OPEN CORE SUMMIT

Lowering the Barrier of Entry in Electric Propulsion for Nanosats Through Open Source Development

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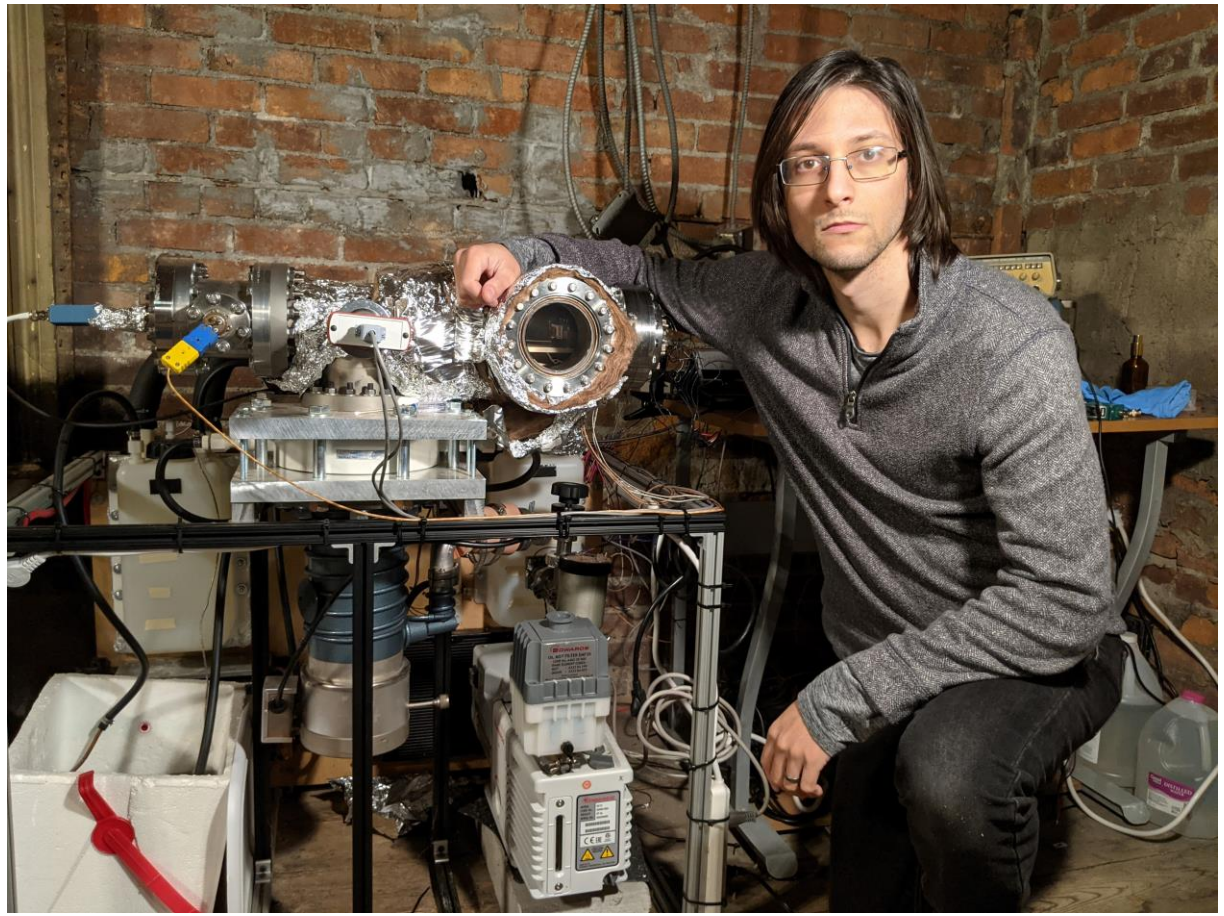
Founder – Applied Ion Systems
@Applied_Ion

