EmDrive Thrust/Load Characteristics. Theory, Experimental Results and a Moon Mission

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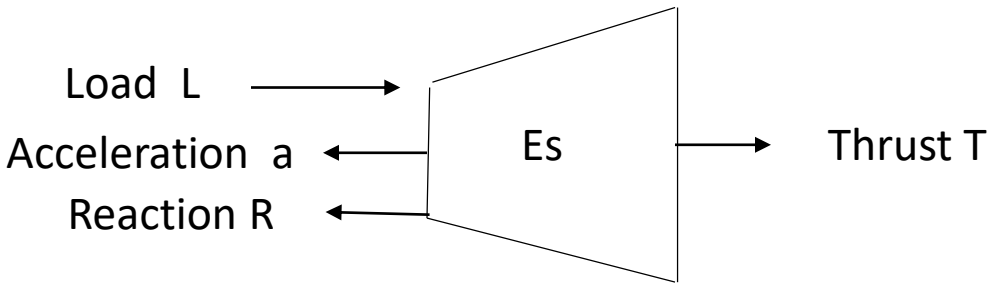
EmDrive Thrust/Load Theory



- EmDrive is an electrical machine producing a force T, leading to acceleration a
- It is a resonant device containing stored energy Es
- If Load L>T then a=0, Reaction Force (R) = -T, no force is measured.

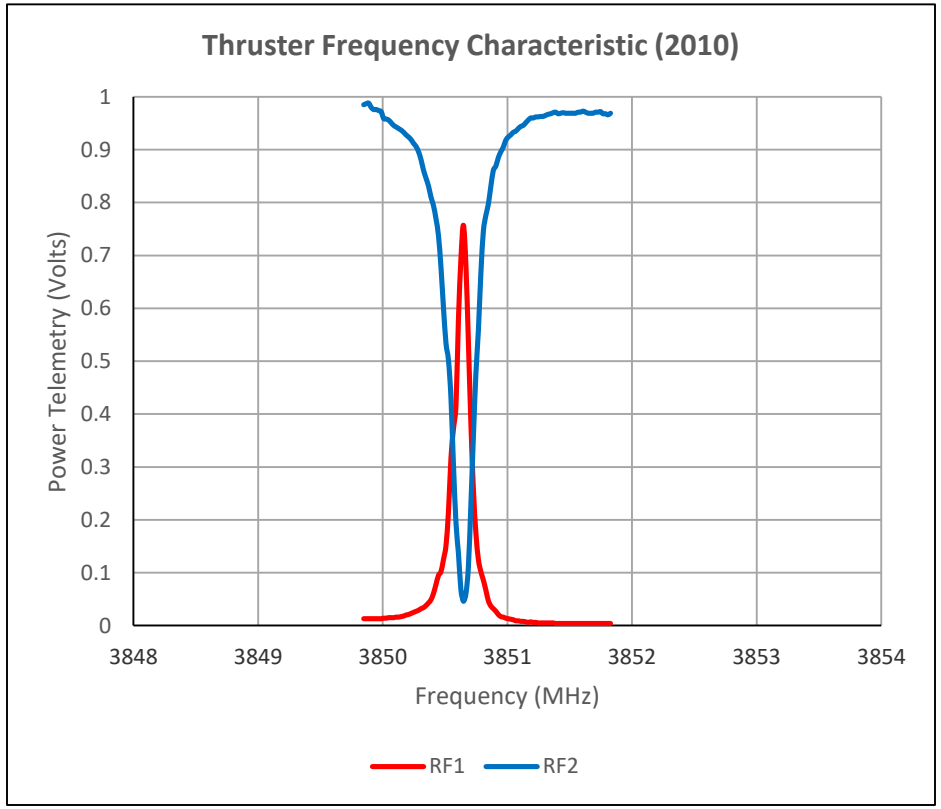
  T+R=0 Momentum is conserved
- If L=0, then as stored energy increases, a increases, but Es is transferred to Kinetic Energy

