G.R.A.S. Sound & Vibration A/S

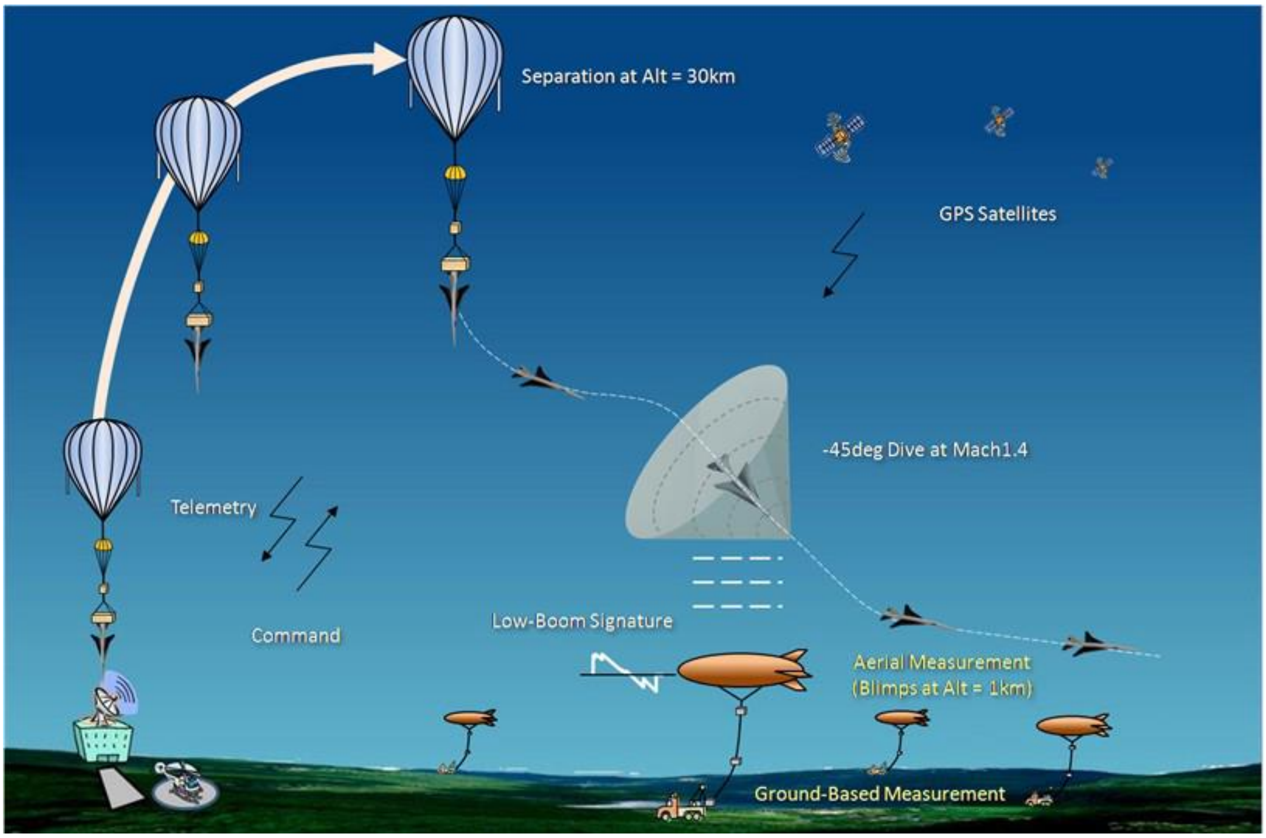
The G.R.A.S. 47AC Infra-sound Microphone Set is a commercially available version of the special microphone that G.R.A.S. developed for the Japan Aerospace Exploration Agency (JAXA) in 2012 to enable realistic measurements of sonic booms. The 47AC has the same properties, and therefore it is ideally suited to meet the kind of challenges that JAXA faced in 2012.

