N76-15041

LIGHTER THAN AIR: A LOOK AT THE PAST, A LOOK AT THE POSSIBILITIES

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In these days of energy concern and the rising cost of all types of fuel, it is not surprising that eminent authorities are casting about for an economical method of flight - inexpensive to operate, causing small noise interference to others, and offering the possibility of great payloads. It is also not too surprising that in the search for economical flight, lighter-than-air aircraft are once again receiving serious consideration as one of the feasible alternatives.

Ever since the first free flight of men, on November 21, 1783, when Pilatre de Rozier and the Marquis d'Arlandes arose from Paris in a "Montgolfiere" or hot-air balloon, lighter-than-air flight has waxed and waned in popularity. Their balloon had a volume of some 60,000 cubic feet of hot air - which was generated by the burning of straw and wool in a brazier suspended under the open neck of the balloon. 1/ Today's modern hot-air balloons typically range from about 77,000 cubic feet to one monster nearly 300,000 cubic feet in size, and instead of burning wool and straw, the modern balloonist burns propane or butane. Although that first free flight of man lasted only about 25 minutes and covered a distance of only five miles, it encouraged others to venture into the age of flight. In January 1793, Jean Blanchard conducted the first free balloon flight in America at Philadelphia. History records that that flight was witnessed by George Washington and his cabinet. 2/

As early as 1794, balloons were used for military purposes. On June 26, 1794, a gas-filled balloon was used by the French to direct fire of artillery onto enemy ranks.

In 1861, during our Civil War, a Professor Lowe introduced balloons into our own military operations for the Union Army. He was cited as influencing a German military attache, Count Ferdinand von Zeppelin, who later designed and built many rigid airships or dirigibles. 3/

The first true airship flight was made in 1852 by Henri Giffard, a Frenchman. Other pioneers included Charles Renard and Captain A. C. Krebs in 1884, and Alberto Santos-Dumont, a Brazilian working in Paris in 1901.

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The first rigid airship, with an interior framework for shape, was constructed in 1895 in Petrograd by David Schwartz, an Austrian. A second ship, all metal (aluminum) was constructed by Schwartz in Berlin in 1898.

On July 2, 1900, Count Ferdinand von Zeppelin and a crew of four others launched the first "Zeppelin" from Lake Constance and in 1908 the Schutte-Lanz Company launched its first airship.

In 1915, Schutte-Lanz and Zeppelin combined forces (resources and patents) to develop the L-30 class of dirigible or "super Zeppelins". They were used during World War I for raids on Allied cities and war vessels. France and Great Britain also built airships for war use, and one of these - the British R-34 - crossed the Atlantic twice shortly after WW I in 1919 - the first airship to accomplish that feat. The United States Navy operated a non-rigid airship on a number of evaluative flights in 1917 and in the same year the Zeppelin L-59 flew a 4,000-mile nonstop round trip from Jamboli, Bulgaria to South Africa.

As part of the reparations following WW I, the United States Navy acquired the German-built Los Angeles, which it operated from 1924 to 1939.

The Germans continued with their successes in dirigibles, and the LZ-127 Graf Zeppelin operated from 1928 through 1937, carrying more than 14,281 passengers and traveling more than a million miles.

