TOPEX/POSEIDON PROJECT
SATELLITE/ SENSORS
PERFORMANCE CHARACTERISTICS
WORKSHOP-8

MANEUVER PERFORMANCE
AND
ORBIT STATUS

RAM BHAT(NAVT)
NAVIGATION & FLIGHT MECHANICS SECTION
JET PROPULSION LABORATORY

AUGUST 10, 1999

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- GROUND TRACK MAINTENANCE REQUIREMENTS
- STATISTICAL DISTRIBUTION OF GROUND TRACKS
- VERIFICATION SITE OVERFLIGHTS
- VARIATION OF KEY ORBITAL PARAMETERS
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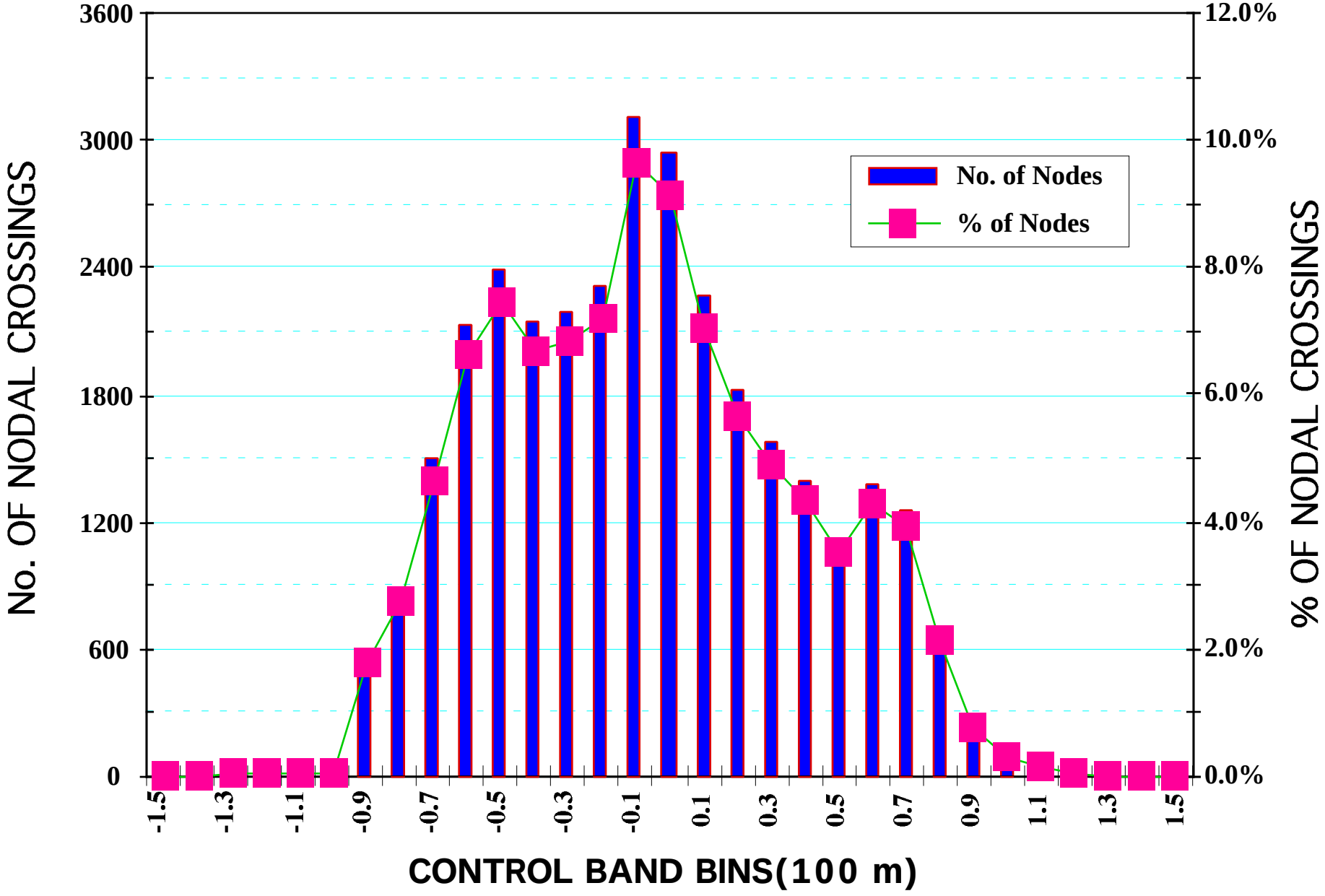
- PERFORMANCE OF MAINTENANCE MANEUVERS
- CONCLUSIONS

