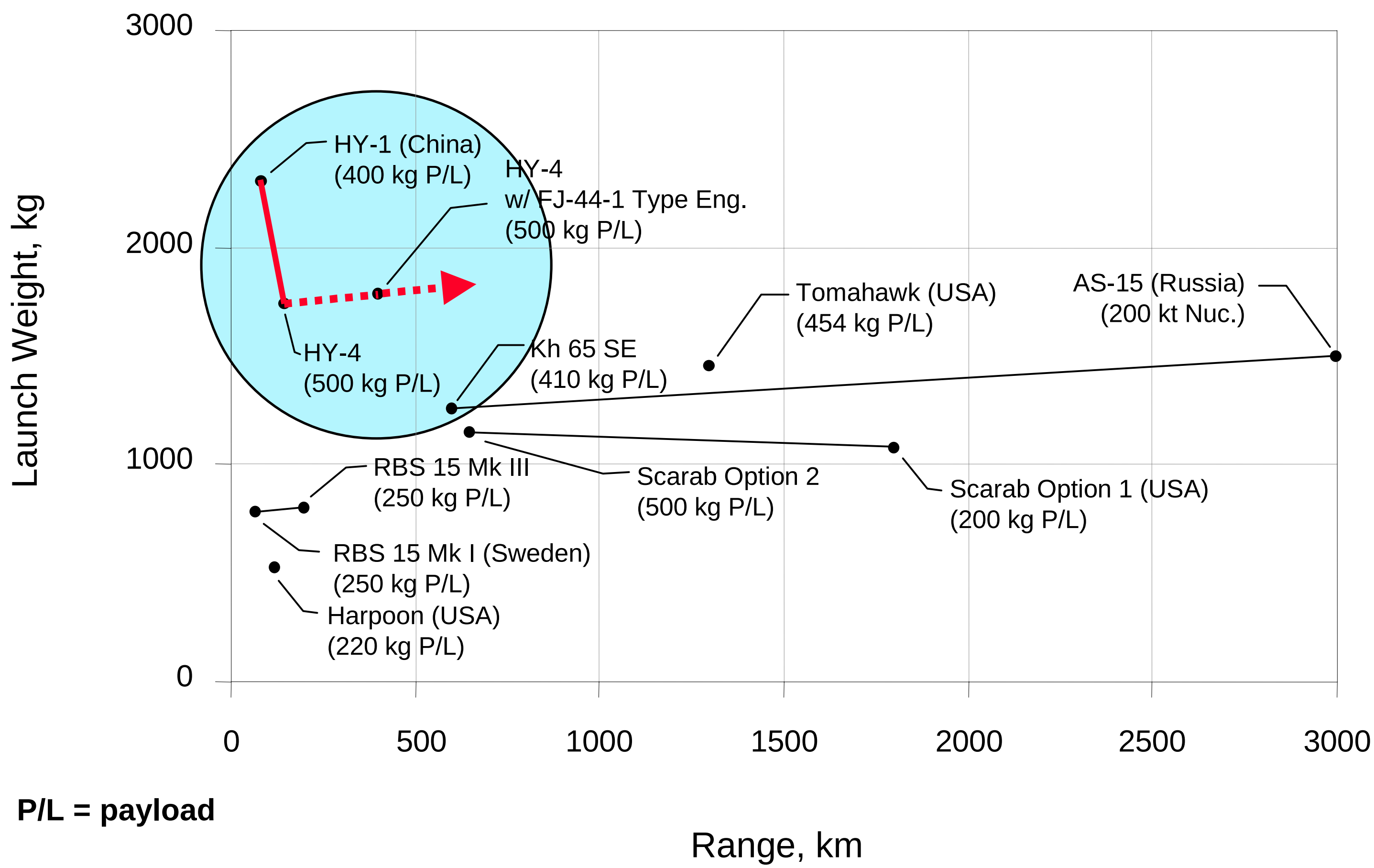
Role:	**Antiship**	**Guidance:**	**INS, AR**
Length:	**7.36 m**	**Propulsion:**	**Turbojet**
Body Diameter:	**0.76 m**	**Fuel:**	**200 kg**
Wingspan:	**2.41 m**	**Cruise Altitude:**	**70 to 200 m**
Launch Weight:	**1,740 kg**	**Maximum Speed:**	**0.78 (mach)**
Range:	**150 km**	**Launcher:**	**Ship, truck/trailer**
Warhead:	**500 kg**	**US Designation:**	**CSS-C-7**

Silkworm Range Extension Capabilities

Converting an existing anti-ship cruise missile into a land-attack weapon system could require modification or replacement of most subsystems depending on the owner's mission requirements. New cruise missile systems would probably include geographic information systems based upon commercially available satellite imagery, lightweight integrated avionics, combined GPS and inertial guidance subsystem, plus a fuel efficient gas turbine engine. Any free space within the airframe could be utilized to add fuel to increase the missile's range capability. Additional performance could be attained by adding fuselage sections, as required, to permit a higher propellant loading.

The HY-4 upgrade shown includes all subsystem changes to make it into an effective land-attack cruise missile. This graph addresses the impact of propellant loading on missile characteristics and performance. The analysis compares the existing Chinese WP-11 turbojet engine and the U.S. FJ-44-1 turbofan engine. As shown, ranges in excess of 700 km (versus 150 km) can be attained by increasing the propellant loading by a factor of 4 using the Chinese WP-11 turbojet as the substainer engine. The cruise missile's maximum range can be increased to 400 km just by replacing the Chinese WP-11 substainer with the more efficient U.S. FJ-44-1 turbofan. Adding more fuel or reducing structural weight would further increase range.

Silkworm Range Extension Capabilities



P/L = payload

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Third World Acquisition Options

- Modify Existing Anti-Ship Cruise Missile for Land-Attack Mission
- Purchase Advanced Cruise Missiles From Developed Nations
- Convert Unarmed UAV to LACM Mission
- Develop Improved / Reduced Signature CMs Indigenously
- Create "Poor Man's" Cruise Missiles from Existing Aircraft
- Weaponize Civilian and Home-built Kit Aircraft

Capabilities Tailored to Customer Needs

The significant investments in cruise missile development made by developed countries is forcing economic decisions about upgrades to existing LACM designs. In order to amortize the large cost of developing such advanced systems, alternative missions have been devised ensuring their longevity and effectiveness. Cruise Missiles originally designed for nuclear weapon delivery during the Cold War have had their payload options modified much like multi-mission manned aircraft.

Weapons developing countries' need to recoup development costs and maintain aerospace industries in the face of declining defense budgets has resulted in a windfall for Third World arms buyers. They need not invest in the infrastructure that created these military systems to acquire the technology and capabilities represented by them. Purchasing an "entry level" anti-ship cruise missile provides significant technology transfer and opens the door for a Third world country to purchase modified designs more suitable for its specific mission needs.

Capabilities Tailored to Customer Needs

- **French Apache available in several mission-tailored configurations**

  Note: The same Labinal TRI-60 turbine powers the Saab RBS 15 and the BAe Sea Eagle

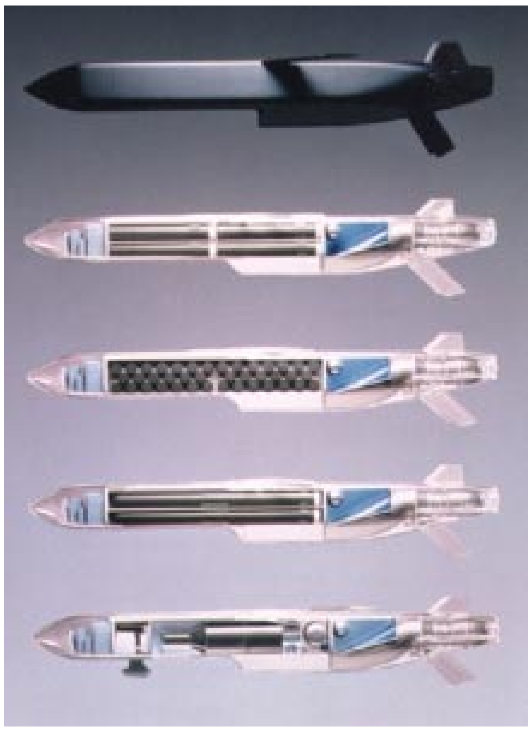


Image From Jane's Intelligence Review

APACHE reduced-signature airframe

Standoff attack payload

Hard target penetration/ Runway Interdiction

Increased range

Special purpose payloads...

Sweden's RBS-15 Cruise Missile Evolution

For each current producer, the evolution of anti-ship cruise missiles has been based upon perceived threats, available subsystems, technical expertise, and production capabilities. Sweden's RBS-15 represents a typical country's evolution of a short range anti-ship cruise missile into a longer range land-attack weapon system.

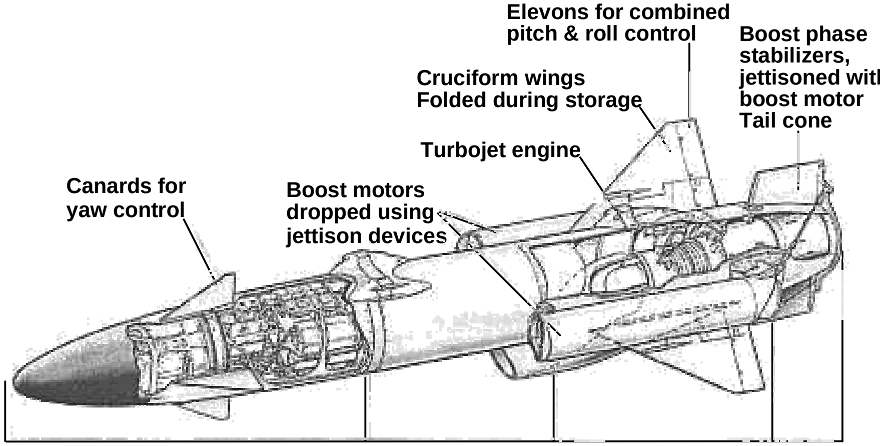
Development of the RBS 15 began in the 1970's as a replacement to the RBS-08 cruise missile. After domestic and foreign solutions were considered, a rapid domestic development began. It took only six years from the initial development contract (1979) to the first ship-based deployment (1985) of the RBS-15 Mark I. The weapon system employs and autopilot midcourse guidance, monopulse J-band radar for terminal guidance and a liquid propellant sustainer.

