Update, Status, and Implementation of the NOAA Aircraft Plan

Building and Sustaining the 21st Century Fleet

August 2022

National Oceanic and Atmospheric Administration

The 2022 NOAA Aircraft Plan

Building and Sustaining NOAA's 21st Century Fleet

An Update to the 2019 NOAA Aircraft Recapitalization Plan

APPROVED:

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Update, Status, and Implementation
of the
NOAA Aircraft Plan
Building and Sustaining the 21st Century Fleet

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EXECUTIVE SUMMARY

This updated National Oceanic and Atmospheric Administration (NOAA) Aircraft Plan amends NOAA's 2019 aircraft plan entitled, "NOAA Aircraft Plan, Building and Sustaining NOAA's 21st Century Fleet." The 2019 plan presented an integrated approach of near- and longer-term actions to extend and sustain the capabilities of NOAA's Aircraft Fleet. The plan evaluated the status of NOAA aircraft and identified the current and future airborne capabilities required to meet NOAA's public safety, economic, and stewardship missions, and presented a plan for ensuring future airborne data collection needs were met, while minimizing the risk from capability gaps that would negatively impact mission-critical data needs. The plan presented here modifies the 2019 NOAA aircraft plan by accounting for updated information on appropriated funds and ongoing procurements, and provides best practices for managing the aircraft fleet moving forward.

NOAA's aircraft continue to face significant challenges – expanding user demands, age and obsolescence, and finite resources for recapitalization. The goal of this updated plan is to ensure that NOAA meets airborne requirements and fulfills aspirational objectives based on requirements for the nation through the most cost-effective means possible. With this plan, NOAA will update its multiyear strategy to recapitalize and sustain the NOAA aircraft necessary to meet mission requirements as well as additional research and operational objectives. This updated plan includes options and proposals for the procurement of additional aircraft to meet expanding airborne observations, modifies aircraft business and management practices, and outlines initiatives to maximize airborne data collection capabilities. The long-term strategy to sustain NOAA's airborne data collection capabilities includes procurement and instrumentation of new aircraft, as well as maximized utilization of current aircraft, continued development of technology, and partnerships.

There will also be a need to hire, train, and qualify pilots, technicians, and maintainers ensuring proper personnel are in place to support the expansion in missions. NOAA will need to appropriately adjust the number of NOAA Corps and civilian personnel to maximize utilization of current and future aircraft.

In 2016, Conklin & de Decker performed aircraft capabilities requirements, business case analyses, and service life assessments on all NOAA aircraft. Based on this study, as well as historical usage analysis and trending utilization increases, NOAA predicts three of its aircraft will reach or exceed their service life between 2021 and 2030 (*see* Figure 3-4).

This plan identifies an operational requirement by NOAA to procure four C-130 aircraft to replace the two current WP-3D aircraft, one WP-3D aircraft decommissioned in 2018, and one additional aircraft to meet the expanding airborne data requirements and objectives. This plan provides detail on the cost, timeline, and capabilities to replace the current two P-3 aircraft with new C-130 aircraft. The plan goes on to include an assessment of additional data objectives for a third and fourth C-130 - these additional two aircraft would meet user needs that directly feed products and services such as hurricane, atmospheric river, tornado, and ocean wind forecasts. In addition, NOAA will bring on line the King Air funded in FY 2022 and the second G550 funded in 2022 through the Inflation Reduction Act, and procure an additional Twin Otter aircraft. The ability of NOAA to meet expanding taskings could have significant beneficial impacts on public safety, and economic and national security.

NOAA aircraft are critical in the storm genesis phase to help increase vital time for decision-making to protect life and property. Aircraft reconnaissance data from WP-3D aircraft is used by forecasters to improve models and forecasts, refine storm surge and hurricane watches and warnings, and provide better information to core partners. NOAA contracted Analytic Services, Inc. to conduct a WP-3D replacement aircraft workshop that, when combined with other data, provided the analytics necessary for NOAA to complete a WP-3D replacement analysis of alternatives. This analysis outlined costs and benefits for NOAA to acquire WP-3D replacement aircraft, which led to the acquisition strategy presented in this plan. NOAA WP-3D replacement aircraft data would also be instrumental for atmospheric river forecasting and air chemistry studies which cannot be fully met with the current number of aircraft.

The second G550 aircraft (funded in 2022) will directly support hurricane, flood, landslide, transportation, agriculture, and power outage forecasts; support the gravity for the redefinition of the vertical datum (GRAV-D) project essential for floodplain mapping and global positioning system calibration; and support Arctic research, monitoring, and observations.

A fifth Twin Otter would help NOAA meet current and emerging observation data demands. Accurate fire weather; water supply, river and flood forecasting; Northeast right whale distribution and abundance surveying, including monitoring of the impact of offshore wind development; accurate coastal bathymetry and shoreline mapping; and accurate assessments of Alaska harbor seals and Steller sea lions to inform commercial fishing decisions are all reliant on a fifth Twin Otter.

Procurement of the additional King Air aircraft (funded in FY 2022) will meet data requirements for high-resolution mapping, water resource management, air chemistry research, weather forecasting, Arctic monitoring, and remote population surveys. Among other activities, this data is essential for coastal mapping to monitor and adapt to shoreline changes; for aviation charts essential for the aviation industry; and distribution surveys to inform government management decisions, including the Bureau of Ocean Energy Management and the United States Navy.

While the long-term strategy to build and sustain NOAA's airborne data collection capabilities relies on the procurement and instrumentation of new aircraft, it also includes technology investments, business practices, and management initiatives to increase current capabilities. This updated aircraft plan provides specific actions that NOAA will take to maximize the capabilities of the NOAA Aircraft Fleet, including:

- Increasing utilization of NOAA aircraft with additional flight hours and associated personnel
- Employing a service life extension program on aircraft
- Continually developing and integrating emerging technologies
- Using a coordinated, systematic approach across NOAA to leverage uncrewed systems
- Using charter aircraft and data buys when available and advantageous
- Strengthening and leveraging partnerships with other agencies to access their assets and capabilities
- Implementing governance and management initiatives where needed

This updated aircraft plan considers current airborne data requirements, anticipated future objectives and is based on a recent analysis[1] conducted on recapitalization planning, as well as airborne data requirements validation and prioritization, availability of charter assets, and the state of technology for gathering and processing data. The plan provides the options and prioritization of aircraft and capabilities to meet NOAA's mission requirements now and in the future and will support public, national, and economic security.

[1] Analytic Services, Inc. (ANSER), *Research Platform Replacement Analysis of Alternatives: 2021 Update* (NOAA Contract 1305M221PNMAN0110, 2021) (copy available upon request from NOAA OMAO); NOAA OMAO, *Cost-Benefit Analysis of NOAA G-550 Procurement* (Nov. 5, 2020) (copy available upon request from NOAA OMAO); Collection of user requirements by NOAA OMAO (Apr. 2022).

I. Introduction

This plan refreshes information from the National Oceanic and Atmospheric Administration's (NOAA) aircraft recapitalization and sustainment efforts outlined in the October 2019 "NOAA Aircraft Plan, Building and Sustaining NOAA's 21st Century Fleet."

Pursuant to the 2019 plan, NOAA is executing a comprehensive, multiyear effort to recapitalize and sustain NOAA's Aircraft Fleet. This updated plan presents a two-pronged approach to extend and sustain airborne data collection capabilities (current aircraft) while bringing expanded capabilities (new aircraft) online.

Section II of this plan summarizes NOAA's airborne requirements and future aspirational objectives. Section III outlines NOAA's strategy to recapitalize and sustain NOAA aircraft. Budget and schedule estimates provided in this plan are preliminary and will be updated, including the execution of Independent Cost Estimates for the assets, during the program development cycles. Further, NOAA will revalidate the mission requirements identified in this plan, and update the plan as needed based on requirements, technology, and the specialized role of aircraft within NOAA's observational systems.

> NOAA provides a wide range of specialized airborne environmental data collection capabilities vital to understanding the Earth, conserving and managing coastal and marine resources, and protecting lives and property.

II. The Need to Fly – Airborne Requirements

NOAA is America's environmental intelligence agency. From the surface of the sun to the depths of the ocean floor, NOAA is responsible for predicting and monitoring the changing planet. NOAA aircraft are an essential element in a complex network of observational tools (e.g., satellites, radars, aircraft, ships, gliders, floats, and buoys) which serve as the foundation for the environmental intelligence they provide. Each day, nearly every American relies on the data, products, and services NOAA provides. Through its network of observations, models, forecasts, and assessments, NOAA continually provides environmental information to citizens, planners, emergency managers and other decision-makers with the reliable information they need, when they need it.

NOAA flies missions ranging from hurricane reconnaissance and surveillance, atmospheric rivers, and tornado missions to provide timely and accurate weather and water forecasts, as well as life-saving watches and warnings. NOAA conducts snow surveys using gamma radiation remote sensing to obtain soil moisture and snow water equivalent measurements for flood forecasts, watches and warnings, river level forecasts, and drought outlooks in 37 states and eight Canadian provinces. Snow surveys have been conducted for more than two decades and are critical to the success of NOAA's hydrologic services mission. NOAA aircraft support mapping, charting, and geodesy for developing accurate and updated nautical charts which support safe navigation in America's seaports.[2] Data collected by NOAA aircraft are critical for monitoring and responding to climate-induced changes including movement of fish and marine mammals. When there is a natural disaster, imagery from emergency response flights of hurricane damage can be processed by NOAA's National Geodetic Survey immediately upon the aircraft landing and posted online for public access. Data from aircraft are transmitted via satellite for assimilation into

[2] AM. ASS'N. OF PORT AUTHS., INFRASTRUCTURE 2-PAGER, https://www.aapa-ports.org/files/PDFs/Infrastructure2pager.pdf.

weather models and use by forecasters. NOAA aircraft data directly support Department of Defense decisions such as aircraft repositioning and ship routing, commercial development such as offshore wind, and other defense and energy development projects. All standard aircraft instrumentation data is available through NOAA's National Centers for Environmental Information.

NOAA's world-class workforce instrument, maintain, and operate a fleet of highly specialized aircraft in support of national and economic security, and changing environmental conditions. Even during the COVID-19 pandemic, NOAA quickly developed and adhered to rigorous protocols to ensure national needs, such as accurate hurricane and water forecasts, were delivered. NOAA worked collectively to develop scripts and procedures to deliver and process data in different ways during COVID, ensuring the mission requirements were met while keeping people safe.

Capacity Requirements

Airborne data and mission activity requirements determine total flight hour (capacity) requirements. The airborne activities conducted to support NOAA's missions drive the requirement for flight hours on NOAA aircraft. The table below shows the total number of aircraft hours per year flown by NOAA from 2008 through 2021. It is important to note the composition of the NOAA aircraft fleet has changed over this timeframe as NOAA has worked to consolidate the types of aircraft into the current fleet of four types of aircraft to most efficiently meet airborne requirements. NOAA aircraft are near capacity; adding new additional aircraft, such as the third King Air currently in production, will provide needed capacity.

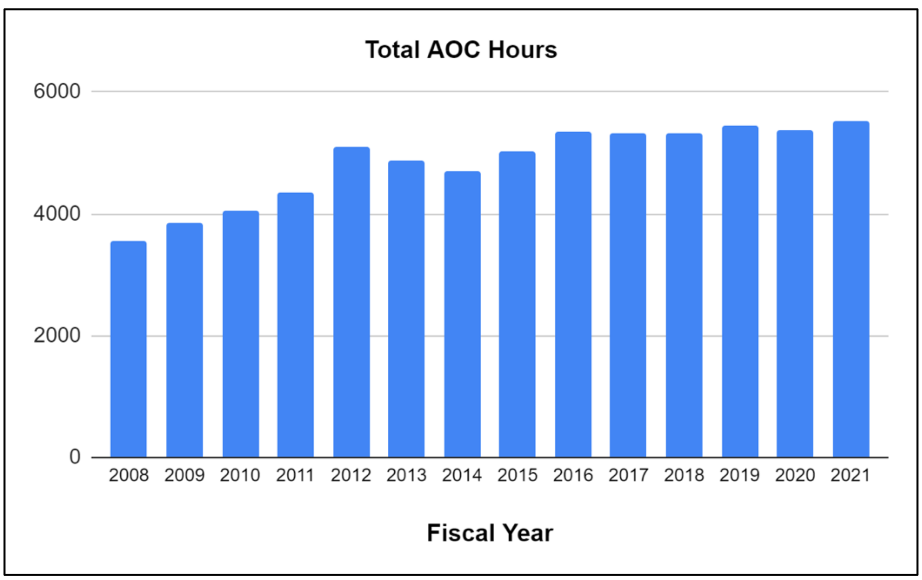


Figure 1-1: Total Flight Hours all NOAA Aircraft[3]

[3] The WP-3D aircraft were alternately in Standard Depot Level Maintenance (SDLM) in 2011- 2013 (N42RF in SDLM June 2011 – May 2012, and N43RF in SDLM June 2012 – May 2013). During this time, NOAA operated one WP-3D aircraft to the extent possible.

Overall, the demand for NOAA aircraft and aircraft hours have increased during the past twelve years, most notably on the WP-3D aircraft. The increase in hurricane hours on the WP-3D from 2015 to present was partially driven by the requirement of Tail Doppler Radar (TDR) as noted in the NHOP into operational hurricane forecasts beginning in 2015. TDR data was first assimilated in the HWRF) in 2013. The WP-3D aircraft are at capacity and NOAA cannot fly any additional hours on these two aircraft. Figure 1-2 shows the increase in NOAA WP-3D flight hours from 2008 through 2021.

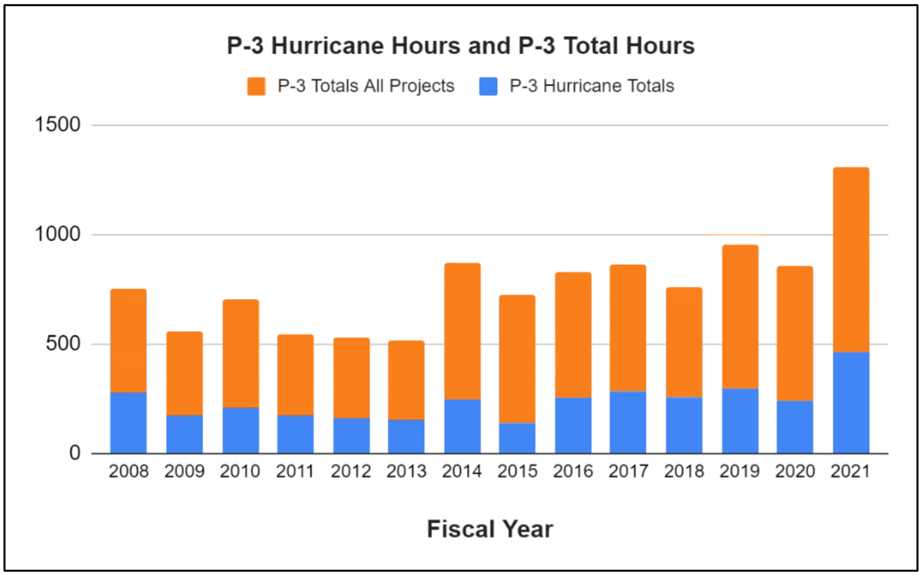


Figure 1-2: Total Flight Hours all NOAA WP-3D aircraft[4]

The maximum utilization of a WP-3D (or WP-3D replacement aircraft) is 400 program flight hours per year based on training and maintenance requirements. New C-130 aircraft will be capable of flying up to 600 mission hours per year with two crews per aircraft. The current level of tasking is not sustainable; NOAA has started hiring a third WP-3D crew with FY 2022 appropriations. NOAA will require additional C130J aircraft to meet forecasted demands. Despite the more limited crew and aircraft availability, NOAA continues to dominate hurricane tasking. The proportion of hurricane tasking by aircraft (NOAA's WP-3Ds and the U.S. Air Force's C-130s) and crew is shown in Figures 1-3 and 1-4.

