ARLISS: A Rocket Launch for International Student Satellites

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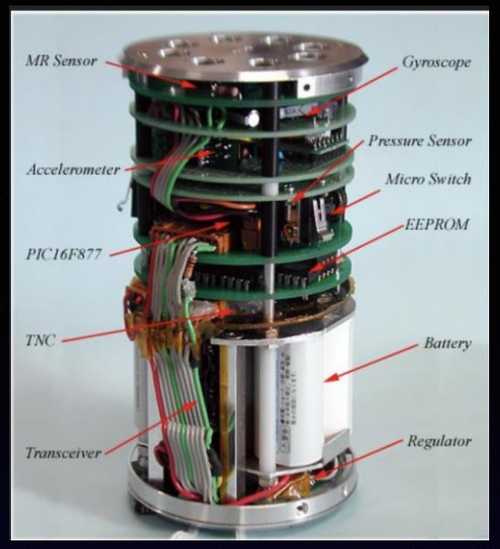
22 years of Rockets, Robots and STEM
Thank You!
Many More!

Who Am I?

- I wanted to be an astronaut
- But …
  - Sadly, not a fighter pilot
  - So my robots need to explore for me
- Physicist, computer scientist, entrepren (CEO/CTO)
  - Wireless networking expert
  - WiFi, cable modems, Internet
- ~30 years in amateur rocketry
  - HAM, TRA/NAR Level 3, TAP
  - TRA BoD, AeroPac BoD, ARLISS BoD since 2001
  - Held amateur altitude records (30+ km)
  - Picosatellite (temporarily) in LEO
  - Mentoring adults and students for 20 years

How It Began

- Challenging to develop engineering training for space
  - Long development cycles
  - Long time in queue for orbit
- Most engineers build payloads rather than rockets
  - Focus training on payloads not just rockets
- New standard for satellites (payloads) - CubeSat
  - And now PocketQubes - 1/8 CubeSat @ 5 cm
  - Cost highly coupled to mass: lighter is cheaper
- LEO relatively benign space place
  - Commercial electronics work pretty well for reasonable amounts of time
- Train for space closer to the ground



20+ Year History

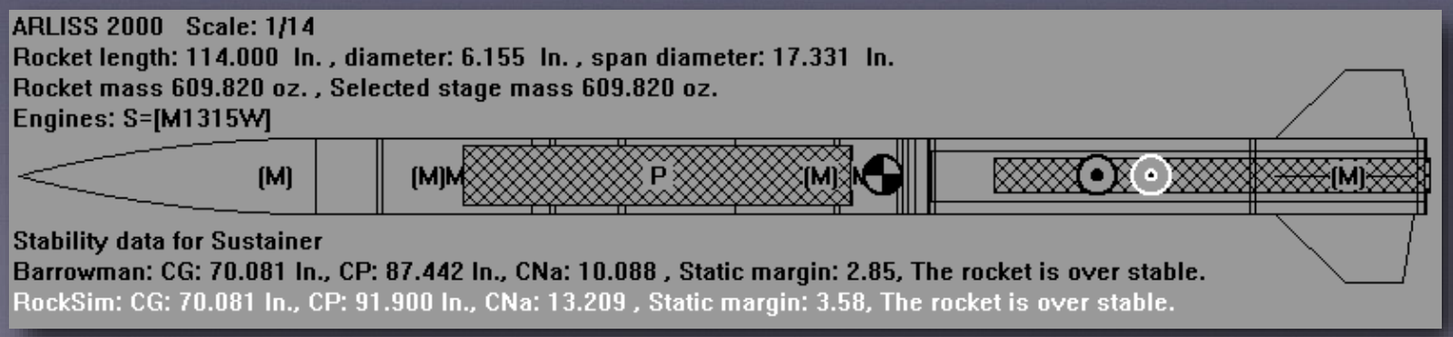
- Original “CanSat” program
  - https://www.dropbox.com/s/z3ryakkvn7jfzq9/Professor%20Robert%20Twiggs%20%28father%20of%20CanSat%20and%20CubeSat%29%205th%20Virtual%20UNISEC-Global%20Meeting.mp4?dl=0
- ARLISS program was started in 1999 by Professors Bob Twiggs of Stanford, Shinichi Nakasuka of Tokyo University and their colleagues at other universities from around the world, and the members of the AeroPac Rocket Club led by Pius Morizumi and Tom Rouse
  - Unique partnership of amateurs to provide the rocket flights and students to provide the payloads
  - Today, ARLISS is hosted by AeroPac and organized jointly with UNISEC Global - world wide University Space Engineering Consortium
  - ARLISS both a TRA activity and a NAR section
- ARLISS has flown over 700+ missions with only three failures to deliver payload - 99.8% deployment success rate
- Thousands of students have passed thru program

