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The Great Leap?
China's Ballistic Missile Programme
A Technical Report

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Abstract

Since its inception in the 1950s, China's missile programme has undergone significant development. This research report traces the evolution of China's ballistic missile capabilities over a period of more than 70 years, drawing primarily on open-source information to provide a technical analysis of the available data. Additionally, it offers a concise overview of the Chinese missile industry, which remains highly state-controlled, as well as an assessment of the current state of China's missile forces, including operational systems, force levels, and deployment locations. This analysis highlights how, over decades – initially with Soviet assistance and later through independent advancements – China has leveraged long-range missile systems as a tool to project threats. Particularly in recent years, China has intensified its investment in missile research, development, and production. This is reflected in its notable expansion of medium- and long-range systems and the comprehensive modernisation of its existing arsenal.

This report offers a comprehensive overview of the current state of China's missile programme. It aims to shed light on its technical foundations, thus enabling a better assessment of its capabilities, intentions, and underlying strategies, as well as future courses of action and implications for the international community.

Keywords:
China, Missiles, Ballistic missiles, Delivery systems, Missile technology

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Glossary

AALPT: Academy of Aerospace Liquid Propulsion Technology, a subsidiary of → CASC.

AASPT: Academy of Aerospace Solid Propulsion Technology, a subsidiary of → CASC.

Ballistic missile: Ballistic missiles are powered solely during their launch phase, after which they follow a trajectory determined by the laws of ballistics – the laws of freefall.

Booster: A simple, unguided → rocket stage, typically equipped with a → solid-fuelled motor, mounted on the side of a rocket to provide additional thrust during the launch phase and discarded after → burnout. This term is also used for simple solid-fuelled rockets that rapidly accelerate an → HGV or an entire missile (e.g. anti-aircraft missiles) to high speeds, effectively functioning as the first stage of a multi-stage missile.

Burnout: The shutdown or exhaustion of a rocket motor at a defined moment, such as upon reaching a specific velocity.

CALT: China Academy of Launch Vehicle Technology, a subdivision of → CASC.

CASC: China Aerospace Science and Technology Corporation Limited, a state-run rocket development enterprise in China; further details provided in Section 2.

CASIC: China Aerospace Science and Industry Corporation Limited, a state-run rocket development enterprise in China; further details provided in Section 2.

CRBM: Close-range ballistic missile (German: *Gefechtsfeldrakete*). This term is sometimes used to refer to guided ballistic missiles with ranges under 200 km, although in German usage it typically refers to a specific subset of short-range ballistic missiles (→ SRBMs).

CSIS: Center for Strategic and International Studies, a renowned research institution specialising in the analysis of missile programmes.

Triconic warhead: A distinctive → warhead characterised by its pointed tip, cylindrical body, and flared base, earning it the nickname "baby bottle warhead".

FOBS: Fractional Orbital Bombardment System. A system in which a payload (single or multiple warhead) is delivered by a missile into a stable low Earth orbit, which it exits after a short duration (fractional orbit) to strike a target on the Earth's surface.

HGV: Hypersonic glide vehicle (German: *Hyperschallgleitflugkörper*). A → hypersonic weapon that is initially accelerated by a rocket (e.g. a → booster) but then glides without its own propulsion in the final flight phase.

Hypersonic weapon: A → missile capable of travelling within the atmosphere at speeds exceeding five times the speed of sound (Mach 5, approximately 6,000 km/h) and of performing manoeuvres using aerodynamic features (such as control surfaces and movable wings).

ICBM: Intercontinental ballistic missile (German: *Interkontinentalrakete*). This category comprises missiles with → ranges exceeding 5,500 km.

Intercontinental ballistic missile: → ICBM.

IRBM: Intermediate-range ballistic missile (German: *Mittelstreckenrakete größerer Reichweite*). This category comprises missiles with → ranges between 3,000 km and 5,500 km, although other ranges are occasionally cited.

Launch vehicle: A rocket designed to deliver objects (e.g. satellites, probes, or crewed capsules) into sustained orbit or space. The term is not used for missile systems designed to carry → warheads.

Liquid-fuelled engine: A rocket propulsion system powered by liquid propellants. Liquid propellants allow rocket engines to be flexibly turned on and off and are categorised as either cryogenic or storable. Cryogenic propellants are highly efficient, deep-cooled propellants that are now primarily used in space exploration and must be loaded in the rocket just before launch. Storable propellants, by contrast, can remain in a rocket for years, making them well-suited for use in military missiles.

Liquid-fuelled rocket/missile: A rocket/missile powered by a → liquid-fuelled engine.

MEL: Mobile erector launcher (German: *Startfahrzeug*, also *Raketenwerfer* or *Startrampe*). Unmotorised → TEL, towed by a tractor unit.

MIRV: Multiple independently targetable re-entry vehicle, → multiple warhead.

Missile: General term for uncrewed objects that are propelled towards their target by an onboard propulsion system, damaging it upon impact. Examples include ballistic missiles and cruise missiles. While "missile" is often mistranslated as Rakete in German, the correct equivalent is Flugkörper.

MRBM: Medium-range ballistic missile (German: *Mittelstreckenrakete mittlerer Reichweite*). This category comprises missiles with → ranges between 1,000 km and 3,000 km, although other ranges are occasionally cited.

MTCR: Missile Technology Control Regime. A non-binding international agreement aimed at curbing the proliferation of → missiles capable of delivering a → payload above 500 kg to a → range of over 300 km, as well as technologies relevant to their development and production.

Multiple warhead: An arrangement of several individual warheads on a single missile. On certain systems, these warheads can be aimed at different targets.

Payload: The weight of the object (and the object itself) that a → missile can transport over a certain → range. This value is range-dependent: the payload can be increased (within certain limits) by reducing the range, while the range can be extended by using a lighter payload.

Range: The distance a specific missile can travel with a specific → payload.

Re-entry vehicle: A warhead equipped with thermal protection (a "heat shield") to ensure that its → weapon charge remains intact when re-entering the Earth's atmosphere from space over long → ranges.

Rocket stage: Part of a multi-stage rocket that contains its own engine(s) and propellant. Rocket stages are jettisoned after → burnout when the rocket is still in flight, in a process known as staging.

Silo: A secure, underground missile launch site from which a pre-positioned missile can be launched within a very short timeframe.

Single warhead: A missile payload consisting of a single → warhead, compared to missiles with → multiple warheads.

SLBM: Submarine-launched ballistic missile (German: *U-Boot-gestützte ballistische Rakete*). This category comprises ballistic missiles launched from submarines, typically with ranges exceeding 5,500 km.

Solid-fuelled motor: A rocket propulsion system that uses solid propellants. After ignition, solid propellants can only be shut off using a thrust termination system, after which they cannot be restarted. In the absence of such a system, they will burn until completely consumed, much like a firework. Like fuelled rockets with storable liquid propellants, solid-fuelled rockets are ready for immediate use without the need for prior fuelling.

Solid-fuelled rocket/missile: A rocket/missile powered by a → solid-fuelled motor.

Space launch vehicle: → Launch vehicle.

SRBM: Short-range ballistic missile (German: *Kurzstreckenrakete*). This category comprises missiles with → ranges between 200 km and 1,000 km, although other ranges are occasionally cited.

TEL: Transporter erector launcher (German: *Startfahrzeug*, also *Raketenwerfer* or *Startrampe*). A motorised tracked or wheeled vehicle capable of independently transporting, erecting, and launching missiles.

Throw weight: A meaningful measure of a missile’s performance, indicating its → range with a specific → payload.

Topol: Russian for “poplar”, a family of Russian mobile → intercontinental ballistic missiles powered by → solid-fuelled motors.

Warhead: The → payload of a military missile, containing a weapon charge with a destructive agent (e.g. conventional explosives, a nuclear weapon, a chemical or biological agent). Warheads for missiles that leave the atmosphere must be designed as → re-entry vehicles.

1 Introduction

Since its inception in the late 1950s, China's ballistic missile programme has undergone steady development. The country now possesses a comprehensive range of short-, medium-, and long-range missiles, supported by a robust development and production industry. Missiles serve as an effective means of constructing threat scenarios, irrespective of their actual deployment. In its function as a "capability", the available technology thus shapes the parameters of possible political "intentions".

Understanding the historical development of China's military capabilities and deriving insights into possible intentions and implications for the international community requires a thorough understanding of the technical background of China's missile programme within its broader context.

This report addresses this need. From a technical perspective, it analyses the development and orientation of China's ballistic missile programme over the decades, beginning with its first projects in the late 1950s and continuing to the present day. Among other issues, it addresses the following key questions: What types of ballistic missiles does China currently possess or have in development, and what are their capabilities? What is known of each system's operational status and test outcomes? In addition to these topics, the report investigates the underlying context by addressing questions such as: Who are the key actors in China's missile development and production? How self-sufficient are China's missile development and production capabilities? What export activities has China's missile programme undertaken?

A comprehensive overview – for instance one based on official Chinese information – has yet to be made available. Accordingly, extensive research was undertaken to gather public information from various sources in order to address these questions. Technical expertise in missile technology was instrumental in filtering sources and assessing the technical plausibility of the information gleaned (for instance regarding missile specifications).

Similar studies have been conducted by experts in the past. Lewis and Di (1992), for example, meticulously detailed the early stages of the Chinese programme. Wood and Stone (2021) focused extensively on the industrial aspects of the programme, while Xiu (2022) conducted thorough research into the current status of China’s missile forces. Western institutions and think tanks such as the James Martin Center for Nonproliferation Studies (CNS), the Center for Strategic and International Studies (CSIS), the Federation of American Scientists (FAS), and the International Institute for Strategic Studies (IISS) also regularly publish analyses of specific aspects of China’s missile programme.

This report builds on these prior studies, incorporating additional state-level sources, particularly from the United States. It seeks to consolidate existing insights into a cohesive overview and to provide readers with an up-to-date understanding. Given the vast amount of material available, some gaps remain unavoidable, for example due to discrepancies in specific details across individual sources. Despite extensive effort, it is beyond the scope of this report to resolve these issues definitively.

Table 1 summarises key information, offering an overview of the relevant Chinese missile systems, past and present, which are discussed in more detail in subsequent sections. It also highlights key challenges, such as the significant inconsistencies in the publicly available data on range. In this regard, the report draws primarily on data from the U.S. Defence Intelligence Ballistic Missile Analysis Committee (NASIC and DIBMAC 2020) for contemporary systems and on other sources (e.g. Lewis and Di 1992) for older ones. The data on certain other details is likewise not always well defined. For example, identifying which institutions are responsible for which programmes can be a challenge, given the numerous reorganisations of the various academies. Some projects that can now be attributed to the same academy originated in institutions that were once competitors but have since merged. Table 1 offers a broad overview but does not purport to provide fully accurate information.

The report is divided into five main sections. Section 2 offers a brief overview of the structure of the defence industry responsible for the various missile programmes. Section 3 presents a comprehensive review of China’s known activities in the development and construction of ballistic missiles, arranged chronologically as far as possible given the close interrelations between the relevant programmes and institutions. Section 4 provides an overview of China’s operational long-range missile systems, based on current knowledge. Section 5 discusses China’s import and export of relevant technologies, while Section 6 provides a detailed overview of the country’s currently operational missile forces.

Thanks to its extensive data collection, this report provides a comprehensive overview of the current state of China's missile programme, tailored to a wide specialist audience. In addition, its detailed account of the programme's history and structure provides valuable context on past developments.

Table 1: Overview of Chinese missile systems

SYSTEM	ALTERNATIVE DESIGNATION	FIRST FLIGHT	SERVICE ENTRY	CLASS	RANGE [KM]	PAYLOAD [KG]	STAGES	PROPULSION	NUC/CONV	CURRENT AUTHORITY	STATUS
Project 1059	DF-1	1960	1961	SRBM	590	950	1	liquid	conv	CASC 1st	D
DF-2	CSS-1	1962	-	MRBM	1,050	1,500	1	liquid	conv	CASC 1st	D
DF-2A		1965	1966	MRBM	1,250	1,500	1	liquid	1x nuc	CASC 1st	D
DF-3	DF-1, CSS-2	1966	1971	MRBM	2,800	2,150	1	liquid	1x nuc	CASC 1st	D
DF-4	CSS-3	1970	1980	ICBM (IRBM)	5,500+ (4,750)	2,200	2	liquid	1x nuc	CASC 1st	D?
DF-5	CSS-4	1971	1981	ICBM	9,000+	3,200	2	liquid	1x nuc	CASC 1st	D
JL-1	CSS-N-3	1981	(1983)	SLBM	1,700	600	2	solid	1x nuc	CASIC 4th CASIC 6th	D
DF-21	CSS-5	1985	1985?	MRBM	1,700	600	2	solid	1x nuc	CASIC 4th CASIC 6th	D
DF-3A	CSS-2 Mod 2	1985	1987	IRBM	3,500	2,150	1	liquid	1x nuc	CASC 1st	D
DF-5A	CSS-4 Mod 2	1988?	1990?	ICBM	12,000+	~3,900+	2	liquid	1x nuc	CASC 1st	O
DF-15	M-9, CSS-6	1988	1991	SRBM	600	500	1	solid	conv	CASC 1st	D?/E
-	M-7, CSS-8	1980s	-	CRBM	150	~200	2	solid/ liquid	conv	CASIC 2nd	E
DF-11	M-11, CSS-7	1990	1992	SRBM	300	500	1	solid	conv	CASIC 4th	D?/E
DF-21A	CSS-5 Mod 2	1991	1996	MRBM	1,750+	500+	2	solid	1x nuc	CASIC 4th CASIC 6th	O
DF-31	CSS-10 Mod 1	1992	2006	ICBM	7,000+	1,000+	3	solid	1x nuc	CASC 4th CASIC 2nd CASC 1st	O
DF-15A	CSS-6 Mod 1	1993?	1996	SRBM	600? (900?)	500+	1	solid	conv		O
DF-11A	CSS-7 Mod 1	1997	1999	SRBM	600	~500	1	solid	conv		O
DF-25	M-18	90s? (2004)	-	MRBM	1,700+ (2,400)	2,000 (800+)	2	solid	conv	CASC 1st	E
	B611	90s?	-	CRBM	150	480	1	solid	conv	CASIC 2nd	E
DF-15B	CSS-6 Mod 3	2003?	2006	SRBM	725+	500+	1	solid	conv		O
DF-21C	CSS-5 Mod 4	2004?	2008?	MRBM	1,500+	~600?	2	solid	conv	CASIC 4th CASIC 6th	D?