[4] The WP-3D aircraft were alternately in Standard Depot Level Maintenance (SDLM) in 2011- 2013 (N42RF in SDLM June 2011 – May 2012, and N43RF in SDLM June 2012 – May 2013). During this time, NOAA operated one WP-3D aircraft to the extent possible.

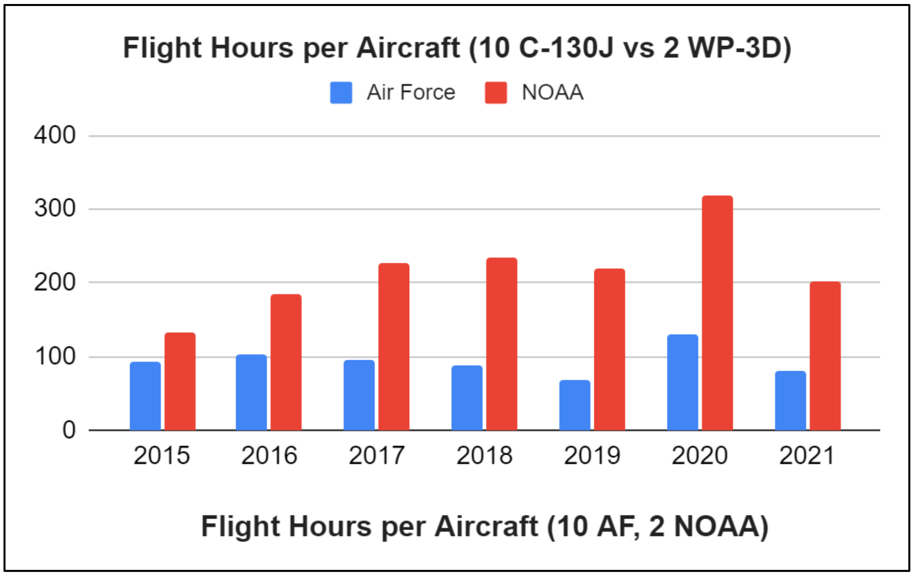


Figure 1-3: Number of Hurricane Reconnaissance Flight Hours by Aircraft by Calendar Year

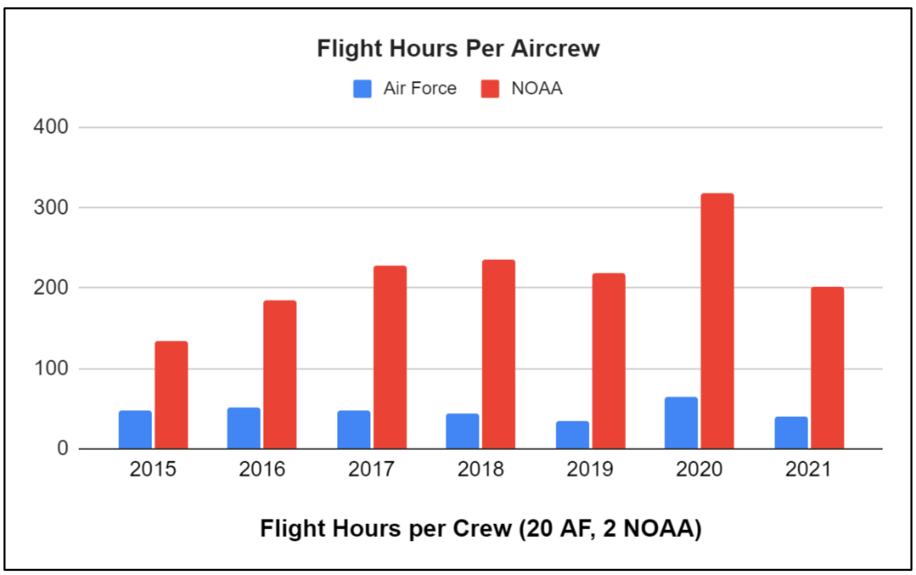


Figure 1-4: Number of Hurricane Reconnaissance Flight Hours by Aircrew by Calendar Year

The following describes contributing factors to the demand for NOAA WP-3D hurricane tasking relative to the USAF mission responsibilities as defined in the National Hurricane Operations Plan.

- Increased utility of tail Doppler radar and other reconnaissance data in numerical weather prediction models.
- Blanket overflight clearance with Cuba to fly within their airspace. Foreign aircraft are prohibited from encroaching or entering Cuban airspace, including the disputed areas over international waters, except when permission has been granted explicitly by the Cuban government. The agreement with Cuba provides NOAA permission to fly in Cuban airspace and collect data in a very important region for tropical cyclone intensity and track changes. The

(USAF) aircraft do not have this clearance. Data collected by NOAA WP-3D aircraft over Cuba during several hurricanes, including Hurricane Irma, were key to accurate forecasts for U.S. landfall. The inability to collect aircraft data over Cuba would have a detrimental impact on forecast accuracy.

- NOAA utilizes a full-time active-duty uniformed service, the NOAA Commissioned Officer Corps, dedicated to the hurricane hunting mission and providing personnel at all times during the year to fly as tasked. The Air Force utilizes a reserve squadron, focusing personnel duty assignments on the peak of the hurricane season. Reserve officers serve in other full-time careers when not on reserve duty.
- NOAA aircraft have also flown numerous "double duty" missions. NOAA has the unique capability to transition from an assigned research mission to an operational mission while in flight. This enables NOAA to meet emergent requirements to fix the center of the tropical cyclones as required by the National Hurricane Center that otherwise would have been missed. This ability to fly both operational and research missions in a single flight is only possible on NOAA aircraft due to specific instrumentation, technicians on the aircraft, embedded engineers and sheet metal expertise to build and certify research instrumentation, scientific expertise to operate instruments and process data, systems to ingest data, and bandwidth capabilities to transmit data near real-time. This capability results in only one aircraft in the storm environment, meaning fewer flight hours and airframe maintenance, fuel cost savings, and ultimately longer service life of the airframes. NOAA will continue this capability in the next generation of aircraft. It is unknown if other non-NOAA aircraft will modify their respective concepts of operations to adapt to both reconnaissance and research dual missions and flexibility. The National Hurricane Operations Plan (NHOP) clearly defines the responsibilities of the Department of Defense (DOD) and Department of Commerce (DOC) in meeting the nation's tropical cyclone warnings and forecasts. Currently, DOC is the only agency in the nation with the stated responsibility, and capabilities, to conduct research flights.[5]

To ensure availability of appropriate capabilities, NOAA continually assesses current and emerging data and aircraft objectives through user meetings, the annual aircraft request process, and the NOAA Fleet Council. The mission and measurement requirements are documented in the NOAA Consolidated User Requirements List, or COURL, and were updated in April 2022 through user input. Data objectives and requirements are developed by users and Subject Matter Experts, validated through the acquisition processes, and ultimately acted upon through the annual budget and annual operating plans such as the National Hurricane Operations Plan (NHOP) and the National Winter Season Operations Plan.[6] The demand for data from NOAA aircraft for critical products and services has been growing in key areas including hurricane forecasting, atmospheric rivers, snow surveys that inform water supply and spring flood forecasting, fire weather, marine mammal assessments, mapping and charting, and Arctic heat. The capacity to meet all the data demands significantly exceeds the capacity available on current aircraft. These growing airborne data requirements, summarized in Table 1-1 and discussed in the following paragraphs, drive the need for additional aircraft. The requests in the table capture the full need of each mission within constraints of seasonal impacts (e.g. the hurricane reconnaissance need is defined within the six month window).

[6] INTERAGENCY METEOROLOGY COORDINATION OFFICE, FCM-P13-2022, 2022 NATIONAL WINTER SEASON OPERATIONS Plan (2022), https://www.icams-portal.gov/resources/ofcm/nwsop/2022_nwsop.pdf.

Aircraft	Missions	Task	Projected Flight Hour Objectives			
			FY 2022 Flight Hours Requested	FY 2022 Flight Hours Scheduled	FY 2030 Scenario All User Requests	Unmet Requests in FY 2030 without recap
WP-3D/C-130J (Max utilization 400 mission FH/aircraft with single crew[7])	Weather Forecasting, Research, and Modeling	Hurricane Reconnaissance	350 FH 6 months	350 FH 6 months	1000 FH 18 months (3 AC x 6 months)	1000 FH 18 months (3 AC x 6 months)
		Hurricane Research	305 FH 6 Months + 2 months field campaign	115 FH 6 months	305 FH 6 Months + 2 months field campaign	305 FH 6 Months + 2 months field campaign
		Atmospheric Rivers[8]	0	0	480 FH 10 months (2 AC X 5 months)	480 FH 10 months (2 AC X 5 months)
		Ocean Winds winter and summer	150 FH 3 months	94 FH 1.5 months	500 FH 4 months (2 AC X 1 month + 1 AC X 2 months)	500 FH 4 months (2 AC X 1 month + 1 AC X 2 months)
		Tornados	100 FH 1.25 months	100 FH 1.25 months	300 FH 4 months	300 FH 4 months
		Air Chemistry	160 FH 3 months	0	200 FH 2 months	200 FH 2 months
	Charting and Surveying	Long Endurance GRAV-D	330 FH 3 months	245 FH 2 months	100 FH 1 month	100 FH 1 month
		Coastal Mapping	0	0	300 2 months	300 FH 2 months
G-IV/G550 (Max utilization 600 mission FH/aircraft)	Weather Forecasting, Research, and Modeling	Hurricane Surveillance	200 FH 6 months	105 FH 6 months	600 FH 12 months (2 AC X 6 months)	0
		Hurricane Research	155 FH 6 Months + 2 months field campaign	72 FH 6 months	155 FH 6 Months+ 2 months field campaign	0
		Atmospheric Rivers	200 FH 2.5 months	130 FH 1.5 months	640 FH 10 months	240 FH 3 months
	Charting and Surveying	GRAV-D	200 FH 6 months	130 FH 2 months	See WP-3D	See WP-3D
Twin Otter (Max utilization 750 mission FH/aircraft)	Weather Forecasting, Research, and Modeling	Snow Survey	700 FH 12 months	298 FH 6 months	700 FH 12 months	400 FH 5.5 months
		FIREX	160 FH 1.5 months	105 FH 1 month	170 FH 2 months	65 FH 1 month
		Air Chemistry	175 FH 1.5 months	0	175 FH 1.5 months	175 FH 1.5 months
		Arctic Heat	100FH 1.5 months	66 FH 1.5 months	100FH 1.5 months	45 FH

[7] The C-130Js can fly 600 mission FH/aircraft with two crews based on reduced maintenance requirements as compared to existing 50 year-old P-3 aircraft.

[8] The USAF flies AR with C-130 aircraft. The request for outyear flight hours and geospatial coverage will require a combination of USAF C-130 and NOAA C-130 aircraft.

Aircraft Type	Missions	Task	Projected Flight Hour Objectives			
			FY 2022 Flight Hours	FY 2022 Flight Hours	FY 2030 Scenario All	Unmet Requests in FY 2030
	Charting and Surveying	Coastal Mapping / Post-Disaster Mapping	600 FH 10 months	600 FH 9 months	1200 FH 15 months (1 AC X 12 months + 1 AC X 3 months for ER)	600 FH 6 months
	Assessment and Management of Living Marine Resources	Right Whale (NE)	550 FH 11.5 months	550 FH 7.5 months	800 FH 18 months (1AC X 12 months + 1 AC X 6 months)	250 FH 6 months
		Right Whale (SE)	300 FH 4 months	0	300 FH 4 months	300 FH 4 months
		AMAPPS (NE/SE/GOM)	240 FH 3months	220 FH 3 months	240 FH 6 months	40 FH 3 months
		AK Harbor Seals	140 FH 1.5 months	140 FH 1.5 months	160 FH 4 months	20 FH 2.5 months
		AK Steller Sea Lions	70 FH 1 month	70 FH .75 month	70 FH 1 month	0
		West Coast Turtles	100 FH 2 months	100 FH 2 months	100 FH 1 months	0
		GOM Sea Turtles	45 FH 0.5 months	45 FH 0.5 months	45 FH 0.5 months	0
King Air (Max utilization 1000 mission FH/aircraft)	Weather Forecasting, Research, and Modeling	Snow Survey	600 hours 12 months	340FH 6 months	800 hours 15 months (1 AC X 12 months + 1 AC X 3 months)	450 hours 9 months
		SPLASH	45 FH 0.5 month	45 FH 0.5 month	45 FH 0.5 month	0
	Charting and Surveying	Coastal Mapping / Emergency Response	600 hours 10 months	500 FH 9 months	1100 hours 15 months (1 AC X 12Months + 1 AC X 3 months)	600 hours 6 months
		Grav-D	350 hours 6 months	350 FH 3.3 months	200 hours 2 months	0
	Assessment and Management of Living Marine Resources	Ice Seals	250FH 1.5 Months	0	250FH 2 Months	0

Table 1-1: Current and Projected Requests by Aircraft Type, Mission, and Task

To meet airborne requirements most efficiently, NOAA uses four types of aircraft. Meeting prioritized airborne requirements consists of a combination of flight hours (FH) and calendar time (months). For example, the WP-3D and G-IV aircraft are on stand-by for tropical cyclone tasking for the duration of the hurricane season, June 1 – November 30. During this time the aircraft have limited availability to support other missions, such as focused tropical cyclone research campaigns[9], air chemistry, and GRAV-D, as they must be available to deploy into a tropical cyclone within 24 hours of a tasking per the NHOP. Available capacity must also account for maintenance and training requirements which place aircraft out of operation to meet these tasks. The capacity requirement is based on a combination of FH and calendar time as reflected in Table 1-1. In FY 2022, the difference between the requested hours and actual scheduled hours based on funding and aircraft availability is as follows: Twin Otters (1009 FH); King Airs (610 FH); WP-3Ds (491 FH); and the G-IV (318 FH). Based on projected objectives in 2030, as summarized in Table 1-1, NOAA aircraft capacity gaps will continue to expand.

The number, and sequence, of aircraft in this plan is prioritized based on requirements: two C130 aircraft are requested to replace the current two WP-3D aircraft while a third and fourth will increase redundancy and backup capability as well as provide capacity for high priority weather forecasting projects (as listed in Table 1-1), required maintenance, and training. The King Air appropriated in FY 2022 and the second G550 supported in the 2022 Inflation Reduction Act will largely meet the unmet requirements listed in Table 1-1. NOAA will also continue to work with partners, charters, and leverage uncrewed systems to meet airborne requirements.

