Airborne Photography of the Solar Eclipse of the Quiet Sun; Project APEQS

by Tim Williams

The APEQS DC-8, N801E, on the West Ramp on July 17, 1963. Two days later it would fly a "dry run" on the eclipse course in Northwestern Canada. One week after that, it would have completed the scientific mission, been reconverted to a passenger carrying DC-8-51 and delivered back to Delta. (DAC photo C 52585 from the author's collection)

Project APEQS (Airborne Photography of the Solar Eclipse of the Quiet Sun) was an expedition that gave a large group of astronomers an opportunity to observe and record various phenomena during the total eclipse of the sun on July 20, 1963, from a stratosphere vantage point over the Northwest Territories of Canada. The expedition was undertaken jointly by the National Geographic Society and the Douglas Aircraft Company, Inc.

1964 was designated the Year of the Quiet Sun. It was one of the mid-century efforts at international scientific cooperation. The quiet sun meant a period of minimum sunspot activity. And, while the Year of the Quiet Sun officially began on January 1, 1964, there were no total solar eclipses in 1964. As it happened there was to be a total solar eclipse in western Canada on July 20, 1963, and this was within the quiet sun period. The opportunity to study the July 20, 1963 solar eclipse was not to be missed. The Douglas Aircraft Company's Advanced Research Program proposed and developed an airborne solar eclipse observation project.

One of the major hurdles in the realization of the project was engaging an aircraft to serve as a platform for the instruments and scientists. Aircraft were not available because airlines were building their jet fleets as rapidly as they could. Delta had scheduled the return of Ship 14 to Douglas, in Long Beach, for conversion to DC-8-51 standard in July 1963. Douglas and National Geographic were able to negotiate a lease of the aircraft within the month of July. The lease covered a period of days. Indeed, N801E was redelivered to Delta, as a DC-8-51, on July 25, 1963, five days after the eclipse flight.

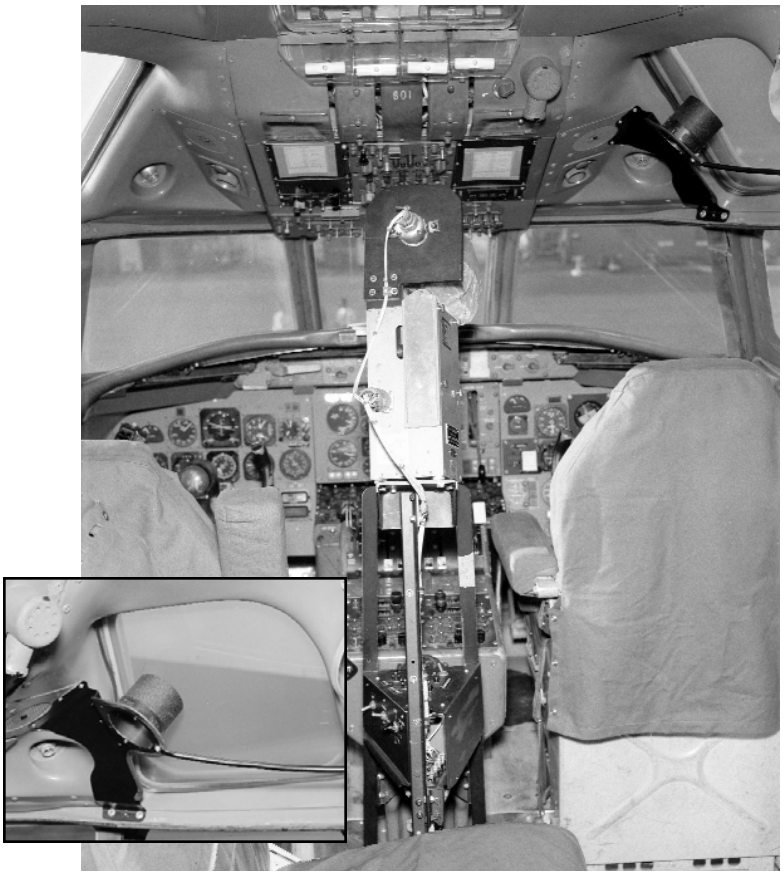
Modifications Required to Accomplish the APEQS Mission

Autopilot

In commercial operation stratospheric flight, first generation airliners experienced oscillation amplitudes of plus or minus 2 degrees on all three axes with periods of 5 to

APEQS DC-8-51, N801E, showing logos of project participants on forward fuselage. (DAC photo C 52587 from the author's collection)

15 seconds. These oscillation periods did not provide sufficient stability for long exposures required for gathering observations such as eclipse corona spectrography. Autopilot specialists were confident they could improve stability significantly. Tests were conducted using DC-8-54JT, 45640, on February 13, 1963, and DC-8-54JT, 45669, with the standard SP-30 autopilot on April 19, 1963. The second test produced motion amplitudes of half a degree over 30 seconds. These tests enabled Sperry Phoenix Company to provide a very sensitive advanced autopilot system for the Quiet Sun project DC-8. Indeed, the autopilot achieved a wingtip stability of less than one fourth of a degree throughout the actual July 20 observation run and longitudinal deviations were even less.



