



Forward Modelling of Ground Based SST Telescope Images

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Master thesis at Swedish Space Corporation

Space debris

Space Environment

12,070 launched satellites

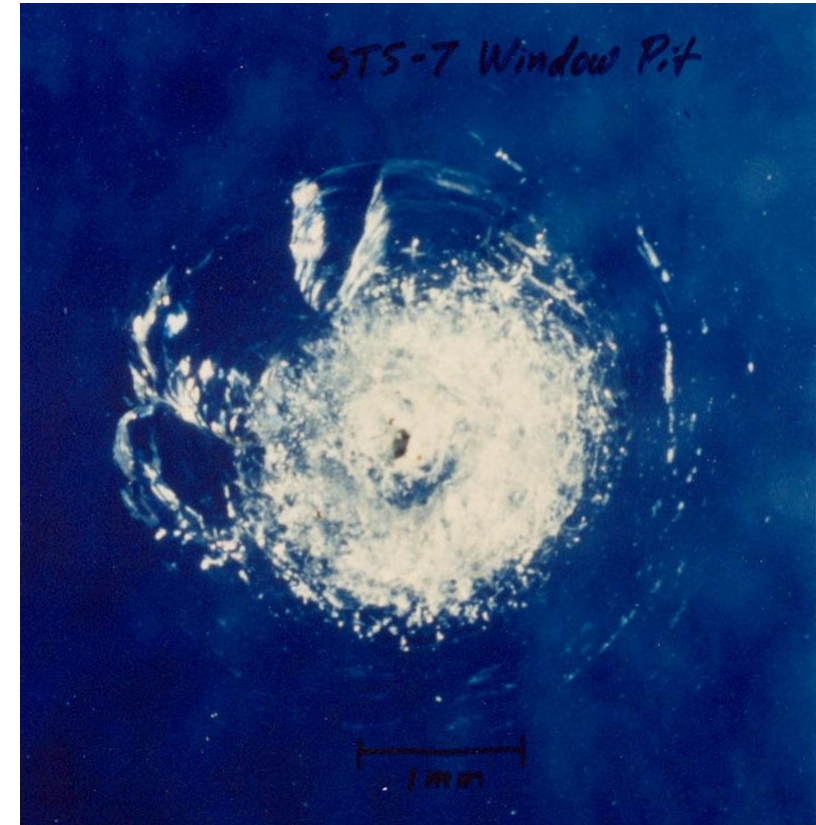
4,700 functional satellites

Source: www.esa.int/Safety_Security/Space_Debris/Space_debris_by_the_numbers

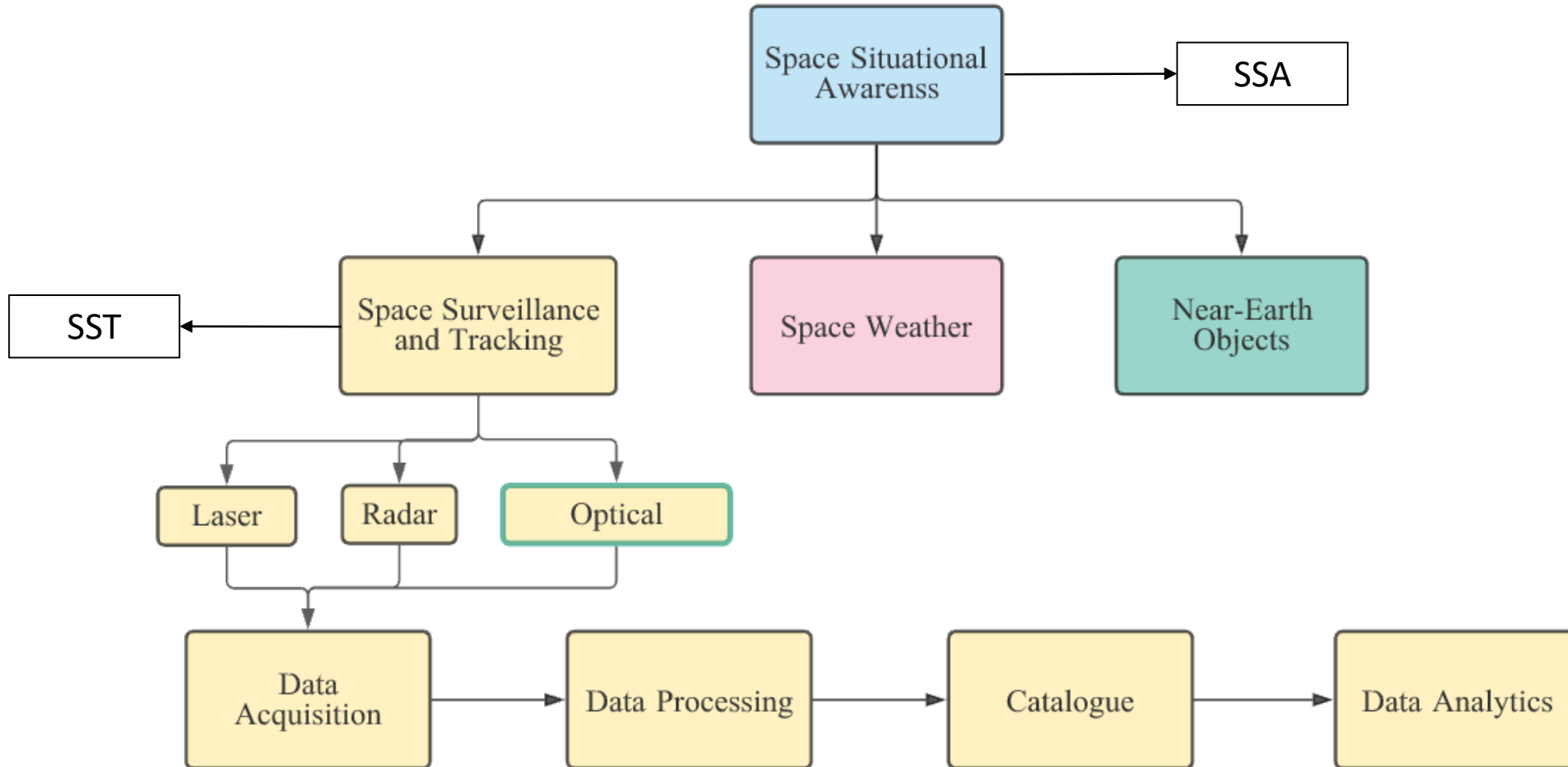
Definition:

“Space debris is a non-functional, man-made object in space”

- Used rocket stages
- Fragments from collisions
- Paint flakes



Space Situational Awareness



Purpose and objectives

Swedish Space Corporation (SSC)

