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CO-ORBITING MECHANICS

L. E. LIVINGSTON  
JOHNSON SPACE CENTER  
JUNE 22, 1982



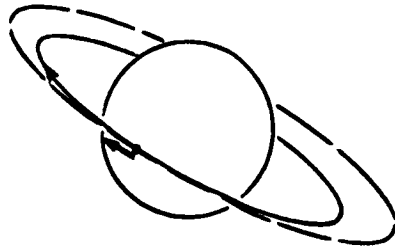
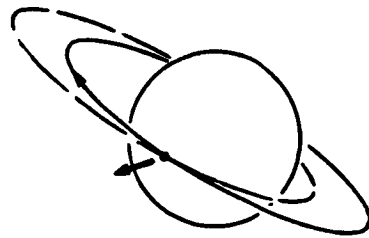
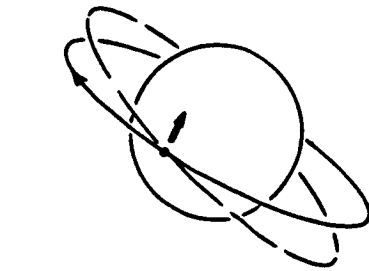
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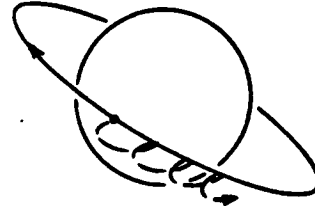
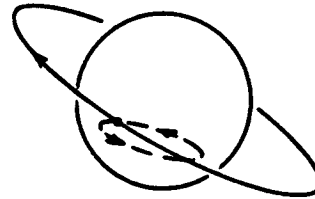
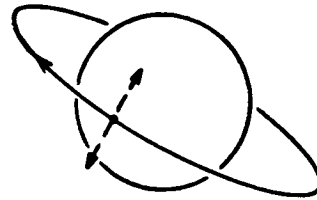
MOTION OF CO-ORBITING SATELLITES

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RELATIVE TO EARTH



RELATIVE TO SERVICING BASE

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**DIFFERENTIAL ORBIT DECAY**

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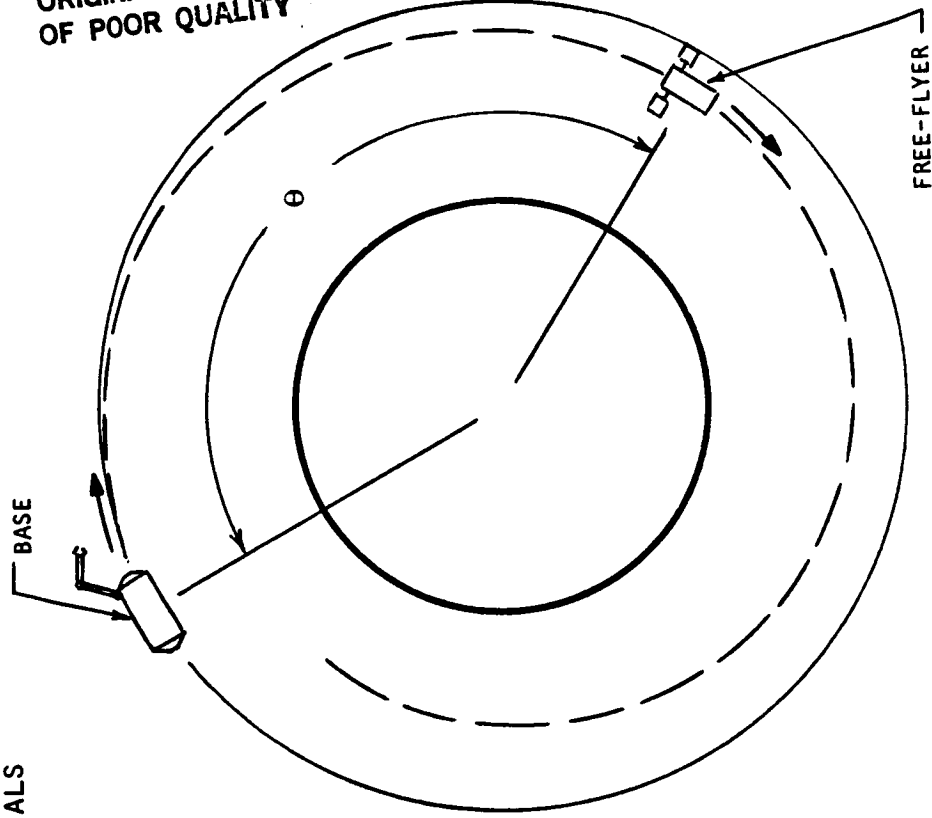
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- SOME FREE-FLYING SATELLITES (E.G., MATERIALS PROCESSING OR LARGE TELESCOPES) REQUIRE:
  - EXTENDED PERIODS WITHOUT PROPULSIVE MANEUVERS OR OTHER DISTURBANCES.
  - PERIODIC SERVICING.

- ORBITING IN THE VICINITY OF A PERMANENT BASE FACILITY COULD PERMIT SERVICING AS REQUIRED WITHOUT DEDICATED SHUTTLE FLIGHTS.

- EVEN MODERATE ORBIT DECAY REDUCES PERIOD OF FREE-FLYER ENOUGH TO CAUSE RAPID SEPARATION FROM BASE.

- IF BASE ORBIT IS NOT MAINTAINED, IT WILL GENERALLY DECAY AT DIFFERENT RATE, REDUCING BUT NOT ELIMINATING THE DIFFERENTIAL.





