Tuparev AstroTech - Software, Space Junk and (Robotic) Observatories

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Tuparev AstroTech/Tuparev Technologies

AstroTech Talk MPIA - 31/10/2022

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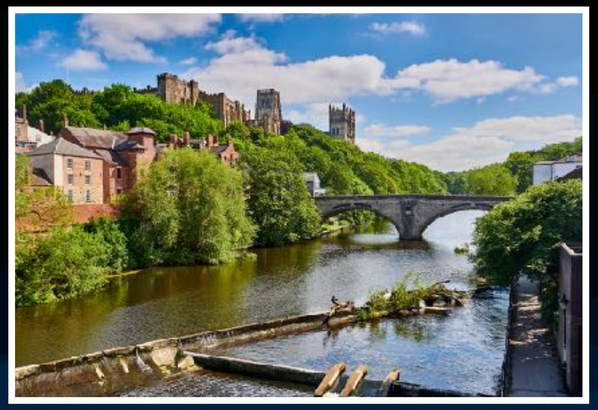
About me

- BSc Physics at York
- MScR astronomy at Durham University
  - Prof. Dave Alexander & Dr. David Rosario - Low redshift AGN host galaxies
- PhD astronomy at University of Heidelberg
  - Dr. Anna Pasquali - Low redshift galaxy assembly and evolution
- Working at Tuparev AstroTech since Jan. 2022



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Parent Company

- Founded in 1999 by Georg Tuparev
- Team members worldwide
- Financial and business software consulting
- Software for Astronomy projects (e.g. MONET)

TUPAREV TECHNOLOGIES

Lifting your expectations

Credit: S.Potter/SAAO

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Tuparev AstroTech History

- Potential projects 2018 - 2020
- Official BG founding in 2021
- 10 new astronomers and/or software developers (June 2020 and present)
- Tuparev AstroTech DE and AM founded in 2022

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Current projects

- Space Junk and Satellite tracking
- Modern astronomy toolkit - 3 software packages
- Affordable spectrograph
- 100+PB archive
- Telescope sales and renovation
- New observing site in Armenia
- Client requested projects

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Tuparev AstroTech: Part 1 - Space Junk

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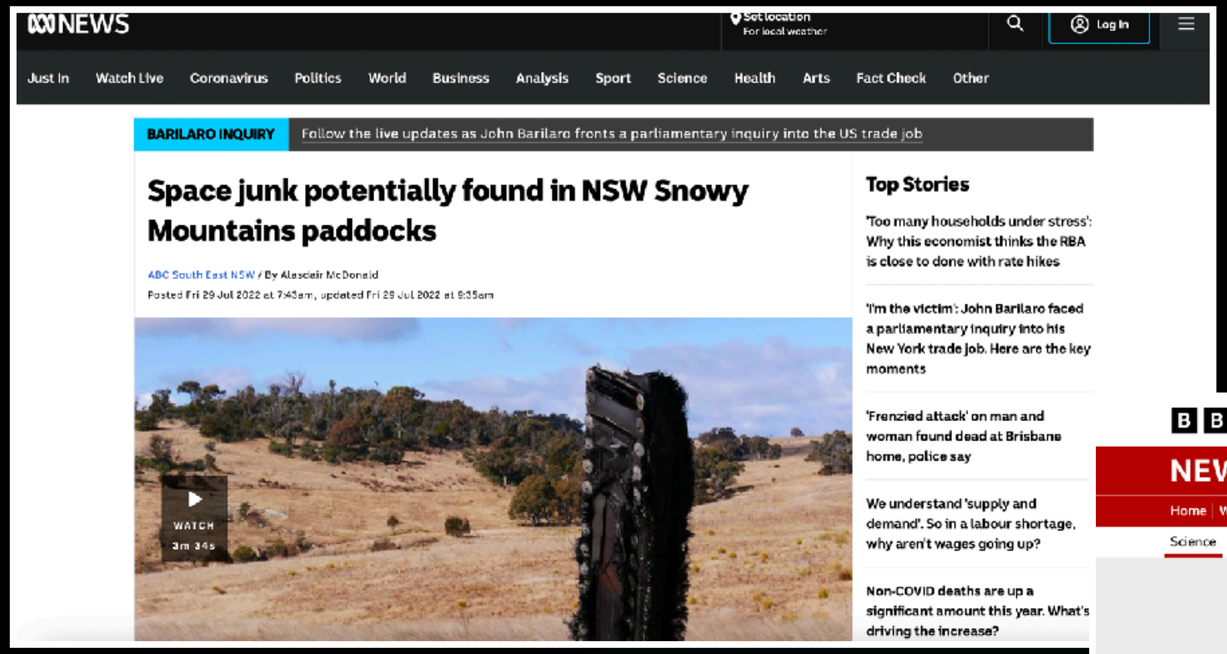
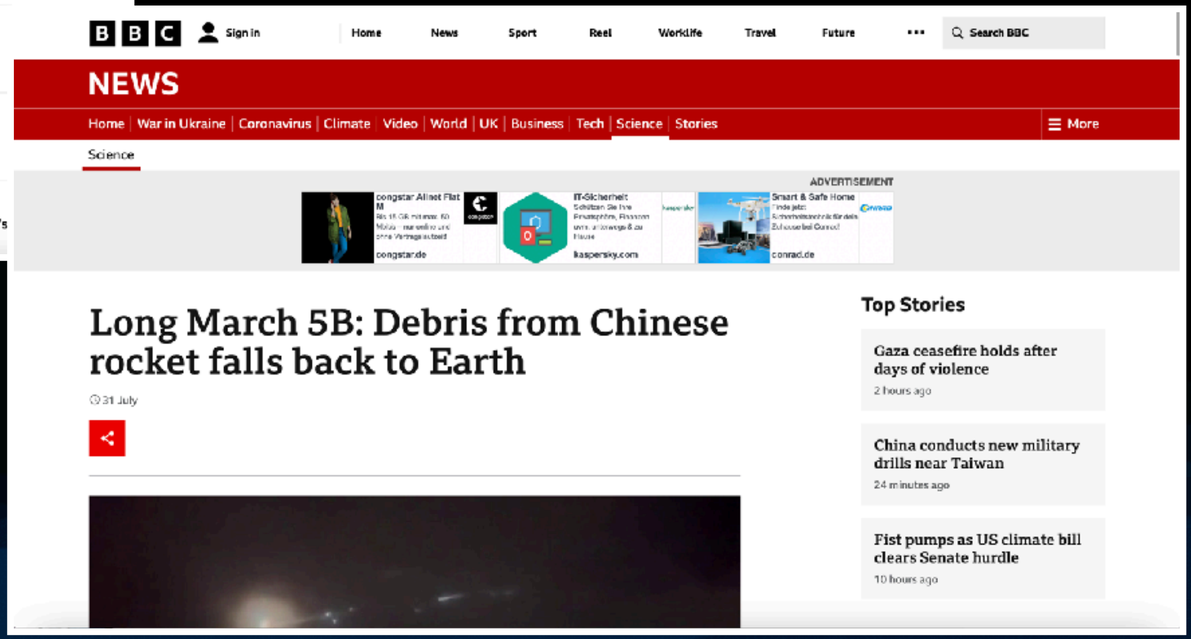
Space Junk - The problem



