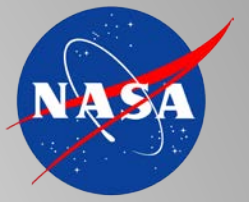

Availability Estimation for Facilities in Extreme Geographical Locations

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John W. Evans, PhD, NASA HQ

Outline

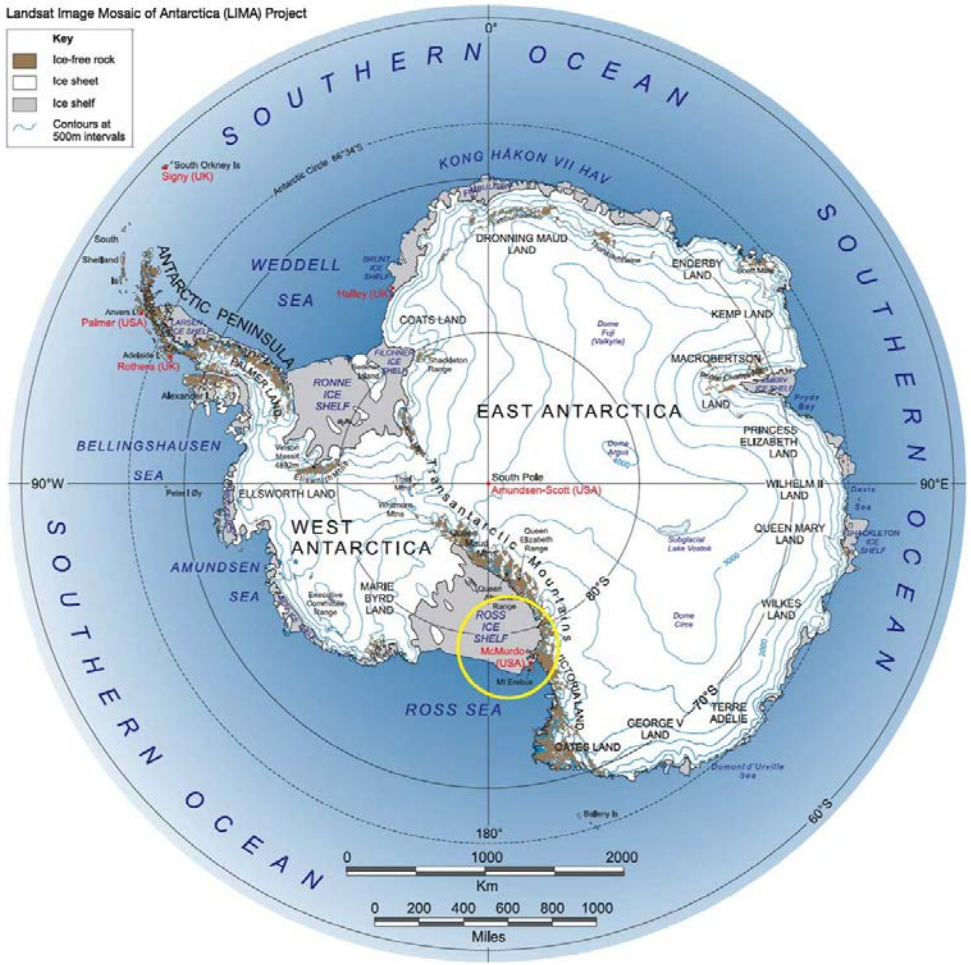
- Project Objectives
- McMurdo Ground Station
- Seasonal accessibility of McMurdo Station
- Travel restriction at McMurdo Station due to weather
- Operational Availability Simulation Results
- Summary

Project Objectives

- Create a System Model in ReliaSoft BlockSim and perform Monte-Carlo Simulations for Operational Availability
- Consider special conditions for extreme location
  1. Winter access closure to Antarctica
  2. Accessibility restriction of Radome and Building 71 due to weather based travel restrictions at McMurdo Station
- Recommendations for Sparing and Maintenance Planning and RCM implementation

