Long-term Plan for USGS Astrogeology Science Center Software Development

Last updated: September 10, 2020

For additional information about the projects listed under each objective, please see the associated directory for the given fiscal year. For example, if you are interested in the *ISIS PVL and BLOB Extraction* project listed under objective 1, please see the FY21 directory README.

Objective 1: Initiate and foster an open source community, initially centered around software developed by the ASC (including ISIS).

The ASC software portfolio, including the source code, has always been distributed at no cost, but the planetary community has not had a means to contribute any modifications, enhancements, or original solutions to this portfolio. By Open Sourcing the ISIS (and other) software, the ASC intends to build a community of users and developers who can more easily modify and share enhancements to this software. This change would improve our collective ability to meet community needs by bringing together experts in sensor models, projections, and spatial data who collectively will make a more robust and functional software than any single group could do alone. This objective also directly addresses several findings from the NASA-MAPSIT Special Action Team (SAT) review of the ASC software portfolio, including findings 4, 5, 9, 11, 13, and 15.

Ongoing Efforts:

- Continue to be the steward of ISIS, continue to facilitate and work towards broad participation by contributors (addresses SAT finding 4).
- Maintain mechanisms for widespread use for user engagement with the ASC software portfolio and its developers (addresses SAT finding 5).
- Maintain a formal Open Source governance policy that clearly describes how outside contribution can be submitted, including required coding standards, and the process for incorporating them into the code base (addresses SAT finding 11).

- Continue to release the ASC software portfolio code base on a public GitHub (addresses SAT finding 9).
- Release all ISIS general and test data so that outside developers can also run, and expand upon, these tests (addresses SAT findings 13 and 15).

Activities in FY 20:

- Open Source Community Development
- ASC Software Portfolio Releasees
- Indirectly addressed by ISIS Testing Modularization

Acitvities in FY 21:

- Open Source Community Development
- ISIS Application Modularization
- ISIS PVL and BLOB Extraction

Longer-term (5-year horizon):

- Evaluate the effectiveness of our efforts and make reasonable changes to our approach based on community feedback and lessons learned.
- Support a planetary software stack composed of ASC and non-ASC software packages
- Build and support the external development of community desired analytical tools that make use of our lower level, gold standard, libraries.

Objective 2: Improve the performance of the code base and the user experience.

The ASC will build, support, and integrate with the infrastructure necessary for users to install our software with a minimum amount of effort. The ASC will also release software at a cadence selected to support the largest possible subset of the community. Additionally, ASC will seek to improve the user experience by, when possible, reducing the total volume of data necessary to store locally and improving the overall performance (speed) of the code base.

Ongoing Efforts:

- Continue to improve the ISIS build system, through regular support and maintenance.
- Continue to improve the ISIS distribution system by maintaining the conda-based distribution system to provide a more universal binary distribution of ISIS (addresses SAT finding 12) and continuing to improve this distribution system in response to user feedback (addresses SAT finding 13).
- Continued software support and maintenance of the ISIS codebase (addresses SAT finding 24).
- Improve the availability of appropriate test data (addresses SAT finding 15).
- Maintain continuous deployment.
- Improve application performance, when needed (addresses SAT finding 16).
- Continue to improve ISIS program documentation both as new functionality is developed and as performance or accuracy concerns are identified and addressed within the legacy codebase (addresses SAT finding 6).

Activities in FY 20:

- ASC Software Support
- Improvement of ISIS third party dependency management
- ISIS Testing Modularization

Activities in FY21:

- Remote SPICE Calibration
- ISIS3 to ISISX cleanup
- ISIS Application Modularization
- ISIS PVL and BLOB Extraction
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Longer-term (5-year horizon):

- Evaluate the effectiveness of our efforts and continue to be response to community feedback and lessons learned.
- Fully transition to supporting remote SPICE server capibility reducing the total data volume significantly.
- Explore the potential for remote data processing in line with the general shift to cloud based data storage and processing in collaboration with our user base.

Objective 3: Modularize components of ISIS and support published APIs.

The ASC will build and maintain a stable software API and separate, smaller libraries, which will, over time, replace the current ISIS software portfolio. Like ISIS, this suite of Open Source applications will continue to meet the infrastructural needs of the planetary community. We envision a transitional approach to replacing the ISIS software system (as opposed to a 'cut-over'), while continuing to provide high-level support to current missions and ensuring that data processing and product production pipelines are interrupted as little as possible.

Activities in FY 20:

- ISIS Testing Modularization
- Community Sensor Model Bundle Adjustment
- Complete ALE Integration
- Develop and release a Request for Comment (RFC) regarding the ISIS Software Modularization plan
    - Appropriately incorporate community feedback into this plan
    - Maintain the publicly available ISIS Software Modularization plan by updating the document at least annually (addresses SAT finding 8).

