



# **MACH 30**

**FOUNDATION FOR  
SPACE DEVELOPMENT**

## **2014 Annual Report**

*01 January - 31 December 2014*

Mach 30  
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## Message from the President

If you compare the history of Mach 30 to the launch of a rocket, our founding in January 2009 would be ignition. By forming a non-profit corporation, the original founders committed to a future where access to space was available to everyone. After ignition comes liftoff, the moment when the rocket takes its first clearly visible steps toward space, and for Mach 30, the idea was brewing for quite some time before we received our 501c3 status, our own personal liftoff day. Being recognized as a public charity demonstrated publicly the Board's commitment to seeing the Mach 30 vision become reality. And in 2014, Mach 30 cleared the tower at its Apogee I event.

Apogee I, and 2014 in general, represents a turning point for Mach 30 as it moved from being a board only organization to an organization made possible by a community of volunteers around the country. Unlike a certain famous rocket company that started out with a billion dollars, Mach 30 started with three people meeting around a kitchen table plus three more who had to join in over a phone bridge. This team of founders were not sure there was enough work to warrant monthly board meetings; now Mach 30 volunteers meet two or more times per week over Google+ Hangouts and there is enough work to push toward funding part time and eventually full time positions.

And Mach 30's work is of monumental importance. Unlike everything that has come before, when Mach 30 solves a problem (technical, legal, business, or otherwise) we solve it for the world. When our government, or that certain rocket company, solves a problem the solution (no matter how critical) is locked up behind layers of security and intellectual property ownership, making the problem essentially unsolved for the rest of us.

In 2014, Mach 30's work covered fields ranging from satellite communications to open source hardware processes, from export controls to open source CAD tools, and from public events to rocket test stands. I am humbled and honored by the contributions of each and every volunteer; Mach 30's accomplishments would not be possible without them. Mach 30 has truly grown from my "crazy idea" to an organization that will change the world.

*ad astra per civitatem,*



J. Simmons, President Mach 30



# Open Source Spaceflight Hardware (OSSHW) Programs

Mach 30 activities for 2014 included several projects, from Open Source Hardware (OSHW) to Open Source Software (OSSW), and also included policy related to these in the form of working to become fluent in Export Control regulations and their impact on Mach 30 activities. These programs include rocket motor testing in the form of the Shepard Rocket Motor Test Stand, satellite communications with the Ground Sphere Satellite Receiver, hardware modeling through CadQuery, and the Export Control Task Force's activities around export control regulations.

The Shepard Rocket Motor Test Stand was the first rocket motor test stand developed by Mach 30, after Alan Shepard, the United States' first astronaut, as well as Mach 30's first OSHW and first OSSHW project. It is the first in a series of projects intended to develop the required skills for the practice of safe rocket motor operation, and to measure and record data about a rocket engine's performance. Shepard was reproduced by one of our educational partners, CCSSC<sup>1</sup> in 2014 in order to teach middle and high school students hands-on rocket science, safely. The thrust measurement component of Shepard was also adapted to help support research on rocket fuel configurations by Jones Boys' Rocketry. This was done as a science fair project, and helped Christopher of Jones Boy's Rocketry to win a 3 day workshop at NASA's Goddard Spaceflight Center. Both of these instances show the effectiveness of the Mach 30 OSHW development model.

The second OSHW project Mach 30 has undertaken was started in 2014, with the prototype Ground Sphere Satellite Receiver. This is a joint project between Mach 30 and Southern Stars Group, LLC. Southern Stars had successfully completed a Kickstarter campaign to launch a small CubeSAT named SkyCube. Mach 30's part of the partnership was to take the lessons learned from an earlier ground station and create a low cost satellite ground station so backers, students, and space enthusiasts could listen to SkyCube tweet from space. Unfortunately, SkyCube did not deploy properly after being launched from the International Space Station, and so Ground Sphere was not able to be fully tested for its intended purpose. The lessons learned from this project have had a wide reaching impact on Mach 30, and were a primary catalyst in the creation of the Mach 30 Open Source Hardware Ground Rules.

In support of future OSHW projects, Mach 30 volunteers have approached the developers behind CadQuery in hopes of contributing to its growth and maturity, and have contributed several notable additions. The Mach 30 hardware team has struggled with the selection of open source CAD software that's currently available. In this search for software that would fit Mach 30's needs, the hardware team adapted their approach to assume that they would create or contribute to a CAD package to help add features Mach 30 needed. After an in-depth research and evaluation process, the hardware team identified CadQuery as a potential candidate.

