OMAR BLAS

CUBESATS NANOSATELITES

CLASE: 1

Estructura Mecánica de CubeSats
Procedimiento, Diseño y Desafíos

INDICE

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1999

Prof. Jordi Puig-Suari at California Polytechnic State University (Cal Poly), San Luis Obispo, and Prof. Bob Twiggs at Stanford University's Space Systems Development Laboratory (SSDL). https://www.cubesat.org/s/CDS-REV14_1-2022-02-09.pdf

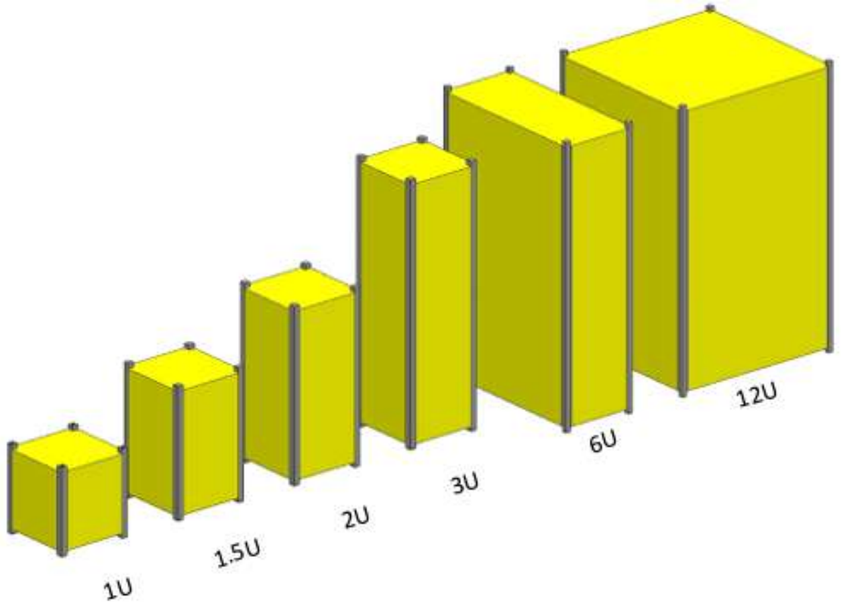


Figura 1: A. Johnstone (2022). Arreglo de cubesats de 1U a 12U [Diseño]. CubeSats org. https://www.cubesat.org/s/CDS-REV14_1-2022-02-09.pdf

U Configuration	Mass [kg]
1U	2.00
1.5U	3.00
2U	4.00
3U	6.00
6U	12.00
12U	24.00

Figura 2: A. Johnstone (2022). Tabla de masas [Diseño]. CubeSats org. https://www.cubesat.org/s/CDS-REV14_1-2022-02-09.pdf

GENERALIDADES 2 de 4

Nanosats launched: **2604**

CubeSats launched: **2396**

PocketQubes launched: **83**

Interplanetary CubeSats: **16**

Most nanosats on a rocket: **120**

Countries with nanosats: **86**

Companies in database: **751**

Forecast: over **2080** nanosats to launch **2022-2027**

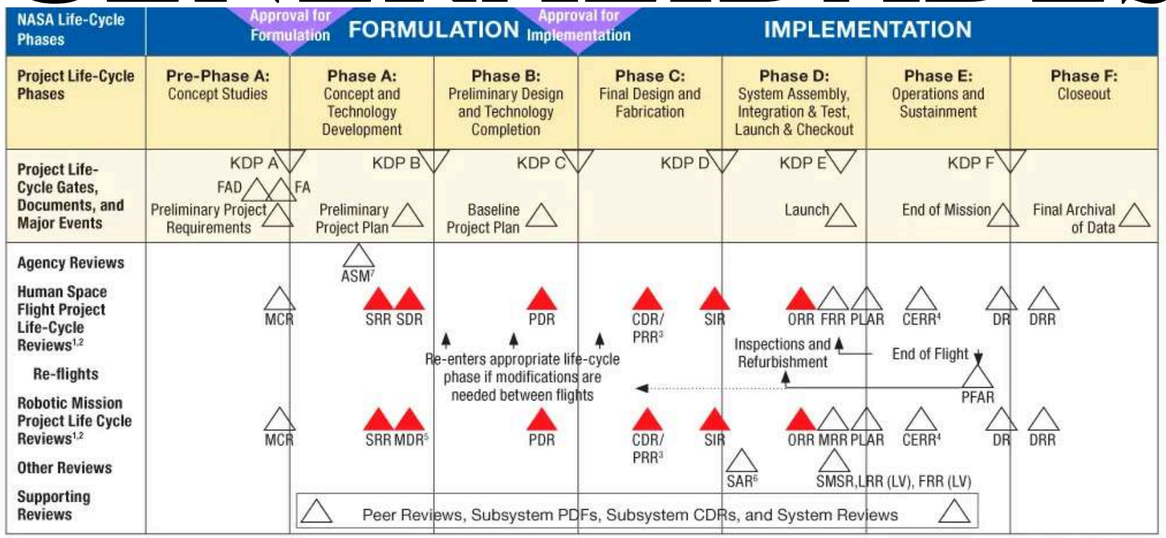
Erik Kulu, (2024). Nanosats Database Erik Kulu. https://www.nanosats.eu/

Figura 3: Isispace (2016). Tabla de masas [Fotografía]. CubeSat Deployers. https://www.isispace.nl/wp-content/uploads/2016/02/ISIS-CubeSat-Deployers-Brochure-v1.pdf

	Type	Max Volume	Access Ports	Additional Mass	Extended Body Length	Extended Protrusions	Power/ Data Port	Purge	RF Insulation	Vibration Attenuation	X-Y Constraint	Z Constraint	-Z Additional Volume (Tuna Can)
PSL Astro-Fein	Rail	3U	X								X	X	
PLS-P Astro-Fein	Rail	12U	X									X	X
P-POD Cal Poly	Rail	3U	X					X	X	X		X	X
COSPOD COSATS	Rail	12U	X	X	X	X				X	X	X	X
EXOpod Exolaunch	Rail	12U	X	X		X					X	X	X
ISIPOD ISIS	Rail	3U			X	X					X	X	X
6-POD ISIS	Rail	6U			X	X					X	X	X
QuadPack ISIS	Rail	12U	X	X	X						X	X	X
E-SSOD JAXA	Rail	3U	X									X	
J-SSOD JAXA	Rail	3U, 6U	X	6U	X								
CSD Planetary Systems	Tab	3U, 6U, 12U	X		X		X				X	X	
RailPOD Tyvak	Rail	3U	X									X	X
NLAS Tyvak	Rail	6U	X	X	X	X	X	X	X			X	X
12U Dispenser Tyvak	Rail	12U	X	X	X	X	X	X	X		X	X	X
RAMI UARX	Rail	12U	X	X	X	X	X					X	X