Credit: ABC news: https://www.abc.net.au/news/2022-07-29/space-junk-found-in-nsw-snowy-mountains-paddocks-/101277542



Credit: BBC news: https://www.bbc.com/news/science-environment-62333546

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28%

Satellites in orbit that are no longer operational

https://www.esa.int/Space_Safety/Space_Debris/Space_debris_by_the_numbers

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36500

Space debris objects greater than 10cm

https://www.esa.int/Space_Safety/Space_Debris/Space_debris_by_the_numbers

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1 million

Space debris objects between 1cm and 10cm

https://www.esa.int/Space_Safety/Space_Debris/Space_debris_by_the_numbers

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130 million

Space debris objects between 1mm and 1cm

https://www.esa.int/Space_Safety/Space_Debris/Space_debris_by_the_numbers

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Space Junk - The problem

As of August 11, 2022...

- 13630 satellites launched (+310 since July 11)
- 8850 satellites currently in orbit

Knock-on effects:

- Satellite manoeuvres
- Kessler Syndrome
- Emergency procedures for astronauts
- Uncontrolled re-entry

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Space Junk - Current efforts

Radar

+ Tracking accuracy, known satellites

- Surveying, finding new objects

Credit: ESA

Laser Ranging

+ Tracking accuracy, known satellites

- Interfere with air traffic, finding new objects

Credit: Astrosysteme Austria

Passive radio frequencies

+ mining data, more possible observational time

- Relatively new and untested

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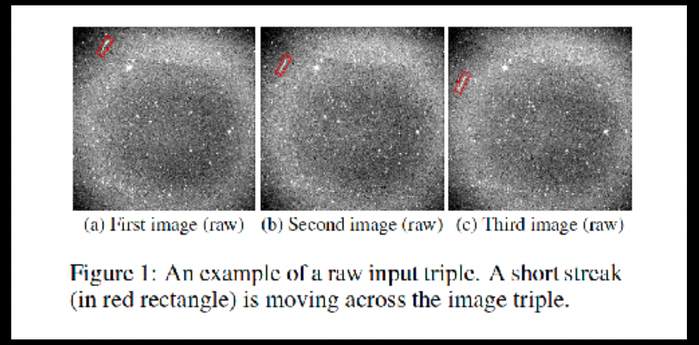
Space Junk - Current efforts

Current techniques

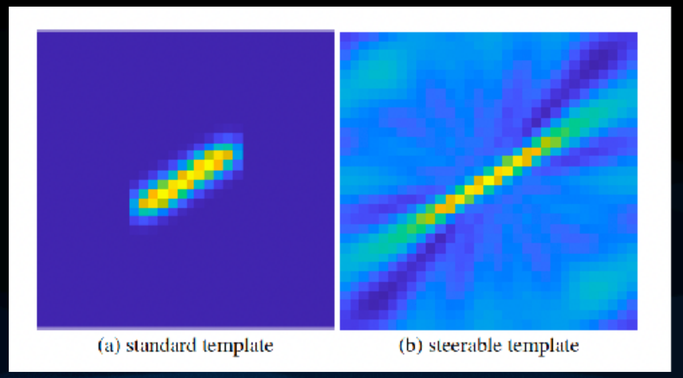
- Object segmentation
- Image shifting and overlaying
- Template matching
- Transforms



