Historical Literature Survey and Technical Summary of High Altitude Tethered Programs

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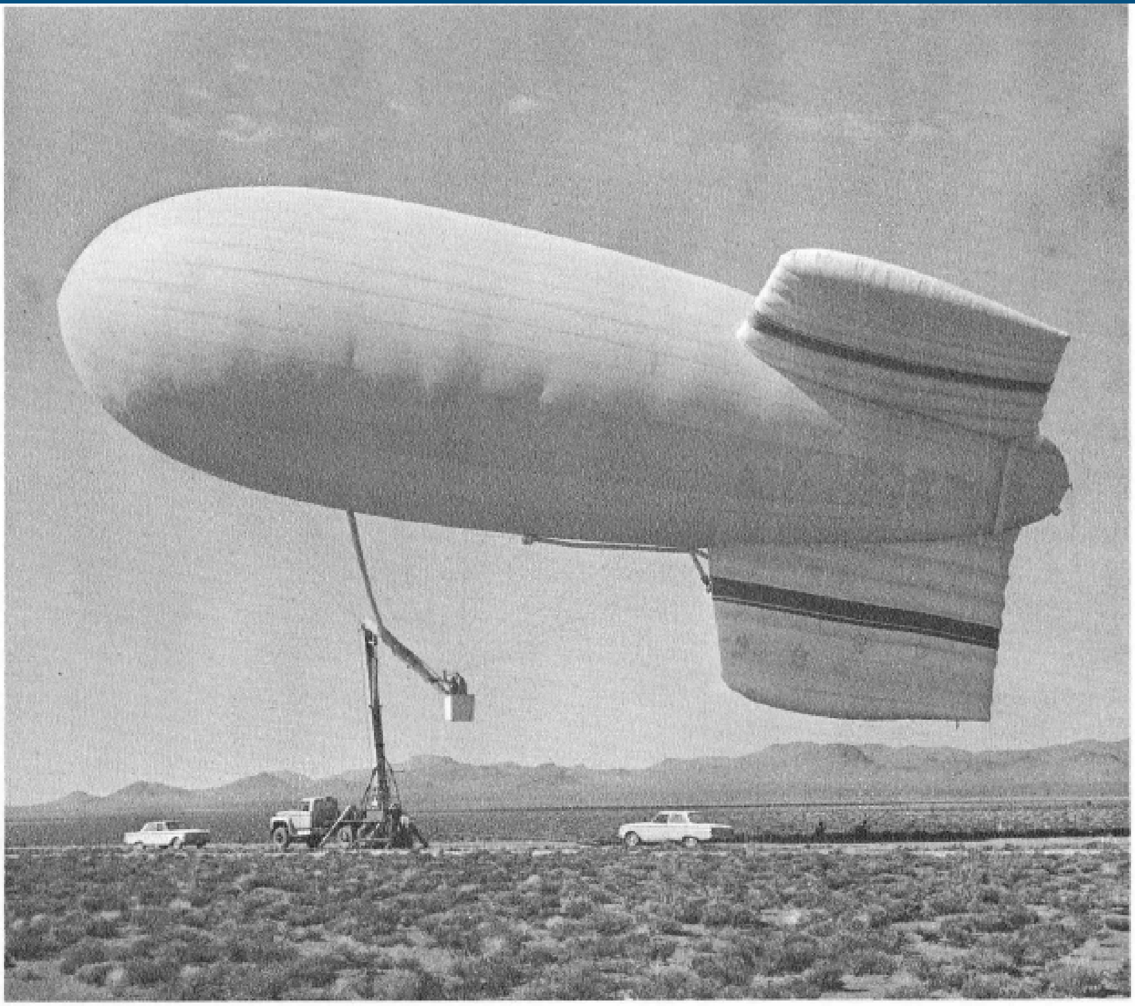
Basis of the Study

- In-house hard copy of the GSFC Balloon Technology Library
- 4,492 fully indexed individual records on subjects spanning operations, performance, materials, and electronics.
- Areas include free balloons, tethered aerostats, airships, and payload recovery systems.

Summary of Findings

- 25 entries found specifically on high-altitude tethered aerostats.
- Most were paper studies – not test or demonstration programs.
- The most comprehensive study was conducted by Goodyear Aerospace in 1967-68 for ARPA (now DARPA).
- Some recent studies were conducted in the mid 1990's.
- References to CNES project in 1976 were found, but no records exist in the BT library.

NCAR News Letter November 1962



Heavy Load Captive Blimp, Unleashed, Reaches 40,000 Feet

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Accompanying Text from 1962 Article

Heavy Load Captive Blimp, Unleashed, Reaches 40,000 Feet

The blimp pictured in the photograph above is called a "GEOCAP" by its manufacturer, VIRON, a division of Geophysics Corporation of America. As part of a series of reliability tests in the western part of the U.S., a GEOCAP was recently released and allowed to ascend to 40,000 feet, establishing what is believed to be an altitude record for a blimp of this type.

For over a week before releasing the blimp, technicians flew it at an altitude of one mile, tethered and lifting a payload of 6,000 pounds. Radio command brought the balloon to a gentle landing from the 40,000 foot height.

