**STATEMENT OF WORK
FOR IMPLEMENTING ARRANGEMENT #26
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 #26 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 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 (AWIPS) 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 to support the mission of establishing hazardous weather monitoring and forecasting. Figure 1 illustrates the potential WFO-Advanced components listed here:

- National and local data feeds

- 3DVAR data assimilation and NWP (Numerical Weather Prediction)

- Satellite and remote sensing products

- HRQ2 (High-Resolution Quantitative Precipitation Estimation 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 National Weather Service (NWS) Office of Hydrology

- A component that contains General X applications

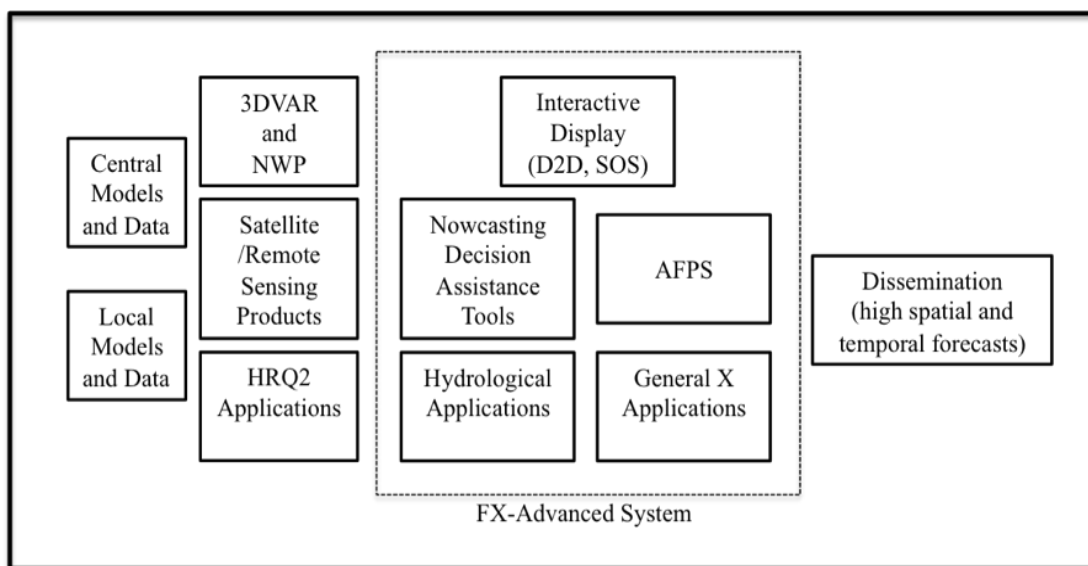- Dissemination of high spatial and temporal forecast and warning products

Figure 1: WFO-Advanced

Six 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) Enhancement of 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; and (6) Continuing Interaction on earlier cooperative projects.

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, 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, 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 #26 (IA #26). It describes the performance period, deliverables, and resource requirements.

2.0 - Task Descriptions

In terms of the overall program schedule, the following six tasks have been identified as critical during the January 1 to December 31, 2014 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 #26, AIT's designated representative, 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 and products data from AMSU-A and MHS onboard NOAA-18, NOAA-19, MetOp-A, MetOp-B and MetOp-B satellites. Also STAR/SMCD will provide SSMIS onboard DMSP

F16, F17, F18, blended TPW products, MetOp-A ASCAT winds products, WindSAT wind products and Global Data Assimilation System (GDAS) gridded data for MiRS. Remote technical support will be provided for satellite 1b data recovery.

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

STAR/SMCD will continue the effort to implement the HWRF satellite data assimilation system for the Pacific region during IA #26. It includes an updated HWRF package and technical support and documentation on upgraded systems, on-site or remote technical support for HWRF implementation and direct broadcast ATMS BUFR data for HWRF. Two CWB staff will visit STAR/SMCD for evaluation of HWRF performance, polar orbit satellite data assimilation and community radiative transfer application.

