

Visual Orbit Design for Next Mars Exploration Mission

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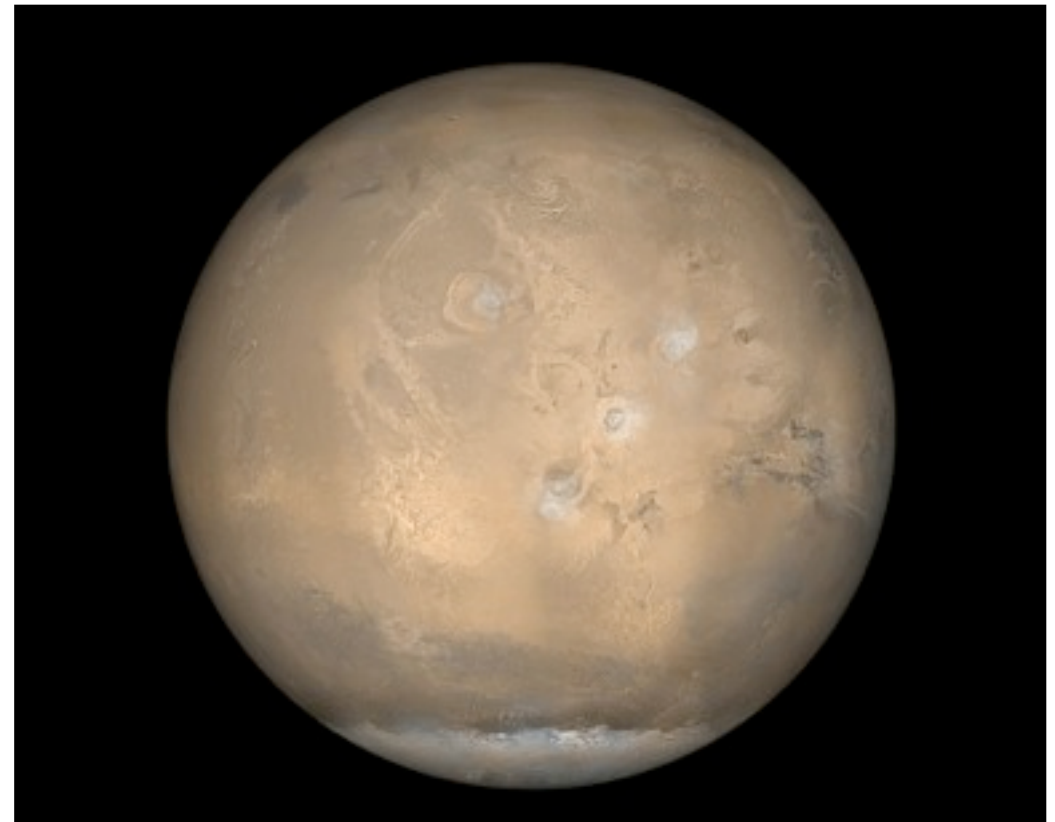
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Mission Purpose

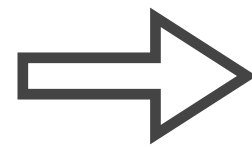
Past



Present



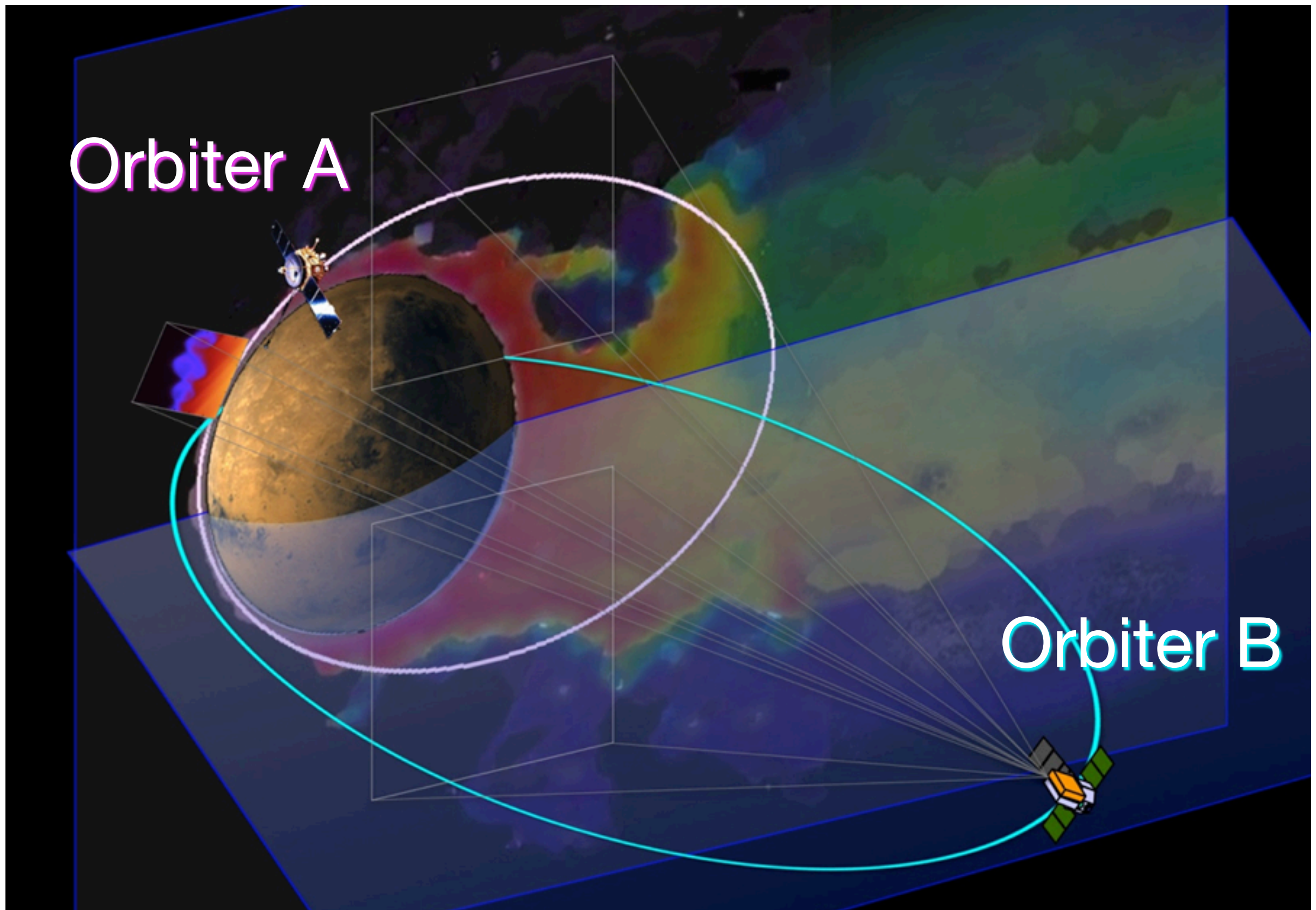
Plenty of Water and
Thick Atmosphere



No Water and
Thin Atmosphere

**To understand mechanism of
Atmospheric Evolution and Habitable Zone**

Mission Configuration



Orbit Constraints

A1 | Periapsis altitude is around 150 km

A2 | Apoapsis altitude is about 5000 km - 7000km

A3 | A period in which periapsis is in the dayside is over the two thirds of mission period

B1 | Apoapsis altitude is about 4 Mars radius km - 6 Mars radius km

B2 | A period in which orbiter is in the solar wind region is more than 75 % of the mission period

B3 | A period in which orbiter can image a Martian rim is about 12 h - 15 h in the local time is more than 75 % of the mission period

C1 | An opportunity in which orbiterB being solar wind region image orbiterA whose SZA is less than 60 degrees and altitude is about 300 km - 800 km is more than one hundred times

C2 | When C1 is filled, a formed angle made by orbiterB's visual line of imaging with orbiterA's direction of movement is more than 70 deg

