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SPORT ROCKETRY

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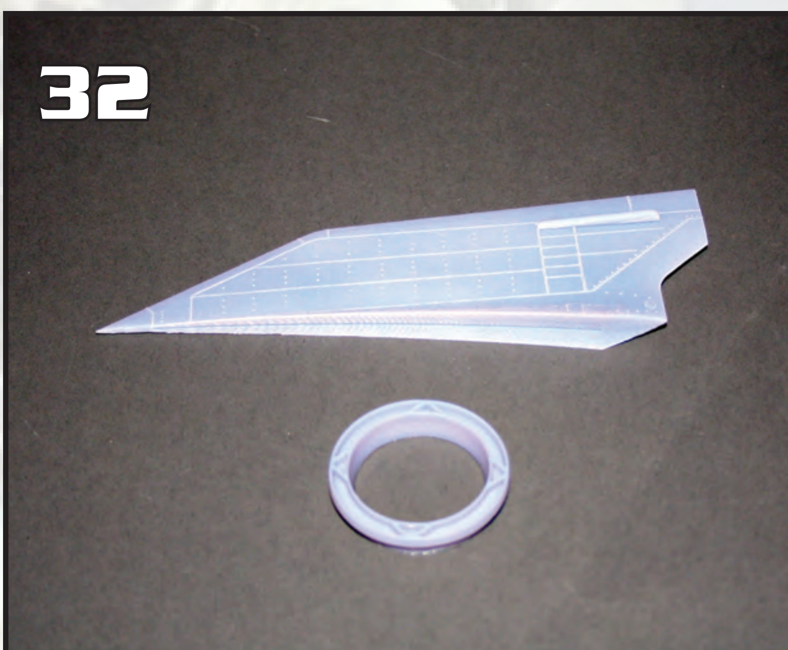
Feature Articles

On The Cover

Tia Carmichael hooks up her Estes Big Daddy with its special October paint scheme.



EDITOR'S SPACE

Ivan Galysh received the 2013 Howard Galloway Spacemodeling Service Award for broad and sustained contributions over the last decade to every major national program using sport rocketry to educate and motivate students. As a mentor and organizer for student teams in TARC and NASA's Student Launch Initiative, Ivan mentored multiple teams, developing these students from novice rocketeers into confident teams designing sophisticated payloads and high-power rockets, presenting their work for review by a panel of NASA engineers, and eager to pursue future careers in technical fields as a result. At the TARC national finals he has been the manager of a key portion of the event for all twelve years it has been held. He founded a Federation of Galaxy Explorers program at Chantilly High School, where he organizes and runs a summer camp each year teaching students to design, build, and

then fly CanSat instrument payloads for rockets. He organizes and runs the annual CanSat Competition rocket launch for student teams from around the world. He also founded, organizes, and runs the Battle of The Rockets competition for high school and university student teams involving designing and launching rover-type payloads on large rockets.

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Submission Guidelines

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March/April	March 3	Jan. 14, 20134
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July/Aug.	July 8	May 16
Sept./Oct.	Sept. 8	July 18
Nov./Dec.	Nov. 4	Sept. 19

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Always include your name, address, phone number, and e-mail address with all submissions (and not just on the envelope). Including an email address allows us to acknowledge receipt of your submission and conduct correspondence faster. If you have questions about the current disposition of a submission, contact the editor via email, phone, or mail.

Content: We prefer articles that have at least one photo or diagram for every 720 words of text. Any type of rocketry related submission will be considered, including: plans, photos, launch reports, product reviews, articles, tips, techniques, historical, and club activities. Both model rocket and high-power rocket articles are accepted.

Articles may be submitted by email, on computer disk, or as hardcopy (even handwritten). Be aware that publication of hardcopy submissions may be delayed until it can be keyed in. Computer files may be submitted on CD or DVD, in either Macintosh or PC formats; always enclose a hardcopy printout as well. ***Save the article as a plain ASCII text-only file***. You may also save it as a word processor file to preserve formatting (save using an older file format to make file conversion easier for us).

Photographs can be submitted as prints or 35 mm slides. Prints should be glossy, color or black & white, no larger than 8x10 and no smaller than 3x5. ***Always affix your name and a caption to the back of the photo.*** Do not write directly onto photos; use tape or post-notes. Ship photos with the faces protected.

Digital Images require at least 150 ppi at the final size and cropping used in the magazine. Higher resolutions are preferred. Minimal image compression is preferred. Images should be in separate files, not embedded in the article file.

Graphics may be submitted in computer form on disk, or as camera-ready hardcopy. Hand drawn sketches are accepted. Be aware that publication may be delayed if we must prepare publication quality drawings from hardcopy. Computer generated graphics are preferred in vector formats, such as EPS (encapsulated Postscript), rather than bitmapped formats. Contact the editor about file formats to use.

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ARLIS

ARLISS: A Rocket Launch for International Student Satellites

by Ken Biba & David Raimondi

SS 2013

ARLISS rocket launches from a 30-ft. launch rail.
Photo ©2013 Ken Adams

What is ARLISS?

ARLISS is the acronym for "A Rocket Launch for International Student Satellites" and with its origins in 1999 is the oldest program for educational suborbital student satellites—CanSats. The ARLISS program teaches Science, Technology, Engineering, and Math (STEM) by providing an exciting hands-on environment for University and High School students from around the world to learn an aerospace engineering view of STEM—not just the theory, but the hard and rewarding practice. ARLISS, unlike some STEM educational programs using rocketry, is based on a unique collaboration between students and very experienced amateur rocketeers. The students are challenged to build, test, launch, and recover a 100% autonomous miniaturized prototype robotic satellite experiment. They partner with experienced volunteer Tripoli and NAR Level 2 and 3 fliers who provide the airframes and flight service to reliably and repeatedly launch and deploy these student payloads.

The ARLISS program provides students a low cost environment to test their engineering ideas and skills that can lead to a career in aerospace, launching real satellites into Earth orbit and beyond.

The ARLISS program was started by Professor Bob Twiggs of Stanford and his colleagues at other Universities from around the world (particularly Japan's university consortium for aerospace education—UNISEC—University Space Engineering Consortium—http://www.unisec.jp), and the members of the AeroPac Rocket Club then led by Pius Morizumi and Tom Rouse. Prof. Twiggs is noted as one of the key creators of both the CanSat and CubeSat small satellite concepts. ARLISS has been flying student satellite projects since 1999, and has fifteen years, 2000 students, and over 600 flights of successfully deploying student projects.

ARLISS is a challenging international competition in which student teams from around the world gather in the middle of the Black Rock Desert in Nevada to test their ideas and skills, and to compete against the best in the world for honor of winning and (often) prize money. To date, most of the students participating have come from Japan, which has programmatically supported ARLISS as a capstone of aerospace education. Over 2000 students from 25 countries have participated in the ARLISS program. The ARLISS 2013 schedule was impacted by one less flying day due to an unscheduled thunderstorm and included students from 7 countries, 22 schools, and 25 teams to fly 42 M flights over three days.

The CanSats (student satellites) can range in size from a soft drink can that weighs about 350 grams to about the size of a 6" diameter coffee can that can weigh as much as 1050 grams. The larger CanSats are referred to as Open Class projects. The standard CanSats are launched in K-motor powered rocket to 8,000' to 9,000' AGL (2,500 meters) before being deployed from the rocket. The Open Class projects are launched on an M-motor powered rocket that reaches 10,000' to 12,000' (3,500 meters). Once the CanSat is deployed from the rocket, the CanSat recovers via parachute, deployable wings, or some other means that brings the project back to earth in a safe and controlled manner. The rocket that launched the CanSat deploys parachutes to bring the rocket down safely so it can be quickly turned around to launch another project.

ARLISS, like the NAR's Team America Rocketry Challenge (TARC), is a results oriented event. It neither dictates nor manages the process by which the teams develop their projects, leaving that responsibility to their teachers and mentors. Teams succeed purely on the basis of results and the ability to articulate those results.

ARLISS is unique in that it is held in the mecca of amateur rocketry, the Black Rock Desert of Northern Nevada. The unique properties of the playa enable ARLISS to sponsor the unique Comeback Competition in which autonomous robotic CanSats find their way "home" after launch, often traversing kilometers of Black Rock playa in the process. A great video about

ARLISS 2013 assembled by AeroPac member Ken Adams can be found at http://www.youtube.com/watch?v=VRqJROFvJoE.

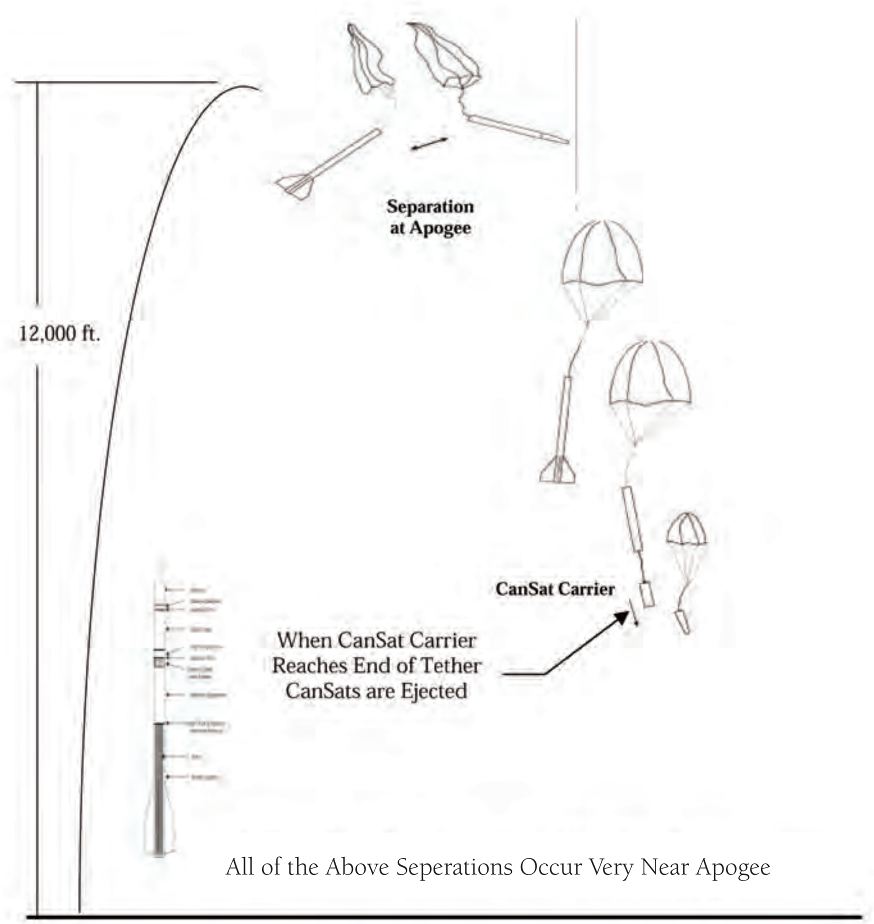
Overview of the ARLISS Program

The ARLISS mission is the collaborative design, fabrication, launch, and operation of sophisticated autonomous robotic payloads designed for near space-like deployment. The ARLISS airframes, provided by AeroPac volunteer members, reliably deliver standard student payloads (CanSat, CubeSat, and Open) to a consistent altitude of 10-12,000 feet (3,500 meters) with uniform deployment to subsequently accomplish a challenging mission.

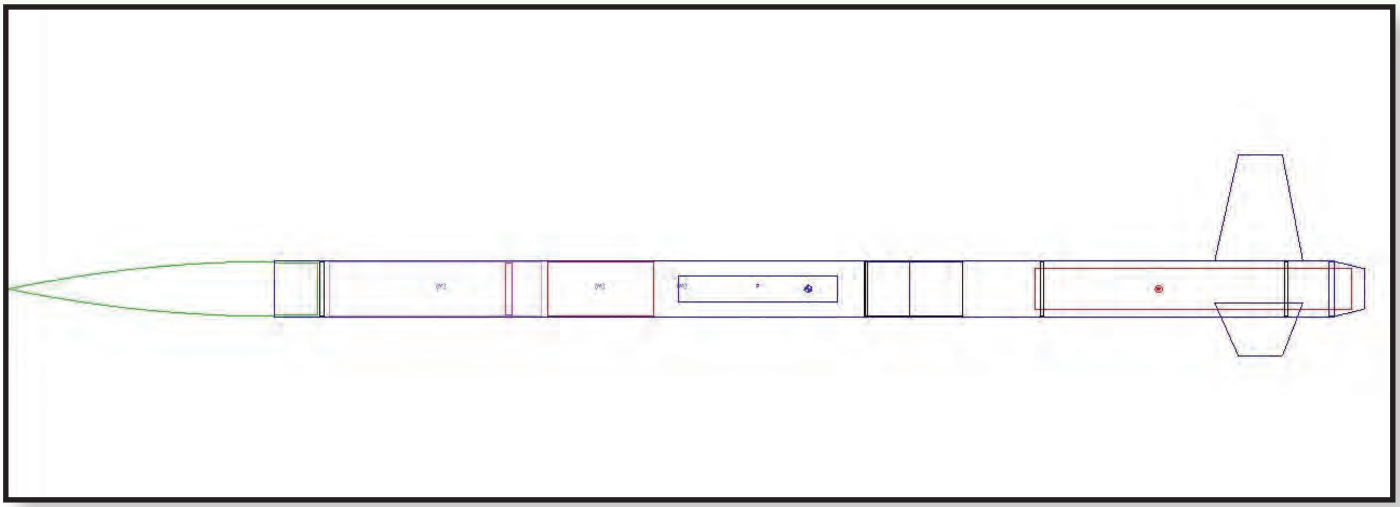
The ARLISS program provides a mutual learning experience. The students learn about collaborative design processes and design a complex electronic payload (an autonomous robot satellite) that will have to operate in the harsh environment of Nevada's Black Rock desert. The fliers learn to hone their skills of designing and executing highly reliable and repeatable flight operations.

Since 2009, the ARLISS program supports two events per year at AeroPac's launch site in the Black Rock Desert coinciding with existing AeroPac club launches. The launch on the third weekend in June (typically Father's Day weekend) is more convenient for schools in the United States. The launch on the second week in September is very convenient for international students. A typical ARLISS event will have 40-50 M Open Class flights. ARLISS also acquired a state-of-the-art satellite Internet and radio infrastructure that supports multimedia participation for worldwide student participation. For more information about the program visit www.arliss.org.

ARLISS depends on two key elements: reliable delivery and deployment of student satellites, and, secondly, an encouraging environment and competition for astonishingly creative student projects.



CanSat ARLISS Rocket Launch Profile



Proven Rockets and Deployment

ARLISS flights follow a consistent and repeatable profile:

- Launch
- Airframe separates at apogee to allow the main airframe recovery system to deploy.
- The airframe payload bay settles pointing down, and the onboard avionics delays 6 seconds to allow the configuration to settle.
- The airframe avionics fire a charge to deploy the satellite carrier from the downward pointing payload bay.
- The satellite needs to deploy its own recovery system after deployment.
- Airframes recover in two to three sections: nosecone and either one or two airframe sections.

ARLISS uses two standard sizes of airframe: a 3" airframe for deploying individual standard CanSats on K motors, and a 6" airframe for deploying multiple standard CanSats or one Open Class CanSat on M motors. It is expected that these airframes are used and reused and it is not unusual to have airframes with 20-30 flights or more.

The K class airframe is designed to economically carry a single standard CanSat. The standard motor is an AeroTech K550 with a standard flight profile of 12 Gs ascent, 8-9k' AGL apogee at Black Rock with a 0.3 Kg standard CanSat. The airframe is 3" diameter, 76" long, has a 54mm motor mount, and weighs 9.8 lbs. fully loaded with a 350 gram standard CanSat.

The M class airframe is designed to

carry and deploy satellite carriers that either deploy three standard CanSats or one Open Class payload. The standard motor is an AeroTech M1419 with a typical flight profile of about 8 Gs ascent, 10-12k' AGL apogee at Black Rock with a 1 kg Open Class CanSat. The airframe is 6" diameter, 114" long, has a 98mm motor mount, and weighs 45-50 lbs. fully loaded.

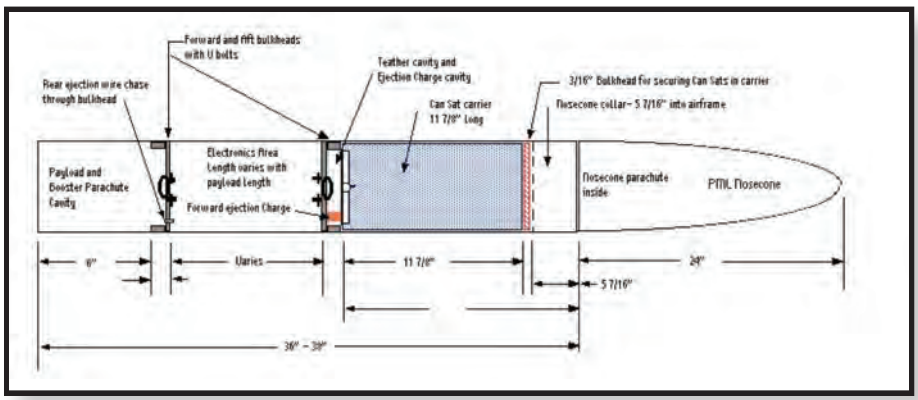
Every airframe has redundant flight avionics and is test flown to demonstrate reliability before flying with a student payload.

The payload bay of each airframe is behind the nosecone and forward of the avionics bay. The CanSat is placed in a 11.875" long carrier in the payload bay tethered to the avionics bay. The nosecone is then secured with shear pins. A charge is placed between avionics bay and carrier that when fired propels the carrier forward, breaking the nosecone shear pins, ejecting the nosecone (recovered separately under its own parachute), then ejecting the carrier+payload. The force of the carrier ejection will deploy the CanSat.

In the early years of the program, most flights were of standard CanSats on either class of airframe. In recent years, the program has been dominated by Open Class projects launched on M motors. A typical ARLISS competition will have 45-50 M flights and 2-5 K flights.

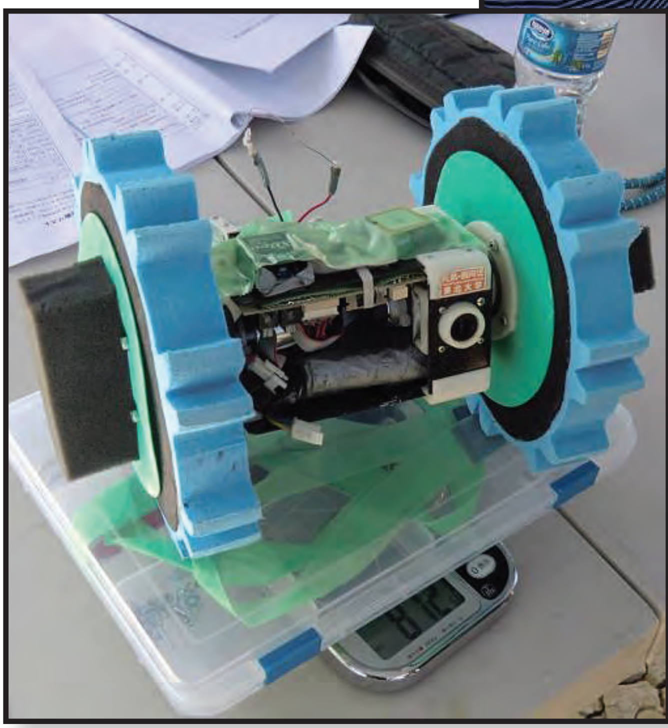
In the 15 years of the program, over 600 flights have been made, losing only two student projects due to launch failure—a deployment success of 99.7%! This extraordinary reliability rate is a compliment to the skill and diligence that ARLISS fliers take in their responsibility to deliver student payloads reliably and safely.

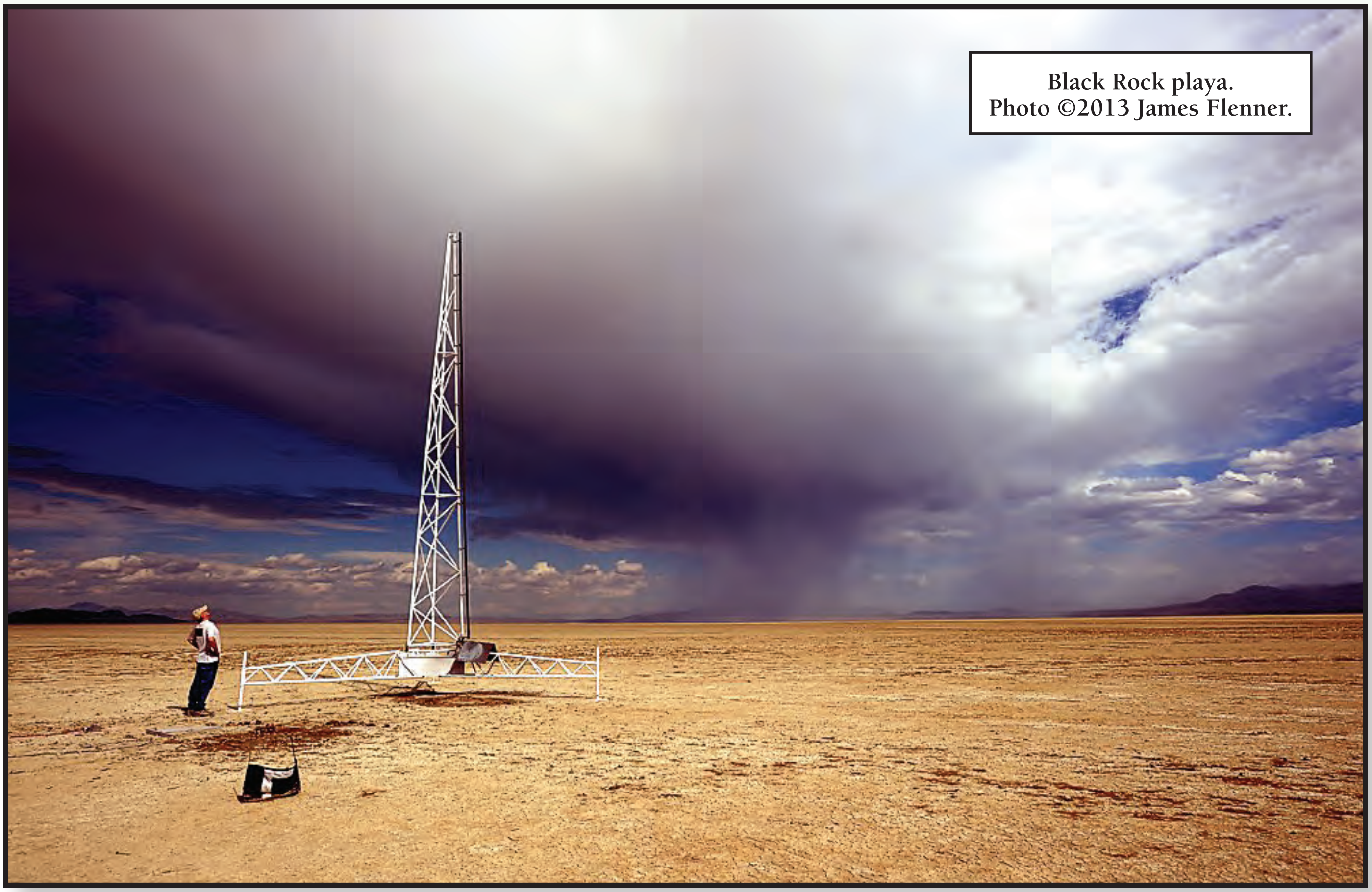
Student satellites are housed in carriers for flight and deployment. In 2013, ARLISS flier Bob Feretich and other AeroPac volunteers upgraded these carriers to now contain an integrated miniature custom 6DOF inertial measurement unit that measures and records acceleration and spin of each deployment to help insure the consistency and reliability of the flight experience for the students.



Experimental Student Satellites

ARLISS focuses the students' attention on the design and execution of CanSat missions, just as they will likely do as professional engineers. Few engineers do a complete system—rather they work as part of a larger team specializing in one aspect of the overall project. In the case of ARLISS, it is a challenging robotic satellite launched and recovered in a challenging environment, the Black Rock Desert.

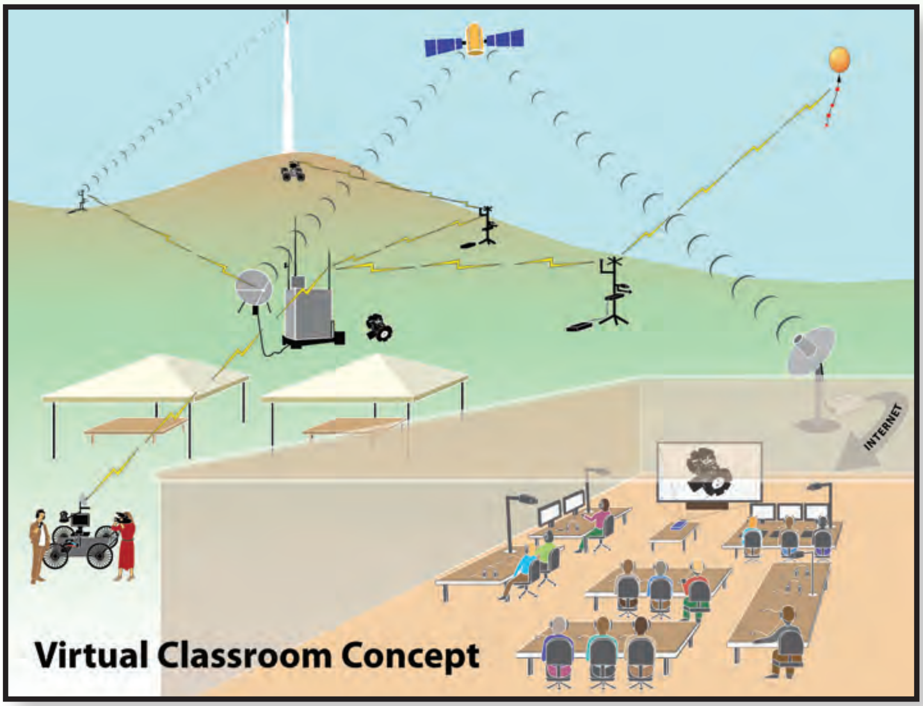




Black Rock playa.
Photo ©2013 James Flenner.

All student satellite CanSats share a common requirement to survive and (perhaps) prosper through launch and recovery. The general requirements all CanSats need to meet are summarized below.

- Dimensions: Small Carrier interior dimensions are 75 mm dia. x 250 mm long. Large Carrier interior dimensions are 144 mm dia. x 250 mm long.
- Weight: Small CanSats have a weight limit of 350 grams. Large CanSats have a weight limit of 1050 grams.
- Flight Dynamics: +8G launch. +20 G deployment at approximately 3,500 meters above ground level. Recovery system needs to return satellite safely to the ground at ~4 to 6 m/s. Post deployment the payload must perform an experiment or participate in a competition. Projects need to survive in a physically extreme remote location far from the controlled laboratory environment.



But once the basics are satisfied, CanSats have enormous diversity and creativity. For the Comeback Competition there are no requirements on how the CanSat can accomplish the task—the CanSat can fly, crawl, or wiggle its way to the target destination. And over the years, the program has witnessed an enormous variety of solutions to the problem. In recent years, crawlers have been the most successful design approach but flying designs, either powered planes or gliders, are always impressive to see.

Black Rock: A Unique Location for Rocketry

The Black Rock desert is 280 miles NE of San Francisco in northwestern Nevada. Managed by the U.S. Bureau of Land Management, it is a prehistoric dry lake bed of 1000 square miles, 70 miles long and 20 miles wide. When it dries out from winter rains, it is flat and empty—a perfect location for amateur rocketry. AeroPac has been flying there since 1989.

