LEIDEN, NETHERLANDS - DECEMBER 2015

THE FUTURE OF ISS UTILIZATION: AN INDUSTRY PERSPECTIVE

NANORACKS

BLUE ORIGIN

AIRBUS DEFENCE & SPACE

#FUTUREISS

NEW SHEPARD SUBORBITAL RESEARCH FLIGHTS

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NanoRacks Leiden Workshop
December 7, 2015

BLUE ORIGIN

NOVEMBER 23, 2015

BLUE ORIGIN

BLUE ORIGIN OVERVIEW

- Blue Origin has a long-term vision of increasing the number of people that can fly to space
- Blue Origin was founded by Jeff Bezos, Founder and CEO of Amazon.com
- Focus on developing vehicles and technologies to lower cost and increase safety
- Suborbital *New Shepard* vehicle first test flight in April 2015, with first 100 km flight and recovery Nov. 2015
- Orbital vehicle planned for later this decade
- *New Shepard* flight test program includes untended research and education payloads
  - Standard units up to 50 lbm (22.7 kg)
  - Power, command, and data interfaces provided
  - Benchtop development units

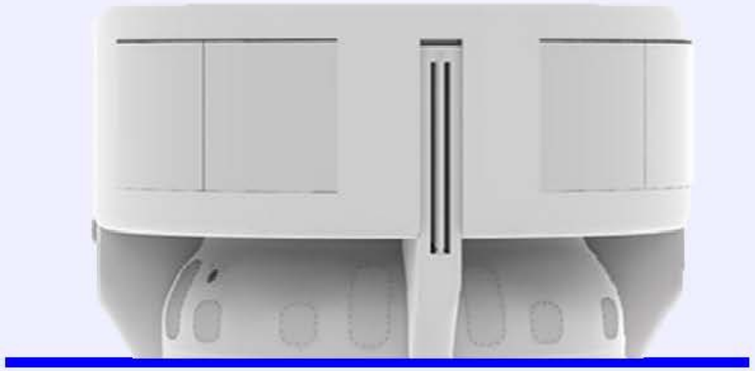
ASTRONAUT EXPERIENCE

Capsule

- Up to six astronauts
  - Multiple capsule configurations
- Largest windows in spaceflight history
- Full-envelope escape system

