NOAA Technical Memorandum OAR LCI-002

Analysis of OAR Transition of Research and Development (FY18)

Rebecca Certner
Laura Newcomb
Gary Matlock

NOAA/Laboratories and Cooperative Institutes
Silver Spring, Maryland
January 2020

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UNITED STATES DEPARTMENT OF COMMERCE

Wilbur Ross
Secretary

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Neil Jacobs, Ph. D.
Acting NOAA Administrator

Office of Oceanic and Atmospheric Research

Craig McLean
Assistant Administrator

NOTICE

Abstract

This document is the third NOAA technical memorandum on OAR transitions. Here we inventory all OAR research and development (R&D) projects that have moved to Readiness Level nine - application, operation, commercialization, or other uses - during FY18. The previous two memoranda reported on transitions from January 2013 - July 2014[1] (Sen 2015) and from August 2014 - July 2017[2] (Kroll et al. 2018) respectively. Using methods established in the inaugural report, FY18 transitions were categorized based on function, output, application, recipients, and strategic goal. This report also tracks FY18 transitions as they relate to NOAA's current goals of reducing societal impacts of severe weather and supporting the Blue Economy.

During FY18, 66 projects were reported as transitioned to operation. Of these, 57 (86.4%) were consistent with OAR's definition of transitioned R&D (NAO 216-105B[3]). This relatively high proportion represents an upward trend in accurately reported transitions; the 2018 memo noted that 71% (101 submissions of 143) of projects fit the R&D transition definition while the 2015 memo noted that only 39% (96 submissions of 244) of projects fit the definition (Figure 1). The increased percentage of reported transitions coupled with the decrease in misidentified submissions indicates that the understanding of transitions within the OAR community continues to improve.

Despite the improvement, there still exists confusion surrounding transitions. A few notable gaps persist, including the precise definition of a transition. As in the 2018 memorandum, the nine misidentified submissions from the current report tended to display one of two issues: (1) they were projects with no identified recipient; and (2) they were projects that produced data or routine observations. Finished transitions must have an identifiable end user even if that user consists of multiple or amorphous entities like an academic community or the public. Furthermore, projects that produce data and/or observations are considered research and do not necessarily fall into the category of successful transitions. Exceptions include projects that add data to global databases, such as the global carbon dioxide record, because this further establishes a worldwide standard.

OAR continues to engage with the wider NOAA community to promote an understanding of transitions. This memorandum provides a number of transition examples - both accurately reported and misidentified - and also reiterates definitions associated with the R&D transition process, which can also be found in the NOAA Administrative Order on Research and Development Transitions (NAO 216-105B) and its associated handbook (Appendix B, C). Furthermore, the NOAA Research and Development Database (NRDD) has undergone a redesign and includes many improvements aimed at facilitating the process of tracking R&D progress toward transition.

Introduction

The transition of NOAA research and development (R&D) to operation, application, commercialization, or other uses (transition) serves to illustrate the myriad public products and services that NOAA provides to the country. As a result, efficient transition has become increasingly important to NOAA leadership and is listed as a priority under several NOAA policies, including the NOAA Administrative Order on Research and Development Transitions (NAO 216-105B) (Appendix B).

Transitions represent an important metric of progress and accomplishment for NOAA, particularly for the Office of Oceanic and Atmospheric Research (OAR), the research-focused Line Office supporting the entire NOAA enterprise. Consistent and accurate reporting of successful OAR transitions underscores OAR's invaluable contributions to the NOAA mission. As such, OAR continues to lead in the promotion of planning, tracking, facilitating, and executing of transitions within and outside the Line Office.

Although NOAA-wide understanding of the transition process continues to improve, confusion regarding transitions still persists, including the definition of a transition. The inaugural technical report on transitions outlined a set of guidelines regarding what constitutes a proper transition: (1) the output is the product of R&D; (2) the application is particular and verifiable; (3) the activity is focused on translation and adaptation; and (4) the output is a productive system or component thereof (Sen 2015). In short, a specific project output must be delivered to a definable end user for a project to culminate in a successful transition. Additionally, the project output must be specific, although it can take any number of forms. Acceptable outputs include but are not limited to, a report, an assessment, a model, a new technology, a piece of equipment, a scientific protocol, a new methodology, or a service. Distinct updates and improvements to existing transitions may also quality as a separate transition.

Here within, we characterize the OAR transitions that occurred in FY18 and OAR transition data trends based on three transition reports spanning several years. We also provide further clarity on what constitutes a transition by administering further guidance and highlighting more examples of accurate and misidentified transitions.

Methodology

Data were collected from two sources to determine the number of OAR projects that transitioned in FY18: the FY18 OAR Annual Operating Plan (AOP) and a manual data call to OAR laboratories and programs.

AOP Data

To complete the AOP, OAR labs and programs are asked to submit their planned milestones at the beginning of the fiscal year. Once these milestones are reached, each FMC (Financial Management Center) is asked to update the AOP by Q4 of the fiscal year. These milestones include technology transition information for each project as the project moves through the readiness level categories. Out of 161 projects submitted to the AOP, 29 projects were reported as transitioned to "Operations or Applications" in FY18. Of these 29 projects, 25 (86.2%) were identified as accurately reported transitions while four were misidentified as transitions.

Manual Data Call

To supplement the information contained in the AOP, OAR leadership requested more information on all FY18 transitioned projects in July 2018. Following the methodology outlined in the first OAR Transitions memorandum (Sen 2015), a spreadsheet of informational queries was sent to each OAR laboratory and program director. This spreadsheet included project name, thing transitioned, purpose of transition, from where the project transitioned (organization, point of contact, and email), to where the project transitioned, and date completed (organization, point of contact, and email). This data call received a total of 76 projects from 15 of the 16 OAR labs and programs from this data call. Of these projects, 48 were reported as transitioned in FY18: 43 were accurate and five were misidentified as transitions. Additionally, 18 projects submitted to the data call were also found in the AOP; 11 of these were transitions completed in FY18.

Transition Categorization

In total, 57 projects - 25 from the AOP, 43 from the data call, 11 overlapping both sources - were reported by OAR labs and programs as successful transitions in FY18 (Figure 2, Appendix E). Projects were categorized following the qualitative labeling system outlined in Sen 2015 (categories described in Appendix D). Categories were assigned independently by two Office of Laboratory and Cooperative Institute staff (Rebecca Certner and Laura Newcomb) and validated by the OAR Deputy Assistant Administrator for Science (Gary Matlock). A tally of reported transitions was taken for all options within respective categories and figures were created.

In addition to the above metrics, the 57 FY18 projects listed as successful transitions were also divided into additional categories representing the priorities of the current administration, including NOAA focus area, the Blue Economy[4,5], and reducing societal impacts of severe weather[5,6]. The NOAA focus areas include: Earth System Modeling, eDNA/Omics, Machine Learning/Artificial Intelligence, and Unmanned Systems.

Transitions Through the Years

The number of transitions per FMC from calendar years 2013-2018 were counted based on the two previous reports and the current report for a total of 264 transitions (Figure 3). Entries that did not list a date (21 projects) were excluded.

Results

The AOP yielded 29 FY18 transitions, 25 accurate and four misidentified. The manual data call yielded 48 FY18 transitions, 43 accurate and five misidentified. There was an overlap of 11 transitions between the AOP and the manual data call. All in all, 66 transitions were submitted in FY18, 57 accurate and nine misidentified (Appendix D).

In FY18, 66 projects were reported as transitioned to operation. Of these, 57 (86.4%) were consistent with OAR's definition of transitioned R&D (Figure 1). From August 2014-July 2017, 71% (101 submissions of 143) of projects fit the R&D transition definition (Figure 1). Finally, from January 2013-July 2014, 39% (96 submissions of 244) of projects fit the definition (Figure 1).

The 57 FY18 transitions consistent with OAR's definition of transitioned R&D are further broken down by the 16 OAR FMCs (Figure 2). Transitions per FMC ranged from 13 (ESRL-GMD) to zero (PMEL, OAP, UAS). Number of transitions over time (calendar years 2013-2018) are also shown for each of the 16 OAR FMCs (Figure 3).

The subsequent figures attempt to characterize the 57 FY18 transitions including function type (Figure 4), output type (Figure 5), recipient type (Figure 6) and number (Figure 7), application type (Figure 8), NOAA strategic goal (Figure 9), NOAA focus area (Figure 10), NOAA policy priorities (Figure 11), OAR FMC mapped to NOAA strategic goal (Figure 16), and OAR FMC to function (Figure 17). In addition to the metrics established in the inaugural report, we also explore how these 57 transitions relate to NOAA focus areas and NOAA policy initiatives.

For figures that depict gaps in the understanding of transition, the total number of 66 reported transitions was used including type of function (Figure 4), function to output (Figure 14), function to NOAA strategic goal (Figure 15), and OAR FMC to function (Figure 17). Essentially, any figure that portrays the project's initial function was created using the 66 reported transitions, accurate and misidentified combined.

Discussion and Future Suggestions

Continued improvement in understanding of transitions

Since the inaugural report started tracking this metric, there is a discernible positive trend in the understanding of transitions over time. In Sen (2015), merely 39% of the reported transitions were correctly identified. This increased to 71% in Kroll et al. (2018) and increased again to 86.4% in FY18. This clear progression indicates that the understanding of transitions within OAR has improved significantly in a relatively short time frame. Although it is evident that OAR labs and programs have a better grasp on what constitutes a transition, it is ambiguous whether or not this improved understanding results in a greater number of total transitions. We plan to publish these reports at regular intervals by fiscal year. The standardization of transition reporting will shed light on whether OAR labs and programs continue to improve in their understanding of transitions.

Variable reporting exists among OAR FMCs

In FY18 there was a wide range of accurately-reported transitions among the OAR FMCs. ESRL-GMD yielded the greatest number with 13 transitions while multiple OAR programs reported zero or one transition (Figure 2). This has been the case in previous years when the total number of accurately-reported transitions was broken down by OAR FMC (Figure 3). For example, the highest reporter in FY18, ESRL-GMD, reported zero transitions in 2016 while one of the low reporters in FY18, AOML, reported 15 transitions in 2017. The lack of pattern supports the notion that FMCs do not produce a steady stream of transitions and that progress occurs in surges. This may be due to the nature of the research and funding cycle where multiple projects are begun and ended at around the same time.

Some OAR FMCs consistently report low numbers of transitions but there is no lab or program that regularly stands out regarding high numbers of transitions. Continued data collection and increased understanding of transitions may illuminate patterns in the future.

Confusion around transitions

In addition to variable reporting within OAR, continued confusion around transitions within OAR and NOAA implies this current report does not capture the full extent of FY18 OAR transitions. Our methodology includes counts of misidentified transitions, amounting to approximately 14% of the projects reported in FY18. However, we have no way to count unreported transitions. Logically, if 14% of reported projects were erroneously thought to transition, there are likely several projects that were overlooked. Anecdotal evidence suggests this is the case based on the wide range of understanding of the definition of transition even within OAR. As a result, we assume the results in this report represent a low estimate of OAR transitions.

In order to provide guidance over what constitutes a transition, we have created a decision tree designed to both prevent the misidentification of false transitions and to promote the identification of true transitions (Figure 18). Based on the data collected for this report - specifically misidentified transitions - there are four questions to ask when reporting a transition: (1) Does the thing to be transitioned stem from NOAA R&D? (2) Is the thing to be transitioned a system, process, product, service, tool, or assessment? (3) Does the transitions have a definable end user? (4) Is the transition fully deployed and taken over by the end user?

OAR's biggest customer is the federal government, particularly NOAA

A large proportion (40%) of OAR transitions are internal to NOAA (Figure 6). Because many of the OAR transitions (35.1%) list more than one end user, 40% is a low estimate of the number of internal transitions (Figure 7). However, of the 40% that listed NOAA as the sole end user, many of the completed transitions were handed off to the National Weather Service (NWS). This finding supports the continued funding of OAR R&D since OAR demonstrably collaborates with and improves operations conducted by other NOAA Line Offices. OAR transitions also include a number of public-facing assessments including congressionally-mandated reports and open-source data.

OAR transitions widely support environmental intelligence
The majority of OAR transitions (54.4%) can be categorized as tools to promote environmental intelligence, specifically information measured, gathered, compiled, exploited, analyzed, and disseminated to characterize the current state and/or predict the future state of the environment at a given location and time (Figure 8). This is perhaps not surprising considering OAR's close partnership with NWS and many products aimed at improving weather forecasts. This result also speaks to the strength and flavor of the OAR mission: to provide the research foundation for understanding the complex systems that support our planet.

OAR transitions are distributed across NOAA's strategic goals
The seven strategic goals mentioned in this report originate from the R&D priorities identified by the NOAA 2013-2017 Five Year R&D Plan. Similar to transitions outlined in the Kroll et al. 2018 report, the FY18 transitions are distributed across the seven strategic goals, particularly Climate Adaptation and Mitigation and Weather Ready Nation (Figure 9). This results demonstrates both the diversity of OAR research and the alignment of OAR research to the OAR mission. The particular focus on weather and climate meshes well with OAR's commitment to studying earth systems and the ensuing robust partnership with NWS to turn research into application. the Similar to Kroll et al. 2018, Stakeholder Engagement was the second least represented goal despite the fact that many FY18 transitions (30.3%) listed Extension and Outreach as a function (Figure 4). Resilient Coastal Communities was the least represented goal, which is interesting given that many OAR products improve municipalities' emergency response. However, this is likely an artifact of having to choose only one strategic goal to describe each project since a resilient community is a secondary goal to emergency response. In reality, many transitions support multiple strategic goals.

The FY18 OAR transitions are less evenly distributed across the four NOAA R&D Focus areas with Earth System Modeling dominating (61.4%) the other three categories (Figure 10). This is to be expected considering OAR's overarching mission of providing the research foundation for understanding the complex systems that support our planet. With the large number of Earth System Modeling transitions, it was surprising to see that zero projects in FY18 fell into the category of Unmanned Systems.

OAR transitions support NOAA policy and legislation
Slightly over half (56.2%) of the FY18 transitions are in direct support of current NOAA priorities (Figure 11). 21.1% of the products contribute to projects that further the Blue Economy (Figure 12) and 40.4% of the products directly address the 2017 Weather Act (Figure 13). Three areas of the Blue Economy were addressed with an emphasis on Coastal Risk Reduction and Preparedness, Seafood Production and Competitiveness, and Ocean Mapping and Exploration (Figure 12). Tourism and Recreation and Marine Transportation fall under the purview of other Line Offices and are less central to OAR's mission. As a mission-driven agency, it is important for transitions to have direct societal impact and demonstrate the science, service, and stewardship that NOAA provides to the public. These results highlight the range of OAR research that directly strengthens the American economy and addresses Congressional mandates.

OAR transition trends
Although the transitions addressed many of NOAA's strategic goals, a few trends emerged. The Technology Transfer transitions were likely to address the strategic goal of Weather Ready Nation and Integrated Environmental Modeling (Figure 15). A large number of these transitions fell into the category of new or improved weather forecasting models. Conversely, Extension and Outreach transitions were likely to address the strategic goal of Climate Adaptation and Mitigation (Figure 15). This result demonstrates a divide between technology and social science/knowledge transfer. Although there are exceptions, transitions of technology in OAR tend to be weather and environmental models while social science transitions (i.e. reports and assessments) tend to examine climate change.

Produce this report on an annual basis by fiscal year
The three existing reports do not cover a comparable time frame. Without standardizing the structure of these reports, it will be difficult to track trends through the years. Going forward, this report will be produced annually every fiscal year; the next report will cover transitions that occurred in FY19. Not only will annual reports facilitate equitable comparisons between years, they will establish a dependable precedent that will increase reporting from the OAR labs and programs.

Use the NRDD to populate this report
The NOAA Research and Development Database (NRDD) is a web-based repository for R&D projects developed and funded by NOAA. NRDD submissions should include all of the information needed to populate this report including project outcome, purpose, end user, and readiness level. Using the NRDD rather than the combined results of the AOP and a manual data call has the potential to significantly streamline data collection, the time-limiting step in completing this report. Report authors will avoid manual reconciliation of multiple sources of information on transitions and OAR FMCs will not have to respond to reiterative data calls. Currently, the NRDD is far from up-to-date; it is missing information on many entries and a number of projects are not in the database at all. However, a NRDD redesign aimed at expediting and improving the reporting experience has recently been completed.

Continue to utilize NOAA and OAR resources to increase the understanding of transitions
Although the understanding of transitions is undoubtedly improving, there remain a few misconceptions among the OAR labs and programs. These gaps in understanding are similar to the gaps that were reported in Kroll et al. 2018 namely projects with no identifiable end user and/or projects whose end product is data production or observations. As a result, we have created a transition decision tree (Figure 2) designed to weed out misidentified transitions. We will also continue to socialize the concept of transitions within OAR and NOAA with more guidance materials, such as this latest report.

Literature Cited

1. Sen A. (2015 January). NOAA Technical Memorandum OAR PPE-5. What Does "Transition" Mean? A Qualitative Analysis of Reported Transitions at OAR.
2. Kroll I, Newcomb L, Moses C, and Matlock G. (2018 April). NOAA Technical Memorandum OAR LCI-001. Analysis of OAR Transition of Research and Development (2014-2017).
3. NOAA Administrative Order 216-105B: Policy on Research and Development Transitions (2016 October).
4. RDML Timothy Gallaudet, Ph.D. (2019 April 22). Interview with the Marine Technology Society. https://www.mtsociety.org/2019/04/22/the-latest-from-noaa-a-qa-with-deputy-administrator-rdml-tim-gallaudet/

5. RDML Timothy Gallaudet, Ph.D. (2019 May 21). Written statement on the NOAA FY20 Budget Request before the House Committee on Natural Resources Subcommittee on Water, Oceans, and Wildlife.
6. H.R. 353 - Weather Research and Forecasting Innovation Act of 2017

Figures

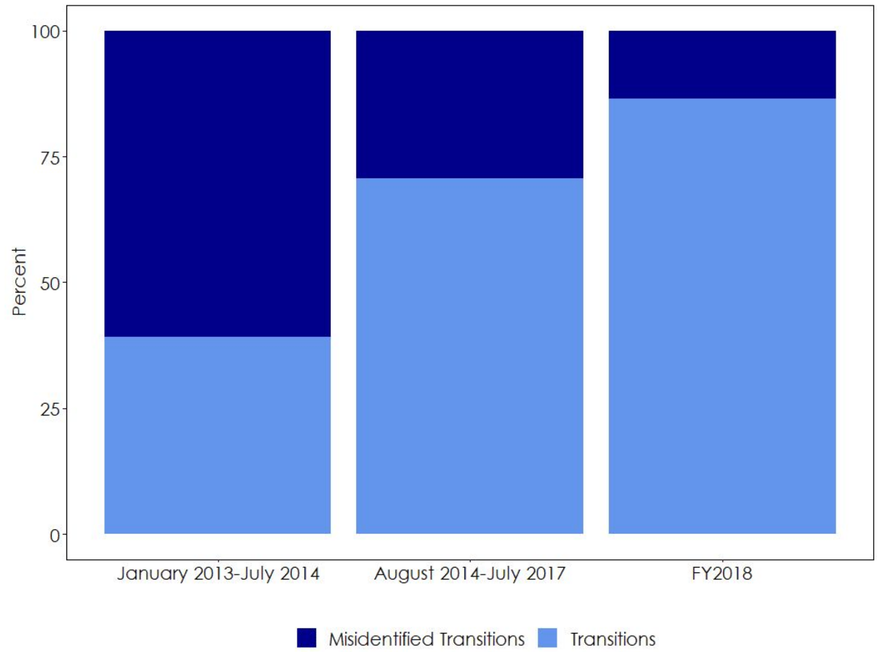

Figure 1. Accurately-Reported Transitions Versus Misidentified Transitions Through Time
Each iteration of the OAR Technical Memo on Transitions has shown an increase in accurately-reported transitions compared to misidentified transitions. From January 2013-July 2014, 96 out of 244 (39%) submissions were true transitions. From August 2014-July 2017, 101 out of 143 (71%) submissions were true transitions. Finally, in FY18, 57 of the 66 (86.4%) projects were found to be true transitions.

