



THE MISSION PLANNING LAB

at NASA's Wallops Flight Facility

(GPS elect) 3.3v
(LNA) 12v.

GPS

Novatel OEM 615

Thermal/
Heaters

GPS
Antenna



ST
-X

20 cells

X

25cm



ST

-Y

A Strong Start for SmallSat Missions

MISSION PLANNING LAB

BY THE NUMBERS

36 studies done so far.

5 days to complete a study.

8 investigations for NASA Headquarters.

10-15 participants per study.

The Mission Planning Lab guides early-stage SmallSats through a weeklong study to turn a science concept into a feasible mission that gives the science team a solid foundation on which to build a competitive proposal.

Since 2014, the Mission Planning Lab (MPL) has worked with NASA SmallSat developers and their partners to provide services in systems engineering, 3D modeling, simulation, flight trajectory formulation, and more. MPL has served mission concepts of all kinds, from formation flying proposals to deep space missions to Mars and Venus. Additionally, MPL has sub-orbital experience and works with sounding rockets, balloons, and other platforms.

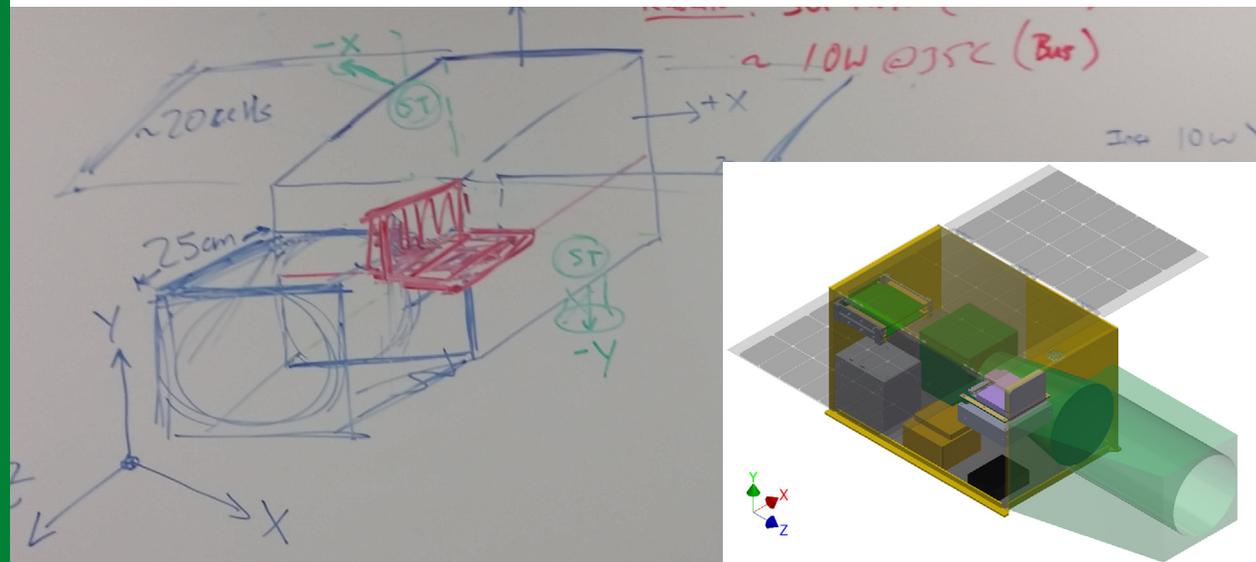
Over the course of one action-packed week, engineers across a range of specialties come together to meet with a mission's science team and crunch numbers. At the end of the process, scientists gain a better understanding of how to achieve their research objectives, and they come away with a valuable packet of information describing the technical details of their mission.

8,640 sq ft of whiteboard space utilized.

Above: Team members meet at Wallops Flight Facility to plan key mission details and better understand technical requirements.

Below: The Mission Planning Lab makes ample use of whiteboards, where team members can swap ideas and illustrate their concepts. From this whiteboard drawing of GUCI++ on the left, engineers generated the CAD image on the right.

Image courtesy Caitlin Burth. Photos courtesy NASA/Antti Pulkkinen and Ben Cervantes



A WEEK AT MPL

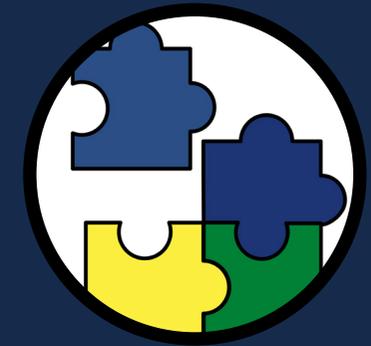
PRE-PLANNING

Before the study begins, MPL engineers ask the mission's principal investigator (PI) and team to fill out pre-work forms, detailing the mission's high-level characteristics, which can include mission class, cost, target launch date, instrument and data requirements, mass, and power. MPL staff meet repeatedly with mission leadership to choose team members for the study, set expectations, and gain more insight into the mission before the study begins.



WEDNESDAY

Halfway through the study, engineers tackle any unexpected roadblocks and address risk as they refine subsystem models and run further analyses.



MONDAY

The study launches at full speed on Monday morning. The science team presents their mission to the planning team, working through details and determining how the satellite's subsystems will need to adapt to the mission. By the end of Monday, the team has pulled together the basic components of the mission through brainstorming sessions and whiteboard sketches. They've also defined the concept of operations and key requirements.