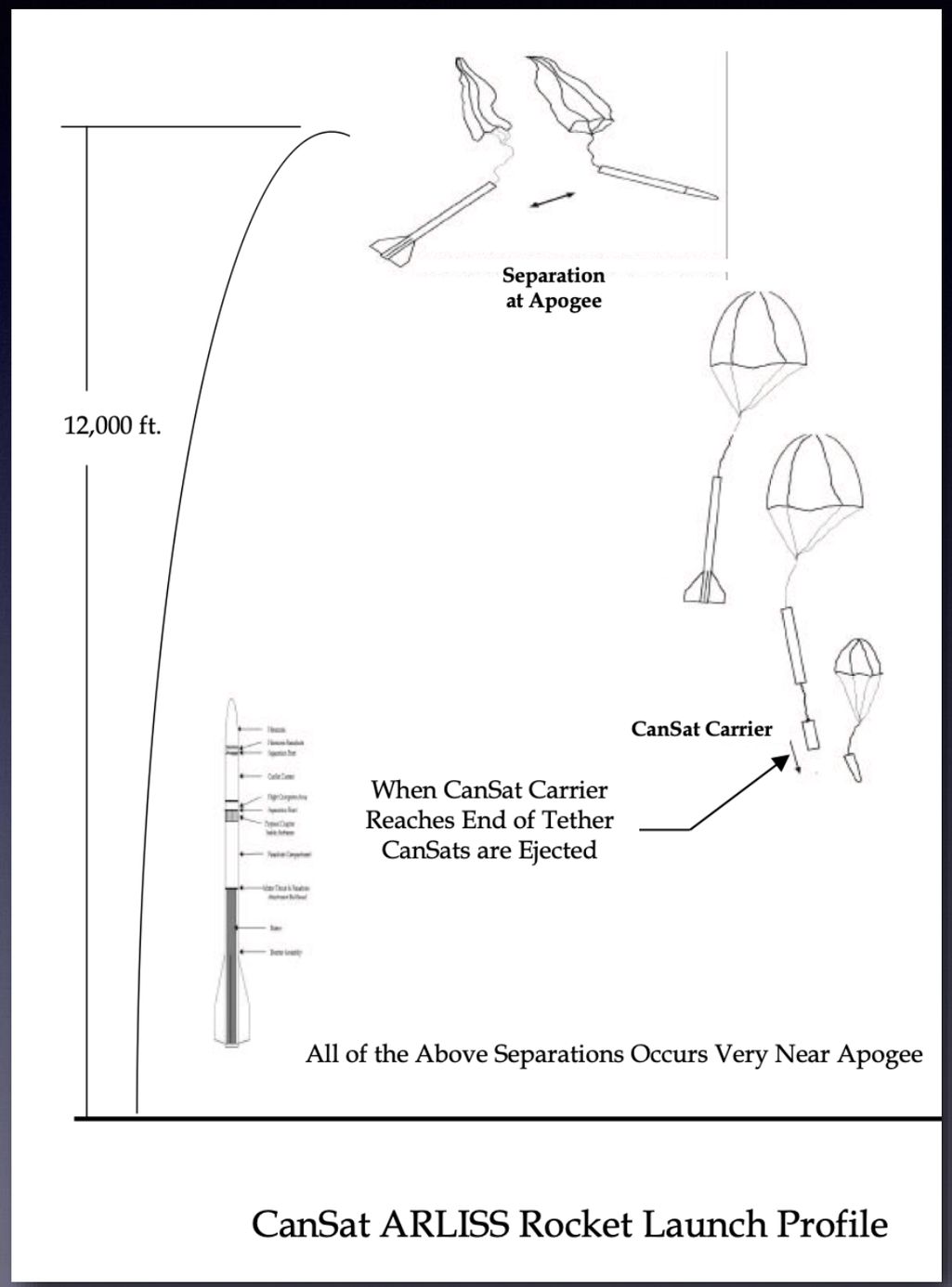
ARLISS Projects

- ARLISS Classic w/ CanSats -> Autonomous Drones
- Virtual Classroom - ARLISS to the Internet
- Instrumented Deployment - Metrics of the Experience
- ARLISS Extreme - ARLISS towards the Karman Line
- ARLISS S4 - PocketQubes are the new CanSats
- ARLISS Lite - ARLISS from Park to LEO

