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UPDATED REPORT ON FENGYUN SATELLITE PROGRAM AND DEVELOPMENT

Executive summary

China Meteorological Administration (CMA) is operating FENG YUN (or FY for acronym) geostationary and polar-orbiting satellite systems. The current FY operational sun-synchronous polar-orbiting fleet is composed of FY-3s, the Chinese second-generation LEO meteorological satellite series. The latest fly unit of FY-3 series, FY-3D, launched 15 Nov 2017, is in service since Jan 2019. Observational capability of FY-3D includes VIS, IR and MV imaging, IR and MV atmospheric sounding, greenhouse gas detection, radio occultation sounding, and space weather monitoring. Core instruments on FY-3D are MERSI (Medium Resolution Spectral Imager) for monitoring environment with main products of ocean color, vegetation indexes, and so on and so forth; MWHS (Micro-Wave Humidity Sounder) and MWTS (Micro-Wave Temperature Sounder) for atmosphere sounding, and HIRAS (Hyperspectral Infrared Atmospheric Sounder) for IR atmosphere sounding, and MWRI (Micro-Wave Radiation Imager) for microwave characteristic of ground surface. The observational data is provided to users through FY-3 Direct Broadcast (DB) service with X-band AHRPT data format. According to program, CMA will deploy FY-3E to an early morning orbit. Launch of FY-3E is planned for the end of 2020.

The CMA operational geostationary satellite observation is supported by FY-2 series. FY-2F/2G/2H are positioned at 112°E, 99.5°E,and 79°E, respectively.FY-2 satellite transmits 5-channel S-VISSR imagery. And FY-2E which located at 86.5°E was out of service since Jan. 2019. CMA is developing the secondgeneration geostationary series FY-4, the first unit, FY-4A, is in service since May.1 2018 and currently located at 105°E（nominal）. It's a three-axis stabilized platform carrying AGRI (Advanced Geo Radiation Imager), GIIRS (Geo Interferometric Infrared Sounder), LMI (Lightning Mapping Imager), and SEP (Space Weather Package). FY-4A transmits LRIT & HRIT format data and is capable of Data Collection Service(DCS).

Action/Recommendation proposed: None

UPDATED REPORT ON FENGYUN SATELLITE PROGRAM AND DEVELOPMENT

1 INTRODUCTION

The CMA Feng Yun Meteorological Satellite Programme includes both geostationary and polar orbiting satellite missions. Feng Yun satellites, or FY in acronym, take place in series. The odd number series is the polar-orbiting series, the even number series the geostationary. The capital letter after the serial number refers to the seat of a particular satellite in the launching sequence.

2 CURRENT SATELILTE SYSTEMS

2.1 Status of current GEO satellite systems

The first generation of GEO satellites is the FY-2 series spacecrafts containing 8 flight units. The FY-2 spacecraft is spin–stabilized rotating at velocity of 100 rpm, primary payload is a 5-channel Visible and Infrared Spin Scan Radiometer (VISSR). FY-2 transmits hourly full-disk imagery of the earth in VIS, IR, and water vapour spectral bands.

The current FY-2 constellation consists of 3 satellites, namely FY-2F/G/H. They are positioned at 112°E, 99.5°E,and 79°E, respectively.

The CMA second-generation GEO satellite series is FY-4. Unlike FY-2, FY-4 is three-axes stabilized; apart from inherited and enhanced imaging capability, FT-4 is designed to have sounding, lightning mapping, and space weather monitoring capabilities.

On 11 December, 2016, the first FY-4 unit, FY-4A, was launched from the Xichang satellite launch center. It is in service since May. 2018 and currently located at 105°E.

