

# AA 236A: Spacecraft Design

## Problem Set 2

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### Problem 1

- (a) The Virgin Orbit Launcher 1 succeeded in placing 9 nano-sats into orbit on January 17, 2021. The rocket is taken up to upper atmosphere on a modified Boeing 747, named Cosmic Girl, before it is released. This method has some clear advantages such as the launch location versatility given by the use of a plane rather than a launch pad. Compared to planes designed to use rocket fuel for a similar purpose, it has the disadvantage of not being fully reusable while it has the advantage of needing less fuel (due to the reduced weight from the reduction of aircraft wings and controls), the first stage is completely reusable, and the second stage is completely un-piloted.

There are some risks associated with liquid rockets. High amounts of CG changes and sloshing is an inherit risk when using liquid rocket propellants. They can also leak causing explosive mixtures.

(b) A list of the passes bounded by time is below in Figure 1.

pass #	AOS day	AOS time	TCA day	TCA time	LOD day	LOS time	Duration	Max EI	AOS Az	LOS Az	TCA (EST)
1	2/3/2021	3:18:48 PM	2/3/2021	3:22:58 PM	2/3/2021	3:27:09 PM	0:08:20	12.56	188.03	70.54	10:22:58 AM
2	2/3/2021	4:53:00 PM	2/3/2021	4:57:51 PM	2/3/2021	5:02:43 PM	0:09:43	45.02	241.94	46.12	11:57:51 AM
3	2/3/2021	6:29:39 PM	2/3/2021	6:33:37 PM	2/3/2021	6:37:35 PM	0:07:55	9.49	287.69	36.28	1:33:37 PM
4	2/3/2021	8:06:40 PM	2/3/2021	8:10:01 PM	2/3/2021	8:13:22 PM	0:06:42	5.54	318.74	46.06	3:10:01 PM
5	2/3/2021	9:42:07 PM	2/3/2021	9:46:19 PM	2/3/2021	9:50:30 PM	0:08:23	12.33	322.69	82.25	4:46:19 PM
6	2/4/2021	3:41:45 PM	2/4/2021	3:46:34 PM	2/4/2021	3:51:24 PM	0:09:39	44.7	216.85	55.83	10:46:34 AM
7	2/4/2021	5:17:23 PM	2/4/2021	5:21:52 PM	2/4/2021	5:26:22 PM	0:08:59	17.56	265.87	39.47	12:21:52 PM
8	2/4/2021	6:54:32 PM	2/4/2021	6:58:00 PM	2/4/2021	7:01:28 PM	0:06:56	6.14	306.48	37.71	1:58:00 PM
9	2/4/2021	8:30:46 PM	2/4/2021	8:34:26 PM	2/4/2021	8:38:06 PM	0:07:19	7.28	323.72	61.75	3:34:26 PM
10	2/5/2021	2:31:02 PM	2/5/2021	2:35:12 PM	2/5/2021	2:39:23 PM	0:08:20	12.65	188.27	70.42	9:35:12 AM
11	2/5/2021	4:05:12 PM	2/5/2021	4:10:03 PM	2/5/2021	4:14:54 PM	0:09:41	44.41	242.18	46.03	11:10:03 AM
