WBS 3 - Diagnostics

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NCSX WBS 3 Manager

Outline

- Requirements
- Interfaces
- Design, fabrication, and installation status or plans and schedule by job
- Estimates to complete
- Risks and mitigation

Diagnostics requirements

- Ex-vacuum vessel magnetic sensors (job 3101):
  - Flux loops on external surface of vessel to sense stellarator-symmetric and non-symmetric modes
    - 205 Flux loops on external surface of vacuum vessel subassemblies (VVSAs)
    - 20 Flux loops on vacuum vessel spacers
  - 4 toroidal loops on vessel to measure loop voltage
  - 62 Flux loops co-wound with modular coils, TF coils, solenoid, and PF coils to sense flux through coils for feedback control
  - 3 Rogowski coils to measure plasma current
  - General requirements on these sensors:
    - Reliability and longevity
    - Redundancy in case of failure
    - Tolerance to bakeout temperature (350 C) and liquid nitrogen temperature
  - Field cables and instrumentation (integrators, digitizers, crate, and PC) to support data acquisition from 8 sensors for first plasma
  - Extension and termination of thermocouple leads (348) and heater tape leads (96) in boxes at ends of large vertical ports (job 3101)

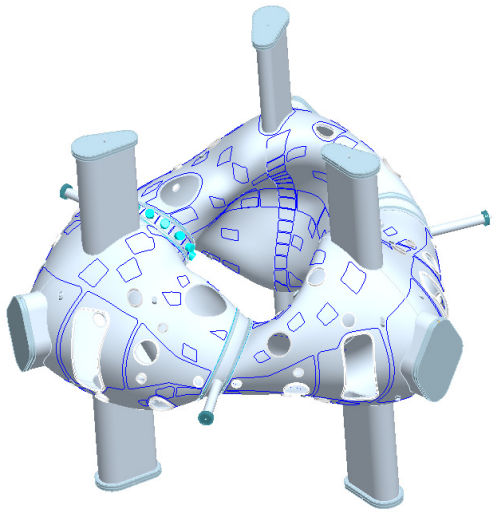
Diagnostics requirements-cont.

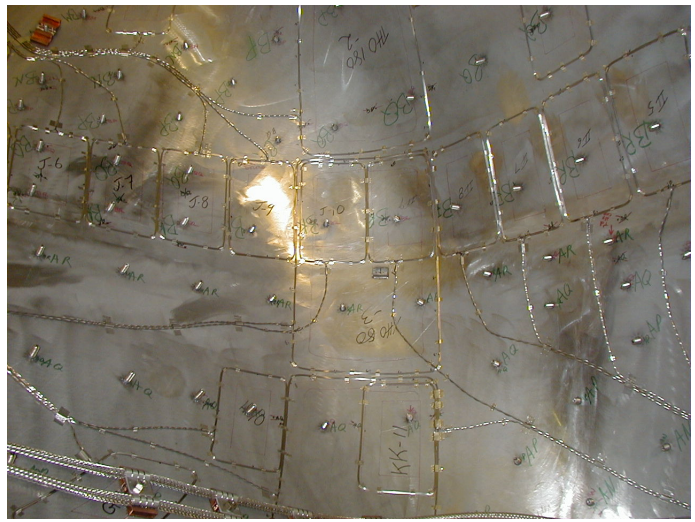
- Visible TV camera system (job 3601)
  - Capable of observing plasma shape during first plasma operation
- Electron beam field line mapping system (job 3801):
  - Capable of field line mapping following first plasma
- Diagnostics integration (job 3901):
  - Management of WBS 3 jobs

Interfaces

- Ex-vessel magnetic sensors:
  - Vacuum vessel (WBS 12)
  - Conventional coils (WBS 13)
  - Modular coils (WBS 14)
  - Cryostat (WBS 17)
  - Data acquisition (WBS 53)
  - Field period assembly (WBS 18)
- Extension and termination of thermocouple and heater tape leads:
  - Vacuum vessel (WBS 12)
- Visible TV camera system:
  - Vacuum vessel (WBS 12)
  - Data acquisition (WBS 53)
- Electron beam field line mapping system:
  - Vacuum vessel (WBS 12)
  - Data acquisition (WBS 53)
  - Cryostat (WBS 17)

