Hot Science Cool Talks

UT Environmental Science Institute

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Space Exploration: From Science Fiction to the Texas Spacecraft Laboratory

Dr. Glenn Lightsey

March 1, 2014

Texas Spacecraft Laboratory

Space Exploration: From Science Fiction to the Texas Spacecraft Lab

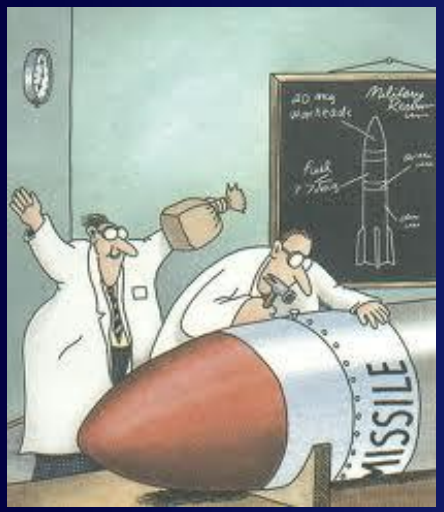
E. Glenn Lightsey

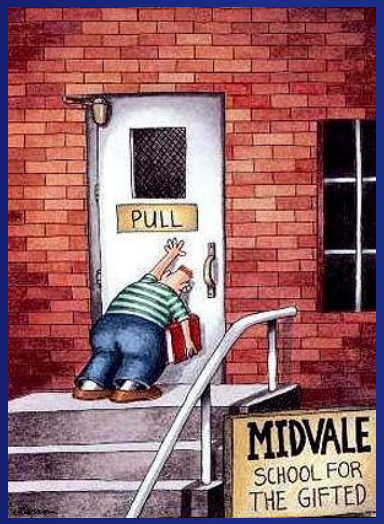
Professor

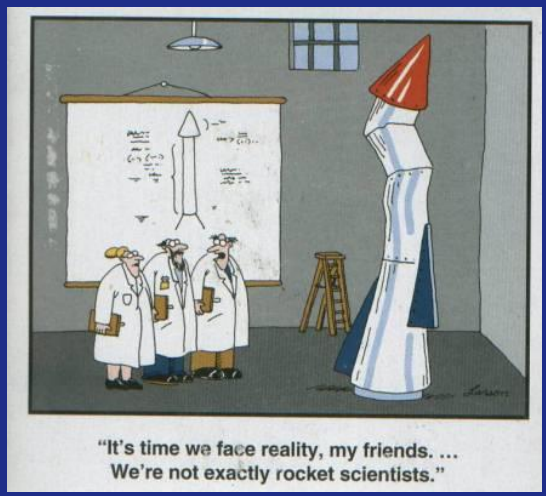
Dept. of Aerospace Engineering and Engineering Mechanics

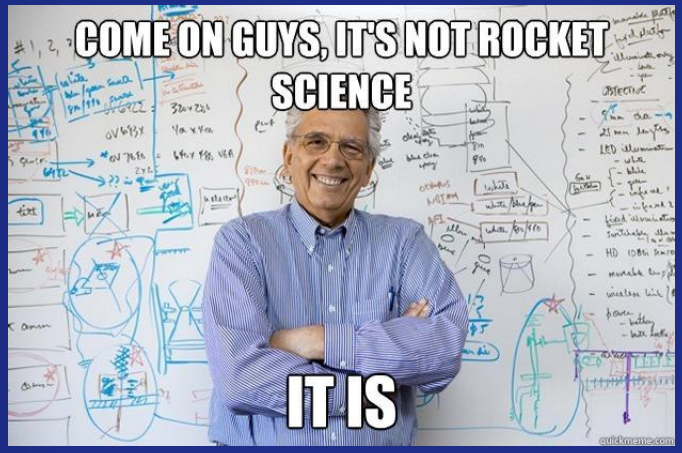
March 1, 2014

Yes, This Is Rocket Science!









Images: G. Larson, Big Bang Theory, internet meme

Images I Watched Growing Up

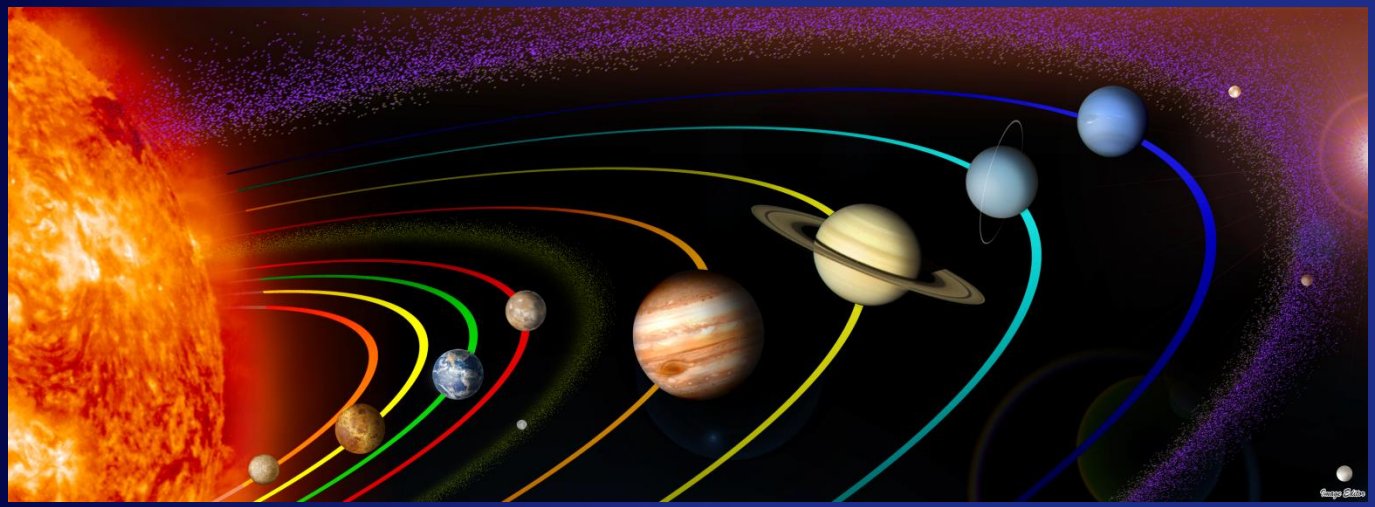
Space Images Today
You May Have Seen

Today's Talk

- Space Myths
  - Some interesting facts about space
- Are We There Yet?
  - Some basic information about space travel
- The Texas Spacecraft Lab
  - A description of my research lab and the projects my students and I are working on

Space Myths

- Myth #1: “The Earth orbits around the…”
  - 25% of Americans could not correctly answer this question in a 2013 survey
- *All of the planets in our solar system orbit the Sun.*

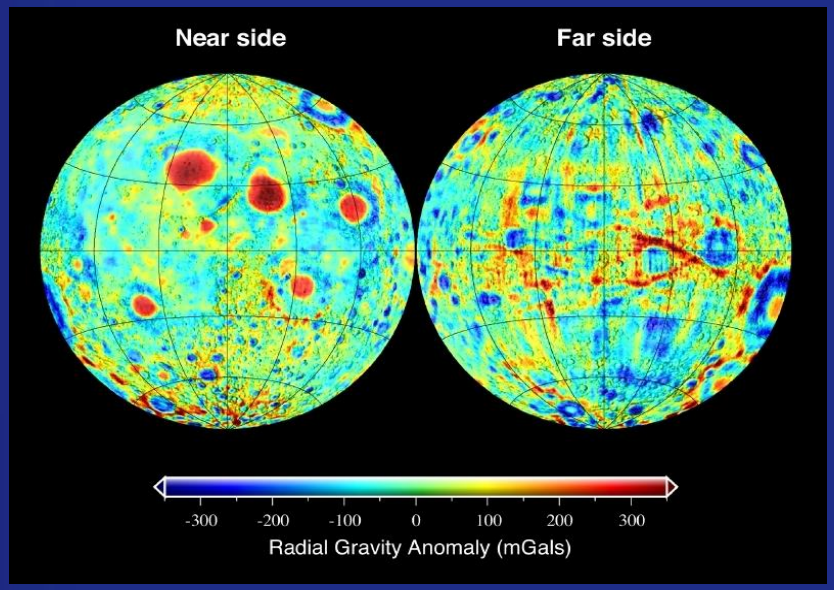


Flickr: Image Editor, for SciTech Lab blog post

Space Myths

- Myth #2: “There is no gravity in space.”
- *All objects have mass and gravity, even in space.*

Wikipedia: STS-129 and Expedition 21 crew members shortly after Atlantis and the ISS docked.

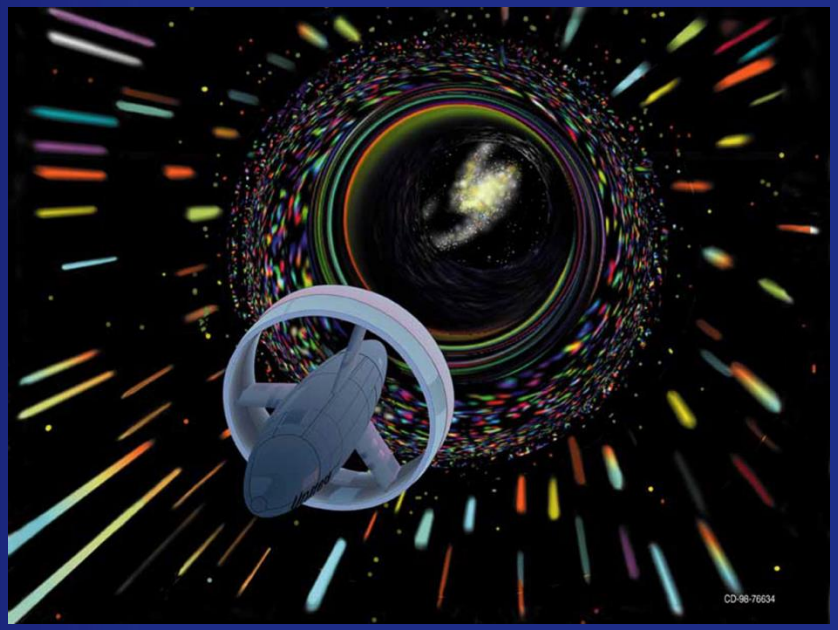


Wikipedia: Gravitation of the Moon

Space Myths

- Myth #3: “Faster Than Light travel is possible.”
- *FTL travel breaks physics as we understand it today.*

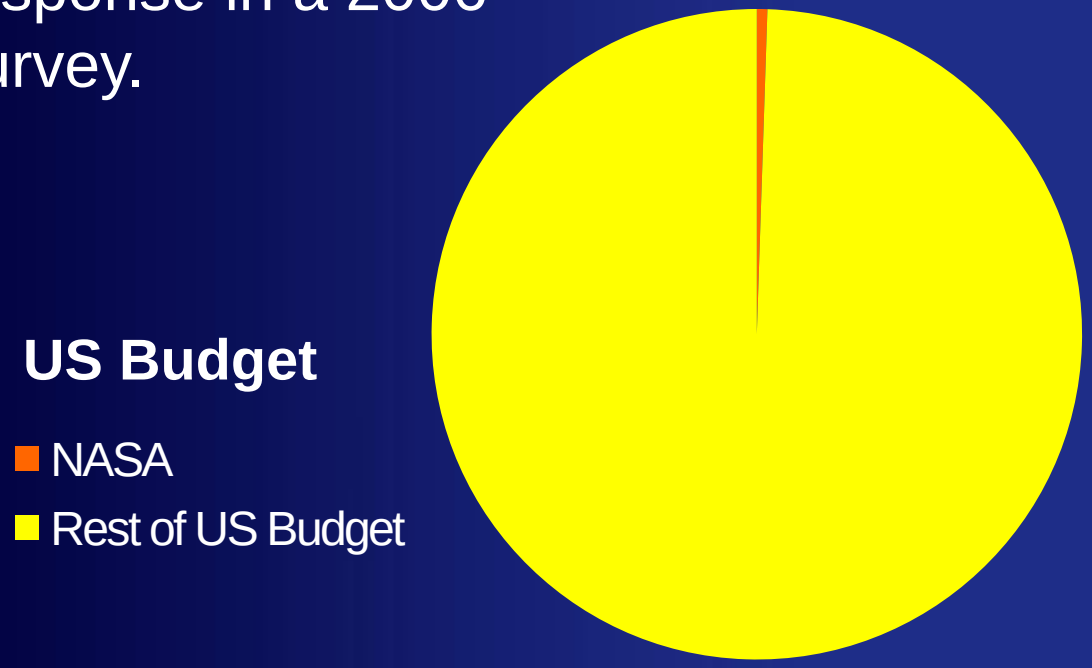
Wikipedia: Faster Than Light



Wikipedia: Interstellar travel

Space Myths

- Myth #4: “NASA consumes 25% of the US Budget.”
  - Most common response in a 2006 survey.
- *It’s actually <0.5%, the lowest level since 1959. NASA founded in 1958.*



