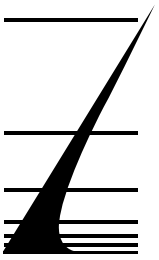
The Market for Air-to-Air Missiles

Product Code #F659

A Special Focused Market Segment Analysis by:



FORECAST INTERNATIONAL

Analysis 4
The Market for Air-to-Air Missiles
2011-2020

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Introduction

The Beginnings. Aircraft technology was little over a decade old when Gavrilo Princip, a member of the terrorist group Black Hand, shot Grand Archduke Franz Ferdinand in Sarajevo. This June 28, 1914, assassination provided an easy excuse for Austria to attack Serbia, a conflict that widened to become the First World War.

Although the Italians had used aircraft in combat in Libya, dropping bombs on Turkish troops in 1911, no single-seat "fighter" aircraft existed when the fighting started. In 1914, the era's generals saw these aircraft fit for reconnaissance and surveillance missions exclusively (many did not think them fit for this purpose, however).

When the war started, France had 132 frontline aircraft, Germany 246, Russia 24, Austria 36, the British Royal Flying Corps 84, and the Royal Navy 71.

The low numbers were in part due to the many problems that existed with early aircraft: low reliability, limited range, fragility, limited payload, poor maneuverability, flammability, and accidental explosions. Still, as the war progressed and intensified, the importance of aircraft steadily grew.

By October 1914, many pilots were experimenting with placing machine guns on their two-seat "reconnaissance" aircraft. The introduction of "interrupter gear," allowing a machine gun to fire through a spinning propeller without hitting it, helped convince leaders of the value of fighter aircraft.

All sides were expanding their "air corps" as fast as possible by the end of 1915. In July 1916, the Battle of the Somme saw the RFC employing 27 squadrons with 421 aircraft. The RFC established air superiority over the frontline and some 30 miles behind enemy lines. By December of that year, the British government had approved the further expansion of the RFC to 106 frontline and 95 reserve and training squadrons.

Total aircraft production during World War I exceeded 200,000 units.

FIRST WORLD WAR AIRCRAFT STATISTICS (a)

Nation	Total Production	Combat Aircraft – 1914	Combat Aircraft – 1918	Lost (b)
Austria	5,431	35 (some claim 86)	200-250	N/A
France	67,987	132-160	3,222	52,640
Germany	48,537	246	2,709	27,637
Italy	20,000	150	1,200	N/A
Russia	4,700	300-360 (c)	1,000 (d)	N/A
United Kingdom	58,144	110-155	4,000	35,973
United States	15,000	55	740	N/A

N/A = Not Available.
(a) Figures provided in part by www.theaerodrome.com.
(b) Losses due to combat and crashes. Total includes aircraft damaged.
(c) May include some non-combat aircraft.
(d) Figure for 1917.

Throughout World Wars I and II, the main air-to-air weapon of a fighter was the machine gun. The most produced fighter of WWI, the Messerschmitt Bf109, usually carried 13mm machine guns and 20mm cannons (the number depended on the variant). The British Spitfire sported three .303-caliber machine guns and two 20mm cannon, while the U.S. was outfitted with the P-51 carrying six .50-caliber machine guns. Air-to-air missiles did not appear until late in the war.

Research into the development of various components, eventually incorporated into air-to-air missiles, had been ongoing since the 1930s. Germany was the first to develop the technology into the prototype stages.

By the midpoint of the war, Germany was facing ever-increasing numbers of high-quality Allied aircraft, and needed a means to restore the Luftwaffe's superiority in the air. Long-range (for that time) guided air-to-air projectiles seemed to be the answer; in 1943, Germany successfully completed its first airborne launchings against an aerial target.

Ruhrstahl Allgemeine Gesellschaft (AG) developed the X-4 missile. Sources disagree, but the first launching of this missile reportedly occurred in August 1945 from an Fw190 fighter.

