HUBBLE SPACE TELESCOPE

G. Nurre, NASA/Marshall Space Flight Center

The Hubble Space Telescope will employ magnetic torque controllers, which make use of the earth's magnetic field augmented by four reaction wheels. DC torques are easily allowed for, but variations, orbit by orbit, can result in excessive wheel speeds which can excite vibratory modes in the telescope structure. If the angular momentum from aerodynamic sources exceeds its allocation of 100 Nms, the excess has to come out of the maneuvering budget since the total capacity of the momentum storage system is fixed at 500 Nms. This would mean that maneuvers could not be made as quickly, and this would reduce the amount of science return.

In summary, there is a definite need for a model that accurately portrays short term (within orbit) variations in density for use in angular momentum management analyses. It would be desirable to have a simplified model that could be used for planning purposes; perhaps applicable only over a limited altitude range (400-700 km) and limited latitude band.

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THE EFFECTS OF ATMOSPHERIC DENSITY ON THE ST PCS

ST PCS DESCRIPTION

EFFECTS OF THE EARTH'S ATMOSPHERE

RECOMMENDATIONS FOR DENSITY MODELING

THE EFFECTS OF ATMOSPHERIC DENSITY ON THE ST PCS

ST PCS REQUIREMENTS

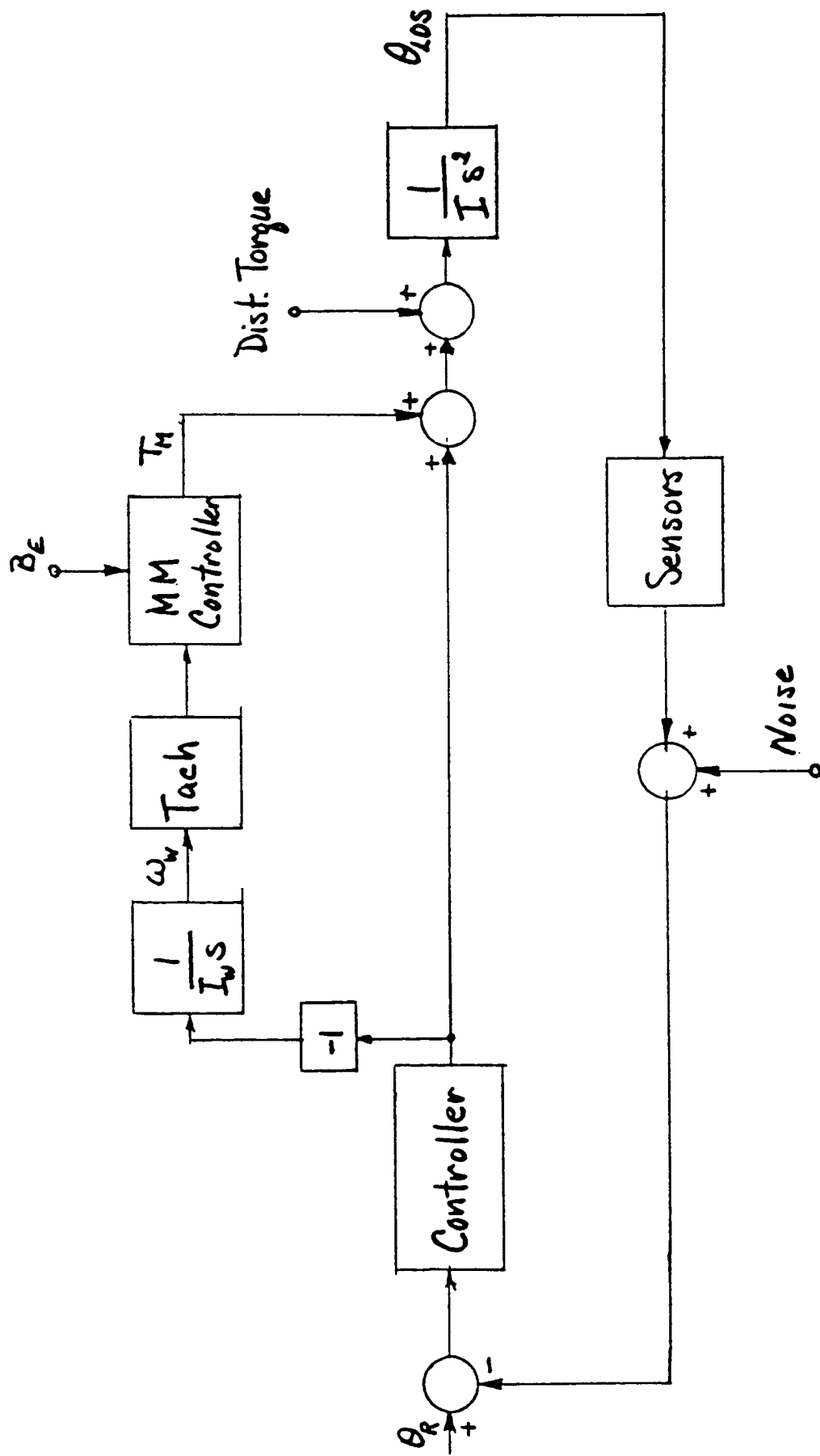POINTING STABILITY   0.007 $\hat{s}$ RMS

POINTING ACCURACY   0.01 $\hat{s}$ (1σ)

