

The envelope for my balloon was designed using a computer program I wrote to calculate a natural shaped envelope based on a given set of input parameters.

Inputs to the program are:

- 1) Design altitude = the altitude your envelope size will be based on. If you want a balloon that is capable of flying to a maximum altitude of 10,000 feet, setting this input to 10,000 will insure that you have this capability.
- 2) Standard atmosphere prompt = an input of “yes” lets you base your balloon design on a standard day atmosphere. A “no” input allows you to select a non-standard day ambient temperature which is important if you will often fly on hot summer days.
- 3) Desired lift = the estimated total gross weight of your balloon.
- 4) Average internal air temperature = this is the average internal air temperature that the program uses to calculate the envelope shape. My program estimates that this temperature is 15% higher than the envelope fabric temperature. If you want your maximum fabric temperature not to exceed 190 degrees F, then you should input $190 \times 1.15 = 218.5$ degrees F.
- 5) Envelope mouth diameter = the mouth diameter for your design.
- 6) Number of gores = the number of symmetrical gore panels used by the program to size a cut-out pattern for your gores. You must add your known seam allowance to the edges of your gores.

My balloon was to be flown as an ultralight, so my primary interest was light weight and small size. My final envelope design had a volume of 22,000 cubic feet. A plot of my balloon's radius as a function of height is shown in Figure 1. For comparison purposes, a 22,000 cubic foot envelope designed using Smalley factors is also shown in Figure 1. The Smalley factor shape is similar to, but not identical to the shape generated by my program. The reason for the difference is due to the 8 foot diameter open mouth on my design. Smalley factors will generate a natural shape balloon envelope, but only for a balloon with no mouth opening that terminates at a single point on the bottom end. To prove that my program was calculating the natural shape properly, it was run with a zero mouth diameter. This resulted in a shape that exactly matches the Smalley shape as shown in Figure 1.

