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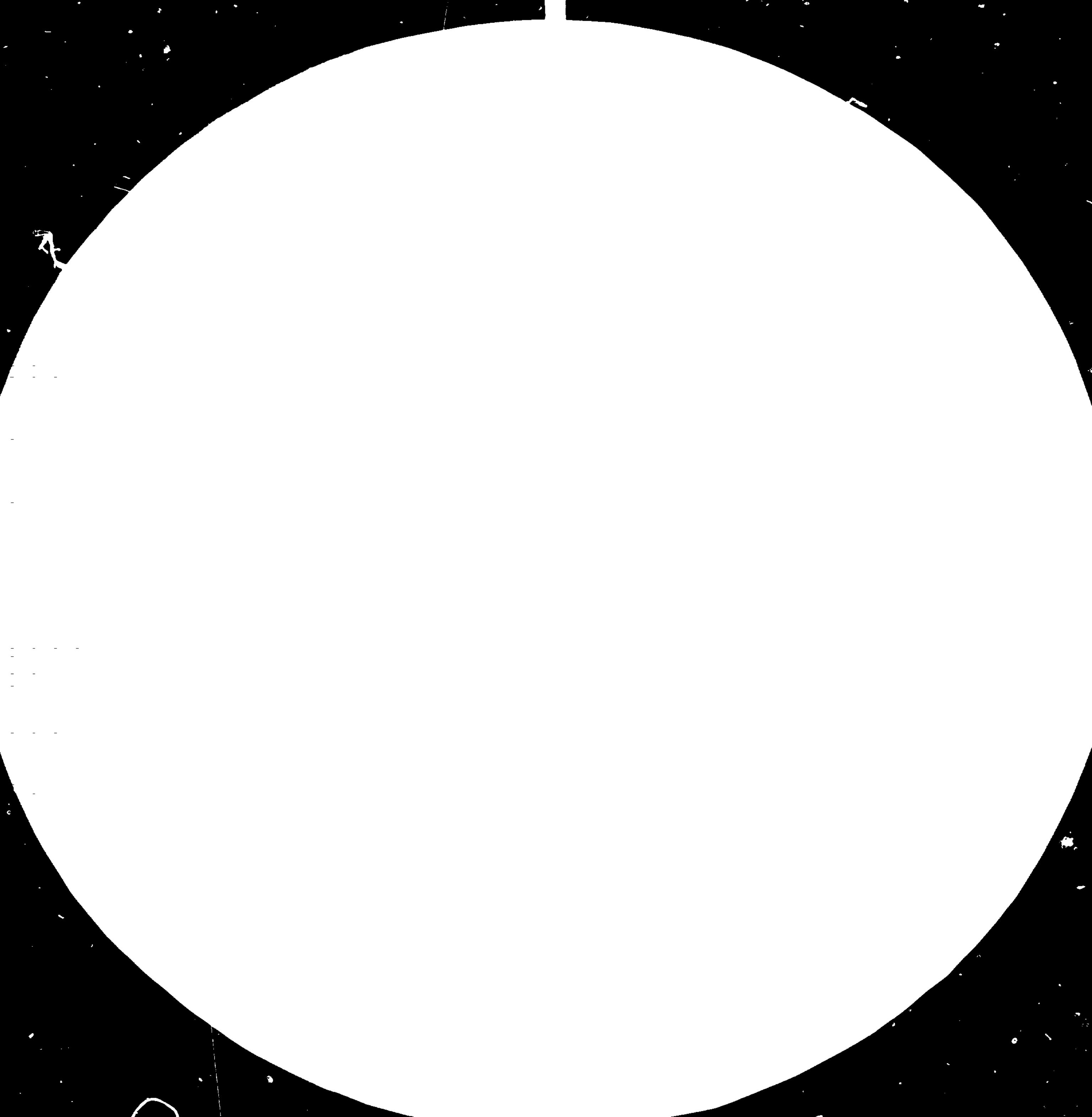

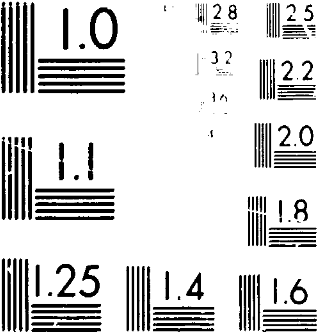

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United Nations Industrial Development Organization

Expert Group Meeting on the Implications of Technological Advances in Lighter-than-air Systems Technology for Developing Countries
Vienna, 19-22 October 1981

REPORT*

(Meeting on Lighter-than-air systems).

