Preliminary Risk Management Plan
for the
Neutron Electric Dipole Moment Project
(nEDM)

Project MIE #71RE

at
Los Alamos National Laboratory
Los Alamos, New Mexico
managed by
Los Alamos National Security, LLC

For the U.S. Department of Energy
Office of Science
Office of Nuclear Physics (SC-26)

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1. Introduction

The Neutron Electric Dipole Moment (nEDM) Project uses a formal, systematic process for the management of risk. Risk management is an integral element of the nEDM Project management. The nEDM risk process is compliant with the intent of DOE Order 413.3 and utilizes tailored versions of DOE Office of Science past project risk practices.

The purpose of this document is to describe the risk-management approaches and processes used on the nEDM Project. The document describes "what" the risk-management process is, and "how" it is to be implemented.

Following CD-0 approval, nEDM Project risk management and mitigation was initiated. This involved development of the project risk process, dissemination of risk process instructions to the nEDM Project team, initial identification of risks and mitigation strategies, and development of the Project Risk Log.

At the point of the CD-1 approval presentation, the nEDM Project risk process will have been well exercised. Appendix A provides an extract of the nEDM Project Risk Log. The most current Project Risk Log is available in the nEDM Project Office.

2. Concept

(1) The review of possible risks to the nEDM Project considers both the near-term time horizon and all remaining phases of the project. The DOE and nEDM Project Office recognize risks as dynamic and ever changing as the project progresses. However, the anticipation of risk in advance enables the management and mitigation of many risks. The actionable philosophy is to anticipate risks before they become issues or events with negative consequences, and thereby prevent and minimize risk to the degree possible. It is also recognized that some risks may have to be consciously accepted as a "risk of doing business". Risks nonetheless can be subjected to a defined management and decision process.

(2) nEDM risk management begins with an active involvement of the DOE (HQ and Site Office) and the nEDM Project Office as stewards of the risk process. Both DOE and the nEDM Project Office, as well as the entire collaboration, actively seek to identify for discussion and appropriate action any potential event, circumstance, prior experience, stakeholder expectation, schedule, budget, funding or contingency exigency, or management decision at any level that may represent a risk to the project. Following discussion(s), the nEDM Project Manager will direct, where merited, that the risk be recorded on the Project Risk Log, and appropriate actions initiated.

3. Risk Relationship to Other Business Processes

3.1 Risk Management and Contingency Relationship

Risk relates to cost and schedule contingency in that both deal with uncertainty. The identification of risks by the nEDM Subsystem Managers and Project Manager is an ongoing process. Risk is considered by Subsystem Managers as one factor in the development of their recommended levels of contingency, along with the nature of the work, the stage of development, whether the work has been done before, or is "breakthrough", as well as other factors. Please see the Contingency section of the Preliminary Project Execution Plan (PPEP) for a full discussion of this process.

3.2 Risk and Baseline Change Control Relationship

Changes to the nEDM Project scope, schedule, and cost baseline (as defined in the PPEP) will be managed through a formal change-management process. As part of the approval process, all proposed internal and external changes will be formally evaluated for their impact and risk to the project. Proposed baseline changes may be merited to mitigate risk(s). Correspondingly, the nEDM Project Office will evaluate proposed changes to fully understand their potential risk consequence, either positive or negative. Externally directed changes will also be evaluated for risk consequence. Any risk emanating from proposed or authorized project baseline changes will be managed through the nEDM Project risk-management process.

3.3 Risk and Research and Development Relationship

The nEDM Project, in concurrence with the DOE, has developed a Research and Development (R&D) Risk Plan that addresses the specific risks of the nEDM R&D program. This action was considered advisable given the high dependence of final nEDM Project and technical goals on the outcome of the defined R&D tasks. The selected risk-management approach for R&D is consistent with the nEDM and DOE project risk-management approach, but is more stringent. This allows for higher visibility to assess each R&D task against the stated R&D goal, which is to achieve close to optimal performance from each R&D measurement. Please see the nEDM Risk-Based R&D Plan for a full discussion.

4. Roles and Responsibilities

4.1 The DOE Federal Project Director

The DOE Federal Project Director oversees the project risk environment and statuses the project risk management activities. Of particular interest to the DOE are the risks rated “High” overall and any risk that may negatively impact the project scope, schedule or cost baseline.