GROUND TRACK MAINTENANCE REQUIREMENTS

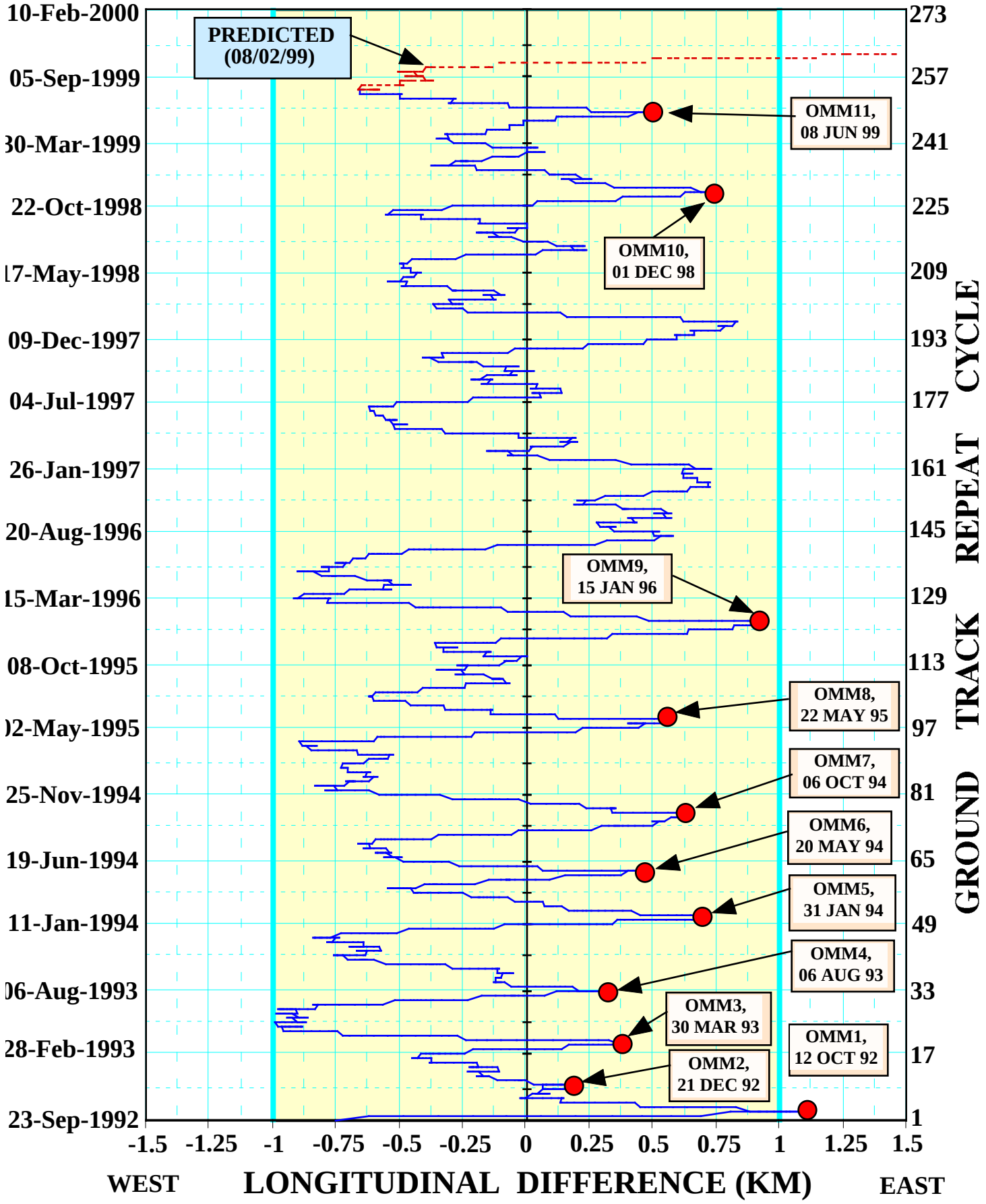
- 95 % OF ALL EQUATORIAL CROSSINGS ARE CONTAINED WITHIN A 2-km LONGITUDE BAND AT EACH ORBIT NODE
- 95 % OF ALL VERIFICATION SITE OVERFLIGHTS WITHIN 1-km ABOUT THE SITE DURING INITIAL VERFICATION PHASE (FIRST SIX MONTHS). HOWEVER, CURRENTLY THIS REQUIREMENT CONTINUED.
- MEAN VALUE OF ECCENTRICITY CONTAINED WITHIN 0.001
- MANEUVER SPACING CONSISTENT WITH POD REQUIREMENTS
- BURN OVER LAND

GROUND TRACK MAINTENANCE STATISTICS

32142 Nodes through August 06, 1999 since beginning of Cycle 1 (September 23, 1992)
99.70 % of all Nodal Crossings were within Control Band



