

The Core Flight System & The Space Industry Transformation



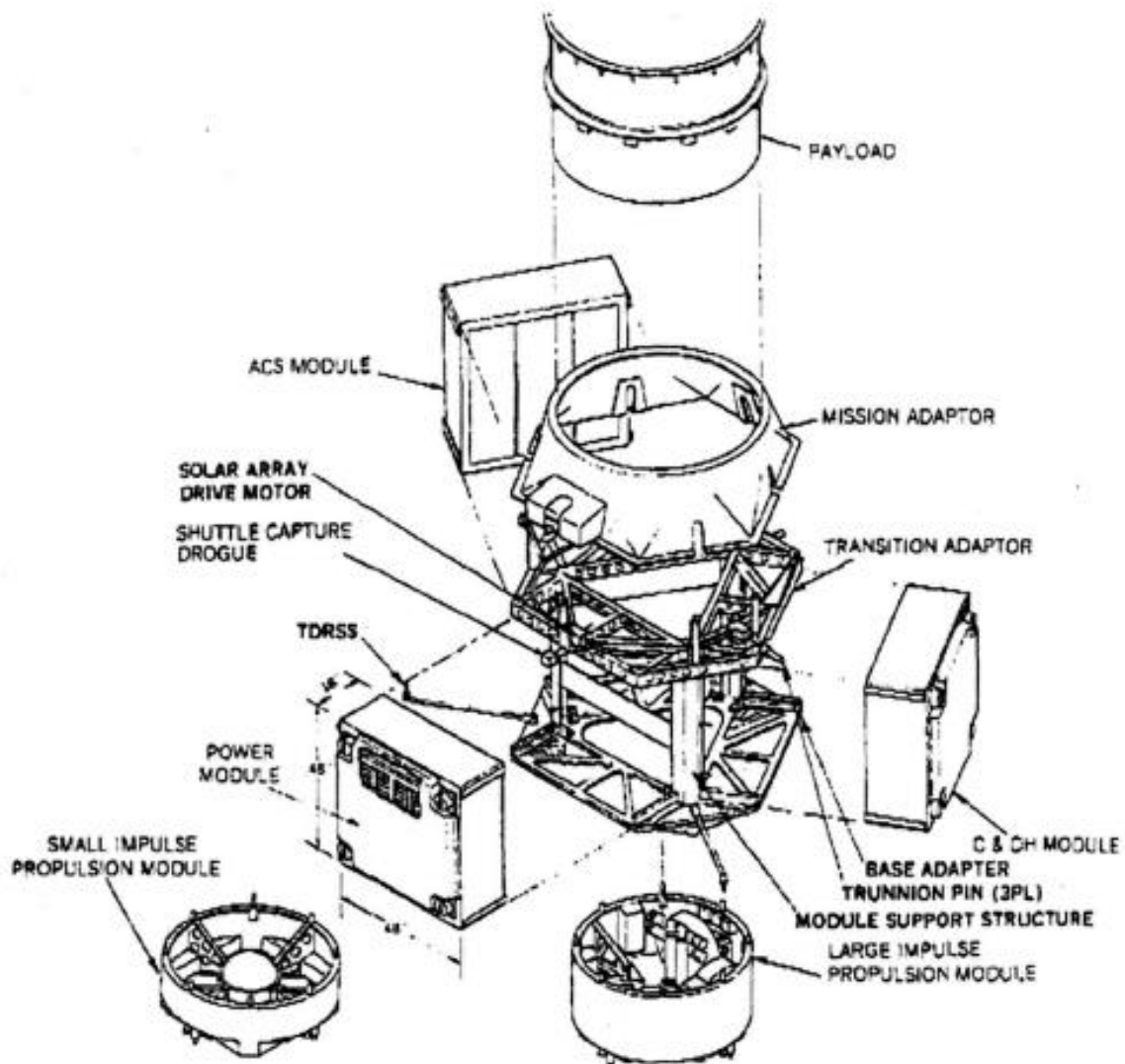
GRAA Luncheon

3/14/21

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Multi-mission Modular Spacecraft



1980 - Solar Max Mission

1982 - LandSat-4

1984 - LandSat-5

1991 - Upper Atmosphere Research Satellite

1992 - Extreme Ultraviolet Explorer

1992 - TOPEX/Poseidon

FIGURE 2. The Multi-mission Modular Spacecraft (Bartlett and Cepollina, 1975)

National Aeronautics and Space Act



- Promote technology development and contribute to national technology base
- Create science, technology, engineering, and mathematics (STEM) education opportunities

cFS Released as Open Source in 2015



CubeSat Growth

CubeSats Each Year by Mission Type (2074 missions)