- Deploying an optical SST station, part of SSA initiative

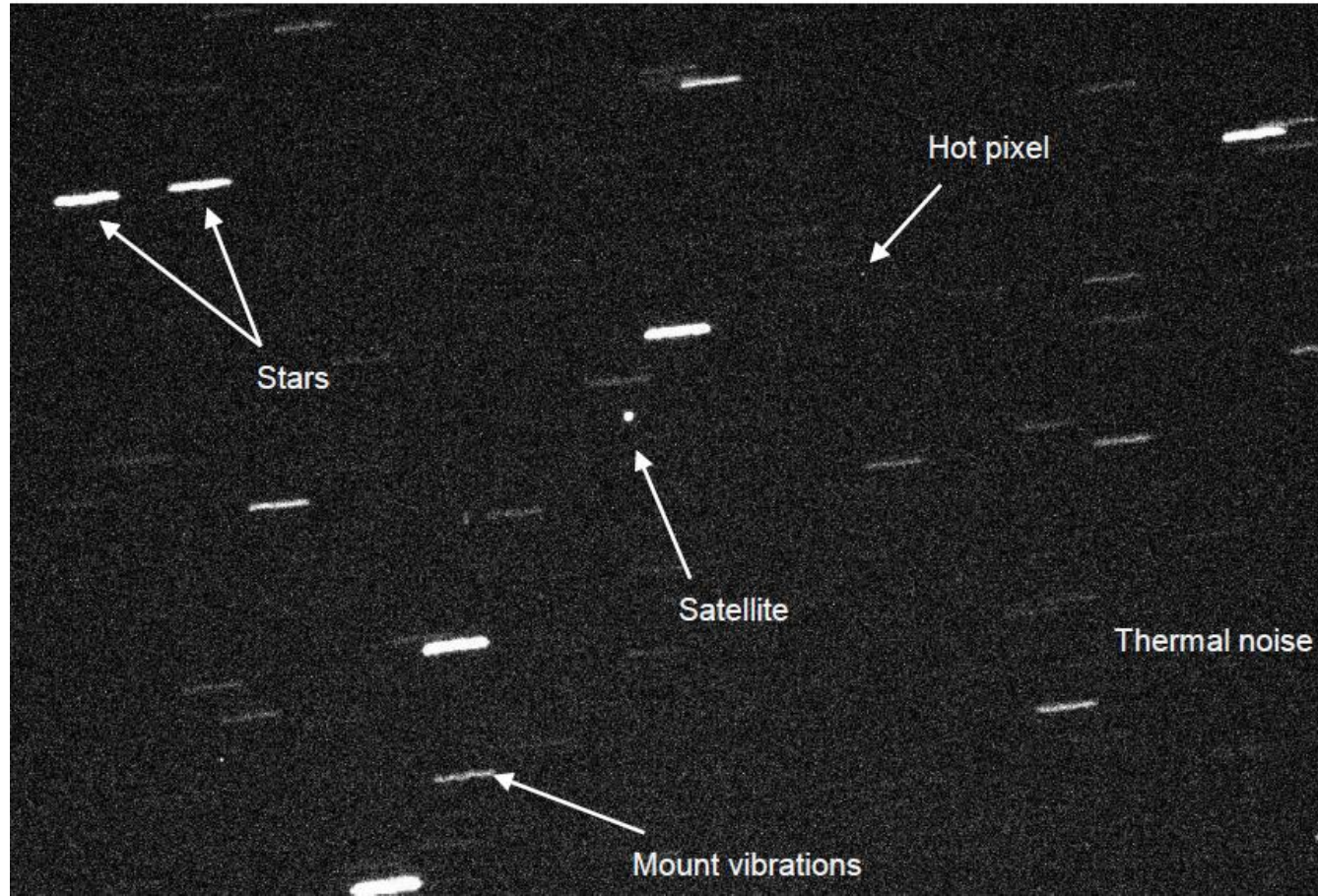


Objective:

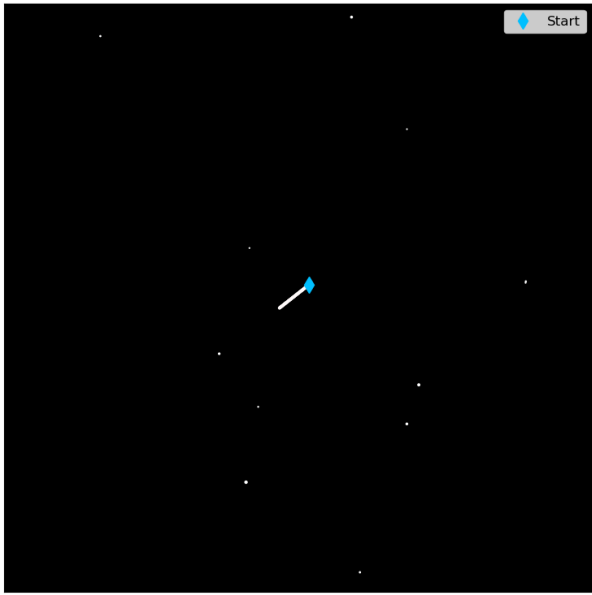
Produce a tool that can simulate images of satellite passes in the night sky, at a given time and location provided by coordinates, as detected from a professional optical telescope system.

- Based in Python
- Help determining feasible observation scenarios
- Test an orbit determination software