4.2 nEDM Project Manager

The nEDM Project Manager has overall responsibility for project risk management and for implementation of the risk-management process and plan. Responsibilities of this position are to

- develop and manage the overall risk-management approach;
- keep the DOE informed of risk status;
- serve as the “risk owner” for all R&D risks, and develop the R&D Risk Plan;
- use project risk data as a management tool within the nEDM Project Team and with members of the collaboration;
- oversee and assess “project-level” risks, in that these risks may affect the project as a whole;
- ensure the risk analysis results are documented and risk-mitigation plans are brought to closure;
- lead the project’s risk-management analysis, such as determination of mitigation plans, especially with interfacing risks between subsystems;
- oversee the collection and history of risk information; and
- direct the maintenance of the nEDM Project Risk Log.

4.3 Subsystem Managers

Responsibilities of this position are to

- serve as the “risk owner” for their assigned subsystem of the work breakdown structure (WBS);
- perform risk analysis including
  - identifying potential risks/vulnerabilities,
  - assessing the risk(s) likelihood of occurrence and impact on the project,
  - and determining the overall risk rating;
- develop and implement risk-mitigation strategies; and
- keep the nEDM Project Manager informed of risk status.

5. Risk Management Process

Project risk management consists of a fundamental five-step process

(3) risk identification

(4) risk analysis

(5) risk strategy

(6) risk mitigation

(7) risk disposition, tracking, and reporting

The specific subprocesses for each of the five steps in the risk process are described below.

5.1 Risk Identification

Risk identification is a responsibility of the nEDM Project Office and the Subsystem Managers, although risks are solicited from anyone associated with the project. Project risks may be "project wide" or be isolated to one or more areas of the project WBS. The development of the preliminary baseline identified risks at the total project, subsystem, and work package levels.

Risks may be of many types, including but not limited to

- technical (scientific, research, or engineering);
- schedule/time;
- budget/cost;
- funding;
- resource availability;
- procurement;
- integration;
- performance variances;
- proposed changes; and
- many other types (e.g., political, economic, etc.)

and may be of a source internal or external to the project. Risks may be at the "project level" (generally affecting the entire project) or at any sublevel of the project.

Meetings between the DOE and the nEDM Project Manager, as well as planning activities, project-status meetings, various technical meetings and project reviews (internal and external) serve as standing mechanisms for identifying project risks.

5.2 Risk Analysis

Risk analysis consists of

- determining the likelihood of the identified risk actually occurring,
- assessing the impact if it does occur, and then
- assigning an overall rating to the risk so that it can be monitored according to its relative importance.

These functions are initially accomplished by the responsible Subsystem Manager; the nEDM Project Office will make a final risk determinations following discussion with involved members of the project team.

5.3 Risk Strategy

This step involves selecting a response strategy (accept, avoid, control, or transfer) appropriate for the risk. These functions are initially accomplished by the responsible Subsystem Manager, or the assigned risk owner; the nEDM Project Office will make a final determination on risk strategy following discussion with members of the project team.

5.4 Risk Mitigation

Mitigation strategies are those planned actions that will be taken to prevent a risk from occurring, or to reduce or otherwise lessen the severity of the risk to the project should the risk occur. Executing mitigation strategies is accomplished by the "risk owner" assigned by the nEDM Project Office, usually the Subsystem Manager, following approval by the nEDM Project Manager.

5.5 Risk Disposition, Tracking, and Reporting

The recording of risks occurs on a continuous basis by the nEDM Project Office.

All risks assessed overall as "Medium" or "High" are entered on a Project Risk Log, maintained and administered by the nEDM Project Office. The Project Risk Log is the key means to record and consolidate the programmatic, technical, schedule cost and other project related risks, associated project mitigation strategies and the status of those strategies. The value of the Project Risk Log is to provide DOE and the nEDM Project Office risk visibility, and a management tool to track, manage, and record the disposition of project risks.

The **quarterly** internal project-status meeting, to include Subsystem Managers and other key project team members from the nEDM Project Office and collaboration, will be used to

- review all high-level risks,
- identify new actual or potential risks, and
- assign and disposition mitigation actions.

The nEDM Project Manager will schedule a meeting at least semiannually to discuss risk status with the DOE Federal Project Director. Key risk information will also be included in the monthly report to the DOE. In addition, the Project Manager will inform the project senior/executive sponsors of the high-level project risks, the selected risk strategy and disposition, identify the potential impacts, and request support as may be necessary.

