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REPORT ON THE STATUS OF CURRENT AND FUTURE SATELLITE SYSTEMS

In response to CGMS Permanent Action 01

Executive summary

CMA operates the FY geostationary and the polar-orbiting systems. The current polar-orbiting fleet contains 3 spacecrafts: FY-3A, FY-3B, and FY-1D; the latter has been retired in the end of 2011. The FY LEO operation is carried on by FY-3A in AM orbit, and FY-3B the PM orbit. The two spacecrafts are identical in design: 3-axis stabilized, flying in sun-synchronous orbits, capable of the IR/MW atmospheric sounding, the VIS/IR/MV imaging, the ozone detection, and the space environment monitoring. The designed-life time of FY-3 is 3 years. In addition to the function of FY-3A/B, CMA plans to develop certain observational capabilities for the follow-up spacecraft models, for instance, the **WindRAD** for sea winds, the **GAS** for greenhouse gases absorption measurement. The atmospheric sounding shall be enhanced by replacing the current **IRAS** with **HIRAS** (Hyper-spectral Infra-red Atmospheric Sounder), and by the deployment of radio occultation sounder **GNOS**. Also, there is plan to develop rainfall measurement satellite: FY-3RM that shall carry Ku/Ka band radar, and the microwave sounding and imaging instruments.

Four identical FY geostationary satellites（FY-2C/D/E/F）are currently in orbit, all spin-stabilized, carrying the **VISRR** instrument for hourly VIS/IR imagery of the earth. Operationally, 105^{o}E is used by CMA as the primary position for GEO, and 86.5^{o}E as the backup. At present, the two positions are occupied by FY-2E, and FY-2D, respectively. The operational schedule for the two satellites is made in such a way that one satellite will begin observation the moment while the other one is measuring the earth halfway through. The ground station will benefit from this schedule with data acquisition at a doubled frequency. Since January 2012, the FY2 operational calibration for VISRR infrared channels has been upgraded using the IASI/Metop-A in the approach of inter-calibration.

The FY-2F at 112.5^{o}E was launched early 2012. It is stored in orbit for future replacement of FY-2D (or FY-2E) in operation. FY-2C at 123.5^{o}E is retired due to end of its fuel life.

CMA is developing FY-4 - its next generation of geostationary meteorological satellite. FY-4 is a three-axis stabilized platform to carry the Advanced Geo Radiation Imager, the Geo Interferometric Infrared Sounder, the Lightning Mapping Imager, and the Space Weather Monitor, for the mission of multiple-channel imaging, atmospheric sounding, lightning mapping, and space environment monitoring. The LRIT/HRIT data transmission and DCP function shall be available. The first FY4 spacecraft model is being manufactured and launch is scheduled for 2015, it will serve for test and demonstration of the system.

Report on the status of current and future satellite systems

1 INTRODUCTION

According to the Chinese Meteorological Satellite Program, the Fengyun meteorological satellite, or FY in acronym, take place in series. The odd number series is the polar-orbiting series, the even number series the geostationary. 12 satellites have been launched so far since the Program's been being implemented in 1980s.

Table.1 – chronology of FY Polar-orbiting satellites

Satellite	Launch	End of service	Height	LST	Status (Sept. 2012)	Instruments
FY-1A	7 Sep 1988	16 Oct 1988	900 km	11.30	Inactive	VIRR, SEM
FY-1B	3 Sep 1990	5 Aug 1991	900 km	16.00	Inactive	VIRR, SEM
FY-1C	10 May 1999	26 Apr 2004	862 km	11.30	Inactive	VIRR, SEM
FY-1D	15 May 2002	6 May 2011	866 km	11.30	De-missioned	VIRR, SEM
FY-3A	27 May 2008	expected ≥ 2011	836 km	10.15	Experimental	VIRR, MERSI-1, MWRI, IRAS, MWTS-1, MWHS-1, TOU/SBUS, ERM-1 ,SIM-1, SEM,
FY-3B	05 Nov 2010	expected ≥ 2013	836 km	13.38	Experimental	VIRR, MERSI-1, MWRI, IRAS, MWTS-1, MWHS-1, TOU/SBUS, ERM-1 ,SIM-1, SEM,
FY-3C	2012/3	expected ≥ 2016	836 km	10.00	Approved	VIRR, MERSI-2, IRAS, MWTS-2, MWHS-2, MWRI,TOU/SBUS, ERM-1,SIM-2, SES
FY-3D	2014	expected ≥ 2017	836 km	14.00	Approved	MERSI-2, ASI, MWTS-2, MWHS-2, MWRI, (GAMI), GNOS ,SES
FY-3E	2016	expected ≥ 2019	836 km	10.00	Approved	MERSI-2, ASI, MWTS-2, MWHS-2, WindRAD,(OMS), ERM-2,SIM-2,GNOS,SES
FY-3F	2018	expected ≥ 2021	836 km	TBD	Plamed	MERSI-2, ASI, MWTS-2, MWHS-2, MWRI, (GAMI),GNOS, SES
FY-3G	2020	expected ≥ 2023	836 km	TBD	Planned	MERSI-2, ASI, MWTS-2, MWHS-2, WindRAD,(OMS), ERM-2,SIM-2,GNOS,SES