Table 1 – Current Feng Yun Geostationary Satellites (as of May 15, 2019)

Sector	**Satellites currently in Orbit (+type)** P: Pre-operational Op: operational B: Back-up L: Limited availability	Operator	Location	Launch date	Status
West-Pacific (108^0E-180^0E)					
	FY-2F(P)	CMA	112 °E	13 Jan 2013	Orbital storage/ 5 channel VISSR, DCS, SEM

Indian Ocean(36^{0}E-108^{0}E)	FY-4A (Op)	CMA	105 °E	11 Dec 2016	14 channel AGRI, GIIRS, LMI, SEP; DCS
	FY-2G(Op)	CMA	99.5 °E	31 Dec 2014	5 channel S-VISSR, DCS, SEM
	FY-2H(Op)	CMA	79 °E	5 Jun 2018	5 channel S-VISSR, DCS, SEM

2 .1.1 Mission objectives, payload/instruments

2.1.1.1 FY-2 program

Primary objectives:

- Continuously observing to obtain the earth imagery in visible, infrared, and water vapor spectral bands, from which sea surface temperature, cloud parameters, and wind vectors can be derived;
- Operating the Data Collection System (DCS) to collect and transmit data from domestic and overseas data collection platforms (DCPs).
- Broadcasting data in HRIT/LRIT formats, and
- Monitoring space environment.

Payloads:

- **S-VISSR(Stretched Visible and Infrared Spin Scan Radiometer)** – The version for FY-2A/B had three VIS/IR channels (05-1.05μm, 6.3-7.6μm, and 10.5-12.5μm), the improved version for FY-2C/D/E/F/G/H splits the IR channels into two and adds a 3.5-4.0μm channel. The resolution is improved from 5.76km (IR) and 1.44km (VIS), to 5.0km (IR) and 1.25 (VIS). The image cycle is 30 min.

- **DCS(Data Collection System)** – Main feature: two uplink bands, frequencies 402.0-402.1MHz for international DCPs (33 channels of bandwidth 3KHz, bit rate 100bps, modulation BPSK/PCM) and frequencies 401.1-401.4MHz for domestic DCPs (400 channels of 750Hz spacing, bit rate 600bps, modulation QBSK); polarization: right-hand circular.

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

Status of spacecraft:

FY-2H

Launched 5 Jun 2018, operational at 79E currently.

FY-2G

Launched 2014/12/31; operational at 105E till 2018/04/16 to be relocated at 99.5E; currently operational.

FY-2F

Launched 13 January 2012, currently at 112E as orbital storage.

FY-2E

Launched 2009/12/23 currently active at 86.5E for IODC; retirement.

FY-2D

Launched 2006/11/15, operational at 86.5E till retirement to current location 123.5E.

FY-2C

Launched 2004/10/09; operational at 105E till retirement to 123.5E in Oct 2009; de-orbited from 123.5E.

FY-2B

Launched 2000/06/25, used to be stationed at 105E. On 2001/02/28 the S-VISSR transponder failed; After 2003/06/08, FY-2B was only used to observe the northern hemisphere till de-missioned to 123.5E in Sep, 2004. On 2006/08/31, it was abandoned.

FY-2A

Launched 1997/06/10; used to be stationed at 105E. Operation is intermittent due to S-band antenna failure. It moved to 86.5E in July 2000 and de-orbited in 2006.

2.1.1.2 FY-4 program

Primary objectives:

- To take multiple spectral channel imagery of the earth with high temporal resolution;
- To measure atmospheric vertical profile of temperature and humidity with improved vertical resolution and detection accuracy.
- To detect and map lightning events.
- To monitor solar activities and space environment for space weather forecast service.
- To collect data from data platforms and transmit to users.
- To broadcast observational images, data and derived products with aboard transponder.

Status of spacecraft:

FY-4A

Launch time 2016/Dec/11; orbital check out was conducted at 99.5E; the first AGRI imagery was received and, afterward, it was published on 2017/Feb/27. FY-4A was relocated to operational position 105E 2018/04/16.

Payloads/instruments:

- ***AGRI (Advanced Geo. Radiation Imager)***: to fly on FY-4A/B/C, multi-spectral imager with 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-board calibration for all bands, full optic length of radiation considered in calibration; resolutions : 500m x1(ch), 1km x 2(ch), 2 km x 4(ch), 4km x 7(ch); S/N: 90～200. NE△T: 0.2～0.7K@300K; full disk time＜15min.