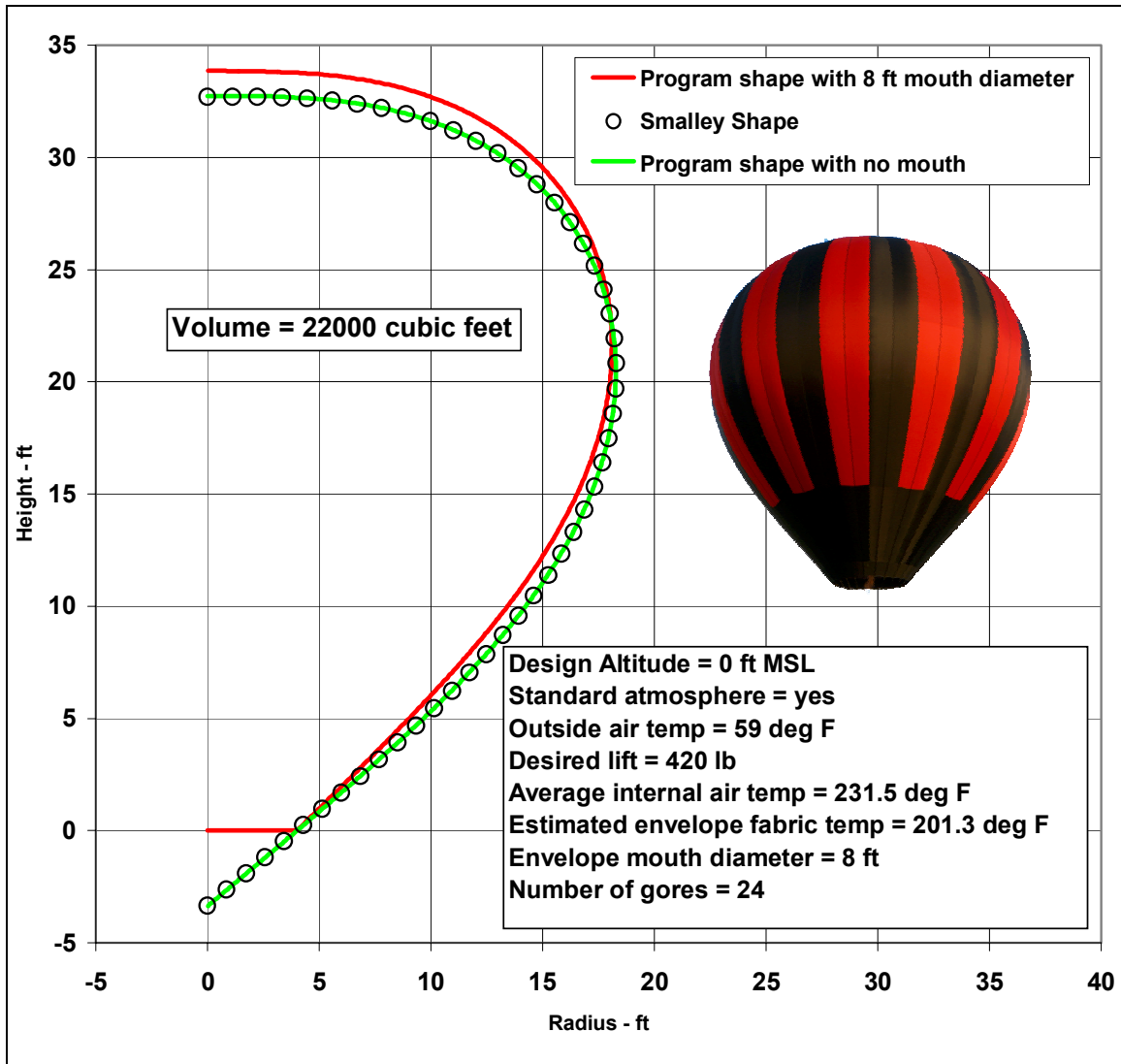


Figure 1

The output data file generated by my program is shown in Table 1. The output parameters are:

- 1) Station radius = the radius from the balloon vertical centerline to the envelope surface at the corresponding station height.
- 2) Station height = the station height from the mouth of the balloon.
- 3) Gore length = the gore length from the mouth end along the gore centerline.
- 4) Gore width = the symmetrical gore width at the corresponding gore length location
- 5) Station lift = the envelope lift generated by the part of the envelope between the mouth and the corresponding station. It can be seen that the lower part of the envelope, below the maximum radius station, produces negative lift.
- 6) Station volume = the envelope volume below the corresponding station height.

Table 1

station radius (ft)	station height (ft)	gore length (ft)	gore width (ft)	station lift (lb)	station volume (ft**3)
4	0	0	1.047	0.0	0.0
4.179	0.175	0.25	1.094	0.0	9.2
4.357	0.35	0.5	1.141	0.0	19.2
4.536	0.525	0.75	1.187	-0.1	30.1
4.714	0.7	1	1.234	-0.1	41.8
4.893	0.875	1.25	1.281	-0.2	54.5
5.071	1.05	1.5	1.328	-0.3	68.2
5.249	1.225	1.75	1.374	-0.4	82.8
5.428	1.401	2	1.421	-0.6	98.5
5.606	1.576	2.25	1.468	-0.8	115.3
5.784	1.751	2.5	1.514	-1.0	133.2
5.962	1.927	2.75	1.561	-1.2	152.2
6.14	2.102	3	1.608	-1.5	172.4
6.318	2.278	3.25	1.654	-1.8	193.8
6.496	2.454	3.5	1.701	-2.1	216.5
6.674	2.63	3.75	1.747	-2.4	240.4
6.851	2.806	4	1.794	-2.8	265.7
7.028	2.982	4.25	1.84	-3.3	292.4
7.205	3.158	4.5	1.886	-3.7	320.5
7.382	3.335	4.75	1.933	-4.2	350.0
7.559	3.512	5	1.979	-4.8	381.0
7.736	3.689	5.25	2.025	-5.3	413.5
7.912	3.866	5.5	2.071	-6.0	447.6
8.088	4.044	5.75	2.117	-6.6	483.3
8.263	4.222	6	2.163	-7.3	520.7
8.439	4.4	6.25	2.209	-8.1	559.7
8.614	4.578	6.5	2.255	-8.9	600.5
8.789	4.757	6.75	2.301	-9.8	643.0
8.963	4.936	7	2.346	-10.7	687.4
9.137	5.116	7.25	2.392	-11.6	733.6
9.31	5.296	7.5	2.437	-12.6	781.7
9.483	5.476	7.75	2.483	-13.7	831.7
9.656	5.657	8	2.528	-14.8	883.8
9.828	5.838	8.25	2.573	-15.9	937.8
10	6.02	8.5	2.618	-17.1	994.0
10.171	6.202	8.75	2.663	-18.4	1052.2
10.341	6.385	9	2.707	-19.7	1112.6

