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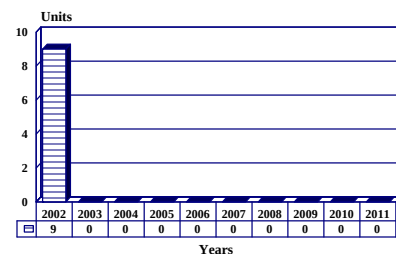
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Arjun – Archivce 2/2003

Outlook

- After over two decades of development, program has been effectively canceled just as low-rate serial production was getting under way
- Long delays in the program were due to technical problems, most of which have yet to be resolved
- Base chassis may be used as basis for new self-propelled 155 millimeter howitzer

10 Year Unit Production Forecast
2002 - 2011



Orientation

Description. A tank.

Sponsor. The development of the Arjun has been sponsored by the Indian Ministry of Defence through the Defence Research and Development Organization and the Indian Army.

Contractors. This tank has been under continued development by the Combat Vehicle Research and Development Establishment, Madras, India. The serial production has been undertaken by the Heavy Vehicles Factory of Avadi Company, Madras, India. Major subcontractors include Bhabha Atomic Research Center, Bharat Electronics Limited, Feinmechanische Werke Mainz, Mishra Dhatu Nigam, and Motoren- und Turbinen-Union.

Licensees. None

Status. Despite the fact that the program has been effectively canceled, as of 2002, the Arjun remains in very low-rate serial production to complete the

remaining tanks on the line. The plan for the delivery of 124 tanks by 2003 has been allowed to go dormant, but the base chassis may be used as the basis for the 600-unit self-propelled artillery requirement.

Total Produced. As of January 1, 2002, a total of 33 Arjun tanks had been manufactured: 3 automotive test rig tanks, 12 developmental prototype tanks, 17 pre-production and low-rate production series tanks, and 1 prototype Arjun Mark II tank.

Application. A tank for the projection of power, as well as defensive missions. This tank was to be the primary offensive weapon of the Indian Army.

Price Range. The unit price of the Arjun was projected at equivalent 2001 US\$5.005 million. Reports of significantly lower unit prices were erroneous, as protracted development and changes in key components have driven up the total program cost, as well as the associated unit price.

Technical Data

Crew. Four: commander, gunner, loader, driver.

Armor. An indigenous composite armor called Kanchan has been developed for this tank. Some

sources state that the attachments for explosive reactive armor may be fitted.

Dimensions. Only a minimal amount of technical information is available for this tank. All data are for the latest prototype Arjun Mark I tank as of 2002. The official inquiry of the Indian Comptroller and Auditor

General states that the weight of the Arjun (based on the last of the 15-unit low-rate pre-production run) is 60 tonnes (66.14 tons).

	<u>SI units</u>	<u>US units</u>
Length	10.19 meters	333.43 feet
Width	3.85 meters	12.63 feet
Height	2.32 meters (est)	7.61 feet (est)
Combat weight	58.5 tonnes	64.49 tons
Fuel capacity	1,610 liters	428.19 gallons

Performance. The maximum speed and range figures are for use on a metaled road; the range figure is estimated.

	<u>SI units</u>	<u>US units</u>
Maximum speed	64.4 kilometers per hour	40 miles per hour
Maximum range	430 kilometers	267.03 statute miles
Step	90 centimeters	2.95 feet
Trench	2.43 meters	7.97 feet
Slope	40%	40%
Gradient	77%	77%
Fording	1.4 meters	4.59 feet

Engine. Originally, a 1,119 kilowatt (1,500 horsepower) indigenously developed vehicular gas-turbine was to power the Arjun, but this was discarded early on in favor of an indigenously developed advanced-design diesel engine designated Kirloskar. This 12-cylinder engine is air-cooled and uses variable compression ratio technology. Its designed power is 1,119 kilowatts (1,500 horsepower), but the initial versions gave only 373 kilowatts (500 horsepower). The power output rating was subsequently increased to almost 745.7 kilowatts (1,000 horsepower), but was still considered insufficient.

