GTOC12: Results from Σ Team

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GTOC12 Workshop

2024.1

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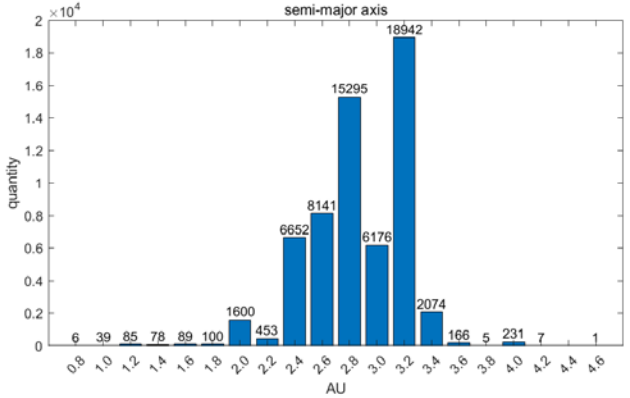
1 Preliminary Analysis

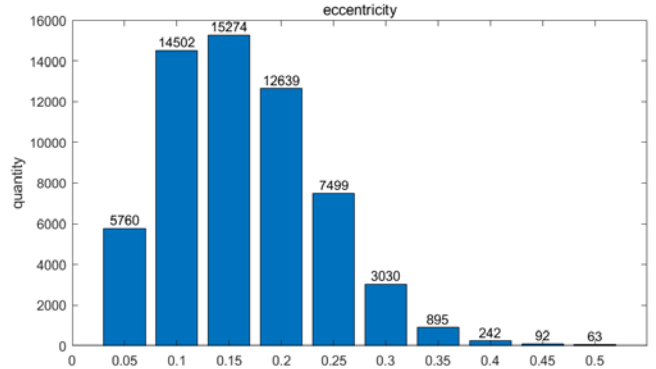
BACC

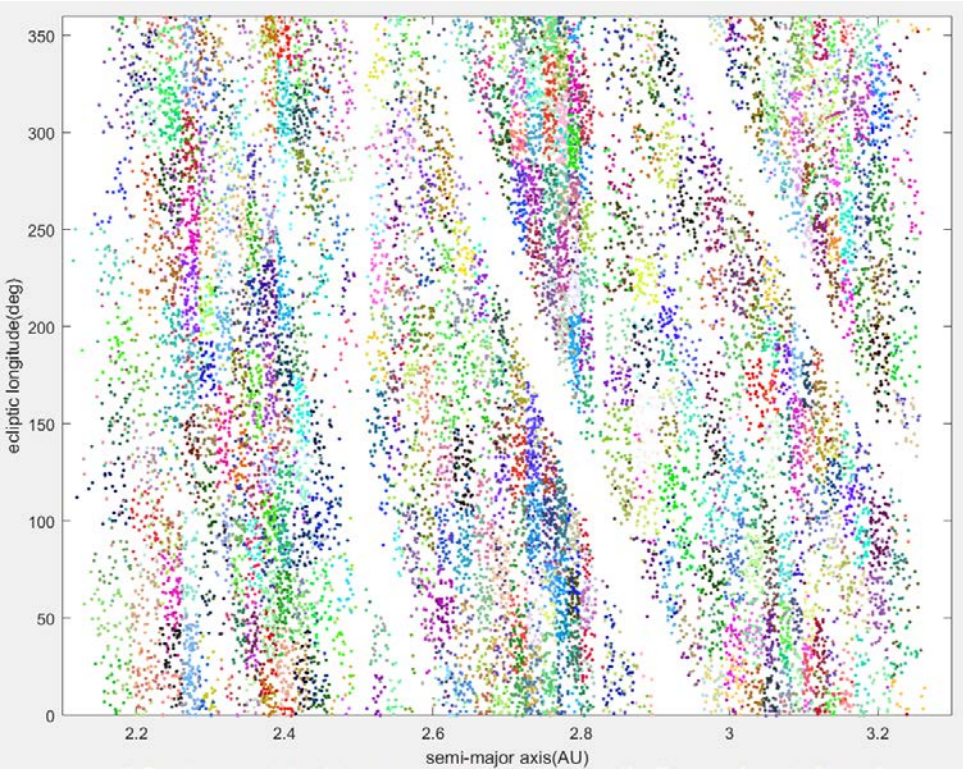
Characteristics of Data:

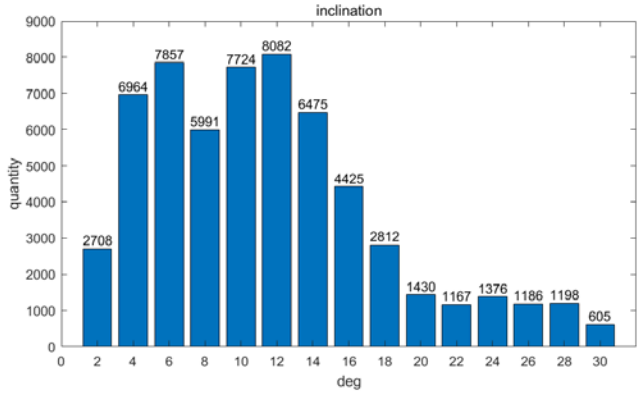
Abundant Dataset

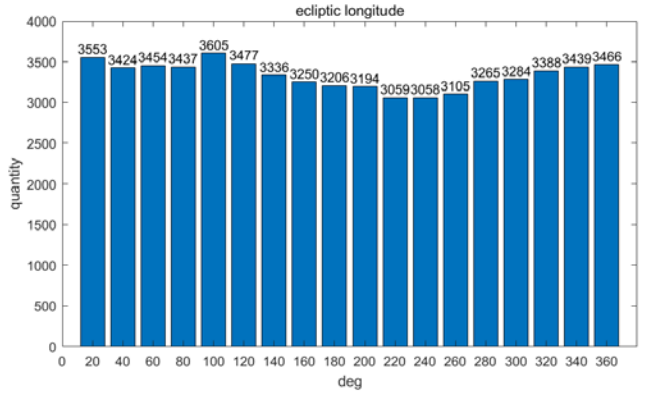
Widespread Distribution











Avoid too many asteroids within each group,

Reduce the computational load,

Ensure easy transfer between asteroids within each group.

1 Preliminary Analysis

" Each Mining Ship Completes One Sequence " strategy

Assume it would take 500 days for one-way transfer between Earth and Asteroid belt

- 25-30 mining ships can be launched;
- each ship can set up 7-8 miners;
- the total score should be 16,000 to 20,000.

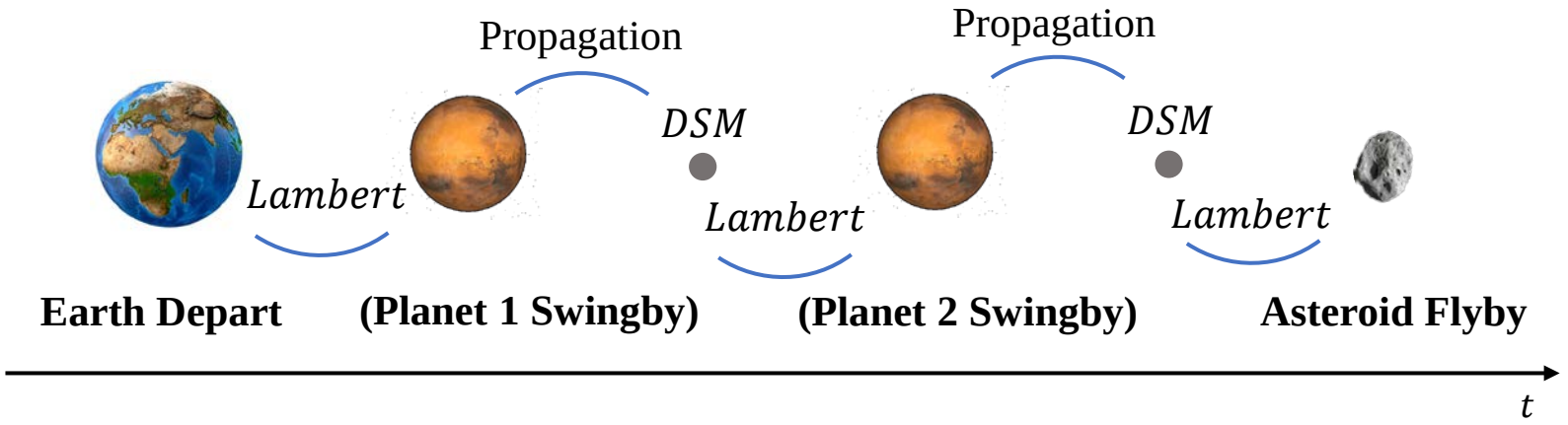
The number of asteroids collected	Total mass of collected minerals (kg)		
	180 days (0.5 years)	219 days (0.6 years)	256 days (0.7 years)
1	132	132	132
2	258	256	254
3	372	366	360
4	476	464	452
5	570	550	530
6	654	624	594
7	728	686	644
8	792	736	680
9	846	774	702
10	890	800	710

