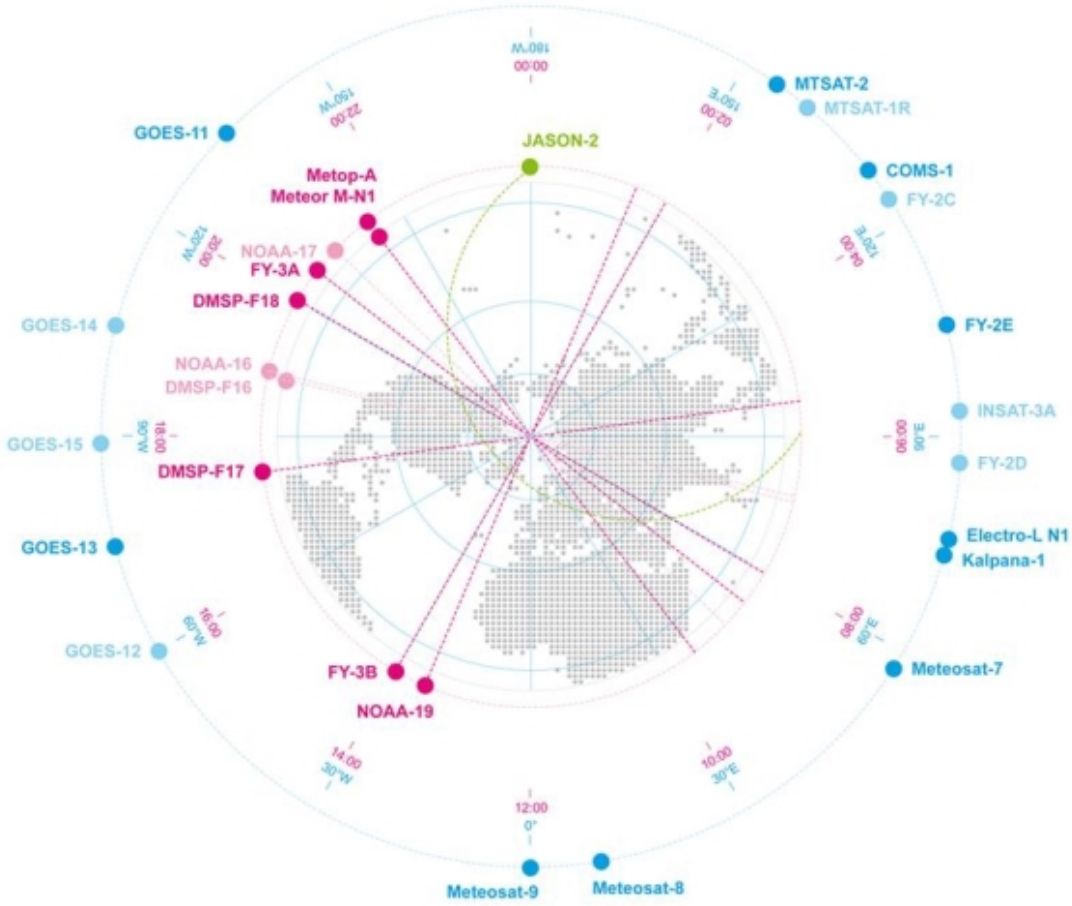


Results of the 5th CGMS Risk Assessment (2023)

Following the 5th CGMS risk assessment review on 21-23 February 2023

Updates*

- Updates to mission data were solicited in late January
- Each flyout chart has been updated with the new launch and EOL information provided:
  - MetOp-SG-A1 launch date moved to 2025 and EOL to 2032
  - MTG-I1 launch date moved to 2022 and MTG-I2 launch date moved to 2026
  - OceanSat 3A launch date moved to 2024
  - GCOM-C and GCOM-W EOL moved to 2023
  - GOSAT-GW launch date moved to 2024 and EOL to 2031
  - GOSAT and GOSAT-2 EOL moved to 2023
  - OCO-2 EOL moved to 2023 and OCO-3 EOL moved to 2026
  - ACE EOL moved to 2025
  - Microcarb launch date moved to 2024 and EOL to 2029
  - ALOS-3 launch date moved to 2023 EOL to 2030
  - FY-3F launch date moved to 2023 and EOL to 2029
  - FY-3G launch date moved to 2023 and EOL to 2028
  - FY-3H launch date moved to 2024 and EOL to 2030
  - GOES-16 EOL moved to 2031
  - Meteosat-11 EOL moved to 2033

Updates in italics were made during the 5th Risk Assessment Workshop

Updates cont.

- The flyout charts also reflect the following additional updates:
  - Jason-CS-B/Sentinel-6B is now included in the flyout chart for Energetic Particle Sensor: LEO & L1
  - GOSAT, GOSAT-2 and GOSAT-GW now included in the flyout chart for Scatterometer
  - ALOS-4 now included in the flyout chart for Synthetic Aperture Radar
  - Meteosat-9 orbit is updated to Geostationary (45.5E)
  - *JPSS-2 changed to NOAA-21*
  - *GEO-XO East, launching in 2032, has been added to flyout charts for Multi-purpose Meteorological Imager GEO, Lightning Mapper, and Narrow Band Visible Imager*
  - *Added KOMPSAT-2B to the Multi-purpose Meteorological Imagers - GEO flyout*
  - *Removed SWFO-L1 from the X-Ray Spectrograph flyout*
  - *Added Hotbird F2 to the High Energy Particle Sensor and Energetic Heavy Ion flyouts*
  - *Magnetometer flyout separated between L1 and GEO*
  - *Energetic Particle Sensor flyout separated between L1 and LEO*
  - ALOS-3 has been removed from the High Resolution Optical Imager flyout

- Additional updates made to the risk assessment:
  - *All individual sensor assessments have been updated in accordance with the workshop review*
  - *CGMS Baseline Process has been updated to reflect current process*
  - *Radio Occultation graphics have been updated to reflect baseline requirements*

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).

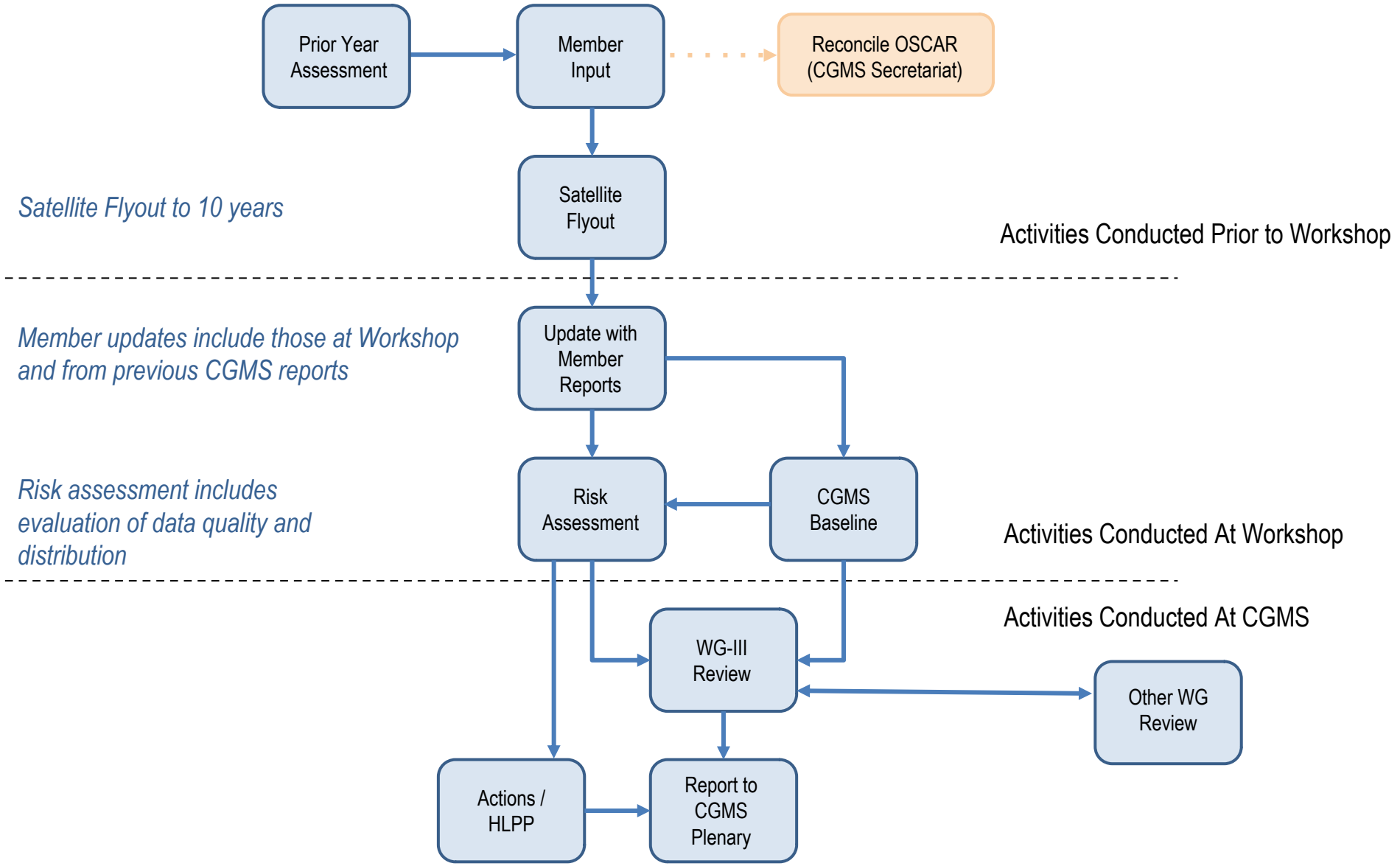
- The CGMS Baseline strives to support the WMO Integrated Global Observing System (WIGOS) 2040 vision.

- 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.

