Report: Research Aircraft

Chapter 142 section 67 Footnote 16.

"16. For the use of the university aircraft after the effective date of this footnote, the university shall identify and distribute to a reserve fund amounts to cover the cost for routine and planned maintenance, engine and propeller reserves. Additional amounts to support funding of replacement of the research aircraft shall be included in any contract for use of the aircraft to the extent practicable.

Amounts received to support replacement of the aircraft shall be held in the reserve fund. Not later than October 1, 2015, the university shall report to the joint appropriations interim committee a budget for the cost of acquisition of a replacement research aircraft, and a plan for the acquisition and operation of the aircraft including revenues anticipated to be credited to the research fund and repaid to the state of Wyoming. Proceeds from the sale of the research aircraft, engine or any related research instrumentation shall be credited to the reserve fund."

This report describes why a research aircraft is important to Wyoming, cost estimate of a new research aircraft, how monies will flow into the reserve funds and used to 1) support maintenance of the research aircraft including the engines, and; 2) purchase a future research aircraft.

What research is enabled by this aircraft at UW and how does this benefit Wyoming?

The Atmospheric Sciences Department is the most highly regarded and the only Tier 1 program within the UW College of Engineering and Applied Sciences and one of the premier atmospheric science departments in the world. The department operates the Wyoming King Air Research Aircraft, which is a unique national and international research platform. The National Science Foundation (NSF) has operationally supported this research aircraft as a national facility for more than three decades. Currently, the NSF is on its seventh, 5-year round of providing funding supporting the King Air as a national facility. The latest continuing agreement provides almost $2 million annually. Some 21 people are employed in whole or in part as a result of this funding supporting the aircraft and the associated equipment including technicians, pilots, mechanics and engineers involved in the design and deployment of the instrumentation which flies in the plane.

The research supported by the aircraft benefits the State of Wyoming directly in a number of ways, including:

- Nighttime thunderstorms: Nighttime thunderstorms, such as recently devastated Lusk, are also a potential hazard through excessive rainfall, flash flooding and

dangerous cloud to ground lightning. The aircraft is used in the nationally recognized NSF PECAN program, designed to understand this phenomena, help develop more accurate predictive models, and help communities better prepare.

- Weather modification (cloud seeding) program that has been funded by the state for a number of years and seeks to mitigate the effects of drought on our agriculture and ranching industries and local communities.
- Fugitive gas emissions: Together with ground based measurements, the aircraft is a powerful tool to gather data for the state and its industry stakeholders, independently and without bias. Wyoming needs the best data possible to guide the state's response to an increasingly hostile federal regulatory framework.
- The Wyoming Supercomputer: Data gather by the aircraft is used to develop predictive weather models using our supercomputer, thus leveraging and complementing a critical state asset.

The Wyoming King Air Research Aircraft draws faculty and students to UW's Atmospheric Sciences Department thus establishing an international reputation. In 2014 Atmospheric Sciences received almost $6.2 million in external funding, the majority of which is associated with projects either directly supporting the research aircraft or using the research aircraft. It is a major factor in the success of Atmospheric Sciences and the College of Engineering and Applied Sciences. As a research platform it also creates opportunities for collaborating with faculty and students literally around the world.

The Beechcraft King Air Model 200T and the instrumentation built by UW engineers to measure atmospheric phenomena are both critical in understanding how precipitation forms, cloud structure and ultimately how these relate to precipitation in the form of snow or rain. For example, a recent and very topical project involving UW faculty and technicians and the King Air examine nighttime thunderstorms on the Great Plains – like the one that devastated Lusk, Wyoming. Another is the Wyoming Legislature funded weather modification study. Over the years significant modifications have occurred to support the needs of various research missions. Manufactured in 1977, the current UW research aircraft is 38 years old. It has had to accommodate specific, very precise and unique equipment to make innumerable and extremely varied measurements of the atmosphere while flying. Due to airframe modifications, the weight of the plane and equipment, and heavy weather this airplane experiences due to the nature of the research, the Federal Aviation Administration (FAA) has limited the airframe to 10,000 hours. With about 8,000 hours logged at present, the plane is estimated to have three to five years of lifetime remaining. This number depends on the number and type of missions it flies.

A new plane that continues to support cutting edge technology and research in atmospheric science is critical in maintaining this Tier 1 College of Engineering and Applied Sciences department. In addition, a new replacement aircraft will enhance research capabilities by

allowing for extended range on missions, permitting an increased payload of instrumentation, making more electrical power available and increasing the altitude capabilities of the research platform. Without this aircraft, this Tier 1 program may well cease to exist at UW and be reinitiated in a different state.

