Marshall Space Flight Center
Engineering, Science & Technical Services

Task Order Plan (TOP)

Contract Number: *NNM05AB50C*
TO Title: *Solid Motor Stress Analysis Support*
TO Number: *33-040114* **Revision:** *12*

Period of Performance: *10/02/2010* to *3/31/2011*

MSFC Initiator: *Jim Hawkins*

(b)(4) [redacted]

Emergency: *No*

Revision 12: The purpose of this revision is to extend this task into Contract Year 6 of the NNM05AB50C ESTS contract. This revision defines and estimates work for the period October 2, 2010 through March 31, 2011. Additionally, the Schedule, Performance Plan and Risk Assessment have been revised to reflect changes in task activities for the new period of performance.

Subelement 01, Reusable Solid Rocket Motor (WBS 520871)
This subelement is closed. Work performed on this subelement will be continued under Task Order 33-040114-SA.

Subelement SA, Reusable Solid Rocket Motor (WBS 520871)
This new subelement continues work previously performed under Task Order 33-040114-01. Estimated (b)(4) [redacted] and one trip for a total cost estimate of (b)(4) [redacted]

Subelement EA, Launch Abort System (WBS 644423.06.34)
This subelement is closed by this revision.

The total estimate for revision 12 of this Task Order is (b)(4) [redacted]

Revision 11: The purpose of this revision is to update labor projections based primarily on the re-prioritization of labor re-sources to address additional insight support requested for the Launch Abort System during preparation for the Pad Abort 1 test. In addition, this revision incorporates re-planning of the Reusable Solid Rocket Motor (RSRM) subelement to incorporate the following task support in addition to the typical production and flight readiness support activities:

- Develop a Structural Primer to document and standardize analytical methods and material characterization techniques. Facilitate knowledge base retention and skills development though the establishment Best Practices for dissemination to solids technical community.
- Initiate updates to RSRM component analyses with respect to material obsolescence and constitutive behavior research. Possible introduction of and/or comparison of damage tolerance methodologies with existing failure approaches.
- Perform dynamic assessments of existing RSRM test/flight data to further the dynamic characterization of the RSRM. Process test/flight data for entry into archived database.

The Schedule and Performance Plan have been revised to reflect changes in task activities and progress to date. Changes by subelement are as follows:

Subelement 01, Reusable Solid Rocket Motor (WBS 520871)
Increased the labor estimate for this subelement by (b)(4) resulting in an increase of (b)(4) from Revision 10. Estimated (b)(4) and a trip for a total cost estimate of (b)(4)

Subelement CA, Reusable Solid Rocket Motor V (WBS 136905.08.01.11)
This subelement was administratively closed effective July 3, 2010. This revision also removes (b)(4) previously estimated for the period October 1-14, 2010.

Subelement CB, Upper Stage Small Solids (WBS 136905.08.05.13.02.01.08)
This subelement was administratively closed effective July 3, 2010. This revision also removes (b)(4) previously estimated for the period October 1-14, 2010.

Subelement CC, Ares I-X (WBS 136905.08.01.09)
This subelement was closed by Revision 10.

Subelement EA, Launch Abort System (WBS 644423.06.34)
Increased the labor estimate for this subelement by (b)(4) resulting in an increase of (b)(4) from Revision 10. This revision also balances sign-on and referral bonuses (b)(4) paid for the most recent new employee hired to support this subelement, and accounts for a trip to support the Pad Abort 1 test ((b)(4) Estimated (b)(4) and 5 trips for a total cost estimate of (b)(4)

The total cost estimate for Revision 11 of this Task Order is (b)(4) an increase from Revision 10 of (b)(4)

Revision 10: The purpose of this revision is to close subelement CC, Ares I-X, as no post-flight contingency support was required. In addition, this revision increases the scope of subelement EA, Launch Abort System, to provide enhanced insight in the development of the Launch Abort Motor, Attitude Control Motor, and Jettison Motor. The revision reflects the addition of labor hours for another analyst, as well as associated recruiting and relocation costs. The Schedule and Performance Plan have been revised to reflect changes in task activities and progress to date. Changes by subelement are as follows:

Subelement 01, Reusable Solid Rocket Motor (WBS 520871)
No change from Revision 9. (b)(4) (b)(4)

Subelement CA, Reusable Solid Rocket Motor V (WBS 136905.08.01.11)
No change from Revision 9. (b)(4) (b)(4)

Subelement CB, Upper Stage Small Solids (WBS 136905.08.05.13.02.01.08)
No change from Revision 9. (b)(4)

Subelement CC, Ares I-X (WBS 136905.08.01.09)
This subelement is closed by this revision. The Task Order estimated is reduced (b)(4) by this subelement closure.