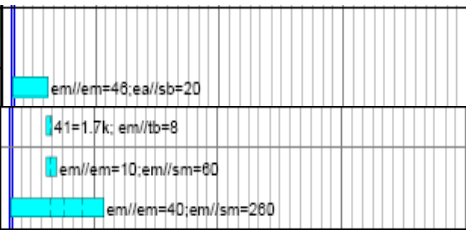
Vacuum vessel flux loops & voltage loops status





Voltage Loops & Protective Boxes

3101-800		Design Routing and Boxes	76*		31JAN08A	15MAY08	1,596	9,342.48
3101-802		Fab 3 protective Boxes (Use Existing Box)	10		16MAY08	30MAY08	1,606	3,341.64
3101-806		Check elect characteristics of coax	20		16MAY08	13JUN08	1,596	9,365.40
3101-807		Check elect characteristics ex-vessel flux loops	193		31JAN08	30OCT08	1,499	40,337.24



- Installation and termination of VV flux loops complete
- Final electrical check of terminated loops planned to be complete by Aug. 2008
- Loop segments installed on vacuum vessel subassemblies (VVSAs)
- Voltage loop leads to be protected in boxes on modular coils until assembly
- Connection of voltage loop segments to be done during final machine assembly
  - Low technical risk but a critical path activity

Spacer flux loops status

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Spacer Flux Loops & Boxes

3101-900		Peer review	2		02OCT08	03OCT08	426	2,604.00	em//em=16
3101-901		Purchase Copper	5		13OCT08	17OCT08	426	325.50	em//em=2
3101-902		Purchase CoAx Cable-2000ft .059 ss	5		27OCT08	31OCT08	426	325.50	em//em=2
3101-903		Purchase flex ss protective tube	5		27OCT08	31OCT08	426	5,714.62	em//em=2;ee//em=32
3101-904		Design Templates	10		06OCT08	17OCT08	426	6,510.00	em//em=40
3101-905		Machine Cu Templates	10		20OCT08	31OCT08	426	668.56	em//tb=8
3101-908		Design protective box	10		06OCT08	17OCT08	426	3,906.00	em//em=24
3101-909		Fab protective boxes	10		20OCT08	31OCT08	426	3,906.00	em//em=24
3101-910		Prep dwgs of spacer loops	10		20OCT08	31OCT08	426	11,311.60	em//em=40;ea//sb=40
3101-911		Check elec characteristics of coax cables	10		09DEC08	22DEC08	440	15,434.50	em//em=10;em//sm=100
3101-907		Autocad dwgs of field runs	24		09DEC08	20JAN09	426	3,906.00	em//em=24
3101-906		Engr support Title III	24		09DEC08	20JAN09	426	1,953.00	em//em=12

- Plan to start design Jan. 2009 and complete installation April 2009
  - Fits availability of experienced engineer
  - Does not affect critical path
- Low risk: design and installation technique similar to VV flux loops

