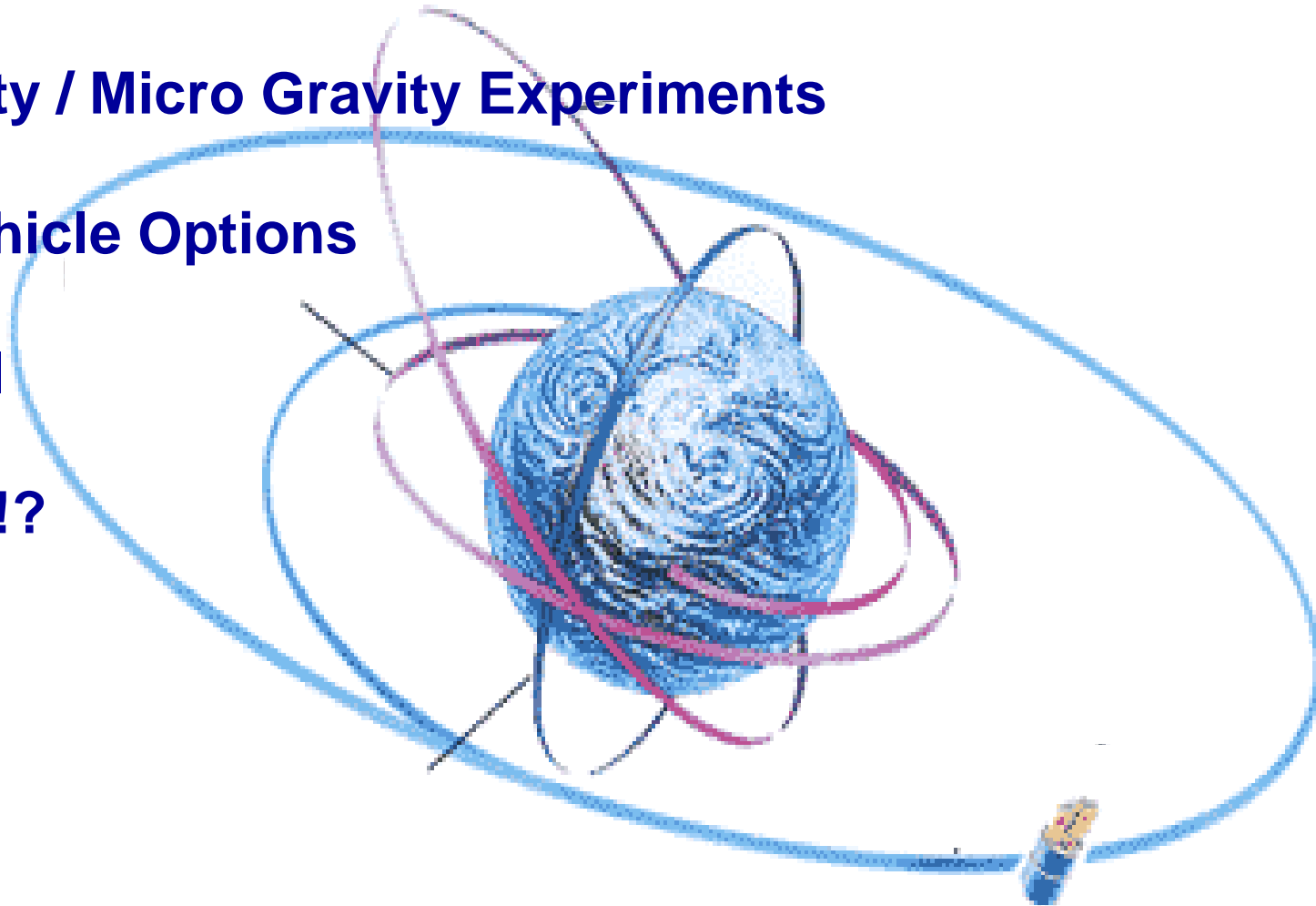


Summer of Innovation Thoughts

Doc Aguilar

AFRL/Space Vehicles Directorate

- Traditional Middle School Space Experiments
- Zero Gravity / Micro Gravity Experiments
- Launch Vehicle Options
- Sub-orbital
- Orbital ?!?!?





