

## **FY-3A METEOROLOGICAL SATELLITE (1)**

### **Mission and Instruments**

#### Summary and purpose of paper

FY-3 is a new series of polar orbiting meteorological satellites of China. There are 7 satellites starting with FY-3A and end with FY-3G to cover the period of 2006-2020. This paper describes the mission and the instruments of FY-3. Compared with FY-1 series, new instruments to be added include the Medium Resolution Spectral Imager (MERSI), the Microwave Radiation Imager (MWRI). Sounding instruments include the Infrared Atmospheric Sounder (IRAS), the Microwave Temperature Sounder (MWTS), and Microwave Humidity Sounder (MWHS). Also, there will be a Total Ozone Unit and Solar Backscatter Ultraviolet Sounder (TOU/SBUS). According to the plan, FY-3A is to be launched in 2006.

## **FY-3A METEOROLOGICAL SATELLITE (1)**

### **Mission and Instruments**

#### **1. FY-3 SATELLIE SERIES**

FY-3 is the second generation of China's polar orbiting meteorological satellite. This series includes 7 satellites operating for the period 2006-2020. The first two satellites FY-3A and FY-3B and the instruments are being manufactured.

#### **2. MISSION OF FY-3**

The mission objectives of FY-3 include:

- To provide global 3-dimensional atmospheric thermal and moisture structures, cloud and precipitation parameters, in order to support global numerical weather prediction.
- To provide global imagery for monitoring large-scale meteorological and hydrological disasters and biosphere and environment anomaly.
- To derive geophysical parameters to support research activities in study global and regional climate change.

#### **3. PAYLOADS ONBOARD FY-3**

The following primary instruments are the core meteorological payloads. Detailed specifications for these instruments are given in the Appendix of this report.

##### **3.1 The Imaging Mission Payload**

###### **1) Visible and Infrared Radiometer (VIRR)**

This is a copy of the Multi-channel Visible and Infrared Scanning Radiometer (MVISR with 10 channels) inherited from FY-1C/D satellites. For the sake of operational continuity and risk reduction, this instrument basically remains the same as MVISR of FY-1 C and D.

###### **2) Medium Resolution Spectral Imager (MERSI).**

With reference to MODIS on-board USA/EOS satellite series, this instrument on the FY-3A will have 20 channels located mainly at VIS and near IR spectral range and be complementary to VIRR's IR channels.

###### **3) Microwave Radiation Imager (MWRI)**

This is a conical scanning microwave imager at 6 frequency points with 12 channels. This sensor measures thermal microwave radiation from land and ocean surfaces, as well as being sensitive to various forms of water and moisture in the atmosphere, clouds and surfaces. For microwave band, the wavelengths are much longer on the electromagnetic spectrum compared with visible and infrared and at some channels the wavelengths can be longer than one millimeter. At these channels the radiation can penetrate clouds, and provides forecasters with an all weather measurement capability. At higher frequency channels, the scattering signatures

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the cloud and precipitation are also good indicators for detecting rainfall.

### **3.2 The Sounding Mission Payload**

#### **1) Infrared Atmospheric Sounder (IRAS)**

This is the primary sounder for FY-3A. The main characteristics are:

- Optical FOV 1.2 degrees, that makes the ground IFOV of 17 km in diameter.
- There are 26 channels in total. The first 20 channels are similar to HIRS/3 of NOAA. The rest six channels are aimed to measure aerosol, carbon dioxide content and cirrus, etc.

#### **2) Microwave Temperature Sounder (MWTS)**

This is a 4-channel passive scanning microwave sounder for improving the temperature sounding in cloud-covered area. There are four channels around 50 GHz. Table 4 shows the major specifications of MWTS.

#### **3) Microwave Humidity Sounder (MWHS)**

This is a 5-channel passive scanning microwave radiometer for improving humidity sounding in atmosphere. There are 3 channels around 183 GHz. There are 2 channels in 150 GHz. Table 5 shows the major specifications of MWHS.

#### **4) Total Ozone Unit and Solar Backscatter Ultraviolet Sounder (TOU/SBUS)**

TOU is a 6-channel spectrometer whose wavelength ranges from 308nm to 360nm, resolution 50km at the nadir. The SBUS is a 12-channel spectrograph with the wavelength locating from 252nm to 380nm. The spatial resolution of OP is around 200 km at nadir.