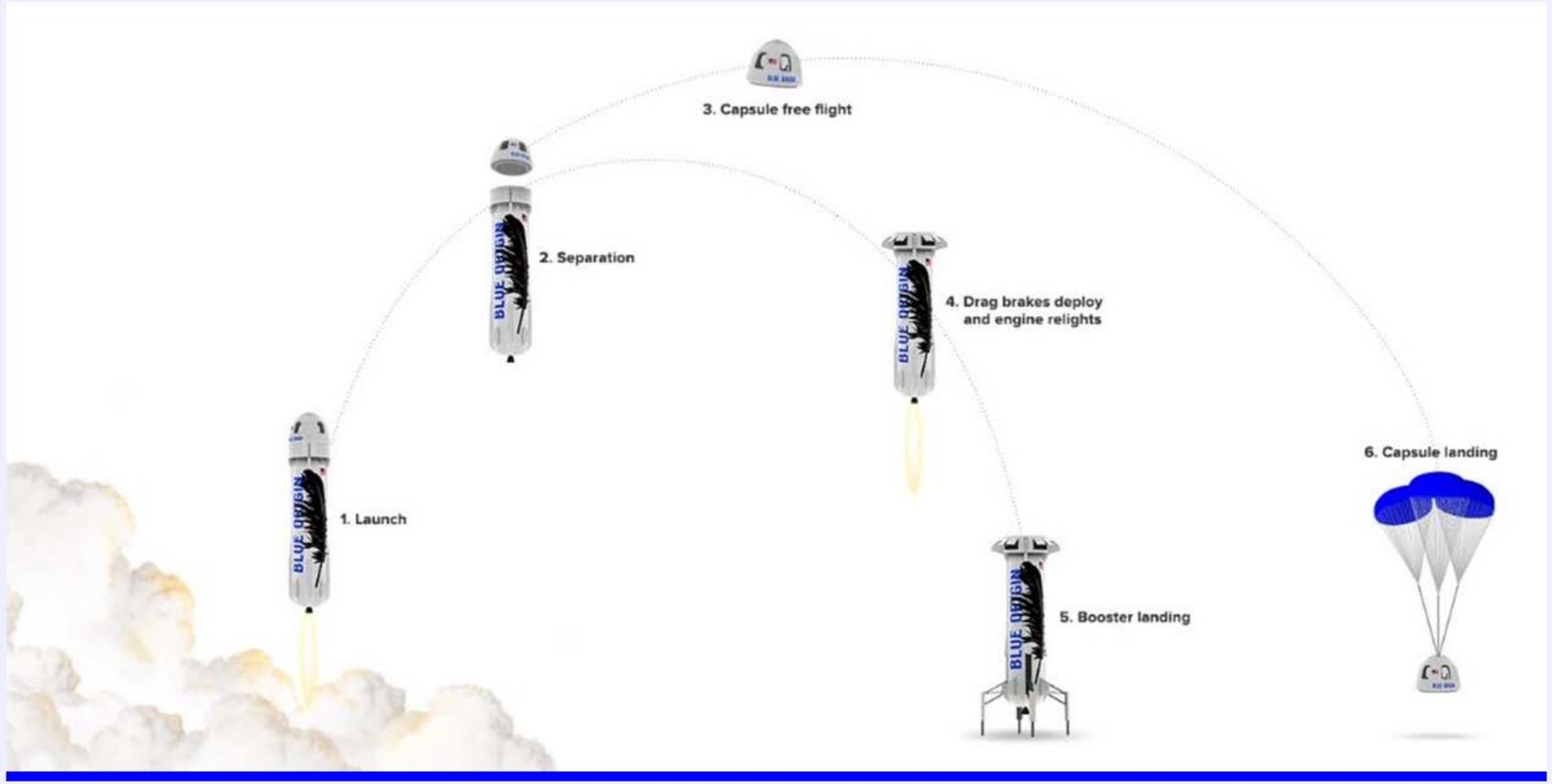
Flight

- 11 min for complete flight
- Flight over 100 km
- Weightlessness for approximately 4 min



NEW SHEPARD SUBORBITAL SYSTEM

Capsule separates from booster and lands classically under three parachutes with a cushioning retro-thrust system



HISTORIC ROCKET LANDING – NOV 23, 2015

329,839 ft
(100.5 km)

Mach 3.7

Flawless BE-3
Performance

Clean
Separation

Booster
Landing
on Pad

Smooth
Capsule
Touchdown

BLUE ORIGIN

SUBORBITAL RESEARCH CAPABILITIES

Initial Capabilities

- 100 km apogee
- ~3 mins of milli-g accelerations
- Blue Origin Payload System or custom interface
- Nominal access L-2 hrs and R+4 to 8 hrs
- Sales and integration with NanoRacks

Future Capabilities

- Up to six astronauts and/or payload stacks
- Access to large windows
- Payload access L-30 mins and R+20 mins
- Additional possibilities as demand grows:
  - External mounting and deployment
  - Science-quality window inserts
  - Capsule replacement payloads

HARDWARE & MECHANICAL INTERFACES

Payload Lockers

- Similar to middeck locker in size
  - Single and double height variants
- Payload weight limit:
  - 25 lbs (11.3 kg) for single locker
  - 50 lbs (22.7 kg) for double locker
- Custom solutions available

Payload Support

- Payload Controllers provide power, command and data handling to four distinct payloads per stack
- Full-system checkout capability at user's lab

