N76-15021

SOME ECONOMIC TABLES FOR AIRSHIPS

Richard D. Neumann*

ABSTRACT: During the course of the Southern California Aviation Council study on Lighter Than Air it was determined that some form of economic base must be developed for estimation of costs of the airship. The tables are part of this paper.

During the course of the first study on Lighter Than Air by the Southern California Aviation Council, Inc. it was determined rather quickly that little material was available to make a proper economic determination of the airship. What does exist is fragmentary, or ancient and not applicable.

Application of construction techniques and manpower, materials, powerplants and personnel if considered in current technology, would leave the airship as only an anachronism. It was, therefore, essential to determine some of the characteristics of the airship as it will be in the immediate future and its method of manufacture, operation, and administration.

*Chairman, Lighter Than Air Committee, Southern California Aviation Council, Inc., Lighter Than Air Technical Task Force, Pasadena, California, U.S.A.

The following tables were developed and used as guides to the overall study of the airship's economics. We have not provided the entire study since it is weighted by many conclusions of the SCACI group that others may not agree with. In determining manufacturing costs the use of cubic displacement was applied rather than cost per pound and ton of airframe. The latter may also be acceptable and use of both could provide an excellent cross check of the manufacturing economics.

Crew costs were not included because SCACI operations and flight people have very definite ideas of what would comprise a crew and what would not and these estimates would certainly not agree with what has been past practice or suggested by airship proponents of late. GSA and general operational practices are considered closer to seagoing operations than to air transport, but this too may not agree with preconceived ideas, and was not included.

We hope that these tables will act as a guideline and permit further efforts to go forward to truly provide a reasonable economic basis upon which the airship can be viewed objectively. One need only remember that air transportation and global access in hours has only existed for the 16 years since the jet transport.

We have a long way to go in aviation and it may be fitting that the airship will be among those future advances. Future passenger exposure to the airship will certainly have a bearing on its future, as profoundly as the ability of the jet to eliminate vibration and give the feeling of living-room comfort at 450 mile per hour speeds.

It has been man's dream and also his major necessity to develop transportation and communications as vital to his well being and survival. The airship appears to offer massive gains if it can be adequately managed to reduce transportation costs measurably and at the same time provide greater operating freedoms and access to cargo or passengers than any other form we use today, airplanes, truck, ships, helicopters and barges.

Arguements over the questions of the handling, mooring survivability and applications of the airship belie that innate ability that lies within the aerospace industry worldwide to solve problems of immense magnitude and achieve great advances which have led to space, the moon and now the galaxies. If the economics are correct or within reason then it is necessary to get on with the job and prove it by an operating product on which further refinements can be made and determined.

AIRSHIP GROSS LIFT/USEFUL LIFT

SERIES	Helium Volume (@ 95% Purity) Cubic feet	Gross Lift in Tons @ 95% purity. (61.5Lbs per 1000CF)	Percent Gross Lift weight to Hull weight (%)	(TONS)	Useful Payload Lift-Tons
MC-7.4	7,400,000	220.14	48%	105.6	114.4
MC-15	15,000,000	461.25	40%	184.5	276.75
MC-22	22,000,000	676.5	38%	257.07	419.43
MC-35	35,000,000	1,076.5	37%	409.1	667.4
MC-42	42,000,000	1,291.5	35%	452.1	839.4
MC-52	52,000,000	1,599.0	33%	527.6	1,071.4
MC-55	55,000,000	1,691.25	31%	524.1	1,167.15

