by Mark Canepa

The purpose of this article is to review and compare the requirements for Level Three certification for both the National Association of Rocketry (NAR) and the Tripoli Rocketry Association (Tripoli). This article also provides practical information to help rocketeers reach Level Three safely and on their first attempt.

The Basics

Level Three is the pinnacle of high-power rocketry. It allows rocketeers to launch rockets equipped with M motors or larger and generally involves the most expensive and sophisticated rockets in high power.

The basic requirements necessary to achieve Level Three are substantially the same with either Tripoli or NAR. As a preliminary matter, the rocketeer must be a member of one of these two rocketry organizations. Memberships are typically open to all adults and the specific requirements for each organization can be found online at the website for NAR at www.nar.org or for Tripoli at www.tripoli.org.

Prior to a Level Three attempt, candidates must also attain Level One and Level Two certifications. Level One is achieved by successfully launching and recovering a high-power rocket on an H-class motor, single-use or reloadable. Level Two is obtained by launching a rocket using a motor with at least 640.01 Newton-seconds of impulse (usually a J motor or larger) and by passing a written examination. Once Level One and Level Two certification are attained, the rocketeer is eligible for a Level Three attempt.

The Paperwork

The first step in any Level Three certification attempt is to obtain the appropriate documents from either Tripoli or NAR. Both clubs offer their Level Three applications online, but there are significant differences in the paperwork and the forms between the two rocketry organizations are not interchangeable.

The Tripoli application is known as the "Level 3 Data Capture Form." This form must be filled out prior to any Level Three attempt and submitted to two Tripoli advisory panel members (also called TAP officers) 30 days prior to flight. Both TAP members must sign off on the document if the rocketeer has satisfied the application and construction requirements for Level Three. One of the TAP members must also witness the successful flight and recovery of the rocket.

Locating TAP members is not difficult. A current list is available by logging on to Tripoli's website. If the Level Three flight is successful, the paperwork is submitted by the applicant to Tripoli headquarters for certification.

NAR follows a similar procedure but the paperwork is a bit more extensive. Currently, NAR requires completion of two forms. The first form is a two-page document known as the "NAR High Power Certification Application." The second form is a one-page supplement. Both forms are available online as are the rules and regulations for Level Three certification. The NAR paperwork must be completed prior to flight and the application is then submitted to a Level Three Certification Committee (L3CC) member who signs the documents, certifying proper completion of the forms and appropriate construction of the rocket.

As with Tripoli, an L3CC member and another witness (who is a member in good standing of the NAR) must be present to attest to the pre-flight preparation, flight, and safe recovery of the rocket on launch day. The forms are then returned to the NAR for certification.

The applications for both Tripoli and the NAR require the rocketeer to provide basic construction information and anticipated performance data regarding the rocket and its flight. This data includes, among other things, information about the rocket's center of pressure and center of gravity, construction photographs (a sample or two), rocket weight, motor size, deployment plans, and altitude calculations. Specifications regarding the rocket's anticipated performance, including velocity and altitude, may be obtained using readily available simulation programs, such as Winroc, RockSim, or SpaceCAD. Copies of the flight simulation and other launch characteristics are usually printed right off the rocketeer's computer and then handed to the TAP or L3CC member along with the application for certification.

Although the overall process is similar, there are significant differences in the application information that must be provided to either Tripoli or the NAR in advance of a Level Three attempt.

For example, Tripoli's Data Capture Form requires the rocketeer to calculate and provide the precise thrust-to-weight ratio of the rocket with the anticipated motor for the Level Three flight. NAR does not specifically require this information on the application, although as a practical matter, rocketeers should make this calculation for every rocket they fly, especially a Level Three project. A proper thrust-to-weight ratio helps ensure that the rocket will have a stable trajectory. NAR does require its Level Three candidates to provide information to their L3CC to indicate that the flight is likely to be stable.

NAR, on the other hand, requires its Level Three applicants to calculate the rocket's anticipated descent rate. The descent rate must not exceed 20 feet per second for any component weighing more than eight ounces. Descent rate calculators are available online and are an important component to any launch. An improperly sized parachute can lead to a hard recovery and significant damage, particularly with large rockets and hard landing areas. This can turn an otherwise good flight into a Level Three failure. So even though this is not a requirement with Tripoli, calculating the descent rate is good practice prior to the flight of any large project.