10.511	6.569	9.25	2.752	-21.1	1175.3
10.681	6.753	9.5	2.796	-22.5	1240.2
10.849	6.937	9.75	2.84	-24.0	1307.4
11.017	7.123	10	2.884	-25.6	1376.9
11.184	7.308	10.25	2.928	-27.2	1448.9
11.351	7.495	10.5	2.972	-28.8	1523.3
11.516	7.682	10.75	3.015	-30.6	1600.2
11.681	7.87	11	3.058	-32.3	1679.6
11.845	8.059	11.25	3.101	-34.2	1761.7
12.008	8.248	11.5	3.144	-36.1	1846.3
12.17	8.439	11.75	3.186	-38.0	1933.7
12.332	8.63	12	3.228	-40.1	2023.8
12.492	8.822	12.25	3.27	-42.1	2116.7
12.651	9.014	12.5	3.312	-44.3	2212.5
12.809	9.208	12.75	3.353	-46.5	2311.1
12.966	9.403	13	3.394	-48.7	2412.7
13.121	9.598	13.25	3.435	-51.1	2517.2
13.276	9.795	13.5	3.476	-53.4	2624.8
13.429	9.993	13.75	3.516	-55.9	2735.5
13.581	10.191	14	3.555	-58.3	2849.2
13.732	10.391	14.25	3.595	-60.9	2966.2
13.881	10.591	14.5	3.634	-63.5	3086.4
14.028	10.793	14.75	3.673	-66.1	3209.8
14.174	10.996	15	3.711	-68.8	3336.5
14.319	11.2	15.25	3.749	-71.5	3466.6
14.462	11.405	15.5	3.786	-74.3	3600.0
14.603	11.611	15.75	3.823	-77.2	3736.9
14.743	11.819	16	3.86	-80.0	3877.2
14.88	12.028	16.25	3.896	-83.0	4021.1
15.016	12.237	16.5	3.931	-85.9	4168.4
15.15	12.449	16.75	3.966	-88.9	4319.3
15.282	12.661	17	4.001	-91.9	4473.7
15.412	12.875	17.25	4.035	-95.0	4631.8
15.539	13.089	17.5	4.068	-98.1	4793.5
15.665	13.306	17.75	4.101	-101.2	4958.8
15.788	13.523	18	4.133	-104.3	5127.8
15.909	13.742	18.25	4.165	-107.4	5300.4
16.028	13.962	18.5	4.196	-110.6	5476.7
16.144	14.183	18.75	4.227	-113.7	5656.7
16.258	14.406	19	4.256	-116.9	5840.3
16.369	14.63	19.25	4.285	-120.0	6027.5
16.477	14.855	19.5	4.314	-123.2	6218.4
16.583	15.082	19.75	4.341	-126.3	6412.9
16.686	15.31	20	4.368	-129.4	6611.0
16.786	15.539	20.25	4.395	-132.5	6812.7
16.883	15.769	20.5	4.42	-135.6	7017.8
16.977	16.001	20.75	4.445	-138.6	7226.5

