International coordination for continuity and interoperability: a CGMS perspective

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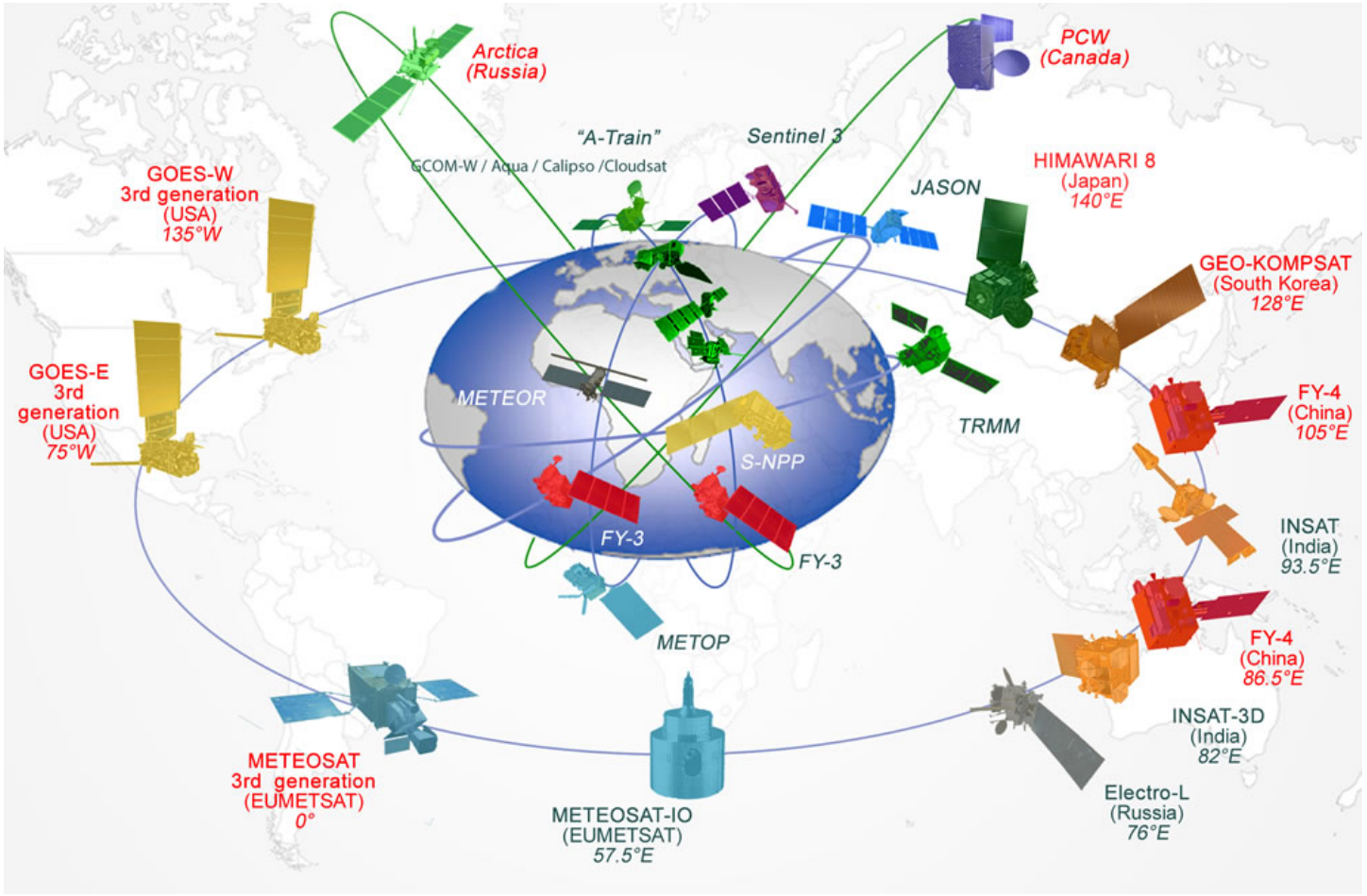
WMO space-based component of WIGOS

- reliable and sustained observation in operation
- Free, timely and standardized access