The sun compass is shown installed in the cockpit in N801E. The lens in the starboard eyebrow window is mounted at the angle of the altitude of the sun. In flight with level wings the sun's image is centered on the light colored grid in the position of the pilot's right armrest. The equipment mounted on the pole between pilot positions is a V-10 motion picture camera to record flight information. Inset shows the detail of the lens mount. The sun compass was used to aid in keeping the wings level during the data gathering run. (DAC photos C 52613 and C 52614, respectively, from the author's collection)

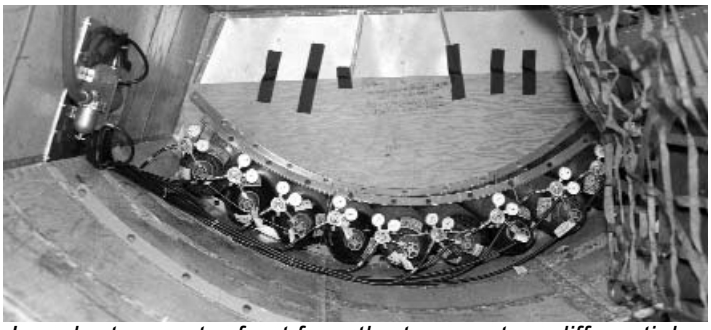
Sun Compass

In order to keep the various instruments aimed at the sun a jury-rigged sun compass was devised. It consisted of a lens mounted in the starboard cockpit eyebrow window at the angle of the sun's altitude above the horizon (48 degrees on July 20). With the wings level an image of the sun would be projected on a pad above the captain's right knee. Keeping the image centered would assure the correct aim for the scientific instruments.

One of the articulated type observation windows is shown from the outside. These windows could be adjusted on a vertical axis. (DAC photo C 51625 from the author's collection)

Windows

While some observations could be made through standard multi-pane Plexiglas cabin windows, modified windows were necessary for some experiments. Modified windows included optically flat single pane windows kept frost-free by dry nitrogen jets, articulated windows, windows mounted at the angle of the altitude of the sun. Windows with jettisonable Mylar sheets to protect window exteriors from rain and dust were tested, but proved to be unreliable.



In order to counter frost from the temperature differential on the single pane observation windows a nitrogen manifold system was used. Nitrogen bottles, regulators and lines are shown in the cargo hold. (DAC photo C 52644 from the author's collection)