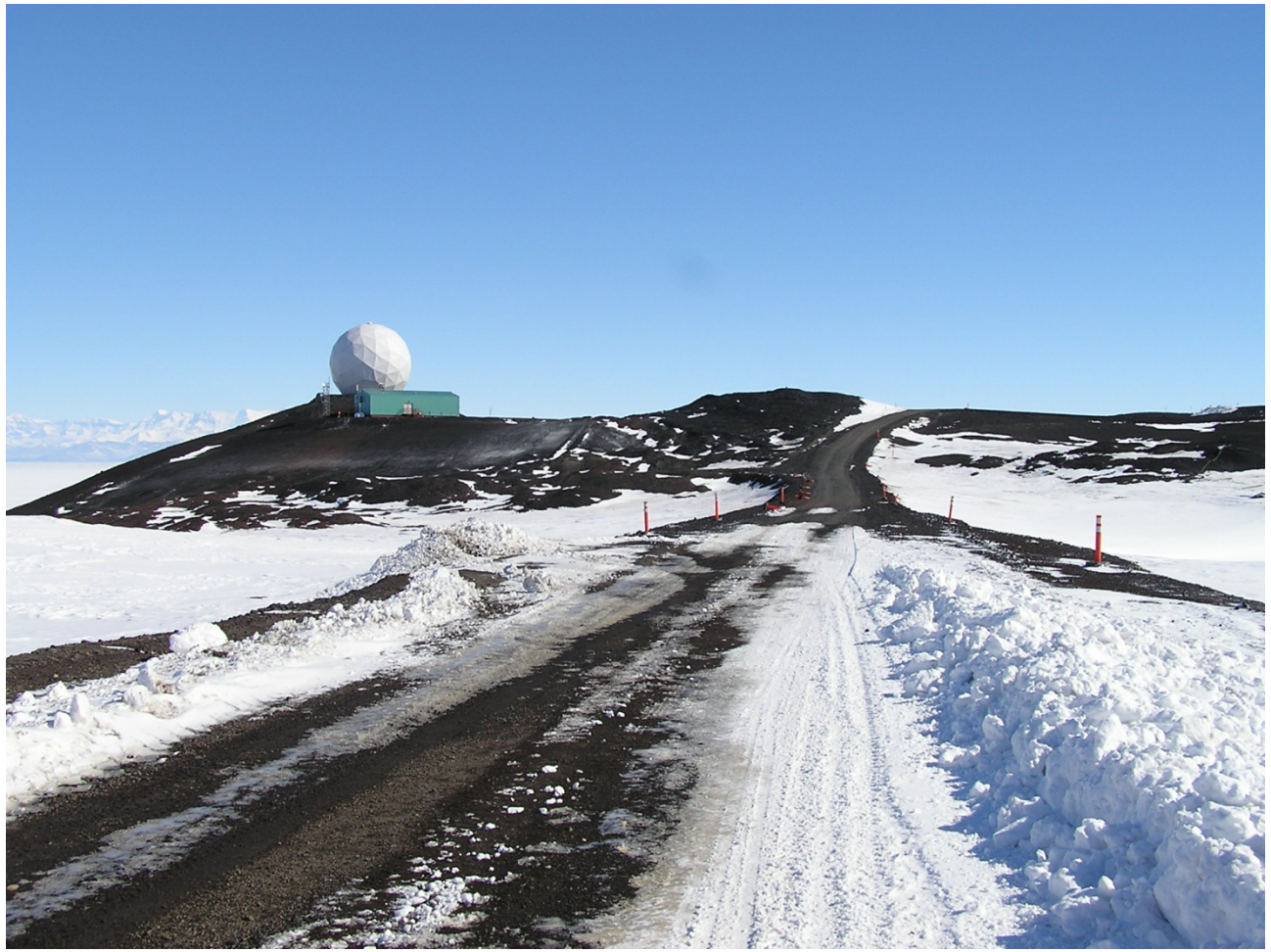
    Benefits: Cost effective preventive maintenance and predictive maintenance to ensure availability

