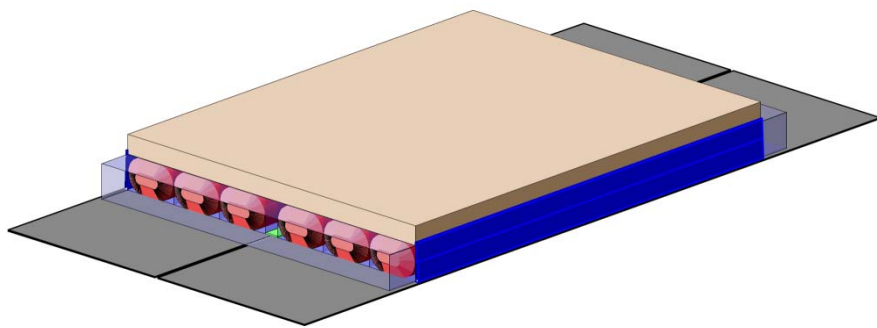


# *Lightweight Cargo Sleds for Polar Traverses*

**Jim Lever, Arnold Song, Jason Weale  
CRREL**



***PolarTech 17 Apr 14***

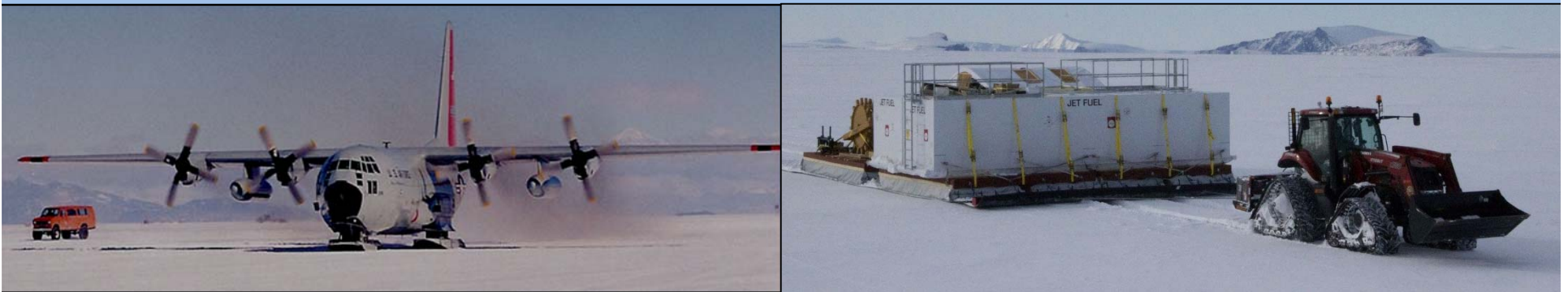
# Polar Heavy Traverses

## Haul heavy cargo over unprepared snow

- Resupply stations, install/remove camps
- Enable science along routes
- Greenland (GrIT), Antarctica (SPoT, PIG, WISSARD)

## Justification (vs aircraft status quo)

- Save money, hedge cost increases
- Lower fuel consumption & emissions
- Carry oversize/overweight cargo
- Free up LC-130s for remote science



# Efficiency = Payback

## **Maximize return on investment**

- High payload per tractor
- High reliability & durability
- Low capital & operating costs

## **Want high-efficiency cargo sleds**

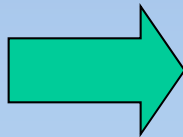
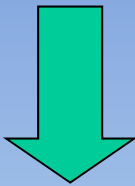
- Lower resistance & tare weight
- Durable lightweight materials
- Low maintenance

## **Benefits beyond payload weight**

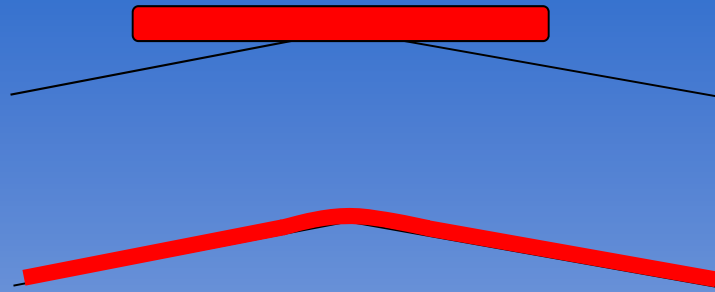
- Outsize & overweight cargo
- Maximize prefabrication
- Minimize field labor