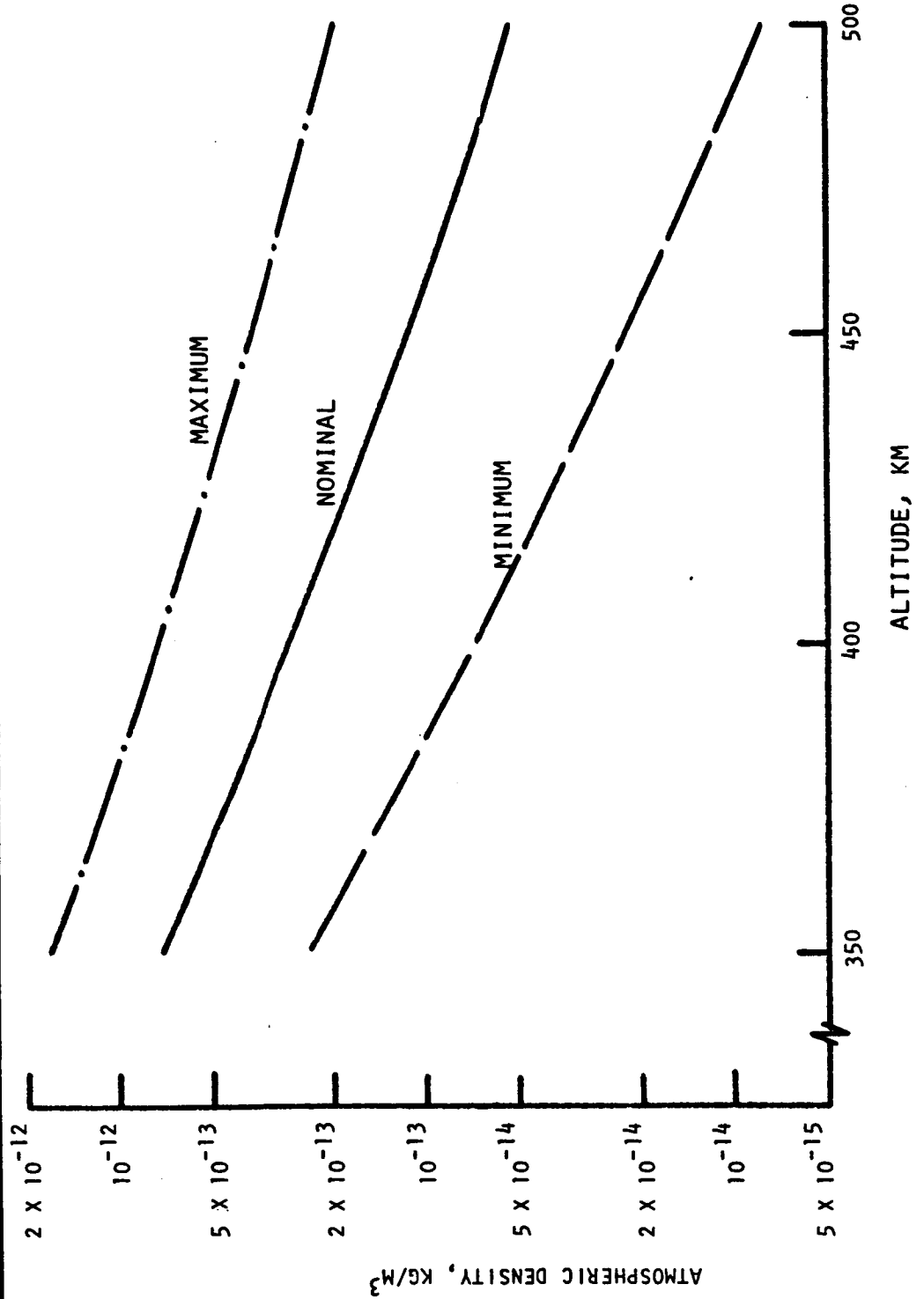
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ATMOSPHERIC MODELS

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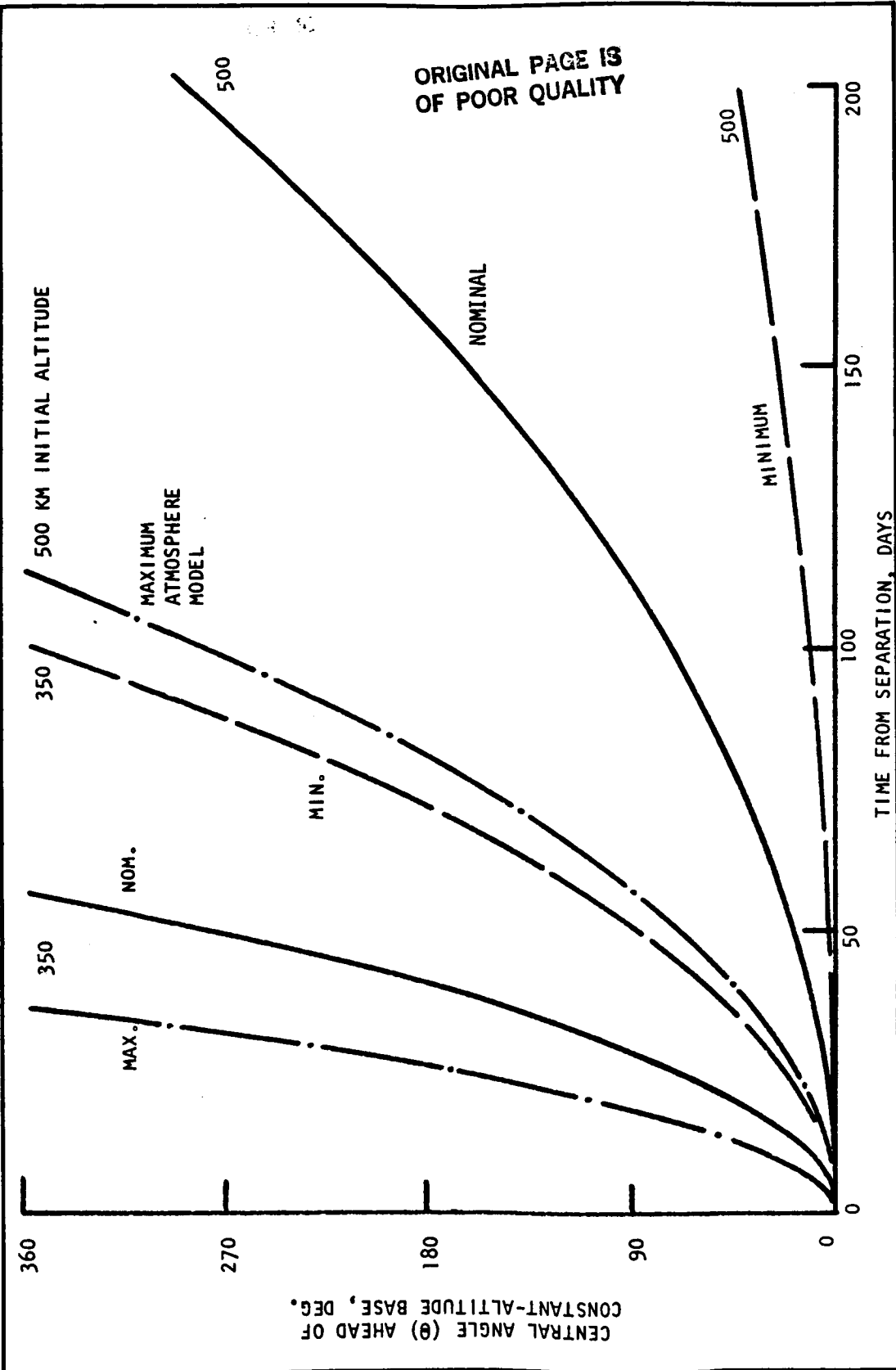