As of 2001, research indicates that technical problems still plague the Kirloskar engine, and its development may well have been suspended or even terminated. In 1993, in order to keep the development program close to schedule, the first prototypes were fitted with the MB 838 Ka 501 diesel engine from Motoren- und Turbinen-Union of the Federal Republic of Germany. In early 1996, it was confirmed that this engine will power the production Arjun tank, although the development of the Kirloskar engine will continue. If it ever comes up to design specifications and reliability, it will be used. In any event, the MB 838 Ka 501 10-cylinder, liquid-cooled, supercharged engine is rated at 1,044.4 kilowatts (1,400 horsepower) at an engine speed of 41.67 revolutions per second (2,500 revolutions per minute). The power-to-weight ratio is 17.85 kilowatts per tonne (21.71 horsepower per ton).

For additional details on the propulsion problems and options in relation to the Arjun, see the **Program Review** section below.

Gearbox. Production tanks were scheduled to use an unspecified indigenous semi-automatic gearbox with four forward and two reverse gear ratios. In the interim, an unspecified automatic gearbox from Renk with four forward and two reverse gear ratios was installed. This unit is now expected to be used on the production tanks.

Suspension and Running Gear. Other than the fact that the Arjun uses seven dual-tired road wheels and seven track return rollers on each side, most details of the Arjun suspension and running gear are still not known outside India. A hydropneumatic suspension system is used. Further details of the suspension and running gear (including whether the system uses torsion bars) are unavailable at this time.

Armament. For a long time, reports differed as to the type of armament that would be fitted to the Arjun. Some sources stated that a 120 millimeter smoothbore cannon similar to the Rh 120 would constitute the main armament, but instead, an unknown indigenous rifled 120 millimeter tank cannon was chosen. The cannon's development has been undertaken by the Armament Research and Development Establishment.

Few details of the rifled tank cannon mounted on the Arjun are known, except that a thermal sleeve and fume extractor are fitted. All operations are electro-hydraulic, with the gun control system provided by Feinmechanische Werke Mainz.

Originally, an indigenous gun control system was being developed for the Arjun by the Combat Vehicle Research and Development Establishment. Due to technical shortcomings in this equipment, the system provided by Feinmechanische Werke Mainz was

decided to be used in production tanks. The elevation of the main armament is +20 degrees and the depression is -8 degrees. A total of 39 rounds of main armament ammunition are carried. The tank cannon is fabricated from electro-slag refined steel and uses indigenously developed semi-combustible cartridge-case technology. A full range of ammunition types (including Armor Piercing Fin Stabilized Discarding Sabot) can be fired by this tank cannon. The secondary armament consists of a 12.7 millimeter HCB machine gun that is pintle mounted on the roof of the turret and a 7.62 millimeter TK715A machine gun that is coaxially mounted. Nine smoke grenade launchers are mounted on each side of the turret.

Fire Control. As of 2002, little is known regarding the fire-control fit of this tank. Developed by the Defence Research and Development Organization's Instruments Research and Development Establishment, Bharat Electronics Limited is the contractor responsible for the integration of the system. The contractor calls the system a third-generation director-type integrated fire-control system. The main armament is electronically slaved to the sights. The fire-control suite includes a laser rangefinder and ballistic computer of indigenous design. Bharat Electronics Limited states that the fire-control system allows the tank to search, acquire, track, range, and engage hostile tanks while stationary or moving in daylight or darkness.

The gunner's sighting equipment consists of combined dual magnification day/thermal sight and integral laser rangefinder using a common sight head that is stabilized in elevation and azimuth. The commander has a panoramic dual magnification sight that is stabilized in elevation and azimuth and rotates independently of the turret. The main armament is electronically slaved to the fire-control system. A coincidence window incorporated into the system allows for the main armament to be fired only when it is in the desired position as directed by the fire-control computer. A variety of sensors feed into the computer-based fire-control system.

