Space System Design I

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Earth Observation Satellite Mission Design

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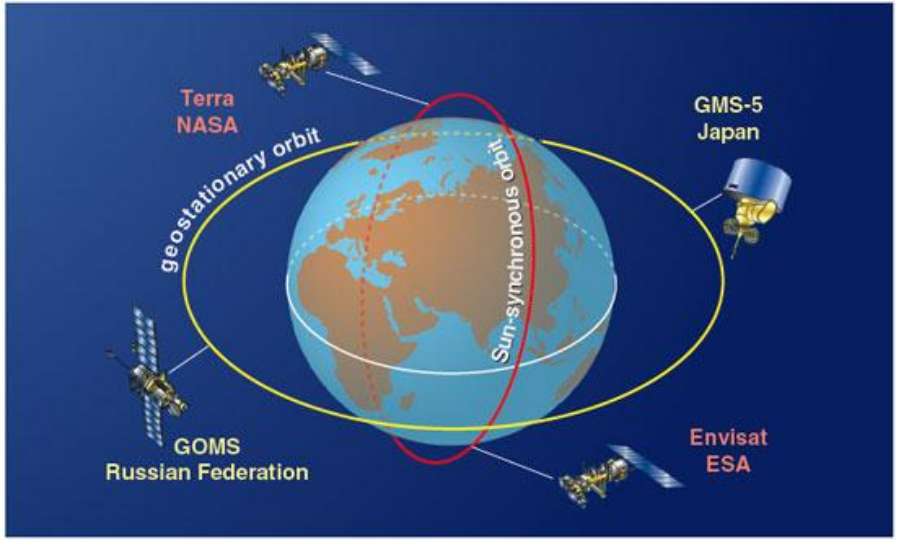
Table of contents

Objective

Mission:

- Goal is to monitor deforestation, urban expansion, and land-use changes globally.

- Objectives include tracking natural disasters like wildfires and floods.



Requirements:

- High-resolution imaging for detecting changes in small areas (~10m resolution).
- Global coverage every two days to ensure timely data.
- Near-real-time data relay to decision-makers for disaster response.

Key Parameters of Payloads:

Multispectral Camera:

- Spectral bands: RGB, NIR.
- Resolution: 10m for detailed land mapping.
- Swath width: 300 km for wide-area coverage.
- Onboard storage: 512 GB to store large amounts of data before transmission.

Infrared Sensor:

- Thermal resolution: 50m for identifying heat sources.
- Temperature sensitivity: ±0.5°C for precise monitoring.

Communication System:

- X-band transmitter for high-speed data downlink (1 Gbps).
- S-band for command and telemetry (real-time satellite health updates).

Operational Orbit

Design:

- Type: Sun-synchronous orbit (SSO) to pass over the same location at the same local solar time, ensuring consistent lighting for images.
- Altitude: 705 km to balance resolution and revisit time.
- Inclination: 98.2° for global coverage, including polar regions.
- Orbital Period: 99 minutes, allowing 14 orbits per day.

Rationale:

- Sun-synchronous orbits ensure consistent lighting conditions, critical for imaging payloads.

- Polar coverage is essential for global environmental monitoring.

