

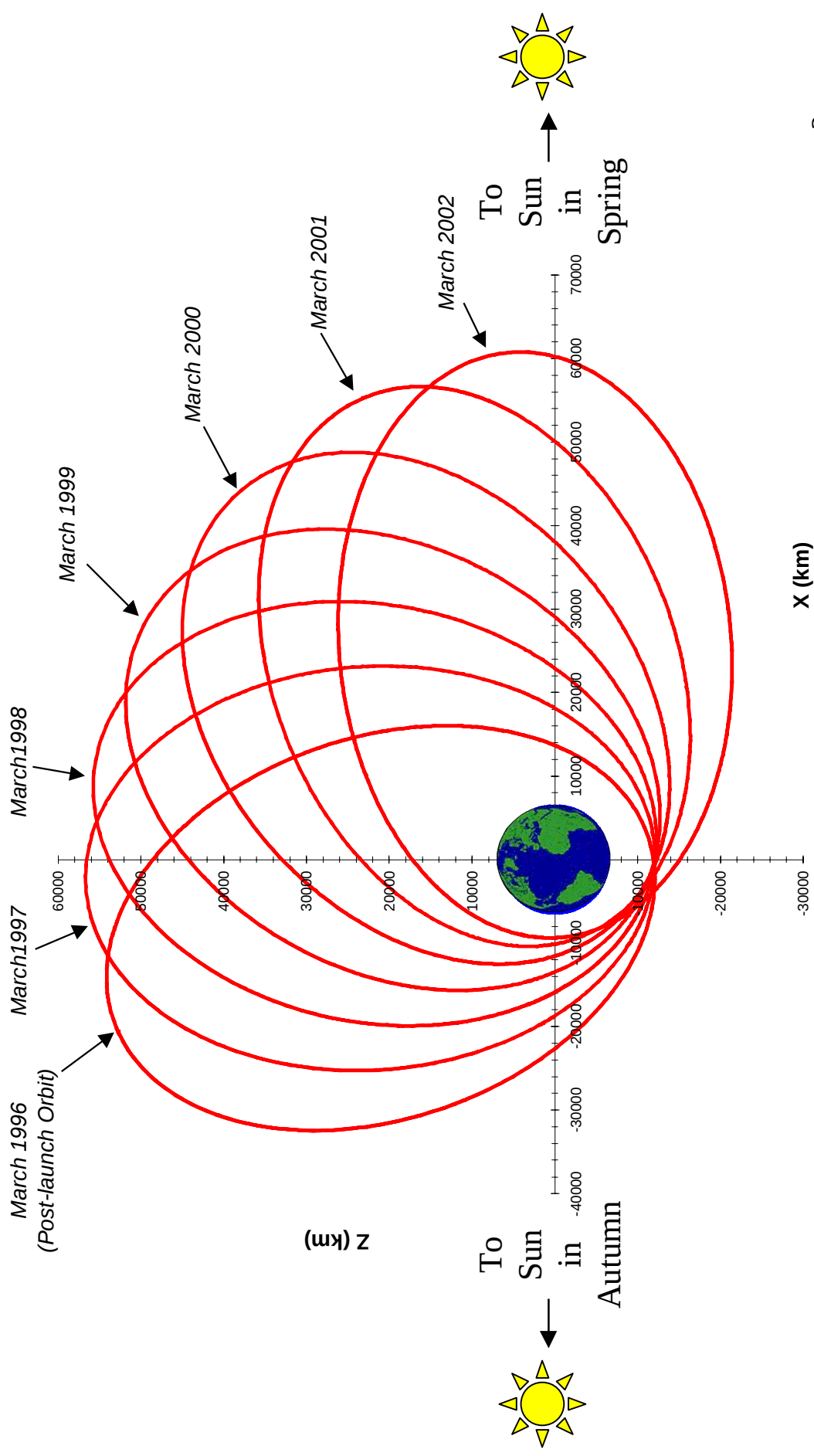
Polar Flip Maneuver Planning and Horizon Sensor Assembly (HSA) Issues

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Precession of Polar's Orbit

(Earth-centered Mean-of-J2000 Earth Equator Coordinates)



Polar Flip Maneuver Planning Strategy

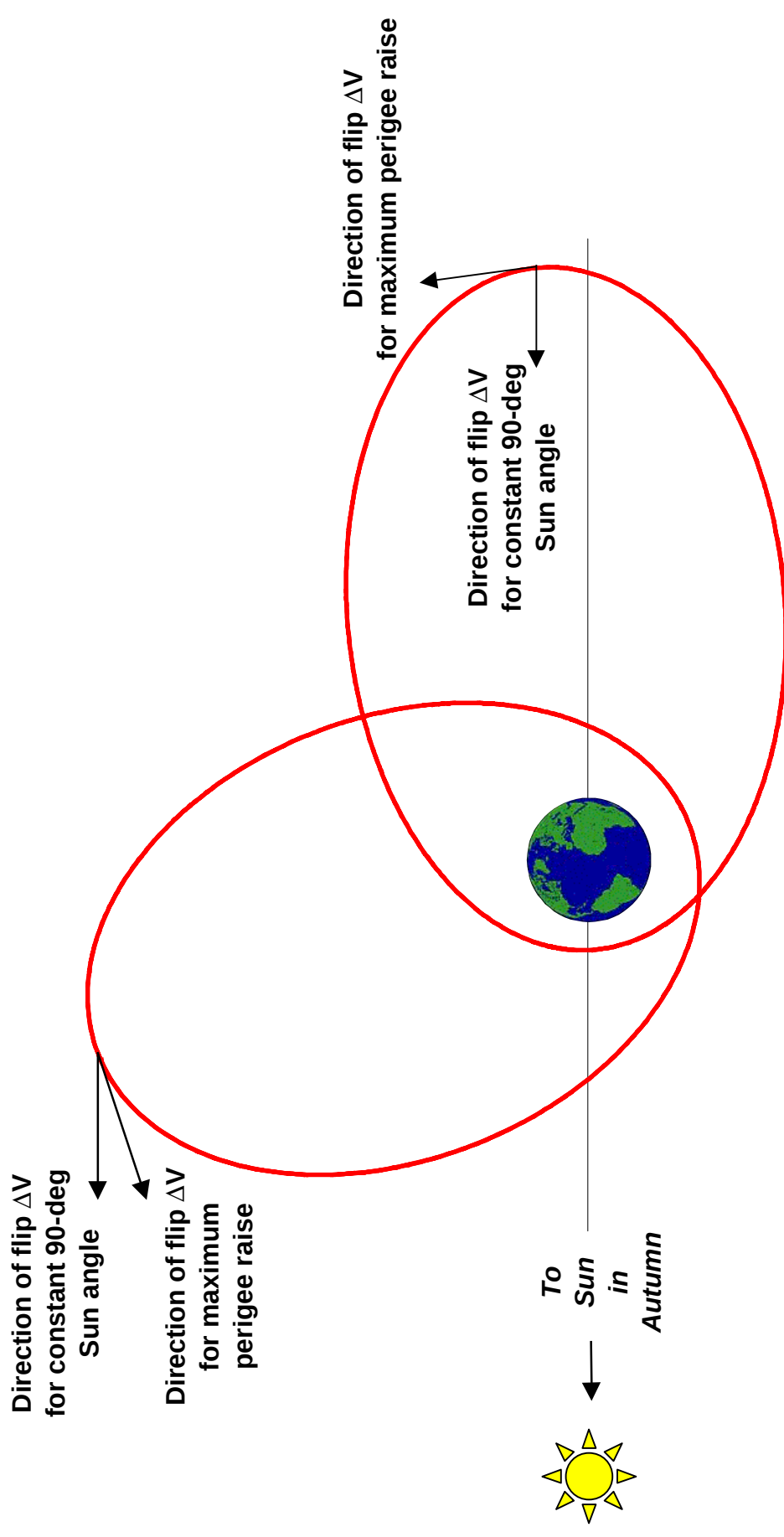
- Sun angle constraints require a semi-annual 180° reorientation of Polar's spin axis along the orbit normal/anti-normal line.
- It is a Polar mission constraint that the semi-annual flip maneuvers must be planned so that the residual ΔV raises perigee.
- The direction of the residual ΔV and the resulting effects on both perigee and apogee depend on the path of the spin axis during the flip maneuver.
- The maneuver planning strategy devised before launch considered only the nominal mission phase and did not address any changes necessary as the apogees moved away from the polar region.