SYSTEM	ALTERNATIVE DESIGNATION	FIRST FLIGHT	SERVICE ENTRY	CLASS	RANGE [KM]	PAYLOAD [KG]	STAGES	PROPULSION	NUC/CONV	CURRENT AUTHORITY	STATUS
DF-5B	CSS-4 Mod 3	2006	2015	ICBM	12,000+	~4,000	2+PBV	liquid	3x nuc	CASC 1st	O
DF-21D	CSS-5 Mod 5	2006?	2010?	MRB ASBM	1,500+	500+	2	solid	conv	CASIC 4th CASIC 6th	O
DF-31A	CSS-10 Mod 2	?	2007	ICBM	11,000+	1,000+	3	solid	1x nuc	CASC 1st	O
DF-16	CSS-11 Mod 1	2007?	2011	SRBM	700+	500–1,000	1	solid	conv		O?/D?
DF-12	M-20	2010?	2013	CRBM	280	480	1	solid	conv	CASC	O/E
BP-12A	-	2010?	-	CRBM	280	480	1	solid	conv	CASIC	E
JL-2	CSS-N-14	2011?	2015?	SLBM	7,000+	1,000+	3	solid	1x nuc	CASC 4th CASIC 2nd CASC 1st	O
DF-41	CSS-20	2012	2017?	ICBM	unknown (15,000)	~2,500	3+PBV	solid	3-10(?)x nuc		O
DF-31AG	-	2012?	2016?	ICBM	unknown (11,000+)	1,000+	3	solid	1x nuc		O
DF-11AZT		?	2013?	SRBM	600	?	1	solid	conv		O
DF-15C	CSS-6 Mod 2	?	2013?	SRBM	850+	500+	1	solid	conv		O
DF-16A	CSS-11 Mod 2	?	2016?	SRBM	700+	500–1,000	1	solid	conv		O
DF-26	CSS-18	?	2016	IRBM (ASBM)	3,000+	1,000+	2	solid	1x nuc, conv		O
DF-17	CSS-22	2014/ 2017?	2020	MR HGV	unknown (2,000+)	?	1	solid	conv		O
DF-5C	-	*2017?*	*?*	*ICBM*	*14,000*	*?*	*2+PBV*	*liquid*	*10x nuc*	*CASC 1st*	*T*
JL-3	-	*2018*	*?*	*SLBM*	*10,000+*	*?*	*3+PBV*	*solid*	*?x nuc*		*T*

D = decommissioned / O = operational / T = tests / E = export / nuc = nuclear / conv = conventional

Data sources: Author's own assessment, as well as Lewis and Di (1992), NASIC and DIBMAC (2020), and Missile Defense Project (2021g)

2 The Chinese Missile Industry

China's missile and aerospace industry is a complex system that has undergone numerous reforms, mergers, divisions, restructurings, and name changes over time. This section provides an overview of the key structures and developments.

The current structure of the Chinese defence industry can be traced back to the establishment of the "First Ministry of Machine Building" in 1952. By 1980, a total of seven such ministries had been created, each with different areas of responsibility.

The initial work on missile technology was conducted within the "Fifth Academy of the Defence Ministry", founded in 1956 for this purpose. In 1964, this organisation was renamed the "Seventh Ministry of Machine Building" and assumed responsibility for all activities related to spaceflight and missiles. In 1988, it merged with the "Third Ministry of Machine Building", which oversaw aviation, to form the "Ministry of Aerospace Industry". This ministry was subsequently divided into an aviation branch (China Aviation Industry Corporation) and a missile and aerospace branch (China Aerospace Corporation) in 1993. In 1999, purportedly to foster competition, the latter was again split into two separate, competing conglomerates now known as the China Aerospace Science and Technology Corporation Limited (CASC) and the China Aerospace Science and Industry Corporation Limited (CASIC) (Wood and Stone 2021).

The early ministries each oversaw specific academies, many of which now exist as part of the present-day conglomerates. In their respective domains, these academies can be likened to Soviet design bureaus (OKBs and the like), which competed with one another and presented independent project proposals to win favour with the Politburo (Schmucker and Schiller 2015). They included various "bases" established over time by the military, such as "Base 067", which was restructured into its own academy in 1993.

Despite the inclusion of "Corporation Limited" in their official names, the conglomerates remain state-owned enterprises, as do their subordinate academies. The leadership at all levels is closely intertwined with the Chinese Communist Party. Within these institutions, research and development, design, testing, and production departments operate alongside affiliated "graduate schools", which offer degrees up to the doctoral level. Here too, the close integration of industry and education is reminiscent of the former Soviet Union. This structure complicates international academic cooperation, as the work carried out by the affiliated institutes cannot be treated as independent research.

Determining the specific responsibilities of individual academies is also a challenge thanks to their frequent name changes (often to very similar names), mergers, and divisions, resulting in a confusing and occasionally contradictory body of source material. Information on these academies' locations and workforce sizes varies across Chinese state sources and external expert assessments. In addition to the usual secrecy within the industry, this may be due to the extensive branching of institutions at lower levels. Many academies are associated with numerous additional bases, laboratories, and factories located at various sites, resulting in further inconsistencies in the data.

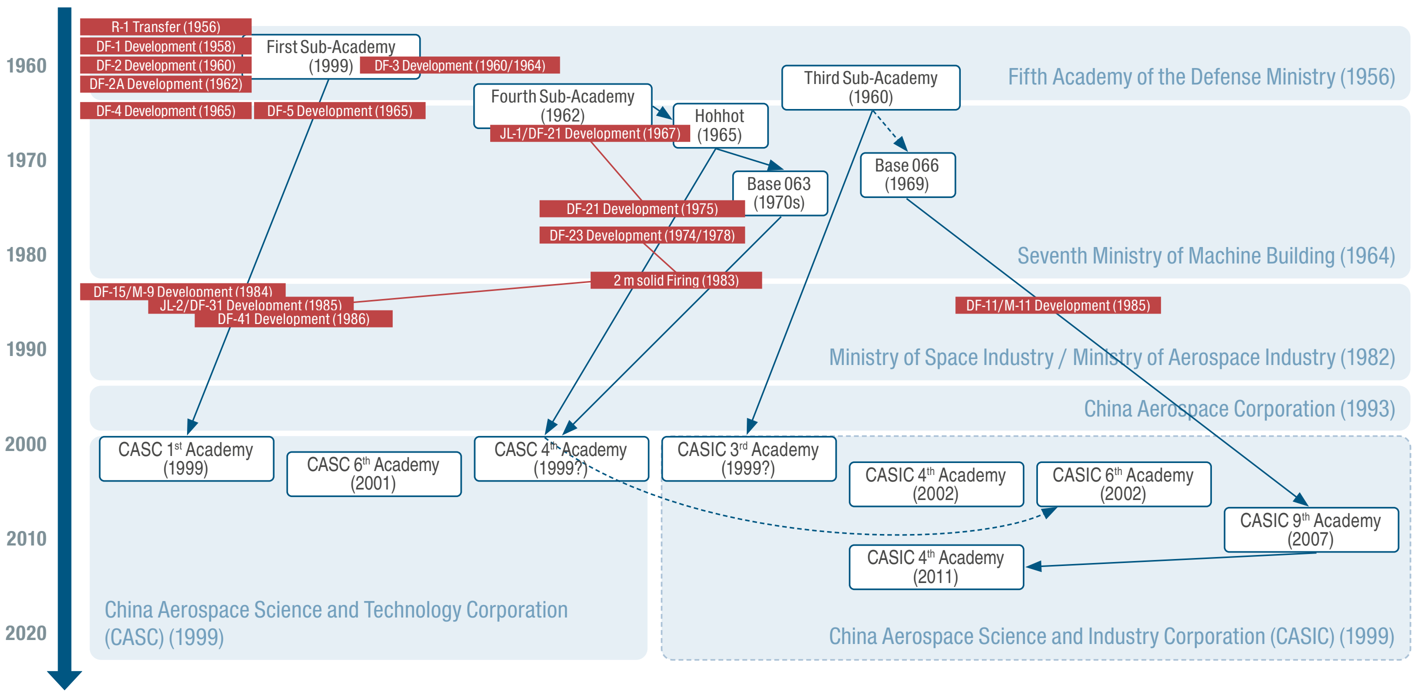
Table 2: Relevant institutions

CONGLOMERATE	ACADEMY	LOCATION AND PERSONELL	RESPONSIBILITIES
China Aerospace Science and Technology Corporation Limited (CASC)	CASC 1st Academy (China Academy of Launch Vehicle Technology – CALT)	Beijing approx 33,000	space launch vehicles, ballistic missiles (DF series)
	CASC 4th Academy (Academy of Aerospace Solid Propulsion Technology – AASPT)	Xi'an approx 10,000	large solid-fuelled motors
	CASC 6th Academy (Academy of Aerospace Liquid Propulsion Technology – AALPT)	Xi'an approx 10,000	liquid-fuelled engines
China Aerospace Science and Industry Corporation Limited (CASIC)	CASIC 2nd Academy (Academy for Defence Technology, China Chang Feng)	Beijing approx 16,000–19,000	air defence missiles (HQ series); DF-31/JL-2 ?
	CASIC 3rd Academy (Chinese Academy for Missile Technology)	Beijing approx 25,200	anti-ship missiles (HY series)
	CASIC 4th Academy	Wuhan approx 18,000	tactical ballistic missiles; DF-11, DF-16, DF-21/JL-1
	CASIC 6th Academy	Baotou/Hohhot approx 12,000 ?	small solid-fuelled motors (<2 m diameter)

Data source: Author's own assessment, as of 2023

Figure 1 outlines the development of the Chinese missile industry over the past seven decades. This overview is highly simplified and focuses on selected institutions and missile programmes. For instance, the JL-1/DF-21 missile programme involved far more institutions than those mentioned, with responsibilities including the motor, guidance system, and structure. Over time, these institutions were assigned to different parent organisations. Furthermore, a lack of available information makes it difficult to accurately pinpoint the origins of more recent missile programmes, such as those for the DF-26, DF-16, and DF-17. One source, for example, links the DF-26 to the CASC 1st Academy, while the same source speculates that its final assembly took place in "Changyang Aerospace City", which is associated with CASIC. Interestingly, this source places the DF-16 under the CASIC 4th Academy, whereas the DF-15 – often regarded as the predecessor of the DF-16 – is attributed to the CASC 1st Academy (Wood and Stone 2021). This may indicate that the DF-15 and the DF-16 are not as closely related as commonly assumed.

Figure 1: Simplified schematic representation of the Chinese missile industry, including the origins of selected programmes



Data source: Author's own depiction, based on Lewis and Di (1992), Wood and Stone (2021)

In recent years, China has seen the emergence of a veritable "startup scene" in the field of rocketry, with numerous companies promising an alternative route into space by developing and operating innovative small space launch vehicles, also known as "microlaunchers". As early as 2014, LinkSpace became the first private provider of small launch vehicles. However, the true starting point of this "startup scene" is widely considered to be a paper issued by the Chinese State Council on 26 November 2014, which called for private investors to fund the development of space infrastructure, including the necessary launch vehicles (State Council 2014). Following this, companies such as LandSpace and One-Space were founded in 2015, with i-Space joining in 2016 and Galactic Energy in 2018. Today, more than a dozen ostensibly private firms can be identified as offering or developing small launch vehicles.

A closer look reveals the deep entanglement of this startup scene with the existing structures, particularly the two conglomerates CASC (often through its subsidiary CALT) and CASIC. This suggests that, although they present themselves as independent enterprises, these firms are, at the very least, closely aligned with the state. This alignment offers opportunities for a better understanding of certain ballistic missile programmes, as it appears that some of these companies use engines that are also employed in ballistic missile systems. Table 3 provides an overview of some of these firms and their launch vehicles, as well as their suspected links to military missile systems and prominent state institutions.

Table 3: Space launch vehicles based on ballistic missiles

COMPANY	SPACE LAUNCHER	FIRST FLIGHT	CONNECTED TO	PRESUMABLY BASED ON
LandSpace	Zhuque-1	27 October 2018		DF-26
OneSpace	OS-M	27 March 2019		DF-15
i-Space	Hyperbola-1	25 July 2019	CASC	DF-26?
China Rocket	Jielong-1	17 August 2019	CASC/CALT	?
Expace	KZ-11	10 July 2020	CASIC	DF-41
Galactic Energy	Ceres-1	07 November 2020		DF-26?
Orienspace	Yinli-1	11 January 2024	CASC/AALPT	?

Data source: Author's own assessment

3 Chinese Ballistic Missile Activities

The earliest accounts of rocket-like missiles being used as weapons in China date back to the 13th century (von Braun and Ordway III 1979). Although these were likely repurposed firework rockets, China can rightly be regarded as the "cradle of rocket technology". Even so, the transition to modern, high-performance rocketry – capable of powering long-range weapons or space exploration – occurred many centuries later in Europe. Until then, progress in rocket technology remained minimal, even in China.

Modern missile technologies made their way back to China shortly after the end of the Second World War. Today, China is regarded as one of the leading nations in missile technology, a position that is reflected in its numerous successful civilian and military programmes. The following sections discuss key programmes in detail.

3.1 ASSISTANCE FROM THE SOVIET UNION

From a technological perspective, the origins of modern Chinese missile programmes can be traced back to 1956. At that time, the transfer of R-1[1] missiles from Soviet stock marked the beginning of China's collaboration with the Soviet Union – a superpower that, with achievements like Sputnik and Gagarin, was poised to dominate the global rocket sector in the coming years.[2]

Although the initial transfer of two Soviet R-1/SS-1 missiles had little immediate impact in China – presumably due to the outdated technology and relatively short range of the R-1 – the subsequent transfer of the more advanced R-2 missiles in 1957 captured the attention of Chinese policymakers and, consequently, the industry. This led to the launch of **Project 1059** in 1958, China's first attempt at "indigenous development". This project was essentially a licensed production of the R-2, made possible through extensive Soviet support in the form of comprehensive documentation (including 10,151 volumes of technical drawings and documents alone; Lewis and Di 1992) and supporting personnel (Schmucker and Schiller 2015). A maiden flight was successfully conducted in 1960 (Cox et al. 1999). This programme was subsequently designated as the **DF-1** ("DF" for Dong Feng, meaning "East Wind"; Lewis and Di 1992) but should not be confused with a separate and independent DF-1 project later renamed the DF-3 (discussed below).

In December 1959, China also acquired the first Soviet submarine-launched missile, the R-11FM – better known as the sea-based version of the land-based Scud A – along with a Golf-class submarine. Subsequently, in June 1960, China began replicating the R-11FM under Project 1060. This initiative was discontinued in August 1961, however, as the Chinese leadership shifted its focus to long-range weapons.