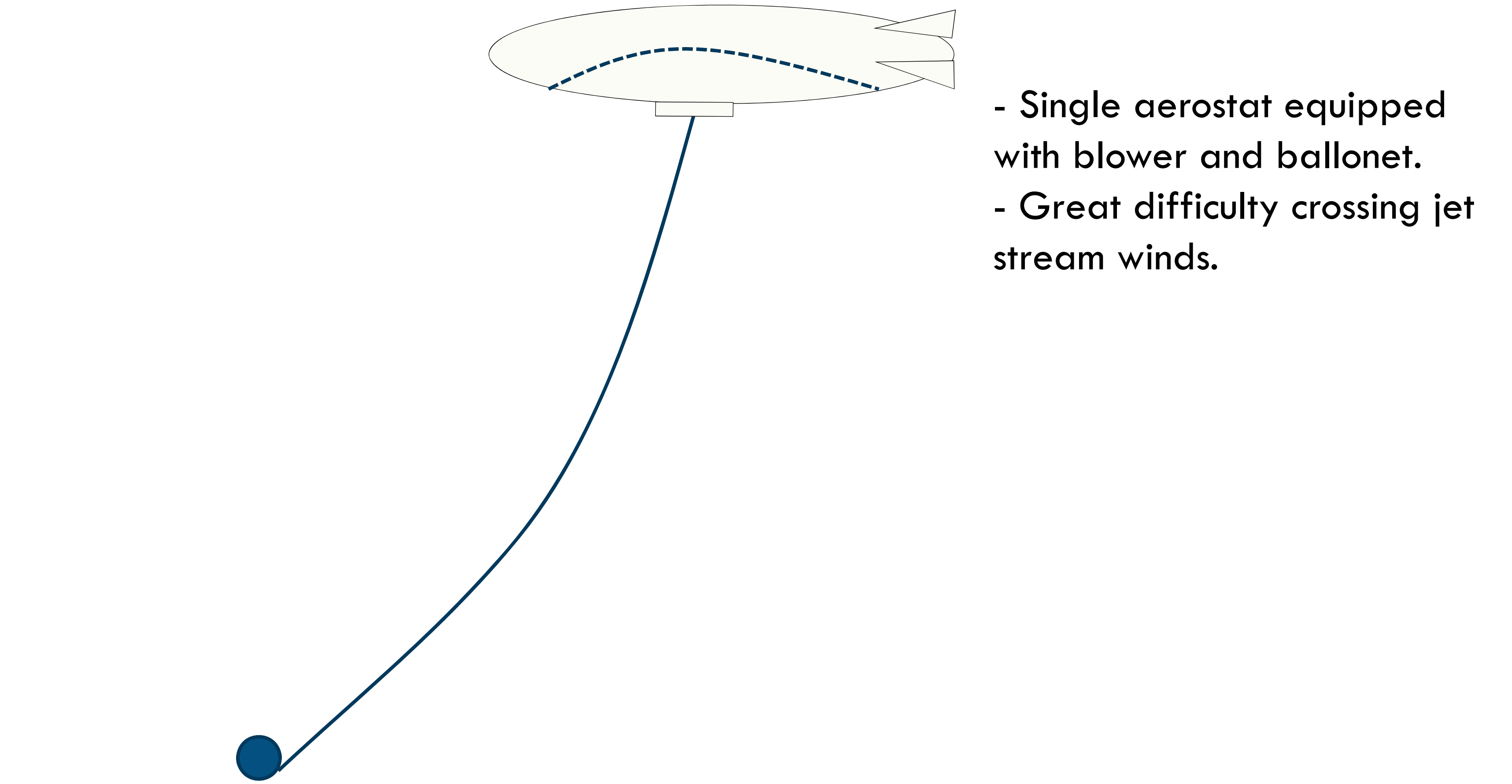
These modern blimps, weighing much less than the barrage balloons used in World Wars I and II, are some of the world's largest and can lift loads of up to 10,000 pounds. Their lightness is due to the use of new lightweight fabrics in their construction.

Captive blimps are currently being used for numerous scientific tests involving space re-entry, and nuclear, radar, meteorological, and instrumentation effects.

Common Themes

- Consistently, the goals were communications and persistent surveillance – staying over one spot on the ground.
- Steady-state design is the easy part.
- Maybe we can get up there, but we're not sure how to get back.
- It will require innovative thinking to deal with the gas expansion on ascent and the contraction on descent. If the balloon goes flaccid during descent, things could get ugly.
- Studies consistently concluded that the concept was feasible.

Approach 1– Brute Force and Luck



- Single aerostat equipped with blower and ballonet.
- Great difficulty crossing jet stream winds.

