

# ARCHIVED REPORT

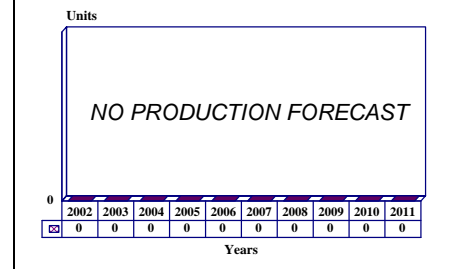
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## GC-45 and FGH-155 155 mm Howitzers – Archived 1/2003

### Outlook

- Production of the late Dr. Gerald Bull's pioneering GC-45 has been completed; no further production forecast
- No further action in FGH-155 program expected
- This report is being maintained only to describe Extended Range Full Bore history and technology

10 Year Unit Production Forecast  
 2002 - 2011



### Orientation

**Description.** Towed 155 millimeter artillery systems.

**Sponsor.** The GC-45 artillery system was a private venture program of the Space Research Corporation of Canada. The FGH-155 program was sponsored by Space Research Corporation Limited with Desarrollos de Sistemas y Technologies SA.

**Contractors.** This technology was developed and (as the GC-45) previously manufactured by the original Space Research Corporation of Canada, with the assembly of 10 pieces performed by the old Voest-Alpine firm of Austria. Subsequently, SRC International SA of Brussels, Belgium, was formed jointly by Space Research Corporation of Canada, which developed and started producing the artillery piece, and the former Poudres Reunies de Belgie of Belgium. Following the demise of Space Research Corporation of Canada, SRC International held the marketing/production rights for the artillery piece, although no production was undertaken. The license was transferred to the former Voest-Alpine firm of Linz, Austria, where production of a slightly modified version of the GC-45 was undertaken as the GHN-45. In 1981, the late Dr. Gerald Bull formed a new Space Research Corporation Limited as a separate entity under the SRC Group of Companies in the United Kingdom. Before Dr. Bull's murder and the breakup of the reformed Space Research Corporation,

the firm was working in conjunction with several of its subsidiaries and other firms in the continued development of the Extended Range Full Bore/45 caliber technology. One piece, designated 155/45 ST-012, was fabricated in Spain under an agreement with Desarrollos de Sistemas y Technologies SA (SITECSA) in conjunction with Explosivos Rio Tinto SA of Madrid. The People's Republic of China was also involved in this development program, fabricating some components. Meanwhile, before its demise, the second Space Research Corporation was further developing the 155/45 ST-012 under the designation FGH-155.

**Licensees.** A number of technology transfer agreements for the Extended Range Full Bore/45 caliber technology have been in effect over the years. Due to the confusion surrounding the breakup of the second Space Research Corporation and the proprietary nature of the technology, it is not known whether a license for the continued development or manufacture of the FGH-155 in itself is or was in effect. In any event, beginning in the mid-1980s, the Extended Range Full Bore/45 and greater caliber technology was being exploited by a steadily increasing number of firms and organizations in various nations. The technology has

been further developed, especially in relation to the ammunition and 52 caliber ordnance.

**Status.** The GC-45 as such is no longer in production; the 12 pieces produced are in service with the Royal Thai Marines. A modified version of this piece was manufactured as the GHN-45 for several nations' armed forces. This program, which is enjoying a new lease on its production life, is covered in a separate report in this tab. Prior to April 1990, the development of the technology, first as the ST 155/45 and later as the FGH-155, was continued by the second Space Research Corporation and possibly one or more additional firms under license. The development of the Extended Range Full Bore base technology also continued. The status of these programs has been unclear since the liquidation of Space Research Corporation in April 1990, although the

development of the ST-012 went dormant many years ago.

**Total Produced.** A total of 12 GC-45 pieces, one 155/45 ST-012 (FGH-155 Mark 1), one FGH-155 Mark 2 and one 155/45 ST-012B (Polyvalent carriage) were manufactured.

**Application.** Fire support for the field army at the battalion level.

**Price Range.** The GC-45 is no longer in production; in equivalent 1982 United States dollars, the unit price of the very similar GHN-45 was put at \$511,700. If placed into production in 1990, the unit price of the ST-155/45 and FGH-155 would have been slightly higher. If this piece were placed into production in 2002, it would have an estimated \$607,200 unit price in equivalent United States dollars.