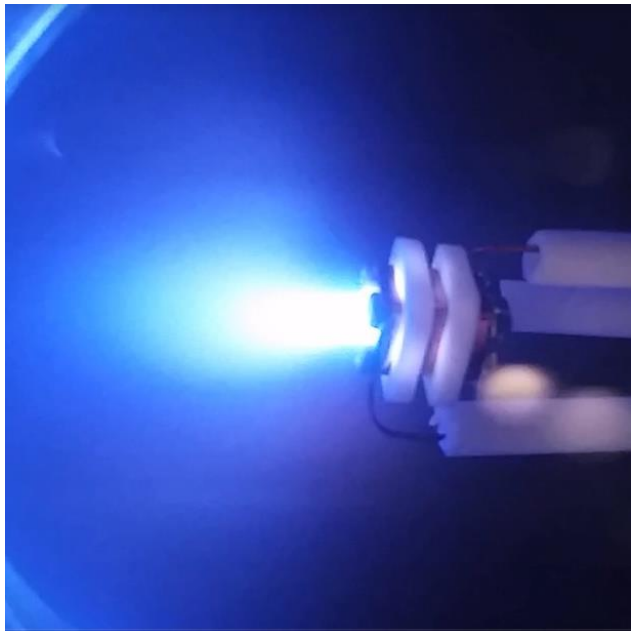
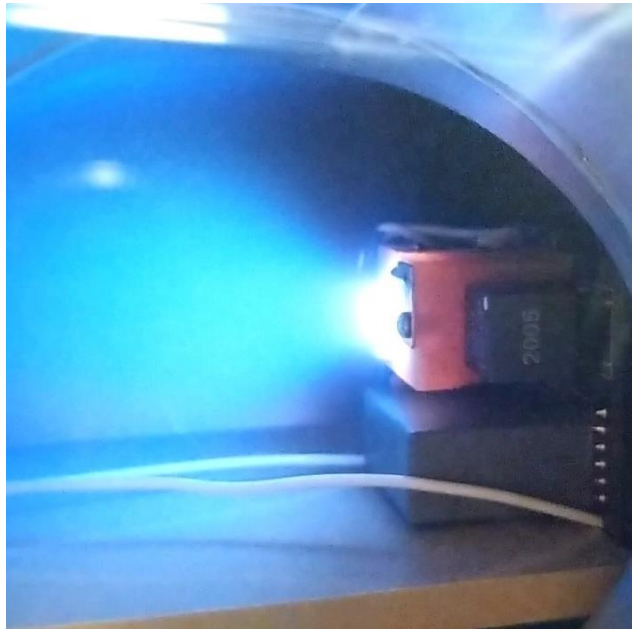
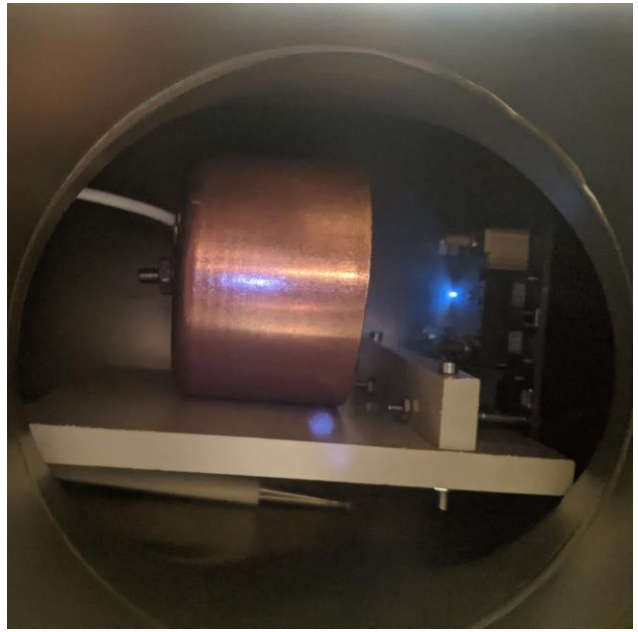
Background



- Founder of Applied Ion Systems
- Only official independent “homebrew” R&D program for advanced plasma/ion thruster development
- First and currently only open source electric propulsion company
- Started from a side hobby in the basement and passion for making

What is Electric Propulsion (EP)?

- Generating thrust by imparting electrical energy to ionize and/or accelerate fuel
- DC, AC, RF, Pulsed, Resistive Heating, Laser
- Gridded ion, RF plasma, Hall Effect, FEEP, VAT, PPT, etc.

Why Do We Need Propulsion?

- Maneuverability in Space
  - General station keeping (extending lifetime)
  - End of Life deorbiting (mitigating debris)
  - Orbital transfers
  - Collision avoidance
  - Formation flying
  - Precision pointing/attitude control
  - Supporting deeper space missions beyond LEO

Not every mission needs propulsion though!

Current Issues Facing the EP Field

- **Exorbitantly Expensive**
  - $40k to $100k+ (just for nanosat systems!)
  - Most nanosat teams cannot afford propulsion
- **Lengthy Development**
  - ~10-15 years from initial concept to first prototype testing in space
- **Traditionally Extremely High Barrier of Entry**
  - Vacuum testing infrastructure, diagnostics, system development, advanced manufacturing

Current Issues Facing the EP Field

- **Single Stream Development**
  - Start-ups usually an academic spin-off
- **Funding Structure**
  - Multi-million dollar government grants, military, academic
- **No financial incentive for anyone to develop propulsion for low-cost, entry level access**
  - *Current structure and mentality of the EP field makes it impossible to develop technologies at an affordable cost*

Current Issues Facing the EP Field

- **Lack of Transparency**
  - Excessive sensationalism
  - Overplaying “sci-fi” card, making it appear ultra-futuristic, out-of-reach, new, revolutionary
  - Hyping up launches/groundbreaking first tests, refusal to publish orbital test results
  - Presenting only best case hypothetical performance
  - Obfuscating critical performance constraints
  - Overall highly secretive/stealth mentality

Why Open Source?

