Evolution of the Global Observing System: a Vision for 2025

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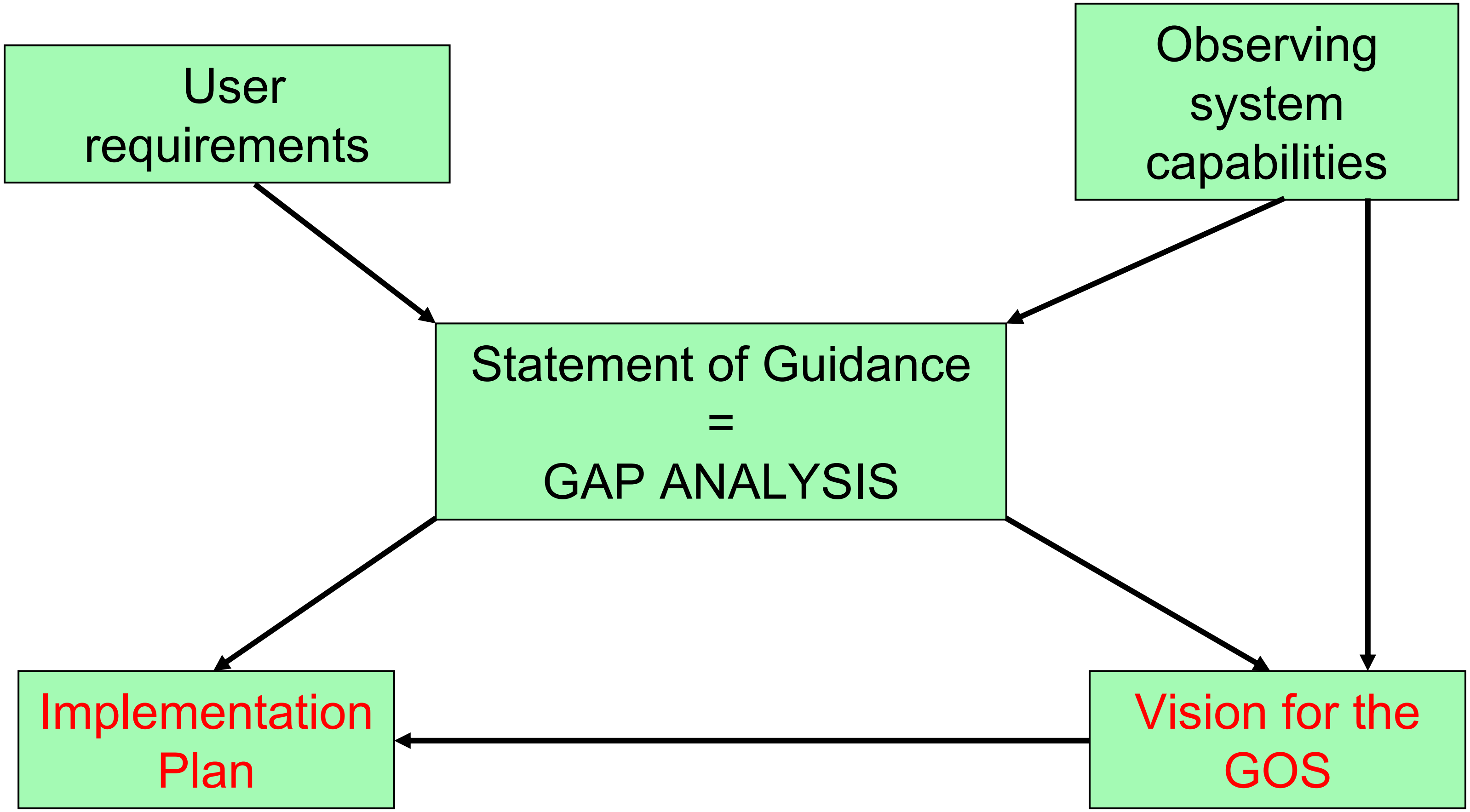
ITSC-16, Angra dos Reis, Brazil; 7-13 May 2008

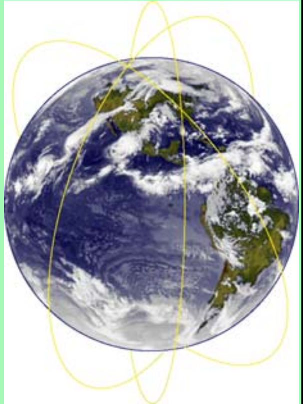
Evolving the Global Observing System (GOS) of WMO

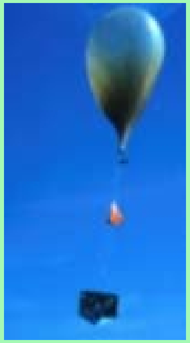


The future GOS

- globally co-ordinated
- built on existing components, both surface- and space-based
- capitalise on existing and new observing technologies
- increasing role of space
- leading to improved data, products and services from NMHSs









Vision for the GOS in 2025

Document currently in draft

Content:

- General trends and issues
- Space-based component
    - operational geo
    - operational sun-synchronous leo
    - additional operational
    - R&D capability
- Surface-based component

General trends and issues

- Response to user needs
- Integration - WIGOS
- Expansion
- Automation
- Consistency and homogeneity

