SLS Block 1C with four RS–25D core and no upper stage. Payload to 51.6° 400 km orbit LEO = 28.7 t. 14 Dec. 2013. Author: Steven S. Pietrobon, PhD.

RSRMV thrust curve obtained from page 56 of [2]. There is a discrepancy in that Loaded Mass minus Burnout Mass in [2] is 650,743 kg compared to 633,233 kg in [1] and 628,701 kg in [3]. Therefore, we have adjusted the propellant mass and impulse in [2] to match the values in [1].

Boosters: RSRMV 2x5–Segment	SLS1C4
Aft Skirt Diameter (m)	5.156
Nozzle Diameter (m)	3.875
Sea Level Thrust at 0.2 s (N)	15,599,386
Vacuum Isp (m/s)	2,622.3
Total Mass (kg)	733,776
Usable Propellant (kg)	632,791
Residual Propellant (kg)	442
Burnout Mass (kg)	100,543
Action Time (s)	131.9

The simulations have no thrust bucket and reduced the thrust rating to 109%, as reported in [4].

Core Stage: 4xRS–25 Engines	SLS1C4
Stage Diameter (m)	8.407
Nozzle Diameter (m)	2.304
Vacuum Isp (m/s)	4,436.5
Engine Thrust (N)	2,278,824
Engine Thrust Rating (%)	109
Thrust Bucket (%)	109
Total Mass (kg)	1,091,525
Usable Propellant (kg)	966,061
Reserve Propellant (kg)	8,210
Fuel Bias Propellant (kg)	1,678
Startup Propellant (kg)	7,439
Dry Mass (kg)	115,575
Interstage (kg)	5,346

Simulation results for SLS1C4 are shown in Figures 1–4. To allow core to reach orbit, the maximum acceleration after booster separation is limited to 15 m/s^2. When maximum acceleration is reached all engines are incrementally reduced in thrust 1% at a time to a minimum of 65%. Engines are then shut down one at a time when the maximum acceleration is reached. Payload into a 400 km 51.6° orbit is 28.7 t.

	SLS1C4
Orbit (km)	400 ± 0.1
Liftoff Thrust at 0.2 s (N)	38,623,742
Liftoff Mass (kg)	2,593,115
Liftoff Acceleration (m/s^2)	14.90
MaxQ (Pa)	26,701
Maximum Acceleration (m/s^2)	25.50
Spacecraft (kg)	28,692
Remaining Propellant (kg)	0
Total Payload (kg)	28,692
Total Delta–V (m/s)	10,071

[1] B. Donahue and J. Bridges, “The Space Launch System capabilities for enabling crewed Lunar and Mars exploration,” *63rd Int. Astronautical Congress*, Naples, Italy, IAC–12–D2.8.7, Oct. 2012.

[2] Alliant Techsystems Inc., “ATK space propulsion products catalog,” Aug. 2012.

[3] P. Phillips, “Ground systems development and operations,” NASA, July 2012.

[4] M. Davidson, “RS–25: The Clark Kent of engines for the Space Launch System,” 13 Sep. 2013. http://www.nasa.gov/exploration/systems/sls/rs25–engine–powers–sls.html

[5] R. Ryan, “Lesson in system engineering – The SSME weight growth history,” NASA, Aug. 2008.