Maximum utilization of all aircraft and new aircraft per the timeline proposed in the plan will mitigate the existing and future unmet objectives. Execution of the Aircraft Plan, as proposed in Figure 3-2 and 3-3, will reduce the unmet requirements in 2030 (based on Table 3-1) to the following extent:

Aircraft	FH	Months
2 WP-3D Replacements	2430	33.5
3rd WP-3D Replacement	1830	24.5
4th WP-3D Replacement	1230	15.5
2nd G550	350	4
Twin Otter	0	0
King Air (2022 appropriation)	0	0

Table 1-2: Unmitigated Flight Hours and Months in 2030 by Aircraft Type with Recapitalization

NOAA cannot meet anticipated demand for future data objectives with two, three, or four WP-3D replacement aircraft. **In fact, based on an independent analysis by Analytic Services, Inc. (ANSER) in 2021,[10] the probability of satisfying at least 75 percent of tropical cyclone reconnaissance flight hour**

[9] Tropical Cyclone field campaigns require a dedicated effort at a remote location (i.e. Africa or Japan) for 4-6 weeks planned many months is advance. These are often multinational, multi-agency campaigns to which the NOAA Hurricane Hunters bring a unique capability and data set not otherwise obtained.

[10] ANSER, *supra* note 1.

requirements in the future with three aircraft is 32 percent and with four aircraft is 85 percent; it is only 2 percent probable with two aircraft. This analysis focused on NOAA requirements and capabilities; it assumed the USAF capacity and capabilities continued in a steady state. ANSER's study used historical data from 2000 to 2019 to make assumptions about the number of tropical cyclones NOAA will need to respond to in the future.

More specifically, two WP-3D replacements (C-130s) would allow:

- Two C-130s would replicate the current NOAA WP-3D capability with the ability to provide two recon flights per day into a single tropical cyclone or disturbance. This posture will maintain the status quo with two reconnaissance flights by NOAA aircraft per day during TC activity. Additional crews could allow a situational ability to fly recon into multiple storms with one aircraft each, but with reduced temporal coverage, as long as there are no maintenance or training issues to address. Any lack of availability of aircraft due to maintenance or training could result in missed fixes, however having new rather than nearly 50-year-old aircraft is expected to increase availability.
- In a scenario with two land-threatening hurricanes, two NOAA C-130s would allow for two NOAA reconnaissance flights per day into one storm, maintaining the current capability for NOAA to provide NOAA aircraft data for two out of four forecast cycles per day in a single storm. However, this would leave the second storm with limited NOAA recon data, unless additional crews allow a situational ability to fly NOAA recon into multiple storms with one aircraft each. This posture however increases risk of reduced temporal coverage and no backup aircraft if maintenance problems occurred, and aircraft would not be available for any other missions, to include hurricane field research, during hurricane season.
- There is a growing need for public seven-day track and intensity forecasts of tropical cyclones (TC) for multiple users, including the marine commerce and transportation sector. Currently, aircraft data are having positive impacts on track and intensity forecasts in model guidance out through day seven. If WP-3D replacements are not acquired, some of the impact of these data, including TDR, would be lost. As forecasts extend from five to seven days, additional aircraft will be needed to fly storms earlier and at an increasingly large geographic range (farther east, farther offshore), to collect critical data.
- Longer lead time for TC forecasts will be imperative as coastal populations and infrastructure continue to grow and evacuation decision times increase.
- More accurate TC hazard information at longer lead times are particularly valuable as storm surge vulnerability increases in magnitude alongside the exposure of new coastal areas to storm surge risk as a result of a warming climate and sea level rise.
- The replacement planes would allow for continued flying of two to three non-hurricane missions per year (outside hurricane season), dependent on aircrew availability, maintenance and training requirements.
- The two WP-3D replacements would provide little to no capacity to support Atmospheric Rivers (AR) tasking; NOAA would continue to rely solely on USAF to support AR.

Three WP-3D replacements would allow:

- Three C-130s would expand beyond the current NOAA WP-3D hurricane capability in multiple ways. First, it would allow increased temporal and spatial coverage of a single TC, including nearly continuous coverage for all four forecast cycles per day, and partial coverage of a second storm which is not possible with current WP-3D aircraft and crews. Second, three aircraft would allow coverage of two simultaneous storms to collect critical data. For example, it would allow simultaneous coverage with NOAA aircraft for hurricanes threatening the continental United States (CONUS) and Hawaii, which is currently not possible. The additional aircraft would also increase the capability to simultaneously fly research and operational missions with NOAA aircraft, which is limited now due to aircraft resources.

- In a scenario with two land-threatening hurricanes (e.g., one in the Gulf of Mexico and another approaching Hawaii), three NOAA C-130s would allow for two NOAA recon flights per day into one of the two storms and at least one flight per day into the second storm (or possibly a second flight into the second storm with an increase in crews). This would expand the ability to collect NOAA data, to more than one storm simultaneously, potentially increasing forecaster situational awareness and track and intensity forecast model performance assuming future NOAA aircraft will have expanded instrumentation, bandwidth, and the current concept of operations.
- One NOAA aircraft may be available to support Research flights and test research equipment, depending on the prioritization of other non-hurricane and AR missions.
- NOAA could also continue flying three non-hurricane missions per year (outside hurricane season), dependent on aircrew availability, maintenance, and training requirements.
- One NOAA aircraft may be available to support AR depending on prioritization of other non-hurricane missions.

Four WP-3D replacements would allow:

- Four C-130s would ensure consistent (four cycles per day) presence of NOAA aircraft recon in any land-threatening TC.
- Four aircraft are required to collect data in concurrent storms across the National Weather Service TC Areas of Responsibility (AOR) (i.e. one TC near landfall and one pre-genesis or one storm threatening the CONUS and another near Hawaii) to provide accurate model and forecast guidance for multiple TCs.
- In a scenario with two land-threatening hurricanes (e.g., one in the Gulf of Mexico and another approaching Hawaii), four NOAA C-130s would allow for two NOAA recon flights per day into both storms, greatly expanding the ability to collect NOAA data.
- Expand research tasking during breaks in operational tasking to complete highly beneficial research modules that inform TC understanding, instrumentation development, and forecast improvements.
- NOAA also anticipates improved model forecasts of AR position, strength, and structure and associated rain and snow over the U.S. West Coast,[11] as well as improved forecast skills at longer lead times for ARs (up to eight days) for flood evacuation guidance and water management.[12]
- It would also permit for simultaneous projects outside of hurricane season (see below) that are currently not possible with only two aircraft due to aircraft availability maintenance or training. As noted above, this would be limited with three aircraft, as well.

[11] More than 90 percent of all flood damage in West Coast states over the past 40 years was due to ARs. Changes in climate are expected to double or triple these damages in coming years.

[12] Aircraft recon data in ARs enabled reservoir management to retain 20 percent more water than possible without AR forecast improvements providing water for 20,000-30,000 households for a year during the third driest year on record in central CA. Reservoir management based on AR forecasts being expanded to WA. Expanding AR recon to include the Western Pacific from November 1-March 31 annually to increase AR forecast accuracy, especially for long lead times.

- Collecting critical aircraft recon data for satellite calibration, validation, and product improvement in TCs and during North Atlantic winter storms through dedicated aircraft time.
- Capacity for improved forecasts and warnings for tornados through data collection during tornado-genesis to understand novel quad-doppler velocity of inflow and outflow boundaries around mesoscale convective complexes using Compact Raman Lidar (CRL) and cloud physics data.
- Validate and augment microscale climate data collected by uncrewed aircraft systems around severe storms to transition these systems to operations.
- Data collection on lake effect snow and cloud microphysics events for super-cooled icing during winter months to improve weather models, forecasts, and warnings.
- Capacity to support continuing GRAV-D quality control and international partnership requirements during hurricane season.
- Collecting aircraft recon data to inform global monitoring and chemical science campaigns that inform public health planning and decisions related to air quality. These deployments are currently not possible with only two aircraft, and would be limited with three aircraft.
- In addition to air quality and fire weather, a third and fourth aircraft will be required to support the Congressionally-directed multiyear Earth radiation budget (ERB) initiative to investigate natural and human activities that might alter the reflectivity of the stratosphere and marine boundary layer, and the potential impact of those activities on the Earth system. The NOAA WP-3D is well suited to meet ERB objectives for studying the marine boundary layer.

This analysis assumes NOAA C-130s will be equipped with the same instrumentation that the NOAA WP-3D aircraft currently have, and that the USAF C-130s will continue operations with their current capabilities and capacity. This assumption is based on the historical factor that TDR data is unique to NOAA aircraft and provides a comprehensive 3-D view of storm structure that complements other reconnaissance data and improves intensity forecasts. While USAF is considering technology modernization investments that would adapt technologies currently on the NOAA aircraft (i.e. doppler radar) it is too soon to determine the capabilities in the 2030s when the NOAA replacement aircraft need to be on-line. NOAA and the USAF operating the same aircraft type (C-130s) has significant advantages for the nation that will be leveraged; these advantages are discussed in detail in Section III.

The second G550 will:

- The second G550 will increase forecast accuracy of concurrent TCs in the same AOR and different AORs (e.g., TCs threatening the CONUS and Hawaii simultaneously).
- It will support targeted data collection far from a specific TC to address long-range forecast sensitivities (e.g., NE Pacific targeting for long-range North Atlantic CONUS threats).
- NOAA further anticipated improved model forecasts of AR position, strength, and structure and associated rains and snow over the U.S. West Coast.
- Improved forecast skills at longer lead times for ARs also support flood evacuation guidance and water management.[13]
- NOAA will also be able to meet the Congressionally-directed ERB objectives for studying the stratosphere.

[13] Minghua Zheng et al., *Improved Forecast Skill Through the Assimilation of Dropsonde Observations from the Atmospheric River Reconnaissance Program*, " 126 J. GEOPHYSICAL RESEARCH ATM. 21 (2021).

The fifth Twin Otter would allow for:

- The fifth Twin Otter would support expanded snow density surveys and expand to under-covered areas in Alaska.
- It would also allow for expanded survey of critically endangered North Atlantic right whales for mandated management responsibilities. The NOAA Twin Otters are the most effective and safest platform to provide the data that directly impacts commercial and recreational fishery decisions, maritime shipping and transportation, and offshore development.
- Additional capabilities for the Atlantic Marine Assessment Program for Protected Species inform models of assessed species which informs regulations and actions related to federal and private industry offshore operations.
- Improved weather, wildfire, smoke, and air quality forecasting products will support first responders and air quality managers.
- NOAA will be able to provide timely assessments from 12 stocks of harbor seals impacted by human activity and development, and critical to USN operations and monitoring impacts. There is only a four-week survey window for pupping and molting. Two Twin Otters operated simultaneously are required to survey both activities and provide a complete data set.
- Annual monitoring of endangered Steller sea lion populations is depended upon by the North Pacific Fishery Management Council for commercial fisheries management. Recent heat waves and climate change have caused impacts on marine mammals, birds, and fish requiring additional surveys. The ninety-four percent decline of the westernmost population requires increased monitoring for mitigation efforts that directly impact fisheries when survey requirements are not met.

Data Requirements

NOAA aircraft collect data across the full NOAA portfolio as described below. This section describes the specific mission and activity areas that require airborne data to deliver products and services to the nation. NOAA aircraft collect the data to support the NOAA missions of: Charting and Surveying, Assessment and Management of Living Marine Resources, Weather Forecasting, Research, and Modeling, and Emergency Response.

Charting and Surveying – NOAA promotes safe and efficient transportation and commerce through hydrography, shoreline mapping, and nautical charting. In 2019, the marine economy contributed $397 billion to the gross domestic product (GDP) and supported 2.4 million jobs, growing at a pace that outstripped the U.S. economic growth as a whole. By 2030, global growth is projected to reach $3 trillion.[14] NOAA aircraft data are fundamental to supporting safe navigation and coastal intelligence that are the foundation for community resilience now and in the future. Investments into the nation's marine transportation infrastructure system will vastly increase the need for responsive and accurate charting products. This requires NOAA aircraft map the shoreline and nearshore bathymetry, and contribute to the requirement for the additional King Air and Twin Otter to meet expanding requirements for updating nautical charts for safe navigation in the nation’s waterways and ports. Present Twin Otter aircraft capabilities are insufficient to meet the coastal bathymetry, shoreline, and stereo mapping requirements for 15-year cycle near shore bathymetry and five-year port bathymetry. Current airborne capabilities limit NOAA to a 20-25-year cycle for shoreline and nearshore bathymetry. NOAA is currently maintaining a

[14] NOAA, Story Map: Our Dynamic Marine Economy: An Updated Look at Its Value, https://www.noaa.gov/stories/story-map-our-dynamic-marine-economy (last visited June 9, 2022).

five-year cycle on shoreline mapping for ports, but that requirement is changing (shortening) with increased port expansion and maritime commerce. NOAA currently updates 57 ports (33% of the United States' 175 ports) per year; the metric is moving towards doing all 175 ports each year. This deficiency results in increased risk for safe navigation, a problem exacerbated by the rapid growth of maritime commerce and development of coastal areas. The third King Air aircraft funded in the FY 2022 appropriation will provide capabilities and capacity towards this requirement.

Data is required for not only these periodic and planned surveys, but for emergency response mapping as well.[15] NOAA has responded to 17 emergency events over the past five years and is the imagery provider of choice for the Federal Emergency Management Agency (FEMA). NOAA has recurring mission assignments from FEMA and receives many inquiries from the agency for emergency response imagery. Most recently, FEMA requested NOAA support in capturing imagery of the wildfires in New Mexico during the first week of May 2022.

Having accurate maps of coastal and nearshore regions of the nation is critical to informing resource management, domain awareness, safety, and security of coastal communities and the nation's Blue Economy. NOAA has been appropriated more than $40 million through recent hurricane supplementals[16] to provide coastal mapping data – this has increased the size, scope, and location of required mapping needs.

NOAA Aircraft imagery of Bayou Lafourche following Hurricane Ida

The requirement for charting and surveying was demonstrated shortly after the eye of Hurricane Ida (2021) devastated the working waterway that leads inland to Port Fourchon, LA. NOAA aircraft collected high-resolution imagery over more than 32,000 square kilometers to document damage and provide detailed information for port operations, emergency management, businesses, and the public. An example of the images collected by NOAA aircraft is shown here. This data, provided to federal agencies including the United States Army Corps of Engineers and the USN Supervisor of Salvage and Diving, as well as state and local agencies, was essential to safely resuming maritime operations in the port. The imagery from NOAA aircraft also identified the location and extent of oil sheens, a particular challenge in the vicinity of Hurricane Ida landfall given the 18,000 miles of decommissioned oil and gas pipelines and the importance of fisheries in the area.[17]

- **Navigation, Observations and Positioning**: NOAA produces physical oceanographic and geodetic observations and applications for safe and efficient marine commerce along America's oceans, coasts, and Great Lakes. This includes airborne gravimetry essential for establishing an accurate reference surface for determining heights (elevations). This foundational data informs many

[15] NOAA, National Geodetic Survey, Emergency Response Imagery, https://storms.ngs.noaa.gov/ (last visited June 9, 2022).