# Fuel Sled Innovations



# Steel Ski vs Flexible Sled



## Steel Ski

- High local pressure (crush snow)
- Slamming motion over peaks
- Stiff structure increases weight & cost
- Short length = higher friction
- High conductivity carries away frictional heat
- *Durable*

## Bladder sleds

- Cost 1/6<sup>th</sup>, tow better
- 2 – 3 times greater payload delivered per tractor

# What About Cargo Sleds?



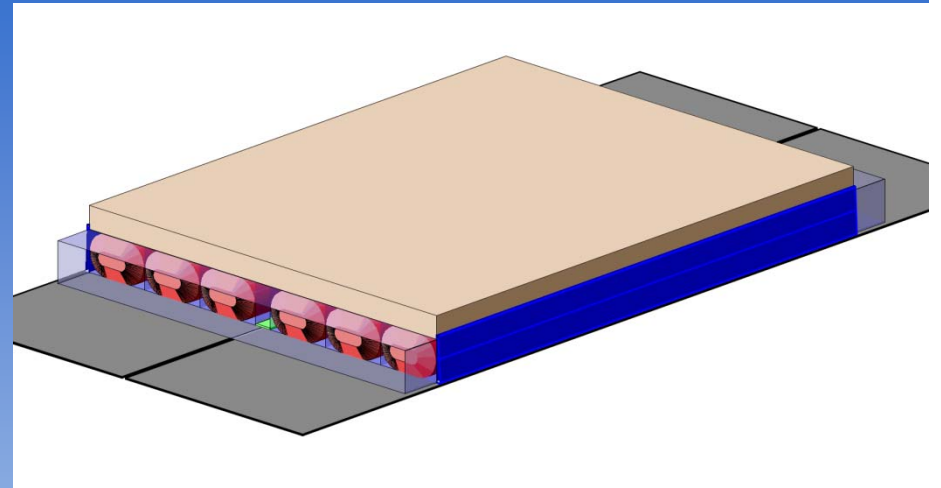
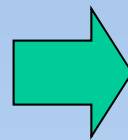
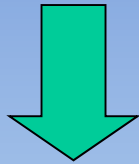
## **Very poor towing performance**

- 25,000 lb tare for 20,000 lb cargo
- high sinkage & friction

**Expensive: ~ \$100k per sled**



# Air-Ride Cargo Sleds (ARCS)



# Tube-in Pouch ARCS

## Approach

- Pouch is structural, keeps out snow, easy to swap tubes
- Tubes – tough shells with air bladder inside (air beams)
- Screened 6 vendor pontoons at -40F x 10,000 cycles

## Field Performance

- PIG11-12 (~ 1,700 mi x 4 sleds)
- GrIT12 (~ 1,400 mi x 5 sleds)
- SPoT12-13 (~ 1,000 mi x 2 sleds)
- Great ride over sastrugi
- No leaks
- Fabric cracks, tears at corners
- Must optimize weight & pressure to reduce friction





# GrIT12 ARCS

- Great cargo loading, ride, unloading
- Pouch material stiff, tore at edges



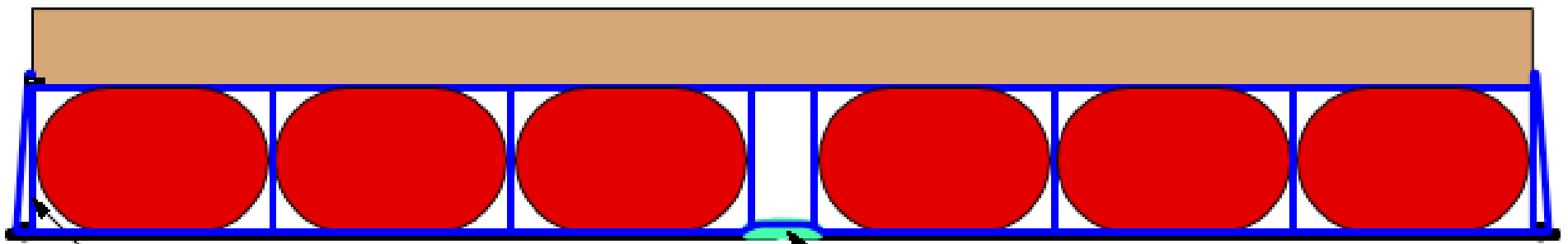
# Gelbo Tests for Pouch Fabrics

- ASTM F392 – flex durability
- 8 fabrics screened at -40°C
- GrIT12, PIG, SPoT material cracked after 10 cycles
- Black polyurethane-coated material survived 510 cycles and is hand-flexible
  - Used for GrIT14 pouches



