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 propellent have 1.0 N thrust each
- There is sufficient propellent 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)							
G	MASSm	RADIUSm				NH3OHNO3	81.8%		CH3OH	18.2%	9.8	1.62441							
6.67E-11	7.35E+22	1.74E+06	Orbit H	CubeSat mass	SG	1.48			1.48		1 atm				Helium				
			100000	1.00	Ox/Fuel				1		1.01E+05				Radius				
Orbital v	Orbital U	U -> v			Isp				275			Tanks (atm)	0.015		Volume	2.5245e-06			
1633.4014	153598.1577	554.2529	Delta v		v ex				2695		Tank Stress	15	Pressure	1.4137e-05					
			2187.654		Fraction	0.50000			0.50000		Ultimate	Pressure	Vol. Ratio	Thickness					
					Mass	0.28599			0.28599		9.00E+08	2E+06	Sphere t	Cylinder t	27.3373	0.0003			
					Volume	0.00019			0.00019		Sphere t	Cylinder t	0.00002	0.00004	He Press.	x2 safely			
				2 tanks each	5 cm tank sph.	0.00013			0.00013		0.00002	0.00004	x2 Safety	0.00008	41538989.0561	0.0007			
				Radius	5 cm tank cyl.	0.01587			0.01587		x2 Safety	0.00008				Helium			
				0.025															
m0/m	m/m0	m propel.			Tank	Radius	Cylinder	Area	Thickness	Density	Mass	Volume	Both Vol.		0.0002	Tank m			
2.2518	0.4441	0.5559	Weight	Total Propel.	Fuel	0.025	0.01587	0.01035	8.44E-05	8000	0.00699	0.000097	0.0002			0.0157			
		Hover m dot	0.721	0.57198	Oxidizer	0.025	0.01587	0.01035	8.44E-05	8000	0.00699	0.00010	0.0002						
		0.0003	1 min hover									Tot. Volume	0.0004						
Descent Thrust	Descent m dot	Descent time	0.016							2 tanks	0.0140								
3.0000	0.0011	499.3995	Descent min				k		4 tanks	Total Mass	0.0280								
	m dot	V dot	8.323			Pressure (psi)	Pressure (Pa)	(or gamma)	Cf	At	Dt	Expan. Ratio	D2		Length		Dc		
Fuel	0.0006	0.0004		**Thrust Chamber**		700	4.8238E+06	1.24	1.9	3.2732e-07	0.00065	100	0.00646		0.01084		0.00129		
Oxidizer	0.0006	0.0006				300	2.0673E+06	1.24	1.9	7.6376e-07	0.00099	100	0.00986		0.01656		0.00197		
						150	1.0337E+06	1.24	1.9	1.5275e-06	0.00139	100	0.01395		0.02342		0.00279		

T (K)	M (kg/mol)	R																	
3372	0.0215	8.314		etta c	Tanks, Fuel & Ox. Mass														
				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 propellent 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 ocket 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 Δ**v** is 2,170 m/s