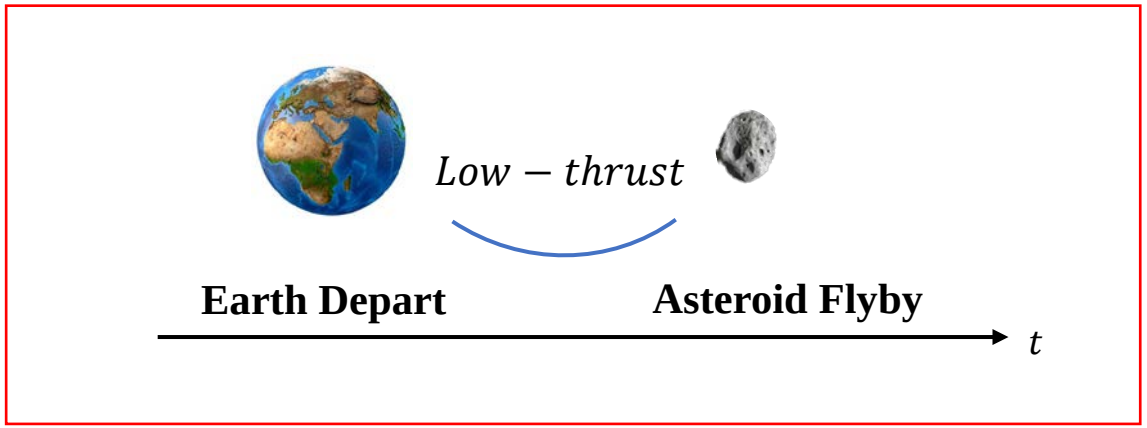
2 Flight Sequence Search

$$\vec{X} = \{t_{Ed}, t_{ga1}, t_{DSM1}, h_1, \varphi_1, (t_{ga2}, t_{DSM2}, h_2, \varphi_2,)t_{Aa}\}$$