Figure 1: Altitude versus time for SLS Block 1C

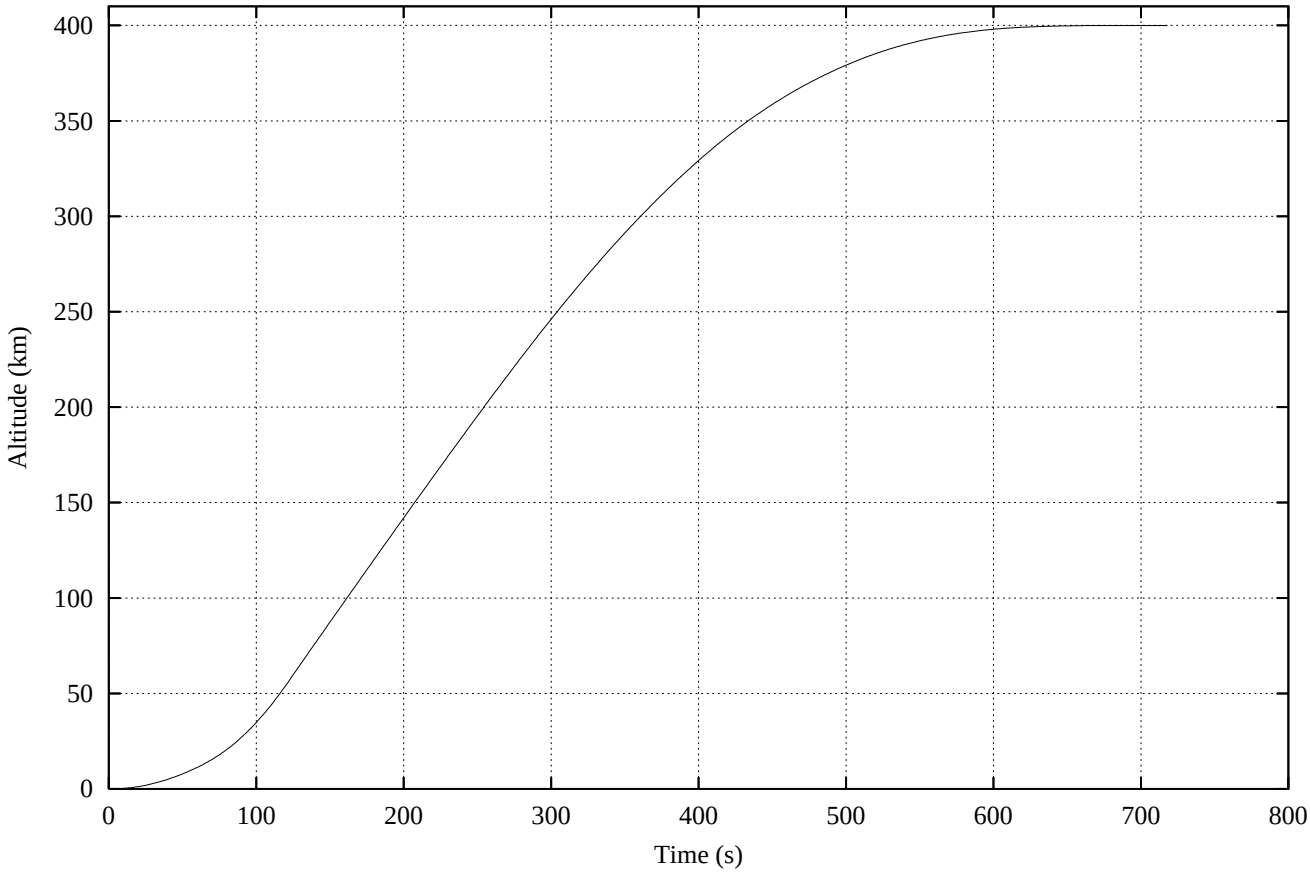

Figure 2: Speed versus time for SLS Block 1C

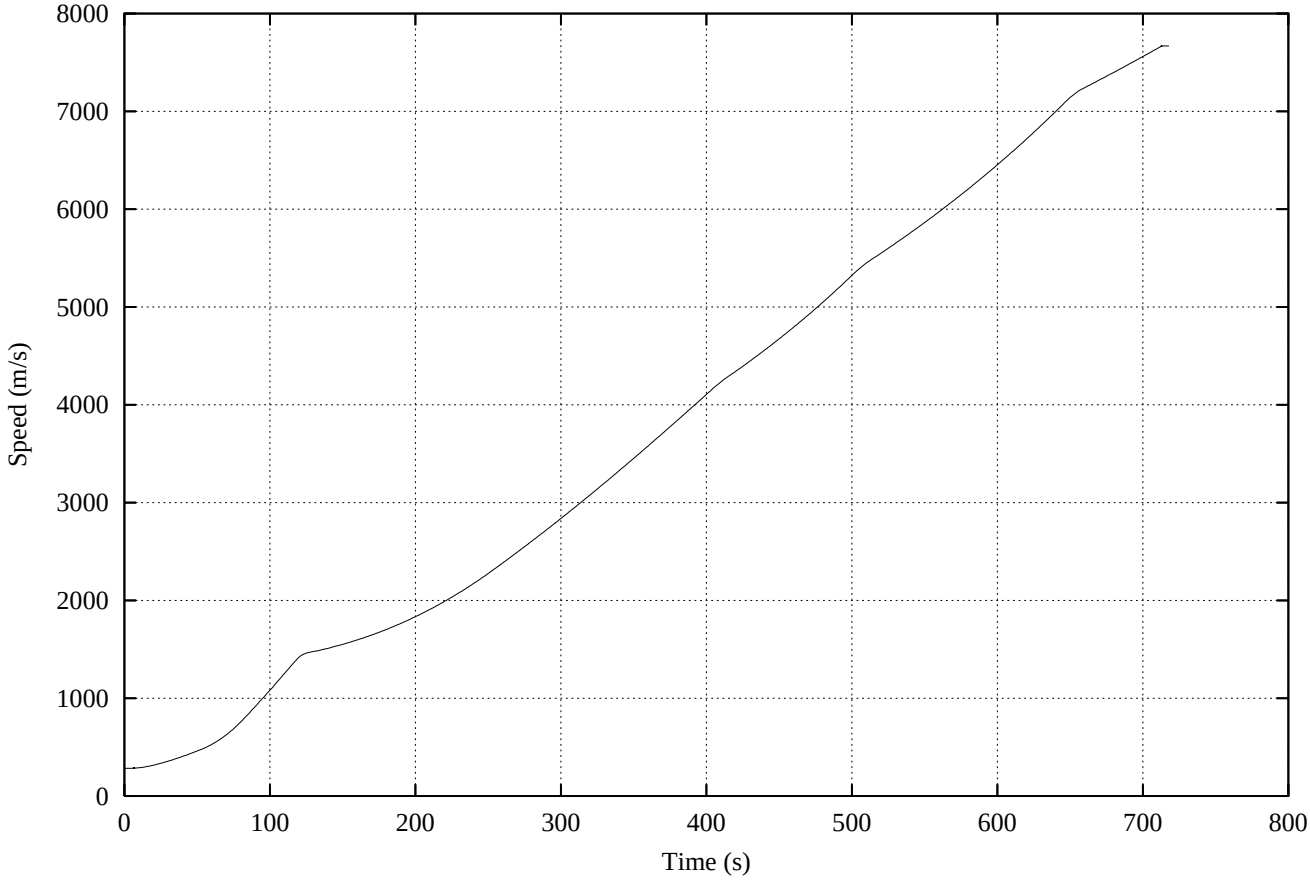

