Annual RFO Research Report - 2025

Research Committee Executive Summary – 2025

The Research Committee achieved a major transformation of the RFO research program in 2025, advancing both scientific capability and educational impact. The committee successfully transitioned the RC20 telescope into a fully automated, research-grade instrument, expanded the range of science that can be conducted at RFO, and established a scalable model for collaborative, publishable research involving students, volunteers, and professional scientists.

The RC20 reached full production status for research imaging through the deployment of the NINA automation platform. End-to-end workflows were implemented, including automated sequencing, autofocus, plate solving, closed-loop slews, and post-sequence calibration. Custom software and standardized procedures now produce fully calibrated, research-ready data products that are automatically stored in imagelib.rfo.org. A formal operator checklist and training process were developed, enabling consistent, repeatable research operations by a growing pool of qualified observers.

Scientific capabilities at RFO expanded significantly during the year. The committee launched spectroscopy at RFO with successful first-light observations using a Star Analyzer spectroscope, opening new research avenues beyond photometry. Speckle interferometry was established as a viable technique on the RC20, resolving close double stars previously unobservable with traditional imaging. Photometric transformation coefficients were derived for the RC20, enabling high-quality, standardized BVRI photometry suitable for submission to the AAVSO and for publication.

The Research Committee oversaw multiple active scientific programs with meaningful outputs. These included long-term monitoring of variable stars, detailed studies of eclipsing and contact binaries, RV Tauri variables, supernova photometry, and exoplanet transit observations. Notably, the year-long monitoring of the R Coronae Borealis star Z UMi captured a full decline and recovery event and the beginning of an unexpected second decline and analyzed the observations with a novel V-I color index.

Equally important was the committee's success in integrating student research and education into its scientific mission. High school and college students participated directly in data acquisition, analysis, and paper writing. Several student-led projects progressed to submission or publication in peer-reviewed journals such as JAAVSO and the Journal of Double Star Observers. These efforts demonstrated a repeatable pathway from telescope operation to scientific publication.

Inspired by best practices shared at the Society for Astronomical Sciences conference, the committee formalized a team-based research model built around small groups, defined projects,

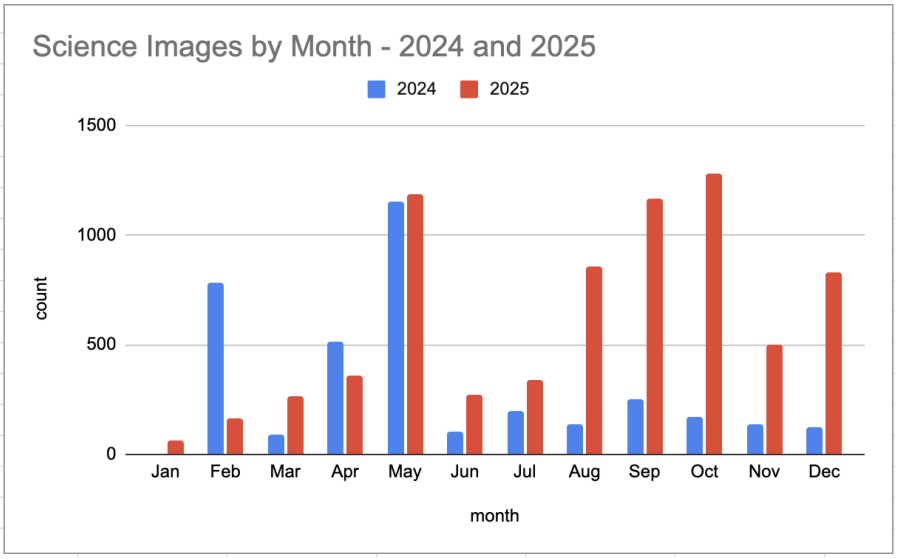
mentoring, and dedicated writing time. This structure supports participants at varying experience levels and ensures steady progress from observations to results.

By the end of 2025, the Research Committee had established RFO as a productive center for citizen science and student research, with professional-grade instrumentation, reliable workflows, active scientific programs, and a growing research community. The groundwork is now in place for sustained scientific output, expanded collaboration, and increased visibility through publications and conference presentations.