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INTRODUCTION

1. A number of experts in the field of lighter-than-air (LTA) systems met with representatives from developing countries at Vienna, 19-22 October 1981 to review the implications of LTA technologies for developing countries. The meeting was organized by the United Nations Industrial Development Organization (UNIDO).

2. The main objective of the meeting was to review the state-of-the-art of LTA technology development, to consider the needs and requirements of developing countries, and to identify the potential role and applications of LTA technologies in meeting these needs and requirements. The meeting was also organized with the aim of identifying specific measures by which appropriate LTA technologies could be developed and applied in the developing countries.

3. The meeting was organized as part of a series of activities initiated by UNIDO in regard to ongoing technological developments of possible interest to the developing countries.

4. Opening the meeting for UNIDO, Mr. G.S. Gouri, Director, Division of Industrial Studies, welcomed the participants and conveyed the good wishes of Dr. Abd-El Rahman Khane, Executive Director of UNIDO, for the success of the meeting. Mr. Gouri referred to the structural problems faced by the developing countries in accelerating their social, economic and technological development. These problems, he observed, called for innovative approaches and solutions. He observed that LTA technology had a long history and has witnessed a revival of interest in recent years accompanied by new efforts to modify and upgrade existing technologies, as well as to develop new vehicles incorporating recent technological advances. UNIDO, therefore, felt it an opportune time to review the technology and its potential to developing countries. Mr. Gouri suggested that such a review should be made as objectively as possible and not result in raising undue hopes or expectations with respect to possible future applications in the Third World, whilst, at the same time, acknowledging the unique areas of application which the technology appears to offer.

5. The meeting elected Mr. R. McFarlane as its Chairman and Mr. E. Lombolou its Rapporteur. A list of participants and observers is given in Annex I. A list of documents prepared for the meeting is is given in Annex II.

6. The structure of this report is as follows:

In section I, the main types of LTA vehicle are defined. The past performance of airships is briefly reviewed in section II. Section III describes the current state-of-the-art in LTA developments and lists some of the problems which remain to be overcome. The possible areas of application of LTA systems is the subject of section IV, focussing on their possible usefulness in the developing countries.

7. The meeting adopted its report on 22 October 1981.

CONCLUSIONS AND RECOMMENDATIONS

8. Rising energy costs, environmental considerations and a number of diverse requirements have directed specific attention to the possibility that LTA technologies could be a solution in both developed and developing countries to answer specific needs where other means are impossible or impractical and as a complement to other existing modes of transport, communications and other aerial work. While several firms in some developed countries are engaged in the development of new types of LTA systems, particularly in the hybrid heavy lift and conventional LTA with high operational precision, actual experience is available only in conventional non-rigid airships, which are operating and which have existed for several decades, and in tethered aerostates for communications, which constitute a recent application during the last decade. Development and application of advanced LTA systems are hindered by the attendant large development and/or unit costs and the lack of a clear and well defined market.

9. Studies and actual experience indicate in some countries a variety of needs and potential applications such as coastal surveillance and patrol, fishing, development of remote areas, communications and a possible means of transport. However, the high development costs and limited operating experience in regard to this technology dictate a gradual application of LTA starting with systems currently available and proven. At the same time developing countries should continuously monitor and participate in the developments in this field and identify precisely situations where the applications may be necessary for satisfaying specific requirements.

10. In order to progress towards an evaluation of the merits of LTA technology and to match available capabilities with identified requirements; and in order to provide a suitable technical and economic data base, it is recommended that:

(i) At the request of the Government of Peru, UNIDO be requested to support an ongoing programme with a current technology airship to be selected by the Government of Peru for the purpose of gathering realistic data and developing a nucleus of experience in maritime airship operations, including enforcement of laws and treaties, oceanographic studies and gathering of meteorological data.

(ii) UNIDO is requested to co-ordinate with the Government of Peru the invitations of interested countries and organizations to participate in project planning, operations, data analysis and results during the period of the project.

(iii) Furthermore, UNIDO is requested to co-ordinate necessary travel, a final review and dissemination of results to all interested countries and organizations.

11. In addition to the above action, it is requested that UNIDO analyse, summarize and distribute all availab[illegible] realistic information that facilitates decision-making. This compilation must contain data relevant to current operations and current developments; it should not contain conjectural or hypothetical information. The information distributed should be of special relevance to developing countries.

12. Developing nations should establish focal points in the government to stimulate and co-ordinate inter-organizational studies and investigations of cases of potential LTA applications, and keep UNIDO informed of this activity.

13. Governments of countries in co-operation with manufacturers of LTA equipment and interested agencies are invited to encourage the preparation of market studies covering the possible areas of applying LTA technology.

