Site Visit Team (SVT) Report: University of Wyoming King Air (UWKA) Facility Review

Virtual Site Visit
April 27 -28, 2022

Executive Summary

The University of Wyoming (UW) is effectively managing the UWKA, WCR and WCL assets, and these assets are being used to support valuable research and educational deployments for the scientific community. The management is well-organized, and individual team members are qualified and capable. The team has satisfactorily addressed issues raised during the 2016 site visit, including making historical data sets available on the website and providing a list of scientific publications arising from facility use. The panel was particularly impressed with the extensive upgrades associated with the new King Air (FL-862) and planned increases in science capabilities.

Demand for access to the UWKA, WCR, and WCL assets, and demonstrated success in producing high quality datasets and resulting peer-reviewed publications justify continued support of UWKA as a national facility.

Several recommendations are provided in the final section of this report. We find no major concerns with operations of the facility, and the recommendations are largely intended as suggestions to increase the value of the facility. Specific recommendations fell into categories of improved documentation and presentation of information, education and outreach, and instrumentation.

Overview

The University of Wyoming King Air (UWKA) together with the Wyoming Cloud Radar (WCR), Wyoming Cloud Lidar (WCL), and associated in situ instrumentation is an NSF Lower Atmospheric Observing Facility (LAOF), initially supported through the LAOF Program and more recently through the Facilities for Atmospheric Research and Education (FARE) Program. The University of Wyoming has operated in this role since 1987 and logged more than 8500 flight hours with the current aircraft. The Cooperative Agreement (CA) between NSF and the University of Wyoming provides support for a group of scientists, engineers, technicians, pilots, and an aircraft mechanic, along with base support to maintain the aircraft, instrumentation, and infrastructure required to ensure the UWKA is available to support research and education deployments requested through the NSF AGS (Atmospheric and Geospace Sciences) programs. The CA also provides funding support for the WCR and WCL.

Between 2016 and 2022, there were a total of 23 requests for new or substantially revised projects through NSF-funding requiring a facility feasibility assessment. Ten of these requests were allotted, nine executed and one cancelled due to COVID-19. Given this demand and the

demonstrated success in producing high quality datasets and resulting peer-reviewed publications, we conclude that there is sufficient community demand to justify continued support of UWKA as a national facility, though some additional reporting of science findings is recommended.

One of the major recommendations from the 2016 SVT Report and a bullet point in the CA8 agreement between UW and NSF is to develop a replacement aircraft facility. Because deployment activities were reduced in years 1 and 2 of the current CA due to COVID-19, more effort was placed on the development of new capabilities. Several new instruments and infrastructure were acquired/developed, tested, and have been brought online over the last two years. In short, good progress has been made toward the development of the new King Air aircraft. Overall, the team has successfully juggled the demands of deployments, COVID-19, development of the next generation WCL and WCR, and have maintained forward progress on UWKA-2. Staffing mix, shared values, and strong sense of team identity have made this possible.

Findings

- The University of Wyoming is meeting NSF core expectations set forth in the cooperative agreement, effectively managing the UWKA, WCR and WCL assets, and using these assets to support valuable research and educational deployments.

The UWKA Facility presentations and documentation provided to the review panel clearly demonstrate that the University of Wyoming is effectively managing the UWKA, WCR and WCL assets and that these assets are being used to support valuable research and educational deployments for the scientific community. The management is well-organized and individual team members are qualified and capable. The panel was particularly impressed with the extensive upgrades associated with the new King Air (FL-862) and planned increases in science capabilities. Notable NSF selected projects accomplished since 2016 include:

- Pre-BBFlux-17 & RadFIRE-16: “RAPID” Deployments
- Pre-BBFlux-17: JPL Instrument collaboration (MTHP)
- SEAR-MAR17 & TECPEC-19: Educational Projects
- BBFLUX-18: In concert w/ WECAN-18, mini-deployments, EOL CO
- CHEESEHEAD-19: Three-IOP deployment over three months
- TRANS2Am-21: First all-female PI team to use the KA
- CHACHA-22: AVAPS operational, NSF Polar Programs Collaboration
- SWEX-21: Postponed & canceled due to COVID19; the WCL installed on NPS Twin Otter for SWEX-22

Throughout these projects, UW has continued to expand their suite of core instrumentation, demonstrated their in-house capability to provide software, electronics and hardware engineering support for installation of PI instrumentation that has not flown on the KA