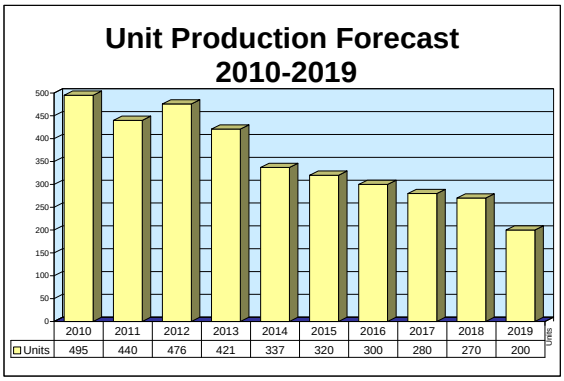
The X-4 was wire-guided and powered by the BMW 109-448 rocket motor. The missile's guidance wires unwound from two bobbins attached to the wing tips. Control was via a "joystick" in the launching

Continued…

AAM-3

Outlook

- In production
- Japan reconsidering policy banning arms exports
- Type 90 AAM-3 and Type 04 AAM-5 short-range air-to-air missiles are in service
- AAM-5 is still in production
- Procurement of locally designed air-to-air missiles will not stop Japan from acquiring foreign-built AAMs



Orientation

Description. Short-range dogfighting air-to-air missile.

Sponsor. The Japan Air Self-Defense Force (JASDF) through the Japan Ministry of Defense, Technical Research and Development Institute, Tokyo, Japan.

Status. The Type 90 AAM-3 is in production. Development of the AAM-3 was completed during the Japanese FY89 (the Japanese fiscal year runs from April to March). Initial tests were conducted in 1988, with operational testing concluding in February 1990. Initial deliveries commenced around March 1993.

Japan is developing a successor to the AAM-3, designated the AAM-5. Flight testing began in 2001, with full-scale development completed and LRIP begun.

Total Produced. Approximately 450 AAM-1, 60 AAM-2, 5,223 AAM-3, and 2,324 AAM-5 missiles were in production or completed by the end of 2009. The number of AAM-3 missiles needed to meet the minimum JASDF requirement is about 2,000.

Application. For short-range air-to-air dogfighting missions. The AAM-3 will eventually replace the AIM-9L in Japanese inventory.

Price Range. Japanese government documents had mentioned an AAM-3 per-unit price of $267,000. This price is high due to the missile's low annual production rate. If produced in quantity, the AAM-3 would likely have a unit price between $90,000 and $150,000 apiece. The AAM-5 may have a unit price of $190,000 to $250,000.

Contractors

Prime

Mitsubishi Heavy Industries Ltd (MHI)	http://www.mhi.co.jp/en/, 16-5 Konan 2-chome, Minato-ku, Tokyo, 108-8215 Japan, Tel: + 81 3 6716 3111, Fax: + 81 3 6716 5800, Prime

Subcontractor

Komatsu Ltd	http://www.komatsu.com, 2-3-6 Akasaka, Minato-ku, Tokyo, 107-8414 Japan, Tel: + 81 3 5561 2616 (Warhead)
Mitsubishi Electric Corp	http://global.mitsubishielectric.com, Tokyo Bldg, 2-7-3, Marunouchi, Chiyoda-ku, Tokyo, 100-8310 Japan, Tel: + 81 3 3218 2111, Fax: + 81 3 3218 2185 (Infrared Seeker)

AAM-3

Mitsubishi Nagoya Aerospace Systems Works	http://www.mhi.co.jp, 10, Oye-cho, Minato-ku, Nagoya, 455-8515 Japan, Tel: + 81 52 611 2121, Fax: + 81 52 611 9360 (Missile Production)
NEC Corp	http://www.nec.co.jp, 7-1, Shiba 5-chome, Minato-Ku, Tokyo, 108-8001 Japan, Tel: + 81 03 3454 3388, Email: webmaster@nec.co.jp (Infrared Seeker; Proximity Fuze)

