Annual Progress Report: Year 2
for the
Next Generation Wyoming King Air
Atmospheric Research Aircraft Project
(UWKA-2)

MSRI-1 Award # 1935930

at the

University of Wyoming

Division of Atmospheric and Geospace Sciences
Directorate for Geoscience

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List of Acronyms

ADL	Airborne Doppler Lidar
CCB	Change Control Board
CDR	Conceptual Design Report
CMP	Change Management Process
CPI	Cost Performance Index
CU	University of Colorado, Boulder
CY	Calendar Year
DER	Designated Engineering Representative
EAC	Estimate at Completion
EOL	Earth Observing Laboratory (NCAR)
ES&H	Environment, Safety and Health
ETC	Estimate To Complete
EVM	Earned Value Management
FTE	Full Time Equivalent Employee
FY	Fiscal Year
ICD	Interface Control Document
KA	King Air
KAAP	King Air Advisory Panel
KPI	Key Performance Indicator
KPP	Key Performance Parameter
KPR	Ka-Band Precipitation Radar
LAOF	Lower Atmosphere Observing Facilities
MARLi	Multi-function Airborne Raman Lidar
MSRI	Mid-Scale Research Infrastructure
NCAR	National Center for Atmospheric Research
NSF	National Science Foundation
ODA	Organization Delegation Authorization
PI	Principal Investigator
PEP	Project Execution Plan
PM	Project Manager
PSCP	Project Specific Certification Plan
PO	Program Officer
PO	Purchase Order
QA	Quality Assurance
QC	Quality Control
R&D	Research and Development
SPI	Schedule Performance Index
STC	Supplemental Type Certificate
TLR	Traffic Light Report
TPC	Total Project Cost
T&C	Terms & Conditions
UM	Unit Member (of an ODA)
US	United States
UW	University of Wyoming
WBS	Work Breakdown Structure
WCR	Wyoming Cloud Radar

1 Summary

The next-generation UW King Air Project had a successful second year (MSRI Year 2). Year 1 laid the groundwork for the start of major development efforts and creative work across projects scheduled for Year 2. Throughout Year 2, all five Projects that compose this grant remained largely on track, notwithstanding the COVID-19 pandemic.

The highlight of Year 2's efforts is *the progress made with modifications to the baseline aircraft*, a 2013 King Air 350 (s/n FL-862), at UW's prime aircraft contractor, Avcon. The avionics, heavyweight gear, -67 engines and 400A generators were acquired, installed, tested and certified early in Year 2. Since then, continued progress has been made with the design, installation, and certification of the major research modifications for the aircraft. There have been major schedule issues resulting in invoicing and performance delays. *There have been some delays in the modification design process, but uncertainty continues to be reduced for the aircraft delivery time and for instrument Projects under this award*, i.e. Projects 2-5. In particular, design elements and component choices in Projects 2 and 5 are dependent on aircraft modifications reaching the preliminary design review stage.

Project 1 (Aircraft): Deeper integration of design efforts between Avcon, ATSI (an Avcon subsidiary), Avcon's subcontracted ODAs, and UW, along with more in-depth UW oversight (esp. by Blosser Engineering), have resulted in the successful completion of planned new research capabilities such as the dual nadir camera ports, wing hardpoints, wing pylons and underwing wire tunnels. These modifications were based on existing STCs (owned by Avcon) or were new standalone design and modification efforts to obtain STCs. (An STC or Supplemental Type Certificate is an FAA-recognized modification.) Once issued, the pylon STC will be the second STC issued specifically for design work done as part of this project, the first STC being the under-wing hardpoints.

All special mission modifications (engines, avionics, audio system, 400A generators) were completed and accepted by UW early in Year 2.

Research modifications are well underway. The design is complete for the noseboom and nose extension and parts are being fabricated. The accompanying PSCP required for the nose STC has been reviewed and submitted. The design of the upper major/minor zenith ports, research electrical system and antenna provisions are nearly complete and will soon be ready for parts manufacture and installation. Flight-testing is taking place as necessary to determine the baseline performance of the aircraft.

Two on-site visits, one in January and one in August 2021, allowed the UW team to view the aircraft firsthand and approve the work. During the second meeting, we discussed the certification path for the research instrumentation. This is the MSRI element with the most risk. The revised work plan now includes an STC path for all modifications, with STC completion (rather than just completion of the aircraft modification) as the milestone. Many of the smaller research modifications now are tied to the final STC payment. This slightly reduces the level of risk, as Avcon now has a much larger payment that is contingent on the completion of the STCs. Project 1 overall cost has not increased; the change is simply in the timing of the payment invoices. Our consultant Randy Blosser is championing efforts to have the research instrumentation STC accommodate dynamic instrument payloads that would be approved provided they can be demonstrated to fit within loading and performance "envelopes", rather than the aircraft being limited to pre-selected research payload configurations. Operating in this manner is critical for the Next Generation Wyoming King Air to serve the atmospheric science community.

Contractor performance in Year 2 has resulted in a non-recoverable delay of at least three-months in the delivery of the aircraft to UW. UW is hopeful Avcon can minimize further delays. UW is working with Avcon and the Project Leads to evaluate the continued impact of the aircraft schedule changes on other MSRI projects. The significant changes in Avcon's payment plan and schedule during Year 2 warrant a revision of the Project Execution Plan (PEP), so future progress can be correctly compared against Avcon's schedule. This PEP release will occur early in Year 3, after all parties have agreed to schedule changes that effectively capture the high-risk elements of the project (such as final aircraft certification), and finalize a schedule (including the certification process and schedule) that is practical and reasonably certain. A finalized schedule is a priority for the start of Year 3. Neither the total Project 1 cost nor the Avcon contract amount will change due to this process.

Considering the final research instrument installation STC and related certification efforts, *the aircraft is now scheduled to return to UW in May 2023 with the Avcon contract complete in July 2023, once the full research STC is issued*. UW installation of research infrastructure will start following delivery of the aircraft with an *anticipated "ready for research" date six to eight months after*.

Project 2 (Radars): Project 2 has gone very smoothly and is on track for both WCR4 and KPR2. ProSensing has received preliminary specifications for the aircraft dual-zenith antenna port interfaces (with only a minimal delay) and is working on the RF redesign and integration of the CPI modulator. The QPC mode software option was approved and is progressing. KPR2 was successfully tested on N2UW in Q6 and is being finalized at ProSensing with larger antennas and software. KPR2 delivery will occur in Q9 (by Dec '21). WCR4 and KPR2 have been requested for CAESAR (an NSF/NCAR C-130 deployment in early 2023), so they may be tested and deployed on the C-130 first.

Project 3 (Lidars): Project 3 is making good progress and is returning to normal following many months of institutional COVID restrictions on lab work. MARLi-2 is nearly complete. The new laser has been integrated into the optical bench, the PMT and optical filter system have been updated and a new data system has been delivered and tested. Testing is ongoing to ensure laser cooling is adequate and that the new optical system is working properly. MARLi-2 has been requested for CAESAR and will be ready if allocated. The single-beam ADL has been assembled and underwent lab and outdoor testing. Initial returns look promising and testing is ongoing. The design of a laser cooling system was determined to be necessary to maximize laser power in warm environments. Work is continuing on the FPGA-FFT routines, data system and processing.

Project 4 (Air chemistry): This Project started in Quarter 8. A promising new technology for NOx measurements continues to be discussed with NCAR. Ongoing inlet testing on N2UW for the Trans2am deployment has been beneficial for port and inlet placement on FL-862. The initial Q8 purchase of an isokinetic aerosol inlet has been delayed until Q11, after CHACHA22, as a risk management technique. A similar CVI inlet is currently being installed on N2UW to support CHACHA22 and facility experiences with the installation and field operation of the CVI will be beneficial in writing the final specifications for the isokinetic aerosol inlet. The design of the FL-862 upper aerosol hardpoints will also benefit from a better understanding of the CVI, as both inlets share components.

Project 5 (Enhanced Communications and Education): Project 5 is still awaiting finalization of antenna placements on the aircraft upper crown and belly so the project can move forward with equipment procurement. This critical milestone has been delayed by 14 months due to continued contractor schedule changes. To minimize risk, the communications systems cannot be ordered until a location for the antennas has been finalized. Antenna interface control documents (ICDs) have been provided to Avcon.

Current contractor scheduling has the locations being finalized in Q9. This will allow Aviator and GoGo procurement to be made by Q10. Development of a network model has taken place and will be used for system development while the systems are on order. Some field-testing of remote interaction protocols has taken place in conjunction with separate (not MSRI funded) field projects. The PI user-display is in the initial stages of development. The survey is available in document and electronic survey format for investigators to complete.

Project Management: Because of a more direct communication channel between UW and CU finance departments, many previously anticipated subawardee invoices have now been received and paid by UW, resulting in more accurate Project 3 Earned Value Management (EVM) tracking. Internally, expenditures are being tracked by UW's financial software. In general, financial information is still a month or more behind, with personnel expenditure reporting further delayed. Any quarterly report includes updates to the previous quarter data as necessary, based on recently cleared expenditures as reported by the institution. While not as timely as the UW MSRI Project team would desire, the data herein is, nonetheless, fully representative of UW MSRI efforts and expenditures.

Blosser engineering has been engaged to provide the majority of the Project 1 updates, now that there is significant design and modification work occurring on the aircraft. Blosser will also provide management oversight as Avcon moves forward with the research instrumentation STC.

2 Major goals of the project

The University of Wyoming King Air (UWKA) aircraft is part of the NSF Lower Atmospheric Observing Facilities (LAOF) Program, and is approaching the end of its useful life. Through this grant, we will build the next generation research King Air (UWKA-2), a facility that will not only meet the needs of the NSF-supported community within this same niche in the LAOF fleet, but will include new instruments and capabilities that are not currently available on any of the three LAOF aircraft. Specifically, we will convert a relatively new, slightly larger King Air aircraft, owned by the University of Wyoming, into an atmospheric research platform more capable than the current aircraft, equip it with instruments that allow new research perspectives, and bring these new capabilities to a technical readiness level and a data accessibility level where they can be requested and used by the NSF-funded community. Project 1 will modify a King Air 350 and certify the various modifications. The new instruments will enhance the UWKA's already strong tropospheric profiling capabilities, in particular clear-air measurements of humidity, temperature, aerosol, and 3D winds (Raman lidar and Doppler lidar) and improved measurements of cloud and precipitation properties (dual-frequency mm-wave radar system). Project 2 will develop or upgrade W-band and Ka-band profiling radars. Project 3 will develop a Doppler Wind Lidar and a Raman lidar for temperature and humidity profiling. These remote sensors, deployed in synergy, together with a series of atmospheric chemistry probes (Project 4), will make the UWKA-2 a supreme yet cost-effective airborne lab. An advanced air-to-ground communication technology (Project 5) will give scientists and students an immersive and highly-informed flight experience from the ground, thus enabling remote flight decisions.

3 Accomplishments

3.1 Project management

The Quarter 5 – 7 reports were made to NSF by the requisite deadlines; the Q8 report will be submitted by 30 October 2021 (30 days after the end of the quarter). A revised traffic light report (TLR) reflecting updated Avcon schedule tasks has been used since the Q6 report. This TLR better aligns progress tracking

with the updated Avcon schedule and highlighted areas of risk. While the tasks should remain the same for future TLRs, the scheduled quarter for completion for many items remains TBD, but this will be refined in Q9 following the UW-Avcon certification-scheduling meetings, which began in late August 2021.

Note that this Year 2 annual report is being issued ahead of the Q8 report, consistent with submission deadlines. Fiscal data is only available through August 2021. Efforts have been made to account for progress that will be finished in the remaining one month of Year 2 – which ends September 2021. Final Year 2 budget numbers will not be available until early October 2021, and will be included in the Q8 report.

Randy Blosser, Blosser Engineering, started providing detailed status updates and objective opinions on Avcon's modification progress for Project 1 quarterly reports in Q6. Project 1 aircraft performance-related discussions are based on Randy's industry and FAA experience and provides an unbiased account of what has, and needs to occur, to keep the project moving forward. The majority of the Project 1 updates will come from Blosser Engineering through the completion of the Avcon modification contract in Q16.

Starting with PEP r.3., Oracle Primavera P6 software is being used to develop the schedule and spending plan. It was used to support the EVM reporting in Q3, and continues to be used for future reports.

The Fall 2020 King Air Advisory Panel (KAAP) meeting was held virtually on 10/29/2020. The highlight of the meeting was the MSRI project and all five projects gave an extensive presentation of objectives and schedules. There was a good dialog between UW and KAAP members and constructive comments on the new aircraft and MSRI projects were received. The Spring 2021 King Air Advisory Panel (KAAP) meeting was held virtually in two parts: 4/14/2021 and 4/21/2021. All five Project leads provided an update on their projects. The KAAP has provided NSF and the PIs with reports following their Spring meeting. These have included specific recommendations that we have found to be quite useful.

Project progress reporting, both quarterly and annually, follows the format first used for the Q3 report. We plan to keep this format for the remainder of the grant, through Q20. Project management software (Primavera) is used for Earned Value Management (EVM) reporting (Section 5) and PEP progress tracking. The Traffic Light Report (TLR) has been updated to reflect the WBS in the PEP (Section 4).

3.2 Project 1: Research Aircraft

The Baseline Aircraft (MSRI Element 1.1) and the Special Mission Modifications (MSRI Element 1.3) were completed during Y2, roughly 3 months ahead of schedule and within budget. The Avionics Upgrade (MSRI Element 1.1.2) installation was completed in early Y2 and the system acceptance tests were completed by UW in Q5. The Research Modifications (MSRI Element 1.4) have begun and design work for the majority of the major Block 2 modifications has been completed and is ready for installation or awaiting final design reviews. Installation of the dual nadir ports (MSRI Element 1.4.2.2) was completed. Baseline performance flight-testing is ongoing.

The Special Mission Modifications included an upgrade to larger, more powerful PT6a-67 engines and an increase in maximum takeoff weight (MTOW) to 16,500 Lbs. The new -67 engines include 5-blade composite propellers and were installed as per an STC developed by Blackhawk Aviation. The increased maximum take-off weight (MTOW) required changes to the landing gear struts and to the vertical stabilizer rudder. These were installed as per an STC developed by the aircraft manufacturer, Beechcraft/Textron Aviation. A test flight was completed in Q5, followed by acceptance by UW. Figure 3.2.1 shows the new avionics installation in the cockpit and Figure 3.2.2 is a picture of the new port side engine, propeller and gear.

Figure 3.2.1 Garmin 1000 avionics suite installed.

Figure 3.2.2 PT6a-67 engine with 5-blade composite propeller and heavy weight gear

Designs for the nose extension and noseboom (MSRI Elements 1.4.2.4 and 1.4.2.5) have been completed. Figure 3.2.3 shows the conceptual noseboom and extension. Yellow pads are research instrument mounting locations. With all design work on the Nose Extension and Nose Boom complete, fabrication of detail parts for the Nose Extension and Nose Boom is progressing and assembly of the Nose Extension is awaiting completion of assembly jig tooling. The certification process for the nose modifications (1.5.2.2) is progressing and the PSCP has been submitted to the FAA.

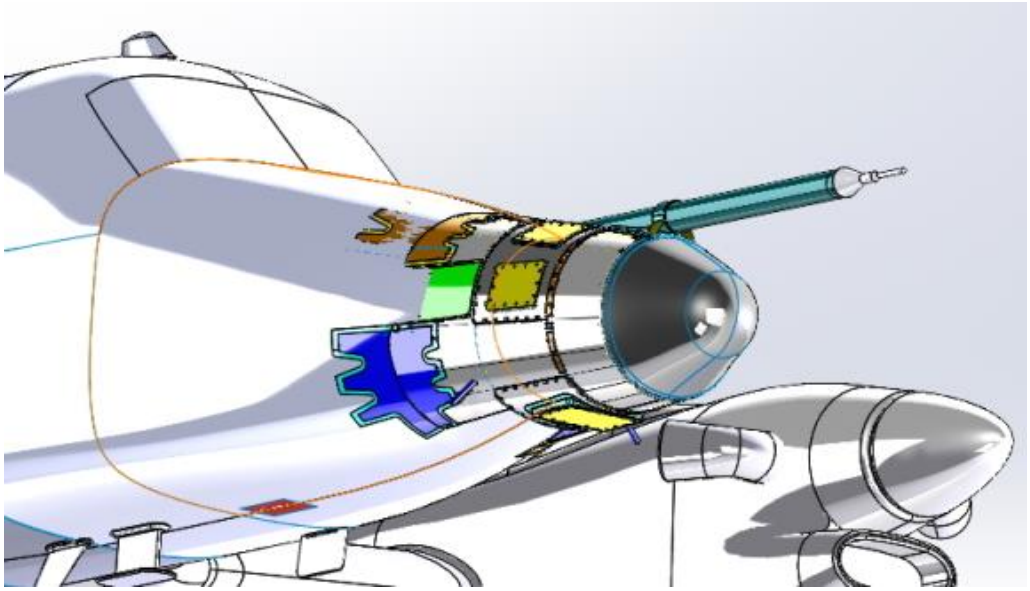


Figure 3.2.3 Extended nose with instrument mounting plates (yellow) and noseboom

Detailed design for the five smaller Zenith Ports (MSRI Element 1.4.2.6) and two larger Zenith Ports (MSRI Element 1.4.2.3) continues to mature. Structural substantiation of the large zenith ports showed that three starboard side windows below the zenith ports needed to be removed so that additional structure could be added; however, this change also provided the opportunity to add two small research ports in the area of each removed window, at no additional cost. An upper crown layout was completed and the positioning of the smaller ports in concert with the aerosol inlet ports and numerous antennae on the top of the aircraft is in final review. The current design of the upper zenith ports is shown in Figure 3.2.4. The hypothetical WCR4 radar “beams” are shown. The composite fairing that encloses the box structures is not shown.

