

**Statement of Work**  
**Associated with**  
**Implementing Arrangement Number 9**  
**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 decade 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 initial 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 enhance and support the AOAWS-I 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-I system (version 4.3) during FY2006. AOAWS-I components are located at the Taipei Aeronautical Meteorological Center (TAMC), the Sungshan Airport (SS) Weather Station and Flight Information Service (FIS), CKS Airport Weather Station, Radar Facility and FIS, Kaohsiung Airport (KH) Weather Station and International Flight Information Service (FIS), and the Taipei Area Control Center (TACC).

AOAWS-I software components that are covered by this support and maintenance service include the Multi-dimensional Display System (MDS), System Monitor Display (SMD), Web Multi-dimensional Display System (WMDS), and Model Display.

Defects in the AOAWS-I 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-I.

Support and maintenance services for hardware, communication network links, and network components used by the AOAWS-I that are operated by local telecommunications companies and/or the CAA, TECRO's designated representative, are not covered; however, UCAR will assist the CAA in troubleshooting hardware and network problems.

AIT's designated representative, UCAR, will respond as necessary to ensure that the AOAWS system serviceability level remains consistently high. Technical points of contact at UCAR will be provided to the CAA.

In addition to the support and maintenance work referred to above, UCAR will implement and install AOAWS-ES version 5.0, which will include the installed AOAWS-I functionality (version 4.3) in addition to the new components to be delivered during FY2006.

Specifically, the following sub-tasks will be carried out for the System Implementation, Support and Maintenance task during FY2006:

- Provide assistance to the CAA in troubleshooting AOAWS-I problems if and when they occur



- Support and maintain installed AOAWS-I version 4.3 software
- Correcting AOAWS-I version 4.3 defects that may arise (e.g., software bugs)
- Installing AOAWS-ES version 5.0

Resources Required:

<sup>1</sup>Staff:

System installation, maintenance and client support

(42 person-weeks) (III) US\$ 107,000

Software engineering (5 person-weeks) US\$ 25,270

Travel

1 trip @ 1-week each US\$ 9,500

**Task # 1 Total US\$ 141,770**

**2.2 Task #2 – JMDS – Advanced Java-based Multi-dimensional Display System.**

FY2006 will include initial development of the AOAWS-ES JADE Multidimensional Display System (JMDS). This will be referred to as JMDS version 5.0, corresponding to AOAWS-ES version 5.0.

The JADE display software will be implemented in Java and will be based on JADE, a software framework component developed at UCAR. JMDS will be an interactive map-based display, similar to CIDD on the MDS, allowing the user to zoom, animate, inspect data values, select the time of displayed data, and choose different static and dynamic data overlays. The display software will access AOAWS data via existing AOAWS-I data-serving technology, which will be upgraded to handle new data sets as they become available.

For FY2006, the JMDS functionality will include the features and functions of the main display (CIDD version 4.3) on the latest version of the MDS. The list of products for JMDS version 5.0 is presented in Table 1 below.

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<sup>1</sup> All manpower values are given as person-weeks. Costs reflect UCAR's full loading (for FY2006: overhead @ 0.506, benefits @ 0.488, the UCAR fee @ 0.03, and computer service charge of \$5.78 per hour per user) or the costs of approved subcontractors.

Table 1: JMDS version 5.0 products

<b>Product Name</b>	<b>Product type</b>	<b>Comments</b>
METAR	Symbolic	Station plot – location, text
Lightning strikes	Symbolic	Location (if data available)
AIREPs	Symbolic	Location, text
SIGMETs	Symbolic	Polygons, text
CWB Radar Mosaic	Gridded	2D and 3D, Domain4
Cloud Top Height	Gridded	2D, Domain1, Domain2, Domain3
Satellite: Visible, IR, Water Vapor	Gridded	2D, Wide View, Domain1, Domain2, Domain3
MM5: Wind Speed, Humidity	Gridded	3D, Domain1, Domain2, Domain3, Domain4
MM5, Temperature	Gridded	3D, line contours, Domain1, Domain2, Domain3, Domain4
MM5: Freezing Level	Gridded	2D, line contours, Domain1, Domain2, Domain3, Domain4
Turbulence Probability	Gridded	3D, Domain3, Domain4
Turbulence Probability - All Levels	Gridded	2D, all levels
Icing Severity	Gridded	3D, Domain3, Domain4
Icing Severity – All Levels	Gridded	2D, all levels
Flight Category	Gridded	2D, Domain4
Lightning Rate	Gridded	2D, if data available