Outline

- CGMS, especially WG III
- Continuity
- Interoperability
- Challenges

1. CGMS and WG III

- Coordination Group for Meteorological Satellites
- Established in 1972, 16 members and 6 observers currently
- Operational or R&D satellite operators contributing to WMO and WMO-supported programmes (e.g. WWW, GAW, GCOS, JCOMM..)
- WMO and IOC representing global user communities

Organisation	Website	Accession
China Meteorological Administration	CMA	1989
Centre National d'Etudes Spatiales	CNES	2004
China National Space Administration	CNSA	2006
The European Space Agency	ESA	2003
EUMETSAT	EUMETSAT	1987
India Meteorological Department	IMD	1979
Intergovernmental Oceanographic Commission / UNESCO	IOC/Unesco	2001
Indian Space Research Organisation	ISRO	2015
Japan Aerospace Exploration Agency	JAXA	2003
Japan Meteorological Agency	JMA	1972
Korea Meteorological Administration	KMA	2005
National Aeronautics and Space Administration	NASA	2003
National Oceanic and Atmospheric Administration	NOAA	1972
Russian Federal Space Agency	ROSCOSMOS	2003
Russian Federal Service for Hydrometeorology and Environmental Monitoring	ROSHYDROMET	1973
World Meteorological Organization	WMO	1973

Organisation	Link
Canada Space Agency	CSA
Environment Canada	ENV CAN
Korea Aerospace Research Institute	KARI
Korea Ocean Research & Development Institute	KIOST
State Oceanic Administration	SOA
Global Climate Observing System	GCOS

CGMS Objectives & HLPP

CGMS provides technical coordination of satellite missions:

- Orbits, sensors, calibration
- Data formats, downlink frequencies
- Dissemination standards and techniques
- Cooperative mission planning and mutual back-up in case of system failure

High Level Priority Plan (HLPP) endorsed in 2012, covering:

1. Coordination of observing systems and protection of assets
2. Data dissemination, direct read out services and contribution to the WIS product development
3. Enhance the quality of satellite-derived data and products
4. Outreach and training activities
5. Cross-cutting issues and new challenges

CGMS Working Groups

- **Working Group I**: Global issues on satellite systems and telecommunication coordination
- **Working Group II**: Satellite data and products
- **Working Group III**: Operational continuity and contingency planning
- **Working Group IV**: Global data dissemination

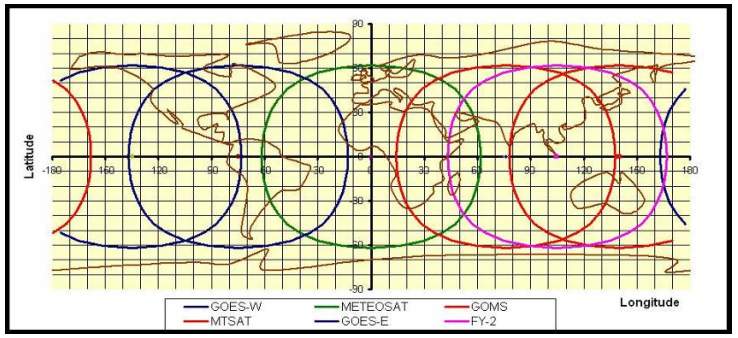
WG III monitors the risk of discontinuity in key data services for weather forecasting and climate monitoring, and deals with contingency action planning to mitigate such risks: global satellite planning supplemented by bilateral agreements based on the “help your neighbour” concept.

2. Continuity

The CGMS baseline: in-principle commitments of CGMS satellite operators to implement operational missions contributing to the WMO Vision for 2025

- Geostationary missions
- Sun-synchronous orbit missions on 3 orbital planes
- Other LEO missions on sun-synchronous or other orbits
- Intercalibration
- Back-up capability and contingency plan
- Near-real-time dissemination

CGMSBaseline : (1) Geostationary



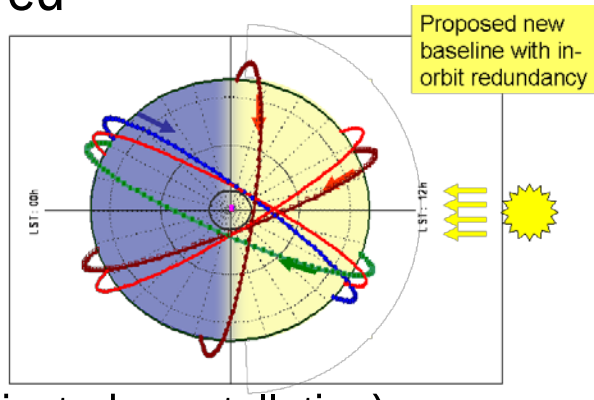
- At least 6 geostationary satellites at evenly distributed locations, with redundancy, and performing:

a) Multispectral Vis/IR imagery **every 15 min**
b) IR sounding (some of them **hyperspectral**)
c) Lightning detection
d) Data collection
e) Other missions as appropriate, e.g. ERB, **high spectral resolution UV sounding, Space Environment Monitoring**, data dissemination.

