

THIS FILE IS MADE AVAILABLE THROUGH THE DECLASSIFICATION EFFORTS AND RESEARCH OF:

THE BLACK VAULT

THE BLACK VAULT IS THE LARGEST ONLINE FREEDOM OF INFORMATION ACT / GOVERNMENT RECORD CLEARING HOUSE IN THE WORLD. THE RESEARCH EFFORTS HERE ARE RESPONSIBLE FOR THE DECLASSIFICATION OF THOUSANDS OF DOCUMENTS THROUGHOUT THE U.S. GOVERNMENT, AND ALL CAN BE DOWNLOADED BY VISITING:

[HTTP://WWW.BLACKVAULT.COM](http://www.blackvault.com)

YOU ARE ENCOURAGED TO FORWARD THIS DOCUMENT TO YOUR FRIENDS, BUT PLEASE KEEP THIS IDENTIFYING IMAGE AT THE TOP OF THE .PDF SO OTHERS CAN DOWNLOAD MORE!



DISTRIBUTION STATEMENT A
Approved for Public Release
Distribution Unlimited

Feasibility of Third World Advanced Ballistic & Cruise Missile Threat Emerging Cruise Missile Threat

Presentation to
68th MORS Symposium
Working Group 4: Air and Missile Defense, TMD Threat
June 22, 2000

Robert E. Woodside
robert.e.woodside@boeing.com

20000517 047

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. **PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.**

1. REPORT DATE (DD-MM-YYYY) 22-06-2000		2. REPORT TYPE Technical Study		3. DATES COVERED (From - To) 1999-2000	
4. TITLE AND SUBTITLE Feasibility of Third World Advanced Ballistic and Cruise Missile Threat: Volume 2: Emerging Cruise Missile Threat				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Robert Woodside, John McIver, Daniel Gadler, James Beyar, James Howe, Milton Gussow, Thomas K. Jones				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) National Defense Industrial Association (NDIA) 2111 Wilson Blvd., Suite 400 Arlington, VA 22201				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) Naval Sea Systems Command 2531 Jefferson Davis Highway NC#2 Arlington, VA 22242				10. SPONSOR/MONITOR'S ACRONYM(S) OPNAV PEO (TSC)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S) N/A	
12. DISTRIBUTION / AVAILABILITY STATEMENT The NDIA Study "Emerging Cruise Missile Threat" has been reviewed and is approved for public release; distribution is unlimited.					
13. SUPPLEMENTARY NOTES Abbreviated study materials presented at 68 th Military Operations Research Society Symposium at USAF Academy 22 June 2000.					
14. ABSTRACT "The Emerging Cruise Missile Threat," study recently released by the National Defense Industrial Association (NDIA) Strike, Land Attack & Air Defense Committee shows how the possibility of long range cruise missile attack by Third World countries is developing rapidly into a serious threat for U.S. interests. Current technology enables the Third World to field a large number of low-cost land-attack cruise missiles that can overwhelm capable defenses. Sophisticated land-attack cruise missiles can be constructed or modified from technologies or components currently available worldwide. The study is Volume 2 of an industry series on the Feasibility of Third World Advanced Ballistic & Cruise Missile Threat. Volume 1, "The Long-Range Ballistic Missile Threat," was presented at the 67th MORSS at West Point in June 1999. Technologies exploited in cruise missilery include GPS/INS (Global Positioning System/Inertial Navigation System), compact avionics, flight programming software, stealth and powerful, lightweight jet propulsion systems. "The Emerging Cruise Missile Threat" focuses on the technical feasibility of production methods likely to be used by Third World countries to improve their cruise missile capability. Working exclusively from unclassified sources, the study reviews the lessons learned from historical cruise missile development programs. It assesses potential cruise missile improvements available to Third World countries. It evaluates possible alternatives to land-attack cruise missiles. It analyzes recent trends in Third World asymmetric threats. And it provides a comprehensive global cruise missile inventory, identifying more than 80,000 cruise missiles worldwide. The study discusses feasible options available to Third World nations to advance their cruise missile capabilities including the following actions: Modify existing ASCMs for land-attack; Purchase advanced cruise missiles from developed nations; Convert UAVs to cruise missiles; Develop indigenous advanced cruise missiles; Create cruise missiles from existing aircraft; Weaponize civilian and home-built kit aircraft.					
15. SUBJECT TERMS Cruise missiles, land attack cruise missiles, history, key technologies, avionics, guidance, payloads, propulsion, employment, threats, stealth, advanced weapons, proliferation					
16. SECURITY CLASSIFICATION OF: UNCLASSIFIED			17. LIMITATION OF ABSTRACT Unlimited	18. NUMBER OF PAGES 48	19a. NAME OF RESPONSIBLE PERSON Robert E. Woodside
a. REPORT UNCLASSIFIED	b. ABSTRACT UNCLASSIFIED	c. THIS PAGE UNCLASSIFIED			19b. TELEPHONE NUMBER (include area code) (253) 773-4164

THIS PAGE INTENTIONALLY BLANK

Overview

- **Introduction**
- **Historical Cruise Missile Developments**
- **Third World Cruise Missile Technology**
- **Improved Designs & Development Approaches**
- **Summary**
- **Appendix: World Cruise Missile Inventory**

Why Cruise Missiles for Third World Forces?

