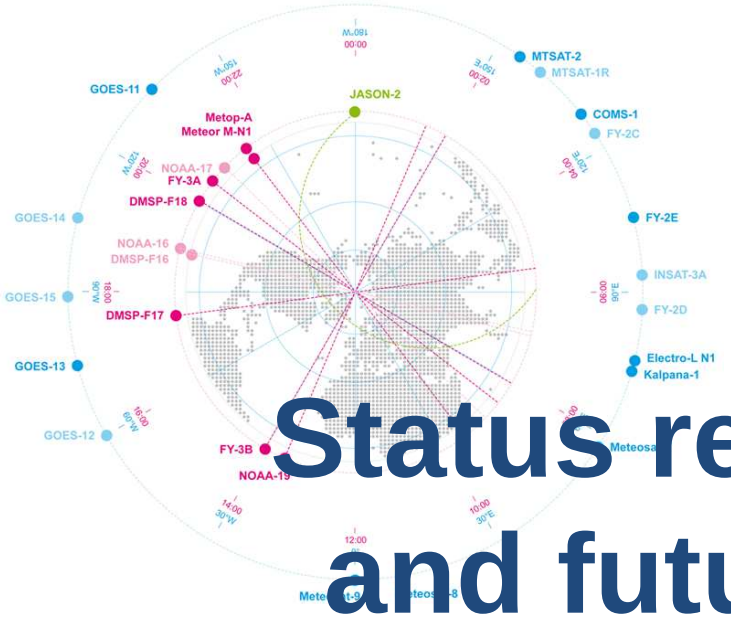

Status report on the current and future meteorological satellite systems by CMA

Presented to CGMS-44Plenary session, agenda item [D.1]

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Overview
- Planning of China satellite systems by year 2025

NSIP: National Space Infrastructure Plan

In 2015, the Chinese government has approved an extensive plan called **NSIP**, which will cover a number of earth observation satellite series including atmosphere, land, and ocean satellites in period of 2015-2025.

Atmosphere Observation （12+2 satellites in coming decade）

- Climate & Environment Monitoring Satellite series: **FY-3 LEO series （7）**
- Weather Monitoring Satellite series: **FY-4 GEO series （5）**
- Air Quality Monitoring Satellite series : **New Series (2)**

CMA satellite programs by 2025

Current Satellite Programs

- FY-2E/F/G(operational, geo.)
- FY-3A/B(R&D, polar)
- FY-3C(operational, polar)

Future Satellite Programs

- FY-2H(operational, geo.)
- FY-3D/E/F/G/H (operational, polar)
- FY-3 Rainfall 1&2
- FY-4A(R&D, geo)
- FY-4B/C/D (operational, geo.)
- FY-4 Mircowave

Others

- TANSAT(R&D，Atmosphere Composition)
- GF-4 (R&D，High Spatial Res. Imaging In GEO）