Traditional Space Experiments for Middle School

- Temperature
- Pressure
 - Correlate to altitude
- Acceleration
 - Calculus ? (Velocity, Position)
- Radiation
 - Dosimetry
 - Geomagnetic field, altitude & solar cycle
- Can be achieved even on spin-stabilized rocket



Zero Gravity / Micro Gravity Experiments

- Require non-spinning launch vehicle
- Traditional experiments can also be accomplished







Middle School Zero-gravity Experiment Topics

Steven H. Collicott, Ph.D.

steven@collicott.com

History



Acting as faculty advisor, Dr. Collicott has led 28 Purdue student zero-gravity experiment teams in the *NASA Reduced Gravity Student Flight Opportunity Program*. His teams perform many K-12 outreach efforts.

Dr. Collicott has launched with Armadillo and has agreements for future launches with Armadillo, Blue Origin, and Masten Space Systems.

Dr. Collicott's experiments in his first drop tower at Purdue led to the highly successful Vane-Gap experiments in the International Space Station. His new, larger drop tower will be operational this winter.

He has been on the Purdue faculty for 20 years after earning his MS and PhD at Stanford University. He serves on the *Sub-Orbital Applications Researcher Group* of the *Commercial Spaceflight Federation*.

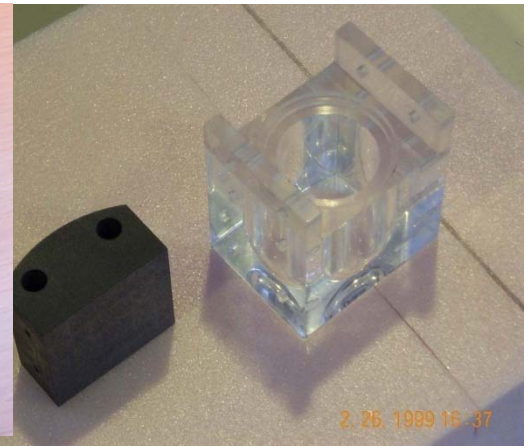
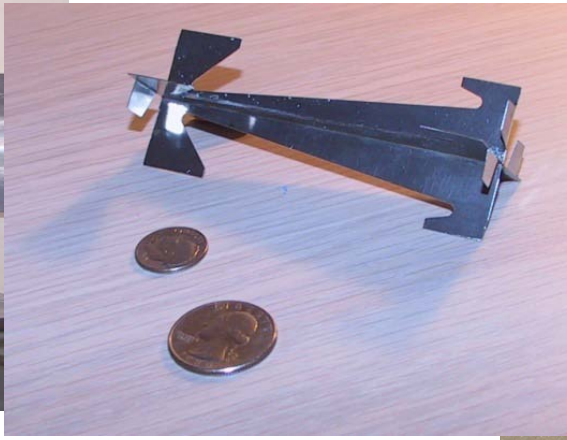
He has been inducted into Purdue's *Book of Great Teachers*, has won the prestigious *NSF Career Award*, and is an Associate Fellow of the *American Institute of Aeronautics and Astronautics*.

He has chaired a *NASA Science Concept Review* panel for a multi-million dollar space station experiment program.

