

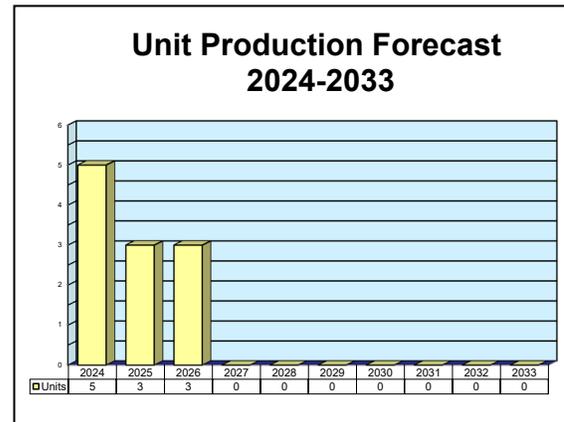
ARCHIVED REPORT

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GDF Series 35mm Anti-Aircraft Artillery Systems

Outlook

- GDF series remains an international standard for AAA systems
- Enhancement packages upgrade older systems to GDF-005 configuration
- Forecast reflects low-rate production for export orders only



Orientation

Description. Towed anti-aircraft artillery systems.

Sponsor. The prime contractor developed the GDF series as a private venture.

Status. Development through serial production.

Total Produced. Through 2023, we estimate the various contractors and licensees produced 2,806 GDF anti-aircraft artillery systems.

Application. Towed anti-aircraft artillery systems, providing tactical air defense for maneuver forces.

Price Range. In 2024 U.S. dollars, the GDF-005 series system carries an estimated unit price (not including the Skyguard fire control unit) of \$1.93 million.

Contractors

Prime

Rheinmetall	http://www.rheinmetall.com/en , Rheinmetall Platz 1, Düsseldorf, Germany, Tel: + 49 211 473 01, Fax: + 49 211 473 4727, Email: info@rheinmetall-defence.com , Prime
China North Industries Corp (NORINCO)	http://www.norinco.cn , 12A Guang An Men Nan Jie, PO Box 100053, Beijing, China, Tel: + 86 10 6352 9988, Fax: + 86 10 6354 0398, Email: norinco@norinco.cn , Licensee
Lockheed Martin Rotary and Mission Systems	http://www.lockheedmartin.com , 199 Borton Landing Rd, PO Box 1027, Moorestown, NJ 08057-0927 United States, Tel: + 1 (856) 722-4100, Licensee

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Makina Ve Kimya Endustrisi Kurumu (MKEK), MKEK General Management	http://www.mkek.gov.tr/en/ , Tandogan, Ankara, Turkey, Tel: + 90 312 296 10 00, Fax: + 90 312 222 22 41, Email: mkek@mkek.gov.tr , Licensee
Nippon-Seiki Co Ltd	http://www.nippon-seiki.co.jp , 2-34 Higashi-Zaoh, 2-chome Nagaoka-Shi, Nigata, Japan, Tel: + 81 258 24 3311, Fax: + 81 258 21 2151, Email: kikaku@nippon-seiki.co.jp , Licensee
Rheinmetall Air Defence AG	http://www.rheinmetall-defence.com , Birchstrasse 155, Zurich, Switzerland, Tel: + 41 44 316 2211, Fax: + 41 44 311 3154, Email: info@ocag.ch , Second Prime

Subcontractor

BAE Systems plc	http://www.baesystems.com , 6 Carlton Gardens, Stirling Sq, London, United Kingdom, Tel: + 44 1252 373232, Fax: + 44 1252 383991 (GSA Mk 3 Optical Sight)
SAPA Placencia SA	http://sapa.es/en/sapa-placencia/ , Carretera NI, PO Box 8, Andoain, Gipuzkoa, Spain, Tel: + 34 943 304 204, Fax: + 34 943 592 703, Email: sapa01@adegi.es (Spanish Army GDF Series Upgrade)

Contractors are invited to submit updated information to Editor, International Contractors, Forecast International, 75 Glen Road, Suite 302, Sandy Hook, CT 06482, USA; rich.pettibone@forecast1.com

Technical Data

Crew. Three for movement/deployment; one for target acquisition/firing.

Cannon Type. Twin Oerlikon Contraves model KDB.

Caliber. 35x228mm.

Muzzle Brake. Modified baffle.