Detailed Subsystems

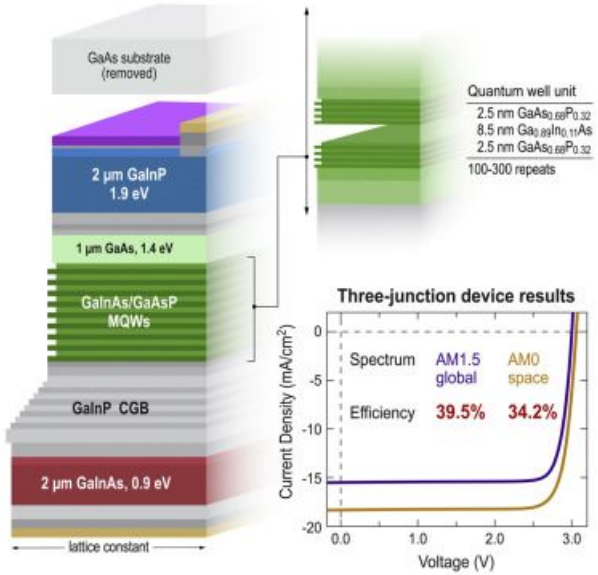
Power System

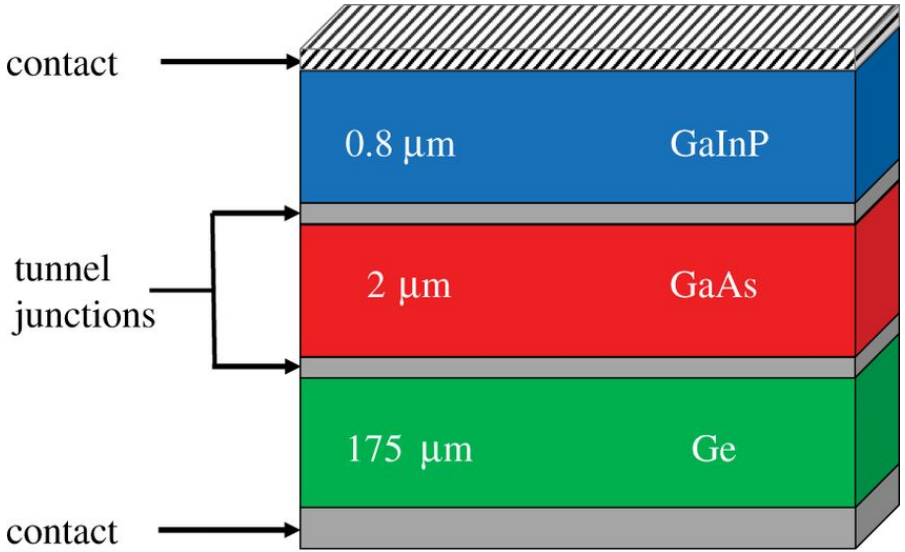
Solar panels

- Triple-junction GaAs solar cells with 28% efficiency
- Size: 2m x 2.3m
- Ability to generate 1.5kW of energy during peak sunlight

Batteries

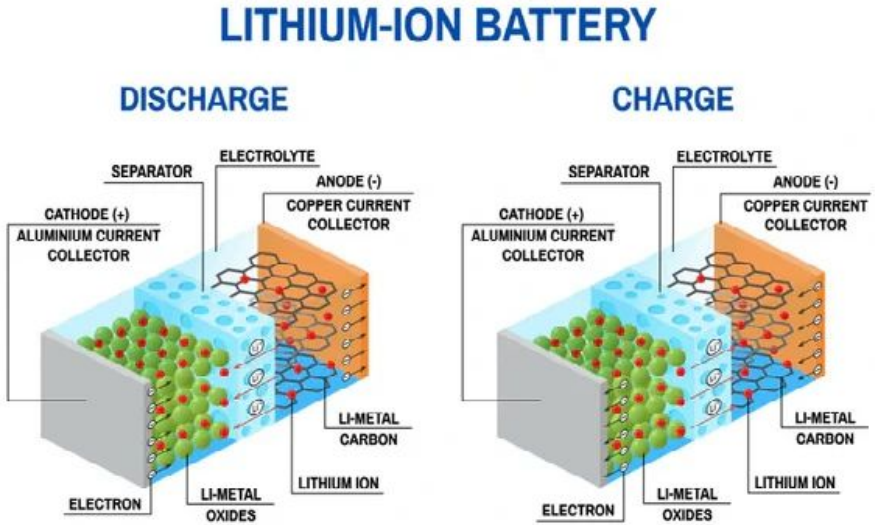
- Lithium-ion batteries with 80Ah capacity for eclipse operations (~35 minutes per orbit)
- Redundant battery banks to ensure reliability





