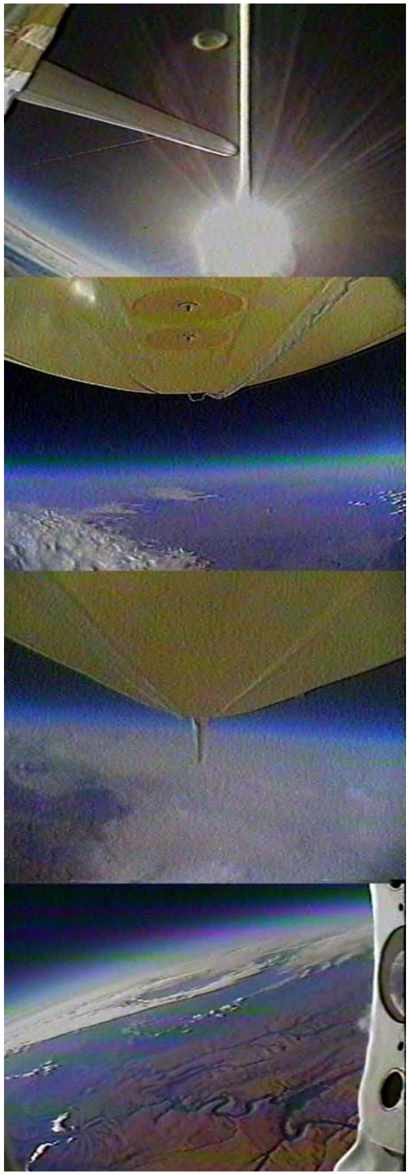


HiSentinel & Stratospheric Airship Design Sensitivity

I. Steve Smith

Stratospheric Airships

- If it was easy you would see the sky littered with stratospheric airships
- Major plague with airships is “it is just a balloon so how hard can it be” attitude
- Levying the requirement on the Wright boys to make their next airplane a 747

Design Space

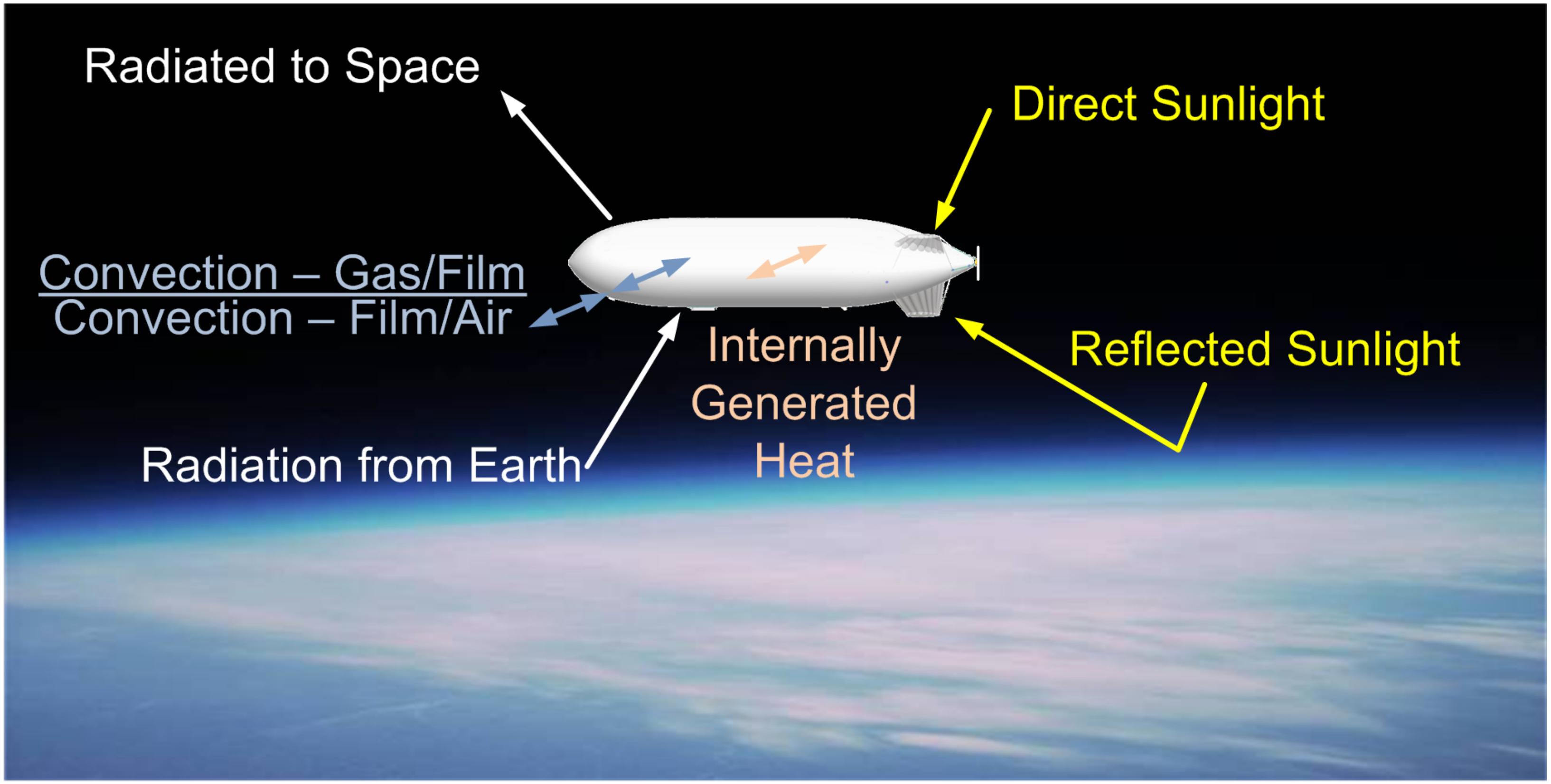
- Stratospheric airships must be designed with:
  - Environmental factors
  - Fabric Properties
    - Strength, Weight, Thermo-optical
  - Hull Shape
    - Fabric Loading, Surface Area, PV location, Leak Rate
  - Manufacturing Processes
  - Overall fabrication costs
- A systems engineering approach is required