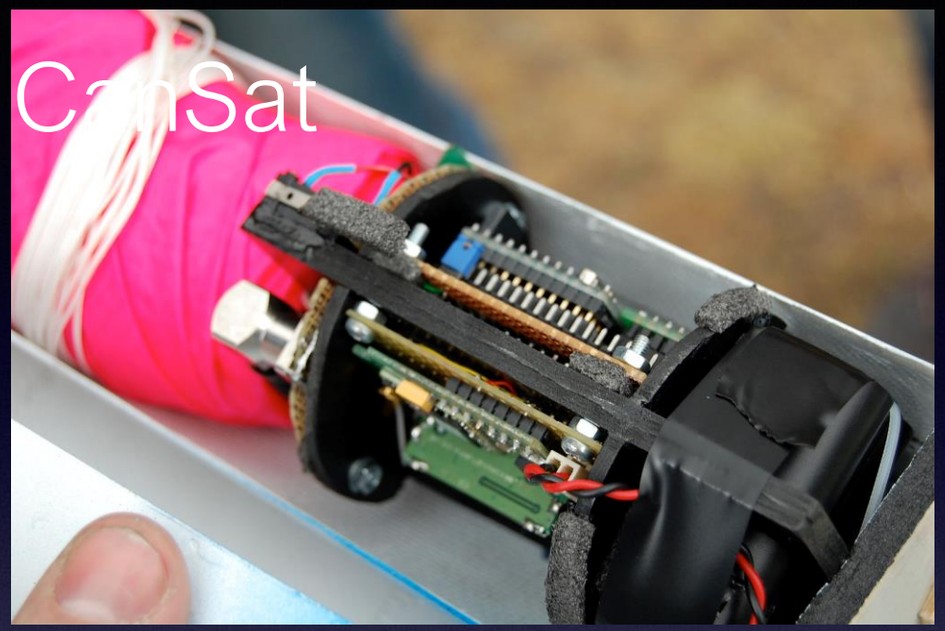
ARLISS Classic

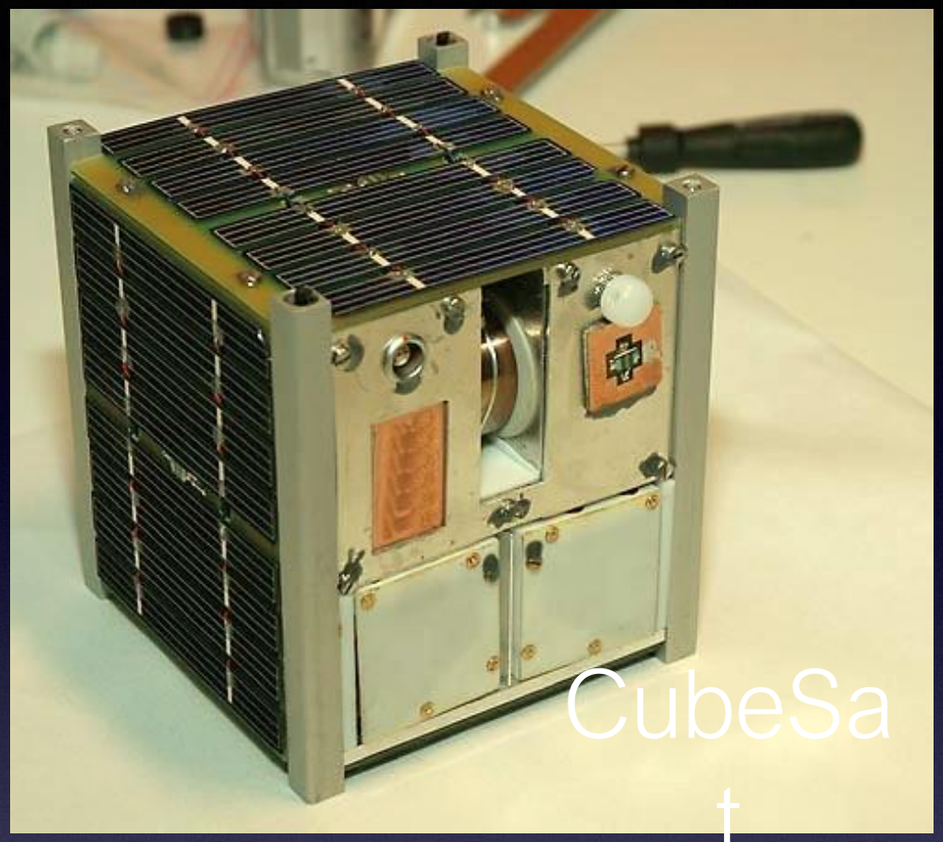
- Very experienced amateurs fly reliable HPR K & M powered payload rockets w/ student satellites
  - Standard payload weight (<1 kg), volume (< 4L), flight acceleration and shock profile
- Deploy student satellite payloads at 3-4km AGL
- Student autonomous satellites find their way back to pre-defined GPS coordinates on the Black Rock desert playa - ComeBack!
  - Fly
  - Crawl
  - Glide
- Resources
  - https://www.dropbox.com/s/9cqc000bp0jwlfp/Sport%20Rocketry%20ARLISS%201.2014.pdf?dl=0
  - https://www.dropbox.com/s/g7vl0qohn93aoco/ARLISS%20Rocketry%20Show%20Podcast.mp3?dl=0

