12 September 2006

Statement of Work

Associated with Implementing Arrangement Number 10

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 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-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 5) during 2007. AOAWS-ES components are located at the Taipei Aeronautical Meteorological Center (TAMC), the Sungshan Airport (SS) Weather Station and Flight Information Service (FIS), Taiwan Taoyuan International Airport(TIA) Weather Station, Radar Facility and FIS, Kaohsiung Airport (KH) Weather Station and International Flight Information Service (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. The Institute for Information Industry (III) will support UCAR with this work. 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 that are operated by local telecommunications companies and/or the CAA, TECRO's designated representative, are not covered under this Implementing Agreement. However AIT's designated representative, UCAR, will assist the 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 at UCAR 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 6.0, which will include the functionality of the AOAWS-ES Version 5 plus the new components to be developed during 2007.

Specifically, the following sub-tasks will be carried out for the System Implementation, Support and Maintenance task during 2007:

- Provide assistance to the CAA in troubleshooting problems with the AOAWS-ES Version 5 if and when they occur.
- Support and maintain installed AOAWS-ES Version 5 software.
- Install AOAWS-ES Version 6.0.
- Correct AOAWS-ES Version 5 and Version 6 defects that may arise (e.g., software bugs).

Resources Required:

[1]Staff:

System installation, maintenance and client support (42 person-weeks) (III)	US$ 107,000
Software engineering (4 person-weeks)	US$ 21,000
Travel:	
1 trip @ 1-week	US$ 10,000
Task # 1 Total	**US$ 138,000**

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

During 2006, the prototype of the JMDS was introduced to the AOAWS-ES as Version 5.0. This version is intended for demonstration and testing at the TAMC.

For 2007, the JMDS team has the following tasks: (a) to support the prototype JMDS in test mode at the TAMC; (b) obtain user feedback on Version 5; (c) add new functionality to the JMDS; and (d) deliver Version 6.

The products supported by the JMDS Version 5.0 are listed in Table 1 of the IA#9 Statement of Work. For 2007, extra functionality which appears on the MDS in the non-CIDD windows will be added. These windows show the text for METARs, TAFs, AIREPs, SIGMETs and AIRMETs, as well as a time history for a chosen METAR station and a SkewT diagram for a selected point.

In the JMDS, some of these features will be implemented as a 'mouse-over' capability rather than in a separate pop-up window. For example, if a METAR exists for a point and the user puts the mouse over that point, the METAR text will appear at the cursor location in the main JMDS window. When the mouse is moved away, the text will be removed. If a METAR and TAF both exist for that point, the text for both the METAR and TAF will be displayed.

The 'Incident Reconstruction Mode' (IRM) for JADE will be completed and testing of this feature will be carried out. This mode will allow JADE to display only data which

[1] All manpower values are given as person-weeks. Costs reflect UCAR's full loading (for 2007: overhead @ 0.517, benefits @ 0.51, the UCAR fee @ 0.03, and computer service charge of $5.95 per hour per UCAR manpower hour) and the fully loaded costs of approved subcontractors.

was already stored in the system at a certain time and date, and will ignore all data stored after that time.

Table 1 lists the features which are to be added to the JMDS during 2007.

Table 1: New functionality for the JMDS in 2007

Feature	Note
DECODED METARS	Pop-up window which shows a table of METARs closest to a mouse click location
RAW METARS	Mouse-over annotation – shows METAR text for cursor location
TAFS	Mouse-over annotation – shows TAF text for cursor location
AIREPS	Mouse-over annotation – shows AIREP text for cursor location
SIGMETS	Mouse-over annotation – shows SIGMET/AIRMET text for cursor location
WINDS/TEMPERATURES ALOFT	Pop-up window which shows a table of winds/temperatures aloft for a mouse click location
METAR TIME HISTORY	Pop-up window which shows the time history for a METAR station closest to a mouse click location
Main window and vertical section window: label route with way-point information.	The way-points will be labeled with names obtained from a static way-point file.
'Smart' fields: other products and/or overlays are turned on/off depending on the main field selected.	Examples: (a) if the user selects the 'wind speed' field, the wind barbs will also be displayed; (b) if the user selects a radar field, the TITAN storm tracks will also be displayed
'Forward' zoom button.	Zoom button to allow users to return to their original zoom after using the 'Back' zoom button
Time-height profile of model data.	Pop-up window. User clicks on a location and obtains a time-height profile of the selected model data field at that location.

