

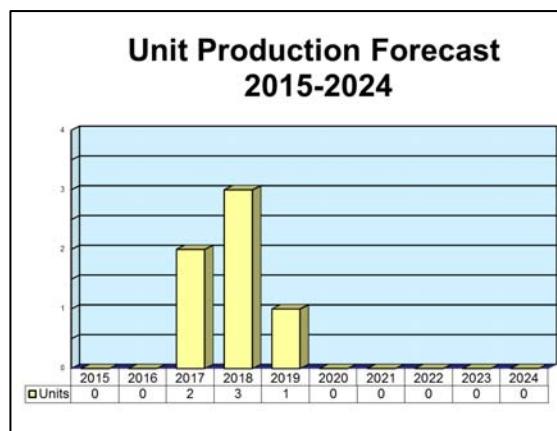
ARCHIVED REPORT

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FH 88, FH 2000 and SLWH Pegasus 155mm Howitzers

Outlook

- FH 88 out of production; FH 2000 and SLWH Pegasus lines remain dormant
- 2012: SLWH Pegasus lost both Australian and Indian towed howitzer competitions to the BAE Systems M777A2 Joint Lightweight Howitzer
- Forecast reflects ST Kinetics' expectations for at least two FH 2000 export orders during the forecast period



Orientation

Description. Towed 155mm artillery systems.

Sponsor. Singapore Technologies Kinetics sponsored the development of these weapons as private ventures.

Licensees. None.

Status. The production lines for the FH 88, FH 2000, and SLWH Pegasus are dormant. The FH 2000 and SLWH Pegasus remain available for future orders.

Total Produced. Through 2014, we estimate the contractor produced 62 FH 88, 38 FH 2000, and 37 SLWH Pegasus artillery pieces.

Application. Indirect fire artillery support for maneuver forces at the battalion through division levels.

Price Range. In 1991 U.S. dollars, the FH 88 carried a unit price of \$551,300.

In 2004 U.S. dollars, the FH 2000 carried a unit price of \$589,300.

Research suggests ST Kinetics may offer the SLWH Pegasus on the international market with a unit price in the \$575,000 range.

Contractors

Prime

Singapore Technologies Kinetics Ltd	http://www.stengg.com , 249 Jalan Boon Lay, Singapore, 619523 Singapore, Tel: + 65 6265 1066, Fax: + 65 6261 6932, Email: comms.kinetics@stengg.com, Prime
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FH 88, FH 2000 and SLWH Pegasus 155mm Howitzers

Subcontractor

Deutz Asia-Pacific (Pte) Ltd	http://www.deutz.com.sg , 10 Gul Crescent, 629523 Singapore, Tel: + 65 6672 7800, Fax: + 65 6264 1779, Email: dap@deutz.com (APU Diesel Engine)
Honeywell Regelsysteme GmbH, Sondertechnik	http://honeywell.com , Honeywellstrasse 2-6, Maintal, 63477 Germany, Tel: + 49 06181 401 0, Fax: + 49 06181 401 592, Email: contact.st@honeywell.com (Flick Rammer)

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Technical Data

155mm FH 2000 Howitzer

Source: Singapore Ministry of Defense

FH 88 and FH 2000**Crew.** Six to eight.**Muzzle Brake.** Double-baffle.**Recoil System.** Hydro-pneumatic.**Breech Mechanism.** Interrupted screw stepped-thread.**Carriage Type.** Split trail.**APU.** The FH 88 and FH 2000 employ a locally produced Deutz air-cooled, supercharged diesel engine

for auxiliary power/propulsion. This engine generates 72 kilowatts (96.51 hp), with a power-to-weight ratio of 5.6 kilowatts per tonne (6.84 hp/ton) in the FH 88 application and 5.45 kW/tonne (6.63 hp/ton) in the FH 2000 application.

Shield. None.

Ammunition. The FH 88 and FH 2000 are compatible with all NATO-standard separate-bagged 155mm ammunition, including Extended Range Full Bore/Base Bleed projectiles and modular charge technology.