Technical Challenges

- The two biggest technical challenges for a stratospheric airship are:
  - The Hull Material: must be strong, lightweight, minimal flaws, good thermo-optical properties, cost & ability to be successfully fabricated into a gas tight pressure vessel
  - The Power: The main power consumption is the propulsion where the power required is proportional to the velocity cubed

Stratospheric Airship Thermal Environment

- Radiation dominated



Hull Material Considerations

- Gas Retention
- Strength/Weight
- Environmental Effects
  - UV Degradation
    - *Impacts a/e ratios usually increasing diurnal temperature & differential pressure swings*
    - *Degrades tensile strength of the material*
  - Thermo-optical Properties
    - Drive gas temperatures and in turn material requirements and system mass
    - Affect efficiency of internal PV array
- Production Processes
  - Seam Strength
  - Seaming Speed
- Cost

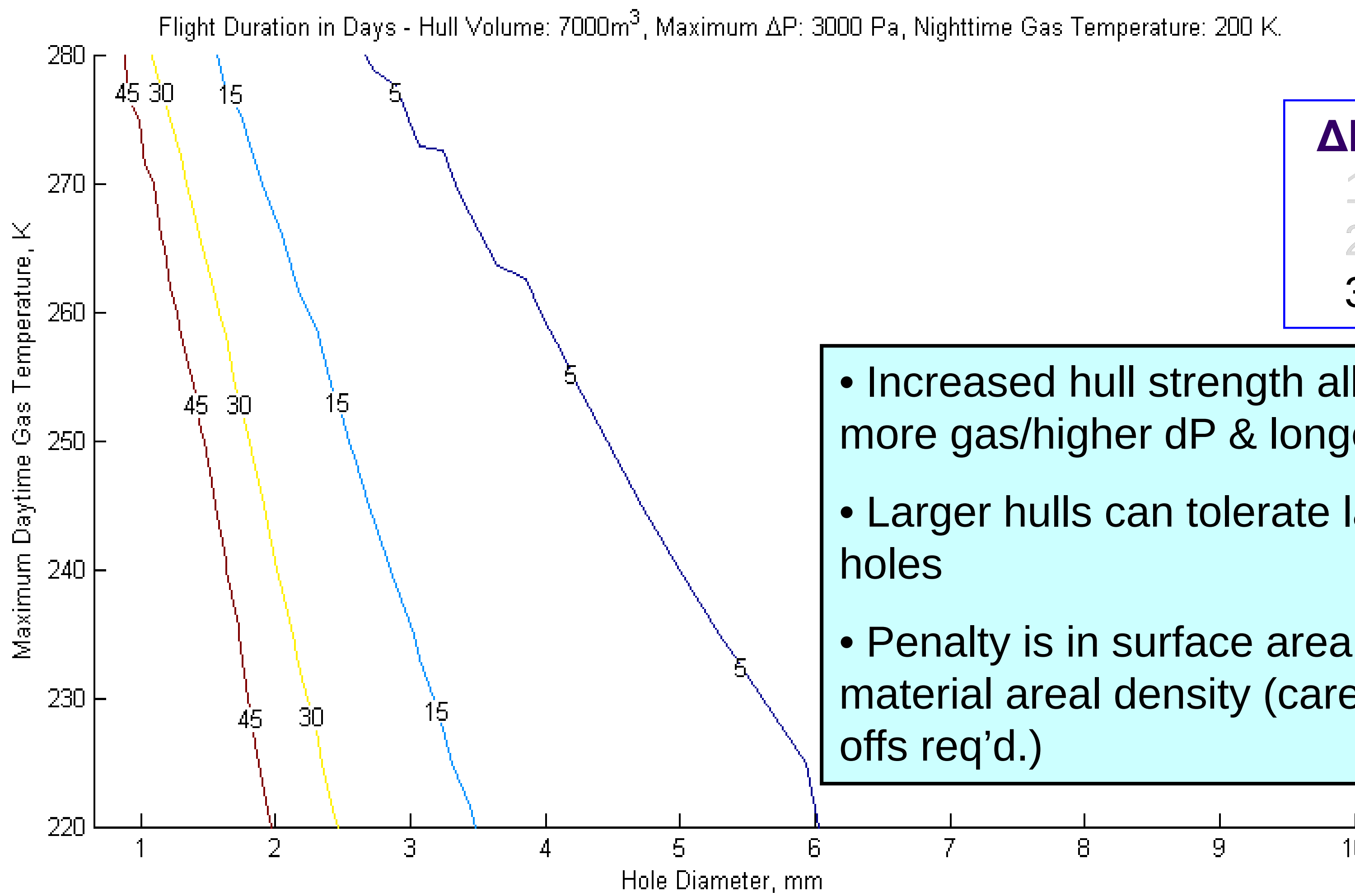
Hull Design

- For these analyses only a single chamber design with no ballonet was considered
- Baseline design was HiSentinel80; modified Class C
- PV array location is major driver of the hull design
    - HiSentinel80 had internal PV array (~70% light transmission)
- Model includes main hull body only
- Vectran yarn count varied to meet hull strength requirements
- Constant thermo-optical properties

Hull Endurance Simulations

- For a given hull volume and float altitude
  - Hull achieves float at prescribed altitude and pressurizes at maximum allowable differential pressure with Helium at the daytime (hottest) gas temperature
  - Hull leaks Helium through a pinhole of constant size