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

Missions	Objectives
<ul style="list-style-type: none">• Threaten/Attack Population Centers• Threaten/Attack U.S. Forward Deployed Forces & Bases• Threaten/Attack Air and Sea Ports• Threaten/Attack Naval & Amphibious Operations	<ul style="list-style-type: none">• Prevent Creation & Maintenance of Coalitions• Deny Facilities 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 described in this study). 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.

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
- Developed Nations Have Strategic Interest in Constraining U.S. Freedom of Action -- Cooperate with Third World
 - 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 Acquiring a Ballistic / Cruise Missile Force

Historical Perspective

Cruise missiles have evolved from multiple origins through diverse development paths unlike the highly focused German ballistic missile program of WW II

CM diversity indicates a very wide range of approaches can 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

Significance of Historical Design Approaches

Fundamental Cruise Missile concepts proven during WW II

- **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

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.

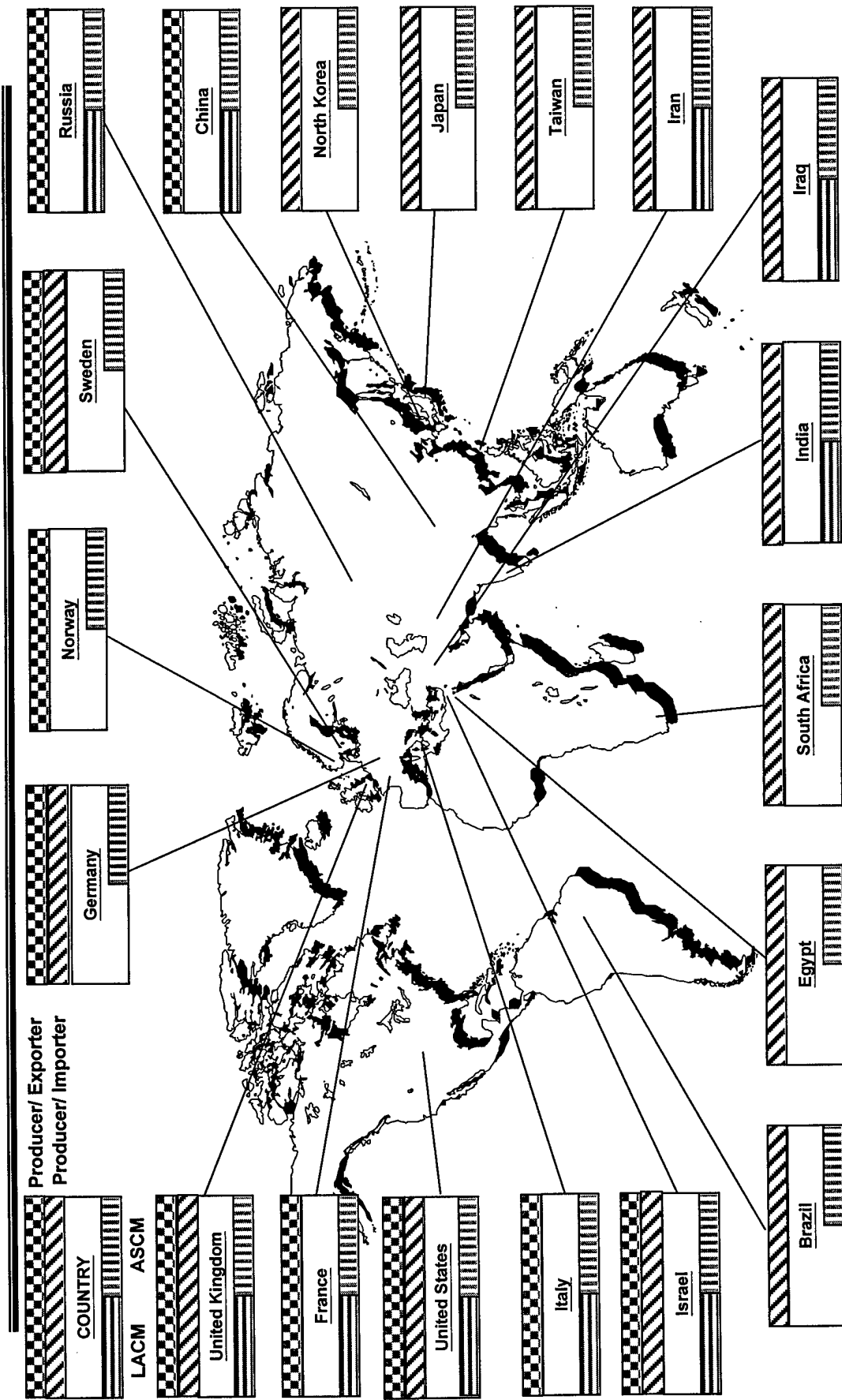
Distinctions between major producers and importing countries are being blurred as indigenous CM development and licensed production is undertaken by Third World nations. As aerospace technology spreads, more countries are able to acquire large numbers of "adequate" cruise missiles to engage regional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

