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PEAK OF FLIGHT

NEWSLETTER

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What Went Wrong On The Apollo 11 Moon Landing?

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Cover Photo: The location of Apollo 11 in the Sea of Tranquility on the Moon

Photo by Joe Zawodny (NAR L2) http://www.flickr.com/photos/jmzawodny/5154403762/

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The Untold Story - What Went Wrong On Apollo 11's Moon Landing? - A Lot More Than You've Been told

By Bart Hennin

For any space history buff or Apollo era enthusiast, the tense first moon landing by Neil Armstrong and Edwin "Buzz" Aldrin has been visited many times. We've all vicariously relived that suspense ridden first Moon landing. With multiple computer alarms threatening to abort the astronauts' journey to the lunar surface, volkswagon size boulders blocking their landing site, and low fuel indicator light flashing, this is one instance where any fiction would not be nearly as fantastic as the true story!

Apollo 11 Lunar Module 'Eagle' Returning to the Mother ship "Columbia" for her rendezvous with history!

However, what most people don't realize is that much more went wrong with Apollo 11's lunar landing than even the above events tell. During the nail biting 12.5 minute descent from lunar orbit, the LM's onboard computer (most critically needed during landing) shut down and recycled 5 times due to an erroneous checklist that had the crew turn on their ship's radar too early resulting in multiple data overloads.

A less well-known problem on Apollo 11 (as well as Apollo 12) was that erroneous data caused the LM's engine thrust to fluctuate wildly. The landings were successful but telemetry coming back to Earth was alarming. The LM engine thrust was surging so vigorously, that the throttle control algorithm was only marginally stable!

Apollo 11 LM Computer Interface With Less Computing Power Than Your Cell Phone!

The root of the problem was a design flaw that resulted from a miscommunication months prior.

The original version of the LM engine had a 0.3 second time delay between input command and throttle response and so the LM's computer algorithm was written to cleverly overcome this.

Then a second brilliant programmer found an ingenious way to rewrite the software so there was only effectively a 0.2 second delay. So far so good.

HOWEVER, the LM engine had since been "redesigned" to cut this throttle response time to 0.075 seconds. This small detail was simply 'missed' by the programmers resulting in a near showstopper. Here's the best part. Had the clever 2nd programmer not reduced the delay from 0.03 to 0.02 seconds, the throttle would have gone from metastable to COMPLETELY UNSTABLE and the landing(s) would have been impossible!

Apollo 11's lunar landing problems started before the lander 'Eagle' even separated from the mother ship "Columbia." It seems that the docking connection wasn't fully depressurized prior to separation of the two spacecraft. The resulting "pop" of escaping gas (equivalent to

Apollo 11 LM "Cramped" Interior Showing Tiny Windows & Flight Control Panel.

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What Went Wrong On Apollo 11?

the opening of an over pressurized soda bottle) ultimately caused the LM to miss its landing target by about four miles!

This combined with Neil's last moment scurry to find a clear landing spot resulted in another extremely perilous (not to mention embarrassing!) problem. Mission Control lost the lander!

Without knowing the crew's precise landing spot, there was no way to put them into the correct rendezvous orbit with Columbia above!

The best the tracking people could come up with was FIVE VERY DIFFERENT landing site "estimates". These estimates were based on where the lunar module said they landed, where the backup guidance system said they landed, where the Earth based ground radars said they landed, where mission control said they landed, and where the geologists said they landed...

"We don't know where the HELL they are!"

Each calculated a different location!

Mike Collins in the command module orbiting overhead was using a telescope to try to locate his lost crewmates! He searched doggedly for hours skipping all sleep but never found them.

The official report to head flight controller Gene Kranz was "We don't know where the HELL they are!"

The final solution devised was to awaken Buzz Aldrin from his sleep period early to do a rendezvous radar check and reverse calculate the vectors to locate them. They were over 5 miles off from any of the landing site "estimates."

Next, while moving within the cramped LM cabin, Buzz Aldrin accidentally broke a circuit breaker.

As luck would have it, this SPECIFIC breaker was needed to arm the LM's main engine for lift off from the moon! Potentially this glitch would leave Neil and Buzz stranded on the lunar surface to slowly asphyxiate when their O2 supply ran out.

IF the Apollo 11 astronauts HAD become stranded on the Moon, there was a morbid plan in place.