Figura 4: A. Johnstone (2022). Tabla de comparación de dispenser [Datos]. CubeSats org. https://www.cubesat.org/s/CDS-REV14_1-2022-02-09.pdf

GENERALIDADES 3 de 4



FOOTNOTES

1. Flexibility is allowed as to the timing, number, and content of reviews as long as the equivalent information is provided at each KDP and the approach is fully documented in the Project Plan.
2. Life-cycle review objectives and expected maturity states for these reviews and the attendant KDPs are contained in Table 2-5 and Appendix D Table D-3 of this handbook
3. PRR is needed only when there are multiple copies of systems. It does not require an SRB. Timing is notional.
4. CERRs are established at the discretion of program .
5. For robotic missions, the SRR and the MDR may be combined.
6. SAR generally applies to human space flight.
7. Timing of the ASM is determined by the MDAA. It may take place at any time during Phase A.

▲ Red triangles represent life-cycle reviews that require SRBs. The Decision Authority, Administrator, MDAA, or Center Director may request the SRB to conduct other reviews.

ACRONYMS

ASM – Acquisition Strategy Meeting
CDR – Critical Design Review
CERR – Critical Events Readiness Review
DR – Decommissioning Review
DRR – Disposal Readiness Review
FA – Formulation Agreement
FAD – Formulation Authorization Document
FRR – Flight Readiness Review
KDP – Key Decision Point
LRR – Launch Readiness Review
LV – Launch Vehicle
MCR – Mission Concept Review
MDR – Mission Definition Review
MRR – Mission Readiness Review
ORR – Operational Readiness Review
PDR – Preliminary Design Review
PFAR – Post-Flight Assessment Review
PLAR – Post-Launch Assessment Review
PRR – Production Readiness Review
SAR – System Acceptance Review
SDR – System Definition Review
SIR – System Integration Review
SMSR – Safety and Mission Success Review
SRB – Standing Review Board
SRR – System Requirements Review

FIGURE 3.0-1 NASA Space Flight Project Life Cycle from NPR 7120.5E

Figura 5: Fases de proyecto segun NASA. https://www.nasa.gov/reference/3-0-nasa-program-project-life-cycle/

Mission lifetime cycle

Phase 0	Mission analysis and identification
Phase A	Feasibility
Phase B	Preliminary Definition
Phase C	Detailed Definition
Phase D	Qualification and Production
Phase E	Utilisation
Phase F	Disposal

Figura 6: https://www.esa.int/Science_Exploration/Space_Science/How_a_mission_is_chosen

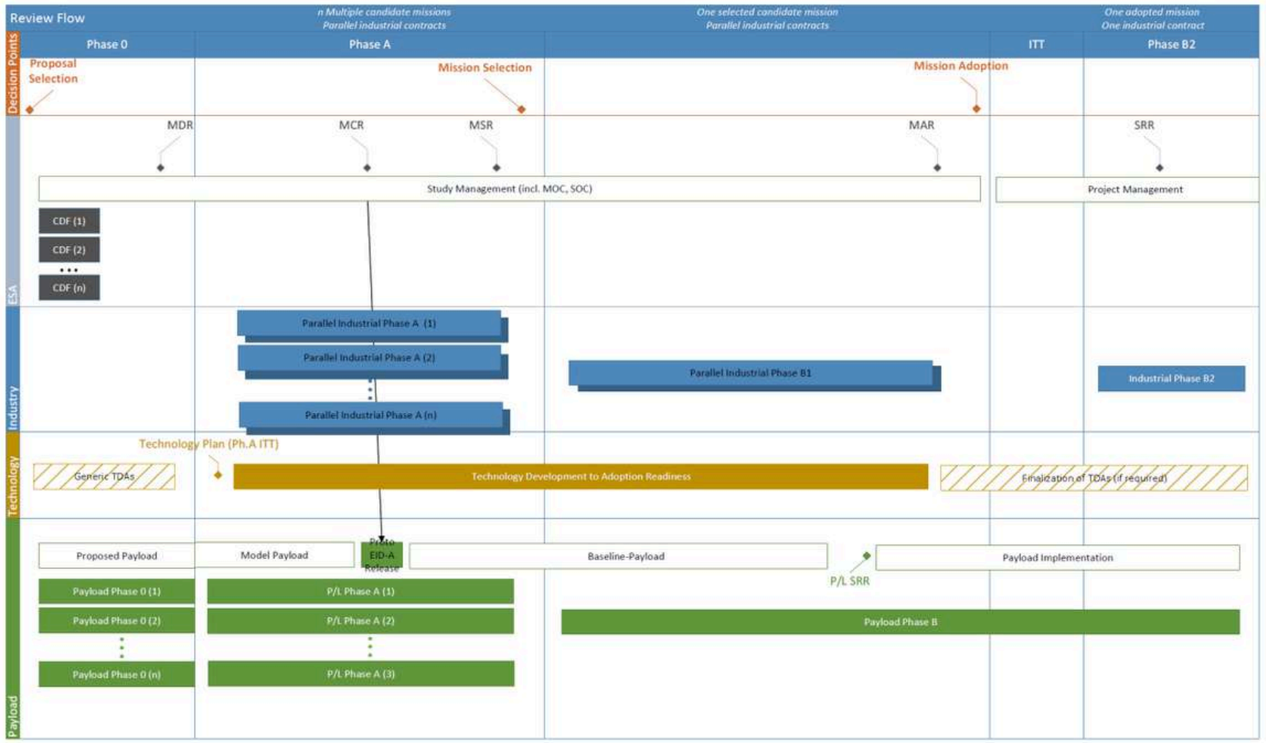


Figura 7: https://cdn.sci.esa.int/documents/34923/35555/1567214408509-Mission_phases_and_project_lifecycle_1280w.jpg/c6aab5d7-25fe-5d73-c37b-50d63f4924e8?version=1.0&t=1567214418161