JAXA's Sonic Boom Tests in 2012

The Japan space exploration agency JAXA is currently investigating new techniques to reduce the impact from supersonic booms generated by supersonic flight. In the D-SEND Program (Drop Test for Simplified Evaluation of Non-Symmetrically Distributed sonic boom) advance full-scale models of "low-boom" design for aircraft body design, fig1, are being investigated.

Fig 1. Jaxa D-SEND No. 2 Test Model

The models are lifted balloons to a height 30 km, where the Test Model is separated from the balloon and glides in a supersonic flights past an array of special low frequency microphones to measure the sonic boom generated by the model.



A typical, traditional supersonic boom has the characteristic N-wave form as shown in fig 3. The sonic boom consist of first a very steep pressure increase, which requires a high bandwidth microphone with the ability to measure relatively high frequencies. This phase is followed by a relatively slow decrease of pressure over a period of 0.1 to 0.3 s and then again followed by a rapid pressure increase.

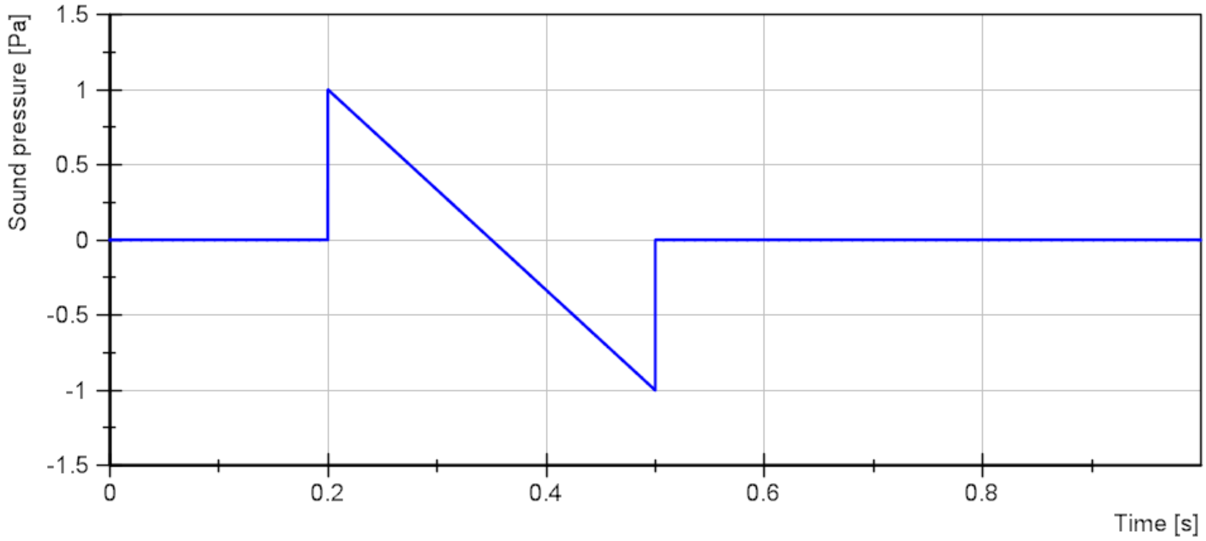


Fig. 3 Typical supersonic boom N-wave

The accurate measurement of the slowly decreasing pressure signal requires microphones which are able to reproduce low frequencies. Normal measurement microphones typically have a lower cut-off in the range from 5 to 10 Hz. Fig. 4 shows a comparison of a supersonic N-wave as measured with an “ideal” transducer and a microphone with a lower cut-off frequency of 10 Hz.