## Technical Data

### GC-45

Crew. Eight

Shield. None

Muzzle Brake. Multibaffle

**Ammunition.** The GC-45 uses separate-bagged ammunition. This artillery system was designed to fire the Space Research Corporation-developed Extended Range Full Bore (including Base Bleed) projectiles; in addition, all standard NATO pattern 155 millimeter ammunition could be fired.

Recoil System. Hydropneumatic

Breech Mechanism. Interrupted screw.

Carriage Type. Split trail.

**Dimensions.** The following data are for the original GC-45 as manufactured by Space Research Corporation of Canada.

	<u>SI units</u>	<u>US Units</u>
Caliber	155 millimeters	6.10 inches
Length overall	10.82 meters	35.50 feet
Barrel length	45 calibers/6.98 meters	45 calibers/22.90 feet
Traveling width	2.69 meters	8.83 feet
Firing width	10.36 meters	33.99 feet
Traveling height	3.28 meters	10.76 feet
Firing height	3.45 meters	11.32 feet
Traveling weight	8.22 tonnes	9.06 tons
Firing weight	8.22 tonnes	9.06 tons

**Performance.** The range figure is with the Extended Range Full Bore/Base Bleed Mark 10 Mod 2 projectile with M11 charge. This artillery piece is designed to be towed by a 5-tonne-class truck at a maximum speed of 90 kilometers per hour (55.9 miles per hour).

	<u>SI units</u>	<u>US Units</u>
Elevation	+69°	+69°
Depression	-5°	-5°
Traverse	45°left/45°right	45°left/45°right
Maximum range	39,000 meters	42,650.4 yards
Maximum rate of fire	4 rounds per minute	4 rounds per minute
Sustained rate of fire	2 rounds per minute	2 rounds per minute

**155/45 ST-012/FGH-155 Mark 1**

Crew. Eight	Shield. None
Muzzle Brake. Multibaffle	Ammunition. The 155/45 ST-012/FGH-155 Mark 1 uses separate-bagged ammunition. This artillery system was designed to fire the Space Research Corporation-developed Extended Range Full Bore projectiles; in addition, all standard NATO 155 millimeter ammunition could be fired.
Recoil Mechanism. Hydropneumatic	
Breech Mechanism. Horizontal sliding block.	
Carriage Type. Split trail.	

Dimensions. The following data are for the Mark 1 version of the 155/45 ST-012/FGH-155 Mark 1; the FGH-155 Mark 2 is essentially the same.

	<u>SI units</u>	<u>US units</u>
Caliber	155 millimeters	6.10 inches
Length overall	13.51 meters	44.32 feet
Barrel length	45 calibers/6.98 meters	45 calibers/22.90 feet
Traveling width	2.70 meters	8.86 feet
Firing width	9.93 meters	32.58 feet
Traveling height	2.20 meters	7.21 feet
Firing height	2.53 meters	8.30 feet
Traveling weight	9.70 tonnes	10.69 tons
Firing weight	9.69 tonnes	10.68 tons

Performance. The range is with the Extended Range Full Bore/Base Bleed Mark 10 Mod 2 projectile with M11 (Zone 10) charge fired from the 45 caliber ordnance; the same charge and non-base bleed projectile fired from the optional 52 caliber ordnance yields a range of 31,759 meters (34,731.6 yards). This artillery piece is designed to be towed by a 5-tonne-class truck at a maximum speed of 90 kilometers per hour (55.9 miles per hour).

	<u>SI units</u>	<u>US Units</u>
Elevation	+72°	+72°
Depression	-5°	-5°
Traverse	35°right/35°left	35°right/35°left
Maximum range	39,000 meters	42,650 yards
Maximum rate of fire	4 rounds/minute	4 rounds/minute
Sustained rate of fire	2 rounds/minute	2 rounds/minute

## Variants/Upgrades

Variants. None at this time, and none are expected, although optional ordnances 39, 45, 50 and 52 calibers in length were developed for integration with the basic carriage and mount of the 155/45 ST-012/FGH-155 Mark 1 and Mark 2.

Auxiliary Propulsion Unit The Mark 2 version of the FGH-155 originally used a Deutz BF 6L913 air-cooled diesel engine rated at 122.34 kilowatts (164 horsepower) driving a hydraulic pump which operates all system functions in addition to driving the wheels.

