EARTH SCIENCE
APPLIED SCIENCES

NASA EARTH SCIENCE
EARLY ADOPTER HANDBOOK

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OVERVIEW

In constant search of solutions to transition science into applications, Early Adopters volunteer to provide feedback that helps NASA missions develop stronger data products with improved capacity to respond to evolving societal challenges. This handbook explains how NASA runs its Early Adopter programs with recommendations for effective implementation based on lessons learned over the past decade. Insights on how to attract and sustain engagement with Early Adopters through an inclusive and equitable process is of interest not only to mission Applications Coordinators, but to anyone interested in more quickly and effectively achieving societal benefits from space-based Earth observations.

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PURPOSE

The purpose of this handbook is to provide a comprehensive set of guidelines for creating and implementing an effective Early Adopter program within a Project Applications program, in accordance with the Applied Science Program's Early Adopter Strategy.

The goal of the Early Adopter Strategy is to maximize the benefit of NASA Earth Science Division (ESD) investments by enhancing the applications value and overall societal benefits of a flight project or instrument (both hereafter referred to as the mission) through:

- Implementation of a mission Early Adopter program
- Demonstration of the mission's benefit to society and contribution to the achievement of positive societal outcomes
- Identification of Early Adopter activities and strategies to maximize the utility of early observations
- Increasing the utility of data products and their value for decision making
- Fostering a community of users who will work with the mission throughout its life cycle

The handbook focuses on the execution of an Early Adopter program throughout the mission lifecycle.

Toward this end, this document contains detailed descriptions of programmatic activities associated with an Early Adopter program, examples of common challenges that may arise and potential mitigation strategies, and commentaries from previous or existing mission Early Adopters, mission Applications Coordinators, and/or Project Scientists.

CREATING AN EARLY ADOPTER PROGRAM

Early Adopter programs aim to accelerate the ingestion and use of NASA data by decision makers and in turn, provide Early Adopters with proxy/simulated data products before launch, build capacity to use these products, and foster interactions between the Early Adopters, Project Scientists, the Science Team, and the Applications Team to enhance algorithms and data products for wider utility. The goals of an Early Adopter program are to:

- Provide individuals and groups with the unique opportunity to partner with Project Scientists in their discovery of the mission data and measurements
- Formalize Early Adopter commitments to provide the mission with valuable feedback on how data can be used for decision support
- Accelerate the use and integration of NASA products into applications post-launch by providing support from the mission and the Applications Team to Early Adopters who commit to engage in pre-launch activities
- Facilitate feedback and insights regarding the potential benefit of observations to society and how these benefits can be integrated into sustained services
- Expand a mission's user communities to include Early Adopters who have a clear connection to decision making

An Early Adopter program consists of five fundamental sets of activities that are planned and conducted throughout the mission life cycle. Each life cycle phase includes Early Adopter program activities that are relevant and timely to the development of mission/instrument data products (see Appendix A for a notional schedule of Early Adopter program activities). Iterative user-centered engagement and involvement throughout the mission life cycle is key to providing effective support to Early Adopters.

Implementation of a mission's Early Adopter program depends entirely on available mission resources (funding, personnel, etc.). Plans for creation and implementation of an Early Adopter program should be well documented within a mission's Project Applications Plan as early as possible.

The following sections of this document provide guidelines for executing the five sets of activities needed to create, implement, and maintain an effective NASA Early Adopter program.

1. UNDERSTAND YOUR STAKEHOLDERS

Recognize Early Adopter Program's Stakeholders and their Responsibilities

A stakeholder is anyone who may be affected by or perceived to be affected by a decision, activity, or outcome of a mission's Early Adopter program. Mission Applications Coordinators shall identify their program's stakeholders early in the mission life cycle by assessing their interest, influence, importance, and impact on the Early Adopter program. Doing so will ensure successful management of stakeholder relationships and expectations by allowing the Applications coordinator to:

- Understand stakeholder priorities and interests
- Develop strategies for effectively engaging and/or reporting to the program stakeholders
- Provide a common understanding of the program goals and commitments
- Clarify expectations and potential impacts of the Early Adopter's feedback or requests
- Adapt Early Adopter program activities to consider different stakeholder needs

Early Adopter program stakeholders include representatives from the NASA ESD Applied Sciences Program, Science Team, Applications Team, Distributed Active Archive Center (DAAC) Team, Early Adopters and broader user communities. Key stakeholders will fulfill the responsibilities highlighted below. Examples of the key stakeholders who might pursue each responsibility are provided in parenthesis with the understanding that the responsible parties may change, and one person may perform multiple sets of responsibilities. Apart from the Early Adopters, these key stakeholders will correspond to members of the mission's Applications Team.

- **Establish, manage, and coordinate all components of an Early Adopter program.** Responsibilities include member recruitment and engagement, planning and hosting of any Early Adopter events, and liaising between Early Adopters and Project Science representatives. (Project Applications Coordinator(s))

- **Provide guidance to Applications Coordinators at the project level and set expectations for high value applications** and guide Early Adopters on functionality of mission data and on mission status. (Project Scientist and Deputy Project Scientist[s])

- **Support the Early Adopter program efforts by guiding Early Adopters on expected data access and discovery tools** and gather feedback from Early Adopters to improve planned user data services. (DAAC Team)

- **Partner with Early Adopters to provide guidance based on their topical, mission, data product, and algorithm expertise relevant to Early Adopter's application.** In addition, one Science Team Member serves on the Applications Team as the liaison and representative of the Science Team and provides guidance on Early Adopter activities. (Science [and Applications] Team Members)

Early Adopters engage in pre-launch and post-launch activities to demonstrate the utility of mission data in applications that benefit society. They provide the mission with valuable feedback on how Earth observation data can be used for decision support.

Overall, the Early Adopter program stakeholders work together to ensure programmatic and individual Early Adopter success by:

- Facilitating incorporation of Early Adopter contributions into mission reporting and information dissemination
- Providing Early Adopters with simulated or proxy data via the DAAC or other appropriate channels
- Providing Early Adopters with planned pre-launch calibration/validation (cal/val) data from field campaigns, modeling, or synergistic studies, and access to data from mission simulators as available and appropriate
- Supporting the Early Adopters in getting access to and resolving issues with pre-launch data sets.

Identify Potential Early Adopters

Applications Coordinators shall identify and characterize their Communities of Practice[1] and Potential, as well as high-value applications, through user research studies. Routine assessment of an applications community shall be conducted throughout a mission lifecycle. An initial assessment shall provide insights into who is interested in the planned mission data and why. Subsequent assessments shall evaluate the diversity of the applications community, identify potential applications for the data, and identify underrepresented thematic areas that would benefit from new Early Adopter activities.

Before launching the Early Adopter program, Applications Coordinators shall:

1. Build a contact list that identifies individuals and groups from the user communities with high-value applications
2. Establish strategic alliances with key users of satellite remote sensing data within the federal government to aid in defining the community of practice and as a key investment towards establishing an initial pool of Early Adopters that could benefit from participation.