Initial work on the RBS-15 Mark II cruise missile began in the early 1980's. However it wasn't until 1994 that a development contract was set for this upgraded anti-ship weapon system (IOC 1998). The Mark II offers no increase in range performance since the emphasis was placed on upgrading its midcourse and terminal guidance and improving its radar and IR signatures.

Development of the RBS-15 Mark III cruise missile started in the mid-1990's with an expected IOC of 2000. Emphasis is on increased range (greater fuel capacity with JP-10 fuel), accuracy (incorporation of GPS), and targeting flexibility (selectable priority targeting). Future improvements (projected for 2010) will likely provide highly accurate capabilities for multi-mission land-attack at extended ranges.

Sweden's RBS-15 Cruise Missile Evolution

- **RBS 15 Mark I CM has**
  - Cylindrical Cross-Section with an Ogival Nose
  - Four Folding Wings of a Cropped Delta Shape
  - Two Rear Vertical Boost Phase Stabilizers
  - Two Solid Composite Propellant Boosters
  - Microturbo Single Spool Turbojet Substainer
  - Autopilot Guidance with a Radar Altimeter
  - Monopulse J-band (13-18 GHz) Terminal Seeker
  - HE Blast Fragment Warhead
  - Hydraulic Actuation Subsystem
- **RBS-15 Mark II CM adds**
  - Upgraded Guidance System
  - New Multiple Purpose Computer
  - Upgraded Terminal Sensor
  - Stealth Materials Incorporated in the Air Intake and Seeker to Improve its Radar and IR Signatures
- **RBS-15 Mark III CM will feature**
  - Substantial Increase in Range
    - Increased Fuel Capacity
    - Higher Energy (JP-10) Fuel
  - New Multi-Purpose Onboard Processor
  - GPS Mid-Course Update
  - Revised Foldable Wings
  - Some Shaping to Reduce RCS
  - Electrical Actuation Subsystem
  - Selectable Priority Targeting in Terminal Phase
- **Potential Future Improvements**
  - New Navigation System
  - New IIR Seeker & Automatic Target Recognition Software



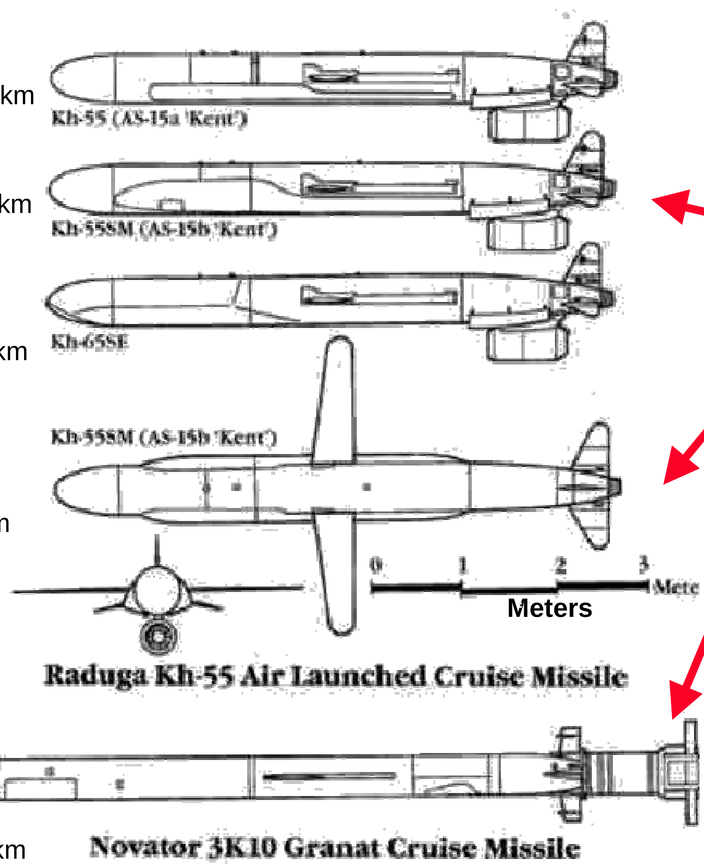
Missile System	RBS-15 Mk 1	RBS-15 Mk 2	RBS-15 Mk 3
IOC	1985-1990	1998	2000
Launch Weight, kg	620/780	620/780	630/800
Range, km	70	70	200

Conversion of Russian Nuclear CMs to Conventional Missions

The original Russian Kh-65 cruise missile has undergone an evolution reflecting changes in technology and operational requirements. The changed world environment since the collapse of the Soviet Union have made aerospace technologies and complete systems such as this available to more countries. Many cruise missile developers are faced with decreasing defense budgets and a need to maintain critical national industrial capability. Foreign sales of capable weapons are at once a source of revenue and a method of expanding or retaining political influence among client states.

Conversion of Russian Nuclear CMs to Conventional Missions

- 1984/Nuclear/ 2500 km
- 1992/ Nuclear/ 3000 km
- 1993/Conventional / 550 km
- 1995 / Nuclear or Conventional/ 1000+ km
- 1987/ Nuclear/ 3000 km



('SS-N-21 Sampson')

- **AS-15 nuclear CM has been modified several times since 1984**
  - **Improved propulsion**
  - **Signature reduction**
  - **Surface-launched variant (SS-N-21 Sampson)**
  - **Conventional payload options**
  - **Increased range**

Drawings From Jane's Intelligence Review, May 1, 1996

Convert Unarmed UAV to Land-Attack Cruise Missile Mission

A Third World country could opt to convert an existing tactical reconnaissance UAV to a land-attack cruise missile. One such UAV system is the U.S.-built Egyptian SCARAB UAV. The existing guidance and control subsystem could be replaced with highly accurate integrated inertial guidance/GPS and terminal sensor subsystems. The existing reconnaissance payload and recovery subsystems could be replaced with a conventional payload. Aerodynamic control surface (wings, elevons, etc.) could be re-sized to permit the vehicle to fly more efficiently at low altitudes (the SCARAB UAV was designed with a service ceiling of 13,000 m). Techniques of varying sophistication could be applied to reduce its RCS signature. Finally, propellant tankage could be modified to optimize the fuel system to better match new land-attack missions.

Third World Acquisition Options

- Modify Existing Anti-Ship Cruise Missile for Land-Attack Mission
- Purchase Advanced Cruise Missiles From Developed Nations
- Convert Unarmed UAV to LACM Mission
- Develop Improved / Reduced Signature CMs Indigenously
- Create “Poor Man’s” Cruise Missiles from Existing Aircraft
- Weaponize Civilian and Home-built Kit Aircraft

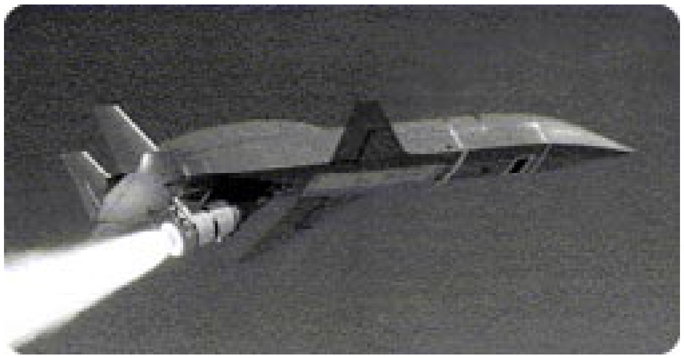
SCARAB UAV - Overview

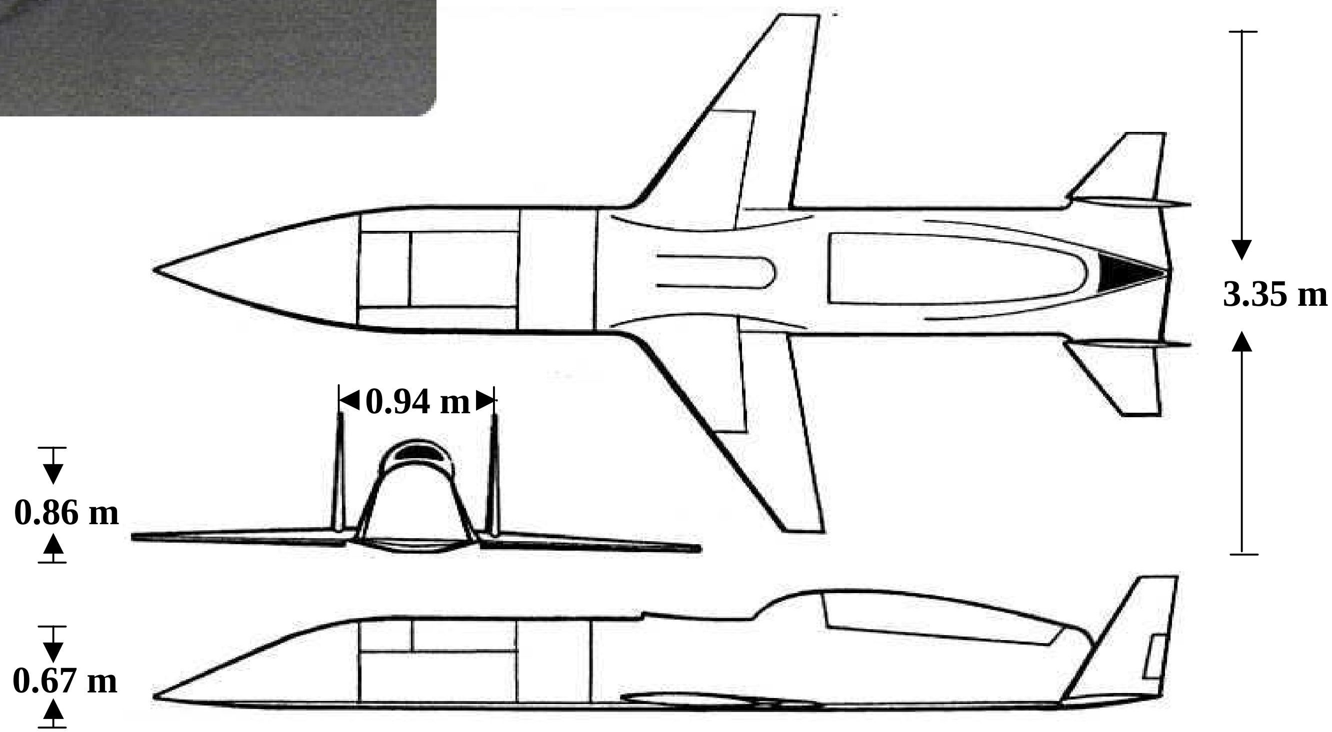
The SCARAB UAV was originally developed by Teledyne Ryan under a 1984 contract from the Egyptian government. The contract was for 29 air vehicles and associated ground support equipment, launch/recovery vehicles and operational spares. All of these were delivered from late 1988. An additional 27 air vehicles and associated support equipment were ordered in late 1989 by the Egyptians and delivered in 1992 - 93. The SCARAB UAV has an overall length of 6.15 meters, an overall height of 0.86 meters and a wing span of 3.35 meters. The SCARAB UAV is booster-launched by a modified Harpoon rocket motor.

