STATEMENT OF WORK ASSOCIATED WITH IMPLEMENTING ARRANGEMENT NUMBER 15 TECHNICAL ENHANCEMENTS 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 aviation weather science and technology has been developed by AIT's designated representative, UCAR, over the past two and a half decades and has been validated in operational environments both in the United States 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 aviation weather information to end users. The AOAWS system components have been integrated to form an operational, turn-key system that serves the aviation community.

TECRO and its designated representative, CAA, will be provided with the necessary technology required to develop and implement enhancements to the AOAWS system, from AIT's designated representative, UCAR, as defined herein.

2.0 Task Descriptions

Task #1: Development of In-Flight Icing Diagnosis Product

The AOAWS includes an in-flight icing prediction product called Forecast Icing Potential (FIP), which was originally developed by AIT's designated representative, UCAR, for the U.S. Federal Aviation Administration (FAA). UCAR has also developed an advanced icing product that generates a diagnosis of current in-flight icing conditions using weather models, surface and upper air observations, radar data, pilot reports, and satellite data. This product is used by pilots (fixed-wing and rotor aircraft) to assess current icing conditions, which supports the tactical decision making process.

The FAA in-flight icing diagnosis product is called the Current Icing Product (CIP) and it combines sensor and numerical model data to provide an hourly, three-dimensional diagnosis of the icing environment. Product output includes calibrated icing *probability* and icing *severity*. Icing severity

encompasses five categories (none, trace, light, moderate, and heavy). Output from the in-flight icing product will be displayed on the Java Multi-Dimensional Display (JMDS) and Web Multi-Dimensional Display (WMDS).

Required tasks and subtasks

AIT's designated representative, UCAR, will develop an in-flight icing diagnosis product based on the CIP product. The development, implementation, and testing activities for this product will occur from 2012 to 2014. In 2012, development, implementation, and testing of the CIP will take place on the UCAR AOAWS test environment. By the end of 2012, a test version of the CIP will be implemented on the operational AOAWS in Taiwan. A test configuration of the JMDS will be provided for evaluation and user feedback of CIP.

Research and development activities associated with this task in 2012 include:

1. Developing and refining the CIP product software to operate using the AOAWS data sources including the Weather Research and Forecasting (WRF) model output, satellite, and surface weather observations.
2. Investigating calibration methodologies and performing the initial calibration process.
3. Evaluating icing case studies to ensure the algorithm is performing appropriately.
4. Preparing CIP development progress reports that will be included in the monthly and quarterly reports.

Estimated Costs[1]

Staff		
Software Engineering (18 person weeks)	US$	93,600
Scientists (11 person-weeks)	US$	57,200
Travel		
1 trip for 1 person@ 1-week	US$	12,000
Task #1 Total	US$	162,800

[[1]All UCAR manpower estimates are given as person-weeks. Costs reflect UCAR's full cost loading. In 2012, the approved rates are as follows: overhead rate is 50.5%, benefit rate is 50.7%, the UCAR fee is 3%, and computer service charge of US$7.18 per UCAR manpower hour is applied.]

Task #2: Development and Implementation of NCAR's Turbulence Detection Algorithm Product

Real-time remote detection of in-cloud turbulence provides a valuable new input to decision support systems such as the AOAWS that help pilots and air traffic controllers assess weather-related aviation hazards, and in particular improve safety and air traffic flow during convective events. The National Center for Atmospheric Research (NCAR) Turbulence Detection Algorithm (NTDA) is an advanced Doppler weather radar based turbulence detection algorithm designed to utilize data from operational Doppler weather radars. The technology, developed at AIT's designated representative, UCAR, under the auspices of the FAA's Aviation Weather Research Program, makes use of the radar-measured reflectivity, radial velocity, and spectrum width data from NEXRAD (S-band) radars. The radar data are quality controlled and processed to produce estimates of eddy dissipation rate (EDR), an

aircraft-independent turbulence metric. The EDR values are then mapped to aviation-relevant turbulence intensity categories (e.g., light, moderate, severe, etc.). The development, implementation, and testing activities for the NTDA product will occur from 2012 to 2014. The resulting NTDA product will eventually be integrated into the AOAWS system and provided to users via the AOAWS display systems.