Approach 2 – Multiple Balloons

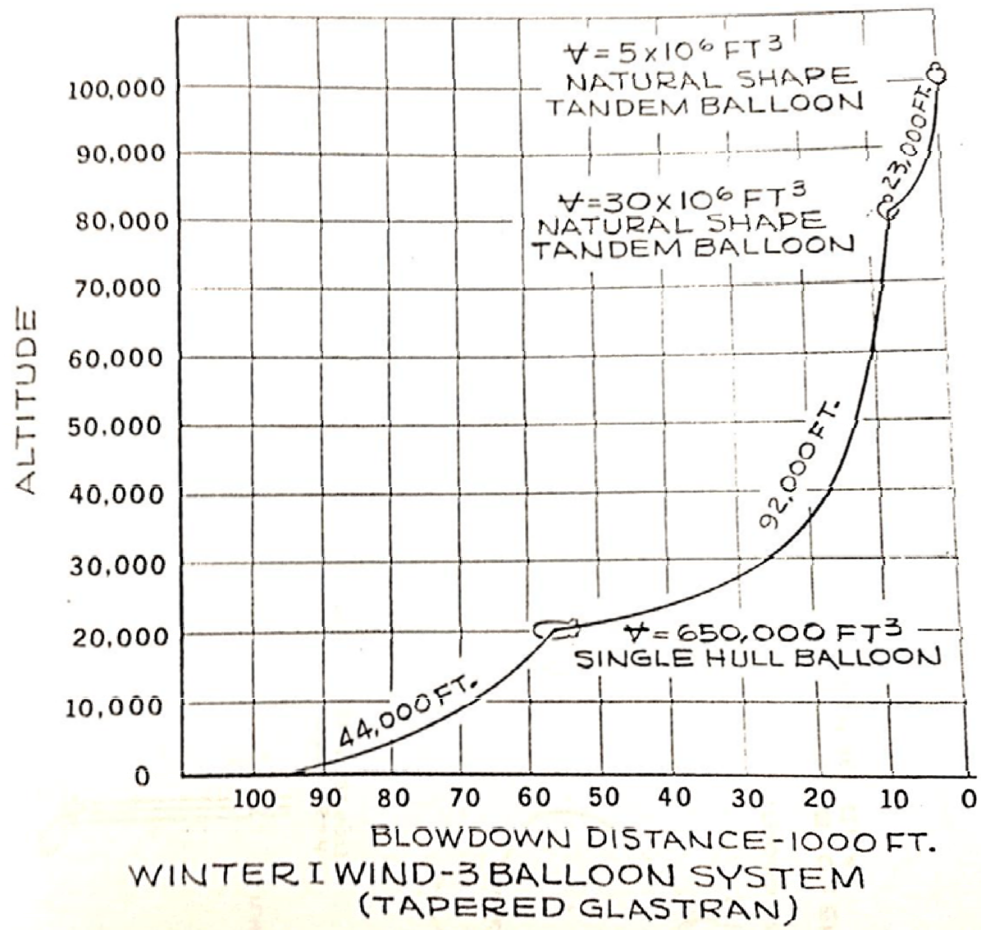


FIGURE 14;

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Natural shape tandem balloon

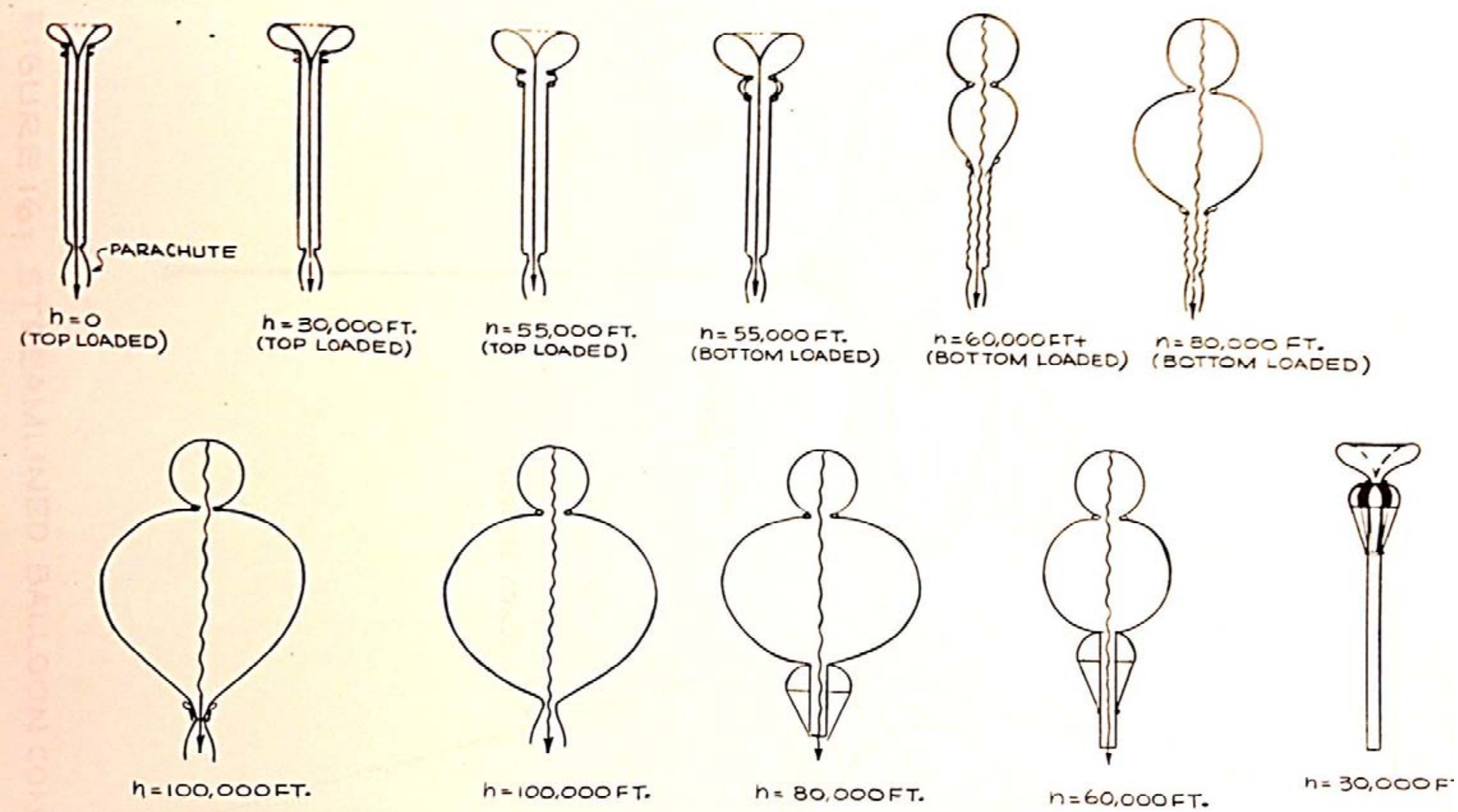

FIGURE 15; OPERATIONAL SEQUENCE OF A TOP LOADED TANDEM BALLOON IN ASCENT AND DESCENT.

