

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

Dr. Thomas Jackson

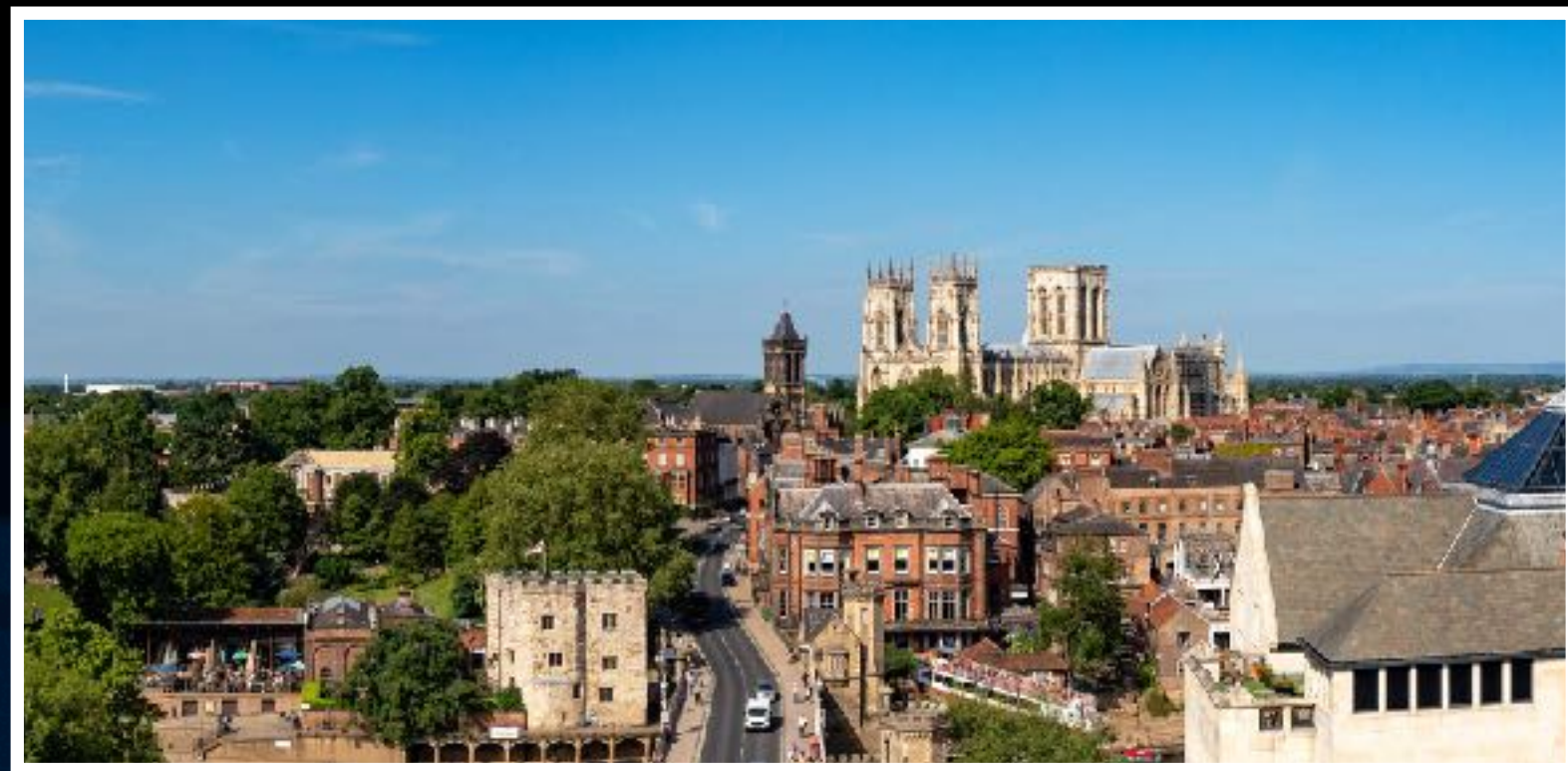
**Astronomer and Software Engineer
Tuparev AstroTech/Tuparev Technologies**

AstroTech Talk MPIA - 31/10/2022



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



Parent Company

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



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



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



Tuparev AstroTech: Part 1 - Space Junk



Space Junk - The problem

ABC NEWS Set location For local weather Log In

Just In Watch Live Coronavirus Politics World Business Analysis Sport Science Health Arts Fact Check Other

BARILARO INQUIRY Follow the live updates as John Barilaro fronts a parliamentary inquiry into the US trade job

Space junk potentially found in NSW Snowy Mountains paddocks

ABC South East NSW / By Alascleir McDonald
Posted Fri 29 Jul 2022 at 7:43am, updated Fri 29 Jul 2022 at 9:35am

WATCH
3m 34s

Top Stories

- 'Too many households under stress': Why this economist thinks the RBA is close to done with rate hikes
- 'I'm the victim': John Barilaro faced a parliamentary inquiry into his New York trade job. Here are the key moments
- 'Frenzied attack' on man and woman found dead at Brisbane home, police say
- We understand 'supply and demand'. So in a labour shortage, why aren't wages going up?
- Non-COVID deaths are up a significant amount this year. What's driving the increase?

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

BBC Sign in Home News Sport Reel Worklife Travel Future Search BBC

NEWS

Home War in Ukraine Coronavirus Climate Video World UK Business Tech Science Stories More

Science

Long March 5B: Debris from Chinese rocket falls back to Earth

31 July

Top Stories

- Gaza ceasefire holds after days of violence
2 hours ago
- China conducts new military drills near Taiwan
24 minutes ago
- Fist pumps as US climate bill clears Senate hurdle
10 hours ago

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



28%

Satellites in orbit that are no longer operational

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



36500

Space debris objects greater than 10cm

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



1 million

Space debris objects between 1cm and 10cm

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



130 million

Space debris objects between 1mm and 1cm

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



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



Space Junk - Current efforts

Radar

- + Tracking accuracy, known satellites
- Surveying, finding new objects

Laser Ranging

- + Tracking accuracy, known satellites
- Interfere with air traffic, finding new objects

