Carleton UNIVERSITY

CQADS CAQAD

Mr. Alan Murchison
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22 St. Clair Avenue East, Sixth Floor
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December 9, 2015

Re: Failure Analysis Simulation Model for the APMRD–II

AMENDMENT

Mr. Murchison,

As a result of the progress made by the Centre for Quantitative Analysis and Decision Support (CQADS) on the first phase of the Failure Analysis Simulation Model for the APMRD–II (CQADS Project # 15-001-01, cf. Proposal of February 20, 2015), in conjunction with recent discussions held between the Nuclear Waste Management Organization (NWMO) and CQADS at a meeting in Toronto on November 10-11, 2015, the NWMO has requested an extension of the scope of the original agreement.

Specifically, the NWMO has requested an addition to the prototype casual chain consisting of a process model of some aspects of the UFC manufacturing process, which can be used to derive the probability in the prototype causal chain that a container that has become flawed during the manufacturing process in particular ways will eventually be placed in the repository in spite of these flaws.

I am pleased to provide a short proposal for this request, as well as an amendment regarding the additional amount of time required in order to carry out the proposed work, and an amendment relating to the preparation of the ISO-level Project Quality Plan.

Contents

In what follows,terms and conditions of the original agreement hold unless otherwise indicated.

1 Proposal for Additional Modeling: UFC Manufacturing Process

Modeling Overview

The NWMO has shown interest in attempting to model the probability of flawed containers passing and moving through the various inspections and tests which will take place during the manufacturing process. The resulting process model would provide input to a specific starting node in the Prototype Causal Chain. Time-wise, the events in the process being modeled will take place prior to the container being sealed in the repository and as such this process model is not in-scope according to the original agreement. In addition to this temporal consideration, the nature of the requested model also requires a particular level of detail which will require further time to complete, albeit subject to the limitations discussed below.

With the NWMO agreeing to the limitations of process mappings, we will produce and implement a prototype manufacturing process-map/causal chain hybrid based on the causal chain that was suggested in November.

Manufacturing Chain Limitations

Process-mapping (such as the manufacturing chain) and causal-mapping (such as the causal chain that was agreed-upon at the Toronto meeting) are different concepts, even though they might appear fairly similar at first glance. Causal networks allow modelers to consider possible counter-factual scenarios to attempt to take into account uncertainty relating to system behaviour, in a sense bypassing all the hard-to-pinpoint sequences of events that could take place over a million years. Process maps, on the other hand, assume (and require) a very clear-cut (and known) sequence of events, and use these sequences to make predictions about inputs, outputs and behaviours of the process in question.

CQADS had originally, and continues to, suggest a causal network approach for the overarching framework of the probability model, because there is substantial uncertainty in both the long-term chain of events that could occur through the system (i.e. the many event paths from time t = 0 to t = 1, 000, 000), and also in the types of events that could occur (i.e. the unknown unknowns).

With respect to modeling the manufacturing process itself, there is a current lack of information available regarding the specifics of the manufacturing process, and some aspects of it may still be in a process of development. This will lead the CQADS modelers to have to make a number of assumptions about the process to be able to implement a reasonable process map by the deadline. In particular, we may have to consider a small number of very specific ways in which the container could become flawed in the manufacturing process, and neglect a number of other possibilities (i.e. we may end up looking at a single through-wall defect at some location on the whole container, as opposed to combinations of flaws such as three thin-wall defects on the Lower Assembly due to failed adhesion of the Copper Coating, to give a specific example).

It is possible that, over time, more information regarding the manufacturing process might become available (to either the NWMO or CQADS) and there will be a desire to add new components

to the manufacturing process chain implementation (perhaps in the form of better conditional probability estimates at each step, say, or in a new type of output to be modeled). At the prototype stage, however, this will not be possible.
Because the behaviours of process models are highly dependent on the number and form of their component nodes, a side-effect of the last item is that whatever numbers are produced by the process-mapping will necessarily be a reflection of the information and assumptions incorporated into the current version of the model. As a result, CQADS again cautions the NWMO against using the absolute numbers that are produced by the prototype process-map (and accompanying causal map) as these are unlikely to be useful (although relative numbers from different scenarios may yield some useful comparisons).

CQADs would also like to note that, because the results of process chain modeling may seem easier to interpret than the results of causal chain modeling, it may prove tempting to model the entire system as a process map (instead of the suggested causal network). This approach is likely to prove unsuccessful, however (consider, for example, the US attempt to produce something of a similar level of complexity); while there may be benefits to modeling some of the underlying behavior of the full-system causal chain nodes as process models, CQADS will not attempt to model the full system as a process map.

2 Proposed Amendments

Project Quality Plan

The original time estimates for creation of the PQP and subsequent compliance (72 hours) were calculated using experience with non-ISO PQP standards and based on preliminary project discussions of the PQP. Creating a PQP that met ISO standards to a level sufficient for NWMO required an additional 216 hours to complete. We further estimate that complying with the stricter ISO requirements (especially for coding validation) will take an additional 109 hours.

Manufacturing Process Model

As noted above, with the NWMO agreeing to the limitations of process mappings, we will produce and implement a prototype manufacturing process-map/causal chain hybrid based on the causal chain that was suggested in November.

Assuming that we simplify the causal chain portion slightly (by paring down some of the underlying processes/modeling on a node-by-node basis), we estimate that this amendment to the project will require an additional 150 hours of work.

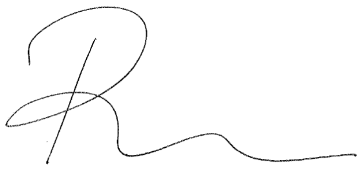
3 Resources and Costs

Dr. Jennifer Schellinck will be the Co-Lead Investigator assigned for this amendment, together with CQADS Managing Consultant Dr. Patrick Boily, and CQADS consultant Shintaro Hagiwara. Other qualified resources may be added as necessary.

These amendments will require an additional 475 hours to complete. At a rate of 80$ per hour, the total cost of these amendments is 38,000$. We estimate that the amendments to the project will delay completion of the first phase by about a month (amended end date: May 31, 2015).

We look forward to continuing to work on Phase 1 to help the NWMO meet its modeling needs.

Regards,



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