CubeSat Constellation Deployment Strategies

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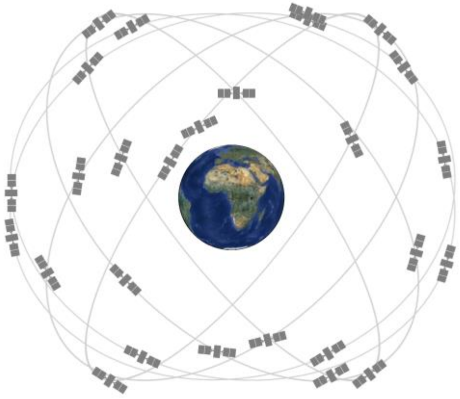
Who am I?

- MSE Student,
  Control and Simulation,
  Delft University of Technology,
  the Netherlands.
- Methodology to determine the optimal deployment strategy for a CubeSat Constellation
- Outline:
  - The problem
  - The methodology
  - Results & discussion

The Problem

- How to design the deployment strategy of a CubeSat constellation?
- CubeSat constellation:
  - Relevance
  - Less reliable individual satellites
  - No individual orbit insertion
  - Limited maneuverability (fuel and performance)
  - Stochastic problem
- Use: improve operational performance through clever design



Source: gps.gov

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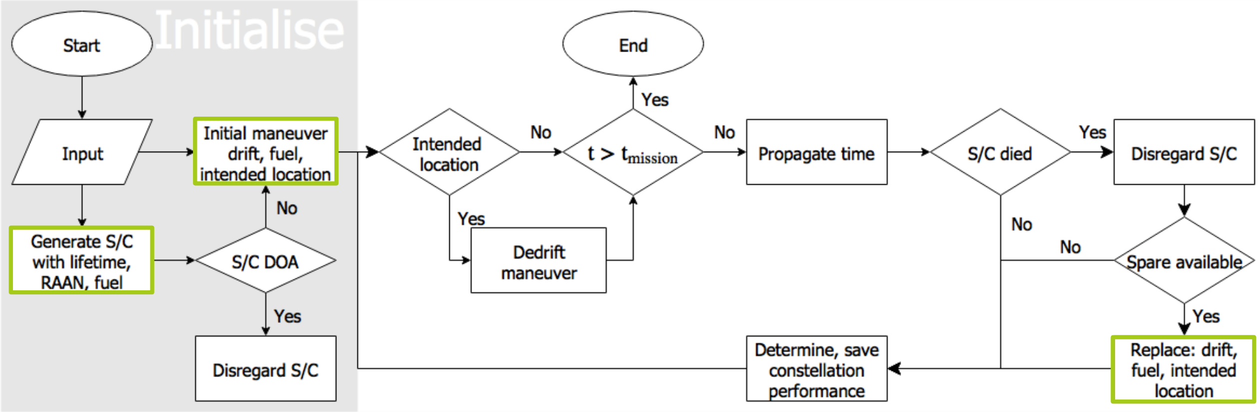
Methodology

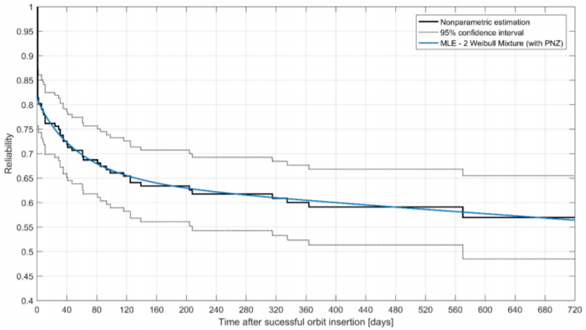
- Monte Carlo approach:
  - Create a finite number of realizations
  - Simulate each realization
  - Statistically analyze the performance of the realizations



Methodology

- Satellite lifetime
  - Random sample from reliability model
  - Reliability model
    - Component failure rate database
    - Historical flight data
  - Historical flight data
    - Limited availability
    - Technological advancements
    - Design and manufacturing quality
    - No partial failures
- Right ascension of ascending node
  - Important parameter
  - Initially determined by launch
- Fuel

