

**U.S. NUCLEAR REGULATORY COMMISSION  
NOTICE OF GRANT/ASSISTANCE AWARD**

|  |  |   |  |                  |            |              |  |                               |  |                             |              |  |        |           |        |                  |              |       |              |  |  |
|--|--|---|--|------------------|------------|--------------|--|-------------------------------|--|-----------------------------|--------------|--|--------|-----------|--------|------------------|--------------|-------|--------------|--|--|
| <b>1. GRANT/AGREEMENT NO.</b><br>NRC-HQ-12-G-04-0083   | <b>2. MODIFICATION NO.</b>   | <b>3. PERIOD OF PERFORMANCE</b><br>FROM: 09/28/2012 TO: 03/27/2015  | <b>4. AUTHORITY</b><br>Pursuant to Section 31b and 141b of the Atomic Energy Act of 1954, as amended |                  |            |              |  |                               |  |                             |              |  |        |           |        |                  |              |       |              |  |  |
| <b>5. TYPE OF AWARD</b><br><br><input checked="" type="checkbox"/> GRANT<br><input type="checkbox"/> COOPERATIVE AGREEMENT   | <b>6. ORGANIZATION TYPE</b><br><br>State Public Institution of Higher Learning<br><br>DUNS: 073133571<br><br>NACIS: 611310   | <b>7. RECIPIENT NAME, ADDRESS, and EMAIL ADDRESS</b><br><br>Regents of the University of Michigan<br>3003 South State Street<br>1072 Wolverine Tower<br>Ann Arbor, MI 48109-1274<br>Email: ebrock@umich.edu   |  |                  |            |              |  |                               |  |                             |              |  |        |           |        |                  |              |       |              |  |  |
| <b>8. PROJECT TITLE:</b><br>Multi-scale Thermal Hydraulic Tool for Nuclear Power Plant Safety Analyses   |  |   |  |                  |            |              |  |                               |  |                             |              |  |        |           |        |                  |              |       |              |  |  |
| <b>9. PROJECT WILL BE CONDUCTED PER GOVERNMENT'S/RECIPIENT'S PROPOSAL(S) DATED</b><br><br>AND APPENDIX A-PROJECT GRANT PROVISIONS  | <b>10. TECHNICAL REPORTS ARE REQUIRED</b><br><br><input type="checkbox"/> PROGRESS AND FINAL<br><input type="checkbox"/> FINAL ONLY<br><input checked="" type="checkbox"/> OTHER (Conference Proceedings)  | <b>11. PRINCIPAL INVESTIGATOR(S) NAME, ADDRESS and EMAIL ADDRESS</b><br>Regents of the University of Michigan<br>Attn: Annalisa Manera<br>3003 South State Street<br>1072 Wolverine Tower<br>Ann Arbor, MI 48109-1274<br>Email: manera@umich.edu  |  |                  |            |              |  |                               |  |                             |              |  |        |           |        |                  |              |       |              |  |  |
| <b>12. NRC PROGRAM OFFICE (NAME and ADDRESS)</b><br>NRC<br>Attn: Heather Dempsey, <a href="mailto:Heather.Dempsey@nrc.gov">Heather.Dempsey@nrc.gov</a><br>Office of Regulatory Research<br>MS: CS C6-D20, (301) 251-7666<br>11545 Rockville Pike<br>Rockville, Maryland 20852<br>Andrew Ireland, Tech Analyst, <a href="mailto:Andrew.Ireland@nrc.gov">Andrew.Ireland@nrc.gov</a>  | <b>13. ACCOUNTING and APPROPRIATION DATA</b><br>APPN. NO: 31X0200<br>B&R NO: 2012-60-11-6-174<br>JOB CODE: G6024<br>BOC NO: 252A<br>OFFICE ID NO: RES-12-228<br>FAMIS: GR0252  | <b>14. METHOD OF PAYMENT</b><br><br><input type="checkbox"/> ADVANCE BY TREASURY CHECK<br><input type="checkbox"/> REIMBURSEMENT BY TREASURY CHECK<br><input type="checkbox"/> LETTER OF CREDIT<br><input checked="" type="checkbox"/> OTHER (SPECIFY) Electronic ASAP.gov<br>(See Remarks in Item #20 "Payment Information") |  |                  |            |              |  |                               |  |                             |              |  |        |           |        |                  |              |       |              |  |  |
| <b>15. NRC OBLIGATION FUNDS</b><br><br><table style="width:100%; border-collapse: collapse;"> <tr> <td style="width:30%;">THIS ACTION</td> <td style="text-align: right; border-bottom: 1px solid black;">\$102,000.00</td> </tr> <tr> <td>PREVIOUS OBLIGATION</td> <td style="border-bottom: 1px solid black;"> </td> </tr> <tr> <td>TOTAL</td> <td style="text-align: right; border-bottom: 1px solid black;">\$102,000.00</td> </tr> </table> | THIS ACTION  | \$102,000.00  | PREVIOUS OBLIGATION  |                  | TOTAL      | \$102,000.00 | <b>16. TOTAL FUNDING AGREEMENT</b><br><br><table style="width:100%; border-collapse: collapse;"> <tr> <td style="width:30%;">NRC</td> <td style="text-align: right; border-bottom: 1px solid black;">\$252,269.00</td> <td style="width:30%; vertical-align: top;">This action provides funds for Fiscal Year</td> <td style="width:10%; text-align: right;">FY2012</td> </tr> <tr> <td>RECIPIENT</td> <td style="text-align: right; border-bottom: 1px solid black;">\$0.00</td> <td style="vertical-align: top;">in the amount of</td> <td style="text-align: right; border-bottom: 1px solid black;">\$102,000.00</td> </tr> <tr> <td>TOTAL</td> <td style="text-align: right; border-bottom: 1px solid black;">\$252,269.00</td> <td colspan="2"> </td> </tr> </table> |                               |  | NRC                         | \$252,269.00 | This action provides funds for Fiscal Year | FY2012 | RECIPIENT | \$0.00 | in the amount of | \$102,000.00 | TOTAL | \$252,269.00 |  |  |
| THIS ACTION  | \$102,000.00   |   |  |                  |            |              |  |                               |  |                             |              |  |        |           |        |                  |              |       |              |  |  |
| PREVIOUS OBLIGATION  |  |   |  |                  |            |              |  |                               |  |                             |              |  |        |           |        |                  |              |       |              |  |  |
| TOTAL  | \$102,000.00   |   |  |                  |            |              |  |                               |  |                             |              |  |        |           |        |                  |              |       |              |  |  |
| NRC  | \$252,269.00   | This action provides funds for Fiscal Year  | FY2012   |                  |            |              |  |                               |  |                             |              |  |        |           |        |                  |              |       |              |  |  |
| RECIPIENT  | \$0.00   | in the amount of  | \$102,000.00   |                  |            |              |  |                               |  |                             |              |  |        |           |        |                  |              |       |              |  |  |
| TOTAL  | \$252,269.00   |   |  |                  |            |              |  |                               |  |                             |              |  |        |           |        |                  |              |       |              |  |  |
| <b>17. NRC ISSUING OFFICE (NAME, ADDRESS and EMAIL ADDRESS)</b><br><br>U.S. Nuclear Regulatory Commission<br>Div. of Contracts<br>M'Lita Carr, <a href="mailto:MLita.Carr@nrc.gov">MLita.Carr@nrc.gov</a><br>Mail Stop: TWB-01-B10M<br>Rockville, MD 20852   |  |   |  |                  |            |              |  |                               |  |                             |              |  |        |           |        |                  |              |       |              |  |  |
| <b>18.</b><br><br>Signature Not Required   | <b>19. NRC CONTRACTING OFFICER</b><br><br><table style="width:100%; border-collapse: collapse;"> <tr> <td style="width:60%; text-align: center; border-bottom: 1px solid black;"><i>Erika Fam</i></td> <td style="width:40%; text-align: right; border-bottom: 1px solid black;">09/28/2012</td> </tr> <tr> <td style="text-align: center;">(Signature)</td> <td style="text-align: right;">(Date)</td> </tr> <tr> <td colspan="2">NAME (TYPED) <u>Erika Fam</u></td> </tr> <tr> <td colspan="2">TITLE <u>Grants Officer</u></td> </tr> <tr> <td colspan="2">TELEPHONE NO. <u>(301) 492-3492</u></td> </tr> </table> |   |  | <i>Erika Fam</i> | 09/28/2012 | (Signature)  | (Date)   | NAME (TYPED) <u>Erika Fam</u> |  | TITLE <u>Grants Officer</u> |              | TELEPHONE NO. <u>(301) 492-3492</u>        |        |           |        |                  |              |       |              |  |  |
| <i>Erika Fam</i>   | 09/28/2012   |   |  |                  |            |              |  |                               |  |                             |              |  |        |           |        |                  |              |       |              |  |  |
| (Signature)  | (Date)   |   |  |                  |            |              |  |                               |  |                             |              |  |        |           |        |                  |              |       |              |  |  |
| NAME (TYPED) <u>Erika Fam</u>  |  |   |  |                  |            |              |  |                               |  |                             |              |  |        |           |        |                  |              |       |              |  |  |
| TITLE <u>Grants Officer</u>  |  |   |  |                  |            |              |  |                               |  |                             |              |  |        |           |        |                  |              |       |              |  |  |
| TELEPHONE NO. <u>(301) 492-3492</u>  |  |   |  |                  |            |              |  |                               |  |                             |              |  |        |           |        |                  |              |       |              |  |  |
| <b>20. PAYMENT INFORMATION</b><br><br>Payment will be made through the Automated Standard Application for Payment (ASAP.gov) unless the recipient has failed to comply with the program objectives, award conditions, Federal reporting requirements or other conditions specified in 2 CFR 215 (OMB Circular A110).   |  |   |  |                  |            |              |  |                               |  |                             |              |  |        |           |        |                  |              |       |              |  |  |
| <b>21.</b> Attached is a copy of the "NRC General Provisions for Grants and Cooperative Agreements Awarded to Non-Government Recipients. Acceptance of these terms and conditions is acknowledged when Federal funds are used on this project.   |  |   |  |                  |            |              |  |                               |  |                             |              |  |        |           |        |                  |              |       |              |  |  |
| <b>22. ORDER OF PRECEDENCE</b><br>In the event of a conflict between the recipient's proposal and this award, the terms of the Award shall prevail.  |  |   |  |                  |            |              |  |                               |  |                             |              |  |        |           |        |                  |              |       |              |  |  |
| <b>23.</b> By this award, the Recipient certifies that payment of any audit-related debt will not reduce the level of performance of any Federal Program.  |  |   |  |                  |            |              |  |                               |  |                             |              |  |        |           |        |                  |              |       |              |  |  |