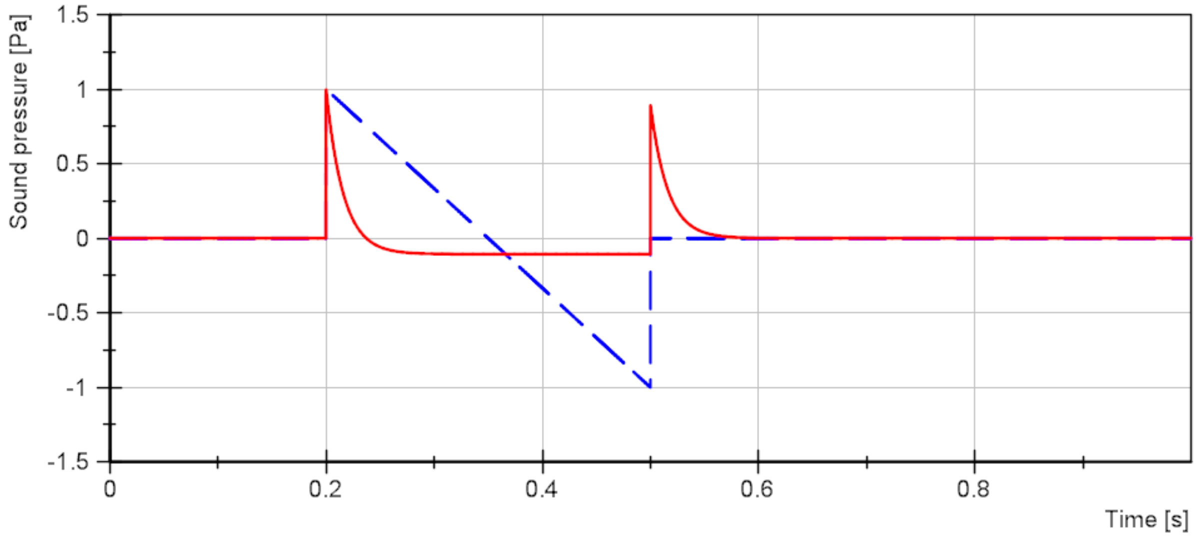


Fig 4. Supersonic boom as measured with a microphone with 10 Hz (red curve) lower limiting frequency

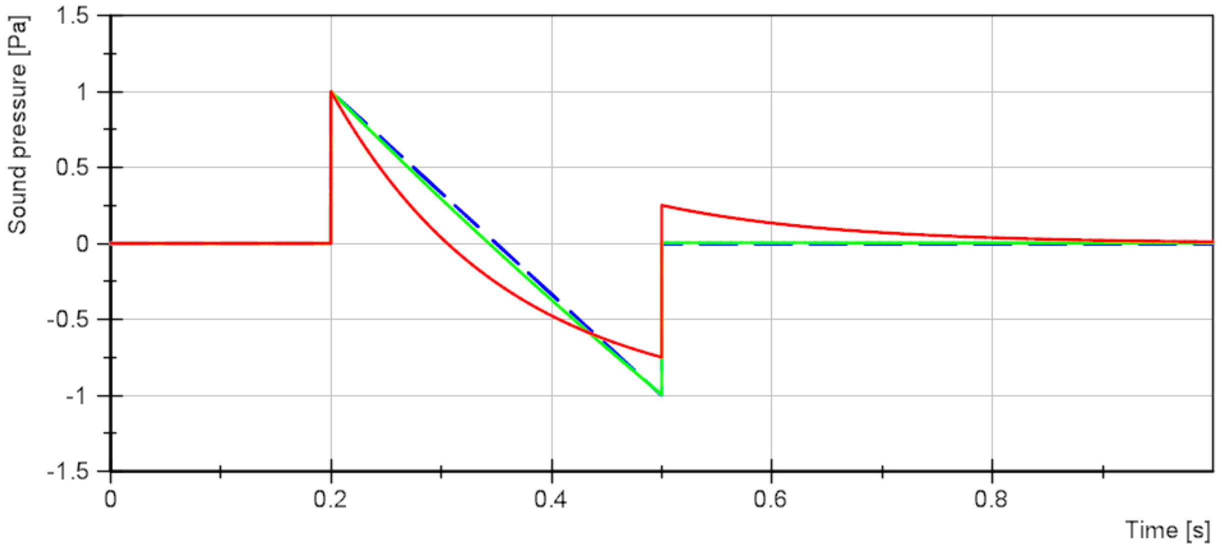


Fig 4. Supersonic boom as measured with a microphone with 1 Hz lower limiting frequency (red curve) and 0.1 Hz lower limiting frequency (green curve)