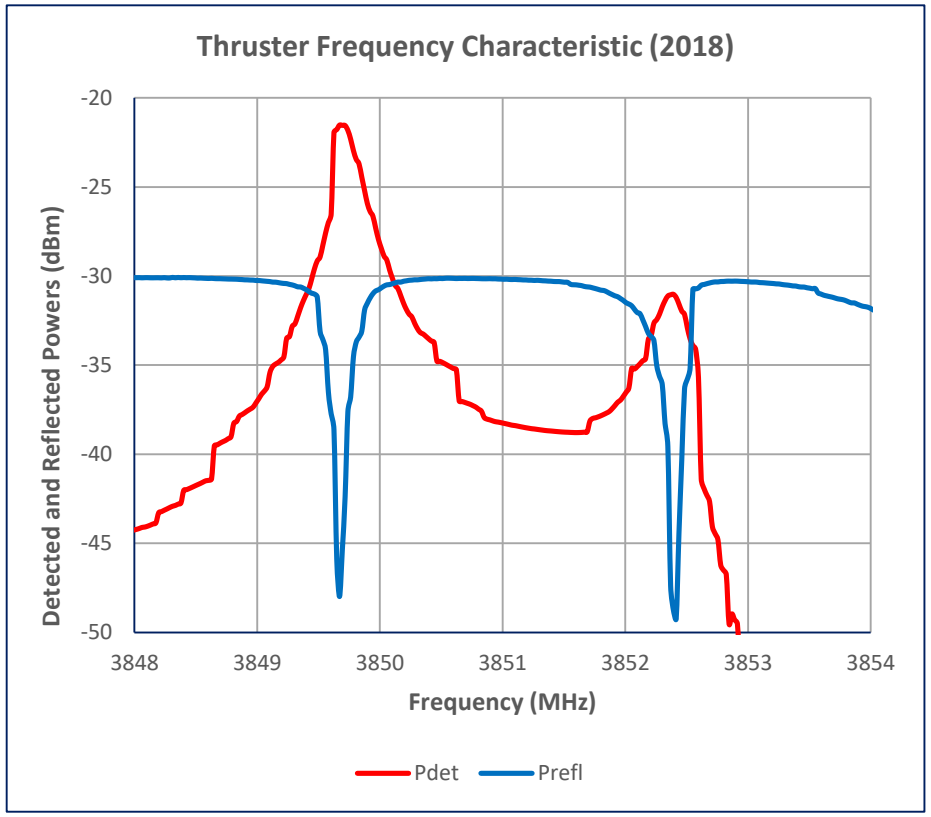
  Es tends to zero therefore T tends to zero, no constant force is measured. Energy is conserved
- T or R can only be measured when L>0 but <T

Flight Thruster

- Flight Thruster originally tested as part of Technology Transfer to US in 2010
- Technical report is referenced
- Subjected to end plate misalignment during further experimental work
- Second series of tests carried out in 2018 to investigate Thrust/Load theory