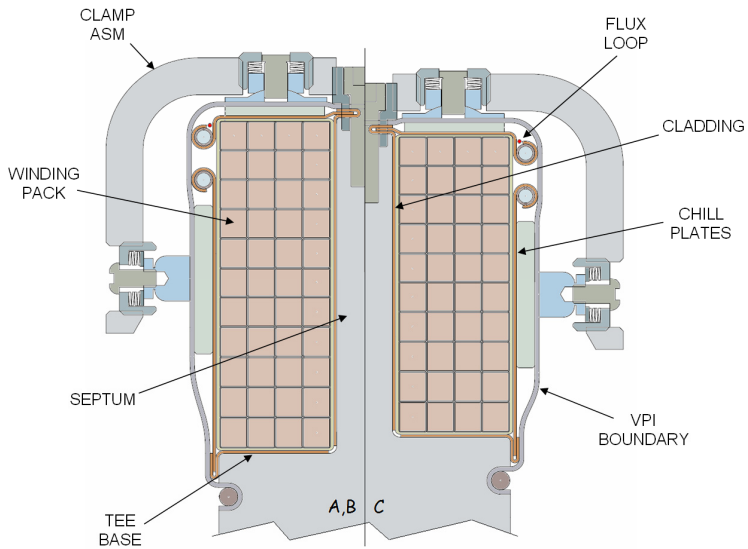
Co-wound flux loops status

NCSX National Compact Stellarator Experiment

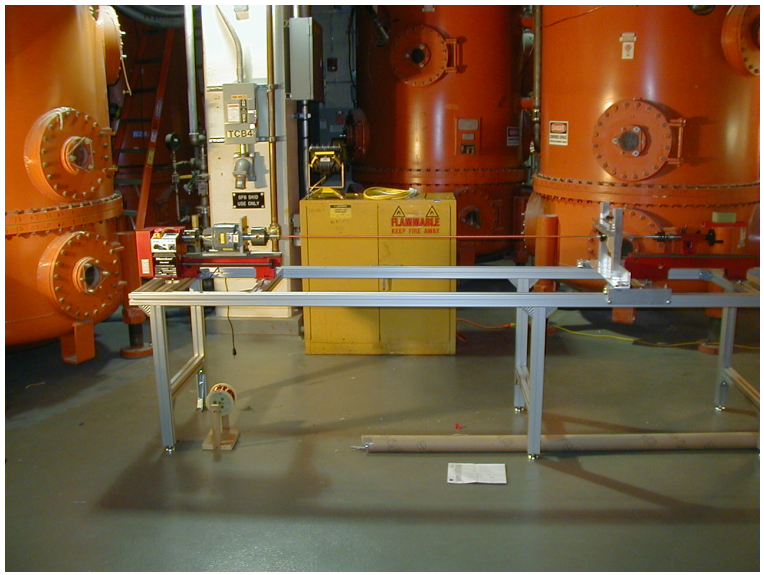
TF and PF Co-wound Loops

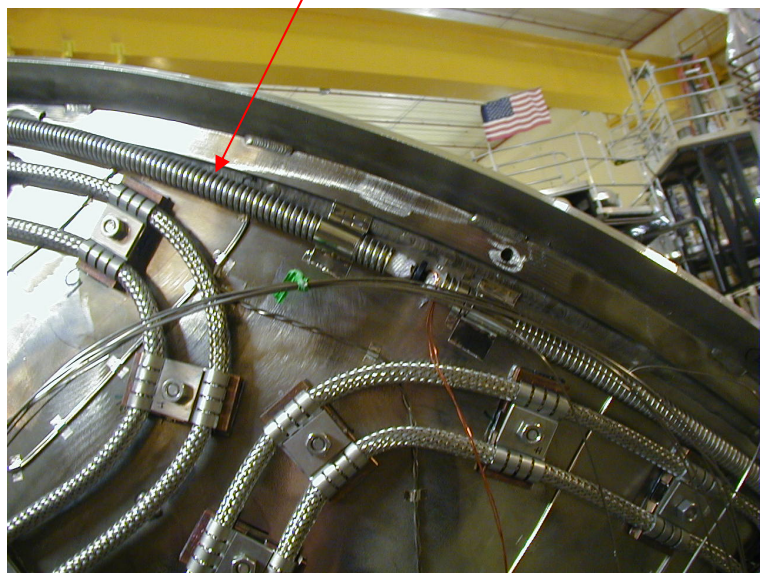
3101-425		Design Protective boxes for PF	100*		01NOV07A	01APR08	1,558	3,558.24	EA/ISB=60hr ; EM/EM=110hr ;
3101-426		Purchase SS Sheet	10		12NOV07A	18JUN08	320	226.93	EM/TB=1; 41=0.87k
3101-452		Form Protective boxes	10		12NOV07A	23JUN08	320	2,661.38	em//sm=102
3101-454		Weld end plates of PF protective boxes	10		09NOV07A	30JUN08	320	284.29	em//tb=18
3101-427		Purchase Heat Shrink tubing	15		12NOV07A	19MAY08	1,495	591.56	EM/TB=6; 41=2.0k
3101-428		Purchase add'l CoAxial cable	46		01MAY08*	07JUL08	316	2,873.47	EM/TB=2hr ; 41=4.55k ;
3101-457		Rebuild connective air furnace	20		31JAN08	27FEB08	1,553	5,836.46	em//em=2;em//sm=40;41=.25k
3101-458		FabTF,PF & solenoid co-wound loops	186		02JUL07A	15AUG08	1,462	8,479.90	em//sm=130
3101-460		Check elect characteristics coax cables	90*		01OCT08*	16FEB09	1,431	18,195.90	em//sm=120; em//em=10
3101-456		Title III	90		01OCT08	16FEB09	1,431	5,859.00	em//em=36

