Current Status and Future Plan of Fengyun Meteorological Satellites

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National Satellite Meteorology Center (NSMC)
China Meteorological Administration (CMA)
Outline

• Fengyun Program Overview
• Current Status and Services
• Latest Progress
• Future Programs
1. Fengyun Program Overview

FENGYUN Satellite Family

**Polar System**
- **First Generation**
  - FY-1 A, B, C, D
- **Second Generation**
  - FY-3 A, B, C, D
  - FY-3E, F, G, H planned until 2025

**Geo. System**
- **First Generation**
  - FY-2 A, B, C, D, E, F, G, H
- **Second Generation**
  - FY-4A
  - FY-4B, C planned until 2025
Since Jan. 1969, China began to develop his own meteorological Satellite.

<table>
<thead>
<tr>
<th>Leo</th>
<th>Launch Data</th>
<th>Geo</th>
<th>Launch Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY-1C</td>
<td>May 10, 1999</td>
<td>FY-2C</td>
<td>Oct. 18, 2004</td>
</tr>
<tr>
<td>FY-1D</td>
<td>May 15, 2002</td>
<td>FY-2D</td>
<td>Dec. 8, 2006</td>
</tr>
<tr>
<td>FY-3A</td>
<td>May 27, 2008</td>
<td>FY-2E</td>
<td>Dec. 23, 2008</td>
</tr>
<tr>
<td>FY-3D</td>
<td>Nov. 15, 2017</td>
<td>FY-4A</td>
<td>Dec. 11, 2016</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FY-2H</td>
<td>Jun. 5, 2018</td>
</tr>
</tbody>
</table>

Overall Development Strategy (4 stages):
1) 1970 - 1990: Conducting satellite research and development
2) 1990 - 2000: Implementing transition from R&D to operational
3) 2000 - 2010: Implementing transition from 1st generation to 2nd generation
4) 2010 - 2020: Pursuing accuracy and precision of satellite measurements
2. Current Status and Services

6 Fengyun satellites operating in orbit
Global Data Receiving Network of Fengyun Satellites

Domestic: Beijing, Guangzhou, Urumqi, Jiamusi and Kashgar, 5 ground stations
The Antarctic Pole: TrollSat station, Norway
The Antic Pole: Kiruna station, Sweden

Global data access time is better than 2 hours.
NSMC:
One of the largest satellite data sharing centers in China.

Over 19PB data, Average daily growth 10TB data, Total data services about 5.4PB in 2019.

Global Openness, Real-time Sharing
Integrated Space and Ground Based FY Satellite Data Service System

- **Real time**
  - Direct Broadcast
  - CMACast

- **Non-Real Time**
  - Website
  - Cloud Service
  - FTP Service
  - Manual Service
## Fengyun Data and Products Service

<table>
<thead>
<tr>
<th>Services</th>
<th>Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fengyun Data Center</td>
<td>108 countries, including 75 Belt &amp; Road countries</td>
</tr>
<tr>
<td>Fengyun Direct Broadcasting Station (DB)</td>
<td>35 countries (6 FY-2 DB Station, 2 FY-3 DB Stations, 53 FY-3 Preprocessing Software packages users from 29 countries)</td>
</tr>
<tr>
<td>CMACast Stations</td>
<td>20 countries</td>
</tr>
<tr>
<td>SWAP 2.0 Website and Stand-alone</td>
<td>58 countries</td>
</tr>
<tr>
<td>Direct Data Download users</td>
<td>30 countries</td>
</tr>
<tr>
<td>FY_ESM members</td>
<td>29 countries</td>
</tr>
</tbody>
</table>
Space-based Services

- Over 2700 DVB-S users
- Over 500 Utilization Stations of Geostationary Meteorological Satellite
- Over 3000 Data User Terminals
- Over billions people viewing Satellite Cloud Images through TV and Internet
- Over 100 countries and regions

FENGYUN DB Users (29 countries)

CMACast Users (20 countries)
2020 Community Meeting on NOAA Satellites

Application Tools

SATs: New Observation Capability

Weather monitoring and analysis
--- Geostationary Satellite data (FY-2/FY-4)

Satellite Weather Application Platform
SWAP

Natural disaster and environment monitoring and analysis
--- Polar orbiting Satellite data

Users: New Applications

Satellite Monitoring Application Remote sensing Toolkit
SMART
NSMC has launched 2 mobile applications on WeChat platform in 2018, FengYun Earth View for LEO satellites and FengYun Live for GEO satellites.