Table 2 – Chronology of FY-2 GEO satellites

Satellite	Launch	End of service	Position	Status (Sept 2012)	Instruments
FY-2A	10 Jun 1997	08 April 1998		Deorbited	S-VISSR（3 channels）, DCS, SEM
FY-2B	25 Jun 2000	Sept. 2004		Deorbited	S-VISSR(3 channels), DCS, SEM
FY-2C	19 Oct 2004	22 Oct. 2009	123.5°E	Retired	S-VISSR (5 channels), DCS, SEM
FY-2D	15 Nov.2006	expected ≥ 2011	86.5°E	Operational	S-VISSR (5 channels), DCS, SEM
FY-2E	23 Dec. 2008	expected ≥ 2014	105°E	Operational	S-VISSR (5 channels), DCS, SEM
FY-2F	13 Jan 2012	Expected ≥ 2016	112.5°E	Pre-operational	S-VISSR (5 channels), DCS, SEM
FY-2G	2013	4 year lifetime	TBD	Approved	S-VISSR (improved), DCS, SEM
FY-2H	2015	4 year lifetime	TBD	Approved	S-VISSR (improved), DCS, SEM

2 CURRENT SATELLITE SYSTEMS

2.1 Status of current GEO satellite systems

Currently, there are four Fengyun geostationary satellites on orbit: FY-2C/D/E/F (ref to table 3). FY-2s is spin-stabilised, rotation velocity 100 rpm. The main payload is the Visible and Infrared Spin Scan Radiometer (VISSR) with 5 channels. The satellite takes hourly full disk imagery of the earth in VIS, IR, and water vapour channels.

The primary operational position of the Fengyun geostationary satellites is 105°E, stationed by FY-2E at present. The FY-2D at 86.5°E provides operational backup to FY-2E.

Table. 3: Current Fengyun Geostationary Satellites

(as of 15 Sept. 2012)

Sector	**Satellites currently in orbit (+type)** P: Pre-operational Op: Operational B: Back-up L: Limited availability	**Operator**	**Location**	**Launch date**	**Status**
West–Pacific (108°E-180°E)	FY-2C (L)	CMA	123°E	23 Dec 2008	Retired
	FY-2F (P)	**CMA**	**112.5°E**	**13 Jan 2012**	**Orbital-storage VISSR(5 channels) ,**
Indian Ocean (36°E-108°E)	FY-2E (Op)	CMA	105°E	19 Oct 2004	S-VISSR (5 channels), DCS, SEM.
	FY-2D (Op)	CMA	86.5°E	15 Nov 2006	S-VISSR (5 channels), DCS, SEM.

2.1.1 Mission objectives, payload/instruments, products

Primary objectives of FY-2 mission:

- Continuous observation of the earth to obtain images in visible, infrared spectral ranges. Sea surface temperature, cloud parameters and wind vectors can be derived;
- Operation of Data Collection System(DCS), collection and transmitting data from national and international data platforms(DCPs);
- Data Broadcast in HRIT/LRIT format, and

- Monitoring space environment.

FY-2 payloads:

- ***S-VISSR (Stretched Visible and Infrared Spin Scan Radiometer)*** – The version for FY-2A/B had three VIS/IR channels (0.5-1.05 μm, 6.3-7.6 μm and 10.5-12.5 μm), the improved version for FY-2 C/D/E/F splits the IR channel in two and adds a 3.5-4.0 μm channel (see table. 4~6). The resolution also is slightly improved: from 5.76 km (IR) and 1.44 km (VIS), to 5.0 km (IR) and 1.25 km (VIS). The image cycle is 30 min.

- ***Data Collection Service (DCS)*** - Main features: uplink: two bands, frequencies 402.0-402.1 MHz for international DCPs (33 channels of bandwidth 3 kHz), 401.1-401.4 MHz for regional DCPs (100 channels of bandwidth 3 kHz); data rate 100bps, polarisation right-hand circular.

- ***SEM (Space Environment Monitor)*** – A space particle monitor and an x-ray monitor are mounted on FY-2C to detect the space environment in proximity of the satellite, the solar activities and relevant space phenomenon. The SEM measurement is transmitted via telemetry to the ground system.

