<u>Acceleration of the LAT within the Transport Box</u>

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The LAT of mass "m" is mounted on springs with a combined spring constant "k". The springs + LAT have a resonant frequency ω0=sqrt(k/m).

One end of the spring is connected to the aircraft (or the box wall). This end of the spring is driven by 1) Vibration and airpockets through contact with the airplane, or 2) Accoustics through pressure on the Transport Box wall.

1) Consider the airplane floor moving with some xfloor(t) irrespective of the mass m. The floor acceleration has a fourier spectrum of afloor(ω)=xfloor(ω)*ω^2 . Assume the floor acceleration amplitude is independent of freq (as it would be for a narrow delta function acceleration of amplitude afloor_vib0). Let xlat(t) be the position of the LAT mass m. The differential eqn for the sysem is:

$$\frac{d^2}{dt^2}\,xlat + \gamma\cdot\frac{d}{dt}(xlat - xfloor) + \frac{k}{m}\cdot(xlat - xfloor) = 0 \qquad \omega0^2 := \frac{k}{m}$$

$g := 9.8$ [m/sec^2] Acceleration of gravity

$afloor\_vib0 := .5\cdot g$ [m/sec2] Vibration acceleration amplitude

$\Delta xmax := \frac{2}{39}$ $\Delta xmax = 0.051$ [m] Max compressive travel of spring from loaded equilibrium

$\omega0 := \sqrt{\frac{afloor\_vib0}{\Delta xmax}}$ $\frac{\omega0}{2\cdot\pi} = 1.556$ [Hz] Resonant freq of spring + LAT

$Q := .1$ Q of the spring (very low to suppress the resonance)

$\gamma := \frac{\omega0}{Q}$ Damping constant

$$xfloor\_vib(\omega) := \frac{afloor\_vib0}{\omega^2} \qquad xlat\_vib(\omega) := \frac{\omega0^2 + i\cdot\gamma\cdot\omega}{\omega0^2 - \omega^2 + i\cdot\gamma\cdot\omega}\cdot xfloor\_vib(\omega) \qquad alat\_vib(\omega) := \omega^2\cdot xlat\_vib(\omega)$$

2) Consider a flat spectrum acoustic pressure wave acting on one side (the floor) of the box with force F(t). Assume the acoustic force on the wall is independent of frequency (db is the same at all frequencies)

$$\frac{d^2}{dt^2}\,xlat + \gamma\cdot\frac{d}{dt}xlat + \frac{k}{m}\cdot xlat = \frac{F(t)}{m} \qquad afloor\_acoustic(\omega) := \frac{F(\omega)}{m}$$

$db := 100$ [decibels] Sound pressure relative to 2x10^-5 Newtons/m^2

$A := 2\cdot 3$ [m^2] Area of side of box

$m := 4000$ [kg] Mass of LAT + perimeter ring + isolation frame

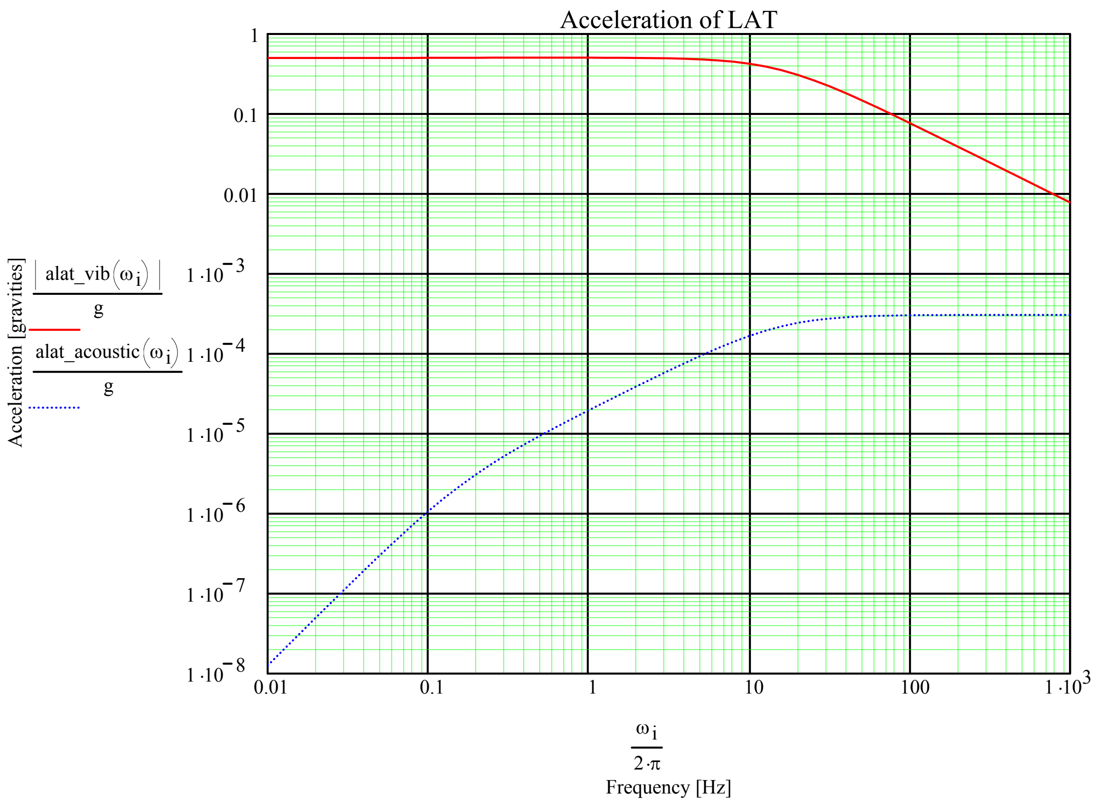
$$afloor\_acoustic0 := \frac{A\cdot 2\cdot 10^{-5}}{m}\cdot 10^{\frac{db}{20}}$$