- Help make advanced/costly technologies more accessible
- Brings it to a level anyone can approach
- Contributing to the community
- Lower cost development
- More rapid development
- Lower barrier of entry

Challenges of Open Source Hardware

- Less clearly defined compared to software
- Less licensing options
- Challenges and concerns with protecting IP, design, and innovation
- Relatively newer movement
- Physical, tangible objects

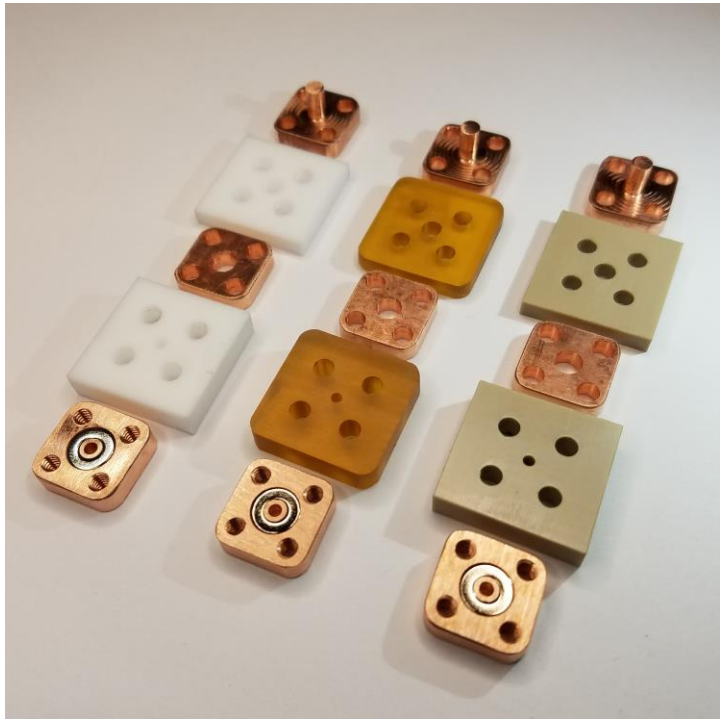
While there is already a very large and well-established open source hardware community, it is still very underdeveloped in the space community.

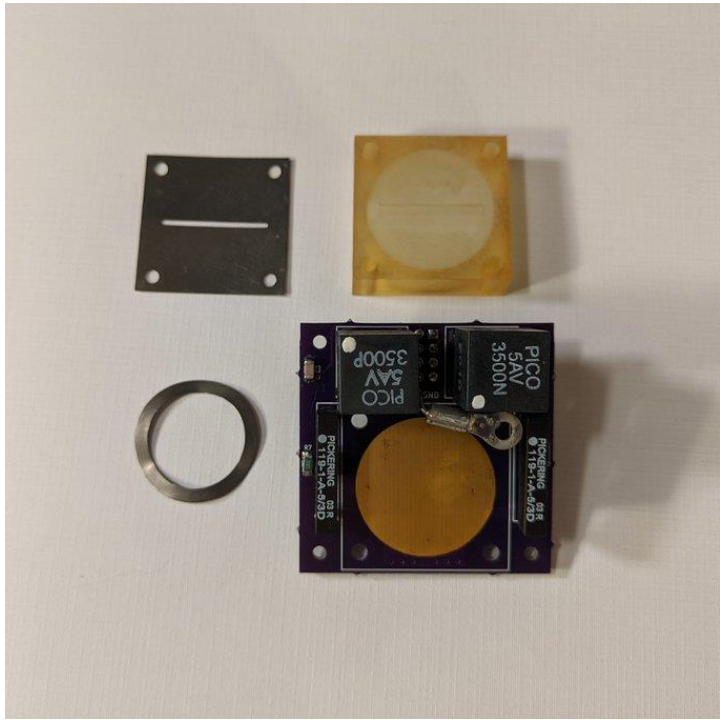
The Applied Ion Systems Approach

- Transparent, open development
- Focus on simplified, low-cost systems
- Manufacturing/assembly with limited resources
- Close engagement with nanosat, educational, enthusiast, and maker communities