Table 4. *The spectral channels of VISSR*

Channel	Wavelength(μm)
IR1	10.3～11.3
IR2	11.5～12.5
IR3	6.3～7.6
IR4	3.5～4.0
VIS	0.55～0.99

Table 5. *The characteristics of VIS channels of VISSR*

Channel	VIS
Wavelength (μm)	0.55～0.99
IFOV(μr)	35
Space resolution (km)	1.25
Dynamic range	0～98%
S/N	1.5 @ 0.5% albedo 50 @ 95%
Number of detectors	4 (primary) + 4 (backup)
Quantization level	64
Calibration	Solar calibration

Table 6. *The characteristics of IR channels of VISSR*

Channel	IR1	IR2	IR3	IR4
Wavelength(μm)	10.3～11.3	11.5～12.5	6.3～7.6	3.5～4.0
IFOV (μr)	140	140	140	140
Space resolution(km)	5	5	5	5
Dynamic range	180～330K		190～300K	180～340K
Temperature resolution	0.4～0.2K	0.4～0.2k	0.5～0.3K	0.6～0.5K
Number of detectors	1(primary)+1 (backup)	1(primary)+1 (backup)	1(primary)+1 (backup)	1(primary)+1 (backup)
Quantization level	1024	1024	1024	256
Calibration	Blackbody calibration			

FY-2 Products

1. Image Products

Product	Coverage	Times/day
S-VISSR full disc earth image	Actual observation coverage to be centered at the satellite sub-point	28
Nominal image	Nominal full disc earth image to be centered at 105°E, 0°N	24
S-VISSR hemispheric image	Half disc earth image of the northern hemisphere	20
Nominal hemispheric	Nominal half disc earth image of the northern hemisphere	20
Quadrant image	Four quadrant images with extension of 10 degree longitude and latitude from 105°E, 0°N	24
4 China area image	China area and proximity	24
Lambert projection	70° –140°E, 5°-55°N	24
Mercator projection	45°-165°E, 45°N-45°S	24
Sea area image	105°-150°E, 0°-45°N	24

Note: 28 times/day – observation starts at each hour time, and at the half-hour dedicated for the AMV detection.
24 times/day – observation starts at each hour.
20 times/day – observation starts at each half-hour exclusive of those on the 28 times/day category.

2. Quantitative Products

Product	Coverage	Times/day
AMV	50°N-50°S, 55°E-155°E	4
SST	50°N-50°S, 55°E-155°E	8
UTH	50°N-50°S, 55°E-155°E	8
ISCCP Dataset, Precipitation index	50°N-50°S, 55°E-155°E	8
Rainfall estimate	70°E-140°E, 5°N-55° N	4
Cloud detection	50°N-50°S, 55°E-155°E	8
Cloud parameters(cloud top temperature, top height, cloud amount)	50°N-50°S, 55°E-155°E	8
Humidity profile by cloud analysis	50°N-50°S, 55°E-155°E	8
Outgoing long-wave radiation	50°N-50°S, 55°E-155°E	8
Downward solar radiation	50°N-50°S, 55°E-155°E	1
Snow coverage	Whole disc	1
Sea ice	Whole disc	1
Flood monitoring	China area	1
Drought monitoring	China area	1
Fire monitoring	China area	24
Tropical cyclone positioning	West pacific to 150°E, the Indian Ocean	24
Dust storm monitoring	China area	8
Fog monitoring product	China area	24
Brightness temperature	50°N-50°S, 55°E-155°E	8

Note: 4 times/day – observation starts at 00, 06, 12, 18 (UTC)
8 times/day- observation starts at 00, 03, 06, 09, 12, 15, 18, 21 (UTC)
1 time/day-average of all the image data received a day.

2.1.2 Status of spacecraft

FY-2F
launched on 13 January 2012, currently is located at 112.5°E as the orbital storage for future replacement of FY-2D or FY-2E.

While standing by, FY-2F used to be switched on in June 2012 to monitor the action of typhoon at the request of user.

FY-2E

launched on 23 December 2009, currently is active as the primary operational satellite at the 105°E.

FY-2D

launched on 15 November 2006, is stationed at 86.5°E. It operationally backs up FY-2E at 105°E. The two satellites alternatively make measurements, enabling the ground station to receive images at 30 minute interval routinely, or 15 minute in the summer season.

FY-2C

launched on 19 October 2004, used to be stationed at 105°E as the primary operational GEO satellite before retirement to 123.5°E in Oct. 2009 due to ending of its fuel life.

In retirement, FY-2C used to be activated again to make limited scanning and transmitted the VISSR images at 10 minute interval to Shenzhen City in response to request for special weather service for the World University Games in August 2011.

FY-2B

launched on 25 June 2000, used to be stationed at 105°E. It started S-VISSR (three channels) transmission and WEFAX on January 1, 2001.

On February 28, 2001, the transmission disrupted due to transponder failure. Later in June 2001 the transponder resumed by carefully adjusting the satellite temperature. However, the EIRP (Effective Isotropic Radiated Power) was 8dBW below the normal level.

The temperature controlling imposed extra pressure upon power supply. During the eclipse period when power was less supplied, S-VISSR transmission had to be switched off.

After June 8, 2003, the FY-2B only made measurement of the northern hemisphere till it was de-missioned and moved to 123.5°E in September 2004. On August 31, 2006, FY-2B was de-orbited.

FY-2A

launched on 10 June 1997, used to be stationed at the 105°E. The satellite made measurement intermittently due to de-spin failure of S-band antenna. It moved to 86.5°E in July 2000 and de-orbited in 2006.