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Dimensions. The following data reflect the last production-standard FH 88, with a 39-caliber barrel. Data for the FH 2000, with the 52-caliber barrel, are in parentheses where different.

	<u>SI Units</u>	<u>U.S. Units</u>
Caliber	155 mm	6.10 in
Length overall	9.88 (10.95) m	32.41 (35.92) ft
Barrel length (FH 88)	39 cal/6.02 m	39 cal/19.75 ft
Barrel length (FH 2000)	52 cal/8.06 m	52 cal/26.44 ft
Traveling width	2.8 m	9.18 ft
Firing width	8.3 m	27.23 ft
Traveling height	2.57 (2.55) m	8.43 (8.37) ft
Traveling weight	12.8 (13.2) tonnes	14.11 (14.55) tons
Firing weight	12.8 (13.2) tonnes	14.11 (14.55) tons

Performance. The maximum range is with the Extended Range Full Bore/Base Bleed projectile. The contractor states that the barrel life of the FH 88 firing ERFB ammunition is 1,750 equivalent full charges. With M107/M56-pattern ammunition, the barrel life is reportedly 2,000 equivalent full charges. The muzzle velocity data reflect the 39-caliber FH 88 only. Data for the FH 2000 are in parentheses where different.

	<u>SI Units</u>	<u>U.S. Units</u>
Elevation	+70°	+70°
Depression	-3°	-3°
Traverse	30° left/30° right	30° left/30° right
Maximum range	30 (40) km	32,808.33 (43,744) yd
Maximum rate of fire	8 (6) rds/min	8 (6) rds/min
Sustained rate of fire	2 rds/min	2 rds/min
Muzzle velocity	820 m/s	2,690.25 ft/s



155mm SLWH Pegasus

Source: Singapore Technologies Kinetics

Singapore Light Weight Howitzer (SLWH) Pegasus

Design Features. According to ST Kinetics, the SLWH Pegasus is the world's first 155mm/39-caliber howitzer with a self-propulsion capability that is also air-transportable by C-130 tactical transport aircraft or CH-47 cargo helicopters (via external slingload). Medium-size tactical vehicles can tow the howitzer.

Note. Although the SLWH Pegasus is in service with the Singapore Armed Forces (SAF), technical data are just beginning to trickle out regarding this weapon system. We will update this program as information becomes available.



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Crew. Eight.

Muzzle Brake. Double-baffle.

Recoil System. Hydro-pneumatic.

Breech Mechanism. Interrupted screw stepped-thread.

Carriage Type. Lightweight solid platform.

APU. The SLWH Pegasus features an auxiliary power/propulsion unit (APU) integral to the carriage

Dimensions. The following data reflect the contractor's promotional literature for the SLWH Pegasus, with a 39-caliber barrel.

	SI Units	U.S. Units
Caliber	155 mm	6.10 in
Length overall	10 m	32.8 ft
Barrel length	39 cal/6.02 m	39 cal/19.75 ft
Width overall	2.75 m	9.02 ft
Traveling height	2.4 m	7.87 ft
Traveling weight	5.4 tonnes	5.95 tons

Performance. The maximum range is with NATO-standard M107 High Explosive ammunition; range with the Extended Range Full Bore/Base Bleed projectile is in parentheses. We expect the barrel life is comparable to that of the 39-caliber FH 88 (1,750 equivalent full charges of ERFB ammunition; 2,000 equivalent full charges of M107/M56-pattern ammunition).

	SI Units	U.S. Units
Maximum range	19 (30) km	32,808.33 (43,744) yd
Maximum rate of fire	4 rds/min	4 rds/min
Sustained rate of fire	2 rds/min	2 rds/min
Muzzle velocity	820 m/s	2,690.25 ft/s

Variants/Upgrades

Variants. None.

Modernization and Retrofit Overview. Aside from the potential retrofit of the 52-caliber ordnance to the FH 88 carriage, the FH 88 and FH 2000 howitzers

have only minimal modernization and retrofit potential. As the SLWH Pegasus is relatively new to service, we do not expect to see significant modernization and retrofit potential for this piece within the forecast period.

