2019 TBPG Workshop Summary

The 2019 NOAA Testbed and Proving Ground Workshop was hosted by the NOAA Earth System Research Laboratory in Boulder, Colorado, March 27-28, 2019. The workshop was held with three main, overarching themes:

- To highlight the successes and challenges of each of the Testbeds and Proving Grounds to both the committee members, and NOAA Leadership/Decision Makers.
- To create a collaborative environment and identify potential pathways to address challenges.
- To identify top strategic or tactical management priorities for the TBPGCC to work on for the next year and beyond to increase future testbed and proving ground transitions to operations, applications, or commercialization.

Sessions included discussions on NOAA research-to-operations (R2O) policy, NOAA testbed/proving ground successes and failures, requirements for transition plans and readiness level assignments, the implementation of the NOAA Unified Forecast System, and future goals for testbeds and proving grounds. This summary lists the discussions and recommendations for a variety of topics relevant to the success and challenges of NOAA Testbeds and Proving Grounds.

Format of Summary Report
This summary is broken down into broad topics that were discussed at the workshop and is not based on the agenda timeline. These topics can be broken down as follows:

- Testbed and Proving Ground successes and concerns
- Input from Line Office Transition Managers (LOTM)
- NOAA Process and Policy discussions

Each of these topics were touched on more than once at different times throughout the workshop and it makes sense to consolidate the information into single units to maintain the cohesiveness of the topic

Test Bed and Proving Ground Successes and Challenges
Each TB/PG provided a roundup of their success and challenges. Below is a high-level synopsis of the two topics.

Challenges:

- DTC: Inadequate HPC resources to test a range of innovations in any given year; over two-thirds of the available resources currently dedicated to simply supporting the software systems to the community (O2R), leaving insufficient funds to conduct/support testing and evaluation activities necessary to support the R2O part of the process; year-to-year shift in targeted research because of top-down direction that leads to abandonment of initiated more basic research.
- JHT: Backlog of active projects due to almost all projects taking a no-cost extension; turnover at leadership positions; IT infrastructure incompatibility.
- JCSDA: Expanding HPC resource need, since satellite experiments require an especially large amount of computations; massive effort required to prepare for operational transition -- no O&M, no space in current infrastructure.

- CTB: 20-year-old systematic errors in S2S models; inability to effectively extract small signal on S2S timescales that are desired by stakeholders; unbalanced agency funding designation neglecting higher-risk/higher reward research that will impact 5-10 years into the future.
- COMT: Struggle to define requirements for transitions to the PIs and for executing transitions following the NAO policy; difficulty identifying a well-defined operational landing spot for research that may have potential or actual success.
- AWT: Understaffing; time to spin up inexperienced staff; lack of resources to do more than address requirements from FAA+NWS (likely missing opportunities since there is currently no funding call for aviation).
- HWT: Infrastructure; lack of a standard approach in NOAA NOFOs for coordinating/conducting/supporting HWT experiments; limited physical space and resource capacities to handle number of projects that require coordination.
- HMT: Limited staffing resources and technical challenges (including inconsistent IT platforms); physical testbed space limitations; difficulty determining landing places for collaborative work.
- ATPG: Staffing; engaging with forecasters remotely; determining operational path when not associated with an NCEP center; acquiring unique Alaskan/Arctic resources as requirements are not aligned with the rest of the NWS.
- GOES-R: Difficulty reaching out to all WFOs collaboratively; long and difficult transition process; continued reliance on NAWIPS by some national centers; frequent liaison turnover.
- SWPT: Obtaining clear requirements from users; lack of available support (workforce and funding) for R2O activities since space weather is a small and young field; lack of mature computing availability.
- OPG: AWIPS restrictions limiting to WFO-only configuration, thus preventing broader collaboration, limited staffing.

