The effects of temperature and thermomechanical loading on the elevated-temperature tensile strength, deformation behavior, and phase transformation were studied for a low-cost metastable beta titanium alloy: Ti-13Cr-1Fe-3Al (wt.%). In-situ and ex-situ tensile tests were performed at temperatures between 25 °C to 500 °C. TEM was performed to investigate the phase transformation behavior, and the strength and Vickers hardness were compared at different loading conditions. The beta phase transformed to the omega phase under a combination of load and time at temperature. The temperature range of the phase transformation was investigated by dynamic mechanical analysis and compared with data from differential scanning calorimetry and electrical resistivity techniques. Slip trace analysis indicated that dislocation slip is the primary deformation mechanism. Both temperature and thermomechanical loading have a significant influence on deformation mode, phase transformation, and tensile strength, which can be increased by over fifty percent at elevated temperatures.