The largest airship ever built, the German LZ-129, or Hindenburg, was completed in 1936. It was 811 feet long, and had a gas volume of 7,063,000 cubic feet. Its cruising range at 78 miles per hour was 8,750 miles, and was powered by four 4,000-horsepower diesel engines. Unable to obtain helium, the Hindenburg was lifted by highly-flammable hydrogen. In May 1937, at the end of its 37th Atlantic crossing, the Hindenburg was racked by explosions and crashed at Lakehurst, New Jersey. Essentially, this was the end of the airship era, except for some non-rigids operated since. The Germans began to construct the LZ-130 and LZ-131 as successors to the Hindenburg, but these were abandoned when the Germans decided to concentrate on heavier-than-air aircraft for their WW II venture. One of the oddities of the era was the ZMC-2, a metalclad blimp constructed for the U.S. Navy in 1929. Known as the "Tin Bubble", it had a 202,000 cubic foot hide of 0.0095 Alclad alloy. It was dismantled in 1942 at Lakehurst. Another all-metal airship was the "City of Glendale". Airship engineering for rigid types ended in 1935 in the United States and in 1938 in Germany. The Navy operated a WW II K-class, non-rigid blimp in Air Sea Warfare (ASW) operations. These blimps were twin-engined, and ranged in size from 416,000 to 456,000 cubic feet. The final Navy non-rigids were 1.5 MILLION cubic feet - ZPG-3 ASW airships of the late fifties. The U.S. Navy abolished its Lighter Than Air program in 1960. Other than hot-air balloons, about the only lighter-than-air craft still in use today are the Goodyear blimps. Goodyear constructed 244 blimps for the Navy and Army under contract - 55 more for commercial uses, and a 300th for use as a commercial vehicle in Europe. Besides Goodyear, Wallenkamper has produced some in Germany and delivered one to Japan.

The Goodyear blimps are most famous for their advertising. The smallest of the three in use today is the Florida-based "Mayflower" built in 1968, which is 160 feet long, 58 feet high, and 51 feet wide, with a capacity of 146,300 cubic feet of helium, powered by twin 175-horsepower, 6-cylinder aircraft engines. The Los Angeles-based "Columbia" and Houston-based "America" are sister ships, constructed by Goodyear in 1969. They are 192 feet 1 inch long, 59 feet 5 inches high, and 50 feet wide, with a capacity of 202,700 cubic feet of helium, and are driven by twin 210-horsepower, 6-cylinder fuel injected, pusher-type aircraft engines. These normally operate between 1,000 and 3,000 feet altitude. Goodyear's most recent airship, a sister to the Columbia and America, was constructed in Carington, England, and is known as the Europa. It was put in service in June of 1972 and has performed public relations and public service assignments in 11 countries.

In a series of public information releases, the Goodyear Corporation has given many facts on its nonrigid blimps. One of those releases contains the following:

> Safety is the primary factor in the overall airship operation. Although it is possible to fly in some types of adverse weather, the Columbia remains moored to her mast when there is rain and/or wind in excess of 20 miles per hour. 4/

Quite obviously, this severely limits utilization of the blimps at certain times of the year, and more specifically, in certain areas of the world. The blimps, when they travel cross-country, must be accompanied by a ground party with vehicles for mooring, service, radio control, and ground assistance. There just aren't airports or other ground facilities capable now of accommodating the blimps - hence, the extensive support convoy for cross-country flights.

"It sounds preposterous, but some enthusiasts believe dirigibles will make economic sense in the seventies", says Tom Alexander in an article entitled "A New Outbreak of Zeppelin Fever". Alexander presents some rather interesting facts in his article and states that the Hindenburg:

> ...was so lightly poised in the ocean of air that a child could shove it about. Loaded with seventy passengers and thirteen tons of cargo, it could cross the Atlantic on $500 worth of diesel fuel...

Alexander also speaks of modern day uses for lighter-than-air vehicles in reporting that Goodyear has a $35,000 contract from the city of Tempe, Arizona to work up a preliminary design for a small, two-place police blimp that might replace the "noisy, fatiguing helicopter". He also discusses the Boston University's proposed passenger Zeppelin, which might possibly be nuclear powered. 5/

Alexander also discusses some limitations on airships. He says:

> ...They will never be particularly fast; because of the air resistance to their huge bulk, the practical upper limit on airship speed appears to be somewhere in the vicinity of 100 to 120 miles per hour...

