An Overview of the NIRA Status

Jeff Larko
NASA GRC

The NASA Glenn Research Center (GRC) has been tasked by NASA JSC's ISS Payloads Office to perform the NIRA (Non-Isolated Rack Assessment) microgravity prediction analysis task for the International Space Station. Previously, the NIRA analysis task had been performed by Boeing/Houston. Boeing's last NIRA analysis was released in 1999 and was denoted as "NIRA 99." GRC is currently close to completing our first full-NIRA analysis (encompassing the frequency range from 0 to 50 Hz) to be released as "NIRA 2003." This presentation will focus on describing the NIRA analysis, the transition of this analysis task from Boeing to GRC, and the current status and schedule for release of the NIRA 2003 results. Additionally, the results obtained from a mini-NIRA analysis requested by ESA and completed by GRC in the Spring of 2003 will be shown. This mini-analysis focused solely on predicting the microgravity environment at the COF-EPF (Columbus Orbiting Facility External Payload Facility).

NASA/CP—2004-212885

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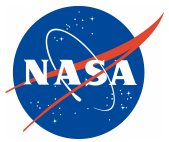

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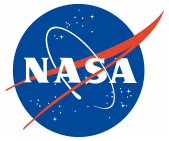
Microgravity Measurements Group Meeting #22

"An Overview of the NIRA Status"

GRC's ISS NIRA Team:

Bill Hughes, Jeff Larko, Alan Hewston, Albert Yu, Mark McNelis

October 23, 2003



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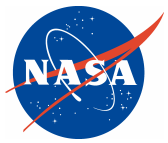
Today's Agenda

- Overview of NIRA Task
- Summary of Mini-NIRA Task for ESA
- Status of NIRA 2003 FEM Analysis
- NIRA 2003 FEM Preliminary Results
- Concluding Remarks
- Appendices A & B



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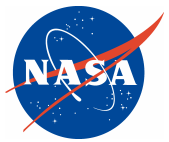
Overview of NIRA Task



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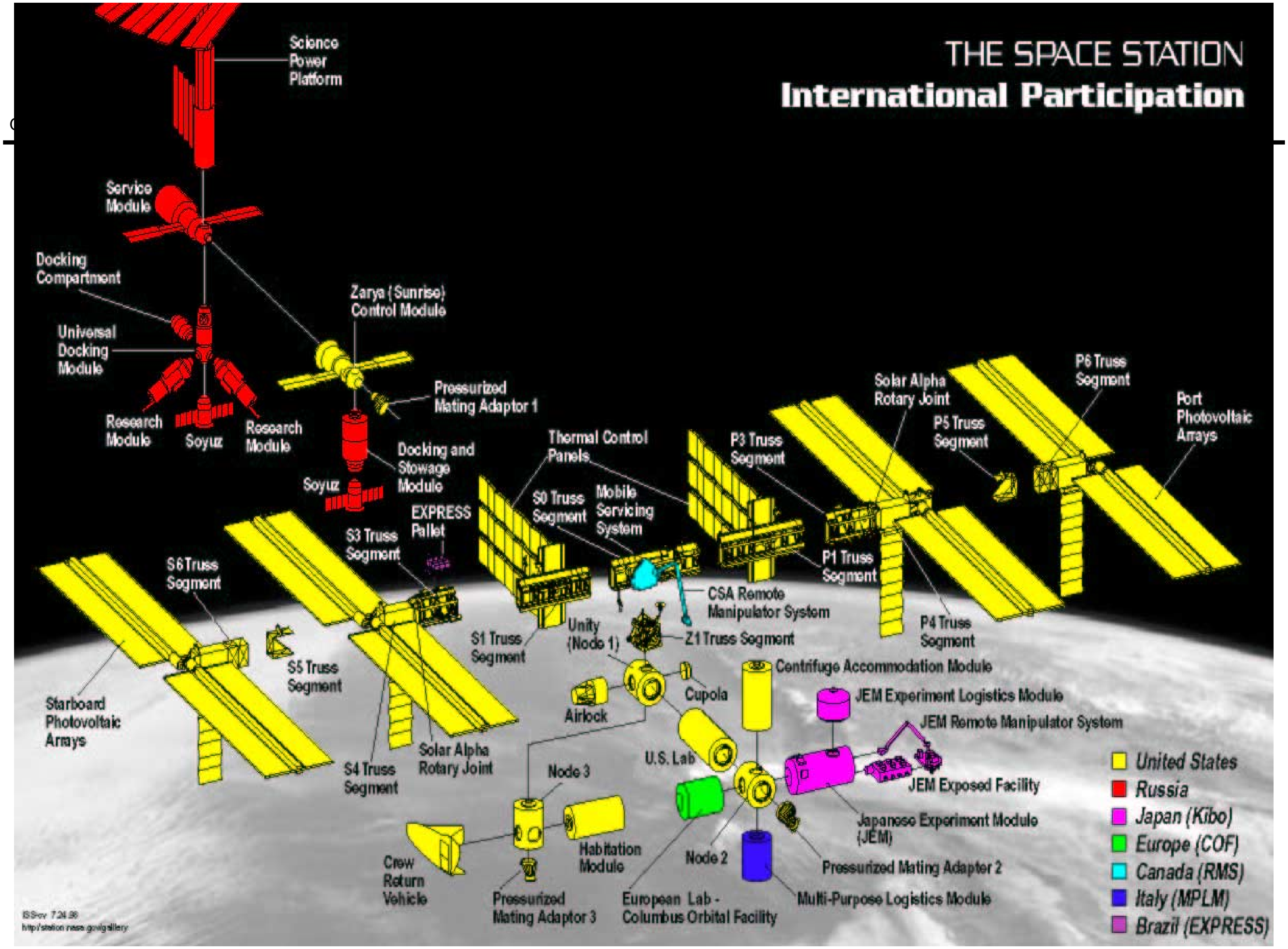
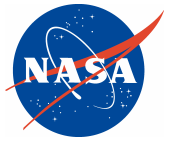
General Information

- **Task Name:** OB-1 Microgravity Lead Analysis
- **Requesting Organization:** OZ3/NASA JSC Payloads Office
- **Point of Contact:** 7735/ William O. Hughes
- **Task Requester:** ES2/Dr. James P. Smith
- **Overall Objective:** Provide microgravity analysis utilized in ISS payload microgravity verification


THE SPACE STATION
International Participation
Science Power Platform
Service Module
Docking Compartment
Universal Docking Module
Research Module
Soyuz
Research Module
Zarya (Sunrise) Control Module
Pressurized Mating Adaptor 1
Docking and Stowage Module
Soyuz
EXPRESS Pallet
S3 Truss Segment
Thermal Control Panels
S0 Truss Segment
Mobile Servicing System
P3 Truss Segment
Solar Alpha Rotary Joint
P5 Truss Segment
P6 Truss Segment
Port Photovoltaic Arrays
S6 Truss Segment
P1 Truss Segment
CSA Remote Manipulator System
Z1 Truss Segment
P4 Truss Segment
S1 Truss Segment
Unity (Node 1)
S5 Truss Segment
Centrifuge Accommodation Module
Starboard Photovoltaic Arrays
Airlock
Cupola
JEM Experiment Logistics Module
JEM Remote Manipulator System
U.S. Lab
S4 Truss Segment
Solar Alpha Rotary Joint
Node 3
JEM Exposed Facility
Japanese Experiment Module (JEM)
Habitation Module
Node 2
Crew Return Vehicle
Pressurized Mating Adapter 2
Pressurized Mating Adaptor 3
European Lab - Columbus Orbital Facility
Multi-Purpose Logistics Module
United States
Russia
Japan (Kibo)
Europe (COF)
Canada (RMS)
Italy (MPLM)
Brazil (EXPRESS)



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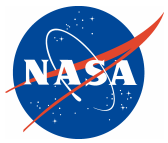
What is NIRA?

- Non-Isolated Rack Assessment
- NIRA is used to assess the suitability of the acceleration environment for "non-microgravity critical" science at locations other than at the isolated "ARIS" rack-to-module interfaces.
- Provide payload organizations with predictions of the acceleration environment at the non-isolated rack-to-module interfaces.
  - FEM analyses (0-50 Hz.) and SEA (50-315 Hz.)
  - Due to vehicle disturbances AND payload and crew disturbances
  - Using 1% system modal damping (more realistic for payloads)
  - At ISS assembly complete configuration for microgravity mode
- The analysis and verification of the vehicle requirements (DAC/VAC still performed by Boeing) do not address the NIRA (payload) criteria.



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Summary of Mini-NIRA Task for ESA

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New Priority: ESA Task

- In March 2003, James Smith our JSC POC reprioritized our basic NIRA analysis in order that GRC could perform analysis to satisfy an urgent request from ESA (to support their design review).
- This “mini-NIRA” analysis determined the microgravity environment for the ACES payload located on the External Payload Facility of the Columbus Orbiting Facility (COF-EPF).
- Performing this special ESA task resulted in a 2-month delay to our original NIRA 2003 FEM schedule.

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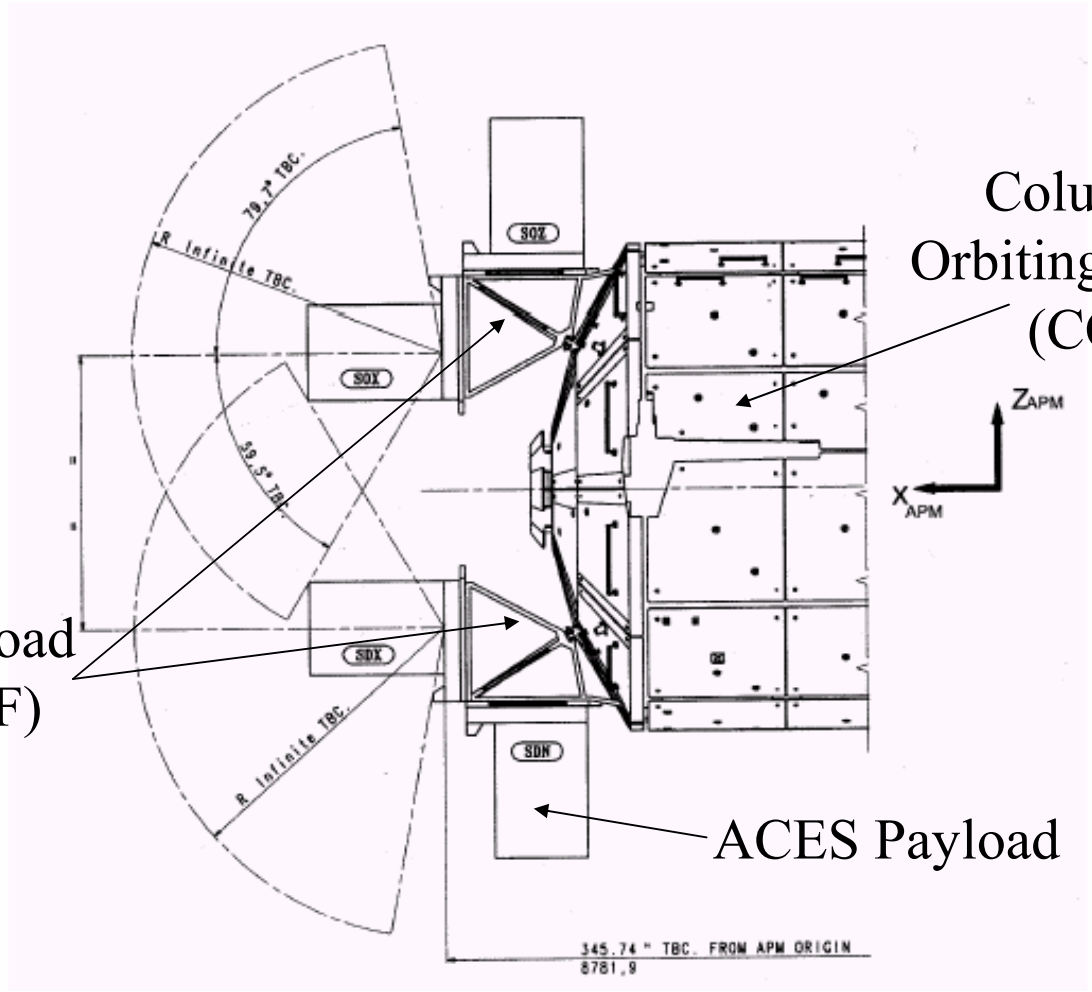
ESA's COF-EPF



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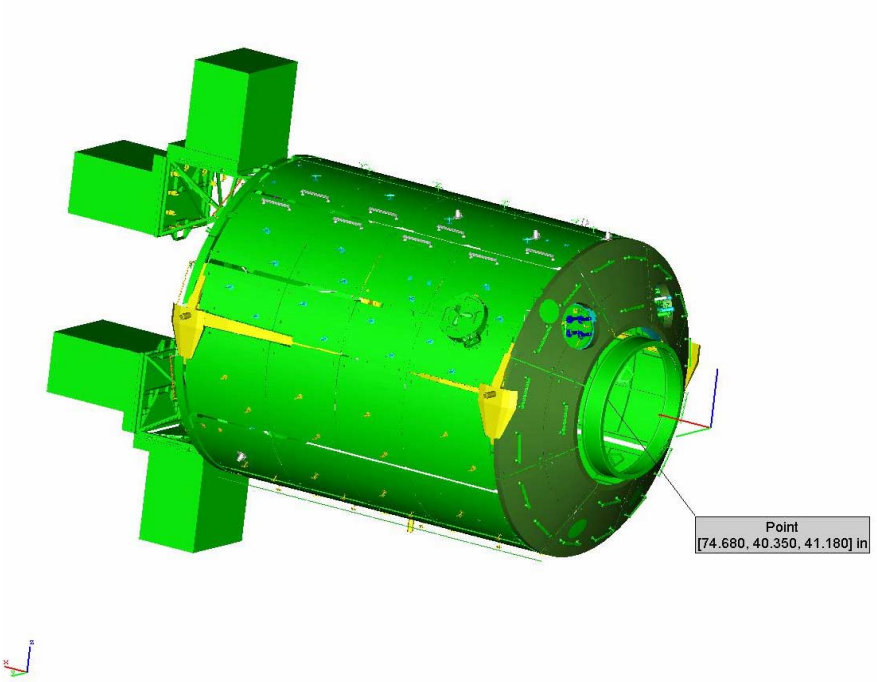
Mini-NIRA for COF-EPF