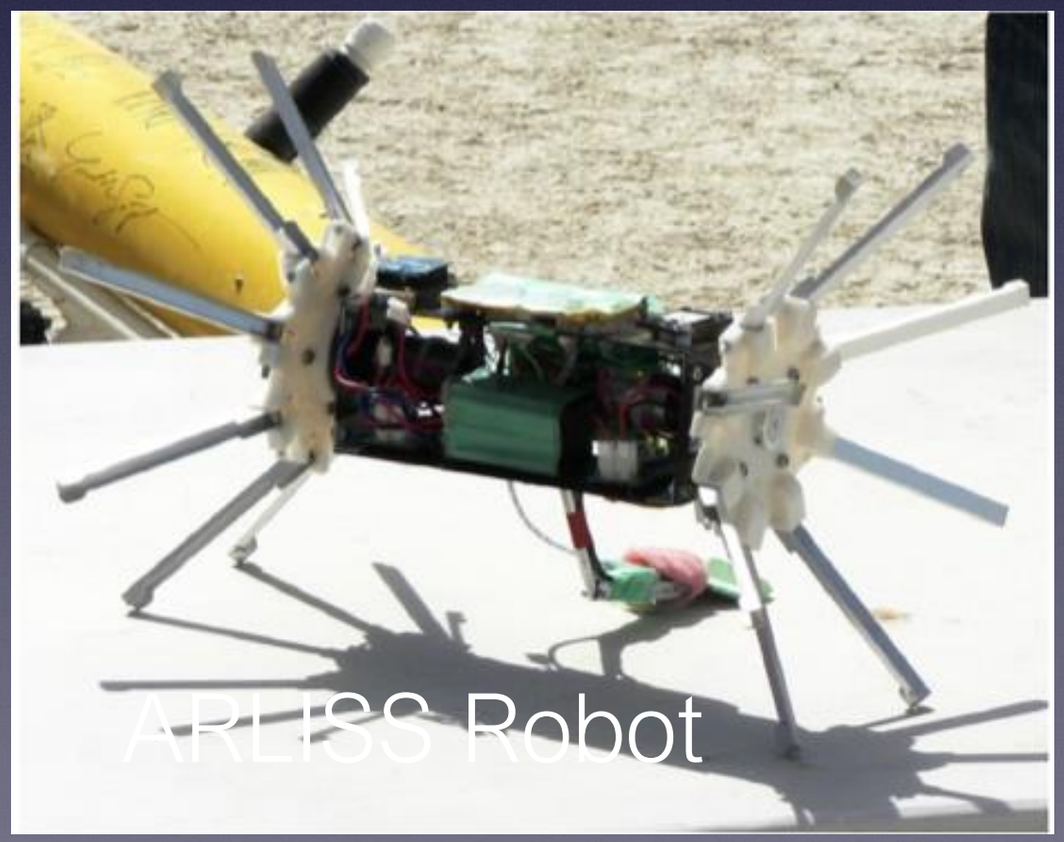




ARLISS Satellites



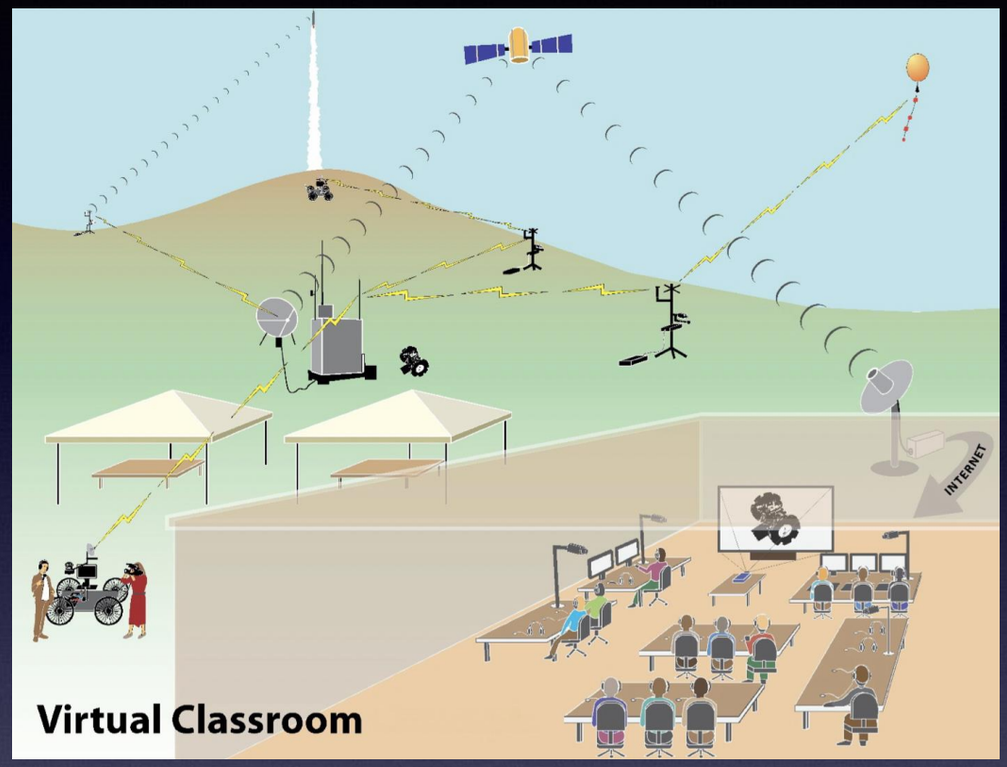




ARLISS Comeback Competition

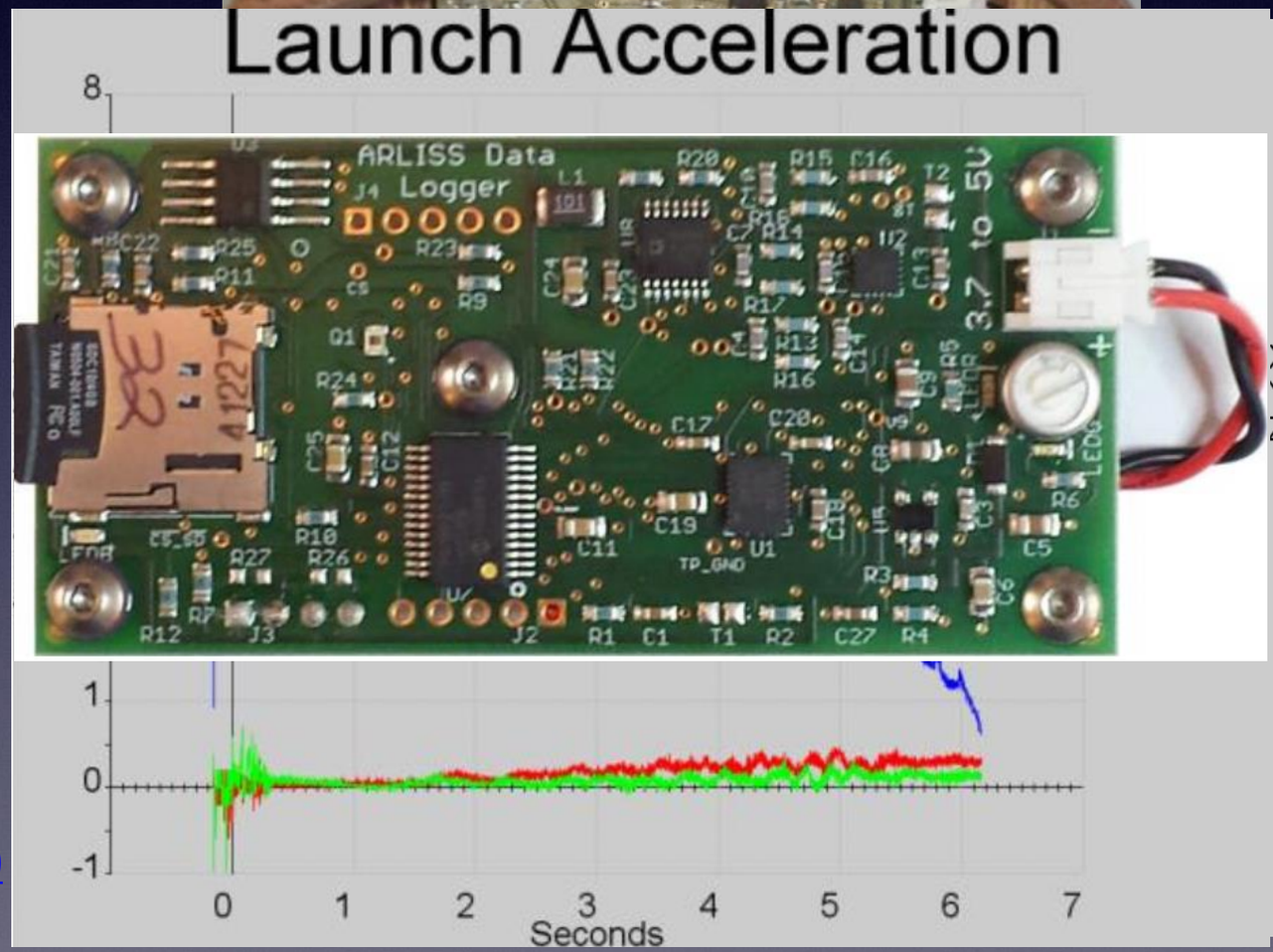
ARLISS Virtual Classroom

- Virtual presence for education, tracking, voice/Internet communication
  - Idea of Bob Twiggs + Ken Biba
  - 2006 thru 2016
- Implementation
  - Van with 40’ mast
  - Satellite + cellular Internet
  - Local servers
  - Local WiFi hotspots
  - Local UHF/VHF voice gateway
  - Local UHF/VHF tracking gateway
- Resources
  - https://www.dropbox.com/s/s82qdtlnrqz3qe5/Virtual%20Classroom%20Overview%202007.pdf?dl=0
  - https://www.dropbox.com/s/h5zuv403di5u6cy/Virtual%20Classroom%202014%20Pamphlet.pdf?dl=0
- Retired to become California emergency services asset



