Statement of Work "B" for Implementing Arrangement #10 Consultancy Service for the Operational Implementation of Taiwan AutoNowcaster System for CWB to the AGREEMENT between the Taipei Economic and Cultural Representative Office in the United States and the American Institute in Taiwan

Work Plan for Developing a Taiwan AutoNowcast (TANC) System

I. Task Descriptions

Task #1: *AIT's designated representative, UCAR, will install a revised and enhanced version of Taiwan AutoNowcaster (TANC) System with Predictors_version2 and a Taiwan township precipitation nowcast product to TECRO's designated representative, CWB, and provide general system support to CWB engineers during the operational demonstration*

The TANC system with the Predictors_version1 was delivered to TECRO's Designated Representative, CWB, in 2012 for weak synoptic-forced situations and based partially on model fields (CAPE, CIN, layer averaged humidity). With this Predictors_version1, the weights and membership functions are the same for all of Taiwan. Based on the evaluation of Predictors_version1, the Predictors_version2 was developed by modifying the storm advection scheme at the storm initiation stage and tuning the weight of CAPE and CIN produced by WRF. In collaboration with CWB, AIT's designated representative, UCAR, will train three CWB staff to become experts in the use of the TANC software. UCAR will work with the TANC experts to revise the Predictors_version2. The revised Predictors_version2 of the TANC System code will be provided to CWB before the 2013 summer convection season for real-time operation and evaluation. Also, collaborating with the CWB experts, a Taiwan township precipitation nowcasting product will be developed.

1.1 Working collaboratively with the CWB TANC experts UCAR will evaluate the performance of the Taiwan nowcast system for prediction of thunderstorms using the Predictors_version2. Results from this evaluation will be used to revise and improve performance of the 30 and 60 minute nowcasts.

1.2 Develop a Taiwan township precipitation nowcast product. The product acronym will be determined jointly by CWB and UCAR.

1.3 UCAR will coordinate with CWB TANC experts to update and document TANC Predictors_version2 output fields for CWB.

1.4 CWB software engineers and TANC experts will continue to familiarize themselves with TANC code and collaborate with UCAR engineers to modify the TANC system as needed. UCAR will provide general system support to CWB throughout the year.

The following summarizes the schedule and deliverables for Task #1:

Task:	Performance Period:
1. Task 1.1a Collaborate with CWB TANC experts to evaluate 30 and 60 min nowcasts based on Predictors_version2	01/01/2013 – 10/31/2013
2. Task 1.1b Collaborate with CWB TANC experts to	01/01/2013 – 06/30/2013

update TANC using Predictors_version2	
3. Task 1.2 Collaborate with CWB TANC experts to develop a Taiwan township precipitation nowcast product	01/01/2013 – 06/30/2013
4. Task 1.3 Collaborate with CWB TANC experts to update the list of TANC Predictor_version2 output fields for CWB	01/01/2013 – 06/30/2013
5. Task 1.4 Provide TANC system support	01/01/2013 – 12/31/2013
Deliverables:	
1. Task 1.1a Collaboratively with CWB TANC experts, report on the performance on 30 and 60 minutes nowcasts using Predictor_version2	10/31/2013
2. Task 1.1b Collaboratively with CWB TANC experts, deliver an updated version of TANC code with Predictors_version2 to CWB	06/30/2013
3. Task 1.2 Install the Taiwan township precipitation nowcast product at CWB	07/31/2013
4. Task 1.3 Collaboratively with CWB TANC experts, update documentation of all TANC Predictor_version2 output fields to CWB	06/30/2013
5. Task 1.4 Provide TANC system support	01/01/2013-12/31/2013

Task #2: Develop a New Version of VDRAS to Include Terrain (Phase 2)

AIT's designated representative, UCAR, began the development of a new version of VDRAS including terrain (Phase 1) in 2012. A newer approach for dealing with terrain effect in fluid dynamics, the Immersed Boundary Method (IBM, Tseng and Ferziger 2003) was implemented, debugged and tested. Adding terrain into VDRAS requires a multi-year effort. The development FORTRAN codes for the "forecast model" were completed in 2012 and the "adjoint model" in VDRAS (Phase 2) that is the key component of the 4D-Var-based VDRAS will be the focus of 2013. Considerable effort will be required to check the code of the "adjoint model" to make sure it is error free and the 4D-Var minimization converges properly.

