

NCSX Risk Register

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MANAGEMENT & ORGANIZATION RISKS												
Mgmt-1		Loss or prolonged unavailability of certain key personnel from the project could substantially impact the schedule.	<i>See mitigation plans for individuals listed below.</i>									
a	1901	Mike Cole (ORNL) Loss of "corporate memory" of stellarator core design intent, delayed turnaround on Title III issues and problem resolution might impact FPA schedule.	Brad Nelson is been budgeted (15%) on the project. Should Cole become unavailable, Nelson would step in and handle Cole's responsibilities until a suitable longer term solution was implemented. ORNL Mgt., Job 1901		Harris	Oak Ridge is investigating securing additional engineering support for Mike Cole. Currently reviewing resumes and re-evaluating work load to determine whether additional staff will indeed be needed.	VU	Marginal	Low	Estimated impact is <0.5 months on the critical path.	\$0	+0.50
b	1810 7503	Tom Brown, Art Brooks, Bob Ellis "Back office" support for FPA and final assembly becomes a chronic bottleneck, stretching out the time required to complete assembly operations	Additional support budgeted for Brown, Brooks, and Ellis providing "2 deep" back office support. Should be available to mitigate peak demands once training in key skills is completed. Jobs 8203, 8204, 8205. Identify backup personnel for "two deep" back office support & provide duplication of critical skills needed. Eng. Mgt. (Heitzenroeder)	After first MCHP	Heitzenroeder	"Two deep" back office support is now in place. Mark Smith has worked in all areas of back office support and will provide back-up for either Tom Brown, Art Brooks, or Bob Ellis as needed to handle over-loads, cover during vacations, etc. A new analyst, Han Zhang, has recently been hired and is providing support to Art Brooks. A new design engineer, Shri Avisarala, has been hired and is expected to start soon and will be working with Tom Brown to provide additional back-up in design integration. Design support has also been significantly increased: Gerald Paluzzi is supporting Bob Ellis his on non-NCSX tasks to help balance his workload ; Tod Cruickshank is working with Fred Dahlgren and Tom Brown on NCSX structures, and Richard Upcavage is working	VU	Significant	Low	Estimated impact is <2 months on the critical path. Cost impact covers up to 2 months of FPA/final assembly.	\$0	+2.00

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c	8202	Phil Heitzenroeder (PPPL)	Larry Dudek can step in to assume Phil's responsibilities as Engineering Manager for Design and Procurement. Erik Perry can step into Larry's role as Construction Manager. As time goes on (and the field period assembly is completed), Mike Viola can continue (with Erik's help) with final machine assembly.	After final machine design and major procurement activities are completed.	Williams	Larry Dudek, Erik Perry and Mike Viola are already intimately involved in NCSX design and construction activities and are able to assume varying responsibilities on short notice.	VU	Marginal	Low	Estimated impact is <0.5 months on the critical path. No impact on FPA cost because impacted personnel would be assigned to other activities.	\$0	+0.50
d	8101	Ron Strykowski	Develop a succession plan Business Ops. Dept.		E. Winkler		VU	Marginal	Low	Cost impact = 50% cost increment cost for 1 year spool-up time for another senior project controls person	\$115	+0.00
e	5301 5401 5501 5601	Loss of staff with experience in specialized software delays operation of Central I&C system.	Staff have recently been brought on board in anticipation of growing NCSX I&C needs. The planned shutdown of NSTX after FY10 will increase the availability of similar resources for NCSX.	NSTX Shutdown (following FY10)	P. Sichta S. Baumgartner A. vonHalle	Staff are presently on-board and available to handle the FY08-10 work plan. More will be available following the shutdown of NSTX.	VU	Marginal	Low	Estimated impact is <0.5 months on the critical path. No impact on WBS 5 cost because impacted personnel would be assigned to other activities.	\$0	+0.50
f	1901 8203	Design integration effort needs to increase to manage space allocations inside the cryostat and in the test cell	Staff has been increased recently. Periodically reassess adequacy.	Sept., 2008	P. Heitzenroeder	Staff increases in progress.	VU	Marginal	Low	1 person-year?	\$300	+0.00
g	12xx, 1601 7304	Paul Goranson (ORNL) Loss of critical design engineering skills and "corporate memory" of vacuum vessel and coil services design intent, delayed turnaround on problem resolution might impact assembly schedule.	Develop succession plan. Job 8102		Harris		U	Marginal	Low	Estimated impact is <0.5 months on the critical path.	\$0	+0.50
h	1810 1815 7304	Kevin Freudenberg (ORNL) Loss of critical engineering analysis skills and familiarity with the analytical models and design intent for the stellarator core, particularly the modular coils.	Develop succession plan. Job 8102		Harris		U	Marginal	Low	Estimated impact is <0.5 months on the critical path.	\$0	+0.50