Its flat surface makes it particularly appropriate for recovery of autonomous robots. Black Rock's astonishing natural beauty matches great technology with the magic of nature.

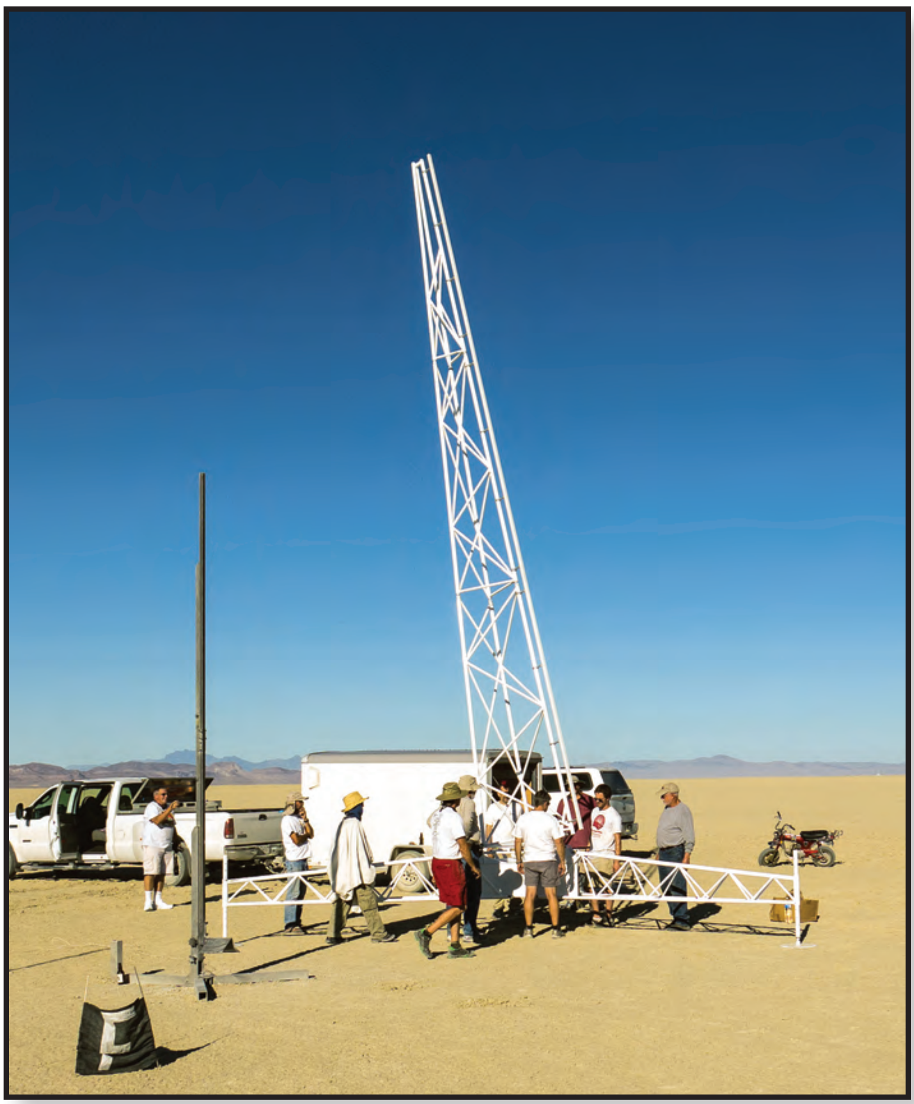
Virtual Classroom: Sharing the Experience from the Playa

Virtual Classroom (inspired by Professor Twiggs) is an integrated wireless network system to provide a distributed, near real-time electronic collaborative environment that allows video, audio, CanSat telemetry data, and participation by a worldwide community of participants in physically remote locations. For example, all of the student members of a robotic satellite team may not be able to be at the launch and recovery site. The Virtual Classroom provides all members of these teams with a broadband Internet connection to view and participate in these experiments with many of the tools that on-site experimenters might not have on site because some tools might be impractical to bring to the remote site.

The Virtual Classroom is used for the ARLISS student satellite program at Black Rock, Nevada. The Virtual Classroom provides real-time streaming video, audio, social media, and telemetry support for people, payloads, and airframes.

AeroPac Rocket Club

The Association of Experimental Rocketry of the Pacific (AeroPac) was founded in 1989 by Bill Lewis. AeroPac is the Northern California and Northern Nevada prefecture of the Tripoli Rocketry Asso-



ciation. However, AeroPac predates its involvement with Tripoli and has roots in the earliest times of high-power rocketry. Many of its members are also members of the NAR's LUNAR section.

The AeroPac club is the parent organization for the ARLISS Program, and is a 503(c) educational non-profit corporation that welcomes corporate and private tax-deductible contributions to help sponsor the student teams and help keep up the infrastructure of the launches.

The AeroPac club holds three high-power launches a year at the Black Rock Desert in Nevada. All of the launches are open to Tripoli and NAR members. The Black Rock Desert is the most perfect place to launch rockets. If you haven't been to the Black Rock Desert, you really owe it to yourself to see this spectacular natural wonder, the largest flat piece of land on earth. AeroPac flies with FAA waivers to 200,000' MSL. It has a complete launch infrastructure for flights from model rockets to its new 30' rail for flights tickling the edge of space.

For more information about the AeroPac club please visit the website at: www.aeropac.org. There is a wealth of information about the Black Rock Desert, including a survival guide. The information about Black Rock is a must read for first time visitors.

ARLISS Competitions

Each year there are competitions in which Teams can participate to win a cash prize that is often offered by sponsoring companies. The competitions are not easy and several years in a row the prize money has been rolled over to the next year. Teams are allowed to make multiple flights with the best results being applied to the competition. The two current competitions are the Comeback Competition and the Mission Competition. In addition, new competitions are always under consideration. One new one recently introduced is Comeback without GPS, requiring using other tools than GPS for navigation, much in the same way that rovers on other planets must currently navigate where there is no GPS constellation.

Comeback Competition with GPS. In this competition, CanSats are launched and have to successfully recover and autonomously return to a predetermined location on the Black Rock playa identified solely by GPS coordinates. Prior to the competition, a stake is driven into the ground about 1 km from the flight line and the GPS coordinate given to the competing teams. The teams need to take into account landing on the opposite side of the flight line from the Target and have the CanSat successfully navigate around the flight-line area. The rules are pretty simple for this competition:

- Teams are given the GPS coordinates of the Target destination.
- Maximum weight of the Open Class is 1050 g.
- Maximum weight of the standard CanSat is 350 g.
- The CanSat must autonomously control its path to the Target.
- No human intervention is allowed in any way.
- Remote Control CanSats are not allowed.
- Moving obstacles that are in the CanSat's path is not allowed.
- The CanSat must record all flight and control data logs and these must be presented to the contest referee at the end of the flight. The log must show evidence of active control of progress to the Target.
- The CanSat will be carried aloft and deployed between 3 km and 4 km altitude.
- CanSat must be within 50 meters of Target to qualify as a potential winner.

Qualifying flights will be judged on Closest Distance to Target and content of data logs to determine the winner. In case of a tie, the winner is determined by the fastest average speed to the target.

Historically, this is a very difficult competition. Teams must make a strategic decision on the mechanism of navigation:

- a rover that lands and crawls across the rough ground of the playa?
- a plane that unfolds and successfully flies to the target?
- a paraglider that deploys and successfully discovers a way to fly upwind?

Teams must not only make that key strategy decision and invent a successful navigation algorithm, but also must design and build a satellite robust enough to survive (and prosper) the flight, deployment, and the Black Rock playa. A fair number of projects fail to consider the complete systems aspect of the problem. However, some projects succeed magnificently. One rover was able to travel at tens of km/hr across rugged playa truck ruts. A video demonstrating the capabilities of the rover can be found at http://www.youtube.com/watch?v=4oL7iL4wVic. A

video showing the complete flight, recovery and return across kilometers of playa can be found at http://www.youtube.com/watch?v=BOUkwmFezdE.

Comeback without GPS: This competition is the same as the classic comeback competition with the exception that use of GPS is not allowed. Competitors must invent another method of navigation.

Mission Competition: Mission Competition scores projects based on their successful implementation of an innovative satellite mission concept.

The maximum score is 120 points in the Mission Competition. The evaluation criteria are broken down into two area: “mission idea” and “mission achievement.” The mission idea will be peer reviewed, and the Mission Competition Committee (MCC) will evaluate the mission achievement. 1st, 2nd, and 3rd place prize awards are given according to final scores. In addition, all teams with more than 100 points will be given an “Excellent Team Award!”

Each Team writes a Mission Statement, in English, which defines what the mission is going to do. The mission report must also contain the success criteria by which the mission will be judged for Full Success and Minimum Success. The success criteria should outline clear and precise objectives and evidence to be collected. (Example of Full Success criteria: Travel from the start location to target area with the total distance traveled be no greater than 20% more than the straight-line distance.)

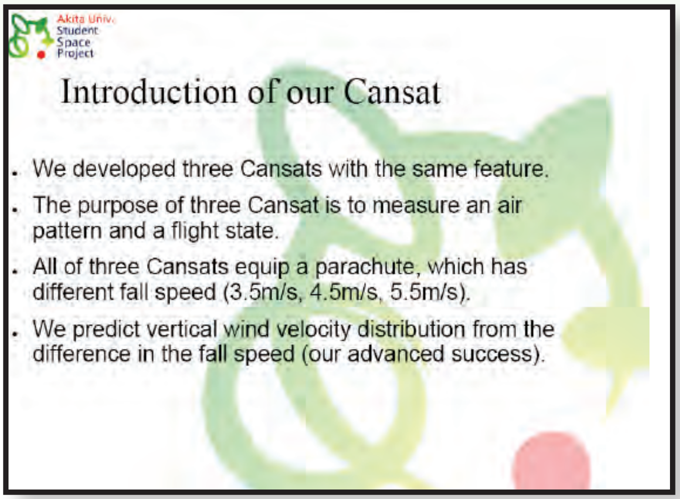
Each Team will review the Mission Statements of fellow competitors paying attention to the mission abstracts and the requirements for Full Success. The Teams (not individuals) will vote on the other Teams Mission Report and provide a score based on the objectives and the Full success criteria. The Teams will provide scores of Basic, Average or Advanced based on the difficulty of the mission and success criteria.

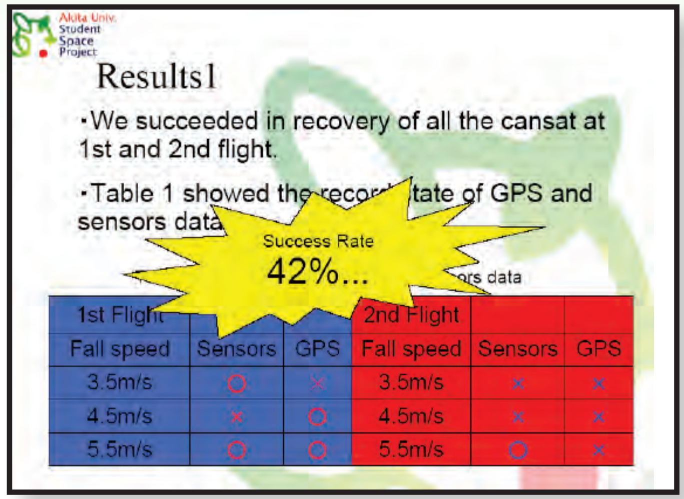
The MCC members will judge Mission Achievement. Each Team writes a Mission Report indicating how well Team met the success criteria. The Mission Report includes the materials and information required to judge the mission achievement with respect to the success criteria. If the MCC judges the team’s materials to be unsatisfactory, then the mission achievement is regarded as a failure and receives 0 points. Meeting the Minimum Success nets 50 points, and 100 points are awarded for Full Success. The MCC calculates the final score by multiplying the Achievement score and the Peer Review score.

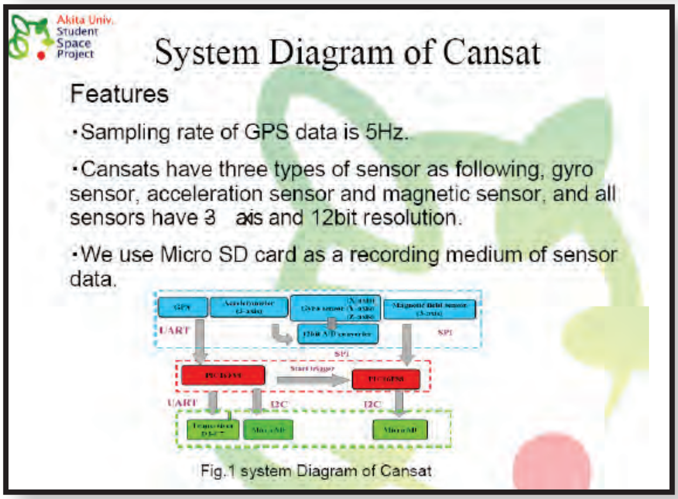
Project Presentations: On the Final Day of each ARLISS event, there is perhaps the most important part: the project presentations. Each team is required to make a 3-5 minute stand up summary presentation of their goals and results of their project. It is inspiring to see the ambition, skill, and perseverance of these teams and the collaboration fostered with the ARLISS fliers that launched their project.

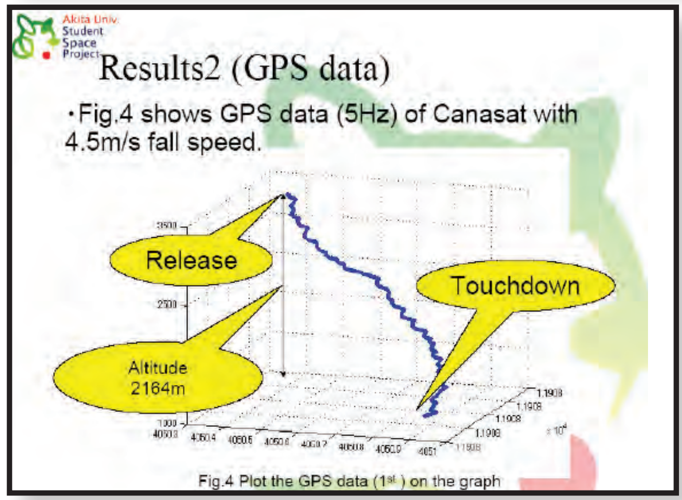
Sample Projects

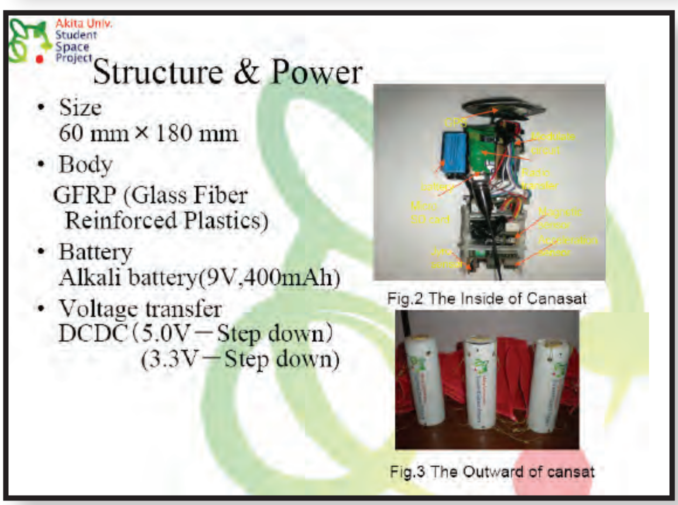
Let’s introduce two different projects that have been flown in the ARLISS Program. These two presentations were made during the Final Day of ARLISS in 2009 and 2011. The projects illustrate the diversity of what is possible.

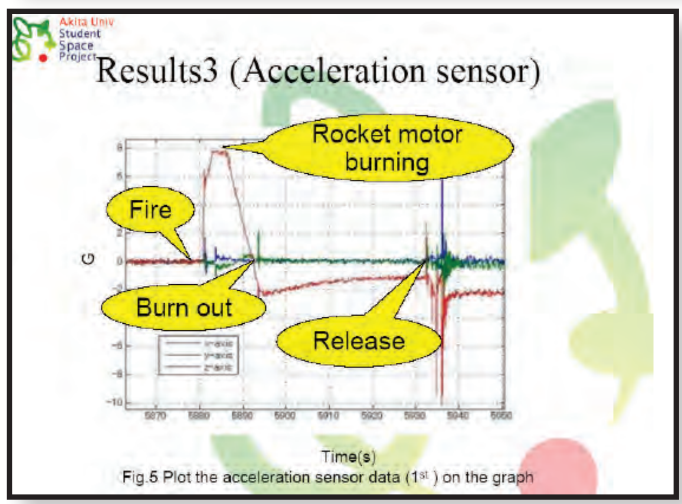










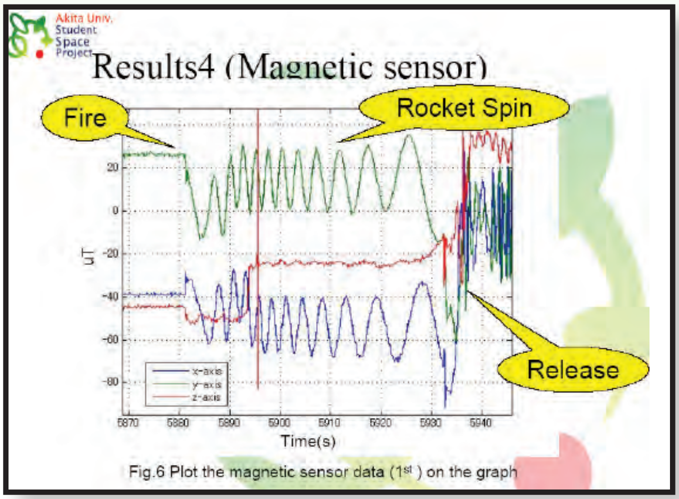


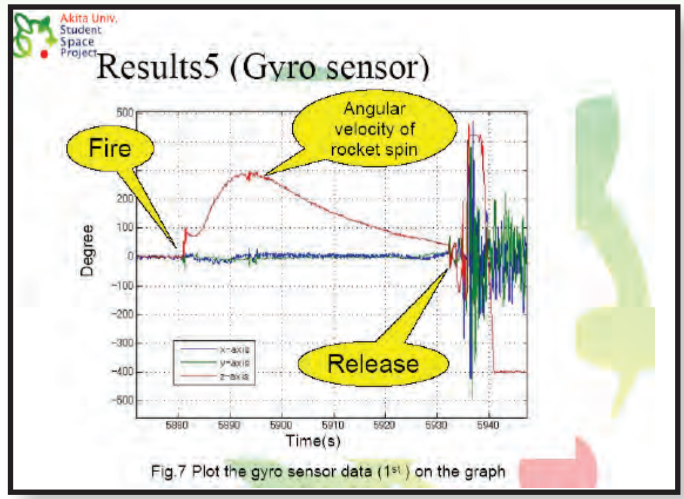
Standard CanSat Project: Mission Competition

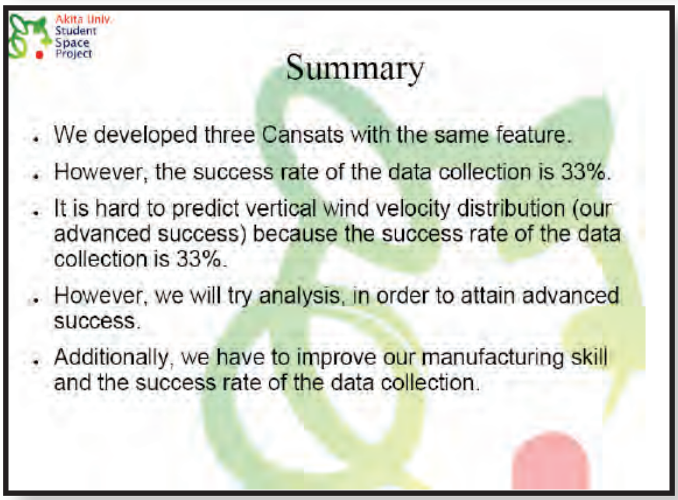
This CanSat project was flown at the ARLISS launch in September 2009 by The University of Akita. This project is interesting since it is comprised of three distinct standard 350 gram CanSats flown in a single carrier on an ARLISS M flight. It attempts to measure and explain the different flight experiences of three distinct satellites, deployed at the same time. It is representative of Mission Competition projects.

Open Class CanSat Project: Comeback Competition

The University of Electro-Communications Takadama Lab flew this Open Class CanSat project described for ARLISS 2011. This project was flown on an ARLISS M airframe. It is representative of a Comeback mission using an innovative expanding wheel to generate increased torque and speed to ease the task of the multi-kilometer return across the Black Rock playa. It worked well, this project did the task of traveling back to the target!





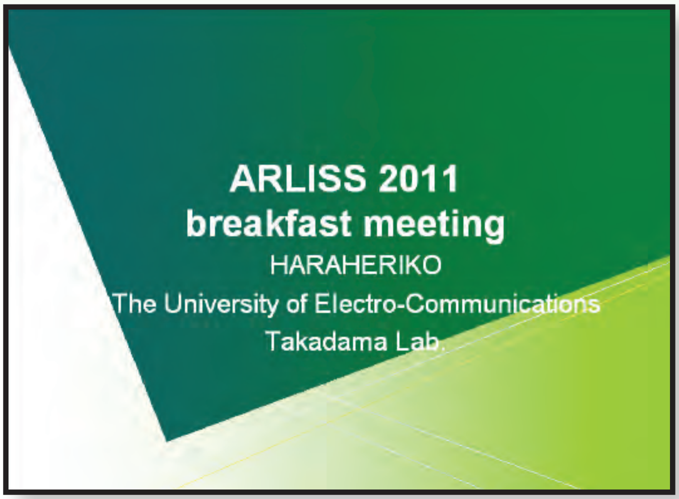


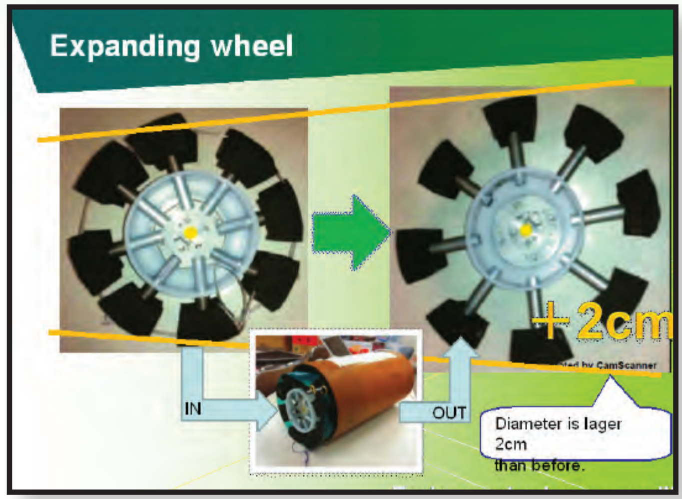
Real World Applications

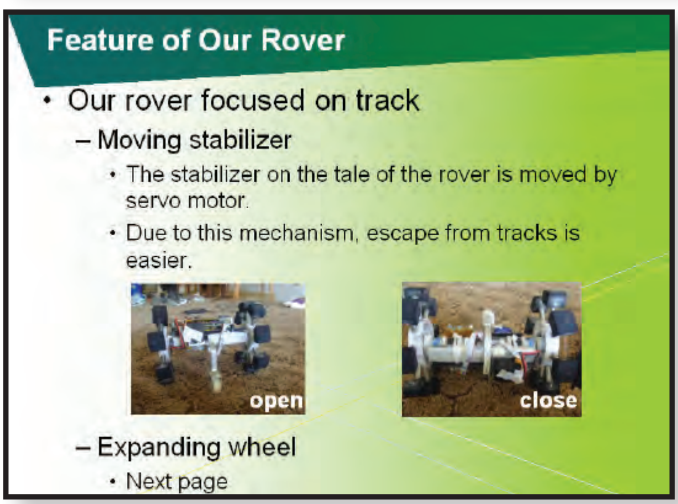
Many of the university students that have flown CanSat Projects with the ARLISS program have gone to work in the aerospace industry. The students are taking the lessons learned in the ARLISS program and applying them to real satellites destined for Earth orbit and beyond. There are twelve satellites built by ARLISS alumni in earth orbit or in orbit around Venus.

On May 21, 2010, UNITEC-1 was launched by JAXA and it is heading to Venus. Here is the news announcement:

UNITEC-1 is the world first type of deep space satellite of the university development. It rides together the satellite of JAXA,







named Planet-C. And it [is] flying toward Venus. Outline of Satellite:

- Size: 30x35cm. 15kg or less in weight
- Communication apparatus: 5.8GHz amateur bands. The transmission output about 15W
- The generation electric power: About 25W. There is no posture control. Omni antenna equipment
- Mission equipment: One science sensor in deep space(Schedule).about 5 or 6 computers of university. (Thanks: Aichi University of Technology / Kawaju Gifu Engineering Co.,Ltd.)

For more information, check out the project website: http://www.unisec.jp/unitec-1/en/top.html.

Another success story is Soka University, which also has a CubeSat riding piggyback on the Venus bound satellite. Here is the press release:

On July 9, the Japan Aerospace Exploration Agency (JAXA) selected a satellite developed by Soka University students for launch in 2010. The Soka satellite, Negai ("wish"), will be part of a four-

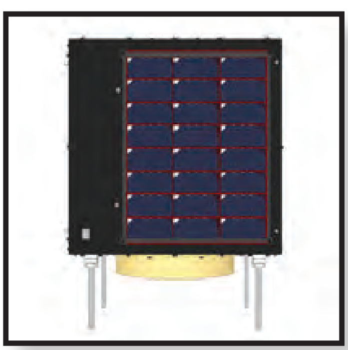
satellite payload slated for a piggyback launch with PLANET-C, which will explore the atmospheric dynamics of the planet Venus, by the H-IIA rocket.

The "Negai" is a microsatellite—it measures just 10 centimeters cubic and weighs a mere kilogram—being developed by Soka's engineering students led by Prof. Seiji Kuroki, who specializes in information systems science. It will be inserted into a near-Earth orbit of 300 kilometers and, after a few weeks, is expected to plunge back into the atmosphere, creating an artificial "shooting star." Which is why it was named Negai, or to "wish upon a shooting star."

Negai's mission will be two-fold. It will serve as a test bed for a highly advanced information processing system presently being developed by Soka students that is extremely reliable and resistant to intense cosmic radiation. It also aims to spur interest in space exploration among children. The microsatellite will contain on microfilm the names and dreams of children recruited through a public campaign, and photographs taken of the Earth by Negai's onboard camera will be distributed to campaign participants.

"The most important aspect of this satellite is that it is handmade by the students" of Soka University, noted Prof. Kuroki. While underscoring Negai's technical potential, the students believe mission should prove as meaningful in broadening vistas of the future for children. "Negai is a shooting star that has captured their dreams," said the professor.

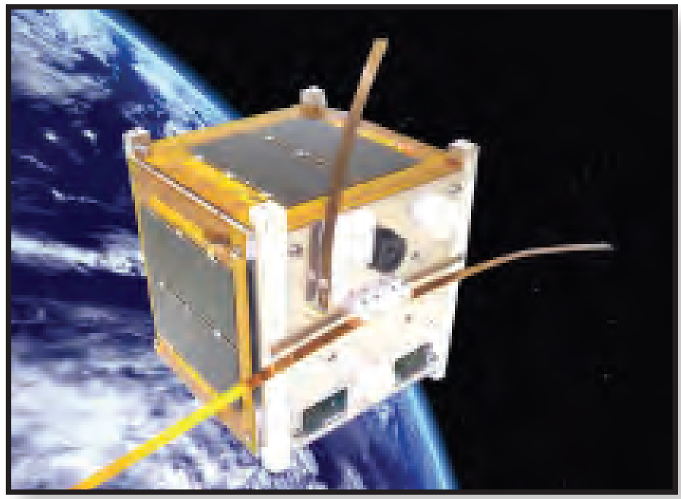
JAXA also chose microsatellites under development by Waseda University and Kagoshima University. The fourth is being developed by a space-engineering consortium comprised of universities.