(a) First image (raw) (b) Second image (raw) (c) Third image (raw)

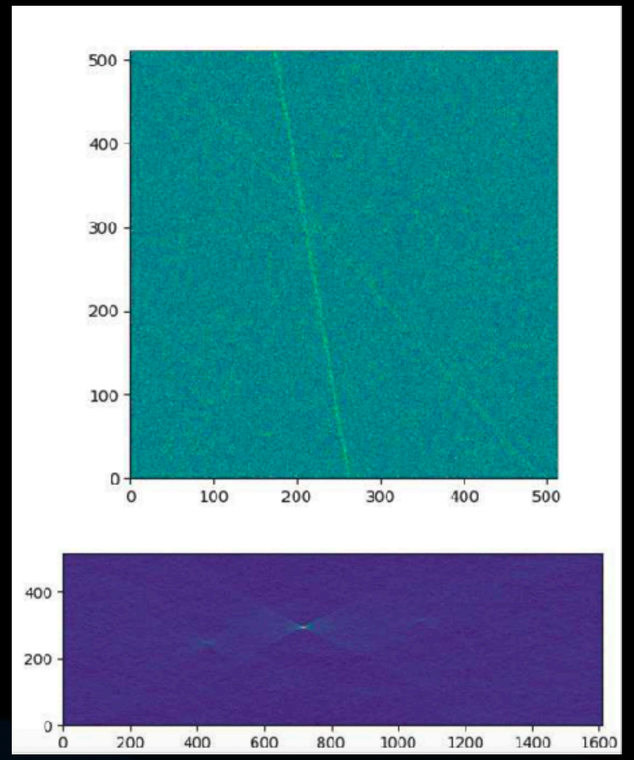
Figure 1: An example of a raw input triple. A short streak (in red rectangle) is moving across the image triple.

Cvrček & Sára 2021



(a) standard template (b) steerable template

Cvrček & Sára 2021



Hickson 2018

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Space Junk - Astro Systeme Austria (ASA)

- Telescopes, mount, and mirror manufacturers (Domes being developed)
- Founded ~15 years ago
- 40cm - 2.5m telescopes
- Products now on every continent

Credit: Astrosysteme Austria

Credit: BBC News

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Space Junk - Our system

- Test station in Sandl, Austria
- 40cm telescope
- CMOS camera (wide FoV, low noise)
- 10,000 sq. degree per telescope per night
- Fully-robotic, controlled from central server

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Space Junk - Our system

- 1-2 month manufacturing time
- 40cm-1m telescope
- 2-3 planned in 2023
- 20-30 stations worldwide in < 10 years
- Up to 200,000 sq deg per 24 hour cycle