Lowering the Barriers:
Low Cost, Simplified Design

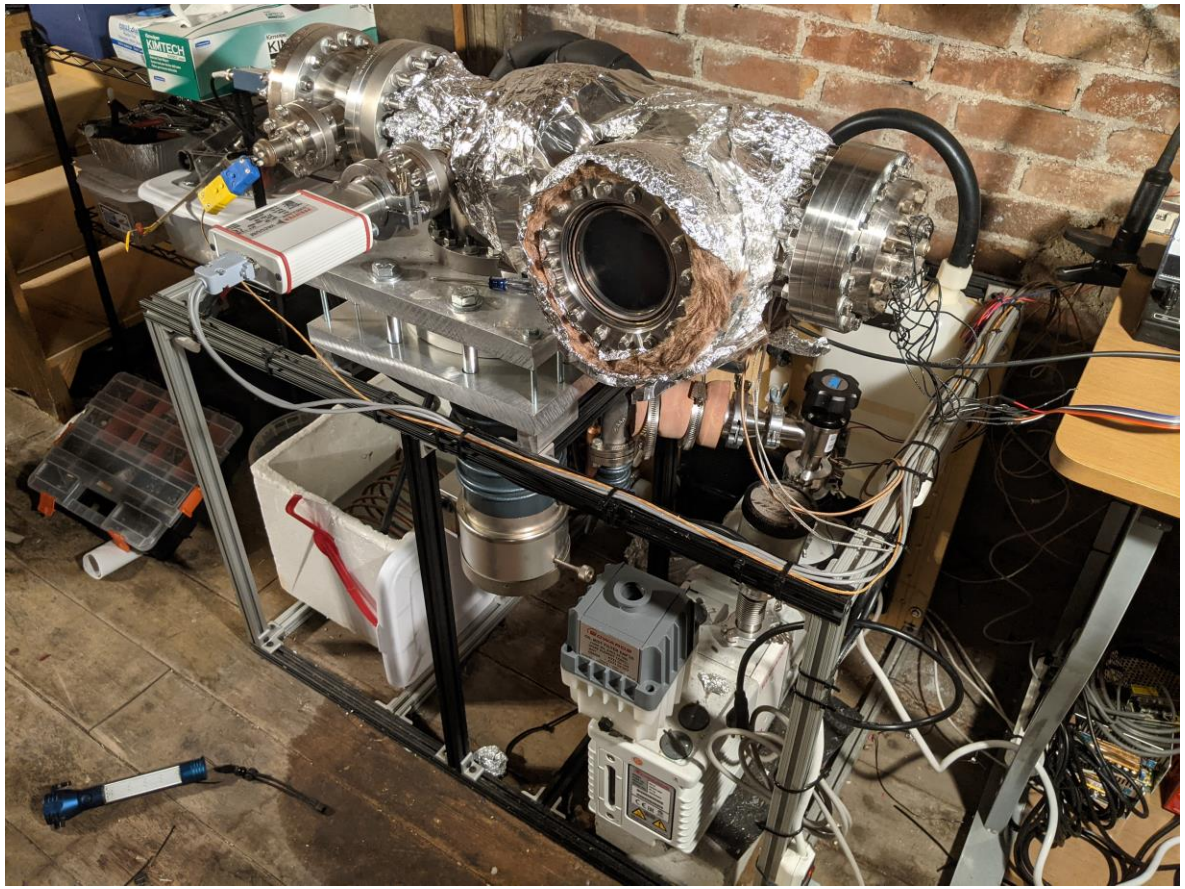
- Develop systems on an incredibly low budget
- Limited resources and manufacturing capabilities
- Ease of manufacture, assembly, and control





