



An Overview of the Astrophysics Cross Observatory Science Support (ACROSS) Pilot

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Agenda & Acknowledgements

- **Background**
- **Vision & Mission**
- **Capability Development Focus Areas**
- **Current Status**
- **Q&A**

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Background

- **In response to the U.S. National Academies of Science Astro2020 decadal report recommendation on Time-Domain and Multimessenger (TDAMM) Astrophysics, NASA’s Physics of the Cosmos (PhysCos) Program was tasked to:**
 - Conduct a study investigating ways to improve coordination within the NASA fleet, with U.S. ground-based observatories, and internationally.
 - Recommend implementation options for enabling TDAMM science.
- **The Astrophysics Cross-Observatory Science Support (ACROSS) pilot is an outcome of the PhysCOS TDAMM study**
 - Enables a “whole-of-fleet” approach to TDAMM by providing organizational, workforce, and technical infrastructure.
 - Involves NASA’s operating missions and those in development.
 - Enriches and supports the broader TDAMM ecosystem.

“NASA’s astrophysics cross-observatory science support (ACROSS) initiative: enabling time-domain and multimessenger astrophysics,” *Frontiers in Astronomy and Space Sciences*, vol. 11, Nov. 2024



Swift influence on ACROSS Concept

- **Swift has encountered issues being a small mission run by a skeleton crew:**
 - How to coordinate with other missions when:
 - Scheduling information is so heterogeneous?
 - Joint visibility is hard to calculate?
 - How to effectively communicate with stakeholders, and organize or be part of a large coordinated observing effort?
- **The mission will likely end soon(?).**
 - How do we preserve the lessons learned from Swift?
 - How do we implement those lessons using NASA missions of all levels, from cubesats to the largest missions.
 - Can we expand those lessons learned to support observatories outside of NASA?
- **The Swift TOO API has been wildly successful, and has allowed third parties to build Swift response into their systems (e.g. TOM Toolkit, SkyPortal).**
- **How can we generalize the tools developed for Swift and apply them to all NASA missions and beyond?**



Vision & Mission Statement



To provide NASA's fleet-wide coordination infrastructure and enrich the global TDAMM ecosystem.

We partner with missions, observers, and science teams across multiple astrophysics domains to maximize the scientific return of NASA's contributions to the evolving TDAMM ecosystem.





How will ACROSS achieve its mission?

- 1. Science Feasibility Tools**
- 2. Modern Target of Opportunity Resources**
- 3. TDAMM Web Portal**
- 4. Community Engagement and Innovation Program**

The ACROSS capability development focus areas enable NASA's "whole-of-fleet" approach to TDAMM within the context of the global TDAMM ecosystem

1. Science Feasibility Tools

Science Feasibility Tools	Capabilities
<p>Standardized Data Interfaces for Pointed and Wide-Field Instrument State/Status Information</p>	<ul style="list-style-type: none"> • Long and short-term observing plans • Target visibility & observability • Constraints on planning / scheduling feasibility • Mission target histories
<p>Value-added Applications for Wide-Field Instruments</p>	<ul style="list-style-type: none"> • Whether an event-of-interest was coincidentally detected. • When was a source last within the Field of View? • When will a source next be within the Field of View?
<p>Ground Observatories</p>	<ul style="list-style-type: none"> • Analogous capabilities as above and/or Interoperability with externally developed services

ACROSS Science Feasibility Tools will be available as open-source software on GitHub and deployed as web applications



2. Modern Target-of-Opportunity (ToO) Resources

ToO Resources	Capabilities
ToO Application Programming Interface (API)	<ul style="list-style-type: none">• A context-aware ToO submission API for all participating missions / observatories• Interoperability with externally developed services
ToO Web Application	<ul style="list-style-type: none">• Front-end web interface for users to interact with the ToO API.• ToO submission history by mission and user• Incorporates cross-observatory science feasibility tools and provides follow-up decision support within the context of the global/ecosystem state and status
ToO Toolkit	<ul style="list-style-type: none">• An open-source python software toolkit to assist in the programmatic planning and execution of ToO requests

ACROSS ToO Resources will be available as open-source software on GitHub and deployed as web applications



3. TDAMM Web Portal

Web Portal	Capabilities
Information Content	<ul style="list-style-type: none">• TDAMM relevant information about NASA missions, funding opportunities, conferences & workshops.• Links to mission and external tools & resources
Dynamic Content	<ul style="list-style-type: none">• Application Programming Interface and Front-end web interface for users to interact with the Science Feasibility Tools and ToO Resources
Help Desk	<ul style="list-style-type: none">• Access to subject-matter-experts to assist in coordinating “ACROSS” multiple observatories• Access to report bugs or make contributions to our open-source software (via GitHub)

The ACROSS TDAMM web portal will provide a single point of entry for TDAMM community support



