



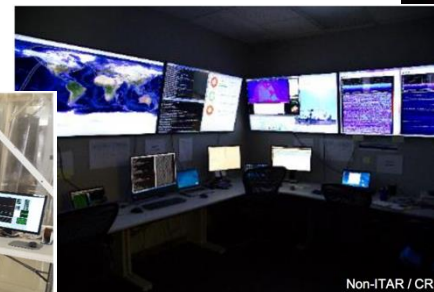
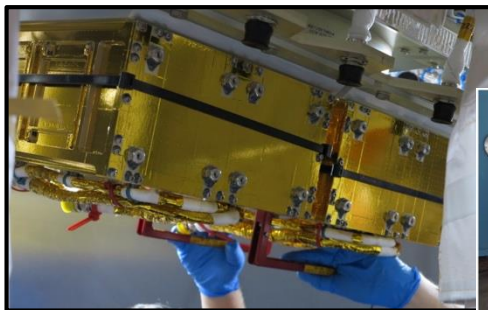
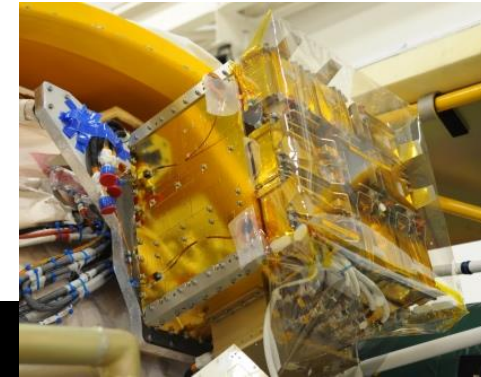
ENTERPRISE Integration, Government, and Industry Impact

CubeSat Developers Workshop, Spring 2017
California Polytechnic State University
San Luis Obispo, CA

Tyvak Company Overview

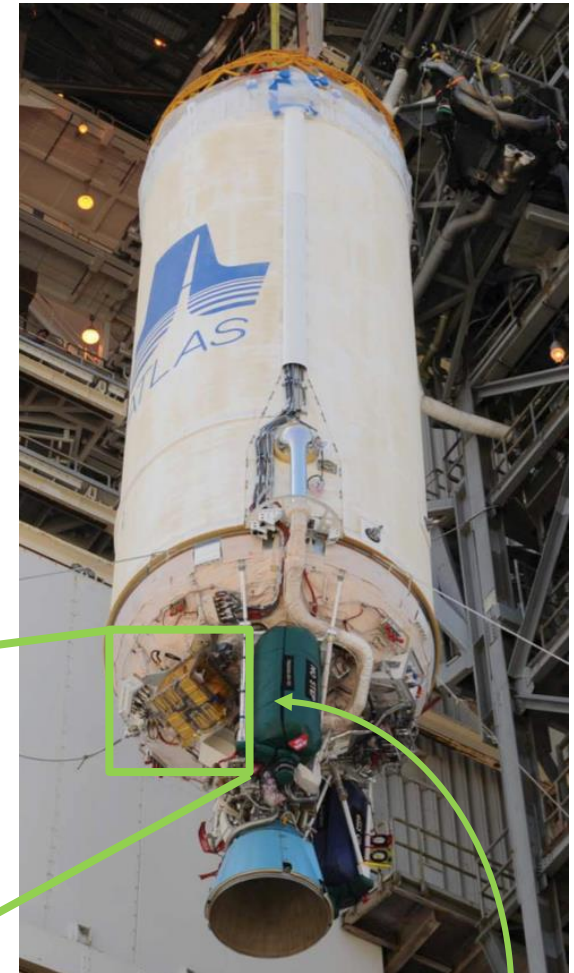
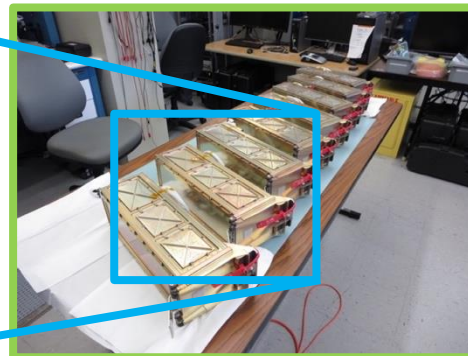
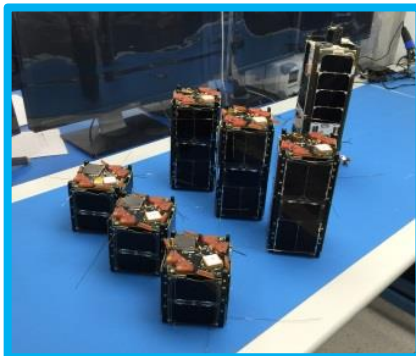
Tyvak Nano-Satellite Systems Inc.