Study Objectives

A1 | Periapsis altitude is around 150 km

A2 | Apoapsis altitude is about 5000 km - 7000km

A3 | A period in which periapsis is in the dayside is over the two thirds of mission period

B1 | Apoapsis altitude is about 4 Mars radius km - 6 Mars radius km

B

B

- To Propose Orbits

C

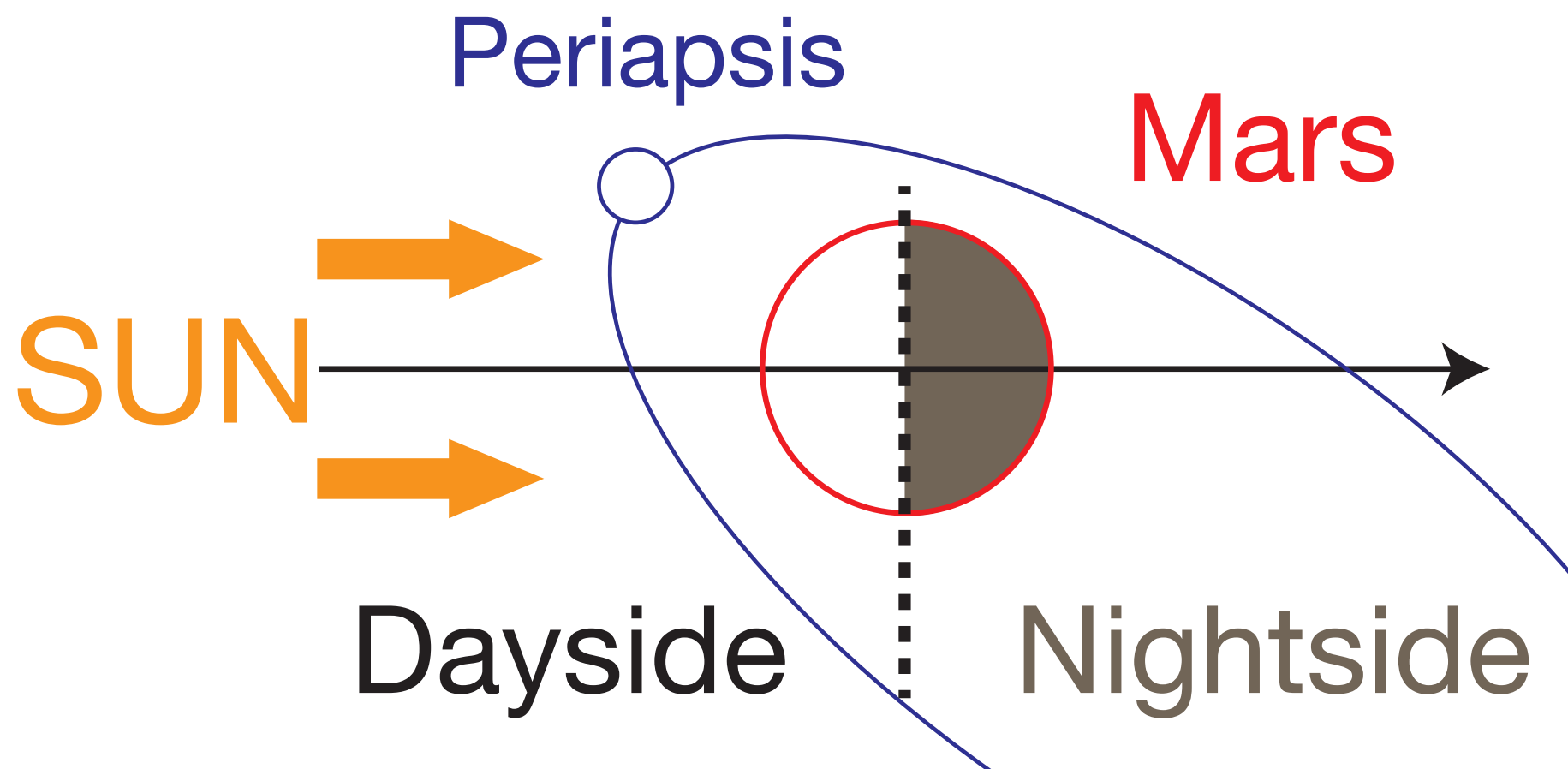
- To Devise Design Methods

C2

with orbiterA's direction of movement is more than 70 deg

Orbit Constraint A3

A period in which **periapsis is in the dayside** is over the two thirds of mission period.



Perturbations change orbital plane and periapsis

Design Variables

Orbital Elements

Symbol	Variable Name	Role
P_A	Periapsis Altitude	Form of Orbit
A_A	Apoapsis Altitude	
i	Inclination	Direction of Orbital Plane
Ω	Longitude of the ascending node	
ω	Argument of periapsis	

J2 Perturbation

Spheroid of planet causes J2 perturbation

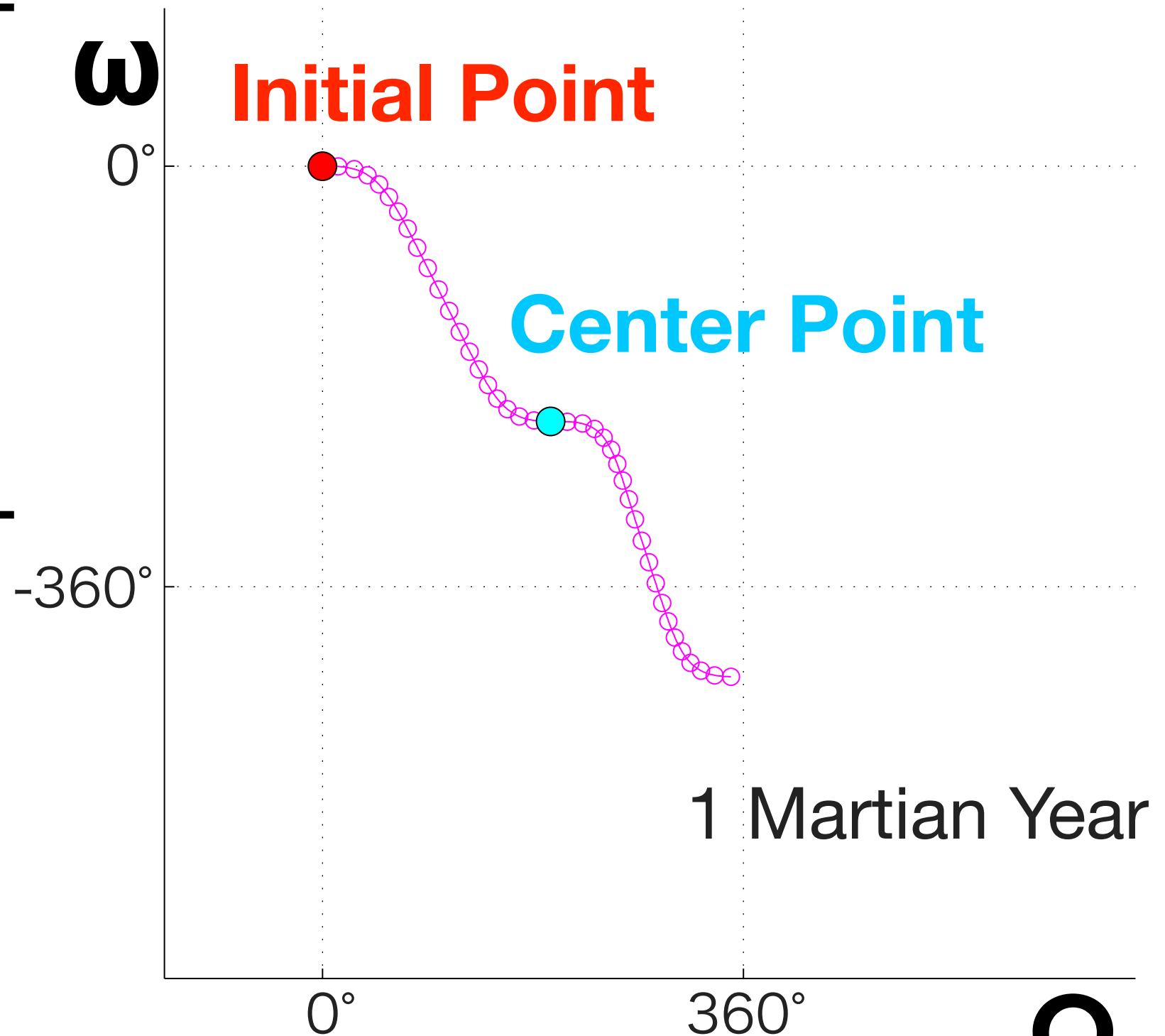
Symbol	Variable Name	Influence
P_A	Periapsis Altitude	Fixed Value
A_A	Apoapsis Altitude	
i	Inclination	
Ω	Longitude of the ascending node	Variations depending on the other variables and time
ω	Argument of periapsis	