MANEUVER 90° IN 20 MINUTES
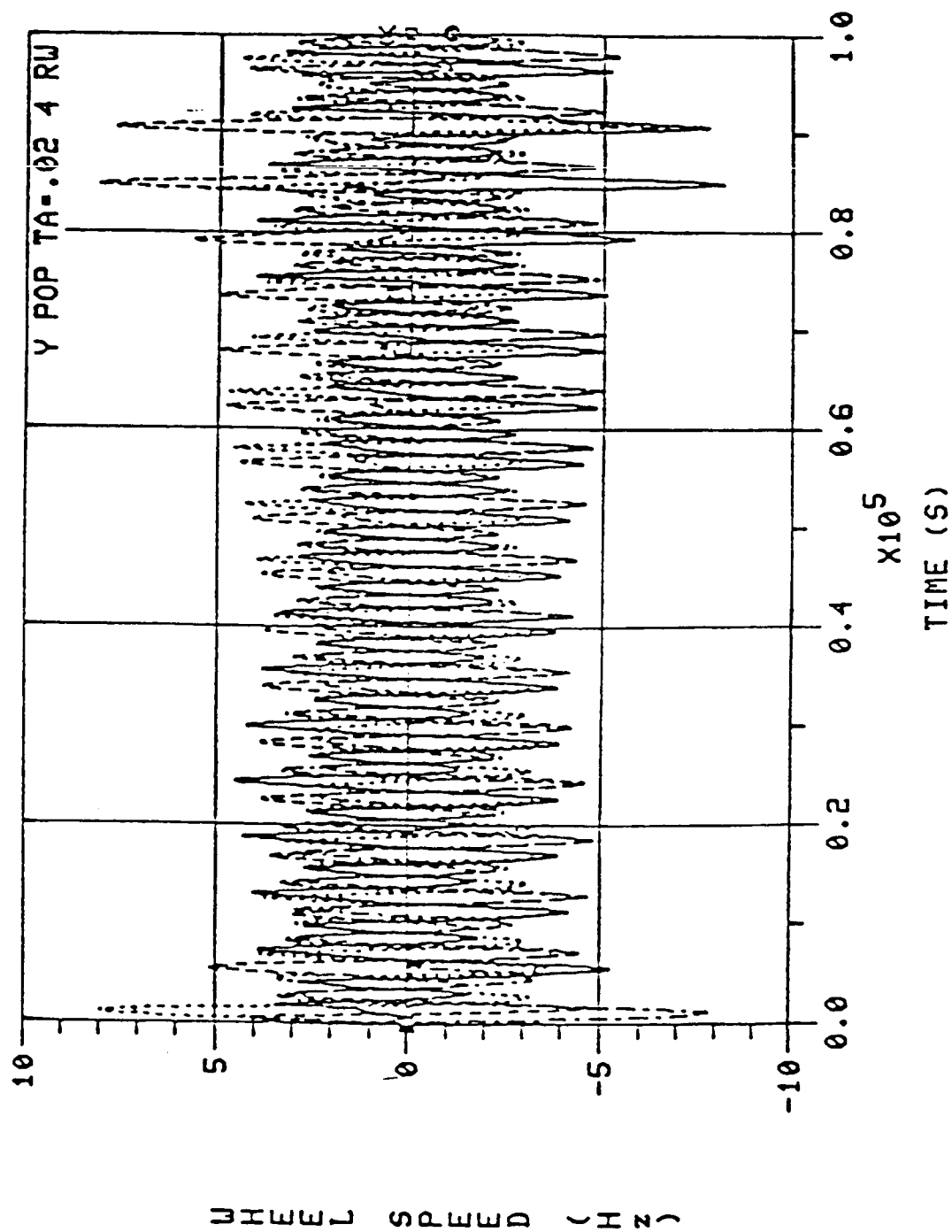
AUTONOMOUS OPERATION

INITIAL ORBITAL ALTITUDE - 593 KM

LAUNCH DATE AUGUST-SEPTEMBER 1986

ST POINTING SYSTEM

THE EFFECTS OF ATMOSPHERIC DENSITY ON THE ST PCS

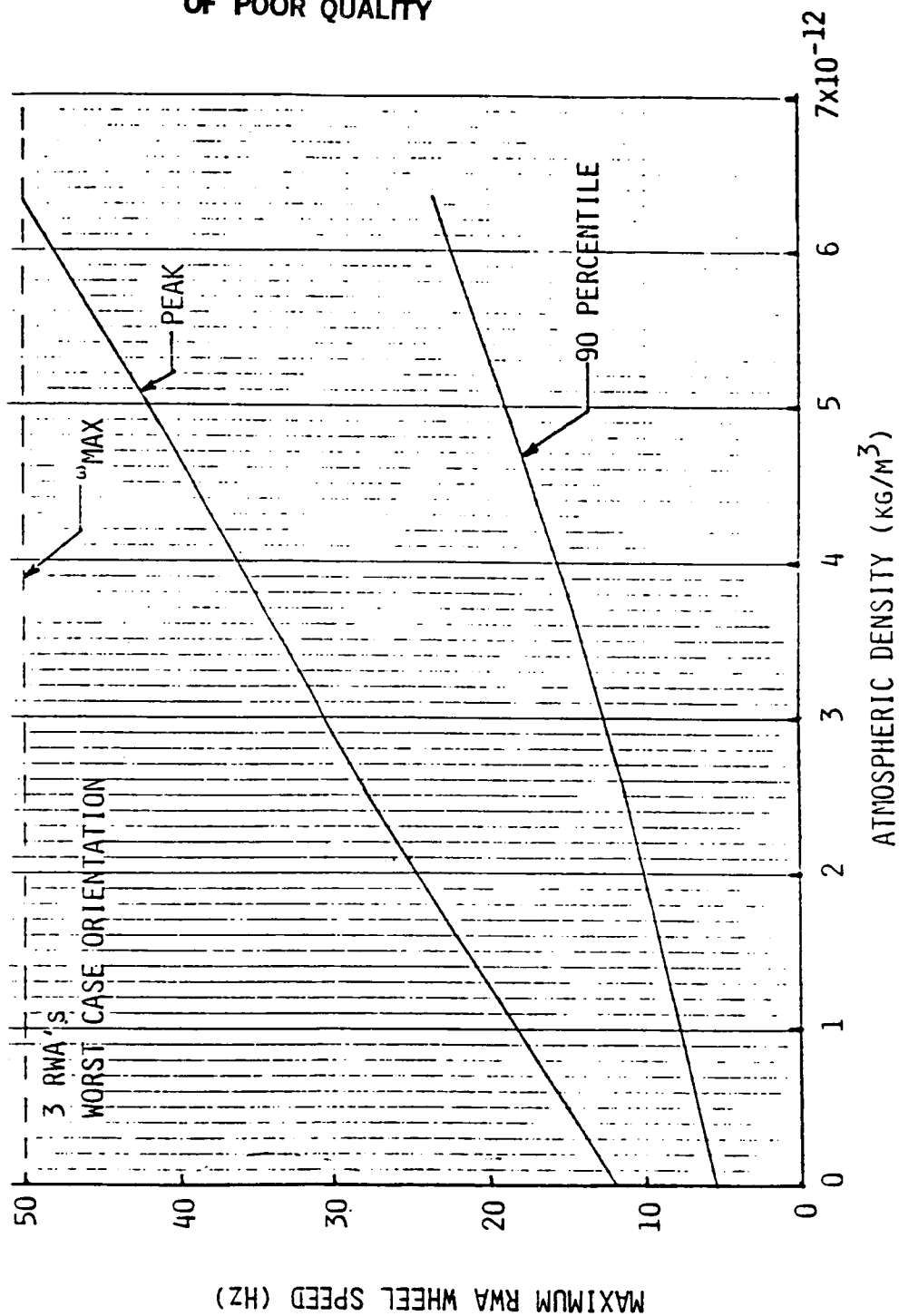MOMENTUM MANAGEMENT
RWA SPEEDS VS TIME

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THE EFFECTS OF ATMOSPHERIC DENSITY ON THE ST PCS

MAXIMUM RWA SPEED VS

ATMOSPHERIC DENSITY

Maximum RWA wheel speed (Hz) vs Atmospheric density (KG/M^3)

PEAK

ω_{MAX}

90 PERCENTILE

3 RWA'S
WORST CASE ORIENTATION

ATMOSPHERIC DENSITY (KG/M^3)
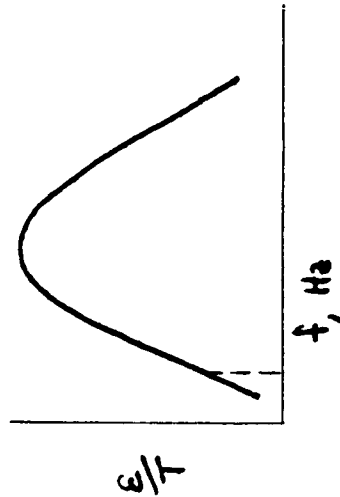
MAXIMUM RWA WHEEL SPEED (HZ)

7×10^{-12}

THE EFFECTS OF ATMOSPHERIC DENSITY ON THE ST PCS

MECHANISMS BY WHICH THE ATMOSPHERIC DENSITY EFFECTS THE PCS

AERODYNAMIC TORQUE $= \frac{1}{2} \rho V^2 A_{REF} (\underline{C} \times \underline{R} + \underline{C}_M)$

DIRECT POINTING ERROR SOURCE DUE TO T_A IS SMALL DUE TO THE INTEGRATOR IN THE CONTROLLER AND THE RELATIVELY LOW FREQUENCY OF T_A.

INDIRECT POINTING ERROR SOURCE DUE TO INCREASED REACTION WHEEL SPEEDS. AS THE WHEEL SPEEDS INCREASE DUE TO INCREASED T_A, THE FREQUENCY SPECTRUM AND AMPLITUDE OF VIBRATIONS FROM THE WHEELS INCREASES, INTERACTING WITH THE ST STRUCTURE TO DISTURB THE POINTING.

ANGULAR MOMENTUM BUDGET IS EFFECTED BY INCREASED T_A. AS THE MOMENTUM REQUIRED TO ACCOMMODATE DISTURBANCE TORQUES INCREASES, THE MOMENTUM AVAILABLE FOR MANEUVERING DECREASES, RESULTING IN A LESS AGILE SYSTEM.

