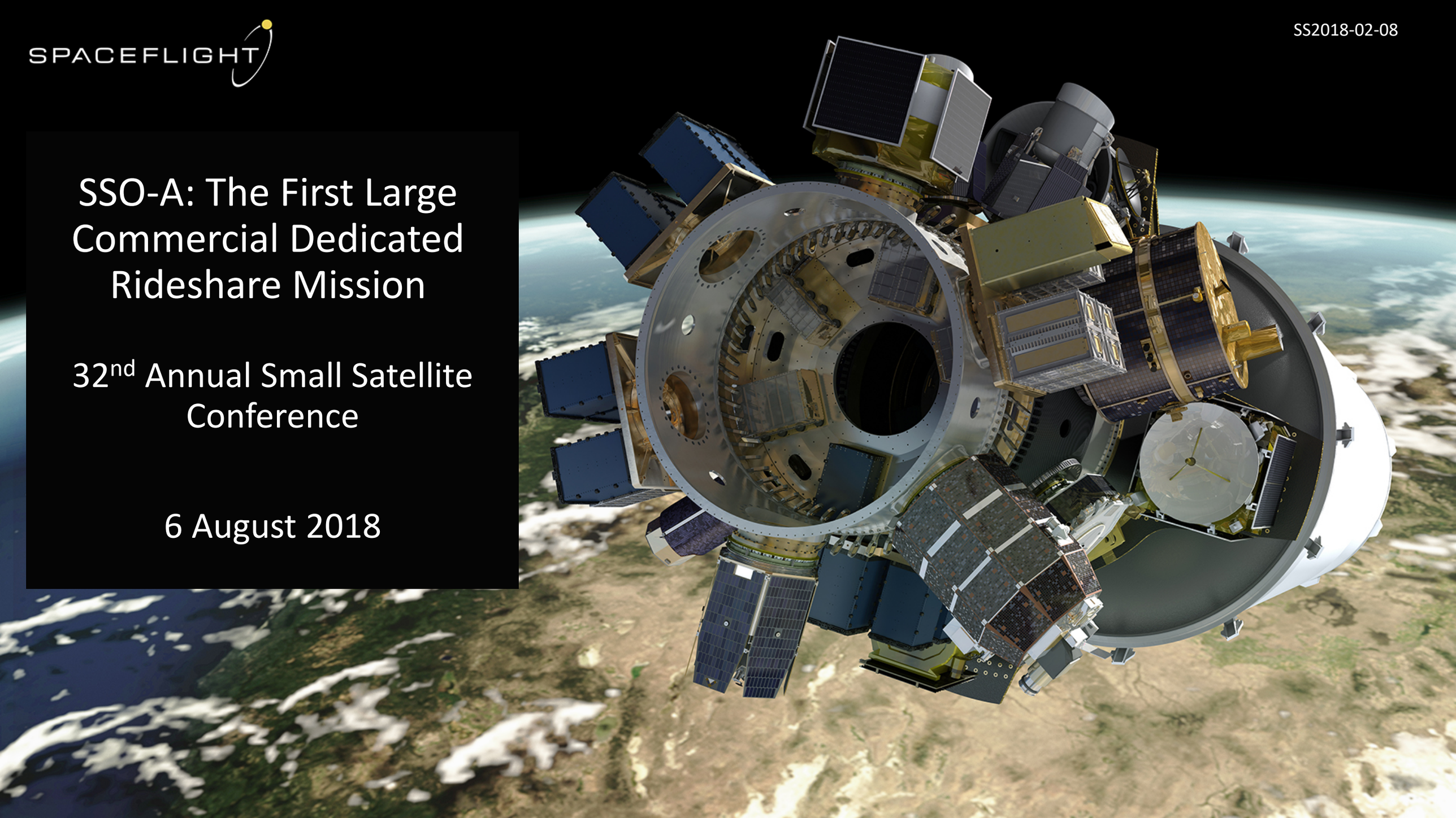
SPACEFLIGHT

SS2018-02-08

SSO-A: The First Large Commercial Dedicated Rideshare Mission

32nd Annual Small Satellite Conference

6 August 2018



Spaceflight Industries Overview

Spaceflight Industries comprises two synergistic lines of business that are leaders in an emerging $100B market opportunity.