- 36 MC, 18 TF coil, and 2 PF coil flux loops complete. Need to make 6 more PF coil and solenoid flux loops. Plan to complete by Aug. 2008
- Check leads of installed loops by Feb. 2009
  - Low risk



Rogowski coil plan



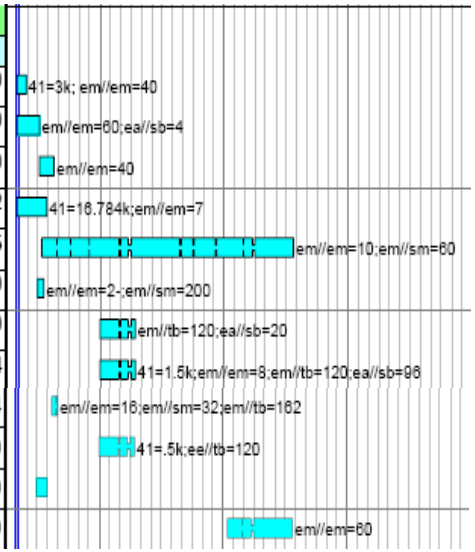


- Wound from mineral-insulated cable on stainless steel mandrels with protective sheath
- One coil installed on each of three VVSAs for redundancy
- Leads twisted and terminated in flux loop junction boxes

Rogowski coil status

Rogowski Coils

3101-350		Winding mandrel work station	20*		31JAN08A	27FEB08	475	9,877.20
3101-352		Assy & detail dgws	46		31JAN08	03APR08	431	25,761.60
3101-353		Prep installation procedure	31		04APR08	16MAY08	431	6,151.20
3101-354		Purchase materials	62		31JAN08	25APR08	446	21,917.22
3101-370		Check elect characteristics of cables	503*		16APR08*	23APR10	1,135	9,863.45
3101-351		Wind coils	13*		31MAR08*	16APR08	453	29,167.60
3101-355		Temp cable trays	65		01OCT08*	12JAN09	272	12,429.20
3101-356		Dsn,purchase,install rack	65		01OCT08*	12JAN09	272	24,813.24
3101-357		Fab coil clamps & ends	12*		15MAY08*	02JUN08	421	19,428.34
3101-358		Prep chassis & timing module	65		01OCT08*	12JAN09	272	10,031.00
3101-359		Install Rogowski coils (budgeted in job 1815)	21*		02APR08*	30APR08	542	0.00
3101-360		Title III support	130		12OCT09	23APR10	1,135	10,050.60



- Fabrication of winding station and prototype winding complete
- Fabrication and installation of all 3 coils in progress and planned to be complete by end of May 2008
- Low risk due to extensive prototyping
- Instrumentation for 8 sensors:
  - Start design in October 2008
  - Low risk: will re-use hardware currently in use on NSTX

Extension and termination of TC & heater tape leads

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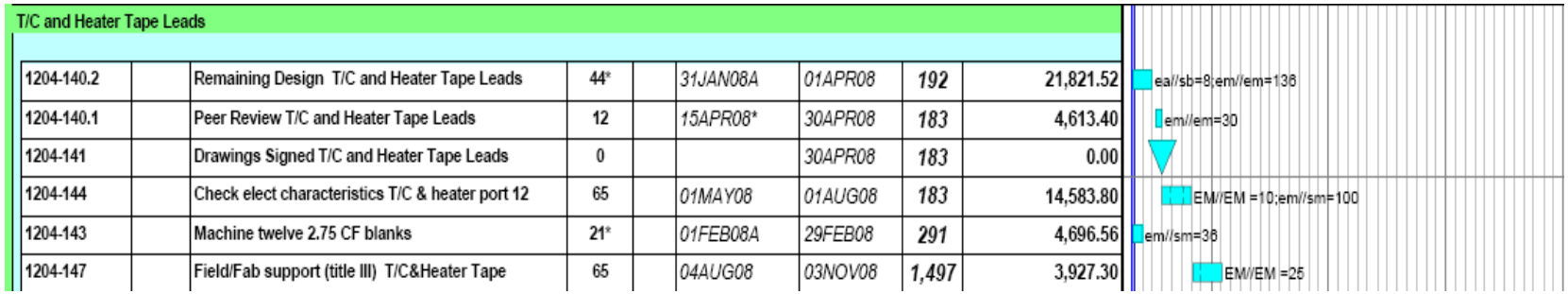


