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Status of CMA Polar-orbiting Meteorological Satellites

Summary of the Working Paper.

The CMA reported on the status of Chinese polar orbiting meteorological satellite program. The FY-1 is the Chinese first polar-orbiting meteorological satellite series that started by the launch of FY-1A on 7 September 1988. The FY-1 program totally produced four satellites, namely the FY-1A/B/C/D. The FY-1 series is a 3-axis stabilized spacecraft programme, carrying the multi-channel Visible and Infrared Scanning Radiometer (VIRR) for the earth environment monitoring at sub-point the resolution is 1.1km; and Space Environment Monitor (SEM) for in situ observation of charged particles in solar wind. Direct Readout Service is available through HRPT transmission. As of 4 October 2009, the FY-1D is operationally active.

The FY-3 is a new series to substitute the FY-1. The first FY-3 satellite FY-3A was launched on 27 May 2008. The satellite is 3-axis stabilized. To keep the continuity of AVHRR observation, the FY-3A carries the multi-channel Visible and Infrared Scanning Radiometer that flies on FY-1. In addition to that, the FY-3A carries the Medium Resolution Spectral Imager (MERIS), the Microwave Radiation Imager(MWRI), the Infrared Atmospheric Sounder(IRAS), the Microwave Temperature Sounder (MWTS), Microwave Humidity Sounder(MWHS), Total Ozone Unit and Solar Backscatter Ultraviolet Sounder(TOU/SBUS), as well as an Earth Radiation Budget instrument. FY-3 transmits data in three modes: L-band AHRPT, X-band MPT, and DPT. Direct Readout Service of AHRPT is globally provided.

According to the schedule of FY-3 program, FY-3B satellite shall be launched in 2010. The satellite is designed for lifetime of 3 years, LST is 14:00pm. FY-3B satellite is being built in Shanghai Institute of Spaceflight Technology.

Status of CMA Polar Orbiting Meteorological Satellites

(As of 4 October 2009)

1. Report on the Status of FY-1 Satellite Program

1.1 Introduction

The FY-1 polar-orbiting meteorological satellite program started in 1988. The first FY-1 satellite FY-1A was launched on 7 September 1988. The program has produced four satellites, namely the FY-1A/B/C/D. FY-1 satellites are 3-axis stabilized flying in circular orbits inclined at approximately 98 degrees. The instruments carried include the multi-channel Visible and Infrared Scanning Radiometer (VIRR) with sub-point resolution 1.1km good for the earth environment monitoring, and the Space Environment Monitor (SEM) for in situ observation of charged particles in solar wind. Direct Readout Service is available on FY-1 series satellites through AHRPT transmission.

Table .1 – Chronology of the FY-1 programme *(in bolt the satellites active in Oct. 2009)*

Satellite	Launch	End of service	Height	LST	Status (Sept 2009)	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 April 2004	862 km	6.45	Inactive	VIRR, SEM
FY-1D	**15 May 2002**	**expected ≥ 2008**	**866 km**	**6.50**	**Operational**	**VIRR, SEM**

FY-1A was launched on 7 September 1988. It is the first meteorological satellite ever made by China due for the test of FY-1 program. 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 the launch when the satellite attitude became uncontrollable.

FY-1B was launched on 2 September 1990. It is a copy of the FY-1A. A series tests was made with FY-1B including the tests to improve the FY-1 ground component. The satellite is abandoned on August 1991 due to attitude failure.

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

FY-1D, whose capability is identical with the FY-1C, was launched on 15 May 2002. It is the last satellite by the FY-1 Program. As of 20 September 2009 the satellite is operationally active.

1.2 FY-1 Satellite Data Transmission

High Resolution Picture Transmission(HRPT): direct read-out for the whole information at full resolution in digital form at S-band frequencies. Main features:

- frequencies: 1700.4MHz; bandwidth: 5MHz; polarization: right-hand circular
- antenna diameter~ 2m, G/T~ 6.0dB/K, data rate ~ 1.33 Kbps

Delayed Picture Transmission(DPT): MVISR imagery is stored on board and transmitted to ground station in S-band. Main features:

- frequency 1708.5MHz; bandwidth: 3 MHz; data rate~ 1.33Mbps.

- DPT is capable of two forms of data format:
  - ·GDPT format: global data of 4 channels (0.58-0.68μm, 0.84-89μm,10.3-11.3μm,11.5-12.5μm) with resolution reduced to 3.3 Km;
  - ·LDPT format: limited-area data of 10 channels with 1.1Km resolution.

1.3 Current Operational FY-1 Satellite: FY-1D

1) Orbital Parameter : See Table 2.

Table. 2 – Orbit Parameters of FY-1D Satellite

Satellite	Orbit	Altitude	Inclination	Eccentricity	Descending Node LST
FY-1D	Sun-synchronous	866 Km	98.80^{o}	<0.005	6:50 am

2) FY-1D MVISR Channels and Primary Use: See Table 3.