Routine intercalibration against reference instruments or calibration sites

CGMS Baseline: (2) Sun-synchronous (SSO)

A constellation of operational SSO satellites deployed around 3 orbital planes and performing :



f) Visible, Infrared and Microwave imagery
g) Microwave sounding
h) Infrared hyperspectral sounding (at least am and pm)
i) Wind scatterometry over oceans
j) Radio-occultation sounding (at least am-pm, plus dedicated constellation)
k) Broadband VIS/IR for Earth radiation balance (at least am-pm)
l) Total Solar Irradiance (at least one spacecraft)
m) Space environment monitoring
n) Data collection
o) Direct Broadcast
p) Other missions as appropriate, e.g. atmospheric composition

Routine intercalibration against reference instruments or calibration sites

CGMS Baseline : (3) Other LEO missions

The following missions shall be performed "on an operational basis" by Low Earth Orbit satellites on "appropriate orbits":

r) Ocean surface topography reference mission (high-precision, inclined orbit, in addition to the 2 altimeters on SSO)

s) Radio-Occultation sounding (constellation of sensors on appropriate orbits)

t) Narrow-band VIS/NIR imagers (at least one SSO am spacecraft) for ocean colour, vegetation, aerosol monitoring

u) High-resolution multi-spectral VIS/IR imagers (constellation of SSO satellites, preferably in am) for land surface imaging

v) Infrared imagery for reference high-accuracy SST (one am spacecraft)

- All passive instruments should be inter-calibrated on a routine basis against reference instruments or calibration sites.

Continuity requirements and implications on architecture

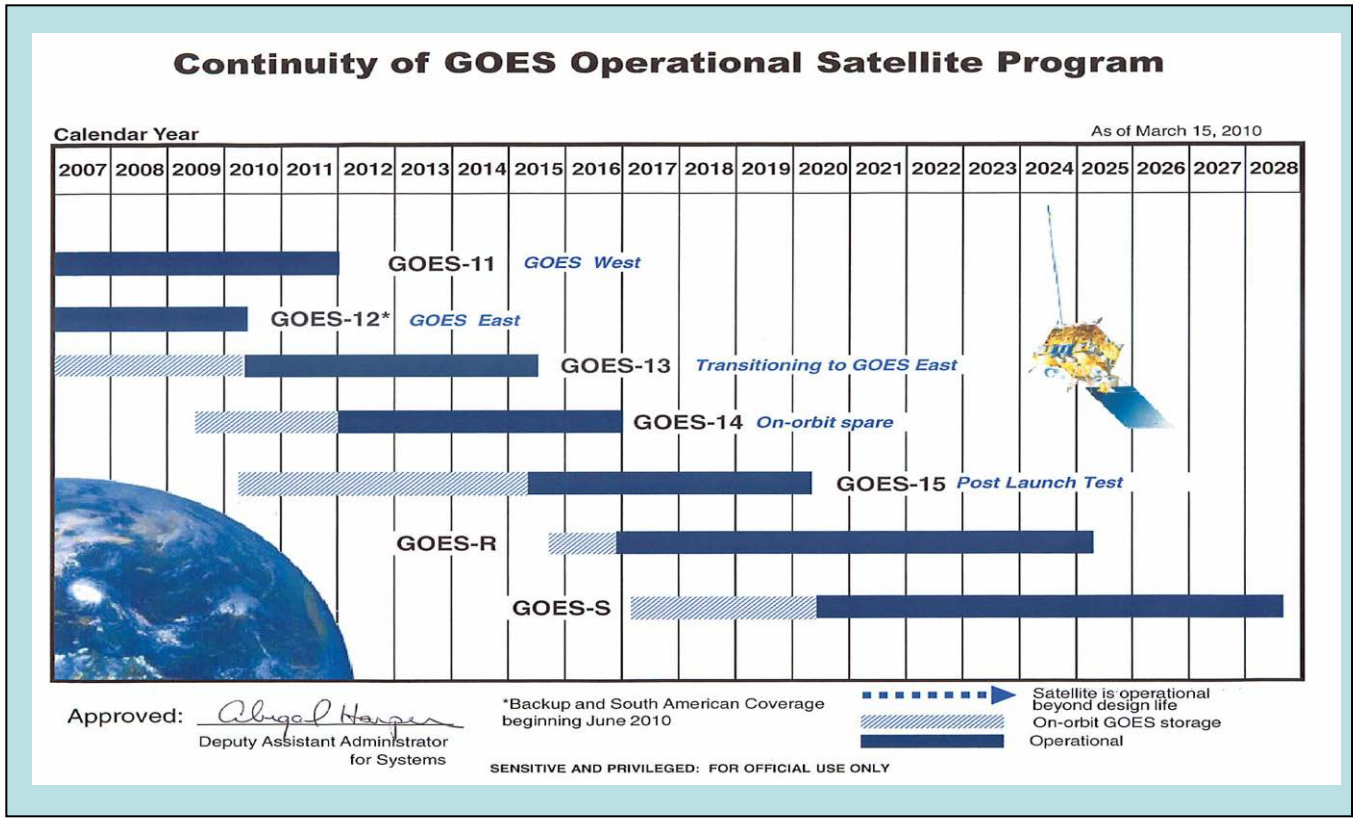
- Baseline should define for each mission :
  - nominal coverage (spatial/temporal sampling)
  - back-up provisions if relevant (contingency planning)
- First thing is to secure long-term funding and nominal planning
- Contingency planning approach
  - ➢ Risk analysis: for each mission, impact of degraded or no data?
  - – Criteria for contingency situation ?
  - – Mitigation strategy ?
  - – Cooperative decision framework for mutual support ?