In addition, the Soka team hopes ham radio operators will also participate in the project if they live within a latitude range of 30 degrees north and 30 degrees south. Operators in that range can tune into a radio signal broadcast by the Negai.

Challenges to Come

ARLISS has grown dramatically since its beginnings with four teams and four M flights in 1999 flying early versions of standard CanSats. ARLISS now commonly hosts 25 teams from multiple countries with often fifty M flights over four days with challenging robotic missions. There have been often substantial cash prizes for winning teams, sponsored by Japanese corporations where many of the teams come from. Schlumberger Japan has been a strong contributor, not for aerospace engineering but rather knowing that the students that participate in ARLISS are extraordinary and solving the problems of ARLISS builds engineers that are not only skilled in aerospace engineering but in a wide set of problems, including exploring under the earth for oil.



ARLISS would delight in welcoming more U.S. teams in a program with such strong international participation. ARLISS's parent organization, AeroPac, is a 503(c) non-profit educational corporation and welcomes corporate and private tax-deductible contributions to help sponsor prizes for the winning student teams. ARLISS is staffed by volunteers and has been successfully self supporting without sponsorship for its infrastructure for ARLISS.

ARLISS is continually evolving. It was research by AeroPac members in the late 1990s that created the airframes used today for the program. Today, ARLISS members are creating a new system that can carry student payloads to the edge of space at modest cost.

ARLISS Xtreme is a two stage fiberglass and carbons composite airframe, powered with only 21k nsec of commercial motors that achieved 104k' in 2012, winning the prize sponsored by John Carmack for the first publicly documented amateur flight over 100k' AGL. It carried a CanSat sized payload based on a Nexus smartphone and is intended as a CanSat payload carrier. A summary of this open source project can be found at aeropac.org, with complete project documentation at http://aeropac100k.rocketryonline.com/AeroPac%202012%20100k'%20Program%20Report.compressed.pdf. Flight video can be found at http://www.youtube.com/watch?v=krNFHr2YZBY.

ARLISS Rocketeers

ARLISS Rocketeers all have years of experience flying student projects and are all accomplished Tripoli and NAR Level 3 fliers. Each flier delights in the opportunity to work with and learn from each of these teams and their projects. The teams bring a tremendous amount of excitement and trust when they hand their project over to the flier. The flier then integrates the payload carrier, inserts it into their rocket, and makes the final preparations on the rocket before the flight. There are simple ARLISS traditions that have become profound: signing team names and schools on each airframe, carrying the airframe to launch pad, pictures before launch, and the announcement by the team of the project and a brief description. Then launch! The flier then recovers his airframe and the students race to track and find their projects.

Each team is unique and the international nature of the event sometimes makes communications a little difficult, but the students and the fliers always meet the challenge. The rocketeers and the students that fly in the ARLISS program are the best of the best.

The ARLISS team encourages experienced fliers to come join the team and experience the profound satisfaction of helping these students accomplish their dreams.

Resources

The place to begin to learn more about ARLISS is the ARLISS website (www.arliss.org) and the AeroPac website (www.aeropac.org).

Then journey to YouTube for three more of the many videos about ARLISS.

Begin with a video made in 2009 by journalist Dale Schornack as the basis for an ARLISS documentary that gives the overview of the program from both the fliers and students: http://www.youtube.com/watch?v=Wz5IJV_MbhY.

A second video also by Dale Schornack illustrates the experience of high school students from New Hampshire that had participated (and won!) other rocketry competitions and how ARLISS was unique:

Sport Rocketry BEST Contest.

YouTube

The NAR would like to make you famous, well almost. We are hosting a YouTube video contest. This is a great way to get all that rocket video off your computer and on to the Web where it will get noticed. We are opening this to all NAR members and want to see what you have. All current and classic video is welcome.

Simply upload your video to a public YouTube channel and submit it to the ***SportRocketry*** channel through email or a YouTube message.

The contest will have multiple categories. Playlists are as follows.

1) **BEST** - General Rocket Video.
2) **BEST** - Rocket Launch Video.
3) **BEST** - On-board Rocket Video.
4) **BEST** - Rocketry Disaster or Failure.
5) **BEST** - Classic Footage.

More categories will be developed as time goes on.

RULES:

1) The contest is open to all NAR members.
2) Observe the NAR safety code in the video.
3) Any video involving model, mid, or high power rocketry will be considered.
4) Keep it professional and clean. If the video is in poor taste, it will be deleted. Criteria for best video includes quality of audio/video, number of views, originality and thoughtfulness of video.
5) The NAR will award a free, one-year NAR membership in each of the above categories.
6) NAR membership and membership renewals awarded in the contest are not transferable to other people.
7) You will retain any copyright and commercial rights to your videos. You grant the NAR the right to publish the video on the NAR channel and the NAR Web site.
8) The top videos will be awarded at the end of each calendar year.

Contact info: http://youtube.com/SportRocketry

http://www.youtube.com/watch?v=vytVgv6pTZU.

The authors presented much of this same material at the 2013 NARCON (http://www.youtube.com/watch?v=eAfH1QC7VFQ).

And finally, detailed questions can be emailed to the authors: Ken Biba (kenbiba@me.com) and Director of Education, AeroPac Inc. (www.aeropac.org)

Acknowledgements

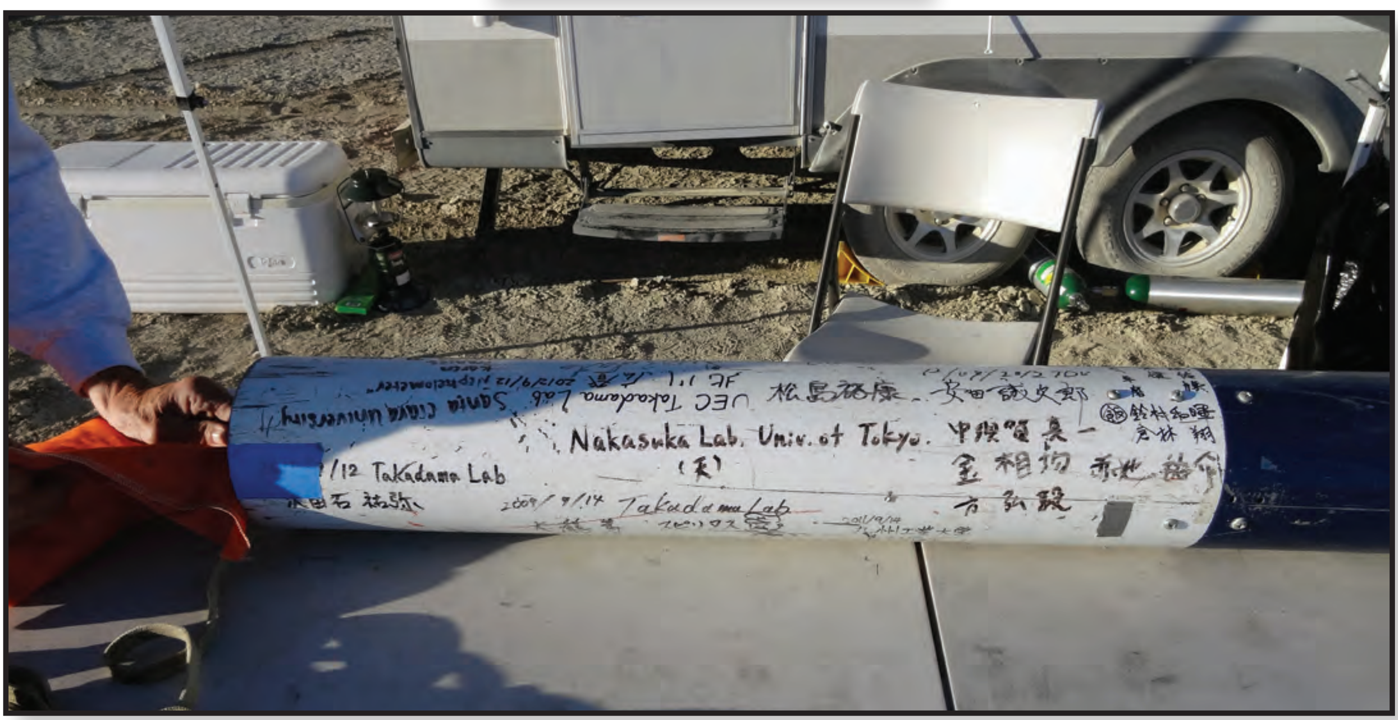
Our first and most important acknowledgement has to be to Professor Bob Twiggs who while at Stanford helped invent the CanSat and the CubeSat, and inspired the collaboration that has become ARLISS.

Becky Green is our key member who does the hard work of organizing and making the events happen.

ARLISS is managed by a Aeropac Committee of volunteers: Ken Biba (Chair), Paul Hopkins, Becky Green, David Raimondi, Tom Rouse, and William Walby.

The ARLISS fliers who contribute their time, skill and devotion to create this extraordinary program: Ken Biba, Scott Bowman, Mike Brest, Peter Clay, Jamie Clay, John Coker, Evan Curtis, Jonathan Dubose, Gary Dwyer, Erik Ebert, Bob Feretich, Bob Fortune, Chet Geyer, Becky Green, Jim Green, Ed Hackett, Richard Hagen, Paul Hopkins, Jacob Hudson, David Kenyon, Thomas Kernes, James Marino, Dick Matthews, Ranny Mitchell, Pius Morizumi, Allen Palmer, David Raimondi, Tom Rouse, Grant Saviers, Matthew Sikkink, William Walby, Seth Wallace, Steve Wigfield, and Charlie Wittman.

Unless otherwise indicated, the images for this article come from the collections of ARLISS teams, UNISEC, and the authors.



Comprehensive CAR/NAR/TRA
Rocket Motor Certification List

As a service to NAR members, the NAR Standards and Testing Committee (S&T) publishes a comprehensive list of rocket motors certified for use at NAR launches in the July/August and January/February issues of Sport Rocketry. Information is current as of the date this article was submitted for publication (December 12, 2013). As the NAR, the Tripoli Rocketry Association (TRA), and the Canadian Association of Rocketry (CAR) maintain a reciprocal certification policy, motors certified by all organizations are included in this list. Members of all organizations may use motors certified directly by any organization if the motor has been certified for transportation in your country (DOT certification in the USA).

Additions, deletions, and other changes to the list of NAR-certified motors will be published in NAR journals as they become available. They will also be published electronically on the NAR web site (http://www.nar.org).

Individuals, such as Contest Directors, requiring the very latest list of NAR certified motors may contact the S&T Secretary, Bill Spadafora, (781) 233-0339, or via email at <billspad@comcast.net>. Other questions may also be directed to the S&T Chairman, Jack Kane, at 23 Bungay Road, Mansfield, MA 02048. Questions regarding Tripoli certified motors should be directed to Paul Holmes, Chairperson, Tripoli Motor Test Committee. Questions regarding CAR certified motors should be directed to Thomas Raithby, Chairperson, CAR Motor Testing.

Order the S&T Motor Data Sheets from NARTS if you desire additional information. This report consists of data sheets for each motor currently certified by NAR S&T. Each data sheet contains a thrust curve together with values from a test firing, including measured average thrust and total impulse, plus 32 datapoints for use in RASP altitude simulation computer programs.

KEY TO NOTES

S Denotes a single use motor
R Denotes a reloadable motor certified only with the manufacturer supplied casing, closures, nozzle, and propellant.
H Denotes a hybrid motor
T Denotes a tribrid motor
* Denotes certified for NAR contest use
(a) Certified for use in Animal hardware only
"Contest approved" means approved for use in contests flown under the US Model Rocket Sporting Code. This is not the same as approved for use in HPR contests or FAI contests.
(HP) before a motor designation denotes a motor to be treated as a high power motor regardless of its total impulse.
Motor designation in red indicates a spark producing motor requiring special precautions.
N/A indicates information not provided by the certifying group.
cc in the Propel. Mass column indicates the volume of nitrous in a hybrid motor
ml in the Propel. Mass column indicates the volume of alcohol in a tribrid motor.

Abbreviation	Company
Aerotech	AeroTech, ISP, or Dr Rocket
Alpha	Alpha Hybrids
Animal	Animal Motor Works
Apogee	Apogee
Cesaroni	Cesaroni Technology Inc.
Contrail	Contrail Rockets
Ellis	Ellis Mountain Rocket Works
Estes	Estes Industries
Gorilla	Gorilla Motor
Kosdon	Kosdon TRM
Kosdon/AT	Kosdon by AeroTech
Hypertek	Hypertek
Loki	Loki Research
PML	Public Missiles, Ltd.
Propulsion	Propulsion Polymers
Quest	Quest Aerospace
RATTWorks	R.A.T.T. Works Precision Rocket Motors
Roadrunner	Road Runner Rocketry
SkyRipper	Sky Ripper Systems
WCH	West Coast HybridsSkyRipper

Notes	Designation	Mfg.	Size (mm)	Total Impulse (N-sec.)	Propel. Mass (grams)	Cert. Group
S*	1/8A.5 (MicroMaxxII)-1,NE	Quest	6 x 26	0.22	0.5	NAR
S	1/8A.2 (MicroMaxx)-1	Quest	6 x 26	0.135	0.4	NAR
S*	1/4A3T-3	Estes	13 x 45	0.62	0.8	NAR
S*	1/2A3T-2,4	Estes	13 x 45	1.25	2.0	NAR
S*	1/2A6-2	Estes	18 x 70	1.25	2.6	NAR
S*	A3T-4	Estes	13 x 45	2.5	3.3	NAR
S	A3T-2,4	Quest	13 x 55	1.71	3.6	NAR
S*	A6-4	Quest	18 x 70	2.5	3.5	NAR
S*	A6-4	Quest	18 x 70	2.3	3.5	NAR
S*	A8-3,5	Estes	18 x 70	2.5	3.3	NAR
S	A8-3	Quest	18 x 70	1.86	3.6	NAR
S*	A8-0	Estes	18 x 70	2.15	3.8	NAR
S*	A10T-3,P	Estes	13 x 45	2.5	3.8	NAR
S*	A10T-0	Estes	13 x 45	1.88	3.6	NAR
S*	B4-2,4	Estes	18 x 70	5	6.0	NAR
S	B4-4	Quest	18 x 70	3.84	10.4	NAR
S*	B6-0	Estes	18 x 70	4.9	5.6	NAR
S*	B6-0,4	Quest	18 x 70	5	6.5	NAR
S*	B6-2	Quest	18 x 70	5	6.5	NAR
S*	B6-4	Quest	18 x 70	4.85	6.5	NAR
S*	B6-2,4,6	Estes	18 x 70	5	5.6	NAR
R	C3.4-P	Aerotech	18 x 72	8.96	5.2	NAR
S*	C6-0	Quest	18 x 70	8.8	11.0	NAR
S*	C6-0,3,5,7	Estes	18 x 70	9	10.8	NAR
S*	C6-3,5	Quest	18 x 70	8.5	11.0	NAR
S*	C6-3,5	Quest	18 x 70	8.76	12.0	NAR
S*	C11-3,5	Estes	24 x 70	9	12.0	NAR
S*	C11-0,7	Estes	24 x 70	9	12.0	NAR
R	D2.3-P	Aerotech	18 x 72	17.21	10.7	NAR
S	D5-P	Quest	20 x 88	19.6	25.0	NAR
S	D5-4,6	Quest	20 x 96	17.61	24.0	NAR
R*	D7-RC	Aerotech	24 x 70	20	10.5	NAR
S	D8-0,3,5	Quest	24 x 70	18.59	22.0	NAR
R*	D9-4,7	Aerotech	24 x 70	20	10.1	NAR
S*	D10-3,5,7	Apogee	18 x 70	18.3	9.8	NAR
S*	D10-3,5,7	Aerotech	18 x 70	18.3	9.8	NAR
S*	D11-P	Estes	24 x 70	18	24.5	NAR
S*	D12-0,3,5,7	Estes	24 x 70	17	21.1	NAR
R*	D13-4,7,10	Aerotech	18 x 70	20	9.8	NAR
R*	D15-4,6	Aerotech	24 x 70	20	8.9	NAR
S*	D21-4,7	Aerotech	18 x 70	20	9.6	NAR
R*	D24-4,7	Aerotech	18 x 70	18.5	8.8	NAR
S*	E6-4,6,8,P	Apogee	24 x 70	37.8	22.0	NAR
R*	E6-RC	Aerotech	24 x 70	40	21.5	NAR

Notes	Designation	Mfg.	Size (mm)	Total Impulse (N-sec.)	Propel. Mass (grams)	Cert. Group
R*	E7-RC	Aerotech	24 x 70	30	17.1	NAR
S	E9-0	Estes	24 x 95	28.5	35.8	NAR
S*	E9-4,6,8,P	Estes	24 x 95	28.5	35.8	NAR
R*	E11J-3	Aerotech	24 x 70	31.7	25.0	NAR
S*	E12-0,4,6,8	Estes	24 x 95	27.24	35.9	NAR
R*	E12J-RC	Aerotech	24 x 70	36	30.3	NAR
S*	E15-4,7	Aerotech	24 x 70	35	16.2	NAR
S*	E15W-P	Aerotech	24 x 70	40	20.1	NAR
R*	E16-4,7	Aerotech	29 x 124	40	19.0	NAR
S*	E16-0,4,6,8	Estes	29 x 114	33.38	40.0	NAR
R*	E18-4,8	Aerotech	24 x 70	39	20.7	NAR
S*	E20W-4,7,10	Aerotech	24 x 65	35	16.2	NAR
R*	E22SS-13A	Cesaroni	24 x 69	24.2	13.4	CAR
R*	E23-5,8	Aerotech	29 x 124	37	17.4	NAR
S	E25R-4,7,P	Roadrunner	29 x 76	38.7	20.6	TRA
R*	E28-4,7	Aerotech	24 x 70	40	18.4	NAR
S*	E30-4,7	Aerotech	24 x 70	33.6	17.8	NAR
S*	E30-4,7	Estes	24 x 70	33.6	17.8	NAR
R*	E31WT-15A	Cesaroni	24 x 69	26.1	11.2	CAR
R	E40F-7	Kosdon	25 x 108.458	34.987	18.0	TRA
R*	E75VM-17A	Cesaroni	24 x 69	24.8	10.4	CAR
S*	F10-4,6,8	Apogee	29 x 93	74.3	40.0	NAR
R*	F12-2,5	Aerotech	24 x 70	45	30.0	NAR
R*	F13-RC	Aerotech	32 x 107	63	32.3	NAR
S*	F15-0,4,6,8	Estes	29 x 114	49.61	60.0	NAR
R*	F16-RC	Aerotech	32 x 107	80	62.5	NAR
S*	F20-4,7	Aerotech	29 x 83	51.75	30.0	NAR
S	F21W-4,6,8	Aerotech	24 x 98	55	30.0	TRA
R*	F22-4,7	Aerotech	29 x 124	65	46.3	NAR
S*	F23FJ-4,7	Aerotech	29 x 73	56	32.0	NAR
S*	F23FJ-4,7	Aerotech	29 x 83	41.2	30.0	NAR
R*	F23SK-RC	Aerotech	32 x 107	70	37.8	NAR
R*	F24-4,7	Aerotech	24 x 70	50	19.0	NAR
S*	F25W-4,6,9	Aerotech	29 x 98	80	35.6	NAR
S*	F26FJ-6,9	Aerotech	29 x 98	62.2	43.1	NAR
S*	F26FJ-6	Estes	29 x 98	62.2	43.1	NAR
S*	F27R-4,8	Aerotech	29 x 83	49.6	28.4	NAR
R*	F29IM-12A	Cesaroni	29 x 98	54.8	30.9	CAR
S*	F30FJ-4,6,8	Aerotech	24 x 90	47	31.2	NAR
R*	F30WH/LB-6A	Cesaroni	24 x 133	73.1	40.0	CAR
S*	F32T-4,6,8	Aerotech	24 x 90	56.9	25.8	NAR
S	F35-6,10	Roadrunner	29 x 112	76.5	40.1	NAR
R*	F35W-5,8,11	Aerotech	24 x 95	57.1	30.0	NAR
R*	F36BS-14A	Cesaroni	29 x 98	51.5	25.6	CAR
R*	F36SS-11A	Cesaroni	29 x 98	41.2	29.5	CAR
R*	F37-6,10,14	Aerotech	29 x 99	50	28.2	NAR
R*	F39-3,6	Aerotech	24 x 70	50	22.7	NAR
R*	F40-4,7,10	Aerotech	29 x 124	80	40.0	NAR
S*	F42T-4,8	Aerotech	29 x 83	52.9	27.0	NAR
S	F45R-5,8,P	Roadrunner	29 x 93	62.3	30.0	TRA