GROUND TRACK HISTORY

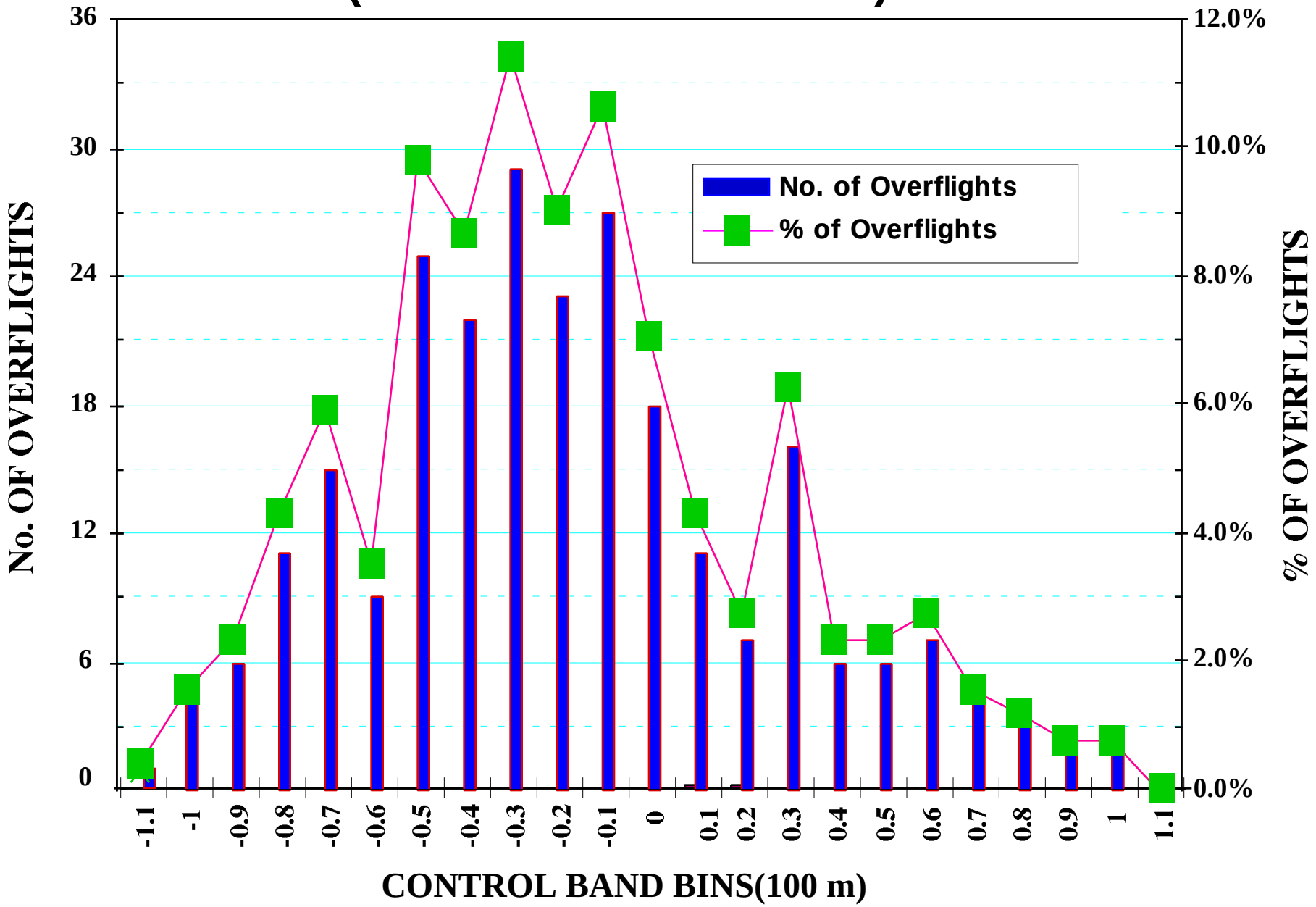


VERIFICATION SITE OVERFLIGHT MAINTENANCE

- CONTINUED TO MAINTAIN VERIFICATION SITE OVERFLIGHTS WITHIN THE CONTROL BAND
- CNES SITE WAS CLOSED ON FEBRUARY 1, 1997. CNES SITE MAINTENANCE STATISTCS ARE GIVEN UP TO THIS TIME
- CONTINUE TO MAINTAIN NASA SITE OVERFLIGHT
- FIVE NASA AND TWO CNES SITE OVERFLIGHTS WERE OUTSIDE THE CONTROL BAND. HOWEVR 95% MISSION REQUIREMENTS WERE EASILY MET
- NO VIOLATION OF NASA VERIFICATION SITE OVERFLIGHT SINCE MAY 1996

HISTOGRAM OF NASA SITE OVERFLIGHTS

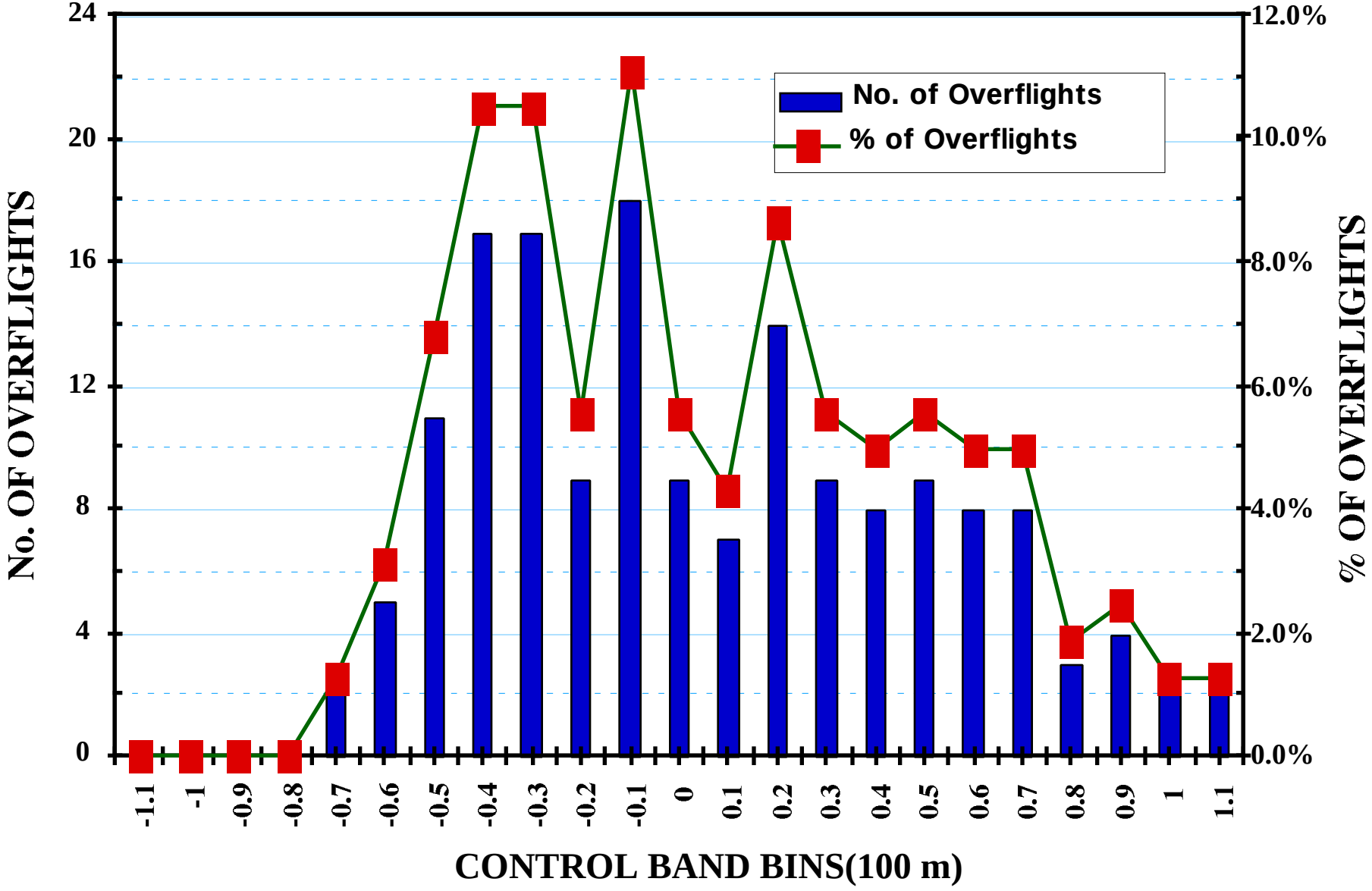
(CYCLE 1 to CYCLE 254)



HISTOGRAM OF CNES SITE OVERFLIGHTS

(CYCLE 1 to CYCLE 162)

(CNES SITE CLOSED ON FEB. 1, 1997)



VERIFICATION SITE OVERFLIGHTS

THE FOLLOWING VERIFICATION SITE OVERFLIGHTS ARE OUTSIDE CONTROL BAND.

