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AEROSPACE
Assuring Mission Success

Project Hermes

"Use of Smartphones for Receiving Telemetry and Commanding a Satellite "

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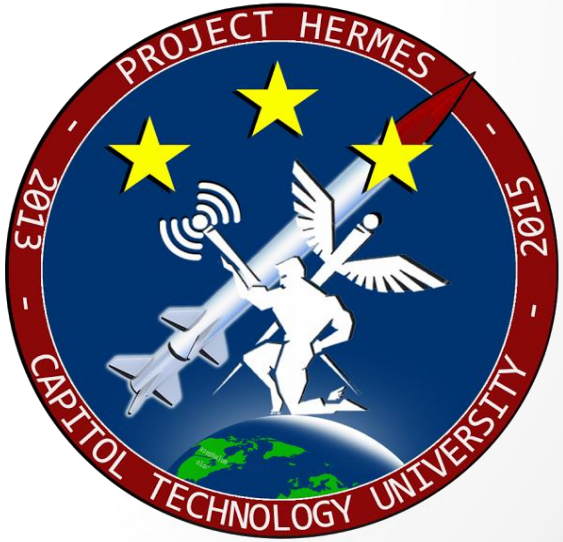


Project History

- Project Hermes was a concept that I developed while teaching an "Intro to Space" class in the Fall of 2013 at Capitol Technology University (CTU).
- The Project Hermes payload has flown onboard (3) high-altitude balloon flights
- Quick transition from high-altitude balloon flights in 2014… to space flight in 2015
- Extremely proud of the entire Hermes team
  - ***Aaron Bush, Jeff Williams, Carl Hansen, Anh Ho, Carlos Del Cid, Ben Serano, Dylan Rankin, Daniel Bottner, & Angela Walters***
  - **I would also like to thank the RockSat-X 2015 program and NASA Wallops Flight Facility for the opportunity to fly Project Hermes into space**

