**STATEMENT OF WORK FOR IMPLEMENTING ARRANGEMENT #22
DEVELOPMENT OF A HAZARDOUS WEATHER MONITORING AND FORECASTING
SYSTEM BETWEEN THE TAIPEI ECONOMIC AND CULTURAL REPRESENTATIVE
OFFICE IN THE UNITED STATES AND THE AMERICAN INSTITUTE IN TAIWAN**

1.0 - Background and Objectives

This Statement of Work addresses tasks that will be undertaken by the joint team of the Global Systems Division (GSD) of the Earth System Research Laboratory, (ESRL), the designated representative of the American Institute in Taiwan (AIT) and personnel of the Central Weather Bureau (CWB), the designated representative of the Taipei Economic and Cultural Representative Office in the United States (TECRO) in accordance with the terms of Implementing Arrangement #22 of the Agreement between the Taipei Economic and Cultural Representative office in the United States and the American Institute in Taiwan for Technical Cooperation in Meteorology and Forecast Systems Development, which provides for technical cooperation between TECRO's designated representative, the Taiwan Central Weather Bureau (CWB) and AIT's designated representative, the U.S. National Oceanic and Atmospheric Administration's Global Systems Division (NOAA/ESRL/GSD).   The two designated representatives cooperate on the development of meteorology and forecast systems.

The WFO-Advanced system currently under development at NOAA's GSD of the ESRL in Boulder, Colorado, has been deployed as an essential part of the AWIPS (Advanced Weather Interactive Processing System) for the U.S. National Weather Service (NWS).   The WFO-Advanced system development has been a very important cooperative activity between TECRO's and AIT's designated representatives, CWB and NOAA/ESRL/GSD, respectively.

The WFO-Advanced system is a realization of the generic FX-Advanced (GSD X-window Advanced) system.   Figure 1 illustrates the WFO-Advanced components:

- National and local data feeds
- 3DVAR data assimilation and NWP (Numerical Weather Prediction)
- Satellite and remote sensing products
- HRQ2 (High-Resolution Quantitative Precipitation and Quantitative Precipitation Forecast) applications

- The interactive display system (D2D) and SOS (Science On a Sphere®)
- Nowcasting decision assistance tools
- The AWIPS Forecast Preparation System (AFPS)
- Hydrological applications developed at the NWS Office of Hydrology
- A component that contains General X applications
- Dissemination of high spatial and temporal forecast and warning products

Nine tasks are included in the Statement of Work: (1) development and improvement of satellite products for tropical storm monitoring and prediction, (2) Realtime analysis and forecasting with ARPS system, (3) Improvement and verification of short range forecasting using STMAS with remote sensing data, (4) HRQ2 (High-resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast) applications improvement, (5) Enhancement of nowcasting decision assistance tools, (6) Development of high resolution product generation assistance tools, (7) Installation of NOAA Science On a Sphere® (SOS), (8) GPS Radio Occultation satellite data assimilation using the NCEP/JCSDA Gridpoint Statistical Interpolation (GSI) analysis system, and (9) Continuing interaction on earlier cooperative projects.
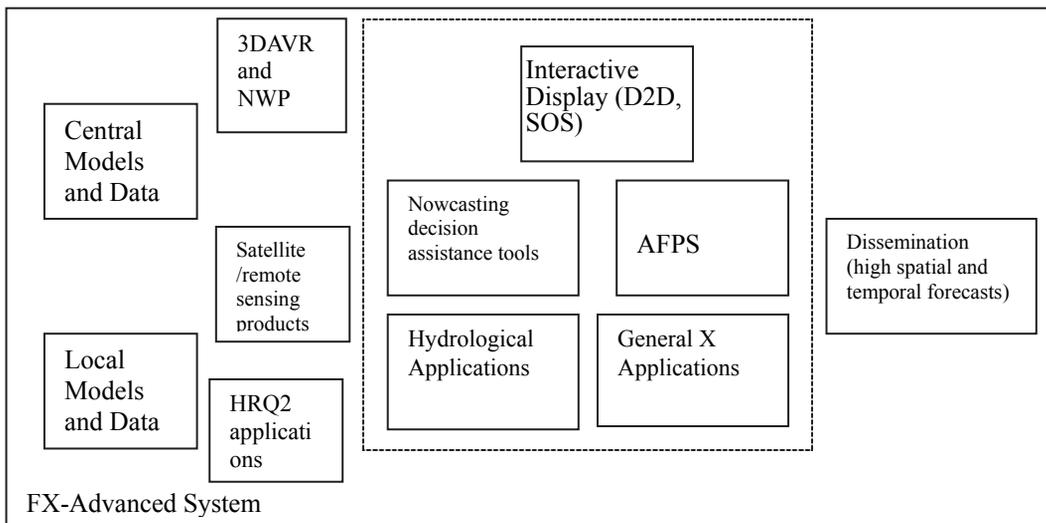