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<sup>1</sup> Coca-Cola Space Science Center (CCSSC) - Columbus State University, Columbus Georgia.  
<http://www.ccssc.org/>



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Please see the "Invited as a Contributor to CadQuery" item in the Highlights section to find out how things have progressed.

Mach 30's Export Control Task Force (ECTF) has continued their vital work on understanding export control regulations, and how to mitigate the risk of violation to Mach 30 in future OSSHW projects. There are a number of export control regulations that Mach 30 hardware projects may fall under, thus making this an important activity to ensure Mach 30's future. Organizations who want to share designs openly, like Mach 30, must do that in accordance with the laws and regulations of the country they live in. To help make that process easier, the ECTF is creating documents such as the ITAR-EZ, and the TCP (Technology Control Plan) template. This is very much in keeping with the spirit of "a rising tide helps all ships", which is at the core of the Mach 30 ethos.

The efforts undertaken in these projects have been critical to gain knowledge, expertise, and technologies that enable future growth. In the coming years, Mach 30 aims to complete a number of these projects and add others, and will make an even bigger impact on both OSHW and the Spaceflight community.



## Highlights of 2014 Accomplishments

This year was filled with new beginnings, project endings, and many great accomplishments. These accomplishments were primarily within OSHW and the community, but can also help to educate in several cases.

The Open Source (OS) contributions of Mach 30 over the year included not just hardware, but software contributions as well. First, Jeremy Wright, a Mach 30 board member, was also invited to contribute to CadQuery, an open source parametric CAD modeling tool, and in that capacity is developing technologies Mach 30 will need in the future. Second, a prototype for a ground station was completed in the Ground Sphere satellite receiver.

Beyond OS contributions, Mach 30 had a number of accomplishments related to its communities. The first of these accomplishments was Apogee I, for both engaging the community and enhancing our planning processes. We also began our engagement with the US Department of State regarding export control regulations in our effort to better understand the regulations, and be able to help others within the Open Source Hardware (OSHW) community navigate export control regulations. Lastly, the work of Mach 30 president J. Simmons was included in the book *Building Open Source Hardware* by Alicia Gibb, founder and executive director of the Open Source Hardware Association (OSHWA).

### Apogee I

Mach 30 held its first ever community engagement event last summer. We partnered with the Club Cyberia Hackerspace in Indianapolis, IN to host a space-related micro-maker faire, demonstrated the Shepard test stand by firing off several Estes motors, and held our first volunteer recognition dinner party. It was great fun to take a step out of the virtual and directly engage with our community in person.

### ECTF Engagement with U.S. Dept. of State

Mach 30's Export Control Task Force (ECTF) made great progress towards managing export control (EC) regulations. This is not a glamorous job, and certainly garners less excitement than the smoke and flames from a rocket motor test, but nonetheless this work is just as important for Mach 30's long term success. Last year the ECTF recruited an EC consultant, digested the applicable portion of ITAR & EAR regulations, and began planning how to conduct Open Source Hardware projects within these guidelines. Even though we did not get the offer of support that we wanted from the State Department, we did open the dialogue. This correspondence sets the stage for more follow up discussion.



## CadQuery Contributions

Jeremy Wright, Mach 30 Board Member, was invited to be a contributor to the open source CAD software package called CadQuery. Jeremy began contributing to CadQuery after the Mach 30 hardware team identified the lack suitable open source CAD as a road block to Mach 30’s hardware projects. Jeremy led a discussion session at Apogee I about CadQuery, which collected good feedback and sparked several conversations both inside and outside of the session. An informal roadmap of Mach 30’s anticipated CAD needs was developed, and the feedback given during Apogee I was incorporated directly into a CadQuery GUI that Jeremy later developed. The creation of this GUI was something that was sorely needed, and has greatly accelerated the adoption of CadQuery by users. CadQuery is shaping up to be the first in a suite of tools developed and packaged by Mach 30 to aid in spaceflight hardware design.

## Contributions to Alicia Gibb’s book *Building Open Source Hardware*

Alicia Gibb, founder and executive director of OSHWA, invited Mach 30 president J. Simmons to contribute lessons learned from Mach 30 projects to her book on developing open source hardware. J.’s contributions covered ground rules for developing and documenting OSHW and a test to determine when a project’s documentation is complete. These lessons are included as an anecdote in *Chapter 2: OSHW Definition and Best Practices* and as *Appendix E: Mach 30’s Documentation Ground Rules*. It was an honor to be included in such a seminal work for the open source hardware movement.