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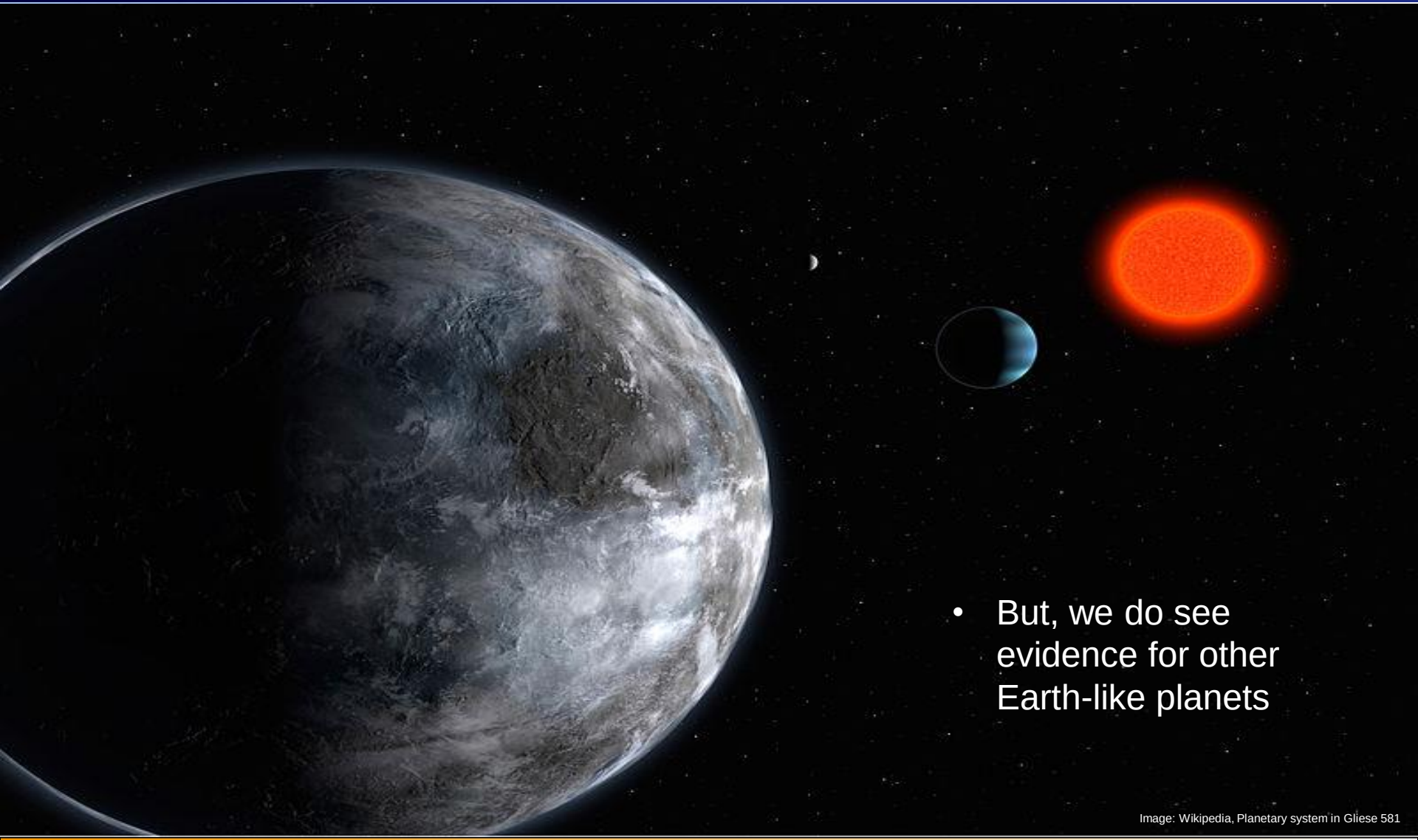
What is Space?



- But, we do see evidence for other Earth-like planets

Image: Wikipedia, Planetary system in Gliese 581

What Is a Space Ship?

- If we can build space ships to leave the Earth's atmosphere, what do they look like and what can they do?

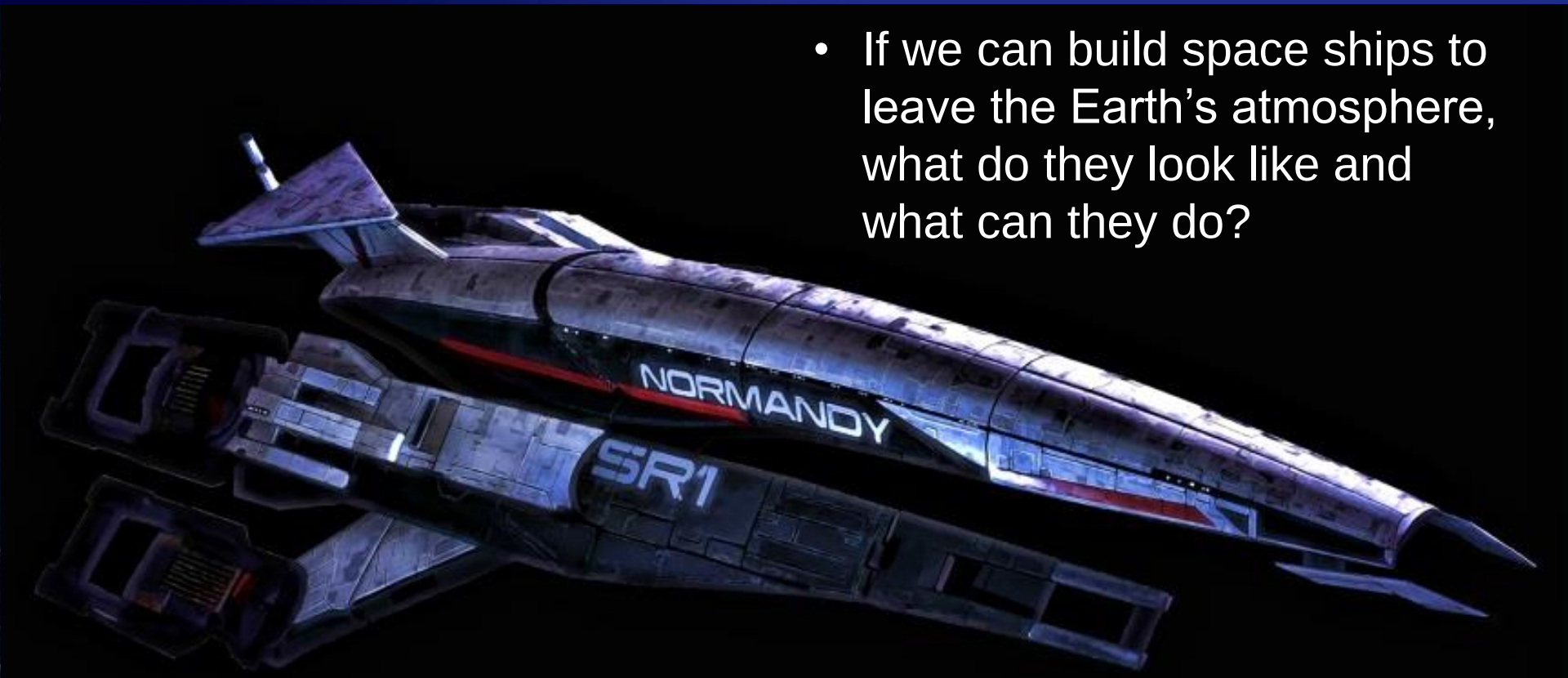


Image: www.wallconvert.com

Space Is Not That Far Away…

- Most of space is an empty void, sparsely populated with atoms and molecules.
- But it exists. We have to move through it if we want to go somewhere else.

Image: NASA

- "Space" is only 400 km above our heads. That's the altitude of the International Space Station.
- **It's just one trip from Austin to Houston *in the vertical direction.***

…But Space Is Really Big

- One cross country flight from NYC to LA is 4,000 km

Image: gcmap.com

How Far Away Is The Moon?

How Far Away Is The Moon?

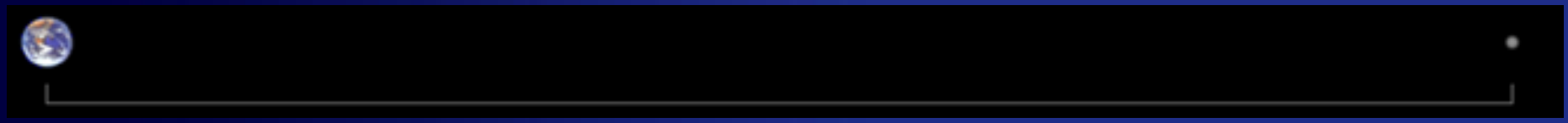
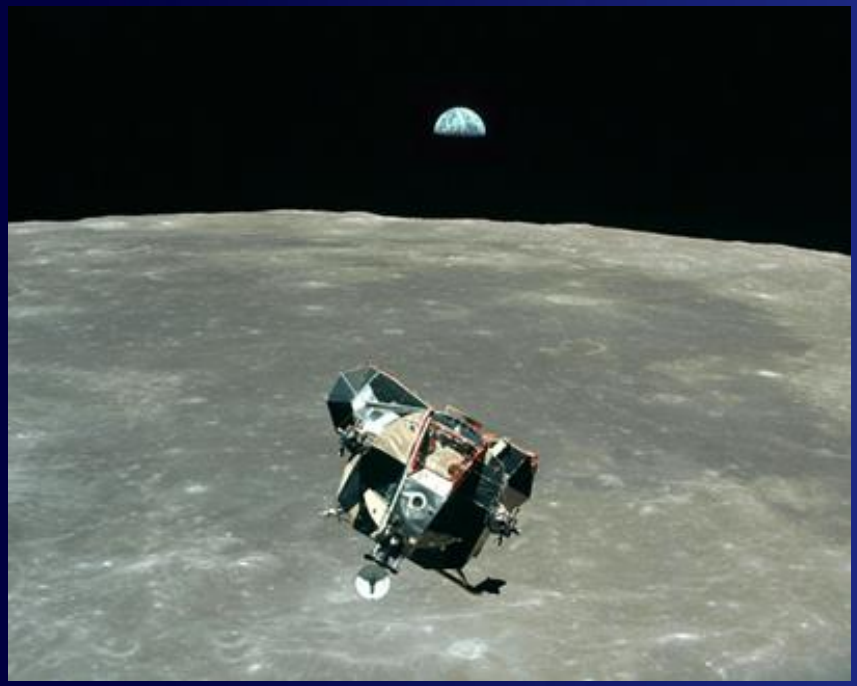


Image: freemars.org

- The Moon is 400,000 km from Earth
  - 100 cross country trips *in the vertical direction*
  - Trip can be made in a few days



- The Moon can be (and has been) visited by humans with current technology.

Image: NASA

How Far Away Is Mars?

How Far Away Are The Planets?

- Mars
  - 500,000,000 km away
  - 133,000 cross country flights
  - Trip takes months/years
  - How do we keep astronauts alive the whole time?

