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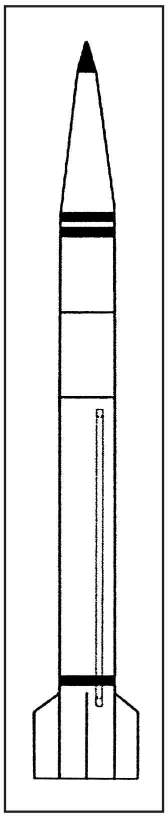


A line diagram of the Chinese B-611 SRBM
(Peter Humphris) 1124439

B-611M version entered service in 2007. It is expected that the B-611 will gradually replace the older CSS-8 (M-7) missiles. Turkey displayed missiles similar to B-611 in 2007, with the name 'Yildirim' and the designator J-600T, and it is believed that these missiles entered service in Turkey in 2002. The missiles were fitted on 6 × 6 wheeled vehicles, similar to the Chinese TEL vehicle used with B-611, but the missiles were not in canisters. However, reports in 2009 indicated that a second TEL vehicle was in service in Turkey, with two missiles carried in square canisters.

Contractor

China Aerospace Science and Industry Corporation (CASIC) are the primary contractors. China National Precision Machinery Import & Export Corporation (CPMIEC) are responsible for export and overseas sales. Baotou Beiben Heavy-Duty Truck Co Ltd are the producers of heavy trucks used for the TEL.

DF-3 (CSS-2)

Type

Intermediate-range, surface-based, liquid-propellant, single warhead ballistic missile.

Development

In the mid-1950s the former Soviet Union supplied China with a number of R-2 (SS-2) missiles, which were an adaptation of the German Second World War style V-2 short-range ballistic missile. Later, some R-2 missiles were produced locally under licence and designated DF-1 (*Dong Feng* = East Wind) by the Chinese.

The first Chinese ballistic missile launch took place in November 1960 using a DF-1 fitted with a dummy payload. It now seems certain that the Chinese also had limited access to the somewhat larger R-5 (SS-3) missile design, a Russian development of the R-2. Following the break with Moscow in the early 1960s, China used its existing production base to build its first indigenous missile, known in the West as the CSS-1 (Chinese Surface-to-Surface Missile-1) and in China as Dong Feng-2. Some sources suggest that the DF-2 was derived from the R-5 (SS-3) airframe, but used an upgraded R-2 (SS-2) propulsion system (liquid oxygen and alcohol) known to have been manufactured in China.

The date of the first DF-2 launch is uncertain, but is generally thought to have taken place in June 1964. What is known is that a DF-2 was used to launch a nuclear warhead into the Lop Nor atomic test area in October 1966.

Production is believed to have ended in 1969 after 100 missiles were built, of which about 90 were deployed through the 1970s.

One of the main shortcomings of the DF-2 as a weapon was the use of liquid oxygen as fuel, the missile could not be stored fully fuelled for long periods or launched at short notice. Recognising this, in the early 1960s, the Chinese started the development of a series of missiles using only storable propellants.

The first of these domestically designed and produced was the Dong Feng-3 (DF-3), which had the NATO designation CSS-2, with a range requirement of 2,500 km sufficient to attack US bases in the Philippine Islands. DF-3 has a payload of 2,000 kg, as this was the expected weight of the original hydrogen bomb under development in China at that time.

Test flights were reported from 1966 to 1968 and the missile is believed to have entered service in 1970.

An improved version, the DF-3A, was developed in the early 1980s, with flight tests starting in 1986.

The DF-3A has an increased range and improved accuracy, and a conventional high-explosive warhead was developed for an export order to Saudi Arabia.

In 1985, flight tests began of a modernised DF-3 missile with a new delivery system, probably a multiple re-entry vehicle type which, according to Chinese sources, would have the ability to place re-entry vehicles on dispersed targets. However, it is believed that the tests were unsuccessful and the missile remains with a single warhead.

While the DF-3 served well as an intermediate-range ballistic missile, its limited range made it relatively ineffective against key targets. With this in mind, the Chinese developed, essentially in parallel with the DF-3, the two-stage DF-4 (designated by NATO as the CSS-3). The DF-4 missile went on to form the baseline design for the Chinese Long March satellite launch vehicles.