2.1.3 Impact on spacecraft due to space weather

Space weather related spacecraft anomalies (Items in bold are required)

Source: Recommendations for Contents of Anomaly Database for Correlation with Space Weather Phenomena, P. O'Brien, J.E. Mazur, T. Guild, November 2011, AEROSPACE Report No.TOR-2011(3903)-5.

1. Date and Universal Time of the anomaly	**2. Fully specified location of the anomaly** (spacecraft location)	**3. Velocity or orbital elements at time of the anomaly**	4. Eclipse state of the vehicle (full, penumbra, partial, none)	5. Vector to Sun in spacecraft coordinates	6. Velocity vector of spacecraft in spacecraft coordinates	7. Initial guess at type of anomaly (See taxonomy below)	8. Estimated confidence of that guess	9. Anomaly category (e.g., affected system or kind of disruption)	10. Vehicle identity	11. Notes (e.g. unusual operational states or recent changes to operations (recent commands, attitude scheme, etc.)
N/A	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
N/A	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**

Taxonomy of Satellite Anomalies Caused by In Situ Charged Particle Environment (to be used for column 7):

1. Electrostatic discharge (charging)
    - 1.1 Surface charging
        - 1.1.1 Plasma sheet (subauroral)
        - 1.1.2 Auroral
    - 1.2 Internal charging
        - 1.2.1 Subsurface charging (e.g., beneath blanket)
        - 1.2.2 Deep charging (e.g., inside a box)
2. Single-Event Effects
    - 2.1 Protons
        - 2.1.1 Solar proton event
        - 2.1.2 Geomagnetically trapped protons
    - 2.2 Heavy ions
        - 2.2.1 Galactic Cosmic Rays
        - 2.2.2 Solar energetic particles
        - 2.2.3 Geomagnetically trapped heavy ions
3. Total Dose
    - 3.1 Long-term dose accumulation (multiple causes combined)
    - 3.2 Short-term (days or less) dose accumulation
        - 3.2.1 Solar protons
        - 3.2.2 Geomagnetically trapped protons
        - 3.2.3 Geomagnetically trapped electrons

2.1.4 Ground segment matters

The main Fengyun GEO ground segment facilities consists of the Command and Data Acquisition Station (CDAS); the Data Processing Centre (DPC); the Satellite Operation Control Centre (SOCC); Ranging Stations (one primary station, three secondary stations including one in Australia). The ground segment also includes the network of DCP, and LRIT/HRIT stations.

2.1.5 Data transmission

FY-2 transmits data in real time.

- ***Command and Data Acquisition Station (CDAS)*** Main transmission characteristics: frequency 1681.6 MHz, bandwidth 14 MHz, linear polarisation, data rate 14 Mbps.
- ***S-VISSR Data Transmission***, compatible with MDUS acquisition stations. Main features:
  - frequency: 1687.5 MHz; bandwidth: 2.0 MHz; polarisation: linear
  - antenna diameter ~ 3 m, G/T ~ 12 dB/K, data rate 660 kbps.
- ***WEFAX*** from FY-2 A/B, ***LRIT (Low Rate Information Transmission)*** from FY-2 C/D, similar to MSG, GOES, MTSAT and GOMS-N2. Main features of LRIT:
  - frequency: 1691.0 MHz; bandwidth: 260 kHz; polarisation: linear
  - antenna diameter ~ 1 m, G/T ~ 3 dB/K, data rate 150 kbps.

2.1.6 Projects, services

FY-2 provides S-VISRR imagery broadcast (HRIT format) and DCS service.

Operationally, the spacecrafts at 105^{o}E and 86.5^{o}E are used for the earth imagery, and usually one starts making measurement the moment while the other one is scanning the earth halfway through. This operational arrangement enables CDAS to alternatively receive data transmission from the two satellites to get observational imagery at a doubled frequency.

2.1.7 User statistics

The FY-2 observational imagery is simultaneously disseminated to HRIT users via the satellite direct broadcast service; or to DVB users through the CMACast dissemination system. There are 2,525 CMACast receiving stations in which 22 overseas by the latest statistics, and over 500 HRIT stations by estimation of Shinetech Company that develops and installs HRIT user stations.

2.2 Status of current LEO satellite systems

Currently, three Fengyun polar-orbiting satellites are in the sun-synchronous orbit: FY-1D, FY-3A, and FY-3B, all 3-axies stabilized. After nearly 9 year operation, the FY-1D was retired in the end of 2011, which marks the completion of FY-1 series. The mission of Fengyun polar-orbiting program is carrying on by FY-3A flying in AM orbit, and FY-3B in PM orbit.