AVIONICS MADE EASY

- Streamlined DAQ and computing solution already approved for flight
- Customized with modules and software for measurement, signal conditioning, control, and communication
  - 4 analog inputs
  - 3 digital I/O channels
  - 2 PWM outputs, up to 10 kHz
  - 1 RS-232 channel
  - 2 GigE Ethernet channels
  - 6 RTD inputs, 100 ohm
  - 32 GB storage plus video
  - >200 Hz logging for all channel types
- HD cameras and selection of lenses
  - 32 GB SD storage per camera

UEIPAC 600-1G

SUBORBITAL AS A PIPELINE TO ORBIT

- Perfect for new users, risk reduction, and fast iteration
  - From concept to flight in weeks to months
  - Lower cost
  - Commercially friendly
  - Fewer hardware constraints
  - Frequent reflights available




LIFE SCIENCE STRENGTHS

- Pre-flight access within 1 hour of launch
- Post-flight access as early as 20 minutes after landing
- Ideal for:
  - Short time constant systems, e.g., vestibular, lung deposition
  - Unique access to g-transition for -omics studies and basic mechanisms
  - Large N studies of model organisms and diverse humans
  - Studies precluded by NASA human flight safety constraints
  - Hardware “shakedown” demos of microgravity functionality
  - Validating experimental environments, e.g., bioreactors

PHYSICAL SCIENCE STRENGTHS

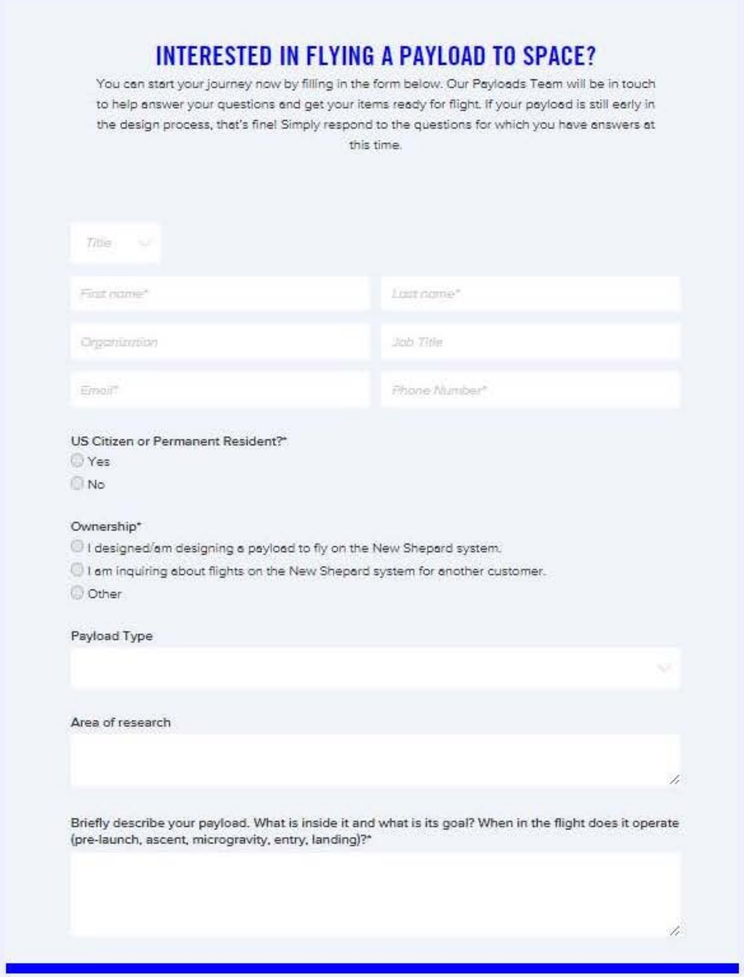
- Clean acceleration environments (on the order of milli-g's) for 3-4 minutes
- Ideal for:
  - Fluid physics, e.g., multi-phase dynamics, interfacial phenomena
  - Early stage materials science, e.g., crystal initiation, colloidal distribution
  - Combustion physics across a wide range of substrates
  - Industrial processes scalable to a dozen or more flights per year
  - Studies precluded by NASA human flight safety constraints
  - Hardware "shakedown" demos of microgravity functionality