Description

The DF-3 is a single-stage, liquid-fuelled ballistic missile, 21.2 m long and 2.25 m in diameter, with four clipped delta fins at the base of the missile. The missile has a launch weight of 64,000 kg and it is thought that, in the early days, it probably used a ground-based radio-command guidance system similar to those employed on some early US missiles. This was later changed to inertial guidance.

Propulsion

The DF-3 uses vanes in the efflux nozzles for control during the boost phase of flight. The motor consists of a cluster of four YF-2 engines, which use storable liquids, unsymmetrical dimethyl hydrazine (UDMH) fuel and AK-27 oxidiser (nitric acid with 27% nitrogen tetroxide), and provide a total thrust of 96 tonnes. The motors have a burn time of around 140 seconds. This gives the DF-3 missile a minimum range of 750 km and a maximum range of 2,650 km. At maximum range, the peak velocity of DF-3 will be 4.7 km/s.

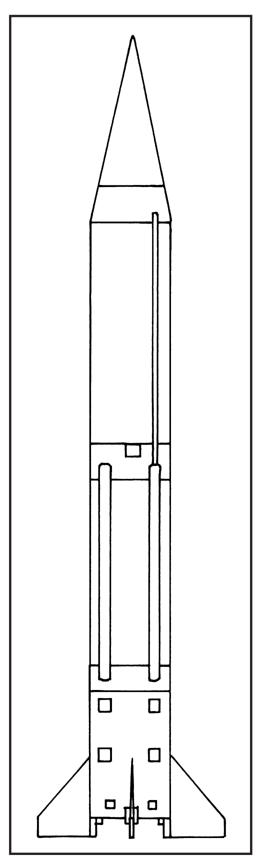
Payload

DF-3 has a separating warhead assembly, weighing 2,150 kg, and it carries a single nuclear warhead with a yield of between 1 and 3 MT. The Chinese tested six warheads in this yield range between 1967 and 1976. The accuracy is believed to be 2,000 m CEP.

A conventional high-explosive (HE) warhead was developed in China for fitting to the DF-3 (or DF-3A) missiles exported to Saudi Arabia, with a weight of 2,500 kg. These missiles are believed to have a maximum range of 2,400 km. However, if the payload were reduced, then the range could be significantly increased.

Guidance

The improved DF-3A version has a range increased to 2,800 km and an accuracy improved to 1,000 m CEP. The pre-launch preparation time is reported to be between 2 and 3 hours. However, if the payload were significantly reduced



A line diagram of the DF-3
(Peter Humphris) 0517674

Cruise missiles

Brazil

TM-Astros

Type
Short range, turbojet powered, surface-to-surface missile.

Development
Avibras Aeroespacial first displayed a model of a Tactical Missile Astros (TM-Astros) at the Paris Air Show in June 1999. This was a modified Astros II (SS-80) unguided rocket, adapted to provide a cruise missile variant. The design was said to be complete but, as this had been a private venture, the company was looking for an export order before going into a development programme.

Development started in 2003 for an Astros III rocket system and launch vehicle for the Brazilian Army, that would have been capable of carrying and launching four SS-80 rockets or four TM-Astros cruise missiles. However, the Astros III programme itself was terminated in 2006.

Avibras stated in 2005 that development work on TM-Astros would continue, and that a revised design was planned for the Brazilian armed forces, with ground-, air- and ship-launched versions. A first test flight of TM-Astros was made in 2000, and further development tests were reported up to September 2004. No further flight tests have been reported.

Description
The original TM-Astros design had a length of 5.9 m, a diameter of 0.45 m, and an estimated launch weight of 600 kg.

Propulsion
The model on display in 1999 showed air intakes either side of the rear body, for a turbojet motor. The missile would be ground- or ship-launched using a solid-propellant boost motor, which would then be ejected after use. The missile was believed to cruise at 200 m altitude, at a speed of M0.6

Payload
The payload was expected to be 140 kg, and with a unitary high explosive (HE) warhead or HE submunitions. There were two folding wings behind the payload bay, and these unfolded after launch.

A development trials launch of a TM-Astros missile (Avibras) 0567930

Guidance
An inertial navigation system (INS)/GPS guidance system would be developed if required, and in 2001 a terminal guidance system was offered as well. The initial missile was reported to have a maximum range of 150 km, but in 2003 it was reported that an improved version would have a range increased to 300 km.

Launcher
The initial TM-Astros version was ground-launched from the existing Astros II Tectran AV-LAU wheeled 6 × 6 launch vehicle, with two missiles carried per vehicle in circular canisters with a diameter of 0.5 m.