**ATTACHMENT A - SCHEDULE****A.1 PURPOSE OF GRANT**

The purpose of this Grant is to provide support to the "Multi-scale Thermal-Hydraulic Tool for Nuclear Power Plant Safety Analyses" as described in Attachment B entitled "Program Description."

**A.2 PERIOD OF GRANT**

1. The effective date of this Grant is September 28, 2012. The estimated completion date of this Grant is March 27, 2015.

2. Funds obligated hereunder are available for program expenditures for the estimated period: September 28, 2012 – March 27, 2015.

**A. GENERAL**

|                                |  |
|--------------------------------|--|
| 1. Total Estimated NRC Amount: | \$252,269.00   |
| 2. Total Obligated Amount:     | \$102,000.00   |
| 3. Cost-Sharing Amount:        | \$0.00   |
| 4. Activity Title:             | Multi-scale Thermal-Hydraulic Tool for Nuclear Power Plant Safety Analyses |
| 5. NRC Project Officer:        | Heather Dempsey, Andrew Ireland (TA)                                       |
| 6. DUNS No.:                   | 073133571  |

**B. SPECIFIC**

|                   |                  |
|-------------------|------------------|
| RFPA No.:         | RES-12-228       |
| FAMIS:            | GR0252           |
| Job Code:         | G6024            |
| BOC:              | 252A             |
| B&R Number:       | 2012-60-11-6-174 |
| Appropriation #:  | 31X0200          |
| Amount Obligated: | \$102,000.00     |

**A.3 BUDGET**

Revisions to the budget shall be made in accordance with Revision of Grant Budget in accordance with 2 CFR 215.25.

|               | <b>Year 1</b>       | <b>Year 2</b>       | <b>Year 3</b>      |
|---------------|---------------------|---------------------|--------------------|
| Salary        | \$45,939.00         | \$34,545.00         | \$17,762.00        |
| Fringe        | \$11,485.00         | \$ 5,793.00         | \$ 2,976.00        |
| Supplies      | \$ 1,500.00         | \$ 5,000.00         | \$ 2,000.00        |
| Travel        | \$ 6,348.00         | \$ 6,348.00         | \$ 2,480.00        |
| Other         | \$ 0.00             | <u>\$20,450.00</u>  | <u>\$10,736.00</u> |
| Total Direct  | \$65,271.00         | \$72,136.00         | \$35,955.00        |
| Indirect Cost | <u>\$36,225.00</u>  | <u>\$28,686.00</u>  | <u>\$13,996.00</u> |
| Yearly Total  | <b>\$101,497.00</b> | <b>\$100,822.00</b> | <b>\$49,950.00</b> |

#### A.4 AMOUNT OF AWARD AND PAYMENT PROCEDURES

1. The total estimated amount of this Award is \$252,269.00 for the 2 year 6 month period.
2. NRC hereby obligates the amount of 102,000.00 for program expenditures during the period set forth above and in support of the Budget above. The Grantee will be given written notice by the Contracting Officer when additional funds will be added. NRC is not obligated to reimburse the Grantee for the expenditure of amounts in excess of the total obligated amount.
3. Payment shall be made to the Grantee in accordance with procedures set forth in the Automated Standard Application For Payments (ASAP) Procedures set forth below.

#### Attachment B – Program Description

##### PROGRAM DESCRIPTION

#### 1. INTRODUCTION

The use of computational fluid dynamics (CFD) codes to improve the accuracy of nuclear system transient analyses has increased significantly in recent years. The use of these tools provides more detailed and realistic descriptions of multidimensional flow patterns than those produced by best estimate thermal-hydraulic (TH) system codes, even taking into consideration the advances in multidimensional flow solutions offered by some of these codes (TRACE, RELAP-3D, CATHARE). Phenomena such as natural circulation, stratification, mixing and natural convection in large volumes have a strong three-dimensional character and the full physics of the important effects cannot be correctly described by the simplified 1D approach used in best-estimate thermal-hydraulic system codes.

A recent paper [1] has identified several important nuclear reactor safety problems where the combination of CFD with a 1D systems code would provide a better understanding of the underlying physical phenomena and where it would be important to quantify the impact of 3D effects on safety margins. Some of the important problems include:

- **Safety analyses of Gen-III+ Light Water Reactors (LWRs) with passive systems;** most of the passive systems currently designed for LWRs involve heat exchange with large water pools, where three-dimensional natural convective motions and stratification play a major role. For the safety evaluation of those reactors, 1D TH system codes are not sufficient, due to the strong coupling existing between the behavior of the primary side of the reactor and the containment.
- **Mixing and stratification in the lower plenum of a Boiling Water Reactor (BWR);** cold water can stratify in the lower plenum of a BWR during a loss of forced circulation (part of the cold water derives from the cooling of the control rod drive mechanisms present in the lower plenum). Also because of the stratification, borated water can accumulate in the bottom of a BWR lower plenum during an Anticipated Transients Without Scram (ATWS). The formation and erosion of this stratified water layer by the main flow can play an important role in the determination of the transient consequences. This can be an important safety analysis for enhanced BWR operating regimes such as MELLLA+.
- **Mixing in the inlet plenum of the steam generators during severe accidents;** analysis carried out by the US NRC [2] has shown that during a station blackout transient a counter current natural circulation flow pattern is established in the hot leg. The study has also pointed out the

natural circulation flow pattern is established in the hot leg. The study has also pointed out the importance of the mixing in the steam generator lower plenum for the determination of the maximum temperature reached in the U-tubes of the steam generator. A coupled 1D TH/CFD calculation could be performed where the 3D effects in the steam generator lower plenum and in the hot leg are modeled with CFD and the more naturally 1D steam generator U-tubes are modeled with the 1D system code, to allow for accurate predictions at reasonable computational costs.