Program Review

Background. In 1983, Ordnance Development and Engineering of Singapore – a subsidiary of Chartered Industries of Singapore – initiated the development of a new 155mm field howitzer. Between 1983 and 1986, the contractor fabricated five prototype pieces of its ODE 155 howitzer. In 1986, the contractor conducted operational tests of the new ordnance with the Singapore Armed Forces (SAF).

FH 88 Enters Service

Following the completion of these tests, the contractor placed the ODE 155 (redesignated FH 88) in serial production for the Singapore Army. The FH 88

achieved Initial Operational Capability (IOC) with the SAF in 1988.

The contractor designed the FH 88 to meet the following operational criteria:

- Continuous high rate of fire with a high burst capability
- Accurate fire capability
- A 30-kilometer range with unassisted ammunition
- High lethality with the latest types of 155mm ammunition

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- High tactical and strategic mobility with minimum time and effort for deployment
- High system reliability
- Ease of operation and maintenance
- Good man-machine interface

The resulting FH 88 design is a modern, advanced long-range towed artillery system, with a unit price at the lower end of the international 155mm towed howitzer market. In 2000, Ordnance Development and Engineering changed its name to Singapore Technologies Kinetics.

Description. The complete FH 88 system consists of the following major assemblies:

1. Ordnance
2. Superstructure
3. Auxiliary power/propulsion unit
4. Basic structure
5. Sighting system

Ordnance. The monoblock barrel of the original 39-caliber ordnance exhibits autofrettaged construction; the bore rifling consists of 48 grooves, with a 1-in-20 right-hand twist. The chamber has a capacity of 18.845 liters (1,149.9 cu in). The modified Wellin step-thread breech assembly, with a neoprene obturating ring, automatically opens during the latter portion of the recoil return stroke. Primer feed is automatic, from a 12-round magazine.

The independent hydro-pneumatic recoil system consists of the recoil brake and the recuperator/counter recoil mechanism. The Sondertechnik flick rammer can chamber a round in a third of a second. The electronically controlled, hydraulically operated flick rammer consists of a loading tray mounted on a swivel arm.

Superstructure. The superstructure of the FH 88 consists of an independent pneumatic equilibrator assembly; an alloy steel cradle assembly; the traverse-and-elevation mechanism; and the saddle assembly, which supports the elevating mass through the trunnion bearings. The superstructure also mounts the gunner's seat and platform.

Auxiliary Power/Propulsion Unit. The APU consists of the following components:

- A 72-kilowatt Deutz supercharged diesel engine
- Hydrostatic drive
- The associated hydraulic system

- The braking system
- A manually operated backup system

As with other towed howitzers, the unit provides a self-propulsion capability, power operation of the gun, and the capability to assist the prime mover in operations over rough terrain. However, the FH 88 APU is distinguished by its light weight and high power output rating.

Basic Structure. The chassis, firing platform, and trail legs form the basic structure of the piece. The conventional, hydraulically powered, split-trail legs feature permanently attached spades. Small wheels on each leg steer the piece under APU power; these wheels raise and lower hydraulically. Hydro-pneumatic cylinders on the trailing suspension arms act as shock dampers; these cylinders also raise and lower the two rear main wheels.

Sighting System. The sighting system consists of a cant compensating mount, telescopic sight, direct aiming sight, gunner's display unit, and associated wiring. All components feature self-illumination for night operations.

FH 88 Deployment Options

The 12.8-tonne (14.1-ton) FH 88 can be rigged for sling-loading beneath cargo helicopters such as the Mi-6 or CH-53. The FH 88 is also air-transportable via C-130 tactical transport aircraft. When towed by a 5-ton 6x6 truck, the FH 88 can handle speeds up to 80 kilometers per hour (49.7 mph) on paved roads and 50 kilometers per hour (31 mph) on unpaved roads.

