GeoMetWatch-STORM: Towards Building an Optimal Scale Coupled Next-Generation Geostationary Ultra-spectral Observation System for Improving Regional Weather and Environmental Forecast

- *Presented by: David J. Crain, GeoMetWatch*
- *ITSC-18, Meteo France, Toulouse, March 21, 2012*
- *435-757-6257*

ITSC Acknowledgement

- GeoMetWatch is a true child of the ITSC
- The leadership, fellowship and support of ITSC attendees over the last few years have provided much direction for the GeoMetWatch enterprise.
- GeoMetWatch's primary mission is to implement the Advanced Sounding requirements for Geo recommended by ITSC since 2006.

From ITSC-15

"*Recommendation AS-1 to the space agencies. It is recognized that high spectral resolution imaging radiometers on geostationary platforms would be an important part of the future global observing system. It is recommended that a demonstration mission be conducted in the near future. GIFTS is the best current option for such a mission.*"

And similar recommendations since.

Why a Commercial Advanced Sounder?

- All operational weather programs are at risk due to “structurally unsustainable” procurements. *GAO, 2011*
- Cancelation of HES was stimulus for GMW.
- A commercial approach is much lower cost and properly incentivizes industry to deliver a successful mission.
- There will always remain a government role, especially in new sensor development, ground processing and archiving of data.

Overview

- GeoMetWatch received a US Department of Commerce, Commercial Remote Sensing license to operate 6 GeoStationary Hyperspectral Imaging Sounders in September of 2010.
- Consistent with the principle tenants for the 2010 US Space Policy
- Provides a low cost, low risk option to meet advanced sounding requirements from Geostationary orbit for US Government and other international agencies.
- Development, Implementation, Launch and Operational costs born by private industry.
- Proven business model (i.e. GeoEye and Digital Globe)
- Minimal risk to government, no data, no pay.
- Data costs are a fraction of conventional procurement.
- Small budget needed to prepare for data ingest and utilization (~$25M total from 2012-2015) for 2015 operational turn-on.
- Data available years before other comparable options and at much lower cost.

Mar. 2012 Update

- Initial Investment Round complete, Investment Bank engaged Dec. 2011 to raise implementation funds, anticipated complete by May-August 2012.
- Hosting agreement for Asia secured (100-120E), US slots under negotiation (~60W, ~120W, ~180). Bus Partner Signed.
- SDL and SSEC contract starts by September 2012
- Data Products and Ground Development Proceeding forward with prototype hardware and software available by end of 2013. Ability to process and ingest all current weather satellite products + GMW data. Proprietary Hardware produces all products in near-real time.
  - Infrastructure Development (paid by GMW) for Ground Processing underway
  - Customer will procure end-user software and equipment
- Schedule Opportunity
  - 110E is prime for 2016 Launch
  - 12 month window for 2015 Launch
    - Bus Start by March 2013

Need a Great Team

- SDL – STORM Sensor
- SSEC – GMW data products and end user software
- Thales Alenia Space – Bus Partner leveraging MTG experience
- JSAT – Operator partner for 110E orbit and beyond.

Need a Great Team

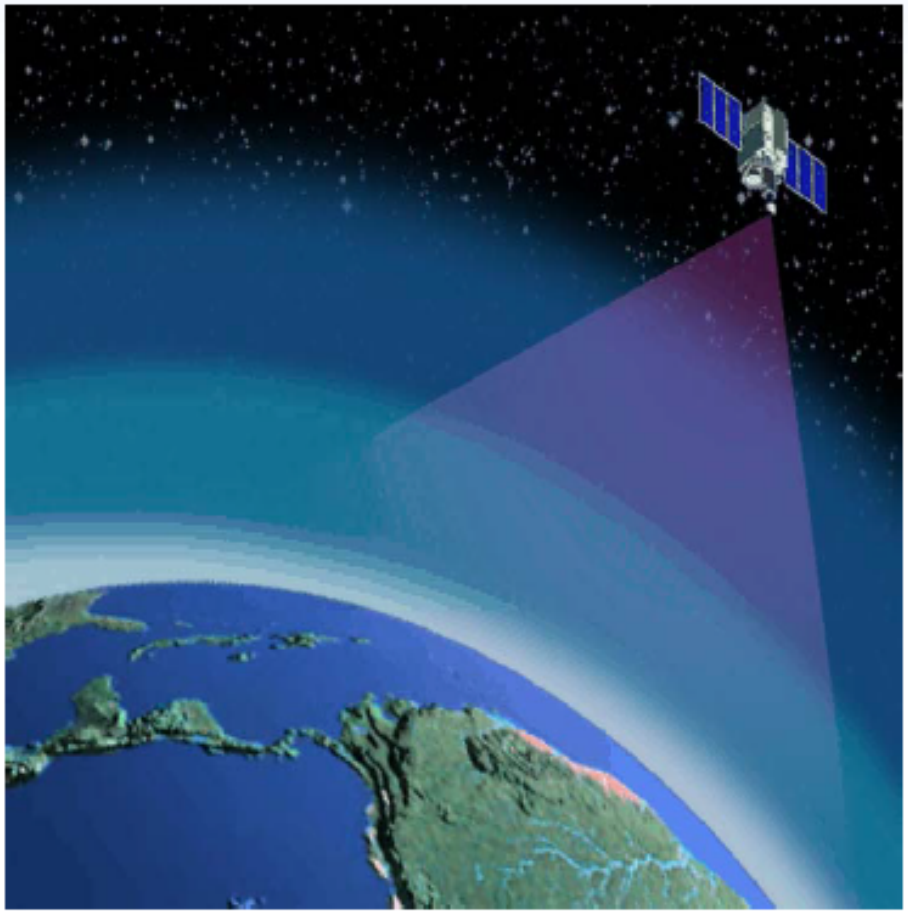
- SDL – STORM Sensor
- SSEC – GMW data products and end user software
- Thales Alenia Space – Bus Partner leveraging MTG experience
- JSAT – Operator partner for 110E orbit and beyond.

