LESSONS FROM HISTORY - POOR WEATHER OPS

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Introduction

Naval airship operations following World War II consisted of two major missions: Anti- Submarine Warfare (ASW) and Airborne Early Warning (AEW). Airship effectiveness for ASW had been well demonstrated during the War when K ships successfully escorted hundreds of coastal vessel convoys in Atlantic and Pacific waters. This role was continued with modernised K types, designated ZSG-2s, 3s and 4s and later designs ZS2G-1 and ZPG-2. The ZPG-2 was fitted with a large radar scanner mounted under the car. A variation was designated ZPG-2W for AEW missions. Since the ZPG-2 and 2W airships had much longer endurance and operated at higher altitudes (in the case of the AEW missions) the question of their capability in weather conditions likely to be encountered remained to be answered. In particular, data were needed on snow and ice build-up and retention and the characteristics of these phenomena. Consequently, projects were established to obtain the required quantitative information as well as operational experience during winter months.

Project Lincoln

An initial investigation to determine airship all-weather capabilities was established by the Office of Naval Research (ONR) in July 1954. It particularly aimed at acquiring data on winter flight operations involving snow and icing conditions. The project was assigned to the Naval Air Development Unit (NADU) based at N.A.S. South Weymouth, Massachusetts. This organisation was already engaged in a program with the Massachusetts Institute of Technology Lincoln Laboratories for the development of improved radar systems. The all-weather investigation became part of this program.

All flights were made with ZPG-2 and 2W airships from NADU and squadron ZW-1, based at N.A.S. Lakehurst. ZPG-2 and 2W specifications are shown below. A ZPG-2W airship is pictured on this page. Ten initial flights were flown by NADU airships during the winters of 1954, 55 and 56.

ZPG-2 & 2W Airship Characteristics

Length: 342.7 ft
Height: 94.7 ft
Width: 75.4 ft.
Envelope Vol: 975,000 cu ft (finess Ratio 4.5)
Gross Weight: 66,400 lbs (max lift: 6000 lbs)
Max Speed: 70.5 kts
Endurance @ 40 kts: 54 hrs

The National Advisory Committee for Aeronautics (NACA) provided personnel and special equipment to monitor snow and ice accumulation on one of the airships during the flights. The scientific gear consisted of rate-of-accretion meters for ice detection, measurement of water droplet sizes and water content of icing clouds. Film and TV cameras also were used to observe snow and ice build-up. Deliberate effort was made to find and fly in icing conditions.

A three-phase program was established following completion of the ten initial flights. This included:

Phase 1. Continuation of NACA data recording of ice and snow accretion while in an AEW patrol situation.

Phase 2. A ten-day continuous on-station demonstration at an AEW barrier location

Phase 3. A long flight across the Atlantic Ocean and return.

A period from January 14-25, 1957 was chosen for the Phase 2 exercise. The AEW barrier station was an area 20 miles in radius (approximately 180 miles off the New Jersey coast). Five airships were involved: two ZPG-2s from NADU, and three from AEW Squadron ZW-1 based at N.A.S. Lakehurst. One airship was to be on- station each day.

Results of Flight Ops

The NACA recorded data on six of the ten initial flights, one of the Phase 1 and two of the Phase 2 flights. In addition to the recorded information, the Agency noted pertinent details of the flight operations and performed an analysis of the physical and meteorological conditions necessary for ice formation.

None of the airships flown in the ten initial flights were equipped with any provisions against ice or snow effects. The NACA equipment was transferred to ZPG-2 bureau no. 141561, dubbed Snowbird, for Phase 1 and 2.

Snow Effects **-** Most snow produced little or no effect on the airship while in flight. Dry snow was swept off by the airstream. Wet snow could accumulate especially in small valleys such as along the catenary seams. The area between the upper fins also experienced some accumulation. These loads were compensated by trimming the airship. A more serious problem was the collection of snow prior to take-off. One instance was cited where forward speed during take-off was relied on to blow off a heavy wet deposit. Some of this occurred, but a sizable amount remained on the aft portion of the envelope causing a tail-heavy condition. Attempts to compensate required the maximum available amount of ballonet air forward plus a large down elevator position. At the same time, icing was encountered which further increased static heaviness. Greater power was required to compensate for the high angle of attack. This was not desired because the higher fuel consumption would reduce capability to meet the endurance requirements for the mission. The situation was corrected by descending to a lower altitude. This increased the air temperature, which melted some of the ice and snow and allowed more air to be available for re-trimming the airship.

Heavy snow was a problem during pick-up of seawater for re-ballasting on one occasion. The low airspeed required for this manoeuvre combined with higher temperatures at the lower altitudes produced wet snow, which did not blow off. However, ballast pick-up was performed many times successfully during the later Phase 2. One of these was conducted at night and another in light snow.