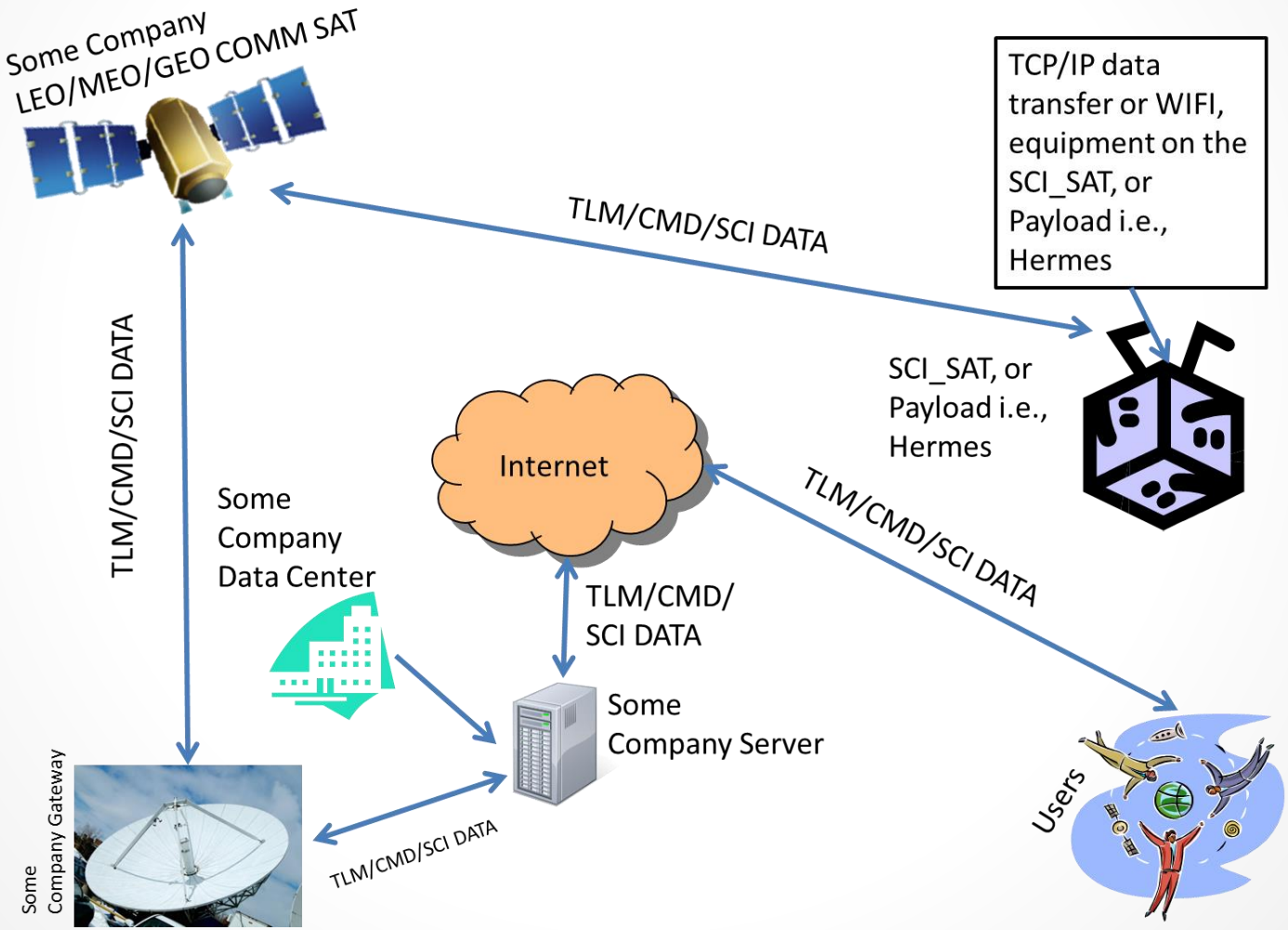
Project Goals

- To design and fly a mission using commercial off-the-shelf (COTS) TCP/IP Compliant equipment
- To test a TCP/IP based bus concept using TCP/IP protocol
- To simply use a web-based interface to send commands and receive telemetry, both on the ground and on the payload/satellite
- To Communicate via commercial satellite networks

The Idea…

1. Pair a smartphone to a communication satellite network compatible Wi-Fi hotspot device, this would create a WIFI Bus between the communication system and the smartphone
2. Use app stores to download apps that would allow the team to:
   a) Send commands to the smartphone in flight
   b) Receive Telemetry from the smartphone in flight
   c) Use the various apps as the flight software for the smartphone in flight
3. Use commercially available apps such as Gmail as our ground system for receiving telemetry and commanding

Concept Diagram



Sub-Orbital Flight

August 12th, 2015 at 06:04 EDT

NASA's Wallops Flight Facility

Total Flight Duration: 15 Minutes

Maximum Altitude Reached: 155.6 KM

Sub-Orbital Flight Achievements

1. Established a Wi-Fi network in space for system bus use

2. Paired an Android smartphone in space to an Iridium-based Wi-Fi hotspot device

3. Used & programmed various applications available on the Google Play store to function as our Flight Software (FSW)

4. Used TCP / IP devices (smartphone & smartwatch) on the ground as our Telemetry & Command System
   - **Smartwatch was used by my student (Aaron Bush)!**

Our Payload

Project Hermes Components - Flown on 8/12/15
LG Optimus G (Android Smartphone)
Iridium Go (Wi-Fi Hotspot Device)
USB Battery Pack (2-port), 9V Lithium Batteries
Arduino
Yoga Mats, Kapton Tape, Silicon RTV, DB-15 Power Pin
USB Cables, TNC-M RF Cable
Relay Circuit
Aluminum Boxes