[1] Lave, Jean; Wenger, Etienne (1991). *Situated Learning: Legitimate Peripheral Participation*. Cambridge: Cambridge University Press. ISBN 978-0-521-42374-8.

"It was the feedback from the user community about having a consistent step size of 100 m (rather than a variable size) that led me to make that [data algorithm] decision." - Amy Neuenschwander, ICESat-2 Science Team Member, describes change to land and vegetation data product algorithm resulting from user feedback

Early Adopters from the Community of Practice may seek to use their research in decision support and will actively foster new partnerships and collaboration to help generate new knowledge and innovations. Early Adopters from the Community of Potential will be eager to learn about the mission data but may not be as active in seeking new partnerships and collaborations. Continued engagement with both communities and increased understanding of the functionality of the mission data by these communities will help foster new ideas, applications, and innovations.

Identify Potential Benefits of your Early Adopter Program

Applications Coordinators shall work with the Applications Team to characterize the potential benefits of their Early Adopters program. Example benefits are highlighted in this section. Early Adopters participate in mutually beneficial partnerships with Science Team members and mission representatives. Knowledge exchanged through these partnerships helps inform decisions, advance ideas, and formulate new research, applications, technology, and/or business prospects. Early Adopters have expressed many benefits of participating in the Early Adopter programs including:

- Networking and building partnerships within the mission's research and applications community
- Opportunities to host or participate in applications activities and to be involved in mission workshops, telecons, and events
- Building new relationships and collaborating with other Early Adopters
- Early interaction with Science Team members to learn about the data products and to readily identify opportunities and challenges associated with using the data
- Gaining efficient pathways to find the right answers
- Receiving constructive feedback, opinions, and thoughts
- Early access to basic and technical information; increased awareness of the mission, data and schedule
- Early access to any data provided by the mission
- Opportunity to see research used in an application
- Opportunity to develop research ideas and to conduct future planning
- Facilitated collaboration and communication with Science Team members and DAAC representatives
- Opportunities to become both an "insider" and "ambassador" for the data, instrument, and mission
- Increased capacity for access and use of pre-launch simulated and proxy mission datasets

It is essential to find dedicated Science Team and Applications Team members who will act as champions and partners of the Early Adopters. Science Team participation in an early Adopter program can help signal a wider organizational commitment to work with the end user community to improve the utility of the data products for decision making. Early Adopter feedback to the Science Team members, mission and DAAC representatives can help inform data product and algorithms development, as well as user services, as exemplified in the examples below:

Based on Early Adopter feedback and need for user-friendly maps with consistent color scales that they can use to communicate risk to their communities, the **Plankton, Aerosol, Clouds, and Ocean Ecosystem (PACE)** mission developed software tools and packages to allow the user to convert to more user-friendly file formats (e.g., NETCDF to a GeoTiff).

- **Benefit to user services:** Feedback from the Plankton, Aerosol, Clouds, and Ocean Ecosystem (PACE) Early Adopter on the need for user-friendly maps with consistent color scales to communicate risk to their communities led the mission to develop software tools and packages to allow the user to convert to more user-friendly file formats (e.g., NETCDF to a GeoTiff).
- **Benefit to algorithm development:** Feedback from Early Adopters and the broader user community to the Ice, Cloud, and land Elevation Satellite-2 (ICESat-2) mission resulted in a change to the land and vegetation data product algorithm. ICESat-2 Science Team member, Amy Neuenschwander noted that, "it was the feedback from the user community about having a consistent step size of 100 m, rather than a variable size, that led [her] to make that [data algorithm] decision. Also, from feedback from the community, we incorporated more relative canopy height metrics in addition to just the top of canopy height."
- **Benefit to product development:** The Soil Moisture Active-Passive (SMAP) mission had a mission requirement to produce its level 2 soil moisture product with a latency of 24 hours. Based on feedback from Numerical Weather Prediction (NWP) users, anything beyond 3 hours latency is not useful for assimilating observations into operational forecasting. SMAP Deputy Project Scientist, Rajat Bindlish noted that, "In response to this feedback expressed pre-launch, the SMAP Project produced a near-real-time (NRT) product with a latency of 3 hours. While the NRT product is of a slightly degraded quality, it has been used by the U.S. Air Force 557 Weather Wing operationally in their weather predictions since 2019."

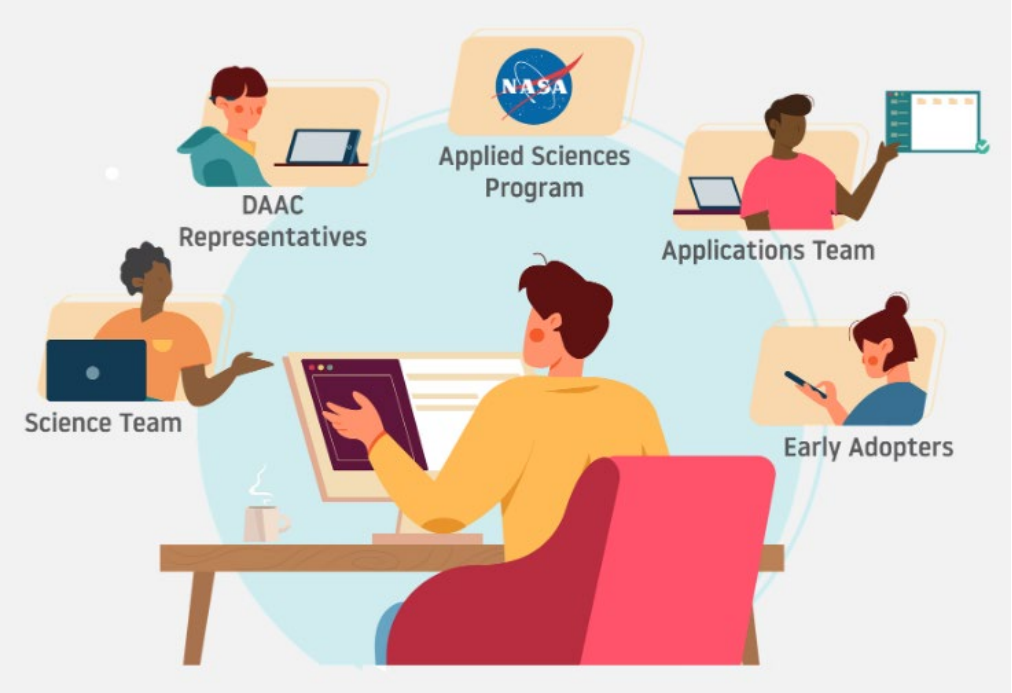
In addition, Science Team and mission representatives will also benefit from collaborating with Early Adopters on validation activities (e.g., post-launch assessments to determine data accuracy/precision using field experiments or in situ monitoring).