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FREE-FLYER DISTANCE FROM BASE

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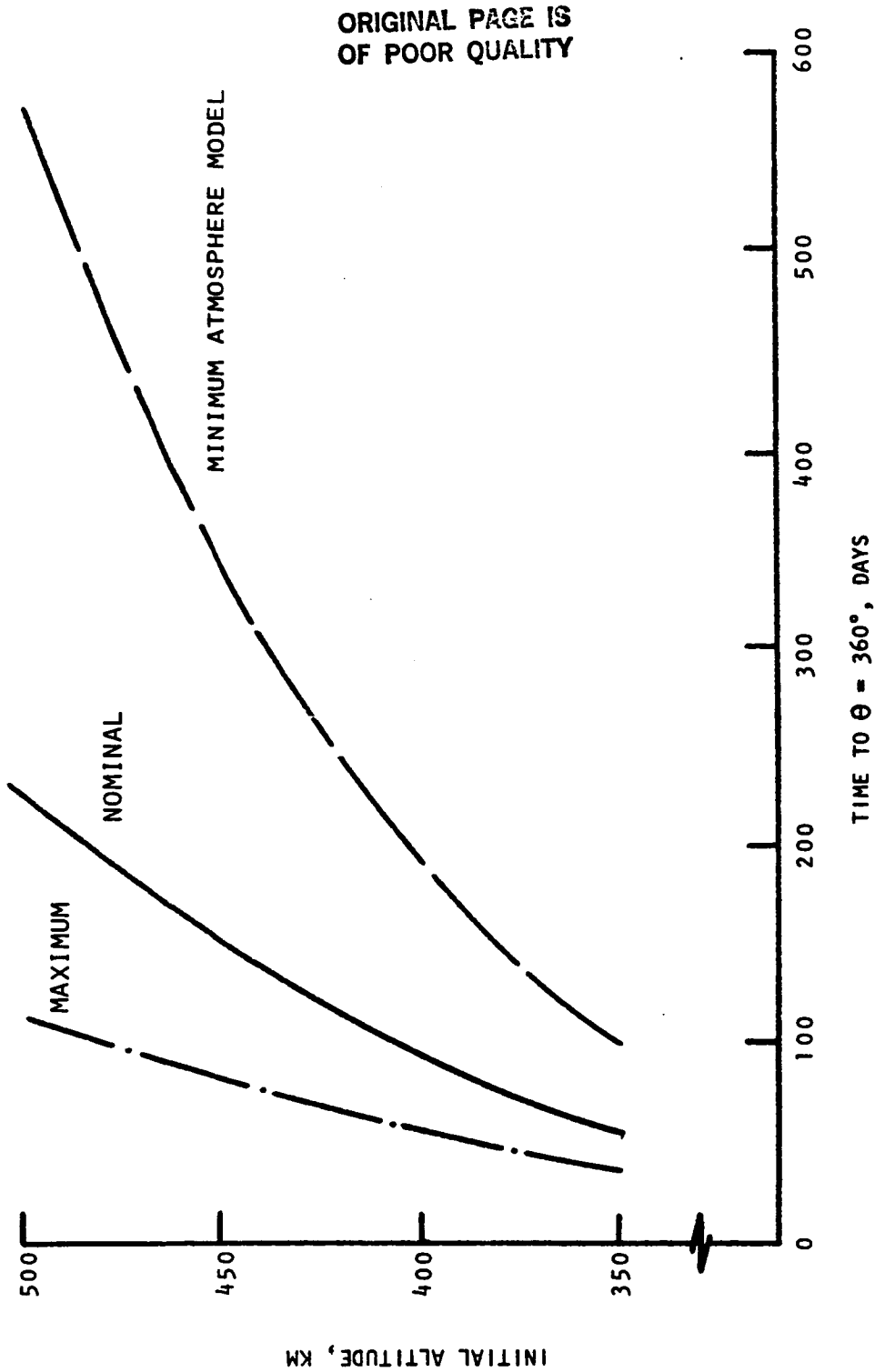
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TIME FOR ONE REVOLUTION RELATIVE TO BASE