- ***GIIRS (Geo. Interferometric Infrared Sounder)***: to fly on FY-4A/B/C, two independent mirrors scanning north-south and east-west directions respectively; 32 x 4 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; Mesoscale: 35 min (1000x1000km), China area: 67 min (5000x5000km).

- ***LMI (Lightning Mapping Imager)***: to fly on FY-4A/B/C, two tubes for observation to achieve more spatial coverage; central frequency: 777.4nm; S/N ≥ 6; spatial resolution: 7.8km; temporal resolution: 2ms.

- ***GHI(Geosynchronous High-speed Imager)***: to fly on FY-4B, 5 channels (VIS:0.55~0.75μm, res~250m; SIR: 1.58~1.64μm, 2.10~2.36 μm, res~1km; LIR:6.30~7.60μm,10.30~11.30μm,res~2km), scanning time: 1 min (2000km×2000km); SNR>4@ρ=1%(VIS channel), NE∆T=0.2K@300K(IR channels)

- ***SEP(Space Environment Package)****:* to fly on FY-4A/B/C, a suite that contains a Magnetometer for 3-D magnetic field intensity, an Energetic Particle Detector detecting high-energy electron storms (1~165MeV, and >165MeV) and proton events (0.4~4MeV), and Space Weather Effect Detectors for the impact of space weathers on spacecraft.

- ***DCS (Data Collection Service)*** – Main feature: two uplink bands, frequencies 402.0-402.1MHz for international DCPs (33 channels of bandwidth 3KHz, bit rate 100bps, modulation BPSK/PCM) and frequencies 401.1-401.4MHz for domestic DCPs (400 channels of 750Hz spacing, bit rate 600bps, modulation QBSK); polarization: right-hand circular.

2.1.3 Ground segment matters

The FY-GEO ground segment consists of the Command and Data Acquisition Stations(CDAS); the Data Processing Centre (DPC), the Satellite Operation Control Centre（SOCC）; Ranging Stations (one primary station, three secondary stations including one back-up in Melbourne, Australia). The ground segment also includes the DCPs, and HRIT/LRIT stations.

2.1.4 Data transmission

2.1.4.1 FY-2 data transmission

- ***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 ～3m, G/T～12dB/K, data rate 660kbps.

- **WEFAX** for FY-2A/B, **LRIT** (Low Rate Information Transmission) for FY-2 C/D/E/F/G/H; Main features of LRIT:
  - frequency: 1691.0 MHz; bandwidth: 260kHz; polarization: linear
  - antenna diameter ～ 1m, G/T ～ 3dB/K, data rate 150kbps.

2.1.4.2 FY-4 data transmission

FY-4 provides 1675 -1687 MHz **HRIT** (High Rate Image Transmission), 1696-1698 MHz **LRIT** (Low Rate Image Transmission) and **WAIB** (Weather Alarm Information Broadcast) services.

- **Raw data transmission** (downlink): satellite to CDAS with X –band 7450-7550 MHz (CR and CL)；
- **HRIT**(High Rate Information Transmission):
  data uplink: frequncy ~8195 MHz; bandwidth ~ 40MHz;
  data downlink: frequncy ~ 1681 MHz; bandwidth ~ 12 MHz
  antenna diameter ~ 7m; G/T ~ N/A; data rate N/A
- **LRIT** and **WAIB:** data uplink: frequncy ~2058 MHz; bandwidth ~ 4MHz;
  data downlink: frequency ~1697MHz；bandwidth~2MHz
- **DCS:** Domestic channels: 401.1-401.4 MHz (data uplink)
  International channels: 402.0-402.1 MHz (data uplink)
  Data downlink: 1686-1692 MHz
- **TARS:** 2042-2052 MHz (uplink: frequency extent)
  1689-1697 MHz (downlink-1), 2222-2232 MHz(downlink-2)
- **Telemetry and command:** 2025-2110MHz (uplink)
  2200-2290 MHz (downlink)