Credit: Astrosysteme Austria

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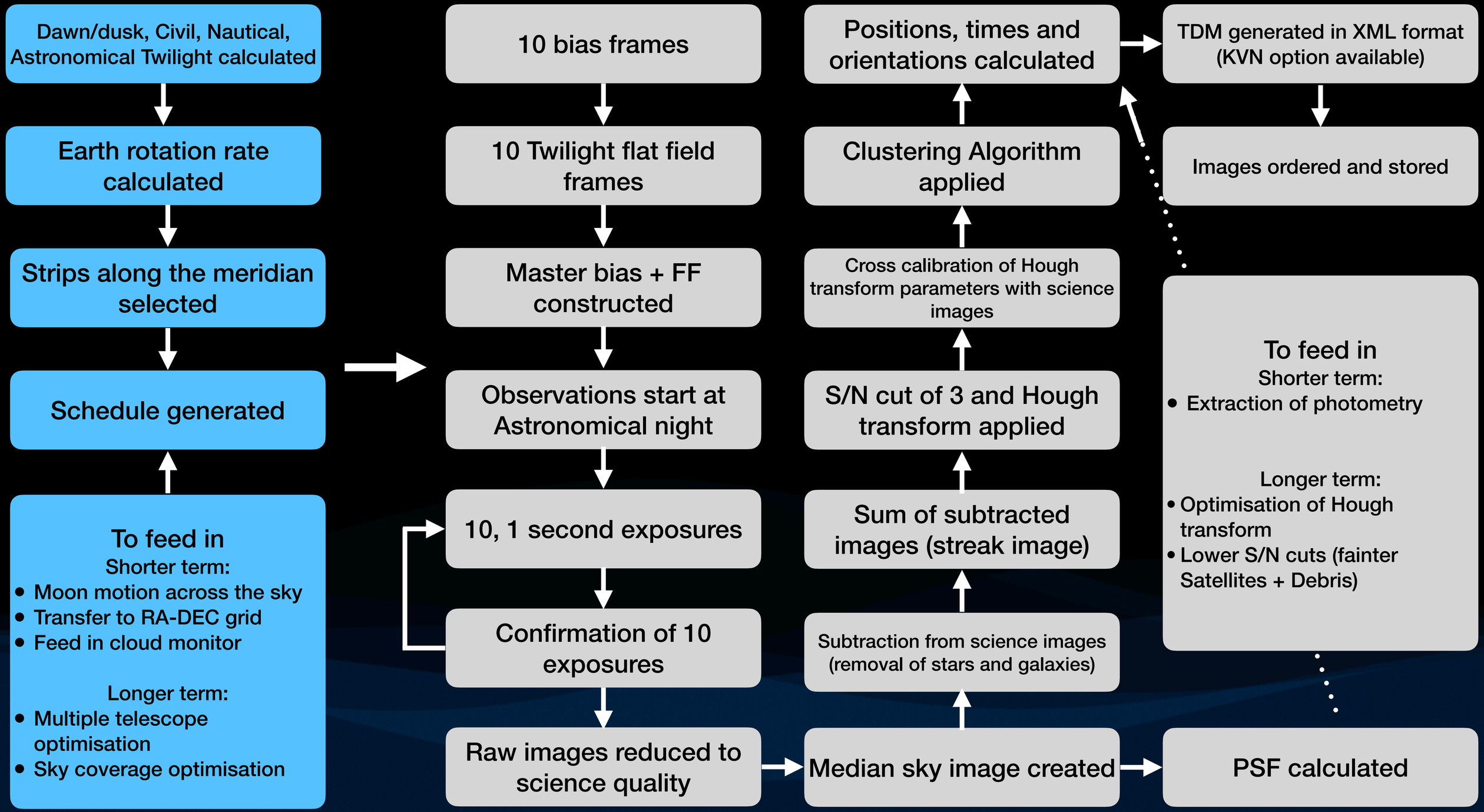