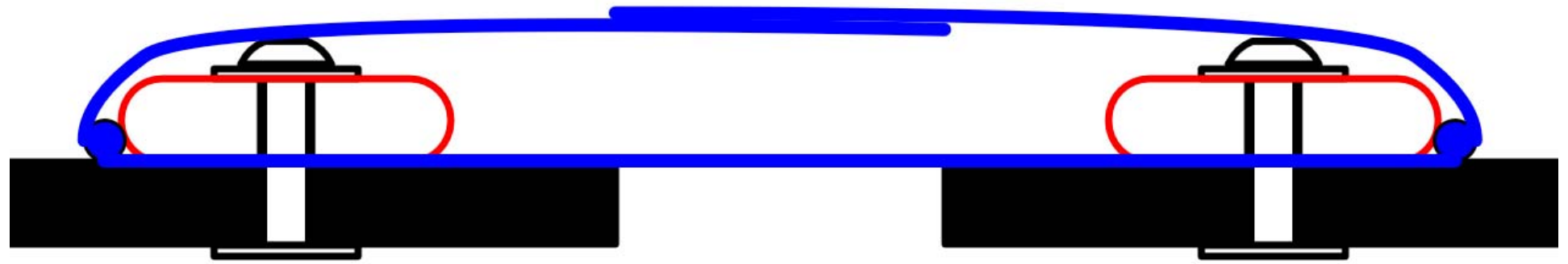
# Design Revisions: Modular ARCS

Cargo deck 15'8" wide x 20' long



Fabric loop forms structural connection between sled & deck. Loop can be continuous along length of pouch to form outer pouch wall. Velcro panels allows access to bolt battens to deck & sled.

Fabric sled joint bolts two HMW sheets together. 16-ft-wide pouch is placed over joined sheets & bolted to outer edges.