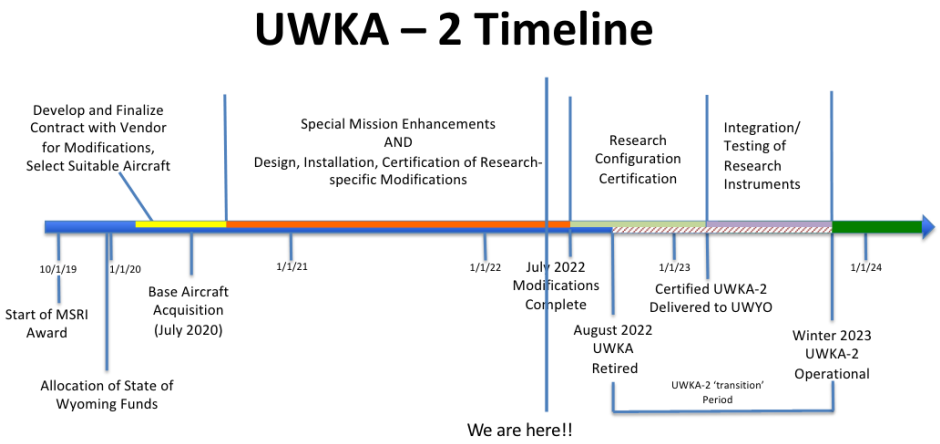
previously, and shown its skill in conducting flight operations that optimize scientific sampling, while also maintaining aircraft and personnel safety.

In total, 88 journal articles using UWKA assets have been published since 2016, along with an average of four theses and Ph.D. dissertations per year.

- The UW Team is making good progress bringing the UKWA-2 aircraft on-line, on schedule.

The UWKA team has invested considerable effort in making the replacement a reality. Resources were obtained from the University and NSF. Much design effort has been invested, and current results show significant progress has been made.

The single largest risk is completion and issuance of the research configuration Supplemental Type Certification (STC) from the FAA, which will allow the UW team to change science instrument configuration without needing re-certification. The team has taken significant mitigation measures. Of particular note are their development of a strongly interactive working relationship with Avcon, the contractor that is modifying the aircraft. This ensures Avcon clearly understands the critical nature of this uncommon type of certification. The UW team is involved in the review of documents that are developed by the ODA (Organization Designation Authorization– the group Avcon has subcontracted to for certification work) and submitted to the FAA. Furthermore, the contract with Avcon is structured in such a way that roughly 15-20% of their total payment (which amounts to ~$1.25 M) is tied directly to completion of this research certification.



- The UW Team demonstrated broad technical expertise and a good process for assessing feasibility of new mission proposals.

The UWKA Team has demonstrated a strong team environment and great teamwork in supporting unique field projects with new instrument installations in challenging deployment environments during the unprecedented time period of the pandemic. Despite personnel turn over and retirement, the team has pulled together, and many individuals have stepped

up to ensure continuity of aircraft safety, maintenance, user support, field planning and deployment, and day-to-day operations while also working hard to continue timely efforts towards certifying the new aircraft.

The Team has deep expertise in a wide variety of instrumentation and mission types, and they seem completely prepared and motivated to help new PIs develop feasible mission concepts. Their "can-do" attitude to accommodate new PIs and to help them along the learning curve is a solid foundation for diversifying the PI base.

The Team demonstrated technical expertise across the spectrum of Operations, Engineering, and Scientific domains. This is even more noteworthy given the relatively small size of the team and the recent personnel changes.

The Team is creative and motivated to find solutions that help facility users. In a recent example, the UWKA Team helped the science team prioritize the individual instruments in a payload suite into two subsets, deciding when to turn on which instruments to make the power budget work without limiting scientific objectives and sampling efforts. They didn't say "no" - they said "how can we help make it work"?

- Upgrades to WCR and WCL represent a significant improvement in remote sensing capabilities.

Adding up- and down-looking radar and lidar will enable detailed vertical profiling of atmospheric structure, clouds and air motion, thereby increasing the range of scientific questions which can be addressed.

- Outreach efforts are strong.

A variety of outreach activities were documented, including two education deployments (SEAR-MAR in 2017 and TECPEC in 2019) and two open houses (Cheyenne Frontier Days), as well as conference and workshop presentations. The site visit team was particularly pleased with the two educational deployments, which were focused on the participation of graduate students and training the next generation of airborne atmospheric scientists. Some of the students later pursued careers in atmospheric technology and even airborne technology.

Overall, the Team has an excellent understanding of their niche and the value they can bring to faculty at a variety of career levels. They seem to have a sincere desire to expand the PI pool and have set for themselves the goal of making UWKA the premier facility for educating and training next generation scientists.

- Partnerships with NCAR/EOL are an asset.