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.

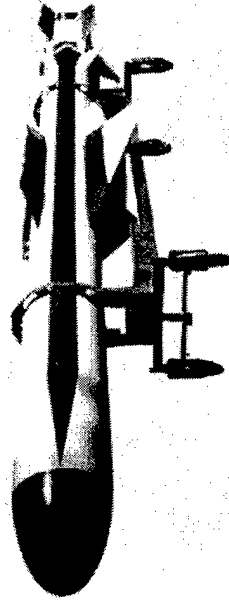
"Sources indicate that the UAE version of the Apache missile, dubbed Black Shahine, will have a range in excess of 300km, thereby breaching the MTCR guidelines. Although the MTCR is a voluntary code of conduct and there are no enforcement proceedings, it is expected that signatory nations will abide 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 Launched 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	Larzac04 C20	Larzac04 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/lbfhr)	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	Primer 1, SU30-2	Alpha Jet, Mig-AT	Alpha Jet	Business 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 new/experimental installations... 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>

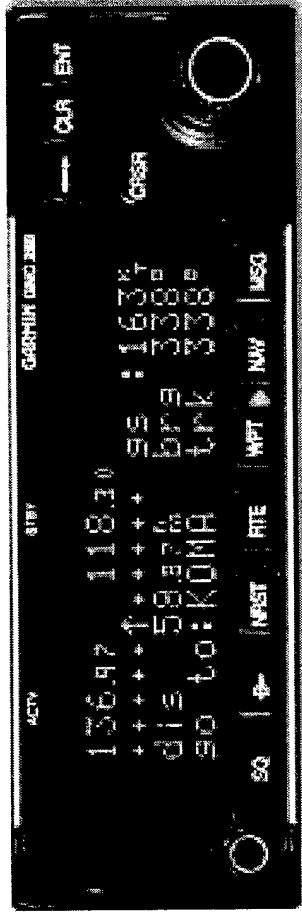
Other GPS navigation companies such as Trimble also provide to the world GPS planning software for flight optimization directly on the internet: <http://www.trimble.com/satview/index.htm>

“... 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

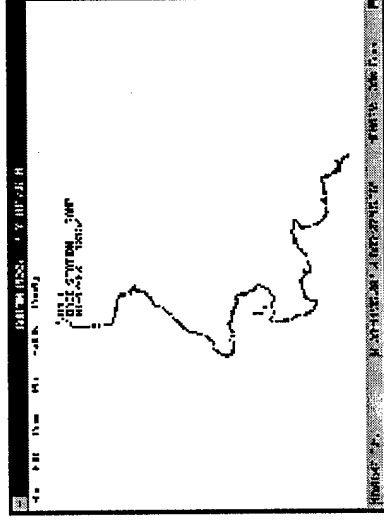
Commercial GPS Navigation...