Subelement EA, Launch Abort System (WBS 644423.06.34)
Estimated (b)(4) in recruiting and relocation costs, and 4 trips for a total cost estimate of (b)(4) from Revision 9.

The total cost estimate for Revision 10 of this Task Order is (b)(4) an increase from Revision 9 of (b)(4)

Revision 9: The purpose of this revision is to extend this task into Contract Year 5 of the NNM05AB50C ESTS contract. This revision defines and estimates work for the period October 3, 2009 through October 14, 2010. Additionally, the Schedule, Performance Plan and Risk Assessment have been revised to reflect changes in task activities for the new period of performance. This revision affects the following APO elements: First Stage (subelement CA), Upper Stage (subelements CB), and Flight & Integrated Test Office/Ares I-X (subelement CC). Changes by subelement are as follows:

Subelement 01, Reusable Solid Rocket Motor (WBS 520871)
Estimated (b)(4) and a trip for a total cost estimate of (b)(4)

Subelement CA, Reusable Solid Rocket Motor V (WBS 136905.08.01.11)
Estimated (b)(4) and 4 trips for a total cost estimate of (b)(4)

Subelement CB, Upper Stage Small Solids (WBS 136905.08.05.13.02.01.08)
Estimated (b)(4) for a total cost estimate of (b)(4)

Subelement CC, Ares I-X (WBS 136905.08.01.09)
Estimated (b)(4) for a total cost estimate of (b)(4)

Subelement EA, Launch Abort System (WBS 644423.06.34)
Estimated (b)(4) 4 trips for a total cost estimate of (b)(4)

The total cost estimate for this Task Order is (b)(4)

Revision 8: The purpose of this revision is to adjust labor and subcontract hours to reflect actual utilization. Labor and subcontract hours that are not anticipated to be utilized in Contract Year 4 (CY4) are removed from the estimate. Travel estimate is updated to reflect actual utilization. Recruiting expenses incurred in CY4 are fully accounted in this revision. The net change in the Task Order cost estimate for this revision is a decrease of (b)(4) from the previous revision. Changes by subelement are as follows:

Subelement 01, Reusable Solid Rocket Motor (WBS 520871)
Delete (b)(4) that are not expected to be utilized as activity for this subtask is expected to decrease for the remainder of CY4. Delete (b)(4) or travel that will not be utilized. The net change in cost estimate for this subelement is a decrease of (b)(4)

Subelement CA, Reusable Solid Rocket Motor V (WBS 136905.08.01.11)
Delete (b)(4) to account for new subtask personnel transitioning to this task later than originally planned. Add (b)(4) travel to cover trips to the Reusable Solid Rocket Motor-V Contractor for required technical interchange meetings. Add (b)(4) ODC for recruiting advertising costs. The net change in cost estimate for this subelement is an increase of (b)(4)

Subelement CB, Upper Stage Small Solids (WBS 136905.08.05.13.02.01.08)
Delete (b)(4) that are not expected to be utilized due the cancellation of an anticipated new hire to support this task. Add (b)(4) subcontractor (b)(4) to cover greater subcontractor utilization than initially estimated. The net change in cost estimate for this subelement is a decrease of (b)(4)

Subelement CC, Ares I-X (WBS 136905.08.01.09)
Delete (b)(4) due to less support actually required to meet task objectives than originally estimated. Delete (b)(4) for travel that will not be utilized. The net change in cost estimate for this subelement is a decrease of (b)(4)

Subelement EA, Launch Abort System (WBS 644423.06.34)
Add (b)(4) to cover additional subtask personnel. Add (b)(4) travel for additional required oversight of the Attitude Control Motor Contractor. Add (b)(4) for recruiting advertising costs and a referral bonus. The net change in cost estimate for this subelement is an increase of (b)(4)

Revision 7: The purpose of this revision is to adjust the phasing of labor hours or re-estimate, as required, to reflect planned utilization. Unused labor hours were retained and moved forward in the task schedule in anticipation of work to be performed later in the period of performance. Changes by subelement are as follows:

Subelement 01, Reusable Solid Rocket Motor (WBS 520871)
No changes applied in this revision.