SPACEFLIGHT

Revolutionizing access to space by offering routine, cost-effective launch services for commercial, government, and academic missions.

BLACK SKY

Operating the unifying platform and analytics infrastructure to understand the planet in real time.

- Founded in 1999 as Andrews Space
- Spaceflight established in 2010
- SSO-A Initiated in Oct 2015
- Headquartered in Seattle, WA with office in Herndon, VA

- Over 140 satellites launched to date
- 12 missions on 7 different launch vehicles
- Partnering with established and new entrant Launch Vehicle Providers

SSO-A: Smallsat Express

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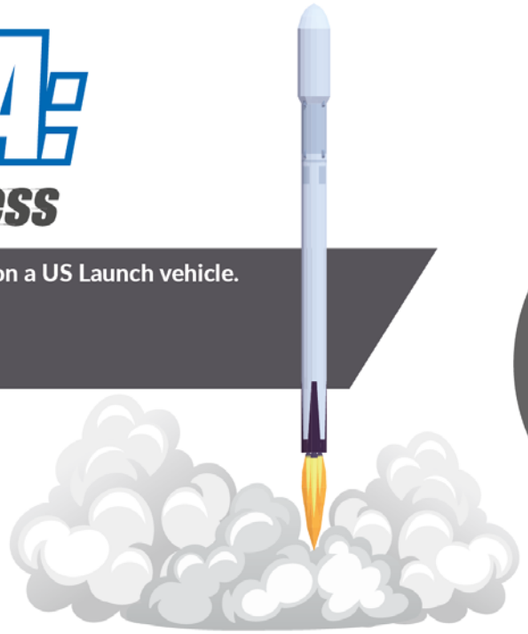
Single largest dedicated rideshare mission on a US Launch vehicle.

Launch Vehicle: SpaceX Falcon 9

Launch Site: Vandenberg Air Force Base

Destination: Sun Synchronous Lower Earth Orbit

Parameter	Osculating Value at Descending Node
Perigee	584 km
Apogee	584 km
Inclination	97.75 deg
LTDN	10:30 AM