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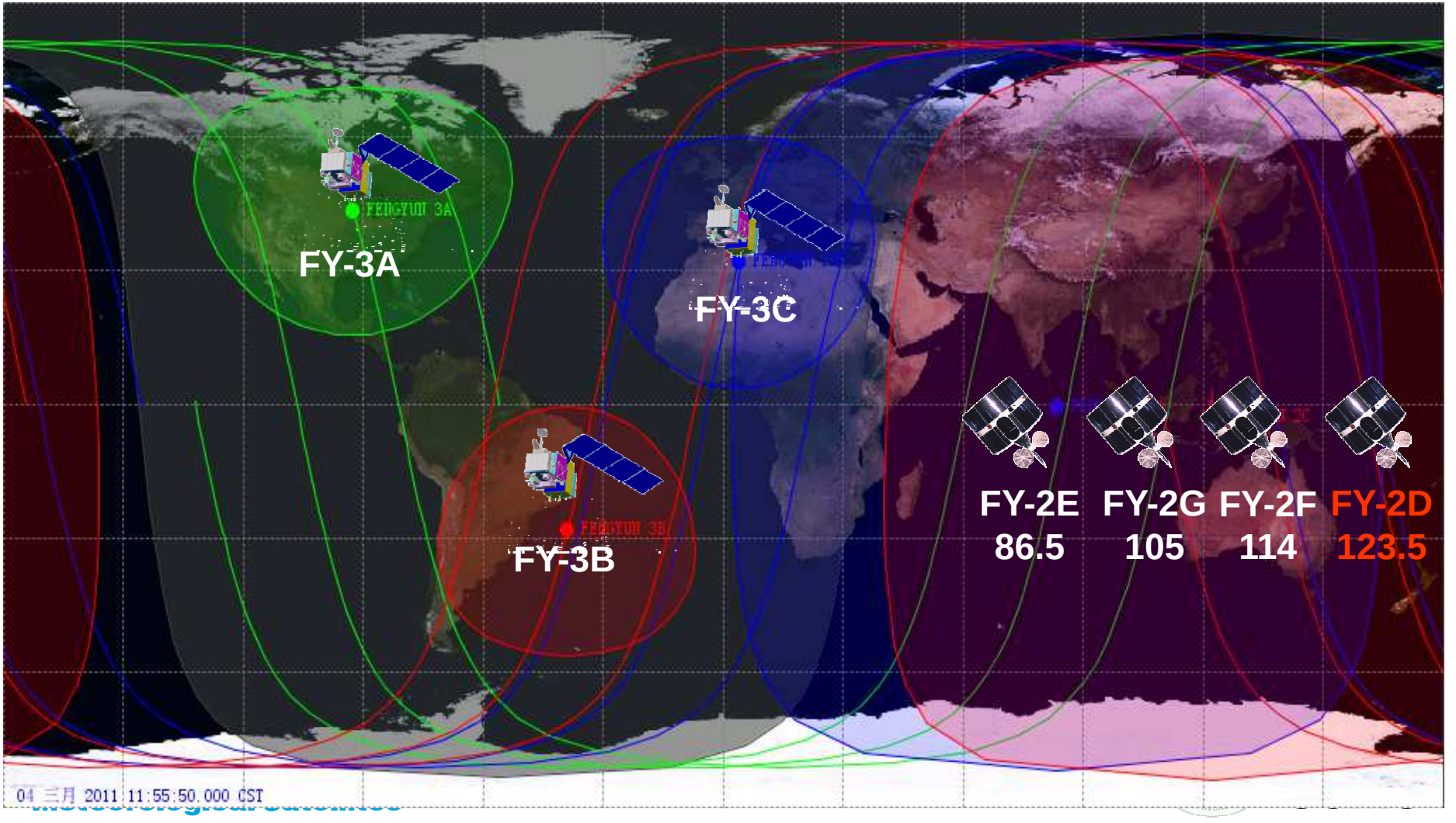
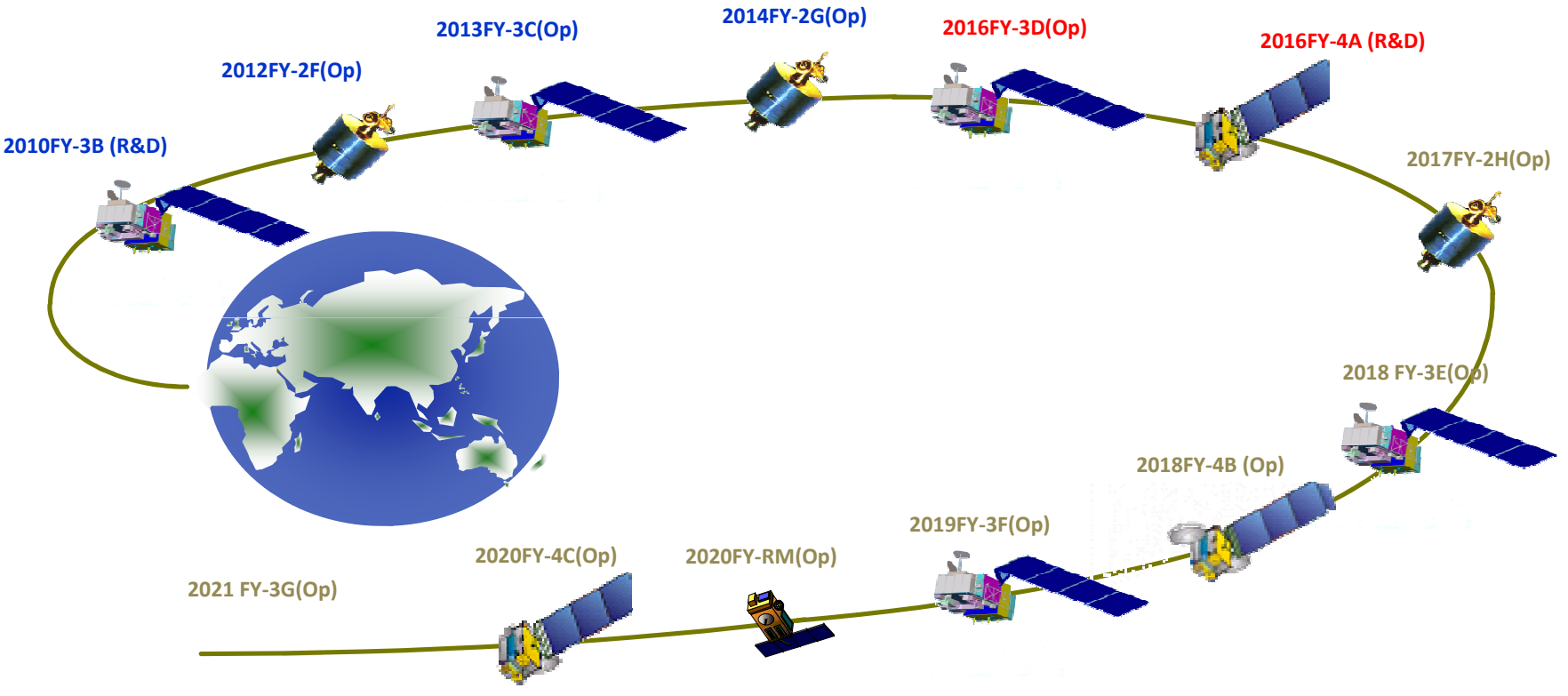
Currently In-orbit FengYun Satellites(6/7)
(6 operational, 1 retired)



Overview - Planning of CMA satellite systems



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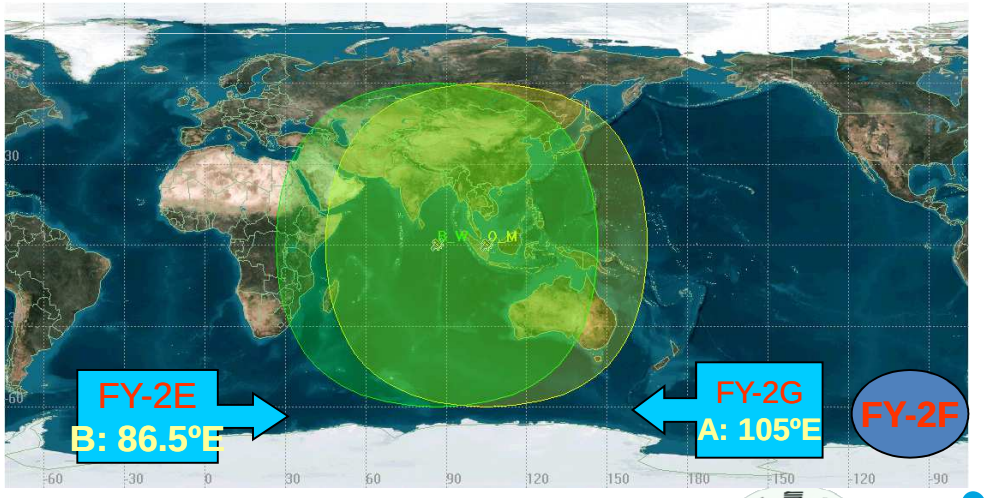
FY-2: Current CMA GEO. Constellation

No.	Position	Status	Launch
FY-2E	86.5E	Operational	Dec.23, 2008
FY-2F	112.5E	Operational	Jan. 14, 2012
FY-2G	105E	Operational	Dec.31, 2014

Platform: Spin stabilization
Payload: 5 chl. VISSR
Disc Obs: Every 30/60 min.

