NASA CubeSat 101: Chapters 1-3 Summary & Cheatsheet

Comprehensive Reference Guide for First-Time CubeSat Developers

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CHAPTER 1: INTRODUCTION

1.1 What is a CubeSat?

Definition & Standards

A **CubeSat** is a standardized small satellite that must conform to specific criteria for shape, size, and weight:

- **1U (Unit)**: 10 cm × 10 cm × 10 cm cube, mass ~1-1.33 kg
- **Common sizes**: 1.5U, 2U, 3U, 6U, 12U

Why Standardization Matters

- Enables mass-produced, off-the-shelf components
- Reduces engineering and development costs
- Simplifies transportation and deployment
- Makes space more accessible to universities, schools, and small organizations

Key Document: CubeSat Design Specification (CDS)

- Available at: http://www.cubesat.org
- Contains general requirements for all CubeSats
- **NOT** the official requirements for your specific launch
- Essential for preliminary design planning

1.2 CubeSat Dispenser Systems

What is a Dispenser?

The **dispenser** is the interface between the CubeSat and the launch vehicle (LV). It provides: - Attachment to the launch vehicle - Protection during launch - Controlled release into space at the appropriate time

1.2.1 3U Dispensers

Poly-Picosatellite Orbital Deployer (P-POD) - First CubeSat dispenser (developed by Cal Poly) - Holds up to 3U of payload (any combination: three 1Us, two 1.5Us, one 3U, etc.) - Bolts directly onto launch vehicle - Door opens via electrical signal from LV

Key Features: - Safe container with door mechanism - Launch vehicle sends deployment signal - Multiple vendors now available

1.2.2 6U Dispensers

Introduced: 2014 **Form Factor**: Two 3Us side-by-side (twice as wide) **Flexibility**: Can accommodate any configuration (one 6U, six 1Us, two 3Us, etc.)

Important Note

You typically won't choose your dispenser—whoever pays for the launch does. However, understanding dispenser types is critical for design planning.

1.3 Launch Vehicles (LVs) - aka: Rockets

How CubeSats Get to Space

Primary Method: Dispenser bolted to rocket where space is available

Alternative Methods: 1. **ISS Deployment**: Sent with cargo resupply missions, deployed from Space Station 2. **Manual Release**: Extremely uncommon (e.g., Peruvian Chasqui 1 hand-tossed by cosmonaut)

U.S. Launch Vehicles Used for CubeSats

- Super Strypi
- Minotaur I & IV
- Taurus XL
- Delta II
- Antares
- Falcon 9 & Falcon 9 Heavy*
- Atlas V
- Electron*
- LauncherOne*
- Space Launch System (SLS)*

*As of 2017, these had not yet flown CubeSats but had them manifested

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1.4 NASA CubeSat Launch Initiative (CSLI)

What is CSLI?

NASA initiative providing **free launch opportunities** for qualified CubeSats as: - Auxiliary payloads on launches with excess capacity - Deployments from the International Space Station (ISS)

What NASA Provides

- Launch services (up to $300,000 value, typically enough for 3U to LEO)
- Integration services
- Dispenser

What YOU Must Provide

CRITICAL: CubeSat developers are responsible for ALL development and operational costs: - Materials and labor to build the CubeSat - Testing expenses - Ground station development and operations - Travel costs for required meetings and delivery

Eligibility Requirements

Your CubeSat **investigation** must: - Clearly benefit NASA - Support at least one goal/objective in NASA Strategic Plan - Available at: http://www.nasa.gov

Application Process

- **When**: Annual solicitation, typically early August
- **Where**: Announcement of Partnership Opportunity (AoPO) on https://sam.gov
- **Deadline**: Typically November of the same year

CSLI Mission Areas

Science (~50% of missions): - Space Weather - Earth Science - Biological science - Near Earth objects - Climate change - Orbital debris - Planetary science - Space-based astronomy - Heliophysics

Technology Development (~66% of missions): - Communications - Propulsion - Navigation and control - Radiation testing - Solar sails - Additive manufacturing - Femtosatellites

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CHAPTER 2: DEVELOPMENT PROCESS OVERVIEW

Complete Timeline: Concept to Operations

Project Duration

- **Minimum**: 9 months (design, build, test, deliver)
- **Typical**: 18-24 months
- **After delivery**: 4 weeks to 6 months until launch
- **Post-launch**: Mission operations variable, up to 20 years

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2.1 Concept Development (1-6 months)

Key Questions

1. What do you want your CubeSat to do?
2. Does it align with NASA's interests?
3. Is funding available?
4. Are there potential partners?