Successes:

- DTC: DTC's interactions with RRTMG developers (DTC Visitor Program) and participation in pre-implementation testing led to new cloud overlap scheme becoming part of 2018 HWRF
- JHT: FSU Hart/Halperin TC genesis product very popular with forecasters & CSU/CIRA heat content/daily SST processing system implemented in NHC operations for 2018 hurricane season
- JCSDA: Accurately and efficiently simulated satellite radiances form 200+ sensors. Developed next generation community data assimilation system to facilitate flexibility.
- CTB: Development and testing of a flash-drought monitoring and prediction tool. Development and testing of the ensemble-Kalman Filter based Hybrid GODAS system, which will replace the current operational 3DVar GODAS system.
- COMT: Designating Transition Principal Investigators for each project and reformatting projects down to 3 year life cycles from 5 year cycles.
- AWT: Graphical Forecasts for Aviation (GFA): Completed domain expansion to include Gulf of Mexico, Caribbean, and portions of the Atlantic Ocean. Digital Aviation Services (DAS): Completed Collaborative Forecast Process (CFP) tests with the OPG to create TAFs using DAS cloud and wind shear grids.

- HWT: 44 NWS Forecasters, 8 Emergency Managers, 10 Broadcast Meteorologists, and 115 developers, researchers, students, & managers participated in 6 experiments over the course of the year. Tested a prototype Warn-on Forecast ensemble system for prediction of short-term severe weather hazards
- HMT: Conducted successful virtual Winter Weather experiments, with focuses on ptype and in-house collaborative discussions. Flash Flood and Intense Rainfall Experiment focused on forecast process to synthesize atmospheric and hydrologic guidance for rapid risk assessment and prediction of Flash Flooding.
- ATPG: Initiated long awaited Sea Ice Verification Project. Implementation of 375m SNPP/JPSS data in AWIPS. Implementation of the Operational Alaska HRRR at EMC after 2 years collaborating with ESRL/GSD in testing and evaluation
- Satellite Proving Ground: Combined VIIRS/ABI Flood Maps Provided in near-real time to NWS River Forecast Centers and FEMA.
- SWPT: Upgraded solar wind model delivered to NCO, to be operational in May; Establishing in-house modeling for on-demand flexibility. Geospace model upgraded to higher resolution with physics improvements, new validation techniques developed, and installed on WCOSS development machine
- OPG: Mesoanalysis Think Tank, OPG AWIPS Expansion and Lab Upgrade, GLM Product Validation and Risk Reduction Activities

Challenges and Recommendations as identified by NWS/NOS LOTMs

LOTM members provided their viewpoints on R2O challenges concerning why transitions in NOAA are still encountering problems. Below are their observations and recommendations.

Challenges:

- Scientists tend to focus on science, not where the results go and who maintains it.
- Lack of end-to-end funding agreements, differing concepts of what operations means (between researchers and operators and between line offices), lack of funding for operational POCs
- Lack of communication between developers and end-users
- Lack of focus on doing research with operational tools where possible.
- Conflicting private- and public-sector priorities (one is to make money and the other is to serve the public. The community needs to recognize and discuss this from the start)
- The need for subject matter experts and managers to make decisions on new research adding complexity to the operational landscape
- Lack of clarity regarding the roles of the testbeds and proving grounds and NOAA operational organizations
- Incompatible IT infrastructure between research and operational environments
- Fear of saying that a research endeavor is a failure or cannot work in an operational environment. This includes keeping prototypes alive with research funding when we have already decided that there is sustainable path to operations.

Recommendations:

- Allow the process to work. Think end-to-end, or at least with the end in mind. (consider Cost-benefit analysis when moving through RLs).

- Culture change: build incentives for transitions over publications, encourage use of R&D database, commit to complete research/operations team effort (including different perspectives from operations).
- Vocabulary: maintain consistent definitions with project collaborators at all levels. Oftentimes operations or a transition does not quite fit into a NOAA definition.
- Weigh the pros and cons of creating a new product instead of updating an existing one. Existing products already have an existing pipeline into operations, but transitioning a new product is more challenging.
- Researchers and developers should consider these five key questions: (1) what is the technical viability of the project?; (2) how much will it cost?; (3) what are the benefits?; (4) do benefits outweigh the cost?; and (5) who does the work and maintenance?
- Tighten the Federal Funding Opportunity (FFO) language to include a specific description of projects sought to improve, and the IT infrastructure of the operational environment to better target research environments that are compatible (and aligns with the UFS) prior to proposal. Assure that TBPG activities fit in the larger NOAA goals and priorities.
- Create an accepted path for research failure: Identify an off-roading process and a justification for the research deserving exploration but not demonstrating success, thus must end.
- Standardize the way FOs, including TBPG FOs are managed. JTTI is presently used to do this between OAR and NWS, and could be used as a template or all FOs including those for TBPG direct and indirect funding.
- For all OF including those for TBPG activities, identify and provide needed operational resources for final implementation, and operational POC involvement.