- Tyvak Nano-Satellite Systems Inc., a U.S. owned private company, provides turnkey nano-satellite solutions and Launch Services for civil and commercial customers around the world
 - Founded in 2011, 100% US owned,
 - Satellite Design, Manufacture, and Launch Services
- Principals Have Extensive Launch Integration Experience
 - Over a decade integrating SmallSats, beginning at Cal Poly
 - First launch in 2003
 - From Suborbital to Interplanetary
 - 83 Dispensers, 80+ Satellite Programs, 155 SmallSats
 - 11 Different launch vehicles and 9 ranges worldwide
 - 10+ Launch Campaigns Ongoing
 - >50 SmallSats, >50 Dispensers



What is 'ABC' ?

- The ULA Aft. Bulkhead Carrier (ABC) interface has been in development since 2010
 - 5 Missions Flown, 53 CubeSats on orbit, Active Manifesting through 2020
 - Servicing LEO, GTO, and Interplanetary Orbits
- ABC is located on the aft end of the Centaur upper stage
 - Compatible with Atlas V and Vulcan launch vehicles
 - Approx. 80kg of secondary payload lift capability
 - 1U-12U CubeSats
 - 15inch Bolt Circle for single separating satellites
 - Flight demonstrated at both Eastern and Western Range



ULA Aft. Bulkhead Carrier (ABC)

ABC Flight Heritage (1)

Tyvak Nano-Satellite Systems Inc.

- **100% Success Rate**
 - 5 Missions, 53 CubeSats
 - NASA, USG, University, Commercial Payloads
 - Mission Partners:
 - NRO/OSL, NASA, Cal Poly, SRI, NPS, ULA, Aerospace Corp

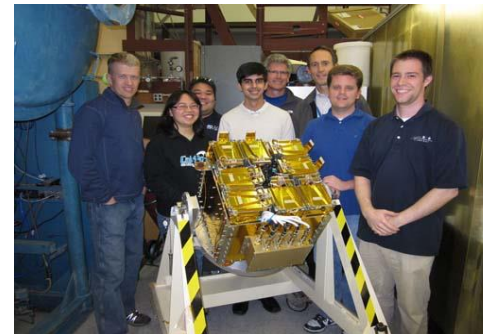
CAL POLY
SAN LUIS OBISPO



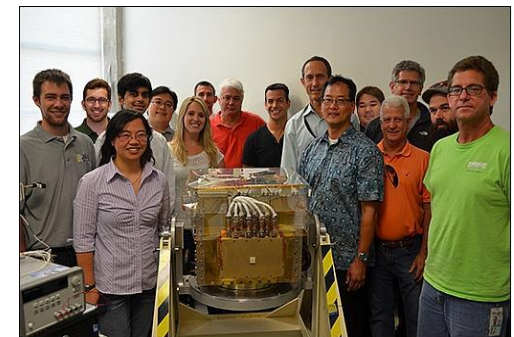
tyvak
Nano-Satellite Systems Inc.



- **L-36 / OUTSat**
 - September 2012
 - ULA Atlas V, Vandenberg Air Force Base
 - 11 CubeSats



- **L-39 / GEMSat**
 - December 2013
 - ULA Atlas V, Vandenberg Air Force Base
 - 12 CubeSats



ABC Flight Heritage (2)

Tyvak Nano-Satellite Systems Inc.