- GRC's COF-EPF Analysis Report sent to JSC and ESA on May 15, 2003.
  - Analysis plan
  - Disturbance information
  - "Standard" skyline frequency spectrum curves
  - Response time histories (extra request)



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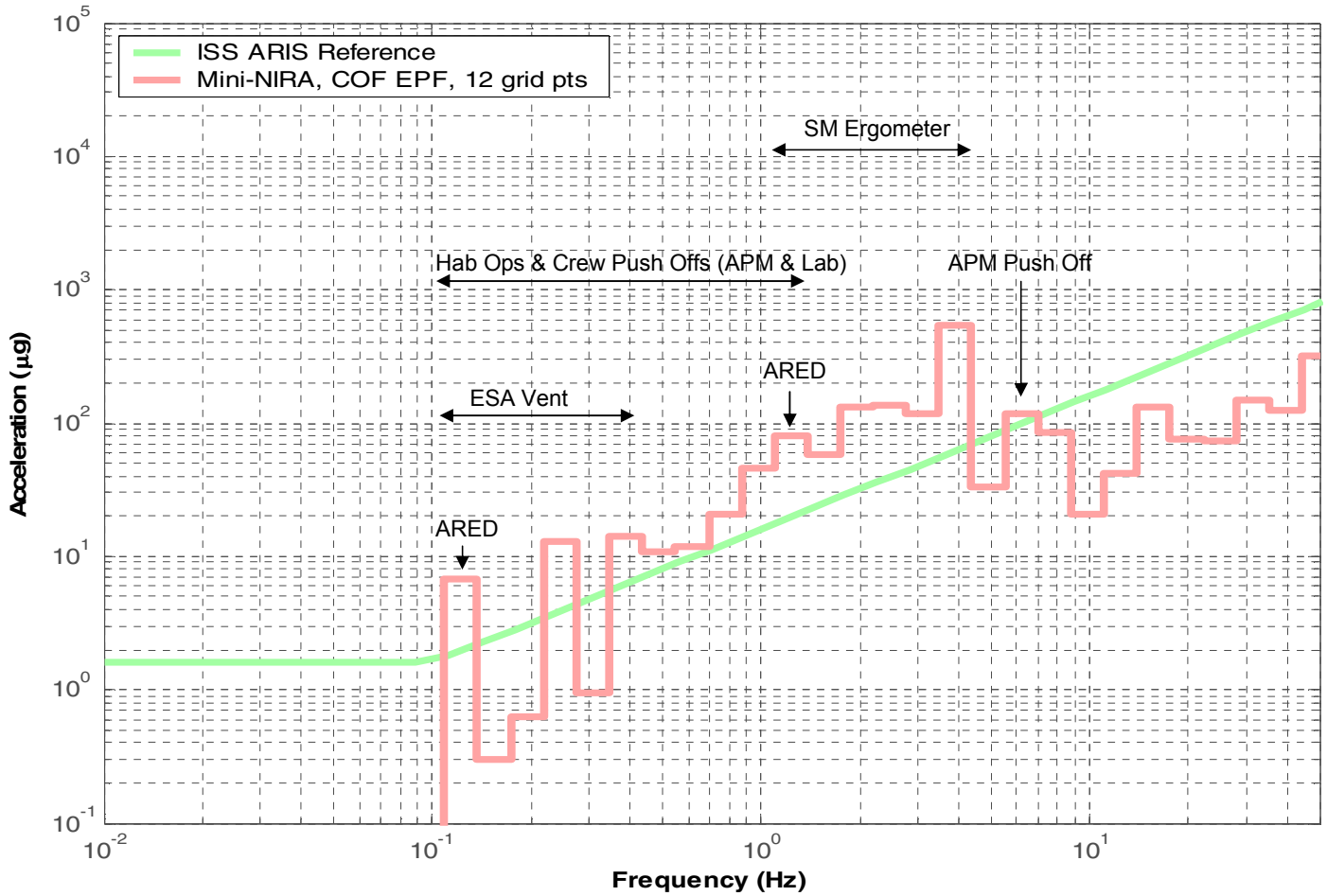
Microgravity Skyline for COF-EPF



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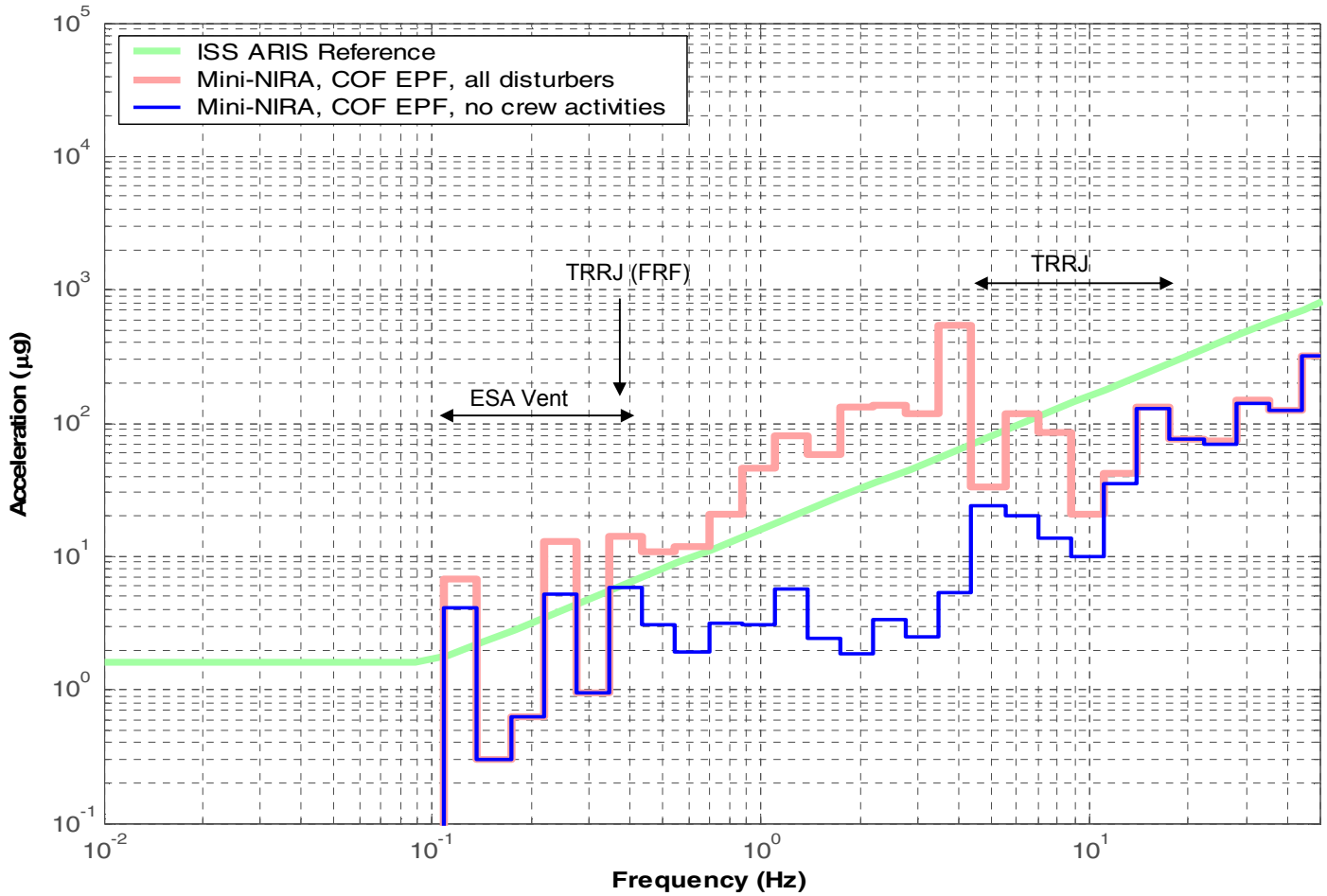
Improvement of Microgravity Environment during Inactive Crew Periods



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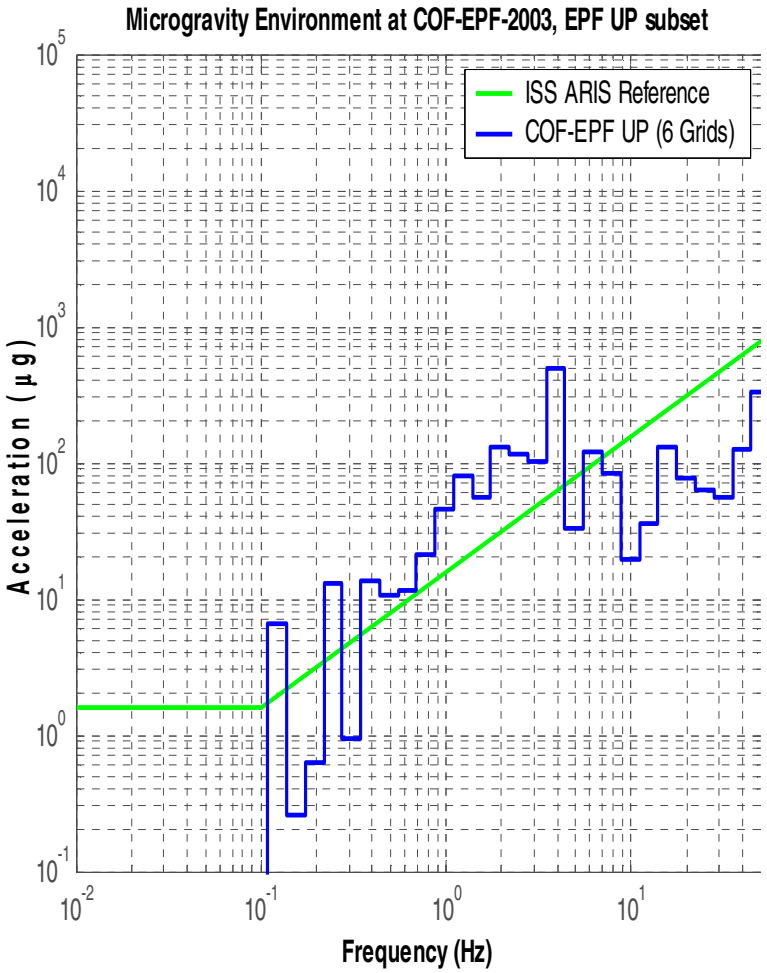
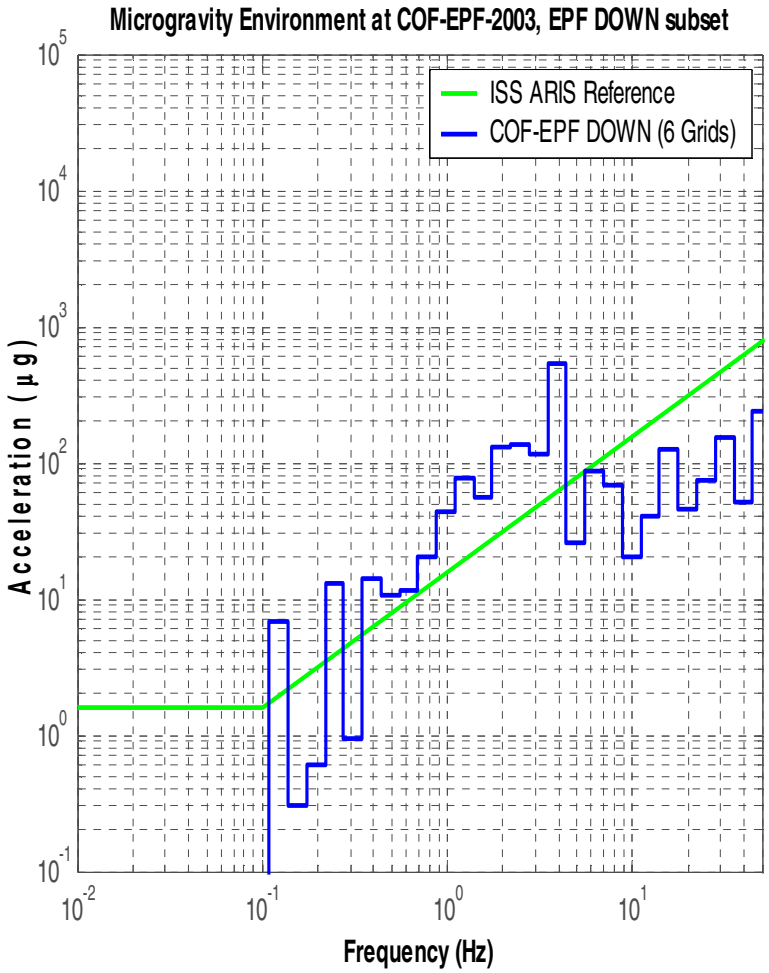
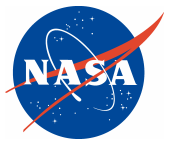
Comparison of "Up" and "Down" Platforms







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Status of NIRA 2003 FEM Analysis

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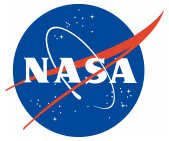
NIRA 2003 FEM Introduction

- NIRA 2003 FEM analysis began in May 2003 and is still continuing with a target completion date of October 31, 2003.
- All ISS models and disturbances provided to GRC by JSC/Boeing-Houston.
- Extensive communication with JSC and International Partners to arrive at agreed upon “frozen” Analysis Plan (Appendix A&B) on July 8, 2003.
- Currently performing post-processing for module level skyline plots.



