China in Space

Jonathan McDowell

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Contents

1 Brief summary of Chinese space organizations

Formally, the Chinese space agency is CNSA, the Chinese National Space Administration. It is part of COSTIND (Commission of Science, Technology and Industry for National Defense). Administrator since 1998 is Luan Enjie. [1]

(CNSA known until 1993 as the Ministry of Aerospace Industry, prior to 1988 its space component was a separate Ministry of Astronautics Industry). Associated with CNSA are several enterprises, CGWIC (China Great Wall Industry Corp) which commercializes foreign launch services, and CASC (China Aerospace Science and Tech Corp.) which manages the Chinese space program. CASC has several research academies including CALT and CAST (see below).

Two organizations developed launch vehicles: CALT (c. 1970, formerly Beijing Wan Yuan Industry Corp, 1957) in Nan Yuan near Beijing, and SAST (Shanghai Academy of Space Technology), formerly SBA (Shanghai Bureau of Astronautics, founded 1969). SAST developed FB-1, CZ-2D and CZ-4, and builds the CZ-3 lower stages; the rest were from CALT. Solid rocket motors are made in Shanxi/Hohhot by Hexi; liquid rocket motors by CALT and by SAST's SIPM component. Satellites are developed by CAST/Beijing (founded 1968) and SAST's Shanghai Institute of Satellite Engineering (SISE).

CASC (or CASTC), the China Aerospace Science and Technology Corp., is paralleled by CASIC (the China Aerospace Science and Industry Corp); CASC and CASIC were formerly CASC (China Aerospace Corp.), split up in 1999.

In Aug 2001, ADSC (Aerospace Dongfanghong Satellite Company, DFH Satellite Co.) was founded by CAST and CASC for joint projects. It built the SJ-5/HY-1 satellite.

The Chinasat enterprise, part of the Ministry of Post and Telecoms, began operating the commercial communications satellite system in around 1993-94. EuraSpace was a joint project between CASC and Germany's DASA for the DFH-3 system. Sino Satellite Comms. Co (Sinosat) is a Shanghai based company operating the single Sinosat satellite. Tsinghua University is developing small satellites.

Organization	Location	Role
CNSA	Beijing	Adminstration
CASC	Beijing	Management
CALT (1 Acad.)	Beijing/Nan Yuan	Launch vehicles, liquid engines
Hexi/ARMT (4 Acad.)	Shanxi/Hohhot	Solid motors
CAST (5 Acad.)	Beijing/Haidian	Satellites
SAST (8 Acad.)	Shanghai	Launch vehicles
SISE (509)	Shanghai	Satellites (FY)
SIPM	Shanghai	Liquid engines
CLTC		Launch sites, tracking

[1] *The organizational stuff is not my area of expertise. This section is a summary of the FAS site, the NTI site, and the Harvey book.*

2 Chinese satellite programs

Here is a quick index to domestically produced Chinese satellites. There seem to be at least three types of names: literal descriptions such as FSW ('Experimental Recoverable Satellite'); true project names such as Feng Huo (named after the beacon-fire communications system on the Great Wall); and names such as Zhongxing for ITU geostationary locations.

It may be worth comparing with Soviet and US practice: in the USSR there were manufacturer names (Raduga), military service names (Gran') and ITU names (Statsionar) for the same satellite, as well as a variety of alphanumeric designations. In the US the same satellite might be TDRS C, TDRS 3, and TDRS East for pre-launch, post-launch and geostationary role. In the table below I separate out the literal descriptions used for early satellites, although many of the 'true names' are very close to being literal descriptions (e.g. Resource).

