

STK Grundlagen 2

Astrogator

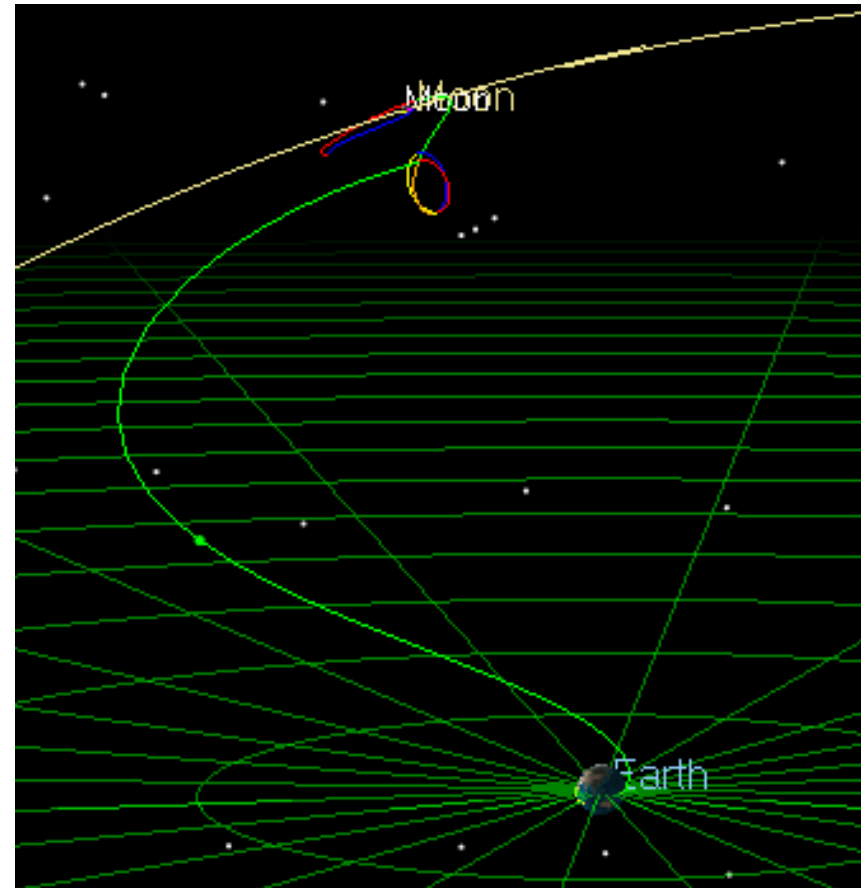
Michael Lachenmann
Oliver Zeile

Inhalt

- Einführung Astrogator
- Einfacher Hohmann-Übergang mit vorgegebenem ΔV
- Zielgerichteter Hohmann-Übergang LEO- \rightarrow GEO
 - Positionierung eines GEO Satelliten

Einführung Astrogator

- Astrogator ist eine visuelle Programmiersprache um komplizierte Missionsabläufe sequenziell zu simulieren
 - Starts, Manöver, Interplanetare Missionen, Rendezvous und Docking
 - Missionsplanung, Design und Analyse
- Bahnberechnung durch numerische Integration