6. Risk Assessment Methodology

6.1 Methodology

The nEDM Project employs an established risk methodology for consistency and quality in the risk-management process, as represented by the *risk assessment matrix* (Table 6-1, shown below). The y-axis determination (likelihood of occurrence) is first made for an identified risk, followed by the x-axis (impact/consequence). The table then yields an "overall risk rating." This overall rating is initially reviewed and validated as the "best fit" by the person identifying the risk, and then presented to the nEDM Project Office for review. Adjustments may be made based on an initial "fact finding" period. The risk is then expeditiously entered into the Project Risk Log. Later adjustments in the overall risk rating may be made, up or down, depending on governing events and/or the relative success of applied mitigation strategies.

The nEDM Project overall *risk assessment matrix* is shown below.

Table 6-1. Overall Risk-Assessment Matrix

Likelihood of Occurrence	Baseline Impact/Consequence		
	Marginal	Significant	Critical
Very likely	Medium risk	High risk	High risk
Likely	Low risk	Medium risk	High risk
Unlikely	Low risk	Low risk	Medium risk

6.2 Determining Likelihood

Risks will be categorized as "very likely," "likely," or "unlikely" depending on their likelihood of occurrence. A risk that is *very likely* to occur is one that has a probability of 90% or greater. A risk that is *likely* to occur is one that has a probability between 50%–90%. A risk that has less than a 50% chance of occurring is categorized as *unlikely*. It should be noted that even *unlikely* to occur risks may still happen! The probabilities are summarized in Table 6-2.

Table 6-2. Likelihood Matrix

Likelihood Rating		
Very Likely to Occur	**Likely to Occur**	**Unlikely to Occur**
>90%		
	50%–90%	
		<50%

6.3 Determining Impact/Consequence

Risks can also have varying impacts/consequences on a project. If a risk occurs, a negative consequence usually results. That consequence will typically adversely affect the technical accomplishment, result in a schedule or milestone slip, and/or cause a cost increase. The degree of the consequence is what is measured in this step. Table 6-3 applies in making the determination of the impact to the nEDM Project.

Table 6-3. Impact/Consequence

	Marginal	Significant	Critical
Cost (Impact on project contingency is…)	**<$200K**	**$200K–$500K**	**>$500K**
Schedule (Impact on project schedule is…)	**All else**	**Level 1 or 2 Milestones**	**Impacts project completion date**
Technical (Impact on project performance is…)	**CD-4 will be met and performance will exceed minimal specifications**	**CD-4 will be met and performance will be degraded from minimal specifications**	**CD-4 will not be met**

6.4 Overall Risk Rating

A risk's probability must be weighed against its potential impact in order to effectively gauge the measures necessary for dealing with that risk. A risk that has a high probability of occurrence can have a negligible impact upon the project. Conversely, a low-probability risk can have a devastating impact upon the project's technical accomplishment, schedule, or cost. Consequently, each nEDM Project risk will be assigned an overall risk rating as high, medium, or low—based on the x- and y-axis intersection point of the risk-assessment matrix. The management actions to be taken correspond to the overall risk rating.

- **High Risks**. Require close DOE monitoring and active on-going involvement of the nEDM Project Manager and the assigned Subsystem Manager. These risks also require the identification of a mitigation strategy (recorded on the Risk Log), and regular review at project-management meetings. Frequent high-level visibility of these risks is required. Elimination and/or mitigation of risks rated as *high* overall is a priority.

- **Medium (Moderate) Risks**. Require regular, periodic assessment and action by the Subsystem Manager (or Project Manager, if a project-level type risk), as appropriate to reduce the chance of these risks occurring or escalating. Although not usually of the severity of *high* risks, the risks with an overall categorization of *medium* can still have, in some cases, a notable impact to the project if they occur. *Medium* risks will be reviewed at the project-status meetings as a management control mechanism.
- **Low Risks**. Risks with an overall categorization of *low* will be monitored by the Subsystem Manager and any escalation reported to the Project Manager.

7. Risk Strategy

The nEDM Project Office, in consultation with the Project Team, selects one of four basic strategies for the handling of each recorded risk. The selected strategy conveys the overall approach selected by management based on all available information. The four recognized strategies are given below.