Skew-T sounding from model data	Pop-up window. User clicks on a location and obtains a Skew-T plot for the sounding from the model at that location.
TITAN storm tracks	Configure as necessary to show all available TITAN storm tracks (CWB mosaic and TIA radar).
Time-series of gridded data. (The user will be able to select a location and obtain a time series for the selected data field at that location.)	Work will begin on this product in 2007 and will be completed in 2008.

Specifically, the following sub-tasks will be carried out on the JMDS task during 2007:

- Support JMDS Version 5 in demonstration and test mode at the TAMC.
- Respond to user feedback and as appropriate provide enhancements to address issues raised by the users.
- Add in features from Table 1.
- Create users manual in PDF format, suitable for both printing and on-line browsing. Provide a link to this manual from the WMDS.
- Complete and test the Incident Reconstruction Mode (IRM).
- Implement, test, release and deliver JMDS Version 6.0

Resources Required:

Staff:

Software engineering (46 person-weeks)	US$ 239,000
Travel:	
2 trips @ 1-week	US$ 20,000
Task # 2 Total	**US$ 259,000**

2.3 Task #3 – Thunderstorm Identification, Tracking and Nowcasting (TITAN) System Development and Implementation

During 2006, TITAN was configured and installed to run on the 3-D radar mosaic data provided by CWB. This is 1-km gridded data which arrives every 15 minutes. The mosaic data is suitable for tracking medium- and large-scale storm systems across Taiwan.

In addition, during 2006, the AOAWS-ES data subsystem was enhanced to obtain raw radar data files from the TIA radar, store it on data1 and data2 and distribute the data to the CWB using the caasv1 and caasv2 servers. This data is merged into the CWB 3-D radar mosaic.

The TITAN installation will be enhanced to use the data from the TIA radar because this data has a higher spatial resolution than the 3-D mosaic. For this reason TITAN may produce useful storm track information from the TIA radar in addition to that available from the 3-D mosaic.

Specifically, the following sub-tasks will be carried out on the TITAN task during 2007:

- Maintain TITAN running on the CWB 3-D radar mosaic.
- Develop software to ingest the raw radar data from the TIA radar and convert into MDV format.
- Set up and configure TITAN to process the TIA radar data files.
- Configure the MDS and JMDS to display the radar echo tracks from the TIA radar.

Resources Required:

Staff:

Software engineering (6 person-weeks)	US$ 30,000
Task # 3 Total	**US$ 30,000**

2.4 Task #4 – Data and System Integration

The most significant data system tasks in 2007 will involve the change from running the MM5 model to running the WRF model at CWB. The model output files at CWB are ingested by servers at CWB and then copied over to the CAA via the T3 network connection.

The model output format will need to be decided at some point by the CWB and CAA. UCAR recommends that the output be in NetCDF format because this preserves the precision of the output data which is important for the turbulence algorithm. (Since GRIB has internal compression, precision is lost in the conversion to GRIB.) UCAR will provide assessment on the data volume and the communication bandwidth.

A new data ingest application will be written to convert the WRF model output to MDV.