An alternative transporter-erector-launcher vehicle was reported in 2006 using a Mercedes Benz UNIMOG (4 × 4) truck chassis with an armoured body shell.

Specifications

	TM-Astros (HE Warhead)	TM-Astros (Submunition Warhead)
Dimensions and weights		
Length		
overall	5.9 m (19 ft 4¼ in)	5.9 m (19 ft 4¼ in)
Diameter		
body	450 mm (17.72 in)	450 mm (17.72 in)
Weight		
launch	600 kg (1,322 lb)	600 kg (1,322 lb)
Performance		
Range		
max	162.0 n miles (300 km; 186.4 miles) (est.)	162.0 n miles (300 km; 186.4 miles) (est.)
Ordnance components		
Warhead	1 × 140 kg (308 lb) HE	140 kg (308 lb) submunitions
Guidance	INS, GPS	INS, GPS
Propulsion		
type	solid propellant (booster)	solid propellant (booster)
	turbojet	turbojet

Status
The TM-Astros project is believed to have started in 1998, as a longer range guided variant of the Astros II (SS-80) rocket. The programme has been privately funded by Avibras, and seems to have stopped and then resumed. The present status of this programme is unclear.

In July 2001 an export order was placed by Malaysia for the Astros II (SS-80), and it was reported that Malaysia was also interested in the TM-Astros version. It is believed that the Malaysian Astros II unguided r ocket system is known as the Keris SPRM.

Astros II unguided rockets have been used by the Brazilian Army since 1996, and have also been exported to Iraq (known as Sigeel 30/40/60), Qatar and Saudi Arabia.

Contractor
Avibras Industria Aeroespacial, Sao Paulo, Brazil.

China

C-602 (HN-1/-2/-3/YJ-62/X-600/DH-10/CJ-10/HN-2000)

Type
Short- and intermediate-range, ground-, ship-, submarine-, air-launched, turbojet powered, single warhead, cruise missiles.

Development
Some reports suggest that the Chinese started a development programme around 1977 to develop a long-range cruise missile family. The missiles were required to carry a nuclear warhead for up to 3,000 km range. Initial development work was probably based on a design known as X-600, which had a design range of 600 km. The X-600 is believed to have used an HY-2 (Silkworm type) body, either a C-601 (CAS-1 'Kraken') or a HY-4 (CSSC-7 'Sadsack'), with a turbojet engine attached on a pylon at the rear of the missile underbody. The turbojet may have been fixed on the pylon, or it may have been retracted during carried flight on the aircraft. Flight trials were made using a modified H-6D bomber (Tu-16 'Badger') with the test missiles carried inside the bomb bay or mounted on the underwing pylons. It is possible that the initial design was known as XW-41, which was believed to be a modified HY-4 with extending wings mounted on the underside of the body. Alternatively, the initial design may have been a modified C-601. The development programme

Electronic Research and Development Establishment (ERDE)	surveillance and engagement radars
High Energy Materials Research Laboratory (HEMRL)	propellants for the missile
Israel Aerospace Industries	passive OTH radar
Indian Institute of Technology	associated with the development of phase shifters for radars
Indian Space Research Organisation (ISRO)	associated with satellite targeting
ITR Chandipur Test Range	
KelTech	
Konark (aka Konarak)	radar tracking site 19° 52.04.13 North 086° 06.29.23 East (Big Dome on site)
Larsen and Toubro	
Paradip (aka Paradeep)	radar tracking site 20° 16.08.47 North 086° 40.43.64 East (Small Dome on site)
Pokhran missile test range	
Research Centre Imarat	
Semi-Conductor Complex	crucial sensors
Sriharikota	India's space port
TATA Power Company Limited	passive OTH system
Vem Technologies Private Limited	
Wheelers Island Missile Test Range	

Israel

Israel Multi-Layered Missile Defence

Type

Layered anti-ballistic missile defence system.

Development

Israel has integrated its air defence forces into a single Air Defence Command. This Air Defence Command consists of several systems but is based mainly around the anti-ballistic missile systems Arrow-2 and Arrow-3.

Development of the Arrow family of missiles began in 1986 with the finalised agreement for the programme in 1988. Tests of the system are believed to have started as early as 1993 and continued throughout the 1990s.

Entry into service for the Arrow-2 was 1999 with full initial operating capability (IOC) in 2000/01.

