Automated Sky Survey Analysis Methods (ASSAM)

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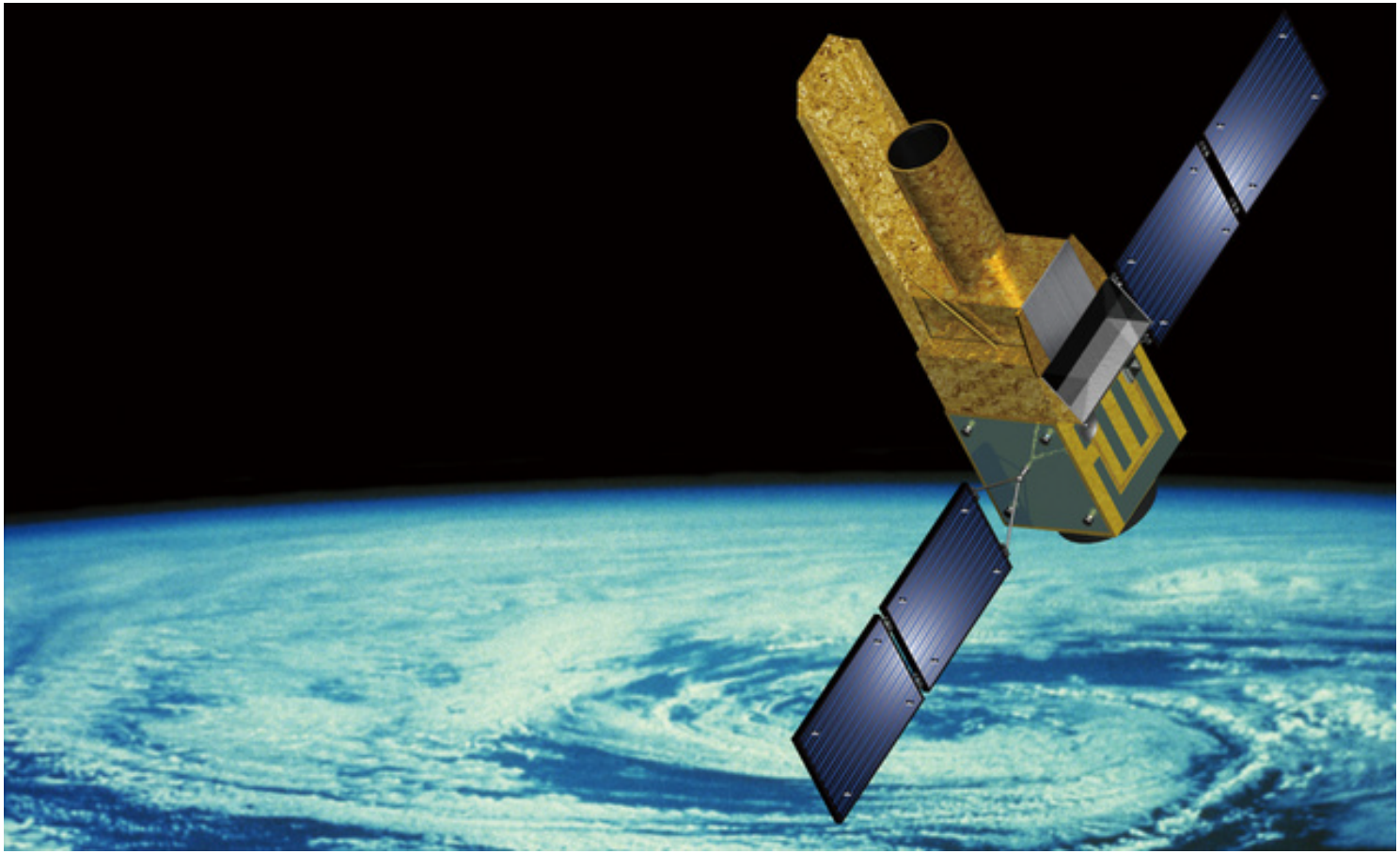
Introduction and Background

Japan Astrometry Satellite Mission for Infrared Exploration (JASMINE)[1,2]

- JAXA M-class mission selected in May 2019 for launch in the mid-2020s
- Infrared telescope designed for Milky Way astrometry
- Three scientific goals:
  1. Investigation of the structure of the Milky Way's central core
  2. Exploration of the formation history of the Milky Way
  3. Discovery of Earth-like habitable planets

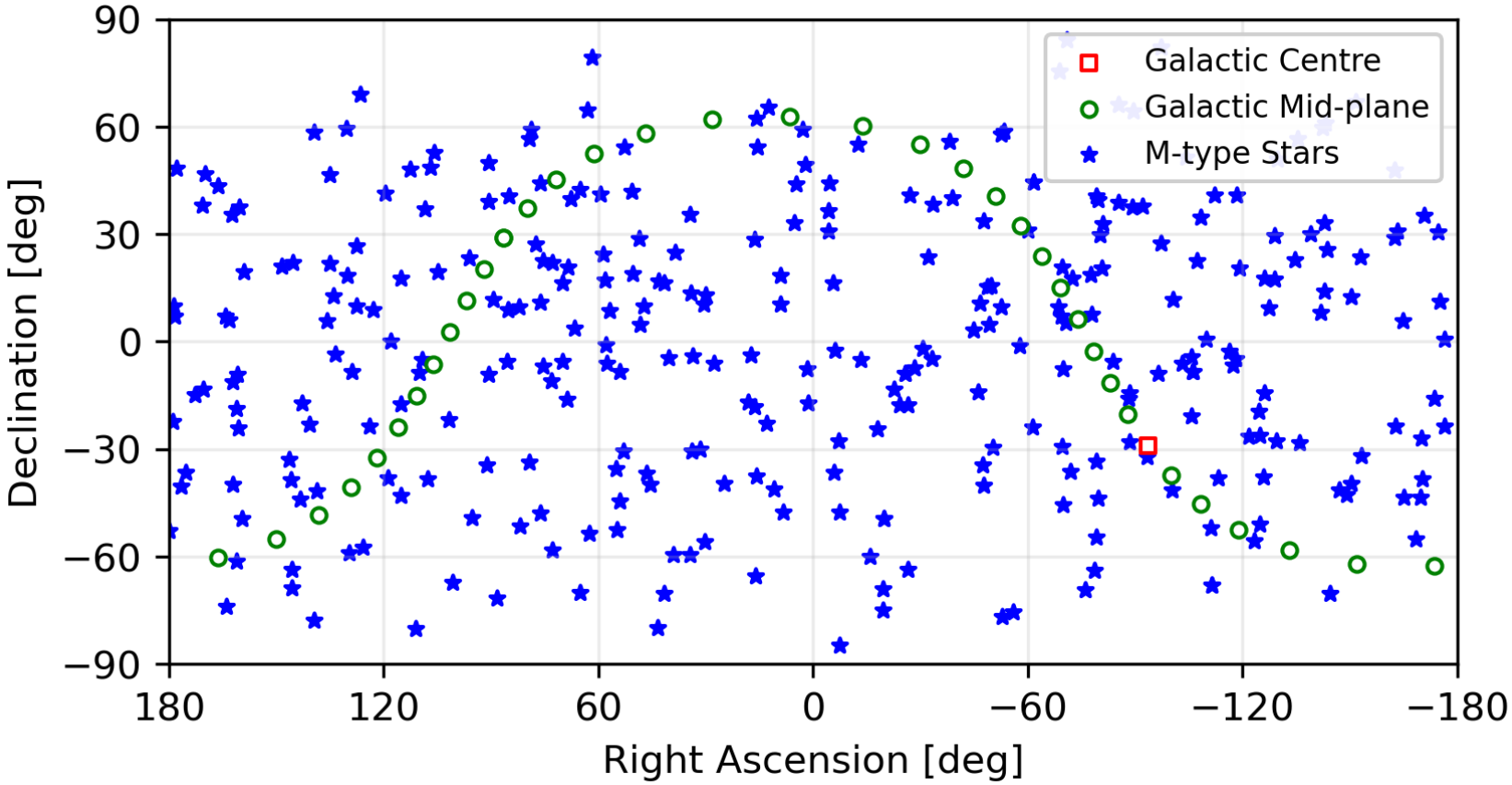
Introduction and Background

JASMINE[3]