Location


Landsat Image Mosaic of Antarctica (LIMA) Project
Key
Ice-free rock
Ice sheet
Ice shelf
Contours at 500m intervals
SOUTHERN OCEAN
KONG HÅKON VII HAV
WEDDELL SEA
ANTARCTIC PENINSULA
DRONNING MAUD LAND
ENDERBY LAND
KEMP LAND
MACROBERTSON LAND
PRINCESS ELIZABETH LAND
WILHELM II LAND
QUEEN MARY LAND
WILKES LAND
TERRE ADELIE
GEORGE V LAND
OATES LAND
COATS LAND
EAST ANTARCTICA
WEST ANTARCTICA
ELLSWORTH LAND
BELLINGSHAUSEN SEA
AMUNDSEN SEA
ROSS SEA
RONNE ICE SHELF
ROSS ICE SHELF
FILCHNER ICE SHELF
BRUNT ICE SHELF
Halley (UK)
Palmer (USA)
Rothera (UK)
Signy (UK)
South Pole
Amundsen-Scott (USA)
McMurdo (USA)
Transantarctic Mountains
MARIE BYRD LAND
90°W
90°E
180°
80°S
70°S
60°S
0 1000 2000
Km
0 200 400 600 800 1000
Miles

McMurdo Station - Radome and JSOC

Access Road to Radome and Building 71



Statistical Distribution for re-stock probability

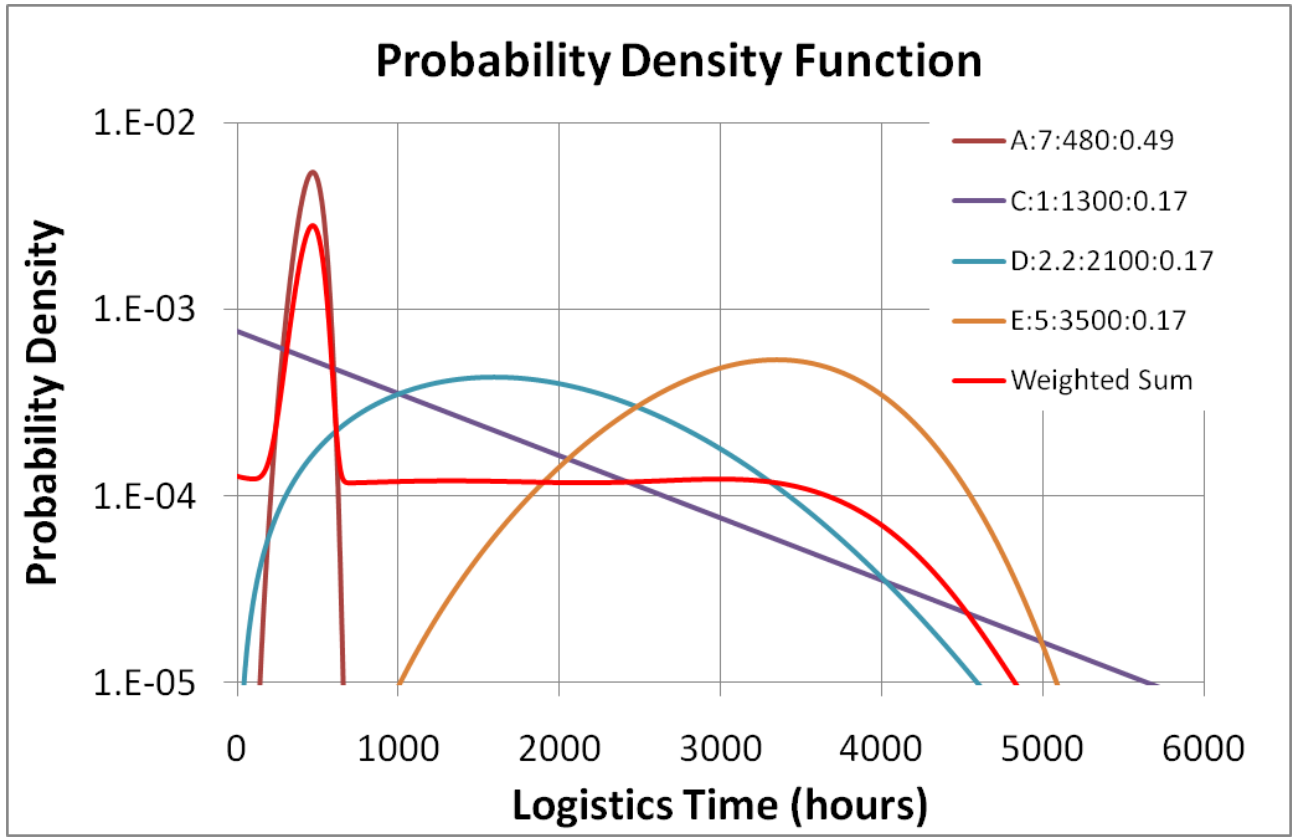
No possibility to re-stock spares during Antarctic winter from April to November