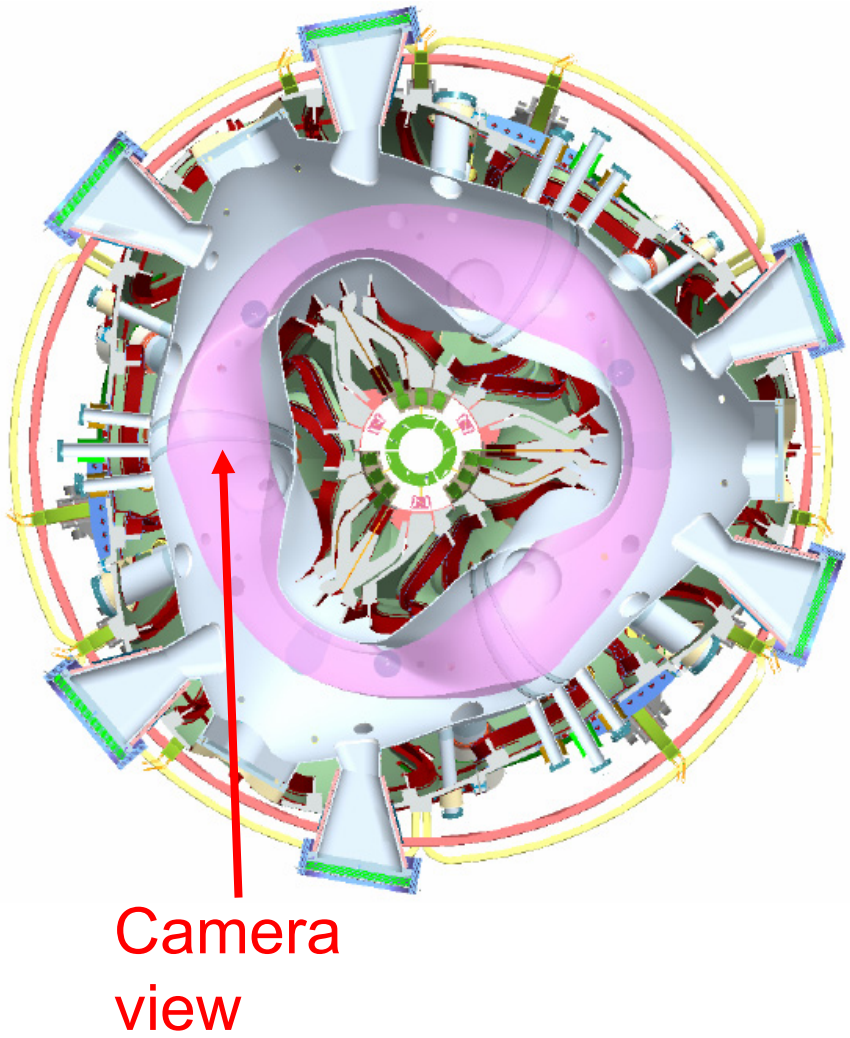
T/C and Heater Tape Leads

1204-140.2		Remaining Design T/C and Heater Tape Leads	44*		31JAN08A	01APR08	192	21,821.52
1204-140.1		Peer Review T/C and Heater Tape Leads	12		15APR08*	30APR08	183	4,613.40
1204-141		Drawings Signed T/C and Heater Tape Leads	0			30APR08	183	0.00
1204-144		Check elect characteristics T/C & heater port 12	65		01MAY08	01AUG08	183	14,583.80
1204-143		Machine twelve 2.75 CF blanks	21*		01FEB08A	29FEB08	291	4,696.56
1204-147		Field/Fab support (title III) T/C&Heater Tape	65		04AUG08	03NOV08	1,497	3,927.30

- Complete on 2 VVSAs
- Plan to complete on third VVSA by end of April 2008
- Low risk

