The Future of ARCSAT

Report prepared for the ARC Board and APO Directors
by the Future of ARCSAT Working Group (FAWG)
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Future of ARCSAT Working Group[1]

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[1] *The Future of ARCSAT Working Group (FAWG) was convened by the APO Director to assess current and potential future uses of ARCSAT, evaluate the current facility's ability to meet community needs, and identify possible paths forward. The eight members of FAWG developed and administered the community survey, analyzed the results, evaluated telescope and operational options, and prepared the recommendations summarized in this report.*

Document Roadmap

This report is organized so that readers can either review the full analysis or begin with the Executive Summary for a concise overview of FAWG's findings and recommendation.

Executive Summary	Primary findings, telescope options considered, FAWG recommendation, and additional recommendations that apply under any telescope option.
Full Report and Supporting Analysis	Survey evidence, technical assessment, option comparison, and rationale supporting the recommendation.
Appendix A	Survey detail and supporting figures for readers who want to trace the conclusions back to the survey results.
Appendix B	Technical background, cost details, and implementation considerations for the telescope and instrumentation options.

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Executive Summary

The 0.5-meter Astrophysical Research Consortium Small Aperture Telescope (ARCSAT) is a valued facility at Apache Point Observatory (APO), but it is not fully utilized. To understand current use, future community needs, and possible paths forward, FAWG was charged with:

1. Identifying use cases for a 0.5-meter telescope that are of interest to ARC members;
2. Assessing ARCSAT's current 0.5-meter capabilities and how well they meet user needs; and
3. Exploring a range of options for the future of ARCSAT.

To guide its assessment, FAWG surveyed ARC members about current ARCSAT use and desired capabilities for a 0.5-meter-class telescope at APO. FAWG received 61 responses from nine ARC member institutions, including current users, past users, and individuals who had never used ARCSAT.

Overall, respondents expressed strong interest in remote access to a small-aperture telescope at APO to support research, training, and educational activities. At the same time, roughly half of respondents indicated that the current ARCSAT facility is not sufficient to meet their future scientific and educational goals. This was a notable finding, given the broad interest in retaining access to a 0.5-meter-class telescope at APO.

Survey responses indicate that the main barriers to ARCSAT use are practical and operational rather than a lack of interest. Respondents identified recurring concerns with telescope performance, camera reliability, ACP/software behavior, pointing, focus, and image quality. Several comments emphasized that the current observing process requires substantial hands-on attention, including real-time monitoring and occasional troubleshooting or system restarts.

If ARC wishes to retain 0.5-meter-class telescope capabilities at APO, FAWG identified three possible paths forward. These options differ in cost, APO staff effort required, and the degree to which they address current operational limitations.

Option 1: Sustain current ARCSAT operations until a critical failure. This option would make the minimum updates needed to keep ARCSAT operating in the near term, including replacing the ARCSAT user computer, updating to a Windows 11-capable system to mitigate cybersecurity risk, and replacing the unsupported ACP user-interface software. This is the lowest-cost active option, but it does not address the existing reliability problems with the telescope, instrumentation, and software environment. It also leaves the legacy telescope/drive hardware and declining DFM manufacturer support unchanged, keeping ARCSAT at high risk of further disruptions or shutdown following a critical hardware failure.

Option 2: Upgrade and maintain the current DFM telescope system. This option would keep the existing telescope system but upgrade the DFM control system from WinTCS to TCSGalil and perform necessary maintenance. It would also include the new user computer and updated interface described in Option 1. This path would improve the current system and address some near-term operational issues, but it requires a substantial investment while leaving the facility dependent on legacy hardware, limited replacement parts, and uncertain long-term support.

Option 3: Replace ARCSAT with a PlaneWave telescope system. This option would replace the legacy DFM telescope with a modern PlaneWave system. ARC could use the donated NIST 20-inch PlaneWave optical tube assembly, if available under acceptable terms, with a new mount and controllers, or purchase a new PlaneWave telescope system. This option has greater installation complexity and some final-cost uncertainty, but it would provide the most substantial modernization of ARC's 0.5-meter-class capability at APO and reduce reliance on legacy DFM hardware.

Summary of Options

Path	Approx. cost	Primary benefit	Primary risk / limitation
Option 1: Sustain current operations	~$2,500 plus APO labor	Preserves near-term access and addresses immediate user-computer/security risk	Does not address reliability or legacy hardware risks
Option 2: Upgrade current DFM system	~$122,000-$145,000 plus APO labor	Improves current control system and performs maintenance	Substantial investment while still depending on aging DFM hardware and limited support
Option 3: Replace with PlaneWave system	~$60,000 donated-OTA path or ~$90,000-$180,000 new system, plus site prep	Most supportable modernization; reduces legacy hardware risk	Installation complexity and final-cost uncertainty

FAWG Recommendation

Based on the survey results and the current condition and supportability of the ARCSAT system, FAWG recommends Option 3. Replacement with a PlaneWave system best addresses the community's priorities for reliability, usability, and performance while reducing long-term risk from legacy hardware. The preferred implementation is to use the donated NIST optical tube assembly if feasible; if not, FAWG recommends purchasing a new PlaneWave system sized to fit the existing dome and pier constraints.

Additional recommendations needed under any telescope option

Regardless of which telescope option ARC selects, successful operation of a 0.5-meter-class facility will require additional planning and resources. These recommendations need not be implemented all at once, but they should be incorporated into the planning and budget process after a telescope decision is made.

User software/interface: Replace ACP with a supported, user-friendly interface. Some respondents expressed interest in an ARCSAT-tailored TUI-style interface, modeled on the 3.5-meter telescope interface, but this would likely require several months of software development. A commercial or otherwise supported interface may provide a faster near-term path.

Cameras/instrumentation: Plan for replacement or modernization of current instrumentation, beginning with the cameras, which are approaching end-of-life. Camera selection should be coordinated with the final telescope configuration so that field of view, plate scale, guiding capability, and detector performance match user needs.

Operations and support: Include dedicated staff support for the 0.5-meter facility in the APO budget. Users expressed appreciation for current APO staff support, but ARCSAT does not currently have dedicated support staff, and troubleshooting, camera/filter changes, system reboots, and dome visits draw staff away from other responsibilities.

Longer-term scheduling and observing modes: After the core telescope, camera, control system, and staffing model are stable, ARC could consider additional scheduling and observing modes, including queue-based observing, long-term monitoring, shorter scheduling blocks, or Target of Opportunity observations. Integration with a network such as SkyNet could be considered as one possible implementation path, particularly for beginner-friendly educational access, but because it would affect telescope access for ARC member institutions, it should require a separate future decision by the ARC community.

Full Report and Supporting Analysis

1. Introduction and FAWG Charge

The 0.5-meter Astrophysical Research Consortium Small Aperture Telescope (ARCSAT) is a valued facility at Apache Point Observatory (APO), but it is not currently used to its full potential. To better understand why some ARC members use ARCSAT while others do not, and to determine how 0.5-meter-class telescope capabilities at APO could better serve the community in the coming years, the APO Director convened the Future of ARCSAT Working Group (FAWG).

FAWG was asked to:

1. Identify scientific and educational use cases for a 0.5-meter-class telescope that are of interest to ARC members;
2. Assess ARCSAT's current 0.5-meter capabilities and how well they meet user needs; and
3. Explore a range of options for the future of ARCSAT.

To guide this work, FAWG developed and distributed a survey to ARC member institutions. The survey asked current users, past users, and non-users about current and past ARCSAT use, barriers to use, desired capabilities, interface preferences, and possible future uses of a 0.5-meter-class facility at APO.

2. Key Survey Findings

The survey was completed by 61 individuals from nine ARC member institutions: 21 current ARCSAT users, 15 past users, and 25 individuals who had never used ARCSAT. FAWG identified three key findings from the survey responses:

- The ARC community has strong interest in retaining access to a remotely accessible 0.5-meter-class telescope at APO.
- Respondents identified undergraduate research, student education and training, and coordinated observations with other facilities as important anticipated uses.
- Roughly half of respondents who answered the question indicated that the current ARCSAT system does not meet their future scientific and educational needs.

2.1 Community interest and anticipated uses

Survey respondents expressed broad interest in having access to a 0.5-meter-class telescope at APO, including among individuals who have not previously used ARCSAT. Only two respondents indicated that they had no potential use for such a facility. As shown in Figure 1, respondents were especially interested in using a 0.5-meter-class telescope for student research and training, independent research-data collection, and observations coordinated with larger or complementary facilities.

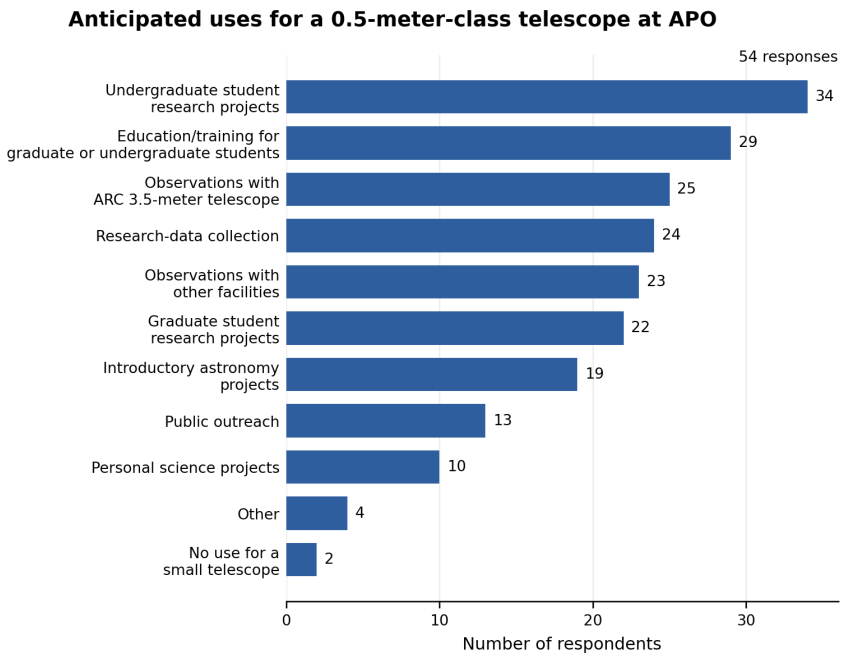


Figure 1. Anticipated uses for a 0.5-meter-class telescope at APO*. Respondents most frequently identified student research and training, research-data collection, and coordinated observations with the ARC 3.5-meter telescope or other facilities as potential uses.*

2.2 Current ARCSAT does not meet Future Needs

Although interest in a 0.5-meter-class telescope is strong, responses were nearly evenly split on whether the current ARCSAT facility would meet future scientific and educational goals. Among the 50 respondents who answered this question, 26 answered No and 24 answered Yes as shown in Figure 2. This is a central finding: the problem is not lack of community interest, but whether the current facility can support that interest in a reliable and usable way.

