National Severe Storms Laboratory
Laboratory Science Review
3-5 February 2015

NSSL's Final Implementation Plan Report on Responses to Review Recommendations

November 22, 2017

Submitted by:
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Introduction & Summary

Laboratory science reviews are conducted every five years to evaluate the quality, relevance, and performance of research conducted in the National Oceanic and Atmospheric Administration (NOAA) Office of Oceanic and Atmospheric Research (OAR) laboratories. This review covered the National Severe Storms Laboratory (NSSL) research since 2009, and was conducted in February 2015. The research themes presented included Radar and Observations Technology; Severe Weather Forecasts and Warnings; and Hydrometeorology and Flooding. The review agenda, presentations, posters, and guiding materials are available on the NSSL website: http://www.nssl.noaa.gov/about/events/review2015/

NSSL provided a response plan for implementing the review recommendations that was approved in November 2016. Since that time, NSSL has implemented and tracked its progress on those responses. This report documents that implementation by updating the Action Items in the original response plan with both completion dates and narrative (see below). NSSL successfully completed or closed out all but three (3) of its 30 proposed actions. These three are pending further action, two of which are outside of our control (#1.3: MPAR Development and #3.8: Data Access) and the third (#4.2: Establishing a Training Program) is still in the works.

Please note the original target dates were established upon submission of the original plan (February 2015). Because that plan was approved in November 2016, many of the original target dates had already passed. Our focus, then, was on completing all Action Items by November 2017. As mentioned above, we are at 90% complete, with progress being made on the final three actions.

1. Radar and Observations Technology

Comment/Recommendation #2. The group is extracting all possible information from the SPY-1 and developing innovative techniques to leverage electronic beam steering in weather radar imaging and prediction. There should be more R&D to improve radar performance and operational parameters to enhance the reliability of weather forecasts and provide for routine weather products in a faster, more reliable manner. NWRT radar performance and operational parameter research could cover, for example, trades between beamwidth, scan time, instantaneous signal bandwidth, relative polarization, Doppler filtering, range, etc., not to mention additional trades against the requirements of air traffic and target surveillance that must be addressed by the other agencies behind MPAR. Given that phased arrays will deliver unprecedented flexibility and performance in performing weather operations, NSSL staff must address the fundamental question of: "if we had such phased arrays at our disposal, how can we design and implement the arrays to achieve ever improved weather prediction? The Office of Oceanic and Atmospheric Research (OAR) could invest more in MPAR engineering specifications, perhaps through OSSE efforts.

Action 1.2: Develop a plan for conducting OSSE studies for a wider variety of phenomena and environments.

- Target date: September 1, 2016
- Approximate completion date: September 2016
- Person(s) responsible: David Turner
- **Result/Status: Completed.** OSSE plan developed by Dr. Turner (click here)

Comment/Recommendation #3. MPAR logistical costs vs. rotating radars should be seriously examined. For the DoD, the long term reduction in operating costs (in addition to increased capabilities) will be a major factor in radar procurements and in moving toward MPAR. The Panel therefore recommends developing data and models that compare: 1) the recurring costs of sustaining the existing WSR-88D with a service life extension program (SLEP) that carries their operation into the decades ahead, vs. 2) replacing the WSR88Ds with stationary phased array radars that provide a multi-agency mission and which are constructed from a common base of components to reduce the costs and timing of servicing logistics while also "future proofing" the systems as improvements in commercially available semiconductor component, computer, and networking technologies take hold.

Action 1.3: Coordinate with other Federal agencies in developing a preliminary cost/benefit analysis of MPAR compared to existing radar technologies.

- Target date: December 1, 2016
- Approximate completion date: December 2016
- Person(s) responsible: Kurt Hondl
- **Result/Status: Pending further progress on MPAR program**. NSSL worked with FAA to prepare a preliminary cost evaluation of Phased Array Radar technology in 2016. This study and the funds made available by the Spectrum Pipeline Act of 2015 has led to

the development of the Spectrum Efficient National Surveillance Radar (SENSR) program. The SENSR program is a joint endeavor by NOAA and the FAA, DOD, and DHS to conduct a feasibility study for a national surveillance radar. Agencies are currently defining their mission requirements and surveying the available technologies to determine the feasibility and cost effectiveness of various radar technologies.

