Global Systems Laboratory
Science Review
May 10-13, 2021

Global Systems Laboratory (GSL)
Response to Panel Review Recommendations

Status as of Aug 5, 2024

Submitted by:
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Introduction

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. The review is for internal NOAA/OAR use for planning, programming, and budgeting, and external interests, and it helps the Laboratory in its strategic planning of future research directions. These reviews are also intended to ensure that OAR laboratory research is aligned with NOAA's Research mission and priorities and other relevant strategic plans, is of high quality as judged by preeminence criteria, and is carried out with a high level of performance.

The Global Systems Laboratory's (GSL's) science review was conducted virtually May 10 - 13, 2021, with a focus on four thematic areas: Organizational Excellence, Advanced Technologies, Earth System Prediction, and Decision Support. Each of the nine reviewers on the review panel independently prepared his or her written evaluations of one or more research areas. The Chair, Dr. Shaima Naisiri of the U.S. Department of Energy, created a report summarizing the individual evaluations but did not analyze individual comments nor seek a consensus of the reviewers.

In this report, each actionable recommendation provided by the Science Review Panel is italicized and followed by GSL's response. A table summarizing the actions with timelines for completion is included below.

In the table, the Champion for each action (the first name listed) is a Division Chief or Executive Leadership team member who will be accountable for that specific action. Additional focal points are listed below the Champion, often from multiple Divisions to ensure cross-Division collaboration. Division identifiers are also provided as follows:

- OD: Office of the Director
- AVID: Assimilation and Verification Innovation Division
- EPAD: Earth Prediction Advancement Division
- ATD: Advanced Technologies Division
- EDS: Evaluation and Decision Support Division
- ITS: Information Technology Services Division

Champions and focal points will involve other GSL staff not listed as needed to accomplish the action.

Targeted completions fall into three categories: specific start and completion dates, a start and interim completion date for specific deliverables with 'ongoing sustainment', or

'ongoing' for continuation of existing activities. All actions will be tracked and reviewed for progress by the GSL Senior Leadership Team on a quarterly basis.

Update Aug 2024

On Oct 1, 2022, GSL reorganized the five Divisions described above into four Divisions, moving specific Advanced Technology teams in ATD into other Divisions, and consolidating verification teams that were previously in multiple Divisions into a single verification group (Branch). The new structure is as follows:

- OD: Office of the Director
- AVID: Assimilation and Verification Innovation Division
- EPAD: Earth Prediction Advancement Division
- WIDS: Weather Informatics and Decision Support Division
- ITS: Information and Technology Services Division

This aligns GSL to more effectively achieve its mission and grand scientific challenge and embeds advanced technology research in respective areas of focus.

Recommendations, Responses, and Action Plans

GSL Science Review Action Sheet				
				Status
Recommendation	**Action**	**Champion/Focal Point(s)**	**Target start & Completion Dates**	
Organizational Excellence				
1) GSL should work with NOAA OAR leadership to develop and implement an all-OAR laboratory plan and timeline for increasing diversity.	- GSL is currently working with other ESRL Labs to develop a DEIA Implementation plan aligned with the NOAA and OAR Implementation plans. We will complete the development of this and the GSL DEIA implementation plan, and ensure alignment with NOAA and OAR implementation plans - Organize a GSL group that will coordinate and collaborate on DEIA activities across all organizations (federal, CI, Contractor) - Track GSL participation in DEIA trainings and workshops	DaNa Carlis (OD) Missy Petty (OD)	Start: Dec 1, 2021 Completion: Implementation plans: May 31, 2022 Tracking: Ongoing	Completed. The ESRL (OAR Boulder) Plan was completed May 2022 with full Director signatures by May 2023. The GSL DEIA Council was established effective May 2022, with a charter and a work plan that is updated annually.