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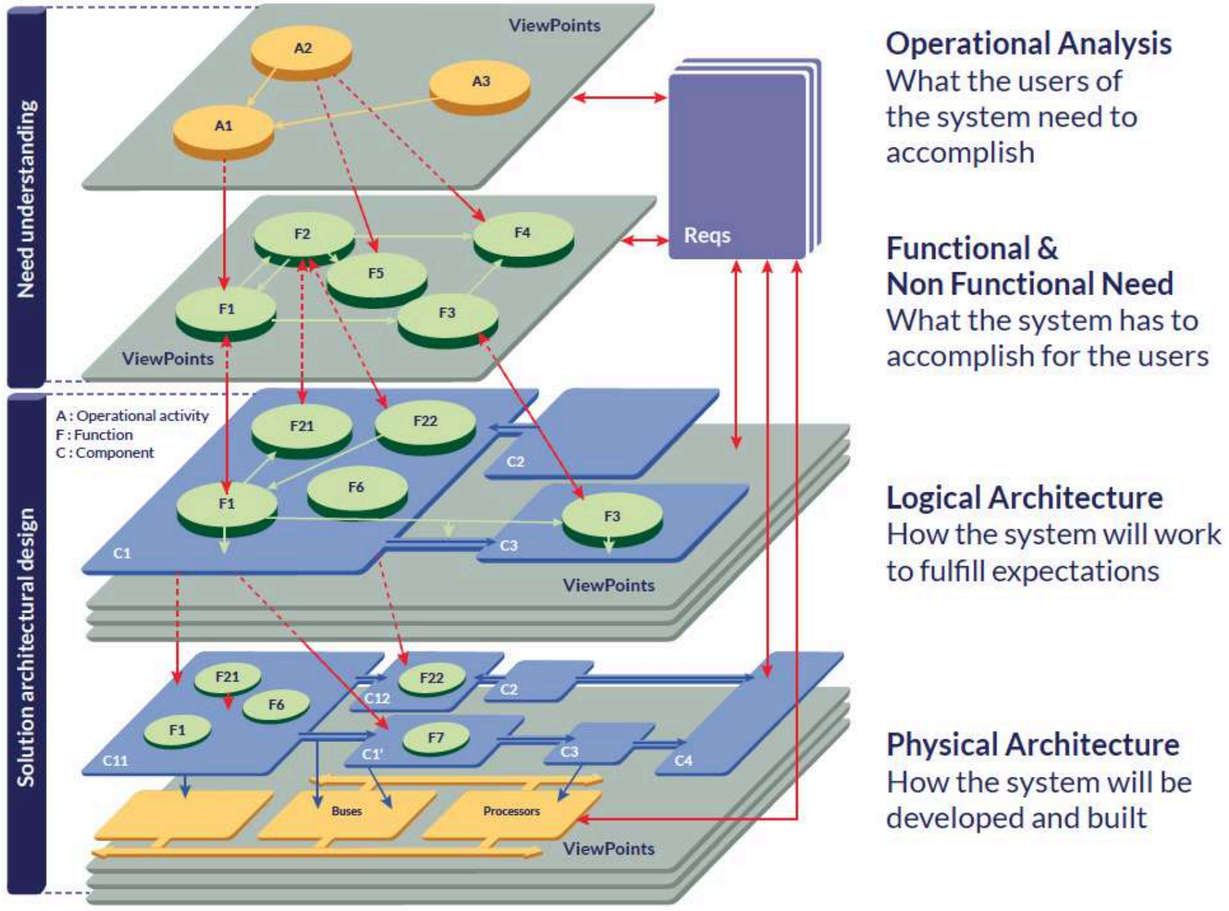


Figura 8: A. Johnstone (2022). Tabla de comparación de dispenser [Datos]. CubeSats org. https://mbse-capella.org/arcadia.html

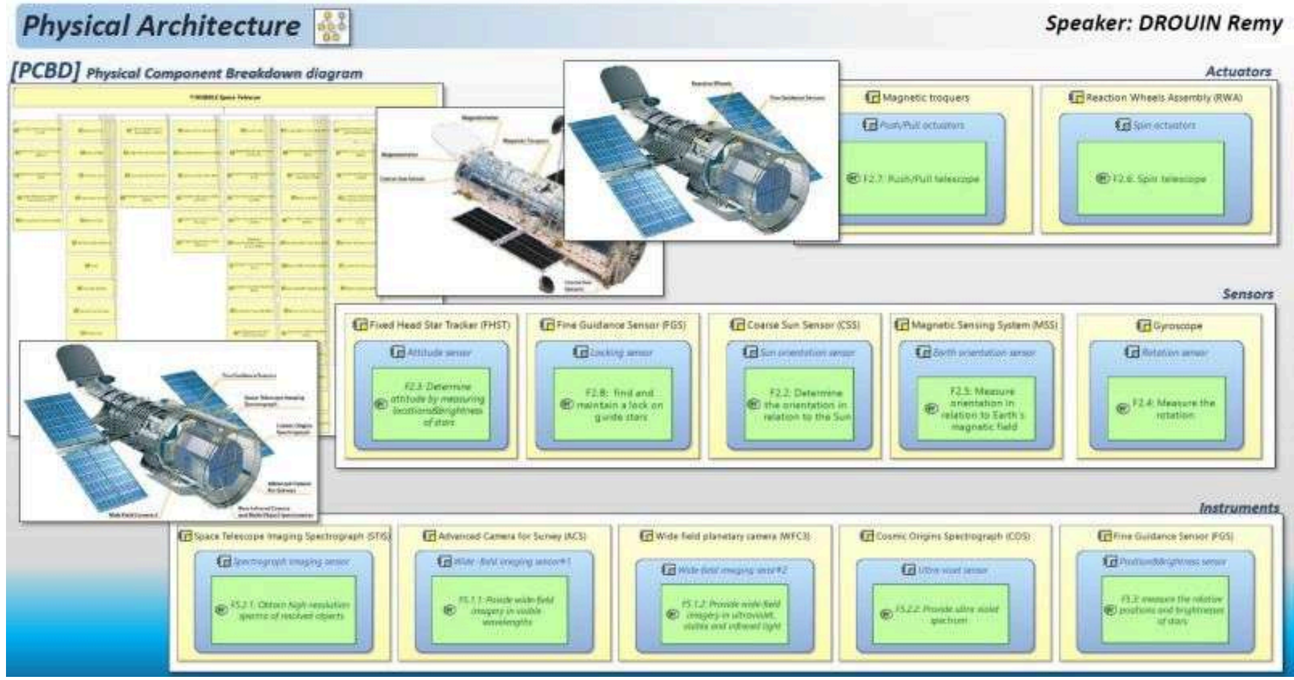


Figura 9: A. Johnstone (2022). Tabla de comparación de dispenser [Datos]. CubeSats org. https://www.linkedin.com/posts/capella-mbse-tool_systemsengineering-digitaltwins-syseng-activity-6874007549159448576-MaX4?trk=public_profile_like_view