Table 7: Current Fengyun Polar-Orbiting Satellites

(as of 16 Sept. 2012)

Orbit type (equatorial crossing times)	**Satellites in orbit** (+operation mode) P=Pre-operational Op=operational B=back-up L=limited availability R= R&D	**Operator**	**Equatorial Crossing Time** A=Ascend (northward) D=Descend (southward) +Altitude	**Launch date**	***Status***
Sun-synchronous local "early morning" orbit (05:00–07:00) (17:00–19:00)	FY-1D	CMA	04:10 (D) 866 km	15 May 2002	Retired in the end of 2011
Sun-synchronous local "morning" orbit (07:00–12:00) (19:00–24:00)	FY-3A(Op)	CMA	10:15 (D) 836 km	27 May 2008	AHRPT/MPT transmission; VIRR, MERSI, MWRI, IRAS, MWTS, MWHS, TOU/SBUS, SEM, SIM, ERM,
Sun-synchronous local "afternoon" orbit (12:00–17:00) (00:00–05:00)	FY-3B(Op)	CMA	13:38 (A) 836 km	5 Nov 2010	AHRPT/MPT transmission, VIRR, MERSI, MWRI, IRAS, MWTS, MWHS, TOU/SBUS, SEM, SIM, ERM

2.2.1 Mission objectives, payload/instruments, products

The ***FY-3*** polar-orbiting satellite series is developed for LEO service from 2008 to 2020 or beyond. Basically, the FY-3 models are capable of global atmospheric sounding, IR/VIS/Microwave imaging, and ozone detection. There is plan of developing the capability of atmospheric composition measurement for FY-3, and developing the spacecraft models (FY-3RM) dedicated to radar sounding of rainfall.

<u>The payloads on FY-3 satellites</u>

- ***VIRR (Visible and Infra Red Radiometer)***, flying on FY-3A/B, 10-channel VIS/IR radiometer for multi-purpose imagery, resolution 1.1 km, swath 2800 km.
- ***MERSI (Medium Resolution Spectral Imager)***, flying on FY-3A/B, 20-channel radiometer (19 in VIS/NIR/SWIR + one TIR at 10.0-12.5 μm) for ocean colour and vegetation indexes;

  resolution 250m for 4 VIS/NIR and the TIR channel, 1 km for all other channels; swath 2800 km.
- ***MWRI (Micro-Wave Radiation Imager)***, flying on FY-3A/B, 6-frequencies / 12 channels (all frequencies in double polarisation) for multi-purpose MW imagery. Conical-scanning radiometer, resolution 9.5 x 15 km at 90 GHz, 30 x 50 km at 19 GHz, swath 1400 km.
- ***IRAS (Infra Red Atmospheric Sounder)***, flying on FY-3A/B, 26-channel IR radiometer (including one VIS) for temperature/humidity sounding, resolution 17 km, swath 2250 km.
- ***MWTS (Micro-Wave Temperature Sounder)***, flying on FY-3A/B, 4-channel MW radiometer for nearly-all-weather temperature sounding, 54 GHz band, resolution 70 km, cross-track scanning, swath 2200 km.

- ***MWHS (Micro-Wave Humidity Sounder)***, flying on FY-3A/B, 4-frequency / 5-channel (one frequency in double polarisation) MW radiometer for nearly-all-weather humidity sounding, 183 GHz band, resolution 15 km, cross-track scanning, swath 2700 km.
- ***TOU/SBUS (Total Ozone Unit and Solar Backscatter Ultraviolet Sounder)***, flying on FY-3A/B, a suite of two UV spectro-radiometers, one (TOU) with 6 channels in the 308-360 nm range, resolution 50 km, swath 3000 km, for total ozone; the other one (SBUS) with 12 channels in the range 252-340 nm, resolution 200 km, nadir viewing, for ozone profile.
- ***SES(Space Environment Suite)*** flying on FY-3A/B, for *in situ* observation of charged particles in solar wind.
- ***ERM (Earth Radiation Measurement),*** flying on FY-3A/B, 2 broad-band channel radiometer for earth reflected solar flux and earth emitted thermal flux over total (0.2-50μm) and short (0.2-4.3μm) waveband; resolution 28km, cross-track scanning with 2 degree NFOV, swath 2300km; nadir viewing with 120 degree WFOV.
- ***SIM (Solar Irradiance Monitor),*** flying on FY-3A/B, 3-channel radiometer over 0.2-50μm waveband for the total incident solar flux; viewing the Sun near the north pole area.

2.2.2 Status of spacecraft

FY-3B was launched on 5 November 2010. It is the same model as FY-3A. The designed lifetime is 3 years, 3-axis stabilised, sun-synchronous, taking the afternoon orbit. FY-3B carries the same instruments as of FY-3A. It is operationally active when this report is written.

FY-3A was launched on 27 May 2008. The designed lifetime is 3 years, 3-axis stabilised, sun-synchronous, taking the morning orbit. The ground stations received the L-band AHRPT data, X-band MPT data, and DPT data. It is operationally active when this report is written.

FY-1D, whose function is identical with the FY-1C, was launched on 15 May 2002. The last satellite of FY-1 Program, FY-1D had been working for 9 years till 6 May 2011, when an operational disruption occurred due to power supply that has become too weak to maintain the stable attitude of satellite. In Sept. 2011, the FY-1D was de-missioned.

FY-1C was launched on 10 May 1999. FY-1C has some improvement from its predecessor: the size of solar panel is enlarged; the VIRR has ten observational channels instead of five. Most importantly, the attitude stability is much improved. After nearly 5 years operation, data acquisition and archive at CMA/NSMC for the FY-1C ceased from 26 April 2004 due to obvious degradation of measurement, the satellite was de-missioned later after that.