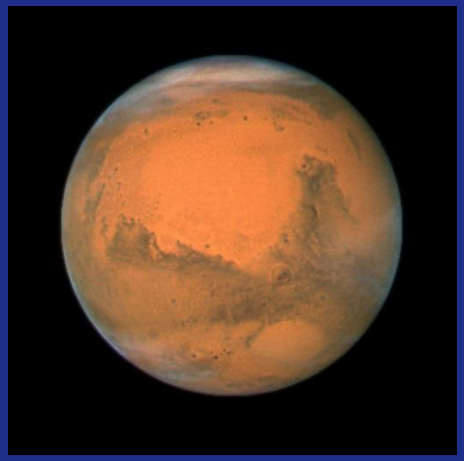


Image: NASA

- Neptune
  - 4,500,000,000 km away
  - A million+ cross country flights
  - Trip takes years in our solar system

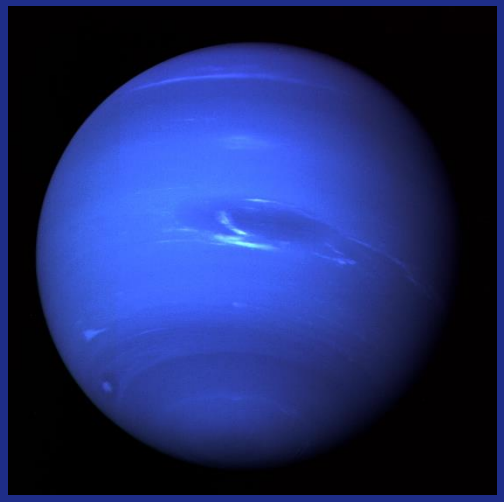


Image: NASA

Our Nearest Star

- Alpha Centauri
  - 4.5 light years away
  - Light travels 300,000 km per second
  - 8,400,000,000 cross country trips!
- Voyager probe
  - Travels 38,000 miles per hour = 17 km per second
  - 75,000 years to reach 4.5 light years
  - History of civilization = 10,000 years

Image: mpl3d.com

Image: spacetoday.org

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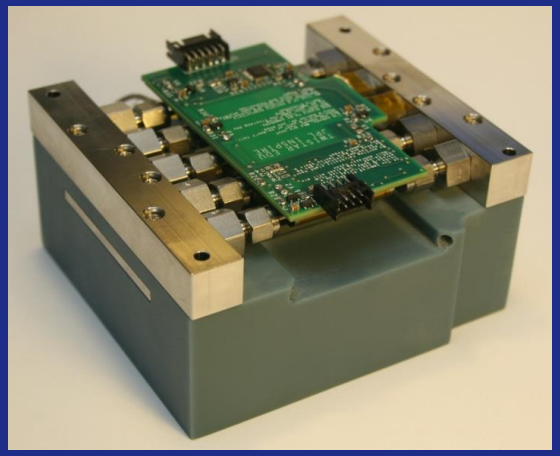
Who We Are

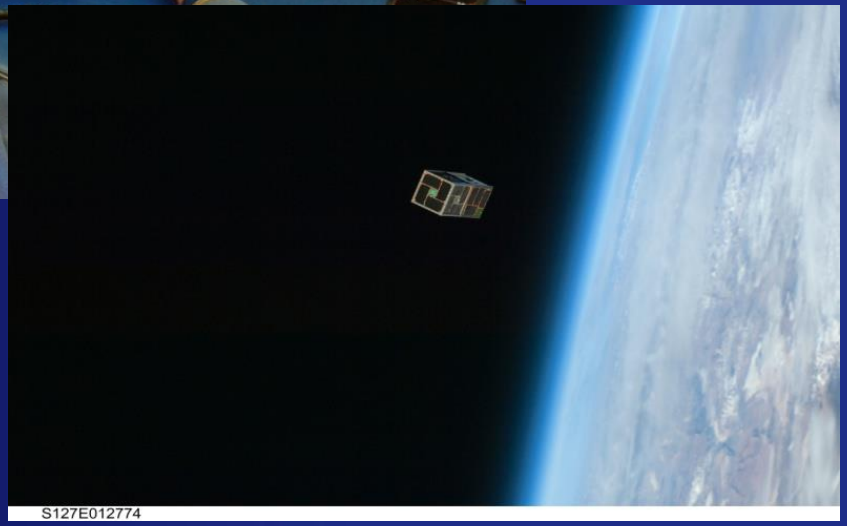
UT Tower is lit orange for ARMADILLO as winner
of the national University Nanosatellite Program, 2013

What We Do

Bevo-2 Satellite Integration



3D Printed Thruster



LoneStar-1 Launch

Why Our Research Matters

- We are advocates for space exploration, and for conducting science and human operations in space.
- But, getting to space is hard.
- With our research, we hope to create a future where space is more accessible and routine for everyone.

Why Going To Space Is Hard

Image: spaceflightnow.com

Image: NASA

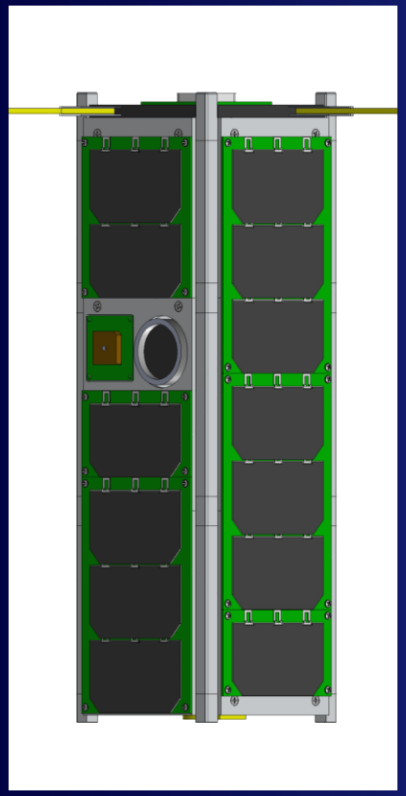
Mars Curiosity Rover

Costs as much as:
(roughly)

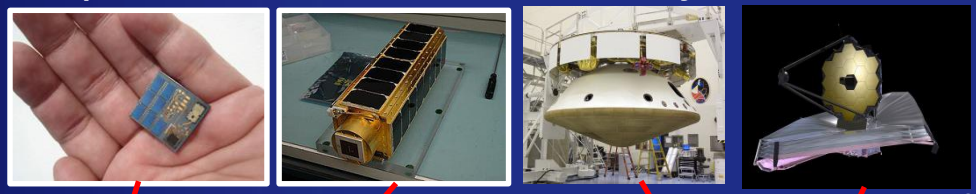
Image: mohammaedjewelers.com

Small Satellites, The Enabler

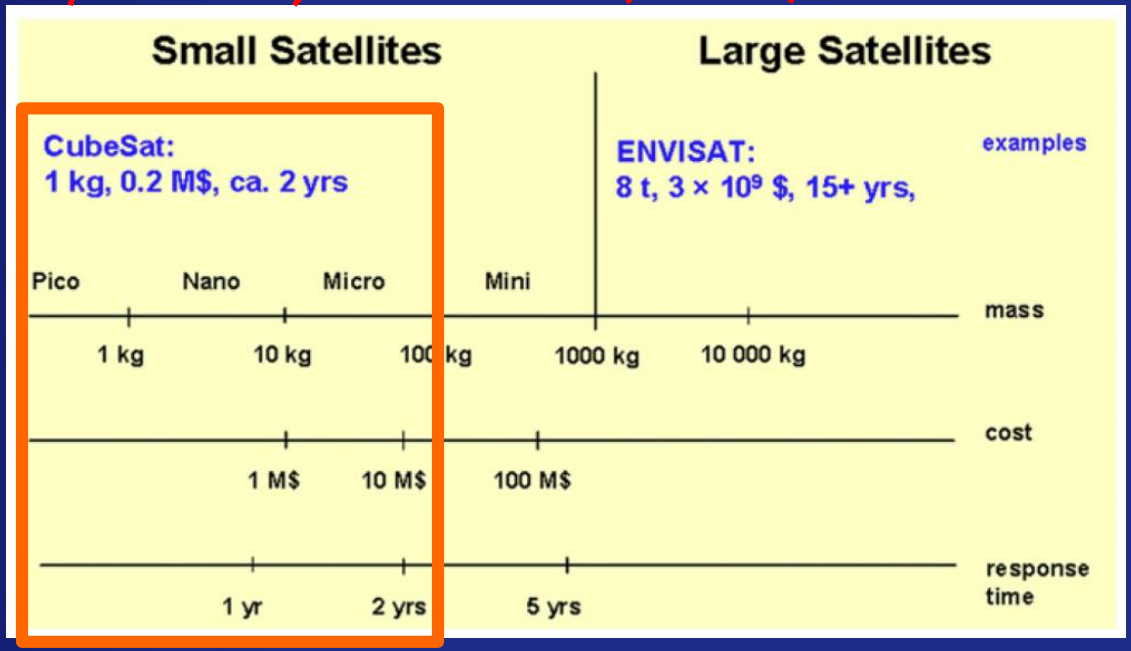
Standard 3-Unit CubeSat



Chipsat Cubesat Curiosity James Webb ST



Images: NASA



Small Satellites Mass-Cost-Time Relation

(from: Sandau et al., ISPRS Journal of Photogrammetry and Remote Sensing, 65, 2010)

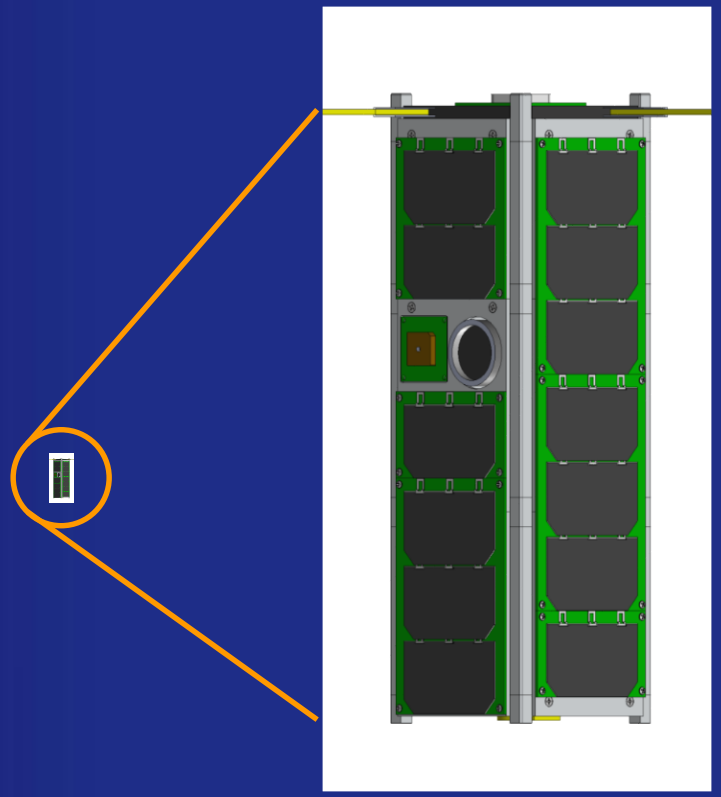
Small Satellites To Scale

Mars Curiosity Rover

Image: NASA

4.5 m, 3900 kg (9000 lbs)

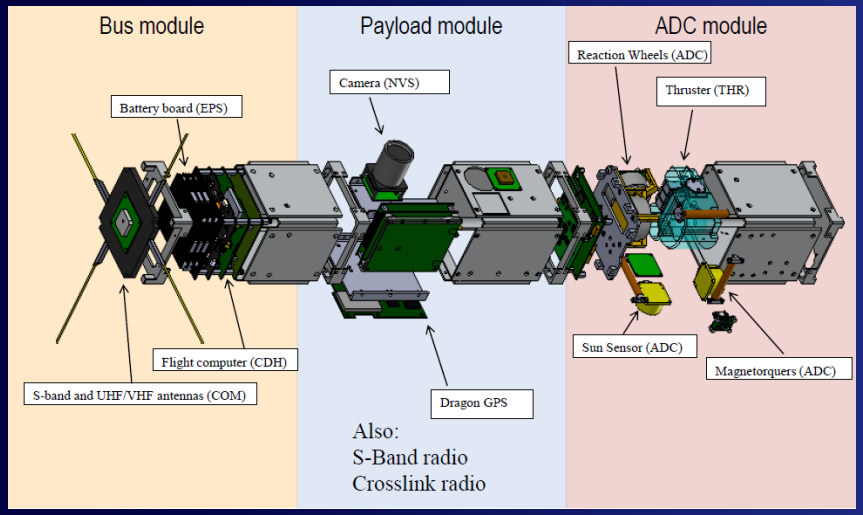
CubeSat



30 cm,
4 kg
(10 lbs)

Your Cell Phone-A Satellite?

