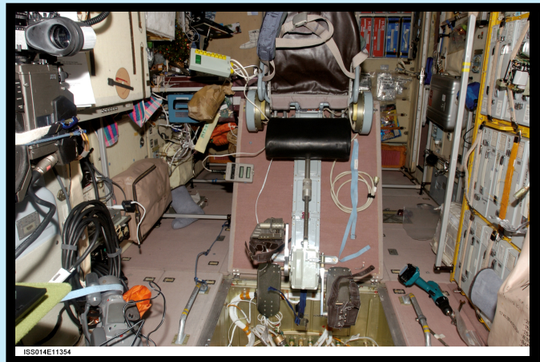
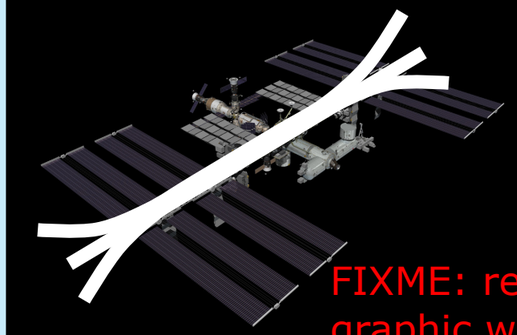
Crew Exercise Shakes The Space Station



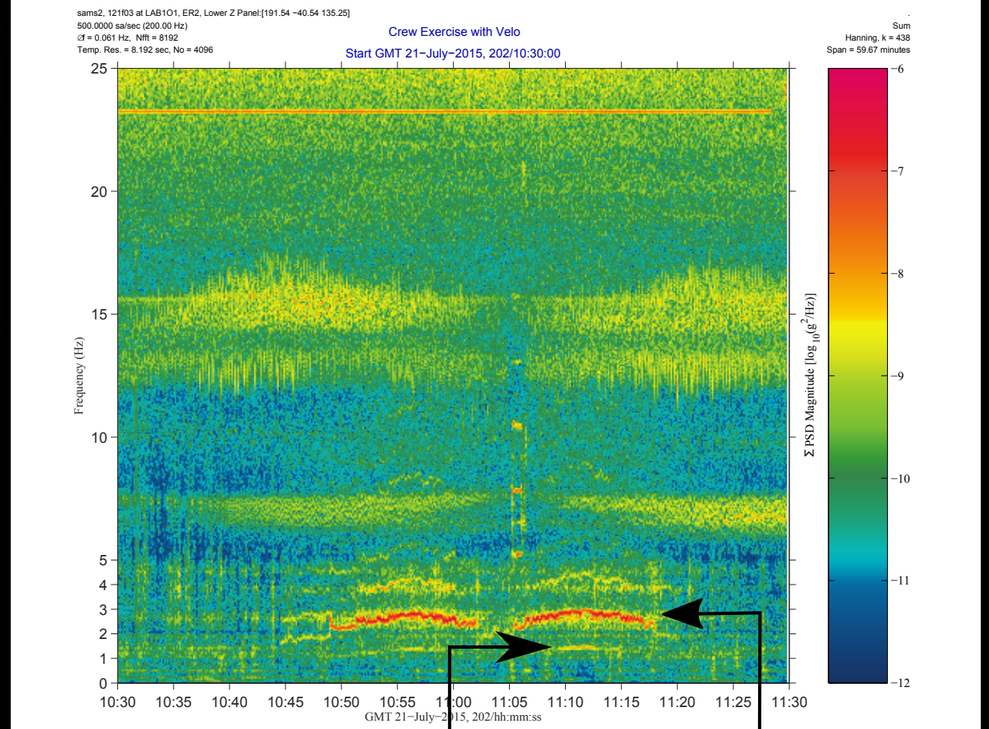
VELO exercise bike located in Zvezda Service module
(see pedals at center-bottom of photo)

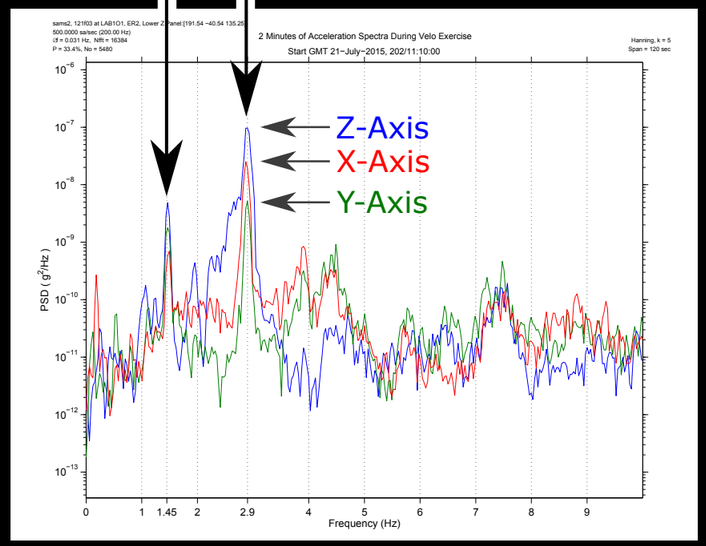
MECHANICAL RESONANCE
Simply stated, resonance occurs when one object vibrates at the natural (preferred) frequency of a second object, it forces that second object into vibrational motion provided that there is some form of mechanical coupling between the two objects.



FIXME: replace ISS graphic with bending (motion blur?) depiction.

STRUCTURAL DYNAMICS
The space station is a complex interconnection of mechanical parts. The graphic above shows an amplified depiction for the displacement associated with the vibrations of its "backbone", its main truss, which is about the same length as a football field (Go Browns!).





The International Space Station (ISS) crew routinely performs physical exercise as a countermeasure to some known physiological effects that come with their reduced gravity environment, such as loss of muscle mass, bone density, and aerobic capacity. A number of exercise devices and protocols are used and here we take a look at the **impact of Velo (bike) exercise on the space station's vibratory environment**. The color spectrogram in the top plot shows an hour of the acceleration spectra vs. time. The **vibratory signature of Velo exercise is evidenced by the red horizontal streaks just below 3 Hz** between 10:45 and 11:20.

The pedaling on the Velo bike was done at a pace near a resonant frequency of space station structure, and while the driving force may be from the pedaling motion of exercise (at the aft-end of the ISS), the acceleration measurements recorded in the US Lab (farther toward the front of the ISS) show that this **crew exercise shakes the station**.

The 3-axis power spectral density (PSD) traces shown in the bottom plot reveal that the **pedaling frequency was at about 1.45 Hz (or 87 RPM), which resonated with the 2nd harmonic of space station structure near 2.9 Hz**. Modal analysis of the space station confirms that the station has a resonant frequency at this frequency aligned with its XZ-plane. Note that the X-Axis and Z-Axis PSD peaks are relatively strong in the bottom plot.

Parseval's theorem was used to calculate the **overall RMS acceleration level (below 5 Hz), and during Velo exercise that RMS value was 144x10^{-6} g, and only 22x10^{-6} g before the exercise began**.

http://pims.grc.nasa.gov