Notes	Designation	Mfg.	Size (mm)	Total Impulse (N-sec.)	Propel. Mass (grams)	Cert. Group
S*	F50-4,6,9	Aerotech	29 x 98	80	37.9	NAR
R	(HP)F50SK-13A	Cesaroni	24 x 133	59.7	31.7	CAR
S*	F50T-6,9	Estes	29 x 98	80	37.9	NAR
S	F50T-6	PML	29 x 98	80	37.9	NAR
R*	F51CL-12A	Cesaroni	24 x 133	75	33.0	CAR
R*	F52-6,8,11	Aerotech	29 x 124	78	36.6	NAR
R*	F59WT-12A	Cesaroni	29 x 98	57	26.1	CAR
S	F60-4,7,10	Roadrunner	29 x 112	75.9	38.1	NAR
R*	F62T-S,M,L	Aerotech	29 x 89	51	30.5	TRA
R*	F79SS-13A	Cesaroni	24 x 133	67.8	40.1	CAR
R	(HP)F85WT-15A	Cesaroni	24 x 133	73.6	33.7	CAR
R	(HP) F120VM-14A	Cesaroni	29 x 98	56	25.3	CAR
R	(HP)F240VM-15A	Cesaroni	24 x 133	68.3	30.3	CAR
R*	G12-RC	Aerotech	32 x 107	93	51.1	NAR
R	G25W-14A	Aerotech	29 x 124	109.48	97.0	TRA
R	G33-5,7	Aerotech	29 x 124	100	72.2	NAR
S*	G38FJ-4,7	Aerotech	29 x 98	94	55.0	NAR
S	G39-6,10,P	Roadrunner	29 x 140	103	58.6	TRA
S	G40W-4,7	PML	29 x 124	120	55.1	NAR
S*	G40W-4,7,10	Aerotech	29 x 124	97.1	55.1	NAR
S*	G40-4,7	Estes	29 x 124	97.1	55.1	NAR
R	G40S-P	Kosdon	29 x 205.74	109.96	60.0	TRA
S	G45-6,10,P	Roadrunner	29 x 140	110	58.6	TRA
R*	G46-11A	Cesaroni	38 x 127	127.3	62.5	CAR
R*	G50IM-15A	Cesaroni	38 x 127	150	77.7	CAR
R*	G53FJ-5,7,10	Aerotech	29 x 124	90.9	60.0	NAR
R*	G54-6,10,14	Aerotech	29 x 124	85	46.0	NAR
R*	G54RL-12A	Cesaroni	29 x 187	159.1	86.5	CAR
H	(HP) G55-P	WCH	38 x 308	150.6	142cc	CAR
R*	G57CL-12A	Cesaroni	29 x 142	107.8	51.4	CAR
R*	G58WH-13A	Cesaroni	38 x 127	136.8	76.3	CAR
R	G60-12A	Cesaroni	38 x 127	139.4	78.4	TRA
R	G60-14A	Cesaroni	38 x 127	134.2	68.3	CAR
R*	G61W-S,M,L	Aerotech	38 x 106	110.5	61.5	TRA
H	(HP) G63-P	SkyRipper	29 x 305	85	75cc	TRA
R*	G64-4,8,10	Aerotech	29 x 124	120	62.5	NAR
R*	G65WH/LB-8A	Cesaroni	24 x 228	144.3	80.0	CAR
R	G65DH-9	Kosdon	29 x 205.74	119.18	90.0	TRA
R*	G68WH-13A	Cesaroni	29 x 142	107.8	59.9	CAR
R*	G67R-S,M	Aerotech	38 x 106	110	60.0	TRA
R*	G69N-P	Aerotech	38 x 106	136.7	62.2	NAR
H	(HP) G69-P	SkyRipper	29 x 406	128	125cc	TRA
R*	G69-12A	Cesaroni	38 x 127	128.8	62.5	TRA
R	(HP) G69SF-17A	Loki	38 x 127	106.1	63.0	TRA
R	(HP) G69SK-14A	Cesaroni	38 x 127	117.15	198.0	TRA
R	G70S-7	Kosdon	25 x 176.276	95.686	50.0	TRA
R	G71R-4,7,10	Aerotech	29 x 124	107	56.9	NAR
R*	G75J-S,M	Aerotech	29 x 194	135.6	104.3	TRA
S	(HP)G75M-4,7,10	Aerotech	29 x 124	120.39	66.8	TRA
R*	G76G-4,7,10	Aerotech	29 x 124	115	60.0	NAR
R*	G77R-S,M	Aerotech	29 x 150	105	58.0	TRA
S*	G77R-4,7,10	Aerotech	29 x 146	102.9	58.1	NAR
R*	G78BS-15A	Cesaroni	38 x 127	140.9	67.0	TRA
S*	G78G-4,7,10	Aerotech	29 x 146	109.9	59.7	NAR
R*	G79SS-13A	Cesaroni	38 x 127	129	100.0	CAR
R*	G79W-S,M,L	Aerotech	29 x 150	108.6	62.0	TRA
S*	G79W-4,7,10	Aerotech	29 x 146	108	60.1	NAR
S*	G80-4,7,10	Aerotech	29 x 124	120	56.9	NAR
S	G80NT-10A	Aerotech	29 x 128	132.17	62.5	TRA
S*	G80T-7,10,13	Aerotech	29 x 128	136.6	62.5	NAR
S*	G80T-7,10	Estes	29 x 128	136.6	62.5	NAR
R*	G80LW-17A	Loki	38 x 127	122.5	60.0	TRA
S	G80T-4,7	PML	29 x 124	120	56.9	NAR
S	G80-4,7,10	Roadrunner	29 x 140	105.7	54.7	NAR
R	(HP) G80SK-14A	Cesaroni	29 x 142	92.9	50.0	CAR
R	(HP) G82W-S,M,L	Kosdon/AT	29 x 206	141	84.0	TRA
R	(HP) G83BS-14A	Cesaroni	29 x 142	107.4	51.1	CAR
R	(HP) G88SS-11A	Cesaroni	29 x 142	84.3	59.0	CAR
R	(HP)G84GR-10A	Cesaroni	24 x 228	131	77.3	CAR
H	(HP) G100-P	Contrail	38 x 407	146	140cc	TRA
R	(HP) G100SK-14A	Cesaroni	24 x 228	114.5	63.3	CAR
R	(HP) G104T-S,M,L	Aerotech	29 x 125	81.5	43.9	TRA
R	(HP) G106SK-14A	Cesaroni	29 x 187	138.3	75.0	CAR
R	(HP)G107WH-12A	Cesaroni	24 x 228	139.1	75.7	CAR
R	(HP) G115-13A	Cesaroni	38 x 127	140.6	61.8	CAR
R	(HP)G117WH-11A	Cesaroni	24 x 228	142.3	79.1	CAR
R	(HP) G118BS-15A	Cesaroni	29 x 187	159.1	76.7	CAR
R	(HP)G120F-10	Kosdon	25 x 176.276	97.206	53.0	TRA
H	(HP) G123-P	Contrail	38 x 407	142	140cc	TRA
H	(HP) G125-P	SkyRipper	38 x 406	145	120cc	TRA
R	(HP) G125RL-14A	Cesaroni	29 x 187	159.6	81.9	CAR
S	(HP)G125T-14A	Aerotech	29 x 127	124.81	62.0	TRA
R	(HP) G126WT-13A	Cesaroni	29 x 142	116	52.1	CAR
R	(HP) G127RL-14A	Cesaroni	24 x 228	137.3	70.5	CAR
H	(HP) G130-P	Contrail	38 x 407	100	140cc	TRA
R	(HP) G131SS-14A	Cesaroni	29 x 187	125.2	88.6	CAR
R	(HP) G135R-SML	Kosdon/AT	29 x 206	146	90.0	TRA
R	(HP)G138T-14a	Aerotech	29 x 124	157.1	70.0	NAR
R	(HP) G142-6,10,14	Aerotech	29 x 113	84.3	38.6	NAR
R	(HP)G145PK-15A	Cesaroni	24 x 228	139.7	66.7	CAR
R	(HP)G150BS-13A	Cesaroni	24 x 228	142.5	65.9	CAR
H	(HP) G170PVC-P	Contrail	38 x 406	82.9	140cc	TRA
R	(HP) G185-12A	Cesaroni	38 x 127	128	62.1	CAR
H	(HP) G234-P	Contrail	38 x 414	118	90cc	TRA
R	(HP) G250VM-14A	Cesaroni	29 x 142	110	50.6	CAR
H	(HP) G300-P	Contrail	38 x 406	100	90cc	TRA
R	(HP) G339-P	Aerotech	38 x 106	110	48.0	TRA
R	H54WH/LB-10A	Cesaroni	29 x 187	167.7	96.6	CAR
S	H55W-6,10,14	Aerotech	29 x 191	162.3	99.7	TRA
H	H70-P	RATTWorks	29 x 457	204.3	135.8cc	TRA
H	H70-P	Propulsion	38 x 464	237	217cc	CAR
R	H70S-9	Kosdon	29 x 290.576	282.95	111.0	TRA
R	H73J-S,M	Aerotech	38 x 152	185.6	142.7	TRA
H	H78-P	SkyRipper	29 x 523	172.9	185cc	TRA
R	H87IM-12A	Cesaroni	29 x 187	167.9	92.7	CAR
R	H90CL-12A	Cesaroni	29 x 187	164.2	77.1	CAR
R	H90LR-14A	Loki	38 x 177	234.4	120.0	TRA
R	H97J-S,M	Aerotech	29 x 238	177.3	137.1	TRA
R	H100SF-17A	Loki	38 x 177	201.5	120.0	TRA
H	H100-P	WCR	38 x 403	247	189cc	CAR
R	H100IM-15A	Cesaroni	38 x 186	286.4	154.4	CAR
R	H105DH-9	Kosdon	29 x 290.576	196.78	148.0	TRA
R	H110WH-14A	Cesaroni	38 x 186	269.1	152.6	CAR
R	H112J-6,10,14	Aerotech	38 x 191	261.1	191.2	TRA
R	H118CL-12A	Cesaroni	29 x 231	216.2	102.8	CAR
R	H120-14A	Cesaroni	38 x 186	260.7	136.6	CAR
H	H121-P	Contrail	38 x 508	225	185cc	TRA
R	H123W-6,10,14	Aerotech	38 x 152	223.6	119.0	TRA
R	H123-14A	Cesaroni	38 x 186	232.4	123.0	CAR
R	H123SK-12A	Cesaroni	29 x 231	176.5	100.0	CAR
H	H124-P	SkyRipper	38 x 533	225	220cc	TRA
R	H125-12A	Cesaroni	38 x 186	265.6	125.0	CAR
R	H128W-S,M,L	Aerotech	29 x 194	172.9	93.6	TRA
R	H130W-P	Kosdon/AT	29 x 291	247	140.0	TRA
R	H133BS-14A	Cesaroni	29 x 187	163.3	76.7	CAR
R	H135WH-12A	Cesaroni	29 x 231	216.7	119.8	CAR
R	H135S-9	Kosdon	29 x 290.576	225.65	132.0	TRA
S	H135W-14A	Aertotech	29 x 216	225.84	82.0	TRA
R	H140CL-11A	Cesaroni	29 x 276	268	128.5	CAR
R	H140VM-14A	Cesaroni	29 x 187	167.7	75.9	CAR
H	H141-P	Contrail	38 x 508	241	185cc	TRA
R	H143SS-13A	Cesaroni	38 x 186	247	187.0	CAR
R	H144LW-17A	Loki	38 x 190	239.3	126.0	TRA
R	H148R-S,M,L	Aerotech	38 x 152	206	122.0	TRA
R	H151RL-15A	Cesaroni	29 x 231	207.2	109.1	CAR
R	H152BS-15A	Cesaroni	38 x 185	275.9	137.0	TRA
R	H153-13A	Cesaroni	38 x 186	258	143.9	TRA
H	H155-P	SkyRipper	38 x 533	229	220cc	TRA
R	H155F(G110)-9	Kosdon	29 x 205.74	146.9	82.0	TRA
R	H159GR-15A	Cesaroni	29 x 320	298.2	176.6	CAR
R	H160CL-12A	Cesaroni	29 x 320	311.7	154.2	CAR
R	H160LB-15A	Loki	38 x 177	260.1	120.0	TRA
R	H160SK-14A	Cesaroni	29 x 276	220.5	125.0	CAR
R	H163WT-14A	Cesaroni	29 x 187	166.3	78.2	CAR
R	H165R-M,L	Aerotech	29 x 194	165	90.0	TRA
R	H170BS-14A	Cesaroni	29 x 231	217.1	102.3	CAR
R	H170M-14A	Aerotech	38 x 192	319.9	182.5	TRA
R	H175SS-14A	Cesaroni	29 x 231	166	118.1	CAR
R	H178DM-14A	Aerotech	38 x 192	283	177.0	TRA
R	H180SK-14A	Cesaroni	29 x 320	258	150.0	CAR
R	H180W-S,M,L	Aerotech	29 x 238	217.7	125.0	TRA
R	H186RT-20A	Gorilla	38 x 249	312.12	178.0	TRA
R	H194RL-14A	Cesaroni	29 x 276	260.3	136.4	CAR
S	H195NT-10A	Aerotech	29 x 222	236.09	107.0	TRA
H	H200BS-P	Contrail	54 x 762	269	N/A	TRA
R	H200BS-14A	Cesaroni	29 x 276	260.8	127.9	CAR
R	H200S-13	Kosdon	25 x 382.54	246.97	132.0	TRA
R	H210R-10,P	Aerotech	29 x 238	220	110.8	NAR
H	H211-	Contrail	38 x 508	206	185cc	TRA
R	H220T-6,10,14	Aerotech	29 x 238	220	106.4	NAR
H	H222-P	Contrail	38 x 406	161	140cc	TRA
R	H225-14A	Cesaroni	38 x 186	273.2	123.6	CAR
R	H225BL-P	Gorilla	38 x 249	226	162.0	TRA
R	H226SK-14A	Cesaroni	29 x 365	305	175.0	CAR
R	H233RL-14A	Cesaroni	29 x 320	311.5	163.7	CAR
R	H237SS-13A	Cesaroni	29 x 276	206.2	147.6	CAR
R	H238T-6,10,14	Aerotech	29 x 194	165.5	85.0	TRA
R	H242T-6,10,14	Aerotech	38 x 152	231.7	115.0	TRA
H	H246-P	Contrail	38 x 508	222	185cc	TRA

Notes	Designation	Mfg.	Size (mm)	Total Impulse (N-sec.)	Propel. Mass (grams)	Cert. Group
H	H245PVC-P	Contrail	38 x 719	262	275cc	TRA
R	H250G-S,M,L	Aerotech	29 x 239	219.5	120.0	TRA
R	H255BS-14A	Cesaroni	29 x 320	315.4	153.4	CAR
R	H255F-9	Kosdon	29 x 290.576	245.87	135.0	TRA
R	H255WT-14A	Cesaroni	29 x 231	229.3	104.3	CAR
R	H268R-10,14,P	Aerotech	29 x 333	320	166.0	NAR
H	H277-P	Contrail	38 x 712	292	370cc	TRA
R	H295SS-13A	Cesaroni	29 x 320	252.7	177.1	CAR
H	H300-P	Contrail	38 x 508	161	185cc	TRA
H	H303-P	Contrail	38 x 508	170	185cc	TRA
H	H340-P	Contrail	38 x 719	304.5	275cc	TRA
R	H340SS-14A	Cesaroni	29 x 365	287.3	206.7	CAR
R	H365F-15	Kosdon	25 x 382.524	235.66	129.0	TRA
R	H399WT-12A	Cesaroni	29 x 320	282.2	132.6	CAR
R	H400-14A	Cesaroni	38 x 186	255	122.4	TRA
R	H470F-17	Kosdon	25 x 488.95	289.13	166.0	TRA
R	H500-17A	Loki	38 x 295	317	156.0	TRA
R	H565-A	Cesaroni	38 x 245	319.8	165.0	CAR
R	H669-P	Aerotech	38 x 152	221	98.0	TRA
R	H999-P	Aerotech	38 x 203	319.9	147.0	TRA
R	I49N-P	Aerotech	38 x 184	383	190.8	NAR
R	I59WN-P	Aerotech	38 x 232	486	251.7	NAR
S	I65W-P	Aerotech	54 x 235	630.5	369.7	NAR
H	I80-P	RATTWorks	29 x 730	360	276cc	TRA
H	I80-P	Propulsion	38 x 646	460	383cc	CAR
H	I90L-P	RATTWorks	29 x 921	493.8	361cc	TRA
R	I100RL/LB-17A	Cesaroni	54 x 236	613.6	350.1	CAR
R	I110LW-M,L	Loki	38 x 305	487	289.0	TRA
H	I110-P	WCR	38 x 606	499.7	334cc	CAR
R	I115W-S,M,L	Aerotech	54 x 156	409.3	229.0	TRA
R	I117FJ-S,M,L	Aerotech	54 x 156	364.9	253.0	TRA
H	I117-P	SkyRipper	38 x 914	592	580cc	TRA
H	I119-P	SkyRipper	38 x 711	407	400cc	TRA
R	I120IM-15A	Cesaroni	54 x 143	501.8	263.1	CAR
H	I130(300CC098J)-P	Hypertek	54 x 546	470.6	300cc	TRA
H	I136(300CC098J2)-P	Hypertek	54 x 546	507	300cc	TRA
R	I140SK-14A	Cesaroni	54 x 143	395.6	210.4	CAR
S	I140W-14A	Aerotech	38 x 203	335.53	183.0	TRA
H	I145FX(300CC098JFX)-P	Hypertek	54 x 546	541	300cc	TRA
H	I147-P	SkyRipper	38 x 711	519	400cc	TRA
R	I150BS-11A	Cesaroni	54 x 152	465.1	224.0	TRA
R	I150S(J166)-9	Kosdon	54 x 250.19	656.26	364.0	TRA
R	I154J-6,10	Aerotech	38 x 241	378	252.8	TRA
H	I155HP-P	Contrail	38 x 719	541	370cc	TRA
R	I155S-9	Kosdon	38 x 257.81	366.19	194.0	TRA
H	I160-P	Propulsion	38 x 646	484	383cc	CAR
R	I161W-S,M,L	Aerotech	38 x 191	328.7	178.6	TRA
R	I165CS-17A	Cesaroni	54 x 69	518.2	230.1	CAR
R	I170S-L	Kosdon/AT	38 x 314	374	182.0	TRA
R	I170-14a	Cesaroni	38 x 245	382	187.5	CAR
R	I170G-10A	Aerotech	54 x 174	418.54	227.0	TRA
R	I175WH-14A	Cesaroni	38 x 245	411.4	228.9	CAR
R	I180SK-14A	Cesaroni	38 x 245	338.43	394.0	TRA
R	I195J-6,10,14	Aerotech	38 x 299	426.1	272.0	TRA
R	I195WW-18	Animal	38 x 249	358	192.2	NAR
R	I195-16A	Cesaroni	38 x 245	396.2	204.9	CAR
R	I200W-6,10,14	Aerotech	29 x 333	324.5	186.5	TRA
R	I204IM-13A	Cesaroni	29 x 320	347.7	185.4	CAR
H	I205(300CC125J)-P	Hypertek	54 x 546	469	300cc	TRA
R	I205-13A	Cesaroni	38 x 245	380.9	206.1	TRA
H	I210-P	Contrail	38 x 915	497	550cc	TRA
R	I210LR-14A	Loki	38 x 292	489.8	240.0	TRA
R	I211W-6,10,14	Aerotech	38 x 248	441.6	238.0	TRA
R	I212SS-14A	Cesaroni	38 x 245	364	275.0	CAR
R	I215R-S,M,L	Aerotech	54 x 156	397	208.0	TRA
R	I216CL(I)-14A	Cesaroni	38 x 367	636.1	312.5	CAR
R	I218R-6,14,P	Aerotech	38 x 203	330	172.7	NAR
R	I218WT-14A	Cesaroni	54 x 152	491.2	230.0	TRA
R	I220SK-20	Animal	38 x 249	358	201.9	NAR
R	I220S-9	Kosdon	38 x 250.19	480.19	256.0	TRA
H	I221-P	Contrail	38 x 712	370	370cc	TRA
H	I222(300CC125J2)-P	Hypertek	54 x 546	519	300cc	TRA
R	I223GT-20A	Gorilla	38 x 249	327.93	181.0	TRA
R	I223SK-14A	Cesaroni	38 x 303	434.05	494.0	TRA
R	I224CL-15A	Cesaroni	29 x 365	381.5	182.5	CAR
H	I225FX(300CC125JFX)-P	Hypertek	54 x 546	527.5	300cc	TRA
R	I225FJ-6,10,14	Aerotech	38 x 250	368	264.0	TRA
R	I229T-S,M,L	Aerotech	54 x 156	411	206.0	TRA
R	I235WC-P	Gorilla	38 x 249	324	313.0	TRA
R	I236BS-17A	Cesaroni	38 x 243	413	204.0	TRA
R	I240-15A	Cesaroni	38 x 303	555.8	279.0	TRA
R	I242WH-15A	Cesaroni	38 x 303	548.2	305.2	CAR
R	I243WH-13A	Cesaroni	29 x 365	381.7	212.1	CAR
R	I245G-S,M,L	Aerotech	38 x 201	334.07	187.0	TRA
H	I247WS-P	Contrail	54 x 711	637	N/A	TRA
H	I250HP-P	Contrail	38 x 719	430	275cc	TRA
H	I250-P	Alpha	54 x 711	540	353.8	NAR
R	I255-16A	Cesaroni	38 x 303	517.3	273.2	CAR
H	I260(440CC172J)-P	Hypertek	54 x 614	570.4	440cc	TRA
R	I271BB-20	Animal	38 x 258	390	188.7	NAR
R	I280F-L	Kosdon/AT	38 x 314	382	182.0	TRA
S	I280DM-14A	Aerotech	38 x 355	561.44	355.0	TRA
R	I284W-6,10,14	Aerotech	38 x 299	607.3	315.9	TRA
R	I285-15A	Cesaroni	38 x 303	510.1	272.4	TRA
R	I285R-10,14,P	Aerotech	38 x 250	420	230.2	NAR
R	I285GG-20	Animal	38 x 258	353	206.5	NAR
R	I287SS-15A	Cesaroni	38 x 303	486	363.0	CAR
H	I290-P	Contrail	38 x 922	430	460cc	TRA
R	I297SK-15A	Cesaroni	38 x 367	542.8	591.0	TRA
R	I300F-16	Kosdon	38 x 257.81	380.79	193.0	TRA
R	I300T-6,10,14	Aerotech	38 x 250	440	221.6	NAR
R(a)	I301W-18	Kosdon/AT	38 x 370	554	310.0	NAR
R	I303BS-16A	Cesaroni	38 x 302	537.6	270.0	TRA
R	I305FJ-6,10,14	Aerotech	38 x 299	452	330.0	TRA
H	I307-P	Contrail	38 x 915	573	550cc	TRA
H	I310(440CC172J)-	Hypertek	54 x 645	574.5	440cc	TRA
R	I310S-S,L,P	Kosdon/AT	38 x 368	633.8	316.3	TRA
R	I315SK-20	Animal	38 x 370	572	333.7	NAR
R	I316SF-17A	Loki	38 x 292	432.2	240.0	TRA
R	I324RT-20A	Gorilla	38 x 370	526.46	299.0	TRA
R	I325WW-18	Animal	38 x 370	594	316.8	NAR
R	I327DM-14A	Aerotech	38 x 337	539	354.0	TRA
H	I333-P	Contrail	38 x 922	556	460cc	TRA
R	I345-15A	Cesaroni	38 x 245	408.58	185.4	CAR
R	I350SS-16A	Cesaroni	38 x 367	601	413.0	CAR
S	I350R-10	Aerotech	38 x 355	634	348.0	TRA
R	I357T-S,M,L	Aerotech	38 x 203	342	170.0	TRA
R	I360-15A	Cesaroni	38 x 367	625.5	334.6	TRA
R	I364FJ-6,10,14	Aerotech	38 x 337	570	396.0	TRA
R	I366R-M,L	Aerotech	38 x 299	539	300.0	TRA
R	I370F-P	Kosdon/AT	38 x 368	634.3	316.9	TRA
R	I375GG-20	Animal	38 x 370	596	340.2	NAR
R	I385F(H585)-12	Kosdon	29 x 383.54	305.83	160.0	TRA
R	I389GT-20A	Gorilla	38 x 370	553.15	303.0	TRA
R	I392BL-18A	Gorilla	38 x 370	446.12	270.0	TRA
R	I396LS-17A	Loki	38 x 406	611	372.0	TRA
H	I400-P	Contrail	38 x 922	432	550cc	TRA
R	I405LW-17A	Loki	38 x 305	493.2	252.0	TRA
R	I420F-16	Kosdon	38 x 313.69	502.02	259.0	TRA
R	I430LB-15A	Loki	38 x 292	532.6	240.0	TRA
R	I435T-6,10,14	Aerotech	38 x 299	568.9	273.0	TRA
R	I450F-L	Kosdon/AT	38 x 368	633	302.0	TRA
R	I455VM-16A	Cesaroni	54 x 143	474.9	212.7	CAR
R	I462WC-18A	Gorilla	38 x 370	556.73	292.0	TRA
R	I470-15A	Cesaroni	38 x 303	540.1	247.2	CAR
H	I500-P	Contrail	38 x 712	336	275cc	TRA
S	I500T-14A	Aerotech	38 x 355	614.45	248.0	TRA
R	I540WT-16A	Cesaroni	38 x 367	635	269.4	CAR
R(a)	I550R-20	Kosdon/AT	38 x 370	575	295.0	NAR
R	I560F-20	Kosdon	29 x 597.662	413.54	265.0	TRA
R	I566-16A	Cesaroni	38 x 245	370	183.6	CAR
R	I599N-P	Aerotech	54 x 156	404.9	195.0	TRA
R	I600R-M	Aerotech	38 x 337	597.3	330.0	TRA
H	I727-P	Contrail	38 x 922	611	410cc	TRA
H	I747-P	Contrail	38 x 719	431	225cc	TRA
R	I800-16A	Cesaroni	38 x 303	419	221.0	CAR
R	I1299N-P	Aerotech	38 x 250	422	192.0	TRA
R	J90W-S,M,L	Aerotech	54 x 243	707.3	426.0	TRA
R	J99N-P	Aerotech	54 x 244	945.2	556.0	TRA
H	J115(440CC076J)-P	Hypertek	54 x 614	474	440cc	TRA
H	J120FX(440CC076JFX)-P	Hypertek	54 x 614	758	440cc	TRA
R	J130S-13	Kosdon	75 x 243.84	1070.8	600.0	TRA
S	J135W-S,M,L	Aerotech	54 x 368	1069	663.0	TRA
H	J140-P	Propulsion	38 x 881	664	596cc	CAR
R	J140WH/LB-P	Cesaroni	54 x 329	1210.6	680.0	CAR
H	J144-P	SkyRipper	38 x 914	699	580cc	TRA
H	J145H2-jetstd.-P	Aerotech	54 x 709	825.7	440cc/172g	TRA
H	J150-P	Contrail	38 x 922	654	550cc	TRA
H	J160-P	RATTWorks	38 x 1219	667	490cc	TRA
R	J167WC-P	Gorilla	54 x 326	950	600.0	TRA
H	J170(440CC098J)-P	Hypertek	54 x 614	728	440cc	TRA
H	J170H3-jetstd.-P	Aerotech	54 x 709	739	440cc/172g	TRA
R	J175LW-PS	Loki	54 x 330	1146	630.0	TRA
R	J180T-S,M,L	Aerotech	54 x 230	764	437.1	TRA
H	J190FX(440CC098JFX)-P	Hypertek	54 x 614	827	440cc	TRA
R	J210-16A	Cesaroni	54 x 236	836	396.0	CAR/NAR
H	J210H4-jetstd.-P	Aerotech	54 x 709	850	440cc/172g	TRA
H	J220(440CC110J)-P	Hypertek	54 x 645	721	440cc	TRA
H	J222-P	Contrail	38 x 1227	928	830cc	TRA