Triple-junction GaAs solar cells

*hình ảnh này chỉ mang tính minh hoạ



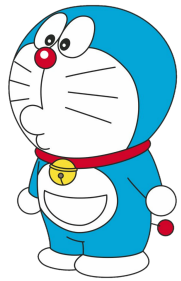
*nhưng cái này thì không

Lithium-ion batteries

Altitude Determination and Control System (ADCS)

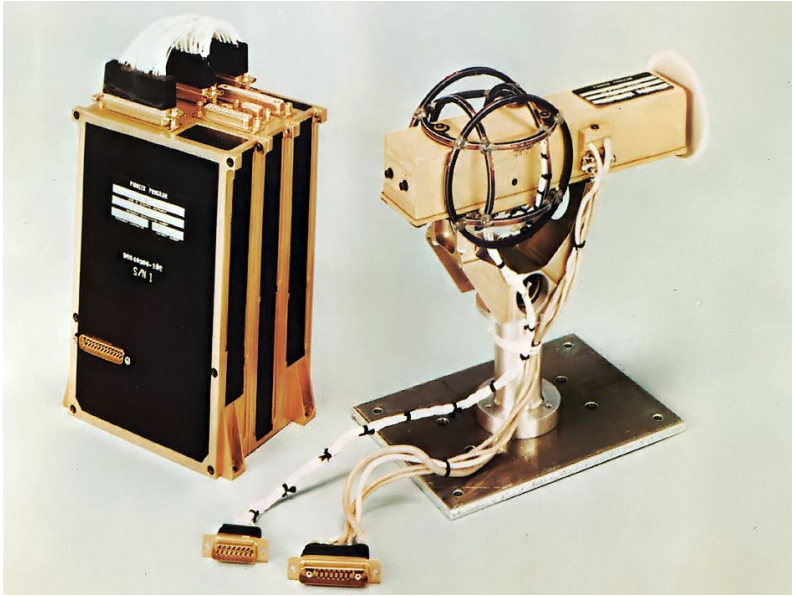
Sensors

- Star trackers for precise orientation
- Sun sensors for coarse pointing
- Magnetometers to detect Earth’s magnetic field for stabilization



Actuators

- Reaction wheels for fine control
- Magnetorquers for detumbling angular momentum
- Pointing accuracy can be reach up to 0.1° for sharp imaging



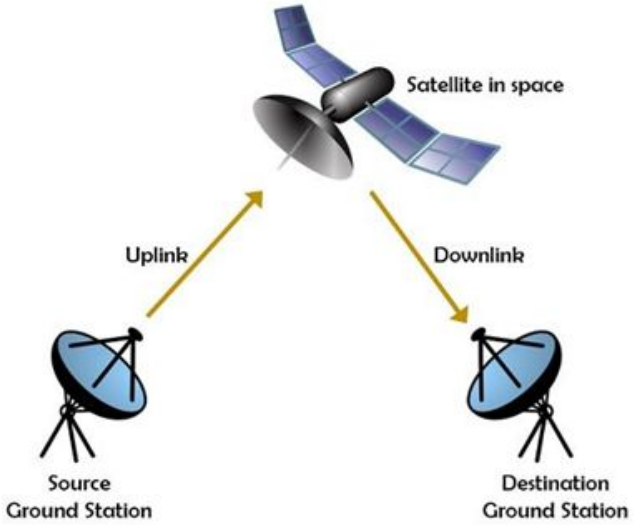
Thermal Control System

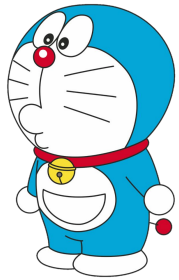
Only need passive solutions

- Multi-Layer Insulation (MLI) blankets to reduce heat exchange
- Radiators for heat dissipation

