ROLES FOR AIRSHIPS
IN ECONOMIC DEVELOPMENT

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ABSTRACT: This paper attempts to demonstrate that airships of known and tested technology could, in some cases, perform routine transport missions more economically than conventional transport modes. If infrastructure for direct surface transport is already in place or if such infrastructure can be justified by the size of the market and there are no unusual impediments to constructing it, then the airships of tested technology cannot normally compete. If, however, the surface routes would be unusually expensive or circuitous, cr if they involve several transhipments, or if the market size is too small to spread infrastructure costs of conventional transport, the airships of tested technology present a workable alternative. The paper argues from a series of special cases. The cases, though unusual, are not unique; there are several similar possible applications which, in total, would provide a reasonably large market for airships.

INTRODUCTION

The World Bank has a substantial interest in transport development. Through fiscal year 1973 the Bank had lent over $6,788 million for various transport projects. Although roads and railroads account for the bulk of this total the Bank also lends for pipelines, ports, and aviation. Our transportation loans have financed investment in virtually all the developing countries of Africa, Asia and Latin America.

The Bank, through its country oriented economic work, transport sector studies and project appraisal, including the analyses of possible alternative investments, attempts to expand the context of countries' plans for transport development. Within the general requirement that a project must have an acceptable payoff in development, the Bank has really unlimited freedom to finance a project using any technique.

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The "final product" of the Bank is simply a loan to a developing country to make an investment. Virtually all of our operations are aimed at helping the country to choose wisely among the alternatives available and to complement the investments with sound development policies. Thus our primary interest in studying airships is to decide whether this form of transport should be recommended to a country for study as a realistic and viable alternative.

The ideas that we present in the rest of this paper are aimed at stimulating discussion among airship experts of possible applications of airships, in special cases, to solve the immediate transport problems of less developed countries. We attempt to demonstrate that, using existing technology, the airship apparently has a series of possible development missions.

In the section that follows we will present extended examples of possible uses of airships of more or less well-known and tested technologies. In each case we attempt to show that there is a prima facie case for applying known technology to a new task.

CASE STUDIES

Two cases of completely different nature will be analyzed, the application of large airships of over 100 ton load capacity for long distance transportation; the utilization of small airships to haul small cargoes for short distances.

Cost Characteristics of the Airships

In order to proceed with a cost comparison of the airships against the conventional modes of transport several assumptions are necessary. For the most part these are implied in Table I or are specifically identified in the footnotes, but a few crucial assumptions should be discussed before turning to the Table.

(a) Cost of Construction: We have no recent direct evidence on capital cost for a large airship. Research and development, however, are very minor cost elements; we are simply attempting to estimate how much the cost of construction has increased over the years. The basic design and operating characteristics are well-known. Dr. Eckener, in 1952, estimated the cost of a new Hindenburg at $7.7 to $12.5 million, i.e. from $68 to $110 per kg empty weight. We have assumed a present construction cost of $200 per kg empty weight for the large airship--about three times Dr. Eckener's low estimate. This seems about an adequate allowance for increased cost since 1952. For the smaller airships (2 tons and 15 tons), we assumed a construction cost of $300 per kg empty weight, in accordance with the average cost estimates given by manufacturers for airships in this size range. Since they are intended for use in more difficult terrain, with many take-off operations, these airships will have to be more maneuverable and have a higher power weight ratio than the larger ship.

(b) Interest and depreciation: Throughout the paper we assume a 10% interest rate for all alternative transport investments. We assume a 20 year life for the large airship and a 10 year life for the smaller airships, in recognition of the rougher job envisioned for the small ship. A 20 year life may be near the outer limit of reasonable assumptions for the large ship but it is not clear that successful airships in this class, e.g., the Graf Zeppelin, were anywhere near

the end of their useful life when they were scrapped for want of helium.

(c) Flight time: We assume that the large airship could fly 6,000
hours a year. By way of comparison, the Hindenburg flew 2,810 hours
in its first nine months of service, an annual rate of 4,215 hours.
The use we are considering is a regular, shuttle type operation and
the 6,000 hours assumption should not be too optimistic in these cir-
cumstances. For the smaller airship, in rougher terrain with irregular
loadings, we assume a 3,000 hour per year performance--roughly, a day-
time only schedule.