Putting variations of Ω and ω in a figure

✧ Ω and ω are in Mars center sun-Mars fixed frame

Orbit Profile

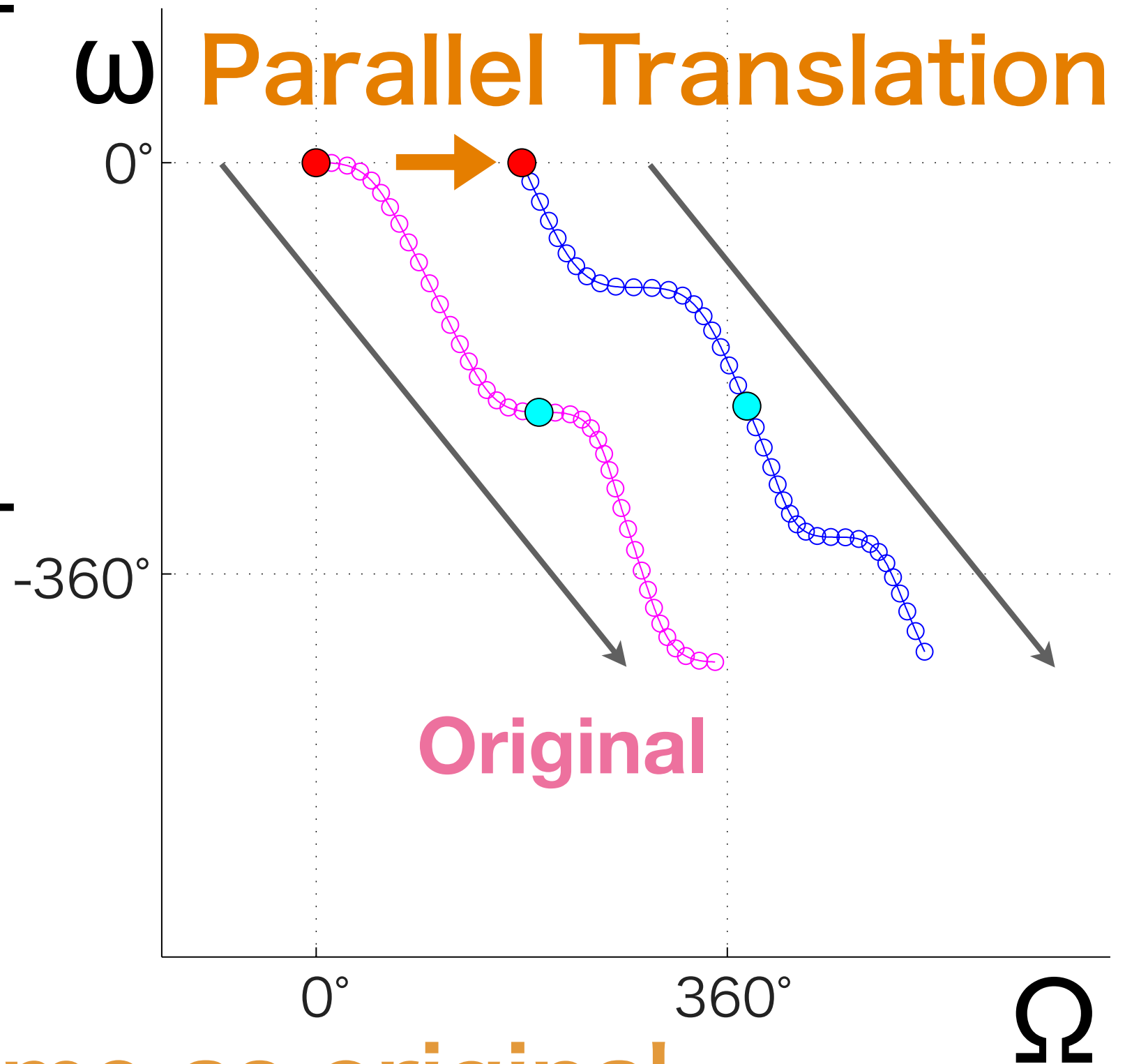
P_A	150 km
A_A	5000 km
i	110°
Ω	0°
ω	0°



Variation behavior of Ω and ω

Parallel Translation

P_A	150 km
A_A	5000 km
i	110°
Ω	$0^\circ \rightarrow 180^\circ$
ω	$0^\circ \rightarrow 0^\circ$



