

Mission Design Overview for the GRAIL Mission

Ted Sweetser

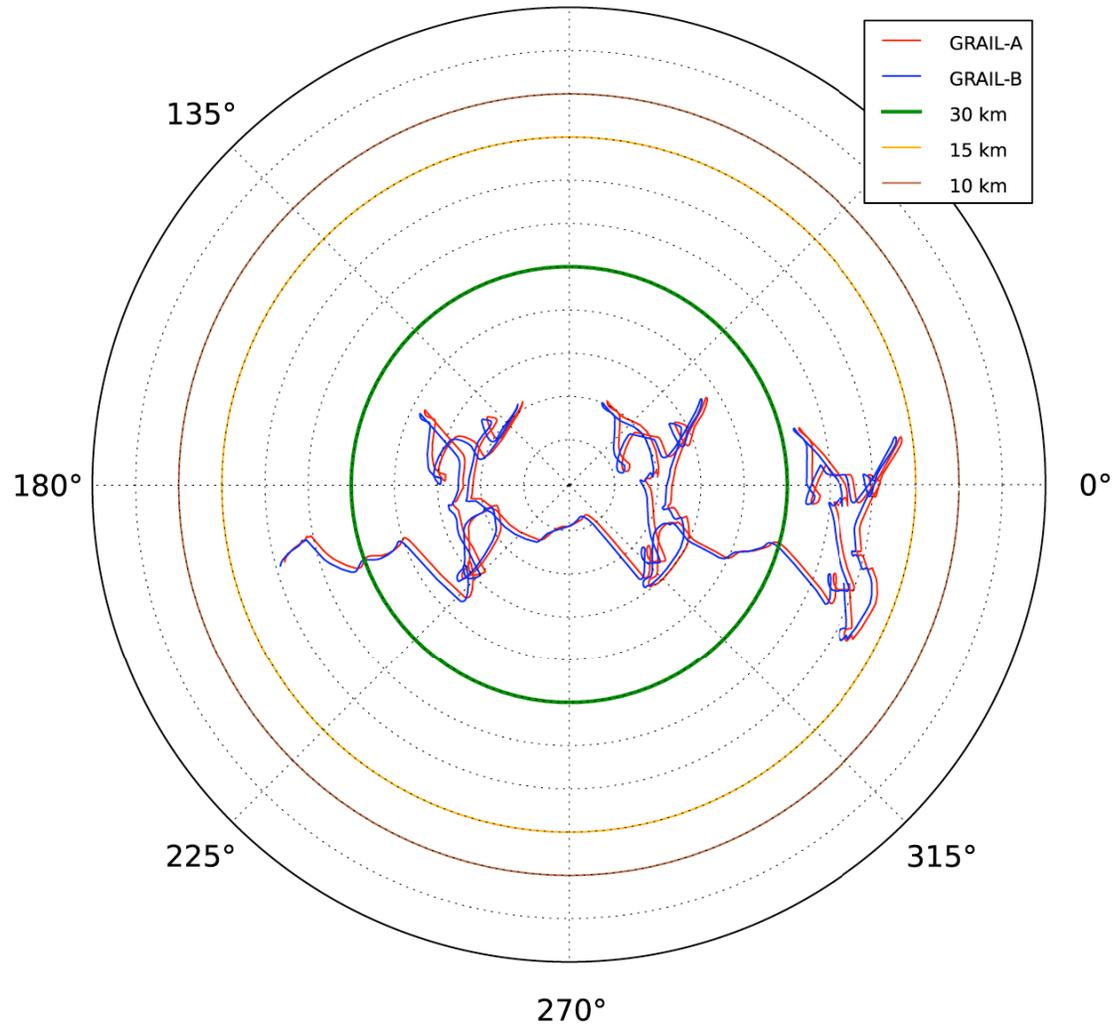
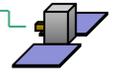
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

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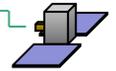
Evolution of the GRAIL science orbit

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The answer! at least locally



