Implementing Arrangement #28

Development of a hazardous weather monitoring and forecast system
Pursuant to 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

Article I - Scope

This Implementing Arrangement describes the scientific and technical activities to be undertaken by the American Institute in Taiwan (AIT), through its designated representative, the Global System Division (GSD) (formally the Forecast Systems Laboratory) of the Earth System Research Laboratory (ESRL) of the National Oceanic and Atmospheric Administration (NOAA), United States Department of Commerce (hereinafter NOAA/ESRL/GSD). It provides for continuing development of the forecast system being developed by the Joint Forecast Systems Project. This project is a cooperative effort between the Central Weather Bureau (CWB), the designated representative of the Taipei Economic and Cultural Representative Office in the United States (TECRO), and NOAA/ESRL/GSD. This Implementing Arrangement is of mutual interest to both TECRO and AIT, hereafter referred to as the parties. The products of this Implementing Arrangement will provide substantial value through development of new and upgraded capabilities and applications that can be integrated into other NOAA/ESRL/GSD systems.

Article II - Authorities

The activities described in this Implementing Arrangement will be carried out under and are subject to the general terms and conditions established by the Agreement between TECRO and AIT for Technical Cooperation in Meteorology and Forecast Systems Development, signed by all parties as of October 21, 2016, and any subsequent amendment thereof agreed to by the parties. This Implementing Arrangement is the twenty-eighth such arrangement under a succession of umbrella agreements between TECRO and AIT.

Article III - Services

During the period of Implementing Arrangement #28 (IA #28), NOAA/ESRL/GSD and CWB have started a new phase VI program on hazardous weather monitoring and forecasting. Therefore the NOAA/ESRL/GSD-CWB joint team will expand work to address this hazardous weather theme. Seven tasks are identified: (1) Development and Improvement of Satellite Products for Tropical Storm Monitoring and Prediction; (2) High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) Applications Improvement; (3) Enhance Nowcasting Decision Assistance Tools; (4) Development of High-Resolution Product Generation Assistance Tools for AWIPS II; (5) Development of Intra-

seasonal to Inter-annual Climate Monitoring and Forecast; (6) Continuing Interaction on Earlier Cooperative Projects; and (7) Provisions of operations, maintenance, and reconditioning support for the WSR-88D system. Tasks under this Implementing Arrangement range from full scale developmental collaboration to system upgrades and support that allow systems to operate with the latest technical and scientific capabilities and specifications. These ongoing activities, described in more detail in the Statement of Work, will include the following seven tasks:

Task #1 Development and Improvement of Satellite Products for Tropical Storm Monitoring and Prediction

During IA #28, NOAA/ESRL/GSD has agreed that STAR/SMCD will lead this task. NOAA/STAR/SMCD will continue providing near real-time polar orbiting satellite global 1b radiance data from AMSU-A and MHS onboard NOAA-18, NOAA-19, MetOp-A, and MetOp-B satellites. Also STAR/SMCD will provide data retrieval script for users to directly download data from public available data servers. Remote technical support will be provided for satellite 1b data recovery.

For Microwave Integrated Retrieval System (MiRS), STAR/SMCD will provide updated MiRS packages and documentation for multiple satellite product retrieval and on-site or remote technical support for MiRS implementation.

Due to the similarity between Himawari AHI and GOES-R ABI instruments, STAR/SMCD will provide GOES-R ABI selected product retrieval algorithms as reference to let customer to develop its own Himawari AHI product retrieval package.

Task #2 – High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) Applications Improvement

During IA #28, NOAA/ESRL/GSD has agreed that NOAA/NSSL (National Severe Storms Laboratory) will continue research towards maintenance, refinement, and improvement of the High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) applications required for CWB, the Water Resources Agency (WRA), and the Soil and Water Conservation Bureau (SWCB).

This task will include documentation of a real-time QPE (Quantitative Precipitation Estimation) and QPF (Quantitative Precipitation Forecast) product verification software package and implementation of the software in the QPESUMS (Quantitative Precipitation Estimation and Segregation Using Multiple Sensors) system. Data from new CWB C-band dual-polarization precipitation radars will be collected and integrated with existing radars in the current HRQ2 system, and impacts of the new data on various radar mosaic and precipitation products will be evaluated. Real-time polarimetric radar QPE products implemented during previous IAs will be evaluated systematically, and enhancements and refinements will be developed based on the evaluation results and new requirements from the CWB, WRA, and SWCB.

NOAA/NSSL will make available to CWB, as requested, documentation of the real-time precipitation product verification software and source code for its implementation in the QPESUMS. NOAA/NSSL will also make available to CWB, as requested, the implementation of the enhanced radar QPE in the real-time HRQ2 system as part of QPESUMS technical support.

Task 3 - Enhance Nowcasting Decision Assistance Tools

The Meteorological Development Laboratory (MDL) of the National Weather Service (NWS) has developed a comprehensive suite of decision assistance tools which cover the full scope of hydrometeorological phenomena and forecaster responsibilities. In the past few years, the MDL has assisted and supported porting various applications into the Weather Integration and Nowcasting System (WINS) of the CWB.

As part of Implementation Arrangement #28 (IA #28) NOAA/ESRL/GSD, has agreed that the MDL will continue to provide technical and training support to the CWB, to enhance the CWB in the area of nowcasting decision assistance tools that have already been implemented. That support includes source code and configuration modification that is appropriate for CWB's use.

First, MDL will focus on more thorough customization support to the Flash Flood Monitoring and Prediction (FFMP) tool on its operational use at the Forecast Center after the Hydrologic Unit Code (HUC) layer implementation is made in IA #27 as the HUC layers would add more important hydrological characteristics beyond the implementation of Township layer and small-basin layer that were completed in IA #25 and IA #26.

Secondly, MDL will continue to technically support CWB on its implementation of System on AWIPS for Forecasting and Evaluation of Seas and Lakes (called SAFESEAS) under AWIPS2 development environment.