14. Government agencies in developed countries are encouraged to support the necessary development of LTA technologies, particularly in meeting the requirements of the developing countries in such key areas as transport.

I. TYPES OF LTA VEHICLES

15. The meeting observed that confusion sometimes surrounds the use of the expression LTA systems. LTA is a generic expression that distinguishes vehicles which derive their performance from aerostatic principles from heavier-than-air craft which do not. LTA systems include both balloons and airships and it was upon the later that the meeting focused. Airships have taken, and can take, different forms and can thus be classified differently.

16. An airship consists of a gas-filled hull (or envelope) with propulsive power, stabilizing surfaces and altitude and directional control. To distinguish the airship from a balloon, which has similar aerostatic characteristics but no propulsion or steering system, it is known as a dirigible balloon, or simply a dirigible.

17. Dirigibles are of two main types:

(a) Pressure airships which maintain their shape by the pressure of the gas contained in their hull. Generally, the envelope is a single gas cell that also contains air ballonets for the purpose of compensating for changes in pressure and temperature. Pressure airships can be subdivided into non-rigid airships or 'blimps' which comprise a fabric envelope and have no rigid structure other than the control car and empennage; semi-rigid airships which similarly depend upon internal gas and air pressure to maintain their envelope form but have, in addition, a supporting structural keel extending longitudinally along the bottom of the envelope; and metal-clad airships which are constructed from thin metal envelopes rather than fabric.

(b) Rigid airships which maintain their shape through a rigid metal girder structure independent of internal gas pressure. The lifting gas is contained in multiple cells within the structure placed throughout the ship's length.
The vast majority of the 3000 airships built to date have been non-rigid vessels. Semi-rigid airships, and rigid have not flown since the 1930s.

18. More recently, hybrid airships have appeared which, althrough based on different design concepts, generally attempt to combine the aerodynamic properties of fixed wing or rotary winged aircraft with the aerostatic characteristics of airships. Hybrid airships can be conveniently divided into two main types: semi-buoyant airships in which airship performance is improved by increasing aerodynamic lift through modifications to the hull, and heavy-lift airships which seek to combine the controllability and manoeuverability of rotor craft with the aerostatic lift of the pressurized airship.

19. A separate category of LTA vehicle is the tethered aerostat, or helium inflated unmanned balloon attached to a ground control station. Tethered aerostats may be fixed high altitude systems designed for purposes of communication and surveillance; or mobile low-altitude systems designed to haul loads over short distances.

II. THE PAST PERFORMANCE OF THE AIRSHIP

20. The meeting recalled that, although the appellation 'airship' remains coloured by the spectacular disasters which brought the development of rigid airships to a close in the 1930s, the history of the airship - especially the non-rigid airship - is essentially one of performance and safety. The much publicized disasters, caused by a variety of reasons, have distorted views and prevented a full appreciation not only of their past performances but also of their possible future applications.

21. In the area of marine patrol, the past performance of the airship is impressive by any standards. Several participants reminded the meeting of the valuable role which LTA craft played as coastal patrol, escort, anti-submarine, and surveillance vehicles in both world wars. In the Second World War, for example, United States Navy blimps performed a wide range of operations in a three million square mile area of ocean space. Those based along the Atlantic seaboard flew a total of 55,900 flights for 550,000 hours and escorted 89,000 ships without the loss of a single vessel to enemy action. In total, the United States Navy flew 30 million kms with airships during World War II with the loss of only one craft.

22. Hardly less impressive is the performance of the airship as a passenger carrying vehicle. Before the First World War, when LTA developments were in their infancy, a small fleet of German airships maintained a service between towns. They made 1,600 flights and carried 34,000 passengers without a single injury. The Graf Zeppelin, perhaps the most famous of all airships, made 590 flights, including more than 140 trans-atlantic crossings and carried 13,000 passengers. In its nine years of continuous service it travelled 1.7 million kms. Goodyear's small fleet of non-rigid airships have carried well over 500,000 passengers without a single accident. It was not until 1937, and the loss of the Hindenburg, that the first fatality on a commercial passenger carrying airship occurred. This safety record was at least as good, if not considerably better, than that of the heavier-than-air craft flying in the same period.

III. CURRENT STATE-OF-THE-ART

23. In the period between the termination of the United States Navy non-rigid airship operation in 1962 to about the mid 1970s, LTA aircraft engineering and development was essentially in a dormant state. The only continuity in that period was provided by flight operations with modified World War II type training airships in the United States of America and the Federal Republic of Germany, supplemented by the sometimes ambitious drawing board designs of LTA advocates and hobbyists.