The Arrow-3 missile is an exo-atmospheric system designed to intercept long-range ballistic missiles in space early in the missile's trajectory.

By 2011, whilst working in conjunction with the Patriot system that was already deployed within Israel, a layered defence is now part of the overall Ballistic Missile and Air Defence of Israel. A new unit was formed around the same time (2011) and was based in central Israel during 2012 that was for the other new missile system known as Magic Wand or David's Sling.

The final part of this future layered defence is the Iron Dome system, this is the very short-range missile that is used to intercept those ballistic firing weapons from Gaza and the West Bank that have been predicted to fall within a populated area of Israel or an area of high value.

Included here is a perceived anti-ballistic missile scenario that may well form part of the new layered missile defence of Israel. Satellite constellations will be used for tracking the launch and boost phase of potential incoming ballistic missiles fired either from submarines or land launched. If possible an Arrow-3 will engage these targets from the land on the ballistic missile ascent phase and also through the mid-course in the exo-atmosphere. Should the target, however, reach its terminal phase then it will fall to the responsibility of the Arrow-2 at endo-atmospheric range and then finally the David's Sling at medium-range

Description

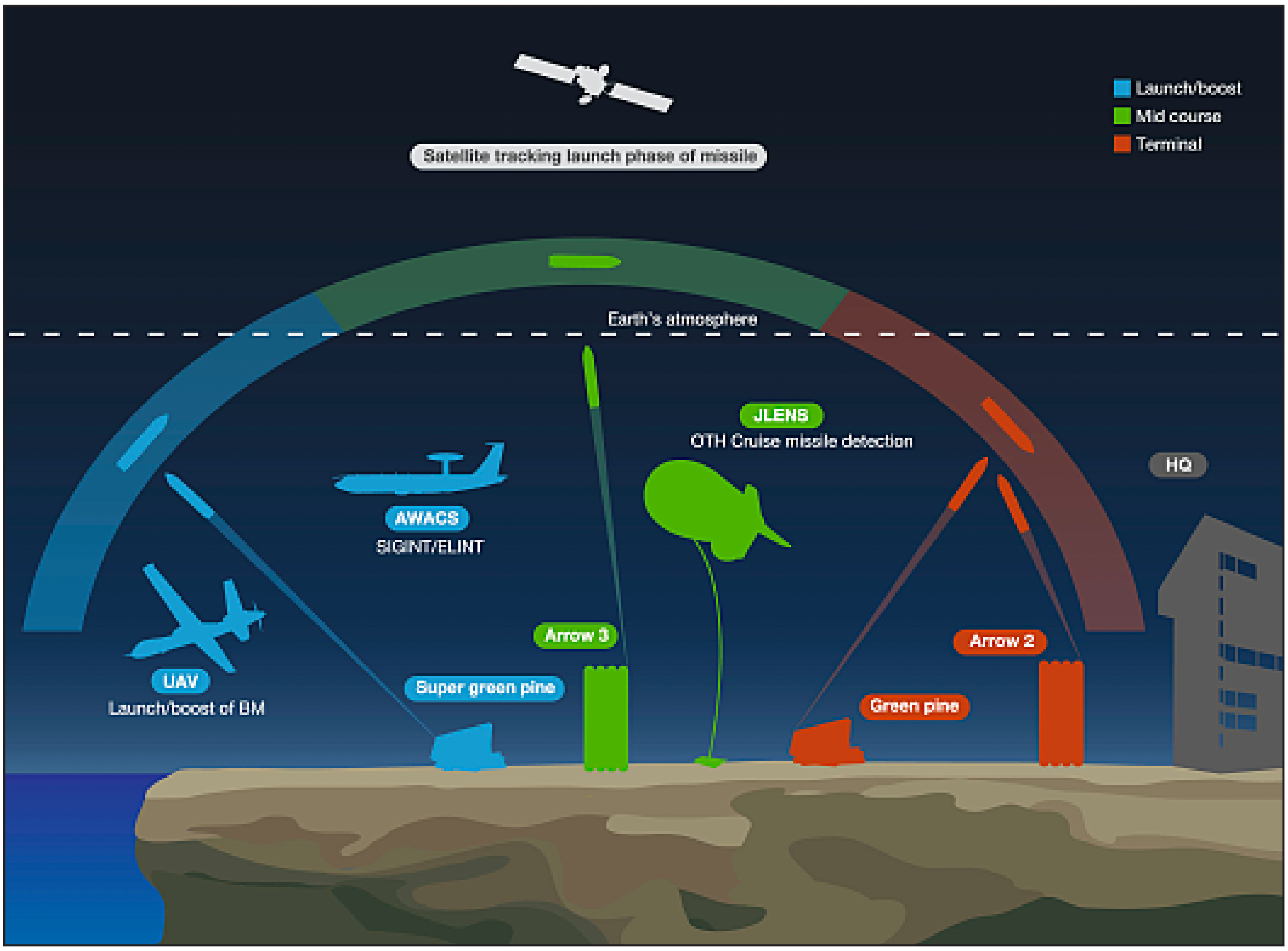
Arrow-2

This system is regarded as the "Intermediate Tier" of the Israel layered defence systems. The Arrow or Hetz is a family of anti-ballistic missiles (ABMs) that have been designed, developed and produced within Israel by the Israel Aerospace Industries with the help and guidance from the United States' Boeing Company to counter theatre ballistic missiles (TBMs) such as the Syrian Scuds, Iran's Shahab and Hizbullah's M600. The system consists of the Elta EL/M-2080 Green Pine early-warning radar, the Citron Tree command, control and communication (C3) centre and the Hazelnut Tree launch control centre.

The first of the family was the Arrow-1, which was a technology demonstrator, this was followed by the Arrow-2 that became the first of the family to be operationally deployed in 2000.