2) To the extent possible, coordinate mentoring programs for early career and postdocs across the embedded stakeholders (e.g., the cooperative institutes). Giving special attention to the postdoctoral fellows within GSL may be low-hanging fruit. Such a program should include mentor and coach training.	- Continue to promote and communicate GSL-wide the various mentoring programs (specific to CIRES, CIRA, federal). - Track number of GSL staff involved in mentoring programs. - Establish a GSL-specific program for mentoring and coaching to new, early career and postdoc employees (identify GSL mentors) that supports employee professional development.	DaNa Carlis (OD) Evergreen Group (cross-Division)	Start: Dec 1, 2021 Completion: Mentoring program: May 31, 2022 Promotion and tracking: ongoing	Completed. All mentoring programs and workshops available to NOAA staff and affiliates are communicated regularly through the GSL Briefs and weekly GSL Notes. GSL established a summer intern program starting with the GSL-CIRES program in summer 2022. This program has continued in 2023 and 2024 leveraging various NOAA intern programs.
3) Develop stronger relationships with the NOAA Cooperative Science Centers. These NOAA-funded entities routinely recruit, train, and support hundreds of students from diverse ethnic identities in NOAA mission sciences.	We established a process to foster ongoing coordination with the CSCs. We will continue regular GSL-CSC engagements (semi-annually) with the goal to - Increase joint proposals between GSL and CSCs, - Increase Co-advising of students, - Increase postdocs and new hires from CSCs.	DaNa Carlis (OD) Missy Petty (OD)	Start: Dec 1, 2021 Ongoing	GSL served as co-organizer for the ESRL (OAR Boulder)-CSC engagement series in 2022. More specific engagements with NCAS-M and CESSRST have been held in 2023-24. GSL participates in an ongoing virtual speaker series with NCAS-M, and supports recurring visits of the GSL senior scientist to NCAS-M. GSL also hired a NCAS-M postdoc in 2023-24, and has hosted several NERTOs and EPP/MSI student interns.
4) Develop a formalized relationship to the Cooperative Science Centers and other Minority-Serving Institution partners that engages their faculty expertise with roles or membership on governance,	-Leverage activities in recommendation 3 to establish MOUs with specific CSCs to crystallize areas of collaboration. -Identify and engage local MSI, TCU, and HSI faculty (This is an activity in the ESRL DEIA Implementation plan, mentioned in recommendation 1).	DaNa Carlis (OD) Missy Petty (OD)	Start: Dec 1, 2021 Completion: MOUs: Oct 31, 2022, with ongoing sustainment of engagement activities	Completed. MOU not established– GSL aligns collaborations with CSCs per cooperative agreement. In addition to the activities in 3), GSL has established a partnership with University of Northern Colorado, which is an MSI, to

advisory, and strategic planning committees.				establish a student program for the 2024-25 academic year.
5) GSL should work to increase the number of journal articles from staff members who are primarily working on science/research. Consider surveying similar organizations when developing the goal to figure out reasonable targets and learn about possible difficulties and solutions. (Options include incentivizing publications in appropriate journals and lowering any existing organizational barriers to publishing.)	- Survey similar organizations to learn about best practices and solutions for increasing the number of journal articles. - Establish process to provide opportunities for and mentor GSL staff on writing journal articles.	Missy Petty (OD) Susan Cobb (OD)	Start: Jan 1, 2022 Completion: Oct 31, 2022	Completed Oct 2022. GSL surveyed other OAR Labs for best practices. Have leveraged guidance from senior, more experienced scientists to provide seminars to students and interested early and mid-career scientists.
6) GSL should consider elevating the status of research to operations transitions and developing a way to present them as a parallel performance metric to journal articles.	Establish transition management process to develop transition plans for all projects that may transition, engage Office of Research, Transition, and Application (ORTA) as needed to find a transition platform, ensure all plans are signed. Track all transition plans similar to the process for publications (OAR AOP). - Publish all signed transition plans in the NOAA Research and Development Database (NRDD). - Explore opportunities to publish R2O activities in journals and/or on the GSL website as feature stories.	Missy Petty (OD)	Start: Jan 1, 2022 Completion: Dec 31, 2022	Completed. GSL's Program Management Office was established in early 2023 and has developed an overarching project/NRDD/AOP/R2O management and tracking process that includes transition plan management and guidance, and tracking of readiness level progression and other preeminence metrics.