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Technical Data

Design Features. The AAM-1, AAM-2, and AAM-3 missiles are believed to share a common airframe, although this would appear to be the only direct relation among the programs. The AAM-3 missile's configuration resembles that of the AIM-9 Sidewinder, which Mitsubishi produced under license. Other observations have drawn a comparison between the Japanese weapons and the R.550 Magic in the use of twin nose-mounted canard fins. It is now known that the AAM-3's cruciform canards are distinguished by a compound sweep that ends in a sharp dog tooth, while its rear wings are somewhat reduced in span compared to the Sidewinder. The AAM-2 and AAM-3 programs have paid particular attention to the development of better missile flight maneuverability, range, scan speed, and guidance. The provision of alternative infrared (IR) and active radar homing heads is said to have been considered, but these features seem to be manifesting themselves in the AAM-4 program (see separate report in this tab).

	Metric AAM-3	Metric AAM-5	U.S. AAM-3	U.S. AAM-5
Dimensions				
Length	260 cm	300 cm	102.36 in	118.2 in
Diameter, Body	12.7 cm	15 cm	5 in	5.91 in
Diameter, Wings	255 mm	N/A	10.1 in	N/A
Weight	91 kg	100 kg	201 lb	221 kg
Performance				
Speed	Mach 3.5	Mach 4	Mach 3.5	Mach 4
Range	7 km	7-9 km	4.35 mi	4-5.59 mi

N/A = Not Available.

Propulsion. The AAM-3 uses an unspecified solid-propellant rocket motor.

Control & Guidance. The AAM-3 uses an all-aspect IR homing seeker having better (in the area of three times wider) off-boresight capabilities than the AIM-9L Sidewinder. This seeker was developed in cooperation with NEC (Tokyo, Japan). Maneuverability has also been improved to follow the new generation of highly agile combat fighters. Mitsubishi Precision provides the missile's gyro unit.

Launcher Mode. The missile can be fired from a standard underwing launcher. The AAM-3 will equip Japanese Air Self-Defense Force fighters, including F-4EJs, F-15Js, and the FS-X. The FS-X fighter is expected to be capable of carrying up to eight AAM-3 missiles on operational sorties.

Warhead. The 15-kilogram high explosive/fragmentation warhead was developed by Komatsu Corporation (Osaka, Japan) and uses a proximity fuze.

Variants/Upgrades

The Japanese have manufactured or developed three indigenous air-to-air missiles. They include the following systems:

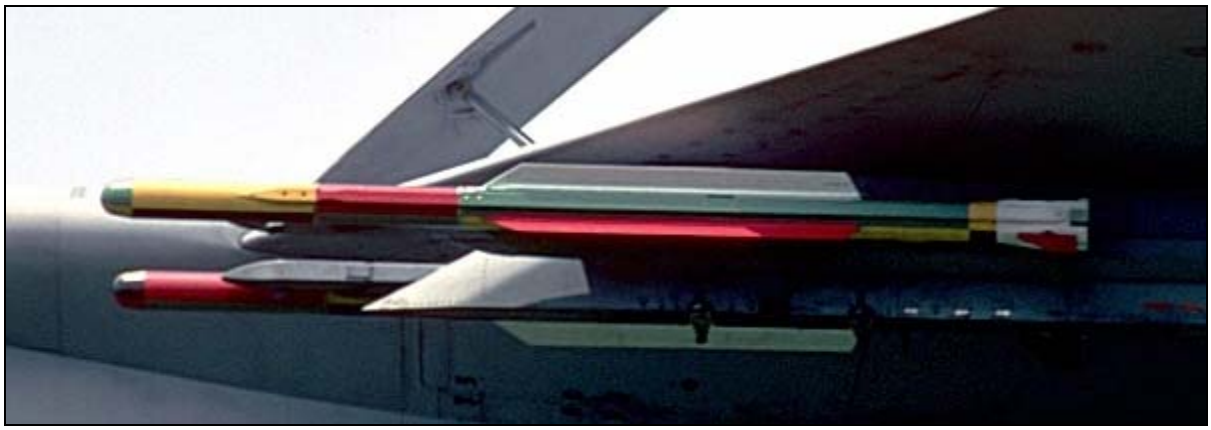
AAM-1. Japan's first attempt to design and fabricate an indigenous air-to-air missile. Designation – Type 69.