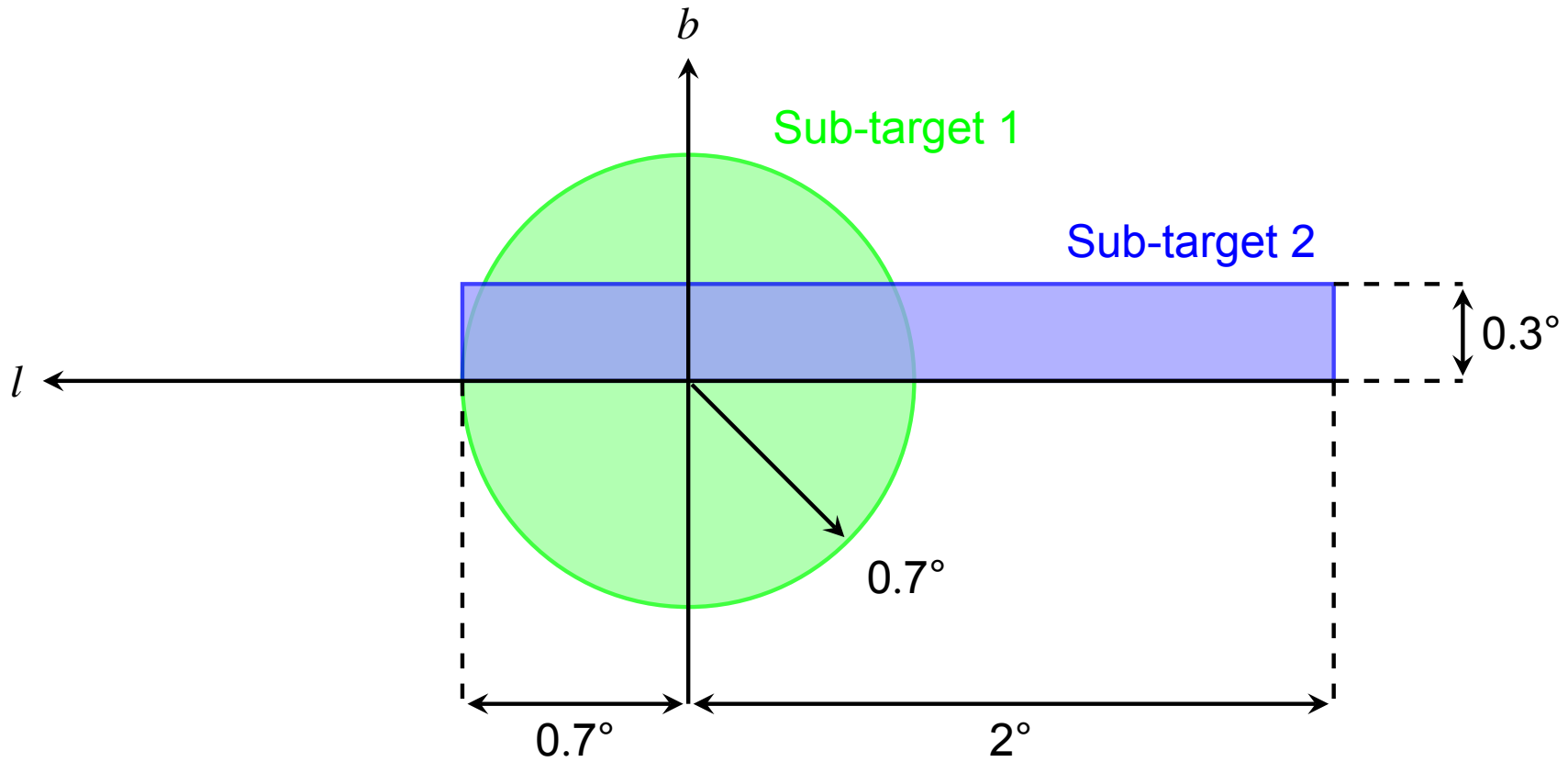
Introduction and Background

Target Distribution[4]



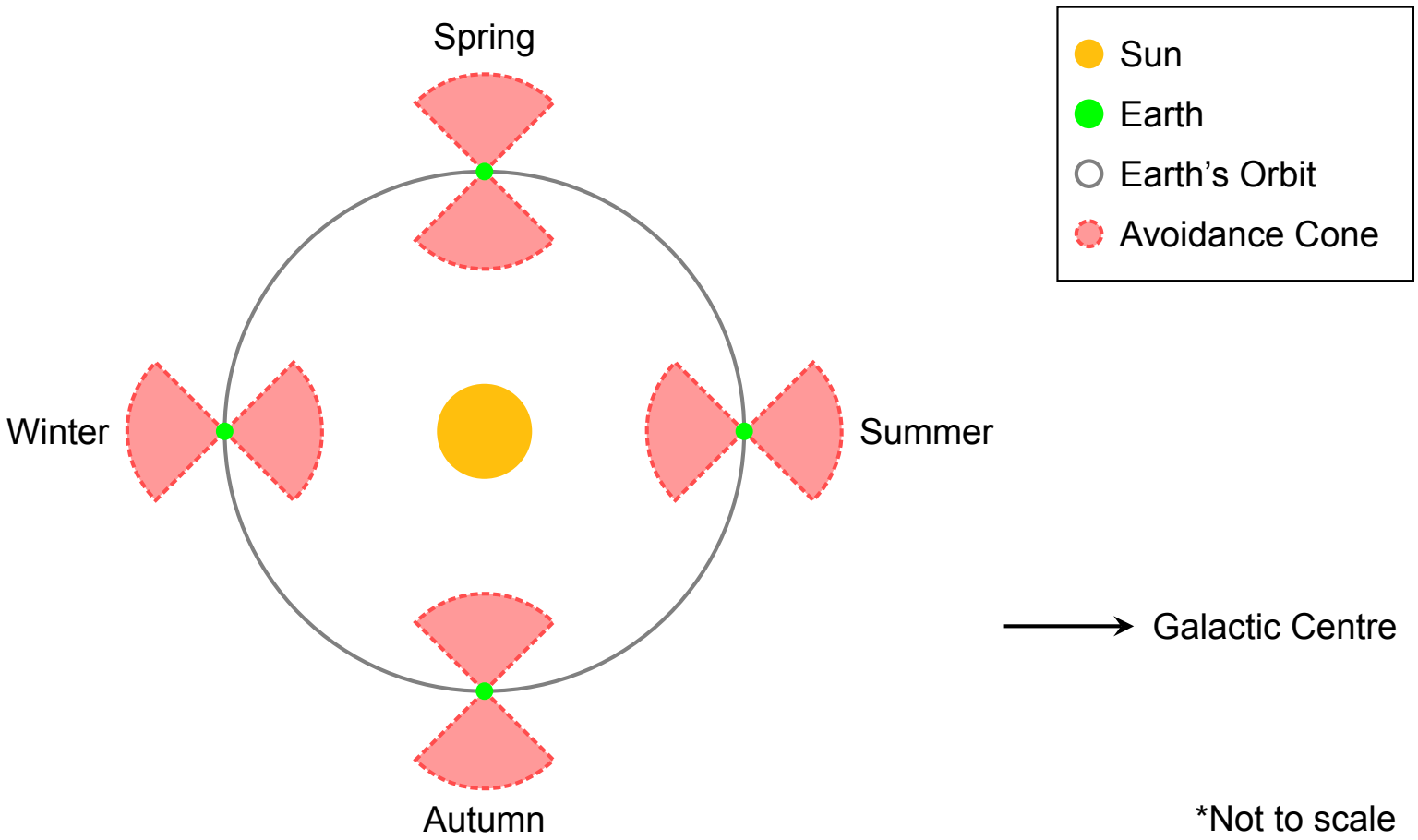
Introduction and Background

Galactic Centre Target[4]