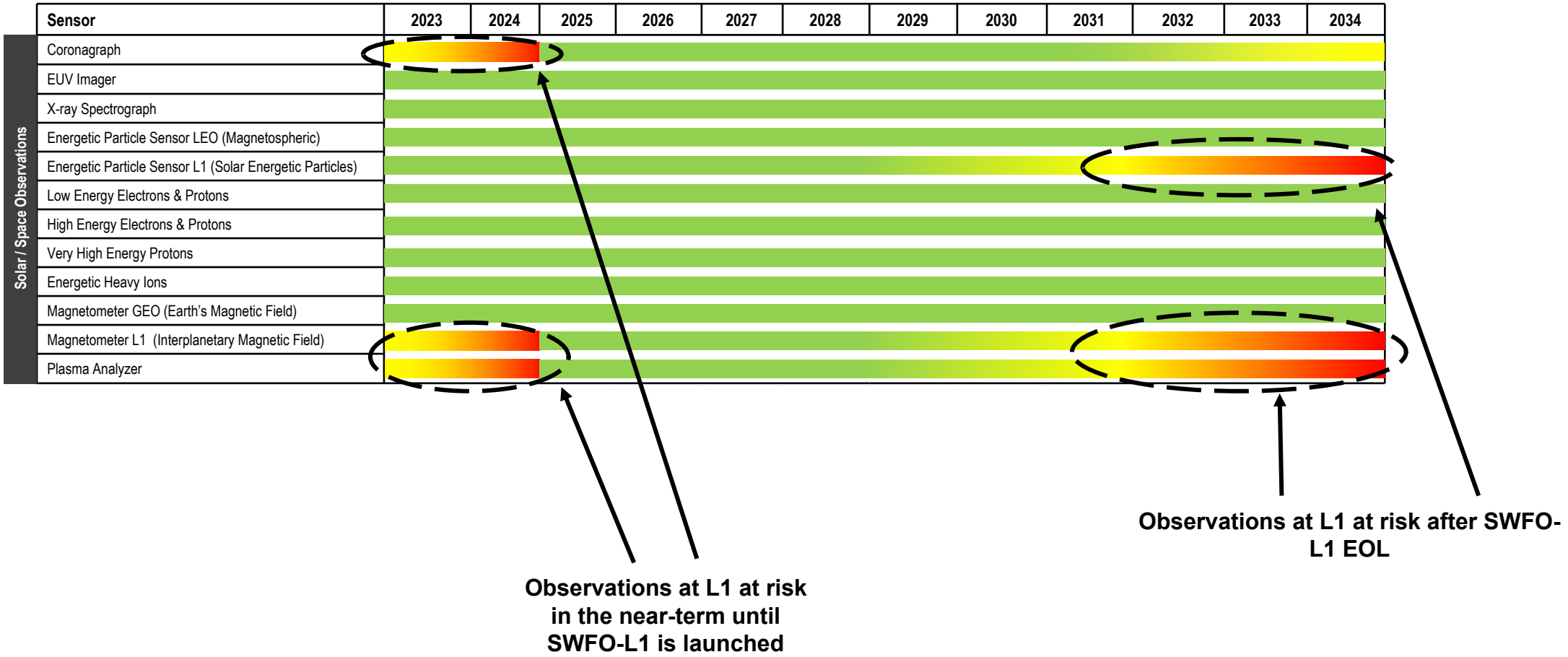
CGMS Risk Assessment Assumptions

- 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

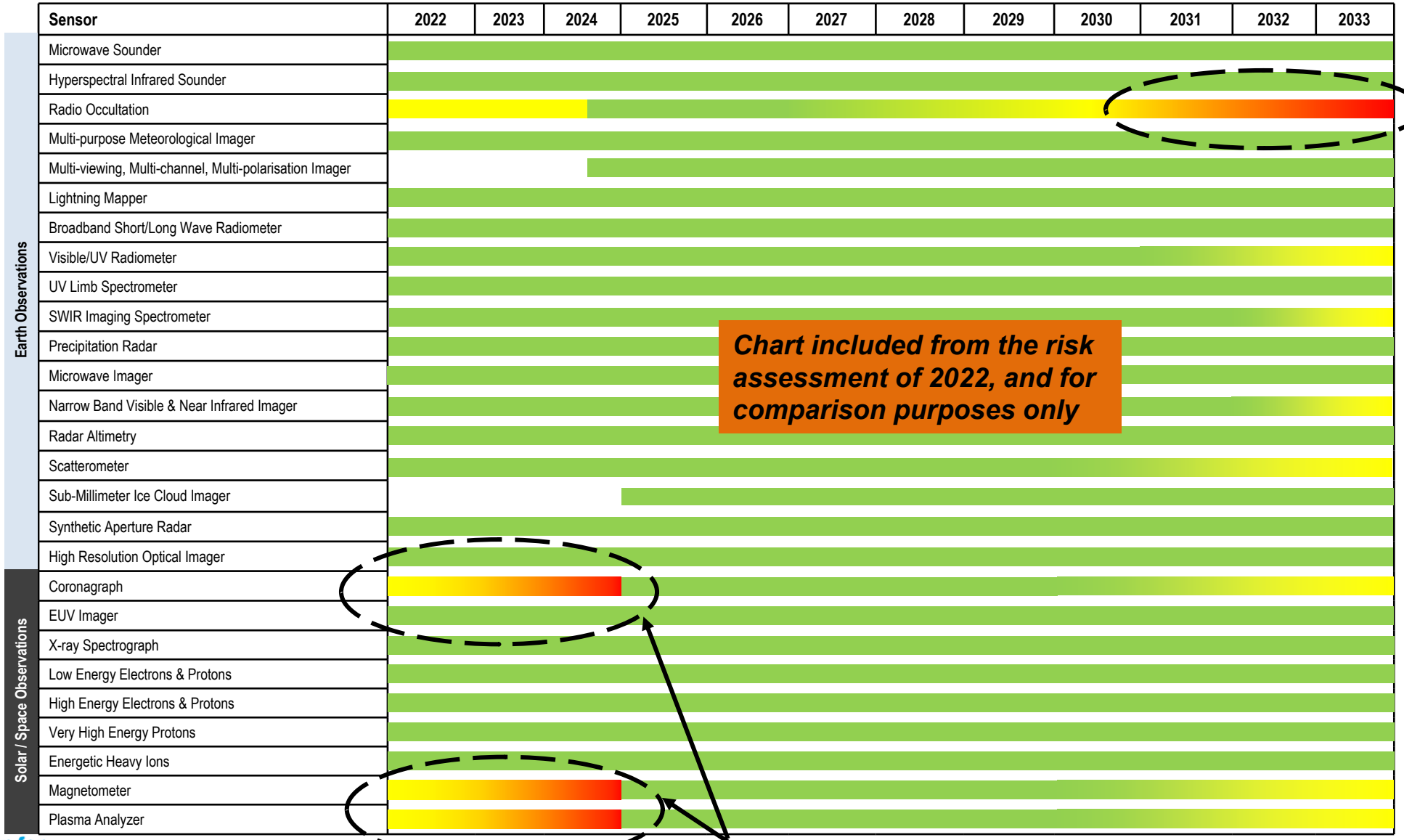
Top-Level Risk Assessment - Earth Observations (2023)

No plans for low-inclination RO observations after COSMIC-2

Top-Level Risk Assessment - Solar/Space Observations (2023)



Top-Level Risk Assessment (2022)



No plans for low-inclination RO observations after COSMIC-2

Chart included from the risk assessment of 2022, and for comparison purposes only

Observations at L1 at risk in the near-term until SWFO-L1 is launched

Coordination Group for Meteorological Satellites

CGMS

Top-Level Risk Assessment (2023) – Focus Areas

- The CGMS Baseline commitment for RO observations is not being met until 2025, and there is a continuity risk from low inclination orbits in the later part of the decade as there are no plans for a follow-on to COSMIC-2
- Slight continuity risk for the Visible / UV Spectrometer in the 128.2E slot in the early 2030s
    - KMA should confirm plans beyond GK-2B
- Continuity risk for the SWIR Imaging Spectrometer in the afternoon orbit in the later part of the decade.
    - The Joint Working Group on Climate is working to coordinate long-term CO2 monitoring.
- Risk of a gap in Coronagraph sensors in the early part of the decade and long term continuity at L1.
    - Additional ground resources used to track STEREO-A may mitigate that risk in the event of SOHO loss before 2024.
- Risk of gap in Energetic Particle Sensor at L1 at the end of the decade.
- Risk of gap in Plasma Analyser and Magnetometer sensors at L1 in the near term and in the early 2030s.

Top-Level Risk Assessment (2023) – Recommended and Existing Associated Actions

Recommended Actions

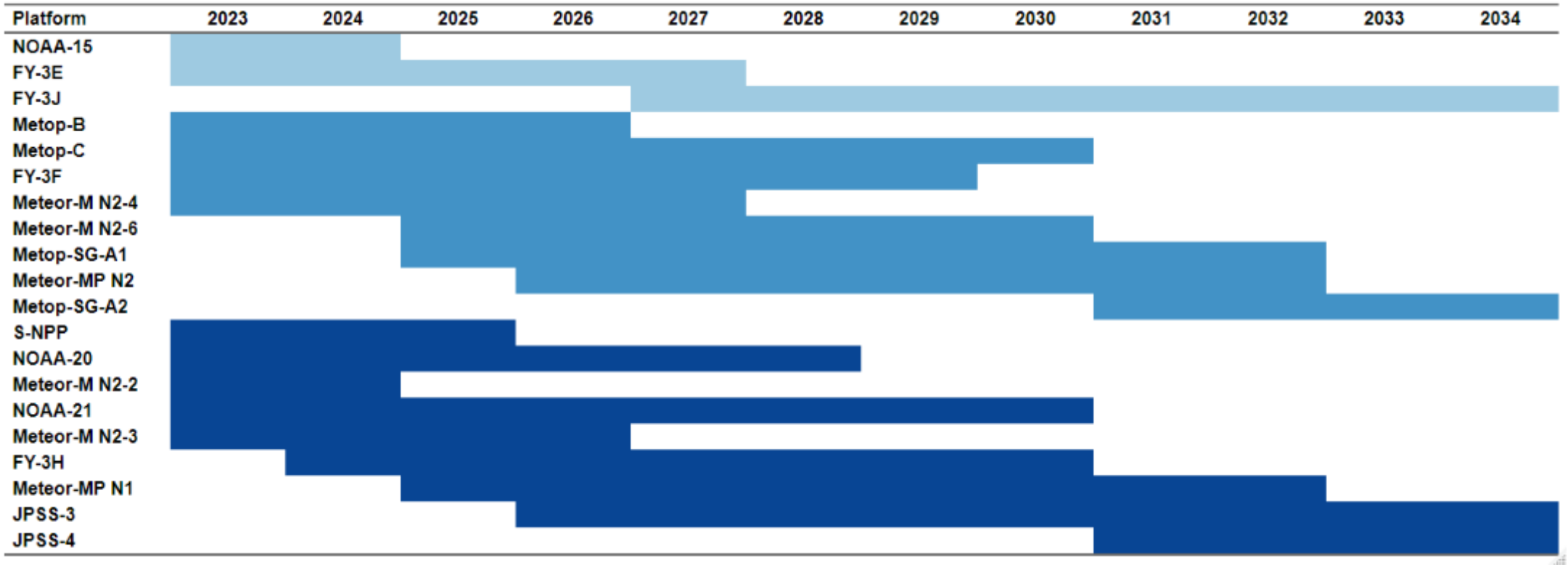
- TBD

Existing Associated Actions

- ISRO to confirm plans beyond OceanSat-3
- 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
- WGIV to consider recommended gap mitigation observation requests and develop plans to ensure near real-time access to those data
- 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
- Determine usability of NSOAS data to provide radar altimetry data availability in the early morning orbit in the short term and to ensure long term for coverage, and to ensure long term coverage for ~6Ghz frequency microwave imaging in at least one LEO orbit for all weather Sea Surface Temperature observations
- KMA should confirm plans beyond GK-2B for the Visible / UV Spectrometer and Narrow Band Visible Imager
- NOAA should review additional ground resources needed to track STEREO-A and PUNCH to provide additional coverage in the near-term.