12	2/5/2021	5:41:49 PM	2/5/2021	5:45:46 PM	2/5/2021	5:49:43 PM	0:07:53	9.4	287.95	36.19	12:45:46 PM
13	2/5/2021	7:18:47 PM	2/5/2021	7:22:07 PM	2/5/2021	7:25:28 PM	0:06:40	5.5	318.91	46.03	2:22:07 PM
14	2/5/2021	8:54:11 PM	2/5/2021	8:58:22 PM	2/5/2021	9:02:34 PM	0:08:22	12.31	322.73	82.31	3:58:22 PM
15	2/6/2021	2:53:19 PM	2/6/2021	2:58:08 PM	2/6/2021	3:02:57 PM	0:09:38	44.33	216.73	55.9	9:58:08 AM
16	2/6/2021	4:28:54 PM	2/6/2021	4:33:23 PM	2/6/2021	4:37:53 PM	0:08:58	17.55	265.82	39.44	11:33:23 AM
17	2/6/2021	6:06:01 PM	2/6/2021	6:09:28 PM	2/6/2021	6:12:56 PM	0:06:55	6.11	306.51	37.56	1:09:28 PM
18	2/6/2021	7:42:13 PM	2/6/2021	7:45:52 PM	2/6/2021	7:49:30 PM	0:07:17	7.22	323.81	61.52	2:45:52 PM
19	2/6/2021	9:17:07 PM	2/6/2021	9:21:46 PM	2/6/2021	9:26:25 PM	0:09:18	25.45	317.82	105.21	4:21:46 PM
20	2/7/2021	1:42:00 PM	2/7/2021	1:46:08 PM	2/7/2021	1:50:16 PM	0:08:16	12.31	187.66	70.81	8:46:08 AM
21	2/7/2021	3:16:05 PM	2/7/2021	3:20:55 PM	2/7/2021	3:25:46 PM	0:09:40	45.29	241.77	46.16	10:20:55 AM
22	2/7/2021	4:52:39 PM	2/7/2021	4:56:35 PM	2/7/2021	5:00:32 PM	0:07:53	9.44	287.65	36.12	1:15:35 PM
23	2/7/2021	6:29:34 PM	2/7/2021	6:32:54 PM	2/7/2021	6:36:13 PM	0:06:38	5.44	318.87	45.66	1:32:54 PM
24	2/7/2021	8:04:56 PM	2/7/2021	8:09:06 PM	2/7/2021	8:13:16 PM	0:08:20	12.1	322.87	81.78	3:09:06 PM
25	2/7/2021	9:39:44 PM	2/7/2021	9:44:34 PM	2/7/2021	9:49:24 PM	0:09:40	83.59	309.82	129.45	4:44:34 PM
26	2/8/2021	2:03:34 PM	2/8/2021	2:08:22 PM	2/8/2021	2:13:10 PM	0:09:35	42.24	215.88	56.29	9:08:22 AM
27	2/8/2021	3:39:04 PM	2/8/2021	3:43:34 PM	2/8/2021	3:48:03 PM	0:08:58	17.88	265.14	39.56	10:43:34 AM
28	2/8/2021	5:16:08 PM	2/8/2021	5:19:35 PM	2/8/2021	5:23:03 PM	0:06:54	6.12	306.1	37.3	12:19:35 PM
29	2/8/2021	6:52:19 PM	2/8/2021	6:55:56 PM	2/8/2021	6:59:33 PM	0:07:13	7.06	323.87	60.78	1:55:56 PM
30	2/8/2021	8:27:10 PM	2/8/2021	8:31:48 PM	2/8/2021	8:36:26 PM	0:09:15	24.58	318.09	104.33	3:31:48 PM
31	2/9/2021	2:25:36 PM	2/9/2021	2:30:26 PM	2/9/2021	2:35:16 PM	0:09:40	47.86	240.68	46.51	9:30:26 AM
32	2/9/2021	4:02:05 PM	2/9/2021	4:06:02 PM	2/9/2021	4:10:00 PM	0:07:54	9.62	286.78	36.1	11:06:02 AM