FengYun Earth View WeChat Applet release the latest 7 days global true color earth image captured by the MERSI-II instrument onboard FY-3D.

FengYun Live WeChat Applet shows the time-series live cloud images taken by AGRI onboard FY-4A.
Fengyun Applications

Weather

Climate

Resource

Disaster

Environment
FY-3D monitoring flood in Venezuela

The flood of Venezuela in August of 2018 was monitored based on FY-3D data. The different colors represent the different water fraction values.

FengYun-3D/MERSI Flood Map in Venezuela
Maximal Flood Extent on Aug 28, 2018

FY-3D and FY-4A monitoring flood in Bangladesh

The flood of Bangladesh in August 2018 was monitored based on FY-3D and FY-4A data.

The spatial distribution information of flood can be obtained by using the 1 km resolution FY-4 satellite at 12:00-16:00.

FY-3D monitoring flood in Iran's southern province

There were flash floods in Iran's southern province of Fars on 25 March, following devastating floods in the north.

Flood map using FY-3D showed that in the southwestern Iran, the range of water body of the Lake Tashk and Bakhtaijan Lake has increased.

It is estimated that the impact of floods in the above areas is about 350 square kilometers, an increase of about 36%.

Super typhoon Kenneth landed on the coast of Cape Delgado Province in northern Mozambique around 2230 hours on April 25, causing floods in northern Mozambique.

The results of Sentinel-1 data fusion on April 26, 2019 and April 16, 2019 show that a number of rivers in Cape Delgado and Nampula provinces have enlarged their water bodies. The widening of the Lurio River is obvious. It is estimated that the expanded water area in the above-mentioned areas is about 185 square kilometers.
In late August 2020, a rare wildfire occurred in the western United States. According to the monitoring of FengYun-3D satellite, a large area of fire occurred along the west coast of the United States in September. The smoke diffused outward obviously, which affected the Pacific ocean, southern and northern parts of the United States. The Aerosol Optical Depth (AOD), Aerosol Index, NO$_2$, CO is high in the polluted areas.
FY-ESM: the Belt & Road Initiative

CMA Announced “Emergency Support Mechanism for International Users of Fengyun Meteorological Satellites in Disaster Prevention and Mitigation” on April 24, 2018
## Examples of Emergency support for 9 countries, 2019

<table>
<thead>
<tr>
<th>Date</th>
<th>Country</th>
<th>Disaster</th>
<th>Requestor</th>
</tr>
</thead>
<tbody>
<tr>
<td>30/01/2019</td>
<td>Brazil</td>
<td>Dam break</td>
<td>China-GEOSS</td>
</tr>
<tr>
<td>28/03/2019</td>
<td>Iran</td>
<td>Flood</td>
<td>China-GEOSS</td>
</tr>
<tr>
<td>06/04/2019</td>
<td>Korea</td>
<td>Wildfire</td>
<td>CHARTER</td>
</tr>
<tr>
<td>25/04/2019</td>
<td>Mozambique</td>
<td>Tropical Cyclone</td>
<td>FY_ESM</td>
</tr>
<tr>
<td>28/06/2019</td>
<td>Russia</td>
<td>Flood</td>
<td>CHARTER</td>
</tr>
<tr>
<td>21/08/2019</td>
<td>Bolivia</td>
<td>Wildfire</td>
<td>CHARTER</td>
</tr>
<tr>
<td>19/09/2019</td>
<td>Mozambique</td>
<td>Early waring</td>
<td>FY_ESM</td>
</tr>
<tr>
<td>10/10/2019</td>
<td>India</td>
<td>Flood</td>
<td>CHARTER</td>
</tr>
<tr>
<td>14/11/2019</td>
<td>Australia</td>
<td>Wildfire</td>
<td>CHARTER</td>
</tr>
</tbody>
</table>
2019 FENGYUN Satellite User Conference

- 15–17 November 2019, Haikou
- 37 countries, 78 representatives
3. Latest Progress

1. **FY-4A**  The first GEO. meteorological satellite of new generation
   - Launched on Dec.11, 2016
   - Official operation on May 1, 2018