Introduction and Background

Galactic Centre Observation Constraints[2]



Introduction and Background

Problem Definition

- Sky survey plans needed to maximise scientific return
- Constraints:
  - Strict thermal requirements
  - Strict pointing requirements
- Issues:
  - Large number of potential targets
  - Long mission duration

Introduction and Background

Project Objectives[2]

Primary Objective

Generate target observation visibility to aid manual scheduling

Secondary Objective

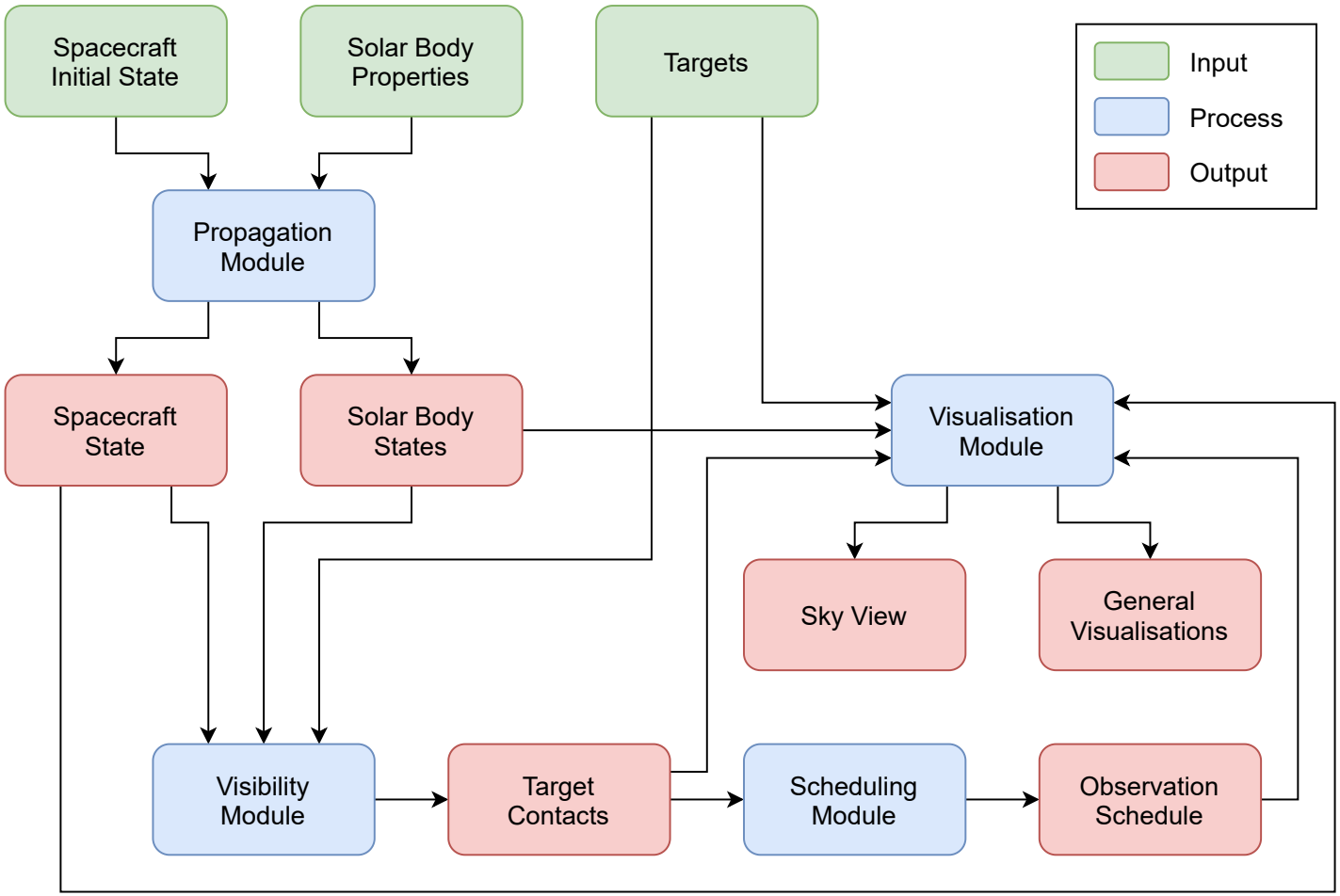
Fully automate sky survey scheduling

Tertiary Objective

Ensure the software is lightweight with high computational performance to enable rapid, iterative, mission planning

Methods

Software Architecture



Methods

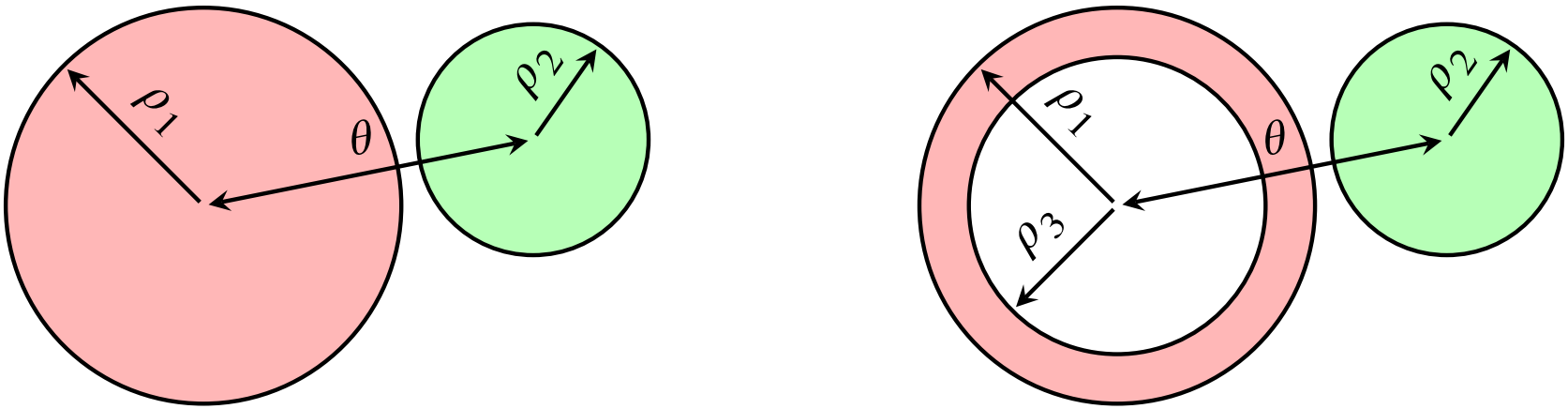
Propagation Module

- Module which propagates the state of the spacecraft and solar bodies
- Spacecraft propagated by interfacing with GMAT[5]
- Solar bodies propagated using JPL ephemeris data through Astropy[6–8]

Methods

Visibility Module

- Module to calculate whether targets are visible
- Currently considers circular targets against visibility constraints



Physical Mission

Figure: Visibility constraints with the avoidance areas in red and the targets in green

Methods

Scheduling Module

- Module which automatically generates observations schedules
- Currently using a dynamic linear programming algorithm
- High performance algorithm which scales with $O(n)$