Passive radio frequencies

- + mining data, more possible observational time
- Relatively new and untested



Credit: ESA



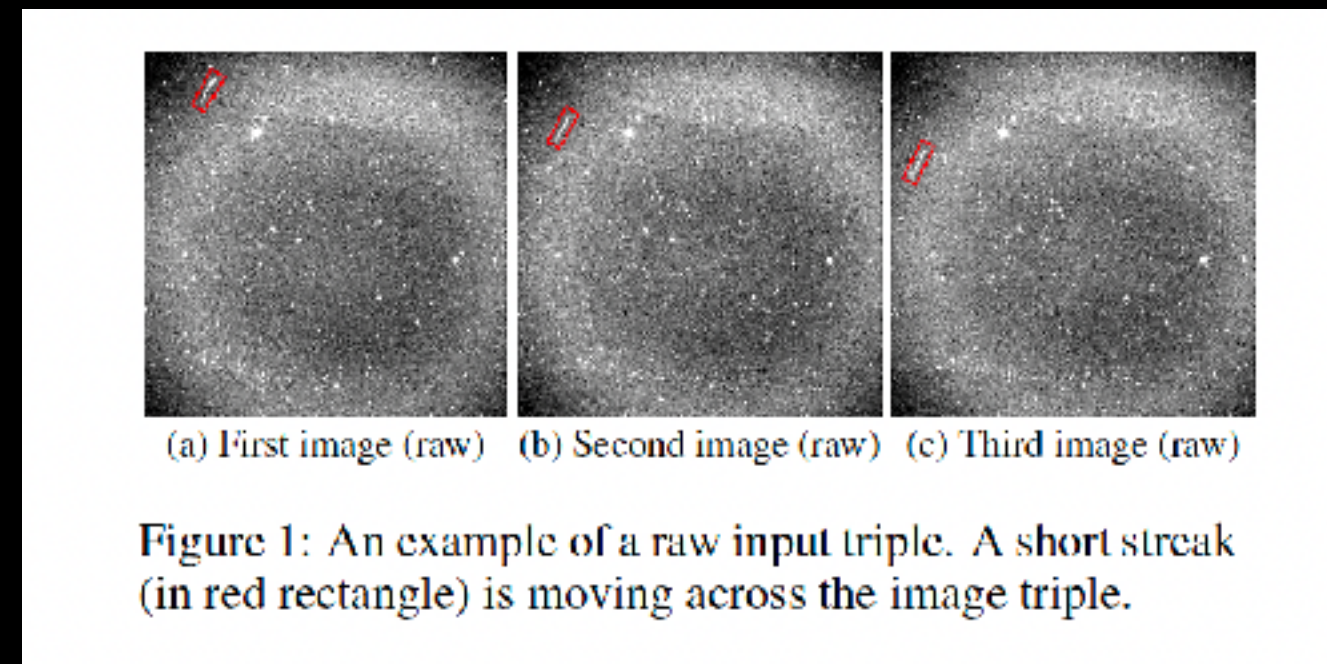
Credit: Astrosysteme Austria



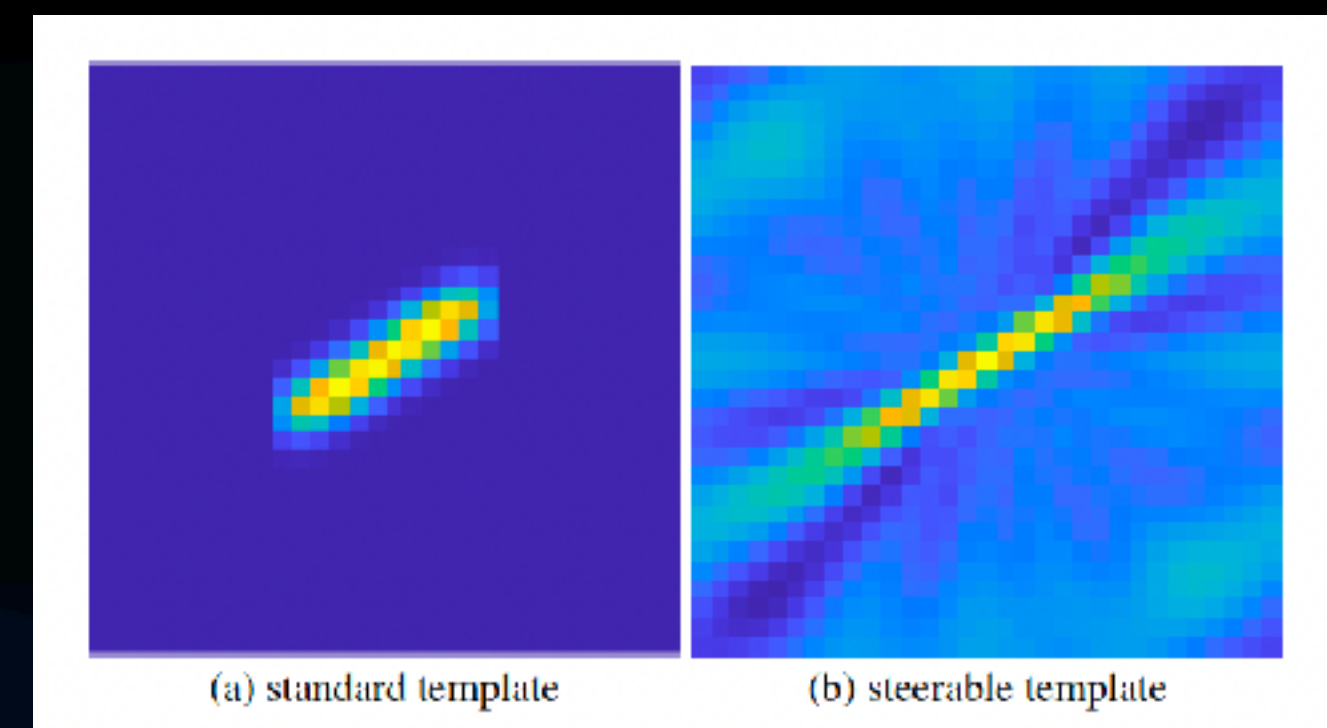
Space Junk - Current efforts

Current techniques

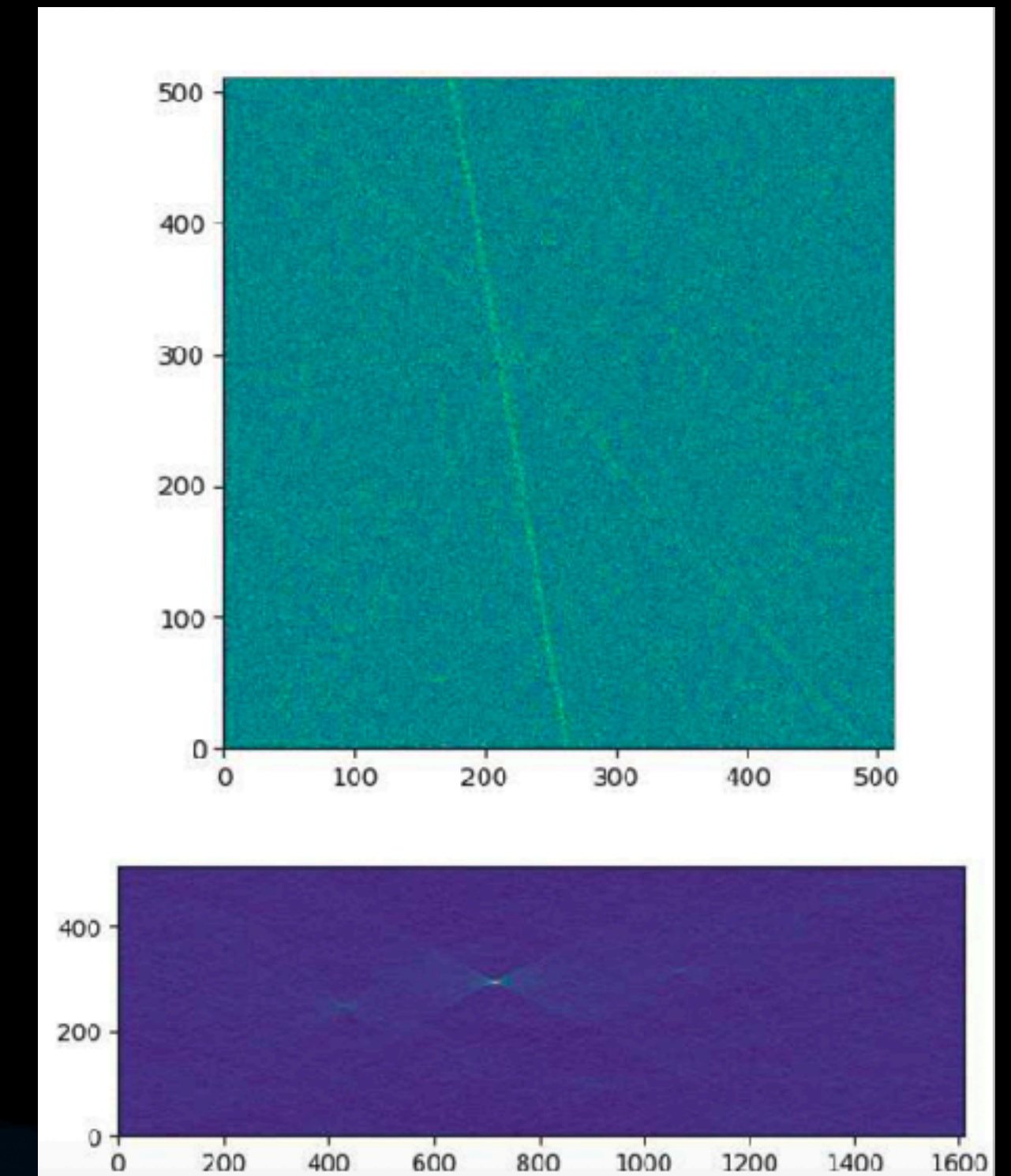
- Object segmentation
- Image shifting and overlaying
- Template matching
- Transforms



Cvrček & Sára 2021



Cvrček & Sára 2021



Hickson 2018



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: BBC News