A side effect of the change to WRF is that the turbulence and icing products, which are computed from the model output data, will need to be updated accordingly. There are two issues of concern for these algorithms: (a) the vertical resolution and coordinate system of the output data and (b) the horizontal resolution of the output data in the various model domains. For the purpose of optimizing the turbulence algorithm, UCAR recommends

that the vertical levels in the output data should be the native SIGMA levels used in the model. In terms of which domains should be used for the icing and turbulence products, UCAR will investigate how the resolution of the output data affects these products. UCAR is confident that the algorithms will work well on any grid with a spacing of 20 km or less. Initially the CWB will run the WRF model on 3 domains: (1) 45 km, (2) 15 km and (3) 5 km. Therefore, the WRF icing and turbulence product will initially be configured to run on domains 2 and 3. The CWB may later change to domains with finer grid resolutions: (1) 27 km, (2) 9 km and (3) 3 km. At that time, UCAR will evaluate the icing and turbulence products on the 27 km domain and if the results appear to be reasonable UCAR will then consider whether to recommend expanding the icing and turbulence products to include the 27 km domain.

Because of the change to WRF, work will also be required to provide system level support for the WRF version of the model display. Other changes will be made to the system to support the change in spatial domains from MM5 to WRF.

The WAFS-based gridded data product will be completed and tested. This global product will be displayed on the MDS and JMDS. The product will include the following fields in the WAFS GRIB data:

- winds
- temperature
- relative humidity

Also during 2007, work will begin on ingesting some of the WAFS non-gridded products available in BUFR format. The BUFR-derived products will be displayed on the MDS and JMDS. (This work will be completed in 2008.)

The JWA is now providing data in a new HRIT format. The JWA will continue to supply data in the older HIRID format for a period, but eventually this will be terminated. Software will be developed to ingest the satellite data in HRIT format and convert it to MDV format.

Specifically, the data and system integration sub-tasks for 2007 are:

- Update data distribution at CWB to handle WRF data files.
- Implement application to ingest WRF model data files and convert to MDV.
- Modify the turbulence and icing algorithms to work on WRF output data.
- Modify the system to handle the different model domains between MM5 and WRF.
- Modify the system for handling the model display content generation.
- Modify the WMDS web pages as necessary to handle any model display changes.

- Complete and test the WAFS-based product using GRIB data for global winds, temperature and relative humidity.
- Develop software to ingest the HRIT satellite data and convert to MDV.
- Start work on WAFS data ingest for BUFR data.

Resources Required:

Staff:	
Software engineering (30 person-weeks)	US$ 150,000
Travel:	
2 trip @ 1-week	US$ 20,000
Task # 4 Total	**US$ 170,000**

2.5 Task #5 – Mesoscale Model Forecast System Enhancement and Upgrade (MM5/WRF)

During 2007, the AOAWS-ES modeling team will continue to support the AOAWS-MM5 system on the CWB IBM supercomputer until the replacement model, WRF, is implemented. This will entail ensuring the operation of all scripts, executables, and capabilities in light of any system changes to the platform. The data ingest, product output, and forecast storage functions will also be maintained.

The second major modeling task for 2007 is to develop, test, and implement the WRF modeling system into the AOAWS-ES on the CWB HPC. This work will involve preliminary development and testing at UCAR. A version of the grid and model configuration expected to be implemented at CWB will be used for system testing on UCAR hardware. The WRF implementation will include coordination with CWB on the model development, configuration, and installation on the CWB computer. It will also entail coordination with CWB on the schedule for initial installation, test runs, and final operation. UCAR will maintain the current model display functionality for the WRF system output. The work will further include the set-up and implementation of the WRF-Var data assimilation system on the HPC. This will require testing of code compilation, basic operation, and, as necessary, troubleshooting.

The third major 2007 task is the implementation of the WRF-Var package into the WRF modeling system. The latest version of WRF-Var will be installed on the CWB computer. In addition, the basic development of the WRF-Var capability at UCAR will continue, and as significant upgrades or bugfixes to the code are available, these will be implemented. The inclusion of new data sources into WRF-Var will also be addressed, with the primary new data source for 2007 being COSMIC GPS soundings.