- ✓ FY-2G was positioned in primary position 105E Since June 1st , while FY-2E was moved to 86.5E to support IOC cooperated with EUMETSAT in July this year.
- ✓ FY-2E & FY-2G are working together to implement 15 min. interval obs., and backup each other
- ✓ FY-2F stands specially for 6 min. flexible rapid scan in case of needs



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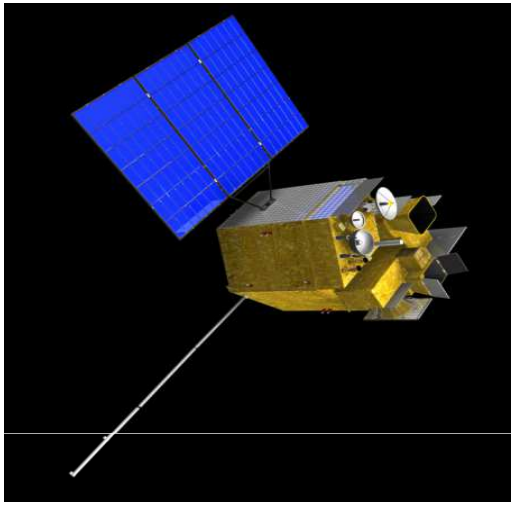
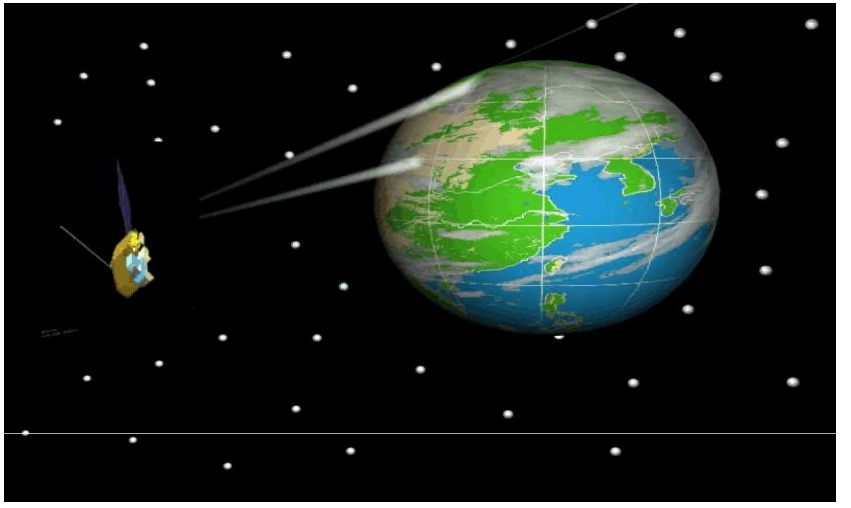
FY-4: New generation of CMA GEO. constellation





No.	Planed Launch	Designed Life	Status
FY-4A	2016	5 years	R&D
FY-4B	2018	7 years	Op.
FY-4C	2020	7 years	Op.
FY-4D	2021-2025 (TBD)	7 years	Op.
FY-4MW	2021-2025 (TBD)	7years	R&D

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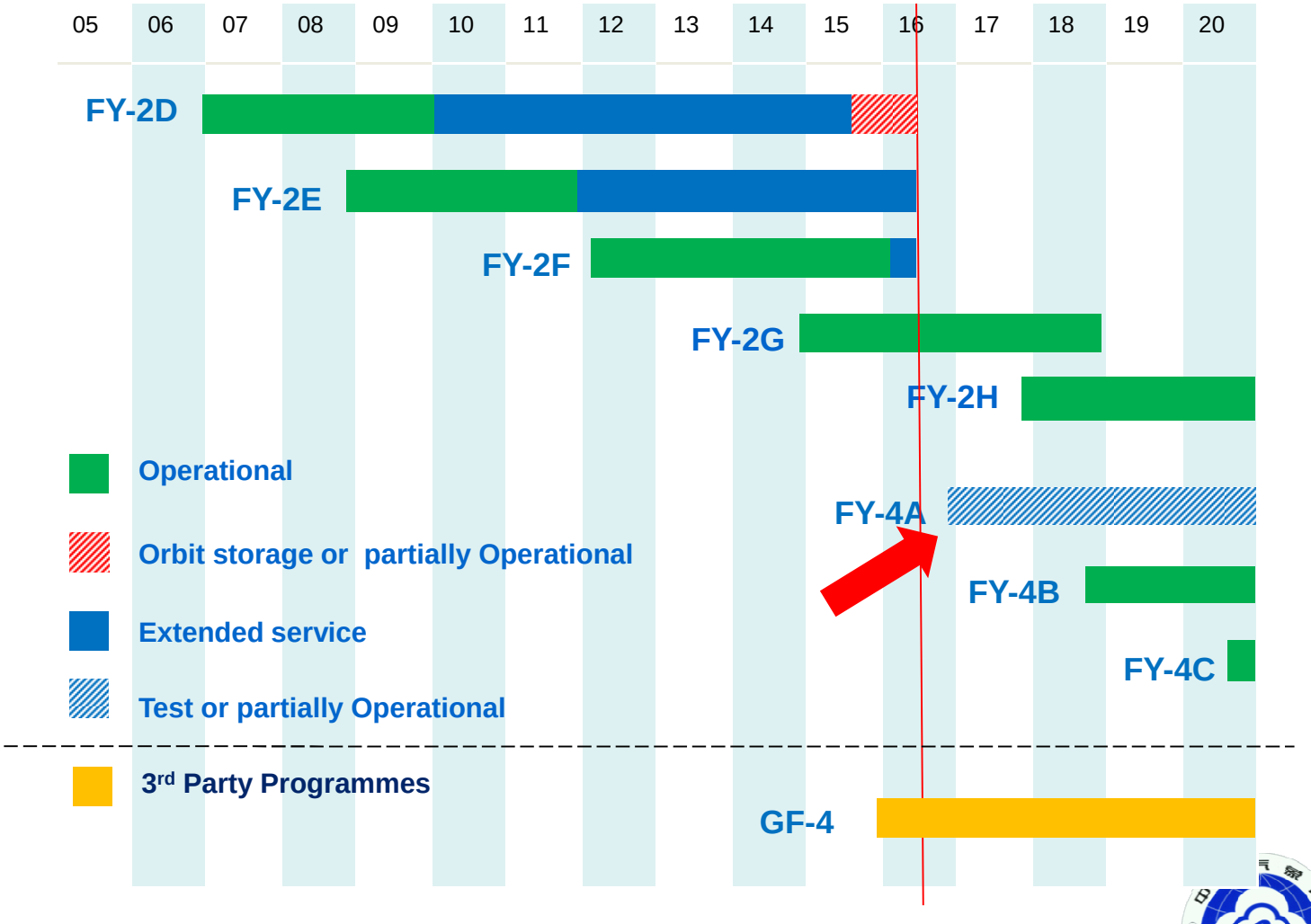
GEO SATELLITES