Our Satellite (ARMADILLO):



Your Cell Phone:

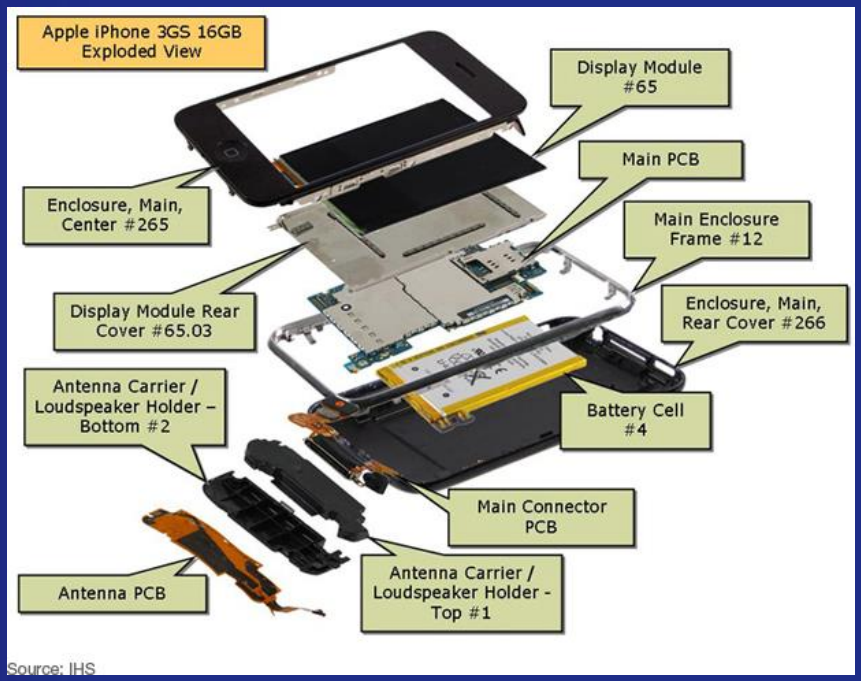
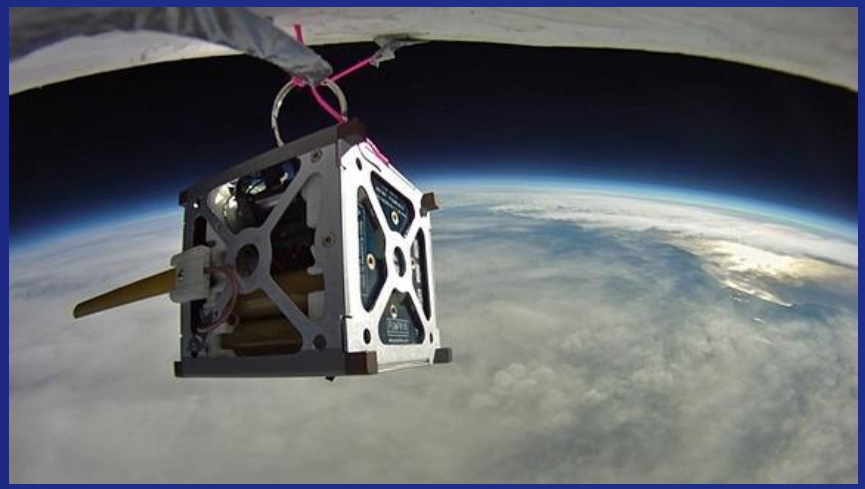


Image: electronics360.globalzone.com

NASA's PhoneSat Missions

Launched on April 2013, November 2013

Image: vrzone.com

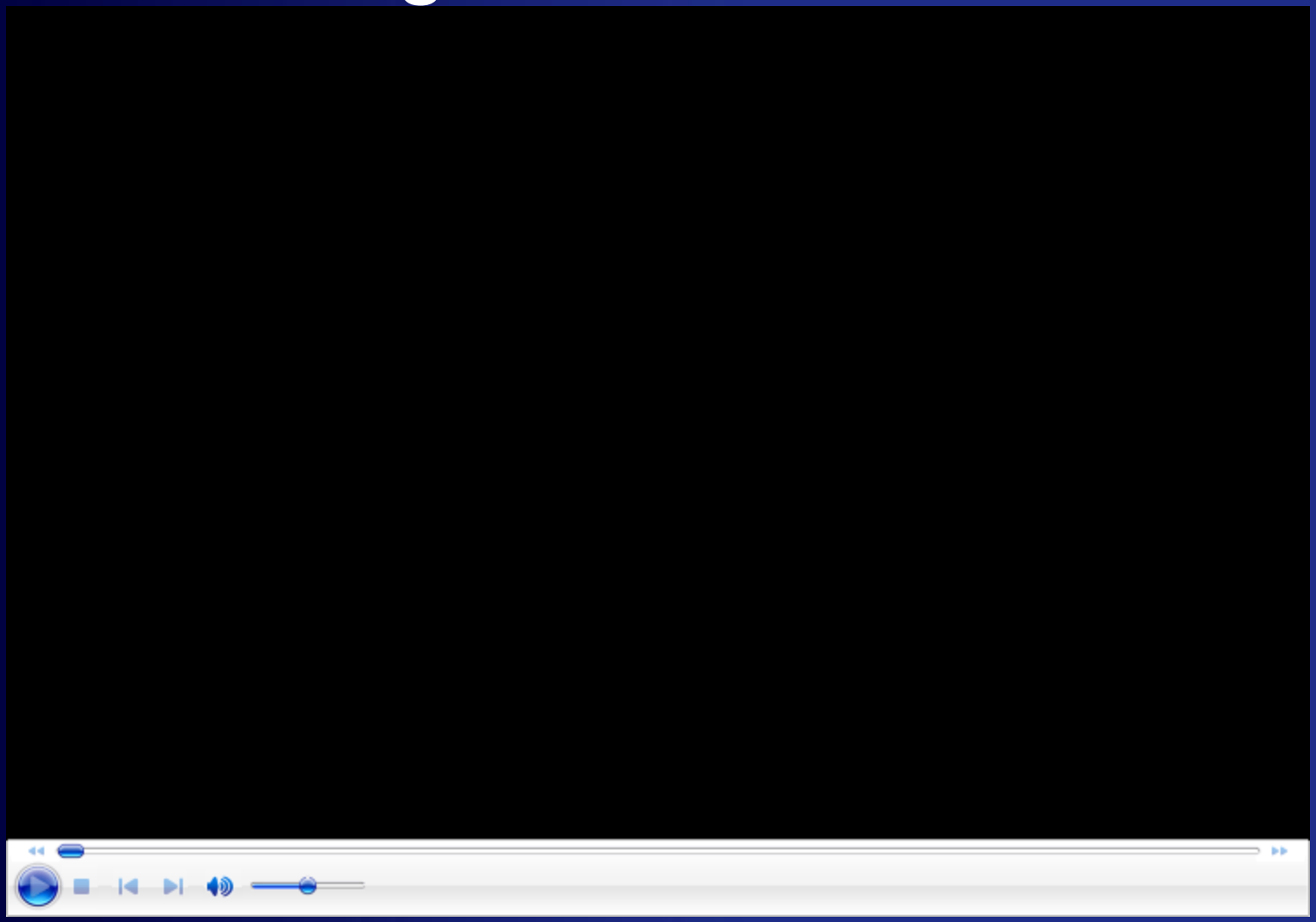


Images: NASA

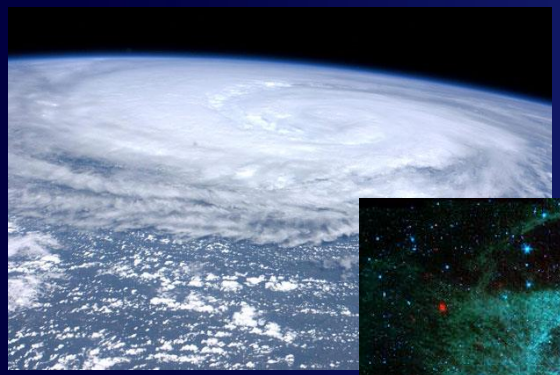
Image received from PhoneSat

Cost of PhoneSat: $7,500

Commercial Ventures Using Small Satellites



What Other Missions Are Possible With Small Satellites?



Images: NASA

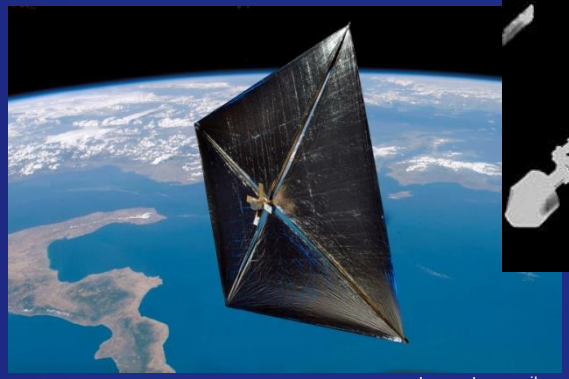


Image: Lunarsail

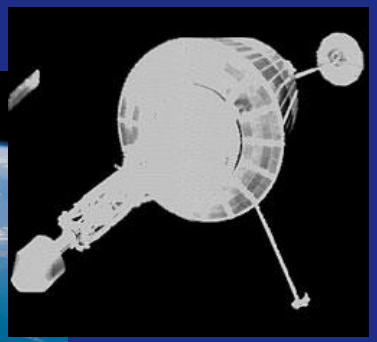


Image: SSTL

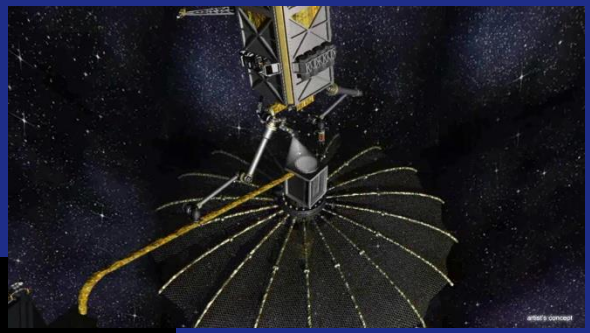


Image: DARPA

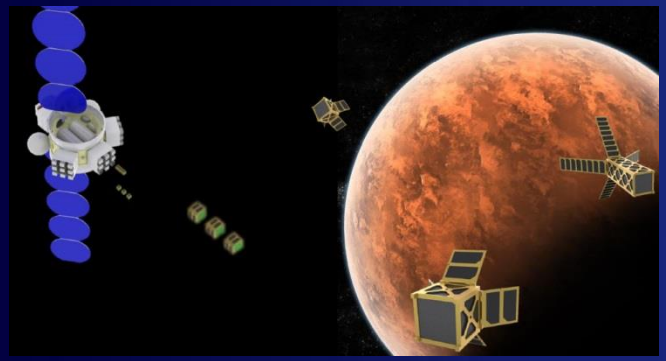


Image: Busek Inc.

