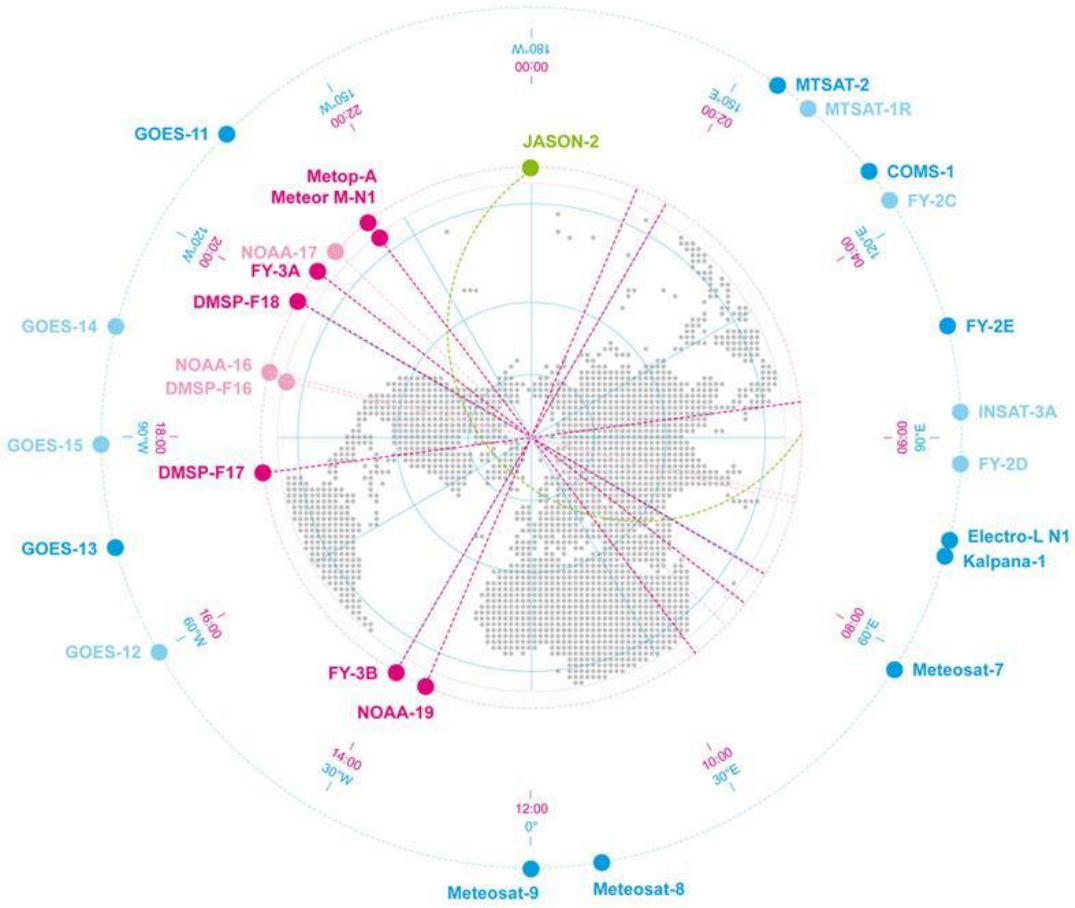


CGMS Risk Assessment

Presented to CGMS-49 Plenary
Following discussions in the CGMS working groups
Agenda Item 4, Working Group reports

CGMS Baseline - Background

- The CGMS Baseline enumerates the sustained observations, measurements, and services that form the CGMS contribution to observing the Earth System, Space Environment and the Sun.

- The CGMS baseline responds to end-user requirements expressed in WMO's Rolling Review of Requirements (RRR).

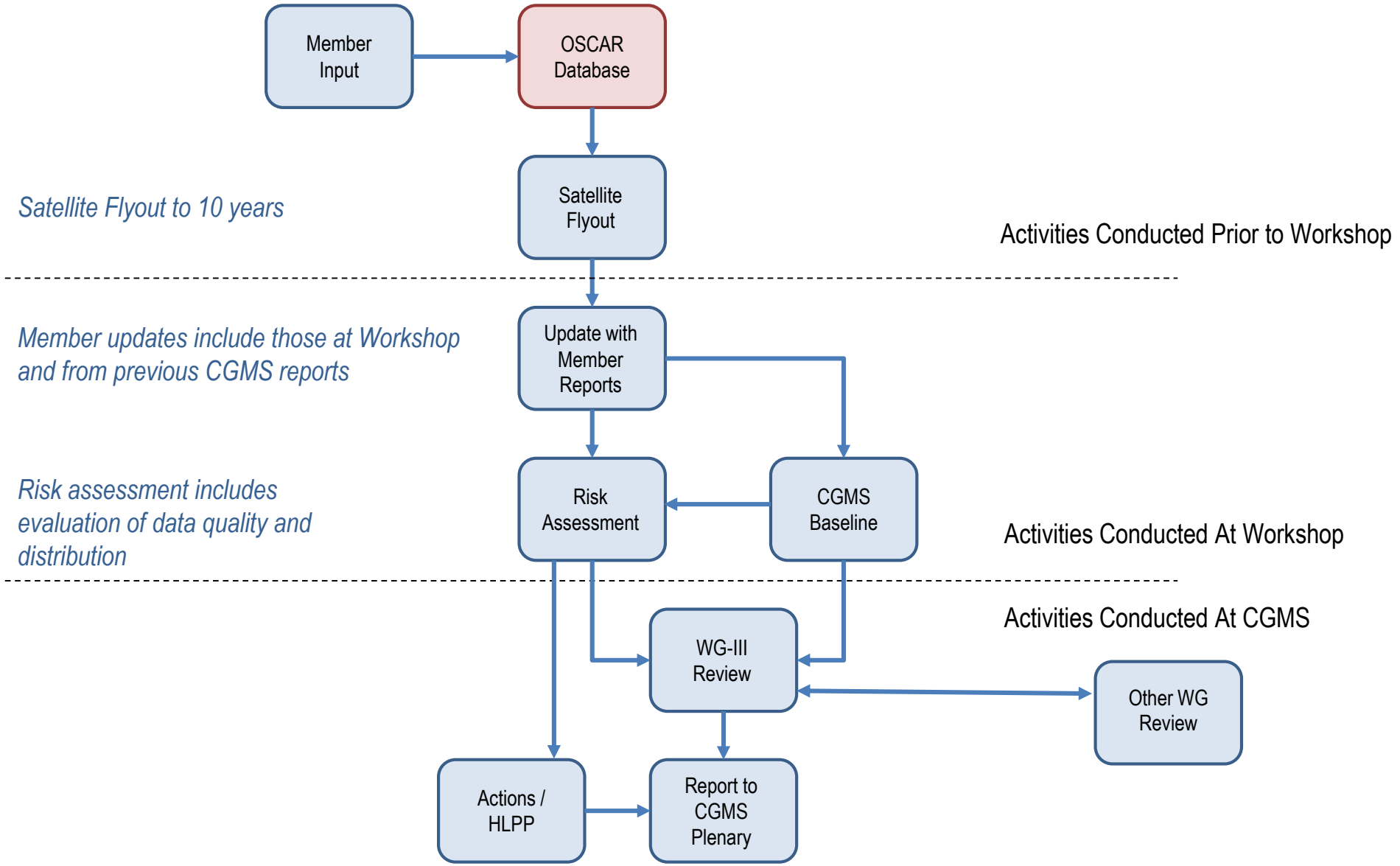
- The CGMS Baseline strives to support the WMO Integrated Global Observing System (WIGOS) 2040 vision.

- Key principles:
  - Commitment: The CGMS Members are providing, or have firm plans to provide, the observations, measurements, and services enumerated in the Baseline
  - Sustained: The observations, measurements, and services are provided on a sustained basis
  - Available: The observations, measurements, and services are available on a free and open basis
  - Operational: The data and products can be utilized in operational applications

CGMS Baseline - Background

- The CGMS Baseline constitutes the CGMS response to the WIGOS 2040 Vision to document what missions are currently being, or planned on being flown. The CGMS baseline will be included in the WMO Manual on WIGOS.
- WMO will conduct a ***Gap Analysis*** between the WIGOS 2040 Vision Tier 1 and the CGMS Baseline to review implementation of WIGOS.
- CGMS conducts an annual ***Risk Assessment*** against the baseline to track how CGMS is meeting its commitments.
- The CGMS Risk Assessment will be completed every year forming the basis for CGMS actions to ensure continuity.

CGMS Baseline Update / Risk Assessment Process



CGMS Risk Assessment Assumptions

- The top-level risk assessment for each sensor/observation is based on a qualitative analysis of all the orbits and satellite missions from which the observation is provided.
- This assessment is given from a CGMS Member prospective and may not:
  - Include contributions from non-CGMS agencies
  - Include contributions from commercial providers
  - Incorporate all WMO requirements (which are covered by the gap analysis).
- CGMS Members will develop and operate satellites in response to their national priorities.
- System resiliency, nor the consequence of not meeting commitments was not specifically addressed.
- Lack of a satellite in geostationary orbit is more likely to cause a gap in observations, while a lack of a satellite in low-Earth orbit may only degrade system performance.
- Quality and availability were not analyzed in detail for all measurements.
- The assessment is based on planned launch dates, design life, and updated by operational experience.

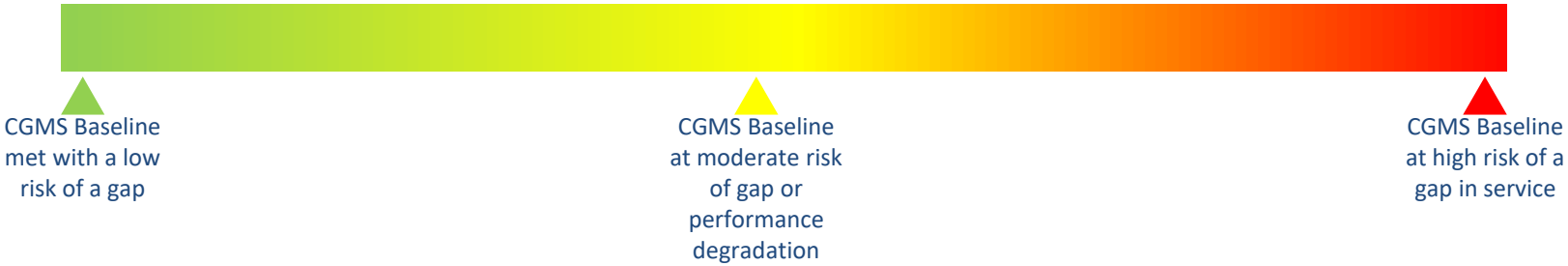
CGMS Risk Assessment Assumptions

- The information and assessment are based on the OSCAR Database as updated by WMO, member organizations and WGIII participants, as well as direct input from CGMS Members.
- The assessment is a qualitative assessment done by Risk Assessment Workshop participants.
- There is uncertainty in planned launch dates, satellite lifetimes (e.g., satellites often operate beyond their design life), operational readiness, and on-orbit health – all of which impact the risk assessment and ultimately the users.
- ***Member owned and operated payloads hosted on commercial platforms are included when launch dates are determined***

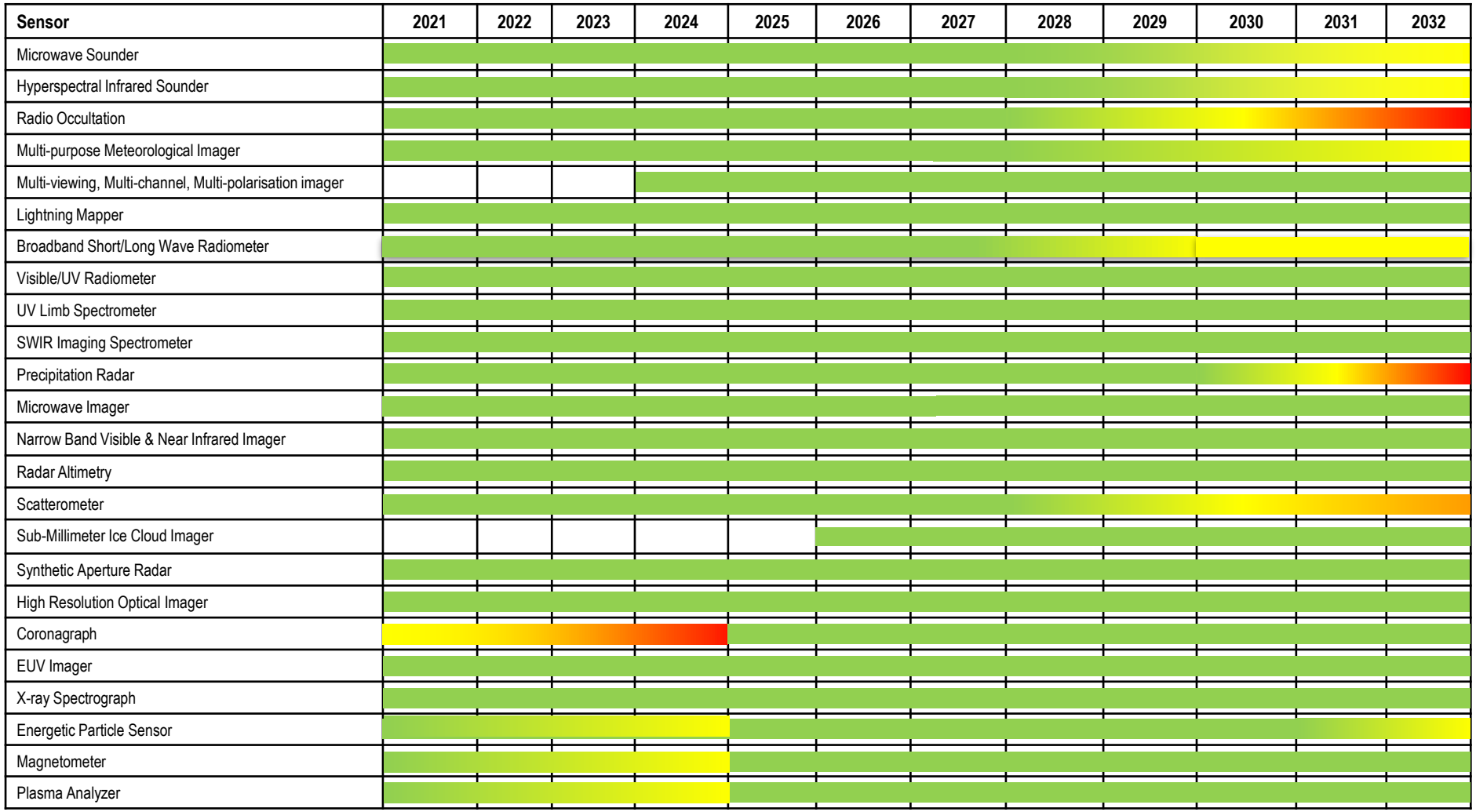
Note: The detailed charts are by calendar year. As such, if a mission launches in June, it will appear for the full calendar year, or if it's EOL is June, it will also still appear to go through the end of the calendar year.