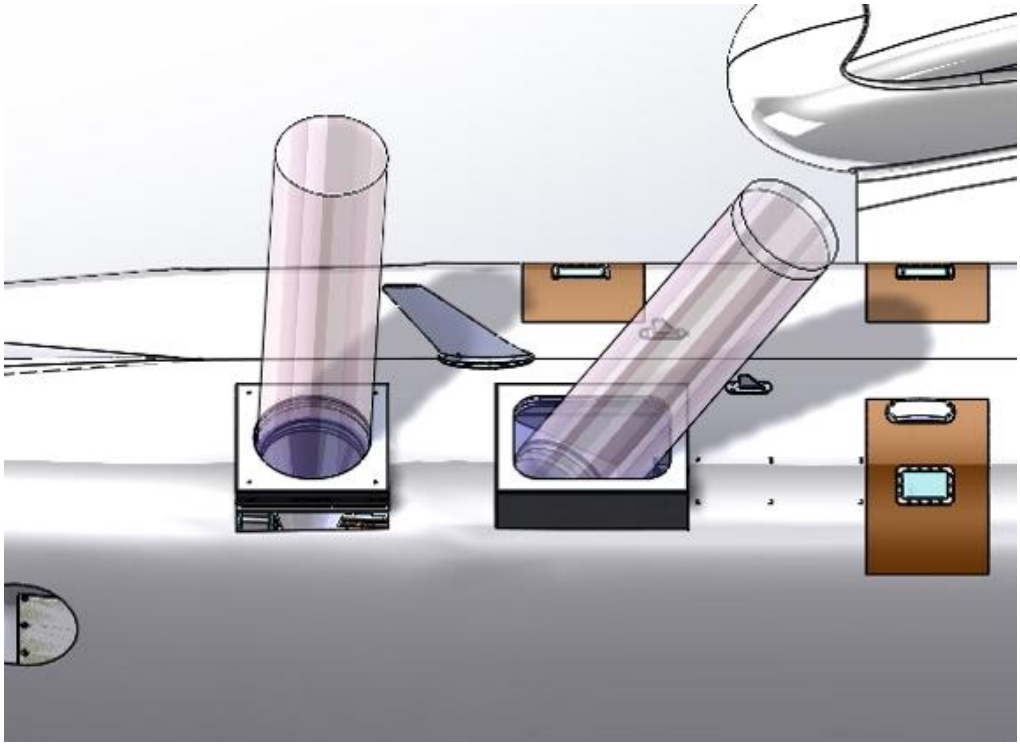


Figure 3.2.4 Upper dual-zenith port design

Electrical modifications include the installation of a 400-amp starter/generator (1.5.2.1) system for increased electrical power (MSRI 1.4.1). This installation is complete and has received an STC. The engine portion of this installation is shown in Figure 3.2.5. However, the development of the research-specific mission electrical bus (MSRI 1.4.2) is roughly six months behind the original schedule. The design is in the analysis phase and will be ready for a PDR in early Q9.

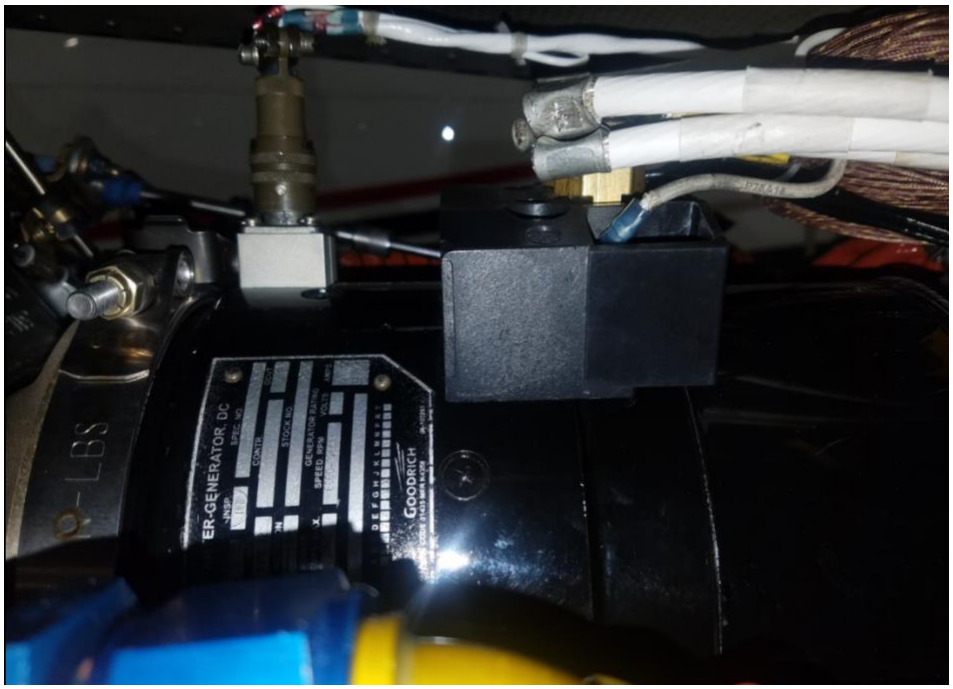


Figure 3.2.5 400A generator installation in engine nacelle

The wing hardpoint and pylon assemblies (MSRI 1.4.2.1) are complete. Under-wing wire tunnels were modified to meet UW requirements and have been installed. Some additional work is required for the internal cable routing and penetrations into the fuselage. The hardpoints are certified. The certification plan (PSCP) for the pylon STC has been accepted by the FAA. This in-progress STC, which will initially seek certification for carriage of just a single payload configuration, will be later expanded to include all potential future payloads. The completed Hardpoints and hinged External Electrical Conduits as installed on FL-862 are shown in Figure 3.2.6.

Figure 3.2.6 Wing External Electrical Conduits and Hardpoints (gold strips near top of photo)

Required Ground Vibration Testing (GVT) with the Research Pylons (MSRI Element 1.4.2.1) on the aircraft, using University of Wyoming-provided standard "PMS" research canisters in six positions was completed in August 2021. Flight-testing will immediately follow satisfactory review of results from GVT, and will be complete by Q9. Flight-testing with that configuration was conducted using FL-381, a similar King Air 350 owned by Avcon. Additional flight-testing, using the wing pylons and research canisters mounted on FL-862 will occur early in Q9. The surrogate aircraft ready for flight-testing is shown in Figure 3.2.7. Figure 3.2.8 shows the canisters as installed on FL-862.

Figure 3.2.7 Wing Pylon and Research Canister Configuration Ready for Flight Test

Figure 3.2.8 UW-provided “PMS” Instrument Canisters and pylon on FL-862

The installation of the Dual Nadir Camera Ports (MSRI Element 1.4.2.2) is essentially complete with both large openings cut in the bottom of the aircraft and structural doublers installed. A temporary external fairing is currently installed to allow for completion of baseline performance flight-testing. The nearly complete external and internal installations are shown in Figure 3.2.9 and Figure 3.2.10, respectively.

Figure 3.2.9 Dual Camera Port External Installation

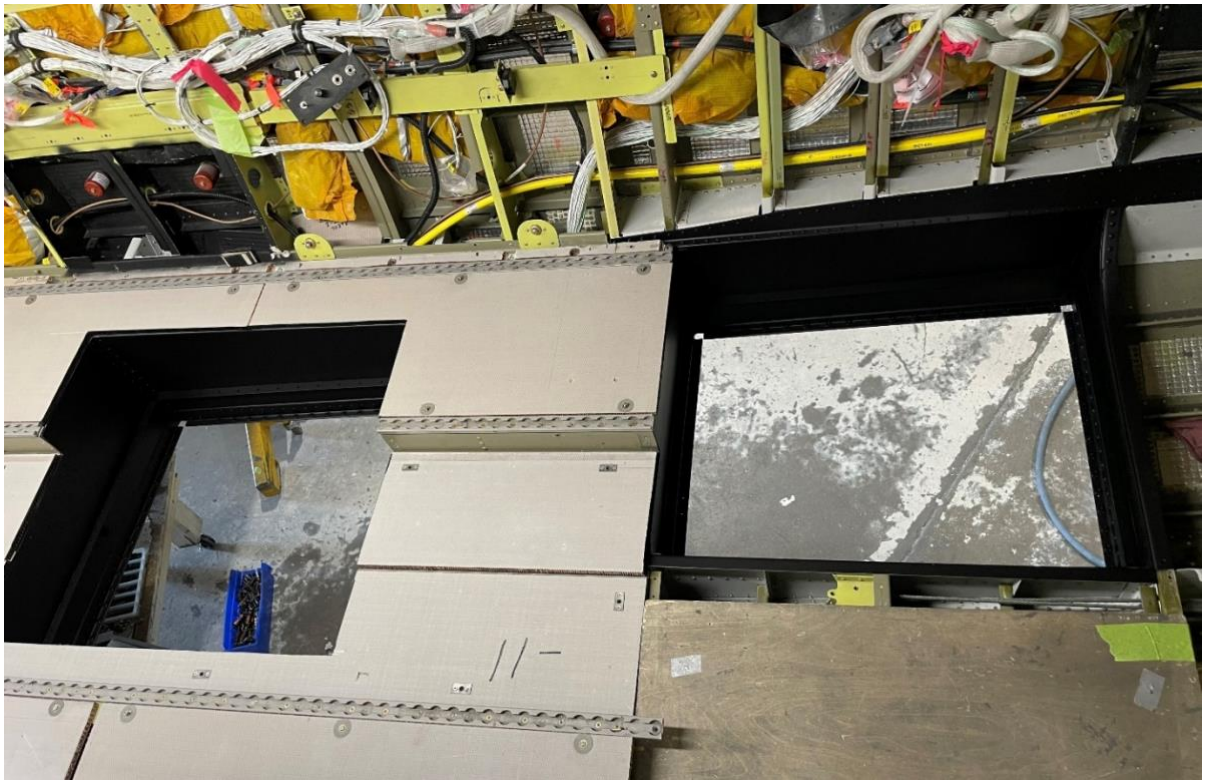


Figure 3.2.10 Dual Camera Port Internal Installation. A crew audio panel interface can be seen in the upper left.

Upper crown and belly layouts (MSRI Element 1.4.2.9) to support design of the antenna and port modifications are chronically delayed – directly affecting Project 5. The final placement and approval of these provisions in now expected in Q9 – a delay of 14 months. Figure 3.2.11 shows the working model of FL-862 being used to refine the layout of the upper and lower aircraft surfaces.

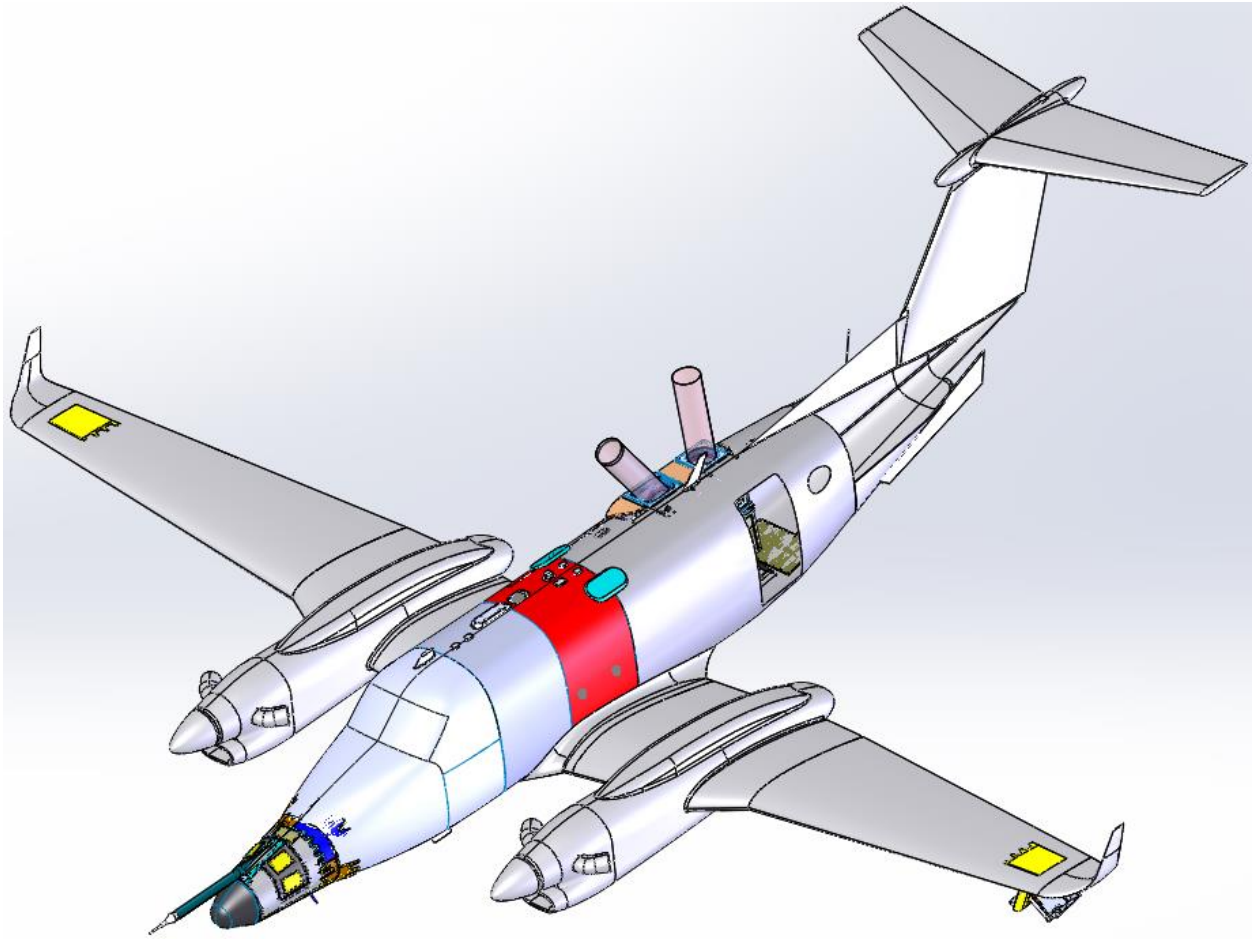


Figure 3.2.11 Working model of FL-862, current as of Q8.

Multiple interface control documents (ICDs), created by UW, support the Research Modifications (WBS 1.4) by describing the mechanical interface and loading requirements. These technical documents are being developed, or are in progress, for the wing pylons, noseboom, nose extension, sensor mountings and various antennas. These ICDs ensure the Avcon designs can accommodate existing sensors while implementing UW requirements for future capabilities.

A detailed weight breakdown for all installations is nearly complete, only awaiting the weight "delta" due to additional reinforcement below the zenith ports, as previously discussed. The results show that the hypothetical UW science payloads presented as key performance parameters (KPP) in the project description will be able to be flown for the anticipated mission durations with good reserve.

Coordination memos continue to be used to track questions and responses so that the SOW and supporting designs can be updated as needed. Schedule and payment complications continue to exist and a non-recoverable 3-month delay in the aircraft delivery to UW is present.

UW traveled to Newton, KS in January and August 2021 to view the aircraft, inspect modifications and review logbook entries. The August on-site visit included a significant discussion on the certification method that will be used to enable the research configuration. The STC-route is being proposed; Avcon and the Organization Designation Authorization unit members (ODA/UMs) contracted by Avcon to work the certification program, will travel to Laramie in Q9 to view how research payloads are installed on N2UW. This will provide context for developing the "process" that will be followed by UW to install research payloads on FL-862. This remains the most risky development effort for the entire MSRI.

Certification of the aircraft in normal category (MSRI Element 1.5.2) is progressing. Certification of the Wing hardpoints (1.5.2.3) is complete. The Outboard Wing Hardpoints STC, which provides a structural hardpoint for mounting the wing research pylons, is now complete, with the first STC specifically for the UW project, SA01965WI, being issued by the FAA on May 6, 2021.

Avcon developed a new payment plan in Q6 to address concerns by Wyoming regarding payment relations to physical performance. The original schedule provided by Avcon laid out many of the WBS elements being completed in parallel; thus, scheduled payment milestones combined several WBS elements together. The result was that the physical work performed by Avcon did not follow the original schedule and a discrepancy from the MSRI EVM was noted. As of late Y2, the payment plan has been working well and invoices now track the physical progress of the modifications better.

No payments were made in Q7 since Avcon did not submit any invoices. However, invoices for submittal of manuals and substantiation documents for the 400 Amp Generators, the Outboard Wing Hardpoints STC, completion of Wing Pylons and External Electrical Conduits and substantiation, and Nose Extension and Nose Boom PDR and CDR's were received in Q8 as all of that work is now complete. This represents outstanding invoices of $693,847. Avcon has agreed, as of the Q8 on-site meeting, to invoice UW on a quarterly basis for all work completed and accepted in the past quarter. Following this agreement, work was evaluated in Q8 and the most recent Avcon invoice for $593,289 was received and paid in Q8.

New schedule management personnel were assigned by Avcon in Q8 to address continued scheduling deficiencies. The Avcon schedule now aligns with the payment schedule milestones. However, there is still concern that the proposed schedule does not adequately represent the efforts required, the end date of the contract, and final delivery of the aircraft. UW has continually encouraged Avcon to avoid "waterfall" scheduling and identify areas where parallel development can occur. UW has requested a review of the schedule for areas of improvement rather than continuing to allow all schedule activities to slip due to a single delay.