(Above) Mark Hanna stands next to the pad with his nine-foot-tall Aerobee 150, which he launched on an Aerotech M1315 on his L3 certification attempt in July 2004.

(Left) NAR member Mark Hanna's Aerobee 150 takes to the air on an Aerotech M1315 in his quest for Level 3 at LDRS 23 in New York.

The Reloadable M Motor

Choosing the right motor for a certification flight is the same as picking a motor for any high-power launch. Personal preference and familiarity with a given manufacturer plays a role, as does price and availability of casings and reloads. Some rocketeers certify with smaller and less expensive, but very powerful, motors such as Aerotech's 75mm M1315 or the Animal Motor Works M1350, while others break the bank with upper-end M or even N motors on their first Level Three flight.

No matter what motor is chosen, there are some important rules to keep in mind. First, the motor in a Level Three certification flight must exceed 5,120.01 Newton-seconds of impulse. This means an M motor, or larger. Next, motors must be approved by Tripoli or the NAR. Experimental motors are prohibited for a certification flight by both rocketry organizations.

Although there is no requirement that a particular manufacturer be chosen, Level Three attempts are commonly flown on motors from manufacturers such as Aerotech, Animal Motor Works, or Cesaroni. These motors are usually in the 75mm to 98mm size and range in price from $250 to $600, reload only. Hybrid motors are also gaining in popularity for Level Three certification, provided they exceed the minimum size in Newton-seconds.

Multiple Motors on a Certification Flight?

A rocket equipped with two or more high-power motors is known as a cluster. Clusters are a common sight at launches all over the country. However, their use in Level Three certification is limited. In fact, NAR prohibits the use of a cluster to obtain certification. To certify Level Three for NAR the rocket must be flown on one motor only.

The rules for Tripoli are slightly different. Although Tripoli does not allow clustering to reach the minimum requirement of 5,120.01 Newton-seconds, clusters are allowed if the extra motors are necessary for the rocket to obtain the proper thrust-to-weight ratio for the flight. For example, Tripoli would allow the use of three K700s around a central M1315 in a Level Three attempt if the rocket is too heavy to be safely lifted on the M1315 alone. The NAR has no similar allowance for cluster use.

Multi-stage flights, on the other hand, are prohibited by both Tripoli and the NAR for Level Three certification flights. There are no exceptions. Of course, once Level Three certification is obtained, clusters and multi-stage rockets with M motors or larger are allowed by both organizations.

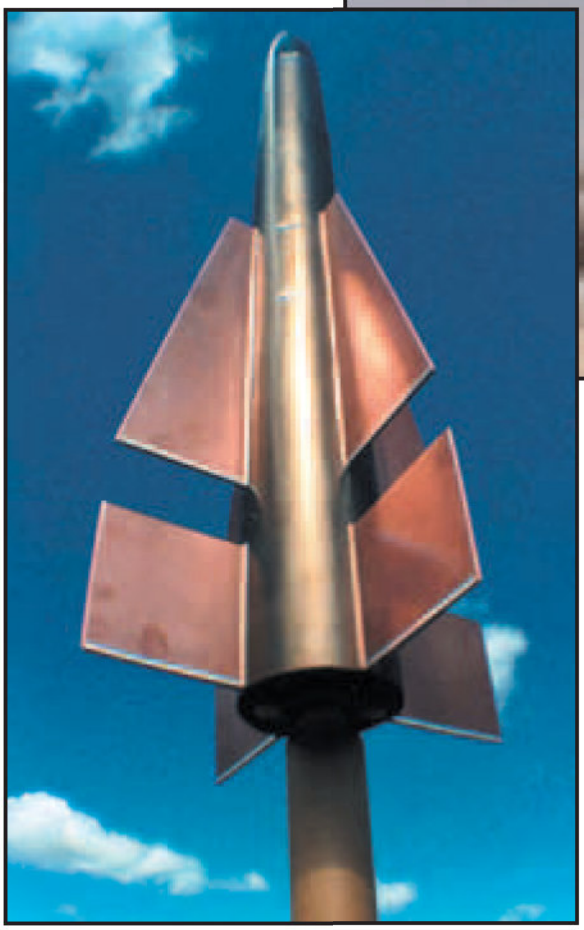
Electronics and Recovery

Tripoli and the NAR both require that electronics be used to deploy the main parachute in a Level Three attempt. This is usually accomplished with an on-board altimeter.