- From Battin's *An Introduction to the Mathematics and Methods of Astrodynamics*:

$$\mu \frac{de}{dt} = 2(\mathbf{v} \cdot \mathbf{a}_d) \mathbf{r} - (\mathbf{r} \cdot \mathbf{a}_d) \mathbf{v} - (\mathbf{r} \cdot \mathbf{v}) \mathbf{a}_d .$$

- For circular orbits, CNES's *Spaceflight Dynamics, Part I* reduces this to:

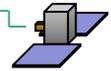
$$\frac{de_x}{dt} = \frac{2 \cos \alpha}{V} T_P + \frac{\sin \alpha}{V} R_P ,$$

$$\frac{de_y}{dt} = \frac{2 \sin \alpha}{V} T_P - \frac{\cos \alpha}{V} R_P .$$



The impulsive answer

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To first order in e , this becomes:

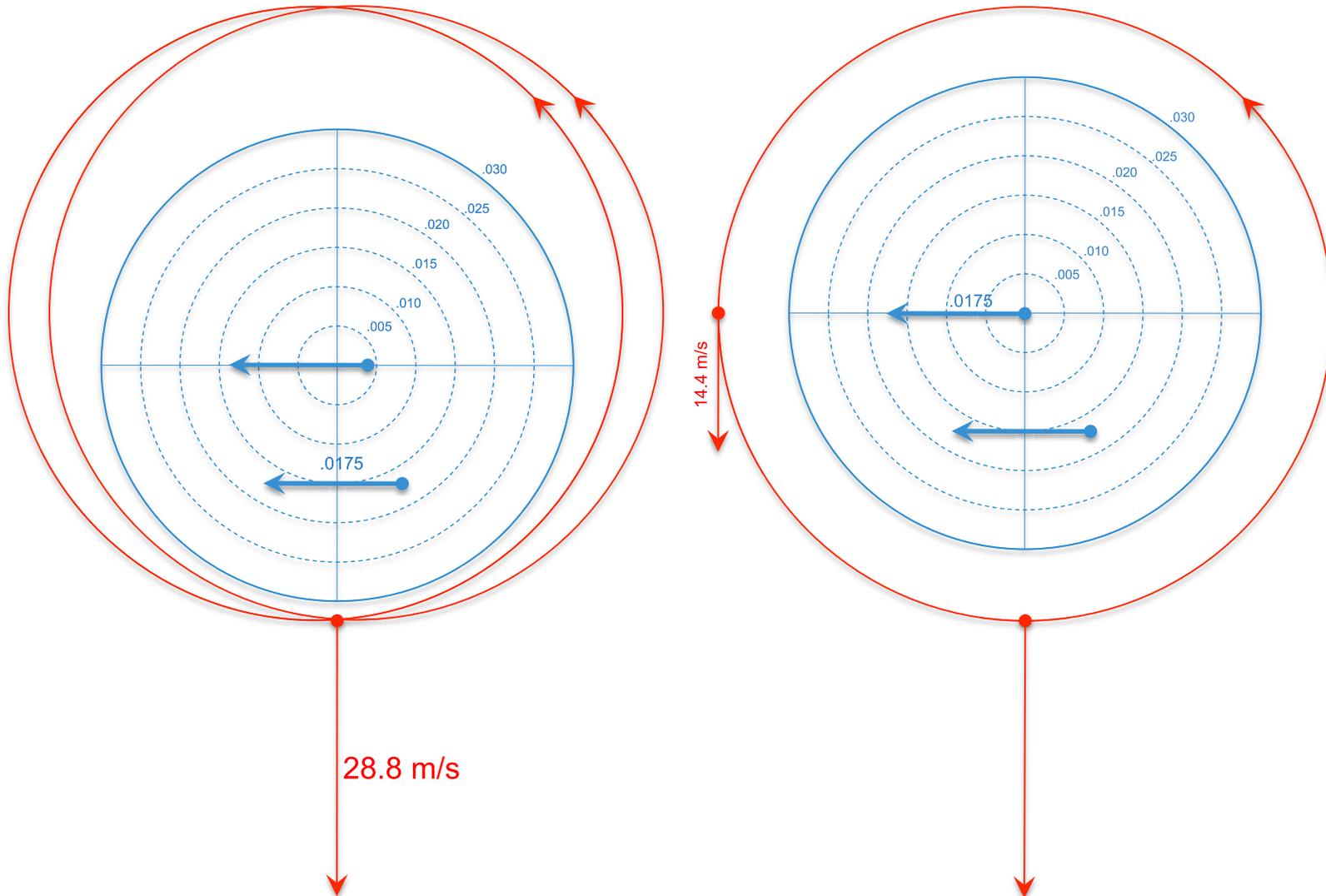
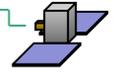
$$\Delta \mathbf{e} \approx \frac{1}{v} \left(2\Delta \mathbf{v}_T + \Delta \mathbf{v}_R \right)^{\perp_\ell}$$