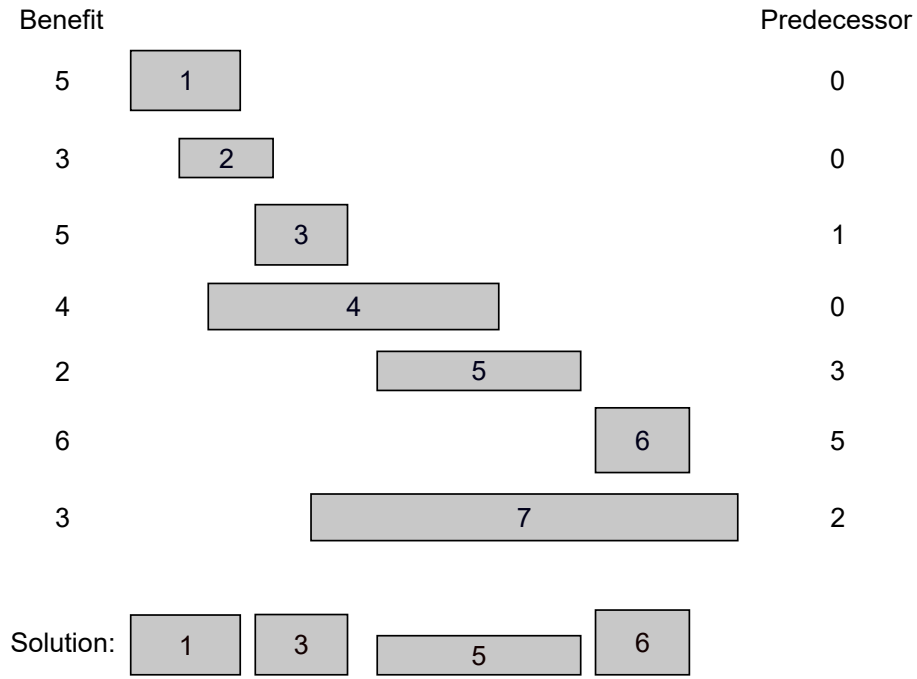


Figure: Example of a telescope scheduling problem[4,9]

Methods

Visualisation Module

- Module which generates visualisations from the calculated results from other modules
- Sky views generated as a bitmap using a grid of pseudo-targets
- General visualisations generated with target statistics, using seaborn[10,11]

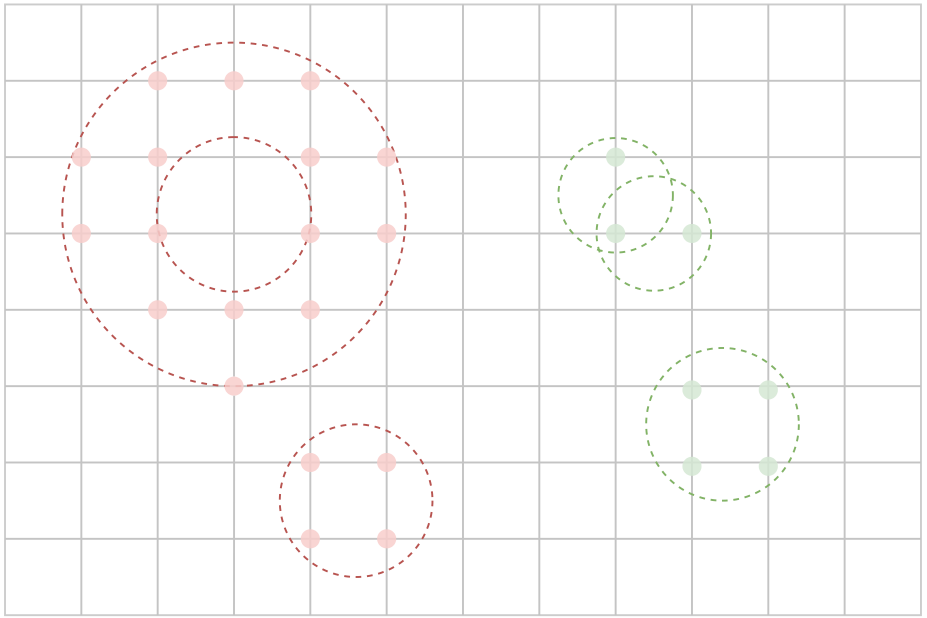
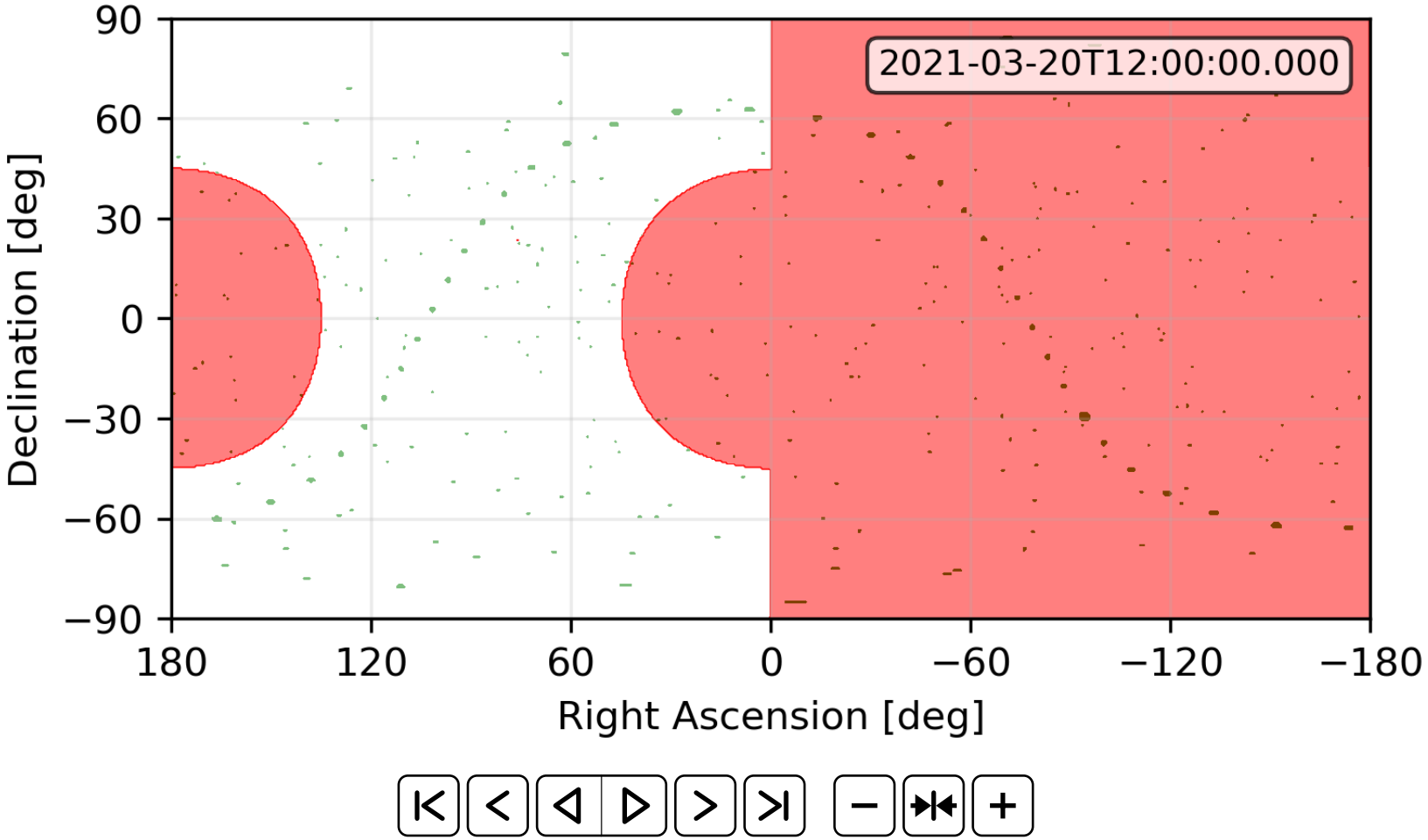


Figure: Example of the structured mesh used to generate the sky views[4]