	Name	Translation	Dates	Number	Mission
FSW	Fanhui Shi Weixing	Exptl. Recoverable Sat.	1975-1987	10	Recovery
FSW-1	Fanhui Shi Weixing	Exptl. Recoverable Sat.	1987-1993	5	Recovery
FSW-2	Fanhui Shi Weixing	Exptl. Recoverable Sat.	1992-1996	3	Recovery
JSSW	Ji Shu Shiyan Weixing	Test Exptl. Satellite	1973-76	6	Sigint?
SKW	Shiyan Kexuedi Weixing	Exptl. Science Sat		= SJ	Science
SW	Shiyan Weixing	Exptl. Sat.	1984	1	Comms test
STTW	Shiyan Tongbu Tongxin Weixing	Exptl. Synch. Com Sat.	1984	1	Comms test
STTW	Shiyong Tongbu Tongxin Weixing	Operational Synch. Com. Sat.	1984	1	Comms
BD	Beidou	North Star	2000-	3	Navigation
CK	?	?	1973-76	= JSSW	Sigint?
CX	Chuan Xing	Innovation	2003-	1	Comms
DFH	Dong Fang Hong	East is Red	1970	1	Test
DFH-2/2A	"	"	1984-1991	7	Comms
DFH-3	"	"	1994-1997	2	Comms
DQ	Da Qui	Atmosphere	1990	2	Science
FH	Feng Huo	Beacon Fire	2000-	2	Comms
FY	Feng Yun	Wind/Cloud	1988-1999	3	Weather (polar)
FY-2	Feng Yun	Wind/Cloud	1997	1	Weather (GEO)
KF	Kua Fu	Kua Fu[2]	1994	1	Dummy sat
HY	Hai Yang	Marine	2002	1	Oceanography
JB	Jian Bing	Pathfinder		= FSW	Recovery
SJ	Shi Jian	Practice	1971-	9	Science, Tech
SZ	Shenzhou	Celestial Ship	1999-	5	Spaceship
TC	Tan Ce	Probe	2003-4	1+	Science
ZX	Zhongxing	Chinasat	1988-	= DFH	Comms
ZW	Zhongwei	Chinastar		1	Comms
ZY-1	Zi Yuan	Resource	1999-	2	Remote sensing
ZY-2	Zi Yuan	Resource	2000-	2	Imaging Recon

The early Chinese program (1970-1) saw the launch of the DFH test satellite and the SJ-1 scientific satellite on the small CZ-1 launch vehicle. The 1970s saw Beijing's FSW recoverable satellite program launched on the CZ-2 rocket, and Shanghai's JSSW satellite launched on their similar but independently developed FB-1 rocket. Western observers speculate that FSW was an imaging reconnaissance satellite programme and that JSSW was a signals intelligence satellite, but this is not proven. The JSSW/FB-1 program was abandoned in the late 1970s but advanced versions of the FSW program continue under the JB (Jian Bing) codename. Some sources believe that all FSW satellites are JB military satellites, while others claim that only a subset are. Sven Grahn reports that the

[2] Kua Fu was a foolish giant in a Chinese myth; appropriate for a heavy dummy satellite.

JSSW satellite's codename may be CK, and an internet source reported that this stood for Chang Kong (I don't know the translation).

The 1980s saw the CZ-3 launch vehicle with a hydrogen/oxygen upper stage, which placed experimental communications satellites in geostationary orbit. The satellite bus was called DFH-2, DFH-3 etc. (Dong Fang Hong); the orbital locations were registered as Zhongxing (Chinasat), not to be confused with the US-built Zhongwei (Chinastar) launched in 1998. Recently DFH-3 satellites have been launched as part of the Feng Huo series, thought to be a military communications network. The DFH-3 was developed in cooperation with Germany's DASA.

In 1988 the CZ-4 was introduced to launch the FY (Feng Yun) polar orbit weather satellites built by Shanghai.

A new program, ZY (Resource), began in 1999. There are two variants: the high orbit ZY-1 which is a joint China-Brazil earth resources program and the low orbit ZY-2 which appears to be a Chinese military imaging satellite.

In 2000, China's first navigation satellite system was launched. Unlike the US GPS and the Russian Glonass systems which use large numbers of satellites in medium altitude orbits, the Chinese Beidou system is a regional one using a few satellites in geostationary orbit.

SAST/SISE flew two DQ ballon satellites in 1991. The SAST team introduced a small CX satellite in 2003 for technology and comms; the CAST team built the TC satellites for joint European-Chinese magnetospheric research.

CALT build several dummy satellites for launch vehicle tests: the Aussat B mockup launched in 1990 with the EPKM perigee motor. Two dummy Iridium satellites launched with the first Smart Dispenser stage may have been built in the US.

The Tsinghua University group is building small satellites for use with the solid-propellant KT-1 launch vehicle.

Of course, the most well-known Chinese project is the Shenzhou spaceship. With an architecture (and some hardware design) derived from the Russian Soyuz, Shenzhou consists of a propulsion module, a descent module carrying astronauts, and an orbital module. The orbital module is an independent spacecraft which carries military recon payloads and remains operating for months after the descent module returns to Earth. The first four flights were made in automatic mode, and a fifth flight in 2003 carried a single astronaut, Yang Liwei.