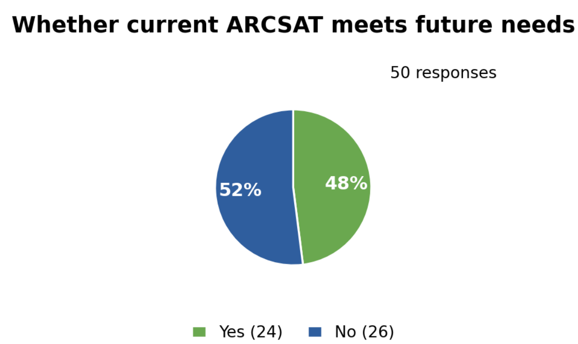


Figure 2. Whether current ARCSAT meets future needs. *Slightly more than half of respondents who answered this question indicated that the current ARCSAT telescope would not meet their future scientific and educational goals.*

2.3 Desired improvements

Respondents were asked what improvements would be needed for a 0.5-meter-class telescope at APO to better support their research and educational goals. Among the most important desired capabilities were improved hardware reliability, improved tracking and pointing, a beginner-friendly interface, and a reliable guide camera (Figure 3). These priorities closely match the barriers reported by current and past users and the facility-level risks identified in FAWG's technical assessment.

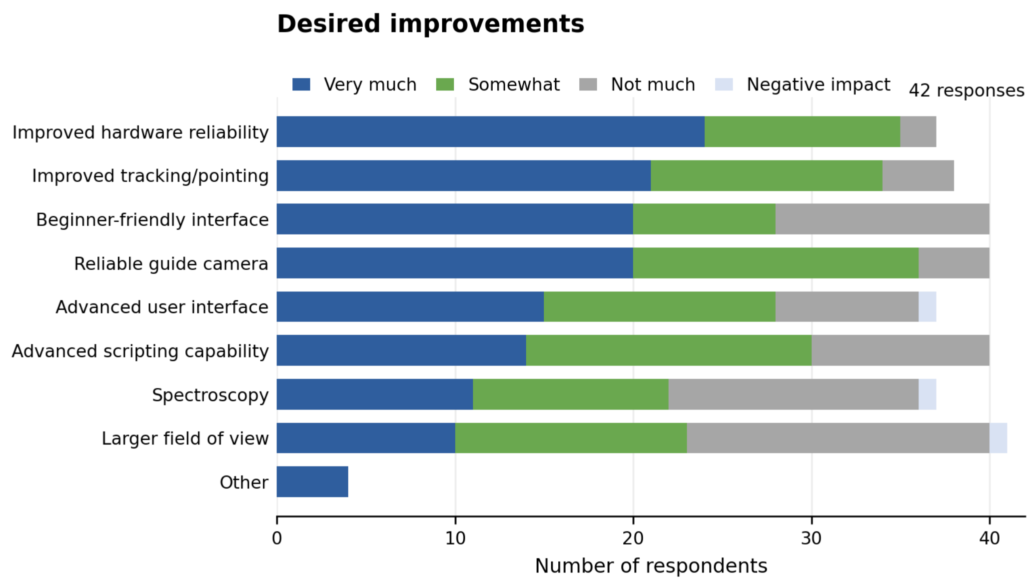


Figure 3. Desired improvements for a 0.5-meter-class telescope at APO. *Respondents identified hardware reliability, tracking/pointing performance, interface improvements, and guiding capability as important enhancements needed to better support future use.*

3. Current ARCSAT Operational Barriers and Technical Risks

Survey respondents identified operational barriers that limit their ability or willingness to use the current ARCSAT system. Most current users reported experiencing software or technical problems either quite often or occasionally, and software-related problems were ranked as the most common issue, followed by camera-related and telescope-related problems (Figure 4). Free-response comments also highlighted the observing burden imposed by the current system, including the need to stay up at night, work within limited scheduling flexibility, and cope with unreliable data quality and telescope performance. Together, these responses show that current users face recurring operational problems when trying to use ARCSAT.

APO staff identified facility-level risks that affect the telescope's long-term viability. They indicated that long-term reliability is a concern because the current telescope system depends on aging control computers, unsupported ACP software, and legacy DFM hardware that will become harder to maintain as replacement parts become scarcer. Together, these findings show that ARCSAT faces both operational barriers for users and supportability risks for the observatory.

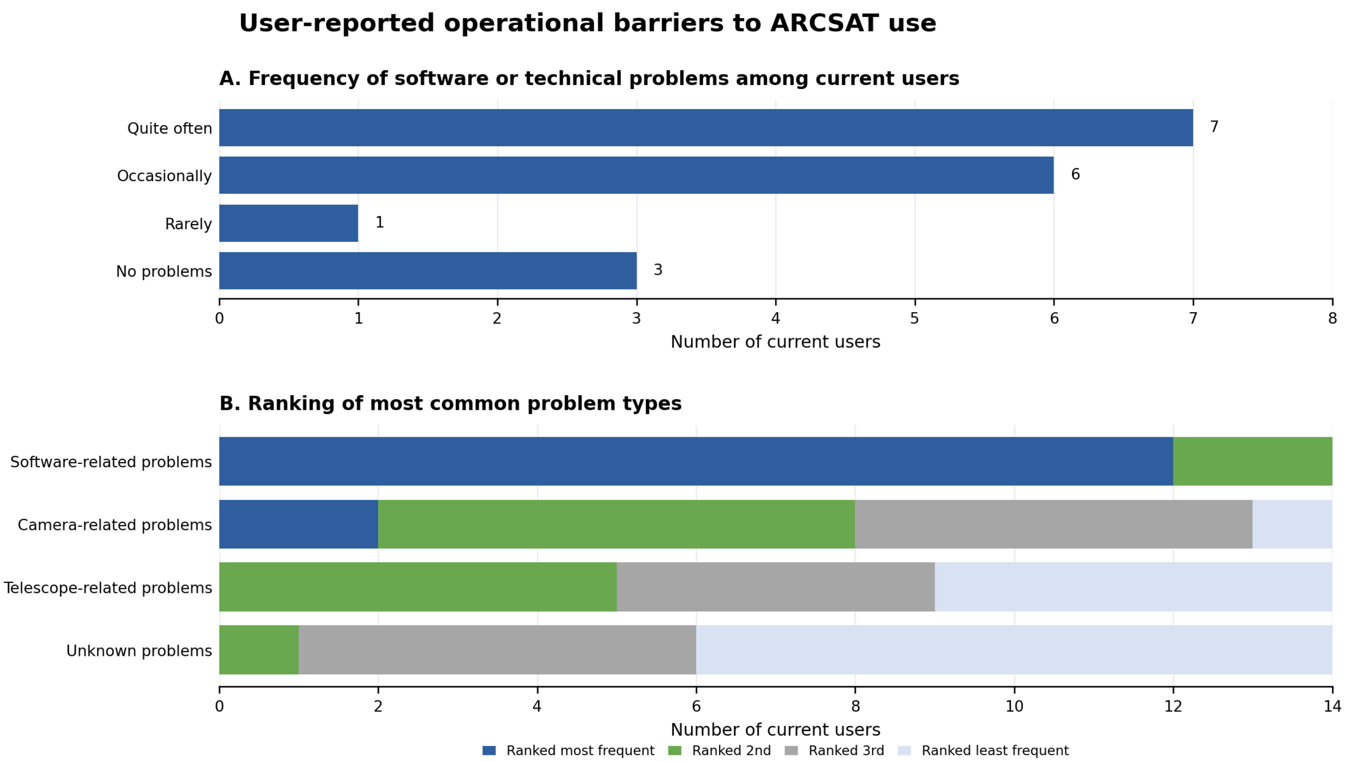


Figure 4. User-reported operational barriers to ARCSAT use. *Current users reported recurring software or technical problems, with software-related problems ranked as the most common issue, followed by camera-related and telescope-related problems.*

3.1 User-identified Barriers to use

Survey responses indicate that the main barriers to ARCSAT use are practical and operational rather than a lack of interest in 0.5-meter-class capability. Respondents identified recurring concerns with telescope performance, camera reliability, ACP/software behavior, pointing, focus, and image quality. Several comments emphasized that the current observing process requires substantial hands-on attention, including real-time monitoring and occasional troubleshooting or system restarts.

These barriers affect whether users are willing to build observing programs around ARCSAT. Past users pointed to the need for more flexible scheduling, guiding capability, and more automated or queue-based observing modes. Several respondents also indicated that the effort required to observe with ARCSAT is difficult to justify when comparable small-telescope facilities provide more automated access or more consistent data quality.

3.2 Technical and Operational Risks

In addition to the user-reported barriers above, APO staff identified several facility-level risks that affect the long-term viability of ARCSAT:

- **Limited support for the DFM telescope and control system:** Critical electronics are no longer manufactured, spares are limited, and long-term software support is uncertain.
- **Control-computer security and maintainability:** The control environment depends on legacy Windows systems that cannot be fully modernized without changes to hardware and architecture.

- **ACP remote-observing software:** The current ACP interface is legacy software and is being sunset, creating a near-term risk to continued remote operations.
- **Cameras/instrumentation:** The current camera suite is aging, increasingly difficult to repair, and exhibits multiple failure modes.
- **Staff support requirements:** ARCSAT does not have dedicated support staff, so troubleshooting and routine maintenance must be absorbed by APO staff whose time is already assigned to other responsibilities. This includes troubleshooting telescope failures, changing cameras or filters, rebooting system components, and going to the ARCSAT dome to resolve problems. When the 3.5-meter operator provides this support, it can pull them away from their primary responsibility of supervising 3.5-meter operations.

Taken together, these constraints increase the risk that ARCSAT could become unusable following a single critical failure. They also mean that simply preserving the existing system would not fully address the desire from survey respondents for a reliable and usable 0.5-meter-class facility.

4. Options for the Future of ARCSAT

The survey results and the operational and supportability challenges facing the current ARCSAT system indicate that, if ARC wants to maintain 0.5-meter telescope capability for its users, it must choose a path forward that addresses both user needs and long-term viability. That path could be no action, but doing nothing would likely leave ARCSAT operational only until a critical failure occurs.

FAWG therefore considered three active options for the future of ARCSAT, ranging from basic upgrades to continue operation of the current telescope system to full replacement with a modern telescope platform. These options differ in cost, APO effort required, the extent to which they address current operational limitations, and the long-term risk to ARC’s 0.5-meter-class telescope capability at APO.

Summary of active telescope options

Path	Approx. cost	Main benefit	Main limitation
Option 1: Sustain current operations	~$2,500 plus APO labor	Lowest-cost short-term mitigation; preserves near-term access	Does not fix reliability or legacy-hardware risk
Option 2: Upgrade current DFM system	~$122,000-$145,000 plus APO labor	Improves control system and maintenance	Still depends on aging DFM hardware and limited support
Option 3: Replace with PlaneWave system	~$60,000 donated-OTA path or ~$90,000-$180,000 new system, plus site prep	Most supportable modernization; reduces legacy-hardware risk	Installation complexity and final-cost uncertainty

4.1 Option 1: Sustain current ARCSAT operations until a critical failure

Estimated cost: approximately $2,500 in direct costs, plus APO labor.