Workshop Group Discussion Topics

Project Success and Failure

Projects slated for R2O transitions are currently determined to be a success or failure based on whether or not the operational transition was successful and finalized. Different testbeds have different ways of navigating this metric. For example, DTC planning occurs on an annual basis, meaning that there is the possibility of abandoning evolving projects due to shifting recommendations. COMT generally selects projects that have already established a well-defined pathway to operations. A large number of unsuccessful transitions are due to infrastructural plumbing issues, not necessarily science flaws. Some points that we raised included:

- Does this create funding calls that are too conservative by targeting high-RL projects which are more likely to succeed?
- The current process requires that all projects have an established landing spot in operations but priorities change over the lifespan of the projects that prevents them from being transitioned. Since they provide value to forecasters, they can't be abandoned. When planning projects, consider requirements beyond the 2-3 year grant and work toward a "catcher's mitt" for valuable projects that are left without an operational home.

Transition Plans

Transition plans are mandated by a NOAA Administrative Order (NAO) to promote conversations between organizations involved in transitioning a product from research to operation/application. They are required for projects with an intent to transition at some point, not just those expected to transition during the project's funding period. This also includes transitions outside of NWS operations, such as to a commercial setting. In the past, a varying definition of "operations" has created confusion, and the entire R2O system should be cognizant that an operational center's definition may differ from a researcher's. For example, a web-based product available to forecasters may be considered operational by some, but NWS might not declare a product operational until it is integrated into AWIPS.

There are also differing viewpoints about the timeline for transition plan development. A transition plan should be completed early enough in the project to facilitate contact with NWS that may influence development, but not so early that the receiving agency begins to prepare for a project that will likely not achieve a transition.

The NAO does not prescribe details of a transition plan, just the required content type. It is designed to allow significant latitude for individual programs and projects to adapt it in order to create a better fit for their specific requirements. Transition plans are intended to serve as initial handshake agreements, not legally-binding contracts, and should allow PIs and/or POCs to add any caveat language they deem necessary.

One key area for improvement is the process by which a project's NOAA POC is selected. As the POC's role as a conduit between researchers and operations expands, the identification of an able, interested, and engaged POC becomes even more crucial. Currently, a small number of POCs are assigned to the majority of R2O projects, resulting in administrative overburdening.

Recommendations.

- Develop training on transition plan development
- Develop best practices for PI and POC interaction
- Continue to track transition plans after funding ends
- Define separate landing spots for research projects (cloud, Vlab) and operations (stages/platforms), depending on the end goal of the project.
- Design a space for mini or 'pseudo-transitions' to ease the pressure of expecting full operational transition
- Consider multi-stage transition plans anchored by RLs

Testbed/PI Communication

A challenge for some testbeds is that the testbed manager is often not involved in the project selection process yet is expected to contact the project PIs to coordinate the experiment following the selections. Many projects show up "out of the blue" with limited preparation and coordination time. This needs to change so that all parties who should be involved in the testing and transition phases are involved. For example, the JTTI program utilizes a relevancy review which helps weed out projects with little to no realistic chance of reaching operations.

When should PIs be in contact with testbed managers? There is a general consensus that the current system of encouraging initial PI/POC interaction during transition plan development does not engage the testbeds early enough in the R&D process. One suggestion is to require a signed letter of support from testbed managers as part of the research proposal; however, all parties must consider legal restrictions of what may be required of non-fed PIs.

Testbed Infrastructure

Large increases in JTTI and hurricane supplemental funding are increasing testbed usage and straining staffing and infrastructure, particularly since testbed infrastructure funding has generally remained stagnant.

There is not a one-size-fits-all solution for testbeds. Different testbeds have different needs and experience different staffing constraints. For example, not all have full-time employees dedicated year-round to testbed planning and management.

Role of Testbeds

Where do testbeds fit in the R2O process? The original NAO was written with testbeds filling a role fairly close to operational transition, after most development has occurred. We must determine if the goal of a testbed is to report on research metrics only or also to determine readiness level and suitability for operations. Future discussions may also focus on further defining the role and scope of official test plans.