However, NAR has an additional requirement for deployment. To certify with NAR the rocketeer must have a back-up system for parachute deployment. This requirement helps ensure that if the primary ejection charge fails for any reason the parachute will still be deployed by the back-up. NAR rules allow for the back-up charge to be motor-based, although as a practical matter most back-up systems for Level Three flights are controlled by on-board electronics. This is because most, if not all, commercial 75mm and 98mm motors are plugged, with no provision for motor-based charges.

Tripoli does not require back-up systems for Level Three certification. Instead, Tripoli's rules provide that back-up systems are "strongly encouraged." Since Level Three rockets are generally large and expensive projects, common sense dictates that back-up ejection charges always be used.

Once Level 3 is obtained, anything is possible. Here, Tripoli member Wedge Oldham's 700-pound Black Brandt takes to the air on multiple P motors at the Black Rock Desert in September 2004. The rocket cleared 18,000 feet.



A fisheye view of NAR member Phillip Hathaway's M-powered Phoenix missile as it sat on the pad at LDRS23 in New York in July 2004. The 10" scratch-built rocket cleared more than 7,000 feet on an Aerotech M1419 for a successful certification flight.

"Safing" Ejection Charges

In an NAR Level Three certification flight, the rocketeer must be able to externally disarm all ejection devices in the rocket. This is also known as the ability to "safe" the ejection charges in the rocket. This means that the rocketeer must be able to disarm the rocket's ejection charges by physically breaking the connection between the charge and its power source. This entails more than just turning off an on-board altimeter. Typically, safing is accomplished by wiring the ejection charge through a phono jack or external switch that can be armed or disarmed from outside the rocket.

The safing requirement is not found in the Tripoli Level Three certification rules, but it is not a bad idea for all high-power rockets. Ejection charges can be dangerous, and they have been known to go off accidentally while the rocket is being loaded on the pad or during final assembly of the component pieces on the field. A safe switch is an extra bit of insurance that protects not only the rocketeer but also spectators in the area. The only drawback to "safe" ejection charges is that the addition of an extra switch in the altimeter/ejection charge circuit is one more point where failure can occur.

Team Projects and Kits

A group of individuals cannot certify Level Three with the same rocket. Both Tripoli and NAR require that the rocket be constructed by the certification applicant.

The NAR's language is specific: The rocket must be "substantially built" by the certifying flyer. "Substantially built" means: (1) fabrication of the engine mount with centering rings, if applicable; (2) alignment and mounting of the individual fins (prefabricated fin cans are specifically disallowed); (3) installation of attachment points for the recovery system; (4) mounting and installation of airframe electronics; and (5) final flight preparations including pyrotechnic installation, recovery system packing, motor assembly, and motor installation.

Smiling NAR members John Russo, left, and NAR L3CC member Rich Pitzeruse retrieve Russo's Cobra after his certification launch at LDRS 23 in New York.

Do these rules mean that Level Three certification rockets cannot be based upon or built from kits prepared by commercial

manufacturers? The answer to that question is no.

There is no rule that Level Three projects be scratch-built. Indeed, NAR specifically provides that certification rockets can be built from commercially manufactured kits and may also "contain components built to the specifications of the certifying flyer but fabricated by others." These components include, but are not limited to, electronics, recovery systems, motor mounts, and fins. Tripoli has no similar rule on point, but there is nothing in the Tripoli rules that would suggest that a commercial kit could not be used for a Level Three certification attempt.