2.1 Chinese domestic satellite chronology

Date	Name	Manu.	LV	Mass/kg	Orbit
1970 Apr 24	DFH-1	CAST	CZ-1	173	441 x 2386 x 68.4
1971 Mar 3	SJ-1	CAST	CZ-1	221	268 x 1830 x 69.9
1973 Sep 18	JSSW	SISE	FB-1	1138	Launch failure
1974 Jul 14	JSSW	SISE	FB-1	1108	Launch failure
1974 Nov 5	FSW	CAST	CZ-2	1790	Launch failure
1975 Jul 26	JSSW	SISE	FB-1	1107	184 x 461 x 69.0
1975 Nov 26	FSW	CAST	CZ-2	1790	179 x 479 x 63.0
1975 Dec 16	JSSW	SISE	FB-1	1109	186 x 387 x 69.0
1976 Aug 30	JSSW	SISE	FB-1	1108	195 x 2145 x 69.2
1976 Nov 10	JSSW	SISE	FB-1	1208	Launch failure
1976 Dec 7	FSW	CAST	CZ-2	1790	174 x 469 x 59.5
1978 Jan 26	FSW	CAST	CZ-2	1810	161 x 479 x 57.0
1979 Jul 30	SJ-2	CAST	FB-1	250	Launch failure
1979 Jul 30	SJ-2A	CAST	FB-1	480	Launch failure
1979 Jul 30	SJ-2B	CAST	FB-1	30	Launch failure
1981 Sep 19	SJ-2	CAST	FB-1	257	240 x 1610 x 59.5
1981 Sep 19	SJ-2A	CAST	FB-1	483	240 x 1610 x 59.5
1981 Sep 19	SJ-2B	CAST	FB-1	28	232 x 1598 x 59.5
1982 Sep 9	FSW	CAST	CZ-2	1780	170 x 355 x 63.0
1983 Aug 19	FSW	CAST	CZ-2	1840	173 x 389 x 63.3
1984 Jan 29	SW (DFH-2?)	CAST	CZ-3	915?	451 x 6580 x 36.1
1984 Apr 8	DFH-2	CAST	CZ-3	920	GEO
1985 Oct 21	FSW	CAST	CZ-2	1810	172 x 395 x 63.0
1986 Feb 1	DFH-2	CAST	CZ-3	920	GEO
1986 Oct 6	FSW	CAST	CZ-2	1770	172 x 378 x 57.0
1987 Aug 5	FSW	CAST	CZ-2	1810	171 x 393 x 63.0
1987 Sep 9	FSW-1	CAST	CZ-2	2070	206 x 310 x 63.0
1988 Mar 7	DFH-2A/ZX-1	CAST	CZ-3	1040	GEO
1988 Sep 6	FY-1A	SISE	CZ-4	757	SSO 881 x 904 x 99.1
1988 Aug 5	FSW-1	CAST	CZ-2	2130	205 x 306 x 63.0
1988 Dec 22	DFH-2A/ZX-2	CAST	CZ-3	1040	GEO
1990 Feb 4	DFH-2A/ZX-3	CAST	CZ-3	1040	GEO
1990 Jul 16	Mockup	CAST?	CZ-2E	2700?	204 x 990 x 28.5
1990 Sep 3	FY-1B	SISE	CZ-4		SSO 884 x 899 x 98.9
1990 Sep 3	DQ-1	SISE	CZ-4	4	SSO 878 x 898 x 98.9
1990 Sep 3	DQ-2	SISE	CZ-4	4	SSO 878 x 897 x 98.9
1990 Oct 5	FSW-1	CAST	CZ-2	2080	203 x 293 x 57.0
1991 Dec 28	DFH-2A/ZX-4	CAST	CZ-3	1040?	GTO 2131 x 33939 x 31.5
1992 Aug 9	FSW-2	CAST	CZ-2	2590	175 x 330 x 63
1992 Oct 6	FSW-1	CAST	CZ-2	2060	215 x 299 x 63.0
1993 Oct 10	FSW-1	CAST	CZ-2	2100	207 x 295 x 56.9
1994 Feb 8	KF-1	CAST	CZ-3A	1342	GTO 208 x 36086 x 28.6
1994 Feb 8	SJ-4	SISE	CZ-3A	400	GTO 189 x 36152 x 28.7
1994 Jul 3	FSW-2	CAST	CZ-2	2760	173 x 329 x 63.0
1994 Nov 29	DFH-3	CAST	CZ-3A	2230	GEO
1996 Oct 20	FSW-2	CAST	CZ-2	2970	170 x 340 x 63.0
1997 May 11	DFH-3/ZX-6	CAST	CZ-3A	2260	GEO
1997 Jun 10	FY-2A	SISE	CZ-3	1380	GEO
1999 May 10	FY-1C	SISE?	CZ-4B	958	SSO 849 x 867 x 98.8
1999 May 10	SJ-5	SISE	CZ-4B	298	SSO 844 x 868 x 98.8
1999 Oct 14	ZY-1 (CBERS)	CAST	CZ-4B	1540	SSO 773 x 774 x 98.6
1999 Nov 19	Shenzhou 1	CAST	CZ-2F	5800?	197 x 323 x 42.6
1999 Nov 19	SZ-1 OM	CAST	CZ-2F	2000?	204 x 324 x 42.6
2000 Jan 25	FH-1 (ZX-22)	CAST	CZ-3A	2300	GEO