CGMS Global Contingency Plan

- Recalls baseline GEO/LEO configurations for « weather missions »
- Risk management recommendations for programme implementation
  - Including back-up provisions
- Contingency criteria based on critical mission continuity requirements
  - GEO imagery, LEO sounding/ imagery, Data access , Tropical Cyclone regions
- Framework for mutual support in case of contingency on GEOs
  - « Help-your-neighbour ! » aproach, supported by bilateral agreements
- Climate missions addressed in referring to GCOS Climate Monitoring Principles for satellites: avoid drift of ECT (LEO), launch on schedule with overlap, ground-truth for calibration

Different « continuity » approaches

(a) Classical « operational » continuity with on-orbit back-up



Different « continuity » approaches

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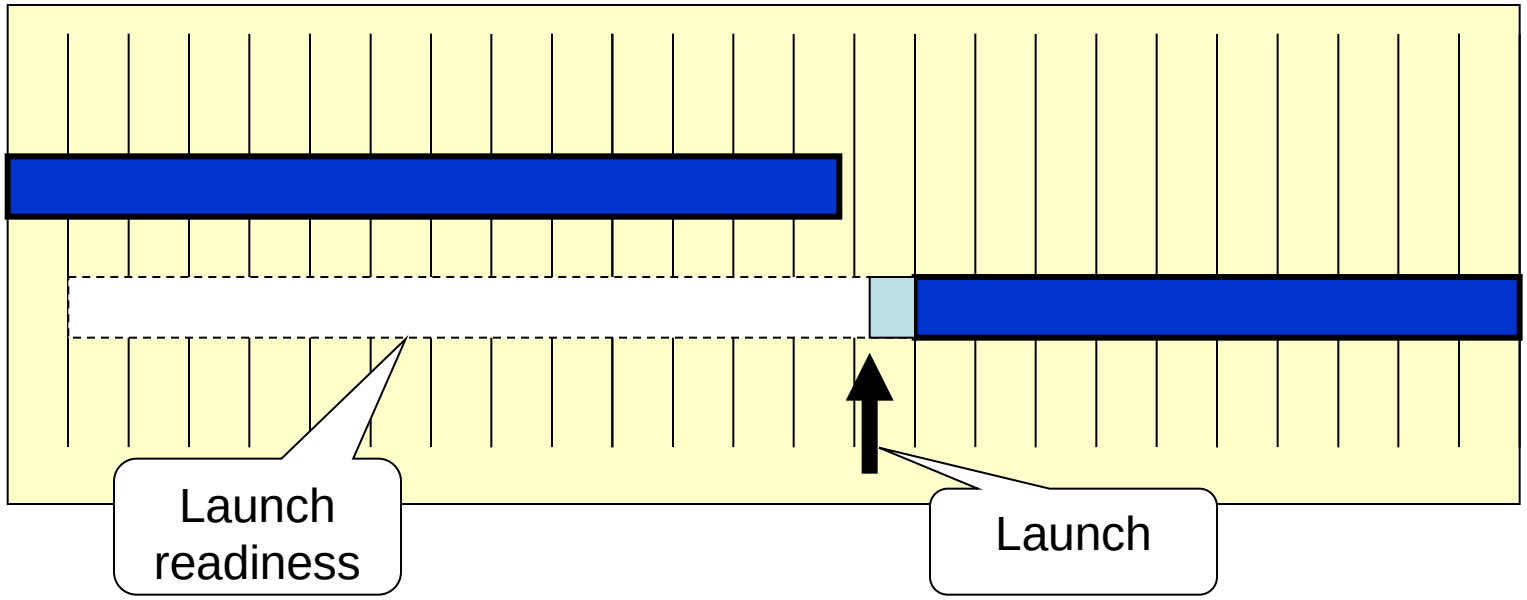
(b) Launch upon failure