#### **5) Others (see the Appendix: FY-3 Instruments)**

## Appendix: FY-3 Instruments

### 1) Visible And Infrared Radiometer (VIRR)

#### Major Specifications

1. VIRR Channel Characteristics is given in Table 1.
2. Sub-point Resolution: 1.1Km
3. Earth Scan Angle:  $\pm 55.4^\circ$
4. Scan Motor: 360 RPM
5. Each Scan Line: 2048 spots
6. MTF $\geq 0.3$
7. Quantizing Level: 10 bit
8. Calibration Accuracy
  - Visible and Near IR: 7% ( $\square$ )
  - IR: 1k (270k)

Table 1: **VIRR** Channel Characteristics

Channel No.	Spectral Range ( $\square$ m)	NE $\Delta$ P $\square$ (%) NE $\Delta$ N (300k)	Dynamic Range ( $\square$ or k)
1	0.58-0.68	0.1%	0-100%
2	0.84-0.89	0.1%	0-100%
3	3.55-3.93	0.3k	180-350k
4	10.3-11.3	0.2k	180-330k
5	11.5-12.5	0.2k	180-330k
6	1.55-1.64	0.15%	0-90%
7	0.43-0.48	0.05%	0-50%
8	0.48-0.53	0.05%	0-50%
9	0.53-0.58	0.05%	0-50%
10	1.325-1.395	0.19%	0-90%

### 2) Medium Resolution Spectral Imager (MERSI)

#### Major Specifications

1. MERSI Channel Characteristics is given in Table 2.
2. Quantization Levels: 12 bit
3. Earth Scan Angle:  $\pm 55.4^\circ$
4. Each Scan Line: 2048 spots ( $\square$ 1000M), 8192 spots ( $\square$ 250M) spots
5. Pixel Registration:  $< 0.3$  pixel
6. MTF:  $\geq 0.27$  (1000M)

≥0.25 (250M)

7. Onboard VIS/IR Calibration

8. Lab Calibration Accuracy

- VIS/Near IR: 5% (□)

- IR: 1k(270k)

Table 2. **MERSI** Channel Characteristics

<b>CH No.</b>	<b>Center Wavelength (□m)</b>	<b>Band Width (□m)</b>	<b>Resolution (M)</b>	<b>NEΔP □(%) NEΔN (300k)</b>	<b>Dynamic Range (□or k)</b>
1	0.470	0.05	250	0.45	100%
2	0.550	0.05	250	0.4	100%
3	0.650	0.05	250	0.3	100%
4	0.865	0.05	250	0.45	100%
5	11.25	2.5	250	0.5	330k
6	0.412	0.02	1000	0.1	80%
7	0.443	0.02	1000	0.1	80%
8	0.490	0.02	1000	0.05	80%
9	0.520	0.02	1000	0.05	80%
10	0.565	0.02	1000	0.05	80%
11	0.650	0.02	1000	0.05	80%
12	0.685	0.02	1000	0.05	80%
13	0.765	0.02	1000	0.05	80%
14	0.865	0.02	1000	0.05	80%
15	0.905	0.02	1000	0.10	90%
16	0.940	0.02	1000	0.10	90%
17	0.980	0.02	1000	0.10	90%
18	1.030	0.02	1000	0.10	90%
19	1.640	0.05	1000	0.05	90%
20	2.130	0.05	1000	0.05	90%

**3) Microwave Radiation Imager (MWRI)**

Major Specifications: see Table 3.

Table 3. MWRI Instrument Characteristics

<b>Frequency (GHz)*</b>	10.65	18.7	23.8	36.5	89	150
<b>Polarization</b>	V.H	V.H	V.H	V.H	V.H	V.H
<b>Bandwidth (MHz)</b>	180	200	400	900	4600	3000
<b>Sensitivity (k)</b>	0.5	0.5	0.8	0.5	1.0	1.3
<b>Cal. Accuracy (k)</b>	1.0	2.0	2.0	2.0	2.0	2.0
<b>Dynamic Range (k)</b>	3□340					
<b>Spots/Line</b>	240					
<b>Quantization Levels</b>	12 bit					
<b>Beam Efficiency</b>	≥90%					
<b>Sub-point Resolution ≤(km×km)</b>	51×85	30×50	27×45	18×30	9×15	7.5×12
<b>Scan Type</b>	Conical Scan					
<b>Swath Width (Km)</b>	1400					
<b>Beam Nadir Angle (°)</b>	45±0.1					
<b>Scan Period (s)</b>	1.7±0.1					
<b>Period Error (ms)</b>	±0.1					

\* TBC

#### 4) Infrared Atmospheric Sounder (IRAS)

Major Specifications: see Table 4-1 and 4-2.