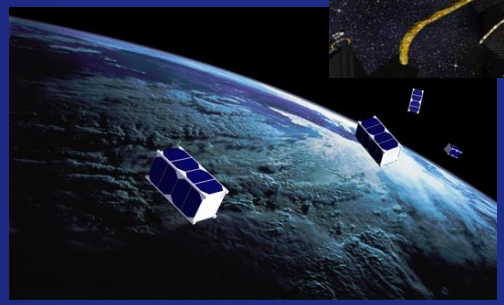


Image: Lithuania World

Texas Spacecraft Lab
Flight Project Activity Timeline

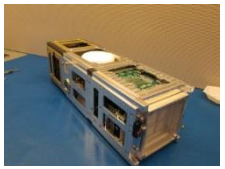
Texas Spacecraft Laboratory

Sponsor

2003 ’05 ’07 ’09 ’11 ’13 ’15 ’17 ’19

FASTRAC

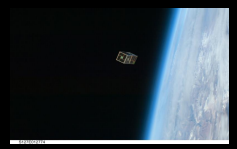
ARMADILLO



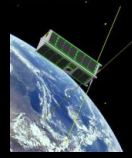
Johnson Space Center

NASA

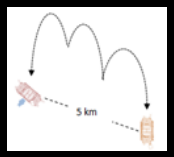
LONESTAR-1



Bevo-2



LONESTAR-2



NASA JPL

JPL Signed Strategic University Partnership With UT-Austin in October 2012

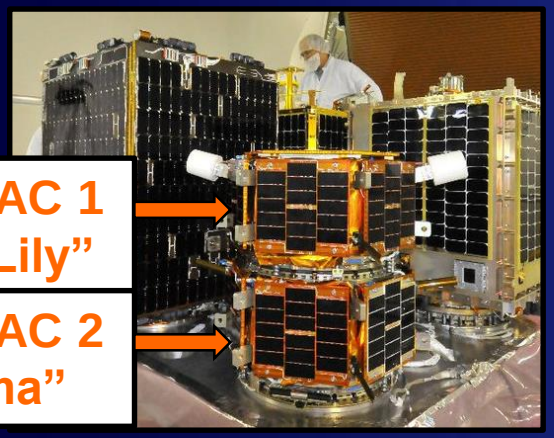
RACE

INSPIRE

We Are Here

FASTRAC

Formation Autonomy Spacecraft with Thrust, RelNav, Attitude & Crosslink



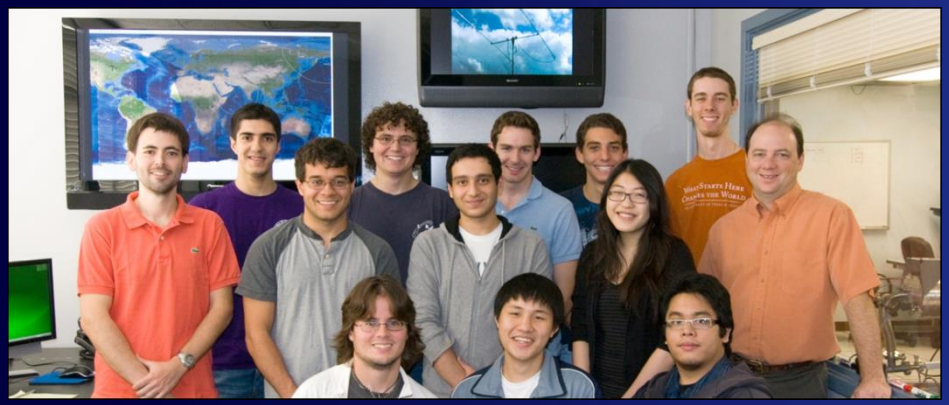
FASTRAC 1 "Sara Lily"

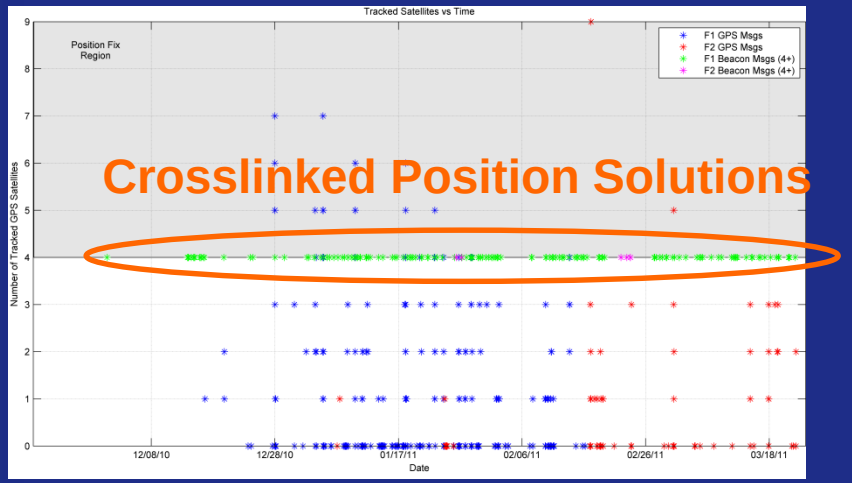
FASTRAC 2 "Emma"

2005 Univ. Nanosatellite Program Winner (first time entry)

Mission Success Objectives Were Achieved

Total Univ. Grant Award: <$250k





Both Satellites Are Still Operational Today After ~3 Years In Space

2004 FASTRAC Environmental Test Team Where Are They Now?

Married

NASA Goddard
Space Flight Center, MD

Formerly NASA Ames
Research Center
Completing PhD, CA

Started Aerospace
Company, TX

Employee 6 at
Aerospace Company
PhD, CO

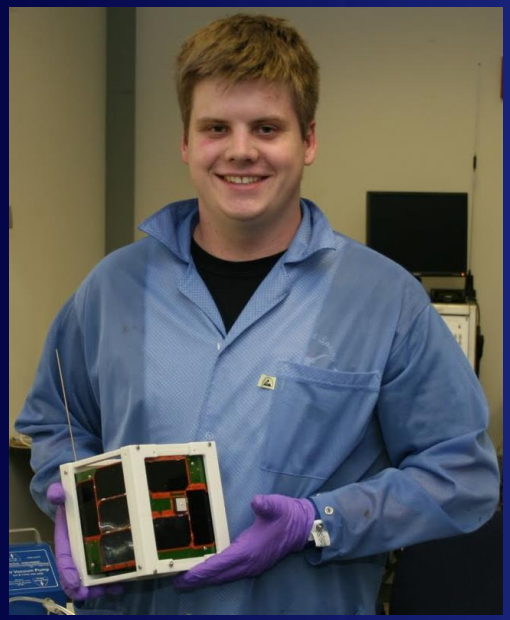
Lab for
Atmospheric
And Space
Physics, CO

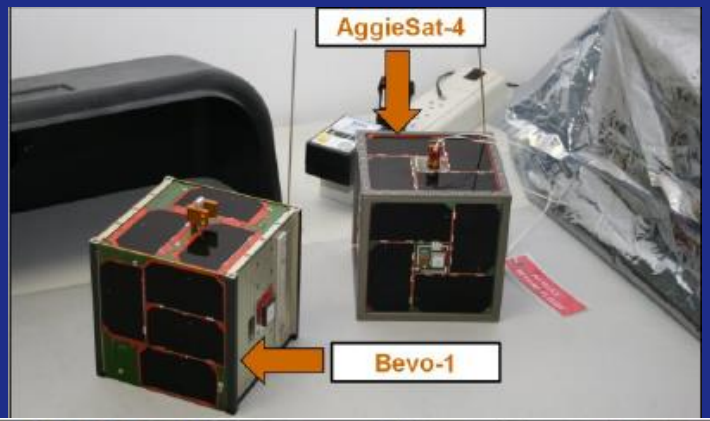
Lockheed-Martin, CO

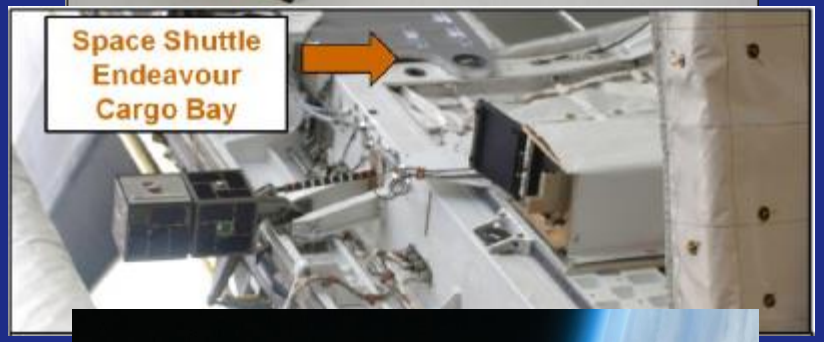
NASA Johnson Space Center
PhD, TX

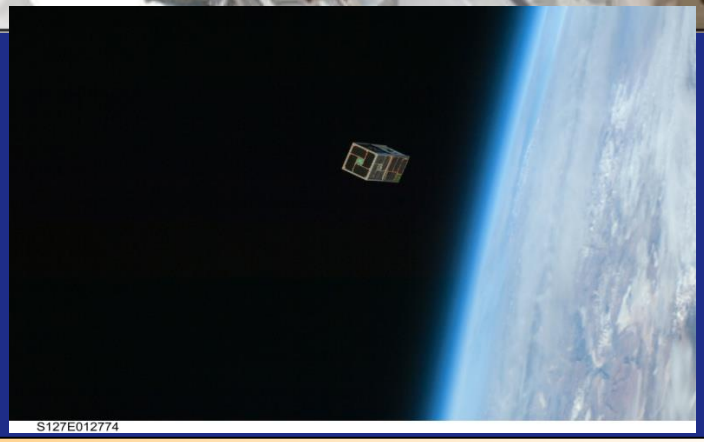
LoneStar-1

Launched from Space Shuttle July 2009,
re-entered atmosphere March 2010



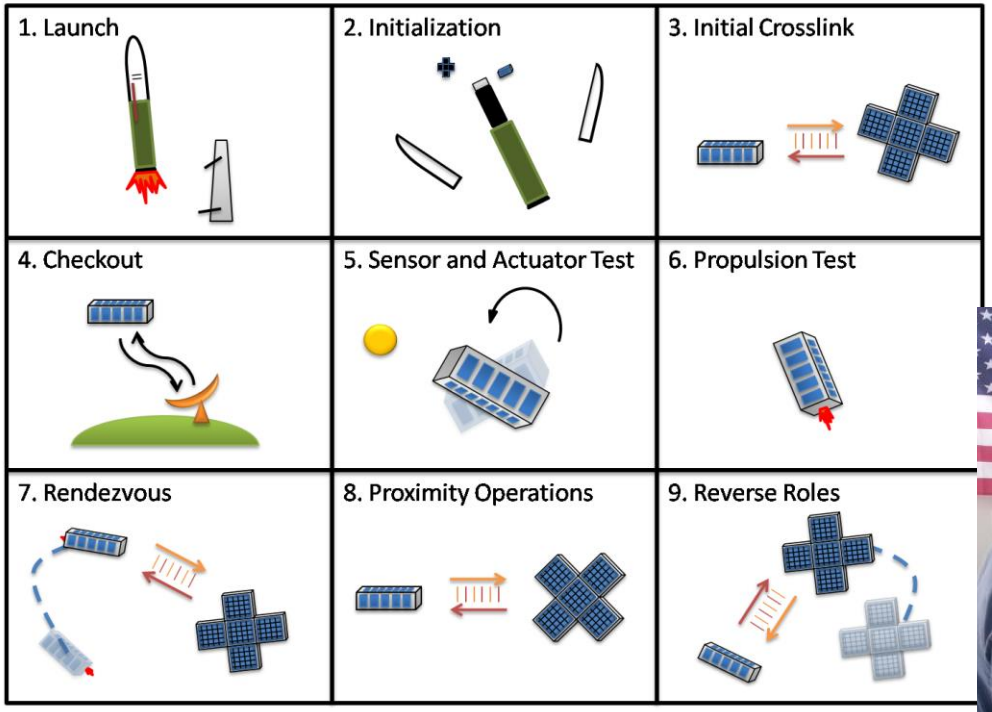






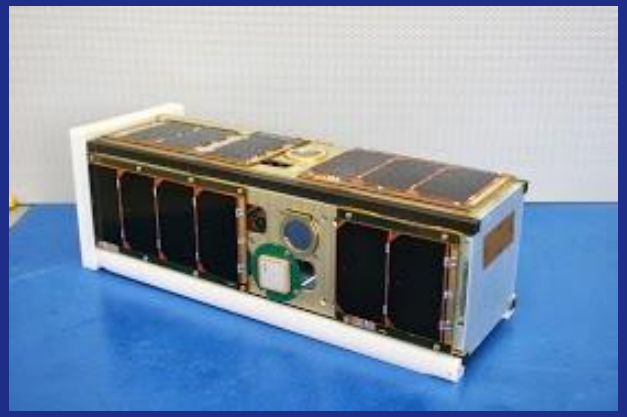
LoneStar-2

- Scheduled for Launch in 2014 (This Year!)