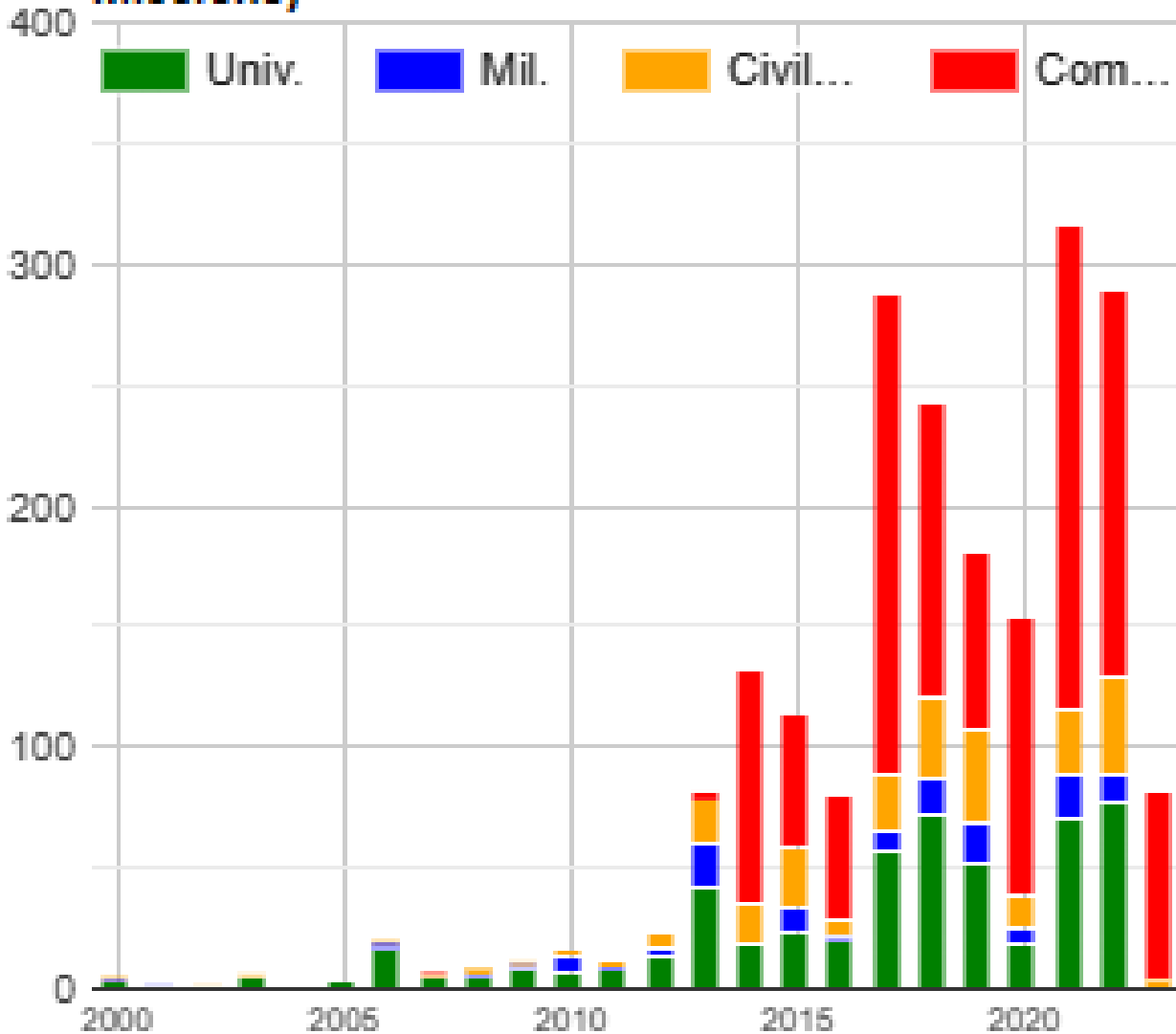
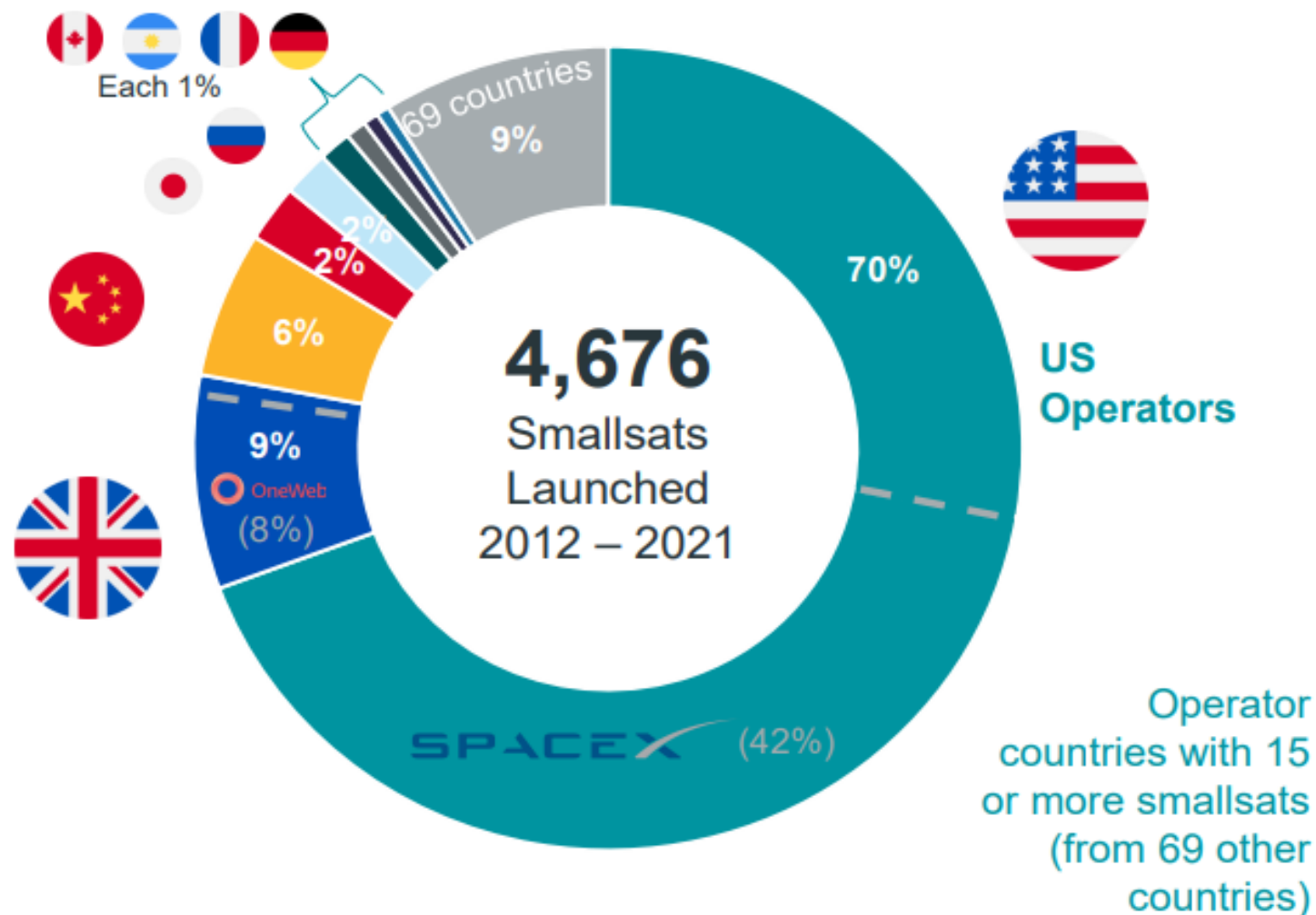