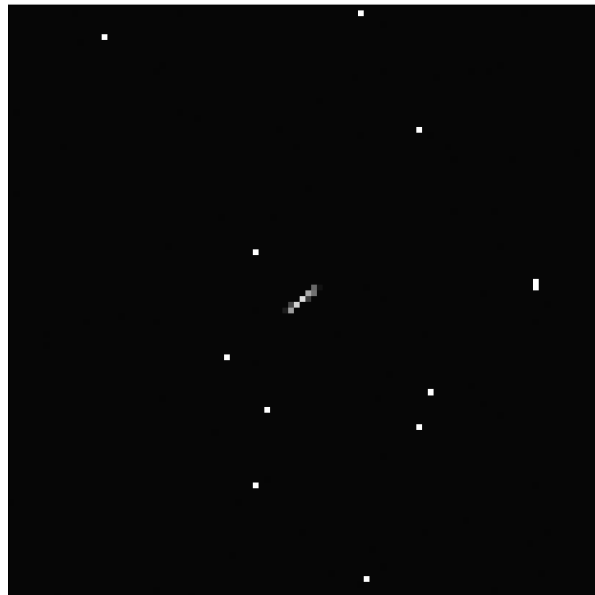
Example image



Development strategy



1. Perfect sky



2. Perfect sensor

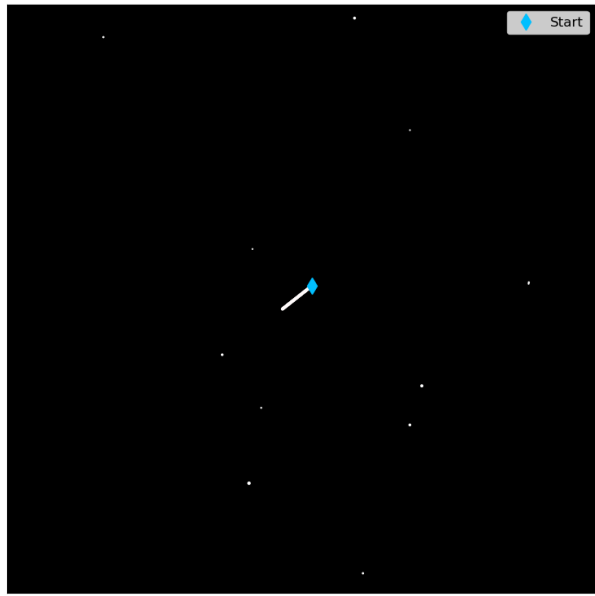


3. Scattered sensor

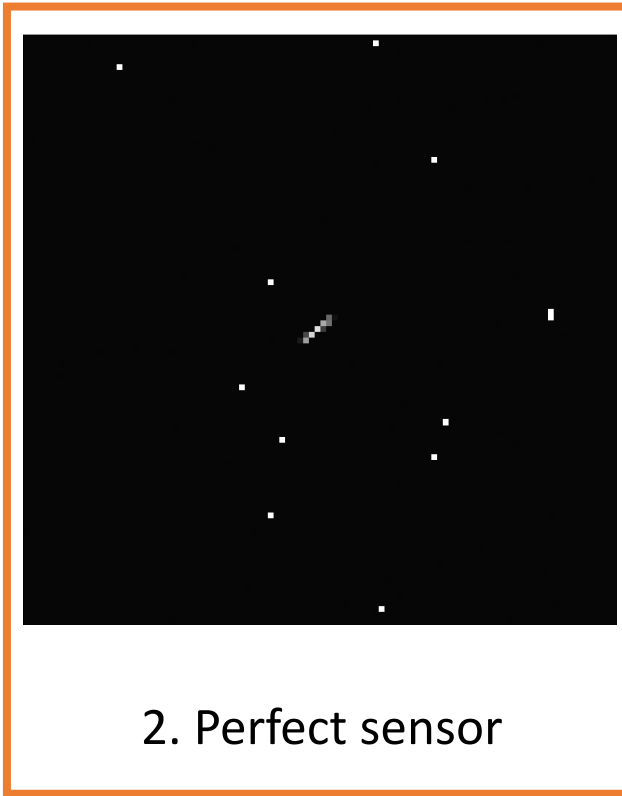


4. Disturbances

Development strategy



1. Perfect sky



2. Perfect sensor

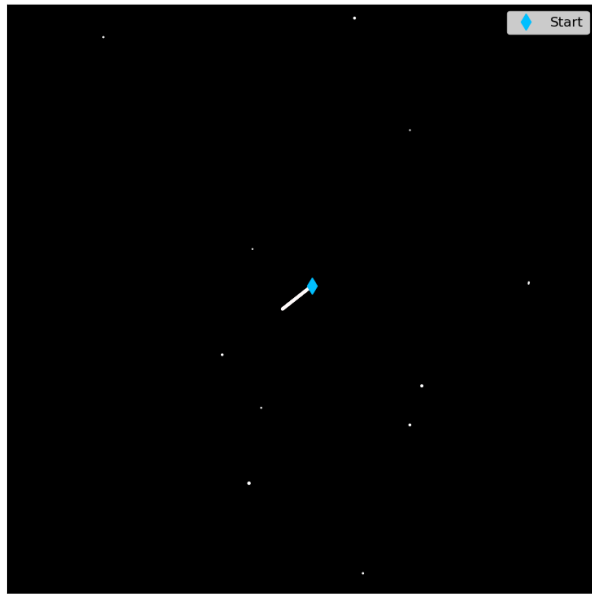


3. Scattered sensor