AAM-2. The second Japanese air-to-air missile development program, which was begun in 1972. No designation; program canceled prior to production start.

AAM-3. This version replaces the AIM-9L Sidewinder currently in Japanese inventory.

AAM-5. A follow-on to the AAM-3, this is expected to incorporate an advanced IR seeker.

For additional information, see the pertinent entries in the **Program Review** section of this report.



AAM-5

Source: JDA

Program Review

Background. The Japanese are developing a range of air-to-air missiles in an effort to promote indigenous production. These missiles will help ease Japan's dependence on U.S.-designed weapons while meeting the requirements of the Japan Self-Defense Force for improved aircraft defense and engagement capabilities.

Japan Develops AAMs While Purchasing Foreign-Built Missiles

The first air-to-air missiles developed by Japan were the AAM-1 and AAM-2. The Japanese military was not satisfied with the performance of these missiles and quickly commenced an all-new effort: the AAM-3. The AAM-3 is the first indigenous Japanese air-to-air missile to enter extended full-scale production. The AAM-3 could be superseded by either the AAM-5 or the next-generation Sidewinder in the near future.

Helmet Sight for AAM-5. The Japan Air Self-Defense Force (JASDF) wants to acquire a helmet-mounted sight for use with its new-generation AAM-5 short-range air-to-air missile. Since Japan has no indigenous helmet-mounted sight system in development, it has begun examining potential foreign suppliers, including Elbit, BAE Systems, and Sextant Avionique.

Missile Models. Japan has developed, or is developing, a number of air-to-air missile systems for use by its armed forces. Information on these programs is provided below.

AAM-1. The AAM-1 was Japan's first attempt to design and fabricate an indigenous air-to-air missile. The program eventually produced a missile similar in appearance to the AIM-9 Sidewinder, but its capabilities were said to have been limited to fair weather operations. The AAM-1 entered Japanese military service in 1969, but only a little over 400 production missiles were manufactured. The missile was deployed on JASDF F-86 and F-104 fighters. Production was concluded in 1972.

The designation for this missile was Type 69.

AAM-2. The second Japanese air-to-air missile development program began in 1972. The AAM-2 was to replace the AAM-1, with the first 40 missiles being purchased by the JASDF in 1976 for air-launched trials in 1977. The missile was to use an all-aspect infrared homing seeker developed by NEC. However, in 1979, development was stopped in favor of the new AIM-9J Sidewinder. Only some 60 test missiles were completed.

Replacing Sidewinder with AAM-3

AAM-3. The technical research pertaining to the AAM-3 (now designated Type 90) commenced in FY74, with three successive research programs conducted since FY78. The missile replaces the AIM-9L Sidewinder currently in Japanese inventory.

The AAM-3 is said to be the Japanese equivalent to the United Kingdom's ASRAAM (see separate report in this tab), previously under development by a NATO consortium. The AAM-3 is highly agile and capable of engaging close-in targets at supersonic speed. It has a

higher turning rate than the AIM-9L, as well as a better hit probability. The missile's off-boresight acquisition capability is said to be three times better than that of current-generation infrared-homing air-to-air missiles. The AAM-3 also includes infrared counter-countermeasures and self-search/detection capabilities. However, U.S. Navy officials have remained skeptical of such Japanese claims.

Actual AAM-3 technical development started in FY86. During that year, the first prototype development was conducted at a cost of JPY6.610 billion. The contract was awarded to Mitsubishi Heavy Industries. The second prototype development contract, worth JPY3.371 billion ($46.9 million), was signed with Mitsubishi in FY87. Three models were subsequently tested.