LoneStar-2 Mission Concept

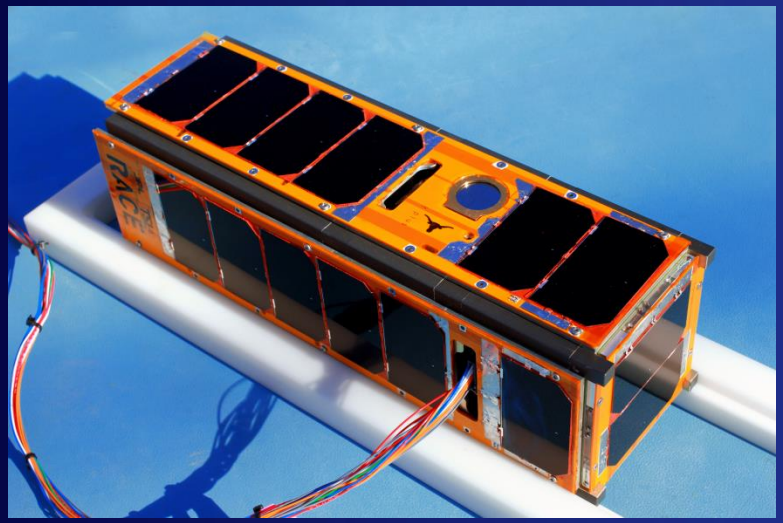
Bevo-2 CubeSat



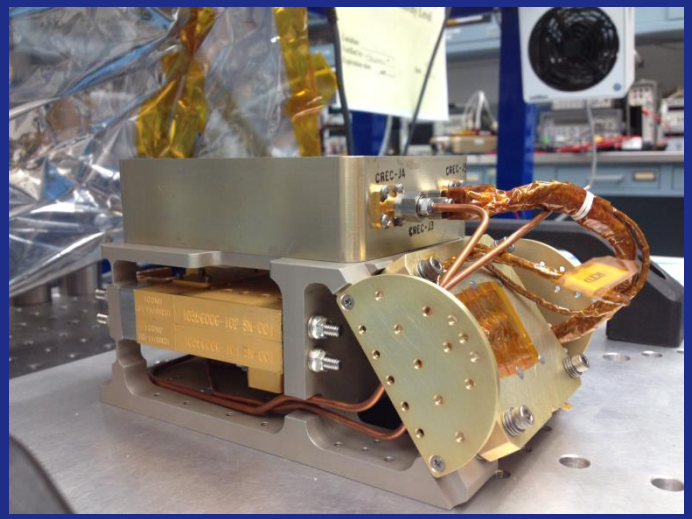
Satellite Inspection by NASA engineers

RACE

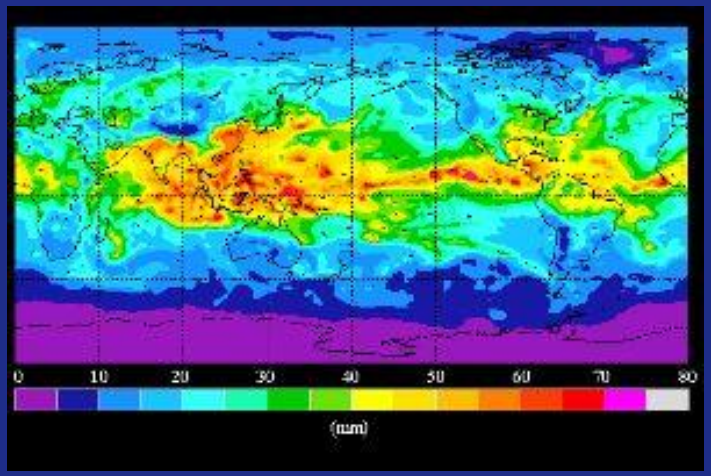
RACE Flight Unit
Satellite



Instrument: 183 GHz Radiometer

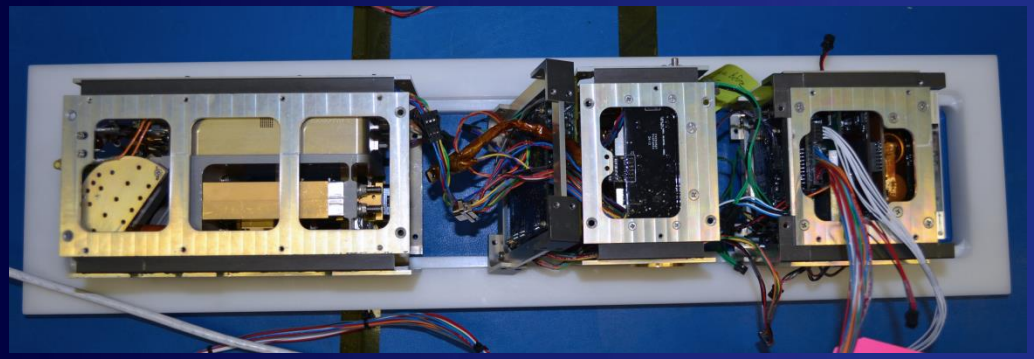


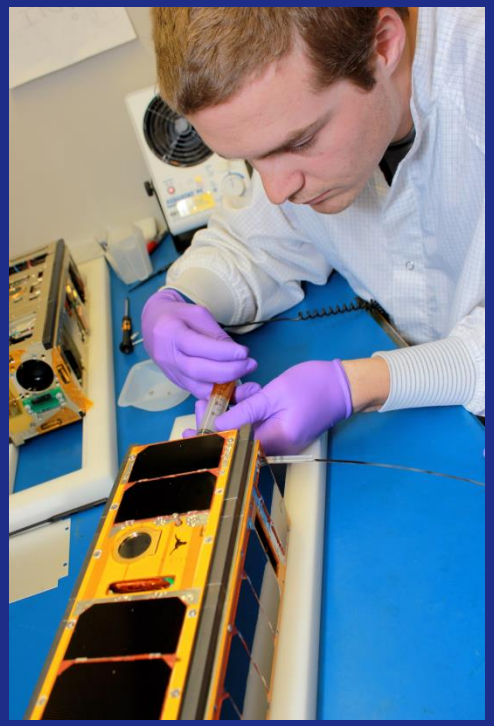
Satellite Delivery: February 2014
10 months from program start!

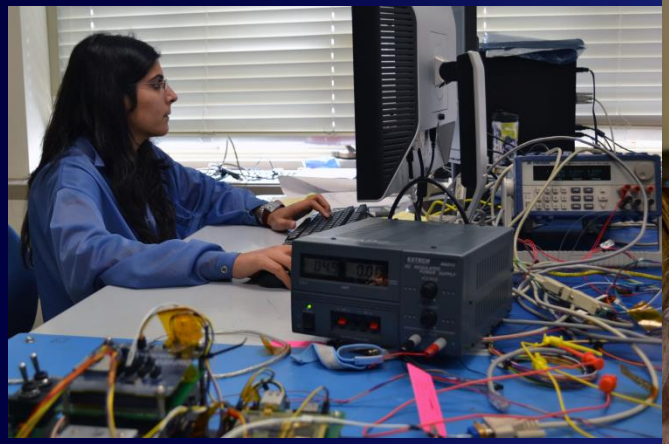


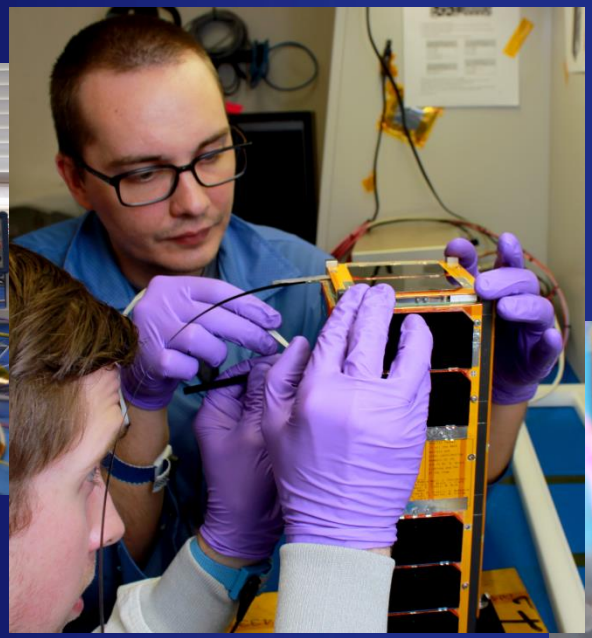
Example Science Result

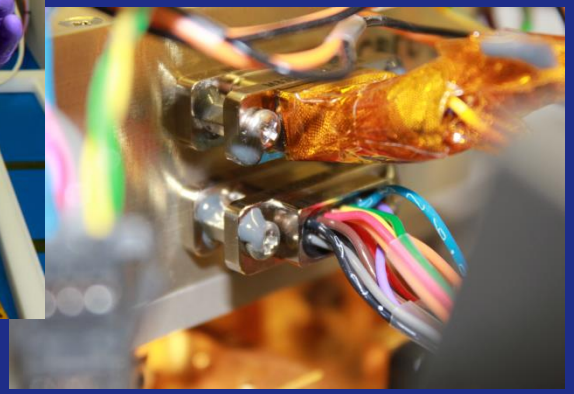
The Making of RACE





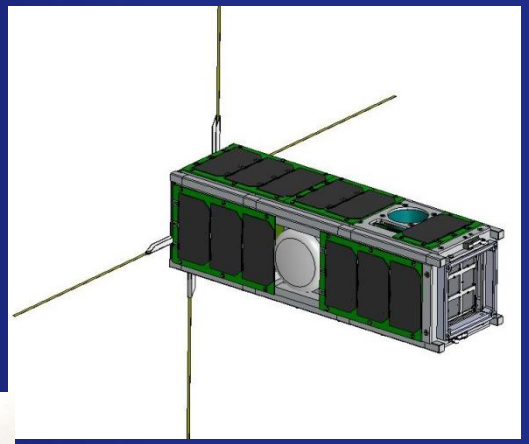




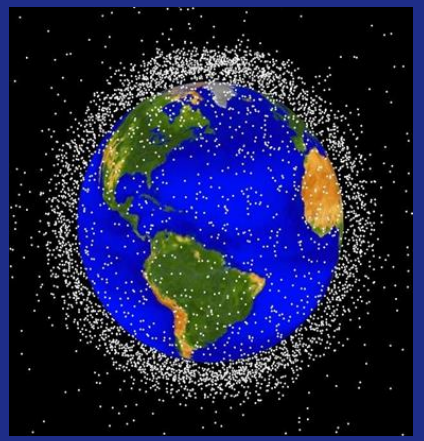


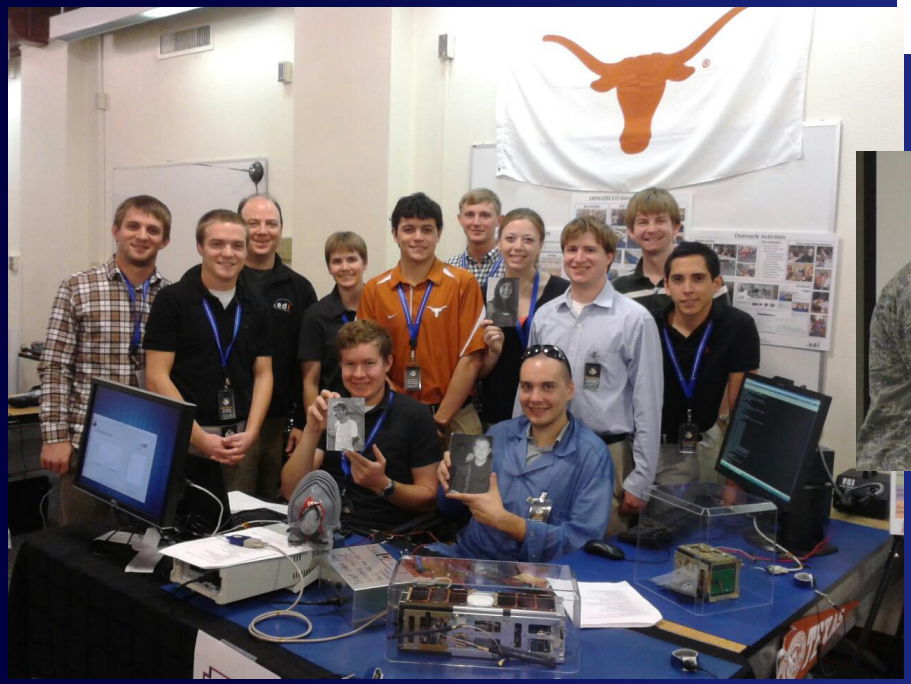
ARMADILLO

- Atmosphere Related Measurements And Detection of sub-mILLimeter Objects
- 2013 University Nanosatellite Program winner
- UT-Austin only two time winner (2005 & 2013, FASTRAC & ARMADILLO)