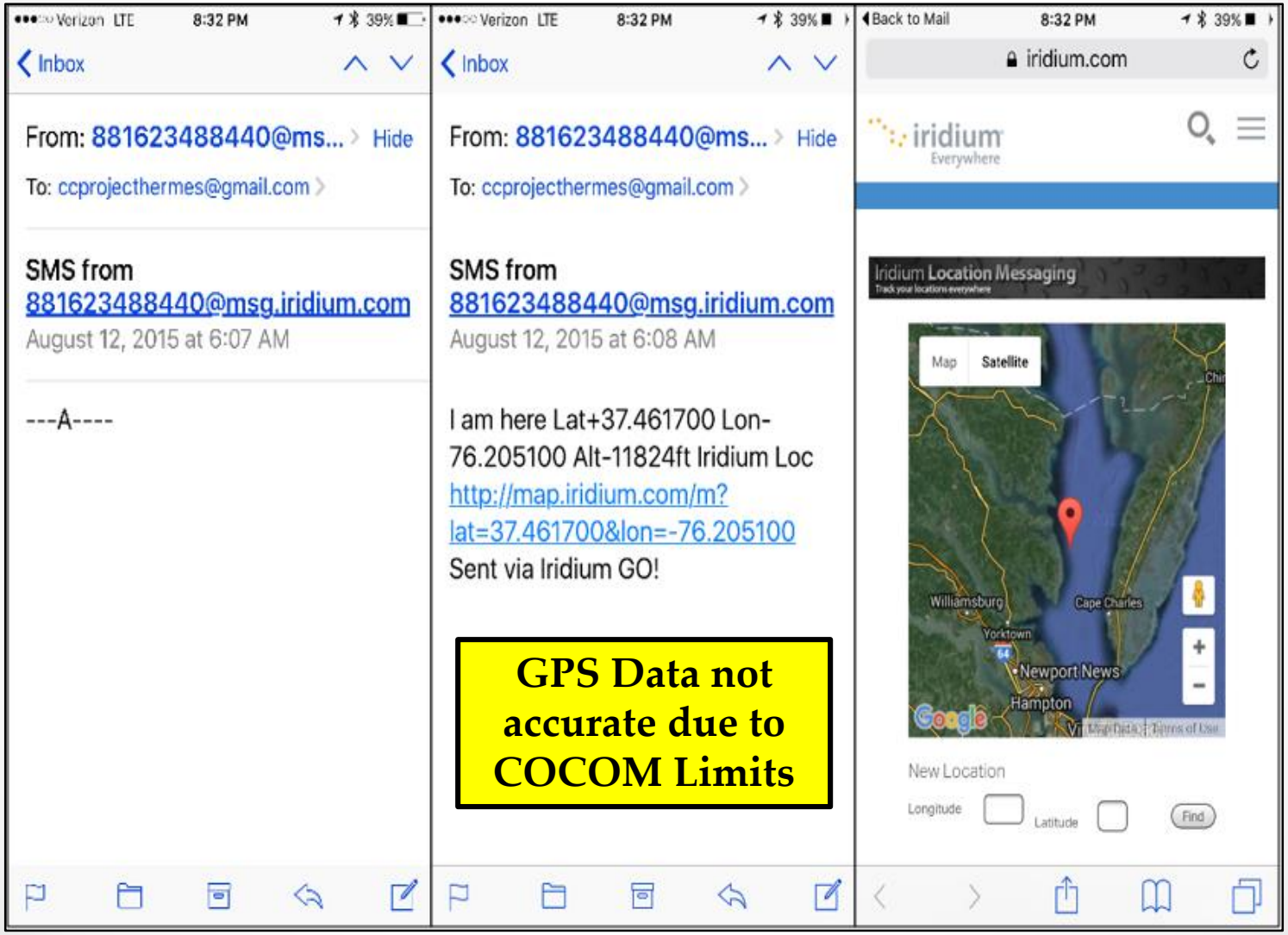
Links to Videos from our YouTube channel

- https://www.youtube.com/watch?v=zGcHYlxdTc4
  - (Shows launch as seen from my PI's phone)
- https://www.youtube.com/watch?v=R7cdO9cPnCY
  - (Video recorded by Colorado University Boulder; you can see our planet Earth, rocket parts, our antenna)
- https://www.youtube.com/watch?v=G548GDgeWj4
  - (Video from our MOC (a tent on the launch pad and our victory cheer while calling the mission sequence))

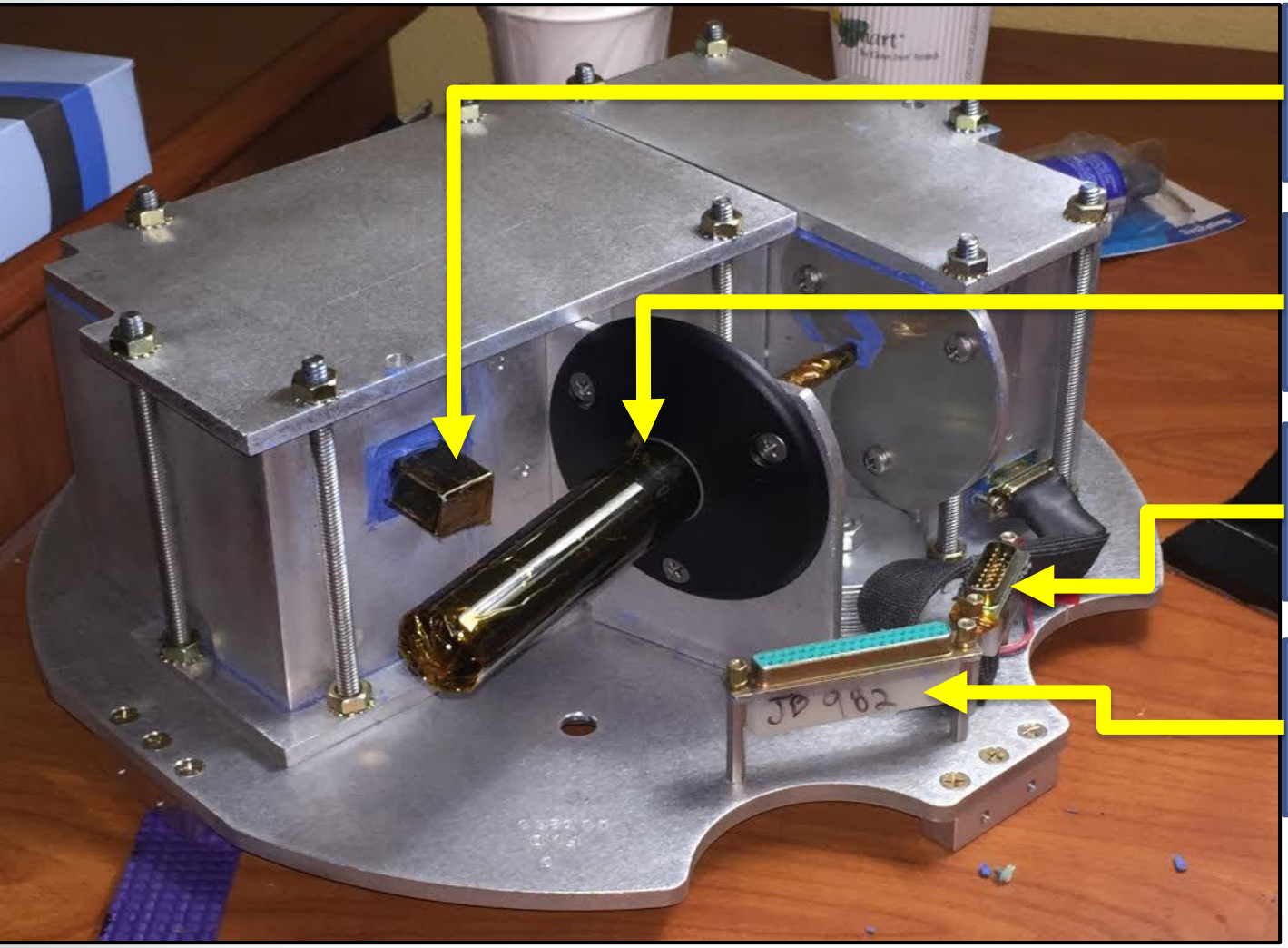
Facts to be Considered...