The Japan Air Self-Defense Force planned to conduct air-launch tests and operational trials in FY88 and FY89 at a cost of JPY2.9 billion. This was the third phase of an effort to develop an indigenous air-to-air missile. A total of 18 prototypes were fired during the operational test phase, which was completed in February 1990. Deliveries began in the Japanese fiscal year of 1992 (although the missiles probably did not reach the military until calendar year 1993).

AAM-5. The Technical Research and Development Institute (TRDI) of the Japan Ministry of Defense has announced plans to develop an advanced short-range infrared-guided air-to-air missile. The new missile, designated the AAM-5, will eventually replace the Japan Air Self-Defense Force's inventory of AAM-3 systems (although perhaps not completely).

The AAM-5 missile is expected to make use of advancements in infrared seeker technology, aerodynamics, and maneuverability control. According to Japanese sources, the missile is expected to be roughly the same size as the AAM-3, but it will be outfitted with an imaging infrared (IIR) seeker, which is expected to increase the AAM-5's resistance to jamming flares and decoys. Currently, the pilot locks on to a target before firing the missile, but the AAM-5 will use an in-air automatic lock-on after launch function (LOAL mode), which will increase aircraft survivability. In addition, the missile has a steering device that provides a high degree of mobility and can reliably track a target that makes evasive movements. Together, Japan claims, these capabilities will put the AAM-5 in the same category as the ASRAAM and MICA-IR.

TRDI Heads Up New Missile Design Effort

Research on the AAM-5 commenced in 1991. The schedule offered by Japan called for completion of the first prototype before 1993, initial development of a preproduction version in 1994, and evaluations in 1995. Despite this schedule, preliminary development was still under way in 1995, and full-scale development was not begun until FY98. The TRDI requested JPY970 million ($8.2 million) in FY98 for the AAM-5 program.

Japan began flight tests of the AAM-5 from an F-15J in 2001. Delivery of the first production missile commenced four to five years after the award of a full-scale development contract. One Japanese source said the AAM-5 was designated Type 04. The missile entered service in 2006. No details have been provided concerning the new missile's cost or official designation.

The AAM-5 could face competition from the AIM-9X to meet Japanese short-range AAM requirements. There have been rumors that the United States may be putting pressure on the Japanese government to abandon the AAM-5 development program in favor of the next-generation Sidewinder.

Related News

Japan Might Revise Ban on Exporting Armaments – Japan could lift its ban on exporting weapons systems, with the Ministry of Defense (MoD) is seeking to ease the restriction. Lifting the ban would enable Japanese defense firms to cooperate in the development of new weapons. Cooperating with foreign firms would also enable Japan to possibly offer less expensive defense systems. The leading Japanese defense firms are Mitsubishi Heavy Industries, Mitsubishi Electric, Kawasaki Heavy Industries, and Ishikawajima-Harima Heavy Industries.

Even a partial lifting of this ban requires Cabinet approval and would face strong opposition from within the Democratic Party-led government of Japan. In particular, this opposition would come from the Social Democratic Party of Japan, a junior partner of the ruling coalition, which favors pacifism. Japan's MoD wants to revise this policy, not scrap it. (*Financial Times*, 4/10)

Funding

The Japan Air Self-Defense Force placed its first order for the AAM-3 missile in FY90. The first procurement covered 400 missiles; deliveries began in 1993. This was an initial procurement batch; additional orders followed in subsequent fiscal years. The initial funding award was for $106.8 million. The Japanese government approved the procurement of 210 AAM-3 missiles in FY91. These systems were to be produced over an extended period of possibly two years. Japan has been reluctant to release specific information on the AAM-3 procurement program, but has said that Mitsubishi is to receive further orders in the future.

As for the AAM-5 program, Japan's TRDI requested JPY970 million ($8.2 million) for design and prototype development. Initial funding for this program was included in the FY98 budget. Additional money was allocated in FY99, but no specific amount was mentioned.