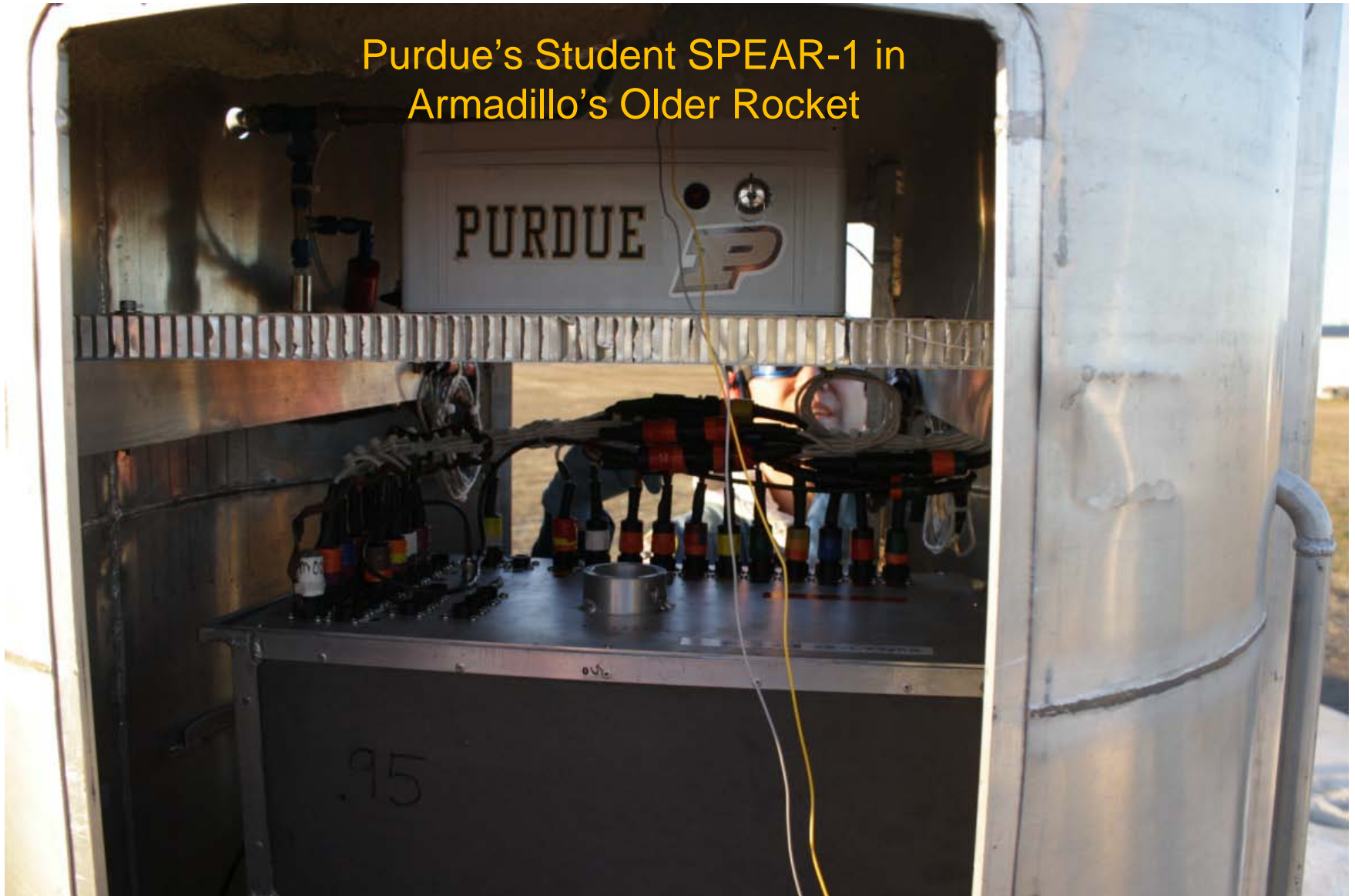
Dr. Collicott has trained as a Sub-Orbital Scientist in preparation for research in the new commercial sub-orbital spaceflight industry.

His company has delivered on numerous industrial zero-gravity fluids tasks for \$200M commercial satellites and high-profile science missions since 1997.


Dr. Collicott's Leadership of Purdue Student Zero-G Activities



Purdue's Student SPEAR-1 in
Armadillo's Older Rocket



Topic Examples

- 
- **Build on a visible event present in everyday life**
 - **Capillary action (ie. Soda wicks $\frac{1}{4}$ inch up a drinking straw)**
 - **Weak on Earth but dominates other forces in 0-g**
 - **Numerous “tricks” to illustrate different fluid positioning or motion in 0-g**
 - **Stimulate student thinking about the effect of gravity**
 - **Broaden thinking about everyday physics**
 - **Fields of mechanics and dynamics also provide other options**
 - **Digital video data is acquired in each case... most captivating format for students**
 - **Most experiments available fully assembled or as kits**