7) Related to the previous two recommendations, GSL should strive to prioritize its documentation of research results and software development so that current information is easy to find and cite, and authors are easy to contact.	- Explore the use of the new publication database, smartsheets, and other solutions for documentation of code, research results, etc. Develop plan and implement process. - Establish and follow best practices for documentation of research results and software development such as DOIs, README files, and use of Github repositories.	Missy Petty (OD) Susan Cobb (OD) Software Engineering working group (cross-Division)	Start: Jan 1, 2022 Completion: Dec 31, 2022	Completed. RPTS was implemented Q4 FY23. Code management practices have been implemented through a code manager hire, also Q4 FY23.
8) If GSL wants to move forward with its plans to focus on lower readiness-level research, GSL should assess the risks and identify/document current barriers to research and development and share with OAR leadership before putting together a plan with milestones.	Perform risk assessment (will engage SMT for risk assessment discussion). Document barriers and develop strategies for overcoming barriers. Include strategies in GSL Implementation plan.	DaNa Carlis (OD) Missy Petty (OD)	Start: Jan 1, 2022 Completion: June 30, 2022	Risks identified and provided to OAR through risk registry Jul 2022, with ongoing annual updates. Barriers were identified and discussed at GSL retreat April 2023, and are being addressed through internal competitive proposals like Shark Tank and the Innovation Hub.
9) Develop a consistent outreach and branding strategy that makes clear to stakeholders, peer institutions, and potential funding sources who GSL is, what GSL does, and why GSL is unique. Such a strategy should engage GSL staff at all levels.	- Continue to develop and refine outreach and branding strategy. - Ensure the gsl.noaa.gov webpage is consistent with this branding image/strategy. - Ensure website targets and supports intended audiences, including GSL staff, external organizations and partners, and the public. - Provide more resolution in the org chart to help both those internal and external to NOAA understand the organization.	Missy Petty (OD) Susan Cobb (OD) Web Improvement Group (cross-Division)	Start: Dec 1, 2021 Completion: Oct 31, 2022	Completed Oct 2022 GSL branding strategy was refined and implemented through website, slide styling, and wordmark in Q4 FY23. GSL website redesign deployed Sept 2024 with accessibility focus. In Q2 FY24 GSL established social media accounts distinct from ESRL (OAR Boulder).

10) GSL should consider adding to its website more high-quality graphics and model output visualizations targeting the general public.	Upgrade website to meet objectives. Dedicate resources to improve GSL visualization capabilities, including: - Building graphics capabilities to showcase GSL experimental products and implement on website, - Improved tools for near-real-time displays.	Missy Petty (OD) Susan Cobb, Craig Hoffman (OD) Web Improvement Group (cross-Division)	Start: Dec 1, 2021 Completion: Dec 31, 2022	Completed Q4 FY23. Established visualization and graphics design team to develop graphics showcasing GSL and GSL products. Graphics are used on website and in outreach materials. DESI and IDSS Engine are two newer tools that provide improved visualization for near-real-time displays.
Advanced Technologies				
11) GSL should play a leadership role within NOAA in developing and showcasing best practices to improve computing efficiency, save money, and reduce environmental harm. To start, GSL should identify the carbon footprint of its lab, computing resources, and ultimately the models/tools it develops. This footprint could be used as an additional criterion in decision making at many levels (e.g., procurement, model development, etc.).	Improve computing efficiencies: 1) Identify and provide carbon footprint info related to GSL VM environment and Jet. 2) Develop resource management strategies to evaluate tradeoffs and techniques for improving computing resource utilization. 3) Implement processes for resource management to improve efficiencies.	Scott Nahman (ITS) Forrest Hobbs (ITS)	Start: Dec 1, 2021 Completion: Strategy development: Oct 31, 2022 Implementation: Oct 31, 2023	Completed. A Recent data center assessment was performed by the NOAA OCIO with recommendations for efficiency improvements. A report on Jet composed by ITS and presented to OCIO identified tradeoffs and cost savings. ITS has provided tools to monitor reservation usage and disc usage, and HPC users respond accordingly.
12) Identify one or more driving needs around exascale computing and develop and implement an end-to-end plan that includes model readiness (e.g., GPUs,	Perform needs assessment and develop a plan for exascale computing with application to GSL modeling efforts. Execute as part of GSL implementation plan.	Curtis Alexander (OD) Isidora Jankov (EPAD)	Start: Dec 1, 2021 Completion: Exascale computing plan: June 30, 2022	Completed. A needs assessment and associated modeling application plan was completed Nov 2022.