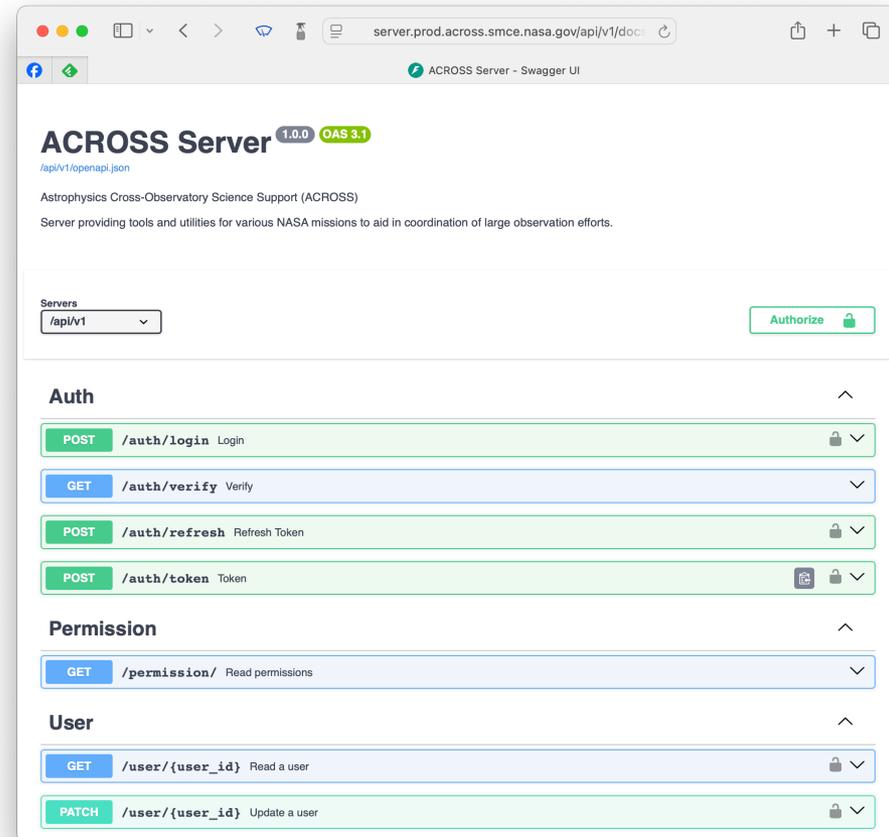
4. Community Engagement and Innovation Program

Community Support	Capabilities
TDAMM Workshops	<ul style="list-style-type: none">• Organize and support TDAMM workshops (ACROSS organized this meeting!)• Facilitate definition and explore implementation options for enabling community science cases• Tutorials and training on ACROSS tools
Funding Opportunities	<ul style="list-style-type: none">• Several concepts for incentivizing community engagement and innovation are under active development• All concepts are subject to funding availability
ACROSS participation in external / community-led initiatives	<ul style="list-style-type: none">• Access and engagement to obtain community feedback.• Access and engagement to ensure cross-organization process and technical interoperability and to coordinate capability development roadmaps

ACROSS is a community resource and will adapt to respond to community priorities!

Current Status - API

- ***ACROSS API v1.0 is now live!**
- API v1.0 has scheduling data from the following NASA missions:
 - IXPE
 - Fermi
 - TESS
 - NuSTAR
 - NICER*
 - Chandra
 - Swift
 - Hubble
 - JWST
- In addition we also ingest schedule data from ESA's XMM-Newton.