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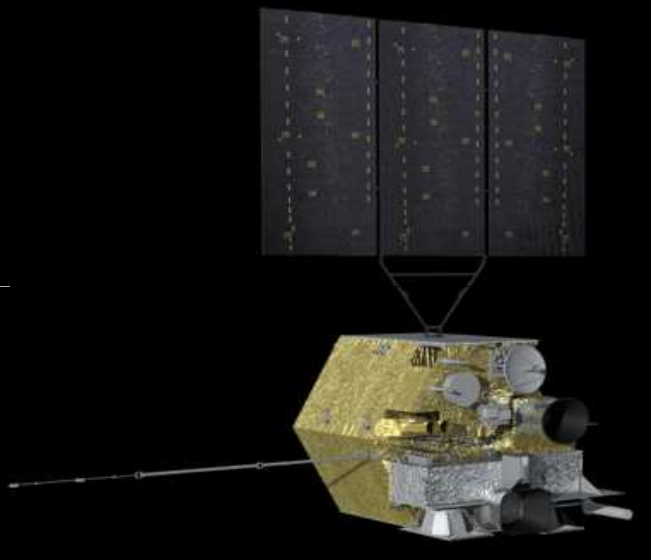
FY-4A: New Era of GEO Satellite, together with GOES-R, MTG, Himawari-8. Launch is scheduled in the end of 2016



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

GIIRS: Geo. Interferometric Infrared Sounder
AGRI: Advanced Geosynchronous Radiation Imager
LMI: Lightning Mapping Imager
SEP: Space Environment Package

Development Flow of FY-4 Ground Segment

Prephase (Mission Definition)

before 2009.12

- User Requirements Analysis
- Feasibility Analysis for payload configuration
- Key Technology of Payloads Research

Phase A (Preliminary Definition)

between 2010.1 and 2013.12

- Tradeoff study
- Navigation & calibration conceptual research
- Key Product Algorithm Design

Phase B (Detailed Definition)

2014.1 to 2014.12

- Design, integration and validation of the whole ground-segment, including data acquisition and service, mission definition and observation schedule arrangement, INR, C&V, product generation and applications
- Interface between space and ground segments optimization and confirmation

Phase C (Qualification and Production)

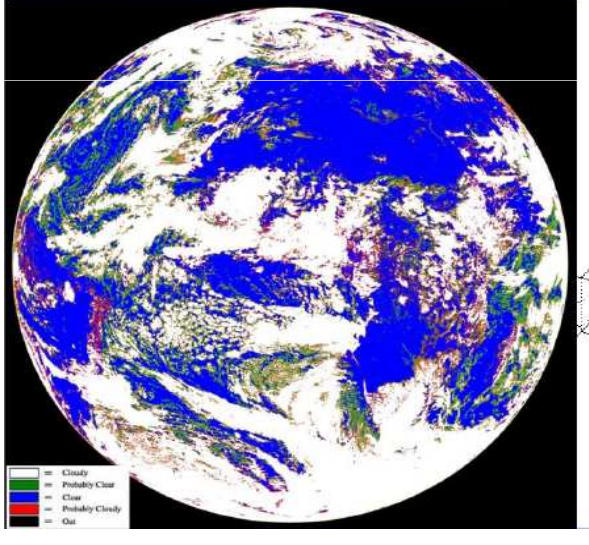
2015.1 to now

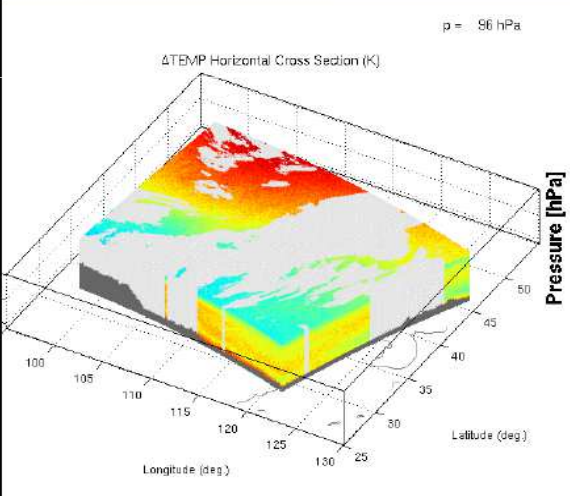
- Engineering development for the whole ground-segment