Breech Mechanism. Vertically sliding, positively locked, gas operated, with two locking catches.

Recoil System. Hydromechanical.

Carriage Type. Four-wheel, three-point hard support.

Shield. None.

Dimensions. The following data reflect the production-standard GDF-005. The system weight includes ammunition.

	<u>SI Units</u>	<u>U.S. Units</u>
Caliber	35 mm	1.38 in
Traveling length	8.68 m	28.48 ft
Firing length	8.05 m	26.41 ft
Barrel length	90 cal/3.15 m	90 cal/10.33 ft
Traveling width	2.26 m	7.41 ft
Firing width	4.49 m	14.73 ft
Traveling height	2.61 m	8.56 ft
Firing height	1.72 m	5.64 ft
System weight	8.2 tonnes	9.04 tons

Ammunition. The KDB ordnance fires the following 35x228mm ammunition types. The proprietary Oerlikon designation for each type appears in parentheses.

- High Explosive Incendiary-Tracer (MLD)
- High Explosive Incendiary (MSD)
- Semi-Armor Piercing High Explosive Incendiary-Tracer (PLD)
- Target Practice-Tracer (ULD)
- Target Practice (UGD)

The GDF series also fires the AHEAD munition, discussed below.

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Performance. The KDB ordnance achieves a muzzle velocity of 1,175 meters per second (3,854.9 fps) with all ammunition types. The maximum range is for vertical fire; the rate of fire is per barrel.

	<u>SI Units</u>	<u>U.S. Units</u>
Ordnance elevation	+92°	+92°
Ordnance depression	-5°	-5°
Traverse	360°	360°
Maximum range	4,000 m	13,123.33 ft
Maximum rate of fire	550 round/m	550 round/m

Variants/Upgrades

Variants. None. The various models represent incremental developments of the basic GDF system.

Modernization and Retrofit Overview. The prime contractor offers three enhancement packages for the original GDF system, designated NDF-A, NDF-B, and NDF-C.

NDF-A: The NDF-A package features the following components:

- The BAE Systems GSA Mk 3 sight. This dual-optic sight system is simple in operation, requiring manual entry of only the target range.
- An automatic breech lubrication system.
- A camouflage system and a rudimentary gunner's shelter.

NDF-B: The NDF-B package features the following components:

- Automatic ammunition reloaders (one per gun), which reduce the firing crew from three to just the gunner.
- The Rheinmetall (Contraves) Gun King three-dimensional mini-sight, with a built-in laser rangefinder and computer.
- A new weapon control system, with an integrated power unit (see below).
- A cover, with an integral weapon lubrication system and redundant circuitry.
- An improved gunner's shelter, providing ballistic, environmental, and nuclear, biological, and chemical (NBC) protection.

The NDF-B package also increases the available ammunition supply to 280 rounds from 238.

Integrated Power Supply Unit. In place of the basic GDF system's towed generator, the NDF-B package includes an integral power source (diesel or spark ignition engines are available) mounted at the rear of the carriage.

Automatic Reloaders. In the NDF-B package, automatic reloaders, featuring hydraulic-mechanical devices, feed ammunition as the barrel elevates to +90°. Electrical and mechanical limiters prevent inadvertent firing during the cycle. The automatic loaders increase the ready ammunition supply to 280 rounds from 112.

NDF-C: The NDF-C upgrade combines the A and B packages. It upgrades the GDF-001, -002, and -003 to the GDF-005 configuration.

Fire Control. The Gun King mini-sight optronic fire control system of the NDF-C is a computer-controlled optical sight that eliminates parameter estimation by the gunner. Sight operation requires only that the gunner bring the crosswire (crosshairs) into coincidence with the target. A loud acoustic signal indicates that firing can commence. The integrated digital computer processes data from the built-in laser rangefinder with angular data, meteorological data, and continuously registered muzzle velocity values; the computer automatically transfers the resulting gunnery data to the gun control system.

Skyguard Fire Control System. The radar-based Skyguard system superseded the original Oerlikon Contraves Super Fledermaus fire control system. Skyguard can also integrate a surface-to-air missile system such as the Aspide or RIM-7. The Argentines scored at least 12 kills with this system in the Falkland Islands War (1982). The Skyguard III is essentially a complete rebuild of the original Skyguard, featuring a fire control unit based on the Skyshield system.