Icing **-** Icing was considered to be potentially a more serious problem. No special provisions were made on the airship to prevent ice formation or protect against its effects during the first seven recorded (NACA) flights. It was found that the greatest icing rate occurred at 3000 ft., a mission altitude for AEW flights. Two types of icing were encountered: rime ice, resulting from small supercooled clouds which formed on exposed objects and protuberances but not on the envelope and glaze ice produced by freezing drizzle which formed on upper envelope surfaces and other components. This latter type was considered to produce the most icing conditions. However, it was judged that conditions that produce freezing rain are much less likely to be encountered as the distance from land increases.

The greatest deposit of ice was encountered on NACA flight 3. About 4000 lbs. was estimated. As accumulation increased, it was evidenced by vibration in the car, which became more severe as it continued. The cause was propeller imbalance due to ice formation and release. An air damper froze shut preventing airflow into the center ballonets. Ice on the windshield obscured forward visibility. As ice formed on the antenna wire, it caused a severe whipping action, which could have fouled the ripcord and the propeller, although this did not happen. A descent to lower and warmer altitudes caused the ice to melt. Large quantities fell off envelope surfaces striking propellers and other components. Thirty punctures of the lower fins occurred, mainly caused by oscillating brace cables and chunks falling from upper fin leading edges.

Other flights produced similar conditions of somewhat lesser severity. Icing of exposed control cables caused one cable to jump a pulley and jam in the guard housing. The airship was able to return to the base for correction of the problem.

The experience gained during the initial flights provided guidance for installing special equipment on the Snowbird to control the effects of ice build-up. These included:

- a shielded control cable system at ruddervator horn pulleys
- flush mounted antennas
- electrically heated centre ballonet air inlet dampers
- improved heat to windshield
- a protective coating to lower fin top surfaces
- a protective blanket inside the envelope in the propeller plane
- electrically heated propellers.

The pilot in command for several initial Phase 1 flights was the late Charles A. Mills Jr., who was awarded the International Harmon Trophy for his pioneering effort.

The barrier station was maintained during the entire 10-day period of Phase 2. The weather was anything but cooperative consisting of icing, snow, sleet, rain and fog and winds as high as 60 knots. The average flight was 37.8 hrs. in duration including 22.2 hrs on station. It took an average of 5.8 hrs. to reach the barrier station and 6.3 hrs. to return. The longest flight was 56.3 hrs. and the shortest was 23.7 hrs. Wind was the responsible factor in making these differences.

One of the most difficult tasks was in ground operations. These had to be accomplished in snow, low visibility, rain and high wind. One launch was done with high winds and gusts to 35 kts. One of the airships landed and was masted with winds gusting to 39 kts. Other limited conditions included a landing with a 200 ft. ceiling and 3/16-mile visibility, and a take-off with a 100 ft. ceiling and visibility 1⁄4 mile. Maintenance checks had to be accomplished in below-freezing temperatures. Frozen latches on mooring masts were a problem at times.

The Snowbird departed South Weymouth on March 4, 1957. The take-off was made between high banks of snow and in very cold weather. Continuous snow and some icing were experienced for the first day and night of the flight. The route included a transatlantic crossing to the coast of Portugal, south along the African coast, recrossing the Atlantic and landing at NAS Key West. A new endurance record for un-refuelled flight was established at 264.2 hrs. while covering 9448 miles. CDR. Jack R. Hunt received the Harmon Trophy in recognition of his command of this flight. *(We covered this story in an earlier edition of AIRSHIP - Editor)*.

Squadron ZW-1 Experience

Squadron ZW-1 was established in January 1956, operating ZPG-2W airships. Valuable all-weather training and experience were gained from the squadron's participation in the Project Lincoln exercise. The squadron became fully operational in July 1957. A one-year evaluation of its performance was made in 1958. The winter weather during that period was reported as severe. Ice and snow conditions were similar to those experienced during Project Lincoln. From July 1957 through June 1958, a total of 5,118 hours were flown. The squadron was committed to provide 288 hrs. of radar coverage per month at the picket patrol station about 180 nautical miles southeast of NAS Lakehurst. It actually achieved 292.6 hrs. for an annual total of 3,512 hrs. of coverage. WV-2 airplanes were flown over the same barrier station and achieved a detection rate of only 53% compared with the airships' 81%. The most serious winter weather problem was high winds of long duration. Two flights were aborted for this reason. These might have been permitted if an alternate base had been available. Alternate bases became available later.

Operation Whole Gale

This project was established by Airship Wing One in an attempt to counter the decision by the high command that airships were no longer suitable or at least not necessary for ASW missions. Helicopters and airplanes were being equipped to provide this function. Again, the all-weather capability of airships was a prime factor. Hence, the months of February and March 1960 were chosen to demonstrate that ASW missions could be flown under winter conditions. Airship squadron ZP-3, assisted by squadron ZP-1, both based at N.A.S. Lakehurst were directed to carry out the operation. Six ZPG-2 airships were involved. The "On-Station" area was about 150 miles due east of Lakehurst to about 250 miles SSE beginning 25 miles offshore. Continuous ASW patrols were to be maintained over that area for the two-month period.