The SCARAB UAV entered service with the Israeli Air Force in 1995, which has renamed it SIKSAK (Peregrine).

SCARAB UAV - Overview

- Teledyne - Ryan Model 324





SCARAB UAV - Design Details

The primary function of the Egyptian UAV is low-level photo reconnaissance. The missions are normally preprogrammed into the onboard flight control system providing automatic attitude and flight path control under the authority of a mission logic unit. The UAV employs an all-composite airframe stealthy design with a flat-bottomed fuselage. Propulsion is provided by the Teledyne CAE 373-8C turbojet engine. The payload is a CAI/Recon Optical camera. Alternate payloads include a television camera or a Loral D-500 infrared laser system (IRLS). On mission completion, the SCARAB is recovered by a two-stage recovery parachute system. Impact is cushioned by inflatable airbags.

The SCARAB UAV has a launch weight of 1,077 kg of which 443 kg is loaded fuel. The launch booster is jettisoned once the UAV is airborne. The UAV, as currently configured, has a maximum operating radius of just under 970 km or a maximum straight line range of 2,250 km.

SCARAB UAV - Design Details

- **Description:** Teledyne Ryan Model 324
- **Developed:** For Egyptian Armed Forces
- **Primary Mission:** Low-level photo reconnaissance
- **Structure:** All composite stealthy design
- **Propulsion:** Teledyne CAE 373-8C turbojet
- **Guidance:** INS, pre-programmed or remote control (LN-81 strapdown w/Collins GPS receiver updates)
- **Payloads:** Film storage daylight camera /TV/IRLS
- **Launch/Recovery:** Two-stage parachute & airbags
- **Booster:** Modified Harpoon rocket motor
- **Max Speed** 0.8 M (at 13,000 m / 40,000 ft.)
- **Dimensions:**

Dimensions		Weights:	
Wing Span	3.35 m	Booster	138.0
Wing Area	2.33 m^2	Recovery System	68.5
Overall Length	6.15 m	Payload	131.5
Overall Height	0.86 m	Guidance/Air Frame	233.0
		Turbojet Engine	63.0
		Fuel	443.0
		Launch Weight, kg	1077.0

Convert SCARAB UAV - Option #1 to a Land-Attack Cruise Missile

Some feasible, near term modifications to the SCARAB UAV to convert it into a land-attack cruise missile include:

- Deletion of reconnaissance payload
- Deletion of UAV recovery system
- Replacing the existing guidance and control subsystem with an integrated inertial guidance/GPS subsystem
- Addition of an explosive warhead or Chem/Bio payload and dispenser.

And, if greater terminal precision is required:

- Addition if an accurate terminal guidance system (some type of terrain/target matching system based on available radar or electro-optic sensor)

For this study it was assumed that the LACM midcourse and terminal guidance system has the same weight and volume as the existing UAV guidance and control system. In addition, it was assumed that deletion of the reconnaissance payload and recovery system provided sufficient space for a small conventional payload.

The SCARAB UAV modified to a land-attack cruise missile (Option #1) could deliver a 200 kg conventional payload to a maximum range of 2,250 km flying the high altitude UAV flight profile. Flying a low altitude profile (less than 500 m altitude instead of 13,000 m) enables a range capability of approximately 1,800 km. Part of this performance loss (typically 15-20%) can be regained by reducing the wing size and shape and other changes to make the vehicle more efficient for low altitude operation.

Convert SCARAB UAV - Option #1 to a Land-Attack Cruise Missile

Modify SCARAB UAV - Option #1

• Delete reconnaissance payload	-	131.5 kg
• Delete recovery system	-	68.5 kg
• Add conventional payload	+	200.0 kg

Launch Weight		1,077 kg
Fuel Weight		443 kg
Range - high altitude profile		2,250 km
Range - low altitude profile	~	1,800 km

Convert SCARAB UAV - Option #2 to a Land-Attack Cruise Missile

If a larger payload is desired, the vehicle's fuselage and tankage could be modified to accommodated a larger payload. This would result in a loss in fuel loading to maintain the same overall vehicle envelope.

Option #2 incorporates the same SCARAB-LACM conversion changes identified for Option #1, but further modifies the vehicle to accommodate a 500 kg conventional payload. The change results in a 237 kg loss in loaded fuel. The Option #2 SCARAB-LACM is capable of delivering the 500 kg conventional payload to a maximum range of either 810 km or 650 km flying the high or low altitude flight profiles, respectively. Some of the range losses can be regained if selected aerodynamic changes are also made.

Convert SCARAB UAV - Option #2 to a Land-Attack Cruise Missile

Modify SCARAB UAV - Option #2

• Delete reconnaissance payload	-	131.5 kg
• Delete recovery system	-	68.5 kg
• Modify fuselage/tankage for increased payload volume	+	20.0 kg
• Modify fuselage/tankage for decreased fuel loading	-	20.0 kg
• Reduce fuel loading	-	237.0 kg
• Add conventional payload	+	500.0 kg

Launch Weight		1,140 kg
Fuel Weight		206 kg
Range - high altitude flight	~	810 km
Range - low altitude flight	~	650 km

Modified SCARAB-LACM Capabilities

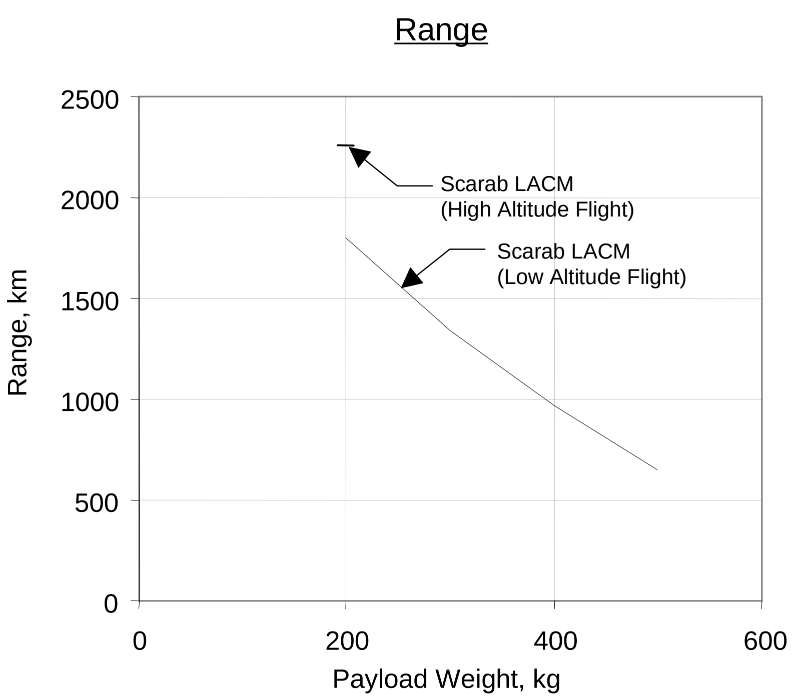
The modified SCARAB-LACM range performance can be varied without altering the vehicle's overall external geometry. The missile's airframe/tankage can be revised to accommodate less fuel to increase volume for payload. As shown, a 300 kg increase in payload weight (200 to 500 kg) requires a 227 kg (206 versus 443 kg) reduction in loaded fuel weight. The HE payload is assumed to have a density ~ 30% greater that the JP-4 fuel (JP-4 weighs 0.78 kg/liter). By varying the payload weight and corresponding fuel loading, the SCARAB-LACM can achieve a factor of three in range performance without changing the vehicle's external geometry.

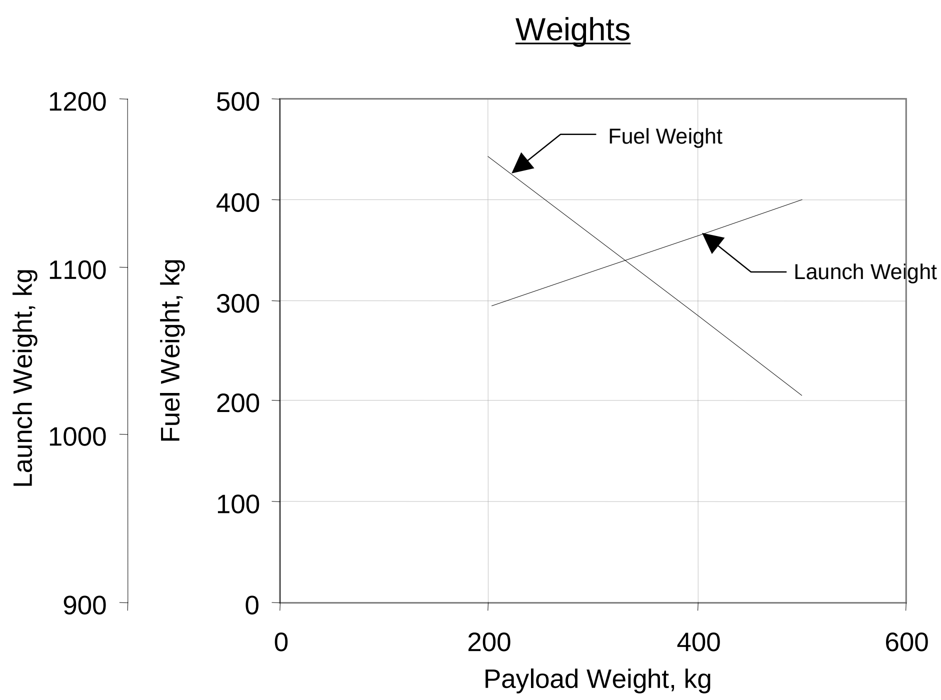
There are a number of additional design modifications that a country could make to the SCARAB UAV to increase its performance (range and payload) capabilities for the land-attack role. They include:

- **Increasing the fuselage length to accommodate a larger payload**
- **Increasing the fuselage/tankage lengths to accommodate a greater fuel loading**
- **Replacing the existing Teledyne CAE 373-8C turbojet engine with a more fuel efficient low altitude sustainer engine**
- **Reduce the vehicle's RCS in the land-attack role by shaping critical surfaces or adding radar absorbing materials (RAM)**
- **Employing a TERCOM type terminal guidance system**

Modified Scarab-LACM Capabilities

• Constant Missile Length





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Third World Acquisition Options

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- Create “Poor Man’s” Cruise Missiles from Existing Aircraft
- Weaponize Civilian and Home-built Kit Aircraft

Stealth Technology Now Widely Available

World wide media are full of publicity surrounding the phenomenal advantages provided by stealth aircraft the US has deployed successfully in combat since the Gulf War. Drawings, photographs and significant technical details have been presented providing a ready tutorial to aircraft designers anywhere. Understanding radar-defeating characteristics that result primarily from shaping the airframe are complemented by electrical engineering education about radar detection and propagation phenomena.