(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

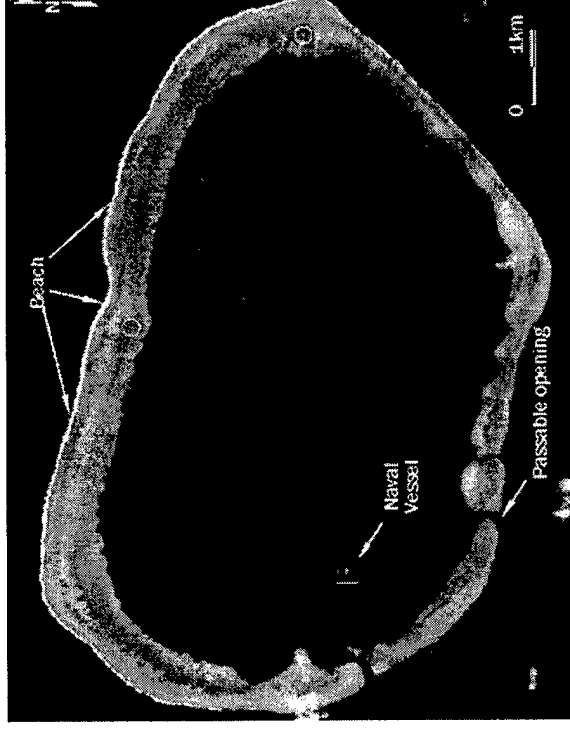
The importance and techniques of using satellite imagery to target precision weapons has been proven by developed countries. Satellite imagery targeting improvements for Third World cruise missiles and other weapons will soon be available even from indigenous satellite systems as indicated by this *Defense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

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 markedly improved delivery systems. 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**

Chinese Anti-Ship Cruise Missiles

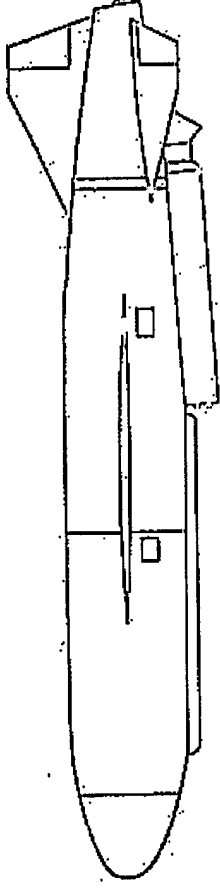
In the late 1950's the former USSR supplied China with a number of P-15 cruise missiles. The Chinese designated these Russian built cruise missiles as SY-1 (CSS-N-1 Scrubbrush is the NATO designation). They formed the basic design for the major part of the Chinese cruise missile development from the 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.

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**

THIS PAGE INTENTIONALLY BLANK

Silkworm -- Third World CM Building Block



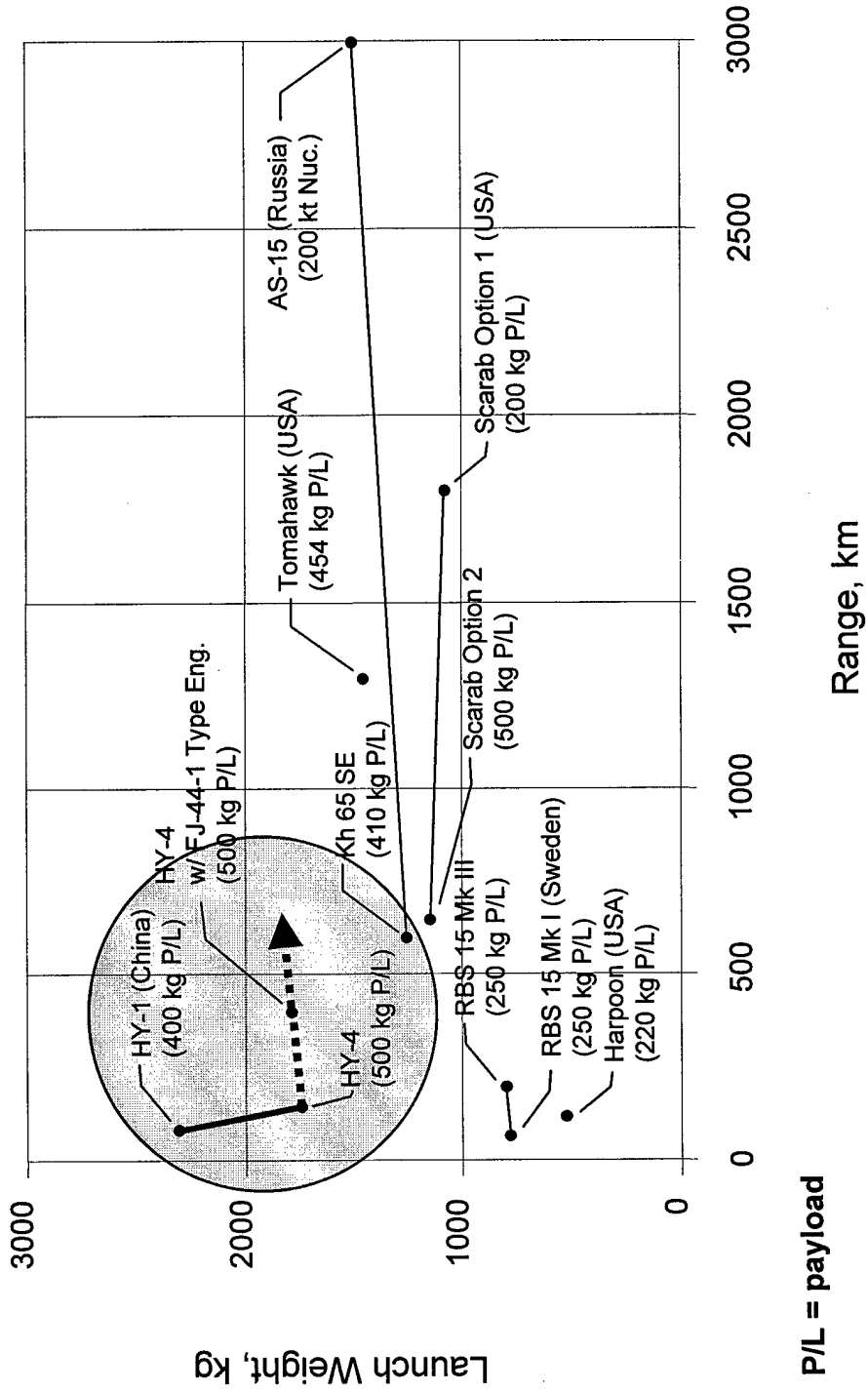
Jane's Strategic Weapon systems, 14 Feb 2000