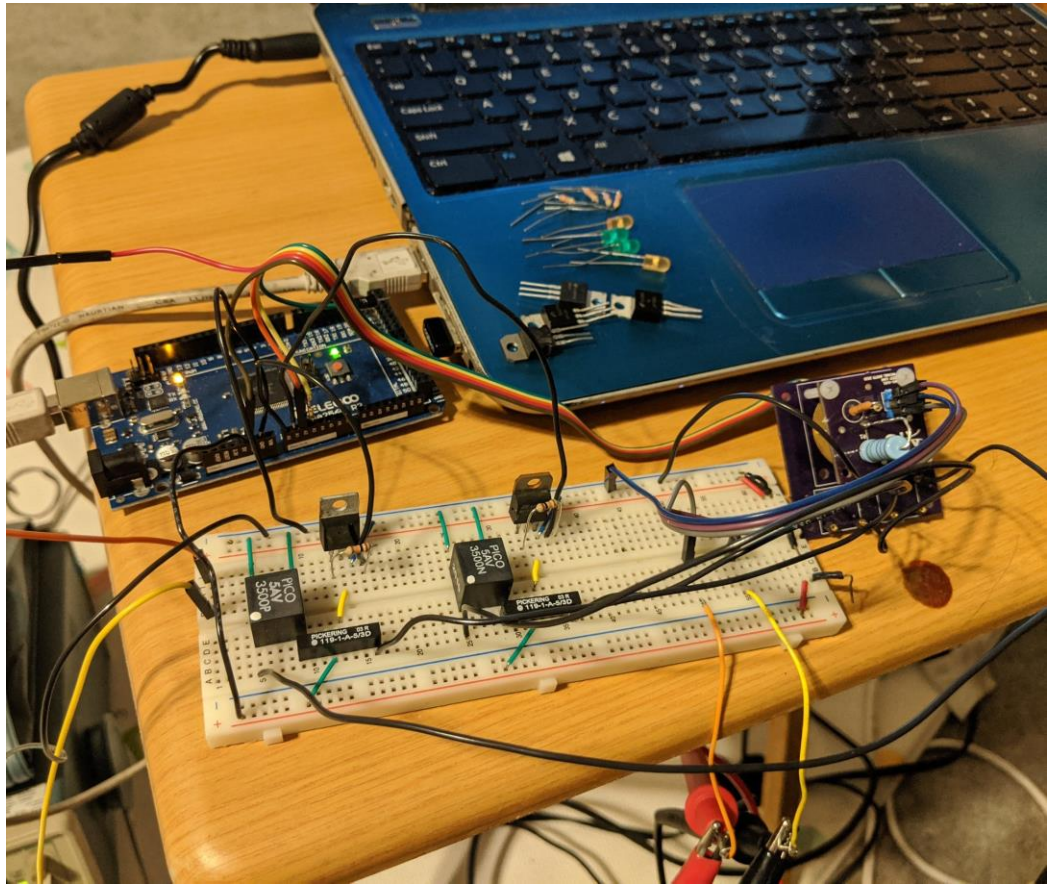
Lowering the Barriers: Simplified Testing Infrastructure

- Conduct tests with high compact/modular vacuum infrastructure
- Leveraging free design software (MOLFLOW+, TRIM, FEMM, etc.)
- Demonstrate propulsion testing at this scale



Lowering the Barriers: Open Design, Testing, and Development

- Design, prototyping, testing, and development openly shared
- Significant documentation of builds along every step
- Live Tweeted/streamed propulsion tests
- Engaging with the community

