CA Risk Assessment Condensation

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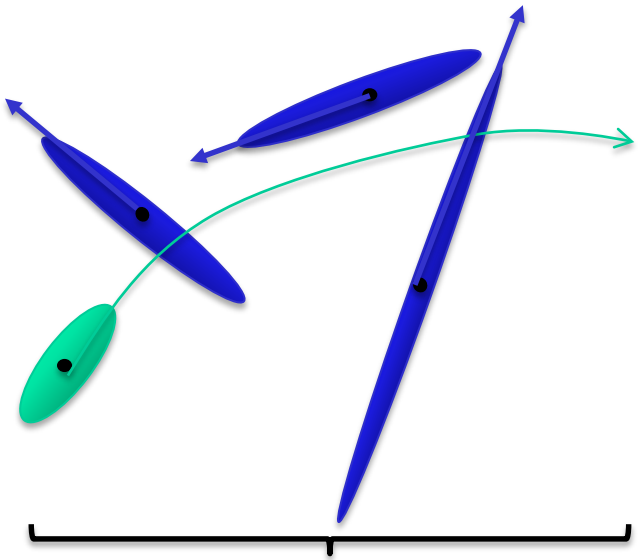
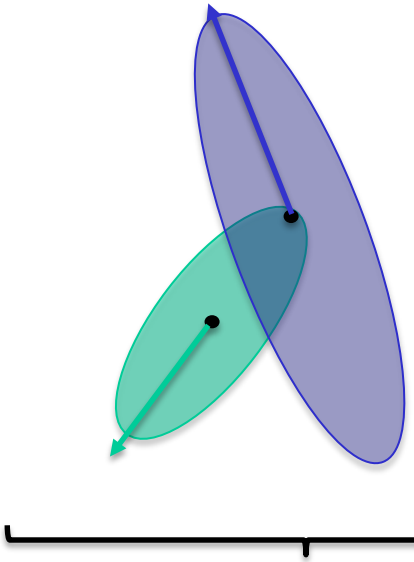
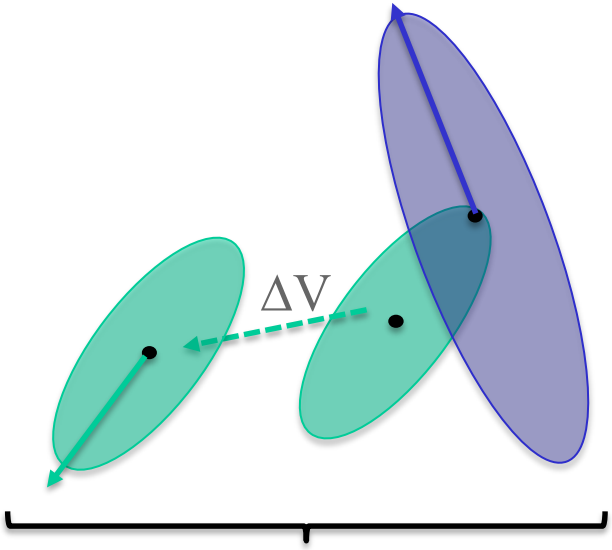
Conjunction Assessment: Basic Definitions and Responsibilities



Conjunction Assessment (CA) is the process of identifying close approaches between two orbiting objects; sometimes called conjunction “screening”

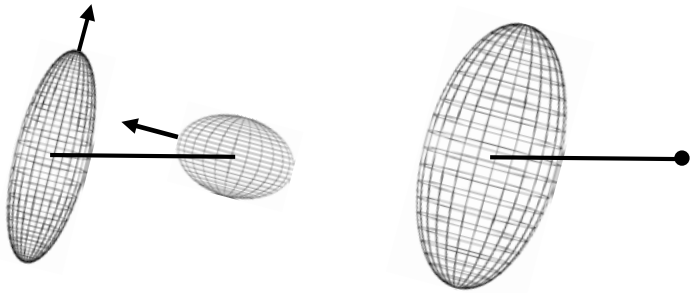


CA Risk Analysis (CARA) is the process of assessing collision risk and assisting the planning of maneuvers to mitigate that risk, if warranted

