STATEMENT OF WORK "B" FOR IMPLEMENTING ARRANGEMENT #9 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 at TECRO's designated representative, CWB, and provide general system support to CWB engineers during the operational demonstration.

The TANC system with the "First Guess" predictors (or Predictors_version1) to be delivered to CWB in 2012 are intended for weak synoptic-forced situations and based heavily on model fields (CAPE, CIN, layer averaged humidity, and precipitable water). It will be important to assess the quality and representativeness of the stability fields from NWP model fields versus values derived from the operational soundings, and in particular, the Banchiao soundings. These predictors are partially based on data documented in the Lin et al. (2012) journal paper. With this Predictors_version1, the weights and membership functions are the same for all of Taiwan.

In the second phase of predictor implementation (Predictors_version2) additional predictors will be derived from surface weather stations and sounding observations. The specific predictors that are selected will be heavily dependent on the performance of the phase 1 environmental predictors obtained from NWP model fields. Efforts will be directed toward studying the evolution of weak synoptic-forced thunderstorms associated with heavy rainfall.

A revised version of the TANC System code will be provided to CWB based on evaluation of 2011 nowcast performance and testing of additional predictors. CWB software engineers 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.

1.1   Evaluate the performance of the Taiwan nowcast system for prediction of thunderstorms using   the "first guess" predictor fields (Predictors_version1) that will be tested on the weak synoptic-forced thunderstorm cases from 2011 (Year 2).   Results from this evaluation will be used to revise and improve performance of the 30 and 60 minute nowcasts.

1.2   Develop version 2 predictors (Predictors_version2) for Taiwan and a selected set of predictors for northern Taiwan (based on Lin et al 2012) for heavy rainfall under weakly-forced synoptic situations.

1.3   Test and evaluate Predictor_version2 for heavy rainfall under weak synoptic-forced situations using cases collected in 2011.

1.4   For the TANC Predictors_version 1 compile a list of all ANC output fields for CWB that includes the purpose of these output fields and citations of relevant research articles associated with these output fields.

1.5   Provide general TANC system support.

The following summarizes the schedule and resources required for Task #1:

Task:	Performance Period:
1. Task 1.1 Evaluate 30 and 60 min nowcasts based on Predictors_version1	01/01/2012 – 05/31/2012
2. Task 1.2 Develop updated version of TANC using Predictors_version1	01/01/2012 – 05/31/2012
3. Task 1.3 Develop, evaluate and test version2 predictors (Predictors_version 2) for weak synoptic-forced thunderstorm cases	06/01/2012 – 10/31/2012
4. Task 1.4 Compile a list of TANC Predictor_version 1 output fields for CWB	01/01/2012 – 02/28/2012
5. Task 1.5 TANC system support	01/01/2012 – 11/30/2012
Deliverables:	
1. Task 1.1 Report on the performance on 30 and 60 minutes nowcasts using Predictor_version1	05/31/2012
2. Task 1.2 Deliver an updated version of TANC code with Predictors_version1 to CWB	05/31/2012
3. Task 1.3 Report on testing of TANC with Predictors_version2 and plans for 2013 installation	11/30/2012
4. Task 1.4 Provide documentation of all TANC Predictor_version 1 output fields to CWB	02/28/2012
5. Task 1.5 TANC system support	01/01/2012-11/30/2012

Task #2 - Localization of VDRAS for Taiwan

Continued tuning, optimization and localization of VDRAS will be performed through assimilation of data from Taiwan's observation network to improve its performance in the Taiwan area. The optimal VDRAS domain in the Taiwan area for best performance of the analysis fields will be evaluated. AIT's designated representative, UCAR, will deliver a revised version of VDRAS code to TECRO's designated representative, CWB.

2.1. Add the capability of assimilating CWB real-time dual-Doppler winds into VDRAS.

2.2. Evaluate the VDRAS winds (in 2.1) with operational real-time dual-Doppler winds before and after the addition of this capability.