Partnerships between UW and NCAR are beneficial to both. The span of cooperation is very wide and includes software for data processing, advice and consultation, instrument loans, joint participation in field projects, staff visitations, workshops and publications. UW is encouraged to continue to expand this capability to use EOL processes, infrastructure, and

staff for data archiving. This is a great way to serve the goals of NSF and the science community, to leverage NCAR capabilities and not re-invent the wheel.

- The Team has an enhanced awareness of the impact of their operations on the community at home and when deployed.

The investments made in developing safe working protocols during the COVID-19 pandemic has increased the Team's awareness of the variety of team members' needs and work styles, as well as their "footprint" in the communities where they are based. This cognizance, coupled with the obvious attention to safety in all aspects of their work, can lead to greater effectiveness and enhanced respect for host communities in a variety of diverse situations in the future.

Recommendations:

Category: Documentation and Presentation of Information to the Community

- Continue to develop the UWKA User Guide and supporting documentation to improve effectiveness of the facility.

Explanation: The effectiveness of the facility would be further enriched by continuing to develop the KA User Guide and supporting documentation to better assist newer PIs in assessing the capabilities of the UWKA and appropriately planning facility use and instrumentation integration. Developing more thorough supporting data documentation, dataset specific Read-Me files (which altitudes, temperature measurements, GPS data, etc. are optimal or more reliable under certain conditions, etc.), and higher level composite data products (cloud flag, composite cloud particle or composite aerosol size distributions, etc.) or analysis tools would strengthen the usability of facility-provided datasets, particularly for non-experts in facility instrumentation. It is also strongly recommended to expand the current instrument documentation to include measurement ranges, resolution, uncertainty, and probe references or citations. It would also be helpful to users to identify which staff or faculty member is the on-site expert or point of contact for each facility instrument / measurement to streamline data support and ensure the data are optimally utilized and analyzed by the PI science teams. As new resources become available for UWKA-2, such as models of payload electrical and mechanical characteristics, these should also be included in or referenced by the User Guide.

- Provide a simple, high-level overview of capabilities and nominal mission parameters in an easy-to-find location on the website.

Explanation: While the King Air Facility web site does contain a "facility users guide" and instructions on how to request the UWKA, WCR, and WCL assets, the web site provides relatively little information explaining what constitutes a small/simple or large/complex request. For example: How many flight hours might there be in a small, average and large

deployment? Do deployments need to be in the Continental U.S? Western U.S.? Can they be International? How long is a small, average or large deployment? The SVT recommends collecting high-level contextual information into one location at a very high-level on the website. Please see Appendix A for one suggested implementation.

- Maintain and make available a summary of science objectives and short summary of key results for each campaign that can be used to help assess the scientific value of supported deployments.

Explanation: In response to the 2016 facility review, a list of publications using the UWKA, WCR and WCL assets in being maintained. This is important, and there is a healthy list of publications. But additional information on the science objectives and results of deployments (several years afterwards) would aid in assessing the value of the UWKA facility and should be included in future site visits. Having this kind of information publicly available (on the web site) could also inspire greater use of the measurements and future experiments.

- Maintain and make available a list of guest instrumentation that has successfully flown on the UWKA.

Explanation: Guest or individual investigator instrumentation has played a prominent role in many UWKA deployments, but information on such instrumentation is not provided on the web site. Providing this information could be extremely valuable to prospective applicants to help them identify potential additional capabilities and potential co-investigators. This key information also lowers the access hurdle for newer or younger PIs since there is inherently less integration-related time and resource demand for installing instrumentation that has successfully flown on the aircraft previously.

This information, as well as a list of related publications should be easily found on the web site. (Several panel members were unable to find the publication list on the web site).

Category: Outreach and Education

- Develop a more deliberate outreach strategy going forward.

Explanation: Significant efforts to encourage applications (especially from young investigators) have and are being made through UW faculty attending LAOF workshops and making presentations at major conferences including AGU and AMS general meetings, and AMS cloud physics conferences. This is an important activity, but appears to be somewhat haphazard rather than being routinely planned.

- Investigate the possibility of hosting annual or bi-annual one- or two-week summer school for graduate students from across the country.

Explanation: UW has done very well with student outreach, and the SVT encourages expanding the opportunities to serve more students beyond Wyoming and Utah. With the

help of UW faculty and NCAR, summer schools/camps could be organized, where the flights and measurements utilizing UWKA could last a week or two, and during the following weeks the students could return home and work with the data on various projects under the virtual mentorship of the UW faculty. Bringing a small cadre of students to Laramie for a week or two could be a more cost-effective strategy than bringing the UWKA to different locations around the U.S.

- Investigate the possibility of including/supporting one undergraduate research project per year, which might also help expand pool of PIs.

