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DESCENT
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DESCENT Engineering Requirements Document (ERD)

School of Mechanical & Aerospace Engineering
Ithaca, New York

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Preface

This is the Engineering Requirements Document (ERD) to be shared with relevant stakeholders on the DESCENT project. The ERD shows the requirements necessary for the mission, safety, deployer, chipsat, power, communications, command and data handling, mechanical, and environmental requirements.

Any questions should be addressed to:

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Change History Log

Revision	Effective Date	Description of Changes	Sections Affected
0	Sept. 9th, 2025	Document formatting created based on NASA example[7]. Table of Contents outline created. Initial requirements transcribed from DESCENT requirements meeting.	All

0 What is an ERD?

An Engineering Requirements Document (ERD) is a collection of information that shares the "shall" statements, or the requirements, of a project. Engineers use these requirements to determine the scope of the design. An ERD may take other forms as well. Some examples of a technical requirements document used by NASA are a System Requirements Document (SRD), Project Requirements Document (PRD), Interface Requirements Document (IRD), and a Software Requirements Specification (SRS)[1].

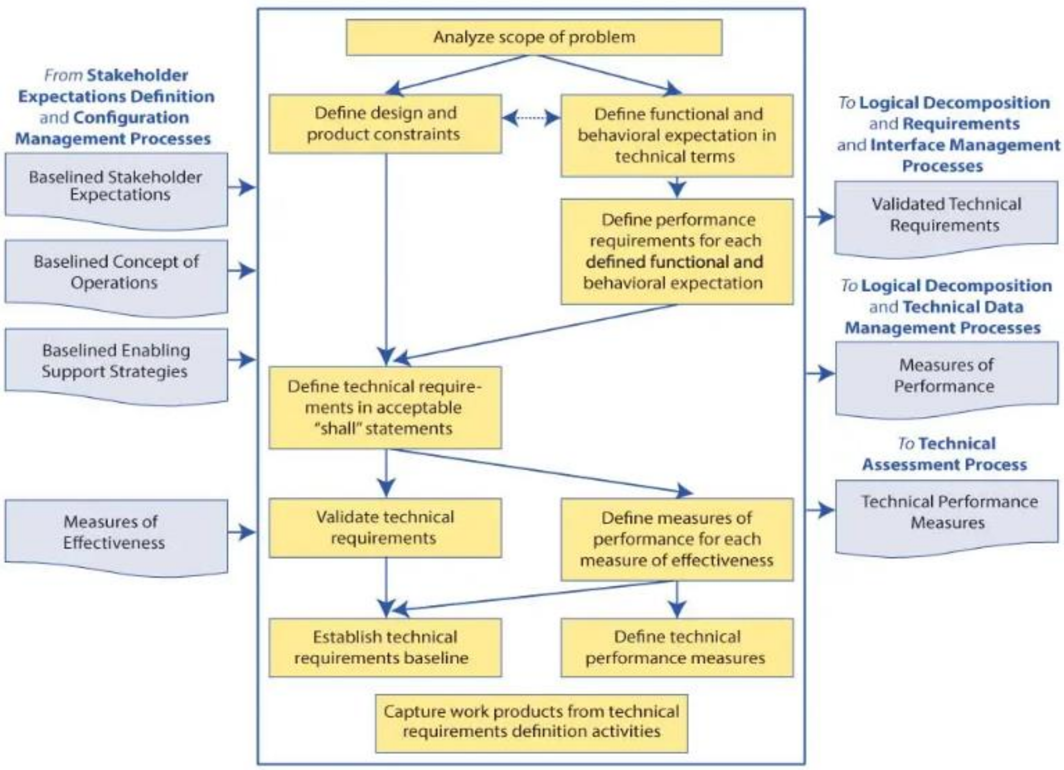

Figure: Technical Requirements Definition Process[1].

Defining requirements connects the vision of the product or mission between stakeholders like the project managers, engineers, and customers; on the left side of the diagram above, we see those inputs mentioned. In the middle section, it outlines important actions in the process like defining constraints, functional vs performance requirements, and validation techniques. A requirement is as good as its applicability and validity. Measures of Performance (MOPs) and Technical Performance Measures (TPMs) are the measurable numbers in the requirements[1].