17.068	16.234	21	4.468	-141.6	7438.5
17.155	16.468	21.25	4.491	-144.5	7653.9
17.239	16.703	21.5	4.513	-147.4	7872.6
17.32	16.94	21.75	4.534	-150.3	8094.5
17.398	17.178	22	4.555	-153.0	8319.5
17.472	17.416	22.25	4.574	-155.7	8547.6
17.542	17.656	22.5	4.592	-158.3	8778.6
17.608	17.897	22.75	4.61	-160.8	9012.5
17.671	18.139	23	4.626	-163.2	9249.0
17.73	18.382	23.25	4.642	-165.4	9488.2
17.785	18.626	23.5	4.656	-167.6	9729.8
17.836	18.871	23.75	4.67	-169.6	9973.7
17.883	19.116	24	4.682	-171.6	10219.8
17.926	19.363	24.25	4.693	-173.3	10467.9
17.964	19.61	24.5	4.703	-174.9	10717.8
17.998	19.857	24.75	4.712	-176.4	10969.3
18.028	20.106	25	4.72	-177.7	11222.4
18.053	20.354	25.25	4.726	-178.8	11476.7
18.074	20.603	25.5	4.732	-179.7	11732.1
18.09	20.853	25.75	4.736	-180.4	11988.4
18.101	21.103	26	4.739	-180.9	12245.3
18.108	21.353	26.25	4.741	-181.2	12502.7
18.11	21.603	26.5	4.741	-181.3	12760.2
18.107	21.853	26.75	4.74	-181.2	13017.8
18.099	22.102	27	4.738	-180.8	13275.0
18.086	22.352	27.25	4.735	-180.2	13531.8
18.068	22.601	27.5	4.73	-179.3	13787.8
18.045	22.85	27.75	4.724	-178.2	14042.8
18.017	23.099	28	4.717	-176.8	14296.5
17.984	23.347	28.25	4.708	-175.1	14548.8
17.946	23.594	28.5	4.698	-173.2	14799.3
17.902	23.84	28.75	4.687	-171.0	15047.7
17.853	24.085	29	4.674	-168.4	15293.9
17.799	24.329	29.25	4.66	-165.7	15537.6
17.74	24.572	29.5	4.644	-162.6	15778.6
17.676	24.813	29.75	4.627	-159.2	16016.5
17.606	25.054	30	4.609	-155.5	16251.2
17.531	25.292	30.25	4.59	-151.5	16482.5
17.451	25.529	30.5	4.569	-147.2	16710.1
17.365	25.764	30.75	4.546	-142.7	16933.8
17.275	25.997	31	4.522	-137.8	17153.3
17.179	26.228	31.25	4.497	-132.6	17368.6
17.078	26.456	31.5	4.471	-127.2	17579.4
16.972	26.683	31.75	4.443	-121.4	17785.5
16.86	26.907	32	4.414	-115.4	17986.8
16.744	27.128	32.25	4.384	-109.0	18183.2
16.623	27.347	32.5	4.352	-102.4	18374.4