machine learning, etc.), data and workflow requirements, codesign, leadership, and stakeholder buy-in around this need.		Georg Grell (EPAD)		Ongoing activities are executed through the SENA program.
13) Strategically develop and demonstrate applications of AI/ML to simplify, accelerate and improve the quality of NOAA products, including improving forecaster workflow by automating routine tasks, guiding forecaster attention to where it can add the most value and providing decision recommendations to end-users. Ensure that GSL has a strategic plan for AI that is in line with NOAA's strategic plan.	Develop an AI/ML strategy for GSL development that is aligned with NOAA's strategic plan, including decision support tools such as IDSS engine.	Daniel Nietfeld (WIDS) Jebb Stewart (WIDS) Dave Turner (AVID) Isidora Jankov (EPAD)	Start: Jan 1, 2022 Completion: AI/ML strategy: Jun 30, 2022	The AI/ML environment is constantly changing, driving evolution of GSL's strategy. An initial draft was completed June 2022. The strategy was further refined in Nov 2023 through the NOAA AI4NWP workshop. An AI/ML leadership team was established in early 2024, with a GSL AI/ML summit held Aug 2024.
14) Continue to help shape and engage with the NOAA Center for AI and maintain collaboration with the NSF AI Institute for Research on Trustworthy AI in Weather, Climate, and Coastal Oceanography.	GSL currently has active members of AI2ES and will continue to engage with this Institute. GSL also has an active collaboration with CIRA and their Machine Learning Lead. GSL will continue to collaborate with CIRA through post doc opportunities. Related recommendation 13, GSL will work to integrate AI/ML techniques into GSL applications for potential R2O.	Daniel Nietfeld (WIDS) Jebb Stewart (WIDS) Dave Turner (AVID) Isidora Jankov (EPAD)	ongoing	Participation in AI2ES is an ongoing effort. Strategies to integrate AI/ML into GSL applications were developed through the NOAA AI4NWP workshop.

15) Look for longer-term funding opportunities to broaden the Advanced Technologies area to reach critical mass or to broaden your portfolio in highly relevant advanced technologies.	Work across Divisions to capture long-term technology requirements. Develop longer-term strategies and collaborative efforts to advance GSL technologies and capture in GSL Implementation plan. Take advantage of funding opportunities as they arise to execute strategy.	Curtis Alexander (OD) Isidora Jankov (EPAD)	Start: Dec 1, 2021 Completion: May 31, 2023	The SCNAB Branch Chief works across the Division to capture requirements. Longer term strategies have been developed and are supported primarily through the SENA program.
16) Scale, replicate and document the AQPI project for additional regions and use cases, and as a paradigm for building end-user-focused weather systems.	- Seek funding opportunities to sustain the AQPI project. - Identify best practices and capabilities from AQPI to incorporate into other GSL projects.	Greg Pratt (ITS) Dave Turner (AVID)	Start: Dec 1, 2021 Completion: Identification of best practices: Dec 31, 2022	Project completed Sept 2022 with delivery to CSU. Further funding opportunities were sought, but not available. Documentation for the project was completed Oct 2023.
17) Draw on GSL's expertise in environmental observations, modeling, cloud, AI and verification to create and make available curated datasets and compute environments to support workforce education and experimentation with AI training and evaluation techniques.	Determine best dataset and compute environment examples to help create education material for AI training and evaluation for workforce development. Coordinate GSL AI presentations on current AI/ML techniques at various workshops in collaboration with NOAA Center for AI.	Daniel Nietfeld (WIDS) Jebb Stewart (WIDS)	Start: Dec 1, 2021 Completion: June 30, 2022 with ongoing participation in workshops	Completed June 2022 with ongoing development. GSL is leveraging the NOAA Center for AI workforce development plans, and partnering with NCAI to develop educational materials showcasing weather and climate challenges. GSL partners with the NSF AI2ES where additional training modules for AI and using NOAA data are being developed. GSL has created Jupyter notebooks that can be used for training. GSL participates in a variety of NOAA AI workshops and leads conference sessions for AMS.