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THE EFFECTS OF ATMOSPHERIC DENSITY ON THE ST PCS

R.W.A. 1003 INDUCED JITTER
AT THE WF/PC DETECTORS   (.003 DAMPING)
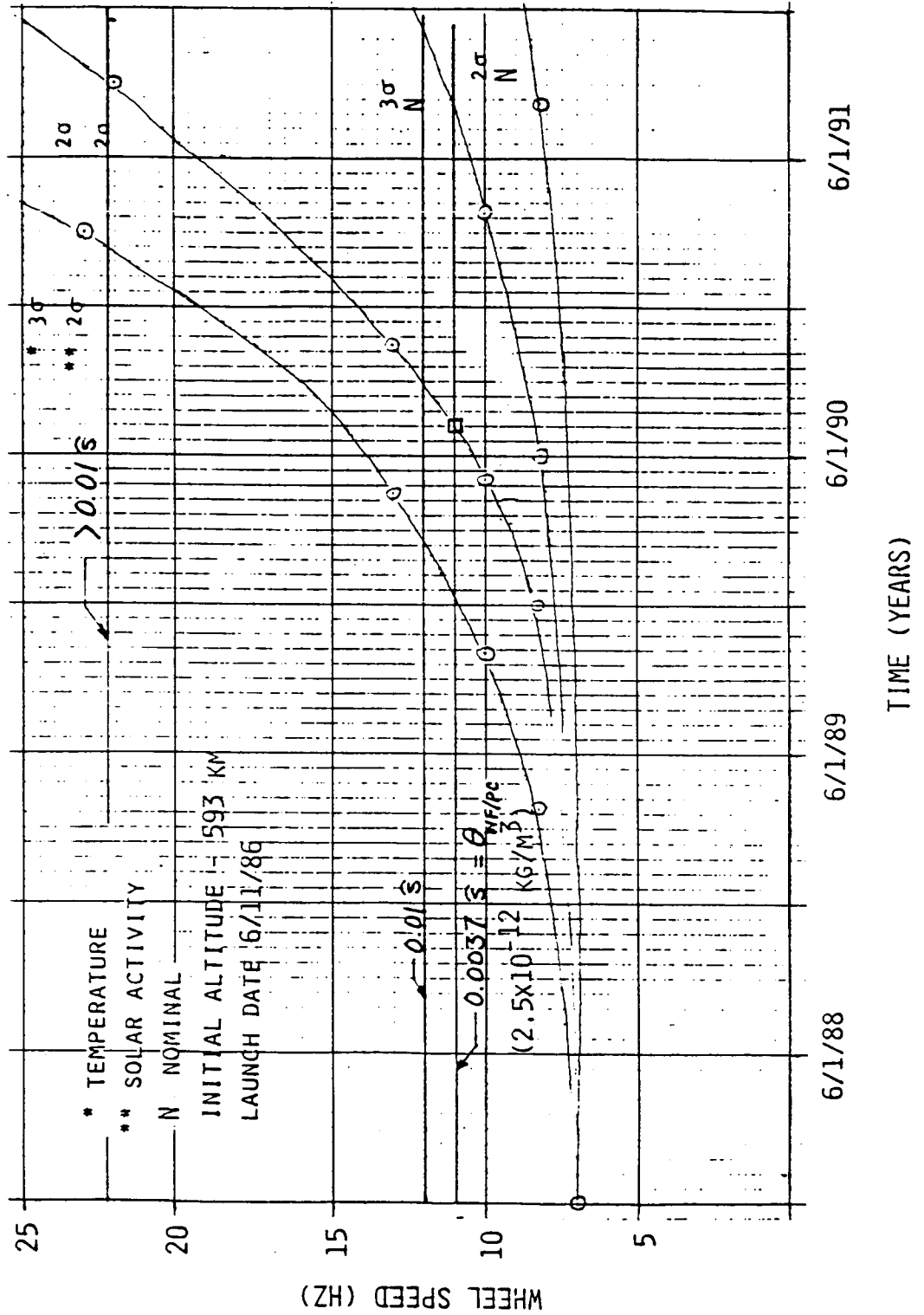DYNAMIC MODEL OF OCT. 1982
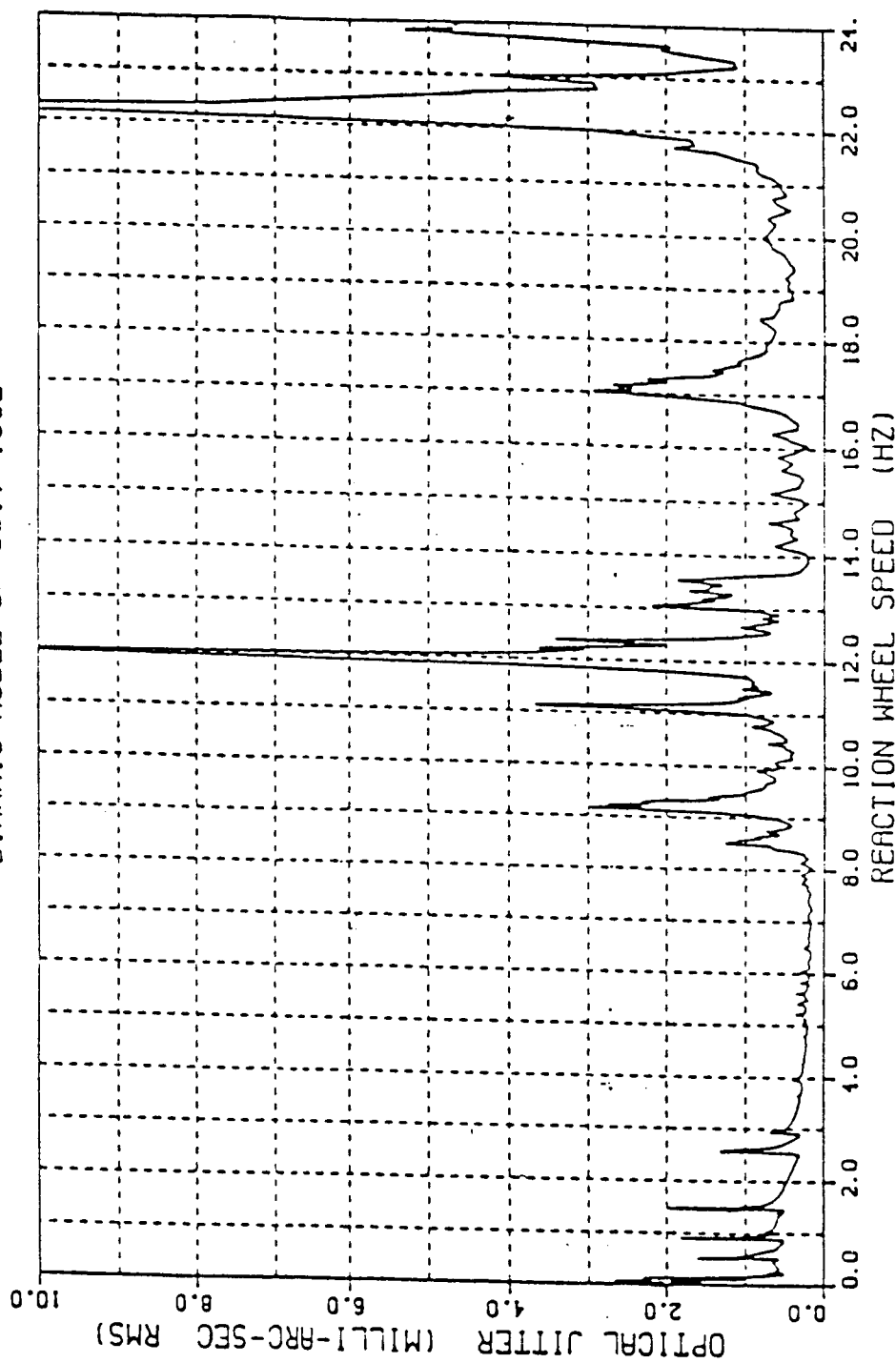
OPTICAL JITTER (MILLI-ARC-SEC RMS)