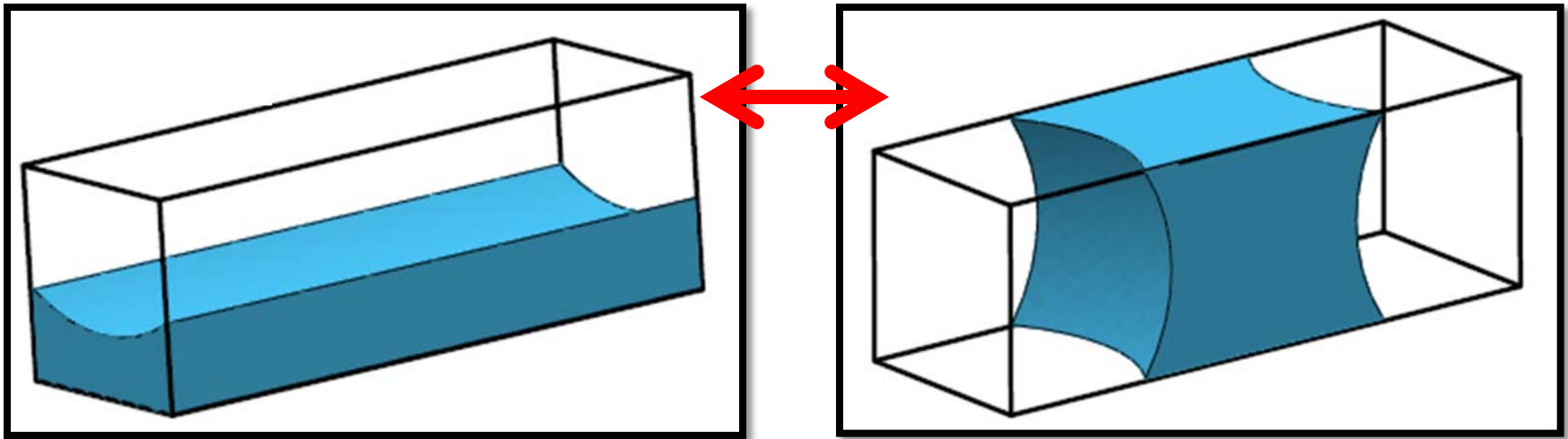
Passive Fluids Experiments



- No moving parts
- Use change in acceleration from 1-g into 0-g to create a change in liquid positioning
- IE. Puddle in bottom of pipe becomes a plug in 0-g that changes back to a puddle on re-entry
- Many variations
- Typically 3 tests in each experiment
- Each experiment's combinations of geometry and condition will be unique
- 1-g analogs for table-top demonstrations, computational results, lesson plans, and teaching materials are available to aid in education

Passive Fluid Experiment Example

Liquid changes from puddle to plug and back during the mission. Identical containers and volumes with differing viscosity liquids can show fast and slow transitions. Energy, friction, motion, acceleration, and conservation of mass are introduced to students.