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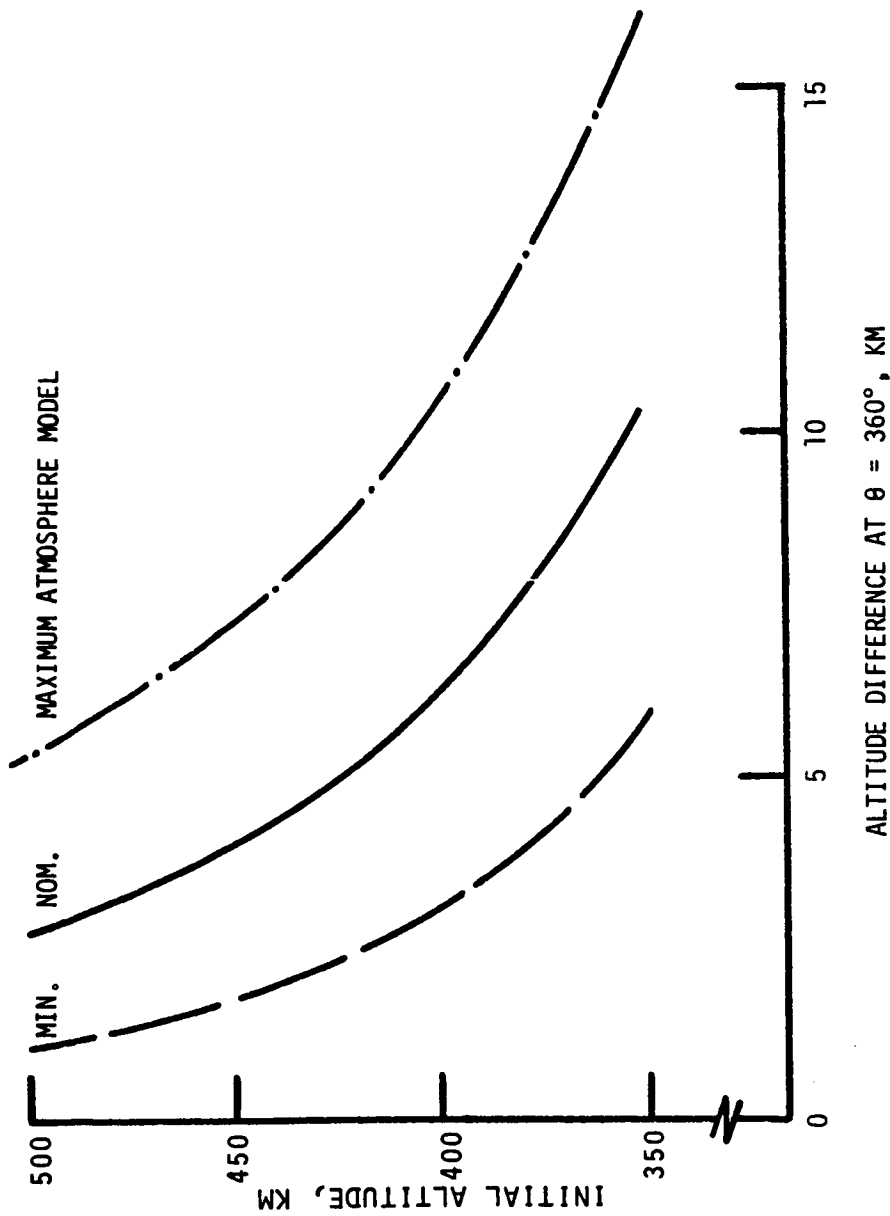


ALTITUDE DIFFERENTIAL

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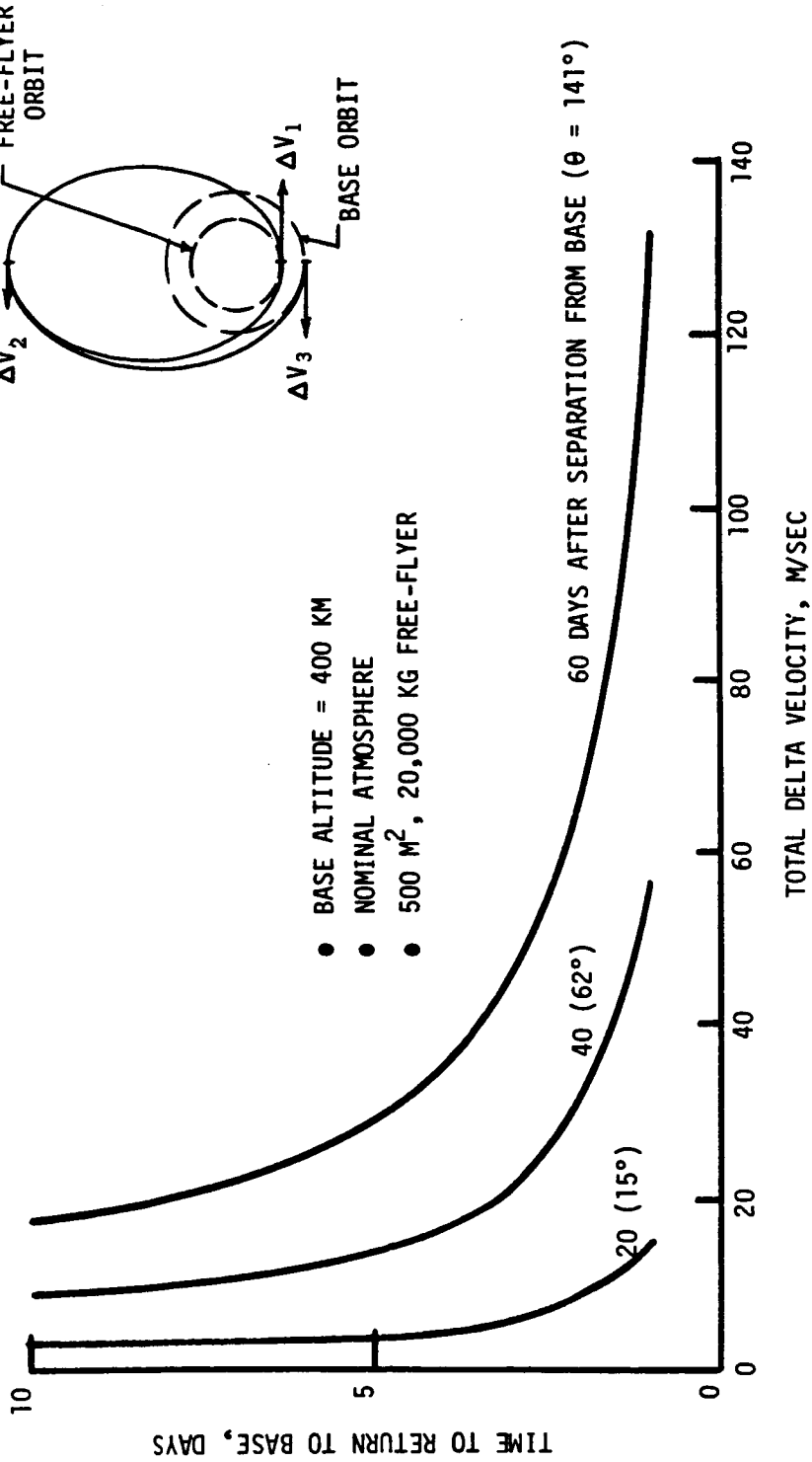
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RETURN AT ARBITRARY TIME