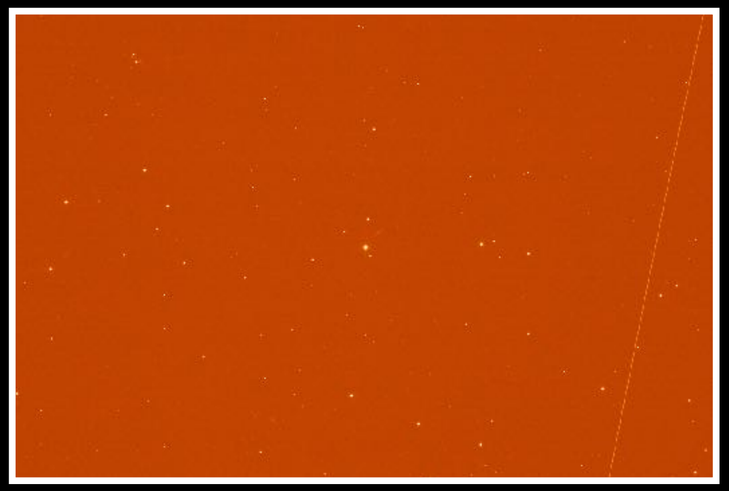
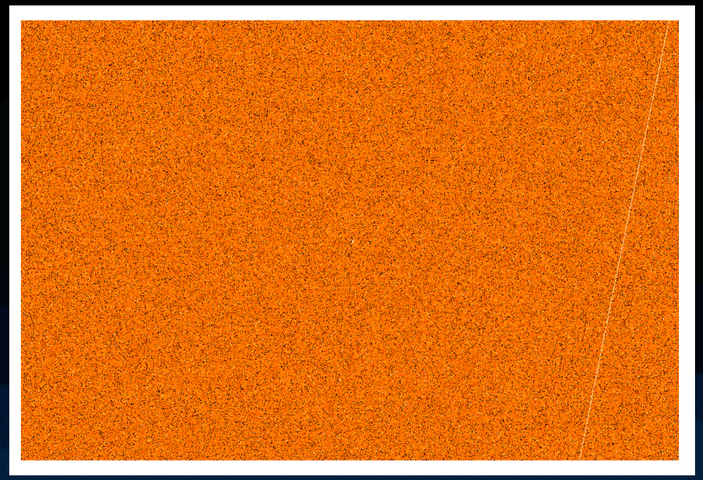
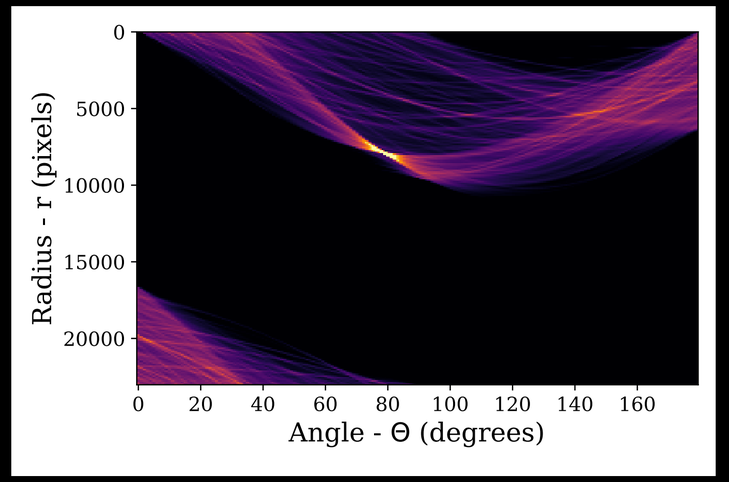
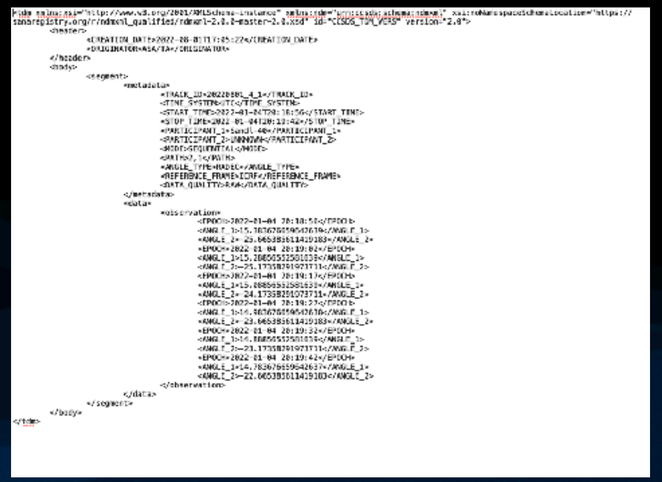