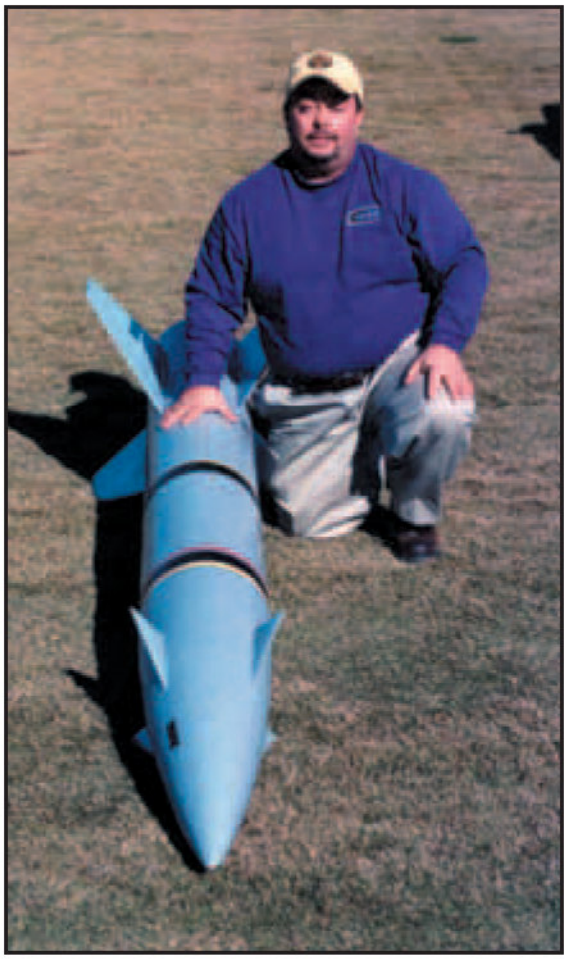
Nor is there a rule with either Tripoli or NAR that the certification rocket conform to a particular size or shape. Any safe design is acceptable, whether scratch-built or constructed from a kit. Depending on the objectives of the rocketeer, Level Three flights may take the form of minimum-diameter missiles, large and heavy projects, or anything in between.

Do the rules regarding team projects preclude or forbid rocketeers from assisting each other in certification attempts? No. It is common for people to give each other advice, expertise, and helpful suggestions at any stage in the process, particularly with Level Three projects. Rocketeers may loan one another electronics, motor casings, and other components for Level Three flights and it is a great idea to check with more experienced flyers at every major juncture to ensure that you are on the right track with your own project. This includes asking questions even on the day of your Level Three certification attempt.

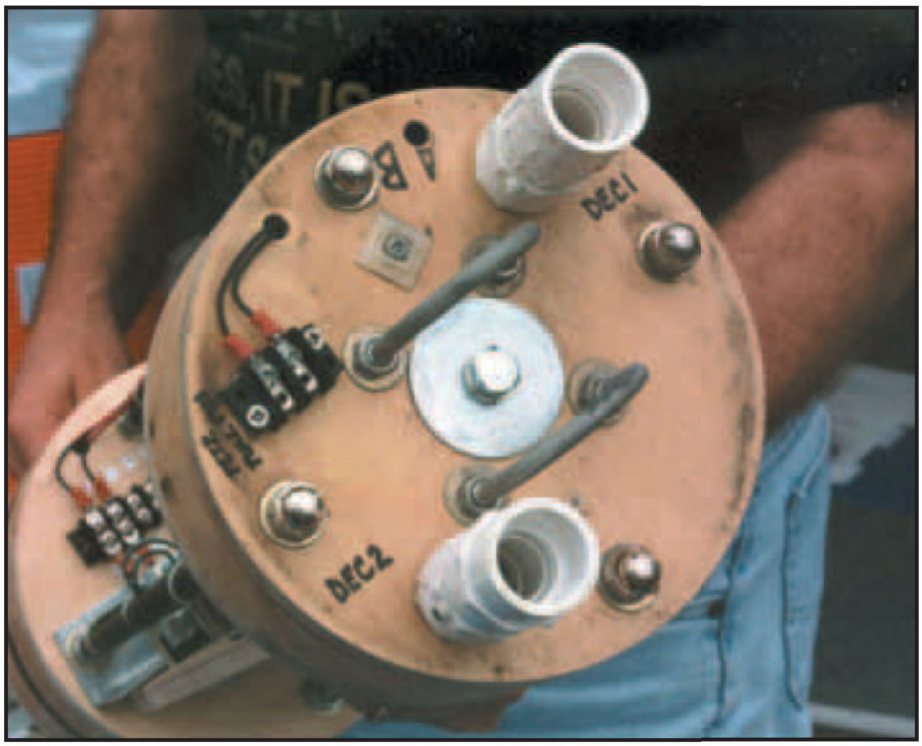
Putting it All Together

Prior to the certification flight, the Level Three candidate must present the TAP or L3CC member with a written package containing all the required information about the rocket and its flight, including sample photos of construction and anticipated flight data. For Tripoli members, this must occur at least 30 days prior to flight. NAR requires its package to be presented to the certifying officer a minimum of five days prior to flight.