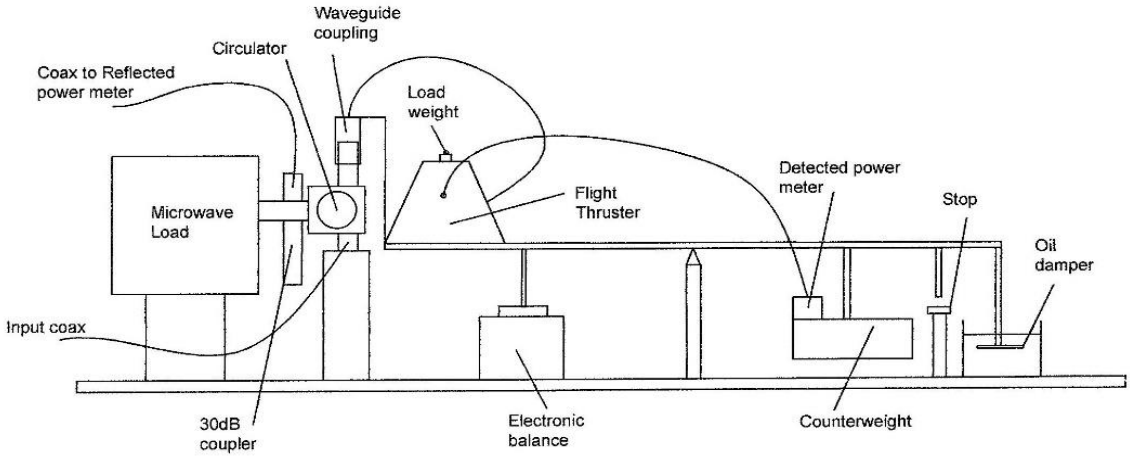
Effect of End Plate misalignment





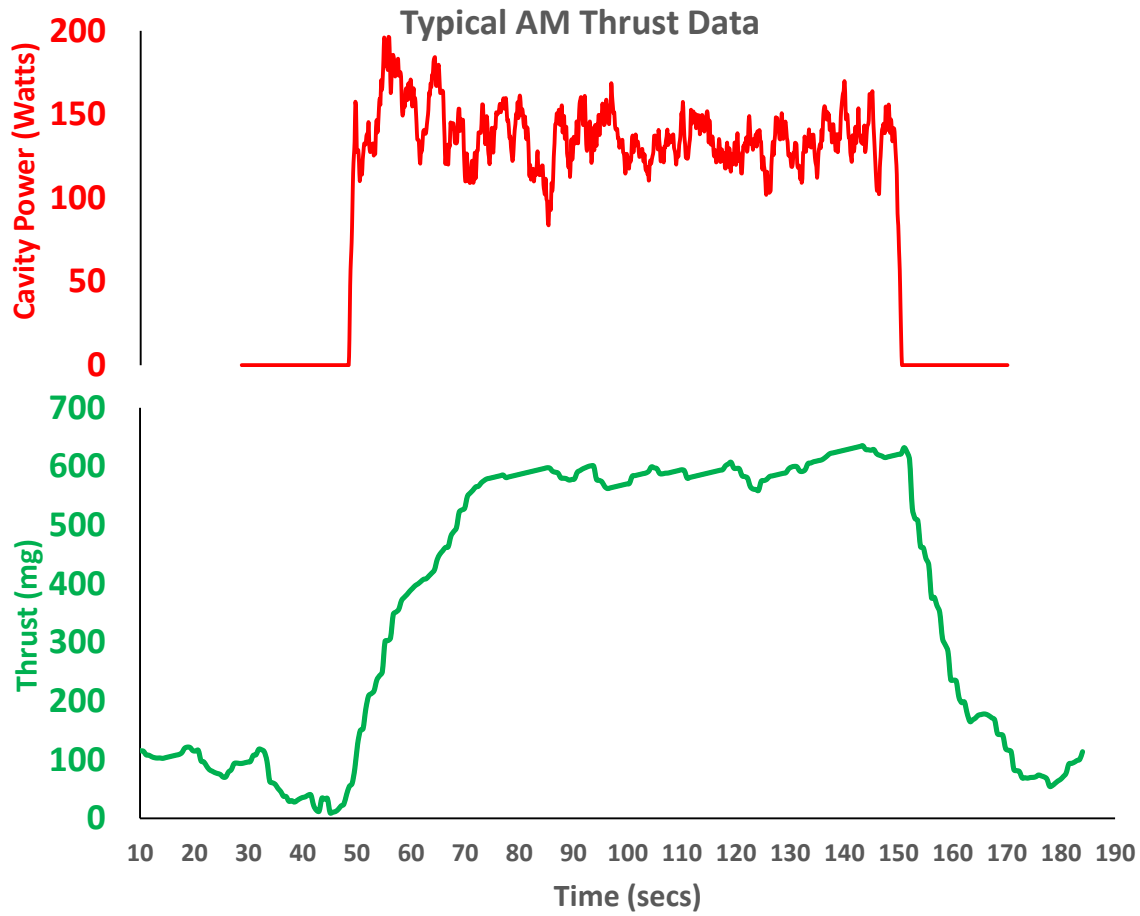
- Second resonant peak found
- Unloaded Q reduced from 55,000 to 31,000
- Specific Thrust reduced from 326 mN/kW to 37mN/kW
- Performance highly dependent on accurate end plate alignment