Comment/Recommendation #4. Recommend hiring in-house radar system engineering experts. NSSL relies on outside third parties (aerospace contractors and government-sponsored labs) in MPAR-related programs such as the ATD. Their expertise is often with defense radar systems and not weather radars. NSSL would benefit by a full time employee to deal with MPAR from a hard core engineering perspective and would be useful in establishing useful performance parameters specific to future phased arrays.

Action 1.4: Submit paperwork to fill an Electronics Engineer position and hire an additional person with radar hardware and electromagnetic modeling experience.

- Target date: September 1, 2016
- Approximate completion date: August 2017
- Person(s) responsible: Mike Jain
- **Result/Status: Completed.** Despite long delays due to hiring freezes and other challenges, two positions have been hired.

Comment/Recommendation #5. An acknowledged NSSL weakness is winter storms prediction. NEXRAD products often do not depict nominal and severe winter blizzards because the storms lie below the coverage of the radar. A formal program to address this gap should be initiated, with possible solutions including: 1) electronic beam steering to lower elevations with intelligent clutter mitigation and use of polarized returns, and 2) fusion with other data sources (social/human inputs, radio beacons, infra-red (IR) measurements, satellite, etc.).

Action 1.5a: Develop a plan for exploring beam forming techniques conducive to winter precipitation detection with the ATD.

- Target date: September 1, 2016
- Approximate completion date: March 2017
- Person(s) responsible: Dusan Zrnic and Alexander Ryzhkov
- **Result/Status: Completed.** We are in the process of developing an optimal beamforming and scanning strategy to generate columnar vertical profiles (CVP) of polarimetric radar variables with high vertical resolution within the atmospheric layers where winter precipitation is forming. Our objective is to create CVPs in the selected weather-sensitive locations such as airports or densely populated urban areas. Concrete antenna elevations and their number depend on the distance of the "vertical column" from the radar, and the required flexibility can be achieved either using PAR or by utilizing a multitude of specially designed VCPs for mechanically scanning weather radars. A preliminary

algorithm for generating CVP is already available and its further development and testing is planned as part of the 2018 RPI MOU SOW (item 6.5).

Action 1.5b: Explore prospects for enhanced winter weather storm prediction research within the Lab.

- Target date: September 1, 2016
- Approximate completion date: May 2017
- Person(s) responsible: Alexander Ryzhkov, Terry Schuur, Heather Reeves
- **Result/Status: Completed.** We have just finished (in May 2017) the NSF project "Investigations of winter precipitation microphysics with polarimetric radar and explicit modeling" (PI A. Ryzhkov) which resulted in 28 published or submitted journal articles. As a continuation of this effort, a new NSF proposal "Investigations of the ice microphysical processes of precipitation formation and evolution using polarimetric, multifrequency, and Doppler spectral radar measurements combined with cloud modeling" (PI A. Ryzhkov) has been written and is ready for submission. The work will be in partnership with the Stonybrook University (SBU) and the University of Colorado in Boulder (CIRES). The primary experimental research area will be centered on the SBU campus in close proximity to the KOKX WSR-88D radar and heavily instrumented SBU remote sensing facility, i.e., in the region heavily impacted by adverse winter weather. Radar-based nowcasting of heavy snowfall will be based on the detection and analysis of polarimetric radar signatures within the dendritic growth layer between the -20 and -10^0 isotherms where the bulk of snow is generated. Such detection will ensure nowcasting of snow at the ground with a lead time of about 30 min.

Comment/Recommendation #6. There are limited opportunities for winter weather research in the Oklahoma region, therefore the NWRT might be only of limited utility for assessing how a phased array could improve low lying weather observation. However, phased arrays could be constructed with highly intelligent beam forming that mitigates the effects of ground clutter, while also complying with rules to assure safe exposure of populated areas to the array RF output. Therefore, NSSL should conduct modeling and simulation of radar designs, with the assistance of phased array modeling experts from OU, the DoD, NASA, and other agencies, to investigate how intelligent low elevation beamforming will improve low lying weather observation and prediction.

Action 1.6: Explore collaboration opportunities with GTRI and other entities on ATD applications to low-elevation beamforming.

- Target date: September 1, 2016
- Approximate completion date: March 2017
- Person(s) responsible: Dusan Zrnic and Djordje Mirkovic
- **Result/Status: Completed (and ongoing).** Principally new algorithms for quantification of snow and ice water content have been developed since last lab review. These are the

first polarimetric algorithms for snow measurements which show very good promise. Their further exploration is planned as part of 2018 RPI MOU (item 6.7). A postdoc (P. Bukovcic) will be hired by the CIMMS starting from February 2018 to work on winter storms studies.