CGMS Risk Assessment Assumptions

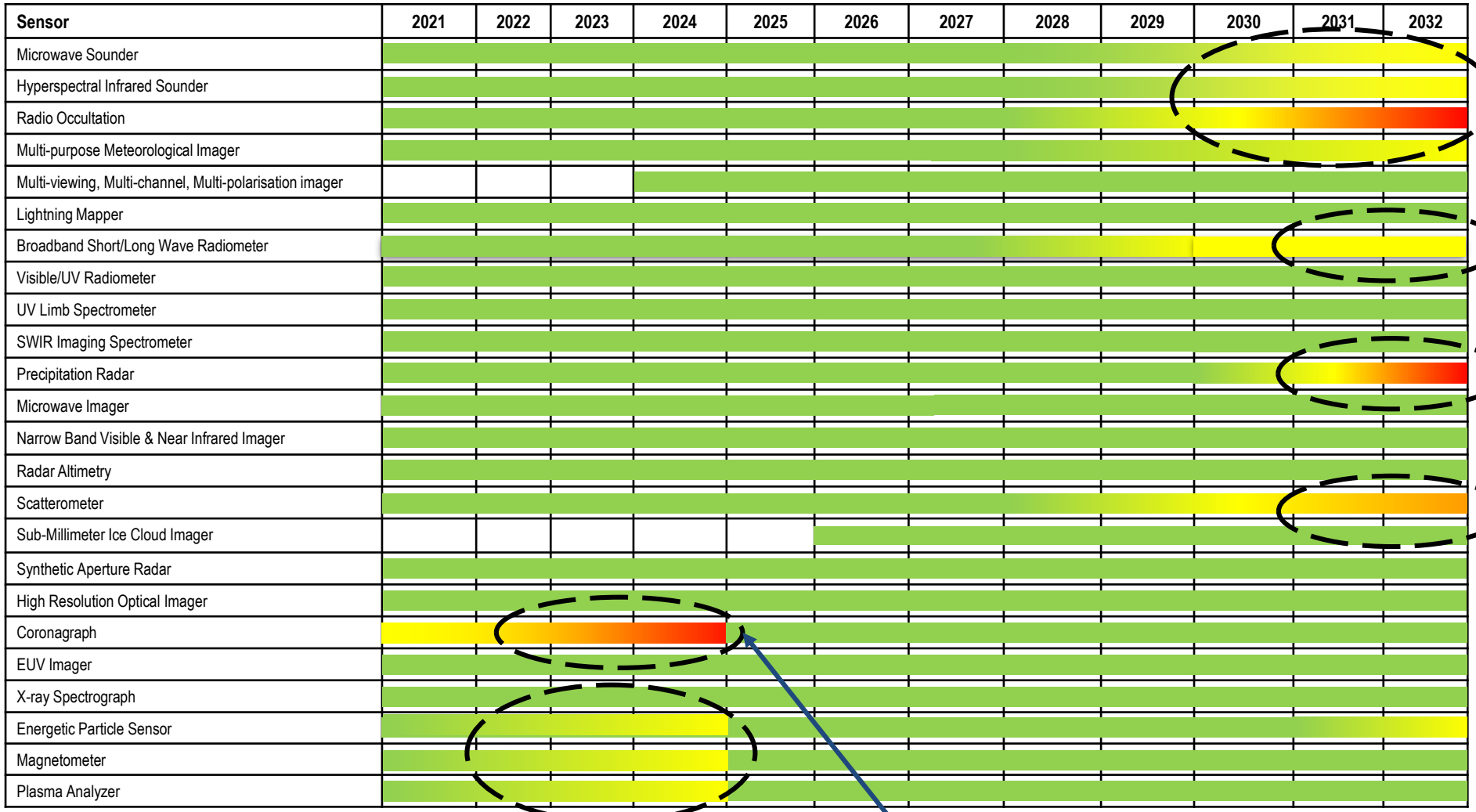
- CGMS Risk Assessment uses **Green**, Yellow, and Red to graphically represent the overall status of that sensor/observation. The criteria for each colour is as follows:
  - **Green:** CGMS Baseline met with a low risk of a gap.
  - **Yellow:** The CGMS Baseline is at moderate risk of not being fully met. Some mitigation by CGMS Members may be required.
  - **Red:** There is a high risk of not meeting the CGMS Baseline without CGMS Member action
  - No Colour: Observation is not planned to be available until a later date



Top-Level Risk Assessment (2021)



Top-Level Risk Assessment (2021)



Top-Level Risk Assessment (2021) – Focus Areas

- Long term continuity risk for critical sensors (e.g., Microwave and Hyperspectral Sounders and Multipurpose Imagers) in the early morning orbit towards the end of the decade
  - CMA planning underway for a follow-on to FY-3E in the early morning orbit
  - A WMO Tiger Team will assess the benefit of the early morning orbit to inform CMA's plans
- Continuity risk for the number and geographic distribution of radio occultations; especially in the low inclination orbits
  - Recommendation to CGMS members to fly RO sensor providing coverage in the low- to mid-latitudes
- Long term continuity risk for Broadband Short/Long Wave Radiometer in the early morning orbit
  - CMA planning is underway for a follow-on to FY-3E in the early morning orbit
  - GEO contributions are not identified in the CGMS Baseline; the WG has taken the action to consider whether they should be added at the WGII/III Joint Session in April
- No long term plans for Precipitation Radar observations
  - CMA should confirm plans beyond FY-3G
  - NASA and JAXA should confirm plans beyond GPM Core

Top-Level Risk Assessment (2021) – Focus Areas

- Long term continuity risk for Scatterometry in the early morning and afternoon orbits
  - ISRO should confirm plans beyond Oceansat-3
- Risk of a gap in Coronagraph sensors in the near term
  - Recommend SWCG identify alternative data sources to mitigate potential unavailability of coronagraph observations
  - CGMS Members to continue to propose near-term alternative data sources for consideration as gap mitigation in event of loss or degradation of current L1 capabilities prior to SWFO-L1 data availability
  - WGIV to consider recommended gap mitigation observation requests and develop plans to ensure near real-time access to those data
- Risk of gap in Energetic Particle sensor in the near term
  - Recommend SWCG review baseline requirement for orbital positions as opposed to number of satellites
- Risk of gap in Plasma Analyser and Magnetometer sensors at L1 in the near term
  - CGMS Members to identify near-term alternative data sources for consideration as gap mitigation in event of loss or degradation of current L1 capabilities prior to SWFO-L1 data availability

Top-Level Risk Assessment (2021) – Recommended and Existing Associated Actions

Recommended Actions

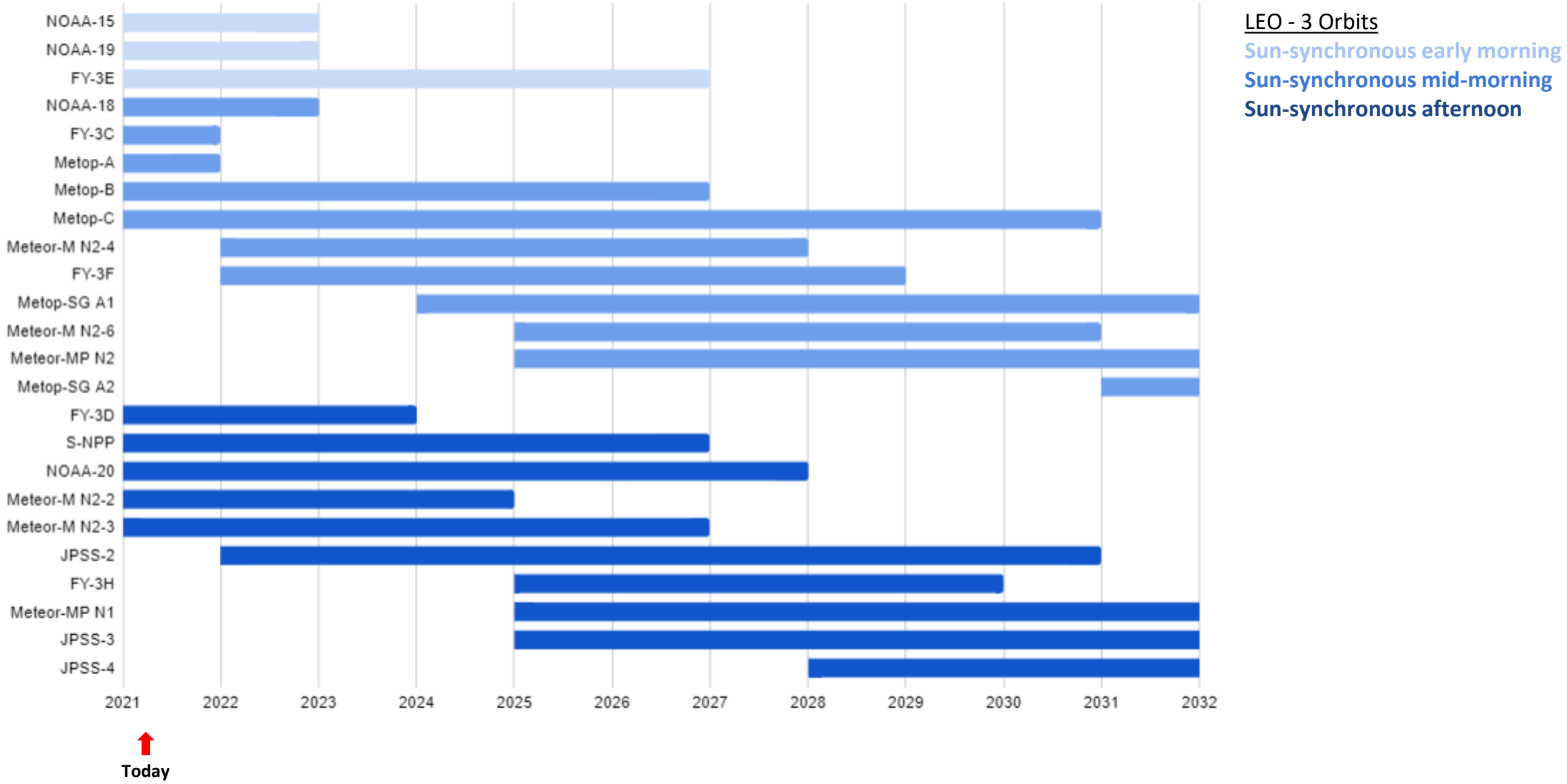
- Recommend action for ISRO to update CGMS-50 on their plans for a hyperspectral sounder in geostationary orbit.
- Recommend action for CMA to confirm plans to fly a precipitation radar beyond FY-3G.
- Recommend action for NASA and JAXA to confirm plans to fly a precipitation radar beyond the GPM Core.
- Recommend action for EUMETSAT and ESA to report on plans for the CIMR (Copernicus Imaging Microwave Radiometer) Mission
- ISRO to confirm plans beyond Oceansat-3 series
- Recommend SWCG identify alternative data sources to mitigate potential unavailability of coronagraph observations
- Recommend SWCG review baseline requirement for orbital positions as opposed to number of satellites for energetic particle observations

Existing Associated Actions

- CMA planning is underway for a follow-on to FY-3E in the early morning orbit
- CMA and WMO will establish a Tiger Team following the launch of FY-3E to assess the benefit of the early morning orbit to inform CMA's future planning
- NOAA and NASA to confirm plans on accommodation of a radiation budget instrument on JPSS-3 and beyond
- WGII/III to consider whether observations from geostationary orbit should be added to the CGMS baseline requirements for the broadband short/long wave radiometer
- CGMS Members to continue to propose near-term alternative data sources for consideration as gap mitigation in event of loss or degradation of current L1 capabilities prior to SWFO-L1 data availability; WGIV to consider recommended gap mitigation observation requests and develop plans to ensure near real-time access to those data

Coordination Group for Meteorological Satellites - CGMS

Microwave Sounder (Atmospheric Temperature, Humidity, and Precipitation)



Microwave Sounder (Atmospheric Temperature, Humidity, and Precipitation)