(d) The large airship would operate at nearly ideal altitudes and tem-
peratures in the main use considered. The smaller airships would oper-
ate out of a set of bases about 700 meters above sea level, conducting
most of their operations over territory of about that altitude.

The large airship is patterned on the Hindenburg, one of the largest
airships ever in operation. It was a rigid dirigible with a gas volume
of 216,000 cubic meters, a static gross lift of 206,400 kg, empty
weight of 113,000 kg and useful lift of 93,000 kg. S.L.T.A. Inc. has
made a series of estimates on the characteristics of a modernized
Hindenburg (which we shall call the "H2"). The H2 is similar in design
to the Hindenburg, incorporates no radical technological change, but is
increased linearly in dimensions by 10%. This increases the volume of
the H2 to 266,000 m^3, and the gross lift to 266,000 kg. Incorporating
modern structural materials, lighter engines, and modern advances in
gearing, the H2 should be able to achieve a slightly better static
efficiency; we have assumed a useful lift equal to empty weight,
133,000 kg, using helium as the lifting gas.

On these assumptions, the cost estimates of Table 1 were prepared.

TABLE I

C0ST CHARACTERISTICS OF VARIOUS AIRSHIPS

	133 ton airship	15 ton airship	2 ton airship
Airspeed (km hr)	129	130	130
Ground Speed (km hr)	113	110	110
Stage length studied (km)[a/]	1,290	220	220
Flight duration (hours)	11.4	2	2
Horsepower required	4,937	1,700	1,000
Fuel required [b/](kg per trip)	11,256	680	400
Payload (metric tons)	121.7	11.25[c/]	1.50[c/]
Productivity in ton km per hour	13,752	1,238	165
Personnel and Maintenance cost ($/hr)	150	83	43
Personnel and Maintenance cost (¢/ton km)	1.09	6.7	26.1
Fuel cost (¢/ton km)	.84[d/]	2.7[e/]	12.1[e/]
Direct operating cost (¢/ton km)	1.93	9.4	38.2
Yearly capital recovery charge ($million)	3.12[f/]	.68[g/]	.31[h/]
Yearly payload (million ton km)	82.51	3.71	.50
Capital charge (¢/ton km)	3.78	18.3	62.0
Total Cost (¢/ton km)	5.71	27.7	100.2

a/ Average stage length of the main comparison study included below.
b/ 0.2 kg per hp per hour.
c/ Assumed 75% load factor.
d/ Price per kg, April 1974 price FOB Matadi.
e/ Price per kg $0.10.
f/ Cost $26.6 million, depreciated over 20 years at 10% interest.
g/ Cost $4.20 million, depreciated over 10 years at 10% interest.
h/ Cost $1.89 million, depreciated over 10 years at 10% interest.

Source: Based on data furnished by Studiengruppe Luftshiffbau und Anwendungs Bereiche.

Use of the H2 in the Zaire export/import trade

The cost calculation for the H2, shown in Table 1, was derived to approximate the cost per ton km of the shuttle service of copper from the Katanga to an Atlantic port, Lobito, and the return of general cargo to Katanga, a stage length of about 1,290 km. Adequate balanced bulk cargo traffic is generated on this route to insure a virtually continuous full load operation. Hence the 100% load factor implied in the Table 1 calculations. The operating conditions on this route are nearly ideal: moderate temperatures and low land elevation.

To compare the cost of the H2 against conventional modes of transport, we calculated the cost per ton via airship over the 1,290 km stage length from Katanga to Lobito: $73.6 per ton (5.71¢ per ton km times 1,290 km).

The first set of costs against which to evaluate the performance of the H2 are the short run costs of conventional transport modes: the direct operating cost of vehicles (railroad rolling stock and river fleets); the costs of administration repair and maintenance of infrastructure that vary with use of the infrastructure; the depreciation and interest cost of the vehicle fleet.

Specifically excluded are any construction or capital charges for infrastructure, or any charge for fixed administration or maintenance.