- **Pressurized thermal shock (PTS);** during transients such as SBLOCA, a plume of cold water entering the reactor pressure vessel can form as a consequence of the ECCS (emergency core cooling system) injections in the cold legs. Because of the embrittlement of the RPV material caused by the neutron fluence, an accurate prediction of the plume formation in the downcomer and its mixing is crucial to correctly predict the temperature distribution on the RPV inner wall, and to assess the eventuality of cracks propagation due to thermal stresses. PTS is particularly important for life extension of relatively small reactors.
- **Boron dilution problems;** a slug of low borated water can be formed following a small-break loss-of-coolant accident (SBLOCA) or a steam generator tube rupture (SGTR). The injection of the low borated water plug into the reactor core yields a positive reactivity insertion. The evaluation of the slug mixing in the downcomer and lower plenum of the reactor pressure vessel (RPV) is crucial for a correct estimation of the core power response and the evaluation of an eventual occurrence of local power excursions.
- **Main steam line break transients (MSLBs);** during a MSLB the temperature in the loop of the affected steam generator can drop considerably with respect to the other loops. Similar to boron dilution cases, the mixing of the colder water with the hotter water streams coming from the unaffected loops is crucial to determine the reactivity insertion and therefore the power response of the reactor core.

In general, a coupled 1D TH/CFD code would have strong benefits for the prediction of transients where the phenomena of single-phase mixing, stratification, plume oscillation and dispersion, and natural convection play an important role for the overall response of the nuclear power plant. Based on extensive assessment and validation efforts during the last several years, CFD codes have the potential to more accurately describe these phenomena than existing 1-D systems codes. A production quality coupled CFD/1-D system code has the potential to significantly enhance the understanding of the underlying physical phenomena for several important reactor transients, and to quantify the impact of 3D effects on safety margins.

## 2. RESEARCH PLAN

The objective of this proposal is to couple the US NRC thermal-hydraulic system code TRACE with the CFD code STAR-CCM+, and the ultimate goal of this work is to provide a US NRC SQA qualified code capability that can address thermal-hydraulic transients of nuclear power plants where three-dimensional effects play an important role. The work here will leverage previous efforts performed by a PhD student under the guidance of the PI at the Paul Scherrer Institute (Switzerland) [3]. The present proposal addresses the following specific aspects which extend the previous work:

- Extension of the previous work from a separate domain to an overlapping domain decomposition approach.

- Implementation of a numerical scheme which optimizes the convergence rate (and thus reduce the computational time) and which improves the accuracy of the coupled code solution. It is important to note that the numerical schemes of interest are the ones that do not necessitate changes in the solvers of the individual codes to be coupled. More details are given in section 2.2 of this proposal.
- Validation of the TRACE/STAR-CCM+ coupled code against experiments designed and performed specifically for the validation of coupled 1D-TH/CFD codes. These experiments have already been performed at the Paul Scherrer Institute under the PI's guidance, and constitute an unique experimental database for the validation of coupled 1D-TH/CFD codes. A detailed description of the experimental set-ups is reported in section 2.3 of this proposal.

Because of current limitations in CFD for two phase flow applications, the scope of the work proposed here will be limited to cases where the portion of the system domain that is to be modeled by the CFD code remains in single-phase conditions.

## 2.1 COUPLING STRATEGY

When a multi-scale approach is used for the modeling of a problem, so-called domain decomposition methods are applied. A possible decomposition of a PWR primary loop. There are basically two fundamental approaches possible for decomposing the domain, one based on separate domains and a second based on overlapping domains. In the former case the system is divided into two separate domains, each modeled with one of the two codes of the coupling respectively. However, in the case of overlapping domains as proposed here for the coupling of a CFD code with a 1D TH code, there can be overlapping between the parts of the systems modeled with the two codes

When overlapping domains are employed for the 1D-TH/CFD coupling, the most appropriate strategy consists of modeling the entire system with the 1D TH code, and modeling the part of the system where three-dimensional effects are expected to play a dominant role (e.g. the reactor pressure vessel, a containment pool, etc.) with the CFD code. The use of overlapping domains should have the main advantage of providing a more robust and efficient numerical coupling, since the pressure balance for the entire system is solved within the same code. In addition, the input deck used for a stand-alone run of the 1D TH code can be employed for a coupled 1D-TH/CFD run without the need for modifications. Source terms for the balance equations of the 1D TH codes are provided by the CFD code, in order to "correct" the 1D TH solution in the region modeled by CFD.

While most of the 1D-TH/CFD coupling codes developed in the nuclear field employ a separate domain approach [4,5,6, 7], overlapping domains are used in other fields of fluid-dynamics (see for example [8]). Recently, also CEA (France) has adopted the overlapping domain approach for the coupling of the CFD code TRIO\_U with the 1D TH code CATHARE. A systematic comparison between 1D-TH/CFD coupling based on separate and overlapping domains respectively has not yet been performed. Such an effort would be a very worthwhile undertaking, in the search for the most robust and efficient coupling scheme for 1D/3D coupled nuclear power plant simulations.

## 2.2 NUMERICAL SCHEMES

Most of the existing coupled code systems apply an *operator splitting* coupling technique, where iterations are first performed on one code to provide boundary conditions to the second code. Iterations are then performed on the second code which then provides boundary conditions to the first code. The accuracy of such coupling is driven by the code that uses the least accurate numerical scheme and by the accuracy in the data exchange between the codes. With the exception of the work reported in [5] and [9], which employ a semi-implicit operator splitting numerical scheme for the

coupling between the 1D system code and the CFD code, all coupling efforts reported in literature for 1D/CFD couplings make use of an explicit marching (or sequential) operator splitting scheme. In this numerical scheme the 1D TH code solves one time step iteration before passing the necessary boundary conditions to the CFD code. The CFD code then solves the time step integration on the CFD domain, and passes the newly computed boundary conditions to the 1D TH code. At this point, a new time step is computed.

This coupling scheme is the one currently employed in many coupled codes used in the nuclear field, among others in the couplings TRACE/PARCS and TRACE/RELAP5 [10]. This method suffers from the poor accuracy of the variables exchanged between the two coupled codes, which limit the accuracy of the overall solution. A variant of the above scheme, called nested (or semi-implicit) scheme, consists in iterating between the 1D TH code and the CFD code within each time step until the boundary conditions computed by the two codes at the interface between the 1D and the 3D domain have reached convergence.

In the explicit marching scheme, the convergence of the results at the boundaries between 1D and 3D domains is not guaranteed, and a relatively small integration time step has to be employed in order to ensure numerical stability and a certain degree of accuracy of the solution. The nested (or semi-implicit) scheme is numerically more robust and stable, and allows for larger integration time steps than the explicit scheme. Our previous work has shown that nested schemes can achieve the same accuracy of explicit schemes with much larger integration time-steps. From a computational point of view, the gain of larger integration time steps achievable with nested schemes is however counteracted by the number of additional (so called "inner") iterations needed during each integration time step in order to reach convergence at the interface between the two codes domains. One possible remedy to cope with the low accuracy of the explicit marching scheme mentioned above is to correct for the nonlinearities in the variables exchanged between the two solvers. One of such methods has been proposed in [11] and consists in employing an higher order discretization for

the non-linear coupled terms, such as  $u = u + (u - u) + O(\Delta t^2)$ . This modification helps improve the accuracy of the explicit scheme, though the stability requirements on the integration time step remain. Also in Ref. [11], more complex schemes aimed at improving accuracy are proposed based on Fixed Point Iteration, which are however more CPU intensive and have to be combined with acceleration techniques (in Ref. [11] the Aitken  $\Delta^2$  acceleration scheme is employed).

More sophisticated techniques are based on so-called Jacobian-Free Newton-Krylov schemes (JFNK) [12]. Among those, the Approximate Block Newton (ABN) methods [13] are of particular interest for the present proposal since they are based on a less intrusive approach than standard JFNK schemes. As a matter of fact, in ABN methods the solvers of the two codes to be coupled can be preserved as "black-boxes", therefore requiring no fundamental modifications of the codes to be coupled.

Based on an extensive literature review of the existing numerical methods for multiphysics/multi-scale applications [14, 15], a systematic comparison of the performance of the most promising numerical schemes is planned within the present proposal.