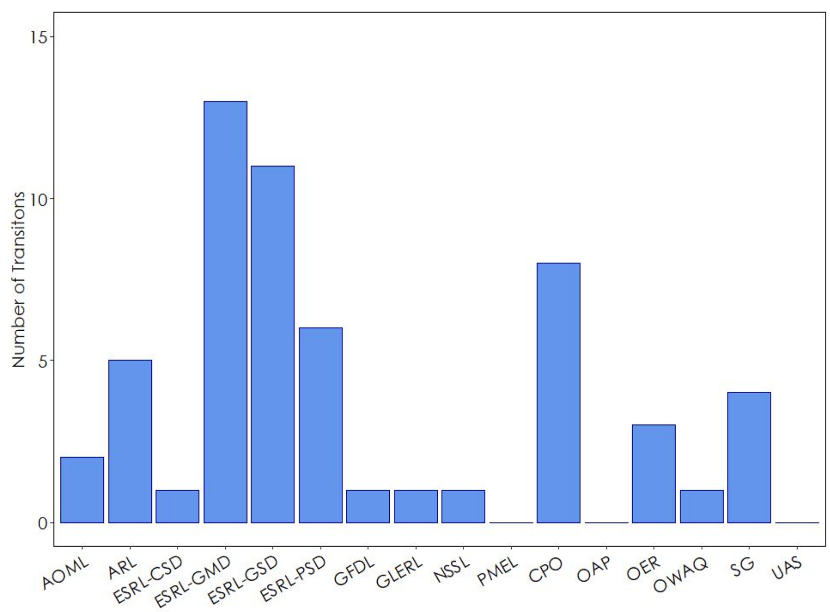

Figure 2. FY18 Transitions by FMC
The 57 transitions of FY18 were categorized by their FMC. Of the 16 OAR FMCs, ESRL-GMD facilitated the most transitions (13) while OAP and UAS reported none. It is possible the absence of transitions in some labs and programs is the result of underreporting and not inactivity in transition.

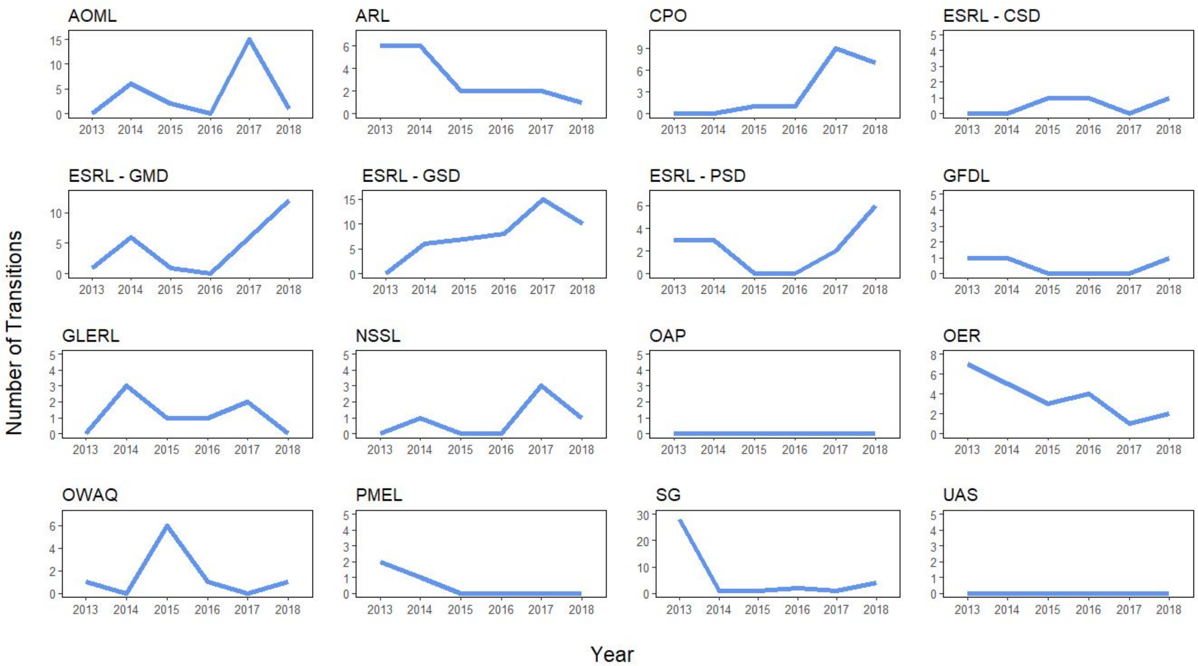

Figure 3. OAR Transitions by FMC from 2013-2018
264 total transitions occurred in OAR between the years of 2013-2018. These were divided amongst FMC to show the rate of transition over time for each FMC. 21 entries did not list a date and were excluded from this analysis. The distinct lack of pattern within these FMCs supports the conclusion that the rate of transitions is erratic and unpredictable.

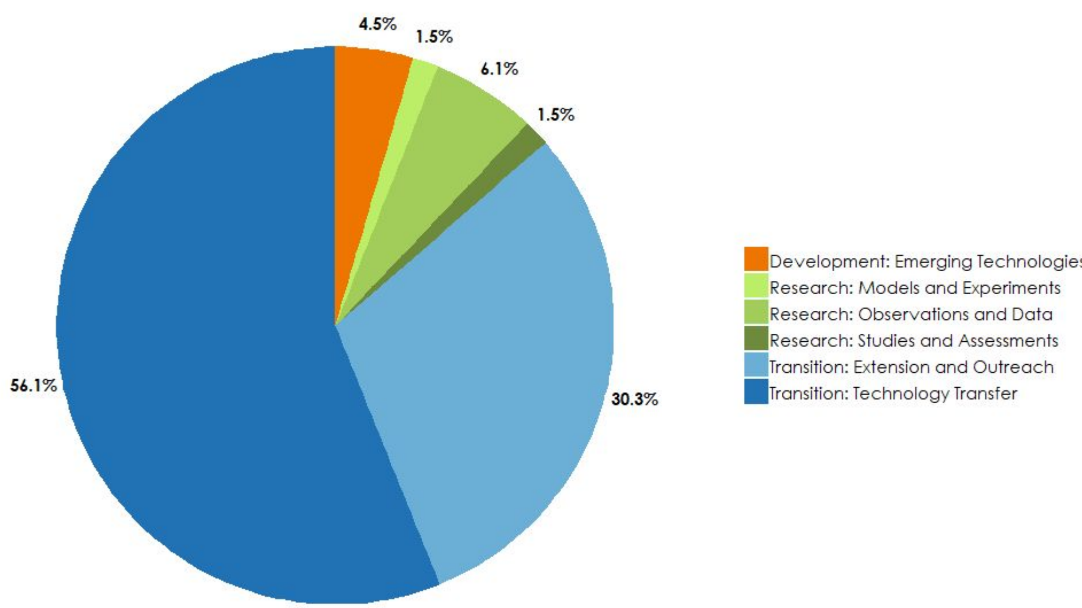

Figure 4. Type of Function
Based on assessment of information submitted by OAR labs and programs, the 66 FY18 transition submissions were categorized into activities. Two categories correspond to transitions: Technology Transfer and Extension and Outreach. All other functions are considered part of Research and Development and are not transitions. The vast majority (86.4%) of the reported projects are accurately-reported transitions with 37 projects (56.1%) leading to a Technology Transfer and 20 projects (30.3%) leading to Extension and Outreach. The following pie charts will focus on these 57 projects.

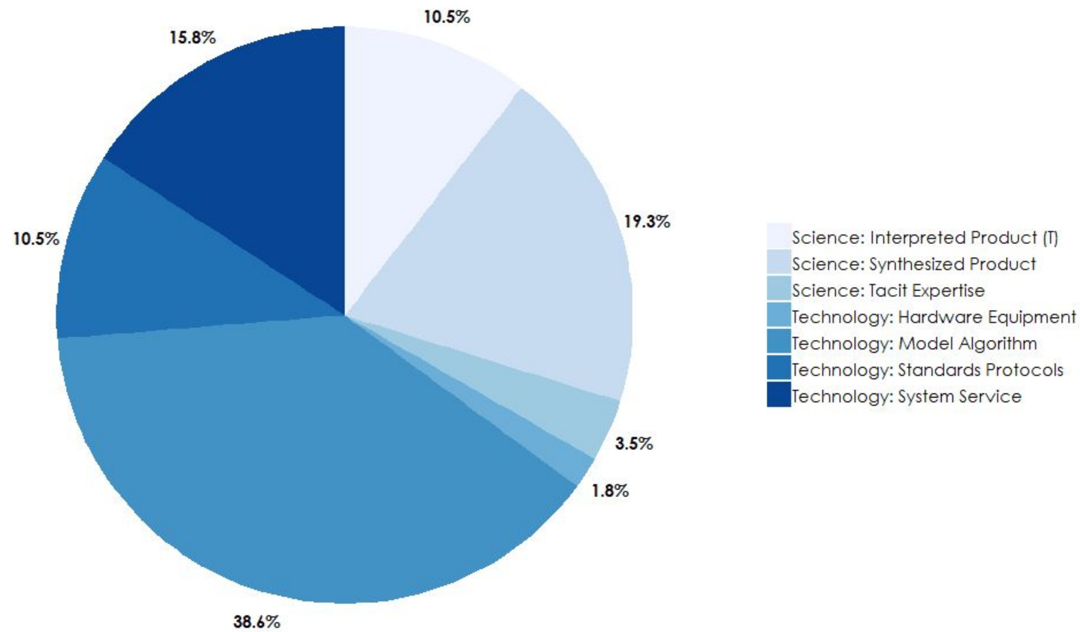

Figure 5. Type of Output

For the 57 transitions, the above figure categorizes the project product. Science outputs such as assessments and interpreted products can be transitions when discipline-specific knowledge is used to inform application, operation, or commercialization. As in previous years, the largest category of output was a Model Algorithm, many of which were model updates or improvements.

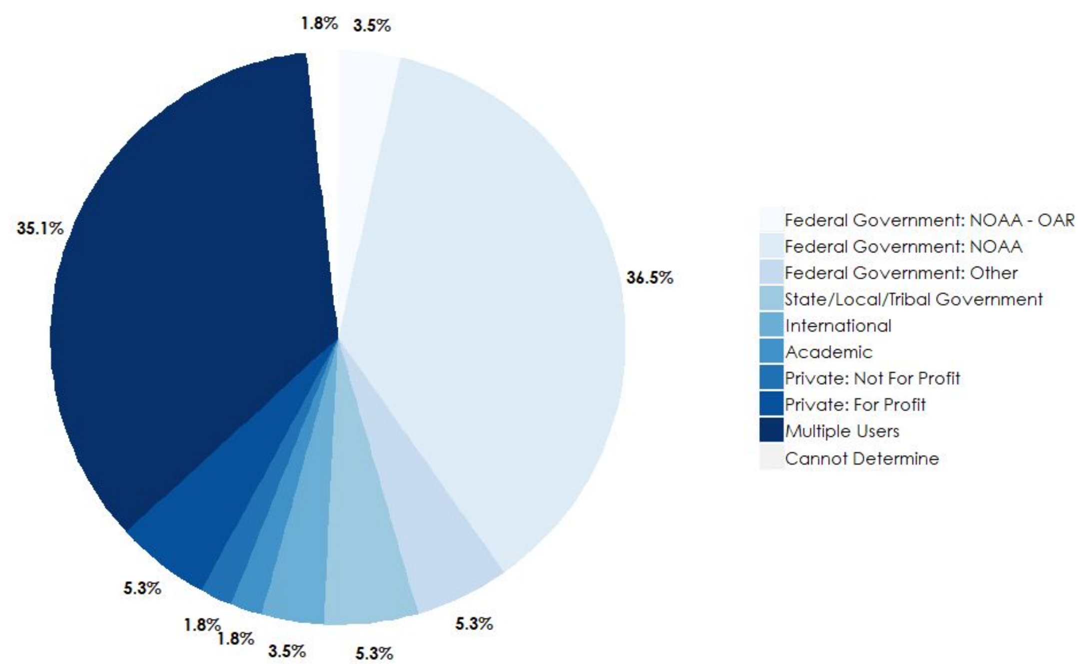

Figure 6. Type of Recipient

For the 57 transitions, the above figure categorizes the end user of the project product. By itself, information regarding the type of recipient cannot determine whether a project has transitioned. However, proper transitions require a definable end user. Submissions that did not report an identifiable end user (e.g. "the public") were generally characterized as misidentified transitions. Transitions can occur within an agency and OAR may transition products to itself or to other parts of NOAA. The highest proportion of transitions in FY18 were transitioned back to NOAA or other parts of the federal government.

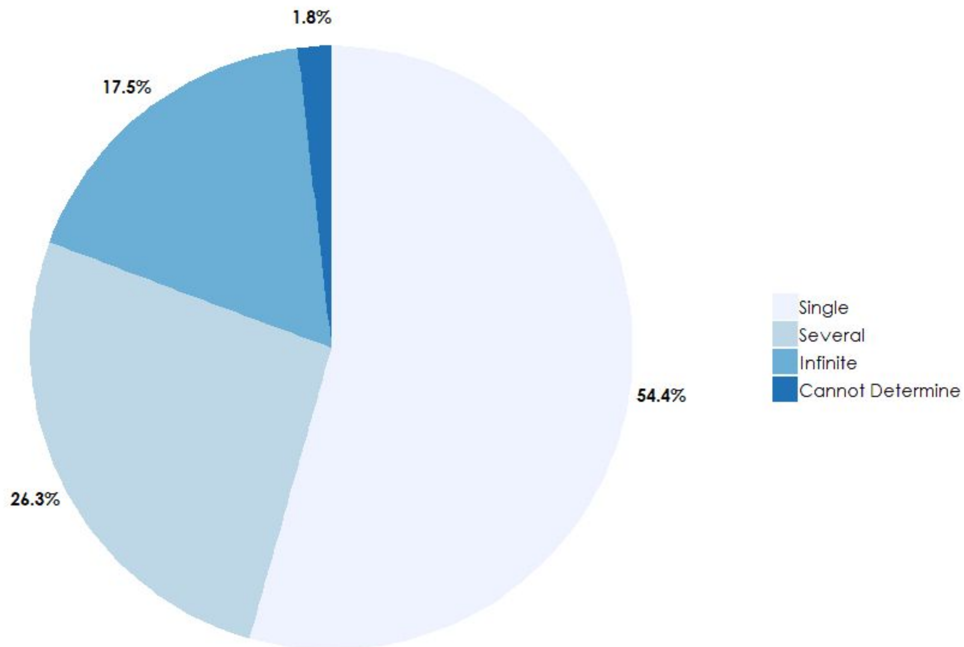

Figure 7. Number of Recipients

Along with recipient type, number of recipients was also categorized for the 57 transitions in FY18. A small majority of project products were transitioned to a single end user however, many products had multiple endpoints. Projects associated with infinite recipients - although not a specific end user - can be considered transitions in certain cases. For example, if the project product is mandated by another body (e.g. Congress) or produced at regular intervals (e.g. the annual Arctic Report Card).

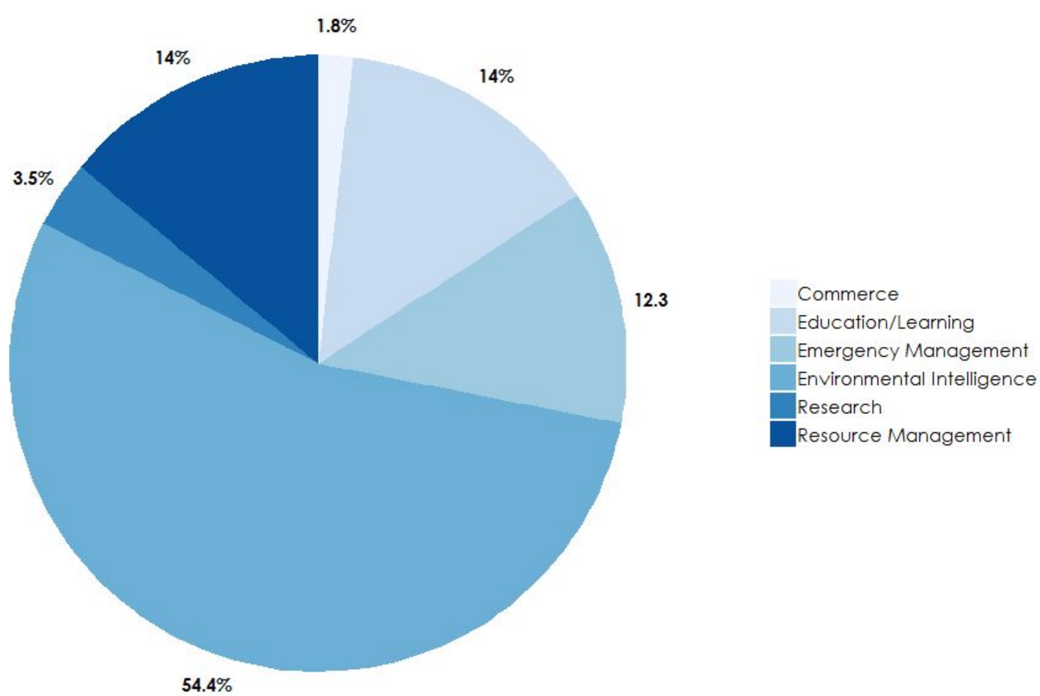

Figure 8. Type of Application

The 57 transitions were also characterized by application type. In previous years, research was not considered an application of transition however this was the appropriate application for specific transitions in FY18. The vast majority of transitions involved improving environmental intelligence.