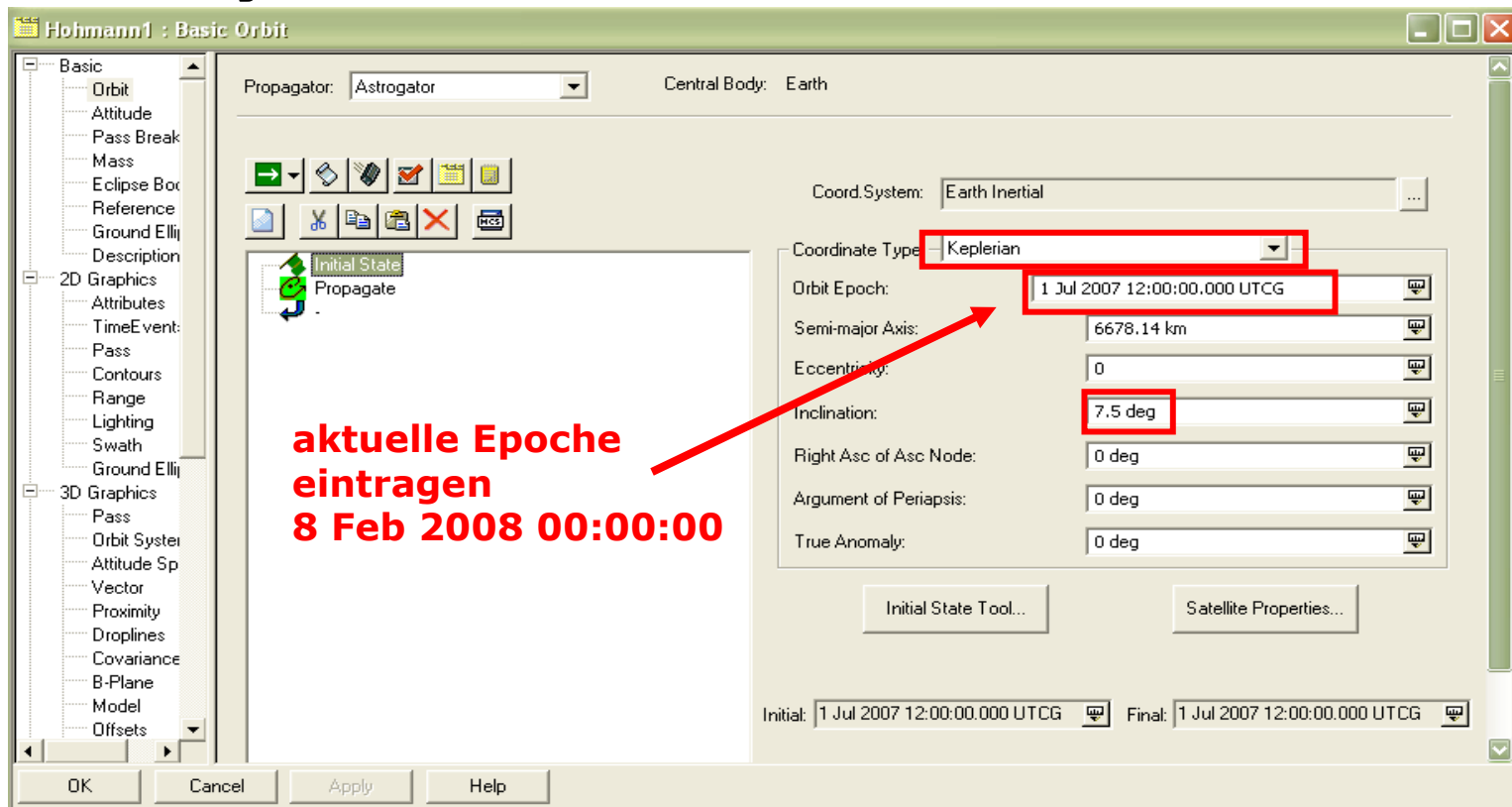
Astrogator

- Neues Szenario erstellen: Astrogator1
 - Start: 8 Feb 2008 00:00:00
 - Stop: 9 Feb 2008 00:00:00
 - Epoch: 8 Feb 2008 00:00:00
- 3D Graphics 1 – Properties – Grids: Show ECI Coordinates aktivieren
- Neuer Satellit: Hohmann1
 - Orbit Wizard abbrechen
- Satellite Properties – 3D Graphics – Pass – Orbit Track – Lead Type: All
- Satellite Properties – 3D Graphics – Model – Detail Thresholds: Marker, Label auf Maximum setzen



Initial State

- Satellite Properties – Orbit – Propagator:
Astrogator



Propagate

Hohmann1 : Basic Orbit

Propagator: Astrogator Central Body: Earth

Propagator: Earth HPOP Default v8-1-1 Advanced...

Stopping Conditions Insert... Remove

| On | Name | Sequence | User Comment | Descriptio |
|-------------------------------------|---------------|----------|---------------------------------|-----------------------|
| <input checked="" type="checkbox"/> | Duration STOP | | Stop after a specified duration | Stop after a specifie |

Trip: 7200 sec Criterion: [dropdown]

Tolerance: 1e-008 sec Repeat Count: 1

Sequence: STOP Max Trip Times: 10000

User Calc Object: [dropdown] Constraints: [dropdown]