Figure 1   WFO-Advanced

The tasks will be undertaken by the CWB-NOAA/ESRL/GSD Joint Team as the designated representatives of the TECRO and AIT working at the NOAA/ESRL/GSD facility in Boulder, Colorado, and by CWB staff at the CWB facility in Taipei, Taiwan, as appropriate.   This Statement of Work addresses only tasks that will be undertaken by the CWB-NOAA/ESRL/GSD Joint Team under the terms of Implementing Arrangement #22.   It describes the performance period, deliverables, and resource requirements.

2.0 - Task Descriptions

In terms of the overall program schedule, the following nine tasks have been identified as being critical during the January 1 to December 31, 2010, time period. These are listed in detail below, along with the estimated proportion of resources that is to be allocated to each task.

Task #1 Develop and improve satellite products for tropical storm monitoring and prediction

Primary hazards from tropical cyclones including storm surge, inland flooding and wind damage (directly from the storm winds and from typhoon-spawned tornados). Preparing for these hazards requires accurate forecasting of storm tracks, storm intensities, sizes of storm wind field, and precipitation. These forecasts are currently obtained from numerical model predictions and from simpler empirically-based techniques. The United States (NOAA/NESDIS and NASA) has invested in satellite products from operational and research satellites that can be used for storm monitoring and forecasts. But, the product quality needs to be improved further under severe storm conditions. Also, transition of existing algorithms and products to operational centers needs to be improved and accelerated.

During Implementing Arrangement #22, AIT's designated representative, NOAA/ESRL/GSD, agrees that NOAA/NESDIS (National Environmental Satellite, Data, and Information Service) will lead this task. NESDIS will provide the access to advanced microwave satellite products, product analysis system and algorithms for SST and SSW products from the Aqua satellite. NESDIS will also provide improved microwave sounding products and the data processing system from AMSU (Advanced Microwave Sounding Unit) and SSMIS (Special Sensor Microwave Imager and Sounder).

In order to demonstrate the forecast improvement value of using satellite data, NESDIS will improve the quality control software for microwave sounding products, develop tangent linear and adjoints of clouds and moisture physics, and demonstrate the use of microwave sounding products over land in the NWP system. This task will benefit TECRO's designated representative, CWB, in improving the use of satellite products for tropical storms' monitoring and prediction.

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

Resources Required: 21.6 % NOAA/ESRL/GSD/CWB

Deliverables and Schedule:

1. Satellite products and algorithms
   a. EOS Aqua AMSR-E 1B real time access   06/30/10
      analysis system
   b. EOS Aqua AMSR-E SST and SSW   06/30/10
      algorithms and products
   c. NOAA/METOP-A AMSU-A/MHA data   09/30/10
      processing system
   d. AMSU-A/MHS and SSMIS sounding   09/30/10
      products
   e. DMSP SSMIS data processing system   11/30/10

2. NWP modeling and DA (data assimilation) systems
   a. Improving quality control software for
      AMSU-A/MHS sensor   11/30/10
   b. Developing tangent linear and adjoints of
      clouds and moisture physics   11/30/10
   c. Exploratory demonstration on uses of
      AMSU-A/MHS sensor over land   11/30/10

Task #2 Real-time analysis and forecasting with ARPS system

The ARPS (Advanced Regional Prediction System) has been developed at the Center for Analysis and Prediction of Storms (CAPS) at the University of Oklahoma. The ARPS a comprehensive regional to storm-scale atmospheric modeling system. It is a complete system that includes a realtime data analysis and assimilation system, a forward prediction model and a post-analysis package. The assimilation of radar and other high-resolution observations for convective-scale forecasting is a noted strength of the ARPS system. The 3DVAR-cloud analysis package of ARPS is a computationally efficient for producing convective-scale initial condition including radar data, while ARPS's Ensemble Kalman Filter (EnKF) data assimilation system promises to provide optimal initial conditions for both deterministic and ensemble predictions when computational resources become available.