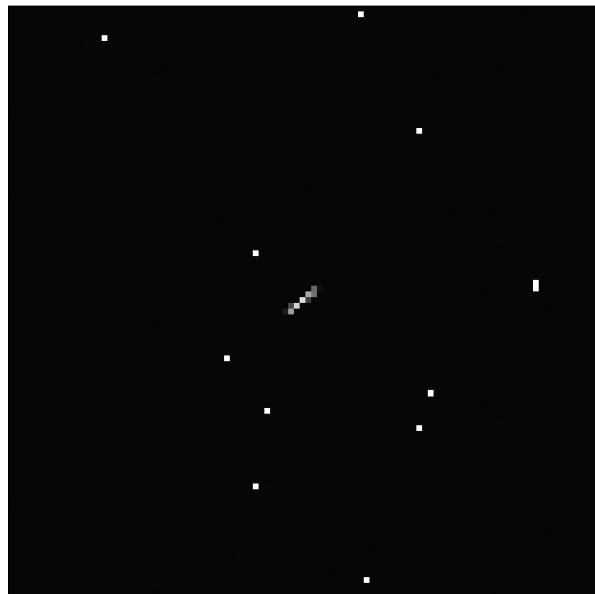


4. Disturbances

Development strategy



1. Perfect sky



2. Perfect sensor

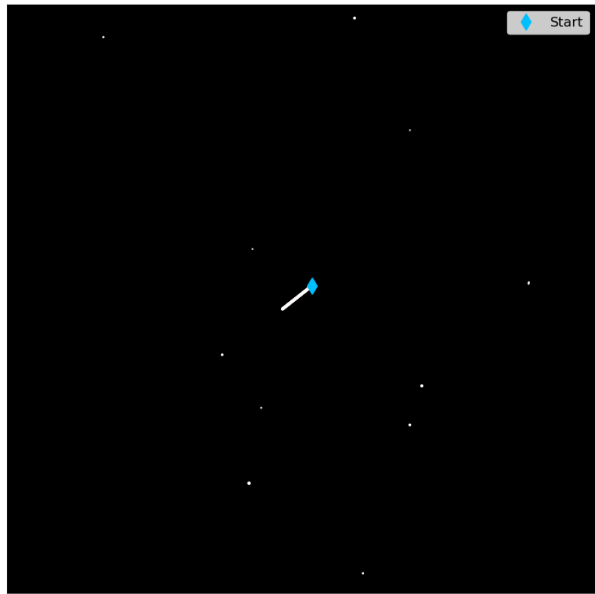


3. Scattered sensor

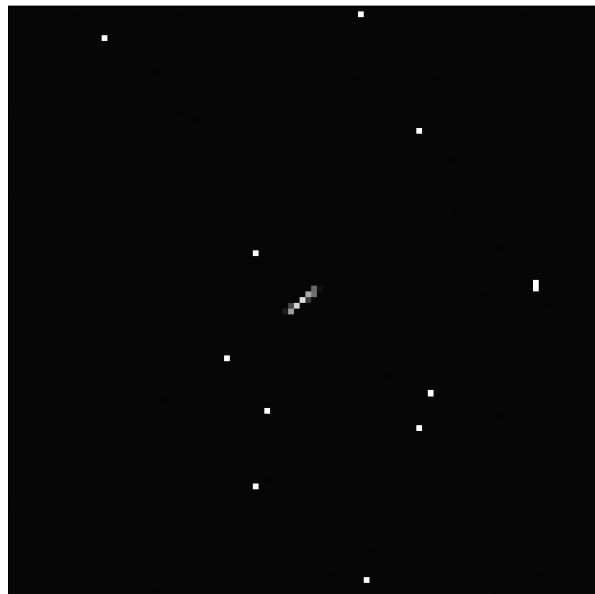


4. Disturbances

Development strategy



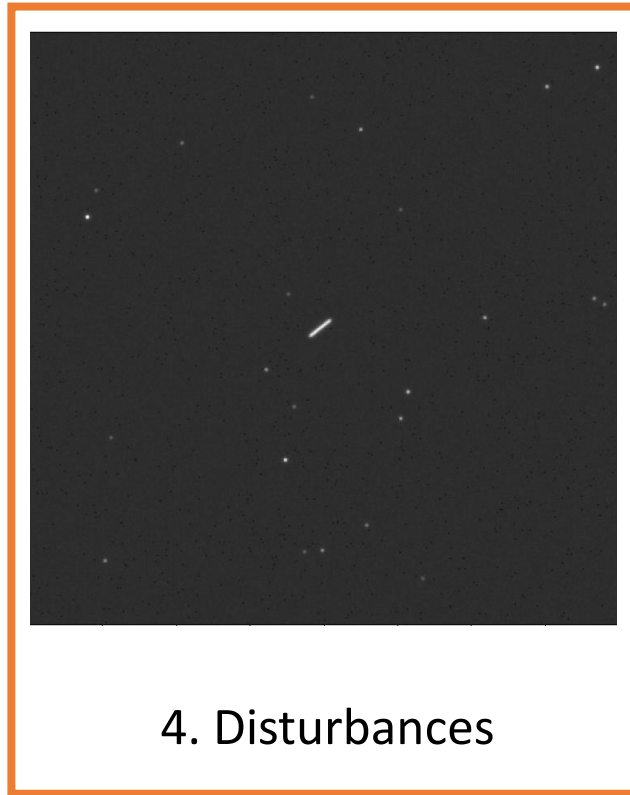
1. Perfect sky



2. Perfect sensor



3. Scattered sensor



4. Disturbances

Replication

Inputs

- **Satellite:** NAVSTAR 65
- **Location:** South African Astronomical Observatory
- **Telescope:** CDK20
- **Sensor:** FLI ProLine CCD camera KAF-16803
- **Date:** 22/02/2021, 18:04:40.780
- **Exposure time:** 5.074937 seconds
- **Dead and hot pixels:** 200 each

- **Sky background:** 20 [electrons/pixel/second]
- **Atmspheric efficiency:** 0.8
- **Sigma:** 0.5