Polar Flip Maneuver Planning Strategy, continued

- Previous flips were planned to maintain a constant Sun angle of approximately 90° throughout the maneuver.
 - This worked fine early in the mission, when apogees were over the North pole.
 - As the apogees have precessed toward the equator, the ΔV has moved away from the optimal direction for raising perigee.
 - The last few flips have also raised apogee, which was already being increased by lunar perturbations as the apogees moved closer to the lunar orbit plane, contributing to violations of HSA minimum Earth-width constraints.

$\Rightarrow$ A revised planning strategy is needed for Flip 12 in Fall 2001 to optimize its effect on Polar's orbit.

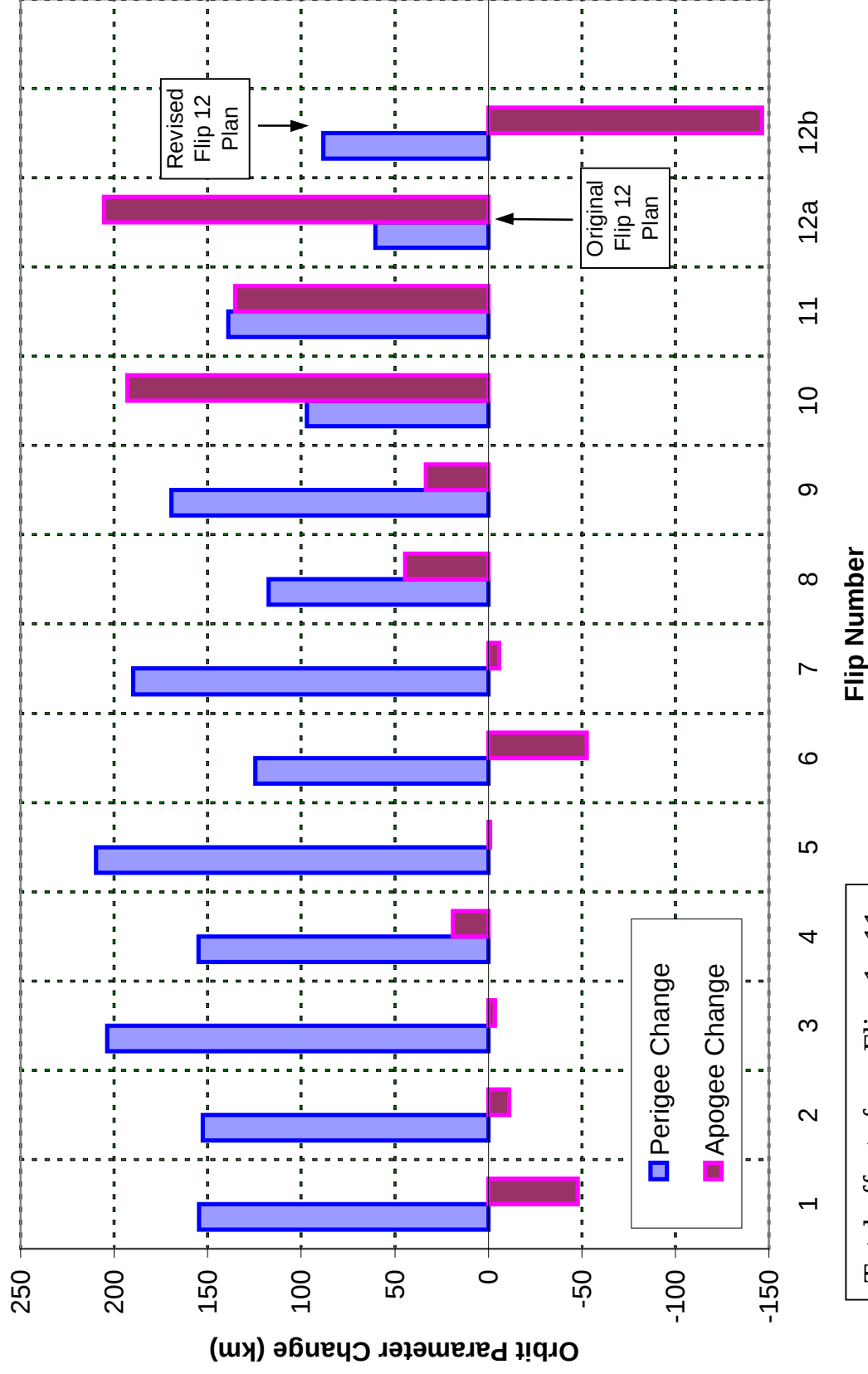
Change Since Launch in Perigee-Raising Effect of Flip Maneuvers with Constant Sun Angle



Revised Polar Flip Maneuver Planning Strategy

- Rather than holding the Sun angle constant during the flip, determine the best maneuver path in terms of orbit alteration that meets all mission constraints.
- Ideally, raise perigee while lowering apogee.
Although the flip cannot lower apogee enough to eliminate the HSA Earth width problem, we can at least try to avoid making it worse.