2000 Jun 25	FY-2B	SISE	CZ-3	1380	GEO
2000 Sep 1	ZY-2	CAST	CZ-4B	1500?	SSO 474 x 493 x 97.4
2000 Oct 30	Beidou 1	CAST	CZ-3A	2500?	GEO
2000 Dec 20	Beidou 2	CAST	CZ-3A	2500?	GEO
2001 Jan 9	Shenzhou 2	CAST	CZ-2F	5800?	330 x 346 x 42.6
2001 Jan 9	SZ-2 OM	CAST	CZ-2F	2000?	388 x 404 x 42.6
2002 Mar 25	Shenzhou 3	CAST	CZ-2F	5800?	330 x 337 x 42.4
2002 Mar 25	SZ-3 OM	CAST	CZ-2F	2000?	353 x 356 x 42.4
2002 May 15	FY-1D	SISE	CZ-4B	950	SSO 851 x 873 x 98.8
2002 May 15	Haiyang 1	DFH	CZ-4B	360	SSO 792 x 792 x 98.8
2002 Sep 15	HTSTL-1	HTSTL	KT-1	50	Launch failure
2002 Oct 27	ZY-2	CAST	CZ-4B	1500?	SSO 470 x 483 x 97.4
2002 Dec 29	Shenzhou 4	CAST	CZ-2F	5800?	330 x 337 x 42.4
2002 Dec 29	SZ-4 OM	CAST	CZ-2F	2000?	359 x 364 x 42.4
2003 May 24	Beidou 3	CAST	CZ-3A	2500?	GEO
2003 Sep 16?	HTSTL?	HTSTL	KT-1	50?	Launch failure (?)
2003 Oct 15	Shenzhou 5	CAST	CZ-2F	5800?	331 x 334 x 42.4
2003 Oct 15	SZ-5 OM	CAST	CZ-2F	2000?	343 x 352 x 42.4
2003 Oct 21	ZY-1 (CBERS)	CAST	CZ-4B	1550	SSO 772 x 774 x 98.5
2003 Oct 21	CX-1	SISE	CZ-4B	90?	SSO 685 x 759 x 98.5
2003 Nov 3	JB-4	CAST	CZ-2	3200?	193 x 324 x 63.0
2003 Nov 14	FH-2 (ZX-20)	CAST	CZ-3A	2300	GEO
2003 Dec 29	Tan Ce 1	CAST	CZ-2C/CTS	350	555 x 78051 x 28.5

2.2 Foreign satellites purchased by China and Hong Kong

In the 1990s China began to purchase satellites abroad, and Hong Kong operators developed satellite systems. Many of these satellites were launched on Chinese rockets.

Date	Name	Manu.	LV	Owner	Orbit
1993 Jun 26	Zhongxing 5	LM 3000	-[3]	Chinasat	GEO
1996 Aug 18	Zhongxing 7	Hughes 376	CZ-3	Chinasat	GTO (failed)
1998 May 30	Zhongwei 1	LM A2100	CZ-3B	China Orient Tel.Sat.Co	GEO
1998 Jul 18	Sinosat	Alcatel SB3000	CZ-3B	Sinosat	GEO
2000 Jun 28	Tsinghua 1	SSTL MB-70	Kosmos-3M	Tsinghua	LEO
1990 Apr 7	Asiasat 1	Hughes 376	CZ-3	Asiasat (HK)	GEO
1995 Nov 28	Asiasat 2	LM 7000	CZ-2E	Asiasat (HK)	GEO
1997 Dec 24	Asiasat 3	Hughes 601	Proton	Asiasat (HK)	Failed[4]
1999 Mar 22	Asiasat 3S	Hughes 601	Proton	Asiasat (HK)	GEO
1994 Jul 21	Apstar 1	Hughes 376	CZ-3	APT Satellite (HK)	GEO
1995 Jan 25	Apstar 2	Hughes 601	CZ-2E	APT Satellite (HK)	Failure
1996 Jul 3	Apstar 1A	Hughes 376	CZ-3	APT Satellite (HK)	GEO
1997 Oct 16	Apstar 2R	Loral 1300	CZ-3B	APT Satellite (HK)	GEO

