

Statement of Work

Associated with Implementing Arrangement Number 13 Enhancement and Support Services for the Advanced Operational Aviation Weather System subject to the Agreement between the Taipei Economic and Cultural Representative Office in the United States and the American Institute In Taiwan for Technical Cooperation associated with Establishment of Advanced Operational Aviation Weather Systems

1.0 Background and Objectives

The Agreement between the Taipei Economic and Cultural Representative Office in the United States (TECRO) and the American Institute in Taiwan (AIT) provides for technical cooperation between the Civil Aeronautics Administration (CAA), as TECRO's designated representative, and the University Corporation for Atmospheric Research (UCAR), as AIT's designated representative. CAA and UCAR will cooperate on the development and establishment of operational aviation weather systems.

The Advanced Operational Aviation Weather System (AOAWS) developed by TECRO's designated representative, CAA, requires up-to-date scientific and technical components in order to provide a high level of service to the aviation community on Taiwan. Most of this science and technology has been developed at UCAR over the past two decades and has been validated in operational environments both in the U.S. and in other countries.

The AOAWS consists of advanced meteorological sensor systems (at airports and within the Taiwan airspace), a communications infrastructure, a product generation component, a system server component that distributes products, and product displays that present the advanced weather information to end-users. The AOAWS system components have been integrated to form an operational, turn-key system that serves the aviation community. In 2006, a multiyear AOAWS enhancement and support program began and the enhanced version is now referred to as the AOAWS-ES.

TECRO and its designated representative, CAA, will be provided with the necessary technology required to enhance and support the AOAWS-ES system from AIT's designated representative, UCAR, as defined herein.

2.0 Task Descriptions

2.1 Task #1 - System Implementation, Support and Maintenance Services

System administration and software engineering support and maintenance will be provided for the installed AOAWS-ES system (Version S.x) during 2010. AOAWS-ES components are located at the Taipei Aeronautical Meteorological Center (TAMC), the Songshan Airport (SS) Weather Station and Flight Information Service (FIS), Taoyuan International Airport (TIA) Weather Station and Radar Facility, and FIS, Kaohsiung Airport (KH) Weather Station and FIS, and the Taipei Area Control Center (TACC).

Defects in the AOAWS-ES System software that arise or develop during this period will be addressed and resolved by AIT's designated representative, UCAR. Support and maintenance services cover only software components of the AOAWS-ES. Support and maintenance services for hardware, communication network links, and network components used by the AOAWS-ES are not covered under this Implementing Agreement. However, AIT's designated representative, UCAR, will assist TECRO's designated representative, CAA, in troubleshooting hardware and network problems.

TECRO's designated representative, CAA, is responsible for running the AOAWS-ES system. AIT's designated representative, UCAR, will respond as appropriate to help the CAA ensure that the AOAWS-ES system serviceability level remains consistently high. Technical points of contact for UCAR staff members for support and maintenance services will be provided to the CAA.

In addition to the support and maintenance work referred to above, UCAR will install the AOAWS-ES Version 9.x, which will include the functionality of the AOAWS-ES Version 8.x plus the new capabilities to be developed during 2010.

Specifically, the following sub-tasks will be carried out for the System Implementation, Support and Maintenance task during 2010:

1. Provide general assistance to the CAA in supporting and operating the AOAWS-ES including assisting the CAA with any new hardware installation and network configuration changes. UCAR will be responsible for any operating system upgrades to the AOAWS hosts.
2. Provide assistance to the CAA in troubleshooting problems with the AOAWSES Version 8.x and Version 9.x, if and when they occur.
3. Support and maintain installed AOAWS-ES Version 8.x software.
4. Install, test, and support AOAWS-ES Version 9.x.
5. Correct AOAWS-ES Version 8.x and Version 9.x defects, if any, that may arise.

Resources Required:

Staff¹

System installation, maintenance and client support

Software engineering (20 person-weeks) US\$ 97,760

Task # 1 Total US\$ 97,760

[¹All manpower values are given as person-weeks. Costs reflect UCAR's full loading (for 2010: overhead @0.491, benefits @0.519, the UCAR fee@0.03, and computer service charge of US\$6.82 per UCAR manpower hour) and the fully loaded costs of approved subcontractors.]

