1. **Overview of the NSTX Upgrade Research Plan for 2014-2018**

1. **Research Goals and Plans for Transport and Turbulence**
2. **Research Goals and Plans for Macroscopic Stability**
   1. Overview of goals and plans
      1. Establish predictive capability for the performance of FNSF and ITER
      2. Thrusts and goals by topical area
         1. Understand and control optimal profiles for macroscopic stability
         2. Achieve the predictive capability on 3D field and NTV physics
         3. Understand disruption physics for detection, mitigation, and avoidance
   2. Research Plans
      1. **Thrust 1 – Understand and control optimal profiles for macroscopic stability**
         1. Year 1 of NSTX-U operation
            1. Recover and explore NSTX MS control capabilities on stability
            2. Assess the βN or q limit with new shaping control and off-axis NBCD
            3. Recover and upgrade RWM BP+Br and state space control with new SPAs, including n>1 and multi-mode control
            4. Study and control early rotating MHD modes
         2. Year 2 of NSTX-U operation
            1. Validate RWM physics in reduced ν\* and varied fast ion populations
            2. Utilize off-axis NBCD to vary q-profile and apply to RWM/TM
            3. Understand and control internal n=1 mode physics towards long pulse scenarios
         3. Year 3 of NSTX-U operation
            1. Optimize rotation feedback control to improve RWM/TM stability
            2. Explore the lowest ν\* regimes and optimize RWM/TM stability
            3. Assess and optimize tradeoffs between q, rotation, β to improve RWM/TM/internal mode stability
         4. Year 4 of NSTX-U operation
            1. Combine rotation and β feedback control to maximize performance
            2. Provide FNSF/Pilot projection on macroscopic stability
      2. **Thrust 2 – Achieve the predictive capability on 3D field and NTV physics**
         1. Year 1 of NSTX-U operation
            1. Recover and explore NSTX MS control capabilities on 3D field
            2. Identify n=1,2,3 error fields and optimize corrections with new SPAs
         2. Year 2 of NSTX-U operation
            1. Explore NTV physics with new NBIs and SPAs
            2. Begin implementation of rotation control with new NBIs and SPAs
         3. Year 3 of NSTX-U operation
            1. Study NTV physics in the lowest ν\* regimes
            2. Optimize rotation feedback control to improve RWM/TM stability
            3. Utilize 3D field to assess and optimize tradeoffs between q, rotation, β to improve RWM/TM/internal mode stability
         4. Year 4 of NSTX-U operation
            1. Combine rotation and β feedback control to maximize performance
            2. Provide FNSF/Pilot projection on 3D field physics predictability
      3. **Thrust 3 – Understand disruption physics for detection, mitigation, and avoidance**
         1. Year 1 of NSTX-U operation
            1. Revisit disruptivity and study halo current dynamics and heat loads on divertor
            2. Install MGI and conduct initial tests
            3. Study the feasibility of EPI and CT injector system
         2. Year 2 of NSTX-U operation
            1. Identify disruption characteristics in various scenarios obtained by off-axis NBCD
            2. Conduct MGI tests by varying positions and actuators
            3. Test EPI and CT injection system if installed
         3. Year 3 of NSTX-U operation
            1. Investigate disruption precursors and avoidance scenarios with various MHD origins
            2. Explore MGI triggering and other mitigation techniques for real-time actuation
         4. Year 4 of NSTX-U operation
            1. Couple real-time mitigation techniques to other MHD sensors
            2. Provide FNSF/Pilot projection on disruption physics
      4. **Year 5 of NSTX-U operation**
         1. First use of NCC (if resources permitting)
         2. Integrate MS control to avoid RWM/TM/ELM/internal mode instability, disruption, with disruption mitigation protection
         3. Integrate validation of models for FSNF/Pilot
   3. Summary timeline for tool development to achieve research goals
      1. Theory and simulation capabilities (both existing capabilities to be utilized and new capabilities to be developed)
         1. EFIT
         2. DCON
         3. IPEC / GPEC
         4. MISK
         5. POCA
         6. VALEN
         7. MARS-K
         8. M3D-C1
         9. DEGAS
      2. Diagnostics
         1. Magnetic sensors including BP and BR sensors will be refurbished and upgraded
         2. Real-Time Velocity measurement for successful implementation of rotation control, and disruption detection
         3. Toroidally displaced multi-energy SXR to study 3D physics including island dynamics, and RWM eigenfunctions
         4. Core X-ray imaging spectrometer to study rotation effects on error field and early MHD without NBIs
         5. Internal magnetic fluctuation measurement for island structures
         6. Real time MSE and MPTS for fast and precise kinetic equilibrium reconstruction
      3. Other facility capabilities including plasma control
         1. Non-axisymmetric Control Coil (NCC) to achieve:
            1. Rotation control, and thereby RWM kinetic stabilization, error field correction, tearing mode stabilization
            2. RWM active control for significant multi-mode spectrum
            3. ELM control and stabilization
            4. Prediction for ITER 3D coil capabilities
            5. Simultaneous control for rotation, RWM, error field, TM, ELM
            6. IPEC, NTV, VALEN-3D, RWMSC codes will be actively used for 3D physics studies with NCCs