33	2/9/2021	5:38:59 PM	2/9/2021	5:42:18 PM	2/9/2021	5:45:36 PM	0:06:36	5.37	318.59	44.96	12:42:18 PM
34	2/9/2021	7:14:20 PM	2/9/2021	7:18:28 PM	2/9/2021	7:22:36 PM	0:08:15	11.68	323.1	80.63	2:18:28 PM
35	2/9/2021	8:49:05 PM	2/9/2021	8:53:54 PM	2/9/2021	8:58:44 PM	0:09:38	78.17	310.3	128.19	3:53:54 PM
36	2/10/2021	1:12:28 PM	2/10/2021	1:17:13 PM	2/10/2021	1:21:59 PM	0:09:31	38.68	214.26	57.03	8:17:13 AM
37	2/10/2021	2:47:51 PM	2/10/2021	2:52:21 PM	2/10/2021	2:56:51 PM	0:09:00	18.61	263.81	39.82	9:52:21 AM
38	2/10/2021	4:24:50 PM	2/10/2021	4:28:18 PM	2/10/2021	4:31:46 PM	0:06:55	6.19	305.24	36.92	11:28:18 AM
39	2/10/2021	6:01:02 PM	2/10/2021	6:04:36 PM	2/10/2021	6:08:10 PM	0:07:08	6.83	323.87	59.52	1:04:36 PM
40	2/10/2021	7:35:51 PM	2/10/2021	7:40:27 PM	2/10/2021	7:45:02 PM	0:09:10	23.17	318.54	102.78	2:40:27 PM
41	2/10/2021	9:10:51 PM	2/10/2021	9:15:26 PM	2/10/2021	9:20:01 PM	0:09:09	25.88	299.11	153.84	4:15:26 PM
42	2/11/2021	1:33:43 PM	2/11/2021	1:38:33 PM	2/11/2021	1:43:23 PM	0:09:39	52.64	238.87	47.12	8:38:33 AM
43	2/11/2021	3:10:06 PM	2/11/2021	3:14:05 PM	2/11/2021	3:18:03 PM	0:07:57	9.96	285.31	36.14	10:14:05 AM
44	2/11/2021	4:46:59 PM	2/11/2021	4:50:16 PM	2/11/2021	4:53:33 PM	0:06:33	5.3	318.04	43.95	11:50:16 AM
45	2/11/2021	6:22:20 PM	2/11/2021	6:26:25 PM	2/11/2021	6:30:29 PM	0:08:08	11.08	323.41	78.85	1:26:25 PM
46	2/11/2021	7:57:02 PM	2/11/2021	8:01:50 PM	2/11/2021	8:06:39 PM	0:09:37	69.89	311.05	126.21	3:01:50 PM
47	2/11/2021	9:32:48 PM	2/11/2021	9:36:23 PM	2/11/2021	9:39:58 PM	0:07:09	7.55	281.84	184.15	4:36:23 PM
48	2/12/2021	1:55:10 PM	2/12/2021	1:59:42 PM	2/12/2021	2:04:14 PM	0:09:03	19.82	261.8	40.27	8:59:42 AM
49	2/12/2021	3:32:06 PM	2/12/2021	3:35:35 PM	2/12/2021	3:39:04 PM	0:06:57	6.33	303.87	36.47	10:35:35 AM
50	2/12/2021	5:08:19 PM	2/12/2021	5:11:49 PM	2/12/2021	5:15:20 PM	0:07:01	6.53	323.8	57.72	12:11:49 PM
51	2/12/2021	6:43:07 PM	2/12/2021	6:47:39 PM	2/12/2021	6:52:12 PM	0:09:04	21.35	319.16	100.53	1:47:39 PM
52	2/12/2021	8:18:01 PM	2/12/2021	8:22:38 PM	2/12/2021	8:27:15 PM	0:09:14	29.08	300.35	151.26	3:22:38 PM
53	2/13/2021	2:16:38 PM	2/13/2021	2:20:39 PM	2/13/2021	2:24:41 PM	0:08:02	10.5	283.18	36.27	9:20:39 AM
54	2/13/2021	3:53:31 PM	2/13/2021	3:56:46 PM	2/13/2021	4:00:02 PM	0:06:31	5.23	317.14	42.66	10:56:46 AM