STORM

GIFTS OVERVIEW

A review of the GIFTS program: design, capabilities, status

GIFTS Characteristics

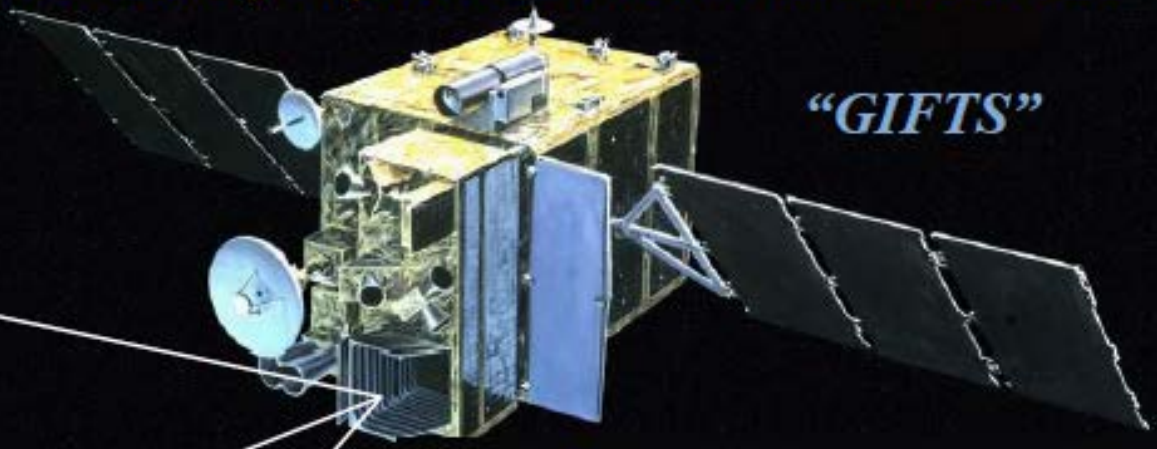


- Two 128x 128 infrared focal plane detector arrays with 4 km footprint size
- A 512 x 512 visible focal plane detector array with 1 km footprint size
- Array field of view footprint is 512 km x 512 km at satellite sub-point
- 11 second FTS scan time per field of view for full spectral resolution
- ~ 80,000 atmospheric soundings every minute

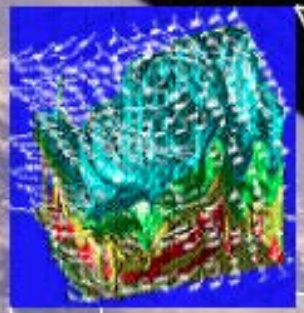
Geosynchronous Imaging Fourier Transform Spectrometer

Revolutionary Technology for Observing Atmospheric Temperature, Moisture, Winds, and the Transport of Pollutant Gases

An Opportunity for Greatly Improved Environmental Forecasts



"GIFTS"



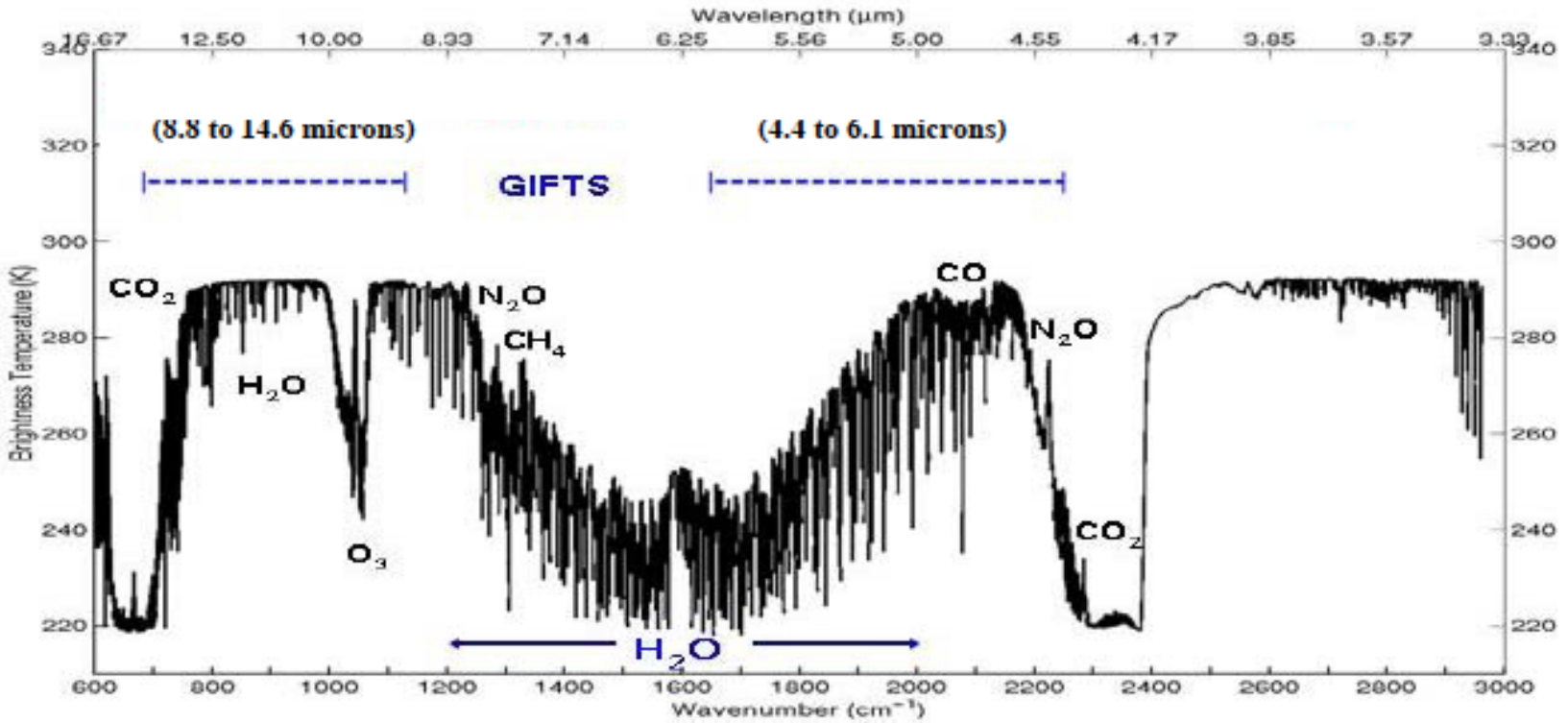
4-d Digital Movie Camera:

2-d Horizontal: Large area format focal plane detector arrays

Vertical: Fourier transform spectrometer

Time: Geostationary satellite

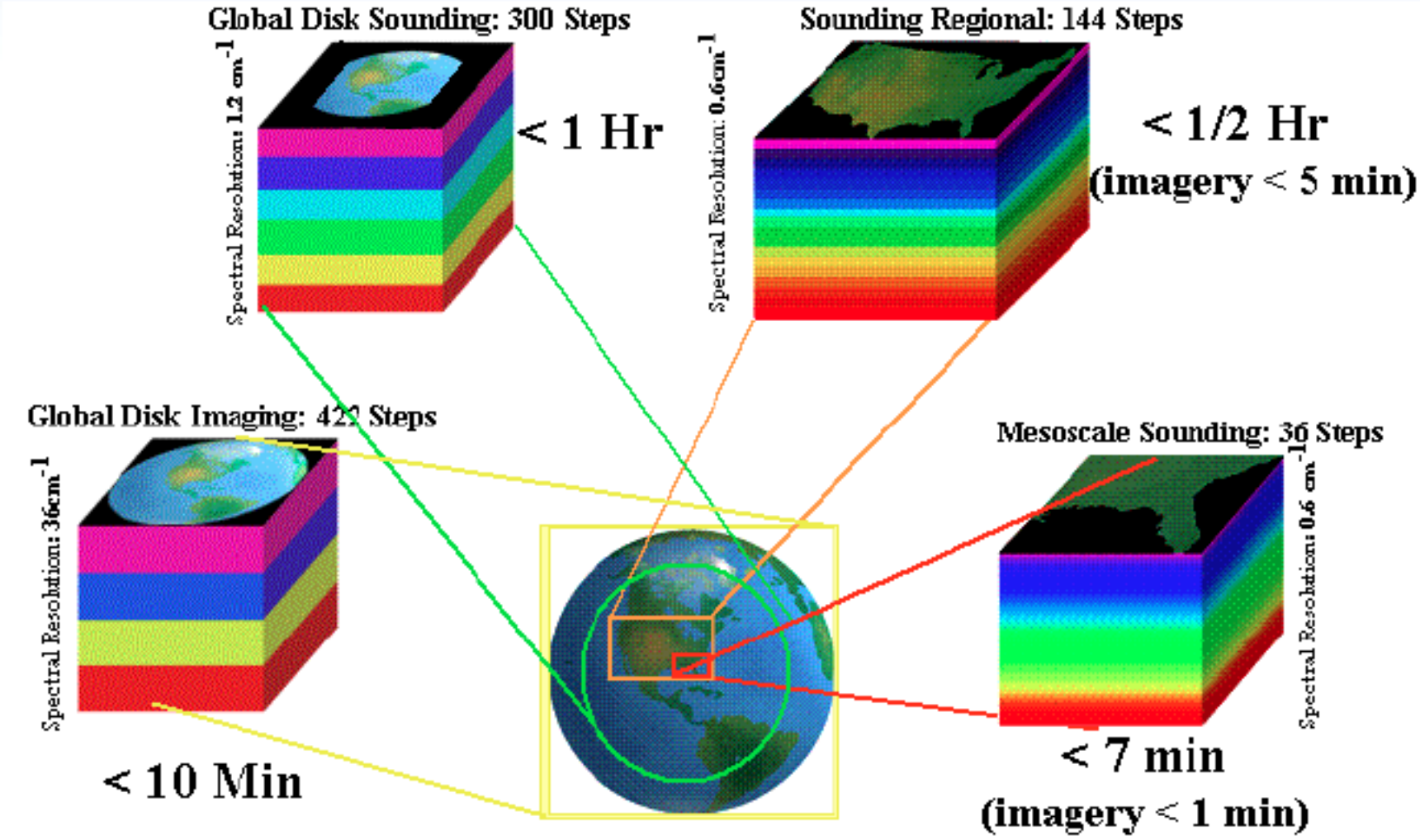
GIFTS Spectral Coverage



GIFTS Performance and Data Products

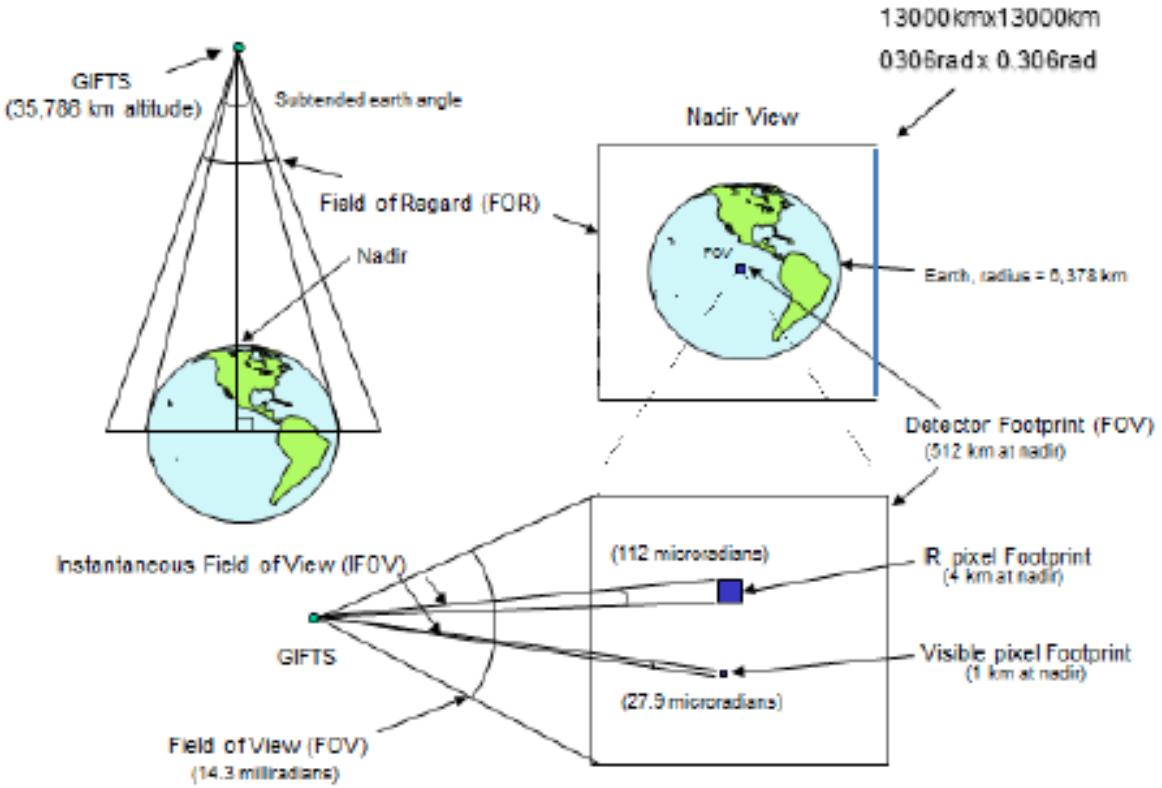
- **Performance Objectives:**
  - **Spectral Coverage:** (1) 680 - 1150 cm^{-1} (2) 1650-2250 cm^{-1}
  - **Spectral Resolution:** 0.6 cm^{-1}, unapodized
  - **Spectral Stability:** 1 part per 10^6 (3 σ)
  - **Absolute Radiometric Accuracy:** 1.0 K (3 σ)
  - **Radiometric Noise:** LW Band: 0.4 mW/m^2-sr-cm^{-1}
    SW Band: 0.06 mW/m^2-sr-cm^{-1}
- **Data Products:**
  - **Water vapor** (soundings, fluxes, winds): $\varepsilon <$ 20% / 1-2 km layers
  - **Temperature** (sounding, stability): $\varepsilon <$ 1K /1-2 km layers
  - **Wind Velocity:** $\varepsilon <$ 4 m/s / 2 km layers
  - **Carbon monoxide concentration** (2 Layers): $\varepsilon <$ 10% / 5 km layers
  - **Ozone concentration** (4 Layers): $\varepsilon <$ 10% / 8 km layers
  - **Surface Temperature**: $\varepsilon <$ 0.3K for sea, $\varepsilon <$ 1K for land
  - **Clouds** (altitude, optical depth, microphysical properties, "winds")
  - **Aerosol** Concentration and Depth: $\varepsilon <$ TBD