REACTION WHEEL SPEED (HZ)

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THE EFFECTS OF ATMOSPHERIC DENSITY ON THE ST PCS

WHEEL SPEED VS TIME

* TEMPERATURE
** SOLAR ACTIVITY
— N NOMINAL
INITIAL ALTITUDE – 593 KM
LAUNCH DATE 6/1/86

$\dot{S} > 0.01/s$

3σ
2σ

2σ
2σ

3σ
N

2σ
N

$\dot{S} = 0.01/s$

$0.0037/s = \dot{S} = \rho_{WF/Pc}$
$(2.5 \times 10^{-12} \ KG/M^3)$

WHEEL SPEED (HZ)

25

20

15

10

5

6/1/88   6/1/89   6/1/90   6/1/91

TIME (YEARS)

82

THE EFFECTS OF ATMOSPHERIC DENSITY ON THE ST PCS

EFFECTS ON ANGULAR MOMENTUM BUDGET

MOMENTUM ALLOCATIONS (NOMINAL)

|	MOMENTUM, NM
GRAVITATIONAL TORQUE	50
AERODYNAMIC TORQUE	100
MANEUVERING	300
CONTROL SYSTEM AND OTHER	50
TOTAL	500

SINCE THE CAPACITY OF THE MOMENTUM STORAGE SYSTEM IS FIXED AT 500 NM, AN INCREASE IN ATMOSPHERIC DENSITY FROM ITS NOMINALLY ASSUMED VALUE WILL REQUIRE A REDISTRIBUTION OF MOMENTUM, REDUCING THAT ALLOTTED FOR MANEUVERING.