In October of 1994, the fire-control system developed by the Instruments Research and Development Establishment and Bharat Electronics was rejected by the Indian Army. Components of the fire-control system were redesigned and a ballistic computer from Hughes Aircraft (through the Spanish Empresa Nacional de Optica firm) was incorporated into the system.

Variants/Upgrades

Variants. None at this time, although an armored vehicle launched bridge, a self-propelled anti-aircraft artillery system, an armored engineer vehicle and other variants are in the paper design and development phase. In 1996, a Defence Research and Development Organization spokesman confirmed these plans for variants based on the Arjun chassis. To date, one prototype armored recovery vehicle has been fabricated, the details of which are not known.

In 1994, stories began circulating that the chassis of the Arjun was to be used as the basis for India's new 155 millimeter self-propelled artillery system. As of 1995, the continued troubles with the Arjun's powerplant, plus the fact that India had then only recently completed its license manufacture of the T-72 tank, seemed to preclude such a plan. These suspicions were subsequently confirmed with the official listing of the T-72 chassis as the new self-propelled artillery

requirement. Later, it was determined that the T-72 chassis integrated with several different turrets could not meet the required mobility standards. In 1998, it was learned that India had integrated the Denel/Lyttleton Engineering Works T6 turret with the chassis of the Arjun for mobility tests and test firings. This system was called Bhim, but the name could be applied to whatever system is selected to meet the self-propelled artillery requirement. As of 2002, the best evidence indicates that, although the Arjun tank program may be going dormant, the base chassis is still the preferred option for the self-propelled artillery requirement.

Modernization and Retrofit Overview. None at this time, although our research indicates that a number of final design changes would have been integrated with the tank as a result of the extended operational testing of the first 100 tanks delivered under the low-rate initial production program.

Program Review

Background. In 1972, the Indian Army issued a requirement for a new tank to replace the Vijayanta, the license-produced Vickers Mark 1 tank. The new tank

was originally called Chetak, but the name was changed in 1984 to Arjun, a legendary Hindu warrior. Work on the tank began in 1974 by the Combat Vehicle Research

and Development Establishment. The Arjun has also been called the MBT 80, and more recently the MBT 90. After gaining experience in tank production by license-producing the Vijayanta, T-54/55, and T-72, India planned for the Arjun to be produced using nothing but indigenously developed and manufactured components. Development of these components, including the engine, gearbox, and main armament, began shortly after 1973.

Development. In April of 1985, the first Arjun prototype was rolled out at the Combat Vehicle Research and Development Establishment at Madras. Due to the technical problems associated with the original Kirloskar engine (as described elsewhere in this report), the prototype was fitted with the MB 838 Ka 501 diesel engine from Motoren- und Turbinen-Union of Germany.

According to official Indian sources, 12 initial prototypes were built, with the first six fabricated from mild (non-ballistic) steel. In addition, two automotive test rigs, including one torsion bar test tank, were built. The schedule originally called for 10 prototypes followed by 24 pre-production tanks. Completion of all 34 vehicles was originally slated for 1988 and delivery by 1990, but the technical problems in the program seriously delayed this schedule. The first low-rate initial pre-production Arjun tank was delivered in January of 1996. This run came to 15 tanks, each apparently with various component improvements.

The most recent plan was to produce up to 124 Arjun tanks through 2002 for extended operational tests. Changes resulting from these tests were to be incorporated into the design before full-scale serial production of the Arjun Mark II begins. As of 2002, a single Arjun Mark II had been fabricated. It was originally planned that more than 2,000 Arjun tanks would be delivered over a 10- to 15-year period, but, as detailed further on, this is now not possible.

Description. As of 2002, only a minimal amount of technical information has been released regarding the engine, armament, fire-control, and other major systems of the Arjun. This is probably because many of the components have yet to be selected.