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ISS System FEM Model

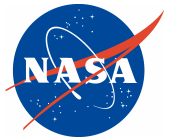
•Three (3) distinct ISS configurations and corresponding system mode databases.

•The system model is composed of 127 external database files and 126 bulk data files.

•A summary of the system model properties include:

- 48,231 grid points
- 289,386 degrees of freedom
- 95 super elements.

•Each system modes database represents ~8500 dynamic modes from 0 – 50 Hz, and is the cornerstone of the NIRA analysis.



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Scope of NIRA 2003 FEM Analysis

- NIRA 2003 FEM analysis is ~ 10x bigger than ESA mini-NIRA task.
- 0 to 50 Hz only
- Constant modal critical damping of 1.0%
- 103 Recovery Grid Points at 12 ISS modules
- 63 Active Disturber Cases
- Combination of MATLAB and NASTRAN used to complete transients and FRF runs.
- Post-processing of results (combining disturbance responses in modules) is still in work.

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Appendix A:
NIRA 2003 Overall Analysis Plan (1 of 13)

Part 1: GRC NIRA 2003 Overall Analysis Plan-FINAL (10/1/03)				
Node/ Disturber	**Analysis Type**	**Input Grid(s)**	**NASTRAN Files**	**ISS System Model Config**
ALK ESPAD strut	FRF	130520	Force/Moment: dac9tf_ai_alkf_r4.dat dac9tf_ai_alkm_r4.dat	Joints Locked Model
ALK Airlock to HPGC (High Pressure Gas Cylinder?)	TR	130551	Force: dac9ltl_ai_alkhpgc.dat dac8_hpgc.time xyplot_alkhpgc.dat	Joints Locked Model
ALK ND1 Starboard I/F to Airlock	TR	100184	Force: dac9ltl_ai_alksvlv.dat dac6_sol_valve.time xyplot_alksvlv.dat	Joints Locked Model
ALK ND1 Starboard I/F to Airlock	TR	100184	Force: dac9ltl_ai_alkrvlv.dat dac6_rel_valve.time xyplot_alkrvlv.dat	Joints Locked Model
S3 APAS #1-#4 (AMS & Express Pallet Guide Vanes)[10]	FRF	231837, 231937, 232837, 232937	Force/Moment: dac9tf_ai_apf_r4.dat dac9tf_ai_apm_r4.dat	Joints Locked Model
BGA Beta Gimbal Assembly	TR	407	Moment: dac9ltl_ai_bga.dat vac3_bga.time xyplot_bga.dat	Joints Locked Model
CAM AAA Fan[11]	FRF	751105	Force/Moment: dac9tf_ai_camf3_r4.dat dac9tf_ai_camm3_r4.dat	Joints Locked Model

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Appendix B:
Customer Recovery Grid Point Locations (1 of 5)

Grid Pt	Module	Location	Customer / Payload	Detailed Descriptions (revised 7/8/03)
100180	Node 1	I/F	LAB	Node1 Fwd i/f to Lab
100181	Node 1	I/F	PMA1	Node1 Aft i/f to PMA1 (RS)
100182	Node 1	I/F	Z1	Node1 Zenith i/f to Z1
100183	Node 1	I/F	Node 3	Node1 Nadir i/f to Node3
100184	Node 1	I/F	Airlock	Node1 Stbd i/f to Airlock
100185	Node 1	I/F	Cupola	Node1 Port i/f to Cupola
160017	Node 2	I/F	MPLM	Node2 Nadir i/f to MPLM
160037	Node 2	I/F	COF	Node2 Stbd i/f to ESA-COF
160057	Node 2	I/F	CAM	Node2 Zenith i/f to CAM
160077	Node 2	I/F	JEM PM	Node2 Port i/f to NASDA-JEM
161037	Node 3	I/F	PMA3 & CRV1	Node3 Stbd i/f to CRV
161077	Node 3	I/F	HAB	Node3 Port if to Hab
202514	CAM			CAM CR Rack Interface Point
224074	S3	AP	EXPRESS Pallet	Express Pallet point, Face 3, Bay 1, +Y Zenith s3uo
224221	S3	AP		AMS Internal point , Face 3, Bay 2, +Y Zenith s3ui
224324	S3	AP	EXPRESS Pallet	Express Pallet point, Face 5, Bay 1, -Y Nadir s3lo
224424	S3	AP	EXPRESS Pallet	Express Pallet point, Face 5, Bay 2, -Y Nadir s3li
231837	S3	AP	APAS #1 EXPRESS Pallet	APAS #1 S3 UI AMS Guide Vane, Face 3, Bay 2, +Y Zenith
231937	S3	AP	APAS #2 EXPRESS Pallet	APAS #2 S3 LI Express Pallet Guide Vane, Face 5, Bay 2, -Y Nadir
232837	S3	AP	APAS #3 EXPRESS Pallet	APAS #3 S3 UO Express Pallet Guide Vane, Face 3, Bay 1, +Y Zenith
232937	S3	AP	APAS #4 EXPRESS Pallet	APAS #4 S3 LO Express Pallet Guide Vane, Face 5, Bay 1, -Y Nadir

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NIRA 2003 FEM Analysis Status

- Working to complete our first NIRA 2003 FEM analysis including report documentation by Fall 2003.
- NIRA transition to GRC began with JSC/Boeing-Houston "training" in April 2002.
- Strived to "duplicate" Boeing's previous NIRA methodology. However, in some areas we have deviated with the goal of maintaining sufficient conservatism while incorporating a more specific representation of grid-point disturbances.
- JSC/Boeing-Houston has been very supportive throughout the NIRA cycle.

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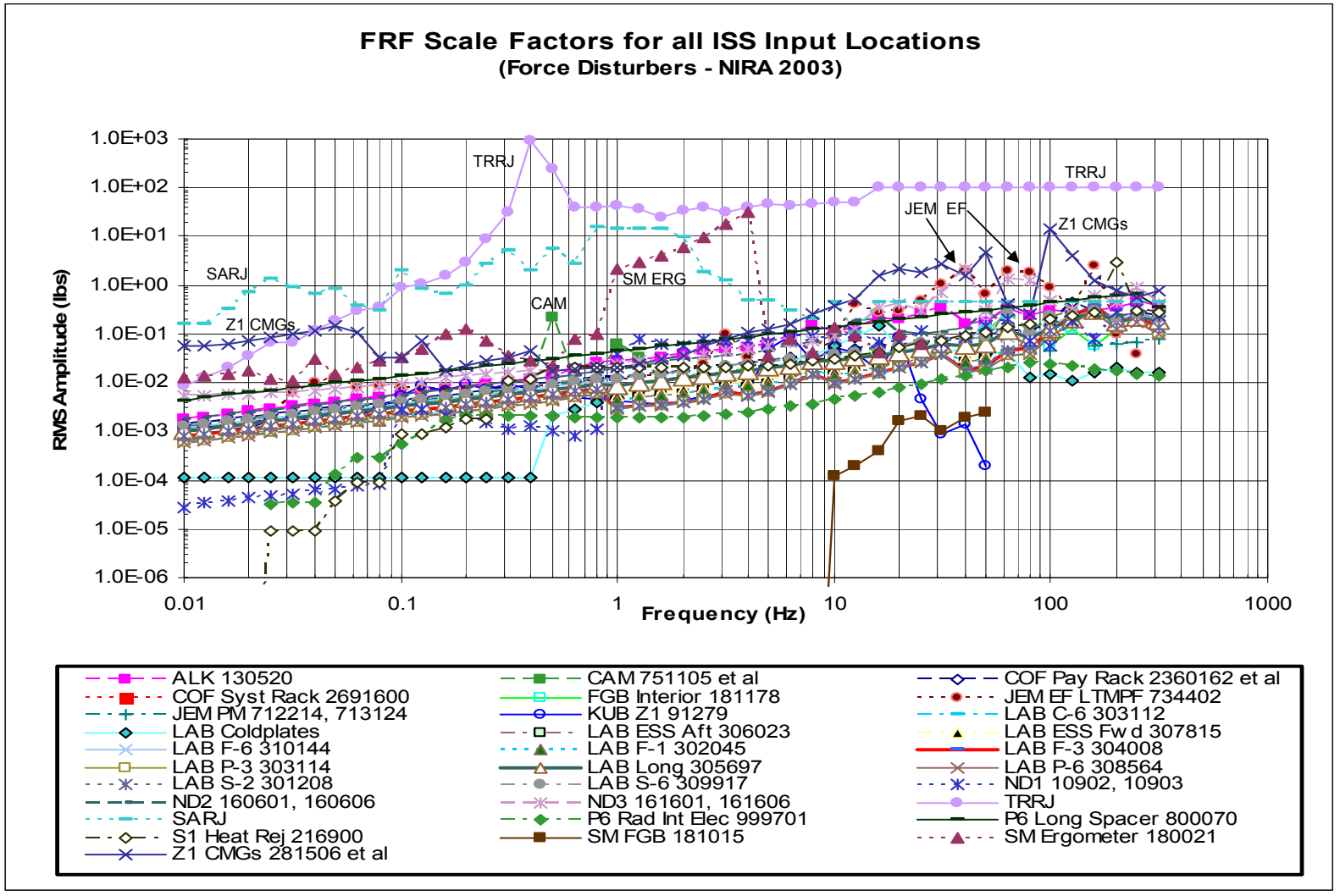
NIRA 2003 Scale Factors-Forces



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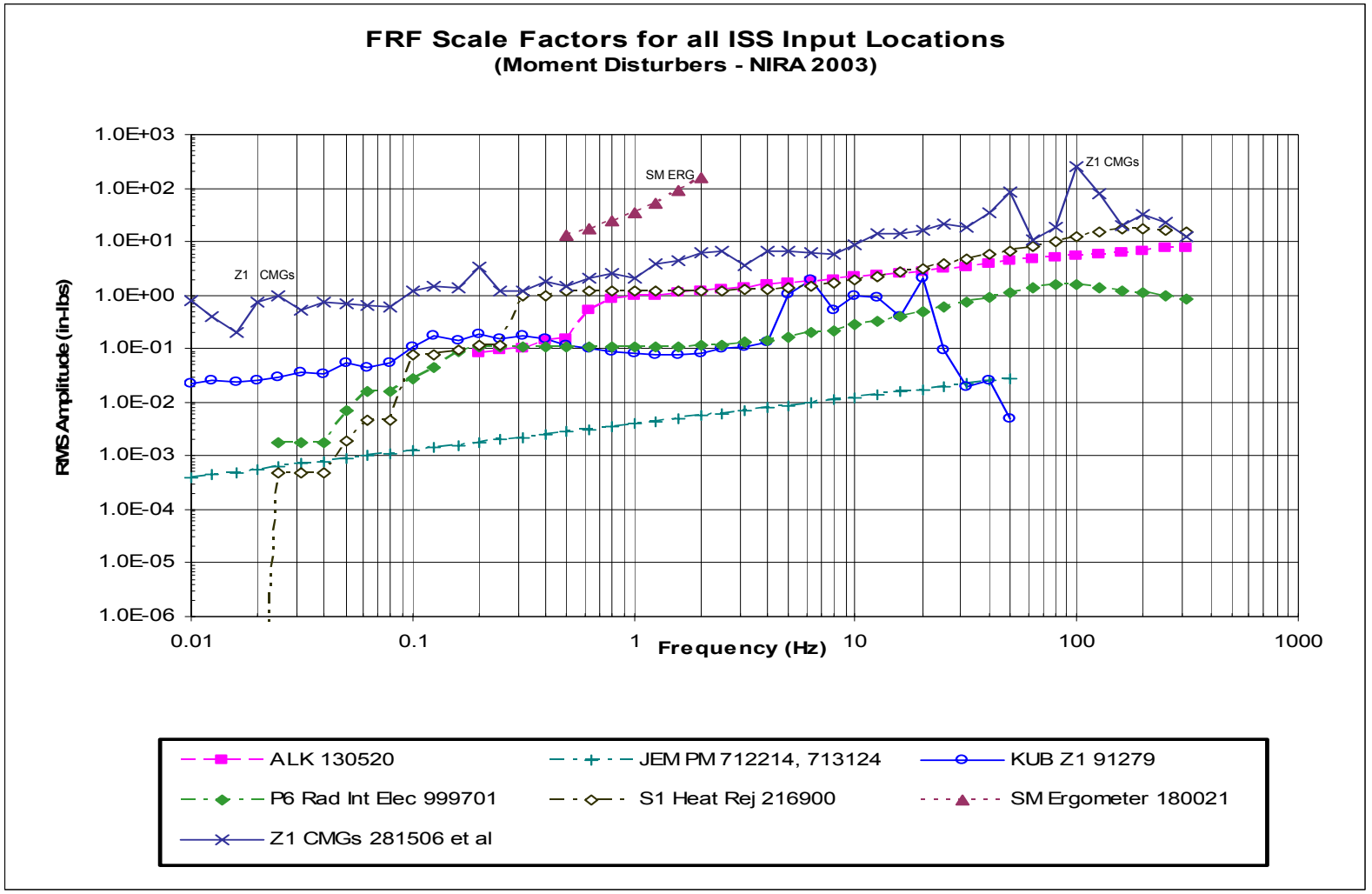
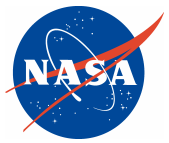
NIRA 2003 Scale Factors-Moments





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NIRA 2003 FEM Preliminary Results

Note that the following preliminary results reflect updates to the presentation made at the MGMG #22 (October 23, 2003)

- All transient cases were reprocessed using a smaller delta frequency.
- Upon further review, the "JEM LTMPF" disturbance case was determined to be valid and therefore was included in our analysis.