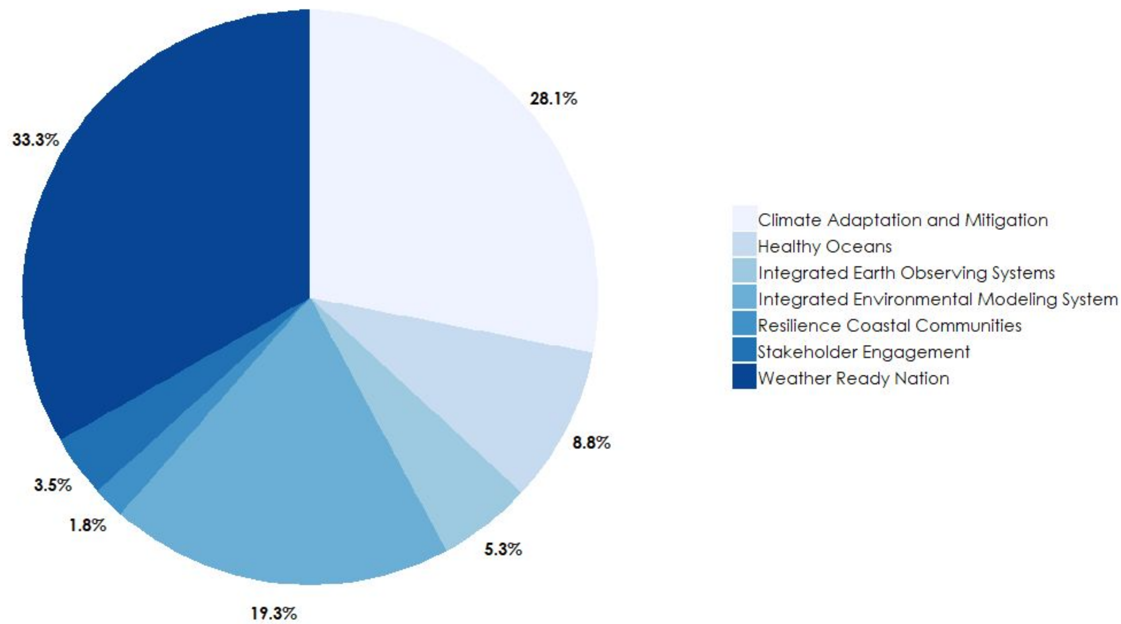

Figure 9. NOAA Strategic Goal

As a mission-driven agency, it is important to align R&D to NOAA's overarching objectives. As a result, the 57 transitions were categorized into one of NOAA's strategic goals described in the NOAA Five-Year Research and Development Plan for 2013-2017. OAR transitions support all of NOAA's mission areas, and though there was no dominant goal, Weather Ready Nation was the most prominent.

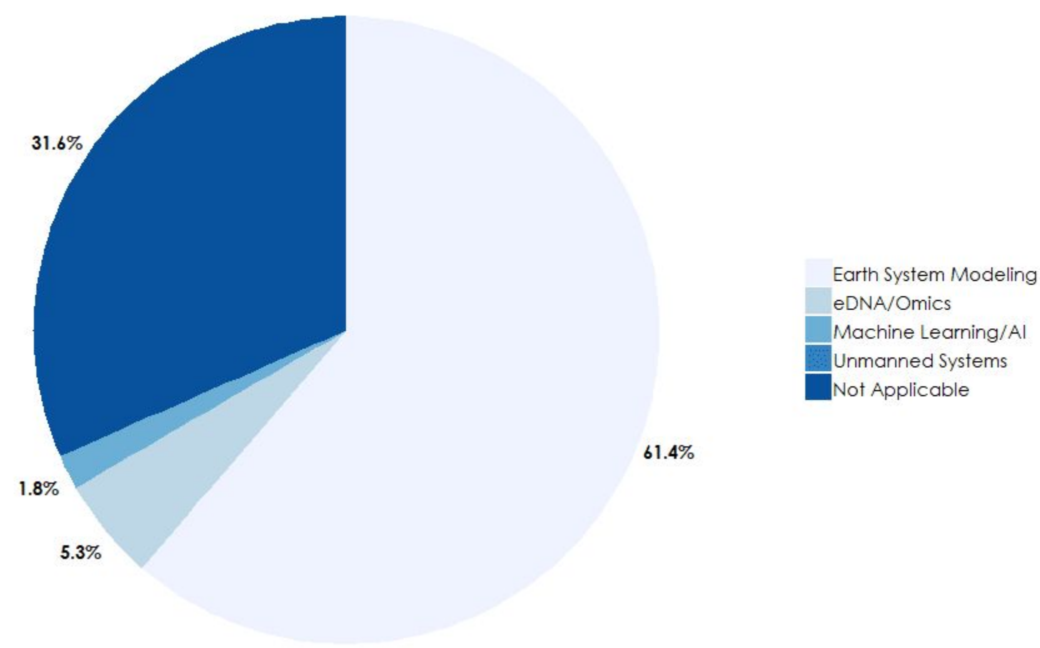

Figure 10. NOAA R&D Focus Areas

In addition to overarching strategic goals, NOAA leadership has also identified a number of focus areas for R&D: Earth System Modeling, eDNA/Omics, Machine Learning/AI, and Unmanned Systems. A large majority (61.4%) of OAR FY18 transitions support NOAA's Earth System Modeling objective.

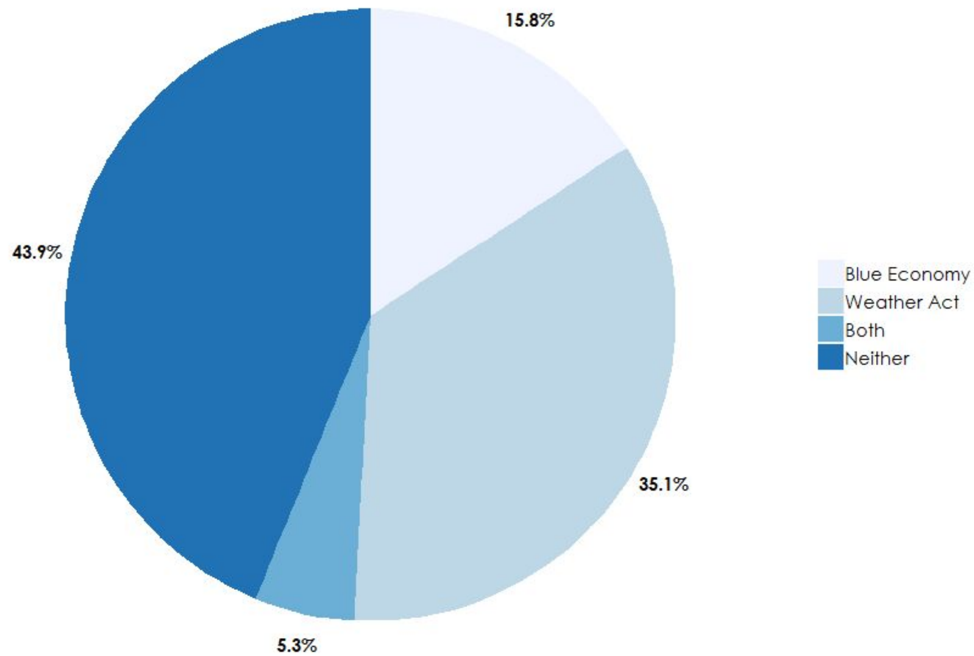

Figure 11. NOAA Policy Priorities

In addition to R&D focus areas, NOAA has concentrated on a number of policy initiatives, namely the Blue Economy and reducing society impacts from severe weather and other environmental phenomena. The FY18 transitions were broken down into four categories depending on whether they supported the Blue Economy (9), severe weather (20), both (3), or neither (25). Over half of the 57 transitions had direct ties to at least one of these two priorities.

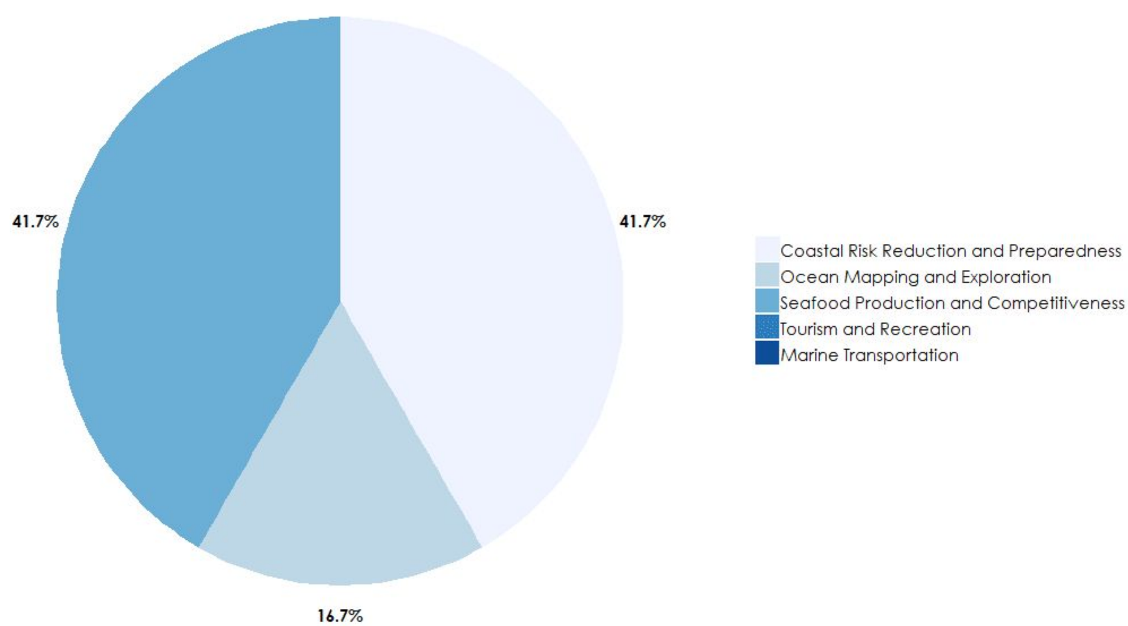

Figure 12. The Blue Economy

Of the 12 transitions that supported the Blue Economy, project products were further broken down by pillars within the Blue Economy.

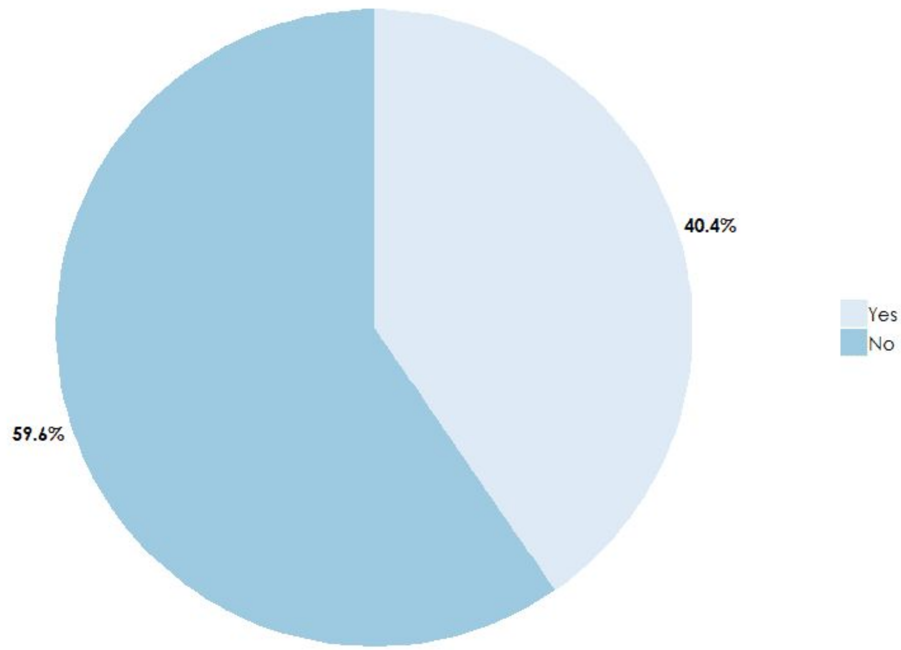

Figure 13. Reducing impacts of severe weather

Going back to the 57 FY18 transitions, a large proportion of the project products (40.4% or 23 products) dealt with reducing society impacts from severe weather and other environmental phenomena by supporting aspects of the 2017 Weather Act (amended in 2018). OAR R&D is more aligned with NOAA's strategic goal of reducing societal impacts of severe weather and other environmental phenomena compared to the Blue Economy.

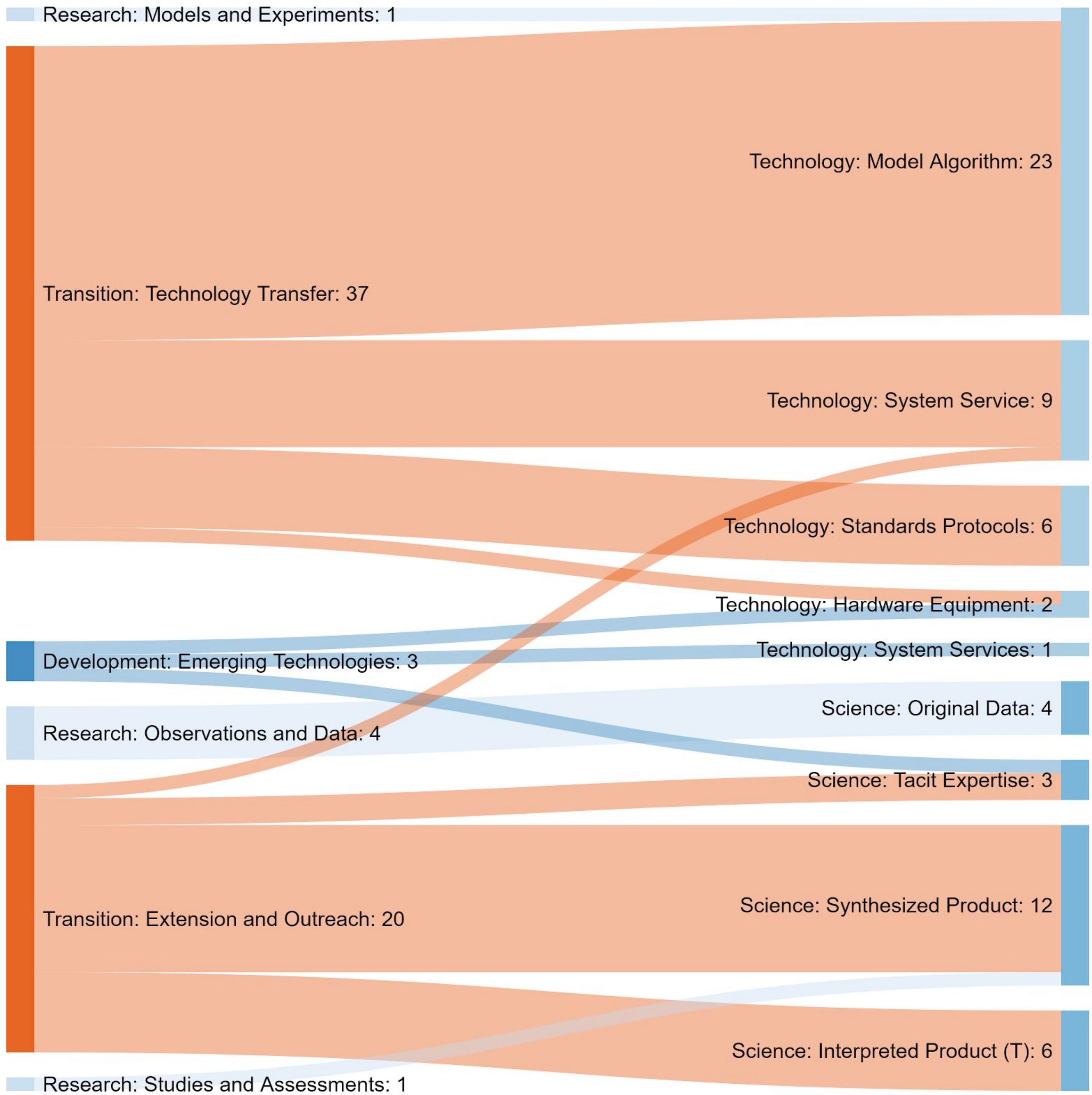

Figure 14. Function to Output

This figure shows the trajectory of the 66 FY18 submissions by illustrating the frequency with which specific functions result in specific outputs. Submissions categorized as Transition: Technology Transfer all resulted in an output associated with a technology. Conversely, submissions categorized as Transition: Extension and Outreach tended to be associated with outputs related to science and knowledge transfer

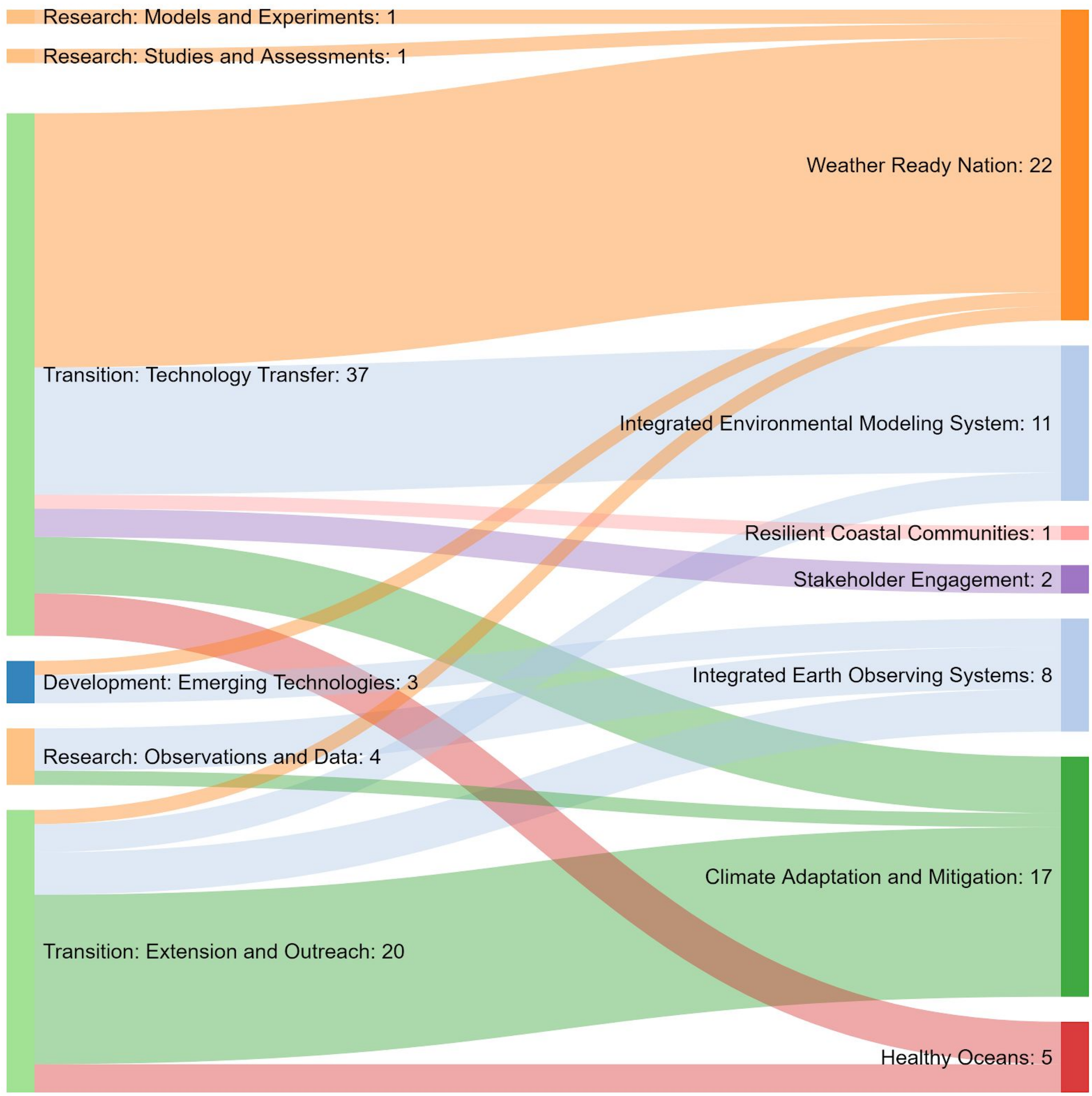

Figure 15. Function to Strategic Goal
This figure shows how the 66 FY18 submissions align with NOAA's strategic goals. A project's strategic goal cannot determine whether or not it is a transition. However, linkages between function type and strategic goal illustrate the diversity of the OAR research portfolio. All seven of NOAA's strategic goals are represented in FY18's 66 submissions with Weather Ready Nation and Climate Adaptation and Mitigation being the most abundant categories.

