FEMCI NASTRAN Jitter Analysis Primer

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NASA GSFC Code 542
Aug. 21, 2003

Outline

- Presentation Scope
- What is Jitter Analysis?
- NASTRAN Implementation
- Example Problem
- Multiple Load Cases
- Interfacing with Other Software
- Conclusions

Presentation Scope

- This presentation is:
  - a general introduction to performing jitter analysis in NASTRAN
  - Focus is on jitter for full, on-orbit spacecraft
  - Jitter input assumed to be in frequency domain (PSD format)
  - Modal method rather than direct method of frequency response

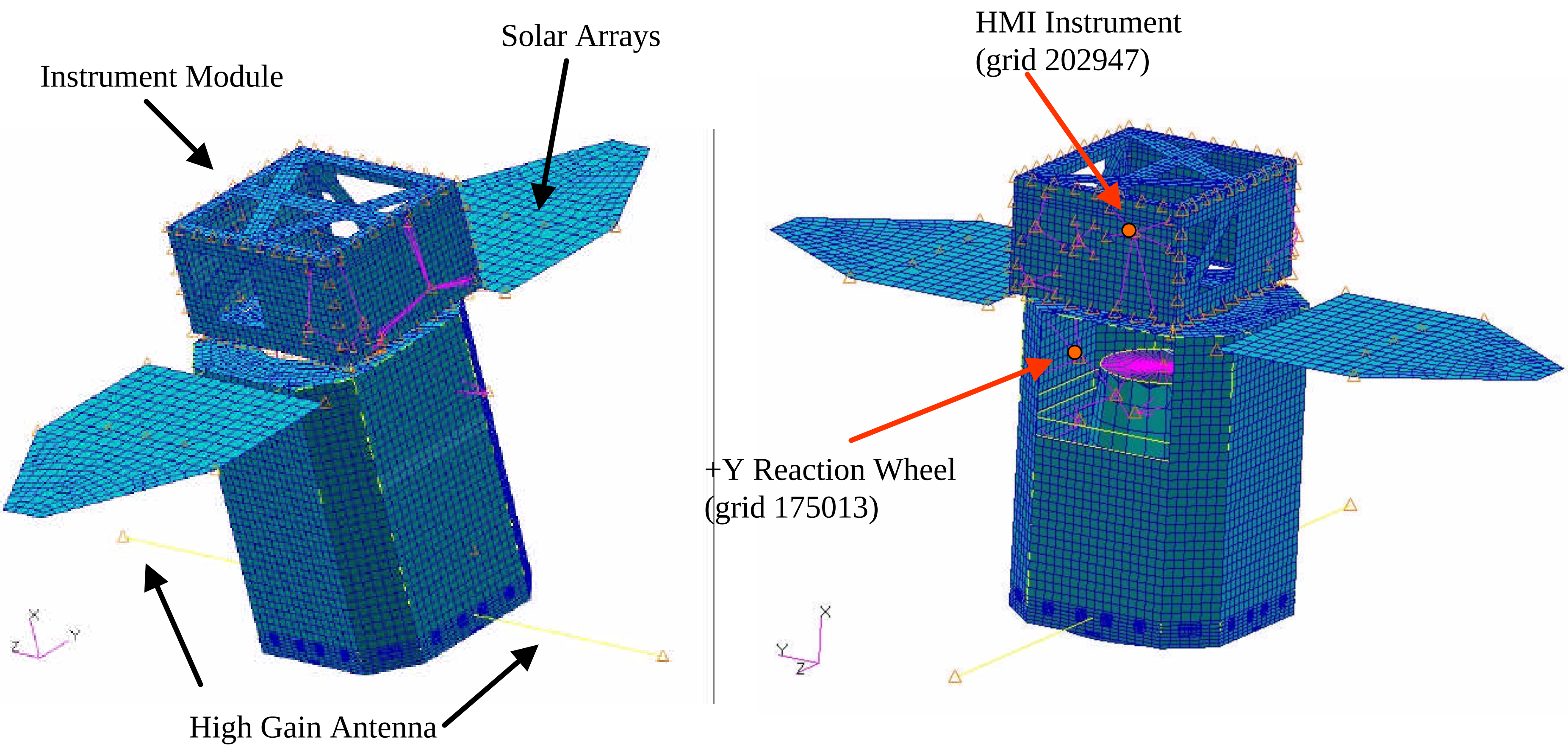
What is Jitter Analysis?