Length 6-7 meters Diameter .76 meters Launch wt. 2-3,000 kg Warhead 400 kg
Terminal radar seeker Liquid propellant sustainer @ M 0.7 Range 95 km

- Exported by Russia late 1950s as P-15 (NATO SS-N-2A)
- Copied by China 1960s as Hai Ying-1 (NATO CSSC-2)
- Coastal defense version modified for ship launch (NATO CSS-N-2)
- Chinese export version upgraded HY-2 called C-201
- C201s displayed at weapons exhibitions as late as 1996

THIS PAGE INTENTIONALLY BLANK

Silkworm Range Extension Capabilities



THIS PAGE INTENTIONALLY BLANK

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**

Convert Unarmed UAV to Land-Attack Cruise Missile Mission

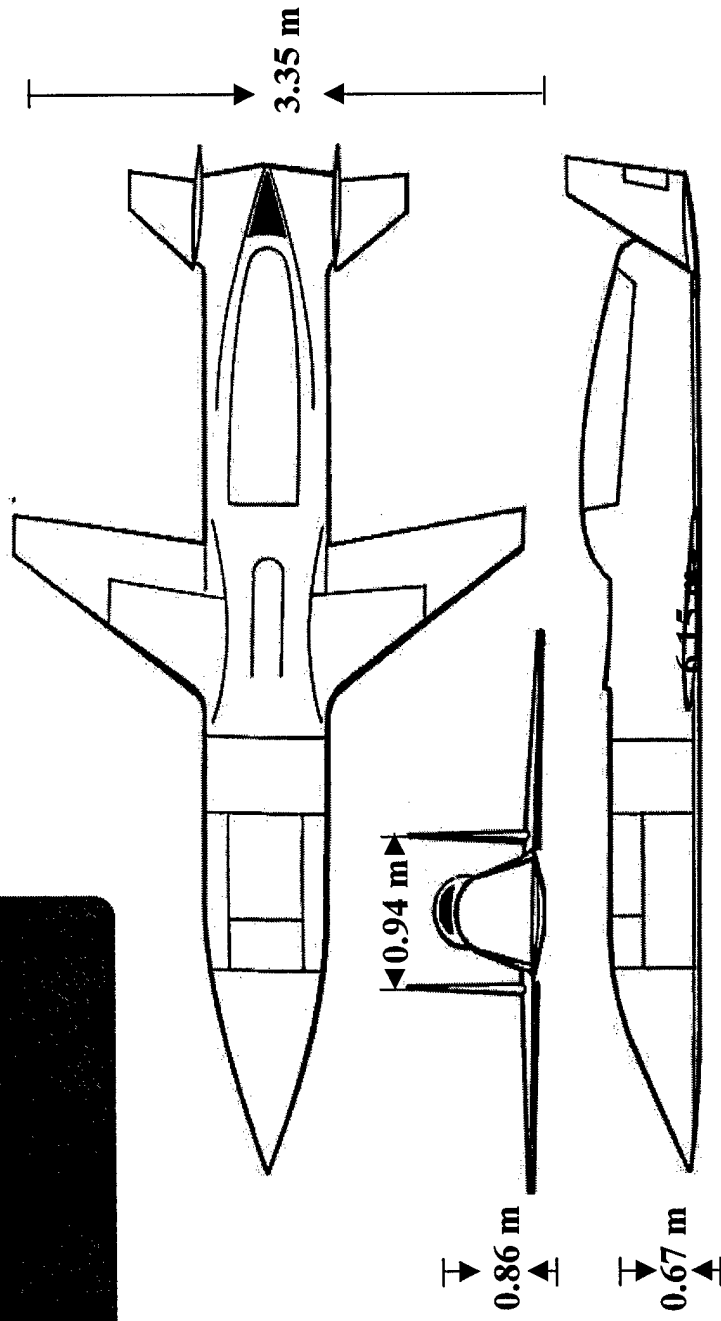
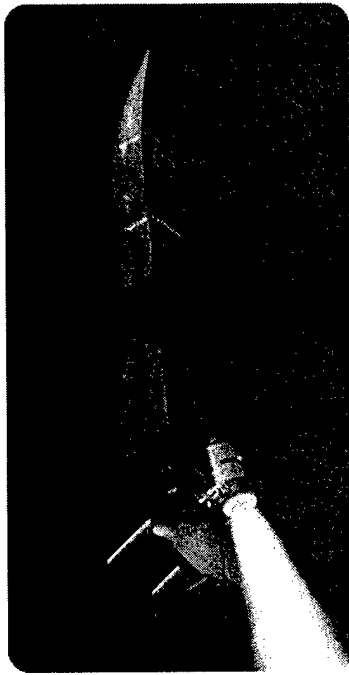
A Third World country could opt to convert an existing tactical reconnaissance UAV to a land-attack cruise missile. One such UAV system is the U.S.-built Egyptian SCARAB UAV. The existing guidance and control subsystem could be replaced with highly accurate integrated inertial guidance/GPS and terminal 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.