REQUERIMIENTOS 1 de 3

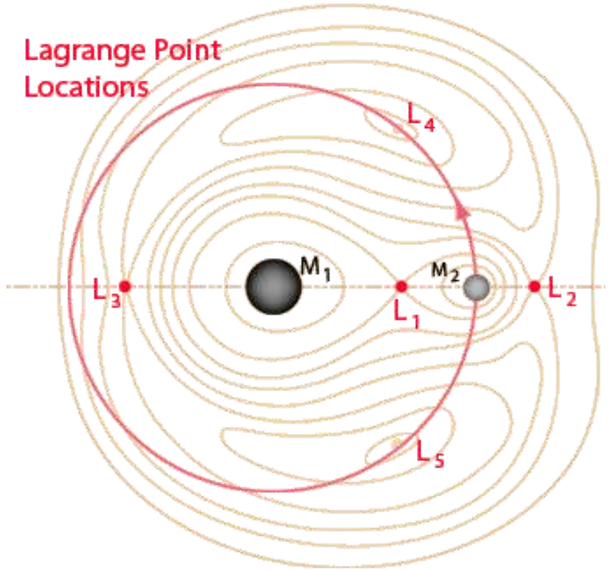
REQUERIMIENTOS 1 de 3

El nanosatélite deberá estudiar el lado oscuro de la Luna

REQUERIMIENTOS 2 de 3

https://www.esa.int/Enabling_Support/Space_Engineering_Technology/Shaping_the_Future/LUMIO_New_CubeSat_Illuminating_Lunar_Impacts

L2



REQUERIMIENTOS 3 de 3

PAYLOAD

https://dragonflyaerospace.com/wp-content/themes/dragonfly/images/page-products/product-komodo.png

SATELITE

MS **EPS** **TT&C** **OBC** **ADCS**

DISEÑO 1 de 3

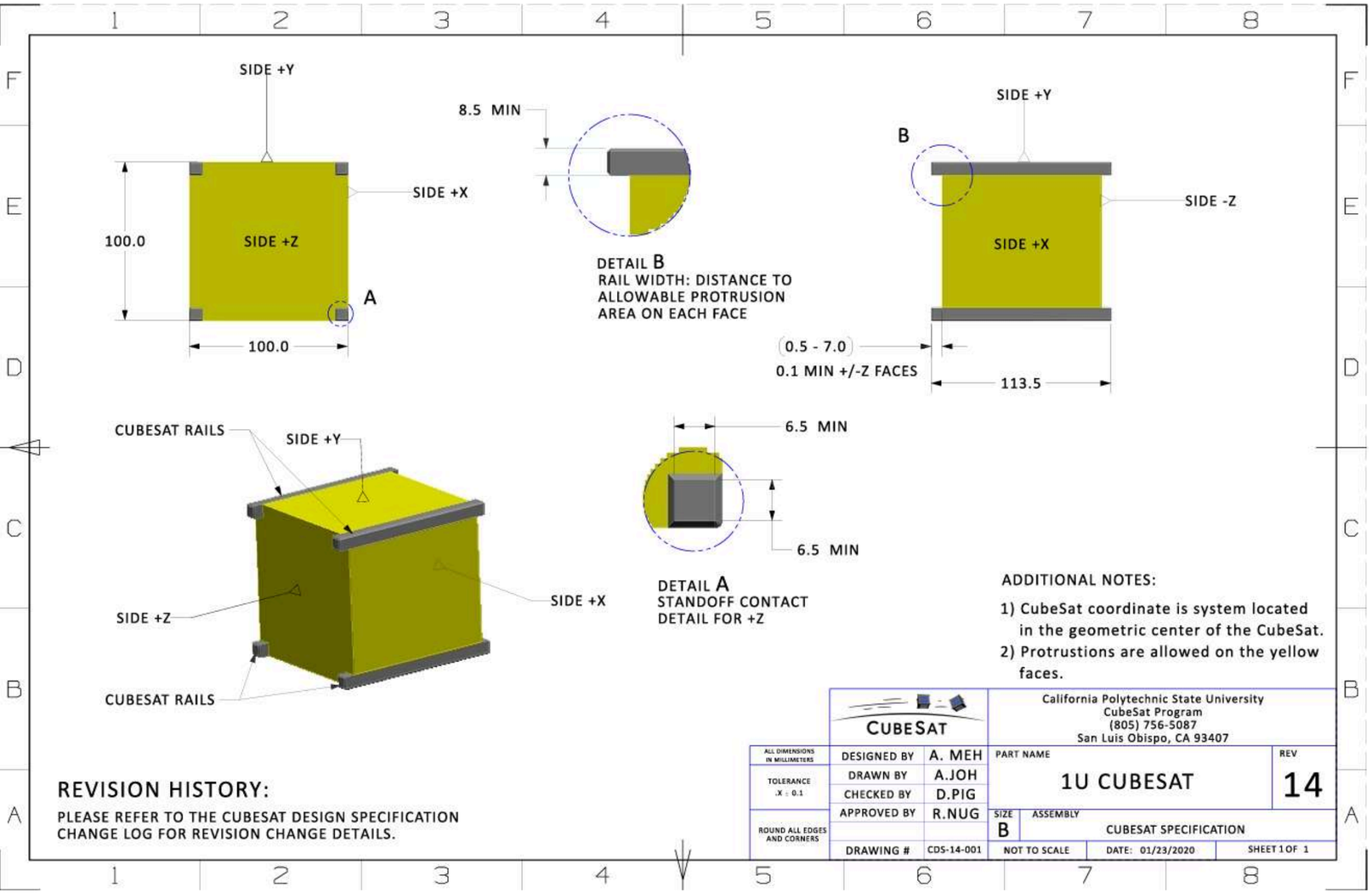


Figura 9: A. Johnstone (2022). Tabla de comparación de dispenser [Datos]. CubeSats org. https://www.linkedin.com/posts/capella-mbse-tool_systemsengineering-digitaltwins-syseng-activity-6874007549159448576-MaX4?trk=public_profile_like_view

