

THE VALUE OF PERFORMANCE.
NORTHROP GRUMMAN

CSBF Requirements & Recommendations for Balloon Gondola Design

Scientific Ballooning Technologies
Workshop 2019

*Justin Marsh, CSBF
Mechanical Engineering Mgr, NBOC*

Design Philosophy

- **Structural Integrity**
 - Primarily to survive “termination event” (*i.e. momentary free-fall followed by parachute opening*)
 - Safety
 - Mission Assurance
 - Has been sufficient for landing – although not a requirement
- **Mission Assurance**
 - Important to prevent damage
 - Allows for less than ideal launch conditions
- **Staging/Pickup**
 - Must be able to fit inside existing high bays
 - Allows for hoist pickup and roll out to launch vehicle
- **Recovery**
 - Some existing recovery limitations – particularly Antarctica
 - Crucial to stay within limitations for critical components



Structural Requirements

- Requirements are Changing
 - OM-220-10-H will be superseded by WFF-820 Program Guidance document
 - **DRAFT available upon request, TBD on final release date**
 - Structural requirements only – Handbook/Guidelines to be relocated

- Notable Changes

Design Limit Loads (DLL) G's		
Vertical	@ 45°	Horizontal
10	5	5



Design Limit Loads (DLL) G's		
Vertical	@ 45°	Horizontal
8	4	4

Design Factor of Safety	
Yield	Ultimate
N/A	1.0

Design Factor of Safety	
Yield	Ultimate
1.25	1.4

- Metallic materials with failure stress of **5%** (previously 10% at -60°C) strain or less, at worst case temperature limit shall be considered brittle.
- Deliverables and Review Schedule better defined

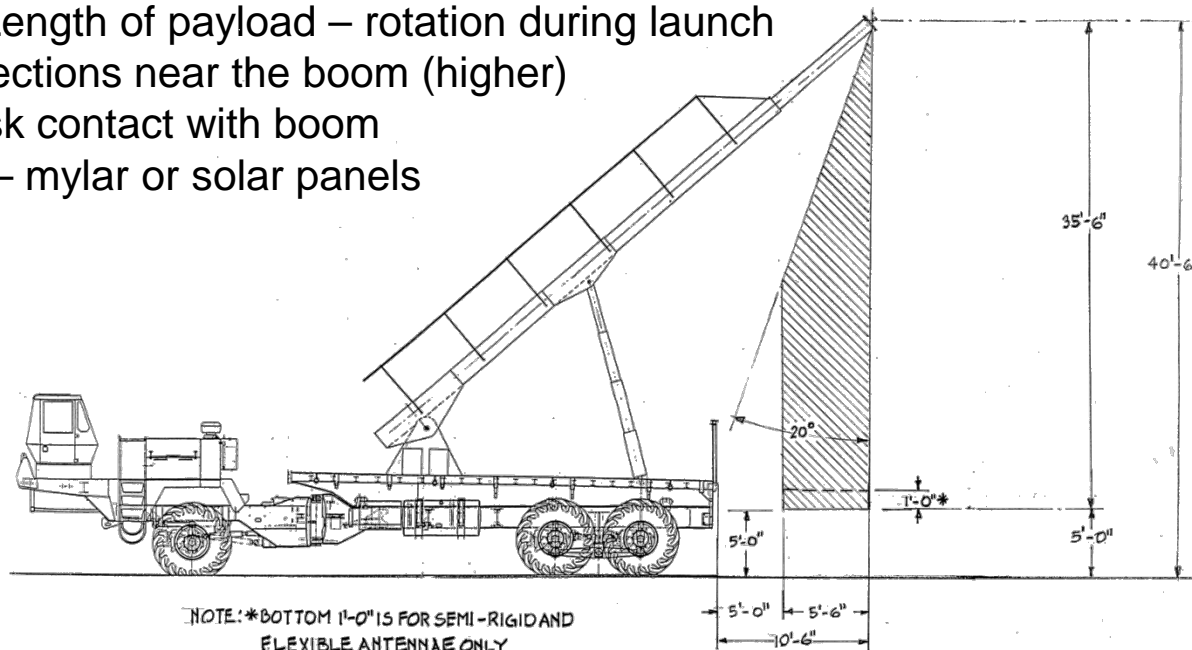
- What isn't Changing?

- Prescribed load cases for analysis
 - Inertial relief defined as preferred analysis method
- Welded joints discouraged
 - Critical welds require proof testing

- Legacy Gondolas

Mission Assurance

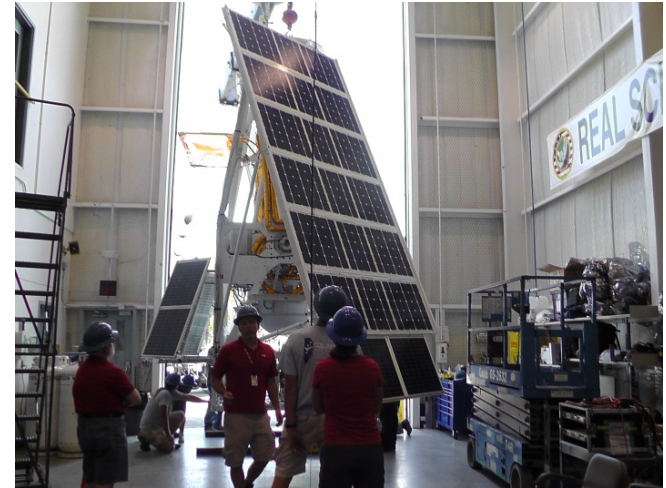
- Payload Must Be Able to Survive Launch
 - Dynamic Launch
 - Damage to antennae, solar panels, or other protruding objects
- Minimum Desired Distances From Launch Vehicle
 - “20 degree rule” – Assures minimum desired clearance from Launch Vehicle
 - 6 feet of ground clearance – avoids contact with ground (pendulum)
 - 5 feet of vehicle clearance – avoids contact with front of vehicle
- Other Observations
 - Width/Length of payload – rotation during launch
 - Wide sections near the boom (higher)
 - Risk contact with boom
 - “Sails” – mylar or solar panels