where \perp_ℓ means rotate -90 deg, and there's a twist in the definition of T and R .



Effects of simple impulsive maneuvers

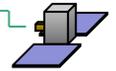
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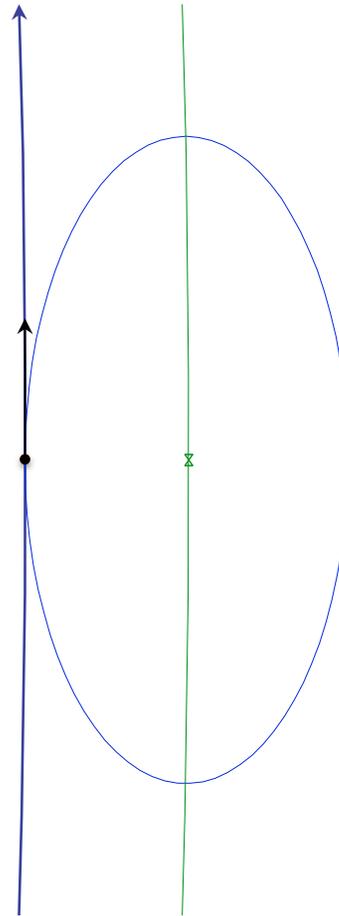


HCW View of Transverse Maneuver

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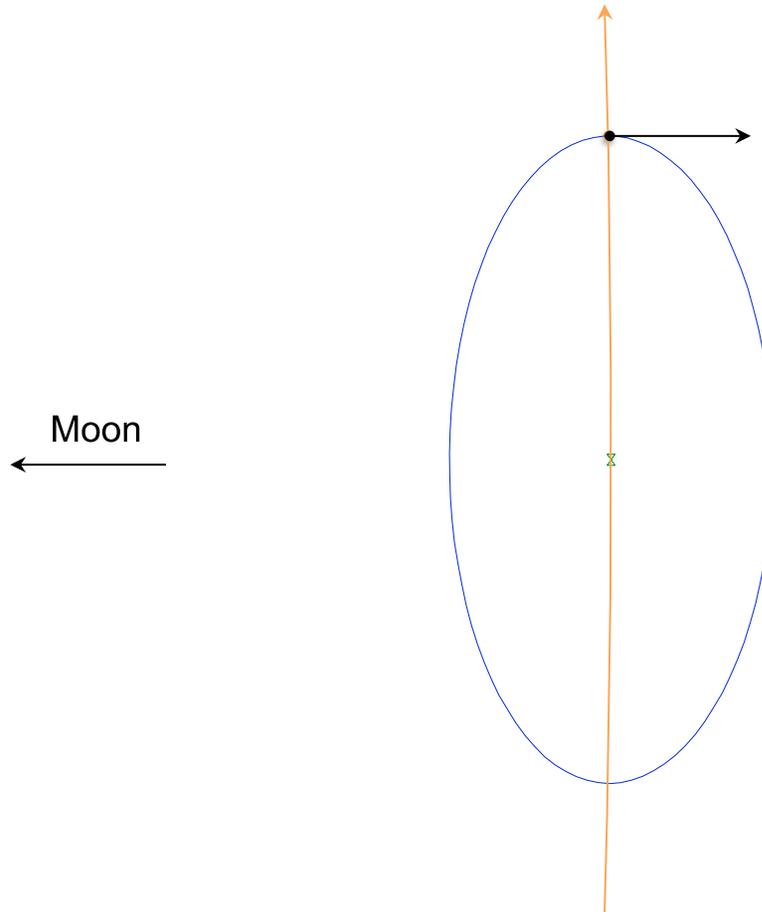
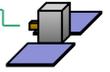
← Moon