Thirdly, MDL will continue provide CWB training and technical support on the AutoNowCaster (ANC) system. The MDL's version of ANC, which is substantially different from its original NCAR version and has been improved with far fewer software crashes and much easier configuration for its operational use, was delivered to CWB along with a verification package in IA #27. The ongoing training and technical support are needed to configure it, use it, and interpret its results so that the CWB's forecasters make informed use of ANC's output.

Task #4 - Development of High-Resolution Product Generation Assistance Tools for AWIPS II

The National Weather Service (NWS) has been developing AWIPS II for several years. This replacement for the original AWIPS (the basis of the current CWB Weather Integration and Nowcasting System (WINS) is running at all NWS WFO (Weather Forecast Offices) sites before the end of 2015. AWIPS II provides essentially the same appearance and function ("look and feel") as AWIPS I, reducing the need for extensive forecaster training. The underlying software is written largely in Java and loosely follows a services oriented architecture (SOA) design.

During IA #27, NOAA/ESRL/GSD received permission from NWS to provide an evaluation copy of the AWIPS II software to CWB. This support continued through IA #28, with periodic updates provided. GSD also provided AWIPS II training for CWB developers. Two CWB visitors to GSD in 2015 learned much about AWIPS II and, with GSD, began design/development work on some CWB-specific data ingest such as lightning data and display plugins, working toward eventual realization of a WINS-II.

For IA #28, GSD will continue to support CWB developers by providing updated versions of the AWIPS II software. GSD will work with NWS/Meteorological Development Laboratory to set

up a shared software repository, where GSD and CWB visitor(s) will maintain code that they will share with other CWB staff who are developing and testing new software.

GSD has explored the new FDSE (Forecaster Decision Support Environment) system to view and data pertinent to the given weather scenario. There are three major components that make up the FDSE: Ensemble tools, Grid monitor and Short-term update tool. During IA #28, GSD will provide some training of FDSE to CWB forecasters to explore new data management and processing capabilities to enhance situation awareness, allow forecasters to work more efficiently, and improve model ensemble capabilities in order to explore probabilistic forecast products. Additional collaborative work will address ingest and display of CWB-specific lightning, satellite, and grid datasets.

During IA #28, GSD will provide technical support for the Graphical Forecast Editor (GFE), GFE Smart Tools (techniques to automate or semi-automate grid editing), and the text formatters (TF) used in CWB's Forecast Information Editing System (FIES). In conjunction with NWS, GSD continues to work on improvements in Smart Tools, and is developing new forecast monitoring and ensemble-based forecast support tools, some of which will be included in the AWIPS II release in mid-2016.

This interaction will benefit CWB, with updated knowledge of the forecast assistant and decision making systems developed at NOAA including AWIPS II. Throughout the period of IA #28, NOAA/ESRL/GSD will provide training and support to CWB visitors and forecasters, continue the exchange of visits, provide reports, attend annual meetings, and continue e-mail interactions.

Task #5 – Development of Intra-seasonal to Inter-annual Climate Monitoring and Forecast

During IA #28 NOAA/ESRL/GSD has agreed that NWS/NCEP's (National Centers of Environmental Prediction) will lead this task. NCEP will continue to support CWB in advancing the monitoring and forecast capabilities, in particular for the intraseasonal to interannual time scales.

CWB holds the responsibility to informed society preparing for and responding to weather and climate variations and their impacts, by delivering real-time products and information that predict and describe weather and climate variations on timescales from hours to years thereby promoting effective management of meteorological risk and a resilient society.

Meteorological services around the world all are facing the expanding requirements for providing, and improving, climate services. The services subjects could range from providing extended range forecasts, hazard outlooks, historical data, to tailored derivative information requested by government agencies and industrial sectors for national interests. It mandates the meteorological services, such as CWB, to layout a new strategic plan, developing new capabilities in human talents, absorbing scientific discoveries, devising new tools, and implementing technical advances.

Specific for IA #28, NOAA will continue to assist CWB in developing capability for climate services, by 1) providing training, either through NCEP's International Monsoon Training Desk Program or EMC visitor/guest programs; 2) Attending CWB-organized workshop on TWCFS and providing planning and scientific consultation to CWB at the workshop and meetings; and 3) Assisting and facilitating CWB professionals to attend scientific conferences and meetings in the territory of the authorities represented by AIT.

To help improve the satellite data application in CWBGFS (CWB Global Forecast system), NOAA/STAR/SMCD will provide technical support on satellite data assimilation implementation and improvement.

Task #6 - 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 CWB. The task for NOAA/ESRL/GSD, in this area is the development of new tools that extend and enhance the forecast applications. Further NOAA/ESRL/GSD interaction with CWB is critical to keep CWB staff up to date on current AWIPS II developments. This task will directly improve and update CWB's current forecast assistant and decision making systems at appropriate levels, including ALPS (AWIPS Linux Prototype System) which is an upgrade of AWIPS with ensemble forecast products.

NOAA/ESRL/GSD has U.S. export control approval to provide CWB with AWIPS II software as released by the contractor. The software was first made available to CWB in 2013. During IA #28, NOAA/ESRL/GSD will continue provide updated versions and training to CWB visiting scientists on the new AWIPS II extended/ enhanced forecaster applications such as GFE improvements and Collaboration that are being developed by NOAA/ESRL/GSD.

NOAA/ESRL/GSD will continue to provide the NOAAPORT data feed and data transmission support for CWB's data assimilation and forecasting purposes during IA #28. This continuing interaction task will benefit both NOAA and the CWB, with the updated knowledge of the forecast assistant and decision making systems developed at NOAA including AWIPS II. Throughout the period of IA #28, NOAA/ESRL/GSD will provide necessary training and support to CWB visitors and forecasters, continue the exchange of visits, provide necessary papers and reports, attend annual meetings, and continue e-mail interactions, as applicable.