The "stranded" contingency said that Mission Control was to "close down communications" with the Lunar Module. In a public memoriam paralleled to a "burial at sea" a clergyman would commend the astronauts souls to "the deepest of the deep". Presidential telephone calls to the astronauts' wives were also planned, and President Richard Nixon had a speech pre-drafted in preparation for a national televised broadcast. The beginning of that speech would have gone as follows...

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What Went Wrong On Apollo 11?

"Fate has ordained that the men who went to the moon to explore in peace will stay on the moon to rest in peace. These brave men, Neil Armstrong and Edwin Aldrin, know that there is no hope for their recovery. But they also know that there is hope for mankind in their sacrifice.

These two men are laying down their lives in mankind's most noble goal: the search for truth and understanding. They will be mourned by their families and friends; they will be mourned by the nation; they will be mourned by the people of the world; they will be mourned by a Mother Earth that dared send two of her sons into the unknown."

Fortunately a felt-tip pen was enough to activate the switch.

Finally, a ten year old kept Apollo 11 from losing communication with Earth! As the three astronauts began their homeward journey, the Guam tracking station, which supplied communication on the final segment of Apollo's flight, FAILED! A staff member employed his ten-year old son to do the necessary repairs that were only made possible with his very tiny hands!

Resources & Further Reading:

Computers in the Apollo Program: http://njnnetwork.com/2009/07/engineers-working-on-apollo-11-lem-computer-could-only-guess/

Finding the LM: http://www.popularmechanics.com/science/space/moon-mars/4318496

Tales From The Lunar Module Guidance Computer: http://klabs.org/history/apollo_11_alarms/eyles_2004/eyles_2004.htm

Complete Apollo 11 Mission Time Line (Including LM Alarm Chronology): http://history.nasa.gov/SP-4029/Apollo_11i_Timeline.htm

Apollo 11 Mission Summary (Including Lunar Descent Chronology): http://www.spaceline.org/flightchron/apollo11.html

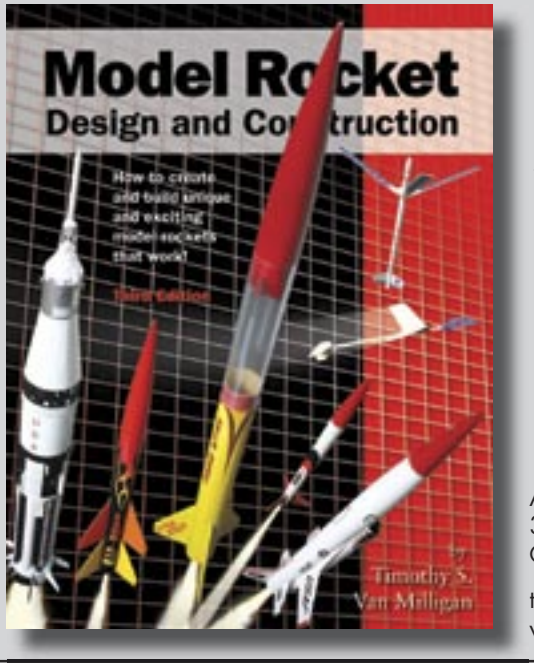
Transcript Of The First Lunar Landing (Including Reboots Of The Guidance Computer): http://history.nasa.gov/alsj/a11/a11.landing.html

A Software Simulation Of The AGC (Automated Guidance Computer) You Can Download FREE! http://www.ibiblio.org/apollo/ForDummies.html

The 10-Year Old Boy Who Brought Them Home: http://articles.cnn.com/2009-07-20/tech/apollo11.irpt_1_apollo-antenna-grease?_s=PM:TECH

About the Author:

Bart Hennin graduated in 1984 with a BaSc in Mechanical Engineering from the University of Windsor, Ontario. His senior year thesis was "Optimization Of A Model Rocket For Highest Altitude" which earned a top of the class mark of A+. Following graduation, Bart worked for several years in auto manufacturing engineering, then migrated to technical sales, and eventually ended up in general sales and marketing.