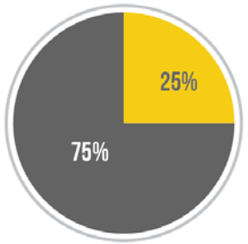
70+ spacecraft

35+ customers

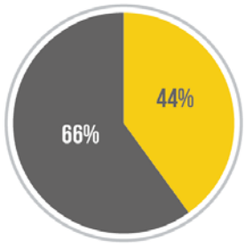
Microsats: 15

Cubes: 56

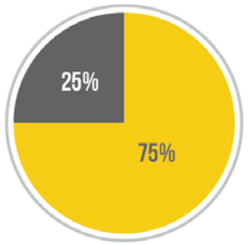
Countries represented: 18



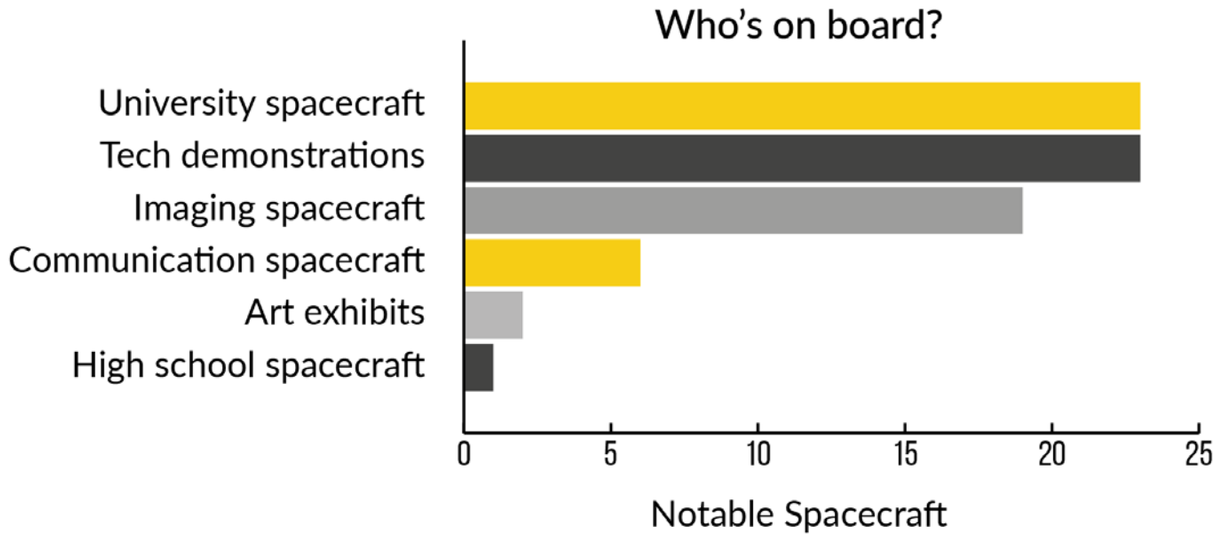
First time customers Return customers



International Domestic



Commercial Government



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Managing a Large Dedicated Rideshare Mission: Minimize the Entropy!

- Managing and accommodating dozens of spacecraft = a lot of potential for entropy increase!
- Hardware selection – Strategic ‘make versus buy’ decisions
  - Used existing – or modified designs – wherever possible -> Develop new hardware only for mission-unique needs
  - Used proven vendors to minimize risk
- Mission Management: Herding the Cats!
  - Developed standardized templates for common documents
    - System Safety (MSPSP, Requirements Tailoring, Battery Hazards etc.)
    - Integration planning (Integration Flow, Ground Ops Plans, etc.)
    - Readiness Review Presentations
  - Standardized ICDs with on-line review
    - Jama used for ICD and System requirements
- Mission Assurance
  - Emphasis on ‘Do No Harm’
  - ‘Test Like You Fly’…and test often
- Be Good Stewards of the Space Environment -> Close coordination with FCC, NOAA, and JSPOC
  - Conjunction analyses, orbital debris & demise analyses

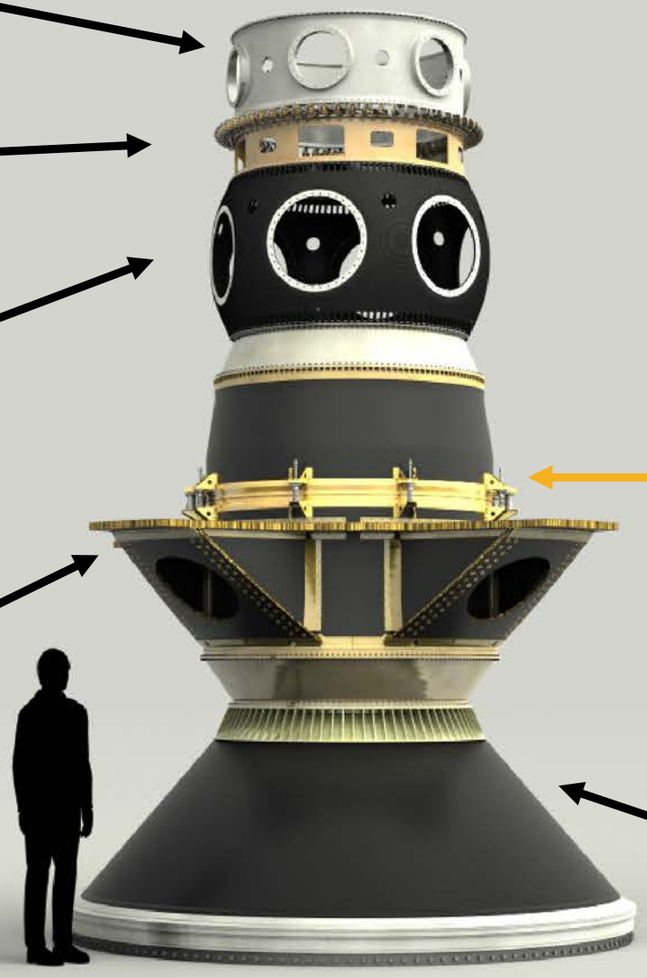
SSO-A Integrated Payload Stack (IPS)