Research Committee Accomplishments – 2025

1. RC20 Telescope: Transition to a Fully Automated Research Instrument

- Successfully **brought NINA into full production use** on the RC20, replacing manual and semi-manual workflows.
- Achieved **end-to-end automation** including target selection, sequencing, autofocus, plate solving, closed-loop slews, and post-sequence calibration.
- Established **research-ready data ingestion** into imagelib.rfo.org with calibrated products clearly identified.
- Created, tested, and refined a **formal NINA Research Checklist and troubleshooting guide**, now used for operator training.
- Conducted multiple **hardware upgrades and maintenance efforts**, including:
    - Improved guiding via new guide scope and camera
    - Significant backlash reduction through mechanical adjustments
    - Improved polar alignment and slewing accuracy
- Demonstrated new capabilities including **tracking moving targets** (e.g., Comet C/2025 R2 and others) and high-volume image acquisition for speckle interferometry.
- Increased observations over 2024:



Total observing nights in 2024 were 78 versus 103 in 2025. Total science images taken

in 2024 were 5,686 versus 9,294 in 2025. The top 10 objects in the science image count, excluding the thousands of images taken for speckle interferometry, were:

V2552 Cyg	1285
RW Com	1086
NS Dra	531
ASAS-J1946	372
V1226 Her	356
ASASSN-J0124	325
TT Oph	319
NP Cam	314
EP Lyr	310

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2. Expansion of Scientific Capability at RFO

- **Launched spectroscopy at RFO** with the successful installation and first-light results from a Star Analyzer slitless spectroscope.
- Demonstrated initial stellar spectra and began characterization of instrument performance.
- Established **speckle interferometry capability**:
    - Acquired and processed 1,000-image speckle data sets
    - Successfully resolved double stars and measured separations consistent with catalog values
- Implemented **photometric transformation coefficients** for the RC20:
    - Processed multi-night Landolt field observations
    - Generated and applied BVRI transformation coefficients
    - Enabled RC20 photometry to be directly comparable with standard AAVSO data

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3. Significant Research Outputs and Ongoing Scientific Programs

- Produced extensive **variable star photometry**, including:
    - Multi-session light curves of eclipsing contact binaries (RW Com, NS Dra, V2552 Cyg)
    - Modeling of eclipsing contact binary systems using PHOEBE
    - Long-term monitoring of RV Tauri candidates (NP Cam, V1226 Her, AC Her)

- Completed a **year-long observational campaign of Z UMi (**R Coronae Borealis variable star**)**:
    - Tracked a full decline and recovery of nearly 7 magnitudes
    - Identified non-synchronous behavior between brightness and V-I color index
    - Results are considered potentially publishable
    - Observed the start of a new decline sooner than expected
- Initiated and sustained **exoplanet transit research** using TESS targets, AstroImageJ analysis, and modeled results consistent with published parameters.
- Conducted **supernova photometry** (NGC 7331), contributing measurements during the decline phase.

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4. Formalization of a Scalable Research Model

- Adopted a **team-based research structure** inspired by best practices learned at the SAS Conference:
    - Small teams (3–4 people)
    - Assigned mentors
    - Projects with defined goals and writing time
- Established active research teams in:
    - Eclipsing/contact binary stars
    - Exoplanet transits
    - Double star astrometry
    - Speckle interferometry
    - Photometric transformation coefficients
    - Spectroscopy
- Lowered barriers to participation by pairing **novice and experienced researchers** and offering structured training.

5. Strong Student Engagement and Educational Impact

- Supported multiple **student-led research projects**, several reaching publication or late draft stages:
    - Double star astrometry papers (Journal of Double Star Observers)
    - Variable star papers prepared for JAAVSO
- Integrated research directly into **high school and college programs**, including:
    - Buckingham Charter School (multiple cohorts, repeat visits)
    - RR Lyrae and double star classes led by Freed
- Enabled students to:
    - Acquire data on professional-grade instrumentation
    - Analyze and model data
    - Submit observations to AAVSO
- Created pathways for students to **return annually** and build on prior work.

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6. Growth of the Research Community

- Added numerous **new members** in 2025, including:
    - High school and college students
    - Professional scientists and engineers
    - Experienced amateur astronomers
- Expanded the committee's expertise across photometry, spectroscopy, data analysis, and instrumentation.
- Built momentum for **long-term, sustainable research activity** at RFO.

Overall Impact

In 2025, the Research Committee transformed the RC20 from a capable telescope into a **robust, automated research platform**, significantly expanded RFO's scientific capabilities, produced meaningful research results, and established a sustainable, mentor-driven model that integrates education, citizen science, and publishable astronomy.