One major change to the schedule was the incorporation of the decision *not to return the aircraft to Laramie for installation of research equipment in mid-2022*. This is necessary to support research STC testing and certification. The research equipment work may now be done by UW personnel in Newton in parallel with other work done by Avcon, although no decision has yet been made on this. This work does not diminish efforts by UW personnel to install research infrastructure equipment once the aircraft returns to UW. **With this change, and the other status updates, the fully certificated aircraft is scheduled to be delivered to UW at the end of May 2023 with the research STC being issued in July 2023.**

UW King Air facility personnel have begun initial planning for the design and installation of the equipment necessary to support the research mission of the aircraft. This work includes the permanent infrastructure to support various instruments (such as power distribution, racks, and signal cabling) as well as the physical mechanical and electrical interfaces necessary to support data acquisition, display and the standard and

optional facility instruments. Based on a May 2023 aircraft delivery, FL-862 should be “ready for research” between November 2023 and January 2024.

Facility personnel continue to engage in aircraft training courses to enable safe maintenance and operations of the aircraft upon arrival. Two pilots and a mechanics completed training in Year 2.

3.3 Project 2: Radars

WCR4 is nearly on schedule as of the end of Year 2. The modulator PO has been issued and acknowledged by the manufacturer. The delay in zenith port design work (WBS 1.4.2.3) by Avcon slightly affected the radar project. The schedule had enough float to accommodate this delay in the zenith port specifications from Avcon. The design of the two major zenith ports for the aircraft is nearly complete and a critical design review will occur in Q9. UW continues to work with ProSensing on the redesign of the RF unit. The design of the up-point antenna mounting, compliant to the Avcon zenith port design, has been delivered to ProSensing in SolidWorks format. Figure 3.3.1 shows the conceptual design of the dual zenith antennas and RF enclosure mounting in the King Air 350. The outline of the nadir port for the downward antennas can be seen below the cabinet.

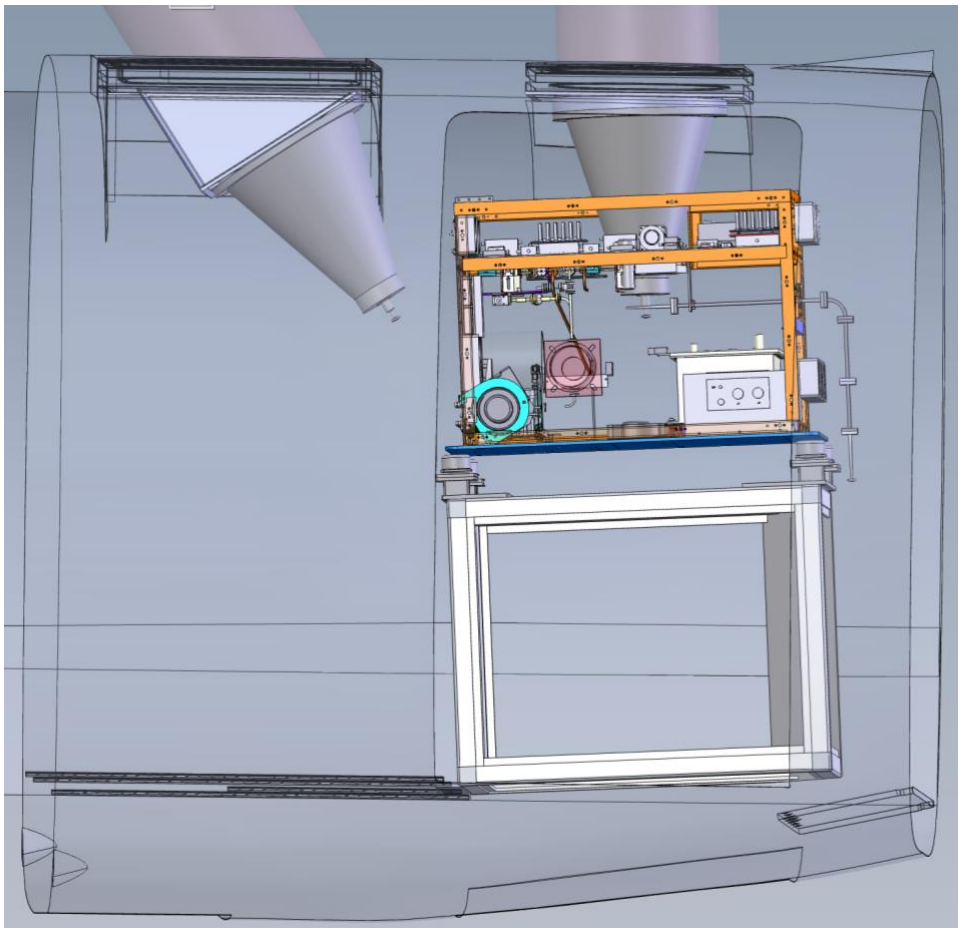


Figure 3.3.1 Model of WCR4 installed with dual zenith antennas

KPR2 is on schedule and on budget. KPR2 was delivered for flight-testing at the beginning of February 2021. All hardware systems were tested with the small antenna head during three flights on the existing UW King Air (N2UW). The radar performed well. No issues with overheating when running at a higher

transmit power were observed. Initial tests of the new QPC high-power acquisition mode were also carried out. Preliminary results show that this mode is working well and provides significant improvement in the sensitivity of the radar, especially at close range, where the conventional compression acquisition mode is not applicable. The radar was shipped back to ProSensing at the conclusion of Q6 and the N2UW test flights for implementation of Phase 2, QPC mode.

KPR2 Phase 2 work is ongoing as agreed upon by UW MSRI PIs through a Q6 change management request. This removes the Phase 2 $120,000 payment from the contingency funds. The decision was based on the importance of completely finishing KPR2 and making it available to the community for deployment, which is necessary, as KPR2 has been requested to support the CASEAR campaign on the NCAR C-130.

The new large antennas have been delivered to ProSensing and are undergoing acceptance testing and integration. Figure 3.3.2 shows KPR2 with the large antennas. Hardware and software work continue. KPR2 remains on schedule to be delivered by the end of Q9 and no budget overrun for KPR2 is expected.

Figure 3.3.2 KPR2 with large antennas

3.4 Project 3: Lidars

The laser power supply and cooling for MARLi2 (WBS 3.1) have been integrated into a laboratory rack for testing that will use a high-current DC power supply to replicate aircraft power. The new laser uses ~50 A at 28 V, which is ~ 30% of the old flashlamp pumped laser. The decreased power consumption also makes the laser cooling significantly easier. Optical output power is maintained. The new smaller and lighter laser head is positioned on the optical bench and design work is nearly complete for a mechanical adapter to secure the new laser head to the bench (using existing fastener holes to ease aircraft certification) and align the laser optical output with the existing beam shaping optics input. The PMT drive circuits have been redesigned to reduce high-frequency noise and the MPL module assembly has been modified. New warm and cold temperature filters have been tested. MARLi-2 is shown in Figure 3.4.1. The lab integrations and testing that were previously delayed, due to CU and Colorado COVID restrictions, are now being conducted and MARLi-2 is on-track to return to the pre-COVID schedule by Q9.

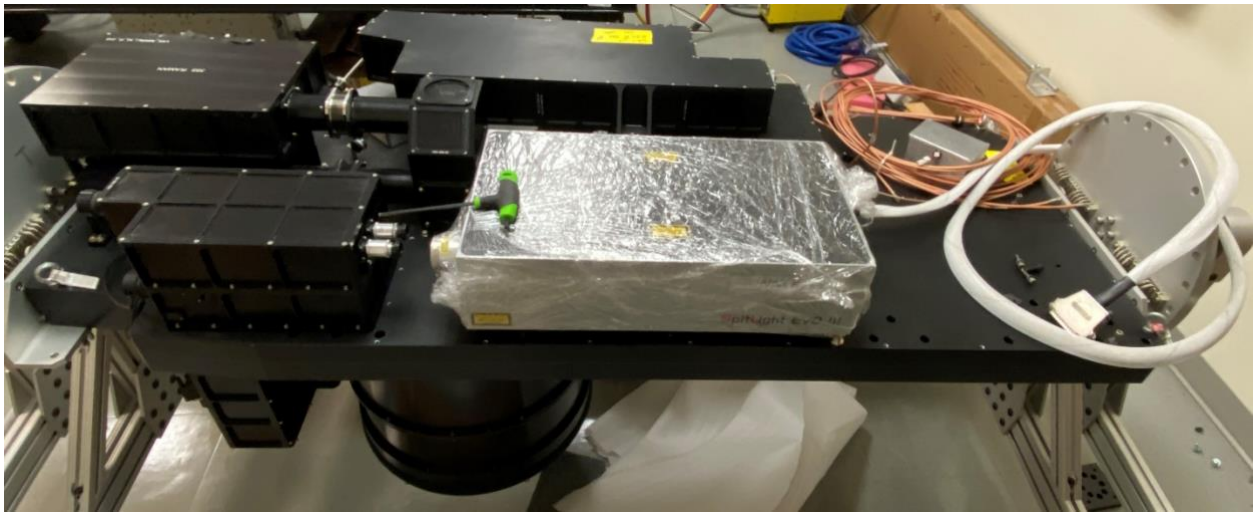


Figure 3.4.1 MARLi-2 configured for lab testing

The Airborne Doppler Lidar (MSRI Element 3.2) is making good progress in the lab and with preliminary field-testing, after some initial delay in the laser delivery and lab work, due to pandemic-related restrictions. The software for the Xilinx-based FPGA development board and data acquisition is complete to the point of supporting the end-to-end system working from optical receiver RF ADC sampling, FFT, transmission to a Windows computer over Ethernet and plotting in Matlab. The system was tested and evaluated with signal supplied by a laboratory signal (function) generator; FFT results to 500 Mhz are accurate with minor background issues. Beam pointing simulations continue to explore different pointing angles and the design for aircraft integration. After detailed evaluation, a CSM 40 Gyro Stabilization Mount was integrated to provide the vertical-beam to minimize the errors associated with pointing corrections for vertical velocity measurements. The ADL lab integrations and testing that were previously delayed, due to CU and Colorado COVID restrictions, are now being conducted and ADL is on-track to return to the pre-COVID schedule by Q9.

The single-beam ADL components have been integrated and successfully lab and ground tested using a ground scanning setup as shown in Figure 3.4.2. The initial results show the design works well. Using a 1-second integration time, radial velocity measurements can cover the entire boundary layer. For middle level mixed-phase clouds, updrafts expected in the supper cooled water cells (high SNRs) are clearly resolved by the radial velocity. Figure 3.4.3 shows initial returns from the scanning one-beam ADL. Outdoor testing indicated that cooling the fiber laser when operating in high ambient temperatures was required to maximize laser output, and hence, returns.

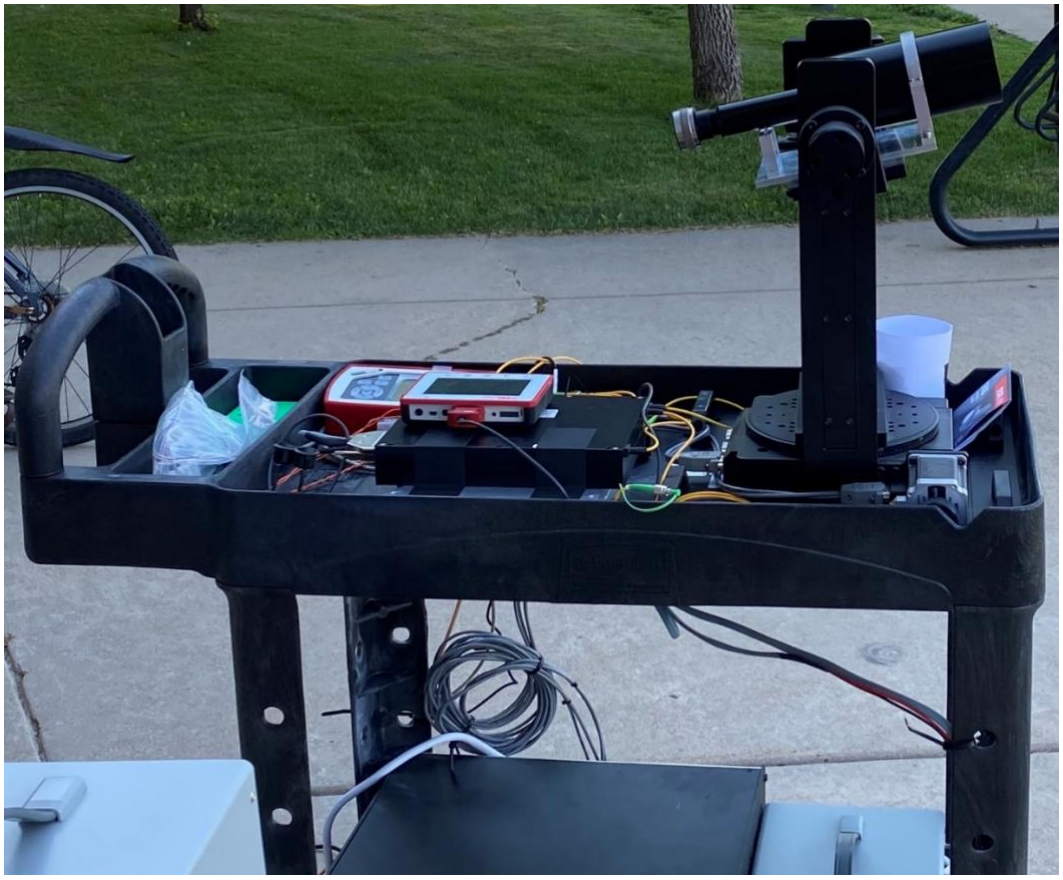


Figure 3.4.2 ADL with scanner being tested

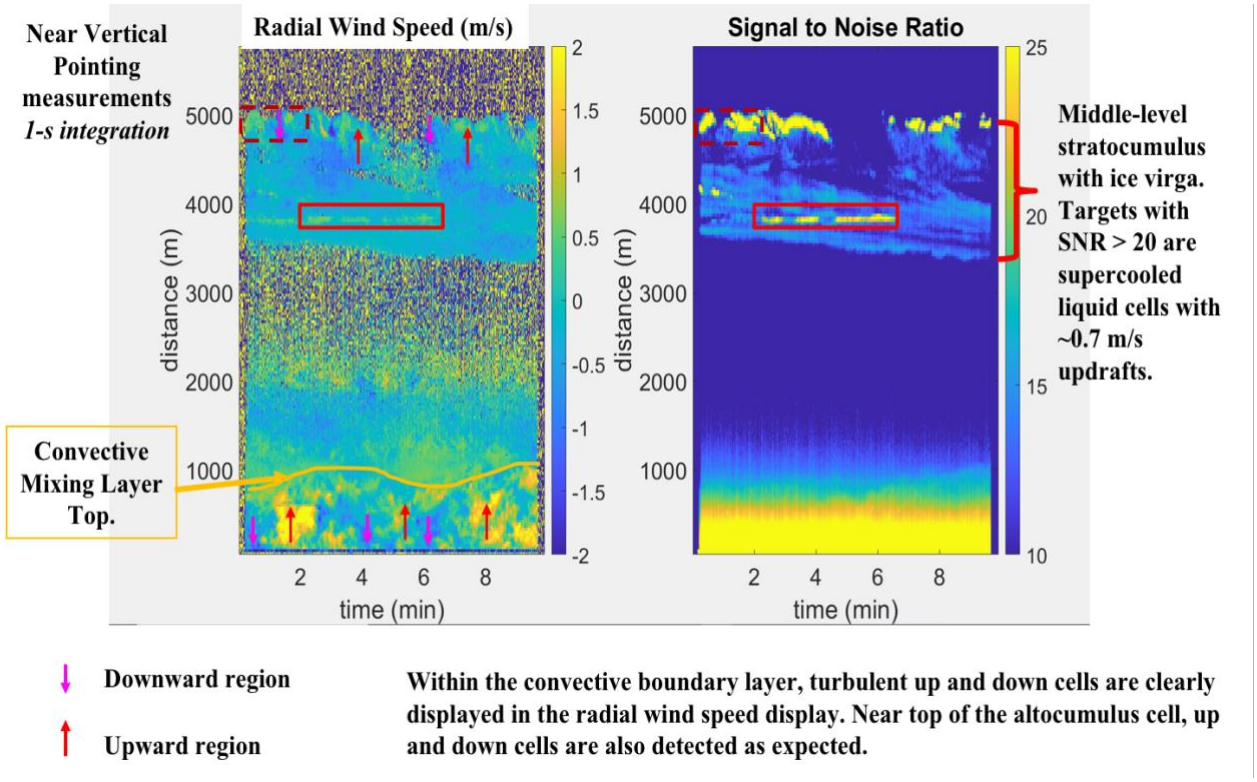


Figure 3.4.3 ADL initial test scan data of the lower troposphere, on a summer afternoon.

1-Beam ADL field data will be compared to that obtained by NREL and NOAA systems. Evaluation continues on the five-beam pointing requirements to achieve projected measurement requirements and resolve fine-scale spatial variability. We are collaborating with Dr. Philipp Gasch at the Karlsruhe Institute of Technology (KIT) to leverage their efforts in similar efforts with a scanning Doppler lidar.

3.5 Project 4: Trace Gas Chemistry

Project 4 started as scheduled in Quarter 8. The first milestone was to be the purchase of the isokinetic inlet system. This has been delayed until Q11 (Apr-Jun '22), after the CHACHA22 project, as a risk reduction measure. UW recently learned that the configuration of the Counterflow Virtual Impactor (CVI) and isokinetic inlets has changed, which will allow easier mounting on the new King Air. A CVI using this new configuration is currently being installed on N2UW as part of the CHACHA22 project. Lessons learned from the installation will help finalize the design requirements for the FL-862 upper hardpoints. Additionally, Facility personnel will have hands-on experience with the CVI during the project and will be able to recommend changes to the manufacturer prior to purchase of the isokinetic inlet MSRI Element 4.1.4.1). Regardless of the purchase delay, the integration of the aerosol inlet continues to be discussed during UW/Avcon project meetings to ensure the statement of work for the aircraft captures the evolving inlet mounting requirements and those requirements are supported by the Avcon designs. This delay is not anticipated to involve a cost increase.