During Implementing Arrangement #22, AIT's designated representative, NOAA/ESRL/GSD, agrees that CAPS at the University of Oklahoma will lead this task. CAPS will set up an ARPS domain within the CWB's Nonhydrostatic Forecast System (NFS) model, assimilating radar data for CWB's initial ARPS Forecast System. TECRO's designated representative, CWB, will provide support to set up CWB's HPC systems for running the ARPS Forecast System at CWB.   CAPS will perform case studies for heavy precipitation cases, that include the evaluation of domain size, computational

requirements and configurations for HPC platforms, as well as forecast performance evaluation. This task will benefit TECRO's designated representative, CWB, in improving its short-range forecasting capabilities, in particular, those related to heavy precipitation.

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

Resources Required: 12.3 % NOAA/ESRL/GSD/CWB

Deliverables and Schedule:
1. ARPS forecast system setup
    a. Initial ARPS setup at CWB for 2.5 km 06/30/10
        resolution
    b. Use CWB NFS model as background and 06/30/10
        boundary condition (5 km every hour)
    c. Use one CWB radar data   06/30/10
    d. Adopt CWB HPC configuration   06/30/10

2. Be able to generate timely QPF products (0-3 hr) 11/30/10
    "off- line" for selected cases and report testing results
    for evaluation.

Task #3 – Improvement and verification of short range forecasting using STMAS with remote sensing data

STMAS (Space and Time Multi-scale Analysis System) is a new and advanced data assimilation technique with a superior analysis advantage. STMAS combines the advantages of objective analysis and modern variational analysis into a unified data assimilation system and removes the limitations of these data assimilation schemes. During the past few years, TECRO's designated representative, CWB, has demonstrated its benefit from using this system for its operational applications especially for surface analysis and verification against observation data.

During Implementing Arrangement #22, two STMAS tasks will be performed by AIT's designated representative, NOAA/ESRL/GSD; one is STMAS surface analysis, and the other is STMAS 3D system implementation. The surface analysis is mainly used for CWB weather reanalysis to provide the ground-truth for establishing climatology statistics. The STMAS 3D system can further improve CWB weather reanalysis using upper air datasets to overcome the complex terrain effect.

Under the STMAS surface analysis task, AIT's designated representative, NOAA/ESRL/GSD, will modify the software package to improve the performance against

complex terrain problems in Taiwan to meet the application requirement for TECRO's designated representative, CWB. Also, the AIT's designated representative, NOAA/ESRL/GSD, will start developing a multi-grid 4DVAR system to handle terrain changes.

With support of AIT's designated representative, NOAA/ESRL/GSD, TECRO's designated representative, CWB, will perform a 3-year reanalysis with calibrated parameters for STMAS, such as length-scale, multi-grid levels, smoothing and penalty function for various reanalysis fields such as P, T, Td, U, V and precipitation. For a longer-term reanalysis, a careful verification is required to examine each of the reanalysis fields and to build up climatology verification statistics. These verification statistics can provide valuable evidence for further improvement of STMAS surface analysis in the future.

Under the STMAS 3D system implementing task, AIT's designated representative, NOAA/ESRL/GSD, will assimilate all conventional data and radar radial wind, perform case studies, and initialize the WRF model with STMAS 3D at the GSD facility. AIT's designated representative, NOAA/ESRL/GSD, will start the model forecast process using the STMAS analysis, and develop a hot-start capability using the STMAS 3D radar reflectivity analysis operator. This will be applied to the CWB regional models for improving short range forecasts. TECRO's designated representative, CWB, and AIT's designated representative, NOAA/ESRL/GSD, will collaborate on the verification and model initialization of the STMAS 3D system. This task will benefit TECRO's designated representative, CWB, in improving and verifying short range forecasting operations.