18) Adopt coding standards and encourage uniform staff use of version control (e.g., GitHub) to facilitate code sharing, building a shared reservoir of capability, onboarding new staff, and ensuring sustainability.	- Start divisional collaboration efforts to build a shared GitHub repository. - Provide practical opportunities (training, workshops) for staff to learn use of git/ gitHub.	Curtis Alexander (OD)	Start: Dec 1, 2021 Version control practices and practical opportunities: ongoing	Completed. A Git workshop was provided Jan 2021 with further activities ongoing. A Shared git repo was established by AVID as of Nov 2022. A NOAA GSL GITHUB exists with all divisions actively adding and sharing code. The ITS/DSG team moved from CVS/RCS to GIT for its coding efforts in 2023.
19) As part of longer-term NOAA strategy, GSL could explore how quantum computing may be used to dramatically accelerate NWP, AI and other computing relevant to NOAA's mission.	Start educating staff on quantum computing. Continue to closely follow quantum computing advancements and identify potential opportunities for use of quantum computing to advance GSL modeling activities.	Curtis Alexander (OD) Isidora Jankov (EPAD)	Start: Dec 1, 2021 Monitoring quantum computing opportunities: Ongoing	Completed. An initial exploration of quantum computing was completed for situational awareness. Ongoing monitoring occurs for quantum computing possibilities for GSL developments.
Earth System Prediction				
20) NOAA has labs with strongly overlapping interests and research programs in earth system model development, e. g. GSL, NCEP/EMC, and GFDL. At a higher level, it is important for NOAA leadership to clearly define the distinct roles of these labs so that they are rewarded for collaborating and do not duplicate effort more than is necessary.	- Identify and implement strategic partnerships and approaches to articulate GSL's role on GSL's website, implementation plan, etc. - Update GSL's charter.	Jennifer Mahoney (OD) Curtis Alexander (OD) Georg Grell (EPAD) Scott Nahman (ITS) Daniel Nietfeld (WIDS)	Start: Dec 1, 2021 Completion: Charter: March 30, 2022	Charter updates were completed in Q3 FY22. GSL has identified and further developed several strategic partnerships, including with NSSL, EMC, GFDL, and NWS OSTI. GSL held planning summits each with NSSL and GFDL in Q4 FY23 and with OSTI in Q3 FY24, identifying areas of collaboration and roles and responsibilities. Graphics have been developed to distinguish

				GSL's role in NWP in communications.
21) GSL should work with other NOAA labs and OAR leadership to establish clear targets and responsibilities regarding UFS development.	Maintain consistent communications with NOAA Labs and other OAR Labs about UFS R&D activities. Include targets in GSL Implementation Plan.	Curtis Alexander (OD) Georg Grell (EPAD) Mark Govett (EPAD)	Start: Dec 1, 2021 Completion: Communications: ongoing Implementation plan: June 30, 2022	Curtis Alexander (GSL Deputy) is a co-lead of the UFS short-range weather/convection allowing model (SRW/CAM) team and leads bi-weekly to monthly meetings with the entire team that spans representatives from OAR labs, NWS centers, WPO, universities and other members of the community to discuss CAM R&D activities and opportunities including the UFS R2O project, JTTI, etc.
22) A detailed, resourced plan should be produced to enable understanding of the implications for GSL of the transition of the RAP/HRRR to RRFS in the UFS framework. In particular which types of activities will GSL be doing more of and which less and what are the implications for your deployment of resources? This ties in with GSL's goal of doing more research. As part of this there needs to be a realistic and resourced plan for incorporating the FV3 dycore.	Create a document that communicates GSL's investment in UFS, the UFS drivers for GSL research, and describes the implications and resources needed for GSL to transition the RAP/HRRR to RRFS in the UFS framework.	Curtis Alexander (OD) Steve Weygandt (AVID) Georg Grell (EPAD)	Start: Jan 1, 2022 Completion: June 30, 2022	The RRFS plan and work breakdown structure were completed June 2022.