This option would make only the minimum updates needed to keep ARCSAT operating in the near term. It would replace the ARCSAT user computer, update to a Windows 11-capable system to mitigate current cybersecurity risks, and replace the unsupported ACP user interface. APO estimates approximately 1–2 person-weeks of effort to configure the new PC and restore software packages and system configurations.

If ARC chooses to develop an in-house TUI-style interface, additional months of APO staff time would be required; alternatively, ARC could purchase and deploy a supported commercial interface.

This option would preserve near-term access to ARCSAT, but it would not address the underlying reliability problems with the telescope, instrumentation, or software environment. Intermittent failures, the need to reboot system components during operations, legacy telescope/drive hardware, and declining DFM support would remain unchanged. As a result, ARCSAT would remain at high risk of additional disruptions or shutdown following a critical hardware failure.

4.2 Option 2: Upgrade and maintain the current DFM telescope system

Estimated cost: approximately $122,000-$145,000, plus APO labor.

This option would keep the existing DFM telescope system but upgrade the control system and perform needed maintenance. It includes the new user computer and updated user interface described in Option 1, upgrades the DFM control system from WinTCS to TCSGalil, and includes the associated maintenance and validation work. The estimated effort includes two DFM engineers on site for approximately one week, plus 1–2 person-weeks of APO time to configure and validate software and system performance.

This option would improve the current ARCSAT system and address some near-term operational issues. However, it would still leave the facility dependent on aging DFM hardware, limited replacement parts, and uncertain long-term support. Although this path extends the life of the current system, it does not eliminate the risk of future critical hardware failure.

4.3 Option 3: Replace ARCSAT with a PlaneWave telescope system

Estimated cost: approximately $60,000 for the donated NIST optical tube assembly path, or approximately $90,000–$180,000 for a new system, plus installation and APO preparation.

This option would replace the legacy DFM telescope with a modern PlaneWave telescope system. ARC could either install a donated 20-inch PlaneWave optical tube assembly from NIST, if available under acceptable terms, or purchase a new PlaneWave telescope system. If ARC uses the donated NIST optical tube assembly, it would need to purchase a compatible mount, counterweights, and axis controllers, and pay for installation support. If ARC purchases a new system, the final cost would depend on aperture size, optical configuration, mount choice, installation, and site preparation.

APO preparation would include crane rental to remove the current telescope and an engineering assessment to determine whether pier modifications are needed to accommodate the new mount. This option would provide the most substantial modernization of ARC's 0.5-meter-class telescope capability at APO and would reduce reliance on legacy DFM hardware. Its main risks are installation complexity, possible pier or infrastructure modifications, and uncertainty in final cost.

5. FAWG Recommendation

Based on the expressed needs of the ARC user community and the current condition and supportability of the ARCSAT system, FAWG recommends Option 3: replacing ARCSAT with a modern PlaneWave telescope system. Although Option 3 may require greater initial investment and APO effort than Option 2, it offers a more durable long-term solution and best aligns with the community's needs for a reliable, usable 0.5-meter-class facility.

FAWG does not recommend Option 2, the major upgrade of the existing DFM telescope, as the long-term solution. Although this path would improve the current system, it is costly and would still leave ARC dependent on legacy mechanical components, limited parts availability, and an uncertain long-term support environment. By contrast, Option 3 provides a more durable and supportable solution for ARC's 0.5-meter-class telescope capability at APO.

The preferred implementation of Option 3 would be to use the donated NIST 20-inch PlaneWave f/7 RC optical tube assembly if it remains available and can be paired with an updated mount, controllers, and feasible APO site preparation. If the NIST optical tube assembly is not available, FAWG recommends purchasing and installing a new PlaneWave system sized to fit the existing dome and pier constraints.

6. Recommended Implementation

In addition to a new telescope, survey respondents and APO staff identified other changes needed for a 0.5-meter-class facility at APO to better serve the ARC community, including an improved user interface, updated cameras and instrumentation, dedicated staff support, and more flexible scheduling and observing modes such as queue-based observing and long-term monitoring. To address these needs, FAWG recommends a phased implementation that would spread costs over time and reduce near-term risk.

1. **Phase 1 - Telescope replacement:** Replace the telescope and mount as required, and address cybersecurity risk by installing a new Windows 11-capable ARCSAT user computer.
2. **Phase 2 - Camera/instrumentation:** Procure a modern, supportable camera system aligned with user preferences and the final telescope configuration.
3. **Phase 3 - Interface and observing modes:** Replace ACP on a defined timeline, then implement additional observing modes and/or network integration such as SkyNet, contingent on reliability and staffing.

6.1 Replacement of Current Cameras/Instrumentation

Camera replacement should remain part of the implementation plan, but it does not need to be immediate. The current ARCSAT camera suite is near end-of-life and would eventually limit the facility even after a telescope upgrade, but the new telescope could begin operating with the existing cameras while a replacement is planned. If a suitable camera is not obtained through donation or other external support, ARC should plan to include the cost of a replacement camera in a future budget.

A replacement camera is still needed because the current cameras are old, unreliable, and no longer fully supported. Survey comments show that users are reluctant to invest observing time when the resulting data are poor, and some past users said camera and telescope performance were a reason they no longer used ARCSAT. The survey also identified the key requirements for a replacement camera: better reliability, a reliable guide camera, improved tracking and pointing, a larger field of view, native plate scale, and faster readout times. Based on the camera options considered in the draft, a reasonable planning range is roughly $33,000 to $130,000 for a new camera before installation or integration costs.

6.2 Software Interface, Staff Support, and Observing Modes

In addition to the telescope and camera decisions, survey respondents identified several lower-cost changes that could be implemented on a separate timeline to improve ARCSAT's usability. These include a supported user interface, dedicated staff support, and more flexible observing modes. Because these changes do not depend on a new camera being installed, they could be pursued whenever funding and staffing allow.

Survey respondents expressed interest in alternatives to the current ACP interface, including a TUI-style interface modeled on the 3.5-meter telescope interface and a SkyNet-type web-based interface that could support beginner-friendly educational use (Figure 5). Few respondents preferred retaining ACP as the long-term interface. A commercial or otherwise supported interface may provide a faster near-term path, while a custom TUI-style interface would likely require several months of software development.

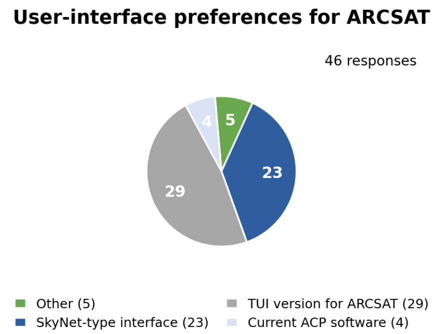


Figure 5. User-interface preferences for a 0.5-meter-class telescope at APO. *Respondents expressed interest in both TUI-style and SkyNet-type interfaces, while few selected the current ACP software as the preferred long-term interface.*

Users also indicated that dedicated staff support is important for sustained operation of a 0.5-meter-class facility. Current APO staff support is appreciated, but ARCSAT does not have dedicated support staff, and troubleshooting, camera and filter changes, system reboots, and dome visits draw staff away from other responsibilities. Dedicated staff support would reduce the burden on APO staff, improve response to observing problems, and help make the 0.5-meter facility more usable for ARC members.

Survey respondents also expressed interest in additional observing modes, including queue-based observing, long-term monitoring, shorter scheduling blocks, and Target of Opportunity observations (Figure 6). These modes should be considered after the core telescope, camera, control system, and staffing model are stable, since more flexible scheduling would require additional operational oversight. Integration with a network such as SkyNet could be considered as one possible implementation path for beginner-friendly educational access, but because it would affect telescope access for ARC member institutions, it should require a separate future decision by the ARC community.

These additional recommendations need not be implemented all at once, but they should be incorporated into the planning and budget process after a telescope decision is made.

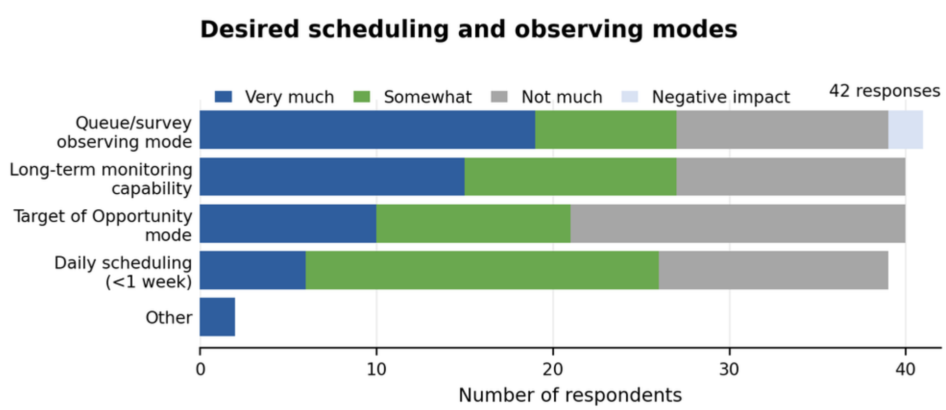


Figure 6. Desired scheduling and observing modes. *Respondents expressed interest in queue/survey observing, long-term monitoring, daily or shorter scheduling intervals, and Target of Opportunity capability.*

Appendix A. Survey Detail and Supporting Figures

Appendix A provides details and supporting figures from the survey so readers can trace the conclusions in the main report back to the responses that informed FAWG's findings and recommendations. It follows the survey's main themes in the same general order as the report: who responded, why some respondents never used ARCSAT, how ARCSAT has been used, what problems current users encountered, what respondents want from a future 0.5-meter-class facility, and what operational changes and camera requirements would improve its usefulness. The figures and table below provide the survey evidence supporting the conclusions in the FAWG report.

A.1 Survey Distribution and Respondent Groups

A survey was developed in Qualtrics and distributed through the 35m-general and 05m-general mailing lists, as well as by direct email from working group members to colleagues at ARC member institutions. The survey received 61 responses from nine ARC member institutions, including current ARCSAT users (n=21), past users (n=15), and individuals who had never used ARCSAT (n=25). This mix was important because the survey was designed to capture both current operational experience and the needs of potential future users. Current and past users received tailored questions about prior use, and all respondents answered the same questions about future use. Figure A1 shows the institutional distribution of responses, and Figure A2 shows the split among current, past, and never-users.