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Mgmt-2	4501	Loss of knowledgeable staff delays operation of legacy power supplies.	Train staff in legacy systems. Eng. Dept.	Power Systems ISTP	A. von Halle	Staff presently assigned to NSTX are available to backup the staff presently responsible for the NCSX power supply work scope	VU	Marginal	Low	Estimated impact is <0.5 months on the critical path. No impact on WBS 4 cost because impacted personnel would be assigned to other activities.	\$0	+0.50
Mgmt-3	8101	Labor rates may be significantly lower than projected Opportunity	None		Strykowski	Current estimates reflect latest labor rates. Will revisit in semi-annual EAC update.	U	Opportunity	Opportunity	Retirements / resignations replaced with younger lower-salaried staff	(\$1,000)	+1.00
Mgmt-4	8101	GPP projects not completed in time to support project needs	The crane and the HVAC systems are the main GPP projects that would need to be completed. The GPP projects have strong Lab and DOE oversight. Ample float is provided in the schedule so project delays due to GPP delays are not considered credible (P<1%). Eng. & Infrastructure Dept.	End of FY-09	Perry	All GPP projects supporting the NCSX inhabiting the C-Site test cell are presently scheduled for completion prior to the end of FY09.	NC	Significant	Low		\$0	+1.00
Mgmt-5	8101	CR may delay funding to project.	None		Strykowski	Current estimates reflect latest OFES guidance. Will revisit in semi-annual EAC update.	U	Significant	Moderate	Expected increase in FY-09 may be delayed by CR.	\$0	+2.00

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TECHNICAL RISK - Generic Assembly Risks													
Assy-1	1810	Station 3: cost and schedule grows when Assembly Sequence Plan fully matures	Expedite Tooling Design and Assembly Sequence Plan Jobs 1803 / 8203	When Station 3 Tooling FDR is complete	Brown	Future Risk	VL	Marginal	Moderate	15% increase in time required for each F.P	\$240	+0.68	
Assy-2	1815	Station 5: cost and schedule grows when Assembly Sequence Plan fully matures	Expedite Component Designs and Assembly Sequence Plan Jobs 1354, 1501, 1601, 8203	Coil services PDRs	Brown	Future Risk	VL	Significant	High	25% increase in time required for each F.P	\$500	+1.13	
Assy-3	7503	Station 6: cost and schedule grows when Assembly Sequence Plan fully matures	Expedite Component Designs, Plant Layout, and Assembly Sequence Plan Jobs 1701, 1702, 1803, 8215	Cryostat PDR	Brown	Future Risk	VL	Significant	High	15% increase in time required.	\$650	+2.18	
Assy-4	1810/ 1815 7503	Photogrammetry replaces laser tracker for some operations and saves time and money. (Opportunity)	Acquire equipment, develop experience, assess potential. New H/W in place & personnel being trained. 1810 / 1815	~Sept., 2008	Dodson / Dudek	Future Risk	L	Opportunity	Opportunity	33% reduction in metrology tasks?	(\$901)	(3.0)	
Assy-5	1810/ 1815 7503	Assembly delayed due to metrology equipment breakdowns or anomalies.	Maintain high availability via maintenance contracts, spares, and trained staff. F&OM Div.	Completion of FP#1, Station 5	Priniski / Dudek	Have acquired new hardware and trained staff.	L	Significant	Moderate	2 occurrences @ 0.5 month each.	\$0	+1.00	
Assy-6	1810 1815 7503	General purpose tooling/ lifting equipment (e.g. cranes) not available to support the schedule.	Budget lift equipment in FPA . Jobs 1810, 1815	After Station 5?	Dudek	Lift equipment estimated in 1810 & 1815 WAF.	U	Marginal	Low	Up to 2 week impact on FPA and critical path.	\$0	+0.50	

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Assy-7	1302/1352 1354	Permeability of components outside 3m from machine to test cell walls exceed the permeability limit of $\mu = 1.2$.	Analyze existing conditions to determine if an issue exists. At worst case, may have to utilize more expensive low magnetic materials and/or utilize combination of rebaised trim and PF ring coils to mitigate field errors.	~ May 1, 2008	Brooks Kalish Chrzanowski	Brooks will work with Physics to determine issues and whether Project can accept $\mu > 1.2$ cases.	U	Marginal	Low	Estimated cost of obtaining low magnetic materials.	\$200	+0.00