Following the Sino-Soviet split, it is widely believed that Soviet–Chinese cooperation in missile technology ceased around 1960 (see, e.g., Cox et al. 1999). However, the technological similarities between later generations of Chinese missiles and their Soviet counterparts suggest that collaboration at the operational level may have continued for several more years, despite the deterioration of political relations at higher levels (Schmucker and Schiller 2015).

In February 1960, China began work on the first missile in the DF series, then referred to as the DF-1 and later renamed the DF-3. This design was heavily based on the Soviet R-12/SS-4 missile, about which Chinese engineers had gained substantial knowledge during their time in Moscow.[3]

Concurrently, in February 1960, work commenced on the DF-2, based on Project 1059. The DF-2 had a range of up to 1,200 km, roughly half that of the DF-1/DF-3, which was still in development. Engine tests for the DF-2 began in 1961, followed by an unsuccessful launch in March 1962. This failure led to a redesign, resulting in the DF-2A, which was successfully tested for the first time in 1965. In October 1966, a DF-2A was used to launch China's first nuclear weapon for testing purposes (Lewis and Di 1992). The DF-2A bears a strong resemblance to the Soviet R-5M/SS-3, which had been operational in the Soviet Union since 1956. In another striking parallel to the DF-2A programme, the R-5M was also used in a nuclear test in February 1956.

3.2 THE EIGHT-YEAR PLAN AND THE PUSH INTO SPACE

The successful flight of the DF-2A sparked an ambitious new initiative. The Chinese leadership now saw a viable pathway to the gradual development of a nuclear-armed intercontinental ballistic missile. An initial attempt had been made in November 1961 with the development of a conceptual design. However, economic challenges stemming from the "Great Leap Forward" and insurmountable technical difficulties led to the project's abandonment in 1963. Instead, the leadership opted to build incrementally on the successes of existing programmes (Lewis and Di 1992). In March 1965, inspired by the achievements of the DF-2A programme, the First Academy launched an "Eight-Year Plan for the Development of Missile Technologies". This plan, running from 1965 to 1972, envisioned the development of four missile types: the DF-2, as well as the more advanced DF-1/DF-3, DF-4, and DF-5 (Wood and Stone 2021).

At the same time, in November 1966, the Fourth Academy began developing a solid-fuelled motor with a diameter of 1 metre. This motor was later added as a third stage to the DF-4, forming China's first space launch vehicle, the **Long March 1** (also known as the LM-1 or CZ-1 for Chang Zheng, meaning "Long March"), which sent China's first satellite into orbit in 1970. Encouraged by the progress of the 1-metre motor, the Fourth Academy proposed the development of a tactical solid-fuelled rocket called the DF-41 (later renamed the DF-61, not to be confused with the modern DF-41). However, this project was abandoned due to Beijing's limited interest in tactical weapons. As a "consolation prize", the Fourth Academy was tasked in March 1967 with developing the motors for the JL-1, a two-stage solid-fuelled missile. Initially named Ju Long ("Great Dragon") and renamed Ju Lang ("Great Wave") in April 1972 – following Mao's rejection of the dragon as a traditional symbol of China (Lewis and Di 1992) – the JL-1 became China's first submarine missile after its first successful test flight in 1982. Its land-based variant, the DF-21, remains in service today (Wood and Stone 2021; Lewis and Di 1992).

Doubts have been raised about this historical account, as the timeline – spanning from November 1966 to March 1967 – appears improbably short. Within just four months, the Fourth Academy would have had to initiate a solid-fuelled motor programme, adapt it into a design for a tactical solid-fuelled missile, present the concept to the Chinese leadership, proceed with some level of internal development despite a lack of formal approval, and subsequently be assigned the JL-1 programme by the leadership. This sequence of events seems implausible. Even so, the JL-1 marked China's transition from liquid-fuelled rockets to solid-propellant technology in ballistic missile development.

In the meantime, the liquid-fuelled missile programmes outlined in the 1965 Eight-Year Plan progressed largely successfully, albeit with significant delays. Since development of the DF-3 had initially begun under the name DF-1 in 1960, its first test launch was able to take place by late 1966, despite substantial revisions to the design in the spring of 1964 (when it was renamed the DF-3). The DF-3 entered service in 1971, and an improved version, the **DF-3A**, underwent its first test in 1985, achieving operational status in 1987. Some decommissioned DF-3 missiles were then sold to Saudi Arabia in 1988 (Lewis and Di 1992).

Figure 2: Early Chinese missiles and their Soviet counterparts

Image sources: R5 and DF-2A from Schmucker and Schiller (2015); R-12 from Wikimedia Commons (2007); DF-3 from Brügge, n.d.-a

The **DF-4** was initially designed with a range of 4,000 km, sufficient to reach the U.S. base on Guam. Development of the missile began in March 1965, utilising the DF-3 as the first stage and the DF-3 warhead, which allowed the DF-4 programme to focus on the second stage and on modifying the warhead to withstand higher re-entry speeds. The escalation of the conflict with Russia in September 1969 prompted a revision of the design, despite a successful maiden flight in January 1970. The updated design aimed to extend the missile's range to 4,500 km, enabling it to reach Moscow from its planned deployment location in Da Qaidan, Qinghai Province. This modification, coupled with delays caused by the Cultural Revolution beginning in 1966, slowed progress. Although testing later confirmed the DF-4's range to be 4,750 km, it was not declared operational until November 1980 (Lewis and Di 1992).

There is disagreement among sources regarding the actual range of the DF-4. Some (such as NASIC and DIBMAC 2020) cite a range exceeding 5,500 km, which would qualify the DF-4 as an intercontinental ballistic missile. Based on the author's current knowledge, however, a range under 5,000 km appears more plausible. The range of a ballistic missile depends on numerous factors in addition to payload, and thus such figures should not be regarded as absolute values (see Schiller 2022).

During the development phase, a third stage was added to a prototype of the DF-4 to form the Long March 1, which successfully launched China's first satellite into Earth orbit in April 1970. Another successful flight followed in March 1971 (Wade n.d.-a), and three additional flights of an enhanced version called the Long March 1D took place in 1995, 1997, and 2002, during which re-entry vehicles were reportedly tested (Wade n.d.-b). The last DF-4 missiles, stationed with Brigade 662 in Luoyang, appear to have since been decommissioned (Xiu 2022).

The fourth missile in the development plan, the **DF-5**, was China's first true intercontinental ballistic missile. Due to its sheer size, it was designed for silo deployment. The first test took place in 1971, but successful full-range tests did not occur until 1980, requiring the mastery of numerous new technologies that had not been utilised for the DF-3 or the DF-4. These included large engines each producing 70 tonnes of thrust, the use of pure nitrogen tetroxide as an oxidiser, steering via gimballed engines and vernier engines rather than jet vanes, and the use of aluminium-copper alloys for structural components. The silos themselves reportedly presented challenges. The urgency of completing the project, driven by ongoing tensions with the Soviet Union, is reflected in the fact that the first DF-5 units were delivered to the military less than a month after the successful tests in May 1980 and were stationed in experimental silos by December 1980 – just one month after the handover of the DF-4. The first two operational silos were not completed until mid-1981. Thus, the "Eight-Year Plan" initiated in 1965 ultimately took twice as long as originally envisioned (Lewis and Di 1992).

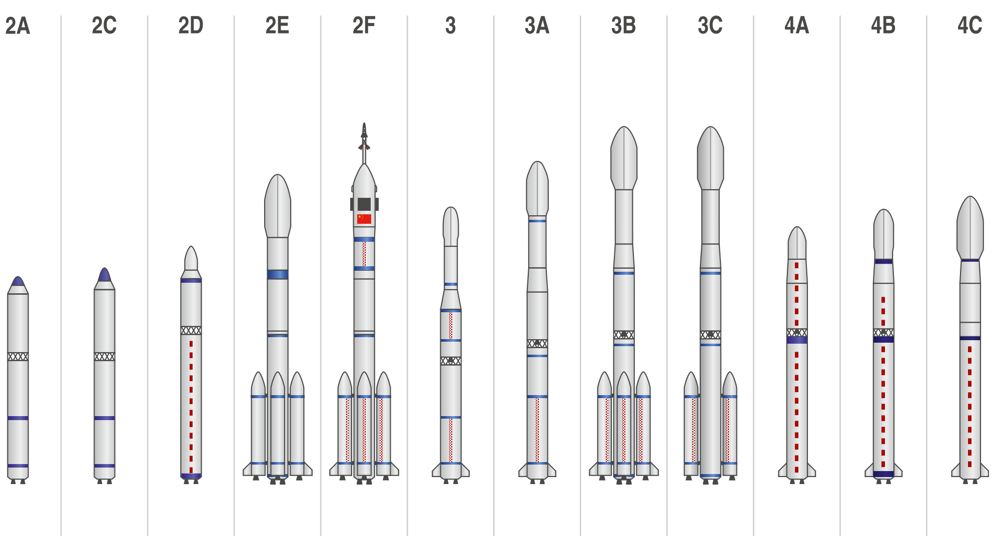
In November 1983, the First Academy began work on improving the performance of the DF-5, which led to the development of the **DF-5A** in 1986. By 1992, four units of the DF-5A were operational (Lewis and Di 1992). Over subsequent years, China apparently replaced the deployed DF-5 units with DF-5A models. In 2015, a further version, the **DF-5B**, was publicly unveiled during a military parade. Unlike its predecessors, this version is reportedly equipped with multiple warheads. A further enhanced version, the DF-5C, is said to be under development and may have been tested as early as 2017 (Wood and Stone 2021). The DF-5B is now believed to be operational with at least two brigades (631 and 661) (Xiu 2022). Whereas the DF-5 and the DF-5A were equipped with single nuclear warheads, the DF-5B reportedly carries three nuclear-armed re-entry vehicles, and the DF-5C could carry up to ten (Missile Defense Project 2021b).

Until the introduction of the DF-5B with its purported three nuclear-armed multiple independent re-entry vehicles (MIRVs) in 2015, China did not possess missiles equipped with multiple warheads. In comparison, the Soviet Union and the United States had achieved this capability as early as the 1970s, making China a technological latecomer. This delay reflects the often underestimated engineering challenges associated with achieving reliable operational performance. For example, the First Academy had planned to add MIRVs to the design of the DF-6 ICBM in 1970, following the deployment of MIRVs on the Minuteman III. The plan was abandoned due to foreseeable difficulties, however, particularly when it came to the necessary miniaturisation of the nuclear warheads. It was only in 1983, as part of the DF-5 modernisation programme, that the MIRV option was revisited. Part of the reason for the delay was also strategic: China initially prioritised the survivability of its long-range missiles over the penetrative power against enemy defences offered by MIRVs. It thus focused on shortening launch sequences for the DF-3 and DF-4 and deploying the DF-5 in hardened silos (Lewis and Di 1992).

The DF-5 served as the basis for the **Long March 2** series of space launch vehicles (Wade n.d.-a; Wade n.d.-b; Janes 2024: 8) and, by extension, for the **Long March 3** and **Long March 4** series as well (Janes 2024: 8). Like the DF-4, the DF-5 was used during its development phase to launch satellites. Although the DF-5 was not declared operational until 1980 (Lewis and Di 1992), a modified version was tested as early as 1974. While the first attempt, conducted as the Long March 2 in November 1974, ended in failure (Wade n.d.-c), all three subsequent launches using a modified version (the **Long March 2C**) in 1975, 1976, and 1978 were successful (Wade n.d.-d). The Long March 2C remains in use today and, as of March 2024, has completed 77 successful flights with only one failure (Krebs n.d.-a), demonstrating reliability comparable to the European Ariane 5. Additional versions, some with a third stage and extra boosters, were introduced in the 1990s. The Long March 2F, which is still used to launch China's "taikonauts" into space (Wade n.d.-e), is also based on the DF-5, as are the various versions of the Long March 3, which have conducted over 150 launches since 1984, placing satellites into low Earth and geostationary orbit (Krebs n.d.-b). The same holds true for the Long March 4 variants, which have been in use since 1988 (Wade n.d.-f).

The DF-5 and its improved variants were China's last liquid-fuelled ballistic missiles. By the early 1980s, the country underwent a significant paradigm shift.

Figure 3: "Long March" space vehicles derived from the DF-5



The external similarity of the core stages reflects their close technical relationship.

Image source: Author's own depiction based on Wikimedia Commons (2008)

3.3 THE SHIFT TO SOLID PROPELLANTS

As noted earlier, the Fourth Academy was tasked in March 1967 with developing the submarine-launched solid-fuelled **JL-1** missile (Wood and Stone 2021). Progress was initially slow, as China did not receive Soviet support for solid-fuelled missile development and faced significant challenges in miniaturising the nuclear warhead. Development of the nuclear-powered submarine intended to carry the missile also advanced at a glacial pace, reducing the urgency to achieve rapid operational readiness for the JL-1 – unlike the parallel efforts in the realm of liquid-fuelled missiles. Progress was also hampered by political headwinds. Some officials were averse to loading multiple missiles onto a submarine, fearing the potential for catastrophic loss, particularly given China’s limited missile inventory. The concurrent Cultural Revolution introduced additional delays. In addition, the strategic value of a Chinese submarine armed with medium-range ballistic missiles for threatening Moscow or the United States was considered relatively limited. Consequently, in 1975, the future Defence Minister Zhang Aiping decided that a land-based version of the JL-1 should also be developed. In 1978, the Fourth Academy (today largely the CASC 4th Academy or AASPT) successfully tested a large solid-fuelled motor with a 1.4-metre diameter, paving the way for work on the land-based variant. This missile was designated the **DF-21** after Deng Xiaoping, Mao’s likely successor, expressed an interest in mobile land-based missiles. From 1978 onward, the project was apparently transferred to the Second Academy, known for its expertise in air defence missile development.[4] In parallel, work had also begun in 1974 on a larger solid-fuelled missile initially designated the DF-23, which had been proposed as early as 1970. This effort would eventually lead to the development of the DF-31 and its submarine-launched variant, the JL-2. First, however, the JL-1/DF-21 was developed to completion. The JL-1 had its first successful test flight in 1982 and was declared operational in August 1983. The first successful flight of the DF-21 followed in May 1985, and the first operational DF-21 regiment was established that same year (Lewis and Di 1992).

Even so, the military use of the JL-1 was far from a success story. By 2006 – more than 20 years after its first flight – it had yet to achieve full operational readiness. This delay has been attributed to ongoing problems with the Xia-class submarines on which the JL-1 was deployed (Kristensen, Norris, and McKinzie 2006). According to publicly available sources, all first-generation DF-21 missiles and JL-1 missiles were equipped with single nuclear warheads.