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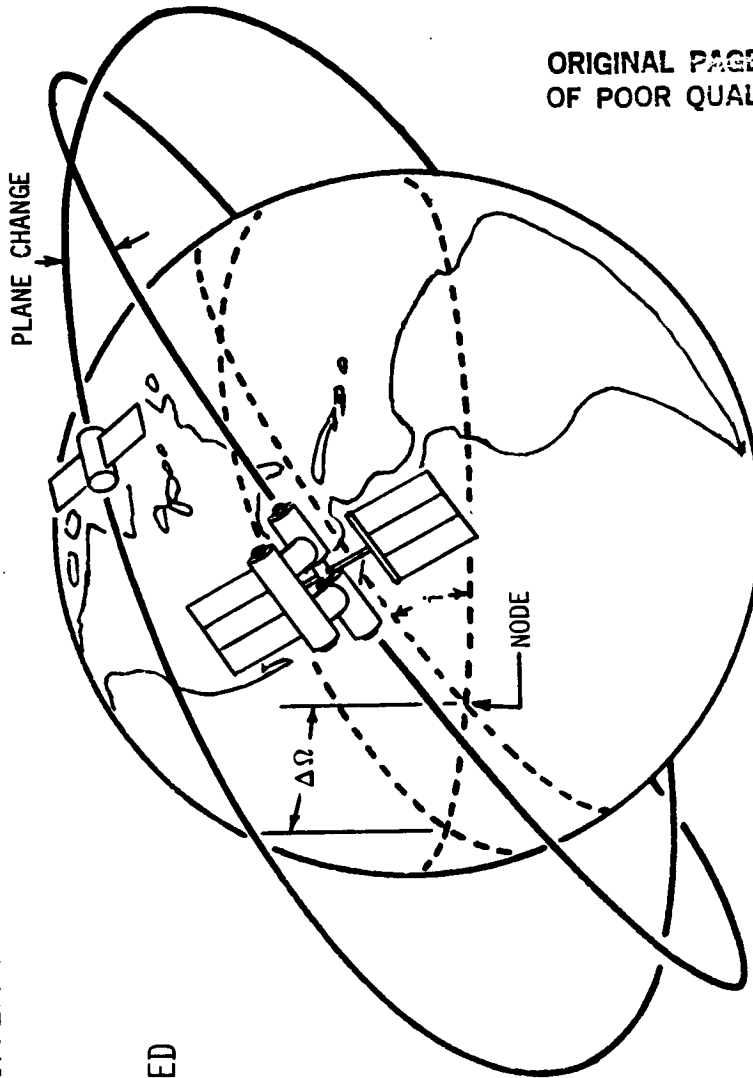


**DIFFERENTIAL NODAL REGRESSION**

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- EARTH'S OBLATENESS CAUSE NODE TO MOVE ALONG EQUATOR.
- RATE DEPENDS ON ALTITUDE AND INCLINATION.
- FREE-FLYER REGRESSES AT DIFFERENT RATE FROM BASE.
- PLANE CHANGE GREATLY INCREASES PROPELLANT REQUIRED FOR TRANSFER.



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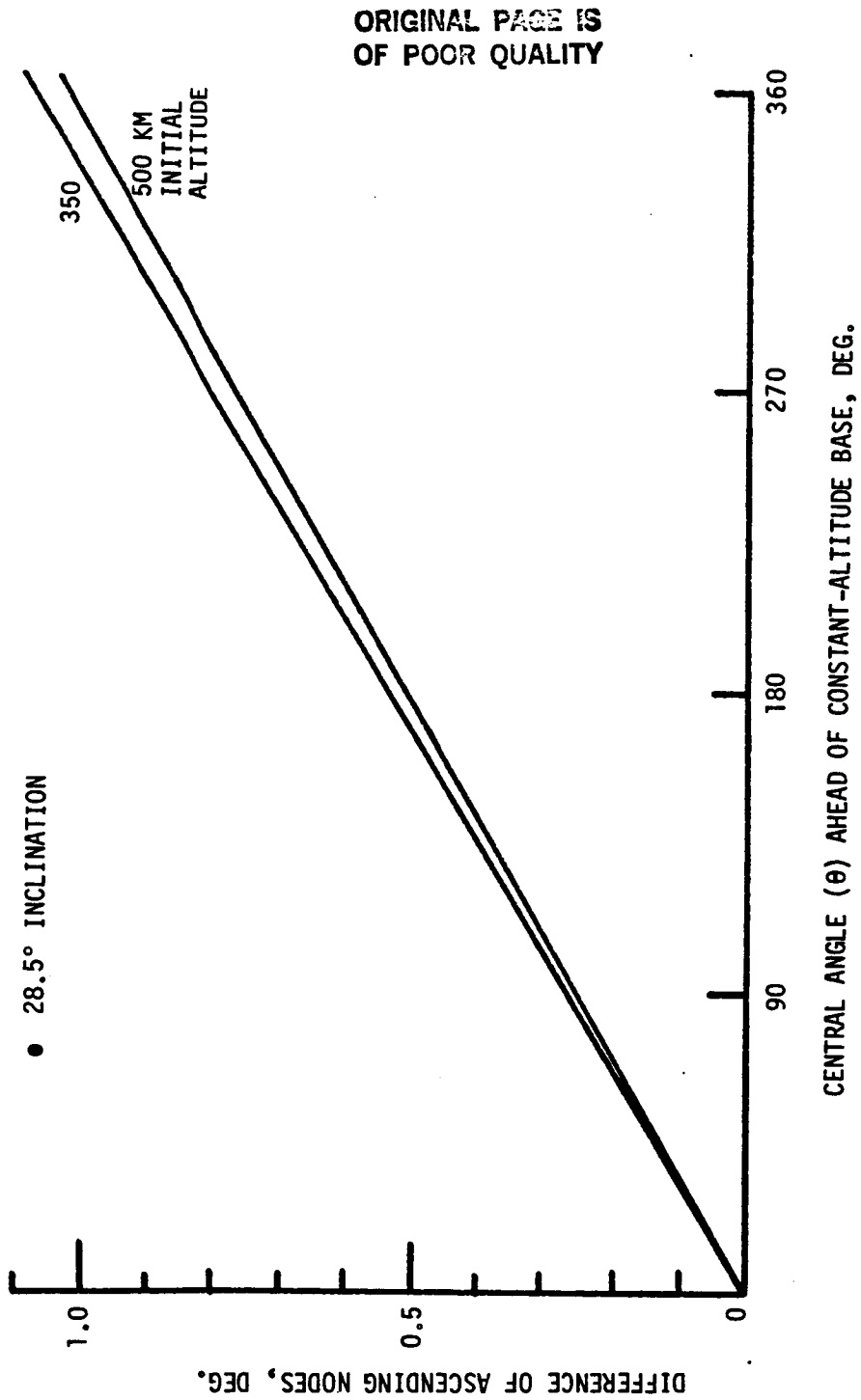
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### DIFFERENTIAL NODAL REGRESSION