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

Resources Required: 25.8 % NOAA/ESRL/GSD/CWB

Deliverables and Schedule:

1. Near real-time polar orbiting satellite level 1b radiances and   11/15/14
    products
        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   09/30/14
        a. Updated MiRS package and document
        b. Technical support for MiRS implementation

3. Beta version of HWRF satellite data assimilation system for   11/15/14
    Pacific region applications
        a. Upgraded HWRF satellite data assimilation
            package and document
        b. Technical support for HWRF implementation
        c. Broadcast ATMS BUFR data for HWRF

4. Two CWB developers training on HWRF evaluation and   11/15/14
    CRTM application

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

During IA #26, AIT's designated representative, 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 TECRO's designated representatives, CWB, the Water Resources Agency (WRA), and the Soil and Water Conservation Bureau (SWCB).

This task will include integration of two new radars: one RCWF polarimetric radar, and one Japanese C-band single-pole radar at the Ishigaki-jima island which is about 200 km east of Taiwan. For the RCWF radar data, NSSL will test polarimetric radar algorithms and integrate QPE into QPESUMS, and also integrate RCWF hydrometeor classification into the 3D mosaic. For the Japanese radar data, NSSL will decode the data and develop reference data sets, and integrate the data into a reflectivity mosaic and QPESUMS.

NOAA/NSSL will make available to TECRO's designated representative, CWB, as requested, software source code for the integration of the new polarimetric RCWF data and the Japanese radar into the QPESUMS. NOAA/NSSL will also make available to CWB, as requested, the implementation of the aforementioned modules 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: 12.2 % NOAA/ESRL/GSD/CWB

Deliverables and Schedule:

1.	Integration of the new polarimetric RCWF data into the QPESUMS	11/30/14
	a. Test Polarimetric radar algorithms on new RCWF data	06/30/14
	b. Integrate new RCWF polarimetric radar QPE into QPESUMS	09/30/14
	c. Integrate RCWF hydrometeor classification into the 3D mosaic	11/30/14
2.	Integration of a Japanese radar into the real-time QPESUMS	11/30/14
	a. Decode the radar data and develop reference data sets	03/31/14
	b. Integrate the radar data into the reflectivity mosaic	09/30/14
	c. Integrate the radar data into QPESUMS	11/30/14
3.	Technical support for QPESUMS operations	11/30/14

Task #3 Enhance of Nowcasting Decision Assistance Tools

As part of IA#26, AIT's designated representative, NOAA/ESRL/GSD, has agreed that MDL will continue to provide technical support and training to TECRO's designated representative, CWB, to enhance CWB's WINS in the area of nowcasting decision assistance tools that have already been implemented. This support includes source code modification and configuration appropriate for CWB's use of the tools which have been already ported.

After customizing most of MDL's decision assistance tools, the implementation of FFMP (Flash Flood Monitoring and Prediction) on WINS became one of the major tasks during IA #25. FFMP conducts precipitation analyses over the area of small basins and thus is an integrated suite of multi-sensor applications which detect, analyze, and monitor precipitation and generate short-term warning guidance for flash flooding automatically. During IA #25, the MDL assisted the CWB in customizing FFMP to process and display various data sources such as radar Digital Hybrid Reflectivity (DHR), SCAN (System for Convection Analysis and Nowcasting) QPF, sampled Flash Flood (FFG), CWB's QPESUM data and rain gauge observations. During IA #26, the MDL will continue to provide the CWB with more thorough customization and training support on MDL's decision assistance tools, especially on FFMP to support its operational use at CWB's Forecast Center.

During IA #26, the second task will be to provide CWB's Meteorological Satellite Center (MSC) with software and training so that MSC can tune CWB's ANC (AutoNowCaster) automatically in a flexible and timely manner. Tuning ANC automatically involves choosing data sets, employing an objective forecast verification technique, and devising a fitness function to create forecasts using weights iteratively generated by the genetic algorithm. Automatic tuning is done in a fraction of the time that it takes experts to analyze the data and tune the weights manually.

In the past, CWB used ANC to provide objective guidance for the prediction of afternoon thunderstorms in northern Taiwan during the warm season and found that there was a tendency for the forecasters to over-forecast the number of days on which afternoon thunderstorms actually occurred. To improve CWB's forecast of convective storm initiation and evolution during a field experiment in northern Taiwan, MSC wants to learn the automatic ANC tuning methodology.