Rocketeers who are serious about certification should present their paperwork as far in advance as possible. This ensures that any glitches in either their paperwork or, more importantly, their rocket, can be corrected in time to launch on schedule. Candidates who are planning to certify at a large regional or national launch—such as LDRS or NARAM—but do not submit their paperwork until the last minute are asking for trouble.



NAR member Mike Scicchitano with his Level 3 certification rocket, a 10" Bullpup Missile from Skunk Works, prior to his successful flight on an Animal Motor Works M motor at Orangeburg, South Carolina, in September 2003.



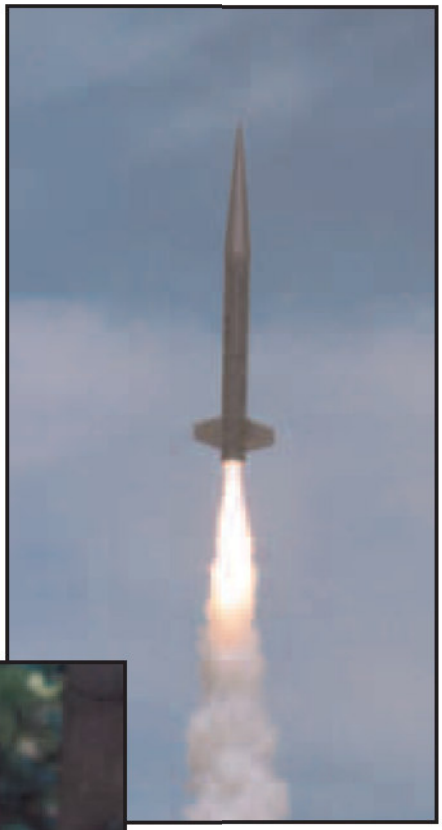
"Start early with your L3CC or TAP certification team member," advises L3CC officer Stephen Lubliner of Arizona. "Show the member the proposed design and solicit comments. The L3CC members I have worked with are looking out for the flier's success."

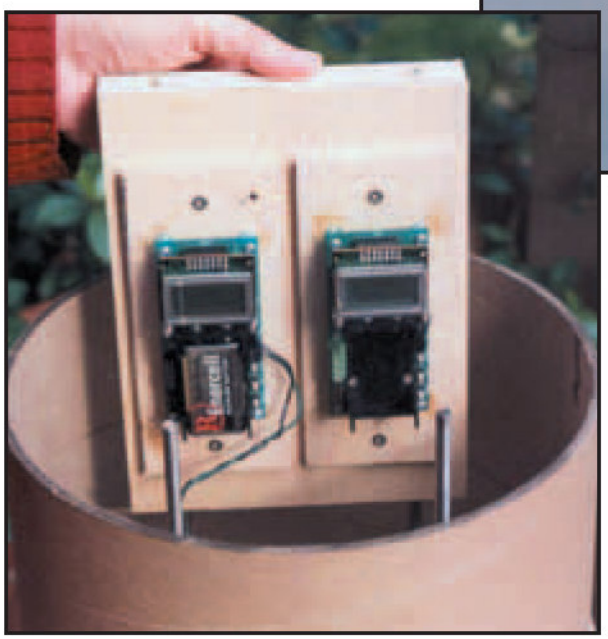
Presentation of the package can be accomplished in any number of ways. There are no hard and fast rules. The first thing to do is to contact the TAP or L3CC member and ask if they have any preferences. If they do, follow them. If they do

Multiple ejection charges are a must in any large rocketry project, especially Level 3 certification attempts. Here is a view of the multiple ejection canisters on Chuck Neff's Level 3 project. Neff obtained his Level 3 at Whittakers in North Carolina in 2004.

not, put yourself in their shoes. Present them with something that you would like to be presented with if you were a committee member. Be neat and concise. If you can type your paperwork, do so. If you cannot, make sure your information is easily readable.