The present transport route we are considering is composed of three parts: the Kinshasa-Dilolo-Lubumbashi Railroad (KDL), from the copper areas of the Katanga to Port Francqui (1,430 km); a river barge portion from Port Francqui to the Port of Kinshasa (800 km); and a further railroad, the Chemin de fer de Matadi Kinshasa (CFMK), 366 km from Kinshasa to Matadi, the port on the Congo river with access to the Atlantic.

ZAIRE COPPER TRAFFIC - Conventional versus Airship Route
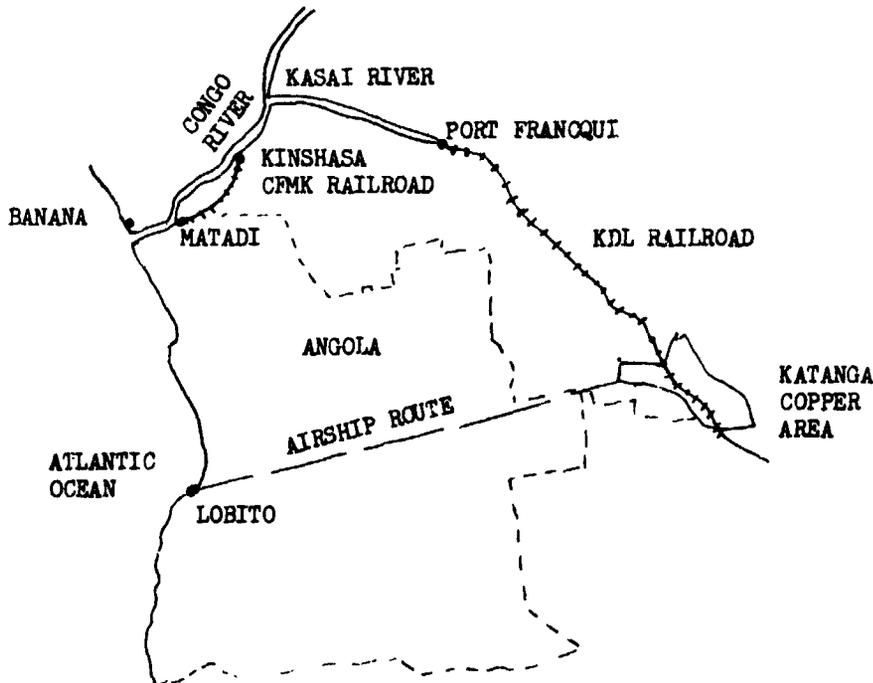
The cost characteristics of the present modes were studied in a major work published in 1971 by the French consulting firm BCEOM. Without updating for the inflation since then, except to take account of the increase in fuel prices, we obtain the following cost estimates:

TABLE II

OPERATING COSTS OF MATADI-KATANGA TRIP-CONVENTIONAL MODES

	US¢/ton km	KM	$/ton
Katanga-Port Francqui (rail)	2.86[a/]	1,430	40.89
Port Francqui Trans-shipment			5.95
Port Francqui-Kinshasa (river)	0.92	800	7.36
Kinshasa Trans-shipment			5.95
Kinshasa-Matadi (rail)	1.75[a/]	366	6.40
Total Operating Costs			66.33
Inventory Cost of Goods in Transit [b/]			5.04
Total transit cost exclusive of infra-structure investments costs (per ton/trip)			71.59

Source: BCEOM, Etude de Transport de la Voie National, October 1971.

a/ To update the fuel price changes, the fuel component in marginal cost for the two railways was multiplied by a factor of 3.715, the latter being the ratio of gas oil prices in 1974 ($117 per metric ton CIF Matadi) and 1971 (estimated at $31.50 per metric ton CIF West African ports).

b/ An interest rate of 10%, a copper price (FOB Matadi) of $1,624 per ton, and a bulk goods price (backhaul cargo) of $200 per ton, were used to calculate the inventory cost for 20.2 days (the average trip time from Katanga to the port).

A comparison of the two modes shows that there is a very slight difference between the costs (less infrastructure costs) of conventional modes of transport ($71.6 per ton) and the total costs (including construction costs) of the H2 ($73.6 per ton). Turning the analysis on its head, we calculate that the H2 would just break even against conventional modes for the trip from the copper fields to an Atlantic Port if the H2 could be built for about $25.5 million instead of the $26.6 million which we assumed.