2.1.5 Project and service

Indian Ocean Data Coverage

At the 43rd CGMS Plenary Session in May 2015, CGMS Members agreed on a strategy for the continuation of the Indian Ocean Data Coverage(IODC) Services beyond 2016 and on a roadmap for its implementation. This strategy is based on the combined use of assets provided by CMA, EUMETSAT, ISRO and ROSHYDROMET.

CMA provides the essential data and products from observations at the point 86.5E as its contribution to implementation of agreed IODC roadmap: hourly broadcasted VISSR imagery and products made available through CMACast: blackbody brightness temperature, surface incidence solar radiation, humidity profile derived from cloud analysis, outgoing longwave radiation, AMV(IR,MV), cloud type, cloud total amount, snow cover, total precipitable water for clear sky, and precipitation estimate.

2.1.6 User statistics

FY GEO satellites provide DB service (HRIT format) to users; also, users can get access to FY GEO data via the CMACast DVB-S broadcast. There are 2,525

deployed CMACast receiving terminals, in which 22 overseas; there are over 500 HRIT stations according to statistics of the Shinetech Company that develops and supports Feng Yun satellite users with receiving equipment.

2.2 Status of current LEO satellite systems

The current operating LEO satellite system of CMA is the FY-3 series satellites flying on AM and PM orbits.

Table 2 - Current Feng Yun Polar-orbiting Satellites
(as of 15 May, 2019)

Orbit type (equatorial crossing times)	**Satellite 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**	**Other information**
Sun-synchronous Local "early morning" orbit (05.00-07.00) (17.00-19.00)	N/A	CMA			
Sun-Synchronous Local "morning" Orbit (07.00-12.00) (19.00-24.00)	FY-3C(Op)	CMA	10.15(D) 836 km	23 Sep 2013	AHRPT Transmission: VIRR, MWRI, IRAS,MWTS-2, MWHS-2, GNOS TOU/SBUS, SIM-2 ERM, SEM Transmission: MERSI
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 Transmission: VIRR, MWRI, IRAS,MWTS, MWHS, TOU/SBUS, SEM,SIM ERM MPT Transmission: MERSI
	FY-3D(Op)	CMA	14.00 (A) 836 km	15 Nov. 2017	AHRPT X-band Transmission: MERSI-2, HIRAS, MWRI, MWTS-2, MWHS-2, GAS, GNOS, SWS

2.2.1 Mission objectives, payload/instruments

Primary objectives

The FY-3 polar-orbiting satellite series is developed for LEO service from 2008 to 2020 or beyond. Basically, the FY-3 is capable of global atmospheric sounding, IR/VIS/MV imaging, ozone detection and greenhouse monitoring. There is plan to deveop radar measurment of precipitation for future missions.

FY-3 payload/instruments

● ***VIRR (Visible and Infra-Red Radiometer)***, flying on FY-3A/B/C, 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/C, 20- channel radiometer (19 in VIS/NIR/SWIR + one TIR at 10.0-12.5μm) for ocean color and vegetation indexes. Resolution 250m for 4 VIS/NIR and the TIR channel, 1 km for other channels; swath 2800 km.

● ***MWRI (Micro-Wave Radiation Imager)***, flying on FY-3A/B/C, 6-frequencies / 12 channels (all frequencies in double polarization) for multi-purpose MW imagery. Conical-scanning radiometer, resolution 9.5 x 15 km at 90 GHz, 30 x 50 km at 19GHz, swath 1400 km.

● ***IRAS(Infra Red Atmospheric Sounder),*** flying on FY-3A/B/C, 26-channel IR radiometer (including one VIS) for temperature/humidity sounding, resolution 17 km, swathe 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.