2. STRATEGIZE COMMUNICATION

Regular engagement and communication with all Early Adopter program stakeholders is essential to increase programmatic visibility, feedback, and support. One of the first steps of an Applications Coordinator in building an Early Adopter program is developing an effective engagement plan. Development of an Early Adopter engagement plan consists of mapping out internal and external communication goals and processes at the various levels of engagement.

The SWOT Applications Working Group (SAWG) provided the SWOT Project with a detailed assessment of user needs with respect to data latency, based on survey, workshop, and direct engagement with a broad spectrum of future applications data users, including many who have subsequently become SWOT Applications Early Adopters. Consequently, the SWOT Project reduced the latency of some instrument data products from 45 days to less than 3 days. As a result of this project investment, the data from SWOT will be more widely available for applications with short time critical needs and will demonstrate the value of the significant investments made by NASA and partners in satellite remote sensing for societal benefit. - Margaret Srinivasan, SWOT Mission

Establish Feedback Loops



Effectively managing large interdisciplinary teams and stakeholders is critical to fulfilling the goals of an Early Adopter program. Management of an Early Adopter program requires ongoing conversations where feedback and opinions are incorporated quickly, efficiently, and accurately to inform program changes and improvements. Effective communication of program results (i.e., reporting) to stakeholders is an important part of this effort. The following reporting strategies and feedback loops shall be established to ensure successful engagement with various stakeholders of an Early Adopter program:

NASA ESD Applied Sciences Program. Reports to Applied Sciences leadership shall describe how the Early Adopter program is progressing towards high-level goals and metrics and inform leadership of the status, successes, and challenges of the program. Reporting on the value proposition of data products (i.e., factors that increase or decrease the value of mission data for data user communities) can assist ESD leaders to make decisions regarding investments or lead to short-term changes that can create long-term benefits for applications. Reporting may occur at monthly meetings with the Project applications program lead, flight program review meetings, mission applications review meetings, and Science Mission Directorate's monthly status reviews. Data and information reported at this level shall include status, successes, and challenges (where an impact to the application value is possible). One-page briefings that provide a snapshot of the Early Adopter activities may also be developed.

Science Team. Since Science Team members partner with Early Adopters, it is important to continuously solicit feedback regarding their engagement with Early Adopters. This feedback can help mission Applications Coordinators determine the value of these collaborations and opportunities for growth. Science Team meetings offer the perfect opportunity to engage team members, raise awareness of the Early Adopter program, and increase the number of members that will champion and partner with Early Adopters.

Reports to the Science Team shall include information on Early Adopter selection and activities, planned activities where Science Team members may interact with Early Adopters, solicitations for new partnerships by Early Adopters, as well as Early Adopter feedback that may inform Science Team product and algorithm design.

Applications Team. The Applications Team shall meet regularly to discuss progress on all applications activities, including the Early Adopter program. These meetings shall be used to discuss new Early Adopter applications, to report on Early Adopter progress, and to address concerns and questions received via feedback from Early Adopters. Such meetings also offer an opportunity to discuss any gaps in Early Adopter activities with respect to the goals of the mission, help formulate new activities, or target new communities of users. Mission Applications Coordinators shall clearly report any actions or requests for information from the Project Scientist/Deputy Project Scientist and Science Team to optimize the engagement with those parties.

DAAC Team. The DAAC Team supports missions by maintaining ingest, archival, and distribution data systems, by developing tools and services for data access and usage, by ensuring data integrity and by providing users with scientific and data product expertise. Periodic reports to the DAAC staff by Applications Coordinator(s) are helpful for communicating user community feedback, including information from Early Adopters on data access needs. The DAAC staff shall use this feedback to create or enhance planned tools and services (e.g., reformatting, data readers).

Early Adopters and Broader User Communities. One of the goals of engaging Early Adopters is to develop a narrative on the use of the mission data to address public value goals. Reporting on and creating awareness of Early Adopter activities can help motivate new areas of application in the broader user community. Similarly, providing feedback and reporting on Early Adopter's applications to a mission assists with creating a data value proposition for societal benefit. Applications Coordinators shall work with Early Adopters to develop case studies, story maps, knowledge flow maps, journal articles or special issues for publication, applications white papers, and applications traceability matrices to help communicate their narratives. These products can be shared via the mission website, as well as during conferences, workshops, and other community events. Newsletters or periodic email messages to user communities can also highlight these narratives. Additionally, facilitation of communication between teams of Early Adopters can aid with knowledge sharing, help promote new research and application ideas, and assist with troubleshooting. Use of various reporting and feedback mechanisms such as messaging applications can ensure successful community engagement. As an example, the NASA Ecosystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) mission set up a Community of Practice/Early Adopter Slack channel to support collaborations, discussions, and feedback regarding ECOSTRESS data and use.

Engaging with Early Adopters

Prior to the Early Adopter recruitment and acceptance process, the Applications Team shall develop a strategy for communication as part of the engagement plan between the mission and its user community. This plan outlines the type, timing, and frequency of communications, events, data trainings, and mission outreach. The plan shall identify strategies and actions required to promote productive involvement of Early Adopters in the Project Applications program. The plan shall be updated as Early Adopter engagement needs change and the mission progresses through its life cycle phases.

Formal Early Adopter Engagement

Activities, programming, and one-on-one engagement that enable Early Adopters to voice their experiences and concerns and to realize those concerns are being heard and addressed are essential to sustain Early Adopter engagement during a mission's pre-launch phases. Project Applications program activities include at least one event per year to communicate with user communities. Applications Coordinators shall leverage at least one of these events to engage Early Adopters and explore how a mission's data can help serve their needs. The following are examples of the types of events that could serve this purpose:

- **Early Adopter teleconferences** are routinely scheduled meetings to communicate status, provide updates, and share ideas relevant to mission applications and an Early Adopter program. Telecons allow for informal collaborative discussion between Early Adopters and various mission representatives.
- **Workshops** are widely announced meetings that cover a broad diversity of topics to facilitate collaboration among mission user communities with diverse interests. At a minimum, missions should host at least one workshop per year, as part of their Project Applications programs.
- **Focus Sessions** are smaller events tailored to specific mission user communities and provide detailed information about a connected group of products and/or applications.
- **Tutorials** are meetings to explore potential synergies between datasets and to leverage innovation on how to best combine them.
- **Town Halls** provide an interface for questions to be answered by the mission Project Scientists, Science Team, and Application Team.

Additionally, missions may host their own trainings to help participants learn about specific mission data access and/or processing tasks. Applications Coordinator(s) can leverage these trainings to increase Early Adopter awareness of mission data products, visualization software, processing tools, etc. As an example, the PACE mission periodically updates and provides trainings/tutorials on its data analysis software package, SeaDAS[2].

[2] NASA/OB.DAAC Data Processing Software, SeaDAS. https://seadas.gsfc.nasa.gov/

Informal Early Adopter Engagement

Mission Applications Coordinator(s) shall routinely engage with Early Adopters and user communities in an informal fashion. No one-size engagement strategy fits all missions' programs; however, a strategy that combines small working groups, newsletters, social media campaigns, and individual meetings can increase Early Adopter program success. Applications Coordinators act as a liaison between a mission's science and user communities, advocating for the needs of the user related to applications. This role is critical in advancing the societal value of NASA mission data.