Thrust Measurement



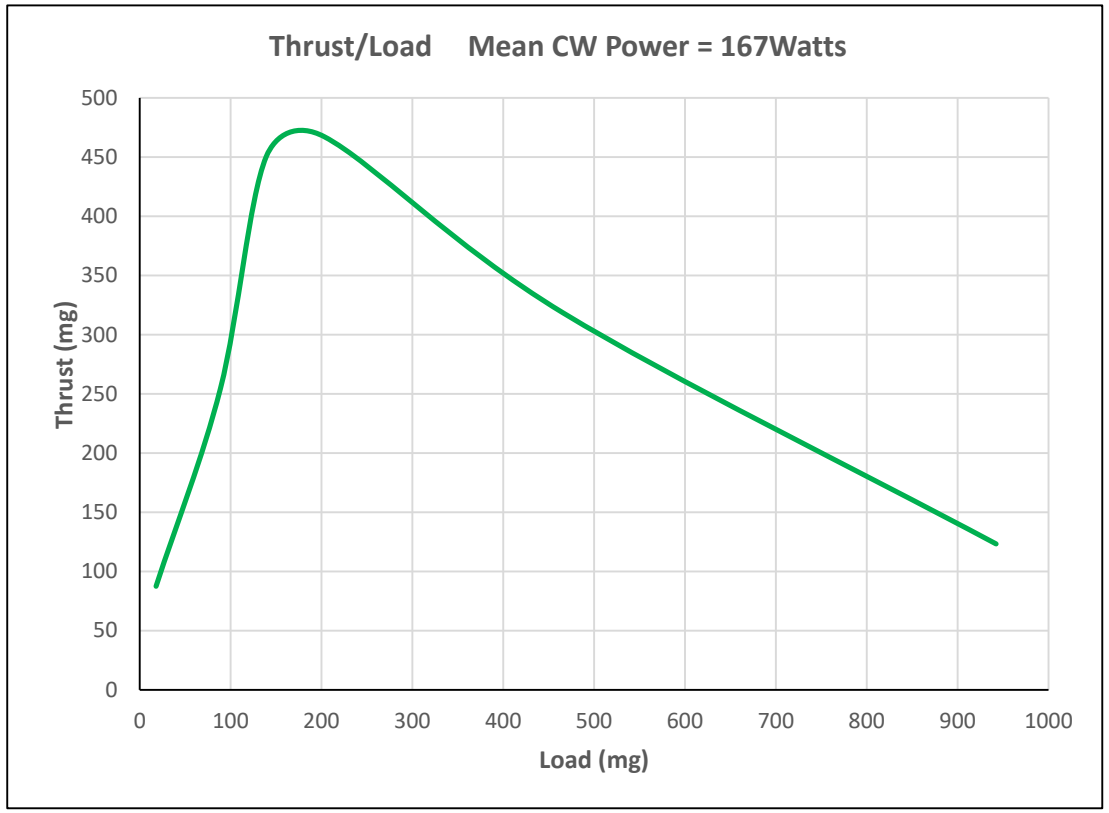
Thrust Balance

Simple counterbalanced beam with added load
Capable of measuring both Thrust and Reaction Force