But Mr. Alexander isn't all condemnatory of dirigibles. He describes Gordon Vaeth as the principal activist for the "airship underground" and cites that what

> ...lighter-than-air craft have going for them is the 'square-cube' law - which simply says that if you double the radius of a sphere, the surface area (and therefore weight) will quadruple while the volume increases eight-fold. Applied to airships, what this means is that as they get bigger, they should get better and better in lifting capacity and operating economics. By now, few people in the movement are much interested in airships smaller than the Hindenburg. Vaeth and several others seem to think that dirigibles containing around 20 million cubic feet of helium - or around three times the volume of the Hindenburg - would be about right for starters. 6/

Alexander also credits John Norton, president of J. R. Norton, Co., which is headquartered in Phoenix, with interest in shipping produce by lighter-than-air. He says that Norton ships the equivalent of 10 to 12 carloads of lettuce around the nation daily, but is at the point of despair over conventional transportation.

The Southern California Aviation Council, Inc. (SCACI), has a Lighter-Than-Air Committee which has done prodigious work in exploring the possibilities for future uses of airships. The committee even urged, in a resolution, that research should be conducted into the possible use of dirigibles to help solve some of the nation's transportation problems. 7/ In their unpublished Technical Task Force Report of May 15, 1974, SCACI discusses airships ranging in size from 7,400,000 cubic feet to 55 MILLION cubic feet and with payloads ranging from 114.4 tons to 1,167.15 tons. 8/ The same report speaks glowingly of speeds ranging up to 200 miles per hour (174 knots), and dimensions from 712 feet 7 inches to 1,390 feet 7 inches in length. Diameters range from 142 feet 5 inches to 278 feet 1 inch.

Power is another question entirely. The report indicates that for speeds up to 50 miles per hour, from 2,500 to 21,000 horsepower will be required. Between 51 and 100 miles per hour, the horsepower range is from 5,000 to 27,000. To achieve speeds of 101 to 200 miles per hour, however, the report predicts horsepower requirements of from 30,000 horsepower for the smallest airship to 144,000 horsepower for the largest. Neumann states that engines are available which can generate 1 horsepower for each 1/2 pound of weight. Even if that is achievable, it would take a 72,000 pound engine to generate 144,000 horsepower, not including the weight of fuel. It is conceivable that nuclear power could be developed for use in airships, but problems of shielding and gearing would have to be considered. Safety considerations would also have to be fully brought into any study aimed at nuclear uses for propulsion. The lifting capacity of the airship, naturally, would have to be adequate and it goes without saying that cost considerations would be paramount. Estimates have ranged from 50 million to 500 million to create the first prototype modern airship. In these days of the commonplace cost-overrun, however, it would be conceivable that the cost for the first airship - on the scale envisioned - could easily reach 1 billion dollars.

Although some of the modern visionaries of the airship speak in glowing terms of huge passenger loads, most of the realists in their number devote their efforts to the area of cargo movement. As to the "airlift" capacity of the airship, some of the authorities in the field are talking about payloads of more than 500 tons:

> Let it be clearly stated and understood that the current technology exists within the U.S. to produce an airship capable of carrying payloads in the 250- to 500-ton range. The potential use of a nuclear power plant is technically possible but is politically unacceptable at this time, therefore conventional power plants would have to be considered. 9/

It is also readily conceded by all of the airship advocates that the lifting gas used would be helium. Even though a cubic foot of hydrogen can lift about 10 percent more weight than a cubic foot of helium, the flammability of the hydrogen makes it unacceptable.

Critics of the airship concept are quick to point out the time lag between conceptual design and actual fabrication of any air vehicle, but the airship defenders point out that the Slate Metal Airship and the ZMC-2 - the Navy's "Tin Bubble" - were completed in less than six months after completion of the detailed engineering and construction of hangar facilities.