2.3. Evaluate the optimal VDRAS domain and operational setup in the Taiwan area by comparing results from a single domain and multiple domains.

The following summarizes the schedule and resources required for Task #2:

Task:		Performance Period:
1. Task 2.1 Add the capability to assimilate CWB real-time dual-Doppler winds		01/01/2012 – 08/31/2012
2. Task 2.2 Analyze VDRAS winds vs. the real-time dual-Doppler winds		07/01/2012 – 11/30/2012
3. Task 2.3 Evaluate the optimal VDRAS domain for the operational setup in Taiwan		01/01/2012 – 05/31/2012
Deliverables:		

1. Task 2.1 Deliver an updated version of VDRAS code for assimilating real-time dual-Doppler winds provided by CWB	11/30/2012
2. Task 2.2 Report on testing of CWB dual-Doppler winds assimilated into VDRAS	11/30/2012
3. Task 2.3 Update CWB nowcast system with new specifications for the VDRAS domain	05/31/2012

Task #3 -   Develop a new version of VDRAS to include terrain (phase 1)

Adding terrain into VDRAD requires a multi-year effort. The main efforts include developing FORTRAN codes for the "forecast model" and the "adjoint model" in VDRAS that involves new numerical technique to solve the Poisson equations. The prototype VDRAS with terrain can be completed in two years where phase 1 focuses on the "forecast model" in 2012 and phase 2 focuses on the "adjoint model" in 2013. AIT's designated representative, UCAR, will deliver an updated version of VDRAS code to TECRO's designated representative, CWB. Specific tasks include:

3.1 Develop and merge the Fortran code that includes the terrain effect in the VDRAS forecast model into UCAR's new MPI version of VDRAS.

3.2 Upgrade and test the Poisson solver algorithm (e.g., the Immersed Boundary Method) to improve the computational efficiency.

3.3 Test the forecast model with the terrain effect using idealized terrain to make sure the forecast model produces reasonable simulations.

3.4 Test the forecast model with the terrain effect using real data from Taiwan.

The following summarizes the schedule and resources required for Task #3:

Performance Period:	
1. Task 3.1 Develop and merge Fortran code that include the terrain effect in the MPI version of VDRAS forecast model	01/01/2012 – 05/31/2012
2. Task 3.2 Upgrade and test the Poisson solver algorithm	04/01/2012 – 09/30/2012
3. Task 3.3 Test the forecast model with the terrain effect	08/01/2012 – 11/30/2012
Deliverables:	
1. Task 3.1 Deliver the new MPI version of VDRAS code including the terrain effect in VDRAS forecast model	06/30/2012
2. Task 3.2 Update VDRAS code with new Poisson solver algorithm	09/30/2012
3. Task 3.3 Report on the impact of the terrain effect in VDRAS forecast model	11/30/2012

Task #4- Conduct Training Workshop on Taiwan AutoNowcast System.

Work with TECRO's designated representative, CWB, and university researchers to conduct nowcast training at CWB at an agreed upon time in 2012.

4.1 Training topics may include examination of Taiwan weather events, MFC-identified synoptic regime thresholds, nowcast performance (using the Taiwan AutoNowcaster system and VDRAS) during 2011-2012, and the role of forecaster.

The following summarizes the schedule and resources required for Task #4:

Performance Period:		
1. Task 4.1 Work with CWB to plan and prepare a training workshop at CWB		01/01/2012 – 05/31/2012
Deliverables:		
1. Task 4.1 Conduct a training workshop on the Taiwan AutoNowcaster System		06/1/2012 - 11/30/2012

II. Budget

The following are the estimated cost for Implementing Arrangement #9B:

Tasks	Personnel Costs	Travel	Total
Task #1	$164,000	$0	$164,000
Task #2	$82,000	$0	$82,000
Task #3	$150,000	$0	$150,000
Task #4	$20,000	$16,000	$36,000
Total	**$416,000**	**$16,000**	**$432,000**