FY-1B was launched on 2 September 1990. It is a copy of the FY-1A model. A series tests was made on FY-1B and demonstration of ground segment. The satellite is de-missioned on August 1991 due to attitude failure.

FY-1A was launched on 7 September 1988. As the first meteorological satellite ever made by China, it is used for test and demonstration of system. The VIRR instrument onboard has five observational channels(0.58-0.68μm, 0.725-1.1μm,0.48-0.53μm,0.53-0.58μm,10.5-12.5μm). Satellite failure was announced not long after launching when the satellite attitude became uncontrollable.

2.2.3 Ground segment matters

CMA operates four ground stations to receive the Fengyun polar orbiting satellite data. The ground stations are located in Beijing, Guangzhou, Urumuqi, and Jiamusi. The received data are relayed to the Data Processing Center (DPC) through optical fibre links. The data is processed to generate various products, which are archived or disseminated to users.

In 2007 CMA signed a service leasing contract with the Sweden Space Center(SSC). The SSC receives the three format (AHRPT/MPT/DPT) downlinks of FY-3A/B at the Esrange Ground Station and transmits the data to DPC, Beijing.

2.2.4 Data transmission

FY-3A/B provides X-band (MPT format, China region) and L-band (AHRPT format) global direct read-out services.

- ***MPT (Medium-resolution Picture Transmission)***, for full information transmission of MERSI measurement. Main features:
  - frequency: 7775 MHz; bandwidth: 45 MHz; polarisation: right hand circular;
  - antenna diameter ~ 3 m, G/T ~ 21.4 dB/K, data rate 18.7 Mbps;
- ***AHRPT (Advanced High Resolution Picture Transmission)*** for selected information in L-band. Main features:
  - frequency: in the range 1704.5 MHz; bandwidth: 6.8 MHz; polarisation: right hand circular
  - antenna diameter ~ 3 m, G/T ~ 6.8 dB/K, data rate 4.2 Mbps.

FY-3A/B also uses X-band to dump data (DPT format) for global data recovery.

- ***Delayed Picture Transmission (DPT)***: frequency 8146 MHz, bandwidth 149 MHz, data rate 93 Mbps.

2.2.5 Projects, services

Package for Pre-processing FY-3 Satellites Data

NSMC/CMA has released two software packages, FY3L0pp V1.0 and FY3L1pp V1.0, to help FY-3A/B DB users processing the X-band MPT data (MERSI instrument) and the L-band AHRPT data (all instruments but MERSI), which are packed into CCSDS format. The two software packages are capable of processing raw data of 4 instruments: MERSI, VIRR, MWTS and MWHS onboard the FY-3A/B. Users shall obtain the package and ancillary data by sending request and approved by CMA (Fax: +86-10-62172724). For more information about the package please refer to CMA working paper to CGMS-39 meeting (CMA-WP-16).

Program to promote satellite applications

CMA launched a 5-year plan to promote meteorological satellite application. The plan focuses on the six themes as follows:

- Satellite data application in NWP
- Satellite data application in weather analysis
- Satellite data application in climate and climate change study
- Satellite data application in assessment of environmental and natural disasters
- Satellite data application in agricultural meteorology
- Validation and application tools

It’s selected to support 21 projects that are considered of priority concerns in CMA satellite application，in particular with regard to data assimilation (IR, MW, hyper- spectral IR, GPS, and AMVs), fast model for estimation of radiation transfer, now-casting for severe weathers, navigation and calibration method in data re-processing, generation of CDRs, multiple spacecrafts data assimilation for ocean model, standardization in disasters assessment, crop yields estimation, agriculture and drought, satellite product validation, etc..

2.2.6 User statistics

According to information from the Shinetech Company that develops and installs HRPT user stations that it's estimated over a hundred HRPT user terminals having been deployed across China.

FUTURE SATELLITE SYSTEMS

2.3 Status of future GEO satellite systems

According to the Fengyun program, the Fengyun-4 (FY-4) – CMA's new generation of geostationary meteorological satellite, a three-axis stabilized platform is being developed. Launch of the first flight model is scheduled for 2015 and to serve for the test and demonstration of the system.

Table 8: Future Geostationary Satellites Coordinated within CGMS

(as of 25 Sept. 2012, sorted by CMA)

Sector	Future additional satellites	Operator	Planned launch	(Planned location) Other remarks
Indian Ocean (36˚E-108˚E)	FY-2G	CMA	2014	5 channel VISSR
	FY-4A	CMA	2015	Multi-spectral imager, Interferometric Infrared Sounder, lightning mapper, SEM
West-Pacific (108˚E-180˚E)	FY-2H	CMA	2016	5 channel VISSR
	FY-4B	CMA	2018	Multi-spectral imager, Interferometric Infrared Sounder, lightning mapper, SEM

2.3.1 Mission objectives, spacecraft, payload/instruments, products

The main objectives of FY-4 mission:

- To take multiple spectral band measurements with high temporal resolution and accuracy, to obtain imagery of the earth surface and cloud, including the segment images;
- To measure the vertical profile of temperature and humidity of the atmosphere with improved detection accuracy and vertical resolution.
- To detect the lightning to obtain the map that positions the lightning occurrences.
- To broadcast the observational images, data and derived products with onboard transmitter.
- To collect the earth environmental measurements from data platforms and transmit to users.
- To monitor solar activities and space environment to provide the data for space weather research and service.