[16] 2017 Harvey, Maria, Irma: $12.5; 2019 Florence, Michael, Yutu: $24M; 2022 Ida: $4.7M.

[17] *Dozens of Groundings and Sinkings Block Louisiana's Island Waterways*, THE MARITIME EXEC., Sept. 9, 2021, https://www.maritime-executive.com/article/dozens-of-groundings-and-sinkings-block-louisiana-s-inland-waterways.

other NOAA products and services including hazard and inundation forecasting, emergency response, habitat restoration, fishing, recreation and coastal energy development.

NOAA supports the GRAV-D project with the WP-3D, G-IV, and King Air aircraft. GRAV-D is a multi-year project to produce next generation datums. Datums underpin all position data in our country and are an essential component of the National Spatial Reference System. GRAV-D will provide accurate vertical heights throughout the United States within two centimeters that serves as the baseline for nation-wide flooding maps. While the goal to release the modernized National Spatial Reference System (NSRS) was 2022, the timeline is delayed due to budget, COVID-19, and staffing. GRAV-D is a keystone project that must be completed to develop the NSRS products and services; GRAV-D is limited by access to capable and affordable aircraft of which the NOAA King Airs are among the most efficient platforms for the mission. Support by NOAA aircraft will be required indefinitely to complete the project and perform updates once the baseline data collection is completed.

- **Coastal Science and Assessment:** NOAA delivers data and consistently expands the nation's readiness for disaster response and management, protection, and restoration of ocean and coastal resources. Coastal managers rely on this data to guide communities in managing ocean space, anticipating and responding to climate change, and protecting fisheries and drinking water from harmful algal blooms and other contaminants. NOAA mapping, charting, and geodesy activities will see exponential growth in the next ten years to inform data-driven decisions for infrastructure improvements and community resiliency. Meeting these demands and responding to natural disasters will require specialized aircraft with the latest sensors to observe the environment geospatially. This will require aircraft with the capability to carry multiple passive and active sensors, provide real time wideband telemetry, and possess the capability to survey across all U.S. interests including the Pacific, Alaska, and the Arctic.

Assessment and Management of Living Marine Resources – NOAA is responsible for the stewardship of the nation's living ocean resources and their habitat. Timely, geographically-driven, and capabilities-dependent access to the sea supports the sustainability and economic value of fisheries; ensures the resiliency of fishing communities and working waterfronts; protects and recovers threatened and endangered species; and maintains and restores healthy coastal habitats for living marine resources.

Airborne data are essential to the accomplishment of assessment and management of living marine resources. Uncertainty about the abundance of protected species populations can impact fishery quotas. By law,[18] poorly-assessed protected species populations require the regional fishery management councils to make more conservative harvest decisions when managing fisheries that potentially affect protected populations. The impacts of these decisions in places where protected marine species co-exist with large-scale commercial fisheries, such as Alaska, can be significant. The requirement for this data has increased with movement of fish and marine mammal stocks, offshore wind development, defense and energy development projects, and changes in climate. For example, the westernmost portion of the Steller sea lions' range has declined ninety-four percent in the last forty years, requiring increased monitoring to inform modeling-based mitigation and direct impact on commercial fisheries management decisions.

[18] Magnuson-Stevens Fishery Conservation and Management Act, 16 U.S.C. §§ 1801-1882 (2018).

- **Protected Resources, Science, and Management:** NOAA assesses threatened and endangered marine and anadromous species and the ecosystem that sustain them to develop and implement best practices and conservation actions to reduce threats to protected species and their marine ecosystems.

- **Fisheries Science and Management:** NOAA manages marine fisheries, including aquaculture, using the best available science resulting in sustainable fisheries harvest and production, rebuilding of depleted fish stocks, conservation and restoration of essential habitats, and other support for fishing businesses and communities. The Arctic and Pacific Islands are highly vulnerable regions, and the loss of capabilities to monitor sea level rise in these regions required due to climate-induced changes will also have an adverse effect on NOAA products and services. Specifically, acquisition of a fifth Twin Otter and the third King Air will help meet mission requirements for Alaska, Polar, Aleutian Islands, Central Bering Sea, Chukchi Sea, and Beaufort Sea surveys critical for fisheries management and marine mammal monitoring requirements not currently met with current aircraft.

- **Habitat Conservation and Restoration:** NOAA protects and restores habitat to sustain commercial and recreational fisheries, recover protected species, and maintain resilient coastal ecosystems and communities.

Weather Forecasting, Research, and Modeling – NOAA conducts weather surveillance, reconnaissance, and research that increases knowledge of freshwater supply, climate, weather, oceans, and coasts. Weather, research and modeling contributes to accurate storm and weather forecasts, enables communities to plan for and respond to climate events such as drought and flooding, and enhances the protection and management of the Nation's coastal and ocean resources. Weather data collected by NOAA aircraft with aircraft instrumentation, dropsondes, and unscrewed aircraft systems are directly fed into weather models, forecasts, and oceanographic circulation models. Without recapitalization of lost aircraft capabilities, the accuracy of weather and climate forecasts will be degraded, impacting severe storm, flooding, and drought preparation and response, agricultural planning, urban planning, and coastal management.

Operational hurricane reconnaissance missions include:

1) "fix" missions flown into existing tropical cyclones to provide information on the location, intensity, and wind field of the system;

2) "invest" missions flown into areas of disturbed weather to determine if a tropical cyclone has formed;

3) tail Doppler radar missions flown to collect tail Doppler radar and dropsonde data; and

4) "synoptic surveillance" missions flown to collect high-altitude dropsonde data in and around the tropical cyclone.

Data from these missions are used directly by National Hurricane Center (NHC)/Central Pacific Hurricane Center (CPHC) hurricane forecasters in their analysis and forecast process and are assimilated into operational numerical weather prediction models such as the global forecast system (GFS) and the hurricane weather research and forecasting (HWRF) system with increasing impact. Recent studies[19] by NOAA's Hurricane Research Division show that in the Atlantic basin GFS track forecasts are improved by 15-20 percent when aircraft data are available, with HWRF intensity forecasts improved by 10-15 percent. The 15-20 percent track improvements in the GFS are seen at days two-five (48-120 hours). The HWRF intensity improvements of 10-15 percent are noted for days one-three (24-72 hours). Smaller improvements in intensity have been seen through day seven forecasts. A recent study concluded that the "2021 GFS track forecasts were much more skillful than CLP5 (Climatology and Persistence Model) when reconnaissance was available. Most notable is the improvement at the extended lead times, where the difference in skill approaches 30%." Inclusion of aircraft reconnaissance data improves the 72-hour forecast by 5-10%, the 96-hour forecast by 20%, and the 120-hour forecast by 25-30%[20]. Compared to the most recent National Hurricane Center (NHC) verification, it took NHC track forecast skill 10-15 years to improve the 72-hour forecast by 10-15%, 15 years to improve the 96-hour forecast by 20%, and 20 years to improve the 120-hour forecast by 25-30%[21].

The combined use of aircraft reconnaissance data by NHC/CPHC forecasters and numerical weather prediction models directly leads to improved forecasts, more refined storm surge and hurricane watches and warnings, and higher quality, impact-based decision support services for decision-makers, leading to a reduction in the loss of life and property[22] from tropical cyclones and their hazards.

- NOAA aircraft collect data that feed directly into **weather forecast models**. Instrumented with specialized equipment such as the tail Doppler radar and step frequency microwave radiometers, aircraft target specific features of a tropical cyclone to improve intensity and track forecasts.

- **Atmospheric rivers** carry up to fifty percent of the water supply for much of the nation. Understanding the water content of these systems and corresponding rainfall is critical for reservoir management that drives water resource decisions, and flooding and landslide planning. For atmospheric rivers, ensemble-based sensitivity tools are used to target regions of high uncertainty to improve precipitation forecasts from the global models. During the 2021 season, the G-IV flew an atmospheric river mission six consecutive days. Preliminary data analysis of the global forecast system (GFS) model error on precipitation showed that inclusion of the G-IV data improved the five-day model accuracy with aircraft data to that of the two-day model accuracy without the aircraft data. This improvement gives emergency managers, reservoir operators, and the transportation sector three additional days to plan.

[19] Jason A. Sippel, et al., *Impacts of Assimilating Additional Reconnaissance Data on Operational GFS Tropical Cyclone Forecasts* (April 2022) (conditionally accepted by Weather and Forecasting).

[20] *Id.*

[21] John Cangialosi, NOAA, National Hurricane Center 2021 Preliminary Forecast Verification (2021), https://hfip.org/sites/default/files/events/269/140-cangialosi-nhcverificationpptx.pdf.

[22] *Id.*

There is a need for sequential data on atmospheric rivers in the Western Pacific, as well as other regions, to further improve accuracy and model guidance for critical planning. Atmospheric river reconnaissance observing season should also expand from current partial cool-season deployment (ten weeks) to the full season (twenty weeks). NOAA aircraft support for atmospheric rivers starts in late January due to maintenance requirements on the single aircraft following hurricane season. Flight support needs to start in November or December – West Coast storms in November and December result in major flooding in the Pacific Northwest and record precipitation in California. The NOAA G-IV atmospheric river support needs to double in 2023 to provide the required data to support accurate forecasts. A second G550 is required to provide data for accurate forecasts.

> Case Study: AR in California
>
> During January 2021, an atmospheric river and a strong surface cyclone produced significant impacts across much of California. The atmospheric river made landfall and gradually propagated southward along the coast of California, with some areas in central California experiencing atmospheric river conditions for nearly forty-eight consecutive hours. The NOAA G-IV aircraft conducted a sequence of reconnaissance missions from Hawaii, sampling the features associated with the atmospheric river with more than 180 dropsondes. The data was transmitted in real-time to be ingested in the National Centers for Environmental Prediction (NCEP) GFS model, resulting in more than a 20 percent improvement in precipitation forecasts over the West Coast.

- Data from NOAA aircraft is fundamental for accurate **snow surveys**–data that informs spring flooding forecasts. Local river forecast centers rely on aircraft data to produce flooding forecasts in 37 states and have a requirement for more data to inform accurate forecasts. This requirement cannot solely be met by more aircraft hours as concurrent airborne surveys are needed in different geographic areas to inform accurate forecasts. There are also unmet requirements in the Alaska region where data from NOAA aircraft surveys are part of a very limited data set that informs weather forecasts, critical spring breakup timing, and flood severity forecasts for a majority of Alaska, including Native Alaskan and underserved communities. The data requirements exceed the ability to be delivered with current aircraft due to limited aircraft availability and seasonality of requests. Additional King Air and Twin Otter aircraft will further meet requirements and expand the program's capabilities through integration of additional sensors such as snow penetrating radars, light detection and ranging (LiDAR), or other novel sensors.

NOAA aircraft support accurate **hurricane forecasts**. The likelihood of a tropical cyclone developing into a major hurricane (Category 3 or higher) has increased by about eight percent per decade for the past four decades; forty percent of TCs are now expected to be Category 3 or higher events.[23]

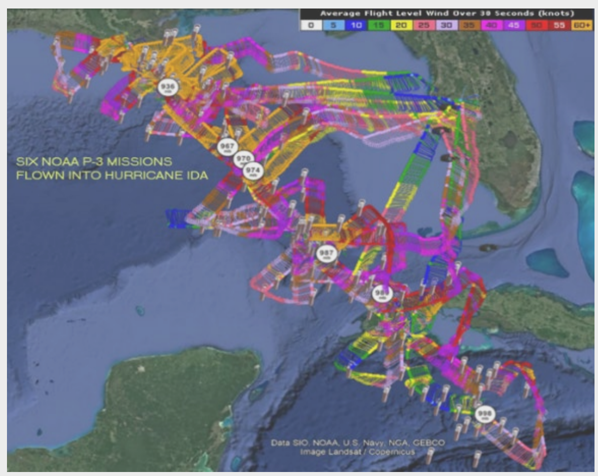
Storm frequency and intensity has increased in recent years as measured by several indices. There have been more Category 3 and 4 land-falling hurricanes in the U.S. since 2016 than the cumulative 50 years prior. The Power Dissipation Index (measurement of frequency, strength, and duration of tropical cyclones based on wind speed measurements) show fluctuating cyclone

[23] James P. Kossin, et al., *Global Increase in Major Tropical Cyclone Exceedance Probability Over the Past Four Decades*, 117 PROC. OF THE NAT'L ACAD. OF SCI. 22 (2020).

intensity for most of the mid- to late 20th century, followed by a noticeable increase since 1995. These trends are shown with associated variations in sea surface temperature in the tropical North Atlantic.[24] The total annual Accumulated Cyclone Energy also shows that cyclone intensity has risen noticeably over the past 20 years.[25] Predictions about the anticipated frequency of tropical storms over future decades in the Atlantic basin remains uncertain and a source of scientific debate.[26] Regardless of future tropical cyclone intensity trends, sea-level rise will increase the risk associated with storm surge and higher rainfall totals; rainfall rates will also increase the risk from rainfall flooding hazards. Data from NOAA aircraft, combined with improvements in all elements of NOAA's end-to-end observing system including improved models and enhanced satellite observations, have significantly contributed to improvements in the average three-day hurricane track forecast error from around 310 nautical miles (1990) to as low as 80 nautical miles (2020).[27]

This recent increase in the frequency of storms affecting land in the western Atlantic basin, and the increasingly positive impact of aircraft data on numerical model forecasts of hurricane track and intensity, has driven a significant increase in the requirement for data from NOAA aircraft for hurricane surveillance, reconnaissance, and research.

NOAA WP-3D flights into Hurricane Ida



Hurricane Ida (2021) intensified rapidly - winds increased from one hundred miles per hour to 150 miles per hour in the twenty hours before it made landfall as a Category 4 storm with storm surges up to fourteen feet. The high level of confidence in understanding the storm and its environment, provided largely by data from NOAA's hurricane hunter aircraft and forecast models that assimilated that data, was key to issuing highly accurate forecasts by NOAA's National Hurricane Center and allowed emergency managers and the public to focus on preparations for impacts including wind, surge, and flooding. Because of these efforts, direct fatalities from Ida's landfall in coastal Louisiana were minimized - zero deaths due to storm surge and only one death due to wind. NOAA's hurricane hunter aircraft collected and transmitted critical data spanning over seventy flight hours and nine flights through and around this rapidly intensifying storm, penetrating the eyewall twenty times, deploying nearly 300 dropsondes and over fifty bathymetric buoys to inform forecasts.

24 NOAA, North Atlantic Hurricane Basin (1851-2021) Comparison of Original and Revised HURDAT, www.aoml.noaa.gov/hrd/hurdat/comparison_table.html (last visited June 9, 2022).

25 *Id.*

26 https://www.gfdl.noaa.gov/global-warming-and-hurricanes/

27 NOAA, Average NHC Atlantic Track Forecast Errors (n mi): All Tropical Cyclones, https://www.nhc.noaa.gov/verification/pdfs/1989-present_OFCL_ATL_annual_trk_errors.pdf.