2. **FY-3D**  A new operational afternoon orbit LEO. satellite, will co-work with FY-3C in morning orbit
   - Launched on Nov. 15, 2017.
   - Official operation on Jan 1, 2019
   - Contracted South polar ground station (Troll) in operation

3. **FY-2H**  The last one of FY-2 series to support IOC and serve for the belt & road countries
   - Launched on June 5, 2018
   - Official operation on Jan 1, 2019
FY-4A: Launched on 11 Dec, 2016

Spacecraft:

1. Launch Weight: approx 5300kg
2. Stabilization: Three-axis
3. Attitude accuracy: 3"
4. Bus: 1553B+Spacewire
5. Raw data transmission: X band
6. Output power: >= 3200W
7. Design life: over 7 years

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Purposes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AGRI: Advanced Geosynchronous Radiation Imager</strong></td>
<td>14-channel Earth images</td>
</tr>
<tr>
<td><strong>GIIRS: Geostationary Interferometric InfraRed Sounder</strong></td>
<td>Clear-sky atmospheric temperature and humidity profiles</td>
</tr>
<tr>
<td><strong>LMI: Lightning Mapping Imager</strong></td>
<td>Lightning distribution map in China area</td>
</tr>
<tr>
<td><strong>SEP: Space Environment Package</strong></td>
<td>Space electric and magnetic environment information</td>
</tr>
</tbody>
</table>
GIIRS:
First Geo. Interferometric Infrared Sounder
<table>
<thead>
<tr>
<th>Parameters</th>
<th>Satellite Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orbit type</td>
<td>Near-polar sun-synchronous orbit</td>
</tr>
<tr>
<td>Orbital altitude</td>
<td>836 Km</td>
</tr>
<tr>
<td>Orbital inclination</td>
<td>98.75°</td>
</tr>
<tr>
<td>Precision orbit</td>
<td>Semi-major axis deviation: $</td>
</tr>
<tr>
<td></td>
<td>Orbital inclination deviation: $</td>
</tr>
<tr>
<td></td>
<td>Orbital eccentricity $\leq 0.003$</td>
</tr>
<tr>
<td>Repeat cycle</td>
<td>5.5d (Design range is in 4-10 d)</td>
</tr>
<tr>
<td>Eccentricity</td>
<td>$\leq 0.0025$</td>
</tr>
<tr>
<td>Local time drift at ascending node</td>
<td>15 min within 4 yrs</td>
</tr>
<tr>
<td>Launch window</td>
<td>local time at ascending node: 13:40 – 14:00</td>
</tr>
<tr>
<td>Design lifetime</td>
<td>5 yrs for design, 4 yrs for assessment</td>
</tr>
</tbody>
</table>

FY-3D: Launched on 15 Nov, 2017
- Four brand new instruments added (HIRAS, GAS, WAI, IPM)
- One Successive instrument updated (MERSI-2)
- All the successive Instruments performance are improved significantly

<table>
<thead>
<tr>
<th>Payload Name</th>
<th>Channel Numbers with Spectral Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEdium Resolution Spectral Imager (MERSI-2)</td>
<td>25 (0.413 – 12 μm)</td>
</tr>
<tr>
<td>Hyperspectral InfraRed Atmospheric Sounder (HIRAS)</td>
<td>1370 (3.92 – 15.38 μm)</td>
</tr>
<tr>
<td>MicroWave Radiation Imager (MWRI)</td>
<td>10 (10.65 – 89 GHz)</td>
</tr>
<tr>
<td>MicroWave Temperature Sounder (MWTS-2)</td>
<td>13 (50.3 – 57.29 GHz)</td>
</tr>
<tr>
<td>MicroWave Humidity Sounder (MWHS-2)</td>
<td>15 (89.0 – 183.31 GHz)</td>
</tr>
<tr>
<td>GNSS Occultation Sounder (GNOS)</td>
<td>29 (--)</td>
</tr>
<tr>
<td>Greenhouse-gases Absorption Spectromter (GAS)</td>
<td>5540 (0.75 – 2.38 μm)</td>
</tr>
<tr>
<td>Wide angle Aurora Imager (WAI)</td>
<td>1 (140 – 180 nm)</td>
</tr>
<tr>
<td>Ionospheric PhotoMeter (IPM)</td>
<td>3 (130 – 180 nm)</td>
</tr>
<tr>
<td>Space Environment Monitor (SEM)</td>
<td>25 (--)</td>
</tr>
</tbody>
</table>
Global Imaging from MERSI
FY-2H: Launched on 5 Jun, 2018

