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HURRICANE HUNTING

The Next Generation

David Reade, of P-3 Publications, reports on the National Oceanic and Atmospheric Administration's high-speed, high-altitude jet.

"...in the month of June, there rose such a boisterous tempest of wind from the southwest as hath not lately been heard of. The violence here was of such force that it plucked up by the roots whatsoever great trees were within the force thereof. The inhabitants also affirm that the sea extended itself further into the land and rose higher than it ever did before in the memory of man, by the space of a cubit..."

Above: ***The NOAA's new hurricane searcher, a Gulfstream IV-SP operated by the US Department of Commerce.*** (Gulfstream/NOAA)

THIS PASSAGE, taken from a dispatch written in 1495 by Christopher Columbus to the King of Spain, is considered to be the earliest known Hurricane Advisory. Called *Hurakan* in the various dialects of the early Caribbean inhabitants encountered by Columbus, these tropical storms were thought to be evil monsters that preyed upon those natives that had angered them. Today, we know these storms to be a product of nature's forces, a natural interaction between the sea and sky.

Although classified as 'tropical cyclones' by science, simple understanding of how these storms are formed does not diminish the destructive power unleashed by them. The *Hurakan* of old is just as or more dangerous to mankind today than it was more than 500 years ago. With an explosion in population since the 1400s and the influx of that population living along the coastlines of the southeastern United States and the islands of the Caribbean, the loss of life and property in a hurricane is great. In order to protect life and property, great demands have been placed on science to understand the influences of tropical storms and predict their coming.

Today marks a milestone in that understanding — a technological leap that could increase our knowledge of hurricanes by 20% — an aircraft with the capability to provide scientists with data to help accurately predict the track and intensity of hurricanes. That aircraft, a Gulfstream IV-SP (Special Performance), is a high-altitude, high-speed jet specially modified for the National Oceanic and Atmospheric Administration (NOAA) for the new mission of hurricane surveillance. An aircraft that is the 'next generation' in hurricane hunting.

History

All through US history efforts have been made to understand hurricanes and get the warnings out. In the 1870s the American Government developed capabilities to issue hurricane warnings through the 'Signal Corps' meteorological service. The system worked in 1873 when warnings of an approaching storm were issued from the mid-Atlantic States up to New England.

Unfortunately, these measures did not prevent the 1900 'Galvez Town' disaster. A violent hurricane that swept away the tiny Texas coastal island community of Galvez Town (later to become Galveston), killing an estimated 6,000 people. It became the single most natural disastrous event that led Congress to the establishment of the US Weather Bureau, a service dedicated to providing ample warning of approaching storms. The Bureau was (at the time) set up under the Department of Agriculture with numerous observation centres located throughout the Caribbean and along the

coastal United States. These centres were augmented by a fleet of picket ships that maintained positions at sea to act as early detection platforms, locating developing storms.

Since that time, reconnaissance of hurricanes has kept pace with technology. The advent of the aircraft as a hurricane reconnaissance platform during World War Two propelled our knowledge of hurricanes to new heights. The US Air Force and US Navy took the lead establishing dedicated weather reconnaissance units and developing specially-equipped aircraft. Aircraft with airborne radars became the principal tools to peer into these violent torrents in a bid to unlock their mysteries. Although the military's main contribution, to what has been labelled the longest-running humanitarian effort, has been one of reconnaissance, there was still an overriding need for scientific research to assist efforts aimed at predicting a hurricane's path and strength. It was vital to fully understand how these storms form and what makes some worse than others and more importantly, to see if they could be tamed.

It was after a series of hurricanes in 1954 and 1955, that a serious effort was made to investigate the structure of hurricanes to develop improved forecasting techniques. The National Hurricane Research Project, under the Department of Commerce, was initiated at the end of the 1955 hurricane season. The research project was to incorporate air operations to penetrate hurricanes and collect scientific data on the storms, it thus prompted the acquisition of aircraft and in 1956 these were borrowed from the US Air Force. Later, in 1960, the Commerce Department purchased two used DC-6 airliners and modified them with meteorological instruments and radars tailored for the hurricane research mission.

But it was not until 1975, when the Department of Commerce received the first of two WP-3D Orion flying laboratories, that the science of hurricane research was really advanced. The WP-3Ds were highly specialised for data collection, designed from the ground up for atmospheric and oceanographic research. They were the most advanced instrumented aircraft at that time and technologically superior over those used to conduct the previous 20 years of hurricane research. The WP-3D penetrated hundreds of storms, gathering data on hurricane formations and characteristics that could assist scientists in understanding their inner workings and so help predict their path and intensity.