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TECHNICAL RISKS - Station 2 Assembly													
Stat2-2	1810	Station 2: Unacceptable distortion in a field period when welding modular coil shims requiring rework and or chair installation.	Perform extensive welding R&D and careful monitoring during welding. Develop suitable weld procedures and train welders to minimize likelihood of unacceptable distortion. Job 1810	After first MCHP	Viola	See response to RR #5. Current weld trials dealing with options to control distortion.	U	Significant	Moderate	Cut apart and re-weld two coils back together. Nominally a 2.5-man crew in 12 weeks. Fabrication and installation of chair nominally requires 2.5-man crew and ~3 weeks.	\$135	+1.00	
Stat2-3	1810	Station 2. Unacceptable distortion in a field period when welding modular coil shims requiring complete disassembly and redesign and reassembly	Perform extensive welding R&D and careful monitoring during welding. Develop suitable weld procedures and train welders to minimize likelihood of unacceptable distortion. Job 1810	After first MCHP	Viola	Weld trials should mitigate probability of occurrence.	VU	Critical	Moderate	Cut apart and re-weld two coils back together. Nominally a 2.5-man crew in 12 weeks.	\$150	+3.00	
Stat2-5	1810	Station 2. Risk of loss of weld equipment or trained personnel.	Procure more equipment & qualify more staff	After first MCHP	Viola	Future Risk	NC	Negligible	Low		+ \$0	+0.25	
Stat2-7	1810	Station 2. Shim sets not adequate or fail - need to fabricate more shims and measure and test	Change to G10 design and fabricate more shims than needed Job 1810	After first MCHP	Viola	Switched to G10 design	U	Significant	Moderate	Up to 3 week impact on FPA and critical path.	\$0	+1.00	
Stat2-9	1810	Station 2 - shim bag rupture & requires replacement	Pre-qualify shim bags. Use wing chair in compression. Could require taking coil apart in worse case. Job 1810	After first MCHP	Viola	Considered unlikely due to other mitigation plan options.	VU	Critical	Moderate	Rough assessment of cost and schedule impact of disassembling/re-assembling coils. 5 techs. X 3 months	\$200	+3.00	
Stat2-10	1810	Station 2. Nose opens up while tightening outboard bolts	Change bolt tightening sequence Job 1810	After first MCHP	Viola	Future Risk	U	Marginal	Low	Up to 2 week impact on FPA and critical path.	\$0	+0.50	
Stat2-11	1810	Station 2. Nose opens up while tightening outboard bolts. Change bolt tightening sequence is not adequate	Reexamine alignment criteria and potential impact Job 1810	After first MCHP	Viola	Future Risk	U	Significant	Moderate	Up to 4 week impact on FPA and critical path.	\$0	+1.00	

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Stat2-13	1810	Station 2. Modular coil damaged during assembly requiring significant rework to coil. (Complete coil re-fabrication excluded)	Equipment will be handled during FPA using carefully constructed procedures to minimize likelihood. Include provisions to guard against coil damage in FPA procedures. Job 1810	After Station 2	Viola	Station 2 assembly has just started. Repeated trial fits have served to benchmark processes.	L	Negligible	Low	Nominally repaired with a 2-man crew within 2 weeks. Cost: 3-4 occurrence. No schedule impact	\$50	+0.00
Stat2-14	1810	Station 2. Modular coil damage requiring coil re-fabrication.	Extreme care will be taken when transporting and handling coils. Develop and follow appropriate procedures. Job 1810	After Station 2	Viola	Future Risk	N/A	N/A	N/A	High impact-low probability event that has been excluded as a bounding assumption.		
Stat2-15	1810 7503	Issues reported by W-7X: Loss of bolt tension with time.	Verify/monitor elongation w/ ultrasonic tester. May decide to instrument a limited number of bolts. Hot cracking of welds should not be an issue for NCSX. On W7-X, they cryocool their welds which promotes hot cracking.		Viola		VU	Negligible	Low	Assumes 2/hrs per flange x ~36	\$30	+0.00

