A Thermo-Magneto-Mechanical Free Energy Model for NiMnGa Single Crystals. Phillip Morrison[1], Stefan Seelecke[1], Berthold Krevet[2] and Manfred Kohl[2]; [1]Department of Mechanical and Aerospace Engineering, North Carolina State University, Raleigh, North Carolina; [2]Institute of Microstructure Technology, Forschungszentrum Karlsruhe, Karlsruhe, Germany.

The paper extends the authors' recent model for one-dimensional rate-dependent magneto-mechanical behavior of NiMnGa single crystals to account for temperature-dependent effects including austenite/martensite and ferro-/paramagnetic phase transitions. The magneto-mechanical model consists of a constitutive Helmholtz free-energy landscape constructed for a meso-scale lattice element with strain and magnetization as order parameters. This two-dimensional energy landscape includes three paraboloidal wells representing the two easy-axis and one hard-axis martensite variants relevant for the one-dimensional case. Phase transformations resulting from applied stresses and magnetic fields follow from a system of evolution laws based on the Gibbs free energy equations and the theory of thermally-activated processes. The phase fractions subsequently determine the macroscopic strain and magnetization of a sample of NiMnGa by a standard averaging procedure. To account for phase transitions to austenite, additional wells representing the stable states of austenitic NiMnGa are added to the Helmholtz energy landscape. The transition from ferromagnetic to paramagnetic states is modeled as a second-order transformation. The temperature evolution of the sample follows from an energy balance equation, incorporating joule heating, heat transfer with the environment, and latent heats of transition between martensite and austenite, thus accounting for a full thermo-magneto-mechanical coupling.