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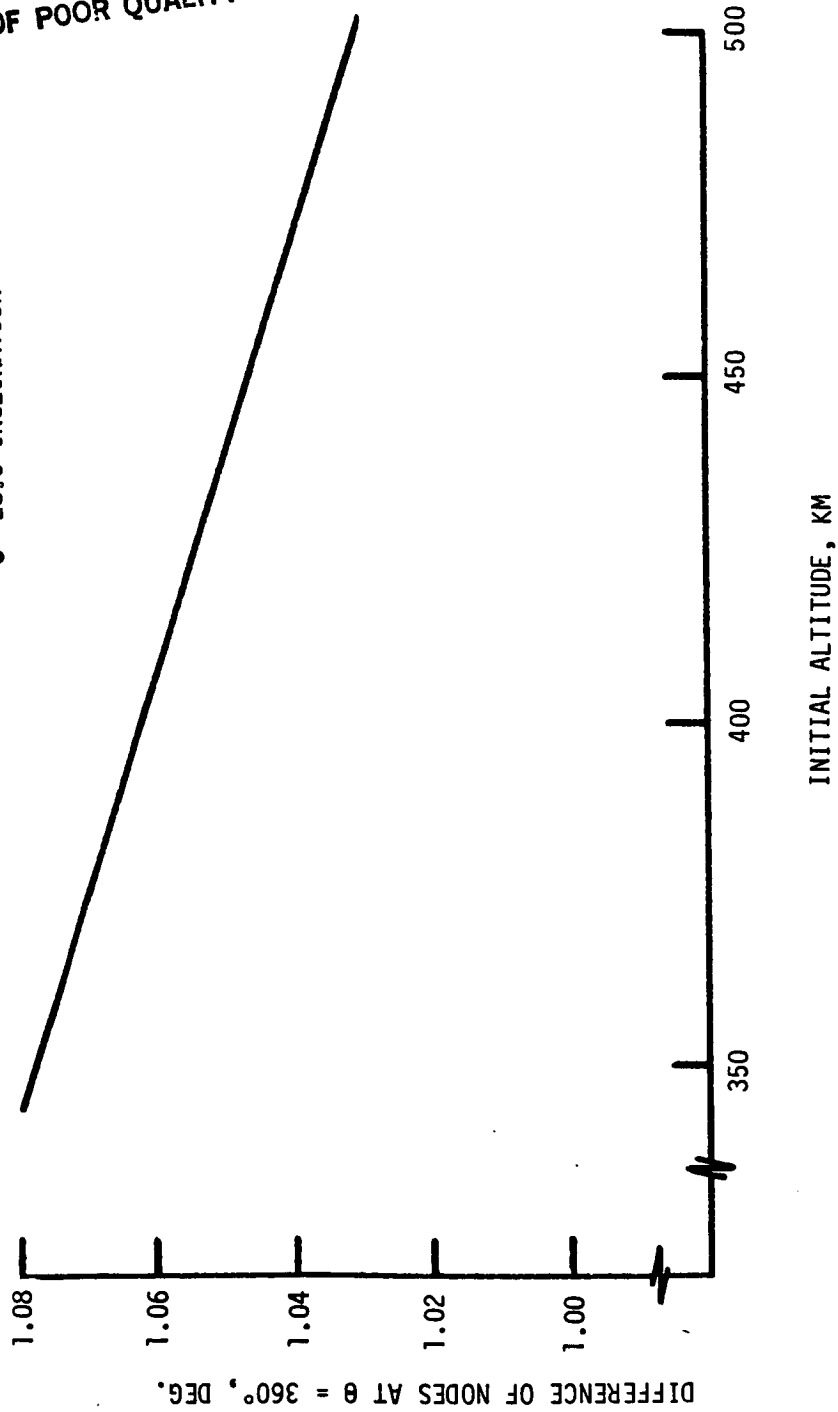
DIFFERENTIAL NODAL REGRESSION