AUTODESK Inventor

SOLIDWORKS

	X Axis	Y Axis	Z Axis
1U	+ 2 cm / -2 cm	+ 2 cm / -2 cm	+ 2 cm / -2 cm
1.5U	+ 2 cm / -2 cm	+ 2 cm / -2 cm	+ 3 cm / -3 cm
2U	+ 2 cm / -2 cm	+ 2 cm / -2 cm	+ 4.5 cm / -4.5 cm
3U	+ 2 cm / -2 cm	+ 2 cm / -2 cm	+ 7 cm / -7 cm
6U	+ 4.5 cm / -4.5 cm	+ 2 cm / -2 cm	+ 7 cm / -7 cm
12U	+ 4.5 cm / -4.5 cm	+ 4.5 cm / -4.5 cm	+ 7 cm / -7 cm

Figura 9: A. Johnstone (2022). Tabla de comparación de dispenser [Datos]. CubeSats org. https://www.linkedin.com/posts/

DISEÑO 2 de 3

Según la clasificación del Estado del Arte (https://www.nasa.gov/smallsat-institute/sst-soa/structures-materials-and-mechanisms/) de las pequeñas naves espaciales de NASA hay dos tipos de estructuras.

1. Construcción monocasco
2. Diseños de marcos modulares

Las estructuras también se dividen en primarias que tienen contacto directo con el dispensador, las secundarias que permiten proteger a los subsistemas y a unir a estos y a las terciarias como clips y las estructuras terciarias para dar soporte a los componentes como para los sensores solares como los conectores que permiten unir a los cables.

Estructura primaria

https://satsearch.co/products/2ndspace-verse-01-1u-structure

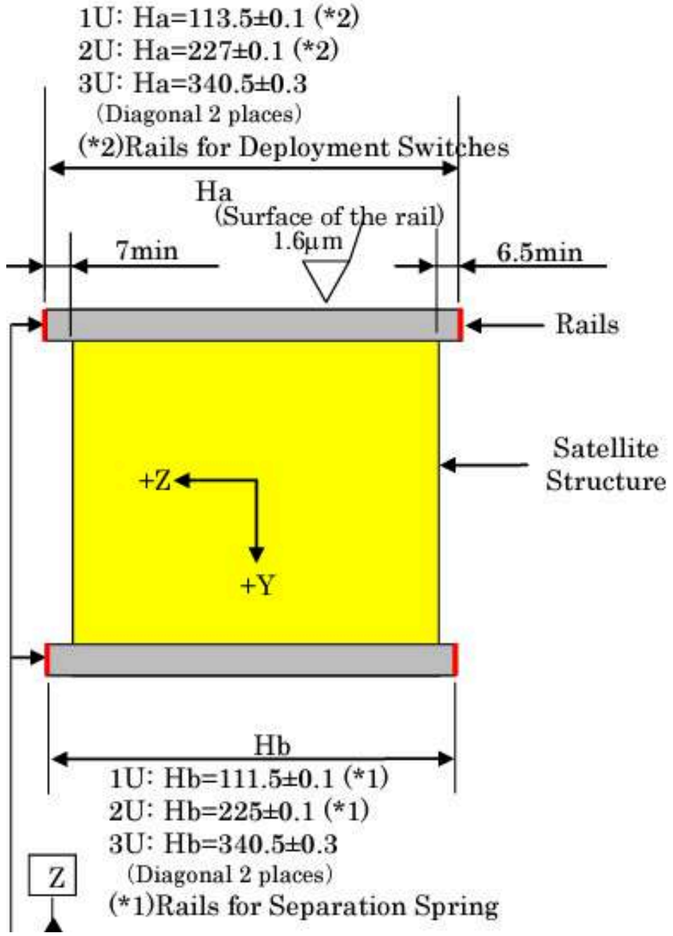
Estructura secundaria

https://alen.space/wp-content/uploads/2024/01/ordenadores.jpg

Estructura terciaria

https://lh4.googleusercontent.com/proxy/DaSOkW_EmHGRhh7vkNhaLFfkubiOozas8pdZEgDfdie3yR-WdIdGCx-Qob5V_h1H5sqZCbFsBt_Jh-I8oY2TQnWzA9Of

DISEÑO 3 de 3



https://aerospacebiz.jaxa.jp/wp-content/uploads/2016/07/jem_handbook_eng.pdf

Materiales

Aluminio:

7075, 6061, 6082, 5005 y 5052

Outgassing Database

https://outgassing.nasa.gov

Vacío

Radiación térmica

Oxigeno Atómico

Plasma

SIMULACIONES

Según la guia para cargas utiles de SPACEX las pruebas necesarias que se deben de realizar a un nanosatelite son verificar que su primera frecuencia modal sea mayor de 40 Hz. Las pruebas de vibraciones aleatorias tambien es requerido.

Ansys INNOVATION COURSES

Modal Analysis of a Satellite

- Problem Specification — Lesson 1
- Pre-Analysis & Start-Up — Lesson 2
- Geometry — Lesson 3
  - 1 Topic
- Mesh — Lesson 4
- Physics Setup — Lesson 5
- Numerical Solution — Lesson 6
- Numerical Results — Lesson 7
- Post Completion Survey
- Meet the Instructor

Mode	Frequency(Hz)
1	158.18
2	160.84
3	166.12
4	166.68
5	383.71

https://innovationspace.ansys.com/courses/courses/modal-analysis-of-a-satellite/lessons/numerical-results-lesson-7-16/

Table 4-6: Random Vibration MPE

Frequency (Hz)	Random Vibration MPE (P95/50), All Axes
20	0.01
50	0.015
700	0.015
800	0.03
925	0.03
2000	0.00644
GRMS	5.57

Tablas de Rideshare de SpaceX: https://storage.googleapis.com/rideshare-static/Rideshare_Payload_Users_Guide.pdf

Table 6-6: Manual Notch Limits (Primary Mode ONLY)

Primary Mode Frequency f_c (Hz)	Maximum Notch Bandwidth (Hz)	Maximum Notch Floor Width (Hz)
40 – 80	20	10
81 – 160	40	20
161 – 320	80	40
321 – 700	100	50
700 – 2000	Notching not allowed	