Example GIFTS Spatial Coverage Objectives

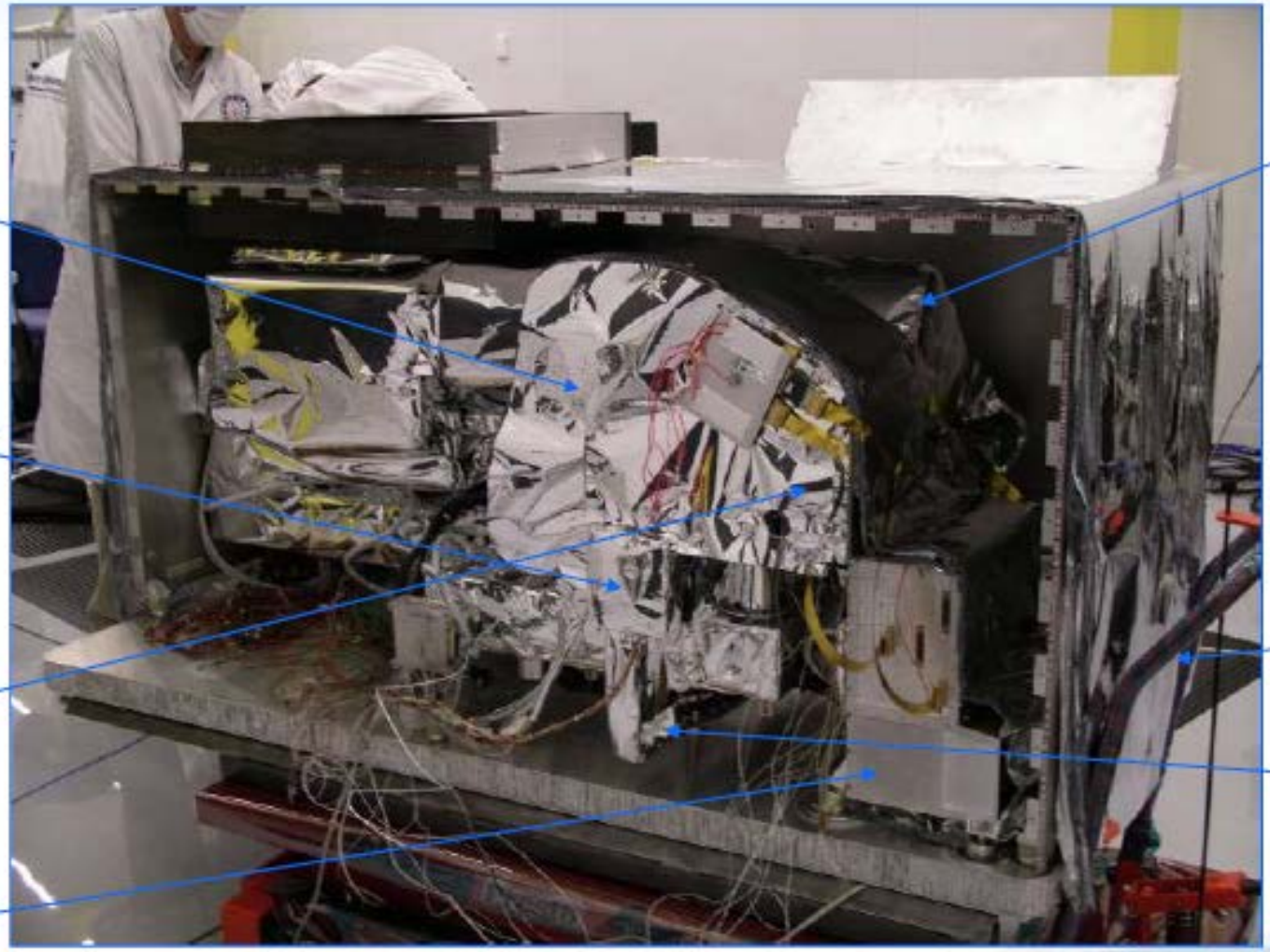


GIFTS Observation Scenario

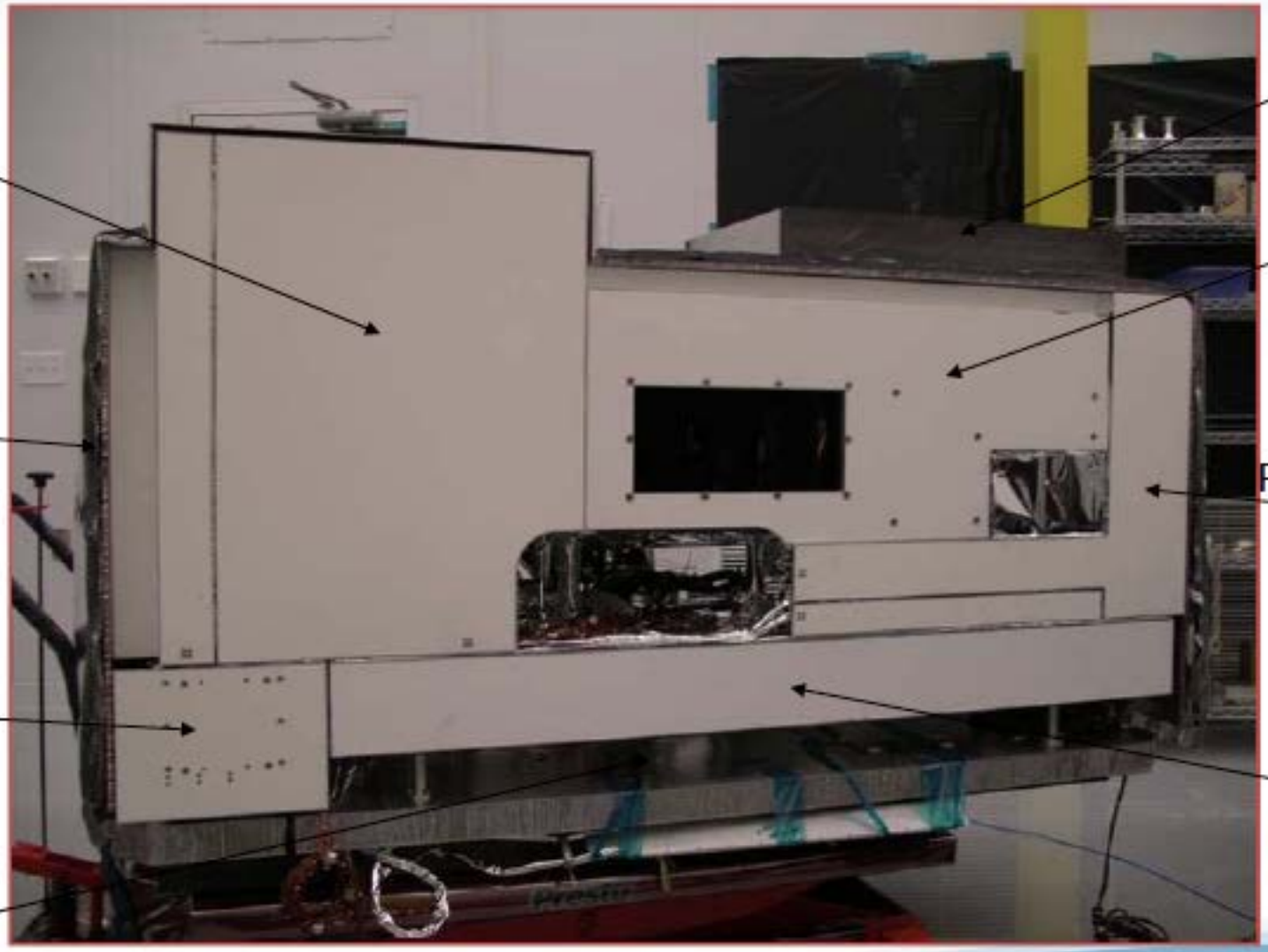
- GIFTS had a two-axis pointing mirror (PMA) which directed the optical line-of-sight for full-disk, regional, and targeted observations
- Nominal spacecraft pointing direction with respect to an ECI system should be maintained to approximately ± 2°



GIFTS During Integration



GIFTS System Configuration



Top-Level GIFTS / STORM Comparison

Parameter	GIFTS	STORM
Spectral Bands	LW: ≤685 cm^{-1} to ≥1130 cm^{-1} SMW: ≤1650 cm^{-1} to ≥2250 cm^{-1} VIS: ≥0.725 μm to ≤0.875 μm	same
Spectral Resolution	7 resolutions in range 0.6 - 36.7 cm^{-1}	0.6, 1.2, and 9.6 cm^{-1}
FPA Field-of-view (FOV)	14.3 mrad (0.82°)	same
Field-of-regard (FOR)	≥0.306 rad (17.53°) (pointing mirror design: 0.450 rad)	same
IR FPA format	128 X 128 pixels, 60 μm pixel pitch	same
Noise equivalent spectral radiance (NESR) goal	LW: ≤0.4 $mW/(m^2\text{-}sr\text{-}cm^{-1})$ SMW: ≤0.06 $mW/(m^2\text{-}sr\text{-}cm^{-1})$	same
Calibration accuracy goal	≤ 1K (3σ)	same
Data Rate	Max: 70 – 80 Mb/sec Nom: 58 – 73 Mb/sec	same
Mass*	200 kg	300 kg
Volume	1.8 X 1.0 X 1.4 m^3	same
Power*	535 W	550 W avg, 650 W peak
Thermal Rejection *	Design assumed yaw-flip	≥400 W @ 0 °C

* Mass, power, and thermal rejection change due to expected no-yaw-flip operations

Need a Great Team

- SDL – STORM Sensor
- SSEC – GMW data products and end user software
- Thales Alenia Space – Bus Partner leveraging MTG experience
- JSAT – Operator partner for 110E orbit and beyond.

GeoMetWatch-STORM Products

- **Imagery**
  - **High resolution “true” color and RGB composite animation**
  - **High resolution spectral image animation**
  - **High quality digital visible and infrared image**