Figure 3: Acceleration versus time for SLS Block 1C

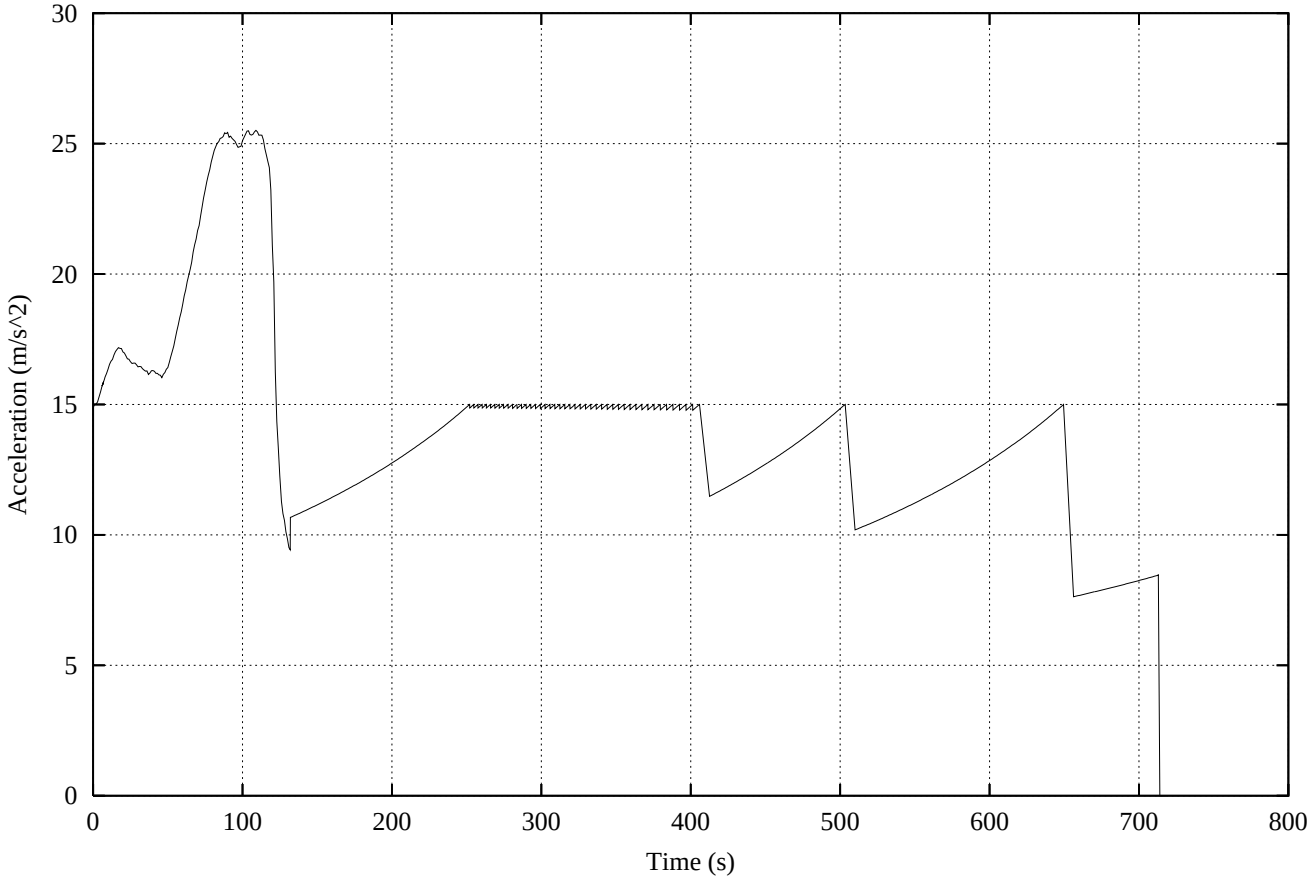

Figure 4: Dynamic pressure versus time for SLS Block 1C