Skyguard III (also known as Skyshield) features a multibeam I-band search radar, and an I-band tracking radar for tracking smaller targets at longer ranges. This version also features an improved identification friend or foe (IFF) component and an electro-optic target tracking component.

The NDF-C package also includes rate-of-fire regulators to compensate for longer firing bursts and higher chamber temperatures. By regulating the rate of fire, the upgrade reduces stoppages, as well as the risk of ammunition "cook-off" in an overheated chamber.

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The AHEAD System. Advanced Hit Efficiency and Destruction (AHEAD) technology greatly enhances the performance of the GDF series weapons against modern missiles, smart munitions, and attack helicopters. The technology features the AHEAD round, which explodes a cloud of up to 200 high-velocity projectiles toward the target. KDB ordnance firing the AHEAD munition

requires AHEAD muzzle-velocity-measuring and data-relay coils, replacing the standard flash suppressors. In addition, the Skyguard fire control system requires a software upgrade to fire AHEAD munitions.

Canada, Oman, Pakistan, Taiwan, and Turkey all employ the AHEAD package.



35mm GDF-005 Anti-Aircraft Artillery System

Source: Rheinmetall Defence

Program Review

Background. Oerlikon Contraves (formerly Oerlikon Bührle) has long been one of the two world leaders in the development and production of 20mm to 40mm anti-aircraft weapons. Bofors of Sweden (now operating as Saab Bofors Dynamics) has been the other world leader. Since the Second World War, the products of Oerlikon and Bofors have been so popular that they have often served on both sides of a conflict.

Six Decades and Counting

The GDF design first appeared in prototype form in 1959, under the nomenclature 1 ZLA/353MK. Following developmental testing, the slightly modified weapon entered production as the 2 ZLA/353MK. In 1963, the contractor redesignated the 2 ZLA/353MK the GDF-001. An improved version, the GDF-002, appeared in 1971; the further improved GDF-003 appeared in 1981. Improvements centered on the mount, the traverse and elevation (T&E) mechanism, and the automatic ammunition feed system.

The GDF-004 was a developmental system; it never entered production. In May 1985, Oerlikon introduced the GDF-005 model.

Corporate Evolution

In September 1999, Rheinmetall Defence acquired Oerlikon Contraves. On January 1, 2009, the prime contractor officially changed its name to Rheinmetall Air Defence AG.

Description. The basic GDF-002/003 consists of two KDB (formerly 353MK) 35mm cannon, the upper and lower mount, the cradle, the sighting system, and two automatic ammunition feed systems. The ordnance slides in the cradle during recoil. A cover over the ordnance contains the ammunition feed mechanism and the ammunition containers/automatic loaders; it also provides a mounting for the manual cocking assembly. Ammunition feed is electric, with manual backup.

The 56-round ammunition containers (one for each cannon) mount on each side of the cradle. The upper mount features two 63-round reloading or reserve containers, which the crew reloads manually via standard seven-round stripper clips.

The GDF system mounts an auxiliary sight for air and ground target combat. An optical alignment sight allows the crew to determine the cannon position, or parallax values (slant range, bearing, elevation), with respect to the location of the fire control unit.

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Rapid Employment

A three-man crew places the individual GDF up to 80 meters (262.46 ft) from the electrical supply trailer. Using electrohydraulic power, the crew deploys and locks the outriggers, and lifts the piece clear of the roadwheels with three lift jacks. Once they swivel the wheels out from the carriage, the crew lowers and levels the piece with the lift jacks. The entire employment process requires less than five minutes. All powered operations feature manual backup.

With the original Contraves Super Fledermaus fire control system, a GDF battery consisted of two towed pieces, two power supply trailers, and the fire control van with radar. The Contraves Skyguard (including the Skyguard III/Skyshield) greatly enhances GDF battery effectiveness. Nine people operate a GDF battery. Three people can operate a single GDF autonomously; a single crewmember can fire the piece.

Combat-Proven and Relevant

During the Falkland Islands War (1982), Argentinean forces employed 12 GDF-001 systems with the Skyguard fire control system. They shot down 12 British aircraft – accounting for almost a third of all British aircraft losses. Light-caliber air defense systems remain doctrinally valid weapons systems on the modern mobile battlefield, with towed systems providing point defense of installations while self-propelled systems support maneuver forces. Continuing developments in the fields of fire control and ammunition will further enhance the capabilities of air defense systems such as the GDF series.