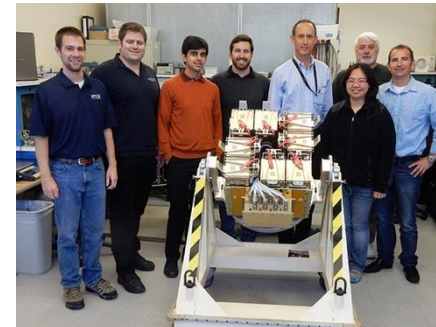
- **AFSPC-5 / ULTRASat**

- May 2015
- ULA Atlas V, Cape Canaveral Air Force Station
- 10 CubeSats



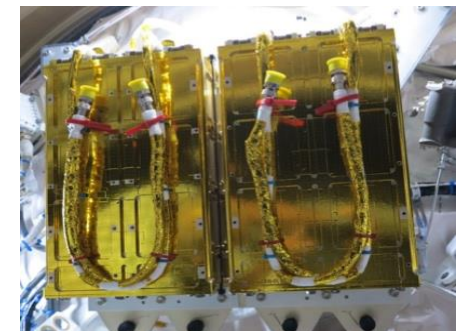
- **L-55 / GRACE**

- October 2015
- ULA Atlas V, Vandenberg Air Force Base
- 10 CubeSats



- **DigitalGlobe WV-4 / ENTERPRISE**

- November 2016
- ULA Atlas V, Vandenberg Air Force Base
- 7 CubeSats



On Orbit CubeSat Deployments (GRACE)

Tyvak Nano-Satellite Systems Inc.



Source: ULA YouTube

<https://www.youtube.com/watch?v=2yq0PXzRxsY>

ENTERPRISE Mission Overview

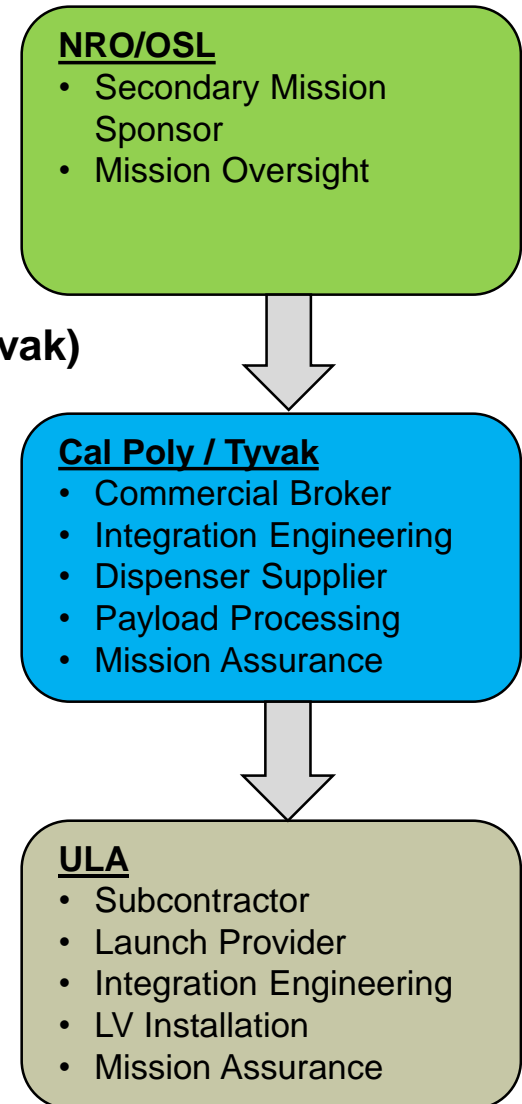
- First NRO/OSL flight utilizing commercial rideshare

- **Mission partners:**

- Primary Mission: WV-4 (DigitalGlobe)
- Secondary Mission: ENTERPRISE (NRO/OSL, Cal Poly, Tyvak)
- Launch Vehicle: Atlas V/Centuar (ULA, Lockheed Martin)
- Launch Date: November 2016 out of VAFB

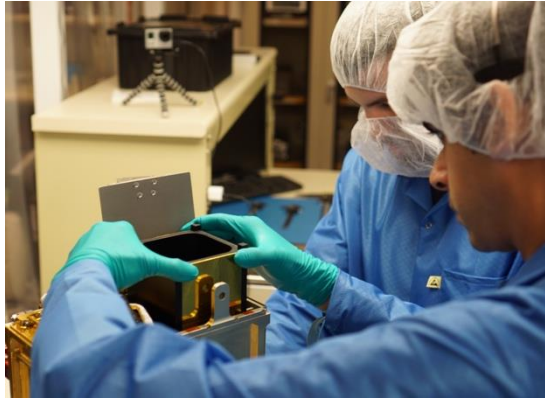
- Rapid turn around enabled manifesting to on orbit deployment in less than a year

