

SLS Block I with RSRMV boosters, four RS–25D core and one RL–10B–2 upper stage. Payload to 200 km LEO = 89.0 t. 14 Oct 2018. Corrected 1 Sep 2019. 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.

Boosters: RSRMV 2x5–Segment	IB	I
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	15,471,544
Vacuum Isp (m/s)	2,605.4	2,605.4
Total Mass (kg)	729,240	729,240
Usable Propellant (kg)	631,185	631,185
Residual Propellant (kg)	1,304	1,304
Burnout Mass (kg)	96,751	96,751
Action Time (s)	128.4	128.4

The core values have been updated according to [2]. RS–25D data is from [3].

Core Stage	IB	I
Stage Diameter (m)	8.407	8.407
Additional Area (m ²)	2.073	2.073
Engines	RS–25E	RS–25D
Number of Engines	4	4
Nozzle Diameter (m)	2.304	2.304
Vacuum Isp (m/s)	4,420.8	4,419.9
Engine Thrust (N)	2,320,637	2,280,914
Engine Thrust Rating (%)	111	109.1
Total Mass at Liftoff (kg)	1,074,908	1,074,288
Dry Mass (kg)	100,682	100,062
Total Propellant (kg)	982,663	982,663
Usable Propellant (kg)	964,564	960,210
Unusable Propellant (kg)	9,662	14,016
Startup Propellant (kg)	8,437	8,437

The size of the upper stage mass parameters [4] and interstage mass were obtained from [2]. Ullage engine data is from [5]. Choice and number of ullage engines is from [6].

Upper Stage:	IB	I
Stage Diameter (m)	8.407	8.407
Engines	RL-10C-2	RL-10B-2
Number of Engines	4	1
Nozzle Diameter (m)	2.146	2.146
Vacuum Isp (m/s)	4,530.7	4,535.6
Single Engine Thrust (N)	110,093	110,093
Ullage Engines	R-40B	R-40B
Number of Ullage Engines	4	4
Ullage Nozzle Diameter (m)	0.040	0.040
Ullage Vacuum Isp (m/s)	2,873.3	2,873.3
Ullage Single Engine Thrust (N)	4,003	4,003
Total Mass (kg)	63,450	20,782
Total Propellant (kg)	48,864	16,880
Usable Propellant (kg)	45,764	15,591
Deorbit Propellant (kg)	189	55
Reserve Propellant (kg)	387	145
Unusable Propellant (kg)	2524	1,089
RCS Propellant (kg)	71	71
Dry Mass (kg)	14,515	3,831
Interstage Mass (kg)	3,752	4,581

The PLF jettison time was obtained from [6]. Simulation results are shown in Figures 1–4.

	IB	I
Orbit (km)	200 ± 0.0	200 ± 0.0
Liftoff Thrust at 0.2 s (N)	38,536,173	38,377,282
Liftoff Mass (kg)	2,707,388	2,656,849
Liftoff Acceleration (m/s ²)	14.24	14.45
MaxQ (Pa)	25,445	26,775
Maximum Acceleration (m/s ²)	33.65	39.72
PLF Jettison Time (s)	330	330
Payload Fairing (kg)	9,707	9,707
Total Payload (kg)	97,091	89,011
Total Delta-V (m/s)	9,516	9,343

- [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] R. O. Ballard, “Next-generation RS-25 engines for the NASA Space Launch System,” *European Conf. for Aeronautics and Space Science*, Milan, Italy, July 2017.
- [4] B. Donahue and D. Sauvageau, “The Space Launch System capabilities for beyond Earth missions,” *Space Access Int. Conf.*, Paris, France, Apr. 2014.
- [5] Aerojet, “R-40B 4,000 N (900-lbf) bipropellant rocket engine,” IAF-1987-0283, June 2006.
- [6] S. Creech, J. Holladay and D. Jones, “SLS dual use upper stage (DUUS) opportunities,” NASA, Apr. 2013.