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 programmed 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:**

Weights:	
Wing Span	3.35 m
Wing Area	2.33 m ²
Overall Length	6.15 m
Overall Height	0.86 m
Booster	138.0
Recovery System	68.5
Payload	131.5
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 of 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

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.

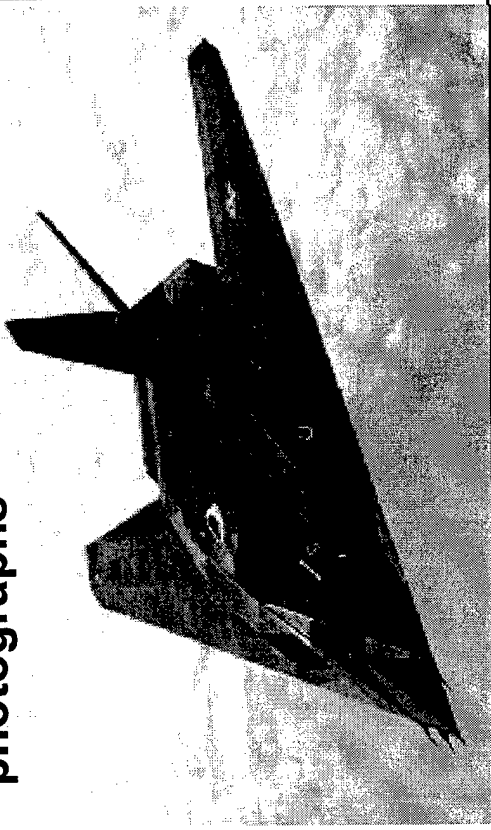
Motivated by overwhelming evidence of Western development of ever more sophisticated defensive missiles and radars, Third World cruise missile developers will likely place some stealth requirements on any indigenous CM designs or modifications. Even inexpensive and unsophisticated cruise missiles may 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 m² at a range of at least 370 km, [therefore] a 0.1 m² target will be seen at a range of 130 km. (*RAND report RP-463, 1995*).” A 0.1 m² 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