The inclusion of a reasonable allowance for infrastructure investment would make the airship's cost advantage very striking. Relying again on BCEOM data, the cost per ton for the trip Katanga-Matadi, on a full cost basis, would be about $20-25 per ton higher than shown in the comparison. In other words, on a total cost basis for both modes, the airship is about 25% cheaper ($73 per ton vs $95 per ton).

The full cost comparison is not very precise; the BCEOM estimate refers to full cost of past investment rather than the full cost of future investment which might be avoided by use of airships, but it is not unreasonable to assume that the BCEOM estimate is less than full future cost. The list of conventional investments required to handle increments to traffic is indeed impressive, totalling from $148 million to $266 million, at 1971 prices, for the period to 1990 depending on the assumption concerning use of foreign routes. The bulk of this investment might be avoided or postponed for many years by use of airships. [1/]

A few other features of the comparison of costs between conventional modes and the H2 seem worthy of special note. The competitiveness of the airship against conventional modes without infrastructure cost depends on the much longer surface route. This suggests that at the present state of the arts the airship will not be generally competitive for bulk loads in cases where surface infrastructure is adequate and the trip is fairly direct, but that the flexibility of routes may tip the scales in favor of the airship when the surface route is indirect. Second, higher fuel prices make airships more competitive rather than less so. Fuel costs are only about 15% of total airship cost; the bulk of the cost is the capital charge. At 1974 prices fuel is in the neighborhood of 35% of operating costs for the competitive modes. Our comparison will hence be more favorable as oil prices increase, less favorable for a decline in oil prices. Third, inventory costs, even for a commodity as expensive as copper, do not turn out to be very important relative to other transport cost items.

We have made this comparison only to the Atlantic ports because we have no basis for a comparison of port costs for the H2 and conventional modes. No airship has ever undertaken this type of commercial freight operation. But it is generally believed that port costs could be lower for the H2. Using the airships ability to operate from a sheltered water base, the H2 might lighter onto a special purpose barge, and pick up return cargo, without ever using the normal port facilities. It seems quite clear that this will always give the airship a decided advantage over other air transport because conventional airplanes with a landing site away from the port require at least one more transhipment and a short surface haul. In normal circumstances, transhipment to ships from the H2 would probably be cheaper than transhipment from rail.

Use of H2 for Exports of Horticulture Products from Kenya

An often mentioned possible mission for airships is the intercontinental shipment of fresh produce. For our example, we investigated the possibility of increasing the vegetable and fruit shipments from East Central Africa to Europe--specifically the shipment of such goods from Nairobi to London. At Nairobi to London backhaul rates ranging from $.48 per kg (IATA rate) to $.35 per kg (the most favorable contract rate) the transportation of produce by air has increased from just over one thousand metric tons in 1969 to 6.5 thousand metric tons in the first nine months of 1972. The 1972 traffic experienced shortages of cargo space at backhaul rates, and the growth of this traffic is expected if transport at these rates can be expanded. Sufficient volumes already exist to employ an H2, and traffic can be expected to expand.

The cost per ton km at backhaul rates (for comparison to Table I) ranges from 7.08¢ (IATA rates) to 5.16¢ (contract rates). As Table I shows, the cost per ton km for the H2 in virtually ideal conditions is 5.71¢. Increasing costs by about one-half to compensate for less favorable operating conditions the H2 could still deliver at rates in the general neighborhood of the 1973 IATA backhaul rates.

The H2 presents a transport alternative, not very much more costly than the backhaul rates which have fostered rapid expansion of the Kenya-London vegetable and fruit trade, and well below the costs of transport at orindary rates, which at the beginning of 1973 were about 18¢ per ton km from the Nairobi Region to Europe. It would appear therefore that the H2, or eventually a more advanced airship, may be important in breaking the backhaul bottleneck that now impedes further horticulture development in Kenya.[2]/