Before: N/A Condition Inherited by Automatic Sequences

Initial: 8 Feb 2008 00:00:00.000 UTCG Final: 8 Feb 2008 12:00:00.000 UTCG

OK Cancel Apply Help

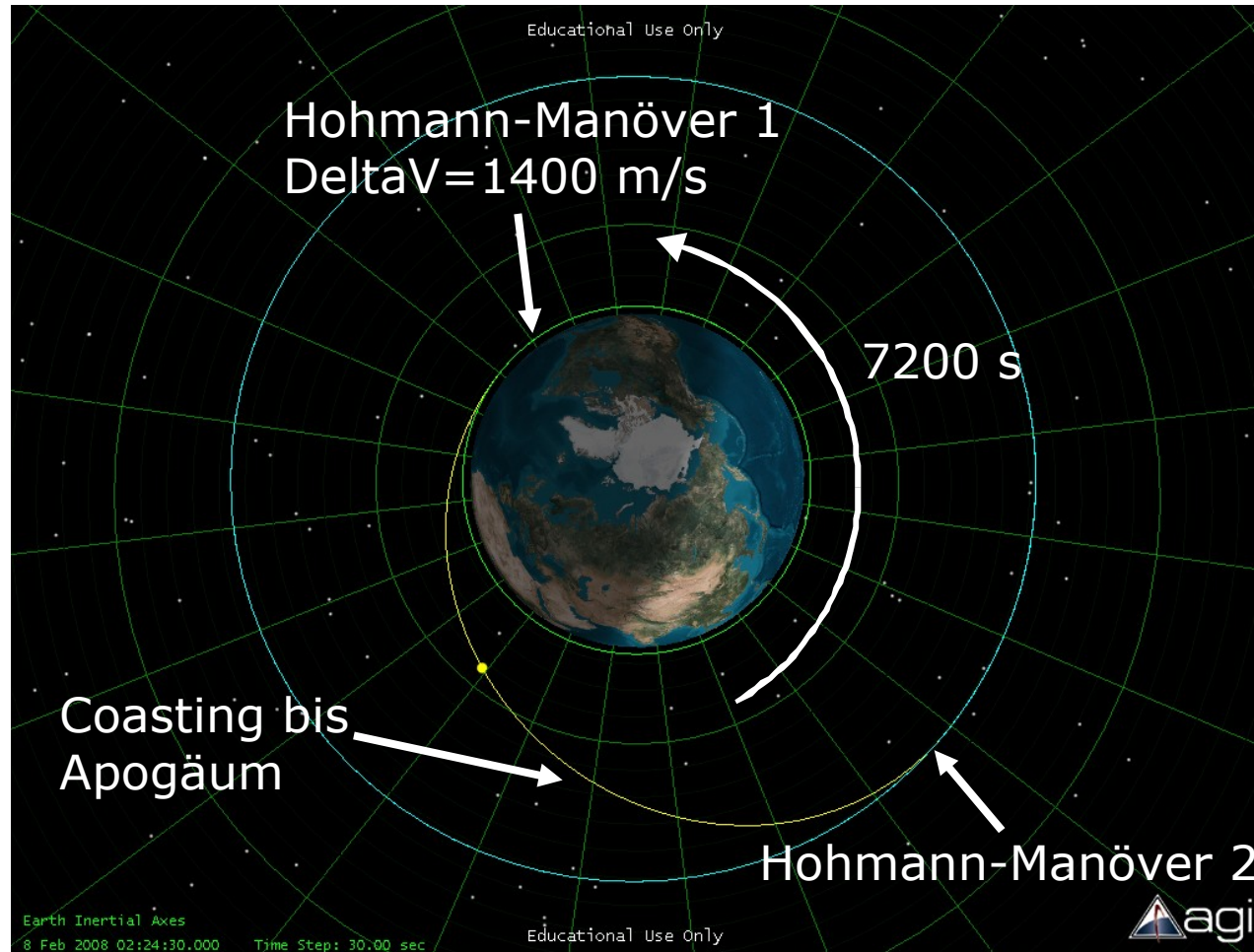


Hohmanntransfer – Ausgangsorbit

- Run entire Mission Control Sequence



Hohmannübergang



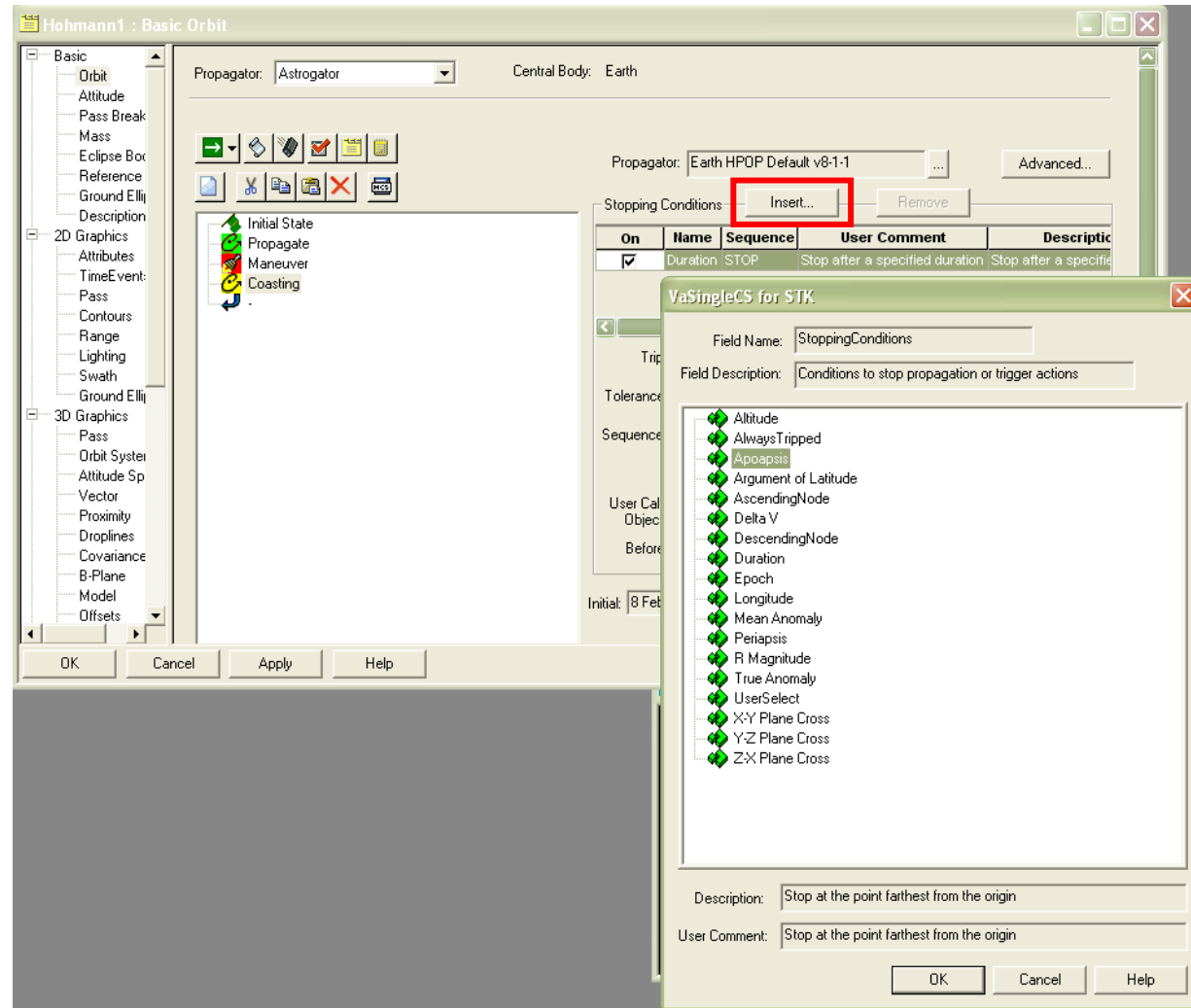
Hohmannübergang – 1. Maneuver

- Insert Segment – Maneuver
- Delta V Magnitude: 1400 m/sec
- Insert Segment – Propagate:
umbenennen in `Coasting`
- Run entire Mission Control Sequence
- Animation abspielen



Hohmannübergang – 2. Manöver

- Coasting – Stopping Condition – Insert: Apoapsis
- Run!