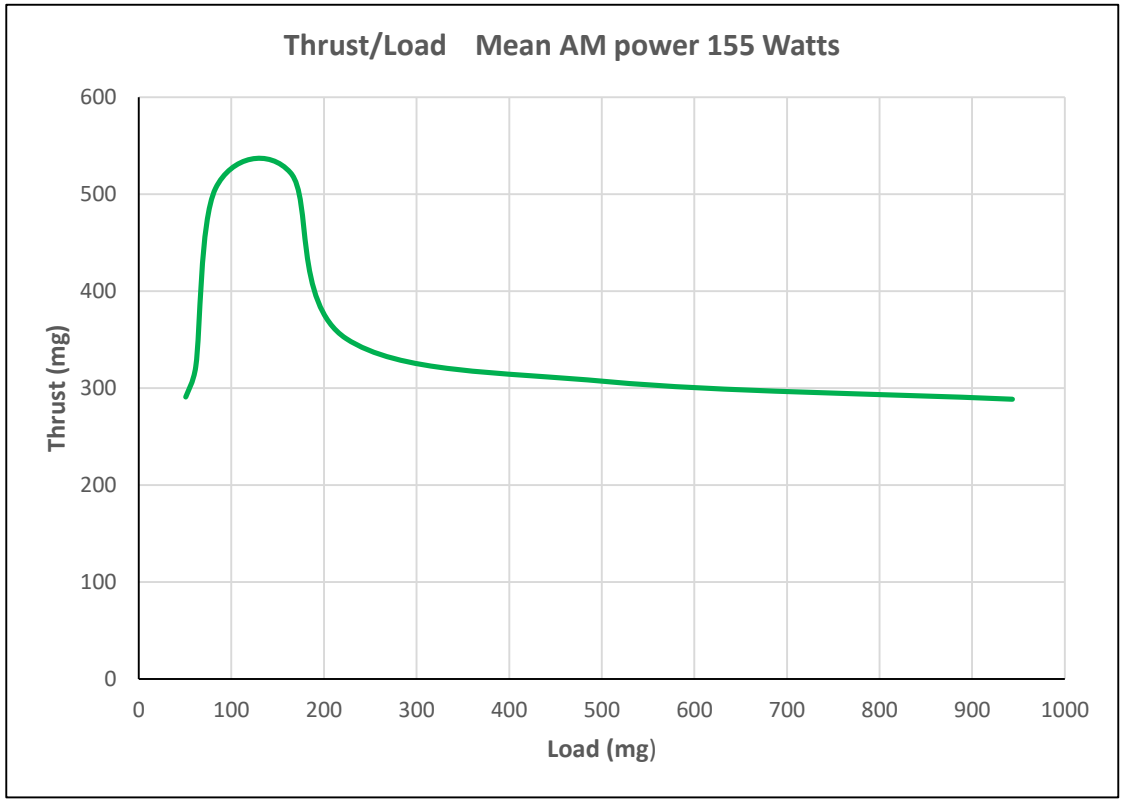


Mean Thrust =506 mg Mean Power = 134 Watts

Thrust/Load Results

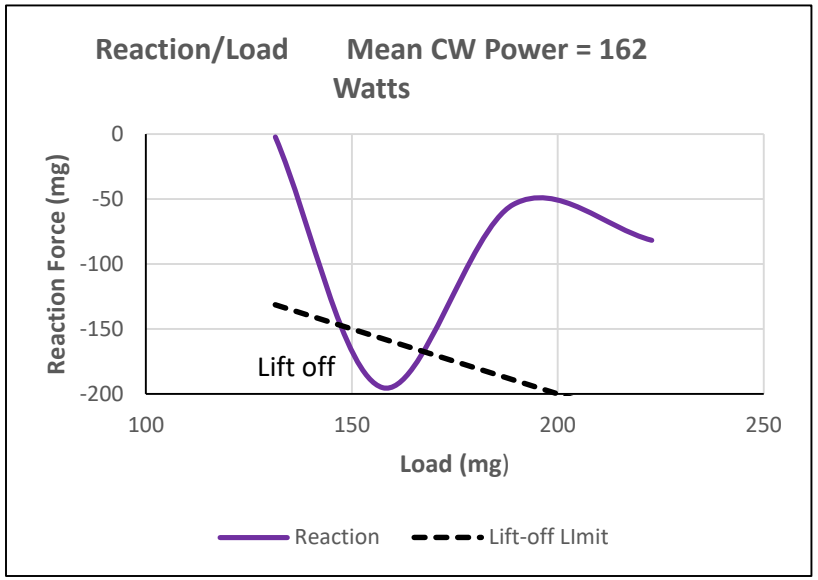


CW results support Thrust/Load Theory

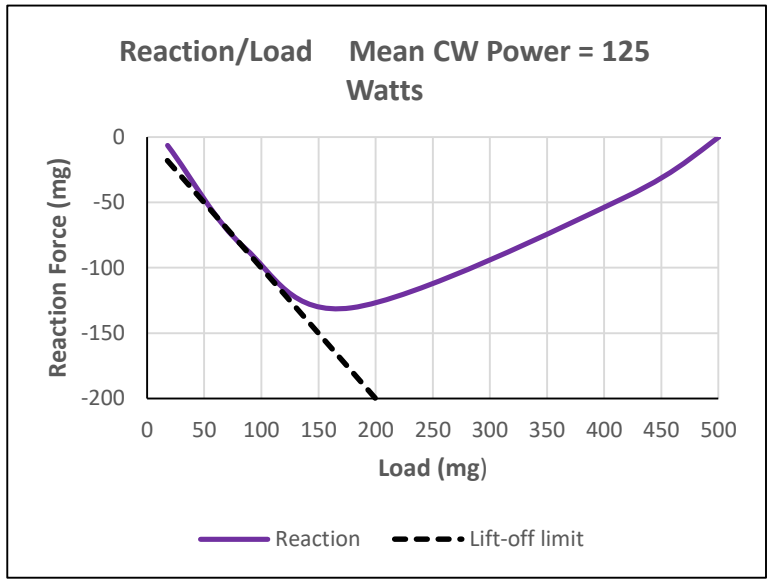