Credit: Astrosysteme Austria



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



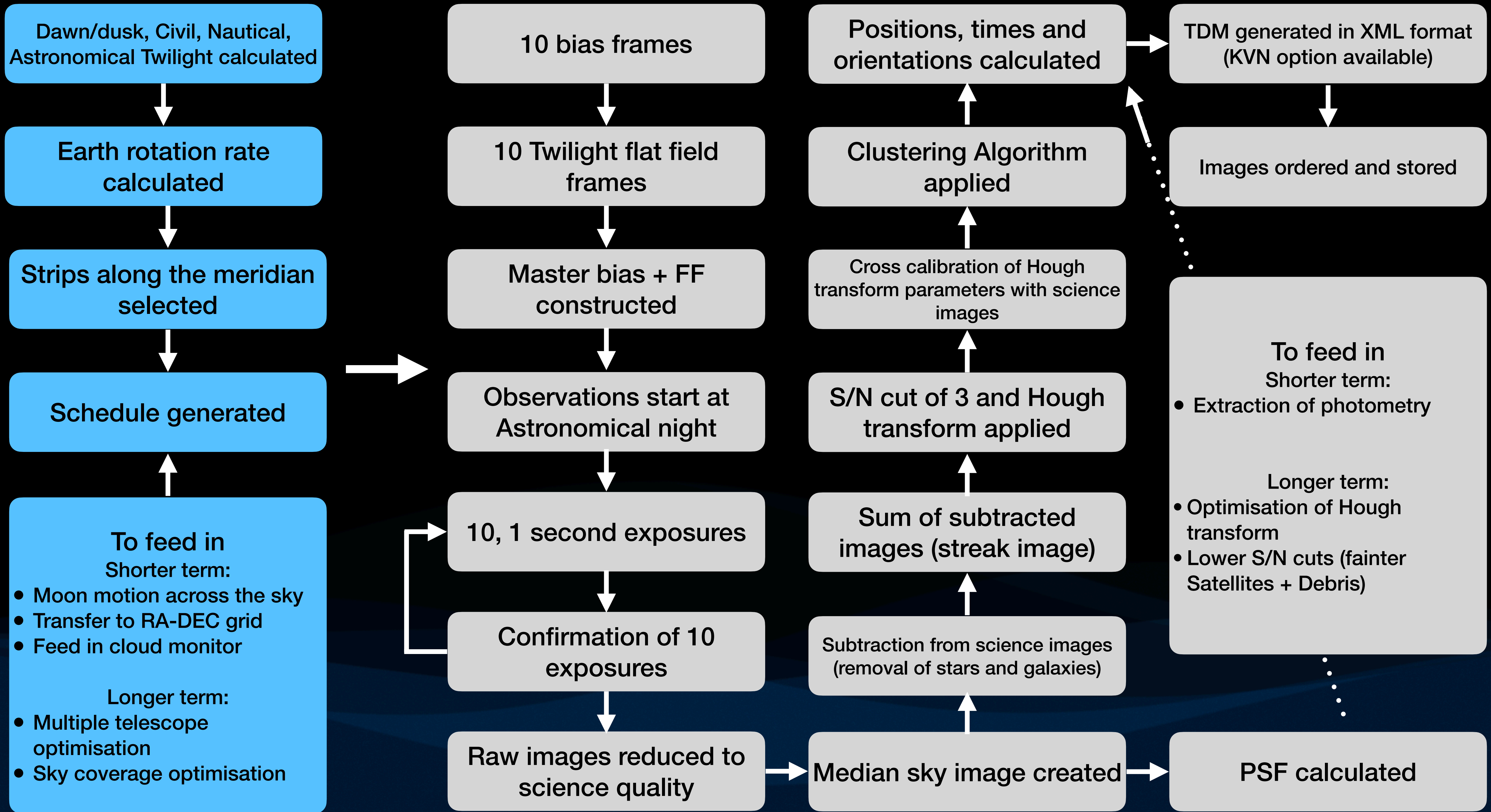
Space Junk - Our system

- 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





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

Positions, times and orientations calculated

Clustering Algorithm applied

Cross calibration of Hough transform parameters with science images

S/N cut of 3 and Hough transform applied

Sum of subtracted images (streak image)