AEROSPACE APPLICATION STRENGTHS

- Largest windows in the industry
- Frequent access to mesosphere (60-100 km)
- Future plans for external mounting/sampling
- Ideal for:
  - Sensor and component validation in flight environments
  - Deployable structures
  - Entry, descent, and landing technologies
  - Propellant slosh, transfer, and other fluid dynamics demonstrations

FOUR STEPS TO FLIGHT

1. Web Form
   - Identifies goals and scope for integration
2. Payload Data Package
   - Evaluate compatibility of proposed payloads with standard Blue Origin interfaces
   - Used to fill out the Interface Control Document (ICD) – a contract for ensuring compatibility between Crew Capsule and the developing experiment
3. Payload Safety Package
   - Evaluate potential hazards and risk mitigations necessary for payloads to attain flight clearance
4. Launch Site Integration Package
   - Ensure both the payload team and Blue Origin understand the level of facility support, Crew Capsule access, supplies, and flight timeline while at the launch site



INTERESTED IN FLYING A PAYLOAD TO SPACE?

You can start your journey now by filling in the form below. Our Payloads Team will be in touch to help answer your questions and get your items ready for flight. If your payload is still early in the design process, that's fine! Simply respond to the questions for which you have answers at this time.

Title

First name* | Last name*

Organization | Job Title

Email* | Phone Number*

US Citizen or Permanent Resident?*
- Yes
- No

Ownership*
- I designed/am designing a payload to fly on the New Shepard system.
- I am inquiring about flights on the New Shepard system for another customer.
- Other

Payload Type

Area of research

Briefly describe your payload. What is inside it and what is its goal? When in the flight does it operate (pre-launch, ascent, microgravity, entry, landing)?*

WEST TEXAS LAUNCH SITE

Location

- About 2 hours east of El Paso
- Teams generally stay south of the launch site in the town of Van Horn (numerous hotel options)

Payload Processing Facility

- Provides storage, staging, and post-mission processing of experiments
  - Amenities: Work space, phone, internet, power, tables and chairs, sink, refrigerator, soldering station
  - Safety: Chemical storage locker, fume hood, PPE, first aid
  - Other tools: Suggest bringing your standard toolset

SUMMARY

Flights have begun

- Blue Origin has entered flight test, and we look forward to carrying research and education payloads beginning early next year.

Easy to use

- Benchtop units with command and data capabilities allow you to rapidly move from concept to flight.

Customization available

- From single payloads to fully custom capsules, we are open to optimizing our interfaces to meet your needs.