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TECHNICAL RISKS - Station 3 Assembly												
Stat3-1	1810	Station 3: vertical weld distortion excessive. Have to take apart, modify design or procedure, re-weld.	Perform vertical welding R&D and careful monitoring during welding. Develop suitable weld procedures and train welders to minimize likelihood of unacceptable distortion. Refine welding capabilities on Station 2. Job 1810	After first A-A weld	Viola	Future Risk	L	Significant	Moderate	5 techs x 1 month	\$70	+1.00
Stat3-2	1810	Station 3. Problems installing coils over vacuum vessel. Trajectory following scheme does not work like the concrete block. Have to re-invent.	R&D has been performed. Check in advance with trial dry fit. 1810	After first MC-to-VV assembly	Viola	Future Risk	VU	Marginal	Low	5 techs x .5 month	\$35	+0.50
Stat3-3	1810	Station 3. VV surface component (coolant tube, flux loop, or TC) damaged during FPA requiring significant rework. (Note: There is only 0.2" of clearance currently projected.)	Equipment will be handled during FPA using carefully constructed procedures to minimize likelihood. Include provisions to guard against coil damage in FPA procedures. Job 1810	After Station 3	Viola	Future Risk	VU	Marginal	Low	Nominally repaired with a 2-man crew within 2 weeks	\$20	+0.50
Stat3-4	1810	Station 3. Interferences discovered during assembly; components don't go together as planned. Assemblies have to be taken apart, components moved or re-worked, re-assembled.	CAD modeling with as-built dimensions to find interferences off critical path. Do simulations carefully Job 1901 & 8203	After first MCHP assembled over VV	Cole	Future Risk	U	Marginal	Low	0.5 months on C.P.	\$0	+0.50
Stat3-5	1810	Station 3. Sag distortion while MCHP are vertical in station 3	Our models have predicted acceptable amounts. Careful modeling continues. Job 1810	After first MC-to-VV assembly	Viola	Future Risk	U	Significant	Moderate	Fabricate and install bracing. Nominally a 2.5-man crew in 2 weeks. Up to 4 week impact on FPA and critical path.	\$25	+1.00
Stat3-6	1810	Station 3. Assembly tooling allows too much deflection and has to be redesigned.	Exercise tooling off the critical path. Compensated by design, metrology, exercise tooling & follow demonstrated procedures Assy steps allow for this. Demonstrated in Station 2 Job 1810	By start of Station 3	Viola	Future Risk	VU	Significant	Low	Rough assessment of cost and schedule impact of reinforcing or redesigning tooling.	\$50	+1.00
TECHNICAL RISKS - Station 5 Assembly												
Stat5-1	1815	Station 5: Trim coils not available when needed in field period assembly sequence. Have to implement workaround.	Expedite design and procurement. Jobs 1354	When 10% of coils are wound.	Kalish	Presently 200+ days of float in the schedule. Design of coils simplified to two coil types minimizing risk of late delivery	U	Marginal	Low	2 weeks on CP	\$0	+0.50

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Stat5-2	1815	Station 5. TF Coils cannot be aligned	Reexamine alignment criteria and potential impact. Job 1810	By start of Station 5	Viola	Future Risk	U	Significant	Moderate	Up to 4 week impact on FPA and critical path.	\$0	+1.00
Stat5-3	1815	Station 5. TF coils become warped and have to be racked to restore proper geometry.	Measure a sampling of coils to assess need for racking. Add hard points on the coils- Jim C. WBS 13	After measuring 2 coils.	Kalish	Future Risk	U	Marginal	Low	2 weeks on CP & some retrofit of clamps. Have to do some re-design of clamps. Maybe 4 weeks of Fred & designer + hardware	\$60	+0.50
Stat5-5	1815	Station 5. Problems installing ports due to interferences. Have to move components or modify ports.	CAD modeling with as-built dimensions to find interferences off critical path. Job 1901	By start of Station 5	Cole	Future Risk	L	Marginal	Moderate	Cost, not schedule 4 techs. X 2 weeks x 10 occurrences	\$250	+0.00
Stat5-6	1815	Station 5. Interferences discovered during assembly; components don't go together as planned. Assemblies have to be taken apart, components moved or re-worked, re-assembled.	Design integration during Title I & II design of components. Job 8203	Coil Services PDRs	Brown	Future Risk	VU	Negligible	Low	Trim coil - port interferences are biggest concern. Leads are a concern too?? 4 techs. X 2 weeks X 1 occurrence	\$30	+0.00
Stat5-7	1815	Station 5: Multiple vacuum leaks during initial pumpdown	Welds will be leak checked during FPA when leaks can be addressed without significantly impacting the critical path. Job 1810	After leak check of first FP.	Viola	Future Risk	L	Negligible	Low	Impact of having only a few leaks is covered in estimate uncertainty with present mitigation plan	\$25	+0.00
Stat5-8	1815 7503	Station 5. Rework/replacement of high permeability components	Expedite design & procurement of at-risk parts. Dudek	Coil structures FDR	Dahlgren	Assessing impact of annealing and machining on permeability	U	Marginal	Low	Initial impact assessment based on VVSA experience	\$200	+0.00
Stat5-9	1815	Station 5. Field period damaged during loading, transport, or unloading from TFTR TC to NCSX TC	Extreme care will be taken when transporting a field period. Additional reviews including external reviewers will be performed. Develop appropriate procedures for transporting field periods. Arrange for a peer review of the procedures prior to transport. Will replace rollup door in CS test cell. Job 1815	After first FP.	Viola	Future Risk	N/A	N/A	N/A	High impact-low probability event that has been excluded as a bounding assumption.		