Explanation: Two recent campaigns, SEAR-MAR and TECPEC, had significant focus on educational outcomes and serve as examples of what the UWKA facility can contribute to this national need. Undergraduate research is very important, exposing and encouraging talented students to continue their education in graduate school in STEM disciplines and geosciences in particular. While acknowledging that the UW Department of Atmospheric Sciences has only graduate program/students, we encourage the UWKA facility to support some undergraduate research educational projects in collaboration with other educational institutions nationwide. A broader reach to a wider variety of institutions could enhance the diversity of student populations who will have access to hands-on science and education activities.

Category: Instrumentation

- The University of Wyoming and NSF should investigate options to expand core capabilities to include cloud particle imaging and aerosol composition, as well as general sharing of instrument/capabilities with NCAR/EOL.

Explanation: The core or baseline UWKA cloud and aerosol physics in situ sampling instrumentation is good but (with the exceptions of the SP2) appears to largely limited to particle sizing. In particular, core capability supporting cloud particle imaging, aerosol composition and collection would substantially improve the value of the UWKA asset for scientific applications. In particular NCAR/EOL has some capabilities along these lines, and further sharing of instrumentation should be investigated.

- Determine the flow environment of UWKA-2 using modeling calculations and measurements in support of external payloads and inlet placement.

Explanation: Accurate flow modeling calculations and measurements support the correct placement and alignment of external probes, air sample inlets and remote sensing beams. These factors are important for sampling efficiency, boundary layer thickness, setting air sample rates (isokinetic or other), optimal distance from inlet sample point to aircraft skin, estimating the risk of shadowing or shedding biases induced from propellers and aircraft fuselage features, identifying inlet placement and design modifications to reduce airflow distortion, potential air contamination from aircraft engines or vents, etc.

The UW team should ensure that an understanding of the flow environment is fully developed during the outfitting of UWKA-2, either through their own efforts or in collaboration with others at the University or elsewhere. Portions of these studies of flow modeling and flow boundary layer measurements could be suitable as student research projects.

To perform this modeling, a digital 3D solid model of the UWKA-2 exterior is needed, in addition to flow modeling software and computer resources. Perhaps Beechcraft can provide a solid model for the King Air 350i. Another option would be to use a 3D scanning laser triangulation approach of the actual, modified aircraft. The model should include other components that are added or relocated for different flight projects – such as fuselage or wing-mounted cloud probes and air sample inlets.

The flow boundary thickness can be measured during flight at several existing mounting points (belly, roof, window) with a pressure rake system for recording the flow profile from the aircraft skin out to ~30cm for different flight conditions and aircraft configurations. An example of such measurements for the NSF/NCAR GV is available at [1]. It is likely that UW could borrow a pressure rake system from NCAR/RAF. An article [2] in NASA TechBriefs magazine (1999) describes how they made a pitot rake for flight tests on an F-15B aircraft.

Cited websites:

[1] https://archive.eol.ucar.edu/homes/dcrogers/ProgSci/PressureRake/

[2] https://www.techbriefs.com/component/content/article/tb/pub/briefs/mechanics-and-machinery/29819

Site Visit Team:

Laura T. Iraci (Chair), NASA Ames Research Center

Dorothea Ivanova, Embry-Riddle Aeronautical University

Roger Marchand, University of Washington, Department of Atmospheric Science

David Rogers, NCAR/RAF, retired project scientist & consultant

Sarah Woods, SeaSky Analytics, LLC

APPENDIX A: Detailed Suggestion/Example of Website text

Over the last 40+ years, the University of Wyoming King Air has been part of a wide variety of atmospheric research missions and educational outreach activities.

Typical research applications including studies of:

- Boundary-layer turbulence/fluxes
- Mesoscale dynamics
- Air-sea interactions
- Cloud & Aerosol physics
- Tropospheric profiling
- Radiometric measurements, satellite validation/characterization
- Atmospheric chemistry

Baseline measurements capabilities include

- W-band Cloud Radar
- Lidar
- Cloud/precipitation particles sizing probes (CDP, 2DS, HVPS)
- …Other examples as appropriate

Many guest / individual investigators instruments (including those listed below) have been flown on the UWKA and we welcome discussions on accommodating new instruments.

- …Examples

Deployments vary in size and duration, and can be proposed for deployment in <geographic region> for small simple and <locations> as part of larger requests.

- Total flight hours vary from … to … hours, with individual flights limited to about 4 hours.
- Typically based at a single base of operation …

Detailed instructions on how to apply for use of UWKA, WCR, and WCL can be found (here) but first please contact us by email. We are here to help you with your requests.