Keys to CSLI Selection

- Adequate funding
- Great merit and feasibility reviews
- Clear demonstration of benefit to NASA
- **FLEXIBILITY IS KEY**: Keep orbital requirements and launch dates as flexible as possible

Strategic Partnering

Consider collaborating with other organizations to: - Combine resources - Share expertise - Increase funding opportunities - Formalized through agreements

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2.2 Securing Funding (1-12 months)

Critical Warning

- NASA only covers **launch costs** (up to $300,000)
- If you run out of funds and can't complete your CubeSat:
  - Launch opportunity lost
  - May demanifest other co-manifested CubeSats
  - Could be required to reimburse NASA for integration/launch costs

Funding Sources

Government Agencies: - National Science Foundation - NASA Earth Science Technology Office (ESTO) - NASA Space Grant Consortium (every state has one)

Educational Institutions: - Faculty and administrators - University funding for prestige projects

Other Options: - Technology demonstration sponsors - Crowdfunding (supplementary funding) - Request for Proposals (RFPs) from various organizations

Cost Components

Major Expenses: - Materials - Labor - Environmental testing (vibration, thermal vacuum, shock, EMI/EMC) - Ground station development - Travel (for reviews, integration, delivery) - **Budget tip**: Include at least 10% reserve for unexpected events

Technology Demonstration Missions

- Government/commercial organizations fund CubeSats to test new tech
- Lowers risk for expensive primary missions
- Excellent option for newer organizations/universities

2.3 Merit and Feasibility Reviews (1-2 months)

Purpose

Assure mission stakeholders that your team can: - Fulfill obligations - Complete a successful mission - Deliver on time and on budget

Merit Review

Assesses: - Quality of investigation (science/education/technology) - Alignment with NASA Strategic Plan goals - Why flight opportunity is required

Reviewers: Experts with knowledge/experience in your focus area

Feasibility Review

Assesses: - Technical implementation feasibility - Resiliency and risk - Probability of success - Team's ability to deliver on time/budget

Reviewers: Ideally space flight/spacecraft experts, or hardware/project development specialists

Important Notes

- Reviewers must NOT be on project team
- Not just "checking a box"—seek honest, valuable feedback
- CSLI interested in how you addressed reviewer findings

2.4 CubeSat Design (1-6 months)

Research Phase

- Learn from others' mistakes and successes
- Attend CubeSat conferences
- Review published materials online
- Network with experienced developers

Component Selection

Commercial Off-The-Shelf (COTS): - Increasingly available - List of vendors at http://www.cubesat.org (Developer Resources page)

In-House Development: - Keeps costs low - Enhances educational experience - Requires more time and expertise

Design Best Practices

1. KEEP IT SIMPLE - CDS requirements are conservative - Prohibits pyrotechnics - Discourage complex systems (e.g., propulsion) - Complex features may limit launch opportunities

2. IMPORTANT COMPONENTS ON EXTERIOR - Easier access for repairs - May avoid re-testing after fixes - Components inside structure = disassembly = likely re-test

3. DO NOT DESIGN TO LIMITS - Stay within CDS envelope (length/height/width) - If it doesn't fit, it doesn't fly - Target optimal dimensions, not maximum - Watch protrusions (CDS allows up to 6.5mm)

4. DOUBLE UP ON BURN WIRE - Used to constrain deployable components (solar panels, antennas) - Fishing line around resistor, melts when current applied - Risk: line can come loose during vibration/ascent - Solution: Use TWO separate burn wires

5. USE FAMILIAR COMPONENTS - Choose components with flight heritage - Major components: batteries, antennas, ADCS - Reduces risk and increases launch provider confidence

6. USE UL LISTED BATTERIES - UL, LLC certification = industry-recognized reliability - Non-UL batteries require extensive additional testing - Tampering with UL batteries voids certification

7. USE HIGH-MELTING POINT MATERIALS - Critical for safety and debris mitigation

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2.5 Development & Submittal of Proposal (3-4 months)

Timing

- **AoPO Posted**: Early August
- **Proposals Due**: November
- **Instructions**: Detailed in AoPO at https://sam.gov or http://go.nasa.gov/CubeSat_initiative

Critical Requirements

- Follow AoPO instructions exactly
- Include ALL requested information
- **Non-compliance = removal from consideration**
- Must resubmit to future AoPO if rejected