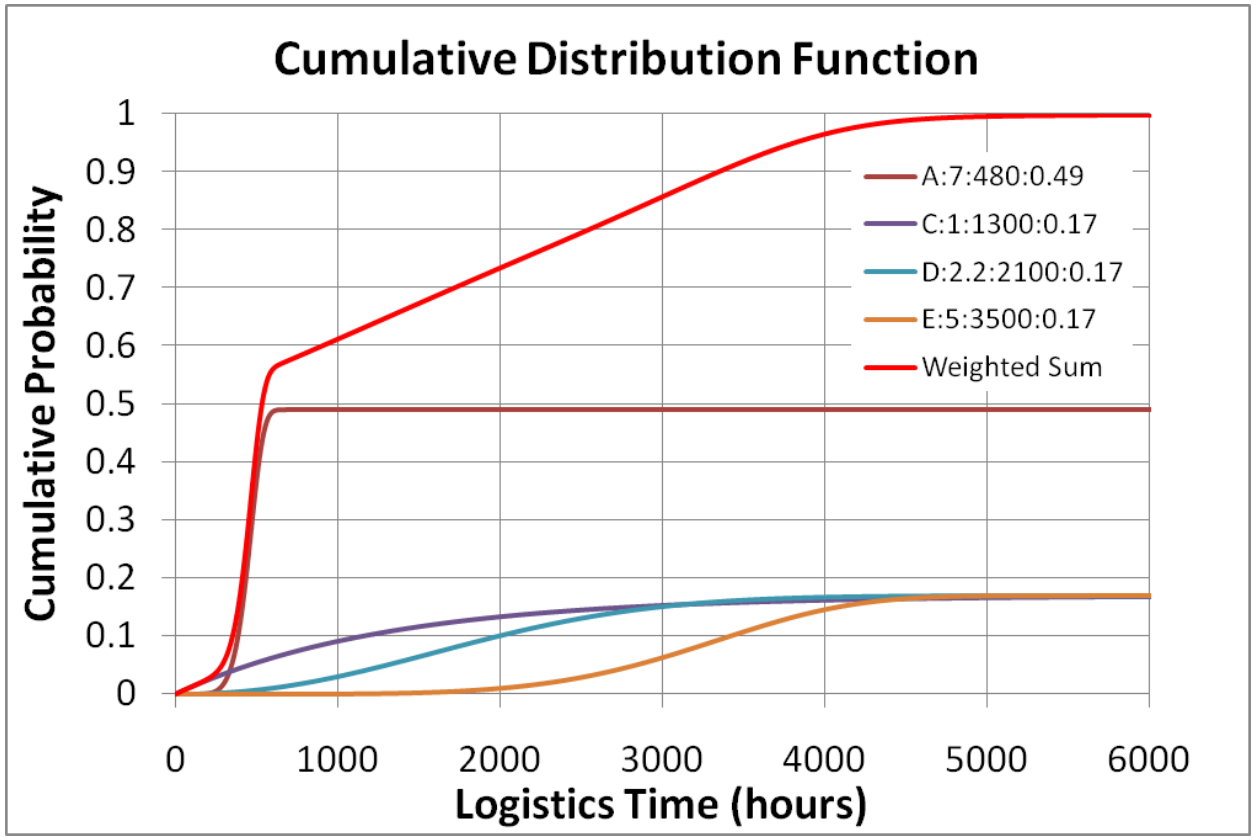
- Is taken into account in BlockSim simulation with **statistical distribution for re-stock probability**

Assumptions:

- During 6 summer months (50% of the spare parts) spares are provided within 500 hours (21 days)
- During winter closure constant probability density of wait time to provide spares
  (0 hours to ~ 4380 hours ≈ 6 months)