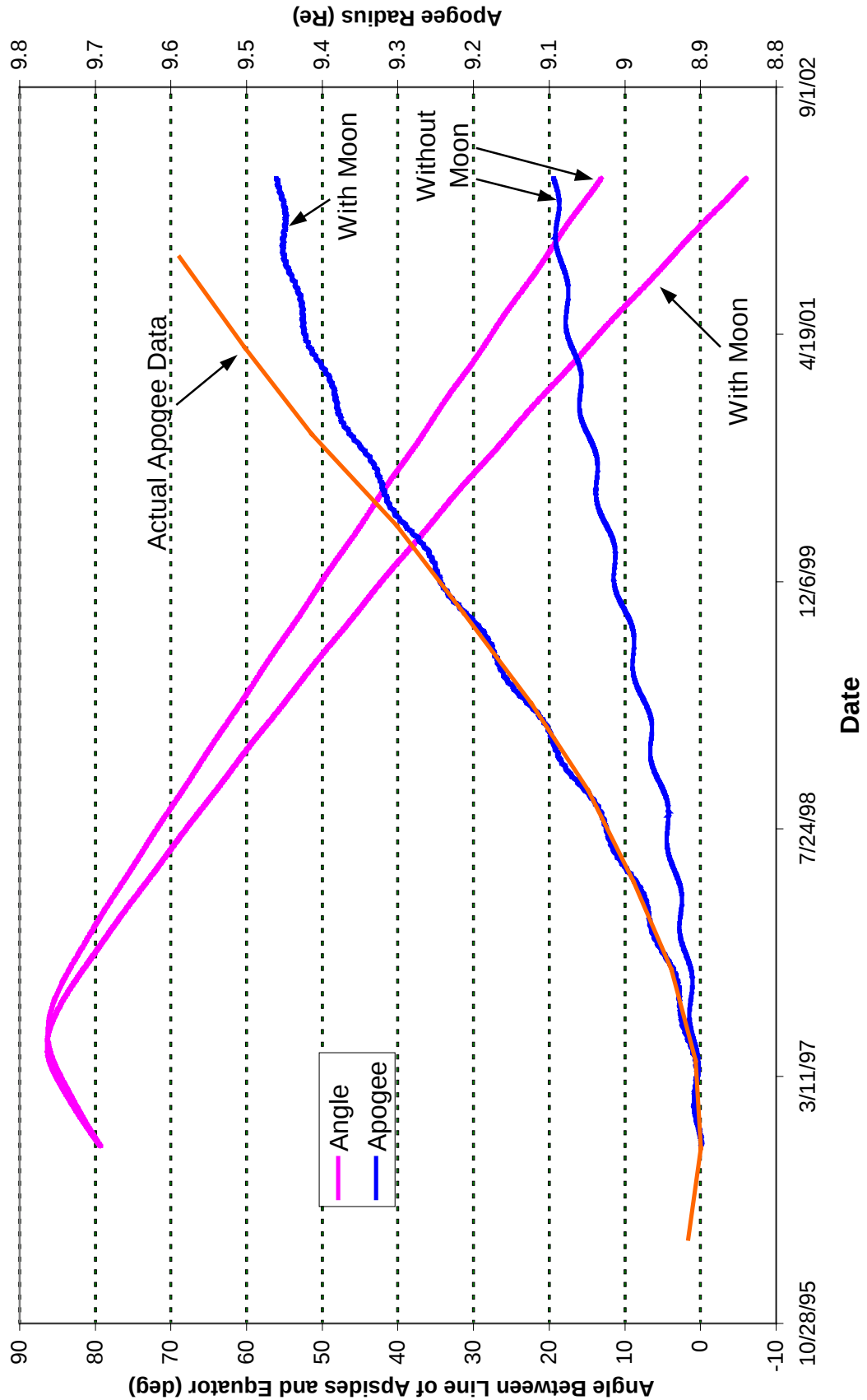
Change in Polar's Orbital Parameters Resulting from the Flip Maneuvers



Total effects from Flips 1 - 11:
 Perigee change = 1712 km
 Apogee change = 304 km