*Not active due to NICER being offline



ACROSS coming real soon

- We hope to open our GitHub as open source soon, waiting on final step of NASA approval (held up for obvious reasons).
- ACROSS Website (informational + tools).
- We have example **Jupyter Notebooks** that demonstrate the use of the ACROSS API for querying cross-mission scheduling information and visibility calculation.
- We expect to release Python modules for ACROSS API access on PyPI “soon” (dependent on Open Source approval).
- If you want a demonstration of the ACROSS API please ask me or seek out our fantastic ACROSS software developers at this meeting:
 - Kiril Vorobyev
 - Nitzan Frock

```
2.1. Observatories

In the ACROSS system, observational resources are captured as Observatory, Telescope, and Instrument objects. The hierarchy is in that order--an Observatory can have many Telescopes, which in turn can have many Instruments. Instruments can also have many Filters, which describe the wavelength ranges that Instrument can observe in a given exposure.

At the top level, an Observatory contains data such as a name, type (SPACE_BASED or GROUND_BASED), and a collection of telescopes. We can filter and search on any one of those parameters using the client's observatory.get_many method, which returns a list of Observatory objects that match the input parameters:

[2]: # GET an observatory by name
observatories = client.observatory.get_many(name="JWST")
observatory = observatories[0]
observatory.name

[2]: 'James Webb Space Telescope'

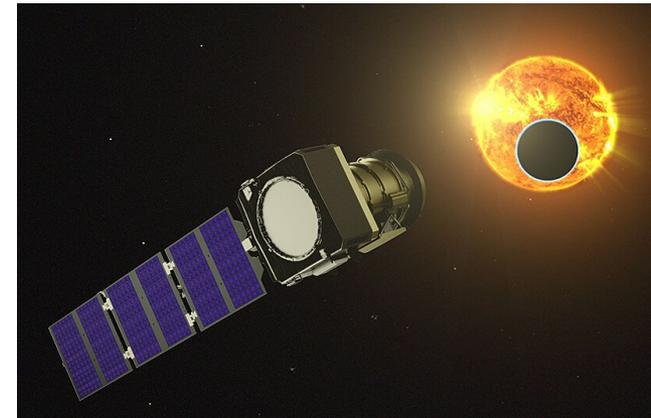
[3]: # GET a list of observatories by type
space_based_observatories = client.observatory.get_many(type="SPACE_BASED")
for obs in space_based_observatories:
    print(obs.name)

Imaging X-Ray Polarimetry Explorer
Fermi Gamma-ray Space Telescope
Transiting Exoplanet Survey Satellite
Nuclear Spectroscopic Telescope Array
Neutron Star Interior Composition Explorer
Chandra X-ray Observatory
Neil Gehrels Swift Observatory
Hubble Space Telescope
James Webb Space Telescope
X-ray Multi-Mirror Mission

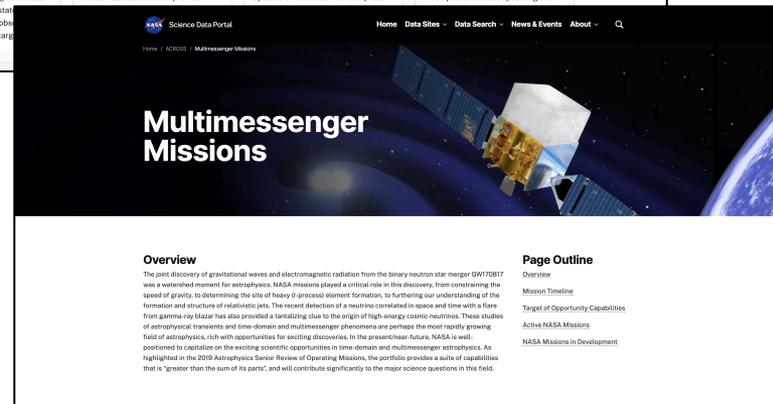
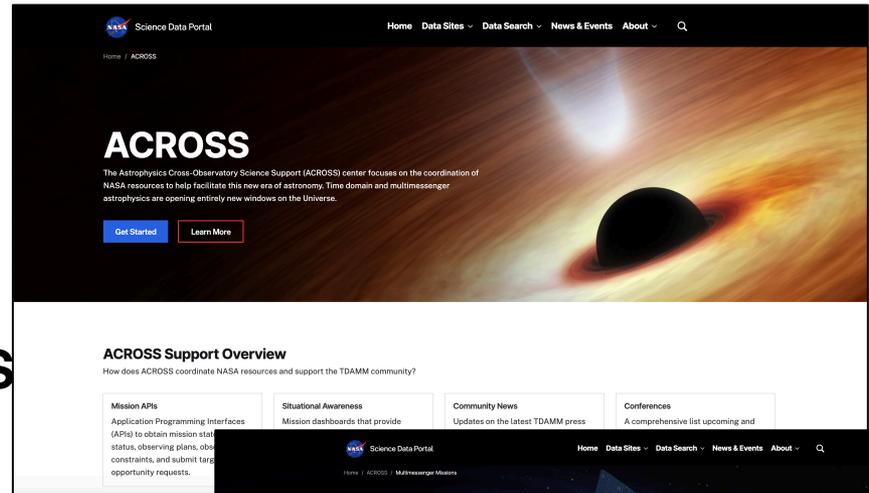
[4]: # GET an observatory by its telescope name
observatories = client.observatory.get_many(telescope_name="UVOT")
```

ACROSS Future Plans - API

- **Future plans for ACROSS include:**
 - Support for IVOA endpoints, specifically ObsLocTAP (schedule query) and ObjObsSAP (visibility query).
 - ACROSS database designed specifically to support IVOA protocols.
 - Prototype of this IVOA support developed for Swift (ObjObsSAP):
 - https://www.swift.psu.edu/vo/objobsdap/query?POS=266%2C-29&MIN_OBS=0
 - TOO Toolkit - Easily build a TOO website / API for your mission using our open source tools.
 - This is being prototyped for the Pandora mission, and a TOO system for Pandora will be the MVP for our TOO Toolkit.
 - More observatories supported! Ground Based (NOIRLAB), Space Based (ESA, JAXA etc).
 - More interoperability - e.g. discussions with SCIMMA HEROIC to share data between systems.



- **ACROSS is actively working to make cross-mission coordination of observations for rare events possible.**
- **Version 1.0 of the API is now released, please ask ACROSS Team Members for a demo!**
- **More is coming from ACROSS... once we get over the current hurdles!**



ACROSS Web Portal Structure & Page Layouts

We will be hosted as a Science Mission Directorate Interdisciplinary Site
science.data.nasa.gov/TBD