Focus Areas

Select one or more: - Science - Technology investigation - Education

Important: If multiple focus areas selected, proposal must address goals/objectives for EACH equally

CRADA (Cooperative Research And Development Agreement)

- Contract between NASA and developer after selection
- Contains legal terms (liability, risk, data-sharing)
- **Strongly advised**: Have legal expert review
- Universities: Use university legal department

2.6 Selection and Manifesting (1-36 months)

Selection Process

1. CSLI Selection Recommendation Committee reviews proposals
2. Creates prioritized list of qualifying projects
3. Prioritized list released ~12-16 weeks after proposal deadline

How to Rank High

- Excellent merit and feasibility reviews
- Hit all "Keys to CSLI Selection" points
- Clear contribution to NASA Strategic Plan goals
- Interesting and/or groundbreaking proposal

Manifesting

Priority Next Launch - Must be matched with compatible launch - Higher priority = first dibs on matching launches - NASA LSP pairs CubeSats with best-suited launches - Considers: orbit, completion dates, special constraints - ELaNa mission number assigned when manifested

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2.7 Mission Coordination (9-18 months)

What is Mission Coordination?

Overall mission planning and documentation tracking between: - CubeSat developers - Launch vehicle provider - Mission integrator (manages coordination)

Mission Integrator Responsibilities

- Managing integration schedules
- Tracking deliverable documentation
- Requirement verification management
- Creating mission-specific ICD (Interface Control Document)
- Providing document templates
- Organizing regular teleconferences

Your Responsibilities

- Attend kickoff meeting (teleconference)
- Follow hardware/document deliverable schedule
- Show CubeSat meets all ICD requirements

- Regular status updates via telecons
- Work with integrator on requirement verification

Interface Control Document (ICD)

The Official Rulebook: - Derived from CDS and LV-specific needs - Specifies environmental testing levels and durations - Must meet EVERY requirement in ICD

2.8 Regulatory Licensing (4-6 months)

Critical Timeline

- **Start application**: Within 30 days of manifesting (or earlier)
- **Must have licenses**: Before final delivery date
- **No license = Demanifest from mission**

Radio Frequency (RF) License

Who Regulates: - **NTIA** (National Telecommunications and Information Administration): U.S. Government-operated satellites - **FCC** (Federal Communications Commission): All other non-Federal Government satellites

Why Needed: Federal law requires license for RF transmission

Remote Sensing License

Who Regulates: NOAA (National Oceanic and Atmospheric Administration)

When Needed: Non-Government owned U.S. CubeSat with imager/camera

Important: FCC needs NOAA license before finishing RF license processing

Licensing Horror Story

Real incident: - CubeSat integrated into dispenser and onto LV - No approved FCC RF license - Days before launch, still not approved - Integrator planned to disable release mechanism - License came through just in time - **Otherwise: Mission scrubbed AND CubeSat lost**

2.9 Flight-Specific Documentation (10-12 months)

Purpose

Verify CubeSat meets all safety and launch requirements in ICD

Process

- Mission integrator provides deliverables list
- Each document has specified due date
- First documents due shortly after kickoff meeting
- Templates provided by mission integrator

Documentation Details

See Chapter 6 of full document for complete requirements

2.10 Ground Station Design, Development, & Testing (2-12 months)

Basic Requirements

Minimum Components: - Radio - Antenna

Build Early

- Consumes significant time and energy
- Critical for mission success

Resources

Amateur Radio Community: - Off-the-shelf amateur radio components - Local amateur radio clubs willing to help - American Radio Relay League: http://www.arrl.org/ - Design information: http://www.cubesat.org

Testing is Critical

Ground station functions: - Locate satellite - Send commands - Downlink data

Inadequate ground station = Mission killer

Development Testing Strategies

1. Monitor Existing Satellites: - Gain operational experience - Practice with equipment - Learn software and command structure

Recommended Targets: - **437 MHz (70 cm) band**: CubeSat beacons (look for recently launched) - **140 MHz (2 m) band**: NOAA weather satellites (produce images)

2. Contact Satellite Operators: - Some allow commanding with coordination - Invaluable operations experience

3. Join CubeSat Community: - IRC channel: irc.freenode.net #cubesat - Active during/after launches - Many "first contacts" happen here - Volunteer trackers worldwide

