The focus of this dissertation is on turbomachinery blade vibration measurements and unsteady fluid-structure interactions. Vibration of turbomachinery blades are critical to jet engine durability and performance. The combined high natural frequency of the vibrations and long service life of modern jet engines can result in high cycle fatigue. There are two main topics discussed in this dissertation. The first topic of this dissertation is the investigation of unsteady fluid-structure interactions an isolated compressor blade in transonic flow. This was preferred as a simpler alternative to a cascade of blades. Note that the boundary conditions of an single vibrating blade are much simpler than those for a vibrating cascade, and so a more clear understanding of the fundamental interactions are provided with the simple setup. New insights were obtained regarding aerodynamic damping and “quasi-steady” blade vibrations in transonic flow.

The second topic of this dissertation discusses the development and application of a novel blade vibration measurement technique. Accurate blade vibration measurements are critical in product aero-mechanical design validation and can be difficult to obtain. This measurement technique, termed Blade Image Velocimetry, provides an alternative to the current measurement methods which is both easy to implement and can have the potential to exceed the current
accuracy of Blade Tip Timing. The theory of measurement and uncertainty analysis and benchtop validation measurements will be presented. This will be followed by the application of the measurement technique to a high speed axial compressor rotor. Tip deflections as low as 8μm were resolved by the measurement technique at a rotor tip speed of 350 m/s.