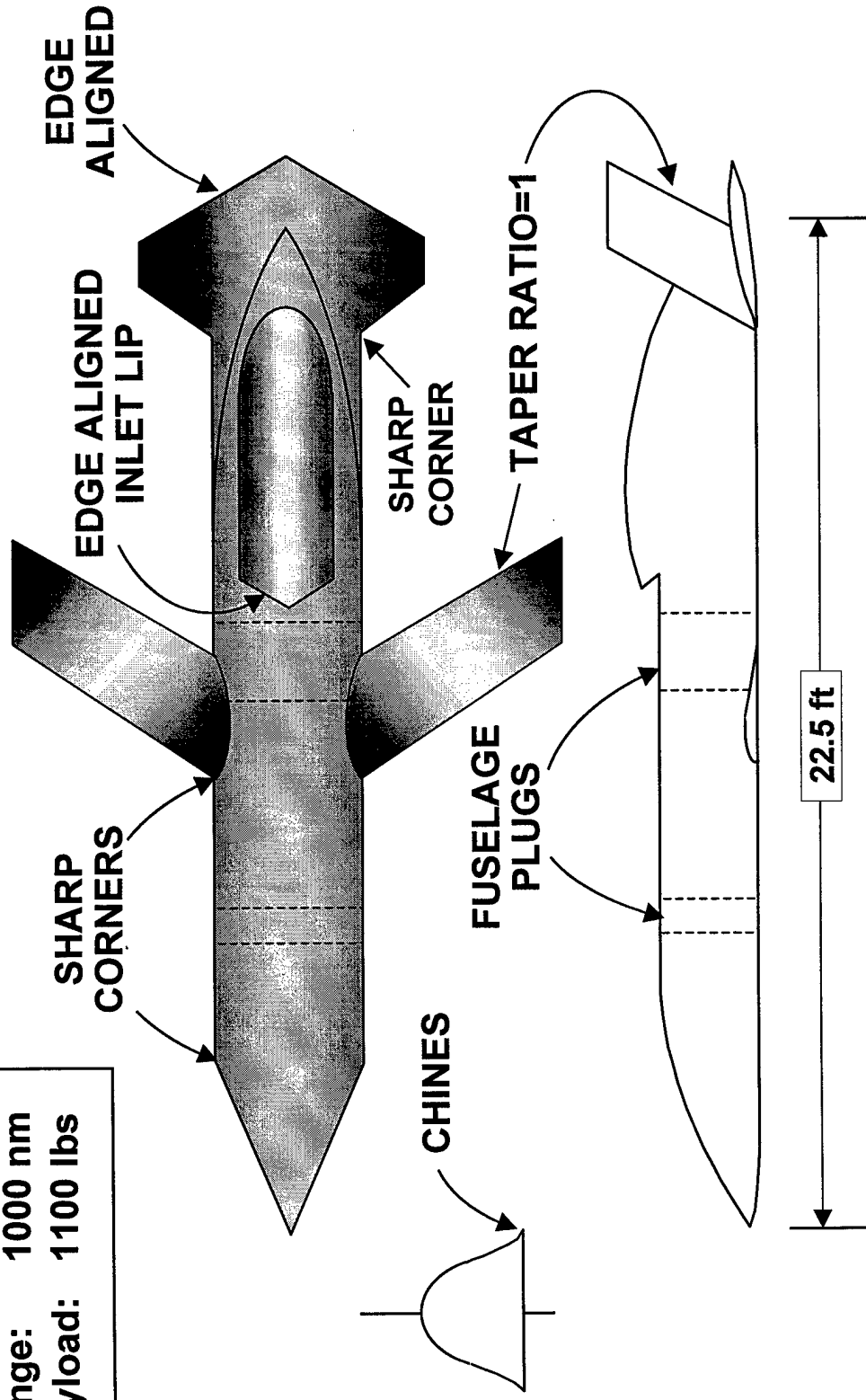
• The West has convinced the world stealth is essential