HCW View of Radial Maneuver

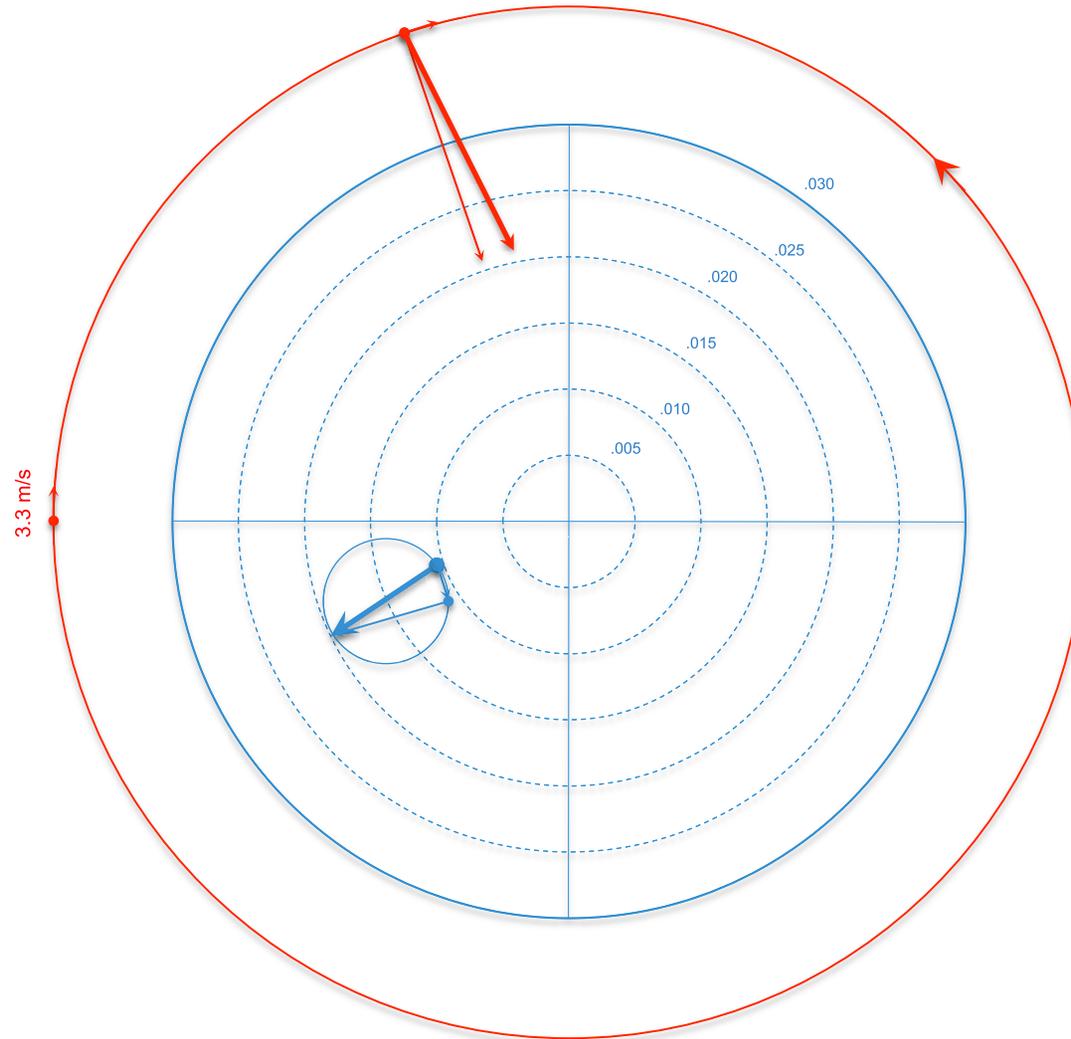
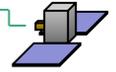
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Including a Specific Period Change