Subelement CA, Reusable Solid Rocket Motor V (WBS 136905.08.01.11)
Added (b)(4) for additional personnel authorized to support this subelement. The cost estimate for this subelement is increased by (b)(4)

Subelement CB, Upper Stage Small Solids (WBS 136905.08.05.13.02.01.08)
Adjusted labor hours within the subelement schedule to reflect actual utilization. No net change in the cost estimate for this revision.

Subelement CC, Ares I-X (WBS 136905.08.01.09)
Adjusted labor hours within the subelement schedule to reflect actual utilization. No net change in the cost estimate for this revision.

Subelement EA, Launch Abort System (WBS 644423.06.34)
Adjusted labor hours within the subelement schedule to reflect actual utilization. Increased travel estimate to (b)(4) to accommodate additional customer-requested travel in December and February. The cost estimate for this subelement is increased by (b)(4)

The net change in cost estimate for this Task Order is an increase of (b)(4)

Revision 6: The purpose of this revision is to adjust the phasing of labor hours or re-estimate, as required, to reflect actual utilization. Unused labor hours were retained and moved forward in the task schedule in anticipation of work to be performed later in the fiscal year. Changes by subelement are as follows:

Subelement 01, Reusable Solid Rocket Motor (WBS 520871)
Added (b)(4) More support than initially estimated was required to support the investigation and analysis of the Polybenzimidazole Liner (PBL) and Insulation investigation of the formation of large non-bonded areas between the Flight Support Motor-15 Propellant Liner Insulation (PLI). The cost estimate for this subelement increased by (b)(4)

Subelement CA, Reusable Solid Rocket Motor V (WBS 136905.08.01.11)
Added (b)(4) More support than initially estimated was required to support the development of a new methodology for evaluating mechanical failure of Reusable Solid Rocket Motor Five Segment (RSRM-V) PLI components. Also required more than estimated interaction with the RSRM Contractor concerning the inadequacies of the existing analytical approaches, flight logic and certification path for the new RSRM-V nozzle. The cost estimate for this subelement increased by (b)(4)

Subelement CB, Upper Stage Small Solids (WBS 136905.08.05.13.02.01.08)

Converted unused labor hours to subcontract dollars in anticipation of additional requirements for utilization of subcontractor personnel later in the fiscal year. The cost of this subelement had a decrease of (b)(4) due to incompatibilities between labor and subcontract cost estimating.

Subelement CC, Ares I-X (WBS 136905.08.01.09)
Moved unused labor hours forward in the task schedule. There is no change in cost estimate for this subelement.

Subelement EA, Launch Abort System (WBS 644423.06.34)
Adjusted labor hours within the subelement schedule to reflect actual utilization. Increased travel estimate to (b)(4) to accommodate customer-requested travel in October and November. The cost estimate for this subelement is increased by (b)(4)

The net change in estimate for this Task Order is an increase of (b)(4)

Revision 5: The purpose of this revision is to extend this task into Contract Year 4 of the NNM05AB50C ESTS contract. This revision defines and estimates work for the period September 27, 2008 through October 2, 2009. Additionally, the Schedule, Performance Plan and Risk Assessment have been revised to reflect changes in task activities for the new period of performance. This revision affects the Ares-I First Stage (subelement CA), Upper Stage (subelement CB), and Ares I-X (subelement CC). Changes by subelement are as follows:

Subelement 01 (WBS 520871)
Estimated (b)(4) and 1 trip to support meetings for a total cost estimate (b)(4)

Subelement CA (WBS 136905.08.01.11)
Estimated (b)(4) and 3 trips to support meetings for a total cost estimate of (b)(4)

Subelement CB (WBS 136905.08.05.13.02.01.08)
Estimated (b)(4) and (b)(4) for a total cost estimate of (b)(4)

Subelement CC (WBS 136905.08.01.09)
Estimated (b)(4) and 1 trip to support meetings for a total cost estimate of (b)(4)

Subelement EA (WBS 644423.06.34)
Estimated (b)(4) and 1 trip to support meetings for a total cost estimate of (b)(4)

The total estimate for this Task Order is (b)(4)