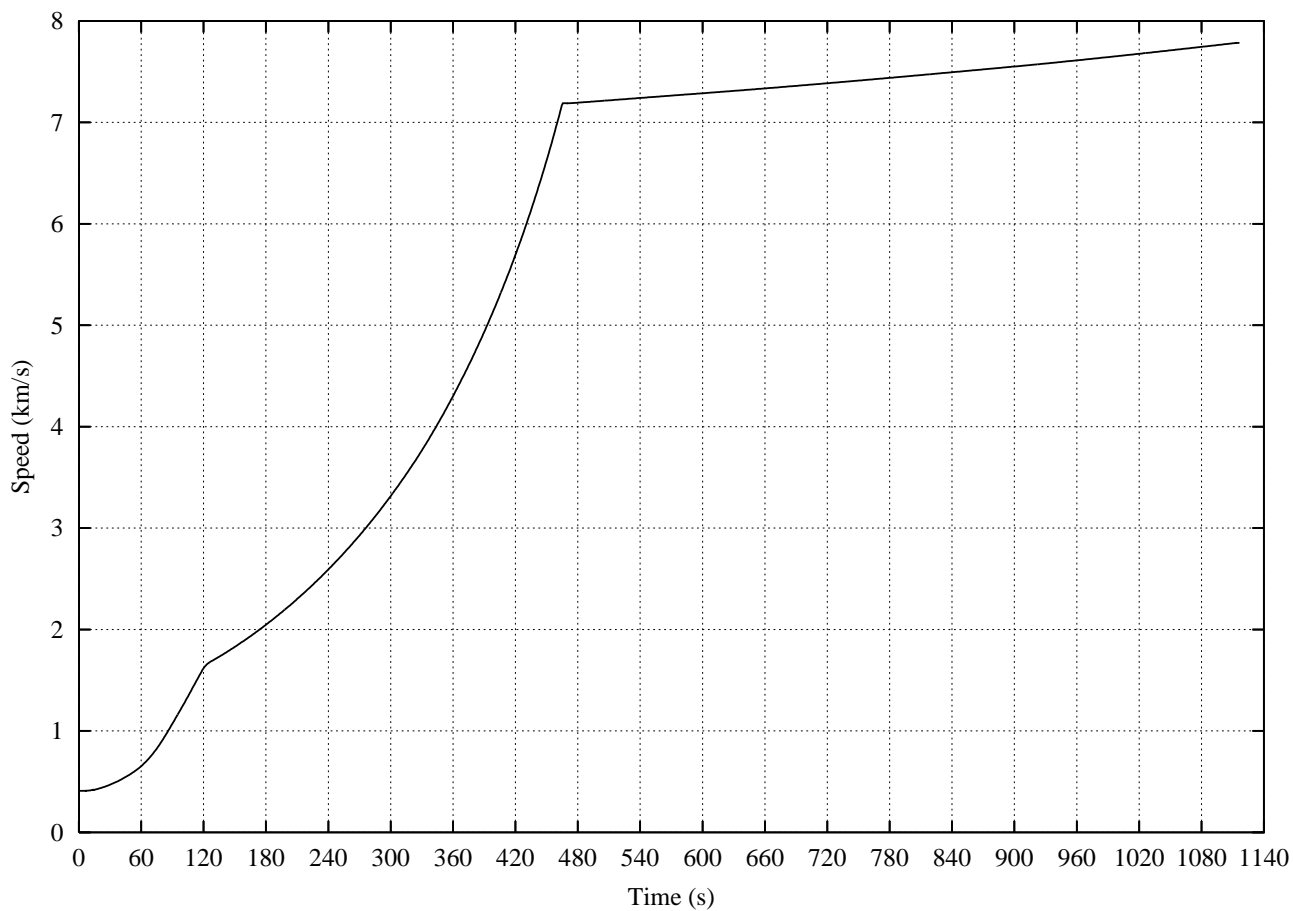


Figure 1: Speed versus time.