In order to run VDRAS at a 1 km grid resolution to capture Taiwan's complex terrain, VDRAS will be upgraded to MPI version. This MPI version of VDRAS will require a 64-processor workstation (provided by CWB) to be operational in real time. Specific tasks include:

    2.1 Develop the "adjoint model" in VDRAS including terrain and upgrade VDRAS with terrain to MPI version.
    2.2 Perform "adjoint model" gradient check to ensure the minimization converges properly.
    2.3 Test MPI version of VDRAS with the terrain effect using real data from Taiwan.
    2.4 Deliver the MPI version of VDRAS with the terrain effect to CWB.

The following summarizes the schedule and deliverables for Task #2:

Performance Period:		
1. Task 2.1 Develop VDRAS adjoint model and merge Fortran code that include the terrain effect in the MPI version of VDRAS forecast model		01/01/2013 – 06/30/2013
2. Task 2.2 Perform "adjoint model" gradient check		07/01/2013 – 09/30/2013
3. Task 2.3 Test MPI version of VDRAS with the terrain effect using real data from Taiwan		10/01/2013 – 12/31/2013

Deliverables:	
1. Tasks 2.1 and 2.2 Report on the test results of "adjoint model" development and its gradient check	09/30/2013
2. Task 2.3 Report on the impact of the terrain effect in VDRAS analysis using real data on Taiwan	11/30/2013
3. Task 2.4 Deliver the update MPI VDRAS code with terrain to CWB	11/30/2013

Task #3: Update and Install MPI VDRAS without Terrain

Continue tuning, testing and optimization of MPI VDRAS without terrain. AIT's designated representative, UCAR, will deliver an updated version of MPI VDRAS code without terrain on a computer at TECRO's designated representative, CWB. This MPI VDRAS will be run in parallel with the current version at CWB. UCAR will monitor this MPI version of VDRAS during the real-time operation during the summer of 2013. Specific tasks include:

3.1 Update MPI VDRAS to be identical to the latest TANC real-time VDRAS and compare runs with the two versions to ensure the same results.

3.2 Install the MPI VDRAS without terrain on CWB's linux clusters with 64 processors by 5/31/2013.

3.3 Monitor and bug-fixing during the summer of 2013.

The following summarizes the schedule and deliverables for Task #3:

Task:	Performance Period:
1. Task 3.1 Update and test the MPI version of VDRAS code without terrain	01/01/2013 – 05/31/2013
2. Task 3.2 Install the MPI VDRAS without terrain to CWB	05/01/2013 – 05/31/2013
3. Task 3.3 Monitor the MPI VDRAS without terrain in real time in Summer 2013	06/01/2013 – 09/30/2013
Deliverables:	
1. Task 3.1 Deliver the MPI VDRAS code without terrain	05/31/2013
2. Task 3.2 Install the MPI VDRAS code on CWB machine	05/31/2013
3. Tasks 3.3 Report on the performance of the MPI VDRAS code without terrain during real-time operation in summer 2013	11/30/2013

Task #4: Conduct Training on Taiwan AutoNowcast System

4.1 Train CWB Staff on the use of the Taiwan AutoNowcast System

AIT's designated representative, UCAR, will work with TECRO's designated representative, CWB, to train CWB staff to become experts on the use of TANC and VDRAS. UCAR will host three CWB staff as visitors to work with UCAR staff to enhance their ability to use TANC and VDRAS; and, during the

summer operations in 2013, UCAR staff may travel to CWB to continue the TANC and VDRAS training at CWB's facility.

The following summarizes the schedule and deliverables for Task #4:

Performance Period:		
1. Task 4.1 Train CWB staff to become familiar with the TANC and VDRAS system		03/01/2013 – 06/30/2013
Deliverables:		
1. Task 4.1 Host 3 CWB visitors to train on TANC and VDRAS		03/01/2013 – 06/30/2013

II. Budget

The following are the estimated cost for Implementing Arrangement #10B:

Tasks	Personnel Costs	Travel	Total
Task #1	$60,000	$0	$60,000
Task #2	$100,000	$0	$100,000
Task #3	$90,000	$0	$90,000
Task #4	$40,000	$0	$40,000
Total	**$290,000**	**$0**	**$290,000**