2.2 Task #2 - ADAWS Display Systems

Enhancements to the Java-based Multi-dimensional Display System (JMDS) will be developed by AIT's designated representative, UCAR, based on user feedback.

For 2010, the JMDS development team has the following major tasks: (a) support the Java-based Multi-dimensional Display System (JMDS) software system; (b) continue to obtain user feedback on Version 8.x; (c) add new functionality to the JMDS; and (d) deliver Version 9.x.

Table I lists specific features and functions that will be added to the AOAWS display systems during 2010. Additional enhancements to the display systems will be developed, if resources permit after the items in Table I are completed.

Table I: New ADAWS Display Functionality for 2010

| Display System: Feature | Notes |
|--|-------|
| 1. JMDS: Complete development and implement the graphical TAF depiction product that was prototyped in 2009. | |
| 2. JMDS, MDS, WMDS: Ensure all displays function properly with new WRF model grids. | |
| 3. CAA Web Page: Update the TAMC web page. | |

Specifically, the following sub-tasks will be carried out on the JMDS during 2010:

1. Support JMDS Version 8.x and AWOS Display Version 8.x.
2. Respond to user feedback and as appropriate, provide and develop enhancements to address issues raised by the users.
3. Implement display features from Table 1.
4. Update JMDS users manual. Provide a link to this manual from the JMDS.
5. Implement, test, release and deliver JMDS Version 9.x.

Resources Required:

Staff:

Software Engineering (16.6 person-weeks) _____ US\$ 81,208

Task # 2 Total _____ US\$ 81,208

2.3 Task #3 - AOAWS Icing and Turbulence Products

(a) Turbulence. During 2009, the AOAWS WRF model-based turbulence product was tested by AIT's designative representative, UCAR, using the new higher-resolution WRF model grid configuration that was selected during 2009. The new WRF grid configuration will be implemented in early 2010. AIT's designated representative, UCAR, will evaluate the performance of the turbulence product using the new grid spacing based on three to five selected case studies collected during the winter of 2010. This analysis will be used to determine if any fine tuning of the

turbulence product will be required. If required, the turbulence product will be adjusted and this update will be implemented prior to the final AOAWS software release.

(b) In-Flight Icing. During 2009, the AOAWS Forecast Icing Potential (FIP) product was implemented. The FIP product was tested by AIT's designative representative, UCAR, using the new higher-resolution WRF model grid configuration that was selected during 2009. The new WRF grid configuration will be implemented in early 2010. AIT's designated representative, UCAR, will evaluate the performance of the FIP product using the new grid spacing based on case studies collected during the winter of 2010. This analysis will be used to determine if any fine tuning of the FIP product will be required. If required, the FIP product will be adjusted and this update will be implemented prior to the final AOAWS software release.

Specifically, the following sub-tasks will be carried out on the AOAWS Turbulence and Icing Products task during 2010:

1. Evaluate the performance of the AOAWS WRF-based turbulence product operating on the new WRF grids based on selected case studies.
2. Based on this evaluation, tune the turbulence algorithm.
3. Evaluate the performance of the AOAWS FIP product operating on the new WRF grids based on selected case studies.
4. Based on this evaluation, tune the FIP algorithm.
5. Implement the turbulence and icing products prior to the final AOAWS code release.
6. Document changes to the turbulence and icing products in the AOAWS product manuals.