Space-based GOS: current Vision to 2015

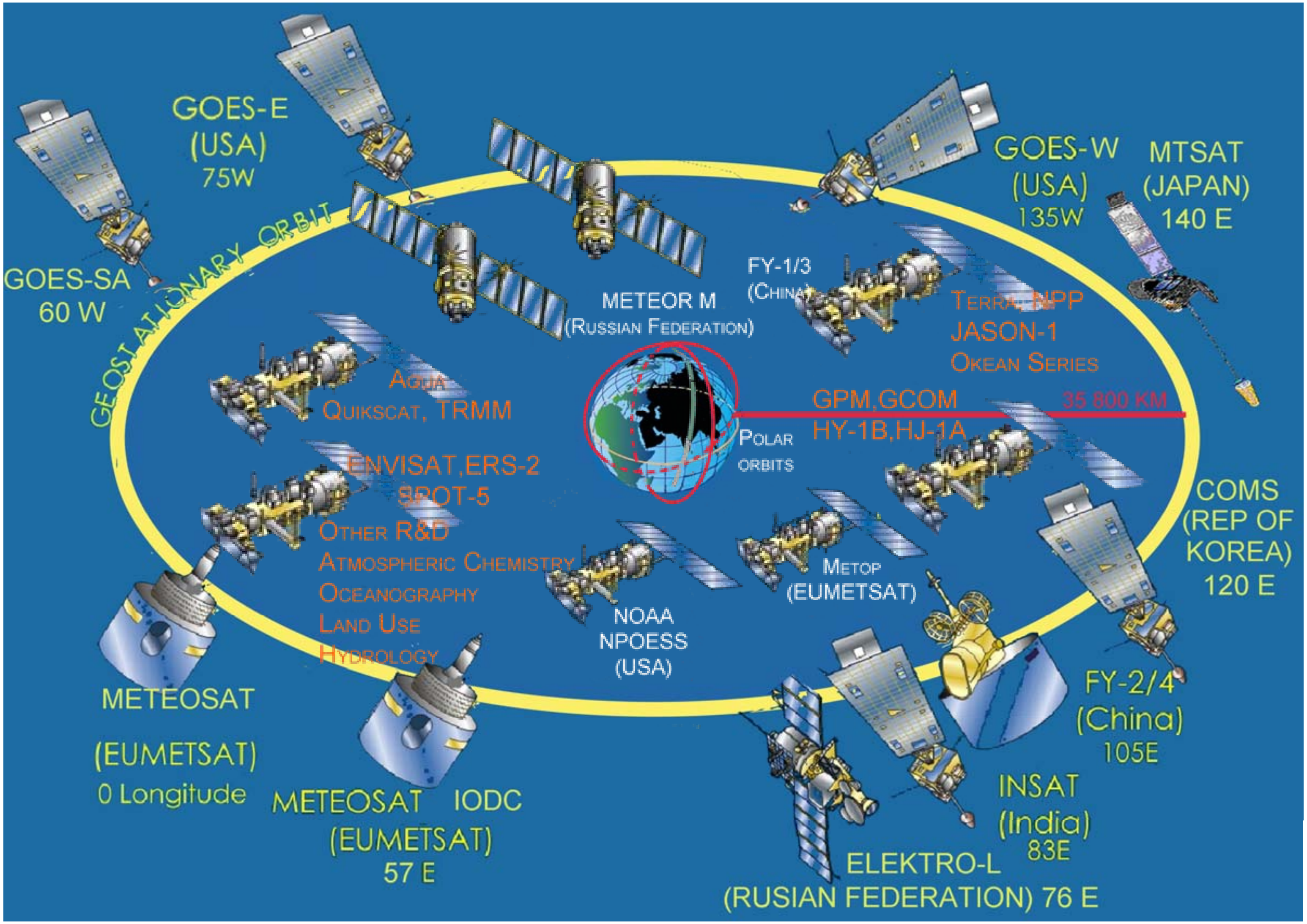
- 6 operational GEOs, all with multi-spectral imager (IR/VIS); some with hyper-spectral sounder (IR)

- 4 operational LEOs optimally spaced in time, all with multi-spectral imager (MW/IR/VIS/UV), all with sounder (MW), 3 with hyper-spectral sounder (IR), 2 with altimeter, 3 with conical-scan MW or scatterometer

- Several R&D satellites: constellation of small satellites for radio occultation (RO), LEO with wind lidar, LEO with active and passive microwave precipitation instruments, LEO and GEO with advanced hyper-spectral capabilities, GEO lightning

- Improved inter-calibration and operational continuity

Space-based component of the GOS



Proposed developments of space-based GOS

under the draft Vision for 2025

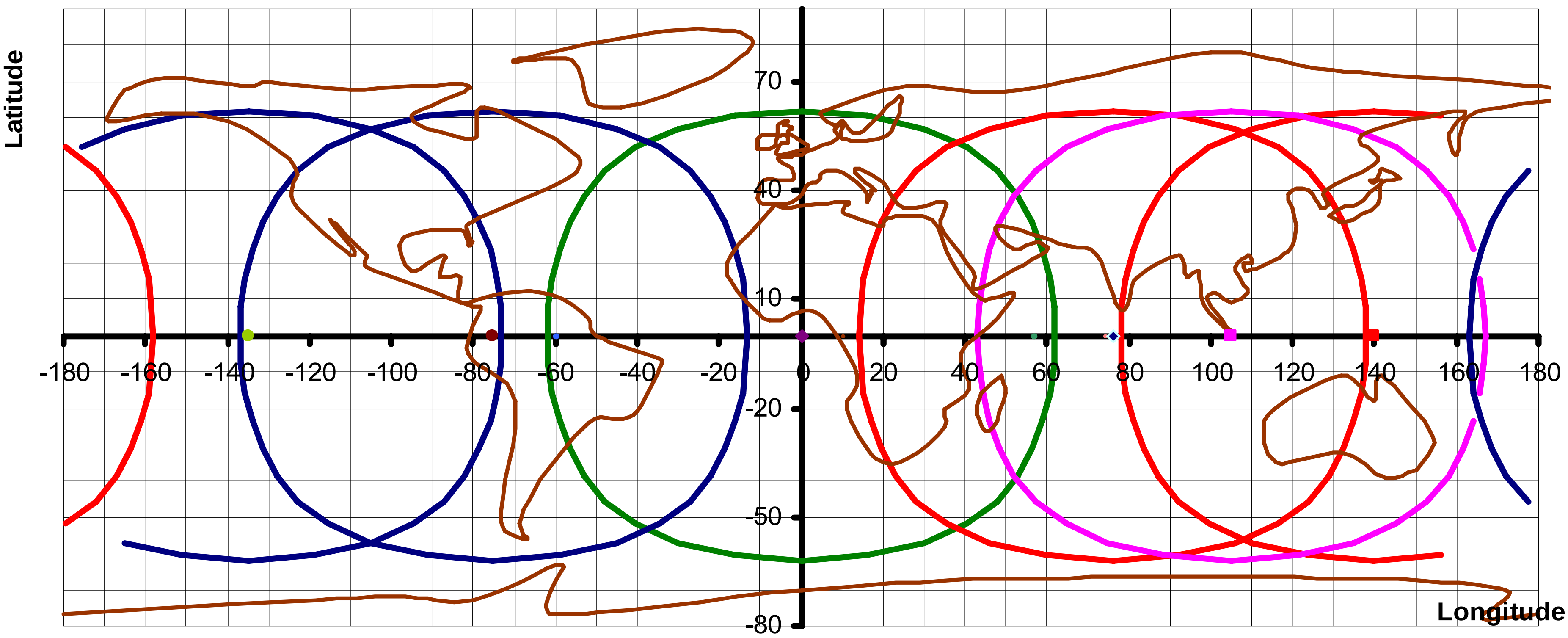
Main themes:

- Optimize current geostationary constellation
- Optimize current sun-synchronous orbit sounding missions
- Implement operational radio occultation sounding constellation
- Review ocean altimetry observation strategy
- Refine ocean surface wind vector observation strategy
- Make additional missions operational, e.g. for GCOS ECVs

Optimizing the geostationary constellation

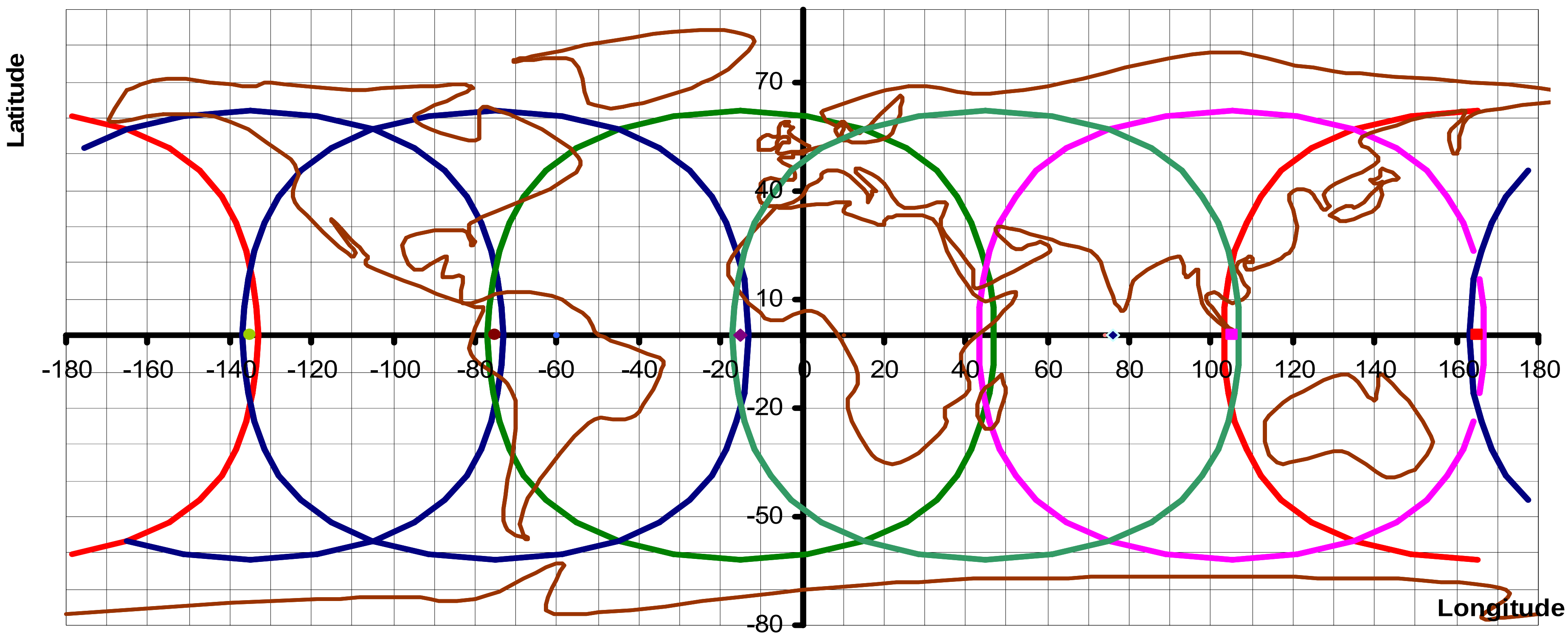
Current nominal locations : 135 W, 75W, 0, 76 E, 105 E, 140 E

Footprints for a maximum zenith angle < 70 deg



Optimizing the geostationary constellation

Recommendation: at least 6 satellites separated by ≤ 60° longitude with multispectral imager & hyperspectral IR sounder