Creating Distribution for re-stock probability



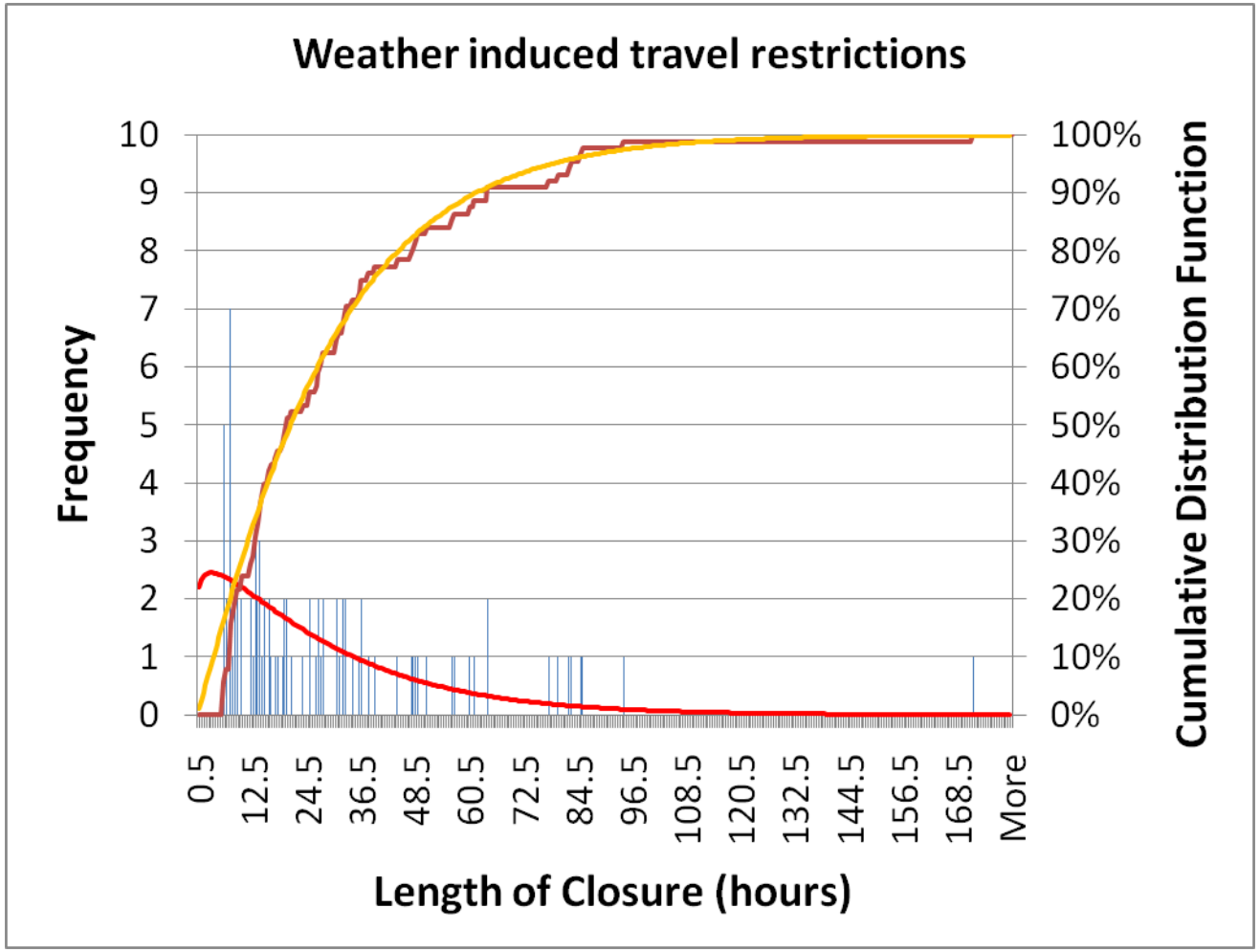


Weather Conditions at McMurdo

Limited access to Radome / Building 71 due to local travel restrictions based on severe weather conditions