Comment/Recommendation #7. Recommend prioritizing various tasks related to evaluating ATD's performance since the timeline is constrained by the FAA's decision point.

Action 1.7: Complete a MPAR program science plan.

- Target date: September 1, 2016
- Approximate completion date: July 2016
- Person(s) responsible: Kurt Hondl
- **Result/Status: Completed.** The MPAR R&D Roadmap was completed in mid-FY2016 and was used to develop the SENSR R&D plan. The SENSR plan has been funded and is now underway.

Comment/Recommendation #8. NSSL should establish collaborative agreements with research institutes and universities or create visiting engineers/scientists opportunities in the areas of radar architecture, transmitter/receiver (T/R) module design and scan strategies to incorporate independent opinions and views for program development.

Action 1.8: Establish a robust and active Visiting Professionals Program.

- Target date: April 1, 2016
- Approximate completion date: April 2016
- Person(s) responsible: Lans Rothfusz
- **Result/Status: Completed (and ongoing).** NSSL has set aside funding to support Visiting Professionals and, since its inception, has supported visits by two esteemed researchers (one of them twice).

2. Severe Weather Forecasts and Warnings

Comment/Recommendation #1. WoF research could benefit from recruiting satellite data and quantitative verification expertise and by access to additional High Performance Computing (HPC) resources.

Action 2.1a: Pending funding, hire an expert in the storm-scale assimilation of satellite data.

- Target date: September 1, 2016
- Approximate completion date: July 2017
- Person(s) responsible: Jack Kain

- **Result/Status: Revised and completed.** Owing to the growing need for project management oversight for WoF, and the fact that a CIMMS research scientist with expertise in satellite data assimilation is already on staff (Dr. Thomas Jones), the decision was made to hire a WoF Project Manager. This federal hire occurred in summer FY17.

Action 2.1b: Pending funding, hire an expert in storm-scale objective verification.

- Target date: December 1, 2016
- Approximate completion date: May 2016
- Person(s) responsible: Jack Kain
- **Result/Status: Completed.** NSSL hired an OU CIMMS research scientist who is an expert in storm-scale objective verification in May 2016.

Action 2.1c: Develop a plan for utilizing the newly-procured Cray system and the requested three-fold increase in computer resources for 2016 on the Jet (HPC) computing system.

- Target date: January 1, 2016
- Approximate completion date: July 2016
- Person(s) responsible: Louis Wicker
- **Result/Status: Completed.** WoF has procured a new compute server system for the WoF team which has approximate threefold increase in computing power of the former system. This system is being brought online. FRDD has also doubled its request to Jet.

Comment/Recommendation #2. WoF team activities and outcomes are strongly dependent on MPAR technology. This is a significant risk if MPAR is not adopted as the next generation remote sensing platform by the operational weather community. Recommend testing the robustness of WoF findings on other potential remote sensing platforms by assimilating data at storm scales.

Action 2.2: Develop a plan to conduct studies of at least two additional cases using rapid scan radar (PAR) data as well as further OSSE studies to determine benefit to the WoF objectives.

- Target date: September 1, 2016
- Approximate completion date: September 2017
- Person(s) responsible: Louis Wicker
- **Result/Status: Completed.** One additional study using rapid-scan radar data (PAR) has been completed (including publication) for a tornadic supercell. A research scientist was hired at the end of September 2017 (via SENSR funding) to support the completion of additional PAR data assimilation case studies and complete further OSSE studies to determine benefit to the WoF objectives. In spring of 2016, several key data sets were collected with rapid-scan PAR and 2-minute volume scans from KOUN polarimetric

radar data sets. These data sets will be used in the SENSR program for testing. An OSSE experiment is also planned using the PAR emulator software available from the RRDD group.

Comment/Recommendation #3. The WoF team should consider a roadmap for transition to operations within NWS and NCEP, especially with regards to data assimilation methods, algorithms and protocols.

Action 2.3: Develop a roadmap/strategic plan for WoF research and a demonstration-ready project.

- Target date: July 1, 2016
- Approximate completion date: July 2017
- Person(s) responsible: Louis Wicker
- **Result/Status: Completed.** A strategic plan for WoF was vetted with members of the Science Steering Committee and completed in mid-2017. The experimental WoF system was demonstrated in 2016 and 2017 within the NOAA HWT and will continue to undergo development/demonstration/testing cycles to raise the system TRL from a level 5 to a level 7 during the next 3-5 years.