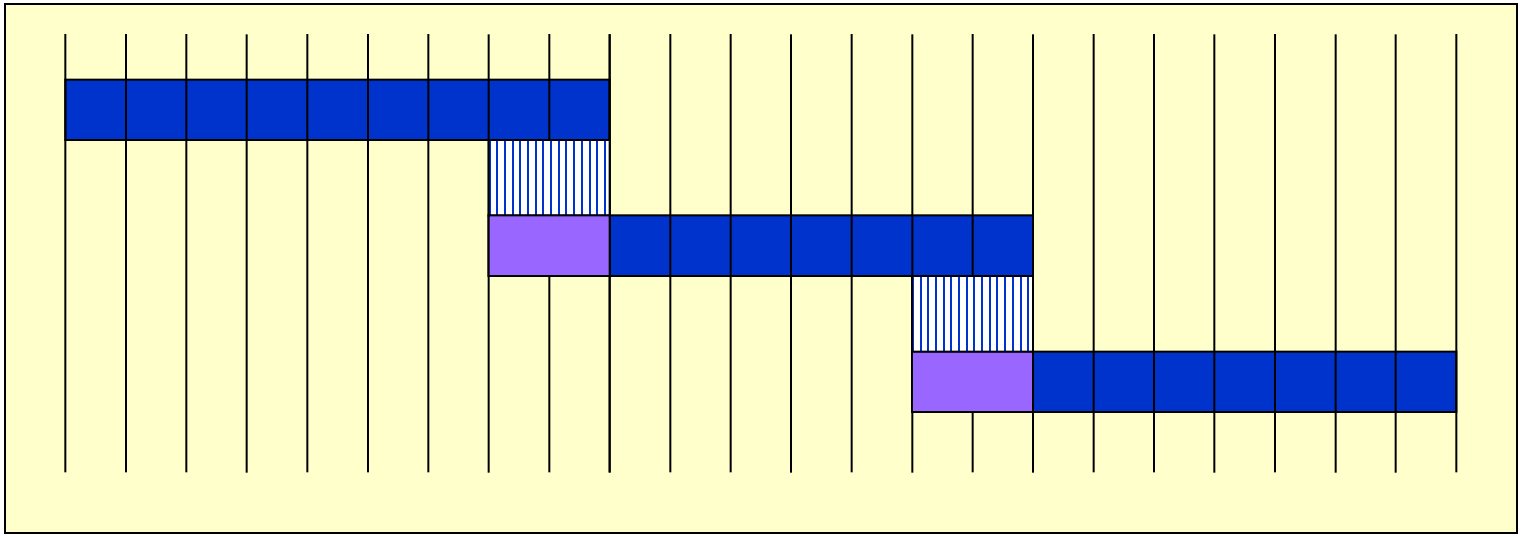


Different « continuity » approaches

(a) Classical « operational » continuity with on-orbit back-up

(b) Launch upon failure

(c) Overlap for cross-calibration and product validation



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(a) Classical « operational » continuity with on-orbit back-up