Notes	Designation	Mfg.	Size (mm)	Total Impulse (N-sec.)	Propel. Mass (grams)	Cert. Group
R	J230S-10	Kosdon	54 x 326.39	986.5	546.0	TRA
R	J230SK-P	Animal	54 x 326	995	525.7	NAR
H	J234-P	Contrail	54 x 922	1033	910cc	TRA
R	J240-16A	Cesaroni	54 x 236	806	446.0	CAR
H	J242-P	Contrail	38 x 1220	752	830cc	TRA
R	J244WH-14A	Cesaroni	54 x 236	867.2	472.1	CAR
H	J245-P	Contrail	54 x 719	644	530cc	TRA
H	J246-P	Contrail	38 x 922	673	550cc	TRA
H	J250-P	Contrail	38 x 711	430	370cc	TRA
H	J250(440CC125J)-P	Hypertek	54 x 614	744.5	440cc	TRA
R	J250F-13	Kosdon	75 x 243.84	1099.95	608.0	TRA
R	J250FJ-S,M,L,XL	Aerotech	54 x 241	711.6	511.0	TRA
R	J250SK-15A	Cesaroni	54 x 236	682.8	406.0	TRA
H	J260HW3-jetEFX-P	Aerotech	54 x 709	1150	440cc/299g	TRA
H	J261G-P	SkyRipper	54 x 727	1248	830cc	TRA
H	J263G-P	SkyRipper	54 x 607	844	550cc	TRA
H	J270FX(440CC125JFX)-P	Hypertek	54 x 614	802.2	440cc	TRA
R	J270GR-13A	Cesaroni	38 x 367	650.3	376.0	CAR
S	J270W-14A	Aerotech	38 x 355	703.39	381.0	TRA
H	J272-P	Contrail	54 x 922	1065.5	910cc	TRA
R	J275W-S,M,L,XL	Aerotech	54 x 230	774	472.0	TRA
H	J277WS-P	Contrail	54 x 914	1031	N/A	TRA
R	J280S(I247)-11	Kosdon	38 x 369.57	589.07	322.0	TRA
R	J280SS-16A	Cesaroni	54 x 236	716.5	512.0	CAR
R	J285-15A	Cesaroni	38 x 360	684	327.0	CAR
R	J290WH-15A	Cesaroni	38 x 367	683.6	381.5	CAR
H	J292-P	Contrail	54 x 719	734	530cc	TRA
R	J293BS-13A	Cesaroni	54 x 236	837.8	414.0	TRA
R	J295-16A	Cesaroni	54 x 320	1196.3	594.0	CAR
R	J295DH-17	Kosdon	54 x 402.59	1173.3	831.0	TRA
H	J295FX(440CC172JFX)-P	Hypertek	54 x 552	655	440cc	TRA
R	J300-15A	Cesaroni	38 x 360	694	345.4	TRA
R	J315R-L,P	Aerotech	54 x 230	763.3	438.0	TRA
H	J315-P	Hypertek	81 x 552	998.8	440cc	TRA
R	J316PK-17A	Cesaroni	38 x 367	654.3	337.9	CAR
R	J320LR-14A	Loki	38 x 406	721	372.0	TRA
R	J325-P	Cesaroni	54 x 326	1099	537.0	CAR
R	J330-16A	Cesaroni	38 x 419	765	392.0	CAR
H	J330FX(835CC172JFX)-P	Hypertek	81 x 552	1051	835cc	TRA
H	J333-P	Contrail	38 x 1220	752	830cc	TRA
H	J335BG-P	Contrail	54 x 719	679	530cc	TRA
R	J335-15A	Cesaroni	38 x 367	649.2	341.5	CAR
H	J337B-P	SkyRipper	54 x 727	1073	830cc	TRA
R	J340F-12	Kosdon	54 x 250.19	755.2	368.0	TRA
R	J340M-14A	Aerotech	38 x 336	651.7	365.0	TRA
R	J450F(I377)-10	Kosdon	38 x 250.19	619.83	3223.0	TRA
H	J345-P	Contrail	38 x 1227	891	735cc	TRA
R	J345S-18	Kosdon	38 x 475.742	708.4	394.0	TRA
H	J348B-P	SkyRipper	54 x 607	716	550cc	TRA
R	J350SF-PS	Loki	54 x 327	931	574.0	TRA
R	J350W(0.5"core)-S,M,L	Aerotech	38 x 337	670.1	361.1	TRA
R	J350W(.425 core)-S,M,L	Aerotech	38 x 337	697.4	381.1	TRA
R	J480F-15	Kosdon	54 x 326.39	1065.1	584.0	TRA
R	J354WH-16A	Cesaroni	38 x 421	818.7	457.8	CAR
H	J355-P	Contrail	54 x 712	678.9	530cc	TRA
R	J355-16A	Cesaroni	54 x 329	1189.5	669.0	CAR
R	J357BS-17A	Cesaroni	38 x 360	657.6	338.0	TRA
R	J357WW-P	Animal	54 x 326	1000	548.1	NAR
H	J358-P	Contrail	54 x 922	913.9	910cc	TRA
R	J360-15A	Cesaroni	38 x 419	826	413.1	TRA
R	J360SM-16A	Cesaroni	54 x 320	1015.9	606.0	TRA
R	J365SK-P	Animal	54 x 403	1125	702.3	NAR
R	J365BL-P	Gorilla	54 x 326	852	498.0	TRA
R	J370GG-P	Animal	54 x 326	1040	598.3	NAR
R	J380SS-16A	Cesaroni	54 x 320	1043	769.0	CAR
R	J381SK-15A	Cesaroni	38 x 421	659.9	688.0	TRA
R	J390HW-3 jet-P	Aerotech	54 x 709	1280	440cc/391g	TRA
R	J394GR-13A	Cesaroni	38 x 500	970.4	572.1	CAR
R	J395RT-P	Gorilla	N/A x N/A	1026	524.0	TRA
R	J395-P	Cesaroni	54 x 326	1079.3	573.0	CAR
R	J400RR-P	Animal	54 x 326	1100	558.0	NAR
R	J400SS-16A	Cesaroni	38 x 419	700	490.0	CAR
R	J400-P	Cesaroni	54 x 326	976.9	723.0	CAR
R	J401FJ-S,M,L	Aerotech	54 x 314	1115.4	730.0	TRA
R	J405S-L	Kosdon/AT	38 x 476	722	367.0	TRA
R	J410-16A	Cesaroni	38 x 421	773.8	409.8	CAR
R	J415W-S,M,L	Aerotech	54 x 314	1232	697.0	TRA
H	J416-P	Contrail	54 x 922	1130	910cc	TRA
R	J420CL-15A	Cesaroni	38 x 500	1007.8	479.6	CAR
R	J420R-S,M,L	Aerotech	38 x 337	658	345.0	TRA
R	J425BS-16A	Cesaroni	38 x 419	78309	406.0	TRA
R	J430WT-18A	Cesaroni	54 x 236	821.1	384.0	CAR
R	J440BB-P	Animal	54 x 326	1109	528.4	CAR
R	J440BB-20	Animal	38 x 370	653	313.1	NAR
R	J449BS-15A	Cesaroni	54 x 320	1260.5	624.0	TRA
R	J450F-10	Kosdon	38 x 369.57	619.83	3223.0	TRA
R	J450ST-P	Animal	54 x 326	1070	533.1	NAR
R	J450BL-P	Gorilla	54 x 402	1121	658.0	TRA
R	J453WH-16A	Cesaroni	38 x 500	1012.6	585.5	CAR
R	J460T-S,M,L	Aerotech	54 x 230	806	386.0	TRA
R	J465GT-P	Gorilla	54 x 326	1023	566.0	TRA
R	J475-P	Cesaroni	54 x 326	1024.9	723.0	CAR
R	J475BB-P	Animal	54 x 403	1233.4	704.5	CAR
R	J480BB-P	Animal	54 x 326	1165	556.0	NAR
R	J480F-15	Kosdon	54 x 326.39	1065.1	584.0	TRA
R	J485WC-PS	Gorilla	54 x 326	1059.7	552.0	TRA
R	J500ST-20A	Animal	38 x 370	660	327.0	TRA
R	J500G-S,M,L	Aerotech	38 x 344	693.35	375.0	TRA
R	J510WL-L	Aerotech	38 x 584	1162.4	662.0	TRA
R	J520SK-16A	Cesaroni	38 x 510	658	498.0	TRA
R	J525LW-P-SM	Loki	54 x 330	1112.5	625.0	TRA
R	J528LW-17A	Loki	38 x 419	741	374.0	TRA
R	J530IM-15A	Cesaroni	38 x 500	1115.5	576.5	CAR
R	J540R-S,M,L,P	Aerotech	54 x 314	1161	679.0	TRA
H	J555-P	Contrail	38 x 1220	795	735cc	TRA
R	J570W-S,M,L	Aerotech	38 x 479	973	535.8	TRA
R	J575FJ-S,M,L	Aerotech	38 x 479	805	519.0	TRA
R	J580SS-17A	Cesaroni	38 x 510	896.3	550.0	TRA
R	J595BS-16A	Cesaroni	38 x 510	985	510.0	TRA
R	J600RL-16A	Cesaroni	38 x 510	998.6	688.0	TRA
R	J605F-L	Kosdon/AT	38 x 476	737	367.0	TRA
R	J607WC-18A	Gorilla	38 x	677.94	360.0	TRA
R	J630F-16	Kosdon	38 x 475.74	728.34	391.0	TRA
H	J642-P	Contrail	54 x 922	1092.6	910cc	TRA
R	J675F-16	Kosdon	38 x 475.742	749.35	404.0	TRA
R	J712LB-15A	Loki	38 x 406	751.9	372.0	TRA
R	J745-P	Cesaroni	54 x 326	1196.4	549.0	CAR
R	J750SP-16A	Loki	38 x 622	942	617.0	TRA
R	J760WT-19A	Cesaroni	54 x 329	1265.7	576.0	CAR
R	J800T-S,M,L,XL	Aerotech	54 x 314	1295	619.4	TRA
H	J800-P	Contrail	38 x 1227	928	685cc	TRA
R	J825R-M	Aerotech	38 x 479	970	497.0	TRA
R	J850F-21	Kosdon	38 x 575.818	828.02	466.0	TRA
R	J975F-16	Kosdon	38 x 739.394	943.33	576.0	TRA
R	J1055-17A	Cesaroni	54 x 236	746.6	358.0	CAR
R	J1299N-P	Aerotech	54 x 230	845	371.6	TRA
R	J1365-P	Cesaroni	54 x 326	932.4	444.0	CAR
R	J1423N-P	Aerotech	54 x 230	845	371.6	TRA
R	J1520-17A	Cesaroni	54 x 329	1092.5	1026.0	CAR
R	J1799N-PS	Aerotech	54 x 314	1066.1	540.0	TRA
R	J2135N-P	Aerotech	54 x 314	1261	557.4	TRA
R	K160CL-6	Cesaroni	54 x 404	1525.5	772.0	CAR
R	K185W-S,M,L	Aerotech	54 x 437	1417.2	836.8	TRA
R	K222WC-P	Gorilla	54 x 402	1315	800.0	TRA
H	K234-P	Contrail	54 x 1220	1657	1490cc	TRA
R	K235WC-P	Gorilla	75 x 368	2049	1189.0	TRA
H	K240(835CC125J)-P	Hypertek	81 x 552	1292	835cc	TRA
H	K240H-P	RATTWorks	64 x 908	1844.7	1507cc	TRA
R	K250LWM-P-SM	Loki	54 x 499	1607	938.0	TRA
S	K250W-P	Aerotech	54 x 673	2484	1543.0	TRA
S	K250W (LMS)-P	Aerotech	54 x 649	2342	1400.0	TRA
H	K257G-P	SkyRipper	54 x 912	1733	1130cc	TRA
R	K260CL-P	Cesaroni	54 x 572	2285.1	1149.3	CAR
R	K261WH/LB-P	Cesaroni	54 x 488	2020.9	1151.9	CAR
H	K265SP-P	Contrail	54 x 1219	1684	1490cc	TRA
R	K270W-S,M,L,XL	Aerotech	54 x 579	1968	1188.0	TRA
H	K300-P	Contrail	75 x 1016	1909	2050cc	TRA
R	K300CL-P	Cesaroni	54 x 649	2546	1265.7	CAR
H	K321-P	Contrail	54 x 1220	1570	1490cc	TRA
R	K327WC-P	Gorilla	54 x 491	1616	1000.0	TRA
H	K347B-P	SkyRipper	54 x 912	1529	1130cc	TRA
R	K350LWM-P-SM	Loki	54 x 736	2374	1400.0	TRA
R	K350S-13	Kosdon	54 x 402.59	1338.7	730.0	TRA
T	K350TR-P	RattWorks	64 x 914	1861	1170cc/250ml	TRA
R	K360WH-13A	Cesaroni	54 x 329	1280.9	708.2	CAR
R	K365RR-P	Animal	75 x 244	1675	946.0	NAR
R	K375WP-P	Aerotech	54 x 570	2228.1	1292.0	TRA
R	K400GR-14A	Cesaroni	54 x 404	1596.7	924.3	CAR
R	K400S-S,M,L	Kosdon/AT	54 x 403	1386.2	721.8	TRA
H	K404-P	Contrail	75 x 1016	2441	2050cc	TRA
R	K411BL-PS	Gorila	75 x 368	1785.8	1132.0	TRA
R	K445-17A	Cesaroni	54 x 404	1636.3	792.0	CAR
R	K450BB-P-SM	Animal	75 x 244	1845	881.6	NAR
R	K454SK-19A	Cesaroni	54 x 404	1363.7	769.2	CAR
R	K455-P	Cesaroni	54 x 403	1483	716.0	CAR
H	K456-P	Contrail	75 x 813	1628	1400cc	TRA
R	K458W-P	Aerotech	98 x 275	2464.6	1425.0	TRA
H	K460-P	WCH	75 x 762	1988	1493cc	CAR
R	K465DM-14A	Aerotech	54 x 401	1281	866.0	TRA
R	K470ST-P	Animal	75 x 302	1679	826.0	TRA

Notes	Designation	Mfg.	Size (mm)	Total Impulse (N-sec.)	Propel. Mass (grams)	Cert. Group
R	K475WW-P	Animal	54 x 403	1400	728.6	NAR
R	K480W-PS	Aerotech	54 x 570	2273.3	1318.0	TRA
H	K485HW-3 jet-P	Aerotech	54 x 699	1686.8	440cc/634g	TRA
R	K490GR-16A	Cesaroni	54 x 488	1978.4	1155.4	CAR
R	K500SK-P	Animal	75 x 368	1811	1123.5	NAR
H	K500SP-P	Contrail	54 x 1524	2237	N/A	TRA
R	K500-18A	Cesaroni	54 x 404	1595.6	892.0	CAR
R	K510-P	Cesaroni	75 x 350	2486	1197.0	CAR
R	K513FJ-S,M,L,XL	Aerotech	54 x 410	1496.3	974.0	TRA
R	K515SK-16A	Cesaroni	38 x 500	1653.9	961.5	CAR
R	K520RT-P	Gorilla	N/A x N/A	1356	698.0	TRA
H	K525WS-P	Contrail	54 x 1219	1620	N/A	TRA
R	K530GG-P	Animal	54 x 403	1410	796.7	NAR
R	K530SS-16A	Cesaroni	54 x 404	1412	1025.0	CAR
R	K533BL-P	Gorilla	54 x 491	1420	900.0	TRA
R	K535-P	Cesaroni	54 x 403	1441.8	764.0	CAR
R	K540M-14A	Aerotech	54 x 401	1596.3	876.7	TRA
R	K550W-S,M,L,XL	Aerotech	54 x 410	1568	889.1	TRA
R	K555SK-P	Animal	54 x 492	1300	862.0	NAR
R	K555GT-P	Gorilla	54 x 401	1397	780.0	TRA
H	K555BG-P	Contrail	54 x 1220	1687	1490cc	TRA
R	K555WH-P	Cesaroni	75 x 350	2406.2	1407.0	CAR
R	K560RR-P	Animal	54 x 430	1480	750.0	NAR
R	K560W-P-SM	Aerotech	75 x 396	2511	1425.0	TRA
R	K570-17A	Cesaroni	54 x 488	2062.9	990.0	CAR
R	K570WW-P	Animal	54 x 492	1700	914.6	NAR
R	K575SS-P	Cesaroni	75 x 395	2493	1803.0	CAR
R	K590-P	Cesaroni	54 x 403	1336.5	964.0	CAR
R	K600F-S,M,L,P	Kosdon/AT	54 x 403	1428.5	724.3	TRA
T	K600TR-P	RATTWorks	64 x 1219	2170	1476cc/370ml	TRA
R	K600WW-P-SM	Animal	75 x 368	2500	1223.3	NAR
R	K605RR-P	Animal	75 x 368	2410	1231.0	NAR
R	K610SK-P	Animal	54 x 491	1531	861.0	CAR
H	K630-P	Contrail	75 x 813	1341	1400cc	TRA
R	K630BS-15A	Cesaroni	54 x 404	1679.4	912.0	TRA
R	K630WC-PS	Gorilla	54 x 403	1414.8	736.0	TRA
R	K635-17A	Cesaroni	54 x 488	1994.4	1115.0	CAR
R	K650PK-21A	Cesaroni	54 x 488	1997.1	1135.0	CAR
R	K650RR-P	Animal	54 x 492	1840	931.0	NAR
R	K350S-13	Kosdon	54 x 727.964	1338.7	730.0	TRA
R	K650SS-16A	Cesaroni	54 x 488	1749.5	1281.0	CAR
R	K650T-P	Aerotech	98 x 289	2405.7	1280.0	TRA
H	K654BS-P	Contrail	75 x 711	2132	1400cc	TRA
R	K660-17A	Cesaroni	54 x 572	2437	1177.0	CAR
R	K661BS-P	Cesaroni	75 x 350	2430.4	1182.0	CAR
R	K665-P	Cesaroni	54 x 403	1379.9	964.0	CAR
R	K670GG-P	Animal	54 x 492	1751	1014.0	NAR
R	K670-P	Cesaroni	54 x 491	1806.1	955.0	CAR
R	K670WC-PS	Gorila	75 x 368	2364.7	1184.0	TRA
R	K675SK-18A	Cesaroni	54 x 572	2009.6	1140.0	CAR
H	K678-P	Contrail	75 x 1016	1847	2050cc	TRA
R	K680R-P	Aerotech	98 x 289	2358	1316.0	TRA
R	K690SF-PS	Loki	54 x 483	1616	920.0	TRA
R	K695R-M,L,P	Aerotech	54 x 410	1514	903.0	TRA
R	K700BB-P	Animal	54 x 430	1650	745.0	NAR
R	K700F-14	Kosdon	54 x 402.59	1377.8	730.0	TRA
R	K700W-P	Aerotech	54 x 568	2261	1303.0	TRA

Notes	Designation	Mfg.	Size (mm)	Total Impulse (N-sec.)	Propel. Mass (grams)	Cert. Group
R	K700RT-P	Gorilla	54 x 492	1691	856.0	TRA
R	K700-P	Cesaroni	54 x 491	1659.6	1205.0	CAR
H	K707-P	Contrail	75 x 813	1386	1400cc	TRA
R	K710BB-P	Animal	54 x 491	1791.4	880.7	CAR
R	K735SK-P	Cesaroni	75 x 350	1955.2	1173.0	CAR
R	K740CS-18A	Cesaroni	54 x 404	1873.9	846.2	CAR
R(a)	K750W-P	Kosdon/AT	54 x 728	2468	1315.0	NAR
R	K750-18A	Cesaroni	54 x 572	2352.5	1321.0	CAR
R	K763GT-P	Gorilla	54 x 491	1740.3	975.0	TRA
H	K777-P	Contrail	75 x 1017	1833	2050cc	TRA
R	K777F-10	Kosdon	75 x 368.3	2389	1216.0	TRA
R	K780BS-15A	Cesaroni	54 x 488	2107.8	1140.0	TRA
R	K780R-P	Aerotech	75 x 395	2371	1268.0	TRA
R	K800BB-P	Animal	54 x 492	1950	914.0	NAR
R	K805G-P	Aerotech	54 x 401	1762	871.1	TRA
R	K805WC-PS	Gorilla	54 x 492	1765	920.0	TRA
R	K815SK-P	Cesaroni	54 x 649	2303.7	1342.1	CAR
R	K820BS-17A	Cesaroni	54 x 572	2383	1164.0	CAR
R	K828FJ-S,M,L,XL	Aerotech	54 x 579	2052.2	1450.0	TRA
R	K830SF-PS	Loki	54 x 726	2287	1376.0	TRA
R	K855-P	Cesaroni	54 x 491	1725.2	1205.0	CAR
H	K888BM-P	Contrail	76 x 1016	2400	2050cc	TRA
R	K940WT-18A	Cesaroni	54 x 404	1632.7	768.0	CAR
R	K950ST-P	Animal	54 x 492	1860	887.4	NAR
R	K960LWB-P-SM	Loki	54 x 499	1946	960.0	TRA
R	K975WW-P-SM	Animal	54 x 728	2450	1357.3	NAR
R	K1000SK-P-SM	Animal	54 x 728	2120	1297.0	NAR
R	K1000S-P	Kosdon/AT	54 x 728	2592.7	1301.0	TRA
S	K1050W-P	Aerotech	54 x 676	2530	1362.2	TRA
R	K1050W-PS	Aerotech	54 x 648	2426	2240.0	TRA
R	K1075GG-P	Animal	54 x 728	2400	1399.9	NAR
R	K1075SK-P	Cesaroni	54 x 728	2245.1	1259.0	CAR
R	K1085WT-P	Cesaroni	75 x 350	1125	2412.0	CAR
R	K1100T-S,M,L,XL	Aerotech	54 x 398	1472	771.0	TRA
R	K1103X-14A	Aerotech	54 x 401	1789.5	830.0	TRA
R	K1130BB-P	Animal	54 x 728	2550.7	1334.0	CAR
R	K1200-16A	Cesaroni	54 x 404	1364	960.0	CAR
R	K1250WW-P	Animal	54 x 491	1950.9	915.0	CAR
R	K1275R-P	Aerotech	54 x 568	2224.9	1170.0	TRA
R	K1440-17A	Cesaroni	54 x 572	2437	1129.0	CAR
R	K1499N-P	Aerotech	75 x 260	1321	604.0	TRA
R	K1620-P	Cesaroni	98 x 240	2436.9	1193.0	CAR
R	K1720-P	Cesaroni	54 x 403	1176.2	592.0	CAR
R(a)	K1750R-P	Kosdon/AT	54 x 728	2423	1253.0	NAR
R	K1185GT-P	Gorilla	54 x 728	2460	1314.0	TRA
R	K1999N-P	Aerotech	98 x 275	2569	1195.0	TRA
R	K2000VM-P	Cesaroni	75 x 350	2329.9	1102.0	CAR
R	K2045-17A	Cesaroni	54 x 404	1407.6	716.0	CAR
H	L200(1685CC098L)-P	Hypertek	75 x 1031	2639	1685cc	TRA
H	L225FX(1685CC098LFX)-P	Hypertek	75 x 1031	2789	1685cc	TRA
R	L339N-P	Aerotech	98 x 302	2793	1796.0	TRA
H	L350(1685CC125L)-P	Hypertek	75 x 1031	3042.9	1685cc	TRA
H	L355FX(1685CC125LFX)-P	Hypertek	75 x 1031	2851	1685cc	TRA
H	L369-P	Contrail	75 x 1347	3829	3200cc	TRA
R	L400W-PS	Aerotech	98 x 444	4654.6	2696.0	TRA
R	L425WC-PS	Loki	76 x 498	3372	1837.0	TRA

Notes	Designation	Mfg.	Size (mm)	Total Impulse (N-sec.)	Propel. Mass (grams)	Cert. Group
H	L475(1685CC172L)-P	Hypertek	75 x 1031	2774	1685cc	TRA
R	L480LR-P	Loki	76 x 498	3203.4	1830.0	TRA
H	L535FX(1685CC172LFX)-P	Hypertek	75 x 1031	2994	1685cc	TRA
H	L540(2800CC172L)-P	Hypertek	75 x 1387	4615	2800cc	TRA
H	L550(1685CCRGL)-P	Hypertek	75 x 1031	3095	1685cc	TRA
H	L570FX(2800CC172LFX)-P	Hypertek	75 x 1387	4716	2800cc	TRA
H	L575(2800CCRGL)-P	Hypertek	75 x 1387	4831	2800cc	TRA
R	L585DH-8	Kosdon	75 x 497.84	2696.9	1974.0	TRA
R	L585IM-P	Cesaroni	75 x 350	2653.4	1449.8	CAR
H	L600-P	RATTWorks	64 x 1066	3152	1858cc	TRA
H	L600-P	WCH	75 x 1016	3161	2363cc	CAR
R	L610-P	Cesaroni	98 x 394	4842	2415.0	CAR
H	L610FX(1685CCRGLFX)-P	Hypertek	75 x 1031	3131	1682cc	TRA
H	L625FX(2800CCRGLFX)-P	Hypertek	75 x 1387	4951	2800cc	TRA
R	L640DT-P	Cesaroni	54 x 649	2772.2	1293.0	CAR
R	L645GR-P	Cesaroni	75 x 486	3419.8	2072.0	CAR
R	L666SK-P	Animal	75 x 870	2700	1646.7	NAR
R	L700BB-P-SM	Animal	75 x 368	2590	1193.9	NAR
R	L730-P	Cesaroni	54 x 649	2765	1351.0	CAR
H	L740FX(2800CC200MFX)-P	Hypertek	75 x 1438	5033	2800cc	TRA
R	L777WW-P-SM	Animal	75 x 497	3140	1762.3	NAR
R	L780SF-PS	Loki	76 x 498	3006	1772.0	TRA
R	L789RT-PS	Gorilla	75 x 498	3251.8	1796.0	TRA
R	L800-P	Cesaroni	75 x 486	3759	1795.0	CAR
H	L800-P	Contrail	75 x 1372	3759	3200cc	TRA
R	L805WH-P	Cesaroni	54 x 649	2833	1640.0	CAR
R	L820SK-P	Cesaroni	75 x 486	2945.6	1760.0	CAR
R	L850S-12	Kosdon	54 x 497.84	2451	1318.0	TRA
R	L850W-P	Aerotech	75 x 531	3642	2075.0	TRA
R	L851WH-P	Cesaroni	75 x 486	3683.2	2110.0	CAR
R	L890SS-P	Cesaroni	75 x 530	3762	2670.0	CAR
R	L900DM-PS	Aerotech	75 x 653	3787	2594.0	TRA
R	L900RR-P	Animal	75 x 497	3450	1771.0	NAR
R	L910CS-P	Cesaroni	75 x 350	2856.1	1270.0	CAR
R	L930LWB-P-SM	Loki	75 x 499	3587	1836.0	TRA
R	L935IM-P	Cesaroni	54 x 649	3146.8	1567.0	CAR
R	L952W-P-SM	Aerotech	98 x 427	4656	2749.7	TRA
H	L970(2800CC300M)-P	Hypertek	75 x 1438	5098	2800cc	TRA
R	L985-P	Cesaroni	54 x 728	2664.6	1295.0	CAR
R	L985GT-PS	Gorilla	75 x 497.84	3580	1875.0	TRA
R	L990BS-P	Cesaroni	24 x 649	2771	1369.4	CAR
R	L995RL-P	Cesaroni	75 x 486	3618	1912.5	CAR
R	L1000S-P	Kosdon/AT	54 x 728	2592	1301.0	TRA
R	L1030-P	Cesaroni	54 x 649	2787.9	1516.0	CAR
R	L1040DM-PS	Aerotech	75 x 653	3769	2602.0	TRA
R	L1050BS-P	Cesaroni	75 x 786	3727	1774.0	CAR
R	L1060GG-P-SM	Animal	75 x 497	3622.6	1917.8	NAR
R	L1065BL-BS	Gorilla	75 x 787	4209.7	5329.0	TRA
R	L1080BB-P	Animal	75 x 497	3700	1717.0	NAR
R	L1090SS-P	Cesaroni	75 x 665	4815	3490.3	CAR
R	L1100RR-P-SM	Animal	54 x 728	2576	1346.0	NAR
R	L1111ST-P	Animal	75 x 497	3480	1642.0	TRA
R	L1115-P	Cesaroni	75 x 621	5015	2394.0	CAR
R	L1150WC-PS	Gorilla	75 x 498	3575.7	1974.0	TRA
R	L1150R-P	Aerotech	75 x 530	3517	1902.0	TRA
R	L1170FJ-PS	Aerotech	75 x 665	4229	2805.0	TRA
R	L1175F-30	Kosdon	75 x 497.84	3142	1710.0	TRA

Notes	Designation	Mfg.	Size (mm)	Total Impulse (N-sec.)	Propel. Mass (grams)	Cert. Group
H	L1222SF-P	Contrail	75 x 1524	3895	3200cc	TRA
R	L1276RR-PS	Animal	54 x 728	2729	1475.0	TRA
R	L1290SK-P	Cesaroni	76 x 785	4701.1	2705.0	CAR
R	L1300BB-P-SM	Animal	54 x 728	2672	1314.0	NAR
R	L1300R-P	Aerotech	98 x 443	4567	2632.0	TRA
R	L1350CS-P	Cesaroni	75 x 486	463.1	1905.0	CAR
R	L1355SP-P	Cesaroni	75 x 621	4025.5	3012.4	CAR
R	L1390G-PS	Aerotech	78 x 531	3948.7	4104.0	TRA
R	L1395-P	Cesaroni	75 x 621	4895.4	2364.9	CAR
R	L1400SK-P	Animal	75 x 785	4744	2829.4	NAR
R	L1400LW-P-SM	Loki	54 x 736	2850.6	1400.0	TRA
R	L1400F-P	Kosdon/AT	54 x 728	2640	1248.0	TRA
R	L1400M-PS	Aerotech	75 x 653	4900.9	2648.0	TRA
R	L1410SK-P	Cesaroni	75 x 757	4828.3	2875.0	CAR
R	L1420R-P	Aerotech	75 x 443	4603	2560.0	TRA
H	L1428SF-P	Contrail	76 x 1753	4733	3200cc	TRA
R	L1482LB-P-SM	Loki	54 x 497	3882	1839.0	TRA
R	L1500T-P	Aerotech	98 x 665	5089.3	2490.9	TRA
R	L1520T-PS	Aerotech	75 x 518	3715.9	1854.0	TRA
R	L1685SS-P	Cesaroni	75 x 757	5069.3	3773.1	CAR
R	L1720WT-P	Cesaroni	75 x 486	1688	2660.0	CAR
R	L1860F(K1329)-23	Kosdon	54 x 727.96	2470	1322.0	TRA
R	L2200G-P	Aerotech	75 x 653	5104	2518.0	TRA
R	L2375WT-P	Cesaroni	75 x 621	2225	4864.0	CAR
H	L2525GF-P	Contrail	75 x 1524	4681.4	3200cc	TRA
R	L3000F-P	Kosdon	54 x 1113.79	2826.3	1936.0	TRA
R	L3150-P	Cesaroni	98 x 394	4807.8	2386.0	CAR
R	L3200-P	Cesaroni	75 x 486	3300.3	1555.0	CAR
R	L585DH-8	Kosdon	75 x 497.84	2696.9	1974.0	TRA
R	L850S-12	Kosdon	54 x 727.964	2451	1318.0	TRA
R	M480WH/LB-P	Cesaroni	75 x 879.3	7521.2	4249.0	CAR
R	M520-P	Cesaroni	98 x 548	7278.5	3713.0	CAR
R	M650W-P	Aerotech	75 x 801	5964	3351.0	NAR
R	M685W-PS	Aerotech	75 x 911	7560.8	4320.0	TRA
H	M700-P	WCH	75 x 1473	5592	3951cc	CAR
H	M711BS-P	Contrail	75 x 1371	5507	3200cc	TRA
H	M740(2800CC200M)-P	Hypertek	75 x 1438	5143	2800cc	TRA
R	M745WC-PS	Gorilla	75 x 785	5368	2900.0	TRA
R	M750W-P	Aerotech	98 x 732	9325	5300.0	NAR
R	M795-P	Cesaroni	98 x 702	10133	4892.0	CAR
H	M845HW-4 jet-p	Aerotech	98 x 782	6159	1163cc/2278g	TRA
H	M900-P	RATTWorks	69 x 1828	6463.5	3716cc	TRA
R	M900-P	Loki	76 x 785	5332.4	3030.0	TRA
H	M956(3500CCRGM)-P	Hypertek	98 x 1166	6421	3500cc	TRA
H	M960FX(2800CC300MFX)-P	Hypertek	75 x 1438	5126	2800cc	TRA
H	M1000(4630CCRGM)-P	Hypertek	98 x 1405	9155	4630cc	TRA
H	M1001(5478CCRGM)-P	Hypertek	98 x 1438	9835	5478cc	TRA
H	M1010FX(4630CCRGMFX)-P	Hypertek	98 x 1405	9114	4630cc	TRA
R	M1015DH(L917)-P	Kosdon	75 x 784.86	4464.5	3180.0	TRA
H	M1015FX(3500CCRGMFX)-P	Hypertek	98 x 1166	6334	3500cc	TRA
R	M1025WC-P	Gorilla	98 x 870	9581	5329.0	TRA
H	M1040FX(4630CCRGMFX)-P	Hypertek	98 x 1438	10098	4638cc	TRA
R	M1060-P	Cesaroni	98 x 548	7441	3622.0	CAR
R	M1075DM-PS	Aerotech	98 x 649	5571	3846.0	TRA
R	M1085WC-PS	Gorilla	75 x 1039	6958	3932.0	TRA
R	M1160GR-P	Cesaroni	75 x 757	5880.2	3454.0	CAR