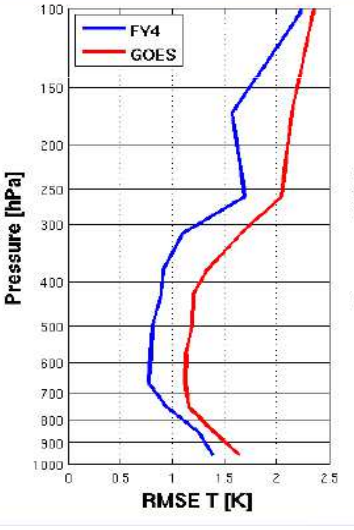
Readiness before Oct.,2016

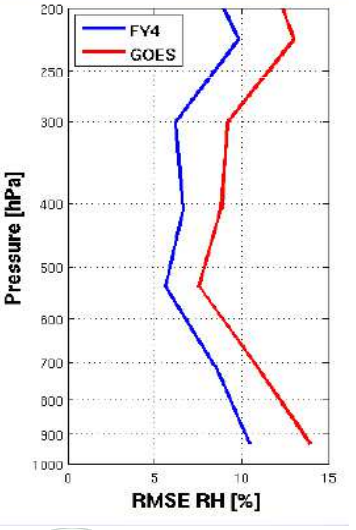
Important Milestones of Product Development

- Key Products Algorithm Design — Jan. 2010 – Dec. 2013
- Prototype Software Development & Validation — Jan. 2014 – Dec. 2014
- Algorithm Engineering & Testing — Since Jan. 2015









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GEO Launch plan 2016

- FY-4A R&D

FUTURE GEO SATELLITES

2016-2017： Solving the problems presented on FY-4A, determine the status the FY-4B/C operational satellites, Improving the 2nd generation CMA Geo. Ground system;

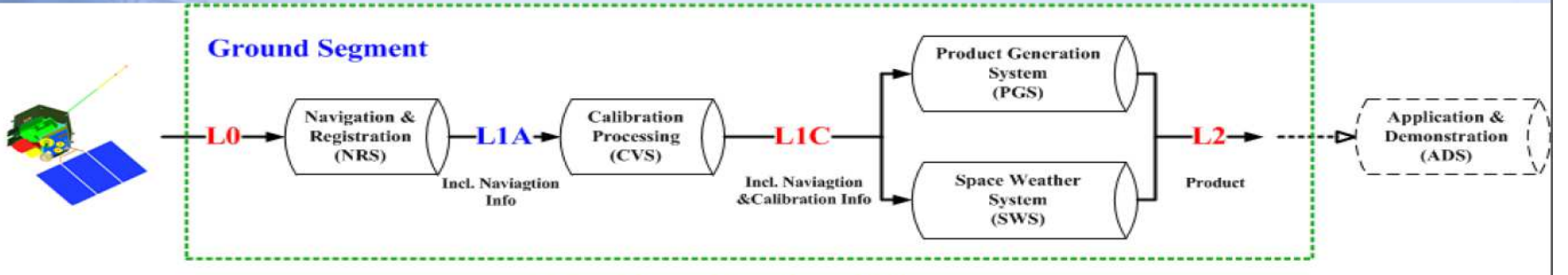
2016-2022： Develop FY-4 microwave satellite;

2019-2020： Determine the status the FY-4B/C operational satellites, Optimization of AGRI,GIIRS and LMI instrument.

Data Broadcasting & Classification

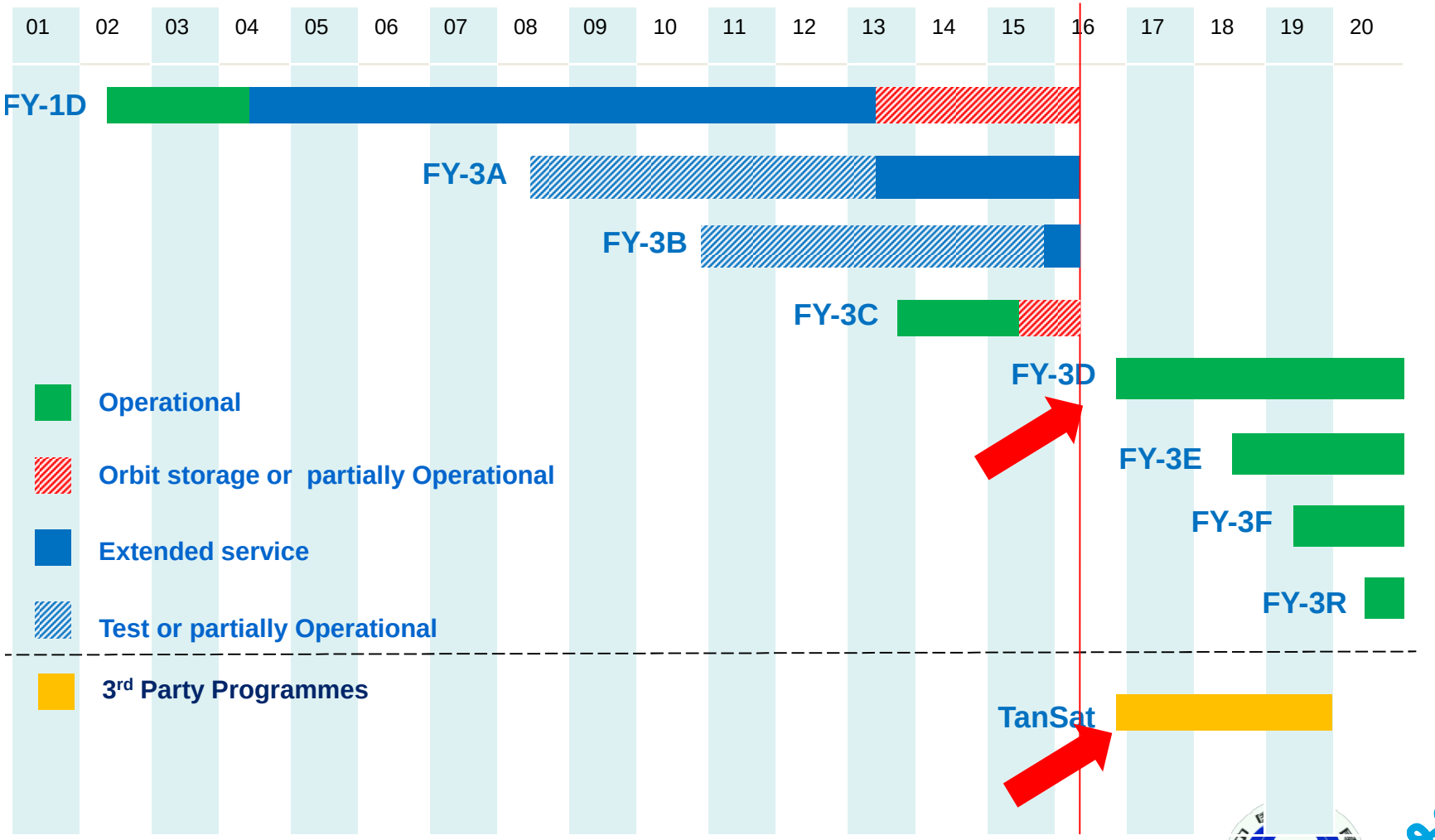
Total Data Rate: 21Mbps (GOES-R GRB: 31Mbps)