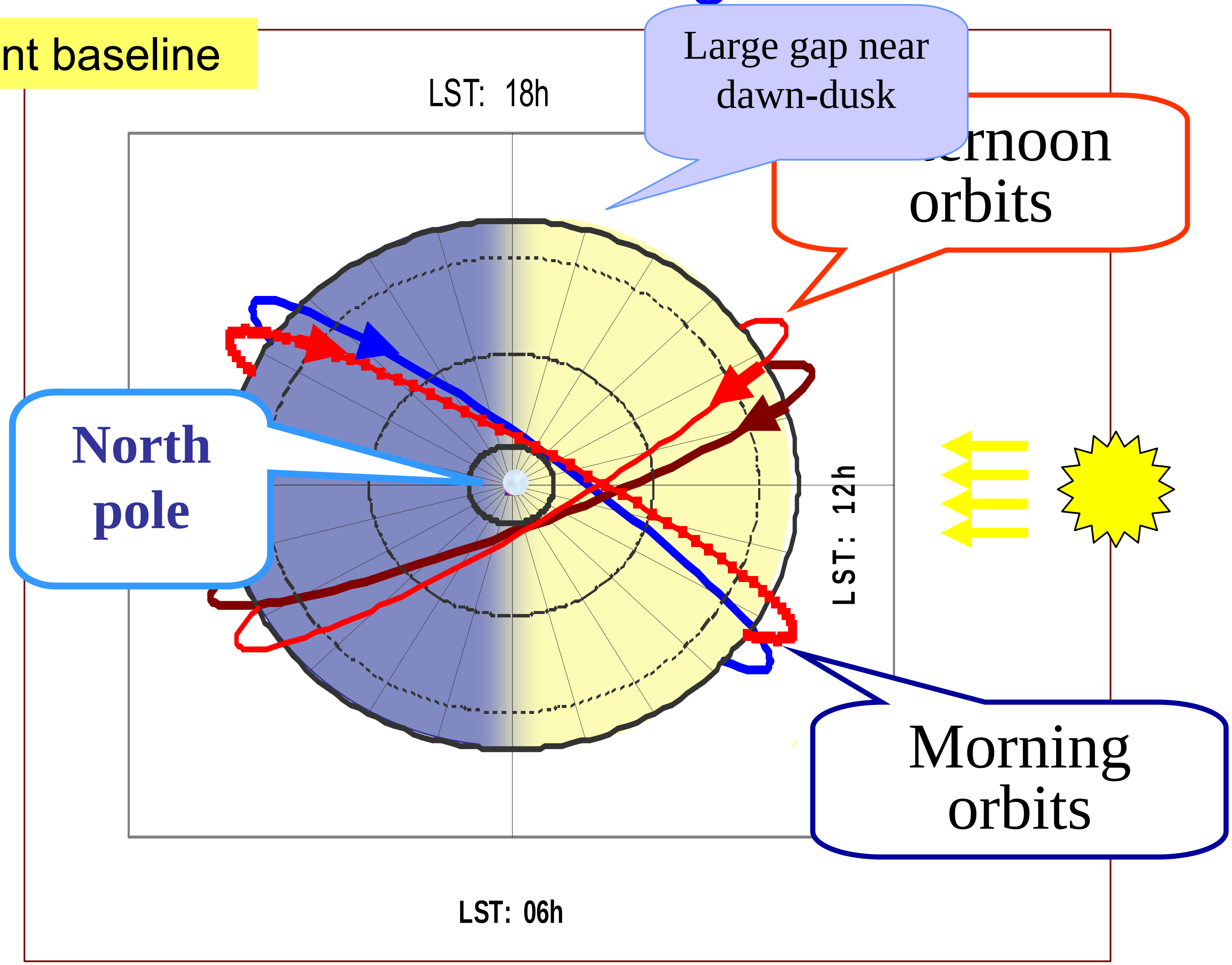
IR hyperspectral sounding from geo orbit

Current plans of satellite operators:

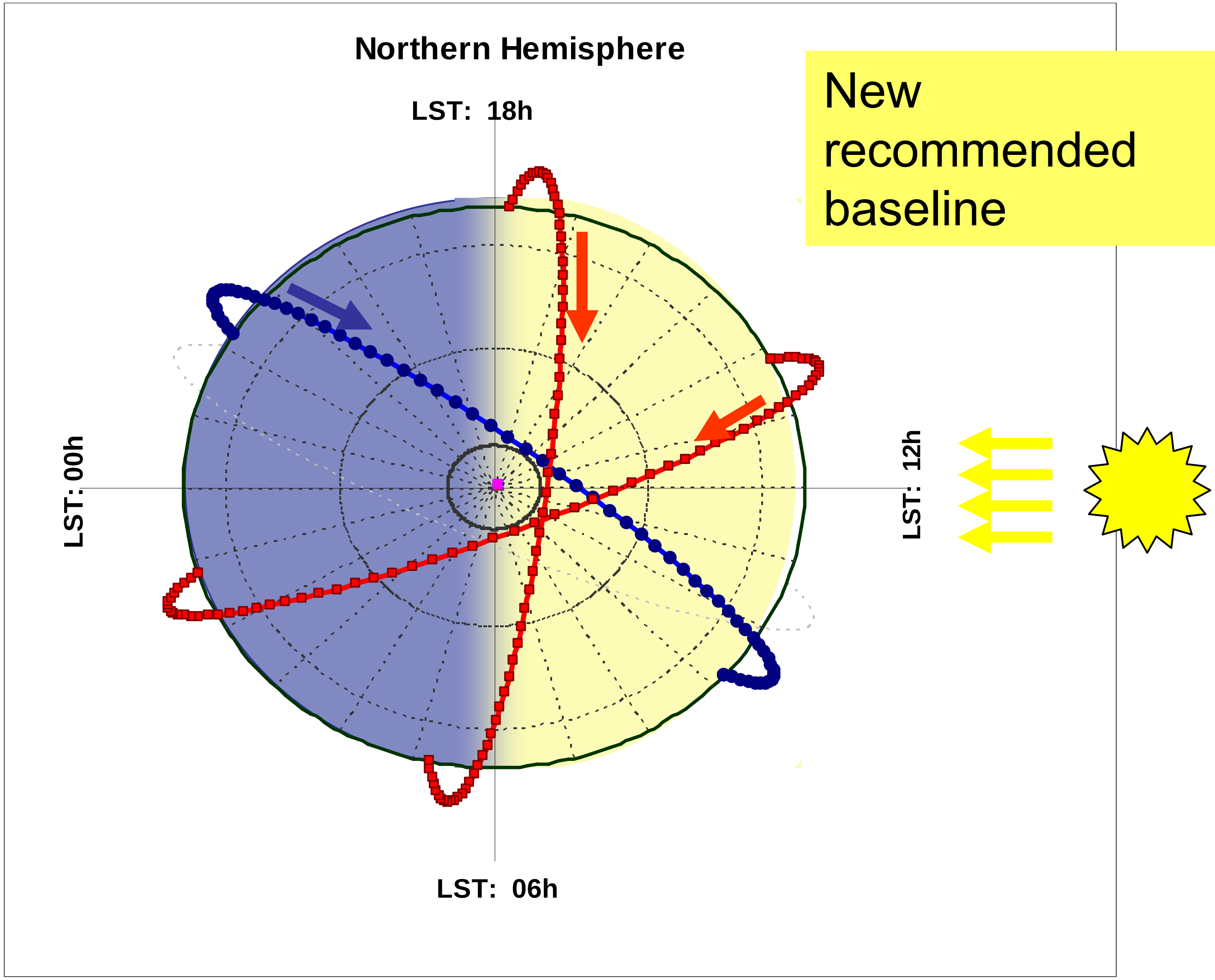
- MTG / IRS (2018)
- FY-4 O / IIS (2016)
- GOES-R series / HES, under consideration after GOES-S
- MTSAT-FO / Sounder, under consideration by JMA-JAXA
- GIFTS: prototype instrument was proposed for a demo mission in 2010+ as part of IGeoLab cooperation concept