However, the H2 faces special problems not encountered by backhaul traffic. First, the bulking requirements (100 tons) would be much more demanding at the point of origin. Second, the low speed would make the H2 less flexible in meeting the timing requirement at markets than is backhaul traffic. Finally, the airship is barely competitive with conventional airplanes on a cost basis for handling the traffic once volumes are large enough (say 15,000 tons per year) to justify a cargo plane devoted to this use. Costs, calculated on the same basis as those for the H2 ranged from 3.5¢ to 5.5¢ per ton km for conventional aircraft in 1972. For comparable planes the cost increase has been about 60% since that time, mainly on account of fuel cost increases which have more than doubled. Costs for conventional aircraft would thus be in the 6 to 8 cent range, per ton km, at this point in 1974, roughly competitive with the H2. Ground cost advantages of the H2 would probably be minimal in this situation where the infrastructure for planes is already highly developed.[3]/ [4]/

The H2 as an Alternative to Infrastructure Development, a Burundi Case

Another possible use of the H2 is to fill the (often discussed) transport vacuum in the case where a clearly important potential traffic faces a lack of some of the required infrastructure components for conventional transport. The economic choice is between the three options: not developing the resource; infrastructure development for surface or cargo plane transport; and shipment by airship. The particular case we shall summarize is the movement of nickel deposits from an area in Burundi to the seaport of Dar es Salaam.

A large and rich nickel deposit lies very shallow (susceptible to open gap mining), near Rutava in Central Burundi. The potential output of the mine is not precisely known, but 30,000 tons per year of metal (perhaps 45-50,000 tons of concentrates if it is shipped in that form) is the expected output of the mines once they are established.

Approximate location of deposit

Direct Air Route to Mombasa Port, 1072 km
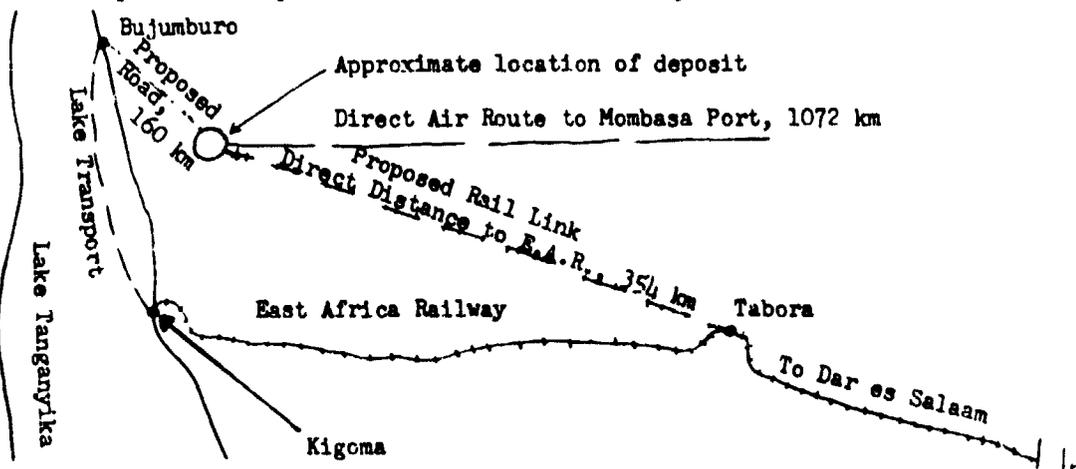
The conventional transport alternatives can be briefly summarized:

(a) A road can be built (or existing roads upgraded) between the Rutava region and Bujumbura, a distance of about 160 km. From Bujumbura (a lake port on Lake Tanganyika) the metal or concentrate could go by barge to Kigoma (about 320 km), and from there to Dar es Salaam aboard the East African Railroad (about 1,200 km). This long, indirect route (1,680 km), with two trans-shipments, and inevitably long stage time (say, 20-25 days) would be similar in direct cost to the Zaire traffic discussed above, but it would require a new road link and improvement in infrastructure for the Lake traffic. Our previous analysis in the case of Zaire would suggest that the H2 would roughly be competitive with this mode even without capital costs on the surface route. The airship needs to fly only a little over 1,000 km to reach the port of Mombasa (Kenya) where sheltered water areas are available for loading to ships, compared to the 1,680 km journey by surface. The capital cost of surface transport infrastructure by this route is comparatively modest--perhaps $45-50 million for the needed investment in roads, rolling stock, barges and tugs, and lake ports, but this cost difference would appear to be decisive.