The upper crown hardpoints are still in development and the current Avcon schedule update has this being completed in Q11 or Q12. Project 4 PI's were involved in the design review of the upper crown small zenith port locations. Port locations were optimized to improve inlet access to clean undisturbed flow and better understand potential contamination of inlets located in the ports due to aircraft boundary layer and/or engine exhaust emissions. Results of Q7 N2UW inlet contamination testing and aircraft skin boundary layer thicknesses at similar port locations were analyzed and used to support these decisions.

Project 4 PI's will be involved in the development of the aerosol inlet ICD and design review process to ensure support for the inlet. Development of the CVI installation for N2UW may reduce the development effort necessary to integrate the sampling inlet onto the new aircraft.

The Project 4 team continues to investigate developments in trace gas analyzer technology to stay apprised of the most recent advancements. In addition, communications with the Project 1 team are ongoing to ensure that the schedule and interface definitions for the structural modifications to support the trace gas instruments are current.

Informal discussions continue with NCAR regarding the construction and availability of a new LIF NOx instrument. This is a replication of an instrument that has been shown to have superior capabilities to any currently available commercial (COTS) instrument. The build of the instrument will concentrate on making it "flight-ready". No additional information on this development is available as of Q8. The potential Q7 spending change request related to the COTS NOx instrument (mentioned in the Q6 report) has been delayed, pending further discussions with the NCAR instrument development team.

3.6 Project 5: Enhanced Communications and Educational Opportunities

Project 5 continues to await the finalization of the aircraft antenna layout and supporting designs for the antenna installations before proceeding with the purchase of the Cobham Aviator 300 and GoGo Avance L5 communication systems (MSRI Element 5.1.3). The 14-month delay by Avcon in addressing the antenna

locations has placed Project 5 significantly behind schedule. A guaranteed location for the system antennas, with no/limited interference, is critical to the successful functionality of the systems. It is not prudent to purchase system if the performance will be significantly degraded by antenna placement. The layout design and supporting modifications was started initially started in Q6. However, Avcon priorities changed again and further work did not occur until late in Q7. The layout is currently scheduled by Avcon for Q9 design reviews. *Procurement of the communications systems will now be delayed until Q9 or Q10 with no change in cost*. The original Avcon schedule used to baseline the UW MSRI had completion of this layout task in Q4 and purchase of the systems in Q6. ICDs for all antennas have been completed and Avcon can proceed with the provision designs immediately following the placement decisions.

Preliminary modified draft upper crown and belly layouts were delivered by Avcon in late Q6 and the belly layout was refined in late Q7. This layout contains nearly enough detail to move forward with approval. GoGo engineering support has indicated preliminary support for the proposed GoGo L5 directional antennas on the belly. Final approval is pending the final FS and BL aircraft locations as well as a survey of any potential intrusions into keep-out zones and available under-floor space. The design of the upper crown layout has progressed minimally since Q6 and still lacks sufficient detail to locate the Aviator 300 antenna and complete the system order.

Project 5 critically depends on the communication systems antennas. There is <u>significant</u> risk associated with procuring the hardware systems prior to having dedicated antenna placements. Detailed design work for remote system control and interactive operational environments cannot proceed until the final communications system hardware is approved so the transfer speeds, bandwidths and latencies can be determined and a network model created. Final configuration of the avionics, audio system and cabin layout will also affect the design of Project 5 systems for inflight data display and data transmission.

Design work has started on the co-pilot display (MSRI Element 5.3) and the flight operations group is involved in the initial discussions of acceptable solutions from a “safety of flight” aspect. Users are being consulted for feedback regarding the usability of proposed options. A plan is being made to receive input from Avcon regarding the cost and effort of implementation.

Initial evaluation of remote interface protocols and data transfer methods (MSRI Element 5.2) started in Q6. Design of a testing system is nearly complete. This system emulates the anticipated bandwidth and latencies anticipated in the final FL-862 communications systems. Vendors for software and hardware network emulation have been identified and proposed solutions continue to be evaluated. Some testing has been completed with two of UW’s remote field sites. The upcoming N2UW CHACHA22 project will allow implementation and testing of a portion of the remote instrument control and data transfer system using the Aviator 200 system on N2UW and a single instrument or data feed.

As mentioned previously, a now-expired COVID-19 purchase “incentive” presented a potential cost savings in the procurement of the communication systems. However, this savings was not realized due the continued design delay by Avcon. The original budget did not consider this savings so there is no net gain/loss. There may still be a small promotional savings offered by one manufacturer if procurement is made by the end of Q4 2021. The original quote for the system is still valid; however, delivery is now significantly delayed due to the current COVID-19 global chip/semiconductor shortage. Manufacturer delays of twelve months are currently being quoted by the vendor. Additionally, any allocations of systems for sale are on a first-come-first-serve basis and the delay may be longer based on demand. A robust network emulation system will be in place to allow system development during the delayed delivery period.

The user survey for remote instrument control and data displays is available in both fillable document format (Word) and a web-based survey. Responses will be taken through Q10.

4 Traffic Light Report

The current traffic light report (TLR), through September 2021 (the end of Q8 and Year 2) as shown in Figures 4.1a & 4.1b, communicates risk and performance for significant WBS elements and milestones relative to the baseline as reported by project PIs/leads. The TLR is used in conjunction with the project performance narrative to communicate an overall idea of project state. The TLR base structure is adjusted slightly starting in Q7 from the TLR used through Q6. The adjusted TLR structure was shown as a "draft" TLR in the Q6 report and implemented in Q7. The adjustment reflects the updated, but still-in-progress, Avcon schedule under which a modification arrangement proposed by Avcon to break the modifications into three distinct blocks, incorporating modifications, which are similar in scope (off-the-shelf, new STCs and straightforward minor modifications). The TLR also breaks out the various certification processes so progress can readily been visualized. This is especially beneficial for the "Research Instrumentation Installation" certification, which is the most risky aspect of the entire MSRI – and a task, which is, by its nature, completed late in the project. *UW and Avcon are actively engaged in discussions to solidify this schedule, and in turn the TLR, by the end of Q9*.

Project 1 is the most critical of course, given that the four other projects depend on it. Several highly critical WBS elements have been completed on schedule while others are significantly delayed. There are some minor delays for Projects 2 and 3; major delays are occurring for Project 5, as detailed. All Projects are within budget, as detailed further in Section 5.

NSF MSRI grant: Next Generation Wyoming King Air
Year 2 Traffic Light Report, 1 October 2020 - 30 September 2021

Notes:

"Baseline" refers to the project outline given in the Baseline PEP v.3

"Risk": baseline probability of not meeting planned scope within budget ("in budget") or by date ("on time").

"Critical": given in terms of impact on downstream tasks:

"Low": Completion date has little direct downstream effect

"Medium": Dependent tasks within the same Project (1-5) delayed if not completed on time

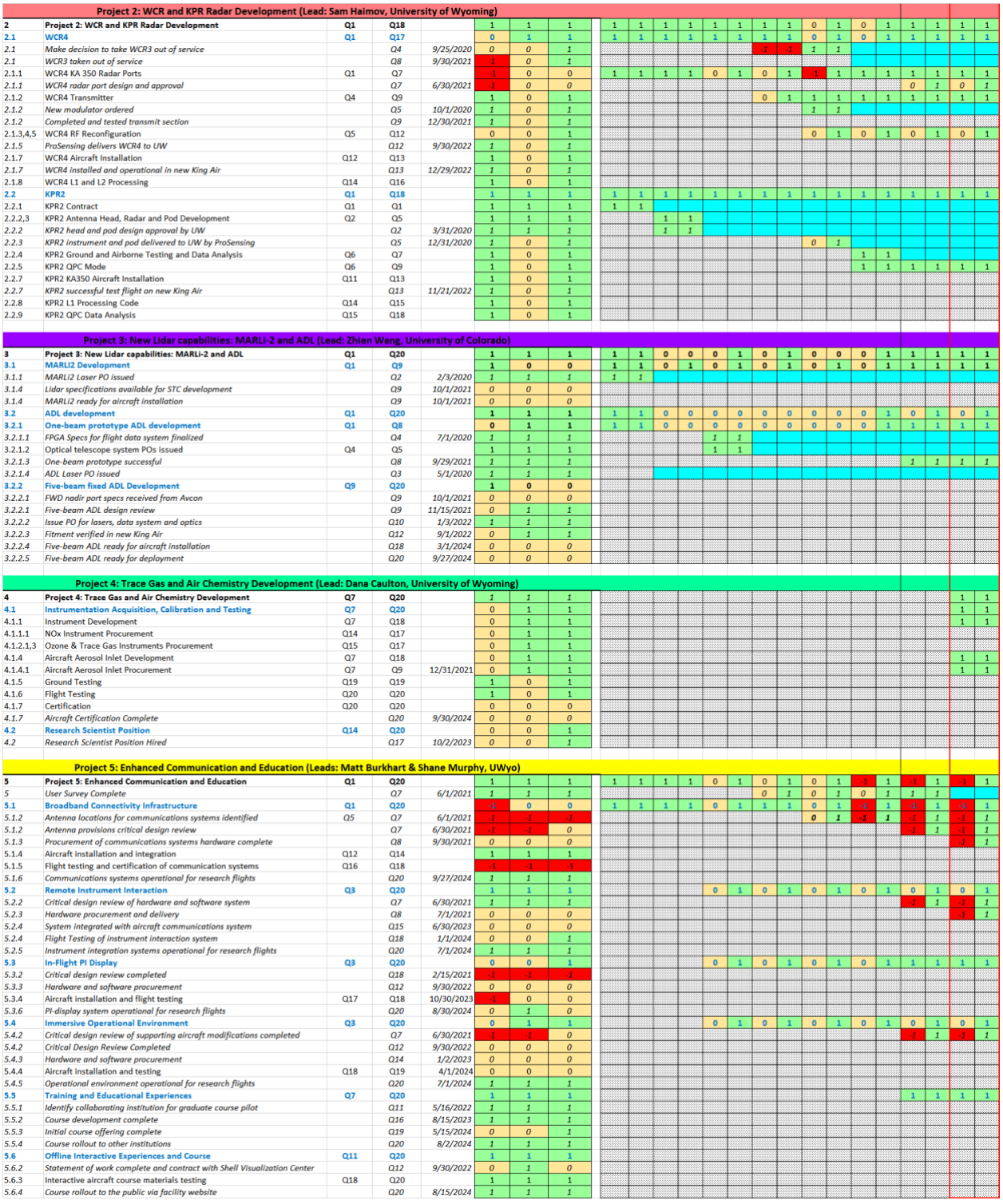
"High": Dependent tasks within same and one or more other Projects delayed if not completed on time

Baseline color legend		
Traffic Light	Critical?	Risk Severity
1	Low	Low Risk
0	Medium	Medium Risk
-1	High	High Risk

Quarterly Reports color legend		
Current Quarter shaded in blue		
Traffic Light	"time" metric for tasks/milestones	"cost" metric regarding WBS project costs
	task completed	task completed within budget
1	on track	so far within budget
0	< 3 months behind	<10% over planned budget
-1	> 3 months behind	>10% over planned budget

WBS	Tasks / Milestones	Baseline plans from PEP v.3						31-Dec-19		31-Mar-20		30-Jun-20		30-Sep-20		31-Dec-20		31-Mar-21		30-Jun-21		30-Sep-21	
		Schedule				Risk		Q1		Q2		Q3		Q4		Q5		Q6		Q7		Y2 / Q8	
		Start	Complete	End Date (milestones)	Critical?	On time	In budget	time	cost	time	cost	time	cost	time	cost	time	cost	time	cost	time	cost	time	cost
Project 1: Research Aircraft Acquisition and Modification (Lead: Jeff French, University of Wyoming)																							
1	**Project 1: Research Aircraft Acquisition and Modification**		**Q20**		**-1**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	1	1	0	1	0	1	0	1	0	1
1	***Aircraft Ready to conduct Research***		***Q17***	***12/31/2023***	***-1***	***0***	***0***																
1.1	**Baseline Aircraft**	**Q1**	**Q6**		**-1**	**0**	**1**	1	1	0	1	1	1	1	1								
1.1.1	Aircraft Acquisition	Q1	Q4		-1	0	1	1	1	0	1												
1.1.1	*Aircraft SLIB loan approved*		Q1	12/5/2019	-1	1	1	1	1														
1.1.1	*UW BOT contract approvals*		Q3	4/20/2020	-1	1	1					1	1										
1.1.1	*Contract with Avcon for aircraft selection*		Q3	6/1/2020	0	1	1					1	1										
1.1.1	*Purchase agreement signed by UW BOT*		Q4	7/1/2020	-1	0	0																
1.1.1	*New aircraft acquired, purchase complete*		Q4	8/28/2020	-1	0	0																
1.1.2	Avionics Upgrades	Q3	Q6		0	1	1					1	1	1	1								
1.1.2	*Avionics upgrade contract signed with Avcon*		Q4	7/15/2020	0	1	1																
1.1.2	*Avionics upgrade completed*		Q6	3/1/2021	0	1	1							1	1								
1.2	**Avcon Project Oversight and Contract Administration**	**Q1**	**Q17**		**1**	**1**	**1**	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Modification contracts with Avcon		Q3	6/1/2020	-1	0	0					1	1										
	Aircraft Completion Activities (inspections, maintenance, interior, paint)	Q1	Q16		1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	UW acceptance of modified aircraft		Q11	6/30/2022	0	0	1																
	Delivery of certified aircraft to UW		Q16	8/1/2023	-1	-1	1																
1.3	**Avcon "Block 1" Modifications "Special Mission Modifications"**	**Q3**	**Q7**		**0**	**0**	**1**					1	1	1	1	0	1	0	1	1	1		
1.3	*Special mission modifications test flights*	Q3	Q7		0	0	1							1	1								
1.3	*Special mission modifications completed*		Q6		0	0	1							1	1								
1.3.1	*New engines ordered*		Q5		0	1	1																
1.3.1	*New engines installed*		Q5		0	1	1							1	1								
1.3.2	*MTOW kit ordered*		Q5		0	1	1																
1.3.2	*MTOW kit installed*		Q5		0	1	1							1	1								
	400A Generators Installed		Q5		0	1	1									1	1	1	1	1	1		
	400A Generators Testing Complete		Q6		0	0	1									0	1	0	1	1	1		
	400A Generators STC		Q7		-1	1	1											0	1	0	1		
1.4	**Avcon "Block 2" Modifications "Major Research Modifications"**	**Q3**	**Q9**		**-1**	**0**	**0**			1	1	1	1	1	1	0	1	-1	1	0	1	0	1
	Dual Nadir Port Kit Installation	Q5	Q7		-1	1	1									1	1	1	1	0	1		
	Wing Pylon design and approval		Q7		-1	0	1																
	Wing Pylon fabrication, installation and testing	Q7	Q8		-1	0	1																
	Wing Pylon STC		Q8		-1	0	0					1	1	0	1	0	1	0	1	1	1	1	1
	Wing Wiring Provision design and approval	Q5	Q6		-1	0	0									0	1	0	1	1	1	1	1
	Wing Wiring Provision fabrication, installation, testing		Q7		0	0	0													1	1	1	1
	Wing Wiring Provision STC		Q8		0	0	1													1	1	1	1
	Nose Extension design and approval	Q5	Q6		-1	0	1									1	1	0	1	0	1	1	1
	Nose Extension fabrication, installation and testing	Q7	Q8		-1	0	1													0	1	0	1
	Nose Extension STC	Q9	Q10		-1	0	0																
	Nose Boom design and approval	Q5	Q6		-1	0	0									1	1	0	1	1	1	1	1
	Nose Boom fabrication, installation and testing	Q7	Q8		-1	0	0													0	1	0	1
	Nose Boom STC	Q9	Q10		-1	0	0																
	Research Power System design and approval	Q6	Q7		-1	0	1											1	1	0	1	0	1
	Research Power System fabrication, installation and testing	Q7			0	0	1													0	1	0	1
	Research Power System STC		Q8		-1	0	1															0	1
1.4	**Avcon "Block 3" Modifications "Minor Research Modifications"**	**Q5**	**Q11**		**-1**	**0**	**0**									1	1	0	1	0	1	0	1
	Upper Crown and Belly layout and approval	Q6	Q7		-1	1	1											0	1	0	1	0	1
	Major (Radar) Zenith Ports design and approval	Q6	Q7		-1	0	1											1	1	0	1	0	1
	Major (Radar) Zenith Ports fabrication, installation and testing		Q8		-1	0	1																
	Major (Radar) Zenith Ports STC	Q9	Q10		-1	0	1																
	Upper Crown Ports and Hardpoints design and approval		Q7		-1	0	1													0	1	0	1
	Upper Crown Ports and Hardpoints fabrication, installation and testing	Q9	Q10		-1	0	1																
	Belly Ports and Hardpoints design and approval		Q10		-1	0	1																
	Belly Ports and Hardpoints fabrication, installation and testing		Q10		-1	0	1																
	Aft Fuselage Modifications design and approval		Q9		-1	0	1																
	Aft Fuselage Modifications fabrication, installation and testing	Q9	Q10		-1	0	1																
	Fuselage and Cabin Modifications design and approval	Q10	Q11		0	1	1																
	Fuselage and Cabin Modifications fabrication, installation and testing	Q10	Q11		0	1	1																
	Research Antenna Modifications design and approval	Q7	Q8		-1	0	1																
	Research Antenna Modifications fabrication, installation and testing	Q9	Q10		-1	0	1																
	Misc. Minor Modifications design and approval	Q8	Q10		0	1	1																
	Misc. Minor Modifications fabrication, installation and testing	Q10	Q11		0	1	1																
	Minor Research Modifications ("Block 3") STC	Q9	Q11																				
1.5	**Aircraft Certification** (Dates in red are preliminary and based on current Avcon-data)	**Q4**	**Q16**		**-1**	**0**	**0**							1	1	1	1	0	1	0	1	0	1
1.5.1	*Fatigue Safe-Life*	Q8	Q10		0	0	1															1	1
1.5.2	*Normal Category*	***Q4***	***Q10***		-1	0	0							1	1	0	1	0	1	0	1	0	1
1.5.2.1-4	*Normal Category Modification PSCPs submitted to FAA*		***Q5***		-1	0	1									0	1	-1	1	-1	1	-1	1
1.5.2.1-4	*Normal Category Modification PSCPs approved by FAA*		***Q6***		-1	0	0											-1	1	-1	1	-1	1
1.5.2.1-4	*Normal Category Modification Document package submitted to FAA*		***Q9***		0	0	1																
1.5.2.1-4	*Normal Category Modification STCs issued by FAA*		***Q10***		-1	-1	0																
1.5.3	*Restricted Category Modification Certification*	***Q8***	***Q11***		-1	0	0															0	1
	Restricted Category Modification PSCPs submitted to FAA		***Q8***		-1	0	1															0	1
	Restricted Category Modification PSCPs approved by FAA		***Q9***		-1	0	0																
	Restricted Category Modification Document package submitted to FAA		***Q10***		0	0	1																
	Restricted Category Modification STCs issued by FAA		***Q11***		-1	-1	0																
1.5.3	*Research Instrument Installation Certification*	***Q7***	***Q16***		-1	-1	-1															-1	1
	Research Instrument Certification Schedule Development and Approval		***Q7***		0	1	1													-1	1	1	1
	Research Instrument Certification PSCP submitted to FAA		***Q8***		-1	0	0															-1	1
	Research Instrument Certification PSCP approved by FAA		***Q8***		-1	0	0															-1	1
	Research Instrument Certification documentation and test plan developmen	***Q8***	***Q9***		-1	0	0															1	1
	Research Instrument Certification document package submitted to FAA		***Q9***		0	1	1																
	Research Instrument Certification testing completed		***Q13***		-1	0	0																
	Research Instrument Installation STC issued by FAA		***Q15***		-1	-1	0																
1.5.4	**Lidar Certification**	**Q13**	**Q20**		1	0	1																
1.5.4.1-2	*Lidar STC PSCP*		Q14	1/4/2023	1	0	1																
1.5.4.1-2	*Document package submitted to FAA*		Q19	4/1/2024	1	0	1																
1.5.4.1-2	*Lidar STCs issued by FAA*		Q20	7/1/2024	1	0	1																
1.6	**Aircraft Completion By Univ. Wyoming**	**Q11**	**Q20**		**1**	**0**	**1**																
1.6.1	Research Infrastructure	Q8	Q20		0	0	1															-1	1
1.6.1.3	*Power distribution system test*		Q16	7/31/2023	0	0	1																
1.6.1.4	*Cabling test*		Q14	3/31/2023	0	1	1																
1.6.2	Research Instrumentation	Q10	Q17		1	0	1																
1.6.2.2	*Permanent instrumentation installed*		Q13	11/30/2022	0	0	1																
1.6.2.3	*Research Systems sucessful flight test*		Q17	12/31/2023	1	0	1																
1.6.3	Flight Testing and Training	Q1	Q20		0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1
1.6.3.2	Flight Testing Y3-5	Q10	Q20		1	1	1																