Optimizing sun-synchronous IR/ MW sounding missions

Current baseline

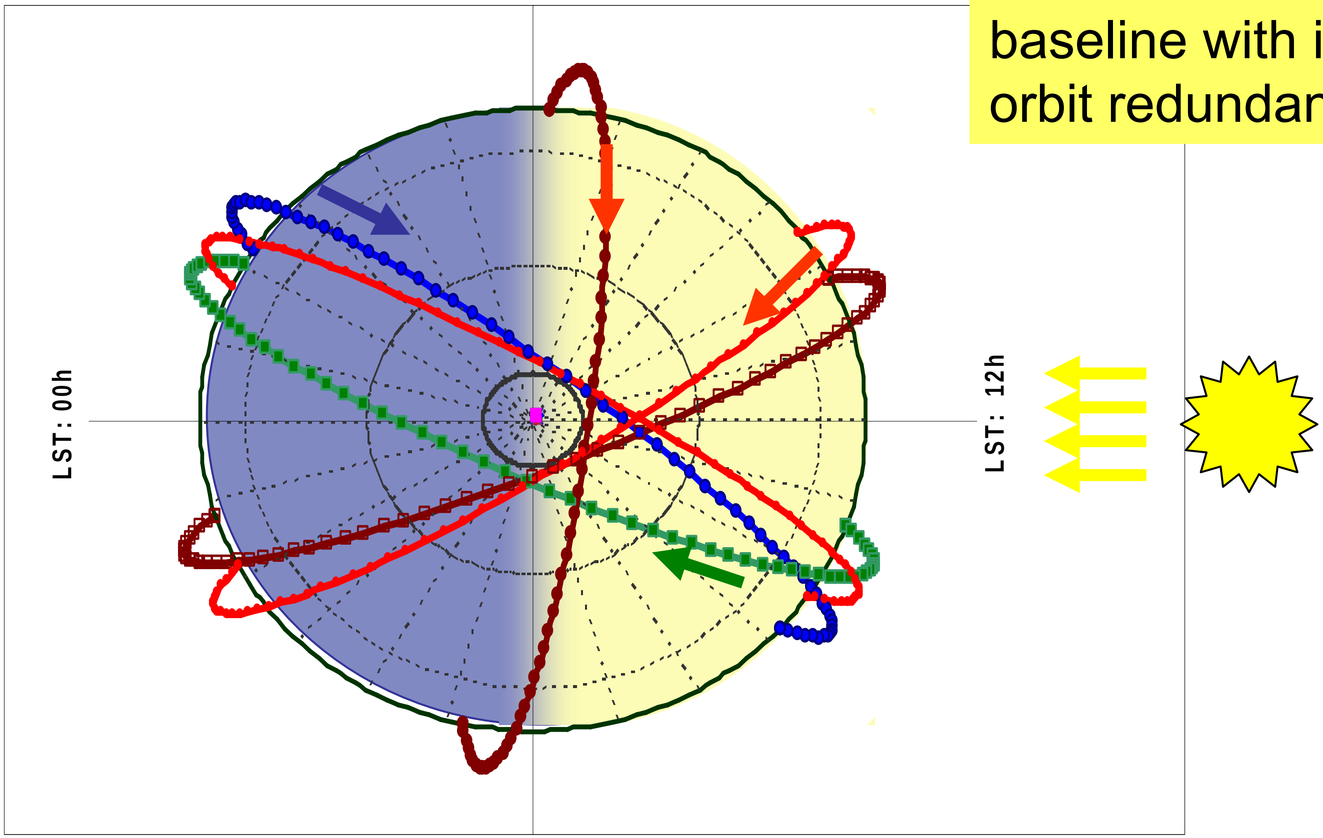


Optimizing sun-synchronous IR/ MW sounding missions



New recommended baseline

Optimizing sun-synchronous IR/ MW sounding missions

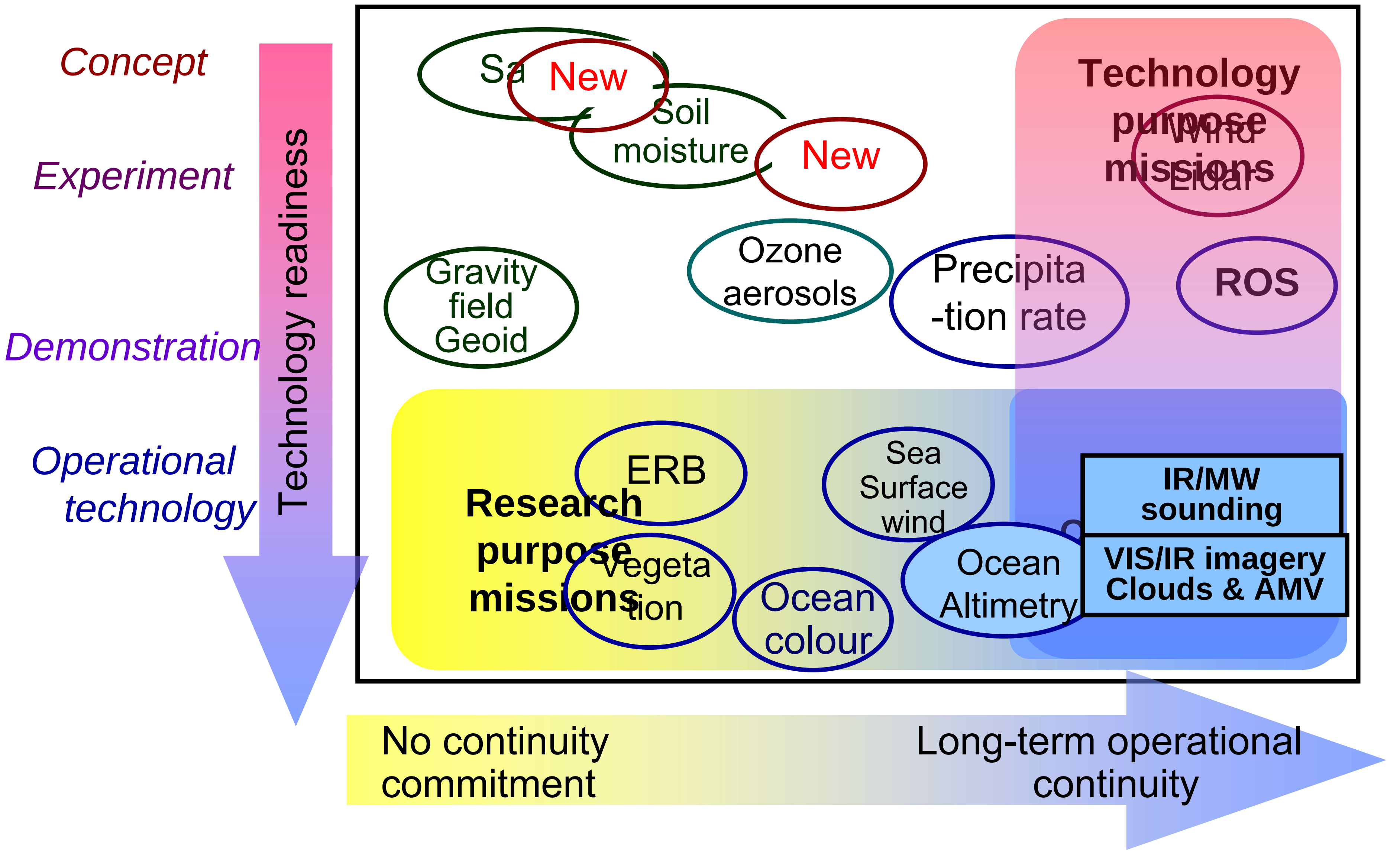


Recommended baseline with in-orbit redundancy

Radio occultation sounding

- Complementary to passive IR/MW sounding
- High number of satellites needed to meet coverage and observing cycle requirements
  - at least 6 satellites
  - optimal configuration TBD (including OSSEs)
  - constellation with several clusters / orbits
- Scope for international cooperation

Transition of R&D missions to operations



Vision for the space-based GOS in 2025: Summary (1)

At least 6 operational geostationary satellites:

- All with IR/VIS multi-spectral imager
- All with IR hyper-spectral sounder
- With no more than 60°longitude difference between neighbouring locations

Operational polar-orbiting sun-synchronous satellites on 3 orbital planes:

- All with IR/VIS multi-spectral imager
- All with MW sounder
- All with IR hyper-spectral sounder

Vision for the space-based GOS in 2025: Summary (2)

Additional operational missions in appropriate orbits:

- 2 sun-synch. sats with scatterometer
- 2 sun-synch. sats with conically-scanning polarimetric MW imager
- 2 sun-synch. sats with narrow-band VIS/NIR imagers for ocean colour + veg.
- Constellation of high-resolution VIS/IR imagers for land surface imaging
- Constellation for radio occultation
- Constellation for altimetry: 2 in sun-synch orbits and 1 high-precision ref.
- Constellation of LEO satellites for precipitation measurements: combined use of active instrument in low-inclination orbit and passive microwave instruments in several high-inclination orbits
- Constellation of sensors for Earth radiation budget: including at least 1 broad-band multi-angle viewing radiometer in LEO, and 1 total solar irradiance sensor, together with auxiliary LEO measurements and geo sensors
- Constellation of instruments/missions to address atmospheric composition

Vision for the space-based GOS in 2025: Summary (3)

Several R&D satellites and operational pathfinders including:

- LEO with Doppler wind lidar
- LEO Low-frequency MW radiometer addressing salinity and soil moisture
- GEO microwave

Considered as optional:

- Satellites in highly elliptical orbit (HEO) ensuring polar region coverage
- Geostationary lightning detection

Improved availability, timeliness, and intercalibration through operational cooperation among agencies.