There are a number of constraints inherent in airship operations. One of these is the tremendous expenditure of power needed to achieve useful speeds. Forward movement of an airship is calculated to require approximately 10 horsepower per ton of airship weight - and this is at low speeds of 50 to 90 miles per hour. On the other hand, dynamic lift can increase gross loads from 8 to 13 percent. In the past there was a 50/50 ratio of structural weight to payload, but new design criteria call for a ratio of 35/65. The SCACI report 10/ also states that an airship applies a lift ratio of 65 pounds for every 1,000 cubic feet of helium gas. Applying that lift ratio to the 55 million cubic foot monster envisioned in the report, we find that the total lift capacity would be 3,575,000 pounds - and at a ratio of 65/35 (payload to structural weight), the payload computes to 2,323,750 pounds - or more than 1,161 tons. It appears that the engineers have adequately done their homework.

The SCACI report 11/ also accepts the metalclad concept for the airship of the future and indicates that using laser welding equipment now available, aluminum sheet can be welded at a speed of 500 inches per minute - 2,400 feet per hour. Technicians and scientists are currently evaluating the need for heat treating the welds produced by the laser technique.

Another of the constraints less susceptible to solution is the problem of a construction facility capable of housing and sheltering the airship during its construction. West Coast shipping yards have been exploring the possibility of using some of their docking capacity for just such a purpose, and some have even speculated on using the Rose Bowl at Pasadena for a construction port. Perhaps the major constraint, however, is overcoming the inertia and lack of any real interest in investing the massive amounts of capital needed for airships.

Researchers have estimated that the supply of helium available is adequate:

> Finally, in recent weeks, as word that the U.S. Government has ended its helium conservation program, the question has arisen whether there is enough helium available to support an airship revival program on a long-term basis. Helium that has been extracted from natural gas and stored underground now totals about 30 billion cubic feet. 12/ A careful analysis of long-term helium reserves (raw helium), particularly that found in natural gas which is not well suited for heating, shows that lack of helium should not be a problem and that a major airship effort can go forth without concern over this point. 13/

We note quickly that the 30 billion cubic feet now stored is considerably more than needed for a fleet of 55-million-cubic-foot airships, even those of the monster proportions spoken of in the SCACI report. It is more than enough, even, for several airships of the proportions envisioned by William Kitterman, a member of the Atomic Energy Commission's Division of International Security Affairs. Kitterman contemplates a 75-million-cubic-foot airship, 10 times the size of the Hindenburg, and nearly a quarter of a mile in length. It could carry a 750-ton payload. 14/

SCACI has been in contact with a number of congressional leaders, including Senators Barry Goldwater, Warren G. Magnuson, Charles H. Percy, and Herman E. Talmadge. They have also contacted airline people and representatives of NASA and the office of the U.S. Navy's Chief of Naval Operations (Air Welfare). Some of the responses have been lukewarm acknowledgements, while others might be construed as half-hearted endorsements of the uses of airships to solve our transportation problems.

In most of the material available on the subject, there is precious little in the way of discussion of the ground-handling facilities necessary to accommodate the huge and ungainly airships of the size discussed. True enough, some of the writers speak of cargo delivery without landing of the airship, but there still has to be a large enough cleared area for maneuvering space.

In "The Helium Horse", Stehling and Vaeth report some interest has been evinced at the working levels within the U.S. Navy - for anti-submarine warfare - and within the U.S. Air Force - for strategic airlift. Almost everyone knows of the role played by "barrage balloons" in guarding strategic installations during WW II, and the use of blimps for convoy escort during that same conflict. Let us, for the moment, concede that there are many uses for which the airship or dirigible might be readily adaptable. Let us also concede that construction of large airships is feasible - in the light of present day technology. Are there enough peacetime and/or wartime uses of airships to warrant the infusion of huge amounts of capital into construction, and if so, what will be the source of that capital? Research and development costs would surely be expected to be underwritten by the U.S. Government - at least, that is the expectation voiced by the airship advocates. Who, then, would be the expected users or operators of these giant airships? The only existent airships today (not counting the hot air balloons) are used in public relations and advertising - or for an occasional sight-seeing trip. It would seem to this writer that there is much work yet to be accomplished by the airship advocates if they are to persuade the public that airships are a feasible answer to public transportation problems. It would also seem that power plants must be designed and constructed with a capacity to generate the tremendous horsepower required to propel the huge airships conceived by airship advocates. Fuel considered to be useful for the airship must be lightweight, readily available, and low in cost. Our truckers now know that diesel fuel is no longer inexpensive. With all the opposition to nuclear power plants evidenced today, it hardly seems reasonable that the public will readily accept an atomic power plant which might conceivably fall on them. Cooling an atomic reactor would present a logistic problem of mammoth proportions to handle the coolant liquid, and shielding of the crew and passengers would be a small problem when compared to protecting those on the earth below.