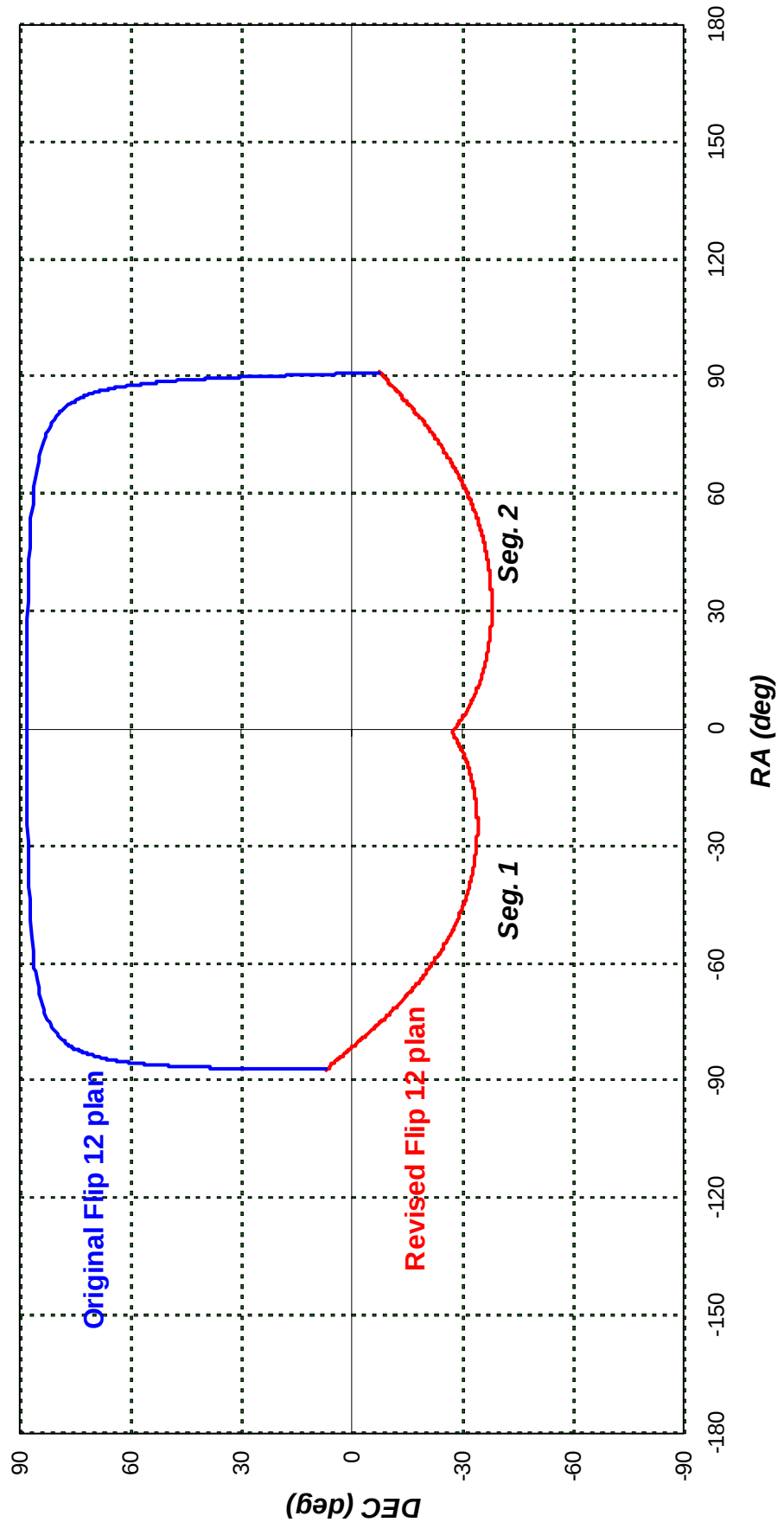
Effect of Lunar Perturbations on Polar's Apogee Evolution

(Note: Propagations were performed without modeling the effects of the flip maneuvers)