  - **Local, regional and full disk single spectral or multi-channel composite image and animation**
- **Radiance**
  - **Routinely calibrated digital spectral radiances traceable to national standard**
  - **Routine digital radiance signal, noise, and quality status for scientific and quantitative applications**
  - **Any customized digital radiance subsets at various coverage and frequency**
- **Real-time Product**
  - **4D fields of primary products of temperature, water vapor, clouds, and wind.**
  - **3D fields of aerosol, pollutions, and trace gases.**
  - **3D fields of volcanic ash and gases.**
  - **3D fields of land and ocean surface temperature.**
  - **3D fields of surface emissivity and albedo.**
  - **3D fields of land surface type, coverage and vegetation index.**
  - **3D fields of hot spot.**
  - **3D fields of weather instability.**
  - **3D fields of ice/snow, cover, depth and motion.**
  - **3D fields of visibility, turbulence, icing threat, low cloud and fog.**
  - **3D fields of flood and standing water.**
  - **3D fields of Hurricane intensity and track.**
  - **3D fields of longwave and shortwave radiation.**
  - **Customized products such as high spatial and temporal resolution temperature, humidity, wind, cloud transient, surface temperature, surface type and other products critical for fire management, aviation safety, sever storm watch, air pollution monitoring, renewable energy production, and hazardous events warning and so on.**

GeoMetWatch/STORM Applications

Applications:

- **Hazard Events Monitoring/Prediction**
- **Air Pollution Monitoring/Forecasting**
- **Aviation Safety Warning/Prediction**
- **Renewable Energy Production Prediction**
- **Fire Management**
- **Regional High Resolution Numerical Weather Forecasting**

