

SLS Block IIB with four RS–25E core and small upper stage with one AJ10–190 engine. Payload to 51.6° 400 km orbit LEO = 91.3 t. 18 May 2016. Author: Steven S. Pietrobon, PhD.

RSRMV thrust curve obtained from page 56 of [1]. A number of corrections have been made so as to match the parameters in [2] and other sources. The propellant mass and dry mass of ATK's Advanced Boosters (AB) were obtained from [3]. The vacuum Isp was assumed to be same as for the Titan IV Solid Rocket Motor Upgrade (SRMU), which also uses HTPB propellant [1]. The RSRMV thrust curve was adjusted so that the peak vacuum thrust is 20.0 MN [3] and has the same impulse given by the Isp multiplied by the propellant mass. This resulted in a burn time of 130.2 s, compared to the 110 s reported in [3]. The same skirt and nozzle diameters as the RSRMV was assumed.

Boosters	SLS1B4O1	SLS2B4O1
Name	RSRMV	Dark Knight
Segments	2x5	2x4
Aft Skirt Diameter (m)	5.288	5.288
Additional Area (m ²)	−0.038	−0.038
Nozzle Diameter (m)	3.875	3.875
Sea Level Thrust at 0.2 s (N)	15,471,544	18,027,271
Maximum Vacuum Thrust (N)	17,355,582	20,016,997
Vacuum Isp (m/s)	2,605.4	2,756.6
Total Mass (kg)	729,240	777,004
Usable Propellant (kg)	631,185	679,920
Residual Propellant (kg)	1304	469
Burnout Mass (kg)	96,751	96,615
Action Time (s)	128.4	130.2

The core values have been updated according to [2] and other sources with RS–25E engines.

Core Stage	SLS1B4O1	SLS2B4O1
Stage Diameter (m)	8.407	8.407
Additional Area (m ²)	2.073	2.073
Engines	RS–25E	RS–25E
Number of Engines	4	4
Nozzle Diameter (m)	2.304	2.304
Vacuum Isp (m/s)	4,420.8	4,420.8
Engine Thrust (N)	2,320,637	2,320,637
Engine Thrust Rating (%)	111	111
Total Mass at Liftoff (kg)	1,074,908	1,074,908
Dry Mass (kg)	100,682	100,682
Total Propellant (kg)	982,663	982,663
Usable Propellant (kg)	964,564	964,564
Reserve Propellant (kg)	7,984	7,984
Fuel Bias Propellant (kg)	1,678	1,678
Startup Propellant (kg)	8,437	8,437

At the end of the core burn, the core is separated, ascends to apogee and then reenters at perigee. The upper stage and payload ascends to apogee where the upper stage engine fires, circularising the orbit.

Parameters	SLS1B4O1	SLS2B4O1
Engine	AJ10–190	AJ10–190
Number of engines	1	1
Nozzle Diameter (m)	1.168	1.168
Vacuum Isp (m/s)	3071.4	3071.4
Engine Thrust (N)	26,689	26,689
Total Mass (kg)	3,865	4,616
Total Propellant (kg)	2,783	3,368
Usable Propellant (kg)	2,701	3,274
Reserve Propellant (kg)	27	32
RCS Propellant (kg)	32	39
Unusable Propellant (kg)	23	23
Dry Mass (kg)	1,082	1,248
Adaptor Mass (kg)	971	1,175

Simulation results for SLS2B4O1 are shown in Figures 1–4. Figure 5 shows the ascent to apogee. Payload into a 400 km 51.6° orbit is 91.3 t.

	SLS1B4O1	SLS2B4O1
Orbit (km)	400.0 ± 0.0	400.0 ± 0.1
Transfer Orbit (km)	37.0×399.0	37.0×398.6
Liftoff Thrust at 0.2 s (N)	38,536,173	43,647,627
Liftoff Mass (kg)	2,623,307	2,735,710
Liftoff Acceleration (m/s ²)	14.70	15.97
MaxQ (Pa)	28,488	34,102
Maximum Acceleration (m/s ²)	39.24	39.23
Fairing Mass (kg)	9,707	9,707
Fairing Jettison Time (s)	330	330
Spacecraft (kg)	75,376	91,296
Total Delta–V (m/s)	9,404	9,294

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

[2] B. Donahue and S. Sigmon, “The Space Launch System capabilities with a new large upper stage,” *AIAA Space Conf. and Exhib.*, San Diego, CA, USA, Sep. 2013.

