SUGAR SHOT to SPACE

Rocket Science is all of art, computer science, engineering, mathematics, physics and soothsaying. Of some 50 Sugar Shot to Space participants, about 3/4ths of us are Americans. One might aptly call us a western amateur volunteer space project, with Australia in the “far-west”.

In June of 2005, none of us had any idea of that next month the topic would change from our usual experimental low-energy rocket motor discussions. On July 11th, 2005, our member from Slovenia asked; “I'm wondering if it would be possible to build a rocket capable of reaching space (100km), which would be powered by sugar propellant and how should this rocket look like.”

After a few calculations, a few days, and the thought of it, most of us had stepped forward as volunteers and our project had a name: *Sugar Shot to Space*.

Since then we've had a website, www.sugarshot.org.

A rocket is propelled by mass ejection. If a man stands on a skateboard and throws a basketball, he and his skateboard will move in the opposite direction of the basketball. The primary force that moves a rocket is similar, that by throwing gases out of the nozzle, a rocket moves the opposite way.

There are many sugars, differing in molecular structure but similar in content. Our primary sugar will be sorbitol, noting that table sugar is only slightly more powerful in a solid rocket motor. In order for sugar to function as a fuel, it is required that the propellant also consists of about 2/3rds solid oxidizer.

Our rocket will be 27.4 centimeters in diameter and 8.2 meters tall, and will be launched from a desert in a southwestern state. Permission to launch is granted by the FAA after a rigorous application process.

The rocket will be assembled at the launch site, and we plan for about two weeks or longer. Except for video web-conferencing, I expect to be meeting most of us for the first time in one of several assembly tents.

Most individual parts will be made in our homes and shops, but I think the motor will have to be cast at the launch site (permits to transport a rocket motor of this size might be impossible to get). Every component will be thoroughly tested during development.

We expect to be hosting environmental sensors as our contribution to research in ozone depletion, global warming, or storm-tracking weather research.

Flight Chronology

If something were to go wrong during motor operation, an operator on the ground could terminate the flight, and the flight computer system would recognize how to attempt a safe recovery during any unlikely abnormal flight modes.

Our latest computer simulations show that upon starting the motor, the initial thrust will be about 2,540 kilograms. With an initial weight of 491 kilograms, liftoff will be rather hasty. It should sound like thunder, with lightning overtones.

At 5.2 seconds after liftoff, the rocket will break the speed of sound at mach 1, or 1,225 kilometers per hour.

Peak thrust during the first stage burn will be 3,417 kilograms. About 9 seconds after starting the first stage fuel will be spent and the rocket will be passing through an altitude of 2,156 meters at a speed of 1,965 kilometers per hour.

Due to novel motor design features, and inertial planning, the first stage will remain with the rocket throughout the flight.

After coasting skywards for another 16 seconds, the rocket will have slowed to 977 kilometers per hour when the motor is re-started at an altitude of 8.4 kilometers, so the rocket will soon break the speed of sound again 1.3 seconds later.

At T=32 seconds after ignition, the rocket will leave the troposphere and enter the tropopause.

At T=33 seconds after ignition, the rocket will be at an altitude of 15.4 kilometers travelling upwards at a hypersonic velocity of 5,550 kilometers per hour or 1.54 kilometers per second , well-exceeding the velocity of a bullet exiting a high-powered rifle. Given the speed of sound at this altitude, that's mach 5.2. Between mach 1.2 and mach 5 is supersonic. Greater than mach 5 is hypersonic. The speed of sound is dependant on temperature, so the airspeed meaning of mach number changes a bit with altitude on that basis. The rest of the trip will be inertial, with gravity gradually taking away inertial momentum until zero, when it will start to fall back to Earth.

At T=46 seconds, the rocket will enter the stratosphere region of our atmosphere, travelling 4,436 kilometers per hour.

At T=51 seconds, the rocket will be above the ozone layer at about 38.6 kilometers altitude going 4,221 kilometers per hour.

At T=70 seconds, the rocket will leave the stratosphere and enter the mesosphere, travelling at 3,550 kilometers per hour.

Lacking sufficient velocity to enter orbit (or join the 7,500 large pieces of space debris tracked by NORAD), the rocket will continue to slow down, now weighing 88 kilograms, pulled by gravity which is still close to what it is at sea level.