The array of prototype Arjun tanks have been modified as the technical and design problems became apparent. For example, the serious shot trap between the turret and hull that existed on the first Arjun tanks was eliminated. The Arjun is of fairly conventional design with the driver seated forward, the fighting compartment in the center, and the powerpack to the rear. As an aid to survivability, the ammunition is stored in watertight containers. A fire detection and suppression system is also fitted. The Indian Defence

Metallurgical Laboratory has developed a new composite armor, Kanchan, for the Arjun. When placed into production, the Kanchan armor will be manufactured by Mishra Dhatu Nigam.

Arjun Program Problems. In mid-1986, it was learned the Arjun program was in serious trouble. The prototypes were reported to have major problems with fire control, but the main problem was still in the powerpack. In fact, the entire engine development program for the Arjun has been especially troublesome, leading to a delay of the overall program by well over 50 months. The technical troubles in the fire-control system have led to significant delays. In addition, the original design had a serious shot trap between the turret and hull.

The technical troubles with the engine have plagued the Arjun program from its beginning. Although the first six prototypes had the Motoren- und Turbinen-Union diesel, the rest of the prototypes were originally fitted with the indigenous Kirloskar diesel, then rated at 373 kilowatts (500 horsepower). However, the 12-cylinder, variable compression ratio, air-cooled engine was expected to put out 1,119 kilowatts (1,500 horsepower) in the Arjun application. One source states that in the effort to increase the power output, most recently put at slightly over 746 kilowatts (1,000 horsepower), the engine's reliability has dropped to unacceptably low levels. This problem was still a concern in mid-1988, when a decision-making process related to the powerpack began. However, work to complete the development of this indigenous engine technology has continued.

Due to the engine development problems, additional diesel engines had to be imported from Germany and installed in additional prototypes to keep the program moving ahead. In 1988, India essentially gave up on the Kirloskar engine as the engine for the first production Arjun tanks and evaluated other options, including the Motoren- und Turbinen-Union MB 873 Ka 501, the Perkins (Rolls-Royce) Condor V12-1200, and the Textron Lycoming AGT 1500. Information then indicated that the German engine had been selected to power the production Arjun tanks. But in at least the first 15 low-rate production tanks, there was a mismatch between the engine and gearbox. This necessitated a redesign of the hull, which resulted in pronounced bulges. However, as noted above, the effort to get the Kirloskar engine put right is continuing, and official statements still claim it will be used on the Arjun sometime in the future, although other sources state that the Kirloskar program has been abandoned.

Continued Development – And Continued Problems. Despite the technical problems in the development

program, India has stayed with it, and in mid-1993 it was announced that the initial low-rate serial production program covering 15 tanks had begun. However, continued technical problems with the integration of the German engine, the fire-control suite, and the gun control system again delayed this schedule. The rejection of the indigenously developed fire-control suite in October 1994 added a further significant delay to the program, and the first initial low-rate serial pre-production tank was finally delivered in January of 1996.

Problems continued to plague the program, and in 1998, the Indian Comptroller and Auditor General issued a scathing report criticizing the Arjun program for continued technical deficiencies and low levels of operational maneuverability and system reliability. The report further stated that the tank failed to meet the Indian Army's standards in numerous areas. Further criticisms in the 1998 report are:

- The engine overheats, especially in the critical desert regions of India.
- The fire-control system performs erratically and with unpredictable accuracy. The report noted that the Indian Army was on record as stating that the current fire-control system had reached its limits of development and could not be improved further.
- The tank cannon is not accurate, which is possibly a result of low manufacturing standards.
- Containerization of the main armament ammunition is unsatisfactory.
- The main armament cannot be fired over the engine deck at 0° elevation, due to the design of the engine-cooling component.
- The level of protection and overall survivability of the tank is questionable.

- The tank is too wide, which affects both local transport and battlefield maneuverability.
- The 60 tonne weight is excessive. It affects local transport and requires the development and procurement of specialized transport wagons. The weight also yields an unacceptably low power-to-weight ratio and reduces battlefield maneuverability.