Notes	Designation	Mfg.	Size (mm)	Total Impulse (N-sec.)	Propel. Mass (grams)	Cert. Group
R	M1200SF-PS	Loki	76 x 785	5122.6	2968.0	TRA
R	M1230IM-P	Cesaroni	75 x 621	5506.5	2900.0	CAR
R	M1290WH-P	Cesaroni	98 x 548	7649.3	4295.0	CAR
R	M1297W-P	Aerotech	75 x 665	5416.6	2722.0	TRA
R	M1300IM-P	Cesaroni	75 x 757	6438.2	3437.0	CAR
R	M1305M-PS	Aerotech	98 x 649	6891	4080.0	TRA
R	M1315W-P	Aerotech	75 x 801	6713.5	3499.4	TRA
R	M1350WW-P-SM	Animal	75 x 785	5725	2927.3	NAR
R	M1355RT-PS	Gorilla	75 x 787	5164.6	5216.0	TRA
R	M1400-P	Cesaroni	75 x 757	6251	2992.0	CAR
R	M1401WH-P	Cesaroni	75 x 757	6268.3	3508.0	CAR
R	M1419W-P	Aerotech	98 x 579	7755.5	4077.0	TRA
R(a)	M1450W-P	Kosdon/AT	75 x 1039	7813	4150.0	NAR
R	M1450-P	Cesaroni	98 x 702	9955	4830.0	CAR
R	M1480RR-P-SM	Animal	75 x 785	5800	3000.0	NAR
R	M1500G-P	Aerotech	75 x 653	5220	2631.0	TRA
R	M1520BS-P	Cesaroni	98 x 548	7579	3602.0	CAR
R	M1540IM-P	Cesaroni	75 x 757	6819.4	3624.4	CAR
R	M1545GR-P	Cesaroni	75 x 1025	8186.7	4835.0	CAR
R	M1550R-P	Aerotech	75 x 801	5600	3170.0	TRA
R	M1560WT-P	Cesaroni	98 x 394	5342	2452.0	CAR
R	M1565BL-P	Gorilla	98 x 870	7533	4992.0	TRA
H	M1575-P	Contrail	98 x 1524	6547	5300cc	TRA
R	M1590CL-P	Cesaroni	75 x 893	7544.6	3590.0	CAR
R	M1600R-P	Aerotech	98 x 579	7084	4026.0	TRA
R	M1610BL-PS	Gorilla	75 x 1039	5973.5	3654.0	TRA
R	M1630TT-P	Cesaroni	75 x 1039	8212.1	3948.0	CAR
R	M1665WC-PS	Gorilla	75 x 787	5705	5579.0	TRA
R	M1670BS-P	Cesaroni	75 x 757	6041.7	2956.1	CAR
R	M1675PK-P	Cesaroni	75 x 757	6162	3019.0	CAR
R	M1730SK-P	Animal	98 x 870	8115	4945.2	NAR
R	M1770SK-P	Cesaroni	75 x 893	5933.4	3520.0	CAR
R	M1780NT-PS	Aerotech	75 x 653	5383.5	2460.0	TRA
R	M1790SK-P	Cesaroni	98 x 702	8088.9	4706.0	CAR
R	M1800BS-P	Cesaroni	98 x 702	9867.7	4802.0	CAR
R	M1800FJ-P	Aerotech	98 x 665	8200	9163.0	TRA
R	M1810RL-P	Cesaroni	75 x 757	6132	3196.0	CAR
R	M1830CS-P	Cesaroni	75 x 621	5603.7	2542.0	CAR
R	M1845NT-PS	Aerotech	98 x 597.9	8307.8	3772.0	TRA
R	M1845S-P	Kosdon	75 x 1038.86	6782	3520.0	TRA
R	M1850GG-P	Animal	75 x 781	5920	3375.0	TRA
R	M1850W-P	Aerotech	75 x 924	7680	4009.0	TRA
R	M1882LW-PS	Loki	76 x 787	6303	3130.0	TRA
R	M1890-P	Cesaroni	98 x 702	9875.6	5280.0	CAR
R	M1900BB-P	Animal	75 x 785	6100	2733.0	NAR
R	M1939W-P	Aerotech	98 x 732	10482	5719.1	TRA
R	M2000R-P	Aerotech	98 x 732	9218	5368.0	TRA
R	M2020IM-P	Cesaroni	75 x 757	8429.4	4349.0	CAR
R	M2045BS-P	Cesaroni	75 x 893	7388	3547.0	CAR
R	M2050SK-P	Cesaroni	76 x 1039	6744.6	3870.0	CAR
R	M2075SS-P	Cesaroni	75 x 893	6286.6	3982.0	CAR
R	M2080SK-P	Cesaroni	75 x 1025	6827.3	4107.0	CAR
R	M2100G-P	Aerotech	98 x 598	7802	3948.0	TRA
R	M2150RL-P	Cesaroni	75 x 893	7455.4	3835.0	CAR
R	M2200SK-P-SM	Animal	75 x 1039	6350	3766.0	NAR
R	M2240F-P	Kosdon	75 x 784.86	5254.5	2770.0	TRA
R	M2245-P	Cesaroni	75 x 1025	9976.7	5074.0	CAR

Notes	Designation	Mfg.	Size (mm)	Total Impulse (N-sec.)	Propel. Mass (grams)	Cert. Group
R	M2250CS-P	Cesaroni	75 x 621	5472.2	2489.0	CAR
H	M2281BF-P	Contrail	75 x 1524	5481	5300cc	TRA
R	M2400T-P	Aerotech	98 x 597	7717	3692.6	TRA
R	M2500GG-P-SM	Animal	75 x 1039	7800	4248.0	NAR
R	M2500T-P	Aerotech	98 x 751	9671	4711.2	TRA
R	M2505-P	Cesaroni	98 x 579	7450	3339.0	CAR
R	M2550LB-P-SM	Loki	76 x 785	6502	3065.0	TRA
H	M2700BS-P	Contrail	98 x 1524	6034	5300cc	TRA
H	M2800BG-P	Contrail	98 x 1524	6060	5300cc	TRA
R(a)	M2900R-P	Kosdon/AT	75 x 1039	7310	3755.0	NAR
R	M2925WC-PS	Gorilla	75 x 1039	7897.8	3820.0	TRA
R	M3000LW-PS	Loki	76 x 1039	8924.3	4350.0	TRA
R	M3000ST-P	Animal	75 x 1039	7367	3819.0	TRA
R	M3100WT-P	Cesaroni	75 x 757	6117.8	2903.0	CAR
R	M3200F-P	Kosdon	75 x 1038.86	6744.6	4370.0	TRA
R	M3400WT-P	Cesaroni	98 x 702	9994.5	4452.0	CAR
R	M3500R-P	Aerotech	75 x 1039	7310	3755.0	NAR
R	M3700WT-P	Cesaroni	75 x 803	6800.3	3019.0	CAR
R	M4770-P	Cesaroni	98 x 548	7312.4	379.0	CAR
R	N1000W-P	Aerotech	98 x 1046	14126	7925.0	NAR
R	N1100-P	Cesaroni	98 x 1046	14005	6790.0	CAR
R	N1720WC-PS	Gorilla	98 x 1213	14237	7456.0	TRA
R	N1800WH-P	Cesaroni	98 x 702	10367	5727.0	CAR
R	N1975GR-P	Cesaroni	98 x 1010	14272	8560.0	CAR
R	N2000W-P	Aerotech	98 x 1046	13347	7752.6	TRA
R	N2020WW-P	Animal	98 x 870	10281	5160.9	NAR
R	N2200PK-P	Cesaroni	98 x 1010	12067	6122.0	CAR
R	N2540GR-P	Cesaroni	98 x 1239	17907	10700.0	CAR
R	N2500-P	Cesaroni	98 x 1010	13633	6778.0	CAR
R	N2501WH-P	Cesaroni	98 x 1010	15227	8496.0	CAR
R	N2600GG-P	Animal	98 x 870	10607	5591.4	NAR
R	N2600SK-P	Cesaroni	98 x 1010	11077	6618.0	CAR
R	N2700BB-P	Animal	98 x 870	11452	5147.1	NAR
R	N2712WC-PS	Gorilla	98 x 870	10813	5286.0	TRA
R	N2800WW-P	Animal	98 x 1213	14802	7694.7	NAR
R	N2850BS-P	Cesaroni	98 x 1010	13767	6759.0	CAR
R	N2876SK-PS	Animal	98 x 122	11940	13675.0	TRA
R	N2900CL-P	Cesaroni	98 x 1239	17614	8449.0	CAR
R	N3180-p	Cesaroni	98 x 1010	14200	7460.0	CAR
R	N3300R-PS	Aerotech	98 x 1059.46	14041	7512.0	TRA
R	N3301WH-P	Cesaroni	98 x 1239	19318	10658.0	CAR
R	N3400SK-P	Cesaroni	98 x 1239	14263	8282.0	CAR
R	N3800BS-P	Cesaroni	98 x 1239	17632	8449.0	CAR
R	N3800LW-PS	Loki	102 x 1041	12490	6124.0	TRA
R	N4000BB-P	Animal	98 x 1213	16461	7565.7	NAR
R	N4100RL-P	Cesaroni	98 x 1239	17790	9101.0	CAR
R	N4800T-P	Aerotech	98 x 1201	19361	9570.8	TRA
R	N5600WT-P	Cesaroni	98 x 1010	13628	6363.0	CAR
R	N5800CS-P	Cesaroni	98 x 1239	20146	9021.0	CAR
R	N10000-P	Cesaroni	98 x 1010	10347	5200.0	CAR
R	O3700SK-P	Cesaroni	161 x 957	29920	17157.0	CAR
R	O4900BS-P	Cesaroni	161 x 957	37148	17700.0	CAR
R	O5100-P	Cesaroni	161 x 803	29990	13245.0	CAR
R	O5800-P	Cesaroni	161 x 754	30606	13950.0	CAR
H	O6300-P	Contrail	156 x 1829	27244	15000cc	TRA
R	O8000-P	Cesaroni	161 x 957	40960	18610.0	CAR
S	O25000VM-P	Cesaroni	132 x 1407	30795	14471.0	CAR

Figure 1: Matt Steele's 1/24 Bumper Wac used resin parts to add scale detail to the fins and aft ring.

Pres

ssure Cast Resin Parts

FOR MODEL ROCKET APPLICATIONS

by Matt Steele

Presented by the Pod Bay Doors for the Research and Development event at NARAM-54.

Introduction

Polyurethane resin cast parts have become more and more popular for scale and fantasy model rockets in the past ten years. With the wide availability of hobby resin systems (such as Alumilite), it is now easy for modelers to make multiple copies of lightweight, detailed parts, suitable for use on flying model rockets. In the past, basic molding techniques have been adequate for most parts. However, for some models, basic techniques were unsuitable, as the parts often contained large bubbles and other flaws. This study aimed to establish some advanced techniques that would yield good parts on a repeatable basis.

Background

In 2009, Matt Steele was selected to the 2010 U.S. International team for the S5C (C Scale Altitude) event. In this event, Matt chose to fly a 1/24-scale model of the Bumper Wac (Figure 1). One of the challenges was to replicate the detail of the aft ring and the fins. Resin cast parts made in silicone rubber molds were though to be an ideal solution to the problem. Matt made over 100 fins and 25 aft rings, eventually using them on his model. However, all of them had minor flaws, usually caused by trapped air bubbles that required filling and sanding. The process did not yield acceptable parts on most attempts.

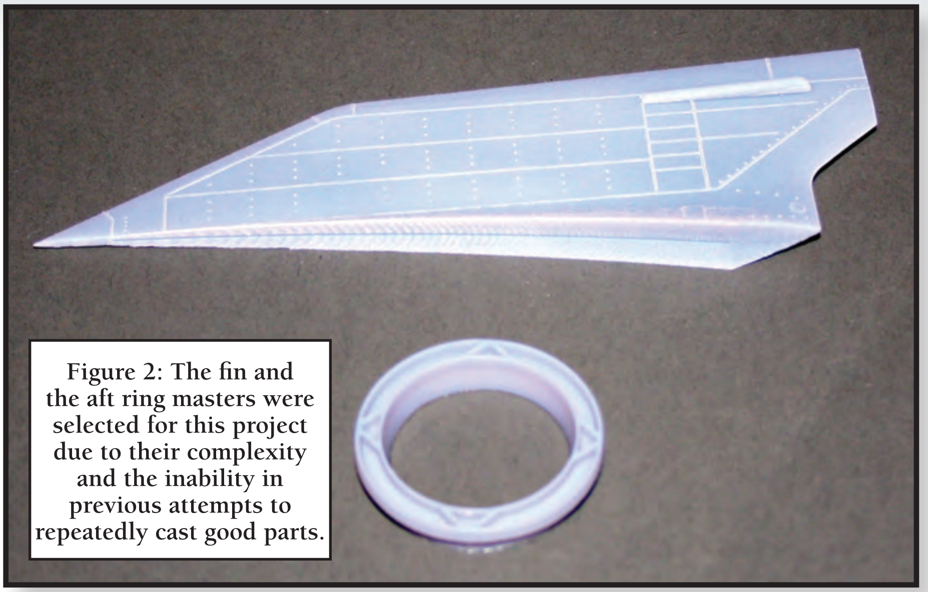


Figure 2: The fin and the aft ring masters were selected for this project due to their complexity and the inability in previous attempts to repeatedly cast good parts.

Attempting to cure the parts under vacuum did not solve the problem, so the process was shelved until Matt was selected for the 2012 U.S. International Team for S5C. Matt had read that some of the professional resin casting operations cured their parts under pressure, and was eager to use the technique for his Bumper Wac parts.

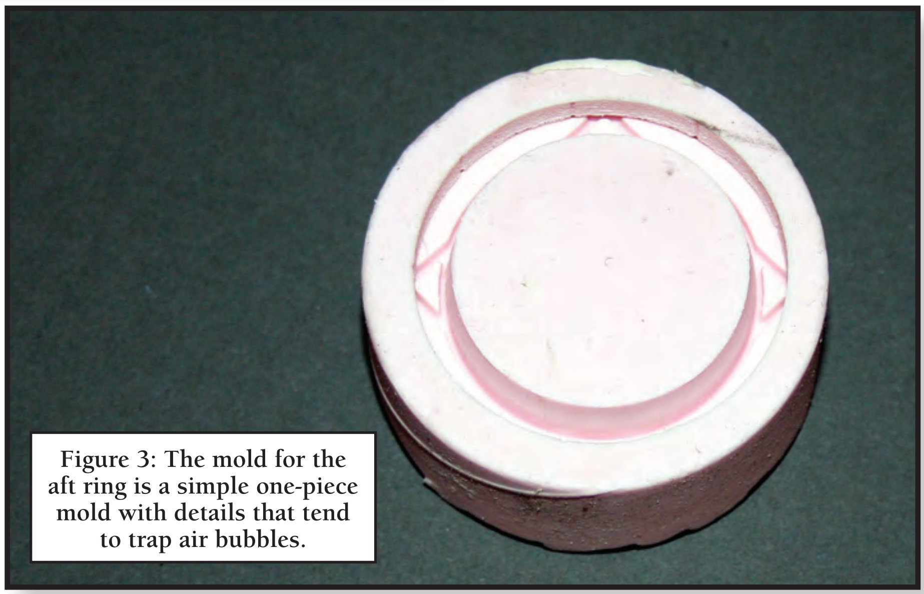


Figure 3: The mold for the aft ring is a simple one-piece mold with details that tend to trap air bubbles.

Key Questions

Would curing the resin under pressure reduce the number of bubbles in a part and give an acceptable yield? What would the mold need to look like? What pressure would work? What would a pressure cure setup look like?

Test Setup

Two parts of the Bumper Wac were selected for testing this approach. The first was a fin, and the second was the aft ring of the V-2. The parts were designed in SolidWorks, a 3D CAD program, and then saved in .stl format. The files were then sent to RedEye on Demand, a company that makes rapid prototyping parts.

The parts were fabricated with the "PolyJet" process, which is an additive fabrication process that produces models using photopolymer jetting. A jetting head slides back and forth along an X-axis, like a line printer, depositing a single-layer of photopolymer onto the build tray. Immediately following each layer built, ultraviolet (UV) light is applied to cure resin material used. Using the Polyjet process provides the following advantages:

- Smooth surface finish
- Fine feature detail
- Super thin layers (16 micron /0.0006 inches)

PolyJet is a great alternative to Stereolithography (SLA) and Selective Laser Sintering (SLS) because it uses similar materials and builds with greater accuracy. For the Bumper Wac parts, the fine details of the rivets and panel lines were preserved in the master using the Polyjet process. Figure 2 illustrates both master parts.

Selection of the right kind of mold rubber is critical to getting good parts. We chose to use Alumilite's High Strength 3 silicone mold making rubber. It is a great for parts with deep undercuts and negative drafts. It has a low viscosity, is easy to use, and has very good tear strength. The High Strength 3 product is a tin base silicone rubber. It is recommended for one-piece molds, and molds that require a very high tear strength and good flexibility to remove the parts—perfect for our two test parts. These molds do not require any sort of mold release; the silicone rubber does not stick to the parts.

The mold for the aft ring was pretty straightforward—it is of the standard "one piece" mold type. The detail in the part

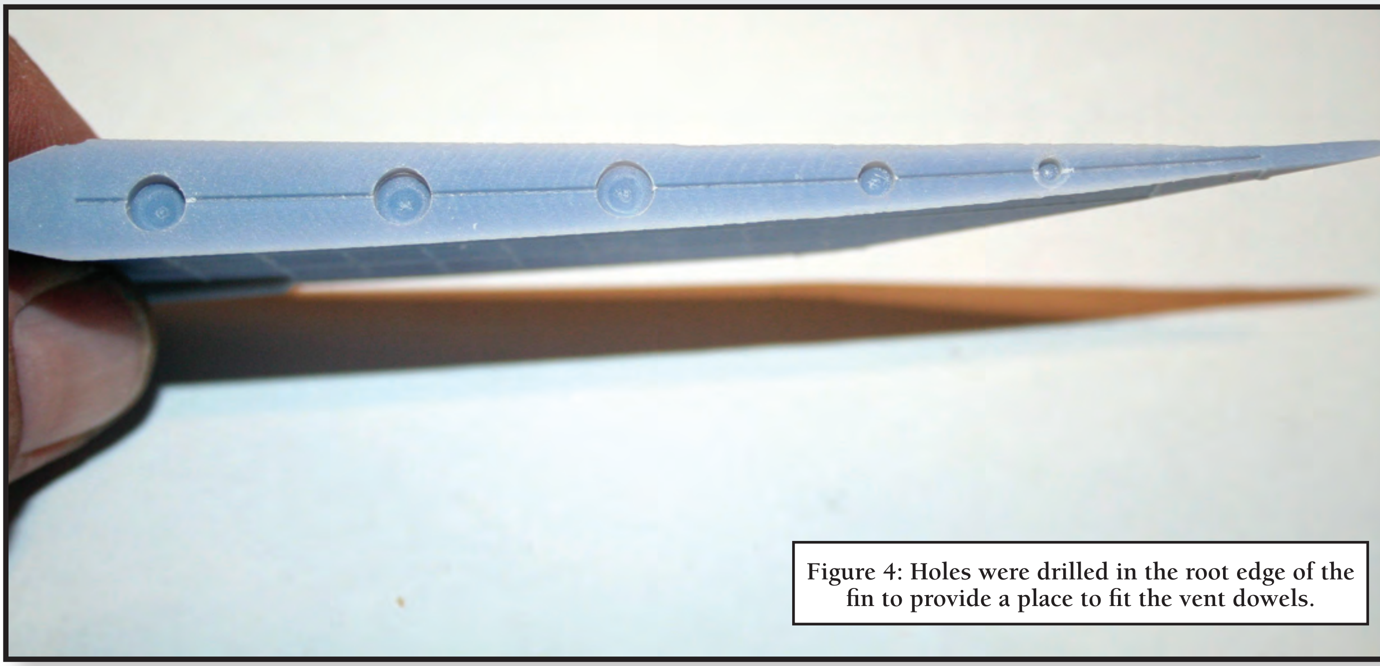


Figure 4: Holes were drilled in the root edge of the fin to provide a place to fit the vent dowels.

makes it hard for all the air bubbles to get out, however.

To make the mold for the aft ring, the master ring is glued to a plastic base plate with CA. When the CA has cured, a body tube that is about ¼" larger in diameter than the part, and about ¼" longer than the part, is glued to the base plate as well. When the CA has cured, a small batch of silicone rubber is mixed and then degassed under vacuum. Alumilte's High Strength 3 silicone gives good results without degassing, but since we were trying to get the best possible mold to make the best possible parts, we went to the extra effort to degas the material. We then poured the silicone over the part until it was completely covered by at least 1/8" of material, and then set it aside for 24 hours to cure. Once the rubber was fully cured, the base plate was removed, and the paper tube peeled away. The master part is then carefully removed from the mold. Figure 3 shows the completed mold for the aft ring.

The mold for the fin is more complex. It is technically a one-piece mold, but it is mostly closed at the top face, requiring the need for vents to fill the mold with resin. This type of mold, once constructed, yields good parts without flash with a minimum amount of work (as compared to a two part mold of the same part).

To make the mold, the vents are added to the root edge of the fins as shown in Figures 4 and 5.

The mold box parts are then cut out, as shown in Figure 6. For this mold, we used foam core board. The fin master is then glued to the bottom piece of the mold box base by the vent posts, and then the

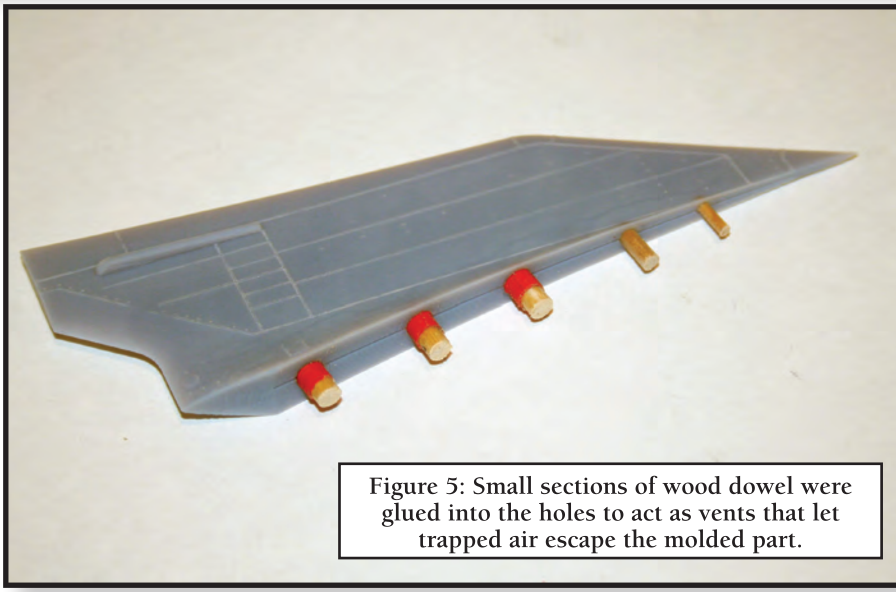


Figure 5: Small sections of wood dowel were glued into the holes to act as vents that let trapped air escape the molded part.

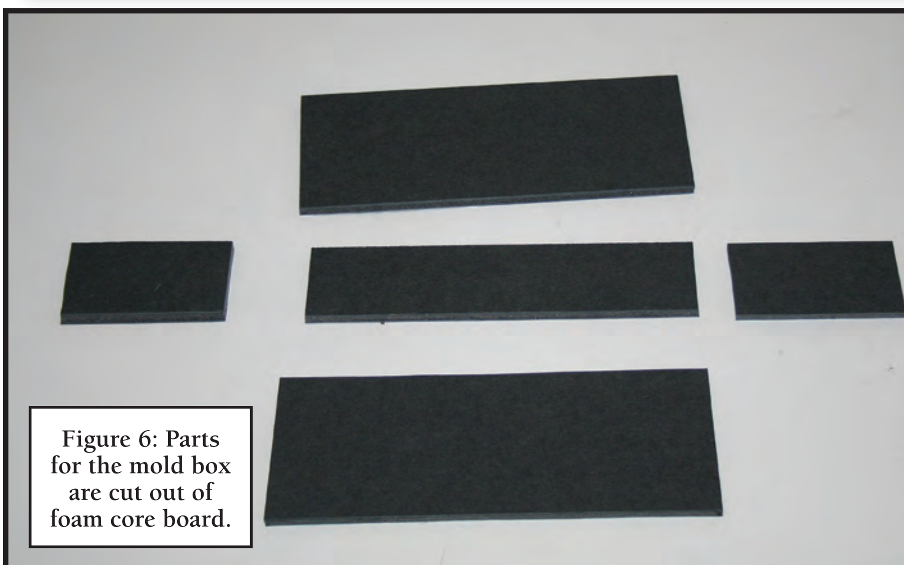


Figure 6: Parts for the mold box are cut out of foam core board.

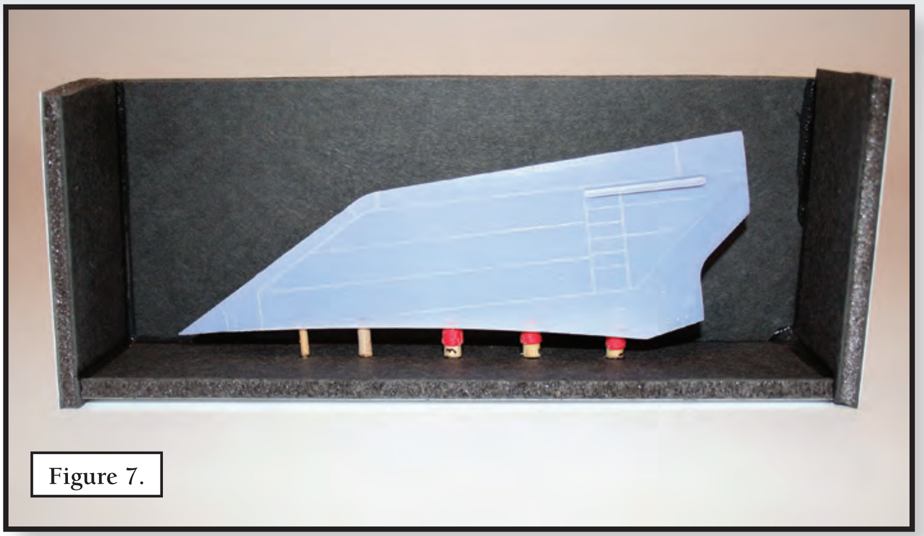


Figure 7.

Figure 8.

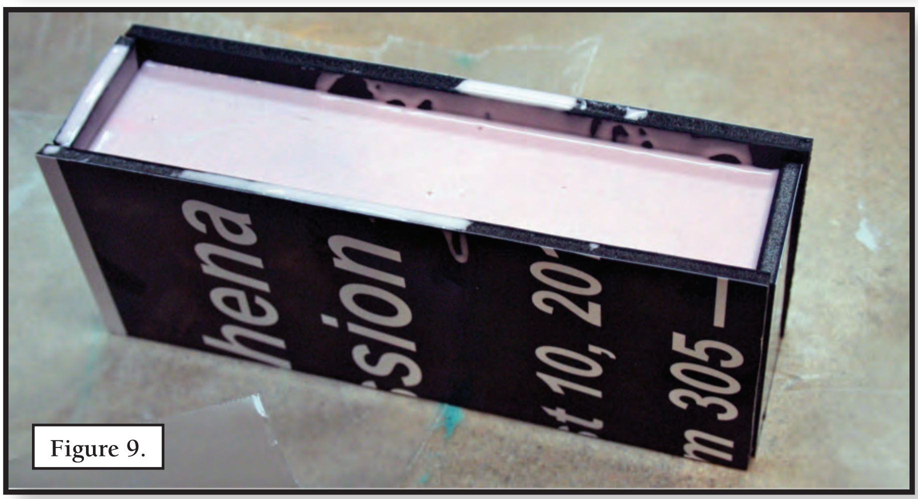


Figure 9.