In 2012, development, implementation, and testing of the NTDA will take place on the UCAR, AOAWS test environment. TECRO's designated representative, CAA, will collaborate with AIT's designated representative, UCAR, to provide technical information about Taiwan weather radars, which are similar to the U.S. NEXRAD radar systems, and begin to evaluate, develop, refine, and test the NTDA algorithm on these datasets. This task also includes performing an initial analysis of product performance to ensure that the product is performing as designed using the test datasets.

Research and development activities associated with this task in 2012 include:

1. Obtaining and evaluating technical information about the Taiwan weather radars such as technical specifications, data formats, data quality, scan strategies, and other operational details.
2. Obtaining sample Taiwan Doppler radar datasets.
3. Developing and refining the turbulence detection algorithm to utilize Doppler weather radar data from selected Taiwan Doppler weather radars.
4. Begin testing the turbulence detection algorithm to ensure it is functioning as designed.
5. Begin establishing AOAWS related connections to the radar data in Taiwan and archiving data for research and development.
6. Evaluating the processing requirements for running the NTDA algorithm within the AOAWS environment.
7. Preparing NTDA development progress reports that will be included in the monthly and quarterly reports.

Estimated Costs

Staff		
	Software Engineering (18 person-weeks)	US$ 93,600
	Scientists (11 person-weeks)	US$ 57,200
Travel		
	1 trip for 1 person@ 1-week	US$ 12,000
Task #2 Total		US$ 162,800

Task #3: Enhancement of Airport Ceiling & Visibility Prediction Product

Data from the most recent WRF modeling system configuration will be analyzed with historical WRF model and METAR data at airports selected by TECRO's designated representative, CAA, to statistically optimize predictions of wind, temperature, ceiling, and visibility for those airports using statistical post-processing techniques. Data mining, random forest, and other appropriate statistical analysis methods and techniques will be investigated. The resulting algorithms will replace the current,

more simplistic statistical techniques, and the new techniques will be integrated into the AOAWS to improve its airport wind, temperature, ceiling, and visibility prediction capability.

Research and development activities associated with this task in 2012 include:

1. Obtaining and processing historical METAR and WRF model data for CAA selected airports.
2. Applying statistical methods and techniques to develop statistical relationships between model and observational data.
3. Verifying the best approaches and developing algorithms for use in the operational AOAWS.
4. Testing the revised ceiling and visibility algorithm in the UCAR test environment.
5. Integrating the revised algorithm code into the AOAWS.
6. Verifying the performance of the ceiling and visibility predictions.

Estimated Costs

Staff		
Software Engineering (8 person-weeks)	US$	41,600
Scientists (6 person-weeks)	US$	31,200
Task #3 Total	US$	72,800

Task #4: Display System Enhancements

Enhancements or refinements to the Java-based Multi-dimensional Display System **(**JMDS), Web-based Multi-dimensional Display System (WMDS), Automated Weather Observing System (AWOS) Display, and/or System Monitor Display (SMD) will be developed and implemented based on user feedback and resources available during 2012.

In 2012, the display system enhancements task includes: (a) beginning software modifications required to incorporate the new CIP and NTDA products; (b) refactoring the JMDS code to make it easier to support and configure; (c) beginning development of the JMDS functionality needed to replace CIDD and its graphics generation for the MDS; (d) providing the annual software release for the new code; and (e) updating user manuals to reflect new capabilities.

As with any large-scale software system there is a diminishment of capability over time without the necessary level of maintenance and code refinements. The AOAWS is no exception. The JMDS and MDS display system code framework will be updated in 2012 and 2013. The foundation of this effort is to refactor the JMDS to use the new Jadite display software framework that was developed and currently in use at AIT's designated representative, UCAR. Jadite is a simplified coding approach to system configuration that allows display users to edit configurations themselves rather than requiring a display code expert. At the end of 2012, the updated JMDS code will be installed on the operational system.

In addition to the Jadite effort, development will begin on the functionality needed to replace CIDD and its graphics generation for the WMDS. This development is required to remove the

dependencies on CIDD graphics processing for WMDS products. At the end of 2012, a test version of this capability will be running in the UCAR lab environment.