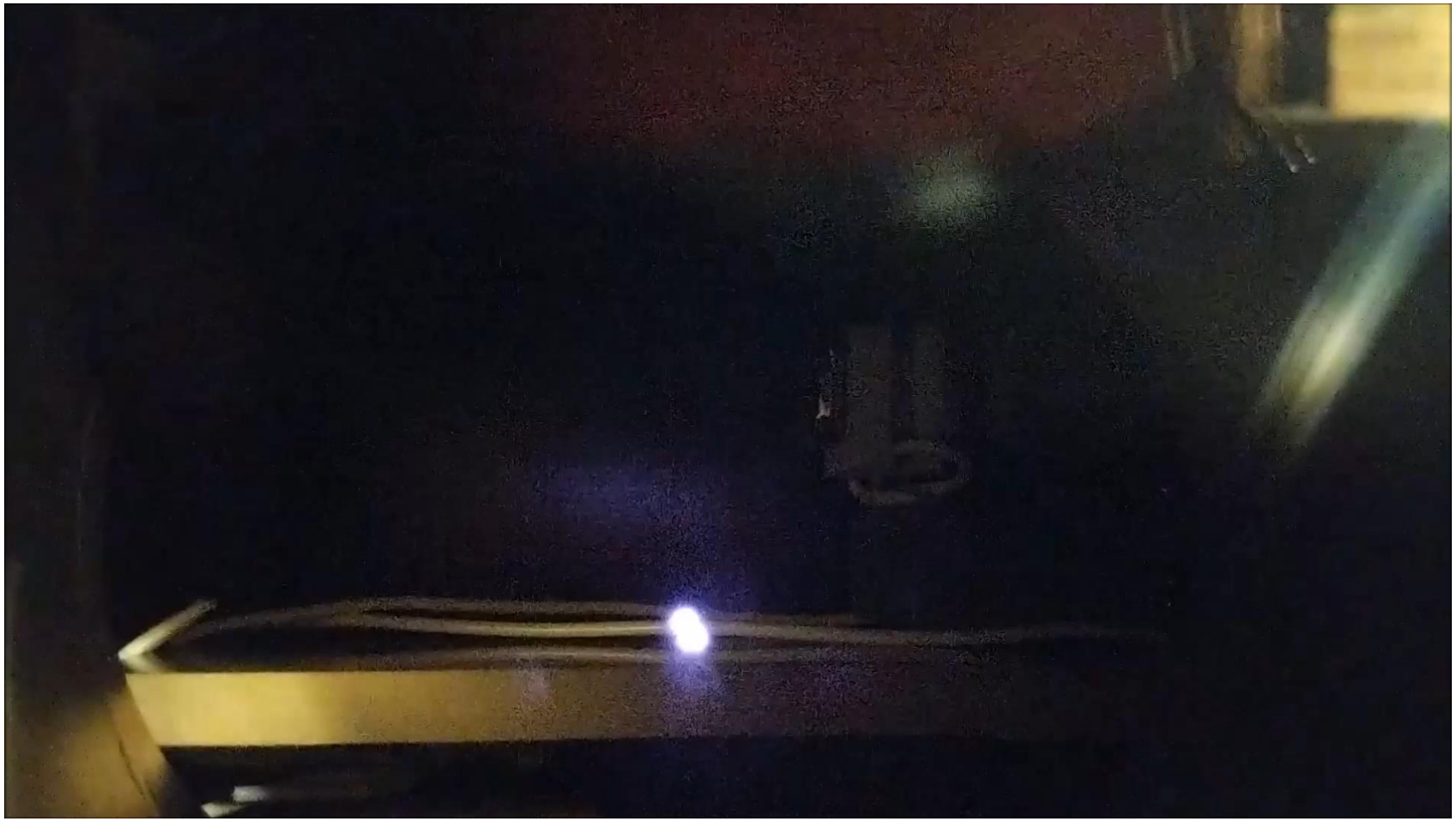


Lowering the Barriers:
Open Source Hardware Licensing

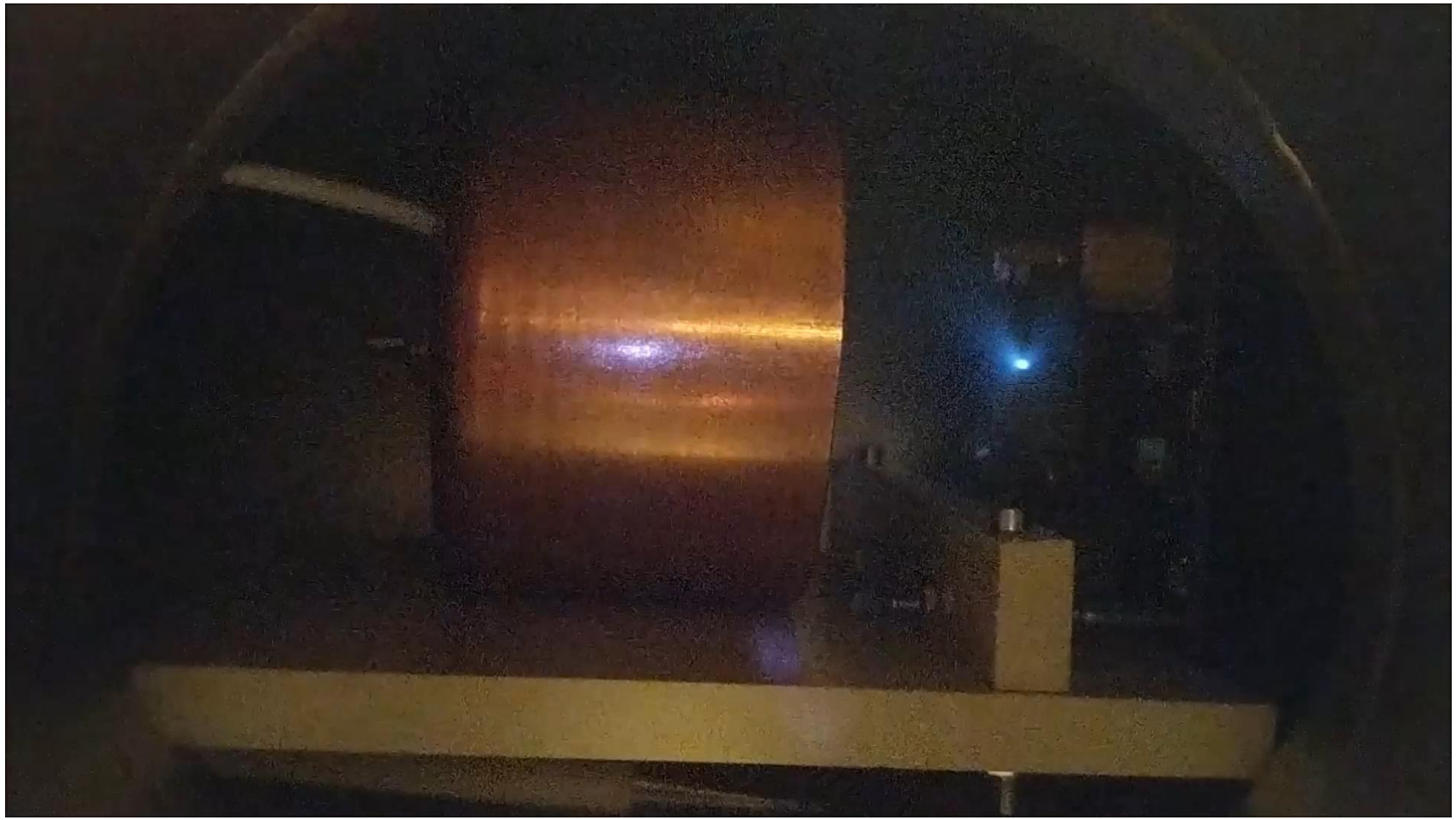
- Currently using CERN Open Hardware License V2 (Strongly Reciprocal Version)
- CAD, PCB, BoM, schematics, pictures, and test reports openly available (both successful and unsuccessful builds)