  - Instantaneous leak rate varies with differential pressure
  - Diffusion through gas barrier is negligible by comparison
  - Helium gas temperature undergoes daily swings, from a nighttime temperature (200K) to some maximum daytime temperature
  - Flight is terminated when differential pressure drops below the threshold required to prevent buckling of the hull and subsequent control loss

Leak Rate –
Duration for ΔP Values



ΔP - Pa
1000
2000
3000

- Increased hull strength allows more gas/higher dP & longer flight
- Larger hulls can tolerate larger holes
- Penalty is in surface area & material areal density (careful trade-offs req'd.)

High Altitude Envelope Quality

- 54 day ULDB flight shows it is possible to construct large envelope with quality standards required for long duration flight
- Rough calculation for the SPB yields pinhole no larger than 1/16” diameter in the 6.9 MCF envelope
- Stratospheric airship hull with similar quality (leaks per unit surface area) will make possible month+ duration flights

SPB/ULDB vs HiSentinel

- Differential pressure fluctuations are not as pronounced for these missions relative to HiSentinel platform
- SPB/ULDB film material is more forgiving regarding defects – film will strain to redistribute stresses instead of opening holes
- Construction process for SPB/ULDB is founded upon decades of construction experience and methods developed for zero-pressure balloons

HiSentinel Program

HiSentinel is a tactically deployable, unmanned, high-altitude platform capable of station-keeping and long endurance missions. It is designed for lower cost, single use.