TECHNICAL RISKS - Station 6 Assembly

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Stat6-2	7503	Station 6. Original base structure vendor(s) unable to deliver on schedule; not available when needed in machine assembly sequence. Have to implement workaround.	Alternate vendors exist & sufficient float exists to engage an alternate vendor. We procure components and assemble on site. Job 1702	Coil structures FDR	Dahlgren	Still in design phase - future risk	VU	Negligible	Low	Base supports must be in place prior to the 3-period machine assembly	\$50	+0.00
Stat6-3	7503	Station 6. PF 5L & 6L not available when needed in machine assembly sequence. Have to implement workaround.	Expedite design and procurement. Could put FP#1 in place if we had to. Could absorb 4 months delay Jobs 1302/1352	When 1st coil is wound.	Chrzanowski	Future Risk	NC	Negligible	Low	Would impact CP. PF coils have ample float	\$0	+0.25
Stat6-4	7503	Station 6. PF coils out of round or not flat. Supports have to be modified.	Include adjustment provisions in coil structure designs. This is being done Job 1501	Coil structures FDR	Dahlgren	Future Risk	NC	Negligible	Low	Addressed in base estimate	\$0	+0.25
Stat6-5	7503	Station 6. PF 4L, 4U, 5U, 6U not available when needed in machine assembly sequence. Have to implement workaround.	Expedite design and procurement. Jobs 1302/1352	When 1st PF is wound.	Chrzanowski	Future Risk	NC	Negligible	Low	Would impact CP day for day, but PF coils have ample float	\$0	+0.25
Stat6-6	7503	Station 6: Trim coils not available when needed in machine assembly sequence. Have to implement workaround.	Expedite design and procurement. Jobs 1354	When 10% of coils are wound.	Kalish	Presently 200+ days of float in the schedule. Design of coils simplified to two coil types minimizing risk of late delivery	NC	Negligible	Low	Would impact CP day for day, but risk mitigated by design and float.	\$0	+0.25
Stat6-7	7503	Station 6: Leads not available when needed in machine assembly sequence. Have to implement workaround.	Expedite design and procurement. Jobs 1601	Electrical leads FDR	Goranson	Future Risk	NC	Negligible	Low	Would impact CP day for day, but risk mitigated by design and float.	\$0	+0.25
Stat6-8	7503	Station 6. High temperature Rogowski Loop damaged during installation resulting in loss of toroidal current measurement capability	Triple redundancy - 3 installed but only 1 required. Job 3101	Rogowski loop FDR	Stratton	Starting installation in Feb 2008	VU	Negligible	Low		\$0	+0.00
Stat6-9	7503	Station 6. Interferences discovered during assembly; components don't go together as planned. Assemblies have to be taken apart, components moved or re-worked, re-assembled.	CAD modeling with as-built dimensions to find interferences off critical path. A Pro E model/sterolithography of the three period assemblies and mechanism for positioning the FPA will be fabricated to evaluate the assembly of the coils.	By start of Station 6	Cole	Future Risk	L	Significant	Moderate	1 month on C.P. 4 techs x 1 mont	\$50	+1.00
Stat6-10	7503	Station 6. Problems making up vacuum vessel field joint. Have to re-machine spool piece.	Careful metrology in FPA, back office analysis and CAD modeling. Job 8202 (Eng. Mgr.)	After first VV joint successfully made up.	Perry	Future Risk	U	Critical	Moderate	3 joints @ 1 month C.P. each	\$0	+3.00

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No.	Affected Jobs (absorb the impacts)	Risk Description	Mitigation Plan (& job where budgeted)	Deadline to Retire Risk or Absorb Impact	Owner	Current Status (As of March 21, 2008)	Likelihood of Occurrence	Consequences	Risk Ranking	Basis of Estimate	Cost Impact (\$k)	Critical Path Schedule Impact (mos)
Stat6-11	7503	Station 6. Retainer and pucks do not stay on flange during assembly and moving of half field periods. Potential safety risk if individuals are under the machine.	Pucks will be held in place by Nomex felt and is being demonstrated to show feasibility. Stud assembly sequence will be developed in model studies Job 1901	By start of Station 6	Cole	Future Risk	U	Significant	Moderate		\$30	+1.00
Stat6-12	7503	Station 6. Problems making up C-C joint. Interferences, bolt access problems.	A Pro E model/sterolithography of the three period assemblies and mechanism for positioning the FPA will be fabricated to evaluate the assembly of the coils. Also CAD modeling Job 1901 / 8203	By start of Station 6	Cole	Future Risk	U	Negligible	Low	Risk is mitigated in the estimate	\$0	+0.25
Stat6-13	7503	Station 6. Pourable insulation installation problems; can't get what we need, don't know if it fills all the voids, leaks out all over the place; have to invent methods to ensure complete fill and seal.	Perform R&D. Design special tooling for installation and verification. Job 7503 & 1901	At least 1 year before start of Station 6	Cole	Future Risk	U	Negligible	Low	Risk is mitigated in the estimate	\$0	+0.25
Stat6-14	7503	Station 6. Modular coils are shorted across toroidal break between field periods causing problematic field errors	Ensure that required electrical breaks are not compromised. Check carefully during assembly. Job 1810, 1815, 7503		Viola (FPA) Perry (MA)	Future risk - N/A	NC	Negligible	Low		\$25	+0.25
Stat6-15	7503	Station 6. Assembly sled for final assembly is not adequately stiff or does not provide repeatable motion	Functionality of sled will be determined with first FP. Ample time to make design modifications between arrival of the first and third FPs. Job 7503	By start of Station 6	Perry	Future risk - N/A	U	Negligible	Low	Nominal cost impact is 1 man-month of engineering design and up to half the fabrication cost of the sled	\$75	+0.00
Stat6-16	7503	Station 6. Vacuum leaks occur. Takes time to locate and repair.	Leak check each field period independently in FPA. Job 1815	After final VV weld	Perry	Future Risk	U	Negligible	Low	Risk is mitigated in the estimate	\$0	+0.25
Stat6-17	7503	Welding of the Vacuum Vessel pieces to the spool pieces may require the addition of thin Inconel plates to bridge gaps caused by radial and/or angular out-of-tolerance conditions of either the VV or spool pieces.	Add Inconel plates to extend the vessel flange if radial out-of-tolerance and add flange plates to spool pieces and then bridge to vessel flange extension if angular out-of-tolerance.		Perry	Future Risk	VU	Critical	Moderate		\$50	+4.00