## Prototype Ground Sphere Satellite Receiver

The Mach 30 engineering community completed the design and prototypes for the Ground Sphere CubeSat Ground Station. The development of Ground Sphere was done in partnership with Southern Stars to support their KickStarted CubeSat SkyCube. Ground Sphere was a derivation of earlier ground station research performed by Mach 30 volunteer Aaron Harper specifically tuned to SkyCube’s operating frequency. Unfortunately, SkyCube did not deploy properly once placed in orbit preventing the Mach 30 engineering community from receiving signals from SKyCube. Developing Ground Sphere was an exciting project and provided numerous lessons in satellite communication and in open source hardware processes. No future development is planned for Ground Sphere as no other publicly available satellites currently operate on SkyCube’s frequency.

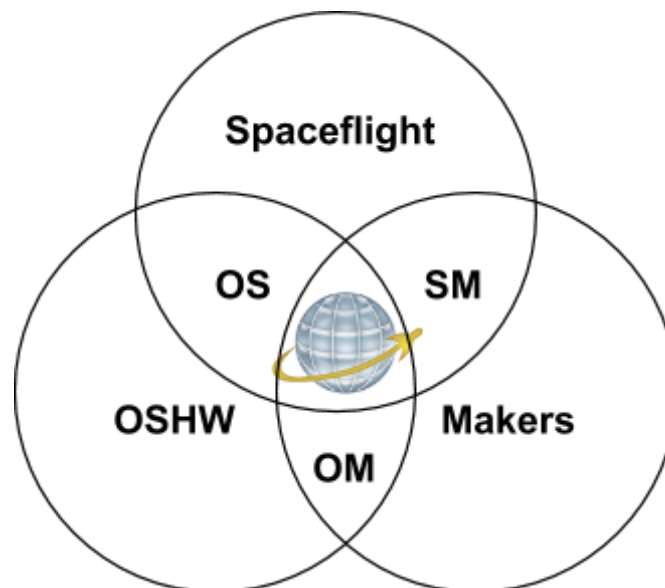


## Envisioning Mach 30's Future

In a word, the future of Mach 30 is *growth*: growth in our community, growth in capability, growth in the scale of our projects, growth in our budgets, and growth in the impact we have on the world. You can see this focus on growth in the Apogee I work envisioning what Mach 30 would look like at Apogee VII in 2020. Below are the highlights of that vision.

- Mach 30 is connected and is sought after as a collaborator by individuals and groups in the space, maker, open source hardware, and education communities.
- Mach 30 is recognized as a tech startup with the right balance of structure and flexibility to take on ever increasing challenges.
- Mach 30 has fully addressed how export controls impact open source spaceflight development.
- Mach 30 is a recognized brand along the lines of other pop culture icons in New Space.
- Mach 30 and its volunteers are seamlessly connected virtually and in workshops around the country.
- Mach 30's open source spaceflight hardware teams are focused on enabling a fully open architecture for access to space.

The key to achieving the growth above is a diverse and active community. Fortunately, Mach 30 stands at the intersection of three existing and passionate communities: proponents of spaceflight, the open source hardware movement, and the ever growing maker scene (see figure below).



Mach 30's unique position in the center of these communities as Open Source Spaceflight Hardware Makers (OSM) makes us ideally suited to developing a community with the diversity and energy we need. But as we approach these groups, we must remember to ask ourselves





"what can Mach 30 do for them?" instead of "what can they do for Mach 30?" Asking what we can do for members of these communities focuses Mach 30's interactions with them on those aspects of our mission that are important to them which is the first step to connecting with an audience. Once we establish a relationship with an audience, then we can ask for things in return which support our mission and spread the word about Mach 30 and open source spaceflight.

Mach 30 started to ask itself this question in a session at Apogee I during the summer of 2014. The Mach 30 board continued this work through the second half of 2014. Below are some preliminary ideas that have come from these discussions.

- The Maker Community
  - Driven by the desire to build "awesome" things and to share what they have accomplished (not necessarily how they accomplished it)
  - Mach 30 can provide awesome things to build in the form of kits or plans for open source spaceflight hardware (from Mach 30 or other groups). Makers building spaceflight projects promote Mach 30 to other makers. When those projects come from published designs instead of kits, the act of building them confirms the projects are adequately documented.
- The Spaceflight Community
  - Driven by the dream of spaceflight, space policy, and the technical details required for spaceflight. Education and delivering results are key areas of interest for this community.
  - Mach 30 can publish reports of our work at relevant conferences. These reports should focus on educational applications, technical accomplishments, and policy work from open source spaceflight.
- The Open Source Hardware Community
  - Driven by the ideals of open source design as applied to hardware, this community is interested in any work that promotes or further develops the state of the art in open source hardware.
  - Mach 30 can continue to develop and share the tools that we need for our open source spaceflight projects as open source software (for example CAD packages, math software, project hosting tools, and export control procedures). Mach 30 can also continue to publish lessons learned from its own open source hardware projects.
- Open Source Spaceflight Community (OS)
  - This community is the intersection of the OSHW and Spaceflight communities, and as such is interested in solving Spaceflight problems through OSHW.
  - Mach 30 can do things for this community through activities targeted at either OSHW or the Spaceflight Community.
- Spaceflight Makers (SM)
  - Spaceflight Makers are similar to the OS community, but being more of the maker community, might be more interested in tinkering or working from kits than necessarily publishing their work as OSHW to share with the world.