Comment/Recommendation #4. Lightning detection and prediction research programs should begin linking their algorithms to NOAA modeling operational standards.

Action 2.4: Adapt current tools to be able to test effectiveness of cloud-scale total lightning data assimilation in NCEP models.

- Target date: September 1, 2016
- Approximate completion date: January 2017
- Person(s) responsible: Ted Mansell
- **Result/Status: Completed (and ongoing).** The lightning-based water vapor nudging method (Fierro et al. 2012) has been adapted as a 3D-Var operator (Fierro et al. 2016) and implemented in GSI and tested with WRF-ARW using total lightning data. It is ready for testing with NCEP models.

Comment/Recommendation #5. Operational users are not always fully involved in the planning and strategy for applications and technologies they will be using in the coming years.

Action 2.5: Develop and implement a practice by which operational clients of NSSL research are engaged in the planning and guidance of future activities (e.g., annual workshops with SSD Chiefs and/or SOOs, NWS Headquarter coordination, full implementation of NAO 216-105A Policy on Research and Development Transitions etc.).

- Target date: September 1, 2016
- Approximate completion date: September 2017
- Person(s) responsible: Alan Gerard
- **Result/Status: Completed (and ongoing).** Mr. Gerard worked with NWS STI representatives and Dan Nietfeld of GSD to develop an STI chartered team to provide guidance and input from STI field reps (SOOs and SSDs) for OAR research and R2O activity plans. The NSSL rep on the team is engaging with the team to gather and vet routine input and feedback on lab activities and priorities. WRDD is also leading monthly calls with SSD chiefs to provide updates on latest lab projects.

Comment/Recommendation #6. Strengthen collaboration with national and international partners to reduce the risk for inbreeding of scientific ideas and concepts.

Action 2.6: Make joint decision whether to establish a MOA with Howard University.

- Target date: April 1, 2016
- Approximate completion date: April 2016
- Person(s) responsible: Lans Rothfusz
- **Result/Status: Completed (decision made).** MOA was developed by NSSL, HU and CIMMS and we are awaiting a response from HU legal review.

Comment/Recommendation #7. Recommend more investment in emerging areas of severe weather forecasting and warning such as winter precipitation, data assimilation and ensemble forecasting.

Action 2.7a: Evaluate the feasibility of partnering with the NWS/Weather Prediction Center to have a winter weather experiment.

- Target date: September 1, 2016
- Approximate completion date: October 2017
- Person(s) responsible: Ken Howard (and Alan Gerard)
- **Result/Status: Evaluation completed (and ongoing).** Conversations are taking place between NSSL and NWS to conduct a FACETs Winter Weather experiment in the HWT. A proposal will be submitted to the OWAQ FY18 R2O FFO.

Action 2.7b: Develop a report on the feasibility of a fully three-dimensional hydrometeor classification algorithm for aviation applications. Target date:

- Target date: September 1, 2016
- Approximate completion date: March 2017
- Person(s) responsible: Heather Reeves and Terry Schuur
- **Result/Status: Completed.** Although not in the form of a formal report, NSSL is advocating a two-pronged approach to hydrometeor classification for aviation. The first

is to diagnose the processes relevant to microphysics (deposition, melting, aggregation, etc.). This is in response to the needs of the HRRR and RAP developers to have more precise methods to gauge the performance of the microphysical parameterization scheme and to make more meaningful improvements. A forward plan has been established for this task that will make use of quasi- and column-vertical profiles of the various radar moments. Continuation of this work is pending funding. The second approach is a more traditional classification of the hydrometeor types relevant to aviation, which includes discrimination between high-density ice crystals and dendrites as well as between freezing rain and freezing drizzle. The classifier will be composed of two steps. In the first step, a background classification is made using model-derived wetbulb temperature profiles. This portion of the classifier is complete and has undergone preliminary testing. We await funding to import it into MRMS. The second step is to refute or confirm the background classification using dual-polarized radar observations. Efforts toward this end for the surface classification are underway in RRDD. We have not begun similar work for the classification aloft and will not until we can secure adequate funding.

Action 2.7c: Develop a plan for increasing our understanding of the microphysical processes involved in the formation and evolution of winter precipitation particles.