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Stat6-18	7503	Friction shims in sizes needed for C-C joint not available when needed.	Qualify sources for alumina shims; investigate use of G10 shims in some locations. Make measurements after Station 3 to determine needed thicknesses.	After Station 3	Dudek	Future Risk	VU	Significant	Low	6 weeks on CP	\$0	+1.50

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TECHNICAL RISKS - Startup												
S/U-1	8501	Unanticipated problems with cryostat penetrations (icing, excessive condensation). May require warming up the stellarator core to effect repair with consequent impacts to critical path activities.	Careful cryostat design, including consultation with experts and R&D. Job 1701	Cryostat FDR	Raftopoulos	Future Risk	U	Significant	Moderate	Nominally repaired with a 4-man crew in 1 week with 3 weeks for warmup/cooldown (if required)	\$30	+1.00
S/U-2	8501	Coil cooling system fails to cool coil structure down to cryogenic temperature	Robust design with excess capacity. Job 6201	Cryostat PDR	Raftopoulos		U	Significant	Moderate		\$0	+1.00
S/U-3	8501	Insulation on modular coil fails during initial cooldown and testing requiring in situ repair.	C1 tested at full current at cryogenic temperature. All modular coils will be tested at RT at elevated (50% higher) voltage for faults to ground. Job 1421 In addition, routine field tests will be performed on each assembly station to ensure that the electrical integrity is OK. Job 1810	After Station 3	Chrzanowski (MC) Viola (FPA) M. Viola & E. Perry implement mitigation plan during field period and final assembly.	Future Risk	VU	Significant	Low	Insulation fault in lead area is considered the most likely failure scenario. Repair in situ is assumed recovery scenario taking 2-3 months. 1 month to warmup and cooldown the stellarator core. 3 techs/1 engr for duration of active repair (1-2 months).	\$150	+2.00
S/U-4	8501	Insulation on modular coil fails during initial cooldown and testing requiring stellarator core disassembly	C1 tested at full current at cryogenic temperature. All modular coils will be tested at RT at elevated (50% higher) voltage for faults to ground. Job 1421 In addition, routine field tests will be performed on each assembly station to ensure that the electrical integrity is OK. Job 1810	After Station 3	Chrzanowski (MC) Viola (FPA) M. Viola & E. Perry implement mitigation plan during field period and final assembly.	16 of 18 coils successfully wound. Remaining 2 coils in winding process.	N/A	N/A	N/A	High impact-low probability event that has been excluded as a bounding assumption.		
S/U-5	7503 1352 1361 8501	Insulation on TF/PF coil fails during initial cooldown and testing requiring in situ repair	1st of each kind will be tested at cryogenic temperature at elevated (50% higher than routine field tests) voltage for faults to ground. All coils will be tested at RT at elevated (50% higher than routine field tests) voltage for faults to ground. Job 1361 Job 1352	After 1st PF Coil	Kalish (TF) Chrzanowski (PF)	Mitigation plan being implemented during TF fab. There was an issue with TF Coil #3, but this has now been resolved. 6 TF coils shipped and/or received. 9TF Coils Received at PPPL and Tested	VU	Significant	Low	Insulation fault in lead area is considered the most likely failure scenario. Repair in situ is assumed recovery scenario taking 2-3 months. 1 month to warmup and cooldown the stellarator core. 3 techs/1 engr for duration of active repair (1-2 months).	\$150	+2.00