After the 2011 Japan Tohoku earthquake and tsunami and the previous severe event in Chile in 2010, there is the real potential large-scale tsunami threats to the territory of the authorities represented by TECRO. According to historical records dating from 1661, this territory has been struck by six disastrous tsunamis, occurring in 1661, 1721, 1781, 1792, 1866, and 1867. The PTWC (Pacific Tsunami Warning Center, a United States federal agency) located in Hawaii, has contributed substantially to reducing damage caused by tsunamis.

CWB has a plan to enhance tsunami warning system in the territory of the authorities represented by TECRO by installing additional DART® (Deep-ocean Assessment Reporting of Tsunamis) south of this territory. DART®, originally developed by NOAA, is a critical component of NOAA tsunami program. NOAA NWS is responsible for the overall execution of the tsunami program. NWS also supports observations and data management through the National Data Buoy Center (NDBC). During IA #28, GSD will coordinate an assessment study of CWB's tsunami warning system requirement from NOAA research.

Task #7 – Support of Restoral of CWB's Wu-Fan-Shan WSR-88D Radar

During IA #28, NOAA/ESRL/GSD has agreed that NWS/OBS (Office of Observations) will lead this task. NWS/OBS will provide support for restoral of the Wu-Fan-Shan WSR-88D radar required for CWB. AIT will: provide guidance to NWS on consultations with representatives of

TECRO; coordinate the transfer of funds to NOAA/NWS for all reimbursable activities; and accept support documentation and distribute as appropriate.

This task will include analysis of the damage to the WSR-88D radar and identification of the hardware that need to be repaired or replaced. NWS/OBS will make available to CWB, as requested, documentation of the hardware that need to be repaired or replaced. This documentation will identify the hardware to be replaced that CWB will be able to obtain commercially. The documentation will identify the WSR-88D unique hardware to be replaced or repaired that is only available through NWS/OBS.

On a reimbursable basis, ROC (Radar Operations Center) will provide CWB with replacement and depot repair of line replaceable units for WSR-88D unique hardware. The total cost for the support activities provided by NWS/OBS are dependent on a number of variables, such as extent of damage and cost of repair or replacement of hardware. NWS/OBS, however, estimates the following costs: 1) $100,000 for repair or replacement costs reconditioning and replacement part costs for WSR-88D unique parts, 2) $75,000 for electronics technicians, 3) $36,000 for travel costs and 4) $96,000 for shipping depot corrective equipment.

In order for ROC to provide the reconditioning of hardware identified, the following conditions must be met by the CWB, all customs clearances must be coordinated and all taxes and costs for shipment of WSR-88D equipment, parts, and consumables to and from the territory of the authorities represented by TECRO must be paid to restore the radar.

Article IV - Responsibilities of AIT

In addition to participation in the joint project team, AIT, through its designated representative, shall:

A. Provide overall coordination project activities at the NOAA/ESRL/GSD facility in Boulder, Colorado;

B. Provide administrative support for preparing reports for delivery to CWB in accordance with this Implementing Arrangement;

C. Assign appropriate staff to perform the activities defined in this Implementing Arrangement and provide support in accordance with the terms of the Umbrella Agreement; and

D. Fulfill its responsibilities under the Statement of Work for Implementing Arrangement #28.

Article V - Responsibilities of TECRO

In addition to participation in the joint project team, TECRO, through its designated representative, shall:

A. Provide overall coordination project activities at the CWB facility;

B. Assign appropriate staff to perform the activities defined in this Implementing Arrangement and provide support in accordance with the terms of the Umbrella Agreement; and

C. Fulfill its responsibilities under the Statement of Work for Implementing Arrangement #28.

Article VI - Financial Provisions

In accordance with the Umbrella Agreement, TECRO is required to reimburse AIT for all costs incurred by NOAA/ESRL/GSD in association with the project covered by this Implementing Arrangement. AIT shall transfer to NOAA/ESRL/GSD all payments made by TECRO to AIT for costs incurred by NOAA/ESRL/GSD in association with this Implementing Arrangement.

The total cost for activities described in this Implementing Arrangement is mutually agreed to be U.S. $1,395,000. TECRO agrees to transfer fifty percent of the funds to AIT in advance, with the remaining fifty percent to be transferred upon completion of the year's activities, to the extent that funds for this purpose have been provided by TECRO.

NOAA Information
Treasury Symbol: 13x1450
Business Event Type Code: COLL
CBS ACCS:
5037000000000000
DUNS: 16-2008767
EIN: 84-1040636
ALC: 13-14-0001
OMB MAX CODE: 006-48
BETC CODE: COLL

The performance by NOAA/ESRL/GSD of activities under this Implementing Arrangement is subject to the availability of funds.

Article VII - Intellectual Property Considerations

No intellectual property considerations are expected to arise in conjunction with activities described in this Implementing Arrangement. Existing system designs and computer software of the forecast system of NOAA/ESRL/GSD are in the public domain. Reports, specifications, and computer software prepared under this Implementing Arrangement also will be in the public domain once NOAA and CWB have approved them in final form.

Article VIII - Effective Date, Amendment, and Termination

This Implementing Arrangement is effective on the date of the last signature hereto. This

Implementing Arrangement may be amended and/or terminated in accordance with the terms of the Umbrella Agreement. The estimated completion date for the activities described in this Implementing Arrangement is December 31, 2016, and the termination date of this Implementing Arrangement is June 30, 2017.