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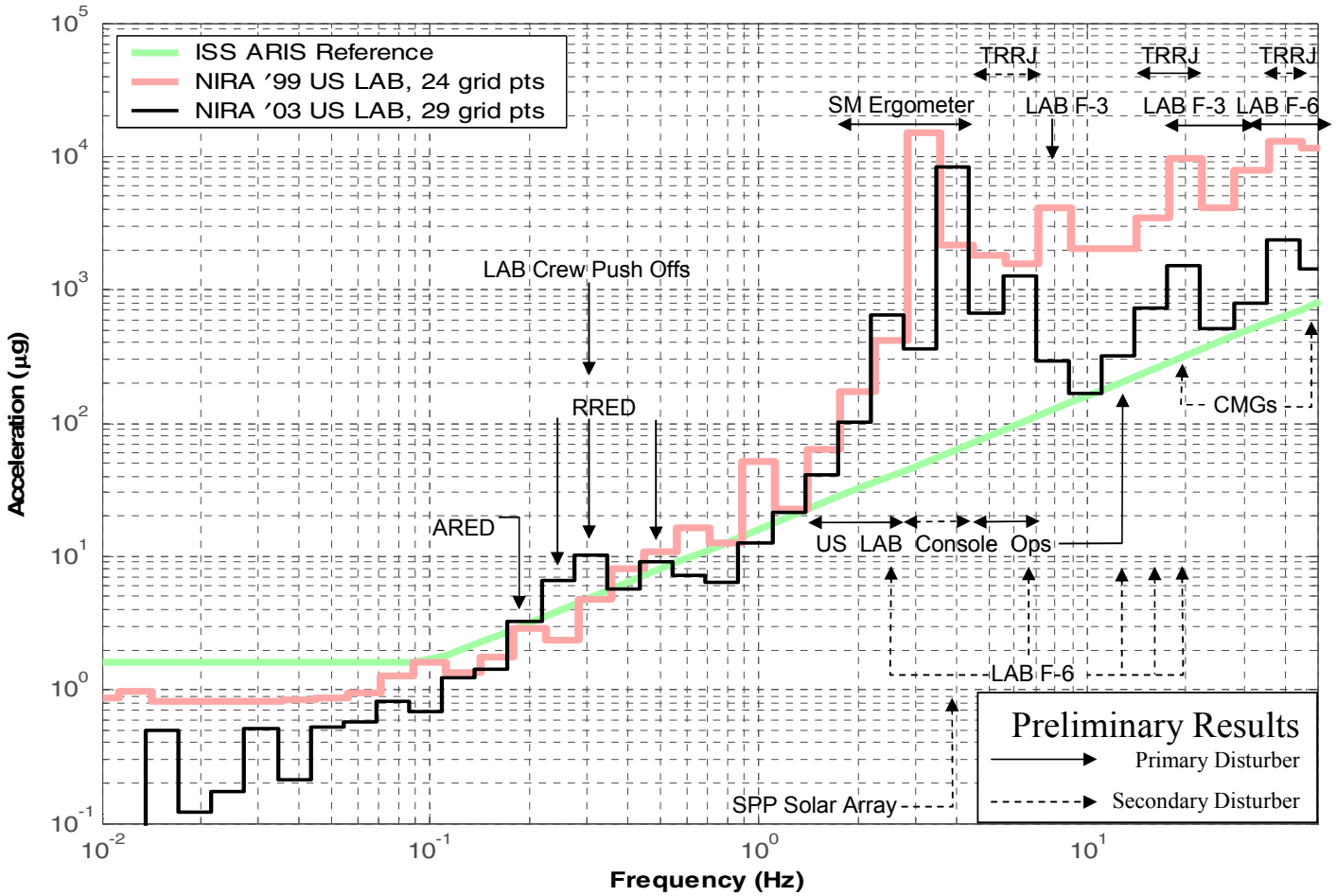
Preliminary Microgravity Environment in US Lab Module



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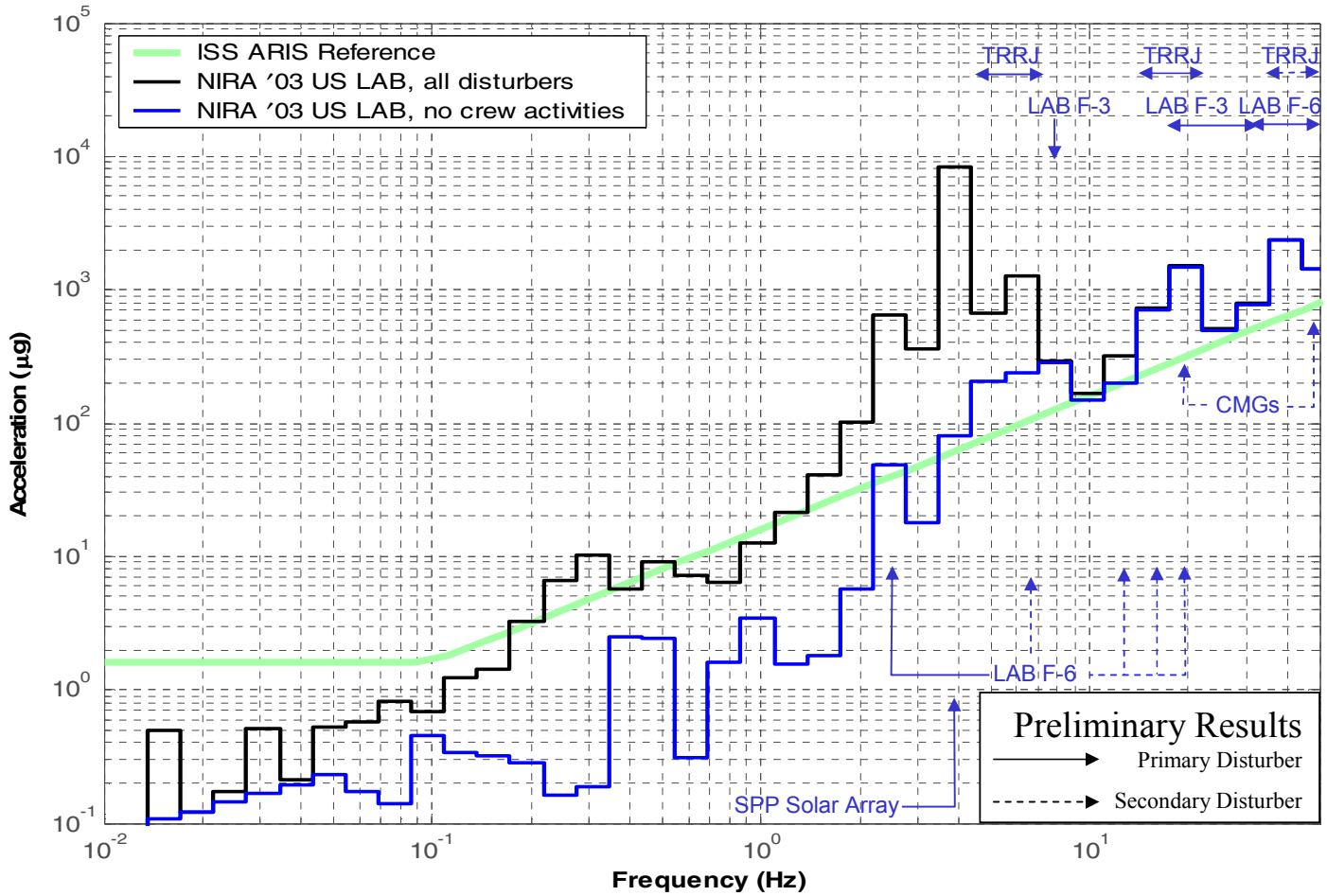
Preliminary Microgravity Environment in US Lab - **No Crew Activities**



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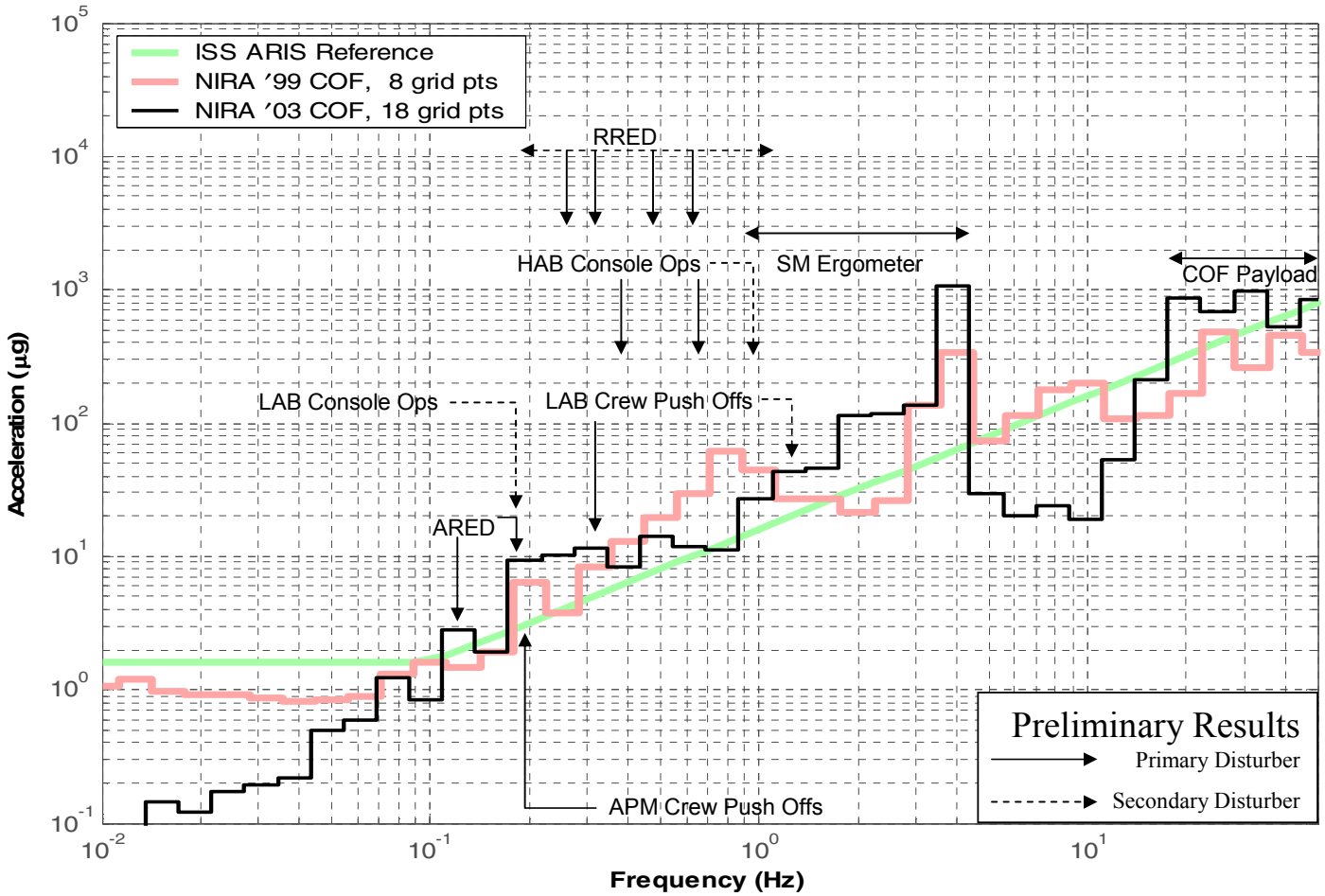
Preliminary Microgravity Environment in ESA-COF Module