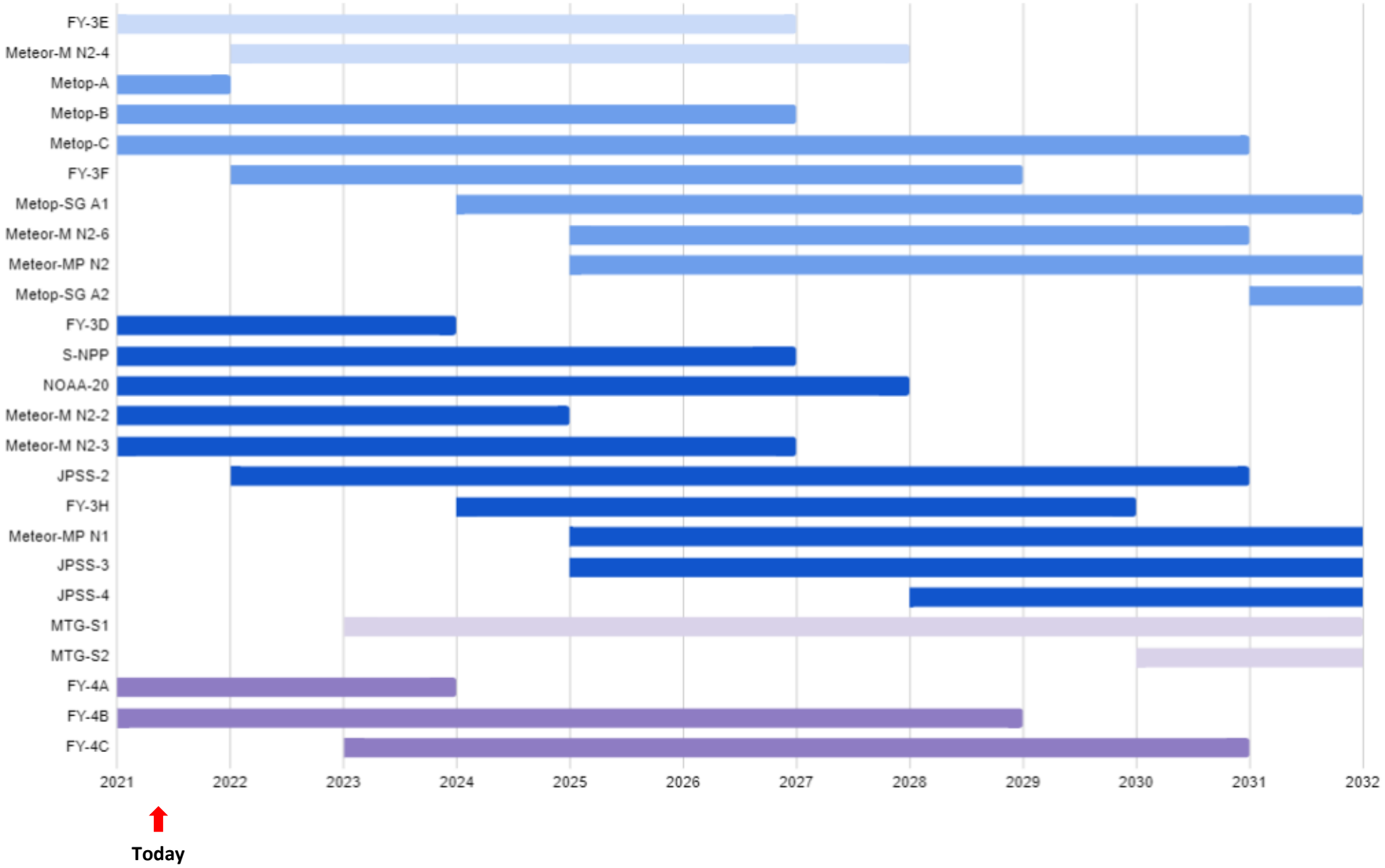
- The CGMS Baseline commitment is met through the first part of the decade; there is a risk of a gap in the later part of the decade
- CMA planning is underway for a follow-on to FY-3E in the early morning orbit
- A WMO Tiger Team will assess the benefit of the early morning orbit to inform CMA's plans
- The HLPP already has an objective (1.1) to ensure long term continuity of the early morning orbit, in particular for IR/MW soundings

WGIII Assessment:

The CGMS Baseline commitment is met for the first half of the decade and at risk of a gap in the early morning orbit later in the decade. No additional recommendation necessary.

Coordination Group for Meteorological Satellites - CGMS

Hyperspectral Infrared Sounder (Atmospheric temperature, humidity, and winds Atmospheric composition: CO, CO2, SO2 , depending on spectral band also CH4 and NH3)



LEO - 3 Orbits

Sun-synchronous early morning

Sun-synchronous mid-morning

Sun-synchronous afternoon

GEO - 2 Slots

0°

86.5°-105°E range

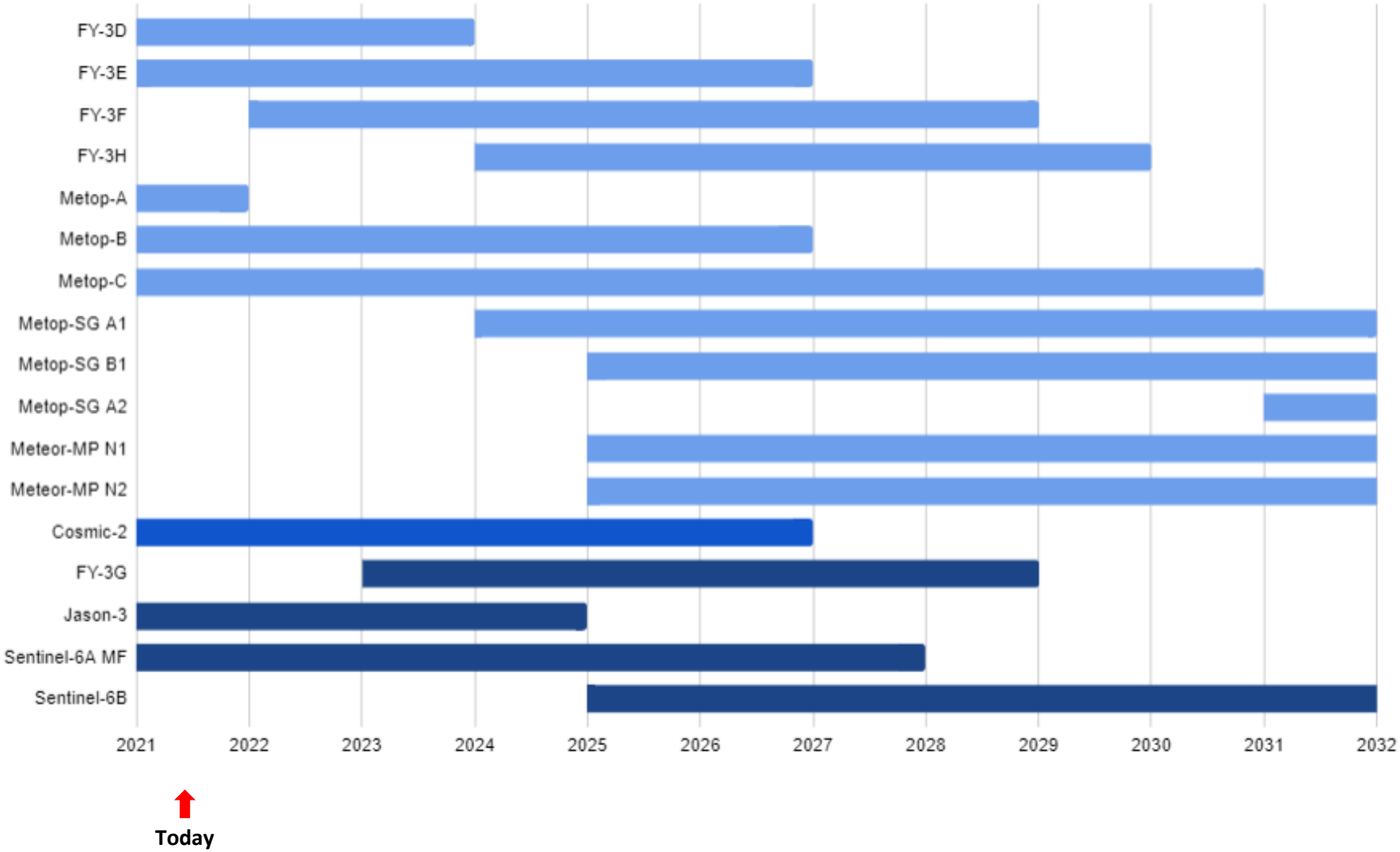
Hyperspectral Infrared Sounder (Atmospheric Temperature, Humidity, Atmospheric Composition &

- The CGMS Baseline commitment is met through the first part of the decade; there is a risk of a gap in the early morning in the later part of the decade
- CMA planning is underway for a follow-on to FY-3E in the early morning orbit
- A WMO Tiger Team will assess the benefit of the early morning orbit to inform CMA's plans
- The HLPP already has an objective (1.1) to ensure long term continuity of the early morning orbit, in particular for IR/MW soundings

WGIII Assessment:

The CGMS Baseline commitment is met for the first half of the decade and at risk of a gap in the early morning orbit later in the decade. No additional recommendation necessary. Note the HLPP objective (1.2) to expand hyperspectral sounding from GEO to the full geostationary ring. Propose action for ISRO to update CGMS-50 on their plans for a hyperspectral sounder in geostationary orbit.

Radio Occultation (Atmospheric Temperature, Humidity, and Ionospheric Electron Density)



LEO - 3 Orbits

7600 occultations from sun-synchronous

6000 occultations from **low inclination (<30°)**

1000 occultations from **other drifting orbits**

Radio Occultation (Atmospheric Temperature, Humidity, and Ionospheric Electron Density)

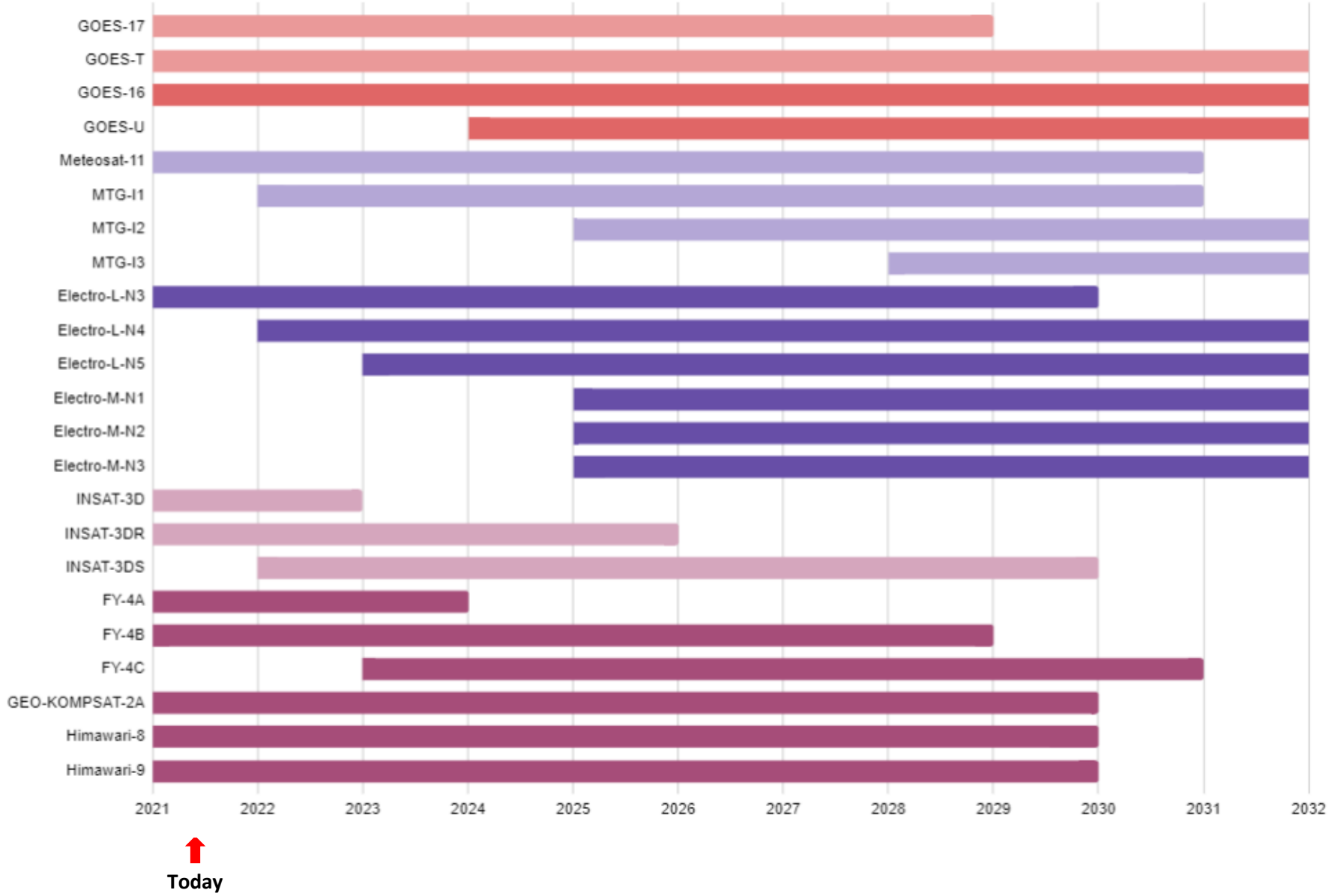
- The CGMS Baseline commitment is met through the first part of the decade; however, there is a high risk of not meeting the commitment from low inclination orbits in the later part of the decade as there are no plans for a follow-on to COSMIC-2
- Inconsistent coverage from polar and high inclination orbits throughout the period (commitment for number of occultations can be met, but not the geographic distribution or performance to meet NWP requirements

WGIII Assessment:

The CGMS Baseline commitment is met in for the first half of the decade but may not fully meet NWP requirements. Commercial operators could offer some risk mitigation (would need to ensure compliance with national and international mandates and policies). FY3RM may offer additional mitigation. An HLPP objective (1.2) already exists to advance the atmospheric Radio Occultation constellation, with the long-term goal of providing 20000 occultations per day on a sustained basis; consider an additional recommendation for tropical missions to carry RO sensors.

Coordination Group for Meteorological Satellites - CGMS

Multi-purpose Meteorological Imagers (multispectral, visible and IR) (Sea Surface Temperature, Aerosols, Land Surface Temperature, Cloud Properties, Feature Tracking Winds (AMV), Flood Mapping, Fires, Cryosphere Applications (sea ice, snow cover, etc.)