● ***MWTS-2 (Micro-Wave Temperature Sounder)***, flying on FY-3C/D/E, 13-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-A/B, 4 frequency / 5 channel (one frequency in double polarization) MW radiometer for nearly-all-weather humidity sounding. 183GHz band, resolution 15 km, cross-track scanning, swath 2700 km.

● ***MWHS-2 (Micro-Wave Humidity Sounder)***, flying on FY-C/D/E/F, 15 channel MW radiometer for nearly-all-weather humidity sounding. 183GHz 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.

● ***SEM (Space Environment Monitor)***, flying on FY-3A/B/C/D/E, for in situ observation of charged particles in proximity of satellite.

● ***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 2300 km, 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.

● ***GNOS(GNSS Occultation Sounder)***, flying on FY-3C/D/E/F; receives signal from GPS or China BeiDou satellites; observing over 1000 occultation events per day.

2.2.2 Status of spacecraft

FY-3D

Launced on 2017/Nov/15. operational.

FY-3C

Launch time 2013/Sep/23; operational.

FY-3B

Launch time 2010/Nov/5. It's the same model as FY-3A, designed life-time is 3 years, 3 axis stabilized, sun-synchronous, taking the afternoon orbit. FY-2B carries similar instruments on FY-3A.

FY-3A

Launch time 2008/May/27, designed life-time 3 years, 3-axis stabilized, sun-synchronous, taking mid-morning orbit. Service ends 5 Jan 2015.

FY-1D

Launch time 15 May 2002 with the same mission objective as the FY-1C; the last satellite of FY-1 program. FY-1D had been working 9 years till 6 May 2011 when power supply was becoming too weak to maintain the satellite attitude stable. In Sept. 2011 FY-1D was de-missioned.

FY-1C

Launch time 10 May 1999. Some improvement seen from its predecessors. The size of solar panel was enlarged, the VIRR has ten channels. The attitude stability is much improved. It had been operating for nearly 5 years. Data acquisition and archive for FY-1C at NSMC ceased 6 April 2001 due to obvious degradation in the measurements. The satellite was de-missioned afterwards.

FY-1B

Launched time 2 September 1990. It's a copy of FY-1A model. A series tests was performed to demonstrate the ground system. The satellite is de-missioned in August 1991 due to attitude control failure.

FY-1A

Launched on 7 September 1988. The first meteorological satellite ever made by China, it was used to test and demonstrate the system. The only observational instrument, VIRR, had five 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 launch when the satellite attitude control became impossible.

2.2.3 Ground segment matters

CMA operates four ground stations to receive the FY 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 fiber link. The data is processed into various products, disseminated, or archived.

NSMC uses 2 antennas at the North Pole Satellite Station of Esrange Space Center，Kiruna, Sweden to receive FY-3 satellites under contract between CMA and SSC(Sweden Space Company) for long-term on-orbit services of FY-3 and other polar satellite to be operated by NSMC. SSC receives downlinks of FY-3 at the Esrange Ground Station and transfers the data to the Beijing DPC.

2.2.4 Data transmission

FY-3s provide 7775MHz X-band and 1704.5MHz L-band direct broadcast services.

● **MPT (Medium-resolution Picture Transmission)**, for full information transmission of MERSI measurement on FY-A/B/C. Main features:

- frequency: 7775MHz; bandwidth: 45 MHz; polarization: right hand circular;
- antenna diameter ～3 m, G/T～21．48dB/K, data rate 18.7 Mbps.

● **AHRPT (Advanced High Resolution Picture Transmission)** for full information transmission of the instruments exclusive of the MERSI on FY-3A/B/C. Main features:

- Frequency: in the range 1704.5MHz; bandwidth: 6.8MHz; polarization: right hand circular.
- Antenna diameter ～3 m, G/T～6.8 dB/K, data rate: 4.2 Mbps.

It's must be advised that FY-3D satellite uses 1704.5MHz X-band to transimt full information of all instruments' measurments, but with **AHRPT** format.