(b) A second alternative which has been discussed is to build a rail link directly to Tabora for a continuous rail journey from the mines, to Tabora, hence to Dar es Salaam aboard East African Railway. Costs for the new link have been estimated as high as $300 million, since the railroad would have to traverse very difficult swampy areas. Once in place, the railway would have reasonably low variable costs for the entire trip length--about 1,200 km in a route nearly as direct as an air route. The relative costs of this alternative compared to the airship will depend, crucially, on the anticipated traffic volume. At relatively low volumes (such as 30,000 to 50,000 tons per year) the capital cost of the rail link would clearly be prohibitive, annual interest on the railroad investment being about three times the total annual cost of moving the traffic by airship.

(c) The third alternative would be to build a large enough airport at the mining area to fly the metal to Dar es Salaam or Mombasa aboard efficient cargo planes. On an operating cost basis, the H2 could compete almost equally with a large jet cargo plane, but the low traffic volumes would not employ even one medium sized cargo aircraft. The infrastructure advantage of the H2, and the cheaper trans-shipment at the port, would also seem to make the H2 preferable even at traffic volumes large enough to employ a plane.

Clearly the Burundi nickel export is a special case. In some cases (perhaps in this one) the additional development impact of a conventional mode would offset the airships advantages. But this and similar cases command attention for more detailed study.

Using Small Airships in the Region East of the High Andes in Peru

In the use of airships in the Andean region, the development program is considered in two basic steps: the use of a small airship, with useful load capacity of about 2 tons; the use of a 15-ton capacity dirigible to replace the small airship in a particular area once the

technical aspects of the use of an airship in the area have been proven, experience has been gained with its developmental impact and crews have received adequate training. Because the crew will generally not have good ground support, they will need skill in maintenance and unassisted landings, as well as for operating in difficult terrain. From the economic point of view, only the larger dirigible will be competitive, as shown below. But to gain experience with maximum safety, the smaller high-powered, easily handled ship will be used. The cost characteristics of both airships were presented in Table 1. The general zone that we are considering for use of these airships is east of the Andes mountains in Peru. The region reaches from the mountain side called "ceja de montana" in Peru, to the Amazon valley. A zone with similar geographic characteristics reaches into Ecuador and Colombia to the north and into Bolivia in the south. The altitude varies from 1,500 m in the mountains to 700 m in the east into uncharted country, forests, and eventually into tropical jungles through which run the head waters of the Amazon. The valleys are sparsely populated, and the area is, for the most part, undeveloped. These areas could potentially support a much larger population if better transportation and communications are supplied and if agriculture production is improved. Peru is now a large importer of food, over $230 million per year, in spite of having large unutilized areas for agriculture.

In these regions, roads are costly to construct and hard to maintain, and may be impassable in many periods of the year. Vehicles deteriorate rapidly and have high maintenance requirements. The high freight rates reflect the condition and type of road, the topography, and the irregularity of loads, vehicle circulation, and backhauls. Transport presents a particular problem in the flow of agricultural products because the distribution of arable land is in relatively small valleys separated by rough gorges and ravines. A valley can therefore remain quite isolated, economically, even though it is quite near a road. The construction of access or penetration roads is extremely costly in the regions under consideration (above $250,000 per km). Although distances are relatively short, the linking of all of the main valleys with penetration roads is therefore not justified until and unless a high level of development is reached.

Air transport with conventional aircraft would require a large number of airstrips to provide adequate access and it is doubtful if they could be constructed at a reasonable cost. Cost of transportation with alternative airborne modes have higher direct costs as well, for example, the 5 to 1 De Havilland twin otter, $0.56 per ton km, the Helicopter Sikorski, $1.49 per ton km, as compared to the 15-ton airship $0.30 per ton km. Consequently, the VTOL air transport mode is envisioned to fulfill the communication needs.5/

The transportation needs are for moving small cargos for short distances to road, rail or river heads. The aspects favoring the dirigible, in addition to its relatively reasonable cost of operation, are its flexibility and very low infrastructure cost. It does not require landing strips. An open field in size a little over twice the length of the vehicle, with a simple mooring tower in its middle, around which the airship can weather-vane, will suffice. Thus in such region as described the airship could provide the link between the many isolated small communities and the few roads which provide general access to the region (see map, page 13).