Subtraction from science images (removal of stars and galaxies)

Median sky image created

TDM generated in XML format (KVN option available)

Images ordered and stored

To feed in Shorter term:

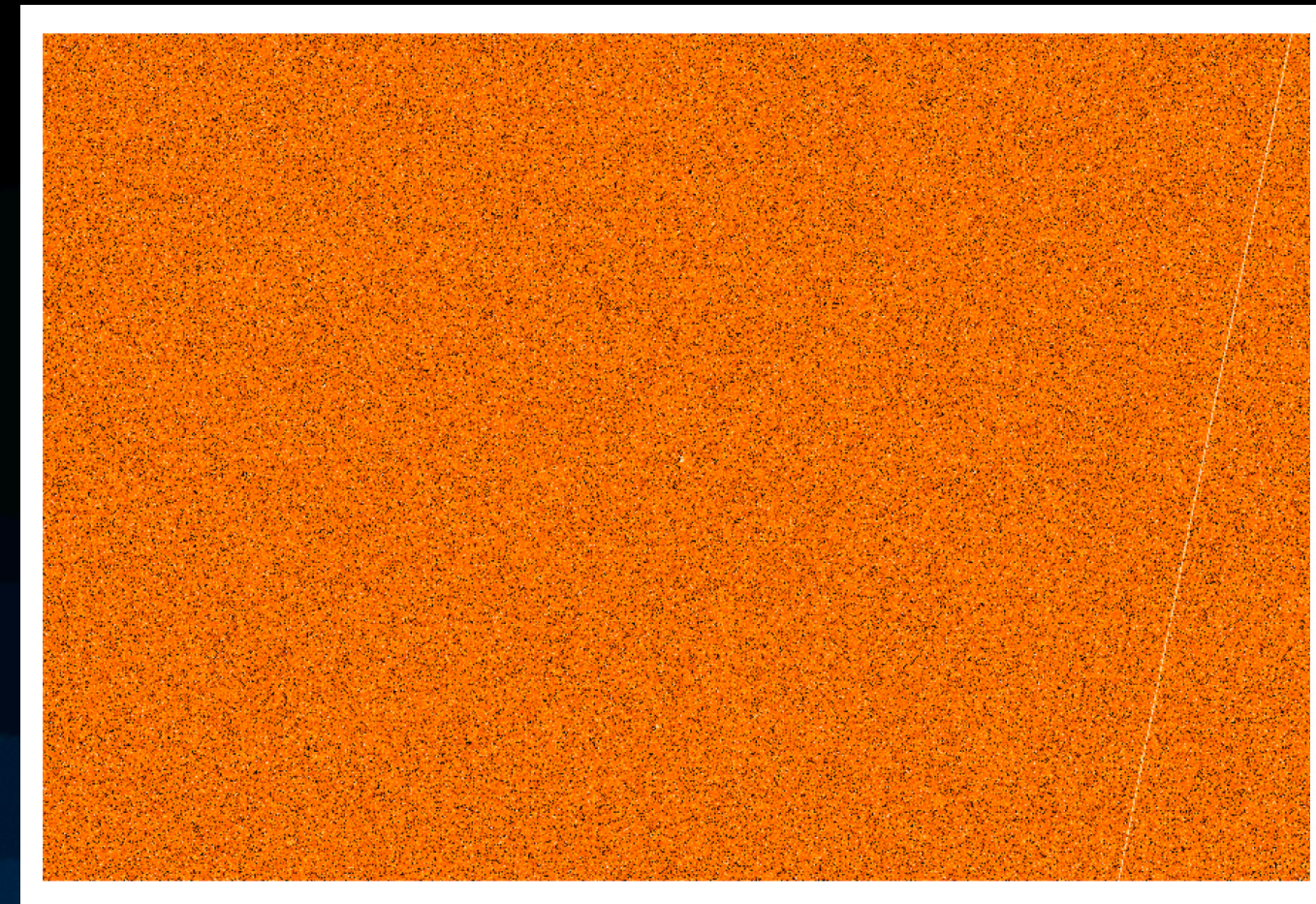
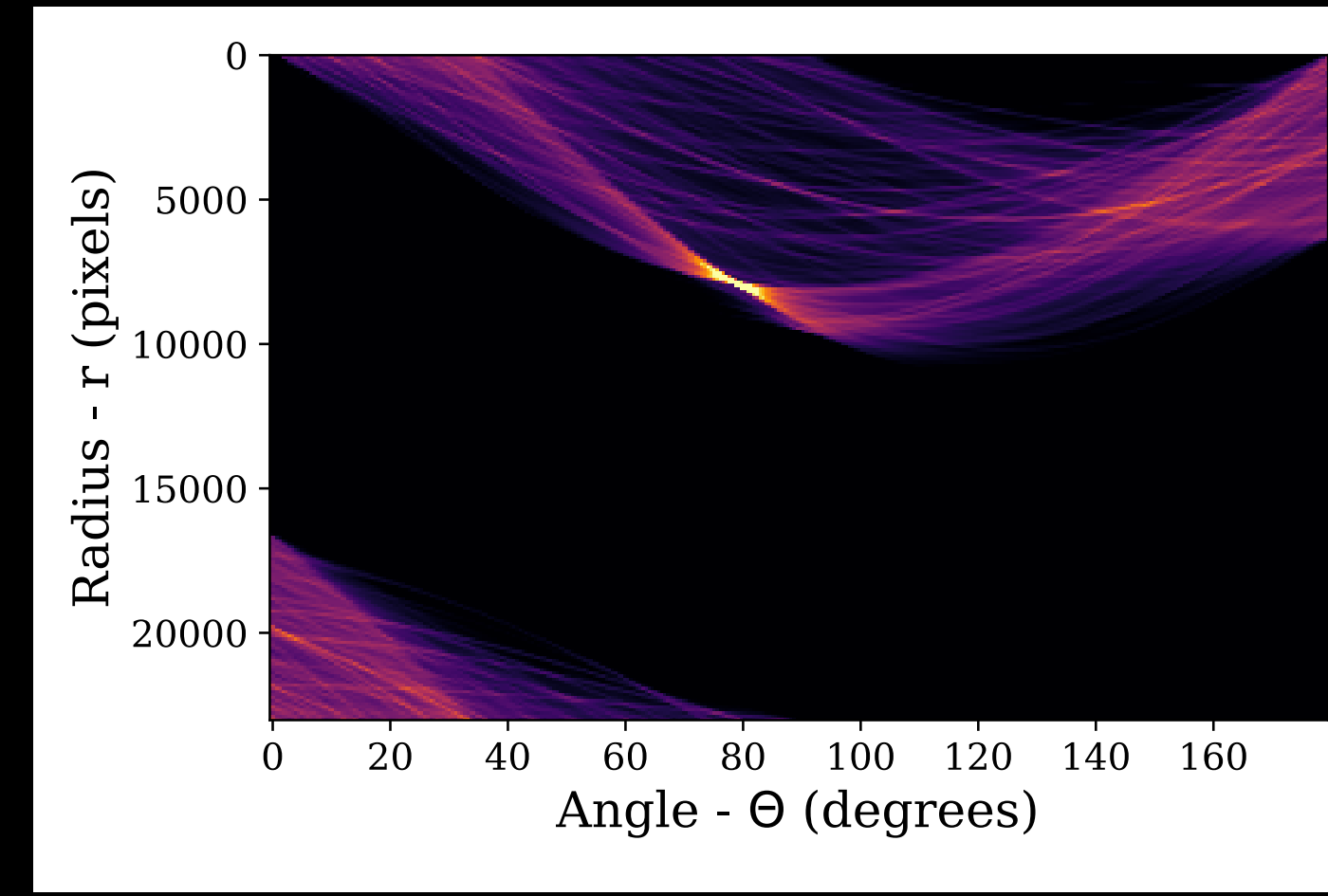
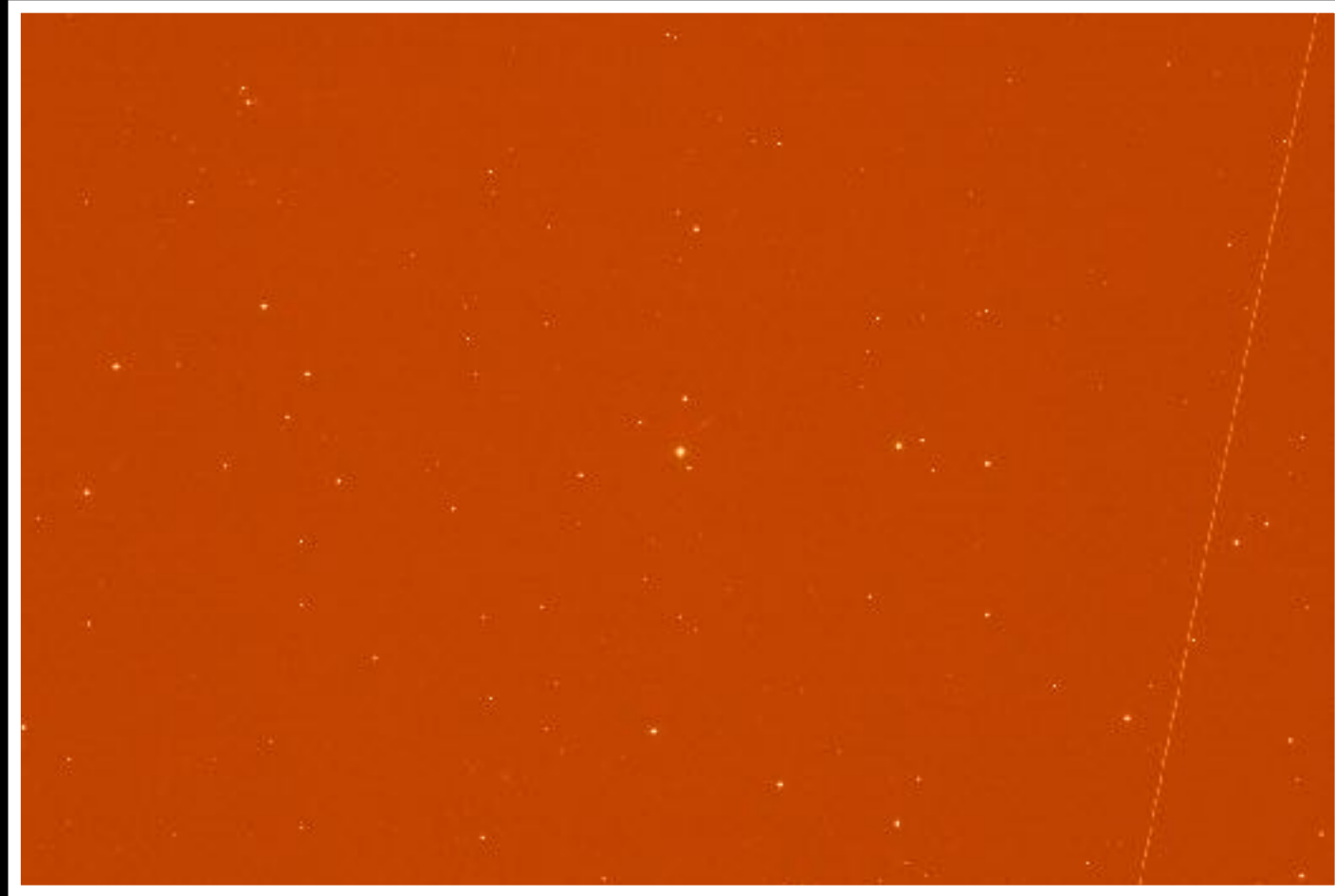
- Extraction of photometry

