MODAL SPACE - IN OUR OWN LITTLE WORLD by Pete Avitabile

Illustration by Mike Avitabile

Do you need to mount triaxial accelerometers at all locations? That can result in more channels needed and more cost. Let's discuss this and think about it.

Well, let's talk about this as well as a few other things that relate to how your structure is instrumented.

First, let me say that triaxial accelerometers are very useful in many, many applications. They allow for a very compact package to be used to monitor all three directions from one physical mounted transducer on a structure. Yes, I do use them but as it turns out I really don't use them all the time and there are many cases where I absolutely will not use triaxial accelerometers and we will discuss some of the reasons why.

First of all, we all realize that we can "make" a triaxial accelerometer by mounting three separate accelerometers onto one mounting block. Now of course this is not as elegant as a triaxial accelerometer, but it is one simple and economical way to accomplish this. And of course it also means that you can buy three separate accelerometers which are just about the same price as the triaxial accelerometer. But remember that there is one different distinction.

When I mount the triaxial accelerometer on my structure under test and I really only need to measure one direction, then I have wasted two accelerometers for all practical purposes. And if someone else needs to make some measurements, you have three accelerometers tied up for each measurement location whether or not you use all three. Now if you had three separate accelerometers then you wouldn't be tying up all the accelerometer inventory! Now this may sound silly but when you don't have a lot of accelerometers and all of them are triaxial, then you have tied up a lot of instrumentation if you really only needed a single axis accelerometer. I have seen some laboratories that have bought all triaxial accelerometers and when there are multiple tests to be run, all the instrumentation is tied up on one test.

OK. So now let's discuss a few more things. Let me first start with a simple free-free beam test. (You know that all of us "educators in academia" all test beams all the time.) So if we want to test a simple beam and find the modes in transverse bending in only one direction, then we would have a test set up with something like that shown in Figure 1 where there are 15 measurement locations along the length of the beam.

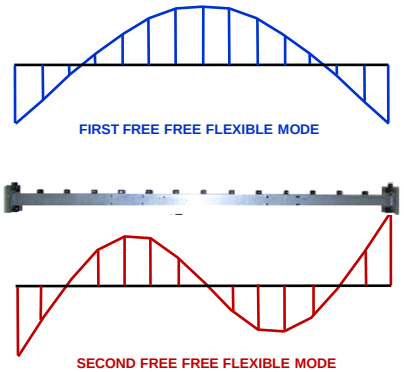

Figure 1: Schematic Planar Beam Modal Test

Now if all I had was traxial accelerometers, I would be tying up 45 measurement transducers and really only needing 15 of those for the measurement at hand. Now of course you could argue that I might need to also test the other planar beam bending direction too and would need another 15 accelerometers for that. But I still would have 15 measurement transducers that are not utilized if I really didn't need the axial direction too.

And again you would probably say that this is an academic situation and you may really need all those triaxial accelerometers for a typical application. So I will agree but let me show a few cases where you might want to rethink this.

Recently we have done quite a few big wind turbine blade modal tests where the main interest is the bending in two directions referred to as the flapwise and edgewise modes of the anchored wind turbine blade. (And so realize this is nothing more than a "really big" beam for all practical purposes.) Figure 2 shows the schematic for a 9 meter wind turbine blade test with some accelerometer configurations. Notice that there are only measurements in 2 directions (x and y) because the axial direction is really not of interest. This test was run with a very portable 8 channel system with 7 accelerometers and one hammer. When the test was run the first set of measurements were made with 7 accelerometers at 7 points but all in the x-direction. Then the accelerometers were all reoriented to the y-direction for the second set of measurements. Eventually the accelerometers were all roved to all the points of interest. Now one advantage of using single axis accelerometers here was that all the cables remained attached to the accelerometer and DAQ as they were reoriented and then roved to all points. In this way, there was never a concern that there were any cable swaps resulting in a mismatch between accelerometer location or direction. Had all triaxial accelerometers been used then there is a much greater possibility of getting cabling screwed up.