BLUE ORIGIN

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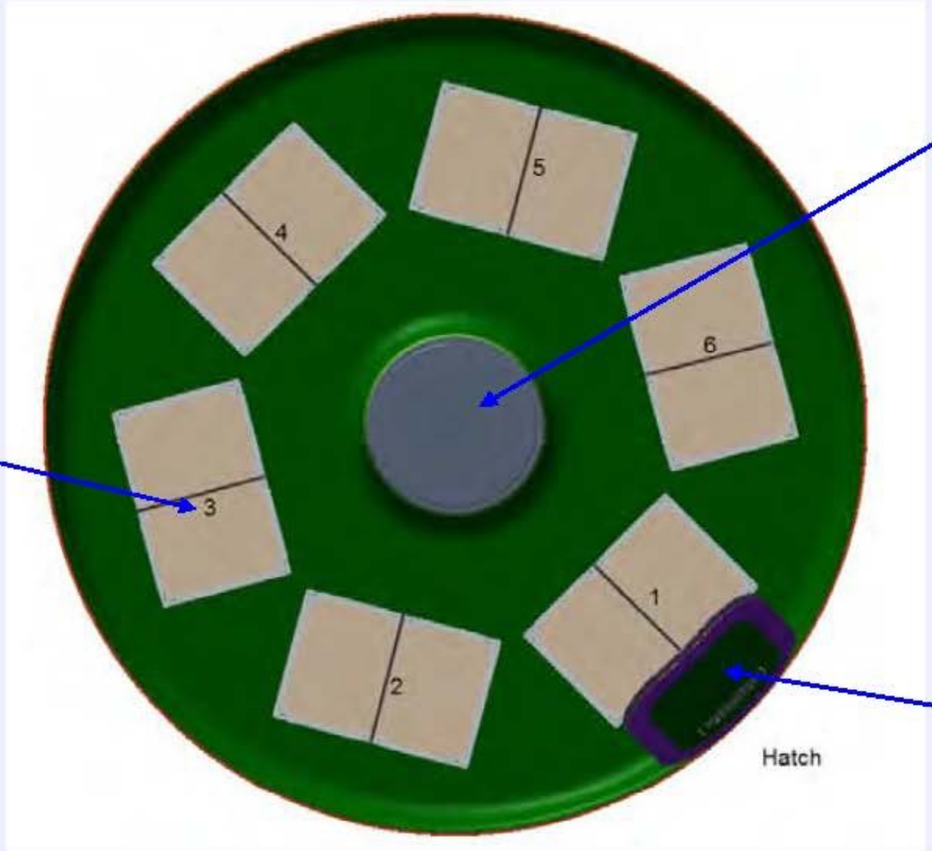
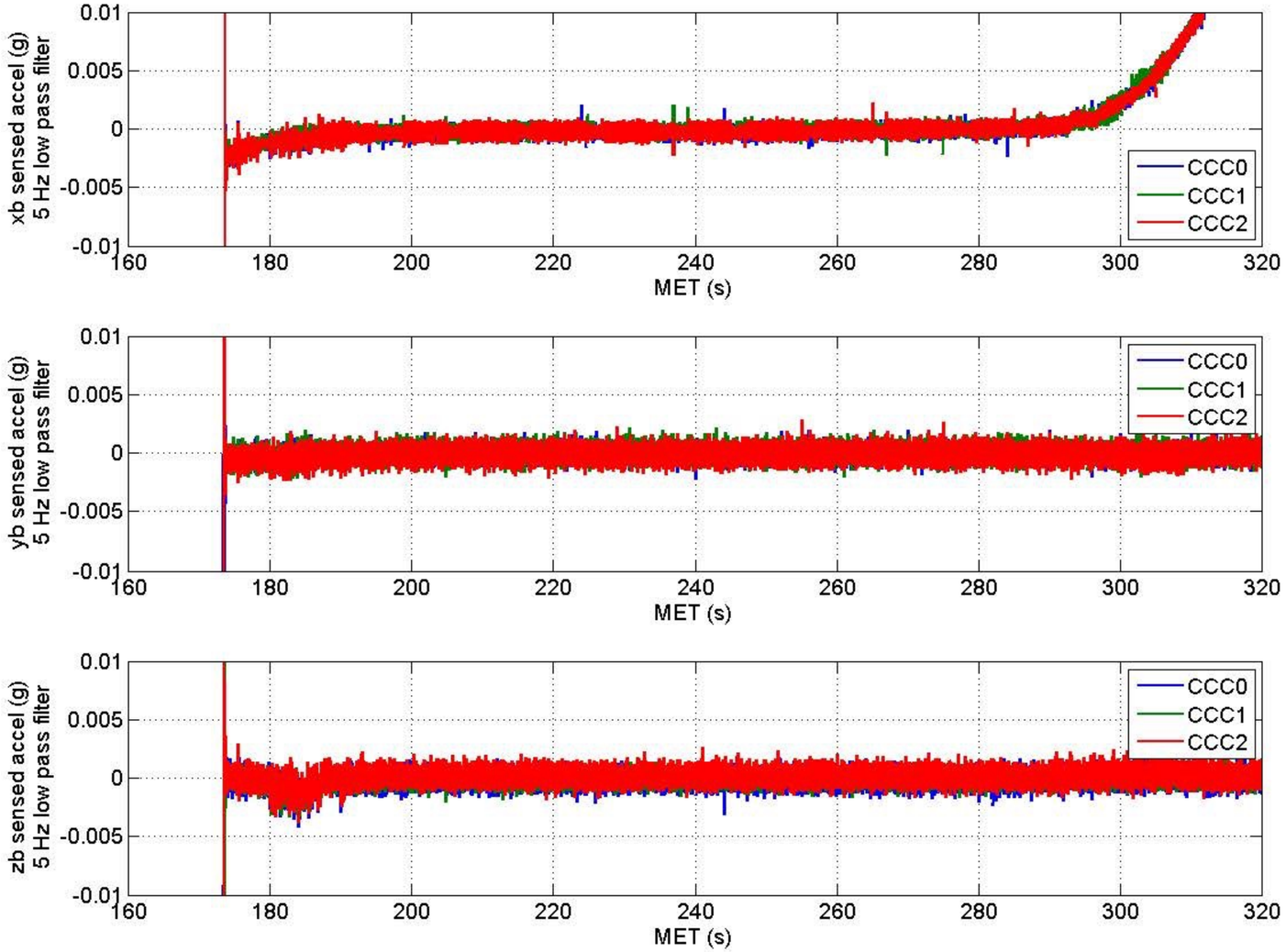
CURRENT CAPSULE INTERIOR