Communication System

- Downlink: X-band with data rates of 1 Gbps
- Uplink: S-band with telemetry commands sent at 10 Mbps
- Antenna
  - Deployable high-gain parabolic antenna for data transmission
  - Omnidirectional antennas for telemetry

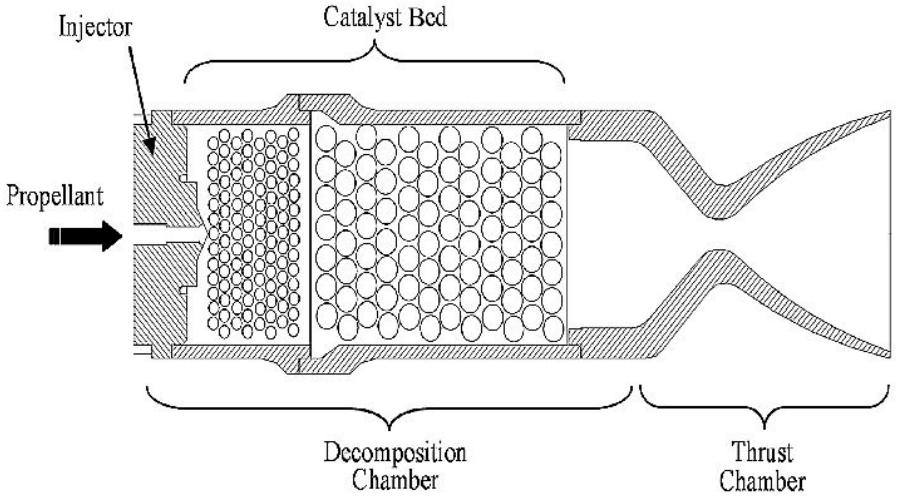




Propulsion System

Thrusters

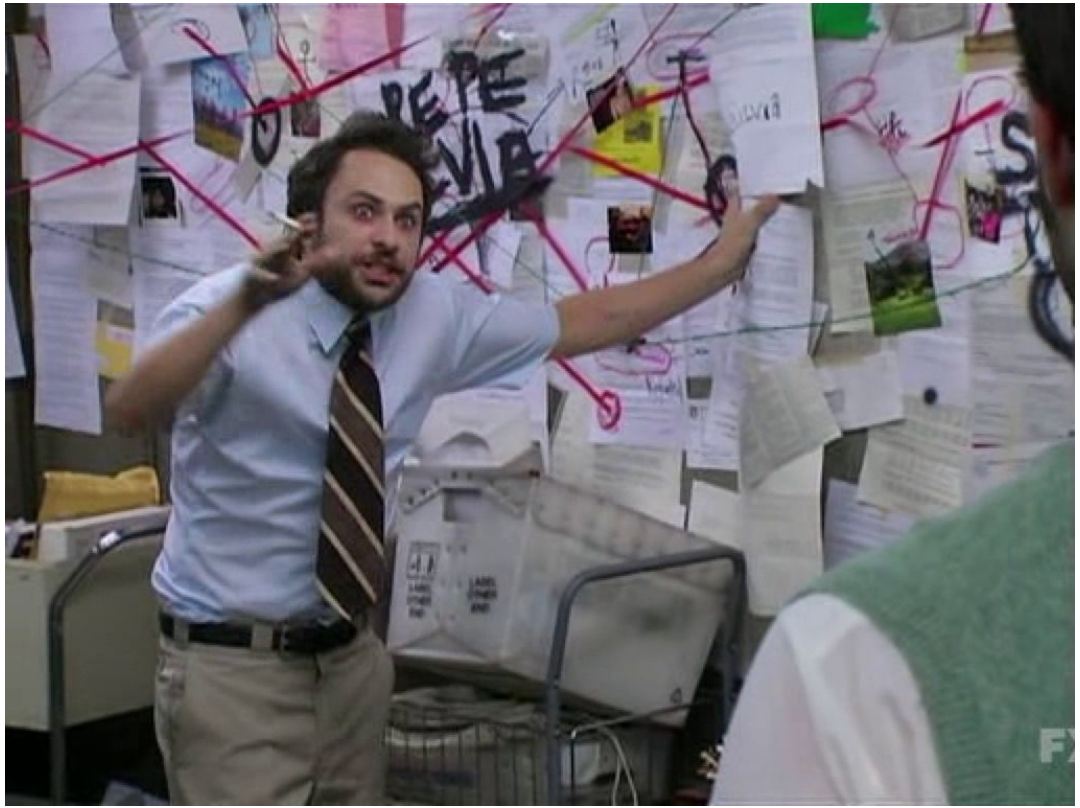
- Hydrazine monopropellant system with four 1N thrusters
- For orbit maintenance, collision avoidance, and deorbiting at end-of-life