Standard ESPA
- 6 – 15” Ports
- Microsats & CubeSats

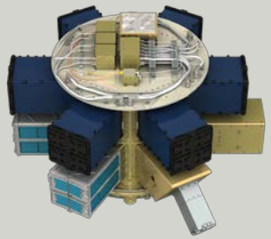
CubeStack
- Avionics
- CubeSat Dispensers

Hub – Composite Ring
- 6 – 24” Ports
- Microsats

Multi Payload Carrier (MPC)
- Internal – Lower Free Flyer
- External – 4 Platforms w/ Microsats



Upper Free Flyer (UFF)



Lower Free Flyer (LFF) (Inside MPC)

Falcon 9 Payload Attach Fitting (PAF)

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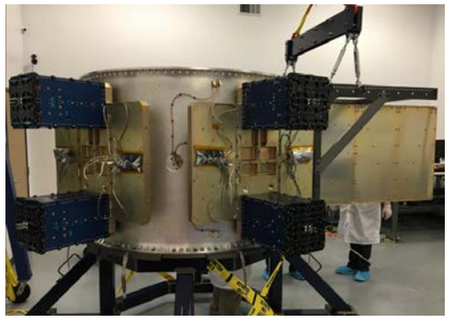
SSO-A Spacecraft Launch Integration Facilities

- **Most IPS and Spacecraft-to-IPS integration takes place at Spaceflight's Integration Facility in Auburn, WA**
  - CubeSats and some MicroSats
  - Four major elements integrated at WA and shipped to Vandenburg AFB
- **Large high-bay for spacecraft integration**
  - 100k cleanroom w/ overhead rail crane
  - Portable cleanroom for CubeSat integration or 10k cleanroom processing
- **Final launch integration in SpaceX PPF at Vandenburg AFB, Starting at L-30 days**
  - Remaining Microsats (primarily for fueling)
  - Integrated elements of IPS stacked for launch