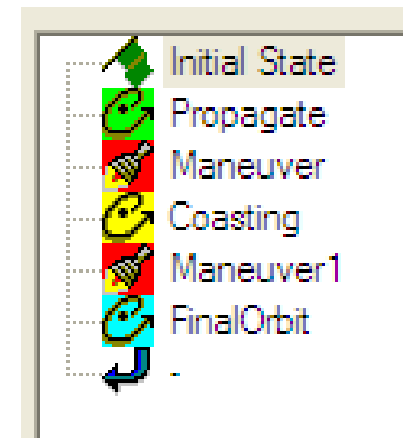
Hohmannübergang – 2. Maneuver

- Insert Maneuver
- **Wie groß muss das Delta V sein, damit der Orbit kreisförmig wird?**

$$\Delta v_2 = v_{2,k} - v_{2,HE} = \sqrt{\frac{\mu}{r_2}} - v_{2,HE}$$

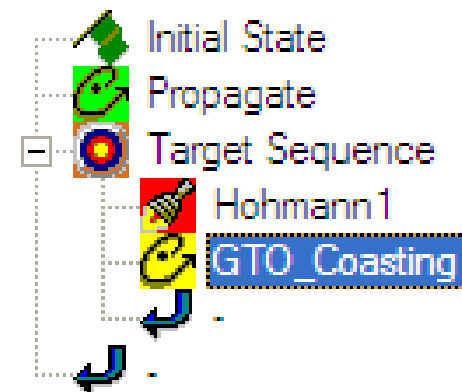
$$\mu = 3.989 \times 10^{14} \text{ m}^3 \cdot \text{s}^{-2}$$

- Insert - Propagate Segment:
Final_Orbit
- Run, Animation starten!
- Exzentrizität überprüfen



Target Sequence

- Hohmann1 Satellit kopieren und einfügen
- Alle Segmente bis auf Initial State und Propagate löschen
- Insert – Target Sequence
- Target Sequence öffnen
 - Neues Manöver innerhalb der Target Sequence erstellen: Hohmann1
 - Neues Propagate-Segment einfügen: GTO_Coasting



GTO_Coasting

- GTO_Coasting – Stopping Conditions
– Insert: `Apoapsis`
- Duration Condition deaktivieren
- GTO_Coasting – Results – Keplerian
Elements: `Radius of Apoapsis`
einfügen



Target Sequence – 1. Maneuver

- Target hinter Delta V Magnitude aktivieren
- Initial Guess für Delta V eintragen: 2 km/s
- Target Sequence – Profiles – Properties:
 - Impulsive Maneuver aktivieren
 - Radius of Apoapsis aktivieren
 - Radius of Apoapsis – Tolerance: 1m
 - Desired Value: 42164.17 km

Target Sequence – 1. Maneuver

Differential Corrector

Variables | Convergence | Advanced | Log | Output

Control Parameters

| Use | Name | Final Value | Last Update | Object |
|-------------------------------------|-----------------------------------|-------------|-------------|----------|
| <input checked="" type="checkbox"/> | ImpulsiveMnvr.Spherical.Magnitude | 2 km/sec | 0 km/sec | Maneuver |

Initial Value: 2 km/sec Perturbation: 0.0001 km/sec Scaling Method: By initial value Value: 0.001 km/sec

Correction: 0 km/sec Max. Step: 0.1 km/sec

Tolerance: 1e-009 km/sec

Equality Constraints

| Use | Name | DesiredValue | CurrentValue | Object |
|-------------------------------------|----------------|--------------|--------------|----------|
| <input checked="" type="checkbox"/> | Semimajor_Axis | 0 km | -Not Set- | Maneuver |

