Exascale-class simulations will be achieved through a combination of high concurrency and energy efficiency. Although accelerator architectures like GPUs are so equipped, the task of adapting a feature-rich legacy application to modern HPC hardware can be daunting. We present the implementation of such GPU capability in the NASA Langley FUN3D computational fluid dynamics (CFD) flow solver. The Summit system at the Oak Ridge Leadership Computing Facility was used to demonstrate the implementation at scale. With this effort, a thousand of today's 6-GPU nodes can do the work of over a million CPU cores for a fraction of the energy cost. Our work will enable timely simulation of large-scale applications relevant to a broad range of NASA missions.