FY-2H: To better support IOC and serve the Belt & Road countries

- Launched on June 5, 2018
-positioned at 79° E and operational by September, 2018
FY-2H coverage at 79° E
Latest progress on CMA satellite programs

1. FY-3B
   • Out of service from Jun. 1, 2020
   • Launched on Nov. 5, 2010

2. FY-3C
   • Some instruments on-board FY-3C were forced to suspend for the sake of the energy failure on the satellite platform.
   • Launched on Sep. 23, 2013

3. FY-3E
   • Scheduled to be launched on Jan. 2021

4. FY-4B
   • Scheduled to be launched on Apr. 2021
## FY-3E satellite instrument configuration

<table>
<thead>
<tr>
<th>Payloads Type</th>
<th>Instrument Name</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optical imager</td>
<td>MERSI-LL</td>
<td>Improved</td>
</tr>
<tr>
<td>Passive microwave sounder</td>
<td>MWTS</td>
<td>Improved</td>
</tr>
<tr>
<td></td>
<td>MWHS</td>
<td>succeed</td>
</tr>
<tr>
<td>IR Hyper-spectral Sounder</td>
<td>HIRAS-II</td>
<td>Improved</td>
</tr>
<tr>
<td>Active microwave</td>
<td>Wind RAD</td>
<td>New</td>
</tr>
<tr>
<td>Radio occultation instrument</td>
<td>GNOS</td>
<td>Improved</td>
</tr>
<tr>
<td>Solar Radiation observation package</td>
<td>SIM-II</td>
<td>Improved</td>
</tr>
<tr>
<td></td>
<td>SSIM</td>
<td>New</td>
</tr>
<tr>
<td>Space weather package</td>
<td>SEM</td>
<td>Improved</td>
</tr>
<tr>
<td></td>
<td>Ionospheric spectrometer</td>
<td>Improved</td>
</tr>
<tr>
<td></td>
<td>XEUVI</td>
<td>New</td>
</tr>
<tr>
<td>satellite</td>
<td>Scheduled launch</td>
<td>Planned Location</td>
</tr>
<tr>
<td>-----------</td>
<td>------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>FY-4B</td>
<td>Apr. 2021</td>
<td>105°E</td>
</tr>
</tbody>
</table>
4. Future Program

National Program for Fengyun Meteorological Satellite from 2011-2020

- 2013 FY-3C(Op)
- 2014 FY-2G(Op)
- 2017 FY-3D(Op)
- 2018 FY-2H(Op)
- 2012 FY-2F(Op)
- 2021 FY-3E(Op)
- FY-4C(Op)
- 2023 FY-3H(Op)
- 2022 FY-3F(Op)
- 2022 FY-RM(Op)
- 2021 FY-4B (Op)

6 satellites will be launched within this decade
## Payloads Coming FY-3 Successor

<table>
<thead>
<tr>
<th>No.</th>
<th>Sensor</th>
<th>Satellite</th>
<th>FY-3E (05) EM Satellite</th>
<th>FY-3F (06) AM Satellite</th>
<th>FY-3R (07) Rainfall Satellite</th>
<th>FY-3G (08) PM Satellite</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Scheduled Launch Date</td>
<td>2021</td>
<td>2022</td>
<td>2022</td>
<td>2023</td>
</tr>
<tr>
<td>1</td>
<td>Optical Imagers</td>
<td>MERSI</td>
<td>✓ (III-Low Light)</td>
<td>✓ (III)</td>
<td>✓ (III-Simplified)</td>
<td>✓ (III)</td>
</tr>
<tr>
<td>2</td>
<td>Passive Microwave Sensors</td>
<td>MWTS</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MWHS</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MWRI</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>3</td>
<td>Occultation Sounder</td>
<td>GNOS</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>4</td>
<td>Active Microwave Sensors</td>
<td>WindRAD</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rainfall RAD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Hyperspectral Sensors</td>
<td>HIRAS</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAS (Greenhouse Gases Absorption Spectrometer)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OMS (Ozone Mapping Spectrometer)</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>ERB Observation Sensor Suite</td>
<td>ERM</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SIM</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SSIM (Solar Spectral Irradiation Monitor)</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Space Weather Sensor Suite</td>
<td>SEM</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wide Angle Aurora Imager</td>
<td>✓ (Multi-angle)</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ionosphere photometer</td>
<td>✓ (Multi-angle)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Solar X-EUV Imager</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>
### Future additional satellite