$$\boldsymbol{minimize}\ J(\vec{X}) = dv$$

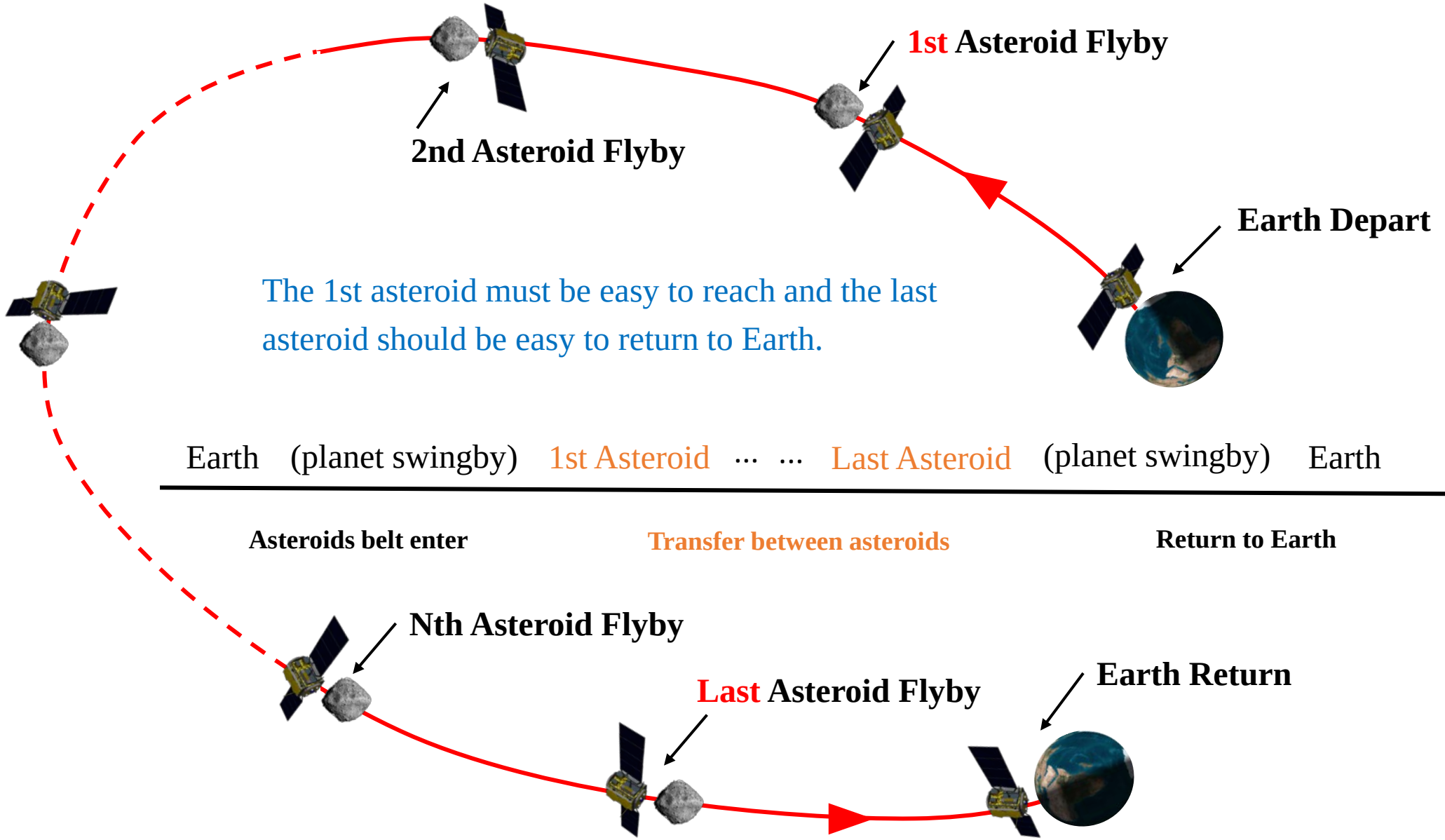
$$\boldsymbol{subject\ to}\ v_{rE} \leq 6km/s$$