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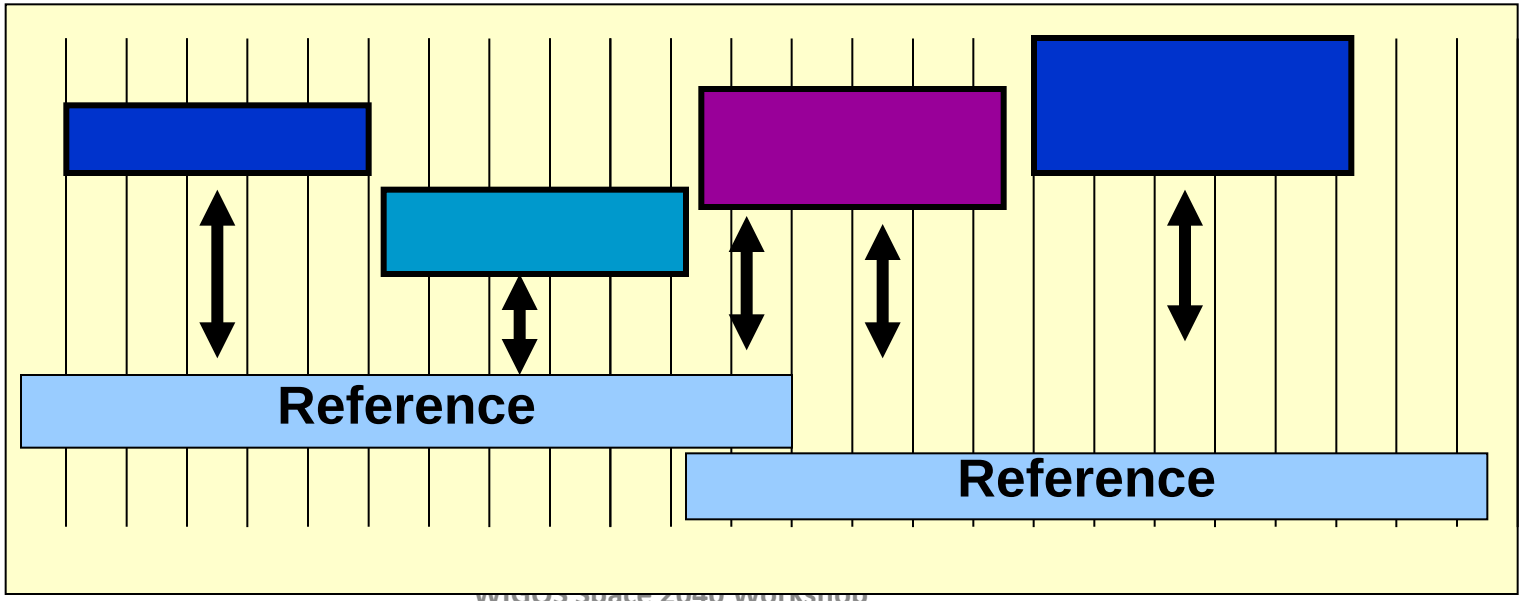
(d) Consecutive missions with reference for consistent calibration