24. The meeting noted that the lack of interest in LTA vehicles can be largely attributed to the rapid development of other modes, notably the aeroplane and helicopter with their speed and manoeuvrability, fuelled by cheap supplies of energy, and the fact that airships appeared unable to fulfill needs which could not be met with other vehicles.

25. The situation changed in the mid 1970s for a combination of reasons. Not the least of these has been the need to search for more fuel-efficient forms of transportation following the dramatic increase in the price of fuel required to propel heavier-than-air craft. In addition, there is the need to find ways of accelerating the social and economic development of the developing countries, the need to open up inaccessible areas in both developed and developing countries with the aim of exploiting their natural resources, and, more recently, the need to find efficient and cost effective methods for monitoring and patrolling the exclusive economic zones afforded coastal states by the United Nations Law of the Sea Conference.

26. These and other reasons have resulted in renewed interest in LTA vehicles, in both developed and developing countries, and given a new impulse to LTA developments, evidenced by several governments and privately sponsored studies and some actual airship development.

27. The meeting was told that at present there are only three companies which have built and are operating a fleet of six airships, all of approximately the same size, and that there are only a small number of companies which have built and have operated aerostats. It was also informed that a variety of non-rigid and hybrid airships are planned or under

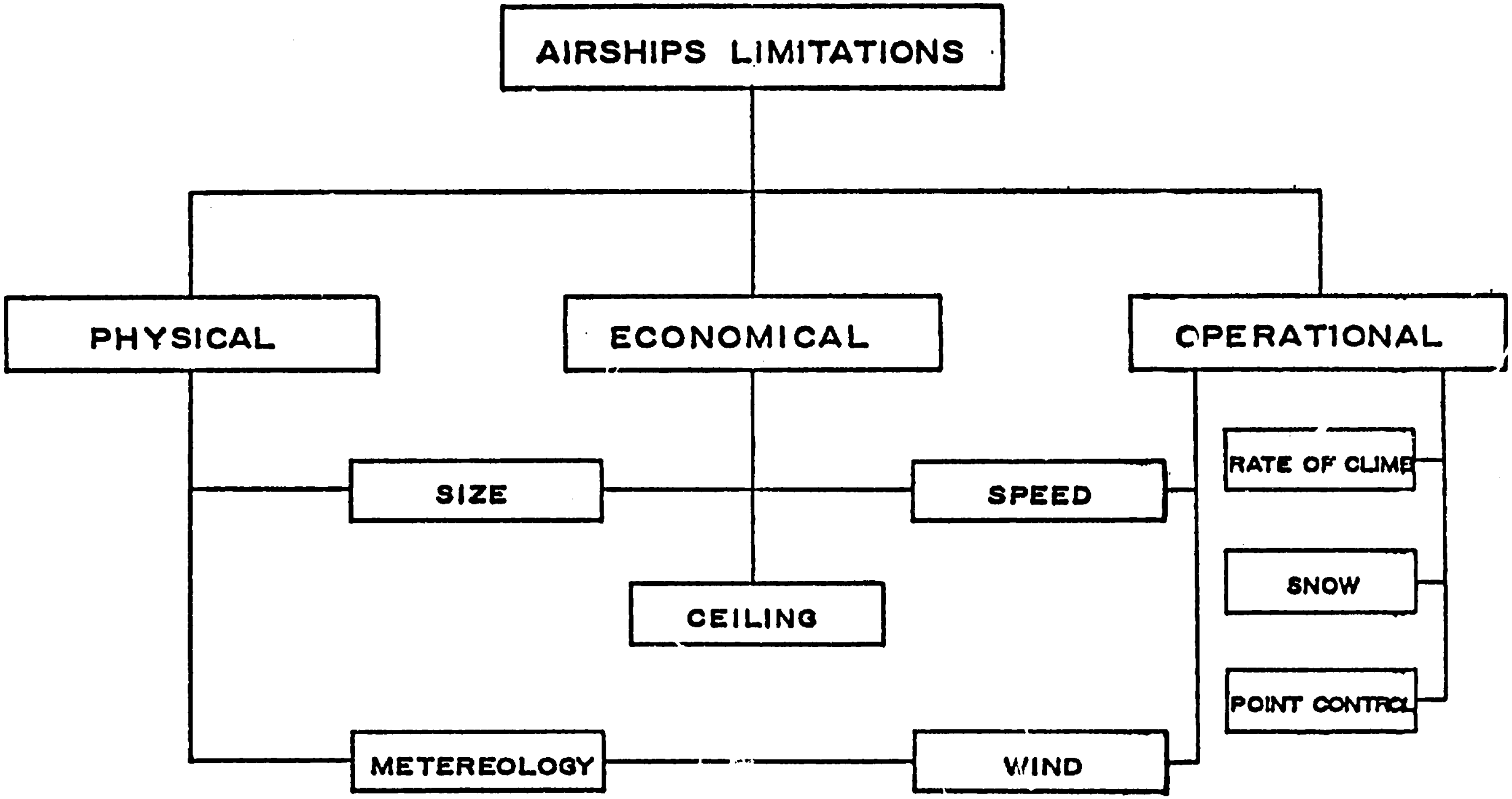

Figure I. Airship limitations

construction in a number of industrialized countries and that several developing countries have expressed an interest in not only operating but also buildingL TA systems.