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S/U-6	7503 1352 1361 8501	Insulation on TF/PF coil fails during initial cooldown and testing requiring dismantling stellarator core	1st of each kind will be tested at cryogenic temperature at elevated (50% higher than routine field tests) voltage for faults to ground. All coils will be tested at RT at elevated (50% higher than routine field tests) voltage for faults to ground . Job 1361 Job 1352	After 1st PF Coil	Kalish (TF) Chrzanowski (PF)	Mitigation plan being implemented during TF fab. There was an issue with TF Coil #3, but this has now been resolved. 6 TF coils shipped and/or received. 9TF Coils Received at PPPL and Tested	NC	Negligible	Low	High impact-low probability event. Exclude as a bounding assumption.		
S/U-7	8501	Coils are hooked up with incorrect polarity	Ensure that coils are connected with correct polarity during final assembly by specifying testing in the assembly procedure. Job 7503 Test during ISTP and fix if necessary. Job 8501		Perry	Future Risk	NC	Negligible	Low	Covered in estimate uncertainty with present mitigation plan	\$0	+0.25
S/U-8	8501	Ground faults delay coil testing.	Machine Techs will be trained to search out / identify and correct ground faults. Implement ground fault detection system before other systems are installed in test cell. WBS 4401	Start of installation	Ramakrishnan	Allowances made in current S/U plans	VL	Negligible	Low	Experience on NSTX S/U	\$10	+0.25
S/U-9	8501	Loop faults delay coil testing.	Machine Techs will be trained to search out / identify and correct ground faults. Implement ground fault detection system before other systems are installed in test cell. WBS 4401	Start of installation	Ramakrishnan	Allowances made in current S/U plans	L	Negligible	Low	Experience on NSTX S/U	\$10	+0.25
S/U-10	8501	Control System problems delay testing	During the development of the ISTP specific (first plasma) waveforms will be tested to ensure that they will work. WBS 5	Start of installation	Sichta	Allowances made in current S/U plans	L	Negligible	Low	Experience on NSTX S/U	\$10	+0.25

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S/U-11	8501	Loss of a key component or system delays testing - e.g., pump failure	Comprehensive PTP's will be conducted prior to implementing the ISTP. WBS 1-6	Start of installation	Gentile	Allowances made in current S/U plans - replace pumps => suspend S/U unitl replaced/repaired.	U	Marginal	Low	Experience on NSTX S/U	\$50	+0.50
S/U-12	8501	Islands detected in e-beam mapping require troubleshooting and repair; delay CD-4.	Control sources of field error and maintain inventory. WBS 8204	Completion of e-beam mapping	Brooks	Allowances made in current S/U plans - if islands deemed to be unacceptable, would have to adjust coils.	N/A	N/A	N/A	<i>High impact-low probability event that has been excluded as a bounding assumption.</i>		
S/U-13	8501	Loss of a key component or system delays testing - e.g., turn to turn failure	Comprehensive PTP's will be conducted prior to implementing the ISTP. WBS 1-6	Start of installation	Gentile	Allowances made in current S/U plans	N/A	N/A	N/A	<i>High impact-low probability event that has been excluded as a bounding assumption.</i>		
S/U-14	3801	E-beam mapping diagnostic is not installed and ready for use during start-up. Risk is possibly complex and challenging interface of hardware borrowed from Auburn University.	Start design of needed hardware early. Bring the work forward to mitigate the risk	Completion of installation	Stratton	Work has not yet started on job 3801. Start of work will be brought forward to January 2009.	VU	Significant	Low		\$50	+1.00

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TECHNICAL RISKS - Components & Systems												
Sys-2	1352	PF vendor produces a non-compliant coil requiring fabrication of an additional coil	Conductor for extra coil will be procured in advance and available to wind a new coil if required. Job 1352 Float in schedule appears adequate to avoid critical path impact.	Completion of Last Coil	Chrzanowski	Future Risk	VU	Negligible	Low	Increase PPPL Title III by ~1 man-month	\$35	+0.00
Sys-3	1361	TF vendor produces a non-compliant coil requiring fabrication of an additional coil	Conductor for extra coil already procured. Ample float in schedule to avoid critical path impact. No additional action required Job 1361	Completion of Coil #18	Kalish	Quality improving - production mode established. 9 TF Coils delivered 500 days of float from critical path	VU	Negligible	Low	Increase PPPL Title III by ~1 man-month	+ \$35	+0.00
Sys-4	1451	Failure of major piece of winding equipment (e.g., motor, gear box, etc.) resulting in extended downtime in a winding station	Use three remaining winding stations to continue MC fabrication while fourth station is being repaired. Job 1451	Retired?	Chrzanowski	Future risk, has not occurred yet - N/A. Only 2 coils left. Redundant winding tooling makes this risk negligible.	U	Negligible	Low	~\$10K for equipment plus repair costs	\$30	+0.00
Sys-5	1451	Damage or loss of modular coil during VPI or testing requiring the conductor to be stripped off and re-wound.	Continue to use same rigorous process used for first 14 coils during which there were no fabrication mishaps requiring re-winding a coil. Job 1451	After last coil complete.	Chrzanowski	16 of 18 coils successfully wound. Remaining 2 coils in winding process.	N/A	N/A	N/A	<i>High impact-low probability event that has been excluded as a bounding assumption.</i>		
Sys-8	4301	Legacy power supplies unexpectedly require modifications or additional protection as a result of failure modes analysis.	Complete failure modes analysis and/or testing. WBS 4401	Power Systems PDR	Ramakrishnan		U	Negligible	Low		\$50	+0.00
Sys-9	4401	Coil protection system costs grow when requirements fully mature.	Establish requirements Job 4401.	Power Systems PDR	Ramakrishnan		U	Negligible	Low		\$35	+0.00
Sys-10	1260	NB Transition duct design is vintage and revisit could result in criteria changes, i.e. diagnostic requirements, number of ports, NB alignment, further design review, etc.	Schedule was made more aggressive with early start to assure ageement with design.		Goranson		U	Negligible	Low	Engineering hours to redo models and hold design review.	\$60	+0.00
Sys-12	1601-162	Design of cables not firmly established, satisfying field error requirements could require more costly solutions and longer lead time.	Moving preliminary design into FY08 to give more lead time.		Goranson		L	Negligible	Low	Increased time for Engineering study of alternate configurations.	\$60	+0.00