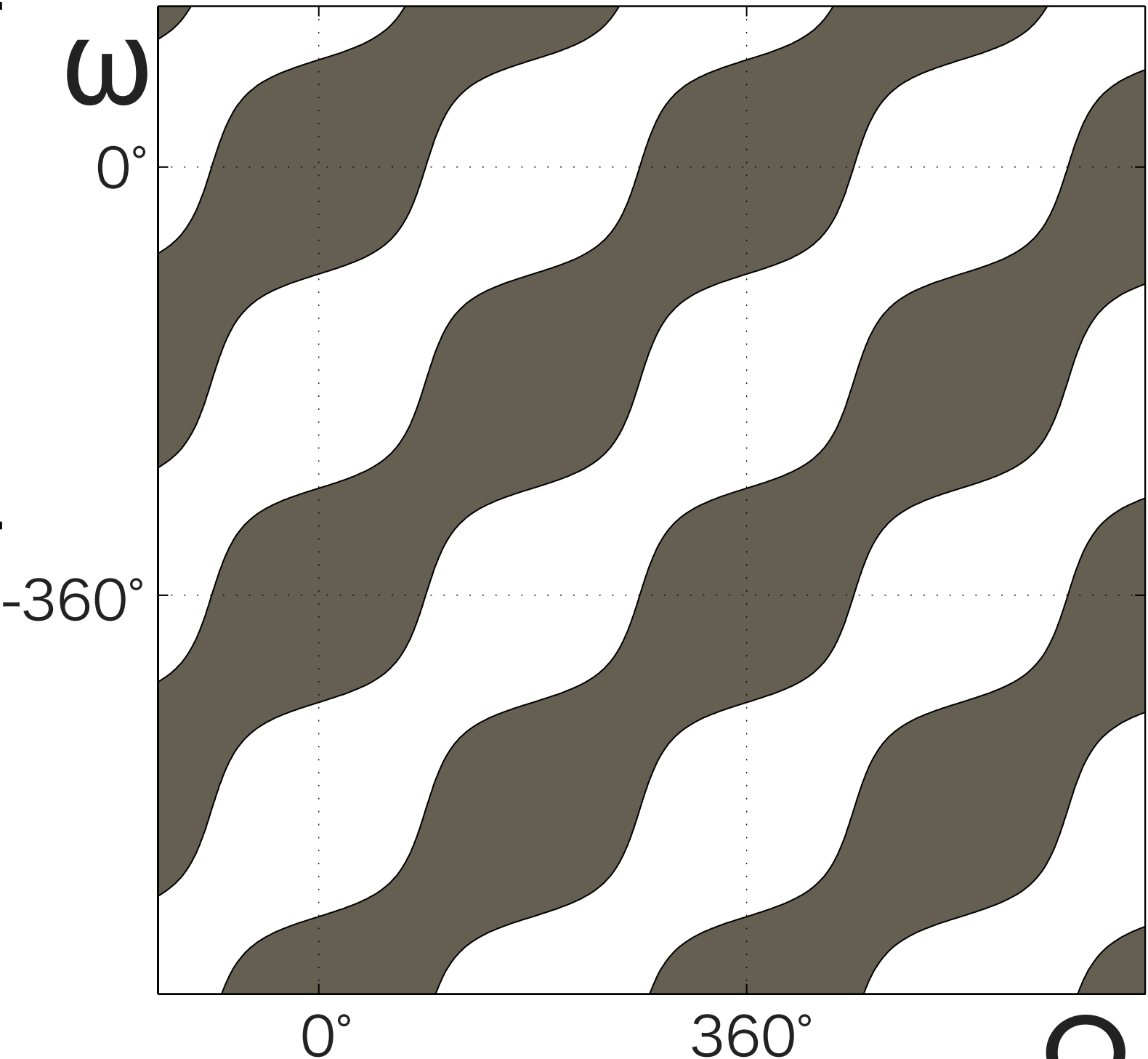
Direction is same as original

Day-Night Map

P_A	150 km
A_A	5000 km
i	110°
Ω	-
ω	-

In one orbit pass,
periapsis is in the

- Dayside
- Nightside



A3 | A period in which periapsis is in the dayside is over the
two thirds of mission period

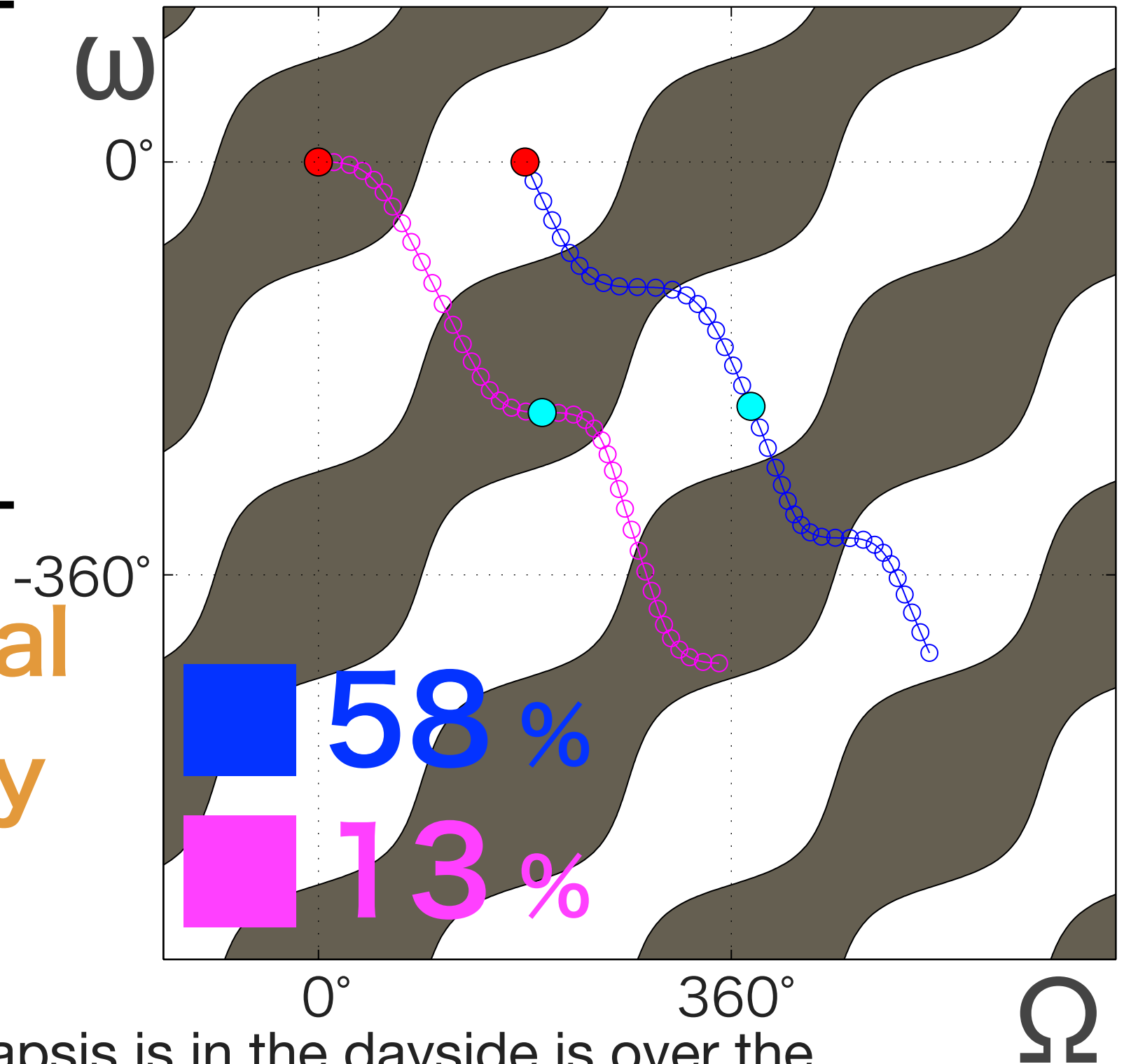
Ω

Designing Ω and ω

P_A	150 km
A_A	5000 km
i	110°
Ω	-
ω	-

To search initial
point to satisfy
constraint

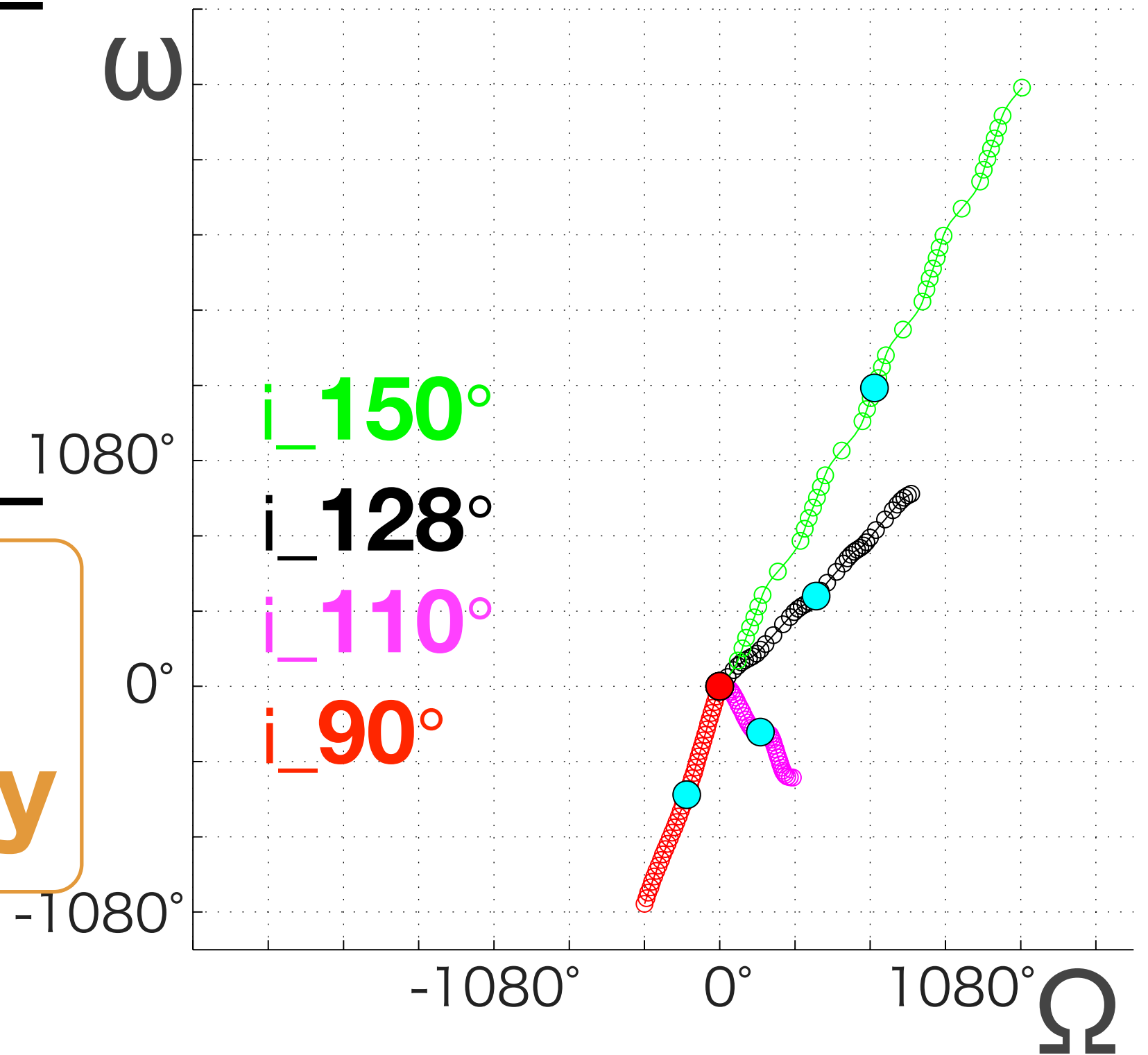
A3 | A period in which periapsis is in the dayside is over the
two thirds of mission period