The report further criticized the program's level of imported content of the supposedly indigenous tank, which rose from 27 percent in 1987 to nearly 60 percent in the 15 low-rate production tanks.

Program Dies. By 2001, the problems with the Arjun were such that India had decided to procure the Russian T-90 tank in a licensed assembly/coproduction program. Although the development of the Arjun was continued, the writing was on the wall for the program. Indian officials connected with the program became embarrassed when queried over it. It appeared that the government was allowing the program to go dormant, at least for the tank portion. The final nail in the coffin came when the advent of a new indigenous tank program, the Karan, came to pass in late 2001. However, as noted above, the base chassis of the Arjun may still be used as the basis of India's requirement for a new self-propelled artillery system.

It seems that India has been overambitious with the Arjun program from its beginning. A tank, especially one designed for the 1990s and beyond, is an extremely sophisticated and complicated piece of equipment. India had to learn the hard way that it is relatively easy to license-assemble tanks that the developing organization has already spent the equivalent of hundreds of millions of dollars and years to research and design. This simple license-manufacturing of other designs is not so easily transferred to the development of a completely indigenous design.

Funding

Funding for development of the Arjun has been provided by the Indian Ministry of Defence through the Defence Research and Development Organization and the Indian Army.

Recent Contracts

Not available, as contractual information is not released.

Timetable

This timetable relates to the Arjun program only and not to the Indian license-manufacture of the Mark 1 or T-72.

<u>Month</u>	<u>Year</u>	<u>Major Development</u>
	1972	Requirement issued
	1974	Development begun
April	1985	First prototype rolled out
	1985-1991	Additional prototypes fabricated
July	1986	News circulated of technical troubles
	1986-1996	Contractor and operational testing
October	1994	Indigenous design fire-control suite rejected
January	1996	First initial low-rate pre-production Arjun tank delivered to Indian Army
Early	1998	Fifteenth low rate pre-production Arjun tank delivered to Indian Army
June	1998	Comptroller and Auditor General released critical report on Arjun program
January	1999	India decided to procure the T-90 tank
Early	2002	Program going dormant as last low-rate production tanks are completed

Worldwide Distribution

Export Potential. India had difficulty getting rid of its old Centurion tanks in a glutted market. Although India has not tried to sell the Vijayanta, T-54/55, or T-72 on the export market, any export of Arjun was going to be a difficult process at best, due to the increasing number of competitors offering new tanks. A major handicap is the fact that the program's technical troubles are widely known throughout the world.

Countries. **India** (33 prototype/developmental and low-rate production tanks).

Forecast Rationale

Our latest review of the Arjun program finds that India has finally thrown in the towel for the long troubled Arjun tank, which is referred to in some quarters as a "national disaster." But the advent of the new Karan tank program indicates that this nation remains doggedly committed to field an indigenous tank. The only bright spot in the entire Arjun program is the possibility that the base chassis will be utilized as the

basis for the country's long delayed self-propelled artillery program.