AM modifies Thrust/Load at low and high loads

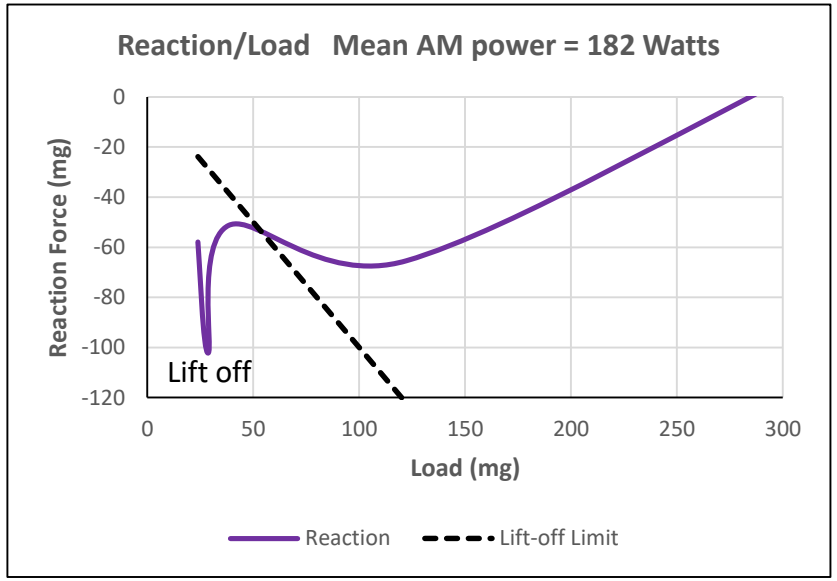
Reaction Force/Load Results



Lift off from balance occurs when Reaction Force > Load



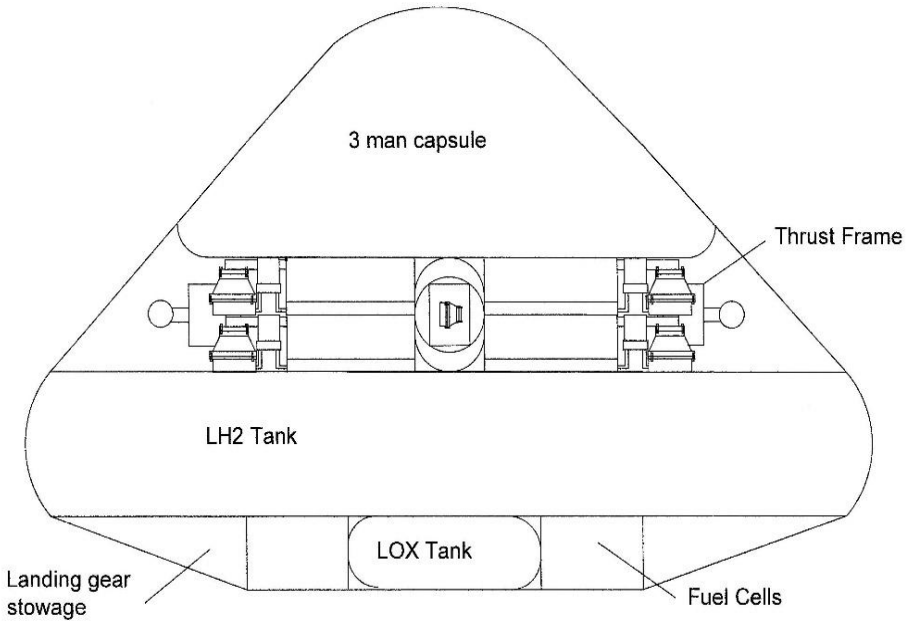
Inverse of CW Thrust/Load. Supports theory