Visible TV camera plan

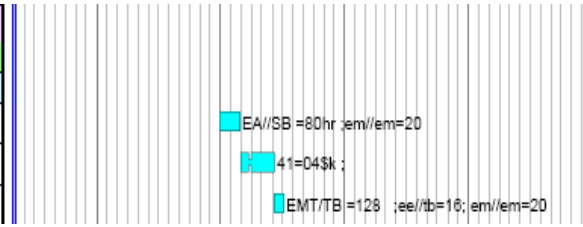
- Will view along one vacuum vessel period
  - Requires window mounted on neutral beam port and camera mount
- Camera and data acquisition hardware to be re-used from NSTX



Visible TV camera status

Job: 3601 - Edge Divertor Diagnostics-STRATTON

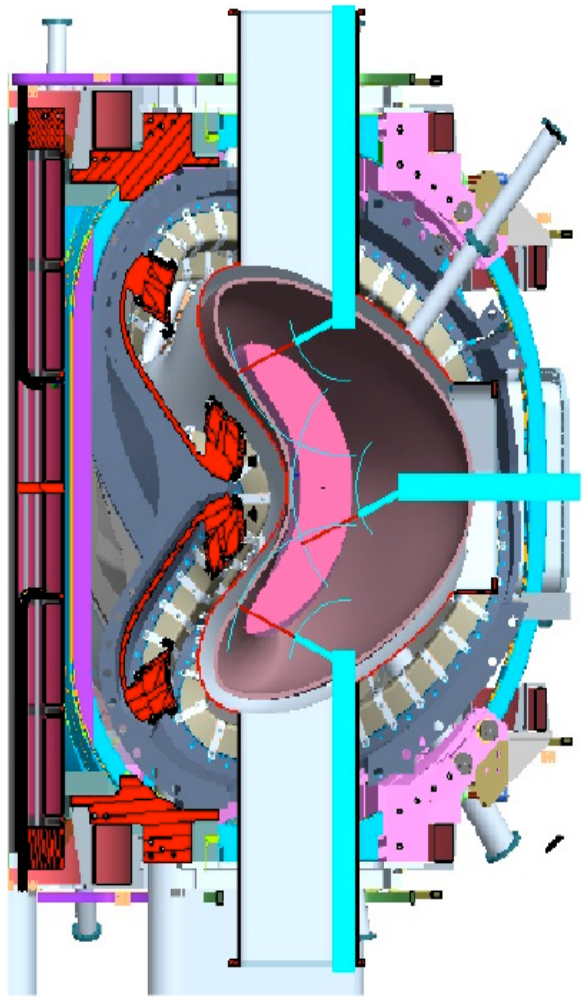
361-001		Design Visible Camera sys	40	01OCT09*	25NOV09	309	13,234.20
361-015		Procure flange,window and material	65	30NOV09	10MAR10	309	4,679.50
361-016		fabricate and assemble Visible tv camera sys	20	11MAR10	07APR10	309	12,205.96



- Start design in October 2009
- Low risk: simple system similar to installations on NSTX

Electron-beam field line mapping plan

- Injected low energy electrons follow field lines and emit visible light when they strike a swept fluorescent rod or stationary screen. Visible camera images rod to provide map of field line structure in poloidal plane.
  - Hardware will be borrowed from Auburn University/University of Wisconsin.
  - WBS 3 and WBS 5 responsible for vacuum interface and control/data acquisition hardware



Electron-beam field line mapping status

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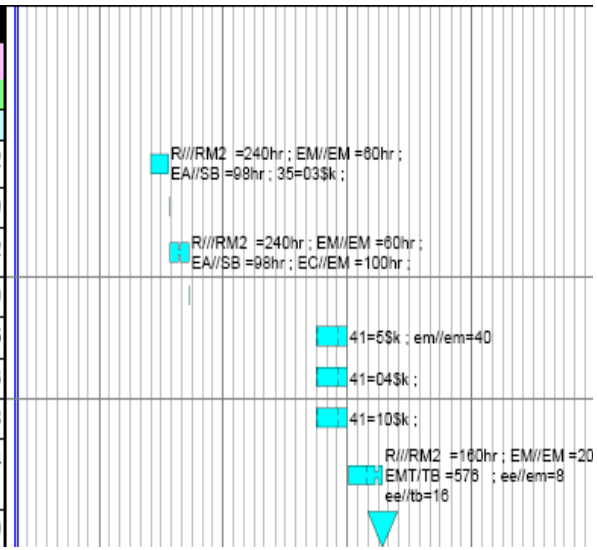
38 - Electron Beam (EB) Mapping