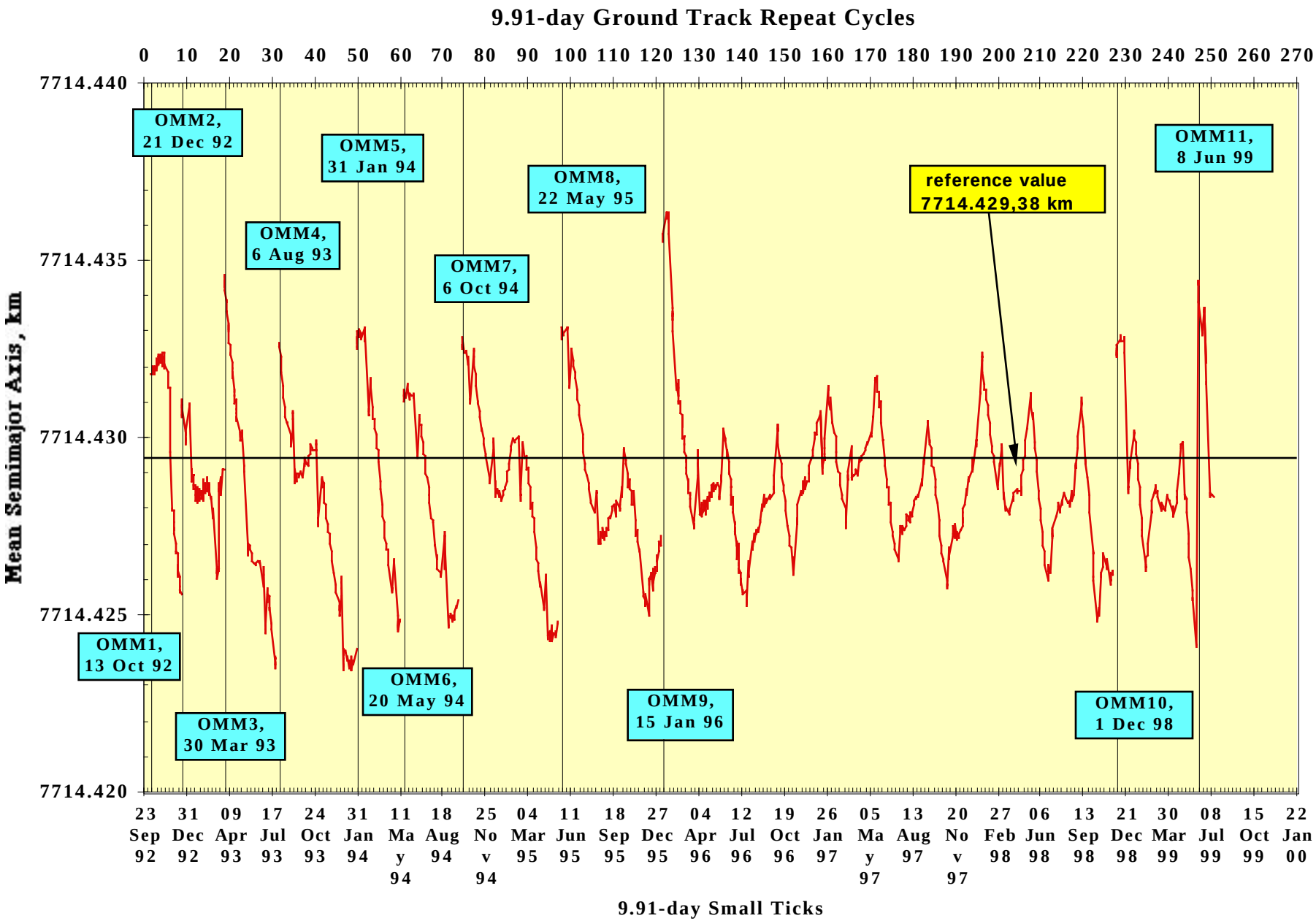
NASA

DATE	TIME	OVERFLIGHT DISTANCE FROM SITE (KM)
24 - SEP - 1992	19: 39: 17	- 1.00756
17 - MAR - 1996	00: 30: 20	- 1.07655
26 - MAR - 1996	22: 28: 52	- 1.10241
05 - APR - 1996	20: 27: 24	- 1.00852
15 - MAY - 1996	12: 21: 30	- 1.02652