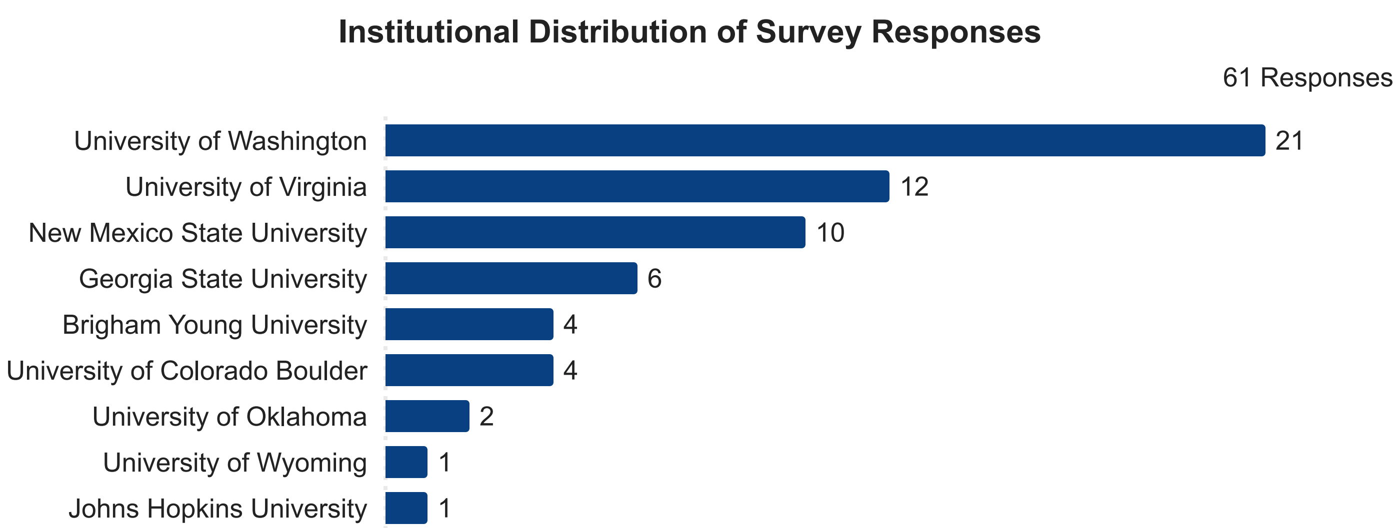


Figure A1. Institutional distribution of survey responses. *Responses came from all nine ARC member institutions, showing that the survey captured input from across the consortium rather than from a single campus.*

Respondent Group Breakdown

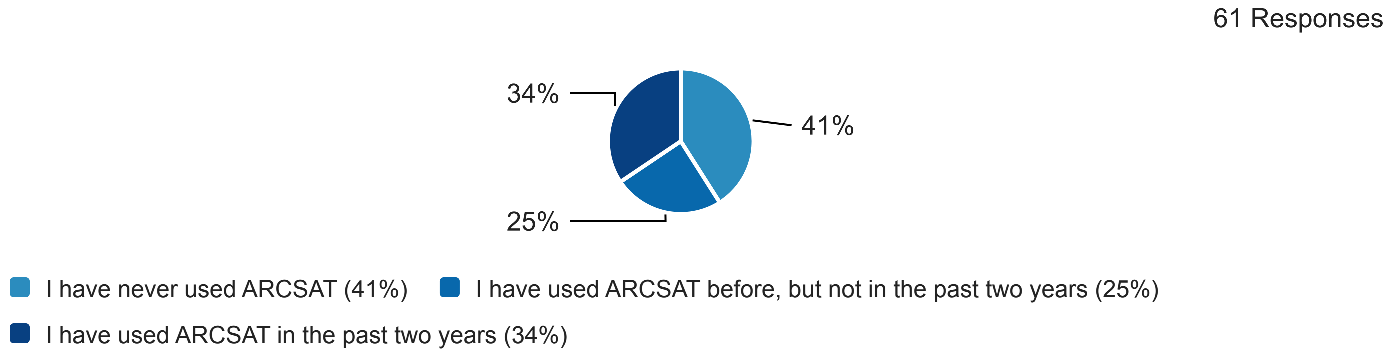
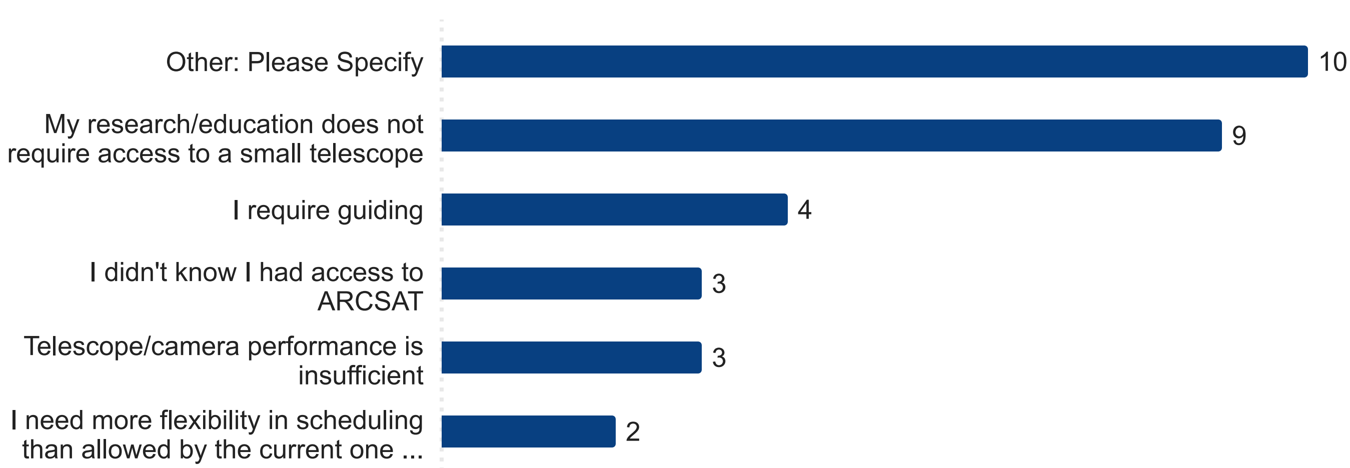


Figure A2. Respondent group breakdown. *The survey included current users, past users, and respondents who had never used ARCSAT, allowing the results to reflect both experience with the telescope and interest in possible future use.*

A.2 Reasons Some Respondents Have Never Used ARCSAT

Among respondents who had never used ARCSAT, the most frequently cited reason was that ARCSAT was not needed for their research or educational goals. Other responses identified limitations in telescope and camera performance, the need for guiding, more flexible scheduling, and an improved user-interface. Some respondents also reported that they did not previously have access to ARCSAT or were unaware that access was available, and a small number indicated that they already had access to another 0.5-meter-class telescope. Because the never-user group was the largest respondent group, these answers are important for understanding the barriers to future adoption. Figure A3 shows that non-use often reflects fit, access, and usability constraints rather than a lack of interest in a 0.5-meter-class telescope.

Reasons respondents have never used ARCSAT



Specific reasons given by respondents

Other: Please Specify - Text

We have another small telescope and I would encourage users at our institution to use it.

Also, the user interface perhaps leaves something to be desired, especially if users are not given access to the full desktop.

I just started recently and will have future needs

I have been reluctant to plan ARCSAT observing runs because of a general impression that the instrument/telescope/dome system is unreliable and failure-prone. This has made me worried that a carefully constructed plan and a significant investment of time could all be lost to equipment failures.

My research uses mainly high contrast imaging (large telescopes) or high resolution spectroscopy (such as 3.5m/ARCES). When my group does photometric monitoring (e.g. stellar variability and rotation curves) we typically use TESS.

I have not had institutional access to ARCSAT until now.

I would be interested in using the telescope with undergraduate students for introductory projects and for undergraduate non-majors to obtain authentic data for use in introductory astronomy courses. The primary reason that I have not used the telescope is the lack of a simple, web-based observation request system. I need a system where students can submit observation requests through a simple to understand interface that even beginners can understand. The UNC Skynet system offers exactly this kind of interface. I strongly suggest that you put the telescope on Skynet.

I have not had the need to obtain additional observations of any kind yet in my research.

I would prefer automated observing.

All responses apply to the past. I have a large, new grant that specifically uses ARCSAT.

We have our own 0.6 m telescope, so there's no need for arcsat.

Figure A3. Reasons respondents have never used ARCSAT. *Many non-users said ARCSAT was not needed for their work, but others pointed to reliability, access, scheduling, and usability barriers that could affect future adoption.*

A.3 Current and Past Use of ARCSAT

Current and past ARCSAT users were asked to select all the purposes for which they had used the telescope. Responses show that ARCSAT has been used primarily for research, training, and education. Current users most often reported undergraduate research, student training, and coordinated observations with the ARC 3.5-meter telescope or other facilities, while past users reported similar patterns. Figure A4 shows that ARCSAT has supported a mix of research, teaching, and coordinated-observation use cases rather than a single narrow application.