Climate research is a key component of NOAA aircraft responsibilities, including collecting data to sustain atmospheric composition and dynamics observations and research; understand and predict climate variability and change; and incorporate research into information and products. Data collected using NOAA aircraft are critical for constraining and improving the representation of atmospheric processes in global climate models that are used to understand and predict changes in the Earth's climate.

- NOAA aircraft resources are also critical for advancing the understanding of **atmospheric conditions**, including air quality, climate change, and the Earth's radiation budget. Data collected by the NOAA WP-3D and Twin Otter aircraft inform weather forecasts, monitoring, and urban planning related to atmospheric composition. Poor air quality, including elevated concentrations of ozone and fine particulate matter, accounts for about five percent of the U.S. GDP in damages ($790 billion in 2014) annually, over 100,000 premature deaths annually, and significant negative impacts to agriculture and transportation. [28, 29] Through aircraft campaigns with the NOAA WP-3D and Twin Otter aircra2ft, in areas including Salt Lake City, Los Angeles, Tampa, and Houston,[30] aircraft have measured chemical conditions leading to particulate pollution. This data has been provided to Federal, State, and local environmental quality entities to inform decisions related to mitigating and improving air quality.

- **Arctic Heat** research obtains novel real-time observations needed for the development of long-range (two to three month) sea ice projections, and the improvement of marine weather forecast and domain awareness capabilities. These include autonomous air-deployed and ice-adapted ocean profilers and low-cost expendable sensors and aircraft instrument packages. Capabilities provided by the NOAA Twin Otter allow regular and efficient access to ocean areas that are practically out of reach by other means, especially in early and late season. The Twin Otter allows both direct observation and distribution of autonomous sensors over long distances, and it supports responsive and collaborative deployment capability if required, especially as targeted to particular ocean features, before/after storm events, or other emerging issues such as extreme ice-loss events.

- **Non-hurricane research** including air quality, fire weather, and the Congressionally-directed multi-year Earth radiation budget (ERB)[31] initiative to investigate natural and human activities that might alter the reflectivity of the stratosphere and marine boundary layer, and the potential impact of those activities on the Earth system, require data from NOAA aircraft.

- Data collected by NOAA aircraft support research and accurate, timely warnings and forecasts of **high-impact weather events**. Aircraft data fed directly into El Niño and La Niña weather forecasts are critical for safety of lives and property, emergency management, and economic planning.

[28] Neal Fann, et al., *Estimating the National Public Health Burden Associated with Exposure to Ambient PM2.5 and Ozone*, 32 RISK ANAL. 81, (2012).

[29] Ellis Robinson, *How Much Does Air Pollution Cost the U.S.*, STANFORD EARTH MATTERS MAG., Sept. 19, 2019, https://earth.stanford.edu/news/how-much-does-air-pollution-cost-us#gs.b4wdmj.

[30] *See, e.g.* NOAA, Utah Winter Fine Particulate Study, https://csl.noaa.gov/groups/csl7/measurements/2017uwfps/ (last visited June 9, 2022); NOAA, Shale Gas and Natural Gas Nexus, https://csl.noaa.gov/projects/songnex/ (last visited June 9, 2022); NOAA, CalNEx2010, https://csl.noaa.gov/projects/calnex/ (last visited June 9, 2022).

[31] NOAA, Earth's Radiation Budget, https://csl.noaa.gov/research/erb/ (last visited June 9, 2022).

Airborne data collected on atmospheric composition and air chemistry help improve NOAA's operational National Air Quality Forecast Capabilities (NAQFC) model and provides support to environmental regulators and stakeholders to make informed decisions at local, regional, state and federal levels. Data also inform the understating of physical processes underlying weather and climate event, including high-impact weather events like hurricanes.

- From 1980 to 2021, **wildfires** accounted for 18 billion-dollar events totaling more than $106 billion in damages.[32] However, there are gaps in the understanding of the weather that generates wildland fire conditions. NOAA's aircraft collect critical data to study fire weather. Fire dynamics studies at altitude require additional Twin Otter and King Air assets to gather sufficient data for model improvements. Improved models would further inform smoke plume movement and air quality across the United States. Access to the WP-3D aircraft, or its replacement, during hurricane season would be beneficial to fire weather studies.

- Measurements made on board NOAA aircraft are critical for constraining and improving the representation of **atmospheric chemistry and composition** in air quality and weather forecasting and global climate models, and for evaluating the quality of satellite instrument products. This work is used to understand and predict changes in the Earth's climate. Improved air quality and weather forecasts and climate projections protect lives and property and foster environmental justice. The NOAA WP-3D and Twin Otter aircraft have been used numerous times[33] to study atmospheric chemistry, composition, and dynamics to improve the understanding of urban air quality and fire weather, improve NOAA's operational NAQFC model, and provide support to environmental regulators and stakeholders. These research studies require heavy-lift long-duration aircraft that can accommodate a sophisticated scientific payload (i.e., WP-3D or replacement aircraft), and smaller aircraft for remote sensing instrumentation (i.e., Twin Otter).
- NOAA investigates **ocean, coastal and Great Lakes** habitats and resources to help manage and understand fisheries, conserve and restore the nation's coasts, and build a stronger economy. NOAA aircraft collect shoreline mapping and coastal habitat data used to quantify shoreline losses and changes to shoreline habitat due to anthropogenic and natural causes.

Emergency Response – In addition to flights for hurricane reconnaissance, surveillance, and research, coastal mapping, and water and marine resource management, NOAA aircraft routinely respond to natural and manmade disasters of national concern. Aerial imagery is a crucial tool to determine the extent of the damage inflicted by flooding, for example, and to compare baseline coastal areas to assess the damage to major ports and waterways, coastlines, critical infrastructure, and coastal communities. This imagery provides a cost-effective way to better understand the damage sustained to both property and the environment.[34] The second and third King Airs will meet requirements to provide increased capability for emergency response during catastrophic events including hurricanes, tornadoes, and flooding.

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[32] NOAA, Billion-Dollar Weather and Climate Disasters, https://www.ncei.noaa.gov/access/billions/ (last visited June 9, 2022).

[33] *Supra,* note 27; *see, e.g.,* NOAA, FIREX-AQ, https://csl.noaa.gov/projects/firex-aq/ (last visited June 9, 2022); NOAA, SENEX 2013, https://csl.noaa.gov/projects/senex/ (last visited June 9, 2022); NOAA, Texas Air Quality Study (TexAQS), https://csl.noaa.gov/projects/texaqs2k/lidar/ (last visited June 9, 2022); NOAA, NEAQS-ITCT 2004, https://csl.noaa.gov/projects/2004/ (last visited June 9, 2022).

[34] NOAA, Hx IDA Imagery, https://storms.ngs.noaa.gov/storms/ida/index.html#9/29.7167/-90.7484 (last visited June 9, 2022).

Capability Requirements

In addition to meeting capacity (flight hours) requirements, NOAA aircraft must have specific capabilities (collect specific types of data in specific environments) to meet the data collection requirements. Airborne data and mission activity requirements drive aircraft capability requirements. Many missions and airborne activities require aircraft with more than one capability. With the need for multidisciplinary capabilities, there may be overlap in aircraft capabilities to support the temporal and spatial observational requirements demanded by NOAA's programs. To assess the impact of the airborne capabilities lost with the retirement of aircraft, the capabilities required by each mission and airborne activity were identified. Table 2-1 illustrates the linkage between NOAA's missions and airborne activities, and the aircraft capabilities needed to conduct those activities.

Mission	Activity	Current Aircraft Capabilities
Charting and Surveying	Navigation, Observations, and Positioning	Multi- and hyperspectral imagery, topographic and bathymetric light detection and ranging (LiDAR) data, airborne gravimeters, survey quality digital imagery
	Coastal Science and Assessment	Bathymetric data, multi- and hyperspectral imagery, topographic and LiDAR data, aerial surveys and videos
Assessment and Management of Living Marine Resources	Protected Resources, Science, and Management	Bathymetric data, low level and low speed aerial surveys and videos
	Fisheries Science and Management	Bathymetric data, low level and low speed aerial surveys and videos
	Habitat Conservation and Restoration	Digital photography, bathymetric data
Weather Forecasting, Research, and Modeling	Observations and Forecasting	Vertical atmospheric profiling (dropsonde data system, small uncrewed aerial systems), lower fuselage, tail Doppler radar, Doppler LiDAR, stepped frequency microwave radiometer, wide swatch radar altimeter, vertical ocean profiling (airborne expendable probes), gamma radiation detection, real-time large data set transmission, topographic, and bathymetric LIDAR data, high altitude, long range
	Climate Research	Lower fuselage, Doppler radar, atmospheric profiling, air chemistry sampling, high endurance
	Weather and Air Chemistry Research	Lower fuselage, Doppler radar, atmospheric and air chemistry sampling, high endurance
	Ocean, Coastal, and Great Lakes Research	Topographic and bathymetric LiDAR data
Emergency Response	Various Activities	All in differing combinations specific to response

Table 2-1: Aircraft and Payload Capabilities by Mission and Activity

NOAA continues to pursue enhanced capacity and capability to meet national priorities. As requirements continue to grow and outpace available resources, NOAA will continue to make trade-off decisions to best meet requirements in the mission and activity areas discussed.

III. Building and Sustaining NOAA's 21st Century Aircraft Fleet

NOAA relies on four types of aircraft that each focus on one or two primary missions along with secondary missions that make the best use of the aircraft's capabilities. Table 3-1 shows the primary and secondary missions of each aircraft type. The minimization of aircraft types in NOAA's fleet is critical to maximize utilization and to efficiently streamline maintenance, training, and system integration of the fleet.

Aircraft	Primary Mission	Secondary Mission
King Air	Charting and Surveying and Weather Forecasting, Research and Modeling	Assessment and Management of Living and Marine Resources
G-IV/G550	Weather Forecasting, Research and Modeling	Charting and Surveying
Twin Otter	Assessment and Management of Living, Marine Resources and Weather Forecasting, Research and Modeling	Charting and Surveying
WP-3D[35] and WP-3D replacement	Weather Forecasting, Research and Modeling and Charting and Surveying	Assessment and Management of Living and Marine Resources

Table 3-1: Aircraft and Primary and Secondary Missions

NOAA's aircraft must be adaptable to provide the platforms necessary to meet NOAA's mission now and in the future. While the long-term strategy of this aircraft plan is to sustain NOAA's airborne data collection capabilities through the procurement and instrumentation of new aircraft, it also includes improved management practices to sustain and increase current capabilities and capacities. Accordingly, this plan integrates asset acquisition with management practices and represents the best comprehensive solution for long-term recapitalization of NOAA aircraft.

Funding for two King Airs (the first funded in FY 2018 and operational in 2021, the second funded in 2022) and two G550 high-altitude jet (first funded in FY 2018 and 2021 and operational in FY 2024; second funded in 2022 and estimated operational date of 2025[36]) has provided NOAA with a solid foundation to begin implementation of its aircraft plan. The simultaneous acquisition of the King Air and G550 aircraft have allowed for standardization of core instrumentation, training, maintenance, and regulatory requirements, which will result in decreased maintenance and operating and instrumentation costs. The new King Air currently is meeting data requirements for weather forecasting, monitoring and research, and charting and surveying missions. This aircraft provides additional capacity and capabilities from previous generations, including dual camera ports and a cargo door for emergency response and charting and surveying missions critical for safe maritime and aeronautical navigation. The second new King Air will be similarly configured to provide additional capacity to meet data requirements.

Once completed, the G550s will replace and significantly expand the capabilities of NOAA's G-IV aircraft. It will support essential weather forecasting, research, and modeling missions, along with secondary missions of charting and surveying. The G550s will have increased range and endurance to more effectively sample storms, and have multiple apertures, wing hard points, and inlets to expand instrumentation and data collection. It is imperative that the G550 acquisition stay on schedule to replace

[35] The NOAA WP-3D aircraft are scheduled for retirement in 2030.

[36] Schedule pending contract option execution

the G-IV in 2024. The G-IV is an aging platform, and without a more capable replacement, NOAA will be unable to collect vital data critical for storm track and intensity forecasts. The data from the G-IV feeds into NOAA's global forecast system (GFS) model, and it is estimated that it improves the track forecast over 24 hours (statistically significant improvements in track extend through four-five days during reconnaissance periods) by as much as 25 percent.

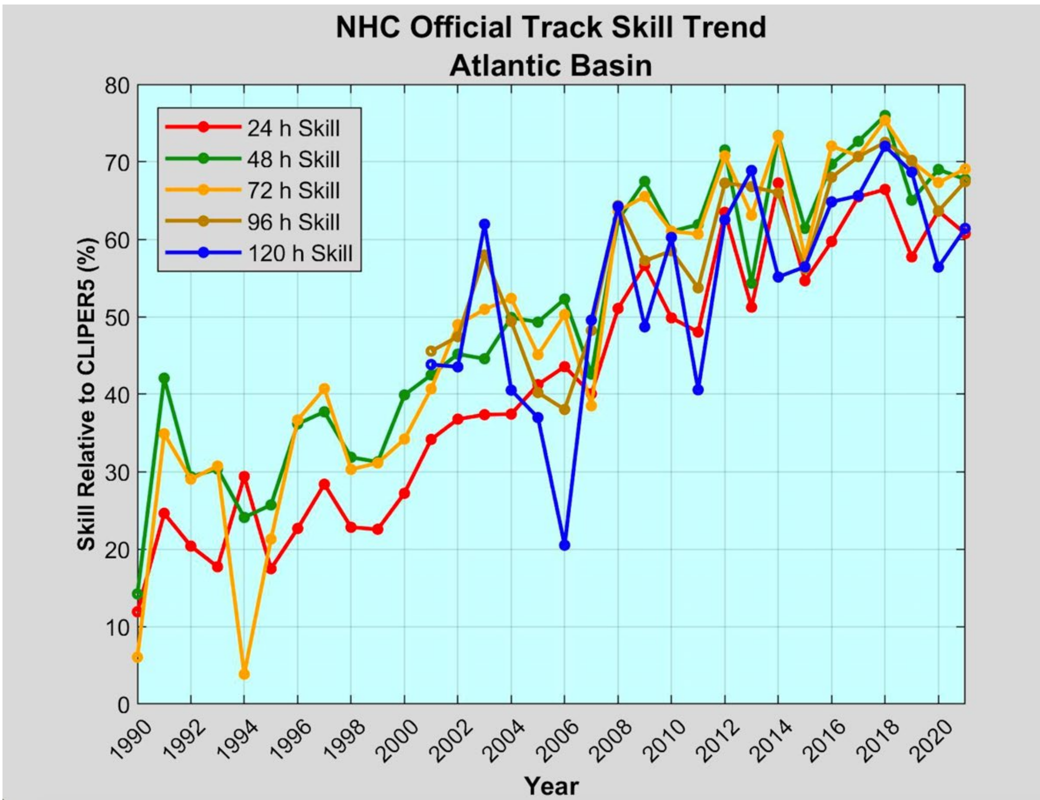

Figure 3-1: National Hurricane Center Official Track Skill Trend for the Atlantic Basin

G-IV data also makes a significant impact on the hurricane weather research and forecasting (HWRF) model intensity forecast. The G-IV's benefits were seen in the pinpoint accuracy of the hurricane track and intensity forecasts in 2020 and 2021. The G-IV's suite of data fed directly into hurricane track. The intensity forecasts that were relied upon heavily by emergency managers, the insurance industry, and the public will be eliminated without recapitalization.