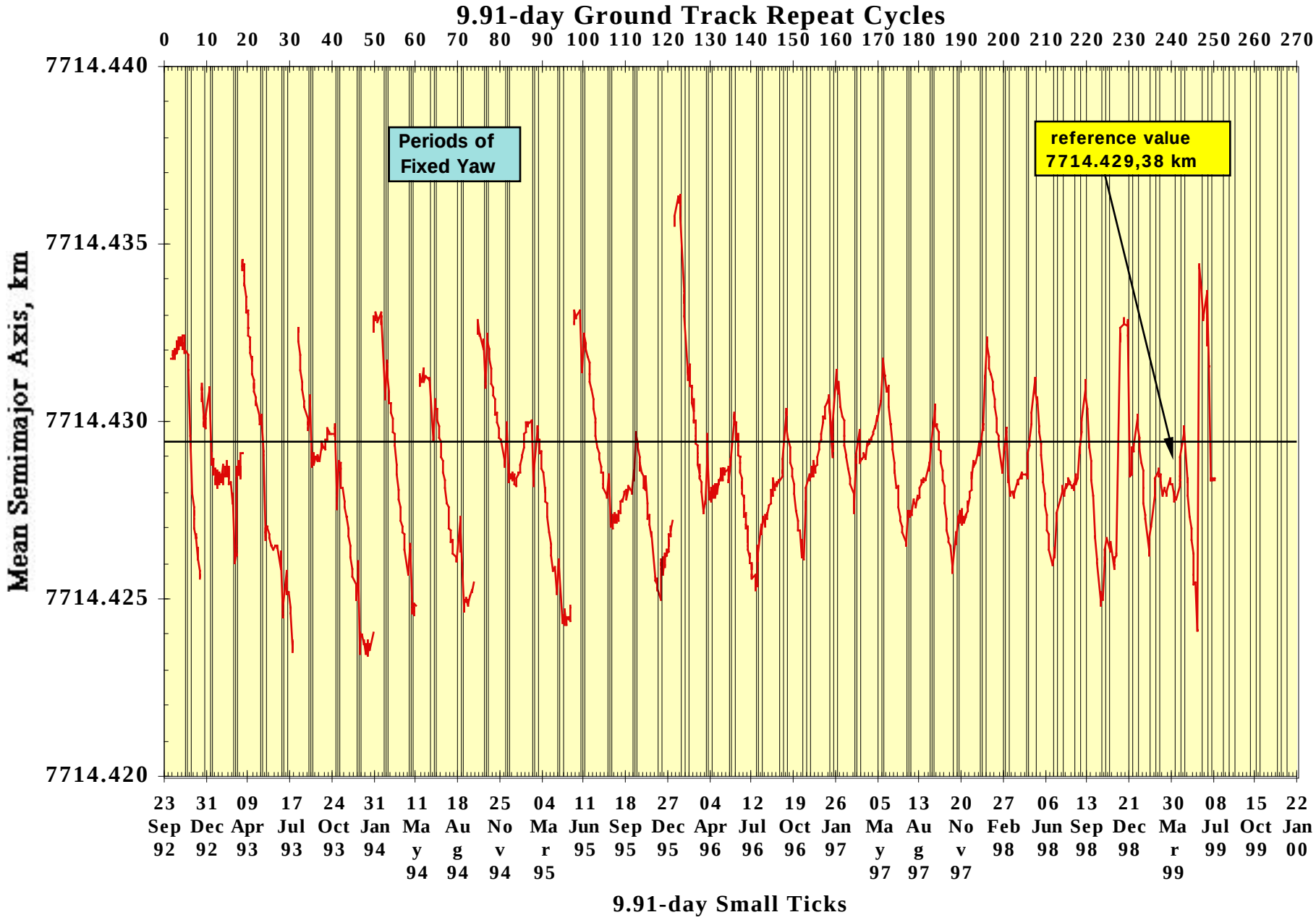
CNES

28 - SEP - 1996	09: 20: 32	1.07145
25 - JAN - 1997	09: 02: 51	1.05976

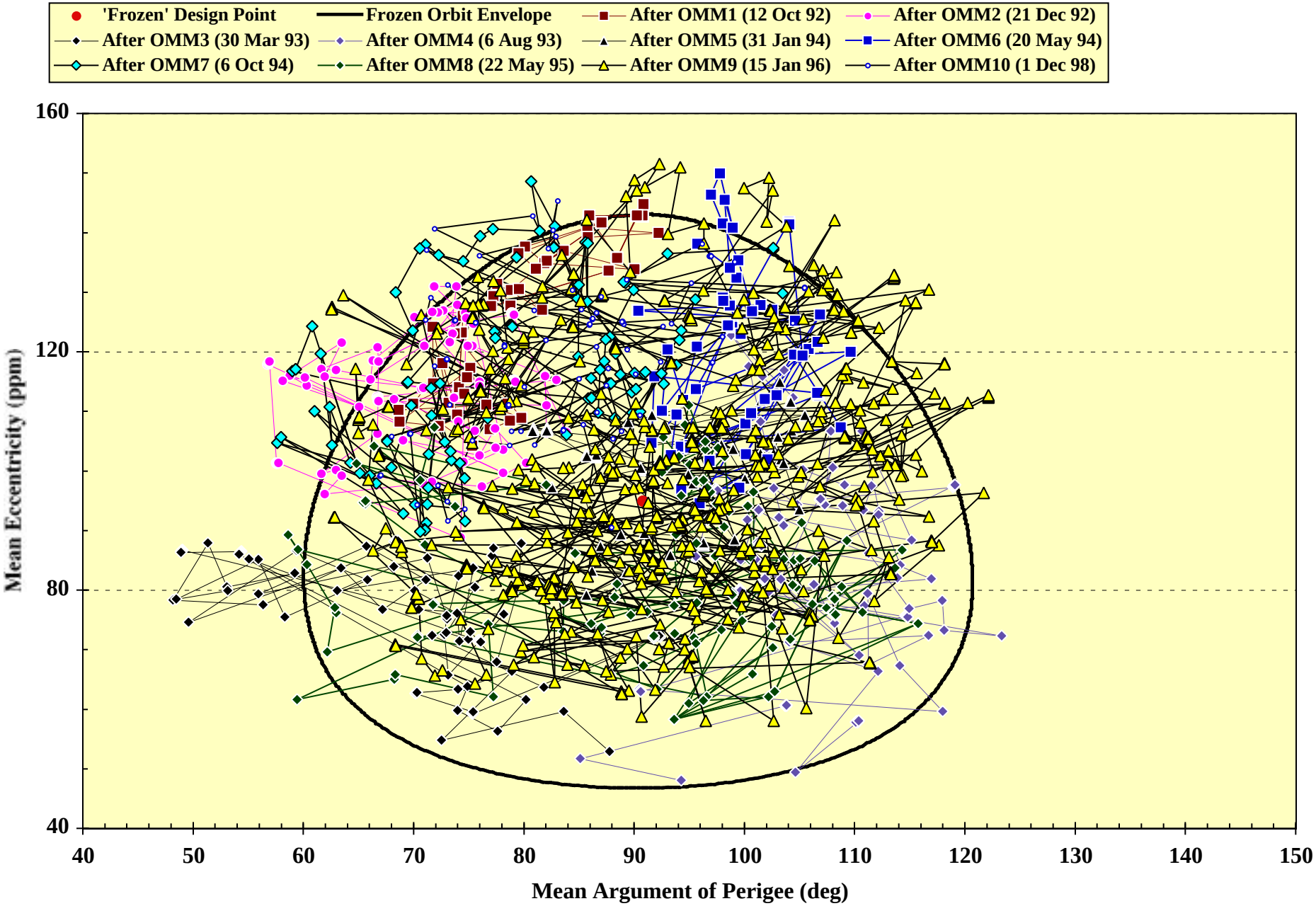
Mean Semimajor Axis History
Showing OMMs (as of 16 July '99)