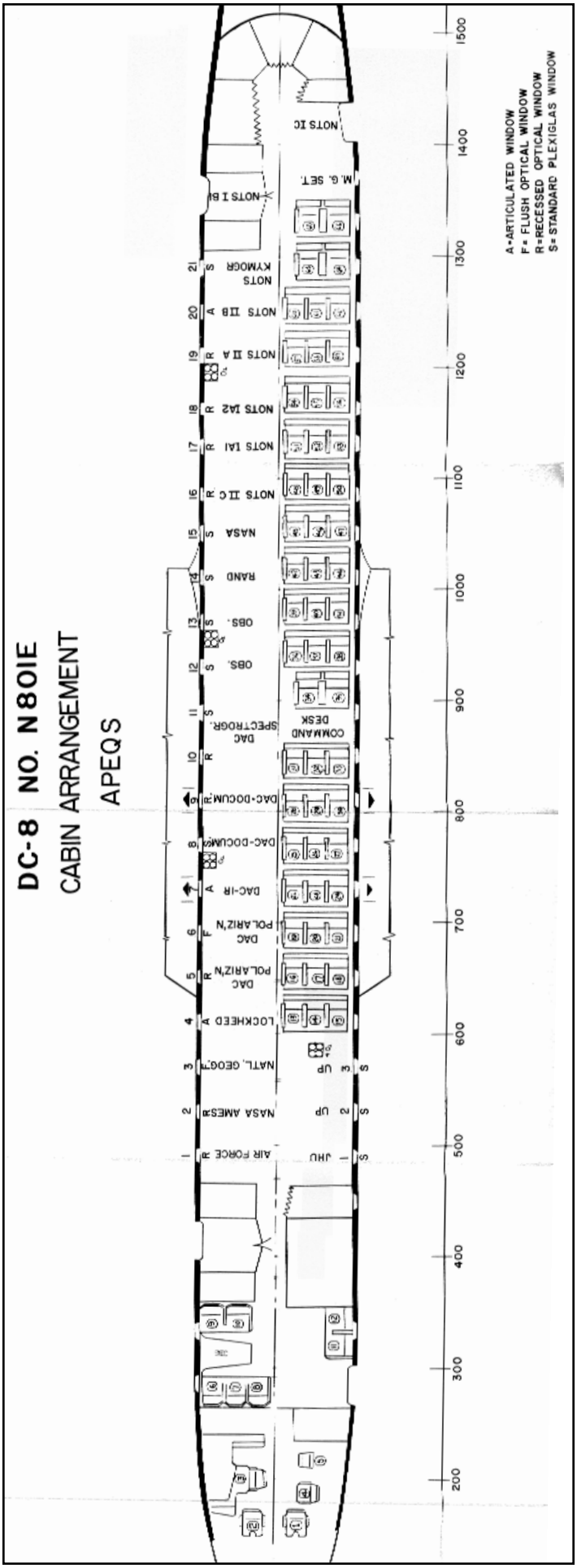
Nitrogen Supply

Eighteen bottles of dry nitrogen were installed in two cargo compartments. Each window station had a dispensing valve and a flow meter which allowed the operator direct the dry nitrogen to keep the pane frost-free.

Electrical Power

To power some of the experimental equipment, a 900-lb five-kilowatt generator was installed in the cabin. A control panel station was also installed in the cabin.

A 110 volt generator was used to power equipment related to the data gathering. (DAC photo C 52633 from the author's collection)



This diagram shows the layout of the various scientific data gathering experiments. The types of viewing windows are identified by the following code: A= articulated window, F= Optically flat, R= Flat pane positioned at the angle of the altitude of the sun, S= standard passenger window. (DAC drawing from the author's collection)

Darkroom

The forward restrooms were converted into darkrooms. They were not usable because their water flushing systems were made inoperative to prevent window contamination.

Exterior Paint

Part of the upper surface of the starboard wing was painted with an anti-glare panel. The forward fuselage carried special mission markings, including logos of the organizations participating in the project.

The seats were removed from the starboard side and the first four rows on the forward port side of the main cabin to make room for instrument stations to observe and record phenomena for the 25 experiments. There were 55 scientists and support personnel on the flight.

Organizations participating in APEQS Program:

Douglas Aircraft Company Advanced Research Program
National Geographic Society
NASA
Aeronautical Research Laboratory of the U. S. Air Force
Naval Ordinance est. Station, China Lake Naval Missile Center
Rand Corporation
Lockheed-California Company
Service d'Aeronautic of Verrierres-Buisson, France in association with the University of Pittsburgh
Johns Hopkins University
Mount Wilson and Palomar Observatories
Astrophysical Observatory of Arcetri, near Florence, Italy

The path of the total eclipse would begin in Hokkaido, Japan, and travel across the Bering Strait, Alaska, Canada and Maine before disappearing over the Atlantic. The area where the total eclipse would last longest was centered around Fort Providence in northwest Canada. The flight would follow a race course pattern west-northwest, opposite the track of the moon's shadow, and turning 180 degrees, allowing the shadow to overtake the flying laboratory from behind. The race course was intended to be 200 miles long and 24 miles wide. The ground speed of the moon's shadow was 1,710 mph. With the DC-8's speed at 525 mph, the scientists would have 144 seconds of totality to record their observations.

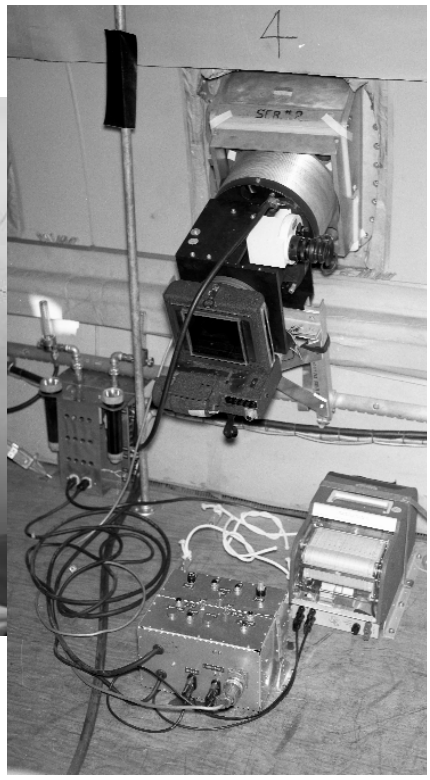
The APEQS Project DC-8 left Douglas Long Beach on July 18, 1959, to be in place for a dry-run flight on July 19. The project flight operated out of Edmonton International Airport. The DC-8 flight crew were Douglas Aircraft employees: Captain A. G. "Heimie" Heimerdinger, Copilot and