The development of the **DF-31** and its submarine-launched counterpart, the JL-2, stemmed from the aforementioned consideration of a larger solid-fuelled missile during a particularly tense period in Sino-Soviet relations in August 1970. While preliminary work began in September 1974, significant progress was not made until 1978, under the initial designation DF-23. In 1983, a solid-fuelled motor with a 2-metre diameter was successfully tested during a static burnout. This, combined with the successful flight of the JL-1 in 1982 and its deployment from 1983 onwards, led to increased interest from the Chinese leadership in solid-propellant technology in general and the JL-2/DF-31 programme in particular (Lewis and Di 1992).

Encouraged by these successes and a relaxation of the security situation, the Chinese leadership opted to terminate the last remaining programme for the development of a new liquid-fuelled ballistic missile, the DF-22, focusing future efforts on solid-propellant technology for military applications. On 26 December 1984, the then Ministry of Space Industry, which oversaw all missile development, ordered four fundamental changes to China's ballistic missile programme: a shift from liquid to solid propellants, a focus on tactical rather than strategic missile systems, a transition from first-generation to second-generation launch vehicles, and a move from experimental to applied satellite missions. The significance of this transition to second-generation strategic missiles was clarified in January 1985: the DF-23 programme was renamed DF-31 and prioritised alongside a submarine-launched variant called JL-2, developed as successors to the two-stage DF-21/JL-1. Unlike the earlier programme, however, in which the sea-based JL-1 was prioritised over the land-based DF-21, the new programme reversed these priorities, giving precedence to the land-based DF-31 over the sea-based JL-2. Intensive development of this combination of three-stage solid-fuelled missiles, building on previous work on the DF-23, began in early 1986 (Lewis and Di 1992).

By July 1986, plans for an even more advanced three-stage solid-fuelled missile, the DF-41, were pushed forward. With a range of 12,000 km, the DF-41 was intended to replace the liquid-fuelled DF-5 by no later than 2010. The transition to solid-propellant technology made the development of a mobile ICBM fleet feasible, and planned infrastructure improvements were intended to make China's road network suitable for handling the expected weight of mobile ICBM launchers (Lewis and Di 1992).

Zhang Aiping, the highly decorated general and later Defence Minister mentioned earlier, had advocated for an enhanced version of the DF-21 as early as February 1981. This initiative culminated in the launch of the **DF-21A** programme in July 1986, which focused on reducing structural mass and increasing propellant mass (Lewis and Di 1992). The first known flight test occurred in 1991, and by 1996 the older DF-21 missiles were being replaced with the new DF-21A (Missile Defense Project 2022).

3.4 TACTICAL MISSILES AND EXPORTS

Until the mid-1980s, all Chinese ballistic missiles were designed to carry nuclear warheads. Conventional strikes with ballistic missiles were regarded as too inaccurate and as offering an unattractive cost-to-performance ratio. With the exception of Project 1059, all Chinese systems also had ranges exceeding 1,000 km, making them strategic weapons according to Chinese standards.[5]

Initially, the then Fourth Academy had already initiated the development of a tactical solid-fuelled missile with a 1-metre diameter in 1966. The same technology was intended to be used in the development of the third stage of the Long March 1 launch vehicle mentioned earlier. However, the programme, initially designated the DF-41[6] (and later the DF-61), was abandoned due to a lack of interest from the political leadership. Another tactical programme, this time for a liquid-fuelled missile with a range of 600 km with conventional warheads and 1,000 km with nuclear warheads, was also designated DF-61 and commenced in 1975 at the suggestion of North Korea. This programme was similarly cancelled when its primary advocate on the Chinese side fell out of favour in 1978 (Lewis and Di 1992).

From 1979 onward, the industrial sphere was encouraged to support military programmes through additional civilian business ventures. The international sale of military goods was also promoted, now largely free of the ideological constraints that had previously limited such efforts. In contrast to the Second Academy, which developed air defence missiles, and the Third Academy, which specialised in anti-ship missiles, the First Academy struggled to achieve success in the international arms market until 1984. A proposed two-thirds cut in state funding for research and technology in 1985, combined with the Soviet arms industry's evident success in exporting the Scud B missile to the Middle

East, prompted the First Academy to pursue the development of a new class of tactical missiles. These missiles were intended to surpass the Scud B in both performance and ease of operation.

In April and May 1984, the First Academy submitted proposals for what would later be designated the DF-15 and DF-25 missiles. With a planned range of 1,700 km and a payload capacity of 2,000 kg, the two-stage DF-25 would have been classified as a strategic weapon under Chinese standards. From an operational perspective, however, its conventional warhead rendered it a tactical weapon. Although its range was similar to the existing DF-21, the proposed heavy warhead could cause significantly more damage than a conventionally retrofitted DF-21, which could only carry a payload of 600 kg (Lewis and Di 1992).

The **DF-15**, by contrast, was designed for much shorter ranges and was marketed as an export version under the designation **M-9**.

In April 1984, a proposal for the missile was submitted by the First Academy to the overseeing institution, which at the time was called the Ministry of Space. It called for the development of a single-stage solid-fuelled missile with a 600-km range, armed with conventional warheads and intended for export. The proposal was approved, and development of the M-9 began in October 1985. The People's Liberation Army took notice of the project, and in November 1986 the M-9 programme was incorporated into the DF series under the designation DF-15. Nevertheless, the focus remained on the export version. Even before its first test flight in 1988, a memorandum for the purchase of the M-9 was signed with Syria (Lewis and Di 1992). Additional units were delivered to Pakistan in the early 1990s (Wood and Stone 2021). Meanwhile, in August 1991, China established its first conventionally armed missile brigade with the DF-15 (Wood and Stone 2021).

The M-9 was not the only missile developed primarily for export, however. At a trade fair in 1986, China unveiled an entire family of missiles for export under the "M" designation (Lewis and Di 1992). At the time, it was still unknown in China that certain missiles would, just a year later, fall under the restrictions imposed by the Missile Technology Control Regime (MTCR), established in 1987.

Base 066, which was spun off from the Third Academy (responsible for anti-ship missiles) and later integrated into today's CASIC 4th Academy, had already developed expertise in solid-fuelled motors through its work on solid-fuelled rocket boosters for non-ballistic missiles. Motivated by the same budget cuts that led to the development of the M-9/DF-15, Base 066 began developing a single-stage solid-fuelled missile in 1985 with an initial target range of 300 km, identical to the range of the Soviet Scud B, which was a major export success (at 0.88 metres, the missile's diameter was also identical to that of the Scud). The export version of this missile was designated the **M-11**, while the People's Liberation Army referred to it as the **DF-11**. Base 066 received support for its development from experts at the 12th Institute (responsible for guidance systems) and the 13th Institute (responsible for inertial systems). The programme lagged behind the M-9 programme by about two years, with a successful test flight occurring in mid-1990. By early 1991, the first M-11 missiles were reportedly delivered to Pakistan (Lewis and Di 1992).

The Second Academy, responsible for air defence missiles, also developed a tactical solid-fuelled ballistic missile based on one of its surface-to-air missiles, likely inspired by its success with the JL-1 and DF-21 development programmes, which had been transferred to it in 1978. By 1986, however, the overseeing ministry ordered a stop to these activities, instructing the Second Academy to focus on air defence missiles. This notwithstanding, 1986 saw the launch of **Project 8610**, which converted the Chinese surface-to-air missile HQ-2 (itself based on the Soviet S-75/SA-2) into a two-stage surface-to-surface missile with an initial range of 200 km. This relatively small missile did not play a significant role in China and was therefore not given a DF designation. It was later marketed for export under the designation **M-7** and reportedly delivered to other countries, including Iran (Feickert 2005; Meisel 2017; Missile Defense Project 2021a).

In February 1992, under pressure from the United States, China declared that it would abide by the rules of the MTCR and refrain from exporting missiles with a throw weight of more than 500 kg over a distance greater than 300 km (Lewis and Di 1992). It is conceivable that deals already in place at that time were kept confidential so that China could save face. For example, Pakistan continues to deny any Chinese assistance with its missile programme and insists that its ballistic missiles, such as the Ghaznavi, Shaheen 1, and Shaheen 2, are entirely domestic developments. Clear technical similarities with the M-11, M-9, and DF-25/M-18 suggest otherwise, however (Schmucker and Schiller 2015). To this day, China is not a formal member of the MTCR.

3.5 CURRENT MISSILES

The available sources on developments since the early 1990s are limited. For the period up to 1992, Lewis and Di's excellent overview of the Chinese missile programme, which serves as a primary source for many publications on the topic, provides credible first-hand insight. For the period thereafter, only secondary sources are available. Additionally, many of the developments initiated after 1992 are now operational or nearing completion, making secrecy a much higher priority for Chinese authorities in these programmes and further restricting access to information.

For instance, the available sources provide no information on the maiden flights of modern variants of the DF-21 and the DF-15, or the entire DF-16 family and the DF-26. Similarly, little reliable information exists on the background of these missiles and the institutions involved in their (further) development, leaving much to be interpreted from fragments. These gaps notwithstanding, the information that can nonetheless be gleaned from open sources paints a consistent overarching picture of the continued development of China's missile forces.

3.5.1 SHORT-RANGE MISSILES: VARIANTS OF THE DF-11, DF-15, AND DF-16

Following the introduction of the short-range DF-11 missile into service with the People's Liberation Army in 1992, development reportedly began as early as 1993 on a more advanced version, the **DF-11A**, which was said to have a significantly extended range of up to 600 km. Its maiden flight took place in 1997, before the existence of the programme was made public in 1998. The People's Liberation Army adopted the DF-11A in 1999 (Missile Defense Project 2021d).

Additionally, a DF-11 variant known as the **DF-11AZT** is reported to be equipped with a penetrator warhead designed for hardened targets. This system is said to have entered service in 2013, with photographs appearing in Chinese media in 2016 and footage of a 2013 launch released in 2017 (Missile Defense Project 2021d; Kenhmann 2017).

According to the available sources, the DF-11 was developed as a conventional system. Nevertheless, rumours of an optional nuclear payload have persisted.

Based on the current evidence, these rumours appear unfounded. The only brigade still operating this system today (the DF-11A version, possibly also the DF-11AZT) is listed in a secondary source as a conventional brigade (Xiu 2022).

The DF-15, initially developed as the export variant M-9, has also undergone various updates over the years. The available information is again sparse and at times contradictory. The **DF-15A** reportedly entered service in 1996 and is said to be capable of carrying nuclear warheads (Missile Defense Project 2021e). However, the only brigade that, as of 2022, may still be operating the DF-15A is described in secondary sources as conventional (Xiu 2022). Open sources provide range estimates of 600 km to 900 km, with most suggesting an increase in range over the original DF-15.

The **DF-15B** was first showcased in a parade in 2009 and is said to feature a distinctive triconic warhead with control fins, indicative of a manoeuvrable re-entry vehicle (MaRV). The DF-15B has reportedly been operational since 2006 (Missile Defense Project 2021e).

Reports also indicate the existence of a fourth version introduced in 2013, the **DF-15C**. The shape of its warhead suggests that, like the DF-11AZT, it is designed to serve as a bunker buster for heavily fortified targets (Wood and Stone 2021).

Naming conventions for the DF-15 remain ambiguous in the publicly available sources. For example, while the DF-15B is typically referred to as "CSS-6 Mod 3", the DF-15C is often labelled "CSS-6 Mod 2", suggesting that Western observers identified the DF-15C before they identified the DF-15B (Missile Defense Project 2021e). By contrast, other sources designate the DF-15B as "CSS-6 Mod 2" and the DF-15C as "CSS-6 Mod 3" (China Defense Today 2016). The DF-15A is generally referred to as "CSS-6 Mod 1", which would naturally render the original DF-15 "CSS-6", contrary to the naming conventions of the U.S. Defense Intelligence Agency. This confusion also extends to range estimates. While some sources attribute the DF-15A, an improved version of the DF-15, with a range of 900 km (Army Recognition 2022), others assign it the original 600-km range of the DF-15 (Missile Defense Project 2021e).

Currently, it appears that only two brigades are equipped with the DF-15, which would seem to be in the process of being replaced by the newer **DF-16**. Externally, the DF-16 strongly resembles the DF-15, except that it lacks fins, suggesting a more advanced guidance and control system capable of stabilising aerodynamically unstable missiles. Initially, the DF-16 was thought to have the same diameter as the DF-15, but it can now be assumed to feature a slightly larger booster. As a result, the actual range may be somewhat higher than initially estimated, potentially exceeding 1,000 km, which would classify it as an MRBM.

The information available on the DF-16 is quite sparse. It was first showcased in a parade in 2015 but is believed to have been introduced into service as early as 2011 or 2012. A variant with a manoeuvrable warhead, likely the **DF-16A**, was identified in early 2017 in a video of a Chinese military exercise, indicating that it was already in service before 2017. In 2018, Chinese media showcased another warhead on a DF-16, interpreted as evidence of a further variant called the DF-16B. The available information suggests that all DF-16 variants are conventionally armed (Missile Defense Project 2023).

Naming conventions for the DF-16, like those for the DF-15, remain unclear. Some sources reference only two versions: “CSS-11 Mod 1” and “CSS-11 Mod 2” (NASIC and DIBMAC 2020; IISS 2023), which aligns with reports of the DF-16 and DF-16A in People’s Liberation Army inventories (Xiu 2022). Other sources, however, describe three versions: “CSS-11”, “CSS-11 Mod 1”, and “CSS-11 Mod 2”, which would correspond to the DF-16, DF-16A, and DF-16B.

3.5.2 LONG-RANGE MISSILES: DF-31, JL-2, DF-41

In 1999, the **DF-31** was publicly unveiled for the first time during a parade. Its development can be traced back to the previously mentioned large solid-fuelled missile first initiated in 1970, advanced to preliminary development in 1974, and more seriously pursued as the DF-23 from 1978 onward. Following the successful static test of the 2-metre solid-fuelled motor in 1983, the programme was prioritised and revised, renamed the DF-31/JL-2 in 1985, and pushed forward intensively starting in 1986 (Lewis and Di 1992).

Reportedly due to difficulties in procuring guidance systems, it was not until 2006 that the first DF-31 missiles entered service (Missile Defense Project 2021f). No units were deployed with the system until 2006 (Kristensen, Norris, and McKinzie 2006).

The DF-31 serves as a mobile solid-fuelled ICBM, comparable to the Soviet-Russian Topol. The U.S. Minuteman III is also similar in size and configuration, although the latter is exclusively silo-based and significantly outperforms the original DF-31. The introduction of the DF-31 marked a shift from a reliance on China's few heavy liquid-fuelled DF-5 ICBMs, which were restricted to silo deployment, to a larger number of smaller mobile solid-fuelled ICBMs.