GeoMetWatch/STORM Services

Services:

To provide an end-to-end real-time and/or routine support system for the

- **Decision Making**

  For the management of the above weather and environmental events for public safety, security, recreational, sport, business, government function and many other social and special activities

- **Resources Management**

  For the operational management of the land use, agriculture production, transportation, aviation safety, renewable energy and other resources

- **Risks Mitigation**

  For social, economical, environmental informational/impact analysis, and investment, business, and policy strategic planning

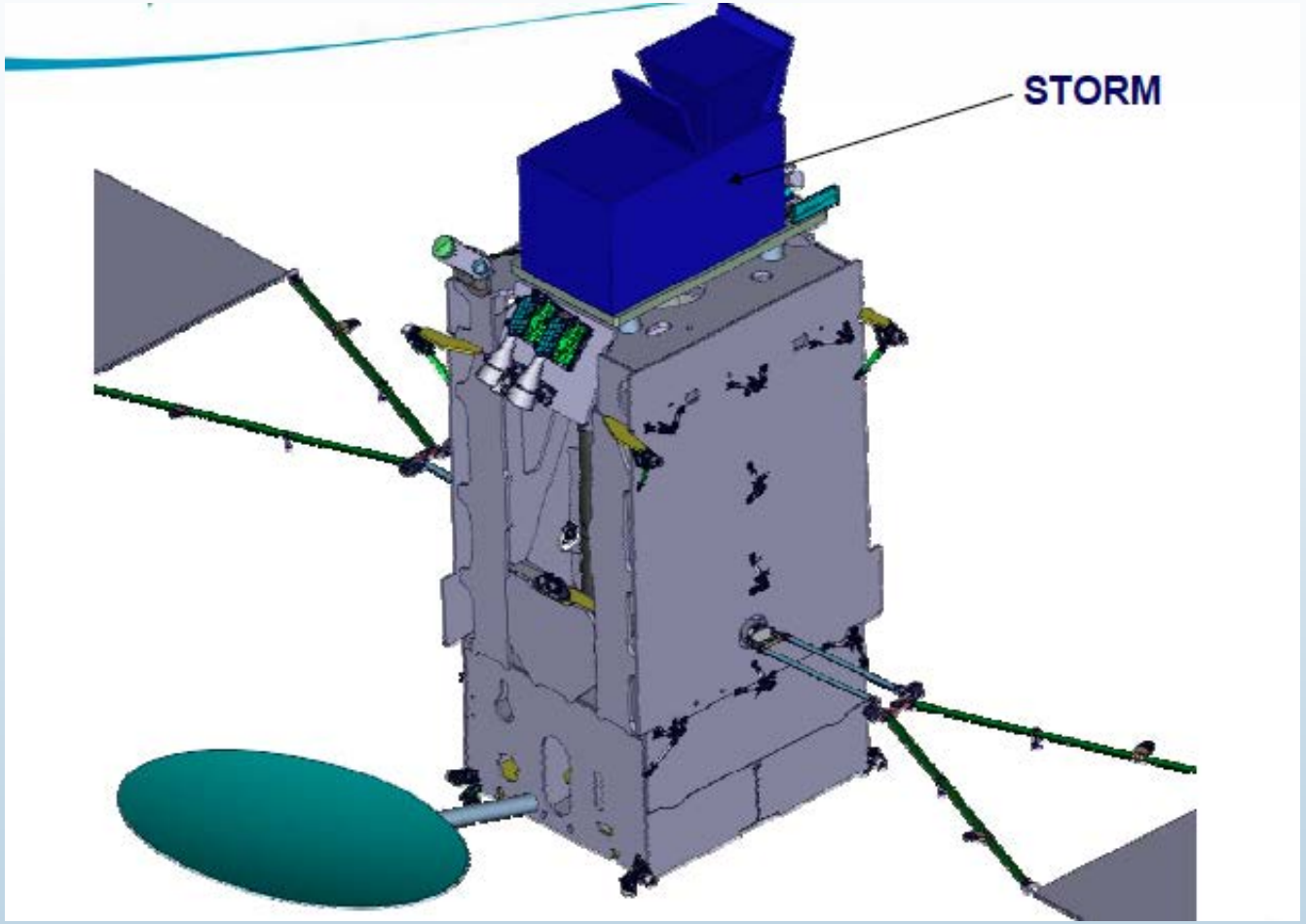
Need a Great Team

- SDL – STORM Sensor
- SSEC – GMW data products and end user software
- Thales Alenia Space – Bus Partner leveraging MTG experience
- JSAT – Operator partner for 110E orbit and beyond.

JCSAT-110E with STORM hosted payload

Bus	**Spacebus 4000 C2, 110°E**
Mission	**Japan beam & Geostationary sounding hosted payload STORM** ULR Ku Tx 2.4 m ULR Ka & Ku Rx 2.4 m
Repeater sizing	30:24 Ku band - 140 W class - Radiative TWTA's – Single EPC 2:2 Ka band - 120 W class - Conductive TWTA's – Single EPC
Payload power	6400 W (JCSAT-110E payload inc. TTC) 600 W (STORM payload)
EPS configuration	SA: W31S3 (3 panels GaAs 3J cells per wing) Battery: 2 x 19s3p SAFT VES140 cells or MELCO
Power budget	> 7.5% power margin with one string failed per wing < 80% DoD with one pack cell failed per battery
Propulsion	Chemical, 2900 kg propellant capacity
Maximum launch mass	5050 kg (inc. 300kg for STORM payload)
Lifetime	≥ 16 year lifetime on Ariane 5 ECA, Sea Launch, Proton M/BM