Table 4-1. **IRAS** Instrument Characteristics

<b>Characteristics</b>	<b>Value</b>
Earth Scan Angle	$\pm 49.5^\circ$
Earth Scan Steps	56
Sub point resolution	17km (836km)
Step and Dwell Time	100ms
Scan and Retrace Time	6.4s
Black Body Calibration	290K
Deep Space Calibration	3K
IR Cal. Accuracy	1K (270K)
Visible Cal. Accuracy	5% $\square$
Frequency of Radiometric Cal.	256s
Signal Quantizing Levels	13bit

Table 4-2. IRAS Spectral Characteristics

CH. No.	Central Wave Number (cm <sup>-1</sup> )	Wave Length (μm)	Half Power Bandwidth (cm <sup>-1</sup> )	Max. Scene Temperature (K)	NEΔN (mW/m <sup>2</sup> -sr-cm <sup>-1</sup> )
1	669	14.95	3	280	4.00
2	680	14.71	10	265	0.80
3	690	14.49	12	250	0.60
4	703	14.22	16	260	0.35
5	716	13.97	16	275	0.32
6	733	13.84	16	290	0.36
7	749	13.35	16	300	0.30
8	802	12.47	30	330	0.20
9	900	11.11	35	330	0.15
10	1030	9.71	25	280	0.20
11	1345	7.43	50	330	0.23
12	1365	7.33	40	285	0.30
13	1533	6.52	55	275	0.30
14	2188	4.57	23	310	0.009
15	2210	4.52	23	290	0.004
16	2235	4.47	23	280	0.006
17	2245	4.45	23	266	0.006
18	2388	4.19	25	320	0.003
19	2515	3.98	35	340	0.003
20	2660	3.76	100	340	0.002
21	14500	0.69	1000	100%A	0.10%A
22	11299	0.885	385	100%A	0.10%A
23	10638	0.94	550	100%A	0.10%A
24	10638	0.94	200	100%A	0.10%A
25	8065	1.24	650	100%A	0.10%A
26	6098	1.64	450	100%A	0.10%A



**5) Microwave Temperature Sounder (MWTS)**

Major Specifications: see Table 5-1 and 5-2.

Table 5-1 MWTS Instrument Characteristics

Characteristics	Value
Earth Scan Angle	$\pm 48.3^\circ$
Earth Scan Steps	15
Step Angle	$6.9^\circ$
Sub-point Resolution	50 $\square$ 75 KM
Calibration	Black Body and Deep Space
Scan Period	16 s
Signal Quantization Levels	13 bit

Table 5-2 MWTS Channel Characteristics

Ch No.	Center Freq. (GHz)	Main Absorber	Band Width (MHz)	NE $\square$ T (k)	Antenna Beam Efficiency (%)	Dynamic Range (K)	Cal. Accuracy (K)
1	50.30	Window	180	0.5	$\square$ 90	3-340	1.2
2	53.596 $\pm$ 0.115	O <sub>2</sub>	2 $\times$ 170	0.4	$\square$ 90	3-340	1.2
3	54.94	O <sub>2</sub>	400	0.4	$\square$ 90	3-340	1.2
4	57.290	O <sub>2</sub>	330	0.4	$\square$ 90	3-340	1.2

**6) Microwave Humidity Sounder (MWHS)**

Major Specifications: see Table 6-1 and 6-2.

Table 6-1. MWHS Instrument Characteristics

Characteristics	Value
Earth Scan Angle	$\pm 48.95^\circ$
Earth Swath Width	2200 KM
Each Scan Line	98 spots
Sub-point Resolution	15 KM
Calibration	Black body and deep space
Scan Period	8/3 s
Quantization Levels	14 bit
Cal. Accuracy	1.5K

Table 6-2. MWHS Channel Characteristics

CH No.	Center Freq. (GHz)	Main Absorber	Band Width (MHz)	NE $\square$ T (k)	Freq. Stability (MHz)	Antenna Beam Efficiency	Integration Period (ms)	Dynamic Range (K)
1	150(V)	Window	1000x2	0.9	50	$\geq 95\%$	12	3-340
2	150(H)	Window	1000x2	0.9	50	$\geq 95\%$	12	3-340
3	183.31 $\pm$ 1	H <sub>2</sub> O	500x2	1.1	30	$\geq 95\%$	18	3-340
4	183.31 $\pm$ 3	H <sub>2</sub> O	1000x2	0.9	30	$\geq 95\%$	18	3-340
5	183.31 $\pm$ 7	H <sub>2</sub> O	2000x2	0.9	30	$\geq 95\%$	18	3-340