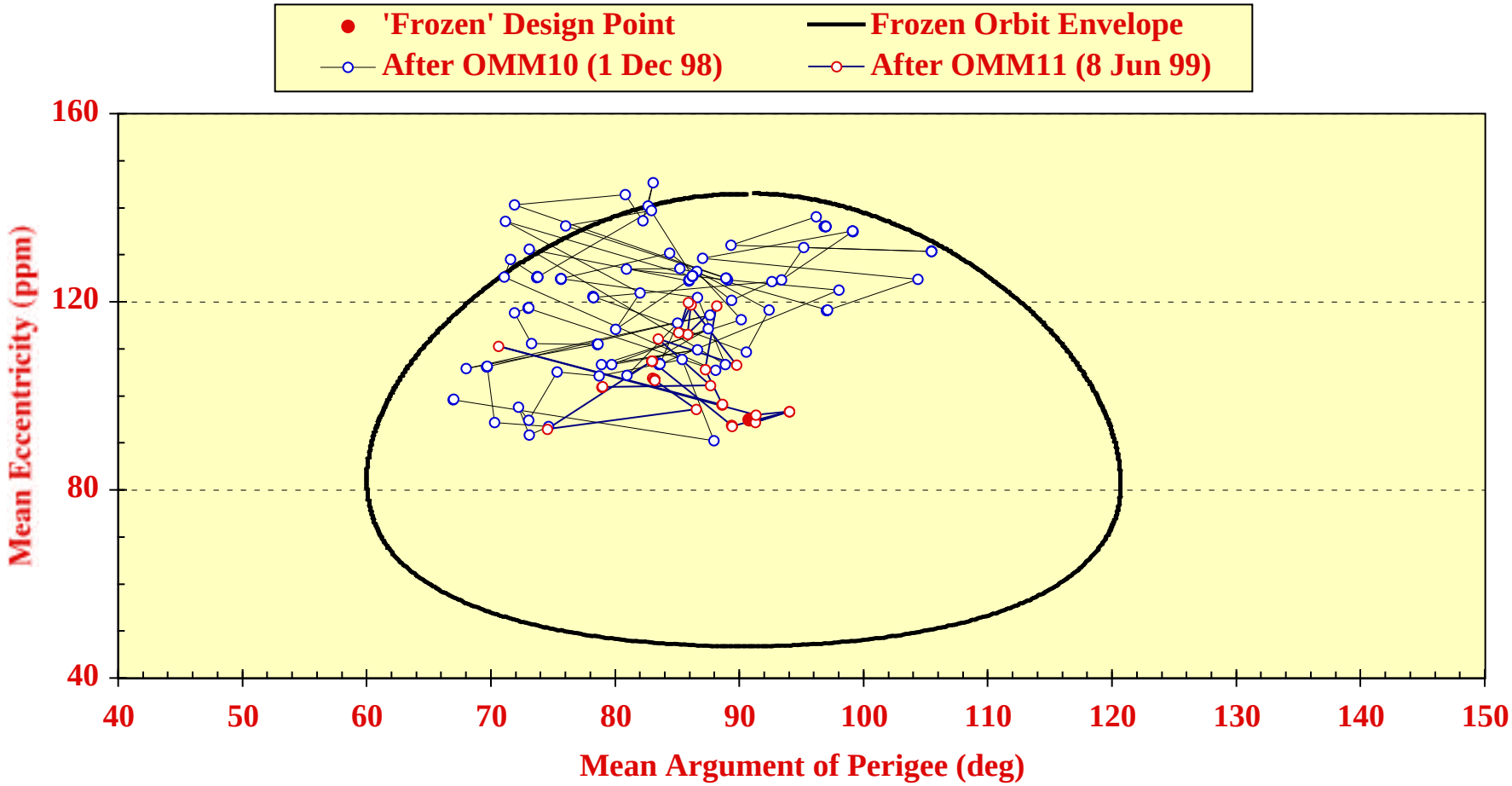
Mean Semimajor Axis History Showing Fixed Yaw Periods
(as of 16 July '99)



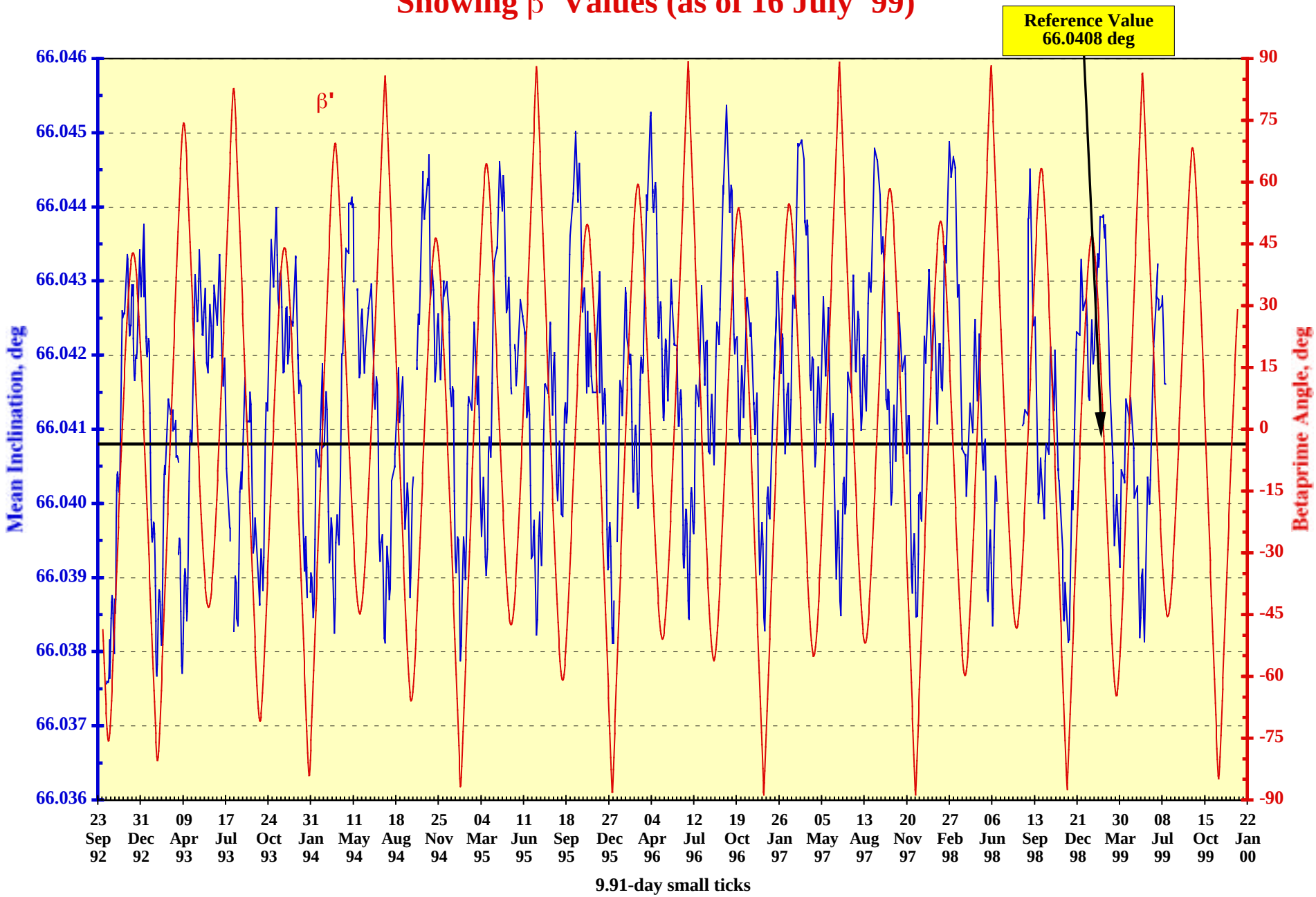
Mean Eccentricity Vector
(as of 8 June '99)