ARMADILLO Deployed Configuration





Engineering Model

INSPIRE

INSPIRE

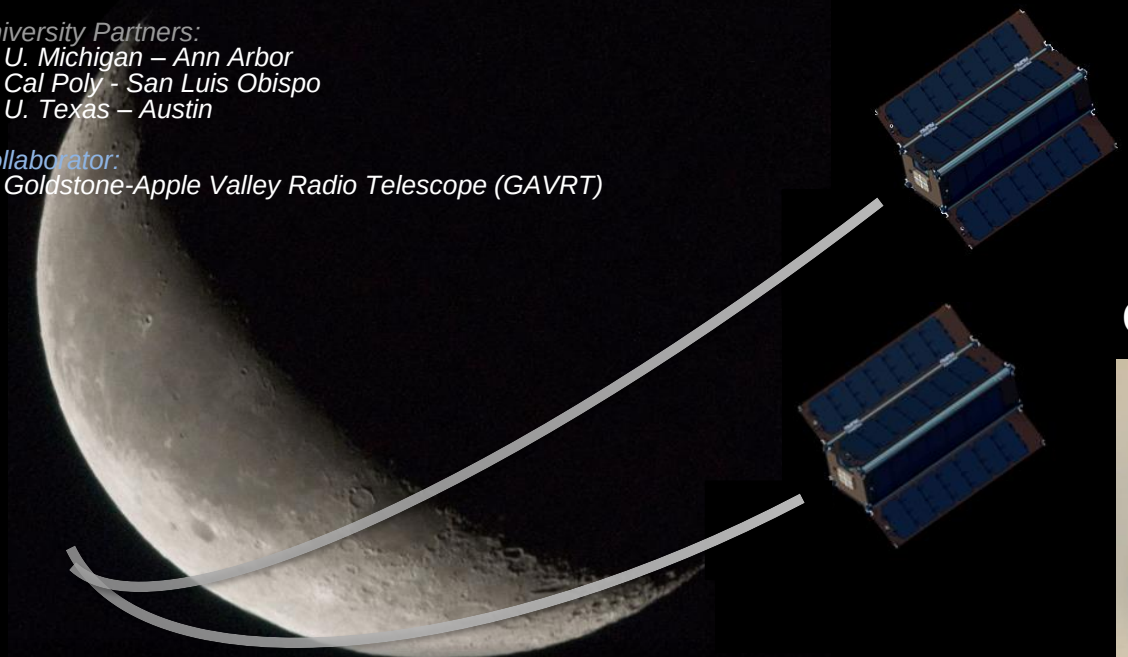
Interplanetary NanoSpacecraft Pathfinder In a Relevant Environment

Low-cost mission leadership with the world's first CubeSat beyond Earth-orbit

PI: Dr. Andrew Klesh, Jet Propulsion Laboratory, California Institute of Technology
PM: Ms. Lauren Halatek, Jet Propulsion Laboratory, California Institute of Technology

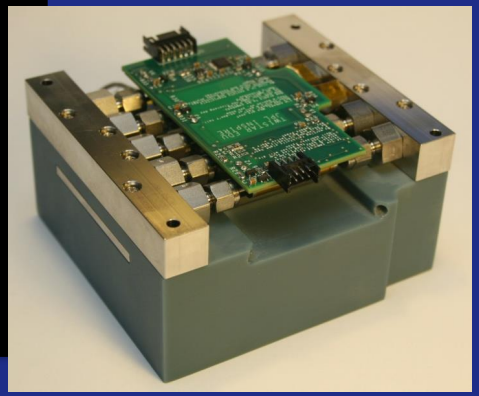
University Partners:
- *U. Michigan – Ann Arbor*
- *Cal Poly - San Luis Obispo*
- *U. Texas – Austin*

Collaborator:
- *Goldstone-Apple Valley Radio Telescope (GAVRT)*



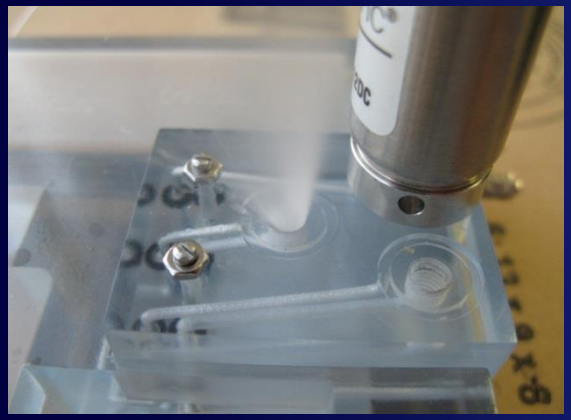
Will Fly In 2015-16!

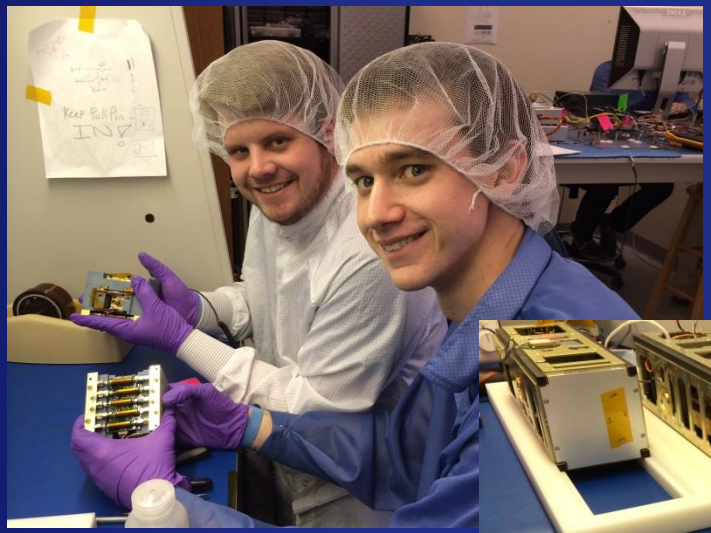
Our Contribution:

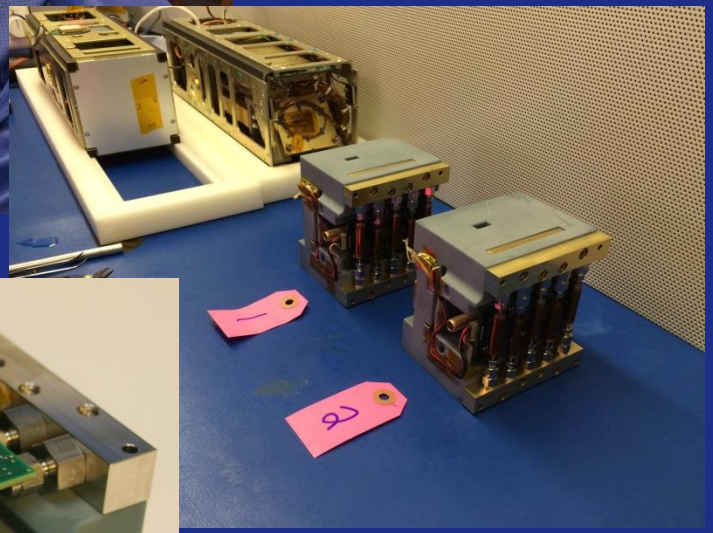


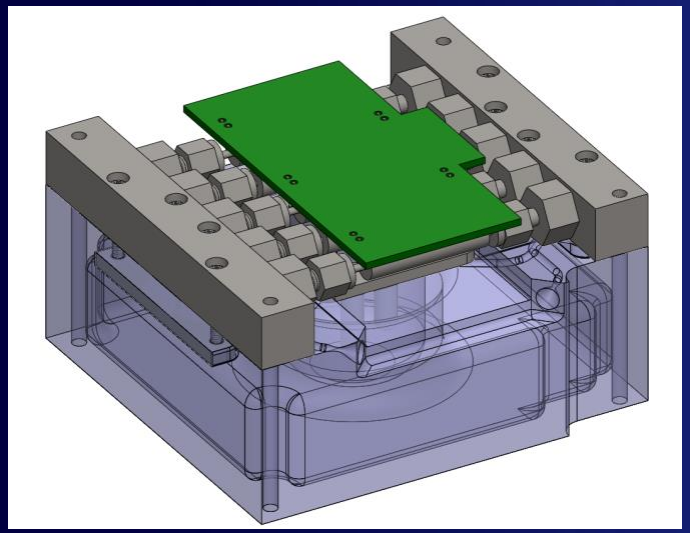
In House Developed 3D Printed Thruster

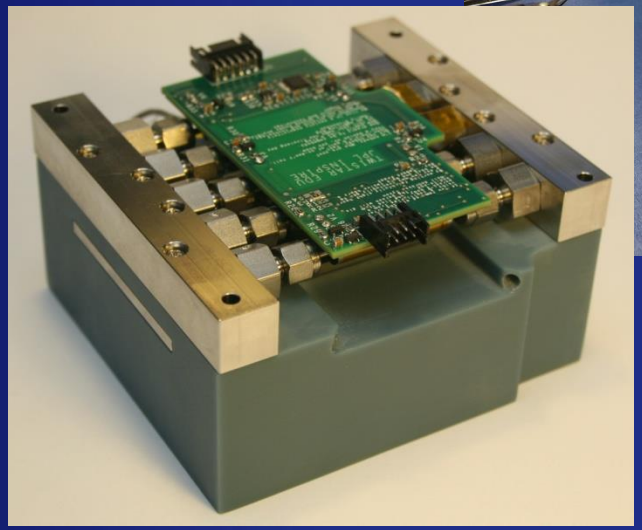
3D Printed Spacecraft Thruster











Suborbital Rocket Flight To Measure Aurora Emission

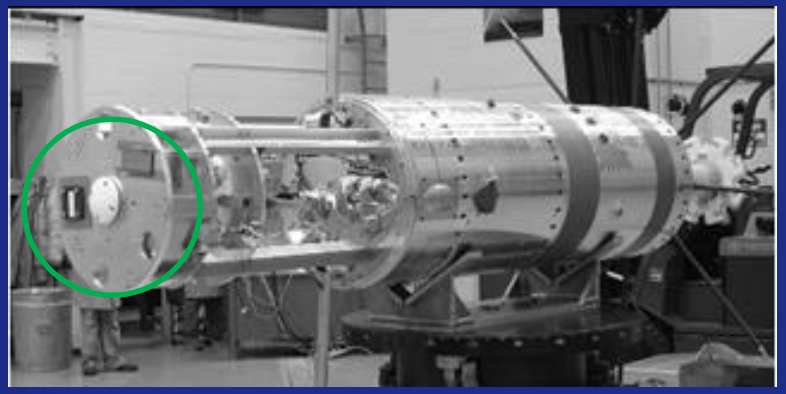
Texas Spacecraft Laboratory

- Launched into aurora borealis at Poker Flat, AK on Feb. 19, 2012

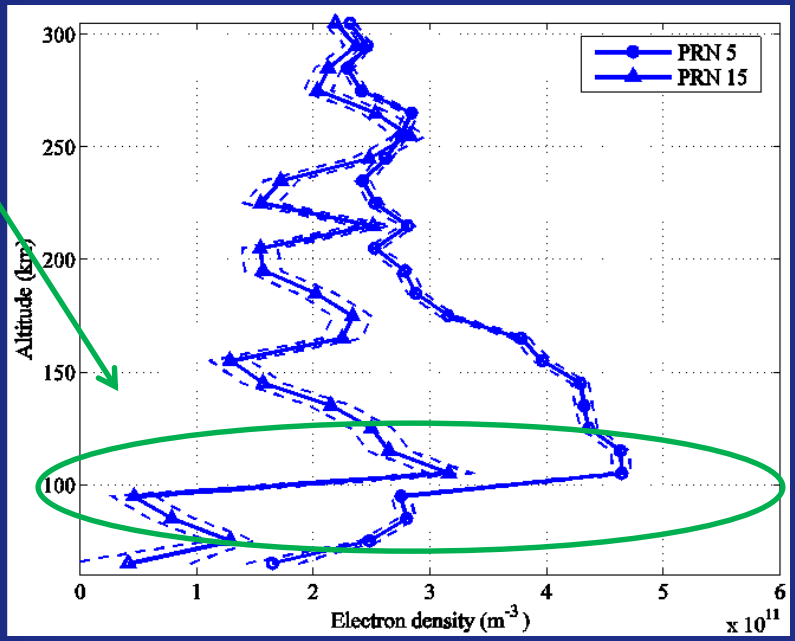
Sounding rocket launched into aurora

- 7 minute flight with 325 km peak altitude

- Ionospheric E-layer emission clearly present at 100 km altitude indicates strong absorption for nighttime aurora