● **DPT (Delayed Picture Transmission)** for dump data transmission. .

- Frequency: 8146 MHz; bandwidth 149 MHz, data rate: 9.3 Mbps.

2.2.5 Projects, services

Online User Support

To support DB users receive and process FY-3 transmission data, NSMC/CMA provides on http://satellite.nsmc.org.cn the “Satellite to Ground Interface Control Document”, pre-processing software packages for instruments MERSI, VIRR, MWTS, MWHS, MWRI, GNOS, and HIRAS(FY-3D).

2.2.6 User statistics

According to information from the Shinetech Company, which develops and installs the HRPT user stations, over a hundred HRPT terminals were deployed across China area based on statistics in 2012.

3 FUTURE SATELLITE SYSTEMS

3.1 Status of future GEO satellite systems

According to plan, the FY-4A will be followed by FY-4B/C.

In the meantime, FY-2 series is looking forward to the arrival of FY-2H in June 2018. It is planned that FY-2H will locate to 79E for data coverage of the Indian Ocean.

Table 3 - Future Feng Yun Geostationary Satellites
(as of 15 May, 2019)

Sector	Future additional satellites	operator	Planned launch	(planned location) Other remarks
Indian Ocean (36°E-108°E)				
	FY-4B	CMA	TBD	(TBD) AGRI, GIIRS, LMI,GHI,SEP,DCS
West-Pacific (108°E-180°E)	FY-4C	CMA	TBD	(TBD) AGRI,GIIRS, LMI,SEP,DCS

3.1.1 Mission objectives, spacecraft, payload/instruments, products

(Refer to 2.1.1.2)

3.2 Status of future LEO satellite systems

Program planning enables FY-3 service into 2020s, to be covered by FY-3E/F/G, taking both morning (AM) and afternoon (PM) orbits, particularly, FY-3E will take early morning orbit.

Table 4 – Future Polar-Orbiting Satellite Coordinated within CGMS
(as of 15 May 2019)

Orbit type (equatorial crossing times)	**Satellite in orbit**	**Operator**	**Equatorial Crossing Time** A=Ascend (northward) D=Descend (southward) +Altitude	**Launch date**	**Other information**
Sun-synchronous Local "early morning" orbit (05.00-07.00) (17.00-19.00)	FY-3E	CMA	Early morning	2020	AHRPT X-band Transmission: FMERSI, MWTS-2, MWHS-2, WindRAD, HIRAS, GNOS, SWS
Sun-Synchronous Local "morning" Orbit (07.00-12.00) (19.00-24.00)	FY-3F	CMA	10.00(D) 836 km	2021	AHRPT X-band Transmission: MERSI-2, HIRAS, MWRI, MWTS-2, MWHS-2, GAS, GNOS
Sun-Synchronous Local "afternoon" Orbit (12.00-17.00) (00.00-05.00)	FY-3G	CMA	14:00（A） 836 km	2022	AHRPT X-band Transmission: MERSI-2, MWTS-3, MWHS-2, MWRI, GAS, HIRAS, GNOS，SWS

3.2.1 Mission objectives, spacecraft, payloads / instruments

Similar to FY-3A/B/C, future FY-3 models are able of the earth measurements, real-time transmission for the operational use of IR/MW atmospheric sounding data, and VIS/IR/MW imaging data. CMA plans to develop atmospheric composition measurements, rainfall measurement for future FY-3s.