Channel	Data Rate	Broadcast Hours	Max Data Volume(GB)	Data	Frequency	Antenna
HRIT-H	11.6Mbps	24	123.05	AGRI L1	Follow Observation Mode	7.3m
HRIT-V1	9.3Mbps	16	65.86	GIIRS L1 Product LMI L2 L2 NRT Product*		7.3m
HRIT-V2	750Kbps	8	2.64	AGRI Low-Resolution Data**	24 Full Disk	2m
LRIT	150Kbps	24	1.58	AGRI Images	48 Full Disk	1.2m /1.8m
		Event		EWAIB***	Event	



Data Classification Scheme

LEO SATELLITES



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FY-3: New Generation of CMA LEO. Constellation

No.	Orbit	Status	Launch
FY-3A	AM	R&D, working	May 27, 2008
FY-3B	PM	R&D, working	Nov.5, 2010
FY-3C	AM	Op., working	Sep. 23, 2013
FY-3D	PM	Op. planed	2016
FY-3E	EM	Op, planed	2018
FY-3F	PM	op., planed	2019
FY-3 RF1/2	Inclined	R&D, Planed	2019-2025,TBD
FY-3G	TBD	Op., planed	2021-2025,TBD
FY-3H	EM	Op., planed	2021-2025,TBD

Significant Change 2014: To support global NWP, within the coordination framework of CGMS, Dr. Zheng made a commitment in WMO EC-66 in 2014 that CMA will adjust its satellite plan to develop an early morning orbit mission, **FY-3E is changed as a early morning orbit satellite rather than previous morning orbit one.**

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Assessment of the benefits of a satellite mission in an early morning orbit

Report from the WMO-CGMS Tiger Team

April 2013

1. BENEFITS OF AN EARLY MORNING MISSION FOR NWP
2. BENEFITS FOR OTHER APPLICATIONS
   - Diurnal cycle and daily operations schedule
   - Tropical cyclones and other severe events
   - Climate monitoring
   - Air quality
   - Solar observations

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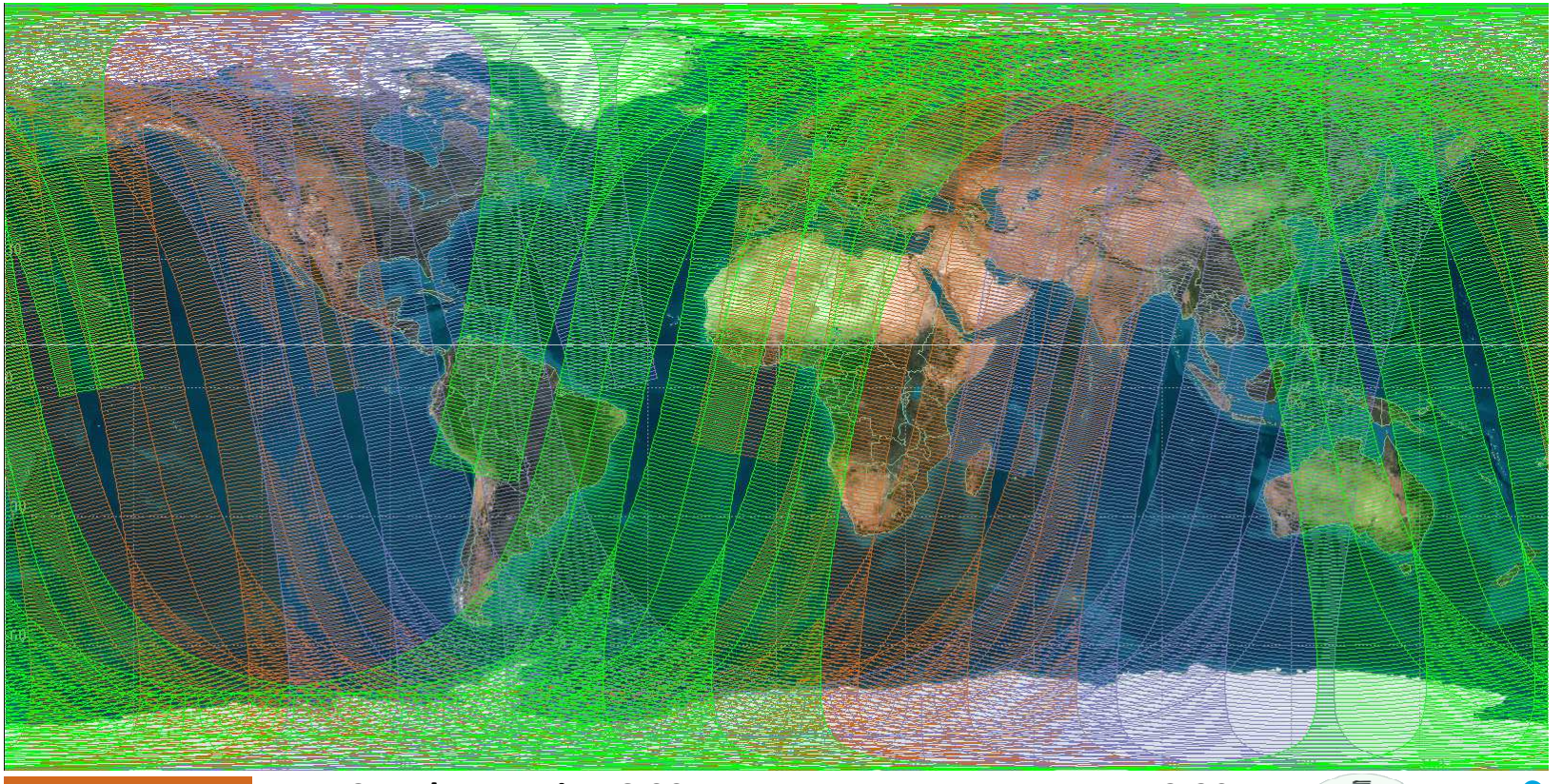
Orbit Option: FY-3 Early Morning + NPP + Metop