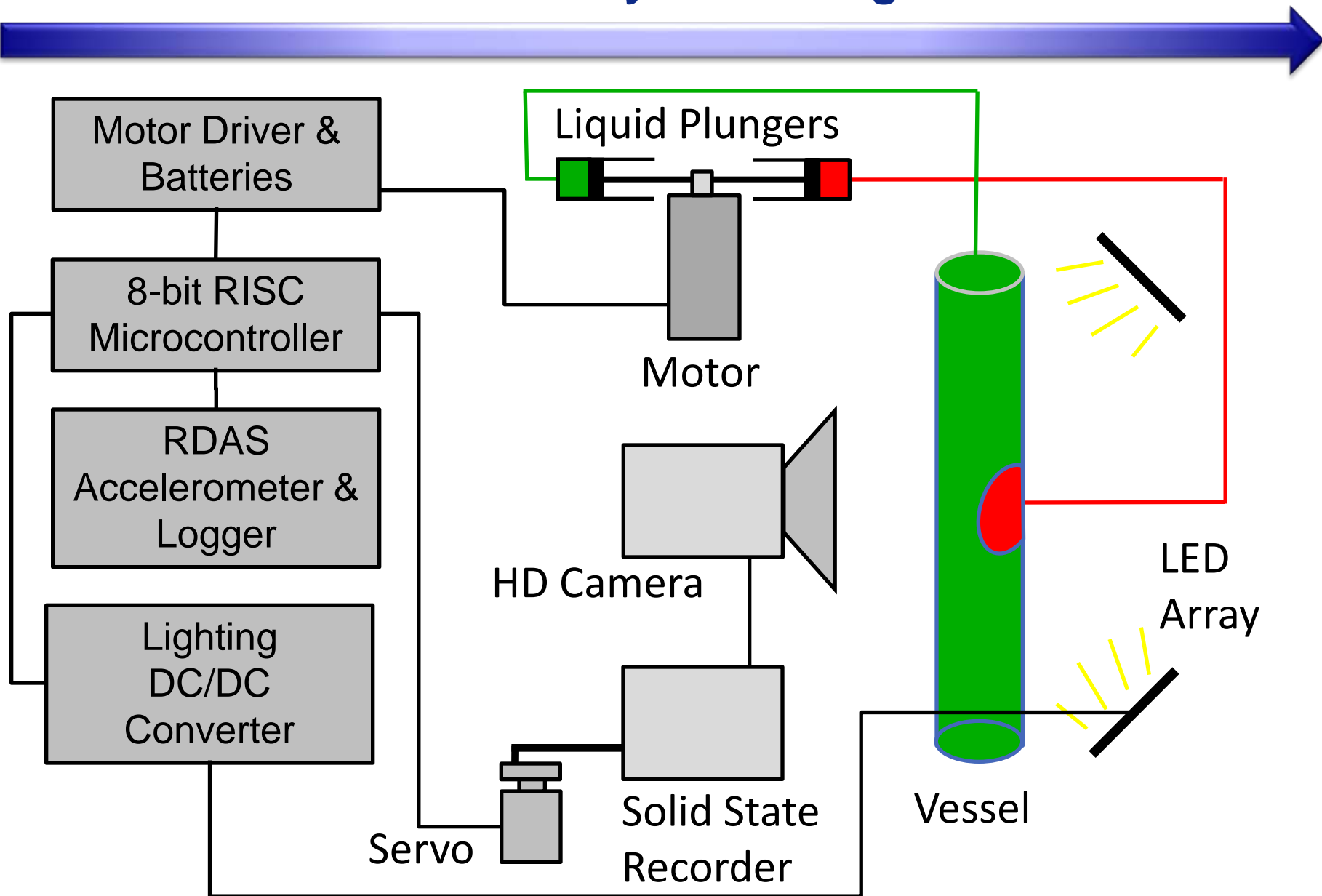
The onset of aerodynamic drag during re-entry may also be observed.