0.1 Acronyms

APL	Applied Physics Laboratory
ADCS	Attitude Dynamics & Control Subsystem / Attitude Control System
CDH	Command and Data Handling
CONOPs	Concept of Operations
DPLY	Deployer
ERD	Engineering Requirements Document
ESD	Electrostatic Discharge
FCC	Federal Communications Commission
FMEA	Failure Modes & Effects Analysis
FMSA	Fault Management & System Autonomy
GPS	Global Positioning System
I&T	Integration & Test
INT	Integration
LV / LVA	Launch Vehicle
MIS	Mission
MIL-STD	Military Standard
MPP	Maximum Power Point
NASA	National Aeronautics Space Administration
NIR	Near Infrared Light
NTSS	NASA Technical Standards System
NTSP	NASA Technical Standards Program
OCE	Office of the NASA Chief Engineer
PCB	Printed Circuit Board
PLD	Payload
PWR	Power Subsystem / Power System / Electrical Power System
RF	Radio Frequency
SE	Space Environment
SSDS	Space Systems Design Studio
T&C	Telemetry & Command / Command & Data Handling
TBC	To Be Confirmed
TBD	To Be Determined
TCS	Thermal Control Subsystem / Thermal System
TPM	Technical Performance Measure
TRL	Technical Readiness Level
TTFF	Time to First Fix
FM	Fault Management

1 Mission Goals

Goal 1 The mission shall collect in-situ sensor data from a distributed fleet of chipsats.

Goal 1.1 The mission shall collect data that demonstrates the potential of chipsats for atmospheric science. **[Goal 1]**

Goal 2 The mission shall characterize the free-fall dispersion dynamics and the landing ellipse of a chipsat fleet.

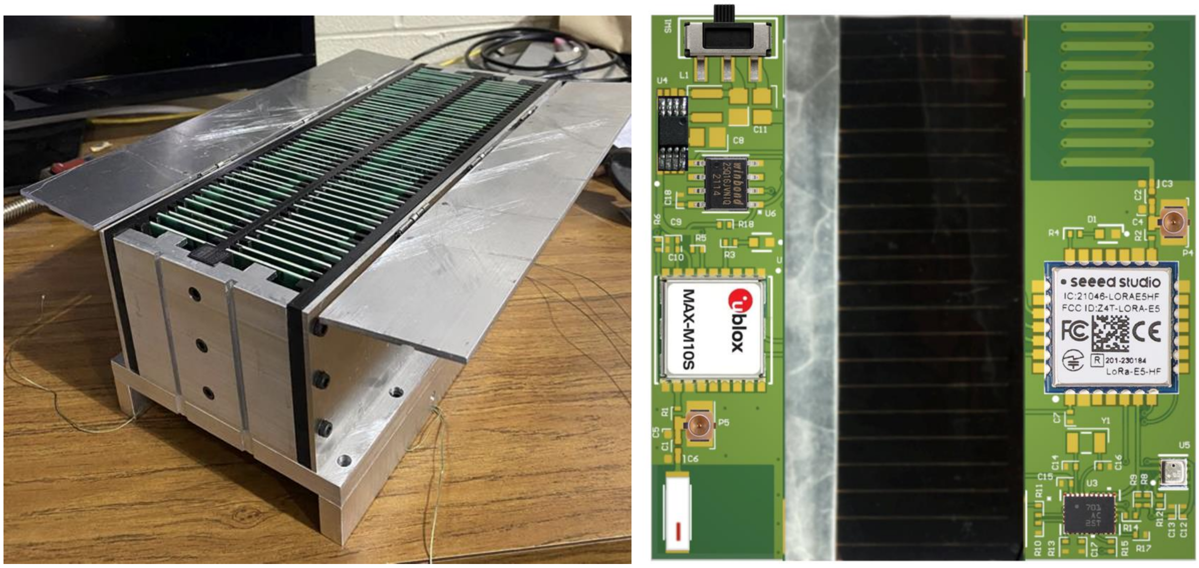

Figure 1: Flight unit deployer and CAD model.