The 2019 Earth Prediction Innovation Center (EPIC) mandate will greatly affect the R2O2R interface for community modeling. The testbed and proving ground community should become familiar with EPIC and consider where testbeds fit into this new paradigm.

A Plan for Unsuccessful Research

It is important to stress that not all projects are or should be transitioned to operations, and that the ones that do not should not be considered “failures.” Non-transitions provide new information on algorithm issues, technological needs, and more, and should be framed as non-operational knowledge. This should be codified to remove pressure on PIs to get their work into operations. There is a difference between acceptable and unacceptable failures, therefore fear of failure is better defined as “**risk aversion**.” If we accept the risk, it is inherently understood that there is a higher allowance for it to not be successful. Unsuccess should be because we are being scientifically challenged - never because our procedures have failed. A goal of EPIC is to use a springboard approach for new ideas, encouraging new approaches with the understanding that a small percentage may advance later.

One common failure point in R2O transitions is resource limitation on the operational side. In NOAA, WCOSS, AWIPS, and IDP have severe capacity limitations and many products competing for space. SBN and terrestrial communication networks are also subject to severe limitations.

UFS

The Unified Forecast System approach is designed to bring consistency to the modeling framework. The goal is to have a unified, strategic focus for NOAA modeling, with open-source code and thorough documentation. NOAA researchers and managers will need to work with CIs, universities, and private sector to gain clearance for their work to become open-source. The result will be community-based model development and improvement with governance.

Local → Regional → Global

Hour → Day → Week → Month → Year

With the shift toward UFS, all projects relatively close to the demonstration and transition stages should fit in the UFS framework. In general, no models incompatible with the UFS should not be accepted into a testbed (with a few exceptions). It should be noted that the role of the testbeds in the UFS has yet to be determined. UFS developers should plan and implement a full, end-to-end system from the beginning of the project, with a vision of its final outcome. Redundancies in model application development will be limited or eliminated during this process. Whereas this concept is new for the whole production suite, the concept of effective O2R2O in operations has been proven with the HWRF hurricane and WAVEWATCH III wave models. For both models most if not all research is done in a common community model that is also used in operations, resulting in the final R2O process typically taking less than a year (compared to typically 5 years for bringing in a model that is new to operations).

The NOAA/NCAR MOA focuses on coupled model infrastructure needed in the UFS. The UFS governance is presently focused on Strategic Implementation Plan (SIP) working groups that annually provide 3-year development recommendations for the UFS. Those interested in providing input to the UFS development are encouraged to get involved with the SIP working groups.

Readiness Levels

There are some common misconceptions about readiness level definitions, particularly beyond RL4. NOAA leadership is open to re-visiting the language of these definitions to improve clarity if deemed necessary. For R2X transitions, it is especially important for PIs and POCs to understand the meaning of RL8 and RL9.

RL8 - “finalized system”: It is tested, proven, documented, in final form, and only needing final handoff to an operational center.
RL9 - It is used routinely in an operational center. Note that used “in NWS WFOs” means something different than “in SPC.”

In modeling, a “finalized system” requires no additional code edits, documentation, or training development. One recurring problem with projects being defined as RL8 is their products are often handed off to EMC with additional work necessary to fully operationalize the product. Since OAR cannot mandate NWS procedures, RL9 should not be included in a work or transition plan unless funding and infrastructure is already secured for implementation at the operational center’s

“landing spot.” It is also important to consider the RL definitions across ALL LINE OFFICES of NOAA, not just NWS (NOS has different definitions).

Takeaways and Lessons Learned

- The TBPG committee needs to be more engaged with LOTMs.
- Not every project is required to be transitioned, but if funded by a source whose purpose is to accelerate transition to ops, then some accountability is needed to plan for an eventual transition.
- The language describing specific goals and requirements of programs in FFOs is critical.
- Further discussion on RLs could be brought to LOTMC. A workshop to bridge inconsistencies might be useful.
- There are differing perceptions of the role of testbeds when defined by the testbeds, planning documents, and senior leadership.
- Why are there testbeds? What are they supposed to be doing? This will need to be firmly established not only within the current paradigm but also as we look toward the UFS and EPIC.
- The bigger discussion point is not the testbeds themselves, but the transition process and where the testbeds fit.
- Individual testbeds and proving grounds have unique challenges, and there is not one cookie-cutter solution to improve all testbeds.
- One desired outcome of testbeds is to provide evidence that new products are useful and impactful. How can we better capture these successes?
- The risk of failure will increase if not all relevant NOAA line offices are included in the R2O transition planning process.
- HPC resources and infrastructure for test environments as well as “landing spots” within the operational environment are R2O-wide obstacles that continue to hinder progress and limit successes.
- Testbed and transition requirements should have more clearly defined relationships between OAR and NWS. NWS needs to make the requirements known to the LOTMC so they can be distributed to the R&D community. An entry-level transition plan can be developed with an outline to accomplish the goal.