QUIET ACCELERATION ENVIRONMENT



BLUE ORIGIN

KEY VALUE PROPOSITIONS

1. **Pipeline to orbit:** easy first step to space for TRL-raising, preliminary data collection, and hardware shakedown
2. **Scalable profits:** commercial access offers entrepreneurs the ability to significantly expand industrial processes, in-space manufacturing, or other value streams
3. **Marketing:** access for brands looking to associate with space without the hurdles associated with a federal platform
4. **Right-sized research and education**: for users needing more than a parabolic flight can offer, but less than ISS, we can offer access in weeks to months rather than months to years, and much streamlined processes

VERTICAL LANDING

RING FIN

Upon reentry, airflow through the ring fin shifts the center of pressure

WEDGE FINS & DRAG BRAKES

Wedge-shaped fins enhance aerodynamic stability and drag brakes reduce speed by half

AFT FINS

Guide booster over the pad from altitude

ENGINE RESTART

BE-3 engine throttles down to low power to reduce descent rate to 5 mph for landing

LANDING GEAR

Landing gear deploy to cushion landing

NEXT STEP: ORBITAL

- First launch later this decade
- Reusable first stage with vertical landing
- Expendable upper stage
- Powered by Blue Origin BE-4 and BE-3U engines
- Launch from LC-36 in Florida

PRE-FLIGHT CONOPS

- Early: Team ships hardware to launch site
- L-3 Day
  - Site briefing by Payload Integration Manager
  - Unpack and assemble experiments
  - Full system check in Payload Staging Facility with Flight Avionics modules
  - Troubleshooting

- L-2 Day
  - Standard payloads installed in Crew Capsule
  - Conduct last functional check
  - Horizontal mating of capsule to booster
- L-1 Day
  - Final preparations for late load payloads
  - Pre-flight briefing

FLIGHT AND POST-FLIGHT CONOPS

- L-0 Launch Day
  - Late load payloads installed on launch pad
    - Last payload access currently ~2 hours prior to launch
    - Working towards secondary window at ~30 minutes prior to launch
  - Research teams located in viewing area during launch
  - Upon request, payload access available ~20 minutes after Capsule safing; otherwise, payload access and data retrieval expected within 8 hours of Capsule return to Vehicle Processing Facility
  - Post-flight review
- L+1 and L+2 Days
  - Disassemble experiment and prepare for shipping
  - Depart launch site