Troubleshooting Basics

Systematic Approach: - Check antenna pointing (use calibration: mountains, Sun, Moon) - Use vector network analyzer for impedance checks (antenna, cables, adapters) - Confirm radio tuning, mode, and line levels - Software defined radios (RTL2832, FunCube) for RF capture/replay practice

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2.11 CubeSat Hardware Fabrication & Testing (2-12 months)

Build Strategy

Multiple Units Recommended: 1. **Engineering Test Unit (ETU)**: Practice assembly, fit checks, testing 2. **FlatSat**: Components on flat board (no structure) for troubleshooting 3. **Two Flight Units**: Choose best hardware for flight

Why Multiple Units: - Launch opportunities are fluid - Launch failures possible - Cheaper to build multiple at once - No two satellites are exactly the same

Documentation is Critical

Take Photos Throughout: - Regular intervals during assembly - All integration phases - All testing phases

Why It Matters: - Photo documentation has saved missions - Prevents knowledge loss when team members leave - Critical for student organizations (graduations) - Avoid "reinventing the wheel"

Two Types of Testing

1. Development Testing: - Internal testing for your purposes - No documentation due to CSLI - Test as much as you want

2. Verification Testing: - Proves to CSLI/LV provider safety and sturdiness - Specific testing required by ICD - Test plans and reports submitted to mission integrator - **After verification: NO MORE WORK or must re-test**

Required Verification Tests

- Vibration testing
- Thermal vacuum testing
- Shock testing (sometimes)
- EMI/EMC testing (sometimes)
- Static load tests (sometimes)
- Day In The Life (DITL) testing

Testing Best Practices

"Test Like You Fly": - Use evaluation/development kits before fabricating boards - Test PCBs standalone before interfacing with other systems - Keep scope small, add components systematically - Never assume standalone success = integrated success - Thermal/vibration test subsystems before full integration - Catches design issues early, reduces over-testing

Testing Containers: - Simplified version of flight dispenser - Flight-like interface for testing apparatus - Ask mission integrator about availability

Timing

All testing and documentation must be submitted **at least 1 month before readiness reviews**

2.12 Mission Readiness Reviews (Half-Day)

What is MRR?

Presentation summarizing evidence that CubeSat satisfies all ICD requirements

Prerequisites

- All deliverable documentation submitted AND accepted
- All testing completed
- CubeSat completely finished

Format

- **In-person presentation required** (at least one representative)
- Cannot be completed by telephone
- Budget for travel!
- Location determined by LSP and mission integrator

Timeline

- **1 month before review**: Receive MRR outline/template
- **2+ weeks before review**: Submit draft presentation
- **Purpose of pre-check**: Catch errors, ensure all information covered

Attendees

- All CubeSat teams manifested on mission
- Mission integrator
- CSLI representatives

2.13 CubeSat-to-Dispenser Integration & Testing (2 days)

Day 1: Integration

Delivery Day Checklist: - Arrive at integration site (location determined by integrator) - Unpack CubeSat in clean room - Pre-integration physical measurements - May assist with integration (positioning, insertion into dispenser) - Photo opportunities (great publicity!) - Dispenser door closed and sealed

Important: Last time you'll see your CubeSat!

Day 2: Final Testing

- Dispenser + CubeSat vibration test as single unit
- Verifies successful integration
- Integrator takes over from here

Special Accommodations

Request at mission start: - Clean room requirements - Temperature/humidity needs - Security requirements - Storage needs - Ground Support Equipment (GSE) you'll bring - Potential hazards (e.g., laser emitters—you provide safety gear)

Pre-Delivery Activities (if approved)

- System diagnostics
- Battery charging
- **After dispenser closed**: No access (except extreme circumstances with long delays)

Post-Integration

- Dispenser inspected one more time
- Packaged and shipped to LV integration site

2.14 Dispenser-to-Launch Vehicle Integration (1 day)

What Happens

Loaded dispenser attached to rocket

Who's Invited

Essential Personnel Only: - LSP representatives - Mission integrator - Launch provider technicians

You are NOT invited (LV providers protective of rockets)

Integration Process

1. Mission integrator arrives with loaded dispenser
2. LV technicians lead to attachment location
3. Final cleaning and inspection
4. Integrator hands off dispenser to LV technicians
5. Prescribed procedure to attach dispenser
6. Photos taken as evidence

Timing

Typically **2 weeks to 4 months before launch** (varies by LV)