Arrow-3

This system is regarded as the "First Tier" of the Israel layered defence system. The Arrow-3 system is due for IOC in 2016. Meanwhile testing of the system will continue from 2012 onwards.



Perceived Layered Defence Israel (IHS/Mark Newton) 1521313

The GBR-P at Kwajalein Atoll (US Army) 0543434

Specifications

OBV

Length:	16.61 m
Body diameter:	1.28 m
Launch weight:	21,600 kg
Warhead:	64 kg EKV
Guidance:	Inertial with command updates, IIR and visual
Propulsion:	Two or three-stage solid
Range:	3,500–4,000 km (2 stage), 5,000 km (3 stage)

LM-BV

Length:	16.26 m
Body diameter:	1.02 m (1st stage), 0.7 m (2nd and 3rd stages)
Launch weight:	14,682 kg
Warhead:	64 kg EKV
Guidance:	Inertial with command updates, IIR and visual
Propulsion:	Three-stage solid
Range:	4,500 km

Status

The GBR-P has been located at Kwajalein Atoll in the Marshall Islands on the south Pacific test range since 1998, with several test launches of inter-continental ballistic missiles (ICBM) and suites of test targets being made each year.

A test flight in September 2000 had 35 objects within the test suite, to examine the discrimination capabilities of the radar software.

A flight test programme for the GBI initially planned for 25 flight tests up to 2006, but this was altered in 2002.

IFT-1 and IFT-2 were the competing sensor design tests flown in June 1997 and January 1998.

IFT-3 was flown in October 1999 and resulted in a direct hit.

IFT-4 was flown in January 2000 and resulted in a miss due to a failure of the IIR detector cooling system.

IFT-5 was flown in July 2000 and failed as the EKV did not separate from the third stage.

IFT-6 was flown in July 2001 and IFT-7 in December 2001 and both were successful intercepts of a warhead with one decoy balloon. Both intercepts were made at an altitude of 225 km and at a range of 700 km from the interceptor launch.

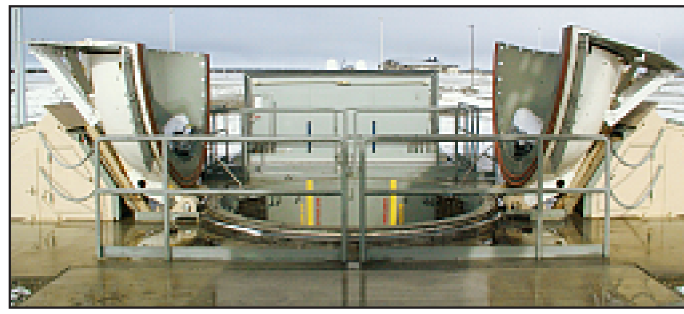
IFT-8 was flown in March 2002 against a warhead and three decoy balloons and was successful with an intercept at an altitude of 175 km.

IFT-9 was flown in October 2002 and was successful, using an Aegis ship AN/SPY-1 radar for the first time.