Informal engagement with Early Adopters shall be conducted at both the individual and group levels. One-on-one calls or meetings between the Applications Coordinator(s) and an Early Adopter can help clarify expectations for participation in the Early Adopter program. These calls offer an opportunity to exchange information on prior use of satellite data, current use of proxy/simulated datasets, expected use of planned data products, and expected benefits of and barriers to data use. Informal engagement also helps clarify the capacity of the Early Adopter to use the mission data to reap insights that affect decision making, thus helping formulate a narrative about the societal benefits that mission data can generate.

Informal engagement can also help a Project Scientist, Science Team members, and/or DAAC representatives identify emerging challenges associated with data use and initiate proactive action to ensure mission data is accessible, useful, and actionable. Building relationships with Early Adopters through informal engagement can have long-term benefits such as enhanced public perception of the mission, generation of new ideas and applications, and agreement on purpose and direction of an Early Adopter's use of mission data.

Determining Frequency of Engagement

One of the first considerations for determining the frequency of engagement with Early Adopters is the mission phase. At program conception, it may be necessary to actively engage with Early Adopters more frequently to bring them "up to speed" on program goals, activities, and expectations. For example, the NASA PACE Early Adopter program hosted monthly telecons during its first year to ensure all new Early Adopters had the opportunity to connect with existing members of the community, then later transitioned to quarterly telecons. Similarly, as the launch date approaches, it may be more appropriate to increase the frequency of engagement using data trainings, Early Adopter spotlights—briefings shared with NASA ESD leadership and publicly, and telecons to prepare the Early Adopter community for launch and delivery of mission data/products.

The appropriate level, type, and frequency of engagement also depend on the Early Adopters and their expertise with the applied topics and mission datasets. Likewise, Applications teams shall determine frequency of engagement with stakeholders based on the team's capacity and the Early Adopter's needs. Some Early Adopters may require only occasional engagement, while others may benefit from more frequent engagement. For example, some Early Adopters may simply need a website or information repository that they can visit at their leisure to obtain information. Other Early Adopters will need more active engagement, such as routine emails, online presentation requests, and/or face-to-face meetings.

3. LAUNCH YOUR EARLY ADOPTER PROGRAM

Launching an Early Adopter program requires building awareness of the program goals and benefits via Early Adopter events, as well as recruiting new Early Adopters through a carefully planned, inclusive recruitment and acceptance process.

Recruit Early Adopters

There are many strategies that can be leveraged to increase awareness of an Early Adopter program and recruit Early Adopters throughout the project's pre-launch lifecycle.

> **Active recruitment** includes advertising for participants at scientific conferences, workshops, and other engagement events; reaching out directly to individuals with known interest; and media or press releases.
>
> **Passive recruitment** consists of calls for participation via the mission website, via newsletters or periodic emails to the applications community, as well as by word-of-mouth. Science Team members, existing Early Adopters, mission scientists, and DAAC representatives—all potentially strong champions for the Early Adopter program—may also nominate and recommend potential Early Adopters.

The number of Early Adopters will depend on the available mission resources. Limiting the pool of Early Adopters will ensure the Early Adopters, Applications Coordinators, Science Team members, and mission team members have enough time to engage productively.

Considerations for Inclusive Recruitment and Diversity within Early Adopter Programs

A carefully planned and inclusive recruitment process is crucial to ensure that Early Adopters represent the *diverse types of expertise, knowledge, and actors* needed to support different pathways for sustained use of applications in decision making. There are several ways to promote broad, inclusive, and equitable recruitment. Applications coordinators shall implement the following steps when recruiting and maintaining Early Adopters.

- **Widen your search to include a diverse range of Early Adopters** by considering users external to the research community. Potential Early Adopters could include individuals or groups from a national or international public or private sector organization, native regional corporation, industry association, university, and/or non-government organization that could apply the data products or measurements to support actionable decisions.

- **At least two members of your recruitment team** should actively challenge any assumptions that may arise when developing the selection criteria and when

selecting the Early Adopters. This practice helps identify unconscious biases and assumptions that may arise from cultural differences.

- **Make it easy for individuals to participate in the Early Adopter program** by increasing the visibility of the Early Adopter program and clarifying the expectations and commitments associated with the program.

- **Create incentives to encourage equitable Early Adopter participation** including:
    - Access to and support for pre-launch simulated, proxy, calibration, and validation data
    - Partnerships with Science Team members and direct access to Project Science representatives
    - Presence on mission websites, project promotion, and advocacy at internal NASA and external scientific events
    - Opportunities to network with NASA Headquarter representatives, Science Team members, mission scientists, and other Early Adopters
    - Participation in Applications program events, including workshops, focus sessions, tutorials, and quarterly webinars that facilitate direct support from the mission scientists and NASA DAACs
    - Opportunity to attend the mission launch and highlight their Early Adopter activities

Additionally, to ensure that Early Adopter events and activities are inclusive and accessible, it is crucial to accommodate different attendee capabilities, including the ability to see and hear event websites, presentations, and/or slideshows. Early Adopters' technological limitations and challenges, including access to a computer with high-speed internet, shall also be considered.

Develop and Implement a Vetting Process

A vetting process shall be conducted to make sure that Early Adopters who join the program will focus on accelerating the use of Earth observations in decision-making contexts. The vetting process shall involve a signed agreement or an application form that defines the Early Adopter's intended use and integration of mission data. This vetting process shall require evaluation of the following, which shall be provided by applicants when proposing to conduct activities as an Early Adopter:

1. Description of the application (including data currently used and ancillary data needs), including explanations of how it will be used by end-user and how it will support any existing decision-making activity.
2. If not a decision maker for a particular application, the applicant should demonstrate that work will be conducted in close coordination with (or on the behalf of) decision makers.
3. Willingness to learn about and access developmental products and to interact with the product developers—which will increase understanding and enable integration of the new products or measurements into the applicant's decision systems.
4. Agreement to provide feedback to the mission and Applications Team regarding data product utility as well as potential calibration and validation information (e.g., pre-launch simulated data products and plans).

5. Identification of metrics and testimonials that explain how the use of a data product or measurement will improve a policy or decision relevant to the applicant's organizational goals and objectives (i.e., a post-launch implementation strategy).
6. Institutional support (e.g., leadership support, access to resources and/or a plan to acquire needed resources) required to test the utility of simulated, proxy, or early mission data in their application.

Mission Applications Coordinators shall make sure that the language used in their agreement or application form does not come across as discriminatory by excluding age, gender or race references or criterion. The Early Adopter program shall provide applicants with clear guidance on what to expect in terms of commitments required and the process to join the Early Adopter program. The Surface Water and Ocean Topography (SWOT) mission, for example, created a SWOT Early Adopter program Guide that (1) identifies responsible persons within the program, (2) defines commonly used terms and roles, (3) outlines program goals and commitments from the mission and Early Adopter, (4) explains the application, selection process and areas of focus; and (5) outlines the planned engagement and activities.