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

Resources Required: 18.5 % NOAA/ESRL/GSD/CWB

Deliverables and Schedule:
1. STMAS 2D data assimilation software (complex terrain)
    a. Run past 3-year analysis   06/30/10
    b. Verify the projected surface analysis of   11/30/10
        STMAS 3D analysis
    c. Start multigrid 4DVAR system for handling   11/30/10
        dramatic terrain change (progress report)
2. Use satellite data assimilation in STMAS 3D analysis (Community Radiative Transfer Model, 11/30/10 CRTM) (status report)

3. STMAS 3D data assimilation software

    a. Assimilate all conventional data and radar 06/30/10
        radial wind (real time run)

    b. Run case analysis for 2009 Morakot case 06/30/10

    c. Initialize WRF (Advanced Research WRF, 11/30/10
        ARW) with STMAS 3D at GSD 11/30/10

4. Forecast using STMAS 3D and WRF

5. Hot-start capability (using existing package as 06/30/10
post-processing)

6. Radar reflectivity analysis (develop STMAS 3D radar 11/30/10
reflectivity analysis operator)

Task #4 – HRQ2 (High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast) applications improvement

During Implementing Arrangement #22, AIT's designated representative, NOAA/ESRL/GSD, agrees that the National Severe Storms Laboratory (NSSL) will continue research towards refinement, development, and maintenance of HRQ2 applications required for TECRO's designated representatives, CWB, Water Resources Agency (WRA), and the Soil and Water Conservation Bureau (SWCB) operations. The NSSL research is directed towards the integration of the dual-pol (dual-polarization) radar applications in the HRQ2 system.

This task will include the integration of the dual-pol radar reflectivity and the radar QPE in the real-time HRQ2 system to support CWB operations. This task will perform an initial evaluation of the real-time reflectivity mosaic and QPE with dual-pol radar.

Two brand-new C-band dual-pol radars have been installed in Taiwan (RCMK at Makung and RCCK at Ching Chung Kung). These radars will add new capability to measure rainfall and discriminate hydrometer types. These two radars and a CWB radar at Chi-Kuo will provide excellent area coverage over western Taiwan. NSSL will implement a hydrometer classification algorithm and a QPE merging algorithm encompassing the dual polarized radars. NSSL will make available to the CWB, as requested, software source code for the hybrid scan reflectivity module, dual-pol hydrometer classification module and dual-pol QPE module.
The following summarizes the schedule and resources required for Task #4:

Resources Required: 15.4 % NOAA/ESRL/GSD/CWB

Deliverables and Schedule:

1. Integration of the dual-pol radar reflectivity in the real-time HRQ2 system to support CWB operations   03/30/10

2. Integration of the dual-pol radar QPE in the real-time HRQ2 system to support CWB operations   06/30/10

3. Initial evaluation of the real-time reflectivity mosaic with dual-pol radar   09/30/10

4. Initial evaluation of the real-time HRQ2 QPE with dual-pol radar   11/30/10

Task #5 – Enhancement of nowcasting decision assistance tools

During Implementing Arrangement #22, AIT's designated representative, NOAA/ESRL/GSD, agrees that the Meteorological Development Laboratory (MDL) will provide technical support to the TECRO's designated representative, CWB, to enhance CWB's current forecast workstation, called the Weather Integration and Nowcasting System (WINS), in the area of nowcasting decision assistance tools. One of the MDL missions is to develop a comprehensive suite of decision assistance tools, called SCAN (System for Convection Analysis and Nowcasting), implemented in AWIPS to cover the full scope of hydro-meteorological phenomena and forecaster responsibilities. The current MDL activity is to migrate SCAN from AWIPS to AWIPS II.

One of the SCAN suites is SAFESEAS (*S*ystem on *A*WIPS for *F*orecasting and *E*valuation of *Se*as and L*a*ke*s*), which is a decision assistance tool engineered to continuously monitor marine and adjacent overland conditions for specific marine weather hazards. It automatically alerts CWB forecasters when such conditions are detected. SAFESEAS provides capabilities to display observed marine conditions in ways that help CWB focus on the most important events. Thus, the benefit of SAFESEAS is to assist CWB in making fast, earlier, and higher-quality decisions regarding marine watches and warnings.

During Implementing Arrangement #22, MDL will provide SAFESEAS technical support and customize the thresholds at which conditions will be considered threatening and the thresholds at which conditions will be considered hazardous. MDL will also provide experience to CWB forecasters for training and evaluation of using other decisions assistance tools such as FFMPA (Flash Flood Monitoring and Prediction Advanced), and the preliminary ANC (AutoNowCaster) system.