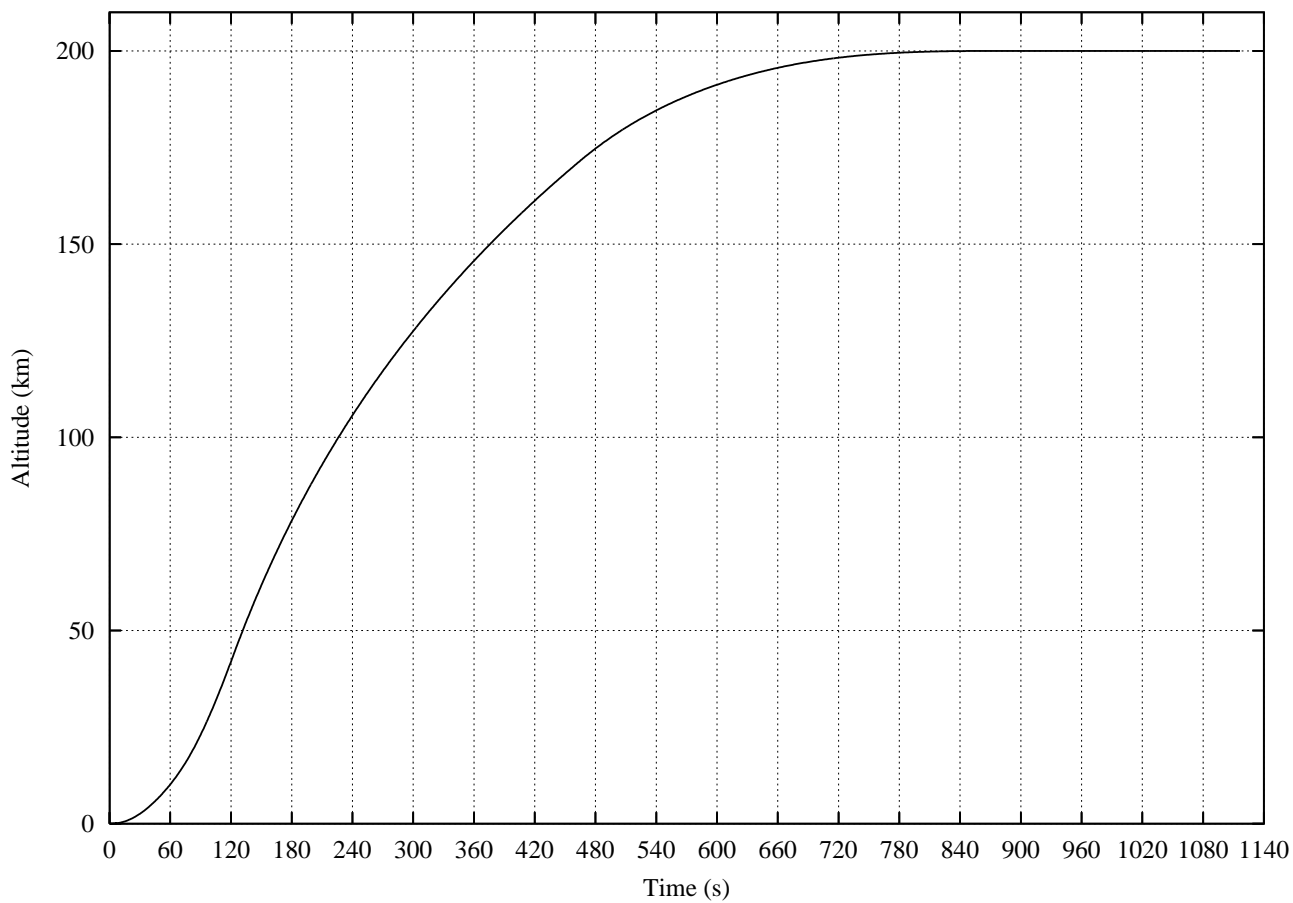


Figure 2: Altitude versus time.