[3] D. Sauvageau and A. Corliss, “Advanced booster for NASA Space Launch System,” *63rd Int. Astronautical Congress*, Naples, Italy, IAC–12–D2.8.6, Oct. 2012.

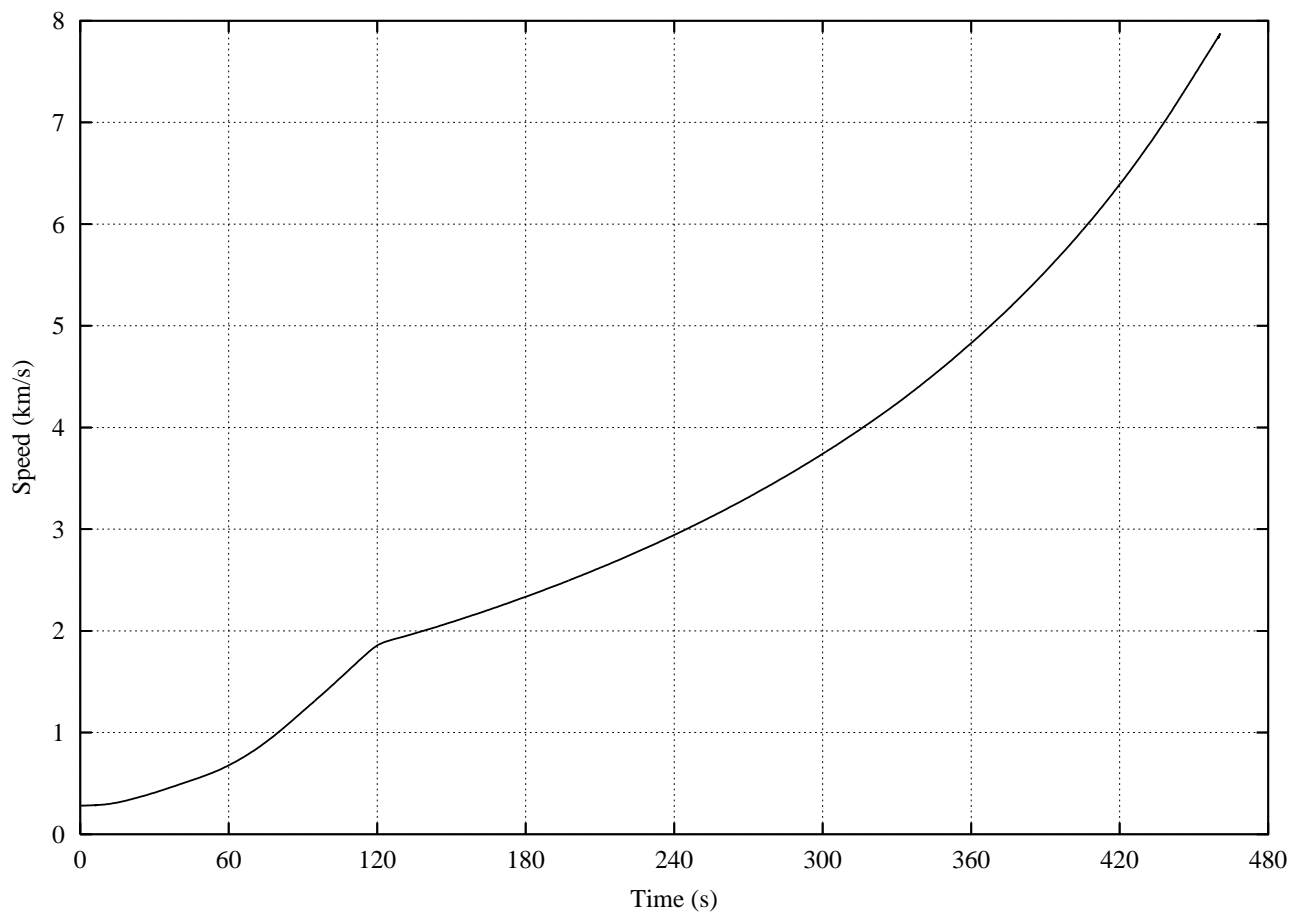


Figure 1: Speed versus time.