55	2/13/2021	5:28:53 PM	2/13/2021	5:32:53 PM	2/13/2021	5:36:53 PM	0:07:59	10.34	323.79	76.4	12:32:53 PM
56	2/13/2021	7:03:31 PM	2/13/2021	7:08:19 PM	2/13/2021	7:13:06 PM	0:09:34	59.74	312.06	123.48	2:08:19 PM
57	2/13/2021	8:39:07 PM	2/13/2021	8:42:51 PM	2/13/2021	8:46:36 PM	0:07:28	8.81	284.23	180.34	3:42:51 PM
58	2/14/2021	1:01:01 PM	2/14/2021	1:05:35 PM	2/14/2021	1:10:09 PM	0:09:07	21.7	259.06	40.92	8:05:35 AM
59	2/14/2021	2:37:51 PM	2/14/2021	2:41:22 PM	2/14/2021	2:44:53 PM	0:07:01	6.56	301.92	35.99	9:41:22 AM
60	2/14/2021	4:14:07 PM	2/14/2021	4:17:33 PM	2/14/2021	4:21:00 PM	0:06:53	6.18	323.59	55.47	11:17:33 AM
61	2/14/2021	5:48:55 PM	2/14/2021	5:53:23 PM	2/14/2021	5:57:51 PM	0:08:56	19.26	319.95	97.57	12:53:23 PM
62	2/14/2021	7:23:42 PM	2/14/2021	7:28:22 PM	2/14/2021	7:33:02 PM	0:09:19	34.23	301.95	147.88	2:28:22 PM
63	2/15/2021	1:21:38 PM	2/15/2021	1:25:43 PM	2/15/2021	1:29:48 PM	0:08:10	11.29	280.35	36.55	8:25:43 AM
64	2/15/2021	2:58:31 PM	2/15/2021	3:01:46 PM	2/15/2021	3:05:00 PM	0:06:29	5.2	315.83	41.16	10:01:46 AM
65	2/15/2021	4:33:57 PM	2/15/2021	4:37:51 PM	2/15/2021	4:41:45 PM	0:07:48	9.49	324.19	73.35	11:37:51 AM
66	2/15/2021	6:08:31 PM	2/15/2021	6:13:17 PM	2/15/2021	6:18:02 PM	0:09:30	49.15	313.3	119.99	1:13:17 PM
67	2/15/2021	7:43:55 PM	2/15/2021	7:47:50 PM	2/15/2021	7:51:45 PM	0:07:50	10.59	287.09	175.66	2:47:50 PM
68	2/16/2021	1:42:03 PM	2/16/2021	1:45:37 PM	2/16/2021	1:49:11 PM	0:07:08	6.91	299.32	35.58	8:45:37 AM
69	2/16/2021	3:18:23 PM	2/16/2021	3:21:45 PM	2/16/2021	3:25:07 PM	0:06:43	5.82	323.17	52.78	10:21:45 AM
70	2/16/2021	4:53:11 PM	2/16/2021	4:57:34 PM	2/16/2021	5:01:57 PM	0:08:46	17.04	320.87	93.89	11:57:34 AM
71	2/16/2021	6:27:52 PM	2/16/2021	6:32:34 PM	2/16/2021	6:37:16 PM	0:09:23	42.63	303.86	143.69	1:32:34 PM
72	2/17/2021	2:01:56 PM	2/17/2021	2:05:11 PM	2/17/2021	2:08:25 PM	0:06:29	5.22	313.98	39.54	9:05:11 AM
73	2/17/2021	3:37:27 PM	2/17/2021	3:41:14 PM	2/17/2021	3:45:02 PM	0:07:34	8.58	324.57	69.69	10:41:14 AM
74	2/17/2021	5:11:59 PM	2/17/2021	5:16:41 PM	2/17/2021	5:21:24 PM	0:09:25	39.42	314.76	115.73	12:16:41 PM
75	2/17/2021	6:47:09 PM	2/17/2021	6:51:16 PM	2/17/2021	6:55:22 PM	0:08:12	13.11	290.31	170.11	1:51:16 PM