Aircraft Reserve Funds

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Routine and Planned Maintenance Reserve Fund:

The turbine engines on the King Air require partial overhaul every 1,800 hours and full overhaul each 3,600 hours. We charge users based upon hours they fly with a contribution to the funds needed for these overhauls. These funds are accumulated in an interest-bearing account at the university. An example of that computation follows.

- A partial overhaul was done at the end of CY 2013 and cost $79,000
- The annual inflation rate for overhaul costs = 3%, and for our interest bearing account =2%
- The research aircraft flies 200 hours per year
- The average cost of partial overhaul = $85K in 2014 based on our market survey
- The average cost of the full overhaul = $650K in 2014 based on our market survey

The resulting prediction is that a full engine overhaul will be due at the end of CY 2022, will cost $848K, and we will have sufficient funds in the Routine and Planned Maintenance Reserve Fund.

Periodically, we look at aircraft utilization and market conditions, and update our prediction of when the overhauls are needed and how much they will cost.

Propeller overhauls typically are done very 6 years, with present cost being $20,000. At a projected rate of 200 flight hours/year, we would fly 1,200 hours, so the hourly cost of the propeller overhaul is then $20,000/1,200=$17/hour which is also charged to the user and accumulated in anticipation of the overhaul.

Currently $350,688 is in this reserve fund, by 2019, the proposed date the new aircraft will be delivered, $615,848 will reside in the fund. Any money existing in this reserve fund will be partitioned between the Routine and Planned Maintenance and Engine Reserve Fund and the new aircraft and the Replacement Aircraft Reserve Fund is practicable.

Replacement Aircraft Reserve Fund:

A new reserve fund, the Replacement Aircraft Reserve Fund, will be created and used for the purchase of the next research aircraft. This reserve fund will be operated over a long period of time, currently estimated to be 30 years. Three major sources of continuing funding, available to the University of Wyoming, will be used to fill the reserve fund, these are: 1) indirect costs paid to the University of Wyoming by the National Science Foundation associated with the Cooperative Agreements allowing the aircraft to be used as a national facility for the nation's meteorology community; 2) fees and indirect costs associated with other, (non-NSF Cooperative Agreement) research that use the aircraft (examples of this are contracts with NOAA, NASA, UCAR, FAA to name agencies that have used the plane in the past), and; 3) funds received by UW for the sale of the existing research aircraft.

UW used the following numbers to estimate the amount that will reside in the Replacement Aircraft Reserve Fund in 30 years. Each year at least $366,000 will be placed into the replacement reserve fund from the collected indirect costs from the NSF Cooperative Agreements and other research missions and fees that use the research aircraft. In year four (FY 2020) proceeds from the sale of the old research aircraft will be deposited into the Replacement Aircraft Reserve Fund. To be conservative we used a sale price of $1 million dollars (what we estimate if the plane was purchased for useable parts; engines, landing gears, control electronics, etc.). Because the university is allowed to hold interest bearing investments we used a 3% interest rate to calculate interest income and a 30 year investment period length. Using these numbers, it is estimated that $19,506,380 will be generated for the purchase of the next research aircraft.

In another analysis using the same number for the annual contributed amount ($366,000), but instead of $1 million dollars as the amount recovered from the sale of the research aircraft, we used $4 million dollars, the analysis resulted in $25,787,714 being generated over the 30 year period.

Both analyses represents a significant accumulation of funding and should cover the cost of the next aircraft.

Requirement:

Footnote 16. ***Not later than October 1, 2015, the university shall report to the joint appropriations interim committee a budget for the cost of acquisition of a replacement research aircraft****, and a plan for the acquisition and operation of the aircraft including revenues anticipated to be credited to the reserve fund and repaid to the state of Wyoming. Proceeds from the sale of the research aircraft, engine or any related research instrumentation shall be credited to the reserve fund.*

Response:

The first step in the process for replacement of the research aircraft is to select and purchase a suitable replacement aircraft. In addition to the aircraft purchase, numerous modifications must be made to the basic aircraft in order to mount, power and control the various scientific instruments required for the atmospheric science research. For the existing UW research aircraft, these modifications and installations were added over a 30 year period to support various scientific studies. The plan is to re-install as much of this existing capability into the new, replacement aircraft, as soon as possible, allowing ongoing studies to be continued in a timely manner.