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Mid-tether streamlined blimp

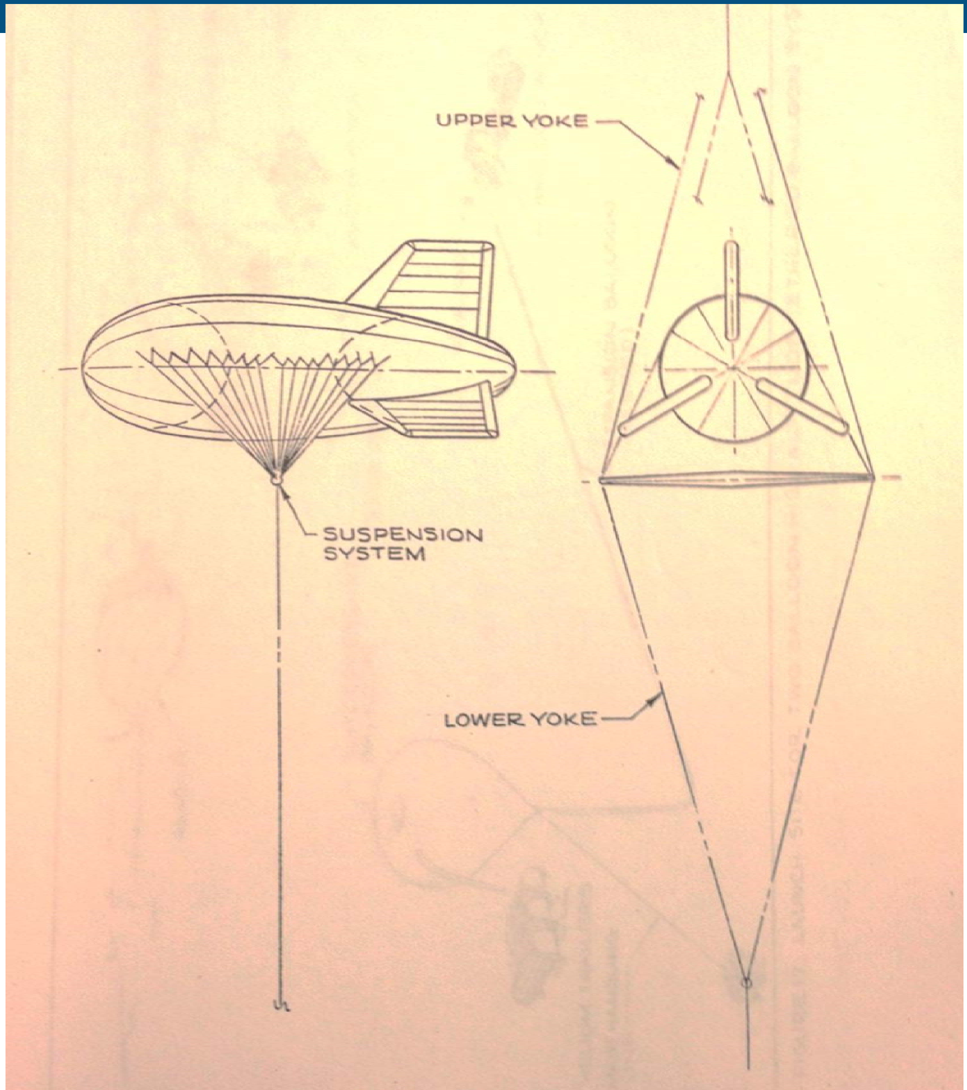

FIGURE 16; STREAMLINED BALLOON CONFIGURATION