Goals for TBPGCC coming out of workshop: (Note: we need specific actions)

- Improve Committee engagement with LOTMS and NRC
- Provide input on needed changes/updates to NAO 216-115A & NAO 216-105B
- Increase awareness for the need for greater infrastructure (personnel and equipment) funding within the TB/PG.
- Develop solutions (or at least raise awareness) for technologies that are successfully tested but cannot be transitioned.
- Develop alternative pathways beyond operations for technologies to transition to.

2019 NOAA Testbed and Proving Ground Workshop

What best practices does your testbed use to ensure timely and successful R2X transition?

Draft 6/11/2019

From the Breakout Group presentations, sorted into overarching themes, and in no particular rank order….

Planning

1) A Test Plan is co-developed by PIs and testbed staff in advance to assure consistent understanding of PI's testing needs and testbed's resources and requirements
2) Have a research to operations playbook, tying readiness level to internal or external R2O involving FAA processes
3) Create a repeatable process, matrix, steps for each level including whom to involve; easy to have checklist if quite focused and contained (i.e., no outside partners); hard to make Standard Operating Procedures when collaborating with outside partners such as NASA who have different requirements
4) Know line office requirements (scientific and technical objectives, awareness of governance)
5) Research agency requirements before writing the science priorities for a testbed; knowing something being tested meets a requirement (although requirements are hard to find and work with); coordination with NWS/AFS and CARDS
6) Prioritization of testbed activities based on requirements; wish list (desirement) is not a requirement
7) Proposal peer review process to select best testbed projects based on coordinated agency science priorities and needs
8) Engage funding program managers with testbed managers on ways to improve testbed project selection processes
9) Modify annual testbed planning year to better follow fiscal year (timelines for testbed planning vs. program planning)
10) Testbed projects are included in NWS AOP
11) Transition Plan development and alignment; earlier the better
12) Ensure the proper NWS POC is assigned to the Transition Plan and is engaged early in the testbed project

Testbed Management and Execution

13) Several testbeds host in-house experiments when all partners are drawn in; enables better communication
14) Use real-time demonstrations during the project
15) Successful R2O when demonstration is done “in house” on operational computers
16) Computing environment set up so that the final stage of testing can be done in a semi-operational environment
17) Include forecasters and end users in testing
18) HWT requires consistent data formats for testing at the testbed
19) Satellite PG good at evaluation – put products in proper format for evaluation in their operational platform
20) Have satellite liaisons present during the projects that test new satellite products
21) Post-project performance evaluation by JHT testbed staff, forecasters, and NHC management; formal decision-making process for transition to operations of each testbed project based on standard evaluation criteria across all JHT projects

Communication and collaboration

22) Close collaboration worked well via cross functional team (researchers, developers, forecasters, end users); end-to-end as a team understanding the products; forecasters involved early in the process
23) Communicate with PI as early as possible after project start to get on the right track
24) Most successful projects have ongoing dialogue with developers; ongoing testing with open communication throughout the process
25) JHT hosts a JHT session at the annual International Hurricane Conference in Miami to hear from PIs on their JHT project activities and share with the public

2019 NOAA Testbed and Proving Ground Workshop

What are your biggest challenges or barriers to achieving success? Where can NOAA/LO leadership help?

Draft 6/11/2019

From the Breakout Groups and Roundup presentations, sorted into overarching themes, and in no particular rank order….