GEO - Evenly spaced satellites

137°W

75.2°W

0°-41.5°E range

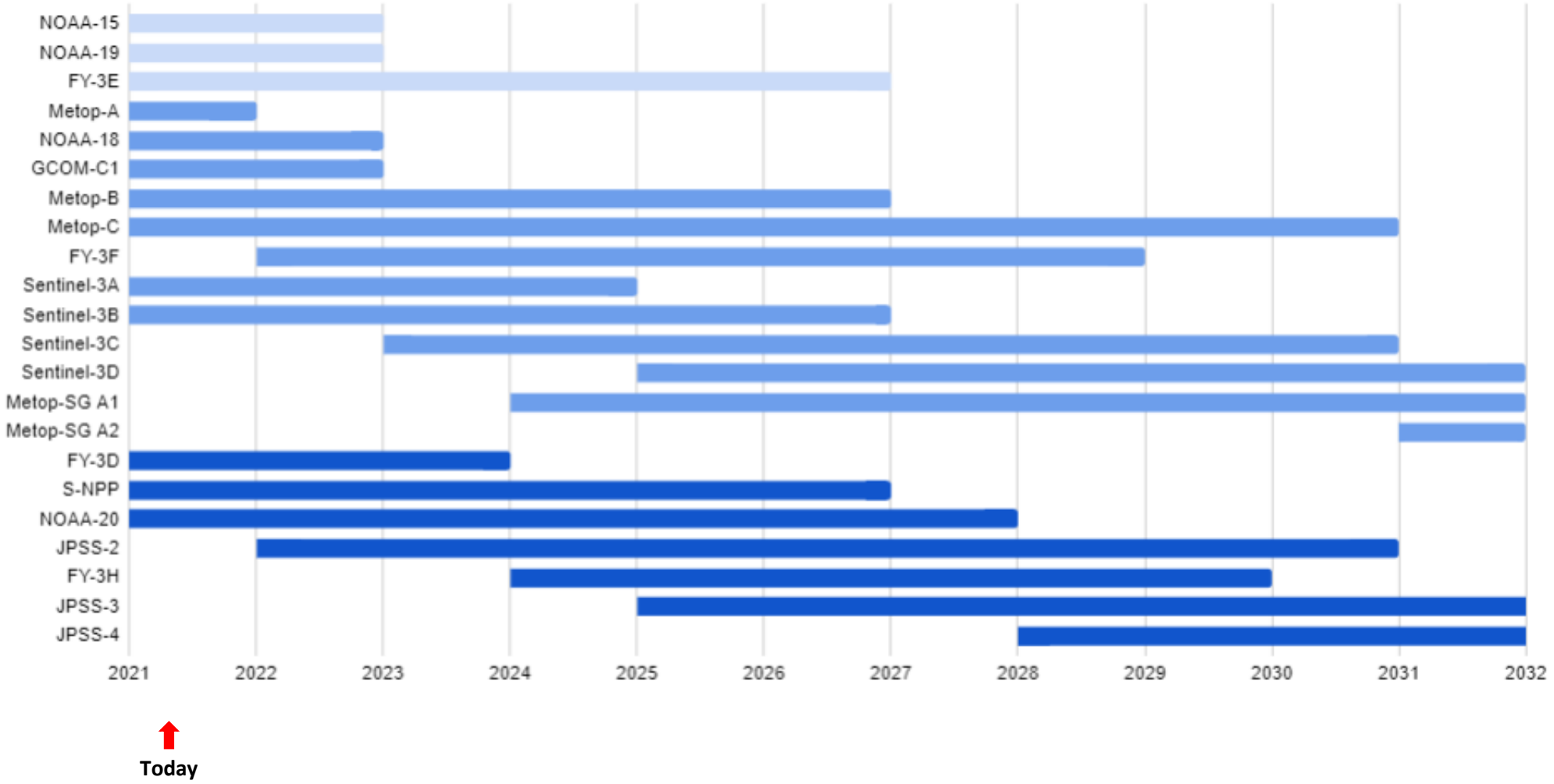
14.5°W-165.8°E range

74°-82°E range

86.5°-140°E range

Coordination Group for Meteorological Satellites - CGMS

Multi-purpose Meteorological Imagers (multispectral, visible and IR) (Sea Surface Temperature, Aerosols, Land Surface Temperature, Cloud Properties, Feature Tracking Winds (AMV), Flood Mapping, Fires, Cryosphere Applications (sea ice, snow cover, etc.),



LEO

Sun-synchronous early morning

Sun-synchronous mid-morning

Sun-synchronous afternoon

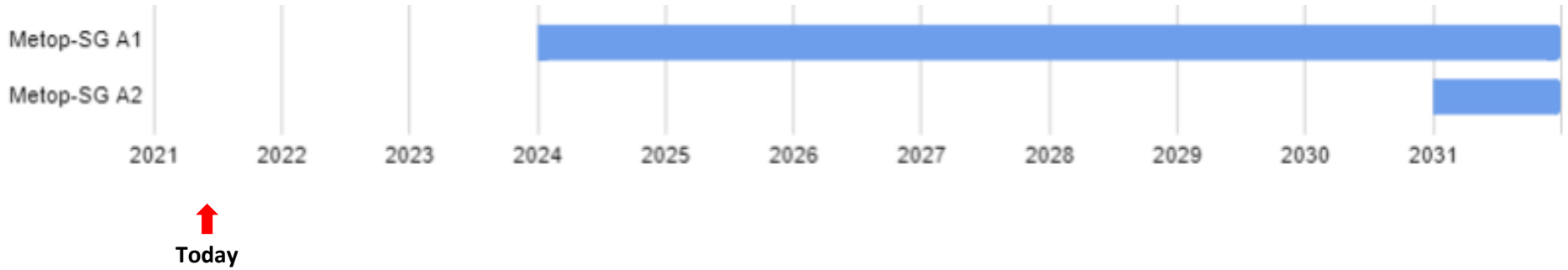
Multi-purpose Meteorological Imagers (multispectral, visible and IR) (Sea Surface Temperature, Aerosols, Land Surface Temperature, Cloud Properties, Feature Tracking Winds (AMV), Flood Mapping, Fires, Cryosphere Applications (sea ice, snow cover, etc.), Ocean Colour)

- The CGMS Baseline commitment is met through the first part of the decade; there is a risk of a gap in the early morning orbit in the later part of the decade
- CMA planning is underway for a follow-on to FY-3E in the early morning orbit
- A WMO Tiger Team will assess the benefit of the early morning orbit to inform CMA's plans
- The HLPP already has an objective (1.1) to ensure long term continuity of the early morning orbit

WGIII Assessment:

The CGMS Baseline commitment is met for the first half of the decade and at risk of a gap in the early morning orbit later in the decade. No additional recommendation necessary.

Multi-viewing, Multi-channel, Multi-polarisation Imager (Aerosol)

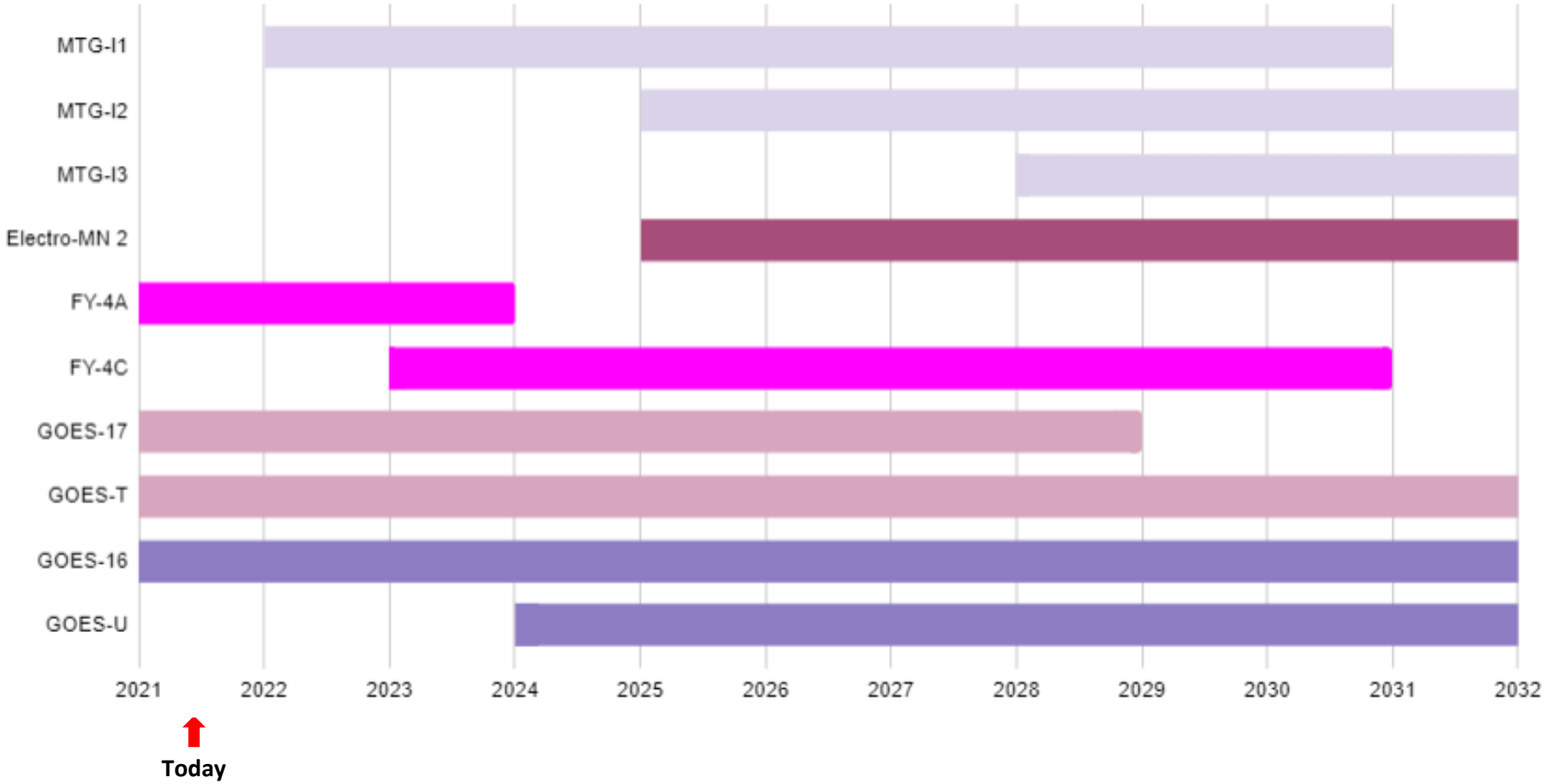


LEO - 1 orbit
Sun-synchronous

WGIII Assessment:

The CGMS Baseline commitment is met starting in 2023. Low risk of a gap in meeting commitments. No additional recommendation necessary.

Lightning Mapper (Lightning)

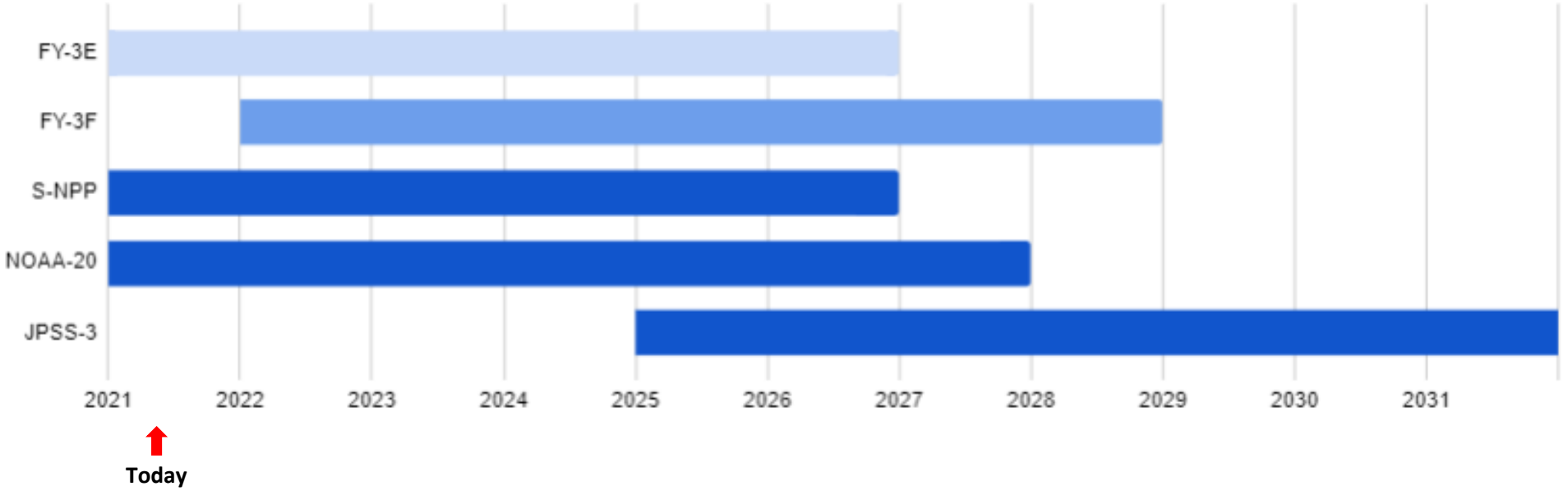


GEO
0°
76°E
86.5°-105°E range
137°W
75.2°W

WGIII Assessment:

Low risk of not meeting the CGMS Baseline commitment. An HLPP objective (1.2) exists to provide the capability for the whole geostationary ring.