Figure 4.1a TLR for Project 1



Project 2: WCR and KPR Radar Development (Lead: Sam Haimov, University of Wyoming)																															
2	**Project 2: WCR and KPR Radar Development**	**Q1**	**Q18**		**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**0**	**1**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
2.1	**WCR4**	**Q1**	**Q17**		**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**0**	**1**	**0**	**1**	**1**	**1**	**1**	**1**	**1**						
2.1	*Make decision to take WCR3 out of service*		*Q4*	*9/25/2020*	*0*	*0*	*1*							*-1*	*-1*	*1*	*1*														
2.1	*WCR3 taken out of service*		*Q8*	*9/30/2021*	*-1*	*0*	*1*																								
2.1.1	WCR4 KA 350 Radar Ports	Q1	Q7		-1	0	0	1	1	1	1	0	1	0	1	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2.1.1	*WCR4 radar port design and approval*		*Q7*	*6/30/2021*	*-1*	*0*	*0*																						*0*	*1*	*0*	*1*
2.1.2	WCR4 Transmitter	Q4	Q9		1	0	1							0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2.1.2	*New modulator ordered*		*Q5*	*10/1/2020*	*1*	*0*	*1*									*1*	*1*														
2.1.2	*Completed and tested transmit section*		*Q9*	*12/30/2021*	*1*	*0*	*1*																								
2.1.3,4,5	WCR4 RF Reconfiguration	Q5	Q12		0	0	1									0	1	0	1	0	1	0	1								
2.1.5	*ProSensing delivers WCR4 to UW*		*Q12*	*9/30/2022*	*1*	*0*	*1*																								
2.1.7	WCR4 Aircraft Installation	Q12	Q13		1	0	1																								
2.1.7	*WCR4 installed and operational in new King Air*		*Q13*	*12/29/2022*	*1*	*0*	*1*																								
2.1.8	WCR4 L1 and L2 Processing	Q14	Q16		1	0	1																								
2.2	**KPR2**	**Q1**	**Q18**		**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**						
2.2.1	KPR2 Contract	Q1	Q1		1	1	1	1	1																						
2.2.2,3	KPR2 Antenna Head, Radar and Pod Development	Q2	Q5		1	1	1			1	1																				
2.2.2	*KPR2 head and pod design approval by UW*		*Q2*	*3/31/2020*	*1*	*1*	*1*			*1*	*1*																				
2.2.3	*KPR2 instrument and pod delivered to UW by ProSensing*		*Q5*	*12/31/2020*	*1*	*0*	*1*									*0*	*1*														
2.2.4	KPR2 Ground and Airborne Testing and Data Analysis	Q6	Q7		1	0	1													1	1										
2.2.5	KPR2 QPC Mode	Q6	Q9		1	0	1													1	1	1	1	1	1						
2.2.7	KPR2 KA350 Aircraft Installation	Q11	Q13		1	0	1																								
2.2.7	*KPR2 successful test flight on new King Air*		*Q13*	*11/21/2022*	*1*	*0*	*1*																								
2.2.8	KPR2 L1 Processing Code	Q14	Q15		1	0	1																								
2.2.9	KPR2 QPC Data Analysis	Q15	Q18		1	0	1																								
Project 3: New Lidar capabilities: MARLI-2 and ADL (Lead: Zhien Wang, University of Colorado)																															
3	**Project 3: New Lidar capabilities: MARLI-2 and ADL**	**Q1**	**Q20**		**1**	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**1**	**0**	**1**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**								
3.1	**MARLI2 Development**	**Q1**	**Q9**		**1**	**0**	**0**	**1**	**1**	**0**	**1**	**0**	**1**	**0**	**1**	**0**	**1**	**0**	**1**	**1**	**1**	**1**	**1**								
3.1.1	*MARLi2 Laser PO issued*		*Q2*	*2/3/2020*	*1*	*1*	*1*	*1*	*1*																						
3.1.4	*Lidar specifications available for STC development*		*Q9*	*10/1/2021*	*0*	*0*	*0*																								
3.1.4	*MARLi2 ready for aircraft installation*		*Q9*	*10/1/2021*	*0*	*0*	*0*																								
3.2	**ADL development**	**Q1**	**Q20**		**1**	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**0**	**1**								
3.2.1	**One-beam prototype ADL development**	**Q1**	**Q8**		**0**	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**								
3.2.1.1	*FPGA Specs for flight data system finalized*		*Q4*	*7/1/2020*	*1*	*1*	*1*					*1*	*1*																		
3.2.1.2	Optical telescope system POs issued	Q4	Q5		1	1	1					1	1																		
3.2.1.3	*One-beam prototype successful*		*Q8*	*9/29/2021*	*1*	*1*	*1*																						*1*	*1*	*1*	*1*
3.2.1.4	*ADL Laser PO issued*		*Q3*	*5/1/2020*	*1*	*1*	*1*																								
3.2.2	**Five-beam fixed ADL Development**	**Q9**	**Q20**		**1**	**0**	**0**																								
3.2.2.1	*FWD nadir port specs received from Avcon*		*Q9*	*10/1/2021*	*0*	*0*	*0*																								
3.2.2.1	*Five-beam ADL design review*		*Q9*	*11/15/2021*	*0*	*1*	*1*																								
3.2.2.2	*Issue PO for lasers, data system and optics*		*Q10*	*1/3/2022*	*1*	*1*	*1*																								
3.2.2.3	*Fitment verified in new King Air*		*Q12*	*9/1/2022*	*0*	*1*	*1*																								
3.2.2.4	*Five-beam ADL ready for aircraft installation*		*Q18*	*3/1/2024*	*0*	*0*	*0*																								
3.2.2.5	*Five-beam ADL ready for deployment*		*Q20*	*9/27/2024*	*0*	*0*	*0*																								
Project 4: Trace Gas and Air Chemistry Development (Lead: Dana Caulton, University of Wyoming)																															
4	**Project 4: Trace Gas and Air Chemistry Development**	**Q7**	**Q20**		*1*	*1*	*1*																						1	1	
4.1	**Instrumentation Acquisition, Calibration and Testing**	**Q7**	**Q20**		0	1	1																						1	1	
4.1.1	Instrument Development	Q7	Q18		0	1	1																						1	1	
4.1.1.1	NOx Instrument Procurement	Q14	Q17		0	1	1																								
4.1.2.1,3	Ozone & Trace Gas Instruments Procurement	Q15	Q17		0	1	1																								
4.1.4	Aircraft Aerosol Inlet Development	Q7	Q18		0	1	1																						1	1	
4.1.4.1	Aircraft Aerosol Inlet Procurement	Q7	Q9	12/31/2021	0	1	1																						1	1	
4.1.5	Ground Testing	Q19	Q19		1	0	1																								
4.1.6	Flight Testing	Q20	Q20		1	0	1																								
4.1.7	Certification	Q20	Q20		0	0	0																								
4.1.7	*Aircraft Certification Complete*		*Q20*	*9/30/2024*	*0*	*0*	*0*																								
4.2	**Research Scientist Position**	**Q14**	**Q20**		0	0	1																								
4.2	*Research Scientist Position Hired*		*Q17*	*10/2/2023*	*0*	*0*	*1*																								
Project 5: Enhanced Communication and Education (Leads: Matt Burkhart & Shane Murphy, UWyo)																															
5	**Project 5: Enhanced Communication and Education**	**Q1**	**Q20**		1	1	1	1	1	1	1	0	1	0	1	0	1	-1	1	-1	1	-1	1								
5	*User Survey Complete*		*Q7*	*6/1/2021*	*1*	*1*	*1*							*0*	*1*	*0*	*1*	*0*	*1*	*1*	*1*										
5.1	**Broadband Connectivity Infrastructure**	**Q1**	**Q20**		-1	0	0	1	1	1	1	0	1	1	1	0	1	-1	1	-1	1	-1	1								
5.1.2	*Antenna locations for communications systems identified*	*Q5*	*Q7*	*6/1/2021*	*-1*	*-1*	*-1*									*0*	*1*	*-1*	*1*	*-1*	*1*	*-1*	*1*								
5.1.2	*Antenna provisions critical design review*		*Q7*	*6/30/2021*	*-1*	*-1*	*0*													*-1*	*1*	*-1*	*1*								
5.1.3	*Procurement of communications systems hardware complete*		*Q8*	*9/30/2021*	*0*	*0*	*0*																						*-1*	*1*	
5.1.4	Aircraft installation and integration	Q12	Q14		1	1	1																								
5.1.5	Flight testing and certification of communication systems	Q16	Q18		-1	-1	-1																								
5.1.6	*Communications systems operational for research flights*		*Q20*	*9/27/2024*	*1*	*1*	*1*																								
5.2	**Remote Instrument Interaction**	**Q3**	**Q20**		1	1	1					0	1	0	1	0	1	0	1	0	1	0	1								
5.2.2	*Critical design review of hardware and software system*		*Q7*	*6/30/2021*	*1*	*1*	*1*															*-1*	*1*								
5.2.3	*Hardware procurement and delivery*		*Q8*	*7/1/2021*	*0*	*0*	*0*																						*-1*	*1*	
5.2.4	*System integrated with aircraft communications system*		*Q15*	*6/30/2023*	*0*	*0*	*0*																								
5.2.4	*Flight Testing of instrument interaction system*		*Q18*	*1/1/2024*	*0*	*0*	*1*																								
5.2.5	*Instrument integration systems operational for research flights*		*Q20*	*7/1/2024*	*1*	*1*	*1*																								
5.3	**In-Flight PI Display**	**Q3**	**Q20**		0	0	1					0	1	0	1	0	1	0	1	1	1	1	1								
5.3.2	*Critical design review completed*		*Q18*	*2/15/2021*	*-1*	*-1*	*-1*																								
5.3.3	*Hardware and software procurement*		*Q12*	*9/30/2022*	*0*	*0*	*0*																								
5.3.4	Aircraft installation and flight testing	Q17	Q18	10/30/2023	-1	0	0																								
5.3.6	*PI-display system operational for research flights*		*Q20*	*8/30/2024*	*0*	*1*	*0*																								
5.4	**Immersive Operational Environment**	**Q3**	**Q20**		0	1	1					0	1	0	1	0	1	0	1	0	1	0	1								
5.4.2	*Critical design review of supporting aircraft modifications completed*		*Q7*	*6/30/2021*	*-1*	*-1*	*0*															*-1*	*1*								
5.4.2	*Critical Design Review Completed*		*Q12*	*9/30/2022*	*0*	*0*	*0*																								
5.4.3	*Hardware and software procurement*		*Q14*	*1/2/2023*	*0*	*0*	*0*																								
5.4.4	Aircraft installation and testing	Q18	Q19	4/1/2024	0	0	0																								
5.4.5	*Operational environment operational for research flights*		*Q20*	*7/1/2024*	*1*	*1*	*1*																								
5.5	**Training and Educational Experiences**	**Q7**	**Q20**		1	1	1															1	1	1	1						
5.5.1	*Identify collaborating institution for graduate course pilot*		*Q11*	*5/16/2022*	*1*	*1*	*1*																								
5.5.2	*Course development complete*		*Q16*	*8/15/2023*	*1*	*1*	*1*																								
5.5.3	*Initial course offering complete*		*Q19*	*5/15/2024*	*0*	*0*	*1*																								
5.5.4	*Course rollout to other institutions*		*Q20*	*8/2/2024*	*1*	*1*	*1*																								
5.6	**Offline Interactive Experiences and Course**	**Q11**	**Q20**		1	1	1																								
5.6.2	*Statement of work complete and contract with Shell Visualization Center*		*Q12*	*9/30/2022*	*0*	*1*	*0*																								
5.6.3	Interactive aircraft course materials testing	Q18	Q20		1	1	1																								
5.6.4	*Course rollout to the public via facility website*		*Q20*	*8/15/2024*	*1*	*1*	*1*																								

Figure 4.1b TLR for Projects 2, 3, 4 and 5

5 Earned Value Update

Performance graphs for the overall UW MSRI and each individual project are shown by the earned value charts in Figure 5.1 through Figure 5.7. Baseline PEP (v.3) sections 7.3 and 7.6 specify that an earned value management system (EVMS) is being used to support the project and track project performance. Cost efficiency of the project is given by the calculated cost variance and cost performance index (CPI). Time efficiency of the project is given by the calculated schedule variance and schedule performance index (SPI). The methods of calculating the displayed values and the indices are given in the MSRI PEP.

The charts shown in this Year 2 Annual Report are derived from current schedule and cost information, as maintained by the project management software, in relation to the baseline schedule and planned value costs presented in the baseline PEP (v.3). The data is valid for Q5 through Q8 (October 2020 through September 2021).

Delays in financial reporting from UW and CU, Avcon invoicing delays, and capturing accurate schedule performance continue to be addressed to improve the accuracy of future reports. Current chart variations with respect to previous quarters are due to expenses clearing the University of Wyoming's financial software after the reports were submitted, along with the expenditure corrections necessary to correctly categorize previous expenses. This is especially true for personnel expenditures due to University financial system reporting delays.

Standard estimated cost to complete (ETC) calculations give a range of completion costs, calculated at the end of Year 2, of $7,700,713 to $8,912,697. Which would result in a total project cost of $14,903,263.53 to $16,115,248. This is 94% ($-892,932) to 102% ($+319,052) of the planned $15,796,196 project cost at completion. Based on Avcon's schedule and performance discrepancies versus the baseline and the outstanding equipment purchases, delayed due to Avcon's performance or COVID (as is the case for the Lidars), the project team still plans to complete the project for the remaining $8,593,645. The ETC should better track the planned completion costs once the Avcon schedule is updated and rebaselining has occurred. Spending for Year 3 will be $4,984,271, based on the PEP v.3 baseline ($3,405,184) and including major purchases of delayed equipment from Project 3 ($1,155,539) and Project 5 ($423,549).

5.1 MSRI

The overall MSRI performance, Figure 5.1, is on budget for the work performed, but slightly behind schedule. *The CPI value of 1.12 shows the project is under budget*. *The SPI value of 0.86 shows the project as behind schedule*.

CPI is directly related to Avcon invoicing delays and to a smaller part, delays in spending for Project 3 and 5. Project 4 scheduling changes will also shift Q8 and Q9 expenditures to future Quarters. Expenses through Year 2 were $2,513,270 compared to a projected Year 2 baseline spending of $3,234,013. This is less than anticipated primarily due to Avcon schedule changes and the related change in invoicing dates along with invoicing delays and planned, but unspent, equipment expenses for Project 3, 4 & 5. The actual MSRI cost to-date is $7,202,551, compared to a planned $9,369,599.