Open Source Thrusters In Action!
The AIS-gPPT3-1C

Open Source Thrusters In Action!
Hybrid gPPT3/EPPT1



Open Source Thrusters In Action!
The AIS-ILIS1



Open Collaboration – Demonstrating the First Open Source Thrusters to Orbit

- Joint open-source international collaboration: AMSAT-Spain, Fossa Systems, Libre Space Foundation, Applied Ion Systems
- GENESIS N and L 1.5P PocketQubes (EA), PICOBUS Deployer, (Fossa/Libre Space), Plasma Propulsion (AIS)


FOSSA

Libre Space Foundation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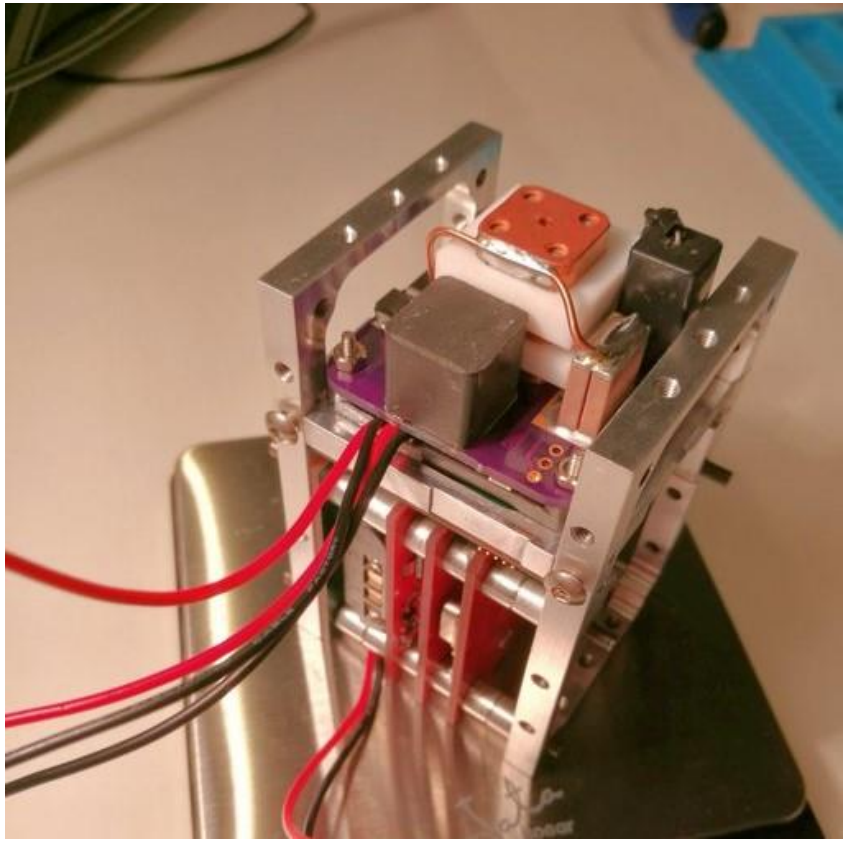

