

# A Detailed CubeSat Lunar Lander Design

## A feasible design for a single unit CubeSat lunar lander

- The lander would begin its descent from a 100 km orbit (as did the Apollo lunar lander)
- Liquid fuel hydroxyl ammonium nitrate (88%) and methanol (12%) are pressure fed to the engine by high-pressure helium
- The corner rails and all panels are graphite composite
- All tanks, piping, valves are stainless steel and the rocket engine is a platinum-iridium alloy
- The four rocket engines, using catalytic decomposition of the propellant have 1.0 N thrust each
- There is sufficient propellant for reducing the orbital velocity to zero, overcoming the potential energy for the drop to the surface and 60 seconds of hovering
- The resulting design was created in the SolidWorks 3-D design software and a Dimension Printing rapid prototyping ABS plastic model was made
- The design parameters are calculated in the spreadsheet below
- The spreadsheet calculates the tank dimensions based on the volume needed, pressure and ultimate strength of the stainless steel. The volume used by the walls is compensated by an increase in height.
- The calculated mass ratio is within 0.2% of that actually used by the Apollo Lunar Lander

CubeSat Lunar Lander		(SI Units) CubeSat Lunar Lander		(SI Units)		Oxidizer		Fuel		g(Earth)		g(moon)		Helium	
G	MASSm	RADIUSm	Orbit H	CubeSat mass	SG	NH3OHNO3	81.8%	CH3OH	18.2%	9.8	1.62441	1 atm		Radius	
6.67E-11	7.35E+22	1.74E+06	100000	1.00	Ox/Fuel	1.48		1.48		1.01E+05		15	0.015	2.5245e-06	Helium m
Orbital v	Orbital U	U -> v	Delta v		lsp			1		Tank Stress	Tanks (atm)	9.00E+08	1.4137e-05	Volume	
1633.4014	153598.1577	554.2529	2187.654		v ex			2695		Ultimate	Pressure	2E+06	27.3373	Vol. Ratio	Thickness
					Fraction	0.50000		0.50000		9.00E+08	2E+06	27.3373	0.0003		
					Mass	0.28599		0.28599		Sphere t	Cylinder t	0.00004	0.00004	He Press.	x2 safely
					Volume	0.00019		0.00019		0.00002	0.00004	0.00002	0.00004	41538989.0561	0.0007
					2 tanks each	0.00013		0.00013		x2 Safety	0.00008				Helium Tank m
					Radius	5 cm tank sph.		0.01587							
					0.025	5 cm tank cyl.		0.01587							
m0/m	m/m0	m propel.	Weight	Total Propel.	Tank	Radius	Cylinder	Area	Thickness	Density	Mass	Volume	Both Vol.		
2.2518	0.4441	0.5559	0.721	0.57198	Fuel	0.025	0.01587	0.01035	8.44E-05	8000	0.00699	0.000097	0.0002		
		Hover m dot	1 min hover		Oxidizer	0.025	0.01587	0.01035	8.44E-05	8000	0.00699	0.00010	0.0002		
		0.0003	0.016									0.00010	0.0004		
Descent Thrust	Descent m dot	Descent time	Descent min									Tot. Volume	0.0004		
3.0000	0.0011	499.3995	8.323												
	m dot	V dot													
Fuel	0.0006	0.0004													
Oxidizer	0.0006	0.0006													
T (K)	M (kg/mol)	R	elta c	Tanks, Fuel & Ox. Mass											
3372	0.0215	8.314	1.025	0.61559											

- Above view is to the right , all tanks are stainless steel
- Top and side graphite composite panels are not shown, hollow graphite corner rails save 100g over aluminum
- Silver tank is high pressure helium for propellant pressurizing, m = 35g
- Red tanks are hydroxyl ammonium nitrate (88%) and methanol (12%), m = 28g
- Green tanks are hydroxyl ammonium nitrate (88%) and methanol (12%), m = 28g
- Bottom panel has optical sensors for lateral motion measurement and landing (not shown)
- Top and side panels have photovoltaic cells
- Top panel is above the CPU board, 2.4 GHz transceiver, camera and batteries (not shown)
- The lander is carried to lunar orbit by a double CubeSat booster of similar design from a geosynchronous launch
- Four landing legs fold out, one from each side (not shown)
- Four rocket engines protrude through bottom panel, their heat shields and mounting is not shown.
- Top and bottom panels have 2.4 GHz patch antennas
- 2.4 GHz transceiver is used as radar altimeter
- Communication would be with the lunar orbiter
- Valves, fuel and oxidizer tubing are not shown
- Three axis solid state gyro and horizon sensing used for attitude determination
- Total de-orbit and landing time is 8 minutes and 40 seconds plus one minute hover
- Total  $\Delta v$  is 2,170 m/s