2.15 Launch (1 day)

Important Facts

- **Launch location**: Depends on primary mission (known before manifesting)
- **Launch date**: May change (only primary mission or LV can change)
- **CubeSats have NO influence** on launch date or window
- **If delayed**: Launch will NOT wait for you
- **If not delivered on time**: LV leaves without your CubeSat

Your Role

- No active role in launch operations
- Usually invited to watch launch
- Travel at your own expense
- May participate in public affairs/outreach (NASA EDGE interviews, photos)

Important Warnings

- Launch date subject to change anytime
- Day-of-launch scrubs are common (weather, other factors)
- Plan extra days for potential delays

2.16 Mission Operations (Variable, up to 20 years)

Initial Operations Challenges

- Most exciting part for first-time flyers
- Also most challenging
- Mission integrator will help with communications

Pre-Launch Preparation

Practice is Essential: - Use ground station on engineering/flight versions - Track existing CubeSats - Request permission to uplink to other CubeSats - Experience helps determine best commands for orbit

Tracking Satellites

Two-Line Element (TLE) Sets: - Data format encoding orbital elements - Entered into satellite tracking software - Predicts satellite position

Primary TLE Source: - **Joint Space Operations Center (JSpOC)** at Vandenberg AFB - Website: http://www.space-track.org - Records back to 1957 - Most widely available and accurate

Post-Launch Satellite Identification

Challenge: Determining which new object is YOUR satellite

Tools Available: 1. **Preliminary State Vectors**: From launch provider before launch 2. **Actual State Vectors**: Provided after ejection, convert to TLEs 3. **JSpOC TLEs**: Rough TLEs in few days to a week, refined over following weeks

Identification Process: - Mission integrator works with JSpOC and teams - GPS-equipped CubeSats help (process of elimination) - Can take several weeks to identify all satellites

Amateur Radio Community Assistance

For amateur band frequencies: - Post announcements online for volunteer satellite trackers - Very helpful for identifying CubeSats - Active community support

CubeSat IRC Channel

- Most active amateur satellite-tracking enthusiasts meet here
- During/after launch
- Share observations and work on identification
- Many "first contacts" from worldwide community
- **Join**: irc.freenode.net #cubesat

CHAPTER 3: MISSION MODELS

Overview

CSLI has worked with different organizations that sponsor launches, each with their own "mission model"—the way they run missions. Your CubeSat team will work with requirements and organizational structures specific to your assigned mission type.

Five Mission Models:

1. NASA-Procured Launch Vehicle
2. Operationally Responsive Space (ORS) Rideshare
3. National Reconnaissance Office (NRO) Rideshare
4. Commercial Launch Service Through Third-Party Broker
5. International Space Station (ISS) Deployment

3.1 NASA-Procured Launch Vehicle Mission Model

Overview

CubeSats ride on NASA missions procured by NASA Launch Services Program (LSP)

Requirements Basis

- LSP-REQ-317.01
- CubeSat Design Specification (CDS)

Organizational Structure

```
NASA Primary Mission
      ↓
NASA LSP (Mission Management)
      ↓
CSLI Mission Integrator (Mission Coordination, Dispenser Integration, Testing)
      ↓
CSLI CubeSats
```

Mission Integrator Duties

- Coordinating safety documentation with range safety
- Interfacing with CubeSat developers
- Verifying ICD requirements
- Point of contact for FCC and NOAA
- CubeSat-to-dispenser integration and testing
- Coordinating with JSpOC for orbit identification

Your Responsibilities

- Regular mission tag-ups via telephone
- Provide development status updates
- Alert integrator to any issues
- Submit all deliverables to mission integrator (reviewed and approved by NASA LSP)
- Present in-person readiness review to integrator with NASA LSP as advisor

NASA's Role

- Ensure orbital debris mitigation compliance
- Generate Orbital Debris Assessment Report for all CSLI CubeSats

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3.2 Operationally Responsive Space (ORS) Rideshare Mission Model

Overview

ORS Office (U.S. Department of Defense joint effort) provides launch opportunities for CSLI and other CubeSats

Organizational Structure

```
ORS Office
      ↓
ORS Mission Integrator (Mission Management)

CSLI Mission    ORS CubeSats
Integrator
      ↓
CSLI CubeSats
```

Two-Tier Integration

ORS Mission Integrator: - Overall mission management - Safety documentation with range safety - ICD verification - FCC and NOAA point of contact - JSpOC coordination - Physical CubeSat-to-dispenser integration