China has continued along this trajectory by incrementally improving the DF-31. The **DF-31A** reportedly had its maiden flight as early as 1999 and is said to have achieved a range of over 11,000 km thanks to a lighter guidance system and other enhancements. In 2017, China showcased the latest version, the **DF-31AG**, during a parade. Unlike its predecessors, which were mounted on a MEL with a tractor-trailer configuration, the DF-31AG is deployed on a highly mobile off-road TEL. This version is currently being integrated into the People's Liberation Army (Missile Defense Project 2021f).

Parallel to the DF-31, the submarine-launched **JL-2** version was also developed and reportedly tested for the first time in 2004, with its first successful test occurring in June 2005 (Kristensen, Norris, and McKinzie 2006). As with the JL-1, the deployment of this system appears to have faced challenges, and U.S. and British sources only began listing the JL-2 as operational around 2015. It is now believed to be deployed on up to six Jin-class (Type 094) submarines (U.S. Department of Defense 2015; IISS 2016).

In addition to the DF-31, China has been working since the mid-1980s on an even larger mobile solid-fuelled missile, originally intended to replace the DF-5 with a planned range of 12,000 km. This programme was designated **DF-41** from the outset (not to be confused with the cancelled DF-41/DF-61 programme from the 1960s) (Lewis and Di 1992).

The DF-41 was first unveiled to the public during a parade in 2019. At the time, it was announced that two brigades were already equipped with this system. In addition to the existing road-mobile version, silo-based and rail-based variants are reportedly in development (U.S. Department of Defense 2022). Unlike the DF-31, the DF-41 is expected to be equipped with nuclear multiple warheads.

3.5.3 MEDIUM-RANGE MISSILES: DF-21, DF-26, DF-17

As the DF-31 was nearing deployment, Brigade 653 reportedly conducted the first launch of a new missile in 2004, believed to have been the DF-21C (Xiu 2022: 145). Unlike the nuclear-armed DF-21 and DF-21A variants, the **DF-21C** is reportedly a purely conventional version. The missile's armament drew criticism upon its disclosure, as there were concerns that the United States might misinterpret a DF-21C launch as a nuclear strike and initiate countermeasures (Kristensen, Norris, and McKinzie 2006). The DF-21C now appears to have been retired. One source identifies Brigade 652 as the last unit to be equipped with the DF-21C, although it has reportedly since transitioned to an unknown version of the DF-31 (Xiu 2022: 143).

It is notable that very little information can be found on a possible **DF-21B** variant. The few indications available suggest it may have been equipped with a manoeuvrable warhead and possibly subsumed under the DF-21D programme, which became public around 2010.

The increased attention surrounding the DF-21D likely stemmed from comments made in May 2010 by a senior U.S. admiral, according to whom the **DF-21D** had achieved initial operational capability (IOC) and was combat-ready. This variant of the DF-21 features a manoeuvrable warhead and was specifically designed to target ships (earning it the classification of an anti-ship ballistic missile, or ASBM) and has been widely interpreted by U.S. analysts as a "carrier killer", targeting aircraft carriers. To the extent that China views U.S. Navy power projection in the Pacific as a building block of American military dominance, and to the extent that aircraft carriers play a central role in that projection, it was logical for China to focus on countermeasures to keep such carriers away from Chinese territory and areas of influence starting in the late 1990s. These efforts were first mentioned in an open report by the U.S. Department of Defense in 2005, and notice of the system's imminent operational status was given in 2009 (Chandrashekar et al. 2011).

The DF-21D has reportedly been successfully tested not only against simulated carrier targets on land but also against actual ships (Missile Defense Project 2022).

Two additional modern Chinese systems are of particular significance to the current capabilities of China’s missile forces. The first is the **DF-26**, which will likely play a dominant role in the coming years due to its numbers alone. This missile appears to be a scaled-up and enhanced version of the DF-21.

Development began sometime before 2010, with initial images appearing in Chinese sources by 2012. U.S. intelligence sources confirmed the existence of the system in 2014 (Missile Defense Project 2021h). The DF-26 is a two-stage solid-fuelled missile mounted on a highly mobile six-axle TEL. It was first publicly displayed during a parade in 2015 and became operational in 2016. The missile can be equipped with either nuclear or conventional warheads, which can be rapidly swapped depending on the mission. An anti-ship version of the DF-26 is also operational (U.S. Department of Defense 2022), comparable to a longer-range DF-21D.

Although the first DF-26 units were first deployed around 2016, their numbers have increased rapidly in recent years. In 2020, the U.S. Department of Defense reported to Congress that China already possessed over 200 launch vehicles for the DF-26 (U.S. Department of Defense 2020). By 2022, this number had risen to 250 (U.S. Department of Defense 2022). At least six brigades are now believed to be equipped with the DF-26 (Xiu 2022).

The second significant modern system is the **DF-17**. This hypersonic weapon features a hypersonic glide vehicle (HGV) that can be launched using a single-stage solid-fuelled booster, with a range exceeding 2,000 km. The system is mobile and was first publicly showcased during a parade in 2019. Reports of China’s experiments with hypersonic weapons since 2014 are thought to be related to tests of the DF-17 (Missile Defense Project 2021c).

The DF-17 entered service in 2020. A Chinese expert described its primary purpose as targeting enemy military bases and naval groups in the western Pacific (U.S. Department of Defense 2022). Here too, the increase in operational units is notable; by the end of 2021, three brigades were reportedly equipped with the DF-17 (Xiu 2022).

3.5.4 OTHER CURRENT SYSTEMS

China continues to offer short-range missiles that comply with the Missile Technology Control Regime (MTCR), such as the **DF-12/M-20** and **BP-12A**, which have been marketed for export for over a decade. However, these conventional close-range ballistic missiles (CRBMs) appear to play only a marginal role within the Chinese armed forces. Unlike other ballistic missiles, they are not assigned to the missile forces, and reliable sources on Chinese military capabilities (e.g., IISS 2021) do not mention them. As such, they will not be discussed further here.

3.6 THE NEAR FUTURE

The **JL-3**, which is likely based on the DF-41, was tested for the first time in 2018. It is intended to complement or replace the JL-2 as a submarine-launched missile but is unlikely to play a significant role for several years to come, particularly given the extended development timelines of China's previous submarine-launched missiles.

Confidential sources indicate that additional missile projects are under development. These include a further improved version of the DF-5, the **DF-5C**; another modernised variant of the DF-31, the **DF-31B**; and a "long-range missile" with a range of 5,000 km to 8,000 km, designated the **DF-27**, which is reportedly equipped with a hypersonic glide vehicle (HGV). In addition, speculation surrounds an object launched on 27 July 2021, which, after travelling more than 40,000 km and completing over 100 minutes of flight time, narrowly missed its target in China. This has been interpreted as a potential first step toward developing a fractional orbital bombardment system (FOBS) with unlimited range and HGV technology (U.S. Department of Defense 2022).

China also appears to be working on an air-launched ballistic missile. During a parade in 2019, the Chinese Air Force unveiled a new version of its H-6 long-range bomber, designated the H-6N. This version, featuring a modified fuselage, is reportedly capable of carrying a ballistic missile on external mounts and launching it mid-flight. It has been speculated that this air-launched missile may be nuclear-armed. In October 2020, an H-6N was observed carrying an object resembling a ballistic missile (U.S. Department of Defense 2022). This object,

Figure 4: H-6N long-range bomber with ballistic missile

Image source: Navy Recognition (2022)

which has since been observed and documented on several occasions, could potentially be another hypersonic weapon. Additionally, a smaller air-launched missile resembling the Russian Kinzhal in both dimensions and appearance also appears to be in development. A model of this missile was displayed at an exhibition in November 2022, and a video surfaced in May 2024 showing the release of such a missile from an H-6K bomber (Newdick 2024).

China is also reportedly advancing the construction of silo fields in at least three different locations. Current estimates suggest that these fields could soon accommodate over 300 new missile silos, which are believed to be primarily designed for ICBMs (U.S. Department of Defense 2022). However, it remains unclear whether all of these silos will actually be equipped with ICBMs (Wood and Stone 2021). In January 2024, the U.S. Bloomberg news agency reported that, according to U.S. intelligence assessments, the construction of these silo fields has been significantly impacted by corruption (Martin and Jacobs 2024).

In any case, rapid development is expected to continue. In 2021 alone, the People's Liberation Army conducted approximately 135 test and training launches of ballistic missiles – more than the rest of the world combined (U.S. Department of Defense 2022).

Together with the expansion of brigades and operational systems, this paints a consistent picture of China as an emerging missile power that will soon likely reach parity with Russia and the United States.

4 China's Ballistic Missile Systems

The following section presents selected Chinese missile systems along with relevant technical data, offering interested readers a concise overview of each system. The focus is limited to ballistic missiles with a throw weight exceeding the MTCR thresholds (i.e. payloads over 500 kg with a range greater than 300 km). Only systems that are currently operational, according to the latest available information, are included in this overview.

Table 4: Overview of operational Chinese missiles

SYSTEM	ALTERNATIVE DESIGNATION	SERVICE ENTRY	CLASS	RANGE [KM]	PAYLOAD [KG]	STAGES	PROPULSION	NUC/CONV	BRIGADE	TELS/MELS/ SILOS
DF-11A	CSS-7 Mod 2	1999	SRBM	600	~500	1	solid	conv	615	~27–36 TELs
DF-11AZT		2013?	SRBM	600	?	1	solid	conv	part 615	
DF-15A	CSS-6 Mod 1	1996	SRBM	600? (900?)	500+	1	solid	conv	616	bis 27–36 TELs
DF-15B	CSS-6 Mod 3	2006	SRBM	725+	500+	1	solid	conv	613, part 616?	~27–36+ TELs
DF-15C	CSS-6 Mod 2	2013?	SRBM	850+	500+	1	solid	conv	part 616?	Wenige TELs
DF-16	CSS-11 Mod 1	2011	SRBM	700+	500–1,000	1	solid	conv	part 636?	~9–18 TELs ?
DF-16A	CSS-11 Mod 2	2016?	SRBM	700+	500–1,000	1	solid	conv	617, part 636	~45–54 TELs?
DF-21A	CSS-5 Mod 2	1996	MRBM	1,750+	500+	2	solid	1x nuc	611 (612)	12 MELs
DF-21D	CSS-5 Mod 5	2010?	MRB *ASBM*	1,500+	500+	2	solid	conv	624, 653?	24 TELs
DF-17	CSS-22	2020	MRB *HGV*	unknown (2,000+)	?	1	solid	conv	614, 627, 655	? TELs
DF-26	CSS-18	2016	IRBM *ASBM*	3,000+	1,000+	2	solid	1x nuc, conv	625, 626, 646, 647?, 654, 666	108+ TELs
DF-5A	CSS-4 Mod 2	1990?	ICBM	12,000+	~3,900+	2	liquid	1x nuc	633	6 silos
DF-5B	CSS-4 Mod 3	2015	ICBM	12,000+	~4,000	2+PBV	liquid	3x nuc	631, 661	12 silos
DF-31	CSS-10 Mod 1	2006	ICBM	7,000+	1,000+	3	solid	1x nuc	641	? MELs
DF-31A	CSS-10 Mod 2	2007	ICBM	11,000+	1,000+	3	solid	1x nuc	622, 652, 663	36? MELs
DF-31AG	-	2016?	ICBM	unknown (11,000+)	1,000+	3	solid	1x nuc	621, 632, 642, 643, 664, (new 612?)	52+ TELs
DF-41	CSS-20	2017?	ICBM	unknown (15,000)	~2,500	3+PBV	solid	3–10(?)x nuc	644, 651, (new 662?)	24? TELs
JL-2	CSS-N-14	2015?	SLBM	7,000+	1,000+	3	solid	1x nuc	6 submarines	up to 12 tubes each

Data source: Author's own assessment, as of mid-2023

nuc = nuclear / conv = conventional

4.1 SHORT-RANGE BALLISTIC MISSILES (SRBMS, RANGES UP TO 1,000 KM)

The following overview provides details on various versions of the short-range systems DF-11, DF-15, and DF-16.

4.1.1 DF-11A

Also known as CSS-7 Mod 2. A conventionally armed mobile short-range missile. An improved version of the M-11/DF-11, which was initially developed for export. Currently active as the weapon system of Brigade 615.

Figure 5: DF-11A

Image: ©CSIS Missile Defense Project

Table 5: Overview of DF-11A

	DF-11A
SERVICE ENTRY	1999
CONFIGURATION	1 stage, mobile
PROPELLANT	solid
LAUNCH WEIGHT	~4.2 t
PAYLOAD	~500 kg
WARHEAD	conventional warhead
RANGE	600 km
STATUS	operational, being phased out (only one active brigade)

Data source: Author's own assessment

4.1.2 DF-11AZT

A conventionally armed mobile short-range missile equipped with a penetrator warhead for targeting fortified structures. Likely uses the DF-11A as its delivery system. Currently active as part of the armament of Brigade 615.

Figure 6: DF-11AZT

Image source: Kenhmann (2017)

Table 6: Overview DF-11AZT

	DF-11AZT
SERVICE ENTRY	2013?
CONFIGURATION	1 stage, mobile
PROPELLANT	solid
LAUNCH WEIGHT	over 4 t
PAYLOAD	?
WARHEAD	conventional penetrator warhead
RANGE	600 km
STATUS	operational, being phased out (only one active brigade)

Data source: Author's own assessment

4.1.3 DF-15A

Also known as CSS-6 Mod 1. A conventionally armed mobile short-range missile. An improved version of the M-9/DF-15, which was initially developed for export. At present, likely active solely as the weapon system of Brigade 616.

Figure 7: DF-15A

Image: ©CSIS Missile Defense Project

Table 7: Overview DF-15A

	DF-15A
SERVICE ENTRY	1996
CONFIGURATION	1 stage, mobile
PROPELLANT	solid
LAUNCH WEIGHT	over 6 t
PAYLOAD	over 500 kg
WARHEAD	conventional warhead
RANGE	600? (900?) km
STATUS	operational, being phased out (only one active brigade)

Data source: Author's own assessment

4.1.4 DF-15B

Also known as CSS-6 Mod 3. A conventionally armed mobile short-range missile with a manoeuvrable warhead (MaRV). An improved version of the M-9/DF-15, which was initially developed for export. Currently believed to be active as the weapon system of Brigade 613, and possibly also part of Brigade 616.