The plan for replacement of the capability can be broken down into five phases.

1) Purchase of a new aircraft suitable for the intended atmospheric science research.

2) Installation of modifications to the preferred aircraft using existing FAA Approved Supplemental Type Certificates (STC) that support the mission. A **supplemental type certificate** (**STC**) is a national aviation authority-approved major modification or repair to an existing type certified aircraft, engine or propeller. As it adds to the existing type certificate, it is deemed "supplemental."

3) Initial UW STC - Provisions Only – This is an STC for all permanent installations unique to the UW atmospheric science aircraft platform. These installations provide the necessary structural and electrical provisions for future installation of research equipment.

4) Re-installation of the scientific instrumentation from the old research aircraft, modified as required, into the new aircraft. In this interim configuration the aircraft must operate with a Special Airworthiness certificate in the Experimental category since it is has not been certified to operate under a Standard Airworthiness certificate with the research equipment installed.

5) Amended STC – Research Configuration Certified – The Initial STC would be amended to remove the “approval does not include installation of atmospheric research equipment” limitation. In the research configuration, the aircraft would be certified in the restricted category.

1. Preferred Aircraft to Purchase

A wide range of both new and used aircraft are readily available in the marketplace. However, many of these aircraft are not suited to the special needs of the atmospheric sciences research mission. The current research aircraft, a King Air 200 has served the university and the research community well because of its large cabin, adequate useful load and acceptable range. These are the key characteristics required of any aircraft being considered for replacement of the existing aircraft.

A review of potential aircraft which could serve this research role was completed with the following criteria;

Useful Load ≥ 5,000 lbs

Range ≥ 1,700 nm

Cabin Larger than the current aircraft

Price < $9M (unmodified aircraft)

The King Air 350ER (Extended Range) has been the choice for many government, commercial and other special mission's operators in this weight class. The reason for this is clear, the King Air 350ER provides the best useful load, range and cabin size and operates at the lowest cost of all large turboprops and light jets.

Selection of the King Air 350ER will provide almost three more feet of useable cabin length and more than 1,000 lbs of additional payload, and significantly more fuel carrying capability. This comes at an additional cost of $1.4M but in the total budget, with training, spares, and required modifications considered, this is less than a 10% cost increase. The higher acquisition cost is additionally justified by the greatly increased range which will allow more experiments to be completed in less flights which reduces overall operating costs. Therefore, the King Air 350ER is considered to be the preferred replacement aircraft.

Similar to the existing aircraft, it is a twin engine aircraft of conventional arrangement and metal airframe. The aircraft is certified for single pilot operation.

The aircraft uses the very reliable Pratt & Whitney Canada PT6A turboprop engines and is certified in accordance with FAR Part 23 Commuter Category, including day, night, VFR, IFR and flight into known icing conditions.

The design is based on damage tolerance concepts. The airframe is certified damage tolerant (unlimited life) ensuring continuing structural integrity through an inspection program and appropriate maintenance action. Due to the unique operating environment for the UW research aircraft the inspection program and life limits will be continuously evaluated. Importantly, unlimited airframe life is a positive change and will help UW maintain a future research aircraft.

2. **Installation Modifications to Purchased Aircraft**

UW will contract with the following vendors to install the necessary modifications to the new aircraft:

Textron Beechcraft Aviation – provides many of the required elements on the aircraft during manufacture
Avcon Industries Inc. - dual mounting ports for Lidar and radar equipment
Straton Park Engineering Inc. – wiring and mounting points for scientific instrumentation on the exterior of the aircraft
AirMods, LLC – nose extension, nose boom
CenTex Aerospace Inc. - auxiliary fuel tank modifications

3. **Initial STC – UW Modification/Installation (Provisions Only)**

The University of Wyoming will submit an application for a Supplemental Type Certificate (STC) to the FAA Aircraft Certification Office (ACO) which will cover the additional modifications required for the new UW atmospheric research aircraft.

4. **Research Equipment**

The UW Atmospheric Research Aircraft operates as a mission specific platform and as such, the payload, cabin configuration and flight plan are tailored for a particular research objective. This requires a modular and flexible approach to instrument deployment, cabin topology and rack configuration while maintaining FAA certification, conformance and compliance. UW's Research Flight Facility maintains a comprehensive, dynamic array of scientific instrumentation and the appropriate racks and mounting fixtures to support them. This infrastructure is typically used to mount user supplied gear as well, although custom racks and mounting options are available.