28. The six non-rigid airships in operation today are modest in comparison to many of their predecessors. They are derived from proven designs, in some case dating from the 1930s, and generally make use of off-the-shelf components. With a lifting capacity of up to two tons, they are currently being offered for sale at prices ranging from US$1.2 million to US$4 million. Although hundreds of expressions of interest have been received for the vehicles, they have yet to result in a single sale. Aerostat systems for communication purposes are on offer for US$800,000, excluding payload, and are in use, notably in logging operations.

29. The current limitations of the non-rigid airships now flying stem from the laws of physics, the laws of economics, the laws of nature and, in the real world, as suggested in Figure I, a complex mixture of all three. Payload capacity is reduced as temperature, humidity and altitude increases, which indicates reduced lifting performance in many developing countries. Wind is another climatic factor which affects performance. It also hampers ground operations and landing. Although the United States Navy has returned larger airships safely to earth in winds of nearly 50 knots, it is considered unsafe for aeroplanes. Gusty wind conditions are particularly difficult in landing and mooring operations and side winds aggravate maintenance and cargo handling operations. Strong head winds do not constitute a danger to an airship in flight but considerably affect economic performance.

30. The payload: gross lift limitations of non-rigid airships generally limit their ceilings to approximately 3000 m and their economic altitudes to less than half this value.

31. The meeting was informed that these and other limitations can be and are being overcome by recent technological advances. Many of these

offer considerable promise for airship applications and should contribute to both the safety and performance of LTA craft. Examples of such advances include modern sensors and variable thrust and direction engines which will improve performance and low-speed manoeuverability. Modern light-weight, low consumption gas turbine engines have also been showing to lend themselves to airship applications, as have light-weight helicopter blade systems, high strength and corrosion resistant alloys, glass fibre and carbon fibre composites, new bonding technologies and low permeability fabrics.

32. Some of these advances have already been applied to the airships most recently constructed and under construction.

33. Despite these advances and promises of further progress there are a number of problems which await adequate solution. The meeting was told that further investigations are required, for example, into:

(a) Aerodynamic drag and the effects of various configuration changes;
(b) The design and location of propulsion units for maximum efficiency and performance;
(c) The development of structural design criteria, including the formulation of realistic requirements for flight turbulence and gusts for various airship concepts;
(d) Envelope materials so as to improve long-term permeability, durability, and to achieve lower weight fractions;
(e) Improved methods of ground handling, maintenance, and determinination of all-weather flight maintenance;
(f) The realistic assessment of design, construction, and operational costs particularly related to particular missions and types.

34. Other problems requiring attention include the development of equipment for monitoring the state of structures and sub-systems, the

development of cost-effective means of fabricating and assembling large hull structures and the control of aerostatic lift and hovering, especially when loading or discharging heavy loads.

35. An additional problem which could conceivably obstruct the development of a large number of airships is a possible shortage of available helium, the airship's lifting gas. Helium production, largely derived from natural gas and mostly concentrated in the United States of America, at present meets industrial demands. Given present growth rates in both the developing and developed countries, demand could outstrip United States supply within the forseeable future. While the costs of helium will remain a small part of airship construction and operating costs, the longer-term availability of the gas for airship operations is a subject which deserves investigation.

36. The finding of solutions to these problems is, the meeting was told, being severely hampered by an acute lack of research and development funds. Investments in airships are essentially longer-term investments and for this reason all airship manufacturers are, despite the renewed interest in LTA vehicles and recent technological advances, experiencing great difficulty in raising the money required to advance the state-of-the-art and to produce airships for missions for which they appear ideally suited. The figures required are considerable. The costs of developing heavy lift airships for payloads of approximately 75 tons were said to vary from US$100 to US$350 million. The general failure of airship companies to obtain such sums has compelled them to restrict activities to the upgrading of well established technologies and to proof-of-concept testing. The fact that so few ships have been able to be built has seriously constrained "learning-by-doing" and resulted in vehicles which, despite their apparent usefulness, are prohibitively expensive, especially for developing countries.