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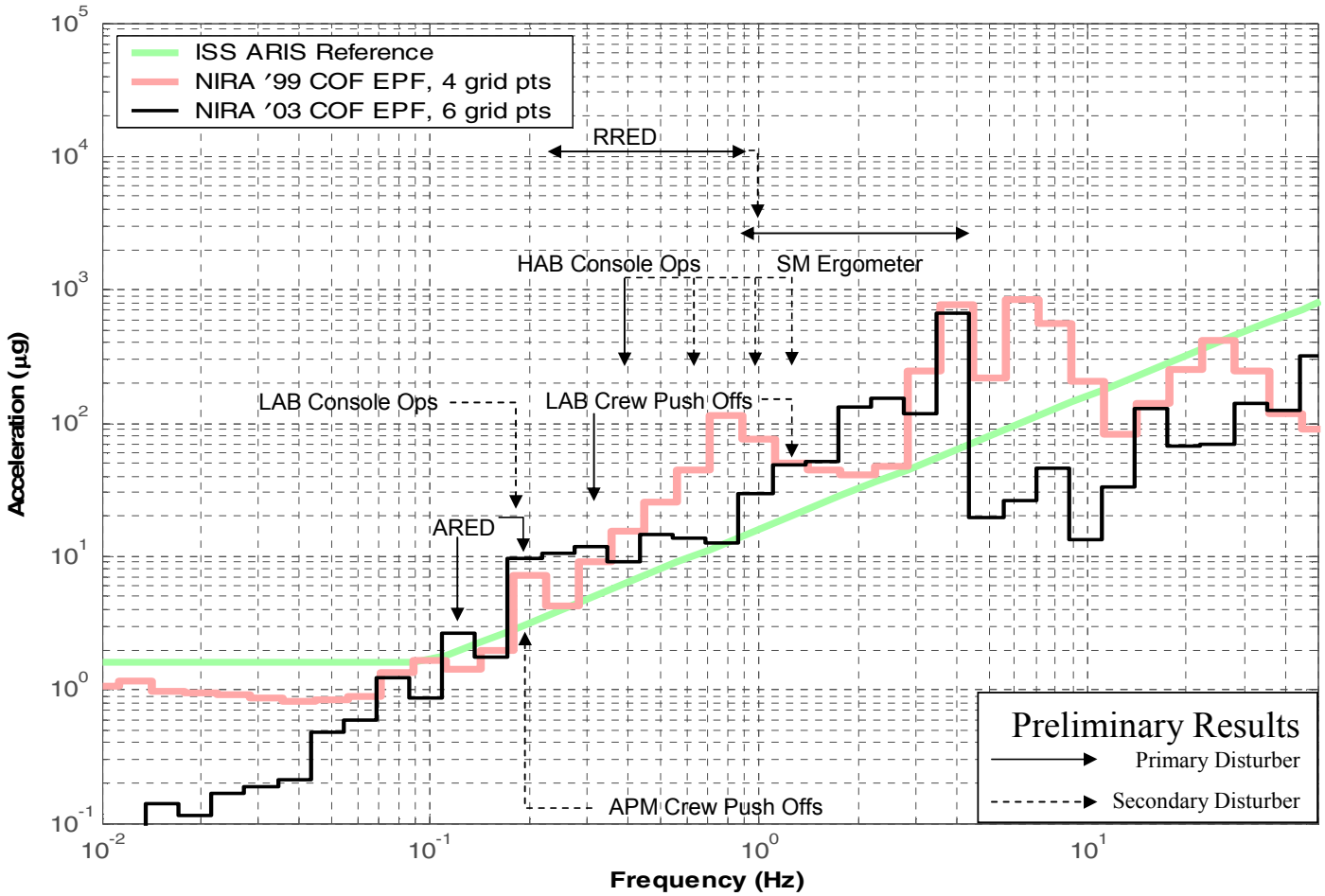
Preliminary Microgravity Environment in COF-External Platform Facility



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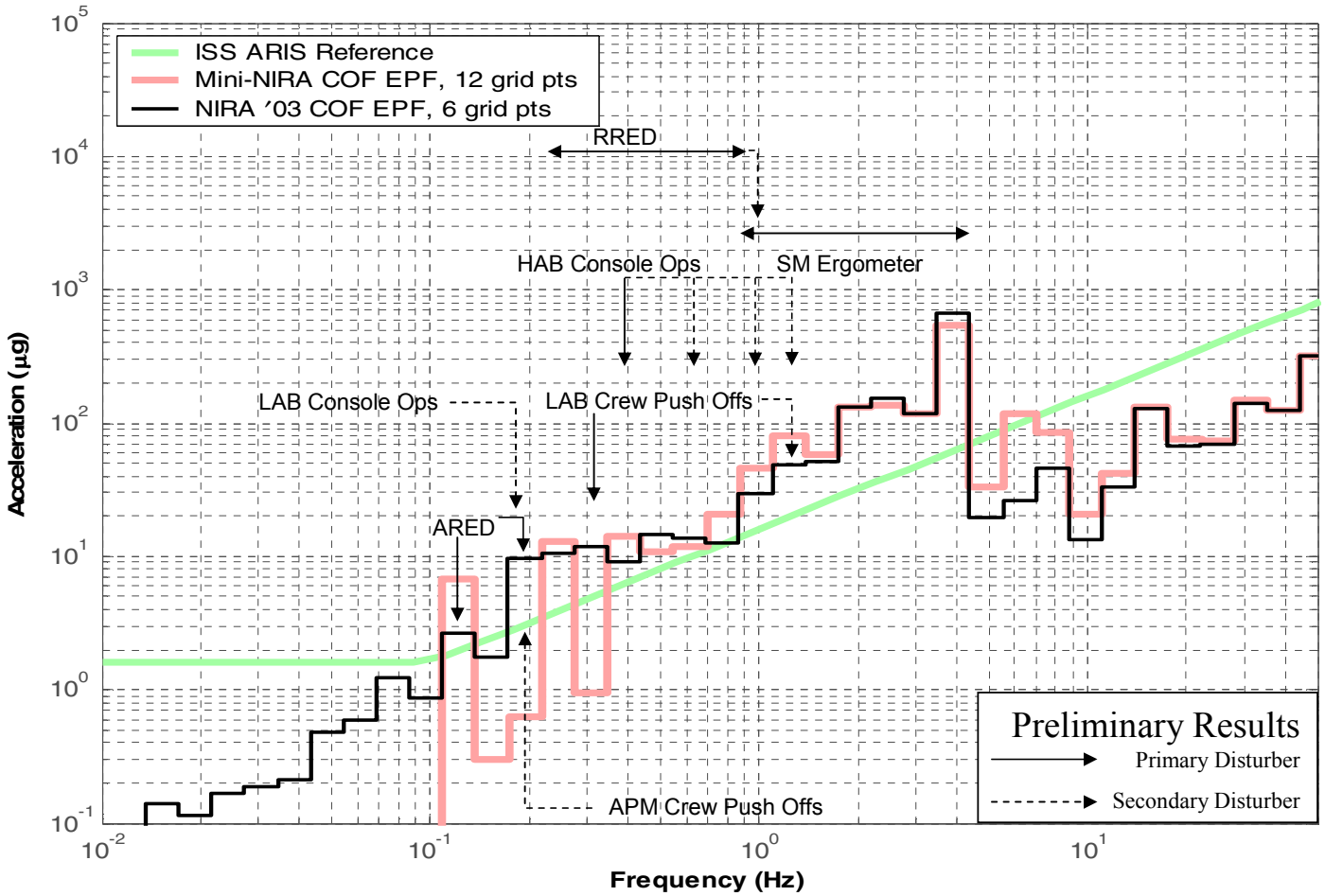
Comparison of COF-External Platform Facility "Mini-NIRA and "NIRA 2003"



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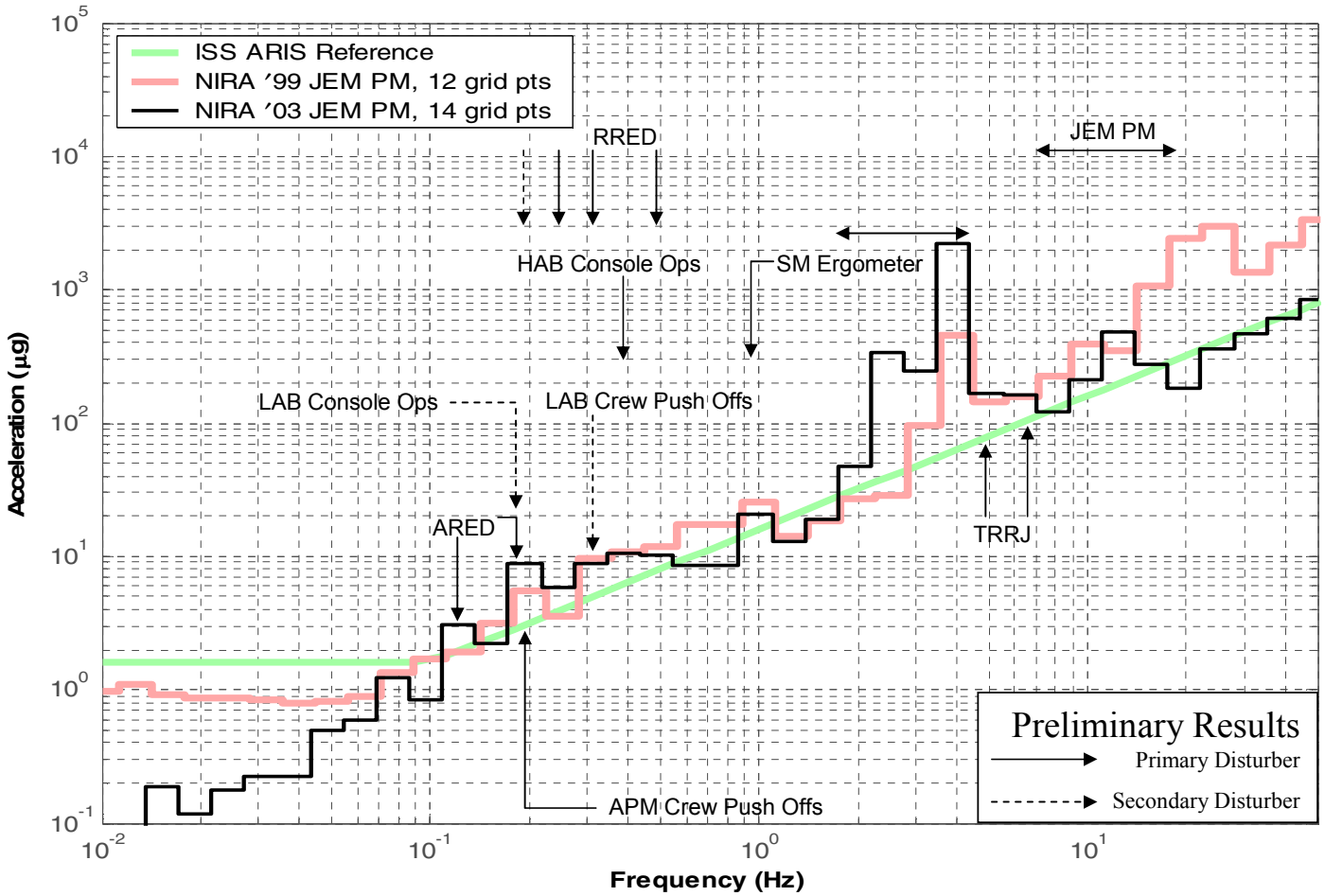
Preliminary Microgravity Environment in JEM Primary Module



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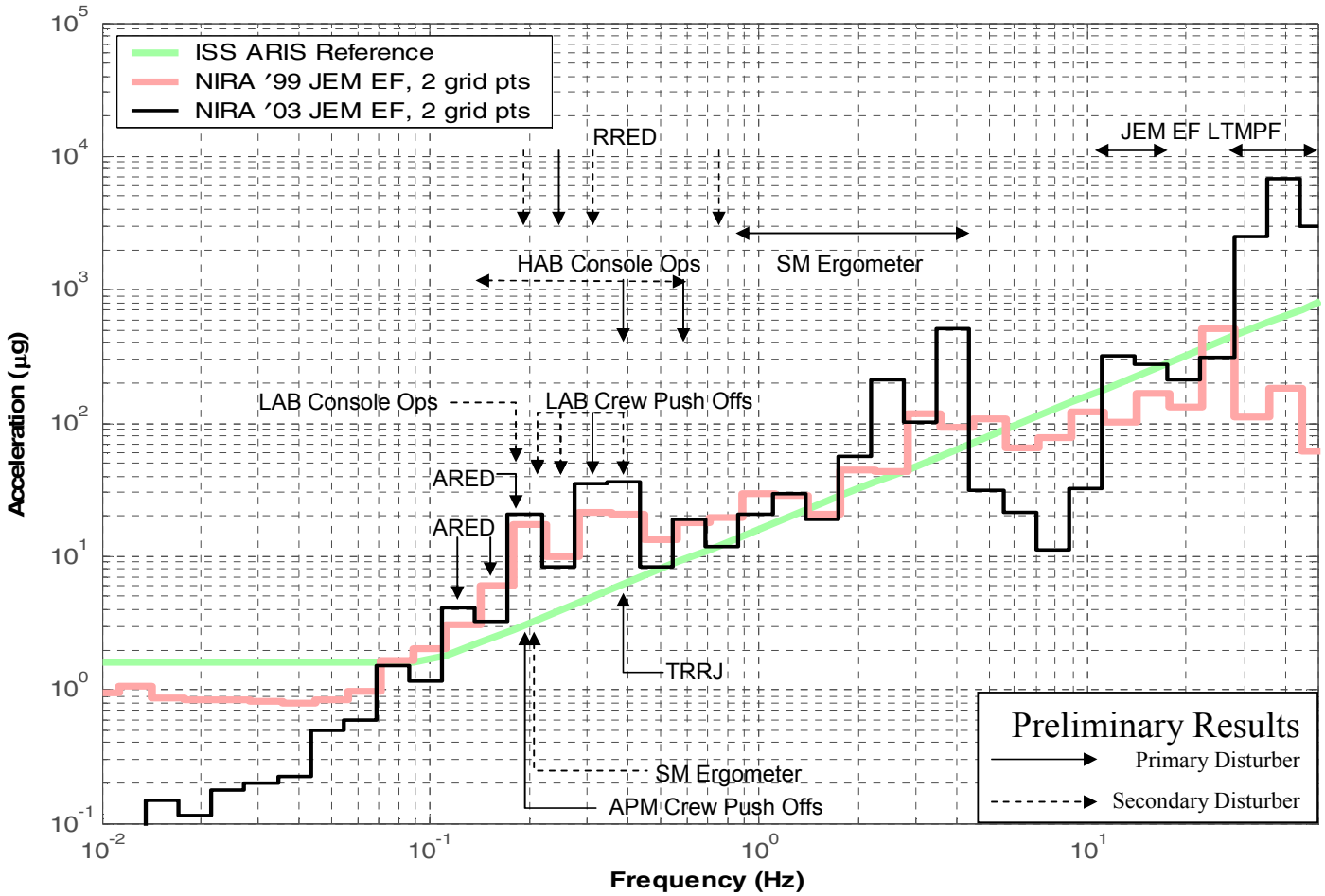
Preliminary Microgravity Environment in JEM-Exposed Facility