- Target date: December 1, 2016
- Approximate completion date: April 2017
- Person(s) responsible: Heather Reeves
- **Result/Status: Completed.** While no formal plan has been completed, efforts toward this end have continued as a part of a collaboration between WRDD and RRDD. Within RRDD, the QVP technology has been used to better understand the effects of seeding aloft on snow habit at lower altitudes within a cloud. Using disdrometer observations, RRDD has also been working toward improved Z-S relations for snow. Last, new methods for examining vertical profiles of radar moments, column-vertical profiles (CVPs) have also been under development. CVPs allow the user to create vertical profiles anywhere in the radar domain. In WRDD, development of the spectral bin classified has continued. The algorithm has been refined to be more computationally efficient and tuned so that it can discriminate between high-density snow and dendrites and freezing rain and freezing drizzle. Investigations of how surface observations of precipitation type should be effectively used have also been conducted. New techniques for dealing with cold-season QPEs in complex terrain have also been under development.

3. Hydrometeorology and Flooding

Comment/Recommendation #1. NSSL leadership should expand collaborations with other NOAA and Federal, academic and private industry researchers in the areas of basic science and the prediction of flash flooding. Leveraging this work would improve the quality of NSSL modeling.

Action 3.1: Explore and identify collaboration opportunities with NSF and other NOAA labs to improve rainfall measurements which, in turn, improve and validate numerical prediction models.

- Target date: December 1, 2016
- Approximate completion date: December 2016
- Person(s) responsible: JJ Gourley
- **Result/Status: Completed (and ongoing).** Scientists from NSSL and ESRL/PSD jointly operated a mobile, X-band polarimetric radar in complex terrain during NASA's Integrated Precipitation and Hydrology Experiment (IPHEx) ground validation campaign. There, they obtained insights about precipitation microphysics in complex terrain regarding the role of collision/coalescence and impacts on radar-based precipitation estimation. In addition, internal seed money through the Director's Directed Research Fund (DDRF) has been obtained by JJ Gourley and Ken Howard to prototype unique radar measurements from a stratospheric balloon. This new platform offers the potential to change the paradigm for precipitation estimation in complex terrain.

Comment/Recommendation #2. NSSL could host or sponsor workshops to enhance the collaborations already in place and to develop new relationships with other groups.

Action 3.2: Participate in National Water Center workshops, planning sessions and conference calls when they are offered.

- Target date: December 1, 2016
- Approximate completion date: January 2017
- Person(s) responsible: Dave Jorgensen (Alan Gerard)
- **Result/Status: Completed (and ongoing).** The relationship between NSSL and the NWC has improved dramatically since the Lab Review. Several meetings and calls have taken place between WRDD staff (Gerard, Gourley, Howard, etc.) and NWS/NWC staff to firm up connections between our work and that related to the National Water Model. The NSSL Director is also forging a visiting scientist program between the NSSL, the NWC, and the NWS Office of Water Prediction. These activities are evidence of a strengthening relationship where it was weak (or absent) before. The November 2017 National Water Meeting attended by the NSSL Director and WRDD Acting Chief validated that improved relationship.

Comment/Recommendation #3. Consider starting a research outreach program to attract university scientists to make contributions to next generation of operational data sets and forecasting models. The program could benefit by working with other hydrologic research and can be achieved by an exchange program which allows researchers and faculty from other institutions to collaborate with the H&F group through short visits etc.

Related Action: See Action 1.8 (Visiting Professionals Program).

Comment/Recommendation #4. NOAA and NWS should better articulate their strategic direction in the hydrology area to better define efforts in the H&F area.

Action 3.4: Develop a preliminary roadmap/strategic plan specific to hydrology and flooding research and link it to Nation Water Center initiatives.

- Target date: January 1, 2017
- Approximate completion date: October 2017
- Person(s) responsible: Dave Jorgensen (Alan Gerard)
- **Result/Status: Completed (and ongoing).** Delayed by the retirement of Dave Jorgensen (and other factors), a preliminary plan was crafted in support of the November 2017 National Water Meeting.

Comment/Recommendation #5. NSSL should ensure that the basic science that supports modeling efforts is sufficiently robust for accurate predictions. Pressures of meeting operational demands might result in deficiencies in some of the basic science/research needed to develop robust operational models of basin hydrology and flash-flooding.

Action 3.5: Following Action 3.4, pursue sources of support to provide for more basic hydrologic research.