Coordination Group for Meteorological Satellites - CGMS

Microwave Sounder (Atmospheric Temperature, Humidity, and Precipitation)



LEO - 3 Orbits

Sun-synchronous early morning

Sun-synchronous mid-morning

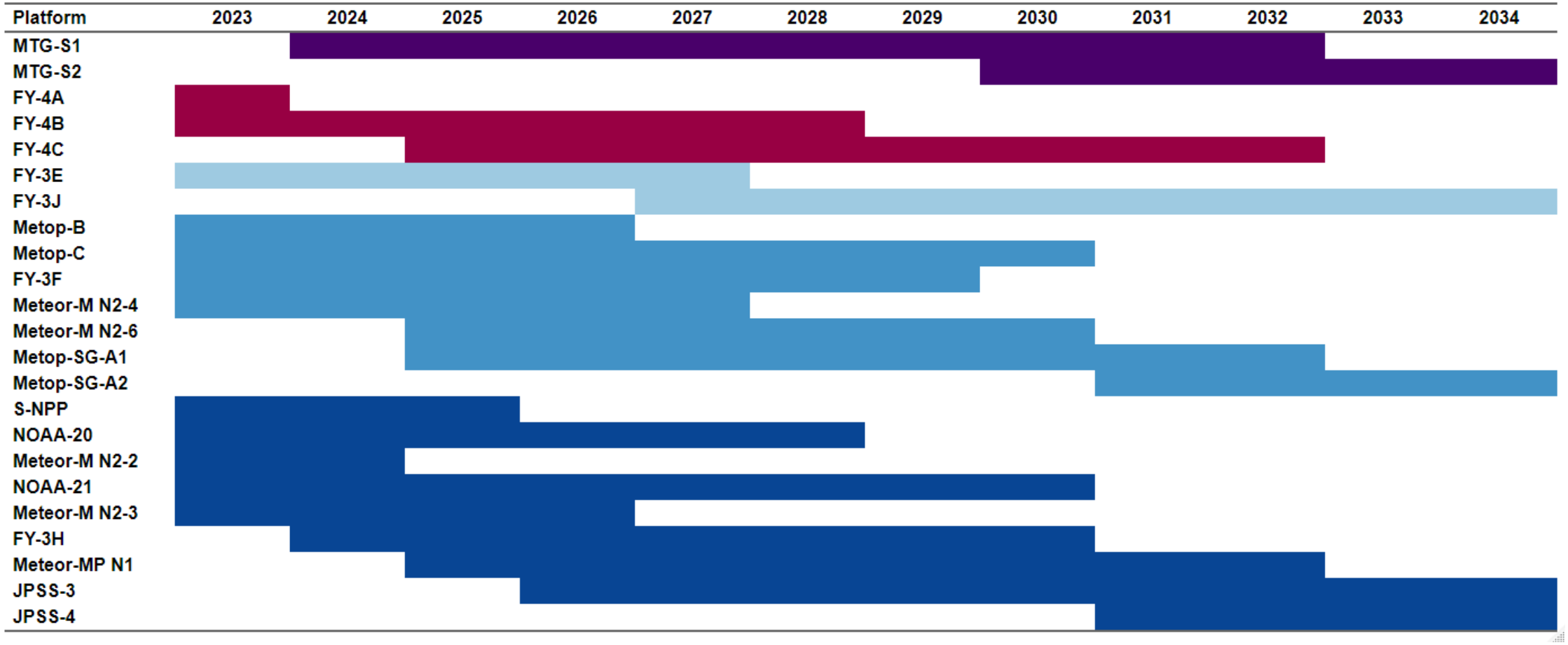
Sun-synchronous afternoon

WGIII Assessment:

Low risk of not meeting the Baseline commitment.

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)



Today

GEO - 2 Slots

0°

86.5°-105°E range

LEO - 3 Orbits

Sun-synchronous early morning

Sun-synchronous mid-morning

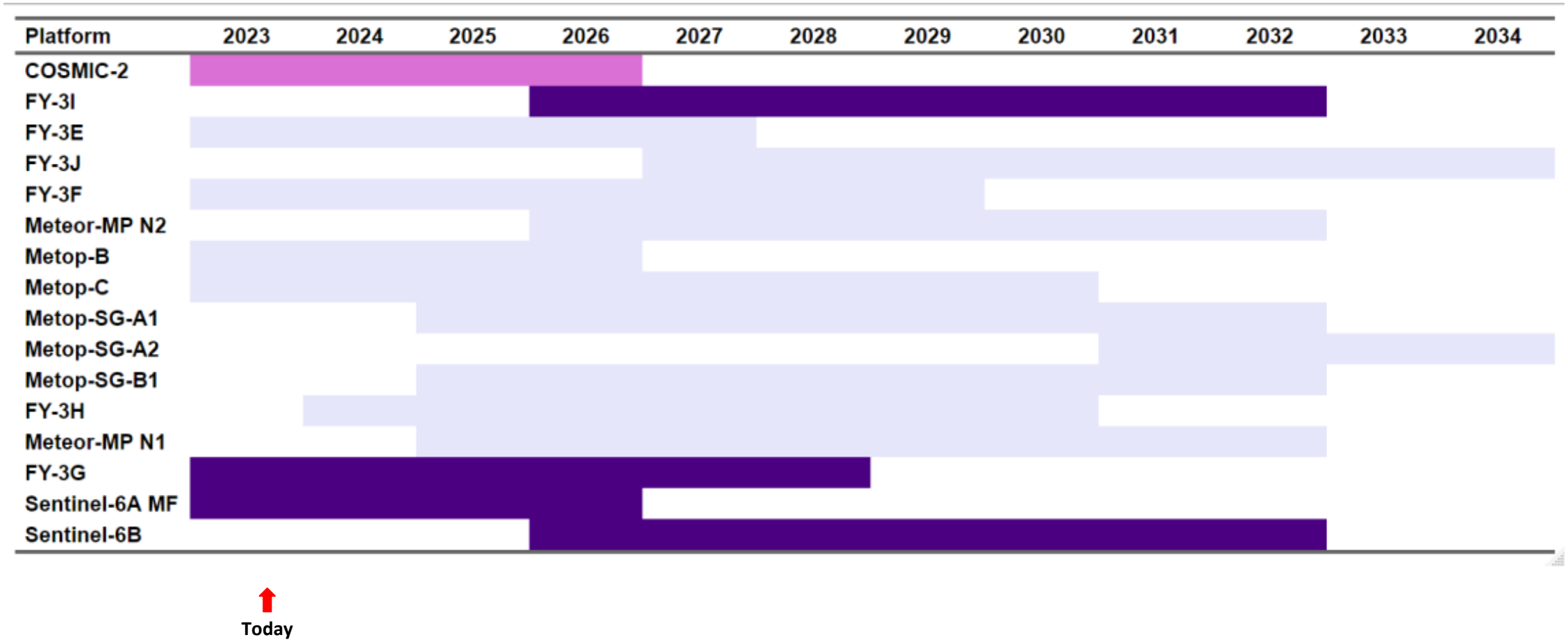
Sun-synchronous afternoon

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

WGIII Assessment:

Low risk of not meeting the Baseline commitment. Note the HLPP objective (1.2) to expand hyperspectral sounding from GEO to the full geostationary ring. ISRO has continued action to update CGMS-51 on their plans for a hyperspectral sounder in geostationary orbit.

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



LEO - 3 Orbits

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

7600 occultations from **sun-synchronous**

1000 occultations from **other drifting orbits**

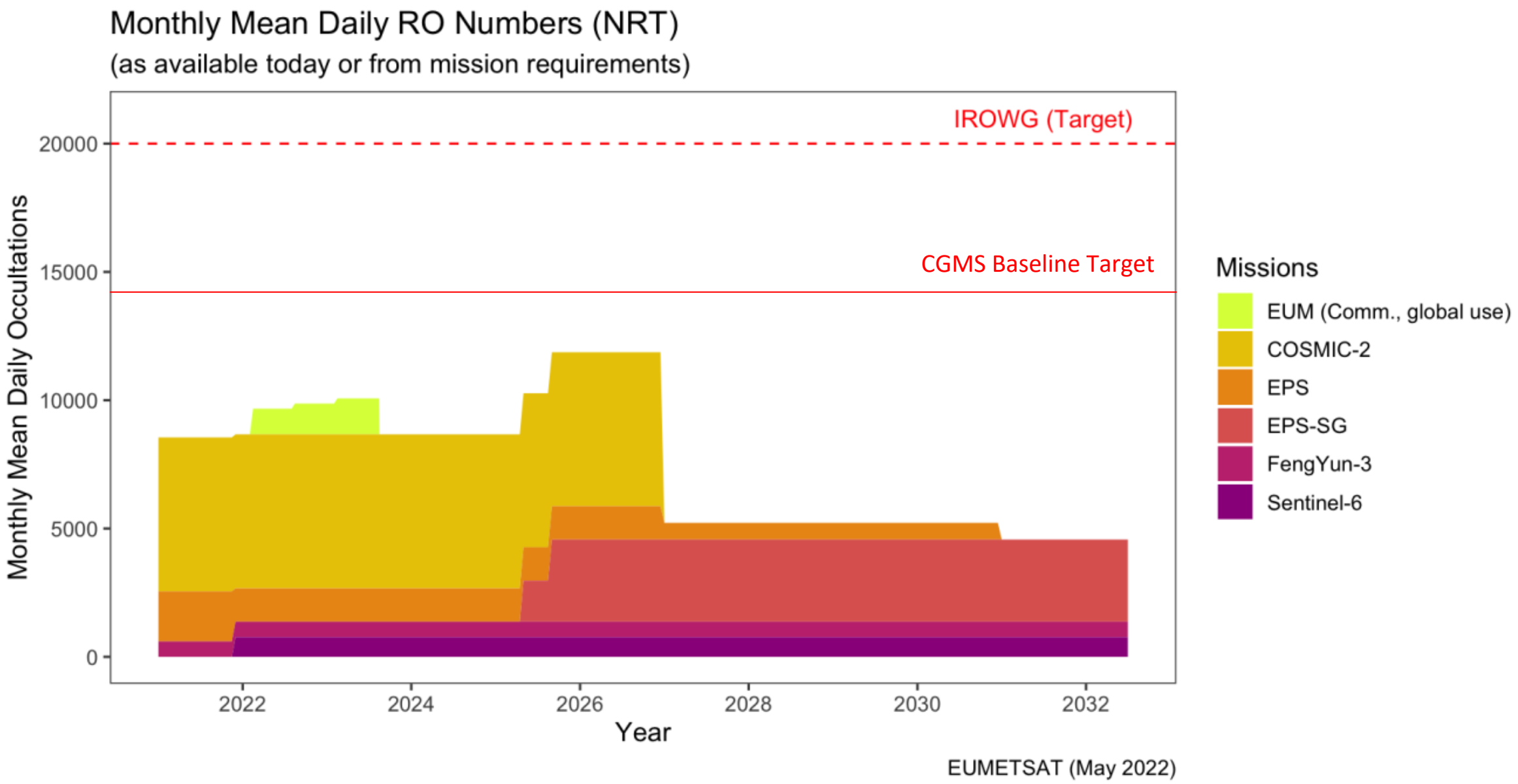
Radio Occultation (Atmospheric Temperature, Humidity, and Ionospheric Electron Density)

WGIII Assessment:

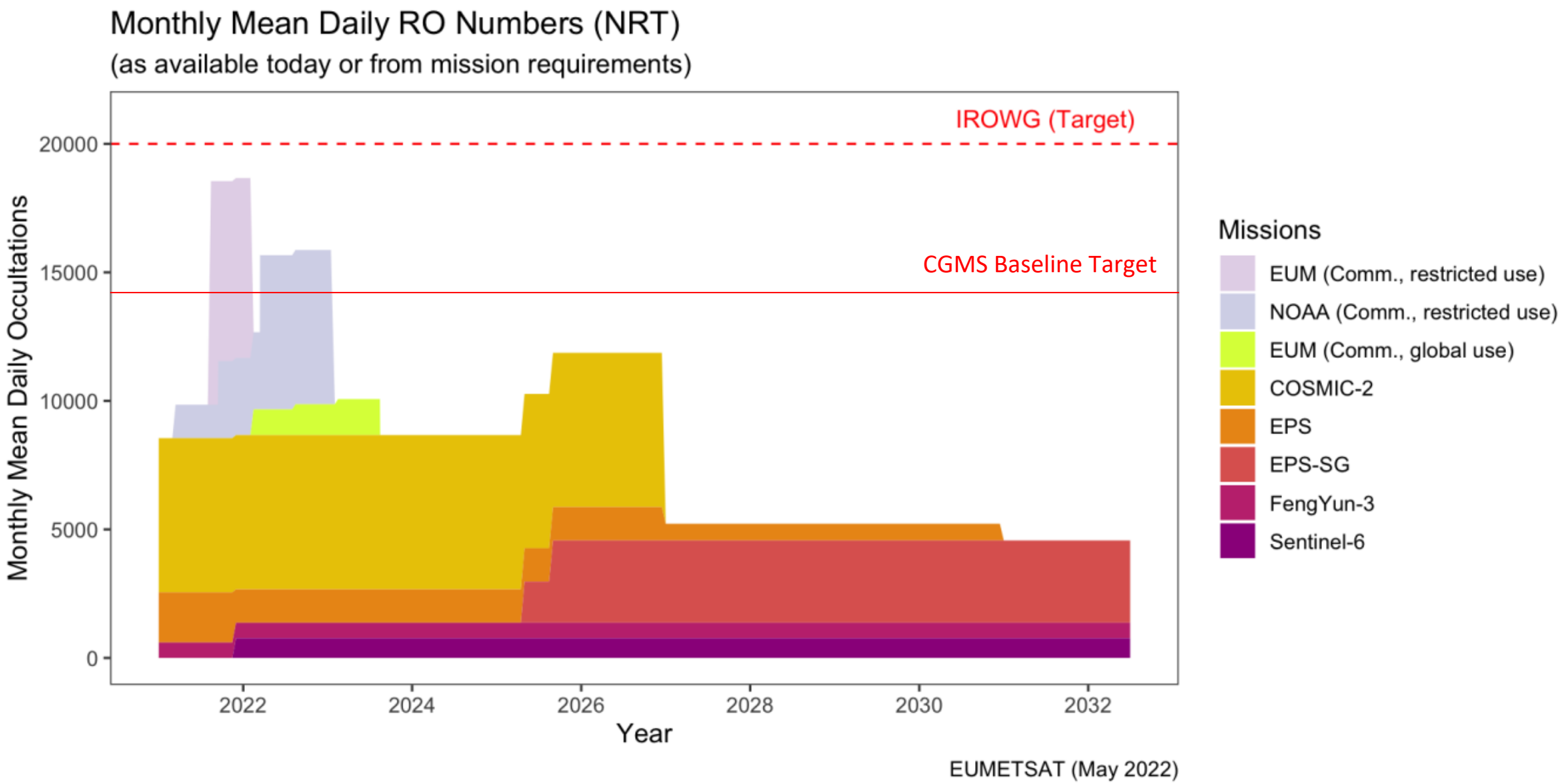
The CGMS Baseline commitment of 14,600 occultations is not being met until 2025 until Metop-SG launches, and there is a high risk of not meeting the commitment from low inclination orbits in the later part of the decade as there are no plans for a follow-on to COSMIC-2. There is inconsistent coverage from polar and high inclination orbits throughout the period.

Commercial operators could offer some risk mitigation (would need to ensure compliance with national and international mandates and policies). 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.

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



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



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°-45.5°E range

14.5°W-165.8°E range

74°-82°E range

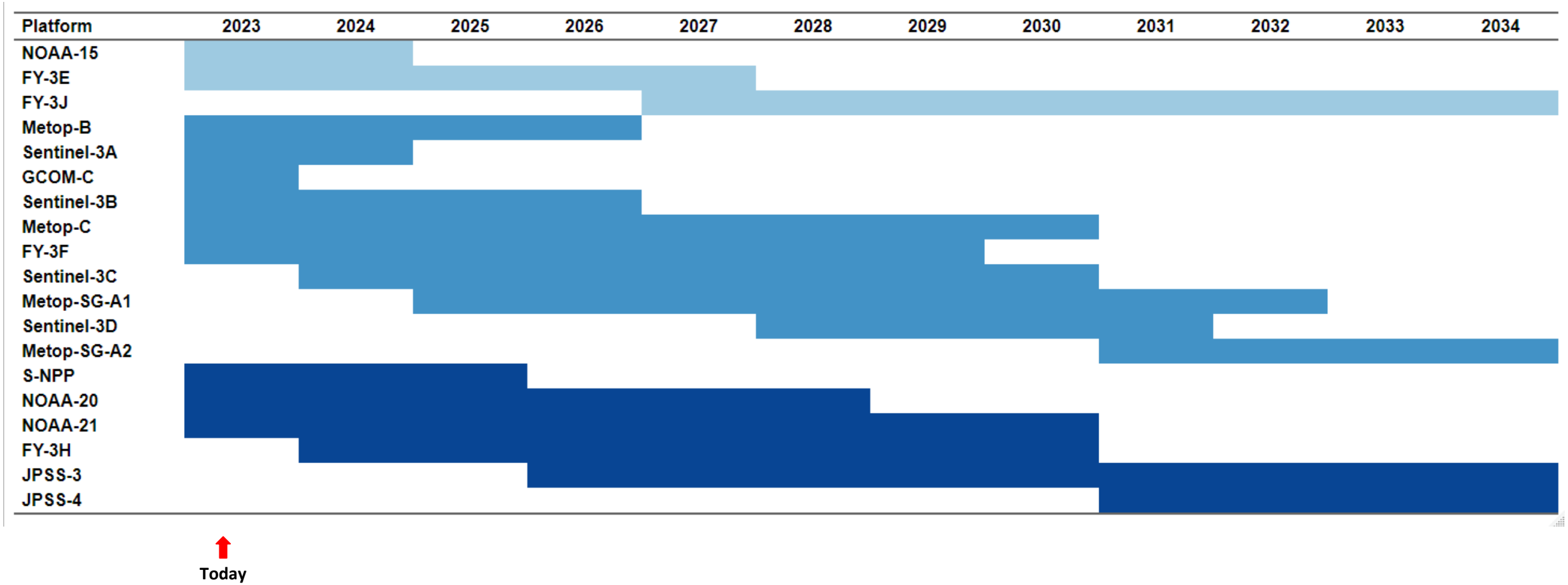
86.5°-140°E range

WGIII Assessment:

Low risk of not meeting Baseline commitments.

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.),

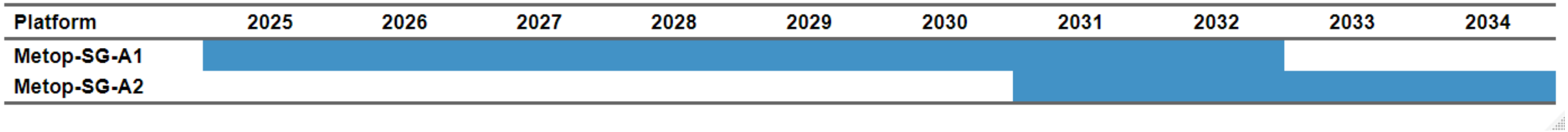


LEO
Sun-synchronous early morning
Sun-synchronous mid-morning
Sun-synchronous afternoon

WGIII Assessment:

Low risk of not meeting Baseline commitments.

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



Today

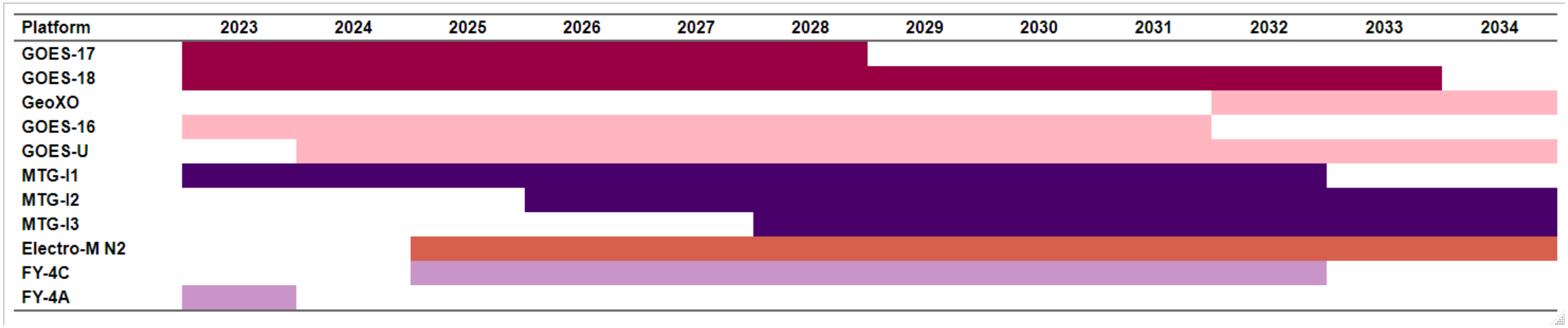
LEO - 1 orbit

Sun-synchronous

WGIII Assessment:

Low risk of not meeting the CGMS Baseline commitment.