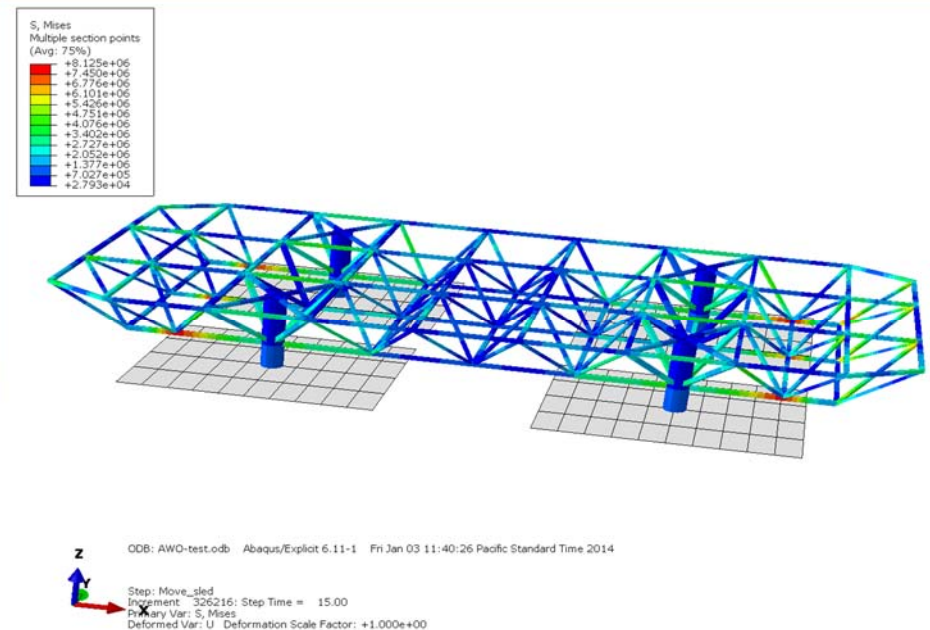
# GrIT14 Modular ARCS



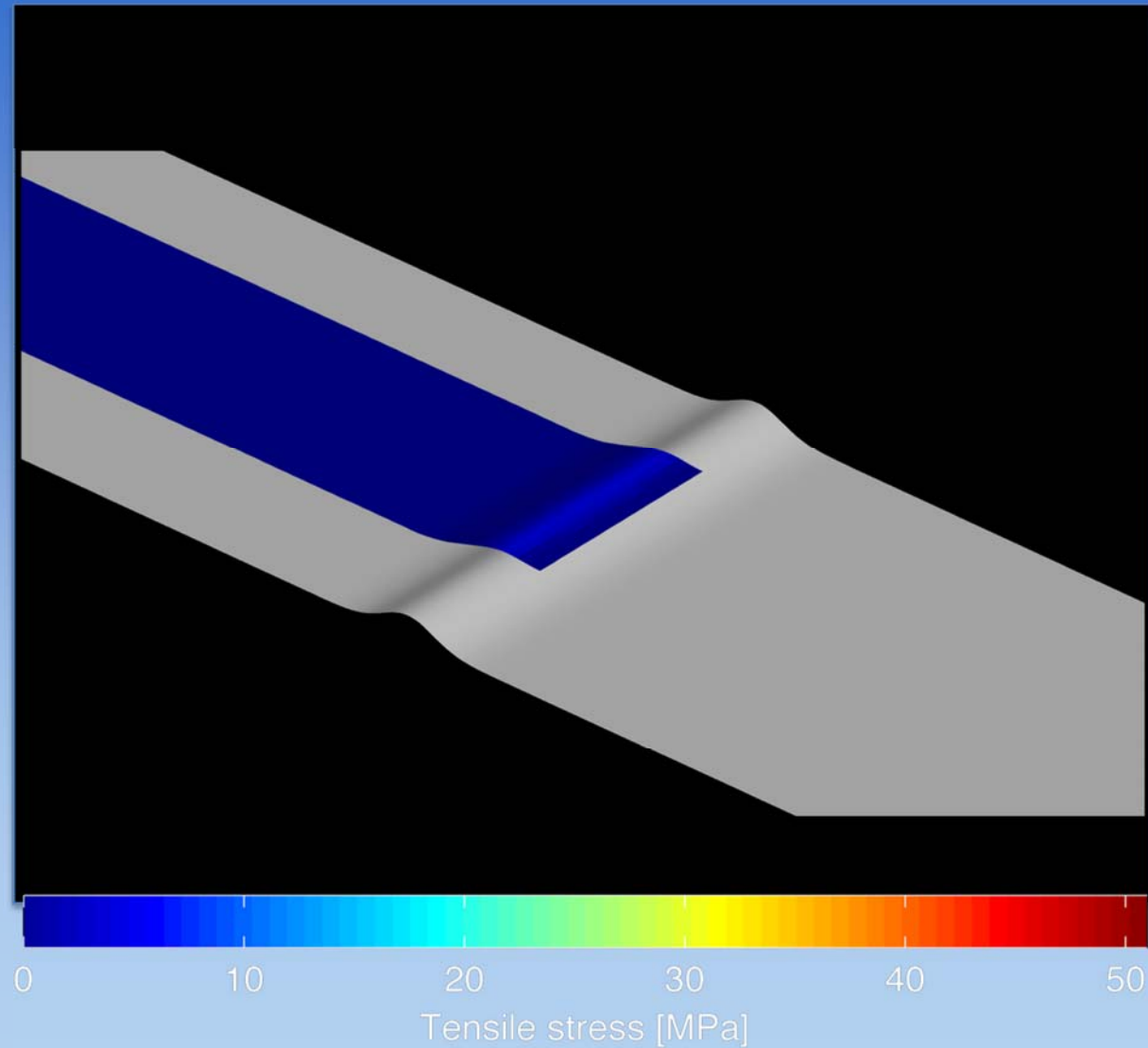
# Stresses on Payloads

## Atmospheric Watch Observatory (AWO)

- GrIT must deliver welded-steel space frame
  - ~ 64-ft x 33-ft x 16-ft high; 41,000 lb
- Big savings if build-out upper structure & add panels
- Transport stresses probably lower than design stresses
  - Supported on diagonally opposite legs