FOR THE TAIPEI ECONOMIC AND CULTURAL REPRESENTATIVE OFFICE IN THE UNITED STATES

Remus Li-Kuo Chen
Deputy Representative

12-27-2016
Date

FOR THE AMERICAN INSTITUTE IN TAIWAN

John J. Norris Jr.
Managing Director

12-27-2016
Date

Statement of Work
For Implementing Arrangement #28
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) (hereinafter NOAA/ESRL/GSD), 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 #28 of the Agreement between the American Institute in Taiwan and the Taipei Economic and Cultural Representative office in the United States for Technical Cooperation in Meteorology and Forecast Systems Development, which provides for technical cooperation between NOAA/ESRL/GSD and CWB. The two designated representatives cooperate on the development of meteorology and forecast systems.

The Weather Forecast Office system (WFO-Advanced) currently under development at NOAA/ESRL/GSD in Boulder, Colorado, has been deployed as an essential part of the Advanced Weather Interactive Processing System II (AWIPS II) for the U.S. National Weather Service (NWS). The WFO-Advanced system development has been a very important cooperative activity between NOAA/ESRL/GSD and CWB to support the mission of establishing hazardous weather monitoring and forecasting. Figure 1 lists the important components and figure 2 illustrates the software architecture for WFO-AWIPS II here:

Environmental Data Exchange(EDEX)	Common AWIPS Visualization Environment(CAVE)	Users System
- Notification Subscription Interface - Statistical Analysis - Event framework - Sync Manager - Bandwidth Manager - Authorization Framework - Retrieval Framework - ebXML Manager - PostgreSQL and PDO Database	- Subset Manager - Dataset Discovery Browser - Subscription Manager - Notification Center - System Management - Bandwidth Utilization Graph - Statistics Display - User Admin	-NOAAPORT -GFE -HS -FFMP (MDL) -global model -NESDIS -WSR-88D

Figure 1. The important components of WFO-AWIPSII and Users System

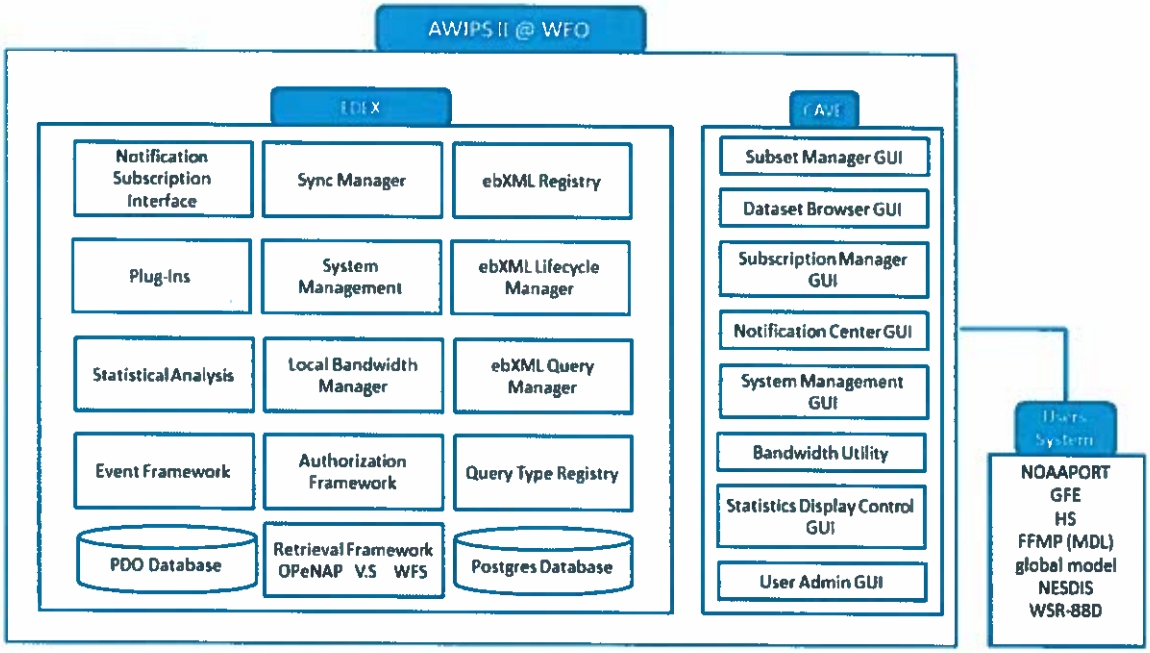

Figure 2. Software architecture for WFO-AWIPSII and Users System

Seven tasks are identified: (1) Development and Improvement of Satellite Products for Tropical Storm Monitoring and Prediction; (2) High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) Applications Improvement; (3) Enhance Nowcasting Decision Assistance Tools; (4) Development of High-Resolution Product Generation Assistance Tools for AWIPS II; (5) Development of Intra-seasonal to Inter-annual Climate Monitoring and Forecast;(6) Continuing Interaction on Earlier Cooperative Projects; and (7) Provisions of operations, maintenance, and reconditioning support for the WSR-88D system.

The tasks will be undertaken by the NOAA/ESRL/GSD-CWB Joint Team as the designated representatives of the TECRO and AIT, working at the NOAA/ESRL/GSD facility in Boulder, Colorado, the NOAA/NSSL(National Severe Storms Laboratory) in Norman Oklahoma, the NOAA/NESDIS (National Environment Satellite, Data, and Information Services) and NOAA/NCEP/CPC (Climate Prediction Center) facility in College Park, Maryland, the NOAA/NWS/MDL (Meteorological Development Laboratory) in Silver Spring, Maryland, the NWS/OBS/ROCC (Radar Operations Center) in Norman, Oklahoma 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 NOAA/ESRL/GSD - CWB Joint Team under the terms of Implementing Arrangement #28 (IA #28). It describes the performance period, deliverables, and resource requirements.

2.0 - Task Descriptions

In terms of the overall program schedule, the following seven tasks have been identified as critical during the January 1 to December 31, 2016 time period. Each task is listed in detail below, along with the estimated proportion of resources that is to be allocated to each task.