Active Capillary Experiments

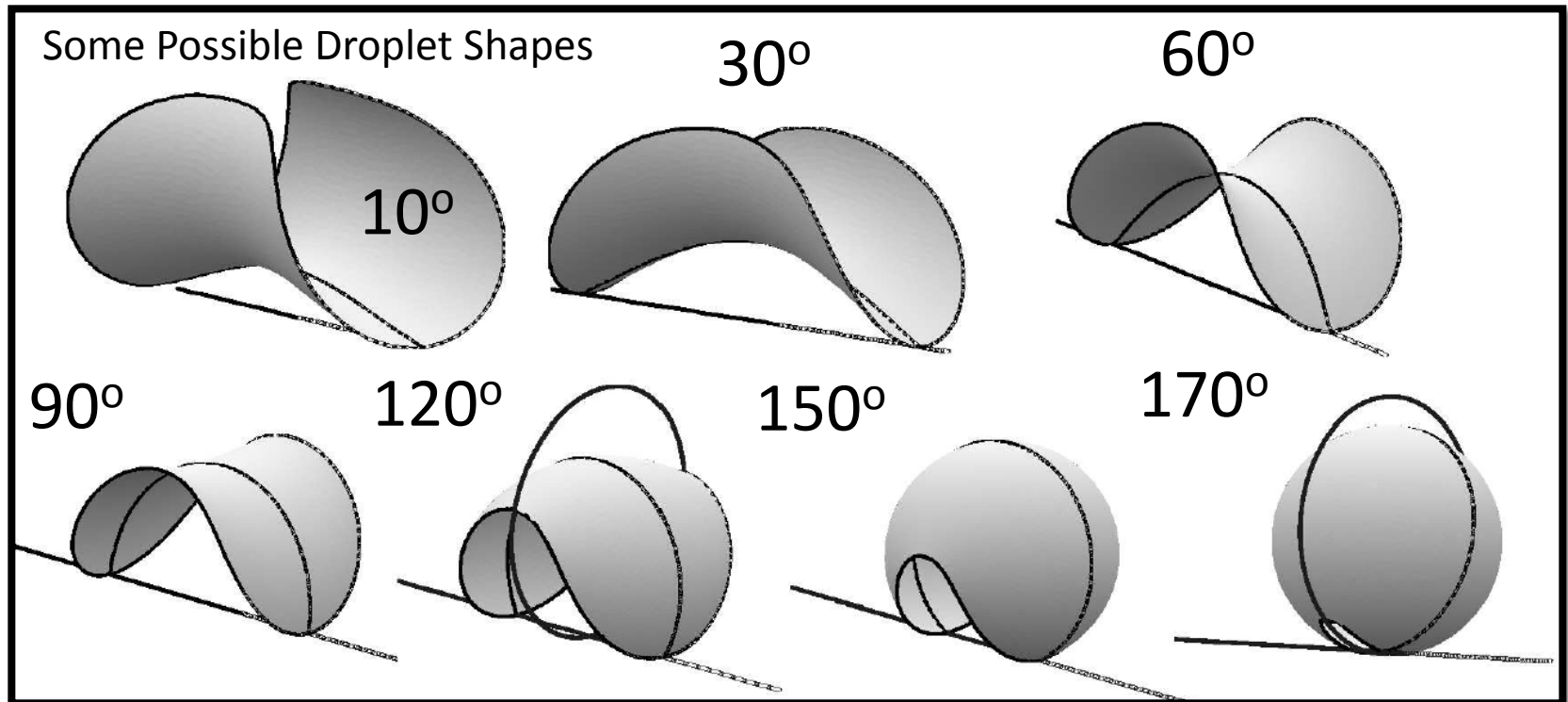
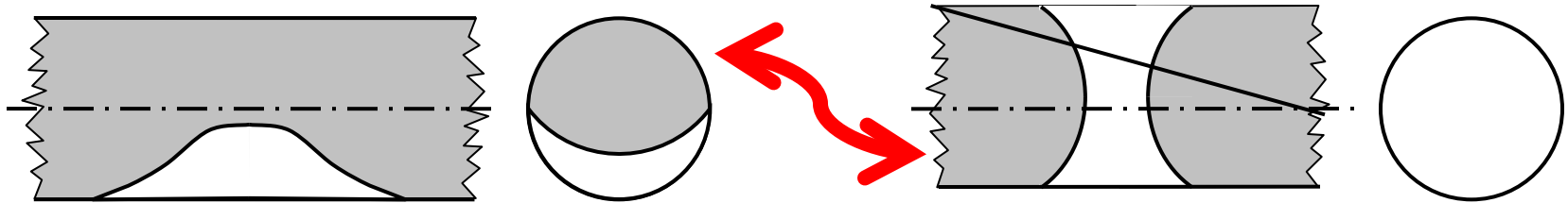


- **More complex than the passive fluids experiments**
 - **Adds expense & risk**
 - **One or more liquid volumes are injected into container**
- or**
- **Container geometry is changed while in 0-g**
 - **Allows for more experiment options**
 - **Can replicate some orbital experiments!**

Active Fluids Experiment: Purdue & Armadillo SPEAR-1 System Design



Active Fluid Experiments – Droplet, plug, annulus, etc. formation based on geometry, liquid volume, and contact angle of liquid on the solid wall. Wide variety of container shapes