The following summarizes the schedule and resources required for Task #5:

Resources Required: 9.3 % NOAA/ESRL/GSD/CWB

Deliverables and Schedule:

1. Decision assistance tools in AWIPS I
    a. SAFESEAS technical support   02/28/10
    b. Provide training and system setup support on   11/30/10
        MDL/SCAN (System for Convection
        Analysis and Nowcasting)
    c. FFMPA (FFMP Advanced) technical support   11/30/10
    d. Provide system setup support on
        MDL/AWIPS ANC software   11/30/10

Task #6 – Development of high-resolution forecast product generation assistance tools

During Implementing Arrangement #22, AIT's designated representative, NOAA/ESRL/GSD, will continue providing technical support on GFE, and Text Formatter (TF) and GHG (Graphical Hazards Generator) to support CWB's development of formatter infrastructure of FIES (Forecast Information Editing System). CWB plans to implement its own rule-based Chinese text formatter to provide a heavy rainfall report. GSD will also provide necessary training to CWB visitor(s) to implement such a Chinese text formatter system as part of CWB's FIES.

GFE/verification system software training (BOIVerify) was coordinated by the AIT's designated representative, NOAA/ESRL/GSD, to TECRO's designated representative, CWB, during Implementing Arrangement #21. GSD will continue to coordinate necessary forecaster training of using BOIVerify during hazardous weather situations during Implementing Arrangement #22. The benefit of this task is for the TECRO's designated representative, CWB, to establish its text formatter infrastructure and assistance tools to support the high resolution forecast product generation.

The following summarizes the schedule and resources required for Task #6:

Resources Required: 6.2 % NOAA/ESRL/GSD/CWB

Deliverables and Schedule:

1. Support CWB's FIES (Forecast Information Editing
    System) development
    a. Provide technical support on GFE for CWB's   06/30/10
        TF development

2. Provide technical support on GFE verification tool   11/30/10

Task #7 – Installation of NOAA Science On a Sphere® (SOS)

Science On a Sphere® (SOS) is a large visualization system that uses computers and video projectors to display animated data onto the outside of a sphere. SOS can display dynamic, animated images of atmosphere, oceans, earthquakes, and the land of a planet. During Implementing Arrangement #22, AIT's designated representative, NOAA/ESRL/GSD, will provide standard SOS implementation, consultation, setup and training to the TECRO's designated representative, CWB. GSD will also provide currently available NOAA SOS education content material and will provide training to enhance presentation skills during installation. CWB will be responsible for all necessary hardware procurements and site facility preparations associated with the SOS system. The benefit of SOS is for CWB to possess an excellent visualization tool to expand meteorological services with local government agencies and to promote public education of hazardous weather monitoring and forecasting for educational institutions. The following summarizes the schedule and resources required for Task #7:

Resources Required: 7.4 % NOAA/ESRL/GSD/CWB

Deliverables and Schedule:
1. Standard SOS implementation
    a. Provide the technical specifications for the   04/30/10
       hardware necessary for SOS system
    b. Provide SOS system facility requirement   04/30/10
    c. Provide the scientific media data sets   04/30/10
       currently available for display on sphere

2. Preparation for and during installation
    a. Provide SOS installation at CWB site   05/30/10
    b. Provide on-site training on how to operate   05/30/10
       and maintain the SOS system, and enhance
       presentation skills
    c. Provide an SOS media developer's kit and   05/30/10
       training on how to use it to allow on-site
       creation of media
    d. Provide technical trouble shooting for SOS   12/30/10
       via telephone and on-line

Task # 8 – GPS Radio Occultation satellite data assimilation using the NCEP/JCSDA Gridpoint Statistical Interpolation (GSI) analysis system

As part of the COSMIC (Constellation Observing System for Meteorology, Ionosphere and Climate) mission, TECRO's designated representative, CWB, will support the inclusion of GPS Radio Occultation (RO) observations from the COSMIC mission into the NCEP's

regional system to implement the Gridpoint Statistical Interpolation (GSI) data assimilation of GPS radio occultation data under the joint collaboration project between NOAA/NASA/DoD, JCSDA and CWB.   NCEP is the National Centers for Environmental Prediction under NOAA's NWS.   JCSDA (Joint Center for Satellite Data Assimilation) is a multi-agency research center tasked with improving the use of satellite data for analyzing and predicting weather, the ocean, climate and the environment.   JCSDA partner agencies are NASA (National Aeronautics and Space Administration), NOAA and DoD (Department of Defense).