Figure 8: DF-15B

Image: ©CSIS Missile Defense Project

Table 8: Overview DF-15B

	DF-15B
SERVICE ENTRY	2006
CONFIGURATION	1 stage, mobile
PROPELLANT	solid
LAUNCH WEIGHT	over 6 t
PAYLOAD	over 500 kg
WARHEAD	conventional manoeuvrable warhead
RANGE	725+ km
STATUS	operational (only one active brigade, possibly part of another brigade)

Data source: Author's own assessment

4.1.5 DF-15C

Also known as CSS-6 Mod 2. A conventionally armed mobile short-range missile equipped with a penetrator warhead for targeting fortified structures. Possibly active as part of Brigade 616's armament.

Figure 9: DF-15C

Image: ©CSIS Missile Defense Project

Table 9: Overview DF-15C

	DF-15C
SERVICE ENTRY	2013?
CONFIGURATION	1 stage, mobile
PROPELLANT	solid
LAUNCH WEIGHT	over 6 t
PAYLOAD	over 500 kg
WARHEAD	conventional penetrator warhead
RANGE	850+ km
STATUS	likely operational (only active as part of a brigade)

Data source: Author's own assessment

4.1.6 DF-16

Also known as CSS-11 Mod 1. A conventionally armed mobile short-range missile. Likely still part of Brigade 636's armament.

Figure 10: DF-16

Image source: You (2019)

Table 10: Overview DF-16

	DF-16
SERVICE ENTRY	2011
CONFIGURATION	1 stage, mobile
PROPELLANT	solid
LAUNCH WEIGHT	?
PAYLOAD	500–1,000 kg
WARHEAD	conventional warhead
RANGE	700+ km
STATUS	operational (only active as part of a brigade)

Data source: Author's own assessment

4.1.7 DF-16A

Also known as CSS-11 Mod 2. A conventionally armed mobile short-range missile with a manoeuvrable warhead (MaRV). Currently active as the weapon system of Brigade 617 and possibly part of Brigade 636's armament alongside the DF-16.

Figure 11: DF-16A

Image: ©CSIS Missile Defense Project

Table 11: Overview DF-16A

	DF-16A
SERVICE ENTRY	2016?
CONFIGURATION	1 stage, mobile
PROPELLANT	solid
LAUNCH WEIGHT	?
PAYLOAD	500–1,000 kg
WARHEAD	conventional manoeuvrable warhead
RANGE	700+ km
STATUS	operational (2 active brigades)

Data source: Author's own assessment

4.2 MEDIUM-RANGE BALLISTIC MISSILES (MRBMS, 1,000–3,000 KM RANGE)

The following overview provides details on various versions of the DF-21 system and the DF-17.

4.2.1 DF-21A

Also known as CSS-5 Mod 2. A nuclear-armed mobile medium-range missile with a single warhead. Currently believed to be active as the weapon system of Brigade 611, with Brigade 612 likely having transitioned to the DF-31AG.

Figure 12: DF-21A

Image source: Panyue (2018)

Table 12: Overview DF-21A

	DF-21A
SERVICE ENTRY	1996
CONFIGURATION	2 stages, mobile
PROPELLANT	solid
LAUNCH WEIGHT	~15.2 t
PAYLOAD	over 500 kg
WARHEAD	nuclear warhead (1x ~250-500 kt TNT)
RANGE	600 km
STATUS	operational, being phased out (only 1–2 active brigades)

Data source: Author's own assessment

4.2.2 DF-21D

Also known as CSS-5 Mod 5 or "Carrier Killer". A conventionally armed mobile medium-range missile with a manoeuvrable warhead (MaRV) designed for targeting naval vessels. Currently believed to be active as the weapon system of Brigade 624 and possibly still with Brigade 653, although it may have been replaced by a new system there around 2020.

Figure 13: DF-21D

Image source: Newdick (2022)

Table 13: Overview DF-21D

	DF-21D
SERVICE ENTRY	2010?
CONFIGURATION	2 stages, mobile
PROPELLANT	solid
LAUNCH WEIGHT	over 15 t
PAYLOAD	over 500 kg
WARHEAD	conventional manoeuvrable warhead
RANGE	1,500+ km
STATUS	operational (1–2 active brigades)

Data source: Author's own assessment

4.2.3 DF-17

Also known as CSS-22. A mobile conventional hypersonic weapon featuring a hypersonic glide vehicle (HGV) atop a solid-fuelled booster, capable of targeting naval vessels. Confidential sources suggest it may also have a nuclear capability. Currently believed to be active as the weapon system of Brigades 614, 627, and 655.

Figure 14: DF-17

Image: ©CSIS Missile Defense Project

Table 14: Overview DF-17

	DF-17
SERVICE ENTRY	2020
CONFIGURATION	1 stage plus HGV, mobile
PROPELLANT	solid
LAUNCH WEIGHT	~15 t
PAYLOAD	?
WARHEAD	HGV
RANGE	likely 2,000+ km
STATUS	operational, being introduced (at least 3 active brigades)

Data source: Author's own assessment

4.3 INTERMEDIATE-RANGE BALLISTIC MISSILES (IRBMS, 3,000–5,500 KM RANGE)

The following section focuses exclusively on the DF-26 system.

4.3.1 DF-26

A mobile intermediate-range missile with an interchangeable conventional or nuclear warhead. Since 2020, it has also apparently been available in the DF-26B version with a manoeuvrable warhead (MaRV) designed for targeting naval vessels. Currently believed to be active as the weapon system of Brigades 625, 626, 646, 654, 666, and possibly 647. The number of units has been rapidly increasing.

Figure 15: DF-26

Image: ©CSIS Missile Defense Project

Table 15: Overview DF-26

	DF-26
SERVICE ENTRY	2016
CONFIGURATION	2 stages, mobile
PROPELLANT	solid
LAUNCH WEIGHT	~20 t
PAYLOAD	over 1,000 kg
WARHEAD	both conventional and nuclear warheads, manoeuvrable conventional warhead
RANGE	3,000+ km
STATUS	operational, being introduced (now at least 6 active brigades)

Data source: Author's own assessment

4.4 INTERCONTINENTAL BALLISTIC MISSILES (ICBMS, RANGES OVER 5,500 KM)

The following section provides details on various versions of the DF-5, DF-31, and DF-41 intercontinental ballistic missiles.

4.4.1 DF-5A

Also known as CSS-4 Mod 2. A heavy nuclear-armed intercontinental ballistic missile with a single warhead. Currently believed to be active in six silos operated by Brigade 633.

Figure 16: DF-5A

Image source: Brügge (n.d.-b)

Table 16: Overview DF-5A

	DF-5A
SERVICE ENTRY	1990?
CONFIGURATION	2 stages, silo
PROPELLANT	liquid
LAUNCH WEIGHT	~183 t
PAYLOAD	~3.9 t
WARHEAD	nuclear warhead (1x 1–3 Mt TNT)
RANGE	12,000+ km
STATUS	operational (1 active brigade)

Data source: Author’s own assessment

4.4.2 DF-5B

Also known as CSS-4 Mod 2. A heavy nuclear-armed intercontinental ballistic missile equipped with multiple warheads (three re-entry vehicles per missile). China's first missile to feature multiple warheads. Currently believed to be active in six silos each for Brigades 631 and 661.

Figure 17: DF-5B

Image source: Asian Defence News (2015)

Table 17: Overview DF-5B

	DF-5B
SERVICE ENTRY	2015
CONFIGURATION	2 stages plus post-boost vehicle, silo
PROPELLANT	liquid
LAUNCH WEIGHT	~183 t
PAYLOAD	~4 t
WARHEAD	nuclear multiple warhead (MIRV) (3x)
RANGE	12,000+ km
STATUS	operational (2 active brigades)

Data source: Author's own assessment

4.4.3 DF-31

Also known as CSS-10 Mod 1. A nuclear-armed mobile intercontinental ballistic missile with a single warhead. Currently believed to be active as the weapon system of Brigade 641.

Figure 18: DF-31

Image: ©CSIS Missile Defense Project

Table 18: Overview DF-31

	DF-31
SERVICE ENTRY	2006
CONFIGURATION	3 stages, mobile
PROPELLANT	solid
LAUNCH WEIGHT	~42 t
PAYLOAD	1+ t
WARHEAD	nuclear warheads (1x 200–300 kt TNT)
RANGE	7,000+ km
STATUS	operational (only 1 active brigade)

Data source: Author's own assessment

4.4.4 DF-31A

Also known as CSS-10 Mod 2. A nuclear-armed mobile intercontinental ballistic missile with a single warhead. Currently believed to be active as the weapon system of Brigades 622, 652, and 663.

Figure 19: DF-31A

Image source: People's Daily Online Deutsch (2015)

Table 19: Overview DF-31A

	DF-31A
SERVICE ENTRY	2007
CONFIGURATION	3 stages, mobile
PROPELLANT	solid
LAUNCH WEIGHT	over 40 t
PAYLOAD	1+ t
WARHEAD	nuclear warhead (1x 200–300 kt TNT)
RANGE	11,000+ km
STATUS	operational (3 active brigades)

Data source: Author's own assessment

4.4.5 DF-31AG

A nuclear-armed mobile intercontinental ballistic missile with a single warhead. More mobile than previous DF-31 variants. Currently active as the weapon system of Brigades 621, 632, 642, 643, and 664, with Brigade 612 likely having transitioned from the DF-21A to the DF-31AG.

Figure 20: DF-31AG

Image source: Jiayao (2019)

Table 20: Overview DF-31AG

	DF-31AG
SERVICE ENTRY	2016?
CONFIGURATION	3 stages, mobile
PROPELLANT	solid
LAUNCH WEIGHT	over 40 t
PAYLOAD	1+ t
WARHEAD	nuclear warhead (1x 200–300 kt TNT)
RANGE	likely 11,000+ km
STATUS	operational, being introduced (at least 5 active brigades)

Data source: Author's own assessment

4.4.6 DF-41

Also known as CSS-20. A nuclear-armed mobile intercontinental ballistic missile equipped with multiple warheads (ranging from 3 to 10 re-entry vehicles, depending on the source). Currently believed to be active as the weapon system of Brigades 644 and 651, with Brigade 662 likely having transitioned from the DF-4 to the DF-41.

Figure 21: DF-41

Image: ©CSIS Missile Defense Project

Table 21: Overview DF-41

	DF-41
SERVICE ENTRY	2017?
CONFIGURATION	3 stages plus post-boost vehicle, mobile or silo
PROPELLANT	solid
LAUNCH WEIGHT	~80 t
PAYLOAD	~2.5 t
WARHEAD	nuclear multiple warhead (MIRV) (3–10(?)x)
RANGE	likely 15,000 km
STATUS	operational, being introduced (2 active brigades)

Data source: Author’s own assessment

4.5 SUBMARINE-LAUNCHED BALLISTIC MISSILES (SLBMS, ALL RANGES)

This section exclusively covers the JL-2 system.

4.5.1 JL-2

Also known as CSS-N-14. A nuclear-armed submarine-launched missile with intercontinental range and a single warhead. Rumours suggest the possibility of a multiple warhead configuration with three to eight re-entry vehicles. A submarine-based version of the DF-31. Currently believed to be active with up to 12 missiles on as many as six Jin-class submarines (Type 094).

Figure 22: JL-2

Image: ©CSIS Missile Defense Project

Table 22: Overview JL-2

	JL-2
SERVICE ENTRY	2015?
CONFIGURATION	3 stages, mobile
PROPELLANT	solid
LAUNCH WEIGHT	~42 t
PAYLOAD	1+ t
WARHEAD	nuclear warhead (1x 1 Mt TNT)
RANGE	7,000+ km
STATUS	operational (6 active submarines)

Data source: Author's own assessment

5 The Import and Export of Ballistic Missile Systems

Various international agreements regulate the import and export of certain weapons systems, as well as components or technologies that could facilitate or accelerate the development of such weapons. Even in cases where transfers are not covered by such agreements, a degree of moral responsibility remains regarding whether a nation should engage in such activities. Missile technology is no exception – in fact, it is a prime example. Almost all missile programmes worldwide have been initiated through extensive transfers of systems, components, technologies, and even expertise and personnel.

The following section examines China's international connections, focusing on the import and export of technologies, components, and systems, both historically and in the present.

5.1 IMPORT

As outlined in section 3.1, China's missile programme was initially established through the import of Soviet hardware and expertise. After decades of independent development, China is now considered technologically self-sufficient, with no reports of complete missile systems being imported in recent decades.

It remains unclear whether critical raw materials are still being imported for current programmes. Likewise, it is uncertain whether specific machinery and tools must be sourced internationally to support missile development and production. That said, it is plausible that China occasionally utilises Western products, although these are rarely explicitly linked to missile programmes due to their dual-use nature.

Insights into the use of system components would be particularly valuable. It has recently become evident that even Russia, long regarded as one of the world's leading nations in missile development, relies on Western products for microelectronics and other parts. For example, debris from Russian missiles in Ukraine has revealed numerous Western components (see, e.g., Byrne et al. 2022). While detailed information on the components used in Chinese missiles is not publicly available, it is reasonable to assume that Western parts have occasionally been utilised in the past and may continue to be used in some instances.

5.2 EXPORT

To begin with, it is important to understand China's stance on the export of ballistic missiles.

As a source noted in 1992, every arms export was regarded within the Chinese defence industry as a success for the nation, as it meant that the many painstaking hours spent on development and construction were finally paying off financially. Even so, the source stated that nuclear and chemical weapons technologies were not to be exported. No such restrictions were placed on ballistic missiles, however; on the contrary, the Chinese view was that long-range missiles – so long as they were not nuclear-armed – were less effective than combat aircraft, which could strike distant targets more cost-effectively and with greater precision. Similarly, aircraft were deemed superior for deploying chemical weapons, as they could adjust to wind conditions at the target site. From this perspective, there was no reason to object to the export of ballistic missiles as long as other nations continued to sell combat aircraft (Lewis and Di 1992: 37f.).

There are indications that China eventually yielded to U.S. pressure to exercise restraint in the export of long-range missiles. In February 1992, Beijing announced that it would adhere to MTCR guidelines, even though China remains a non-member to this day (Lewis and Di 1992: 38).

It is difficult to assess the extent to which China has genuinely complied with these guidelines. No major transfers of systems that would clearly violate the MTCR have been officially reported since 1992. However, there are reports that programmes in other countries have continued to draw heavily on Chinese resources (e.g., Giesen et al. 2023).

The most notable transfer of complete Chinese systems prior to 1992 was the export of several dozen DF-3 intermediate-range missiles to Saudi Arabia around 1987. These were likely the original version of the DF-3, which had already been replaced in China by the upgraded DF-3A. The Arms Transfer Database of the Stockholm International Peace Research Institute (SIPRI) estimates that 50 missiles were delivered between 1987 and 1988 (SIPRI 2023). Saudi Arabia first displayed some of these missiles during a parade in 2014, but no flight tests or operational uses of these weapons have been reported.

