In September 2007 the X-Prize Foundation announced a new contest as a successor to the Ansari X-Prize. The new contest, sponsored by Google, involves the complete mission of launching, transiting, landing, and moving a rover to and on the surface of the moon for a potential first place prize of 20 million dollars. Believing this accomplishment to be achievable at the university level a team of interested Stanford students immediately began investigating potential solutions. Within the larger effort it was further identified that the task of developing a braking / landing motor to slow the craft as it approached the lunar surface was within the scope of the AA284 propulsion system design laboratory class. The goal of the class then became contributing to the maximum extent practical towards the development of a restartable hybrid rocket lunar descent motor capable of carrying a 50 kg payload through a 2.5 km/s velocity change.

On Saturday, March 15, 2008, the team tested two fuel grains for three successful burns. The system remained intact and operational and the tests were conducted safely, which was the primary goal for testing. The first burn was a 3 second "shakedown" burn to test system integrity. The second burn was a restart of the first grain for 10 seconds. The first grain was then checked for regression rate and combustion chamber integrity. A second grain was loaded into the combustion chamber, and the final test was a 25 second burn followed by a 2 second restart burn.

Discrete:
• Stable Combustion: YES
• Restartable: YES

Numerical:
• Combustion Efficiency: 53%
• Injector Discharge Coefficient: .37
• Average Fuel Regression Rate: .07cm/s

We can conclude that further experimentation with the design, most notably in the injector hole arrangement, may lead to improvements in combustion efficiency. Without success in that adjustment, motor length to diameter ratio as well as operational pressures and fluxes would have to be reevaluated.

Final dimensions exceeded the practical capability of the AA284 class, therefore a half length-scale test article was conceived to test the system’s core attributes. The information gathered as well as the test setup itself could then be used by the X-Prize team in future design iterations. Testing a scaled system raises an important question: if we are not testing the actual system, what are we testing? Some attributes of the actual system will be preserved, while some will not.

Based on this division the majority of parameters that are believed to truly characterize the rocket motor combustion chamber are in fact mostly preserved. Therefore, the testing focuses on those elements pertaining to the combustion chamber and injector arrangement and disregard performance metrics such as thrust, impulse, or nozzle efficiency. More specifically the prime testing mandate is thus: Over the range of expected operating pressures and fluxes, will there be stable combustion and if so, what is the combustion efficiency?

All test objectives are tabulated below.

Test Objectives:
- Stable combustion?
- Restartable?
- Combustion efficiency
- Injector discharge coefficient
- Average fuel regression rate

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Bibliography

Further Information
Videos of burns:
Burn 1: http://youtube.com/watch?v=0urrTKZ1M3c
Burn 2: http://youtube.com/watch?v=HoyVc1Ws-TU&feature=related
Burn 3: http://youtube.com/watch?v=MLYRsAm2Y8&feature=related