Different « continuity » approaches

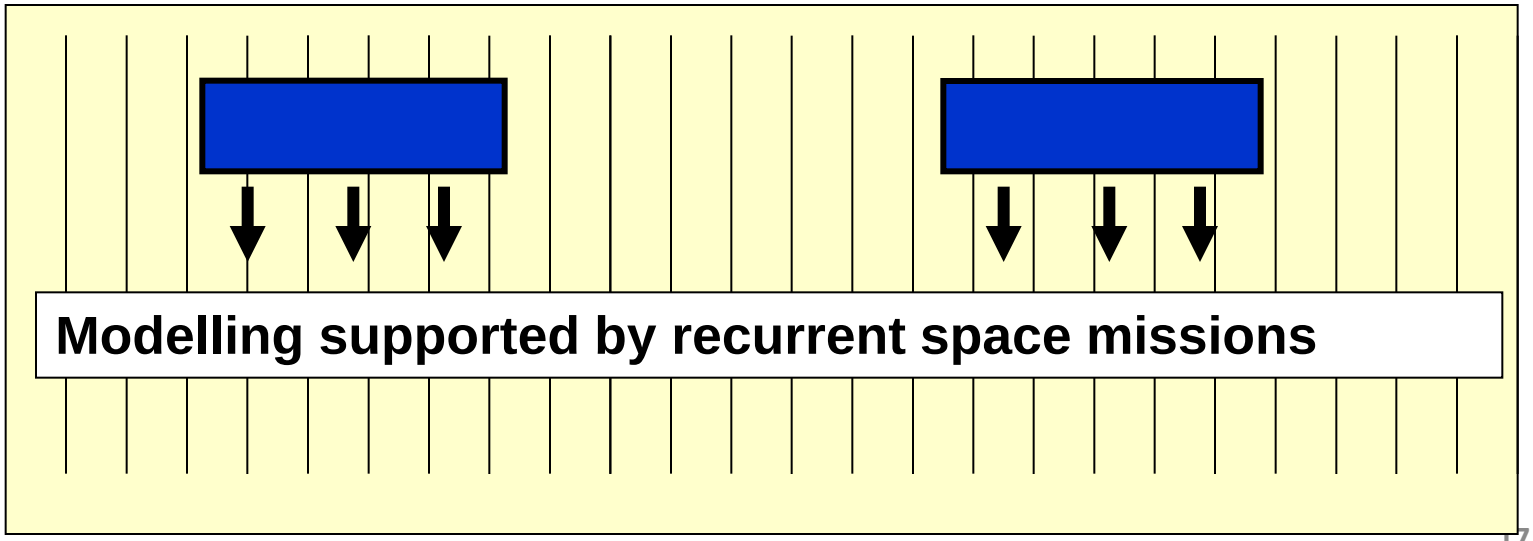
(a) Classical « operational » continuity with on-orbit back-up

(b) Launch upon failure

(c) Overlap for cross-calibration and product validation

(d) Consecutive missions with reference for consistent calibration

(e) Recurrent missions as anchor observations for model validation



3. Interoperability

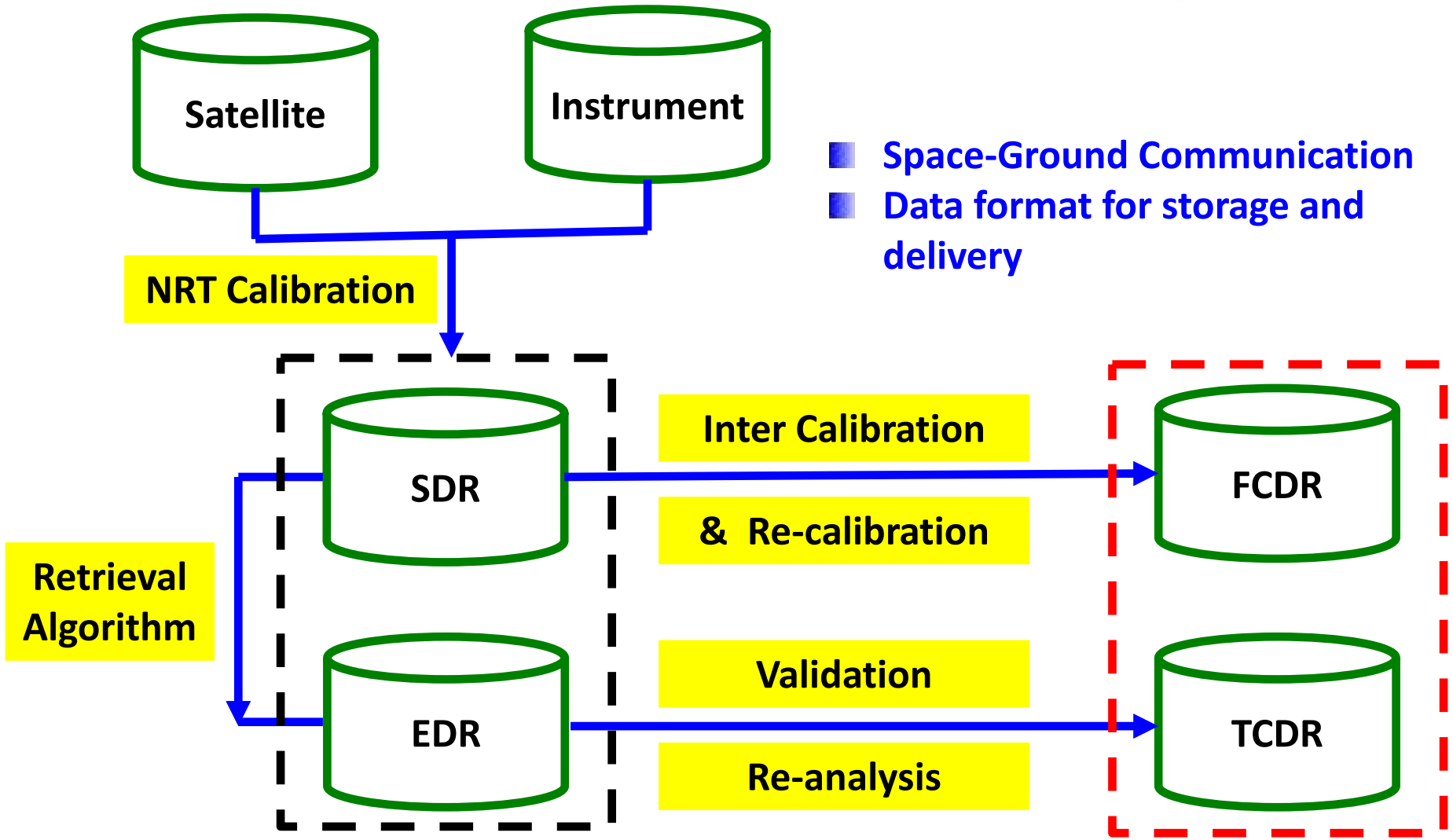
Interoperability is a key requirement which entails