The WRF model output data will be new to the AOAWS-ES in FY2007. Displaying WRF output will therefore become a requirement for the JMDS at that time. During FY2006 the JADE team will assess and design the data ingest system for WRF data. The WRF data ingest application software will be developed in FY2007.

In addition to the products listed in Table 1, work will also begin on the development and testing of the various non-CIDD windows in the MDS, for example the METAR and TAF text windows. During FY2006 this work will be for evaluation and testing purposes only. The operational version will be delivered in FY2007.

Work will begin on the development and testing of the 'Incident Reconstruction Mode' (IRM) for JADE. This mode will allow JADE to display only the data which was already stored in the system at a certain time and date, and will ignore all data stored after that time. During FY2006 this work will be for evaluation and testing purposes only. The operational version will be delivered in FY2007.

Specifically, the following sub-tasks will be carried out on the JMDS task during FY2006:

- Develop and test JMDS version 5.0, including the products list in Table 1
- Begin work on the JMDS functionality of the non-CIDD windows on the MDS
- Begin work on the Incident Reconstruction Mode for the JMDS
- Deliver JMDS version 5.0

Resources Required:

Staff:

Software Engineering (50 person-weeks)	US\$ 225,434
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Travel:

2 trips @ 1-week	US\$ 19,000
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<b>Task # 2 Total</b>	<b>US\$ 244,434</b>
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### **2.3 Task #3 – Thunderstorm Identification, Tracking and Nowcasting (TITAN) System Development and Implementation**

The development and implementation of the AOAWS-ES TITAN system will begin in FY2006. TITAN will be customized to ingest the 3-D radar mosaic from the CWB which is already available on the AOAWS. TITAN will identify storms in this mosaic and



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produce short term extrapolation forecasts. The forecast products will be displayed on the MDS.

Specifically, the following sub-tasks will be carried out on the TITAN task during FY2006:

- Upgrade and configure TITAN software to ingest CWB 3-D radar mosaic data
- Configure TITAN for storm tracking in the Taiwan region
- Add components to the AOAWS-ES to distribute TITAN forecasts to the MDS
- Configure the MDS to display TITAN forecasts
- Install TITAN components as part of AOAWS-ES version 5.0

Resources Required:

Staff:

Software Engineering (9 person-weeks)	US\$ 50,207
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Travel:

1 trip @ 1-week	US\$ 9,500
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<b>Task # 3 Total</b>	<b>US\$ 59,707</b>
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## **2.4 Task #4 – Data and System Integration**

The CAA purchased a WAFS data ingest system, which is separate from the AOAWS. During the course of the project, there is a requirement for the AOAWS-ES to interact with the WAFS system in the following ways: (a) pass the international weather service products, such as the forecast winds and temperature forecasts, from the WAFS system to the AOAWS-ES for display; (b) pass mesoscale model data (from MM5/WRF) from the AOAWS-ES to WAFS, so that the data are available to forecasters preparing forecast products; and, (c) make the forecast products produced on the WAFS system available to the AOAWS-ES users via a web page link.

For FY2006, the WAFS task will concentrate on developing an understanding of the WAFS system, which is running at the TAMC, assessing the available mechanisms for transferring data to and from the WAFS system, and designing the applications for passing data between the WAFS system and AOAWS-ES. In addition, the UCAR team shall evaluate the feasibility of upgrading the MDS and WMDS system to comply with ICAO Annex-3 regulations and automatic pre-flight information requirements.