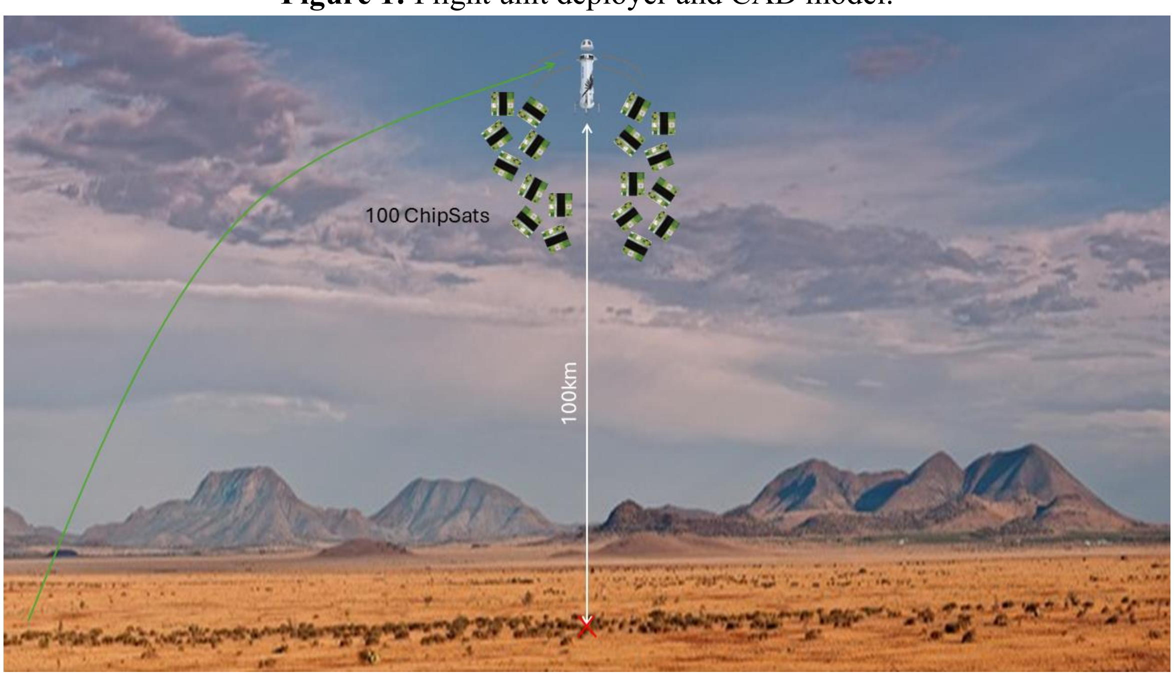

Figure 2: Demonstration of Suborbital ChipSats Ejected from New Shepard Test Flight (DeSCENT).

2 Mission-Level Requirements

MIS 1 One hundred chipsats shall be deployed from the New Shepard suborbital launch vehicle at approximately 100 km apogee.
MIS 2 The chipsat sensor data shall be collected from chipsat descent trajectories and landing positions.

> **MIS 2.1** The collected chipsat data shall contain in-situ atmospheric sensor data and measurements of chipsat free-fall kinematics. **[MIS 2]**

MIS 3 Two percent of chipsats shall survive terminal velocity impact with the ground.
MIS 4 X percent of chipsats shall be recovered after landing.

3 Safety Requirements

FM 1 The chipsat shall be powered off when stowed in the deployer. **[MIS 4]**
FM 2 The chipsat shall have X mAh capacity. **[MIS 4**]
FM 3 The chipsat RF transmissions shall not interfere with the New Shepard launch vehicle. **[MIS 4]**

> **FM 3.1** The chipsat RF transmit power (TX) and frequency shall not interfere with the New Shepard launch vehicle. **[FM 3]**

FM 4 The chipsat shall weigh < X g. **[MIS 4]**
FM 5 The mechanical deployer shall remain in-tact and attached to the rocket. **[MIS 4]**
FM 6 The burn-wire shall not disrupt operations. **[MIS 4]**
FM 7 The chipsat deployer shall cause no harm to the vehicle, payloads, or personnel. **[Blue Origin, APL]**