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The airship will be designed to operate out of a base located 700 m above sea level. Typical base points would be Atalaya at the confluence of the Ucayali and Tumbo rivers in central Peru; Tarapoto or Tingo Maria. Primitive airport facilities exist at these locations.

Transportation in the zone linked by the road Huanuco-Tingo Maria-Aguaytia - Presently the road is semi-completed. It is not paved and 30 km remain as a five-meter wide earth path. From Huanuco westward, the road links up to the coast highway. We are considering the airships as alternatives to road development east of Huanuco.

The cost of completing the construction and the improvement of the 219 km road from Huanuco to Aguaytia was estimated at $57,597,000, $263,000 per km. Depreciation over twenty years with maintenance cost of $650 per km per year results in a total yearly cost of $31,526 per km for this road. Costs that have already been incurred to date, for the original road, have not been included in this estimate.

In 1972, traffic over the 219 km road from Huanuco to Aguaytia varied from 350 vehicles per day between Huanuco and Tingo Maria to about 200-250 vehicles per day beyond Tingo Maria. At 300 vehicles per day the annual cost of the road would be $0.282 per vehicle km or $.115 per ton km at the average load of 2.5 tons. The operating cost of the medium trucks that ply this road has been estimated (in 1973) as $.25 per ton km.6/

TABLE III

SUMMARY OF TRANSPORTATION COST HUANUCO-AGUAYTIA

I.   Road 219 km

1.	Capital Investment $000's	$57,597
2.	Annual Capital Charge plus maintenance per km	$31,500
3.	Annual Capital Charge per ton/km $/ton-km	.115
4.	Total operating cost for truck $/ton-km	.255
5.	Total cost road transport $/ton-km	.370

While the 2-ton airship at $1.00 per ton km is not competitive on a commercial basis, the 15-ton airship (at $0.296 per ton km) is highly competitive. In addition, it has inherent advantages over roads. It can stimulate agricultural development in a much broader zone, in regions far from this principal road where the developing stage would not justify the constructions of costly feeder roads for new agricultural development programs. The investment in an airship is minor, and its use is flexible, making it less risky than high, fixed road investment. The airship can aid the development of potentially rich agricultural zones such as those considered, almost immediately; it would be necessary to wait a long time before a road network is completed.

We conclude that in this case the airships are competitive with the construction and periodic reconstruction of the main road servicing the area. In addition, the airship can connect regions that are not effectively serviced by the road. Compared to feeder roads, which would also have very high costs but much lower traffic volumes, the airship is far less costly.

Transportation in an Isolated Region in the Peru Via Area - The Peru-Via area (see circle on map, page 13) is almost due east of Lima. An all weather road of about 180 km crosses the high Andes from Lima to San Ramon which is just on the western edge of this area.

Lack of transportation facilities represents the major obstacle to agricultural development in the Peru-Via area. Except for a few scattered landing strips for light planes, and small fringe areas where dirt roads penetrate, the region is almost inaccessible. It has been amply demonstrated through unsuccessful colonization experience east of the Andes, that transportation is indispensable to economic development. Without adequate transportation there is economic stagnation, a lack of progress and large-scale farm abandonment. Colonization without proper transportation facilities would result in a waste of national resources.

Several zones in this area are under active consideration in the country's development plans for the settlement of 37,000 families in the Apurimac-Ene valleys and 20,000 in the Palcaza-Pichi region. The regions are apt for cattle, agricultural, and forest production. More generally within the radius of 150 km from Atalaya lie regions with an extremely rich potential. It can be expected that the presently existing population will multiply its output once a market for their products is established, and new production technologies can be introduced.

Atalaya is at a projected road distance of 365 km from the west-east road head near San Ramon which provides communication to the coast. The projected road implies 316 km of mountain road (average construction cost $/km 250,000) and 49 km of level road ($/km 150,000). To provide adequate communication, several hundred kilometers of feeder roads (estimated construction cost $/km 30,000) would also be required.

The yearly capital charge for infrastructure of the principal linkage only, amortized over 20 years, is $27,700 per km. The annual maintenance cost has been estimated at $650 per km giving a total cost of $28,350 per km.