Payoff:
- Launched in-theater
- No Hangar required
- Long duration mission capability for improved mission endurance
- Persistent low cost platform

Project Sponsor

HiSentinel Program Achievements

- Five development flights above 65,000 feet
  ~$11M total
- Propelled flight at altitude
- Accurate flight predictions based on ground testing and analyses

View from 66,000 ft above Page, AZ – HiSentinel80 - Nov 2010

HiSentinel80 Specifications

HiS80 Launch

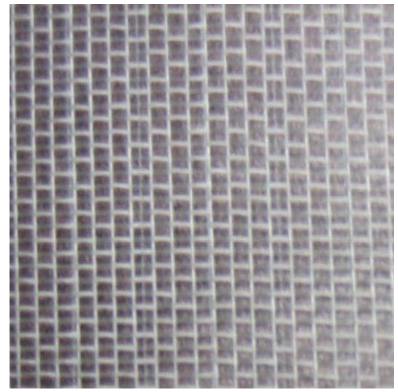
HiS80 Inflation Test

- Single Chamber Design – No Ballonet
- Volume = 6,800 m^3 (240,000 ft^3)
- Length/Diameter = 60m/14m
- Solids Mass = ~500 kg
- Payload = ~36 kg/50W
- Flight Altitude = 20 km (66,000 ft)
- Average Ascent Rate = 7.2 m/s (1425 ft/min)
- Duration = Flight 8 hrs/6 hrs float

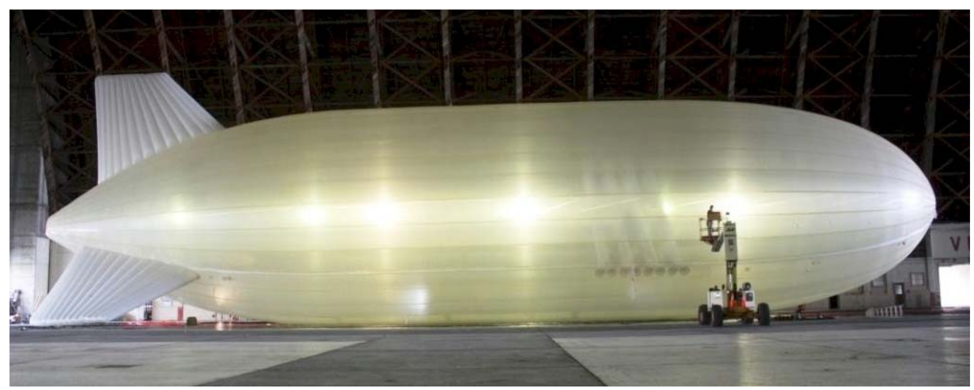
HiSentinel80 Flight Video

HiSentinel Construction

- Hull Material
  - Vectran/Nylon yarns
  - Nylon film gas barrier
- Seam Tape
  - Yarns similar to hull material with bias



- Hull Design Details
  - Seams/Patches
  - Fittings
  - Manufacturing



TALS PROJECT OBJECTIVE

- Internal research project to demonstrate feasibility of a self contained, fully automated inflation and launch system for quickly launching LTA (Lighter-than-air) systems in a tactical field environment.

- Project Team:
  - *Southwest Research Institute*
  - *Aerostar International Inc.*

HISENTINEL80 AIRSHIP FLIGHT TEST LAUNCH

TACTICAL NEED : Rapid Deployment to Areas of Operations

- Minimal facilities infrastructure
- Minimal personnel
- Minimal training
- Rapid response
- Deployment mobility
- Remote site access