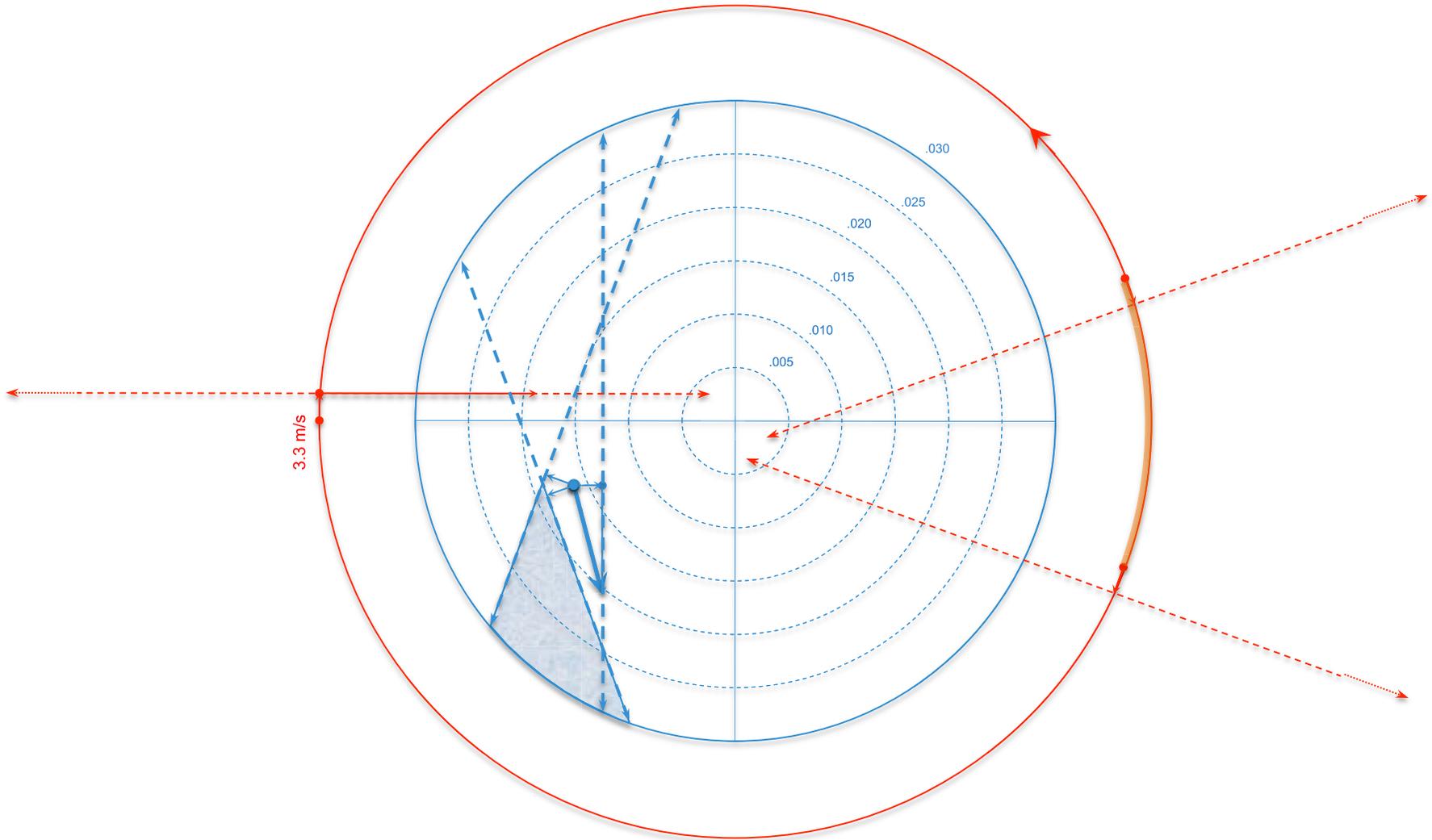
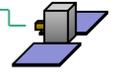
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Including Plane Change Constraints