Task #1 Development and Improvement of Satellite Products for Tropical Storm Monitoring and Prediction

During IA #28, NOAA/ESRL/GSD has agreed that STAR/SMCD will lead this task. NOAA/STAR/SMCD will continue providing near real-time polar orbiting satellite global 1b radiance data from AMSU-A and MHS onboard NOAA-18, NOAA-19, MetOp-A, and MetOp-B satellites. Also STAR/SMCD will provide data retrieval script for users to directly download data from public available data servers. Remote technical support will be provided for satellite 1b data recovery.

For Microwave Integrated Retrieval System (MiRS), STAR/SMCD will provide updated MiRS packages and documentation for multiple satellite product retrieval and on-site or remote technical support for MiRS implementation.

Due to the similarity between Himawari AHI and GOES-R ABI instruments, STAR/SMCD will provide GOES-R ABI selected product retrieval algorithms as reference to let customer to develop its own Himawari AHI product retrieval package.

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

Resources Required: 10.0 % NOAA/ESRL/GSD/CWB

Deliverables and Schedule:

1. Near real-time polar orbiting satellite level 1b radiances and products — 11/15/16
    a. AMSU-A/MHS onboard NOAA-18, NOAA-19, MetOp-A, MetOp-B
    b. SSMIS onboard DMSP F16, F17, F18
    c. Blended TPW products
    d. MetOp-A, MetOP-B ASCAT wind products and WindSAT wind products
    e. Global Data Assimilation System (GDAS) gridded data for MiRS
    f. Remote technical support on data recovery
2. Updated MiRS for multiple satellite product retrieval — 11/15/16
    a. Updated MiRS package and document
    b. Technical support for MiRS

implementation

3. GOES-R ABI selected product retrieval calibration coefficients — 11/15/16
    a. GOES-R ABI aviation convective initiation

Task #2 – High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) Applications Improvement

During IA #28, NOAA/ESRL/GSD, has agreed that NOAA/NSSL (National Severe Storms Laboratory) will continue research towards maintenance, refinement, and improvement of the High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) applications required for CWB, the Water Resources Agency (WRA), and the Soil and Water Conservation Bureau (SWCB).

This task will include documentation of a real-time QPE (Quantitative Precipitation Estimation) and QPF (Quantitative Precipitation Forecast) product verification software package and implementation of the software in the QPESUMS (Quantitative Precipitation Estimation and Segregation Using Multiple Sensors) system. Data from new CWB C-band dual-polarization precipitation radars will be collected and integrated with existing radars in the current HRQ2 system, and impacts of the new data on various radar mosaic and precipitation products will be evaluated. Real-time polarimetric radar QPE products implemented during previous IAs will be evaluated systematically, and enhancements and refinements will be developed based on the evaluation results and new requirements from the CWB, WRA, and SWCB.

NOAA/NSSL will make available to CWB, as requested, documentation of the real-time precipitation product verification software and source code for its implementation in the QPESUMS. NOAA/NSSL will also make available to CWB, as requested, the implementation of the enhanced radar QPE in the real-time HRQ2 system as part of QPESUMS technical support.

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

Resources Required: 11.8 % NOAA/ESRL/GSD/CWB

Deliverables and Schedule:

1. Real-time verification package of QPE and 1-hour QPF in QPESUMS system — 7/31/16
    a. Documentation of the real-time verification software — 7/31/16
    b. Initial implementation of the verification software in QPESUMS — 7/31/16
2. Data ingestion and integration of the new CWB precipitation radars — 9/30/16
    a. Collection of data from new CWB C-band dual-polarization radars. — 7/31/16

b. Analyze new data and document the data quality and create single radar precipitation estimates. 7/31/16
c. Integrate the new radar data into HRQ2 radar mosaic and precipitation products and document the impact of the new data. 9/30/16

3. Update of the CWB C-band and S-band polarimetric radar QPE 10/30/16
   a. Identify areas of the current radar QPE that need improvement and document the scientific issues 10/30/16
   b. Develop and implement solutions in the HRQ2 system and document impacts to the radar QPE products. 10/30/16
4. Technical support for QPESUMS operations 11/30/16

Task 3 - Enhance Nowcasting Decision Assistance Tools

The Meteorological Development Laboratory (MDL) of the National Weather Service (NWS) has developed a comprehensive suite of decision assistance tools which cover the full scope of hydrometeorological phenomena and forecaster responsibilities. In the past few years, the MDL has assisted and supported porting various applications into the Weather Integration and Nowcasting System (WINS) of Taiwan's Central Weather Bureau (CWB).

As part of Implementation Arrangement #28 (IA #28), NOAA/ESRL/GSD has agreed that the MDL will continue to provide technical and training support to the CWB to enhance the CWB in the area of nowcasting decision assistance tools that have already been implemented. That support includes source code and configuration modification that is appropriate for CWB's use.

First, MDL will focus on more thorough customization support to the Flash Flood Monitoring and Prediction (FFMP) tool on its operational use at the Forecast Center after the Hydrologic Unit Code (HUC) layer implementation is made in IA #27 as the HUC layers would add more important hydrological characteristics beyond the implementation of Township layer and small-basin layer that were completed in IA #25 and IA #26.

Secondly, MDL will continue to technically support CWB on its implementation of System on AWIPS for Forecasting and Evaluation of Seas and Lakes (called SAFESEAS) under AWIPS2 development environment.

Thirdly, MDL will continue provide CWB training and technical support on the AutoNowCaster (ANC) system. The MDL's version of ANC, which is substantially different from its original NCAR version and has been improved with far fewer software crashes and much easier configuration for its operational use, was delivered to CWB along with a verification package in IA #27. The ongoing training and technical support are needed to configure it, use it, and interpret its results so that the CWB's forecasters make informed use of ANC's output.