A trained six-man gun crew can deploy the FH 88 in less than one minute; they can recover the piece in even less time. The FH 88 is very stable during firing, enhancing accuracy and ease of operation. An average crew can achieve a burst rate of fire of three rounds in 15 seconds. The maximum rate of fire is eight rounds per minute; the sustained rate of fire is two rounds per minute for one hour.

FH 2000

By the late 1980s, ST Kinetics had introduced the 52-caliber FH 2000 ordnance. With the FH 2000 (a 52-caliber version of the basic FH 88 design), Singapore became the first nation to field the new 52-caliber standard barrel configuration, conforming to the NATO Quadrilateral Ballistics Agreement. The robust design of the basic FH 88 system facilitated integration of the 52-caliber ordnance with minimal changes. The contractor offered the FH 2000 for export orders in 1990; production for SAF requirements began in 1993.



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SLWH Pegasus

The Singapore Light Weight Howitzer Pegasus represents the lightweight member of the ST Kinetics family of 155mm towed howitzers. With the fielding of this system, the SAF can standardize its field artillery assets with NATO-standard 155mm towed and self-propelled howitzers.

The SAF initially awarded ST Kinetics a contract in 1996 to develop a lightweight, air-transportable 155mm towed howitzer system with an integral self-propulsion capability. In October 2005, the SAF officially accepted the SLWH Pegasus into service. In January 2006, the 23rd Battalion Singapore Artillery underwent its Field Artillery Training Evaluation Program with the new SLWH Pegasus, testing the unit's operational readiness and proficiency.

Filling in the Blanks

Even though the SAF has fielded the SLWH Pegasus, definitive technical data and descriptive information regarding this weapon system remain spotty. In order to provide an adequate snapshot of this program, we must therefore draw a number of interim conclusions based on limited hard data.

Ordnance. Available information suggests the SLWH Pegasus may feature the same basic ordnance, hydro-pneumatic recoil system, and flick rammer of the FH 88 howitzer.

Superstructure. Photographic evidence suggests the SLWH Pegasus may feature a superstructure similar to that of the FH 88.

Auxiliary Power/Propulsion Unit. The APU consists of the following components:

- An unidentified 21-kilowatt, air-cooled diesel engine
- Hydrostatic drive, featuring an in-hub radial piston motor

- A hydro-pneumatic suspension system
- Power-assisted steering
- Two-wheel disc brakes

Like the APU of the FH 88, this unit provides a limited self-propulsion capability, power operation of the gun, and the capability to assist the prime mover in operations over rough terrain. The APU can drive the SLWH Pegasus cross-country at a maximum speed of 12 kilometers per hour (7.45 mph); the SLWH Pegasus can negotiate a 30 percent slope under its own power.

Basic Structure. The chassis and firing platform form the basic structure of the piece. The SLWH Pegasus lacks the conventional split-trail legs of most towed howitzer designs. Instead, the ordnance mounts toward the rear of the rectangular firing platform. Small wheels at each corner of the chassis/platform steer the piece under APU power; these wheels raise and lower hydraulically.

Sighting System. Photographic evidence suggests the sighting system may be generally equivalent to that of the FH 88 howitzer.

Pegasus Deployment Options

The 5.4-tonne (5.95-ton) SLWH Pegasus can be rigged for sling-loading beneath cargo helicopters such as the CH-47 Chinook. The SLWH Pegasus is also air-transportable via C-130 tactical transport aircraft. When towed by a medium truck, the SLWH Pegasus can handle speeds up to 80 kilometers per hour (49.7 mph) on paved roads and 50 kilometers per hour (31 mph) on unpaved roads.

An eight-man gun crew can deploy or recover the SLWH Pegasus in less than 2.5 minutes. According to ST Kinetics, a crew can achieve a burst rate of fire of three rounds in 24 seconds. The maximum rate of fire is four rounds per minute; the sustained rate of fire is two rounds per minute for 30 minutes.

Related News

Modernization Efforts, Concerns Over China Giving Rise to Robust Asia-Pacific Defense Market – Despite the tremors felt across much of the international defense market since the global economic downturn of 2008-09, the Asia-Pacific region will serve as a generator of military spending growth through the near- to medium-term, according to a Forecast International analysis.