7.1 Risk Acceptance

Formal recognition of a risk situation and a corresponding formal management decision to accept the risk without undertaking directed actions to control or mitigate it. Acceptance of risk most often applies to risks rated *low* overall, or for situations that are beyond the ability of man to control.

7.2 Risk Avoidance

Actions taken to eliminate the root cause or causative factors of the risk, or to otherwise select a course of action that replaces a higher-level risk with a lower-level alternative. This is the most desirable strategy, when conditions permit.

7.3 Risk Control

Actions taken to reduce the severity of the risk through mitigation and thereby reduce risk likelihood or impact and as well as the overall level of risk to the project. Most risk-management action is of this type owing to the core nature of risk as a fundamental reality of conducting projects.

7.4 Risk Transfer

Collateral actions taken by the nEDM Project Office to move the risk to another part of the project by reconfiguring systems or requirements, as a means of reducing the overall risk to the project.

8. Risk Management Validation

The nEDM Project Office is involved in all aspects of risk management and has special responsibility for project-level risks and risks that cross WBS elements. The nEDM Project Office also ensures that a risk has the proper management visibility for management and mitigation purposes. As one means to accomplish these responsibilities, the Project Office provides independent validation of all risks and trends risks over time to effect positive closure. These activities occur following the initial assessment of an identified risk, and the determination of the initial overall risk rating. In this way, the Project Office can better understand the risk in terms of its relative importance to the project and to other risks. The DOE Federal Project Director also serves an important function in risk management by actively reviewing project risks and querying the Project Office on status and planned management actions.

Appendix A

nEDM Project Risk Log

nEDM Risk Listing and Analysis Form (Risk Log)

A1. Background & Purpose

The nEDM Risk Log & Risk Listing and Analysis Form is designed to assist the Project Office and Subsystem Managers in identifying and evaluating the major risks associated with the project, subsystem or work package. For the purposes of this tool, major risks are considered to be those risks with a high or moderate overall rating. The nEDM Risk Plan is the reference document for the use of the nEDM Risk Log/Risk Listing and Analysis Form, and should be referred to for detailed guidance.

A2. Process

For Subsystem Managers:

- Identify the scenarios that pose the greatest risk to the subsystem and project.
- Evaluate the identified risks using the the two risk tables for: Liklihood and Impact/Consequence.
- Enter and submit the Risk Log/entries to the nEDM Project Office for their review.

A3. Instructions

A3.1 Set up Risk Log

(1) Subsystem Managers obtain one copy of a blank risk log from the nEDM Project Office.

(2) Fill in the date of the latest revision. The revision number is assigned by the Project office, the Subsystem Manager, or the nEDM Project Office.

(3) The Project Office will maintain the total Project Risk Log.

A3.2 Identify & Evaluate the Risks

(1) **WBS Number -** For each risk, enter the WBS number of the activity to which the risk corresponds.

(2) **Subsystem Title -** Many risks will occur within the individual subsystems, and their respective Work Packages.

(3) **Work Package Title -** Risks are identified at the specific work package level; enter the title of the Work Package.

(4) Risk Owner - usually the Subsystem manager or the nEDM Project Manager, or a person designated by the nEDM Project Manager.

(5) **Description of Risk -** Enter a description of the risk using an 'if > then' format. Please adjust the row height should the space provided not be sufficient.

> Also, bold the words 'if' and 'then' to enable reviewers to quickly distinguish between the two statements. The following is an example of a properly formatted risk description:
>
> "**If** the subcontractor fails to manufacture the refrigerator on schedule, **then** there could be a cost and/or schedule impact while the problem is resolved."

(6) **Likelihood of Occurrence -** Use the drop down menu and make a selection (Reference the Risk Liklihood Table in the nEDM Risk Management Plan).

(7) **Impact/Consequence of Risk -** Use the drop down menu to select the impact as High-Medium-Low (Reference the Impact Table in the nEDM Risk Mgmt. Plan).

(8) **Overall Risk -** Use the drop down menu to select an overall risk rating of High-Medium-Low (Reference the Overall Risk Rating Matrix in the nEDM Risk Mgmt. Plan).

