MacroEdTech

COPERNICUS SENTINEL-6B MISSION REPORT

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1. Executive Summary

The **Copernicus Sentinel-6B** mission, successfully deployed on **November 17, 2025**, stands as the critical node in the global ocean observing system. As the twin to the Sentinel-6 *Michael Freilich* (launched 2020), Sentinel-6B is not merely a replacement satellite; it is the custodian of the **"Reference Altimetry Record."**

Since 1992 (TOPEX/Poseidon), humanity has maintained an unbroken, high-precision record of global sea levels. Sentinel-6B extends this record into a fourth decade (2025–2030+). By operating in a unique non-sun-synchronous orbit, it serves as the absolute calibration standard for all other ocean-observing satellites (e.g., Sentinel-3, SWOT, CryoSat-2). Its successful commissioning ensures that the detection of accelerating sea-level rise—a vital climate change indicator—remains robust and uninterrupted.

2. Mission Profile & Operational Timeline

The launch campaign and orbital insertion were executed with precision to ensure the satellite could enter the highly specific "Reference Orbit."

- **Launch Vehicle:** SpaceX Falcon 9 (Block 5)
- **Launch Site:** Vandenberg Space Force Base, SLC-4E
- **Target Orbit:** 1,336 km altitude, 66° inclination

Table 1: Mission Timeline & Status

Phase	Timeframe	Operational Status	Key Objectives
Launch (LEOP)	Nov 17 – Nov 20, 2025	**Complete**	Solar array deployment, X-band downlink acquisition, initial systems check.
Drift & Injection	Nov 20 – Dec 2, 2025	**Complete**	Orbit raising maneuvers to intercept the reference ground track.
Tandem Phase	**Dec 2025 – Dec 2026**	**Active (Current)**	Flying 30 seconds behind Sentinel-6A. Cross-calibration of instruments to eliminate bias.
Operational Phase	2026 – 2030	Planned	Routine generation of L2/L3 data products. Sentinel-6B becomes the primary "Reference Mission."
End of Life	2031+	Planned	De-orbiting to graveyard orbit or controlled re-entry.

3. Spacecraft Systems & Architecture

Built by **Airbus Defence and Space**, the Sentinel-6B bus is a masterclass in stability. Unlike agile imaging satellites that must slew and rotate, an altimeter satellite must be a "flying rock"—exceptionally stable and predictable.

3.1 Platform Design & Heritage

- **Heritage:** Heavily derived from CryoSat-2 and Sentinel-3, reducing development risk.
- **Dimensions:** $5.3\,m \times 4.2\,m \times 2.4\,m$ (In-orbit configuration).
- **Mass:** $\sim 1,192\,kg$ wet mass.
- **Structure:** A central aluminium cylinder houses the propellant tanks, providing the structural backbone, while external panels host the avionics.

3.2 Power Generation & Thermal Stability

The spacecraft's unusual "house-roof" shape is functional, not aesthetic.

- **Fixed Solar Arrays:** The two body-mounted solar arrays (approx. $17.5 m^2$) are fixed in a tent shape. This eliminates the need for Solar Array Drive Mechanisms (SADMs), which create micro-vibrations that can corrupt altimetry readings.
- **Power Output:** Generates ~891 W (End of Life), sufficient to power the dual-frequency radar continuously.
- **Thermal Control:** The altimeter is sensitive to thermal expansion (millimeter changes in antenna shape cause errors). The satellite uses a complex network of heaters and radiators to maintain the instrument bench at a near-constant temperature, regardless of whether it is in sunlight or eclipse.

3.3 Propulsion & Orbit Maintenance

- **System:** Monopropellant Hydrazine (N_2H_4).
- **Constraint:** The satellite must maintain its ground track within $\pm 1\,km$.
- **Maneuvers:** Regular, tiny "trim burns" are executed to counteract atmospheric drag. The satellite predicts these forces weeks in advance to minimize disruption to science data.

4. Primary Payload: The Altimetry Suite

The payload determines the distance to the ocean surface ($Range$) and corrects for atmospheric delays.

4.1 Poseidon-4 Radar Altimeter (SAR/LRM)

This ESA-developed instrument is the world's most advanced operational ocean altimeter.

- **Frequency:** Ku-band ($13.575\,GHz$) & C-band ($5.41\,GHz$).
- **The "Digital" Revolution:**
    - **Open Burst (Interleaved) Mode:** Unlike previous "Jason" satellites that had to stop transmitting to listen for the echo (closed burst), Poseidon-4 transmits and receives simultaneously (interleaved).
    - **Dual Processing:** It produces **Low Resolution Mode (LRM)** data (to match the 30-year historical record) and **Synthetic Aperture Radar (SAR)** data (high-resolution) *simultaneously*.
- **Benefit:** The SAR mode focuses the radar energy into a narrow footprint, reducing measurement noise by 50% and allowing data collection closer to coastlines.