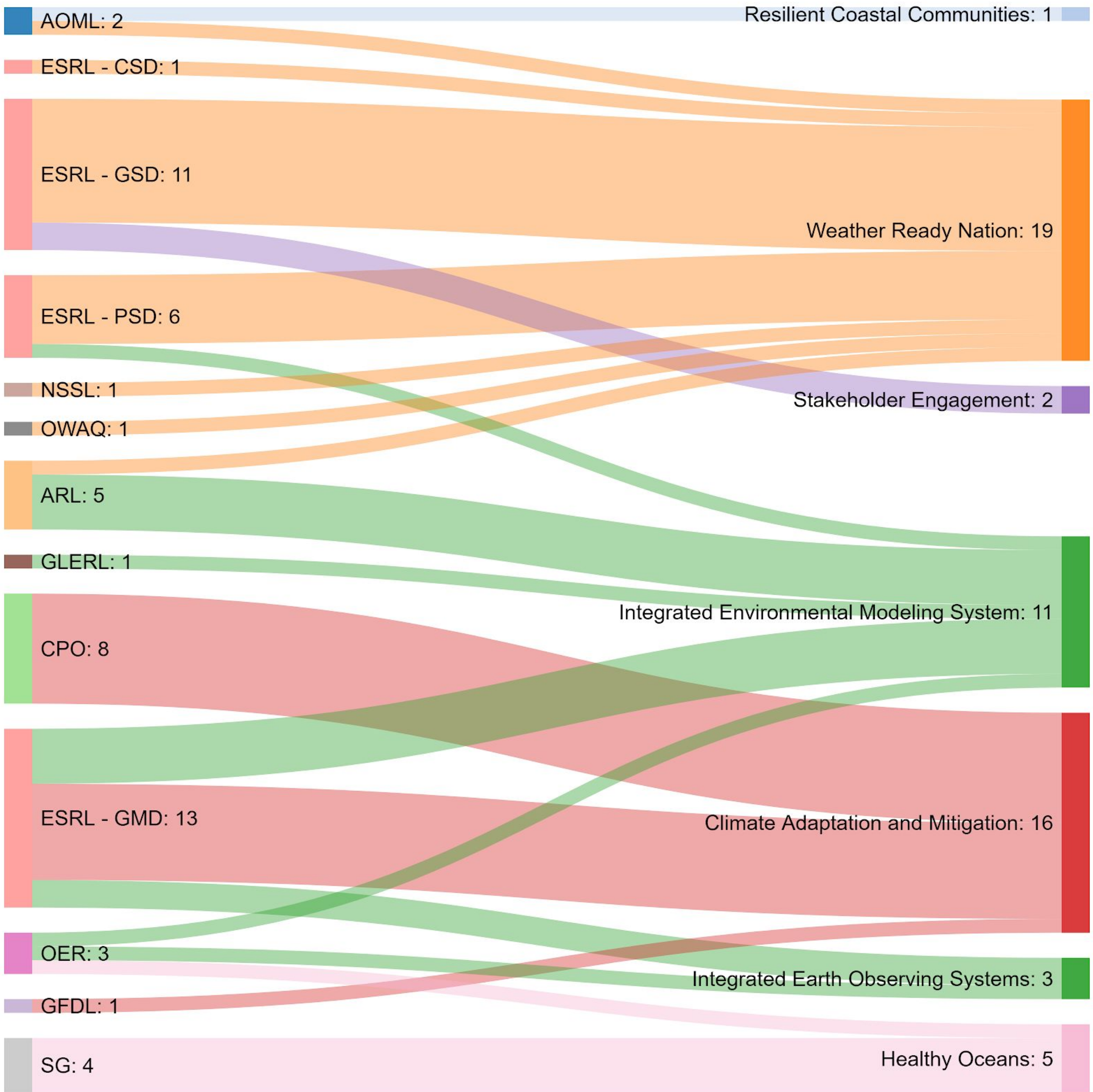

Figure 16. OAR FMC to Strategic Goal

Of the 16 OAR labs and programs, 13 put forth FY18 submissions that were deemed transitions for a total of 57 transitions. These 13 FMCs transitioned products that cover each of the seven NOAA strategic goals. Most FMCs contribute to only one or two of NOAA's strategic goals because OAR labs and programs tend to be more specialized. For example, transitions from the CPO obviously support NOAA's Climate Adaptation and Mitigation strategic goal.

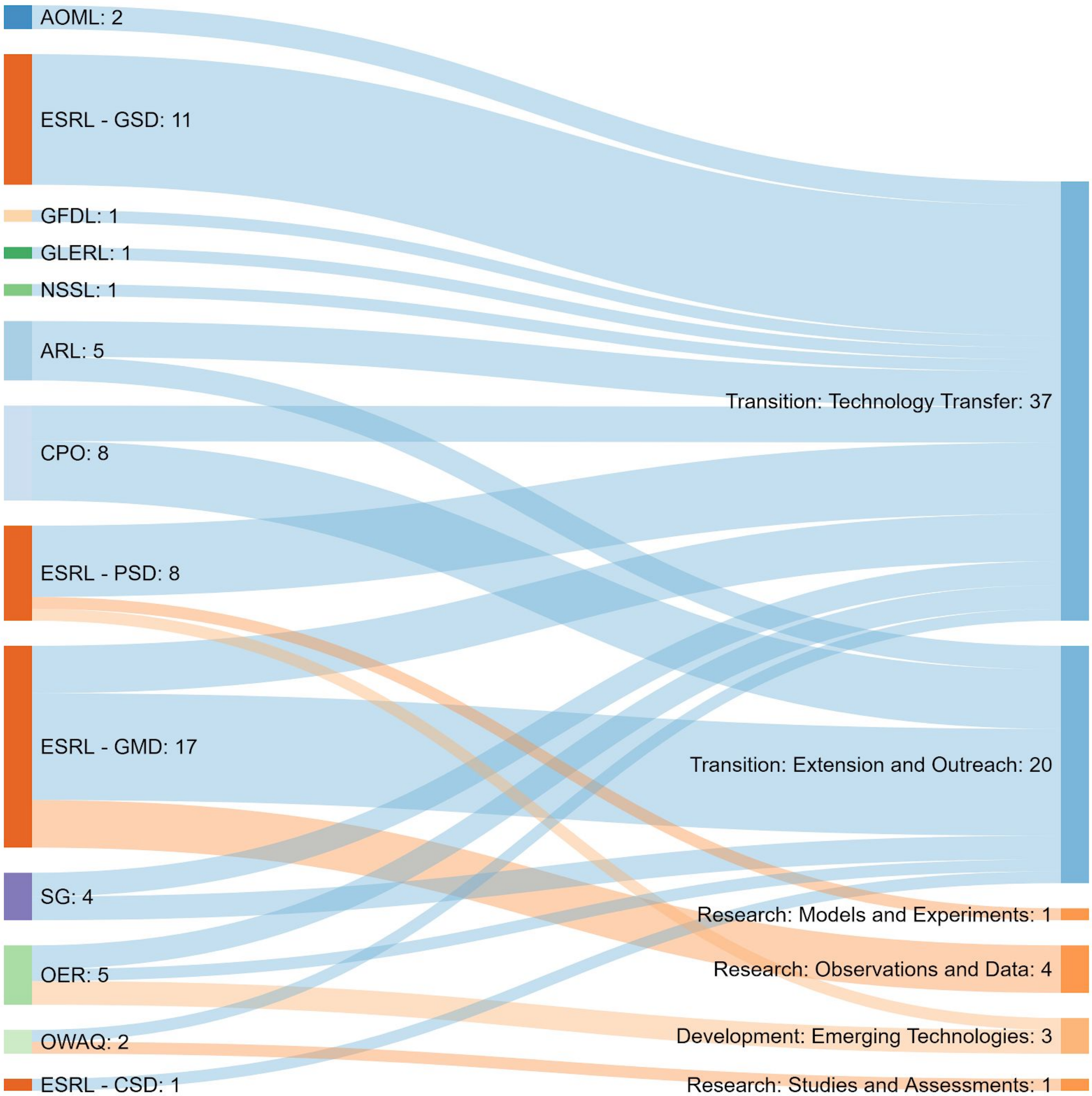

Figure 17. OAR FMC to Function
In order to assess where confusion around transitions still exists, the 13 OAR FMCs were mapped to the function designation of the 66 FY18 submissions. Misidentified transitions came from a number of OAR FMCs.

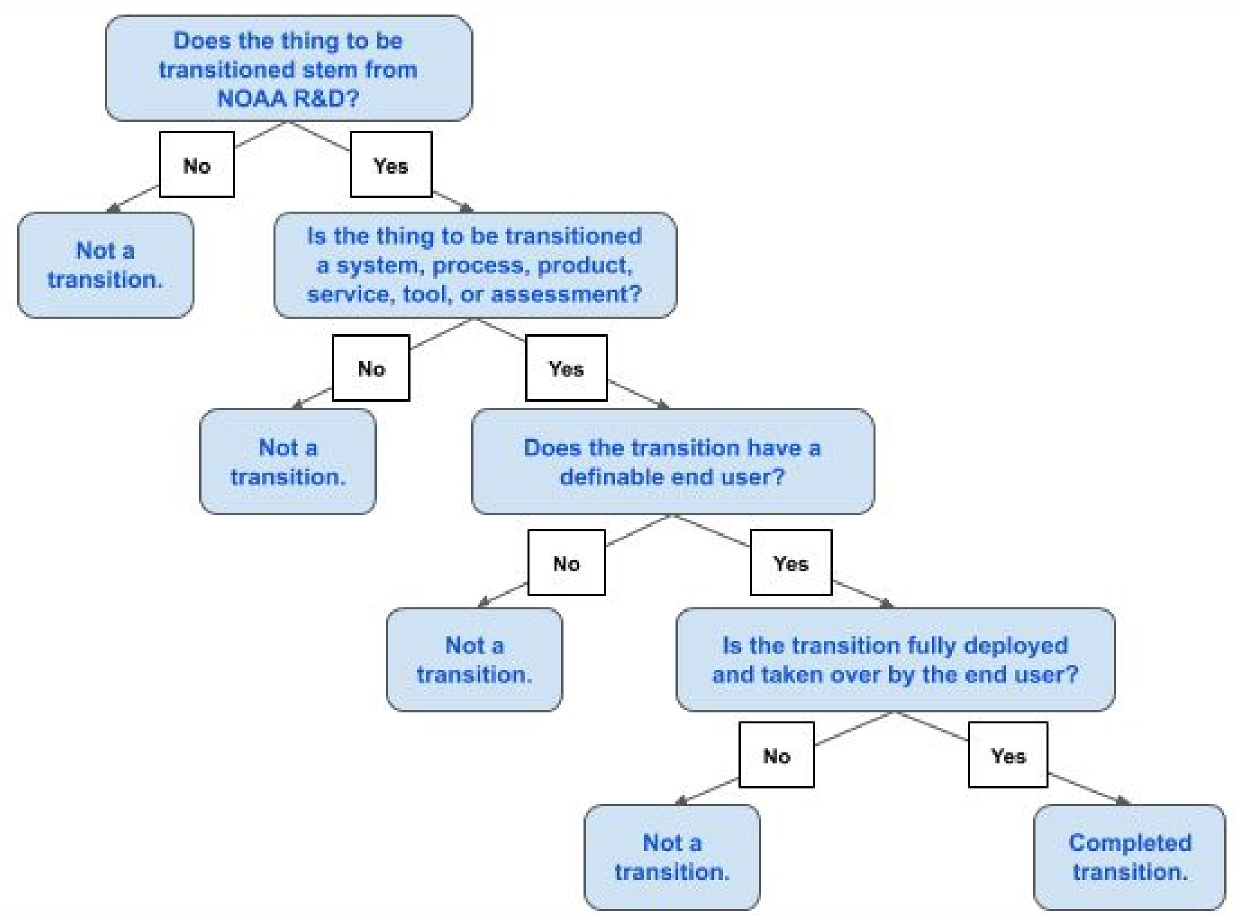

Figure 18. Transition Decision Tree
Confusion persists over what constitutes a transition. This decision tree was designed to prevent the misidentification of transitions and ensure that overlooked transitions are reported. A transition is only completed if the answer to each of these four questions is yes.

Appendix A

List of Acronyms

Abbreviation	Description
AOML	Atlantic Oceanographic and Meteorological Laboratory
ARL	Air Resources Laboratory
CPO	Climate Program Office
DAA/S	Deputy Assistant Administrator for Science
DoC	Department of Commerce
ESRL CSD	Earth Systems Research Laboratory Chemical Sciences Division
ESRL GMD	Earth Systems Research Laboratory Global Modeling Division
ESRL GSD	Earth Systems Research Laboratory Global Systems Division
ESRL PSD	Earth Systems Research Laboratory Physical Science Division
FMC	Financial Management Center
GFDL	Geophysical Fluid Dynamics Laboratory
GLERL	Great Lakes Environmental Research Laboratory
LCI	Laboratories and Cooperative Institutes
NAO	NOAA Administrative Order
NRDD	NOAA Research and Development Database
NSSL	National Severe Storms Laboratory
NWS	National Weather Service
OAR	Oceanic and Atmospheric Research
OER	Office of Exploration and Research
OWAQ	Office of Water and Air Quality
PMEL	Pacific Marine Environmental Laboratory
R&D	Research and Development
R2X	Research to Operations, Applications, Commercializations (etc.)
SG	Sea Grant
UAS	Unmanned Aircraft Systems

Appendix B

NOAA FORM 58-5 (4-04)

National Oceanic and Atmospheric Administration	NOAA Administrative Order 216-105B	
NOAA ADMINISTRATIVE ORDER SERIES	DATE OF ISSUANCE 10/17/2016	EFFECTIVE DATE 10/17/2016
SUBJECT POLICY ON RESEARCH AND DEVELOPMENT TRANSITIONS		

SECTION 1. PURPOSE AND SCOPE.

.01 The National Oceanic and Atmospheric Administration (NOAA) is a science-based service agency. NOAA's ability to meet its mission through the delivery of continually improved products and services relies on the conversion of the best available research and development (R&D) endeavors into operation and application products, commercialization, and other uses. NOAA therefore requires an integrated transition enterprise linking research, development, demonstration, and deployment that is efficient and effective in identifying and using significant new R&D products to meet NOAA's mission needs.

.02 This Order establishes the process for identifying, transitioning, and coordinating R&D output to operations, applications, commercialization, and other uses. This Order outlines the roles and responsibilities of various officials, including Line Office Transition Managers (LOTMs), associated with the transition of R&D. Additionally, this Order identifies those entities with the authority to implement this policy and those who are accountable for transitioning R&D.

.03 This Order applies to all NOAA funded R&D activities, including those conducted by non-NOAA entities.

.04 This Order defines the transition of R&D to any operation, application, commercialization, or other use, and includes products such as 24 hours/7days weather forecasts (typically referred to as research to operations), information products used in resource management (research to application), commercially-available sensors (research to commercialization), or government policies, regulations, synthesis of research, public education and outreach (research to other uses).

.05 This Order does not replace any directive, policy, statute, or other guidance that applies to the prosecution of patents by NOAA or its employees for inventions made in the course of research, the licensing of government owned inventions in the custody of NOAA, or Cooperative Research and Development Agreements and Small Business Innovative Research awards. Such activities are addressed by NAO 201-103: Cooperative Research and Development and Invention Licensing Agreements Under the Federal Technology Transfer Act of 1986 (Public Law 99-502) and other applicable laws, regulations, and related policies. However, this NAO does apply to the identification of potential or realized uses of NOAA's R&D.

.06 Transition projects for which funding or R&D originate outside of NOAA are included in this policy, at the discretion of the respective LOTM.

.07 This Order recognizes that transitions can be either incremental improvements to existing products or applications, or entirely new products or applications.

SECTION 2. DEFINITIONS.

.01 **Application:** The use of NOAA R&D output as a system, process, product, service, or tool. Applications in NOAA include information products, assessments, and tools used in decision-making and resource management.

.02 **Commercialization:** The process of introducing a NOAA product or technology (e.g., invention) into the commercial market, including licensing.

.03 **Construction Projects:** The development, construction, or installation of equipment/asset that is not real property; or the development or modification to software, which will be used internally. The project must equal $200,000 or more; the service life is estimated to be 2 years or more; the project will provide a long-term future economic benefit to the NOAA organization that maintains or obtains control; and it is not intended for sale.

.04 **Demonstration:** Activities that are part of R&D and are intended to prove or to test whether a technology or method does, in fact, work as expected.

.05 **Deployment:** The sustained operation, maintenance, and use of the product of R&D.

.06 **Development:** The systematic work, drawing on knowledge gained from research and practical experience and producing additional knowledge, that is directed to producing new products or processes, or to improving existing products or processes (OECD, 2015).

.07 **Line Office Transition Manager (LOTM):** An individual appointed by each Assistant Administrator (AA) and the Director of the Office of Marine and Aviation Operations (OMAO), who is responsible for managing the Line Office (LO) transition portfolio (collection of transition projects).

.08 **NOAA Invention:** A new, useful process, machine, manufacture, or composition of matter, or any new and useful improvement to a process, machine, manufacture, or composition of matter, developed by NOAA.

.09 **Operations:** Sustained, systematic, reliable, and robust mission activities with an institutional commitment to deliver specified products and services. Examples of operations in NOAA include weather and climate forecast models run on a routine basis to provide forecast guidance or seasonal outlooks, stock assessments conducted to determine changes in the abundance of fishery stocks, and sustained observations for public services and for Earth-System research in the public interest (NSTC 2014).

.10 **Proving Ground:** A framework for NOAA to conduct testing of advanced operations, services, and science and technology capabilities that address the needs of both internal and external users. Successful testing demonstrates readiness to implement into operations. Capabilities to be tested in operational proving grounds have already passed developmental testing. Such capabilities include advanced observing systems, better use of data in forecasts, improved forecast model, and applications for improved services and information with demonstrated economic/public safety benefits.

.11 **Readiness Levels (RLs):** A systematic project metric/measurement system that supports assessments of the maturity of R&D projects from research to operation, application, commercial product or service, or other use and allows the consistent comparison of maturity between different types of R&D projects. (Note: NOAA RL's are similar to Technology Readiness Levels developed by NASA (Mankins, 1995) and embody the same concept for quantifying the maturity of research). A project achieves a readiness level once it has accomplished all elements described within a readiness level. A program may include projects at different RLs depending on the goals of each project. Inventions may be generated at any RL. The nine readiness levels are as follows:

a. RL 1: Basic research, experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view. Basic research can be oriented or directed towards some broad fields of general interest, with the explicit goal of a range of future applications (OECD, 2015).

b. RL 2: Applied research, original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific, practical aim or objective. Applied research is undertaken either to determine possible uses for the findings of basic research, or to determine new methods or ways of achieving specific and predetermined objectives (OECD, 2015).

c. RL 3: Proof-of-concept for system, process, product, service, or tool; this can be considered an early phase of experimental development; feasibility studies may be included.

d. RL 4: Successful evaluation of system, subsystem, process, product, service, or tool in a laboratory or other experimental environment; this can be considered an intermediate phase of development.

e. RL 5: Successful evaluation of system, subsystem process, product, service, or tool in relevant environment through testing and prototyping; this can be considered the final stage of development before demonstration begins.

f. RL 6: Demonstration of a prototype system, subsystem, process, product, service, or tool in relevant or test environment (potential demonstrated).

g. RL 7: Prototype system, process, product, service or tool demonstrated in an operational or other relevant environment (functionality demonstrated in near-real world environment; subsystem components fully integrated into system).

h. RL 8: Finalized system, process, product, service or tool tested, and shown to operate or function as expected within user's environment; user training and documentation completed; operator or user approval given.

i. RL 9: System, process, product, service or tool deployed and used routinely.