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THE EFFECTS OF ATMOSPHERIC DENSITY ON THE ST PCS

TIME FOR 90 DEG MANEUVER VS TIME
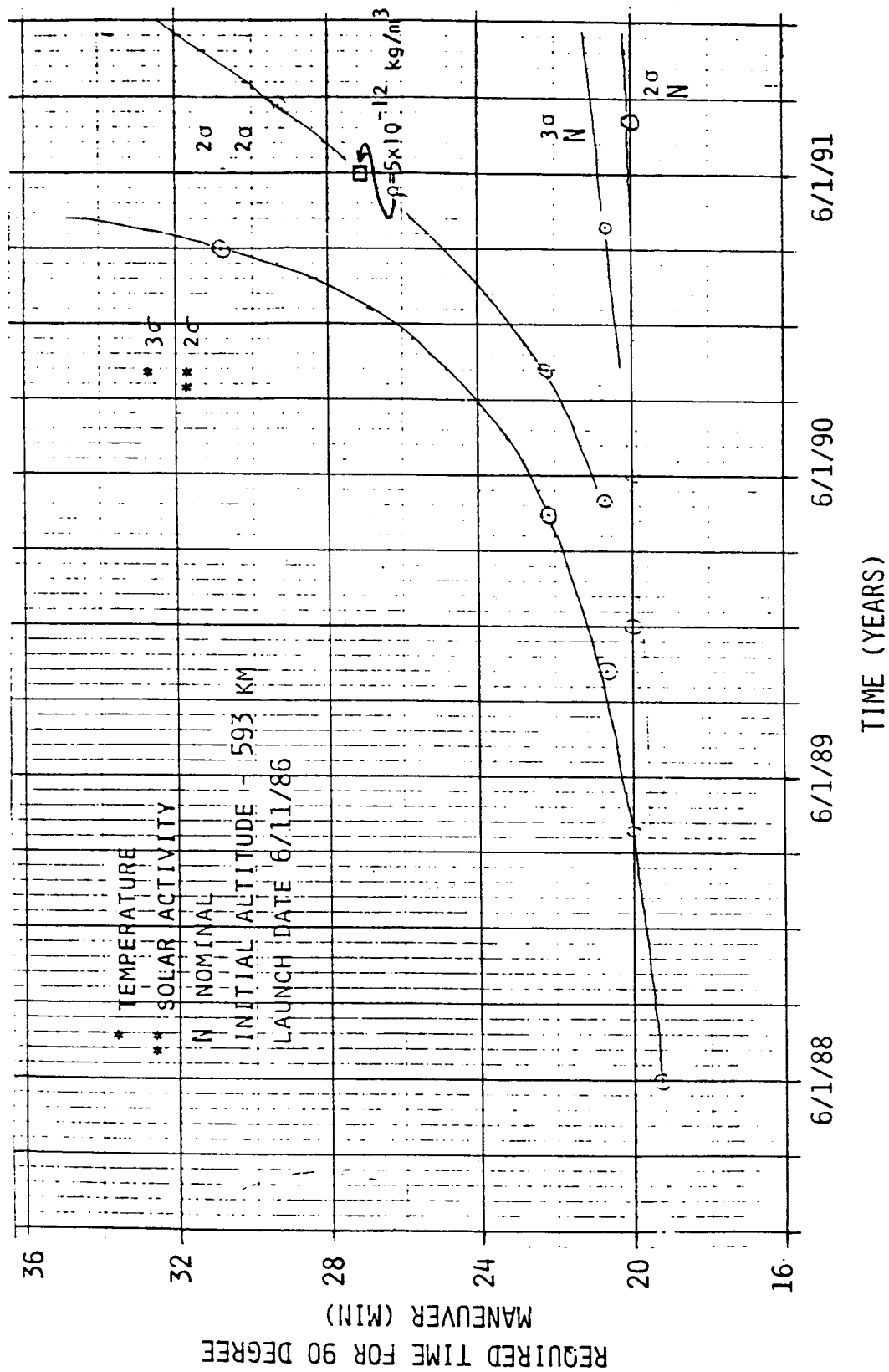
TIME (YEARS)

REQUIRED TIME FOR 90 DEGREE MANEUVER (MIN)

84

THE EFFECTS OF ATMOSPHERIC DENSITY ON THE ST PCS

RECOMMENDATIONS FOR DENSITY MODELING

o THERE IS A NEED FOR A MODEL THAT ACCURATELY PORTRAYS SHORT TERM VARIATIONS.

o THERE IS A NEED FOR LESS COMPLEX MODELS THAT ARE APPLICABLE OVER LIMITED ALTITUDES, E.G., 400-700 KM.