LOW-ALTITUDE WIND CONDITIONS ON HELIOS FLIGHT DAYS AT KAUAI, HI

L.J. Ehernberger
Lancaster, California

Abstract: Aircraft designed for high-altitude long endurance missions using solar cell power use very low wing loading design and fly at low speeds to minimize power requirements. Hence, the Helios aircraft flight days are limited to runway wind speeds below 10 knots and wind speeds aloft which are less than its maximum cruise speed (near 20 knots true airspeed at sea level and 50 knots near 50,000 feet altitude). Its low wing loading combines with structural flexibility to produce noticeable responses to turbulence. As a result of an in-flight mishap on June 26th 2003 comparisons of wind conditions that day with previous flight days were accomplished. This paper reviews the details of the low altitude wind profiles measured on June 26th at Lihue on the south-east coast of Kauai, at the U.S. Navy Pacific Missile Range Facility on the west coast of Kauai and in-situ winds measured by Helios along its flight track. Winds measured on other flight days are also compared at selected altitudes. Relative findings are discussed with respect to wind-induced turbulence in the trade wind wake of Kauai.

1. INTRODUCTION

Aircraft designed for high-altitude long endurance missions using solar cell power use very low wing loading design and fly at low speeds to minimize power requirements. A series of unmanned, prototype, solar powered aircraft have been designed and flown by AeroVironment Inc. and the National Aeronautics and Space Administration's Dryden Flight Research Center (NASA DFRC) at the U. S. Navy's Pacific Missile Range Facility (PMRF) at Barking Sands on the west coast of Kauai HI (Ehernberger 2004, Teets 1999, 2002). Low wind speeds, less than 10 knots, during landing and take off are an operational safety requirement for the prototype flight demonstrations of these aircraft.. The mountain topography at Kauai provides substantial trade wind shelter for the PMRF runway. Wind speeds are especially low during the reversal periods between land and sea breezes. This comes at an expected cost of some exposure to wind shears associated with the local sea breeze and with the trade wind wake on the downwind side of the island. Some light turbulence associated with these features is an operational expectation. Even with efforts to minimize turbulence exposure, some encounters are expected.

Flight operations avoid flying on days that threaten to have turbulence intensity which would be perceived as moderate by conventional aircraft responses or as indicated on routine aviation weather turbulence forecast products. When areas or layers of light or moderate turbulence development are suspected on flight days, the trajectory is managed to minimize the exposure as much as possible. The primary concerns are the surface wind speed at the PMRF runway and the SODAR observations (Donohue 2001) of wind speeds and vertical motion variance immediately above the runway. Strong winds and wind shears aloft as well as clouds and precipitation are additional weather factors, which concern flight safety.

While in the low altitude climb on June 26, 2003, the Helios aircraft experienced an in-flight mishap which led to loss of the vehicle. As reported by new releases issued by the NASA Dryden Flight Research Center on Junly 1, 2003 and July 10, 2003, the mishap occurred off the west coast of Kauai, approximately 10 miles west-northwest of PMRF at an altitude of 2980 feet above mean sea level. Atmospheric turbulence, enhanced wind shear and small-scale updraft or downdraft motions were among several possible contributors to the incident. The trade-wind shear lines often marked by whitecaps at the north and south edges of the island wake were a suspect source of perturbing atmospheric motions. On flight days, the solar powered aircraft were "chased" by a helicopter at low altitude. Radio calls from the chase helicopter crew describe the location of the shear line and the trajectory is adjusted when needed to minimize exposure to "shear line turbulence".

After the mishap on June 26, 2003 investigations were initiated to discern the possible nature of atmospheric perturbations that may have been involved. Three approaches were followed. First, the available meteorological observations were reviewed. These included the runway wind speed observations, SODAR measurements at the airfield, in situ wind data acquired by the Helios airplane. In addition the review included upper-air profiles measured by rawinsondes supporting the flight at PMRF and the synoptic upper-air each 12 hours at Lihue HI. Second, a fine scale atmospheric numerical simulation study supported by additional in-situ aircraft observations was initiated (Lane et. al. 2004). Third, for baseline reference purposes, a comparison of low altitude wind conditions on June 26 with previous solar airplane flight experience was made using wind data from PMRF and Lihue. This presentation describes the low altitude wind measurements on June 26, 2003 and their comparisons with previous solar powered aircraft flight days at PMRF.

2. CLOSING REMARKS

Available wind data from onboard the Helios airplane does not indicate that the Helios penetrated the northern shear line in the wake of trade wind flow at Kauai. Given the lack of offshore wind observations, and airborne measurements in the flight region, fine scale atmospheric simulations may help diagnose the likely flow patterns and perturbations encountered along the Helios flight track. Wind conditions at Lihue on the mishap day, June 26, 2003 compared well with climatological expectations. In addition, the winds were within the envelope of conditions experienced on earlier solar powered aircraft flight days at PMRF.

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