CSLI Mission Integrator (Scaled-back responsibilities): - Track CubeSat development - Perform ICD verification tasks - Provide updates to ORS mission integrator - Participate in ORS mission tag-ups - Speak on behalf of CubeSat teams - Hold separate tag-ups for CSLI CubeSats

Your Responsibilities

- Submit deliverables to CSLI mission integrator
- Regular tag-up meetings with CSLI mission integrator
- Present in-person readiness review to CSLI integrator, ORS integrator, and NASA LSP (advisor)

NASA's Role

- Ensure orbital debris mitigation compliance
- Generate Orbital Debris Assessment Report

From Developer Perspective

Very similar to NASA mission model: regular tag-ups, submit documentation, present readiness review

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3.3 National Reconnaissance Office (NRO) Rideshare Mission Model

About NRO

- U.S. intelligence community agency
- Designs, builds, operates reconnaissance satellites
- Established 1961 (declassified 1992)
- Website: http://www.nro.gov
- Excellent supporter of CubeSat technologies

Organizational Structure

```
OSL (Office of Space Launch, under NRO)

LV Provider   APIC (Auxiliary Payload Integration Contractor)
              Mission Integration
                    ↓
              NASA LSP (Mission Management)
                    ↓
          CSLI CubeSats    NRO CubeSats
```

APIC (Auxiliary Payload Integration Contractor)

- Can be multiple organizations
- Mission integrator duties
- Reports to LV provider and OSL

Your Responsibilities

- **No participation** in APIC reports or reviews to OSL
- Separate biweekly tag-ups with APIC via teleconference
- Provide status updates
- Alert APIC to schedule/requirement issues
- Submit deliverables to APIC (reviewed by APIC)
- Present in-person readiness review to APIC team, NASA LSP, and OSL

NASA's Role

- Ensure orbital debris mitigation compliance
- Generate Orbital Debris Assessment Report

From Developer Perspective

Similar to other models: regular tag-ups, submit documentation, present readiness review

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3.4 Commercial Launch Service Through Third-Party Broker

Overview

Launch purchases through brokers on non-Government (commercial or foreign) missions

Organizational Structure

```
Third-Party Broker (Mission Manager)

LV Provider   CSLI CubeSats
```

Key Differences

- Requirements come from LV provider via broker
- **NASA LSP does NOT verify requirements**
- Broker serves as mission integrator or assigns one
- Mission integrator creates CubeSat-to-dispenser ICD
- Determines schedule for deliverables
- **May not require readiness reviews** (tracks deliverables instead)

NASA's Role

- Ensure orbital debris mitigation compliance
- Generate Orbital Debris Assessment Report

Flexibility

Most flexible model—requirements and processes vary by broker and LV provider

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3.5 International Space Station (ISS) Deployment Model

How It Works

1. CubeSats integrated into dispensers on ground
2. Transported to ISS in pressurized cargo vessel (SpaceX Dragon, Orbital ATK Cygnus, etc.)
3. Hand carried onto ISS from cargo vessel
4. Astronauts deploy CubeSats from ISS (typically 1-3 months after arrival)

Organizational Structure

```
NASA ISS LV Provider
      ↓
Mission Integrator (Mission Coordination, ISS Integration, Acceptance Testing)
      ↓
```

```
NASA LSP (Mission Management)
      ↓
CSLI CubeSats    Other CubeSats
```

Requirements

- Similar to CDS (mechanical and electrical)
- **NanoRacks**: Currently only commercial organization for ISS deployment
- Website: http://nanoracks.com
- Must comply with current NanoRacks ICD

Process

- Submit flight safety review documents to mission integrator
- Mission integrator handles ISS team reviews

NASA's Role

- Ensure orbital debris mitigation compliance
- Generate Orbital Debris Assessment Report

KEY TERMS GLOSSARY

General Terms

CubeSat Developer Any person or organization designing, building, and preparing a CubeSat for flight.

Investigation The mission, scientific or otherwise, that your CubeSat will perform. Used interchangeably with "mission."

Mission All-encompassing term for the entire enterprise from development, testing, integration, launch, to operations. Sometimes used interchangeably with "project" or "investigation."

Form Factor The size, shape, and/or component arrangement of a device. For CubeSats, refers to the standard size and mass specifications.

Interface Any point where two or more components are joined together (mechanical, electrical, etc.).

Payload In aerospace, the cargo being delivered to space. For CubeSat dispensers, the payload is the CubeSat.

Manifesting The process of assigning CubeSats to available slots on a launch opportunity.