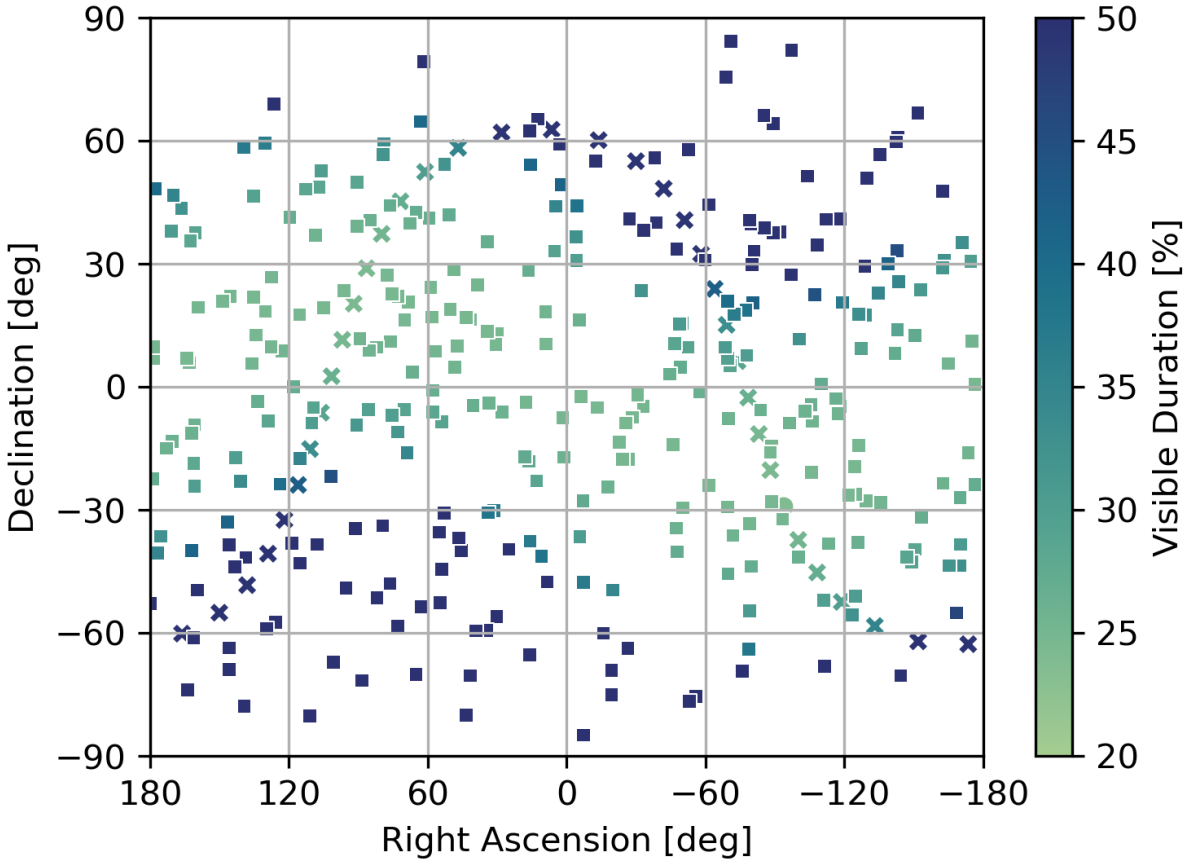
Results

Sky View



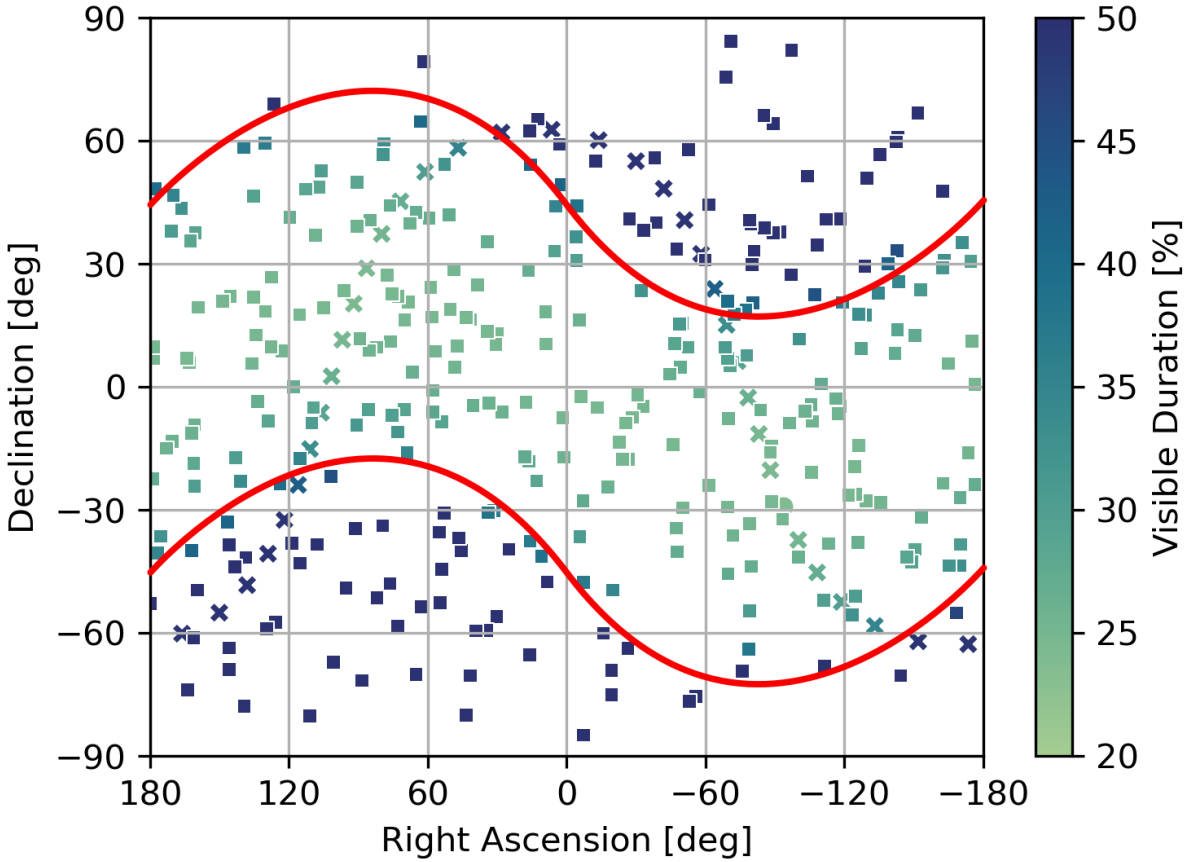
Results

Annual Visibility[4]