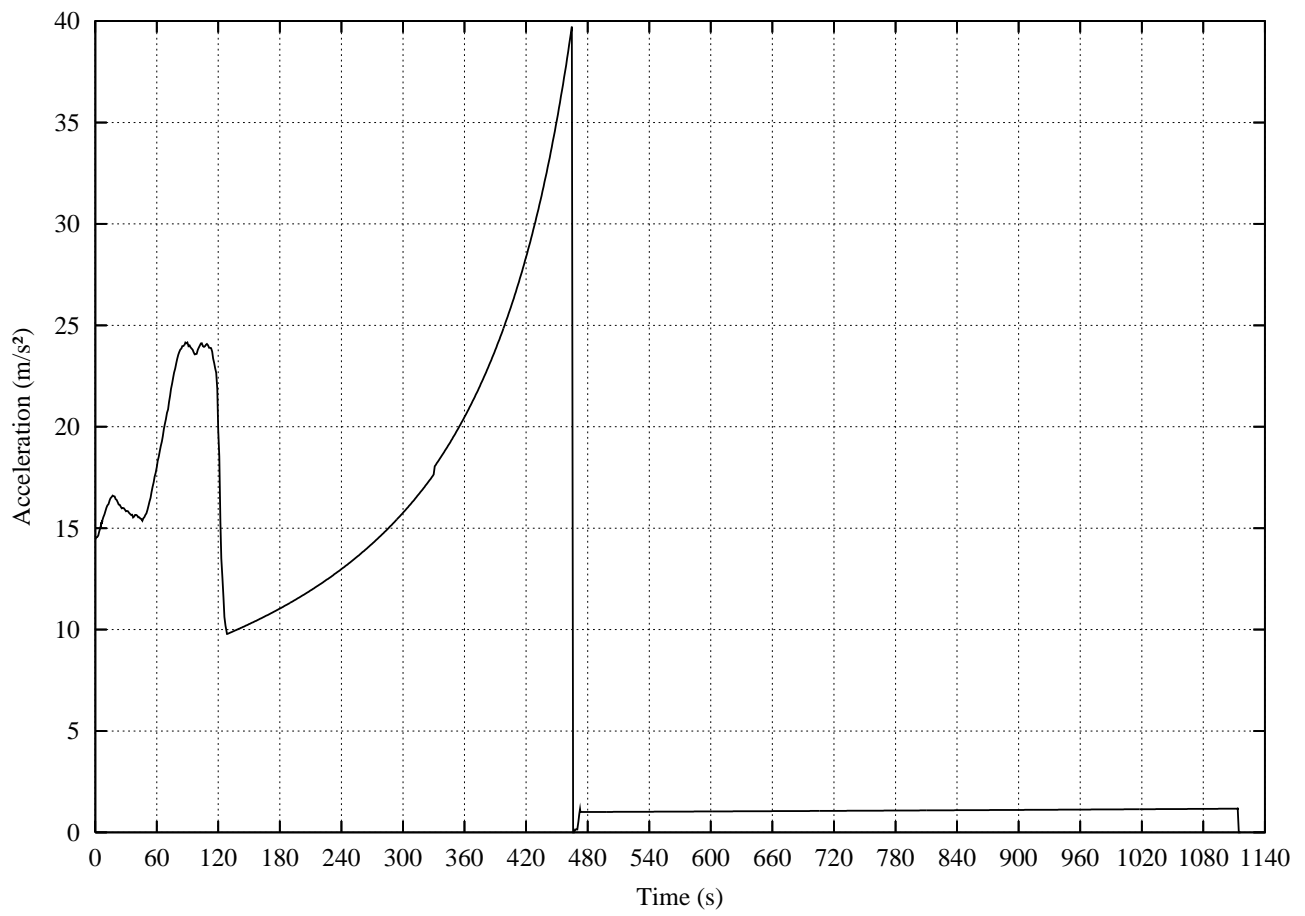


Figure 3: Acceleration versus time.