As previously mentioned (see Section 3.4), China began developing short-range systems explicitly for export in the 1980s. The resulting DF-15/M-9 and DF-11/M-11 were never officially exported, however, nor was the more advanced two-stage M-25. It is widely understood that these systems nevertheless found their way to Pakistan, possibly even after 1992, despite China's pledge to abide by MTCR guidelines and to cease the transfer of such systems, components, and technologies. Pakistan's Shaheen 1 missile appears to be based on the DF-15/M-9 motor, the Ghaznavi on the DF-11/M-11, and the Shaheen 2 bears striking similarities to contemporary Chinese technology. There has been credible speculation that the Shaheen 2 may be based on the DF-25/M-18, which seemingly "disappeared" from China. It is also believed that China supported the establishment of a domestic production line for these missile motors in Pakistan (Schmucker and Schiller 2015). The Iranian missile programme is also reported to have benefited from Chinese support since the 1990s, though not as overtly as Pakistan's programme (e.g., Giesen et al. 2023; Schmucker and Schiller 2015). Such activities would likely have violated the MTCR.

There are known exports of complete Chinese systems that fall below the MTCR thresholds. The M-7 (also known as CSS-8), for instance, which originated from Project 8610, was apparently delivered to Iran in the 1990s, where it was used as the Tondar-69 (SIPRI 2023).

A family of short-range systems appears to have evolved from the smaller solid-fuelled B611 missile in the 1990s. These systems were reportedly delivered to Türkiye in the 2000s, where they served as a starting point for Turkish missile development. In subsequent years, the BP-12 was developed from this system in China and later delivered to Qatar in 2017–2018 and Ethiopia in 2020 (SIPRI 2023).

Overall, China's export activities remain relatively limited compared to the extensive export of U.S. short-range ATACMS to allied nations and the global proliferation and availability of Soviet-Russian systems. Whether this is due to a restrictive Chinese doctrine or a lack of demand cannot be answered here.

6 Number and Locations of China's Missile Systems

The literature contains detailed information on the number and locations of currently operational Chinese missile systems. Based on this data, various insights are derived in the following sections. This section outlines the development of the number of available missile systems in recent years, categorised by range class, to identify trends in the armament of China's missile forces. It also provides an overview of the structure of these missile forces, detailing their weaponry, deployment locations, and corresponding ranges, which together allow for an assessment of the projected threat. An example of this would be the deployment of a short-range missile brigade in close proximity to Taiwan.

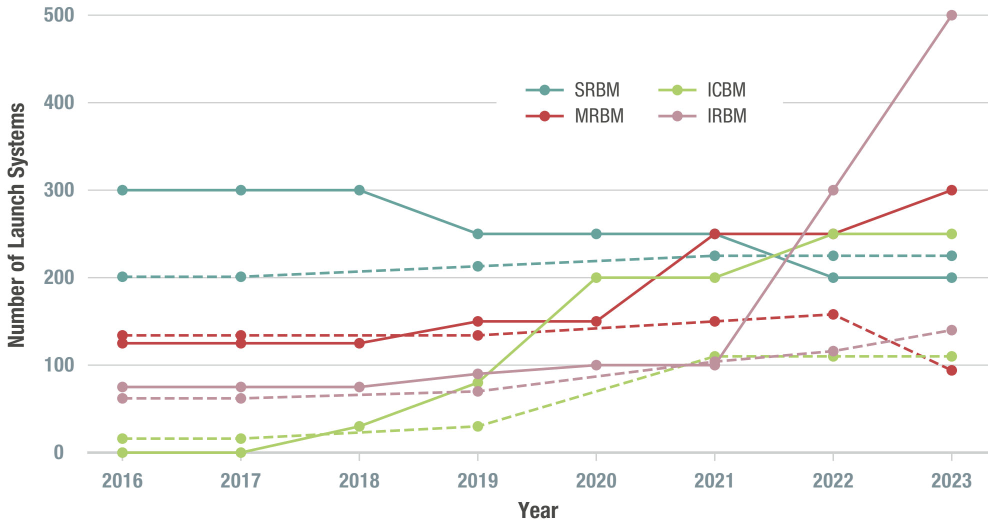
All figures and details in the following sections are based on publicly accessible sources. As such, they serve only as an initial basis for analysing the current situation.

6.1 MISSILE FORCES OVER TIME

Numerous open sources offer information on the number of missile systems available in China. In some instances, individual systems (or system families, such as the DF-15) are specified, while in others only range classes are identified (e.g., SRBM). Additionally, some figures refer only to launch platforms (e.g., the number of silos or TELs), whereas others estimate the number of available missiles.

While these figures vary to some extent, clear trends can still be identified. In recent years, there has been significant growth, particularly in the number of IRBMs and ICBMs.

Figure 23: Trends in the number of launch platforms for SRBMs, MRBMs, IRBMs, and ICBMs



Data source: Author's own depiction based on data from U.S. Department of Defense (2015; 2016; 2017; 2018; 2019; 2020; 2021; 2022; 2023, IISS 2016; 2017; 2018; 2019; 2020; 2021; 2022; 2023)

6.2 CURRENT FORCE LEVELS AND RANGES

The following figures on current force levels are derived from information on deployed brigades and their systems (Xiu 2022; Huxley and Kuok 2022). However, more recent studies (U.S. Department of Defense 2023; Kristensen et al. 2024) suggest that these numbers may already be outdated. For example, the DF-21A may have been decommissioned, while the number of DF-26 systems appears to have grown significantly, potentially exceeding 200 launch vehicles. Similarly, the original version of the DF-31 may have been retired, while DF-31AG and DF-41 numbers appear to have increased. That said, the available data remains highly speculative, with actual figures appearing to fluctuate almost weekly. Consequently, all figures provided here should be regarded as approximate guidelines.

Table 23: Current force levels

SYSTEM	CLASS	RANGE [KM]	NUC/CONV	TELS/MELS/ SILOS	BRIGADES	REMARKS
DF-11A	SRBM	600	conv	~27–36 TELs	1	possibly also DF-11AZT
DF-15A	SRBM	850+	conv	~27–36 TELs	1	possibly also DF-15B and/or DF-15C
DF-15B	SRBM	725+	conv	~27–36 TELs	1	
DF-16	SRBM	700+	conv	~9–18 TELs	1/2 ?	likely still operational, otherwise DF-16A
DF-16A	SRBM	800+	conv	~45–54 TELs	1 1/2 ?	
DF-21A	MRBM	1,750+	nuc	12 MELs	2	1 brigade likely now DF-31AG
DF-21D	MRBM *ASBM*	1,500+	conv	24 TELs	2	1 brigade possibly replaced by a new system starting in 2020
DF-17	MRBM *HGV*	2,000+	conv	? TELs	3	
DF-26	IRBM	3,000+	nuc/ conv	108 TELs	6	likely significantly more by now
DF-5A	ICBM	12,000+	nuc	6 silos	1	
DF-5B	ICBM	12,000+	nuc	12 silos	2	
DF-31	ICBM	7,000+	nuc	? MELs	1	
DF-31A	ICBM	11,000+	nuc	36? MELs	3	
DF-31AG	ICBM	11,000+	nuc	52+ TELs	5	likely an additional brigade replacing DF-21A
DF-41	ICBM	15,000	nuc	24? TELs	2	
JL-2	SLBM	7,000+	nuc	6x12 submarines x tubes		status unclear

nuc = nuclear / conv = conventional

Data source: Author's own assessment, Xiu 2022, Huxley and Kuok 2022

The following figures show the ranges of the missile systems from their respective deployment locations. Taiwan remains the focal point for all short- and medium-range missile systems. The intercontinental ballistic missiles are capable of threatening all of Europe and the United States.

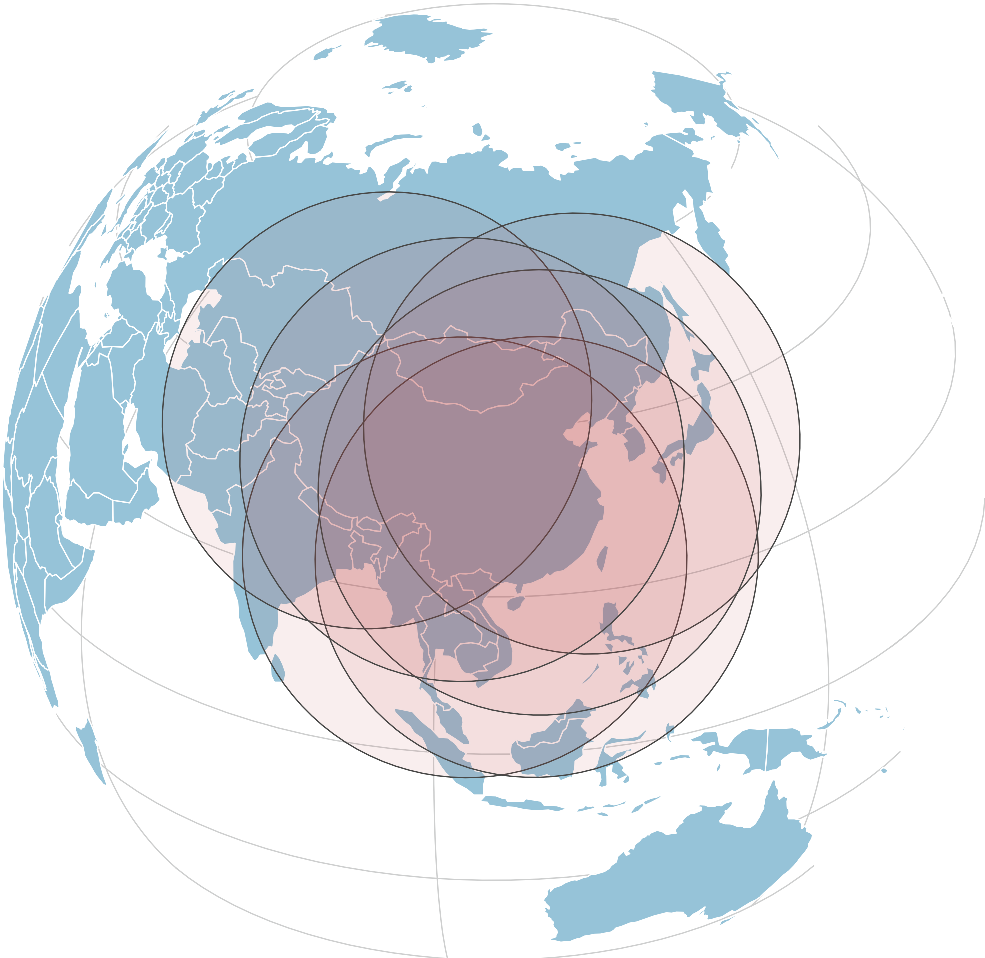
Figure 24: Ranges of known SRBM brigades

Grafik: ©Markus Schiller/Jonas Reithmeier/Moritz Kütt

Figure 25: Ranges of known MRBM, HGV, and cruise missile brigades

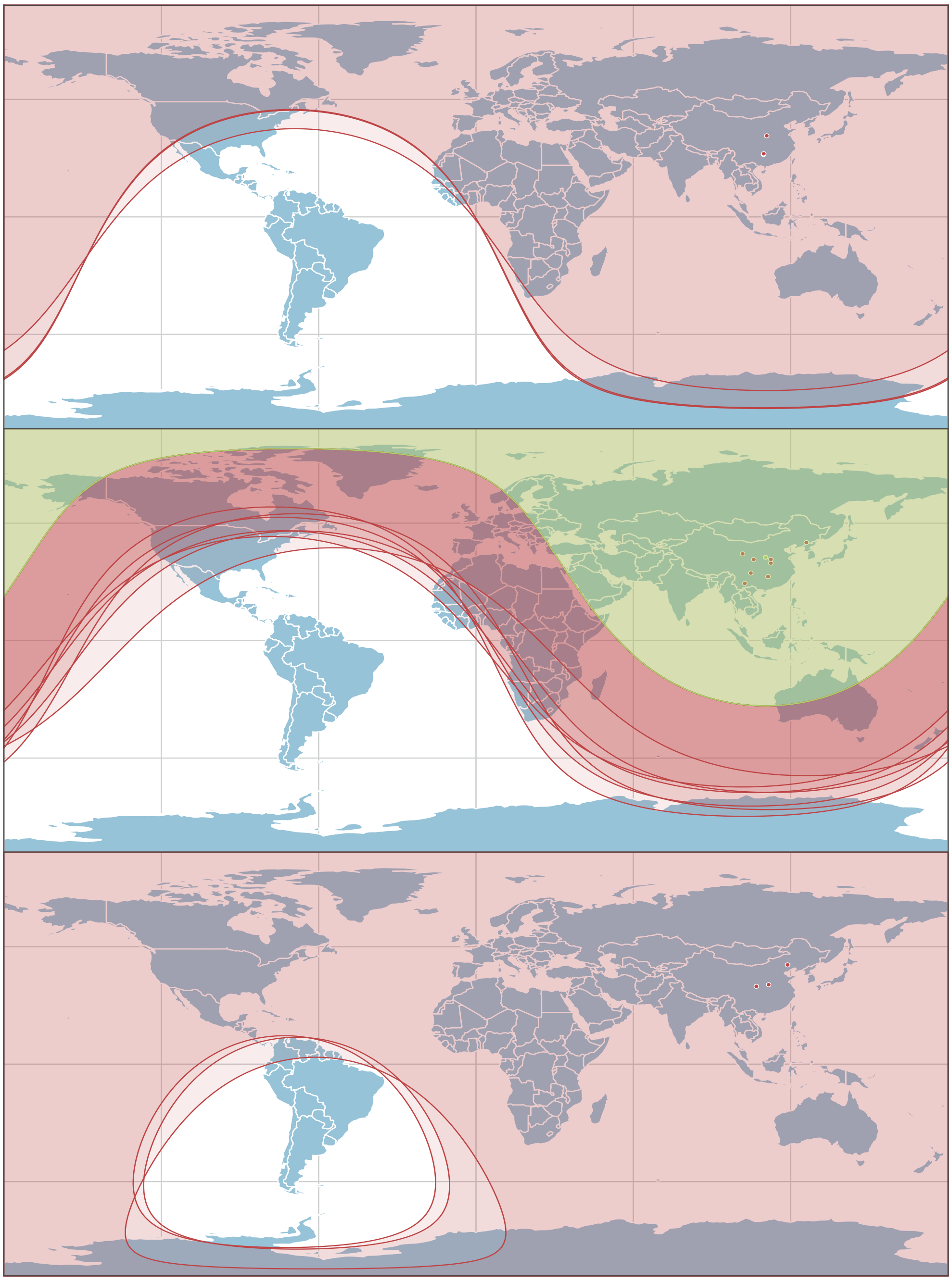
Graphic: ©Markus Schiller/Jonas Reithmeier/Moritz Kütt

Figure 26: Ranges of known IRBM brigades



Graphic: ©Markus Schiller/Jonas Reithmeier/Moritz Kütt

Figure 27: Ranges of known ICBM brigades



Coloured areas indicate the ranges reachable by the respective missiles. The top map shows the ranges for the DF-5, the middle for the DF-31, and the bottom for the DF-41. In the case of the DF-31, the original version with a shorter range is marked in green.