100k Cleanroom



Integration Rehearsal

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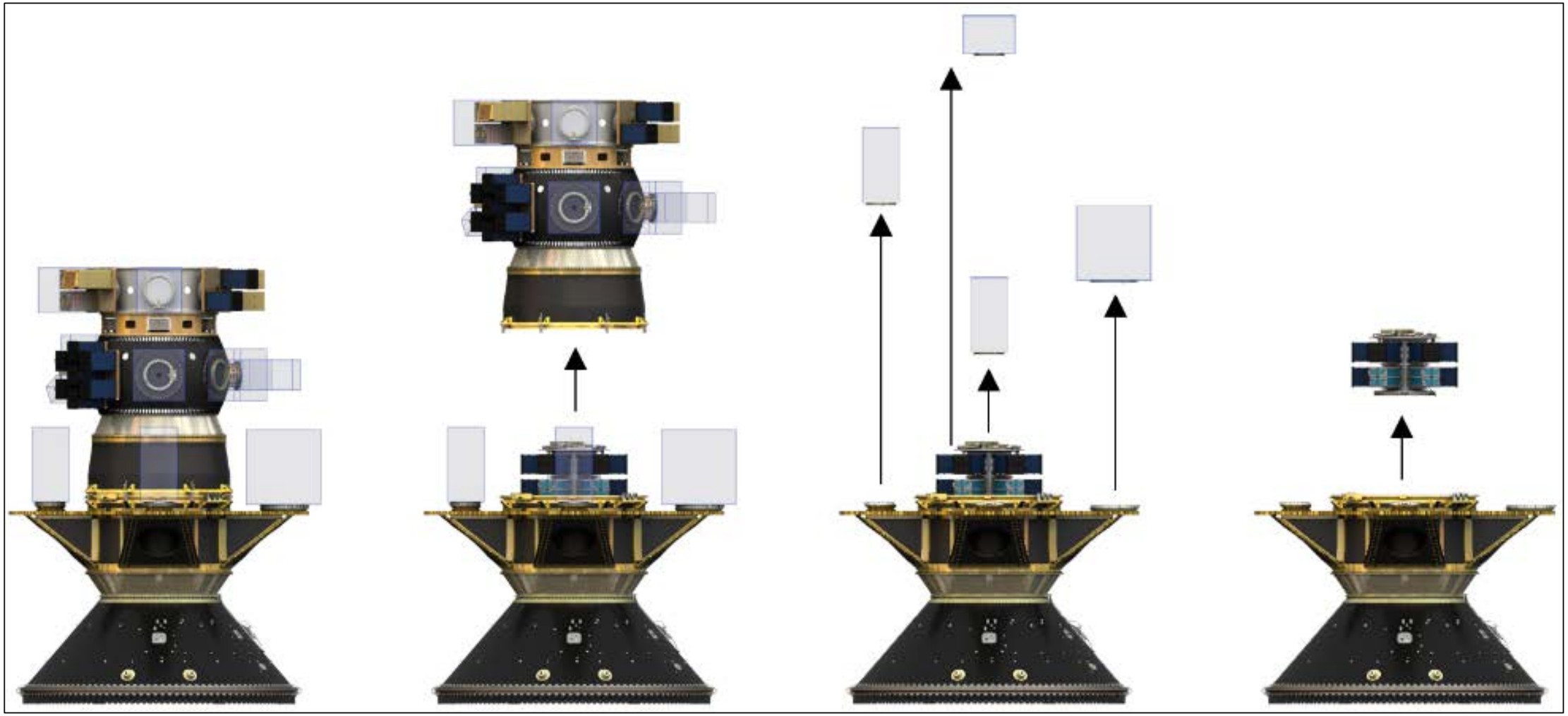
SSO-A Initial Separation Events – From Falcon 9