16.497	27.562	32.75	4.319	-95.6	18560.4
16.366	27.775	33	4.285	-88.4	18741.1
16.23	27.985	33.25	4.249	-81.0	18916.3
16.09	28.192	33.5	4.212	-73.4	19086.0
15.945	28.396	33.75	4.174	-65.5	19250.1
15.795	28.596	34	4.135	-57.4	19408.6
15.641	28.793	34.25	4.095	-49.0	19561.4
15.483	28.986	34.5	4.053	-40.5	19708.5
15.32	29.176	34.75	4.011	-31.7	19850.0
15.153	29.362	35	3.967	-22.8	19985.7
14.982	29.545	35.25	3.922	-13.7	20115.8
14.807	29.723	35.5	3.877	-4.5	20240.3
14.628	29.898	35.75	3.83	5.0	20359.2
14.446	30.069	36	3.782	14.5	20472.5
14.259	30.235	36.25	3.733	24.2	20580.5
14.07	30.398	36.5	3.683	34.0	20683.0
13.877	30.557	36.75	3.633	43.8	20780.4
13.68	30.711	37	3.581	53.8	20872.5
13.48	30.862	37.25	3.529	63.8	20959.7
13.278	31.008	37.5	3.476	73.9	21041.9
13.072	31.15	37.75	3.422	84.0	21119.4
12.863	31.288	38	3.368	94.1	21192.2
12.652	31.421	38.25	3.312	104.2	21260.5
12.438	31.551	38.5	3.256	114.4	21324.5
12.222	31.676	38.75	3.2	124.5	21384.3
12.003	31.797	39	3.142	134.6	21440.1
11.782	31.914	39.25	3.084	144.6	21492.0
11.559	32.026	39.5	3.026	154.6	21540.2
11.333	32.135	39.75	2.967	164.5	21584.9
11.106	32.239	40	2.908	174.4	21626.2
10.877	32.34	40.25	2.848	184.1	21664.3
10.647	32.436	40.5	2.787	193.7	21699.4
10.414	32.528	40.75	2.726	203.3	21731.6
10.181	32.617	41	2.665	212.7	21761.0
9.945	32.701	41.25	2.604	222.0	21787.9
9.709	32.782	41.5	2.542	231.1	21812.4
9.471	32.859	41.75	2.479	240.1	21834.6
9.232	32.932	42	2.417	248.9	21854.7
8.992	33.002	42.25	2.354	257.5	21872.9
8.75	33.068	42.5	2.291	266.0	21889.2
8.508	33.13	42.75	2.228	274.3	21903.9
8.266	33.19	43	2.164	282.4	21916.9
8.022	33.245	43.25	2.1	290.3	21928.6
7.777	33.298	43.5	2.036	298.0	21938.9
7.532	33.347	43.75	1.972	305.5	21948.0
7.287	33.394	44	1.908	312.8	21956.0
7.04	33.437	44.25	1.843	319.9	21963.0

6.794	33.477	44.5	1.779	326.7	21969.0
6.547	33.515	44.75	1.714	333.4	21974.3
6.299	33.55	45	1.649	339.7	21978.8
6.051	33.582	45.25	1.584	345.9	21982.7
5.803	33.612	45.5	1.519	351.8	21986.0
5.554	33.639	45.75	1.454	357.5	21988.8
5.306	33.664	46	1.389	363.0	21991.1
5.057	33.687	46.25	1.324	368.2	21993.0
4.808	33.708	46.5	1.259	373.2	21994.6
4.558	33.727	46.75	1.193	377.9	21995.9
4.309	33.743	47	1.128	382.4	21996.9
4.059	33.758	47.25	1.063	386.6	21997.7
3.81	33.772	47.5	0.997	390.6	21998.4
3.56	33.783	47.75	0.932	394.3	21998.9
3.31	33.793	48	0.867	397.8	21999.3
3.06	33.802	48.25	0.801	401.0	21999.5
2.81	33.809	48.5	0.736	404.0	21999.7
2.56	33.816	48.75	0.67	406.7	21999.9
2.311	33.821	49	0.605	409.2	22000.0
2.061	33.825	49.25	0.539	411.4	22000.0
1.811	33.828	49.5	0.474	413.3	22000.1
1.561	33.831	49.75	0.409	415.0	22000.1
1.311	33.833	50	0.343	416.5	22000.1
1.061	33.834	50.25	0.278	417.7	22000.1
0.811	33.835	50.5	0.212	418.7	22000.1
0.561	33.835	50.75	0.147	419.4	22000.1
0.311	33.835	51	0.081	419.8	22000.1
0.061	33.835	51.25	0.016	420.0	22000.1
0.019	33.835	51.292	0.005	420.0	22000.1