Longer term:

- Optimisation of Hough transform
- Lower S/N cuts (fainter Satellites + Debris)

PSF calculated

Space Junk - Our system



```
<?xml:namespace?="http://www.w3.org/2001/XMLSchema-instance" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns="http://www.starcluster.org/schemas/2.0" version="2.0">
<header>
<meta>
</meta>
</header>
<body>
<segment>
<meta>
</meta>
</segment>
</body>
</xml>
```



Space Junk - Our system

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

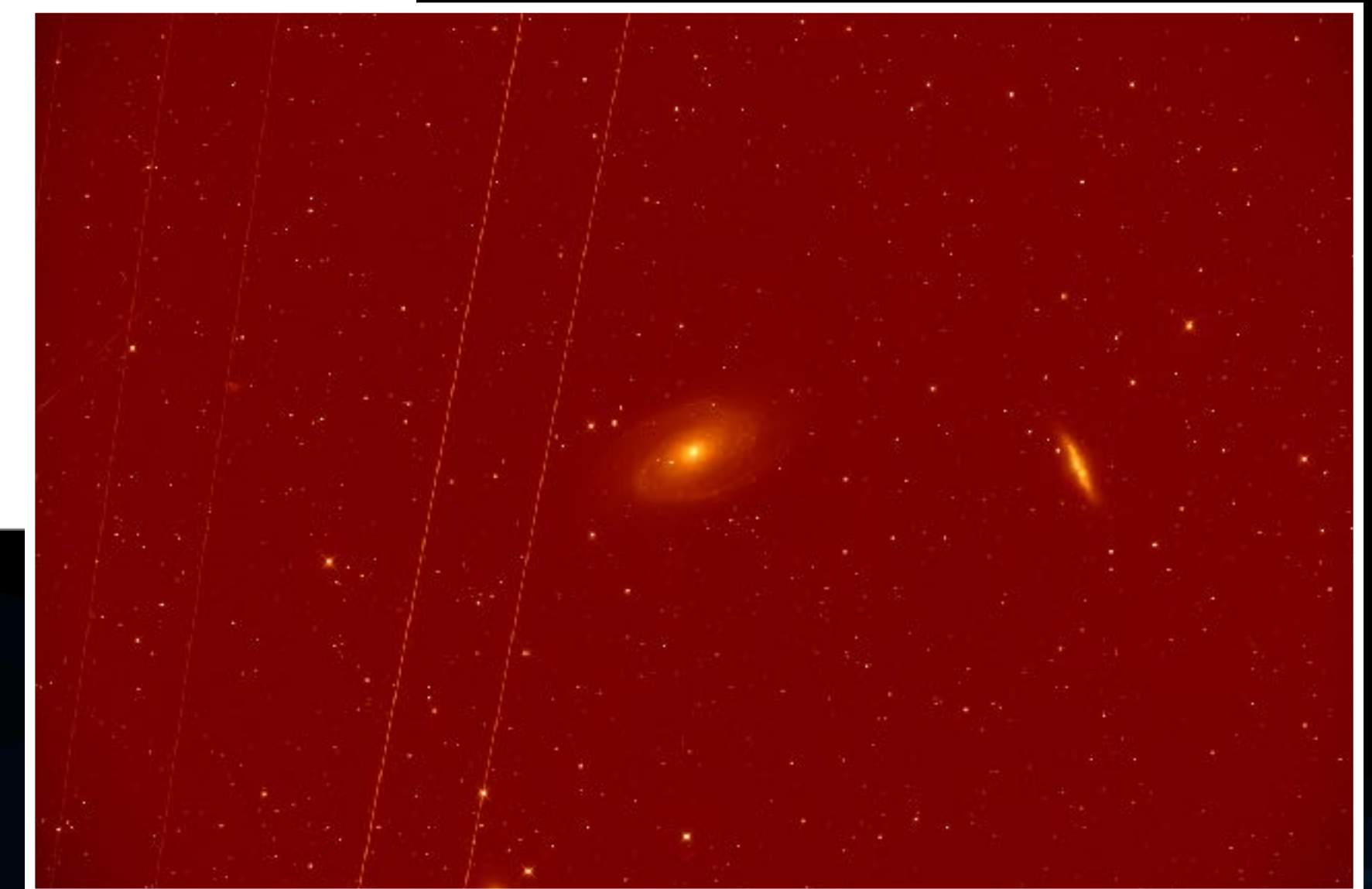


Space Junk - Our system

Data products

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

```
<?xml version='1.0' encoding='UTF-8'>
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satregistry.org/r/nomxml/qualified/ndmxml-2.0.0-master-2.0.250" id="CCSDS_TDM_VER5" version="2.0">
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  </headers>
  <body>
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        <STOP_TIME>2022-01-04T20:19:42</STOP_TIME>
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        <PARTICIPANT_2>UNKNOWN</PARTICIPANT_2>
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        <observation>
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          <EPOCH>2022-01-04 20:19:02</EPOCH>
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          <ANGLE_2>-22.865385611419183</ANGLE_2>
        </observation>
      </data>
    </segment>
  </body>
</tdm>
```



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



Tuparev AstroTech: Part 2 - Software



Software: A modern astronomy toolkit - motivations

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

Where can I store my data?

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

Can I easily connect all steps of the astronomy process?