10 Months	– 11/2015	Contracting and Manifests established
	– 07/2016	CubeSat to Dispenser Integrations
	– 08/2016	Launch Vehicle Integration
	– 09/2016	Initial Launch Attempt
	– 09-11/2016	Range Closure (VAFB Fires)
	– 11/2016	Launch

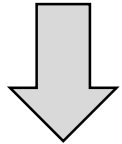


ENTERPRISE Highlights

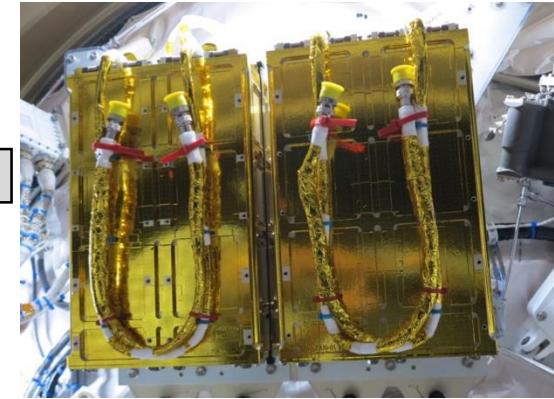
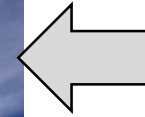
Tyvak Nano-Satellite Systems Inc.



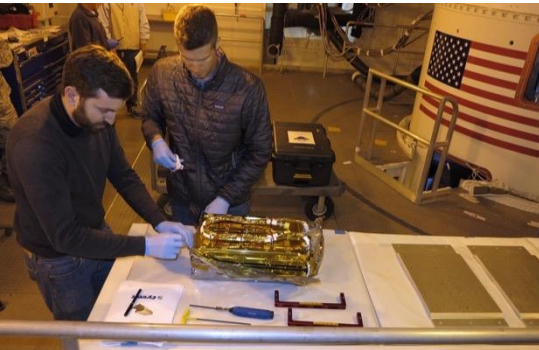
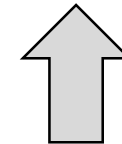
CubeSat Integrations
(San Luis Obispo, CA)



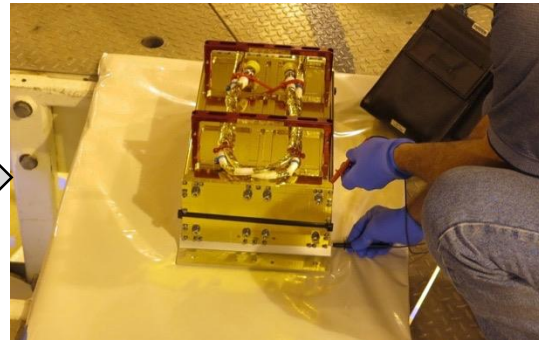
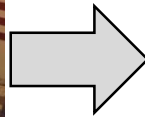
Launch
(VAFB, CA)



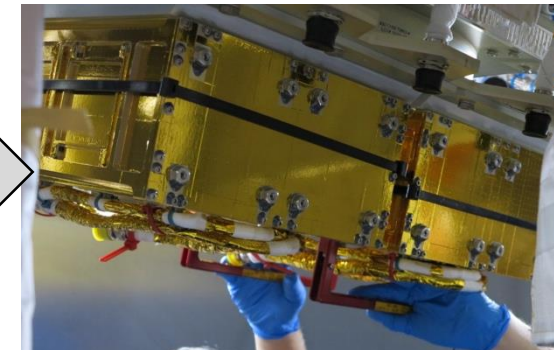
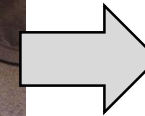
Installed Hardware
(VAFB, CA)



Delivery and LV Install Prep.
(VAFB, CA)



Transition of Hardware in LV
(VAFB, CA)



Installation of Hardware
(VAFB, CA)