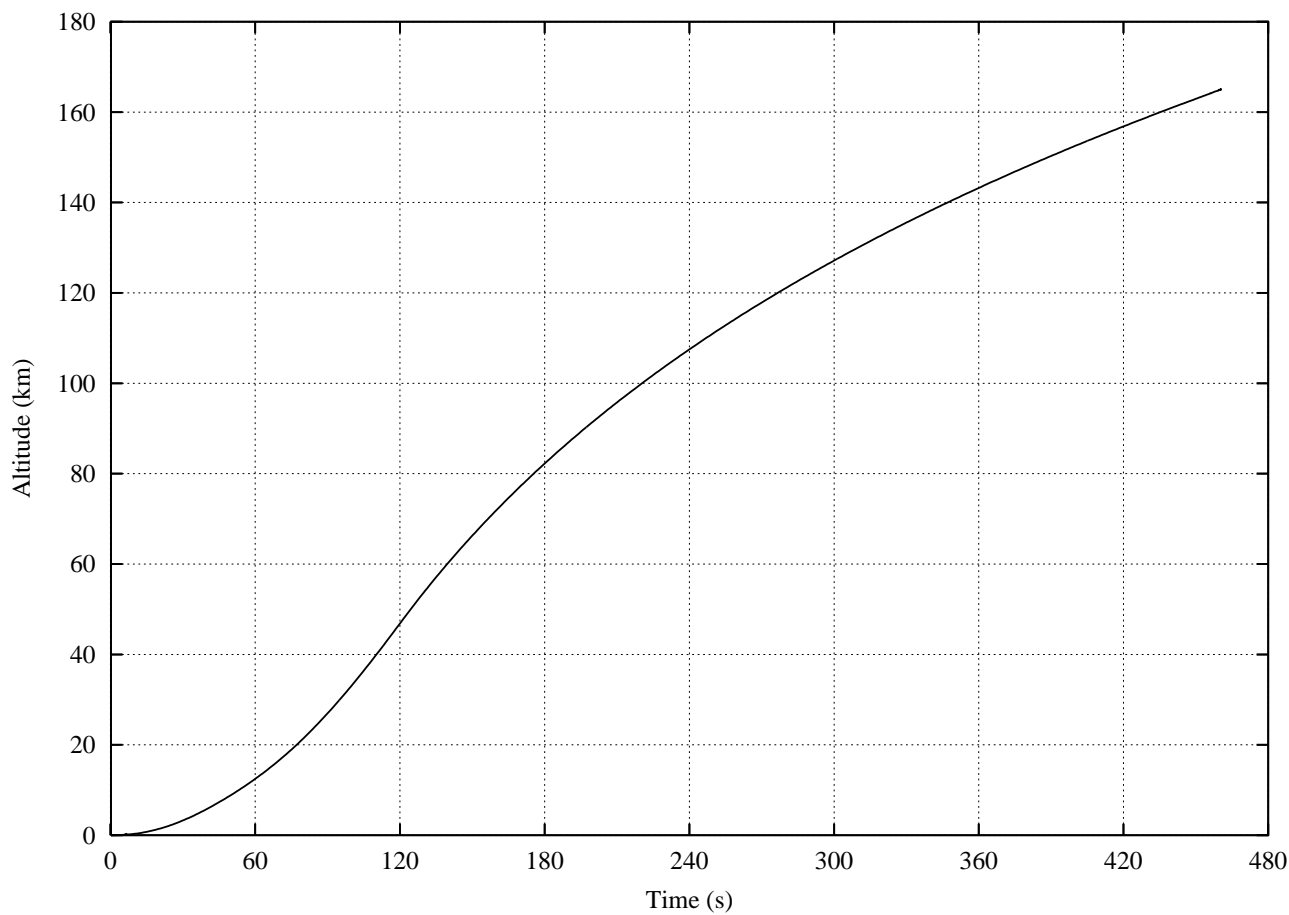


Figure 2: Altitude versus time.