Additional minor enhancements to the JMDS and WMDS will be developed during 2012, if resources permit, based on user feedback and prioritization by TECRO's designated representative, CAA. Updates will be made to the JMDS, AWOS Display, WMDS, and SMD manuals to reflect any system and product refinements and additions.

Development activities associated with this task in 2012 include:

1. Re-engineer JMDS to follow the Jadite framework.
2. Begin development of the JMDS functionality needed to replace CIDD when it is used headless to create images for the WMDS web pages.
3. Create and test in the UCAR lab environment new JMDS configurations to replace CIDD on MDS hosts.
4. Modify JMDS and WMDS to display CIP and NTDA products. Perform testing in the UCAR AOAWS lab environment.
5. Add RCMT to the AWOS Display after the installation of new AWOS hardware.
6. Support the operational versions of the JMDS, WMDS, SMD, and AWOS systems.
7. Respond to user feedback and, as appropriate, provide and develop enhancements to address issues raised by the users as resources permit.

Estimated Costs

Staff	
Software Engineering (22 person-weeks)	US$ 114,400
Travel	
1 trip for 1 person @ 1-week	US$ 12,000
Task #4 Total	US$ 126,400

Task #5: AOAWS Data System Upgrades, Testing, and Integration

This task focuses on ensuring that the AOAWS data system infrastructure and processing system are able to incorporate data and product enhancements developed and implemented during the AOAWS program.

Modifications to AOAWS will be performed to accommodate the transition from the World Area Forecast System (WAFS) to the WAFS Internet File System (WIFS). This change requires the acquisition of data from a new source, as well as possible adjustments to AOAWS processing steps in order to handle changes in data formats.

This task also includes the integration and testing of new software in the AOAWS test environment at AIT's designated representatives, UCAR, before it is released into the operational AOAWS on Taiwan as well as performing software updates on the AOAWS on Taiwan. System enhancements may include incorporating data from the WRF modeling system as it is upgraded and/or its configuration changes, and incorporating and testing system refinements and/or new products and data types, such as NTDA and CIP. It also includes enhancements to the system monitoring capability, where applicable. In addition, UCAR will monitor and correct any problems that arise from system upgrades during the project period.

Research and development activities associated with this task in 2012 include:

1. Supporting TECRO's designated representative, CAA, in troubleshooting any problems associated with the AOAWS data system on Taiwan.
2. Transitioning from WAFS to WIFS, making necessary adjustments to AOAWS processing and updating system documentation.
3. Transitioning from JWA format of MTSAT2 data to the JMA format, which includes any AOAWS architecture and system documentation updates.
4. Developing capability to process EUMETSAT satellite data provided by the JWA. This includes any AOAWS architecture changes precipitated by the inclusion of this new data set. System monitoring and documentation will also be updated.
5. Developing code to integrate new data types into the AOAWS including new and enhanced turbulence and icing product datasets and testing the code in the UCAR AOAWS test environment.
6. Providing assistance to the CAA, to ensure that the necessary data links, hardware, and network capacity are identified and available as AOAWS upgrades are implemented at CAA facilities.
7. Refining AOAWS system operator manuals in PDF format suitable for both printing and on-line browsing. Provide a link to the manuals from suitable AOAWS web pages.

Estimated Costs

Staff	
Engineering (41 person-weeks)	US$ 213,200
Travel	
1 trip @ 1-week	US$ 12,000
Task #5 Total	US$ 225,200

Task #6: AOAWS System Implementation, Support, and Maintenance

System administration and software engineering support and maintenance will be provided for the installed AOAWS system and for system upgrades. AOAWS components are located at the Taipei Aeronautical Meteorological Center (TAMC), the SS Weather Station and Flight Information Service (FIS), TIA Weather Station and Radar Facility, and FIS, KH Weather Station and FIS, and the Taipei Area Control Center (TACC). AIT's designated representative, UCAR, will subcontract to an experienced Taiwan local organization to provide on-site support for the AOAWS system components.

Defects in the AOAWS system software that arise or develop during this project period (2012) will be addressed and resolved by AIT's designated representative, UCAR. Support and maintenance services cover only software components of the AOAWS. Support and maintenance services for hardware, communication network links, and network components used by the AOAWS that are operated by local telecommunication companies and/or TECRO's designated representative, CAA, are not covered under this Implementing Arrangement. However, UCAR, will assist the CAA in troubleshooting hardware and network problems.