Developing a new Vision – who's involved?

WMO

- Expert Team on Evolution of the GOS (requirements for space+surface obs)
- ET on Satellite Utilization & Products
- ET on Satellite Systems
- ET on Automatic Weather Stations

⇩

- Implementation/Coordination Team on Integrated Observing Systems (ICT-IOS)

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- Commission for Basic Systems (CBS)

⇔

- **Optimization workshops**
- **CGMS**
- **CEOS**
- **Other stakeholders**

Developing a new Vision – schedule

July 2007 – Dec 2008
Discussion of draft within WMO Expert Teams and with other stakeholders

*** COMMENTS WELCOME! ***

Early 2009
Adoption by WMO Commission for Basic Systems

Thank you for your attention

Ocean surface topography

The community (including CEOS Ocean Surface Topography Constellation) has recommended 2 components:

- One high-precision reference altimeter system with orbit and coverage avoiding tidal aliasing (*e.g. Jason)*
- Two complementary altimetry systems on higher inclination orbits to maximize global coverage *(e.g. GFO, ENVISAT or Sentinel-3)*

covering from oceanic mesoscale to basin-wide scale and addressing ocean *weather* and *climate applications*

Ocean surface wind vector

- 2 scatterometers
- 2 full-polarization MW imagers

- other MWI (dual polarization) contribute to additional wind speed data

New missions required on long-term basis for GCOS ECVs

- Global precipitation measurement (GPM concept)
- Earth Radiation Budget (*to be refined)*
  - *TSI and TOA upcoming SW-LW*
  - *Contextual parameters (cloud, aerosols, WV)*
  - *Geostationary multi-spectral imagery for diurnal cycle*
- Atmospheric composition constellation (*to be refined)*
  - for O3, GHG, aerosols, and air quality in lower troposphere
- Specific imaging missions for ocean colour and vegetation

Vision of the GOS to 2025
Forward looking but affordable

- Serving broader objectives - step towards WIGOS
- Enhanced and diversified capabilities
- More commitments to long-term continuity
- Requires more resources

- ➢ Possible with wider community of GOS contributors
- ➢ Need enhanced cooperation to optimize global effort
- ➢ Ensuring data exchange and consistent data quality

References

- *User Requirements from CEOS-WMO database*
  http://www.wmo.int/pages/prog/sat/Databases.html
- *Statements of Guidance*
  http://www.wmo.int/pages/prog/sat/Refdocuments.html
- *Gap Analysis presented at the WMO Workshop on*
  Re-design and Optimization of the GOS and at CGMS-XXXV
  http://www.wmo.int/pages/prog/sat/documents/CGMS-35WMO-WP-05.pdf