The FY-4 payloads include:

- **Advanced Geo. Radiation Imager(AGRI):** two independent mirrors scanning north-south and east-west directions respectively; 216 sensors in 14 bands from visible to long-wave infrared(0.55~13.8μm); on-orbit calibration for all bands, full optic length of radiation considered in calibration; resolutions: 500mx1(ch), 1Kmx2(ch), 2Kmx4(ch), 4Kmx7(ch); S/N: 90 ～ 200; NEΔT：0.2～0.7K; full disk time< =15min.

● **Geo. Interferometric Infrared Sounder(GIIRS):** two independent mirrors scanning north-south and east-west directions respectively; 32×4 focal plane arrays for mid-wave (375 S/MIR channels) and long-wave infrared bands(538 LWIR channels); resolution: 16Km; active and radiate coolers. radiometric calibration accuracy: 1K; spectral calibration accuracy:10ppm; Meso-scale : 35min(1000x1000km), China area: 67min(5000x5000km).

●**Lighting Mapping Imager(LMI):** two tubes for observation to achieve more spatial coverage; central frequency: 777.4nm; S/N > =6; spatial resolution: 7.8Km; temperal resolution: 2ms

● **Space Weather Monitor:** N/A

Table 9 lists the FY-4 products.

Table 9: Product list of FY-4 first experimental satellite

No.	Products	No.	Products	No.	Products
1	Clear Sky Masks	10	Upward Long-wave Radiation: TOA	19	Rainfall Rate/QPE
2	Cloud Top Temperature	11	Upward Long-wave Radiation: Surface	20	Convective Initiation
3	Cloud Optical Depth	12	Reflected Shortwave Radiation: TOA	21	Tropopause Folding Turbulence Prediction
4	Cloud Liquid Water	13	Derived Motion Winds	22	Sea Surface Temperature (skin)
5	Cloud Particle Size Distribution	14	Cloud Top Pressure	23	Fire/Hot Spot Characterization
6	Aerosol Detection	15	Vertical Moisture Profile	24	Land Surface (Skin) Temperature
7	Aerosol Optical Depth	16	Ozone Profile & Total	25	Land Surface Emissivity
8	Downward Shortwave Radiation: Surface	17	Cloud Top Height	26	Snow Cover
9	Downward Long-wave Radiation: Surface	18	Lightning Detection	27	Space weather products

2.3.2 Data transmission

FY-4 provides 1675-1687MHz HRIT data transmission, 1696 -1698MHz LRIT data transmission and WAIB(Weather Alarm Information Broadcast).

Raw data transmission (downlink): X-band 7450-7550 MHz (CR and CL)

HRIT: 8175-8215 MHz (data uplink), 1675-1687MHz (data downlink)

LRIT and WAIB(Weather Alarm Information Broadcast):
2056-2060MHz (data uplink), 1696 -1698MHz (data downlink)

DCPS: Domestic channel: 401.1-401.4MHz (uplink)
International channel: 402.0-402.1MHz (uplink)
1686-1692MHz (downlink)

TARS: 2042-2052MHz (uplink; frequency extent)
1689-1697MHz (downlink -1), 2222-2232MHz (downlink -2)

Telemetry and command: 2025-2110MHz (uplink), 2200-2290MHz (downlink)

2.4 Status of future LEO satellite systems

After FY-3A/B, the future FY-3 models (FY-3C/D/E/F) have been approved. CMA will maintian operatonal models on the morning orbit (FY-3AM) and afternoon orbit (FY-3PM).

Table. 10 Future Polar-Orbiting Satellites Coordinated within CGMS

(as of Sept. 2012, sorted by CMA)

Orbit type (equatorial crossing times)	**Future additional Satellites**	**Operator**	**Crossing Time** A=Ascend. (northward) D=Descend. (southward) +Altitude	**Planned launch date**	**Other information**
Sun-synchronous local "morning" orbit (07:00 – 12:00) (19:00 – 24:00)	FY-3C	CMA	10:00(D) 836 km	2012/3	AHRPT/MPT transmission; VIRR, MERSI, MWRI, IRAS, MWTS-2, MWHS-2, TOU/SBUS, SEM, ERM, SIM
	FY-3E	CMA	10:00(D) 836 km	2016	AHRPT/MPT transmission; MERSI-2, WindRD, ASI, MWTS-2, MWHS-2, (OMS), SES,ERM-2, SIM-2, GNOS
	FY-3G	CMA	10:00(D) 836 km	2020	Same as above
Sun-synchronous local "afternoon" orbit (12:00 – 17:00) (00:00 – 05:00)	FY-3D	CMA	14:00(A) 836 km	2014	AHRPT/MPT transmission; MERSI-2, WindRD, ASI, MWTS-2, MWHS-2, (GAMI), SES, GNOS
	FY-3F	CMA	14:00(A) 836 km	2018	Same as above

2.4.1 Mission objectives, spacecraft, payload/instruments, products

Similar to the current FY-3A/B, the future FY-3C/D/E/F spacecrats are able of earth measurements and real-time transimssion for the operational use of IR/MW atmospheric sounding data, VIS/IR/MW imaging data. In addtion, CMA plans to develop for FY-3 follow-up models the capability of atmospheric composition measurement.