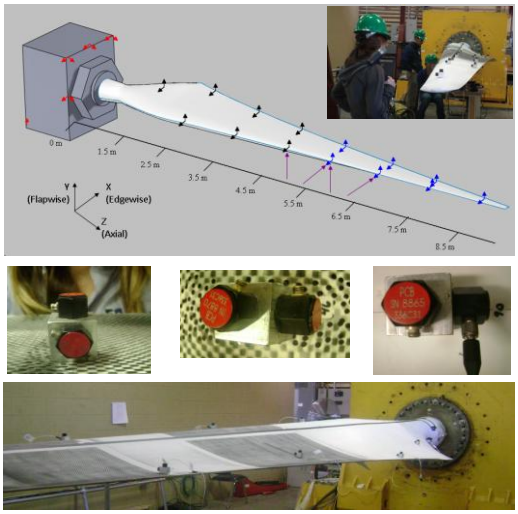

Figure 2: Schematic for 9 Meter Wind Turbine Blade Test

Another wind turbine blade test was performed for a turbine blade that was in the 50 meter long range. This test also was only really interested in the flapwise and edgewise modes of the blade but several argued that it may be necessary to also measure the axial direction too. Figure 3 shows the blade test with cabling configuration and expected mode shapes for the test along with a related measurement.

But the axial direction is very stiff compared to the two flap and edge motions and the displacement is very small. Now I will say that in this test we actually did mount triaxial accelerometers just in case we finally needed to measure all three directions but fortunately many realized that there was very little to measure in the axial direction. But there was another very important concern that many never really consider.

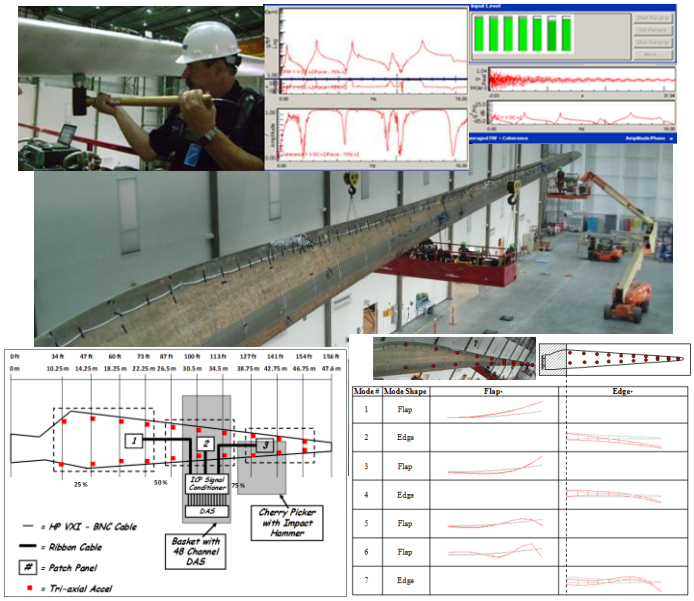

Figure 3: Schematic for Large Wind Turbine Blade Test

The flap and edge motion is large and an accelerometer sensitivity of 100 mv/g is very suitable for the motion in these two flexible directions. However, the motion is very small in the axial direction and a sensitivity of 1V/g or higher is necessary in order to make a good measurement. The problem with a triaxial accelerometer is that the sensitivity in all three directions are nominally the same – so the measurement in the axial direction with a triaxial accelerometer with 100 mv/g would be plagued by noise and poor signal strength and for all practical purposes would not provide a suitable measurement at all!

So here is where I end this article with the very clear statement that for this last test scenario, I would be much better off with three separate accelerometers with sensitivities that are suitable for the motion to be measured for the test of the large wind turbine blade. A triaxial accelerometer would not be the wise choice for this test with everything considered.

But I will point out that we did mount triaxial accelerometers for this test but it was mainly to allow us to pre-cable the entire blade before it was hoisted up on the test stand for the test. And yes I did have one accelerometer direction that we never measured during the test. And in fact we only measured two directions with flap and edge for test and never wired up the axial accelerometer channel for any of the measurement locations. And if I had wired up all three directions of each triaxial accelerometer, then I would have needed more DAQ channels than what were available on my acquisition system used. But I used the triaxial accelerometer "just in case"!!!

I hope that this helps to explain the questions you had. If you have any other questions about modal analysis, just ask me.