

# Amateur Rockets: The Little Giants in the Aerospace Industry

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**Abstract** – *In recent decades, amateur rockets have evolved to require more government regulation to ensure public safety, with the requirement for advance notice to approve of any amateur rocket operation remaining unchanged. The definition of an amateur rocket now includes more operations and research opportunities involving companies and national associations or clubs dedicated to amateur rockets. They are involved in activities ranging from hobbies and competitions to government research and development. This paper discusses amateur rocketry within the context of today's aerospace industry. An overview of amateur rocket classifications and regulations is provided. The role of the Federal Aviation Administration in regulating amateur rocket operations is described including its interaction with operators to determine safe launching requirements and guidelines.*

**Keywords:** amateur rockets, federal regulations, public safety, model rockets, high powered rockets, aerospace industry.

## 1 Introduction

Amateur rockets began to gain popularity in the late 1950s after the launch of Sputnik by the Soviet Union, which marked the beginning of the space race. Amateur rockets have evolved from little regulation from the federal government in the 1960s, with after school programs or regional rocket club events, to contracts with multi-billion dollar companies requiring more government regulation to ensure public safety.

The Federal Aviation Administration (FAA) is the agency within the United States government with the authority to regulate civil aviation and airspace. The law governing unmanned rockets was devised to ensure safe operations of amateur rockets into the National Air Space (NAS) and the safety of people and property close to the launch site. In the 1960s, the law evolved requiring an advance notice to approve of any amateur rocket operation. Over the years more regulations have been added for safety

reasons, but two requirements have remained the same, advance notice and approval before operation.

So what is an amateur rocket? The Federal Aviation Administration has defined amateur rocket as [1] “launch involving rockets propelled by a motor or motors having a total impulse of 200,000 pound-seconds or less and cannot reach an altitude greater than 150 kilometers (93.2 statute miles) above the earth surface.” Previously, the definition of an amateur rocket included the burn time of fifteen seconds and having a ballistic coefficient of less than twelve pounds per square inch. Now, with the burn time taken out of the amateur rocket definition, more operations and research opportunities fall under the definition of amateur rockets.

One of the more notable amateur rocket events was conducted by the Reaction Research Society, one of the oldest amateur rocket clubs in the country. On November 23, 1996 the society launched a solid rocket motor to an altitude of 50 miles, and on May 17, 2004 the Civilian Space eXploration Team (CSXT) successfully launched the first amateur high-powered rocket into space from the Black Rock Desert in Nevada [2]. Although it is hard to compare some of the original amateur rocket black powder total impulse to the current regulated amateur commercial motors, the Federal Aviation Administration remains a fixture in the equation.

## 2 Laws Governing Amateur Rockets

The FAA has classified amateur rockets into three classes. They are model, high powered, and advance high powered; all of the associated regulation can be found in [3]. Most of the model rockets launched today are associated with regional rocket clubs. To launch a model rocket one must follow the general operations limitations which are found in the regulations. For model rockets, notifications to the FAA are not needed based on the rule for not creating a hazard to aircraft. Most clubs would call that ‘looking into the sky before launching’ the rocket.

The divider between a model rocket (class 1) and high powered rocket (class 2) is the weight of the propellant and the material of the rocket. A class 2 rocket is generally

made of substantial metal parts and contains more than a thousand grams of propellant. Most of the commercial motors for amateur rocket activities fall under class 2. They are designated by letters from A (smallest) through O (largest). These commercial motors are built, tested and classified by the total impulse. A motor classified as type A produces a total impulse of 2.50 Newton-seconds whereas a motor classified as type O produces a total impulse of 40,960 Newton-seconds.

The FAA added a new section to the regulation called Information Requirement for this class of rocket. The Information Requirements were based on common requested or provided information to the FAA. Information requirements in the regulations can be addressed in a few sentences. Some new additions to the class 2 operations limitations include the need to have: a quarter of the maximum expected altitude from any person or property that is not associated with the operations, someone eighteen years old in charge, and reasonable precautions to control a fire caused by rocket operations. The quarter of the maximum expected altitude means that if an amateur launch is expected to reach 20,000 feet in altitude, then the clear out distances must be 5,000 feet.