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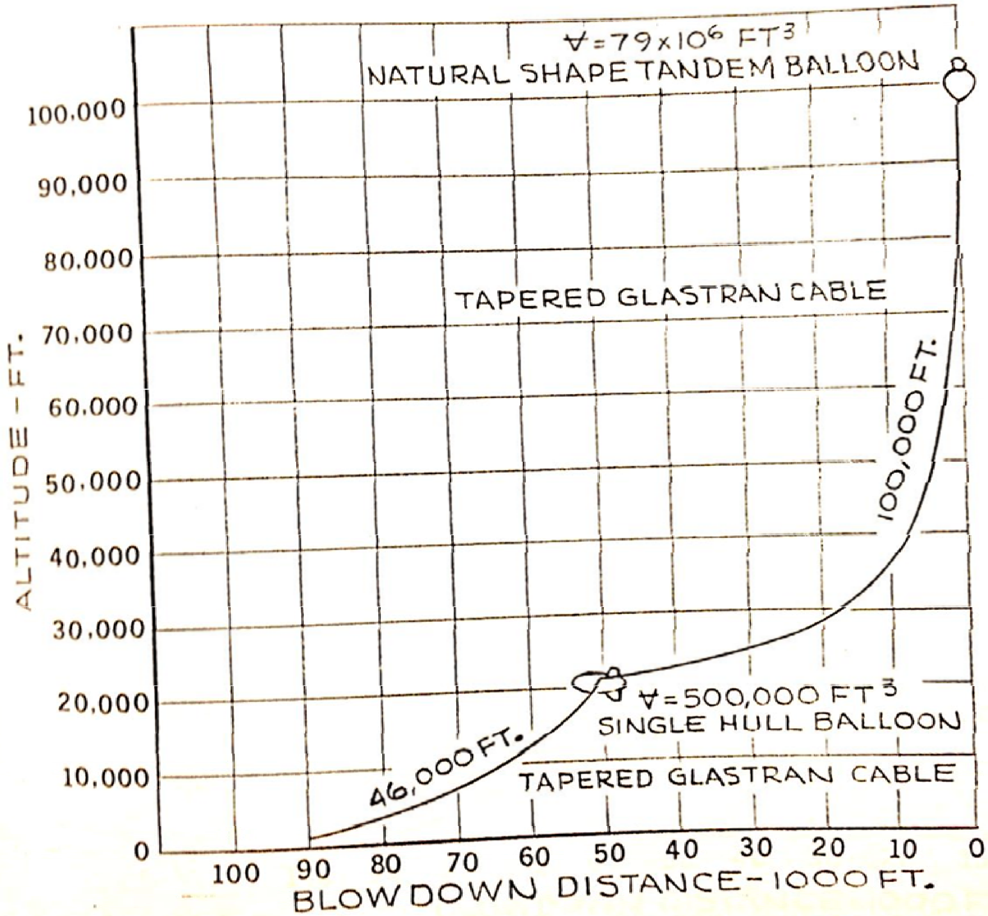
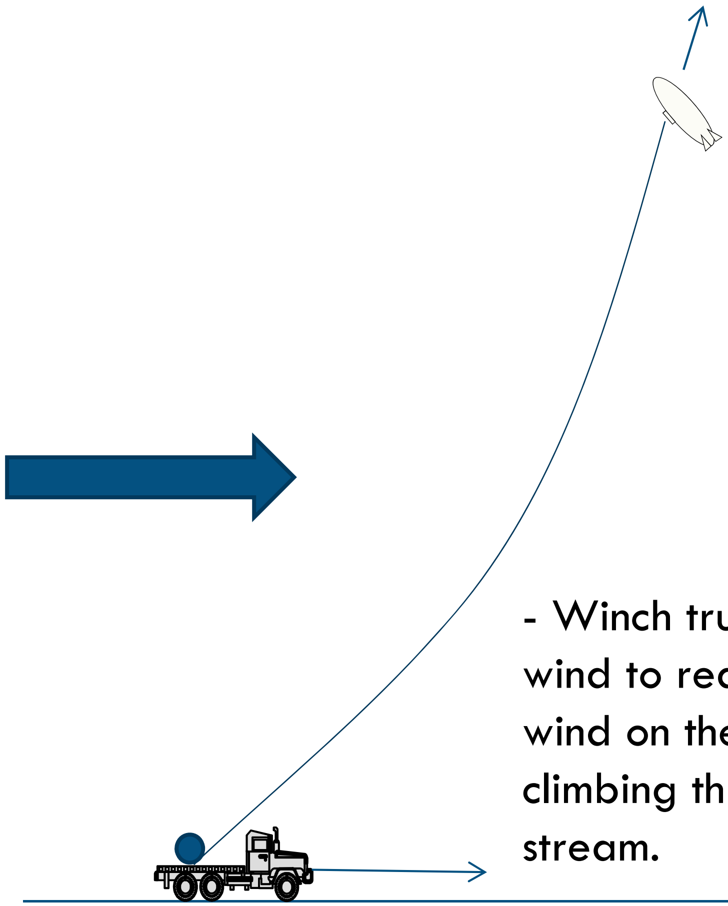
Very difficult to operate in Winter



WINTER I WIND-2 BALLOON SYSTEM (TAPERED GLASTRAN)