Figure 1: Passes over WFF bounded by time

(c) The ground tracks are below in Figure 2, TECHEDSAT-7 was not available.

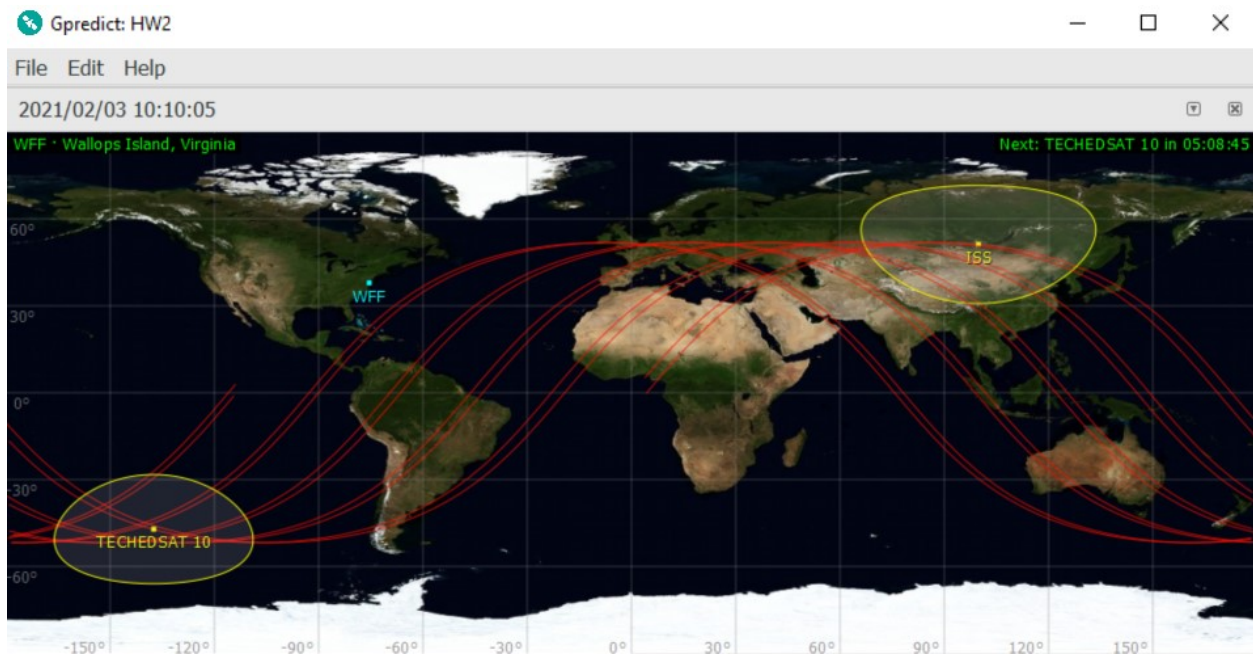


Figure 2: Ground Tracks of ISS and TECHEDSAT-10

## Problem 2

- (a) less then 100 volts can damage a component.
- (b) The most important "tool to safeguard is the highly conductive human body. Relative Humidity can affect the amount of charge, the lower RH is the higher the charge will be.
- (c) An electromagnetic pulse (EMP) is a short burst of electromagnetic energy. Over-current is an excess of current, or amperage, in a circuit. This can be caused by an EMP.

Operation Starfish, or Starfish Prime, was a US high altitude nuclear test in 1962. The explosion caused an EMP that was far larger then expected. It knocked out about 300 satellites and caused damage in Hawaii. This also caused some trapped radiation around the Earth, which caused six or more satellites to fail as well.

## Problem 3

All files for this problem are located [here](#)

## Problem 4

- (a) The code is located [here](#)
- (b) As seen in Figure 3, all sensors work as expected except for the GPS sensor. I am having trouble getting it to connect but will try outside tomorrow (Feb. 4th 2021) and get back to you. Despite the instructions, I do have the code running in a loop so I can see the sensors change as the environment changes. This is easy to modify to have it only print once.