It can be seen that the lower limiting frequency should be below 0.1 Hz in order to reproduce the shape of the supersonic boom correctly. GRAS developed a microphone specifically optimized for this application. The assembly is available in two version as shown in fig 5. The 40AZ-S1 is version in a straight configuration while 40AZ-S2 has a 90 deg angle adaptor. Both versions are complete assemblies of microphone and preamplifier with a low frequency cut-off at 0.09 Hz.

Fig 5. 40AZ-S1 Low frequency microphone and preamplifier combination.

The preamplifier is a CCP type for direct connection to IEPE data acquisition unit and the transducer parameters are stored internally in the TEDS memory chip for easy access by the user.

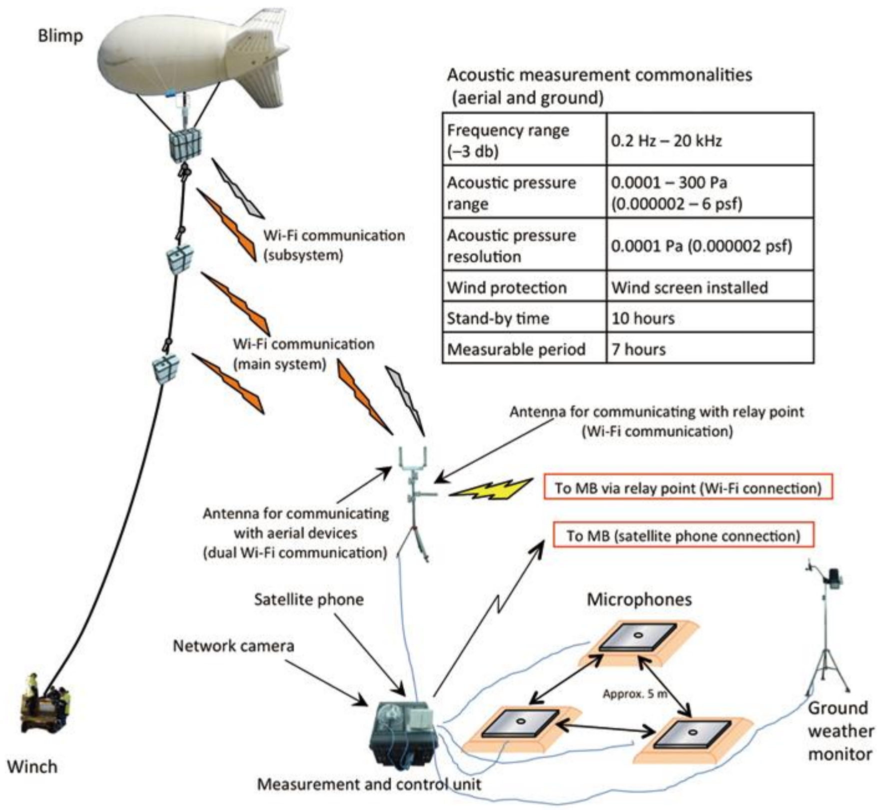


Fig 5. JAXA D-Send measuring system configuration

The microphones were incorporated in the JAXA measuring system in two ways. The 40AZ-S1 microphones were mounted on several positions on wires attached to a number of blimps which were raised to 1000 m height. The 40AZ-S2 was placed on the ground in with the diaphragm parallel to the ground in a number of positions with three microphones in each position.