2.3 Foreign satellites launched by China

Another development of the 1990s was the commercialization of Chinese launch services, with Western countries using the Long March (CZ) rockets. This was a bumpy road, with spectacular early failures raising safety concerns and US export control regulations adding later hurdles.

Date	Name	Manu.	LV	Owner	Orbit
1990 Jul 16	BADR	Pakistan	CZ-2E	SUPARCO	204 x 990 x 28.5
1992 Aug 13	Optus B1	Hughes 601	CZ-2E	Optus (Aus.)	GEO
1992 Oct 6	Freja	SSC/Sweden	CZ-2C	SSC	LEO
1992 Dec 21	Optus B2	Hughes 601	CZ-2E	Optus (Aus.)	Launch failure
1994 Aug 27	Optus B3	Hughes 601	CZ-2E	Optus (Aus.)	GEO
1995 Dec 28	Echostar 1	LM 7000	CZ-2E	Echostar	GEO
1996 Feb 14	Intelsat 708	Loral 1300	CZ-3B	Intelsat	Failure
1997 Aug 19	Agila 2	Loral 1300	CZ-3B	MPSC (Philippines)	GEO
1997 Sep 1	Iridium MFS 1/2	Motorola	CZ-2/SD	Iridium	LEO
1997 Dec 8	Iridium 42/44	Motorola	CZ-2/SD	Iridium	LEO
1998 Mar 25	Iridium 51/61	Motorola	CZ-2/SD	Iridium	LEO
1998 May 2	Iridium 69/71	Motorola	CZ-2/SD	Iridium	LEO
1998 Aug 19	Iridium 78/76	Motorola	CZ-2/SD	Iridium	LEO
1998 Dec 19	Iridium 88/89	Motorola	CZ-2/SD	Iridium	LEO
1999 Jun 11	Iridium 92/93	Motorola	CZ-2/SD	Iridium	LEO
1999 Oct 14	SACI-1	INPE	CZ-4B	INPE (Brazil)	LEO

[3] Purchased on orbit; formerly Spacenet 1

[4] Salvaged by lunar flyby and resold to Hughes

3 Chinese launch vehicles

China's military missiles are given designations in the DF (Dong Feng, East Wind) series. Space launch vehicles, based on the same rockets, are mostly given names in the CZ (Chang Zheng, Long March) series.

3.1 Early missiles

The DF-1 missile was a modified V-2/R-1 class vehicle, with a successor DF-2 based on the R-2. A DF-2A test flight in 1966 with a range of 640 km W of Jiuquan to the Xinjian test site had a live nuclear warhead which resulted in a 12 kT explosion.

The DF-3 introduced an upgraded liquid-fueled domestic missile, and DF-3 formed the first stage of the two-stage DF-4 IRBM. Smaller missiles included the DF-15 (M-9), DF-11 (M-11), and DF-21 (JL-1).

Table 6: Known DF-1 and DF-2 flights

Vehicle	Date	From	Target	Payload	Result
R-2	1960 Sep	JQ			
DF-1	1960 Nov 5	JQ			
DF-1	1960 Dec	JQ			
DF-1	1960 Dec	JQ			
DF-2	1962 Mar 21	JQ			Exploded T+69s
DF-2	1964 Jun 29	JQ			
DF-2	1964 Jul 9	JQ			
DF-2	1964 Jul 11	JQ			
DF-2A	1966 Oct 27	JQ	Xinjian	12 kT warhead	Nuclear explosion

3.2 CZ-1

The 2.25m-diameter CZ-1 launch vehicle was based on the two-stage DF-4 IRBM with a solid GF-02 third stage motor. According to one paper[1], the third stage was 2050 kg full, 3.95l 0.77 dia with impulse 4500 kNs over 38s.