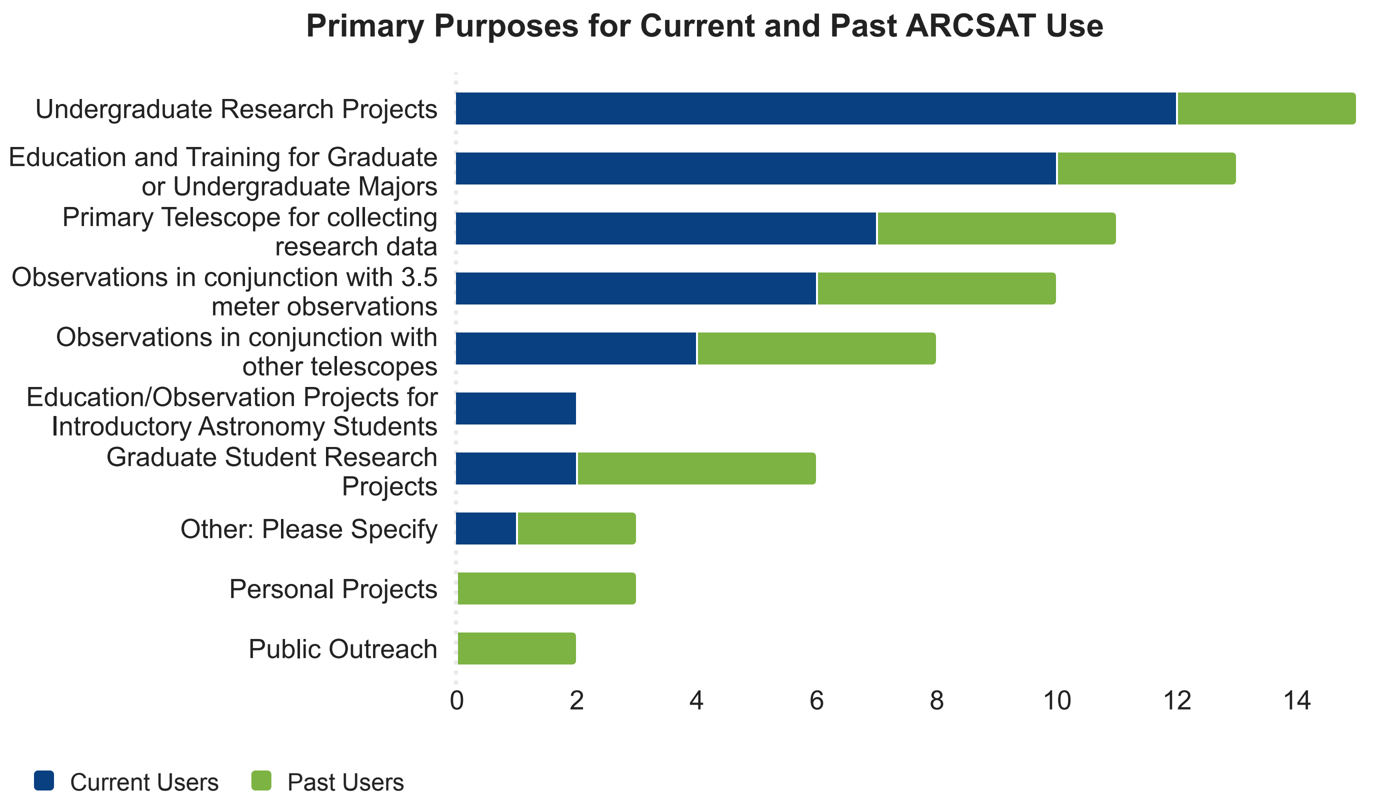
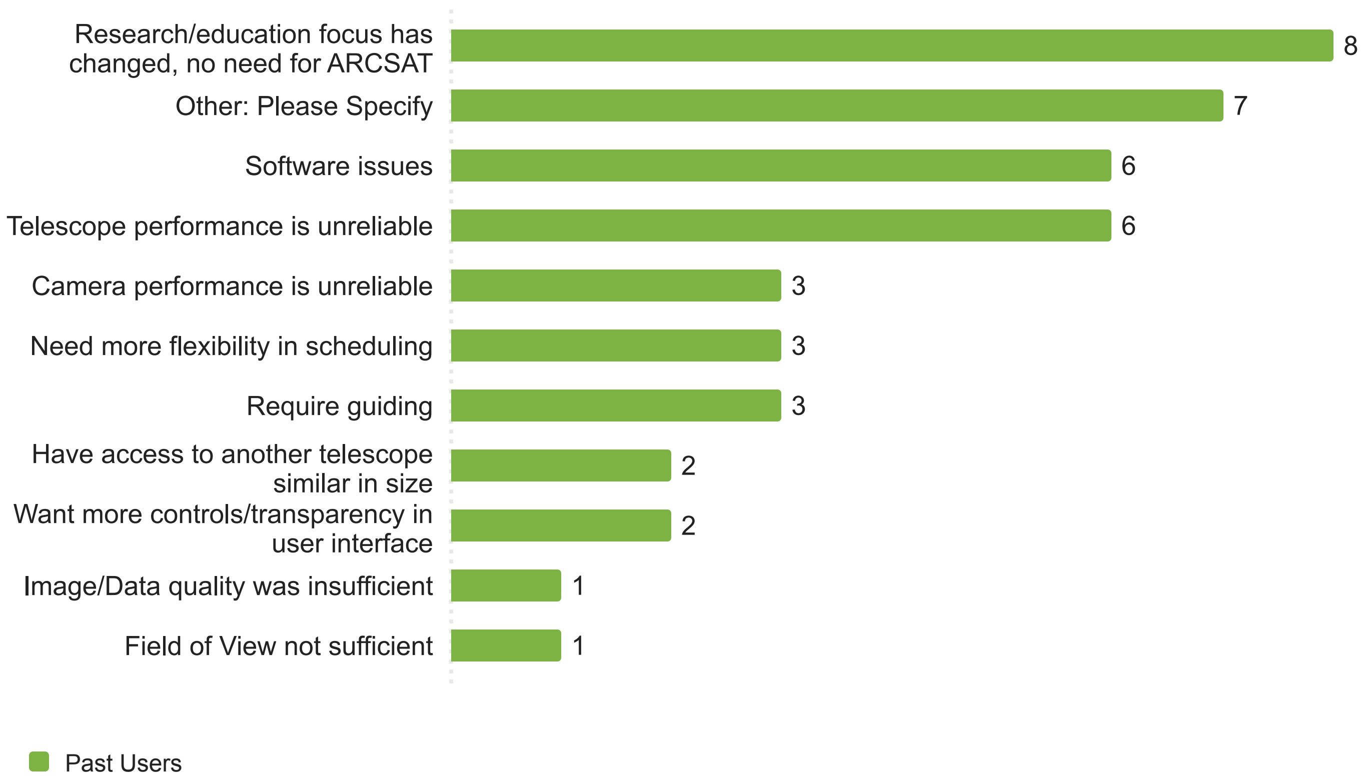


Figure A4. Primary purposes for current and past ARCSAT use. *ARCSAT has been used for research, training, and coordinated observations, showing that the telescope has supported a mix of scientific and educational uses.*

When former users were asked why they no longer use ARCSAT, some said their research or educational needs had changed and they no longer required a small telescope. However, many responses pointed to operational barriers, including software issues, unreliable telescope and camera performance, limited scheduling flexibility, and poor data quality. The free-response comments reinforced this pattern, with several respondents describing ARCSAT as clunky, unreliable, or difficult to use efficiently. Overall, the responses suggest that the decision by former users' to not use ARCSAT often reflect reliability and usability concerns in addition to changes in scientific need.

Reasons former users no longer use ARCSAT



Specific reasons given by respondents

Other: Please Specify - Text
My collaborators still apply for ARCSAT time, but I am not supervising a student at the moment.
I do not often use ARCSAT b/c ACP is very clunky and unreliable. It is very difficult to check images quickly for focus, overall quality, and even pointing, which is unreliable.
Shelyak was longed to another project
We have three similar size telescopes at CU Boulder's campus, for our small telescope needs we've mostly turned to this more flexible local and hands-on option, or to LCOGT for easier queue scheduling. I'm not saying I'll never use ARCSAT, for example for simultaneous observations of bright stars with the 3.5m, but it's not at the top of my radar.
I usually can't fill a week worth of time meaningfully, instead having a few nights worth of science.
The data quality is not worth my time to stay up at night, and I would rather get data from a comparable telescope that is automated or queue based, even if I had to do the reduction myself.

We used ARCSAT for VRI photometry for a few years 5-10 years ago, but found it to be rather finicky with pointing. We got what we needed at the time.

I could imagine with queue scheduling that ARCSAT might be used for stellar rotation studies, but that means a handful of observations per night over months, at least for the M dwarfs we might target.

I used ARCSAT several years ago to do some monitoring of ~15-16 mag objects. I'm actually planning to start using it again for a project this fall. Depending on the quality of the data, I may continue using it. We'll see how this fall's observing turns out.

Figure A5. Reasons former users no longer use ARCSAT. *Some former users no longer need a small telescope, but many cited reliability, scheduling, and usability concerns that discouraged continued use.*

A.4 Operational Problems and Support Experience

Responses from current ARCSAT users reveal that technical problems remain a recurring part of ARCSAT use rather than isolated events. Of the 17 current users who answered the question, 13 reported software or technical problems either quite often or occasionally, while only 4 reported problems as rare or absent. The comments in the previous sections already hint at these issues, and the responses below show that they continue to affect present-day use. The first subsection summarizes the frequency and type of problems current users encounter. The second subsection shows how those problems affect APO support staff and observing time.

A.4.1 Frequency and Type of Current-User Technical Problems

Current users who reported technical problems were asked to rank the type of problem they encountered most often. Software-related problems were ranked most frequently, followed by camera-related problems, with telescope-related problems reported less often. Figure A6 shows how often current users encountered software or technical problems, and Figure A7 shows which types of problems were reported most frequently. These responses indicate that ARCSAT's limitations are not confined to a single component, but instead involve the software environment, the camera system, and the telescope itself. Thus replacing the telescope alone will not address the issues users have with ARCSAT, and plans need to be made to improve the reliability of the software and the performance of the cameras.

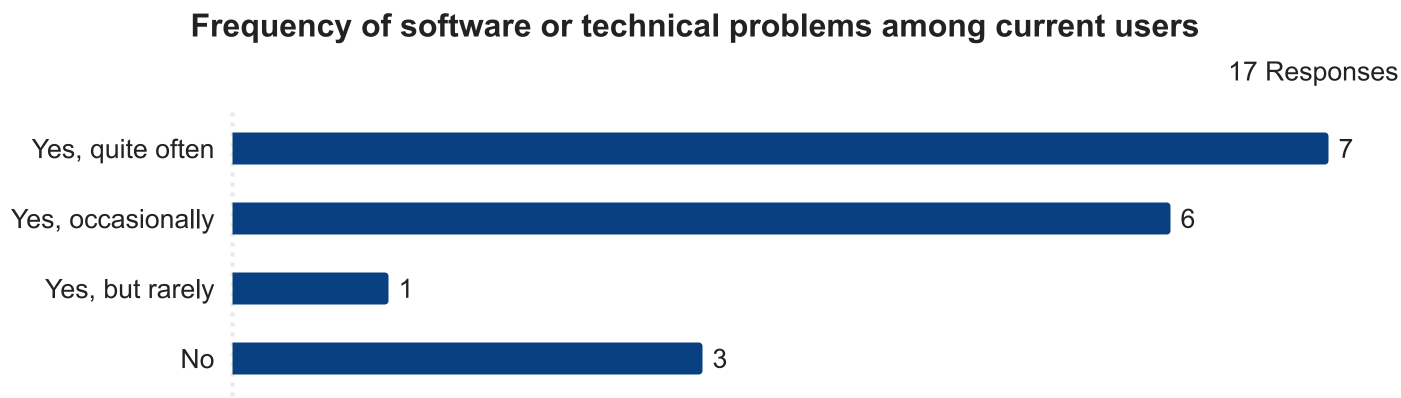


__Figure A6. Frequency of software or technical problems among current users.__ Most current users reported problems either quite often or occasionally, showing that technical issues remain a recurring part of ARCSAT use.