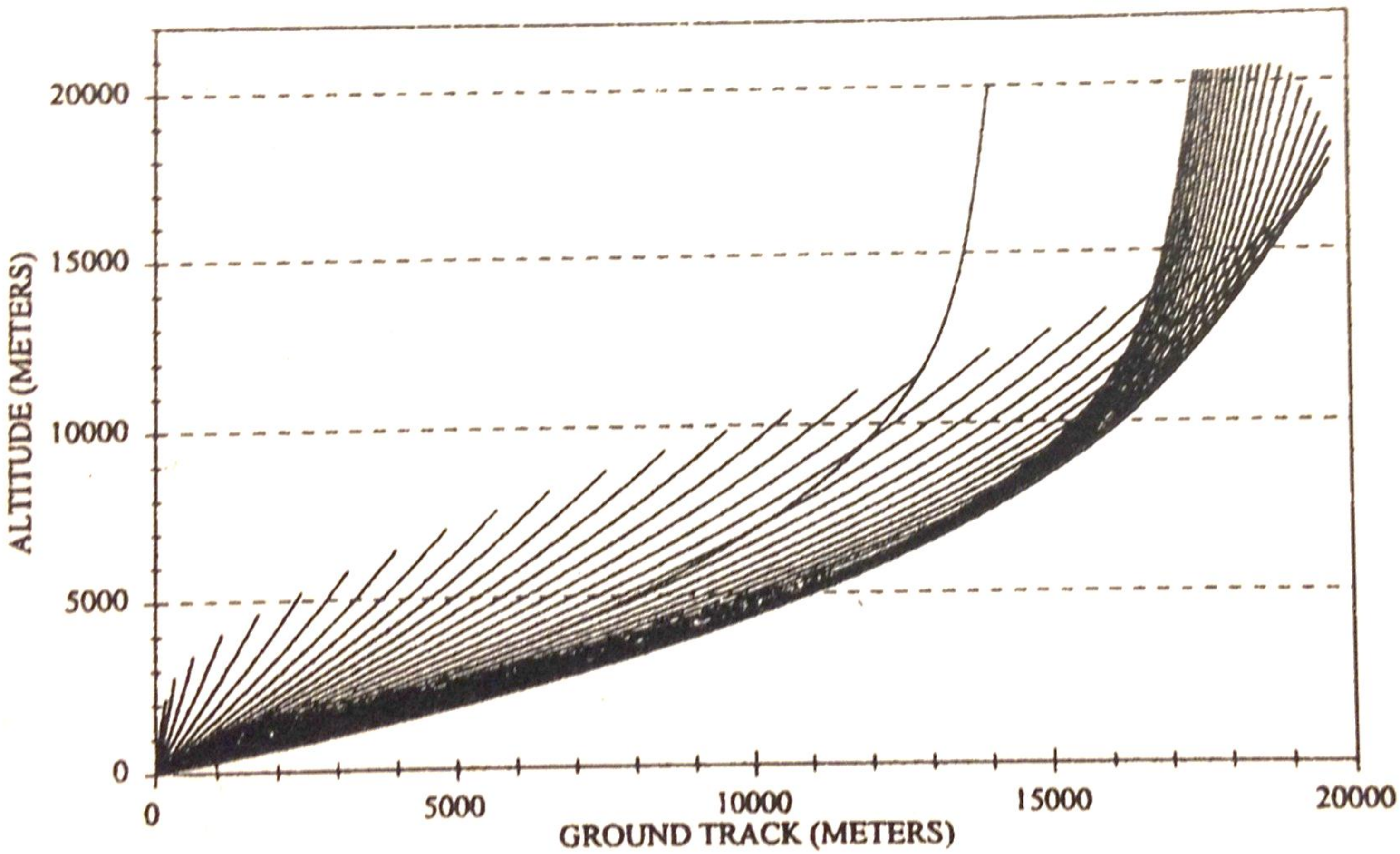
FIGURE 13;

Approach 3 – Non-traditional let-up



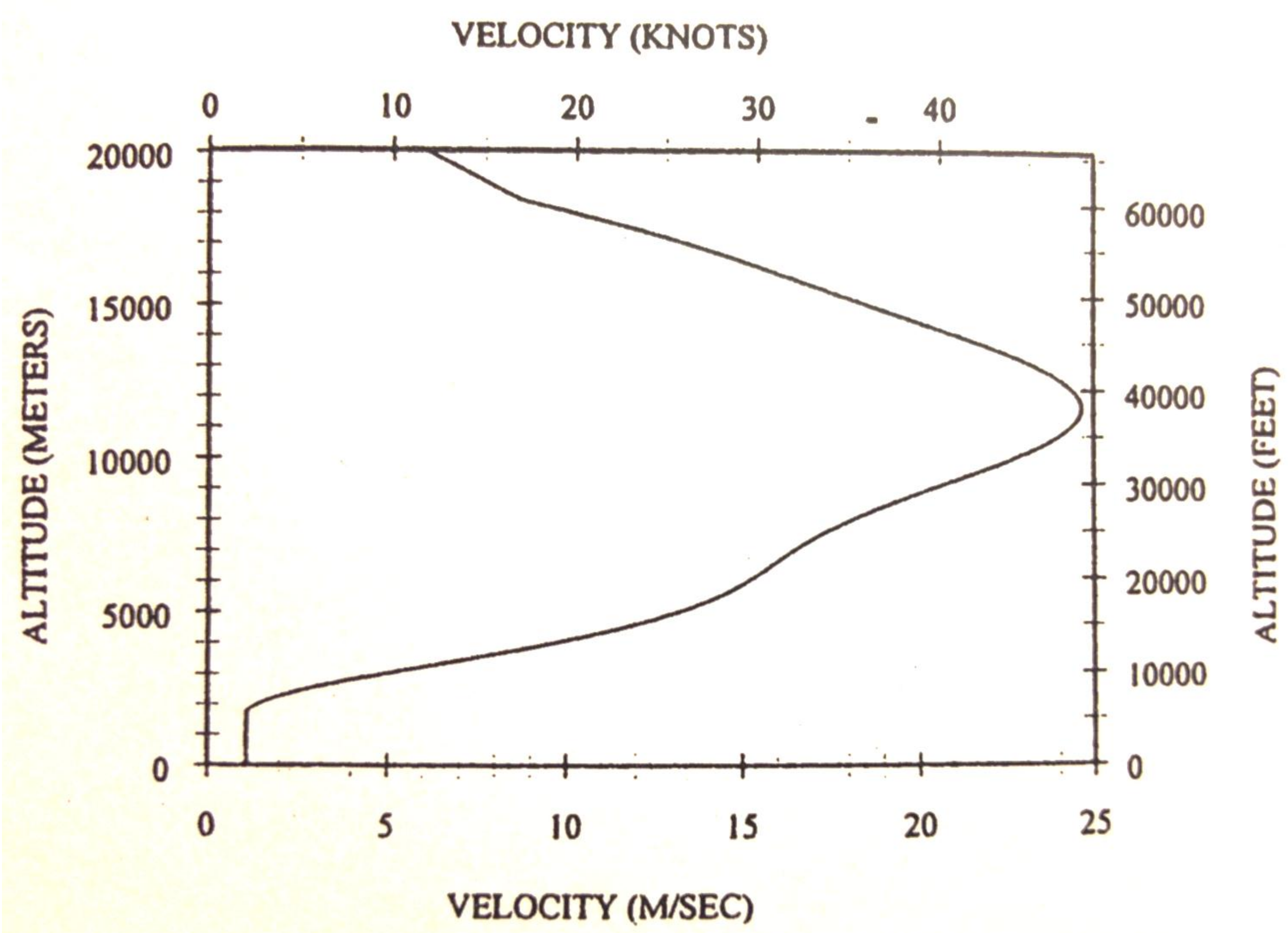
- Winch truck drives with the wind to reduce the relative wind on the aerostat while climbing through the jet stream.