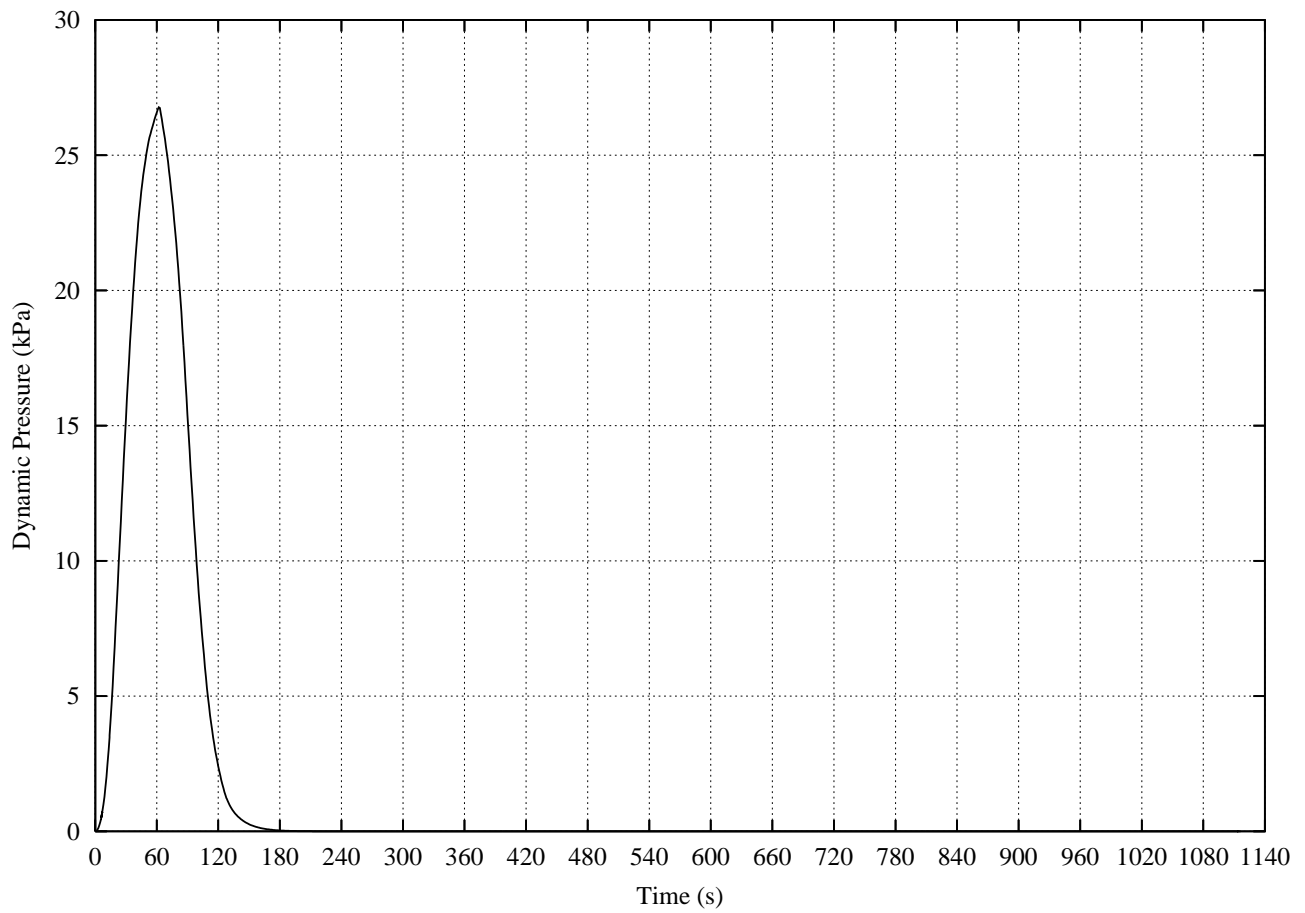


Figure 4: Dynamic pressure versus time.