Generate S/C with lifetime, RAAN, fuel



Source: M. Langer

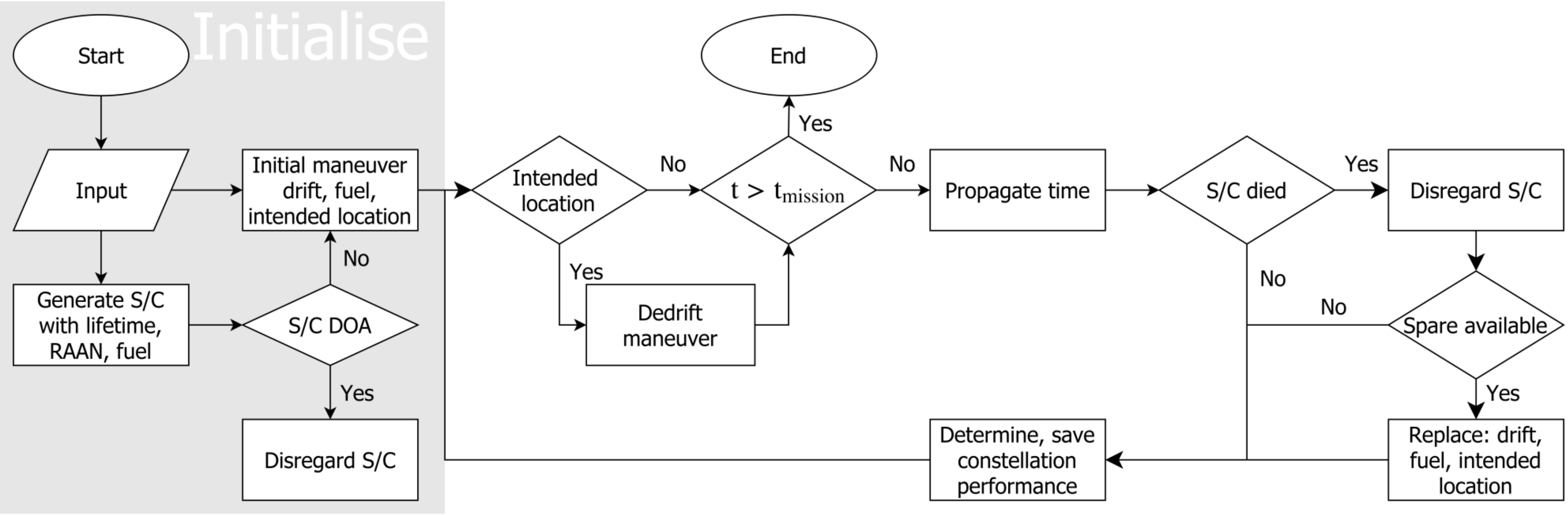
Methodology

- Maneuver
  - Nodal precession
  - Fuel consumption
- Strategy
  - Equal distribution
  - Parking orbit
  - Creative solution

Initial maneuver drift, fuel, intended location

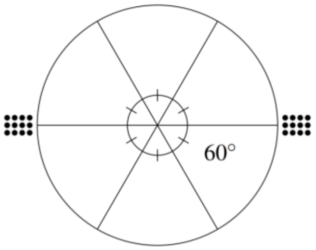
Replace: drift, fuel, intended location

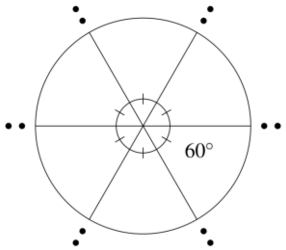
Methodology



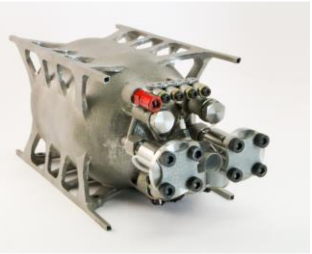
Results and Discussion

- Any parameter simulated for each realization
- Example mission:
  - 2 times 12 satellites inserted at opposite RAAN
  - Walker (55.5:6/6/2) constellation*
  - $\dot{\Omega}$: 0.33°/day, ΔV: 235 m/s





Satellite	Δv [m/s]	Deployment procedure after launch
lower	210.2	1. Hohmann transfer (520km→435km) 2. 6 month drifting 3. Hohmann transfer (350km→520km)
upper	235.1	1. Hohmann transfer (520km→670km) 2. inclination change (55° → 55.37°) 3. 6 months drifting 4. inclination change (55.37° → 55°) 5. Hohmann transfer (669km→520km)



Source: Hyperion Technologies

Results and Discussion

- Example mission
  - Case 1: Equally distribute (redundancy)
  - Case 2: Parking orbit for replacements

Case	Success rate (%)	Time to success	
		mean (days)	90th percentile (days)
1	48	183	183
2	83	251	362

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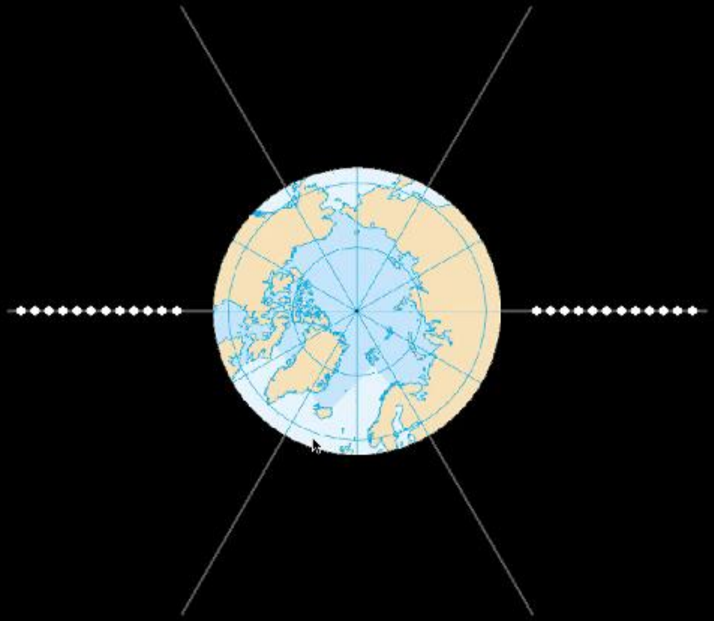
Day 0

Operational

Failed

Results and Discussion



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Result and Discussion

- Future:
  1. Apply to more complex constellations and deployment strategies
  2. Model maintenance launches
  3. Include partial failures
  4. Validate

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Questions

- More information, or want to work with me?
  - IAA-AAS-CU-17-06-03
  - Talk to me