Flying above the Orange County coast, Delta DC-8-51 has been temporarily converted as a flying laboratory to gather data on a solar eclipse - the APEQS Project. Notice the anti-glare black area on the starboard wing and the variety of viewing windows on this side of N801E. (Photo from the author's collection)

This view, looking forward, shows the modified main cabin with some seating on the port side and experiment sensors on the starboard. The experiments from Johns Hopkins and Service d'Aeronautic of Verrierres-Buisson, France in association with the University of Pittsburgh are in front of the seats. (DAC photo C 52652 from the author's collection)

The command desk was located among the seats on the port side of the main cabin. (DAC photo C 52647 from the author's collection)

The two atmospheric aerosol collectors and the aft facing Benson-Lehner motion picture camera mounted on the left turbo compressor access door. (DAC photo C 52615 from the author's collection)



The Lockheed corona experiment mounted K-24 and motion picture cameras on an articulated observation window. (DAC photo C 52619 from the author's collection)

Navigator Paul H. Patten, Flight Engineer Joe Tomich and Assistant Navigator Warren T. Dickinson. Canadian Pacific and Trans-Canada Air Lines ground crews serviced the DC-8 at Edmonton. The Canadian Department of Transport sent men and equipment to put a radio beacon at Fort Providence in support of eclipse expeditions in the area.

July 20, 1959, Eclipse Flight Schedule:

Takeoff was at 10:15 a.m. local time.
Climb to Ft. Smith, arrive 11:30 a.m.
Maneuver to determine winds and to adjust timing; arrive near Ft. Providence 12:45 p.m.
Down-track leg toward Big Island, and turn on race track course 12:51 p.m.
Complete up-track leg 1:16 p.m.
Complete turn-around near Ft. Simpson 1:21 p.m.
Begin intercept umbra at Ft. Providence 1:39 p.m.
Turn to right to fly south 1:41 p.m.
Turn on course parallel to eclipse track 1:49 p.m.
Return onto airway south of Ft. Smith 1:54 p.m.
Land at Edmonton International Airport 3:00 p.m.

N801E was scheduled to depart Edmonton at 4:30 p.m. and arrive at Long Beach at 7:45 p.m.

The project modifications were removed and the aircraft was delivered back to Delta on July 25, 1963, as a DC-8-51.

Acknowledgements:

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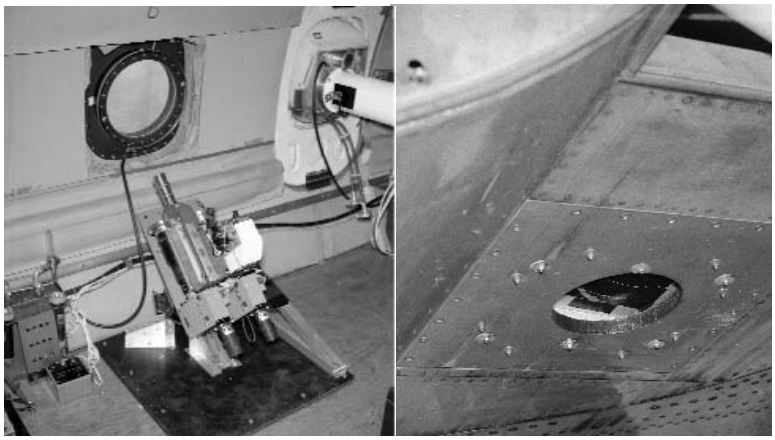

LEFT: The single pane optically flat observation window at station 6 is used for the Douglas Aircraft Company polarization experiment. (DAC photo C 52653 from the author's collection) RIGHT: The round port on the lower surface of the wing was to allow a downward mounted Nikon F 35 mm camera to record the umbra below caused by eclipse as the DC-8 APEQS laboratory made its precise run over Northwest Canada. (DAC photo C 52645 from the author's collection)

The Douglas Aircraft Company's spectrography experiment uses a flat panel placed at an angle equal to the altitude of the sun during the eclipse data gathering run. (DAC photo C 52654 from the author's collection)

This photo shows Delta DC-8-51, N801E, on lease to Douglas Aircraft Co. and the National Geographic Society in mid-July 1963. The logos of the APEQS participants can be found on the forward fuselage and the National Geographic Society flag high on the vertical stabilizer. (Photo from the author's collection)