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Sys-13	1550	Escalation of Stainless Sheet and Inconel higher than base escalation rates or due to foreign exchange rates.	None	After structure materials procured.	Dahlgren	Current estimates have "best" info on SS and Inconel prices. Will revisit in semi-annual EAC update.	VL	Marginal	Moderate	See separate sheet - assume 3% to 20% higher per year escalation rate	\$495	+0.00	
Sys-14	13XX 4, et al.	Escalation of Copper higher than base escalation rates or due to foreign exchange rates.	None	After all conductor procured.		Current estimates have "best" info on Cu prices. Will revisit in semi-annual EAC update.	VL	Marginal	Moderate	See separate sheet - assume 5% to 20% higher per year escalation rate	\$225	+0.00	
Sys-16	1501 1353	Coil structure designs have to be modified after FDR to accommodate changes in interfaces with coil services or cryostat.	Expedite design of coil services and cryostat.	June, 2008 (before procurements placed)	Dahlgren	Some interfaces still not well defined - however, structure does have significant margin.	L	Negligible	Low	Cost: 20% impact on design & fab. Schedule: none	\$95	+0.00	
Sys-17	1701	Cryostat costs grow once design matures and requirements are better understood.	Adopt existing mature design concept if possible. (Downgrade consequences if so.)	October, 2008 (CDR)	Raftopoulos	Re-evaluating "old design" - expect decision by 4/1	U	Marginal	Low	Cost: 50% impact on design & fab. Schedule: none	\$150	+0.00	
Sys-21	1421 1431	The C-C joint may need to be re-designed if it turns out that the 2T, high beta load case is not the worst-case operating condition for the friction shims.	The load cases defined in the modular coil SRD will be run to determine if the present analyses based on the 2T, high beta load case are worst case. If worst case operational conditions are found, develop mitigations and/or operational scenarios consistent with the operational limits defined by these analyses.	Sept., 2008	Brooks/Fan	Load cases being run - expect results by mid-May	VU	Negligible	Low	Redefinition of some operating scenarios.	\$50	+0.00	
Sys-22	1501 1353	Coil structure designs may have to be modified after FDR to accommodate fault modes.	Expedite failure modes analysis.	June, 2008 (before procurements placed)	Dahlgren		U	Negligible	Low	Cost: 20% impact on design. Schedule: none	\$30	+0.00	
Sys-23	3801	E-beam mapping may require opening vs. a retractable design.	Consider retractable design as the baseline.	By completion of PDR in April 2009	Startton		U	Significant	Moderate	Based on time to cooldown, break vacuum, install equipment and restore temperature and vacuum.	\$100	+1.00	
TECHNICAL RISKS - Research Operations (post-CD4) => NOT PART OF MIE PROJECT													

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Ops-1	8204	The operational flexibility of the machine may be limited if it turns out that the 2T, high beta load case is not the worst-case operating condition for the friction shims.	The load cases defined in the modular coil SRD will be run to determine if the present analyses based on the 2T, high beta load case are worst case. If worst case operational conditions are found, develop mitigations and/or operational scenarios consistent with the operational limits defined by these analyses.	Sept., 2008	Brooks/Fan	Load cases being run - expect results by mid-May	U	Negligible	Low	Redefinition of some operating scenarios.	\$50	+0.00
Ops-2	7503	Shield walls found to be inadequate. Limits operation conditions	Calculate doses, assess hazards and needed controls, peer review results. If necessary, re-grout open gaps.	1 year before start of Station 5.	Perry	Impact of grouting gaps.	VU	Marginal	Low		\$150	+0.00