The purpose of this revision (-04) is to more accurately reflect the effort required during this period of performance. Labor estimate on Subelement -01 was reduced by (b)(4) with a corresponding reduction in cost of (b)(4) and the ODC estimate was increased by (b)(4) to cover additional moving expenses for subelement personnel. The labor estimate on subelement -CA was increased by (b)(4 (b)(4) with a corresponding increase in cost of (b)(4) and the travel estimate on subelement -CA was also increased by (b)(4) to account for several trips to support meetings with the RSRM-V contractor in (b)(4) The ODC estimate was increased by (b)(4) to account for additional recruiting expenses. The labor estimate on subelement -CB was reduced by (b)(4) with a corresponding reduction in cost of (b)(4) The subcontractor estimate was similarly reduced by (b)(4) while the ODC estimate was increased by (b)(4) to account for recruiting expenses. The labor estimate for subelement -CC was reduced by (b)(4) with a corresponding reduction in cost of (b)(4) The labor estimate for subelement -EA was reduced by (b)(4) with a corresponding reduction in cost of (b)(4) and the ODC estimate was also reduced by (b)(4) The Schedule, Performance Plan and Risk Assessment have not been revised since there are no expected changes in task activities for this period of performance. All adjustments to subelement financial estimates result in a net decrease in estimated

cost with the exception of subelement -CA which has a net increase of (b)(4) For all others, no additional budget is required.

The purpose of this revision (-03) is to expand the scope of support provided by this Task Order to include the Reusable Solid Rocket Motor (RSRM), Ares I-X Flight Test Motor, and the Crew Exploration Vehicle (CEV) Launch Abort System (LAS). Subelements and related labor allocations will be added for each of these as shown. Relocation is allocated to move new task personnel, if required.

> Subelement (01) supports efforts under NASA MSFC Work Breakdown Structure code 520871, MSFC-RSRM (b)(4)
>
> Subelement (CC) supports efforts under NASA MSFC Work Breakdown Structure code 136905.08.01.09, MSFC-Ares I-X Flight Test (b)(4).
>
> Subelement (EA) supports efforts under NASA MSFC Work Breakdown Structure code 644423.06.34, MSFC-Propulsion LAS (b)(4).

In addition, revision 03 applies a correction for relocation estimated for FY07 that was not invoiced in time to be included in the final FY07 financial statements. The relocation estimate previously approved for FY07 is moved to FY08 in the amount of (b)(4) shared equally between subelements –CA (RSRM-V) and –CB (Upper Stage Small Solids).

The purpose of revision 02 is to extend this task into Contract Year 3 of the NNM05AB50C ESTS contract. This revision defines and estimates work for the period 29 September 2007 through 26 September 2008. Additionally, the Schedule, Performance Plan and Risk Assessment have been revised to reflect any changes in task activities for the new period of performance.

The purpose of this revision (01) is to revise the scope of support provided to the Upper Stage Small Solids, remove unused hours of an (b)(4) cost category to accommodate arrival of new task personnel in mid September, and to increase the value of the relocation allowance for the new task personnel. This revision removes (b)(4) and adds (b)(4) as well as adding (b)(4) in relocation allowance.

1.0 Task Order Description & Objectives

This task order will provide structural analysis support for the Space Shuttle Solid Rocket Motor Project Project. Specific task work items will include Solid Rocket Motor modeling, loads calculations, stress analysis, as well as development of test plans, generation of test predictions, support of ground testing, and other activities as required. These efforts will include structural assessment of the Space Shuttle RSRM and other ER41 responsibilities, as required. In addition, this task will support propulsion element design reviews and applicable regular meetings and Technical Interchange Meetings. Direct support will include supporting meetings, identifying the need for independent analysis, and providing independent assessments/analyses. Indirect support will include providing independent assessments/analyses to support meetings attended by a NASA counterpart.

2.0 Technical Approach (Including required input, guidelines & assumptions)

The ESTS Group will provide structural analysis support to the Shuttle Solid Rocket Motor Project by developing finite element models of the structural elements and components of the First Stage Element. Finite element models will be developed using either drawings or Computer-Aided Design (CAD) models to be provided by the applicable design organization. For certain Commercial-Off-the-Shelf (COTS) components of the Solid Rocket Motors, vendor data will be used to define component-level characteristics such as geometry, mass, material, and other structural characteristics. In some cases, finite element models may have been already developed and will be provided by external organizations

(e.g., MSFC-ER50 or component contractors). Subcomponent models, either developed by the ESTS Group or provided by organizations external to ER41, will be merged, as required, to yield sub-system or system models. The analysis models will be created and/or merged using the appropriate analysis software (ANSYS, ABAQUS, or PATRAN/NASTRAN) and will be fully checked to assure correct model geometry, material properties, and appropriate modeling technique. Generic test cases will be run to assess the credibility of analytical results from each model.