At T=97 seconds into the flight, aerodynamic drag will have dropped to 50,000 times less than what it was when the 2nd stage burned out, and the rocket will be travelling upwards at 2,614 kilometers per hour.

At T=98 seconds, the rocket will leave the mesosphere and enter the thermosphere.

At T=2 minutes 10.8 seconds after ignition, at a velocity of 1,404 kilometers per hour, our rocket will pass through an altitude 100 kilometers as the first amateur rocket in history to reach space using honest-to-goodness amateur propellant, sugar. With members in America, Argentina, Australia, Belgium, Brazil, Canada , the Czech Republic, Denmark, Mexico, the Netherlands, Norway, Romania, Slovenia, Spain, and Ukraine – 15 countries, ours would the third most international space-bound launch in history too, surpassed only by the International Space Station effort and the European Space Agency which have members in 16 and 17 countries respectively.

On approach to apogee (the highest point in the flight) compressed gas jets will be activated in a controlled sequence to slow the rotation of the rocket from four turns per second to zero.

At T=2 minutes and 50 seconds into the flight, our rocket will reach its peak altitude of 107.7 kilometers, which is 7.7 kilometers into ‘space’.

From this altitude, our next goal is to bring it back in a controlled fashion, and also so it could still look pretty when we offer it to the Smithsonian Air and Space museum.

We've chosen to make the return trip in two sections.

Upon arcing through a horizontal position, an electromechanical device will cause the separation of the payload capsule from the rest of the rocket.

All the while, video cameras will be recording the view which is transmitted back, and viewable live via the Internet. Anyone on the Internet can come along for a virtual trip to space, and even log into the rocket (actually a live-mirror of it on the ground) at any point in the flight, to watch the videos and images, or even track the flight and data virtually alongside our teams on the ground.

On the ground, radio-tracking recovery teams will be climbing into specially equipped Pick-up trucks and SUVs, and setting out upon receiving of the first compass heading and computed inertial results transmitted back from each section.

Re-entry will be mostly supersonic.

At around 2 minutes and 8 seconds fall-time, at an altitude of 33.8 kilometers, an ozone sample could be taken, in the middle of the ozone layer.

After free-falling for 2 minutes and 13 seconds, a peak descent speed of 4,162 kilometers per hour is reached upon entering the region of most rapid deceleration, starting at an altitude of 29 kilometers, in the middle of the stratosphere. At this top descent speed the air is getting thicker, so it could be a bit like roasting corn. Put in oven, and over a 16 second period gradually turn up the oven to one megawatt, turning it down again slowly over the next 16 seconds. The surrounding air is –60 degrees Celsius, which is like having a block of dry ice in the oven too. Substantial cooling meets 'stratospheric' heating.

Upon reaching an altitude of 9.7 kilometers, barometric pressure sensors will be activated and air pressure will be measured until confirmed that indeed we are approaching an altitude of 9 kilometers where we expect to be descending at ¾ of the speed of sound, or 917 kilometers per hour. Small parachutes, called drogues, will be deployed at this time. Timers set at apogee (from in-flight altitude prediction) will determine the deadline for this event, so drogue deployment would be forced regardless by the time descent would reach 8 kilometers altitude. If both altitude prediction and air pressure sensing fail, a 'late default' time will be used. This backup plan also has a separate backup system, like all other critical functions.

Simultaneous with drogue deployment, recovery tracking radio beacons will be activated and a transmitter will also start to transmit GPS coordinates.

At 1.5 kilometers altitude both sections will release a main parachute and let go of the drogue that pulled it out. Strobe lights will be activated at this time.

Each section will touch down with a bit of a thud, travelling over 9.1 meters per second, or 32.7 kilometers per hour. In addition to transmitted flight data, each section will have digital recordings in flash memory of the flight and sensor data, along with the video and digital images. The total flight time will be around 12 minutes. Part of the reason for coming back fast is to ensure that it won't be carried very far away by winds.

The flight control electronics will be sophisticated enough to also call it "the first radio-linked website with artificial intelligence to fly faster than its guardian angel".

Every team and every member are making more than a rocket and a few rocket scientists. With an awe-inspiring roar we will be painting the sky with a dream to live by, that you can achieve whatever you set out to do, especially when you pull together and work as one.

- Geoffrey Gallo wrote this synopsis on 2006/06/11