Recognizing that global even distribution of sounding data is of great significance for the 6 hour NWP assimilation window, one approach is to constitute a three orbital fleet including Metop（Mid. Morning） + NPP(Afternoon) +FY-3(Early Morning).



FY-3 Early Morning 6:00 AM

NPP 13:30 PM

Metop-A/B 9:30 AM

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Milestones of FY-3 Early morning mission

1. Potential User Workshop, 2013
2. Engineering Feasibility Seminar, 2012 and 2013
3. **Tiger Team Meeting ,2013**

4. **65th WMO EC: Dr. Zheng's statement on E.M, 2014**
5. FY-3E Mission Requirement approved by CMA in 2014
6. **FY-3E Mission have been approved by state council in 2015**

Instrument Configuration in FY-3C & follow-ons

FY-3 OPERATIONAL SATELLITE INSTRUMENTS	FY-3C	FY-3D	FY-3E	FY-3F
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 — Hyper spectral 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	√			

1)**Improved** : Medium Resolution Spectrum Imager (**MERSI II**) in FY-3D, 3E, 3F
Greenhouse Gases Absorption Spectrometer (**GAS**) in FY-3D,3F

2) **New:** Hyper-Spectral Infrared Sounder (**HIRAS**) in FY-3D/E/F will take replace of current **IRAS** in FY-3C

3) **New :** Sea Surface Wind Radar (WindRAD) in FY-3E

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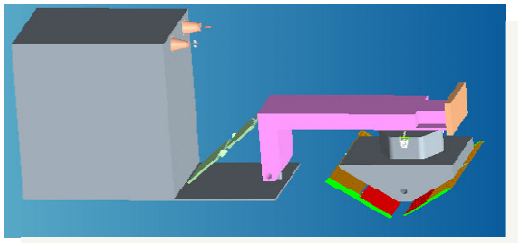
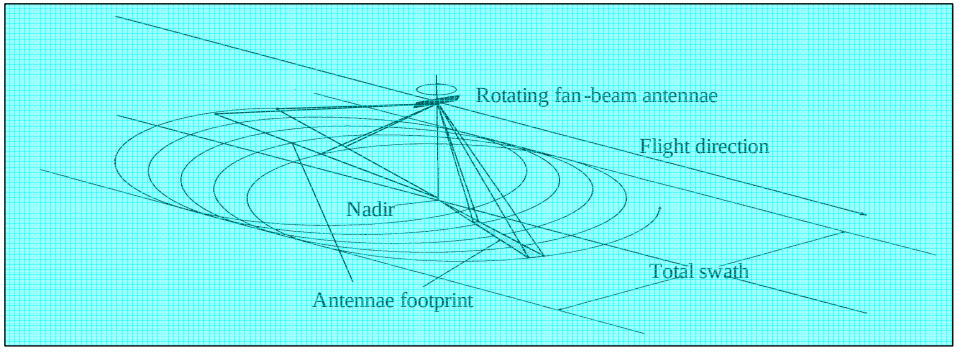
WindRAD

The Wind Radar monitors Global ocean surface wind field (OSWF) from space. The wind radar will measure the radar backscattering of sea surface from different azimuth and then retrieve wind vector with the geophysical model function (GMF). The OSWF data will significantly contribute to improve weather forecast, especially numerical model prediction of typhoon tracks and landfalls.



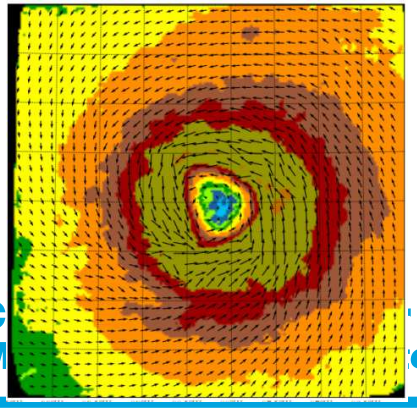
Wind Radar



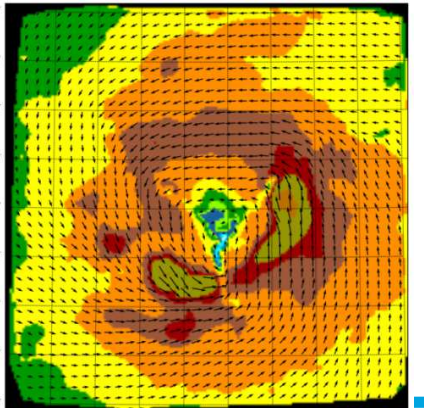
Measurement geometry of Wind Radar

The four antennae (two polarization of each frequency) of Wind Radar rotate slowly around the vertical axis of spin platform, and each pixel within the swath will be illuminated from more azimuth directions than the existing spaceborne sactterometers due to the low rotation rate .