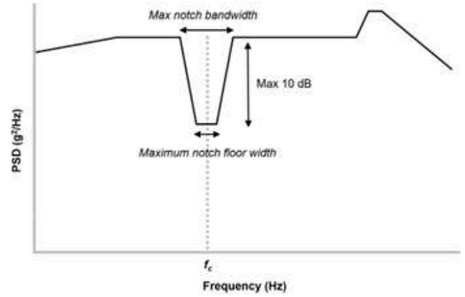
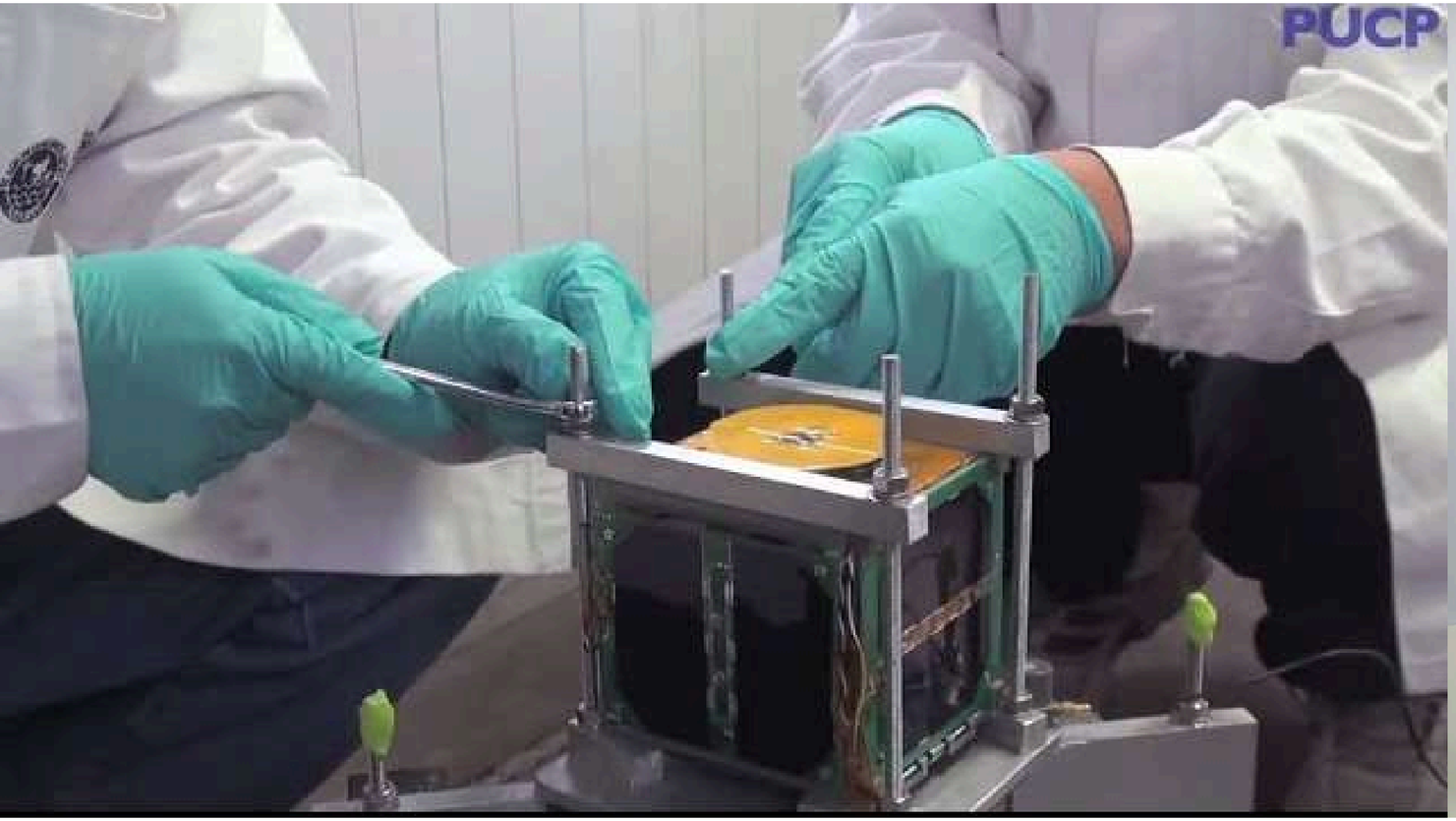


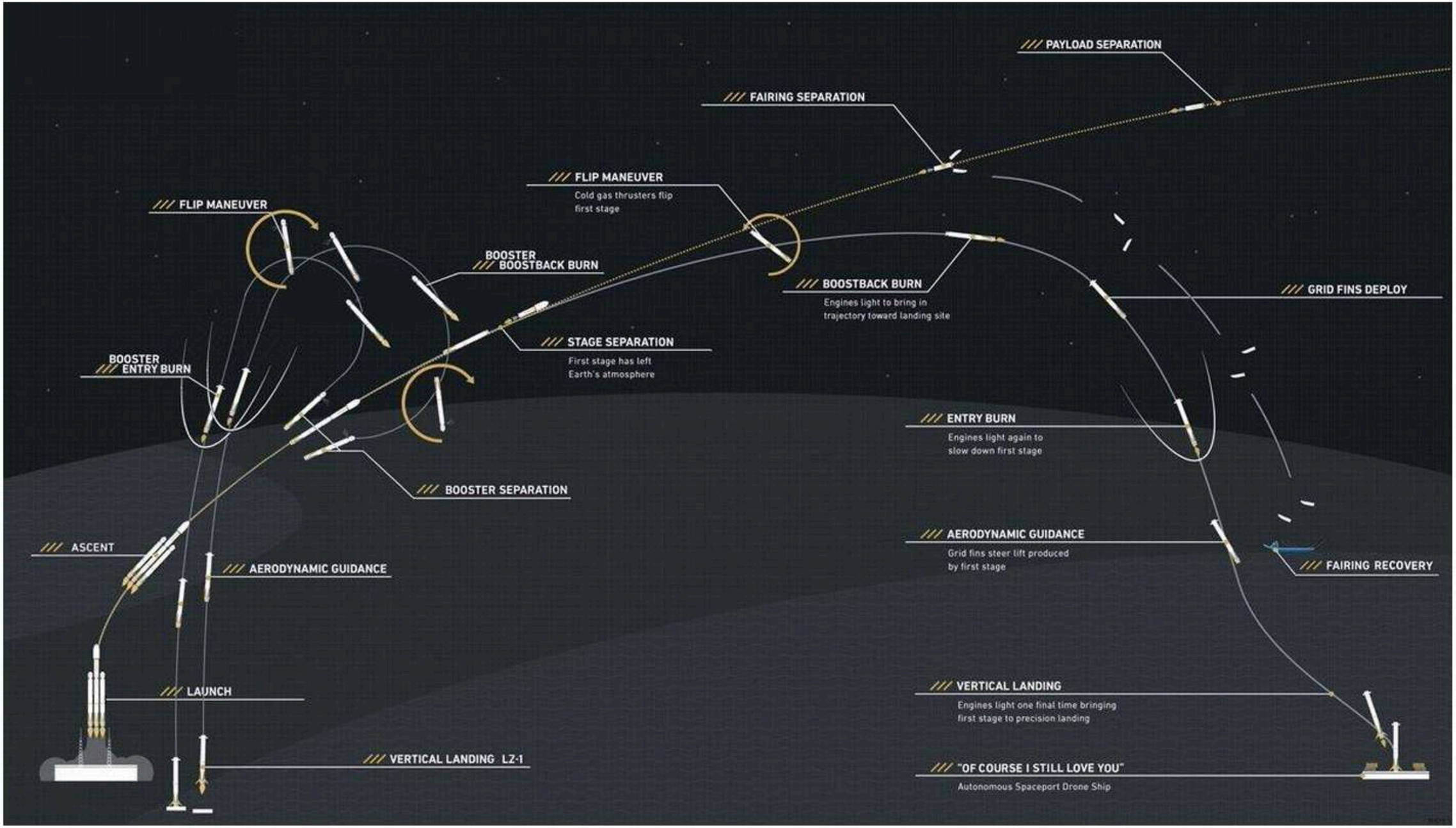
Figure 6-1: Manual Notch Limit Definitions (Primary Mode ONLY)