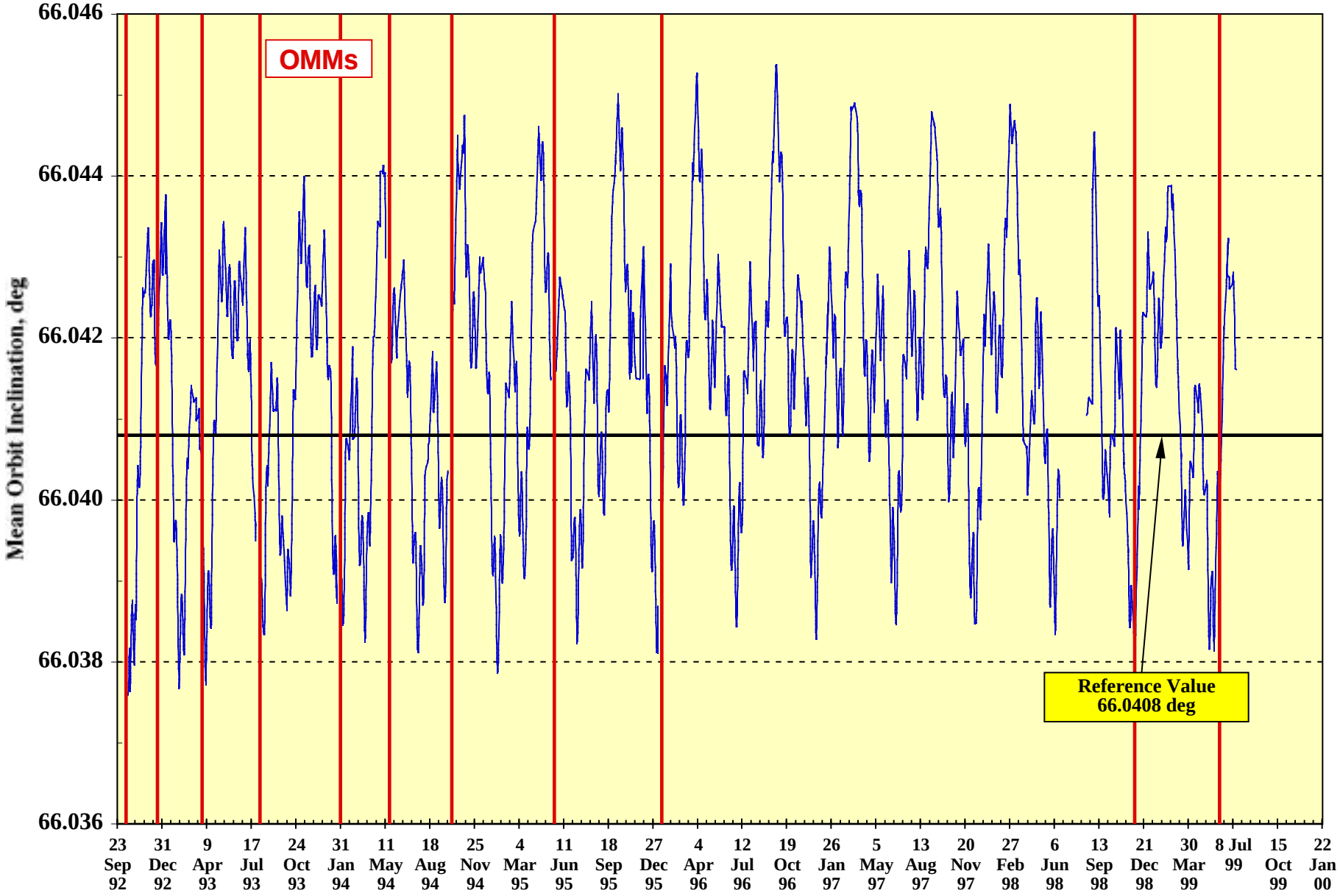
Mean Eccentricity Vector
(as of 16 July '99)



Mean Inclination History
Showing β' Values (as of 16 July '99)



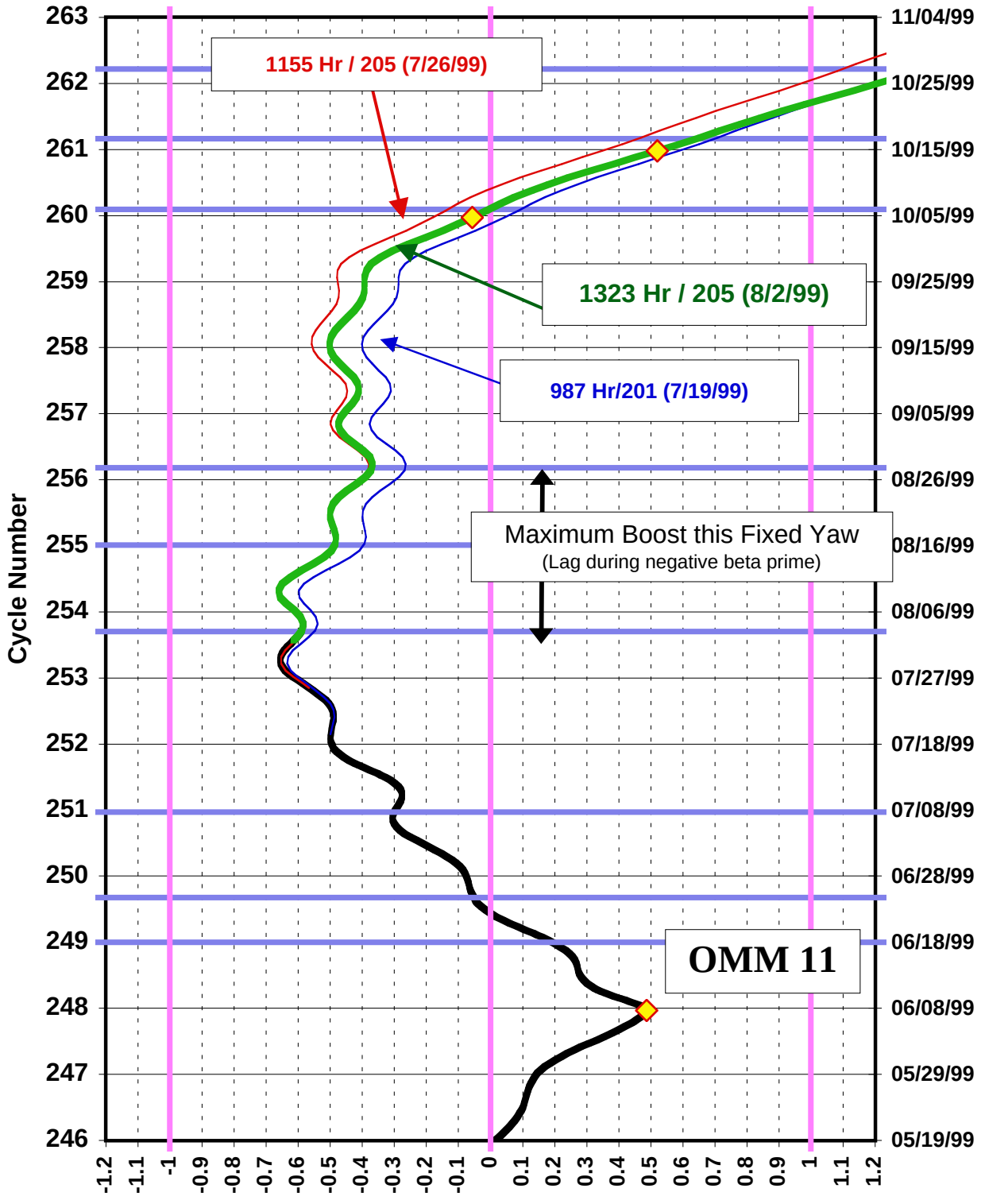
Mean Inclination History
Showing OMMs (as of 16 July '99)