Bus Configuration



Need a Great Team

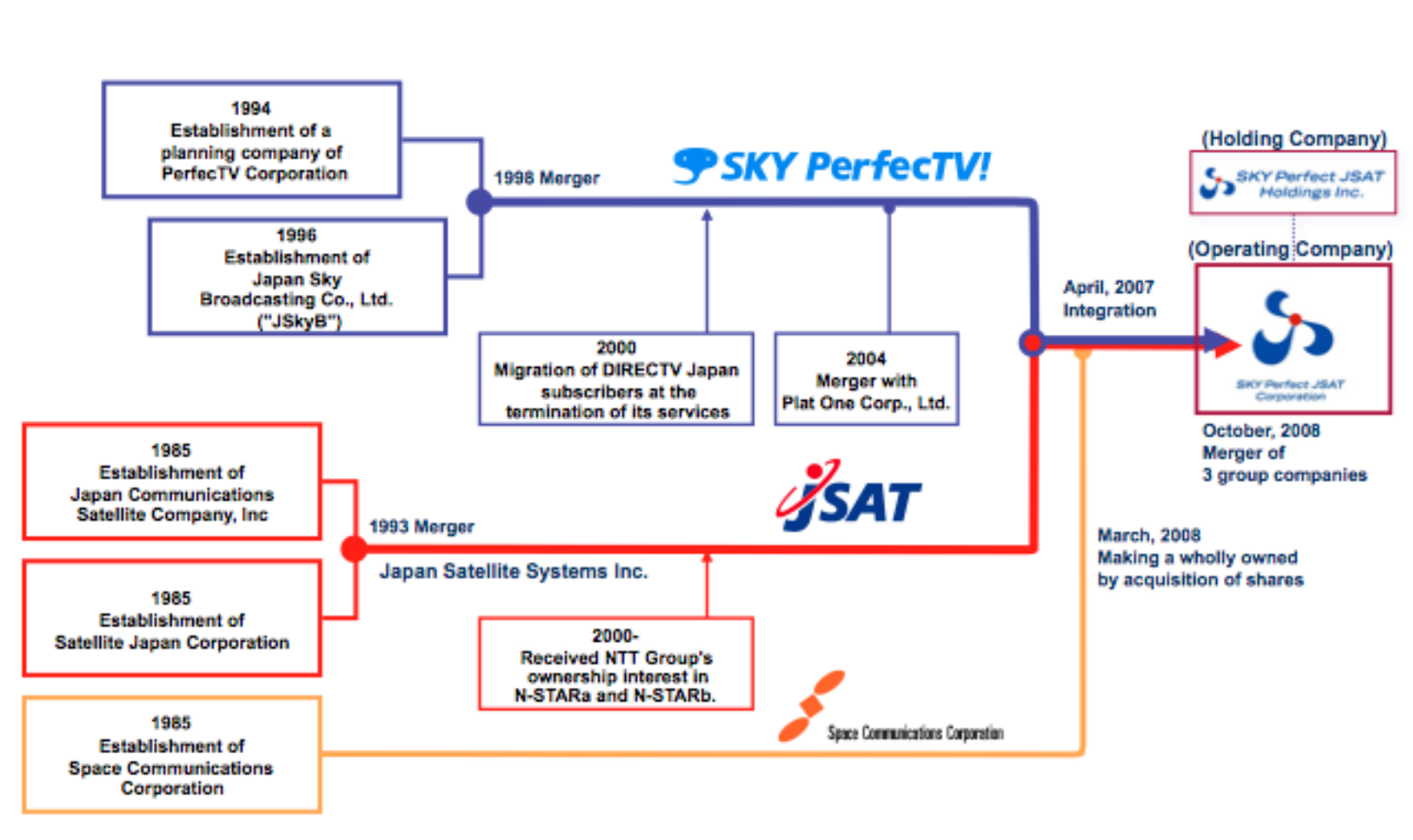
- SDL – STORM Sensor
- SSEC – GMW data products and end user software
- Thales Alenia Space – Bus Partner leveraging MTG experience
- JSAT – Operator partner for 110E orbit and beyond.

Corporate Overview

March, 2012

SKY Perfect JSAT Corporation

Three companies to one.



6. Top Fixed Satellite Service Operators

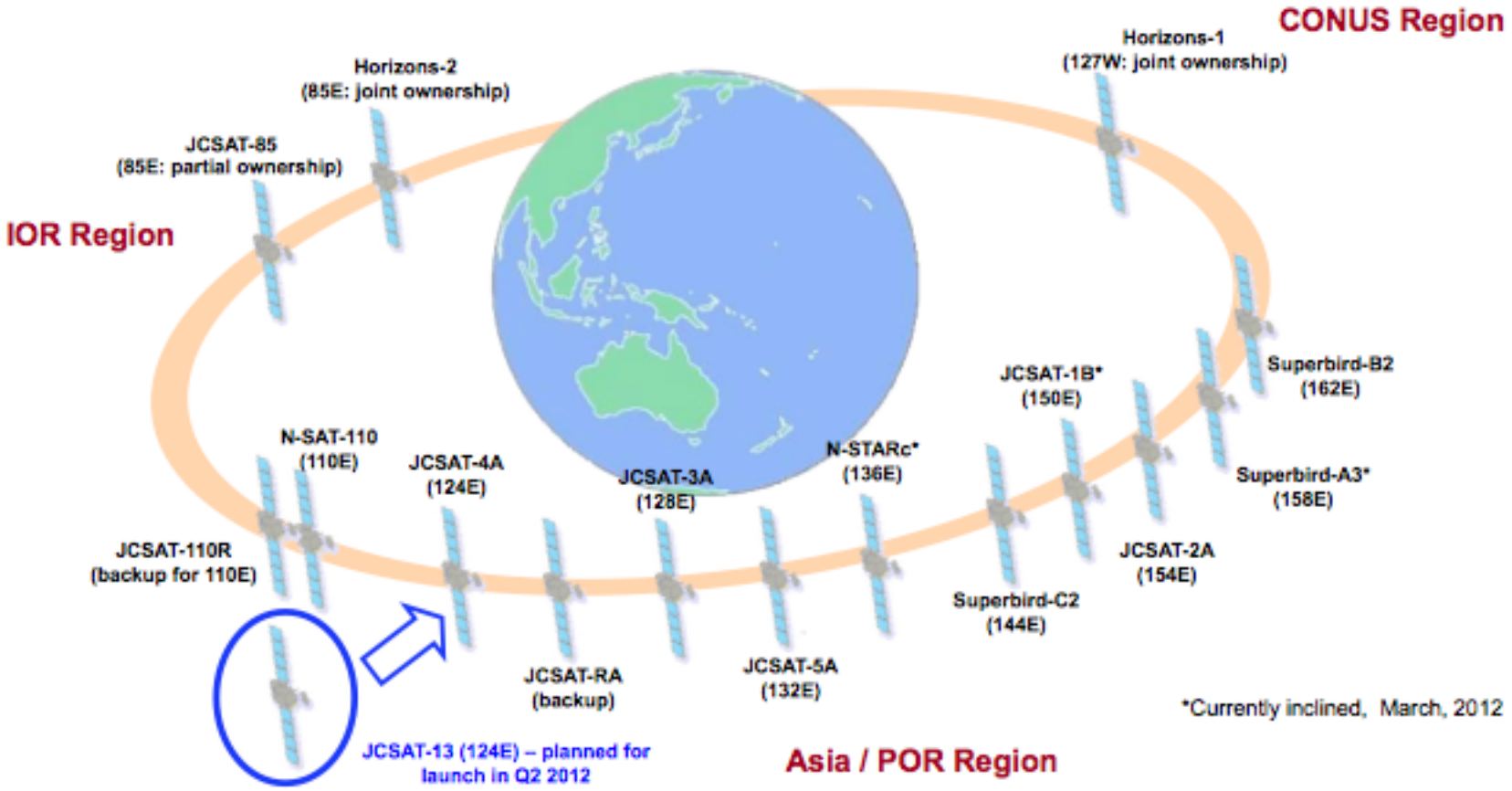
(US$ in million)