Wave band		C	Ku
Centre frequency		5.3GHz	13.256GHz
Polarization		HH,VV	HH,VV
Spatial resolution	azimuth direction	≈25 km	≈10 km
	range direction	≤ 10 km	≤ 5 km
Swath width		> 1200 km	
Incidence angle		36° ~ 45°	37° ~ 43°
Peak Gain		31 dBi	37.5 dBi
Transmitted power		124 W	141 W
Rotation rate		0.4 ~ 0.7 rad/s	
Radiometric accuracy		1dB（≤ 5m/s）; 0.5dB（others）	
Wind speed range		3 ~ 50 m/s	
Wind speed accuracy		1.5 m/s（≤ 20m/s）; 10%（others）	
Wind speed range		0 ~ 360°	
Wind direction accuracy		< 20°	



Wind Radar



SeaWinds

Expected performance of the Wind Radar

- Better spatial resolution than the current spaceborne scatterometers;
- High wind retrieval capability ;
- Nearly all-weather capability .

GNOS

GNOS will receive two types of signal from GPS and China BeiDou. GNOS will observe over 1000 occultations per day with GPS and BD satellites,

Expected Products

- Temperature profiles
- Humidity profiles
- Refractivity profiles
- Electronic content profiles

Frequency	GPS L1/L2/L5; BD1/BD2
Receiver Channels	8 (Navigation) 8 (Occultation)
Sampling rate	1 ~ 50 Hz
Crystal oscillator	1e-11 (100s)
Real-time position	10m（RMS）
Real-time velocity	0.1m/s(RMS)
Phase center accuracy	2 mm (RMS)

		Temperature	**Humidity**	**Refractivity**	**Electronic Content**
RMS Accuracy	Low Tropos.	0.5-3 k	0.25-1.0 g/kg	0.1-0.5%	(100-600 km) < 20%
	High Tropos.	0.5-3 k	0.05-0.2 g/kg	0.1-0.2%	
	Low Stratos.	0.5-3 k	--------	0.1-0.2%	
	High Stratos.	0.5-5 k	--------	0.2-2.0%	


GNOS instrument


GNOS observation

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Satellite application facilities in China

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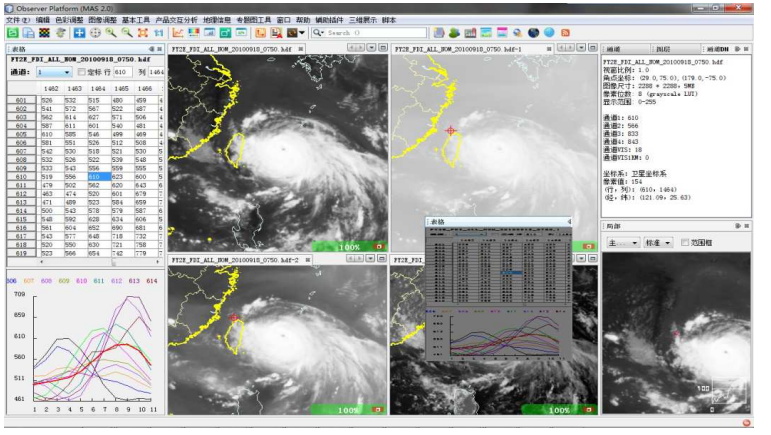
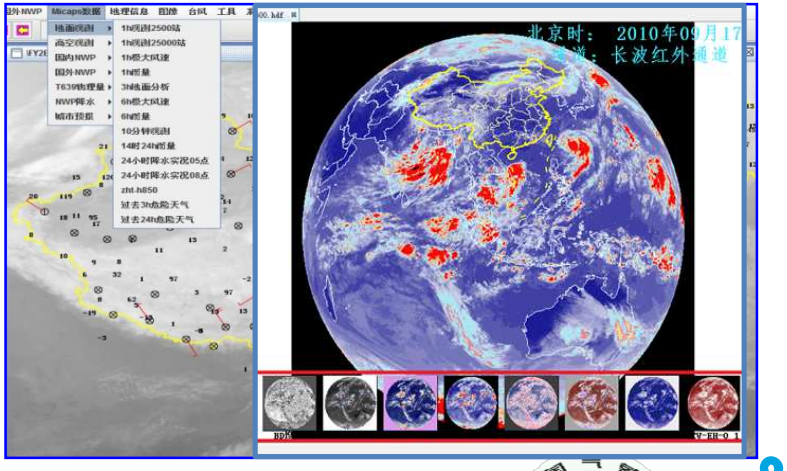
Data access supports for end users

1. HRPT：34 stations at provincial level receiving FY-3 HRPT data in real time
2. HRIT：34 stations at provincial level receiving FY-4 DB data in real time
3. CMACast：2600 user terminals at prefectural level receiving FY-3&FY-4 data and products
4. EWAIB：2400 user terminals at county-level receiving emergency weather information from FY-4
5. Web-based & Cloud-based Services

User preparedness for new generation satellites

- ADS: More than 50 FY-3&FY-4 application projects were open to encourage user community involvement
- SWAP & SMART : user platforms developed as analysis tools for use of FY-3&FY-4 data and products
- The two systems have been promoted to nation-wide local weather services.
- A number of training activities were organized by CMA





Thanks for your attention