Lightning Mapper (Lightning)



GEO - 5 slots

0°

76°E

86.5°-105°E range

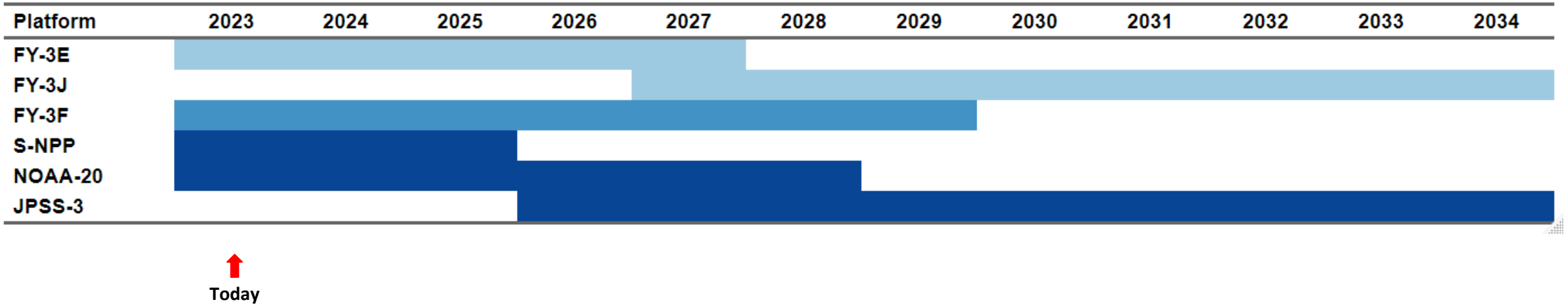
137°W

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

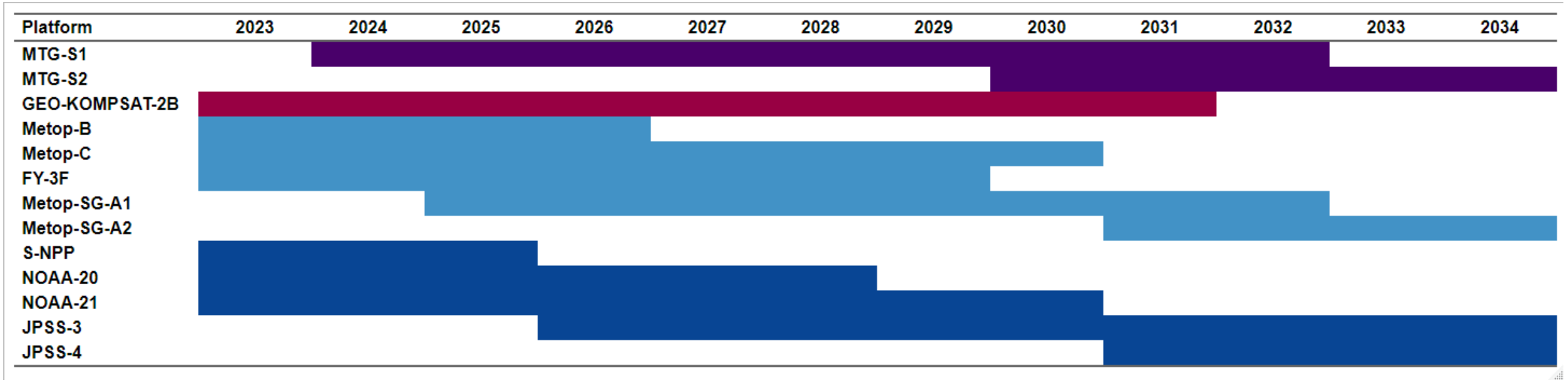
Sun-synchronous mid-morning

Sun-synchronous afternoon

WGIII Assessment:

Low risk of not meeting the CGMS baseline commitment. Action on WGII to investigate the addition of GEO contributions to the CGMS Baseline.

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

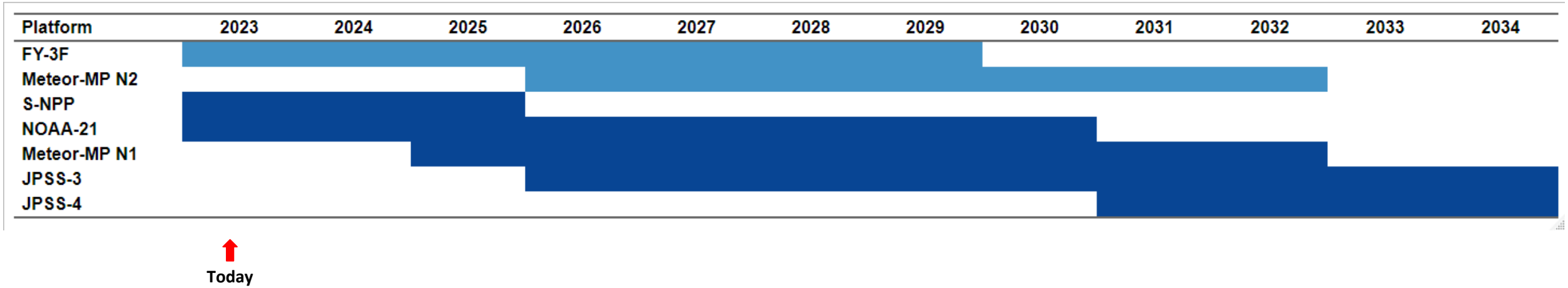
128.2°E

0°

WGIII Assessment:

Slight risk of not meeting CGMS Baseline commitment in the 128.2E slot in the early 2030s. Action on KMA to confirm GK-2B follow-on. An HLPP objective (1.2.3) exists to extend the capability to the whole geostationary ring.

UV Limb Spectrometer (Aerosol, Atmospheric Composition: O3)



LEO - 2 Orbits

Sun-synchronous mid-morning

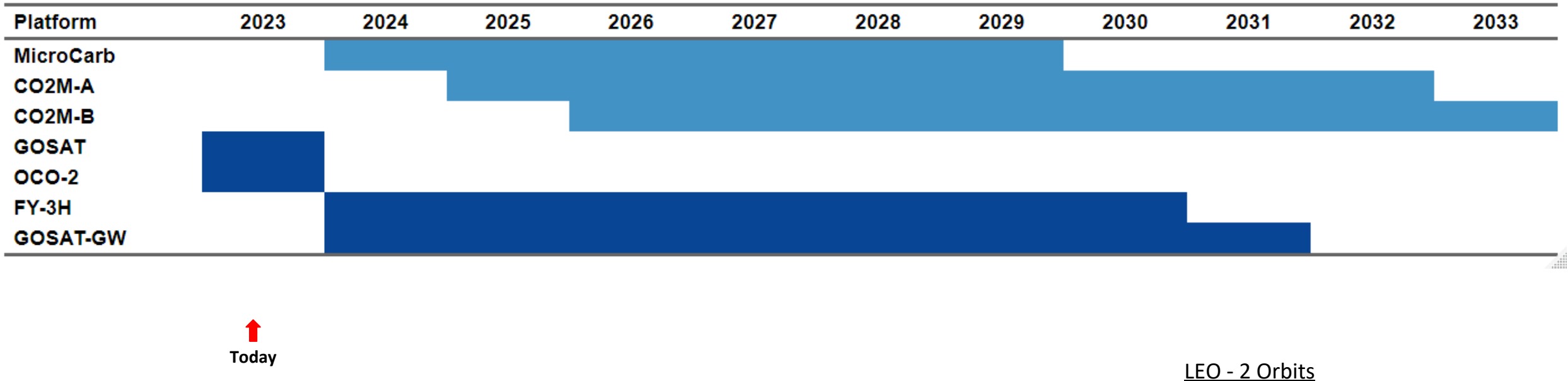
Sun-synchronous afternoon

WGIII Assessment:

Low risk of not meeting the CGMS Baseline commitment.

Coordination Group for Meteorological Satellites - CGMS

SWIR Imaging Spectrometer (Atmospheric Composition: CO2, CH4)

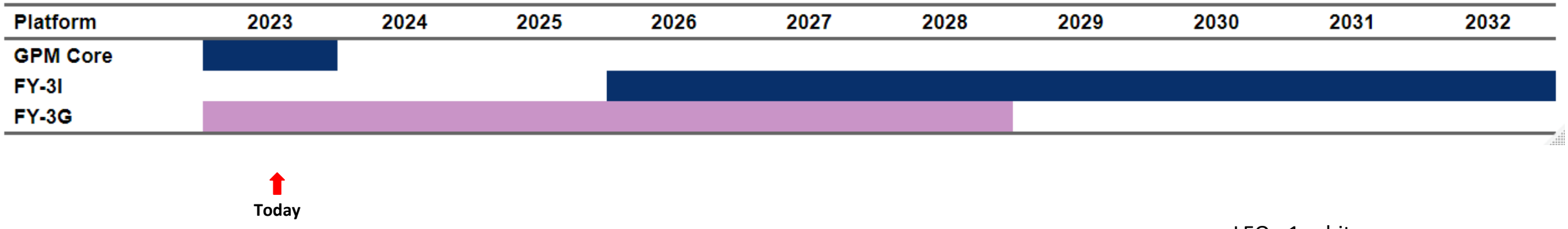


LEO - 2 Orbits
(late morning or afternoon)
Sun-synchronous late morning
Sun-synchronous afternoon

WGIII Assessment:

Low risk of not meeting the CGMS Baseline commitment in the near-term, no long term plans for the afternoon orbit.
The Joint Working Group on Climate is working to coordinate long-term CO2 monitoring.

Precipitation Radar (Precipitation)

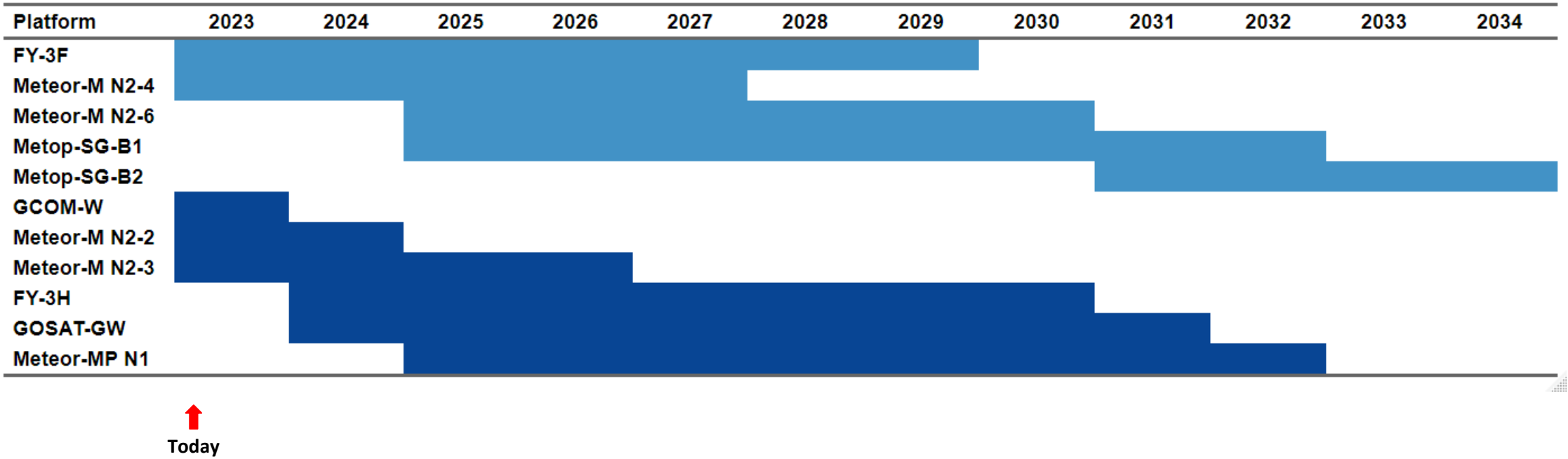


LEO - 1 orbit
Drifting

WGIII Assessment:

Low risk of not meeting the CGMS Baseline commitment. Action on NASA and JAXA to confirm plans beyond the GPM Core. GPM Core expected to last past 2023 but evaluating EOL on a yearly basis.