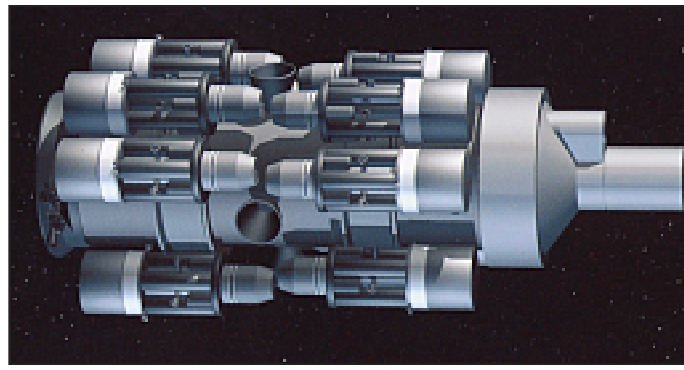
IFT-10 was flown in December 2002, but failed due to the EKV failing to separate from the third stage again. This made the initial test sequence five successful intercepts from eight attempts.

IFT-11 and IFT-12 were cancelled in 2002, completing the tests using the original Minuteman-based launcher assembly.

The first flight test of the Taurus Lite (OBV) booster assembly was made in February 2003, and the second test (BV-6) in August 2003. The second test used a new first-stage motor, and flew to an altitude of 1,875 km and a range of 5,300 km.



The open doors of a GBI silo at Fort Greely (US Army) 1043767



Multiple kill vehicle being developed, possibly for GBI (Lockheed Martin) 1124491

The third OBV was flown in January 2004 on IFT-13B, with a mock EKV. This flight went to an altitude of 285 km and a range of 1,300 km.

The first flight of the LM-BV was made in January 2004 and this flew for 4,150 km. IFT-13C, using an OBV motor assembly, was attempted in December 2004 and again in February 2005, but on both occasions defects occurred that prevented the GBI from launching.

FT-01 was made in December 2005, with an OBV launched from Kwajalein Atoll, but without a target.

FT-02 was made in September 2006, with an OBV launched from Vandenberg and a three-stage target launched from Kodiak Island. FT-02 achieved a successful intercept.

FT-03 was made in September 2007, and was similar to the FT-02 flight test, with the target having a single RV and no decoys.

FTX-03 was made in July 2008, but no interceptor was launched as it was unserviceable, and the test used sensors and communication systems only.

FTG-05 was made in December 2008, with an OBV from Vandenberg and a target from Kodiak Island. The intercept was successful, but the target did not dispense its decoys.

FTG-06 was flown in January 2010, but was not successful.

BVT-1 was flown in June 2010, and was a test of the two-stage GBI without any target.

FTG-06A was flown in December 2010 using an upgraded GBI, but failed to hit the target. The next flight test is planned for mid-2012. The MDA are planning to build some ICBM targets, and to test the system against salvo launches in the future.

The final operational system has not been decided, but plans in 2005 indicated that up to 70 interceptors might be built by 2011, and these would be used to complete the development flight tests and to provide an initial operational capability.

It was reported that Lockheed Martin would deliver a total of 10 GBI booster assemblies (LM-BV), for five operational missiles, four flight test and for one ground test. It was also expected that Orbital Sciences would deliver 60 booster assemblies (OBV).

The initial operating capability was achieved in September 2004, with eight interceptors in silos at Fort Greely and two at Vandenberg AFB in December 2004. Fort Greely was reported to have had 10 operational GBI in December 2006 and Vandenberg two.

It was stated in 2009 that a total of 44 interceptors would be built, with the 14 original operational interceptors refurbished. Vandenberg has had two test silos built, as after each flight test the silos have to be refurbished.

The Fort Greely silos are being altered, as the original six silos were not hardened, and these will be taken out of service.

A second missile field has 20 silos, and a third field is being built.

The third field was to have had 14 silos, but in 2009 it was stated that only seven would be completed.

By December 2011 there were 26 GBI in silos at Fort Greely, and four at Vandenberg, and it was planned that a further eight missiles might be added at Fort Greely by 2015. However, unconfirmed reports suggested that up to 22 new missiles might be built by 2020, depending on the perceived threats.

Contractor

Boeing GBMD, Arlington, Virginia (lead systems integrator).
Raytheon Missile Systems, Tucson, Arizona (GBR-P and SBX).
Orbital Sciences, Dulles, Virginia (motor assemblies).