2015 Research Milestones needed for PAC meeting

- 2015 milestones would address research results after first year of Ugrade ops
  - Don't want to promise too much, but don't want to be too unaggressive either
  - "If you completed all your milestones, you were not ambitious enough!" (my personal view, not necessarily shared by the higher levels of management)
- Will not have achieved full diagnostic implementation & facility capability
- Two levels of milestones:
  - Programmatic, cross-discipline ones (like the ones that appear on Jon's timeline – aiming for 3
  - Targeted research goals that are TSG-specific – up to 3, think about subsequent years as well
- Need "final" text for these by 2/1/13 (week from Friday)

R15-1 - proposed

- Assess dependence of (H-mode) pedestal, core, DIVSOL profiles and confinement on expanded range of dimensional and dimensionless parameters [BP, M&P, T&T, MS(?)]
  - Higher B_T, I_p, $P_{heat}(r)$
  - Lower n_e^* - **FOCUS**
  - Should we be H-mode specific?
  - How much capability will have have to characterize DIVSOL profiles, dependences
    - What can we do in the DIVSOL area (is there a radiative/snowflake divertor Milestone to be developed, or should that be for 2016)?
  - Should we expand to include stability (i.e., confinement and stability)?
    - Separate R15-4 proposed by MS group

R15-2 - proposed

- Assess fast ion confinement; under what conditions is fast ion transport anomalous? [WEP, MS, ASC, T&T]
  - 2nd NBI
  - Effect of AE modes (use of AE antenna)
  - Effect of 3D fields (very high ITER priority)
  - Use TRANSP as basis for assessment

  - Use neutron rates for zeroth order assessement
  - Timing of antenna installation and availability?
  - Timing of diagnostics (FIDA, tFIDA, ssNPA, sFLIP)?
  - Expand to include NTM and other internal modes, RWM for outer NB?

R15-3 - proposed

- Develop high-performance, extended pulse duration operation [WEP, ASC, M&P, MS, BP]
  - Optimize use of 2nd NB for heating/CD
  - Assess effect of PFCs, conditioning (B+HeGDC vs Li)
    - Recycling characteristics
    - Impact on plasma performance, ability to achieve "steady-state"
    - Want to optimize wall conditioning as much as can be done during first year of ops
  - ELM control techniques
  - Increase non-inductive fraction: part of title(?)

  - Availability of key diagnostics (no MAPP? No upward LITER, no Moly, Li granule injector at end of '15)
    - Maybe missing routine kinetic measurements (CHERS w/ no background, at high n_e)

R15-4: Advance stability, control, and error field correction via enhanced profile alteration and 3D physics capabilities
- proposed

- Long-pulse, high beta plasma sustainment is required in future ST fusion devices, such as an ST Fusion Nuclear Science Facility / Component Test Facility. NSTX-U is designed to provide physics knowledge needed to support this goal, and to demonstrate such long pulse operation with very low probability of disruptions. Enhanced capabilities of NSTX-U systems to affect and study MHD stability will be used to explore the new and unique operational space of the device. The theoretically anticipated reduction of ideal stability due to alteration of the plasma geometry, including a slightly increased aspect ratio and altered boundary shaping will be investigated. This will be contrasted with expected improvements to stability based on favorable variations of equilibrium and rotation profiles, and fast particle population. Tools for this study include the initial expansion of operation at higher $I_p < 1.6$MA and $B_T < 0.8$T, potential reduction in plasma collisionality, and the larger variation of NBI power, momentum deposition profile, and current profile available. Kinetic RWM analysis using the MISK code will be compared to experiment. Expansion of rotation profile and mode control capabilities, afforded by the new, independent control of the six RWM coils will support the investigation of 3D physics effects. Neoclassical Toroidal Viscosity (NTV) theory, including a guiding center orbit model (POCA code), will be tested over a wider range of experimentally applied 3D field spectra, allowing greater control of the rotation profile for stability studies. Physics studies related to potential stability improvements through simultaneous control of $n = 1 – 3$ perturbations will be initiated using an expanded 3D model-based, resistive wall mode state-space controller. This controller will also allow dynamic correction of $n = 1 – 3$ error fields. Low plasma rotation regimes accessed via non-resonant NTV will be investigated for greater ITER relevance. Direct sustainment of high beta plasmas will be investigated for steady-state profiles, as pulse lengths of double to triple those of past NSTX discharges are anticipated. The increased ratio of pulse length to momentum diffusion time will enhance steady-state NTV physics studies.

R15-4: Advance stability, control, and error field correction via enhanced profile alteration and 3D physics capabilities

- proposed

- Take advantage of higher I_p, B_T, NB, new geometry
- Low rotation regimes via NTV (ITER-relevant)
- Test NTV over wide 3D spectra
  - POCA cade validation
- Kinetic RWM analysis
- Use space-state controller for dynamic correction of n=1-3 EFs
- Sustainment of high beta profiles, investigate steady-state scenarios at long pulse length
  - Pulse length increased releative to momentum confinement time: enhanced steady-state NTV studies

- Combine with R15-1 for first year?
- Stand by itself for 2016?

R15-5

- Initial assessment of FNSF scenario requirements using new NSTX-U capabilities [ASC,….
  - NBCD for current drive
    - Compare CD from new sources to that from old sources
    - Provides first assessment of q_{min} control via varied R_{tan}
  - Produce high elongation (2.8-3.0) discharges and assess vertical stability
    - Take mitigating steps if vertical control a problem (more flux loops, RWM coils….)
  - Impact of higher TF, n_e variations on these scenarios
    - First assessment of NI ops in NSTX-U
  - Results will provide a basis for planning future NSTX-U research and upgrades, and contribute to understanding the physics and control requirements for an FNSF

  - Is this suitable for Yr 1, or better suited for later years?

Some TSG-specific research goals have been suggested (by TSG leaders)

- SFSU
  - Establish high current CHI discharge for coupling to induction
  - Assess low-Z impurity levels in NSTX-U CHI discharges by comparing flux savings to those achieved on NSTX
  - Assess current ramp-up of a 300 to 600 kA inductively generated target using HHFW and/or NBI (2016)
- WEP
  - Characterize HHFW interaction with NB fast ions
  - Fast ion transport and AE mode stability in the presence of applied 3D fields (part of R15-2?)
  - RF power loss mechanisms in the SOL during fast wave heating
  - ECH goal (technical or physics-based)?
- T&T
  - Characterize the ST H-mode global energy confinement scaling at lower collisionality (part of R15-1)
  - Obtain first k_q measurement from the new FIR high-k_q scattering system in an ETG-dominated regime (2016?)
  - Obtain first internal magnetic fluctuation measurement using polarimetry system in microtearing-dominated regime (2017)

More TSG-specific goals

- ASC
  - Develop high elongation NSTX-U equilibria suitable for high non-inductive fraction and high current exploration, and assess the vertical stability of these configurations
  - Increase the non-inductive current drive fraction using strong shaping, higher toroidal field and current driven by the 2nd neutral beam line
  - Begin assessment of the snowflake divertor configuration
  - Begin assessments of q-profile control using NBCD and rotation profile control using NB and NTV
- MS
  - Test and commission MGI systems on NSTX-U, and use the mid-plane MGI system for a forced disruption test
- MP
  - Investigate the impact of Li coverage and PFC surface composition on long-pulse discharge performance (R15-3?)
- BP
  - Characterize divertor particle flux profiles and neutral pressure dependences as refinement of inputs used in cryopump design
  - Initial heat flux mitigation studies with improved power balance diagnosis; compare to 2D modeling