5. **Amended STC – Research Configuration Certified Planned Aircraft Operating Limitations**

In many cases for the restricted category, an acceptable level of safety for its intended function would be met by operating the aircraft per the limitations shown in the AFMS. The following limitation are expected;

1) Change in maximum take-off and/or zero fuel weight in some configurations.
2) Only minimum crew essential for research operations shall be carried in the aircraft.
3) Type rating, or letter of authorization, require for pilot in command.
4) The airplane must be identified as "Restricted" per 14 CFR part 45.

Estimated Budget and Cash Flow Timeline

Overall Project Cost

Table 1 – Project Budget Summary

PHASE 1 - NEW AIRCRAFT PURCHASE		
BEECHCRAFT	**Total**	**$ 9,855,540**
PHASE 2 - INSTALLATION OF EXISTING STCS		
SPEC	$ 1,075,533	
AVCON	$ 1,102,648	
CENTEX	$ 191,250	
	Total	**$ 2,369,431**
PHASE 3 - INITIAL UWYO STC		
AirMod	$ 863,610	
Other	$ 168,460	
	Total	**$ 1,032,070**
PHASE 4 - INSTALLATION OF RESEARCH EQUIPMENT	**Total**	**$ 478,000**
PHASE 5 - AMEND STC - FULLY CERTIFIED RESEARCH CONFIGURATION		
	Total	**$ 615,544**
PROJECT COST		$ 14,350,585
Contingency		$ 609,415
Total Project Cost		**$ 14,960,000**
SOURCES		
State of Wyoming		**$ 14,960,000**

Appendix 1.

Below is a list of all upgrades (1991-2011) to the research aircraft using federal government or other external funds. Examination of this list demonstrates that the university has made significant and continuing upgrades to the research aircraft.

Upgrades accomplished in previous cooperative agreements **(*) = Accomplished during current agreement**				
Year	**Upgrade**	**Cost**	**Funding**	**Share**
1988	New data system	$ -	UW/Burec	
1991	Honeywell LaserRef SM INS	$250K	NSF	
1993	Flux upgrade	$135K	UW NASA NSF NSF	40% 28% 3% 29%
1995	95 GHz radar	$800K	ONRCR NSF NSF	50% 36% 14%
1996	New FSSP-100	$30K	UW NSF	50% 50%
1996	New data system (phase I)	$30K	UW NSF	50% 50%
(*) 1999	New data system (phase II)	$169K	NSF UW	30% 70%
(*) 1999	Gerber PVM100	$25K	UW ONR	50% 50%
(*) 1999	DMT LWC	$8K	CA4	
(*) 1999	2DC/2DP diode mods	$8K	CA4	
(*) 2000	New avionics	$550K	NSF UW	20% 80%
(*) 2001	Nadir port	$110K	NASA	
(*) 2002	95 GHz radar pointing options	$25K	NASA	
(*) 2002	Ashtech GPS	$18K	CA4	
(*) 2002	PCASP	$32K	Keck Found.	
(*) 2002	TSI Nephalometer	$99K	Keck F.	
(*) 2002	Magee Aethalometer	$12K	Keck F.	
(*) 2003	Upgraded engines	$363K	UW	
(*) 2005	Upgraded radar altimeter	$36K	UW NSF	49% 51%
(*)2007	Lidar	$120K	UW	
(*)2007	Data system	$120K	UW	
(*)2008	WCR-2	$661K	NSF NASA	36% 18%

			UW	45%
2009	New data system	$130K	UW	100%
2009	Avionics (WAAS)	$30K	UW	14%
			NSF	86%
2009	LI-COR 7500	$17	UW	14%
			NSF	86%
2009	DMT CDP	$39K	UW	14%
			NSF	86%
2009	PCASP SPP200 Upgrade	$13K	UW	14%
			NSF	86%
2009	Fast 2DC CIP upgrade	$35K	UW	14%
			NSF	86%
2010	4-bladed propellers	$80K	NSF/ARRA	100%
2010	XM weather avionics upgrade	$40K	NSF/ARRA	100%
2011	Satellite comm system	$50K	UW	100%
2011	Enhanced avionics	$350K	NASA	100%
2011	Applanix GPS/IMU	$100K	NSF/ARRA	100%
2011	WCR Modulator, front end, IRIG card	$62K	NSF/ARRA	100%
2011	WCR test equipment	$108K	NSF/ARRA	100%