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

Resources Required: 21.3 % NOAA/ESRL/GSD/CWB

Deliverables and Schedule:

1. FFMP   11/30/14
     a. Continue support to configure extra data sources
        into FFMP for processing and displaying on
        CWB's operational WINS
     b. User training and support for operational use

2. Other Decision Assistance Tools   11/30/14
     a. Continue technical support for WINS maintenance
        and customization
     b. Continue user training

3. ANC Automatic Tuning	11/30/14
a. Deliver ANC auto-tuning software so that CWB can review the genetic algorithm	01/30/14
b. Two CWB developers train at MDL to learn what the genetic algorithm does, learn how to configure the auto-tuning software, and perform auto-tuning by using collected data	03/30/14
c. Travel to CWB to check both CWB's auto-tuning setup and selected training data sets before the field experiment starts	06/30/14

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) tools) is intended to provide essentially the same appearance and function ("look and feel") to reduce 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#25, AIT's designated representative, NOAA/ESRL/GSD, received permission from NWS to provide an evaluation copy of the AWIPS II software to CWB. GSD also provided training for CWB developers in how to navigate the AWIPS II software repository and how to write plugins to add function to the baseline code.

For IA#26, GSD will continue to support CWB developers by providing updated versions of the software. GSD will do a test installation and configuration before sending updates to CWB, provide support to CWB staff in setting up the new versions, and prepare and deliver additional training on site in Taipei.

AIT's designated representative, NOAA/ESRL/GSD, has developed for AWIPS II a CAVE (Common AWIPS Visualization Environment) Annotation Tool (CAT) that allows NWS forecasters to create and save drawings, including graphics such as Nowcasts and weather stories to publish on the web. NOAA/ESRL/GSD will assist a CWB visiting scientist in understanding the AWIPS II architecture to begin to extend CAT to support CWB's annotation requirements.

During IA#26, AIT's designated representative, NOAA/ESRL/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, NOAA/ESRL/GSD continues to work on improvements in Smart Tools, and is developing new forecast monitoring and ensemble-based forecast support tools. NOAA/ESRL/GSD will prepare and provide on-site GFE training for CWB forecasters. GSD also anticipates hosting a visitor from CWB in 2014 who will participate in this work, thus gaining experience and expertise that will apply to FIES improvements and adaptation for AWIPS II.

NOAA/ESRL/GSD will continue to support CWB's development and customization of BOIVerify by facilitating interaction between visiting CWB forecasters and developers and users of the software.

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

Resources Required: 18.7 % NOAA/ESRL/GSD/CWB

Deliverables and Schedule:

1. Prepare and deliver updated versions of AWIPS II software   6/14, 10/14

2. On-site AWIPS II training for CWB staff   6/14
   a. GFE module and smart tools
   b. Hazard warning services
   c. Operational use of AWIPS II at WFO

3. AWIPS II software development support   10/14

4. Provide technical support on GFE Smart Tools for CWB's TF   04/14 - 11/14
   development

5. Provide CWB forecaster assistance to use and configure   11/14
   BOIVerify software package for CWB's customization and
   development. Help coordinate technical exchange meetings
   with scientists of Boise WFO and BOIVerify software package

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

During IA #26, AIT's designated representative, NOAA/ESRL/GSD, has agreed that NWS/NCEP's (National Centers of Environmental Prediction) /Climate Prediction Center (CPC) and Environmental Modeling Center (EMC) 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.

Meteorological services around the world all are facing the emerging requirements for providing, and improving, climate services. The services subjects could range from providing extended range forecasts, historical data, hazard outlooks, 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.

During IA #26, NOAA will continue to assist CWB in developing climate services capabilities, by 1) providing training through NCEP's International Monsoon Training Desk Program; 2) providing planning and scientific expertise to the Taiwan-West Pacific Climate Forecast System (TWPCFS) Workshop; and 3) Assisting and facilitating CWB professionals to attend scientific conferences and meetings in the US.

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

Resources Required: 7.7 %
                                             NOAA/ESRL
                                             NOAA/NWS/NCEP/CPC
                                             NOAA/NWS/NCEP/EMC

1. Support CWB personnel attending NOAA/NCEP's Monsoon Desk training   11/30/2014
2. Support the 2nd CWB Workshop on development planning for the next generation Global Forecast Model   11/30/2014
3. Support attending the 39th Climate Diagnostics and Prediction Workshop and potentially other workshops and conference meetings relevant for advancing forecast skills, such as S2S and EMUW   10/31/2014
4. Report on the year's tasks.   11/30/2014

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 TECRO's designated representative, CWB. The task for AIT's designated representative, 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 #26, 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 #26. This continuing interaction task will benefit TECRO's designated representative, CWB, with the updated knowledge of the forecast assistant and decision making systems developed at NOAA including AWIPS II. Throughout the period of IA #26, 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.