Approach 4 – Unwind in Jet Stream



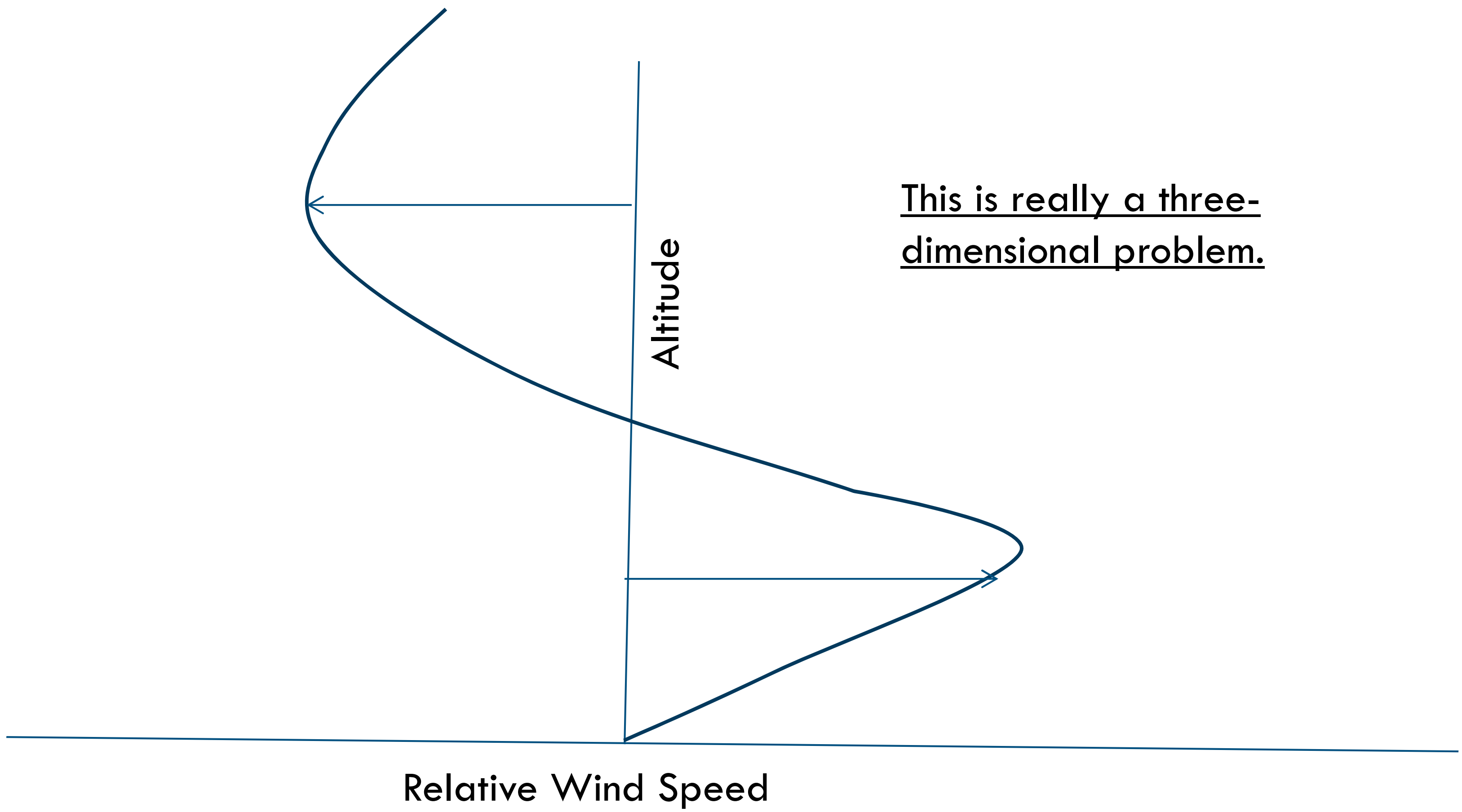
From Rand, Grant (Fairbrother), Crenshaw; A High Altitude Tethered Balloon; Presented at: 12th ESA Symposium on European Rocket and Balloon Programmes and Related Research, 29 May - 1 June, 1991, Lillehammer, Norway.

