Tracking Heliophysics to 2050: Using the Application Usability Levels to Ensure We Stay the Course Authors: A. J. Halford, A. C. Kellerman, S. A. Murray, R. M. McGranaghan, A. J. Mannucci, S. F. Fung, L.K. Jian, C. Cid, J. Klenzing, B. A. Carter, Y. Zheng, L. Rastaetter, B. Thompson, K. Garcia-Sage, S. J. Bingham

1 The Need for A Generalized Tracking System to Work Across Project Types

Tracking a project or team's productivity, progress, and usefulness can help manage institutions and collaborations. Having a framework of metrics that are easy to use and interpret can help show advancement towards goal fulfilment, the success of a program, identify where roadblocks exist, and help plan future directions and resources that may be needed [1]. As we look ahead to 2050, adopting such a framework can help ensure progress towards identified science objectives. Multiple such frameworks exist [1, 2, 3]. However, using a single framework can ensure (1) clear communication for reporting progress across programs and project types; (2) when comparing two or more projects for specific use (i.e. same application and requirements); and (3) consistency with tracking each group's current progress towards usability and on-demand use. A framework should work for all groups and projects within and across institutions. If not all project types can achieve a "top grade," it implies that those projects are less productive or successful, when the reality is that the framework is simply poorly-suited to the particular project type.

There are many tracking systems and frameworks currently available. Perhaps the most well known is the Technology Readiness Levels (TRLs), but others such as the Application Usability Levels (AULs) [3][see references therein for a description of the Application Readiness Level (ARL) Framework] have since been developed to fill identified gaps.

2 Definitions and Terminology

When working across disciplines, one finds that different groups define terms differently. In [3], we defined many of the common words used when describing the AUL framework. For this white paper, we define "researcher" as a person or team developing a product that is being tracked for a specific application. A "user" is the person or team that will be using a product or output of a product. The user may be another researcher or perhaps an industry partner. When working with a cross-disciplinary group of people, we note that the best practice is to keep track of the common words and definitions that may cause confusion. We, as a grassroots group, have put together the start of a living dictionary https://tinyurl.com/HelioLibrary. However, this living dictionary would benefit from living in a more 'concrete house' such as NASA.

3 Two Frameworks

The TRLs : One of the first frameworks developed to communicate a project's readiness for a specific application was the TRLs. The TRL methodology originated at NASA in the 1970s to aid in selecting new technology for spaceflight, and was developed into a 'maturity scale' by 1995 [2]. Equivalently, the European Space Agency (ESA) TRL definitions are at http://sci.esa.int/sci-ft/50124-technology-readiness-level/ [4]. This framework allows for tracking the readiness of flight hardware for use in space. With this framework's success, institutions have attempted to apply TRLs to many other types of projects, including non-hardware, non-spaceflight projects.

The TRL framework was explicitly designed for spacecraft and instruments/software that fly in

space. This can be seen in the requirements to reach specific levels as defined in [2] and provided at ESA [5, 4]. For example, TRL 8's requirements are written as "Actual system completed and qualified for flight through test and demonstration." The initial TRL framework was designed to be high level and general to allow for flexibility between space instrumentation projects but still targeted specifically for space hardware components. While it is essential to keep a framework such as TRLs general, it is also useful to find metrics and requirements which ensure a product or outcome will benefit the user. However, by having requirements written using the spaceflight metrics as above, projects that are not expected to go into space, but may provide a specific use to a user, cannot reach the higher levels and thus cannot be identified as 'TRL 9'.

Thus, the generality of other TRLs does not guarantee that the project fulfills the end user's needs. This is especially true as the TRLs do not specify identifying metrics, requirements, or communication with an identified user. This leads to TRL implementation challenges as reported by Olechowski et al [6] - notably, subjectivity of the assessment and imprecision of the scale across projects. This limits the types of projects that can use the TRL scale to communicate their progress to become operational and useful to the identified user or user community.

The AULs: Members of the space weather community identified a need for a framework to help communicate a user's needs to the researcher [3]. This framework would help ensure that a project was correctly targeted and would produce a usable product. While the TRL framework was considered, it was found to not adequately communicate a project's usability for research, forecasting applications, or space weather tool development. The effort to create such a framework that would benefit these wide varieties of projects resulted in the Application Usability Levels (AULs) described in [3, 7, 8]. The AUL framework focuses on clear communication between the team developing the tool or project for a specific application and their identified user. Focusing on communication ensures that the project will meet the needs and requirements of the user. The benefits of using the AUL framework include improving access to collaborators, project transparency, and communication of project results. Although milestones are identified in each level, they are written in a general format to allow flexibility between individual projects and types of projects; e.g. hardware, software, or research projects.

Like the TRLs, the AULs have nine levels that are divided into three phases. Phase 1 is focused on discovery and viability. Within the first three levels, basic research and development are completed. The user is identified, and the requirements for the project are established. Finally, the viability and feasibility of the project are assessed before moving ahead to Phase 2. Phase 2 is when development, testing, and validation are completed. This includes integration, validation, and demonstration of the project working within the relevant context. Phase 3 concludes the project with its implementation and integration into the operational context.

As always, we welcome new examples and new collaborators for this ongoing project. We hope that through continued and increased use, the AUL framework will improve and enhance new projects' communication and usability now and beyond 2050.

4 Conclusions

Tracking projects and teams from a programmatic perspective has the benefit of ensuring their usefulness to the intended communities, identifying systematic roadblocks (and thus where new

calls for research/missions are necessary to make progress), and shows progress within the field.

Finding- Important to choose the right framework to show progress towards institutional goals: Choosing the right framework is essential when working with multiple project types. No single set of metrics will capture all that is required, and all metrics have built-in biases. For instance, the TRLs have a bias against projects that do not fly in space. The AULs have a bias towards projects with an identified external user. The tracking framework that works best for an institution or a project then comes down to which one provides the right kind of information. The use of multiple frameworks is sometimes applied to mitigate these issues. Within ESA, there is a second step beyond the TRLs to ensure that projects have indeed completed the levels claimed. This process is the Technology Readiness Assessments [5, 4]. It is standard project practice to verify that levels have been reached, and documentation for each level has been provided, e.g. user manual or lessons learned. Much of this is explicit in the AUL milestones. However, it is suggested and encouraged that a similar process, led by an independent validator, be completed if the AULs are used.

Recommendation- When appropriate apply a tracking framework to proposal calls: The Applied Science Division has shown the benefits of using a tracking framework. We believe that many of the Heliophysics Divisions calls could equally benefit by applying a framework such as the AULs.

References

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