Chart created on Feb 18, 2023 using SLU Seradata...

- **Significant rise in CubeSat launches in the past decade**
- **Lower barrier to space**
 - Multiple space agencies have CubeSat launch initiatives
 - Universities (and lower) have access to space
- **Constellations as viable solutions**
 - Space communication infrastructure
 - Advanced science sensor webs

Smallsats 2012 – 2021, by Operator Country

Smallsats in Context and Operator/Mission Type Trends



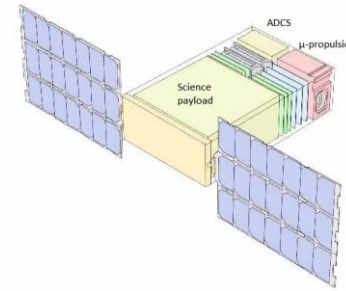
Operator Country	# of Smallsats
USA	3,241 (1,944 Starlink)
UK	421 (394 OneWeb)
China	274
Japan	107
Russia	85
Germany	60
Canada	38
Argentina	28
France	23
Australia	24
Italy	23
South Korea	21
India	21
Spain	19
Finland	18
Israel	17
Switzerland	15

Accessibility and Commercialization

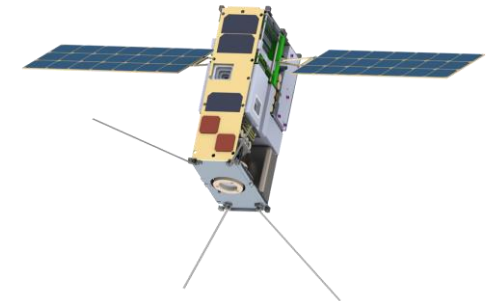
2009 Lunar Reconnaissance Orbiter



2022 Artemis 1 CubeSats



BioSentinel



Lunar IceCube

2023 Astrobotic Peregrine Lunar Lander



NASA Lunar Commercialization Programs

2014 Lunar CATALYST: Lunar Cargo Transportation and Landing by Soft Touchdown

- Astrobotic, Moon Express, Masten Space Systems
- All three contractors used the cFS

2019 – 2022 CLPS: Commercial Lunar Payload Services

- Astrobotic awarded two contracts totaling ~\$279 million
- Intuitive Machines awarded two contracts totaling ~\$122 million

Commercial Services



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STAY UP TO DATE

First Name	Last Name
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Space Industry Flight Software Skills Gap

2021 cFS workshop at Universidad Panamericana



- **Inspired me to start a nonprofit company called Open STEMware**
 - Uses cFS-based software and software/hardware projects for STEM education

Free online cFS projects and learning resources