42164.17 km

Difference: 0 km Scaling Method: By desired value Weight: 1

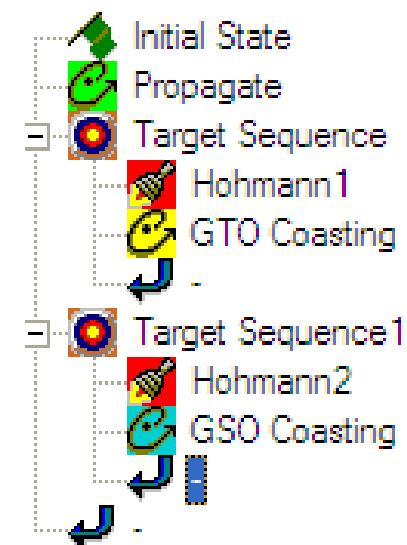
Tolerance: 1 m Value: 0.001 km

OK Abbrechen Hilfe

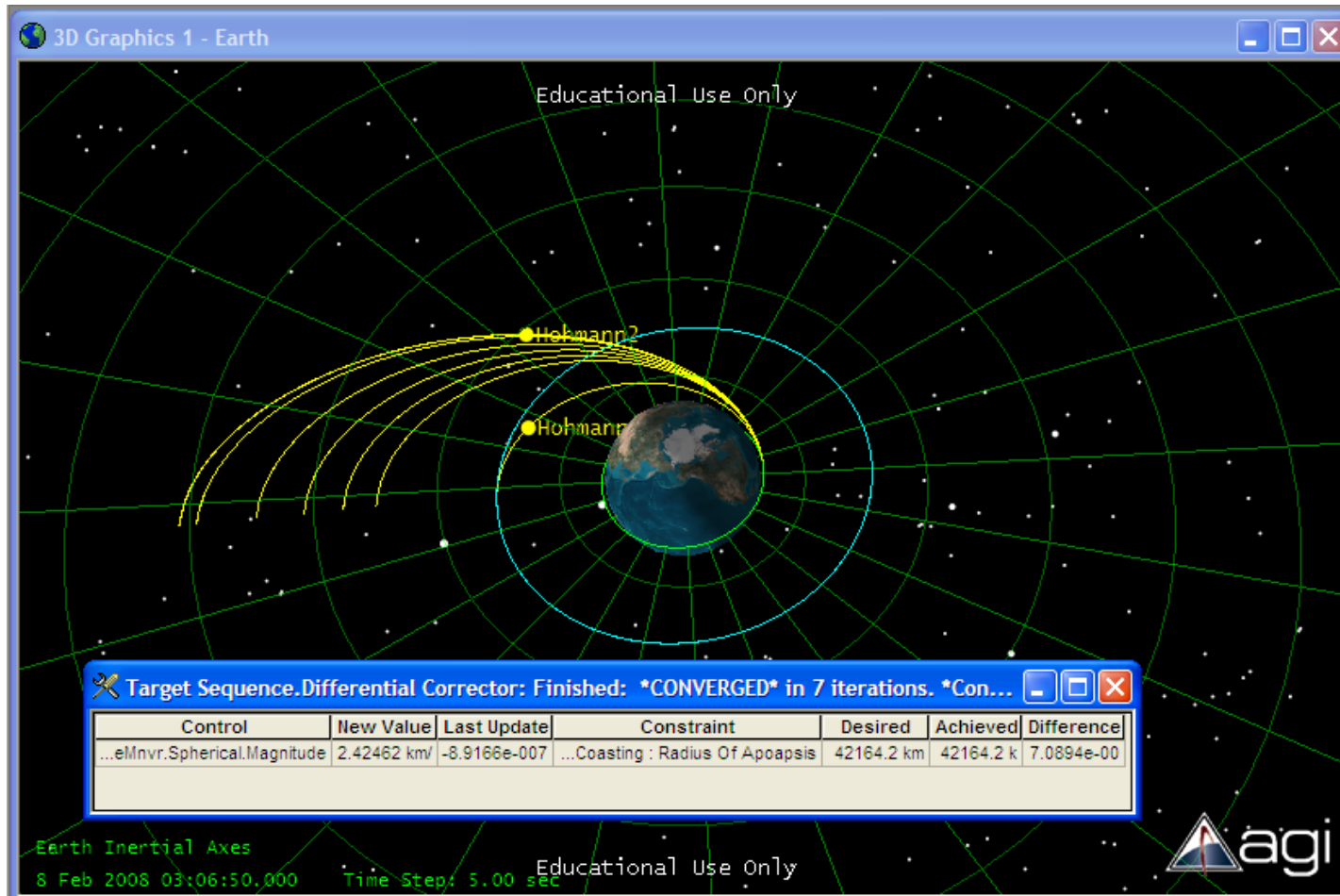


Target Sequence – 1. Maneuver

- Target Sequence – Action: Run active profiles
- Run!
- Target Sequence einfügen
 - Manöver in Target Sequence einfügen: Hohmann2
 - Delta V Target aktivieren
 - Initial Guess eintragen: 1 km/s
 - Propagate einfügen: GSO_Coasting
 - Stopping Conditions – Duration – Trip: 24 hr