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• 28.5 INCLINATION





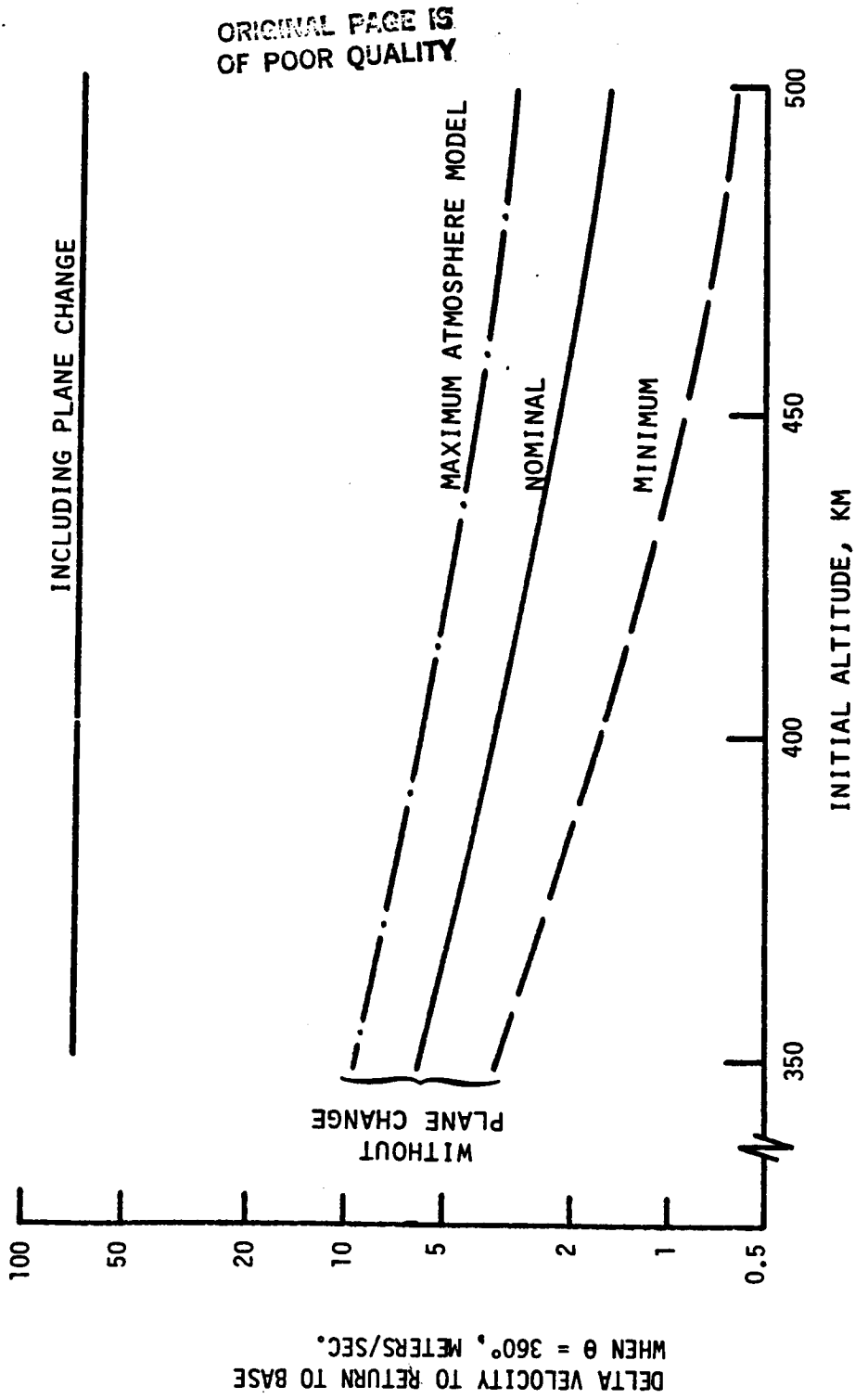
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### RETURN AFTER ONE REVOLUTION RELATIVE TO BASE

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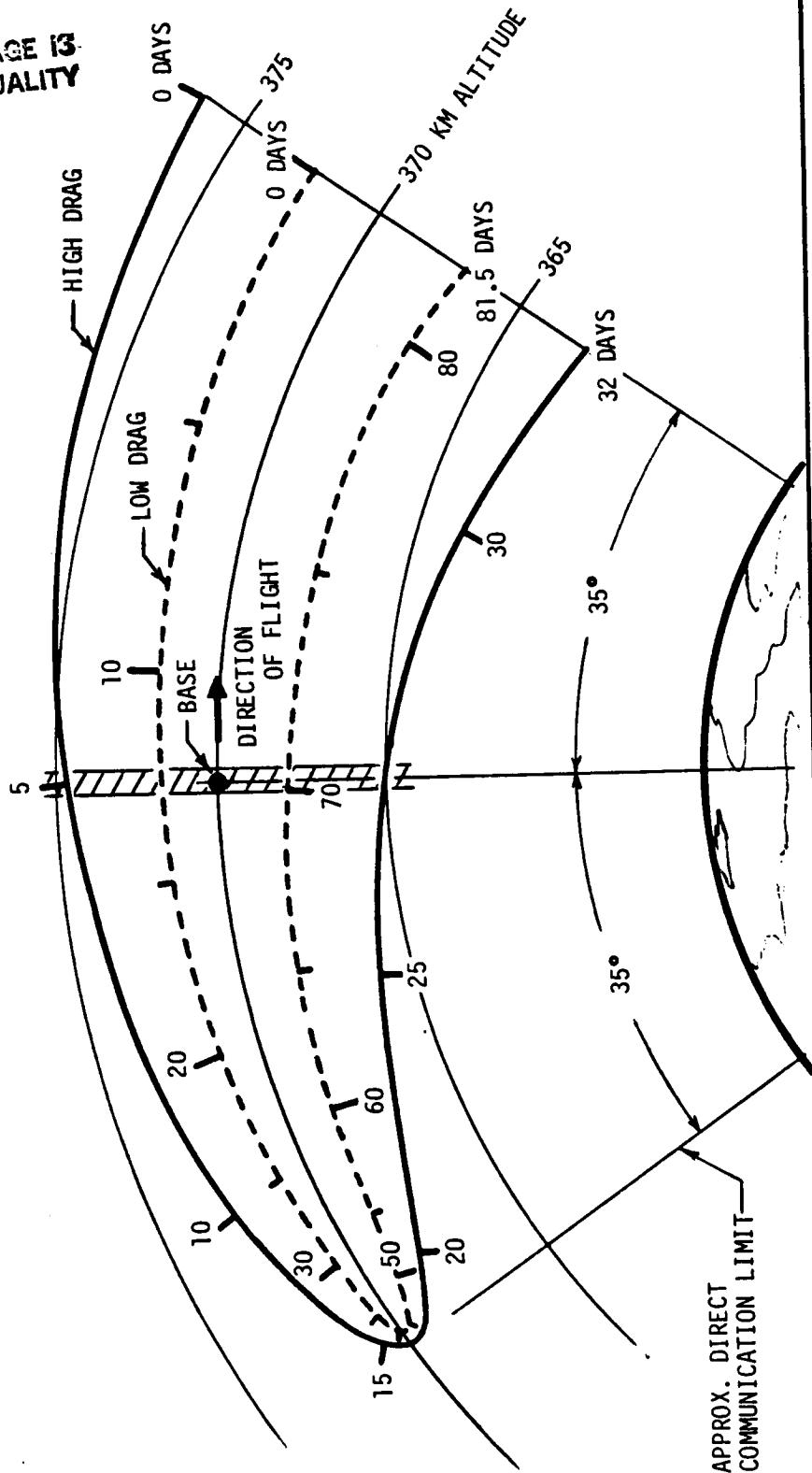
"BOOMERANG" CONCEPT