LEAD/LAG STRATEGY

- FULL AND PARTIAL LEAD/LAG STRATEGIES DURING FIXED YAW PERIODS CONTINUED TO BE USED TO MAXIMIZE MANEUVER SPACING
- FIXED YAW PERIODS STANDARDIZED AND USES -30 deg TO +30 deg OF BETA PRIME. VARIATION TO THIS DONE ONLY IF NEEDED DUE TO SATELLITE AND OPERATIONAL CONSIDERATIONS.
- DUAL SOLAR ARRAY PITCH BIAS STRATEGY BEING FOLLOWED SINCE AUGUST 1998 TO ACCOMMODATE BATTERY MANAGEMENT CONCERNS. SOALR ARRAY PITCH BIAS IS 48.5 deg DURING YAW STEERING AND 42.5 deg DURING FIXED YAW PERIODS. THIS STARTEGY RELATIVELY INCREASED ORBITAL BOOST APPLIED BY LEAD/LAG STRATEGIES.
- DURING RECENT SOLAR MINIMUM THESE BOOST FORCES MORE THAN ENOUGH TO OFFSET DRAG AND THEY ALONE CONTROLLED GROUND TRACK FOR NEARLY THREE YEARS WITHOUT A PROPULSIVE MANEUVER (OMM9 to OMM10).
- NOW SOLAR ACTIVITY INCREASING TOWARD EXPECTED PEAK IN EARLY 2001(FEB.) DRAG FORCES BECOMING DOMINANT FORCES REDUCING INFLUENCE OF LEAD/LAG STRATEGIES. STILL THESE STRATEGIES WILL CONTINUE TO BE USED TO INCREASE MANEUVER SPACING.
- MANEUVER SPACING OF THE ORDER OF SIX MONTHS (OMM10 TO OMM11) ACCOMPLISHED USING LEAD/LAG STRATEGIES EVEN IN PRESENCE OF HIGHER SOLAR ACTIVITY (SOL. AVG. FLUX 140-180).
- OMM11 IMPLEMENTED ON JUNE 8, 1999 AND NEXT MANEUVER EXPECTED AROUND MID OCTOBER 1999.

Predicted and Observed Ground Track



* Highly Speculative Lag Strategy

8/3/99 7:43 AM

SUMMARY OF ORBIT MAINTENANCE MANEUVERS

OMM	DATE	CENTROID TIME (UTC)	ORBIT No.	CYCLE BOUND.	MAN. SPACING (DAYS)
OMM1	10/12/92	23:13:00	807	2/3	—
OMM2	12/21/92	09:03:00	1696	9/10	70
OMM3	03/30/93	12:44:00	2966	19/20	99
OMM4	08/06/93	10:01:00	4617	32/33	129
OMM5	01/31/94	20:50:30	6902	50/51	178
OMM6	05/20/94	23:52:00	8300	61/62	109
OMM7	10/06/94	18:13:00	10077	75/76	139
OMM8	05/22/95	22:03:00	13000	98/99	226
OMM9	01/15/96	19:10:42	16046	122/123	238
OMM10	12/01/98	20:36:40	29508	228/229	1051
OMM11	06/08/99	07:11:00	31922	247/248	189

MANEUVER PERFORMANCE

(Thruster Used - Two 1-N (A4, C4) for all OMMs)

OMM	DATE	IDEAL ΔV (mm/s)	ACHIEVED ΔV (mm/s) (NAVT)	ACHIEVED ΔV (mm/s) (FDF)	DIFFERENCE (%) (ACH.- IDEAL)
OMM1	OCT 12, 92	9.100	9.431	9.425	+3.64
OMM2	DEC 21, 92	3.200	3.153	3.151	-1.47
OMM3	MAR 30, 93	4.676	4.617	4.610	-1.26
OMM4	AUG 06, 93	4.620	4.611	4.611	-0.20
OMM5	JAN 31, 94	4.000	4.116	4.102	+2.90
OMM6	MAY 20, 94	3.150	3.123	3.123	-0.78
OMM7	OCT 06, 94	3.150	3.146	3.162	-0.21
OMM8	MAY 22, 95	3.860	3.832	3.832	-0.78
OMM9	JAN 15, 96	2.500	3.652	N. A.	+46.00
OMM10	DEC 01, 98	3.100	2.877	2.935	-7.19
OMM11	JUN 08, 99	5.200	5.021	5.014	-3.52

CONCLUSIONS

- GROUND TRACK AND ORBIT MAINTENANCE STATUS WELL WITHIN MISSION REQUIREMENTS. VERIFICATION SITE OVERFLIGHTS REQURIREMENTS CONTINUED TO BE MET
- OMM10 AND OMM11 IMPLEMENTED SINCE WORKSHOP #7
- TOPEX AUTONOMOUS MANEUVER EXPERIMENT(TAME) SUCCESSFULLY CONDUCTED VIA OMM10 ON DEC. 1, 1998.
- ANOMALOUS FORCE CONTINUES TO BE UNCERTAIN FORCE. HOWEVER ITS INFLUENCE BECOMING LESS THAN DRAG UNCERTAINTIES.
- LEAD/LAG STRATEGIES CONTINUE TO BE USED TO MAXIMIZE MANEUVER SPACING EVEN DURING PRESENCE OF HIGHER SOLAR ACTIVITY.
- STANDARDIZED FIXED YAW AT MAXIMUM ALLOWABLE BETA PRIME LIMITS ARE BEING USED TO EASE SEQUENCE GENERATION PROCESS.
- OMM12 EXPECTED AROUND MID OCTOBER 1999.