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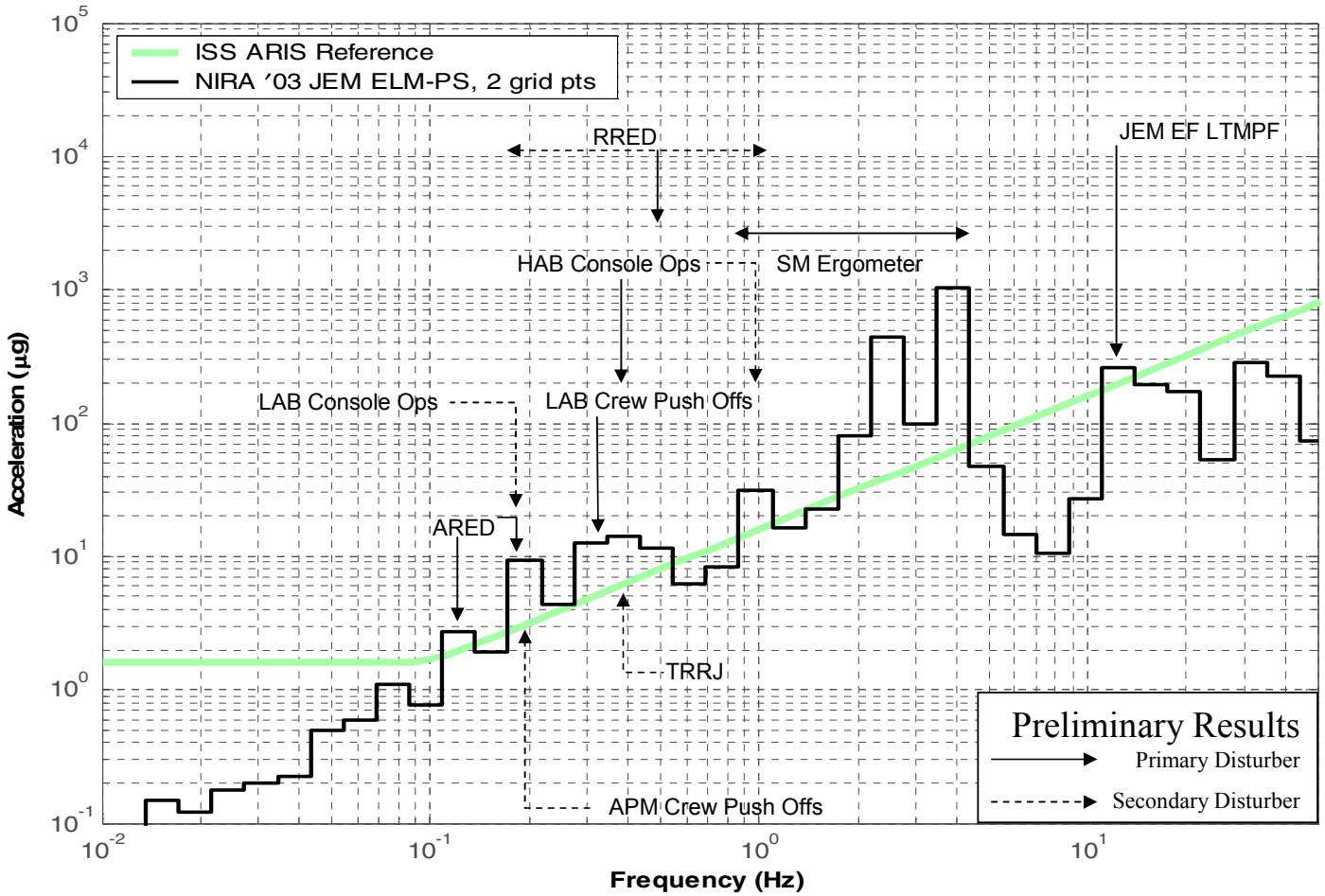
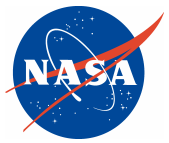
Preliminary Microgravity Environment in JEM Exp Logistics Module





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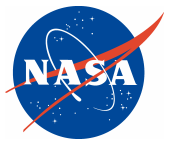
Additional Pending Results

- Additional "Skyline" plots in-work for the following modules:
  - CAM
  - APAS (S3 Truss)
  - Node 1
  - Node 2
  - Node 3
  - P3 Truss



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Concluding Remarks

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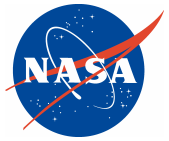
Future Work

- Future work (post NIRA 2003 FEM) includes:
  - SEA (Statistical Energy Analysis) microgravity predictions for 50 to 315 Hz frequency range.
  - More special case studies, such as detailed module predictions and non-microgravity mode predictions.
  - Estimate performing 1 NIRA cycle/year depending on program need (incorporating updated ISS models and disturbances).
  - Use of on-orbit data to benchmark and improve microgravity predictions.



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Summary

- We have successfully transitioned the NIRA task to GRC.
- We now have the capability to perform NIRA FEM analyses at GRC.
- NIRA 2003 FEM Analysis:
  - Preliminary NIRA 2003 results presented at the MGMG #22.
  - Final report to be issued by December 15, 2003.
- We look forward to meeting the needs of the international payload community.

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Appendix A:
NIRA 2003 Overall Analysis Plan (1 of 13)

Part 1: GRC NIRA 2003 Overall Analysis Plan-FINAL (10/1/03)

Node/ Disturber	Analysis Type	Input Grid(s)	NASTRAN Files	ISS System Model Config
ALK ESPAD strut	FRF	130520	Force/Moment: dac9tf_ai_alkf_r4.dat dac9tf_ai_alkm_r4.dat	Joints Locked Model
ALK Airlock to HPGC (High Pressure Gas Cylinder?)	TR	130551	Force: dac9ltl_ai_alkhpgc.dat dac8_hpgc.time xyplot_alkhpgc.dat	Joints Locked Model
ALK ND1 Starboard I/F to Airlock	TR	100184	Force: dac9ltl_ai_alksvlv.dat dac6_sol_valve.time xyplot_alksvlv.dat	Joints Locked Model
ALK ND1 Starboard I/F to Airlock	TR	100184	Force: dac9ltl_ai_alkrvlv.dat dac6_rel_valve.time xyplot_alkrvlv.dat	Joints Locked Model
S3 APAS #1-#4 (AMS & Express Pallet Guide Vanes)[10]	FRF	231837, 231937, 232837, 232937	Force/Moment: dac9tf_ai_apf_r4.dat dac9tf_ai_apm_r4.dat	Joints Locked Model
BGA Beta Gimbal Assembly	TR	407	Moment: dac9ltl_ai_bga.dat vac3_bga.time xyplot_bga.dat	Joints Locked Model
CAM AAA Fan[11]	FRF	751105	Force/Moment: dac9tf_ai_camf3_r4.dat dac9tf_ai_camm3_r4.dat	Joints Locked Model

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Appendix A:
NIRA 2003 Overall Analysis Plan (2 of 13)

Node/ Disturber	Analysis Type	Input Grid(s)	NASTRAN Files	ISS System Model Config
CAM CR rack i/f[11]	FRF	202514	Force/Moment: dac9tf_ai_camf1_r4.dat dac9tf_ai_camm1_r4.dat	Joints Locked Model
CAM Rotor i/f[11]	FRF	702001	Force/Moment: dac9tf_ai_camf2_r4.dat dac9tf_ai_camm2_r4.dat	Joints Locked Model
COF APM Crew Push-off	TR	2190225, 2015582	Force/Moment: dac9ltl_ai_apmy.dat vac3_apmy.time xyplot_apmyrev.dat	Joints Locked Model
COF ESAVAC Vent[5]	TR	2015582	Force/Moment: dac9ltl_ai_esavntvac.dat cof_pirn.time	Joints Locked Model
COF Node 2 I/F	FRF	160037	Moment: dac9tf_ai_com1_r4.dat	Joints Locked Model
COF Standard Payload Rack[1]	FRF	2360162	Force: dac9tf_ai_cof1_r4.dat	Joints Locked Model
COF Standard Payload Rack[1]	FRF	2467969	Force: dac9tf_ai_cof2_r4.dat	Joints Locked Model
COF Standard Payload Rack[1]	FRF	2568528	Force: dac9tf_ai_cof3_r4.dat	Joints Locked Model
COF Standard System Rack[2]	FRF	2691600	Force: dac9tf_ai_cof4_r4.dat	Joints Locked Model
COF External Platform Down	FRF	2195225	Force/Moment: dac9tf_ai_capf2_r4.dat dac9tf_ai_capm2_r4.dat	Joints Locked Model

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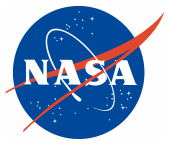
Appendix A:
NIRA 2003 Overall Analysis Plan (3 of 13)

Node/ Disturber	Analysis Type	Input Grid(s)	NASTRAN Files	ISS System Model Config
COF External Platform Up	FRF	2190225	Force/Moment: dac9tf_ai_capf1_r4.dat dac9tf_ai_capm1_r4.dat	Joints Locked Model
CUP Node1 Port I/F	FRF	100185	Force/Moment: dac9tf_ai_cupf_r4.dat dac9tf_ai_cupm_r4.dat	Joints Locked Model
FGB PMA I/F	FRF	181001	Force: dac9tf_ai_fgbf1_r4.dat	Joints Locked Model
FGB interior pt	FRF	181178	Force: dac9tf_ai_fgbf2_r4.dat	Joints Locked Model
HAB Crew Console Ops	TR	120070	Force/Moment: dac9ltl_ai_habcnop.dat dac4_conops.time xyplot_habcnop.dat	Joints Locked Model
JEM EF EF-ELM (Experiment Logistics Mod) I/F	FRF	734510	Force/Moment: dac9tf_ai_jeff1_r4.dat dac9tf_ai_jefm1_r4.dat	Joints Locked Model
JEM EF LTMPF EFU #2	FRF	734402	Force/Moment: dac9tf_ai_jeff2_r4.dat dac9tf_ai_jefm2_r4.dat	Joints Locked Model
JEM (payload rack CB-SE222) upper I/F	FRF	712256	Force/Moment: dac9tf_ai_jemf2_r4.dat dac9tf_ai_jemm2_r4.dat	Joints Locked Model
JEM PM Aft Rack (CB-SE222) lower hinge point [11]	FRF	712214	Force/Moment: dac9tf_ai_jemf1_r4.dat dac9tf_ai_jemm1_r4.dat	Joints Locked Model



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Appendix A:
NIRA 2003 Overall Analysis Plan (4 of 13)

Node/ Disturber	Analysis Type	Input Grid(s)	NASTRAN Files	ISS System Model Config
JEM (Sys rack ECLSS-SE231) pivot I/F [11]	FRF	713124	Force/Moment: dac9tf_ai_jemf3_r4.dat dac9tf_ai_jemm3_r4.dat	Joints Locked Model
KUB Z1 I/F	FRF	91279	Force/Moment: dac9tf_ai_kuf_r4.dat dac9tf_ai_kum_r4.dat	Joints Locked Model
LAB C-1 Isolation Plate/Prod I/F	FRF	331880	Force: dac9tf_ai_lab9_r4.dat	Joints Locked Model
LAB C-6 DDCU LRSPIF [7,11,12]	FRF	303112	Force: dac9tf_ai_lab5_r4.dat	Joints Locked Model
LAB Cold Plates Various types & locations[10]	FRF	Subset of 14	Force: dac9tf_ai_coldplate.dat 306736, 306766, 306074 , 306173, 317363, 307088, 307817, 307049, 307236, 307174, 307476, 307814, 308734, 309734	Joints Locked Model
LAB Crew Console Ops	TR	310287	Force/Moment: dac9ltl_ai_labcnop.dat dac4_conops.time xyplot_labcnop.dat	Joints Locked Model
LAB Crew Push-off	TR	304988, 303069	Force: dac9ltl_ai_labzrev2.dat vac3_labz2.time xyplot_labzrev2.dat	Joints Locked Model
LAB Ergometer	TR	317361, 317362, 317363, 317364	Force: dac9ltl_ai_cevis_54.dat dac9ltl_ai_cevis_56.dat dac9ltl_ai_cevis_57.dat dac9ltl_ai_cevis_58.dat cevis_pabf_54.time cevis_pabf_56.time cevis_pabf_57.time cevis_pabf_58.time xyplot_cevis.dat	Joints Locked Model

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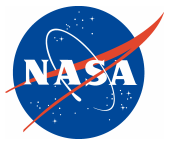
Appendix A:
NIRA 2003 Overall Analysis Plan (5 of 13)