23) Develop a long term (5-10 year) plan to carry out your stated "Grand Scientific Challenge" to develop global, rapidly updating storm-scale models. This project may need to start relatively slowly due to the resource limitations of the UFS transition discussed above. The plan needs to be developed in collaboration with other labs and organizations and will also require significant additional HPC resources.	Complete initial version of GSL's Implementation plan.	DaNa Carlis (OD) Curtis Alexander (OD) Georg Grell (EPAD) Daniel Nietfeld (WIDS) Scott Nahman (ITS)	Start: Dec 1, 2021 Completion: Mar 31, 2022	Strategic Implementation Plan was completed and released Jan 2023.
24) Consider a long term (5-10 year) project, in collaboration with other centers or groups, to develop the capability to run 100-m/urban scale regional models. This will need to include plans to improve the model/parameterizations for 100m scale configurations, improve the representation of the urban surface and work with potential stakeholders in these models. A plan to obtain sufficient HPC resources will also be key here.	Develop a plan for urban-scale model development.	Curtis Alexander (OD) Georg Grell (EPAD) Joe Olson (EPAD) David Dowell (AVID) Isidora Jankov (EPAD)	Start: Jan 1, 2022 Completion: Dec 31, 2022	Completed. Plans for urban-scale modeling were developed through BIL Provision 5 and are currently being implemented. Additional urban-scale development occurs through other funded UAS projects.
25) Increase the development and use of satellite information for data assimilation.	Track the satellite platforms and observation type/counts used in	Curtis Alexander (OD)	Start: Dec 1, 2021 Completion: 10/31/2023	N21 CrIS and ATMS were added to RRFS (RRFS_B) with documented

	assimilation and verification of our model systems (RRFS).	Steve Weygandt (AVID)	Tracking: ongoing	increase in observation counts (and forecast improvement).
26) Build up the collaboration with other testbeds such as the Aviation Weather Testbed to the same level as with the Hazardous Weather Testbed	Engage in regular advanced planning discussions and annual meetings with testbed leaders (AWC, WPC, FireWX, NHC) to determine opportunities for testing new code and technologies.	Curtis Alexander (OD) Terra Ladwig (AVID)	Start: Jan 1, 2022 Completion: Identification of opportunities: Dec 31, 2022, with ongoing sustainment of testbed opportunities	Completed with ongoing engagement. Attending monthly Testbed Proving Ground meetings to align Fire Wx Testbed with testbed procedures and ensuring collaboration with other testbeds. Also coordinate with WPC for FFaIR and AWC for AWC testbed.
27) Develop collaborations with groups using the relatively new convection permitting climate models (which are used for example to understand how heavy rain might change in a future climate).	Identify strategic partnerships with national and international expertise to advance GSL's convection-permitting models to progress toward our Grand Challenge.	Georg Grell (EPAD) Curtis Alexander (OD) Ligia Bernardet (EPAD)	Start: Jan 1, 2022 Completion: Dec 31, 2022, with ongoing sustainment of partnerships	Completed with ongoing engagement. GSL is engaged in many partnerships. International: contribution to a WGNE effort related to aerosols for S2S and another related to stochastic physics. GSL Sr scientist gave a course in Europe and met with various colleagues in Germany. GSL scientists also co-convened sessions at EGU. GSL also has various domestic partnerships with NCAR, NRL, other NOAA Labs, U Michigan, etc.
28) Try to seek more strategic international collaborations. For example, understanding how your models perform and are perceived in other parts of the	Continue and possibly increase collaboration to and within WMO groups such as WMO MU-MIP, WGNE, EUREC4A. COORDE, Greyzone, DYAMOND, GAFIS,...	Georg Grell (EPAD) Curtis Alexander (OD)	Start: Jan 1, 2022 Completion: Dec 31, 2022, with ongoing sustainment of collaborations	GSL participates in international field campaigns (e.g., FESSTVaL). Visited and gave seminars at DWD main office.