Evolution of the GOS

Responding to evolving requirements

High-level definition of the space-based GOS

Vision of the GOS
Manual on the GOS

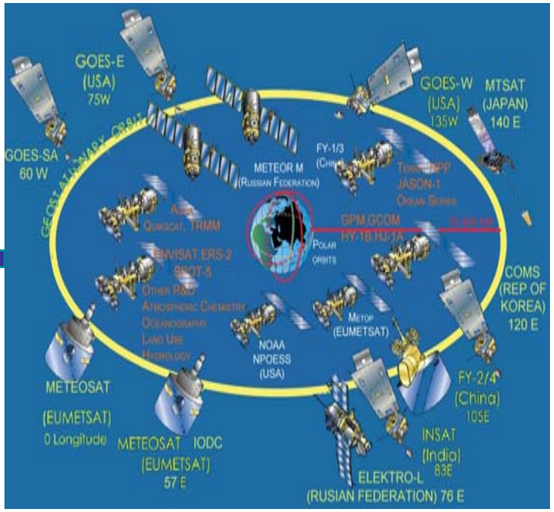
WMO Implementation Plan for GOS
CGMS actions
CEOS Constellations and Implem.Plan

Identification of implementation actions/recomm

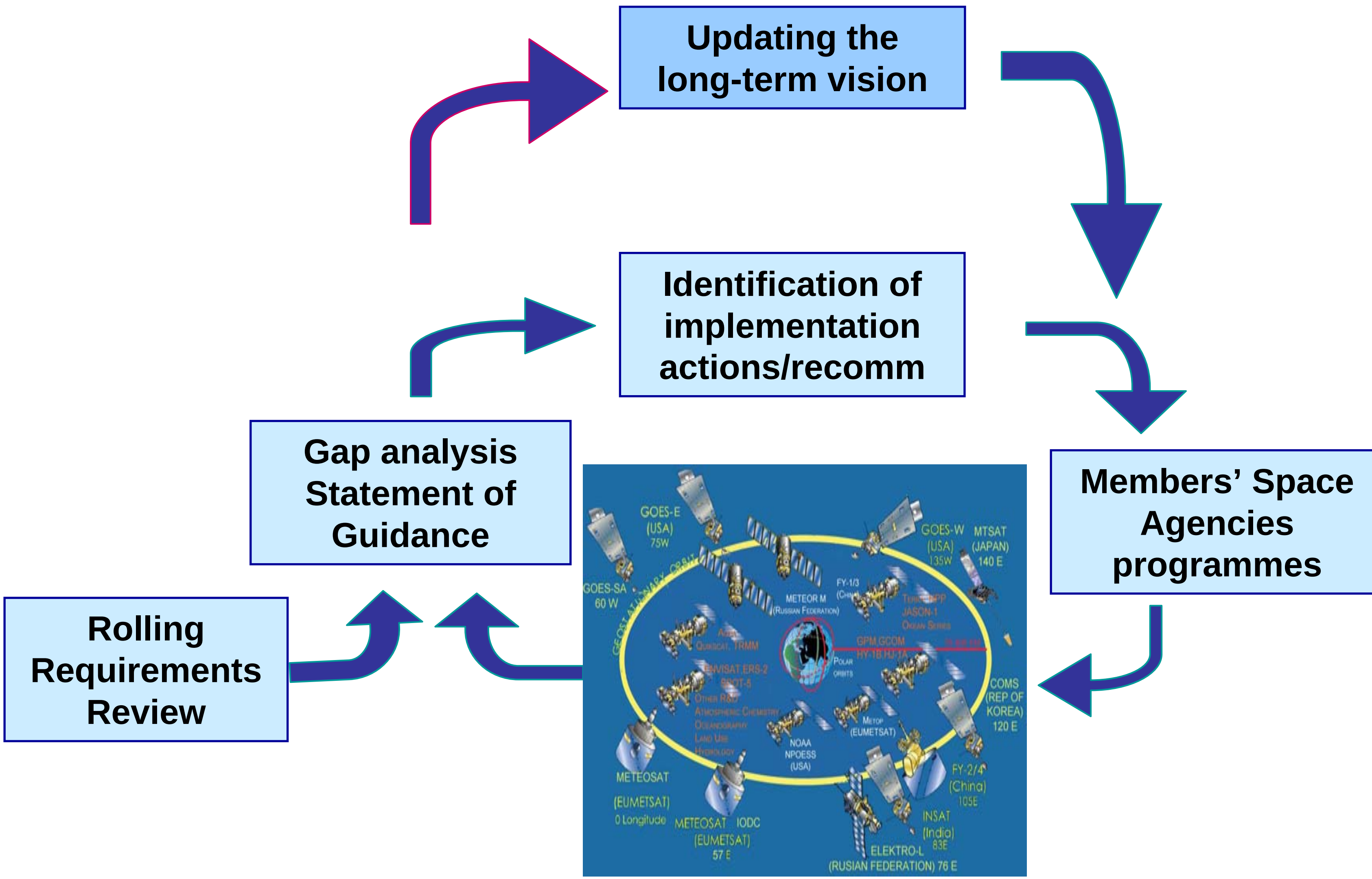
Gap analysis Statement of Guidance

Members' Space Agencies programmes

Rolling Requirements Review



Evolution of the GOS



e.g. - observation requirements for global NWP

- 3D wind
- 3D temperature
- 3D humidity
- surface pressure

- surface variables:
  - sea surface temperature
  - ice/snow cover, snow depth(water equivalent)
  - vegetation, soil moisture

- cloud and precipitation

- other variables that modify radiation or act as tracers:
  - ozone, aerosols

e.g. – gap analysis for global NWP

SUMMARY:

"… the critical atmospheric variables not adequately measured by current or planned systems are:

- ✓ wind profiles at all levels
- ✓ temperature profiles of adequate vertical resolution in cloudy areas
- ✓ precipitation
- ✓ soil moisture
- ✓ surface pressure
- ✓ snow equivalent water content "

Evolution of the GOS
operational geostationary component

- at least 6 spacecraft
  - separated by ≤ 60 deg longitude for a “global” coverage
- VIS/IR multi-purpose imagery
- IR hyperspectral sounding