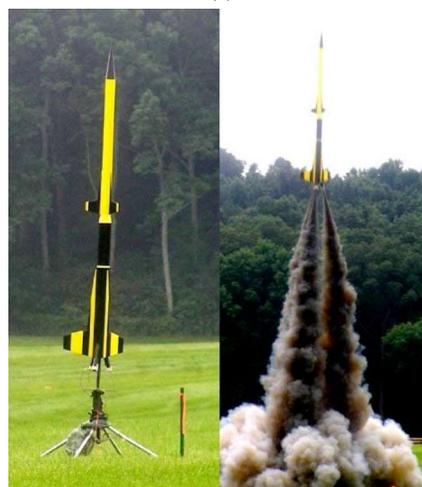
The FAA removed the burn time from the definition of an amateur rocket regulation [4], but added the total impulse separator between class 2 and advanced high powered (class 3) rockets. The advanced high powered rockets are the elite and experimental rockets of the field and supplementary information is required to launch these types of rocket. In addition to the information requirement for a class 2, class 3 must also provide: maximum possible range, dynamic stability, description of all major rocket systems, other support equipment, flight profile and planned impact areas, launch commit criteria, countdown procedures, and mishap procedures.

Why is all of this information of the operation necessary? Well, being the elite and the most powerful group within amateur rockets requires more information to determine safety [5]. Figure 1 shows examples of typical class 1, class 2, and class 3 amateur rockets.

Amateur rockets can travel over 50 miles into the NAS, but where do they land? Who is making sure that the right precautions are being taken for public safety? FAA is responsible to ensure public safety but has worked with the industry to ensure that they incorporate safe landing procedures and public safety into their operations. Industry practice has shown that incorporating these areas into the preparation of the operations ensures the major launch components are answered. The information requirement for a class 3 amateur rocket acts as a guideline to be followed, and was developed from the exploits of past expert groups who have maintained excellent safety records.



(a)



(b)



(c)

Figure 1. Amateur rocket examples: (a) model rocket, (b) high powered rocket, (c) advanced high powered rocket.

The FAA also reviews the information requirements to make a determination on the level of safety needed for these launches. Most of the class 3 launches are launched from Black Rock, Nevada and Spaceport America, New Mexico, which are both remote sites. These locations were chosen with public safety in mind. What makes these sites good locations? It is the large amount of land and airspace

available to conduct launches. There are other sites that have these components.

On the other hand, the class 2 rockets are launched in many places across the country from Washington to Maine due to the lower level of risk to the public. With hundreds of launches over 25,000 feet in altitude and hundreds or even thousands of lower altitude level launches, amateur rockets have slowly become little giants in the aerospace industry based on the increase in launches over the last decade.

### 3 Amateur Rocket Companies and Associations

Amateur rockets can be propelled into the air from a range of a couple of feet to over three hundred thousand feet above the ground. The types of rocket kits and the resulting level of sophistication may vary. The rockets flown in the Northrop Grumman Lunar Lander X PRIZE Challenge (LLC) in 2009 are examples [6]. The Northrop Grumman Lunar Lander Challenge is a competition for vertical takeoff/vertical landing rockets. The Lunar Lander competition consists of two levels. Both levels require the rocket to reach an altitude of 160 feet and fly laterally for at least 160 feet before landing. The difference between the two is that level 1 has a flat surface and level 2 has a simulated lunar surface. The Northrop Grumman Lunar Lander X PRIZE Challenge in partnership with the National Aeronautics and Space Administration (NASA) awarded two amateur rocket companies over 1.5 million dollars in 2009. Those companies were Armadillo Aerospace and Masten Space Systems.