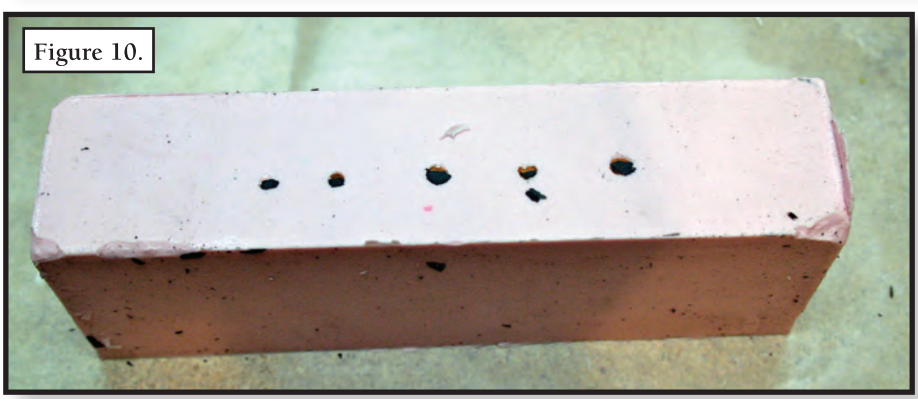


Figure 10.

rest of the parts of the mold box are assembled around the fin (see Figure 7). The completed mold box, open at the top, is shown in Figure 8. Then the mold is filled with degassed silicone rubber completely covering the fin master, and then set aside to cure (Figure 9).

Removing the master requires some finesse. First, the mold box is removed and just the block of rubber is left (Figure 10). The vent holes are visible where the vent dowels were glued to the bottom piece of the mold. A sharp knife was used to make a slit in the rubber the length of the root edge of the fin, as shown in Figure 11. Care is taken to cut the rubber down to the master part, but not cut the master part itself. This is relatively easy, since the rubber is much softer than the master. The mold is gently spread apart to reveal the master part (see Figure 12). This is where the HS III silicone really shines, as it stretches without tearing. Figure 13 shows the master removed from the mold. Resin cast parts cast in this mold are removed in a similar manner.

Testing Method

Alumilite Regular Tan resin was used as the baseline for making these parts. This resin provides users extremely tough, high temperature resistant, rigid parts, ideal for model rocket use. In addition, it has a pot life of 90 seconds and a demold time of 5-8 minutes. Besides being able to make a large number of parts in a short time, the quick demold time means the pressure system does not have to hold the critical pressure for hours, like some longer cure resin systems require. This helps hold the cost of my hobby system down to a minimum.

To cast the parts at ambient pressure, the mold is filled with mixed resin, then set aside to cure (Figure 14). Once the material has cured, the item is removed, and inspected for defects.

Figure 7: The fin master is glued to the mold box base with CA, and then the rest of the mold box is glued together.

Figure 8: Final assembly of the open-top mold box.

Figure 9: The mold is filled with silicone rubber and left to cure.

Figure 10: The mold box is removed. The vent holes are visible along the root edge.

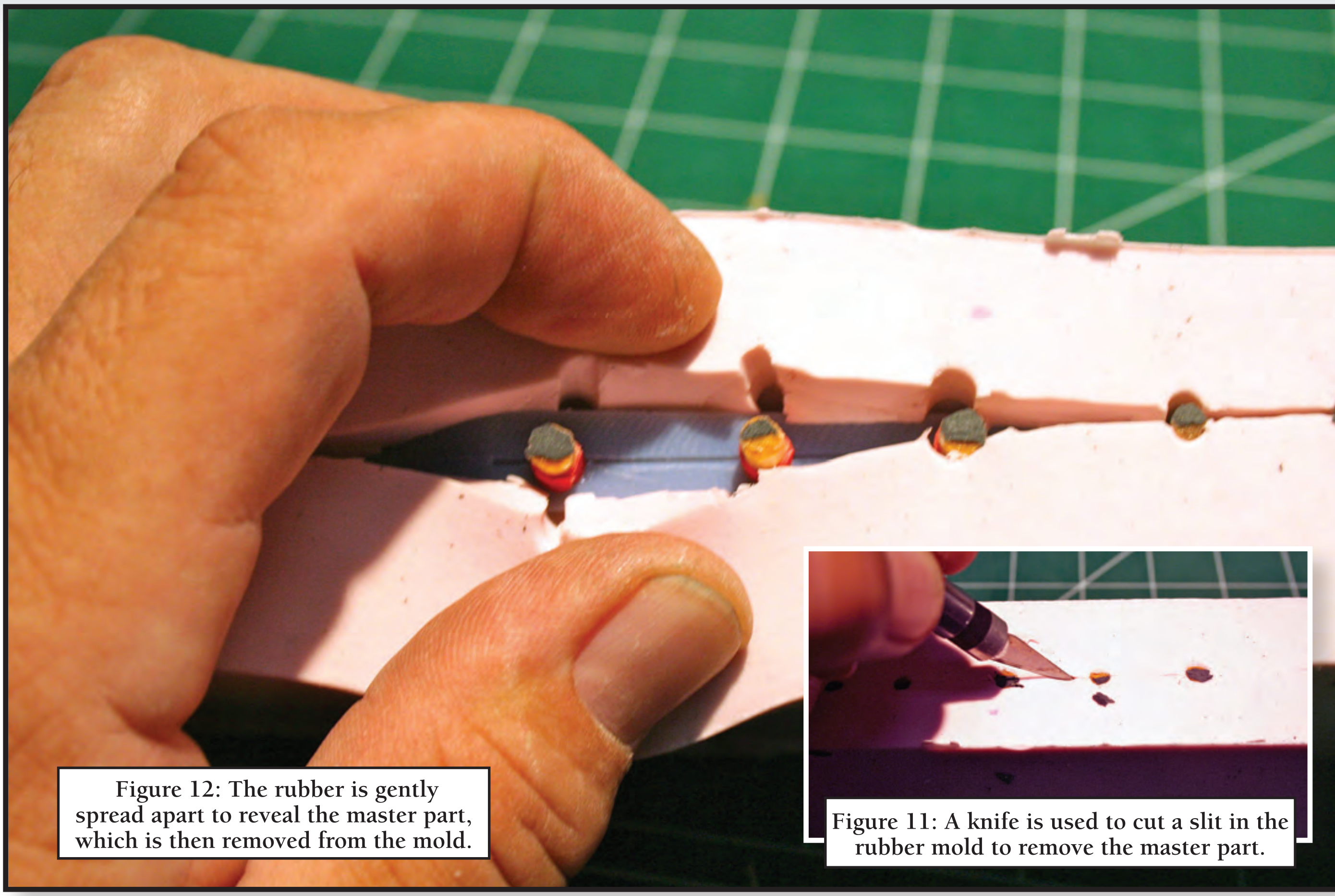


Figure 12: The rubber is gently spread apart to reveal the master part, which is then removed from the mold.

Figure 11: A knife is used to cut a slit in the rubber mold to remove the master part.

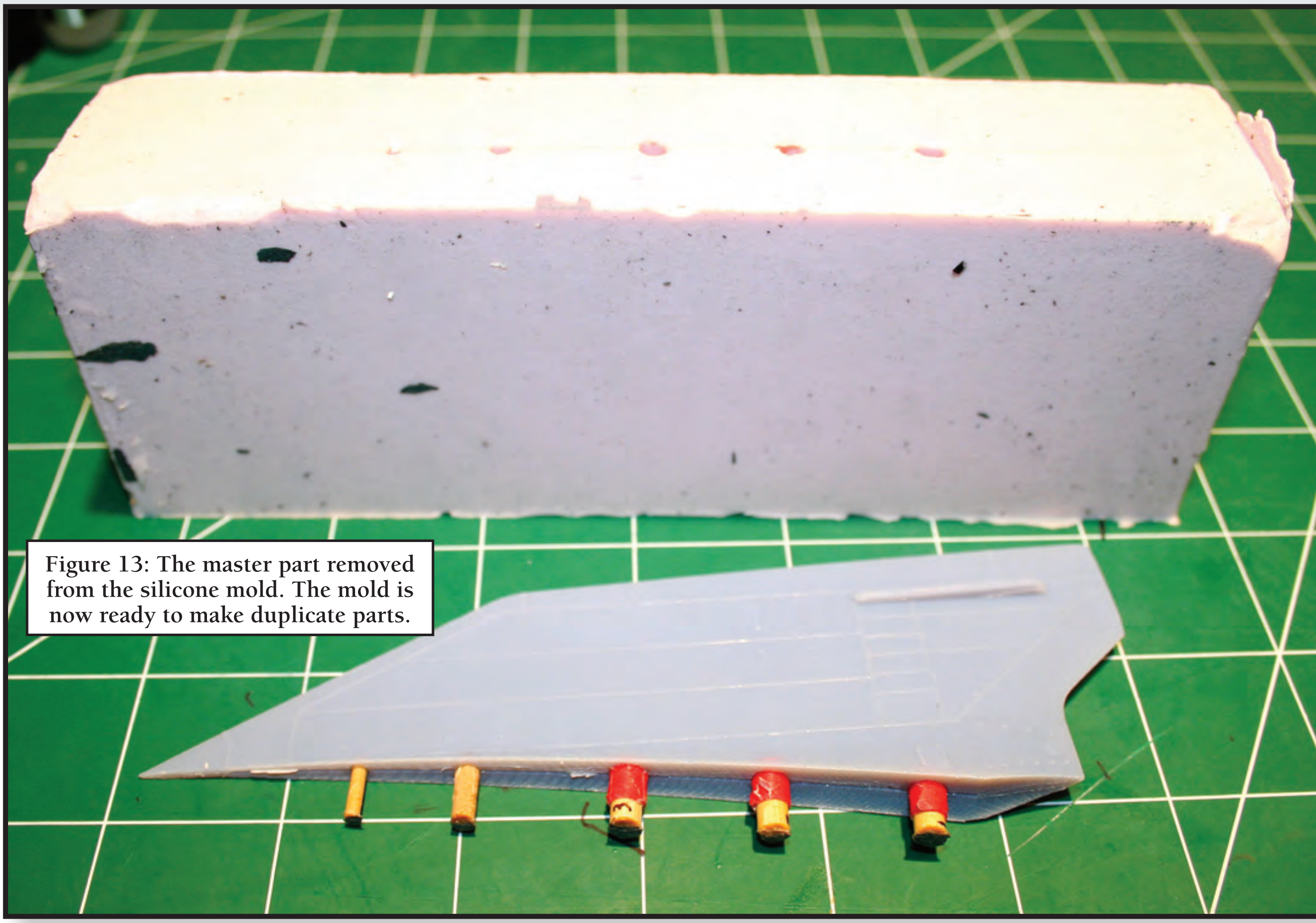


Figure 13: The master part removed from the silicone mold. The mold is now ready to make duplicate parts.

Casting the parts under pressure is more complex. A paint pressure pot, such as those sold at Harbor Freight for $99 (Figure 15), and an air compressor are required are for pressure casting resin parts. In theory, the pressure either forces the air bubbles from the part before curing, or the pressure makes the bubbles much smaller, resulting in better quality parts.

To pressure cast resin parts, the mold

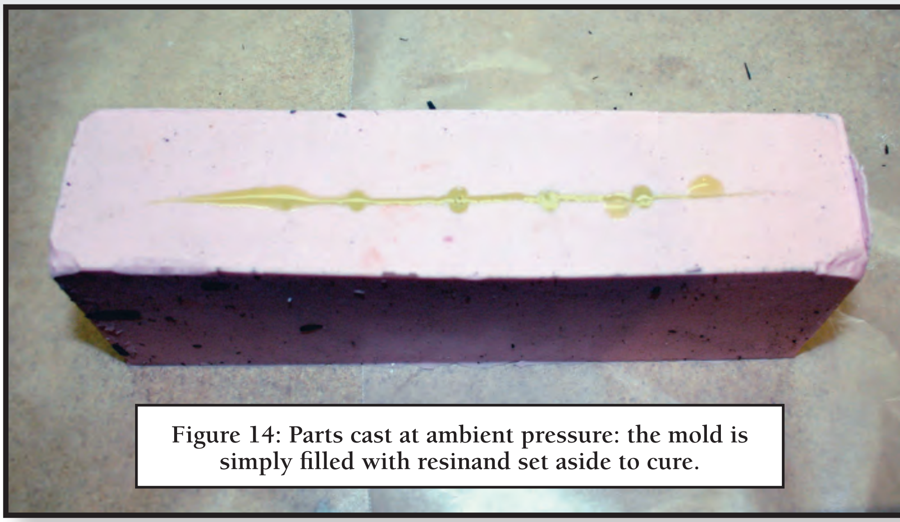


Figure 14: Parts cast at ambient pressure: the mold is simply filled with resinand set aside to cure.

Figure 15: Paint pressure pot used for casting resin parts under pressure.

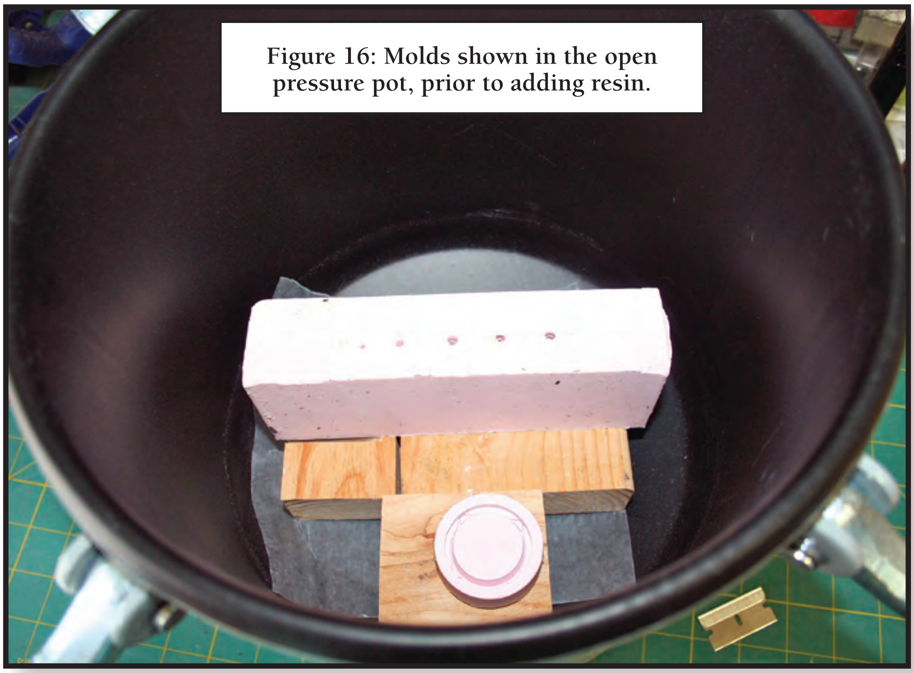


Figure 16: Molds shown in the open pressure pot, prior to adding resin.

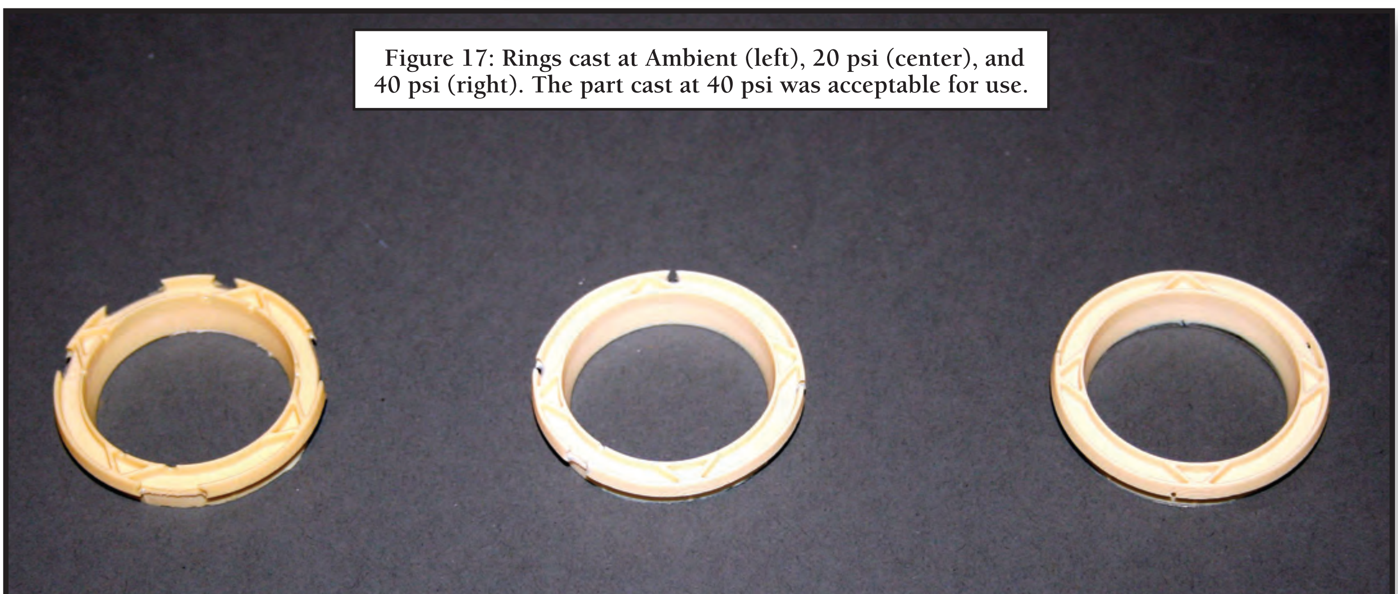


Figure 17: Rings cast at Ambient (left), 20 psi (center), and 40 psi (right). The part cast at 40 psi was acceptable for use.

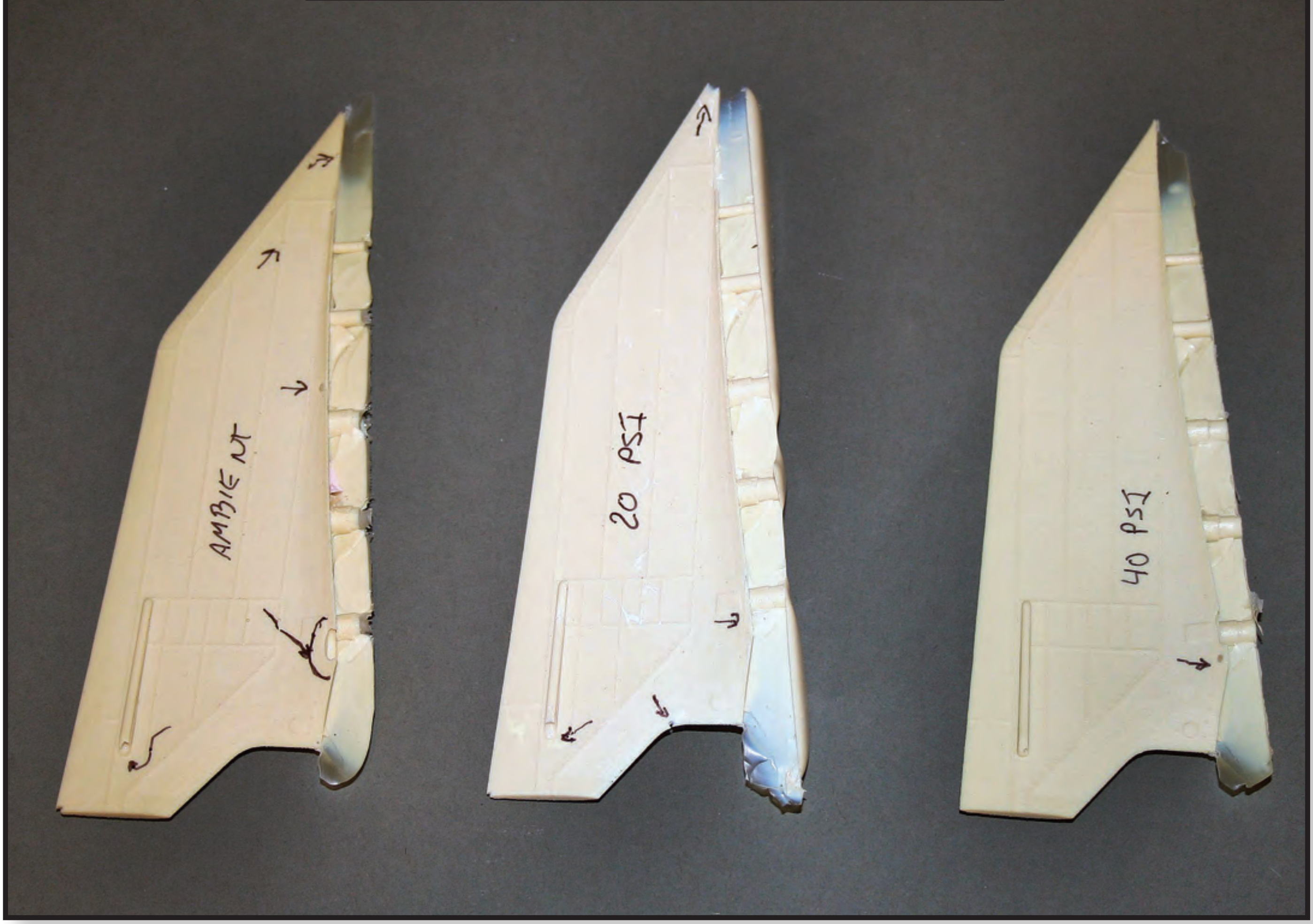


Figure 18: Fins cast at Ambient (left), 20 psi (center), and 40 psi (right). The part cast at 40 psi was acceptable for use.

is filled with resin, and then placed in the pressure pot (Figure 16). The pot is quickly closed, and the pressure is applied. For the purposes of my tests, pressures of 20 psi and 40 psi were evaluated. The pressure was set on the pressure relief valve on the pressure pot, ensuring the parts were not exposed to higher pressures. The pressure gage on the pot made it easy to keep the casting pressure in the desired range.

Test Data

The evaluation criteria were straightforward—the parts were either a pass or fail, depending on the condition they came out of the mold. A passing part could have no more than two defects each; each defect could be no larger than 1/16" in diameter. If the part could meet those criteria, it would be easy to finish and use. If not, the part would be discarded.

Ten fins and ten rings were evaluated at the following pressures: Ambient, 20 psi, and 40 psi.

The data are presented in Table 1. Figures 17 and 18 shows parts cast at ambient, 20 psi, and 40 psi. Table 2 clearly shows that pressure casting at 40 psi provided the highest success rate for these difficult parts.

Table 1: Test Data for Ambient vs. Pressure Casting

Part, Pressure	Pass	Fail
Aft Ring, Ambient	0	10
Aft Ring, 20 psi	3	7
Aft Ring, 40 psi	8	2
Fin, Ambient	0	10
Fin, 20 psi	0	10
Fin, 40 psi	9	1

Conclusion

For difficult or complex parts, pressure casting at 40 psi should be used to get best results. This technique can be useful for aspiring model rocketeers who wish to make flawless multiple resin cast parts.

Table 2: Data Analysis

Pressure	Success Rate
Ambient	0%
20 psi	15%
40 psi	85%

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AVOIDING

by Chris Flanigan NAR 17540 L1

Introduction

Super-roc events are very challenging. They are well known for impressive flights of very tall models. But they're probably best known for spectacular buckling and crimping failures of models that are too long or too flexible.

Super-roc models also have peculiar aerodynamic stability issues. Super-roc models need fins much larger than indicated using the classic Barrowman method. Why is that?

Traditionally, Super-roc models have been designed by trial-and-error. First, you design a model that you hope will work, perhaps based on prior experience. If the model works successfully, you add another length of body tube and fly it again. Eventually, the model will buckle or perhaps go unstable during flight, indicating that you've exceeded some kind of design limit. This is a slow and expensive approach. It also doesn't provide any understanding regarding the behavior of the model.

This article provides insight into the unique characteristics of Super-roc models. In addition, a new analysis approach is presented for designing high performance Super-roc models that will fly successfully the first time.

Overview

Super-roc models have two primary failure modes. The most common failure mode is where the vehicle crimps or buck-

G Super-roc altitude model at NARAM-49. Photo by Chris Taylor, http://www.naramlive.com/naramlive-2007.

G THE BENDS!

Why Super-Roc Models Buckle and How to Design for a Successful Flight

les during ascent. This is often attributed to "my model must have hit a wind shear at high altitude." However, as this article will describe, the problem is caused by a combination of aerodynamics and vehicle flexibility, not wind shear.

The other failure mode for Super-roc models is where the vehicle goes aerodynamically unstable, even though traditional Barrowman calculations [1] show that the model has sufficient stability margins. Prior research [2, 3] has focused on higher order aerodynamic terms (such as lift from body tubes) that the classic Barrowman method did not include. These higher order terms may contribute somewhat to the situation. However, the most significant issue for Super-roc models is the combination of aerodynamics and vehicle flexibility.

Rigid vs. Flexible Airframes

The Barrowman method assumes that a model rocket is a rigid structure as shown in Figure 1a. Aerodynamic forces on the nose cone, transitions, and fins are calculated assuming that all components of the vehicle are at the same angle of attack. For typical model rockets, this is a good assumption. The Barrowman method has been shown to be an excellent and reliable method for designing stable rockets.

However, long Super-roc models are flexible. When a Super-roc model rotates relative to the flow direction, the resulting aerodynamic forces will cause the vehicle to bend. As shown in Figure 1b, the vehicle components (nose cone, fins, etc.) are no longer at the same angle of attack. Airframe bending generally increases the force on the nose cone and decreases the force on the fins. Therefore, the Barrowman method, as typically implemented for a rigid airframe, is not sufficient to determine if a flexible Super-roc model is viable.

Aeroelasticity is the Key

Aeroelasticity is the term used to describe situations where elastic deformation of the airframe interacts with aerodynamic forces. As an example, if you rotate the aileron on the wing of a jet airliner, this will produce lift on the aileron. The lift on the

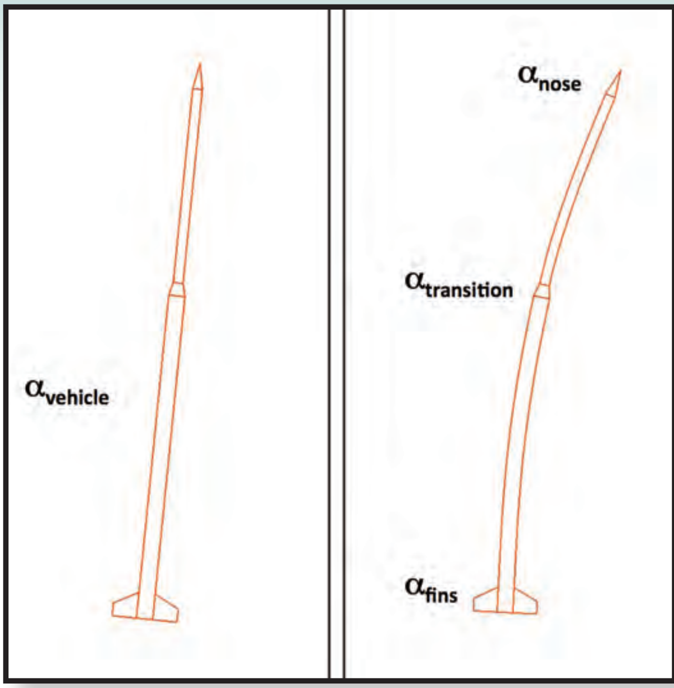

Figure 1a. The Barrowman method assumes that the airframe is rigid.

Figure 1b. Flexible body effects increase the force on the nose and decrease the force on the fins.

aileron will cause the wing to bend and twist, which will affect the lift and torque distribution along the wing.