Model Rocket Design and Construction

By Timothy S. Van Milligan

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APOGEE COMPONENTS

Reader Questions and Answers

By Tim Van Milligan

Paul Blais asks: *I have one a question about the sky angle parachutes (www.ApogeeRockets.com/parachutes.asp#High-Power_chutes), how exactly do you go about attaching the swivel to the shock cord so that the parachute is about 1/3 way down from the nose cone or are you supposed to just tie the swivel at the very top where you tie it to the nose cone as well?*

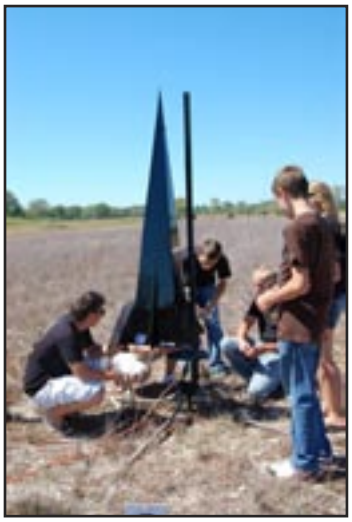
I attached the chute to the shock cord, before attaching the shock cord to the nose cone, so that it is attached 1/3 of the way down from the nose cone. If the shock cord is already attached to the rocket, the other option is to use a quick link to make the attachment. A quicklink is a metal loop that screws together to form a "0" shape.

Figure 1: For high power rockets, it is generally recommend that the parachute be attached below the nose cone, about 1/3 the way along the shock cord.

Figure 2: It is easier to attach the parachute directly to the shock cord before you attach the nose cone.

Pyrotechnic Bolt Revisited

In Newsletter 266 (www.ApogeeRockets.com/Education/Downloads/Newsletter266.pdf), Marc Stevens showed us how to build a pyrotechnic bolt that would separate a rocket into two pieces. At the time of the article, the rocket had not yet launched. I would have loved to have shown you some better photos of the rocket, because it in itself was pretty ingenious. We'll, the rocket finally launched, although it didn't go as planned. Marc paraphrases what happened:



The Black Sabot rocket utilizing pyro bolts.

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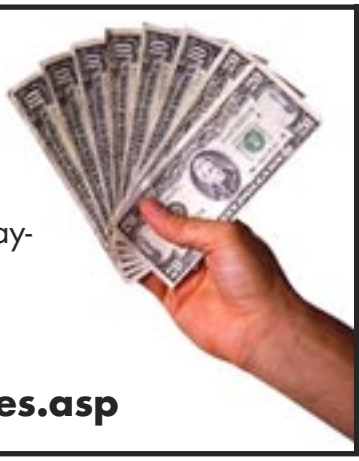

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Reader Questions and Answers

"Denmark Rocket Team's 6'-tall high-power rocket "Black Sabot." It launched on a cluster of four H165 Redline motors at WOOSH Rocketry's ECOF (Eat Cheese or Fly) event the weekend of August 28, 2010.

It came off the pad a bit cocked and quickly arched over due to one motor lighting late. The pyrotechnic bolt we designed blew a bit later than optimal and the pyramid split apart ready to release "Li'l Ozzy" (the rocket that was contained inside).

Unfortunately (but actually, it was very fortunate), I put the delay timer in upside down, so the inside motor never ignited. Had it lit, it would've shot Li'l Ozzy right into the ground.

Black Sabot and Li'l Ozzy survived to fly another day ... after some minor repairs. As a matter of fact, Li'l Ozzy flew solo later in the day. =)"

Very cool rocket Marc. The students did great with your help.

Number Of Fins?

David Foster asks: *"I read your newletter from the archive - "Fin shapes revisited" (www.ApogeeRockets.com/Education/Downloads/Newsletter50.pdf). It was a great article that really helped me understand the functioning of fins. I never really understood the trade-offs .... and how a little more drag created by the fins can help reduce the drag caused by the rocket profile. Also the explanation of airfoils*

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The Black Sabot rocket takes to the air, and arcs over because one engine ignited a bit late. You can see the rocket split apart in the last two frames thanks to the pyrotechnic bolt.

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Reader Questions and Answers

was fantastic. I never really understood that rocket fins keep the rocket stable by the same principal that create lift for airplanes.

I was wondering if you wrote a similar article or have any information on what are the tradeoffs faced when selecting the number of fins to use. Obviously less fins (like 3) is lighter and has less drag. Why would someone want to use more fins? Do additional fins (like 4, 5 or 6) help the rocket align more quickly (like the airfoil), or is it primarily a matter of looks and style?"

Using a silo (tube) launcher would limit the size of fins you could put on your rocket.