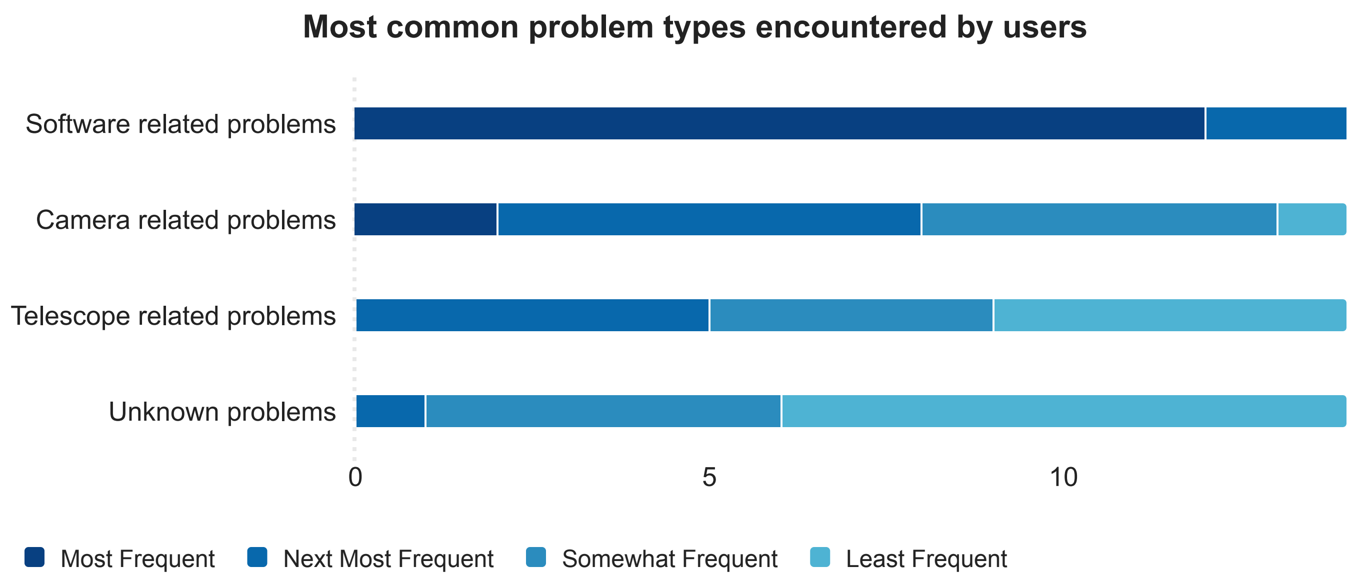


__Figure A7. Most common problem types encountered by current users.__ Software problems were reported most often, followed by camera and telescope problems, indicating that ARCSAT's limitations extend beyond simply replacing the telescope.

A.4.2 Support Burden and Observing Impact

When problems arise, current users often rely on APO staff, especially the 3.5-meter operator, for troubleshooting and recovery. Figures A8 through A11 show that this support is appreciated, but it is also constrained by the operator's primary responsibility for the 3.5-meter telescope. As a result, responding to ARCSAT problems can be delayed and observing time can be lost. Figure A12 adds an important qualifier: despite these issues, most respondents said that software or hardware problems did not significantly change how much ARCSAT time they requested. That response does not lessen the importance of the problems described above; rather, it suggests that current users remain committed to

ARCSAT even when recurring issues make observing more difficult. Taken together, these responses show that the current operating model places a continuing support burden on APO staff and can reduce the reliability of ARCSAT as a user facility.

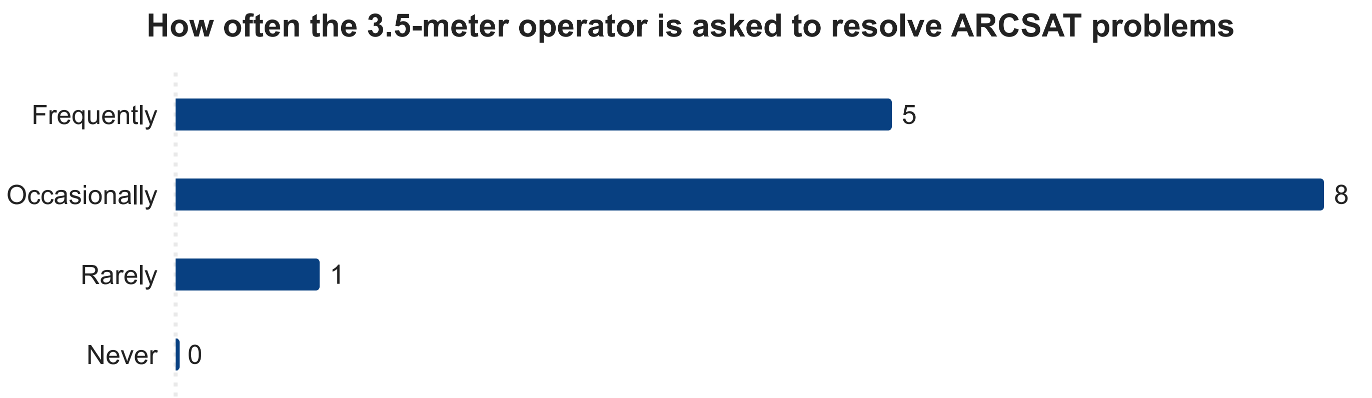


Figure A8. How often the 3.5-meter operator is asked to resolve ARCSAT problems. *Current users often rely on the 3.5-meter operator for help, showing that ARCSAT troubleshooting creates a real support burden for APO staff.*

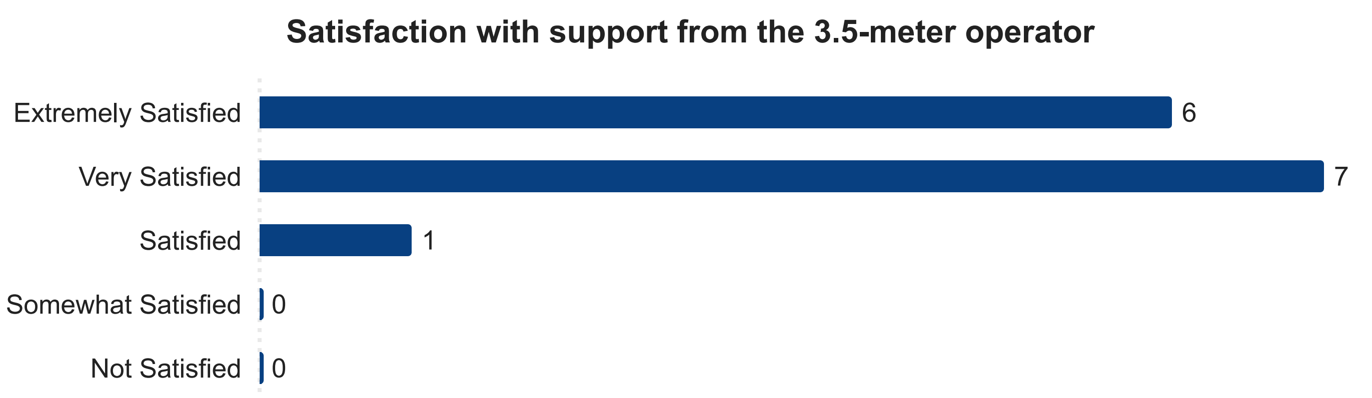


Figure A9. Satisfaction with support from the 3.5-meter operator. *Users were generally satisfied with the help they received, even though that support was limited by the operator's primary responsibility for the 3.5-meter telescope.*

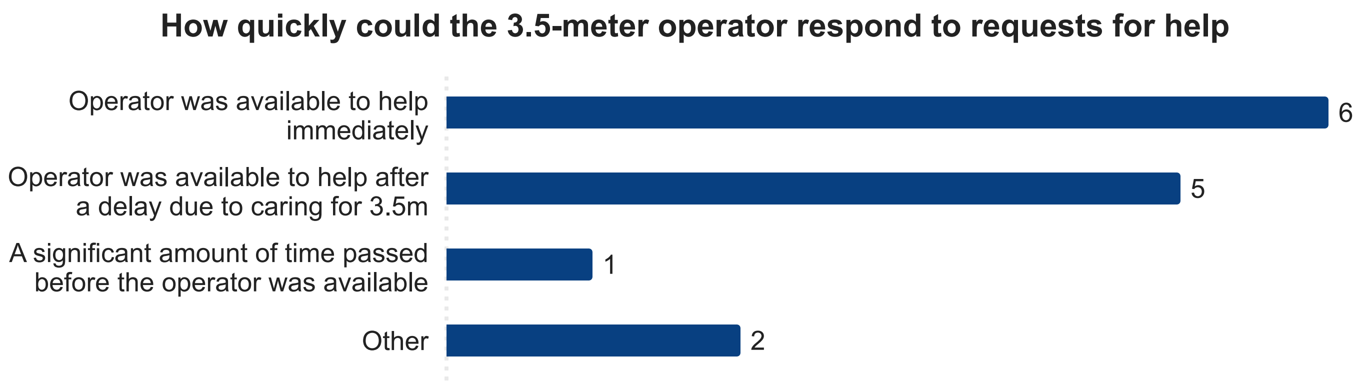


Figure A10. How quickly the 3.5-meter operator could respond to requests for help. *Support was often timely, but delays still occurred when the operator had to prioritize 3.5-meter responsibilities.*

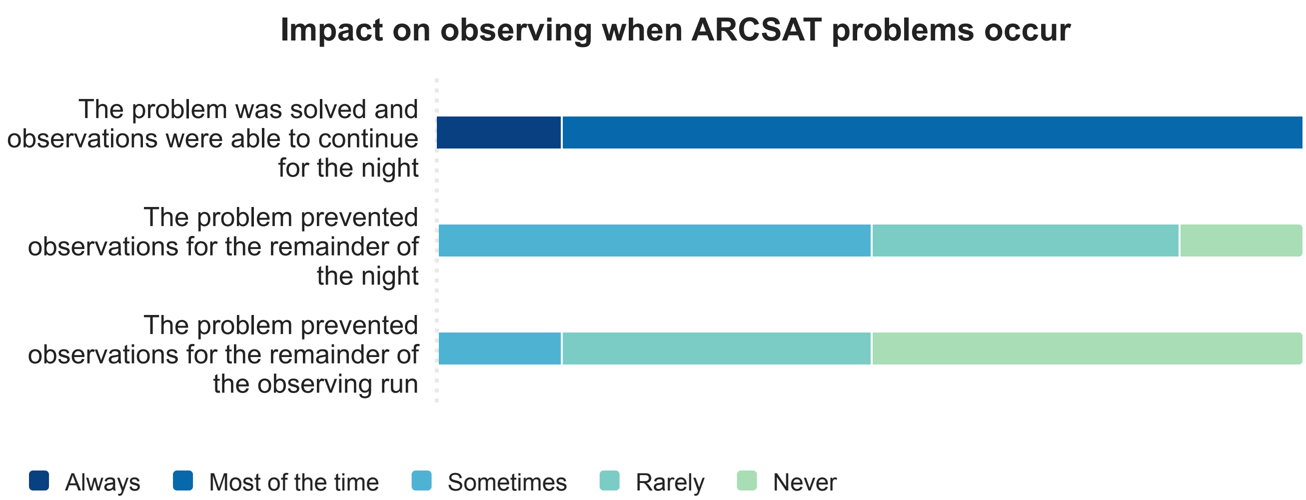


Figure A11. Impact on observing when ARCSAT problems occur. *Most problems could be resolved in time for observing to continue, but some still caused the loss of the remainder of the night or the observing run.*