- Frequency response analysis
- Response of spacecraft and instrument components to on-orbit dynamic excitation
- Caused by reaction wheels, mechanisms, and other moving components
- Usually low energy excitations with low damping
- Used in assessing performance of optics, antennas, etc

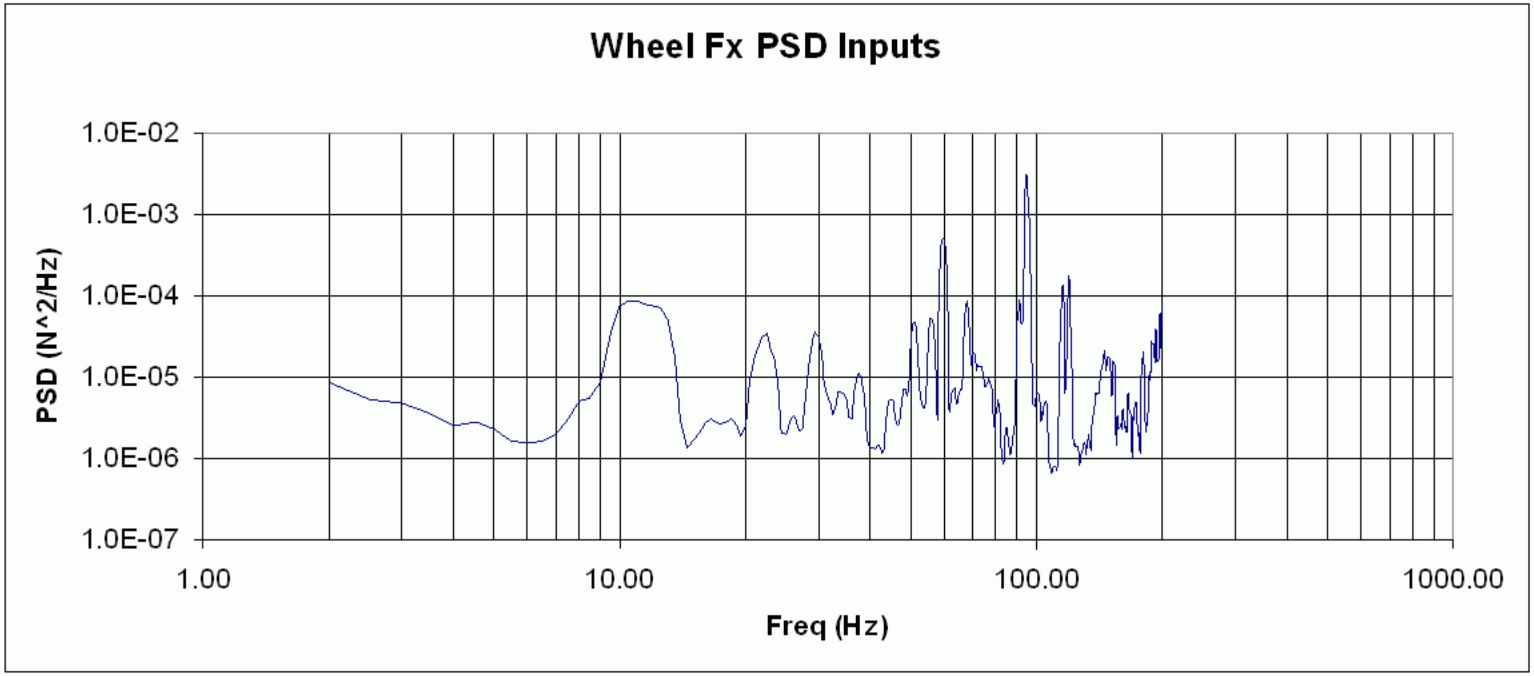
NASTRAN Implementation

- Very similar to base-drive random analysis
- S/C in free-free configuration
- Disturbance input in force units (as opposed to g^2/Hz)
- Overall model damping very low
  - < 0.5% (Q > 100.)

Example Problem - SDO



+Y Reaction Wheel Fx Input



- Wheel disturbance data is usually proprietary and you'll need to go directly to the manufacturer for the specs.
- Data may need to be converted to the frequency domain, PSD format that we typically use.