The first stage has YF-2/2A engines with RFNA oxidizer. YF-2 was a dual engine system made of two YF-1 engines. The DF-4 flight of 1970 Jan 30 was a 2-stage test preparing for the CZ-1. P. Clark claims that CZ-1D suborbital test flights may have been made on 1995 May 29 and in 1997; I don't have other evidence for this.

The CZ-1 stage is 2.25m diameter. CZ-1 first stage is 17.83m long; CZ-1D is stretched to 19.74m. The CZ-1 first stage structure was used for the CZ-2E strapons.

Table 7: DF-3 based configurations

Vehicle	DF-3	DF-4	CZ-1
Stage 1	DF-3 stage 1	DF-3 stage 1	DF-3 stage 1
Stage 2	-	DF-4 stage 2	DF-4 stage 2
Stage 3	-	-	GF-02

Figure 1: The first orbital CZ-1 launch vehicle

3.3 DF-5 and Feng Bao

A larger 3.35-m diameter rocket, the DF-5, was first tested in 1971. Stage 1 is Nitric acid/UDMH and stage 2 is N2O4/UDMH.

Table 8: DF-5 tests

Vehicle	Date	From	Target	Payload	Result
DF-5	1971 Sep 10	JQ			Short range test
DF-5	1970s	Harbin	Tibet		Test
DF-5	1970s	Harbin	Taklamakan		Test
DF-5	1980 May 18	JQ?	Pacific, equator		Full range test
DF-5	1980 May 21	JQ?	Pacific, equator		Full range test

The FB-1 (Feng Bao, 'Storm') was built by Shanghai based on the DF-5. A suborbital test in 1972 was followed by a failed orbital attempt in 1974. and a success in 1975. The FB-1 program was terminated in 1981 after mixed results.

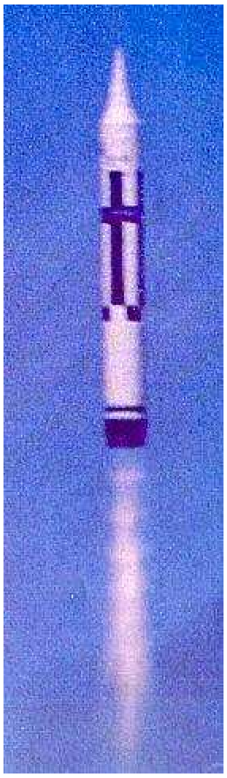

Figure 2: FB-1 launch with JSSW satellite

3.4 CZ-2, CZ-3 and CZ-4

The rival CZ-2 and CZ-3 series of launch vehicles were built by CALT based on the DF-5. An initial CZ-2A launch failure in 1974 was followed by the successful launch of the first FSW satellite in 1975 with the CZ-2C (a minor change to the CZ-2A). The CZ-2C, although outwardly similar to the FB-1, had better performance and proved more reliable.

Both CZ-2 and FB-1 were launched from the Jiuquan launch site in Inner Mongolia. In 1984 the CZ-3 was introduced. Based on the CZ-2, it had a LOX/LH2 upper stage for geostationary orbit missions. It was launched from the new Xichang site.

Figure 3: CZ-2C rocket, circa 1982

Figure 4: CZ-3 first vehicle, 1984

The Shanghai group introduced a new CZ-4 launch vehicle derived from the same basic design in 1988. This rocket had a storable propellant third stage and was used for polar orbit launches from China's third launch site at Taiyuan.

During the 1990s several enhanced versions of these basic vehicles were flown. The CZ-2C was stretched into the CZ-2D for heavier recoverable satellite launches, and the CZ-2E version with strapon liquid boosters used for placing in low orbit Western satellites destined for geostationary orbit but with their own perigee motors. CZ-2E was improved and human-rated for the CZ-2F version used for Shenzhou launches.

Figure 5: CZ-2E rocket, 1990

The basic CZ-2C was also augmented in a CZ-2C/SD version used for Iridium launches, which added a Smart Dispenser stage with a solid apogee motor and liquid deorbit engines. The SD uses the CAMEC/Beijing FG-47 (SpaB-54) solid motor which has a total mass of 158 kg and propellant mass of 125 kg. A similar CZ-2C/CTS rocket with a larger third stage motor was used for the Tan Ce science satellite launch in late 2003.

The CZ-3 was developed into a CZ-3A version with improvements to all three stages, and a CZ-3B version with two LB-40 liquid strapon boosters. The first launch of the CZ-3B in 1996 carrying a US satellite resulted in one of the most serious space accidents, when the rocket's guidance system failed and it crashed into the nearby town; Chinese and US sources continue to disagree on the number of fatalities.

