How a Non-Prime, Heritage Launch Vehicle & In-Space Hardware Company is addressing New Space
Who is Moog? & How did we get here?

- Founded in 1951 by Bill Moog
- Headquarters in East Aurora, NY
  - Over 300 Acre Facility
- Global Company
  - 25 Countries
- Over 10,500 Employees Worldwide
- $2.41 Billion in Revenue (FY 2016)
- Aerospace, Defense, Industrial
- Precision Control Systems Solutions and Component Provider
What industries are we in?...

- **Aircraft**: 44%
- **Components**: 20%
- **Space and Defense**: 15%
- **Industrial Systems**: 21%

As of 11/04/2016
What industries are we in?...Space & Defense

- Spacecraft: 26%
- Space Access and Integrated Systems: 22%
- Missile Systems: 22%
- Defense Control Systems: 14%
- Naval Systems: 6%
- Sensor and Surveillance Systems: 10%

FY 2016 Sales
$366.0M

As of 11/04/2016
What we do in Space?...Spacecraft Controls

- Chemical and Electric Propulsion Tech
- Attitude and Orbit Control
- System Design, Integration and Test
- Rocket Engines
- Valves, Regulators and Transducers
- Integrated Propulsion Modules
- Positioning Mechanisms
- Avionics
What we do in Space?...Access and Exploration

- Motion and Vibration Control
- Propulsion and Fluid Control
- System Design, Integration, and Test
- Structures and Payload Accommodation
- Avionics, Power and GNC
- Actuation Systems
- Valves & Integrated Propulsion Systems
What we do to support Civil market...
But we are seeing a sea change in the New Space market...

**Legacy Space Business**
- Customer buys components and integrates solution
- Custom, high-value and profitable components
- Long-term missions
- Funding sources limited to NASA / DOD

**New Space Business**
- Customer only cares about the end-use mission
- High volume, low-cost and low-margin hardware
- Extreme schedule pressure to satisfy investors
- Billionaires / VCs help launch 100s of new companies

*Launch Rates Increasing Spacecraft Qty. Increasing Size and cost Decreasing*
What is this doing to the commercial landscape?

Historical Report Data* - Commercial Revenue in $B

Data Source – Tauri Group, now Bryce Space Technology Satellite Industry Reports from various years
What are we doing about it?... Re-focus from the middle out

- **Complete systems and solutions**
- **Components**
- **Increasing degree of “complexity”**
- **Integration**
- **Compression**
- **Productization**

**Highly-integrated, high-margin, low-volume system-level solutions**

**Low-margin, high-volume “off-the-shelf” components**

**What are we doing about it?... Re-focus from the middle out**
Moog ShockWave – Flight Ready & Off The Shelf

- Low cost COTS vibration isolation for Cubesats
  - Based on 2 decades of flight isolation experience
  - Short lead times (8 weeks max)
  - Modular (mix and match for performance)
  - Straight forward integration (interfaces with current ICDs)

- Provide launch assurance for sensitive payloads

- Can provide up to an order of magnitude reduction in random vibration loads

FY18 U.S. Commercial Pricing

<table>
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<tr>
<th>Isolator Quantity</th>
<th>Price per Unit</th>
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Moog Orbital Maneuvering Vehicle (OMV)

- OMV provides capability (even on multi-payload launch) to put small satellites in optimal orbit (rather than 'opportunity orbit') to maximize value

- **OMV can facilitate and/or directly support small satellite missions as part of the platform**

- Mission/spacecraft design can be streamlined through elimination and/or simplification of on-board propulsion

OMV is about getting LEO constellations operational and generating revenue rapidly and for low cost
The Focused, Fast, and Flexible (F³) model is working…

- Implemented a ‘site w/in a site’ development & low rate production operation
  - Established a small dedicated team
  - Co-located personnel w/ receiving inspection, stockroom, A&T
  - Building new processes & procedures

- Currently executing contracts w/ several ‘New Space’ companies
  - Customer feedback has been positive
  - Realizing ‘compression’ out of the gate

- Dedicated large scale production cells will be implemented as products mature closer to production

Successful New Space Products
Wrap Up…

- We have built a NEW operation for complete life cycle
  - Utilized a clean sheet, only adding overhead and requirements as needed

- Diligently balancing the strengths and weaknesses of our heritage business(es)

- Applying a **3-Phase Model**
  1. Early engagement on a system and/or mission level for collaborative identification of solutions
  2. Focused, fast and flexible development of productized components & co-development of more integrated system solutions
  3. Preparation for high(er) rate production

- Enabling the ‘compression’ through ‘productization’ and ‘integration’

Moog’s New Space Group is aimed at being an agile and collaborative partner for launch, exploration, and small satellite / constellation based ventures
Remember how it started…

**1951 - Company Beginnings**

Bill Moog starts the Little Gem Valve Company as a basement operation

First Order $800 for the Bumblebee Missile
QUESTIONS