37. These problems have prevented airships from capturing the markets for which they appear ideally suited. And without such a market, the acquisition of funds becomes an even greater problem. This has slowed

the rate of technological innovation. It has prevented, for example, engine manufacturers from developing propulsion systems specifically for airship application.

38. The lack of funds is probably due to two main reasons. Firstly, airships no longer have a clear military application. This has cut them off from the main source of R and D expenditures. Secondly, LTA vehicles appear to have the greatest potential in developing countries, hence the comparative lack of interest in LTA R and D in the industrialized countries.

39. In short, the advance of the state-of-the-art is constrained much more by a lack of R and D funds than by technological problems. It is unlikely, the meeting was told, that the funds required will be secured from private sources. Should they become available from public sources it would prove possible to develop completely new LTA systems rather than to systematically modify, and improve existing technologies, the path the airship industry has so far been compelled to follow. The fact remains that with the recent cancellation of a United States Coast Guard requirement for a patrol and surveillance airship, the airship industry does not have a single concrete order for a non-rigid airship.

IV. AREAS OF APPLICATION

40. The renewed interest in LTA vehicles has unfortunately led some to suggest that airships are a panacea for virtually all communication and transport problems. This is clearly not the case. The meeting was told that airships should be seen as a complement to existing modes of air and ground transportation. It is a mission dependent vehicle; it is suitable for specific uses, under well defined conditions, and according to a specific set of requirements.

41. Its function as a complementary mode is defined by its main attributes. Experienc with airships and the studies conducted in recent years suggest that the main attributes are:

(a) Fuel efficiency. Unlike heavier-than-air craft conventional airships require little fuel to become airborne and have a low power to weight ratio. They are able to carry an indivisible load and operate, according to some studies, at one third of the fuel costs of the widely used C130;

(b) Endurance. An airship can remain in active service for days or even weeks on end compared to the few hours of heavier-than-air craft;

(c) Low environmental impacts. Airships have extremely low vibration, noise, acceleration and pollution levels. They do not require, indeed should avoid, space consuming airports;

(d) Speed range. The speed range of current technology airships varies from a hover condition to up to 130 k.p.h., faster than the fastest surface vessels;

(e) Payload and space capacity. An airship has a large payload and space capacity. Non-rigid airships with conventional technologies and tested materials can be designed to carry payloads of up to 30 tons; hybrid airships which can carry 25 tons are under development. The large space available makes it possible to carry low-density cargoes, such as tea, cotton, fruit and vegetables;

(f) Radar transparency. Airships are difficult to detect with conventional radar, important when the ships are to be used, for example, in tracking illegal operations (pollution discharges, smuggling) and antisubmarine warfare;

(g) Safety. Should their engines fail, airships. unlike heavier-than-air craft, do not fall from the sky. They have, as noted above, a safety record which is at least as good as commercial aeroplanes;

(h) Serviceability. Airships offer the possibility for inflight maintenance and the repair of equipment

(i) Reliability. Airships have a record of reliable performance. Of the 'blimps' assigned to United States Navy fleets in the Second World War, for example, 87 per cent were in operational readiness at all times, thereby establishing a Second World War record for military aircraft.

42. This list of attributes suggests a wide range of possible civilian and military applications, as indicated in Figure II.

43. The meeting was informed that the two most promising areas for LTA applications appear to be marine patrol and surveillance and the transport of goods and equipment into and out of remote areas.

44. With respect to marine patrol, the over-the-water environment has traditionally been the most suitable for airship operations. The for new patrol vehicles has been dramatically increased by the of the territorial waters of coastal states to 200 miles under the provisions of the draft Law of the Sea Convention. This has meant that some coastal states, Peru, Brasil, Indonesia, India and the Philippines, among them, will acquire exclusive economic zones in excess of a half million square nautical miles. The meeting was informed that studies indicate that the airship can fill a need which will be unmet by heavier-than than-air craft and surface vessels and may be able to undertake marine and surveillance duties 2-3 times more cheaply than marine patrol heavier-than-air craft. The airships now flying, however, would not be safely operated at distances of 200 miles from their base.