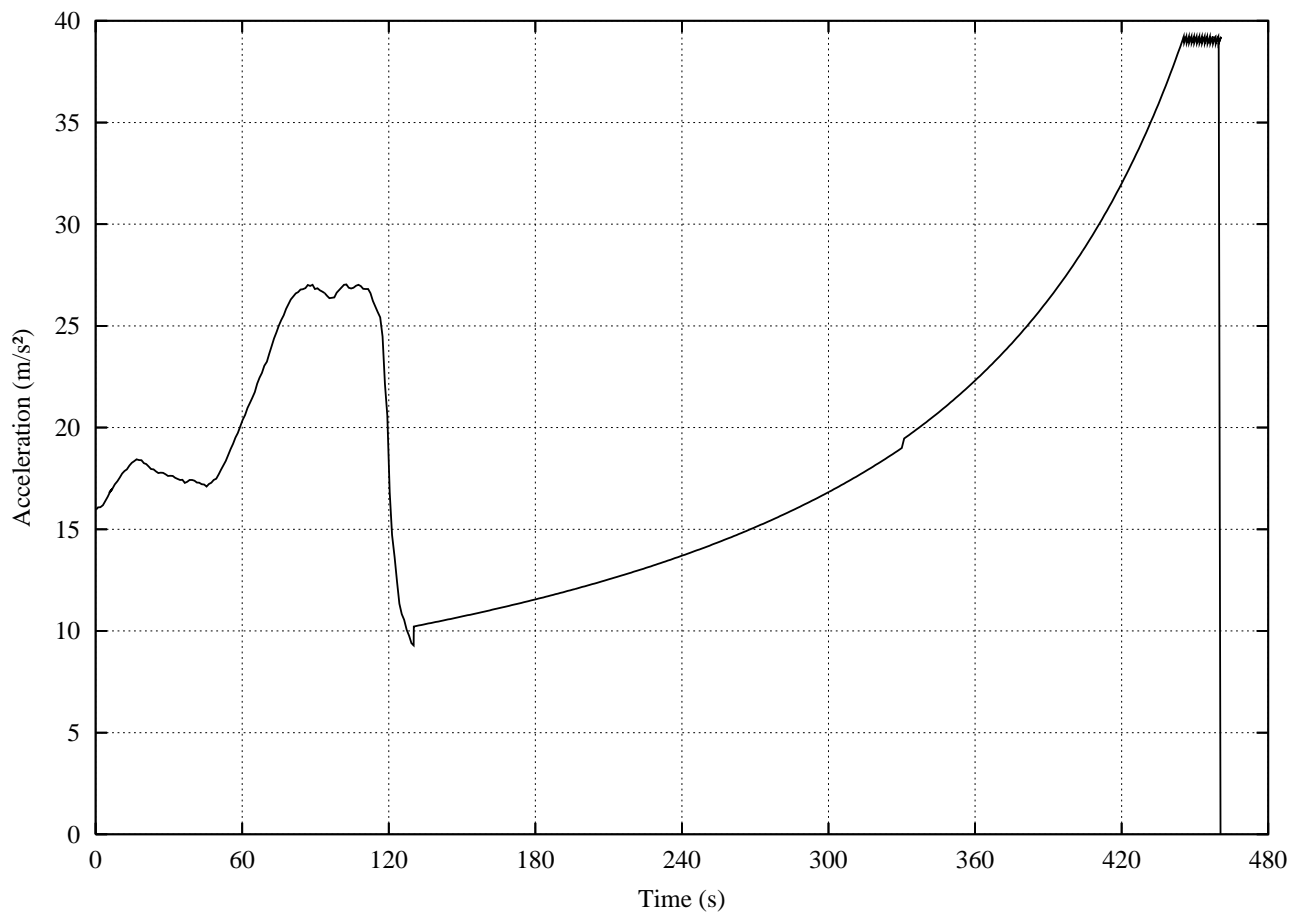


Figure 3: Acceleration versus time.