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

Resources Required:	13.6 % NOAA/ESRL/GSD/CWB
Deliverables and Schedule:	
1. Support on Decision Assistance Tools	11/30/16
a. Continue the consultation support on the modification of FFMP shape files in terms of the hydrological streams provided by Water Resource Agency for HUC layer implementation. Some manual and time-consuming processes for basin delineation are needed after Forecast Center verifies and corrects suspicious rivers and streams.	11/30/16
b. Continue the consultation support on SAFESEAS application in AWIPS2 development environment so that CWB could start the migration of their SAFELand and SAFERain as the development CWB has done for AWIPS1 WINS system.	11/30/16
c. Support the migration of FFMP from AWIPS1 to AWIPS2 systems and provide document training on how to make local customization.	11/30/16
2. ANC System Configuration Support	11/30/16
a. Continue support the MDL's version ANC for CWB to have the comparable functions with the current operational TANC.	11/30/16
b. Continue support CWB using the verification package to verify the 60-minute nowcast of the operational TANC.	11/30/16
c. Convert the gridded binary file to the MDV format. i. Mosaic radar data (gridded binary format to MDV) ii. Lightning data (QPESUMS gridded binary format to MDV)	11/30/16
d. Convert various NetCDF files (wind, RH, and temperature fields) that are obtained from Forecaster Center to the MDV format.	11/30/16

Task #4 - Development of High-Resolution Product Generation Assistance Tools for AWIPS II

The National Weather Service (NWS) has been developing AWIPS II for several years. This replacement for the original AWIPS (the basis of the current CWB Weather Integration and Nowcasting System (WINS) is running at all NWS WFO (Weather Forecast Offices) sites before the end of 2015. AWIPS II provides essentially the same appearance and function ("look and feel") as AWIPS I, reducing the need for extensive forecaster training. The underlying software is written largely in Java and loosely follows a services oriented architecture (SOA) design.

During IA #27, NOAA/ESRL/GSD received permission from NWS to provide an evaluation copy of the AWIPS II software to CWB. This support continued through IA #28, with periodic updates provided. GSD also provided AWIPS II training for CWB developers. Two CWB visitors to GSD in 2015 learned much about AWIPS II and, with GSD, began design/development work on some CWB-specific data ingest such as lightning data and display plugins, working toward eventual realization of a WINS-II.

For IA #28, GSD will continue to support CWB developers by providing updated versions of the AWIPS II software. GSD will work with NWS/Meteorological Development Laboratory to set up a shared software repository, where GSD and CWB visitor(s) will maintain code that they will share with other CWB staff who are developing and testing new software.

GSD has explored the new FDSE (Forecaster Decision Support Environment) system to view and data pertinent to the given weather scenario. There are three major components that make up the FDSE: Ensemble tools, Grid monitor and Short-term update tool. During IA #28, GSD will provide some training of FDSE to CWB forecasters to explore new data management and processing capabilities to enhance situation awareness, allow forecasters to work more efficiently, and improve model ensemble capabilities in order to explore probabilistic forecast products. Additional collaborative work will address ingest and display of CWB-specific lightning, satellite, and grid datasets.

During IA #28, GSD will provide technical support for the Graphical Forecast Editor (GFE), GFE Smart Tools (techniques to automate or semi-automate grid editing), and the text formatters (TF) used in CWB's Forecast Information Editing System (FIES). In conjunction with NWS, GSD continues to work on improvements in Smart Tools, and is developing new forecast monitoring and ensemble-based forecast support tools, some of which will be included in the AWIPS II release in mid-2016.

This interaction will benefit CWB with updated knowledge of the forecast assistant and decision making systems developed at NOAA including AWIPS II. Throughout the period of IA #28, NOAA/ESRL/GSD will provide training and support to CWB visitors and forecasters, continue the exchange of visits, provide reports, attend annual meetings, and continue e-mail interactions.

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

Resources Required: 20.8 % NOAA/ESRL/GSD/CWB

Deliverables and Schedule:

1.	Prepare and deliver updated versions of AWIPS II software	7/31/16; 10/30/16
2.	On-site AWIPS II training for CWB staff	11/30/16
3.	Provide technical support on GFE Smart Tools for CWB's TF development	11/30/16
4.	AWIPS II software development support	11/30/16

Task #5 – Development of Intra-seasonal to Inter-annual Climate Monitoring and Forecast

During IA #28, NOAA/ESRL/GSD has agreed that NWS/NCEP's (National Centers of Environmental Prediction) will lead this task. NCEP will continue to support CWB in advancing the monitoring and forecast capabilities, in particular for the intraseasonal to interannual time scales.

CWB holds the responsibility to informed society preparing for and responding to weather and climate variations and their impacts, by delivering real-time products and information that predict and describe weather and climate variations on timescales from hours to years thereby promoting effective management of meteorological risk and a resilient society.

Meteorological services around the world all are facing the expanding requirements for providing, and improving, climate services. The services subjects could range from providing extended range forecasts, hazard outlooks, historical data, to tailored derivative information requested by government agencies and industrial sectors for national interests. It mandates the meteorological services, such as CWB, to layout a new strategic plan, developing new capabilities in human talents, absorbing scientific discoveries, devising new tools, and implementing technical advances.

Specific for IA #28, NOAA will continue to assist CWB in developing capability for climate services, by 1) providing training, either through NCEP's International Monsoon Training Desk Program or EMC visitor/guest programs; 2) Attending CWB-organized workshop on TWCFS and providing planning and scientific consultation to CWB at the workshop and meetings; and 3) Assisting and facilitating CWB professionals to attend scientific conferences and meetings in the territory of the authorities represented by AIT.

To help improve the satellite data application in CWBGFS (CWB Global Forecast system), NOAA/STAR/SMCD will provide technical support on satellite data assimilation implementation and improvement.