Dawn/dusk, Civil, Nautical, Astronomical Twilight calculated
Earth rotation rate calculated
Strips along the meridian selected
Schedule generated
To feed in
Shorter term:
Moon motion across the sky
Transfer to RA-DEC grid
Feed in cloud monitor
Longer term:
Multiple telescope optimisation
Sky coverage optimisation
10 bias frames
10 Twilight flat field frames
Master bias + FF constructed
Observations start at Astronomical night
10, 1 second exposures
Confirmation of 10 exposures
Raw images reduced to science quality
Median sky image created
Subtraction from science images (removal of stars and galaxies)
Sum of subtracted images (streak image)
S/N cut of 3 and Hough transform applied
Cross calibration of Hough transform parameters with science images
Clustering Algorithm applied
Positions, times and orientations calculated
TDM generated in XML format (KVN option available)
Images ordered and stored
PSF calculated
To feed in
Shorter term:
Extraction of photometry
Longer term:
Optimisation of Hough transform
Lower S/N cuts (fainter Satellites + Debris)

Space Junk - Our system









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Space Junk - Our system

- Pipeline currently in test phase
- S/N limit of < 3
- mag limit > 16 mag
- Optimised, real-time processing (5-10s)

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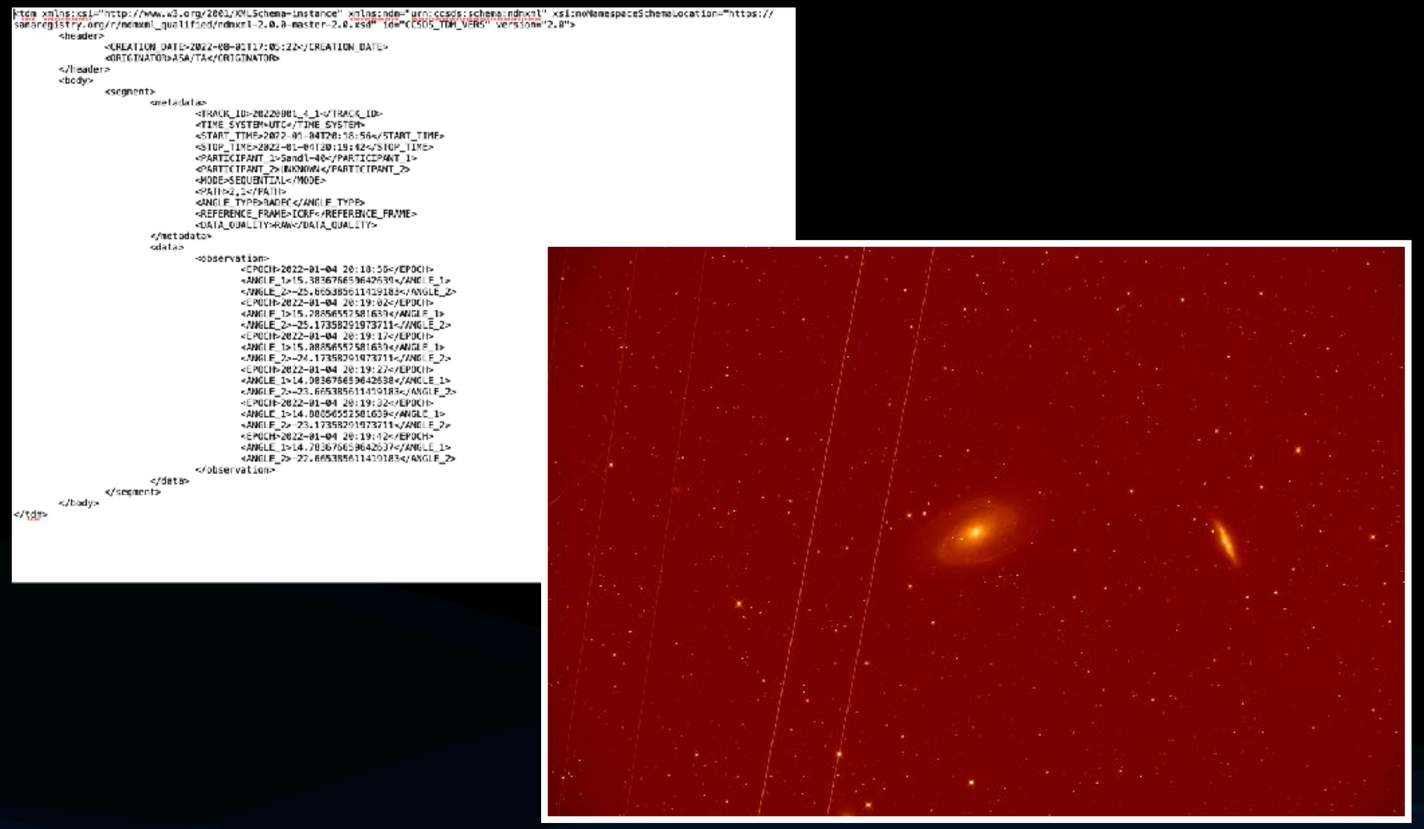
Space Junk - Our system