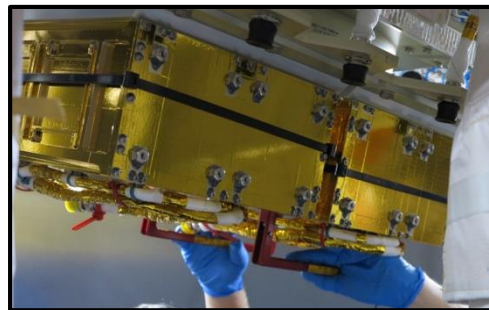
Improved Payload Capabilities

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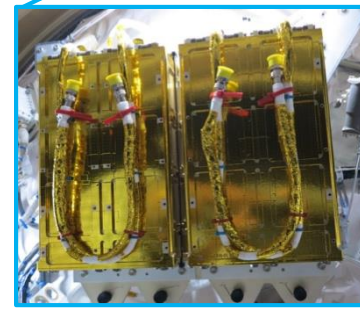
- **ENTERPRISE** expanded what is possible for secondary payloads
 - What was impossible 10 years ago is becoming the norm today (Ex: Interplanetary Ride Share, ISS Deployments, US commercial launch)
 - Attributed to the successful and ongoing efforts with USG stakeholders
- Lower cost, reduced environments, faster Integration timelines
- On-Pad integration of CubeSat payloads onto the Atlas / Centaur
 - Reduces traditional mission lifecycle from 18-24mo to less than 9-12mo
 - Robust contingency and manifest backups reduce Primary Mission risk
 - Secondary Payload mate to LV is improved from L-3mo to L-1mo



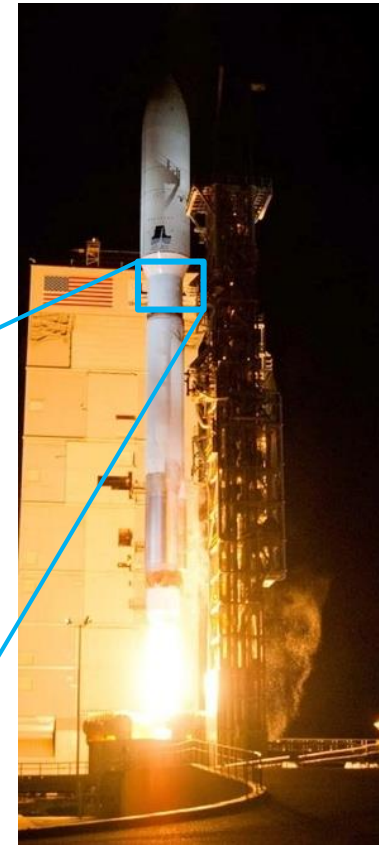
L-6w
CubeSat Delivery



L-4w
Launch Vehicle Mate
On Pad



L-1w
Secondary Payload
Closeouts

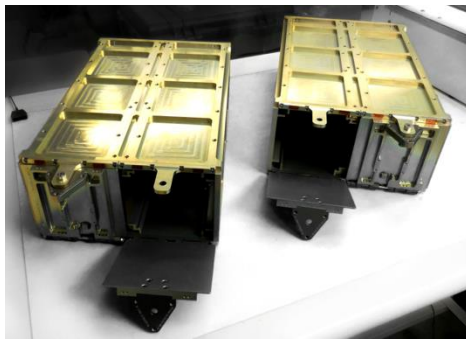


Launch

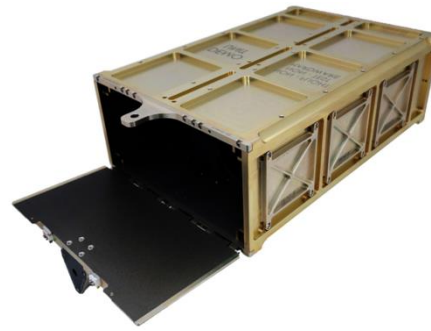
Flexible Dispensing Systems on ENTERPRISE

Tyvak Nano-Satellite Systems Inc.

- Tyvak NLAS Mk.II used on ENTERPRISE builds off the original NASA Ames NLAS Mk.I
 - Incorporates a number of lessons learned and feedback from customers, launch providers, and the NASA Ames team who helped develop the original NLAS
- The Tyvak NLAS Mk. II is designed to be inherently modular, maintaining compatibility With 1U-6U Spacecraft (340.5/366mm Lengths)
 - Identical LV Mechanical Interface
 - Identical electrical circuits, QTY: 1 for a single door, QTY: 2 for independent doors
 - Fully qualified and compatibly tested with Launch Vehicle avionics
- Enables flexible manifesting