The operation was well named. High winds, heavy snows and icing were the norm. In one instance, one of the airships carried a 6000 lb. snow load while on station. It was not clear from the record whether much of this had been accumulated before take-off or had been acquired during the ASW patrol. Although the airship was able to carry the burden, it produced a high drag condition and high fuel consumption such that a landing had to be made at another base to refuel prior to returning to Lakehurst. Conditions on the ground prior to take-off caused the greatest difficulties. Gusting winds made ground handling a hazardous challenge. Snow accumulation on the mat was sometimes a handicap in making take-off runs and maneuvering the airship. Also, high winds sometimes required landing at an alternate base. In general, ground and flight conditions were similar to those experienced during project Lincoln except that they covered a longer period of winter weather. No measurements of snow or ice formation were made.

Design performance values were often exceeded. Times on station were by far greater, the longest being 95 hrs. The on-station coverage for the two-month period was slightly more than 88%. A simultaneous heavier-than-air operation flew 150 hrs. compared to 1647 hrs. of LTA time. Together the combined operation provided 92.8% continuous coverage.

Airship Operational Data

Aside from the discussion of the successful flight operations and the ice and snow information that were collected, it is interesting to compare some of the operational values with design information for ZPG-2 and 2W airships. All Project Lincoln Phase 2 flights took off at 2-10% above design mission gross weight. Also, car design gross weight was exceeded by up to 10%. This was possible because extra lift was provided by helium addition. However mission altitudes had to be attained by valving helium.

Flight commanders complained that the 6000 lbs limitation on static heaviness was the main reason for this arrangement. This is difficult to understand since design specifications allowed for 8,000 lbs heaviness condition with reduced safety factors. Two flights in Phase 2 took off 8000 lbs heavy, while most others were below 6000 lbs. No structural problems or failures were reported. A specific deviation was allowed by the Bureau of Aeronautics for the Phase 3 endurance flight.

Ground handling equipment also must be sufficiently prepared for reliable operation in winter weather. Many flights returning to base were delayed in landing due to lack of readiness of ground crews or poor ground conditions. This meant that pilots had to have sufficient fuel to allow loitering (up to 9 hrs. in some cases). Sustained high headwinds also increased the time required for transit to and from the patrol area and, in some flights, reduced time on station. It is obvious that flight planning was conservative enough to cover these contingencies.

Removal of snow to prevent damage while on the ground and allow improved flight conditions is a necessary procedure when heavy accumulations develop. The use of high- pressure hoses appears to be the most practical method.

Crew comfort was an issue. It was felt that while the design endurance easily could be met by ZPG-2 and 2W airships, facilities for sleeping, washing and lavatory visits were inadequate for such long flights. This was a common complaint from operational squadrons as well as from the development activities.

Conclusions

The results of Project Lincoln, the operational experience of squadron ZW-1, and the later Operation Whole Gale all confirmed that Navy airships were capable of performing their missions under severe weather conditions, especially those involving snow and ice phenomena. Some of the flights exceeded design specification values but encountered no failures. The greatest handicap was high sustained winds, which caused excessive fuel consumption, reduced time on station and increased transit time. Alternate bases were a partial solution. Special provisions to prevent ice accumulation or protect some components can be incorporated. Ground handling equipment needs to equipped for cold weather conditions. Improvements in provisions for crew habitability were recommended.

References

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2. NACA Technical Note 4220, April, 1958
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4. "Kite Balloons to Airships – The Navy's Lighter-than-air Experience" 1986
5. Goodyear Aircraft Corp. Report GER 8438, Sept. 1958
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7. Navy Design Specifications SD-457-1-2, SD-457-1W-2, 1956

Editor's Comments:

I have excluded the various data tables that were published in the original paper, largely due to the limitations of space in this edition of the Journal, but also because the conclusions speak for themselves. The results of these test flights prove that not only can airships operate in adverse weather conditions but they can sometimes provide service when fixed wing aircraft struggle.

No aircraft can fly in any conditions (e.g. the maximum crosswind take-off limit for a modern Boeing 737-800 is just 33 knots) but modern LTA vehicles, with proper flight planning and the benefit of massively improved structural design and flight controls, can operate in a much broader range of weather conditions than people give them credit for. This capability is also confirmed by the findings of the Highlands & Islands Feasibility study reported on *page 10.*

If anyone would like to see the data tables from Project Lincoln and Operation Whole Gale (as originally published in 2004) I have a PDF of that paper and would be happy to forward a copy.

Email at editor@airship-association.org