Table 5 - Instruments & Deployment schedule for FY-3D/E/F/G/RM

Suites	Satellite & Deployment / Instruments	3D(pm) 2017 Nov	3E(early am) 2020	3F(am) 2021	3G(pm) 2022	3RM 2020

Optical imager	MERSI-2	●	FMERSI	●	●	●
MV Passive	MWTS-2	●	●	MWTS-3	MWTS-3	MWTS-3
	MWHS-2	●	●	●	●	●
	MWRI	●		●	●	●
Occultation	GNOS	●	●	●	●	●
MV Active	WindRAD		●			
	Rainradar					●
Hyper-spectral detector	HIRAS	●	●	●	●	
	GAS	●			●	
	OMS			●		
Radiation measurement	ERM			●		
	Solar Radiation Monitor		● Two in one	●		
	Solar Irradiance spectrometer					
Space weather suite (SWS)	SEM	●	●			
	WAI	●			●	
	IPM	●	● MAIPM		●	
	XEUVI		●			

Payloads / instruments

● ***MERSI-2 (Medium Resolution Spectral Imager-2)*****,** to fly on FY-3D/F/G, it's the advanced model of medium resolution spectral imager, with 25 channels (the old model has 20 channels). The VIRR channels are merged.

● ***FMERSI (Faint-light Medium Resolution Spectral Imager)***, to fly on the early-morning satellite observing faint objects.

● ***MWTS-2 (Micro-Wave Temperature Sounder-2)***, flying on FY-3C/D/E, 13-channel MW radiometer for nearly-all-weather temperature sounding, 54 GHz band, resolution 70 km, cross-track scanning, swath 2200 km.
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● ***MWTS-3 (Micro-Wave Temperature Sounder-3),*** flying on FY-3F/G, improved model of microwave temperature sounder, with 23.8GHz and 31.4 GHz included.

● ***MWHS-2 (Micro-Wave Humidity Sounder-2)***, flying on FY-C/D/E/F/G, 15 channel MW radiometer for nearly-all-weather humidity sounding. 183GHz band, resolution 15 km, cross-track scanning, swath 2700 km.

● ***WindRAD (Wind Radar)***, to fly on FY-3E for global ocean surface wind field (OSWF); measure the radar backscattering of sea surface from different azimuth and then retrieve wind vector with the geophysical model function (GMF). Two bands: C-band (5.3GHz, polarization: HH, VV, resolution: 25 km (azimuth direction) and ≤10 km (range direction); and Ku-band (13.256GHz; polarization: HH, VV; resolution: ～ 10 km (azimuth direction) and ≤5 km (range direction)); swath: > 1200 km; rotation rate: 0.4207 rad/s.

● ***HIRAS (Hyperspectral Infrared Atmospheric Sounder)***, to fly on FY-3D/E/F/G, similar to IASI flying on Metop satellite for improved measurement of temperature and humidity. Spectral range: 650-1138cm^{-1}, (LWIR, spectral resolution: 0.625cm^{-1}), 1210-1750cm^{-1}(MWIR, spectral resolution: 1.25cm^{-1}), 2155-2500cm^{-1}(SWIR, spectral resolution: 2.5cm^{-1}); spatial resolution: 16 km at arranged in 2x2 array. Scan angle: ± 50.4^{o} around nadir.

● ***GAS (Greenhouse Gases Absorption Spectrometer),*** to fly on FY-3D/G for global measurement of CO_2 and CH_4.

● ***OMS (Ozone Mapping Spectrometer)***, to fly on FY-3F; an Envisat /SCIAMACHY-like instrument for the detection of ozone and other atmospheric chemicals. It replaces the suite of TOU and SBUS on early FY-3s. The total column content and the profile of trace gases can be retrieved from the nadir view and limb view separately. Nadir direction - spectral range 300～500nm: for O_3 and trace gases total column, spatial resolution 15x25 km; spectral range: 250～310nm: for O_3 profile, spectral resolution 34x60 km; Limb direction – spectral range: 290～500nm for O_3 and trace gases, resolution 3 km.

● ***GNOS (GNSS Occultation Sounder)***, to fly on FY-3C/D/E/F/G; receiving signal from GPS and China BeiDou; observing over 1000 occultation events per day with GPS and BeiDou satellites.

● ***WAI (Wide-angle Aurora Imager)***, flying on FY-3D/G, imaging the ionospheric phenomenon of aurora in solar wind.

● ***IPM (Ionospheric PhotoMeter),*** flying on FY-3D/G, for measurement of the illuminous intensity at the ionosphere.