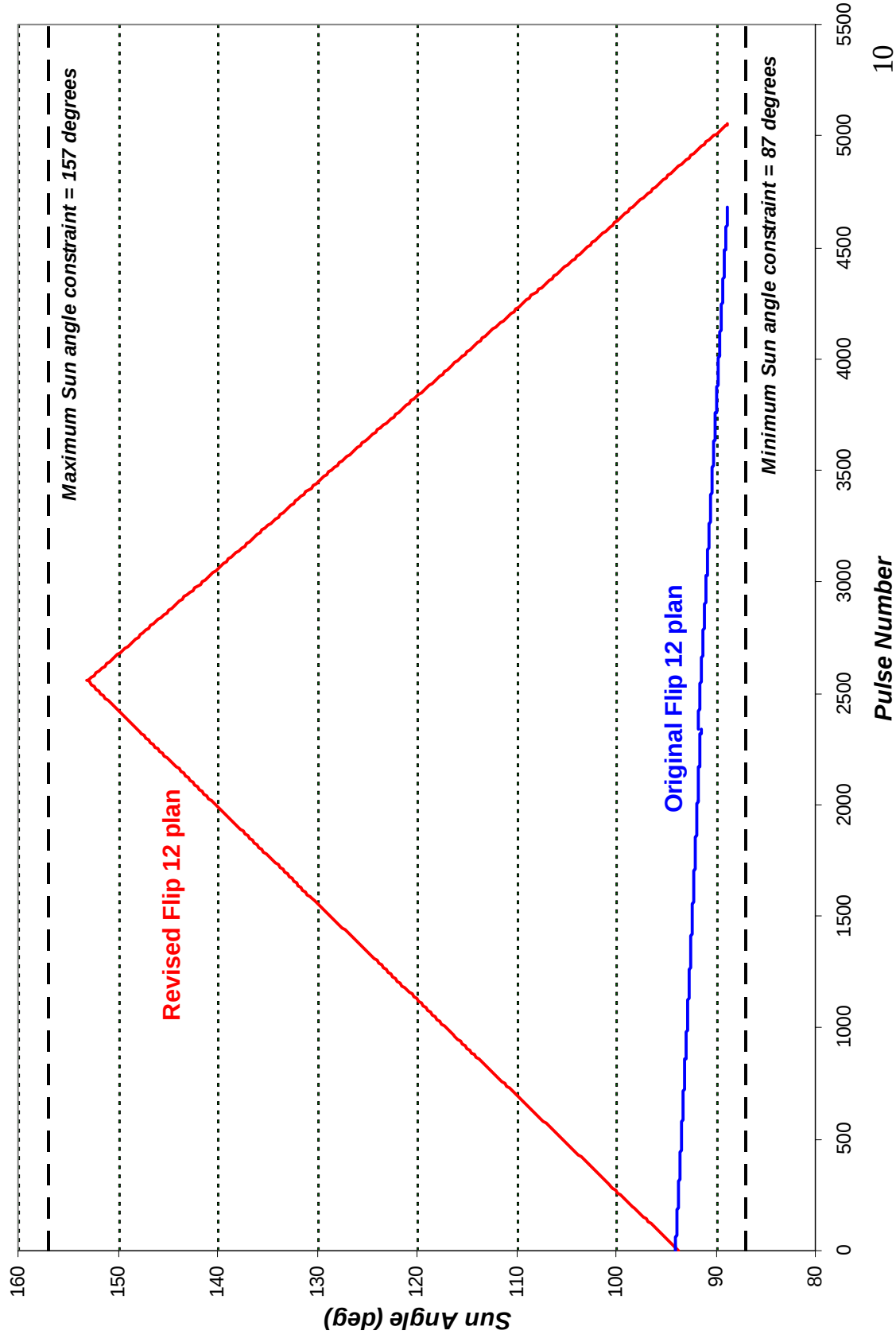


Comparison of Spin Axis Path During Flip 12

Using Old and New Planning Strategies



Comparison of Sun Angle During Flip 12 Using Old and New Planning Strategies



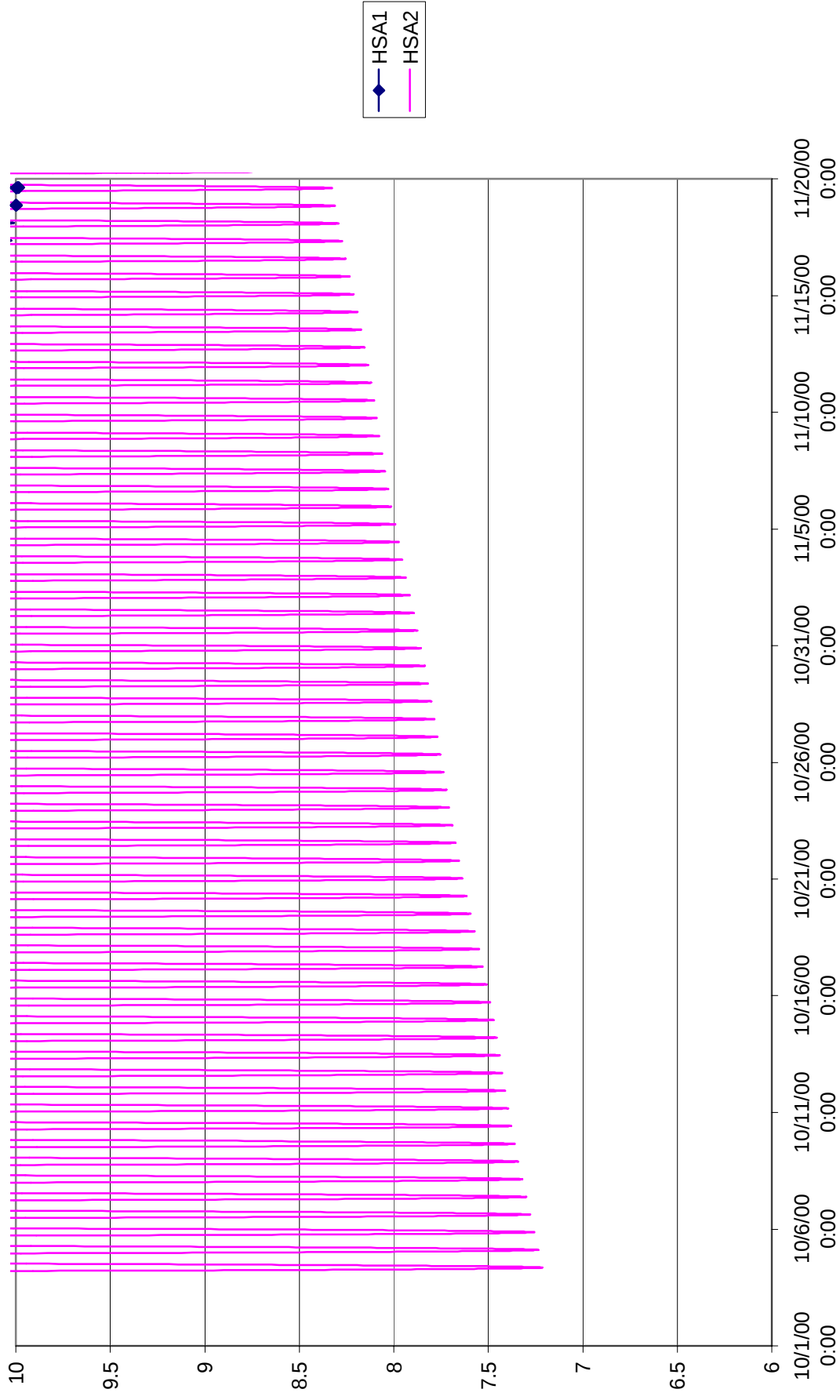
Comparison of Flip 12 Plans Using Old and New Strategies

	<i>Old Strategy</i>	<i>New Strategy</i>
<i>Number of pulses</i>	4681	5056
<i>Fuel Used</i>	14.7 lbm	15.2 lbm
<i>Perigee Change</i>	60.3 km	88.3 km
<i>Apogee Change</i>	205.3 km	-146.3 km
<i>Maximum Sun Angle</i>	91.5 deg	153.2 deg

HSA Constraint

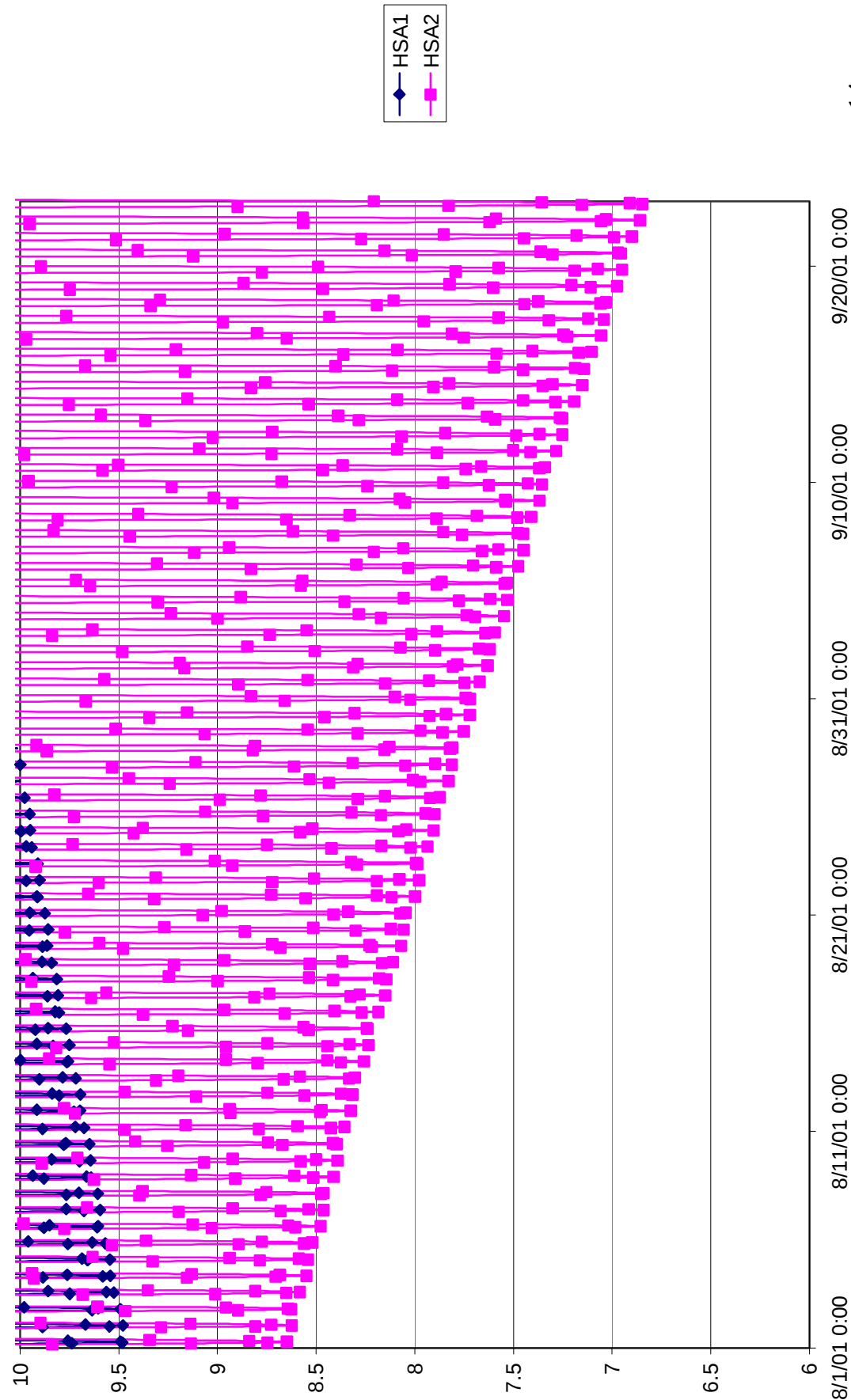
- Despun platform activity is dependent on HSA2 data. HSA1 cannot always be used for this purpose, since it's subject to Sun interference.
- The minimum Earth width constraint for the HSAs is 8° , although the Earth width has been as low as about 7.2° in the past (post-Flip 10) without incident.
- The predicted Earth width for HSA2 will go below 8° in mid- to late-August, although this is not expected to cause problems before the Flip 12 maneuver in September 2001.
- If the nominal target attitude is used for the Flip 12 maneuver, the HSA2 Earth width will be below 6° .
- By choosing a different target attitude for the flip maneuver, we can obtain an acceptable post-maneuver Earth width for both HSAs.