AIRSHIP CHARACTERISTICS WHICH DETERMINE COSTS

ITEM:	MC-7.4	MC-15	MC-22	MC-35	MC-42	MC-52	MC-55
Length:(feet)	712'7"	902"	1,024'8"	1,196'4"	1,271'3"	1,365'6"	1,390'7"
Diameter:	142'5"	180'4"	204'9"	239'2"	254'2"	273'1"	278'1"
Volume-Helium(10)^6	7.4	15	22	35	42	52	55
Fineness ratio:	5	5	5	5	5	5	5
Horsepower 0 - 50 MPH	2,500	4,000	7,500	10,000	13,500	18,000	21,000
Horsepower 51 - 100 MPH	5,000	7,500	9,000	12,000	16,000	23,000	27,000
Horsepower 101 - 200 MPH	30,000	71,000	84,000	95,000	118,000	130,000	144,000
Fuel Consumption - 50 MPH ●							
Gallons/Hour	125	125	188	250	335	415	530
Pounds/Hour 1/	750 2/	750	1,128	1,500	2,010	2,490	3,180
.20¢ per gallon($)	25.00	25.00	37.60	50.00	67.00	83.00	166.00
.30¢ per gallon	37.50	37.60	56.40	75.00	100.50	124.50	159.00
.40¢ per gallon	50.00	50.00	75.20	100.00	134.00	166.00	212.00
Fuel Consumption - 100 MPH							
Gallons/Hour	125	188	229	310	407	582	655
Pounds/Hour	750	1,128	1,374	1,860	2,442	3,992	3,930
.20¢ per gallon	25.00	37.60	45.80	62.00	81.40	116.40	131.00
.30¢ per gallon	37.50	56.40	68.70	93.00	122.10	194.60	196.50
.40¢ per gallon	50.00	75.20	91.60	124.00	162.80	232.80	262.00
Fuel Consumption - 200 MPH							
Gallons/Hour	750	2,000	2,125	2,375	2,937	3,250	3,600
Pounds/Hour	4,500	12,000	12,750	16,250	17,622	19,500	21,600
.20¢ per gallon	150.00	400.00	425.00	475.00	587.40	650.00	720.00
.30¢ per gallon	225.00	600.00	637.50	712.50	881.10	975.00	1,080.00
.40¢ per gallon	300.00	800.00	850.00	950.00	1,174.80	1,300.00	1,440.00

1/ Specific Fuel consumption is projected at 25 patcent higher then currently obtainable with current powerplants.
2/ Fuel weight is computed at 6 pounds per gallon rather then at actual weight of 5.8 pounds/gallon.

AIRSHIP

DEPRECIATION SCHEDULE

ASSUMPTIONS: The depreciation schedule applies a 15 per cent(15%) and a 5 per cent (5%)residual value at 16 years and at 25 years. The utilization schedule A and D column allow for the highest depreciation costs and lowest depreciation costs based on speeds of 100 and 200 Miles Per Hour. Estimated Life of a metal type Airship Hull based on physical experience is set at 25 to 30 years. Residual value may be considered the scrap value of the metal content and component systems values.

AIRSHIP SERIES	Residual Value 15% $(0)^3$	Residual Value 5% $(0)^3$	Full Depreciation 15% residual $(0)^3$	Full Depreciation 5% residual $(0)^3$	16 Year Depreciation 15% Residual - 5% Residual Annual Charge off Schedule- (A Column) (15%)	(5%)	25 Year Depreciation 15% Residual - 5% Residual Annual Charge off Schedule (D Column) (15%)	(5%)
MC-7.4	1,890	630	10,710	11,970	669,300	748,125	428,400	477,200
MC-15	3,937	1,312	22,312	24,937	1,394,531	1,558,593	892,500	997,500
MC-22	5,775	1,925	32,575	36,575	2,045,312	2,285,937	1,310,080	1,463,000
MC-35	9,187	3,062	52,062	58,188	3,253,906	3,636,750	2,082,500	2,324,752
MC-42	11,225	3,675	62,275	69,875	3,892,187	4,367,187	2,491,000	2,799,000
MC-52	13,650	4,550	77,350	86,450	4,209,375	5,403,125	3,094,000	3,458,000
MC-55	14,450	4,817	81,897	91,533	5,118,513	5,720,812	3,275,900	3,661,320