Broadband Short/Long Wave Radiometer (Radiation Balance)



LEO - 2 Orbits

Sun-synchronous early morning

Sun-synchronous mid-morning

Sun-synchronous afternoon

Broadband Short/Long Wave Radiometer (Radiation Balance)

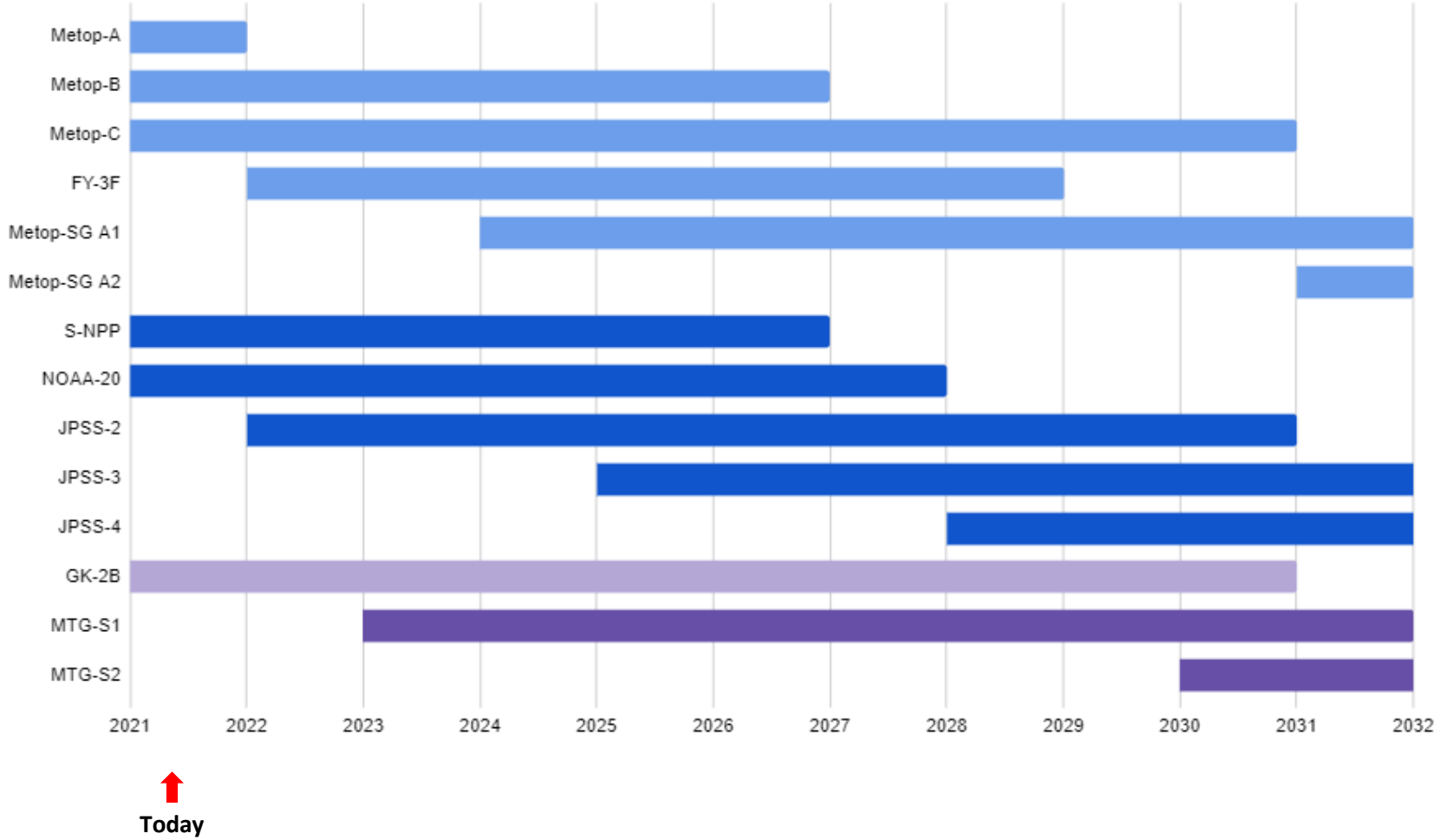
- The CGMS Baseline commitment is met through most of the decade; there is a risk of not meeting commitments at the end of assessment horizon
- CMA planning is underway for a follow-on to FY-3E in the early morning orbit
- There are no plans to fly a RBI on JPSS-2, and NOAA and NASA are to confirm plans on accommodation of a radiation budget instrument on JPSS-3 and beyond
- Additional analysis is required to determine whether observations from geostationary orbit should be added to the Baseline

WGIII Assessment:

The CGMS Baseline commitment is met for the first half of the decade and at risk of a gap in the early morning orbit later in the decade. No additional recommendation necessary.

GEO contributions are not identified in the CGMS Baseline; the WG has taken the action to consider whether they should be added at the WGII/III Joint Session in April

Visible / UV Spectrometer (Aerosol, Atmospheric Composition: O3, CO2, NO2, SO2, BrO. C)



LEO - 2 Orbits

Sun-synchronous mid-morning

Sun-synchronous afternoon

GEO - 2 Slots

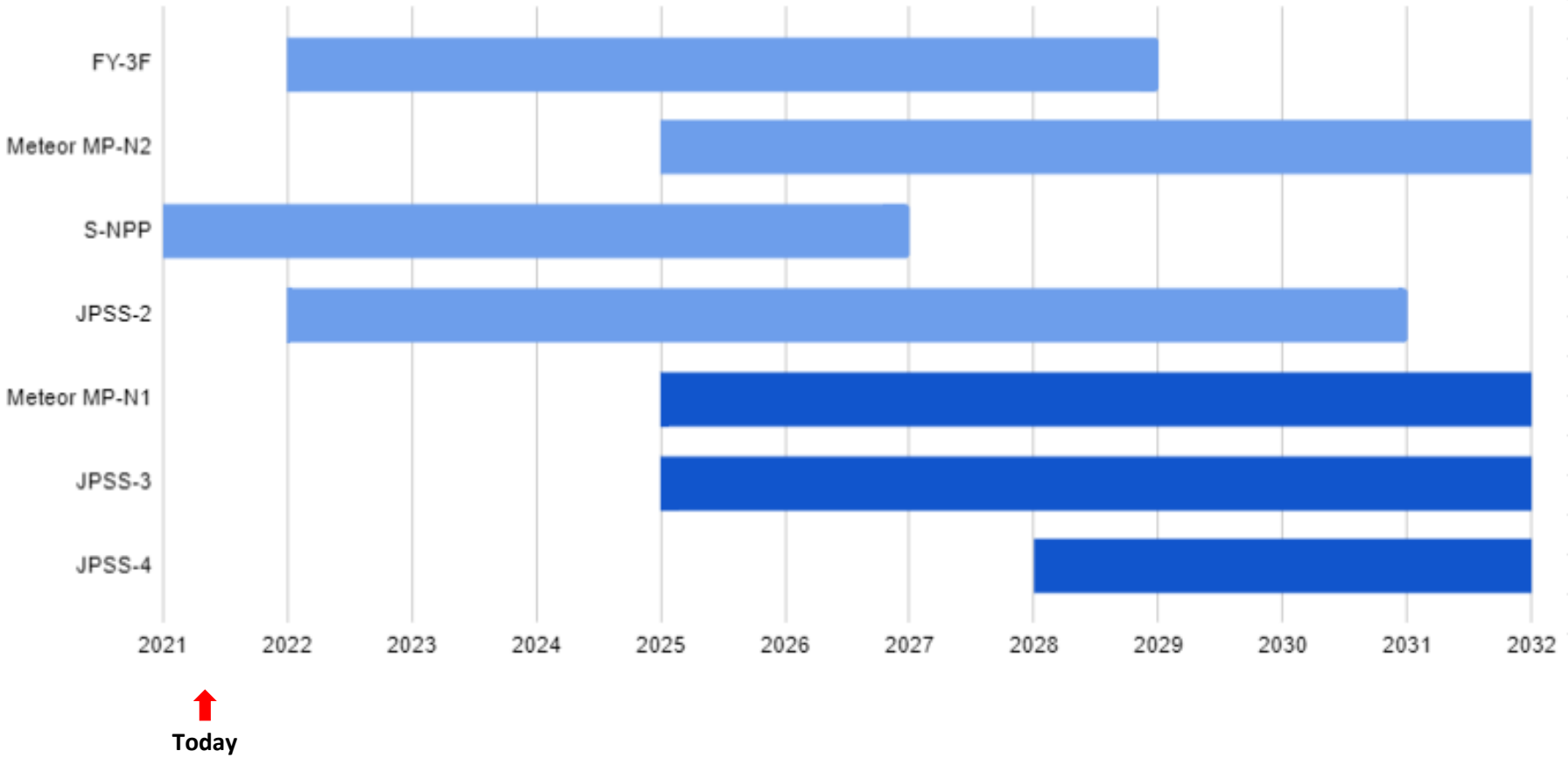
128.2°E

0°

WGIII Assessment:

Low risk of not meeting the CGMS Baseline commitment.

UV Limb Spectrometer (Aerosol, Atmospheric Composition: O3)



LEO - 2 Orbits

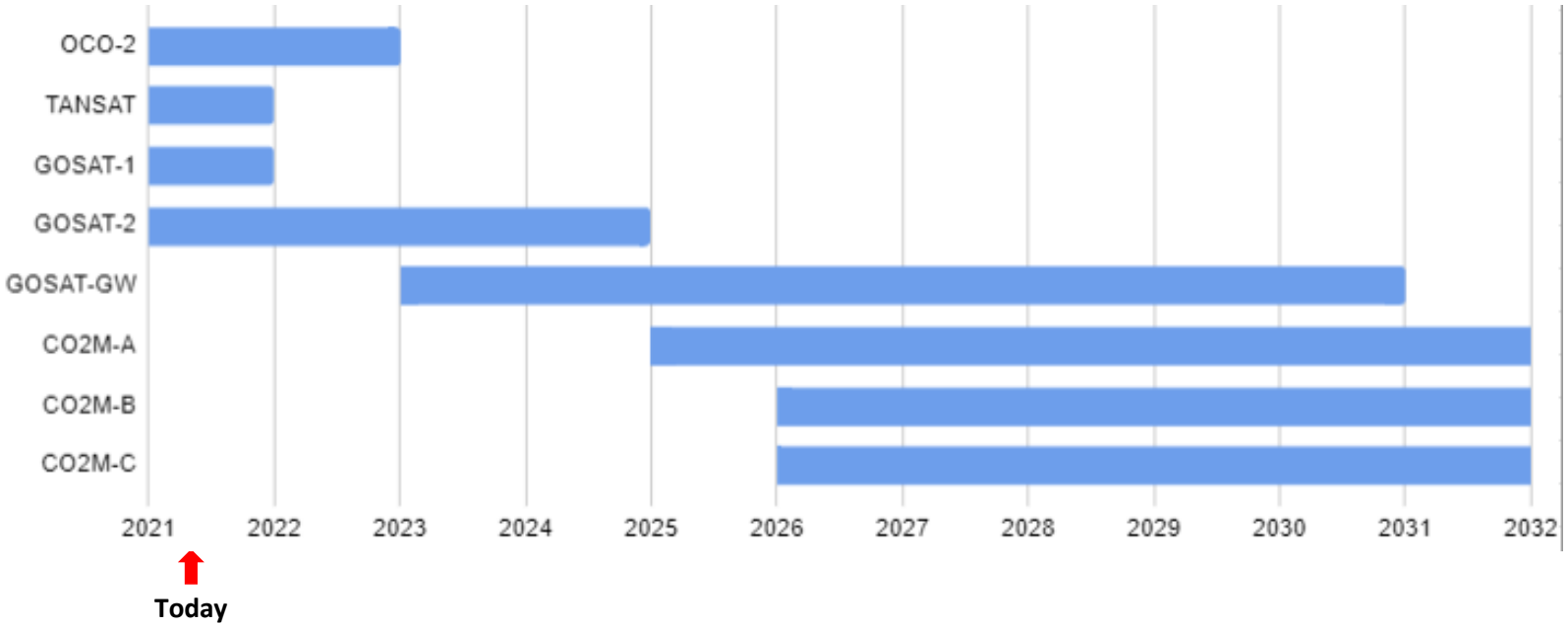
Sun-synchronous mid-morning

Sun-synchronous afternoon

WGIII Assessment:

Low risk of not meeting the CGMS Baseline commitment until later part of the decade.

SWIR Imaging Spectrometer (Atmospheric Composition: CO2, CH4)



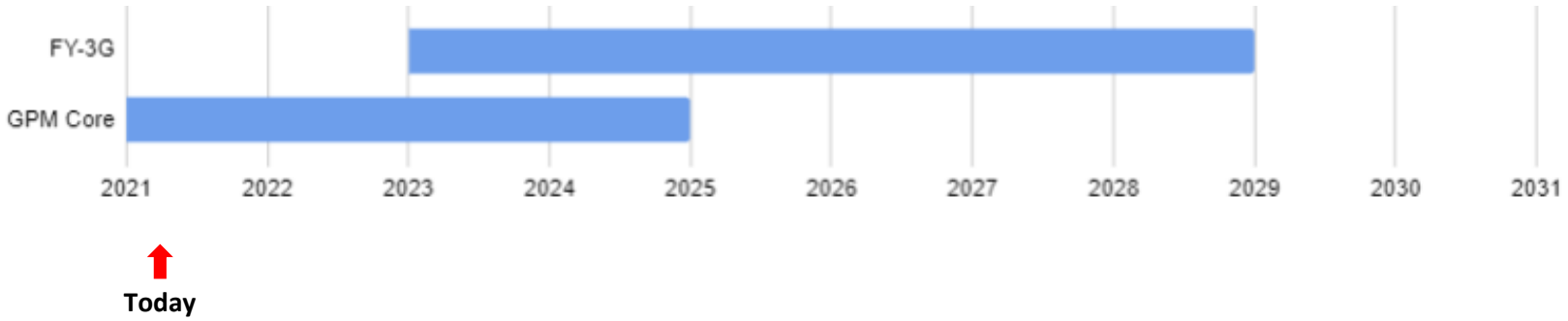
LEO - 2 Orbits
(late morning or afternoon)
Sun-synchronous afternoon

- The CGMS Baseline commitment is met through the decade.

WGIII Assessment:

The CGMS Baseline commitment is met in this decade. An HLPP action to coordinate long-term CO2 monitoring has been taken by the Joint Working Group on Climate.