The main objectives of this collaborative project are to tune and test the assimilation of GPS RO data in the NCEP regional system and to accelerate and enhance the use of GPS RO data in global numerical weather prediction at CWB.   Currently, TECRO's designated representative, CWB, is performing global numerical weather prediction using its own global model and an older version of the NCEP data assimilation system, the Spectral Statistical Interpolation (SSI).   Through this collaboration, CWB would enhance their global data assimilation system and make optimal use of satellite data, including COSMIC/FORMOSAT-3.   Accordingly, CWB would migrate from SSI (Spectral Statistical Interpolation) to GSI, and initialize the CWB global model with an analysis generated by GSI.   This task will cover the use of GSI for both global and regional capabilities.   In exchange, CWB will contribute to the tuning and testing of the GPS RO assimilation in the regional model.

The following summarizes the schedule and resources required for Task #8:

Resources Required: No funding exchanged

Deliverables and Schedule:
1. NOAA will provide GSI code with necessary training   11/30/10
    support on the use of GPS RO data

2. NOAA will host CWB visitors   11/30/10

Task #9 - Continuing interaction on earlier cooperative projects

Several earlier cooperative tasks have been completed.   Technology has been transferred successfully and is beginning to be used operationally at the facilities of TECRO's designated representative, CWB.   NOAA/ESRL/GSD's development activities in these areas will continue, and further NOAA/ESRL/GSD-CWB interaction is important to keep CWB staff up-to-date on current developments.   This task will directly improve and update CWB's current forecast assistant and decision making system at an appropriate level, including new AWIPS and relevant forecast assistant application software releases and available documents.

AIT's designated representative, NOAA/OAR/GSD, has released the latest AWIPS OB 8.3.1 and necessary test datasets to TECRO's designated representative, CWB, near the end of 2008. This version is the one currently used by NOAA/NWS. This version is ready to accept dual-pol radar products and has the capability to integrate radar data with environment sampling of temperature, relative humidity, wind, equivalent potential temperature, wet-bulb temperature, and pressure at the height of the radar beam. CWB will access data from two new dual-pol radars soon, so this new radar product display capability will be extremely useful for its forecast and decision making operation. NOAA/ESRL/GSD will continue to make available any latest AWIPS-build software, and technical support of AWIPS applications such as warning tools (WarnGen, GHG) if applicable, during Implementing Arrangement #22.

Under a NOAA/NWS contract to the Raytheon Technical Services Company (since 2005), a next generation of AWIPS (called AWIPS II) is being developed. AWIPS II is based on Service Oriented Architecture (SOA). AIT's designated representative, NOAA/ESRL/GSD, is tasked with performing an Independent Validation and Verification (IV &V) for each task order released by Raytheon. NOAA/ESRL/GSD plans to share some of its experience with AWIPS II in the area of SOA, EDEX (Environmental Data Exchange handles data ingest, storage and communication) and CAVE (Common AWIPS Visualization Environment is the graphical user interface) with CWB, if appropriate, during Implementing Arrangement #22.

AIT's designated representative, NOAA/ESRL/GSD, has a long history of supporting research and operational weather forecasting by developing advanced prototype workstation display systems, including an ongoing ALPS (AWIPS Linux Prototype System) development, which is an update of AWIPS, and FXC (FX-Collaborate) development. FXC is an Internet-based system for displaying data from AWIPS with additional drawing and briefing tools. CWB has interest in adopting the ensemble forecast products display tool from ALPS.

For the data feed support, AIT's designated representative, NOAA/ESRL/GSD, will continue to provide the NOAAPORT data feed for CWB's data assimilation purposes during Implementing Arrangement #22.

This continuing interaction task will benefit TECRO's designated representative, CWB, with the updated knowledge of the forecast assistant and decision making system developed at NOAA. This task also provides the important data feed of NOAAPORT for CWB's daily numerical weather prediction operation needs. Finally, AIT's designated representative, NOAA/ESRL/GSD, will provide necessary training and support to visitors and forecasters, continue the exchange of visits, provide necessary papers and reports, and continue our e-mail interactions, if applicable.

The following summarizes the schedule and resources required for Task #9:

Resources Required: 9.3 % NOAA/ESRL/GSD/ CWB

Deliverables and Schedule:

1.	AWIPS final build upgrade software	06/30/10
2.	BOIVerify (tool, procedure) user support	06/30/10
3.	Warning tools technical support (WarnGen, GHG)	11/30/10
4.	AWIPS II relevant documents (available documents)	(as needed)
5.	FXC support on products for web site (drawing tools)	(as needed)
6.	ALPS demo system for ensemble forecast products display tool	11/30/10
7.	NOAAPORT data support	11/30/10
8.	Forecaster training support including necessary training and travel (two sessions in 2010)	11/30/10