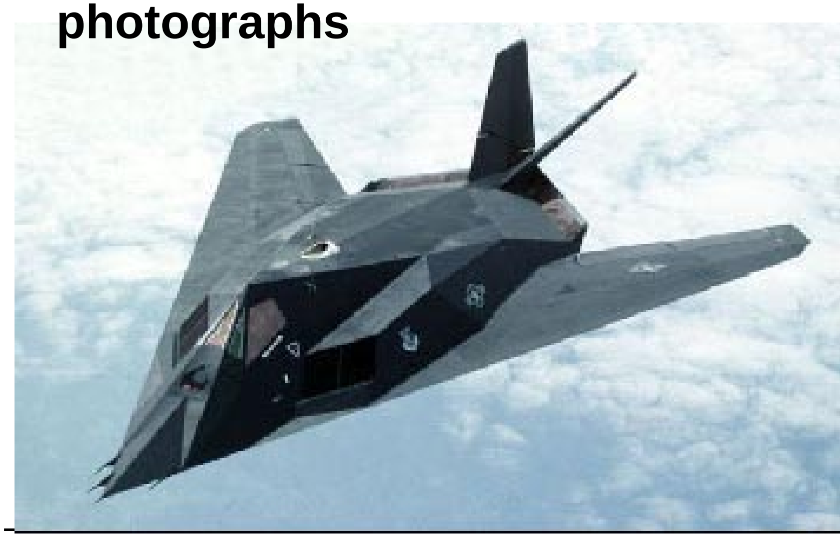
Motivated by overwhelming evidence of Western development of ever more sophisticated defensive missiles and radars, Third World cruise missile developers will likely place some stealth requirements on any indigenous CM designs or modifications. Even inexpensive and unsophisticated cruise missiles may be expected to employ some level of RCS reduction.

The following charts depict "indigenous" Third World stealth modifications to the basic SCARAB UAV. The simplest airframe shaping (Near Term Option) can provide significant survivability improvement over the basic airframe. The New Cruise Missile design employs more sophisticated shaping and coatings (all technologies and materials accessible to a Third World country) if the developer's resources allow.

By reducing the signature of a relatively small UAV airframe, detection by defensive radars is reduced and survivability is increased. For example, "...the AWACS was designed to detect fighters with radar cross sections of 7 m^2 at a range of at least 370 km, [therefore] a 0.1 m^2 target will be seen at a range of 130 km. ***(RAND report RP-463, 1995*****)." A 0.1 m^2 rcs-cruise missile flying at a moderate speed (350 knots) at low altitude would reduce defensive reaction time from over 30 minutes to 12 minutes or perhaps even less depending on the radar's Doppler detection algorithm and ground clutter rejection capability.**

Stealth Technology Now Widely Available

Shapes obtainable from photographs



Wide array of information available on reduction of observables.

- **Magazines**
- **Books**
- **Reports**
- **Universities**
- **Industry**
- **Proliferation of expertise**

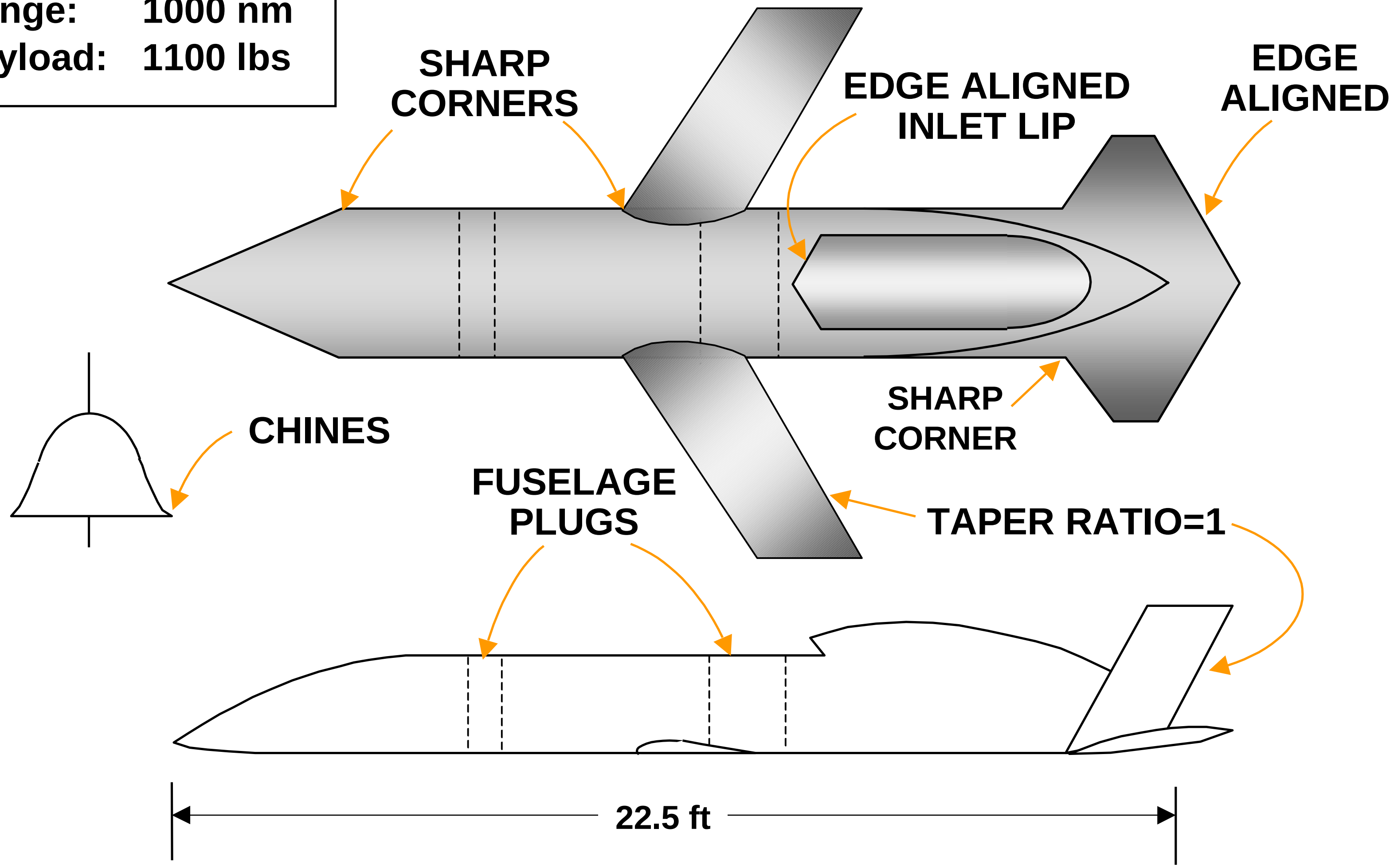
Stealth Materials Readily Obtainable

- **Mag RAM**
- **Composites**

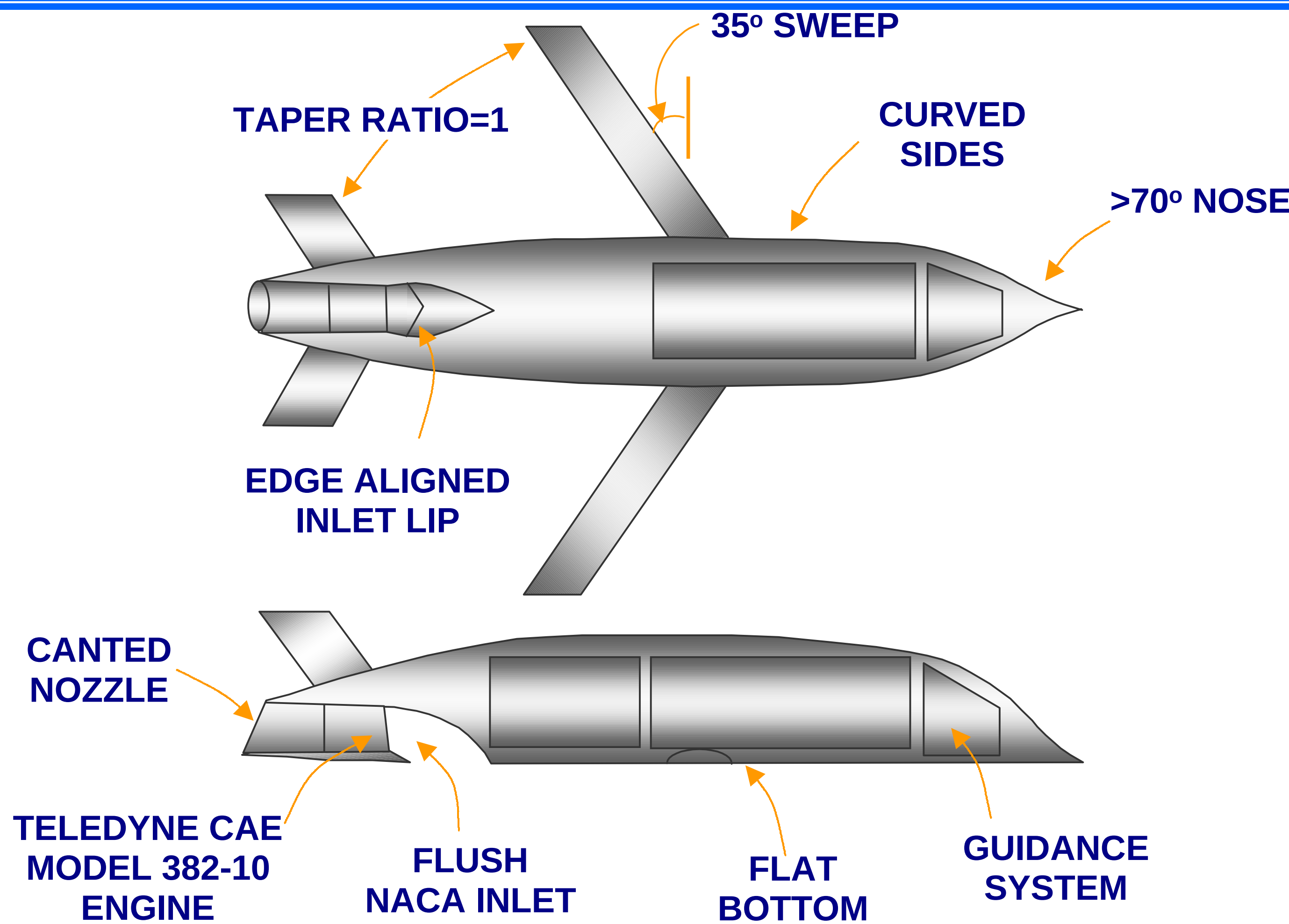
- **The West has convinced the world stealth is essential**
- **Expect "stealth lesson" applied to cruise missile threats as well**