Remember, you want the TAP or L3CC member to see that you are careful, patient, and deliberate. Do not rush through the construction of the rocket and do not speed through the paperwork. Make a good impression, and if problems are discovered and the committee member suggests changes, make them. TAP and L3CC members are there for your benefit. They want to see you succeed and, chances are, they have more experience than you do, so listen carefully to their advice.





(Above) NAR member Jack Garibaldi's 10" Nike Smoke under thrust at a launch in Central California in May 2004. This was a successful L3 certification flight. (Left) Backup altimeters are a good idea for Level 3 certification flights. Here, two Olsen M2 altimeters are test fit into the altimeter bay of a 10" Nike smoke.

Anticipating Problems

Anecdotal evidence and a random survey of L3CC and TAP members reveal that the single biggest cause of unsuccessful Level Three certification flights involves failure of the recovery system. Indeed, deployment problems may be the single largest cause of all rocket failures, Level One through Level Three.

Recovery failures include zippers, tangled or undeployed parachutes, and even lawn darts (no deployment at all). Unfortunately, many rocketeers spend a little too much time worrying about using an M motor for the first time and not enough on the fundamentals of deployment and recovery.

L3CC member Kimberly Harms of Washington sends her L3 applicants a list of the important things to keep in mind for a certification attempt. The top three items? "1. Recovery. 2. Recovery. 3. Recovery." Although her list is tongue-in-cheek, Harms cautions candidates seriously to spend plenty of time considering all aspects of deployment. "Most Level Three failures result from recovery problems and not airframe failure during boost," says Harms.

L3CC member Rick Boyette of Florida agrees. "People tend to either underdesign or make their recovery system overly complex," says Boyette, who encourages rocketeers to keep it simple. "I advise people to use an altimeter, with a

backup timer, and not to mess around with dual deployment. Bring the rocket down in two separate pieces. This eliminates zippering and allows use of two smaller chutes as opposed to one big one." Many other L3CC members share Boyette's views.

TAP member Andy Woerner's experience in Southern California also favors single, rather than dual deployment in Level Three certification flights. "Most of the failures I have seen are either airframe damage at ejection or failure of the deployment system," says Woerner. "Zippers seem to be the most common. I typically encourage candidates to use apogee-only deployment to less complicate the flight."

If certification flights are based on dual deployment, Kimberly Harms advises her candidates to put a lot of thought into it. "The most important thing is the altitude where the chutes come out," says Harms. "If you use dual deployment you should not consider deploying the main at less than 1000 feet. Make sure your electronics can do that. It takes a lot longer than you think to get large chutes fully deployed."

Deployment failures can be minimized by using familiar components, particularly when it comes to electronics. If possible, use altimeters or timers that you have used successfully in the past. If that is not feasible, then bring along a friend or someone from your local rocket club who is familiar with the electronics to watch over your shoulder and provide advice. Level Three certification is not the time to be guessing about how to properly arm and use your new altimeter.

Stephen Lubliner has some additional advice when it comes to deployment and the use of electronics: Use different units in your rocket. "Some altimeter-based deployment systems may have a common software flaw where they improperly respond to pressure transients during transonic flight," says Lubliner, who believes that the safer approach is to use different systems to minimize the chances of a total failure.

It is always a good idea to test your ejection charges prior to flight to ensure that you have sufficient charge to separate the rocket. "Test the recovery system with live loads for the ejection," suggests TAP member Bill Cordova of New Mexico. "Make sure the ejection is energetic enough to throw every facet of the recovery system away from the rocket. Pack everything as you would for flight." Testing of ejection charges is essential for any high-power rocket. All testing should be done outdoors with plenty of room on all sides of the rocket. Also, remember to wear safety goggles for eye protection and use plenty of common sense whenever working with black powder charges.

Blake Prince, right, and his son, Wes, with Blake's successful Level 3 certification rocket at LDRS 23 in New York in 2004.

Launch Day

Bring a checklist. This is a requirement with both the NAR and Tripoli for Level Three certification and it is also good rocket practice.