3.0 - Schedule

Tasks	**Functions**	**Milestones**
1.	Provide satellite products, algorithms and improvement on NWP modeling and data assimilation	12/10
2.	Provide ARPS system for realtime analysis and forecasting	12/10
3.	Provide STMAS 3D and 2D update for short range forecasting	12/10
4.	Provide improved HRQ2 system to support operation and evaluation	12/10
5.	Provide technical support on AWIPS decision assistance tools	12/10
6.	Provide technical support on GFE/TF for CWB's FIES development	12/10
7.	Installation of NOAA Science On a Sphere® (SOS) at CWB	05/10
8.	Provide GSI code and necessary visitor technical support	12/10
9.	Provide technical support and software upgrade of AWIPS, ALPS, FXC, NOAAPORT data transition, and relevant documents	12/10

Schedule by Month

TASKS	1/1	2/1	3/1	4/1	5/1	6/1	7/1	8/1	9/1	10/1	11/1	12/1
Task 1 (Satellite product)												
Satellite products (EOS Aqua AMSR-E 1B access system)	x	x	x	x	x	x	x					

	1	2	3	4	5	6	7	8	9	10	11	12
Satellite products (EOS Aqua AMSR-E algorithms)	x	x	x	x	x	x	x					
Satellite products (NOAA/METOP-A)	x	x	x	x	x	x	x	x	x	x		
Satellite products (AMSU-A/MHS and SSMIS)	x	x	x	x	x	x	x	x	x	x		
Satellite products (DMSP SSMIS data processing	x	x	x	x	x	x	x	x	x	x	x	x
NWP modeling (improve AMSU-A/MHS)	x	x	x	x	x	x	x	x	x	x	x	x
NWP modeling (improve cloud and moisture physics)	x	x	x	x	x	x	x	x	x	x	x	x
NWP modeling (demo of AMSU-A/MHS over land)	x	x	x	x	x	x	x	x	x	x	x	x
Task 2 (ARPS)												
ARPS 3DVAR setup (for 2.5 km resolution)	x	x	x	x	x	x	x					
ARPS setuo (with CWB NFS as background)	x	x	x	x	x	x	x					
ARPS setup (use one CWB radar)	x	x	x	x	x	x	x					
ARPS setup (adopt CWB HPC) HRQ2	x	x	x	x	x	x	x					
Generate QPF "off-line" products	x	x	x	x	x	x	x	x	x	x	x	x
Task 3 (STMAS)												
STMAS 2D (verify surface analysis)	x	x	x	x	x	x	x	x	x	x	x	x
STMAS 2D (run past 3-year reanalysis)	x	x	x	x	x	x	x					
STMAS 2D (start 4DVAR for terrain change)	x	x	x	x	x	x	x	x	x	x	x	x
STMAS 3D with satellite data (CRTM)	x	x	x	x	x	x	x	x	x	x	x	x
STMAS 3D (assimilate all conventional and radar radial wind data)	x	x	x	x	x	x	x					
STMAS 3D (run a case study)	x	x	x	x	x	x	x					
STMAS 3D (initialize WRF with STMAS 3D)	x	x	x	x	x	x	x	x	x	x	x	x
Forecast with STMAS and WRF	x	x	x	x	x	x	x	x	x	x	x	x
Hot start capability	x	x	x	x	x	x	x					
Radar reflectivity analysis	x	x	x	x	x	x	x	x	x	x	x	x

Task 4 HRQ2 (NSSL)												
Integrate dual-pol radar reflectivity	x	x	x									
Integrate dual-plo radar QPE	x	x	x	x	x	x						
Evaluation of reflectivity mosaic with dual-pol radar	x	x	x	x	x	x	x	x	x			
Evlautaion of HRQ2 QPE with dual-pol radar	x	x	x	x	x	x	x	x	x	x	x	x
Task 5 nowcasting decision tools												
AWIPS I decision assistance tool (training on SCAN)	x	x	x	x	x	x	x	x	x	x	x	x
AWIPS I technical support on SAFESEAS	x	x	x									
AWIPS I technical support on FFMPA	x	x	x	x	x	x	x	x	x	x	x	x
MDL/AWIPS ANC system setup technical support	x	x	x	x	x	x	x	x	x	x	x	x
Task 6 high resolution forecast product generation												
Support GFE for CWB's TF development	x	x	x	x	x	x						
Provide technical support on GFE verification tools	x	x	x	x	x	x	x	x	x	x	x	x
Task 7 install NOAA SOS at CWB												
Standard SOS implementation (include technical specification, facility requirement and media data sets)	x	x	x	x	x	x	x					
Provide SOS installation, on-site training, media developer's kit	x	x	x	x	x	x	x					
Provide technical trouble shooting for SOS	x	x	x	x	x	x	x	x	x	x	x	x
Task 8 GSI technical support (NESDIS/JCSDA)												
Provide GSI update code	x	x	x	x	x	x	x	x	x	x	x	x
Support CWB's visitor(s)	x	x	x	x	x	x	x	x	x	x	x	x