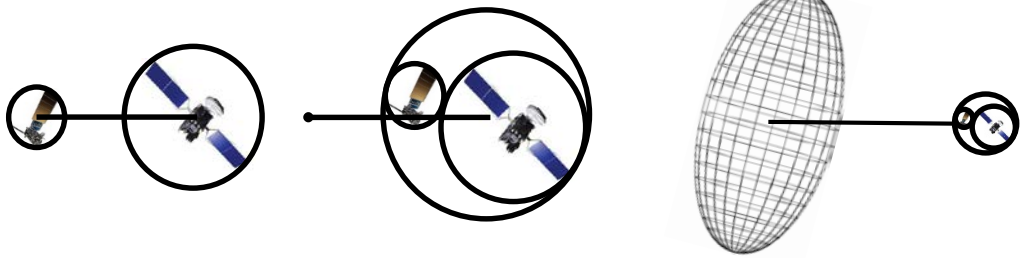


Collision Avoidance (COLA) is the process of executing mitigative action, typically in the form of an orbital maneuver, to reduce collision risk

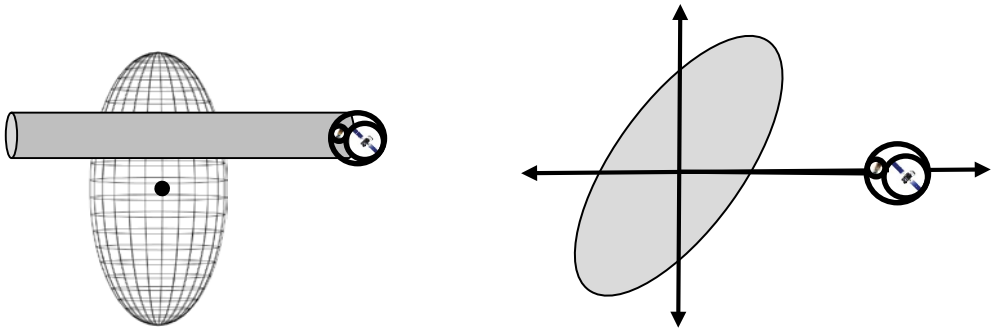
Calculation of Satellite Probability of Collision (condensed to one chart)



Step I: Primary and Secondary uncertainties combined and placed at position of secondary



Step II: Primary and Secondary object sizes combined with circumscribing sphere and placed at position of primary



Step III: If collision hyperkinetic, motion approximated as rectilinear. Primary's motion can be considered a straight cylinder, which marginalizes out that component's contribution to probability--can then project situation into plane

$$P_C = \frac{1}{\sqrt{(2\pi)^2 \left|C^*\right|}} \iint_A \exp\left(-\frac{1}{2}\vec{r}^{\,T} C^{*-1} \vec{r}\right) dXdZ$$

Step IV: Probability of collision is portion of covariance probability density that falls within HBR circle; as given by above integral

Satellite Drag Acceleration

Drag Coefficient: mostly invariant during satellite's lifetime

Frontal Area in Prediction: can vary due to rotation of an uncontrolled satellite

Drag Acceleration

$$\ddot{r} = -\frac{1}{2} C_D \frac{A}{M} \rho v_r^2 e_v$$

Velocity Relative to Atmosphere: well determined in most cases

Satellite Mass: either mostly invariant or well known

Atmospheric Density in Prediction: most variable and difficult of all these parameters to estimate

- **CA is always performed in prediction**
  - Predict conjunction and choose mitigation actions well before close approach
- **Focus thus on prediction error (rather than fit or measurement error)**
- **Atmospheric density forecast error is largest source of drag error**
- **Suggests that problem is space weather index forecasting, not atmospheric density model performance *per se***

Conjunction Assessment: Space Weather Research Goals

- **Density models should characterize and output prediction errors**
  - Most models simply give density estimates, not prediction estimation variances
  - Errors can be incorporated in conjunction assessment calculations
    - *e.g.,* incorporation into position covariances and thus into probability of collision calculation
  - More useful to give reasonable answer with error statement than somewhat better answer with no such statement
- **Focus should be on reducing prediction error, not model fidelity**
  - Typical prediction errors notably exceed static model errors
  - Need especially great under solar storm conditions

Greatest need for satellite conjunction assessment is to reduce atmospheric density forecast error