Structure and Mechanisms

- Design: aluminum-lithium alloy frame for lightweight and rigidity
- Dimensions: 2.5m x 1.8m x 1.8m
- Deployable Solar Panels: two panels stowed during launch and deployed in orbit

Timeline



PHASE DURATION	MILESTONES	DETAILS
Concept Design	6 months	Mission objectives, feasibility studies, approval
Preliminary Design	10 months	Payload and subsystem selection, CAD modeling
Detailed Design	12 months	Full design finalized, critical design review
Manufacturing	24 months	Subsystems built, payloads integrated
Testing	10 months	Environmental testing (thermal, vibration, EMI
Launch Preparation	6 months	Final assembly, integration with launch vehicle
Launch & Operations	1 month	Launch, orbit insertion, commissioning phase

Review Meetings

- Design reviews (Preliminary Design Review, Critical Design Review)
- Testing phase reviews to identify and rectify anomalies

Verification and Validation Plan

- Subsystem testing in lab conditions
- Full satellite integration tests in simulated space environments
- On-orbit commissioning to validate operations

Launch Vehicle

Rocket vehicle: SpaceX Falcon 9

- Cost - effective
  - Medium-class rocket with a competitive pricing structure.
  - Reusable first stage reduces overall launch costs.
- Proven reliability
  - Strong track record of successful launches (>200).
  - Trusted by governmental and commercial clients.
- Payload capacity
  - Up to 22,800 kg to Low Earth Orbit (LEO).
  - Sufficient capacity for satellite and additional payloads.

Launch Vehicle

Launch Site: Vandenberg Space Force Base, USA

- Strategic Location

  - Ideal for polar and sun-synchronous launches, enhancing orbital insertion for Earth observation.

  - Minimize the risk to populated areas.

- Advanced Infrastructure

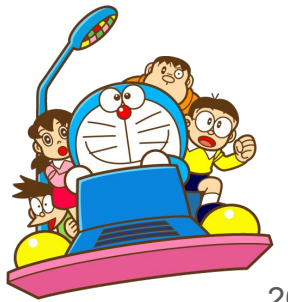
  - Equipped for comprehensive pre-launch checks and preparations.

  - Supports mission readiness and operational efficiency.

Launch Vehicle

Why Falcon 9 and Vandenberg Space Force Base?

- Cost effective: economic advantages due to reusability and competitive pricing.
- Reliability: Proven success rate critical for mission assurance.
- Compatibility: Fairing dimensions compatible with satellite structure for safe transport.



Ground Segment

Ground Stations

- Primary Stations

  - Kourou, French Guiana: Central hub for data reception.

  - Kiruna, Sweden: Supports global coverage and data relay.