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

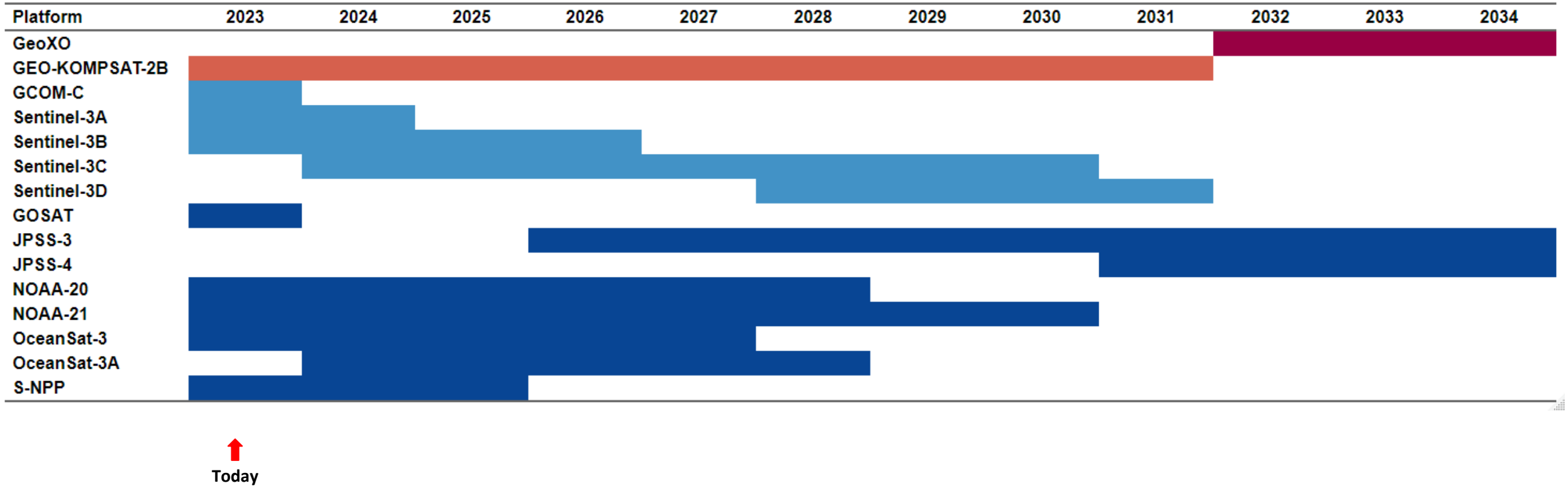
Sun-synchronous afternoon

WGIII Assessment:

Low risk of not meeting the CGMS Baseline commitment; however, sensor performance requirements for different environmental parameters vary; ~6 GHz frequency microwave imaging critical for all weather SSTs, and >90 GHz frequency critical for precipitation. Recommend action for ESA to report on plans for the CIMR (Copernicus Imaging Microwave Radiometer) Mission.

Coordination Group for Meteorological Satellites - CGMS

Narrow Band Visible Imager (Ocean Colour, Aerosols)



LEO - 2 Orbits

Sun-synchronous mid-morning

Sun-synchronous afternoon

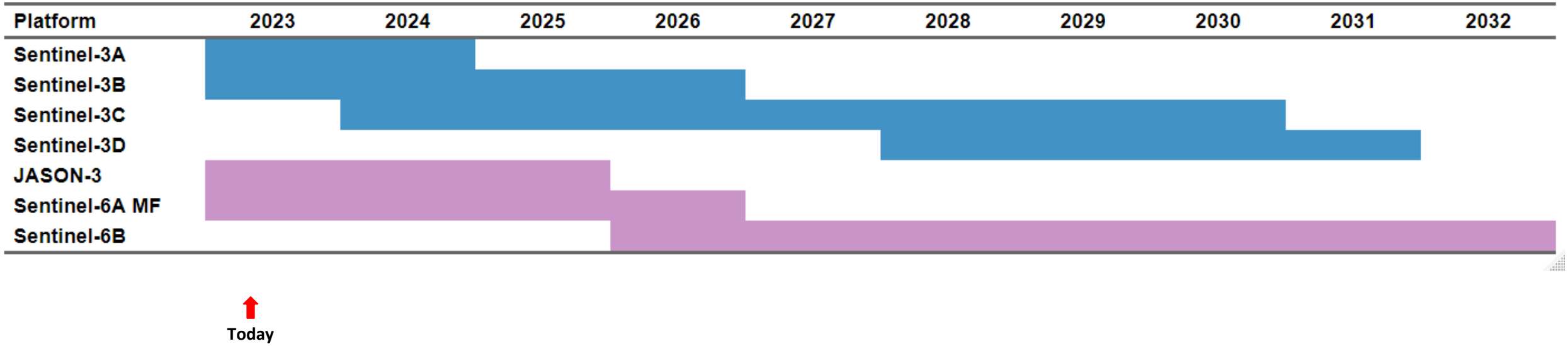
GEO - 1 Slot

128.2°E

WGIII Assessment:

Low risk of not meeting the CGMS Baseline commitment. GEO coverage required beyond GEO-KOMPSAT-2B, KMA to provide confirmation of follow-on.

Radar Altimetry (Ocean Surface Topography)



LEO - 1 Orbit

Sun-synchronous mid-morning

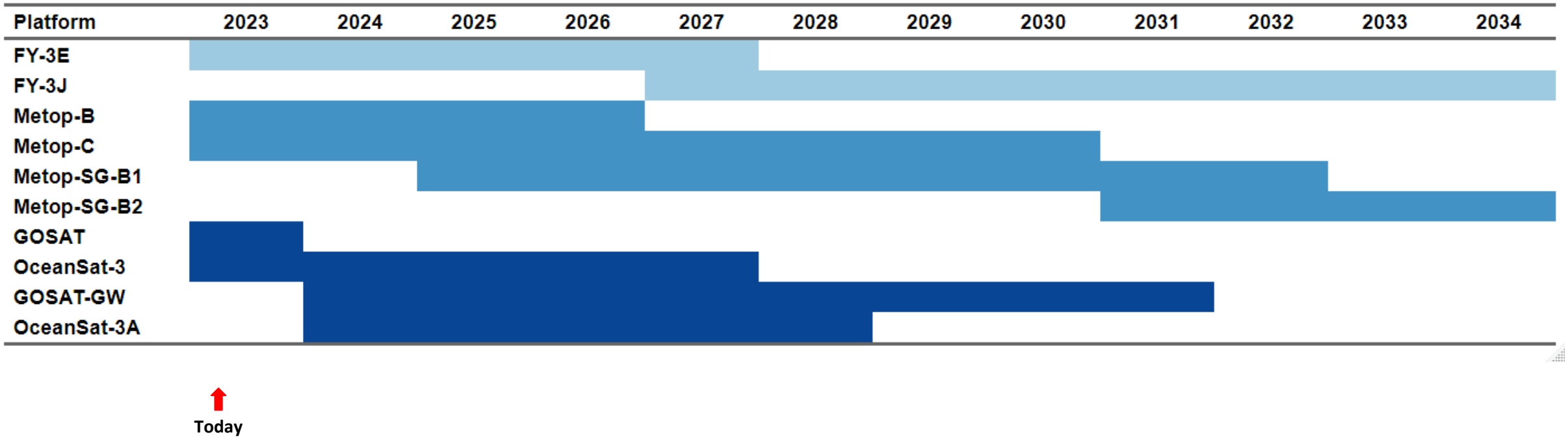
High-precision, drifting reference mission

WGIII Assessment:

Low risk of not meeting the CGMS Baseline commitment.

Coordination Group for Meteorological Satellites - CGMS

Scatterometry (Ocean Surface Winds)



WGIII Assessment:

Slight risk of not meeting CGMS Baseline commitment in the afternoon orbit in the early 2030s. Action on ISRO to confirm plans beyond OceanSat-3A.

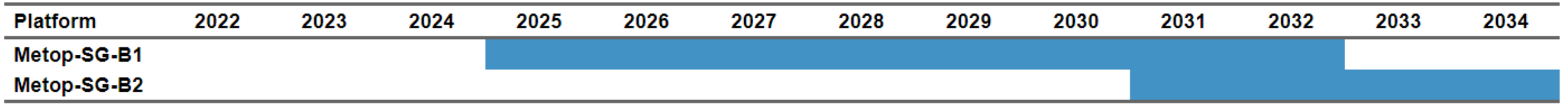
LEO

Sun-synchronous early morning

Sun-synchronous mid-morning

Sun-synchronous afternoon

Sub-millimetre Ice Cloud Imager (Cloud Ice)



Today

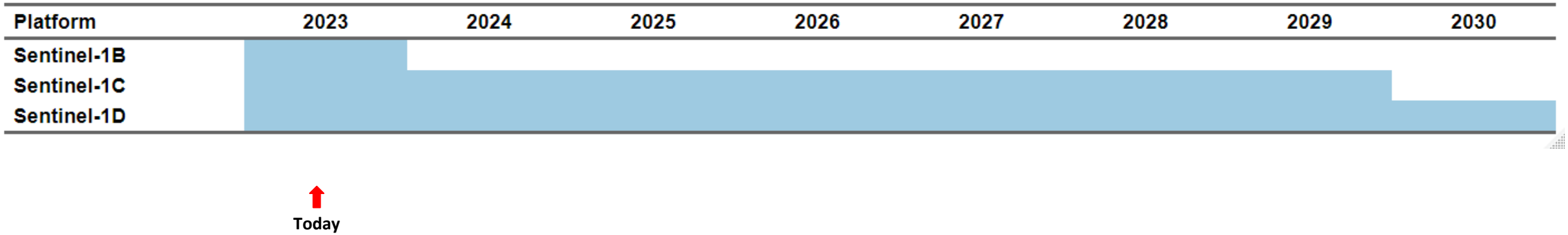
LEO - 1 Orbit

Sun-synchronous mid-morning

WGIII Assessment:

Low risk of not meeting Baseline commitments.

Synthetic Aperture Radar (Soil Moisture, Sea Ice)



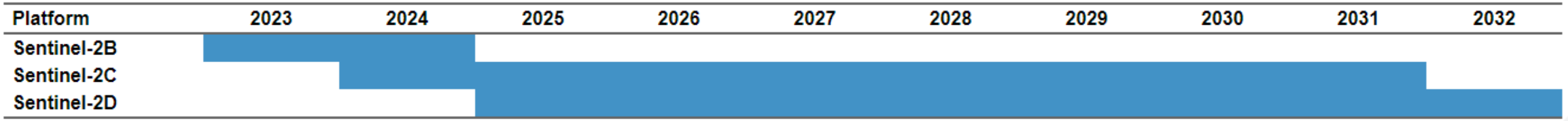
LEO - 1 Orbit

Sun-synchronous

WGIII Assessment:

Low risk of not meeting Baseline commitments.