[m/sec2] Acoustic acceleration amplitude

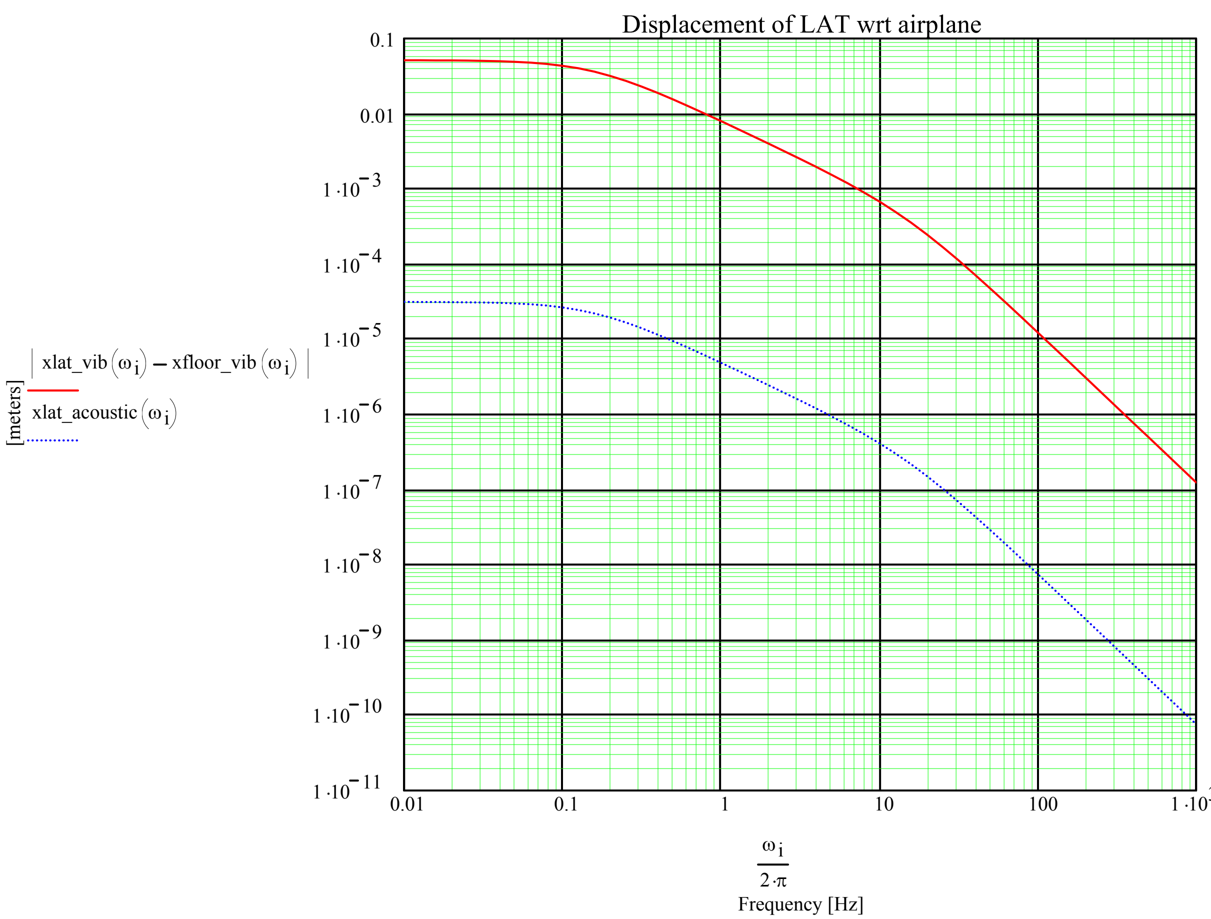
$afloor\_acoustic0 = 3\cdot 10^{-3}$

$$xlat\_acoustic(\omega) := \frac{afloor\_acoustic0}{\sqrt{\left(\omega0^2 - \omega^2\right)^2 + (\gamma\cdot\omega)^2}} \qquad alat\_acoustic(\omega) := \omega^2\cdot xlat\_acoustic(\omega)$$

$i := 0 .. 50$ $\omega_i := 2\cdot\pi\cdot 10^{\frac{i}{10} - 2}$



Acceleration of LAT
1
0.1
0.01
1·10^−3
1·10^−4
1·10^−5
1·10^−6
1·10^−7
1·10^−8
0.01
0.1
1
10
100
1·10^3
Acceleration [gravities]
|alat_vib(ωi)| / g
alat_acoustic(ωi) / g
ωi / 2·π
Frequency [Hz]



Displacement of LAT wrt airplane
0.1
0.01
1·10^−3
1·10^−4
1·10^−5
1·10^−6
1·10^−7
1·10^−8
1·10^−9
1·10^−10
1·10^−11
0.01
0.1
1
10
100
1·10^3