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

Resources Required: 20.1 % NOAA/ESRL/GSD/CWB

Deliverables and Schedule:

1. Providing CWB professional Training and hosting model Co-Development via NCEP's International Monsoon Training Desk Program, or EMC visitor/guest programs; 11/30/16
    a. Support CWB personnel attending NOAA/NCEP's Monsoon Desk training
    b. Support one CWB staff to visit EMC on the development of coupling ocean model to the Global Forecast Model.
    c. Support one CWB staff to visit EMC on the development of model dynamics of the deep atmospheric model
2. NCEP colleagues to visit CWB: for attending CWB workshops, delivering seminars and lectures at research/development institutions, and also providing planning development consultations. 11/30/16
3. Facilitating CWB professionals to attend scientific conferences and meetings in the US. 11/30/16
4. Satellite data assimilation improvement for CWBGFS 11/30/16
    a. Help diagnose radiative transfer model issues in CWBGFS
    b. Test Himawari AHI imager data assimilation in CWBGFS
    c. Technical support for CWBGFS satellite data assimilation part

Task #6 - 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 CWB. The task for NOAA/ESRL/GSD in this area is the development of new tools that extend and enhance the forecast applications. Further NOAA/ESRL/GSD interaction with CWB is critical to keep CWB staff up to date on current AWIPS II developments. This task will directly improve and update CWB's current forecast assistant and decision making systems at appropriate levels, including ALPS (AWIPS Linux Prototype System) which is an upgrade of AWIPS with ensemble forecast products.

NOAA/ESRL/GSD has U.S. export control approval to provide CWB with AWIPS II software as released by the contractor. The software was first made available to CWB in 2013. During IA #28, NOAA/ESRL/GSD will continue provide updated versions and training to CWB visiting scientists on the new AWIPS II extended/ enhanced forecaster applications such as GFE improvements and Collaboration that are being developed by

NOAA/ESRL/GSD.

NOAA/ESRL/GSD will continue to provide the NOAAPORT data feed and data transmission support for CWB's data assimilation and forecasting purposes during IA #28. This continuing interaction task will benefit CWB with the updated knowledge of the forecast assistant and decision making systems developed at NOAA including AWIPS II. Throughout the period of IA #28, NOAA/ESRL/GSD will provide necessary training and support to CWB visitors and forecasters, continue the exchange of visits, provide necessary papers and reports, attend annual meetings, and continue e-mail interactions, as applicable.

After the 2011 Japan Tohoku earthquake and tsunami and the previous severe event in Chile in 2010, there is the real potential large-scale tsunami threats to the territory of the authorities represented by TECRO. According to historical records dating from 1661, that territory has been struck by six disastrous tsunamis, occurring in 1661, 1721, 1781, 1792, 1866, and 1867. The PTWC (Pacific Tsunami Warning Center, a United States federal agency) located in Hawaii, has contributed substantially to reducing damage caused by tsunamis.

CWB has a plan to enhance tsunami warning system in the territory of the authorities represented by TECRO by installing additional DART® (Deep-ocean Assessment Reporting of Tsunamis) south of that territory. DART®, originally developed by NOAA, is a critical component of NOAA tsunami program. NOAA NWS is responsible for the overall execution of the tsunami program. NWS also supports observations and data management through the National Data Buoy Center (NDBC). During IA #28, GSD will coordinate an assessment study of CWB's tsunami warning system requirement from NOAA research.

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

Resources Required:	21.2 % NOAA/ESRL/GSD/CWB

Deliverables and Schedule:

1. ALPS system (necessary technical support)	11/30/16
2. AWIPS II training to CWB users	11/30/16
3. NOAAPORT data supply support	11/30/16
4. DART® requirement assessment for CWB	10/30/16
5. Visitors and travel support	11/30/16

Task #7 – Support of Restoral of CWB's Wu-Fan-Shan WSR-88D Radar

During IA #28, NOAA/ESRL/GSD has agreed that NWS/OBS (Office of Observations) will lead this task. NWS/OBS will provide support for restoral of the Wu-Fan-Shan WSR-88D radar required for TECRO's designated representative, CWB. AIT will: provide guidance to NWS on consultations with representatives of TECRO; coordinate the transfer of funds to NOAA/NWS for all reimbursable activities; and accept support

documentation and distribute as appropriate.

This task will include analysis of the damage to the WSR-88D radar and identification of the hardware that need to be repaired or replaced. NWS/OBS will make available to CWB, as requested, documentation of the hardware that need to be repaired or replaced. This documentation will identify the hardware to be replaced that CWB will be able to obtain commercially. The documentation will identify the WSR-88D unique hardware to be replaced or repaired that is only available through NWS/OBS.

On a reimbursable basis, ROC (Radar Operations Center) will provide CWB with replacement and depot repair of line replaceable units for WSR-88D unique hardware. The total cost for the support activities provided by NWS/OBS are dependent on a number of variables, such as extent of damage and cost of repair or replacement of hardware. NWS/OBS, however, estimates the following costs: 1) $100,000 for repair or replacement costs reconditioning and replacement part costs for WSR-88D unique parts, 2) $75,000 for electronics technicians, 3) $36,000 for travel costs and 4) $96,000 for shipping depot corrective equipment.

In order for ROC to provide the reconditioning of hardware identified, the following conditions must be met by the CWB, all customs clearances must be coordinated and all taxes and costs for shipment of WSR-88D equipment, parts, and consumables to and from the territory of the authorities represented by TECRO must be paid to restore the radar.