Integrated analyses will be performed utilizing self-induced environments and loads, and other salient interface conditions, integrated environments, and external loads. Element-level dynamic loading criteria to be used as input to the integrated analyses will be provided by the Shuttle vehicle loads organization. These criteria may be in the form of force or deflection input spectra, random vibration criteria, or other appropriate format as defined at relevant interface locations. In addition, low-frequency and static inertial loading will be provided by the vehicle loads organization.

Pre-Test Analysis capabilities and documentation will be required for preparation of both ground and flight structural verification efforts. This includes pre-coordination and facilitation of ER41 support for development of test plans and generation of structural models for primary structural and/or performance tests.

The end-products of the analyses performed under this Task Order will include, but are not limited to, predicted structural margins, fatigue capabilities, and fracture disposition rationale for components comprising the Shuttle RSRM.

3.0 Discussion of Skills Required

Senior and journeyman engineers with experience in the structural analysis of solid rocket propulsion systems will be staffed for this task order. Personnel assigned to work this task must be knowledgeable in Finite Element Analysis (FEA), PATRAN, and NASTRAN, ABAQUS, or ANSYS. The personnel should be familiar with structural analysis techniques and background, including structural/proof testing experience.

4.0 Special Tools Required

Knowledge of PATRAN/NASTRAN, ABAQUS, and ANSYS software is required for this task order.

5.0 Participating Subcontractors

None.

6.0 Milestones & Deliverables

a) Periodic Bi-weekly Notes
b) Monthly Activity Reports
c) Presentations as required
d) Analysis/Methodology Reports as required

Report deliverables shall be produced using Microsoft Office products. (Word, Excel, PowerPoint).

7.0 Special Considerations (Recruiting, Special Equipment / Material, Safety, etc.)

Finite element analyses shall be performed using PATRAN/NASTRAN, ABAQUS, or ANSYS on MSFC-provided workstations.

Reports will appropriately reference the source of methodology and analysis data necessary to meet requirements of the ESTS Group’s AS9100-compliant Performance Management System.

Subelement SA, Reusable Solid Rocket Motor (WBS 520871)
One trip will be needed to support meetings. The travel estimate is (b)(4)

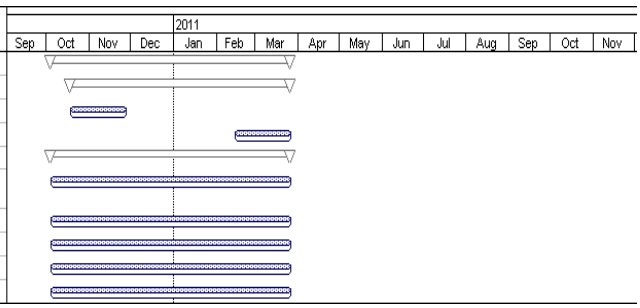
8.0 Work Shelf

The following activities could be accomplished as part of the Task Order performance by personnel that are temporarily available due to program or funding delays on other Tasks. Specific assignments will be coordinated with the Task Initiator to ensure appropriate skills and experience.

TO/Subelement	Description	Due Date	Skill

9.0 Schedule

Task Order	SubElement	Task Work Element
33-040114		**Solid Motor Stress Analysis Support**
33-040114	**SA**	**Shuttle Pre-Flight and Post-Flight Support**
33-040114	SA	STS-133
33-040114	SA	STS-134
33-040114	**SA**	**Reusable Solid Rocket Motor**
33-040114	SA	CoFR Support - Includes production support - MRB, Material testing, FRR and post flight evaluation.
33-040114	SA	Support the RSRM PSTA (Propellant Structural Technology Advancement).
33-040114	SA	Support the material obsolescence program.
33-040114	SA	Develop RSRM Structural Primer/Best Practices.
33-040114	SA	Support meetings, reviews, and telecons.