[meters]
|xlat_vib(ωi) − xfloor_vib(ωi)|
xlat_acoustic(ωi)
ωi / 2·π
Frequency [Hz]

GLAST Random Vibration Spectrum (from Jim Haughton 202-767-4689 via Mike Lovellete) for Military transport aircraft.

$Hz_k :=$

15
105
150
500
2000

$g2Hz_k :=$

.010
.010
.020
.020
.001

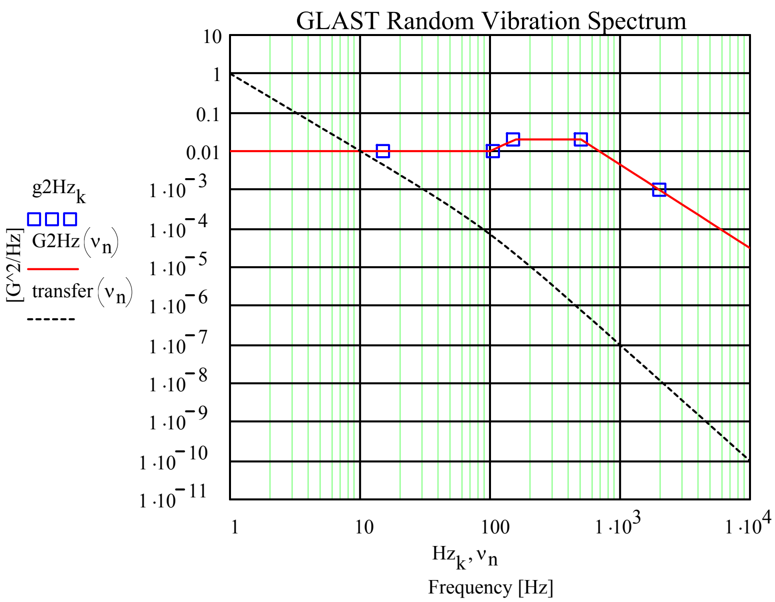
$n := 0 .. 40$

$\nu_n := 10^{\frac{n}{10}}$

$k := 0 .. 4$

$$transfer(\omega) := \left| \frac{1}{\omega^2} \cdot \frac{\omega0^2 + i \cdot \gamma \cdot \omega}{\omega0^2 - \omega^2 + i \cdot \gamma \cdot \omega} \right|$$

$$G2Hz(\nu) := 10^{linterp(\log(Hz), \log(g2Hz), \log(\nu))}$$



$$rms := \sqrt{\int_{.1}^{10000} G2Hz(\nu) \cdot transfer(2 \cdot \pi \cdot \nu)\, d\nu}$$

$rms = 0.05$ [gravities]