Amateur rocket operators must apply for a waiver from regulations when they want to launch a rocket that does not comply with Title 14, Part 101 [3]. Armadillo Aerospace won first place in the LLC level 1 competition in 2008 under a permit from the FAA and won second place in 2009 for the LLC level 2 competition under a Part 101 waiver from the FAA. The Armadillo Aerospace rocket flown in 2009 is shown in Figure 2. Armadillo Aerospace is a startup company founded by John Carmack and is based in Caddo Mills, TX. The company has conducted research and development work for NASA and is currently working on flights to higher altitudes.

Masten Space Systems won second place in the LLC level 1 competition in 2009 under a Part 101 waiver from the FAA and won first place on the LLC level 2 competition under a Part 101 waiver from the FAA. Figure 3 shows the Masten Space Systems rocket. Masten Space Systems is also a startup company, founded by David Masten. The company is based in Mojave, CA. Masten Space Systems would like to continue development of higher altitudes flights as well.



Figure 2. Armadillo Aerospace *Scorpius* rocket launching from the pad on Sep. 12, 2009 during Northrop Grumman Lunar Lander X PRIZE Challenge.



Figure 3. Photo courtesy of Masten Space Systems Masten Space System XA0.1B (*Xombie*) rocket during Northrop Grumman Lunar Lander X PRIZE Challenge.

Another amateur rocket company is Up Aerospace. Up Aerospace is based in Denver, CO. The company launches sounding rockets and other vehicle types from Spaceport America, New Mexico. On April 28, 2007, Up Aerospace launched some of the cremated remains of astronaut Gordon Cooper and James Doohan, an actor on the television show and movie *Star Trek*, into a suborbital trajectory on the SpaceLoft XL vehicle. This was the company that achieved the first successful launch from the site.

The FAA works with rocket operators at amateur rocket competitions and events to evaluate launch safety. In 2006, the FAA determined safe launching requirements and guidelines for amateur rockets working closely with the X-Prize Cup Foundation as well as the Tripoli Rocketry Association [7]. The analysis that supported the FAA decision to approve waivers to launch amateur rockets at the competition is described in [7] along with the FAA findings for evaluating amateur rockets.

The two biggest amateur rocket associations are National Association of Rocketry (NAR) and Tripoli Rocketry Association (TRA). The NAR was established in 1957 by G. Harry Stine and by Orville Carlisle. From all accounts, it is the oldest and largest model rocketry governing body in the world. The second would be TRA, which was founded in 1964 by Francis G. Graham in Pittsburgh, PA and over time has developed into a national organization with an emphasis on more complex rockets.

## 4 The Little Giants

Sometimes when people hear about amateur rockets, they think of 3-foot tall rockets that only go a couple of hundred feet into the air. When they are informed about the advanced high powered rocket's capability and range, they realize that the amateur rocket is far from small or little.

The amateur rocket operators are now offering amateur rockets for service to the private sector and even schools and with the payloads on the suborbital trajectory. The amateur rocket operators are now acquiring research and development contracts. The little and small rockets are now making impacts into the aerospace industry. Looking on the horizon, many of these operators are beginning to structure a business plan to turn a profit in this tough and unforgiving industry.

So, where do these little giants go next? Maybe the rocket vehicles will be placing payload into space. In fact, in the future, Up Aerospace intends to provide low cost access to space and payload with their vehicles to any company. To perform this operation would transform these little amateur giants into the big world of permit and license launches.

## 5 Conclusions

Amateur rocket operators are involved in activities ranging from hobbies and competitions to government research and development. Before operation, they are required to obtain advance notice and approval from the FAA, which has the governmental authority to regulate civil aviation and airspace to ensure public safety. The FAA works with industry and rocket operators at amateur rocket competitions and events to evaluate launch safety and to determine safe launching requirements and guidelines. With operators now offering services to the

private sector and educational institutions as well as acquiring research and development contracts with multi-billion dollar companies, amateur rockets are now impacting the aerospace industry much more than in past decades.

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