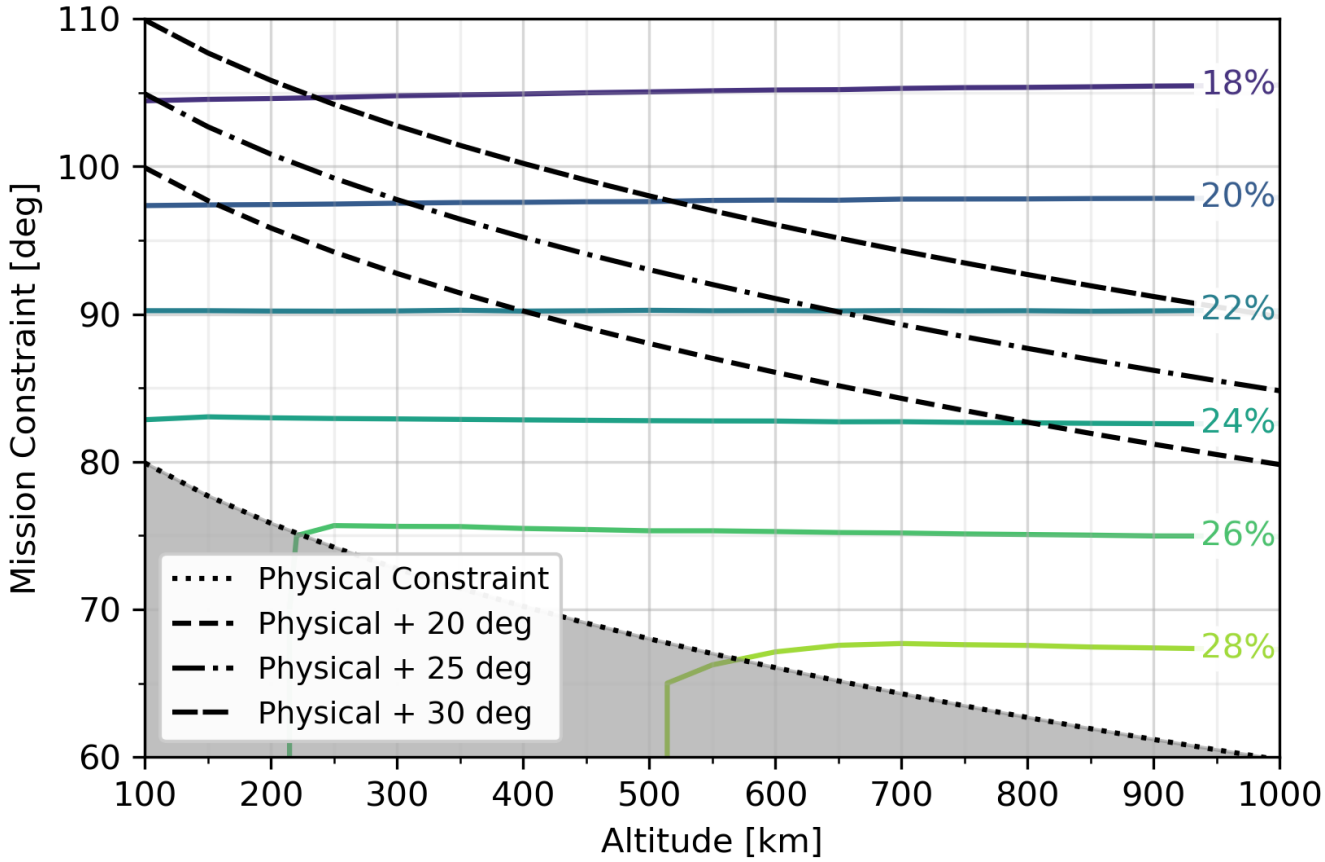
Results

Annual Visibility[4]



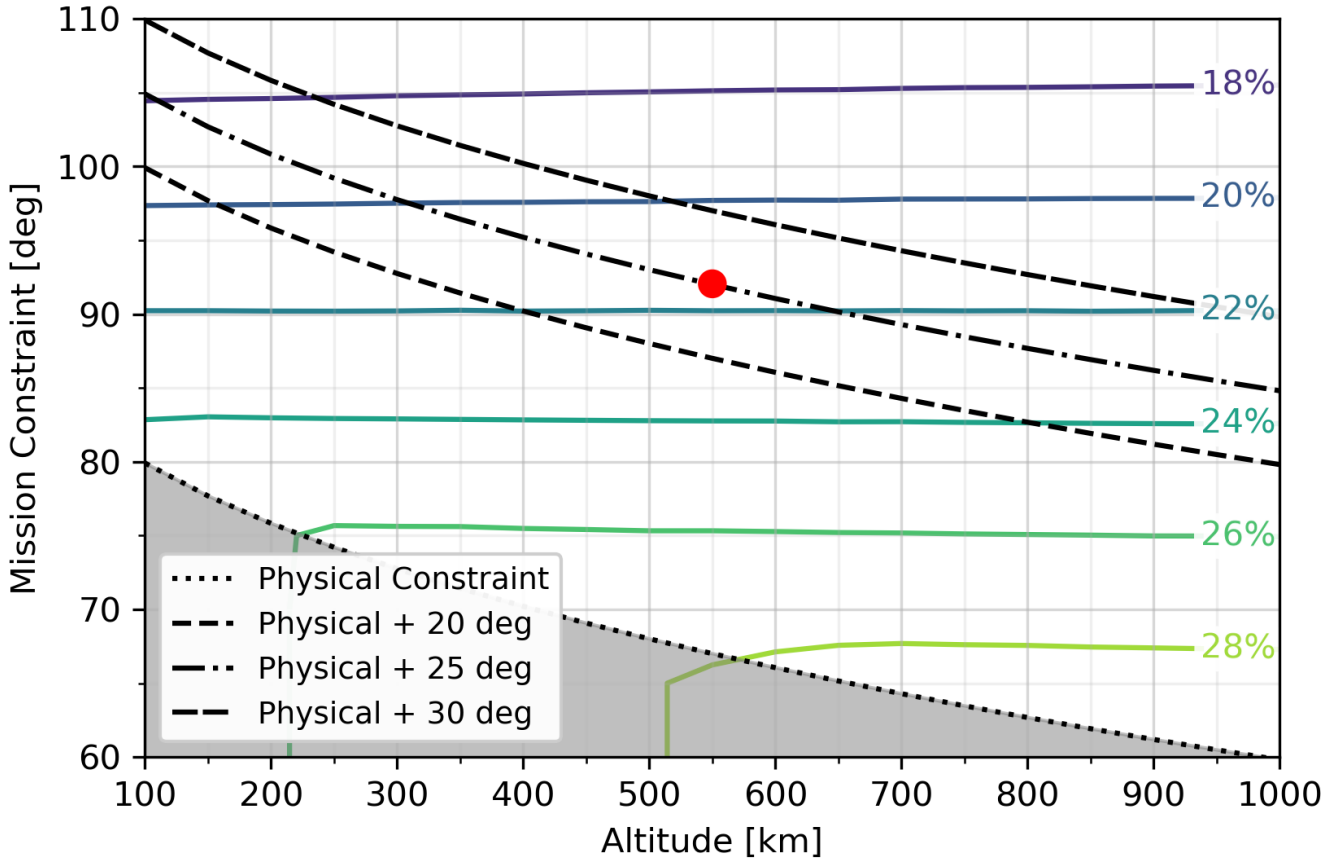
Results

Baffle Sizing[4]



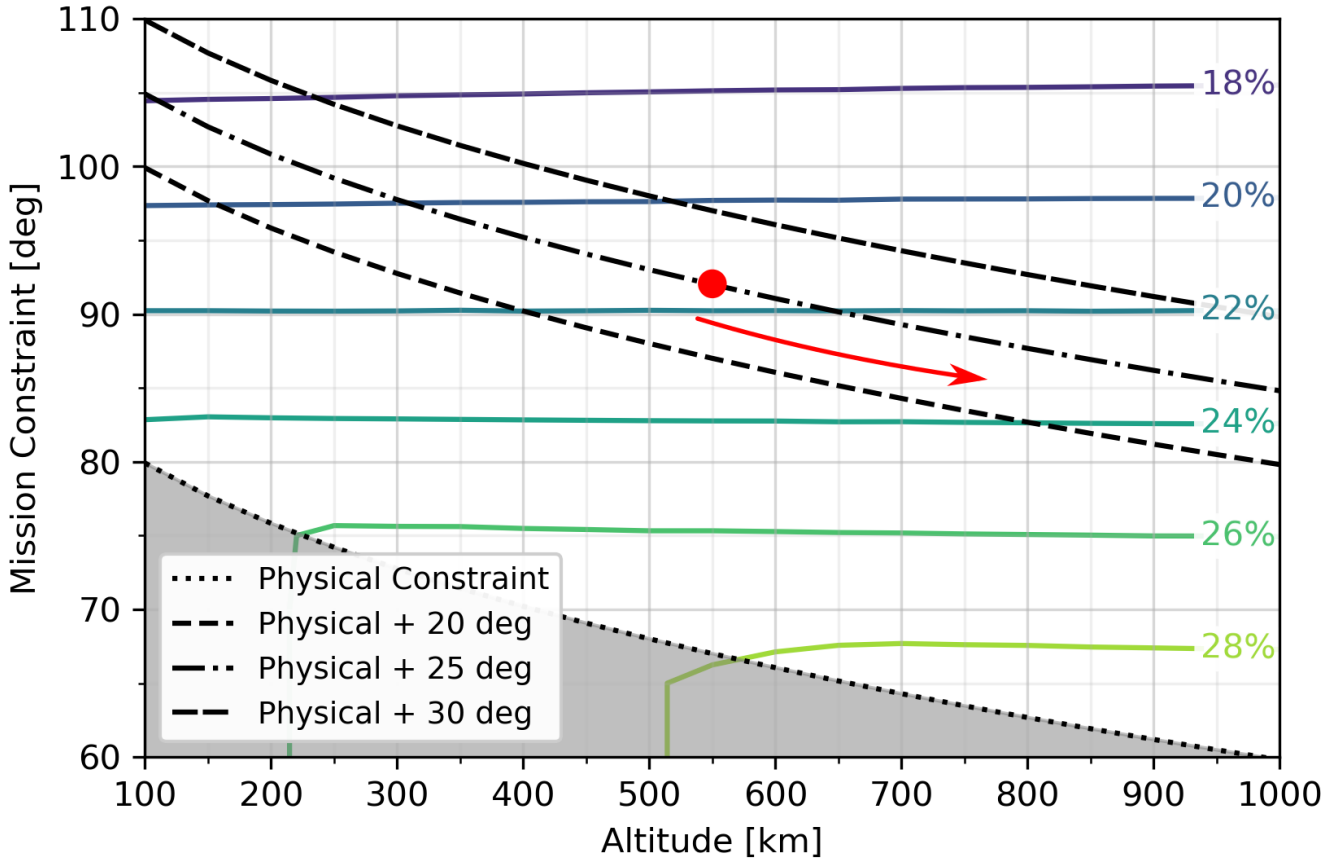
Results

Baffle Sizing[4]