In 1999 the CZ-4 (also called CZ-4A) was replaced by the CZ-4B, which has an improved third-stage engine allowing restart.

Several other improved versions and stages have been discussed. A planned CZ-4(8S) originally slated for 2001 will have 8 FG-19A solid strapons. The FG-19A is 7.6m long, has 500kN thrust and 35000 kNs. The FG-46 (SpaB-17) EPKM perigee motor is 1.70m dia, 5985 kg full 541 kg dry. A planned CZ-2EA will use longer SRBs (2.25d ?l) and avionics from CZ-2F. Launch thrust 8886 kN with 11800 kg to LEO [3]. A future 5-m LV will use a 500 kN LH2/LOX engine and a 1200 kN LOX/Kero engine. Stage 1 is 5 m, stage 2 is 3.35m, stage 3 is 2.25m in size.

Figure 6: CZ-2F launcher for Shenzhou 2

Figure 7: CZ-3A rocket, 1994

Figure 8: CZ-3B failure, 1996

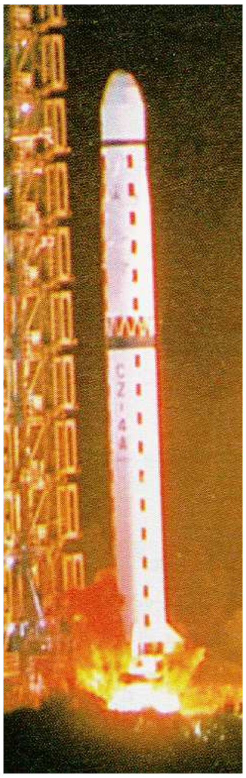

Figure 9: CZ-4A launch in 1988

Figure 10: CZ-4B launch of CBERS-2, 2003 Oct 21; note larger fairing

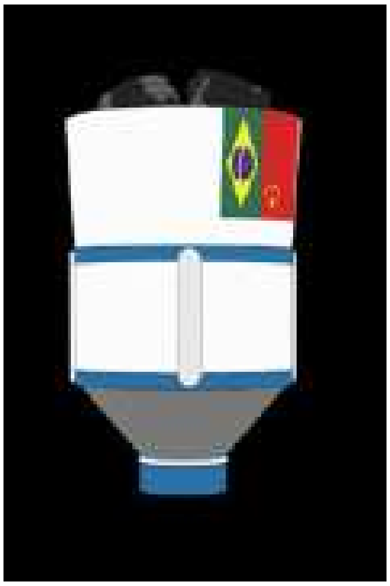

Figure 11: Illustration of CZ-4B stage 3 from CBERS-2 launch graphic

3.5 DF-31 and KT-1

A new solid-fuel ICBM, the DF-31, was developed in the 1990s. DF-31 is built by the Academy of Rocket Motor Technology (Hohhot/Inner Mong.) which includes the 46th RI at Hexi. Production possibly at Xian. The Aug 1999 test was reported as the first, earlier tests may have been the two-stage DF-25 version. A rumoured DF-41 will be DF-31 with a larger third stage.

The DF-31 has been developed into a satellite launch vehicle, the KT-1 (Kai Tuozhe, "Explorer"). KT-1 was test launched in Sep 2002, and probably also in Sep 2003 (although those reports were less detailed). Both launches failed.

Figure 12: Mockup of KT-1 rocket

3.6 M-9

The short range M-9 (DF-15) missile was used in tests from SE China to impact points just off 30-40 km off the coast of Kaohsiung, SW Taiwan and Keelung, NE Taiwan in Mar 1996.

3.7 Summary tables

Table 9: Launch vehicle configurations

Vehicle	Stage 0	Stage 1	Stage 2	Stage 3
	CALT (BWYIC) rockets			
CZ-2A		CZ-2 S1	CZ-2 S2	-
CZ-2C		CZ-2 S1	CZ-2 S2	-
CZ-2C/SD		CZ-2 S1	CZ-2 S2	FG-47
CZ-2E	LB-40 x 4	CZ-4 S1	CZ-2E S2	-
CZ-3		CZ-2 S1	CZ-2 S2	CZ-3 S3
CZ-3A		CZ-4 S1	CZ-4 S2	CZ-3A S3
CZ-3B	LB-40 x 4	CZ-4 S1	CZ-4 S2	CZ-3A S3
CZ-2E(A)	LB-80 x 4	CZ-4 S1	CZ-2E S2	-
	SBA rockets			