Additionally, missions shall enable Early Adopters to request to be partnered with a Science [and Applications] Team member who can provide guidance and information on the measurement concept and data product development. Alternatively, once the Early Adopter is selected, the mission Applications Coordinator and Science Team liaison shall arrange a partnership between the Early Adopter and a Science Team or Project Team member.

The signed agreement or application form submitted by the Early Adopter serves as an initial point of comparison for future performance and process improvements and facilitates the post-launch benchmarking process.

Host Early Adopter Events

To maximize a return on investment and ensure value for mission Early Adopters, missions shall take the following steps to ensure success of the Early Adopter program's events specified in the Early Adopter Engagement Plan:

1. **Know your target audience.** Consider who will attend the event. What are participants hoping to gain by attending the event? What are the needs/goals of the event attendee? Consider asking the target audience for feedback using a pre-event survey.

2. **Establish very clear and defined event goals.** What should the event achieve? What are the tangible outcomes of the event? What does event success look like? Consider developing a prospectus for the meeting in collaboration with hosts, relevant Early Adopters, and Science Team members to establish and communicate event goals, strategies, expectations, and desired outcomes.

3. **Provide opportunity for two-way engagement to solicit audience feedback.** Be open to feedback and organize event sessions around questions that facilitate interaction between presenters, attendees, and event organizers.

4. **Create specific networking opportunities.** Provide space for people to gather, schedule networking events within the main event, leverage social media, and use live chat and live video streams (if virtual) and event gamification.

5. **Provide adequate content.** Supply pre- and post-event information and materials to encourage attendee engagement and follow-up. The more information event attendees receive, the more they value participation and the more likely they are to participate in and recommend future events. Consider sharing a list of participants, their roles, and contact information to help ensure that appropriate points of contact are identified and to facilitate communication after the event.

6. **Send out a post-event survey.** Identify where the event succeeded, how it could be improved, and ideas to incorporate in future events. Develop statistics that document the number and types of attendees; such statistics are particularly useful for high-level briefings about the event.

7. **Document feedback and lessons learned.** It is important to document the feedback and action items developed during the events. This documentation shall include reports to be shared with the mission and publicly via the mission websites, as well as meeting summaries in publications such as NASA's newsletter, The Earth Observer (https://eospso.nasa.gov/earth-observer-archive/).

The value of face-to-face, in-person events is undeniable, however, there may be circumstances that require virtual programming and activities. Virtual events that are hosted successfully may enable a mission to reach a broader user community than an on-site event would permit. Hosting a successful virtual Early Adopter event requires the same care and attention as an in-person event.

It is important to follow the strategies outlined above to create value-added, engagement-driven, and impactful virtual Early Adopter program experiences. Additional considerations relevant to virtual events include:

- **Virtual platform.** Virtual platforms offer an array of features that range from polls, breakout rooms, file sharing and chat to interactive content, built-in webcasting, and one-to-one networking. Identify what features will increase engagement, maximize learning, and promote networking based on your event goals.
- **Timing for your event.** Virtual events open the opportunity for Early Adopters to join from anywhere in the world. Maximize attendance by considering what times work best with different time zones and be sensitive to world holidays and observances. As part of the event agenda, integrate sufficient breaks to allow adequate time for lunch and stretches.
- **Event roles and dry runs.** Identify people to act as moderators, announcers, and technical point-of-contacts and conduct dry runs in advance of the event. Doing so will help balance responsibilities and allow for a smoother implementation of the agenda.
- **Technical troubleshooting.** Mitigate audio and video difficulties by identifying requirements and capabilities of your virtual environment and sharing this information with participants. Make sure to provide attendees with point of contacts for technical help, so that questions in the chat are focused on the

agenda content. Also, consider having an alternative virtual platform in case there is a need to switch over.

4. TRACK AND SHOWCASE EARLY ADOPTER ACTIVITIES

As Early Adopters conduct their work and engage with the mission scientists, they will learn more about how the mission data products function and may strengthen or change the implementation strategy for their application. Applications Coordinators shall track Early Adopters' progress throughout the mission life cycle. This section provides strategies for tracking and showcasing Early Adopter work and examples of useful tools and actions.

Assess Early Adopter Application Readiness

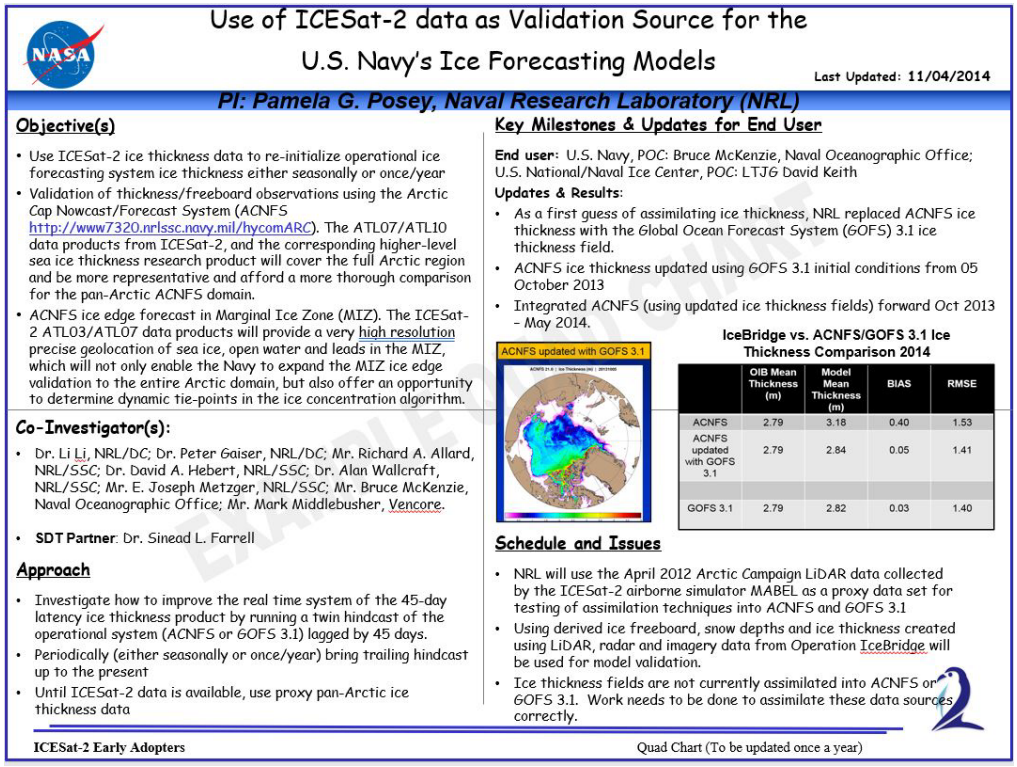
The NASA Application Readiness Level (ARL) scale shall be used to document and track how Early Adopter's ideas transform into sustained actions. NASA Applied Sciences uses the ARL metric to understand how ready an application is to be actively used for decision-making (see Figure 1, below). Early Adopters shall provide an assessment of their ARLs at the beginning of the project and periodically thereafter as application activities progress. The ARL metric will help illustrate progress towards ultimately reaching sustained use of the Early Adopter application system in a decision-making context (achievement of ARL 9).