Precipitation Radar (Precipitation)



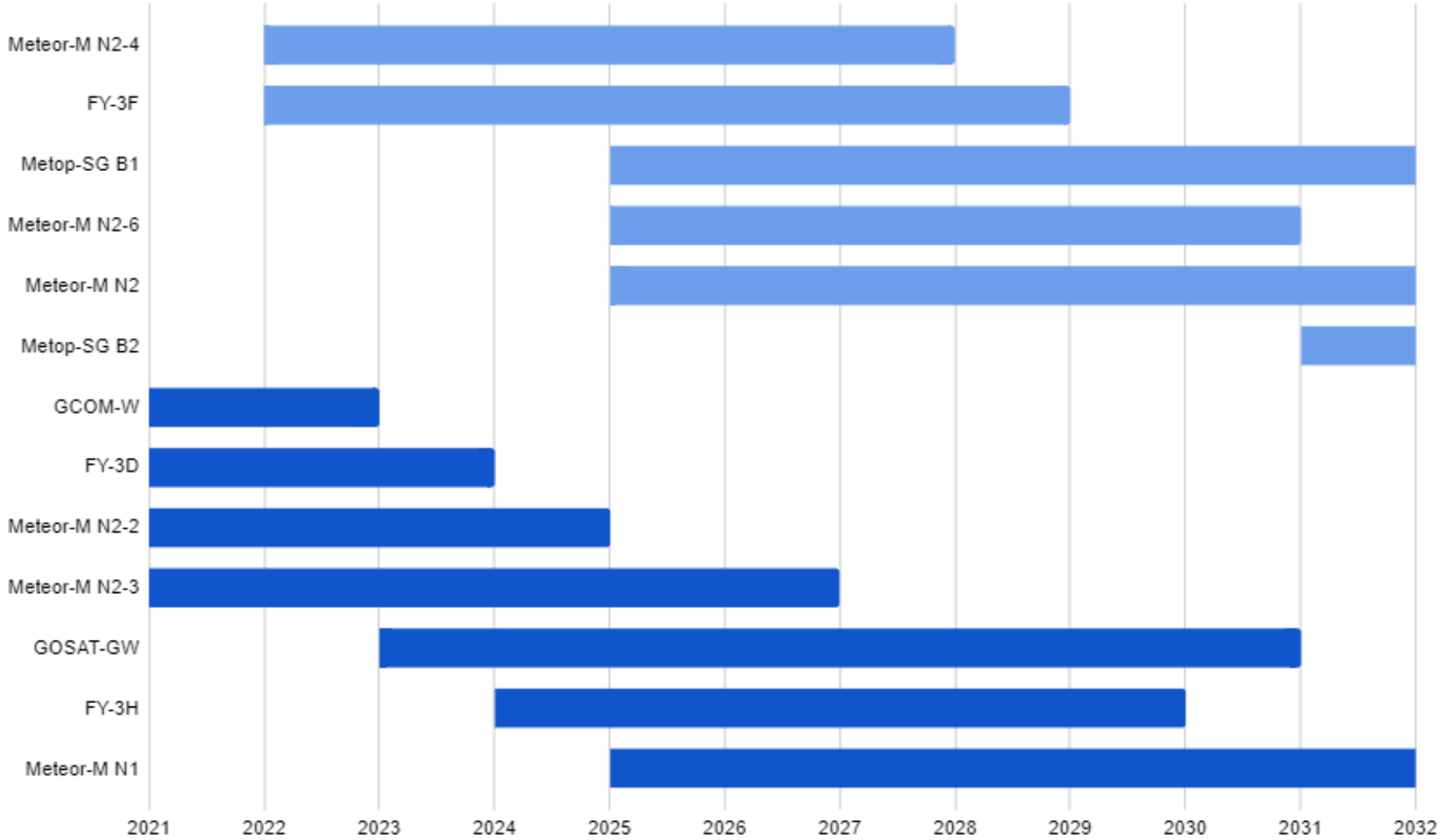
LEO - 1 orbit
Drifting

WGIII Assessment:

The CGMS Baseline commitment is met with launch of FY-3G; but no long term plans beyond. Proposed action on CMA to confirm plans beyond FY-3G. Proposed action on NASA and JAXA to confirm plans beyond the GPM Core.

Coordination Group for Meteorological Satellites - CGMS

Microwave Imager (Sea Surface Temperature, Ocean Surface Winds, Precipitable Water, Soil Moisture, Snow and Ice properties, Sea Ice Properties)



LEO - 2 Orbits

Sun-synchronous mid-morning

Sun-synchronous afternoon

Microwave Imager (Sea Surface Temperature, Ocean Surface Winds, Precipitable Water, Soil Moisture, Snow and Ice properties, Sea Ice Properties)

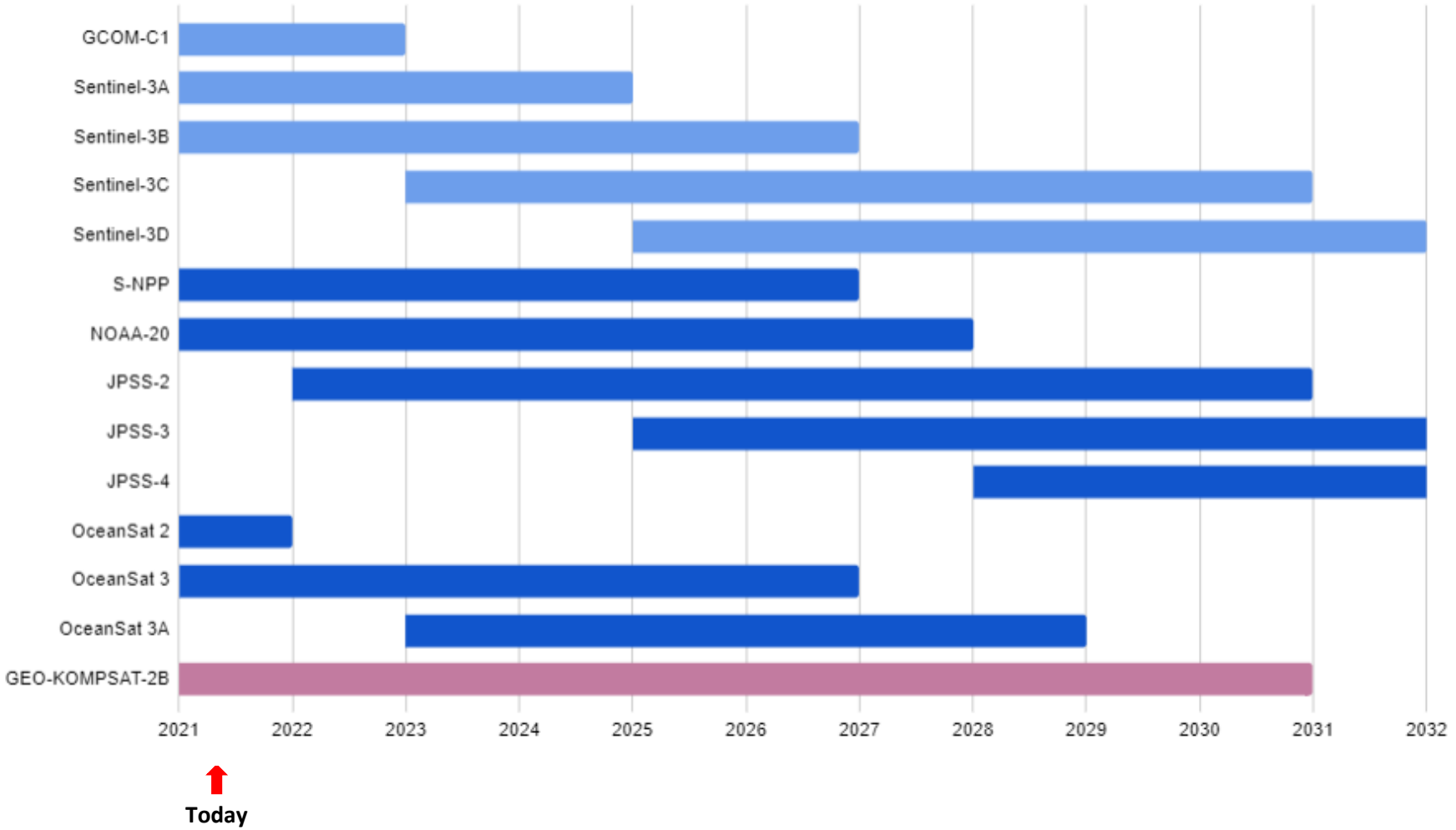
- The CGMS Baseline commitment is met through the reporting period; however senor performance requirements for different environmental parameters vary; ~6 Ghz frequency microwave imaging critical for all weather SSTs, and >9 Ghz frequency critical for precipitation
- Data availability is not assured in the early morning orbit.
- GSICS covering cross calibration between microwave imager.
- Existing action on NOAA to report on follow-on to DMSP in early morning orbit.
- HLPP objective (1.2) to work towards ensuring low frequency microwave imagery for all-weather SSTs.
- Existing action on EUMETSAT to reach out to NSOAS (SOA/MNR) to confirm if the HY missions can be included in the CGMS baseline and risk assessment
- Recommend action for EUMETSAT and ESA to report on plans for the CIMR (Copernicus Imaging Microwave Radiometer) Mission

<u>WGIII Assessment:</u>

Microwave imaging meets the CGMS Baseline; data availability is not assured in the early morning.

Coordination Group for Meteorological Satellites - CGMS

Narrow Band Visible Imager (Ocean Colour, Aerosols)



LEO - 2 Orbits

Sun-synchronous mid-morning

Sun-synchronous afternoon

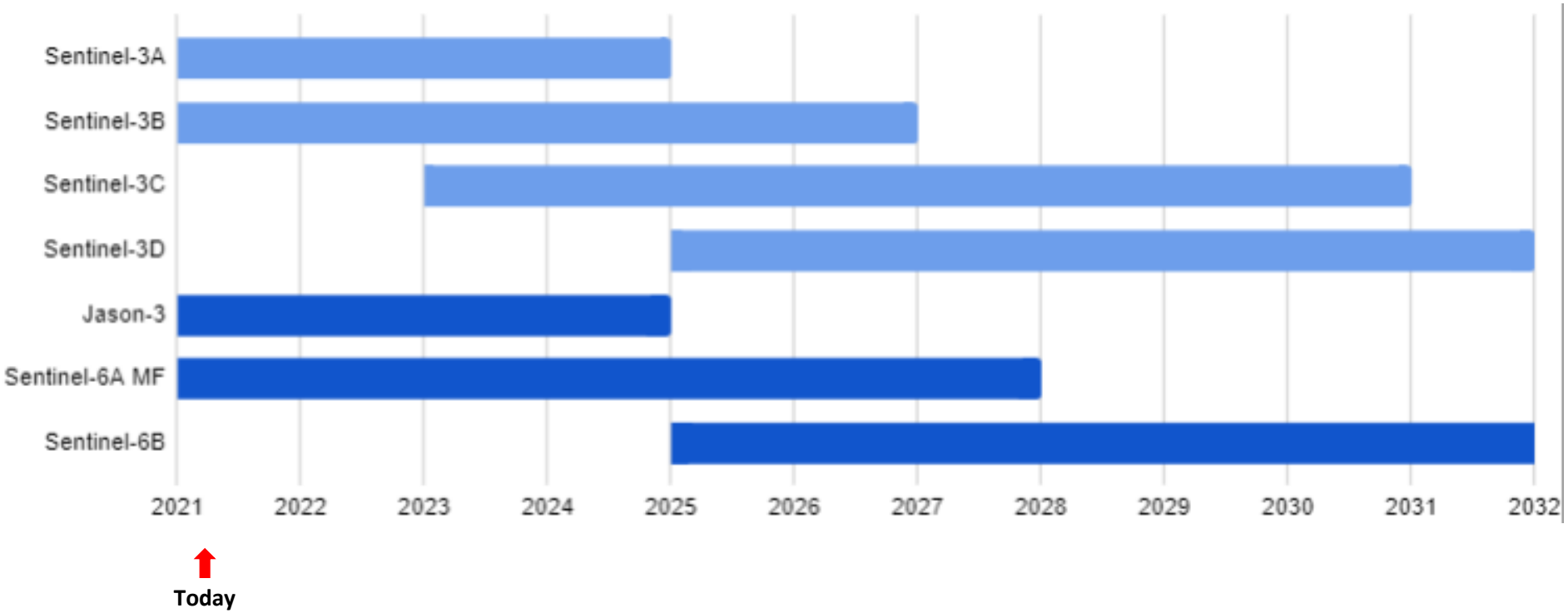
GEO - 1 Slot

128.2°E

WGIII Assessment:

Low risk of not meeting the CGMS Baseline commitment. GEO coverage required beyond GEO-KOMPSAT-2B

Radar Altimetry (Ocean Surface Topography)