The following summarizes the schedule and resources required for Task #7:

Resources Required:	2.5% NOAA/ESRL/GSD/CWB NOAA/NWS/OBS/ROC
Deliverables and Schedule:	
1. Evaluation of damage to Taiwan polarimetric radar	7/31/16
a. Identification of part to be repaired	7/31/16
b. Identification of parts to be replaced	7/31/16
c. Identification of commercial parts to be ordered by CWB	7/31/16
2. Return of WSR-88D hardware for repair	7/31/16
3. Coordination with CWB on Restoral Schedule dependent on availability of commercial items	7/31/16
4. Restoral of CWB's WSR-88D	9/30/16

3.0 - Schedule

Tasks	Functions	Milestones
1.	Provide satellite products, algorithms for tropical storm monitoring and prediction	11/30/16
2.	Provide improved HRQ2 system to support operation and evaluation	11/30/16
3.	Provide technical support on decision assistance tools (FFMP and Others) and MDL's version of ANC and necessary training	11/30/16
4.	Provide AWIPS II software releases, training and technical support on GFE smart tools for CWB's FIES development	11/30/16
5.	Provide NCEP Monsoon Desk training, support CWB workshop and CDPW workshop and support Satellite data assimilation improvement for CWBGFS.	11/30/16
6.	Provide technical support of ALPS and AWIPS II user training, and NOAAPORT data transition, DART® assessment study, visitors and travel support and relevant documents	11/30/16
7.	Provisions of operations, maintenance, and reconditioning support for the WSR-88D system	11/30/16

Schedule by Month

Task 1 Satellite application	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1. Polar level 1b (or SDR) radiance and products	x	x	x	x	X	x	x	x	x	x	x	
2. Technical support on MiRS improvement and updates	x	x	x	x	X	x	x	x	x	x	x	
3. GOES-R AB1 selected products retrieval ATBD	x	x	x	x	X	x	x	x	x	x	x	

Task 2 HRQ2 (NSSL)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1. Real-time verification package of QPE and QPF in QPSUMS	x	x	x	x	x	x	x					
2. Data ingestion and integration of new CWB precipitation radars	x	x	x	x	x	x	x	x	x			
3. Update CWB C-band and S-band polarimetric radar QPE	x	x	x	x	x	x	x	x	x	x		
4. QPESUMS technical support	x	x	x	x	x	x	x	x	x	x	x	

Task 3 Enhanced Nowcasting Decision tools (MDL)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1. Support on Decision Assistance Tools	x	x	x	x	x	x	x	x	x	x	x	
2. ANC System Configuration Support	x	x	x	x	x	x	x	x	x	x	x	

Task 4 High-resolution forecast product generation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1. Prepare and deliver updated versions of AWIPS II software							x			x		
2. On-site AWIPS II training for CWB staff					x	x	x	x	x	x	x	
3. Provide technical support on GFE Smart Tools for CWB's TF development	x	x	x	x	x	x	x	x	x	x	x	
4. AWIPS II software development support	x	x	x	x	x	x	x	x	x	x	x	

Task 5 Climate monitor and forecast (NCEP/CPC)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1. Providing CWB professional Training and hosting model Co-Development via NCEP's International Monsoon Training Desk Program, or EMC visitor programs	x	x	x	x	x	x	x	x	x	x	x	
2. NCEP colleagues to visit CWB	x	x	x	x	x	x	x	x	x	x	x	
3. Facilitating CWB professionals to attend conferences/meetings	x	x	x	x	X	x	x	x	x	x	x	
4. CWBGFS Satellite data assimilation support	x	x	x	x	X	x	x	x	x	x	x	

Task 6 interaction on earlier projects	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1. ALPS system support (necessary support)	x	x	x	x	x	x	x	x	x	x	x	
2. AWIPS II CWB users training	x	x	x	x	x	x	x	x	x	x	x	
3. NOAAPORT data support	x	x	x	x	x	x	x	x	x	x	x	
4. DART requirement assessment for CWB	x	x	x	x	x	x	x	x	x	x	x	
5. CWB visitors and travel support	x	x	x	x	x	x	x	x	x	x	x	

Task 7 Support of WSR-88D system	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1. Evaluation of damage to Taiwan polarimetric radar	x	x	x	x	x	x	x					
2. Return of WSR-88D hardware for repair	x	x	x	x	x	x	x					
3. Coordination with CWB on Restoral Schedule	x	x	x	x	x	x	x					
4. Restoral CWB's WSR-88D	x	x	x	x	x	x	x	x	x	x	X`	

4.0 - Budget

The following are the estimated costs for IA #28:

Tasks	Personnel	Travel/Training	Total
Task #1 (NESDIS/GSD)	$125,000	$ 15,000	$ 140,000
Task #2 (NSSL)	$150,000	$ 15,000	$ 165,000
Task #3 (MDL/GSD)	$175,000	$ 15,000	$ 190,000
Task #4 (GSD)	$275,000	$ 15,000	$ 290,000
Task #5 (NCEP/CPC)	$265,000	$ 15,000	$ 280,000
Task #6 (GSD)	$280,000	$ 15,000	$ 295,000
Task #7 (NWS/OBS/ROC)	$30,000	$ 5,000	$ 35,000
Total	**$1,300,000**	**$95,000**	**$ 1,395,000**

As stated in IA #28, the funds available from TECRO to support the tasks, travel, and meeting expenses described in this Statement of Work will be a total of US$ 1,395,000. US$ 1,045,000 will be provided by CWB, US$ 250,000 by the Water Resources Agency (WRA), and US$ 100,000 by the Soil and Water Conservation Bureau (SWCB). 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 Umbrella 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 U.S. Government Fiscal Year 1991, 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.

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 CWB staff-in-residence at NOAA/ESRL/GSD, NOAA/NESDIS, and NOAA/NWS/MDL. The primary effort of CWB staff at NOAA during the IA #28 period will be directed towards the satellite data, GFE and AWIPS II development tasks. The primary effort of CWB staff at NOAA/NCEP/CPC during the IA #28 period will be to get familiar with the operations of the CPC International Monsoon Desk. It is important that qualified CWB staff be available to work at NOAA research and operations facilities during the period of this Implementing Arrangement. 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 high-resolution forecast product generation assistance tool to

support CWB's FIES;

- Development of forecast applications under AWIPS II environment;
- Receiving training at CPC for ocean couple model development training;
- Receiving training at NSSL for radar QPE training;
- Receiving training at the NCEP International Monsoon Desk and other facility.