## 2.3 EXPERIMENTS FOR THE VALIDATION OF COUPLED 1D/CFD CODES

One of the drawbacks of most coupling schemes between 1D system codes and CFD presented in the literature lies in the lack of an experimental basis for validation of the coupled code, and in the lack of evaluation of the accuracy of the implemented coupling schemes. Both of these drawbacks are addressed in this proposal.

In order to cope with the code validation, the PI has participated to the design and construction of two experimental facilities in collaboration with the Thermal-hydraulics Laboratory of the Paul Scherrer

Institute (PSI, Switzerland). The experiments, performed under the PI's guidance by a PhD student, provide an appropriate and unique basis for coupled codes validation.

### 2.3.1 Double T-junction experiment

The first experiment consists of a single-phase loop, which includes a double T-junction component connecting a main loop with a recirculation loop (see a scheme in Figure 5, left) [5]. The loop was operated at constant flow-rates, and several experiments were performed by changing the flow-rate ratio between main and recirculation loop. A tracer, injected in the side loop, was transported in the double T-junction component and was then divided between main loop and side loop (locations WM3 and WM2 respectively in Figure 5, left). The part of tracer directed into the recirculation loop, re-enters the double T-junction component where is split again between main and recirculation loop. By means of advanced instrumentation using wire-mesh sensors (see Figure 5, right), the tracer distribution in a given cross-section could be measured with high spatial and time resolution [16]. The measurement was performed on a matrix of points distributed in the cross-section where the sensor was installed and was based on the measurement of the fluid conductivity. Three wire-mesh sensors were installed in the double T-junction experiment, at the locations WM1, WM2 and WM3 indicated in Figure 5 respectively. A typical measurement of the tracer injection and its recirculation, averaged over the cross-sections where the wire-mesh sensors were installed, is shown in Figure 6 (left). Because of the shape of the three-dimensional velocity field in the double T-junction component (shown in Figure 6 right), at the second T-junction the tracer is split asymmetrically between recirculation and main loop. This asymmetric split can be predicted correctly by a CFD code but not by a 1-D systems code, as shown in the results.

The results show that TRACE cannot model the three-dimensional velocity field that develops in the double T-junction component and incorrectly predicts the split of the tracer between loops to be equal to the mass-flow ratio between the loops (1:1 in the specific case).

The double T-junction experiments provides therefore a very good basis for coupled 1D/CFD code validation, since the double T-junction component would have to be modeled by means of the CFD code. In case of a separate domain approach, TRACE would be used to model only the loops connecting inlet and outlets of the double T-junction component. In the case of an overlapping domain approach, TRACE would model the entire system, but the solution within the double T-junction component would be corrected at each time step by the solution obtained with the CFD code. Since the experiments are performed with a stationary velocity field, they can be used to challenge the coupling of the transport equation for a scalar quantity (tracer, temperature, etc.).

### 2.3.2 FLORIS Facility

The second validation experiment is the FLORIS facility [17] also built at PSI. This facility features a scaled-down, simplified, two-dimensional vertical section of a BWR reactor pressure vessel (RPV), made of transparent Plexiglas, as shown in Figure 8 (left).

The vessel consists of two jet-pumps, the lower plenum, the core section, and the upper plenum. The three outlets of the upper plenum are connected to two recirculation loops through different sets of valves, in order to allow a high degree of flexibility in the configurations that can be used during the experiments (see Figure 8, right). The two recirculation loops are driven by frequency-controlled pumps, allowing a fine control during transients (e.g. pump start-up or shut-down transients). A wire-mesh sensor is used to measure the mixing flow pattern in the RPV.

Similar to the double T-junction experiments, a 1-D TH code such as TRACE is not able to correctly capture the 3D velocity field and therefore the mixing of fluid streams within the vessel. This is the

case even when a TRACE multidimensional ("vessel") component is employed, as demonstrated in Figure 9, where the results computed by ANSYS-CFX and TRACE are compared with the experimental results obtained at different times during a pump start-up experiment.

The FLORIS experiments were designed to challenge the numerical modeling of both the transport of a scalar and the coupling of the momentum equation in transient conditions. Together with the double T-junction experiments, this provides a unique experimental basis for validating the coupling of TRACE and STAR-CCM+ that is proposed in the work here.

### 3. MILESTONES

#### YEAR 1

- Development and implementation of a coupling between the TRACE code and the CFD code STAR-CCM+ through the CCM+ Java interface (TRACE will be compiled as subroutine to be called from the CFD code without the need for a parallel virtual machine such as PVM or MPI).
- Implementation of both a separate domain and an overlapping domain coupling approach. The latter approach will require a modification of the TRACE balance equations to include source/sink terms generated by the CFD code for the overlapped domain.

#### YEAR 2

- Verification of the coupling schemes against simple tests (straight pipe, closed loop, etc.), and comparison of the performance of the separate vs overlapping domains approach (figures of merit: convergence rate and accuracy).
- Investigation of coupling numerical schemes other than explicit sequential schemes, implementations of the most promising schemes in the TRACE/STARCCM+ code, and assessment of the performance of the schemes (figures of merit: convergence rate and accuracy).

#### YEAR 3 (5 months)

- Validation of the coupled code TRACE/STAR-CCM+ against the experimental data described in section 2.3.
- Preparation of SQA documents and development of a set of guidelines for the use of the coupled TRACE/STAR-CCM+ code.

### 4. SUMMARY

The project proposed here is highly relevant to the research plan of the NRC Office of Nuclear Regulatory Research (RES). As described in Section 2, several nuclear reactor safety phenomena have been identified during important operational and accident events (e.g. station blackout and ATWS) where the combination of CFD with 1D TH system codes would provide a better understanding of the underlying physical phenomena and a quantification of the impact of 3D effects on safety margins.



The work proposed here will advance the state of the art in coupled 1D-TH/CFD codes by employing an innovative overlapping domain method which will provide the ability to assess the potential significance of the specific 3D phenomena modeled with the CFD code. The methods proposed here will be validated using data from two experiments which were designed specifically to test the important aspects of the coupled 1DTH/CFD code and which have already been performed.

The results of this 2.5 year project will provide RES with a validated reactor analysis tool that will complement the capabilities of the US NRC code TRACE, and will significantly enhance the state of the art for the simulation of nuclear power plant thermal-hydraulic transients.

## **Attachment C – Standard Terms and Conditions**

### **The Nuclear Regulatory Commission's Standard Terms and Conditions for U.S. Nongovernmental Grantees**

#### **Preface**

This award is based on the application submitted to, and as approved by, the Nuclear Regulatory Commission (NRC) under the authorization 42 USC 2051(b) pursuant to section 31b and 141b of the Atomic Energy Act of 1954, as amended, and is subject to the terms and conditions incorporated either directly or by reference in the following:

- Grant program legislation and program regulation cited in this Notice of Grant Award.
- Restrictions on the expenditure of Federal funds in appropriation acts, to the extent those restrictions are pertinent to the award.
- Code of Federal Regulations/Regulatory Requirements - 2 CFR 215 Uniform Administrative Requirements For Grants And Agreements With Institutions Of Higher Education, Hospitals, And Other Non-Profit Organizations (OMB Circulars), as applicable.

To assist with finding additional guidance for selected items of cost as required in 2 CFR 220, 2 CFR 225, and 2 CFR 230 this URL to the Office of Management and Budget Cost Circulars is included for reference to:

A-21 (now 2 CFR 220)  
A-87 (now 2 CFR 225)  
A-122 (now 2 CFR 230)  
A-102:

[http://www.whitehouse.gov/omb/circulars\\_index-ffm](http://www.whitehouse.gov/omb/circulars_index-ffm)

Any inconsistency or conflict in terms and conditions specified in the award will be resolved according to the following order of precedence: public laws, regulations, applicable notices published in the Federal Register, Executive Orders (EOs), Office of Management and Budget (OMB) Circulars, the Nuclear Regulatory Commission's (NRC) Mandatory Standard Provisions, special award conditions, and standard award conditions.

Certifications and Representations: These terms incorporate the certifications and representations required by statute, executive order, or regulation that were submitted with the SF424B application through Grants.gov.

#### **I. Mandatory General Requirements**

The order of these requirements does not make one requirement more important than any other requirement.