Table. 3 – MVIRR Channels and Primary Use

Channel	Wavelength (μm)	Primary Use
1	0.58-0.68	Daytime cloud, ice and snow, vegetation
2	0.84-0.89	Daytime cloud, vegetation, water vapor
3	3.55-3.95	Heat source, night cloud
4	10.3-11.3	SST, day/night cloud
5	11.5-12.5	SST, day/night cloud
6	1.58-1.64	Soil moisture, ice/snow distinguishing
7	0.43-0.48	Ocean color
8	0.48-0.53	Ocean color
9	0.53-0.58	Ocean color
10	0.90-0.965	Water vapor

3) FY-1D VIRR Calibration Coefficients

VIRR calibration coefficients are adjusted every year with field measurements. Table 4 gives the updated calibration coefficients.

Table. 4 – FY-1D VIRR Calibration Coefficients

Channel	Slope	Intercept
1	8.930 E-02	-1.0719
2	9.980 E-02	-1.1972
6	8.310 E-02	-2.4113
7	4.230 E-02	-0.5498
8	6.310 E-02	-0.757
9	8.170 E-02	-1.0624
10	8.920 E-02	-1.2486

2. Report on Status of FY-3 Satellite Program

2.1 Introduction

The ***FY-3*** polar-orbiting series is developed to replace the FY-1 series. The FY-3 series include 7 flight models and is scheduled to cover the duration from 2008 to 2021. All satellites are 3-axis stabilised, in sun-synchronous orbit. In addition to the multi-channel Visible and Infrared Scanning Radiometer (VIRR) that flies on FY-1 satellite, FY-3 carries the Medium Resolution Spectral Imager (MERSI), the sounding instruments, Total Ozone Unit, and Microwave Radiation Imager. The following table records the chronology of the FY-3 programme.

2.2 Chronology of the FY-3 Programme

Chronology of the FY-3 programme (as of Oct. 2008)

Satellite	Launch	End of service	Height	LST	Status (Sept. 2009)	Instruments
FY-3A	27 May 2008	expected ≥ 2011	836 km	10.00	Commsioning tests	VIRR, MERSI, MWRI, IRAS, MWTS, MWHS, TOU/SBUS, SEM, ERM
FY-3B	2010	expected ≥ 2013	836 km	14.00	Being built	VIRR, MERSI, MWRI, IRAS, MWTS, MWHS, TOU/SBUS, SEM, ERM
FY-3C	2013	expected ≥ 2016	836 km	TBD	Planned	VIRR, MERSI, MWRI, IRAS, MWTS, MWHS, TOU/SBUS, SEM
FY-3D	2015	expected ≥ 2018	836 km	TBD	Planned	VIRR, MERSI, MWRI, IRAS, MWTS, MWHS, TOU/SBUS, SEM
FY-3E	2017	expected ≥ 2020	836 km	TBD	Planned	VIRR, MERSI, MWRI, IRAS, MWTS, MWHS, TOU/SBUS, SEM
FY-3F	2019	expected ≥ 2022	836 km	TBD	Planned	VIRR, MERSI, MWRI, IRAS, MWTS, MWHS, TOU/SBUS, SEM
FY-3G	2021	expected ≥ 2024	836 km	TBD	Planned	VIRR, MERSI, MWRI, IRAS, MWTS, MWHS, TOU/SBUS, SEM

2.3 Payload of FY-3

- ***VIRR (Visible and Infra Red Radiometer)***, 10-channel VIS/IR radiometer for multi-purpose imagery, resolution 1.1 km, swath 2800 km.
- ***MERSI (Medium Resolution Spectral Imager)***, 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)***, 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)***, 26-channel IR radiometer (including one VIS) for temperature/humidity sounding, resolution 17 km, swath 2250 km.
- ***MWTS (Micro-Wave Temperature Sounder)***, 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)***, 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)***, 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 Monitoring)*** for *in situ* observation of charged particles in solar wind.
- ***ERM (Earth Radiation Measurement),*** 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),*** 3-channel radiometer over 0.2-50μm waveband for the total incident solar flux; viewing the Sun near the north pole area.

2.4 Data transmission from FY-3

The data rate of the MERSI instrument requires moving to X-band, both for global data recovery and for full information real-time transmission. Global data stored on board are transmitted as:

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

Direct read-out is transmitted as:

- ***MPT (Medium-resolution Picture Transmission)***, for full information in X-band. 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.

2.5 Status of FY-3 Satellite

FY-3A was launched on 27 May 2008. The ground stations received the L-band AHRPT data, X-band MPT data, and DPT data.

2.6 Preparation for FY-3B Satellite

According to the schedule of FY-3 program, FY-3B satellite shall be launched in 2010. The satellite is designed for lifetime of 3 years, it is 3–axis stabilised, sun-synchronous, LST is 14:00pm.

FY-3B satellite is being built in Shanghai Institute of Spaceflight Technology.