Near Term Stealth Option: Modified Scarab

Range:	**1000 nm**
Payload:	**1100 lbs**



New Cruise Missile -- Medium Range



• SELECTIVE SURFACES/RAS TREATMENTS

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Third World Acquisition Options

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Convert Existing Jet Aircraft

British aircraft attacked Iraq's drone aircraft program at Tallil airfield in southern Iraq during the December strikes. The US... also attacked L-29's at Al Sava airfield. **Iraq began modifying the Aero L-29 trainer to act as a pilotless drone to deliver biological and chemical weapons in underwing spray tanks.** (Aerospace Daily, 24 Dec 98; Jane's Defense Weekly, 4 Jan 99)

Iraqi L-29, Jane's photo

"Saddam Hussein has appealed for volunteers from the Iraqi armed forces to form a suicide air attack force. The purpose of the unit is both to lure American and British warplanes into air defence traps and to **launch direct attacks on Western targets in the Gulf region.***"* (Electronic Telegraph (London), 21 March 1999)

Third World Acquisition Options

- Modify Existing Anti-Ship Cruise Missile for Land-Attack Mission
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- Weaponize Civilian and Home-built Kit Aircraft

Convert Light Aircraft and Kits

- **LancAir IV -- $52,000 for full airframe kit**

- **335 kts at 24,000 ft**
- **2,300 km range**
- **550 kg payload**
- **LO composite materials**
- **Proven design**
- **GPS [and avionics packages] on request**

LancAir IV from LancAir web site

"...phenomenal performance at an affordable price." (less than $100K)

- **Suitable range / payload "off-the-shelf"**
  - **Cirrus SR20: 160 kts, 1,500 km, 300 kg**
  - **CFM Star Streak: 120 kts, 550 km, 200 kg**
  - **Ultravia Pelican (kit): 140 kts, 1,500 km, 200 kg**
  - **Diamond Xtreme motor glider: 140 kts (powered), 1,000+ km/4+ hours (soaring), 200 kg** *(pictured at right)*

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Agenda

Third World View of Effective Responses to U.S. Technical Superiority

- **Cannot Defeat U.S. / Allies on Battlefield: Land, Sea, Air**
  - **Persian Gulf War showed failure of direct confrontation**
- **Development of Hi-tech Conventional Forces Constrained**
  - **Affordability**
  - **Technological Availability**
  - **National Leadership and Power Structures**
- **Aggressor Nations Must Develop Asymmetric Strategies & Forces to Counter U.S./Allies**

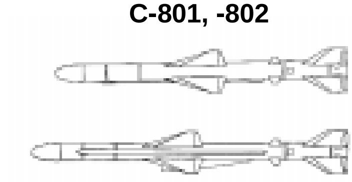
Most Cost-Effective Strategy for Deterring or Fighting U.S./Allies is Acquisition of Ballistic / Cruise Missile Force

Mission	Objective
- Threaten/Attack Population Centers - Threaten/Attack U.S. Forward-Deployed Forces and Allied Bases - Threaten/Attack Air and Sea Ports of Entry - Threaten/Attack Naval and Amphibious Operations	- Prevent Creation and Maintenance of Coalitions - Deny Facilities/LOC's to U.S./Allies - Prevent Entry of U.S./Allied Forces - Raise Risk to Unacceptable Levels

Third World Missiles -- Weapons of Choice

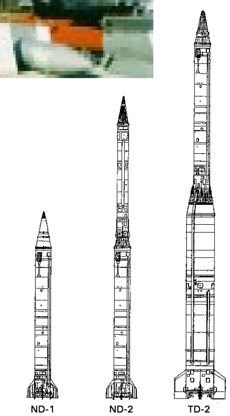
- **Robust Force Structure**
  - **Cruise <u>and</u> Ballistic missiles**
  - **Integrated Air Defense Systems**
  - **Aircraft with long-range missiles**
- **Missiles -- Most Cost Effective Investment**
  - **High speed improves penetration of defenses**
  - **Onboard seekers & GPS guidance for accuracy**
  - **WMD delivery meets military/political goals**
  - **Existing technology conceals development**
- **Improved Targeting**
  - **Increased access to space surveillance**
  - **Modern mobile communications coordinate dispersed launches**
  - **Computer flight planning allows pre-programmed attack profiles**
  - **GPS navigation updates enables cheap precision**

C-801, -802



Su-34 & Missile Armaments

SA-15 Launch



North Korean Ballistic Missiles

"Once we have upper tier [theater missile defense] on line, we'll see the enemy relying on other means to attack our troops, including cruise missiles,... That's why we also need a well developed cruise missile defense system." ***statement by BGen. Larry Dodgen, deputy director of the Joint Theater Air and Missile Defense Office, reported in Defense Daily, May 12, 1999***

Summary

The National Defense Panel's December 1997 report "Transforming Defense," identified homeland defense against cruise missiles and WMD payloads as a main task for America.

POTENTIAL HOMELAND VULNERABILITIES

Cold War *Strategic Nuclear Attack by Superpower*
Today and Tomorrow *Nuclear Attack by ????*

PLUS

Terrorism

Information Warfare

Ballistic and Cruise Missiles

Transnational Threats

Attacks on Critical Infrastructure

America may not be any more or less safe than before, but the challenges to its safety and security will be very different

.Threats to the United States have been magnified by the proliferation of, and the means to produce and deliver, weapons of mass destruction. The increasing availability of relatively inexpensive cruise missiles and the capability to fabricate and introduce biotoxins and chemical agents into the United States means that rogue nations or transnational actors may be able to threaten our homeland. Along with the growth of delivery systems, the technology needed to create warheads housing nuclear, chemical, or biological weapons has also proliferated. The complexity of the WMD challenge lies in the number of potential enemies who have access to, and may choose, this asymmetric means of attacking the United States in an effort to offset our conventional strengths *('Transforming Defense', Report of the National Defense Panel, December 1997)..*

Summary

- Third World Cruise Missiles of increasing capability will pose a serious threat to U.S. interests worldwide
- Technical characteristics of improved land-attack CM threats reflect regional mission requirements
- Development of CM forces may be indistinguishable from conventional aircraft manufacturing
- CM acquisition, development, and deployment is underway now

Current technology enables fielding large numbers of low cost land-attack cruise missiles that can overwhelm even capable defenses

Appendix: World CM Inventory

This appendix reflects an unclassified tally of known cruise missile systems produced and deployed worldwide. Only operationally usable cruise missiles are included in the inventory. Test vehicles or missiles in storage are not included. Producer nations' inventory tables reflect production for their own use, while exports tables identify known transfers to countries from CM system producers. The production and acquisition relationships between nations for some CM systems is perhaps intentionally obscured by co-production and licensing agreements.

Importing countries may also increase the numbers and capabilities of systems by indigenous modification. Because of technology proliferation, more countries than listed may already be committed to acquisition or development programs for cruise missiles. For their own interests, Third World nations may have transmitted technology, subsystems, or entire CM systems from known CM producers to other countries not identified.

The table below does not list cruise missile sales that are unconfirmed, although orders have been identified, and it may include weapons that have been expended in the last year.

PRODUCER COUNTRY INVENTORIES			**EXPORTED INVENTORIES**	
Brazil UNK	China 22,581	Egypt UNK	China 1,772	France 3,452
France 1,891	Germany 390	Iran 680	Germany 160	Israel 626
Iraq UNK	Israel 2,669	Italy 1,226	Italy 627	Norway 230
Japan 1,245	N. Korea UNK	Norway 550	Russia 3,921	Sweden 218
Russia 23,447	S. Africa 210	Sweden 575	UK 389	US 3,186
Taiwan 530	UK 1,102	US 9,002		
Total 66,096			Total 14,581	
World Total 80,677 *				

* **The precision of this inventory number (valid for the 1998-99 time frame) reflects an integrated tally of respected unclassified sources including: *The Military Balance, 1998-99*, The IISS, London; *World Missile Inventories and Forecast -- 1997-1998,* Forecast International; and corroborating national inventories listed in various *Jane's publications*.**

Cruise Missile Inventory of Producer Nations

Country/System	Status	Number	Launch Mode	Mission	Remarks
Brazil					
SM-70 (Barracuda)	Dev				
China					
CSS-N-1 (SY-1)	1966		S/L	ASCM	
(SY-1A)		1000	S/L	ASCM	Coastal Defense
CSS-N-2 (HY-1)	1974		S	ASCM	
(HY-1A)		6312	S	ASCM	Direct copy of Soviet SS-N-2
CSSC-2 (HY-1)	1974		L	ASCM	
(HY-1A)			L	ASCM	
CSSC-3 (HY-2)	1978		S/L	ASCM	A CSS-N-2, See entry; competes with FL-1
(HY-2A)			S/L	ASCM	
(HY-2G)		9416	S/L	ASCM	US designation: includes HY-2 & FL-1
CSSC-3 (HY-2/C-201)		0	S/L	ASCM	
(HY-2/C-601	1985	400	A	ASCM	
(HY-2/FL-3A)		UK	S	ASCM	
CSS-N-4 (YJ-1/C-801)	1984	1432	S	ASCM	
		UK	A	ASCM	
	1985	100	SUB	ASCM	Submarine Launched
CSSC-4 (YJ-1/C-801)	1984	UK	L	ASCM	
CSS-N-1 (FL-1)	1980	0	S	ASCM	A CSS-N-2, see entry
CSS-N-5 (FL-2)	1983	700	S	ASCM	Coastal Defense Missile
(FL-7)	1992	1100	S	ASCM	Competes with C-801
(FL-7)		400	A	ASCM	" " "
CSS-X-5 (C-101)	1989	500	S/L	ASCM	
	Dev	0	A	ASCM	
CSS-X-6 (HY-3/C-301)	1995	100	L	ASCM	See C-101 entry
CSSC-7 (HY-4/C-201)	1985		S	ASCM	
	1985		L	ASCM	
	1990	421	A	ASCM	
(XW-41/C-201W)	Dev	0	S/L	ASCM	
(XW-41/C-611)	Dev	0	A	ASCM	
CSS-X-8 (YJ-2/C-802)	1993	100	S	ASCM	
		UK	L	ASCM	
(C-802 MOD)	Dev	0	A/G/S	ASCM	
CAS-1 (C-601)	1985	300	A	ASCM	PLA - AF
YJ-22/C-802)		100	S	LACM	