.12 **Research:** Research can be classified as basic research or applied research.

a. Basic Research: Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view. Basic research can be oriented or directed towards some broad fields of general interest, with the explicit goal of a range of future applications (OECD, 2015).

b. Applied Research: Applied research is the original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific, practical aim or objective. Applied research is undertaken either to determine possible uses for the findings of basic research or to determine new methods or ways of achieving specific and predetermined objectives (OECD, 2015).

.13 **Testbed:** A NOAA testbed is a working relationship for developmental testing in a quasi-operational framework among researchers and operational scientists/experts (such as measurement specialists, forecasters, IT specialists) including partners in academia, the private sector, and government agencies, aimed at solving operational problems or enhancing operations, in the context of user needs. A successful testbed involves physical assets as well as substantial commitments and partnerships.

.14 **Transition:** The transfer of an R&D output to a capability ready for an operation, application, commercial product or service, or other use.

.15 **Transition Plan:** A document that represents an agreement between clearly identified researchers and potential recipients, organizations, or other users of the product resulting from the transition of an R&D output.

.16 **Transition Project:** A collective set of activities necessary to transfer R&D output to a capability ready for an operation, application, commercial product, or service, or other use (RL 9).

.17 **Transition Project Lead(s):** Individual(s) responsible and accountable for ensuring that the transition project is planned, programmed, budgeted, and executed per the Transition Plan.

SECTION 3. POLICY.

.01 To meet mission needs, NOAA will optimize the timely and efficient use of R&D, including but not limited to that conducted by and funded by NOAA. To fulfill this goal, NOAA shall maintain:

a. A mission-oriented enterprise capable of quickly identifying and applying demonstrated R&D outputs to provide new and improved products, services, or more efficient operations while continuing to maintain reliable, cost-effective services for users;

b. An R&D enterprise that routinely provides proven R&D outputs to serve NOAA's mission while adapting its portfolio to address new research frontiers; and,

c. Project management, planning, and oversight processes that include routine identification of new opportunities/needs for research, development of Transition Plans, status reporting, and test and evaluation procedures.

.02 Transition Plans are essential for describing and facilitating the transition of R&D to potential end use, and represent an agreement between researchers, operators and/or users that describes a feasible transition pathway and potential Concept of Operations (CONOPS).

.03 Transition Plans should be developed as early as possible to reflect the relationship between R&D and NOAA's mission and the commitment by the entities involved to the potential transition of R&D.

.04 Transition Plans are recommended for projects that seek to progress beyond RL 4.

.05 The determination of whether a transition project shall have a written transition plan is at the discretion of the AA(s), or their designees, from the affected LO(s). In making this determination, factors that may be considered include but are not limited to the following:

a. The risks associated with, and the sensitivity of, the transition;

b. The organizations involved in the transition, and their history of implementing transition activities together;

c. The duration of the transition activities;

d. The cost of transition activities;

e. Potential societal impact; and

f. The complexity of the transition, including whether the project is novel or a routine update to existing operations or applications.

For transitions that involve multiple LOs, if any of the AAs or their designees determine that a written transition plan is justified then one shall be developed.

.06 Transition Plans shall incorporate the following:

a. A description of the activities necessary to transfer an R&D output;

b. Clearly defined goals for the new/revised product or service, milestones, schedule, and transition success/acceptance criteria;

c. To the best estimate, the amount and source of funds needed to cover the costs associated with the transition, as well as the cost of future operations as necessary, including relevant requirements for equipment, upgrades, staff training, and maintenance of redundant application capabilities during the transition period;

d. A clear designation of potential researcher(s), operational entity(ies) and/or end user(s), and a description of when they will engage and as often as necessary to ensure all parties are fully invested in the R&D transition process;

e. A mechanism for providing clear communication among all participants concerning the transition, including routine engagement of the management chain in the affected LO(s) and partner organizations; and

f. A mechanism for updating the plan as necessary to reflect changes in the plan warranted by results of the transition process or unforeseen events (e.g., updated budgets).

.07 Transition Plans shall be approved by the AA(s), or their designees, from the affected LO(s).

.08 Transition Planning integrated into Agency Planning: LOTMs shall strive to include transition projects within their portfolio as appropriate into NOAA planning documents, including NOAA strategic plans and LO Annual Operating Plans.

.09 Transition Budgeting integrated into Agency Budgeting: LOTMs shall work towards ensuring that the resources needed to transition R&D outputs to sustainable applications, operations, construction projects, commercialization or other uses are appropriately addressed and included in the Line Office submissions in the appropriate NOAA budget processes.

.10 Evaluation: All Transition Projects shall be reviewed on a periodic basis using the evaluation criteria identified in respective Transition Plans to ensure progress towards readiness levels, goals and milestones.

.11 Reporting: LOTMs will work with Transition Project Leads to report on execution status of transition projects on a regular basis.

.12 This Order follows the guidelines established in NOAA Administrative Order 216-115A, Research and Development in NOAA.

.13 This Order supports the policies and procedures contained in the Paperwork Reduction Act, the Government Paperwork Elimination Act, the Federal Technology Transfer Act, the Bayh-Dole Act, Office of Management and Budget (OMB) Circular No. A-130, Management of Federal Information Resources, the NOAA Information Quality Guidelines, and other applicable relevant laws, regulations, and policies. These authoritative requirements apply government resources to activities in support of the agency's mission, outline procedures to ensure and maximize the quality, utility, and integrity of resultant information, and seek to maximize the benefits of resultant information and intellectual property to society.

.14 NOAA shall be cognizant of and observe the valid rights of patent holders and owners of other intellectual property.

.15 NOAA Invention Disclosure: Prior to any public disclosure (including but not limited to presentations at a public meeting, or publications on a public-facing webpage or in scientific literature), a NOAA invention shall be reported to the NOAA Technology Partnerships Office (TPO) for:

a. Rights determination;

b. Evaluation of patentability and commercial potential; and

c. Inclusion in the NOAA technology and innovation portfolio.

SECTION 4. GOVERNANCE AND RESPONSIBILITIES.

.01 The Under Secretary of Commerce for Oceans and Atmosphere (NOAA Administrator), the Deputy Under Secretary/Operations, and the NOAA Chief Scientist shall provide top management oversight for implementation of this policy, and the development and implementation of associated procedures.

.02 The AAs, the OMAO Director and appropriate NOAA Staff Offices (SOs) support the implementation of this policy through their roles in the NOAA Organizational Handbook.

.03 LO AAs and the Director, OMAO are responsible for the following:

a. Promoting the goals and implementing the requirements of this policy;

b. Appointing LOTMs;

c. Determining, or delegating determination of, whether specific transition projects require written transition plans;

d. When appropriate, approving, or delegating approval of, Transition Plans;

e. Ensuring that Transition Teams are appropriately resourced to carry out their responsibilities;

f. Providing or delegating oversight for all transition projects in their LO;

g. Ensuring LO Transition Project reviews are conducted as appropriate; and

h. Reporting on the execution status of transition projects per instructions provided by the Deputy Under Secretary for Oceans and Atmosphere.

.04 LOTMs include representatives of the LO AAs and the Director, OMAO. The LOTMs are responsible for the following:

a. Collectively monitoring the NOAA transition portfolio (collection of transition projects);

b. Incorporating applicable LO transition projects into NOAA's planning, budget, execution, and evaluation processes;

c. Tracking and providing timely reports to the NOAA Research Council on the status of the portfolio (collection of transition projects);

d. Ensuring the development of appropriate Transition Plans; and

e. Evaluating transition projects with respect to Transition Plans.

The collective LOTMs form a standing committee of the NOAA Research Council. As such, they are expected to report to the Council at least annually on the status of NOAA's transition activities and:

f. Inform the Council on issues of concern related to the transition of research; and

g. Respond to guidance and direction from the Council.

.05 The TPO Director is responsible for:

a. Providing the LOTM committee with updates on TPO activities;

b. Maintaining a database of transitions occurring under TPO purview;

c. Informing the LOTMs of transition opportunities to NOAA application; and

d. Informing the LOTMs of potential intellectual property issues pertaining to specific technology projects.

.06 Transition Project Leads are responsible for managing the transition projects and all associated activities. For transition projects that include construction projects (as defined in 2.03), Transition Project Leads are responsible for providing planning and budgeting documents to a designated Line Office Construction Work-In-Progress Project Manager, who will follow the process and procedures for constructed projects detailed in the NOAA CWIP Policy (http://www.corporateservices.noaa.gov/finance/docs/CWIP/CWIPPolicy--May2016FINAL.pdf).

.07 Transition Teams should include representatives from both the research output and operations or end-user communities. Transition Teams are responsible for the following:

a. Coordinating transition activities; and

b. Identifying, reporting, and responding to significant deviations in the execution of the Transition Plan.

.08 The NOAA Research Council is responsible for the following:

a. Overseeing the LOTM committee;

b. Providing guidance and advice to the NOAA Chief Scientist as pertains to research transition policy, process and practice; and

c. Establishing or overseeing the establishment of policies and processes to foster effective transitions.

.09 Other applicable Councils, such as the NOAA Observing Systems Council and the NOAA Ocean and Coastal Council, are responsible for participating in the NOAA's planning, budget, execution, and evaluation processes and providing comments regarding the identification and readiness of projects for transition and the relative priority of these projects.

SECTION 5. REFERENCES.

.01 Working through the LOTM Committee, the Research Council will develop and disseminate written procedures, plans, and reports as necessary to implement this Order, including but not limited to:

a. Procedural Handbook covering, but not limited to, the following topics:

   i. Use and interpretation of RLs in NOAA; and

   ii. Guidance for developing effective Transition Plans.

.02 Existing documents referenced in this policy are as follows:

a. Mankins, John C. (6 April 1995). "Technology Readiness Levels: A White Paper" (PDF). NASA, Office of Space Access and Technology, Advanced Concepts Office. http://www.hq.nasa.gov/office/codeq/tr l/trl.pdf.

b. NSTC (2014). "National Plan for Civil Earth Observations", https://www.whitehouse.gov/site/default/files/microsites/ostp/NSTC/national_plan_for_civil_earth_observat ions_-_july_2014. pdf

c. NOAA Invention Disclosure and Rights Questionnaire Instructions, http://www.corporateservices.noaa.gov/ames/administrative_orders/chapter_201/201-103-appendix-b.html

d. NOAA Invention Disclosure and Rights Questionnaire http://ocio.os.doc.gov/s/groups/public/@doc/@os/@ocio/@oitpp/documents/content/dev01_002431.pdf

e. OECD (2015), *Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development*, The Measurement of Scientific, Technological and Innovation Activities, OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787/9789264239012-en

SECTION 6. EFFECT ON OTHER ISSUANCES.

.01 This Order supersedes NOAA Administrative Order (NAO) 216-105A, Policy on Research and Development Transitions issued December 3, 2015.

.02 The Under Secretary of Commerce for Oceans and Atmosphere signs because there is no delegation of authority for this NAO.

An electronic copy of this Order will be posted in place of the superseded Order on the NOAA Office of the Chief Administrative Officer website under the NOAA Administrative Issuances Section. http://www.corporateservices.noaa.gov/~ocao/index.html

Under Secretary of Commerce
for Oceans and Atmosphere

Office of Primary Interest:
Office of Oceanic and Atmospheric Research (OAR)

NOAA Administrative Order (NAO) 216-105B:

Policy on Research and Development Transitions

Procedural Handbook

Table of Contents

NAO 216-105B Procedural Handbook: Policy on Research and Development Transitions

Issuing Office: National Oceanic and Atmospheric Administration (NOAA) Office of the Chief Scientist

Release Date: March 21, 2017

1. **Explanation of Material Transmitted:** This Handbook establishes procedures for the planning, monitoring, implementation, evaluation, and reporting of Transition of Research and Development in support of NAO 216-105B.
2. **Filing Instructions:**
    a. Remove: NAO 216-105, Procedural Handbook, dated: 04/28/2014
    b. Insert: NAO 216-105B, Procedural Handbook, dated: 03/21/2017
3. **Additional Information**:
    a. For information on the content of the Handbook, contact the issuing office listed above.
    b. To access the Handbook chapters and appendices online, follow links available from this URL: http://www.corporateservices.noaa.gov/ames/administrative_orders/chapter_216/216-105B.html

Chapter 1 – Purpose and Scope of the NAO for Research and Development Transitions (NAO 216-105B)

A. Purpose

This Handbook supports the NAO on Research and Development (R&D) Transitions (NAO 216-105B[1]). Chapters 2-4 of this Handbook are intended to provide additional guidance for the corresponding sections of the NAO.

This Handbook is established in accordance with NAO 200-3[2] which specifies that NOAA handbooks and manuals containing policy or procedures be elements of the NAO series, providing in-depth coverage of those subjects so complex or extensive as to benefit from coverage in the form of a handbook or manual, and shall have the same force and effect as that NAO.

The use of *Italics* throughout this Handbook indicates language quoted from NAO 216-105B.

B. Policy Background and Scope

The transition of R&D into operations[3], applications[4], commercial product or service, and other regular use (i.e., deployment) is a key process for NOAA as a science-based services and stewardship agency. Efficient conversion of the best available research and development into operations, applications, commercialization and other uses is critical to our mission (Dorman 1999; NRC 2000; NRC 2003; NOAA SAB 2004). NAO 216-105B establishes the process for identifying and transitioning R&D to operations, applications, commercial product or service, and other regular use. The policy outlines the roles and responsibilities of various officials, including Line Office Transition Managers (LOTMs), associated with R&D transition. Additionally, the policy identifies those entities with the authority to implement this policy and those who are accountable for R&D transitions.

NAO 216-105B applies to NOAA R&D activities, including those funded by NOAA but conducted by non-NOAA entities such as academic institutions and consortia. The standard for which R&D activities are subject to the NAO is left to the discretion of the respective Assistant Administrator (AA) or their delegate. The policy also recognizes that transitions can be either incremental improvements to existing products or applications or entirely new products or applications.

C. References

[1] NAO 216-105B: http://www.corporateservices.noaa.gov/ames/administrative_orders/chapter_216/216-105B.html
[2] NAO 200-3 (*The NOAA Administrative Order Series*): http://www.corporateservices.noaa.gov/ames/administrative_orders/chapter_200/200-3.html
[3] Operations: Sustained, systematic, reliable, and robust mission activities with an institutional commitment to deliver specified products and services.
[4] Applications: The use of NOAA R&D output as a system, process, product, service or tool. Applications in NOAA include information products, assessments and tools used in decision-making and resource management.

Please see Appendix A: References for NAO Procedural Handbook (alphabetical order)

D. **Abbreviations**

Please refer to Appendix B: Abbreviations Used in NAO Procedural Handbook

Chapter 2 – Key Terms and Understanding Transition

A. **Purpose**

This Chapter expands on the brief definitions provided in Section 2 of the NAO. Not all the terms and definitions from the NAO are included here, but the concepts that might benefit most from further discussion are presented in this Chapter.

B. **Core Concept of R&D Transition**

Transition of R&D[5] is *the transfer of an R&D output to an operation, application, commercial product or service, or other use*. While it varies from agency to agency or sector to sector, transition requires the evolution of a research project through a clearly defined series of stages. While these stages are set in serial fashion, transition may be achieved without completing all the stages.

C. **Understanding Readiness Levels**

Readiness levels (RLs) are a systematic project metric/measurement system that supports assessments of the maturity of R&D projects from research to operation, application, commercial product or service, or other use and allows the consistent comparison of maturity between different types of R&D projects.

The concept of Technology Readiness Levels was developed by NASA (Mankins, 1995[6]) to manage technology development and risk. NAO 216-105B adapts this concept to NOAA. The NAO provides simple but minimalist definitions of each of nine Readiness Levels that describe the progression of an idea from the research stage to the point where the idea has become a product or tool in regular use. Despite some recent suggestions to define a tenth RL (e.g., Straub, 2015), the NOAA system is constrained to the widely-applied nine RLs described below. The word "technology" was dropped since much of what NOAA produces does not meet the definition of technology.

The purpose of creating a single scale for all of NOAA is to encourage cross-disciplinary understanding of the challenges involved in developing an idea into something that serves a NOAA mission need. With appropriate flexibility in interpretation, it should be possible to successfully classify all relevant R&D projects across the NOAA enterprise by Readiness Level.

Many programs in NOAA run projects at a variety of Readiness Levels and a clear distinction between Readiness Levels and their applicability to each project may be difficult to identify. Program managers are therefore encouraged to use established Line Office, or program standards and benchmarks and engage in dialog with other program managers and their LOTM to define any questionable project Readiness Levels.

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[5] Note: In the NOAA context, R&D means Research and/or Development since not all development at NOAA begins with Research (e.g., new work being done on a more advanced system).
[6] Mankins (1995): http://www.hq.nasa.gov/office/codeq/trl/trl.pdf

At a given project level, the RL is defined at the lowest RL of any of the system components. For example, a project combining two commercial off-the-shelf (COTS) components (by definition, RL 9) with software for a new application that is at RL 4 is considered RL 4 as a project or system.

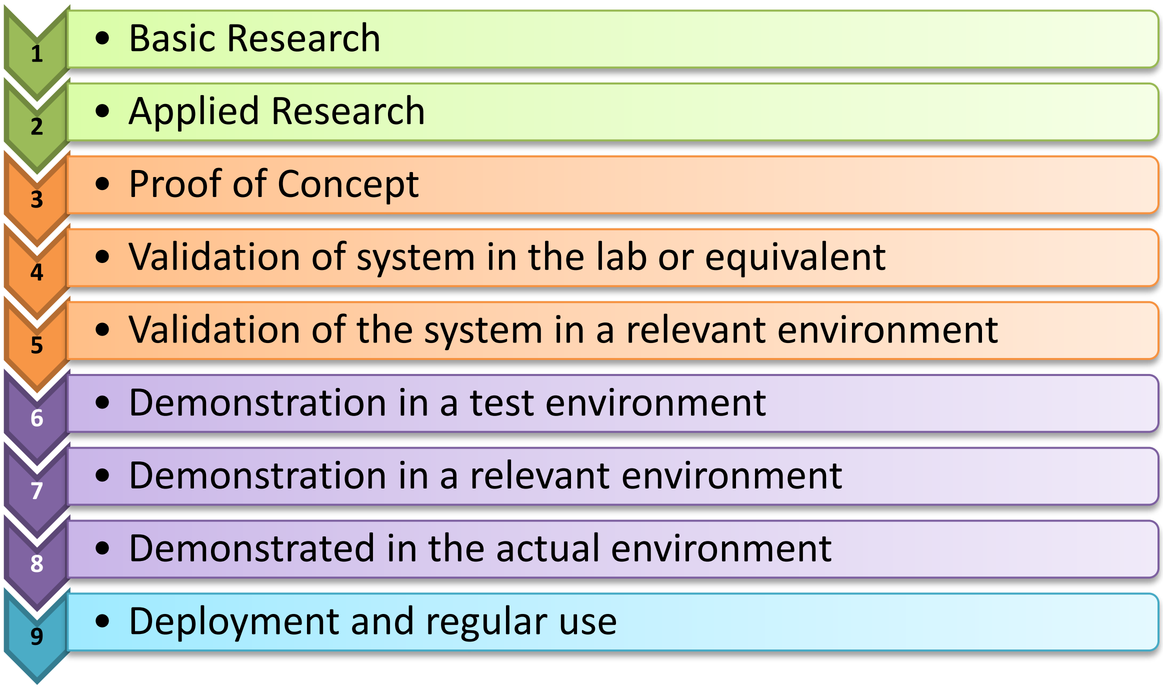

Figure 1. Summary of Readiness Levels (RLs) highlighting the key step for completion of each RL. Colors correspond to the different phases for transition of R&D and RLs are ordered as they would be in the transition funnel (research at the top and deployment at the bottom).