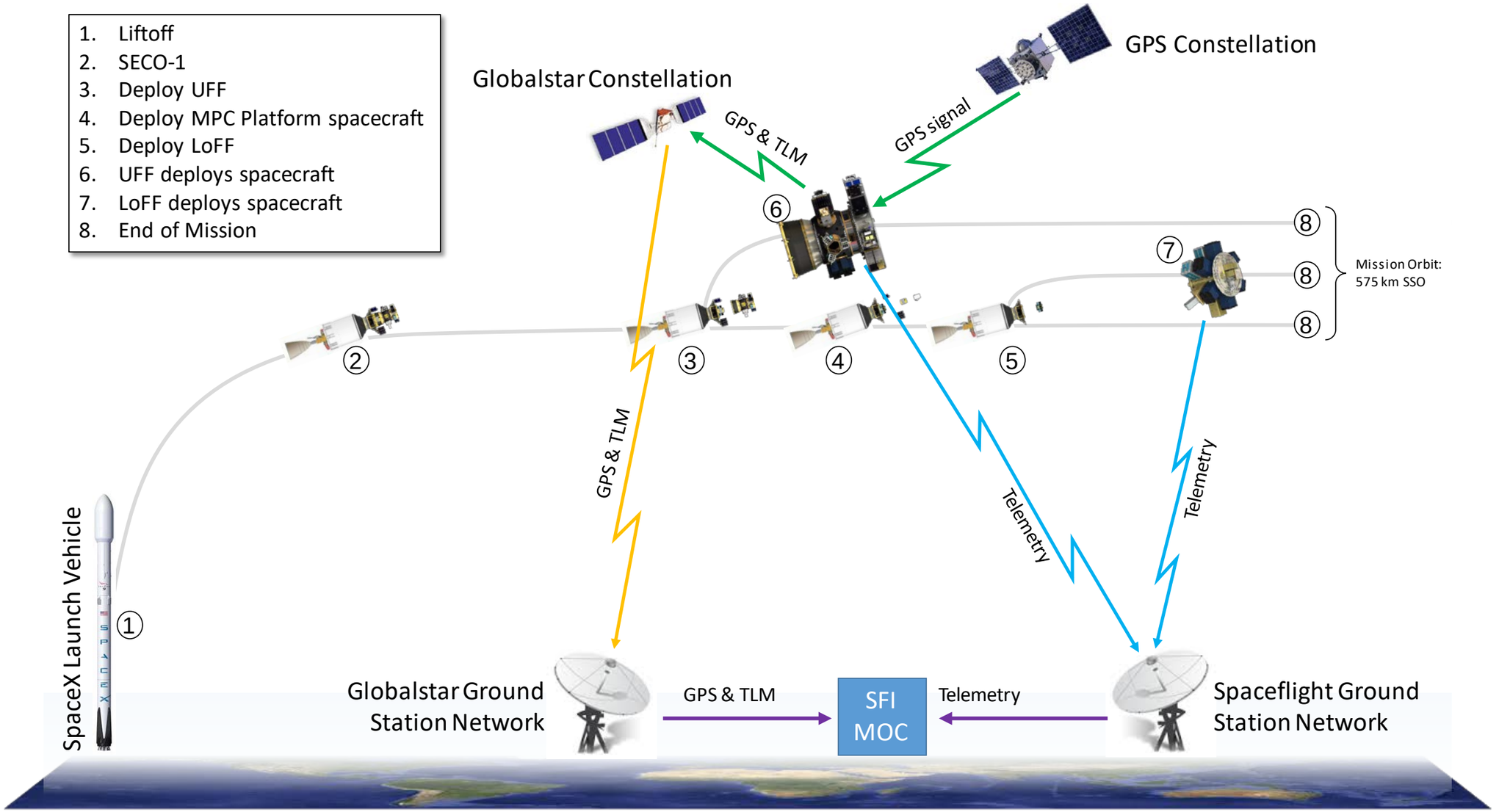
Deploy UFF

Deploy MPC Microsats

Deploy LFF

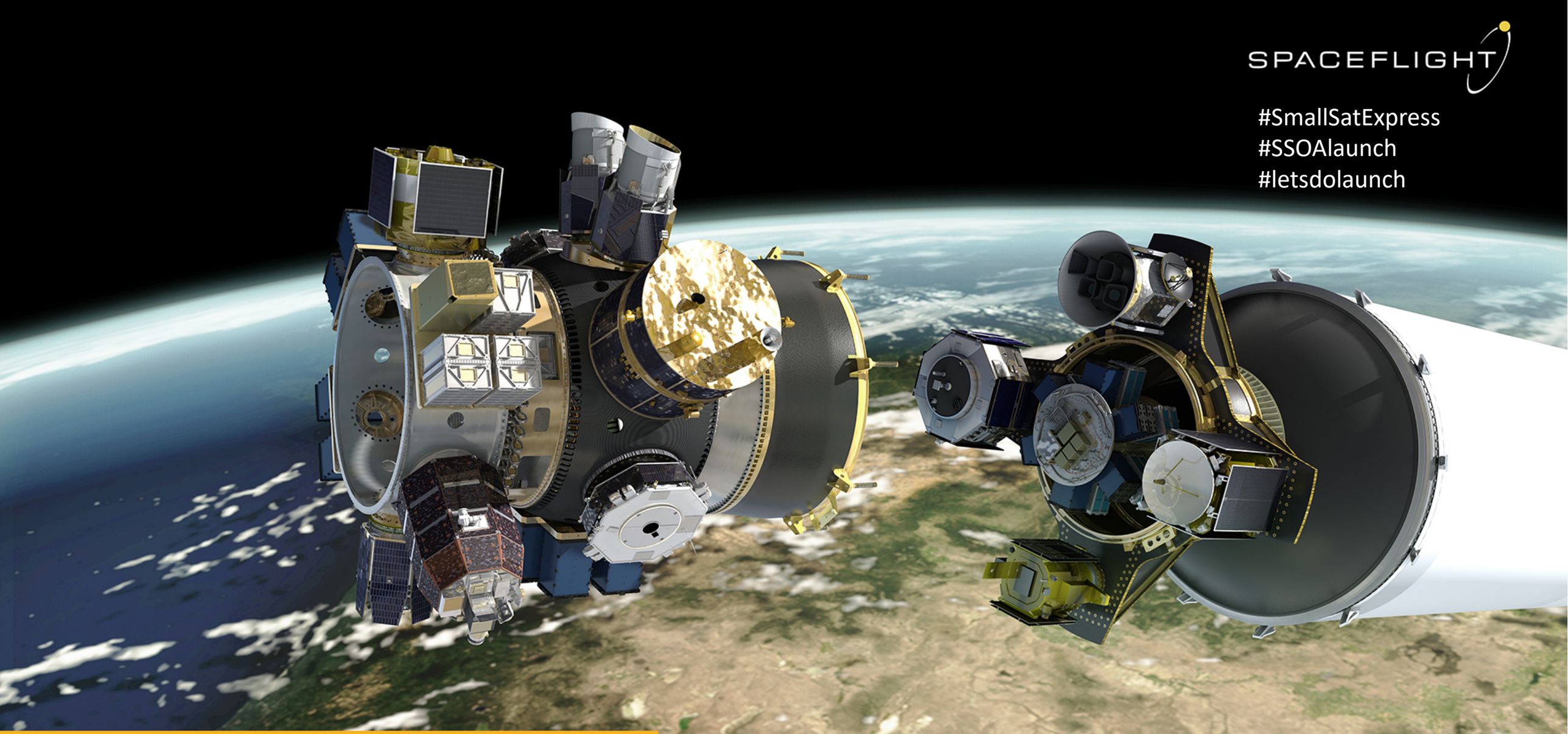
SSO-A Mission Scenario

1. Liftoff
2. SECO-1
3. Deploy UFF
4. Deploy MPC Platform spacecraft
5. Deploy LoFF
6. UFF deploys spacecraft
7. LoFF deploys spacecraft
8. End of Mission



Lessons Learned

- Standardized…and Keep it Simple!
  - Don’t reinvent the wheel…unless you really need a better wheel
  - Templates, Templates, Templates!
  - Establish and Communicate Consistent Schedules
- Stay Flexible
  - Standardized…but adapt
  - Realize that all spacecraft will not make it to the finish line…but keep nudging
  - Be creative in accommodating ‘late entry’ participants
- Pay Attention to the ‘Non-Technical’ Stuff (Licensing, Permits, etc.)
  - Regulatory licenses are a serious impediment to launch if not received in a timely manner
  - Make friends with the FCC and NOAA (in the US) or appropriate international organizations
  - Don’t forget DoT and other transport regulations (IATA, etc). Batteries seem simple it can be a shock if they prevent you from transporting for integration and launch.



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