Data products

- Tracking data messages
- Satellite light curves
- Science quality images
- Orbital data messages (planned)
- Collision determination (planned)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Space Junk - Our system

Photometry

- Photometric catalogues of stars and galaxies
- Long-term -> no funding to expire (10+ years of data)

Imaging

- Continually stack all science images to create an all-sky mosaic
- Science images available for 30 days

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Tuparev AstroTech: Part 2 - Software

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Software: A modern astronomy toolkit - motivations

How do I choose the best Telescope/Instrument for my observations?

Where can I store my data?

What options do I have for follow-up observations? Where can I best get time?

Can I easily connect all steps of the astronomy process?

Are there tools I can use across a number of platforms?

Can I work with my data in a more intrinsic way?

Why are IRAF and MIDAS so outdated?

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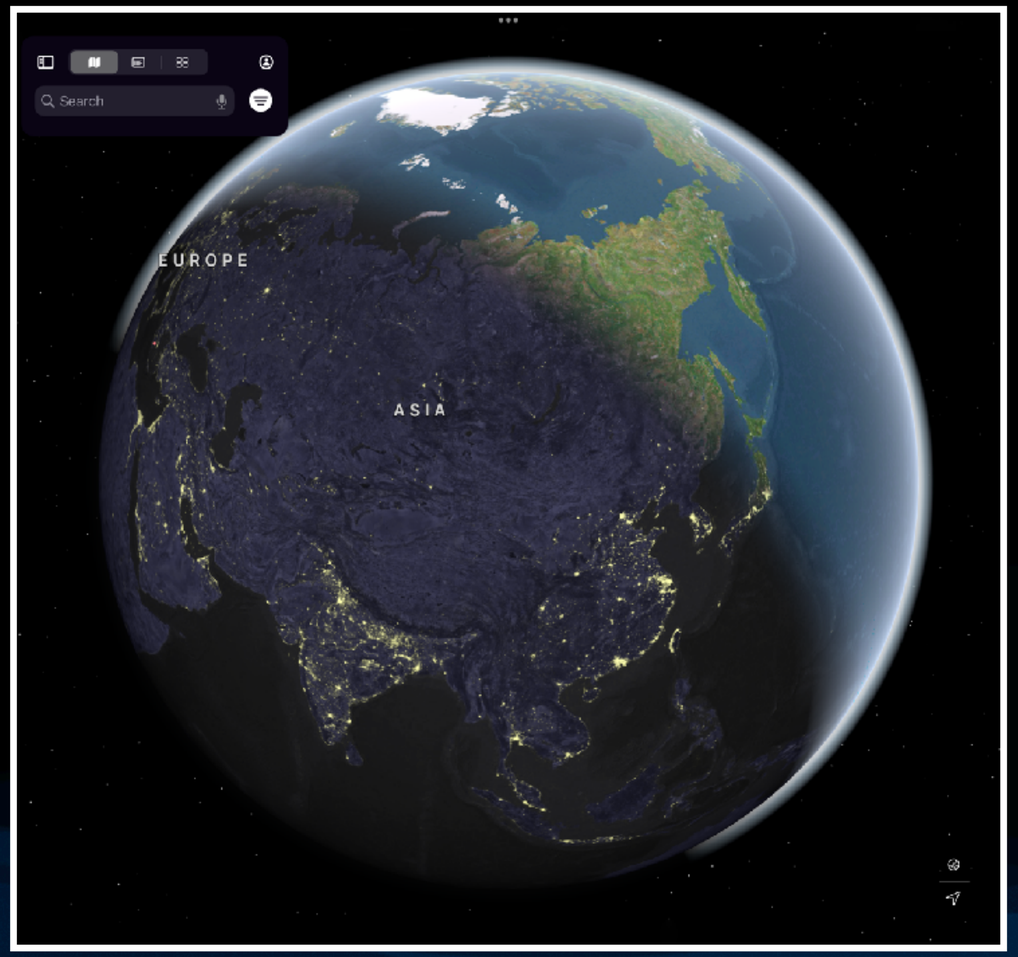
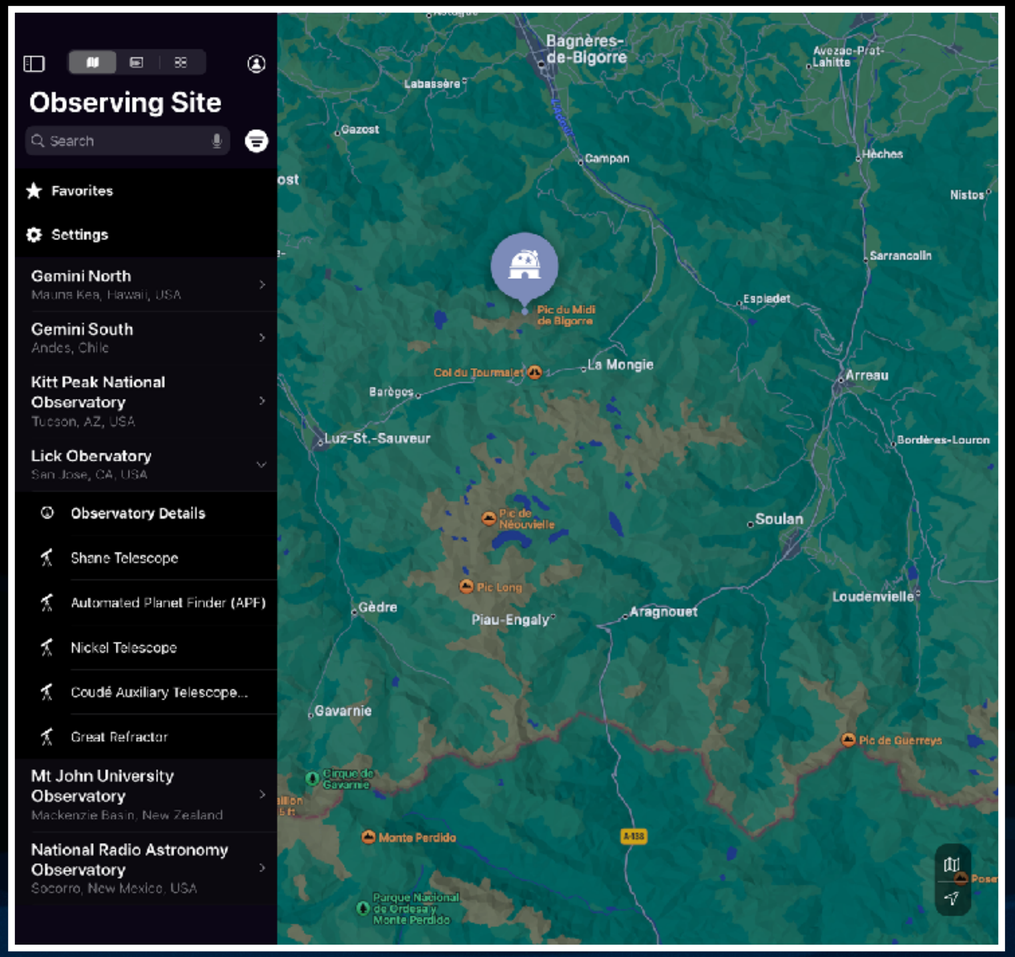
Software: A modern astronomy toolkit - The Telescope Observer App