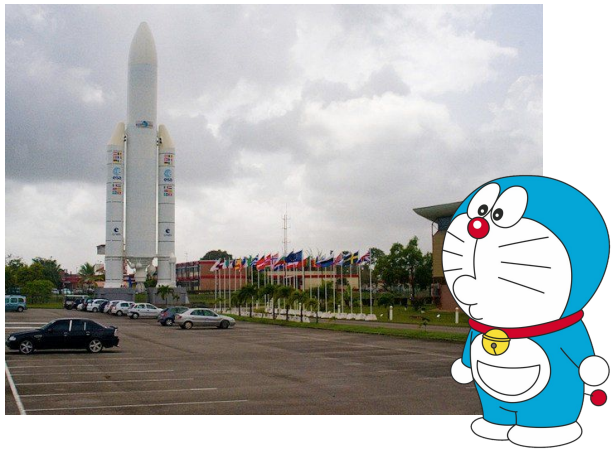
- Backup stations

  - Bangalore, India: Enhances redundancy and data availability.

  - Alaska, USA: Additional support for high latitude coverage.

- Equipment

  - 10m atennas for high speed data reception



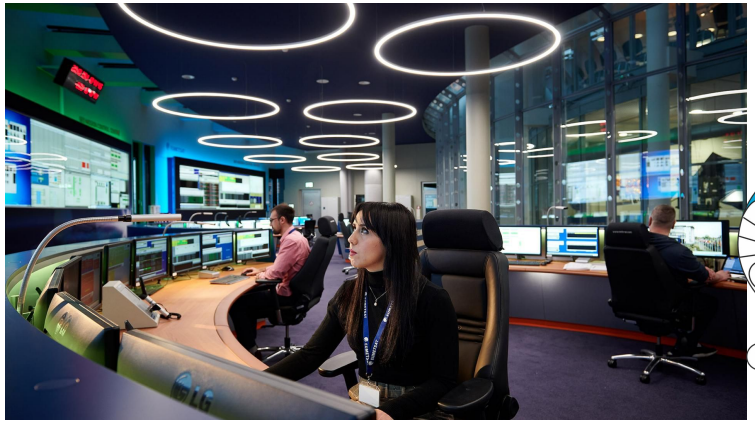
Ground Segment

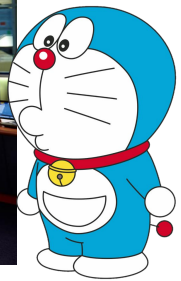
Mission Control Center

- Location: Darmstadt, Germany
- Functions

  - 24/7 satellite operations management.

  - Uplink commands and telemetry data processing.





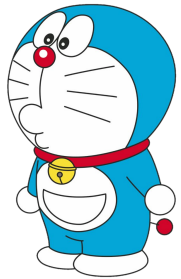
Ground Segment

Data Processing Center

- Cloud-based processing

  - Scalable infrastructure for handling large data volumes.

  - Facilitates rapid analysis and dissemination of information.



Ground Segment

Strategies for Managing Political Challenges

- International Collaboration Agreements

  - Joint Ownership: Countries can co-own ground stations, sharing operational costs and responsibilities.

  - Legal Frameworks: Create a legal framework that outlines each party's rights and responsibilities, dispute resolution mechanisms, and data sharing protocols.

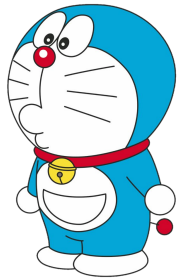
  - Regular Meetings: Set up regular diplomatic meetings to address ongoing challenges, ensuring transparency and fostering trust among parties.

- Private Partnerships

  - Utilizing Existing Infrastructure: Collaborate with companies/ organizations that already have ground stations in place.

  - Shared Operational Costs: Create agreements that allow for shared usage of facilities to minimize costs and enhance operational efficiency.

  - Flexibility in Operations: Private entities may be more agile in adapting to changing political climates, allowing for quicker modifications to operations.



Ground Segment

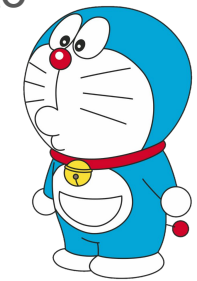
User Access

- Web portal

  - GIS tools for data visualization and analysis

- Application Programming Interface (APIs)

  - Integration capabilities for developers to incorporate satellite data into applications.



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THANKS