RL 1: Basic research: systematic study directed toward fuller knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications towards processes or products in mind. Basic research, however, may include activities with broad applications in mind. (See Appendix C for further details)

RL 2: Applied research: systematic study to gain knowledge or understanding necessary to determine the means by which a recognized and specific need may be met; invention and concept formulation.

If new research is directly addressing a specific NOAA service or stewardship mission requirement, it is RL 2 by definition that it is research applied toward a specific need.

RL 3: Proof-of-concept for system, process, product, service or tool; this can be considered an early phase of development; feasibility studies may be included.

Beginning at RL 3, there should be increasing involvement of the deploying unit, receiving unit, or end user to aid in the focusing of the research on a mission application. The earliest version of a concept of operations (CONOPS) should be developed no later than RL 3. Depending on the scope of work and the amount of resources utilized (i.e., personnel, funding, equipment and facilities), the CONOPS could vary from a short addendum to a larger program research plan.

RL 4: Validation of system, subsystem, process, product, service or tool in laboratory or other experimental environment; this can be considered an intermediate phase of development.

A viable business case should be in place at RL 4 outlining projected costs and other organizational requirements to get from RL 4 to RL 9. The business case needs to also include a best estimate for total costs in operations or application, including the operations and maintenance "tail" (i.e., total life cycle costs). Depending on the scope of work and the amount of resources utilized (i.e., personnel, funding, equipment and facilities), the business case could vary from a short addendum to a larger program resource requirements plan.

If required by the relevant AAs or their delegates, projects needing a transition plan, should not be resourced beyond RL4 without an approved transition plan in place (NAO 216-105B §3.02-3.08). It is reasonable to expect that transition plans will be proportional in scale, scope, and level of detail relative to the scale, scope, and maturity of the project. Smaller, early RL projects will logically have smaller, less developed transition plans, (if at all) in comparison with larger, more mature projects.

RL 5: Validation of system, subsystem process, product, service or tool in relevant environment through testing and prototyping; this can be considered the final stage of development before demonstration begins.

At RL 5, validation should be done on a prototype of at least medium fidelity in a relevant test environment, to show attainment of pre-defined performance specifications. For certain applications, this would include integrating the system with realistic supporting elements so the system can be tested in a simulated end-use environment.

RL 6: Demonstration of prototype system, subsystem, process, product, service or tool in relevant or test environment (potential demonstrated).

At this stage, a high-fidelity system, component, tool, or service is demonstrated to work in a test environment that includes critical components of the end-use environment. RL 6 is a level where it often becomes necessary to engage with a testbed, research platform (e.g., research vessel), or other demonstration facility to have adequate access to critical components of the end-use environment.

RL 7: Prototype system, process, product, service or tool demonstrated in an operational or other relevant environment (functionality demonstrated in near-real world environment; subsystem components fully integrated into system).

Testbeds, while not required, continue to be a valuable demonstration environment for many transition projects at RL 7, and throughout transition testing, to provide stable access to a near-real world environment. Also, at RL 7, the research and deploying units can expect to fully depend on each other's resources to achieve the milestones to mature beyond this RL.

RL 8: Finalized system, process, product, service or tool tested, and shown to operate or function as expected within user's environment; user training and documentation completed; operator or user approval given.

By RL 8, the deploying unit can expect to be investing a significant fraction, likely the majority, of the resources needed to complete the milestones to advance the transition project.

RL 9: System, process, product, service or tool deployed and used routinely.

Once the system, product, process, service, or tool is fully deployed, it has completed the process transition of R&D. However, it is important to realize that the originating research unit will likely continue to be involved (at a greatly reduced level) to continue refinements or incremental improvements throughout the total life cycle of the system, tool, or service.

Not all transition projects will need to pass through all RLs as distinct steps. Many transition projects may start at a relatively high RL (e.g., several mature components being combined in a novel way). In other cases, some transition projects may start at RL 2 or RL 3, and move as a step function to RL 8 or RL 9 without passing through any intervening RLs. This may be particularly applicable for research conducted to better inform resource management decisions or to develop regulations.

The transition funnel is used within NOAA as a visual tool for understanding the overall process of transitioning R&D.

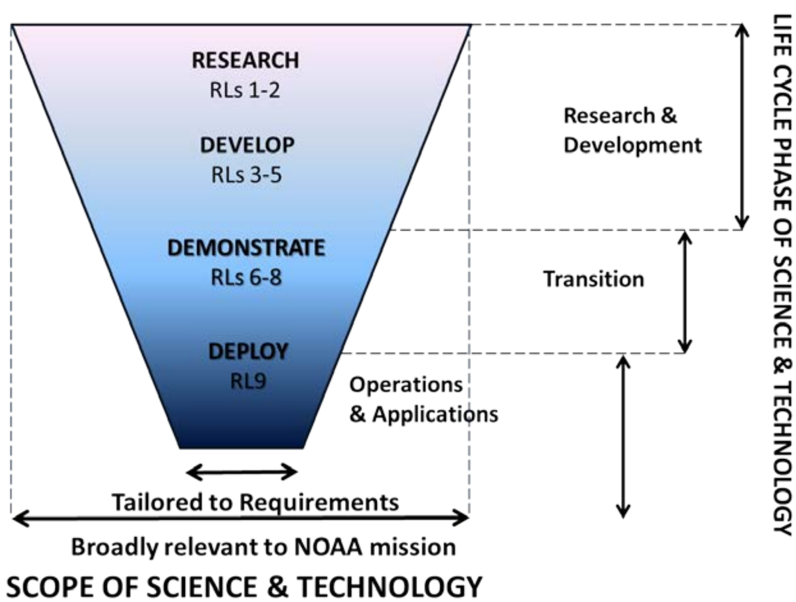

Figure 2. The NOAA transition funnel.

The transition funnel represents at the wide end the range of creative research ideas and projects that emerge in early stages of research. The narrow end reflects the limited number of those early stage research projects that will ultimately transition to deployment at RL 9. Implicit in this representation is that some research projects will fail to meet mission needs along the way towards RL 9 and will be terminated, transferred to an extramural partner, or otherwise divested.

D. **Transition Project Leads and Transition Plans**

1. Transition Project Leads

Transition Project Leads are the *individual(s) responsible and accountable for ensuring that the transition project is planned, programmed, budgeted, and executed per the Transition Plan*. At a minimum, on smaller transition projects, there would be one Transition Project Lead each for:

- The research and development of the system
- The deployment and regular use of the system

However, in more complicated cases, having more Transition Project Leads may be a useful management approach.

It is essential that the Transition Project Leads have sufficient authority and resources to be responsible and accountable for their portions of the transition project. Transition Project Leads will use established Line Office, or program standards and benchmarks to determine the appropriate oversight and coordinate reporting. The NOAA Technology Partnerships Office should be included as a consulting partner in all cases where a new and novel technology has been developed.

2. Transition Plans

Transition Plans are essential for describing and facilitating the transition of R&D to potential end use, and represent an agreement between researchers, operators and/or users that describes a feasible transition pathway and potential concept of operations (CONOPS). Transition Plans are recommended for projects that seek to progress beyond RL4 (NAO 216-105B §3.02-3.03; see also Ch. 2.C.RL4 in this Handbook).

Depending on the scope of work and the amount of resources utilized (i.e., personnel, funding, equipment and facilities), transition plans can vary from a list of milestones to a fully developed program plan. It is also reasonable to expect that projects that are less mature and many years from implementation may have less developed transition plans than those that are only a few years from deployment. Ultimately, each AA or their delegate can set the requirements and expectations for Transition Plans for their Line Office for the projects that require a transition plan.

A Transition Plan Should:

- Be developed once, and updated as necessary;

- Start simple, and gain complexity and detail as a project matures;
- Have complexity and level of effort proportional to the scale, risk, maturity and scope of the project;
- Be widely applicable to a range of planning or management needs;
- Be able to serve as a supporting document to articulate how a specific activity or funding (or lack of), will impact the Transition Project;
- Eventually cover all the expected activities, costs, milestones, etc. for the total life cycle (i.e., from the current RL of the Transition Project through deployment including operations and maintenance costs).

A Transition Plan Should NOT:

- Be tailored to a specific program, request for proposals (RFP), or data call;
- Be a scientific or technical proposal;
- Be an implementation or deployment plan.

At a minimum, the Transition Project Leads should review the Transition Plan on an annual basis, though semi-annual or more frequent review may be more appropriate for faster-paced or more complex Transition Projects. If there are any changes to milestones, timelines, or other aspects of the Transition Plan the respective LOTMs and Division Chiefs (or equivalents) should be consulted about whether the changes are substantial enough to require formal approvals for the updated Transition Plan. Minor changes to transition plans should only require Division Chief (or lower) level approvals for both the research and deployment units. More substantial changes in the transition plan to project milestones, costs, objectives, etc. require a proportionally greater level of approval as guided by the respective LOTMs and Line Office procedures.

A template for a Transition Plan can be found in Appendix D and the generalized process for approving Transition Plans can be found in Appendix E.

E. **Additional Approvals that may be Necessary**

The NAO recommends that transition projects should have an approved transition plan. However, there may be additional project specific requirements beyond a standard transition plan, including, but not limited to:

1. Testbeds and Proving Grounds

If using a testbed[7] or proving ground is part of a transition plan, a letter of support should be obtained from the testbed manager at the earliest practical time. The letter of support should indicate that the testbed manager has reviewed the project requirements, milestones, and transition plan, and that the testbed expects to be able to support the transition project in accordance with what the project requires.

2. Construction Projects

[7] http://www.testbeds.noaa.gov/

If the transition project includes construction, additional clearance will be required in accordance with guidance available from a designated Line Office Construction Work-In-Progress Project Manager, who will follow the process and procedures for constructed projects detailed in the NOAA CWIP Policy[8].

The NOAA CWIP Policy applies to "Property, Plant, and Equipment" (both real property and personal property) and "Internal Use Software Development" that

- Has an aggregate acquisition cost of $200,000 or more,
- Has an estimated service life of 2 years or more,
- Provides a long-term future economic benefit to the NOAA organization which maintains or obtains control, and
- Is not intended for sale.

3. High Performance Computing (HPC)

If a transition project is planning to make substantial demands on HPC resources, or plans to purchase new, or upgrade existing, HPC resources then Transition Project Leads and LOTMs should engage the relevant HPC management bodies within the agency for their approval as early as possible.

4. Invention Disclosure

Each new and novel technology developed should be disclosed to the NOAA Technology Partnerships Office prior to any public disclosure using the CD-240[9] invention disclosure form.

5. Sensitive or Secure Technology Approvals

All technology, software, and materials in transition projects need to be considerate of requirements to comply with DOC Export Administration Regulations (EAR)[10] and DOS International Traffic in Arms Regulations (ITAR)[11]. If a transition project involves any technology, software, or other materials subject to EAR or ITAR, that should be disclosed in the transition plan with approvals indicating that the transition plan will comply fully with those regulations.

[8] http://www.corporateservices.noaa.gov/~finance/documents/CWIPPolicy--March2017FINAL.pdf
[9] http://techpartnerships.noaa.gov/sites/orta/Documents/CD-240-2013.pdf
[10] https://www.bis.doc.gov/index.php/regulations/export-administration-regulations-ear
[11] https://www.pmddtc.state.gov/regulations_laws/itar.html

Chapter 3 – Implementing the Policy on Transition of Research and Development

A. **Purpose**

This Chapter provides details of the process of transition of R&D as it applies across NOAA's mission areas. Emphasis is placed on the essential steps in the implementation process in order to guide the transition practitioner as well as the officials responsible for evaluating transition of R&D in their program or Line Office.

B. **Planning for Transition of R&D**

Successful transition of R&D products to regular use or final deployment or implementation demands careful planning including:

- Early partnership between researchers and potential users/operators
    - The research unit requires a clear understanding of the mission need during the earliest phases of applied research (RL 2) or proof of concept (RL 3), and the deploying unit needs a good understanding of how the new research can address their mission requirements. This is accomplished best by the two organizational units working closely together at the earliest phase of the transition project, including forging clear communication of mission requirements from the deploying unit and clear communication of research potential from the research unit.
    - Where uncertainty exists in the research stage regarding the potential users/operators, a business case and transition plan should be developed as early as possible to ensure identification of the user/operator.
- Early engagement with social science and design experts
    - Recognizing that in many cases for NOAA, the ultimate end user is not the deploying unit, but rather the general public, it is important to engage with social scientists early in the R&D process to ensure that the final state is useful to the intended audience.
    - Recognizing that many applications have interactive interfaces that must be designed for ease of use by intended users.
- Developing an accurate and viable business case
    - A viable business case demonstrates that when the transition project reaches maturity, the deployment is desirable and warranted based on mission needs, and feasible and sustainable with anticipated levels of agency resources.
    - Not all research will have a viable business case for deployment. It is important to realize potential weakness in the business case very early so that changes to the transition project can be made to improve the business case for deployment.
- Incorporation of key decision points for determining progress
    - It is essential that transition projects undergo a thorough review at key decision points in line with Line Office and program office project review standards. These reviews should offer a real option for significant redirection or divestment

    - from the project if performance standards are not achieved or mission needs are not being met.
- Development of "off ramps" in the event that development or demonstration is not successful
    - Even well planned transition projects may fail at any RL for a wide range of reasons, but part of the transition plan should include steps to mitigate the risk of failure.
    - Divestment from failed transition projects, or those that no longer are critical for mission deployment, is essential to preserve the available agency resources for other potentially successful transition projects.

C. **How to Handle Invention(s)**

Prior to any public disclosure of a new and novel technology, the technology manager should contact the NOAA Technology Partnerships Office and discuss the need to disclose project details using the form CD-240. Disclosure kicks off the process for determining ownership and inventorship of any new technology and may help to indicate new pathways for getting a technology into use

D. **Considerations for Dealing with Failure of a Transition Project**

Transition projects have a specific set of performance metrics and milestones to complete each RL. If a transition project has failed to meet the performance metrics or milestones as expected, the project should be carefully reviewed by appropriate lab/office leadership to analyze the root cause of underperforming or missing the milestones. If the transition project is increasing the risk of failure, remedial steps may be taken to salvage the project. If remedial steps prove to be unsuccessful at correcting project shortcomings, the transition project should be considered for divestment.

Divestment from a transition project can occur in several ways, including termination of the project or transfer of the project to an extramural partner. Any decisions to divest from a transition project should proceed in accordance with Line Office standards and policies.

E. **Cadence of Transition and for Monitoring Transition**

1. Cadence of Transition

Movement through the R&D phases and individual RLs is specific to each project and seldom at a linear pace. The early stages of development (RL 3) might require much more time than the late stages of demonstration (RL 8), or for some projects the opposite might be the case. Given the irregular pace of progress through the stages, program managers, supervisors, and other reviewers must be cautious when using rate of maturation as part of the monitoring process.

2. Cadence of Monitoring Transition

The cadence of monitoring progress towards R&D transition to regular use or final deployment or implementation depends on several factors including, but not limited to: total cost of the project (e.g., more expensive projects may require more review), federal government budget cycles, seasonal cycles (e.g., hurricane season), internal NOAA or Line Office planning or review cycles, and sponsoring program review cycles. The cadence of monitoring will also be influenced by the duration of the transition project and the timeline for transition milestones.

3. The Concept of Key Decision Points

Within the transition process for a given project there are logical key decision points for significant review. These key decision points are an essential part of the process that establishes approval to continue with and move to the next step in the transition pathway. Planning to advance a transition project can often represent a commitment of one or more years of dedicated resources. Having project-specific key decision points are thus critical to organizational excellence by serving as pre-planned, and agreed on, opportunities for reviews with respective program managers and project supervisors, course corrections, or even potential divestment from a project with no likelihood of successful transition. The Transition Project Leads should agree on the key decision points and scale them proportionally to the scale and scope of the project. These agreed-upon key decision points could be formally included in the transition plan if desired.

Chapter 4 – Governance, Roles, and Responsibilities for Transition of Research and Development

A. **Purpose**

This Chapter outlines some of the key aspects for managing transition projects through their total lifecycle. The information highlighted in this Chapter is in addition to standard project or program management practices that are more widely used and should be followed routinely with any project.

B. **Who Should Monitor Transition of R&D**

1. Transition Project Leads

Transition Project Leads and their immediate supervisors are the first line of oversight on a transition project, and as such are the most responsive and engaged for governance and monitoring progress of the project. Transition Project Leads are responsible for setting milestones and managing the resources for a transition project on a day-to-day basis. In their capacity, they should maintain a good working relationship with their respective LOTMs as well as all partnering units from other parts of the agency.

2. Line Office Transition Managers (LOTMs)

LOTMs or their delegates are responsible for periodic transition monitoring within and between line offices (in the case of projects transitioning from one line office to another). The LOTMs should work together to monitor the NOAA transition portfolio.

LOTMs or their delegates are also the key line office point of contact for Transition Project Leads with respect to the transition process. In this capacity, LOTMs will be informed on all aspects of the transition by the Transition Project Leads.

LOTMs or their delegates will monitor progress and status of transition projects compared to their approved Transition Plan, and are empowered to recommend changes to the transition plans as needed.

3. Line Office Assistant Administrators (AAs)

Line Office Assistant Administrators (AAs) are responsible for promoting the goals and implementing the requirements of this NAO on transition, and appointing the respective LOTMs to ensure appropriate oversight of transition projects for the Line Office.

Chapter 5 – Reporting on Transition of Research and Development

A. Purpose

This Chapter describes the recommended approach for reporting on transition projects throughout their total life cycle.

B. Who Reports on Transition

LOTMs, program managers, and Transition Project Leads are responsible for reporting on the execution status of transition projects. Depending on programmatic or Line Office requirements, this may be necessary as often as quarterly. At a minimum, reporting should be done in line with the requirements of Line Office level annual operating plans (AOPs). There may also be additional reporting requirements specific to the program that is funding the transition project.

Appendix A – References for this Handbook

Dorman, C., 1999. Technology Infusion Panel - Summary Report, Memorandum to Jack Kelly, 15 March, 1999, National Weather Service, Silver Spring, Maryland.