Aeroelasticity is very important in the aerospace industry. For military airplanes and commercial jet airliners, aeroelastic analysis is performed to verify that the wing and tail will not experience flutter or divergence within the vehicle's flight envelope. For rockets and launch vehicles, aeroelastic analysis is performed to assess interaction between structural flexibility and the guidance system.

Aeroelasticity is also important for low- and high-power model rockets. Boost Glider wings can flutter and shred when flown too fast. For high power rockets, fins can flutter at high speeds if the fins are too flexible. A fascinating example of HPR fin flutter is available at http://www.videorocketry.com/XPRS_2004/video/USS_Bakula.wmv.

Aeroelastic Analysis of Super-Roc Models

Aeroelastic analysis of a Super-roc model is straightforward with the help of a computer program. The procedure described in this article is based on calculating "modes" of the Super-roc vehicle including stiffness, mass, and aerodynamic effects.

To understand what a "mode" is, get out your trusty 1/8" launch rod. Hold it in the middle, and shake it laterally. The resulting bending shape represents the first bending mode of the unrestrained launch rod. You can easily find the excitation frequency that produces the maximum response. This is the natural frequency of the first lateral bending mode. If you insert one end of the launch rod into a launch stand, you'll see a different set of modes due to the constraint applied by the launch stand to the rod. In this condition, it's pretty easy to see the 1st bending mode, perhaps the 2nd bending mode, and maybe even the 3rd bending mode of the constrained launch rod.

A Super-roc model at zero airspeed has three primary modes of interest, as shown in Figure 2:

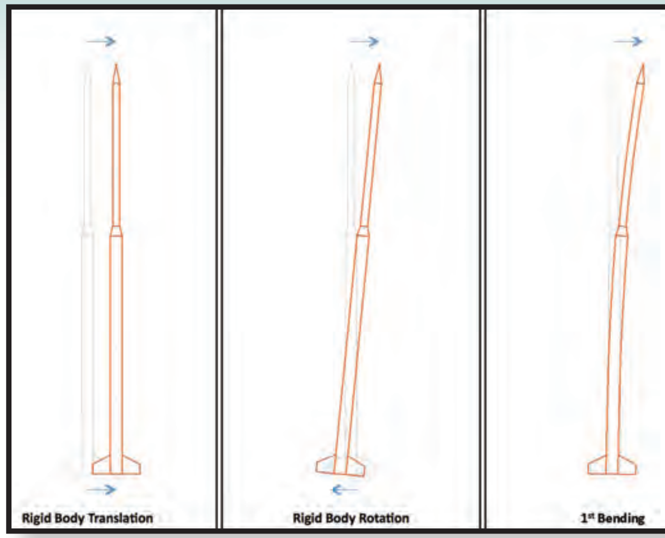

Figure 2. The first three modes are important for Super-roc models.

- lateral translation mode, where the entire rocket moves from side to side
- rotation mode, where the entire rocket rotates about the center of gravity (CG)
- first lateral bending mode

At zero airspeed, the first two modes are "rigid body" modes, and the third mode is the first elastic mode.

Typical aeroelastic results for a Super-roc model are shown in Figure 3. As the velocity increases, aerodynamic forces build on the nose cone, transitions, and fins. These terms are calculated using the Barrowman equations but extended to use the local angle of attack of each component. (For additional details on these calculations, see [4].) The lateral translation mode starts at 0 Hz and remains there. The frequency of the rotation mode starts at zero and increases linearly with velocity. Note that, at low speeds, this is the same value as calculated by RockSim for the pitch rotation frequency. At higher velocities, the aerodynamic terms become significant and begin to couple the vehicle rotation and bending modes. In general, this causes the bending mode frequency to increase with velocity. However, at a sufficiently high velocity, the aerodynamic terms cause the rotation mode frequency to begin decreasing and eventually drop to zero. This is the velocity at which the airframe will buckle or go unstable.

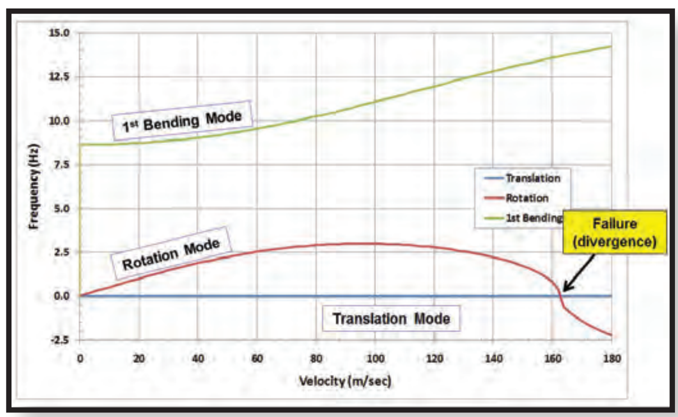

Figure 3. Super-roc airframe failure occurs at the velocity where the frequency of the rotation mode drops to zero.

Analysis Using FlexRoc

FlexRoc is a computer program for performing aeroelastic analysis of Superrocs and other model rockets. FlexRoc can be freely downloaded from the "Files" area of the ContestRoc Yahoo group.

FlexRoc is somewhat like RockSim and OpenRocket in that you define the components of the model rocket (nose cone, body tubes, fins, etc.). You also need to define the velocity range of interest and a reference altitude. Additional information on the input file for FlexRoc is provided in the User's Guide (also freely available on ContestRoc).

Internally, FlexRoc performs an aeroelastic analysis using the finite element method [5, 6]. At each analysis velocity, the first four modal frequencies are calculated using the vehicle stiffness, vehicle mass, and aerodynamic matrices. The modal frequency results are written to an output file, which can be inspected and plotted by the user.

Assumption and Limitations

FlexRoc makes several assumptions regarding the model and analysis methods. Major assumptions include:

The model is assumed to be well constructed (geometrically straight, no large gaps or loose couplers, etc.)

Fins are assumed to be fully effective. The buildup of boundary layer thickness along a long vehicle is not considered.

The fins are assumed to be rigid. The effects of flexible fins and any flexibility at the fin/tube joint are neglected. Fin flutter is not considered.

Aerodynamic terms are calculated using low subsonic aerodynamics. Compressibility and supersonic effects are not included.

An important issue is what margin to apply to the results. For example, the Barrowman method suggests a stability margin of one caliber. What is a suitable margin for FlexRoc results? In the aerospace industry, it is typical to apply a 15% velocity margin for flutter and divergence analysis. This has been shown to be generally suitable for mission-critical aerospace systems. For a competition Super-roc model, a velocity margin of 10% (or perhaps as low as 5%) might be suitable. More experience is needed here.

Predict Success—and Failure!

Several Super-roc models have been analyzed using FlexRoc. So far, on a limited number of samples, FlexRoc has a perfect batting average! It has predicted success for Super-roc models that have flown successfully, and it has predicted failure for Super-roc models that have failed.

As an example, FlexRoc was used to analyze the Estes Mean Machine. Results for a "stock" model (no custom modifications) are shown in Figure 4. FlexRoc predicts that the Mean Machine should be good for velocities approaching 150 m/sec. The maximum vehicle velocity (calculated using RockSim) is 52 m/sec using a D12 and 68 m/sec using an E9. Therefore, the Mean Machine should be fine for these conditions. Some people have flow uprated models of the Mean Machine using larger motors. Care should be used for any model/motor combination where the maximum velocity will approach or exceed 150 m/sec.

Two examples come from G Super-roc Altitude models flown by the Southern Neutron team at NARAM-49. Their first model was a maximum length (450 cm) model using BT-60 body tubes and two Apogee F10 motors. As shown in Figure 5, FlexRoc predicts that the model should have failed at approximately 62 m/sec, well below the maximum velocity of 83 m/sec predicted by RockSim. As documented in their R&D report [7], the Southern Neutron team reported that their first model failed toward the end of the motor burn.

Their second model also used BT-60 body tubes but was augmented with long internal lengths of coupler stock. Propulsion was two E6 motors and one F10 motor. As shown in Figure 6, FlexRoc predicts that model #2 should have worked successfully. The vehicle, shown in Figure 7, flew successfully and took first place in G SRA, Team Division. FlexRoc correctly predicted failure for their model that buckled and success for their model that flew well.

Another example was one of the author's F Super-roc models flown at NARAM-52, shown in Figure 8. FlexRoc wasn't available at that time, so the model was designed using an earlier, more conservative method. The FlexRoc results, shown in Figure 9, indicate that the model should fly successfully, which it did. However, FlexRoc also indicated that the model was overdesigned, with a velocity margin of nearly 38%. This is probably too large a margin for a seriously competitive design, which helps explain why the model finished in 8th place in C Division at NARAM-52.

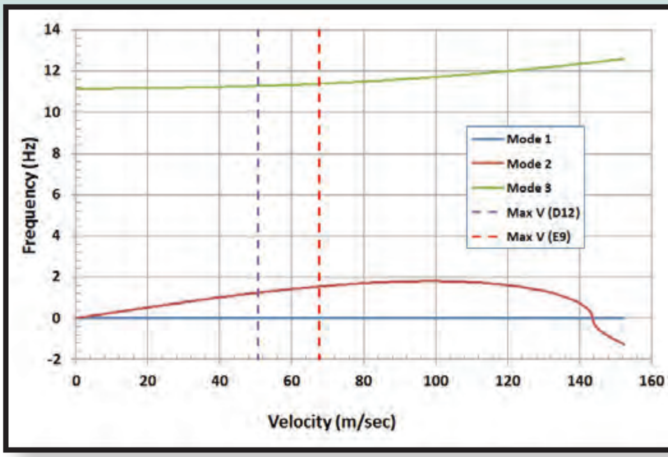

Figure 4. The Estes Mean Machine has large safety margins when flown using D12 or E9 motors.

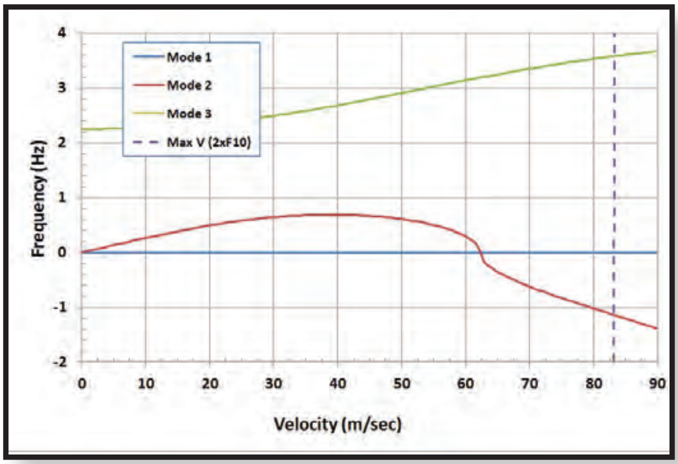

Figure 5. The first Southern Neutron G SRA model was predicted to fail at a velocity below the maximum expected velocity.

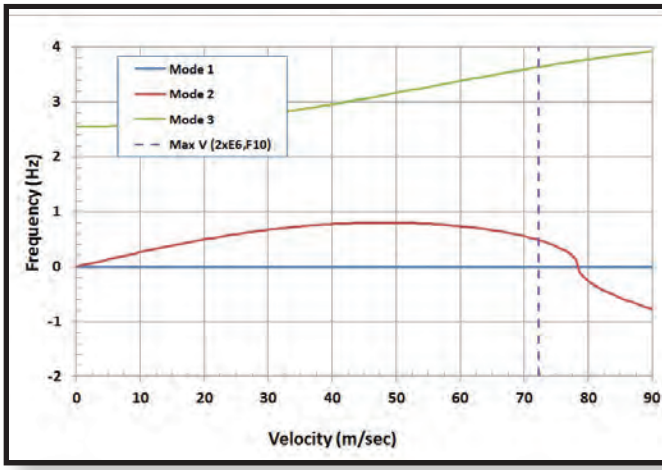

Figure 6. The second Southern Neutron G SRA model was predicted to worksuccessfully, which it did.

Figure 7. The second G SRA model by the Southern Neutron Team flew successfully and took 1st place in Team Division at NARAM-49.

Figure 8. Chris Flanigan's "windy weather" F SRA model used T-52H tubing and finished in 8th place at NARAM-52.

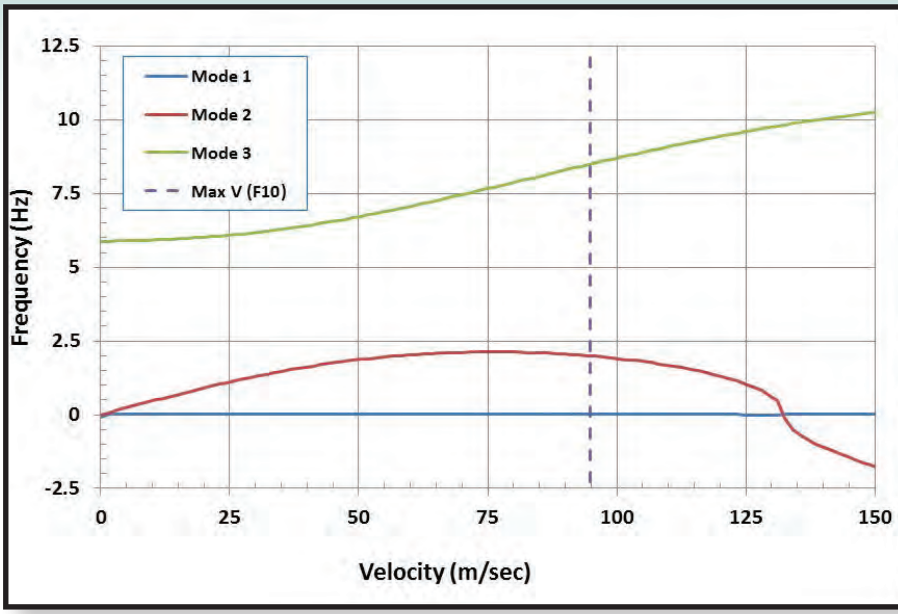

Figure 9. FlexRoc showed that Chris Flanigan's "windy weather" F SRA model was overdesigned for a competition model.

A final example is the author's A Superroc Duration model flown at NARAM-54. This model, shown in Figure 10, consisted of a large diameter (40 mm) base section and a long upper section of BT-4 and BT-3 body tubes. When assembled, the model felt flimsy. However, FlexRoc predicted successful behavior. The model was flown for the first time at NARAM-54, and the model had two successful flights with no buckling or stability issues.

Summary

The Barrowman method is an excellent method for predicting aerodynamic stability for rigid models. For long Super-roc models, flexible body effects must be included. The FlexRoc program performs an aeroelastic analysis to predict the velocity at which a Super-roc model will fail or go unstable. So far, FlexRoc has provided accurate results. It has predicted failure for models that buckled in flight, and it has predicted success for models that have flown successfully. FlexRoc can be a valuable tool for designing high performance Super-roc models that will work the first time.

If any question, feel free to contact the author at ccflanigan@alum.mit.edu.

References

1. Barrowman, J., Barrowman, J., "The Theoretical Prediction of the Center of Pressure," NARAM8 R&D report, 1966.
2. Galejs, R., "Wind Instability - What Barrowman Left Out," http://projetosulfos.if.sc.usp.br/artigos/sentinel39-galejs.pdf.
3. LaBudde, Edward, "Extending the Barrowman Method for Large Angles of Attack," NARCON R&D report, March 1999.
4. Flanigan, C., "Modal Aeroelastic Analysis of Super-roc Vehicles," NARAM-53 R&D report, July, 2011.
5. Robert D. Cook, David S. Malkus, Michael E. Plesha, and Robert J. Witt, Concepts and Applications of Finite Element Analysis, 4th Edition, Wiley (2001), ISBN-10: 0471356050.
6. Craig, R.R., Kurdila, A.J., Fundamentals of Structural Dynamics, Wiley (2006), ISBN 13: 9780471430445.
7. G. Gassaway, E. LaCroix, T. Willard, and R. Woebkenberg, "Development of a High-Scoring G Super-roc by Use of Optimized Engine Choice, Conventional Design, and Conventional Construction Methods," NARAM-49 R&D report, August, 2007.

Figure 10. FlexRoc was used to design the author's A Super-roc Duration model that flew successfully at NARAM-54 on its first flight.

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Access to NAR programs and materials is as close as your computer! Any time you need info. on launches, clubs, certification, or any other NAR member program, simply visit the NAR website at http://www.nar.org. And we've included a brief list of the most popular NAR service programs for you here!

Need to find your next NAR sponsored sport or contest launch? Visit "Launch Windows–at:
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Looking for the official NAR Contest Rule Book? Try:
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http://www.nar.org/NARmessform.html

Need to get some "Education Resources" for your school or youth group? There's a library of those at:
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Need an NAR Form or Informational Resource? They're in our Filing Cabinet at:
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Do you want to contact an NAR Committee or volunteer? Try the Contacts Directory:
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Still Stumped? Contact NAR HQ!
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Photos by Steve Jurvetson

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Please send your news to:
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AeroTech Consumer Aerospace

This year at LDRS 32 near Gerlach, Nevada, AeroTech Consumer Aerospace announced a radical new design change to their Reloadable Motor System. Designated as the "RMS-EZ" line, the reloads now include a molded modular forward bulkhead that replaces the current metal forward end closure so familiar to users of the AeroTech Reloadable Motor System. The molded one-piece thermoplastic bulkhead features a pre-installed delay grain that eliminates the previous six separate components of the current RMS reload kits. According to AeroTech, this significantly reduces motor assembly time and eliminates a substantial risk of user error. The new RMS-EZ motor design will use the existing motor cases and aft closures, and the forward retaining ring from the RMS spacer system. New to the RMS-EZ motor design is the ability to shorten the as-supplied time delay in 2-second increments using AeroTech's new Universal Delay Drilling Tool (UDDT), which is being supplied free of charge to each customer who purchases one or more RMS-EZ reload kits. Packaged in a distinctive yellow shipping tube, the RMS-EZ reloads are also supplied with a generous ejection charge, a First-Fire igniter, and a new internally installed vinyl ejection cap. Best of all, AeroTech advises there is no price increase over current reloads. For more information about the RMS-EZ motor design and other products offered by AeroTech, visit their website at www.aerotech-rocketry.com

LOC Precision

LOC Precision announced their new line of LOC Angel Chutes. These rugged level 3 parachutes are sewn by Mark Lose, a Navy trained rigger, on single and double needle industrial sewing machines. The chutes feature 1.9-ounce low-porosity silicone coated rip-stop nylon, tubular nylon suspension lines, 1500 pound 12/0 swivels, and come with a lifetime warranty. For more information about the LOC Angle chutes, visit their website at www.locprecision.com.

Squirrel Works Rocketry

The folks at Squirrel Works Rocketry have introduced two new model rocket kits for the 2014 flying season. First up is the Acorn, familiar to everyone as the rocket featured in the Squirrel Works Rocketry logo. The Acorn is 2.6 inches in diameter, and stands 12.25 inches tall. Weighing in at 4.1 ounces, the Acorn flies well on a mix of B and C impulse motors. The rocket kit features laser cut fin slots, laser cut fins, parachute recovery, and water-slide decals. The Acorn retails for $24.95.

The other new release is the Sparrow Hawk. At 22.69 inches long and .976 inches in diameter, this long and lean rocket flies great on a mix of A through C impulse motors. The Sparrow Hawk features laser cut balsa fins and a balsa nose cone, a Mylar parachute and water-slide decals. The Sparrow Hawk retails for $16.95. For more information about these new model rocket offerings and other products from Squirrel Works

Rocketry, visit their website at www.squirrel-works.com.

The Cato Chronicles

by Leslie Houk NAR 58525

I was listening to a sports commentator on the radio the other day, and he went off on a tangent about sports terms that have been adopted into general use in non-sports situations. One example he mentioned was "the ball is in your court." (He did point out that nobody in tennis actually uses the phrase, because if you tried, your opponent would volley the ball back before you could finish, and you would lose the point. But I digress.) It occurred to me that it could be a good thing for model rocketry if some of our terms became more widely used. It would bring more attention to the hobby, and would make a rocketeer stand out less when he says something like, "My last kit energetically disassembled when my reload spit its copperhead and catoed." You say something like that in a crowd nowadays, and you're likely to be reported to either Homeland Security or the nearest mental health professional.

With just a little effort, we can get our families and close friends to start sounding just like we do when we have a conversation.

So, I would like to make some suggestions about terms that we should try to work into general conversations. Heck, even a silly phrase like "gangnam style" was able to catch on, so how hard can it be?

PRANG: Why don't we start using this word to refer to a person who falls down a hole, into a fountain, off a cliff, and so on, while texting on their cellphone? Based on the number of YouTube videos I've seen of this happening, we wouldn't go a week without having an opportunity to use it. And when someone asks, "Where did you hear that word?" you could tell them about the last time one of your rockets pranged. (Just try to avoid weeping on their shoulder when you do.)

APOGEE: This is another term that

could be used quickly and often. Just replace "peak," "top," and all such words in your conversation with apogee. For instance, instead of telling your wife, "Your hairline is really receding, honey! That's quite a widow's peak you're getting," you could instead say, "That's quite a widow's apogee you're getting!" After you wake up from having her clock you with a frying pan, she hopefully will ask you where you heard the word. And if someone points out that the term was used for airplanes, missiles, satellites, and so on before it was used for model rockets, just reply witheringly, "Oh, yeah? So what?"

CATO: I like using this word, and not just because I like to start talking to random strangers on the street about my column. It's a nice, short word that can be used to describe any loud, dramatic explosion. "Telling my father-in-law that Obamacare was a great program, but it would have been even better if they hadn't scaled it back so much, caused a real cato in the conversation." I find I can use this word surprisingly often—but maybe that has more to do with my family than anything else...

LAUNCH ROD: How about using this term to refer to any person or organization offering moral or social guidance to a young person? For example, "The Boy Scouts were a good launch rod for young Billy," or "Looking back, the Insane Clown Posse were not the best launch rod for Suzie." Again, it's a short phrase that conveys a relatively complex idea. However, we would need to be a little careful with this term, just because someone at some point will probably confuse a person's having a "launch rod" with "having a stick up his butt."

PLASTIC PARACHUTE: Everyone is already familiar with the term "golden parachute," which refers to a generous retirement package for a high-level corporate executive. Well, what if we start using the term "plastic parachute" for the retirement benefits we real working stiffs have? Something like, "I invested all my 401K money in real estate just before the housing bubble burst. So much for my plastic parachute." This also has an added benefit for the single rocketeer: when some attractive person of the opposite sex asks you what in the world uses a plastic parachute, you can invite him or her back to your place to look at your rocket collection!

With just a little effort, we can get our families and close friends to start sounding just like we do when we have a conversation. Whether this is a good idea or not is an entirely different topic...

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ATTENTION: Educators, Corporations and Concerned Americans

LOC/PRECISION manufactures rocket kits and provides customized packages for youth outreach programs. For over 28 years the company has supplied rockets for use in educational programs. The company is dedicated to providing a centralized location for educators to easily find information, materials, and education support when working with larger rockets.

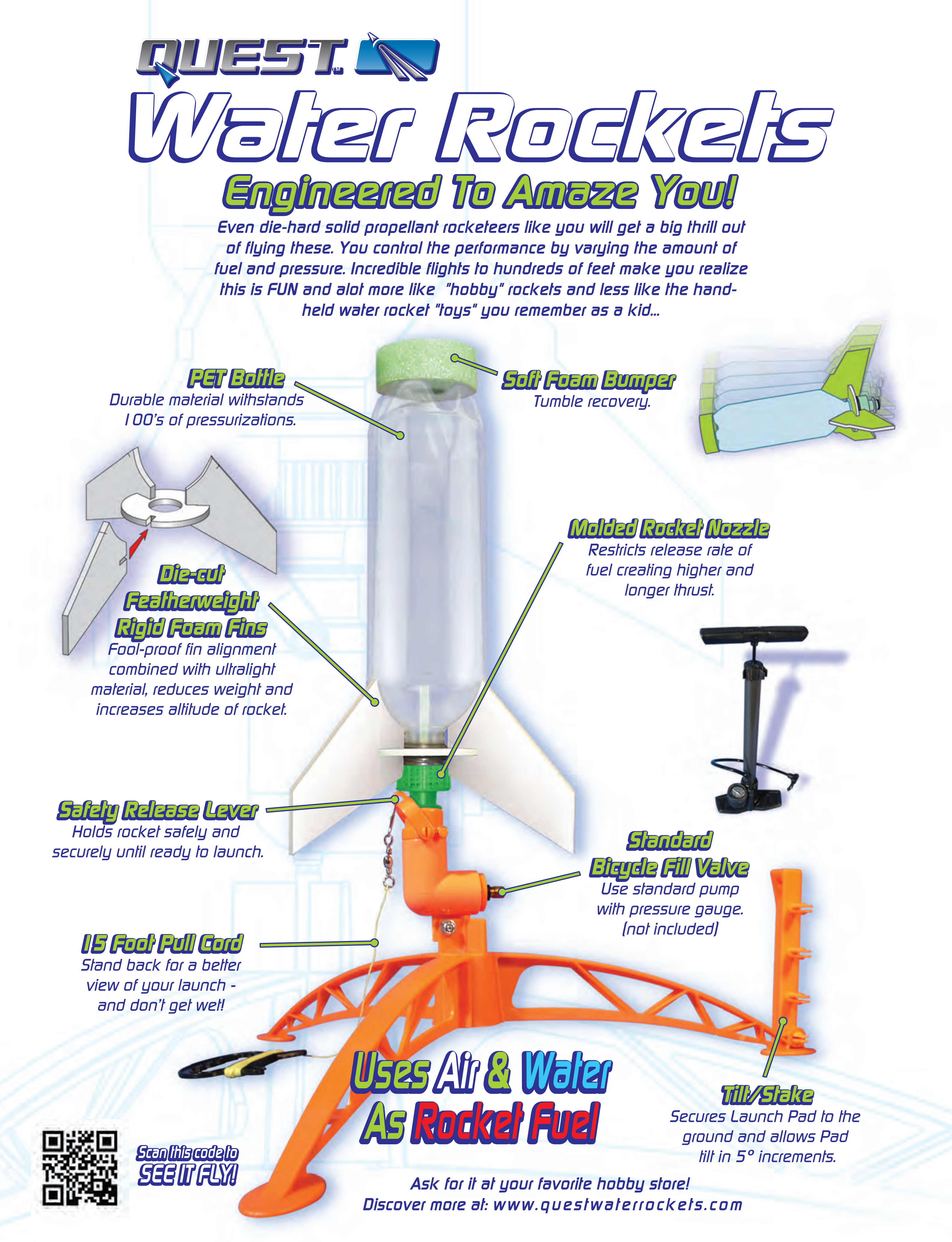
LOC/PRECISION is committed to promoting student interest in exploring the fields of Science, Technology, Engineering and Mathematics (**STEM**). Last year, the company joined the Ohio Aerospace Institute and collaborated with NASA, OAI, and interested industrial and aerospace companies to form alliances to facilitate and enhance the use of rockets in promoting STEM educational outreach.

Over the past 14 months, our Rocketry Education contact, Jerry Appenzeller, has been working closely with many TARC, SLI, USLI, and other rocketry-related program teams. Jerry supports and advises educators, corporations, and community leaders in their rocketry related program efforts and is available for team consultation.

This year we added the Cesaroni Technology line of motors to further support our educational outreach. We stock the motors needed for TARC, SLI, USLI, and other educational outreach programs. These motors are not listed on our web store. Our stock is sold primarily for educational programs. We invite you to contact us with your questions and material requirements.

LOC/PRECISION is investing in America's future. We hope you will join us as we strive to inspire our future leaders. Feel free to contact us with your questions, requirements, and program ideas.

Sincerely,
Barry E Lynch
President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