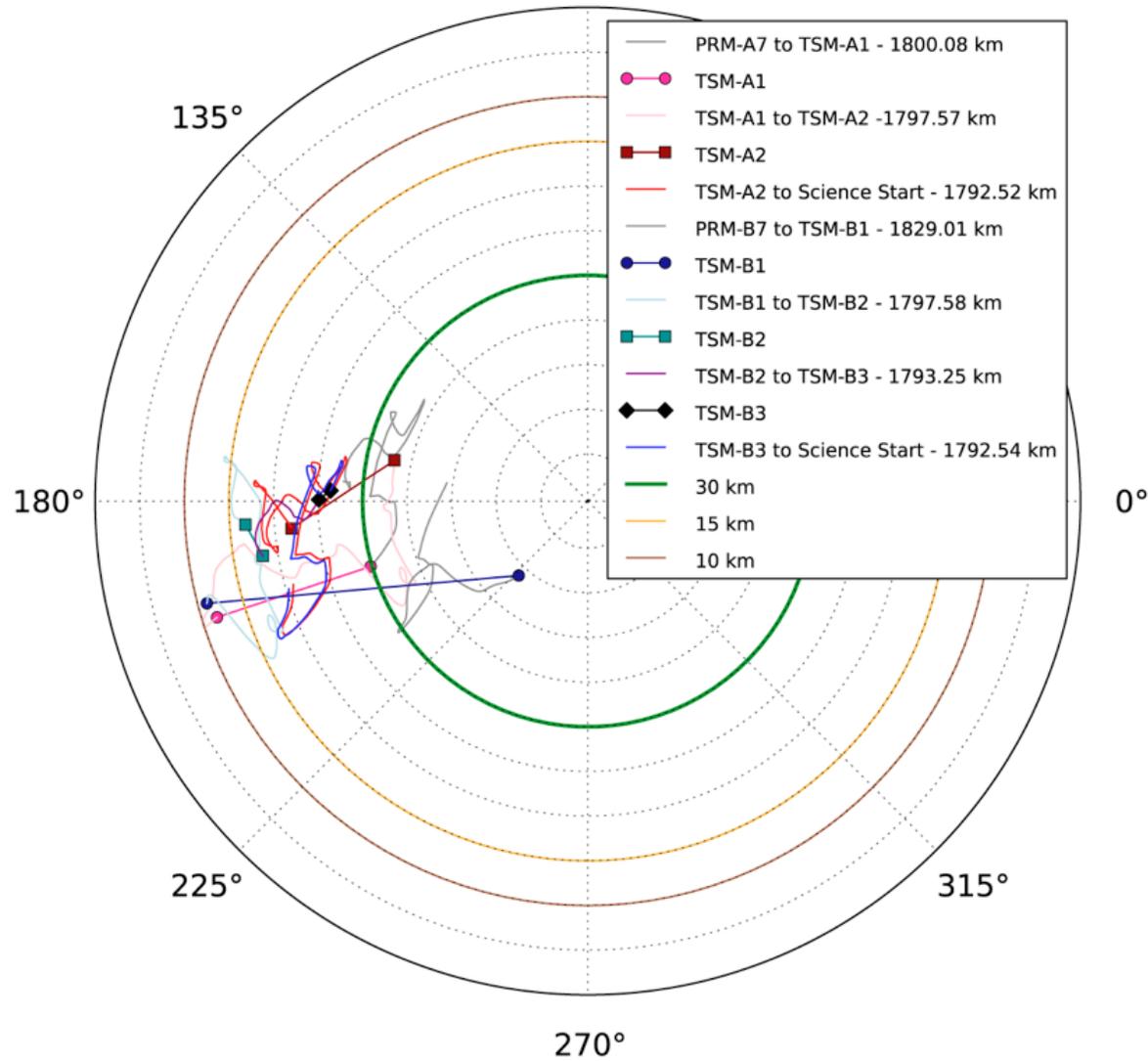
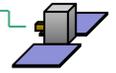
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Getting GRAIL-A and -B to the science orbit