Graphic: ©Markus Schiller/Jonas Reithmeier/Moritz Kütt

6.3 ORGANISATION AND LOCATIONS OF MISSILE FORCES

The People’s Liberation Army Rocket Force (PLARF) was known as the Second Artillery Corps of the People’s Liberation Army until 2016. Established in 1966, it continues to oversee all land-based nuclear and conventional ballistic missile systems, as well as strategic cruise missiles (Xiu 2022).

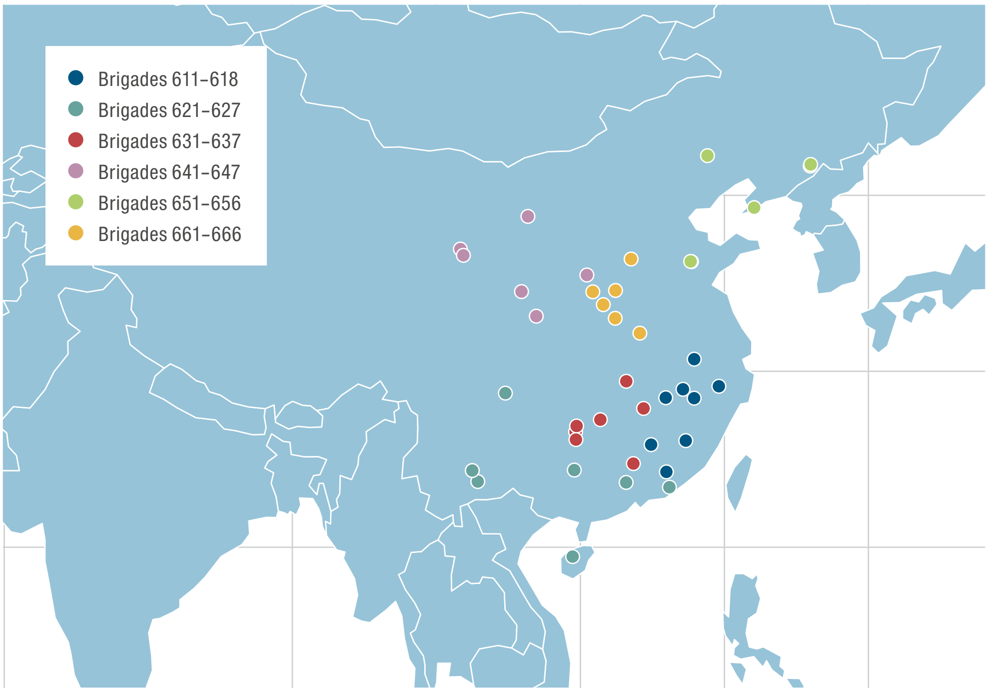
The headquarters in Beijing oversees a total of nine “operational bases”, three of which handle logistical tasks. The remaining six bases (Bases 61 to 66) are responsible for operating and launching missile systems (Xiu 2022).

Each of these six bases comprises command posts, political departments, logistics units, maintenance units, and medical services, as well as six to eight missile brigades, each equipped with a single type of missile system. These brigades form the core of the missile forces and are further divided into six launch battalions, each typically consisting of two launch companies. Additionally, each brigade includes four to six support battalions assigned to various operational roles (Xiu 2022).

The operational bases are geographically distributed. Base 61 and its brigades are located in eastern and parts of southeastern China, Base 62 in the remaining southeastern regions, Base 63 in the interior of the southern territory, Base 64 in northwestern and north-central China, Base 65 in the east and northeast, and Base 66 in central China. Each base has a specific strategic orientation. For example, Base 61 is primarily equipped with conventional short-range missile systems targeting Taiwan, while the inland Bases 64 and 66 have long-range nuclear-armed systems in their inventories (Xiu 2022).

The following details on the bases are primarily drawn from Xiu (2022) and Huxley and Kuok (2022). More recent studies (Eveleth 2023; Kristensen et al. 2024) offer differing accounts, leaving the actual situation unclear. As with current force levels, information on the organisation and locations of the missile forces should be regarded as a guideline rather than definitive or complete. Assessments can change rapidly, as can the actual situation on the ground.

Figure 28: Overview of bases and brigades of missile forces



Graphic: ©Markus Schiller/Jonas Reithmeier/Moritz Kütt

Table 24: Missile forces of the People's Liberation Army

continued on pp. 68–69

BRIGADE	SYSTEM	RANGE [KM]	NUMBER	TYPE	NUC/CONV	REMARKS
611	DF-21A	1,750+	12	mobil	nuc	likely a new system soon
612	DF-21A	1,750+	12	mobil	nuc	likely now DF-31AG
613	DF-15B	725+	~27–36	TEL	conv	possibly a new system since 2021
614	DF-17	2,000+	~27–36	TEL	conv	until 2018 DF-11A
615	DF-11A	600	~27–36	TEL	conv	distributed across 10 locations
616	DF-15A	850+	~27–36	TEL	conv	possibly another version of the DF-15
617	DF-16A	700+	~27–36	TEL	conv	

nuc = nuclear / conv = conventional

BRIGADE	SYSTEM	RANGE [KM]	NUMBER	TYPE	NUC/CONV	REMARKS
618	?	?	?	?	?	rumours since 2020, exact location unknown
621	DF-31AG	11,000+	12	TEL	nuc	strategic, likely DF-31AG
622	DF-31A	11,000+	12	MEL	nuc	
623	CJ-10A	1,500	~27–36	mobile	?	"1st cruise missile brigade"
624	DF-21D	1,500+	12	TEL	conv	anti-ship
625	DF-26	3,000+	18	TEL	nuc/ conv	first DF-26 brigade
626	DF-26	3,000+	18	TEL	nuc/ conv	
627	DF-17	2,000+	?	TEL	conv	first DF-17-brigade, location unconfirmed
631	DF-5B	12,000+	6	silo	nuc	
632	DF-31AG	11,000+	12	TEL	nuc	
633	DF-5A	12,000+	6	silo	nuc	
634	?	?	?	?	?	unknown "new missile type", exact location unknown
635	CJ-10	1,500	~27–36	mobile	conv	second brigade with cruise missiles
636	DF-16 DF-16A	700+	~27–36	TEL	conv	first DF-16 brigade, now likely DF-16 and DF-16A
637	?	?	4	silo	nuc?	mentioned only in IISS (2022), 4 silos under construction
641	DF-31	7,000+	?	MEL	nuc	likely DF-31 from 2018, previously DF-21A
642	DF-31AG	11,000+	8	TEL	nuc	likely DF-31AG
647	DF-26?	3,000+?	18?	TEL?	nuc/ conv?	location unconfirmed, "new missile type" (IISS: "DF-26")
651	DF-41	15,000	?	TEL	nuc	location suspected

nuc = nuclear / conv = conventional

BRIGADE	SYSTEM	RANGE [KM]	NUMBER	TYPE	NUC/CONV	REMARKS
652	DF-31A	11,000+	?	MEL	nuc	last DF-21C brigade, transitioned to DF-31 or DF-31A
653	DF-21D	1,500+	12	TEL	conv	anti-ship, location unconfirmed, possibly new system from 2020
654	DF-26	3,000+	18	TEL	nuc/ conv	
655	DF-17	2,000+	?	TEL	conv	reports since 2018
656	CJ-100	2,000	~27–36	TEL	conv	reports since 2019
661	DF-5B	12,000+	6	silo	nuc	"1st Dongfeng brigade"
662	(DF-4/) DF-41	(5,500+/) 15,000	(?/) 4	(rollout/) silo	nuc	last DF-4 brigade, likely transitioned to DF-41 silo
663	DF-31A	11,000+	12	mobile	nuc	
664	DF-31AG	11,000+	8	TEL	nuc	established in 2017
665	?	?	?	?	?	confirmed in 2019, exact location unknown
666	DF-26	3,000+	18	TEL	nuc/ conv	likely established in 2011 for DF-26 development

nuc = nuclear / conv = conventional

Data source: Author's own assessment, based on Xiu (2022) and Huxley and Kuok (2022)

7 Conclusion

This report provides a comprehensive overview of China's capabilities in the field of ballistic missiles. It traces the history of their development and production, identifies key actors, details the capabilities of individual systems, and analyses their operational status. The report's technical perspective offers insights that may also shed light on the political implications of current developments in this domain.

In recent decades, China has evolved from an emerging missile power to an established global force. In the coming years, its missile programme is expected to rival those of Russia and the United States. While there are no reliable Chinese statements outlining the objectives of this expansion – such as achieving parity with Russia and the USA – it is entirely possible that certain aspects of China's missile programme could soon surpass their American and Russian counterparts. For example, the Chinese military already conducts more ballistic missile launches for testing and training purposes than both other countries combined – indeed, more than the rest of the world together.

In its early stages, China's missile programme relied heavily on significant Soviet support. Through various ambitious milestones, a long-term vision, and intensive development efforts, it eventually achieved a high degree of independence. Over the decades, China successfully transitioned from Soviet liquid-propellant technology to indigenous solid-propellant technology (with the exception of the DF-5 and larger space launch vehicles). This progress was primarily driven by state-controlled institutions, which evolved over time into the state-owned conglomerates CASC and CASIC. Although these organisations may not always have been adequately funded or efficient – evidenced by the lengthy development timelines of certain projects – their long-term objectives and personnel resources have enabled steady progress over the years. This trajectory is expected to continue.

In addition to its military applications, China has sought to leverage its missile programme to advance its space industry. In recent years, several start-up-like enterprises have been established. Politically, however, these entities should be regarded not as independent actors but as closely connected to state-run development and production centres.

China possesses operational missiles across all major categories. These include seven different SRBM variants, three MRBM variants, one IRBM variant, and seven distinct intercontinental ballistic missile systems (one of which is submarine-launched). Each missile class has at least 100 launch systems available.

China's strategic intercontinental ballistic missile (ICBM) arsenal has only recently begun to expand significantly. While it has not yet reached parity with the arsenals of Russia and the United States, it could grow into a comparable force in the medium term. Although China continues to rely on its silo-based, modernised versions of the DF-5 liquid-fuelled missile family, the country has been diversifying its arsenal for years, notably with large numbers of mobile solid-fuelled systems like the DF-31AG and, more recently, the DF-41.

China currently dominates the medium-range missile category (MRBMs/IRBMs). Its decades-long efforts to develop and deploy various medium-range missile systems remain unmatched by current Russian and American capabilities. From 1987 to 2019, both countries were bound by the Intermediate-Range Nuclear Forces (INF) Treaty, which prohibited the development and possession of such systems – a constraint that continues to influence their arsenals even years after the treaty's termination. The DF-26, capable of carrying both conventional and nuclear warheads and tested as a ballistic anti-ship missile, poses a significant threat in the region, particularly given the rapid expansion of operational units.

China is also a major player in the field of short-range ballistic missiles (SRBMs). For over three decades, it has dedicated considerable effort to developing various systems, which are now deployed in substantial numbers across numerous brigades, most notably the DF-16 systems.

Beyond domestic use, Chinese missile systems have attracted significant international interest. China's longstanding support for Pakistan's missile programme is difficult to deny, and there are plausible indications of continued assistance to Iran. At the same time, China appears to be adhering to the guidelines of the MTCR, an international framework aimed at curbing missile exports. There is no evidence of state-led exports of restricted items or complete missile systems that exceed MTCR limits. Whether this restraint will continue, particularly in light of potential economic interests tied to China's missile programme, remains to be seen.

The findings presented in this report are based on currently available public sources, offering a broad overview of the programme and its recent achievements. Technical data on individual systems, as well as their quantity and operational status, are drawn from secondary sources. These sources contain certain gaps, however, particularly regarding recent developments (such as the number and outcomes of test flights). The availability of technical reconstructions, and thus of reliable technical data, has likewise been limited. Future technical analyses could help to bridge these gaps, even within the constraints of the existing data.

Overall, this report demonstrates that China has joined the ranks of the "major missile powers". The presented data provides a comprehensive overview of China's programmes and can help to identify starting points for de-escalatory political solutions. Such efforts could include new arms control initiatives focused on ballistic missiles. Should discussions between the United States and Russia resume, China should have a seat at the table as an equal partner.

Endnotes

1 The R-1, a Soviet reproduction of the well-known German A4/V2 rocket, marked the first successful Soviet rocket project with significant capabilities. In many ways, it served as the foundation for all subsequent Soviet rocket developments (see, for example, Schmucker and Schiller 2015).

2 The phrase "standing on the shoulders of giants" is particularly apt in the field of rocket technology. Every successful modern missile programme can trace its roots to some form of external support. Even countries and programmes that claim complete independence – China included – have benefitted from the proliferation of knowledge, expertise, and equipment, at least in the initial phases of their missile development. The only possible exception is Germany, which laid the groundwork for modern rocket technology (excluding solid-fuelled motor technology) from the 1920s to the 1940s.

3 During this period, Chinese students were permitted to study rocket technology at the Moscow Aviation Institute (Moskovskij Aviatsionnyj Institut, MAI). Through lectures featuring real-life examples, equipment demonstrations at Moscow parades, discussions with Soviet experts, and the copying of restricted notes, they gained significant insight into Soviet rockets such as the R-2, R-5, and R-12 (see Lewis and Hua Di).

4 In 2002, the organisations responsible for the development of the JL-1/DF-21 were spun off and incorporated into the CASIC 4th Academy and CASIC 6th Academy. See also Section 2 on the Chinese missile industry.

5 According to Chinese terminology, only missiles with ranges exceeding 1,000 km are said to be strategic (see Lewis and Di 1992). It remains unclear whether nuclear-armed missiles with ranges below 1,000 km are considered tactical weapons, or whether conventionally armed missiles with ranges above 1,000 km are deemed strategic. One source refers to the conventionally armed DF-25 project, which has a range of 1,700 km, as "strategic" (Lewis and Di 1992).

6 Not to be confused with the present-day DF-41 intercontinental ballistic missile.

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