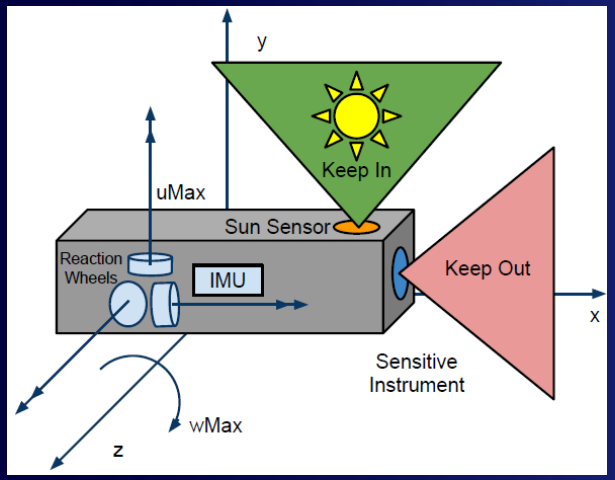
GPS receiver integrated on sounding rocket

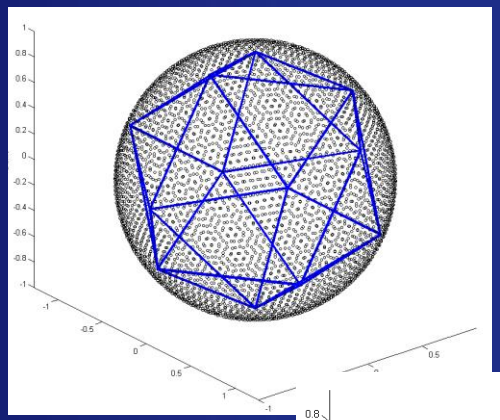


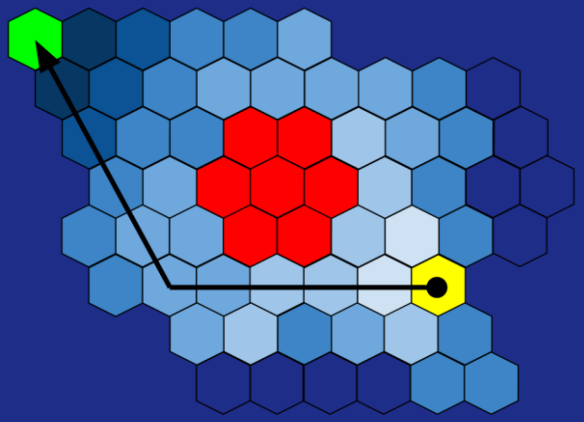
Electron density measurements obtained from FOTON

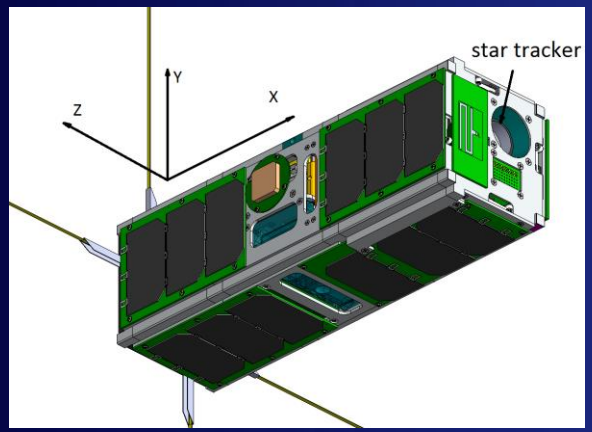
Constrained Pointing for Small Satellites

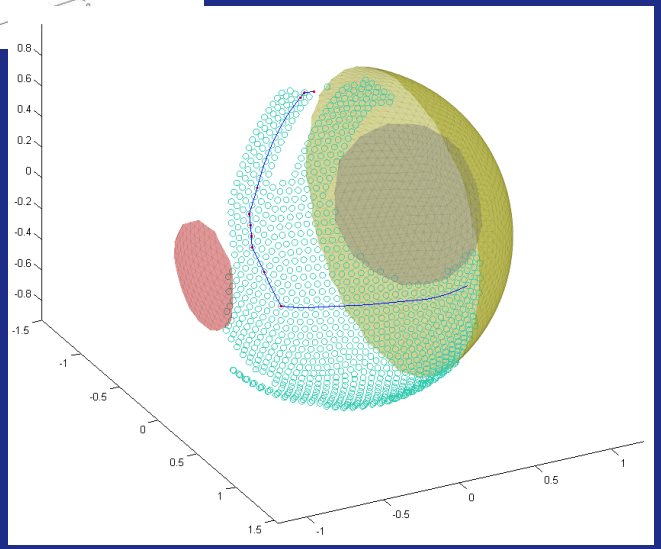
Texas Spacecraft Laboratory





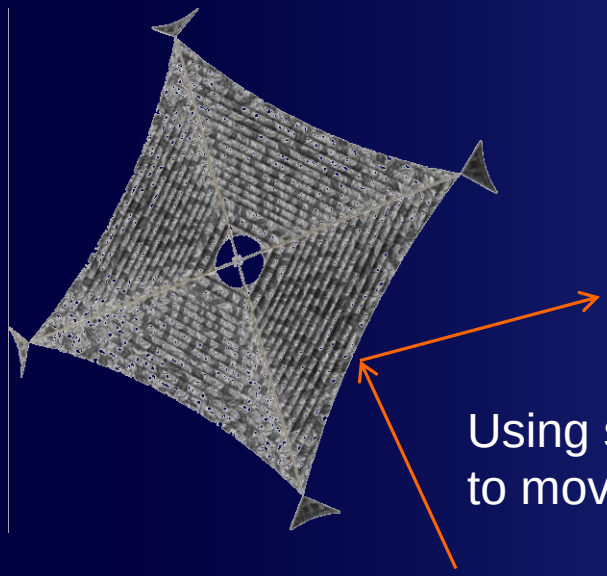




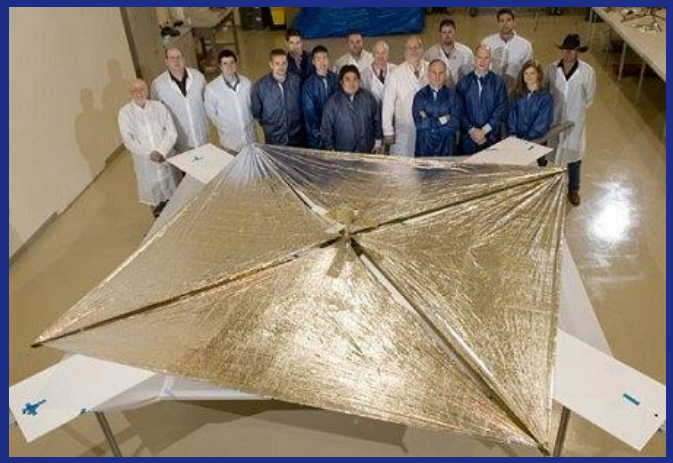


Example pathfinding solution

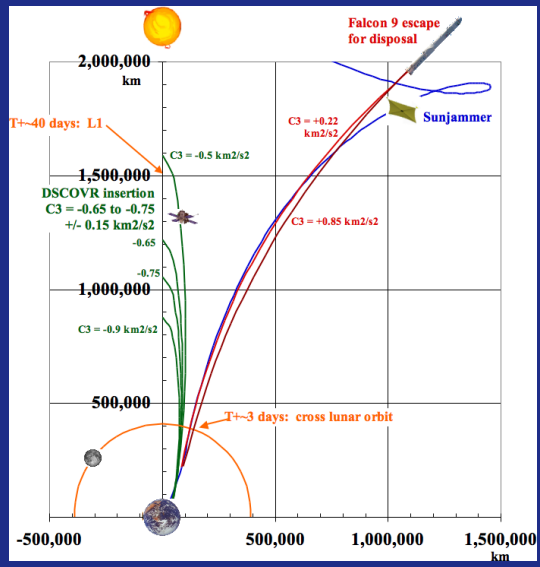
Solar Sails



Using sunlight
to move a spacecraft



Images: NASA



Sunjammer planned trajectory

The Future: On-Orbit Servicing and Assembly

- Small satellites can be building blocks that are assembled on-orbit to form functional groups
- Such satellite groups may or may not be physically connected
- On-orbit assembly of large apertures and satellite lifetime extension by consumables servicing are two possible applications

Explore UT Events

- Interactive Fair: Student Activity Center Ballroom
  - Austin Discovery Dome Planetarium Shows
  - Float in space with the Green Screen
  - Build and Launch Paper Rockets
  - Model Solar Systems
  - DIY Planispheres
  - Environmental Sustainability Games
  - … and much more!

- Department of Aerospace Engineering and Engineering Mechanics: W. R. Woolrich Building (24th & Speedway)
  - Designing, Building, and Flying Airplanes
  - Longhorn Rocket Activity
  - Balloon Rocket Racers
  - Texas Spacecraft Lab (That's Us!)
  - Aerospace Engineering Prospective Student Session
  - On Target to Mars
  - Paper Airplane Contest
  - Bio-Integrated Electronics
  - Sounds of Space

Conclusion

- Space is more accessible than ever before with small satellites
- The University of Texas at Austin's Texas Spacecraft Lab supports a wide range of CubeSat, small satellite and related space missions from design through operations
- Research topics are integrated with and motivated by satellite experiments

- Contact information:
  - E. Glenn Lightsey
  - lightsey@mail.utexas.edu
  - (512) 471-5322

- Additional information:
  - Faculty Research page:
    - http://lightsey.ae.utexas.edu
    - Downloadable papers and presentations
  - Lab Facebook page:
    - https://www.facebook.com/UTSatLab
    - Lots of pictures and videos of hardware and lab activities
      (be sure to 'Like' us for updates!)

Dr. Glenn Lightsey

Glenn Lightsey is the Fellow of the W. R. Woolrich Professor in Engineering in the Department of Aerospace Engineering and Engineering Mechanics at The University of Texas at Austin. He is the Founder and Director of the Satellite Design Lab at UT Austin, which designs, builds, and operates satellites with undergraduate and graduate students. His research program focuses on the technology of small satellites, including: guidance, navigation, and control systems; attitude determination and control; formation flying, satellite swarms, and satellite networks; cooperative control; proximity operations and unmanned spacecraft rendezvous; space based Global Positioning System receivers; radio navigation; visual navigation; propulsion; satellite operations; and space systems engineer.

Prior to joining UT in 1999, Dr. Lightsey worked for 13 years as an aerospace engineer in the Guidance, Navigation, and Control Branch at NASA's Goddard Space Flight Center. He participated in the SOAR Space Shuttle Detailed Test Objective (DTO) experiment. In 1999 he received NASA's Manned Flight Awareness Award and GSFC's Center of Excellence Individual Award. In 2004 he received the Institute of Navigation's Tycho Brahe Award which recognizes outstanding contributions to the science of space navigation, guidance, and control.

Dr. Lightsey instructs undergraduate and graduate students in courses in orbital mechanics, navigation, and control. He has twice served as the Space Representative of the Institute of Navigation's National Council (1998-2000, 2012-2014) and he is an Associate Fellow of the AIAA. He served on the AIAA's Guidance and Control Technical Committee (1999-2008), and he was an associate editor of the Journal of Guidance, Control, and Dynamics (2005-08). In 2008, he was General Chair of the AIAA's Guidance, Navigation, and Control Conference. He has authored more than 100 technical publications in peer-reviewed journals and conference proceedings. He currently serves as the Cockrell School of Engineering's Strategic Planning Area Champion for Space and Earth Engineering; and since 2009 he has been the Graduate Advisor for Aerospace Engineering. In 2010, Dr. Lightsey became Associate Director of NASA's Texas Space Grant Consortium. In 2011, Dr. Lightsey received the American Society for Engineering Education's John Leland Atwood Award for outstanding aerospace engineering education, and the William David Blunk Memorial Professorship for outstanding undergraduate teaching at The University of Texas at Austin. Dr. Lightsey was inducted in The University of Texas at Austin's Academy of Distinguished Teachers in Fall 2012.