Orbit Profile and i

P_A	150 km
A_A	5000 km
i	-
Ω	0°
ω	0°

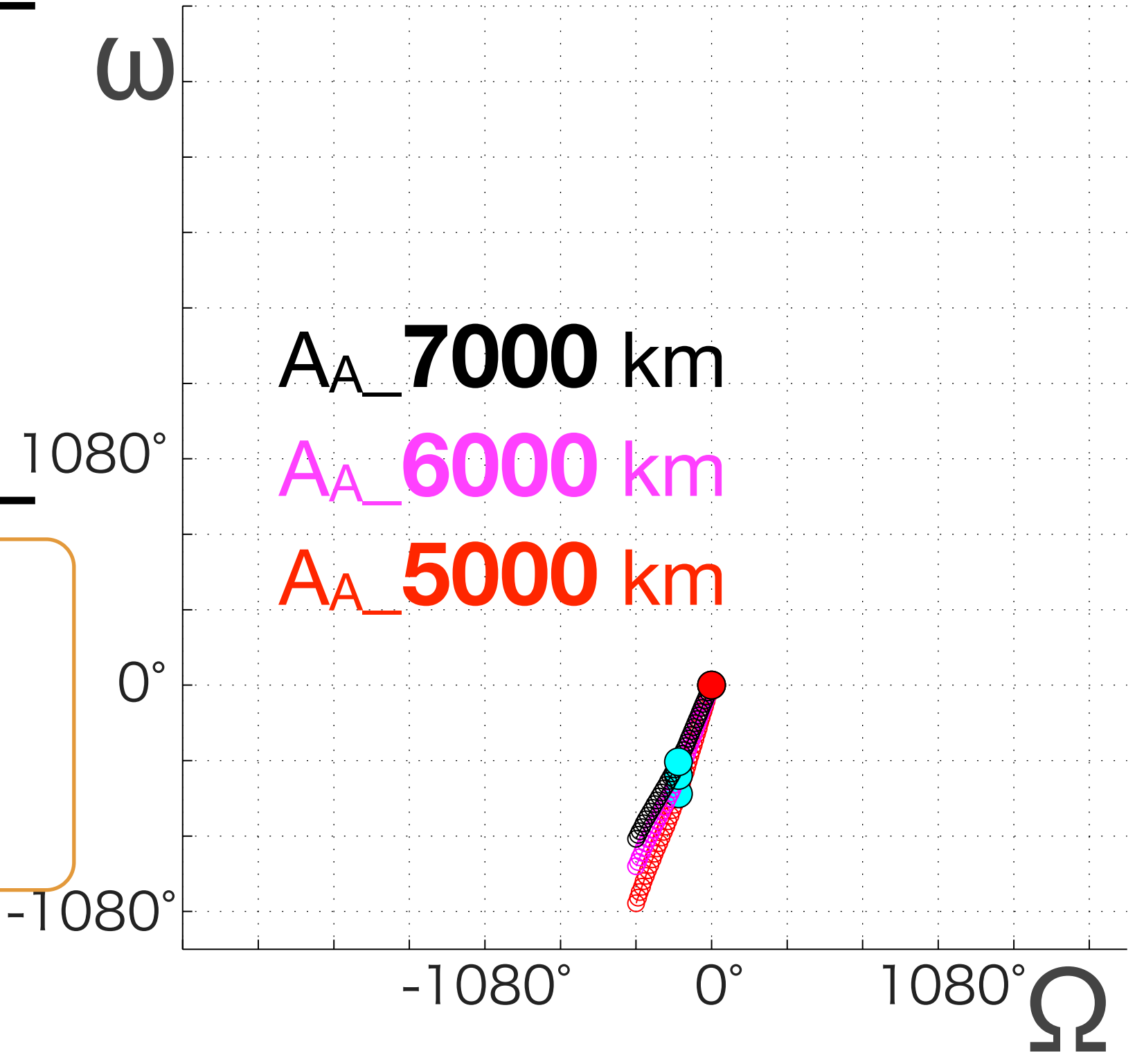
Changing
dramatically



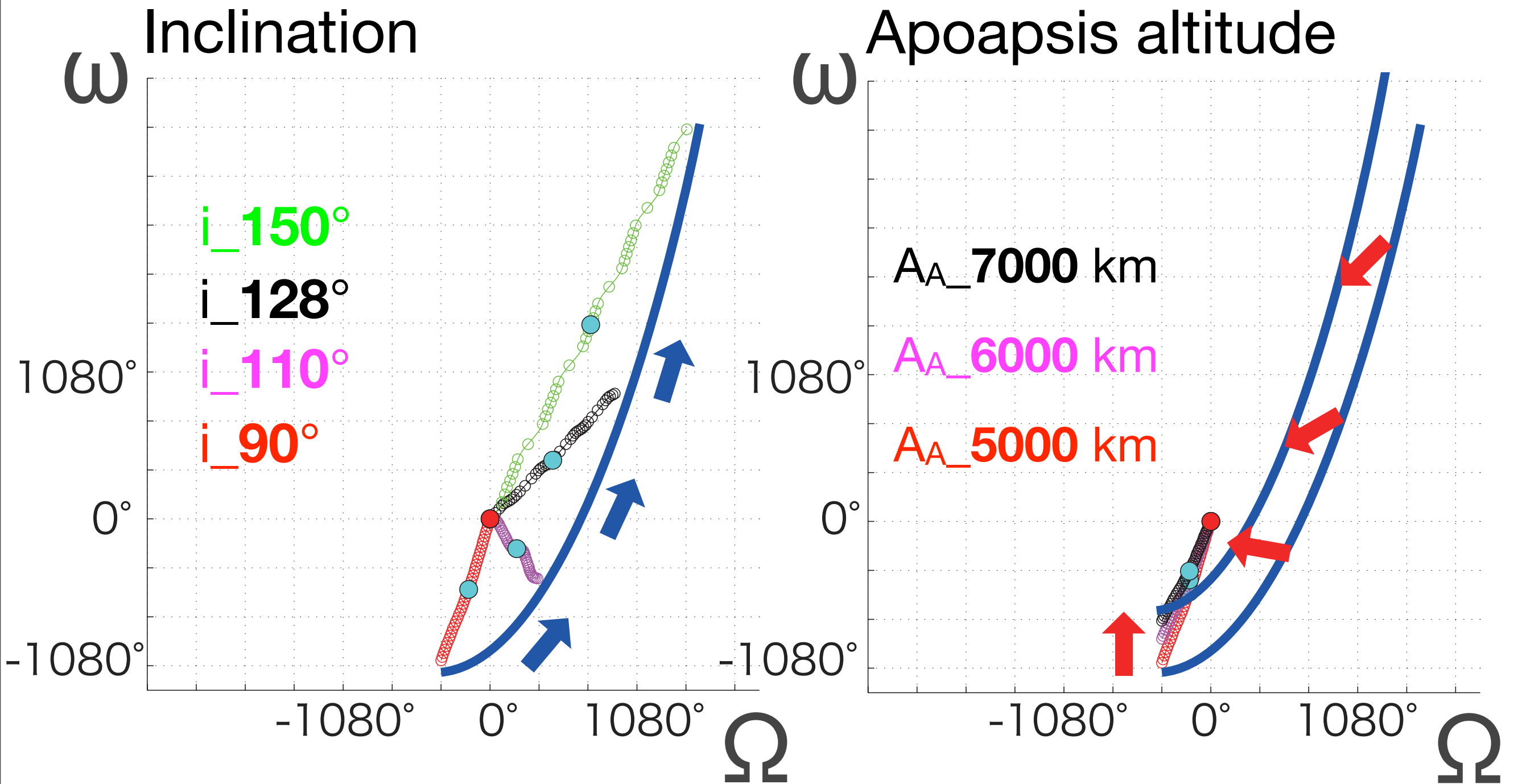
Orbit Profile and A_A | Apoapsis Altitude