Cruise Missile Inventory of Producer Nations

Country/System	Status	Number	Launch Mode	Mission	Remarks
Egypt					
HY-2	UNK	UNK	S	ASCM	Some indigenous production may be underway
HY-4	UNK	UNK	S	ASCM	May have been introduced by China
France					
MM-38 (Exocet)	1975	140	S	ASCM	To be replaced, some missiles second hand
AM-39 (Exocet)	1979	300	A	ASCM	100 missiles exported as war attrition
AM-39 (Exocet) Block 2		10	A	ASCM	Upgraded Exocet missiles already in inventory
SM-39 (Exocet)	1985	101	S	ASCM	
MM-40 (Exocet)	1981	99	S	ASCM	
MM-40 (Exocet) Block 2		50	S	ASCM	On order deliveries underway now in service
ANS	Canceled				
ANL	Canceled				
ASMP	1986	171	A	ASCM/ITD-N	Nuclear stand-off weapon system
SCAP	Dev			LACM	
ARMAT	1984	900	A	LACM/ARM	
Apache	1997	30	A	LACM/ITD-C	On order
Apache-A1	1999			LACM	
Germany					
Kormoran 1 (AS34)	1977	350	A	ASCM	
Kormoran 2 (AS34)	1991	40	A	ASCM	In development/deployment underway
India					
Koral (SS-N-22)	Dev		S	ASCM	In development, nearing deployment
Lakshya				ASCM	
Lakshya (Mod)	Dev			LACM	
Iran					
HY-2 (Hai Ying-2)		480	S	ASCM	Obtained via Libya or North Korea
Karus (C-801) Ying Ji-1		200	L	ASCM	Shore based antishipping
Tondar (C-802) Ying Ji-2	Dev	0	L	ASCM	Ships delivered, missile negotiations underway
NK	1994				
Silkworm (Mod)	Dev			LACM	
Iraq					
FAW 70	Dev			ASCM	
FAW 150	Dev			ASCM	
FAW 200	Dev			ASCM	
Ababil				LACM	

Cruise Missile Inventory of Producer Nations

Country/System	Status	Number	Launch Mode	Mission	Remarks
Israel					
Gabriel II	1976	500	S	ASCM	Israeli Navy
Gabriel III	1980	562	S	ASCM	Israeli Navy
Gabriel IV	1995	507	A	ASCM	Israeli Air Force
Popeye 1	1989	1100	A	LACM/ITD-C	Israeli Air Force
Popeye 2	Early 1990's			LACM	Produced in coordination w/ US
Popeye 3	Dev			LACM	Program status unknown
Delilah (Mod)	Dev			LACM	
Italy					
Marte Mk 1	1983	373	S	ASCM	
Marte Mk 2	1987	110	S	ASCM	
Marte Mk 2	1993	160	A	ASCM	
Otomat Mk 1	1976		S	ASCM	
Otomat Mk 2	1984		S	ASCM	
Otomat Mk 3	1998	402	S	ASCM	
Otomat Mk 4				ASCM/LACM	
Seakiller Mk 2	1971	181	S	ASCM	
Japan					
ASM-1 (Type 80)	1983	640	A	ASCM	
ASM-1c (Type 91)	1983	10	A	ASCM	To be deployed on P-3C aircraft
ASM-2 (Type 93)	1996	70	A	ASCM	
SSM-1 (Type 87)	1993			ASCM	
SSM-1 (Type 88)		425	L	ASCM	24 launchers
SSM-1b (Type 90)		100	S	ASCM	
North Korea					
HY-1 (Hai Ying)		UNK	S	ASCM	(Combined Chinese imports and indigenous production)
HY-2 (Hai Ying-2)		UNK	S	ASCM	
Silkworm (Mod)	Dev	-			

Cruise Missile Inventory of Producer Nations

Country/System	Status	Number	Launch Mode	Mission	Remarks
Norway					
NSM	2004			ASCM	
Penquin Mk 1	1970	150	S	ASCM	Deployed with Norwegian Navy
Penquin Mk 2 (Mod 3)	1978			ASCM	
Penquin Mk2		200	A	ASCM	Deployed by Norwegian Navy
Penquin Mk3	1989	200	A	ASCM	Norwegian Air Force
Penquin Mk2 (Mod 7)	1989				
Russia					
AS-1 (Kennel)		0	A	ASCM/ITD-C	No longer in active inventory
AS-2 (Kipper)		0	A	ASCM	No longer in active inventory
AS-3 (Kangaroo)	1961	1560	A	LACM/ITD-C	
AS-4 (Kitchen)		650	A	ASCM/ITD-N	Has conventional warhead option
AS-4 (Kitchen)	1964		A	LACM/ITD-N	Has conventional warhead option
AS-5 (Kelt)		290	A	ASCM/ITD-C	Small number may remain in active service
AS-5 (Kelt)	1966		A	LACM/ITD-C	Small number may remain in active service
AS-6 (Kingfish)		1000	A	ASCM	Antiship missile version
AS-6 (Kingfish)	1973		A	LACM/ITD-N	Has conventional warhead & antiradar Options
AS-9 (Kyle)		1800	A	ARCM	
AS-9 (Kyle				LACM	
AS-11(Kilter)		3000	A	ARCM	To be replaced, also known as KH-58
AS-11 (Kilter				LACM	
AS-15 (Kent)	1984	1293	A	LACM/ITD-N	
AS-16 (Kickback)			A	LACM/ITD-N	Retired due to nuclear arms cuts
ASM/MMS (Moskit)			A	ASCM	In production, also called KH-41 (see KH-41)
KH-35			S	ASCM	See KH-35 below
KH-35		1000	A	ASCM	NATO designation AS-20
KH-41		1000		ASCM	
KH-65 SE	Dev			LACM	
Alpha	Dev			LACM	
SS-N-2a (Styx)	1959		S	ASCM	
SS-N-2b (Styx)	1961		S	ASCM	
SS-N-2c (Styx)	1967		S	ASCM	
SS-N-2d (Styx)	1978	6000	S	ASCM	
SS-N-3a/c (Shaddock)	1956/1965	560	S	ASCM	

Cruise Missile Inventory of Producer Nations

Country/System	Status	Number	Launch Mode	Mission	Remarks
Russia (Cont.)					
SS-N-3b (Sepal)	1962		S/L	ASCM	
SS-N-7 (Starbright)	1968	1400	S	ASCM	
SS-N-9 (Siren)	1970	476	S	ASCM	
SS-N-12 (Sandbox)	1975	250	S	ASCM	
SS-N-19 (Shipwreck)	1980	2189	S	ASCM	
SS-N-21 (Sampson)		168	S	LACM/STR-N	
SS-N-24 (Scorpion)	Dev			LACM	
SS-N-22 (Sunburn)	1994	841	S	ASCM	
SS-N-25 (Uran)	1993			ADCM	
SS-N-25 (BAL-COM-10)		0	S	ASCM	Same as KH-35
South Africa					
Skorpioen				ASCM	
Skorpioen II		210	A	ASCM	South African produced version of Gabriel
Sweden					
RB04E	1975	100	A	ASCM/ITD-C	
RB08A	1967			ASCM	
RBS8A		45	L	ASH	
RBS15 (Mk I)	1989/1990/1985			ASCM	
RBS15 (Mk II)	1998			ASCM	
RBS15 (Mk III)	2000			ASCM	
RBS15F		190	A	ASCM	Swedish Air Force
RBS15K		0	L	ASCM	See RBS15M entry
RBS15M		240	S	ASCM	Includes missiles for coastal defense
Taiwan					
Ching Feng		0	L	ASCM/STR-C/L	Green Bee: No longer in active service
Hsiung-Feng 1	1980	400	S	ASCM	Gabriel type missile
Hsiung-Feng 2	1993	0	A	ASCM	See alternate Hsiung-Feng 2 entry
Hsiung-Feng 2		130	S	ASCM	Gabriel type missile
Hsiung-Feng 3	Dev				

Cruise Missile Inventory of Producer Nations

Country/System	Status	Number	Launch Mode	Mission	Remarks
United Kingdom					
Centaur	Dev				
Sea Eagle	1985	290	A	ASCM	
Sea Skua	1982	812	A	ASCM	Surface-to-Surface Sea Skua order expected (65 TLAM on order from US (see exports) for deployment on UK submarines)
United States					
AGM-69 (SRAM)	1990			LACM	
AGM-69 (SRAM-A)		1081	A	LACM/ITD-N	Inventory declining to be removed from service
AGM-84A (Harpoon)	1979	1086	S	ASCM	Inventory being remanufactured to Block ID
RGM-84A (Harpoon)	1977			ASCM	
RGM-84A-1 (Harpoon)		700	S	ASCM	
UGM-84A (Harpoon)	1977			ASCM	
UGM-84D (Harpoon)		709	S	ASCM	All submarine launched variants
RGM-84D (Harpoon)	1984			ASCM	
AGM-84E (SLAM)		625	A	LACM/ITD-C	Stand-off attack variant
AGM-84F (Harpoon)	1993			ASCM	
RGM84F (Harpoon)	1993			ASCM	
AGM-86B (ALCM)		1500	A	LACM/ITD-C	Air launched cruise missile
AGM-86C (CALM)		110		LACM	
AGM-86C (ALCM)		152	A	LACM/ITD-C	Conventional warhead air launched cruise missile
AGM-129 (ALCM)				ASCM	
AGM-129A		302	A	LACM/ITD-N	
AGM-129B		0	A	LACM/ITD-N	Air launched cruise missile not procured
AGM-142B	UNK	-	A	LACM	(US production of Popeye by Lockheed Martin)