world would probably be very informative for your model development.		Dave Turner (AVID)		
Decision Support				
29) Continue with the inclusion of social science researchers as part of the GSL Decision Support development team.	- Hire a social scientist to support GSL science activities. - Continue to partner with social science researchers as part of existing projects and potential future projects. - Partner with NCAS-M entities to include social science student interns in decision support projects. - Develop GSL social science strategy to integrate social science researchers into GSL research efforts such as risk communication, social media, user experience, and decision support tools.	Daniel Nietfeld (WIDS) Ken Fenton (WIDS)	Start: Jun 22, 2021 Completion: Social science strategy: Dec 31, 2022	GSL has established a Social and Behavioral Sciences Branch with two federal employees (Branch Chief, researcher) and several CI staff (researchers, UI/UX developer), along with an NCAS-M postdoc. A strategy was developed by the SBS Chief once the Branch was established.
30) Further extend the target of Decision Support and user experience R&D beyond NWS forecasters and traditional stakeholders to end-user consumers of the forecast information and underserved countries (recognizing that external funding may be required).	Explore opportunities for delivery of decision support and user experience R&D to: - Underserved countries such as the Philippine Atmospheric Geophysical and Astronomical Services Administration. - Wildfire decision-making communities including EMs, Incident Commanders, Public safety officials. - Other government agencies with significant weather impacts such as the Dept of Transportation Bureau of Transportation Statistics and FAA.	Daniel Nietfeld (WIDS) Nate Hardin (WIDS) Travis Wilson (WIDS)	Start: Jan 1, 2022 Completion: Identify opportunities: Dec 31, 2022, with ongoing sustainment of established relationships	Completed initiation of opportunities Nov 2022. GSL has shared possible solutions through presentations to the Philippines, New Zealand, and the Bahamas and is currently establishing an agreement with the Bahamas for AWIPS technology. The FWT has engaged with the broader wildfire decision making community and includes them in FWT experiments. GSL has also worked with Department of Transportation for IDSS Engine,

	- Work with ORTA to identify other potential receiving organizations outside of NWS.			and UK Met Office, US Air Force, and several others as potential receiving organizations for DESI.
31) Expand efforts in Decision Support for ensemble weather products to include ensemble uncertainty quantification and how users, both meteorologists and non-meteorologists, should interpret ensemble output.	- Build on the Timing Uncertainty project using CAM ensembles to develop decision support visualizations and data to assist forecasters and decision makers with assessing the uncertainty and ranges of the onset and cessation of weather hazards. - Begin "Dynamic Ensemble-based Situations for IDSS" (DESI) Project and complete prototype for IDSS Engine Project. - Support NWS/FAA transition to ensemble-based aviation hazards per ICAO WAFS requirements.	Daniel Nietfeld (WIDS) Travis Wilson (WIDS) Matt Wandishin (AVID) Jebb Stewart (WIDS) Trevor Alcott (AVID)	Start: Dec 1, 2021 Completion: DESI for IDSS Engine Prototype: Sept 30, 2022	An experimental DESI version was initially released for testing Oct 2022; uncertainty and ensemble-based research ongoing. DESI has leveraged previous timing uncertainty research to create new forecast timing graphics that are used by the NWS. DESI has also been successfully demonstrated in OPG. The IDSS Engine prototype was completed and demonstrated to MDL, and continues to undergo development. GSL participates in meetings with NCAR, NWS, and FAA on NWS/FAA transition to ensemble-based aviation hazards.
32) Develop the capability within GSL to measure economic benefits of weather information.	- Continue and expand on collaboration with the economics department at CSU. - Work to increase impact-based techniques in GSL verification tools.	Curtis Alexander (OD) Daniel Nietfeld (WIDS) Dave Turner (AVID) Matt Wandishin (WIDS)	Start: Dec 1, 2021 Completion: Oct 31, 2022, with ongoing sustainment of CSU collaboration and incorporation of new techniques into tools	Initial project completed Oct 2022 with 3 publications, new project funded to CSU for further economic benefit evaluation. Partnership with CSU will be ongoing.