P_A	150 km
A_A	-
i	90°
Ω	0°
ω	0°

Changing slightly



Dependence on i and A_A

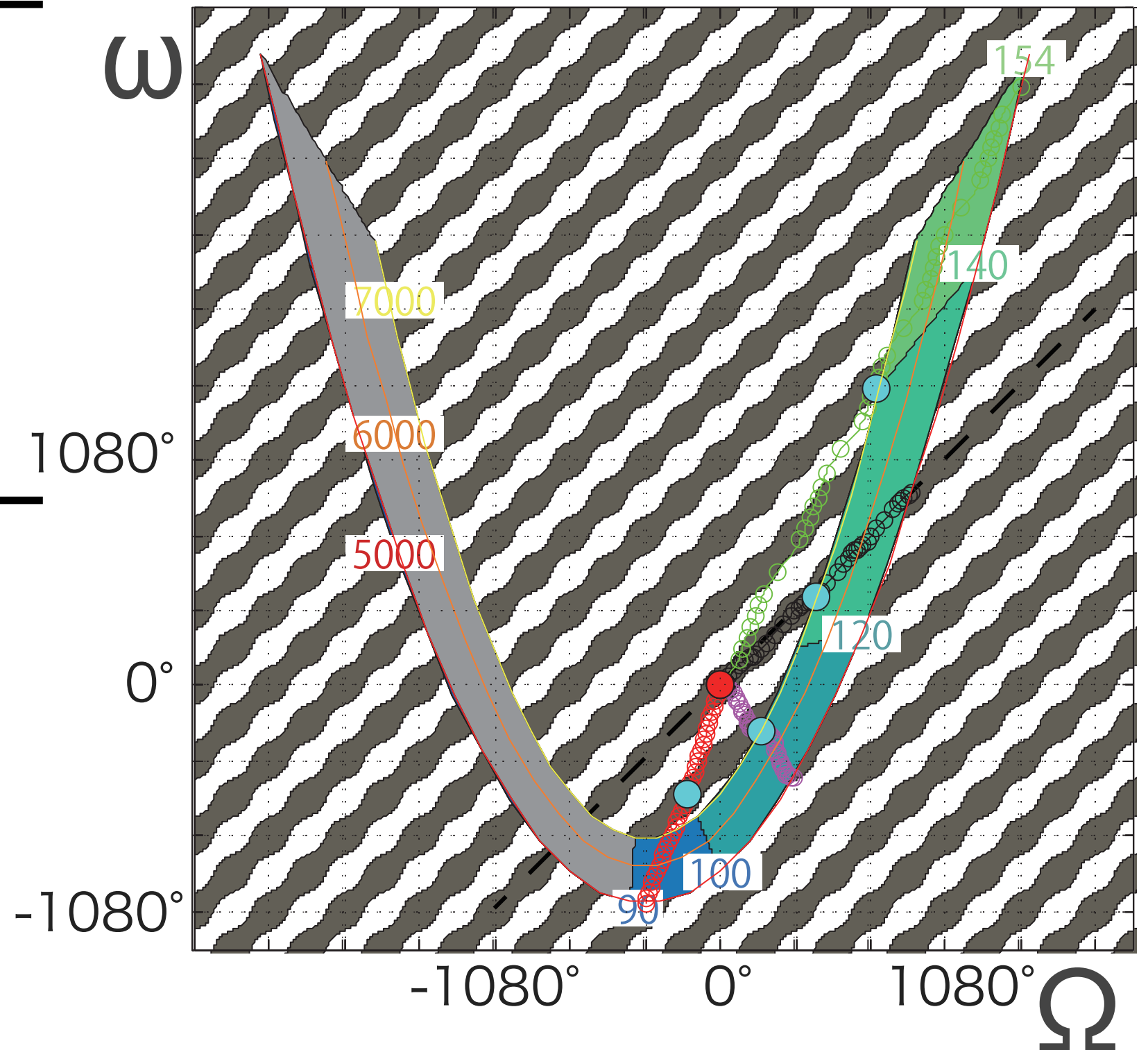


Drawing U-shape

Thickness of U-line

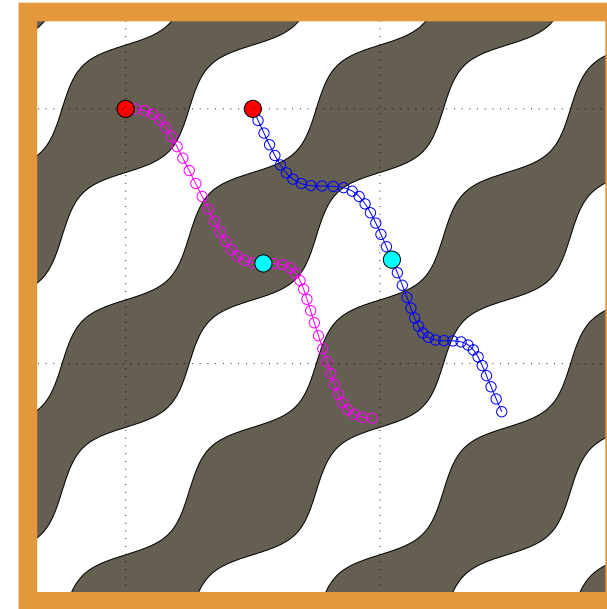
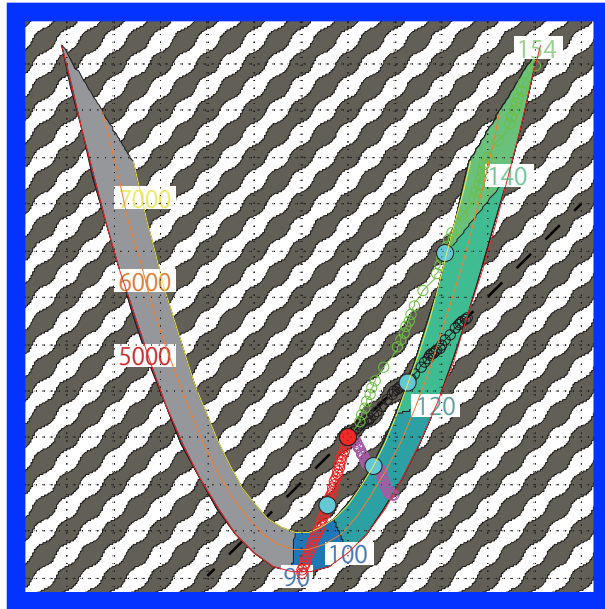
Designing A_A and i