<table>
<thead>
<tr>
<th>Future additional satellite</th>
<th>Scheduled launch</th>
<th>Planned Location</th>
<th>Instruments</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY-4C</td>
<td>2022</td>
<td>TBD</td>
<td>AGRI, GIIRS, LMI, SEP, MUSI, SUVI, SXUS</td>
</tr>
</tbody>
</table>
Vision for Future Fengyun in 2035

Missions included in 2011-2020

Missions included in 2015-2025

FY-4B
FY-4C
FY-4D
FY-4E
FY-4F
FY-4-MW1
FY-4-MW2
FY-5A(AM)
FY-5B(PM)
FY-5C(Lark)
FY-5RM(Swift)
FY-5-small1
FY-5-small2
FY-5DL(Kite)
Radiometric Benchmark Satellite(Libra)

FY-3E(EM)
FY-3F(AM)
FY-3G(RM)
FY-3H(PM)
FY-3I(EM)
FY-3I(RM)
FY-5A(AM)
FY-5C(Lark)
FY-5RM(Swift)

10/19/2020

NSMC
Lark series: EM Orbit (Optimal sounding mission, 5:30 am)

- **Mission description:** Fill in the gap of NWP sounding in Early morning orbit for composing global virtual constellation with METOP(AM) & JPSS (PM)

- **Application:** NWP

- **Major sensors:**
  - IR hyperspectral sounder
  - MW sounder
  - Scatterometer
  - GNSS radio occultation

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Fengyun 5: 3rd generation polar satellites

**AM Orbit (10:30 am)**

- **Mission description:** Imaging and cloud/aerosol measurement

- **Application:**
  - climate
  - Meteorological & environment disaster
  - Ecological environment

- **Major sensors:**
  - Lidar
  - Cloud radar
  - VIS/IR multi-angle imagery
  - MW imagery
  - Sub-mm imagery
  - UV/VIS/NIR sounder (nadir & limb)

---

PM Orbit (2:30 pm)

- **Mission description:** Imaging + sounding mission

- **Application:**
  - Meteorological & environment disaster
  - Ecological environment
  - NWP

- **Major sensors:**
  - VIS/IR imagery
  - MW imagery
  - IR hyperspectral sounder
  - MW sounder
  - GNSS radio occultation
Vision for Future Fengyun in 2035

- Consistent with WIGOS in 2040 for the space-based observing system component, an integrated observing system of Fengyun weather and climate satellites will be established by 2040, which is a backbone system with specified orbital configuration and measurement approaches, will fill in the blanks of space-based profiling of global wind as atmospheric dynamical fields, climatic variables, fill in the gaps of spatial and temporal coverage by optimizing the constellation configuration, promote space/ground co-observing capability to better meet the requirements for emergency response to meteorological disasters.

- The Radiometric Benchmark Satellite mission aiming to establish stable and traceable space calibration reference will be developed as well.

- A backbone system with open orbit configuration and flexibility to optimize the implementation will be developed, which is composed of some small/ large satellites programs for dedicated-objective mission with the capabilities of higher temporal and spatial resolution and fast sampling, global cloud, aerosol, wind etc. dedicated observation, to meet the requirements of weather forecasting, meteorological risk reduction and emergency response promotion.

- Furthermore, the operational pathfinders, technology and science demonstrators will be explored to respond to R&D needs.
5. Summary

- With the open data policy, reliable and sustained satellite, good data accuracy, **FY series** have be one important components of global observation system.

- Current **FY-3** series are expected to work until 2030 with Early Morning orbit, Morning orbit, and Afternoon orbit and Rainfall mission.

- Current **FY-4** series are expected to work until 2035 with FY-4 East (133E) and FY-4 West (79E).

- Future **FY-5** and **FY-6** are expected to provide service since 2030 and 2035 respectively.

- **Fengyun Meteorological Satellites** will contribute to WMO members and serve the **belt and road countries** operationally and continuously.