A3.3 Risk Disposition

A3.3.1 Risk Approach

Select an approach for addressing the risk from the drop down menu provided. The following definitions apply to risk approaches:

(a) **Accept** - To accept the consequences of a risk, should it occur. This risk response strategy suggests that there are simply no strategies available to deal with the risk. For example, technical uncertainties for which there is no known work-around can lead to an acceptance strategy.

(b) **Control** - To reduce the probability of a risk's occurrence or to minimize its impact if it does occur. For example, in order to minimize potential cost and schedule impacts of a particular technical approach, a subsystem manager may prepare alternative designs.

(c) **Transfer** - Shift the risk and responsibility for responding to it to another party. For example, the use of fixed contracts can be a method for transferring the risk associated with producing a problematic piece of equipment to a subcontractor who is better able to meet technical and schedule objectives.

(d) **Avoid** - To eliminate a risk or its impact. For instance, in order to avoid the possible cost or schedule impacts associated with using a new and untried piece of equipment, a subsystem manager may opt for a less complex, simpler component.

A3.3.2 Mitigation Strategy

A mitigation strategy is required for all risks rated "High" overall. Write a two to four sentence statement that outlines the plan and steps needed for employing the risk approach you selected. A mitigation plan can also be written for overall Medium level risks, but is optional. For example, a project risk involving a collaboration the size of nEDM could involve project personnel making ad hoc changes to approved designs during the construction phase. In this case, a subsystem or work package manager might choose to mitigate this risk using the following plan:

> "Implement a web-based change control system by 10/1/07 and review cost, schedule and scope against the approved baseline on a monthly basis.

The steps in this process include modifying an existing change control tool to fit the nEDM Project, testing the system and providing training to collaboration personnel on its use."

A3.3.3 Implement Date

Enter the date by which you plan to implement the risk handling plan. Note that on or before the date you specify, the Project Office may contact you to determine your progress in employing the plan you have outlined.

The following pages are a printout of the Risk Log in its current state. This file is a large-format Microsoft Excel™ file and is most usefully viewed in its native application.

EDM Project Risk Log (Major Item of Equipment)

Risk Analysis and Mitigation Form

Responsible Manager: Martin Cooper, EDM Project Manager.	Note: The Risk Log primary sort is by risks rated "High" overall.				
		Revision Number:	4.7	Date: 12/1/2006	