33) Prioritize verification at the lab level and make more use of verification in the earlier stages of development by approaching data assimilation, verification, and forecasting in a more holistic approach to fully utilize GSL's strengths and resources.	Identify and support cross-Division verification efforts, and foster the ability of individual verification groups to leverage expertise, approaches, and tools across the Laboratory.	Curtis Alexander (OD) Daniel Nietfeld (WIDS) Dave Turner (AVID) Matt Wandishin (AVID) Shan Sun (EPAD) Greg Pratt (ITS)	Start: Dec 1, 2021 Completion: Establish cross-division efforts: Oct 31, 2022, with ongoing sustainment	Completed Oct 2022 with reorg that merged verification teams from two Divisions into one Branch. A cross-Division Verification summit was held June 2024.
34) Re-establish site visits for Decision Support feedback and needs as soon as is safe and feasible.	- Work with NWS Decision Support Integration Branch to identify NWS focal points for user engagement activities related to the IDSS Engine project. - Identify points of contact and begin virtual feedback sessions with users of GSL decision support tools.	Daniel Nietfeld (WIDS) ~~Sarah Detty (EDS)~~	Start: Nov 3, 2021 Completion: April 30, 2022, with ongoing sustainment of user engagement activities	Completed as part of DRSA/IIJA planning. Feedback sessions have resumed with the UI/UX developer hire and establishment of SBS Branch. GSL has established a partnership with MDL for IDSS Engine and DESI, with funding for IDSS Engine through BIL.
35) Consider expanded use of dissemination venues such as public GitHub repositories, blog posts, user manuals, software documentation, social media, and tracking of related key performance indicators such as views or downloads to supplement journal and conference publications in highlighting successes, sharing R&D results and growing the set of GSL stakeholders.	This is jointly addressed with recommendations 7, 9, 18. An analysis of these performance metrics will be conducted in Q4 annually and considered in performance evaluations.	Missy Petty (OD) Susan Cobb (OD) John Schneider (OD)	Start: Jan 1, 2022 Completion: Identify and implement procedures, venues: Oct 31, 2022	Addressed through recommendations 7, 9, 18.

36) Consider expanding connections with private industry as collaborators, recipients, and implementers of GSL decision support R&D outputs. For example, recommended routes provided by Integrated Support for Impacted Air-Traffic Environments (INSITE) might be valuable to airline dispatchers. Create open-source, cloud-ready containerized implementations, and track GSL's expanded impact using performance indicators like GitHub downloads.	Incorporate development practices to - Ensure useful modules are ready for open-source sharing, - Ensure cloud readiness for ease of transition (containerization), - Post useful modules to shared repositories. Continue to pursue CRADAs with private companies through the NOAA Technology Partnerships Office (e.g., INSITE).	Daniel Nietfeld (WIDS) Matt Wandishin (AVID) Kirk Holub (ITS)	Start: Mar 1, 2022 Completion: Establish practices: Dec 31, 2021, with ongoing sustainment of practices	Exploring opportunities with TPO but tangible leads not yet identified. Cloud readiness and containerization practices have been incorporated into IDSS Engine and DESI code development. Various modules and software have been shared to the OAR Github repository and VLAB.
37) Offer objective verification services to industry, e.g., in comparing performance of aviation turbulence forecast skill. This could leverage the techniques developed for FAA evaluations, attract additional funding, and benefit society by fostering competition to improve the quality of commercial forecast products.	Explore and develop concepts of verification as a service, implemented in tools as a platform for product developers to receive objective verification of their product.	Curtis Alexander (OD) Matt Wandishin (AVID) Dave Turner (AVID) Jeff Hamilton (AVID)	Start: Dec 1, 2021 Completion: Demonstration of prototype verification services: Dec 31, 2022	Completed. Concepts of verification services are incorporated into GSL tools. The team is exploring expanding into other sectors such as Renewable Energy and through Fire Wx Testbed. GSL has pursued potential licensing agreements of FCI and INSITE in coordination with TPO and University of Colorado on. CRADAs have been recently established for SOS research.