• Expect “stealth lesson” applied to cruise missile threats as well

THIS PAGE INTENTIONALLY BLANK

Near Term Stealth Option: Modified Scarab

Range: 1000 nm
Payload: 1100 lbs

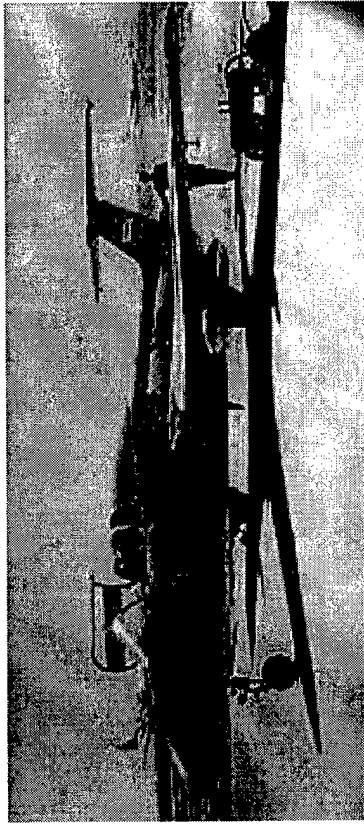


Third World Acquisition Options

- **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**

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

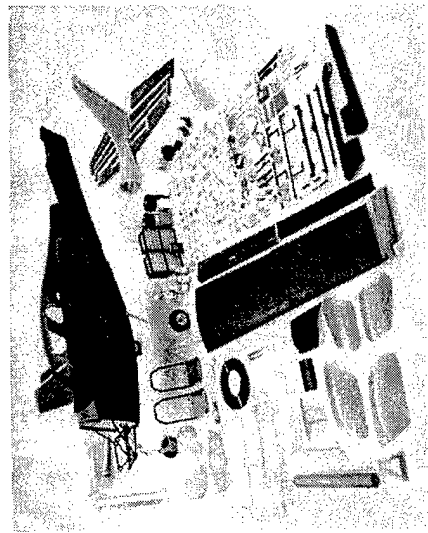
“Saddam Hussein has appealed for volunteers from the Iraqi armed forces to form a suicide air attack force. The purpose of the unit is both to lure American and British warplanes into air defence traps and to launch direct attacks on Western targets in the Gulf region.” (Electronic Telegraph (London),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

Third World Acquisition Options

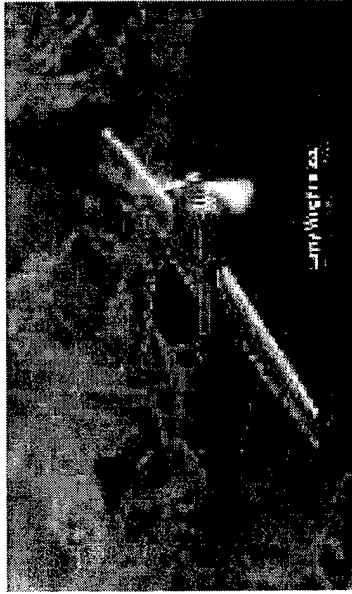
- **Modify Existing Anti-Ship Cruise Missile for Land-Attack Mission**
- **Purchase Advanced Cruise Missiles From Developed Nations**
- **Convert Unarmed UAV to LACM Mission**
- **Develop Improved / Reduced Signature CMs Indigenously**
- **Create “Poor Man’s” Cruise Missiles from Existing Aircraft**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

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

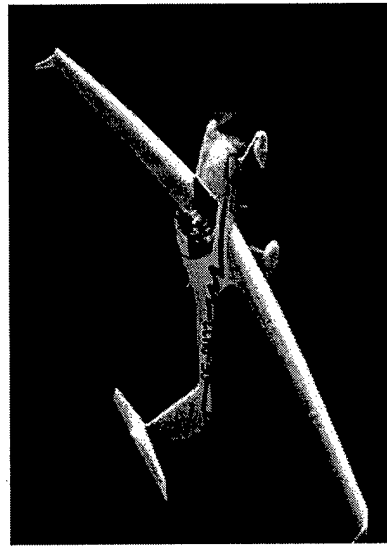


LancAir IV from LancAir web site

*“...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)

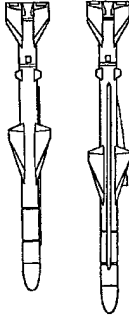


THIS PAGE INTENTIONALLY BLANK

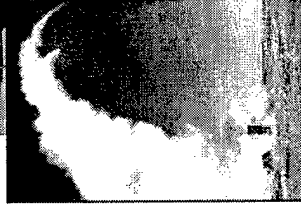
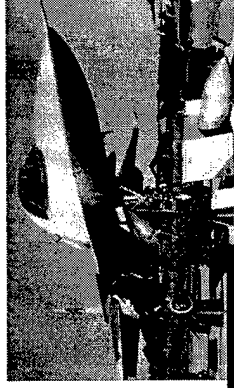
Missiles -- Third World Weapons of Choice

- **Robust Force Structure**
 - Cruise and Ballistic missiles
 - Integrated Air Defense Systems
 - Aircraft with long-range 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
 - Mobile communications to coordinate attacks
 - Computer flight planning for optimum attack profiles
 - GPS inflight updates create cheap precision

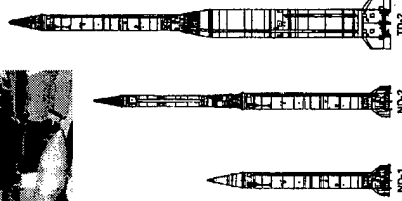
C-801, -802



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. ... 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

The entire "Emerging Cruise Missile Threat" study may be viewed on the NDIA website: <http://www.ndia.org/committees/slaad/ECMTVol2.pdf>

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 1,891	Germany 390	Iran 680	France 3,452
Iraq UNK	Israel 2,669	Italy 1,226	Germany 160
Japan 1,245	N. Korea UNK	Norway 550	Italy 627
Russia 23,447	S. Africa 210	Sweden 575	Russia 3,921
Taiwan 530	UK 1,102	US 9,002	UK 389
	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*.