FB-1	FB-4 S1	FB-4 S2	-	
CZ-2D	CZ-4 S1	CZ-4 S2	-	
CZ-4A	CZ-4 S1	CZ-4 S2	CZ-4 S3	
CZ-4B	CZ-4 S1	CZ-4 S2	CZ-4 S3	1500 kg GTO, 4200 kg LEO, 2800 kg SSO
DF rockets				
DF-2 (CSS-1)				
DF-3A (CSS-2)				
DF-4 (CSS-3)				
DF-5 (CSS-4)				
DF-11 (M-11)				
DF-15 (M-9)				
DF-21				
DF-31				
DF-41				

Comparison of first stages and engines

Name	Desig.	Engines	Size	Fuel	Mass	Thrust
BWYIC CZ-1 S1		YF2 = YF1x4		NA27S/UDMH		1020
SBA FB-1 S1			3.35d 20l?	N2O4/UDMH		2745 kNsl
BWYIC CZ-2 S1	L-140	YF-20 x 4	3.35d 20.52l	N2O4/UDMH	142/151t	2785 kNsl
SBA? CZ-3 S1	L-140	YF-20 x 4	3.35d 20.22l	N2O4/UDMH	142/151t	2785 kNsl
BWYIC CZ-2E S1	L-180	YF-20B x 4	3.35d 23.70l	N2O4/UDMH	187/?t	2961 kNsl
BWYIC? LB-40	LB-40	YF-20B x 1	2.3?d 15.34l			
BWYIC? LB-80	LB-80	YF-20B x 2				
SBA CZ-3A S1	L-180	YF-20B x 4	3.35d 23.08l	N2O4/UDMH	170/180t	2961 kNsl
SBA CZ-4 S1	L-180	YF-20B x 4	3.35d 24.66l	N2O4/UDMH	183/?t	2961 kNsl
SBA CZ-4B S1	L-180	YF-20B x 4?	3.35d 24.66l	N2O4/UDMH	183/?t	2961 kNsl

Comparison of second stages

Name	Desig.	Engines	Size	Fuel	Mass	Thrust
BWYIC CZ1 S2		YF-3		NA27S/UDMH		320
SBA FB-1 S2			3.35d 7.5l?	N2O4/UDMH		
BWYIC CZ-2 S2	L-35	YF-22/YF-23 x 4	3.35d 7.50l	N2O4/UDMH	35/39t	762 kN
SBA? CZ-3 S2	L-35	YF-22/YF-23 x 4	3.35d 9.71l	N2O4/UDMH	35/39t	766 kN
BWYIC CZ-2 S2	(Iridium)		(Stretched)			
BWYIC CZ-2E S2	L-90	YF-22B/YF-23B x 4	3.35d 15.52l	N2O4/UDMH	86/?t	788 kN
SBA CZ-4 S2	L-35	YF-22B/YF-23B x 4	3.35d 10.41l	N2O4/UDMH	35/?t	788 kN
SBA CZ-4B S2	L-35	YF-22B/YF-23B x 4	3.35d 10.41l	N2O4/UDMH	35/?t	788 kN
SBA CZ-3A S2	L-35	YF-22B/YF-23B x 4	3.35d 11.53l	N2O4/UDMH	29/?t	788 kN

Comparison of third stages

Name	Desig.	Engines	Size	Fuel	Mass	Thrust
SBA CZ-4 S3	L-14	YF-40 x 2	2.90d 6.24l	N2O4/UDMH	14t	98 kN
SBA CZ-4B S3	L-14	YF-40M x 2	2.90d 7.5l	N2O4/UDMH	15t	98 kN
BWYIC CZ-3 S3	H-8	YF-73	2.25d 7.48l	LOX/LH2	8.5/10.5t	44 kN
BWYIC CZ-3A S3	H-18	YF-75 x 2	3.00d 8.83l	LOX/LH2	17.6/? t	157 kN

Comparison of fairings

Name	Size

SBA CZ-4 Fairing A	2.90d 4.91l
BWYIC CZ-2 Fairing	3.35d 7.12l
BWYIC CZ-2 Fairing (Freja)	3.35d 8.82l
BWYIC CZ-3A Fairing	3.35d 8.89l
SBA CZ-4 Fairing B	3.35d 8.48l
BWYIC CZ-2E Fairing	4.20d 10.5l