Cruise Missile Inventory of Producer Nations

Country/System	Status	Number	Launch Mode	Mission	Remarks
United States (Cont.)					
RGM/UGM-109A (Tomahawk) TLAM-N	1993	500	S/Sub	LACM/STR-N	
RGM/UGM-109B (Tomahawk) TASM		563	S/Sub	ASCM	
RGM/UGM-109C (Tomahawk) TLAM-C	1989	1099	S/Sub	LACM/STR-C	Used during operation Desert Storm
RGM/UGM-109D (Tomahawk) TLAM-D		575	S/Sub	LACM/STR-C	Used during Desert Storm
RGM/UGM-109E (Tomahawk) TASM	1989	0	S/Sub	ASCM	Plans terminated in mid - 1980's
RGM/UGM-109F (Tomahawk) TASM		0	S/Sub	LACM	Plans terminated in mid - 1980's
RGM/UGM-109G (Griffin)	1984	0	G	LACM	Removed from service on 1991
RGM/UGM-109H (Tomahawk)		0	A	LACM	Development cancelled
RGM/UGM-109L (Tomahawk)		0	A	LACM	Development cancelled

Cruise Missile Producers Inventory
Abbreviations

Guidance:

AP	Autopilot
AR	Active Radar
CG	Command Guidance
GPS	Global Positioning System
I	Inertial
IR	Infrared
IIR	Imaging Infrared
PR	Passive Radar
RC	Radio Command
SA	Semi-Active
TI	Target Illumination
TM	Terminal Matching

Launch Modes:

A	Aircraft
G	Ground
H	Helicopter
S	Surface Ship
Sub	Submarine

Mission:

ARM	Anti-Radiation Missile
ASCM	Anti-Ship Cruise Missile
ATK-M	Anti-Tank Medium Missile
ITD-C	Interdiction-Conventional

Mission Cont.:

ITD-N	Interdiction-Nuclear
LACM	Land Attack Cruise Missile
STR-C	Strategic-Conventional
STR-N	Strategic-Nuclear

Propulsion:

L-Rkt	Liquid Rocket
S-Rkt	Solid Rocket
T-Jet	Turbojet
T-Fan	Turbofan

Payload:

C	Chemical
B	Biological
HE	High Explosive
Nuc	Nuclear

Other:

Dev	Development
FAC	Fast Attack Craft
UNK	Unknown
*	Air/Ground or Ship Launched

Cruise Missile Exports In-Service

*** World Missile Inventories and Forecast, 1997/1998**

Country/System	Number	Launch Mode	Mission	Remarks
Chinese Exports				
Bangladesh				
FL-1 (Feilong)	30	S	ASCM	Jianghu (Os wan) Frigate: Status uncertain
SY-1 (Shang Yao-1)	0	S	ASCM	Arms Durbar Class FACs: May not be in service
HY-2 (Hai Ying-2)	20	S	ASCM	Arms Bangladeshi FAC units
Egypt				
HY-2 (Hai Ying-2)	65	S	ASCM	Some indigenous production maybe underway
Iran				
C-801 (Ying Ji-1)	200	L	ASCM	Shorebased Antishipping missile system
C-802 (Ying Ji-1)	0	S	ASCM	Ships delivered missile negotiations underway
HY-2 (Hai Ying-2)	480	S	ASCM	(Obtained via Libya or North Korea)
Iraq				
C-601	100	A	ASCM	Launch platforms destroyed, missiles in storage
FL-1 (Fei Long-1)	35	L	ASCM	Some destroyed in war, others confiscated by UN
North Korea				
C-801 (Ying Ji-1)	0	L	ASCM	Order pending: Could acquire air & land versions
HY-1 (Hai Ying-1)	100	S	ASCM	Slowly being replaced by HY-2 missiles (may include
HY-2 (Hai Ying-2)	400	S	ASCM	some indigenous No. Korean licensed production)
Pakistan				
C-801 (Ying Ji-1)	6	S	ASCM	Submarine launched anti-shipping missiles
HY-2 (Hai Ying-2)	0	S	ASCM	Silkworm missiles: See HY-4
HY-4 (Hai Ying-4)	36	S	ASCM	Silkworm missiles: Includes HY-2 missiles
Thailand				
C-801 (Ying Ji-1)	300	S	ASCM	
French Exports				
Argentina				
AM 39E (Exocet)	0	A	ASCM	See AM39H entry
AM 39H (Exocet)	0	A	ASCM	Includes all air launched Exocets in inventory
MM 38 (Exocet)	0	L	ASCM	Three MM38 landbased systems captured
MM 38 (Exocet)	40	S	ASCM	
MM 40 (Exocet)	48	S	ASCM	Deliveries suspended - Quantities uncertain

Cruise Missile Exports In-Service

Country/System	Number	Launch Mode	Mission	Remarks
French Exports (Cont.)				
Bahrain				
MM 38 (Exocet)	16	S	ASCM	
MM 40 (Exocet)	24	S	ASCM	
Belgium				
MM 38 (Exocet)	16	S	ASCM	
Brazil				
AM 39 (Exocet)	11	A	ASCM	Deliveries confirmed
MM 38 (Exocet)	0	S	ASCM	Replaced by MM40
MM 40 (Exocet)	40	S	ASCM	
Brunei				
MM 38 (Exocet)	0	S	ASCM	May have been replaced by MM40 - unconfirmed
MM 40 (Exocet)	12	S	ASCM	May have replaced MM38 - unconfirmed
Cameroon				
MM 38 (Exocet)	0	S	ASCM	
MM 40 (Exocet)	11	S	ASCM	
Chile				
AM 39 (Exocet)	20	A	ASCM	Carried by Chilean Navy Super Puma Helios
MM 38 (Exocet)	52	S	ASCM	36 launchers
MM 40 (Exocet)	32	S	ASCM	Replacing MM38 Exocet missiles
Colombia				
MM 40 (Exocet)	32	S	ASCM	
Ecuador				
MM 38 (Exocet)	15	S	ASCM	
MM 40 (Exocet)	36	S	ASCM	
Egypt				
AM 39 (Exocet)	55	S	ASCM	
Gabon				
SS 12M	80	S	ATK-M	
Germany				
MM 38 (Exocet)	216	S	ASCM	
Greece				
MM 40 (Exocet)	40	L	ASCM	1994 buy unconfirmed - may include Block 2
MM 38 (Exocet)	50	S	ASCM	Some may have been redeployed to Cyprus
SS 12M	900	L	ATK-M	Inventory numbers uncertain

Cruise Missile Exports In-Service

Country/System	Number	Launch Mode	Mission	Remarks
French Exports (Cont.)				
India				
AM 39 (Exocet)	81	A	ASCM	
MM 38 (Exocet)	50	S	ASCM	
Iraq				
AM 39 (Exocet)	0	A	ASCM	Depleted
MM 38 (Exocet)	0	A	ASCM	Lost during Desert Storm
Kuwait				
AM 39 (Exocet)	10	A	ASCM	
MM 38 (Exocet)	0	S	ASCM	Replaced by MM40 Exocet
MM 40 (Exocet)	0	S	ASCM	Additional missiles on order - see Block 2 entry
MM 40 (Exocet) Block 2	0	S	ASCM	On order 1994
Libya				
AM 39 (Exocet)	20	A	ASCM	
SS 12M	0	L	ATK-M	See SS12 entry
SS 12	50	L	ATK-M	Includes SS12 M entry
Madagascar				
SS 12	0	L	ATK-M	
Malaysia				
MM 38 (Exocet)	59	S	ASCM	
MM 40 (Exocet) Block 2	0	S	ASCM	On order no deliveries until 1996
Morocco				
MM 38 (Exocet)	25	S	ASCM	Not deployed on a regular basis - in depot
MM 40 (Exocet)	16	S	ASCM	
Nigera				
MM 38 (Exocet)	20	S	ASCM	
Oman				
AM 39 (Exocet)	50	A	ASCM	
MM 38 (Exocet)	4	S	ASCM	
MM 40 (Exocet)	30	S	ASCM	Additional missiles on order - see Block 2 entry
MM 40 (Exocet) Block 2				

Cruise Missile Exports In-Service

Country/System	Number	Launch Mode	Mission	Remarks
French Exports (Cont.)				
Pakistan				
AM 39 (Exocet)	18	A	ASCM	
SM 39 (Exocet)	0	S	ASCM	Order 1994/Deliver 1998 for Agosta 90B
Peru				
AM 39 (Exocet)	18	A	ASCM	
MM 38 (Exocet)	27	S	ASCM	
Philippines				
MM 38 (Exocet)	15	S	ASCM	Operational status questionable
MM 40 (Exocet)	0	S	ASCM	To be acquired with new Cormoran Gunboats
Block 2				
Qatar	50	A	ASCM	
AM 39 (Exocet)	16	L	ASCM	Truck mounted coastal defense system
MM 40 (Exocet)	0	L	ASCM	On order - 1993
MM 40 (Exocet)	24	S	ASCM	
Block 2	0	S	ASCM	On order - 1993
MM 40 (Exocet)	0	A	ITD-C	On order - 1994
MM 40 (Exocet)				
Block 2	0	L	ASCM	On order - 1993
Apache	0	S	ASCM	On order - 1994 Lafayette Frigates
Saudi Arabia				
MM 40 (Exocet)	52	A	ASCM	
Block 2				
MM 40 (Exocet)	60	S	ASCM	
Block 2				
Singapore	100	L	ASCM	Coastal defense - truck mounted unconfirmed
AM 39 (Exocet)	19	S	ASCM	
South Korea	30	S	ASCM	Mounted on 3 Ratcharit class FAC
MM 38 (Exocet)				
Thailand				
MM 40 (Exocet)	24	S	ASCM	
MM 38 (Exocet)	0	L	ATK-M	See SS12 entry
MM 40 (Exocet)	212	L	ATK-M	Includes SS12M models
Tongo				
Tunisia				
MM 40 (Exocet)				
SS 12M				
SS 12				

Cruise Missile Exports In-Service

Country/System	Number	Launch Mode	Mission	Remarks
French Exports (Cont.)				
United Arab Emirates				
AM 39 (Exocet)	68	A	ASCM	
MM 40 (Exocet)	48	S	ASCM	
MM 40 (Exocet) Block 2	0	S	ASCM	On order - 1993
United Kingdom				
AS-37 (Martel)	300	A	ARM	
MM 38 (Exocet)	200	S	ASCM	
Uruguay				
Venezula				
German Exports				
Italy				
AS-34 (Kormoran)	160	A	ASCM	
Israeli Exports				
Australia				
Popeye I	UNK	A	LACM	For use on F-111 aircraft (ordered in 1996)
Chile				
Gabriel	16	S	ASCM	
Ecuador				
Gabriel II	12	S	ASCM	
Kenya				
Gabriel	30	S	ASCM	May include Gabriel II units
Singapore				
Gabriel	37	S	ASCM	
South Africa				
Skorpioen	210	A	ASCM	South African produced version of Gabriel
Gabriel	80	S	ASCM	
Taiwan				
Gabriel	100	S	ASCM	
Thailand				
Gabriel	54	S	ASCM	
Turkey				
Popeye 1	UNK	A	LACM	For use on F-4 aircraft (ordered in 1996)
United States				
Popeye 1	87	A	LACM	For use on B-52 and fighter aircraft (total 160
Popeye 2	UNK	A	LACM	ordered Popeye 1 & 2)