Risk Identification & Evaluation									Risk Disposition		
WBS Number	Subsystem Title	Work Pkg. Title	Risk Owner	Description of Risk	Likelihood of Occurrence	Impact: Marginal-Significant-Critical	Overall Risk		Risk Approach	Mitigation Strategy (Required for High Level Risks)	Implement Date
1.2.3.1	Polarized Neutron Beamline	Procure Neutron Guide	Rick Allen	Guides will be procured from a foreign company. Possible time delays and risks in currency exchange.	Likely	High	High		Accept	Increased contingencies and estimated uncertainty in currency exchange conservatively (using Black-Scholes formula).	CD-2
1.2.3.2	Polarized Neutron Beamline	Procure Magnets	R. Redwine	Magnetic fields have to meet very stringent specs to magnetize polarizing sheets. Completely new design. Fabrication takes longer than expected.	Likely	High	High		Transfer	Use alternative design for single spin state polarizer. This is a standard design and is technically simpler.	CD-3
1.4.10	^{3}He Services (He3S)	Valves	Steven Williamson	**Valve relaxation time and reliability** Valves which come into contact with polarized 3He must not significantly depolarize 3He during the fill time. Materials must be carefully chosen and exposure to non-3He friendly surfaces minimized. The choice of materials (typically plastics) may impact valve reliability. If an adequate design for a reliable valve that does not depolarize the 3He cannot be found, the ultimate sensitivity of the experiment will be impacted.	Likely	High	High		Control	Valve materials and designs will be studied during the R&D period prior to CD-2. Valve designs, which minimize the surface area and time over which 3He is in contact with non-3He-friendly materials will be examined. A trade-off may be required between reliability and relaxation time because of the necessary choice of materials. If a reliable valve with long relaxation time turns out to be impractical, the collaboration may chose to run with lower polarization or more frequent maintenance, and therefore reduced sensitivity.	12/31/2007
1.9.1	Assembly and Commissioning	Coil Package Assembly/Commissioning at the FNPB	D. Haase, B. Fillipone	This task primarily involves debugging a system, which is always difficult to estimate. The consequences of an error are significant because each cooldown, test and warm up cycle is estimated to take 6-8 weeks. The risk is that the cycle time may be even longer, or more cycles than expected will be required. Since the bulk of the labor is off project this is primarily a schedule risk.	Likely	High	High		Control	Care will be taken in the cryogenic design to reduce the cycle time. Subsystems to be assembled into the cryovessel will be first required to undergo stringent tests. Design optimizations will take place during the design phase of the project. Acceptance criteria will be defined prior to acceptance of subsystems at the cryovessel assembly site.	CD1-CD3
1.9.2	Assembly and Commissioning	Insert Assembly/Commissioning at the FNPB	D. Haase, T. Ito	This task primarily involves debugging a system, which is always difficult to estimate. The consequences of an error are significant because each cooldown, test and warm up cycle is estimated to take 6-8 weeks. The risk is that the cycle time may be even longer, or more cycles than expected will be required. Since the bulk of the labor is off project this is primarily a schedule risk.	Likely	High	High		Control	Care will be taken in the cryogenic design to reduce the cycle time. Subsystems to be assembled into the cryovessel will be first required to undergo stringent tests. Design optimizations will take place during the design phase of the project. Acceptance criteria will be defined prior to acceptance of subsystems at the cryovessel assembly site.	CD1-CD3
1.0	Project-Level	N/A	Martin Cooper	Scope Increases - this is of particular concern to the EDM project, given the R&D nature of the project. If additional scope is required as a result of R&D findings, then project cost could increase. Final scope is partially dependent on the outcome of R&D, which is not scheduled for completion until end 2007.	Likely	Medium	Medium		Control	The Project Office will employ formal change control at CD-1; MOU's will be executed with Universities that clearly define scope, schedule and cost baseline management expectations.	At CD-1
1.0	Project-Level	N/A	Paul Huffman	Technical Risk: On construction of one of the individual subsystems, one of the subsystems cannot live within the allocated heat budget. If the failing is sever, then the project might not reach its operating temperature.	Likely	Medium	Medium		Control	Conceptual Design.	CD-3