- The main goal was to demonstrate a proof of concept by downlinking the simplest of data
- We were expecting data at 3 min and 30 seconds into flight, and as is obvious from our video of the launch, that's **EXACTLY** when we received the data!
- We proved that one can use Wi-Fi for a system bus on a space-bound payload
- **Note:** One ***incredible*** feature of our versatile system is that our Mission Operations Center (MOC) was nothing more than a camping tent and a few wireless devices

Types of Data Received



Project Hermes Payload (Pre-Launch)



GPS Antenna

External Iridium Antenna

Timer Event Line Power Connector

Telemetry Connector (not used)

Security Info

- **The goal of the project was not to test security features, but *there are ways* to provide internet security to this bus concept**
- Project Hermes *did* fly a software-based firewall; it wasn't activated, but we did fly it
- The team could have installed security based apps such as McAfee on the Android phone
- The team could have also installed malware detection software on the phone

Thoughts on the TCP/IP Bus

A Non-IP Bus issue

- Each satellite is typically custom built and has many ***proprietary*** interfaces
  - Usually bus/parts/instruments are provided by different vendors
  - Not all ICD documents are successful at uncovering and/or documenting each hardware issue
    - Issues are usually found much later in the game during integration and testing, while the instrument or system is not in the hands of the vendors

Benefits of the TCP/IP Bus

- A Common IP interface could reduce costs, as well as reduce required design, build, & test time for the satellite
- A Common IP interface would also allow for each part/instrument to have a more plug-and-play type of capability, much like a common printer
- Testing can begin while the parts/instruments are still in the possession of their respective vendors
  - This allows simulation with the ***actual satellite*** itself

Communications Advantages of Systems Like Project Hermes

- FOT can get satellite health & safety data at ***anytime***
- Since the data is via the internet, we can use secure servers to monitor the satellites from ***anywhere***
  - Depending on the communication system of choice, one is not required to wait for a ground-based contact
- Scientists can have *direct access* to the satellite for science requests
  - Science data can be *transferred directly* to a cloud server from the satellite itself
- Depending on usage, the project can choose Iridium plans ranging from $50-130/month (this charge **includes** the use of Iridium gateways)

Track a CubeSat….Take a Hybrid Approach?

- CubeSats are hard to track when initially launched, so concepts developed by Project Hermes could be used onboard a CubeSat to:
  - Send out beacons that may include: GPS & basic HK data
    - These messages don't require a conventional T&C, therefore, the operator can be ***anywhere***
- "Big Banner" satellites can fly a Project Hermes type system as a redundant COMM or instant alert for the FOT
  - Various communication satellite networks available based on desired altitude and inclination, i.e., Iridium, Globalstar, Inmarsat, Thuraya
- Also good for suborbital and or high altitude balloon flights

The Way Ahead…

- Seeking a US Patent and wanting to:
  - Develop a satellite system bus and set of components that are TCP/IP compliant
  - Develop flight software that will support TCP/IP compliant bus/satellite hardware
  - Develop a TCP/IP compliant and Web-based T&C system

The End…

- Thank you for your time
- Any questions? Comments?