INTEGRACIÓN



https://inras.pucp.edu.pe/proyectos/pucp-sat-1-y-pocket-pucp

LANZAMIENTO



EMPRESAS

ISISPACE

GOMSPACE
NORTH AMERICA

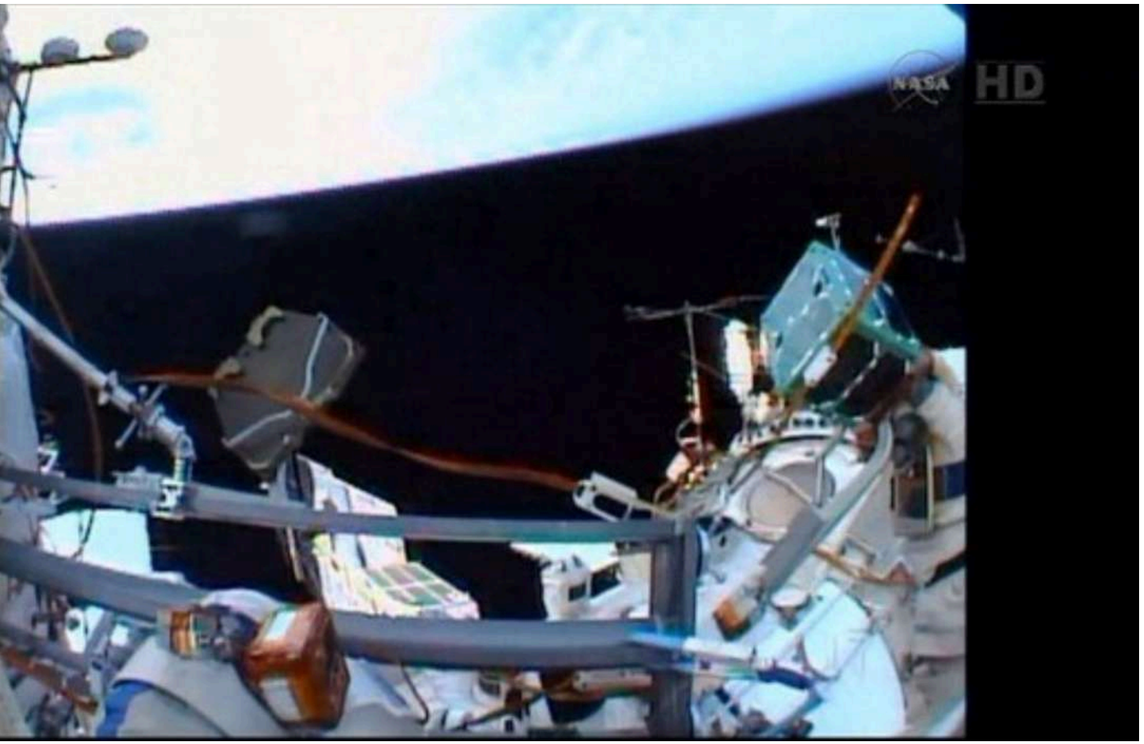
Alén space
A GMV COMPANY

ispace

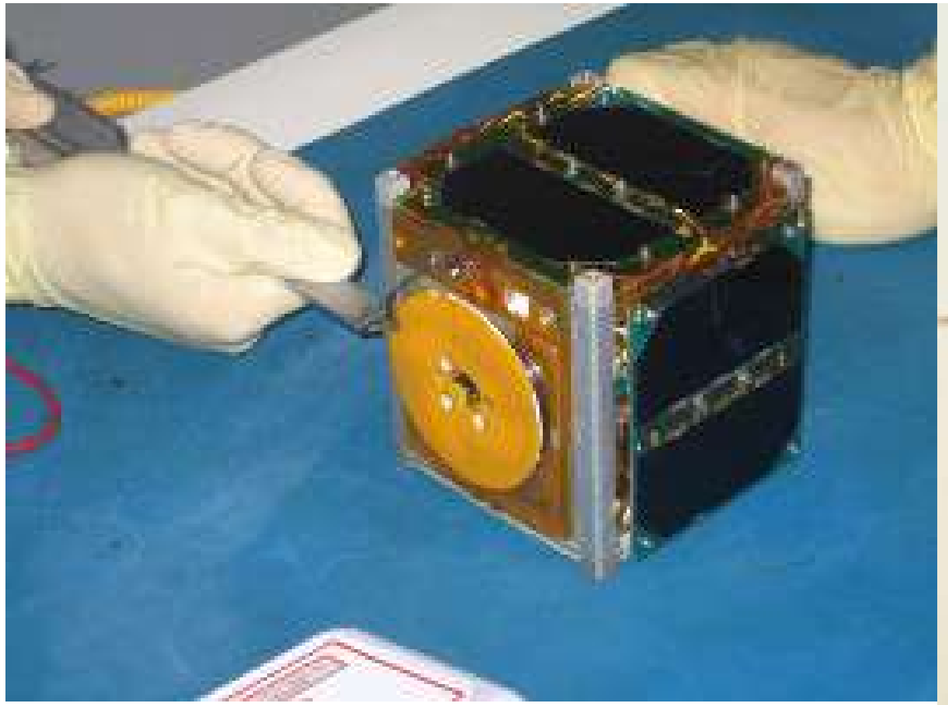
BLUE CANYON
TECHNOLOGIES

AAC
CLYDE
SPACE

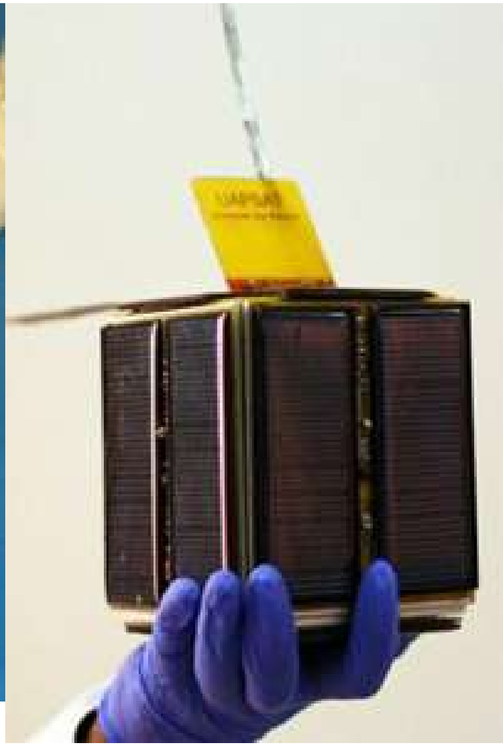
MISIONES PASADAS



https://portal.andina.pe/EDPfotografia/Thumbnail/2014/08/18/000258168W.jpg



https://www.nanosats.eu/img/sat/thumb4/thumbnail_PUCP-SAT-1_3.jpg