Saw a lot of this . . .



Absolute Wind Speed

None of this . . .



<u>This is really a three-dimensional problem.</u>

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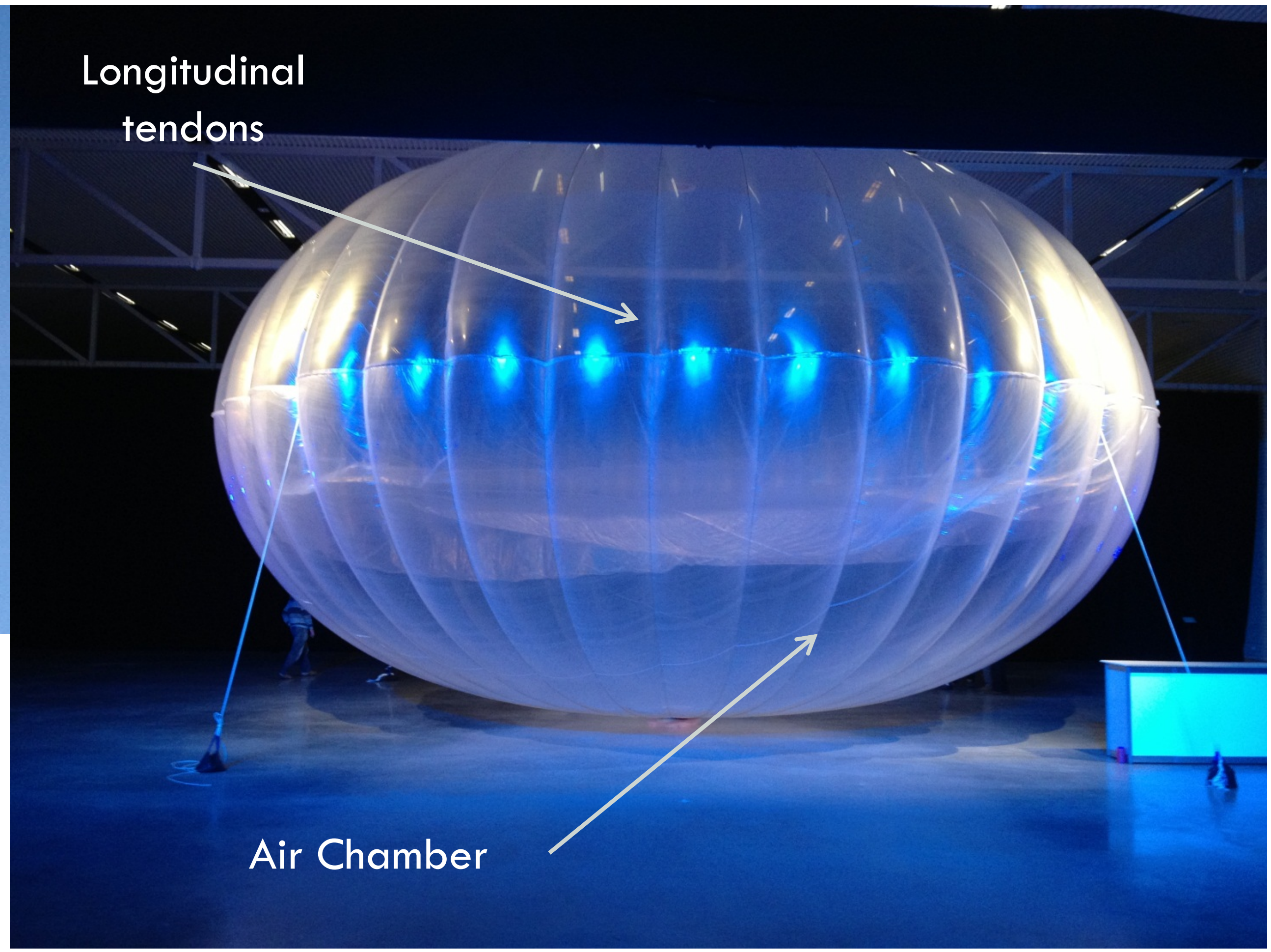
Other items of interest

- Not much on tether dynamics. What shape does the tether take as it hits a different wind layer? How fast does the tether move through the air as it is reaching a new steady state?
- Tether safety factors on strength were usually 2x breaking strength. Our experience with aerostats in Afghanistan suggests 5x sometimes isn't enough.
- System retrieval received only a hand-wave. Some admitted the best approach was to destruct the balloon, and drop the payload on a parachute.
- Almost no discussion of bad weather in the troposphere: thunderstorms, icing, down drafts, etc. Operationally, this was the biggest problem in Afghanistan.

Could Google Balloons Help?



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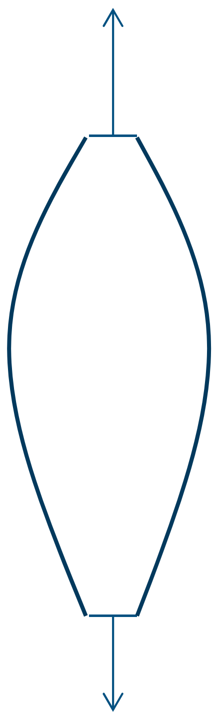
Concept using Loon Balloons



Partially filled balloons would be launched in-line with the tether.

Longitudinal tendons would transfer the tether loads and keep the envelope relatively tight.

A deployment concept would need to be developed.