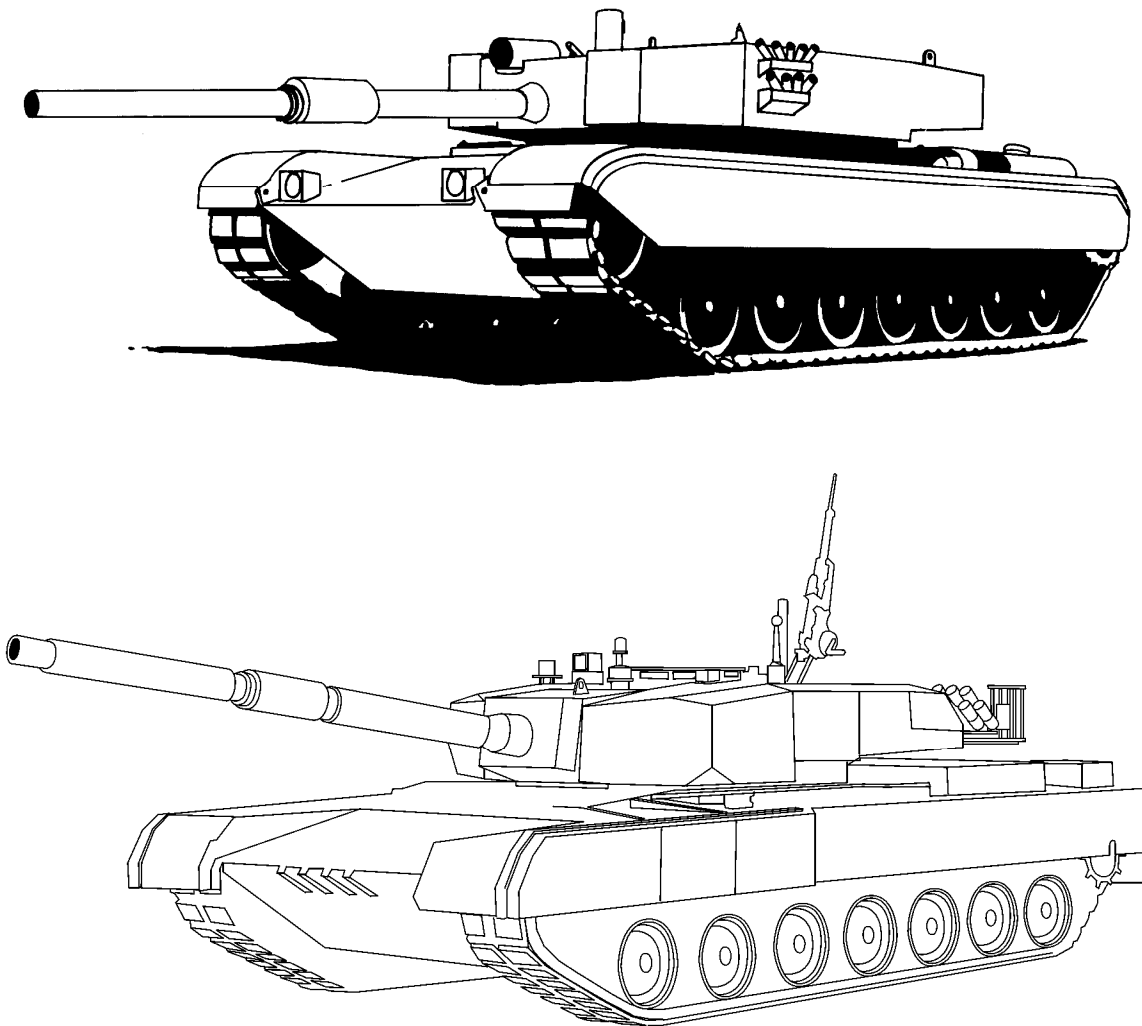
Our latest forecast has the remaining tanks already on the production line (where they have been for months) to be completed and the program ended. Although no further production of the Arjun tank is forecast, we will continue to monitor developments in this, as well as all the other Indian tank programs.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR PRODUCTION

Vehicle	(Engine)	<u>High Confidence</u>				<u>Good Confidence</u>				<u>Speculative</u>			Total 02-11
		through 01	02	03	04	05	06	07	08	09	10	11	
AVADI COMPANY													
ARJUN (a)	MB 838 KA 501	33	9	0	0	0	0	0	0	0	0	0	9
Total Production		33	9	0	0	0	0	0	0	0	0	0	9

(a) Production through 2001 includes the initial twelve prototype tanks (including six fabricated from mild steel), three automotive test rig tanks, 15 additional pre-production tanks for extended service trials and one prototype Arjun Mark II tank.



ARJUN (first prototypes)

Source: Forecast International