New Aircraft

NOAA will need to procure four C130 aircraft - two aircraft to replace the capabilities lost with the upcoming retirement of the WP-3D aircraft, and a third and fourth to meet existing requirements. NOAA will prioritize options to acquire additional aircraft through future budget requests to meet expanding airborne data requirements and objectives.

The sequencing of procuring these new aircraft is critical for mission success. The procurement timeline of the funded aircraft (two G550s and King Air) is provided in Figure 3-2; the procurement timeline of

[37] *Supra*, note 19.

the remaining aircraft is provided in Figure 3-3. **The priority order for acquisition is: 1) two WP-3D replacements, 2) a third C-130 to expand capacity 3) a fourth C-130 to further expand capacity 4) an additional Twin Otter.** As described in an earlier section, four WP-3D replacements would allow for in-storm NOAA aircraft coverage for four cycles per day for a single storm and at least two flights per day into two simultaneous systems, essentially doubling the capacity of the existing NOAA WP-3D aircraft. This increase would provide for the collection of any unique NOAA aircraft data, if relevant, for more than one land-threatening TC simultaneously. Four C-130s would also increase the current capability of NOAA aircraft throughout the hurricane season and support atmospheric rivers research, allowing for maintenance needs to be addressed in-season. Four aircraft would also reliably allow for simultaneous, dedicated research missions independent from operational missions.

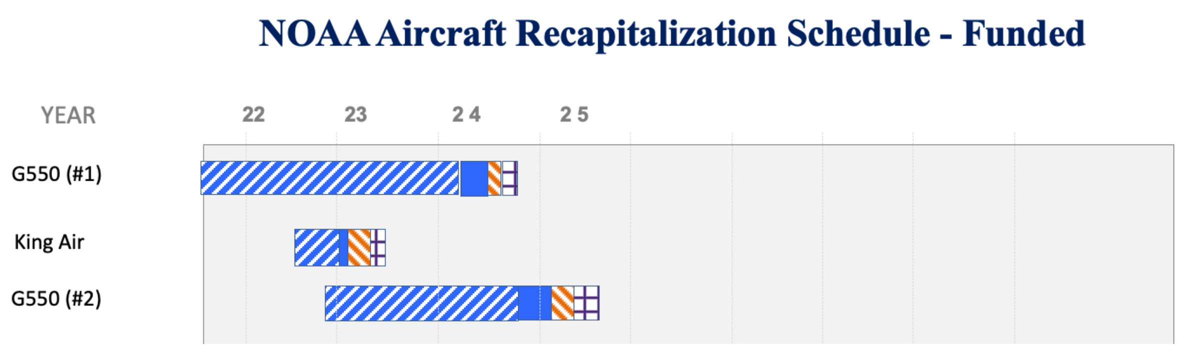

Figure 3-2: NOAA Aircraft Recapitalization Schedule – Funded Aircraft

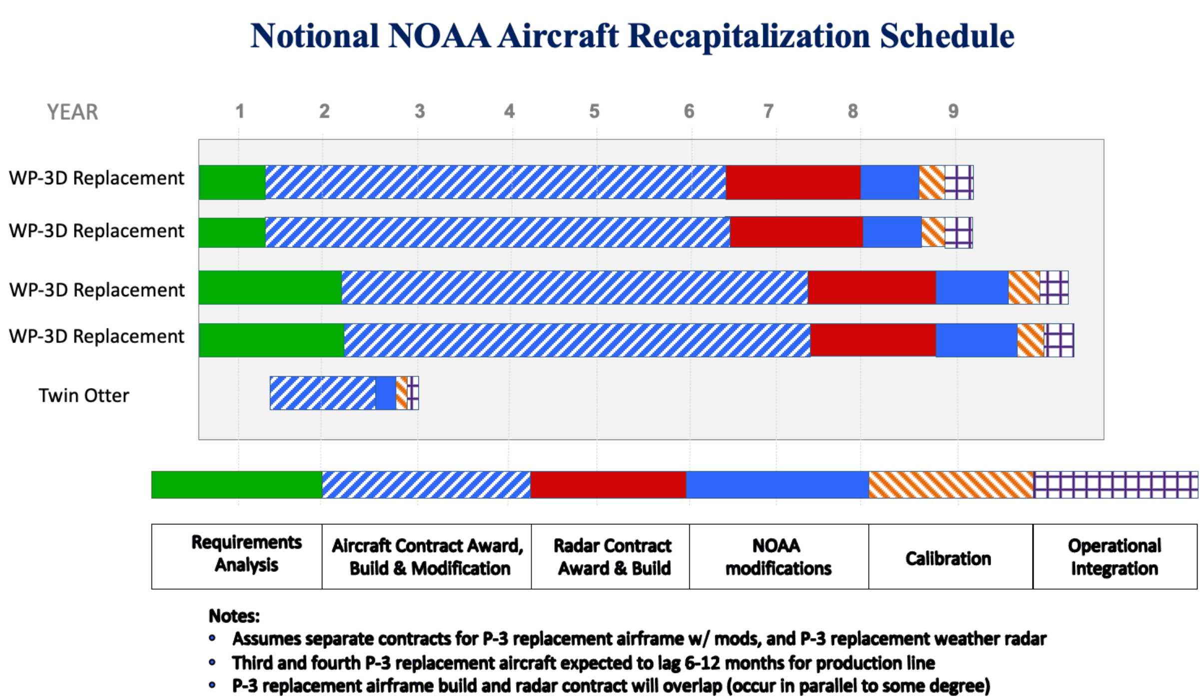

Figure 3-3: Notional NOAA Aircraft Recapitalization Schedule

NOAA's acquisition of aircraft in Figure 3-3 is subject to the annual budget process and the availability of funding. Funding requirements, by fiscal year and aircraft type, based on current information are shown in Figure 3-4. NOAA, in partnership with the Department of Commerce, is conducting preliminary acquisition assessments, including market research and the milestone review process, to award contracts as quickly as possible if funding is available. The figure below assumes year 1 is the first year of funding. The funding amounts by platform and year, and procurement tempo, will be adjusted to match actual funding availability. NOAA is preparing to award funds in the year appropriated.

Total Cost per Aircraft Type
($ in thousands)

Aircraft Type	Green Aircraft & Non-Recurring Engineering	Modifications & Instrumentation	Other	Total
G-550 #2	$41,656	$67,643	$18,572	$127,870
Twin Otter	$7,448	$2,341	$2,031	$11,820
WP-3D Replacements (4)	$470,000	$542,280	$127,296	$1,139,576
Total Cost	$519,104	$612,263	$147,899	$1,279,266

Other costs include testing, calibration, spare parts, and administrative costs.

Figure 3-4: Estimated Costs of Each Aircraft Type

The budget estimates provided here are based on all currently available information. Costs include the airframes, modifications, standard aircraft instrumentation and data systems, required flight testing, calibration and spares, acquisition fees, program management, and reserves. In addition to standard aircraft instrumentation, flight level data systems, and telecommunication systems, scientists may bring their own instrumentation for integration into the aircraft. The G550 cost is based on the contract option cost, additional instrumentation and outfitting, and program management for the G550. The WP-3D replacement cost is based on extensive market research including pricing submitted through a Request for Information, pricing for other government airframes of the same type, additional modifications and instrumentation that have been installed on other government airframes of the same type, the current NOAA P-3 aircraft, and program management. The Twin Otter cost is based on price of available acceptable airframes and cost of required modifications and instrumentation installed in other NOAA Twin Otter aircraft. Updated cost estimates and procurement activities will be supported by Independent Cost Estimates (ICE), as required by Department of Commerce and NOAA procurement practices. NOAA will continue to assess and include technology development, interruptions (such as supply chain), inflation (supplies and labor), and required reserves to inform acquisition plans and costs. NOAA will seek to leverage low-emission options as available, feasible, and reliable. More information on each aircraft type is provided below.

WP-3D Replacement Aircraft and Doppler Radar

The FY 2022 Appropriation Bill stated "NOAA's two turboprop Hurricane Hunter aircraft are critical to accurate hurricane forecasting and predictions. As the aircraft are approaching 50 years in age, it is imperative that NOAA plans for the eventual replacements. As such, the OMAO is directed to continue its partnership with academia, government and industry partners or the engineering, instrumentation, modification, and acquisition of the Hurricane Hunter replacements in fiscal year 2022."[38] As directed, NOAA has conducted extensive market research and continues partnership with government organizations that operate and have modified the replacement airframe, industry, and academia.

As part of the Analytic Services, Inc. (ANSER) 2021 update to the 2016 AoA, extension of NOAA's current WP-3D platforms beyond 2030 was evaluated. The study considered P-3s retired by the U.S. Navy in "flyable storage" condition from inventories held by the U.S. Air Force's 309th Aerospace Maintenance and Regeneration Group (AMARG). The aircrafts are assumed to require:

- The structural modifications and engine upgrades that were performed as part of the WP-3D Service Life Extension in 2015-2019.
- All but one of the extrinsic system modifications are listed in the baseline AoA[39] (including removal of the ASW systems). The exception concerns the expendables launching system, which is already present on these aircraft.
- Installation of all intrinsic mission systems that are listed in the baseline AoA.[40]

It was assumed depot and maintenance services are purchased from a commercial source of supply. Because this alternative involves the operation of aircraft that would be almost 80 years old at the end of the life-cycle period, the impacts of aircraft aging and component obsolescence are special concerns.[41] The study team added an excursion to quantify their potential impact on aircraft availability and mission effectiveness[42] as well as Life Cycle Costs.[43]

Analysis shows that the costs of acquiring, modifying, and operating C-130 aircraft is more cost effective than using existing and retired P-3 aircraft. P-3 aircraft are also becoming increasingly challenging to maintain and operate. P-3 aircraft have not been manufactured for decades. The U.S. Navy, the primary user in the U.S., and foreign operators including Canada, Germany, Australia, and New Zealand are transitioning to new airframes. This is already having a significant impact on maintenance, parts availability, and required training. Additionally, Interservice Transfers (ISTs) that fly P-3 aircraft in the U.S. Navy provide a critical staffing component to meet the increasing NOAA WP-3D tasking. Reduced ISTs coupled with limited training facilities will significantly limit NOAA's ability to provide the required level of stringent experience and training to command hurricane missions. NOAA is already experiencing challenges with procuring parts to maintain their two modified P-3 (WP-3D) aircraft. Maintenance, training and staffing will only continue to be more limited as the U.S. Navy completes their transition out of P-3 aircraft in 2025.

While NOAA and the USAF currently operate different airframes for hurricane hunting, it will be a significant advantage for them to operate the same type of airframe. Through their excellent partnership, NOAA and the USAF have already started discussions about C-130 airframe modifications

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[38] Joint Explanatory Statement, Division B, at 55 (Mar. 7, 2022) (available at https://docs.house.gov/floor/Default.aspx?date=2022-03-07).

[39] *Supra* note 1, at 26-27.

[40] *Id.* at 27-28.

[41] *Id.* at Appendix G: Effects of Aircraft Aging / Obsolescence.

[42] *Id.* at § 5.7.1.

'[43] *Id.* at § 6.3.1.

for flying through heavy weather, operations, and best practices. NOAA will adapt all airframe modifications the USAF has made during the nearly 25 years they have operated C-130s in hurricanes. Operating the same airframe will also provide opportunities to adapt new instrumentation once tested and transitioned from research to operational status. The roll-on, roll-off capability of the C-130s provides an added benefit to adapting instrumentation across aircraft. The Stepped-Frequency Microwave Radiometer (SFMR) is an example of a standard process for new instrumentation to transition through research and become operational. The SFMR started flights as a research instrument in 1980 on NOAA aircraft. This data was first transmitted operationally through High-Density Observations (HDOB) in 2001 from NOAA WP-3Ds. The SFMR became operational on the USAF C-130 in 2007. Similar to the SFMR, NOAA has been flying the Wide Swath Radar Altimeter (WSRA), a unique airborne system that provides observations of the sea surface and rain, as a research instrument since 2008 The WSRA is now operational and the wave data from the WSRA was added as an operational requirement in the 2022 NHOP. The TDR is another example. NOAA has been flying with the Tail Doppler Radar (TDR) for research since the 1970s and began transmitting TDR data in 2015; the requirement for radar images to be transmitted off the aircraft was added to the NHOP in 2015. The USAF has not elected to adopt the TDR to date; a new airborne doppler radar designed for the C-130 airframe may be an opportunity to adapt this technology. Collecting and transmitting TDR data near real-time requires engineering to adapt the instrument, power and cooling requirements; engineers to maintain and operate the instrument; and bandwidth and software systems to transmit the data.

C-130 manufacturing continues and, in fact, orders from domestic and foreign vendors for the foreseeable future are consuming available production capacity. C-130s are operated by several U.S. government agencies including the U.S. Air Force, Cost Guard, Marines, and Navy. There are over 320 active United States military C-130 aircraft. In FY 2022, 22 C-130 aircraft were appropriated for the U.S. military. NOAA will leverage partnerships with these agencies for training and maintenance. There are not relatively new C-130 aircraft for NOAA to acquire, modify, and instrument. Available C-130 aircraft are of the H or Q models which are around 50 years old. It is uncertain if they could be modified for NOAA's mission. Corrosion, non-recurring engineering costs, unknown maintenance history and costs, retrofitting a 1970's era aircraft with 2030 avionics and cooling system requirements, and acquiring data packages and rights for modifications all present significant risks and costs.

In total, the Life Cycle Cost (LCC) of P-3 aircraft is $2.82 billion for two aircraft, $4.33 billion for three aircraft, and $5.84 billion for four aircraft. The LCC cost of new C-130J aircraft is $2.14 billion for two aircraft, $3.17 billion for three aircraft, and $4.24 billion for four aircraft.[44]

ANSER's analysis found three primary developments since the baseline (2016) AoA. First, observing requirements have evolved over the past five years and are expected to continue to evolve, with demands for increasing accuracy and resolution.[45] Second, while the capability of platforms other than crewed aircraft have improved significantly, the relationship between crewed and other platforms remains complementary and crewed aircraft are required for the foreseeable future. Third, the set of

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[44] *Id.*

[45] Tropical Cyclone mission requirements beyond 2032 will include continuous observation of inner core structure, measurement of thermodynamic processes in the air-sea boundary layer, improved data collection in blind spots such as clear air, and data assimilation intervals as short as an hour or less. All these developments are consistent with the general trends and patterns documented in the baseline AoA and do not fundamentally impact the comparison on alternatives.

potential aircraft candidates to replace the WP-3Ds remains the same. ANSER's study used historical data from 2000 to 2019 to make assumptions about the number of tropical cyclones NOAA will need to respond to in the future. Future airborne capacity objectives were based on input from users as defined in the Hurricane Forecast Improvement Plan (HFIP), and the National Hurricane Center (NHC) that include having aircraft in the core four cycles per day (instead of two) providing 24-hour coverage for data assimilation and forecasters use in every tropical cyclone. Since NOAA is not yet able to determine whether NOAA's future C-130s will have equivalent or improved observing capability compared to the Air Force, the NHC cannot determine the preferred cadence of Air Force and NOAA assignment of storm cycles.