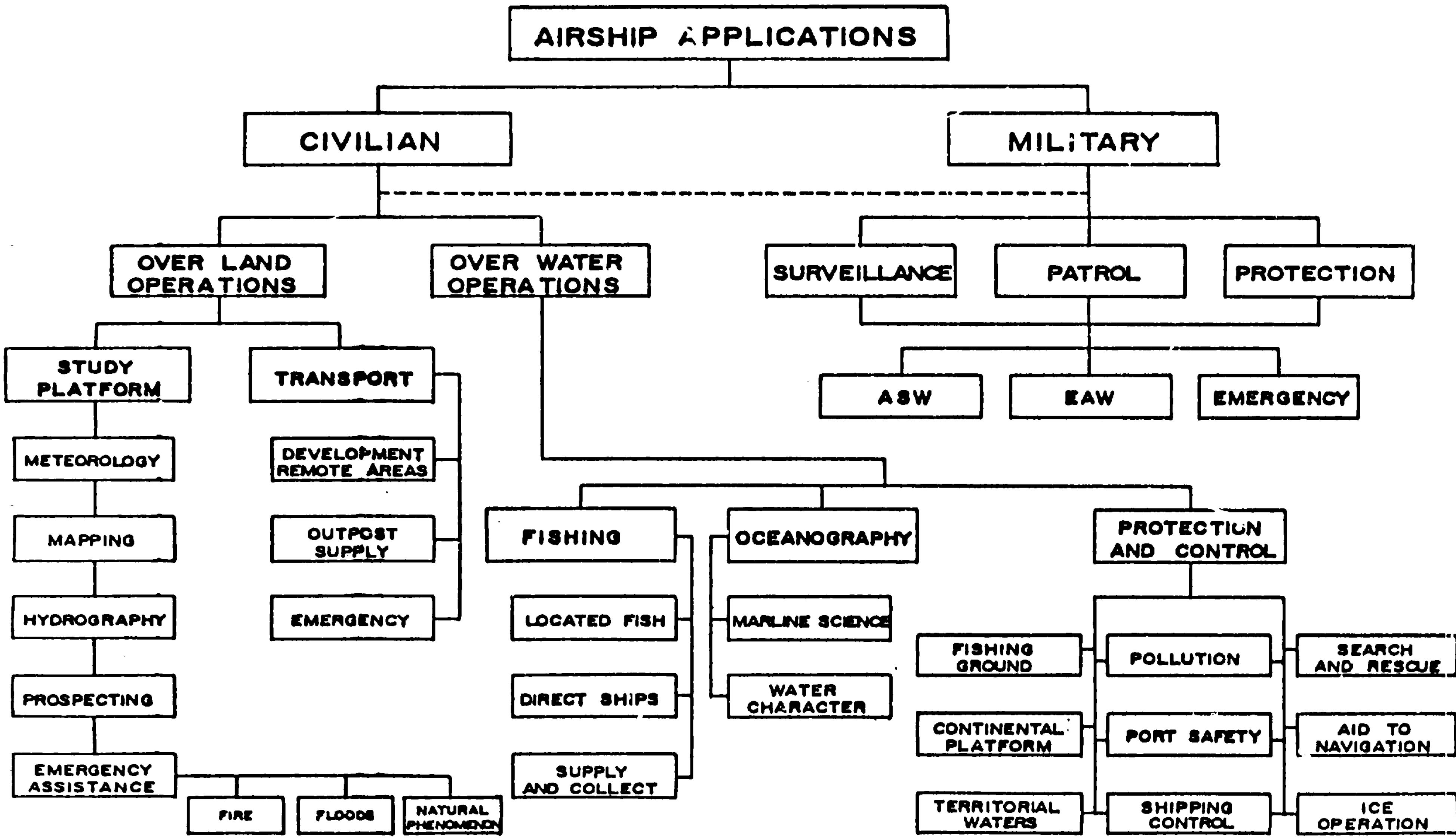

Figure II. Airship applications

45. The opening up of inaccessible areas is a problem not only in many developing countries but also in some developed countries, such as Canada. The meeting was told that in cases where infrastructure in the form of roads and air services do not exist, the airship can be extremely competitive. In cases where alternatives exist, experience shows that preference will be given to an alternative mode even though, judged against technical and even cost criteria, it is not always the most appropriate response. The costs of road construction varies from US$100,000 to close to US$1.5 million (the cost of a current 'blimp') per km in swampy areas, sometimes characteristic of jungles, and in permafrost, where, in both cases, roads due to either periodic flooding or winter conditions not only demand very high maintenance costs but must also be closed for parts of the year. The construction of highways in such areas can lead to soil erosion, environmental damage and sometimes to the destruction of wildlife habitats. The use of airships in such conditions may not only prove cost effective but also environmentally and ecologically the most appropriate mode. They also contribute to the solution of multimodal problems, typical, for example, in the transport of goods and commodities to and from land-locked states to ports. Where airports are used to open up remote areas, ancillary roads and secondary systems are required, these being unnecessary in the case of airships.