The final 2007 modeling task is to complete the WRF verification system. This system will provide users with a web-based capability to access statistical model verification scores and thus provide an indication of WRF performance. The variables to be verified will include temperature, wind, and height. The verification method will involve an automated comparison of the model forecasts with the available observations. The development of the verification package will be coordinated with CWB, and the system will undergo testing at UCAR. When ready, the system will be implemented on the CWB computer for use with the WRF.

Specifically, the following sub-tasks will be carried out for the Mesoscale Model Forecast System Enhancement and Upgrade task during 2007:

- Support and maintain the MM5 on the CWB IBM HPC, including correcting any problems reported by CAA personnel until the WRF system is implemented.
- Develop and test WRF modeling system for the AOAWS-ES.
- Coordinate with CWB on WRF configuration and on installation and operation schedule.
- Test and implement WRF system on CWB IBM HPC.
- Maintain current model display functionality for WRF system output.
- Implement WRF-Var in WRF and install latest version.
- Continue WRF-Var development and incorporate new data source.
- Complete real-time WRF verification system.

Resources Required:

Staff:	
Software engineering (12 person weeks)	US$ 39,000
Modeling Scientists (77 person-weeks)	US$ 248,000
Travel:	
2 trips @ 1 week each	US$ 20,000
Task #5 Total	**US$ 307,000**

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

The hardware upgrade was begun in 2006 and will continue during 2007.

The hardware will be purchased by the CAA based on specifications provided by UCAR early in 2007. 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. The Institute for Information Industry (III) will support UCAR with this work.

Specifically, the following sub-tasks will be carried out for the hardware replacement and upgrade task during 2007:

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

Resources Required:

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

The following sub-tasks will be carried out by the project management team during 2007:

- Carry out general project management, such as planning, budgeting and tracking progress.
- Prepare the Hardware Specifications Document for the hardware replacement and upgrade task.
- Prepare quarterly progress reports.
- Prepare plans for training CAA personnel, as applicable, and facilitate the training.
- Obtain user feedback on the AOAWS-ES Version 5.
- Respond to routine requests from the CAA.
- Administer project sub-contracts.
- Participate in AOAWS-ES-related meetings.
- Prepare AOAWS-ES System Operators Manual in PDF format, suitable for both printing and on-line browsing. Provide a link to this manual from a suitable internal web page.

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 (16 person-weeks):	US$ 62,000
Taiwan Project Management (9 person weeks) (III)	US$ 28,000
Travel:	
2 trips @ 1-week each	US$ 20,000
Task #7 Total	**US$ 110,000**

3.0 Deliverables

AOAWS-ES Quarterly Report #1	15 April 2007
AOAWS-ES Quarterly Report #2	15 July 2007
AOAWS-ES Quarterly Report #3	15 October 2007
AOAWS-ES Quarterly Report #4	01 December 2007
AOAWS-ES Hardware Specification Document	28 February 2007
Draft IA#10 Acceptance Plan	15 July 2007
AOAWS-ES Version 6 software release (source code)	01 December 2007
AOAWS-ES Version 6 Operators manual	01 December 2007
JMDS Version 6 release (source code)	01 December 2007
JMDS Version 6 Users manual	01 December 2007
TITAN Version 6 release (source code)	01 December 2007
WRF release (source code)	01 December 2007
Summary of initial development of AOAWS-ES WRF and verification systems	01 December 2007
Year-End Acceptance Meeting	01 December 2007

4.0 Budget Summary

Task #1 System support and maintenance services	$ 138,000
Task #2 JMDS	$ 259,000
Task #3 TITAN	$ 30,000
Task #4 Data and System Integration	$ 170,000
Task #5 MM5/WRF	$ 307,000
Task #6 Replacement hardware installations	$ 25,000
Task #7 Project management, document preparation, training facilitation, etc.	$ 110,000
Implementing Arrangement Number 10 Contract Total	**US$ 1,039,000**