● ***MAIPM (Multi-angle Ionospheric PhotoMeter),*** flying on FY-3E, for OI136.5nm and N_2LHB band airglow intensities near the solar terminator line.

● ***XEUVI (Solar X-EUV Imager)*****,** to fly on FY-3E, imaging the phenomenon of solar activities at x-ray and extreme ultraviolet.

3.2.2 Implementation of CGMS best practice for LEO direct broadcast

The status of implementation of CGMS Best Practice in support to local and regional processing of future FY-3 satellites direct broadcast is given by the Annex to this report.

4 CONCLUTION

Tremendous efforts have been made for the establishment and improvement of FENG YUN GEO and LEO systems. The Feng Yun Program is long term, application-oriented, continuously being developed for the benefit of user community in pursuit of quality Earth Observation data and products for weather, climate, and environment services.

Annex: CMA Implementation of CGMS Best Practices for LEO Direct Broadcast Data
(as of May 15, 2019)

BP. 01 Global Specification for Direct Broadcast	
FY-3D	The FY-3D Direct Broadcast is compliant with the CGMS Global Specification for Direct Broadcast.
FY-3E	The FY-3E Direct Broadcast will be compliant with the CGMS Global Specification for Direct Broadcast.
BP. 02 Timely provision of Space-to-Ground Interface Control documents	
FY-3D	NSMC/CMA maintains a website to provide the space-to-ground interface control documents. The document now has been publicly released at the http://www.nsmc.org.cn/en/NSMC/Home/index.html.
FY-3E	Space-to-Ground Interface details are not publicly released yet. The link will be included in this table as soon as the document is publicly available.
BP. 03 Provision of Current Orbit Information	
FY-3D	The TLE for FY-3D will be provided on the website http://satellite.nsmc.org.cn/portalsite/Satellite/Satelliteinfo.aspx?satellitetype=0&usedtype=orb&satecode=FY3D&currentculture=en-US
FY-3E	The TLE for FY-3E is not ready yet. It will be provided on the website http://www.nsmc.org.cn/en/NSMC/Home/index.html as soon as the file is ready.
BP. 04 Provision and maintenance of Product Processing software packages	
FY-3D	The Direct Broadcasting Software Package for FY-3D has been provided through the website http://www.nsmc.org.cn/en/NSMC/Home/index.html. The SW has provided the L0 to L1 pre-processing for MERSI-Ⅱ, MWTS-Ⅱ, MWHS-Ⅱ, MWRI, and HIRAS. The DB users can access the software by the registered account and password.
FY-3E	The SW for FY-3E is under consideration.
BP. 05 Provision of auxiliary data for instrument product processing	
FY-3D	Auxiliary data are available on http://www.nsmc.org.cn/en/NSMC/Home/index.html.
FY-3E	Scope and provision of auxiliary data for instrument product processing under
BP. 06 Recommendations of channel selection for hyperspectral instruments	

FY-3D	All the FY-3D/HIRAS geo-located and calibrated radiances are processed and to be delivered to users yet without recommendations for channel selection.
FY-3E	The provision for the channel selection for the hyperspectral instruments is under consideration.
BP. 07 Spacecraft and Instrument Operational Status	
FY-3D	The NSMC/CMA has maintained a website to provide the basic operational status for the spacecraft and instrument.The website is http://www.nsmc.org.cn/en/NSMC/Home/index.html. More detailed information is under consideration.
FY-3E	It will be provided after the satellite is launching.
BP. 08 Operational Announcements	
FY-3D	FY-3 satellites make operational announcements on website http://www.nsmc.org.cn/en/NSMC/Home/index.html
FY-3E	It will be provided after the satellite is launching.
BP. 09 Satellite Direct Broadcast and Reception Station Performance Requirements	
FY-3D	Provided in the FY-3D space-to-ground interface document.
FY-3E	Will be provided in the FY-3E space-to-ground interface document.