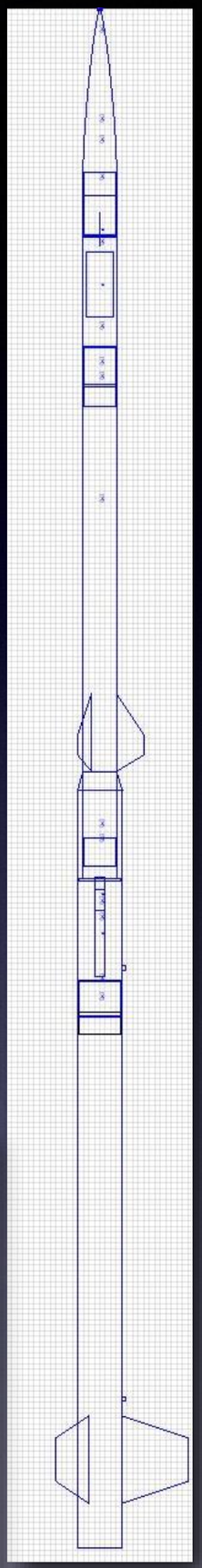
ARLISS Instrumented Deployment

- Document the flight stresses on payloads
  - Shock, vibration, acceleration
  - Fits in ARLISS M payload deployer
- Lead by Bob Feretich and his team (2012-2017)
- Measurement instrument
  - 200 G 3D accelerometer
  - 2000 degree/sec 3D gyro
  - 1.3 Khz data collection
- Great data
  - Flight events
  - Launch acceleration
  - Deployment shock
- Resources
  - https://www.dropbox.com/s/nlfsgmrod0h8wds/ARLISS%20Data%20Logger%20Project%20Part1.pdf?dl=0
  - https://www.dropbox.com/s/lqpuug5wj3peu78/ARLISS%20Data%20Logger%20Project%20Part2.pdf?dl=0