https://www.nanosats.eu/img/sat/uapsat-1__1.jpg

MISIONES FUTURAS

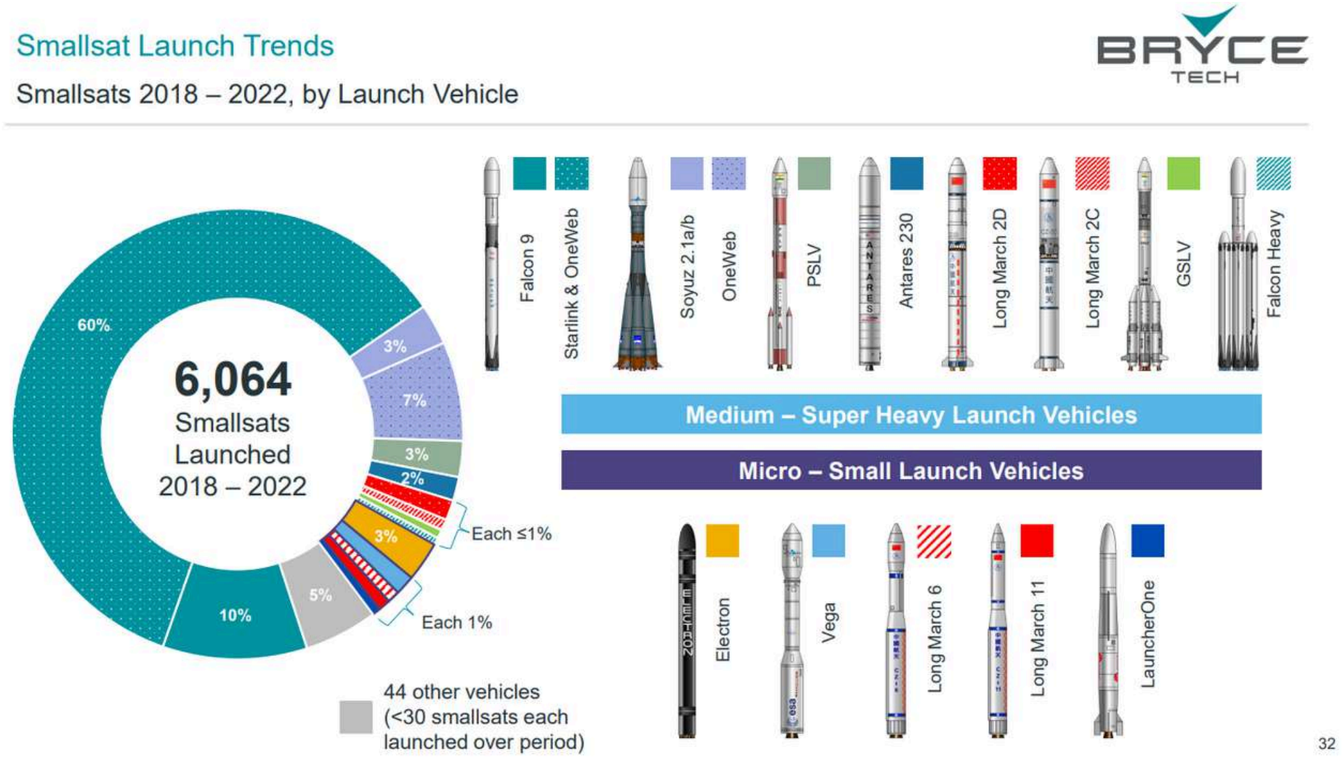
https://www.gob.pe/conida

https://www.esa.int/Enabling_Support/Space_Engineering_Technology/Shaping_the_Future/LUMIO_New_CubeSat_Illuminating_Lunar_Impacts

https://dca.cat/wp-content/uploads/2022/04/Noticies-web-DCA-1-4.png

CONCURSOS Y TENDENCIAS ACTUALES 1 de 2

CONCURSOS Y TENDENCIAS ACTUALES 2 de 2



https://brycetech.com/reports/report-documents/Bryce_Smallsats_2023.pdf