The payload and deployment schedule for future FY-3C/D/E/F spacecraft models is given in Table 12. This schedule assures the listed measurement is taken every day, while the mission of allocated to each spacecraft is not too heavily loaded.

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Table.12 Instruments & Deployment Schedule for FY-3C/D/E/F

Satellite & deployment schedule / Instruments	FY-3C 2012/3	FY-3D 2014	FY-3E 2016	FY-3F 2018
MERSI – Medium Resolution Spectral Imager (Ⅰ, Ⅱ)	√(Ⅰ)	√(Ⅱ)	√(Ⅱ)	√(Ⅱ)
MWTS – Microwave Temperature Sounder (Ⅱ)	√	√	√	√
MWHS – Microwave Humidity Sounder (Ⅱ)	√	√	√	√
MWRI – Microwave Radiation Imager	√	√		√
WindRAD – Wind Radar			√	
GAS – Greenhouse Gases Absorption Spectrometer		√		√
HIRAS – Hyperspectral Infrared Atmospheric Sounder		√	√	√
OMS – Ozone Mapping Spectrometer			√	
GNOS – GNSS Occultation Sounder	√	√	√	√
ERM – Earth Radiation Measurement (Ⅰ, Ⅱ)	√(Ⅰ)		√(Ⅱ)	
SIM – Solar irritation Monitor (Ⅰ, Ⅱ)	√(Ⅰ)		√(Ⅱ)	
SES – Space Environment Suite	√	√	√	√
IRAS – Infrared Atmospheric Sounder	√			
VIRR – Visible and Infrared Radiometer	√			
SBUS – Solar Backscattered Ultraviolet Sounder	√			
TOU – Total Ozone Unit	√			

Note:

The instruments with improved performance include **MERSI** Ⅱ**, MWTS** Ⅱ**, MWHS** Ⅱ**, SIM** Ⅱ and **ERM** Ⅱ.

The advanced MERSI, MERSI-Ⅱ will increase channels from 20 to 25, to merge the VIRR channels.

MWTS-Ⅱ increases channels from 4 to 13, and MWHS-Ⅱ channels increase from 5 to 15. The advanced MWTS and MWHS will provide similar sounding capability as AMSU.

The advanced SIM that automatically tracks the solar disk shall improve the accuracy of the measured solar constant. The advanced ERM increases one broad-band channel to measure the outgoing long wave radiance directly.

Five new payloads include the **Hyperspectral Infrared Atmospheric Sounder** (HIRAS), which is an IASI/Metop-like instrument to improve the measurement of temperature and moisture profile, and replaces the IRAS on FY-3A/B. **Ozone Mapping Spectrometer** (OMS) is a SCIAMACHY/Envisat-like instrument to detect the ozone and other atmospheric chemicals and replaces the suite of TOU and SBUS. The total column content and the profile of trace gases can be retrieved from the nadir view and limb view separately. **Wind Radar** (WindRAD) measures the sea wind. **Greenhouse Gases Absorption Spectrometer** (GAS) measures CO2 and CH4 globally. **GNSS Occultation Sounder** (GNOS) shall improve the measurement of temperature and moisture profile at the upper atmosphere.

Also, CMA is planning to launch the FY-3RM spacecraft dedicated to rainfall measurement. It carries Ku/Ka band radar, and the microwave sounding and imaging instruemtns (MWTS, MWHS, and MWRI) shall be additional options. The inclimation of the orbital plane is to be determined.

3 CONCLUSIOTNS

The Fengyun Program is long term, application-oriented, and constantly improving in development for the goal of providing quality EO data and products for the weather, climate, and environment monitoring. Having established the operational system with space and ground segments capable of both GEO and LEO, CMA is continuing with efforts to maintain a stable and reliable operational system, as well as to improve the satellite measurement, pursuing relentlessly the excellence of the Fengyun system, in order to meet the growing demand for Earth observation in the weather, climate, and environment applications.

The social and economical benefit and people's welfare is the ultimate goal in developing the satellite program. Satellite application and satellite development interact to promote each other. On this point, CMA has launched a five-year plan to promote satellite applications and it led to definition of 21 issues in six thematic areas, each relating to a specific task or project that is considered priority in the implementation of the plan. Also, an objective way to evaluate the benefit of the Fengyun system to the society and economy is considered one of the priority issues for the program planning.