### **1. Applicability of 2 CFR Part 215**

a. All provisions of 2 CFR Part 215 and all Standard Provisions attached to this grant/cooperative agreement are applicable to the Grantee and to sub-recipients which meet the definition of "Grantee" in Part 215, unless a section specifically excludes a sub-recipient from coverage. The Grantee and any sub-recipients must, in addition to the assurances made as part of the application, comply and require each of its sub-awardees employed in the completion of the project to comply with Subpart C of 2 CFR 215 and include this term in lower-tier (subaward) covered transactions.

b. Grantees must comply with monitoring procedures and audit requirements in accordance with OMB Circular A-133. < [http://www.whitehouse.gov/omb/circulars/a133\\_compliance/08/08toc.aspx](http://www.whitehouse.gov/omb/circulars/a133_compliance/08/08toc.aspx) >

### **2. Award Package**

#### **§ 215.41 Grantee responsibilities.**

The Grantee is obligated to conduct such project oversight as may be appropriate, to manage the funds with prudence, and to comply with the provisions outlined in 2 CFR 215.41. Within this framework, the Principal Investigator (PI) named on the award face page, Block 11, is responsible for the scientific or technical direction of the project and for preparation of the project performance reports. This award is funded on a cost reimbursement basis not to exceed the amount awarded as indicated on the face page, Block 16., and is subject to a refund of unexpended funds to NRC.

The standards contained in this section do not relieve the Grantee of the contractual responsibilities arising under its contract(s). The Grantee is the responsible authority, without recourse to the NRC, regarding the settlement and satisfaction of all contractual and administrative issues arising out of procurements entered into in support of an award or other agreement. This includes disputes, claims, protests of award, source evaluation or other matters of a contractual nature. Matters concerning violation of statute are to be referred to such Federal, State or local authority as may have proper jurisdiction.

#### **Subgrants**

##### **Appendix A to Part 215—Contract Provisions**

Sub-recipients, sub-awardees, and contractors have no relationship with NRC under the terms of this grant/cooperative agreement. All required NRC approvals must be directed through the Grantee to NRC. See 2 CFR 215 and 215.41.

#### **Nondiscrimination**

(This provision is applicable when work under the grant/cooperative agreement is performed in the U.S. or when employees are recruited in the U.S.)

No U.S. citizen or legal resident shall be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity funded by this award on the basis of race, color, national origin, age, religion, handicap, or sex. The Grantee agrees to comply with the non-discrimination requirements below:

Title VI of the Civil Rights Act of 1964 (42 USC §§ 2000d et seq)  
Title IX of the Education Amendments of 1972 (20 USC §§ 1681 et seq)  
Section 504 of the Rehabilitation Act of 1973, as amended (29 USC § 794)  
The Age Discrimination Act of 1975, as amended (42 USC §§ 6101 et seq)  
The Americans with Disabilities Act of 1990 (42 USC §§ 12101 et seq)  
Parts II and III of EO 11246 as amended by EO 11375 and 12086.  
EO 13166, "Improving Access to Services for Persons with Limited English Proficiency."  
Any other applicable non-discrimination law(s).

Generally, Title VI of the Civil Rights Act of 1964, 42 USC § 2000e et seq, provides that it shall be an unlawful employment practice for an employer to discharge any individual or otherwise to discriminate against an individual with respect to compensation, terms, conditions, or privileges of employment because of such individual's race, color, religion, sex, or national origin. However, Title VI, 42 USC § 2000e-1(a), expressly exempts from the prohibition against discrimination on the basis of religion, a religious corporation, association, educational institution, or society with respect to the employment of individuals of a particular religion to perform work connected with the carrying on by such corporation, association, educational institution, or society of its activities.

#### **Modifications/Prior Approval**

NRC's prior written approval may be required before a Grantee makes certain budget modifications or undertakes particular activities. If NRC approval is required for changes in the grant or cooperative agreement, it must be requested of, and obtained from, the NRC Grants Officer in advance of the change or obligation of funds. All requests for NRC prior approval should be made, in writing (which includes submission by e-mail), to the designated Grants Specialist and Program Office no later than 30 days before the proposed change. The request must be signed by both the PI and the authorized organizational official. Failure to obtain prior approval, when required, from the NRC Grants Officer may result in the disallowance of costs, or other enforcement action within NRC's authority.

#### **Lobbying Restrictions**

The Grantee will comply, as applicable, with provisions of the Hatch Act (5 U.S.C. §§1501-1508 and 7324-7328) which limit the political activities of employees whose principal employment activities are funded in whole or in part with Federal funds.

The Grantee shall comply with provisions of 31 USC § 1352. This provision generally prohibits the use of Federal funds for lobbying in the Executive or Legislative Branches of the Federal Government in connection with the award, and requires disclosure of the use of non-Federal funds for lobbying.

The Grantee receiving in excess of \$100,000 in Federal funding shall submit a completed Standard Form (SF) LLL, "Disclosure of Lobbying Activities," regarding the use of non-Federal funds for lobbying within 30 days following the end of the calendar quarter in which there occurs any event that requires disclosure or that materially affects the accuracy of the information contained in any disclosure form previously filed. The Grantee must submit the SF-LLL, including those received from sub-recipients, contractors, and subcontractors, to the Grants Officer.

#### **§ 215.13 Debarment And Suspension.**

The Grantee agrees to notify the Grants Officer immediately upon learning that it or any of its principals:

(1) Are presently excluded or disqualified from covered transactions by any Federal department or agency;

(2) Have been convicted within the preceding three-year period preceding this proposal been convicted of or had a civil judgment rendered against them for commission of fraud or a criminal offense in connection with obtaining, attempting to obtain, or performing a public (Federal, State, or local) transaction or contract under a public transaction; violation of Federal or State antitrust statutes or commission of embezzlement, theft, forgery, bribery, falsification or destruction of records, making false statements, tax evasion, receiving stolen property, making false claims, or obstruction of justice; commission of any other offense indicating a lack of business integrity or business honesty that seriously and directly affects your present responsibility;

(3) Are presently indicted for or otherwise criminally or civilly charged by a governmental entity (Federal, State, or local) with commission of any of the offenses enumerated in paragraph (1)(b); and

(4) Have had one or more public transactions (Federal, State, or local) terminated for cause or default within the preceding three years.

b. The Grantee agrees that, unless authorized by the Grants Officer, it will not knowingly enter into any subgrant or contracts under this grant/cooperative agreement with a person or entity that is included on the Excluded Parties List System (<http://epls.arnet.gov>).

The Grantee further agrees to include the following provision in any subgrant or contracts entered into under this award:

'Debarment, Suspension, Ineligibility, and Voluntary Exclusion

The Grantee certifies that neither it nor its principals is presently excluded or disqualified from participation in this transaction by any Federal department or agency. The policies and procedures applicable to debarment, suspension, and ineligibility under NRC-financed transactions are set forth in 2 CFR Part 180.'

#### **Drug-Free Workplace**

The Grantee must be in compliance with The Federal Drug Free Workplace Act of 1988. The policies and procedures applicable to violations of these requirements are set forth in 41 USC 702.

#### **Implementation of E.O. 13224 -- Executive Order On Terrorist Financing**

The Grantee is reminded that U.S. Executive Orders and U.S. law prohibits transactions with, and the provision of resources and support to, individuals and organizations associated with terrorism. It is the legal responsibility of the Grantee to ensure compliance with these Executive Orders and laws. This provision must be included in all contracts/sub-awards issued under this grant/cooperative agreement.

Award Grantees must comply with Executive Order 13224, Blocking Property and Prohibiting Transactions with Persons who Commit, Threaten to Commit, or Support Terrorism. Information about this Executive Order can be found at: [www.fas.org/irp/offdocs/eo-13224.htm](http://www.fas.org/irp/offdocs/eo-13224.htm).

#### **Procurement Standards. § 215.40-48**

Sections 215.41 through 215.48 set forth standards for use by Grantees in establishing procedures for the procurement of supplies and other expendable property, equipment, real property and other services with Federal funds. These standards are furnished to ensure that such materials and services are obtained in an effective manner and in compliance with the provisions of applicable Federal statutes and executive orders. No additional procurement standards or requirements shall be imposed by the Federal awarding agencies upon Grantees, unless specifically required by Federal statute or executive order or approved by OMB.

