The fourth meeting of the Astrophysics Data System Users' Group (ADSUG) was held on November 20th and 21st 2019 in Cambridge, MA. We welcome two new members - Prof Bryan Gaensler (Dunlap Institute) and Martin Lessmeister (arXiv) - and thank those for whom this meeting was their last - Line Nybakk Akerholt, Dr Roc Cutri, Dr Kathryn Flanagan and Dr Josh Peek.

Kudos

Everyone on ADSUG was *extremely impressed* by the accomplishments, dedication and expertise of the ADS team. We particularly note the excellent leadership shown by the ADS PI and Program Manager, Alberto Accomazzi.

NASA ADS is a service that is unique across all fields of research, and continues to be a world leader in bibliographic systems. NASA and the CfA should be incredibly proud to be hosting this team, who provide a free service that has become an essential daily component of the work of everyone in the field. As one member of the ADSUG put it: "People working in fields not indexed by ADS don't know how terrible their lives are."

The ADSUG would like to particularly congratulate the ADS team on their superb work over the last year, in transitioning from the classic platform to the new ADS interface. While we appreciate that many components of the classic code and platform still exist behind the scenes, the user experience during the transition was largely seamless, thanks in part to the education and outreach efforts of the ADS team. In addition, the ADS team were extremely responsive to feedback and concerns received during this critical period. The new user interface now provides all the functionality of the old system and more, is fast and efficient, and allows a range of access methods including direct manual interaction, web crawlers and APIs.

Finally, we cannot end this preamble without noting that we are approaching the end of an era, with the upcoming retirement of ADS Project Scientist, Michael Kurtz. Michael has been involved with ADS since its inception, and many members of the ADS team expressed the sense of impending loss that they will feel without his daily ideas and input. We thank Michael for his innumerable innovative contributions, congratulate him on his accomplishments and wish him a fulfilling retirement, but also note that it will be a big challenge to fill his shoes.

Transition

As noted above, we applaud the success of the front-end transition. The introduction of a Basic HTML option was a good intervention to quickly address a number of issues related to search engine accessibility and low-bandwidth access. Limiting the scope of additional work on this forked UI will help reduce the potential for accruing technical debt inherent in supporting two interfaces.

We recommend that ADS urgently prioritize gathering and regularly analyzing usage metrics. These metrics are critical for guiding development of features and understanding how the community are using the tools which are being provided.

We discussed the team's desire for a refactoring of the front end code, and recommend dedicated planning towards how such an effort might be made. The team should start formulating a concrete architecture for the new front-end (server-side rendered Javascript site most likely) and gather metrics on the level of support for needed for the existing front-end, in order to make a decision on when the new front-end work can begin. This level of planning is required before effort is dedicated to writing code in support of the refactor.

The ADS Users Group supports ADS' decision to prioritize the transition of the back-end services, which still depend on poorly understood legacy code. We encourage pursuing the unification of infrastructure in the cloud to improve infrastructure reliability and to take advantage of the existing DevOps experiences and workflows already used for the front-end services.

However, we recommend an incremental approach to replacing back-end components. The team should establish a policy for new services (e.g. Journals DB), with the recommendation that they be developed under the new deployment platform as much as possible. It is essential to avoid adding to the technical debt of the legacy infrastructure!

Engaging the community through the API

ADS has a powerful set of application programming interfaces (APIs) that allow scientists, institute bibliographers, and major research services to integrate ADS tools into their programmatic workflow. ADS staff showed that API traffic dominates all traffic, and while some of that is driven by Wikipedia and other large research services, it does seem to serve quite a broad range of users, and thus should be a priority for ADS.

We encourage ADS to capitalize on this success. We suggest ADS prioritize continuing to build, expose, and document APIs against as broad a range of internal services as is possible. For instance, the database that exposes information about what journals ADS indexes will be very useful to a number of communities.

Further, we suggest that ADS invest in building and supporting open source, open development Python clients for all their APIs. The community-built and maintained Python API client has proven very useful to the community over the years, but it only exposes some of the ADS API functionality, and its continued development and availability depend, as with all open source projects, on the future goodwill and availability of community members. We suggest that ADS investigate developing an astropy-affiliated package, or that they expand the existing lightweight ADS module for astroquery. ADS should lead the development of these packages, but should develop "in the open" as much as possible in order to maximize community buy in. This software

package should have examples (e.g. in Jupyter notebooks) that demonstrate how to exercise all the APIs.

We suggest that ADS use this package as the core of their outreach efforts to both the technical user community and to peer institutions (other ADCAR archives, global astronomical data archives, arXiv, other bibliographic engines). The APIs and client library should provide a rich platform upon which scientific users can experiment with advanced methods (e.g. machine learning techniques) which could enrich the broader community and perhaps make their way back into the ADS stack. These tools will also be very valuable for other data infrastructure projects, which can then feed requests back to ADS for richer features and tools that would be broadly beneficial to many other services.

User support

The User Group applauds ADS efforts to provide professional support and documentation for users of this service. We recognize that the ADS's outreach efforts, through emails, blogs, and video office hours, successfully softened the transition away from the classic interface for the overwhelming majority of users. The feedback widget, present on every page, is also effective at providing a clear way for users to engage with the curation of content important to them.