P_A	150 km
A_A	-
i	-
Ω	0°
ω	0°



Choosing form of orbit profile matching to Day-Night Map

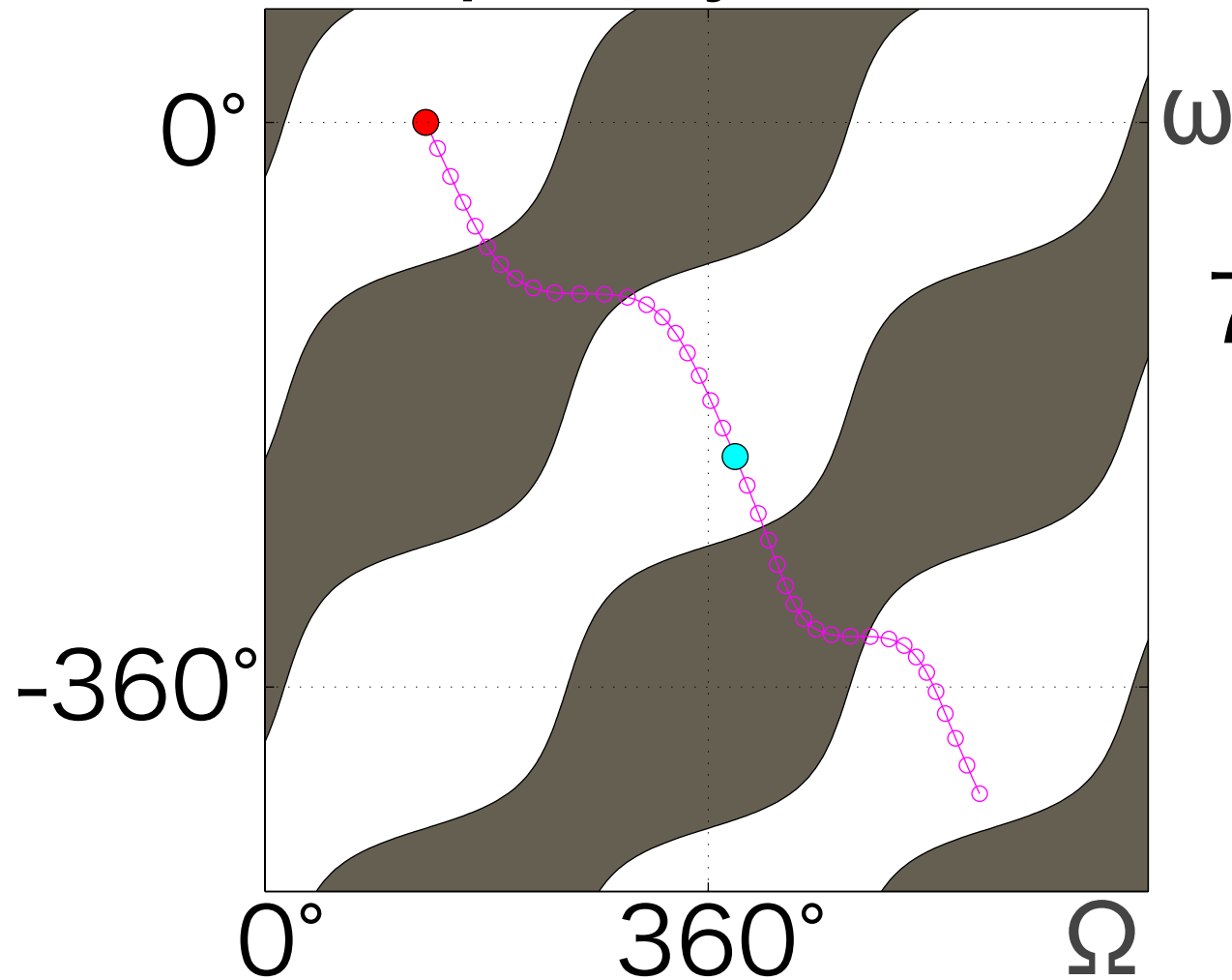
Visual Design Methods



Symbol	Variable Name	Design Methods
P_A	Periapsis Altitude	Orbit Constraint A1
A_A	Apoapsis Altitude	
i	Inclination	
Ω	Longitude of the ascending node	Form of Orbit Profile
ω	Argument of periapsis	
		Initial Position of Orbit Profile