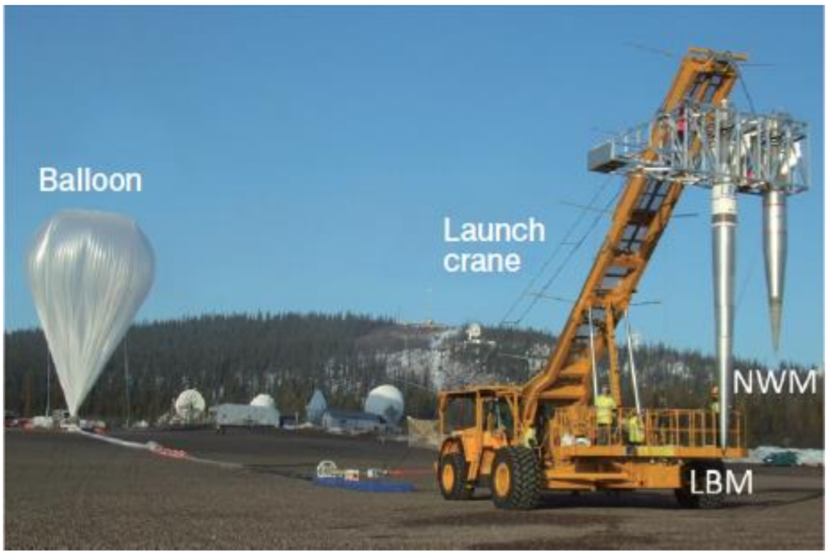


Fig. 7 Balloon launch preparation with two test objects: NWM (Normal Wave Model) and LBM (Low Boom Model).

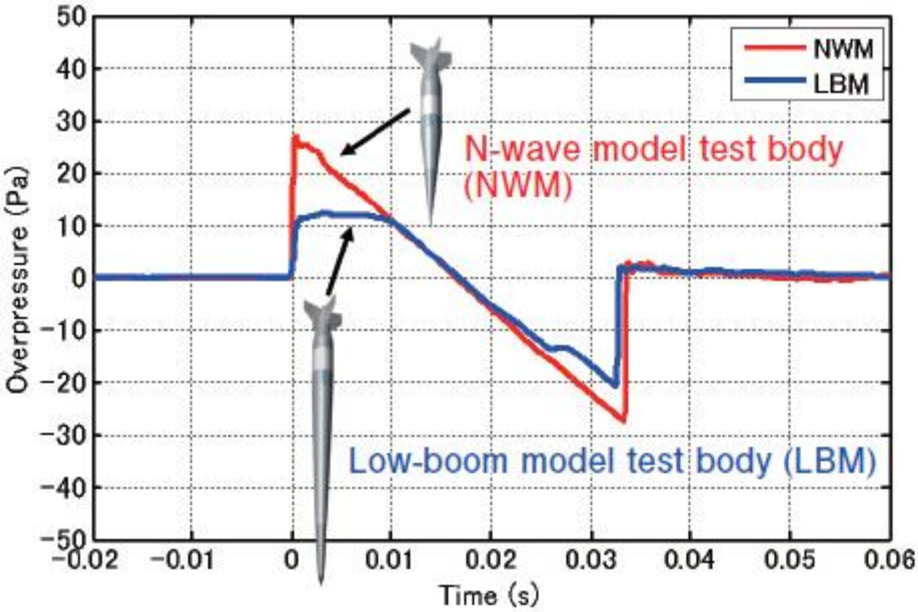


Fig. 8 Comparison of sonic boom from NWM and LBM

Fig 8 shows a typical result obtained from the D-SEND #1 test performed in May 2011 and clearly shows the effect of the special body on the super-sonic boom.

Read more here:
http://www.gras.dk/industries/aerospace-defense/sonic-boom.html

http://www.gras.dk/media/MiscFiles/IndustrySection/Sonicboom_measurement_jaxa.pdf