Task 9 interaction on earlier projects												
AWIPS final build	x	x	x	x	x	x						
BOIVerify user training	x	x	x	x	x	x						
Warning tools technical Support (WarnGen, GHG)	x	x	x	x	x	x	x	x	x	x	x	x
AWIPS II relevant documents (as available)	x	x	x	x	x	x	x	x	x	x	x	x
FXC technical support	x	x	x	x	x	x	x	x	x	x	x	x
ALPS ensemble forecast products display tool	x	x	x	x	x	x	x	x	x	x	x	x
NOAAPORT data support	x	x	x	x	x	x	x	x	x	x	x	x
Forecasters training support (2 sessions in 2010)			x	x						x	x	x

4.0 - Budget

The following are the estimated costs for Implementing Arrangement #22

Tasks	Personnel	Travel/Training	Total
Task #1 (NESDIS/GSD)	$ 335,000	$ 15,000	$ 350,000
Task #2 (OU)	$ 185,000	$ 15,000	$ 200,000
Task #3 (GSD)	$ 285,000	$ 15,000	$ 300,000
Task #4 (NSSL)	$ 235,000	$ 15,000	$ 250,000
Task #5 (MDL/GSD)	$ 135,000	$ 15,000	$ 150,000
Task #6 (GSD)	$ 85,000	$ 15,000	$ 100,000
Task #7 (GSD)	$ 100,000	$ 20,000	$ 120,000
Task #8 (NESDIS/JCSDA)	(no funding exchanged)		
Task #9 (GSD)	$ 115,000	$ 35,000	$ 150,000
Total	**$ 1475,000**	**$ 145,000**	**$ 1,620,000**

As stated in Implementing Arrangement #22, the funds available from TECRO to support the tasks, traveling and meeting expenses described in this Statement of Work, will be a total of US$ 1,620,000.   TECRO agrees that US$ 1,120,000 will be provided by its designated representative, CWB, US$ 250,000 by the Water Resources Agency (WRA) on behalf of CWB and US$ 250,000 by the Soil and Water Conservation Bureau (SWCB) on behalf of CWB.   All budget figures are estimated.   Actual amounts will be accrued for purposes of fulfilling the financial arrangements

described in the Implementing Arrangement, in accordance with the terms of the Agreement.

All programs within the Global Systems Division (GSD) use the same budget procedures, whether they are base-funded programs or externally-funded programs. Beginning in FY91, a facility charge has been applied to all programs to cover management and administrative costs as well as the use of the NOAA/ESRL/GSD facility and all associated equipment and data.

AIT's designated representative, NOAA/ESRL/GSD, staff time is charged at the employee's salary plus the normal NOAA benefit, leave, and overhead charges. NOAA/ESRL/GSD professional staff people are primarily in the civil service grade scales of GS-11 to GS-14. Contract staff is in equivalent categories.

5.0 - CWB Joint Team Assignments at NOAA/ESRL/GSD

Several tasks encourage TECRO's designated representative, CWB, staff in residence at NOAA/ESRL/GSD and NOAA/NWS/NCEP. The primary effort of CWB staff at NOAA/ESRL/GSD during the Implementing Arrangement #22 period will be directed toward developing the HRQ2 task. The primary effort of CWB staff at NOAA/NESDIS during the Implementing Arrangement #22 period will be to get familiar with the GSI code and to receive basic training on use of GPS RO data for the data assimilation system. It is important that qualified CWB staff be available to work at NOAA/ESRL/GSD and NOAA/NESDIS facilities during the period. Specific assignments will be made to most efficiently use the available personnel resources. Assignments for the qualified CWB staff members would be as follows:

- Development of a high resolution forecast products generation assistance tool to support CWB's FIES.
- Study and improve the forward operator for GPS Radio Occultation (RO) data.