Strategic Partnering Combining strengths and resources of multiple organizations to achieve greater goals, typically formalized by agreement.

Testing & Development Terms

ADCS (Attitude Determination and Control System) System designed to stabilize and orient the CubeSat toward a given direction. Critical for mission success (solar panel pointing, Earth imaging, etc.).

ETU (Engineering Test Unit) CubeSat built like flight unit but not intended for launch. Used for practice assembly, fit checks, and testing.

FlatSat Engineering unit with all components except structure, typically mounted on flat board. Used for testing and troubleshooting without full integration.

Breadboard Board used to make experimental model of components for testing.

Margin Extra resources (time, budget, performance) that provide safety buffer against unexpected events.

Electrical Inhibit Physical device that interrupts the power path needed to turn on CubeSat and/or potentially hazardous devices.

Mission & Operations Terms

Mission Integrator Organization/person responsible for mission coordination activities. Sometimes called mission coordinator (terms used interchangeably).

Integration Services Typically includes: deliverables review, dispenser provision, CubeSat integration into dispenser, dispenser/CubeSat system testing, and dispenser/CubeSat integration onto LV.

Deliverables Anything your team agreed to submit to mission integrator as part of legal obligations under CRADA.

Range Safety Person designated to protect people and assets on launch range and downrange when LV might expose them to danger.

Two-Line Element (TLE) Data format encoding orbital elements of Earth-orbiting CubeSat for given point in time (epoch). Used with prediction formula to estimate position and velocity.

Terminal Node Controller (TNC) Device used by amateur radio operators for AX.25 packet radio networks. Assembles data into packets, keys transmitter, and reassembles received packets.

QUICK REFERENCE TABLES

Timeline Summary

Phase	Duration	Key Activities
1. Concept Development	1-6 months	Define mission, align with NASA goals, find partners
2. Securing Funding	1-12 months	Identify funding sources, create budget
3. Merit & Feasibility Reviews	1-2 months	Conduct independent reviews of mission quality and feasibility
4. CubeSat Design	1-6 months	Research, select components, design CubeSat
5. Proposal Development	3-4 months	Develop and submit proposal to CSLI AoPO
6. Selection & Manifesting	1-36 months	CSLI selection process, matching with launch
7. Mission Coordination	9-18 months	Regular tag-ups, coordination with integrator
8. Licensing	4-6 months	RF license (FCC/NTIA), Remote Sensing (NOAA if needed)
9. Documentation	10-12 months	Develop and submit flight certification documents
10. Ground Station	2-12 months	Design, build, and extensively test ground station
11. Hardware Fabrication	2-12 months	Build and test CubeSat units
12. Mission Readiness Review	Half-day	In-person presentation to integrator and stakeholders
13. Dispenser Integration	2 days	Deliver, integrate, final vibration test
14. LV Integration	1 day	Dispenser attached to rocket

Phase	Duration	Key Activities
15. Launch	1 day	Launch day (possibly delayed)
16. Mission Operations	Variable	Up to 20 years

CubeSat Standard Sizes

Size	Dimensions	Typical Mass	Notes
1U	10 cm × 10 cm × 11 cm	1-1.33 kg	Basic unit
1.5U	10 cm × 10 cm × 16.5 cm	~1.5-2 kg	Less common
2U	10 cm × 10 cm × 22 cm	~2-2.66 kg	Moderate size
3U	10 cm × 10 cm × 34 cm	~3-4 kg	Very popular
6U	20 cm × 10 cm × 34 cm	~6-14 kg	Introduced 2014
12U	20 cm × 20 cm × 34 cm	~12-24 kg	Large format

Design Best Practices Checklist

Best Practice	Why It Matters	Reference
Keep it simple	Fewer complex systems = more launch opportunities	2.4
Important components on exterior	Easier repairs, may avoid re-testing	2.4
Don't design to envelope limits	If it doesn't fit, it doesn't fly	2.4
Double up on burn wire	Prevents premature deployable release	2.4
Use familiar components	Flight heritage reduces risk	2.4
Use UL listed batteries	Avoids extensive additional testing	2.4
Use high-melting point materials	Safety and debris mitigation	2.4
Keep mission flexible	Faster manifesting to launch	2.1
Build multiple units	ETU, FlatSat, 2 flight units	2.11
Take extensive photos	Saves missions, preserves knowledge	2.11
Test like you fly	Catch issues early, reduce risk	2.11