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



Today

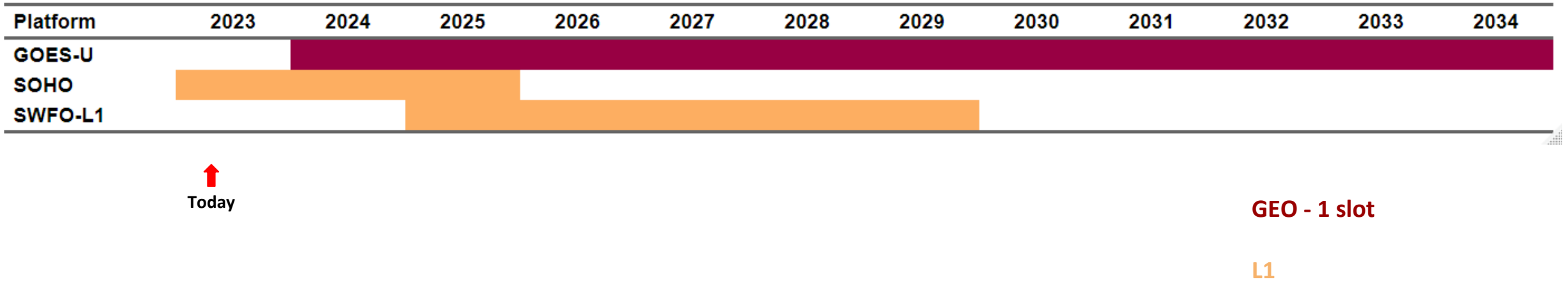
LEO - 1 Orbit

Sun-synchronous

WGIII Assessment:

Low risk of not meeting Baseline commitments.

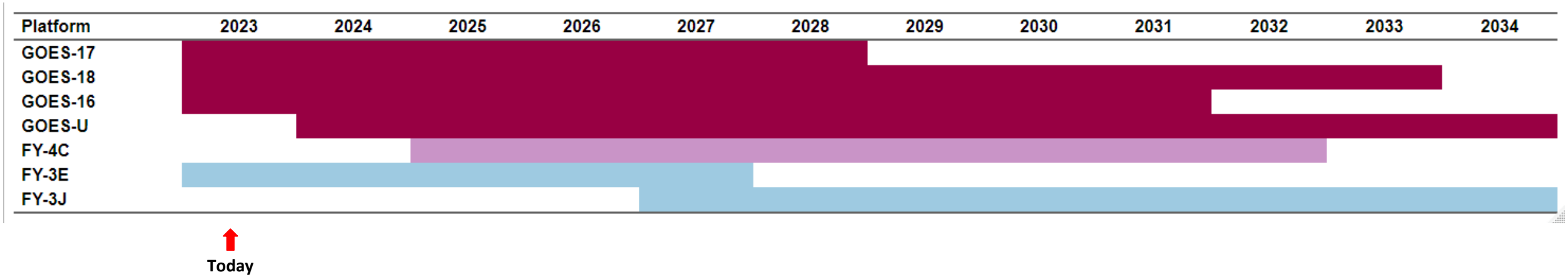
Coronagraph (Coronagraphy)



WGIII Assessment:

Increasing risk of a gap in the early part of the decade and long term continuity at L1. Increasing risk of a gap until GOES-U and SWFO-L1 are launched as SOHO operating well past design life, but additional ground resources used to track STEREO-A may mitigate that risk in the event of SOHO loss before 2024.

EUV Imager (EUV Imagery)



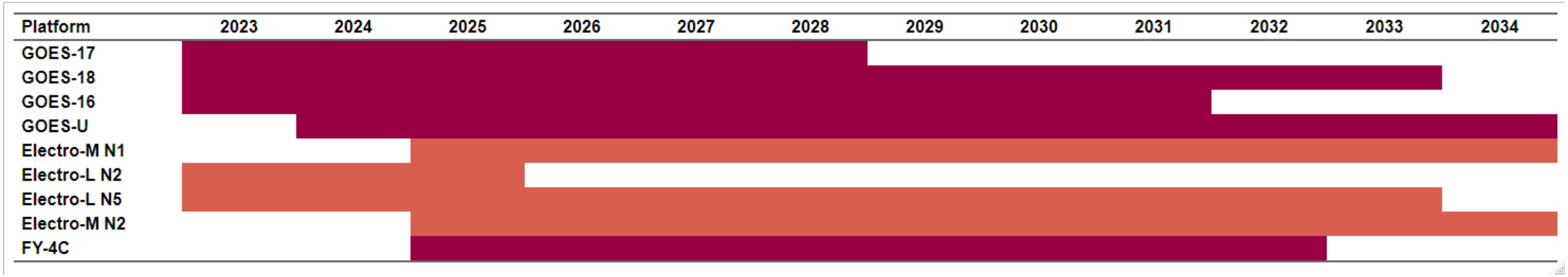
LEO - 1 slot

GEO - 2 slots

WGIII Assessment:

Low risk of not meeting Baseline commitments.

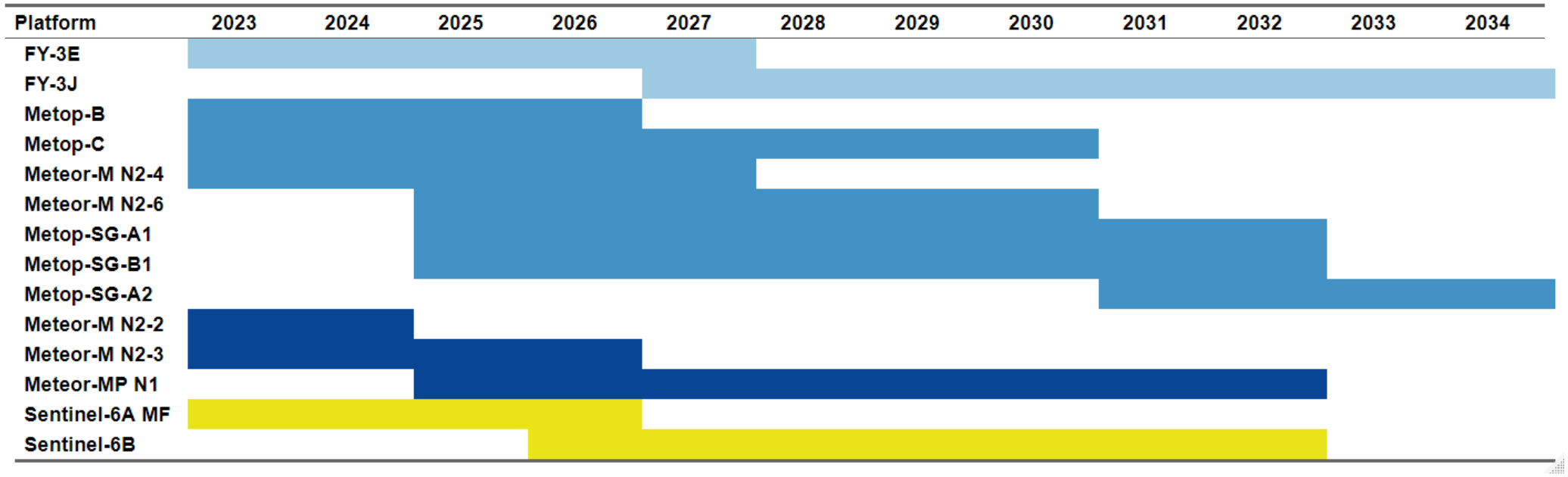
X-Ray Spectrograph (X-Ray Flux)



WGIII Assessment:

Low risk of not meeting Baseline commitments.

Energetic Particle Sensor LEO (Magnetospheric)



LEO - 3 Orbits

Sun-synchronous early morning

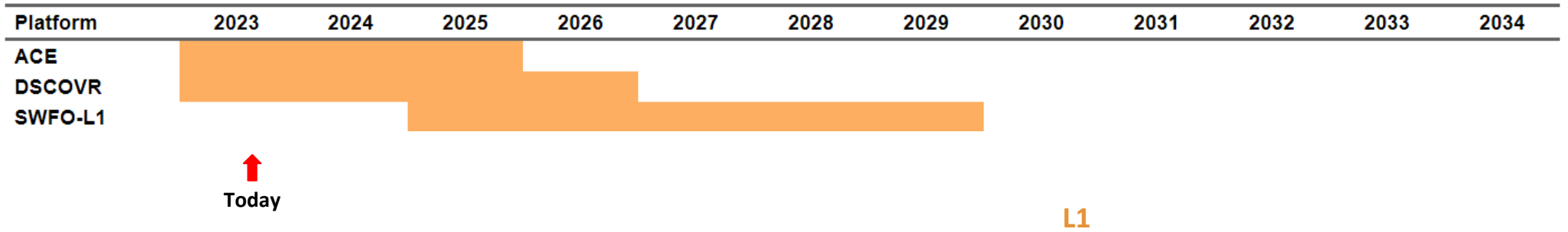
Sun-synchronous mid-morning

Sun-synchronous afternoon

WGIII Assessment:

Low risk of not meeting Baseline commitments.

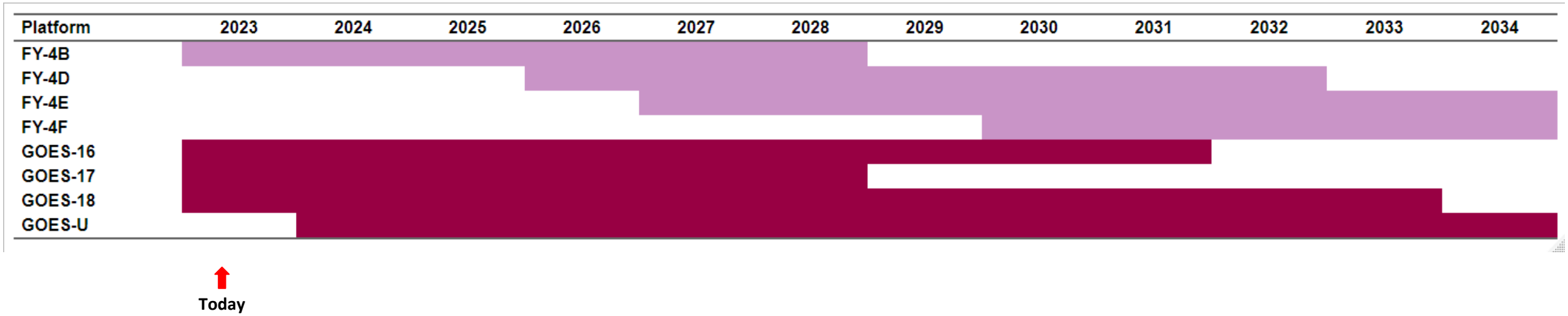
Energetic Particle Sensor L1 (Solar Energetic Particles)



WGIII Assessment:

Increasing risk of a gap at the end of the decade.