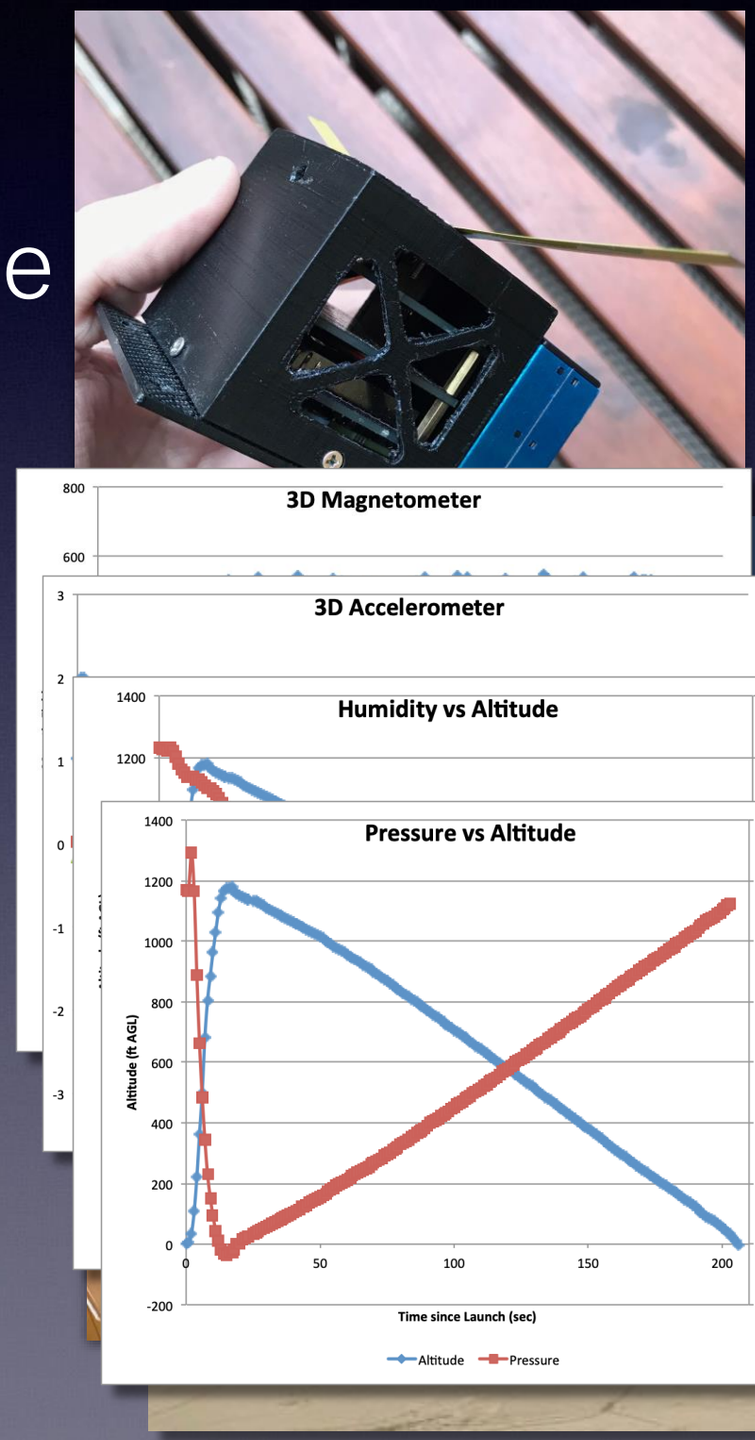
ARLISS EXtreme

- Low cost, reusable amateur sounding rocket
- Based on successful 2012 Carmack Prize winning system
- Science payload missions to 40-80 km
  - 3x1p, 1.5p, 2p PocketQube
  - .3 kg, 250 cm^2,
  - Possible to do real science
- Two stage, 4”->3” airframe
  - Off the shelf parts
  - Commercial rocket motors
- Fully recovered, reusable
  - Cost of propellant: ~$1500
- https://www.dropbox.com/s/gvydn018q448x63/AeroPac2012100kProgramReport.pdf?dl=0



ARLISS S4: Small Satellites for Secondary Students

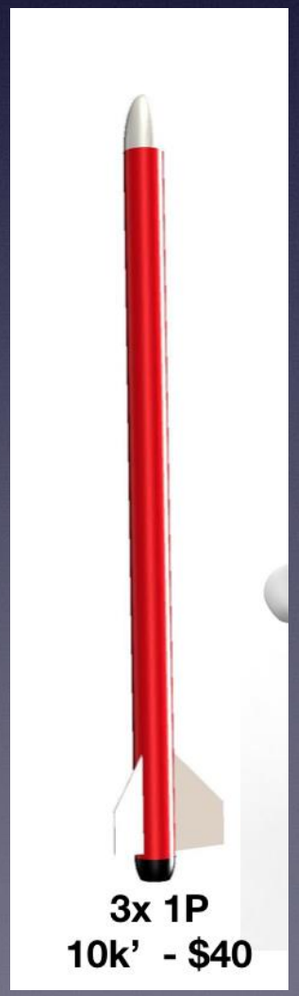
- PocketQubes as the New CanSat



- 3D printed 5 cm PocketQube package
- ARM/Arduino -C++/Python
- Many sensors
- LoRa wireless telemetry
- Design a mission
  - Measure flight dynamics
  - Measure air pollution
  - Measure plant growth
  - Measure water coverage
  - Recover an autonomous robot on virtual Mars
- Extensible to LEO

