Understanding the physics behind multiple parameters that affect the L-H transition power threshold (P_{LH}) but are not included in the current P_{LH} scaling law is crucial for obtaining a physics-based L-H transition power threshold model for ITER/burning plasmas. This work reports several key observations of the long wavelength density fluctuations characteristics and flow dynamics in the edge of the plasmas on DIII-D prior to the L-H transition across multiple parameters: ion ∇B drift direction, divertor configurations and X-point height. It is found that as the ion ∇B drift changes direction from unfavorable to favorable at constant toroidal field, plasma current and input power, turbulence Reynolds stress and turbulence flow shear are significantly increased approaching the transition. The power thresholds for both closed divertor and Small Angle Slot (SAS) divertor are smaller than fully open divertor. As the X-point height moves towards divertor target plate, an increase of the turbulence poloidal flow in the SOL region just prior to the L-H transition is observed. These observations demonstrate the significant roles of turbulence and turbulence driven flow in the L-H transition and might lead to the development of methods to reduce the power threshold for ITER.