Figure 1: The NASA Application Readiness Levels (ARLs)

Whether or not an Early Adopter starts a project at ARL 1 depends on the type of Early Adopter—e.g., whether the early Adopter hails from the Community of Practice or Community of Potential—and on whether the measurement concept for the mission is new or improves upon legacy data.

Document and Share Milestones

Progress milestones shall also be documented via quarterly meetings with Early Adopters. During these calls, Early Adopters shall highlight the status of their applications, provide updates on key milestones, share the schedule, and discuss any challenges. Missions shall provide Early Adopters with guidelines for reporting their application progress. The SMAP and ICESat-2 missions, for example, asked Early Adopters to develop 'quad charts' to provide quick-view, print-version overviews of the information shared during the calls (see Figure 2). These one-page briefings were distributed prior to the calls to participating mission scientists, NASA Headquarters representatives, and DAAC representatives to encourage questions and to facilitate solicitation of feedback from the Early Adopters.



Use of ICESat-2 data as Validation Source for the U.S. Navy's Ice Forecasting Models

Last Updated: 11/04/2014

PI: Pamela G. Posey, Naval Research Laboratory (NRL)

Objective(s)

- Use ICESat-2 ice thickness data to re-initialize operational ice forecasting system ice thickness either seasonally or once/year
- Validation of thickness/freeboard observations using the Arctic Cap Nowcast/Forecast System (ACNFS http://www7320.nrlssc.navy.mil/hycomARC). The ATL07/ATL10 data products from ICESat-2, and the corresponding higher-level sea ice thickness research product will cover the full Arctic region and be more representative and afford a more thorough comparison for the pan-Arctic ACNFS domain.
- ACNFS ice edge forecast in Marginal Ice Zone (MIZ). The ICESat-2 ATL03/ATL07 data products will provide a very high resolution precise geolocation of sea ice, open water and leads in the MIZ, which will not only enable the Navy to expand the MIZ ice edge validation to the entire Arctic domain, but also offer an opportunity to determine dynamic tie-points in the ice concentration algorithm.

Co-Investigator(s):

- Dr. Li Li, NRL/DC; Dr. Peter Gaiser, NRL/DC; Mr. Richard A. Allard, NRL/SSC; Dr. David A. Hebert, NRL/SSC; Dr. Alan Wallcraft, NRL/SSC; Mr. E. Joseph Metzger, NRL/SSC; Mr. Bruce McKenzie, Naval Oceanographic Office; Mr. Mark Middlebusher, Vencore.
- **SDT Partner**: Dr. Sinead L. Farrell

Approach

- Investigate how to improve the real time system of the 45-day latency ice thickness product by running a twin hindcast of the operational system (ACNFS or GOFS 3.1) lagged by 45 days.
- Periodically (either seasonally or once/year) bring trailing hindcast up to the present
- Until ICESat-2 data is available, use proxy pan-Arctic ice thickness data

Key Milestones & Updates for End User

End user: U.S. Navy, POC: Bruce McKenzie, Naval Oceanographic Office; U.S. National/Naval Ice Center, POC: LTJG David Keith

Updates & Results:

- As a first guess of assimilating ice thickness, NRL replaced ACNFS ice thickness with the Global Ocean Forecast System (GOFS) 3.1 ice thickness field.
- ACNFS ice thickness updated using GOFS 3.1 initial conditions from 05 October 2013
- Integrated ACNFS (using updated ice thickness fields) forward Oct 2013 – May 2014.

ACNFS updated with GOFS 3.1

IceBridge vs. ACNFS/GOFS 3.1 Ice Thickness Comparison 2014

	OIB Mean Thickness (m)	Model Mean Thickness (m)	BIAS	RMSE
ACNFS	2.79	3.18	0.40	1.53
ACNFS updated with GOFS 3.1	2.79	2.84	0.05	1.41
GOFS 3.1	2.79	2.82	0.03	1.40

Schedule and Issues

- NRL will use the April 2012 Arctic Campaign LiDAR data collected by the ICESat-2 airborne simulator MABEL as a proxy data set for testing of assimilation techniques into ACNFS and GOFS 3.1
- Using derived ice freeboard, snow depths and ice thickness created using LiDAR, radar and imagery data from Operation IceBridge will be used for model validation.
- Ice thickness fields are not currently assimilated into ACNFS or GOFS 3.1. Work needs to be done to assimilate these data sources correctly.

ICESat-2 Early Adopters

Quad Chart (To be updated once a year)

Figure 2: Example Early Adopter 'Quad Chart' from NASA ICESat-2.

Conduct Semi-structured Discussions

Semi-structured discussions shall be conducted by the mission Applications Coordinator(s) to collect information from each Early Adopter that can be easily compared with responses from other Early Adopters. These discussions shall be used to collect useful information on past and current use of satellite data, foreseen use and value-added of the planned mission science data products, expected benefits and barriers for using the data or measurements, changes in ARL levels, and progress the Early Adopter has made in engaging with the target end-user.

Below are example Early Adopter discussion questions used by the ICESat-2 mission that missions can customize. Applications Coordinators will need to consider when the Early Adopter joined the mission, whether the Early Adopter has changed roles within

their organizations, and the feedback they have provided previously in designing their own questions. While some of these questions will have been addressed by the Early Adopter when joining the program, feedback on them can be obtained again periodically particularly if the Early Adopter has been with the program a long time.

Questions about the Early Adopter and Early Adopter organization:

- How do you describe **your organization** to a broad audience?
- Please describe **your individual role** at your organization.
- How does your organization **use satellite data**, starting from how you access the data?
- Are you currently using any **preexisting NASA data sets** to inform your products/services?
- How do you plan to incorporate **ICESat-2 data and products** into your workflow/products/services?
- What are the **benefits and barriers** of ICESat-2 data for your project?

Questions about the Early Adopter's target end-user organization(s):

- Can you state your **target end-user** and your engagement with them since your involvement with the EA program?
- What is your **end-user's organizational capacity** to transform ICESat-2 data to information to insights, to affect decision making?

Showcase Early Adopter Activities

Benefits to showcasing Early Adopter activities that will transition mission science data into applications include raising awareness and interest in the mission and its observations, allowing the public to discover innovative uses of the mission data products, and demonstrating the societal value of the mission. Applications Coordinators shall highlight Early Adopter work in presentations to NASA ESD leadership, Project Science representatives, cross-mission exchange activities, and at non-NASA meetings, conferences, and events. In addition, missions may create web-profiles of Early Adopters and post them on the mission's Applications or Early Adopter webpages.