> **FM 7.1** The chipsat deployer shall cause no harm to Blue Origin's Propulsion Module. **[FM 7]**
> **FM 7.2** The chipsat deployer shall cause no harm to Blue Origin's Crew Capsule. **[FM 7]**
> The chipsat deployer shall cause no harm to John Hopkins' APL JANUS payload. **[FM 7]**
> **FM 7.3** The chipsat deployer shall cause no harm to other payloads. **[FM 7]**
> **FM 7.4** The chipsat deployer shall cause no harm to Blue Origin personnel. **[FM 7]**

4 Deployment Requirements

DPLY 1 The deployer shall automatically deploy at apogee. **[MIS 2]**

> **DPLY 1.1** The deployer shall deploy during APL pulsed signal. **[DPLY 1]**
> **DPLY 1.2** The deployer shall deploy between two to four minutes. **[DPLY 1]**

DPLY 2 The deployer shall deploy vertically from NS Launch. **[MIS 2]**

DPLY 3 The deployer shall deploy chipsats at 0.2 to 0.4 m/s. **[MIS 4]**
DPLY 4 The deployer shall interface using a MIL-STD D-Sub connector to APL's JANUS payload. **[MIS 4]**
DPLY 5 The deployer shall be bounded by X volume. **[MIS 4]**
DPLY 6 The deployer shall weigh less than 50 lbs (10 kg).
DPLY 7 The deployer shall survive the launch and launch environment.
DPLY 8 The deployer shall deploy at -46 degrees Celsius.
DPLY 9 The deployer shall house and deploy 100 chipsats.
DPLY 10 The deployer shall be mounted to the APL JANUS plate.
DPLY 11 The deployer shall adhere to the Blue Origin Propulsion Module User's Guide.
DPLY 12 The deployer slots shall house chipsats of size X m, X m, X m.
DPLY 13 The deployer shall have the capability to be stowed for 3 months.

5 Chipsat Requirements

5.1 Power Requirements

PWR 1 The chipsat shall remain off when stowed in the deployer and turn on upon deployment
- **PWR 1.1** The chipsat shall have a snap action lever switch to activate the circuit upon deployment. **[PWR 1, MECH X]**
- **PWR 1.2** The chipsat batteries shall be fully charged when stowed before launch.

PWR 2 The chipsat shall remain on during descent and recovery. **[MIS 1, MIS 2]**
- **PWR 2.1** The chipsat shall remain powered on via solar during extended recovery. **[PWR 2]**
  - **PWR 2.1.1** The chipsat maximum power draw shall not continuously, for 1 hour, bleed MPP of solar cell @ 300 mA @ 1.1V. **[PWR 2.1]**
  - **PWR 2.1.2** The chipsat solar panel shall be able to recharge the battery. **[PWR 2.1]**
- **PWR 2.2** The chipsat battery capacity shall be sufficient for X hours of operation. **[PWR 2]**
- **PWR 2.3** The chipsat battery shall be used to store energy during descent and short term recovery. **[PWR 2]**

5.2 Communications Requirements

COMMS 1 The chipsat shall communicate across descent and recovery.
- **COMMS 1.1** The chipsat ground communications link shall be maintained across the longest distance at Propulsion Module apogee. **[COMMS 1]**

COMMS 2 The chipsat TX power shall remain within maximum power draw of the power source.

COMMS 3 The chipsat communications shall be maintained via commercially available, low power, and long range chips.

COMMS 3.1 The chipsat communications shall use a 915 mHz Lora chip. **[COMMS 3]**

COMMS 4 The chipsat communications shall begin when each chipsat leaves the deployer.

COMMS 5 The chipsats shall stop transmitting on command. **[MIS 4]**

COMMS 6 The chipsat communications shall transmit at 0.1 Hz during the descent phase.

COMMS 7 The chipsat shall transmit at X Hz (once every 10-20 sec) when in ground recovery phase.

COMMS 8 The chipsat communications antenna shall fit within the mechanical envelope. **[MECH 3.X]**

COMMS 8.1 The chipsat communications antenna shall be a helical PCB.

5.3 Command & Data Handling

CDH 1 Data acquisition shall start after the chipsats leave the deployer.

CDH 2 All sensors shall sample at > 1 Hz during descent.

CDH 3 The chipsat shall collect internal and external data.