Activites in FY 21:

- ISIS Application Modularization
- ISIS PVL and BLOB Extraction

Longer-term (5-year horizon):

- Transition the suite of ISIS control network programs into a stand-alone application.
- Evaluate the benefits of developing a Python API for ISIS by openly discussing and planning this API with the OS community (addresses SAT finding 21).
- Astro will deprecate old software by (when applicable) processing data using that software, releasing these minimally derived products to the community in a usable format, and archiving the software itself (potentially in the PDS).

Objective 4: Maintain and improve software support for ongoing, legacy, and future missions, with a focus on interoperability and

reduced maintenance costs.

The Astrogeology Science Center (ASC) has historically supported planetary missions that are currently active, are being developed, and are no longer operational (i.e., retired missions). In addition, an external review board found that the ASC's role in NASA mission support has been a cornerstone of the planetary science community, and that it should continue and improve (SAT finding 17). The ASC supports missions by developing and maintaining camera models, aiding in the development of data processing pipelines, developing software and the capability to generate Digital Terrain Models (DTMs) for planetary sensors, and can provide guidance in the geometric calibration of the instrument both before and after flight. The support of missions is a fundamental service that ASC currently provides, not only to the mission, but by extension to the planetary community as a whole and is a role that we should continue to fill.

Ongoing Efforts:

- Address mission-related software concerns, often through the Open Source community and in direct collaboration with mission teams (addresses SAT finding 17).
    - Continue to improve the responsiveness that ASC can offer active mission teams.
    - Advocate for early involvement and consistent communication with mission and instrument teams to help to maintain support.
    - Offer to provide mission teams a technical contact role between the ASC and the team.
    - Continue to clearly communicate to missions scheduling and other resource constraints that allow both parties to plan and adequately budget for mission support.
- Preserve and maintain support for current sensor models and develop new sensor models
- Increase camera/sensor model interoperability
- Improve SPICE infrastructure

Activities in FY 20:

- Community Sensor Model
- Complete ALE Integration

- Lidar Support

Activities in FY 21:

- Community Sensor Model
- PDS4 Support
- ISIS Mission Support
- Community Support (Participation in both the PlanetarySoftware and ISIS Technical Committee Organizations)
- Remote SPICE

Longer-term (5-year horizon):

- ~~PDS4 support may be needed in the near future (in-progress for CASSIS and Hayabusa 1), and a means to more easily generate PDS4 metadata and support files will be required.~~ (Executing in FY21.)
- Work as members of the ISIS TC to determine mission needs with respect to software development and release practices.
- Work as members of mission teams for intial implementation of rigurously tested sensor models, ingestion programs, and where appropriate processing pipelines that support many foundational aspects of mission success.
- Work as members of the support community to address issues as they are reported to our software projects.
- Continue to modularize our software with the goals of (1) improving our testing confidence and the confidence of mission teams in the efficacy of their pipelines and (2) making the process of pipeline development using components of our software portfolio more straight forward.

Objective 5: Continue to develop and integrate the Community Sensor Model into planetary science applications.

Rigorous sensor models are a fundamental requirement for computing the geospatial properties for planetary image observations and are used widely in the core cartographic, control solutions, and orthorectification applications. The creation of accurate orthorectified planetary images (ortho-images) is critical for a wide variety of geospatial activities including production of digital mosaics, digital elevation models from stereo imagery, change detection, landing site analysis, geologic mapping, rover traverse planning, and spectral analysis. To better support software interoperability between different photogrammetric applications (including ISIS), we will continue to implement the Community Sensor Model (CSM) standard. Over the last two years, Astrogeology has been actively developing and testing the CSM standard in order to support interoperability across a range of software tools including SOCET GXP, ENVI, ISIS, and within a stand-alone Python testing environment. For the CSM standard, there are much longer-term goals to see this standard used across the community, as it is used by the military, to standardize sensor models for future proposed instruments.

Activities in FY 20:

- Community Sensor Model
- Community Sensor Model Bundle Adjustment
- Contract NASA Ames to implement these same camera models in Ames Stereo Pipeline both to test this standard outside of Astrogeology and to help promote this standard across the community

Activities in FY 21:

- Community Sensor Model
- Contract NASA Ames to implement these same camera models in Ames Stereo Pipeline both to test this standard outside of Astrogeology and to help promote this standard across the community.

Longer-term (5-year horizon):

- ~~Determine criteria for transitioning current ISIS sensor models into the CSM.~~ (Executing in FY21)
- Determine a means to continue supporting historical data sets that rely on ISIS sensor models.
- Determine whether dual sensor model development is a valuable method to support additional rigurous testing.

Objective 6: Improve the scalability of ASC control applications.

The development of rigorous geodetic and/or photogrammetric control networks are fundamental to generating local, regional, and global mosaics, and subsequent foundational products such as image-based topography and orthoimagery. The ASC has established itself as a leader in the field of planetary geodetic and photogrammetric control. However, continued leadership requires that we continue to improve our technical capabilities.