Updated payment milestones and a corresponding schedule update from Avcon are required to bring the actual spending in line with what was planned, as Avcon invoices UW for physical work completed per the revised modification and payment schedule. Avcon continues to make progress on the aircraft, which contributes positively to the earned value. Their invoices to-date should now closely reflect the physical work completed on the aircraft – a direct outcome of a UW request during the Q8 on-site meeting. There

are still outstanding design and certification efforts to be invoiced. CU subaward expenditures are forecast to increase now that lab work has resumed.

The SPI continues to contain artifacts from the physical work completed by Avcon for high-value major modifications that have not been invoiced and/or are discordant with the baseline schedule. The original baseline used for the planned value was derived from Avcon's original Q1 schedule. Since that time, Avcon has performed work out of order, delaying and accelerating work as they see convenient. Therefore, it is hard to correlate percent complete and planned value for items that are not relevant for the quarter, yet are being invoiced. These inconsistencies have been discussed with Avcon.

A still uncertain Avcon schedule, significant delays in Project 5 and recovering performance by Project 3 (due to COVID) are primary drivers for the project delay. Timely invoicing by Avcon, accompanied by an updated schedule and rebaselining of the MSRI is required to deliver correct EVM metrics. There will be a "step" correction reflecting this baseline change when it occurs.

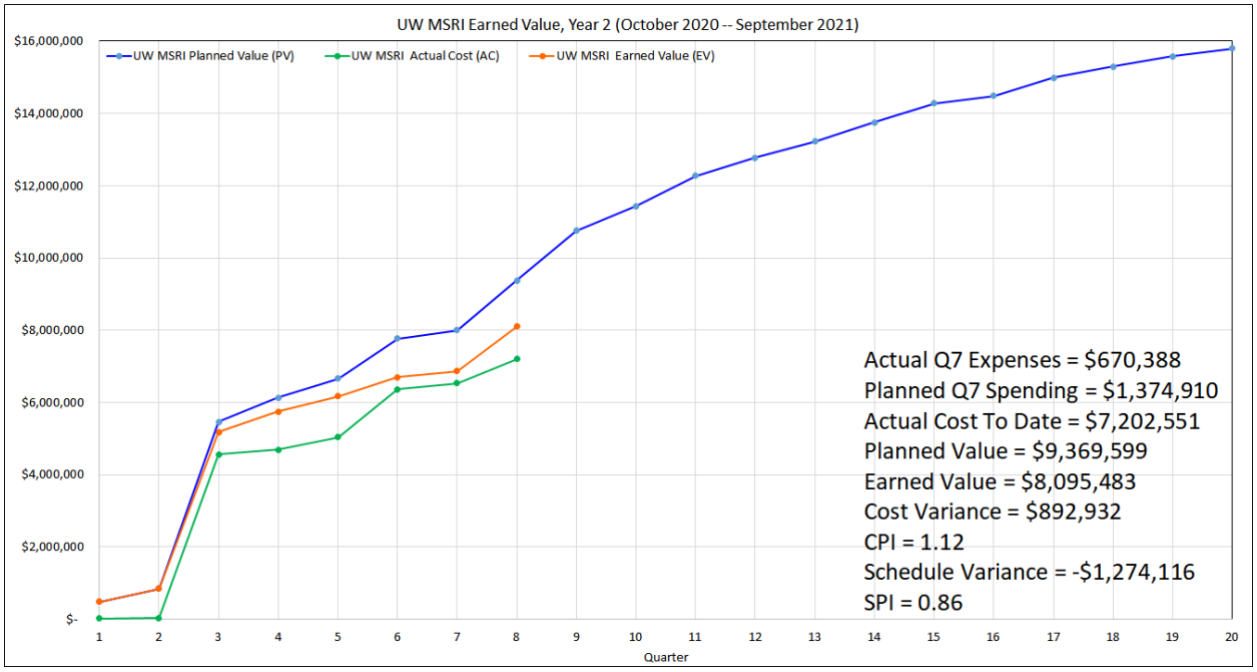


Figure 5.1 MSRI EVM Chart

5.2 Project 1: Aircraft

The overall Project 1 performance, Figure 5.2, is on budget for the work performed, but slightly behind schedule. *The CPI value of 0.97 shows the project is slightly over budget*. *The SPI value of 0.91 shows the project as slightly behind schedule*.

Project 1: Aircraft is ahead of schedule with respect to the Block 1 special mission modifications, but behind schedule for work related to the Block 2 and 3 research modifications. The project is still on track to be completed on budget but, at minimum, a three-month delay in final acceptance and delivery is near certain. The performance delay shown is with respect to the PEP v.3 baseline schedule and will move to "on track" once the adjusted Avcon schedule is finalized based on final certification process and schedule. This change will be agreed upon by UW and Avcon in Q9.

The 0.97 CPI shows the project is slightly over budget. This is a direct result of the change in the payment percentage allocations in the January 2021 revised payment schedule being tracked without a matching performance schedule or corresponding spending baseline. Invoices have been received for most items completed to date. Q6 was considered a "correction" quarter for invoicing, due to the January 2021 payment plan revision being implemented. Q8 is another "correction" quarter based on a new quarterly invoicing arrangement agreed to by UW and Avcon in Q8. An updated performance schedule baseline (PEP v.4) will be required to bring the spending plan and schedule into agreement. The ahead-of-schedule completion of most special mission modifications nearly balances the deficiency in progress for the research modifications.

The 0.91 SPI shows the project is slightly behind schedule, according to the current baseline. This is due to continued research modifications design delays by the contractor and items originally baselined for future completion being completed early, while tasks appearing early in the baseline have been delayed. The contractor is cognizant of the root cause of the delays and is attempting to modify the schedule to return the project to "on track". Blosser Engineering continues to develop performance reports, which detail Avcon's performance and accurately document observed physical percent complete.

As noted in the Q7 report, Avcon had not yet invoiced for a significant amount of work performed. These invoices were received in Q8. Thus, the expenditures through Year 2 reflect the majority of the work completed on the aircraft to date. The SPI has improved as some work has been completed as scheduled; however, as previously mentioned, not all scheduled work is being accomplished. Work scheduled in non-current quarters is being performed out-of-sync by Avcon. Thus, when invoiced, it appears the project is over budget because items being invoiced are not scheduled for completion until a future baseline milestone. UW continues to work with Avcon to ensure an accurate schedule is created so reporting is accurate.

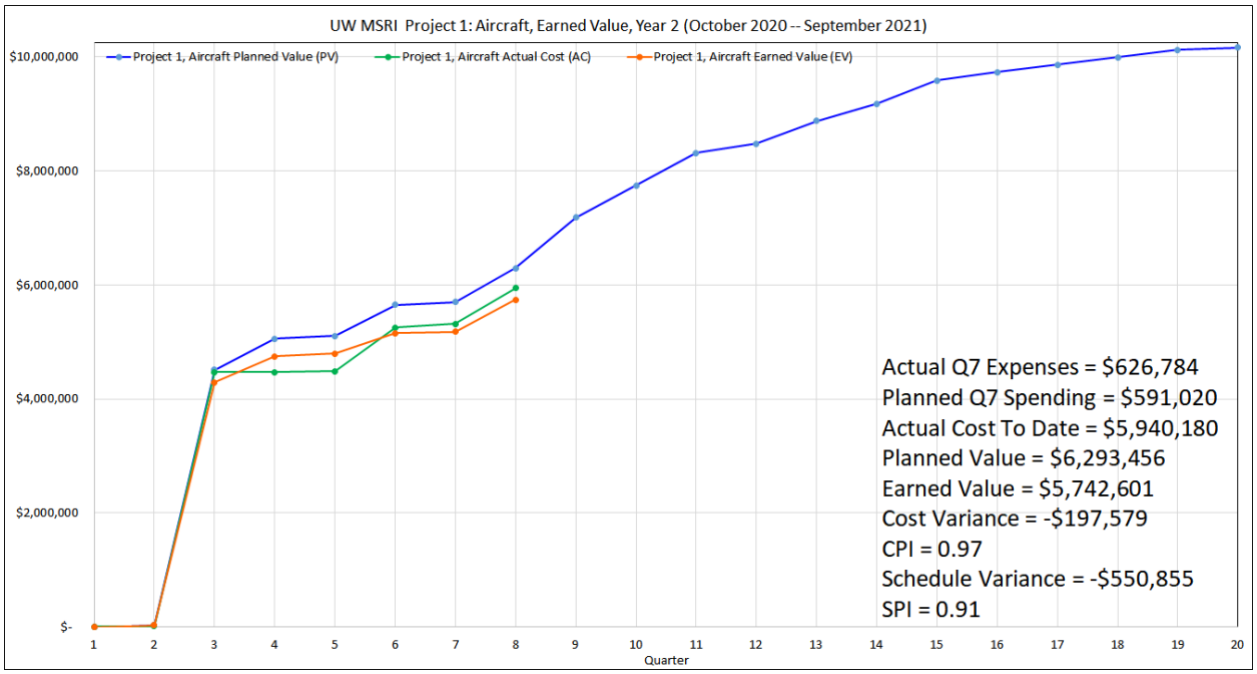


Figure 5.2 Project 1: Aircraft EVM Chart

5.3 Project 2: Radars

Project 2: Radars is presently on track. The 1.56 CPI shows the project is under budget. ProSensing and suppliers have not invoiced as expected so the Q7-Q8 expenses have not been realized. These are anticipated to be expended in Q9. The 0.90 SPI shows the project is slightly behind schedule, owing to the zenith port design delay and the coupled delay in the antenna and RF designs. KPR2 is slightly ahead of schedule with work on antennas complete and the QPC software well underway. Smaller than anticipated labor expenditures to date for the redesign and a delay in the CPI modulator invoice contributes to a positive CPI.

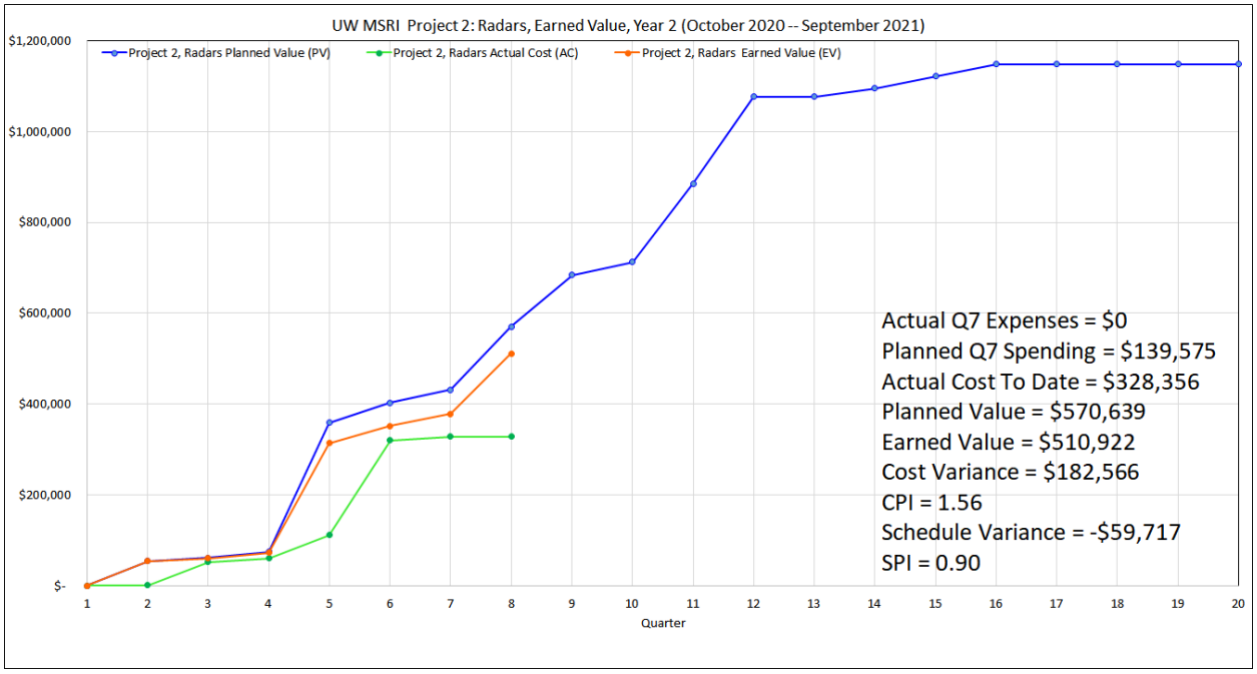


Figure 5.3 Project 2: Radars EVM Chart

5.4 Project 3: Lidars

Project 3: Lidars is presently on track, based on reporting and communications from the Project 3 PI. The 2.04 CPI shows the project is under budget. The 0.86 SPI shows the project is slightly behind schedule. The CPI value continues to improve over time due to better communication between UW and CU regarding expenditures and an increase in development and lab work as COVID restrictions ease. CU invoices to UW for the scheduled subaward payment amounts through Q8 have posted; these values are now reflected in the performance. The CPI is still not a true representation of the project state. This continues to be an artifact of the reporting and involves invoicing delays between the University of Wyoming and the University of Colorado (CU), the subawardee. The delays are gradually being reduced as the two institutions share more timely communications of direct expenditures. Project 3 cost and schedule performance continues to be more reflective of the current project state with each passing Quarter. Hardware expenditures are resuming as lab work increases due to COVID delays easing. SPI is improving due to the Project 3 schedule recovering from CU and State of Colorado COVID-19 restrictions during Year 2. Development work continues to “catch up” to the proposed schedule. UW and CU are separate institutions in different states and COVID-19 policies are different between the institutions as to what research work

was allowed during previous quarters. The Project 3 CPI and SPI impact the overall MSRI CPI and SPI; thus Project 3 is partially responsible for the MSRI SPI.

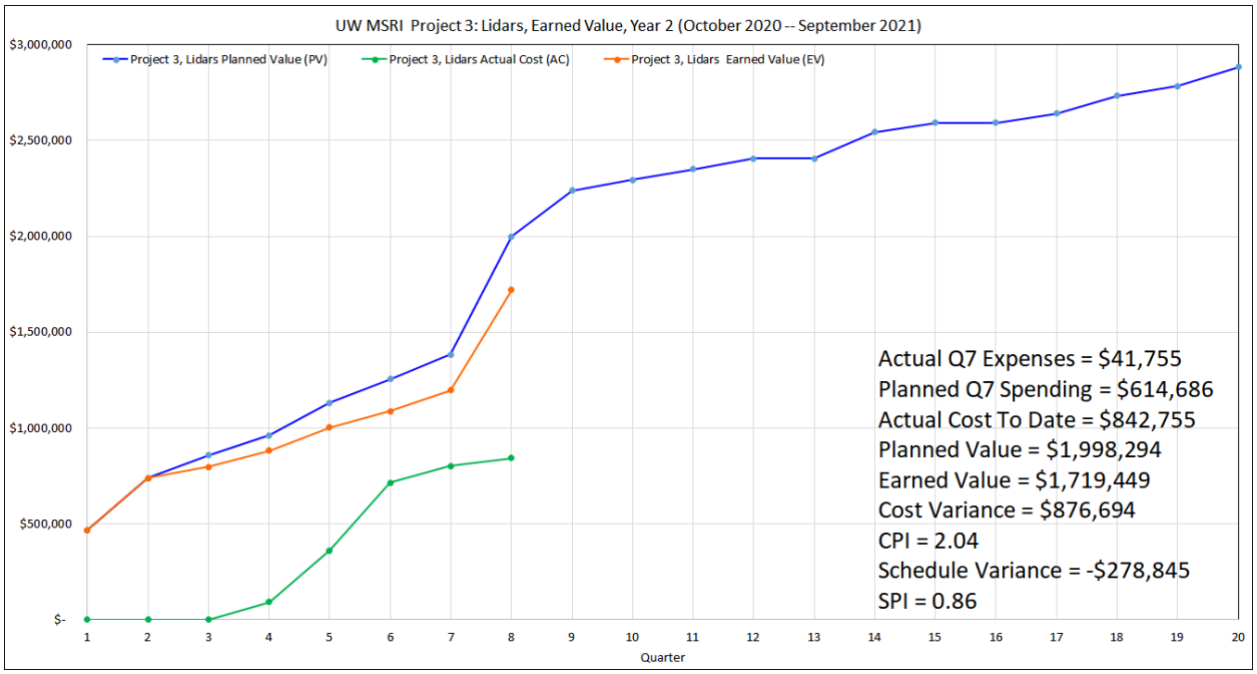


Figure 5.4 Project 3: Lidars EVM Chart

5.5 Project 4: Air Chemistry

Project 4: Air Chemistry is presently on track. The 1.00 CPI shows the project is on budget. The 1.0 SPI shows the project is on schedule. The project started in Q8 but minimal effort was expended; this is due to the first major expense (aerosol inlet) being delayed until at least Q11 because of a risk management decision. There was a small, unplanned PI labor cost in Q4 related to the evaluation of an emerging technology for trace gas sensing.