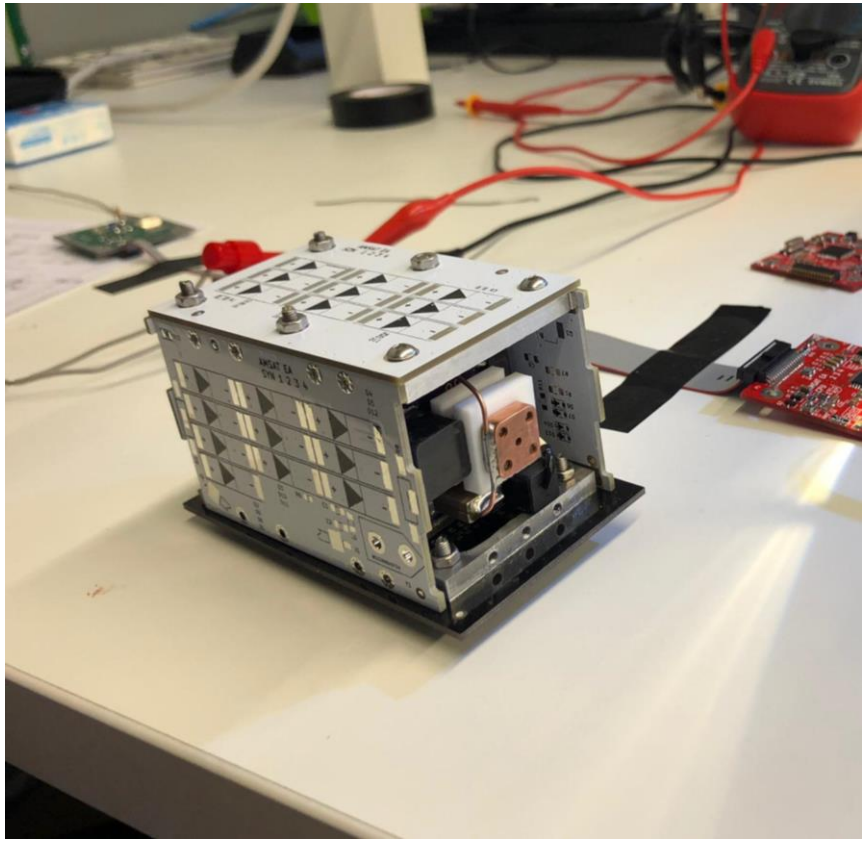

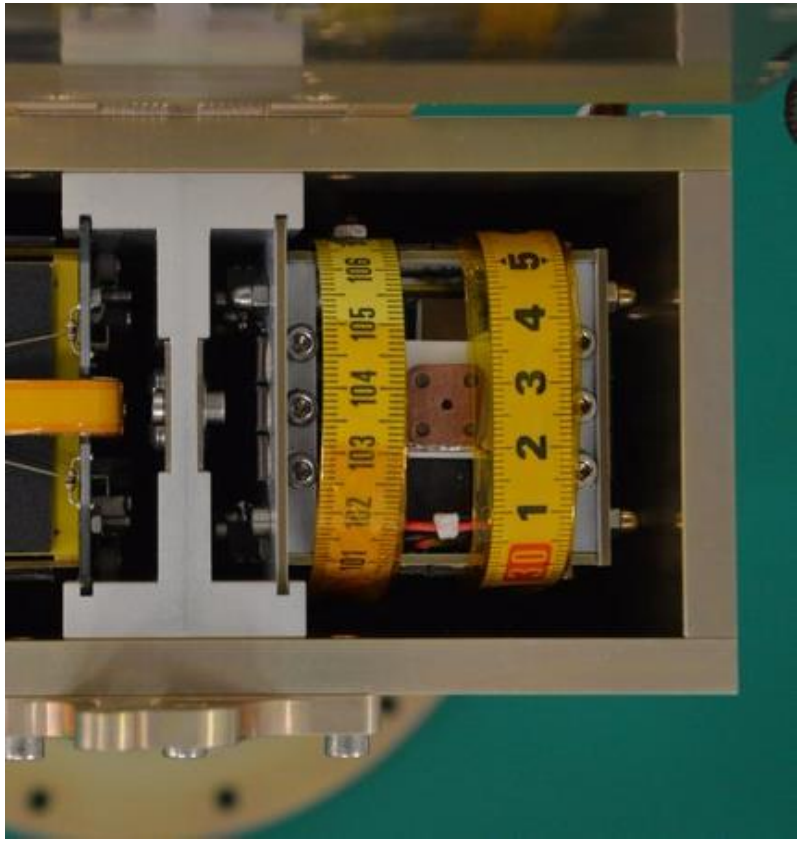

An Unconventional Journey: How Open Source Has Shaped AIS

- Visibility
- Unique identity in the field
- Unique niche
- Incredible support from the community
- Opportunities to collaborate
- Opportunities to share this effort around the world
- Send systems built on the table at home to space!

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Thank You