THURSDAY

Thursday brings the team together to tie up any loose ends and make sure each team member is apprised of the mission's details. With such a fast pace, it's important to regroup and review before the final day of the study. Any unfinished area of the baseline design is worked to closure by the end of the day.



TUESDAY

On Tuesday, the engineering team drafts a preliminary baseline of the mission's components, including a computer-aided design (CAD) model. The shape of the satellite starts coming together as engineers decide where to place apertures, star trackers, solar panels, or other components. Extraneous capabilities get narrowed down, and the team streamlines the PI's wish list to the most important functionalities.



FRIDAY

On Friday, the engineering team presents their completed mission design back to the science team. Beginning with a systems-level overview of the requirements and a description of the spacecraft, the presentation includes the life of the mission and a "day in the life." About a week later, the engineering team compiles the fruits of the study in a package with the presentation slides, a model of the satellite, images of brainstorming sessions from the whiteboard, charts, cost estimates, and any ancillary information the science team might find valuable moving forward.



MPL SUCCESS STORIES

With rapid timelines and unique challenges, SmallSat missions need the best start possible to succeed. Since forming in 2014, the Mission Planning Lab (MPL) has guided more than 30 missions through its study process, helping to answer key questions and build solid mission frameworks. MPL engineers have accrued years of expertise in SmallSat and CubeSat missions, and they know what a mission needs to get off the ground. Learn more with these two mission spotlights.

BURSTCUBE

BurstCube is a 6U CubeSat that will use compact, low-power silicon photomultiplier arrays coupled with scintillating crystals to measure bursts of light associated with colliding neutron stars. BurstCube's instrument will look for short gamma ray bursts, which are electromagnetic counterparts to gravitational wave events.

Jeremy Perkins, a Goddard scientist and BurstCube's PI, says the BurstCube mission went through the Mission Planning Lab in 2015.

"We would never have been able to write the proposal without MPL," Perkins says. "We went in with a rough idea and came out with a full mission design in about a week."

Perkins and his team proposed the BurstCube mission three times before receiving funding from NASA's Astrophysics Re-



Photo Credit: NASA/Bill Hrybyk

search and Analysis Program. MPL engineers worked with Perkins and his team to hone the technical details of the mission, including power numbers, block level diagrams, orbit parameters, and a sketch of the entire mission. Perkins and his team presented the science justification for the mission, and MPL provided the technical case.

Perkins stayed at Wallops for an entire week while the team refined instrument concepts and simulated the course of BurstCube's orbit. MPL engineers lent expertise in their respective sub-disciplines, asking questions in real time and providing engineering solutions to achieve science objectives.

"No matter how involved you are in putting together a CubeSat, there are always details you miss and things you forget," Perkins says. "This process fills in those gaps."

As BurstCube approaches launch readiness in the fall of 2021, Perkins says he's grate-

ful for the assistance and collective domain knowledge provided by the MPL team. Their specialized experience in CubeSat and SmallSat missions made their input particularly valuable.

"You go away not only with a finished product, but also with friends and colleagues that you didn't have before," Perkins adds.

“WE WENT IN WITH A ROUGH IDEA AND CAME OUT WITH A FULL MISSION DESIGN IN ABOUT A WEEK.”

— Jeremy Perkins, BurstCube PI

SCIENCE-ENABLING TECHNOLOGIES FOR HELIOPHYSICS (SETH)

Goddard scientist and PI Antti Pulkkinen went through the Mission Planning Lab twice, once for a SmallSat constellation concept and again for a single SmallSat mission called Science-Enabling Technologies for Heliophysics (SETH). During Pulkkinen's first MPL run, the team realized they needed advanced optical communications technology to carry out the heliophysics mission as initially planned.

"Nobody has developed or flown SmallSat optical communications systems in deep space," Pulkkinen says. "That realization led us to go after a technology demonstration mission instead."

If selected for funding after the team submits a Phase 2 proposal, SETH will demonstrate two technologies – a miniaturized

optical communications flight terminal and an instrument tailored to detect solar energetic neutral atoms.

Pulkkinen describes his MPL experience as "one very intense week" in which MPL's engineering team reviews the mission's science goals and lays out the technical requirements for the mission. The key, he says, lies in the real-time interaction between the science and engineering teams, resulting in the foundation for a mission proposal.

"The critical piece here is the constant and productive communication," Pulkkinen says.

Over the course of the week, the two teams discuss the mission's instruments, orbit, data collection, and other key features. By convening in the same location and working at Wallops throughout the duration of the study, Pulkkinen says information flows smoothly and questions can be answered in an efficient manner.

Pulkkinen recommends staying onsite at Wallops the entire week to reap the full rewards of the MPL's resources.

"If you're a PI planning to use a CubeSat or SmallSat for your mission, I highly recommend reaching out to MPL," Pulkkinen says. "Spending an entire week in-person extracts you from your normal routines and gives you a completely new level of focus. It was a big boost for the quality of our mission design."



Photo Credit: NASA/Bill Hrybyk

THE MISSION PLANNING LAB TEAM

Mission Planning Lab Lead

Ben Cervantes

Email: benjamin.w.cervantes@nasa.gov

Mission Planning Lab Lead Systems Engineer

William Mast

Email: william.r.mast@nasa.gov