Mankins, J.C. (6 April 1995). Technology Readiness Levels: A White Paper (PDF). NASA, Office of Space Access and Technology, Advanced Concepts Office.

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SAB, 2004, Review of the Organization and Management of Research in NOAA: A Report to the NOAA Science Advisory Board, August 6, 2004. ftp://ftp.oar.noaa.gov/SAB/sab/Reports/RRT_Report-080604.pdf

Straub, J., 2015. In search of technology readiness level (TRL) 10. Aerospace Science and Technology 46, p. 312-320.

Appendix B – Abbreviations used in this Handbook

AA	Assistant Administrator
AGM	Annual Guidance Memorandum
AOP	Annual operating plan
CONOPS	Concept of operations
COTS	Commercial off-the-shelf
DAA	Deputy Assistant Administrator
DoC	U.S. Department of Commerce
DoD	U.S. Department of Defense
LOTM	Line Office Transition Manager
LOTMC	Line Office Transition Managers Committee
NAO	NOAA Administrative Order
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
R&D	Research and/or development
RFP	Request for proposals
RL	Readiness level
SRGM	Strategic Research Guidance Memorandum

Appendix C – Example Milestones For Each Readiness Level (RL)

Below is a figure adapted from NASA[12] to illustrate the requirements for a project to be cited as "at RL X." To be at a given RL, <u>all</u> components of your project must have completed all of the preceding milestones. For example, to be considered RL 5, all project components must have completed every milestone indicated above RL 5 in this figure. While the project is at RL 5, it should be working on any of the milestones at or below RL 5.

[12] http://www.nasa.gov/sites/default/files/files/ARLMilestonesFigure10712.pdf


Baseline research conducted and documented
Technology or application components formulated and created
RL 2
Ideas for mission application developed
All technology or application components tested individually
Technical or application components formulated and created
Prospective business case for the technology or application
Transition project reviewed by relevant leadership (transition phase checkpoint)
RL 3
Components of eventual system brought together and technical integration issues worked out
Convincing business case for the viability of technology or application
Initial CONOPS developed
Organizational challenges identified and managed
RL 4
Application or technology components integrated into a functioning prototype system with realistic supporting elements
Well-developed business case for complete life cycle
Formal Transition Plan developed
RL 5
Prototype system beta-tested in a simulated relevant environment
Projected improvements over existing systems achieved in a simulated relevant environment
Transition project reviewed by relevant leadership (suggested key decision point)
RL 6
Prototype system integrated into a relevant environment
Prototype system tested for functionality and initial demonstration potential in a relevant environment
RL 7
Prototype system tested and demonstrated full potential in a relevant environment
RL 8
Finalized system tested and demonstrated full potential in a relevant environment
System qualified for deployment by end user
End user documentation and training completed
RL 9
Sustained deployment

Appendix D – Example Transition Plan Template

A Transition Plan should be as concise as possible and commensurate with scope/complexity/maturity of the project. An example Transition Plan for a more mature project is outlined below. A transition plan for a less mature project might be expected to only address a few of the elements outlined below per guidance from the respective AA or their designee, and/or respective LOTM(s).

Example Transition Plans are available on the NOAA Research Council website[13]. More examples will be added there as they become available.

1. Purpose/Objective
2. Research background
3. Business case
    3.1. Who are the possible end users?
    3.2. Societal and economic benefits
    3.3. User Requirements
    3.4. Current (demonstration) system
    3.5. Justification/acceptance criteria for transition
    3.6. Optional transition project rejection release statement[14]
4. Capabilities and Functions
    4.1. Current (where is it now?)
    4.2. Operational/Application (description of intended end state)
    4.3. Data collection and management
5. Transition Activities:
    5.1. Identify any "gates" and associated documentation for accomplishing progress from one readiness level to another required to be met by the appropriate Line Offices
    5.2. Identify any testbed and proving ground that will be involved
    5.3. Identify any possible new technology development
6. Schedule and deliverables
    6.1. Implementation Plan
    6.2. Milestones
    6.3. Training manuals
    6.4. Mechanism for updating the plan
7. Roles and Responsibilities (for the Transition)
8. Budget overview
    8.1. Cost of current system
    8.2. Cost of transition
    8.3. Cost of operational system and maintenance

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[13] http://nrc.noaa.gov/NOAARDPolicies/ExampleTransitionPlans.aspx

[14] Example: Either Party may at any stage of the transition project terminate plans for further development or final transition acceptance by giving 60 days written notice authorized by the AA or their delegate.

8.4. Optional financial release statement[15]
9. Impacts of Transition
   9.1. Budget- spend plan (proportional resolution appropriate to scale, scope, and maturity of project)
   9.2. Risks and mitigation
10. References
11. Signature page

[15] Example: The Parties specifically acknowledge that this transition plan does not constitute an obligation of funds.

Appendix E – Recommended Process for Completing a Formal Transition Plan

1. Purpose:

The purpose of this document is to describe the process involved in the official review and approval of Transition Plans by the NOAA management.

2. Background:

The NOAA Administrative Order (NAO) 216-105B states that all projects that seek to advance beyond Readiness Level 4 are recommended to have a transition plan. It is reasonable to expect that projects that are less mature and many years from implementation may have less developed transition plans that may not require the full review or approval process outlined below. Ultimately, each AA or their delegate can set the requirements and expectations for Transition Plans for their Line Office, and that will directly influence any review or approval process.

3. Review and Approval Process:

There are three stages in the transition plan review and approval process if the AA or their delegate decide that a particular transition project warrants a full or formal transition plan. The first stage is the working level review and approval, the second stage is the affected Line Office Transition Manager's (LOTM) review and approval, the third stage is the affected Line Office Assistant Administrator's (AA) review and approval with signature for the record.

I. In the working level stage, the Transition Project Lead (i.e., principal investigator) of the project, in coordination with the transition team, is responsible for development of a draft transition plan. This draft transition plan must be reviewed and approved by the division chiefs or other resource managers of both R&D and receiving sides. Once the draft transition plan is approved at the division chief's level, it will be submitted to the responsible LOTM to start the formal review and approval process.

II. In the second stage, the affected LOTMs coordinate the review and approval process of the draft transition plan following his/her Line Office's procedures. For projects involving multiple Line Offices, the LOTMs will coordinate the review and approval across the Line Offices.

III. In the third stage of the review process, the affected LOTM coordinates with the Line Office (LO) clearance process to start the formal review and approval process by the affected LO Assistant Administrator (AA) or their delegate(s), to produce the finalized transition plan, signed by the relevant AA(s) or their delegate(s).

Appendix D

Type of Activity

Research. "Systematic study directed toward fuller scientific knowledge or understanding of the subject studied" (NSF/OMB definition). Per the OAR Strategic Plan, the following are products of research activities:

> Research: Observations and Data. Collecting data on the Earth system for use in models and studies. This includes analyzing observations and developing insights based on those observations, as well as procuring and maintaining observing systems, quality control of data, and archive and access.
>
> Research: Models and Experiments. Models codify our understanding of a system in terms of the relationships among its elements, both qualitatively and quantitatively. Scientific experiments test hypotheses about these relationships as the basis for creating, refining, and rethinking models. This combines lab and field work with coding experimental algorithms and running simulations.
>
> Research: Studies and Assessments. Synthesizing scientific knowledge of Earth systems into tools for decision making and future research, often using observational data, model output, experimental results, and other research as source material.

Development. "Systematic use of the knowledge or understanding gained from research, directed toward the production of useful materials, devices, and systems or methods, including design, development, and improvement of prototypes and new processes. It excludes quality control, routine product testing, and production" (NSF/OMB definition). Per the OAR Strategic Plan, the following are products of development activities:

> Development: Predictions and Projections. Applying advanced models of Earth systems to make predictions about the future (using present-day conditions) or projections (using plausible economic development scenarios). They are pre-operational products intended for use in regular services. They require models, data, advanced computing architectures and techniques, and the publication and interpretation of information.
>
> Development: Emerging Technologies. Creating new or significantly improved technology for observation and modeling systems, as well as tools for information delivery and stakeholder engagement. Typically, this involves the development or application of new hardware or software, or the integration of technologies into systems.

Transition. "Transition is the transfer of knowledge or technology from a research or development setting to an operational setting. Transition occurs in two phases: 1) Demonstration (e.g., the use of test-beds to confirm operational usability or demonstration using rapid prototyping), which is part of R&D; and 2) Deployment (e.g., the integration of new people, equipment, or techniques into an operational environment), which is part of operations" (NAO 216-105B). Per the OAR Strategic Plan, the following are products of transition activities:

> Transition: Extension and Outreach. Working directly with stakeholders on the ground to understand their needs, conduct research that meets those needs, and translate results so that they are meaningful and actionable. Ensuring that the results of R&D are accessible to and understood by stakeholders that might use them.
>
> Transition: Technology Transfer. Working with end-users to integrate mature technologies (and associated expertise) into larger systems, either in NOAA operations or partner applications, via testbeds, patents, etc.

Type of Output

The "things transitioned" were understood as outputs and fell into the broad categories of either science or technology. Within these categories, definitions of specific output types are below. The first three (original data, synthesized product, and interpreted product) are taken from NOAA Information Quality Act Guidelines, maintained by the NOAA CIO. The other definitions were constructed per web searches of relevant terms, which was deemed to be accurate enough for these general concepts.

Science Outputs. These are defined as data, information, or knowledge (either codified or tacit) -- they allow us to understand things we would not have otherwise understood.

> Science: Original Data. Original Data are data in their most basic useful form. These are data from individual times and locations that have not been summarized or processed to higher levels of analysis. While these data are often derived from other direct measurements (e.g., spectral signatures from a chemical analyzer, electronic signals from current meters), they represent properties of the environment. These data can be disseminated in both real time and retrospectively. Examples of original data include buoy data, survey data (e.g., living marine resource and hydrographic surveys), biological and chemical properties, weather observations, and satellite data.
>
> Science: Synthesized Product. Synthesized Products are those that have been developed through analysis of original data. This includes analysis through statistical methods;

model interpolations, extrapolations, and simulations; and combinations of multiple sets of original data. While some scientific evaluation and judgment is needed, the methods of analysis are well documented and relatively routine. Examples of synthesized products include summaries of fisheries landings statistics, weather statistics, model outputs, data display through Geographical Information System techniques, and satellite-derived maps. Science: Interpreted Product. Interpreted Products are those that have been developed through interpretation of original data and synthesized products. In many cases, this information incorporates additional contextual and/or normative data, standards, or information that puts original data and synthesized products into larger spatial, temporal, or issue contexts. This information is subject to scientific interpretation, evaluation, and judgment. Examples of interpreted products include journal articles, scientific papers, technical reports, and production of and contributions to integrated assessments.

Science: Tacit Expertise. Tacit knowledge (as opposed to formal, codified or explicit knowledge) is the kind of knowledge that is difficult to transfer to another person by means of writing it down or verbalizing it. For example, stating to someone that London is in the United Kingdom is a piece of explicit knowledge that can be written down, transmitted, and understood by a recipient. However, the ability to speak a language, use algebra, or design and use complex equipment requires all sorts of knowledge that is not always known explicitly, even by expert practitioners, and which is difficult or impossible to explicitly transfer to other users.

Technology Outputs. These are defined as automated processes or artifacts (hardware or software) -- they allow us to do things we would not have otherwise done.

Technology: Model, Algorithm. A mathematical model is a description of a system using mathematical concepts and language. A model may help to explain a system and to study the effects of different components, and to make predictions about behavior. Mathematical models include dynamical systems, statistical models, differential equations, or game theoretic models. An algorithm is a step-by-step procedure for calculations. Algorithms are used for calculation, data processing, and automated reasoning.

Technology: Hardware, Equipment. The artifacts of technology. Material objects designed, engineered, and built to serve a purpose. Any physical item -- i.e., a tool or device -- that can be used to achieve a goal, especially if the item is not consumed in the process. In NOAA's case, this includes computers, sensors, observation platforms. It does not include software, data, or information. A piece of hardware or equipment is a discrete item, and may be incorporated as a component within a larger system or service.

Technology: System, Service. A system is a set of interacting or interdependent components forming an integrated whole or a set of elements (often called 'components') and relationships which are different from relationships of the set or its elements to other elements or sets. A Service is a set of actions or solutions that are put in place or are performed to provide a repeatable and consistent set of outcomes, deliverables, and performance for people, organizations, and systems that represent consumers or beneficiaries of such results.
Technology: Standards, Protocols. A technical standard is an established norm or requirement in regard to technical systems. It is usually a formal document that establishes uniform engineering or technical criteria, methods, processes and practices. A technical standard can also be a controlled artifact or similar formal means used for calibration. In the natural sciences a protocol is a predefined written procedural method in the design and implementation of experiments. Protocols are written whenever it is desirable to standardize a laboratory method to ensure successful replication of results by others in the same laboratory or by other laboratories.

Number of Recipients

Recipient number for the thing transitioned were captured in rough orders of magnitude: a single recipient, several recipients, or a very large (essentially infinite) number of recipients. This categorization was necessary to understand how widely or narrowly applicable the output is relative to applications.

Single. One party named in submission.

Several. A discrete number of parties named in submission.

Infinite. Recipient is understood as "the public" or "the scientific community".

Unknown/Cannot Determine. Data provided in submission did not provide a clear number of recipients.

Type of Recipient

Recipient type was bundled within three sectors: public, private and academic. The former two sectors were subdivided into more particular categories (e.g. within the public sector, OAR vs NOAA beyond OAR vs other federal agencies). While recipient type and the application type (see below) are related, in the course of the analysis, it became necessary to distinguish between them.

Public - Federal - OAR. Any organization within Oceanic and Atmospheric Research (i.e. Laboratories or Program Offices).

Public - Federal - NOAA (not OAR). Any Line (or Staff) Office at the National Oceanic and Atmospheric Administration besides Oceanic and Atmospheric Research.

Public - Federal (not NOAA). Any Federal agency or body besides the National Oceanic and Atmospheric Administration.
Public - State/Local/Tribal. An organization of a state, regional, municipal, or tribal government (e.g., a local port authority).

Public - International. An organization of a foreign government or multinational organization (e.g. the United Nations).

Private - For Profit. Organizations that operate for profit, including corporations that are either privately held or publicly traded. This also includes start-ups as defined as small, recently founded organizations that operate for profit. Start-ups did comprise their own category in the previous analysis but that distinction was not warranted in this analysis.

Private - Not For Profit. Non-governmental organizations that aim for public welfare outcomes, not profits.

Academic. Colleges, universities, and other institutions focused on research and education.

Multiple Users. A new category was included to incorporate submissions that were targeted for use by multiple users of different recipient types (e.g., a model that is transitioned to Academic, Federal, and state agencies).

Type of Application

Applications were the immediate application of the output, rather than downstream or ultimate application. “Research” was used to label those instances where the immediate use of the output was follow-on research, but is not understood to be an application, per se, as it does not create social or economic value beyond improved scientific understanding.

Application: Environmental Intelligence. Information measured, gathered, compiled, exploited, analyzed and disseminated to characterize the current state and/or predict the future state of the environment at a given location and time.

Application: Resource Management. Environmental resource management is the management of the interaction and impact of human societies on the environment. It aims to ensure that ecosystem services are protected and maintained for future human generations, and also maintain ecosystem integrity through considering ethical, economic, and scientific (ecological) variables.

Application: Policy, Legislation, Law. This includes the crafting and influencing of policy at the local, state, tribal, federal, or international levels. Policy can be the proceedings and directives of legislatures or executives or judiciaries. Applications may be the creation, implementation or the debate over public law.

Application: Education, Learning. This is the imparting of knowledge and understanding. Education and learning applications include, but are not limited to K-12 education. They can also include higher education or "lifelong learning" of adults. This may be lecturing, activity based learning, or the production of educational materials.

Application: Emergency Management. Disaster management (or emergency management) is the managerial function charged with creating the framework within which communities reduce vulnerability to hazards and cope with disasters. Disaster management does not avert or eliminate the threats, instead it focuses on creating plans to decrease the impact of disasters.

Application: Commerce. Commerce is the whole system of an economy that constitutes an environment for business. It can also be defined as a component of business which includes all activities, functions and institutions involved in transferring goods from producers to consumers.

Research. "Systematic study directed toward fuller scientific knowledge or understanding of the subject studied" (NSF/OMB definition). Note that, research is included as an "application" for ease of binning only; follow-on research may be the use of a NOAA research output, but it is not an application in the sense of a mature capability that provides social/economic value beyond that of improved understanding.

Strategic Goal

OAR focuses on NOAA's outcome-oriented goals (per the Next Generation Strategic Plan) for climate, weather, oceans and coasts, which are themselves derived from the NOAA vision.

Those goals, which have been updated in this version to reflect the most recent NOAA 5-Year Research and Development Plan and the OAR Strategic Plan, are as listed below.

Climate Adaptation and Mitigation: An informed society anticipating and responding to climate and its impacts.

- What is the state of the climate system and how is it evolving?
- What causes climate variability and change on a global to regional scales?
- What improvements in global and regional climate predictions and projections are possible?
- How can NOAA best inform and support the Nation's efforts to adapt to the impacts of climate variability and change?

Weather-Ready Nation: Society is prepared for and responds to weather-related Events.

- How can we improve forecasts, warnings, and decision support for high-impact weather events?
- How does climate affect seasonal weather and extreme weather events?
- How can we improve space weather warnings?
- How can we improve forecasts for freshwater resource management?

Healthy Oceans: Marine fisheries, habitats, and biodiversity are sustained within healthy and productive ecosystems.

- How do environmental changes affect marine ecosystems?
- How is the chemistry of our ocean changing and what are the effects?
- What exists in the unexplored areas of our oceans?
- How can emerging technologies improve ecosystem-based management?
- How can we ensure aquaculture is sustainable?

Resilient Coastal Communities and Economies: Coastal and Great Lakes communities are environmentally and economically sustainable.

- What is the value of coastal ecosystems?
- How do coastal species and ecosystems respond to habitat loss, degradation and change?
- How do we ensure that growing maritime commerce stays safe and sustainable?
- How do we reduce the economic and ecological impacts of degraded water quality?
- How is the Arctic affected by expanding industry and commerce?

Stakeholder Engagement

- How can we support informed public response to changing environmental conditions?
- How can we improve the way scientific information and its uncertainty are communicated?

Accurate and Reliable Data from Sustained and Integrated Earth Observing Systems

- What is the best observing system to meet NOAA's mission?
- How can we best use current and emerging environmental data?
- How can we improve the way we manage data?

An Integrated Environmental Modeling System

- How can modeling be best integrated and improved with respect to skill, efficiency, and adaptability?
- What information technology developments can help NOAA improve quantitative predictions?