Job: 3801 - Electron Beam Mapping-STRATTON

380-010		E-beam mapping- Prelim Design	40		02MAR09*	24APR09	372	66,396.32
380-015		E-beam mapping - PDR	1	R	27APR09	27APR09	372	0.00
380-100		E-beam mapping-Final Design	40		28APR09*	23JUN09	372	104,685.32
380-110		E-beam mapping - FDR	1	R	24JUN09	24JUN09	372	0.00
380-115		E-beam mapping-Procure Rack,xfrmr,cable	65		01JUL10*	01OCT10	120	13,393.16
380-120		E-beam mapping-Procure Ports	65		01JUL10	01OCT10	120	5,350.03
380-130		E-beam mapping-Procure Data Acquisition	65		01JUL10*	01OCT10	120	13,375.08
380-135		E-beam mapping- Assemble	65		04OCT10*	12JAN11	120	54,862.24
380-135M	2	E-beam mapping apparatus ready for Installation	0			12JAN11	120	0.00

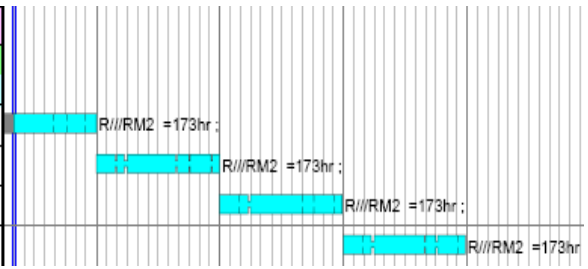


- Design not started
- Medium risk: interface between hardware and NCSX not well defined-could be complex

Diagnostics integration status

Job: 3901 - Diagnostics sys Integration-STRATTON

390-04		LOE Support FY08	249*		01OCT07A	29SEP08	1,522	19,176.19
390-05		LOE Support FY09	247*		01OCT08*	28SEP09	1,274	29,714.48
390-06		LOE Support FY10	246*		01OCT09*	28SEP10	1,026	30,581.21
390-07		LOE Support FY11	248*		01OCT10*	28SEP11	776	32,131.29



- 10% LOE support by one physicist to manage diagnostic work in MIE project
- Sufficient based on experience so far

Estimates to complete

Job	Mech. Eng. (hrs)	Sr. Mech. Tech. (hrs)	Mech. Tech. (hrs)	Design. (hrs)	Elect. Tech. (hrs)	Elect. Eng. (hrs)	Comp. Eng. (hrs)	Res. Staff (hrs)	Travel (k$)	M&S (k$)
Ex-vessel Mag.	1023	1816	460	188	128	32	0	0	0	29.7
Visible Camera	40	0	88	80	16	0	0	0	0	3.5
E-beam Mapping	160	0	576	196	16	8	300	480	3.0	19.0
Diag. Integ.	0	0	0	0	0	0	0	778	0	0
TOTAL	**1223**	**1816**	**1124**	**464**	**160**	**40**	**300**	**1258**	**3.0**	**52.2**

- Estimates to complete based on:
  - Ex-vessel magnetics: experience to date on these tasks; vendor quotes
  - Visible TV camera: experience with similar systems on NSTX; vendor quotes
  - Electron beam field line mapping system: discussion with Auburn University personnel, in-house estimates for specific components; vendor quotes
  - Diagnostics integration: experience to date

Risks and mitigation plans

- Electron beam mapping system design not started-could be complex
  - Mitigate risk by starting design soon-summer 2008
  - This job will be transferred to ORNL in collaboration with Auburn University and University of Wisconsin
  - Plan takes advantage of extensive shared experience in field line mapping at Auburn, UW, and ORNL, who worked as a team on this task for ATF
- There is some risk of damage to VV flux loops, spacer flux loops, Rogowski coils, and heater and thermocouple leads when modular coil three-packs are placed over VVSAs and during machine assembly. Repairs could be on the critical path.