*Ad astra per civitatem* -- "To the stars through community"

- Mach 30 can contribute to and engage with this community through activities such as releasing kits related to spaceflight hardware.
- Open Source Hardware Makers (OM)
  - People identifying more with the OM community have no particularly strong interest in spaceflight hardware, but enjoy making and contributing to OSHW projects.
  - Mach 30's interactions with this community can include such things as continued contribution to Open Source communities, attendance of OSHW conferences, and further community outreach.

Look for Mach 30 to begin its community building in 2015 by testing out these ideas. We will keep those that work and revise or replace those that do not. And with each new person we meet or who hears about us from their friends, we will take another step closer to a world where spaceflight is built on an open architecture and is available for all.



## 2014 Hall of Donors

We are able to do the things that we do because of generous donations of both time and money. This year, the generosity of our donors enabled us to host our first-ever conference, to engage with more of the community. Doing so also allowed us to discuss a number of topics that, without being able to meet in-person, would have taken significantly longer to cover, and may not have had the input of the volunteers that were able to attend. Your charity has also helped to get Mach 30 to a place where we can do more hardware projects, continue to support the OSHW community, such as through Open Design Engine, and our work on export control to enable Mach 30 and others to complete projects in a fully compliant manner.

### To our Volunteers:

All of Mach 30's work is supported by volunteers like you. All efforts are important, whether you work on a specific hardware design team, a policy task force, outreach project, or a Board Membership position. It takes many people to figure out things like export control for open source hardware, and we have been fortunate enough to have a solid group of volunteers to help us across the board. Volunteers: we greatly appreciate all the hours and energy that you spend on Mach 30's behalf. Thank you!

### To our Donors:

Monetary contributions are the lifeblood of any organization without which there would be little progress on our mission. Hardware in particular can be expensive to develop, and as time goes on Mach 30 will have bigger hardware projects to undertake. To our core community of financial backers we say a hearty and sincere thank you.



## Financial Data

Thanks to the support of donors and the work of our volunteers, Mach 30 was able to cover approximately \$1,340 in expenses for 2014, and will start 2015 with over \$4,000 available to continue operations. Our largest single expense during the year was Apogee I at around \$500, which was a third of what was budgeted. A special thanks goes out to Club Cyberia and Hampton Indianapolis East for partnering with us to sponsor the event. The Ground Sphere satellite ground station was our primary hardware project expense at around \$500, but did bring in a \$1,000 donation from the SkyCube team. The expense report and donation for Ground Sphere are still outstanding, and will be rolled into the 2015 budget.

Donors were the sole source of income for Mach 30 during 2014. In total, donors gave \$1440, \$120 of which was tied to the Catalyst Club campaign. We greatly appreciate our donors' willingness to back Mach 30, and as always we will handle our finances in a transparent and careful manner. During 2015 Mach 30 will strive to expand and diversify the makeup of its donor corps. Mach 30 will also continue to develop the Catalyst Club towards being a sustainable and reliable source of donation income.

Insurance is a challenge that Mach 30 will have to face to position itself for product sales, and will likely be a significant expense in 2015. Professional services in the areas of marketing and bookkeeping are also greatly needed, and it is expected that procuring those services will be a factor in the 2015 budget. Lastly, Mach 30 continues its dedication to hardware projects and the exploration of regulatory challenges such as export controls. Areas of operation such as these will always be a part of the Mach 30 budget, and 2015 will be no different.

Thank you again to all of our 2014 donors. The operations of Mach 30 would be seriously hindered without you, and we greatly appreciate your support.



# Board

## Officers and Board of Directors:

J. Simmons, PhD

President

Greg Moran

Vice President/Secretary

Jeremy Wright

Treasurer

## Advisors to the Board:

James Carlson

Chris Sigman, MBA

Charlie Bellows

Matt Maier



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# MACH 30

FOUNDATION FOR  
SPACE DEVELOPMENT

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**Mission Statement:** *To advance humanity into a spacefaring civilization through open design practices, sustainable leadership and a bias towards mature technology.*