### **Travel**

Travel must be in accordance with the Grantee's Travel Regulations or the US Government Travel Policy and Regulations at: [www.gsa.gov/federaltravelregulation](http://www.gsa.gov/federaltravelregulation) and the per diem rates set forth at: [www.gsa.gov/perdiem](http://www.gsa.gov/perdiem), absent Grantee's travel regulation. Travel costs for the grant must be consistent with provisions as established in Appendix A to 2 CFR 220 (J.53). All other travel, domestic or international, must not increase the total estimated award amount.

### **Domestic Travel:**

Domestic travel is an appropriate charge to this award and prior authorization for specific trips are not required, if the trip is identified in the Grantee's approved program description and approved budget. Domestic trips not stated in the approved budget require the written prior approval of the Grants Officer, and must not increase the total estimated award amount.

All common carrier travel reimbursable hereunder shall be via the least expensive class rates consistent with achieving the objective of the travel and in accordance with the Grantee's policies and practices. Travel by first-class travel is not authorized unless prior approval is obtained from the Grants Officer.

### **International Travel:**

**International travel requires PRIOR written approval by the Project Officer and the Grants Officer, even if the international travel is stated in the approved program description and the approved budget.**

The Grantee shall comply with the provisions of the Fly American Act (49 USC 40118) as implemented through 41 CFR 301-10.131 through 301-10.143.

### **Property and Equipment Management Standards**

Property and equipment standards of this award shall follow provisions as established in 2 CFR 215.30-37.

### **Procurement Standards**

Procurement standards of this award shall follow provisions as established in 2 CFR 215.40-48

### **Intangible and Intellectual Property**

Intangible and intellectual property of this award shall generally follow provisions established in 2 CFR 215.36.

**Inventions Report** - The Bayh-Dole Act (P.L. 96-517) affords Grantees the right to elect and retain title to inventions they develop with funding under an NRC grant award ("subject inventions"). In accepting an award, the Grantee agrees to comply with applicable NRC policies, the Bayh-Dole Act, and its Government-wide implementing regulations found at Title 37, Code of Federal Regulations (CFR) Part 401. A significant part of the regulations require that the Grantee report all subject inventions to the awarding agency (NRC) as well as include an

acknowledgement of federal support in any patents. NRC participates in the trans-government Interagency Edison system (<http://www.iedison.gov>) and expects NRC funding Grantees to use this system to comply with Bayh-Dole and related intellectual property reporting requirements. The system allows for Grantees to submit reports electronically via the Internet. In addition, the invention must be reported in continuation applications (competing or non-competing).

**Patent Notification Procedures**- Pursuant to EO 12889, NRC is required to notify the owner of any valid patent covering technology whenever the NRC or its financial assistance Grantees, without making a patent search, knows (or has demonstrable reasonable grounds to know) that technology covered by a valid United States patent has been or will be used without a license from the owner. To ensure proper notification, if the Grantee uses or has used patented technology under this award without license or permission from the owner, the Grantee must notify the Grants Officer. This notice does not necessarily mean that the Government authorizes and consents to any copyright or patent infringement occurring under the financial assistance.

**Data, Databases, and Software** - The rights to any work produced or purchased under a NRC federal financial assistance award are determined by 2 CFR 215.36. Such works may include data, databases or software. The Grantee owns any work produced or purchased under a NRC federal financial assistance award subject to NRC's right to obtain, reproduce, publish or otherwise use the work or authorize others to receive, reproduce, publish or otherwise use the data for Government purposes.

**Copyright** - The Grantee may copyright any work produced under a NRC federal financial assistance award subject to NRC's royalty-free nonexclusive and irrevocable right to reproduce, publish or otherwise use the work or authorize others to do so for Government purposes. Works jointly authored by NRC and Grantee employees may be copyrighted but only the part authored by the Grantee is protected because, under 17 USC § 105, works produced by Government employees are not copyrightable in the United States. On occasion, NRC may ask the Grantee to transfer to NRC its copyright in a particular work when NRC is undertaking the primary dissemination of the work. Ownership of copyright by the Government through assignment is permitted under 17 USC § 105.

**Records Retention and Access Requirements** for records of the Grantee shall follow established provisions in 2 CFR 215.53.

### **Organizational Prior Approval System**

In order to carry out its responsibilities for monitoring project performance and for adhering to award terms and conditions, each Grantee organization shall have a system to ensure that appropriate authorized officials provide necessary organizational reviews and approvals in advance of any action that would result in either the performance or modification of an NRC supported activity where prior approvals are required, including the obligation or expenditure of funds where the governing cost principles either prescribe conditions or require approvals.

The Grantee shall designate an appropriate official or officials to review and approve the actions requiring NRC prior approval. Preferably, the authorized official(s) should be the same official(s) who sign(s) or countersign(s) those types of requests that require prior approval by NRC. The authorized organization official(s) shall not be the principal investigator or any official having direct responsibility for the actual conduct of the project, or a subordinate of such individual.

**Conflict Of Interest Standards** for this award shall follow OCOI requirements set forth in Section 170A of the Atomic Energy Act of 1954, as amended, and provisions set forth at 2 CFR 215.42 Codes of Conduct.

**Dispute Review Procedures**

- a. Any request for review of a notice of termination or other adverse decision should be addressed to the Grants Officer. It must be postmarked or transmitted electronically no later than 30 days after the postmarked date of such termination or adverse decision from the Grants Officer.
- b. The request for review must contain a full statement of the Grantee's position and the pertinent facts and reasons in support of such position.
- c. The Grants Officer will promptly acknowledge receipt of the request for review and shall forward it to the Director, Office of Administration, who shall appoint an intra-agency Appeal Board to review a grantee appeal of an agency action, if required, which will consist of the program office director, the Deputy Director of Office of Administration, and the Office of General Counsel.
- d. Pending resolution of the request for review, the NRC may withhold or defer payments under the award during the review proceedings.
- e. The review committee will request the Grants Officer who issued the notice of termination or adverse action to provide copies of all relevant background materials and documents. The committee may, at its discretion, invite representatives of the Grantee and the NRC program office to discuss pertinent issues and to submit such additional information as it deems appropriate. The chairman of the review committee will insure that all review activities or proceedings are adequately documented.
- f. Based on its review, the committee will prepare its recommendation to the Director, Office of Administration, who will advise the parties concerned of his/her decision.

**Termination and Enforcement.** Termination of this award by default or by mutual consent shall follow provisions as established in 2 CFR 215.60-62.

**Monitoring and Reporting § 215.50-53**

a. Grantee Financial Management systems must comply with the established provisions in 2 CFR 215.21

- Payment – 2 CFR 215.22
- Cost Share – 2 CFR 215.23
- Program Income – 2 CFR 215.24
  - Earned program income, if any, shall be added to funds committed to the project by the NRC and Grantee and used to further eligible project or program objectives or deducted from the total project cost allowable cost as directed by the Grants Officer or the terms and conditions of award.
- Budget Revision – 2 CFR 215.25

- The Grantee is required to report deviations from the approved budget and program descriptions in accordance with 2 CFR 215.25, and request prior written approval from the Program Officer and the Grants Officer.
- The Grantee is not authorized to rebudget between direct costs and indirect costs without written approval of the Grants Officer.
- The Grantee is authorized to transfer funds among direct cost categories up to a cumulative 10 percent of the total approved budget. The Grantee is not allowed to transfer funds if the transfer would cause any Federal appropriation to be used for purposes other than those consistent with the original intent of the appropriation.
- Allowable Costs – 2 CFR 215.27

#### **b. Federal Financial Reports**

The Grantee shall submit a "Federal Financial Report" (SF-425) on a quarterly basis for the periods ending March 31, June 30, September 30, and December 31, or any portion thereof, unless otherwise specified in a special award condition. Reports are due no later than 30 days following the end of each reporting period. A final SF-425 is due within 90 days after expiration of the award. The report should be submitted electronically to: Grants\_FFR.Resource@NRC.GOV and RESGrants.Resource@nrc.gov. (**NOTE: There is an underscore between Grants and FFR**).

#### **Period of Availability of Funds 2 CFR § 215.28**

- a. Where a funding period is specified, a Grantee may charge to the grant only allowable costs resulting from obligations incurred during the funding period and any pre-award costs authorized by the NRC.
- b. Unless otherwise authorized in 2 CFR 215.25(e)(2) or a special award condition, any extension of the award period can only be authorized by the Grants Officer in writing. Verbal or written assurances of funding from other than the Grants Officer shall not constitute authority to obligate funds for programmatic activities beyond the expiration date.
- c. The NRC has no obligation to provide any additional prospective or incremental funding. Any modification of the award to increase funding and to extend the period of performance is at the sole discretion of the NRC.
- d. Requests for extensions to the period of performance should be sent to the Grants Officer at least 30 days prior to the grant/cooperative agreement expiration date. Any request for extension after the expiration date may not be honored.