The HFIP goals include: reduce numerical forecast guidance errors, including during rapid intensification, by 50 percent from 2017; produce 7-day forecast guidance similar to 2017 5-day forecast guidance; and improve guidance on pre-formation disturbances, including genesis timing, track and intensity forecasts, by 20 percent from 2017. Based on ANSER's independent analysis in 2021, the probability of satisfying at least 75 percent of tropical cyclone reconnaissance flight hour requirements in 2030 with three aircraft is 32 percent and with four aircraft is 85 percent. ANSER's study used historical data from 2000 to 2019, and input on requirements from the National Hurricane Center, Hurricane Research Division, and Environmental Modeling Center to make assumptions about the number of tropical cyclones NOAA will need to respond to in the future. The NHOP takes into consideration the capabilities and capacity of NOAA and USAF aircraft, and defines the requirements of each agency in support of hurricane forecasting and research. The ANSER study also concluded that purchasing two aircraft will provide zero additional flight hours, three aircraft will provide 74 additional flight hours (274 flight hours for all missions with two crews), and four aircraft will provide 154 flight hours (354 additional flight hours for all missions with two crews) per aircraft yearly dedicated to non-hurricane projects and training of new pilots. These hours will help meet climate research project goals and ensure a healthy fleet by meeting the maintenance and training requirements.[46]

Schedule Considerations

NOAA's weather research missions will be increasingly at risk if the WP-3D replacement program does not follow an acquisition schedule to be operational by 2030; additional details are provided later in the discussion of extending the life of NOAA aircraft. NOAA's ability to accurately track storms and improve hurricane forecasts, complete satellite calibration and validation, observe changes in atmospheric composition and chemistry for the evaluation of operational air quality forecast models and climate projection models, and predict and understand tornado formation and growth will be reduced. Moreover, significant gains made in forecast track accuracy in recent years could be reversed.

NOAA conducted a request for information (RFI) for WP-3D replacement aircraft in 2021. Based on the results of the RFI and extensive market research, NOAA will consider a justification for other than full and open competition. NOAA also conducted an RFI for the WP-3D replacement aircraft Doppler radar. Based on the results, the airborne phased array radar (APAR) under development at the (NCAR) meets technical requirements. NOAA also plans to issue a feasibility study for Doppler radar capabilities as part of the aircraft contract. The APAR is currently undergoing evaluation for an NSF Mid-scale Research Infrastructure grant. The decision timeline for the grant is February 2023. The timeline for development of the first operational unit on the NCAR C-130 is scheduled for January

[46] *Supra* note 1.

2028. Funding in 2022 and 2023 as provided by the Infrastructure Investments and Jobs Act[47] provides bridge funding to continue engineering development into the final design phase following the completion of preliminary design review, scheduled for late summer 2021, and would accelerate the delivery timeline up to 11 months. Conservatively, to have the WP-3D replacement aircraft operational by the 2030 hurricane season, NOAA needs to be ready to issue a contract for the green (baseline) aircraft with weather modifications imminently after receiving appropriations and issue a contract for the airborne Doppler radar units in FY 2027. NOAA will continue to work closely with NSF and NCAR on the APAR project development. NOAA will also continue work with industry, government, and academia to seek available options to meet the airborne Doppler radar capabilities within the required timeline. Repackaging the TDR into wing pods supplemented by other instrumentation is one possible option NOAA will continue to evaluate. NOAA plans to include a feasibility study in the airframe contract award to explore all available options to meet Doppler radar requirements.

NOAA's proposed acquisition schedule for the WP-3D replacement aircraft and Doppler radars is provided in Table 3-2.

Timeline	WP-3D AIRCRAFT Milestones	RADAR Milestones
FY 2021	Developed user requirements. Started update of analysis of alternatives (AoA). Developed and issued platform request for information.	Developed and issued RFI, including rough order of magnitude pricing for systems and technologies to provide similar data to WP-3D tail Doppler radar. Included airborne phased array radar (APAR) as an alternative.
FY 2022	AoA update complete, market research (input from United States Air Force (USAF) WP-3D replacement acquisition on cost and mods, input from National Center for Atmospheric Research (NCAR) on platform mods for research, determine what options exist), Receive preliminary funding, to start program office activities. Validate concept of operations, capabilities requirements, tech readiness, project management, independent cost estimate update, Department of Commerce (DOC) Milestone (MS) 1.	Evaluate alternatives, schedule and cost for radar system. (feasibility study contracted within 12 months of funding for all airborne Doppler radar options).

47 Public Law No. 117-58.

Year 1 Funding	Receive first tranche of funding and issue request for proposal (RFP) for aircraft plus original equipment manufacturer (OEM) mods (nose radar, propeller reinforcement, etc.), feasibility studies and AoAs as needed for instrumentation and science provisions, and non-APAR modifications (as options). Translate measurement and port/aperture requirements into notional instrumentation and airframe mods. DOC MS 2 for base aircraft and sensor/instrumentation development.	Identify research and development funding as required. Include Doppler radar feasibility study in aircraft contract.
6 months-18 months of initial funding	DoC MS 3 and green light for base aircraft award. Award green aircraft contract with OEM modification package. Receive second tranche of funding, for platform mods. Generate specs for non-APAR airframe mods (provisions for in-situ systems, dropsonde, infrastructure for advanced and non-hurricane systems) and issue request for pricing.	Update Doppler/APAR mods strategy based on USAF, NCAR and OEM input. Issue RFP, on a sole source or competitive basis, for radar system development phase.
12 months of initial funding	Start fabrication of first baseline aircraft. DoC MS 3 for modification options. Exercise options for non-APAR airframe mods. Issue request for pricing for major instruments (multimode radar [MMR], Satcom, upgraded nose radar, etc.)	Award, with research and development funding, the radar system development contract. Complete proposal for Doppler/APAR platform modification.
Within 36 months funding start	Complete spec package for Doppler/APAR aircraft modification. Prelim design review for non-APAR mods. Award contract(s) for instrumentation and other outfitting. First base aircraft(s) complete. Critical design review for airframe modifications.	Demonstration unit (technical readiness level [TRL] 7-8), engineering package for required aircraft mods needed for operational unit installation, FY 2027 budget submission for operational units in production quantities.
36-40 months initial funding	Award contract for airframe mod to accommodate Doppler/APAR. Final Design Review for airframe mods, to include Doppler/APAR. First airframe transferred to contractor's mod facility and start modifications.	Expect operational status of APAR on NCAR C-130H.
48+ months after initial funding	Order parts and materials for airframe mods to be performed at AOC.	First AAPAR production article (complete aircraft system) testing and certification on NCAR C-130H.

72 months after initial funding	Delivery and ground mockup of instrumentation systems. First airframe(s) modified, tested and certified as airworthy. Mods of any remaining aircraft completed. Staffing changes to support new aircraft platform, including initial pilot, crew and maintenance training.	Delivery of first production article. Integration of first production article on first modified platform, to include calibration and operational status.
80 months after initial funding	Delivery of first modified platform(s). Integration, testing and calibration of instrumentation and Doppler radar. Conduct calibration flights with the WP-3D. Initial operating capability on first replacement platforms. Follow-on aircraft modified and tested. Completion of staffing and facilities changes to support new fleet.	Delivery of follow-on units and

Table 3-2: Proposed Acquisition Schedule for the WP-3D Replacement Aircraft and Doppler Radar

The additional King Air aircraft provided for in the FY 2022 appropriation bill will meet data requirements for high-resolution mapping, water resource planning, shoreline mapping, aviation charts, the GRAV-D program, and distribution surveys to inform decisions by the Bureau of Ocean Energy Management and the U.S. Navy. This King Air will collect snow water equivalent data that informs spring flooding forecasts and water management decisions for 37 states and eight Canadian provinces. The third King Air also would be used to collect high-resolution images immediately following hurricanes, floods, earthquakes, tornadoes and other disasters that FEMA, local emergency managers, the public, businesses, and industries rely on.

NOAA is executing the option on the current King Air contract to acquire a third King Air. NOAA expects to execute the option in Q3 FY2022, receive the green aircraft in Q2 FY2023, NOAA modifications and calibration flights complete Q4 FY2023, and full operating capability in FY2024 pending funding for operations, maintenance, and required staffing.

G550

The second G550 will support many requirements. As identified in the 2018 NOAA High-Altitude Hurricane Surveillance Aircraft Requirements Analysis Workshop,[48] simultaneous high-altitude observations in combination would further improve hurricane forecasting. The second G550 will allow NOAA to survey multiple concurrent storms in the same and different ocean areas of responsibility. Notably, the second G550 meets hurricane redundancy included in the Weather Research and Forecasting Innovation Act of 2017.[49]

NOAA is also facing increased demand for its G-IV aircraft to support non-hurricane missions, such as data collection on atmospheric rivers that is used to significantly improve the accuracy of rainfall forecasts across the western and central United States. These forecasts directly support flood, landslide, transportation, agriculture, and power outage planning that significantly impact these regions. No other observational platform can collect this data, and there is a request for NOAA to double the flight support

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[48] Analytic Services, Inc. (ANSER), *High-Altitude Hurricane Surveillance Aircraft Requirements Analysis Workshop Report* (NOAA Contract GS-00F-072CA#AB-133M-17-BA-0030, 2018) (copy available upon request from NOAA OMAO).

[49] Weather Forecasting and Innovation Act of 2017, Pub. L. No. 115-25, § 413 ("The Under Secretary shall acquire backup for the capabilities of the WP-3D Orion and G-IV hurricane aircraft of the National Oceanic and Atmospheric Administration that is sufficient to prevent a single point of failure.")

for atmospheric rivers in the next two years and begin data collection months earlier in the year to capture critical information. NOAA cannot meet this objective with only one high-altitude jet. In addition to atmospheric river data, there is an ever-increasing demand for the G-IV to collect gravimeter data in support of the nation's GRAV-D program (essential for floodplain mapping and global positioning system (GPS) calibration), along with Arctic research, monitoring, and observations.

In the interim before the two NOAA G550s come online, NOAA explored utilization of a second G550 through agreements with the National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA), which own and operate G-V aircraft. NSF was not able to enter into an agreement due to existing aircraft tasking, some of which was originally scheduled and impacted in 2020-2021 by COVID; NOAA and NSF will continue dialogue for future opportunities. NASA's support is limited by availability (notably, the NASA aircraft was not available for any major hurricanes in 2020), and the NASA G-V does not have a flight-level data system or tail Doppler radar which limits its capability. NOAA will continue to engage with partners to fully understand availability, limitations, and tradeoffs of relying on partnerships rather than acquiring a second G550.

NOAA will execute the option for the second G550 on the contract for the first G550. The option cost is $99.7 million. Additional costs include instrumentation and the flight level data system NOAA will install after delivery (replica of the first G550), calibration and flight testing, and project management.

Twin Otter

Airborne data demands exceed the capacity of NOAA's four Twin Otter aircraft. An additional Twin Otter aircraft would allow NOAA to meet current and emerging airborne data requirements critical for accurate weather and water forecasts, management of protected resources and fisheries, air chemistry research, and Arctic monitoring that informs climate models. NOAA would standardize the additional Twin Otter with long-range tip tanks, a removable cabin auxiliary fuel tank, wing hardpoints, a forward-looking infrared (FLIR) turret, a standard meteorological package, and data uplink to have the same configuration as the other Twin Otters for maximum mission versatility and operational and maintenance efficiency.

Extending the Service Life of NOAA Aircraft

NOAA is doing everything it can to extend the service life of its current fleet but has limited options with its aging aircraft. In 2016, Conklin and de Decker completed a study[50] that provided data on the expected service life of each NOAA aircraft type (see Figure 3-4). Based on NOAA aircraft service life expectation, historical usage analysis, and trending utilization increases, NOAA predicts three of its aircraft will reach or exceed their service life between 2021 and 2030. Based on independent analyses, extending the aircraft service life is only an option for two of the current five NOAA aircraft types – the WP-3Ds and Twin Otters. This option was already utilized for the two WP-3D aircraft with service life extensions that included the replacement of wings, engines, and avionics.

Service life extensions continue to be utilized for NOAA's four Twin Otter aircraft, which have been in a service life extension program since 2007 when the FAA approved NOAA's Twin Otter inspection program. This program extends the reliability and service lives of the aircraft; the current Twin Otter end of service life dates in this plan include these extensions. The four Twin Otter aircraft (N46RF, N48RF, N56RF, and N57RF) end of service life dates are based on a total service life of approximately 33,000 flight hours (per

[50] Conklin & De Decker, *NOAA AOC Aircraft Fleet Plan Service Life Analysis and Business Case Analysis* (2016) (copy available upon request from NOAA OMAO).

the service life extension program). Each Twin Otter operates approximately 600 flight hours per year. The remaining service life for N57RF is 9,876 hours or 15 years (2037); the remaining service life for N48RF is 13,500.5 hours or 22.5 years (2044); the remaining service life for N46RF is 19,462.4 hours or 31 years (2053); and the remaining service life for N56RF is 19,588 hours or 31 years (2053). The service life of the Twin Otters varies from 57 to 69 years; this is due to the condition (total hours) each of the aircraft was flown prior to NOAA taking ownership.

NOAA also has completed a program to standardize Twin Otter performance, capabilities and configuration, which reduces maintenance costs, increases utilization, and improves reliability and customer satisfaction. The current aircraft configuration, including instrumentation ports and long-range fuel capacity, has the capacity to meet all airborne data requirements for this aircraft type. Robust commercial support for the Twin Otter should further support the service life of this aircraft.