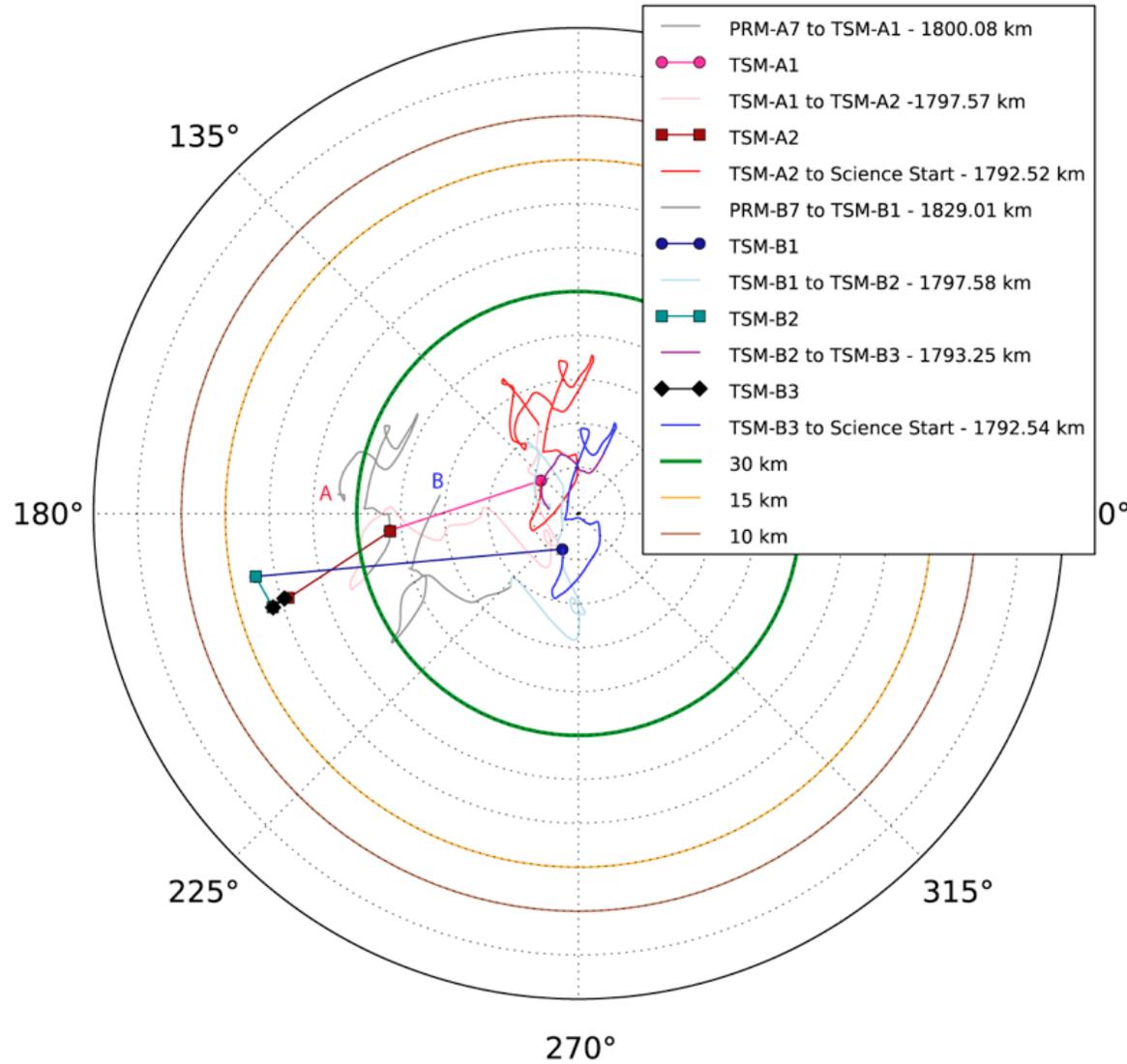
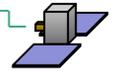
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The GRAIL transitions reordered