We encourage the ADS user group to consider deploying a public support forum to complement their current email support, and to replace their API support forum on Google Groups. Such a forum would make support discussions more useful over their life (questions already answered become a knowledge resource for other readers). A forum is also an excellent way for power users to share tips, such as sharing sophisticated queries or API usage.

User support is a bellwether for potential documentation updates. We encourage ADS to put a process in place to update, refine, or produce new documentation so that most support questions can be ultimately answered by formal user documentation.

Accessibility

Strong support for accessibility is both a good business practice and recognition of the diverse ADS user base. ADS needs to prioritise making the ADS site fully accessible, ensuring that the ADS service remains fully usable by all users, including but by no means limited to those using screen readers or with visual impairments. The ADS team has provided a short-term partial solution through the Basic HTML interface, but this capability is not widely known and likely does not fully address accessibility requirements. Making all parts of the ADS website fully accessible needs to become a priority, even in a landscape of limited resources. We particularly note that both NASA and the Smithsonian Institution aim for full compliance with Section 508 and with W3C Web Content Accessibility Guidelines (WCAG) on their web sites; ADS should plan a path toward a similar standard.

Avoiding legal risk is also critical to all organizations. Compliance with the Americans with Disabilities Act, for example, has been an increasing source of legal action within the United States. Following WCAG guidelines has become the standard practice for becoming compliant with this law. Following accessibility laws and guidelines will also become increasingly urgent at the international stage; maintaining compliance will limit risk. We note that this goal may dictate or contribute to the choice of tools for any front-end refactor.

Institutions, metrics and open access

The success of ADS is a useful example for institutions, and for other disciplines, of the power of 'open bibliometrics' as part of a broader program of 'open science'. ADS users have access not only to the data contained within the system, but also to a vast amount of metadata which can be used to analyse the content. This open access to such data should be encouraged across disciplines, a goal which incorporating planetary science further into ADS would support.

ADS can also benefit from and collaborate with other, open systems. We urge the team to explore options for working with research information management system or repositories where relevant.

Project Scientist Position

The ADS Users' Group recognizes the importance of the project scientist position in providing both leadership and essential long-term thinking about ADS strategy and goals, as well as the research effort that underpins much of the system's expansion. The project scientist is also an invaluable link to the broader research community which ADS serves. The project scientist role will be especially important as ADS completes its technical transition and looks to bold new ways to enhance astronomical research.

The need for planning for succession for this important role was noted in the 2017 ADSUG report, and last year the group recommended a search start '*as soon as possible*'. While interim arrangements are in place for next year, we recommend that the project scientist position - as a full time, ongoing and senior role, with substantial time allowed for independent research - be filled as soon as possible. It is encouraging to see this role included in the baseline budget for the forthcoming review - as a full time, rather than, as previously, a half-time position - but more support may be necessary to ensure that the allocation of resources for this role do not detract from the day to day operational capacity of the team.

Expanding into Planetary Science

Exoplanets, one of the three main science themes in the NASA Astrophysics Division, is not only an extremely rapidly growing field but is also becoming increasingly interdisciplinary. The

astrophysics and planetary science communities are realizing that they need each other's data and results to move the field forward, This problem is growing at an alarmingly fast rate, and so if the ADS were to bring planetary science into their core set of science fields that they actively curate, it would be a boon for the communities on all sides of exoplanet research. As stated in last year's report, there is substantial support for inclusion of these data from the scientific community. The ADS team estimates a need of a roughly 20% increase in resources to curate the planetary science data and support the additional interdisciplinary user community. There is a particular need to interact directly with the PDS nodes to make this task viable. In particular, it is especially difficult to find data associated with manuscripts *across* NASA divisions and scientific disciplines, and thus incorporating the PDS bibliographies into ADS is imperative to accelerating research results in the field. Last year, the ADS submitted a proposal to NASA to include planetary science data and thus enhance its support for the field of exoplanets as a whole. The ADSUG believes this effort is a priority and strongly supports the level and spirit of the request. Thus the ADSUG also strongly encourages NASA to quickly find a way to support this important interdisciplinary endeavor.

Staffing and funding

The current team are, as noted above, working well together and making substantial progress in the transformation of ADS into a modern and flexible system. However, the group noted continued problems in hiring, with positions remaining open for periods of many months, due to the competitive market for software developers. In such circumstances, retaining enough flexibility in the team to cover for vacancies is essential, and the Users Group supports flexible budgeting which allows for ongoing recruitment.

Specifically, in the upcoming 2020 review, we would support the ADS team in applying for a modest overguide funding request to enable the team to fulfil ADS' potential and their ambitions for the system.

We also encourage the ADS leadership to consider alternative funding sources, for example through grant programs, or by exploring opportunities for neighbouring disciplines to astrophysics to contribute. Further, ADS should investigate whether sharing staff with other entities within the CfA (e.g. Chandra) would ease hiring.

Conclusions

The period covered by this review was one of significant change for ADS, and the effort represents the culmination of many year's work. The team are well equipped for the challenges ahead, and we support them in their determination to ensure that momentum is not lost. This is particularly important when it comes to further reducing or eliminating the system's dependence on legacy code. The upcoming review offers a chance to ensure ADS is core to the work of not only astrophysicists, but also planetary scientists, in the decade to come.

Chris Lintott, for the ADS Users Group.