Predicted HSA angles Post Flip 10



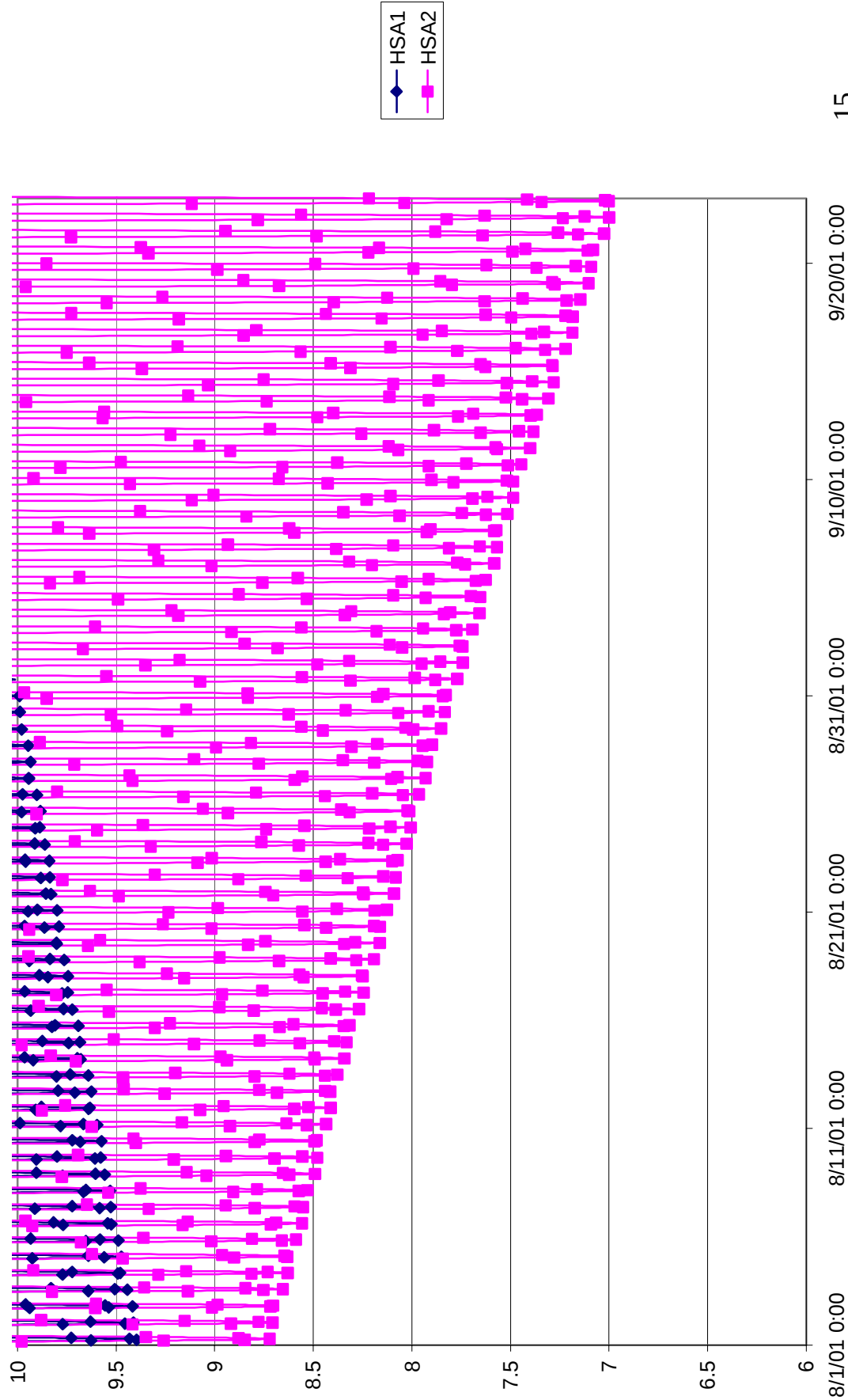
HSA Predictions Using Current Attitude

Attitude on 5/7/01: RA 272.92 DEC 7.528



HSA Predictions Using Predicted Attitude Drift Model

Predicted drift attitude: RA 272.82 DEC 7.71

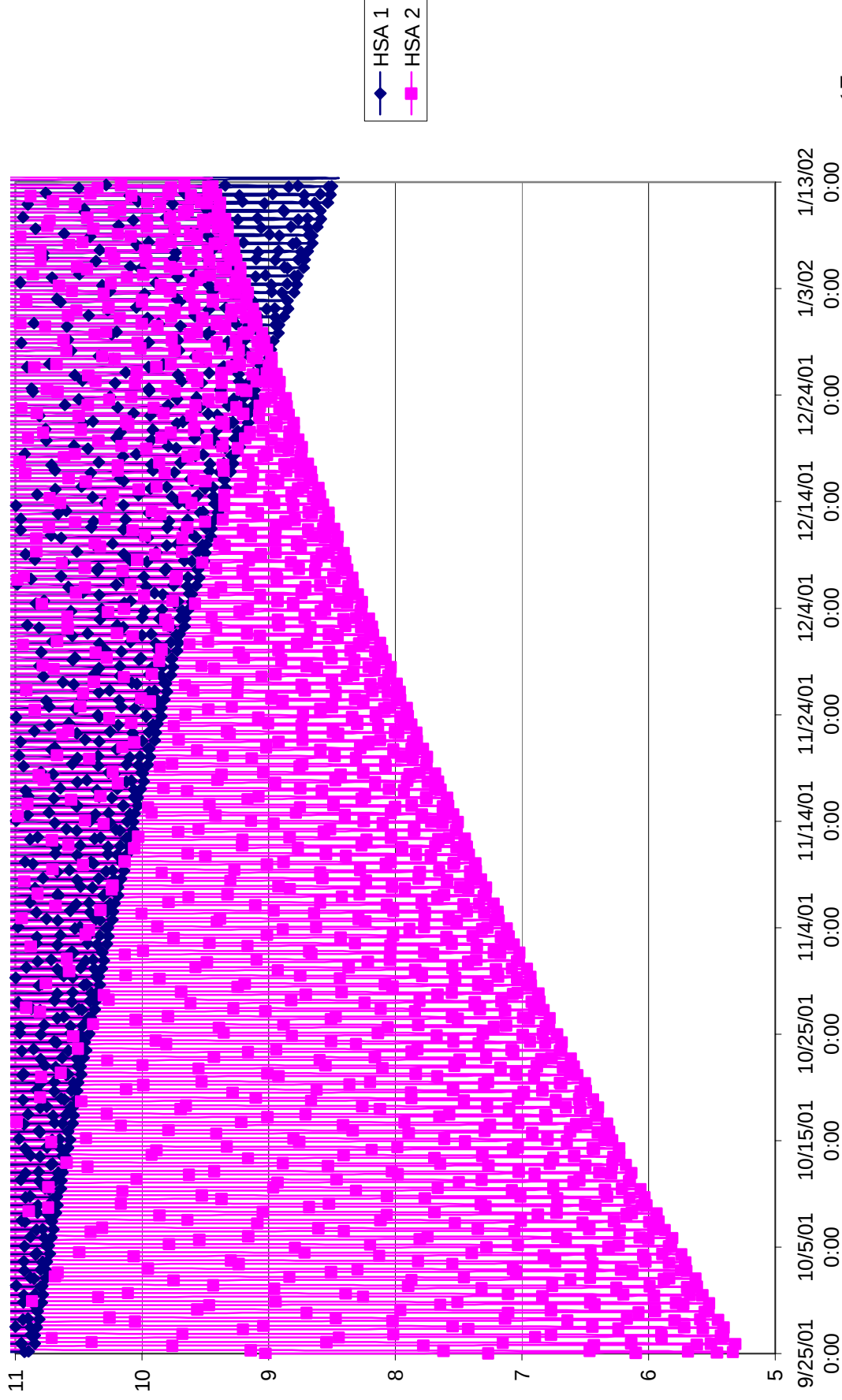


Flip 12 Target Attitude

	<u>Nominal Target</u>	<u>Revised Target</u>
<i>RA (deg)</i>	90.45	91.3
<i>DEC (deg)</i>	-7.54	-7.54
<i>HSA2 Earth width</i>		
<i>after Flip 12 (deg)</i>	5.4	7.9
<i>Difference from</i>		
<i>Negative Orbit Normal:</i>		
10/1/01	1.5	0.8
11/1/01	1.0	0.4
12/1/01	0.4	0.4
1/1/02	0.1	0.9
2/1/02	0.6	1.4
3/1/02	1.0	1.9
3/15/02	1.3	2.1

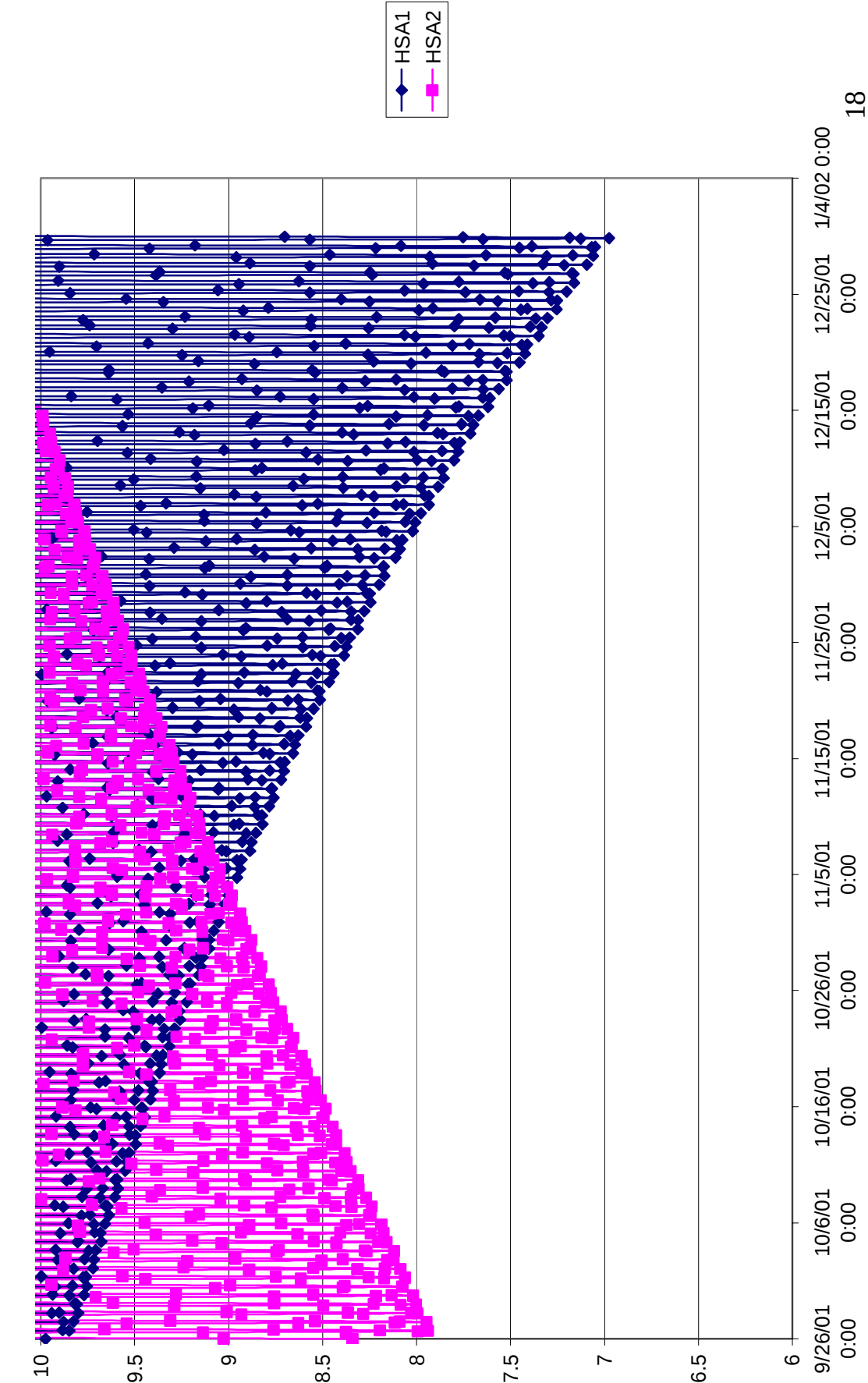
HSA Predictions with Nominal Flip 12 Target