Low Energy Electrons and Protons (Energetic Particles)



GEO - 2 slots

86.5°-123°E range

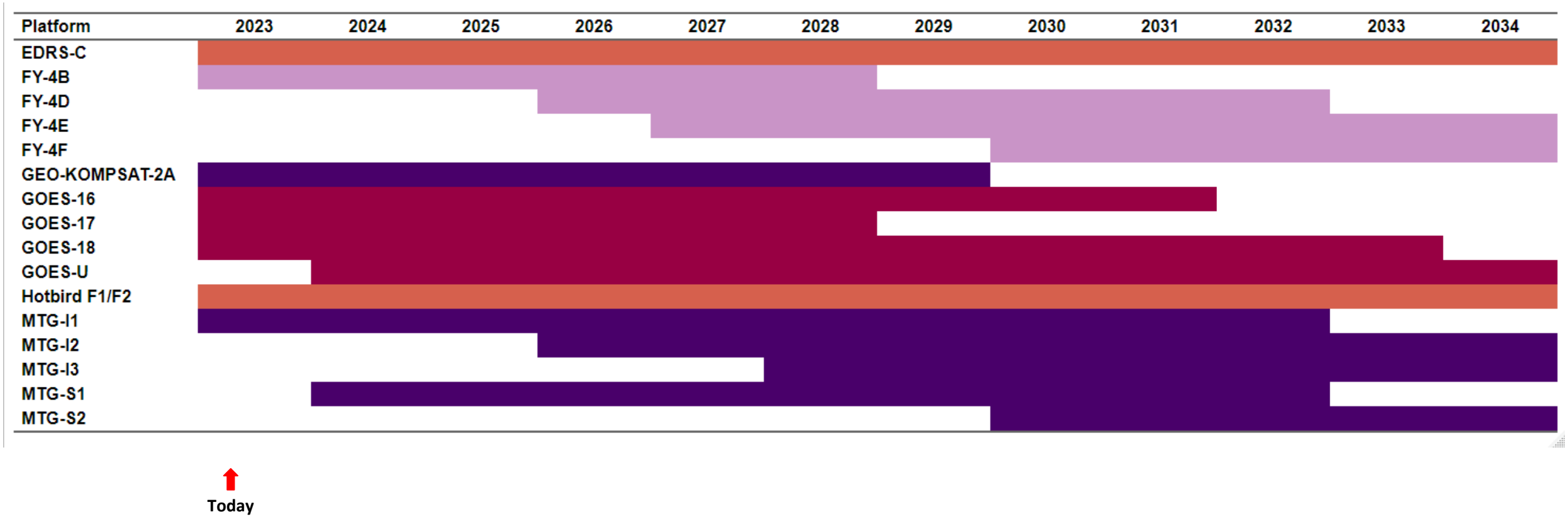
75.2°- 137°W range

WGIII Assessment:

Low risk of not meeting Baseline commitments.

Coordination Group for Meteorological Satellites - CGMS

High Energy Electrons and Protons (Energetic Particles)



WGIII Assessment:

Low risk of not meeting Baseline commitments.

GEO - 3 slots

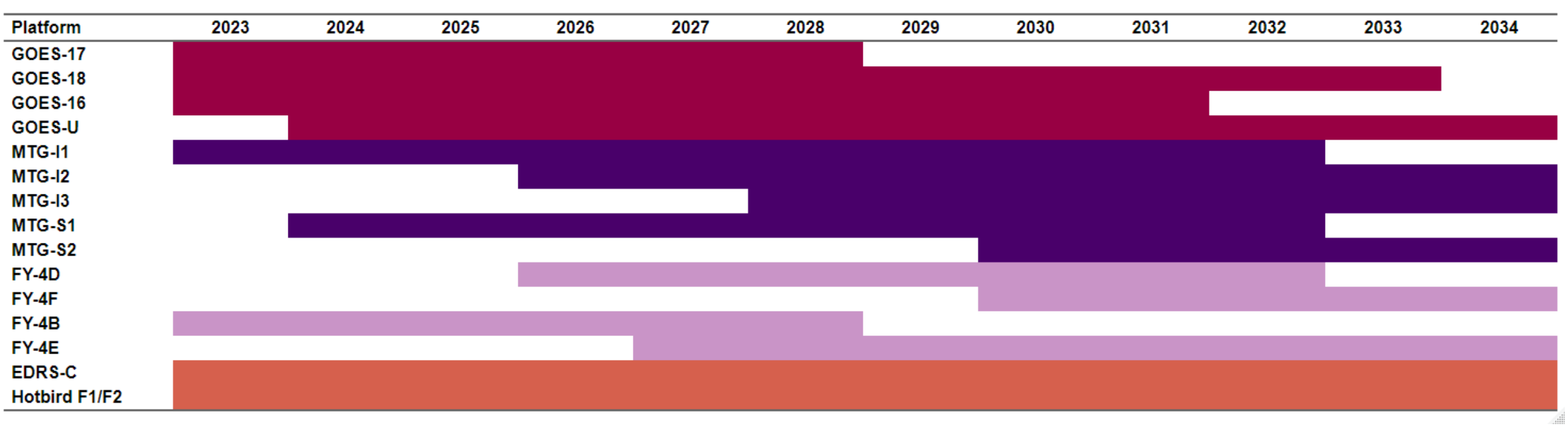
0°

86.5°-123°E range

75.2°- 137°W range

Coordination Group for Meteorological Satellites - CGMS

Very High Energy Protons (Energetic Particles)



GEO - 3 slots

0°

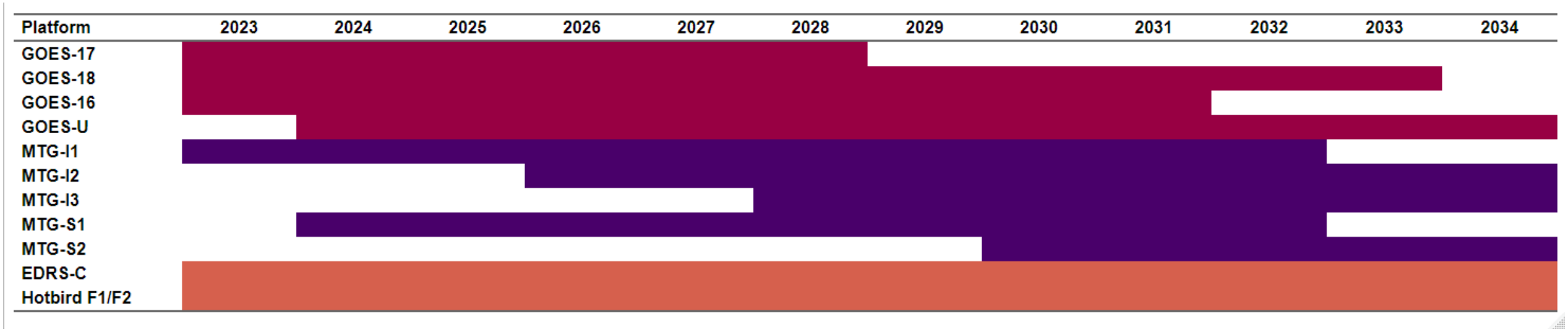
86.5°-123°E range

75.2°- 137°W range

WGIII Assessment:

Low risk of not meeting Baseline commitments.

Energetic Heavy Ions (Energetic Particles)



GEO - 2 slots

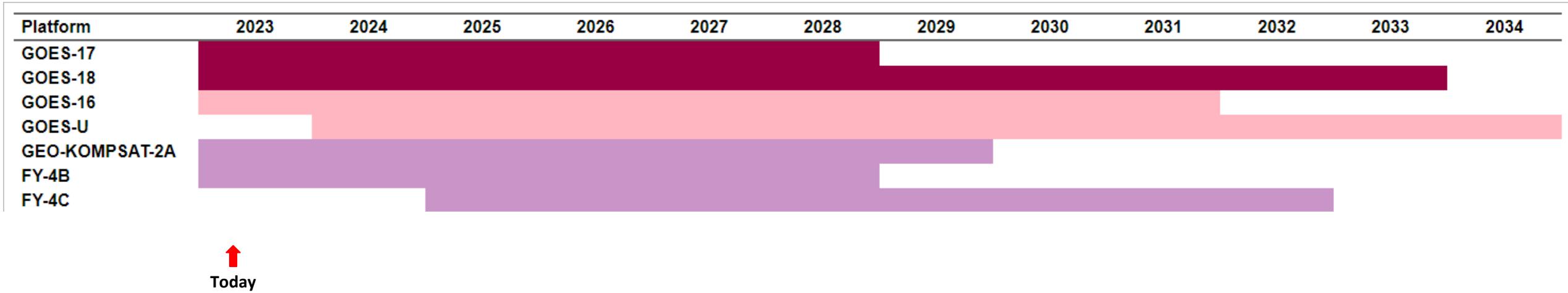
0°

75.2°- 137°W range

WGIII Assessment:

Low risk of not meeting Baseline commitments.

Magnetometer GEO (Earth's Magnetic Field)



GEO – 2 Slots

75.2°W

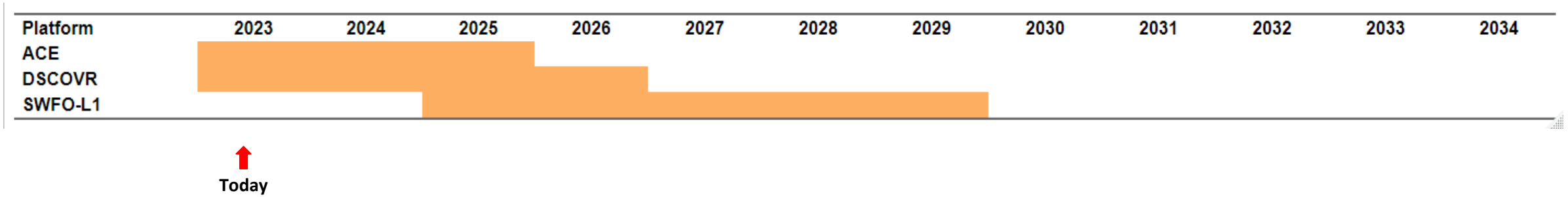
137°W

86.5°-128°E range

WGIII Assessment:

Low risk of not meeting Baseline commitment.

Magnetometer L1 (Interplanetary Magnetic Field)

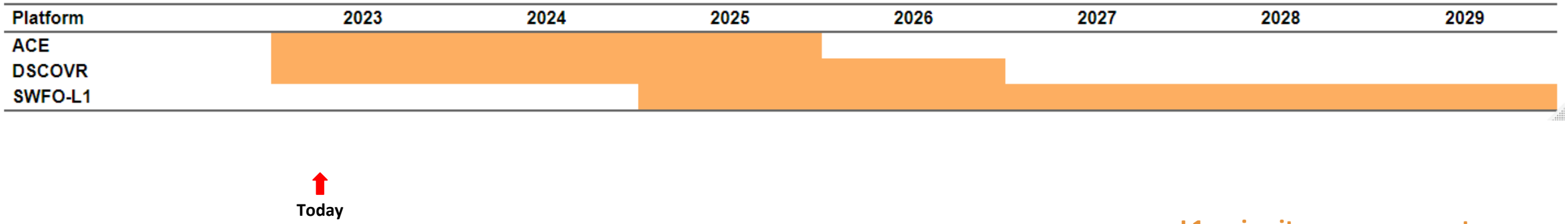


L1, as an in situ measurement

WGIII Assessment:

Risk of not meeting Baseline commitments at L1 until SWFO-L1 is launched; no long term commitment at L1

Plasma Analyzer (Solar Wind)



WGIII Assessment:

Increasing risk of a gap in the early part of the decade until SWFO-L1 is launched; no long term L1 plans.