AIRSHIP UTILIZATION VERSUS DEPRECIATION COST

	4000 Hours Annual Utilization				6000 Hour Annual Utilization		A Column M.P.H.	D Column M.P.H.
	Cost/Hour 16Year/15%	Cost/Hour 16Year/5%	Cost/Hour 25Year/15%	Cost/Hour 25Year/5%	(A-High) Cost/Hr 16Year/15%	(D-Low) Cost/Hour 25Year/5%	100 - 200 ($ per Mile)	100 - 200 ($ per Mile)
MC-7.4	167.30	187.03	107.99	119.30	111.55	79.53	1.115 - .557	.795 - .397
MC-15	348.62	398.64	223.12	249.37	232.42	166.25	2.324 - 1.162	1.162 - .831
MC-22	511.52	571.48	327.50	365.75	340.88	243.61	3.408 - 1.704	2.436 - 1.218
MC-35	813.47	909.18	526.25	581.88	542.31	387.47	5.423 - 2.711	3.874 - 1.937
MC-42	903.04	1,091.79	622.75	699.75	648.69	466.50	6.486 - 3.243	4.665 - 2.332
MC-52	1,052.34	1,350.78	773.50	864.50	701.56	576.33	7.015 - 3.007	5.763 - 2.881
MC-55	1,279.64	1,430.23	818.97	915.43	731.43	610.22	7.314 - 610.22	6.102 - 3.051

AIRSHIP INSURANCE ANALYSIS
(Hull, Public Liability & Property Damage)

ASSUMPTION: The calculations expressed herein are based on typical airframe costs of fixed wing aircraft using a higher value to qualify the experience rate applied to new operations. It is significant to note that German Commercial Airship insurance rates of the 1930's era were less than One per cent (1 %) of hull value based on performance and safety. A probable rate will be in the 2.5 to 3 per cent range.

AIRSHIP SERIES	Hull Value @ $1.75 CF. 1/ (A) $(0)^3$	Hull Value @ $1.50 CF (B) $(0)^3$	Hull Value @ $1.25 CF (C) $(0)^3$	Hull Value @ $ 1.00 CF (D) $(0)^3$	Cost @ 6% of A (A-1) $(0)^3$	Cost @ 6% of D (A-2) $(0)^3$	Cost @ 4% of A(A-3) $(0)^3$	Cost @ 4% of D (A-4) $(0)^3$	Cost @ 2 % of A (A-5) $(0)^3$	Cost @ 2 % Of D (A-6) $(0)^3$
MC-7.4	12,600	10,800	9,000	7,400	756	432	504	288	252	144
MC-15	26,250	22,500	18,750	15,000	1,575	900	1,070	600	525	300
MC-22	38,500	33,000	27,500	22,000	2,310	1,320	1,540	880	770	440
MC-35	61,250	52,500	43,750	35,000	3,675	2,100	2,450	1,400	1,225	700
MC-42	73,500	63,000	52,500	42,000	4,410	2,520	2,940	1,680	1,470	840
MC-52	91,000	78,000	65,000	52,000	5,460	3,120	3,640	2,080	1,820	1,040
MC-55	96,350	82,500	68,750	55,000	5,781	3,300	3,854	2,200	1,927	1,100

UTILIZATION COST BREAKDOWN-INSURANCE

	4000 Hours - cost per hour, Based on Columns		6000 Hours - cost per hour, Based on Columns		COST PER MILE @ 100 & 200 MPH, Based on Columns	
	A-1	A-6	A-1	A-6	A-1 - A-6 100 M.P.H	A-1 - A-6 200 M. P. H.
MC-7.4	189.00	36.00	126.00	24.00	1.890 - .240	.945 - .120
MC-15	393.75	75.00	262.50	50.00	3.937 - .50	1.968 - .250
MC-22	577.50	110.00	385.00	73.33	5.77 - .733	2.887 - .366
MC-35	918.75	175.00	612.50	116.66	9.187 - 1.166	4.593 - .583
MC-42	1,125.00	210.00	735.00	140.00	11.250 - 1.400	5.625 - .700
MC-52	1,365.00	260.00	910.00	173.33	13.655 - 1.733	6.825 - .8666
MC-55	1,445.25	275.00	963.50	183.33	14.45 - 1,833	7.226 - .916