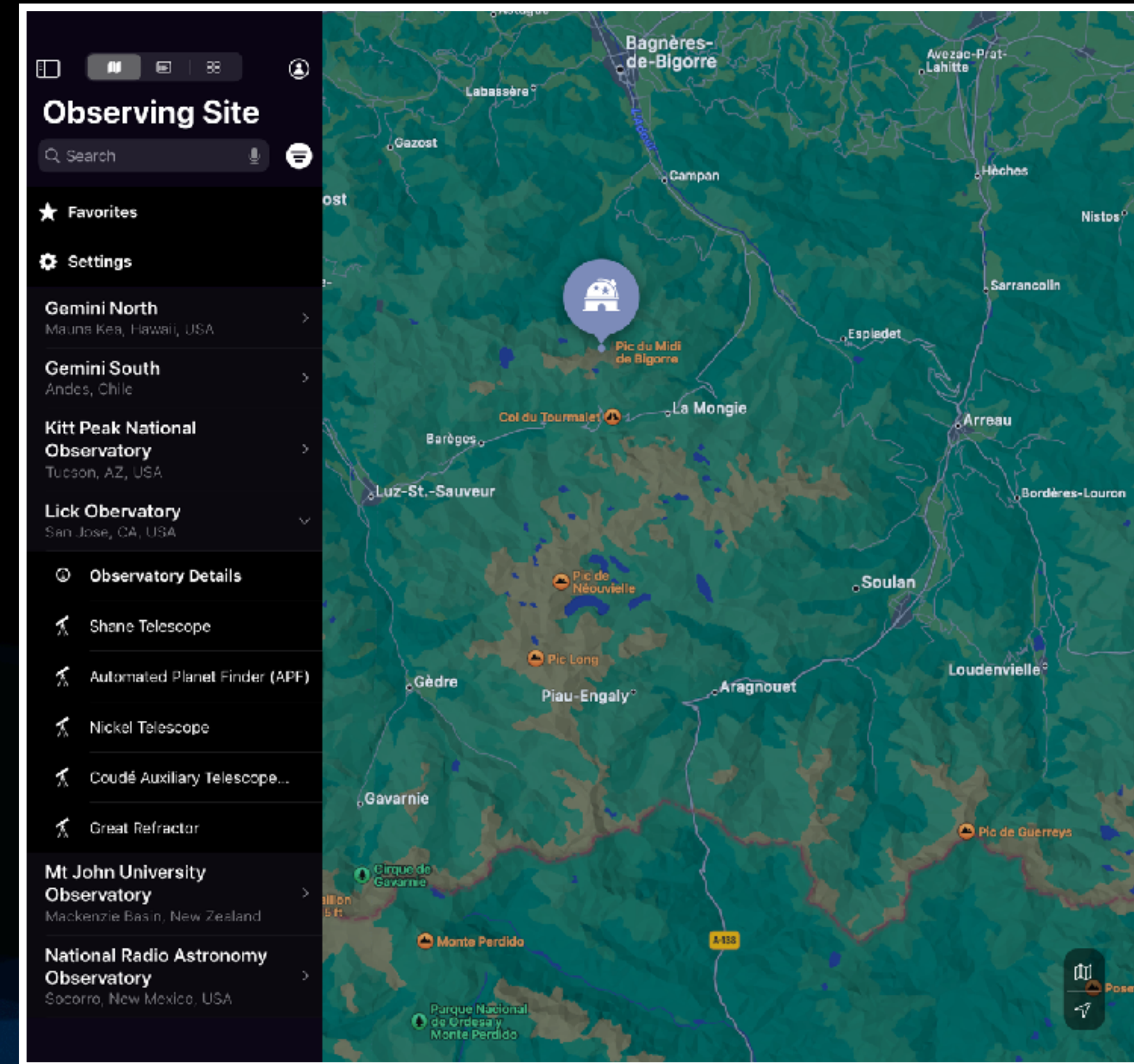
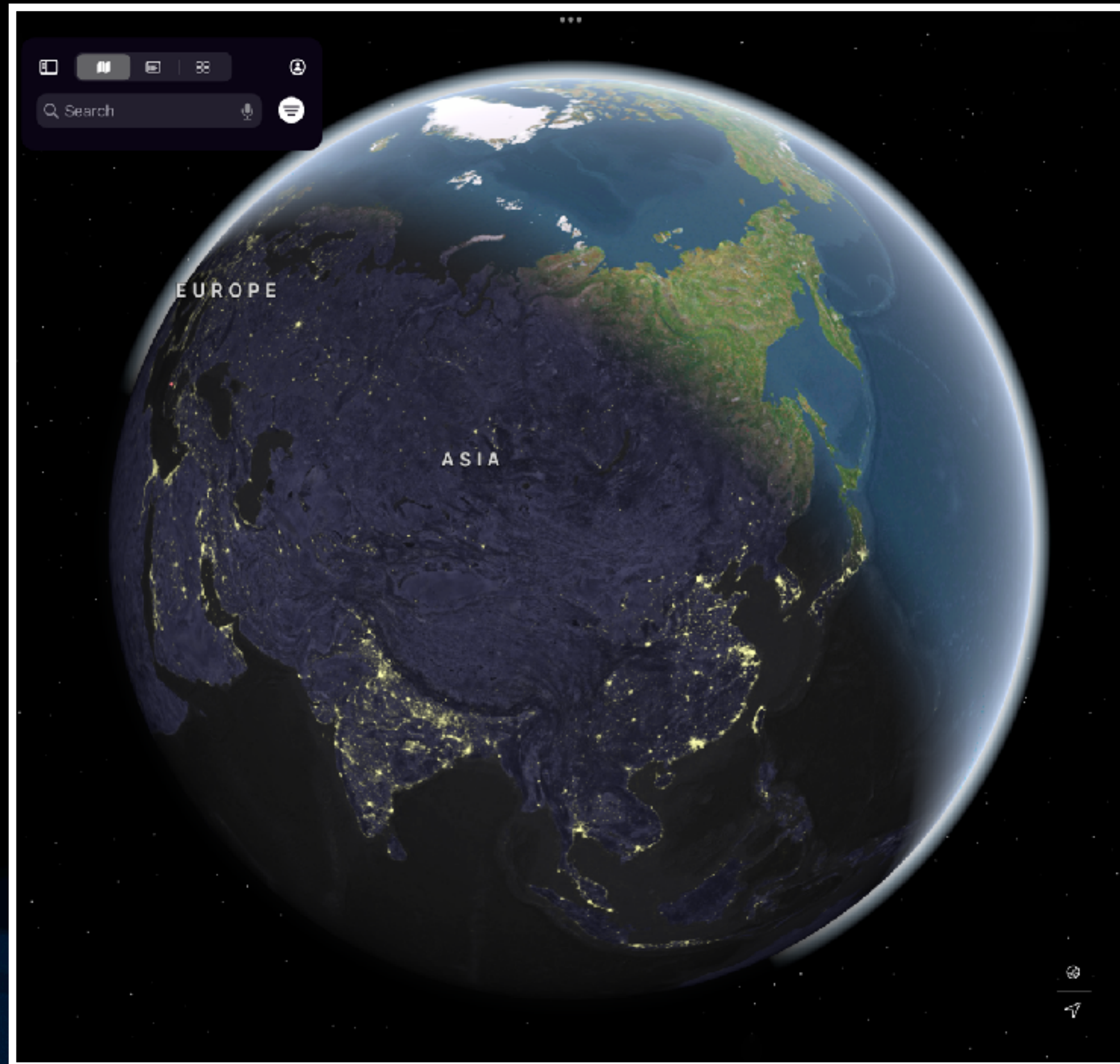
Are there tools I can use across a number of platforms?

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

Why are IRAF and MIDAS so outdated?



Software: A modern astronomy toolkit - The Telescope Observer App



Software: A modern astronomy toolkit - The Telescope Observer App

Lick Observatory

Observing Site

Search

Favorites

Settings

Gemini North
Kitt Peak National Observatory
Lick Observatory
Mt. John University Observatory

Shane Telescope
Automated Planet Finder
Nickel Telescope
Coudé Auxiliary Telescope...
Great Refractor

Location:

Continent	North America
Country	USA
City	San Jose
Coordinates	37°20'28"N 121°38'35"W
Altitude	4,200 ft (1,300 m)

Description:

Lick Observatory is owned and operated by the University of California. It is a major site in the University of California Observatories (UCO), which is responsible for its operations.

Lick began operations in 1888 as part of the University of California. It was founded by a bequest from James Lick, real-estate entrepreneur and California's wealthiest citizen. Lick's gift of \$700,000 was the largest philanthropic gift in the history of science and would amount to \$1.2 billion by today's standards.

Contact:

Automated Planet Finder (APF)

Observing Site

Search

Favorites

Settings

Gemini North
Mauna Kea, Hawaii, USA
Gemini South
Andes, Chile
Kitt Peak National Observatory
Tucson, AZ, USA
Lick Observatory
San Jose, CA, USA

Observatory Details

Shane Telescope
Automated Planet Finder (APF)
Nickel Telescope
Coudé Auxiliary Telescope...
Great Refractor

Location:

Continent	North America
Country	USA
City	San Jose
Coordinates	37°20'28"N 121°38'35"W
Altitude	4,200 ft (1,300 m)

Description:

The APF is the world's first robotic telescope capable of detecting rocky planets that might support life in other solar systems.

Extrasolar planetary research has been very successful at Lick Observatory, yet observing time on the Lick Observatory Shane 3-m telescope and Keck 10-m Telescopes for any one project is extremely limited. By operating robotically every on clear night, APF will greatly increase chances of detecting extrasolar planets. APF's more efficient system and higher resolution spectrometer will increase astronomers' ability to detect these planets.