Tyvak 6U NLAS
3U Configuration



Tyvak 6U NLAS
6U Congifuraiton

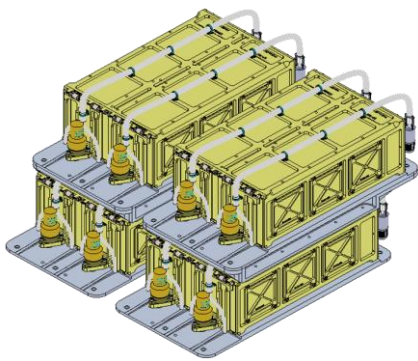


Tyvak 12U NLAS
12U Congifuraiton

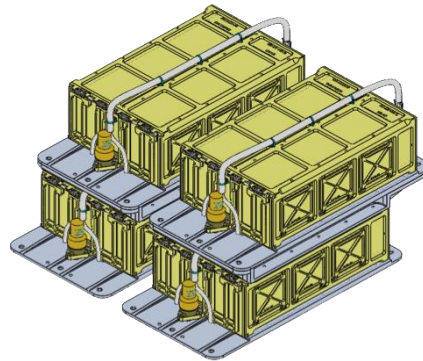
Continued Development and Collaboration: ULA Cube Corp.

Tyvak Nano-Satellite Systems Inc.

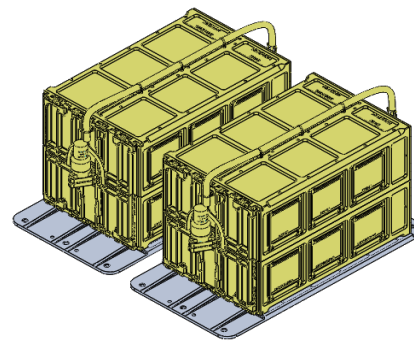
- **Cube Corp. is a integration offering focused on manifesting configurable hardware, reducing launch cost, and integration timelines**
 - Concept borne from lessons learned from NASA, DoD, and Commercial Missions
 - Tyvak configurable hardware accommodates 1U-12U Payloads with no change to Launch Vehicle interface
- **Tyvak NLAS Is designed to be configurable, and accommodate a wide range of payloads**
 - Double Doors, Single Doors, Divided 3U Bays, etc..
 - Tyvak NLAS Design Successfully Qualified for Flight
- **In Use On Atlas / Centaur**
 - Rideshare demonstrated on USG, NASA, and Commercial Missions



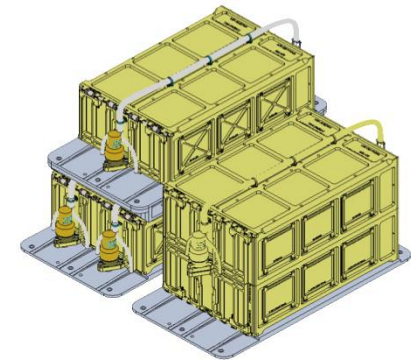
24U of Capacity
Compatible with 1U-3Us



24U of Capacity
Compatible with 6Us



24U of Capacity
Compatible with 12Us



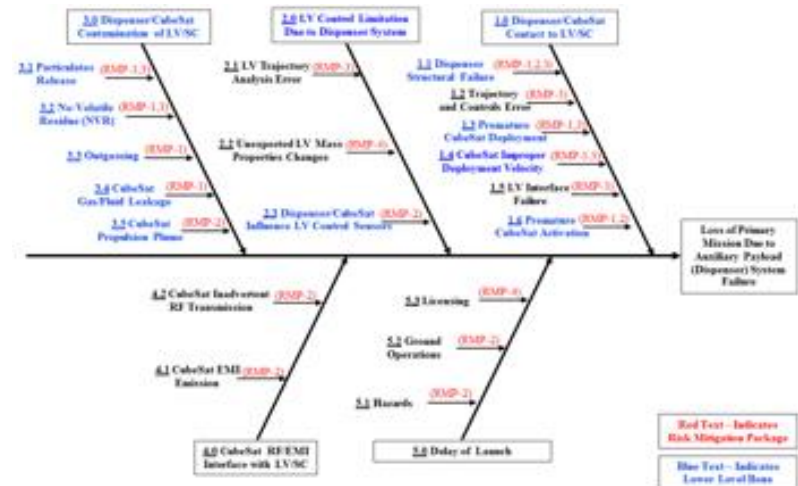
24U of Capacity
Compatible with 1U-12Us

Process Developed in Collaboration with USG

Tyvak Nano-Satellite Systems Inc.