In recent years, a theory has been developed that to accurately predict the track, speed and intensity of a hurricane depends on obtaining a clear picture of the 'steering currents' in the upper atmosphere. This theory was put to the test during Hurricane *Emily* in 1993 when the two NOAA WP-3D Orions conducted a synoptic flow experiment, flying on either side of the storm to map the three-dimensional wind field. The results established that the wind field (in the upper 'outflow' region of the storm) held the keys to predicting the storm's motion. Understanding this high-altitude region of a hurricane and how it is influenced by other atmospheric circulations in the upper atmosphere could vastly improve the accuracy of NOAA's hurricane storm track computer models, which in turn could result in an increase of around 20% in the 24 and 36 hour track forecasts. These are the critical periods where evacuation warnings are issued and action to protect property is taken. Reducing the warning area, currently covering 300 miles (483km) of coastline, could avoid unnecessary and costly evacuations, preparations and personal hardships.

In order to acquire this quantitative data throughout the depth of the troposphere, in the near environment of a hurricane, a new aircraft was required. It needed long endurance, high speed, high-altitude capabilities and the payload to take aloft sophisticated instruments to make soundings around the periphery of the storm. The current batch of turboprop aircraft in use today, although perfectly adapted to low-altitude hurricane penetrations for research purposes, lack the speed and ceiling requirements of the new hurricane surveillance mission. The Gulfstream IV-SP jet meets and exceeds the new mission requirements.

The Gulfstream IV-SP is a performance-enhanced derivative of the world famous Gulfstream business jet. It is the latest generation off the Gulfstream production line (apart from the G-V, which is still undergoing certification flying) that flies higher, faster and is more efficient and reliable than any Gulfstream aircraft before it. The aircraft incorporates state-of-the-art avionics, a glass cockpit, new Rolls-Royce Tay turbofan engines and a large cabin. The fuel-efficient turbofan engines can propel the aircraft to Mach .85 (561mph) and the dual-cabin pressurisation system maintains a cabin pressure equivalent to a height of 6,500ft (1,980m) at the aircraft's certified ceiling of 45,000ft (13,716m). This is perfect for investigating the 'outflow' region of a hurricane that rises up between 20,000 and 50,000ft (6,100 - 15,240m).

The NOAA Gulfstream IV-SP was delivered 'green' from the company's production facility in Savannah, Georgia, to the prime contractor E-Systems Inc in Greenville, Texas. Under a $35.8 million contract with NOAA, E-Systems (recently acquired by Raytheon) procured the aircraft from Gulfstream and outfitted it to NOAA specification. The modifications encompassed floor rails for standardised equipment racks and power/data system outlets installed throughout the cabin. The jet comes with a flight management system, a traffic collision avoidance system, GPS navigation and the above mentioned electronic flight instrumentation system (EFIS) or 'glass cockpit'. It was also equipped with a state-of-the-art communications system, with the capability to transmit in-situ data back to the National Hurricane Center in near real time.

The jet has been initially equipped with three major mission systems, the airborne vertical atmosphere profiling system (AVAPS), main aircraft data system (MADS) and hurricane analysis processing system (HAPS) as well as a Collins C-band colour weather radar and new GPS-based Dropwindsonde system. The interior is fitted out with eight multi-purpose workstations incorporating an adaptable data processing system designed for maximum flexibility, ruggedness and ease of operation and maintenance. The workstations are also

Above: ***One of the Department of Commerce's two WP-3D Orion flying laboratories delivered in 1975.***

Below: ***The heavily-modified WP-3D Orion includes sensors in the tail boom and the ventral radome.*** (via Author)

reconfigurable for different projects and designed for ease of removal, facilitating future mission flexibility. Crew complement consists of two pilots, two observers and six to eight meteorologists and scientists.

The installation of the Dropwindsonde launch 'chute was carried out by Aeromet Inc of Tulsa, Oklahoma, with the HAPS system provided by the Hurricane Research Division. E-Systems delivered the hurricane hunting Gulfstream to NOAA during May 1996 at the agency's Aircraft Operations Center located on MacDill AFB (Tampa, Florida) in time for the 1996 hurricane season which begins in July. Although most of the planned flights are for operational evaluation of the aircraft in proof-of-concept, it is possible that synoptic information generated in this first hurricane season could considerably add to our knowledge of the phenomenon.

The NOAA jet also has the potential to acquire additional future mission capabilities. With the addition of laser profilers, scatterometers and spectrometers, the Gulfstream jet could perform a variety of taskings including weather research, global climate studies, air chemistry, cloud microphysics air pollution monitoring, severe storm (tornado) investigations and remote sensor development.

The jet, with some additional equipment, could even be developed as a hurricane reconnaissance platform which encompasses penetrating the hurricanes to determine the centre of circulation, maximum winds and central pressures. Once equipped, the Gulfstream could easily be a viable successor for current military hurricane reconnaissance aircraft which are due to be replaced sometime after the turn of the century.

The name 'Gulfstream' is derived from the warm ocean current that weaves its way though the Caribbean and up along the eastern seaboard. In nature, the Gulfstream influences hurricanes, often trapping them within its warm waters. Perhaps this man-made Gulfstream will also have an effect over future hurricanes by adding a new dimension in the science of hurricane research. AFM