1.0	Project-Level	N/A	Martin Cooper	R&D related schedule and budget risk: If the R&D program does not yield necessary data by the end of 2007, then project scope and budget uncertainties remain.	Likely	Medium	Medium		Control	Rigorous Project Office management and oversight of the EDM R&D program.	CD-1 to CD-2
1.1	**R&D**	Multiple	Martin Cooper	Please note that a separate Risk R&D Plan has been developed specifically for the research and development efforts, given their high importance to many of the subsystems comprising the EDM project scope. Please reference the R&D Risk Plan for a full discussion of R&D risks.	N/A	N/A	N/A		Control	See R&D Risk Plan.	CD-1 to CD-2
1.2.1.1	Polarized Neutron Beamline	Neutron Guide Modeling	Wolfgang Korsch	Results for proposed design might vary from expectations. New guide geometries need to be tested. Time needed for software development and running the codes.	Likely	Low	Medium		Accept		CD-1
1.2.1.1	Polarized Neutron Beamline	Install Neutronics	Rick Allen	Problems with installation of magnets or spin flipper. Neutron guide will be installed by manufacturer.	Likely	Medium	Medium		Accept		CD-3
1.3.1.3.3	Cryostats, Refrigerators and Related Equipment	Procure cryovessel and shields	David Haase	Vendor does not meet schedule or specifications of construction for cryovessel. Cost impact should be less than $200K, but could cause delay on schedule which is on critical path. This work package will not affect technical specifications of system.	Likely	Medium	Medium		Control	We will work with vendors as soon as possible to refine cryovessel specifications and design for completion within the required budget and schedule. The WBS includes interim reviews in the construction phase.	At beginning of work package
1.3.2.3.2	Cryostats, Refrigerators and Related Equipment	Procure helium electrical insulation volume	David Haase	If the large scale tank built from composite material should fail during the construction or initial testing, then the schedule would be delayed and there might be a need to use other materials. This has marginal technical impact.	Likely	Medium	Medium		Control	The design of the volume will be checked against experiences of others using these materials. The vendor will be selected carefully and monitored during the construction process. We will work on ways to test specimens of the materials at low temperatures.	At beginning of work package
1.3.3.5.3.2	Cryostats, Refrigerators and Related Equipment	Second Dilution Refrigerator or 3He Refrigerator	David Haase	Vendor does not meet schedule or specifications of construction for refrigerator. Cost impact should be less than $200K, but could cause delay on schedule which is on critical path. This has significant technical impact if the refrigerator cannot meet cooling and temperature specifications.	Likely	Medium	Medium		Control	We will work with vendors as soon as possible to refine refrigerator specifications and design for completion within the required budget and schedule. The cooling and temperature specifications are set by issues such as pumping speeds that do not require large amounts of money to fix, but will require more testing time in later steps.	At beginning of work package
1.4.3	^{3}He Services (He3S)	Polarized ^{3}He Collection System	Steven Williamson	**Collection system efficiency and relaxation time.** For optimal performance, the required concentration of polarized 3He and relaxation time in the collection volume must be achieved. If the collection efficiency and relaxation time is not adequate, then the sensitivity of the experiment will suffer.	Likely	Medium	Medium		Control	R&D studies of the collection and relaxation processes in the collection volume should allow concepts to be checked and alternative techniques and procedures to be verified. Should long holding times in the collection volume prove unfeasible, the measurement cycle could be altered with some loss of experiment duty factor.	12/31/2007
1.4.5	^{3}He Services (He3S)	Purifier	Steven Williamson	**The evaporation technique** The purification of 4He using the evaporation technique is untried. It will require R&D and may involve unanticipated design constraints. If evaporation purification turns out to be impractical, major changes to the conceptual design of the experiment will be required.	Unlikely	High	Medium		Control	R&D studies will allow the evaporation technique to be checked. If, this technique proves impractical, the McClintock technique could be used. In that case, additional refrigeration would be required.	12/31/2007