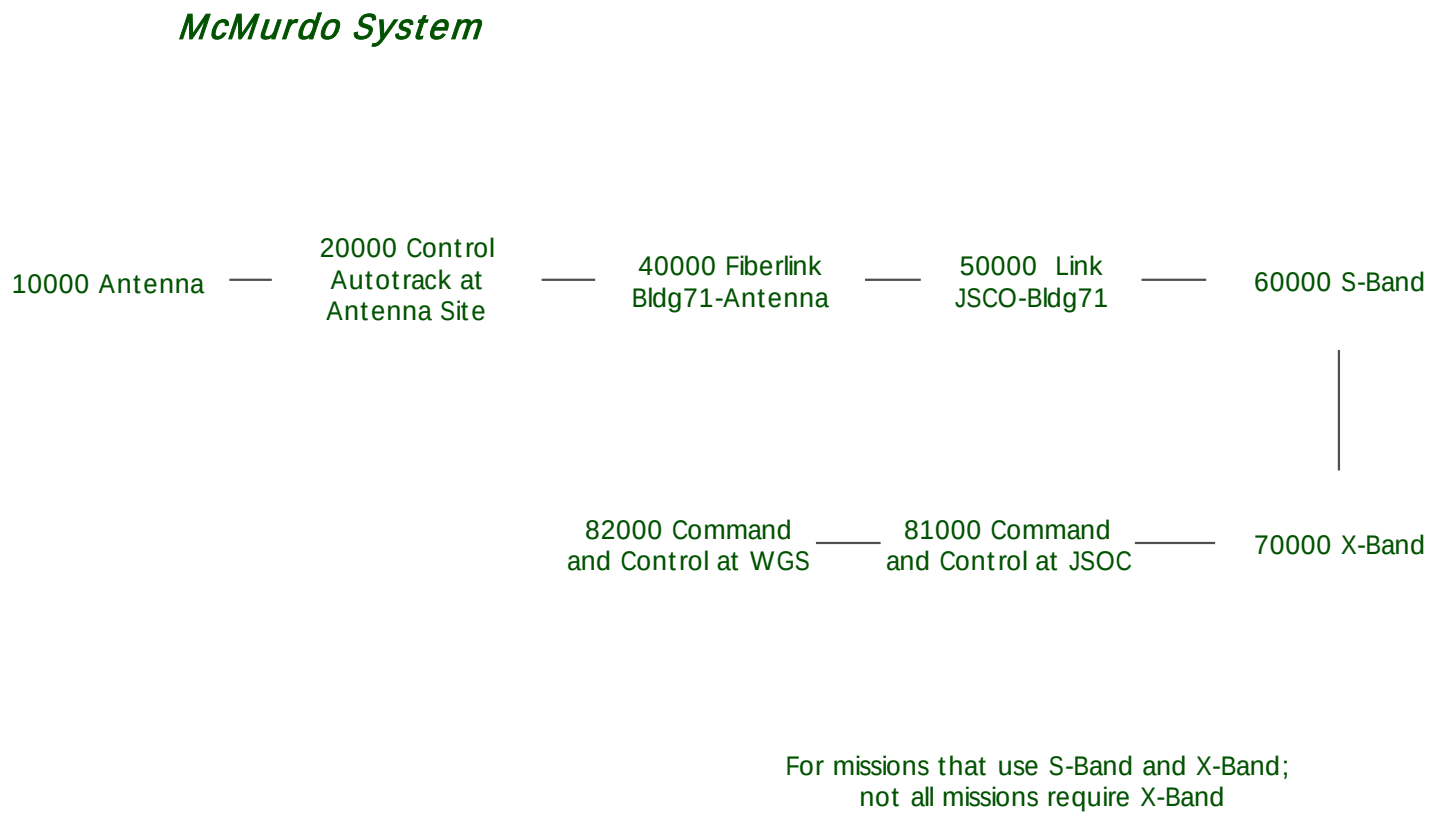
- Is taken into account in BlockSim simulation in **repair crew availability**
- Travel restrictions are based on three factors
  - Wind
  - Wind Chill
  - Visibility
- Created histogram for weather induced travel restrictions based on wind speed and calculated wind chill data at Radome / Building 71
- Approximated histogram with 2-parameter Weibull distribution

Crew Availability at Radome / Building 71



- **Repair Crew Availability** for Building 71 and Radome modeled with Weibull Distribution with beta = 1.25 and eta = 30