- Target date: March 1, 2017
- Approximate completion date: September 2017
- Person(s) responsible: Dave Jorgensen (Alan Gerard)
- **Result/Status: Completed (and ongoing).** HMT R2O funding has been secured from USWRP/OWAQ. JTTI funding is also being pursued. This area of research has benefited from increased focus since the Lab Review. Ken Howard is working closely with the NWS Water Resources Services Branch Chief (Mary Mullusky) and others to pursue adoption of eMRMS into the CARDs requirements approval process. The NSSL Director has obtained strong support from Tom Graziano (NWS Office of Water Prediction Director) and Bill Lapenta (National Centers of Environmental Prediction Director) to shepherd this through to the NWS Mission Delivery Council level of acceptance. This is also directly related to Recommendation #9 below.

Comment/Recommendation #6. More resources support, and guidance is needed from NOAA to support the talent in H&F. The H&F research group appears to have smaller budget and staff compared to other research areas. The hydrologic modeling effort needs additional research staff to achieve have a critical mass of expertise to explore the state-of-the-art developments in the literature and see how best they can be integrated into the hydrometeorological thrust area. Support young scientists by providing meaningful career paths and quality development opportunities.

Related Action: See Action 3.5 (Funding of basic hydrologic research).

Comment/Recommendation #7. Implement a sustained and comprehensive effort to evaluate and verify radar products and models, including error diagnosis and physical characterization.

Related Action: See Action 2.1b (Hire an expert in storm-scale objective verification).

Comment/Recommendation #8. Establish a Data Center where data collected and processed through federally funded research could be made available to the public for broad societal benefits. There are a number of quality science-grade data sets that could be used by Universities and by the private sector in teaching and research.

Action 3.8: Explore mechanisms by which NSSL-developed data can be made available to universities and the private sector either through NCEI or an OU licensing agreement.

- Target date: September 1, 2016
- Approximate completion date: In progress.
- Person(s) responsible: Kurt Hondl and Lans Rothfusz
- **Result/Status: In progress.** We are awaiting decisions by the NCEI leadership on the use of Big Data sources to make NSSL-developed data available to a wider audience. Conversations have taken place and a draft MOU has been written between NSSL, NWS and CIMMS for making such data available.

Comment/Recommendation #9. Establish close cooperation with the Hydrologic Research Lab and other programs within NWS and NOAA, which could be critical to ensure research to operations of the developments.

Related Action: See Action 3.2 (NWC collaboration).

4. Additional Comments for NSSL and OAR Management

a. Personnel

Comment/Recommendation #1. There is a NSSL-wide lack of diversity among the federal workforce with respect to race, gender, age and educational background. Women and minorities are markedly absent from lab leadership or management positions. The diversity is particular absent in the F&W group. A more diverse workforce does not happen overnight, so future (10 – 20 years) increases in diversity must come from increased public outreach and support of educational opportunities for underrepresented groups. NSSL's public outreach work and support of underrepresented groups at all levels of education is a good start, but results are not yet quantifiable.

Action 4.1a: Work with CIMMS leadership to establish a career ladder for its employees.

- Target date: April 1, 2016
- Approximate completion date: January 2017
- Person(s) responsible: Lans Rothfusz and Steve Koch
- **Result/Status: Completed (and ongoing).** Completed by CIMMS, with encouragement and input provided by NSSL.

Related Action: Action 2.6 (Decide on MOA with Howard University).

Action 4.1b: Reconstitute the Staff Development Team to focus explicitly on leadership and management diversity in the Lab and CIMMS.

- Target date: July 1, 2016
- Approximate completion date: June 2017
- Person(s) responsible: Lans Rothfusz
- **Result/Status: Completed (and ongoing).** The specific goal of reconstituting the Staff Development Team was overtaken by events when the NSSL Diversity and Inclusion Sustainability Team (NDIST) was formed as part of the newly-minted NSSL Diversity and Inclusion Plan. That team is currently developing strategies for improving diversity among leadership and management.

Action 4.1c: Hold a Leadership Team retreat to evaluate and establish leadership opportunities for underrepresented personnel.

- Target date: July 1, 2016
- Approximate completion date: July 2016
- Person(s) responsible: Lans Rothfusz
- **Result/Status: Completed (and ongoing).** This action was discussed at a 2016 summer retreat and resulted in the development of the NSSL D&I Plan and, ultimately, the NDIST. The NDIST is currently developing activities to identify and address leadership opportunities for underrepresented personnel.