Applications Coordinators shall work with the mission to enable Early Adopter participation during mission launch. Many outreach activities are planned during this time to engage with the public—in person, and via media/social media—and provide information about the mission and its measurements. These events offer the perfect opportunity to showcase the Early Adopter activities and their potential to inform practical applications. The ICESat-2 mission, for example, collaborated with the mission's Education and Outreach Team to create a station where the public and media could interact with the Early Adopters and obtain posters and handouts that highlighted the proposed applications for the mission data.

Leverage Capacity Building Program for Promotion of Early Adopter

Mission Applications Coordinators will benefit from establishing early relationships and collaborating with NASA Applied Sciences Capacity Building program representatives. Applications Coordinators shall collaborate in training activities through the NASA Applied Sciences Capacity Building program's Applied Remote Sensing Training (ARSET), Digital Earth Virtual Environment and Learning Outreach

Program (DEVELOP), Regional Visualization and Monitoring System (SERVIR), and Indigenous Peoples Pilot projects, to ensure increased visibility of the mission and Early Adopter activities, create awareness of the potential applications for the data/measurements, and recruit new users. The PACE Applications program, for example, hosted representatives from the NASA Capacity Building program during a pre-launch (Phase-C) Applications workshop, while early engagement between the ICESat-2 Applications team and NASA ARSET helped facilitate and support two post-launch ICESat-2 mission trainings.

ECOSTRESS Early Adopters' feedback is being integrated into future NASA mission planning for the Surface Biology and Geology (SBG) Designated Observable study, including the need for mid-infrared to support mapping of high temperature features (fires and volcanoes) and uncertainty in evapotranspiration estimates introduced by temporal separation of normalized difference vegetation index (NDVI) and albedo with thermal measurements. – Christine Lee, NASA ECOSTRESS

5. IMPLEMENT POST-LAUNCH ACTIVITIES

After mission launch, Early Adopters shall demonstrate the functionality of their applications and build confidence for sustained use of these applications in decision-making activities. As data and measurements become available, the Early Adopter's application concept can be tested and integrated into the target decision making process. In this proof-of-concept stage, the Early Adopter program shall focus on documenting the approaches used to improve the utility of the Earth observations and on showcasing the benefits of repeated use of the application. While many Early Adopter program activities are targeted for the pre-launch phase of the mission, the following post-launch activities are considered an integral part of the program.

Measure Success of Early Adopter Program and Projects

Once mission data becomes available, the Early Adopter program shall track and document Early Adopter progress in integrating data into target application(s) so that the value of the mission can be clearly articulated. The following steps shall be taken to measure success of an Early Adopter program and individual Early Adopter projects post-launch:

- **Host a meeting shortly after launch to revisit benchmarking metrics.** The purpose of this meeting is to track progress of Early Adopter's projects, develop or revisit benchmarking metrics, and to prepare Early Adopters for conducting a meaningful evaluation of the mission data/measurement value. The objective of benchmarking is for each Early Adopter to compare their pre-launch integration activities to those that are produced after integration of the data. Each metric used in the benchmarking process is specific to the Early Adopter's project. Benchmarking metrics help the Early Adopters qualitatively or quantitatively evaluate the performance of the mission data products.

- **Assess the willingness of Early Adopters to continue participation in the program.** Sustained engagement into the post-launch phase of the mission may not be possible for some Early Adopters. The Applications Coordinator(s) shall communicate with all Early Adopters and determine their willingness to continue participating in the program.

- **Facilitate value-of-information assessments of Early Adopter activities.** While assessments of the socioeconomic value of the Early Adopter activities shall be

conducted by the Applications Team, the team may also nominate Early Adopter activities for evaluation by value of information (VOI) expert groups (e.g., the Consortium for the Valuation of Applications Benefits Linked with Earth Science [VALUABLES]). Collaborations between Early Adopters and organizations that work on VOI approaches can help identify the socioeconomic impacts to systems, decision processes, and target communities that resulted from mission data use.

- **Conduct post-launch interviews with Early Adopters.** Post-launch interviews help determine how successful implementation of an Early Adopter project has been with respect to chosen metrics and goals for success. During the interview, the Applications Coordinator(s)shall monitor changes in ARL levels, revisit benchmarking metrics, and clarify expected timelines for integrating the data using the post-launch implementation strategies proposed by the Early Adopter. The Application Coordinator(s) shall also solicit information on mission data use in terms of functionality, accuracy, latency, and accessibility, among other attributes. The interviews shall also provide insights into whether the DAAC delivery strategies and tools are consistent with the Early Adopter needs. Application Coordinator(s) shall gather feedback about the overall successes and challenges of the Early Adopter program, formulate lessons learned, and use this information as input to the Mission's Senior Review. If an Early Adopter does not wish to continue participating in the Early Adopter program, the Applications Coordinator(s) shall conduct a final exit interview. Apart from the information collected in a post-launch interview, a final exit interview will solicit information on why the Early Adopter is choosing to leave the program and whether there is another point of contact within the Early Adopter's organization to continue project activities.

Identify post-launch success drivers

Success drivers of an Early Adopter program are those initiatives that highlight the value of the mission's science data products and their impacts to decision making. These include publications on the Early Adopter projects to transition science into applications, finding multi-mission solutions though data fusion, new or improved data algorithms or products, and accelerated speed of data uptake post launch. Applications Coordinator(s) shall document how feedback from Early Adopters post-launch contributed to improvements to data and services and identify metrics that can help capture value-creating activities.

Continued feedback from Early Adopters after mission launch can enable improvements to mission data products and the tools and services used to access them. Once data collection begins, the mission may be able to provide Early Adopters with access to provisional data products. These beta products can be used to test the data in preliminary studies but are not intended for scientific analysis. Mission Applications Coordinators shall work with the mission to establish a process for sharing the data with Early Adopters and obtaining their feedback.

NASA ECOSTRESS, for example, developed an online Data Acquisition Request form to provide Early Adopters with access to the mission's provisional data products and to establish an agreement for obtaining feedback related to data usability, quality, uncertainty, and access. The ICESat-2 mission also provided Early Adopters with early access to two data granules—one of which was used by an Early Adopter during a

collaborative workshop with the U.S. Forest Service to demonstrate how to access and visualize the upcoming ICESat-2 data.

Consider hosting an Applied Users Program

The Applications Team shall continue to engage with Communities of Practice and Potential—including Early Adopters—post-launch. One method to achieve continued engagement is to host an 'Applied Users' program that acts as a continuation of the Early Adopter program. For example, the ICESat-2 Applied Users program includes existing Early Adopters, but also offers an opportunity for others in the user community to join the program post-launch. These new users reap the added benefits of referencing lessons learned from the Early Adopters and working with mission data.

Development of a continued program post-launch of the mission shall follow the same guidelines presented in this handbook. New agreements shall be established with Early Adopters to continue quickly and effectively achieving societal benefits from the mission's Earth observations.