High Level Reliability Block Diagram



For missions that use S-Band and X-Band;
not all missions require X-Band

Monte Carlo Analysis Summary

System Overview	
General	
Mean Availability (All Events):	0.8951
Std Deviation (Mean Availability):	0.0611
Mean Availability (w/o PM & Inspection):	0.8951
Point Availability (All Events) at 87600:	0.8937
Reliability(87600):	0
Expected Number of Failures:	249.5587
Std Deviation (Number of Failures):	21.2275
MTTFF:	312.9974
System Uptime/Downtime	
Uptime:	78412.271
CM Downtime:	9187.7295
Inspection Downtime:	0
PM Downtime:	0
Total Downtime:	9187.7295
System Downing Events	
Number of Failures:	249.5587
Number of CMs:	249.5587
Number of Inspections:	0
Number of PMs:	0
Total Events:	249.5587

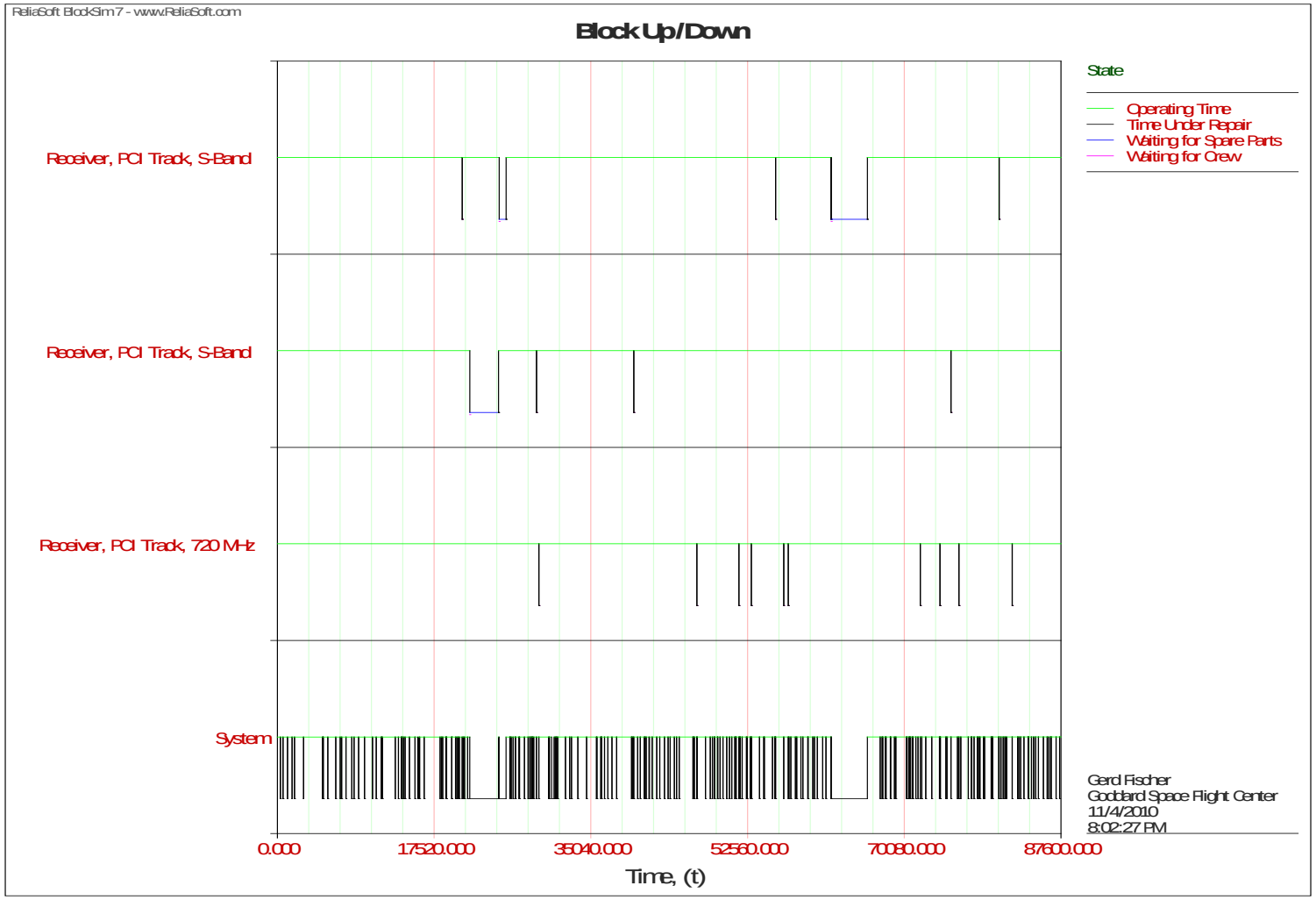
Block Failure Criticality / Downtime Ranking