The last version on the Polyvalent carriage used a Lombardino DS 105 air-cooled diesel engine rated at 82.06 kilowatts (110 horsepower).

Modernization and Retrofit Overview. This is not applicable for the Spanish developmental pieces. There is a limited potential for various enhancements to the 12 pieces issued to the Thai Marines to integrate portions of the GHN-45 technology as part of a general refurbishment.

## Program Review

**Background.** By the early 1960s, Dr. Gerald Bull, a Canadian, was already a world-famous scientist involved in ballistics and missile technology. Dr. Bull set up the Space Research Corporation in order to further develop several of his ideas, among them the use of very large guns to shoot satellites into orbit. In addition, Dr. Bull's firm developed his revolutionary ideas to more aptly suit conventional artillery. To this end, his Space Research Corporation Canada began development of the GC-45 155 millimeter howitzer as a private venture in 1968. The piece was developed to fire the specialized Extended Range Full Bore projectiles. In addition, it can fire all standard and specialized NATO ammunition. Further, it fires the projectiles at a higher muzzle velocity and much greater range than achievable with 39 caliber systems, still representing the majority of 155 millimeter artillery in the early years of the new century. This demonstrated performance is a result of lower breech pressure due to the larger (23 liter) chamber and the 45 caliber barrel, as well as the incorporation of base bleed technology in the Extended Range Full Bore projectiles.

**Development.** Taking note of the performance disparity between NATO and Warsaw Pact artillery, Space Research Corporation of Quebec, Canada, and of Vermont, United States, began to develop technology in the early 1960s to redress this disparity. Space Research Corporation ballisticians approached the problem from a purely ballistic angle. Basically, they refined the shape of the 155 millimeter projectile to greatly reduce wave drag. The first-generation result was termed Extended Range Sub-Caliber and used a discarding sabot and driving band along with a minimally streamlined shell. This resulted in an increase in range of approximately 8 kilometers compared to the standard M107 projectile when fired from the M109 self-propelled howitzer. However, the payload and other performance criteria were below those of the M107 projectile, so the firm continued the development process with the Extended Range Sub-Bore. This projectile was much more streamlined and employed four nubs in addition to a discarding drive band to achieve a 22 kilometer range with a payload closer to that of the standard M107 155 millimeter High Explosive projectile. However, the still reduced payload, along with trouble with the driving band, prompted Space Research Corporation to develop the Extended Range Full-Bore ammunition. This third-generation round combined the best features of the Extended Range Sub-Bore projectile (full ogive shape, boat-tail and the bore riding nubs) with the maximum

possible payload. Because the base of the round is a full 155 millimeters in diameter, a fixed rather than a discarding drive band could be used. With the addition of base bleed technology, a phenomenal range of almost 40 kilometers can be attained with the GC-45 artillery piece. Space Research Corporation developed the GC-45 to meet the then-expected NATO requirement for artillery with a 30+ kilometer range *without* rocket assistance.

**Problems.** In the mid-1970s, the Republic of South Africa turned to Space Research Corporation Canada technology for the modernization of its artillery park. Whether actual full-up weapons, components thereof or simply technology was transferred is still not known. Meanwhile, a new corporation was set up in Belgium to market the GC-45 and the Extended Range Full Bore ammunition worldwide. Formed with the cooperation of the old Poudres Reunies de Belgie ammunition firm, the new company was called SRC International. In 1978, SRC International concluded a contract with Thailand for two batteries (12 pieces) of the GC-45 and the Extended Range Full Bore ammunition. Fabrication of the 12 GC-45 pieces for this order began at the Space Research Corporation facilities at Highwater, Quebec. As these facilities were mainly involved with research and development, the GC-45 pieces were essentially hand-built. In November 1980, Space Research Corporation Canada's dealings with South Africa, deemed a violation of the United Nations-imposed arms embargo as well as various Canadian and United States arms export laws, were exposed, forcing the company to shut down. By that time, Space Research Corporation Canada had completed two of the 12 pieces for the Thai order. These were essentially hand-built pieces that were not optimized for serial production.