Ongoing Efforts:

- Improve our capability to identify and monitor the health of a photogrammetric control network.
- Develop new and improve existing automated matching capabilities for image datasets (addresses SAT finding 19).
- Develop methods to automate tying to ground

Activities in FY20:

- Quantitative metrics for control network
- CTX Controlled Mosaic Generation

Activities in FY21:

- Operationalize FY 20 Quantitative metrics for control network
- Continue CTX Controlled Mosaic Generation

Longer-term (5-year horizon):

- Develop improved capabilities to handle large data and network volumes.
- Include robust error propagation in bundle adjustment and improved documentation describing the bundle adjustment output.

Objective 7: Increase our support of small and irregular-shaped bodies

Small bodies are an increasingly high priority to NASA Headquarters. To date, specific missions have funded the ASC to develop software solutions to address the specific needs of that mission (e.g., ROSSETTA, DAWN, OSIRIS-Res). Although many of these solutions are applicable to all small and irregular bodies, the improved coordination of these efforts, both within the ASC and with outside collaborators), will maximize the ability of the community to support both existing and future missions. The ASC will continue to develop generic solutions that can then be applied to a wide range of small bodies and coordinate efforts with missions and collaborators.

Activities in FY 20:

- Occlusion: Robust Orthorectification in ISIS
    - Research and prototype efforts
- Continue collaborations with the Small Body Mapping Tool and mission teams, with the goal of avoiding duplication of efforts and encouraging a unified approach to software in support of small bodies with a focus on interoperability.

Activities in FY 21:

- Collaboration between ASC staff and the Small Body Mapping Tool development team

Longer-term (5-year horizon):

- Through discussions with the broader planetary community, determine clear data processing, projection, and analysis needs, and determine how the ASC can best contribute.

Objective 8: Continually improve the effectiveness by which the ASC manages software development.

The planetary community relies on the infrastructural software developed by the ASC to process planetary data and generate higher-order derived products. As a result, it is paramount that the ASC software portfolio is developed with a strategic long-term vision that integrates the needs of active and developing missions, research scientists, and developers building upon the applications provided. We acknowledge that substantial internal variability over time in various parts of the ISIS codebase has occurred, and that these inconsistencies make developing external code against ISIS very difficult. We seek to minimize these difficulties, both for internal ASC developers and for the outside community and facilitate the development of a community-based set of infrastructural software through means discussed below.

Ongoing Efforts:

- Maintain an ASC software management structure, which includes the following (addresses SAT finding 22):
    - Software Development Lead (currently Jay Laura; jlaura@usgs.gov / @jlaura)
        - Ensure responsiveness and traceability to ASC and community scientific use cases, funded projects, and mission support
        - Serves as a public advocate for the Astro software portfolio
        - Encourages participation in the OS community
        - Facilitates addressing concerns from the community
        - Gathers comprehensive information regarding community software needs and the effectiveness this software management model.
        - Technical responsibility for strategic direction of software development by ensuring that the strategic goals are technically feasible and appropriate.
    - Technical Operations Lead (currently Robin Fergason; rfergason@usgs.gov / @rfergason)
        - Provides direct oversight to help ensures that the ASC software development portfolio meets user needs and completes funded obligations.
        - Supports the Software Development Lead in fulfilling actions.
        - Aids in gathering comprehensive information regarding community software needs and the effectiveness this software management model.

        - General responsibility for strategic direction of software development by ensuring responsiveness to the high-priority needs of a broad community.

- Support the efforts of ASC project specific Technical Steering Committee by allowing those committee members to make decisions on how to implement identified community needs/tasks into the existing OS software (addresses SAT finding 22).
    - Subject-based committee that provides technical expertise for topics that effect multiple missions and projects
    - Input from broad community expertise (rather than expertise within Astro alone) is included in design decisions, with the goal of reaching very high-quality decisions with large community buy-in
    - Promotes communication across multiple users and projects
    - Ensures consistency across multiple projects and missions
- Maintain the publicly available Software Long-Term Plan document by updating the document at least annually (addresses SAT finding 1).

Longer-term (5-year horizon):

- Evaluate the effectiveness of our efforts and make reasonable changes to our approach based on community feedback and lessons learned.

Objective 9: Provide training opportunities for ASC staff

Improving our software development capacities and efficiency requires well trained software developers, product owners, and product creators. In order to support and retain a knowledgeable and motivated software development team, we must provide both professional development opportunities and career pathways for early- and mid-career developers. In addition, Product Owners must be trained to improve project management (e.g., clear definition of deliverables), and new processors must be trained to maintain a skilled workforce.

Ongoing Efforts:

- Ensure that funded projects exist to continue the development of both new and deeper expertise

- Assign project work to software developers in a team-structured manner that facilitates cross-training among members.
- Continue sending developers to conferences and workshops
- Continue management training (for supervisors, project, and technical managers)

Longer-term (5-year horizon):

- Continuing the above training