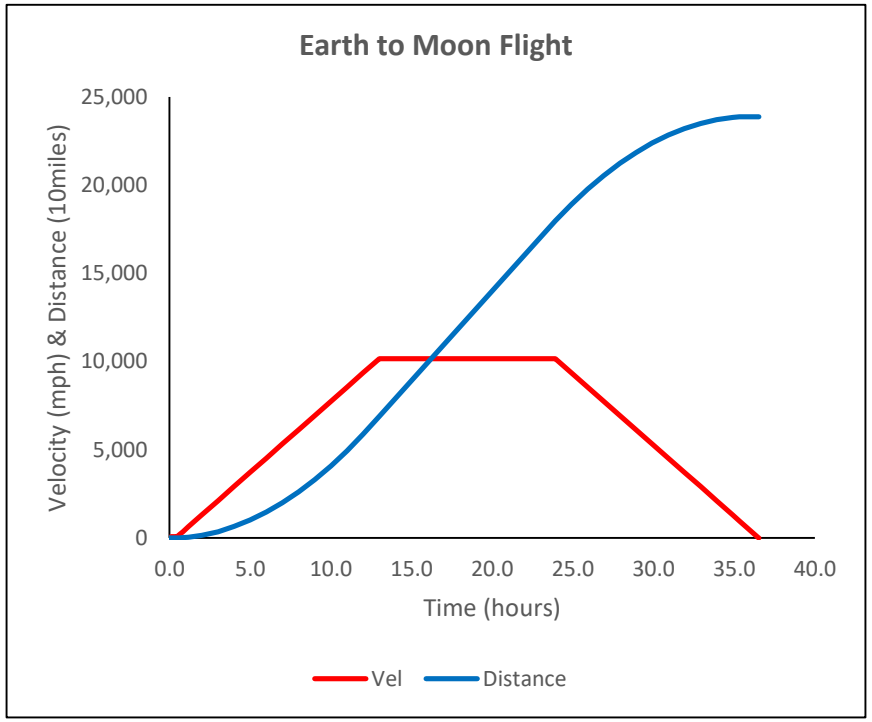


AM modifies Reaction at low Load

Manned Moon Mission

Study requirements were a Moon landing for 3 Astronauts, with safe return and a benign flight environment suitable for Space Tourism