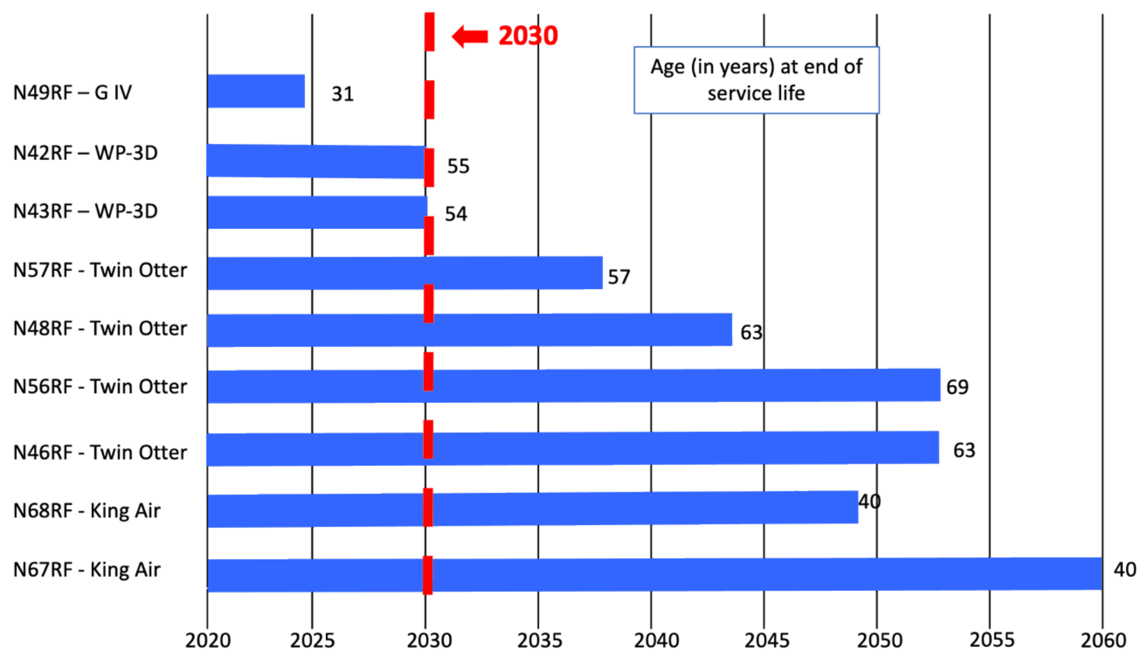

Figure 3-4: Estimated Service Life of Current NOAA Aircraft

Technology Considerations

NOAA considers all sources of technology when planning for the configuration and composition of its aircraft fleet and has sought efficiency in operations of the current fleet through integration of new technologies that leverage available flight hours. For example, NOAA has upgraded the data systems on the Twin Otters to improve the quantity and quality of data, create standardization across all four Twin Otter aircraft, and create parity in capabilities with other NOAA aircraft. NOAA also has replaced all four engines on the WP-3D aircraft, significantly improving fuel efficiency.

The six additional aircraft in this aircraft plan would provide additional capabilities to meet NOAA mission requirements by incorporating data collection technology– including instrumentation, sensors, and uncrewed systems— increasing the quality and quantity of products and services that the agency provides.

Uncrewed Aircraft Systems

The growth in uncrewed aircraft systems (UAS) presents opportunities for meeting and enhancing NOAA's data collection capabilities. NOAA's initial decentralized approach to UAS utilization enabled users of these systems great freedom in platform selection and diversity of operations, but created challenges in addressing technology, safety, policy, staffing, training, and standardization issues. NOAA currently provides operational support, policy input, training, and guidance for UAS operations through the UAS Division of the Uncrewed Systems (UxS) Operations Center, located at NOAA's Aircraft Operations Center (AOC) in Lakeland, Florida. This centralized and comprehensive approach to UAS acquisitions, training, and operations is increasing use of UAS, as well as efficiency and safety within the agency. NOAA is developing a UAS asset management program that standardizes platforms, training, and operations of UAS that meet common mission requirements. A coordinated, systematic approach across NOAA to meet airborne data, operational, regulatory, cyber, privacy, and information technology requirements is imperative to leveraging uncrewed system technologies.

Through cross-NOAA collaboration, including an annual request for funding proposal process, more than 21 individual UAS projects have been funded within NOAA for development to transition to operations. Overall, these projects have demonstrated that in some areas, small UAS are supplementing data provided by crewed aircraft, and small and large UAS have demonstrated the potential to replace some crewed aircraft missions in the future. The potential to use UAS to bridge key information gaps between instruments on Earth's surface and on satellites is rapidly expanding due to technological advances and an improved regulatory environment. UAS are improving NOAA's ability to monitor and understand the global environment and are an important research and operational tool for multiple NOAA programs. NOAA has tested and utilized UAS for a variety of requirements. Details on some of these applications are provided here:

- For certain mission concepts of operation, UAS have provided operational tools to meet data requirements more efficiently than crewed aircraft, particularly for situations where requirements may be met when operating the UAS within visual line of sight. For example, small UAS are now regularly used by the National Fisheries Marine Service to gather high resolution images of marine mammals to assess their size and health in areas not accessible by crewed aircraft.

- Through a partnership with federal agencies and industry, use of large high-altitude, long-endurance (HALE) UAS were evaluated to collect atmospheric data used for high-impact weather prediction and satellite gap mitigation. While this program was not continued due to cost and the inability to meet the requirements of the National Hurricane Operations Plan, benefits gleaned from data denial studies were built into the G550 capabilities requirements.

- NOAA is transitioning a 55 pound hybrid fixed-wing vertical-takeoff UAS with 20-pound payload capability to conduct routine operations from NOAA ships. The development of this capability, in partnership with the NOAA Pacific Marine Environmental Laboratory will provide an observation system capable of operating from ships and remote areas, with an endurance of up to three hours (~105 nautical miles) and a height ceiling of 10,000 feet. Once fully operational, with its modular payload design, this capability will be available for NOAA researchers to design and build payloads for additional applications.

- NOAA is investigating expendable UAS to fill the critical air-sea interface data gap and ultimately improve understanding of hurricane structure, and hurricane track and intensity forecasts. NOAA has completed nine UAS missions from the NOAA WP-3D, collecting kinematic and thermodynamic observations in the hurricane planetary boundary layer. NOAA is continuing to test and evaluate how UAS can complement and augment existing data coverage within the boundary layer to potentially lead to improved forecasts of tropical cyclone intensity through advancements in the physical understanding of boundary-layer processes. By advancing UAS technology to operations, these unique boundary layer observations will be made available in real-time to improve situational awareness for National Hurricane Center (NHC) forecasters and emergency managers responsible for making decisions associated with landfalling tropical systems, as well as to the Environmental Modeling Center for data assimilation into operational models such as Hurricane Weather Research and Forecast system.

NOAA continues to fund and develop UAS to meet NOAA airborne data requirements. Through the UxS Operations Center Request for Proposal process, and Small Business Innovation Research process, NOAA is developing and testing multiple UAS technologies to meet airborne requirements. Based on current technology, capabilities, and airspace requirements, the crewed aircraft proposed in this plan are expected to be essential to meeting NOAA airborne data requirements for significant time to come.

Charter and Data Buys

NOAA will continue to charter aircraft and buy data to meet data requirements when available and advantageous. Charters provide support for protected species management, gravimetry, climate research, coastal mapping, and marine sanctuary management activities, particularly during the spring and summer when there are competing high-priority mission requirements for NOAA aircraft. As one example, NOAA contracts to buy data for nearly 50 percent of its shoreline mapping requirements; over the last two years the cost of these contracts was approximately $18.95 million and covered 8,418 square miles of coastline data. However, the ability of charters to meet data requirements is limited by aircraft capabilities including specialized instrumentation, size, project frequency, and geography. Given these limiting factors and requirements to maintain capacity and data quality assurance for nautical and aeronautical charting, NOAA cannot rely on charter or data buys to replace the need for its own observational platforms. However, we will continue to actively assess available commercial observations and apply charter aircraft to meet valid data requirements where appropriate.

Partnerships

In addition to commercial aircraft charters, NOAA leverages partnerships and relies on partner platforms to help meet airborne data requirements. NOAA has a long-standing agreement with the United States Air Force Reserve Command (USAFRC) 53rd Weather Reconnaissance Squadron to meet airborne hurricane/tropical cyclone reconnaissance, synoptic surveillance, and research missions. The USAFRC 53rd and NOAA operate a complementary fleet of aircraft and each is responsible for responding to NHC taskings for TC reconnaissance. While the missions are complimentary, there are four things that have differentiated NOAA WP-3D aircraft from USAFRC C-130 aircraft: instrumentation (e.g., tail Doppler radar, multimode radar), platform capabilities to integrate user instrumentation (e.g., Doppler wind light detection and ranging (LiDAR), GPS interferometer), data quality and accuracy (e.g., humidity measurements, icing and flow shadowing), and ability to transmit large quantities of data to models and forecasters. These capabilities have led to the significant increase in tasking of and reliance on the NOAA WP-3D aircraft for NOAA missions. NOAA and USAF will continue to collaborate on technology development as NOAA acquires and modifies C-130s, to explore whether it would be advantageous to align the capability of the respective NOAA and AF C-130 fleets.

In addition, NOAA has heavily leveraged partnerships to instrument the G550. NOAA expanded its partnership with NCAR for sensor development and integration, adopting engineering and capabilities from the NCAR G-V aircraft. NOAA also partnered with the German Aerospace Center (DLR) to apply engineering, instrumentation and lessons learned from the acquisition of their G550, acquire a nose boom, and learn about instrumentation calibration, maintenance and operations best practices. NOAA led the development of a four-way proprietary agreement with NCAR, DLR, and Gulfstream Aerospace Company to take advantage of the knowledge and existing engineering for the NOAA G550. NOAA also partnered with NASA to use the Joint Propulsion Laboratory laser hygrometer to analyze heat radiation emitted by oxygen and water molecules in the atmosphere to determine temperature, humidity, and cloud structure under all weather conditions – these measurements are extremely beneficial for hurricane and atmospheric weather forecasts. NOAA also has an agreement with NASA to leverage their G-V aircraft in a back-up capacity for hurricane tasking, if available.

As directed in the FY 2022 Appropriation Bill, NOAA continues to work closely with government, industry and academia on the P-3 replacement aircraft. NOAA has worked with the USAFRC 53rd to learn about airframe modifications made for heavy weather flying, operations, and maintenance. NOAA continues work with current users of the replacement platform including the United States Air Force, the United States Coast Guard, and U.S. Navy to collect information on instrumentation, modifications, operations and maintenance. Collaboration with the USAF contracting office, which handles multiple orders domestic and foreign for the airframe and issues large multi-year buys, has been fruitful in understanding current and future manufacturing requirements. Market research with Lockheed Martin provides invaluable information on airframe production schedules and timelines, available non-recurring engineering, and existing airframe modifications. NOAA is also working closely with NSF and NCAR in the development of the APAR as an option to meet the operational airborne tail Doppler radar capabilities. These partnerships have been invaluable in scoping and planning for WP-3D replacement program.

Management Initiatives

NOAA will leverage oversight, workforce planning, and training to realize the potential of the new aircraft and current aircraft.

Oversight – Successful execution of NOAA's aircraft plan requires appropriate oversight, engagement, and diligence. Existing processes and forums within NOAA and the Department of Commerce (DOC) provide an important governance structure and will be used to ensure projects are monitored and controlled for cost, schedule, and performance; that political engagement is sufficiently addressed where needed; and that any changes needed from mission realignment or technical refresh throughout the life of the plan are accommodated.

To ensure acquisition projects meet their stated objectives, NOAA procurement professionals develop and implement action plans to identify and mitigate the risk associated with the cost, schedule and performance of each project. Aircraft acquisition projects have been briefed at the NOAA Program Management Council (PMC) to give visibility to variances from the plan since FY 2018. The PMC, chaired by NOAA's Deputy Under Secretary and comprised of representatives from every NOAA line and staff office, identifies issues that exceed the agreed-upon thresholds, examine trends in key indicators, and assess program risk. NOAA also meets at least monthly with the DOC Office of Acquisition Management to track acquisition project execution. Each aircraft acquisition project follows all applicable Federal Acquisition Regulations. For acquisitions $75 million and over, processes and approvals are conducted in accordance with the NOAA Acquisitions and Grants Office and Commerce Acquisition Manual. These processes include approval by the NOAA Acquisition Review Board, the DOC Milestone Review Board, and a milestone decision approval memo by the Deputy Secretary of Commerce.

Allocation of NOAA aircraft, including changes in mission realignment and technical refreshes, are managed through cross-NOAA councils. Annual aircraft allocation plans (AAP) are developed by the Aircraft Working Group and approved by the primary members of the NOAA Fleet Council. The annual AAP is developed by members of each NOAA line office to prioritize airborne requirements across NOAA. Changes in mission or tasking are codified through the annual process and can be adjusted during the year through reallocation if emergent requirements arise. The NOAA Observing Systems Council, chaired by the Assistant Secretary for Environmental Observations and Prediction, will conduct periodic assessments of the ongoing need for airborne data observations, considering changes in technology, in the capabilities of other observing assets, and in NOAA mission needs.

Finally, there are multiple existing structures that allow for broader federal engagement on the aircraft plan. The NOAA Office of Marine and Aviation Operations provides quarterly briefings to NOAA and DOC leadership, the Office of Management and Budget (OMB), and Congressional Appropriation Committees. These briefs include status of NOAA aircraft operations, aircraft procurement projects, and staffing. NOAA also conducts topic-specific briefs to Congress and OMB including on APAR, UAS, and aircraft recapitalization.

Workforce Planning – Qualified and experienced personnel are critical to the success of NOAA's aircraft missions. The diversity and specialty of NOAA's aircraft missions require a robust, technically competent, dedicated workforce. NOAA has requirements for pilots, specialized maintenance and avionics technicians, engineers and administrative personnel that are critical to the operations and maintenance of its aircraft. NOAA is committed to workforce planning to support these unique operational capabilities.

The NOAA Aircraft Management Plan identifies the required authorized complements for each projected aircraft type, upgrade time and qualification requirements, annual flight hour requirements, attrition, and selection processes for incoming pilots. There is also a staffing plan, with annual requirements for civilian and NOAA Corps positions to maximize aircraft utilization and efficiently bring new aircraft online. Prior to an aircraft coming online, there is a ramp-up period to hire, train, and qualify pilots and technicians, ensuring proper personnel are in place to support the missions. The requirement for increased staffing is also addressed in the NOAA plan for *Real-time Dissemination of Hurricane Wind Fields Determined from Airborne Radar Doppler Data*. NOAA has initiated the hiring process for a third WP-3D crew which is required to sustain the level of flight hours NOAA has flown in the past two years. This increase in hours is in response to increased hurricane taskings resulting from NOAA's increased role in national hurricane forecasting.

Training – Transitioning from current to replacement aircraft requires type rating, aircraft proficiency, and qualification training. NOAA has begun the process of creating and implementing a transition plan from the G-IV to the G550 and has training timelines built into the staffing plan for NOAA Corps officers and civilians. The matriculation from new employee to mission qualification is rigorous. The third WP-3D crew hired before the start of hurricane season 2022 will need up to two full, active seasons to meet required proficiency checks and storm flight requirements to be fully qualified.

IV. Conclusion

NOAA aircraft collect the data that directly improves hurricane forecasts, supports water resource planning, and fire weather, flood, and drought predictions – vital information used by every U.S. industry, person, and emergency management organization. These activities convey a common message: human health, prosperity, and wellbeing depend upon the accuracy and timeliness of weather and climate forecasts and the health and the resilience of these ecosystems. Managing this interdependence requires timely and actionable information to make decisions. NOAA's aircraft collect data integral to addressing many of the daily challenges facing the nation and preserving the lives and economic prosperity that transcend region, occupation, and lifestyle.

To ensure NOAA aircraft continue to meet critical airborne data requirements, NOAA has developed this comprehensive, multiyear plan that extends and sustains airborne data collection capabilities of current aircraft while bringing the expanded capabilities of new aircraft online. To mitigate the impacts of NOAA's aging fleet, this plan provides long-term recapitalization efforts combined with sustainment actions for the more efficient and effective use of the existing aircraft fleet and takes an integrated approach to the management of the NOAA Aircraft Fleet that balances all of NOAA's aircraft assets. This plan provides the aircraft and capabilities necessary to meet mission requirements now and in the future for public, national, and economic security.