Executive and Case Control

```
SOL 111
TIME 10
$ Direct Text Input for Executive Control
CEND
SEALL = ALL
SUPER = ALL
TITLE = SDO Beginning of Life Jitter
subtitle= Fx Jitter From +Y Wheel
ECHO = NONE
MAXLINES = 999999999
$
SDAMPING=20
RANDOM=30
FREQ=40
METHOD=1
LABEL= X_in_wpy
DLOAD=10
$
OUTPUT(XYPLOT)
XYPEAK,XYPUNCH,DISP,PSDF/ 175013(T1), 202947(T1), 202947(T2), 202947(T3)
```

Frequency Response Solution

Cards controlling overall analysis inputs:
SDAMPING - Calls **TABDMP1** card
RANDOM - Calls **RANDPS** card(s)
FREQ - Calls **FREQ#** cards
METHOD - calls eigenvalue extraction card

Calls **RLOAD** card for dynamic load input

Produces the PSD output files including DISP response in punch file, and RMS values in F06 file

Bulk Data Deck

```
BEGIN BULK
PARAM,RESVEC,ALL
$
RLOAD2,10,11,,,12,,LOAD
DAREA,11,175013,1,1.0
TABLED1,12,,,,,,,,+
+,.1,1.,200.0,1.,ENDT
$
TABDMP1,20,,,,,,,,+
+,.1,0.002,200.0,0.002,ENDT
$
RANDPS,30,1,1,1.0,0.0,31
$
TABRND1,31,LOG,LOG,,,,,,+
+,1.99, 8.78-6, 2.00, 8.78-6, 2.50, 5.37-6, 3.00, 4.69-6,+
…
+,199.50, 3.29-5,200.00, 8.02-5,200.01, 8.02-5,ENDT
$
FREQ1,40,2.0,2.0,99
FREQ4,40,.2,200.0,.1,5
$
EIGRL,1,0.,200.
...
```

Cards for specific load case:
RLOAD2 - calls cards for location and scaling of load as well as specifying type. In this case **LOAD** (applied force or moment)
DAREA - specifies input grid and DOF and constant scaling factor
TABLED1 - specifies a freq. dependent scale factor

Freq. dependent damping (0.1%)

Calls the table with random vibe. inputs

Freq vs PSD

Specify frequencies for response data

Inputting Simultaneous Load Cases

- Can input multiple load cases at different points on model
- Use subcases and specify individual DLOAD cards referencing different RLOAD2, DAREA, and TABELD1 cards for each subcase
- Multiple RANDPS cards (with same SID) indicating subcase and TABRND1
- If load cases are “correlated” you will need to include the coupling spectral densities on other RANDPS cards
- XYPUNCH results will be for the sum of all subcases

Subcase Example

```
SDAMPING=20
RANDOM=30
FREQ=40
METHOD=1
$
SUBCASE 1
 LABEL= X_in_wpy
 DLOAD=10
$
SUBCASE 2
 LABEL= X_in_wpz
 DLOAD=20
$
OUTPUT(XYPLOT)
XYPEAK,XYPUNCH,DISP,PSDF/ 175013(T1), 202947(T1), 202947(T2), 202947(T3)
.
.
```