**7) Solar Backscatter Ultraviolet Sounder (SBUS)**

## Major Specifications

1. Atmospheric Mode: see Table 7.

Solar Mode: Spectral Band 160□400nm; Step Length: 0.07nm

2. Dynamic Range:  $10^6$

3. Wavelength Stability:  $\pm 0.02\text{nm}$

4. Sub-point Resolution: 200Km

Table 7. **SBUS** Spectral Characteristics

CH No.	Center Wave Length (nm)	Bandwidth (nm)
1	252.00±0.05	1+0.2□-0
2	273.62±0.05	1+0.2□-0
3	283.10±0.05	1+0.2□-0
4	287.70±0.05	1+0.2□-0
5	292.29±0.05	1+0.2□-0
6	297.59±0.05	1+0.2□-0
7	301.97±0.05	1+0.2□-0
8	305.87±0.05	1+0.2□-0
9	312.57±0.05	1+0.2□-0
10	317.56±0.05	1+0.2□-0
11	331.26±0.05	1+0.2□-0
12	339.89±0.05	1+0.2□-0
C. C. Radiometer	379.00±1.00	3+0.3

**8) Total Ozone Unit (TOU)**

## Major Specifications

1. Spectral Range: see Table 8.

2. Dynamic Range:  $10^4$

3. Sensitivity:  $\leq 0.0014 \mu\text{w/cm}^2 \cdot \text{sr} \cdot \text{nm} (\text{S/N}=1)$
4. Each Scan Line: 31 spots
5. Scan Period: 8.16s
6. Quantizing Levels: 12 bit
7. Subpoint Resolution:  $\approx 50\text{Km}$

Table 8 TOU Spectral Characteristics

CH No.	Central Wavelength (nm)	Band Width (nm)
1	308.68 $\pm$ 0.15	1+0.3 $\square$ -0
2	312.59 $\pm$ 0.15	1+0.3 $\square$ -0
3	317.61 $\pm$ 0.15	1+0.3 $\square$ -0
4	322.40 $\pm$ 0.15	1+0.3 $\square$ -0
5	331.31 $\pm$ 0.15	1+0.3 $\square$ -0
6	360.11 $\pm$ 0.25	1+0.3 $\square$ -0

**9) Solar Irradiation Monitor (SIM)**

Major Specifications:

1. Irradiation Range: 100 $\square$ 1800W/m<sup>2</sup>
2. Spectral Range: 0.2 $\square$ 50 $\square$ m
3. Sensitivity: 0.2Wm<sup>-2</sup>
4. Cal. Accuracy: 0.5%
5. Stability (2-year):  $\square$ 0.02%
6. Quantization Levels: 16 bit

**10) Earth Radiation Measurement (ERM)**

Major Specifications: see Table 10-1, 10-2.

Table 10-1 ERM Scanning Channel Characteristics

Channel	0.2 $\square$ >3.8 $\square$ m	0.2 $\square$ 50 $\square$ m
Field of View	2 $^{\circ}$ $\times$ 2 $^{\circ}$	2 $^{\circ}$ $\times$ 2 $^{\circ}$
Scan Range	$\pm$ 50 $^{\circ}$	$\pm$ 50 $^{\circ}$
Radiation Range	0 $\square$ 370Wm <sup>-2</sup> Sr <sup>-1</sup>	0 $\square$ 500Wm <sup>-2</sup> Sr <sup>-1</sup>
Cal. Accuracy	1%	0.8%
Sensitivity	0.4Wm <sup>-2</sup> Sr <sup>-1</sup>	0.4Wm <sup>-2</sup> Sr <sup>-1</sup>
Stability (2-year)	$\square$ 1%	$\square$ 1%

Table 10-2 **ERM** Non-scanning Channel Characteristics

<b>Channel</b>	0.2°>3.8°m	0.2°50°m
<b>Field of View</b>	120°	120°
<b>Radiation Range</b>	0°370Wm <sup>-2</sup> Sr <sup>-1</sup>	0°500Wm <sup>-2</sup> Sr <sup>-1</sup>
<b>Cal. Accuracy</b>	1%	0.8%
<b>Sensitivity</b>	0.4Wm <sup>-2</sup> Sr <sup>-1</sup>	0.4Wm <sup>-2</sup> Sr <sup>-1</sup>
<b>Stability (2-year)</b>	±1%	±1%

**11) Space Environment Monitor (SEM)**

Major Specifications: see Table 11-1, 11-2.

Table 11-1 **SEM** High Energy Proton Detector

<b>Channel No.</b>	<b>Channel Designations</b>	<b>Ep Range</b>
1	P1	3.0°5.0 MeV
2	P2	5.0°10 MeV
3	P3	10°26 MeV
4	P4	26°40 MeV
5	P5	40°100 MeV
6	P6	100°300 MeV

Table 11-2 **SEM** High Energy Electron Detector

<b>Channel No.</b>	<b>Channel Designations</b>	<b>Ee Range</b>
1	E1	0.15°0.35 MeV
2	E2	0.35°0.65 MeV
3	E3	0.65°1.2 MeV
4	E4	1.2°2.0 MeV
5	E5	2.0°5.7 MeV