1.4.5	^{3}He Services (He3S)	Purifier	Steven Williamson	**Superfluid film control (absorption pump contamination)** A number of methods have been proposed to stop superfluid film flow in order to reduce contamination of the absorption pump. The choice of which method to pursue will require R&D and may involve unanticipated design constraints and delays. Marginal reduction of the film flow, could reduce the duty cycle of the experiment. If the superfluid film proves uncontrollable, then major changes to the conceptual design of the experiment will be required to implement an alternate purification technique.	Likely	Medium	Medium		Control	R&D studies will determine whether film-burner and/or temperature inversion techniques will work. The collaboration could decide to proceed despite marginal operation of the film control at reduced duty cycle because of additional time needed to regenerate the absorption pumps. In the extreme case, the evaporation technique could be dropped and the McClintock method used instead (at significant redesign and refrigeration cost).	12/31/2007
1.4.8	^{3}He Services (He3S)	Pressurizer	Steven Williamson	**Pressurizer bellows** The pressurizer bellows must be 3He friendly and remain ductile at 0.3K. Most conventional bellows materials will not meet these requirements. If an adequate design for a reliable pressurizer that does not depolarize the 3He cannot be found, then the experiment may be forced to run at low pressure, which could, as a result of consequently lower electric field, reduce the sensitivity of the experiment.	Likely	Medium	Medium		Control	During R&D studies of the high voltage system, it may turn out that pressurization is not actually needed, which would render this risk moot. Designs for the pressurizer may be possible which minimize the surface area and time over which 3He is in contact with the bellows allowing more conventional bellows materials to be used. If a pressurizer turns out to be impractical, the collaboration may chose to run without it, at lower electric field and, therefore, reduced sensitivity.	12/31/2007
1.4.10	^{3}He Services (He3S)	Valves	Steven Williamson	**Pressurizer-standoff valve (V3) leak rate** With the exception of the V3 valve, leak rates of the other valves appear to be manageable. The V3 valve is the only valve required to maintain a seal against superfluid 4He with a pressure differential. The large aperture and reliability spec makes this requirement particularly difficult. If the valve leaks more than it should, the pressure in the measurement cell, and therefore the electric field, will not be maintained, thus affecting the sensitivity of the experiment.	Likely	Medium	Medium		Control	During R&D studies of the high voltage system, it may turn out that pressurization is not actually needed, which would render this risk moot. Operation of the pressurizer could be adjusted to allow for a moderate leak at V3 by over pressurization or by continuously adjusting the pressurizer bellows compression to compensate for a leak. The collaboration may chose to run without pressurization, at lower electric field and, therefore, reduced sensitivity.	12/31/2007
1.4.12	^{3}He Services (He3S)	He3S (Full Subsystem) Test	Steven Williamson	**Failure of He3S (full subsystem) test** A number of aspects of the He3S subsystem, including final (measurement cell) polarization and 3He diffusive transport, will be tested for the first time during the full subsystem test. This test must be passed both to meet CD-4 requirements, and to allow installation of the subsystem in the experiment cryostat. Failures during this test could seriously impact the schedule.	Likely	Medium	Medium		Control	Test of individual work packages are planned. These should identify many problems before the final subsystem test. Early completion of subsystem components, will allow more time for the final test and the resolution of problems before the critical path is affected.	11/11/2009
1.5.1.5	Magnets & Magnetic Shielding	Procure Conventional Shield and Support Structure	Brad Filippone	**If** the commodity price of nickel increases significantly, **then** there will be a corresponding significant increase in the price for the four-layer conventional shield.	Likely	Medium	Medium		Accept		CD-3
1.5.4.4	Magnets & Magnetic Shielding	Fabricate B0 Field and Gradient Field Coil	Brad Filippone	**If** the uniformity and field gradient of the B0 coil does not meet the specified requirments, **then** the experiment may not attain its desired sensitivity.	Unlikely	High	Medium		Control		CD-3
1.6.2	HV system		Takeyasu Ito	Not high enough electric field (due for example to the shape of the electrode or the surface finish quality of the electrode)	Likely	Medium	Medium		Control	Perform finite element analysis on the electric field as part of the design / Quality control in all steps involved in the procurement (for example careful inspection on the surface finish of the electrode) / Debug during the post-assembly test at LANL	CD-3
1.6.4	Measurement cell		Takeyasu Ito	Lower holding time for UCN than the optimal specification due to degradation in the quality of the coating	Very Likely	Low	Medium		Control	Quality control in applying the coating on the inner wall of the measurement cell	CD-3
1.6.4	Measurement cell		Takeyasu Ito	Lower 3He spin relaxiation time than the optimal specification due to degradation in the quality of the coating	Very Likely	Low	Medium		Control	Quality control in applying the coating on the inner wall of the measurement cell	CD-3
1.6.5	SQUID systems		Takeyasu Ito	Noise on SQUIDS too high (due to interference among different channels or due to micro discharge)	Likely	Medium	Medium		Control	Debug during the post-assembly test at LANL	CD-3
1.6.8	V1 valve		Takeyasu Ito	Valve not functioning properly.	Likely	Medium	Medium		Control	Protope the valve if possible/ Debug during the pre-assembly and the post-assembly test	CD-3
1.7.2.2	Data Acquisition System	Electronics, simulations, data analysis	Chris Gould	**If** light output from cells is too low (significantly less than 10 pe's per primary event), **then** particle ID based on after pulsing will likely not be possible.	Unlikely	High	Medium		Avoid	DAQ system can then be made be simpler, but the potential sensitivity of the experiment will be compromised. Light transport simulations will be important in determining the final design of the cells and light guides.	At beginning of design process.
1.8.3	Infrastructure	Plumbing	W. Sondheim	Labor costs unknown at this point in time - and the potential for changes.	Likely	Medium	Medium		Control		CD-3 & CD-4
1.8.4	Infrastructure	Mechanical	W. Sondheim	Unknown design requirements for the mechanical infrastrcture.	Likely	Medium	Medium		Control		CD-3 & CD-4

1.10	Project Mgmt.	N/A	Martin Cooper	Each collaborating University uses its own accounting system. The EDM Project is dependent on the reporting of actual costs on a timely and accurate basis. If incurred costs are not accrued and reported monthly, then an innacurate cost picture will result.	Likely	Medium	Medium		Control	Special measures are required to control this situation. The Project Office will work with each University to understand its accounting system and to implement a monthly cost reporrting approach. This may necessitate the submittal of a monthly cost accrual by a University(s).	CD-1thru 4
1.10	Project Mgmt.	N/A	Martin Cooper	The budgeted amount for EDM project management was reduced at CD-1. If the complexities of maintaining and controlling collaboration and the technical program exceed the budgeted capacity for project management, then issues could result.	Unlikely	High	Medium		Control	The EDM Project Manager is assigned full time to the EDM Project. He is supported by professional project controls part time staff. A well developed project management process has been deployed within EDM.	CD1-CD4