APPENDIX A

Early Adopter Program Notional Schedule

Example schedule of Early Adopter program activities corresponding to mission life cycle phase.

Pre-phase A *(Concept Studies)*	• Identify and characterize a mission's Communities of Practice and Potential through user research studies. • Conduct research to identify high-value applications for the mission. • Identify users (individuals or groups) from Communities of Practice and Potential with high-value applications that can potentially act as Early Adopters. • Conduct initial community needs assessments and write summary reports to share with ESD leadership.
Phase A *(Concept and Technology Development)*	• Compile contact information to support communication and recruitment of Early Adopters within user communities. • Host applications events including workshops to inform users and start building user support for the mission. • Develop Early Adopter program strategies based on the guidelines provided in this handbook. • Develop an Early Adopter Engagement Plan.
Phase B *(Preliminary Design and Technology Completion)*	• Launch Early Adopter program: begin building awareness of program goals and benefits through a call for Early Adopters; recruit diverse Early Adopters through a carefully planned, inclusive recruitment and acceptance process. • Build awareness of expected project flight data products and use of proxy data products; solicit and document initial input and feedback from Early Adopters, including benchmarking metrics for data use. • Solicit feedback from Communities of Practice and Potential, including Early Adopters, on mission concept and design elements; incorporate user feedback to refine mission design. • Articulate DAAC support for the applications community; gather initial feedback from Early Adopters about needs for data access and user services and share this information with the DAAC. • Conduct community needs assessments and report on feedback.

Early Adopter Program Notional Schedule

Phase C & D *(Final Design, Fabrication, System Assembly, Test, and Launch)*	• Continue recruitment of Early Adopters through a carefully planned, inclusive recruitment and acceptance process. • Conduct periodic Early Adopter meetings in collaboration with mission scientists, Science Team members and DAAC representatives to enable information exchange and feedback on project updates; data development; expected data functionality, discoverability, and access; tool development; and user services plans. • Identify and document Early Adopter target applications, opportunities, expected challenges regarding data use, and expected utility of data to address societal needs. • Conduct community needs assessments and report on feedback. • Showcase Early Adopter activities at launch with participation from Early Adopters.
Phase E *(Operations and Sustainment)*	• Host Early Adopter benchmark meeting shortly after launch to revisit benchmarking metrics and expectations for use of the mission data. • Enable use of beta mission data by Early Adopters and obtain initial feedback. • Once mission data becomes available, track and document Early Adopter progress in ingesting data into target application(s), including expected timeframe for reaching sustained use. • Solicit feedback from Early Adopters regarding project metrics and goals for success. • Identify Early Adopters who may be interested in collaborating to assess the socioeconomic value of their Early Adopter program activities. Assessments can be conducted by Applications Teams or Applications Teams can nominate Early Adopter activities for evaluation by expert groups (e.g., VALUABLES Consortium). • Conduct Early Adopter interviews to gather data to inform senior review on progress of Early Adopter activities and on successes and challenges of the Early Adopter program; this effort should include exit interviews with Early Adopters who do not wish to continue participating in a program post-launch. • Continue engagement of Communities of Practice and Potential, including Early Adopters, through Applications program activities. • Establish new agreements with users via an “Applied Users” program, which includes Early Adopters that would like to continue participating in a program post-launch. • Conduct periodic Community of Practice and Early Adopter meetings and events to increase programmatic visibility, feedback, support, and ensure value for mission Early Adopters.

APPENDIX B: Definitions

Application Readiness Level	A nine-step index to track and manage the progression and distribution of projects towards integration of the application into an end-user's decision-making activity.
Applications	Earth science applications are a bridge from the breakthroughs of basic research to real-world uses of that knowledge.
Benchmarking	Process of measuring key performance indicators specific to an end-user's organization during pre-mission activities and comparing them after data integration to understand the qualitative and quantitative value of using mission data for a specific set of applications.
Community of Potential	A group of individuals who are new to using NASA satellite data products and/or a mission's capabilities.
Community of Practice	A group of individuals who actively use NASA data.
Distributed Active Archive Center	Centers that have been selected by NASA to process, archive, and distribute Earth Observing System (EOS) and related data and to provide a wide range of support to global change researchers.
Early Adopter	Individuals or groups from a national or international public or private sector organization, native regional corporation, industry association, university, and/or non-government organization interested in applying EOS data products or measurements to support actionable decisions. Early Adopters are accepted to the mission pre-launch and engage in both pre-launch and post-launch activities to demonstrate the utility of mission data in applications that benefit society. They provide valuable feedback on how Earth observation data can be used for decision support.
Gamification	The use of game design elements in non-game contexts.[3]
Stakeholder	A stakeholder is anyone who may be affected by or perceived to be affected by a decision, activity, or outcome of a mission's Early Adopter program.

[3] Deterding, S., Sicart, M., Nacke, L.E., O'hara, K., & Dixon, D. (2011). Gamification. using game-design elements in non-gaming contexts. *CHI '11 Extended Abstracts on Human Factors in Computing Systems*.

APPENDIX C: Acronym List

ARL	Application Readiness Level
ARSET	Applied Remote Sensing Training
Cal/Val	Calibration/Validation
DAAC	Distributed Active Archive Center
DEVELOP	Digital Earth Virtual Environment and Learning Outreach Program
ECOSTRESS	Ecosystem Spaceborne Thermal Radiometer Experiment on Space Station
EOS	Earth Observing System
ESD	Earth Science Division
GeoTiff	Geographic Tagged Image File Format
ICESat-2	Ice, Cloud, and land Elevation Satellite-2
NASA	National Aeronautics and Space Administration
NDVI	Normalized difference vegetation index
NETCDF	Network Common Data Form
NRT	Near Real Time
NWP	Numerical Weather Prediction
PACE	Plankton, Aerosol, Clouds, and Ocean Ecosystem
SeaDAS	Sea-viewing Wide Field-of-view Sensor Data Analysis System
SERVIR	Regional Visualization and Monitoring System
SMAP	Soil Moisture Active-Passive
SWOT	Surface Water and Ocean Topography
VALUABLES	Consortium for the Valuation of Applications Benefits Linked with Earth Science
VOI	Value of Information

APPENDIX D: RESOURCES

Helpful resources for NASA Applied Science Early Adopter Strategy.
(These links take you outside the Handbook)

NASA Earth Science Applied Sciences webpage; https://appliedsciences.nasa.gov/

Assessment of the NASA Early Adopters Program; https://appliedsciences.nasa.gov/sites/default/files/2021-11/NASA_Early_Adopters_Assessment.pdf

NASA Applications Guidebook; https://appliedsciences.nasa.gov/guidebook/

NASA Earth Science missions; https://appliedsciences.nasa.gov/what-we-do/earth-science-missions

NASA Earth Applied Sciences Strategic Plan (2021-2026); https://appliedsciences.nasa.gov/our-impact/news/2021-2026-applied-sciences-strategic-plan-released

VALUABLEs Consortium; https://www.rff.org/valuables/