Lack of Resources

1) Lack infrastructure funding to run and manage all of the testbed projects (staff, computers, IT support, physical space, etc.); no base funding is available. Need standard approach for testbed infrastructure funding at NOAA such as allocating project-specific infrastructure overhead costs when funding them via NOAA testbed funding programs
2) Capacity issue; some testbeds are overwhelmed with multiple project requests for use of testbed beyond what their resources allow; how does testbed staff deal with many project PI requests to collaborate on testbed projects? How to say no?
3) Need more staff to support testbed management and execution of multiple projects; dealing with multiple rounds of testbed projects from current and past grant competitions
4) Need more IT support staff (JHT has half-time IT facilitator)
5) Lack of funding partners and available funding sources for small testbeds
6) National workforce and funding to address applied research and research-to-operations activities is small (SWPT)
7) Don't have enough AWIPS or high performance computing (HPC) resources; limited access to NOAA HPC (foreign nationals can't get accounts); takes too long to get an account
8) Flat funding during transition period from current NCEP production suite to the Unified Forecast System (UFS) is severely limiting R2O potential; need to provide support for legacy systems while also spinning up knowledge on UFS – little resources for actually testing new innovations
9) SWPT lacks a mature capability to serve and store large quantities of output from new numerical prediction models

Testbed Management and Execution

10) What is the NOAA vision of the responsibilities of each testbed/proving ground? What should we be doing, what should we not be doing? How should this be determined?
11) Need to better align or redirect external partners' (NASA, NSF, FAA, etc.) funded activities with NOAA's testbed priority activities
12) How do needs and requirements fit in the Testbed. Could get spread too thin. How to unify these projects?

13) What to do when each product is different with different users? Helps when model is driven by specific need (requirements) of customers. But standard procedures are a challenge.
14) Difficult to obtain clear requirements for actionable information from users of space weather information
15) Intimate knowledge of projects needed; acknowledgement of that research lift
16) Overturn of testbed manager and understaffing
17) Need improved communication and collaboration between NOAA testbed staff and testbed project staffs, particularly in the earliest stages of the projects when meaningful changes can be agreed upon
18) Improving communication between NOAA funding program managers and testbed managers regarding potential new testbed projects in the pipeline so they are not blind-sided
19) How do testbed staff deal with nearly-duplicate projects funded by different funding programs?
20) Scheduling testbed experiments is getting more difficult as more projects come to testbeds
21) Engaging forecasters in testbed experiments when offices have significant staffing shortfalls (investigating more effective methods to engage with forecasters remotely in busy workload settings)
22) Need to allow for failure of a testbed project after demonstration prior to operational transition and allow its cancellation to avoid consuming limited resources; need to fund higher risk/reward projects that could fail
23) Some testbed projects bring NOAA-incompatible software and/or have real-time data and processing needs not available at the testbed or in operations; incompatible research and operational infrastructure
24) Continued reliance on NAWIPS by some of the National Centers creates developers challenge; interrogation is hard in NAWIPS environment – hard for developers to get the data in a format; how to evaluate in that environment
25) Obtaining resources and appropriate prioritization for our requirements that are often unique from the rest of the NWS (ATB)
26) Evidence-based decisions require large experiments to discriminate signal from noise
27) What are the rules for interacting with potential testbed PI applicants in proposal development process?
28) Had to cancel/postpone Spring Experiment due to government shutdown

R2X Transitions

29) Executing transitions in the way the NAO 216-105B defines transitions
30) Clearly defining the requirements for NOAA transitions to the project PIs
31) Improving transition planning to improve transition success; and follow-through once funded testbed project ends
32) Transition plans are unknown to many; need training
33) Not clear what testbed projects need transition plans and to what level of detail

34) Transition plans need to be clear about who is the “catchers mitt” and landing spot for testbed projects on the operational side; need to coordinate with them during the planning
35) Transition plans and planning need to evolve and mature in stages as RL’s advance (low RL projects only need visionary high-level transition plan; high RLs need more details)
36) Finding the most appropriate and willing end-user Transition POC(s) for a given project’s transition plan is critical
37) NWS office validates a need or requirement for testbed demonstration of a new technology, but there are few resources to implement it operationally once testing is successfully completed; success hinges on how much resources you have on the receiving (operational) end
38) How to fund a testbed project to transition to RL 9 once it ends and is proven to have operational value?
39) Need Readiness Level training; varying interpretation of RLs is an issue
40) Need to find ways to minimize receiving end workload to transition the testbed project’s outcomes to operations
41) Project PIs need to have performance incentives that include not just journal publications but also NOAA transition activities and successes to motivate their active engagement
42) Bottleneck with transitioning new software into operations at NWS’s NCEP Central Operations