- Expanded meteorological launch window

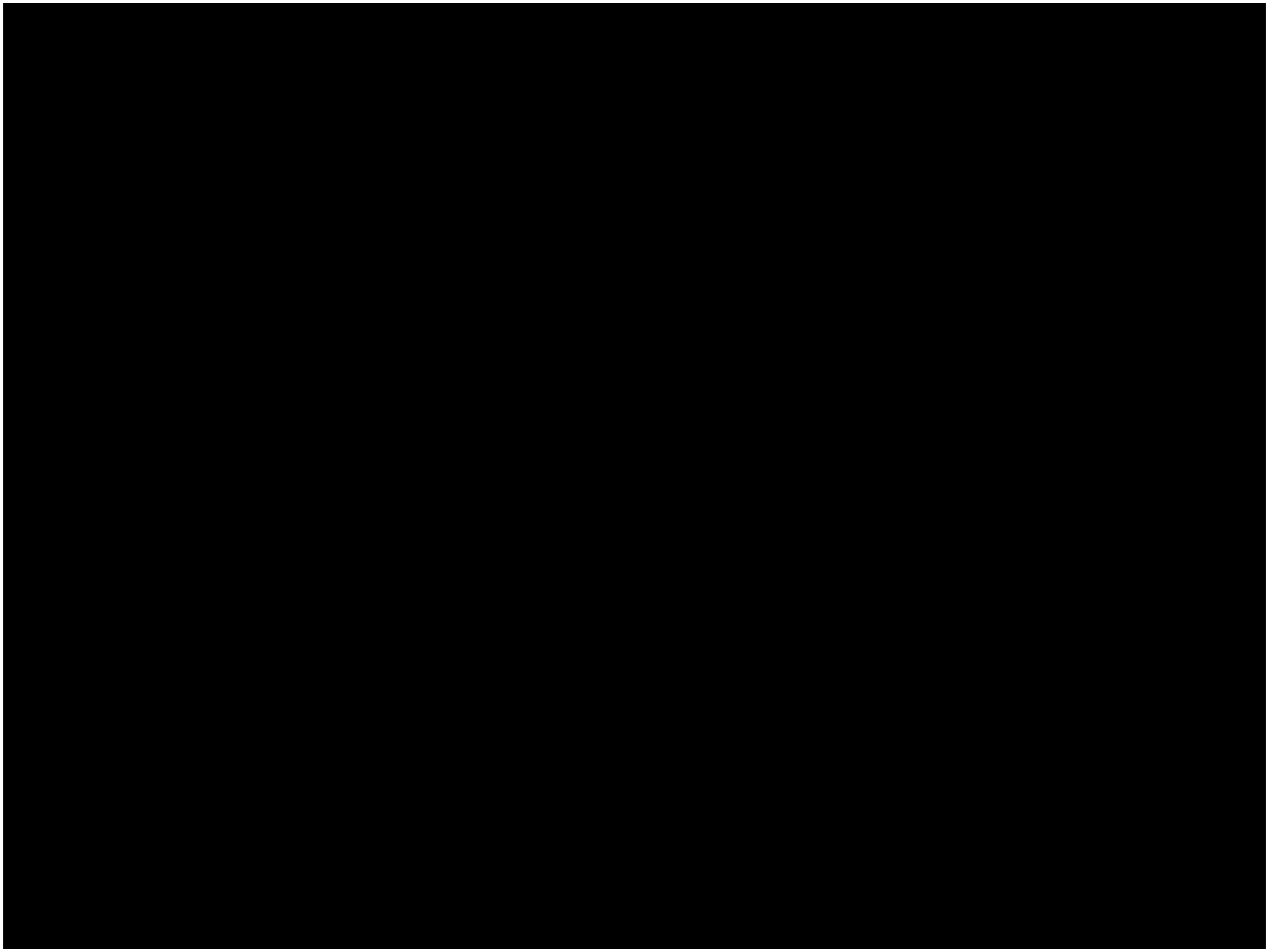
TALS APPLICATIONS

- *Jungle Clearings*
- *Helipads on Naval Ships*
- *Lake or Sea Beaches*

- Deploy balloons, airships and/or aerostats
- Deployable by land or sea

DEMONSTRATOR OPERATIONAL SEQUENCE

TALS DEMOSTRATOR TEST VIDEO



TALS PROJECT SUMMARY

- The TALS has been successfully demonstrated a fully automated launch system concept.
  - Applicable for balloons, airships, and aerostats.
- Self contained and fully automated, capable of launching a LTA vehicle under local or remote satellite control.
- We have consistently been able to set up the TALS demonstrator and launch the airship in less than 30 minutes.
- TALS field testing continues and system will be refined and evaluated in higher winds (15-20 knots).