Comment/Recommendation #2. The NSSL management is urged to develop a succession plan for the aging Federal personnel. Recent NOAA-wide policies regarding contracting new personnel have affected the NSSL by only worsening the situation already highlighted by the previous review panel 5 years ago. It was not clear that there are established and deliberate institutional mechanisms to support career development and reward high- quality efforts. The Lab has been able to attract some outstanding young scientists through CIMMS, but the observed professional developments from two visits five years apart are inconsistent with external perceptions of individual contributions and potential.

Action 4.2: Establish a well-defined, highly-visible, and deliberate program within which Federal personnel will be able to participate and grow their skills. A comparable program within CIMMS will be encouraged.

- Target date: July 1, 2016
- Approximate completion date: In progress.
- Person(s) responsible: Lans Rothfusz and Steve Koch
- **Result/Status: In progress.** NSSL assembled a Staff Development Team to address the NSSL and CIMMS needs. The team will be focused on establishing a leadership development program within NSSL. The CIMMS career ladder program is a direct result of this team's early recommendations.

Comment/Recommendation #3. There are apparent divisions and inequalities between the lab work force classified as "federal" versus "CIMMS" employees in terms of job security, responsibility, and leadership. Many CIMMS employees feel that promotions are tied to being a government employee, but are frustrated due to the limited number of NSSL Federal employee slots. On the one hand, CIMSS employees work exclusively under and are supervised by a federal employee, but on the other hand promotions are handled by a separate system or supervisor who might not be appreciative of their true contributions. These younger investigators are bringing innovations to NSSL in the form of new ideas and new ways of addressing weather research but the limited number of Government billets makes career paths for young investigators very unstable. A better defined career path should be established for young Federal scientists or those seeking to become Fed researchers. Provide more mentorship and incentives to the many young talented CIMMS employees that are funded by NSSL. NSSL should seriously consider converting some of the positions to federal workforce.

Related Action: Action 4.1a (Work with CIMMS leadership to establish a career ladder for its employees).

Comment/Recommendation #4. CIMMS employees have a sense of job insecurity and are unlikely to take a leadership role in projects and initiatives. It is unclear whether the performance of the CIMMS employees has been equitably acknowledged or rewarded. Their achievements were considered part of NSSL research in presentations but formal recognitions were rare.

Action 4.4: Spring-boarding off the recent CIMMS contract renewal, NSSL Leadership will reassert its long-standing support for OU/CIMMS staff and encourage their greater involvement in leadership of projects and scientific initiatives.

- Target date: April 1, 2016
- Approximate completion date: April 2016
- Person(s) responsible: Steve Koch

- **Result/Status: Completed.** A memorandum was written by Steve Koch to all of CIMMS staff expressing NSSL's support for their work and encouraging involvement in Laboratory activities.

Action 4.5: Encourage CIMMS to develop a process by which Federal awards are reflected into comparable recognitions for (non-Fed) CIMMS staff who assisted in the award-winning work.

- Target date: April 1, 2016
- Approximate completion date: April 2016
- Person(s) responsible: Lans Rothfusz
- **Result/Status: Completed (and ongoing).** As a direct result of this recommendation, CIMMS instituted new process for recognizing non-Fed contributions to Fed awards. These recognitions take place during the quarterly Gab at the Lab Celebration events.

b. NSSL Programs

Comment/Recommendation #1(a). A number of issues and recommendations made in the previous 2009 review are yet to be addressed, including: a) gender, ethnicity and educational diversities are still lacking when compared to other similar institutions (with some improvements from the last review), b) no female employees are appointed to management positions, and c) over reliance on CIMMS for staffing which provides a short term solution, but has long term risks.

Related Action: Action 4.1b (Reconstitute the Staff Development Team to focus explicitly on leadership and management diversity in the Lab and CIMMS).

Comment/Recommendation #3. From stakeholder inputs, there appear to be ongoing challenges in the implementation and coordination of NOAA-wide water (rainfall and flooding) forecasting strategies that will be critical for long-term success of related activities not only at NSSL but NOAA wide.

Related Action: See Action 3.2 (NWC collaboration).

Comment/Recommendation #4. Stewardship and facilitation of access to environmental data can be a major service with great economic benefits to the nation. It will require serious computational resources (e.g. NAS DAAC) and a long-term institutional plan.

Related Action: Action 3.8 (Explore mechanisms by which NSSL-developed data are made available to universities and the private sector).

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