Results

Baffle Sizing[4]



Conclusions and Future Work

- ASSAM has been successfully implemented and is ready for release
- Annual visibility confirmed and initial scheduling now possible
- Future work to include refactoring and improved scheduling methods

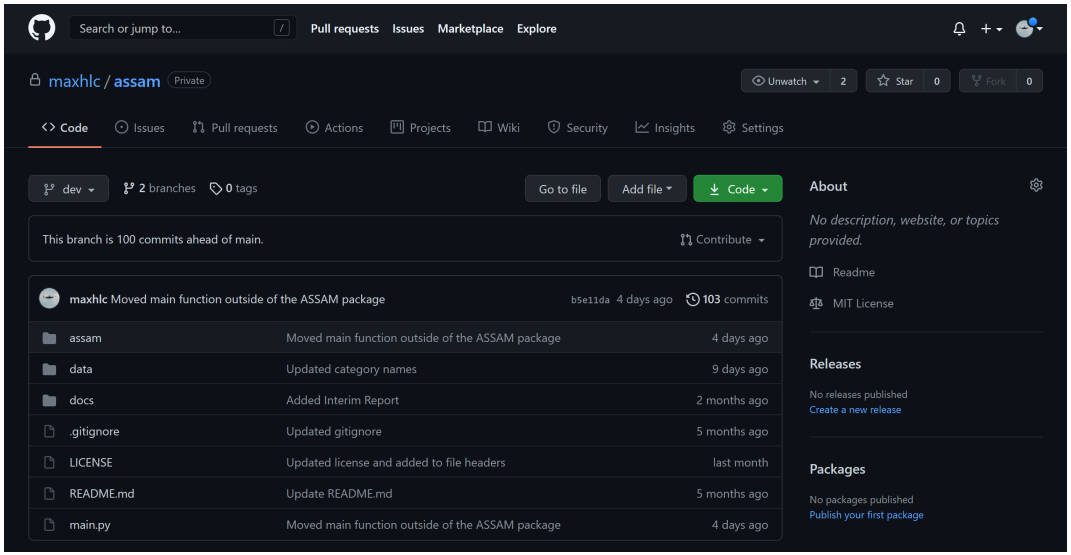


Figure: GitHub repository

Thank you for your time

Any questions?

References I

[1] N. Gouda, 'JASMINE,' *Scholarpedia*, vol. 6, no. 10, p. 12 021, 2011. [Online] Available at: http://www.scholarpedia.org/article/JASMINE [Accessed 8th March 2021].

[2] M. Hallgarten La Casta, *Automated Sky Survey Analysis Methods: Interim Report*, Internal Access Only, University College London, 2021.

[3] D. Kawata *et al.*, 'JASMINE: Near-Infrared Astrometry and Time Series Photometry Science,' *Astronomical Society of Japan*, in preparation.

[4] M. Hallgarten La Casta, *Automated Sky Survey Analysis Methods: Final Report*, in preparation, University College London.

[5] NASA, *GMAT R2020a*, version R2020a, July 2020. [Online] Available at: https://sourceforge.net/projects/gmat/files/GMAT/GMAT-R2020a/ [Accessed 29th June 2021].

[6] Astropy Collaboration *et al.*, 'Astropy: A community Python package for astronomy,' *Astronomy & Astrophysics*, vol. 558, A33, October 2013.

[7] Astropy Collaboration *et al.*, 'The Astropy Project: Building an Open-science Project and Status of the v2.0 Core Package,' *The Astronomical Journal*, vol. 156, no. 3, p. 123, September 2018.

[8] T. Robitaille *et al.*, *astropy/astropy: v4.2.1*, version v4.2.1, April 2021. [Online] Available at: https://doi.org/10.5281/zenodo.4670729 [Accessed 24th June 2021].

References II

[9] M. T. Goodrich and R. Tamassia, *Algorithm Design and Applications*. Wiley, 2015, ISBN: 9781118335918.

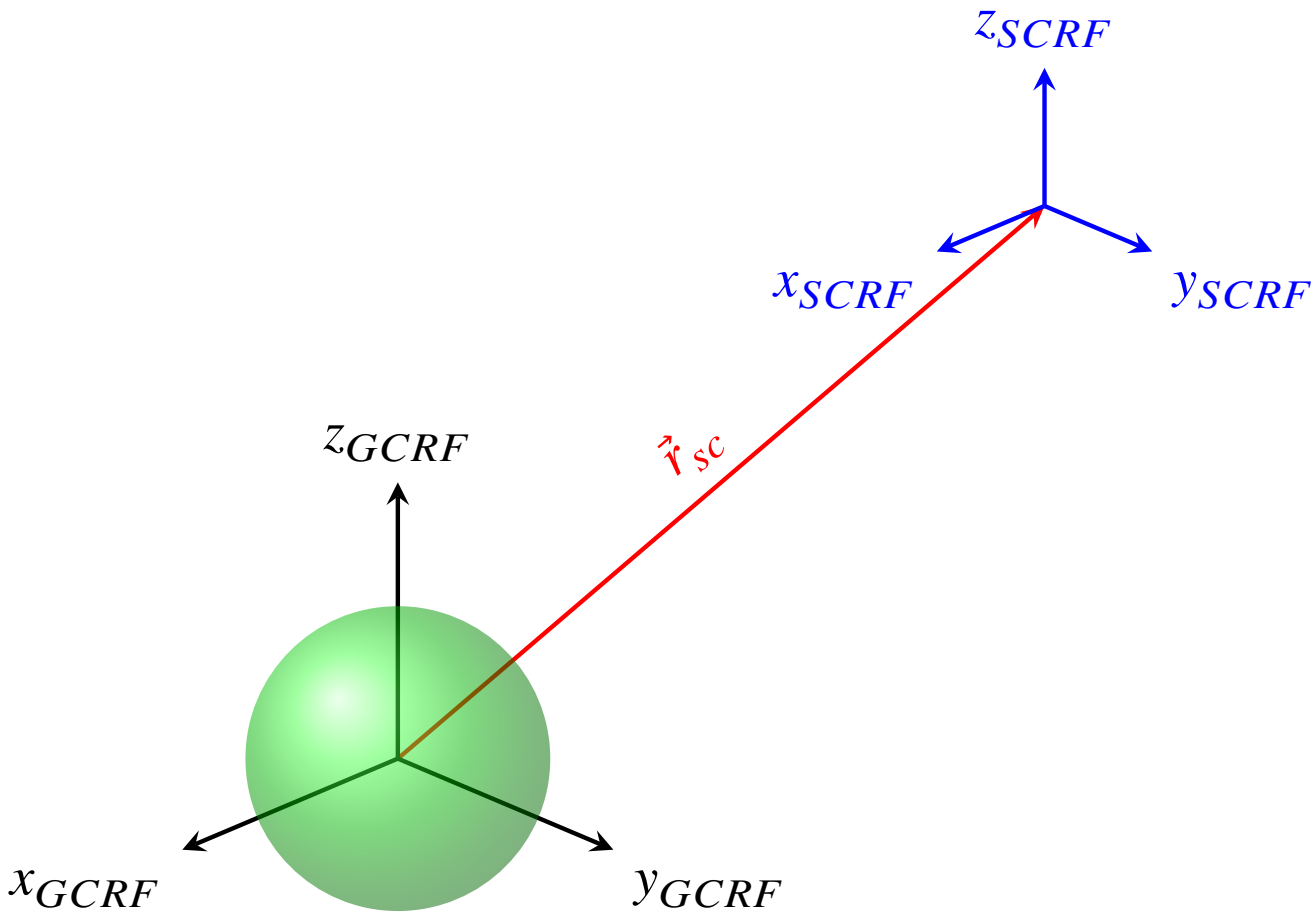
[10] M. L. Waskom, 'seaborn: statistical data visualization,' *Journal of Open Source Software*, vol. 6, no. 60, p. 3021, 2021.