A Range of S4 Launchers

ARLISS
Classic K



3x 1P
10k’ - $40

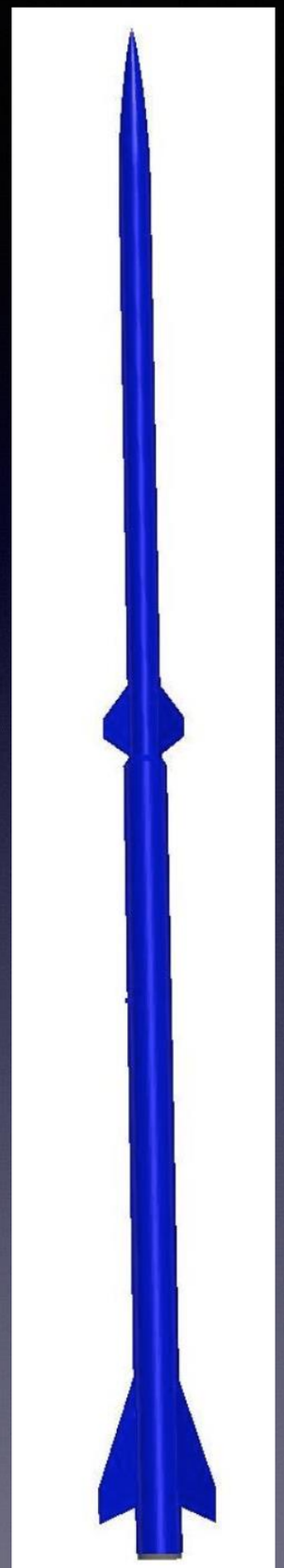
ARLISS
Lite

1x 1P
1k’ - $20

ARLISS
Classic M

12x 1P
10k’ - $40

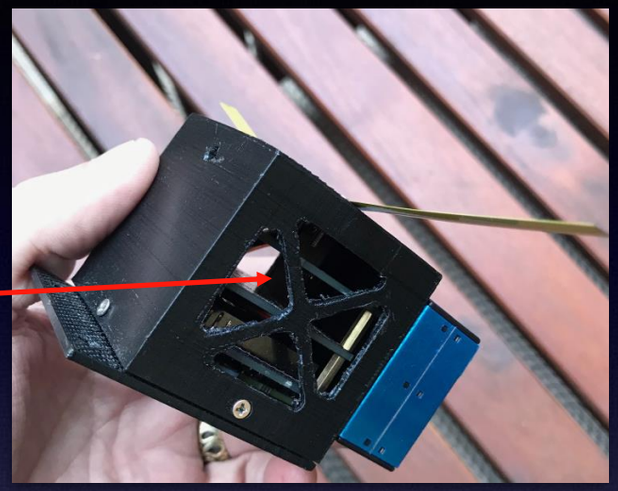
ARLISS
Extreme

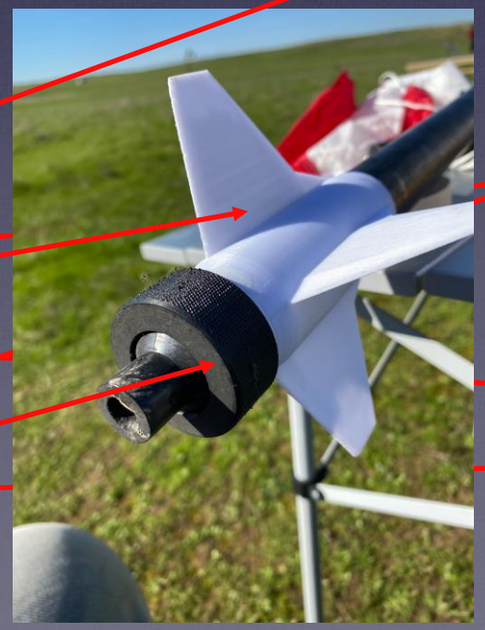


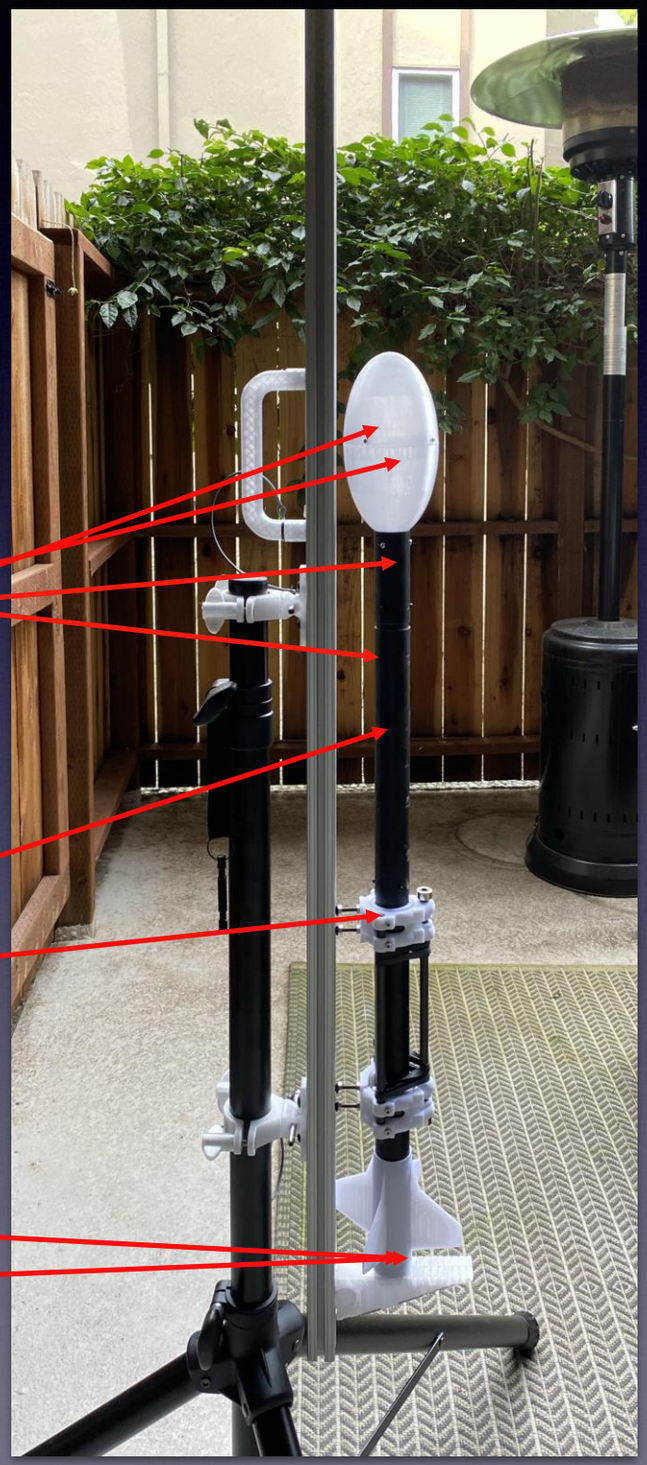
3x 1P
150k’ - $500

S4 ARLISS Lite Payload Rocket

- MPR/HPR carrier rocket for S4 satellite
  - Minimum subsonic drag for max altitude on less propellant -> min cost
  - S4 satellites
- Fiberglass body/coupler, 29mm
- Altus Metrum EasyMini avionics
- 3D printed (PETG)
  - Nosecone
  - S4 satellite payload
  - Flyaway launch system
  - Fin can
  - Recovery anchor
  - Motor retainer







ARLISS 2021

- AeroPac plans for the launch
- Likely availability at the launch site for ~150 people
  - AeroPac team vaccinated
- Big Unknown
  - International travel and COVID

It’s All Possible

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Make It So