**Further Development.** After the original Space Research Corporation was closed down, the Canadian government concluded the Thai contract on a government-to-government basis, with Poudres Reunies de Belgie producing the ammunition and Voest-Alpine of Austria assembling the remaining pieces (Space Research Corporation Canada had already delivered the first two pieces). SRC International, still operating from its headquarters in Brussels, retained the marketing and production rights for both the 45 caliber ordnance and ammunition along with the Extended Range Full Bore modification kit for the M114 howitzer; however, none were produced. South Africa went ahead on its own and put a modified version of the GC-45 into production as the G5 and in self-propelled form as the G6. These two systems are covered in

separate reports in this book. These artillery systems have achieved ranges of 46 kilometers.

In 1981, it was announced that the Voest-Alpine firm had acquired the GC-45 marketing/production rights and would henceforth produce the GC-45 in modified form as the GHN-45; this program is covered in a separate report in this tab. SRC International retained a portion of the marketing and license production rights for the ordnance and ammunition for a short time after the Voest-Alpine announcement and then was shut down. In 1981, Dr. Bull set up a new Space Research Corporation to continue to development of artillery technology. This is described below.

**GC-45 Description.** The carriage and other structural components of the GC-45 are built with high-alloy steel, while the barrel is of high-yield steel autofrettaged construction. The breech assembly has an automatic cam which opens the breech when the barrel assembly returns to the battery position and closes when the cam is swung out of engagement.

A loading tray, mounted at the rear of the cradle, can be swung away and moves in elevation with the barrel assembly. A telescopic rammer is powered pneumatically and rotated into place for loading at high elevation angles. The system is easily maintained in the field and the pneumatic bottle is rechargeable.

The suspension uses a walking beam which allows the gun to be towed at speeds of 90 kilometers per hour (55.9 miles per hour). The wheeled walking beam pivots easily and provides additional mobility for cross-country operations. A screw jack and float system, mounted under the carriage, permits one crew member to jack the gun in 90 seconds. The release of the ball jack allows the gun to settle on the undercarriage wheels. The trails can be spread to wide angles to permit manhandling by the gun crew to traverse 360° quite easily. The spades are pivoted, which permits four angular positions in order to minimize the handling of these heavier components. Trail lifting assemblies are fitted with rubber tires and can be lifted or lowered by handwheels as needed.

**Ammunition.** The GC-45 was designed to fire the Space Research Corporation-developed Extended Range Full Bore projectile weighing 45.4 kilograms (100 pounds) and containing 8.8 kilograms (19.4 pounds) of high explosive. Numerous other types of Extended Range Full Bore ammunition have subsequently been developed and are produced by a large and growing number of firms. Included in these types are Extended Range Full Bore-High Explosive, Extended Range Full Bore-High Explosive/Base Bleed, Extended Range Full Bore/White Phosphorous,

Extended Range Full Bore/Illumination, and Extended Range Full Bore/Smoke-Base Eject. The GC-45 is compatible with all these rounds.

**FGH-155.** In 1985 it was learned that the new Space Research Corporation was further developing the GC-45 design into a new system that the company designated FGH-155. Many design changes were incorporated into this new piece, among them a 30 percent reduction in the number of parts as compared to the GC-45; a new worm and spur traverse mechanism and bearing which eliminates two gearboxes of the original design; and the incorporation of a much simpler pneumatically powered elevation system which eliminates the twin equilibrators of the GC-45 and three types of self-obturing breech mechanisms: sliding block, interrupted screw, and bayonet. Wider self-digging spades were also fitted, as were manually pumped hydraulic systems for activation of the trail wheels and float. One of the major improvements was deepened rifling with a progressive twist. This last parameter, when combined with the use of specialized driving bands, was seen as a way to extend barrel life as expressed in terms of accuracy in light of the increased muzzle velocities associated with the Extended Range Full Bore technology. A new modular charge system which incorporated a new single base, cool-burning propellant was also being developed. This new artillery system was being developed with several different barrels and chamber capacities:

<u>Ordnance Length</u>	<u>Chamber Capacity</u>
39 calibers	18 liters
45 calibers	23 liters
50 calibers	32 liters
52 calibers	23 liters

All the above ordnances are compatible with all NATO standard ammunition types, as well as Extended Range Full Bore and Extended Range Full Bore/Base Bleed types.