Target Sequence – 1. Maneuver



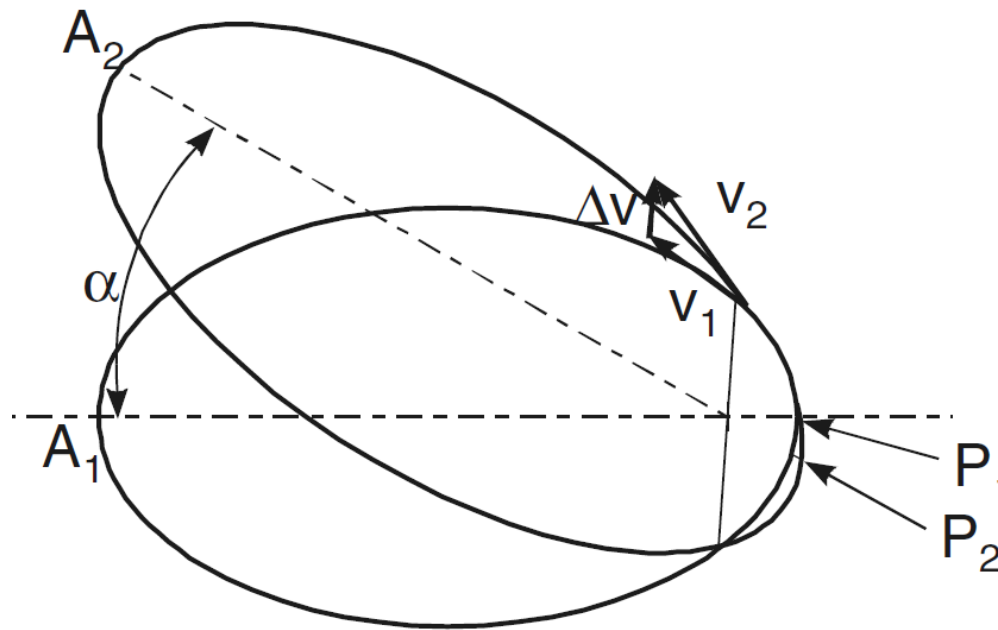
Target Sequence – 2. Manöver

- GSO_Coasting – Results – Keplerian Elements: Eccentricity
- Target Sequence1 – Properties – Impulsive Maneuver: aktivieren
- Target Sequence1 – Properties – Eccentricity: aktivieren
- Target Sequence1 – Properties – Eccentricity – Tolerance: 0.001
- Target Sequence1 – Action: Run Active Profiles
- Run!



Inklination

- Was muss getan werden um die Inklination auf 0° zu verringern?

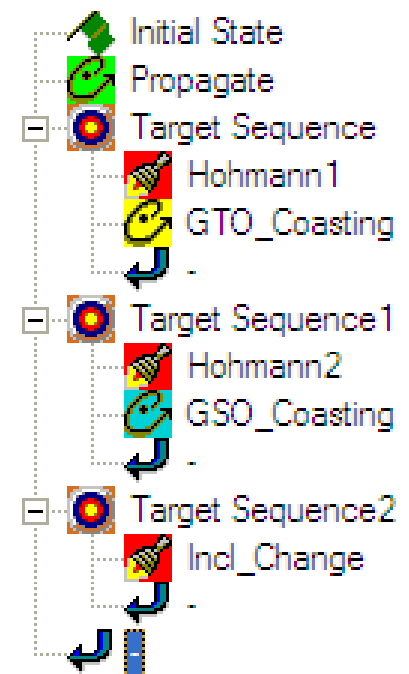


Quelle: Messerschmid, Raumfahrtsysteme



Target Sequence – Inklinationsmanöver

- GSO_Coasting – Stopping Conditions – Insert – Ascending Node
- Target Sequence einfügen
 - Maneuver in Target Sequence einfügen: Incl_Change
 - Maneuver – Attitude Control: Thrust Vector, X (Velocity) aktivieren, Y (Normal) aktivieren



Target Sequence - Inklinationsmanöver

- Incl_Change – Results – Keplerian Elements:
 - Inclination einfügen
 - Eccentricity einfügen
- Target Sequence2 – Action: Run active profiles
- Target Sequence2 – Properties – Impulsive Maneuver X & Y aktivieren, Inclination und Eccentricity aktivieren
- Tolerance: 0.001 deg bzw. 0.001
- Propagate Segment einfügen, Trip: 24 hr



Antriebsbedarf

- Wie lange dauert der gesamte Hohmann-Übergang?
- Wieviel Delta V wird für die drei Manöver benötigt?
- Was muss getan werden um eine Geostationäre Bahn mit 19.2° Ost zu erreichen?