- does not take redundancy into account

Block Failure Criticality Summary	
Block Name (Diagram)	**RS FCI**
Receiver, PCI Track, S-Band {22000_Multichannel Autotrack Receiver}	2.40%
Receiver, PCI Track, 720 MHz {22000_Multichannel Autotrack Receiver}	2.39%
Receiver, PCI Track, S-Band {22000_Multichannel Autotrack Receiver}	2.37%

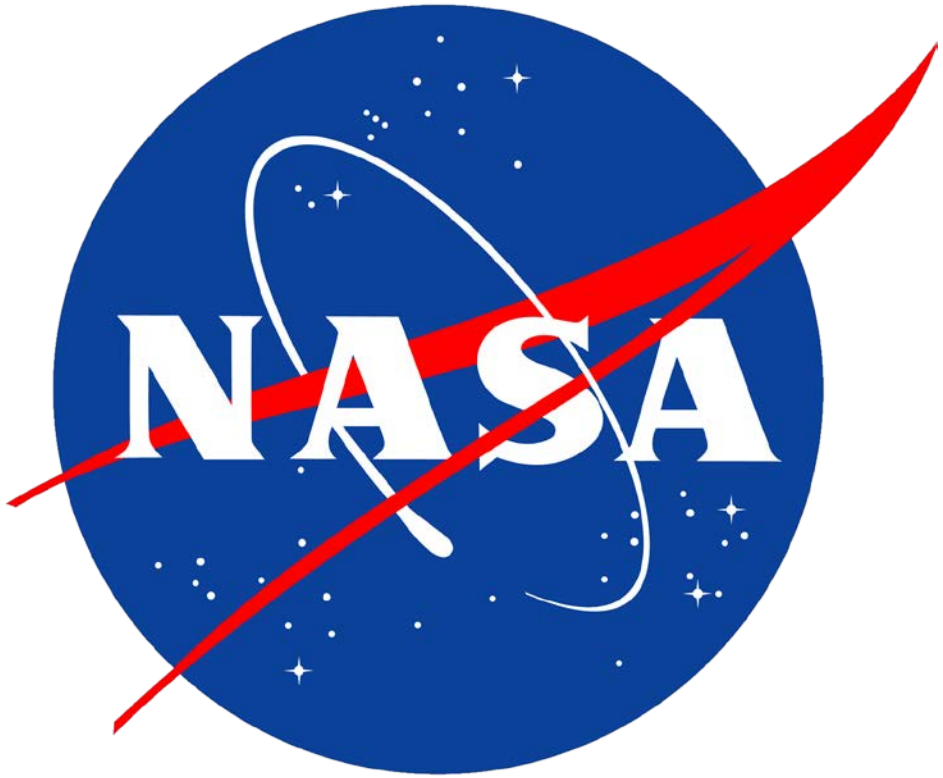
Block Downtime Ranking		
Block Name (Diagram)	**Block Downtime**	**Contribution to Downtime if not in redundant configuration**
Receiver, PCI Track, S-Band {22000_Multichannel Autotrack Receiver}	904.9	9.85%
Receiver, PCI Track, S-Band {22000_Multichannel Autotrack Receiver}	880.8	9.59%
Receiver, PCI Track, 720 MHz {22000_Multichannel Autotrack Receiver}	622.4	6.78%

One run Snapshot for all Blocks



Lessons Learned

- Performed Operational Availability Analysis for McMurdo Ground Station System
- Commercial availability simulation programs are not designed to deal with such special cases, but workarounds can be created, e.g. distribution or re-stock probability
  - Re-stock probability was not conditional to Antarctic seasons
- Custom-built availability simulation programs might not be cost-effective due to the low number of applications
- Essential to collect constraint information for maintenance operations, e.g. times and durations of travel restrictions to Radome / Building 71
  - Travel restriction data should be recorded and made available
- Operational Availability Simulation can help to set performance expectations for NASA Ground Stations
- Operational Availability Simulations can only be as good as the data used for input to the simulation


NASA