While the evolving threat scenarios of the global war on terror no longer envision the tactical air threat of the Cold War, the proliferation of low-level unmanned air vehicles – as well as possible unconventional employment of commercial aircraft – ensures a place for medium-caliber air defense systems.

Funding

The contractor (originally Oerlikon Contraves) funded development of the GDF series as a private venture.

Contracts/Orders & Options

In Dec 2019, Rheinmetall announced that an unspecified international client had awarded the company a contract worth approximately \$128.8 million to modernize its existing Skyguard air defense systems.

Worldwide Distribution/Inventories

Export Potential. Along with the equally famous Bofors L/70, the GDF series has become the world-standard system of its type and caliber. At least 32 nations operate this weapon system in one form or another. Japan, Turkey, Brazil, and India have each engaged in licensed production of GDF series weapon systems in the past.

Countries. The following data reflect known holdings through 2023.

<u>Region</u>	<u>Country</u>	<u>Qty</u>	<u>AAA System</u>
<u>Africa</u>	Cameroon	18	GDF-002
	Republic of South Africa	100	GDF-002
		48	GDF-005
<u>Asia</u>	People's Republic of China	150	GDF-002
	Republic of China	50	GDF-005
	India	150	GDF-005
	Japan	76	GDF-001
	Republic of Korea	36	GDF-003
	Malaysia	38	GDF-005
	Pakistan	200	GDF-005
	Singapore	34	GDF-001
		24	GDF-002

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<u>Region</u>	<u>Country</u>	<u>Qty</u>	<u>AAA System</u>
<u>Europe</u>	Austria	92	GDF-005
	Cyprus	30	GDF-005
	Finland	50	GDF-005
	Greece	44	GDF-002
	Romania	72	GDF-003//GDF-005
	Spain	96	GDF-005
	Switzerland	219	GDF-001//GDF-002
		45	GDF-007
	Turkey	162	GDF-003
	United Kingdom	12	GDF-002 (captured from Argentina)
	<u>Middle East</u>	Bahrain	12
Egypt		72	GDF-005
Iran		92	GDF-002
Kuwait		26	GDF-005
Oman		10	GDF-005
Saudi Arabia		128	GDF-005
United Arab Emirates		30	GDF-005
<u>North America</u>	Canada	34	GDF-005
<u>South America</u>	Argentina	71	GDF-001
		50	GDF-002
	Brazil	38	GDF-001
		22	GDF-003
	Chile	24	GDF-005
	Ecuador	30	GDF-003
	Venezuela	10	GDF-001

In addition to the above, at least six unidentified customers reportedly maintain an estimated 500 GDF systems.

Forecast Rationale

Rheinmetall Air Defence AG maintains production of the 35mm GDF series anti-aircraft artillery system on an as-needed basis. All licensed production runs are reportedly complete; Rheinmetall's as-needed line represents the only GDF series production at this time.

In January 2013, Rheinmetall announced it had secured orders worth a combined \$364 million from Kuwait, Malaysia, and an unnamed Asian country for an unspecified number of GDF series air defense systems, plus support. Equipment deliveries and contractor support under these contracts were reportedly complete in 2020.

In September 2013, Rheinmetall proposed upgrading the South African Army's GDF Mk V ordnance to the Mk VII configuration. South Africa first obtained the Oerlikon GDF system in 1963.

New Orders

In July 2017, Rheinmetall announced new export sales to two unspecified customers – one identified only as an already long-standing customer and one as a new customer. The contracts are worth a combined total of \$257 million.

While evolving threat scenarios no longer envision the tactical air threat of the Cold War, the proliferation of low-level unmanned air vehicles – as well as possible unconventional employment of commercial aircraft – ensures a place for medium-caliber air defense systems. In this environment, the 35mm GDF series anti-aircraft artillery system remains an iconic international standard in the air defense artillery market.

GDF Series 35mm Anti-Aircraft Artillery Systems

Ten-Year Outlook

ESTIMATED CALENDAR YEAR UNIT PRODUCTION												
Designation or Program	High Confidence				Good Confidence			Speculative			Total	
	Thru 2023	2024	2025	2026	2027	2028	2029	2030	2031	2032		2033
Rheinmetall Air Defence AG												
GDF-005												
	255	5	3	3	0	0	0	0	0	0	0	11
Total	255	5	3	3	0	0	0	0	0	0	0	11