LEO - 1 Orbit

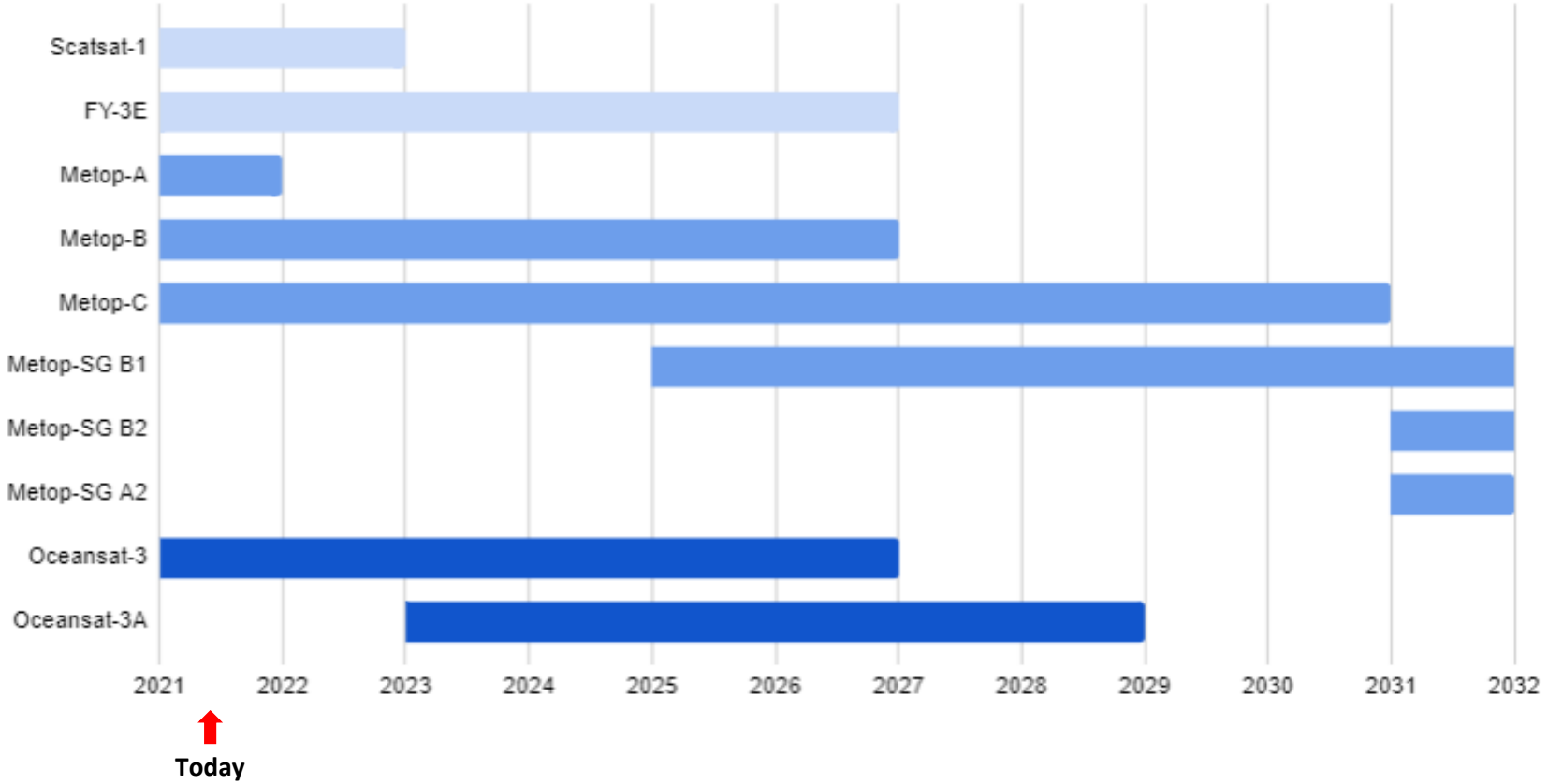
Sun-synchronous mid-morning

High-precision, drifting reference mission

WGIII Assessment:

Low risk of not meeting the CGMS Baseline commitment.

Scatterometry (Ocean Surface Winds)

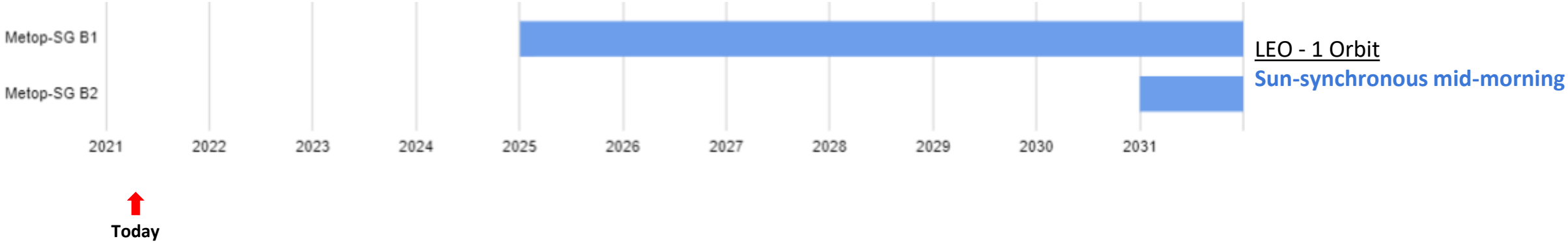


LEO
Sun-synchronous early morning
Sun-synchronous mid-morning
Sun-synchronous afternoon

- There is a risk of a gap in the early morning and afternoon orbits; actions for continuity underway for the early morning orbit
- Need confirmation from ISRO for plans beyond Oceansat-3

WGIII Assessment:
Risk of continuity in the early morning and afternoon orbits.

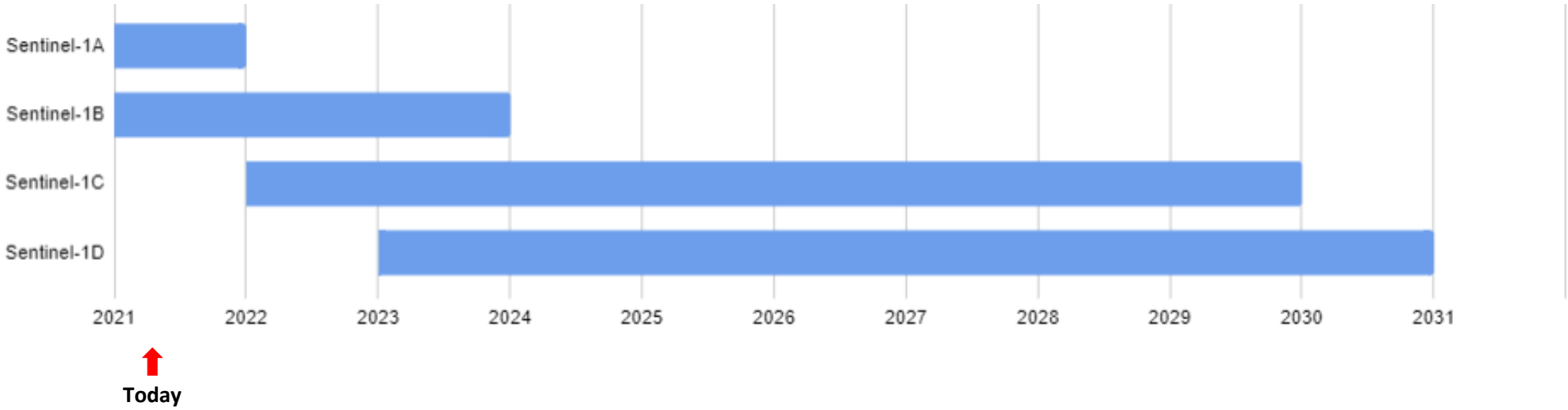
Sub-millimetre Ice Cloud Imager (Cloud Ice)



WGIII Assessment:

Low risk of not meeting Baseline commitments.

Synthetic Aperture Radar (Soil Moisture, Sea Ice)

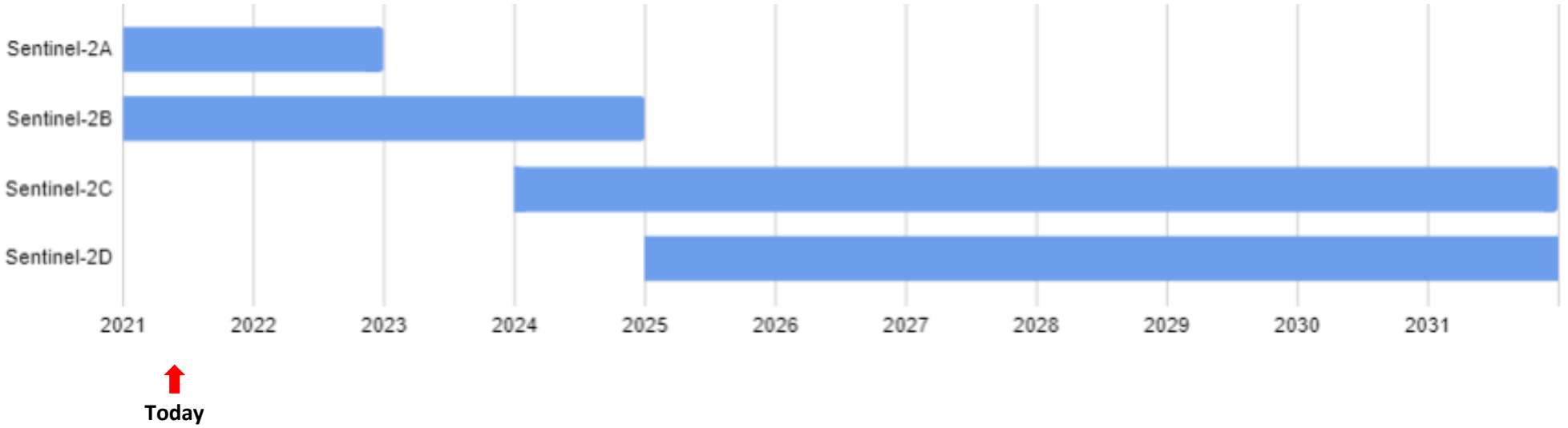


LEO - 1 Orbit
Sun-synchronous

WGIII Assessment:

Low risk of not meeting Baseline commitments.

High Resolution Optical Imager (Land Use, Vegetation Type and Status, Aerosols)

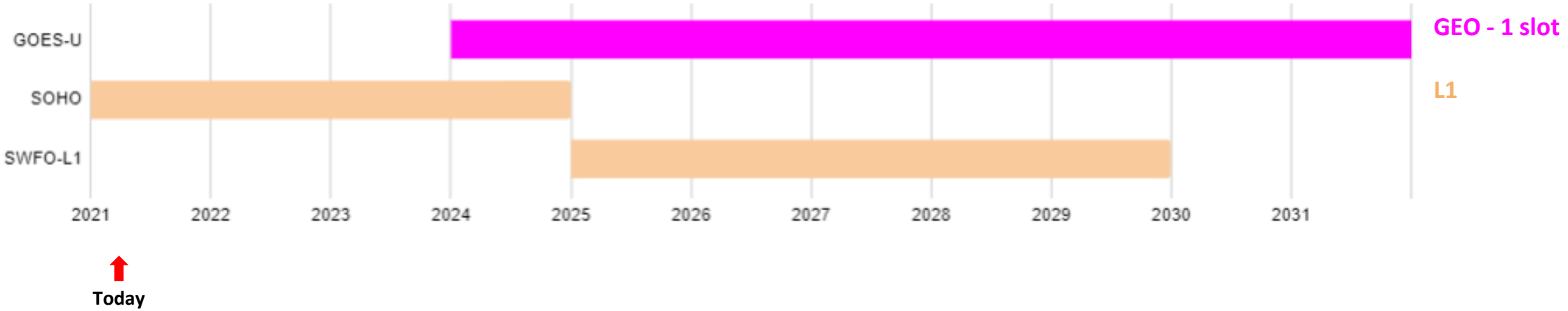


LEO - 1 Orbit
Sun-synchronous

WGIII Assessment:

Low risk of not meeting Baseline commitments.

Coronagraph (Coronagraphy)

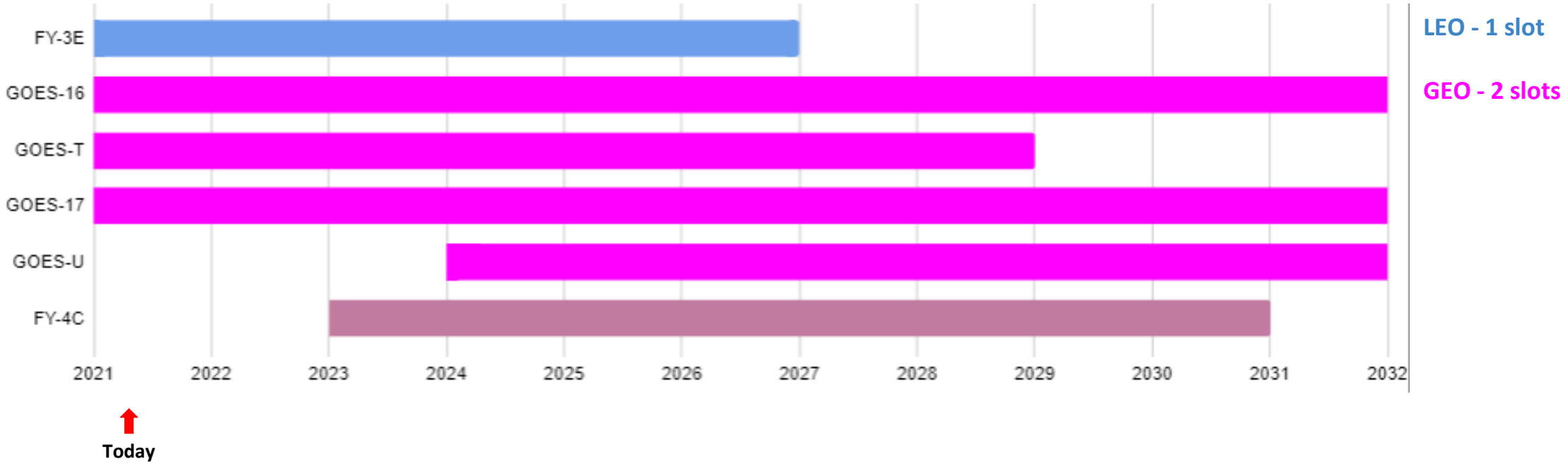


- Increasing risk of a gap until GOES-U and SWFO-L1 are launched
- CGMS Members to continue to propose near-term alternative data sources for consideration as gap mitigation in event of loss or degradation of current L1 capabilities prior to SWFO-L1 data availability
- WGIV to consider recommended gap mitigation observation requests and develop plans to ensure near real-time access to those data
- Recommend SWCG identify alternative data sources to mitigate potential unavailability of coronagraph observations

WGIII Assessment:

Increasing risk of a gap in the early part of the decade.