# FEM for Sleds over Sastrugi

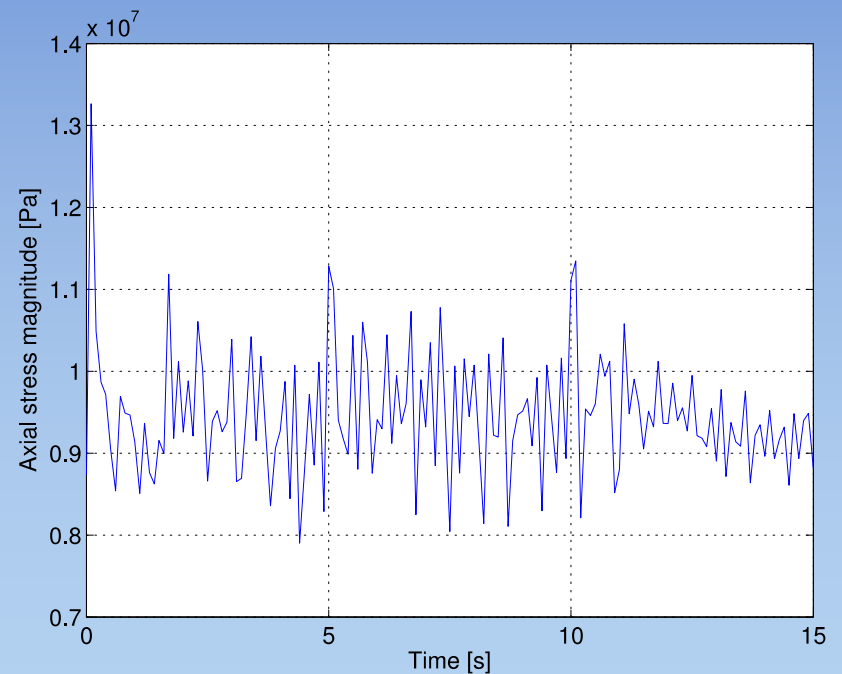




# Travel over uneven terrain



- Weight: 41,000 lb
- Travel velocity: 4.5 mph
- Bump height: 10"
- Max stress ~ 1,700 psi
- HSS = 46,000 psi yield stress
- Design stresses ~ 27,000 psi
- Next:
  - Larger sastrugi
  - Work with AECOM, CPS
  - Check built-out ~ 105,000 lb



# Future Work

## Prefab Buildings

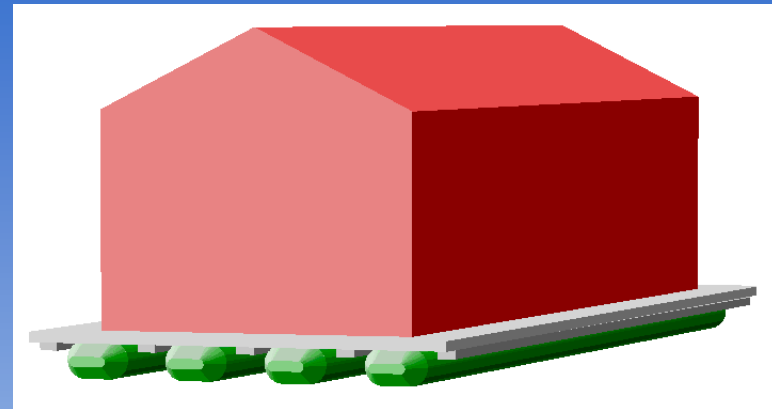
- Summit/Isi mobile garage
- mobile science camp
- SPoT living module

## Composite Decks

- improve durability
- FEM to analyze stresses

## Greenland Telescope!

- ~ 300,000 lb, three pieces
- structural decks or cradles
- minimize stresses on key components



# Conclusions

- ARCS show promise to transport cargo efficiently & safely
- Low-temp fabric selection & design revisions should improve reliability (GrIT14)
- FEM allows analysis of stresses imposed on payloads
  - AWO, buildings, GLT
- Can capitalize on US prefab to reduce costs
- Oversize & overweight payloads welcome!



# Acknowledgements

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SPoT & PIG field crews

## **CRREL**

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