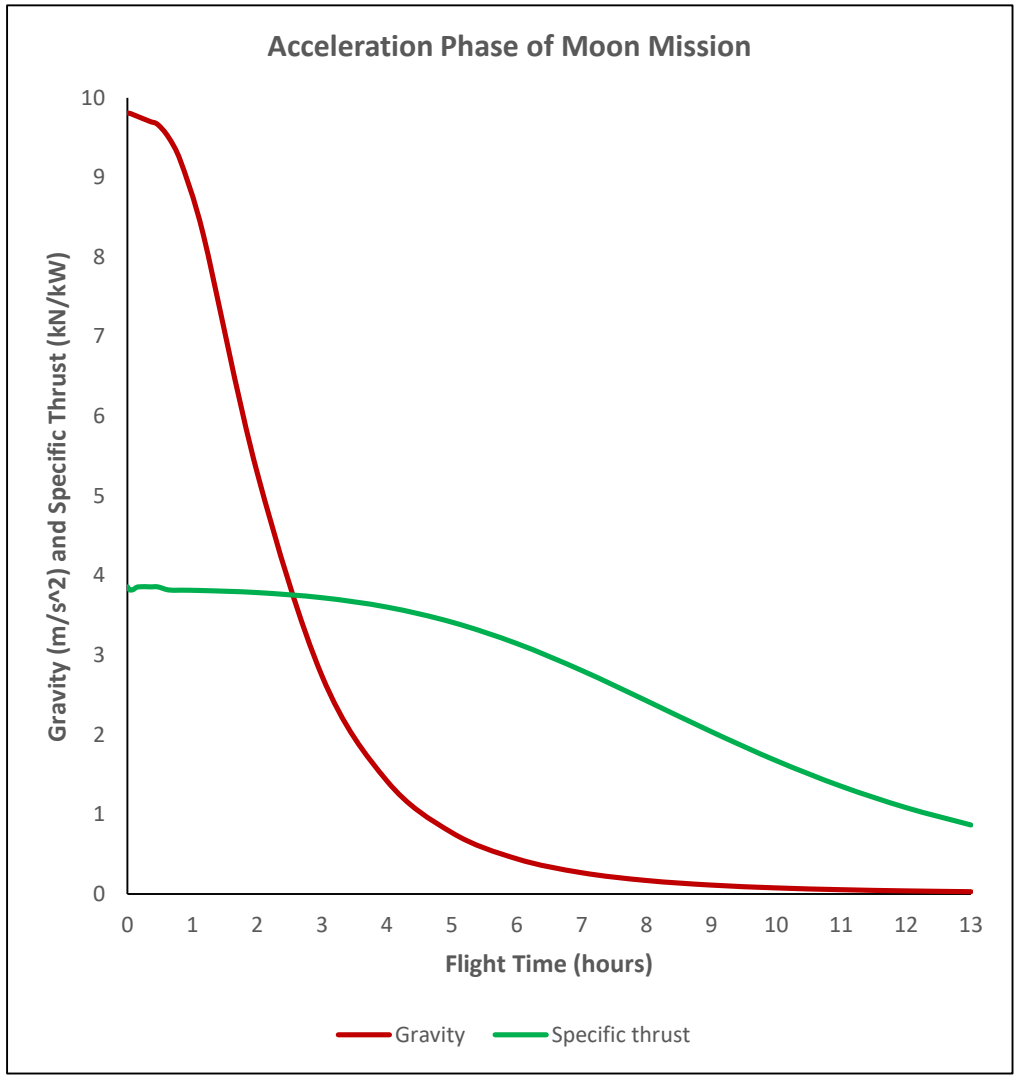


Thrust frame comprises 4 dual cavity 3G Thrusters + 4 single axis gimballed 2G thrusters

Launch mass 10.4 Tonne
Vehicle diameter 9m
Reusable minimum 100 missions

Max acceleration +/- 0.1m/s^2
13 hour acceleration phase. Max speed in atmosphere 70mph
11 hour cruise phase. Speed 10,160mph
13 hour deceleration phase

Effect of Gravity Loading



Initial Specific Thrust of 3G superconducting Doppler compensated thrusters = 3,857N/kW

Thrusters operate at 950MHz in TE211 mode

Each thruster rated at 17kW

Specific Thrust decreases as gravity load decreases

Input power is reduced as gravity load falls to limit acceleration due to internal Doppler constraints

AM optimised for gravity load

Conclusions

- Flight Thruster performance is highly sensitive to end plate misalignment
- Test balance measured both Thrust and Reaction Force, supporting basic radiation pressure theory
- CW test results show good agreement with Thrust/Load theory for both Thrust and Reaction Force
- Amplitude Modulation can be used to overcome loss of Thrust at zero load, allowing in-orbit operation
- Gravity loading affects Specific Thrust in a Moon mission
- The Moon mission illustrates the dramatic improvement offered by third generation EmDrive.
  10 Tonne EmDrive vehicle compared to a 3,000 Tonne Apollo vehicle for the same mission
- This very low cost to orbit approach, will be the enabling technology for Solar Power Satellites and Orbital Sunshields, and help solve global energy and climate change problems