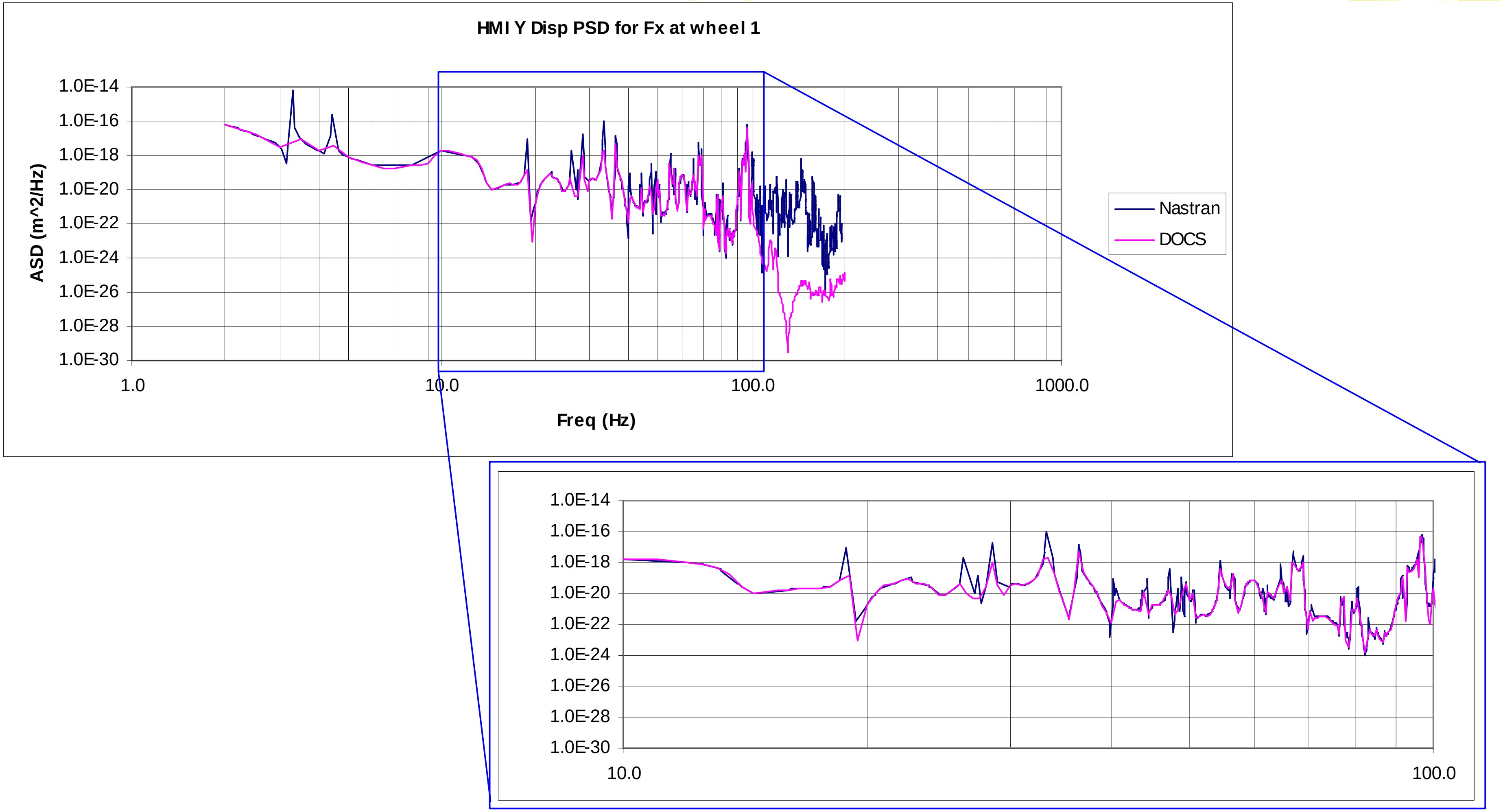
Subcase Example (Cont.)

```
RLOAD2,10,11,,,12,,LOAD
DAREA,11,175013,1,1.0
TABLED1,12,,,,,,,,+
+,.1,1.,200.0,1.,ENDT
$
RLOAD2,20,21,,,22,,LOAD
DAREA,21,175014,1,1.0
TABLED1,22,,,,,,,,+
+,.1,1.,200.0,1.,ENDT
$
TABDMP1,20,,,,,,,,+
+,.1,0.002,200.0,0.002,ENDT
$
RANDPS,30,1,1,1.0,0.0,31
RANDPS,30,2,2,1.0,0.0,32
RANDPS,30,1,2,1.0,0.0,31
$
TABRND1,31,LOG,LOG,,,,,,+
…
$
TABRND1,31,LOG,LOG,,,,,,+
…
$
FREQ1,40,2.0,2.0,99
FREQ4,40,.2,200.0,.1,5
```

Interfacing with Other Software and Engineers

- More tools external to NASTRAN are available for jitter analysis.
- Typically use eigenvectors from specific input and output points in NASTRAN model to create transfer functions and perform modal analysis.
  - Usually assume mass normalized eigenvectors
  - Depend on having sufficient modal information from NASTRAN for accurate results
  - Have greater flexibility than NASTRAN for performing trade studies and varying load cases, damping, etc.
  - Will be eigenvectors for a small subset of nodes. Plots or animations of the full model normal modes may also be useful references

Sample Results Plots from NASTRAN and DOCS



Conclusions

- Jitter analysis in NASTRAN is very similar to our typical random vibration analysis.
  - Low damping
  - Usually free-free condition with force PSD input
  - Multiple load cases
- External tools can allow analysts additional flexibility in performing jitter analyses with NASTRAN normal modes output.
  - Only as good as the NASTRAN modal data