Mission Model Comparison

Model	Primary Contact	Tag-Up Style	Readiness Review Attendees	Key Difference
NASA-Procured LV	CSLI Mission Integrator	Direct with integrator	Integrator + NASA LSP (advisor)	Direct NASA oversight
ORS Rideshare	CSLI Mission Integrator	Via CSLI integrator to ORS	Both integrators + NASA LSP	Two-tier integration
NRO Rideshare	APIC	Separate from APIC-OSL meetings	APIC + NASA LSP + OSL	Developer separate from primary meetings
Third-Party Broker	Broker/Mission Manager	Varies	May not require MRR	Most flexible, varies by broker

Model	Primary Contact	Tag-Up Style	Readiness Review Attendees	Key Difference
ISS Deployment	Mission Integrator	Direct with integrator	Integrator + relevant ISS team	Deployment from Space Station

Critical Deadlines & Warnings

Item	Deadline/Timing	Consequence of Missing
RF License Application	Within 30 days of manifesting	Potential demanifest from mission
RF License Approval	Before final delivery date	**DEMANIFEST** - Mission scrubbed, possibly lose CubeSat
NOAA License (if needed)	Before FCC processes RF license	FCC cannot complete processing
All Testing Complete	1 month before MRR	Cannot proceed to readiness review
Deliverables Submitted	Per integrator schedule	Cannot proceed to readiness review
CubeSat Delivery	Per integrator schedule (4 wks - 6 mo before launch)	Launch leaves without you, no delays
Funding Secured	Throughout development	Possible liability for NASA costs already spent

Essential Resources & Websites

Resource	URL	Purpose
CubeSat.org	http://www.cubesat.org	CDS, component vendors, design resources
CSLI Website	http://go.nasa.gov/CubeSat_initiative	CSLI information, prior awards
Federal Opportunities	https://sam.gov	AoPO announcements
NASA Strategic Plan	http://www.nasa.gov	Alignment for proposal
Space Grant Consortium	(State-specific)	Student STEM funding
JSpOC Tracking	http://www.space-track.org	TLE data, satellite tracking
Amateur Radio League	http://www.arrl.org/	Ground station help
NanoRacks	http://nanoracks.com	ISS deployment requirements
CubeSat IRC	irc.freenode.net #cubesat	Community, tracking, first contacts
NRO Information	http://www.nro.gov	NRO background

Funding Sources Quick Reference

Source Type	Examples	Best For
Government Agencies	NSF, NASA ESTO, NASA Space Grant Consortium	Research, technology, education missions
Educational Institutions	Faculty, administrators, university programs	Student-led projects

Source Type	Examples	Best For
Technology Demonstration	Government/commercial sponsors	Testing new components
Crowdfunding	Kickstarter, etc.	Supplementary funding, public engagement
Partnerships	Strategic partners with similar goals	Complex missions, resource sharing

Common Cost Categories

Category	Examples	Notes
Materials	Components, structure, batteries	Research suppliers early
Labor	Team members, consultants	Often in-kind for universities
Environmental Testing	Vibration, thermal vacuum, shock, EMI/EMC	Varies by facility
Ground Station	Radio, antenna, software	Amateur components popular
Travel	Reviews, integration, delivery	Often overlooked
Reserves	10%+ of total budget	For unexpected events

Study Tips

For Exam Preparation

1. **Memorize timeline**: Know the 16 phases and typical durations
2. **Understand mission models**: Be able to compare and contrast the 5 models
3. **Know critical deadlines**: Especially licensing requirements
4. **Review best practices**: Understand the "why" behind each recommendation
5. **Study glossary**: Many terms are used interchangeably in practice

For Project Planning

1. **Start with timeline**: Use as framework for Gantt chart
2. **Budget early**: Include ALL cost categories, especially reserves
3. **Design conservatively**: Simple designs get more launch opportunities
4. **Document everything**: Photos and notes save missions
5. **Test extensively**: Ground station and CubeSat both critical

Key Takeaways

- **Flexibility is your friend**: Flexible requirements = faster manifesting
- **Licensing is critical**: Start early, no exceptions
- **Testing is insurance**: Development testing prevents verification failures
- **Community helps**: CubeSat community is open and supportive
- **Plan for the long term**: Typical timeline is 18-24 months minimum

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Document prepared from NASA CubeSat 101: Basic Concepts and Processes for First-Time CubeSat Developers, Chapters 1-3

For complete information, refer to full NASA CubeSat 101 document and current CSLI requirements