#### **Automated Standard Application For Payments (ASAP) Procedures**

Unless otherwise provided for in the award document, payments under this award will be made using the Department of Treasury's Automated Standard Application for Payment (ASAP) system < <http://www.fms.treas.gov/asap/> >. Under the ASAP system, payments are made through preauthorized electronic funds transfers, in accordance with the requirements of the Debt Collection Improvement Act of 1996. In order to receive payments under ASAP, Grantees are required to enroll with the Department of Treasury, Financial Management Service, and Regional Financial Centers, which allows them to use the on-line method of withdrawing funds from their ASAP established accounts. The following information will be required to make withdrawals under ASAP: (1) ASAP account number – the award number found on the cover sheet of the award; (2) Agency Location Code (ALC) – 31000001; and Region Code. Grantees enrolled in the



ASAP system do not need to submit a "Request for Advance or Reimbursement" (SF-270), for payments relating to their award.

### **Audit Requirements**

Organization-wide or program-specific audits shall be performed in accordance with the Single Audit Act Amendments of 1996, as implemented by OMB Circular A-133, "Audits of States, Local Governments, and Non-Profit Organizations."

<http://www.whitehouse.gov/omb/circulars/a133/a133.html> Grantees are subject to the provisions of OMB Circular A-133 if they expend \$500,000 or more in a year in Federal awards.

The Form SF-SAC and the Single Audit Reporting packages for fiscal periods ending on or after January 1, 2008 must be submitted online.

1. Create your online report ID at <http://harvester.census.gov/fac/collect/ddeindex.html>
2. Complete the Form SF-SAC
3. Upload the Single Audit
4. Certify the Submission
5. Click "Submit."

Organizations expending less than \$500,000 a year are not required to have an annual audit for that year but must make their grant-related records available to NRC or other designated officials for review or audit.

### **III. Programmatic Requirements**

#### **Performance (Technical) Reports**

a. The Grantee shall submit performance (technical) reports electronically on a quarterly basis for the periods ending March 31, June 30, September 30, and December 31, or any portion thereof, unless otherwise specified in a special award condition. Reports are due no later than 30 days following the end of each reporting period unless otherwise authorized by the Grants Officer. Performance reports should be sent to the Program Officer and Technical Analyst at the email address indicated in Block 12 of the Notice of Award, and to the Grants Officer at: [Grants\\_PPR.Resource@nrc.gov](mailto:Grants_PPR.Resource@nrc.gov) and [RESGrants.Resource@nrc.gov](mailto:RESGrants.Resource@nrc.gov). (**NOTE: There is an underscore between Grants and PPR**).

b. Unless otherwise specified in the award provisions, performance (technical) reports shall contain brief information as prescribed in the applicable uniform administrative requirements 2 CFR §215.51 which are incorporated in the award.

c. The Office of Regulatory Research requires the submission of progress reports on the SF-RPPR on a quarterly basis for the periods ending March 31, June 30, September 30, and December 31, or any portion thereof, unless otherwise specified in a special award condition. Reports are due no later than 30 days following the end of each reporting period.

#### **Unsatisfactory Performance**

Failure to perform the work in accordance with the terms of the award and maintain at least a satisfactory performance rating or equivalent evaluation may result in designation of the Grantee as high risk and assignment of special award conditions or other further action as specified in the standard term and condition entitled "Termination."

Failure to comply with any or all of the provisions of the award may have a negative impact on future funding by NRC and may be considered grounds for any or all of the following actions: establishment of an accounts receivable, withholding of payments under any NRC award, changing the method of payment from advance to reimbursement only, or the imposition of other special award conditions, suspension of any NRC active awards, and termination of any NRC award.

#### **Other Federal Awards With Similar Programmatic Activities**

The Grantee shall immediately provide written notification to the NRC Project Officer and the Grants Officer in the event that, subsequent to receipt of the NRC award, other financial assistance is received to support or fund any portion of the program description incorporated into the NRC award. NRC will not pay for costs that are funded by other sources.

#### **Prohibition Against Assignment By The Grantee**

The Grantee shall not transfer, pledge, mortgage, or otherwise assign the award, or any interest therein, or any claim arising thereunder, to any party or parties, banks, trust companies, or other financing or financial institutions without the express written approval of the Grants Officer.

#### **Site Visits**

The NRC, through authorized representatives, has the right, at all reasonable times, to make site visits to review project accomplishments and management control systems and to provide such technical assistance as may be required. If any site visit is made by the NRC on the premises of the Grantee or contractor under an award, the Grantee shall provide and shall require his/her contractors to provide all reasonable facilities and assistance for the safety and convenience of the Government representative in the performance of their duties. All site visits and evaluations shall be performed in such a manner as will not unduly delay the work.

### **IV. Miscellaneous Requirements**

#### **Criminal and Prohibited Activities**

- a. The Program Fraud Civil Remedies Act (31 USC §§ 3801-3812), provides for the imposition of civil penalties against persons who make false, fictitious, or fraudulent claims to the Federal government for money (including money representing grant/cooperative agreements, loans, or other benefits.)
- b. False statements (18 USC § 287), provides that whoever makes or presents any false, fictitious, or fraudulent statements, representations, or claims against the United States shall be subject to imprisonment of not more than five years and shall be subject to a fine in the amount provided by 18 USC § 287.
- c. False Claims Act (31 USC 3729 et seq), provides that suits under this Act can be brought by the government, or a person on behalf of the government, for false claims under federal assistance programs.
- d. Copeland "Anti-Kickback" Act (18 USC § 874), prohibits a person or organization engaged in a federally supported project from enticing an employee working on the project from giving up a part of his compensation under an employment contract.

#### **American-Made Equipment And Products**

Grantees are hereby notified that they are encouraged, to the greatest extent practicable, to purchase American-made equipment and products with funding provided under this award.

**Increasing Seat Belt Use in the United States**

Pursuant to EO 13043, Grantees should encourage employees and contractors to enforce on-the-job seat belt policies and programs when operating company-owned, rented or personally-owned vehicle.

**Federal Leadership of Reducing Text Messaging While Driving**

Pursuant to EO 13513, Grantees should encourage employees, sub-awardees, and contractors to adopt and enforce policies that ban text messaging while driving company-owned, rented vehicles or privately owned vehicles when on official Government business or when performing any work for or on behalf of the Federal Government.

**Federal Employee Expenses**

Federal agencies are generally barred from accepting funds from a Grantee to pay transportation, travel, or other expenses for any Federal employee unless specifically approved in the terms of the award. Use of award funds (Federal or non-Federal) or the Grantee's provision of in-kind goods or services, for the purposes of transportation, travel, or any other expenses for any Federal employee may raise appropriation augmentation issues. In addition, NRC policy prohibits the acceptance of gifts, including travel payments for Federal employees, from Grantees or applicants regardless of the source.

**Minority Serving Institutions (MSIs) Initiative**

Pursuant to EOs 13256, 13230, and 13270, NRC is strongly committed to broadening the participation of MSIs in its financial assistance program. NRC's goals include achieving full participation of MSIs in order to advance the development of human potential, strengthen the Nation's capacity to provide high-quality education, and increase opportunities for MSIs to participate in and benefit from Federal financial assistance programs. NRC encourages all applicants and Grantees to include meaningful participations of MSIs. Institutions eligible to be considered MSIs are listed on the Department of Education website:

<http://www.ed.gov/about/offices/list/ocr/edlite-minorityinst.html>

**Research Misconduct**

Scientific or research misconduct refers to the fabrication, falsification, or plagiarism in proposing, performing, or reviewing research, or in reporting research results. It does not include honest errors or differences of opinions. The Grantee organization has the primary responsibility to investigate allegations and provide reports to the Federal Government. Funds expended on an activity that is determined to be invalid or unreliable because of scientific misconduct may result in a disallowance of costs for which the institution may be liable for repayment to the awarding agency. The Office of Science and Technology Policy at the White House published in the Federal Register on December 6, 2000, a final policy that addressed research misconduct. The policy was developed by the National Science and Technology Council (65 FR 76260). The NRC requires that any allegation be submitted to the Grants Officer, who will also notify the OIG of such allegation. Generally, the Grantee organization shall investigate the allegation and submit its findings to the Grants Officer. The NRC may accept the Grantee's findings or proceed with its own investigation. The Grants Officer shall inform the Grantee of the NRC's final determination.