Side by side comparison

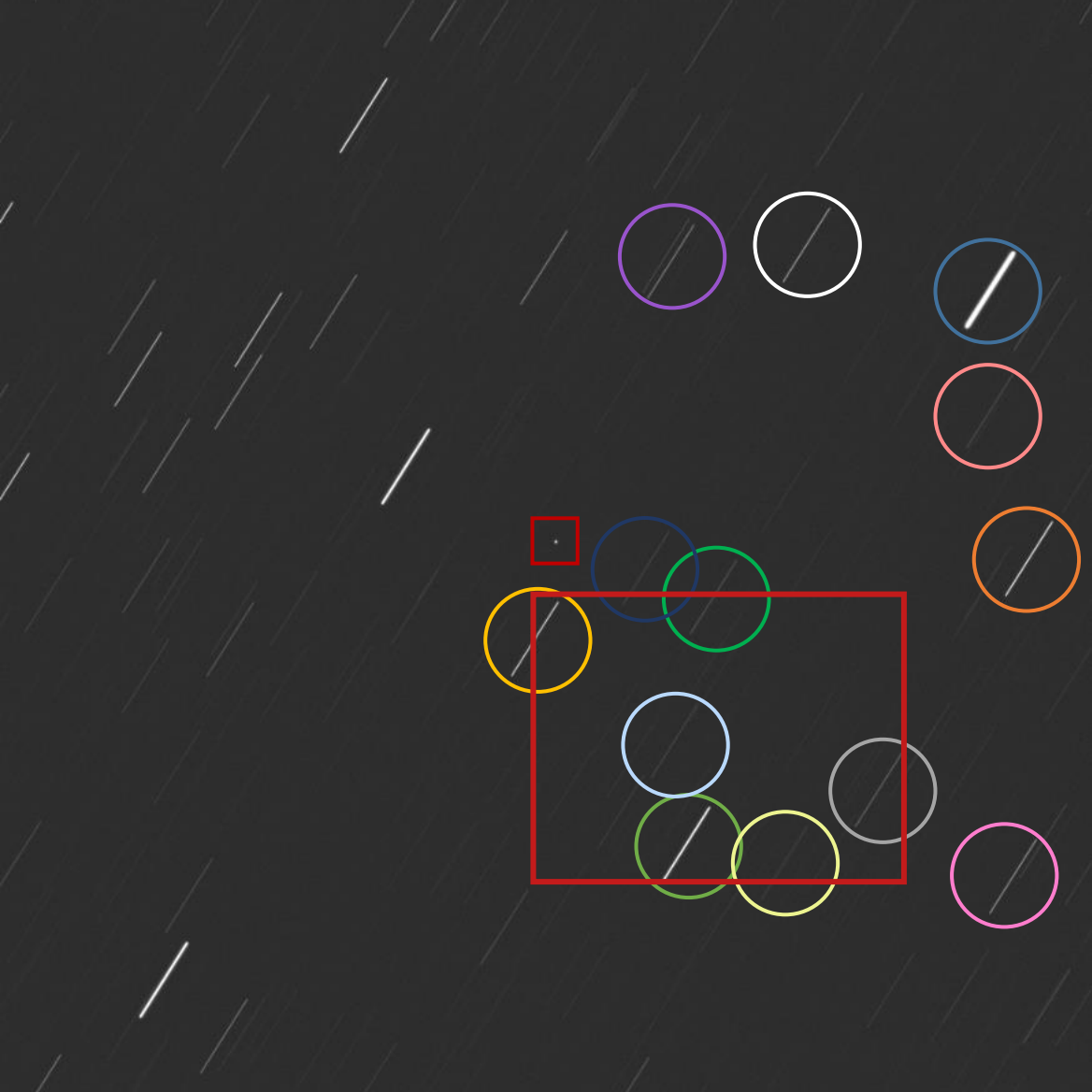


Simulated

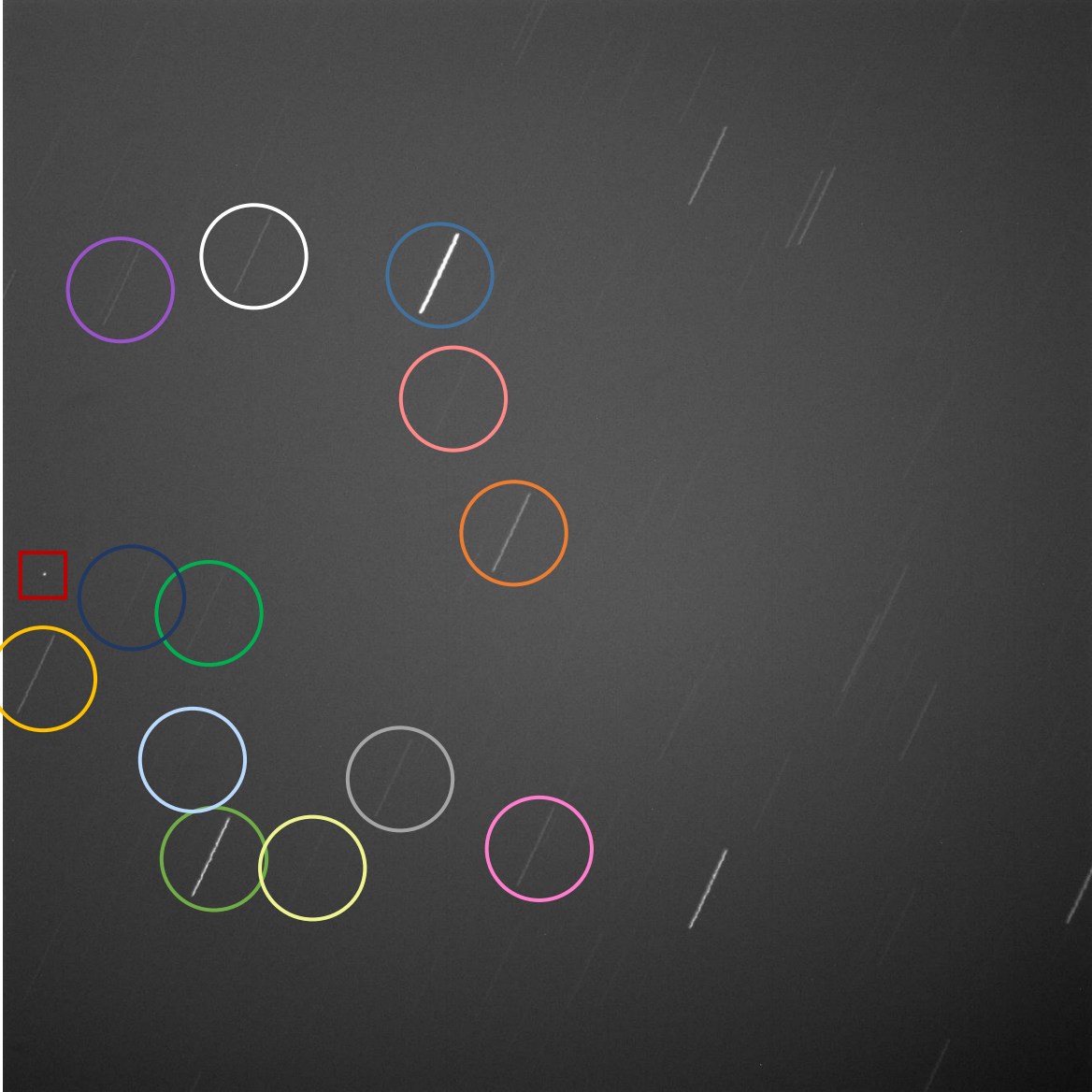


Real

Side by side comparison



Simulated



Real

Side by side comparison - tracklets



Simulated