CDH 3.1 The chipsat shall collect humidity, temperature, pressure. **[CDH 3]**

CDH 3.2 The chipsat shall collect linear acceleration, angular velocity, and magnetic field vector data. **[CDH 3]**

CDH 3.3 The chipsat shall collect GPS position data. **[CDH 3]**

CDH 3.4 The chipsat shall carry the BME280. **[CDH 3]**

CDH 3.5 The chipsat shall carry the BNO085. **[CDH 3]**

CDH 3.6 The chipsat shall carry the UBloxMax 10s-00B. **[CDH 3]**

CDH 4 All sensors shall sample at X Hz (once every 10-20 sec) during ground recovery phase, with GPS exception.

CDH 5 The chipsat shall log all collected sensor data.

CDH 6 The GPS module Time to First Fix (TTFF) shall be less than 3 minutes.

5.4 Mechanical Requirements

MECH 1 The chipsat shall fit within the deployer.

MECH 1.1 The chipsat shall be less than X mm, X mm, X mm. in volume. **[MECH 1]**

MECH 2 The chipsat shall be less than X ballistic coefficient.

MECH 3 The chipsat shall survive deployment and terminal velocity impact with the ground.

MECH 3.1 The chipsat shall be manufactured from a rigid PCB substrate. **[MECH 3]**

MECH 3.1.1 The chipsat shall be made from FR-9. **[MECH 3.1]**

MECH 3.1.2 The chipsat 1.6 mm FRCI shall be used to improve communications and performance. **[MECH 3.1]**

MECH 3.2 The chipsat components shall fit within 3 mm of the face of the PCB. **[MECH 3]**

MECH 3.3 The chipsat components shall extend off the edge of the PCB. **[MECH 3]**

MECH 3.4 All components shall be strongly adhere to the PCB. **[MECH 3]**

MECH 3.4.1 All electrical components shall be high strength mounted with solder or additionally bonded with adhesive when needed. **[MECH 3.4]**

MECH 4 The chipsat switch shall be fully depressed while in the deployer.

MECH 4.1 The chipsat shall fit snuggly within the deployer. **[MECH 4]**

MECH 5 The chipsat shall be mass manufacturable.

MECH 5.1 The chipsat shall have > 90% automated manufacturing process. **[MECH 5]**

5.5 Environmental Requirements

ENV 1 The chipsat shall operate in temperatures ranging from -50 to 85 degrees Celsius.

ENV 2 The chipsat shall operate in a vacuum.

ENV 3 The chipsat shall survive X months of storage in the deployer at temperatures ranging from 0 to 40 degrees Celsius.

ENV 4 The deployed chipsat shall survive 48 hours outside the deployer after landing.

ENV 4.1 The chipsat shall survive 12 hours of direct sunlight.

6 Ground Station Requirements

6.1 Power Requirements

PWR 1 The forward ground terminal shall contain X mAh LiPo battery with energy enough to operate for more than 6 hours in deployed field mode without external power.

PWR 2 The forward ground terminal shall support standby for more than 6 hours with autonomous wake on reception or schedule.

6.2 Comms Requirements

COMS 1 The forward ground terminal shall receive complete LoRa packets from a chipsat at ranges up to X km line-of-sight at NS apogee geometry, with link margin ≥ 10 dB under clear-sky conditions.

COMS 2 The system shall operate in the LoRa 915 MHz band.

COMS 3 The forward ground terminal shall use a directional antenna (e.g., Yagi/patch) with boresight gain more than X dBi.
COMS 4 The forward ground terminal receiver sensitivity shall be better than X.
COMS 5 The RF front-end shall include SAW/BPF filtering.
COMS 6 The ground segment shall support simultaneous reception of more than X concurrent chipsats.
COMS 7 Antenna pointing error shall be within X degrees; for fixed stations, set-and-hold alignment tolerance within Y degrees.
COMS 8 The system shall decode and forward and log 100% of valid CRC packets received above sensitivity.

6.3 Mechanical
MECH 1 The forward ground terminal shall have a packed mass less than X kg and packed volume within Y L.
MECH 2 The forward ground terminal shall be deployable by one person with no tools in ≤ 10 min.
MECH 3 The antenna mount shall withstand gusts to X m/s.

6.4 Environmental
ENV 1 forward ground terminal shall be able to operate in 0 to 50 degrees Celsius.
ENV 2 forward ground terminal electronics enclosures shall be IP54.