Resources Required:

Staff

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|---------------------------------------|--------------------|
| Software Engineering (4 person-weeks) | US\$ 19,552 |
| <u>Scientists (4 person-weeks)</u> | <u>US\$ 19,552</u> |
| Task # 3 Total | US\$ 39,104 |

2.4 Task #4 - Data and System Testing and Integration

During 2009, a new WRF model configuration was selected and it was tested by AIT's designated representative, UCAR, to ensure that the AOAWS software would handle it properly. In 2010, the new WRF configuration will be implemented along with new AOAWS software that is designed to handle the new WRF data. The Taipei Aeronautical Meteorological Center (TAMC) will move its offices from Songshan to Taoyuan in 2010. UCAR will assist TECRO's designated representative, CAA, to ensure that the AOAWS is working properly at the new site. The CAA is responsible for providing the required data links and network capacity to the AOAWS. Specifically, the Data and System Testing and Integration sub-tasks for 2010 include:

1. Implementing new AOAWS software to properly handle the new WRF grids.

2. Provide assistance to the CAA to ensure that the AOAWS is operating correctly at the new TAMC site in Taoyuan.
3. Refine AOAWS-ES system operator manuals in PDF format suitable for both printing and on-line browsing to reflect system changes and enhancements. Provide a link to the manuals from suitable AOAWS web pages.

Resources Required:

Staff

Software Engineering (6 person weeks) US\$ 29,328

Task # 4 Totals **US\$ 29,328**

2.5 Task #5 - Mesoscale Model Forecast System Enhancements and Upgrades

A major component of the AOAWS is the numerical weather prediction system to support CAA forecasting. The Weather Research and Forecasting (WRF) model and the WRF-Var data assimilation system have been adopted for operational use. Testing, maintenance, and improvement of the WRF system have been important components of the AOAWS-ES phase.

First, the WRF system development work in 2010 will feature assistance in the implementation of a new forecast grid configuration. In 2009 and earlier, the model configuration had three forecast domains of 45-, 15-, and 5-km horizontal spacing covering East Asia and Taiwan. These grids will be replaced by a new configuration in early 2011. Before this change takes place, testing of the new configuration is necessary. The new grids will provide the highest resolution over an area larger than the Taipei Flight Information Region (FIR). The model development team of AIT's designated representative, UCAR, will participate in the testing of the enhanced grid. It will troubleshoot problems in the implementation and finalization of the configuration.

Second, AIT's designated representative, UCAR, will provide assistance to maintain and advance the operational modeling system. This will include collaboration on model performance evaluation, model physics configuration and parameterizations, and real-time operation issues. UCAR will continue to support the WRF modeling system for TECRO's designated representative, CAA, and will maintain the WRF model display. UCAR's support of the WRF model development team will also include collaborating on performance evaluations and troubleshooting model forecast issues as they arise.

Third, AIT's designated representative, UCAR, will assist in the upgrading of WRF and the WRF Variational Data Assimilation System (WRF-Var) to more recent versions of the codes. These codes will be implemented under the direction, and on the schedule, of the rest of the WRF model development team. The work will include coordination with the team on software configuration and on the resolution of any implementation problems.

Fourth, AIT's designated representative, UCAR, will conduct testing and tuning to improve the performance of the WRF-Var system, based on the needs of the WRF model development team. UCAR will assist in the troubleshooting and correction of problems as they arise.

The following sub-tasks will be carried out for the Mesoscale Model Forecast System Enhancements and Upgrades task during 2010:

1. Assist the modeling development team in evaluating and improving WRF precipitation forecasts by testing the convective parameterizations and the microphysics schemes.
2. Provide operational support for the WRF model including troubleshooting and investigation of WRF implementation issues, as well as addressing problems reported by CAA personnel.
3. Assist in the design, testing, and selection of the new WRF grids. Develop and test file transfer scripts for the new domains.
4. Maintain and support the AOAWS WRF model display system.
5. Maintain and support the model verification system.
6. Assist in operation and configuration of the WRF-Var data assimilation system. In collaboration with the model development team, perform troubleshooting and investigation of any significant WRF-Var implementation issues.