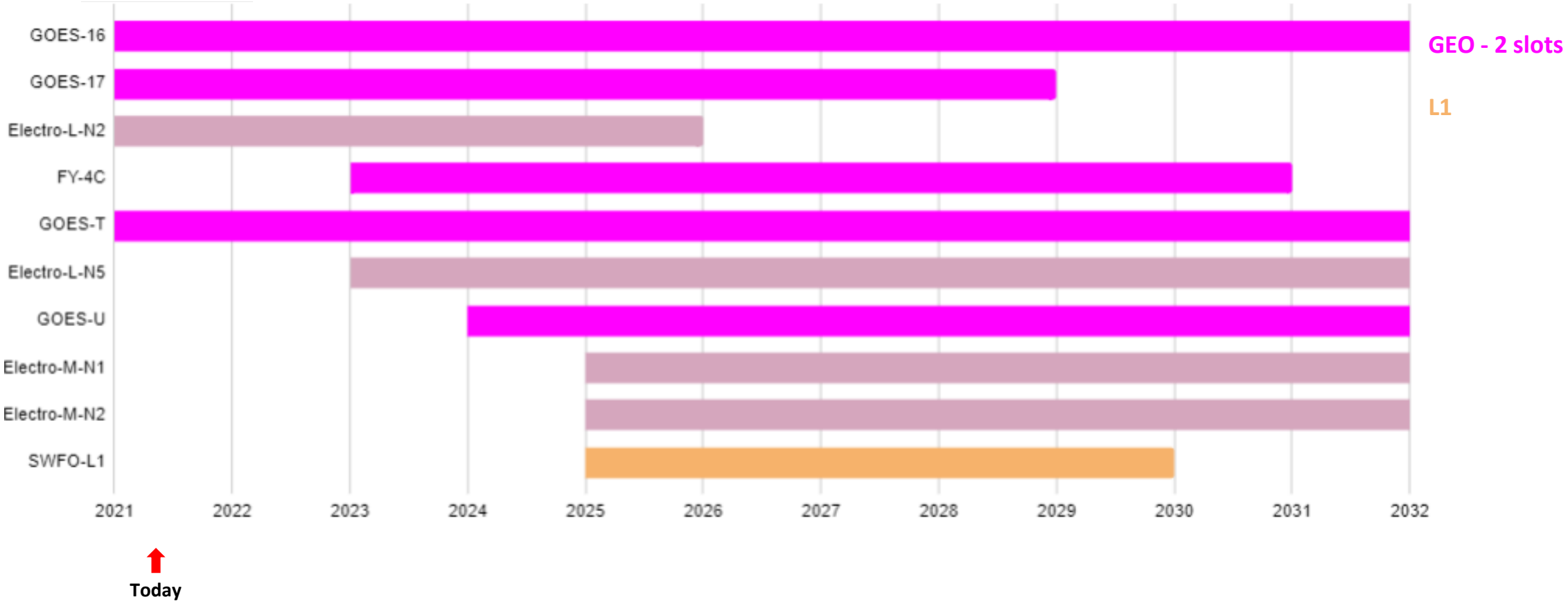
EUV Imager (EUV Imagery)



WGIII Assessment:

Low risk of not meeting Baseline commitments.

X-Ray Spectrograph (X-Ray Flux)

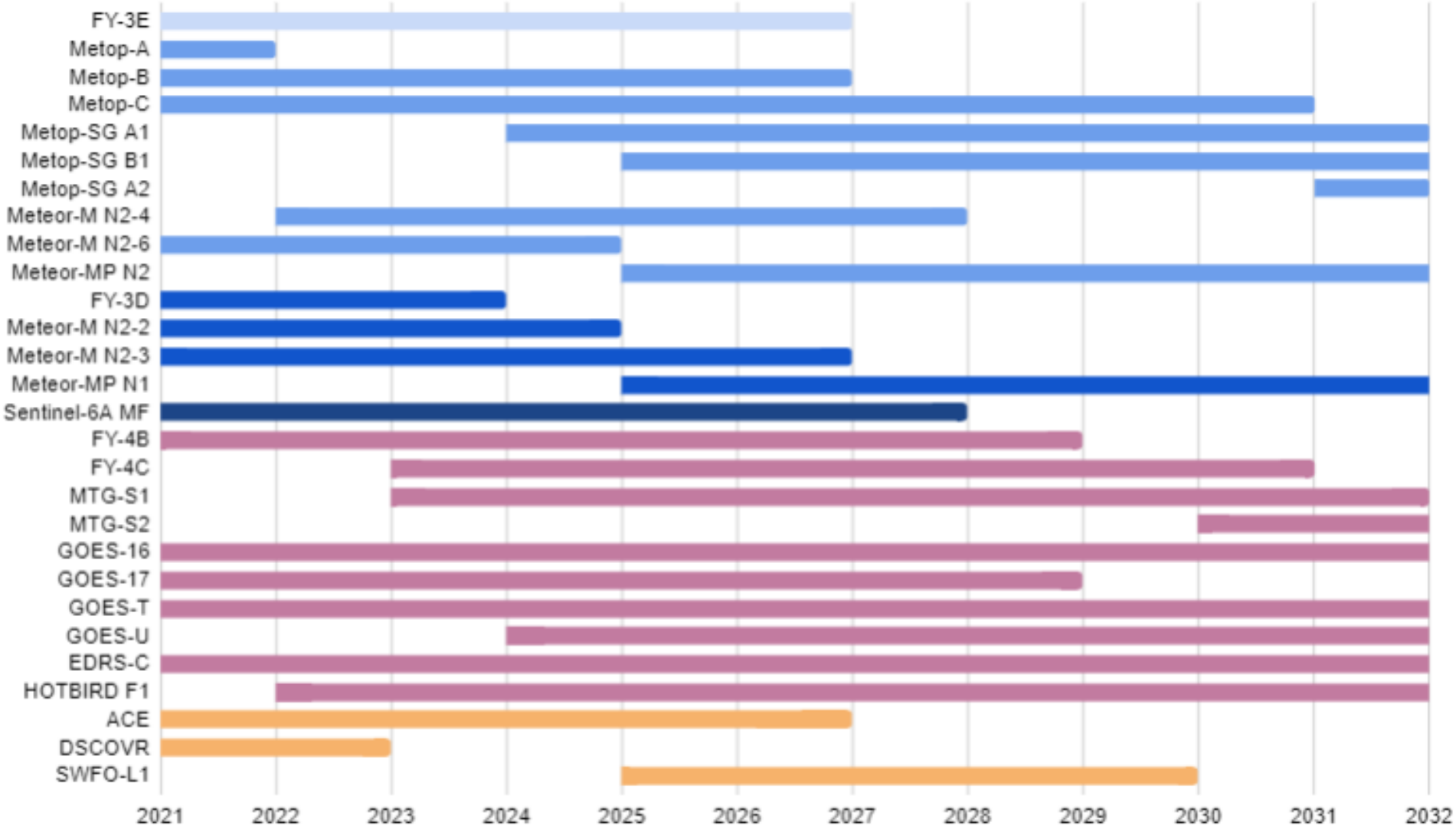


WGIII Assessment:

Low risk of not meeting Baseline commitments.

Coordination Group for Meteorological Satellites - CGMS

Energetic Particle Sensor (Magnetospheric and Solar Energetic Particles)



LEO - 3 Orbits

Sun-synchronous early morning

Sun-synchronous mid-morning

Sun-synchronous afternoon

GEO - 6 Satellites

L1

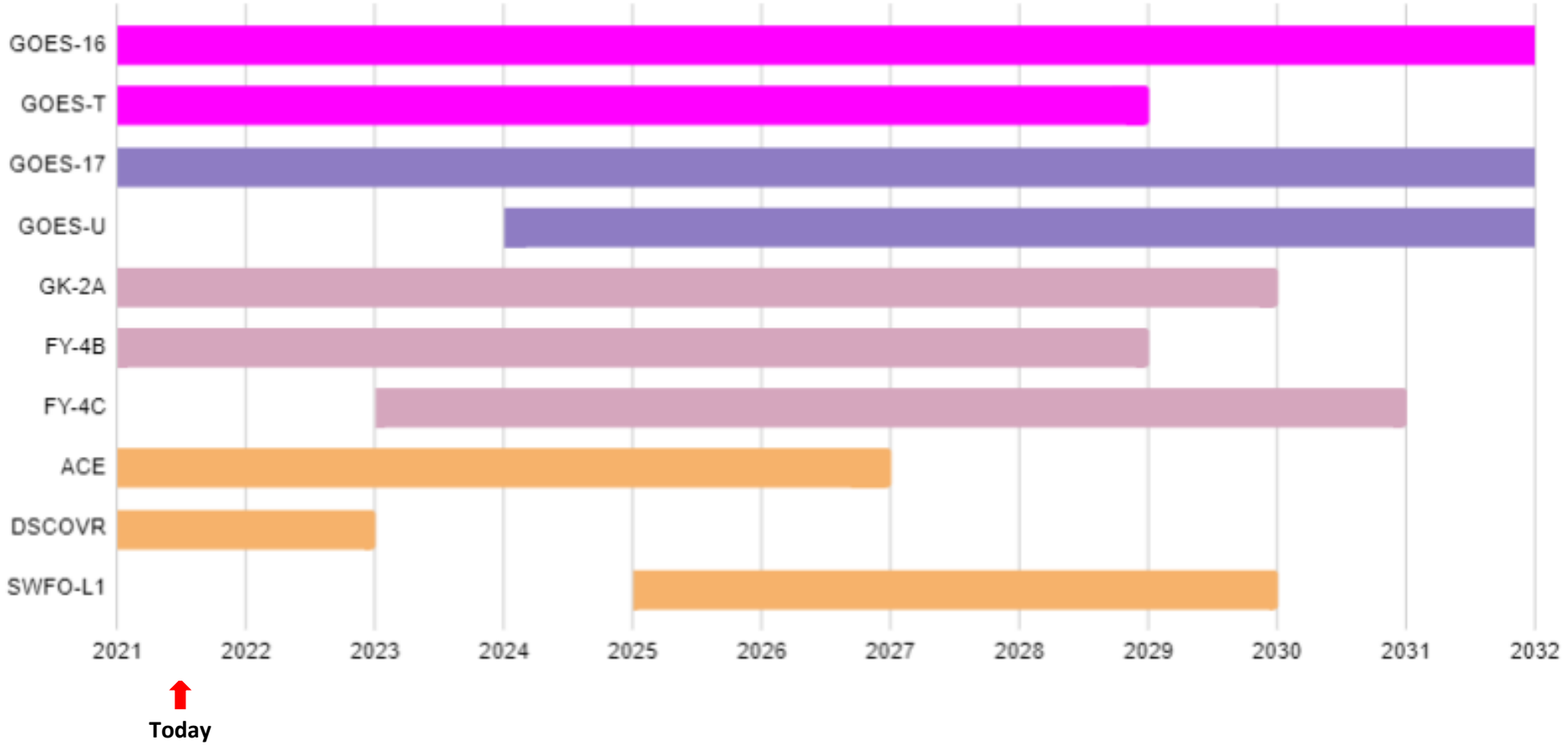
Energetic Particle Sensor (Magnetospheric and Solar Energetic Particles)

- Two satellites operating past their design life are providing this measurement
- Increasing risk of a gap in near term
- No long-term plans for measurements at L1
- Recommend SWCG review baseline requirement for orbital positions as opposed to number of satellites

WGIII Assessment:

Low risk of a gap in GEO and LEO. Increasing risk of a gap in L1 until SWFO-L1 is launched

Magnetometer (Earth's Magnetic Field, Interplanetary Magnetic Field)



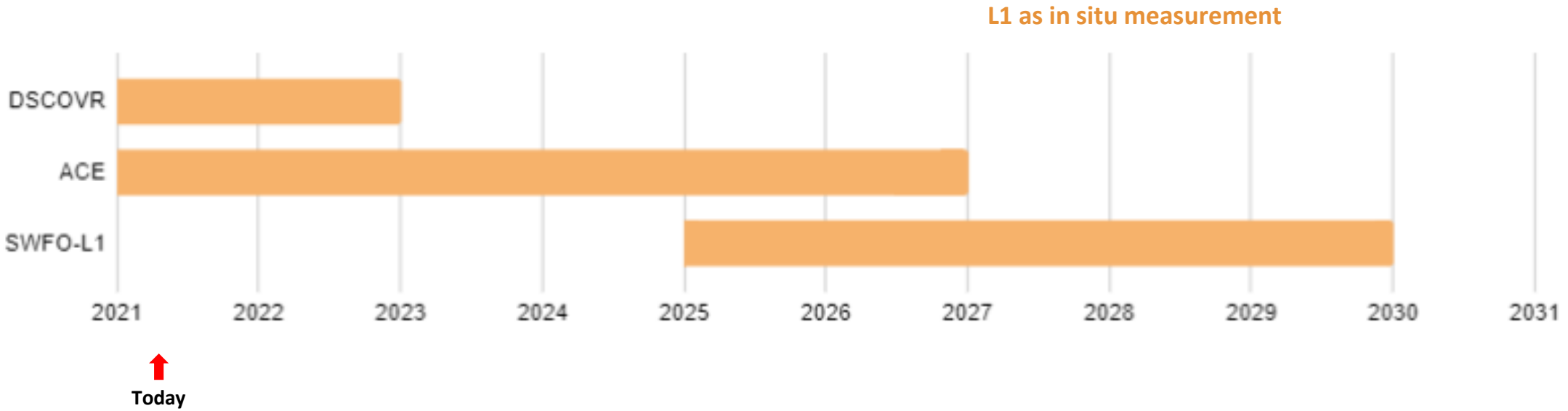
GEO – 2 Slots
75.2°W
137°W
86.5°-128°E range

L1, as an in situ measurement

WGIII Assessment:

Risk of not meeting Baseline commitments in L1 until SWFO-L1 is launched

Plasma Analyzer (Solar Wind)



- Increasing risk of a gap until SWFO-L1 is launched
- CGMS Members to propose near-term alternative data sources for consideration as gap mitigation in event o f loss or degradation of current L1 capabilities prior to SWFO-L1 data availability
- WGIV to consider recommended gap mitigation observation requests and develop plans to ensure near real-time access to those data
- No long term L1 plans

WGIII Assessment:

Increasing risk of a gap in the early part of the decade; no long term L1 plans