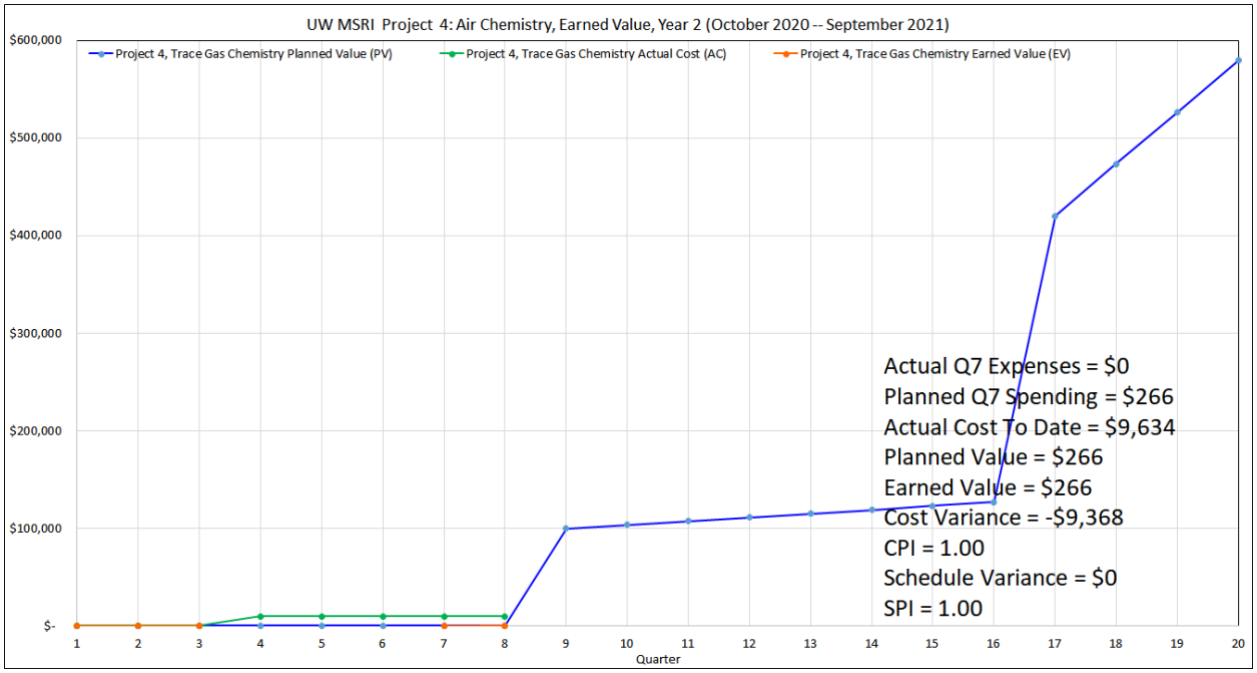


Figure 5.5 Project 4: Air Chemistry EVM Chart

5.6 Project 5: Enhanced Communications and Educational Opportunities

Project 5: Enhanced Communications and Educational Opportunities continues to be significantly behind schedule due to a missed milestone in Q5 for the aircraft contractor to complete a layout for the physical location of the communication system antennas. This is indicated by the 0.14 SPI. Design and procurement of much of the system depends on having suitable locations on the upper crown and belly of the aircraft for these antennas. Ultimately, the remainder of the project relies on the communications system infrastructure for success. Contributing small delays are due to personnel resources scheduled for the project being allocated to the overall MSRI and commitments within the Wyoming King Air cooperative agreement (CA8) due to current and upcoming N2UW project deployments. The 2.90 CPI shows the project is significantly under budget. However, this is a direct artifact of the $393,634 in planned Q6 and Q7 expenditures for the communications systems hardware and interconnects being delayed until suitable antenna locations are determined and approved by UW and the hardware manufacturer. There is significant risk in purchasing systems that do not have guaranteed locations for antennas. There is also a small contribution due to labor expenditures for senior personnel not being utilized due to resource commitments outside the MSRI. The labor and design efforts will still be expended on Project 5, but not until upper and lower antenna locations are determined. Thus, the majority of Q4-Q6 work and procurements will be shifted and compressed into Q9 and beyond. The Project 5 spending plan will be re-baselined to match the updated Avcon schedule regarding antenna placement and the subsequent design of supporting modifications. Definitively determining antenna locations in Q7 would have returned the project to “on track”. However, the contractor missed the placement milestone again and has now indicated a late Q9 completion for this task. The antenna location delay will start to impact the schedule as of Q9, as enough slack is no longer available in the schedule to handle the adjustment. A mitigation is the ability to model the hardware link without physical hardware present. The Project 5 SPI and CPI directly impact the overall MSRI CPI & SPI.

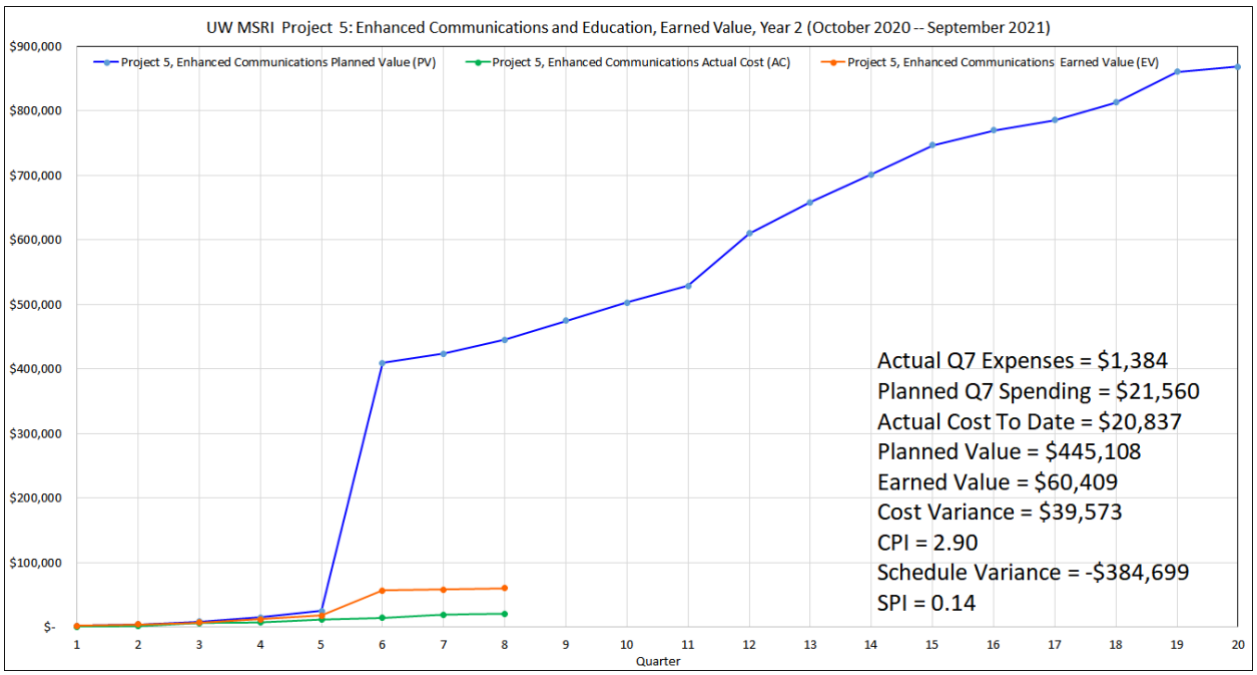


Figure 5.6 Project 5: Enhanced Communications and Educational Opportunities EVM Chart

5.7 Project 6: Project Management

Project 6: Project Management is presently on track. The 1.02 CPI shows the project is under budget. The 1.00 SPI shows the project is on schedule. The MSRI PIs, Project Manager, and Project Leads are working with the Department's executive business manager (EBM) to ensure all charges for MSRI project management activities are being properly tracked through the University's financial system. Corrections to personnel expenditures are made, as required, based on updated data from the University's financial system. The University's financial system is roughly three months behind in tracking personnel expenses. The change in EBM personnel in Q3 & 4 and increased reporting efforts for Project 6 resulted in a change to forecast personnel expenses. As the reporting process becomes routine for the personnel involved, the cost variance should continue to approach one (1.00) and achieve this index by the end of Q9.

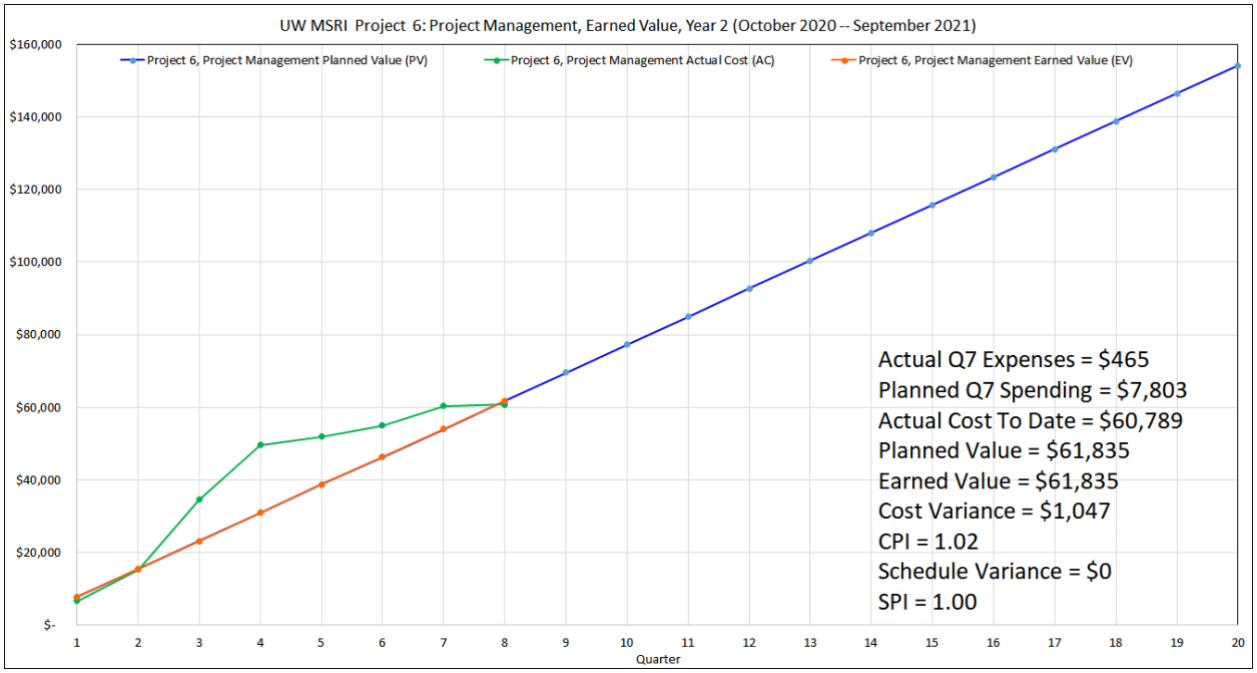


Figure 5.7 Project 6: Project Management EVM Chart

6 Opportunities for training and professional development

As part of Project 1 [WBS 1.6] the flight operations group started plans for formal training in Quarter 4 specific to flying and maintaining the new research aircraft. The training started in Q5. Year 2 has seen two pilots complete the 16-day Flight Safety International course to receive a King Air 350 "type rating". The final pilot will attend this course midway through Year 3 due to project deployments schedules for the existing Wyoming King Air. A Facility mechanic completed the required "Initial Course for Maintainers". Another Facility team member may take this course in Year 4. By the end of Year 3, the Wyoming King Air Facility will be able to conduct flight operations with the new Wyoming King Air 350.

7 Information dissemination

The Facility is working with NSF and the research community to convey the anticipated schedule for FL-862 being "research ready" and available for project deployments. The availability date is ultimately dependent on Avcon's performance and the receipt of the research STC. The dynamics of Avcon's schedule continue to make this date uncertain. We are targeting late December 2023 or early 2024 for aircraft completion and availability. Several small-campaign LOIs and one large-campaign EDO (ICECHIP) have been received. This information has been posted on the NCAR EOL website (https://www.eol.ucar.edu/request-lower-atmosphere-observing-facilities) and the UW King Air website (http://www.atmos.uwyo.edu/uwka/users/request.shtml). The current King Air (N2UW) will now retire following the deployment for CHACHA22 (which ends in April 2022) and the final flights for TRANS2AM (early July 2022). The small extension is due to aircraft complications that prevented finishing TRANS2AM in October 2022. WCR-4 and KPR-2 will be available for deployment in the CAESAR campaign. This is reflected in the CAESAR facility request currently under review.

8 Plans for the next year

8.1 Project 1: Research Aircraft

Based on the most recent Avcon schedule update (September 2021), Year 3 will see the majority of the Block 2 research modifications complete, along with final designs for the remaining Block 3 modifications. The majority of the Block 3 modifications are scheduled to be installed by the beginning of Q12. The research STC PSCP will be approved by the FAA in Q9 and the documentation package will be developed and submitted in Q10. Flight tests for the research STC may start as early as Q12.

The Dual Camera Port installation will be complete in Q9 along following baseline flight performance testing. This will allow the noseboom and nose extension installation to start (Q10) once part manufacturing for these modifications is complete in Q9. The upper zenith port critical design review is on-track for Q9 and parts manufacture will follow. The upper zenith port installation will commence after the noseboom and nose extension have been installed and the required performance testing is complete. This sequence is necessary to support the standalone nature of the noseboom and extension STC. Issuance of this STC is expected in Q10.

The critical design review for the research electrical system will occur in Q9 and installation will be done in tandem with the nose extension/noseboom install. Minor zenith port and upper/lower hardpoint designs will be complete and parts will undergo manufacture in Q10 with a Q11 completion.

UW-Avcon agreed upon layouts of the upper crown area and lower belly areas of the aircraft, with all interferences resolved have again been delayed until Q9. This was originally scheduled to be complete in Q5. Extensive internal (UW) and external coordination is required for these tasks. The design and installation of these antenna provisions is scheduled for completion by Q10

Development of the research STC will continue and the PSCP will be completed and submitted to the FAA in Q9. A face-to-face visit in Laramie with Avcon and the ODA/UMs will occur early in Q9. This is a very important meeting, as it will communicate the importance of UW being able to operate within an “envelope” when installing research equipment as opposed to flying set “configurations” of instruments. The opportunity for the contractor and ODA/UMs to see N2UW populated with instruments is critical. This visit will also facilitate a detailed discussion regarding the certification path and schedule. The remainder of Year 3 will be spend developing the supporting documentation package. This certification effort is the MSRI development effort with the most risk and is now (September 2021) tied to a significant payment event. UW continues to advocate for parallel design and certification efforts by Avcon to accelerate return of the aircraft to UW. A final schedule continues to be requested from Avcon.

A plan to approve lidar installations on FL-862 will be developed and a contractor selected. Avcon may provide this service, pending discussions regarding their previous experience in this area. Other certification partners have been approached about the work. The PSCP for this work will be submitted in Q14.

Internally, initial discussions and planning will take place over Q9 and Q10 to develop the schedule for bringing the aircraft on-line once it returns to Laramie. Initial design work for instrument interfaces has started and is being communicated through ICDs. Once the Block 3 designs and capabilities have been determined, UW can begin detailed design work and component specifications for the wire harnesses, instrument mounts and internal racks and equipment necessary to complete the aircraft. Where possible,

some of the installation of these components will take place at Avcon during Q12-Q14 while the aircraft is undergoing testing.

8.2 Project 2: Radars

ProSensing will complete the redesign of the RF subsystem in Q9. WCR3 will be shipped to ProSensing in Q9 for partial use in the upgraded WCR4. UW personnel will continue to review the WCR structural design, electrical interconnects and power requirements for compatibility with the new aircraft and FAA regulations. WCR4 manufacture will occur in Q10-Q12 and be delivered to UW in Q12. Testing will be conducted prior to test fitting and deployment on the NCAR C-130 for CAESAR – if allocated.

The large KPR-2 antennas will finish evaluation in Q9. ProSensing will continue work on the software required to run the new high-power acquisition mode (QPC) and the radar control and display GUI. This development effort will conclude in Q9. Final delivery of KPR2 is anticipated by Q10. Flight testing and initial deployment of the large-antenna KPR2 will occur on the C-130 for CAESAR – if allocated.

8.3 Project 3: Lidars

Year 3 will be spent on final testing of MARLi-2 in the lab and making it ready for aircraft deployment. The adapter for the laser power head will be completed allowing the full MARLi-2 to be lab tested. This will include extensive testing of the optics, data acquisition, laser and cooling systems. Refinement of the aircraft-mounting interface for MARLi-2 will begin in Q9 with construction and design to occur through Year 3. Initial test flights for MARLi-2 would occur on the C-130 as part of the CAESAR campaign – if allocated. The delayed availability of FL-862 precludes initial flight-testing on the Wyoming aircraft until after Q17.

Work will continue on the multi-channel RF SoC FPGA software development and testing for ADL. The one-beam ADL will continue to be optimized and tested in support of five-beam development activities. The FL-862 nadir port specifications have been provided to CU and a design review for the 5-beam ADL will occur in Q10, followed by the issuance of POs for the components. Initial 5-beam lab configurations and testing will occur in Q11 and Q12. The FL-862 ADL aircraft interface will be ready for fit testing in Q13. The ADL schedule may change due to PI involvement in the CAESAR campaign.

8.4 Project 4: Trace Gas Chemistry

The project will continue to evaluate the best time for aerosol inlet procurement. The CHACHA22 campaign in Q10 and 11 will give the PIs good insights into how the system operates and any design or mounting considerations that should be considered for the UW aerosol inlet. The experience gained by the facility team with the CHACHA22 CVI inlet will greatly minimize installation risk for the isokinetic inlet. Inlet testing from N2UW obtained in Year 2 will be further analyzed and provide insights into instrument location and inlet orientations for FL-862. An updated quote and specifications for the aircraft aerosol inlet will be obtained prior to purchase. This purchase is being delayed to better align with Avcon design activities for the upper aerosol hardpoints. The delayed delivery is not a concern and will not impact Project 4 completion. The Project 4 team will continue discussions with NCAR relating to the LIF NOx instrument development as appropriate.

8.5 Project 5: Enhanced Communications and Educational Opportunities

Year 3 will be a “catch-up” year for Project 5 and will correct the schedule slip resulting from the continuing delays in antenna location activities that began in Q5. The upper crown and lower belly antenna layouts are nearly complete. Avcon will undertake a physical survey of the FL-862 underfloor in the modification areas to ensure the selected locations will support the required GoGo antenna RF cabling. This will be

complete in Q9 following baseline performance flights. The upper crown arrangement will be complete in Q9, taking into account the "keep out zones" and static location requirements for the aircraft avionics system antennas. Following the final placement decisions and provision design, a PDR and CDR will be held in late Q9 with part manufacture occurring in Q10. The provisions will be installed in late Q10.