TECRO's designated representative, CAA, is responsible for running the AOAWS system. AIT's

designated representative, UCAR, will respond as appropriate to help the CAA ensure that the AOAWS system serviceability level remains consistently high. In addition to the support and maintenance work referred to above, UCAR will install the system upgrades (AOAWS Version 11.x), which will include the functionality of the operational AOAWS plus any new capabilities developed and implemented in 2012.

Activities associated with this task in 2012 include:

1. Providing general assistance to TECRO's designated representative, CAA, in supporting and operating the AOAWS including assisting the CAA with any AOAWS related new hardware installation and network configuration changes.
2. Providing assistance to the CAA in troubleshooting problems with various versions of the AOAWS, if and when they occur.
3. Supporting and maintaining the installed operational version of the AOAWS.
4. Installing, testing, and supporting upgraded versions of the AOAWS.
5. Correcting AOAWS defects that arise from the upgrades.

Estimated Costs

Staff

Engineering (25 person-weeks)	US$ 130,000
Task #6 Total	US$ 130,000

Task #7: Conduct Training Program

This task focuses on AOAWS system documentation and training activities that will facilitate the transfer of knowledge to TECRO's designated representative, CAA. AIT's designated representative, UCAR, will continue conducting training programs designed to educate 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, AWOS)
- System operation and monitoring (including SMD display)
- New product development
    - In-Flight Icing Diagnosis Product
    - NCAR Turbulence Detection Algorithm Product
    - Enhanced Airport Ceiling & Visibility Prediction Products
- System configuration

The training will be conducted both at TECRO's designated representative, CAA, facilities on Taiwan, and at AIT's designated representative, UCAR, in Boulder, Colorado, USA. Training materials (e.g., user manuals, PowerPoint presentations, etc.) will also be developed to support the training program. The training materials will be developed by UCAR with CAA input and feedback. A Training Plan will be developed for the training program.

Estimated Costs

Staff		
Software Engineering (8 person-weeks)	US$	41,600
Scientists (3 person-weeks)	US$	15,600
Travel		
1 trip for 2 persons @ 1-week each	US$	24,000
Task #7 Total	US$	81,200

Task #8: Project Management, Administration, and Document Preparation

All technical aspects of the AOAWS-TE project will be managed by AIT's designated representative, UCAR, in cooperation with the project management team from TECRO's designated representative, CAA.

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

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. Obtain and review user feedback on the AOAWS-TE system.
4. Response to routine technical and information requests from CAA.
5. Participate in AOAWS-TE related meetings.

Estimated Costs:

Staff		
General Project Management (15 person-weeks)	US$	78,000
Travel		
1 trip @ 1-week	US$	12,000
Task #8 Total	US$	90,000

3.0 Deliverables

AOAWS-TE Quarterly Report #1	15 April 2012
AOAWS-TE Quarterly Report #2	15 July 2012
AOAWS-TE Quarterly Report #3	15 October 2012
AOAWS-TE Quarterly Report #4	6 December 2012
Draft Training Program Plan	1 April 2012
Draft IA#15 Acceptance Plan	15 July 2012
AOAWS-TE Version 11.x Software Release	6 December 2012
JMDS Version 11.x Release (source code)	6 December 2012
WMDS Version 11.x Release (source code)	6 December 2012
AWOS Display Version 11.x Release (source code)	6 December 2012
Year-End Acceptance Meeting	6 December 2012

4.0 Budget Summary

Task #1 – In-Flight Icing Diagnosis Product	$162,800
Task #2 – Development and Implementation of NCAR's Turbulence Detection Algorithm Product	$162,800
Task #3 – Airport Ceiling & Visibility Prediction Product	$ 72,800
Task #4 – Display System Enhancements	$126,400
Task #5 – Data System Upgrades, Testing, and Integration	$225,200
Task #6 – System Implementation, Support, and Maintenance	$130,000
Task #7 – Conduct Training Program	$ 81,200
Task #8 – Project Management	$ 90,000
Total	**US$ 1,051,200**