Node/ Disturber	Analysis Type	Input Grid(s)	NASTRAN Files	ISS System Model Config
LAB ESS Aft IMV Fan [11,12]	FRF	306023	Force: dac9tf_ai_la12_r4.dat	Joints Locked Model
LAB ESS Fwd IMV Fan [11,12]	FRF	307815	Force: dac9tf_ai_la11_r4.dat	Joints Locked Model
LAB F-6 EXPRESS Rack AAAFan[11,12]	FRF	310144	Force: dac9tf_ai_lab1_r4.dat	Joints Locked Model
LAB F-1 Avionics URKB2BAIF [7,11,12]	FRF	302045	Force: dac9tf_ai_lab6_r4.dat	Joints Locked Model
LAB F-3 WORF LRSPIF [7,11,12]	FRF	304008	Force: dac9tf_ai_lab7_r4.dat	Joints Locked Model
LAB P-3 K-Bar I/F [11,12]	FRF	303114	Force: dac9tf_ai_lab8_r4.dat	Joints Locked Model
LAB Longeron, P-6 I/F [11,12]	FRF	305697	Force: dac9tf_ai_lab4_r4.dat	Joints Locked Model
LAB P-6 Heat Exchanger [11,12]	FRF	308564	Force: dac9tf_ai_lab2_r4.dat	Joints Locked Model
LAB S-2 Light Fr/Prod I/F [11,12]	FRF	301208	Force: dac9tf_ai_la10_r4.dat	Joints Locked Model
LAB S-6 Rack, Water Separator [11,12]	FRF	309917	Force: dac9tf_ai_lab3_r4.dat	Joints Locked Model
LAB Vent	TR	305850	Force/Moment: dac9ltl_ai_labvnt.dat dac9_labvnt.time xyplot_labvnt.dat	Joints Locked Model



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Appendix A:
NIRA 2003 Overall Analysis Plan (6 of 13)

Node/ Disturber	Analysis Type	Input Grid(s)	NASTRAN Files	ISS System Model Config
ND1 Aft Port Fan	FRF	10901	Moment: dac9tf_ai_nd1m1_r4.dat	Joints Locked Model
ND1 Alcove Port Fan [11]	FRF	10902	Force: dac9tf_ai_nd1f2_r4.dat	Joints Locked Model
ND1 ARED (Zenith I/F - Hatch - Exercise 0.7 Hz. Deadlifts) [3]	TR	100182, 100141, 100142, 100143, 100144, 100145, 100146, 100147, 100148	Force: dac9f_ared_xc_deadlifts_p7hz.dat tabled1_deadlift_p7hz_fx.dat tabled1_deadlift_p7hz_fy.dat tabled1_deadlift_p7hz_fz.dat tabled1_deadlift_p7hz_mx_fz.dat tabled1_deadlift_p7hz_my_fz.dat tabled1_deadlift_p7hz_mz_fy.dat	Joints Locked Model
ND1 ARED (Zenith I/F - Hatch Exercise 0.7 Hz Squats) [3]	TR	100182, 100141, 100142, 100143, 100144, 100145, 100146, 100147, 100148	Force: dac9f_ared_xc_squats_p7hz.dat tabled1_squat_p7hz_fx.dat tabled1_squat_p7hz_fy.dat tabled1_squat_p7hz_fz.dat tabled1_squat_p7hz_mx_fz.dat tabled1_squat_p7hz_my_fz.dat tabled1_squat_p7hz_mz_fy.dat	Joints Locked Model
ND1 ARED (Zenith IF Hatch Exercise 0.2 Hz Deadlifts with Deep Deflections) [3]	TR	100182, 100141, 100142, 100143, 100144, 100145, 100146, 100147, 100148	Force: dac9f_ared_xc_deadlifts_p2hz_ts_deep.dat tabled1_deadlift_p2hz_ts_deep_fx.dat tabled1_deadlift_p2hz_ts_deep_fy.dat tabled1_deadlift_p2hz_ts_deep_fz.dat tabled1_deadlift_p2hz_ts_deep_mx_fz.dat tabled1_deadlift_p2hz_ts_deep_my_fz.dat tabled1_deadlift_p2hz_ts_deep_mz_fy.dat	Joints Locked Model

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Appendix A:
NIRA 2003 Overall Analysis Plan (7 of 13)

Node/ Disturber	Analysis Type	Input Grid(s)	NASTRAN Files	ISS System Model Config
ND1 ARED (Zenith IF Hatch Exercise 0.2 Hz Squats with Deep Deflections) [3]	TR	100182, 100141, 100142, 100143, 100144, 100145, 100146, 100147, 100148	Force: dac9f_ared_xc_squats_p2hz_ts_deep.dat tabled1_squat_p2hz_ts_deep_fx.dat tabled1_squat_p2hz_ts_deep_fy.dat tabled1_squat_p2hz_ts_deep_fz.dat tabled1_squat_p2hz_ts_deep_mx_fz.dat tabled1_squat_p2hz_ts_deep_my_fz.dat tabled1_squat_p2hz_ts_deep_mz_fy.dat	Joints Locked Model
ND1 Midbay Port Fan [11]	FRF	10903	Force: dac9tf_ai_nd1f1_r4.dat	Joints Locked Model
ND1 Midbay Stbd Fan	FRF	10904	Moment: dac9tf_ai_nd1m2_r4.dat	Joints Locked Model
ND1 Z1 I/F	FRF	100182	Force/Moment: dac9tf_ai_nd1z1f_r4.dat dac9tf_ai_nd1z1m_r4.dat	Joints Locked Model
ND2 Midbay Port Fan [11]	FRF	160606	Force/Moment: dac9tf_ai_nd2f1_r4.dat dac9tf_ai_nd2m1_r4.dat	Joints Locked Model
ND2 Overhead Alcove [11]	FRF	160601	Force:/Moment: dac9tf_ai_nd2f2_r4.dat dac9tf_ai_nd2m2_r4.dat	Joints Locked Model
ND3 Overhead Alcove [11]	FRF	161601	Force/Moment: dac9tf_ai_nd3f2_r4.dat dac9tf_ai_nd3m2_r4.dat	Joints Locked Model
ND3 Midbay Port Fan [11]	FRF	161606	Force/Moment: dac9tf_ai_nd3f1_r4.dat dac9tf_ai_nd3m1_r4.dat	Joints Locked Model

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Appendix A:
NIRA 2003 Overall Analysis Plan (8 of 13)

Node/ Disturber	Analysis Type	Input Grid(s)	NASTRAN Files	ISS System Model Config
P1 & S1 TRRJ Slew	TR	248868, 248921, 648868, 648921	Force: dac9ltl_ai_trrj_slew.dat vac3_hrs_slew.time xyplot.trrj	***Joint Unlocked Model***
P1 & S1 TRRJ[10]	FRF	248868, 248921, 648868, 648921	Force: dac9tf_ai_trrj_ol.dat	***Joints Unlocked Model***
P3 & S3 SARJ[10]	FRF	226368, 223841, 626368, 623781	Force: dac9tf_ai_sarj_ol.dat	***Joints Unlocked Model***
P4 & S4 Beta Gimbal	FRF	405	Force/Moment: dac9tf_ai_p4f_r4.dat dac9tf_ai_p4m_r4.dat	Joints Locked Model
P6 & S6 Beta Gimbal	FRF	407	Force/Moment: dac9tf_ai_p6f_r4.dat dac9tf_ai_p6m_r4.dat	Joints Locked Model
P6 & S6 EPS-PO Radiator-Integrated Electronic Assembly I/F	FRF	999701	Force/Moment: dac9tf_ai_epsf_r4.dat dac9tf_ai_epsm_r4.dat	Joints Locked Model
P6 & S6 Long spacer / Short spacer I/F	FRF	800070	Force: dac9tf_ai_lspf_r4.dat	Joints Locked Model
S1 & P1 Heat Rejection Subsystem to TRRJ I/F	FRF	216900	Force/Moment: dac9tf_ai_s1f_r4.dat dac9tf_ai_s1m_r4.dat	Joints Locked Model

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NIRA 2003 Overall Analysis Plan (9 of 13)

Node/ Disturber	Analysis Type	Input Grid(s)	NASTRAN Files	ISS System Model Config
S3 & P3 IF to S4 & P4[10]	FRF	234301, 234304	Force/Moment: dac9tf_ai_s3f_r4.dat dac9tf_ai_s3m_r4.dat	Joints Locked Model
S4 & P4 Beta Gimbal	FRF	403	Force/Moment: dac9tf_ai_s4f_r4.dat dac9tf_ai_s4m_r4.dat	Joints Locked Model
S6 & P6 Beta Gimbal	FRF	401	Force/Moment: dac9tf_ai_s6f_r4.dat dac9tf_ai_s6m_r4.dat	Joints Locked Model
SM FGB I/F location	FRF	181015	Force: dac9tf_ai_smbs_r4.dat	***BaseShake***
SM Ergometer[3]	FRF	180021	Force/Moment: dac9tf_ai_smf_r4.da dac9tf_ai_smm_r4.dat	Joints Locked Model
SM Ergometer[3] (2 Hz. Pedal Speed)	TR	180021	Force/Moment: dac9_smerg_f2_t100_qp.dat tabled1_erg_f2_t100_fx.txt tabled1_erg_f2_t100_fz.txt tabled1_erg_f2_t100_mx.txt tabled1_erg_f2_t100_mz.txt	Joints Locked Model
SM RRED (Exercise 0.33 Hz Rowing -Moderate) [3]	TR	180021	Force/Moment: dac9_rred_rowing_mod_100sec.dat tabled1_rred_rowing_mod_100sec_fx.txt tabled1_rred_rowing_mod_100sec_fz.txt tabled1_rred_rowing_mod_100sec_my.txt	Joints Locked Model
SM RRED (Exercise 0.5 Hz Hammer Throw) [3]	TR	180021	Force/Moment: dac9_rred_hammer_2dir_15sd.dat tabled1_rred_hammer_2dir_15sd_fx.txt tabled1_rred_hammer_2dir_15sd_fz.txt tabled1_rred_hammer_2dir_15sd_my.txt	Joints Locked Model

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Appendix A:
NIRA 2003 Overall Analysis Plan (10 of 13)

Node/ Disturber	Analysis Type	Input Grid(s)	NASTRAN Files	ISS System Model Config
SM RRED (Exercise 0.25 Hz Torso Bending Unbending) [3]	TR	180021	Force/Moment: dac9_rred_torso_20cyc.dat tabled1_rred_torso_ub_20cyc_fx.txt tabled1_rred_torso_ub_20cyc_fz.txt tabled1_rred_torso_ub_20cyc_my.txt	Joints Locked Model
SM RRED (Exercise0.5 Hz Forearm Bending Unbending) [3]	TR	180021	Force/Moment: dac9_rred_fa_2s_15c_10sd.dat tabled1_rred_forearms_ub_2ser_15cyc_10sd_fx.txt tabled1_rred_forearms_ub_2ser_15cyc_10sd_fz.txt tabled1_rred_forearms_ub_2ser_15cyc_10sd_my.txt	Joints Locked Model
SM High Gain Antenna (HGA) Slew Disturbance	TR	180028	Moment: dac9ltl_ai_hga.dat dac3_hga.time xyplot_hga.dat	Joints Locked Model
SM HGA Brake Disturbance	TR	180028	Moment: dac9ltl_ai_hgabrake.dat vac3_hgabrake.time xyplot_hga.dat	Joints Locked Model
SM Solar Array	TR	180015, 180016	Moment: dac9ltl_ai_smsa.dat vac2_smsa.time xyplot_smsa.dat	Joints Locked Model
SM Treadmill I/F HTVIS_13	TR	180021	Force/Moment: dac9ltl_ai_htvis_13.dat htvis_13.time xyplot_htvis.dat	Joints Locked Model

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Appendix A:
NIRA 2003 Overall Analysis Plan (11 of 13)

Node/ Disturber	Analysis Type	Input Grid(s)	NASTRAN Files	ISS System Model Config
SM Treadmill I/F HTVIS_14	TR	180021	Force/Moment: dac9ltl_ai_htvis_14.dat htvis_14.time xyplot_htvis.dat	Joints Locked Model
SM Treadmill I/F HTVIS_17	TR	180021	Force/Moment: dac9ltl_ai_htvis_17.dat htvis_17.time xyplot_htvis.dat	Joints Locked Model
SM Vent	TR	180016	Force/Moment: dac9ltl_ai_smvent.dat vac3_sm_vent.time xyplot_smvent.dat	Joints Locked Model
SPP Science Power Platform Radiator	TR	182107	Moment: dac9ltl_ai_spprad.dat dac4_spprad.time xyplot_spprad.dat	Joints Locked Model
SPP Science Power Platform Solar Array	TR	182205	Moment: dac9ltl_ai_sppsa.dat dac6_sppsa.time xyplot_sppsa.dat	Joints Locked Model
SPP Science Power Platform Solar Array	FRF	182205	Force/Moment: dac9tf_ai_sppf_r4.dat dac9tf_ai_sppm_r4.dat	Joints Locked Model
Z1 CMG locations average[10]	FRF	281506, 282506, 283506, 284506	Force/Moment: dac9tf_ai_z1f_r4.dat dac9tf_ai_z1m_r4.dat	Joints Locked Model

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Appendix A: NIRA 2003 Overall Analysis Plan (12 of 13)

Part 2: Notes (superscripts) on NIRA 2003 Overall Analysis Plan

Shaded cases were run, but not used in the final results.

NOTE 1: Each "Standard" Payload Rack includes disturbances from:
1 AAA fan, 1 cold plate, 8 MDM disk drives,
1 urine processor motor, 8 WMC cabin air fan,
1 water dispenser pump, 1 video tape recorder.

NOTE 2: The "Standard" System Rack includes disturbances from:
2 ECLSS IMV fans, 1 ECLSS cabin fan, 1 heat exchanger,
2 waste gas shutoff valves, 2 PPO2 sensors, 1 water pump,
16 TCS valves, 2 3-way modulating TCS valves.

NOTE 3: Only one disturber from this group can be active at a time.

NOTE 4: Deleted.

NOTE 5: ESA Vent 1 & 2 replaced with ESA Vent VAC.

NOTE 6: Deleted.

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Appendix A:
NIRA 2003 Overall Analysis Plan (13 of 13)

NOTE 7: LRSPIF = "Lower Rack to Standoff Pivot Interface" and URKBBAIF = "Upper Rack K-Brace to Bayonet Attachment I/F".