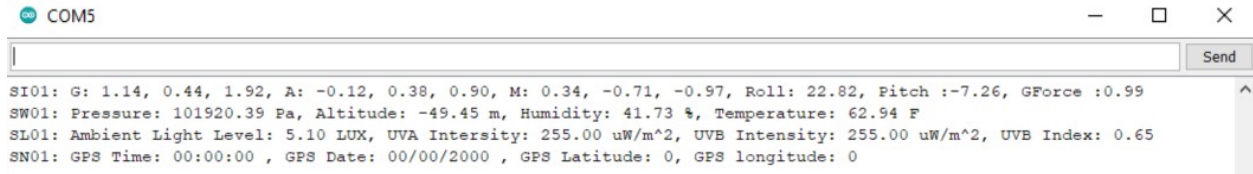


Figure 3: Serial Monitor of the Sensor Test

## Problem 5

The code is located [here](#).

- (a) The predicted altitude starts around 350 km (locally sinusoidally oscillates) and decays to 300 km around 33 days and 100 km around 87 days. this can be seen below in Figure 4.

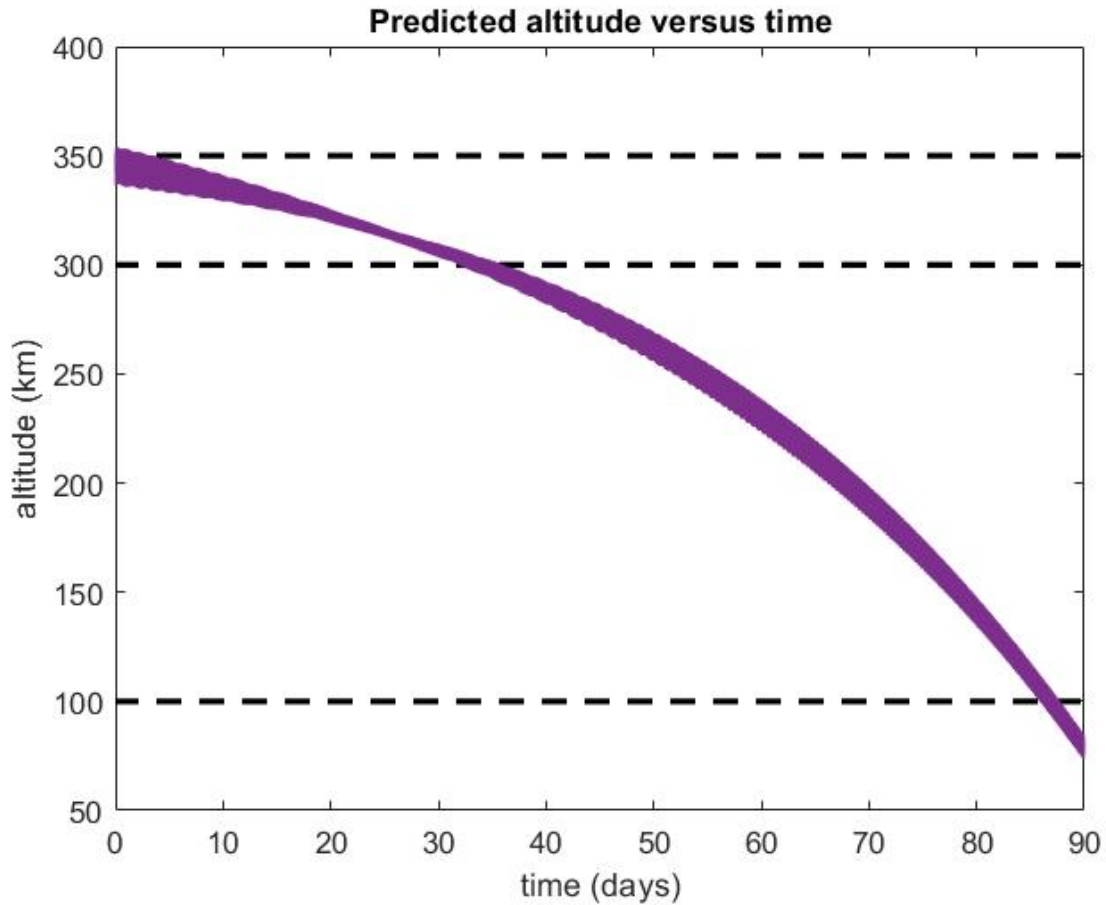


Figure 4: Altitude versus time for TECHEDSAT-10

- (b) The predicted altitude starts around 350 km (locally sinusoidally oscillates) and decays to 300 km around 17 days and 100 km around 44 days. this can be seen below in Figure 5. It would make sense that doubling the drag term will cause the satellite to come to plummet twice as fast.