Resources Required:

Staff:

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|---------------------------------------|--------------|
| Modeling Scientists (30 person-weeks) | US\$ 143,000 |
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Travel:

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| <u>2 trips @ 1 week each</u> | <u>US\$ 22,000</u> |
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| Task #5 Totals | US\$ 165,000 |
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2.6 Task #6 - Technology Transfer and Training

IA#13 represents the final year of the five-year AOAWS-ES Project, so it is imperative that TECRO's Designated Representative, CAA, system users and operators are capable and comfortable using and supporting the system without AIT's designated representative, UCAR, direct scientific and engineering support. This task focuses on AOAWS system documentation and training activities that will facilitate the transfer of knowledge to the CAA by the end of the performance period.

AIT's designated representative, UCAR, will continue conducting training programs designed to educate TECRO's Designated Representative, CAA technical staff on the operation and maintenance of the AOAWS system. Training topics will cover the following categories:

- data sources and data processing
- network configuration and bandwidth requirements
- user display systems (e.g., WMDS, MDS, JMDS, Model Display)
- system operation and monitoring (including SMD display)
- system algorithms

- system configuration

The training will be conducted both at UCAR in Boulder, Colorado USA, and at CAA facilities on Taiwan. Draft enhanced AOAWS system operation, maintenance, and troubleshooting documentation will also be developed to support the training program. The enhanced system operations documentation will be developed with CAA input and feedback.

Resources Required:

Staff:

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|---------------------------------------|-------------|
| Software Engineering (8 person weeks) | US\$ 39,104 |
| Scientists (2 person-weeks) | US\$ 9,776 |

Travel:

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|------------------------------------|-------------|
| 2 trips for 2 persons@ 1-week each | US\$ 44,000 |
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| Task #6 Total | US\$ 92,880 |

2.7 Task #7 - Project Management, Document Preparation, Training Facilitation

The following sub-tasks will be carried out by the project management team during 2010:

1. Carry out general project management, such as planning, budgeting, technical consultations with team members, and tracking progress.
2. Prepare monthly and quarterly progress reports.
3. Prepare plans for training personnel of TECRO's designated representative, CAA, as applicable, and facilitate the training. Organize training program at AIT's designated representative, UCAR, facility in Boulder, Colorado.
4. Obtain and review user feedback on the AOAWS-ES and respond to routine requests from the CAA.
5. Participate in AOAWS-ES-related meetings.

Resources Required:

Staff:

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|--|-------------|
| General Project Management (13 person-weeks) | US\$ 63,544 |
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Travel:

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|----------------------|-------------|
| 1 trip @ 1-week each | US\$ 11,000 |
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| Task #7 Total | US\$ 74,544 |

3.0 Deliverables

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| AOAWS-ES Quarterly Report #1 | 15 April 2010 |
| AOAWS-ES Quarterly Report #2 | 15 July 2010 |
| AOAWS-ES Quarterly Report #3 | 15 October 2010 |
| AOAWS-ES Quarterly Report #4 | 1 December 2010 |
| Technology Transfer and Training Plan | 15 March 2010 |
| Draft IA#13 Acceptance Plan | 15 July 2010 |
| AOAWS-ES Version 9.x Software Release | 3 December 2010 |

(source code)

| | |
|--|-----------------|
| AOAWS-ES Version 9.x User Manual | 3 December 2010 |
| AOAWS-ES Version 9.x Operator Manual | 3 December 2010 |
| JMDS Version 9.x Release (source code) | 3 December 2010 |
| WMDS Version 9.x Release (source code) | 3 December 2010 |
| Icing and Turbulence Product Tuning Report | 3 December 2010 |
| Year-End Acceptance Meeting | 3 December 2010 |

4.0 Budget Summary

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| Task #1 - System Implementation, Support and Maintenance Services | \$ 97,760 |
| Task #2 - AOAWS Display Systems | \$ 81,208 |
| Task #3 - AOAWS Icing and Turbulence Products | \$ 39,104 |
| Task #4 - Data and System Testing and Integration | \$ 29,328 |
| Task #5 - Mesoscale Model System Enhancements & Upgrades | \$ 165,000 |
| Task #6 - Technology Transfer and Training | \$ 92,880 |
| Task #7 - Project Management | \$ 74,544 |
| <u>Implementing Arrangement #13 Total</u> | <u>US\$ 579,824</u> |