Instruments:

2.4 Meter Automated Telescope	>
High-resolution spectrograph	>

Contact:

Phone: 831-459-2991
Fax: 831-459-6244
Email: director@ucolick.org (Director's Office)
Email: lobo@ucolick.org (Business Office)



Software: A modern astronomy toolkit - StarBrush

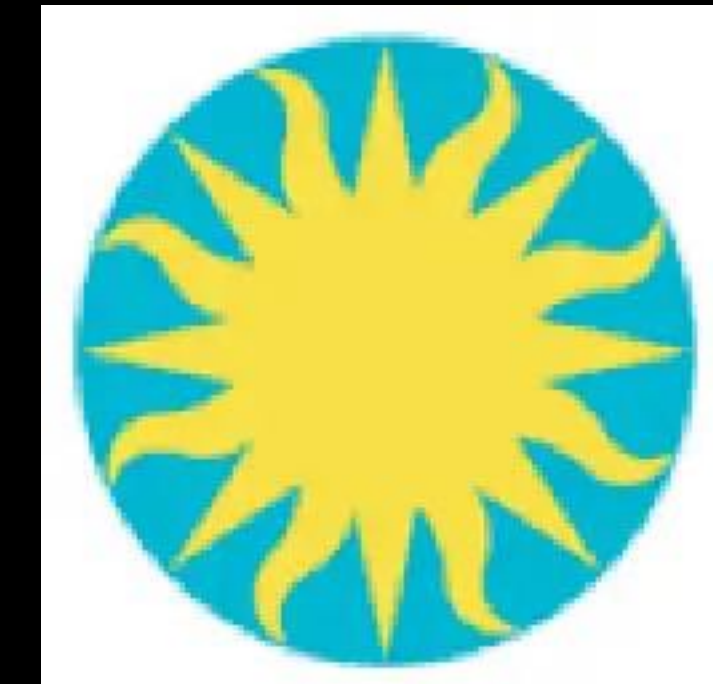
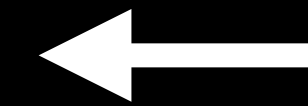
```
=====
IRAF v2.16 Installation
=====

Welcome to the IRAF installation script.  This script will first
prompt you for several needed path names.  Once the installation is
complete, you will be allowed to do some minimal system configuration.

For each prompt: hit <CR> to accept the default value, 'q' to quit,
or 'help' or '?' to print an explanation of the prompt.

=====
Query for System Settings
=====

# iraf root directory (/root/iraf-2.16.1-2018.11.01):
```



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



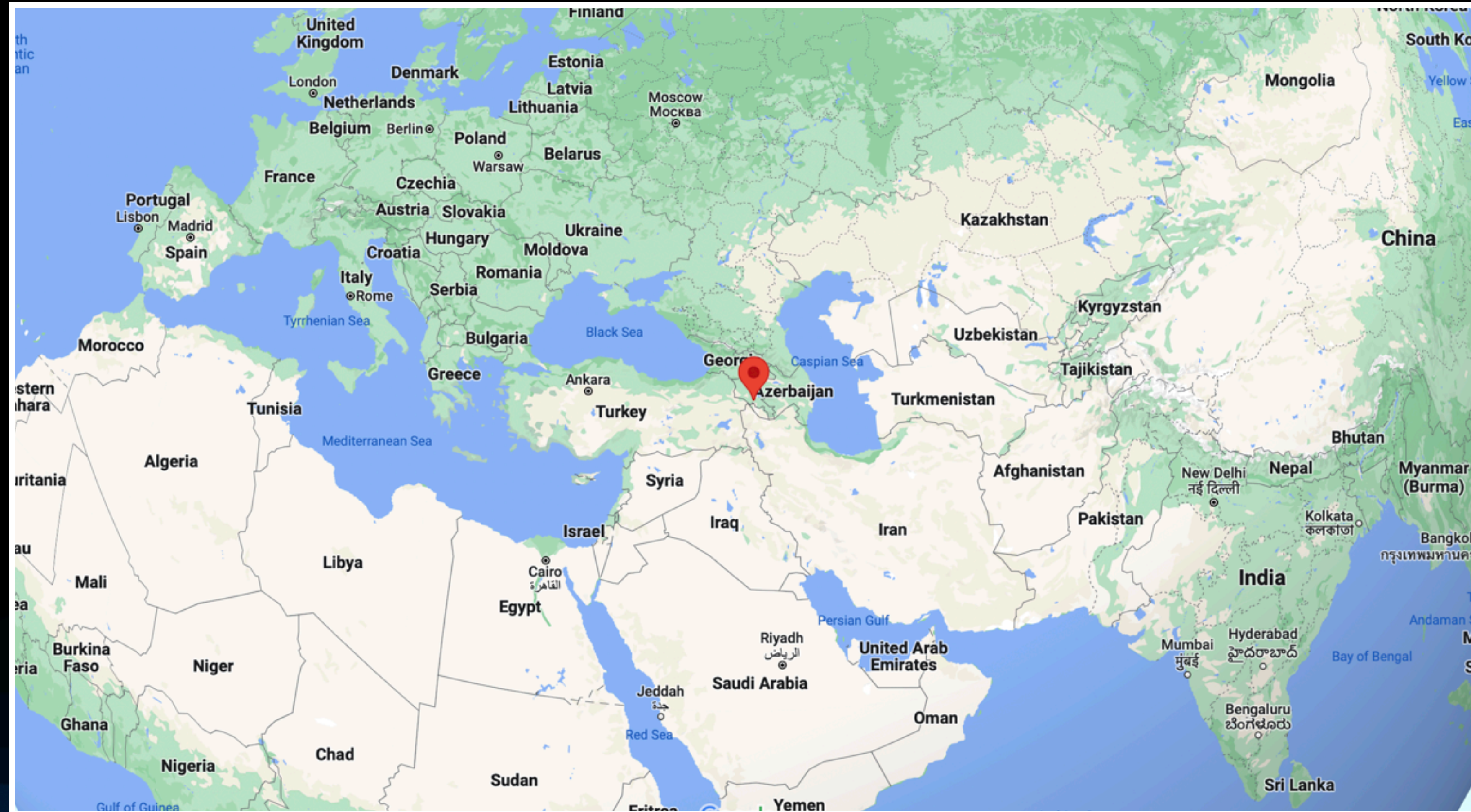
Tuparev AstroTech: Part 3 - (Robotic) Observatories



(Robotic) observatories - our role



(Robotic) observatories - location finding



(Robotic) observatories - location finding



© Andranik Keshishyan

Credit: Byurakan Astronomical Observatory/Andranik Keshishyan



(Robotic) observatories - location finding



(Robotic) observatories - other possible projects



Links

<https://www.tuparev.com>

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

<https://www.astrosysteme.com>

Thanks for listening! Any questions?