Specifically, the data and system integration sub-tasks for FY2006 are:

- Evaluate and assess the technical capabilities of the WAFS system running at TAMC
- Design the WAFS data ingest components for data communication between the WAFS system and the AOAWS-ES
- Evaluate the feasibility of upgrading MDS and WMDS to comply with ICAO Annex-3 regulations and automatic pre-flight information requirement.

Resources Required:

Staff:

Software Engineering (8 person-weeks)	US\$ 31,114
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Travel:

1 trip @ 1-week	US\$ 9,500
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<b>Task # 4 Total</b>	<b>US\$ 40,614</b>
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**2.5 Task #5 – Mesoscale Model Forecast System Enhancement and Upgrade (MM5/WRF)**

During FY2006, the modeling team will support the AOAWS-MM5 on the CWB VPP5000, port the modeling system to CWB's new supercomputer, conduct parallel tests with the operational and new system, then switch the operation system to the new supercomputer, ensuring AOAWS end-users have uninterrupted access to high-quality forecasts. The highest priority for the modeling team will be to maintain operational forecasts first on the VPP5000 and then on the new CWB supercomputer.

In early 2006, before the new CWB supercomputer is available, the modeling team will begin tailoring the MM5 system for the new CWB computer using a local UCAR computer. Once access to the new supercomputer is granted and the CWB Global Model and observations are available, the new MM5 system will be ported to the new CWB computer. The MM5 system is complex, with many components include observation ingest, first guess and boundary condition ingest (from CWBGM), 3DVAR, the MM5 model, post-processing and distribution of output, archiving of results, and system monitoring. The MM5 system will be integrated into the CWB operational schedule. The time constraints of the operational schedule may require adjustments to the AOAWS, such as reducing the number of forecasts per day from 8 to 4. Once the modeling system is stable, parallel output will be made available on the web for the CAA to examine. Once the forecasts are acceptable, the system on the VPP5000 will be turned off, and the new system deemed operational. The new CWB computer system is planned to be operational by September 30, 2006.



Because CWB has not yet selected the new supercomputer, it is not known how difficult it will be to port the system. Because the AOAWS MM5 system is complex, with many programs and scripts developed over a period of several years, it may take most, if not all the resources allocated for this task (Task #5) during FY2006 just to accomplish the porting task. However, if resources permit, the other sub-tasks will be accomplished.

After the software porting task is complete and if resources permit, development of a real-time model verification system for AOAWS could begin this year. The verification system will be designed to work with both the MM5 and the WRF model and be able to objectively assess model changes or improvements. While the work in FY2006 would only begin such development, ultimately the capability will provide error statistics (based on comparisons with observations) for recent model runs. It will also provide the users with information on the recent performance of the model (e.g., biases, RMSEs – error statistics) and will allow longer-term statistics to be compiled and reviewed.

In consultation with CWB, design of a future WRF modeling system will begin. The continuation of this work in the following year will include the testing of WRF on the CWB high-performance computer to determine the optimal nesting, resolution, physics and initialization that can be accomplished in the operation environment.

This task also includes general support and maintenance of the AOAWS MM5 system and will include upgrading the components of the MM5 system if necessary. AIT's designated representative, UCAR, will ensure proper operation of the modeling system and will respond as necessary to ensure that the modeling system serviceability level remains consistently high.

The specific MM5 model system support sub-tasks are as follows.

- Maintain MM5 model on the CWB VPP5000, including identifying and repairing any problems reported by CAA personnel
- From January through March 2006, design and test an MM5 system on UCAR computers that will be ported to the new CWB computer
- Between April and September 2006, build the MM5 system on the new supercomputer, conducting parallel tests with the operational AOAWS
- By October 2006, make the new system operational and shut down the AOAWS MM5 on the VPP5000
- Begin design of the AOAWS WRF
- Begin development of a real-time model verification system

#### Resources Required:

Staff:



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Software Engineering (.65 FTE, 34 person weeks)	US\$ 110,727
Modeling Scientists (1.2 FTE, 62 person-weeks)	US\$ 203,173
Travel:	
2 trips @ 1-week	US\$ 19,000
<b>Task #5 Total</b>	<b>US\$ 332,900</b>

## 2.6 Task #6 – Server and Display Hardware Upgrade

A list of the computer hardware to be upgraded during FY2006.