Final communications system selections will now be made in Q9. Vendor quotes will be updated at that time with no change in cost anticipated. Completion of these activities will allow UW personnel to concentrate work on the schematic design (Q10) and preliminary design reviews for the overall communication system, remote instrument control and interactive operations (Q11). Initial lab testing for the communication systems will begin once the systems are delivered. The delivery dates are uncertain at this point – continued COVID-19-related global semiconductor shortages are impacting the manufacturers and a one-year delivery after receipt of order is possible. The network emulation system will continue to be refined (Q10) and initial software developed to support instrument interfaces and remote visualization (Q12). The in-flight PI display system requirements will be finalized in Q10 with design reviews occurring in Q12. Avcon will be engaged regarding design and certification efforts required to support the final design on FL-862.

9 Products

9.1 Books, Book Chapters

None.

9.2 Journal articles

None.

9.3 Conference papers

French, Geerts, and co-authors, 2020: "The Next-Generation Wyoming King Air Research Aircraft: Plans and Opportunities" Paper 5.1 in the 20th Symposium on Meteorological Observation and Instrumentation. Presented at the AMS Annual Meeting in Boston on 1/14/2020

French, Geerts, and co-authors, 2021: "The Next-Generation Wyoming King Air Research Aircraft" *International Conference on Cloud Physics (ICCP),* Pune, India (virtual) presented 8/2021Theses/dissertations

None.

9.4 Patents, inventions, licenses

None.

9.5 Website

The Department of Atmospheric Science's King Air Facility webpage is nearly finished with an update. The new research aircraft, modifications and the MSRI are highlighted on the new site. https://www.uwyo.edu/atsc/uwka/next-gen-king-air.html There is now an additional page to track status updates (https://www.uwyo.edu/atsc/uwka/next-gen-king-air-updates.html). This provides a simple summary and images describing the main milestones in the modification process, and is updated at the end of each month. The UW Donald L. Veal Research Flight Facility safety webpage is beginning to reflect changes in operations due to the acquisition and future operation of the new King Air. The safety program

is migrating to the Microsoft Teams platform to better disseminate information and support change management.

10 Participants and partnerships

10.1 Key participants and their roles

Figure 10.1 shows the internal organization and indicates roles and responsibilities for the UWKA-2 project

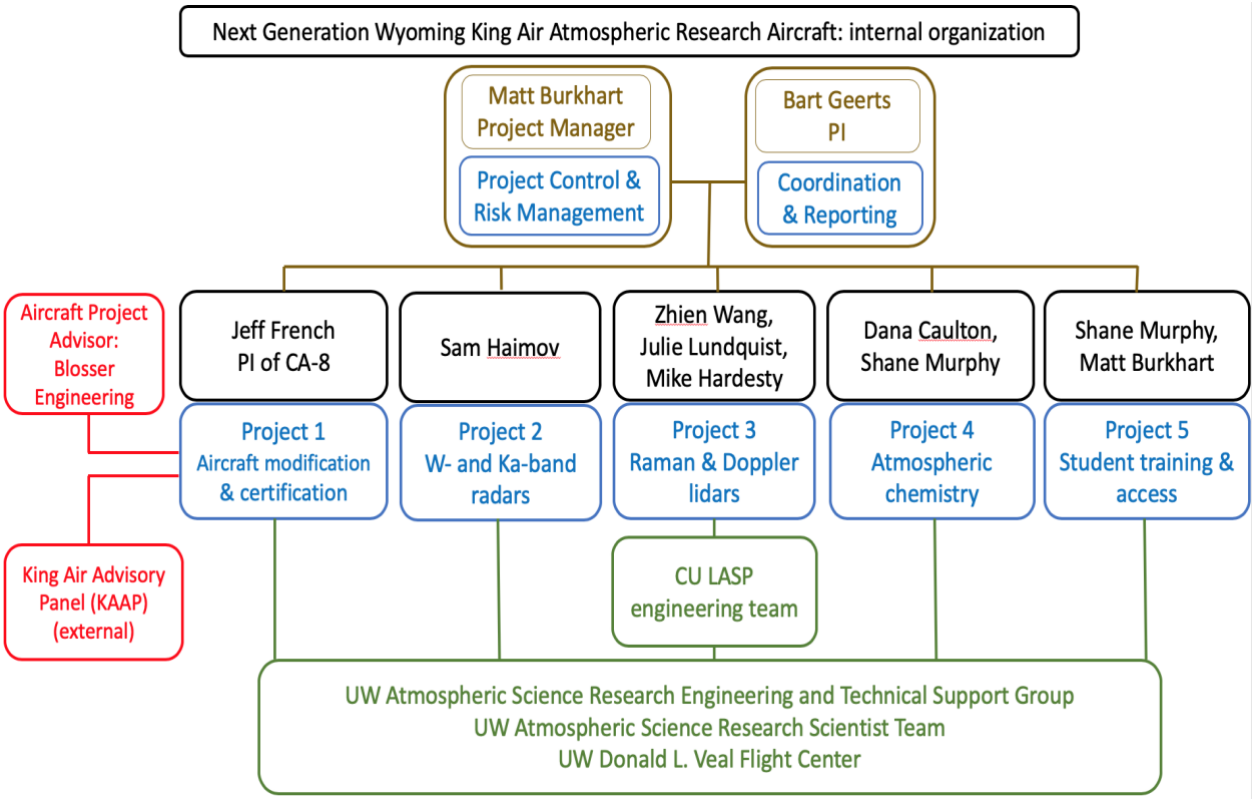


Fig. 10.1: Internal governance and organization

10.2 What other organizations have been involved as partners?

10.2.1 The King Air Advisory Panel

The scientific mission and operation of the UWKA research facility is advised by the King Air Advisory Panel (KAAP), composed of five scientists with expertise and experience using research aircraft to study atmospheric phenomena. Current KAAP members are:

- Paquita Zuidema, Professor, University of Miami, KAAP Chair
- Paul Shepson, Professor, Stony Brook University
- Jeff Stith, Facility Manager (retired), NCAR Research Aviation Facility
- Teresa Campos, Project Scientist II, NCAR Research Aviation Facility
- Beat Schmid, Manager, DOE ARM Airborne Facility

10.2.2 Industry Partners

Avcon Industries acted as the aircraft purchase agent for UW. Avcon also manages the modifications to the aircraft, including special mission and atmospheric research modifications, and coordinates the aircraft

certification. Avcon has engaged ATSI (a subsidiary) to work on the structural and certification aspects of the noseboom and nose extension. The research STC will involve the services of an ODA contracted by Avcon. Blosser Engineering, Randy Blosser, is serving as the University's representative for the aircraft modification and certification process.

ProSensing, Inc. is our partner for the development of the airborne radars (KPR-2 and WCR-4). ProSensing is collaborating with subcontractors, including CPI, for the development of the modulator.

A vendor for the Cobham and GoGo communications systems will be finalized in Q7 and assist with the development of antenna placement provisions.

10.3 What other collaborators or contacts have been involved?

- We worked with the NCAR Director Office (courtesy Krista Laursen) to develop our Earned Value Management.
- We exchanged thoughts with ARM Aerial Facility Manager Beat Schmid and other DOE ARM personnel about the aircraft modification and certification process. DOE ARM recently acquired piloted aircraft (a Bombardier Challenger 850) and is exploring the same issues we are regarding aircraft modification for atmospheric sensors. DOE was involved in Year 1 and Year 2 as we explored certification pathways for FL-862.
- Jeff French reports on the next-generation UWKA and instrument development funded under this grant at the NSF Fall and Spring Observational Facilities Advisory Panel (OFAP) meetings at NCAR. (Current meeting are online only.)
- The University of Wyoming Shell Visualization Center is a collaborator for the offline interactive courses and experience for Project 5. Engagement with the Shell Visualization Center has happened on an informal basis to-date and helps maintain the relationship until late in Year 3 when the development contract begins.
- NCAR EOL has been informally contacted about a LIF NOx instrument that is under development. This instrument may meet the needs of Project 4. Continued discussion will determine if this instrument is the optimal solution for Project 4. It needs to be determined how a partnership between NCAR and UW would work moving forward.

11 Impacts

11.1 Impact on the development of the principal discipline(s) of the project

The UWKA-2 will serve as an ideal platform to train the next generation of observational atmospheric scientists. This facility will lower the barriers of access to the operation of advanced atmospheric airborne instrumentation, and provide these research opportunities to a broader sector of the academic community, including students not just from the University of Wyoming (an EPSCoR state), but from any university that requests the UWKA-2 for NSF-funded educational or research-focused campaigns.

11.2 Impact on other disciplines

Nothing to report

11.3 Impact on the development of human resources

Nothing to report

11.4 Impact on physical resources that form infrastructure

The UWKA-2 will be an atmospheric research platform more capable than the current aircraft. It will be equipped with instruments that allow new research perspectives. These new capabilities will be developed to a technical readiness level and a data accessibility level where they can be requested and used by the NSF-funded community.

11.5 Impact on institutional resources that form infrastructure

Nothing to report

11.6 Impact on information resources that form infrastructure

Nothing to report

11.7 Impact on technology transfer

Nothing to report

11.8 Impact on society beyond science and technology

Nothing to report

12 Changes/problems

12.1 Changes in approach and reason for change

There are no changes in the proposed work in general. The scope of the project remains the same and the requested budget is sufficient for completion.

At NSF's request, we built the baseline PEP, approved as of Q3. This contains a formal project management and scheduling structure, to guide the project and adequately forecast work to be performed and the resources needed. This system will also serve to track schedule, physical and financial performance. We feel comfortable that this system is functional and will again be used beyond Year 2 to support the MSRI. Initial EVM reporting from this system was presented in Q3 and refined, based on NSF feedback, for the Year 1 annual report and future quarters. A uniform quarterly report format was introduced for Q3. An updated Traffic Light Report (TLR) was adopted in Q7. Future quarterly and annual reports will follow these formats.

At NSF's recommendation, a formal contingency management plan was submitted mid-July 2020 (Q4). This plan will help the MSRI team manage contingency needs with cost or scope management should the need arise.

During Q5, it was realized that the original modification and payment schedule provided by Avcon, when the contract was executed, was not working. This was due to the delay in much of the Research Modifications (Block 2 and 3) design work. Avcon was requested to develop a new schedule and payment plan, which they completed in late Q5. They committed to further refining the milestone events, dates and associated payments for UW approval in the beginning of Q6. As of Q8, the Avcon modification and certification schedule is still in flux. Avcon has added reasonable certification milestones but the schedule continues to outpace actual physical completion. Their schedule continues to have significant deficiencies that preclude the ability to accurately determine a completion date for the aircraft. An on-site meeting in mid-Q8 resulted in a new scheduler being assigned by Avcon. The initial refinement of this schedule along with corresponding payments is in review.

A revised payment schedule was agreed to between Avcon and UW in Late January 2021. This payment schedule provided a very clear breakdown of the tasks to be performed and the cost for each task and phase thereof. However, a schedule indicating the completion dates for each of these payment milestone events was not provided. UW has received multiple versions of a schedule: February 2021, April 2021, end of Q7 and mid-Q8. All schedules were incomplete and partially "stale" when issued. UW continues to request that Avcon revisit the schedule and provide an update with realistic timeframes. As of an on-site meeting in Q8, the research certification STC now includes many of the Block 3 modifications and is tied to significant payment events. This is a positive outcome as the research STC is viewed as the highest risk element of the MSRI. The completion of the STC is now financially significant to Avcon.

The PEP will be modified (v.4) once a final aircraft modification and research certification schedule is generated. Avcon has delayed this until after the Q9 on-site visit with UW and ODA/UMs. Corrections based on the significant Avcon scheduling impacts to other projects (notably, Project 2 and 5) will also be incorporated in the revised PEP baseline. Flight testing schedules for Project 2, 3, 4 and 5 instruments, not critical to the research mission infrastructure, will be re-evaluated and alternative testing scenarios discussed. The potential deployment of the WCR4, KPR2 and MARLi-2 MSRI instruments as part of CAESAR will be addressed.

The overall cost of the project will not increase and the schedule will not be extended. UW desires to be as transparent as possible regarding progress, schedule and budget without unnecessarily modifying the PEP. The PEP, a fluid document, will be updated when a significant enough change is presented. The final updated Avcon schedule, including the timeline for the high-risk certification, and the impact on other MSRI Projects warrants such a change.

12.2 Actual or Anticipated problems or delays and actions or plans to resolve them

COVID-19 related closures and supply-chain issues continue to have a minor impact on all but Project 5. Project 5 will be moderately impacted. Lab work, especially for Project 3, has returning to normal and increased efforts by the PI team will put the project back on schedule by Q9. However, uncertainty in new COVID restrictions (Q8 & Q9) may again impact lab work. The schedule continues to handle these delays without major downstream impacts. Project 5 has experienced supplier delays in returning quotes and installation information due to key vendor or manufacturing personnel still working remotely. There were design delays in the aircraft project directly related to COVID impacts on design staff.

COVID-19-related semiconductor shortages may delay communication systems delivery – with delays of up to a year being quoted by vendors at present. This chip shortage is being recognized by other Projects and purchasing timelines will be adjusted as necessary to ensure on-time delivery. There is currently no negative impact to the schedule from these delays, but some redesign (Project 3, SoC FPGA) may be necessary.

Avcon's design process continues to evolve and UW engineering and MSRI PI and senior personnel efforts have significantly increased because of the Avcon design delays. UW's DERs continue to work with Avcon to develop the best solutions for the atmospheric science community and are deferring/delegating non-Project 1 MSRI and facility tasks as necessary to be responsive to Avcon's requests and keep the project on schedule. There is a forecast six-week period in late Q8 and early Q9 where no physical work on the aircraft will take place. UW is working with Avcon to identify stand-alone "Block 3" mods that could fill this period.

A delay in the design of the upper major zenith ports introduced a potential three-month delay into Project 2 (Radars). The design of the ports was needed so UW could accurately position the WCR4 cabinet and antennas within the cabin of the King Air and determine if the apertures were acceptable for the proposed antennas and pointing angles. UW has completed the design and ProSensing has started on the repackaging of the RF section. The overall delay introduced was two months and will not significantly delay the other Project 2 milestones. The modulator design effort is progressing ahead of schedule, which will result in delivery of WCR3 to ProSensing ahead of schedule. The decision to take WCR3 out of service was been resolved with the delay of the CEASER C-130 request. WCR4 and KPR2 will be complete as scheduled and participate in CASEAR if allocated.

The delay in upper crown and belly layouts continues to have a significant impact on Project 5 and has delayed the communication systems purchases and the design work for the communications systems (WBS 5.1), remote instrument interaction (WBS 5.2) and interactive operational environments (WBS 5.4). Schedule adjustments continue to be made and can absorb these changes until the end of Q8. Project 5 will be re-baselined to reflect the new Avcon design delivery dates. Personnel efforts for Project 5 will now be intensified in Year 3 to correct the schedule. Work on other Project 5 items has shifted forward (such as the co-pilot PI display) to occupy time during Avcon and communications system delivery delays.

Meetings with collaborators and the sharing of information continues to use video-conferences when possible with in-person and "hybrid" meetings gradually becoming the norm. The UW MSRI team anticipates being able to make adequate accommodations for the on-site inspection and design visits necessary for the aircraft modification process. COVID procedures did not significantly complicate the Q5 and Q8 on-site visits, although transportation costs were greater than anticipated.

The UW MSRI team continues to work with the Department's Executive Business Manager to mitigate delays in obtaining financial information at month-end due to inherent delays in the University's accounting system. Payroll delays are being handled by tracking efforts internally, separate from the University's account system and then corrected to official records once they are available.

The retirement of three King Air Facility individuals has an impact on the MSRI project. The Facility has filled the machinist vacancy (Q8) that is crucial to the internal manufacturing efforts required to finish the aircraft. A new Radar Scientist search is again underway (Q8) after a failed search (Q5-Q7). The hired individual will be critical in WCR4 and KPR2 integrations for FL-862 and providing long-term facility support. A long-time facility scientist responsible for flight science and data processing will be departing suddenly in Q9 and reassignment of responsibilities is taking place prior to a replacement search. This position contributed to software and networking design and programming efforts in Project 5 and impacts of the departure are being evaluated.

12.3 Changes that have a significant impact on expenditures

No changes are directly noted that increase costs; the project is still on budget. Avcon invoicing delays have previously biased the EVM reporting and project metrics. UW is actively involved with Avcon financial management personnel to resolve this issue. As of mid-Q8, Avcon has invoiced for all outstanding work completed and the Year 2 Project 1 EVM chart represents the current state of the Project. Avcon has agreed to invoice at the end of calendar quarters for work completed in those quarters. This will begin with Q9 and physical work complete will now be supported by invoices submitted. Project 5 hardware purchase delays will shift $362,000 in expenditures to Q9. As the aircraft modification schedule and certification plan is refined, in conjunction with Avcon, there exists the possibility for cost reduction related to the final

delivery of the aircraft to UW. The decision to move forward with KPR2 QPC mode development has removed a $120,000 contingency. The aerosol inlet purchase delay in Project 4 will shift the $99,317 aerosol inlet expense to a future quarter based on the CHACHA22 project experiences. COVID delays have not resulted in significant expenditures. However, Avcon and other on-site visits may increase in cost due to additional travel time and/or distancing of personnel.

13 Special reporting requirements

The complete "traffic light" progress report for Year 2 has been emailed separately to the cognizant Program Director, Dr. Shree Mishra. This large Excel® sheet does not lend itself to detailed presentation within the quarterly report.