This writer also finds it difficult to readily accept the predictions of speeds approaching 150-200 miles per hour, or of airships nearly a quarter-mile in length. It is equally difficult to accept predictions that airships will be capable of carrying 2,000 passengers. When passengers can cross the Atlantic in a matter of hours by airplane, how many will be content to fly at speeds of 90-100 miles per hour by airship? Even with radar, storm penetration is not always easy for the modern airliner - operating at altitudes 30,000 to 40,000 feet, above most storms. But some storms tower to even those heights. When compact aircraft are occasionally damaged by clear-air turbulence, how will an airship - rigid or otherwise - cope with CAT or jet streams? Will they only be able to travel from west to east? With rising fuel costs, will the airship be able to compete with, say, a fleet of Boeing 747s or Lockheed 1011s, or DC-10s in hauling produce from, say, California, or Europe, or New York? With all the pressure brought to bear on airports today, where is the land to come from for airship handling facilities? (Although little land would be required for airships.) When the Goodyear blimps are grounded in the presence of rain or winds of 20 knots, will not the airships also suffer in times of storms? It is enough of a problem today to create the hangars and ground equipment to facilitate maintenance on the Boeing 747 and DC-10. How is the cost for such facilities to be borne for handling and maintaining airships? The true test of the airship concept, of course, can only come with time. The research has been beneficial in resurrecting little-known facts of the past, but little Federal support appears to be forthcoming. Nostalgia is not an acceptable substitute for pragmatism or true cost/benefit analysis.

Maybe the future isn't all gloomy for the airship enthusiasts, though. NASA is reportedly looking at lighter-than-air:

> Three major aircraft manufacturers with no previous experience in building large lighter-than-air craft have revealed in-house study efforts on their part to determine the applicability of airships to modern transport needs. The American Institute of Aeronautics and Astronautics (AIAA), responding to the increasing

professional interest in the subject, scheduled a special panel session on airships on January 29 (1974) as part of its annual meeting. This special session drew one of the largest crowds of the overall meeting. During that session, a NASA representative announced a forthcoming Request for Proposals for a feasibility study of potential applications of buoyant and semi-buoyant aircraft. Further, NASA and MIT are planning a jointly-sponsored summer workshop on airships and their uses.

The airship has a potential for peacetime uses, such as transporting whole hospitals to remote areas; transporting heavy construction equipment; hauling large volumes of produce cross-country at acceptable speeds, but passenger movements will not be as readily acceptable. Even some of the airlines have grounded their Boeing 747s because of a poor load factor, and there is no assurance that a large passenger capacity would be used on airships. The airship has been proven in certain war or military (and naval) operations, but their vulnerability is something else with which we would have to cope. It would have to be accepted that certain meteorological conditions would contra-indicate the utilization of the airship, and harboring an airship in the face of oncoming storms would be a mammoth problem not easily soluble. LTA research will undoubtedly contribute to the "Megalifter", a project about to begin by NASA Ames.

In a paper of this brevity, we have only touched the surface of the uses of airships, and the admittedly sketchy treatment of the subject should only be enough to whet the appetite of the reader for more knowledge on the subject. We commend the interested reader to our very brief bibliography, and we give full credit to all the authors we have cited in this work.

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