[11] M. L. Waskom *et al.*, *mwaskom/seaborn: v0.11.1 (December 2020)*, version v0.11.1, December 2020. [Online] Available at: https://doi.org/10.5281/zenodo.4379347 [Accessed 24th June 2021].

Backup Slides

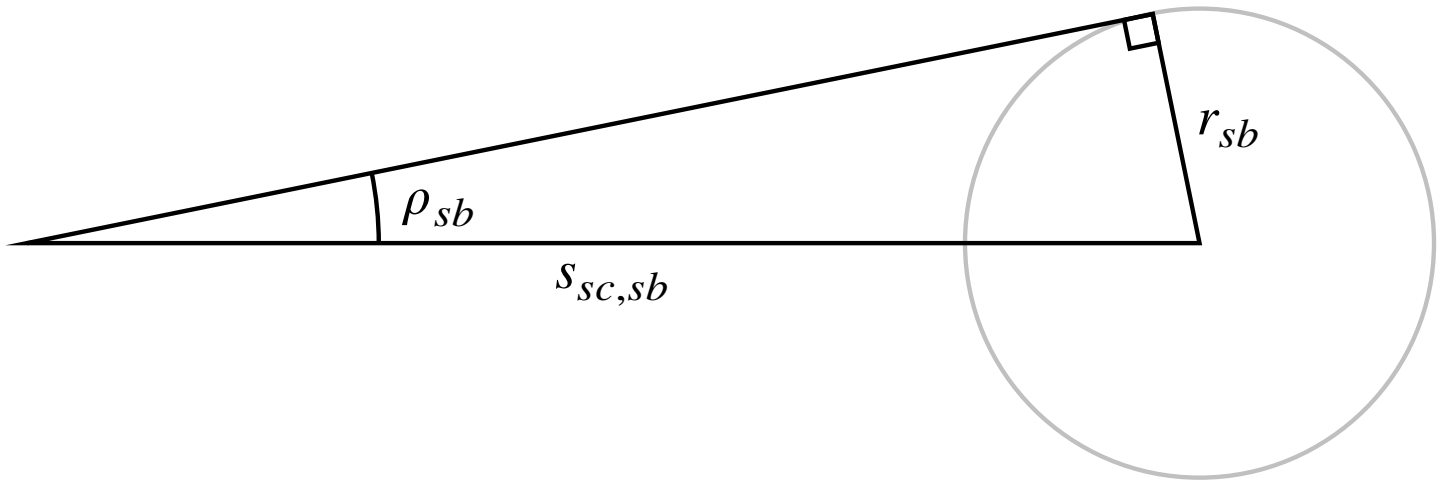
Methods

Spacecraft Celestial Reference Frame (SCRF)[4]



Methods

Physical Radius Calculation[4]



$$\rho_{sb} = \arcsin \frac{r_{sb}}{s_{sc,sb}}$$

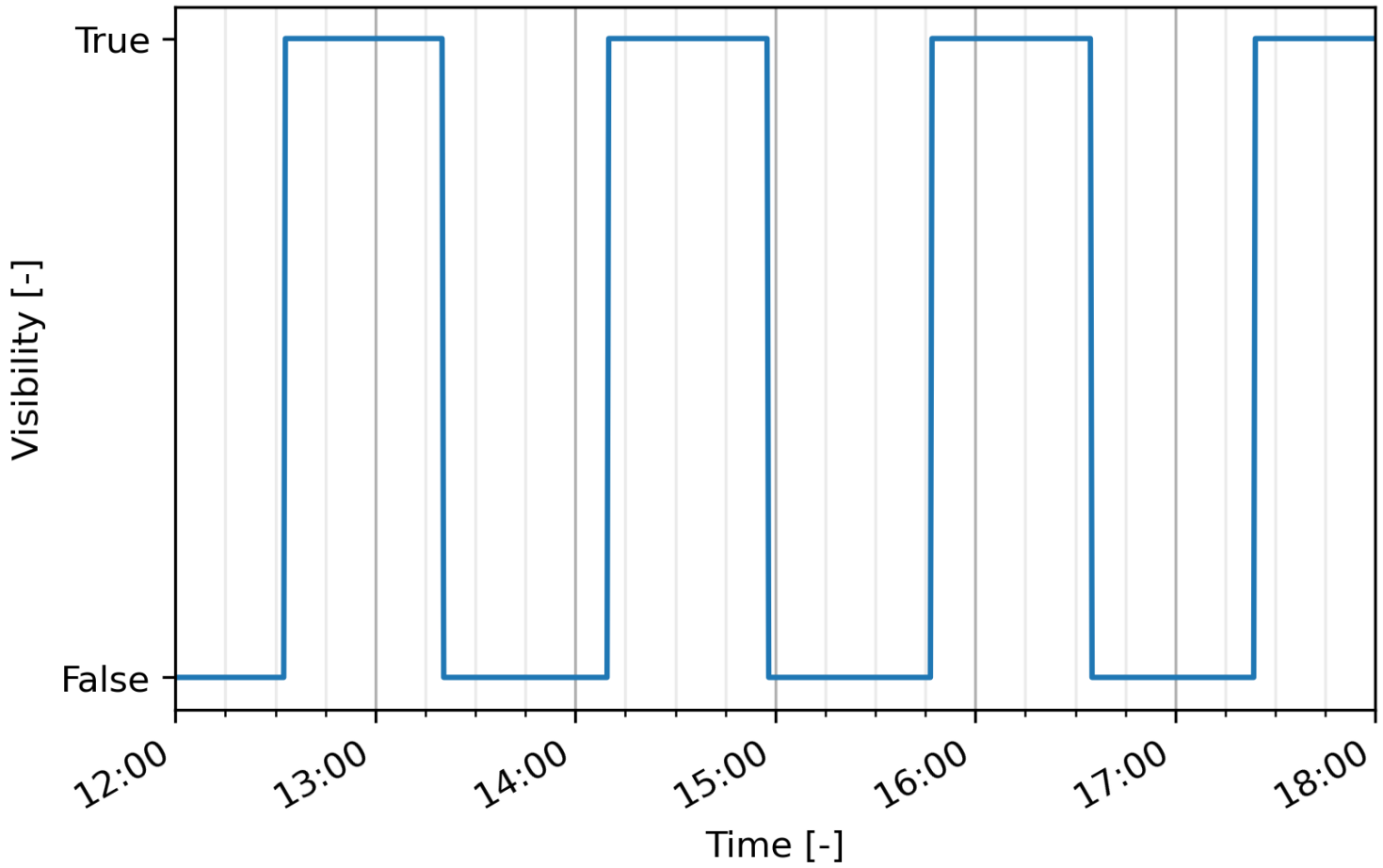
Methods

Target Definition[4]

```
galactic_centre:
    category: galactic_centre
    priority: 1
    subtargets:
        region_1:
            frame: galactic
            centre: [0, 0]
            shape: circular
            width:
            height:
            angular_radius: 0.7
        region_2:
            frame: galactic
            centre: [-0.65, 0.15]
            shape: rectangular
            width: 2.7
            height: 0.3
            angular_radius:
```

Results

Short Term Visibility[4]



Results

Annual Visibility Distributions[4]