Mechanics and Dynamics Experiments



- **Not liquid experiments rather but solids in motion**
- **Use springs, magnets, electro-magnets, pendulums, etc**
- **Video record show students how their table-top device functions differently in 0-g.**
- **Stimulates thinking about the action of gravity in everyday life**
- **May be more ideal than fluids experiments for the youngest students**

Common Items



- **Digital video**
- **Cool, low-power illumination for video**
- **Experiment triggers**
 - **Sense beginning of the weightless period or launch, depending on experiment.**
- **Designed for long hold times on the pad**
- **Liquids**
- **Low-voltage battery**
- **Entirely self-contained**

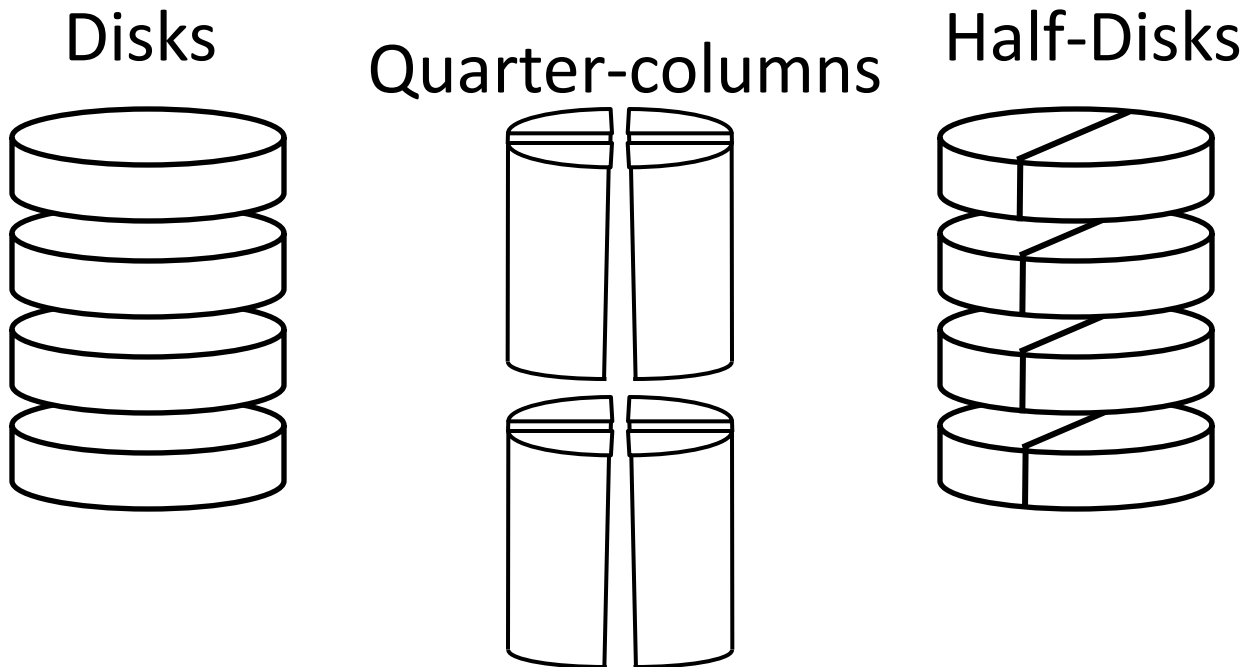
Kits



- **Ready-to assemble experiments**
- **Ready made experiments**
- **Teacher works with one supplier, not dozens**
- **Supplier provides custom circuit assembly and testing**
- **Custom-machined hardware**
- **Students & teacher follow instructions for assembly and testing**
- **Included are lessons in sealing, fastening, measuring, technical communications, testing, etc.**
- **Email and phone advice available**

Container Geometry

- **Container geometry and G-loads must be determined ASAP to minimize risk and cost**



Clinics

- **Dr. Collicott is available for pre-launch assembly or launch-prep clinics**
- **Travel must be funded by the host**



Pricing

- **First must know:**
 - **Payload size & mass**
 - **Flight, boost, re-entry, and landing loads**
- **Must decide on launch vehicle**



Launch Vehicles

- Up Aerospace
- Armadillo
- Masten
- InterOrbital



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