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

Resources Required: 14.3 % NOAA/ESRL/GSD/CWB

Deliverables and Schedule:

1. ALPS system (necessary technical support)   11/30/14
2. AWIPS II training to CWB users   11/30/14
3. NOAAPORT data supply support   11/30/14
4. Visitors and travel support   11/30/14

3.0 - Schedule

Tasks Functions	Milestones
1. Provide satellite products, algorithms and improvement on NWP modeling and data assimilation	11/30/14
2. Provide improved HRQ2 system to support operation and evaluation	11/30/14
3. Provide technical support on decision assistance tools (FFMP and Others) and ANC automatic tuning	11/30/14
4. Provide AWIPS II software releases, training and technical support and user training on GFE/BOIVerify for CWB's FIES development	11/30/14
5. Provide NCEP Monsoon Desk training, support CWB workshop and CDPW workshop and other workshops	11/30/14
6. Provide technical support of ALPS and AWIPS II user training, and NOAAPORT data transition, visitors and travel support and relevant documents	11/30/14

Schedule by Month

Task 1 Satellite application	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Polar level 1b (or SDR) radiance and products	x	x	x	x	x	x	x	x	x	x	x	
Technical support on MiRS improvement and updates	x	x	x	x	x	x	x	x	x			
Beta version of HWRF satellite data assimilation system from Pacific region applications	x	x	x	x	x	x	x	x	x	x	x	
Provide training on HWRF performance evaluation and community radiative transfer application					x	x	x	x	x	x	x	

Task 2 HRQ2 (NSSL)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Integrate the new polarimetric RCWF data into the QPESUMS	x	x	x	x	x	x	x	x	x	x	x	
Integrate Japanese radar data into the real-time QPESUMS	x	x	x	x	x	x	x	x	x	x	x	
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
FFMP support including Configuration extra data and WINS display	x	x	x	x	x	x	x	x	x	x	x	
Other decision assistance tools technical support for WINS	x	x	x	x	x	x	x	x	x	x	x	
ANC Automatic Tuning software delivery and technical 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
AWIPS II software releases						x				x		
On-site AWIPS II training for CWB staff (GFE, HS)	x	x	x	x	x	x						
AWIPS II software development support	x	x	x	x	x	x	x	x	x	x		
GFE smart tools development support				x	x	x	x	x	x	x	x	

| Provide CWB forecaster assistance on BOIVerify software package | 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
Organize Monsoon Desk visit	x	x	x	x	x	x	x	x	x	x	x	
Support TWPCFS second workshop	x	x	x	x	x	x	x	x	x	x	x	
Support 39th workshop and other visits	x	x	x	x	x	x	x	x	x	x		
Annual task report	x	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
ALPS system support (necessary technical support)	x	x	x	x	x	x	x	x	x	x	x	
AWIPS II CWB users training	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	
CWB visitors and travel support	x	x	x	x	x	x	x	x	x	x	x	

4.0 - Budget

The following are the estimated costs for IA #26

Tasks	Personnel	Travel/Training	Total
Task #1 (NESDIS/GSD)	$ 267,500	$ 35,000	$ 302,500
Task #2 (NSSL)	$ 127,500	$ 15,000	$ 142,500
Task #3 (MDL/GSD)	$ 235,000	$ 15,000	$ 250,000
Task #4 (GSD)	$ 205,000	$ 15,000	$ 220,000
Task #5 (NCEP/CPC)	$ 75,000	$ 15,000	$ 90,000
Task #6 (GSD)	$ 153,000	$ 15,000	$ 168,000
Total	**$ 1,063,000**	**$ 110,000**	**$ 1,173,000**

As stated in IA #26, 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$ 1,173,000. NOAA and AIT understand that US$ 823,000 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 are 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 #26 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 #26 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 NESDIS for HWRF performance evaluation and community radiative transfer application;

- Receiving training at MDL for ANC tuning;

- Receiving training at the NCEP International Monsoon Desk.