4.2 AMR-C: Advanced Microwave Radiometer

- **Provider:** NASA/JPL.
- **Problem:** Water vapor in the atmosphere slows down radar pulses. A humid day can make the ocean look 30cm lower than it is.
- **Solution:** The AMR-C measures radiation from the Earth's surface at 18.7, 23.8, and 34.0 GHz. These specific frequencies allow it to calculate the precise amount of water vapor and liquid water in the radar's path.
- **Upgrade:** Sentinel-6B features a "Cold Sky Calibration" system to maintain accuracy as the instrument ages.

5. Precision Navigation: Orbit Determination (POD)

You cannot measure sea level to centimeter precision if you don't know where the satellite is. Sentinel-6B uses a **"Triad of Truth"** for positioning.

Table 2: The POD Triad

System	Provider	Technology	Role
GNSS-POD	ESA/NASA	GPS & Galileo Receiver	**Continuous Tracking:** Provides 3D location data 24/7 with high temporal resolution.
DORIS	CNES (France)	Doppler Shift Measurement	**The Backbone:** Measures frequency shifts from ~60 ground beacons. Unaffected by ionosphere; highly stable.
LRA	NASA	Passive Laser Mirrors	**The Auditor:** Ground stations fire lasers at the satellite. It provides an external, absolute check on the electronic systems.

- **Result:** The radial orbit error is currently $<1.5\,cm$, a feat of modern engineering.

6. Secondary Payload: Radio Occultation (GNSS-RO)

While the main instruments look *down*, the GNSS-RO looks *sideways* at the horizon.

- **Function:** It tracks GPS/Galileo satellites as they set behind the Earth's atmosphere.
- **Physics:** The radio signals are bent (refracted) by the atmosphere. The degree of bending reveals the **Temperature**, **Pressure**, and **Humidity** of the air layers.
- **Impact:** Sentinel-6B provides roughly 4,000 vertical atmospheric profiles per day, directly improving global weather forecasts (e.g., hurricane steering currents).

7. Scientific Applications & Data Products

7.1 Oceanography & Climate Monitoring

- **Global Mean Sea Level (GMSL):** The primary metric of climate change. Sentinel-6B is detecting the *acceleration* of this rise (currently ~4.8 mm/yr).
- **Ocean Heat Content:** By combining Altimetry (height) with Argo float data (temperature), scientists can track how much heat the oceans are absorbing (approx. 90% of excess planetary heat).
- **Geostrophic Currents:** The slope of the ocean surface reveals current velocity. Sentinel-6B maps major currents (Gulf Stream, Kuroshio) that regulate global climate.

7.2 Coastal Altimetry & Hydrology

- **Coastal Zones:** The new SAR mode allows the satellite to measure sea height within **5-10 km of the coast** (compared to 50 km for previous satellites). This is crucial for monitoring storm surges and local sea-level rise impacts on coastal cities.
- **Inland Waters:** Sentinel-6B tracks the water levels of thousands of lakes and large rivers (e.g., Amazon, Congo, Ganges), providing vital data for water resource management.

8. Conclusion & Future Outlook

The successful launch and commissioning of **Sentinel-6B** secures the "Reference Orbit" through **2030**. By flying in tandem with its predecessor for the next 12 months, the mission will perform the most rigorous cross-calibration in the history of altimetry.

Next Steps:

- **2026:** Sentinel-6B becomes the primary reference mission. Sentinel-6A moves to an "interleaved" orbit to double global coverage.
- **2030s:** Planning is underway for the **Sentinel-6 Next Generation**, likely to feature wide-swath interferometry (SWOT-like technology) to transition from 1D profiling to 2D ocean topography mapping.

9. References & Acronyms

- **ESA:** European Space Agency
- **EUMETSAT:** European Organisation for the Exploitation of Meteorological Satellites
- **CNES:** Centre National d'Études Spatiales (France)
- **NOAA:** National Oceanic and Atmospheric Administration (USA)
- **POD:** Precise Orbit Determination
- **SAR:** Synthetic Aperture Radar

- *Donlon, C. et al. (2021). "The Copernicus Sentinel-6 Mission: Enhanced Continuity of Satellite Sea Level Measurements from Space." Remote Sensing of Environment.*
- *NASA/JPL Sentinel-6B Launch Press Kit (Nov 2025).*