While China's ongoing military expansion and modernization efforts capture most of the attention, defense spending and procurement trends in Australia, India, Indonesia, and Japan indicate significant market potential over the next five to 10 years. Australia's center-right government has made clear it intends to move forward with ambitious spending targets and big-ticket defense projects, while the outcomes of recent elections in India and Indonesia should serve to maintain - or accelerate - broad-spectrum force upgrade strategies. Japan's conservative government is charting an upward course in military investment as it seeks to cultivate a highly capable amphibious arm and offset China's growing military capability with its own high-end defense technologies.

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"Due to the strategic dynamics at play and the myriad security concerns and modernization requirements of countries across the region, defense spending is trending steadily upward and should continue to climb for the next five to 10 years barring sharp and prolonged economic slumps," states Forecast's Asia-Pacific analyst Dan Darling. "Even the smaller, developing markets of Southeast Asia are in line for steady defense investment increases as long-neglected modernization cycles are brought to the fore."

Forecast International's defense spending projection for the Southeast Asia slice of the greater market indicates annual year-on-year growth of 3.1 percent over a five-year period, an amount that would be even higher but for inflation fears and the need to factor in currency fluctuations.

Australia's annual military earmarks over that same timeframe project to 6.8 percent growth in absolute terms, while those of India, Indonesia and Japan are estimated at 2.1 percent, 2.3 percent and 6.5 percent, respectively. While not the double-digit year-on-year growth exhibited by China over its past three fiscal years, in U.S.-dollar terms this will amount to an additional \$40 billion in combined nominal military investment above the 2014 budgetary baselines for these four nations.

Ongoing exclusive economic zone (EEZ) disputes and competing territorial claims in the South and East China Seas are spurring many regional actors to improve and expand their air and sea capabilities. Whether looking for fast attack missile boats or special mission aircraft and other assets, Southeast Asian countries are placing an increased urgency on acquiring sea- and airborne force multipliers as Beijing seeks to establish de facto control over resource-rich waters alongside the coasts of Brunei, Malaysia, the Philippines and Vietnam.

"China is attempting to exert its will in contested waters and bring disputed island chains and shoals under its control as part of a larger strategy to increase its regional influence and expand its maritime domain outward while securing its sea lines of communication, and to extract greater energy and fishing resources in the process," says Darling. "But this effort to intimidate and assert control by sheer force of presence in turn triggers the fears of many regional actors."

The knock-on effect is that many of these nations are not only increasing their defense budgets and expanding their procurement requirements, but also are looking to cooperate with nations viewed by China as strategic rivals. Thus Vietnam is looking to broaden its military supply chain to include the U.S., which Hanoi hopes will lift an embargo and sell it multimission assets such as the P-3 Orion. Having eased its longstanding self-imposed weapons export restrictions in April, Japan is in a position to emerge as a defense-technology partner and supplier to the region. India is looking to Tokyo for the supply of US-2 amphibious aircraft, while Australia is interested in potentially harnessing Japanese technologies for its Collins class submarine replacement program.

In the meantime, despite burgeoning defense-technological industrial bases in many populous Asia-Pacific nations, the region continues to import foreign-sourced military hardware on a large scale. Its "Make in India" indigenization emphasis notwithstanding, India currently serves as the world's largest defense-importing nation and meets nearly 80 percent of its weaponry and equipment requirements via foreign vendors. Indonesia, Malaysia and Singapore are also import-heavy defense markets.

Excluded from the U.S. and European Union defense markets, China continues to expand its own defense industry in an attempt to achieve self-sufficiency in meeting the needs of its military. The growth of its defense manufacturing sector and qualitative leap in its capabilities have had the added effect of turning China into one of the world's largest defense-exporting nations. Aided by double-digit defense budget increases that FI estimates will continue to average close to 12 percent annually through 2019, China's military buildup shows little sign of slowing down.