With an average daily estimated traffic of 100 six-ton trucks and a return load factor of 30%, about 142,000 tons per year will be transported. Thus the cost for road usage would be average $.199 per ton km. The truck operating cost per ton km on the new paved road is estimated at $.32 based on the data provided by Sauti.

TABLE IV

SUMMARY OF TRANSPORTATION COSTS SAN RAMON-ATALAYA

I. Roads 365 km

|		
1.	Capital Investment $000's	$86,350
2.	Annual Capital Charge plus maintenance $ per ton	$28,350
3.	Annual Capital and Maintenance Charge $ per ton km	.30
4.	Truck operation cost $/ton-km	.32
5.	Total cost per $/ton-km	.52

This cost is less than the direct transportation cost on a 2-ton dirigible ($/ton-km 1.00), but considerably more than on a 15-ton airship ($/ton-km 0.296) as estimated under present conditions.

The present situation is that the produce of this zone does not leave the region due to lack of transport facility. The production remains limited as there are no accessible markets for trade. Thus we are faced with questions such as:

(a) To develop or not to develop the zone.

(b) To start the transport projects practically immediately, or in several years hence when the surface communication network can become operational.

(c) To risk heavy investment capital to develop surface transport access at this time (before the development of the region is proven) or to postpone the projects until such time when the production of the zone is flourishing.

We would argue that in this case, where the road infrastructure is not yet in place, and the economic risk of road infrastructure is very large, that the investment in airships is far and away the most conservative approach to linking this isolated area to the market.

SCHEME OF ROAD SYSTEM AND CONNECTIONS TO ATLANTIC HIGHWAY - PERU REFERENCE AREA

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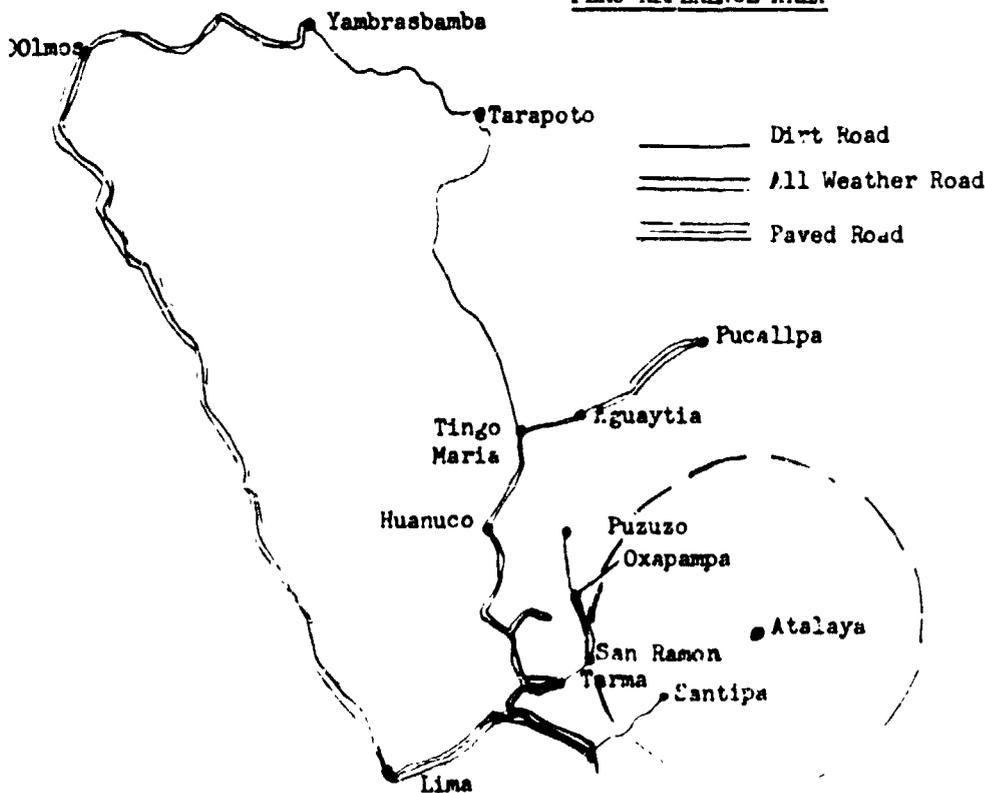
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