Contracts/Orders & Options

In Sep 1990, the Japan Air Self-Defense Force placed its first order AAM-3 air-to-air missiles, ordering 400. The contract was valued at $106.8 million. Deliveries were to begin in early 1993. The new missile would arm the service's F-4EJ and F-15J fighters, and possibly the new FS-X currently under development. Other contract awards include the following:

In 1985, a $2.4 million contract was awarded to the Technical Research and Development Institute from the Japanese government to study active homing radar technology.

A three-year, $3.4 million contract was awarded in 1985 to Mitsubishi Electric Corporation from the TRDI to develop new seeker radar.

A contract was awarded to Mitsubishi from the Japan Defense Agency (now Japan Ministry of Defense) for the development of the AAM-3 advanced dogfight missile. The $46.9 million contract was awarded in Apr 1987.

Timetable

Month	Year	Major Development
	1960s	AAM-1 development and production
	1972	AAM-1 replacement, AAM-2 development authorized
Mid-	1970s	AAM-2 canceled in favor of U.S. Sidewinder
	1974	AAM-3 technical research begun
	1978	Successive research programs conducted
	1981	Initial development of AAM-3 IR-AAM
Early	1985	TRDI-funded research into active radar homing
	1986	AAM-3 technical development started
	1987	Second prototype development contract awarded
	1988-89	Air-launch tests and operational trials
Feb	1990	Operational trials completed
Sep	1990	Initial procurement batch ordered by JASDF
Sep	1990	Japan announces new short-range air-to-air missile program (AAM-5)
	1991(a)	AAM-5 research begun
	1991-92(a)	Full-scale production
	1993	Service entry of AAM-3
	1993(a)	First AAM-5 prototype completed
	1995(a)	AAM-5 preliminary development
	1998(a)	AAM-5 full-scale development
	2004(a)	Deliveries of the AAM-5 begin
	2006(a)	AAM-5 enters service with JASDF
	2010-2011	Production continues

(a) Estimate

AAM-3

Worldwide Distribution/Inventories

No exports of the AAM-3 or AAM-5 are expected owing to Japanese constitutional limitations on the export of military hardware.

User Country. The **Japan Air Self-Defense Force** is expected to be the primary user of the AAM-3 in Japan, although the Maritime Self-Defense Force may also purchase the system.

Forecast Rationale

The global economic downturn is hurting defense budgets around the world. The Democratic Party of Japan (DPJ) leads a left-of-center government and cuts in defense spending are already appearing. The DPJ-led government put the brakes on deployment of further PAC 3 batteries. Still, the extent of these defense cuts will not match the DPJ's rhetoric prior to the elections.

Continuing Procurement of Domestic AAMs

Japan has shown no specific sign that a massive cut in air-to-air missiles spending is approaching. Tokyo will continue its policy of acquiring a mixture of locally and foreign built air-to-air missiles.

Japan's domestic short-range air-to-air missiles are the Type 90 AAM-3 and Type 04 AAM-5. The AAM-5 is superseding the AAM-3. Production of the latter has ceased. The AAM-3 will remain in service with the Japanese military, even as it is slowly replaced on frontline duty by the new AAM-5.

The potential purchase of the U.S.-made AIM-9X Sidewinder short-range air-to-air missile will not have an effect on the AAM-5 program. The total number of AAM-5s to be procured by the Japanese armed forces is unknown. Figures of 2,000 to 4,000 have been mentioned, but no official number has been released. The higher figure could be more easily reached if both the Japanese Air Force and Navy order this missile.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR UNIT PRODUCTION

Designation or Program	High Confidence				Good Confidence			Speculative			
	Thru 2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
Mitsubishi Heavy Industries Ltd (MHI)												
Type 04 <> AAM-5 <> Japan												
	2,324	495	440	476	421	337	320	300	280	270	200	3,539
Total	2,324	495	440	476	421	337	320	300	280	270	200	3,539

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