**Publications, Videos, and Acknowledgment of Sponsorship**

Publication of the results or findings of a research project in appropriate professional journals and production of video or other media is encouraged as an important method of recording and reporting scientific information. It is also a constructive means to expand access to federally funded research. The Grantee is required to submit a copy to the NRC and when releasing

information related to a funded project include a statement that the project or effort undertaken was or is sponsored by the NRC. The Grantee is also responsible for assuring that every publication of material (including Internet sites and videos) based on or developed under an award, except scientific articles or papers appearing in scientific, technical or professional journals, contains the following disclaimer:

“This [report/video] was prepared by [Grantee name] under award [number] from [name of operating unit], Nuclear Regulatory Commission. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the view of the [name of operating unit] or the US Nuclear Regulatory Commission.”

**Trafficking In Victims Protection Act Of 2000 (as amended by the Trafficking Victims Protection Reauthorization Act of 2003)**

Section 106(g) of the Trafficking In Victims Protection Act Of 2000 (as amended as amended, directs on a government-wide basis that:

“any grant, contract, or cooperative agreement provided or entered into by a Federal department or agency under which funds are to be provided to a private entity, in whole or in part, shall include a condition that authorizes the department or agency to terminate the grant, contract, or cooperative agreement, without penalty, if the grantee or any subgrantee, or the contractor or any subcontractor (i) engages in severe forms of trafficking in persons or has procured a commercial sex act during the period of time that the grant, contract, or cooperative agreement is in effect, or (ii) uses forced labor in the performance of the grant, contract, or cooperative agreement.” (22 U.S.C. § 7104(g)).

**Executive Compensation Reporting**

2 CFR 170.220 directs agencies to include the following text to each grant award to a non-federal entity if the total funding is \$25,000 or more in Federal funding.

Reporting Subawards and Executive Compensation.

*a. Reporting of first-tier subawards.*

1. *Applicability.* Unless you are exempt as provided in paragraph d. of this award term, you must report each action that obligates \$25,000 or more in Federal funds that does not include Recovery funds (as defined in section 1512(a)(2) of the American Recovery and Reinvestment Act of 2009, Pub. L. 111–5) for a subaward to an entity (see definitions in paragraph e. of this award term).

2. *Where and when to report.*

i. You must report each obligating action described in paragraph a.1. of this award term to <http://www.fsrs.gov>.

ii. For subaward information, report no later than the end of the month following the month in which the obligation was made. (For example, if the obligation was made on November 7, 2010, the obligation must be reported by no later than December 31, 2010.)

3. *What to report.* You must report the information about each obligating action that the submission instructions posted at <http://www.fsrs.gov> specify.

b. *Reporting Total Compensation of Recipient Executives.*

1. *Applicability and what to report.* You must report total compensation for each of your five most highly compensated executives for the preceding completed fiscal year, if—

i. the total Federal funding authorized to date under this award is \$25,000 or more;

ii. in the preceding fiscal year, you received—

(A) 80 percent or more of your annual gross revenues from Federal procurement contracts (and subcontracts) and Federal financial assistance subject to the Transparency Act, as defined at 2 CFR 170.320 (and subawards); and

(B) \$25,000,000 or more in annual gross revenues from Federal procurement contracts (and subcontracts) and Federal financial assistance subject to the Transparency Act, as defined at 2 CFR 170.320 (and subawards); and

iii. The public does not have access to information about the compensation of the executives through periodic reports filed under section 13(a) or 15(d) of the Securities Exchange Act of 1934 (15 U.S.C. 78m(a), 78o(d)) or section 6104 of the Internal Revenue Code of 1986. (To determine if the public has access to the compensation information, see the U.S. Security and Exchange Commission total compensation filings at <http://www.sec.gov/answers/execomp.htm>.)

2. *Where and when to report.* You must report executive total compensation described in paragraph b.1. of this award term:

i. As part of your registration profile at <http://www.ccr.gov>.

ii. By the end of the month following the month in which this award is made, and annually thereafter.

c. *Reporting of Total Compensation of Subrecipient Executives.*

1. *Applicability and what to report.* Unless you are exempt as provided in paragraph d. of this award term, for each first-tier subrecipient under this award, you shall report the names and total compensation of each of the subrecipient's five most highly compensated executives for the subrecipient's preceding completed fiscal year, if—

i. in the subrecipient's preceding fiscal year, the subrecipient received—

(A) 80 percent or more of its annual gross revenues from Federal procurement contracts (and subcontracts) and Federal financial assistance subject to the Transparency Act, as defined at 2 CFR 170.320 (and subawards); and

(B) \$25,000,000 or more in annual gross revenues from Federal procurement contracts (and subcontracts), and Federal financial assistance subject to the Transparency Act (and subawards); and

ii. The public does not have access to information about the compensation of the executives through periodic reports filed under section 13(a) or 15(d) of the Securities Exchange Act of 1934 (15 U.S.C. 78m(a), 78o(d)) or section 6104 of the Internal Revenue Code of 1986. (To determine if the public has access to the compensation information, see the U.S. Security and Exchange Commission total compensation filings at <http://www.sec.gov/answers/execomp.htm> .)

2. *Where and when to report.* You must report subrecipient executive total compensation described in paragraph c.1. of this award term:

i. To the recipient.

ii. By the end of the month following the month during which you make the subaward. For example, if a subaward is obligated on any date during the month of October of a given year ( *i.e.*, between October 1 and 31), you must report any required compensation information of the subrecipient by November 30 of that year.

d. *Exemptions*

If, in the previous tax year, you had gross income, from all sources, under \$300,000, you are exempt from the requirements to report:

i. Subawards,

and

ii. The total compensation of the five most highly compensated executives of any subrecipient.

e. *Definitions.* For purposes of this award term:

1. *Entity* means all of the following, as defined in 2 CFR part 25:

i. A Governmental organization, which is a State, local government, or Indian tribe;

ii. A foreign public entity;

iii. A domestic or foreign nonprofit organization;

iv. A domestic or foreign for-profit organization;

v. A Federal agency, but only as a subrecipient under an award or subaward to a non-Federal entity.

2. *Executive* means officers, managing partners, or any other employees in management positions.

3. *Subaward*:

- i. This term means a legal instrument to provide support for the performance of any portion of the substantive project or program for which you received this award and that you as the recipient award to an eligible subrecipient.
- ii. The term does not include your procurement of property and services needed to carry out the project or program (for further explanation, see Sec. \_\_.210 of the attachment to OMB Circular A-133, "Audits of States, Local Governments, and Non-Profit Organizations").
- iii. A subaward may be provided through any legal agreement, including an agreement that you or a subrecipient considers a contract.

4. *Subrecipient* means an entity that:

- i. Receives a subaward from you (the recipient) under this award; and
- ii. Is accountable to you for the use of the Federal funds provided by the subaward.

5. *Total compensation* means the cash and noncash dollar value earned by the executive during the recipient's or subrecipient's preceding fiscal year and includes the following (for more information see 17 CFR 229.402(c)(2)):

- i. *Salary and bonus*.
- ii. *Awards of stock, stock options, and stock appreciation rights*. Use the dollar amount recognized for financial statement reporting purposes with respect to the fiscal year in accordance with the Statement of Financial Accounting Standards No. 123 (Revised 2004) (FAS 123R), Shared Based Payments.
- iii. *Earnings for services under non-equity incentive plans*. This does not include group life, health, hospitalization or medical reimbursement plans that do not discriminate in favor of executives, and are available generally to all salaried employees.
- iv. *Change in pension value*. This is the change in present value of defined benefit and actuarial pension plans.
- v. *Above-market earnings on deferred compensation which is not tax-qualified*.
- vi. Other compensation, if the aggregate value of all such other compensation (e.g. severance, termination payments, value of life insurance paid on behalf of the employee, perquisites or property) for the executive exceeds \$10,000.