1/ C.F. = Cubic foot displacement of vehicle

FUEL/PAYLOAD/COST/RANGE
Without Boundry Layer

200 M.P.H. = 174 Kts
100 M.P.H. = 84 Kts

Assumptions: Fossil fuels of JP-4, Karo base for turbine operation. As at 5-10-74, domestic cost per gallon average .19¢ per C.A.B. Monthly report.

AIRSHIP SERIES:	Cost per Hour $	Cost per mile-St.	Fuel Weight-Lbs 2,000 Mile Range: 100MPH-20Hrs 200MPH-10Hrs	Fuel Weight Tons	Crew Weight Pounds	Reserve Fuel Weight Pounds	Crew, Fuel & Res. Fuel weight-Tons	Payload 2000 St. Miles Tons	Cost per Ton Mile	Assuming a 100% error- Cost per mile/Ton
MC-7.4										
High Speed -200MPH										
@ .20¢ per gallon	150.00	.75	90,000	45	5000	18,000	56.5	60	.0215	.025
@ .30¢ " "	225.00	1.15	"	45	"	"	"	"	.091	.038
@ .40¢ " "	300.00	1.50	"	45	"	"	"	"	.025	.050
Low Speed -100 MPH										
@ .20¢ per gallon	25.00	.15	15,000	7.5	"	5,000	12.5	101	.00148	.00296
@ .30¢ per "	37.50	.375	"	"	"	"	"	"	.00375	.00750
@ .40¢ per "	50.00	.50	"	"	"	"	"	"	.0050	.010
MC-15										
High Speed - 200 MPH										
@ .20¢ per gallon	400.00	2.00	120,000	60	"	24,000	74	202	.0099	.0198
@ .30¢ " "	600.00	3.00	"	"	"	"	"	"	.0148	.0296
@ .40¢ " "	800.00	4.00	"	"	"	"	"	"	.0193	.0386
Low Speed - 100 MPH										
@ .20¢ per gallon	37.60	.376	22,560	11.3	"	5,000	16.3	260	.00151	.00302
@ .30¢ " "	56.40	.564	"	"	"	"	"	"	.00261	.00432
@ .40¢ " "	75.20	.752	"	"	"	"	"	"	.00439	.00578
MC-22										
High Speed - 200 MPH										
@ .20¢ per gallon	425.00	2.125	127,500	63.75	"	25,500	79	340	.00625	.0125
@ .30¢ " "	637.50	3.185	"	"	"	"	"	"	.00936	.0187
@ .40¢ " "	850.00	4.25	"	"	"	"	"	"	.0125	.0250
Low Speed - 100 MPH										
@ .20¢ per gallon	45.80	.458	27,480	13.74	"	5,496	19.	400	.00145	.0029
@ .30¢ per gallon	68.60	.687	"	"	"	"	"	"	.00171	.0034
@ .40¢ per gallon	91.60	.916	"	"	"	"	"	"	.00229	.00458

FUEL/PAYLOAD/COST/RANGE - Sheet 2:

MC-35										
High Speed - 200 MPH										
@ .20¢ per gallon	475.00	2.375	162,500	81.25	"	32,500	100	567	.00418	.00836
@ .30¢ " "	712.50	3.56	"	"	"	"	"	"	.00627	.01254
@ .40¢ " "	950.00	4.75	"	"	"	"	"	"	.00837	.01674
Low Speed - 100 MPH										
@ .20¢ per gallon	62.00	.62	37,200	18.60	"	7,400	24.82	642	.000965	.00193
@ .30¢ " "	93.00	.93	"	"	"	"	"	"	.001448	.00289
@ .40¢ " "	124.00	1.24	"	"	"	"	"	"	.00193	.00360
MC-42										
High Speed - 200 MPH										
@ .20¢ per gallon	587.40	2.937	176,220	88.11	10,000	35,244	110.73	728	.00403	.00806
@ .30¢ " "	881.10	4.405	"	"	"	"	"	"	.00605	.01210
@ .40¢ " "	1,174.80	5.874	"	"	"	"	"	"	.00806	.01612
Low Speed - 100 MPH					"					
@ .20¢ per gallon	81.40	.814	48,840	24.42	10,000	9,768	34.30	804	.00101	.00202
@ .30¢ " "	122.10	1.221	"	"	"	"	"	"	.00151	.00302
@ .40¢ " "	162.80	1.628	"	"	"	"	"	"	.00202	.00404
MC-52										
High Speed - 200 MPH										
@ .20¢ per gallon	650.00	3.25	195,000	97.5	"	39,500	122	949	.00342	.00684
@ .30¢ " "	975.00	4.875	"	"	"	"	"	"	.00513	.01026
@ .40¢ " "	1,300.00	6.50	"	"	"	"	"	"	.00684	.01368
Low Speed - 100 MPH										
@ .20¢ per gallon	116.40	1.164	79,840	39.92	"	15,968	52.90	1,018	.00114	.00228
@ .30¢ " "	194.60	1.946	"	"	"	"	"	"	.00191	.00382
@ .40¢ " "	232.80	2.328	"	"	"	"	"	"	.00227	.00454
MC-55										
High Speed -200 MPH										
@ .20¢ per gallon	720.00	3.60	216,000	108	"	43,200	134.6	1,032	.00348	.00696
@ .30¢ " "	1,080.00	5.40	"	"	"	"	"	"	.00523	.01046
@ .40¢ " "	1,440.00	7.20	"	"	"	"	"	"	.00697	.01394
Low Speed - 100 MPH										
@ .20¢ per gallon	131.00	1.31	78,600	39.3	"	15,720	52.15	1,114	.00117	.00234
@ .30¢ " "	196.50	1.965	"	"	"	"	"	"	.00176	.00352
@ .40¢ " "	262.00	2.62	"	"	"	"	"	"	.00235	.00470

BOUNDRY LAYER CONTROL-ECONOMIC EFFICIENCY

Assumptions:
Boundry Layer Control is believed applicable to large airships without the attendent penalties that are imposed on fixed wing aircraft. This study believes that BLC will improve the efficiency by 50 per cent (%). NASA estimates indicate BLC on a cylinirical airform will increase the efficiency by 58 per cent(58%). The study may therefore be as much as 20% understated as to BLC efficiency.

AIRSHIP SERIES:	Horsepower Conventional Design 200 M.P.H.	Horsepower/ BLC Design 200 M.P.H.	Fuel in Pounds/Gals Conventional	Fuel in Pounds/Gals BLC Design	Cost Per hour @ 200 M.P.H. @ .20¢ pG $	.30¢ pG $	.40¢ pG $
MC - 7.4	30,000	15,000	4,500/750	2,250/375	75.00	112.50	150.00
MC - 15	71,000	35,500	12,000/2000	5,310/885	177.00	265.50	354.00
MC - 22	84,000	42,000	12,750/2,125	6,360/1060	212.00	318.00	424.00
MC - 35	95,000	47,500	16,250/2375	7,122/1187	237.40	356.10	478.80
MC - 42	118,000	59,000	17,622/2937	8,100/1350	270.00	405.00	540.00
MC - 52	130,000	65,000	19,500/3250	9,750/1625	325.00	487.50	650.00
MC - 55	144,000	72,000	21,600/3600	12,300/2050	410.00	615.00	820.00