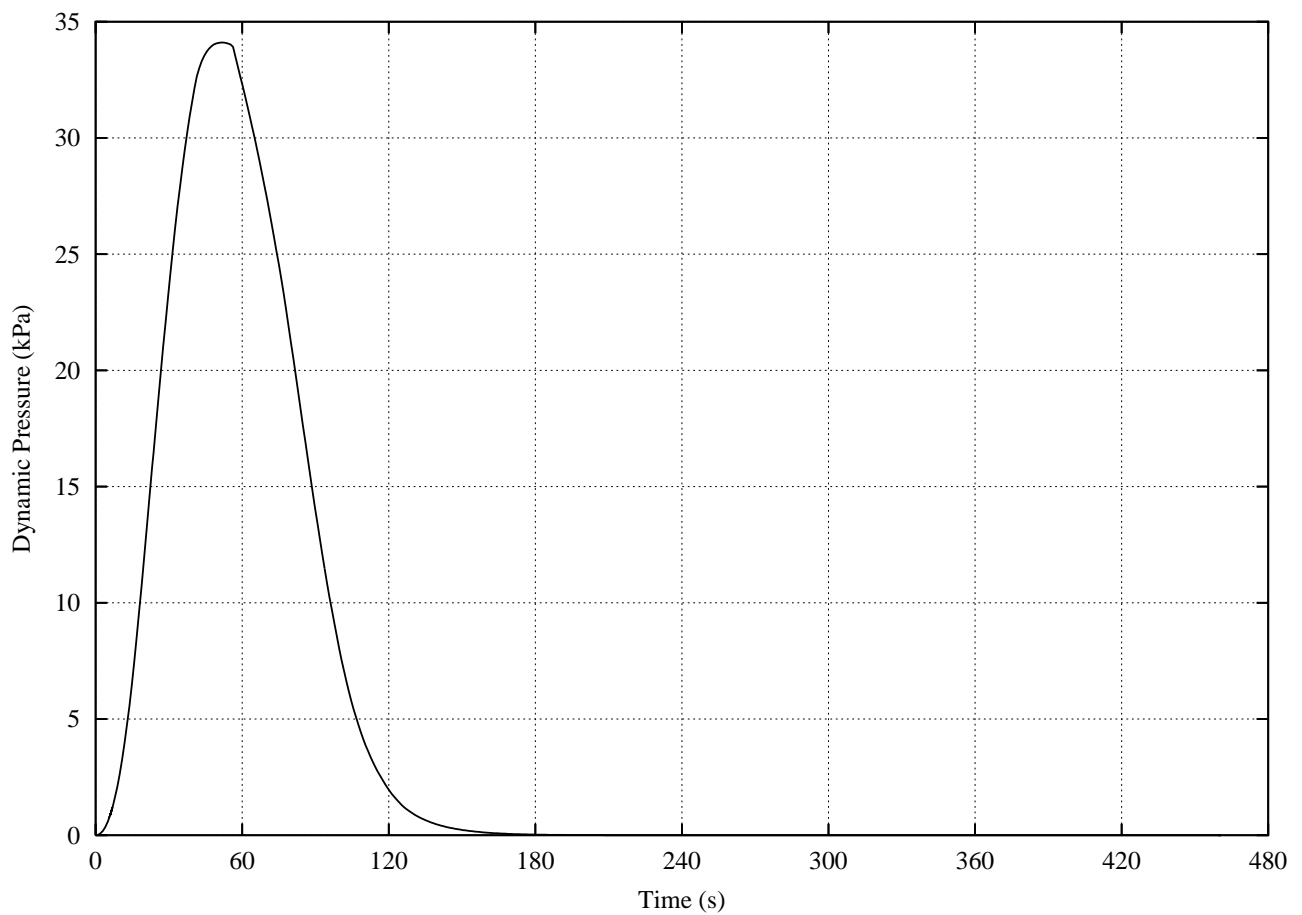


Figure 4: Dynamic pressure versus time.