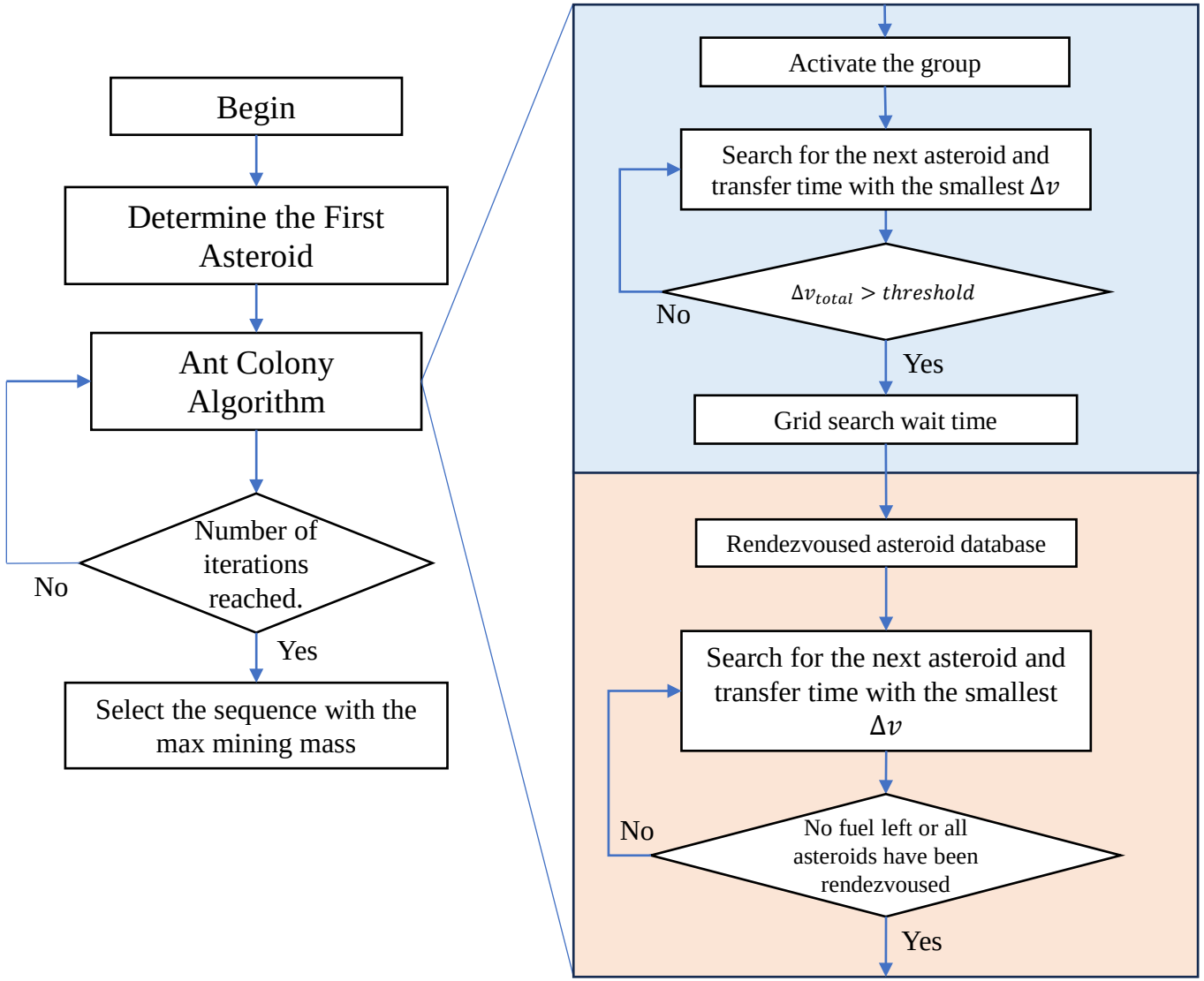


First Asteroid Database

2 Flight Sequence Search



2 Flight Sequence Search



Simplify the problem:

- Earth - Asteroid

Fuel consumption 600kg

Transfer time 550 days

- Criterion for a low thrust model correction

$$m \cdot dv < k \cdot F \cdot t$$

m: current mass

dv: velocity increment

k: coefficient

F: thrust

t: transfer time

3 Local Optimization

BACC

- Reorder the sequence of asteroids;

- Asteroid Sequence Re-Optimization;

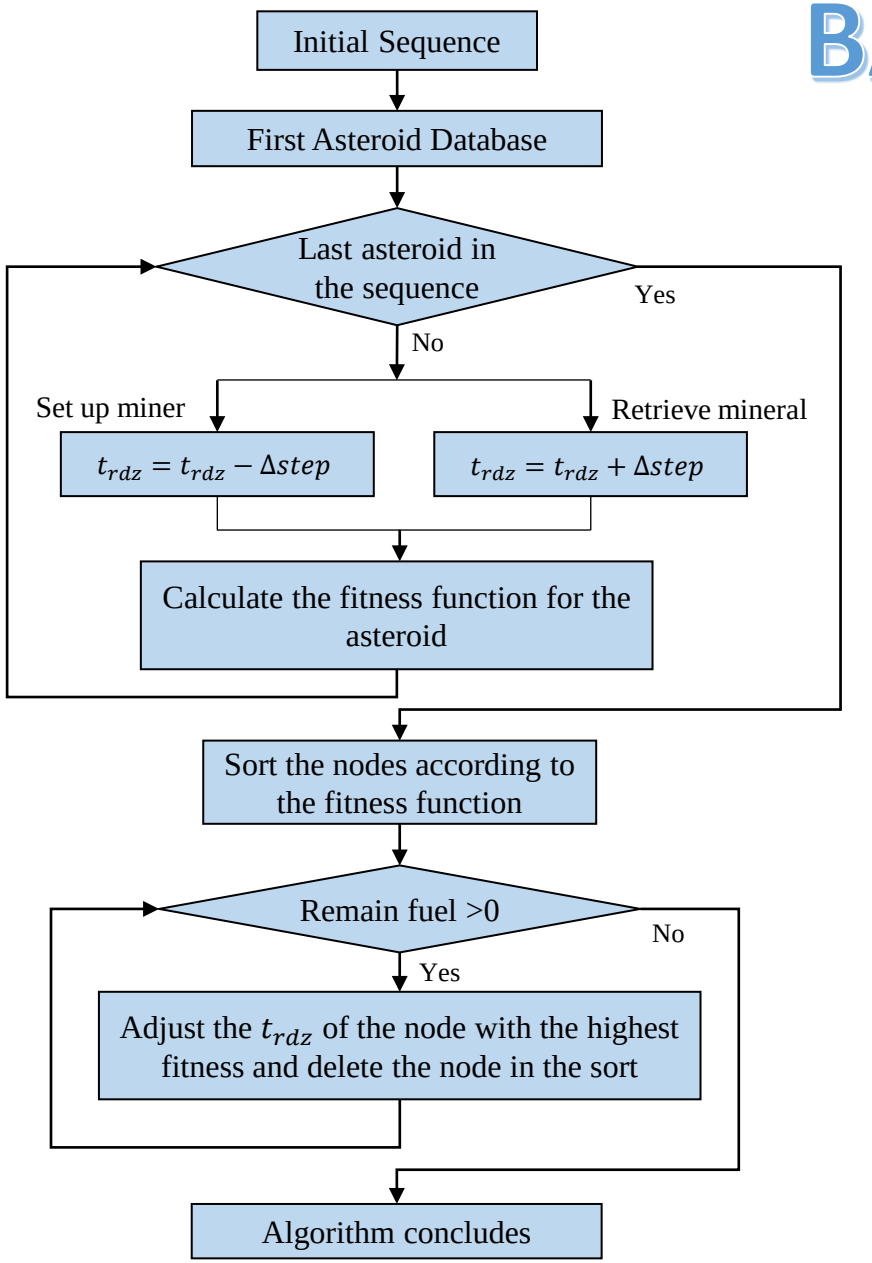
Lambert model: high efficiency but may not be corrected to a low-thrust model:

$$\vec{X} = \Delta t_i (i = 1 \sim 2N)$$
$$\boldsymbol{minimize}\ J(\vec{X}) = \left(\frac{\Sigma \Delta v}{(\Sigma \Delta m)^k}\right)$$
$$\boldsymbol{subject\ to}\ -150 \text{ days} < \Delta t_i < 150 \text{ days}$$

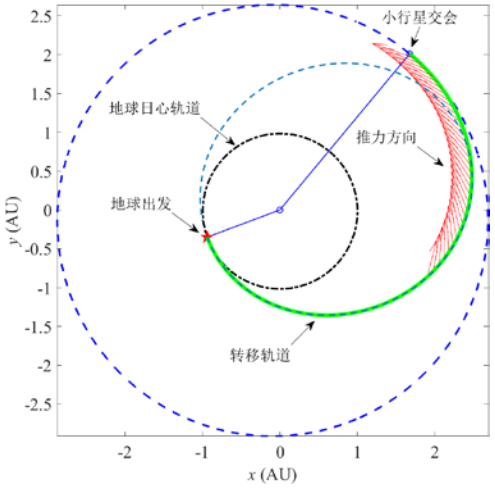
Low-thrust model: hard to converge and low efficiency:

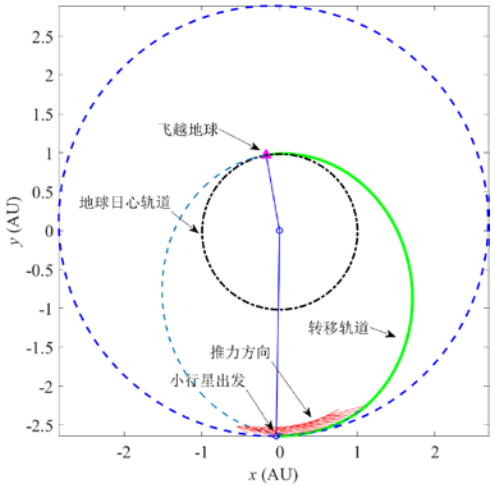
$$\vec{X} = \Delta t_i (i = 1 \sim 2N)$$
$$\boldsymbol{maximize}\ J(\vec{X}) = (\Sigma \Delta m)$$
$$\boldsymbol{subject\ to}\ -150 \text{ days} < \Delta t_i < 150 \text{ days}$$