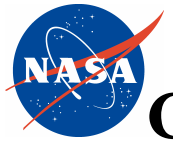
NOTE 8: AREDS Cases reduced from 6 to 4. Drop 0.2 Hz non "deep" cases.

NOTE 9: Lab Cold plates reduced to 1 full NASTRAN run per Boeing suggestion.

NOTE 10: Analysis performed within NASTRAN

NOTE 11: Boeing approach: Some or all disturbers in this module are unassigned to a specific input grid location. Therefore, envelope all FRF transfer functions to each output location and then scale using the RSS of all unassigned disturbers in that module

NOTE 12: Modification of approach in NOTE 11: Considering that the unassigned LAB disturbers are well distributed throughout the module, the RSS of all disturbers has been equally divided and reassigned to each of the 11 input locations.



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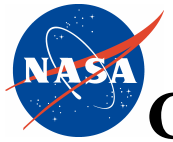
Appendix B:
Customer Recovery Grid Point Locations (1 of 5)

Grid Pt	Module	Location	Customer / Payload	Detailed Descriptions (revised 7/8/03)
100180	Node 1	I/F	LAB	Node1 Fwd i/f to Lab
100181	Node 1	I/F	PMA1	Node1 Aft i/f to PMA1 (RS)
100182	Node 1	I/F	Z1	Node1 Zenith i/f to Z1
100183	Node 1	I/F	Node 3	Node1 Nadir i/f to Node3
100184	Node 1	I/F	Airlock	Node1 Stbd i/f to Airlock
100185	Node 1	I/F	Cupola	Node1 Port i/f to Cupola
160017	Node 2	I/F	MPLM	Node2 Nadir i/f to MPLM
160037	Node 2	I/F	COF	Node2 Stbd i/f to ESA-COF
160057	Node 2	I/F	CAM	Node2 Zenith i/f to CAM
160077	Node 2	I/F	JEM PM	Node2 Port i/f to NASDA-JEM
161037	Node 3	I/F	PMA3 & CRV1	Node3 Stbd i/f to CRV
161077	Node 3	I/F	HAB	Node3 Port if to Hab
202514	CAM			CAM CR Rack Interface Point
224074	S3	AP	EXPRESS Pallet	Express Pallet point, Face 3, Bay 1, +Y Zenith s3uo
224221	S3	AP		AMS Internal point , Face 3, Bay 2, +Y Zenith s3ui
224324	S3	AP	EXPRESS Pallet	Express Pallet point, Face 5, Bay 1, -Y Nadir s3lo
224424	S3	AP	EXPRESS Pallet	Express Pallet point, Face 5, Bay 2, -Y Nadir s3li
231837	S3	AP	APAS #1 EXPRESS Pallet	APAS #1 S3 UI AMS Guide Vane, Face 3, Bay 2, +Y Zenith
231937	S3	AP	APAS #2 EXPRESS Pallet	APAS #2 S3 LI Express Pallet Guide Vane, Face 5, Bay 2, -Y Nadir
232837	S3	AP	APAS #3 EXPRESS Pallet	APAS #3 S3 UO Express Pallet Guide Vane, Face 3, Bay 1, +Y Zenith
232937	S3	AP	APAS #4 EXPRESS Pallet	APAS #4 S3 LO Express Pallet Guide Vane, Face 5, Bay 1, -Y Nadir



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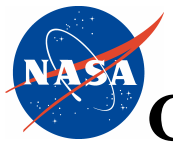
Appendix B:
Customer Recovery Grid Point Locations (2 of 5)

Grid Pt	Module	Location	Customer / Payload	Detailed Descriptions (revised 7/8/03)
301204	US Lab	1O4	EXPRESS #4 or AVCO	overhead light frame interface point (for actuators) LAC-4 (ARIS Rack in model)
301208	US Lab	1S2	CIR	overhead light frame interface point (for actuators) LAS-2 (ARIS Rack in model)
301209	US Lab	1S3	FIR	Upper ARIS Light Frame Attatchment
301210	US Lab	1S4	EXPRESS - 5	overhead light frame interface point (for actuators), ARIS Rack in model
301361	US Lab	1S4	EXPRESS - 5	Upper rack K-Brace to Bayonet Attachment i/f, ARIS Rack in model
301367	US Lab	1O4	EXPRESS #4 or AVCO	Upper rack K-Brace to Bayonet Attachment i/f, ARIS Rack in model
301378	US Lab	1S4	EXPRESS - 5	Upper rack K-Brace to Bayonet Attachment i/f, ARIS Rack in model
301400	US Lab	1O4	EXPRESS #4 or AVCO	Upper rack K-Brace to Bayonet Attachment i/f, ARIS Rack in model
302095	US Lab	1D3	WORF	Upper rack K-Brace to Bayonet Attachment i/f
302108	US Lab	1S4	EXPRESS - 5	Lower rack to Standoff Pivot i/f, ARIS Rack in model
302117	US Lab	1D3	WORF	Upper rack K-Brace to Bayonet Attachment i/f
302203	US Lab	1D6	ARC or EXPRESS	Upper rack K-Brace to Bayonet Attachment i/f
302209	US Lab	1S4	EXPRESS - 5	Lower rack to Standoff Pivot i/f, ARIS Rack in model
302225	US Lab	1D6	ARC or EXPRESS	Upper rack K-Brace to Bayonet Attachment i/f
303007	US Lab	1O4	EXPRESS #4 or AVCO	Lower rack to Standoff Pivot i/f, ARIS Rack in model
303008	US Lab	1O4	EXPRESS #4 or AVCO	Lower rack to Standoff Pivot i/f, ARIS Rack in model
304008	US Lab	1D3	WORF	Lower rack to Standoff Pivot i/f
304020	US Lab	1D6	ARC or EXPRESS	Lower rack to Standoff Pivot i/f
304111	US Lab	1D3	WORF	Lower rack to Standoff Pivot i/f
304223	US Lab	1D6	ARC or EXPRESS	Lower rack to Standoff Pivot i/f
314383	US Lab	?	WORF Camera	WORF Camera CG Point



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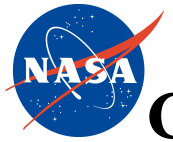
Appendix B:
Customer Recovery Grid Point Locations (3 of 5)

Grid Pt	Module	Location	Customer / Payload	Detailed Descriptions (revised 7/8/03)
334419	US Lab	1O4	EXPRESS #4 or AVCO	front right lower interface (for actuator), ARIS Rack in model
334735	US Lab	1O4	EXPRESS #4 or AVCO	front left lower interface (for actuator), ARIS Rack in model
337419	US Lab	1S2	CIR	front right lower interface (for actuator) LAS-2 (ARIS Rack in model)
337735	US Lab	1S2	CIR	front left lower interface (for actuator) LAS-2 (ARIS Rack in model)
338419	US Lab	1S3	FIR	Isolation Plate Attatch Point (iso8)
338735	US Lab	1S3	FIR	Isolation Plate Attatch Point (iso8)
339419	US Lab	1S4	EXPRESS - 5	front right lower interface (for actuator), ARIS Rack in model
339735	US Lab	1S4	EXPRESS - 5	front left lower interface (for actuator), ARIS Rack in model
624124	P3	SLP	Bay 1	Face 3, Bay 1, -Y Nadir, p3ucas – unpressurized logistics carrier
632837	P3	SLP	Bay 1	Face 5, Bay 1, +Z Zenith
632937	P3	SLP	Bay 1	Face 3, Bay 1, -Y Nadir, p3ucas interface point
702001	CAM			CAM to CR Interface Point
702002	CAM			CAM to CR Interface Point
702003	CAM			CAM to CR Interface Point
711314	JEM PM			Lower Left Hinge Point, Non-ARIS Overhead Rack 3 User Stowage
711356	JEM PM			Upper Right Strut i/f Point, Non-ARIS Overhead Rack 3 User Stowage
712214	JEM PM	1A2	NASDA SAIBO Rack	Lower Left Hinge Point, Non-ARIS , ISPR Fwd. Racks 1, 3, & 5
712256	JEM PM	1A2	NASDA SAIBO Rack	Upper Right Strut i/f Point, Non-ARIS , ISPR Fwd. Racks 1, 3, & 5
712514	JEM PM	1A2	NASDA SAIBO Rack	Lower Left Hinge Point, Non-ARIS , ISPR Fwd. Racks 1, 3, & 5
712556	JEM PM	1A2	NASDA SAIBO Rack	Upper Right Strut i/f Point, Non-ARIS , ISPR Fwd. Racks 1, 3, & 5
713314	JEM PM	1F3	NASDA KOBAIRO Rack	Lower Left Hinge Point, Non-ARIS Floor Rack 3 User Refrigerator



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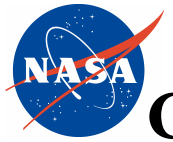
Appendix B:
Customer Recovery Grid Point Locations (4 of 5)

Grid Pt	Module	Location	Customer / Payload	Detailed Descriptions (revised 7/8/03)
713356	JEM PM	1F3	NASDA KOBAIRO Rack	Upper Right Strut i/f Point, Non-ARIS Floor Rack 3 User Refrigerator
714114	JEM PM	1F1	EXPRESS #1	Lower Left Hinge Point, Non-ARIS , ISPR Fwd. Racks 1, 3, & 5
714156	JEM PM	1F1	EXPRESS #1	Upper Right Strut i/f Point, Non-ARIS , ISPR Fwd. Racks 1, 3, & 5
714314	JEM PM	1F1	EXPRESS #1	Lower Left Hinge Point, Non-ARIS , ISPR Fwd. Racks 1, 3, & 5
714356	JEM PM	1F1	EXPRESS #1	Upper Right Strut i/f Point, Non-ARIS , ISPR Fwd. Racks 1, 3, & 5
714514	JEM PM	1F1	EXPRESS #1	Lower Left Hinge Point, Non-ARIS , ISPR Fwd. Racks 1, 3, & 5
714556	JEM PM	1F1	EXPRESS #1	Upper Right Strut i/f Point, Non-ARIS , ISPR Fwd. Racks 1, 3, & 5
721114	JEM ELM-PS	1A1	ZSR	Aft rack 1 Lower Left Hinge Point
721156	JEM ELM-PS	1A1	ZSR	Aft rack 1 Upper Right Strut i/f Point
734402	JEM EF	Bay 2	LTMPF	P/L #2 i/f
734409	JEM EF	Bay 9	Non-specific P/L	P/L #9 i/f (for demo of environment on other side of facility)
751104	CAM			CR Inner VIM Point
751105	CAM	1A5	CAM Rotor Rack	CR FSJ Coupler Point
751108	CAM	1A4 or 1F5	HHR #1 & HHR #2	CR Habitat Rack Point (in a “strong” cross-arm)
751109	CAM	1A4 or 1F5	HHR #1 & HHR #2	CR Habitat Rack Point (in adjacent “week” in-between cross-arm)
759925	CAM		Cam interiror	CAM CR Rack Internal Point
2190189	COF EP	Up	ESA External Payloads	Up
2190225	COF EP	Up	ESA External Payloads	Up
2190408	COF EP	Up	ESA External Payloads	Up
2195189	COF EP	Down	ESA External Payloads	Down
2195225	COF EP	Down	ESA External Payloads	Down



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Appendix B:
Customer Recovery Grid Point Locations (5 of 5)

Grid Pt	Module	Location	Customer / Payload	Detailed Descriptions (revised 7/8/03)
2195408	COF EP	Down	ESA External Payloads	Down
2360162	COF	1A1	EXPRESS #6	Front bottom in ARIS A1 Rack
2364197	COF	1A1	EXPRESS #6	Front bottom in ARIS A1 Rack, common point with A2 rack
2368427	COF	1A2	MSG	Front bottom in ARIS A2 Rack
2466368	COF	1A1	EXPRESS #6	overhead point in ARIS A1 Rack
2467969	COF	1A2	MSG	overhead point in ARIS A2 Rack
2491614	COF	1O1	ESA Fluids Science Lab (FSL)	Overhead, Non-ARIS racks bottom i/f to 01, standoff OA
2493630	COF	1O1 / 1O2	FSL & ESR	Overhead, Non-ARIS racks bottom i/f to 01/02, standoff OA
2495646	COF	1O2 / 1O3	ESR & AVCO	Overhead, Non-ARIS racks bottom i/f to 02/03, standoff OA
2497761	COF	1O3 / 1O4	AVCO & ZSR	Overhead, Non-ARIS racks bottom i/f to 03/04, standoff OA
2499876	COF	1O4	ZSR	Overhead, non-ARIS racks bottom i/f to 04, standoff OA
2562178	COF	1F1	ESA European Drawer Rack (EDR)	Front bottom in ARIS F1 Rack
2566312	COF	1F1	ESA European Drawer Rack (EDR)	Front bottom in ARIS F1 Rack
2683892	COF	1F1	ESA European Drawer Rack (EDR)	overhead point in ARIS F1 Rack
2691600	COF	1O1	ESA Fluids Science Lab (FSL)	Overhead, Non-ARIS racks top i/f to 01, standoff OF
2693616	COF	1O1 / 1O2	FSL & ESR	Overhead, Non-ARIS racks top i/f to 01/02, standoff OF
2695632	COF	1O2 / 1O3	ESR & AVCO	Overhead, Non-ARIS racks top i/f to 02/03, standoff OF
2697747	COF	1O3 / 1O4	AVCO & ZSR	Overhead, Non-ARIS racks top i/f to 03/03, standoff OF
2699861	COF	1O4	ZSR	Overhead, non-ARIS racks bottom i/f to 04, standoff OF