The FGH-155 was being developed in two basic production models. First, the Mark 1, for which the above technical data and description are pertinent, was fabricated in Spain by Desarrollos de Sistemas y Technologies SA (SITECSA) under an agreement with the second Space Research Corporation; it is designated 155/45 ST-012. This weapon features a horizontal sliding wedge breech block assembly provided by the People's Republic of China. This assembly is the same as used on the Type 59-1 130 millimeter field gun, which is itself a direct copy of the M-46 field gun of the former Soviet Union. The M-46 has earned a worldwide reputation for simplicity and ruggedness. This case-obtured breech assembly was possibly

devised to satisfy users that dislike self-obturator breech assemblies because foreign matter can enter the breech.

The FGH-155 Mark 2 was fabricated by the second Space Research Corporation in Belgium before it was shut down. This weapon features a Deutz BF 6L913 air-cooled diesel-based auxiliary propulsion unit. The FGH-155 Mark 2 is fitted with a driver's station, powered hydraulic system and interrupted screw breech assembly, and 45 caliber ordnance. Before its shut down, Space Research Corporation was working on a Mark 3 model featuring an all-new low-pressure 50 caliber ordnance. This new ordnance had a chamber volume of approximately 32 liters (1,952.64 cubic inches). This ordnance would operate at a pressure of around 2,800 bar.

The Mark 4 was still a proposal when the new Space Research Corporation was terminated in April 1990. It would have featured full hydraulic controls, a new muzzle brake, and the new bayonet breech assembly Dr. Bull was developing before his murder. This innovative design is a screw type, but the screw threads are machined onto the exterior of the chamber; a mushroom-shaped obturator is used. This design is lighter yet stronger than all other designs and is also highly cost-effective to manufacture.

Finally, Space Research Corporation planned a turret for the FGH-155 for the future. This turret was planned for integration with an unspecified wheeled vehicle chassis.

The second Space Research Corporation had also begun development of a so-called Polyvalent carriage system featuring a modified recoil system, advanced lightweight materials, quick change barrel technology, and other features to ease operation and maintenance. SITECSA and Space Research Corporation further refined this Polyvalent technology in a third prototype of the ST-012 called the ST-012B, revealed in 1990. The enhancements in this prototype included reduced weight, a new elevation system, modified wheels, a new

design muzzle brake, a new firing jack, and a new auxiliary power unit with a different diesel engine.

Following extensive evaluations of the prototypes by the Spanish Army, in July 1988 the FGH-155 was approved for Spanish procurement as the ST-155/45, also referred to as the 155/45 ST-012. However, due to international business complications, a production order was never placed. Originally the serial production of the piece and ammunition was to be headed by SETSA Ingenieria, a joint venture of Space Research Corporation and Union Explosivos Rio Tinto SA. In 1986, a new firm to replace SETSA Ingenieria was set up. This firm, called SITECSA Desarrollos de Sistemas y Technologies SA, for a period led the Spanish effort to complete the development of the piece. However, this firm as well as the associated programs fell by the wayside following the events of 1990.

Space Research Corporation Dissolved. On March 22, 1990, in a still unsolved crime, Dr. Bull was murdered at his home in Brussels. Following this event, Dr. Bull's son Michael announced on April 19, 1990, that the company was being dissolved. The firm's scientists and technicians dispersed to various firms and organizations throughout the world and the programs, at least as they were then known, disappeared.

Operational Analysis. The world is finally appreciating the advantages of Dr. Bull's favorite technology. It is catching on in many nations and is being investigated by several major countries. The Extended Range Full Bore concept, integrated with base bleed technology, *has proven itself*, and that proof has been in the acid test of combat. The severe bore erosion reported in the GHN-45 pieces used by Iraq was long ago traced to defective ammunition that was not up to the demanding standards required of this high-performance technology. With the excellent performance of the Extended Range Full Bore technology now well known worldwide, it is only a matter of time until this unique and available technology fully catches on in the general mainstream of nations.

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## Funding

The GC-45, FGH-155 and 155/45 ST-012 were developed with private funding.

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## Recent Contracts

None

## Timetable

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The following timetable includes all developments of the original GC-45 system.