I do not recall having an article that describes this situation. So I'll try to answer it here.

Extra fins do add stability, which is why you'd use them. But... You could just as well go with three fins and make those bigger and get the same stability effect. As you mentioned, adding more fins also increases the drag on the rocket, so it will not go as high as a model that uses three fins.

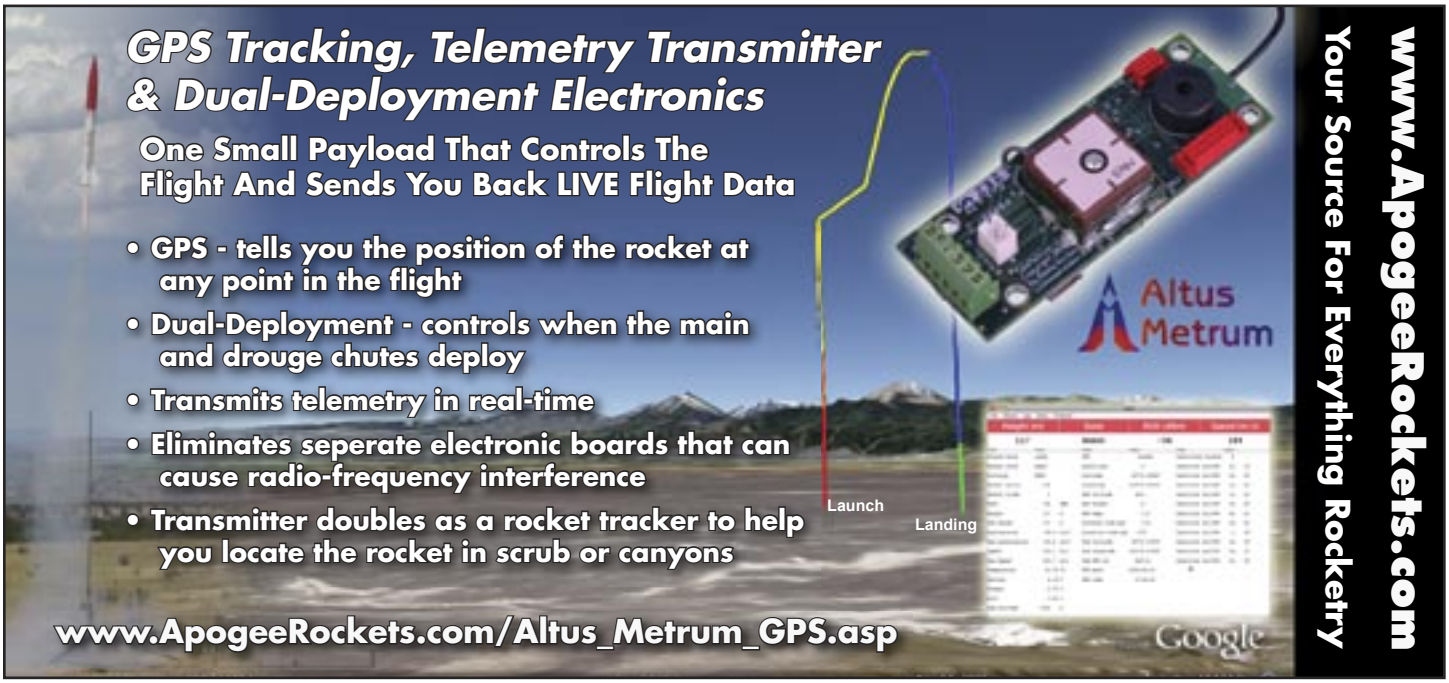
In practical terms, the reason you'd use more fins is more a matter of style. It looks cool!

The only place where you might want more fins is when you're constrained on how big you can make the fins, such as launching the rocket out of a tube (silo).

Good question. I like to see this type of thinking, because I can see all the wheels turning in your head.

Stick Rockets In RockSim

Stan Blatz asks: *"Ever hear of anyone trying to Rocksim a Congreve rocket, "stick rocket"?The model I'm looking at is from 1933 Germany."*

Unfortunately, it doesn't work in RockSim because the equations don't assign a stabilizing force to sticks. Sticks are treated as tubes, and the Barrowman Equations assumes that tubes do not contribute to the CP of the rocket.

So while you can draw it in RockSim (it will look like a Congreve rocket), it will be unstable when you fly it in RockSim.