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- BASE MAINTAINS CONSTANT 370 KM ALTITUDE
- FREE-FLYERS PERFORM NO ORBIT MAINTENANCE
- HIGH-DRAG FREE-FLYER - 10,000 KG, 100 M<sup>2</sup> (———)
- LOW-DRAG FREE-FLYER - 25,000 KG, 35M<sup>2</sup> (---)





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"BOOMERANG" CONCEPT

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- SEPARATION OF NODES FROM DIFFERENTIAL REGRESSION IS PROPORTIONAL TO ANGULAR SEPARATION FROM BASE, AND RETURNS TO ZERO WHEN FREE-FLYER IS BENEATH INITIAL POSITION RELATIVE TO BASE.

- LOW  $\Delta V$  REQUIRED FOR REBOOST (EXAMPLES FROM PRECEDING CHART)

- LOW DRAG: 2.2 M/SEC AT BASE

3.1 M/SEC AT COMMUNICATIONS LIMIT

- HIGH DRAG: 5.6 M/SEC AT BASE

8.0 M/SEC AT COMMUNICATIONS LIMIT

- EASY ACCESS FROM BASE AT FREQUENT INTERVALS.

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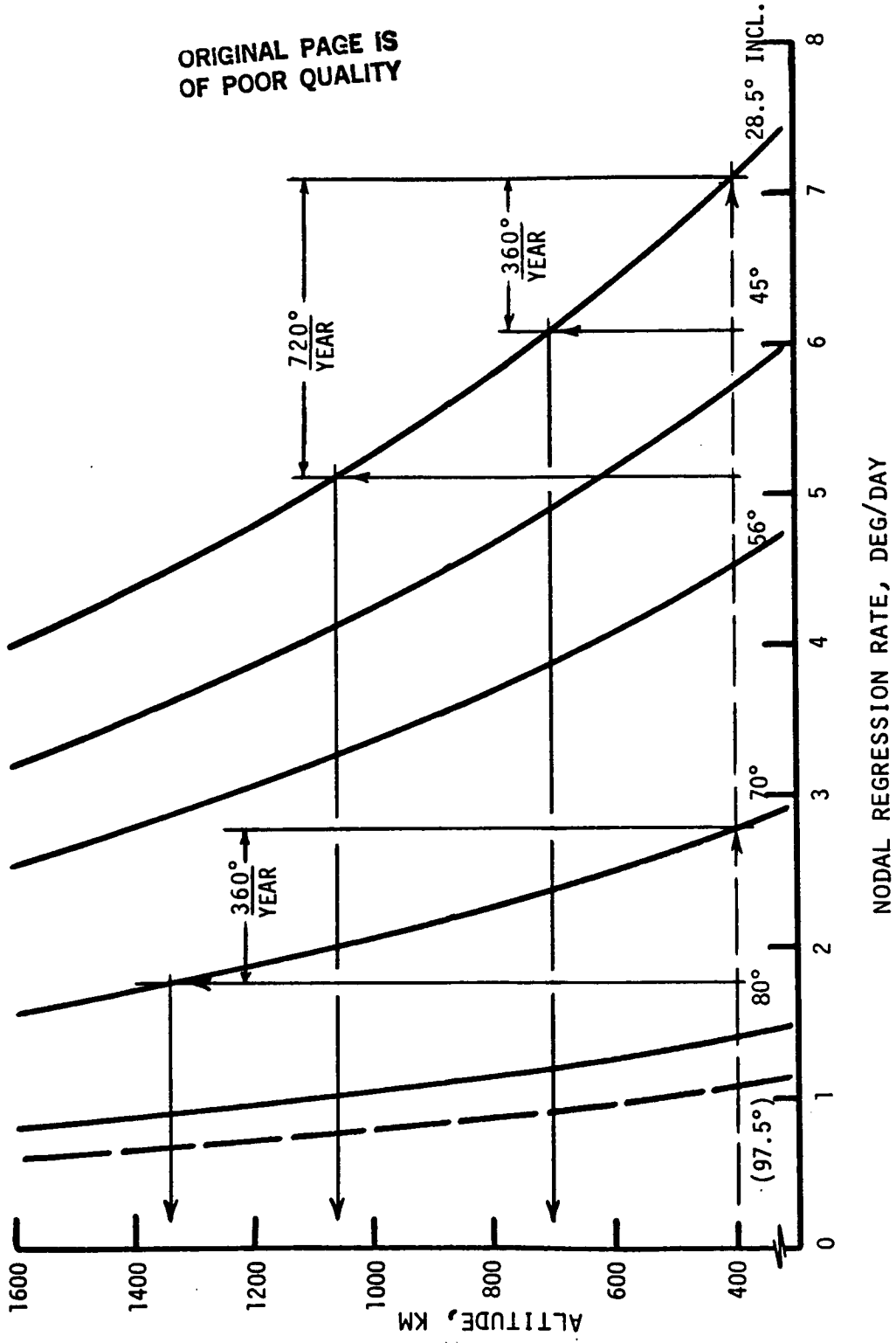
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### PERIODIC CO-PLANARITY

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### PERIODIC CO-PLANARITY

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