<u>Month</u>	<u>Year</u>	<u>Major Development</u>
	1975	Initial development of GC-45 begins
Mid	1977	First preproduction prototype of GC-45 fabricated
	1977-1979	Testing and evaluations of GC-45
Late	1970s	GC-45 technology transferred to South Africa
February	1978	SRC International set up in Belgium to market the GC-45
December	1979	G5 program revealed
March	1980	Initial production of GC-45 by Space Research Corporation Canada
November	1980	Space Research Corporation Canada ceases operations
	1981	Modification kits introduced for M114 howitzers by SRC International
	1981	Voest-Alpine acquires marketing and production rights for the GC-45 and Extended Range Full Bore ammunition
October	1981	Voest-Alpine begins manufacturing the GC-45 as the GHN-45
November	1985	FGH-155 (ST 155/45) development begins
	1986	First FGH-155 prototype fabricated
January	1987	First FGH-155 prototype delivered for test firing
	1987	Initial FGH-155 firing trials begin
October	1987	Second FGH-155 prototype delivered
July	1988	FGH-155 approved for Spanish procurement as the ST-155/45
March	1990	Dr. Bull murdered
April	1990	Space Research Corporation dissolved
Late	1990	Third prototype of ST-155/45 ST-012 with Polyvalent carriage revealed
Early	1990s	Development of ST-012 system goes dormant in Spain

## Worldwide Distribution

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**Export Potential.** While the present distribution of the GC-45 is limited and the FGH-155 (as the ST-012) never received a production order, our long-standing outlook for the future of the basic technology pioneered by Dr. Bull is now being realized.

**Countries.** **Spain** (three prototypes), **Thailand** (12 GC-45).

## Forecast Rationale

Despite the fact that production of the GC-45 ended long ago, this report is being maintained so that a full description of this increasingly world-standard artillery technology can be provided. This technology is referred to in the other applicable reports. The GC-45, the first-generation 155 millimeter artillery system using Dr. Bull's revolutionary technology, will long be remembered, as it introduced the only truly new artillery technology to be fielded in half a century.

The SITECSA Desarrollos de Sistemas y Technologies SA firm, along with its developments of the FGH 155, is moribund.

Extended Range Full Bore technology, in 45 and 52 caliber form, is being exploited in a number of towed and self-propelled artillery designs. These systems are detailed in the reports in this tab as well as Tab A of this book.

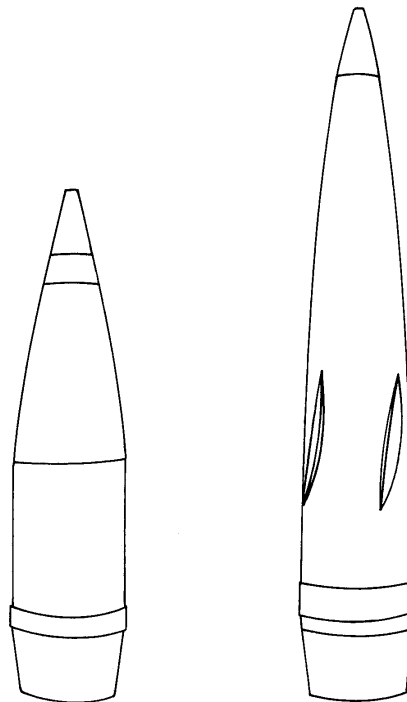
## Ten-Year Outlook

### ESTIMATED CALENDAR YEAR PRODUCTION

Ordnance	(Engine)	through 01	High Confidence Level			Good Confidence Level			Speculative			Total 02-11
			02	03	04	05	06	07	08	09	10	
SITECSA/SPACE RESEARCH CORPORATION												
FGH-155(a)	NO ENGINE	3	0	0	0	0	0	0	0	0	0	0
Subtotal - SITECSA/SPACE RESEARCH CORPORATION		3	0	0	0	0	0	0	0	0	0	0
SRC INTERNATIONAL SA												
GC-45(b)	NO ENGINE	12	0	0	0	0	0	0	0	0	0	0
Subtotal - SRC INTERNATIONAL SA		12	0	0	0	0	0	0	0	0	0	0
Total Production		15	0	0	0	0	0	0	0	0	0	0

(a) The historical production is for the prototype and developmental pieces. One of these was used for evaluations by Spain.

(b) The historical production includes no prototype/developmental pieces; all production was sent to Thailand. Two units were assembled by Space Research Corporation of Canada and the remainder by the old Voest-Alpine firm.



COMPARISON OF STANDARD 155 mm M107 (L) AND ERFB (R) PROJECTILES

Source: Forecast International