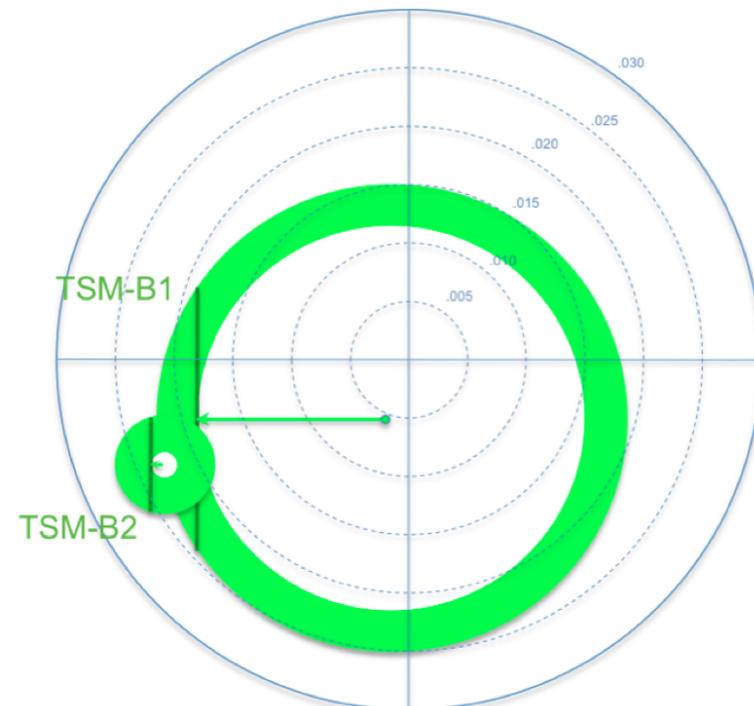
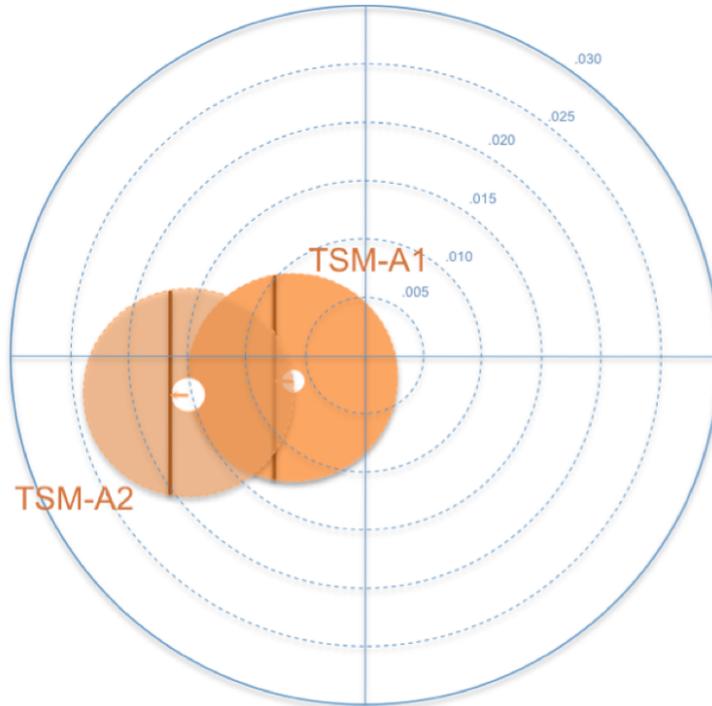
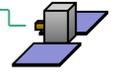
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What maneuvers can do for GRAIL

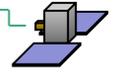
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Acknowledgment

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