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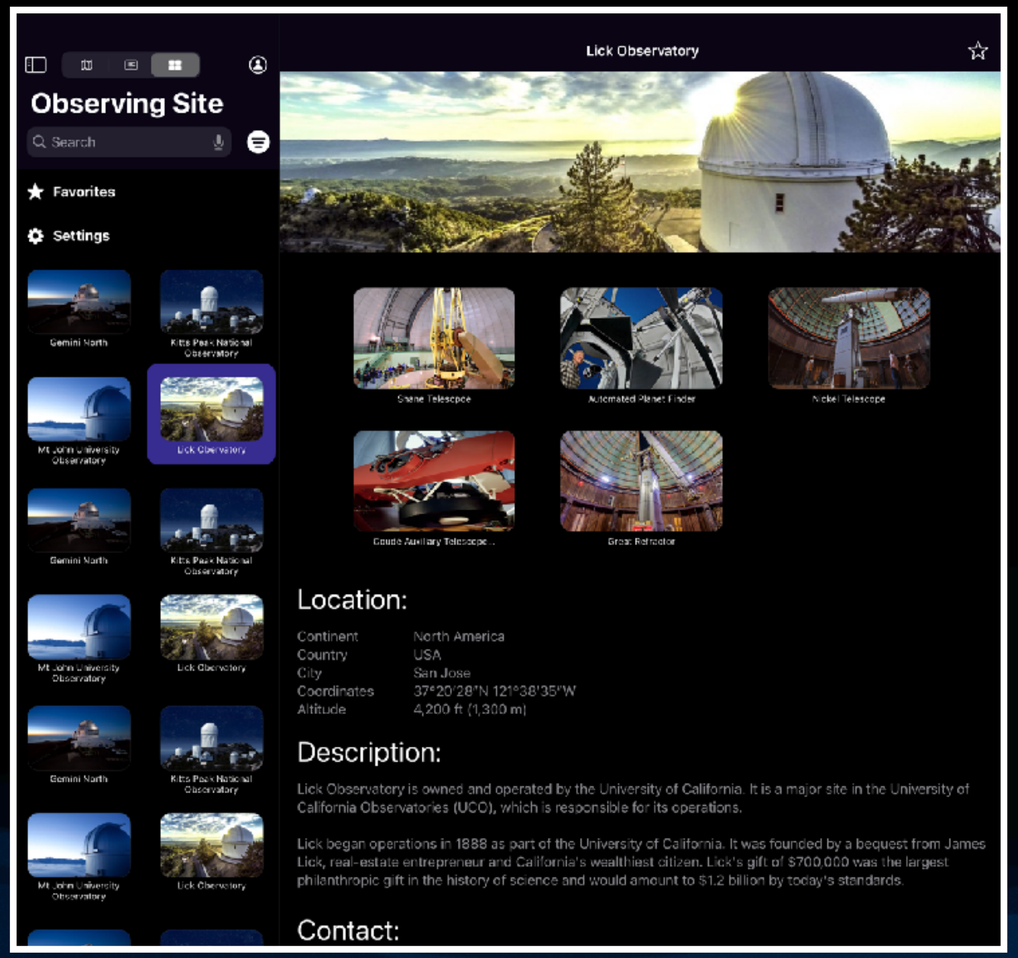
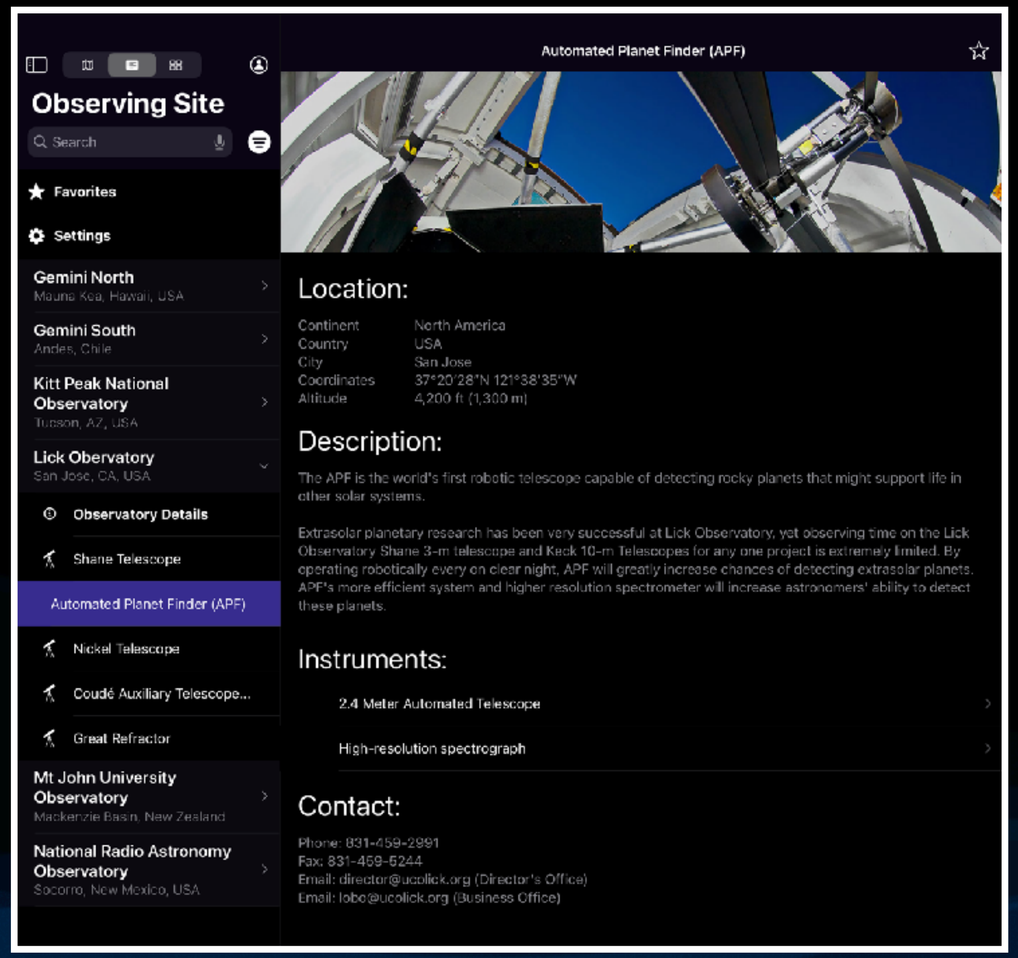
Software: A modern astronomy toolkit - The Telescope Observer App





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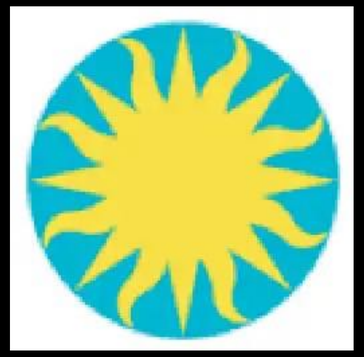
Software: A modern astronomy toolkit - StarBrush



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Software: A modern astronomy toolkit - Observatory Control

Release in 2024

- Fully remote telescope control software - sleeker, more intrinsic, easier to use
- Robotic scheduling modules
- Interfacing with our other applications

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Tuparev AstroTech: Part 3 - (Robotic) Observatories

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(Robotic) observatories - our role

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(Robotic) observatories - location finding

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(Robotic) observatories - location finding

Credit: Byurakan Astronomical Observatory/Andranik Keshishyan

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(Robotic) observatories - location finding

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(Robotic) observatories - other possible projects

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Links

https://www.tuparev.com

https://www.starcluster.app (Currently under a complete re-vamp)

https://www.astrosysteme.com

Thanks for listening! Any questions?

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