Cruise Missile Exports In-Service

Country/System	Number	Launch Mode	Mission	Remarks
Italian Exports				
Egypt				
Otomat	42	S	ASCM	
Iran				
Otomat	0	S	ASCM	No confirmation of arrival
Sea Killer Mk1	0	A	ASCM	Inventory depleted; includes all Sea Killers
Iraq				
Otomat Mk2	0	S		UN embargo prevented delivery - arms resold
Kenya				
Otomat	0	S	ASCM	See Otomat Mk2 entry
Otomat Mk2	17	S	ASCM	May include older Otomat missiles
Libya				
Otomat	172	S	ASCM	
Morocco				
Otomat Mk2	0	S	ASCM	Carried by 2 ASSAD Corvettes
Niger				
Otomat	25	S	ASCM	
Peru				
Sea Killer Mk1	12	A	ASCM	Deployed from AB-2112 ASW helicopters
Otomat	45	S	ASCM	
Philippines				
Saudia Arabia				
Otomat	155	L	ASCM	
Otomat	0	S	ASCM	See Otomat Mk2 entry
Otomat Mk2	70	S	ASCM	Believed to have replaced older Otomat models
Venezuela				
Marte Mk1	47	A	ASCM	
Otomat	42	S	ASCM	May include Otomat Mk2 models
Norwegian Exports				
Sweden				
Penguin Mk2	200	S	ASCM	Swedish designation for Norwegian Pengium is RB
Turkey				
Penguin Mk1	30	S	ASCM	Turkish Navy

Cruise Missile Exports In-Service

Country/System	Number	Launch Mode	Mission	Remarks
Russia Exports				
Algeria				
SSC-3 (Styx)	20	S	ASCM	Coastal defense: 4 batteries - numbers uncertain
SS-N-2a (Styx)	40	S	ASCM	On OSA I class fast attack craft
SS-N-2b (Styx)	160	S	ASCM	On OSA II & Nanuchka II class warships
SS-N-2c (Styx)	12	S	ASCM	
Angola				
SSC-1a (Shaddock)	45	S	ASCM	Coastal Defense
SS-N-2 (Styx)	15	S	ASCM	
Bulgaria				
SS-N-2a (Styx)	43	S	ASCM	16 launch rails
SS-N-2b (Styx)	24	S	ASCM	24 launch rails
SS-N-2c (Styx)	60	S	ASCM	
Croatia				
SS-N-2a (Styx)	12	S	ASCM	Captured form Yugoslav Navy at Sibenik
SS-N-2b (Styx)	65	S	ASCM	Captured from Yugoslav Navy at Sibenik
Cuba				
SS-N-2 (Styx)	380	S	ASCM	
Egypt				
SS-N-2a (Styx)	95	S	ASCM	May include missiles from China & North Korea
Ethiopia				
SS-N-2b (Styx)	6	S	ASCM	Status questionable, based in Djiboati
Finland				
SS-N-2a (Styx)	35	S	ASCM	Finish designation MTO-66
SS-N-2b (Styx)	50	S	ASCM	Finish designation MTO-66
India				
SS-N-7 (Starbright)	15	S	ASCM	On order
SS-N-2a (Styx)	62	S	ASCM	
SS-N-2b (Styx)	150	S	ASCM	
SS-N-2c (Styx)	442	S	ASCM	May be D model missiles
SS-N-2e (Styx)	0	S	ASCM	On order for Project 15 and Project 16 ships

Cruise Missile Exports In-Service

Country/System	Number	Launch Mode	Mission	Remarks
Russia Exports (Cont.)				
Iran				
SS-N-22 (Sunburn)	8	S	ASCM	Eight launchers supplied by Ukraine
Iraq				
SS-N-2 (Styx)	7	S	ASCM	
North Korea				
SS-N-2a (Styx)	0	S	ASCM	See SS-N-2b entry
SS-N-2b (Styx)	400	S	ASCM	May include some Chinese HY-2 silkworms
Poland				
SS-N-2a (Styx)	292	S	ASCM	
SS-N-2c (Styx)	164	S	ASCM	
Romania				
SS-N-2a (Styx)	29	S	ASCM	
SS-N-2c (Styx)	16	S	ASCM	
Syria				
SS-N-2a (Styx)	60	S	ASCM	
SS-N-2b (Styx)	114	S	ASCM	
Thailand				
Vietnam				
SS-N-2a (Styx)	191	S	ASCM	
SS-N-2b (Styx)	265	S	ASCM	
Yemen				
SS-N-2a (Styx)	10	S	ASCM	
SS-N-2b (Styx)	32	S	ASCM	Acquired by Peoples Democratic Republic
Yugoslavia				
SS-N-2a (Styx)	100	S	ASCM	
SS-N-2b (Styx)	202	S	ASCM	
SS-N-2c (Styx)	200	S	ASCM	
Swedish Exports				
Croatia				
RBS 15m	25	L	ASCM	In country development, mounted on Tatra 6x6
RBS 15m	75	S	ASCM	In storage, for deployment on new Corvettes

Cruise Missile Exports In-Service

Country/System	Number	Launch Mode	Mission	Remarks
Swedish Exports (Cont.)				
Finland				
RBS 15f	0	S	ASCM	Finish Navy - see RBS 15k entry
RBS 15m	48	S	ASCM	Finish Navy
RBS 15k	70	L	ASCM	May include RBS 15m missiles
U.K. Exports				
Bahrain				
Sea Eagle	25	A	ASCM	
Brazil				
Sea Skua	57	A	ASCM	
Chile				
Sea Eagle	30	A	ASCM	
Germany				
Sea Skua	61	A	ASCM	
India				
Sea Eagle	60	A	ASCM	
Sea Skua	0	A	ASCM	Unconformed order likely not yet official
Portugal				
Saudia Arabia				
Sea Eagle	126	A	ASCM	
South Korea				
Sea Skua	0	A	ASCM	On order, no deliveries
Turkey				
Sea Skua	30	A	ASCM	
U.S. Exports				
Australia				
AGM-84a (Harpoon)	81	A	ASCM	
RGM-84a-1 (Harpoon)	42	S	ASCM	3 more ordered in 1993
UGM-84 (Harpoon)	24	S	ASCM	
Canada				
RGM-84a-1 (Harpoon)	29	A	ASCM	
RGM-84d-4 (Harpoon)	34	A	ASCM	Could be upgraded a-1 models

Cruise Missile Exports In-Service

Country/System	Number	Launch Mode	Mission	Remarks
U.S. Exports (Cont.)				
Denmark				
RGM-84a-1 (Harpoon)	32	L	ASCM	Coastal defense configuration
RGM-84a-1 (Harpoon)	172	S	ASCM	
Egypt				
RGM-84a-1 (Harpoon)	32	S	ASCM	32 more ordered 1994 - deliveries continuing
UGM-84 (Harpoon)	29	S	ASCM	On order - deliveries getting underway
Germany				
RGM-84a-1 (Harpoon)	71	S	ASCM	
Greece				
RGM-84a-1 (Harpoon)	73	S	ASCM	More on order - includes previous purchases
UGM-84 (Harpoon)	30	S	ASCM	
Indonesia				
RGM-84a-1 (Harpoon)	49	S	ASCM	Missiles may have been transferred from Holland
Israel				
RGM-84a-1 (Harpoon)	148	S	ASCM	
UGM-84 (Harpoon)	12	S	ASCM	
Japan				Additional missiles may have been delivered
AGM-84a (Harpoon)	246	A	ASCM	
RGM-84a (Harpoon)	200	S	ASCM	
RGM-84a-1 (Harpoon)	130	S	ASCM	May have been upgraded to a-1 configuration
UGM-84d (Harpoon)	92	S	ASCM	Deliveries underway - 299 ordered
Kuwait				
AGM-84d (Harpoon)	40	A	ASCM	
Netherlands				Carried by F/A-18 Hornet fighters
RGM-84a-1 (Harpoon)	201	S	ASCM	
UGM-84d (Harpoon)	28	S	ASCM	Includes previously purchased variants
Pakistan				Deliveries continuing
AGM-84 (Harpoon)	0	A	ASCM	
RGM-84a-1 (Harpoon)	55	S	ASCM	On hold, pending Congressional approval
UGM-84 (Harpoon)	0	S	ASCM	Some units transferred to new Type 21 frigates
				Ordered, deliveries may never have taken place

Cruise Missile Exports In-Service

Country/System	Number	Launch Mode	Mission	Remarks
U.S. Exports (Cont.)				
Portugal				
RGM-84d (Harpoon)	24	S	ASCM	
Singapore				
AGM-84 (Harpoon)	0	A	ASCM	On order 1996, for Fokker 50 aircraft
RGM-84a-1 (Harpoon)	105	S	ASCM	
South Korea				
AGM-84 (Harpoon)	0	A	ASCM	Ordered 1995
AGM-84 (Harpoon)	270	L	ASCM	Truck mounted variant
RGM-84a-1 (Harpoon)	117	S	ASCM	27 ordered 1993, 30 ordered 1996
UGM-84 (Harpoon)	0	S	ASCM	Ordered 1996, will outfit SS-209 submarines
Spain				
AGM-84a (Harpoon)	20	A	ASCM	Deliveries continuing thru 1995
RGM-84a-1 (Harpoon)	139	S	ASCM	Shipborne & land-based fire units
Thailand				
AGM-84a (Harpoon)	12	A	ASCM	More units ordered with F-18s in 1996
RGM-84 (Harpoon)	16	S	ASCM	
Turkey				
RGM-84a-1 (Harpoon)	161	S	ASCM	32 ordered in 1993, 16 in 1995
United Kingdom				
AGM-84a (Harpoon)	172	A	ASCM	
RGM-84a-1 (Harpoon)	128	S	ASCM	May include Block 1C missile models
UGM-84d (Harpoon)	154	S	ASCM	
Tomahawk (TLAM-C)	UNK	Sub	LACM	(65 TLAM on order for deployment on UK submarines)
Tomahawk (TLAM-D)	UNK	Sub	LACM	