"As Beijing's stated ambition has been to build a military equal in measure to the country's economic and diplomatic stature, its defense spending projections appear robust across the immediate horizon," Darling notes. "However, each announcement of another year-on-year military budgetary increase is seen in distant capitals as the intention of the world's most populous nation to become the region's hyper-power, capable of imposing its will and asserting control over disputed borders, islands, territorial waters and energy reserves through the sheer overwhelming size and power of its military. The net effect is an acceleration of military modernization and materiel expansion in countries wary of China's expanding presence." (FI, 12/14)

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Funding

The prime contractor, now known as Singapore Technologies Kinetics, funded the development of the FH 88, FH 2000, and SLWH Pegasus as private ventures.

Contracts/Orders & Options

Not available, as ST Kinetics has not released contractual information regarding these programs.

Timetable

Month	Year	Major Development
Jan	1982	Development of ODE 155 begins
	1983	Contractor fabricates first prototype
	1986	SAF conducts operational testing
	1987	Serial production of FH 88 begins
	1988	FH 88 IOC with SAF
	1990	Contractor unveils FH 2000
Oct	2005	SAF accepts SLWH Pegasus into service
Jan	2006	SLWH Pegasus undergoes initial live-fire training with SAF
Oct	2006	Australian Army considers SLWH Pegasus under Project Land 17
	2008	ST Kinetics completes initial SLWH Pegasus production run for SAF
	2012	Both Australia and India select M777A2 Joint Lightweight Howitzer over SLWH Pegasus in competitions
	2015	FH 88, FH 2000, and SLWH Pegasus production lines are dormant; FH 2000 and SLWH Pegasus remain available for new production

Worldwide Distribution/Inventories

Export Potential. Despite attracting a good deal of international interest, the FH 88, FH 2000, and SLWH Pegasus must compete in an extremely glutted international market. At least 11 other new-production towed 155mm artillery systems – most notably, the WA 021 from the People's Republic of China, which presents regional competition – are currently available. Other than Indonesia's purchase of five FH 88 howitzers in the early 1990s, these Singaporean systems have failed to attract any export business. Nevertheless, Singapore Technologies Kinetics continues to offer these howitzers; ST Kinetics continues to plan for at least two moderate-size export sales of the FH 2000 within the forecast period.

While the SLWH Pegasus offers significant market advantages as the first production-standard lightweight 155mm towed howitzer available with an integral self-propulsion capability, we have found no evidence of any export orders to date.

Countries. **Indonesia** (5 FH 88); **Singapore** (57 FH 88, 38 FH 2000, 37 SLWH Pegasus).

Forecast Rationale

ST Kinetics no longer offers the 39-caliber FH 88 towed howitzer for sale. The 52-caliber FH 2000 production line remains dormant following completion of the initial serial production run of 24 pieces for the Singapore Armed Forces (SAF).

In 2008, ST Kinetics completed the initial 37-tube production run of the 39-caliber Singapore Light Weight Howitzer Pegasus for SAF procurement. Thus

far, there are no indications the SAF plans any follow-on procurement of the SLWH Pegasus.

Indeed, during a March 2014 speech, the Singapore Minister for Defence mentioned only the intention to develop platforms such as the SLWH Pegasus to meet specific operational needs. He did not, however, indicate any new procurement of such platforms.

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Still No Export Prospects

The ST Kinetics family of 155mm towed howitzers has hardly set the international market on fire. The five-piece order from Indonesia represents the only export sales success for the FH 88. The FH 2000 has no export sales to its credit. Despite the growing worldwide interest in the fielding of rapidly deployable medium

force options, the SLWH Pegasus has likewise yet to score its first export sale.

The contractor maintains expectations for at least two FH 2000 export sales within the next five years. However, given the glutted condition of the international towed artillery market, prospects for new export sales of the FH 2000 or the SLWH Pegasus are not particularly good.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR UNIT PRODUCTION												
Designation or Program		High Confidence				Good Confidence			Speculative			
	Thru 2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Total
Singapore Technologies Kinetics Ltd												
FH 2000												
	38	0	0	2	3	1	0	0	0	0	0	6
Total	38	0	0	2	3	1	0	0	0	0	0	6