Staging & Gondola Pickup

- Facilities Limitations

- Height & Width of Payload
 - Allow for weighing of payload inside high bay (Antarctica)
 - Allow for ease of roll in/and out of building



- Carts/Wheels/Stand

- Allows operations to work underneath gondola
- Ideally allows for ballast hoppers and solar panels to stay attached for rollout
 - Enormous time saver
- Must be big enough for easy rollout
- Must allow rotation of payload for vehicle pickup



Recovery

- Gondola Disassembly
 - Focus on ease/speed of disassembly
 - Allows for quicker recovery (Antarctica)
 - Accessibility of data vaults and other critical components
 - Trade-off between access and protection
- Transport
 - Critical components to stay within a certain allowable size and weight
 - Limited by recovery vehicle
 - Helo
 - Twin Otter & Bassler (Antarctica)
 - Land Vehicles



Common Pitfalls and Recommendations

- Early Interface with CSBF
 - Aim to follow deliverables/review schedule
 - Pointing systems & critical hardware
 - Source traceable w/ certs
 - Placement of CSBF equipment
 - Thermal considerations
 - Antennae
 - Launch Straps
 - Ballast Hoppers
 - Gondola dimensions
 - “20 degree rule”
- Structural Analysis Margin
 - Final weights are usually higher than predicted!!
- Protective Cage for SIP
- Non-appropriate casters/tires
 - Hard to maneuver



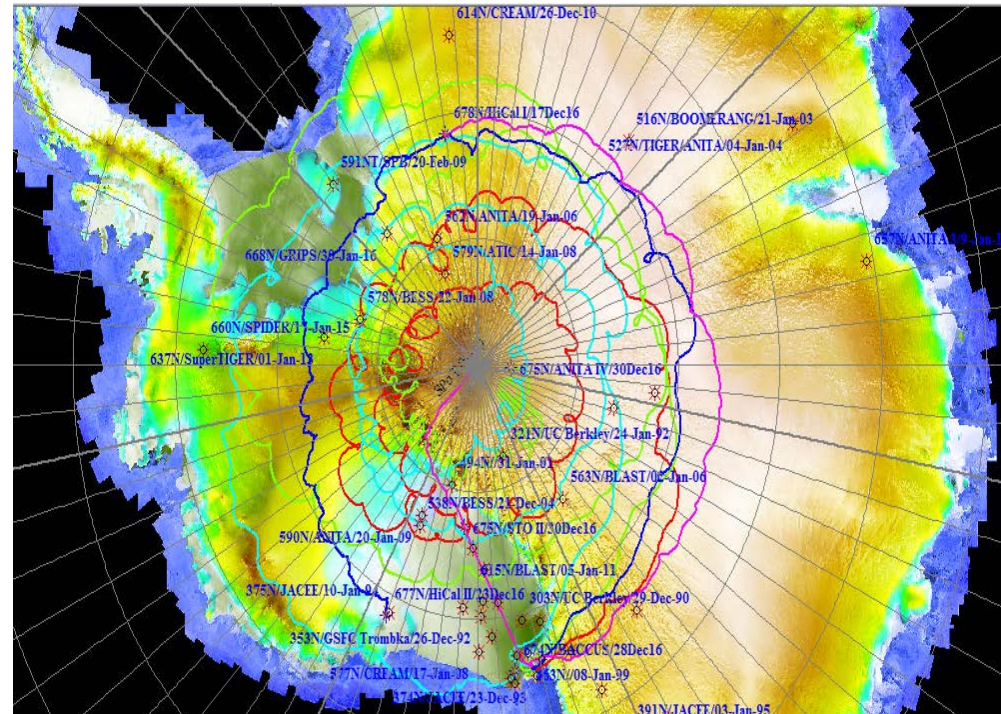
Summary

• Stay in Touch

- Justin Marsh
 - 903-723-8053
 - Justin.I.marsh@nasa.gov
 - Mechanical Engr Manager
- Garret Wilbanks
 - 903-723-8020
 - Garret.s.Wilbanks@nasa.gov
 - Mechanical Engr
- Hugo Franco
 - 903-723-8091
 - Hugo.franco@nasa.gov
 - Operations Manager

• Follow the Link

- Structural Requirements: <https://www.csbf.nasa.gov/documents/gondola/OM-220-10-H-A%20Structural%20Rqrmnts%20Gondola%20Design.pdf>
- LDB Support: <https://www.csbf.nasa.gov/documents/ldb/LDB%20Support%20for%20Science%20EL-100-10-H%20rev%20A.pdf>
- Other Useful Documents: <https://www.csbf.nasa.gov/docs.html>



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