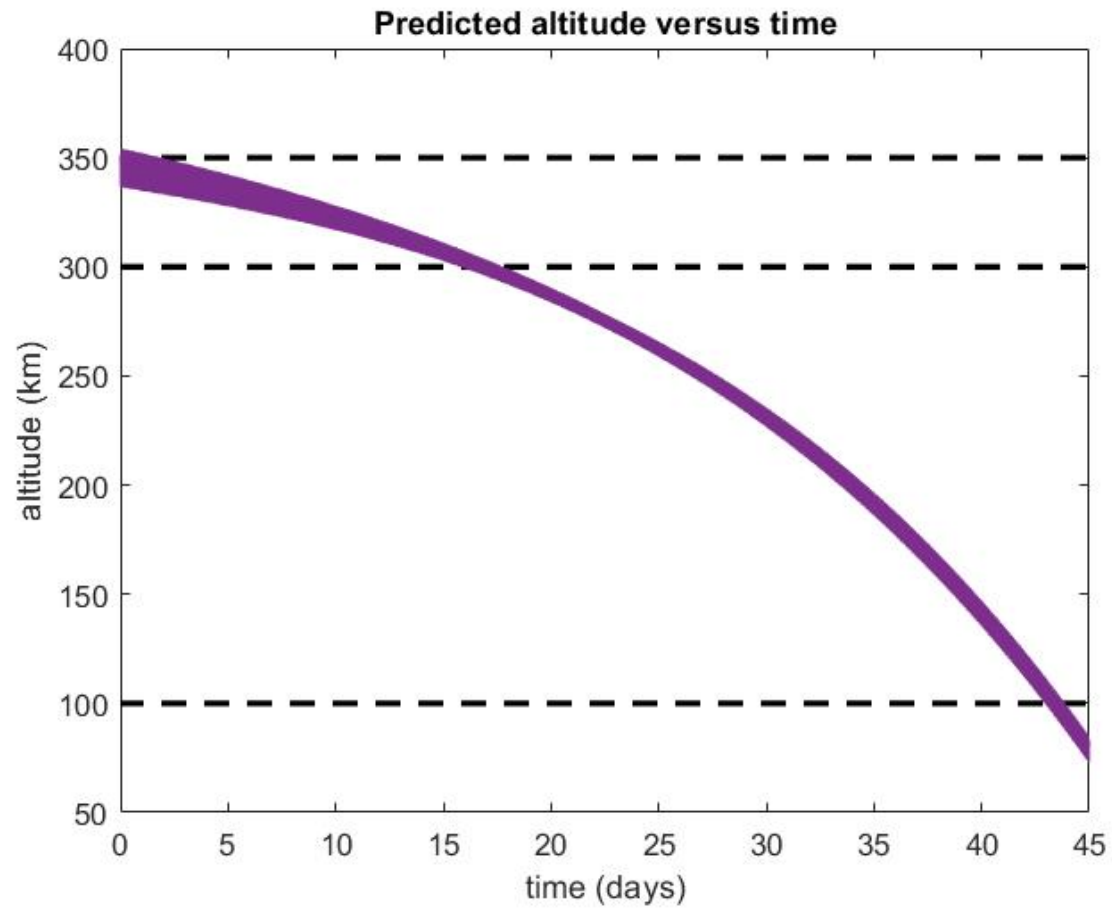


Figure 5: Altitude versus time for TECHEDSAT-10 with doubled BSTAR

- (c) What is missing from this picture is the sinusoidal nature of the altitude and any type of control system or re entry system.