ESTS Contract Task Order Request Performance Plan

Task Order Title: Solid Motor Stress Analysis Support

Task Order Number: 33-040114 Revision: 12

Category	Weighting Technical %	End of Period Technical Score
Technical Objectives	65%	X 65% =
		Justification
Provide structural assessments/analyses and oversight for RSRM Project.		
Schedule Objectives (Milestones)	**Weighting Schedule %** 10% *(min 10%)*	**Schedule Score** X 10% =
		Justification
Provide timely assessments/analyses for the RSRM Project.		
Cost (actual vs. negotiated)	**Weighting Cost%** 25% *(min.25%)*	**Cost Score** X 25% =
		Justification
	Weighting Total % 100.00%	**Total Score**

Technical, Schedule, and Cost Grading Scale

Score	Description
9.0-10.0	Exceeded TO Performance Plan objectives resulting in major benefit(s)
8.0-8.9	Exceeded TO Performance Plan objectives resulting in modest benefit(s)
7.0-7.9	Met TO Performance Plan objectives
3.0-6.9	Did not meet all TO Performance Plan objectives resulting in minimal impact or requiring additional agency funds
0.0-2.9	Did not meet TO Performance Plan objectives resulting in substantial impact and/or requiring additional agency funds

ESTS Contract Task Order Request Performance Plan

Task Order Number: Solid Motor Stress Analysis Support

Task Order Number: 33-040114 Revision: 12

Comments:

Marshall Space Flight Center
Engineering, Science & Technical Services

JACOBS
ESTS Group

Risk Assessment

Contract Number: *NNM05AB50C*
TO Title: *Solid Motor Stress Analysis Support*
TO Number: *33-040114* **Revision:** *12*

Period of Performance: *10/02/2010 to 3/31/2011*

MSFC Initiator: *Jim Hawkins*

(b)(4)

Task Order Risk Assessment to Cost, Technical, and Schedule

List identified risk associated with Task Order performance as related to task cost, technical, and schedule. Classify the risk(s) according to probability of occurrence and impact as defined below and enter the risk into risk matrix.

Risk	Risk Type	Probability (1-4)	Impact (1-4)	Risk Description
Risk C1	Cost	1	1	Staffing commensurate with funding. Negative programmatic cost risk impacts are avoided through reviews. Only positive programmatic cost impacts are expected.
Risk C2	Cost			
Risk T1	Technical	1	1	Technical knowledge of personnel assigned appropriate for work assigned.
Risk T2	Technical	2	3	Program requirements or design are changed.
Risk S1	Schedule	1	2	If required input data is not available on schedule, it may cause delays in associated deliverables.
Risk S2	Schedule	2	2	Task/program schedule changes.

*Note: See page 2 for risk mitigation plan for those risks which are Primary Risk Drivers.

Task Order Risk Matrix

		1 Minimal Impact	2 Minor Impact	3 Medium Impact	4 Major Impact
Inevitable Occurrence (>95% Probability)	4	Y	Y	R	R
High Probability of Occurrence (>60% but <95% Probability)	3	G	Y	Y	R
Medium Probability of Occurrence (>25% but <60% Probability)	2	G	Y S2	Y T2	Y
Low Probability of Occurrence (<25% Probability)	1	G C1,T1	G S1	Y	Y

Legend

- R — **Primary Risk Driver:** Requires Risk Mitigation Plan
- Y — **Caution:** Requires status updates and general plan for risk reduction as determined necessary by Team Lead and Initiator
- G — **Watch:** No Action required

Impact Level	Cost Impact Definition	Technical Impact Definition	Schedule Impact Definition
(1) Minimal Impact	No significant cost impact	No significant technical impact	No significant schedule impact
(2) Minor Impact	Potential to recover cost	Potential to gain required technology without impact	Minor delay in deliverables but no impact to customer
(3) Medium Impact	>0 but <10% subtask cost overrun	Some technical impact but potential to recover	Delay in subtask deliverables but work arounds available and acceptable to customer
(4) Major Impact	>10% subtask cost overrun	Unable to meet technical requirements to perform subtask	Delay in subtask deliverables with impact to customer

Risk Mitigation Plan

Complete the following chart for those risks identified on page 1 as “Primary Risk Drivers”. The following chart will serve as the Risk Mitigation Plan.

Risk No.: Risk Description:		
Mitigation Step No.	Planned Completion Date	Mitigation Step Description