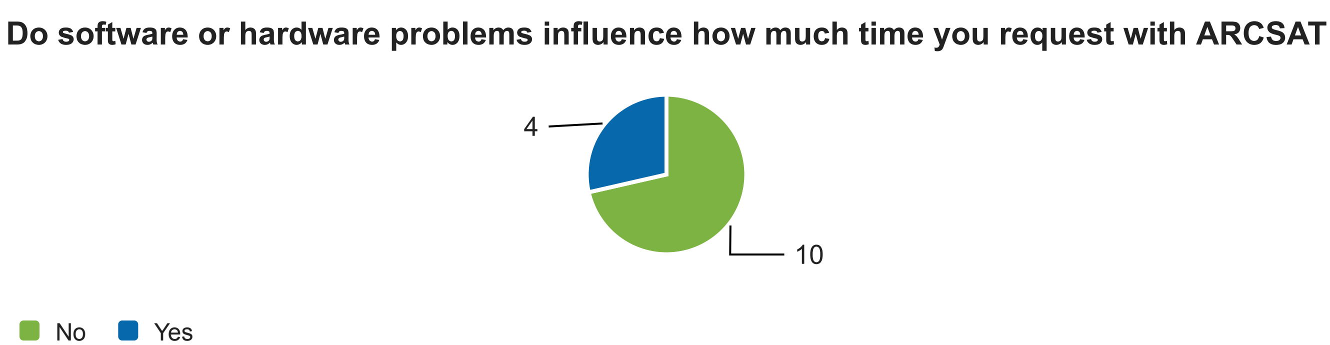


Figure A12. Do software or hardware problems influence how much ARCSAT time users request. *Although problems affect operations, most current users said those issues did not substantially change how much ARCSAT time they request.*

A.5 Future Use Cases and Continued Interest

Even with the operational problems described above, respondents identified substantial future uses for a 0.5-meter-class telescope at APO. Across all respondents (current, past, and never-users), anticipated uses included research projects, coordinated observations with the ARC 3.5-meter telescope or other facilities, training for graduate and undergraduate majors, introductory astronomy projects, and public outreach. Only 2 respondents indicated no potential use for a small telescope. Figure A13 shows the range of anticipated future uses, and Figure A14 shows that roughly half of respondents said the current ARCSAT telescope would not meet their future needs. These responses show that demand for a 0.5-meter-class facility remains strong, even as the current system struggles to meet that demand reliably.

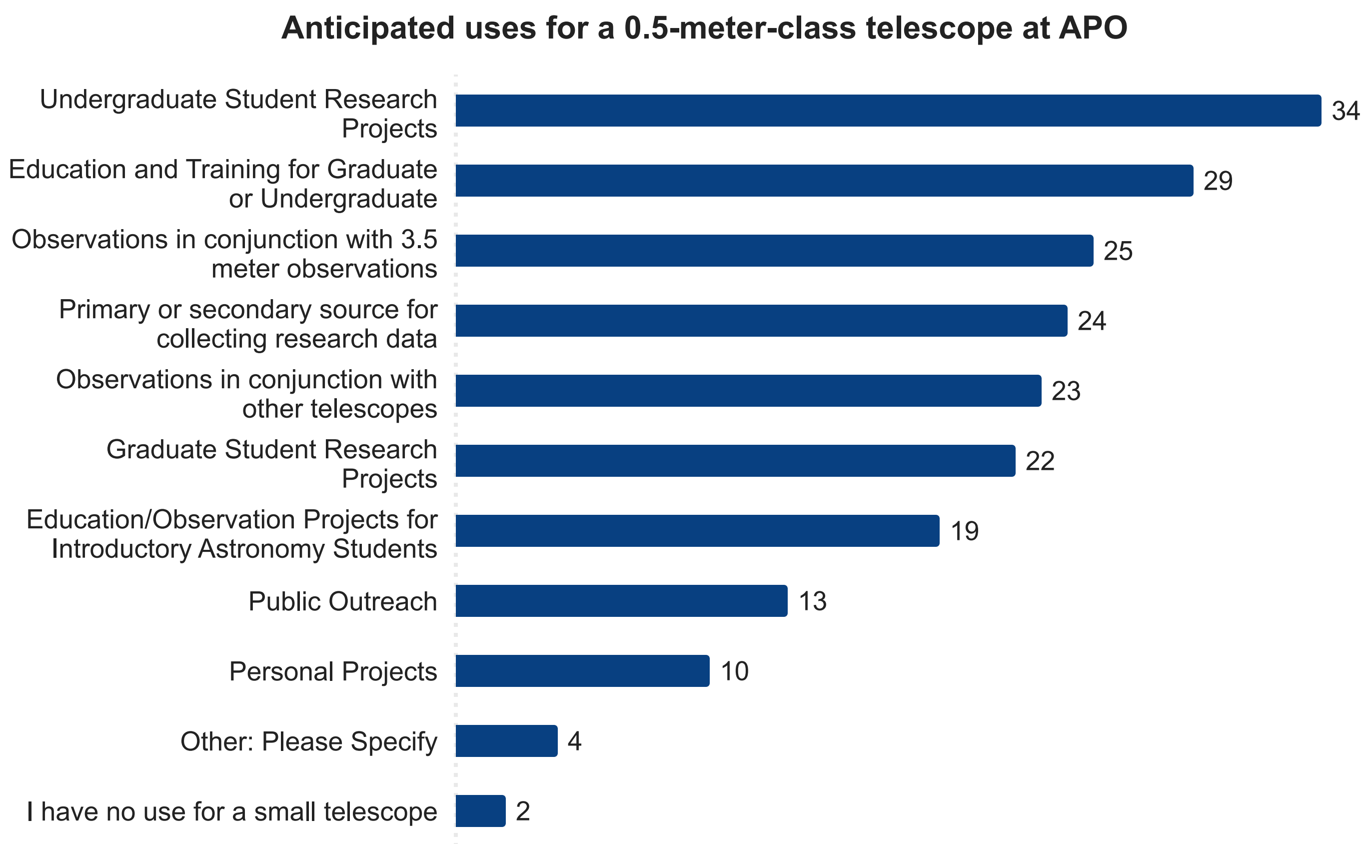


Figure A13. Anticipated uses for a 0.5-meter-class telescope at APO. *Interest in future use remains broad, especially for research, training, and coordinated observations, showing that demand for a small telescope remains strong.*

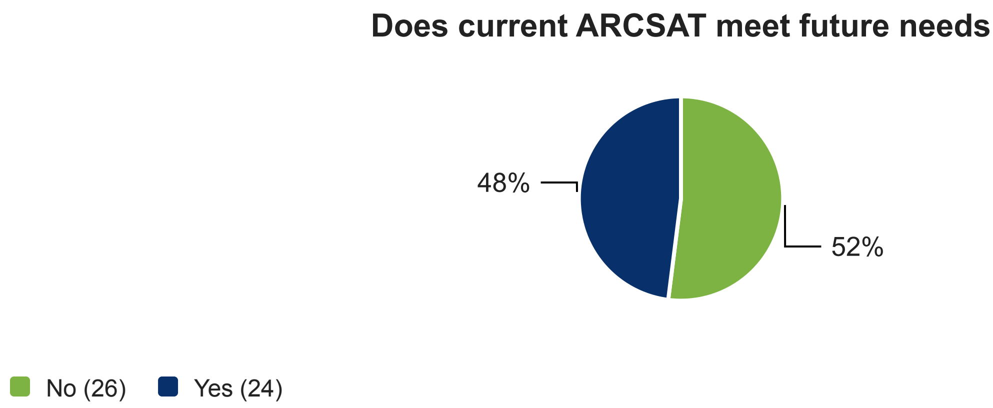


Figure A14. Whether current ARCSAT meets future needs. *Roughly half of respondents said the current telescope would not meet their future goals, underscoring the need for changes to the facility.*

A.6 Current Value and Desired Improvements

Although respondents identified problems with ARCSAT, they also made it clear that the facility still has value. Current users rated ARCSAT as important to their research programs, their students' learning, and their departments' missions and goals. Observations in conjunction with the ARC 3.5-meter telescope and other facilities were also important to a subset of users. Figure A15 shows that users ranked ARCSAT as moderately to extremely important in almost every category.

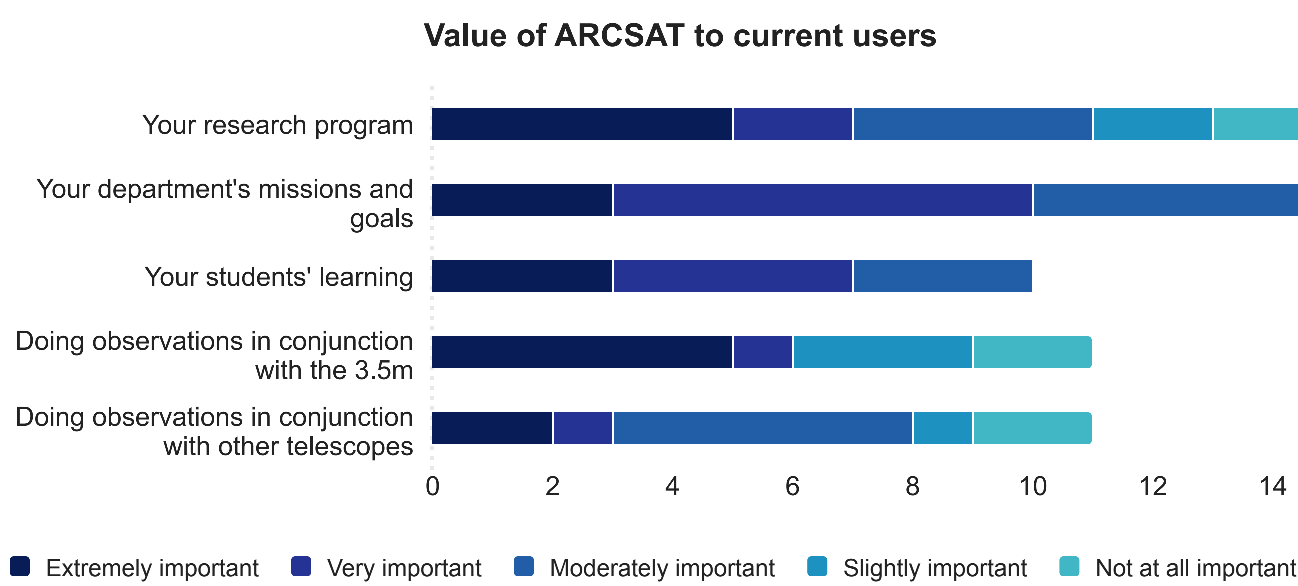


Figure A15. Value of ARCSAT to current users. *Current users rated ARCSAT as important for research, teaching, and departmental goals, showing that the telescope still has meaningful value despite its problems.*

Respondents were asked to identify what improvements to ARCSAT would enhance their ability to use a

0.5-meter telescope at APO. The most important desired capabilities were improved hardware reliability, improved tracking and pointing, a new user interface, and a reliable guide camera. There was interest in providing both a beginner-friendly interface and a more advanced user interface (e.g., a TUI-like option), with moderate interest in advanced scripting capabilities. A larger field-of-view and spectroscopic capability were generally lower-priority enhancements. Figure A16 then shows the improvements respondents most strongly associated with a usable future facility.