Real

Side by side comparison - satellite



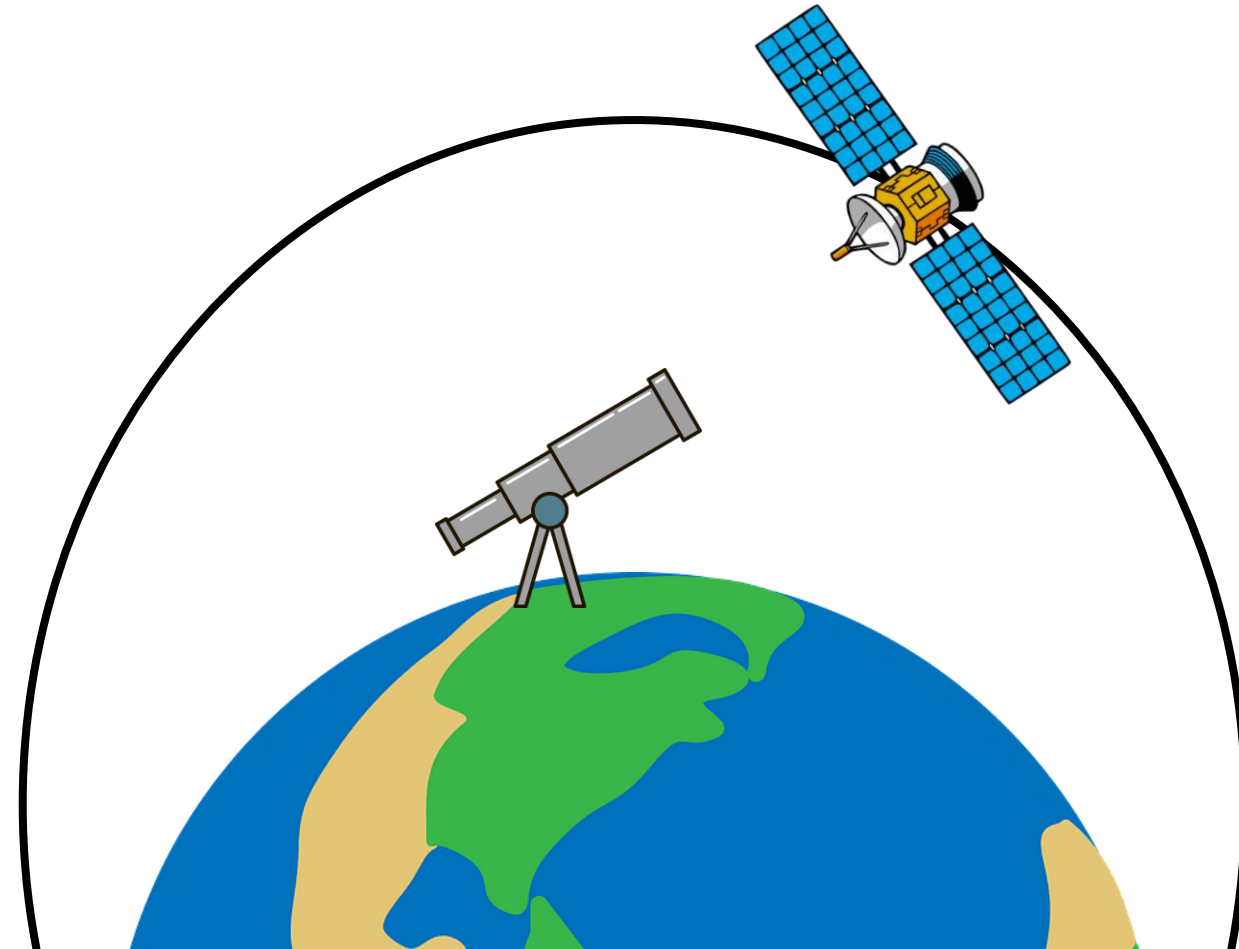
Simulated



Real

Summary

- Designed and developed a simulation tool for SST optical images
- Developed in Python
- Allows user to choose:
 - Satellite
 - Location
 - Time
 - Telescope system
 - Disturbances
- Images are used by SSC to:
 - Test orbit determination software
 - Analyze feasible observation scenarios
 - Plan upcoming observations





Thank you