Appendix E

OAR FMC	Transition	End User	Meets the Definition of Transition	Function Type	Output Type	Recipient Number	Recipient Type	Application Type	OAR Strategic Goal	NOAA Strategic Goal	Blue Economy	Weather Act
AOML	HWRF Upgrades	Not Reported	yes	Transition: Technology Transfer	Technology: Model Algorithm	Single	Federal Government: NOAA	Emergency Management	Weather Ready Nation	Earth System Modeling	Coastal Risk Reduction and Preparedness	Yes
AOML	R2C: CRADA 3RR3HWSP14, Research to Aid Management of Coastal Water and Watershed Quality	Weston Solutions, Inc.	yes	Transition: Technology Transfer	Technology: Standards Protocols	Single	Private: For Profit	Environmental Intelligence	Resilience Coastal Communities	eDNA/Omics	Coastal Risk Reduction and Preparedness	No
ARL	HYSPLIT Volcanic Ash dispersion forecast (v7.4.12)	NWS/NCEP/NCO	yes	Transition: Technology Transfer	Technology: Model Algorithm	Single	Federal Government: NOAA	Emergency Management	Integrated Environmental Modeling System	Earth System Modeling	Not Applicable	No
ARL	HYSPLIT Volcano Trajectories (v7.4.13)	NWS/NCEP/NCO	yes	Transition: Technology Transfer	Technology: Model Algorithm	Single	Federal Government: NOAA	Emergency Management	Integrated Environmental Modeling System	Earth System Modeling	Not Applicable	No
ARL	HYSPLIT READY web site	NOAA, DOD, DOE, EPA, academia, national and international research community	yes	Transition: Technology Transfer	Technology: Model Algorithm	Infinite	Multiple Users	Research	Weather Ready Nation	Earth System Modeling	Not Applicable	No
ARL	Support for EPA for modeling transport of nuclides from foreign accident	EPA	yes	Transition: Extension and Outreach	Science: Tacit Expertise	Single	Federal Government: Other	Emergency Management	Integrated Environmental Modeling System	Not Applicable	Not Applicable	No
ARL	Support to the National Air Quality Forecasting Capability (NAQFC)	NOAA	yes	Transition: Extension and Outreach	Science: Interpreted Product (T)	Single	Federal Government: NOAA	Environmental Intelligence	Integrated Environmental Modeling System	Not Applicable	Not Applicable	Yes
CPO	Climate Resilience Toolkit	Stakeholders and decision makers in the new regions	yes	Transition: Technology Transfer	Technology: System Service	Several	State/Local/Tribal Government	Environmental Intelligence	Climate Adaptation and Mitigation	Earth System Modeling	Coastal Risk Reduction and Preparedness	No
CPO	Annual Arctic Report Card	Arctic science community and public	yes	Transition: Extension and Outreach	Science: Synthesized Product	Several	Multiple Users	Education/Learning	Climate Adaptation and Mitigation	Earth System Modeling	Not Applicable	No
CPO	Annual State of the Climate Report	Climate science community and public	yes	Transition: Extension and Outreach	Science: Synthesized Product	Several	Multiple Users	Education/Learning	Climate Adaptation and Mitigation	Earth System Modeling	Not Applicable	No
CPO	National Climate Assessment	NCA4 authors, USGCRP, climate community, public	yes	Transition: Extension and Outreach	Science: Synthesized Product	Several	Multiple Users	Education/Learning	Climate Adaptation and Mitigation	Earth System Modeling	Not Applicable	No
CPO	Climate Resilience Toolkit	Not Reported	yes	Transition: Technology Transfer	Technology: System Service	Infinite	Multiple Users	Environmental Intelligence	Climate Adaptation and Mitigation	Earth System Modeling	Not Applicable	No
CPO	AC4/Atmospheric Chemistry	Atmospheric chemistry community, agriculture researchers	yes	Transition: Extension and Outreach	Science: Synthesized Product	Several	Academic	Environmental Intelligence	Climate Adaptation and Mitigation	Earth System Modeling	Not Applicable	No
CPO	Improving the NCEP CFS through Enhancing the Representation of Soil-Hydrology-Vegetation Interactions	NOAA NCEP EMC	yes	Transition: Technology Transfer	Technology: Model Algorithm	Single	Federal Government: NOAA	Environmental Intelligence	Climate Adaptation and Mitigation	Earth System Modeling	Not Applicable	Yes
CPO	AC4/Atmospheric Chemistry	ESRL/CSD, GMD, and broader methane research community	yes	Transition: Extension and Outreach	Science: Synthesized Product	Several	Multiple Users	Environmental Intelligence	Climate Adaptation and Mitigation	Not Applicable	Not Applicable	No
CSD	UWFPS	Utah Department of Environmental Quality; Department of Air Quality	yes	Transition: Extension and Outreach	Science: Synthesized Product	Single	State/Local/Tribal Government	Resource Management	Weather Ready Nation	Not Applicable	Not Applicable	Yes
GFDL	Temperature and Precipitation Guidance Tool for week 3-4 outlooks	CPC	yes	Transition: Technology Transfer	Technology: System Service	Single	Federal Government: NOAA	Environmental Intelligence	Climate Adaptation and Mitigation	Earth System Modeling	Not Applicable	Yes
GLERL	Great Lakes Color Producing Agent (CPA) Algorithm	NESDIS/STAR	yes	Transition: Technology Transfer	Technology: Model Algorithm	Single	Federal Government: NOAA	Resource Management	Integrated Environmental Modeling System	Earth System Modeling	Seafood Production and Competitiveness	No

OAR FMC	Transition	End User	Meets the Definition of Transition	Function Type	Output Type	Recipient Number	Recipient Type	Application Type	OAR Strategic Goal	NOAA Strategic Goal	Blue Economy	Weather Act
GMD	Annual Greenhouse Gas Index (AGGI)	WMO Global Atmosphere Watch, Geneva	yes	Transition: Extension and Outreach	Science: Synthesized Product	Single	International	Education/Learning	Climate Adaptation and Mitigation	Earth System Modeling	Not Applicable	No
GMD	Annual Greenhouse Gas Index (AGGI)	OAR/Climate Program Office/climate.gov	yes	Transition: Extension and Outreach	Science: Synthesized Product	Single	Multiple Users	Education/Learning	Climate Adaptation and Mitigation	Earth System Modeling	Not Applicable	No
GMD	BAMS State of the Climate Report	NOAA/NESDIS/National Center for Environmental Information	yes	Transition: Extension and Outreach	Science: Interpreted Product (T)	Single	Federal Government: NOAA	Environmental Intelligence	Climate Adaptation and Mitigation	Earth System Modeling	Not Applicable	No
GMD	Carbon Tracker	e.g., Wageningen University Meteorology and Air Quality Department, Utrecht, Netherlands	yes	Transition: Extension and Outreach	Science: Interpreted Product (T)	Infinite	Multiple Users	Environmental Intelligence	Climate Adaptation and Mitigation	Earth System Modeling	Not Applicable	No
GMD	National Academy of Sciences Report, "Improving Characterization of Anthropogenic Methane Emissions in the United States"	National Academy of Sciences	yes	Transition: Extension and Outreach	Science: Synthesized Product	Single	Private: Not For Profit	Environmental Intelligence	Climate Adaptation and Mitigation	Earth System Modeling	Not Applicable	No
GMD	CarbonTracker	Various -- Science, policy, management -- US and international agencies	yes	Transition: Extension and Outreach	Science: Synthesized Product	Infinite	Multiple Users	Education/Learning	Climate Adaptation and Mitigation	Earth System Modeling	Not Applicable	Yes
GMD	Carbon Tracker -CH4	CarbonTracker-CH4 results were documented in peer-reviewed literature, and were contributed to the Global Carbon Project Methane studies.	yes	Transition: Extension and Outreach	Science: Interpreted Product (T)	Infinite	Multiple Users	Environmental Intelligence	Climate Adaptation and Mitigation	Not Applicable	Not Applicable	No
GMD	WMO/UNEP Scientific Assessment of Ozone Depletion - GMD Ozone Data	UNEP Ozone Secretariat	yes	Transition: Extension and Outreach	Science: Interpreted Product (T)	Single	International	Environmental Intelligence	Integrated Earth Observing Systems	Not Applicable	Not Applicable	No
GMD	Ozone-Depleting Gas Index (ODGI)	EPA Report on the Environment and public	yes	Transition: Extension and Outreach	Science: Synthesized Product	Infinite	Multiple Users	Environmental Intelligence	Integrated Earth Observing Systems	Not Applicable	Not Applicable	No
GMD	Standards - Central UV Calibration Facility	USDA/Colorado State University/UV-B Monitoring and Research Program (UVMRP)	yes	Transition: Technology Transfer	Technology: Standards Protocols	Several	Multiple Users	Environmental Intelligence	Integrated Environmental Modeling System	Not Applicable	Not Applicable	No
GMD	Standards - Dobson Regional Standards	WMO partners with scientists investigating total ozone.	yes	Transition: Technology Transfer	Technology: Standards Protocols	Several	Multiple Users	Environmental Intelligence	Integrated Environmental Modeling System	Not Applicable	Not Applicable	No
GMD	Standards - NOAA Scales	Gas standards are used by atmospheric scientists and chemical oceanographers around the world to study lesser greenhouse gases and ensure that their measurements will be compatible.	yes	Transition: Technology Transfer	Technology: Standards Protocols	Several	Multiple Users	Environmental Intelligence	Integrated Environmental Modeling System	Not Applicable	Not Applicable	No
GMD	Standards - WMO Global Scales	WMO partners and other partners and scientists investigating greenhouse gases, private and public sectors.	yes	Transition: Technology Transfer	Technology: Standards Protocols	Several	Multiple Users	Environmental Intelligence	Integrated Environmental Modeling System	Not Applicable	Not Applicable	No
GSD	AWIPS II Forecaster Decision Support Environment	NWS	yes	Transition: Technology Transfer	Technology: System Service	Single	Federal Government: NOAA	Emergency Management	Weather Ready Nation	Earth System Modeling	Coastal Risk Reduction and Preparedness	Yes
GSD	Common Community Physics Package (CCPP) v1	Public release to numerical weather prediction modeling community	yes	Transition: Technology Transfer	Technology: Model Algorithm	Infinite	Multiple Users	Environmental Intelligence	Weather Ready Nation	Earth System Modeling	Not Applicable	Yes

OAR FMC	Transition	End User	Meets the Definition of Transition	Function Type	Output Type	Recipient Number	Recipient Type	Application Type	OAR Strategic Goal	NOAA Strategic Goal	Blue Economy	Weather Act
GSD	NOAA Environmental Software Infrastructure and Interoperability	NWS, NASA, Navy, NWP modeling community	yes	Transition: Technology Transfer	Technology: Model Algorithm	Several	Federal Government: Other	Environmental Intelligence	Weather Ready Nation	Earth System Modeling	Not Applicable	Yes
GSD	GSD BOIVerify Development	NWS/OCP	yes	Transition: Technology Transfer	Technology: Model Algorithm	Single	Federal Government: NOAA	Environmental Intelligence	Weather Ready Nation	Earth System Modeling	Not Applicable	Yes
GSD	GSD High Resolution Rapid Refresh (HRRR) Model v3	NWS/EMC	yes	Transition: Technology Transfer	Technology: Model Algorithm	Single	Federal Government: NOAA	Environmental Intelligence	Weather Ready Nation	Earth System Modeling	Not Applicable	Yes
GSD	GSD Rapid Refresh (RAP) Model - V4	NWS/EMC	yes	Transition: Technology Transfer	Technology: Model Algorithm	Single	Federal Government: NOAA	Environmental Intelligence	Weather Ready Nation	Earth System Modeling	Not Applicable	Yes
GSD	Meteorological Assimilation Data Ingest System (MADIS)	NWS	yes	Transition: Technology Transfer	Technology: Model Algorithm	Single	Federal Government: NOAA	Environmental Intelligence	Weather Ready Nation	Earth System Modeling	Not Applicable	Yes
GSD	NOAA Environmental Software Infrastructure and Interoperability	NWS, NASA, Navy, NWP modeling community	yes	Transition: Technology Transfer	Technology: Model Algorithm	Several	Federal Government: Other	Environmental Intelligence	Weather Ready Nation	Earth System Modeling	Not Applicable	Yes
GSD	Numerical Weather Prediction (NWP) for Renewable Energy Applications - RAP and HRRR Models	NWS/EMC	yes	Transition: Technology Transfer	Technology: Model Algorithm	Single	Federal Government: NOAA	Environmental Intelligence	Weather Ready Nation	Earth System Modeling	Not Applicable	Yes
GSD	Science On a Sphere® (SOS)	External customers include science museums, science laboratories, universities,etc.	yes	Transition: Technology Transfer	Technology: System Service	Infinite	Federal Government: NOAA - OAR	Education/Learning	Stakeholder Engagement	Not Applicable	Not Applicable	No
GSD	SOS Explorer™ (SOSx)	External customers include science museums, science laboratories, universities,etc.	yes	Transition: Technology Transfer	Technology: System Service	Infinite	Federal Government: NOAA - OAR	Education/Learning	Stakeholder Engagement	Not Applicable	Not Applicable	No
NSSL	Nokia/Union Pacific Track Inundation System	Nokia, Union Pacific	yes	Transition: Technology Transfer	Technology: Model Algorithm	Single	Private: For Profit	Emergency Management	Weather Ready Nation	Earth System Modeling	Coastal Risk Reduction and Preparedness	Yes
OER	Real-Time Image Detection and Tracking for Improved Fish Classification and Counting	NOAA National Marine Fisheries Service	yes	Transition: Technology Transfer	Technology: System Service	Single	Federal Government: NOAA	Resource Management	Integrated Environmental Modeling System	Machine Learning/AI	Seafood Production and Competitiveness	No
OER	Distributed Video Annotations to Increase Understanding and Data Discoverability	Not Reported	yes	Transition: Extension and Outreach	Technology: System Service	Cannot Determine	Cannot Determine	Research	Integrated Earth Observing Systems	Not Applicable	Ocean Mapping and Exploration	No
OER	Coral in Situ Metabolism and Energetics (CISME)	CISME Instruments LLC	yes	Transition: Technology Transfer	Technology: Hardware Equipment	Single	Private: For Profit	Resource Management	Healthy Oceans	Not Applicable	Ocean Mapping and Exploration	No
OWAQ	USWRP Joint Hurricane Testbed	NWS/NCEP/NHC	yes	Transition: Technology Transfer	Technology: Model Algorithm	Single	Federal Government: NOAA	Emergency Management	Weather Ready Nation	Earth System Modeling	Not Applicable	Yes
PSD	Develop and test two potential improvements to the operational NCEP data assimilation system.	NWS/NCEP/EMC	yes	Transition: Technology Transfer	Technology: Model Algorithm	Single	Federal Government: NOAA	Environmental Intelligence	Weather Ready Nation	Earth System Modeling	Not Applicable	Yes
PSD	Develop and test two potential improvements to the physical parameterizations used in the NCEP operational prediction suite.	NWS/NCEP/EMC	yes	Transition: Technology Transfer	Technology: Model Algorithm	Single	Federal Government: NOAA	Environmental Intelligence	Weather Ready Nation	Earth System Modeling	Not Applicable	Yes
PSD	Develop physically-based parameterizations for subgrid scale variation in numerical forecast models based on observations and high resolution model simulations	NWS/NCEP/EMC	yes	Transition: Technology Transfer	Technology: Model Algorithm	Single	Federal Government: NOAA	Environmental Intelligence	Weather Ready Nation	Earth System Modeling	Not Applicable	Yes

OAR FMC	Transition	End User	Meets the Definition of Transition	Function Type	Output Type	Recipient Number	Recipient Type	Application Type	OAR Strategic Goal	NOAA Strategic Goal	Blue Economy	Weather Act
PSD	Not Reported	NWS/NCEP	yes	Transition: Technology Transfer	Technology: Model Algorithm	Single	Federal Government: NOAA	Environmental Intelligence	Weather Ready Nation	Earth System Modeling	Not Applicable	Yes
PSD	Not Reported	NWS/NCEP	yes	Transition: Technology Transfer	Technology: Model Algorithm	Single	Federal Government: NOAA	Environmental Intelligence	Weather Ready Nation	Earth System Modeling	Not Applicable	Yes
PSD	Not Reported	NWS, State and local forecasters, public	yes	Transition: Technology Transfer	Technology: Model Algorithm	Infinite	Multiple Users	Resource Management	Integrated Environmental Modeling System	Not Applicable	Not Applicable	Yes
SG	Information Transfer about Tetraploid Oyster Induction for Florida Aquaculture Industry: A submission to the 2016 Aquaculture Sea Grant Conferences and Workshops	Not Reported	yes	Transition: Extension and Outreach	Science: Tacit Expertise	Several	Multiple Users	Commerce	Healthy Oceans	eDNA/Omics	Seafood Production and Competitiveness	No
SG	Black Gill Disease in Georgia Shrimp: Causes, Distribution and Transmission	Not Reported	yes	Transition: Technology Transfer	Technology: Standards Protocols	Several	Multiple Users	Resource Management	Healthy Oceans	eDNA/Omics	Seafood Production and Competitiveness	No
SG	A semi-automated zooplankton analysis system for Delaware Bay and coastal waters: method development and implementation	Not Reported	yes	Transition: Technology Transfer	Technology: System Service	Several	Multiple Users	Resource Management	Healthy Oceans	Not Applicable	Seafood Production and Competitiveness	No
SG	Coastal Georgia Regional Wastewater Planning	Not Reported	yes	Transition: Extension and Outreach	Science: Interpreted Product (T)	Single	State/Local/Tribal Government	Resource Management	Healthy Oceans	Not Applicable	Not Applicable	No
GMD	Global Total Column Ozone Data	World Ozone and Ultraviolet Radiation Data Center (WOUDC)	no	Research: Observations and Data	Science: Original Data	Single	International	Environmental Intelligence	Integrated Earth Observing Systems	Not Applicable	Not Applicable	No
GMD	SURFRAD Radiation Data Archival	Baseline Surface Radiation Network (BSRN) archive in Bremerhaven, Germany	no	Research: Observations and Data	Science: Original Data	Single	International	Environmental Intelligence	Integrated Earth Observing Systems	Not Applicable	Not Applicable	No
GMD	Monitoring Water Vapor in the Upper Troposphere and Stratosphere	Network for the Detection of Atmospheric Composition Change (NDACC)	no	Research: Observations and Data	Science: Original Data	Single	International	Environmental Intelligence	Climate Adaptation and Mitigation	Not Applicable	Not Applicable	Yes
GMD	SURFRAD Aerosol Optical Depth Data Archival	GAW archive at the World Data Centre for Aerosols	no	Research: Observations and Data	Science: Original Data	Single	International	Environmental Intelligence	Integrated Earth Observing Systems	Not Applicable	Not Applicable	Yes
OER	Profiling Sensor to Map N2 Gas Production in OMZs	The general scientific community	no	Development: Emerging Technologies	Technology: Hardware Equipment	Cannot Determine	Academic	Environmental Intelligence	Integrated Earth Observing Systems	Unmanned Systems	Ocean Mapping and Exploration	No
OER	Telemapping for Ocean Exploration Efficiency	Not Reported	no	Development: Emerging Technologies	Technology: System Service	Cannot Determine	Cannot Determine	Research	Integrated Earth Observing Systems	Unmanned Systems	Ocean Mapping and Exploration	No
OWAQ	USWRP Hazardous Weather Testbed	NWS/NCEP/SPC	no	Research: Studies and Assessments	Science: Synthesized Product	Single	Federal Government: NOAA	Research	Weather Ready Nation	Earth System Modeling	Not Applicable	Yes
PSD	Not Reported	Radiometrics	no	Development: Emerging Technologies	Science: Tacit Expertise	Single	Private: For Profit	Environmental Intelligence	Weather Ready Nation	Earth System Modeling	Not Applicable	Yes
PSD	Not Reported	NWS/NCEP	no	Research: Models and Experiments	Technology: Model Algorithm	Single	Federal Government: NOAA	Environmental Intelligence	Weather Ready Nation	Earth System Modeling	Not Applicable	Yes