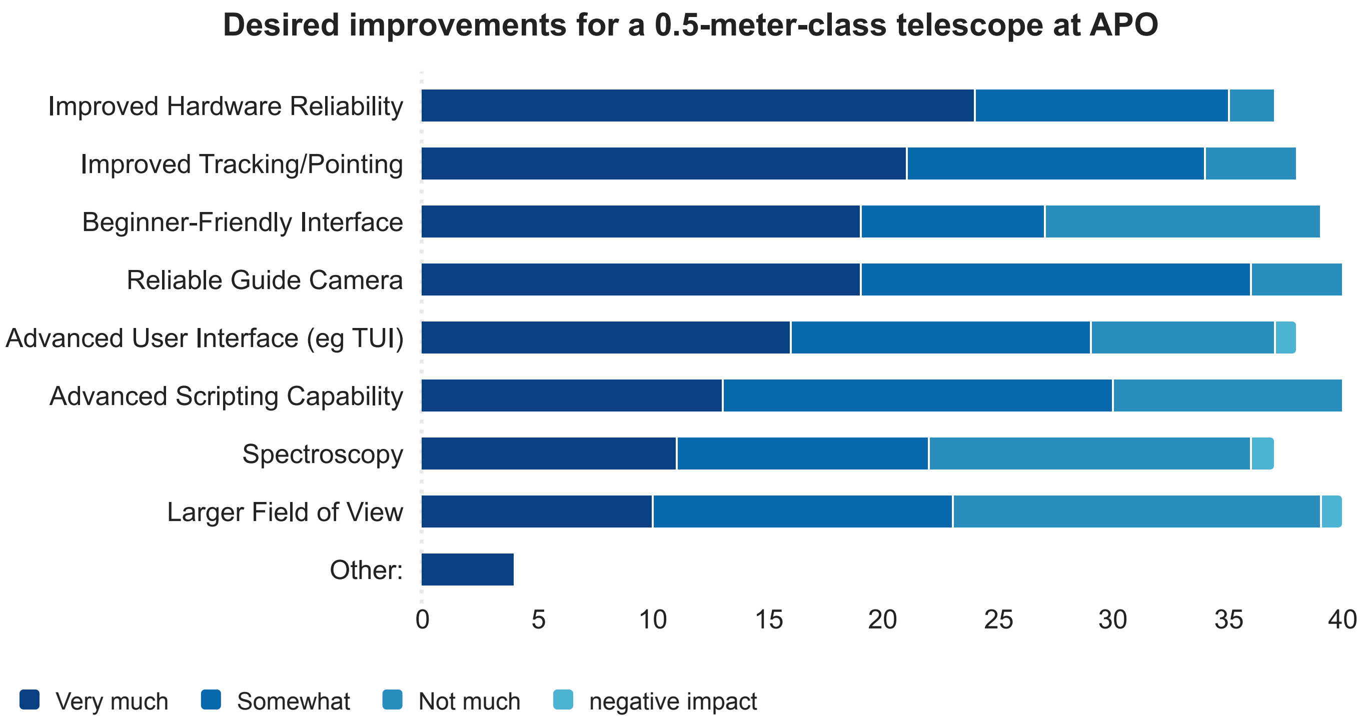


Figure A16. Desired improvements for a 0.5-meter-class telescope at APO. *Respondents most strongly associated future usefulness with improved reliability, better tracking and pointing, a beginner-friendly interface, and a reliable guide camera.*

A.7 User Interface Preferences

Survey respondents were asked what kind of user interface they would prefer and were allowed to select all acceptable options. Responses were split between a beginner-friendly SkyNet-type web interface (50%) and a more advanced TUI-style interface (63%), while relatively few respondents preferred ACP as the long-term interface (9%). FAWG also discussed the UNC SkyNet telescope network as one possible implementation path for a beginner-friendly observing mode, although it was not specifically addressed in the survey. The APO Board would need to consider that possibility in the future if ARC chooses to continue providing a 0.5-meter-class telescope at APO. Figure A17 summarizes these preferences.

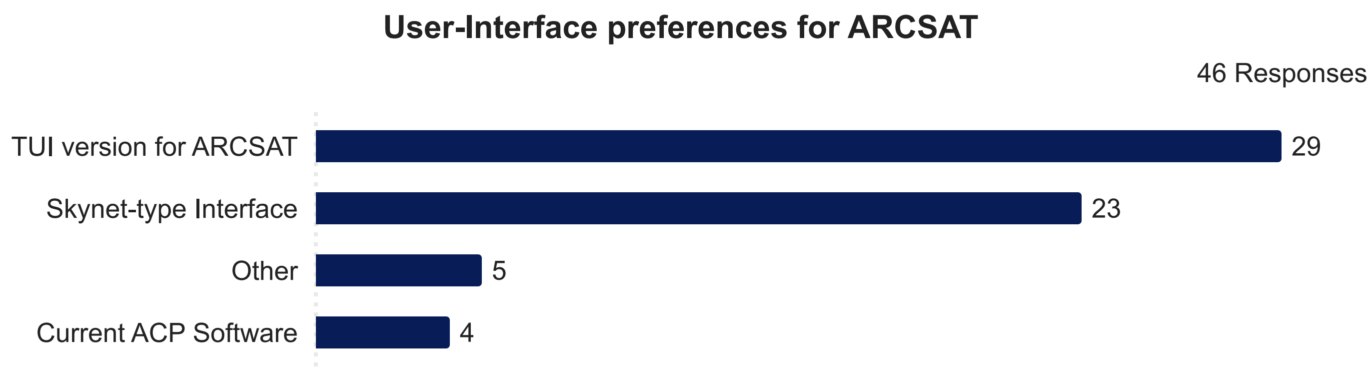


Figure A17. User-interface preferences for ARCSAT. *Respondents were split between a TUI-style interface and a SkyNet-type beginner-friendly web interface, while few preferred keeping ACP as the long-term interface.*

A.8 Scheduling and Observing Modes

ARCSAT currently operates with week-long observing blocks, and respondents were asked whether alternative scheduling modes would improve their ability to use the telescope. Queue-based observing and survey mode received the strongest support, with long-term monitoring, target of opportunity capability, and daily scheduling also receiving meaningful support. Figure A18 summarizes these preferences. These responses show that some of the community's interest in ARCSAT depends not only on hardware performance, but also on how the telescope is scheduled and accessed.

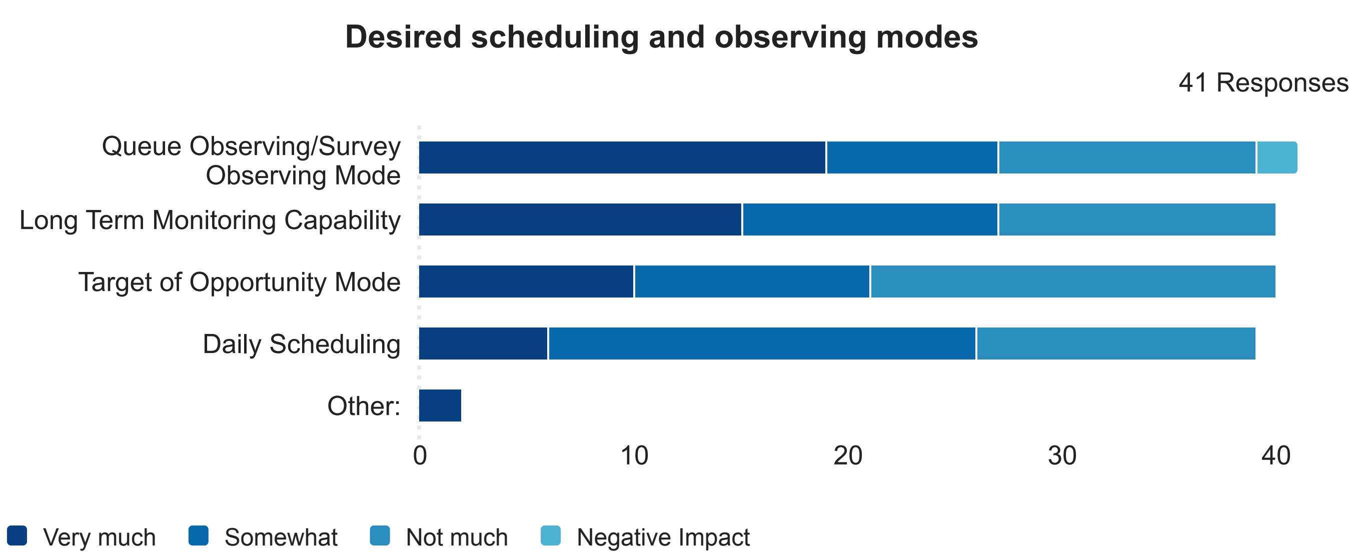


Figure A18. Desired scheduling and observing modes. *Queue-based observing, survey mode, long-term monitoring, and target-of-opportunity capability all received meaningful support, indicating that scheduling flexibility is an important part of future ARCSAT use.*

A.9 Camera and Instrumentation Requests

Survey respondents were asked about the camera characteristics that would best support their use of a 0.5-meter-class telescope. For some items, including field of view, telescope aperture, plate scale, and readout time, they were asked to identify both a minimum acceptable value and an ideal value. Their responses point to a need for a larger field of view, a native plate scale rather than a focal reducer, a reliable guide camera, improved blue sensitivity for at least some science cases, and faster readout times. Table A1 summarizes the ranges and preferences derived from those responses, including acceptable and ideal values for field of view, plate scale, readout time, and aperture.

Survey feedback and operational experience also indicate that camera reliability is a major limiting factor for ARCSAT. The current camera suite is aging, increasingly difficult to repair, and less well supported by manufacturers. Camera selection should therefore be coordinated with the telescope configuration, since field of view and plate scale depend on optical design and focal length. A phased approach is possible, with the new telescope installed first and the existing cameras used temporarily, but that approach carries risk if camera failures continue.

Table A1. Camera and instrumentation preferences. This table summarizes the survey respondents' acceptable and ideal values for field of view, plate scale, readout time, aperture, guiding, and blue sensitivity.

Parameter	Survey summary	Planning note
Field of view	Minimum acceptable: about 15 arcmin; ideal: about 30 arcmin	Use as a target when matching the final telescope optics
Plate scale	Native plate scale preferred; desired scale about 0.5-0.6 arcsec/pixel	Avoid a focal reducer if possible
Readout time	Maximum acceptable: about 30-45 s; ideal: about 5-10 s	Faster readout better for short exposures and flexibility
Aperture	Minimum acceptable: about 0.5 m; ideal: about 0.6 m	Coordinate with the final telescope selection
Guide camera	65% indicated yes	Guiding is desirable, though overhead matters
Blue sensitivity	57% indicated yes	Important for some but not all science cases