HSA After Flip 12: RA 90.45 DEC -7.54



HSA Predictions with Revised Flip 12 Target

HSA After Flip 12: RA 91.3, DEC -7.54



POLAR Fuel Usage as Modeled by GMAN

Maneuver		Fuel Remaining in Each Tank (lbm)						Total Fuel Remaining		Total Fuel Used	
Number	Name	1	2	3	4	5	6	lbm	kg	lbm	kg
46	F8Seg1	28.5735	6.3651	28.5946	6.3343	28.5738	6.3675	104.809	47.540	7.309	3.315
47	F8Seg2	26.1355	6.3651	26.1570	6.3343	26.1359	6.3675	97.495	44.223	7.314	3.317
48	F8Att Trm	26.0502	6.3651	26.0717	6.3343	26.0506	6.3675	97.239	44.107	0.256	0.116
49	F8Spn Trm	26.0397	6.3651	26.0612	6.3343	26.0401	6.3675	97.208	44.093	0.032	0.014
50	F9Seg1	23.5954	6.3651	23.6172	6.3343	23.5959	6.3675	89.875	40.767	7.332	3.326
51	F9Seg2	21.1489	6.3651	21.1709	6.3343	21.1495	6.3675	82.536	37.438	7.339	3.329
52	F9Att Trm	21.1210	6.3651	21.1430	6.3343	21.1216	6.3675	82.453	37.400	0.084	0.038
53	F9Spn Trm	21.1069	6.3651	21.1289	6.3343	21.1075	6.3675	82.410	37.380	0.042	0.019
54	F10Seg1	18.6933	6.3651	18.7155	6.3343	18.6939	6.3675	75.170	34.096	7.241	3.284
55	F10Seg2	16.2653	6.3651	16.2876	6.3343	16.2659	6.3675	67.886	30.792	7.284	3.304
56	F10Att Trm	16.1832	6.3651	16.2055	6.3343	16.1838	6.3675	67.639	30.681	0.246	0.112
57	F10Spn Trm	16.1650	6.3651	16.1873	6.3343	16.1656	6.3675	67.585	30.656	0.055	0.025
54	F11Seg1	13.7277	6.3651	13.7501	6.3343	13.7192	6.3675	60.264	27.335	7.321	3.321
55	F11Seg2	11.2759	6.3651	11.2984	6.3343	11.2674	6.3675	52.909	23.999	7.355	3.336
56	F11Att Trm	11.2271	6.3651	11.2496	6.3343	11.2186	6.3675	52.762	23.932	0.146	0.066
57	F11Spn Trm	11.2119	6.3651	11.2344	6.3343	11.2034	6.3675	52.717	23.912	0.046	0.021
Totals: 603.35										273.67	

Fuel Budget Assuming 2.8 kg half-flips

Date	Odd (kg)	Even (kg)	Comment
4/1/01	15.2632	8.6486	Post-Flip #11 Completed
10/1/01	8.2632	8.6486	Post-Flip #12 scheduled
Date	Total (kg)		Comment
10/1/01	16.9118		Open all latch valves, combine all fuel
4/1/02	14.1118		Post-Half flip to South Ecliptic Pole (RA 90, DEC -66.56)
10/1/02	11.3118		Post-Half flip to Orbit Normal
4/1/03	8.5118		Post-Half flip to South Ecliptic Pole
10/1/03	5.7118		Post-Half flip to Orbit Normal
4/1/04	2.9118		Post-Half flip to South Ecliptic Pole
	1.5		unusable fuel remaining
	1.4118		available fuel remaining for attitude adjustments

South Ecliptic Pole HSA Predictions

TIME YYMMDD.HHMMSS	EARTH WIDTH HSA1	EARTH WIDTH HSA2	SUN-EARTH DIHEDRAL ANGLE
20020319.060000	0	0	186.701
20020319.062000	5.454	0	185.678
20020319.064000	9.551	0	184.716
20020319.070000	11.481	0	183.804
20020319.072000	12.411	0	182.932
20020319.074000	12.643	0	182.094
20020319.080000	12.276	0	181.283
20020319.082000	11.301	5.366	180.494
20020319.084000	9.574	8.815	179.721
20020319.090000	6.562	10.628	178.961
20020319.092000	0	11.623	178.21
20020319.094000	0	12.025	177.464
20020319.100000	0	11.904	176.719
20020319.102000	0	11.242	175.971
20020319.104000	0	9.926	175.218
20020319.110000	0	7.598	174.456
20020319.112000	0	1.803	173.681
20020319.114000	0	0	172.887
20020319.182000	0	0	100.927
20020319.184000	0	0	64.264
20020319.190000	0	41.079	24.223
20020319.192000	84.231	78.056	351.485
20020319.194000	0	0	309.13
20020319.200000	0	0	258.651