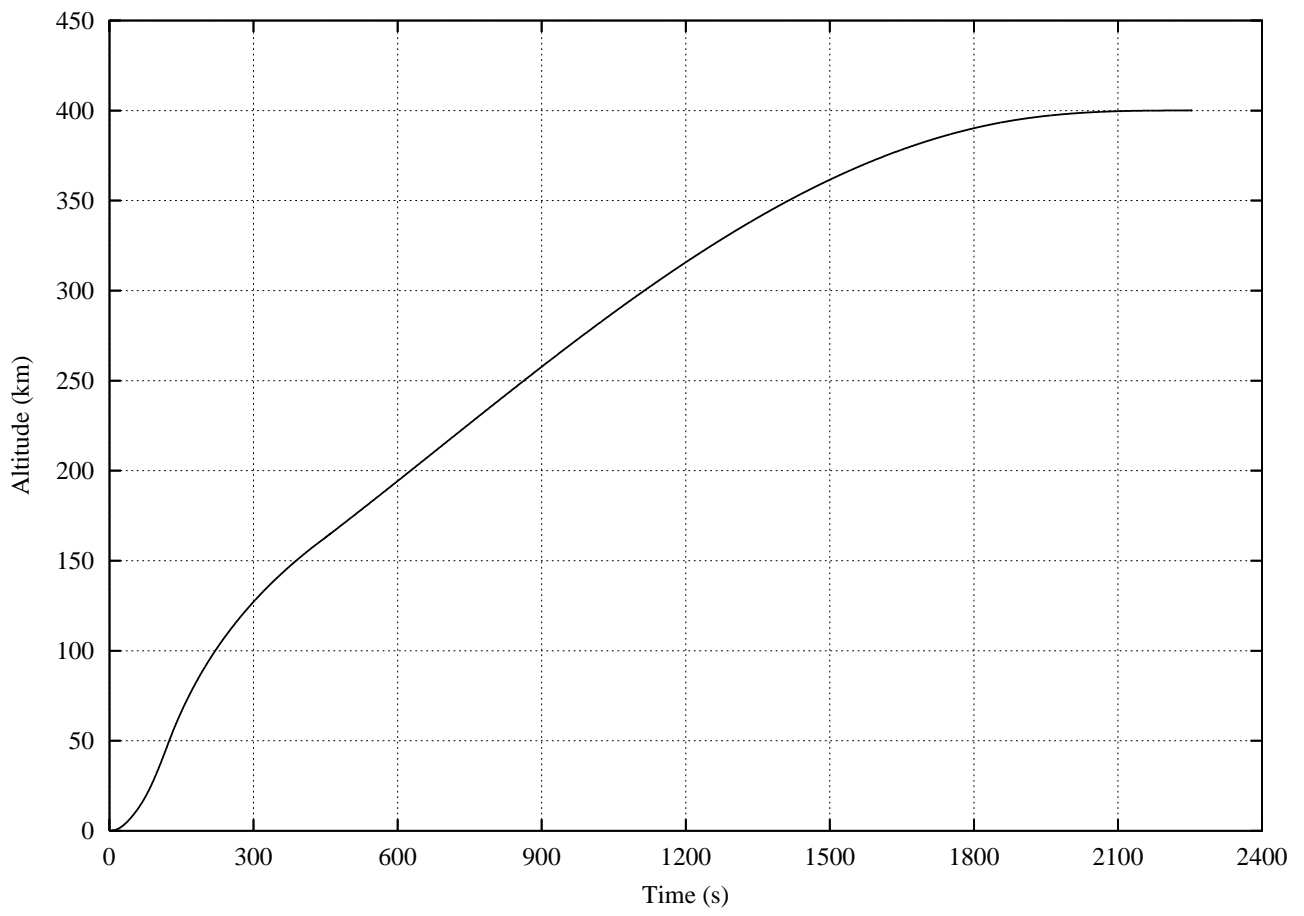


Figure 5: Height versus time to apogee.