- contribution to Earth Radiation Budget monitoring
  - TBD, complement to LEO
- contribution to Atmospheric Chemistry
  - TBD, complement to LEO
- optional: lightning detection
  - complement to ground-based systems

Low Earth Orbit (Polar Sun-Synchronous Orbit (SSO) or other LEO)	
VIS/IR imagery, MW sounding IR hyperspectral sounding	SSO (13:30; 17:30; 21:30)
Radio-occultation sounding	Clusters, ≠ inclinations, mainly non-SSO
Ocean altimetry (2 components)	Precise non-SSO (Jason follow-on) SSO, 2 well separated orbital planes
Sea surface wind (2 scat+2 MWI)	SSO
Global Precipitation (radar)	65° inclination
Global Precipitation (passive MW)	Constellation with various orbits
Earth Radiation Budget	Mainly SSO + complement on GEO
Atmospheric composition	LEO and GEO (TBD)
Specific imagery	SSO
Geostationary and Highly Elliptical Orbit	
VIS/IR imagery (>16 ch), IR hyperspectral sounding	Geo (x 6)
Lightning detection (option)	Geo
High-latitude observation First for demo)	HEO

- User requirements have been assessed and compared with the capabilities of present/planned observing systems
- …leading to a gap analysis for “application areas” within WMO programmes:
  - synoptic meteorology
  - global NWP
  - regional NWP
  - nowcasting
  - seasonal and inter-annual forecasting

  - aeronautical meteorology
  - atmospheric chemistry
  - JCOMM ocean applications
  - agrometeorology
  - hydrology
  - climate monitoring (GCOS Adequacy Report and Implementation Plan)

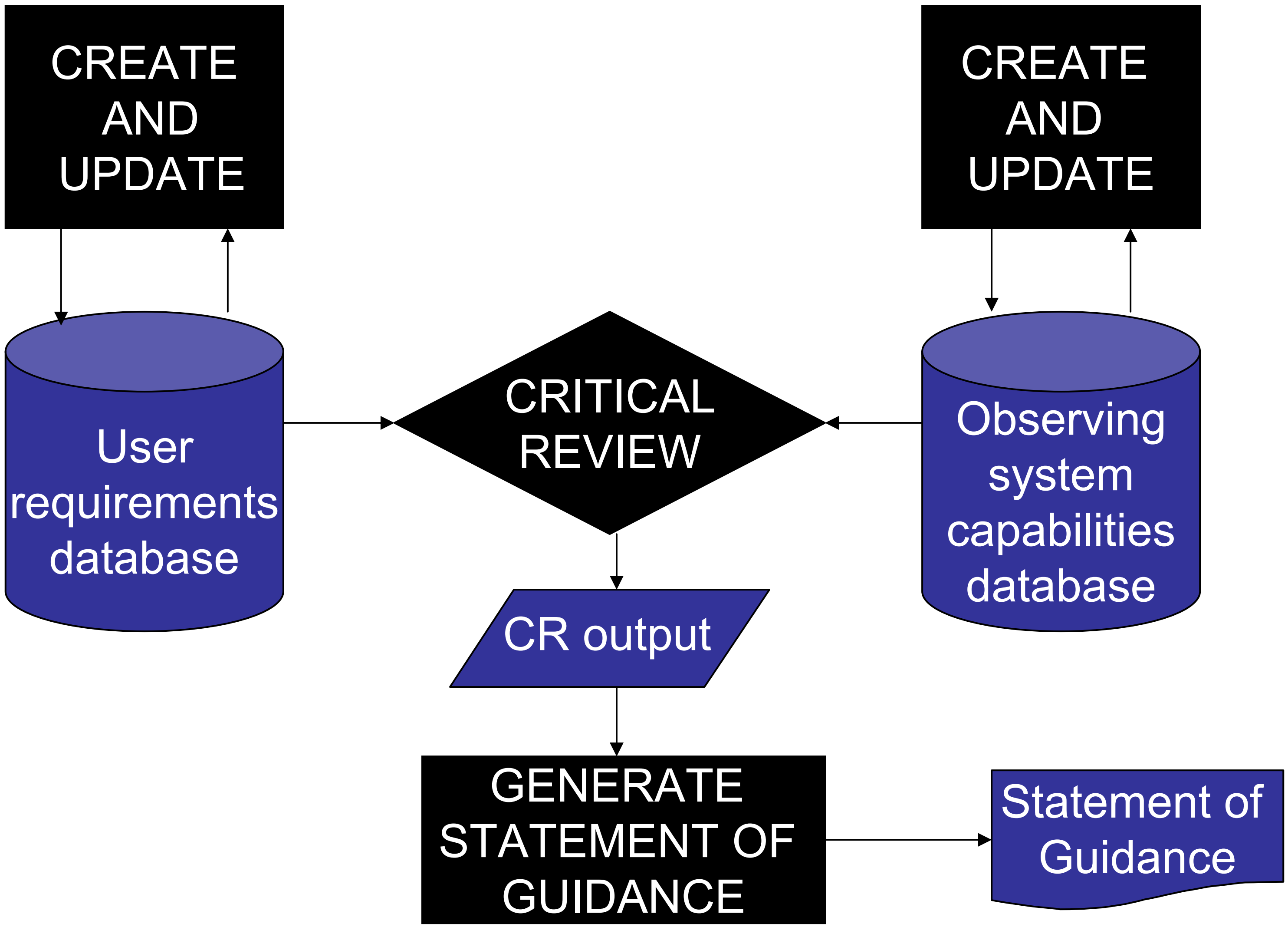
WMO Rolling Review of Requirements (RRR) process

- RRR addresses the question:
  - how well do present/planned/proposed observing systems meet user requirements (URs) for each "application area" within WMO programmes?

- Aims of RRR
  - to inform WMO members how well their requirements for observations are or will be met
  - to provide material to aid dialogue of WMO and its members with "observing system providers" (member states and space agencies)

RRR is intended to provide general guidance - it

The RRR process



Global Observing System (GOS)

- **Globally Coordinated**
- **Space and Surface-based**
- **Increasing role of space**

Evolution of the GOS
(7) Cross-cutting aspects

- Improved calibration
- Improved data access and data timeliness
- Consider the possibility of targeted observations
- Sustainability through transition of a number of R&D missions to operational status