comparable observations

standardized metadata

Interoperability should cover all the components for EO

Components for EO



- Space-Ground Communication
- Data format for storage and delivery

- Sensor-dependent, weather and environmental usage
- Sensor-dependent or sensor-independent, climate usage

Interoperability

Data access

- data format convertible
- metadata standardization
- Direct Broadcast standards (CCSDS …)
- Preprocessing Software package

Satellite and Instrument

- overlap requirement during transition (TBC)
- backward compatibility to the predecessor

Satellite Data Record (SDR)

- Calibration with on-orbit calibration system
- Validation to show the uncertainty of data
- Measurement reference standards (in-orbit, at surface, on Moon) for data inter-calibration and traceability

Environmental Data Record (EDR)

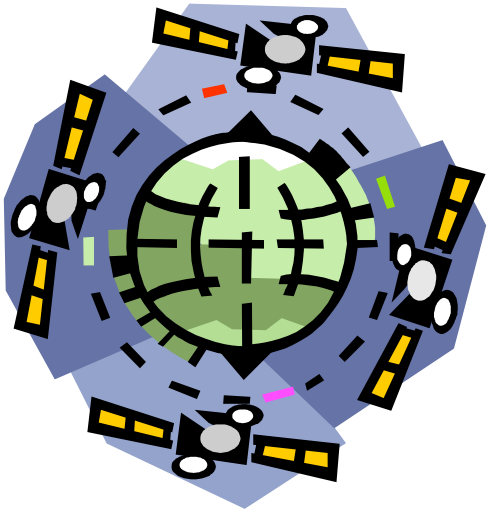
- Retrieval algorithm comparable
- Validation with in-situ, space-based baseline product and model output to show the uncertainty

Fundamental /Thematic Climate Data Records (FCDR and TCDR)

- Gap analysis and planning coordination for continuity
- Comparability of new sensors with heritage datasets
- Consistency and traceability through reference standards and inter-calibration procedures
- Generation and preservation of archived SDR and EDR through the recalibration and reanalysis procedure

4. Challenges

- The WMO Vision for 2040 should specify continuity and interoperability requirements
- CGMS will consider updating its baseline in response to future WMO Vision for 2040 (SDR & EDR)
- Should encompass continuity of climate observation to support the GCOS ECVs (FCDR & TCDR)
- Be open to allow use of new satellite and instrument technology, such as new R&D satellite, cube satellite
- Big Data Information Technology , such as cloud computing



Special thanks to Dr. Jerome Lafeuille for

His excellent work as rapporteur of CGMS WG-III ;

Support and discussions for this slides