Developed tailorable launch documentation and verification process to meet Government and Commercial customer needs:

- Regulatory Approvals
 - Range safety
 - Licensing (Radio, Imaging, etc.)
 - ITAR regulations
- “Do-No-Harm” Philosophy
 - ICD Development
 - Testing & Requirements Verification
- Certificate of Flight Readiness (CoFR)
 - Mission Readiness Review (MRR)

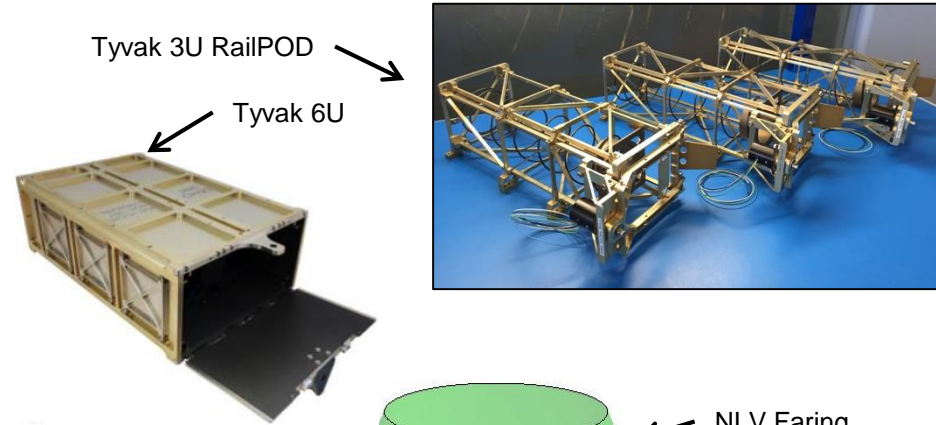


Expanded Capabilities

Tyvak Nano-Satellite Systems Inc.

- **Dispensers and Launch Adapters**

- Tyvak 3U RailPOD (1U – 3U Payloads)
- Tyvak 6U (1U – 6U Payloads)
- Tyvak 12U (1U – 12U Payloads)
- Tyvak INCA (Launch Adapter)

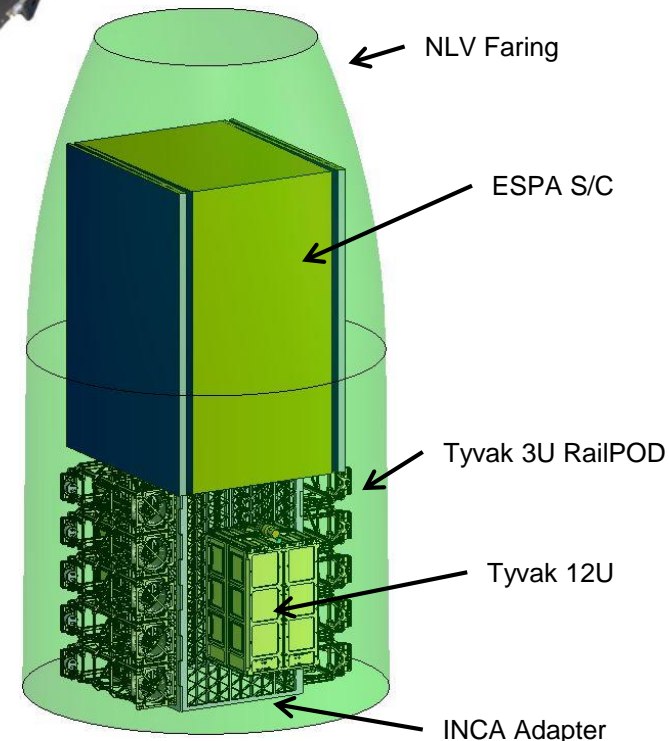


- **Launch Services**

- Identifying and manifest US and Int'l Opportunities
- NASA, USG, University, Commercial Services
- STEM Sponsored Launches through ULA CubeCorp.
- Launch Insurance

- **Payload Processing**

- Dedicated Tyvak test facilities
- Optimized integration and storage facilities



Thank You

Q & A

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justin.carnahan@tyvak.com