For many rocketeers, Level Three certification is a stressful day. Sure, there are a lot of Level Two projects that are much more complicated than the average Level Three certification rocket. But the added pressure of reaching the

highest level of high power can be daunting for even the most capable rocketeers. So bring your checklist to the field and use it. Do not leave it on the dashboard of your truck or tucked away neatly in your toolbox. Level Three rocketeers sometimes do the strangest things, and they usually occur in the absence of a checklist. And do not get rushed, as this usually leads to trouble. "I would advise against setting too firm of a timetable," cautions TAP member Daniel Gates of Minnesota. "You hear about people rushing to meet a self-imposed deadline and find that their haste has led to taking a shortcut or making an unintended omission."

Certification flights have failed because, among other things, the rocketeer neglected to attach his quick-link to the nosecone of the rocket, or because he or she forgot to turn on the altimeter.

L3CC member Charlie Barnett of Texas warns that you may need to use the checklist more than once on launch day, particularly if the rocket has to be removed from the pad prior to flight. This may occur where there are igniter problems or other difficulties on a busy launch day. "If you have to take the rocket off the pad," says Barnett, "go through the checklist again. You might be surprised by how many deployment failures are the result of not arming the rocket the second or third time it goes out to the pad." In addition, says Barnett, make sure that you have some mechanism (e.g., a flag) for ensuring that the rocket is armed before it is launched.

Flight Damage

Although successful deployment and recovery is a fundamental requirement of certification, neither Tripoli nor NAR requires the rocket to be returned to the certifying officer in mint condition. Both TAP and L3CC members are allowed some discretion on the field in evaluating whether damage sustained during the course of a Level Three flight is significant or not. At a minimum, the rocket must be returned in a condition that would allow an immediate repeat flight without repairs. Minor cosmetic damage that would not prevent another launch is usually acceptable.

Final Advice

"Be realistic on your budget," says Stephen Lubliner. "An M1315 reload is $300. Most electronic modules are at least $100 each, and you will need two units. You might save on the cost of a reload casing by borrowing one from another rocketeer. I'd suggest a budget of at least $1,000 for a Level Three effort."

Keeping your Level Three certification project simple also goes a long way toward ensuring success. "Stay with what you know and have experience with," recommends L3CC member Fred Gruis of Iowa. "Try to stick with construction techniques and electronics that you have already had success with and are currently using. Do not make this an 'all new,' from the ground up, rocketry project."

Charlie Barnett agrees. "Take time to learn as you gradually move to Level Three," he suggests. "Do not jump from J to M. Visit with other regular L3 flyers about your project and look carefully at their L and M rockets. The M project should be very much like your previous projects so that very little new is introduced. You want the prep to be as routine as possible."

And ask questions all along the way. "Find people who fly a lot and are almost always successful," suggests TAP member Ed Dewey of Illinois. "Find out what kind of electronics they use and how they put things together. Have them take a look at your design and evaluate it." It is also important to keep in mind the practical aspects of a Level Three launch. For example, with a larger rocket it will be important to have a larger launch pad and plenty of help in transporting the rocket to the pad. Do not assume that the club running the launch will have all of the equipment you may need on the day of your certification flight. Call ahead first. And bring plenty of help on launch day.

"Don't come alone," cautions Kimberly Harms. "You need helpers to get the rocket prepared, transported, loaded, tracked, and recovered. The TAP member who is watching your flight is not your ground crew, so do not expect them to be an extra set of hands for you. Get helpers—you will need them!"

Charles Barnett reminds his candidates that even if deployment is successful, the job is not over. Level Three attempts have failed because although the flight is successful, the rocket is never recovered. "Leave to recover the rocket immediately after it deploys," he warns. "Use a tracking transmitter if the rocket is going to a significant altitude. You only succeed if you find the rocket."

Building the rocket, preparing the appropriate paperwork and getting it all in order for the certifying officer—not to mention getting the rocket to launch and recover—may seem like an impossible task, but taking it a step at a time will get the job done. "Remember," says Harms, "the L3 project will be a major undertaking in time, effort, and money. But you will have something to look back on for years."

This article is a condensed version of a chapter that will appear in the upcoming book, Modern High-Power Rocketry 2, *scheduled for release in the early spring of*

Once Level 3 is obtained, team projects and clusters are allowed for any large-scale rocket. Here, members of the Community Space Program gather before the launch of their mighty Honest John at the Black Rock Desert in September 2004.