No.	Satellite Operator	Sales (2010)	Sales (2009)	Satellite in Orbit
1	Intelsat	2,540	2,510	54
2	SES	2,300	2,440	45
3	Eutelsat	1,480	1,410	27
4	Telesat	821	750	13
5	SKY Perfect JSAT	391 (Satellite business only)	363	14
6	Star One	319	276	6
⋮	⋮	⋮	⋮	⋮

(Source: SPACE NEWS July 4, 2011)

7. Satellite Fleet

15 satellites in orbit, another launch in 2012



9. Extensive Experience in Hosted Payloads

- **Has been hosting X-band payload for Ministry of Defense in Japan for more than 20 years**
  - Superbird-A (1989), Superbird-B (1990), Superbird-A1 (1992), Superbird-B1(1992), Superbird-C (1997), Superbird-B2 (2000), N-SAT-110 (2000), Superbird-A2 (2004), Superbird-C2 (2008)

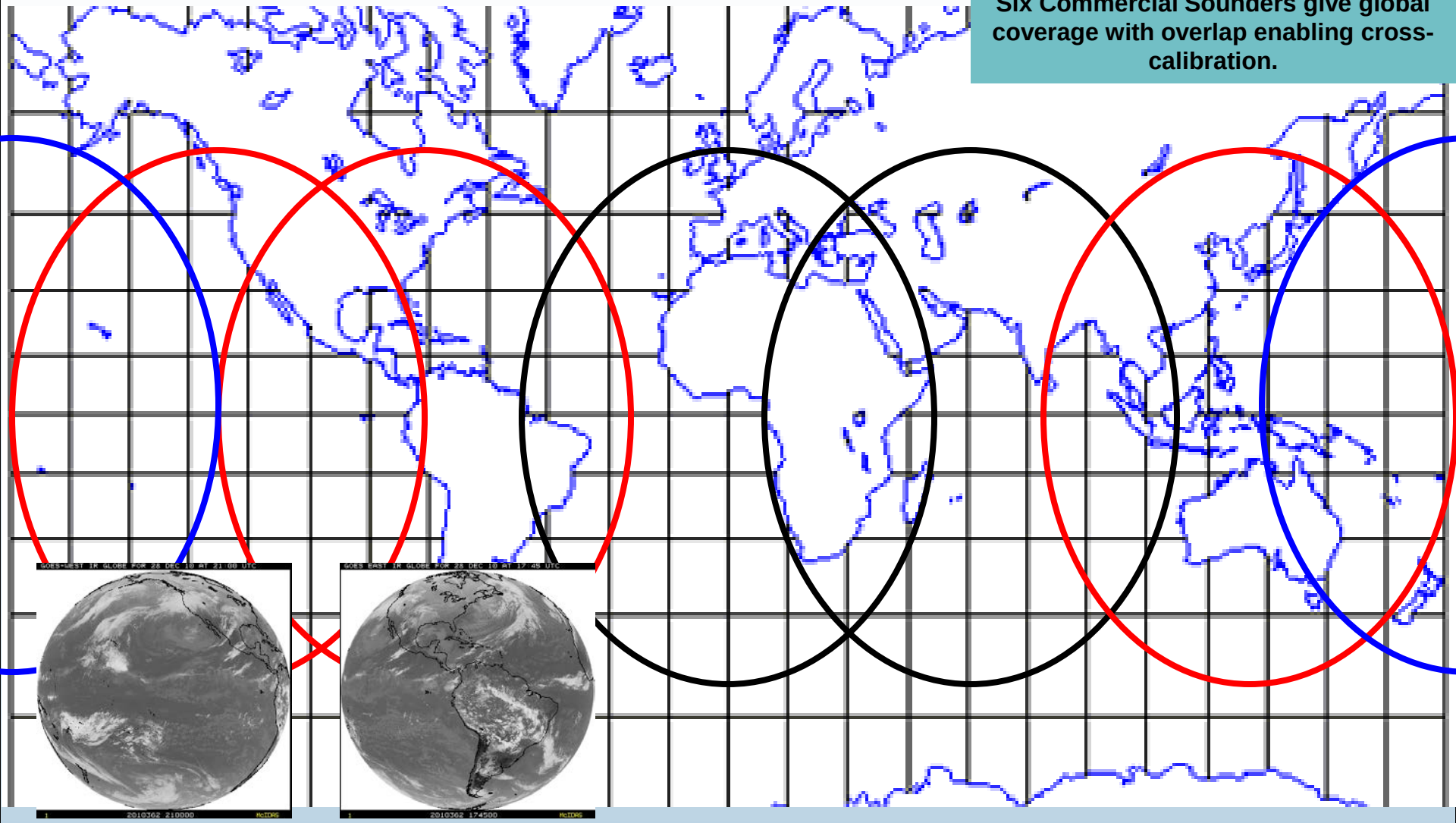
- **Has been hosting MSS S-band payload for NTT Docomo since JCSAT-5A launch in 2006**

10. Reliable Operations

- **Largest-scale TT&C operation in Asian commercial satellite sector**
  - 12 owned satellites and 1 third-party satellite
- **Robust ground facilities**
  - Main satellite operation center in Yokohama
  - 3 backup satellite operation stations
    - Ibaraki
    - Gunma
    - Yamaguchi

Proposed Coverage Implementation 2015-2020

Six Commercial Sounders give global coverage with overlap enabling cross-calibration.



Future Activities

- Official contract starts for sensor and algorithm development anticipated by September 2012.
- Second Source RFP April 2012.
- Planned GeoMetWatch STORM Users Conference in Summer of 2013.
- Possible OSSE planning meeting in near future.
- New Website Launch in June 2012