46. The meeting was informed that airships appear to be more appropriate to developing countries than to developed countries, although it was noted that some decision-makers in developing countries have yet to be convinced that LTA systems are operational and can effectively compete with other modes. It was further noted that, despite the encouraging results obtained with airship trails in some developing countries as well as the conclusions derived from studies on possible potential applications, the awareness of the possible role of airships in meeting specific problems is in many developing countries still low. The plan prepared for the United Nations Transport Decade for Africa, for example, makes no reference to LTA systems.

47. Preliminary studies conducted for the meeting of Egypt, India,, Indonesia, the Philippines, Peru, Brazil and Paraguay suggest a clear potential for LTA applications for missions in addition to those of marine patrol and the opening up of remote areas as noted above. Special reference was made, for example, to the transport of perishable commodities, such as fish, fruit and vegetables from areas of production, such as island lakes and oases, to centres of consumption, and to inter-island transport and communication in archipelagic states, such as Indonesia and the Philippines. Airships, it was also noted, may make it possible to service outposts with medicines and health related equipment. Representatives of developing countries noted that such applications remain at present theoretical applications which have yet to be subjected to serious scrutiny and systematically compared to modes which are presently available. Such a comparison is frustrated by the general lack of "hard" figures for the cost of airship operations. It was also noted that some people in developing countries may feel uncomfortable with the prospect of LTA travel and that social and psychological factors may obstruct the introduction of airships, even in cases where their economic advantages can be demonstrated.

48. Market studies conducted by the industry in African developing countries suggest that LTA systems should meet a broad range of requirements. They should be designed for the 250-500 km range, be able to operate in winds of 40 - 50 knots, in temperatures of up to 50-60°C, carry payloads of 30-50 tons, and be suitable for day and night operations. The systems would require airfields of 300-400 m for safe operation and limited hangar facilities for maintenance should be available. In addition, groundcrew requirements should be low and there should be available ballast - for example in the form of water or sand - for facilitating unloading operations.

49. The meeting concluded that these requirements can be met with existing technologies - vehicles of up to 60,000 cu.m. - and proven materials. Non-rigid airships using state-of-the-art technologies can be constructed to lift up to 30 tons or more although there were differences of opinion on the costs of the development programme for such a vehicle. Some estimates suggest that the cost of a vehicle

designed to meet these requirements would be in the order of US$50 million, other estimates placing the figure at US$10 million, or US$4-5 million if the craft was to be produced in sufficient numbers.

50. The meeting did, however, acknowledge that considerable work remains to be done in specifying the types of LTA systems most appropriate to the varying and different needs of the developing countries. Given the mission dependence of the airship, there is a genuine need for the airship industry to enter into a constructive dialogue with possible users in the developing countries with the aim of defining technical requirements on the basis of well defined missions. The meeting also acknowledged that given the high labour costs associated with the construction of airships and the fact that some developing countries, notably in Latin America, have both the infrastructure required for airship operation and proven relevant skills and experience, some developing countries may have an advantage in the construction and operation of LTA systems.

51. Should a developing country decide to enter airship operation, it was felt that the country should start with small airships based on proven technologies and, if possible, with over-the-water operations. It was also noted, however, that there may be few advantages in introducing single airships, the effectiveness of LTA systems lying in the introduction of a fleet of vehicles which justifies initial investments in the provision of basic infrastructure, the development of appropriate skills, and crew training.

52. The meeting acknowledged that decision-making on LTA systems in developing countries is hampered by the diversity of figures given for airship acquisition and operation. This is particularly the case with respect to possible heavy lift systems - based upon hybrid airships, non-rigid ships and rigid airships - where development costs for respective R and D programmes showed very considerable differences. Decision-making, it was stressed, would be greatly facilitated by objective assessments of the possible costs involved and by sound assessments of the differences between competing modes. This is a subject which was found to require further investigation.

ANNEX I

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ANNEX II

List of Documents

General Applications and Limitations of LTAs (G. Cahn Hidalgo)	ID/WG.367/1
Potential Cases for LTA Uses (G. Cahn Hidalgo)	ID/WG.367/2
Application of Lighter-than-air Technology in Developing Countries (R.L. Ashford, B.B. Levitt, F.R. Nebiker, H.K. Rappoport)	ID/WG.367/3
Helium - Rarer than Thought (H. Grieco)	ID/WG.367/4
Current LTA Technology Developments (N. Mayer)	ID/WG.367/5
The Airship: Past, Present and Possible Future (A. Dolman)	ID/WG.367/6
Lighter-than-air Transport Systems (Background paper submitted by Arab Republic of Egypt)	ID/WG.367/7
Report	ID/WG.367/8