Applications to constraint A3

Temporary Orbit



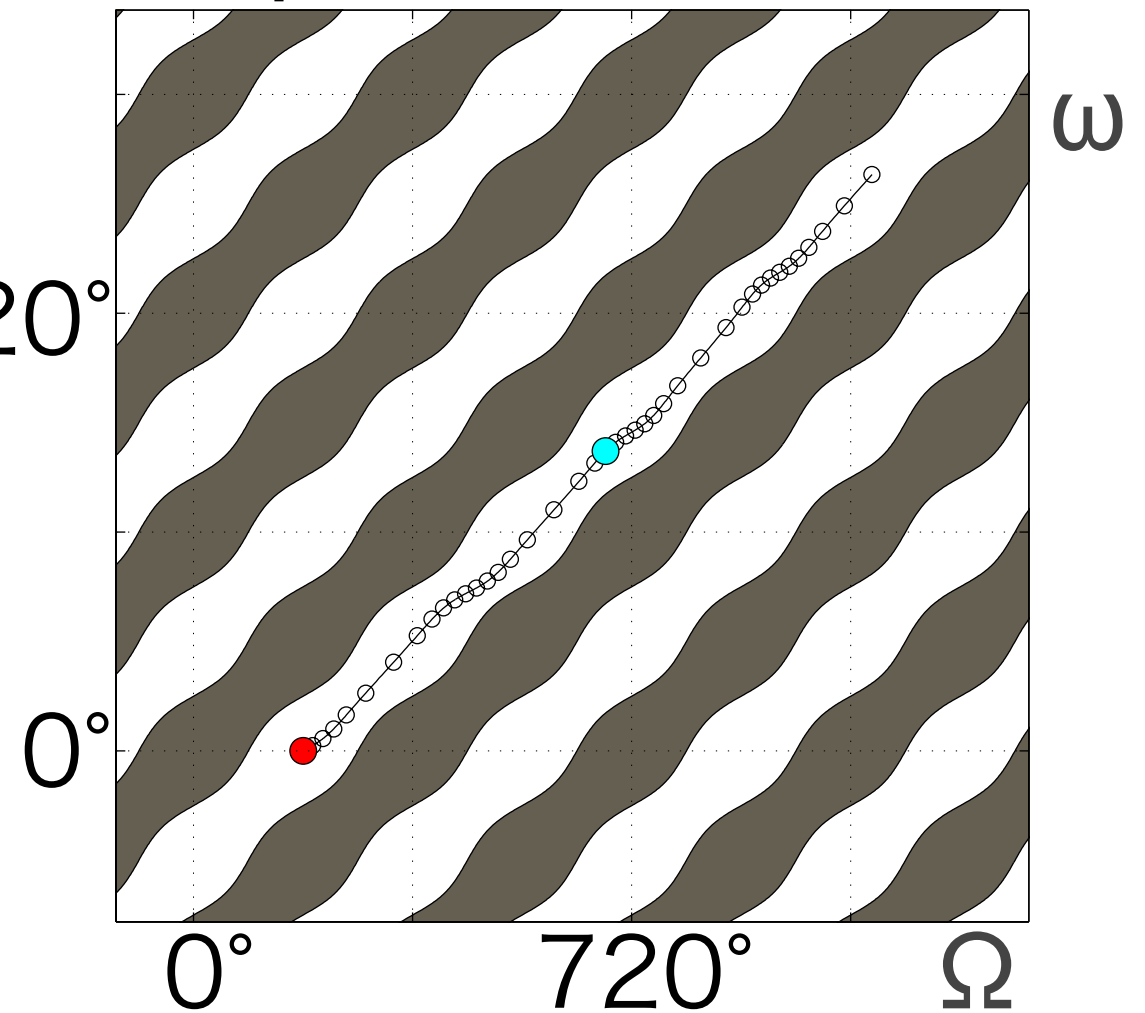
Final Percent

58%

Inclination

110°

Proposed Orbit



Final Percent

100%

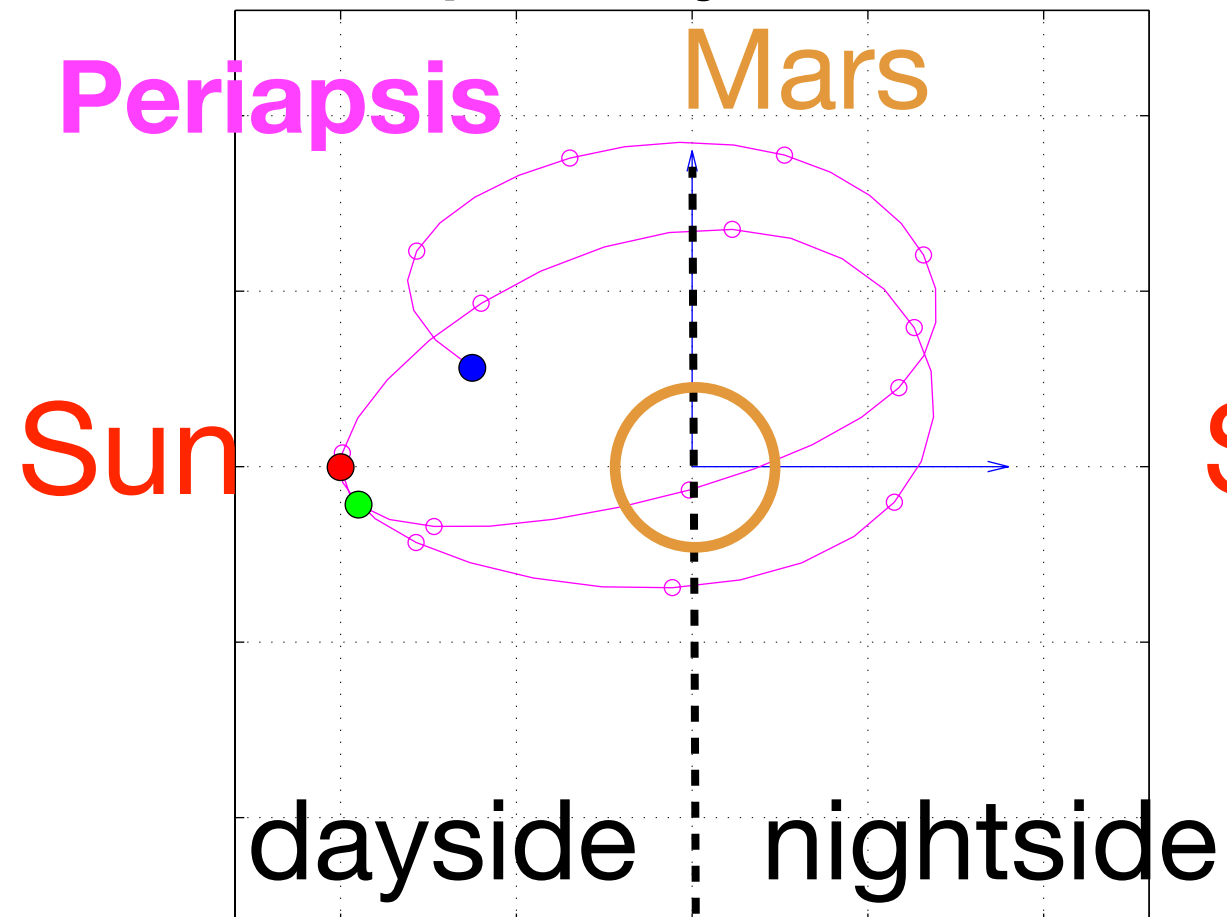
Inclination

128°

A3 | A period in which periapsis is in the dayside is over the two thirds of mission period

Motion of Periapsis

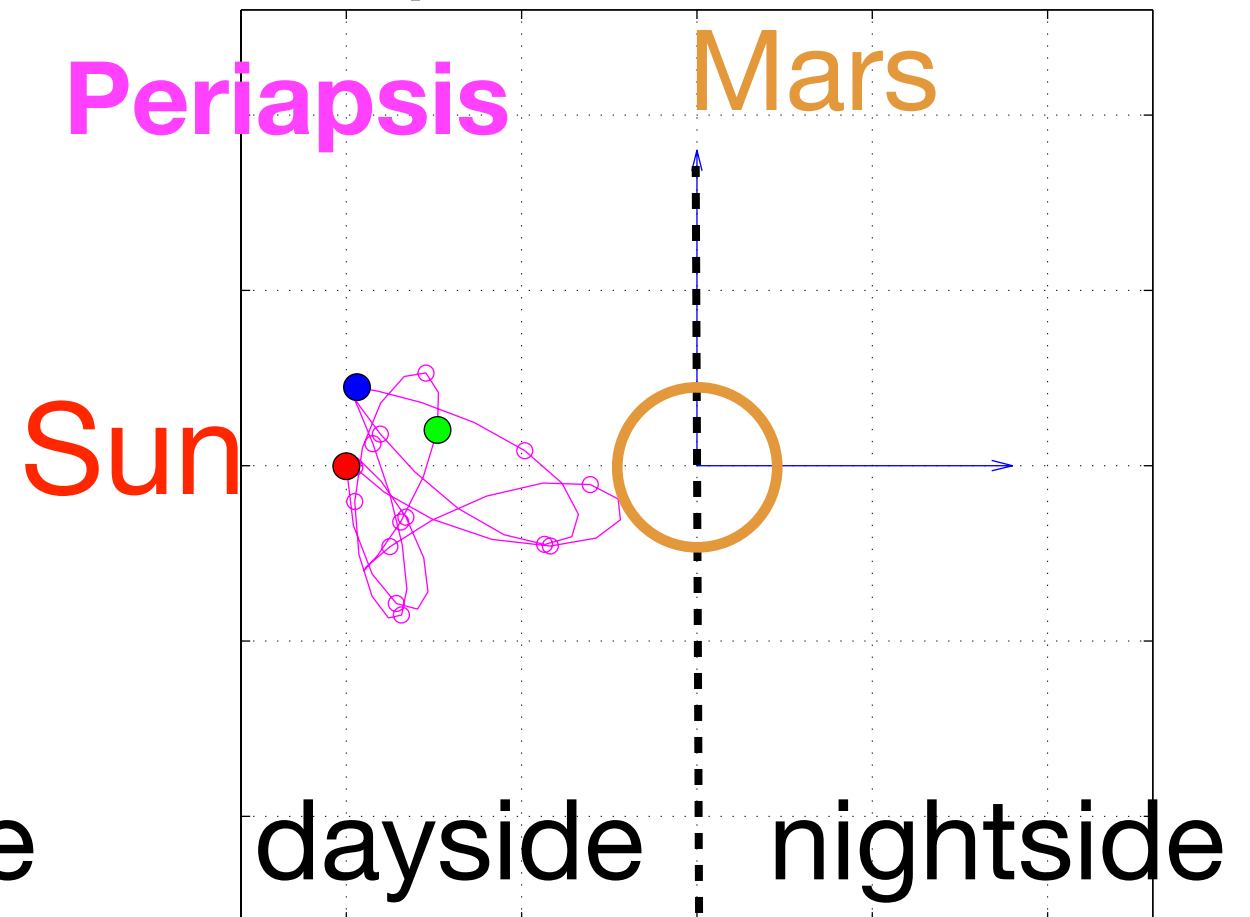
Temporary Orbit



Final Percentage **58%**

Inclination **110°**

Proposed Orbit



Final Percentage **100%**

Inclination **128°**

A3 | A period in which periapsis is in the dayside is over the two thirds of mission period

Conclusion

● We've Devised Design Methods

- To apply to another constraint and mission
- Having a problem with the coverage of i

● Proposing the Orbit fulfilling Constraint A3

- Investigation about orbiter B is ongoing.