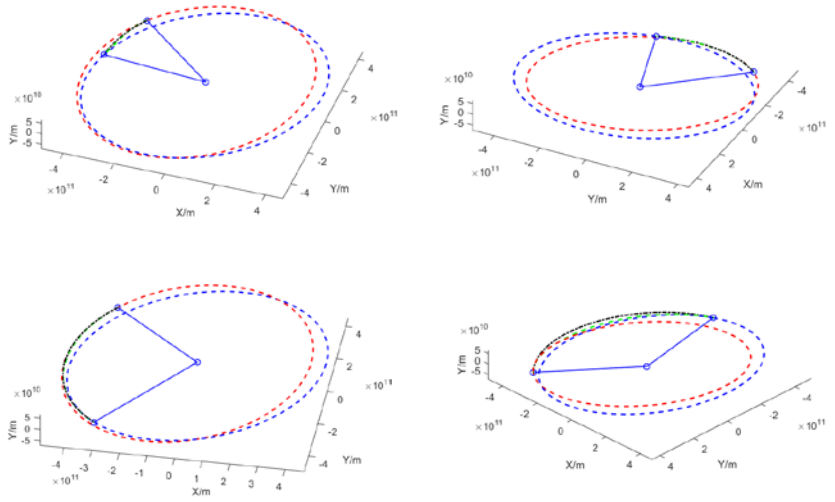
- Extend the mining time for each asteroid using the remaining fuel.

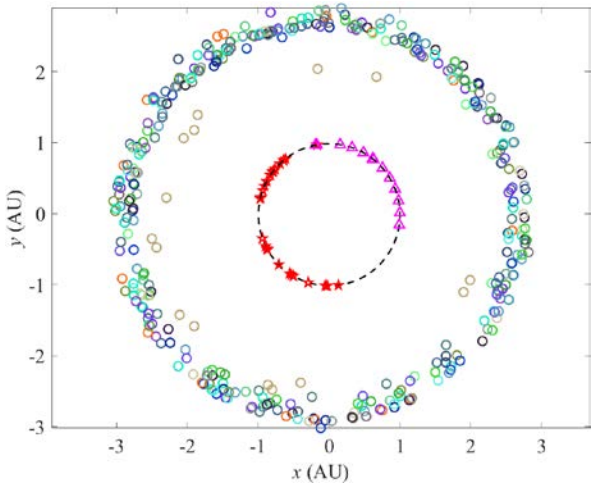


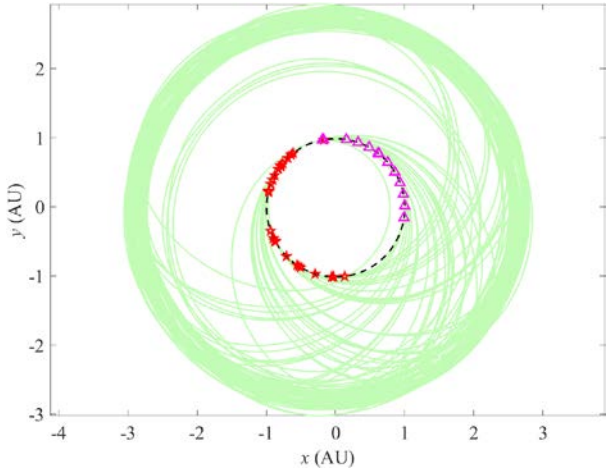
4 Results and Thinking

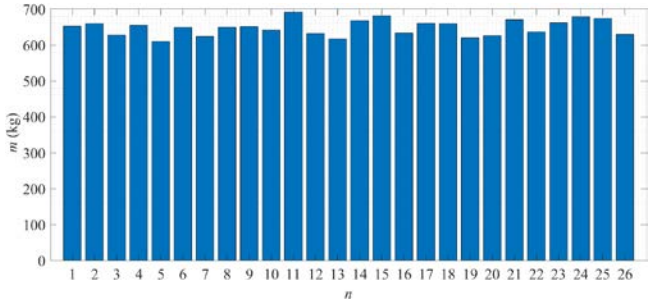












A total of 26 mining ships were launched, and collect minerals from 203 asteroids.

4 Results and Thinking

Deficiencies:

- Should use cooperative mining of multiple ships;
- Should enhance program efficiency;
- Should develop an optimization program to automatically choose the set of sequences.


Thanks for listening!