Center for Tokamak Transient Simulations (CTTS)

Ideal MHD Driven disruption modeling:
Jardin, Kruger, Zhu, Krebs

VDE and RWM:
Sovinec, Ferraro, King, Strauss, Breslau, Lyons, Held, Zhu, Krebs

NTM:
Kruger, Held, King, Lyons, Ramos

Mitigation:
Lao, Kim, Parks, Samulyak, Jardin, Ferraro

Ideal MHD Driven Disruptions

Year	Milestone
1	Develop criteria for when locally exceeding β-limit leads to a disruption
2	Develop validated model that reproduces thermal quench in an ideal MHD disruption
3	Develop validated model for current quench that reproduces current spike and decay times
4-5	Interface M3D-C1 and NIMROD with runaway electron model as developed by SCREAM

Vertical Displacement Events

Year	Milestone
1	Benchmark NIMROD and M3D-C1 for *axisymmetric* VDE in toroidal geometry
	Parametric studies of influence of halo-region properties and compare with analysis
2	Benchmark NIMROD and M3D-C1 for *non-axisymmetric* VDE in toroidal geometry
	Incorporate sheath effects in VDE computations
3	Study effect of non-axisymmetric walls on VDE
4-5	Validation studies with DIII-D, NSTX, JET
	Study of wall forces in mitigated and unmitigated VDE

Resistive Wall Modes

Year	Milestone
1	Benchmark NIMROD and M3D-C1 for linear RWM in toroidal geometry
2	Explore effect of rotation and two-fluid effects on RWM linear stability
3	Nonlinear studies of RWM --- How does RWM precipitate thermal quench?
4-5	Explore kinetic effects on stability with NIMROD, M3D-C1/DK4D: Compare with MARS-K
	Explore disruptions caused by energetic particles (fishbone modes) interacting with RWM

Neoclassical Tearing Modes

Year	Milestone
1	Identify suitable for NTM/locked mode disruptions on DIII-D for modeling
	Implement Ramos-form of DKE closures into NIMROD and M3D-C1.
	Investigate Maxwell torques induced by error fields in the presence of tearing modes
2	Benchmark M3D-C1 and NIMROD with DKE closure about fixed magnetic island geometry
	Work with Δ'>0 cases to produce a saturated TM as an initial state for DKE NTM calculations
	Use Δ'>0 case to study growth of non-rotating magnetic island in presence of a resistive wall
	Investigate resistive-wall torques induced by error fields in the presence of tearing modes
3	Model NTM evolution using DKE closures including temperature equilibrium and perturbation to BS current
	Study side-band induced stochasticity and edge effects in island in presence of resistive wall
	Investigate NTV torques with DKE closures on the mode from field errors
4-5	Understand the locking of NTMs from NTV, field errors and the drag on the resistive wall
	Investigate hypotheses on how locked modes grow and cause disruptions

Disruption Mitigation by Shattered Pellets

Year	Milestone
1	Construct SPI plume model and develop tracking algorithms
	Develop 3D local pellet ablation model for FronTier-MHD and perform single-pellet tests
	Perform SPI scoping and sensitivity studies using NIMROD with an existing analytic SPI model
	Implement full ionization/recombination/radiation model in M3D-C1
2	Implement pellet debris plumes into FronTier-MHD and test tracking algorithms.
	Perform SPI simulations and validation tests using FronTier-MHD and DIII-D data
	Develop analytic kinetic heat flow models for use with NIMROD and M3D-C1
	Complete SPI scoping studies using NIMROD and M3D-C1 with an existing analytic SPI model.
3	Develop algorithms for coupling of FronTier-MHD pellet ablation with NIMROD and M3D-C1
	Test multiscale coupling algorithms using 1D FronTier pellet code and 1D PRL MHD code
	Start multiscale integration of Frontier-MHD with NIMROD and M3D-C1
4-5	Perform test of multiscale coupling of FronTier-MHD pellet ablation w. NIMROD and M3D-C1.
	Studies of accuracy, convergence, and stability of coupling algorithms
	Validation tests using FronTier-MHD/NIMROD and M3D-C1 and DIII-D experimental data
	Perform validation simulations using JET data as available
	Perform simulations of SPI applied to ITER

What should be our goals?

- Complete Milestones

- Standard “benchmark problems” performed by both NIMROD and M3D-C1 and documented well enough for other codes to try
  - This will require some compromises so both codes can participate
  - May require some code development from one or both codes
  - Both codes could then extend these studies in unique ways

- Publish --- Goal should be 3 PP and one PRL /year