Table 2: Hardware to be upgraded in FY2006

Machine type	Count
Servers	6
Display hosts	3
Racks	1
Serial-to-TCP conversion box	2
Tape drive (or possibly multi-sided DVD writers)	1

The hardware will be purchased by the CAA based on specifications provided by UCAR during the first part FY2006. The CAA will be responsible for purchasing the hardware items and having them delivered to the TAMC or CWB, as appropriate. UCAR will be responsible for the new hardware installation, operating system installation and network configuration.

Specifically, the following sub-tasks will be carried out for the hardware upgrade task during FY2006:

- Install server and display hardware
- Install LINUX operating system on server and display hardware
- Configure network for new hardware

### Resources Required:



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Staff:

Hardware installation (10 person weeks) US\$ 25,000

**Task #6 Total US\$ 25,000**

## **2.7 Task #7 – Project Management, Document Preparation, Training Facilitation**

As part of the project management task, three sub-tasks will be performed early in the contract period: (a) assessment of the functional requirements for the AOAWS-ES, (b) preparation of the hardware specification document, and (c) AOAWS User meeting preparation and participation. The hardware specification document will provide detailed specifications on the computers and other hardware to be purchased during FY2006.

Specifically, the following sub-tasks will be carried out by the project management team during FY2006:

- Carry out general project management, such as planning, budgeting and tracking progress
- Prepare for and participate in an AOAWS Users Meeting
- Assess the functional requirements for the AOAWS-ES
- Prepare Hardware Specifications Document for the hardware upgrade task
- Prepare quarterly progress reports
- Prepare plans for training CAA personnel and facilitate the training
- Respond to routine requests from the CAA
- Administer project sub-contracts.
- Participate in AOAWS-ES-related meetings.

Some of these tasks will be carried out by UCAR's sub-contractor, The Institute for Information Industry (III) on behalf of UCAR,.

### Resources Required:

General Project Management (18 person-weeks): US\$ 82,575

Taiwan Project Management (9 person weeks) (III) US\$ 28,000

Travel:

2 trips @ 1-week each US\$ 19,000

**Task #7 Total US\$ 129,575**



### 3.0 Deliverables

AOAWS-ES Enhancement and Support Report #1	15 April 2006
AOAWS-ES Enhancement and Support Report #2	15 July 2006
AOAWS-ES Enhancement and Support Report #3	15 October 2006
AOAWS-ES Enhancement and Support Report #4	01 December 2006
AOAWS Users Meeting	April 2006
AOAWS-ES Hardware Specification Document	28 February 2006
Year-End Acceptance Plan	15 July 2006
MM5 ported to CWB's new supercomputer	15 October 2006 <sup>2</sup>
AOAWS-ES version 5 software release (source code)	01 December 2006
JMDS version 5 release (source code)	01 December 2006
TITAN version 5 release (source code)	01 December 2006
MM5 release (source code)	01 December 2006
Summary of initial development of AOAWS WRF and verification systems	01 December 2006
Year-End Acceptance Meeting	01 December 2006

### 4.0 Budget Summary

Task #1 System Support and Maintenance Services	\$ 141,770
Task #2 JMDS	\$ 244,434
Task #3 TITAN	\$ 59,707
Task #4 Data and System Integration	\$ 40,614
Task #5 MM5/WRF	\$ 332,900
Task #6 Replacement hardware installation	\$ 25,000
Task #7 Project Management, Document Preparation, Training Facilitation, etc.	\$ 129,575
<b>Implementing Arrangement Number 9 Contract Total</b>	<b>US\$ 974,000</b>

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<sup>2</sup> The schedule and completion date for the MM5 system porting to CWB's new supercomputer will depend on the accessibility of the CWB's new supercomputer.