Statement of Work
For Implementing Arrangement #17
Continuing Development of the Local Analysis and Prediction System
and
Development of a Warning Decision Support 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 FSL and CWB personnel in accordance with the terms of Implementing Arrangement #17 of the Agreement Between the Taipei Economic and Cultural Representative Office in the United States (TECRO), and the American Institute in Taiwan (AIT) 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 Forecast Systems Laboratory (NOAA/FSL). The two designated representatives cooperate on the development of meteorology and forecast systems.

The WFO-Advanced system currently under development at the NOAA's Forecast Systems Laboratory (FSL) 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 FSL and CWB.

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

- National and local data feeds
- FSL's Local Analysis and Prediction System (LAPS)
- Quantitative Precipitation Estimation and Segregation Using Multiple Sensors (QPE-SUMS)
- Geographical Information System (GIS) data
- The interactive display system (D2D)
- The AWIPS Forecast Preparation System (AFPS)
- 3-D visualization
- Hydrological applications developed at the NWS Office of Hydrology
- A component that contains General X applications
- Local Data Acquisition and Dissemination System (LDAD)

Four tasks are included in the Statement of Work: 1) the Local Analysis and Prediction

System (LAPS), 2) Warning Decision Support System (WDSS), 3) Forecast Assistant System, and 4) continuing interaction on earlier cooperative projects, such as data assimilation for a numerical weather prediction model.

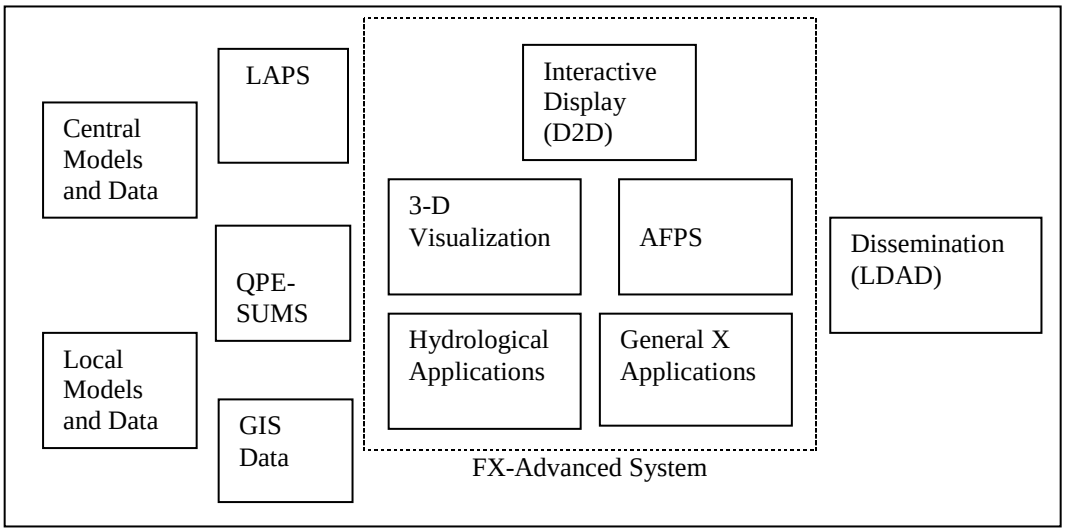

Figure 1 WFO-Advanced

Tasks will be undertaken by the FSL-CWB Joint Team working at the FSL facility in Boulder, Colorado, the NSSL-CWB Joint Team working at the NSSL facility 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 FSL-CWB Joint Team and the NSSL-CWB Joint Team under the terms of Implementing Arrangement #17. It describes the performance period, deliverables, and resource requirements.

2.0 - Task Descriptions

In terms of the overall program schedule, the following four tasks have been identified as being critical during the January 1 to December 31, 2005, time period. These are listed below, along with the estimated proportion of resources that is to be allocated to each task.

- Task #1 - Local Analysis and Prediction System (LAPS) (17%)
- Task #2 - Warning Decision Support System (WDSS) (38%)
- Task #3 - Forecast Assistant System (27%)
- Task #4 - Continuing interaction on earlier cooperative projects (18%)

These four tasks are described in more detail below.

Task #1 – Local Analysis and Prediction System (LAPS)

During Implementing Arrangement #16, FSL and CWB added additional backgrounds such as NFS-15km and NFS-45km as options for LAPS analysis and Hot Start MM5 runs. FSL and CWB also implemented an initial version of the LAPS real-time verification system (LRTVS) for state variables for Hot Start MM5. FSL and CWB continued to improve the cloud scheme and radar QC to enhance LAPS wind analysis. The CWB visiting scientist also began to investigate using typhoon radar derived wind observations for LAPS analysis. FSL has established a shadowing system of CWB's Hot Start MM5 at FSL.

During Implementing Arrangement #17, FSL and CWB will continue to improve the LAPS analysis in the areas of cloud microphysics (Water In All Phases) and assimilation of vertical motion estimates from convective and stratus cloud analysis. FSL and CWB will also investigate any new motion retrieval algorithms based on the horizontal convective wind field using radar winds.

FSL and CWB will begin to adapt the WRF (Weather Research and Forecast) system to link to Taiwan LAPS. Together, we will explore higher model resolution to improve model performance for typhoon rain bands. FSL will implement the typhoon bogussing system in the shadowing system. FSL and CWB will continue to improve the LAPS real-time verification system (LRTVS) for point verification of precipitation and for gridded verification of model QPF with LAPS QPE. FSL will continue running the CWB shadowing system at FSL during Implementing Arrangement #17.

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

Performance Period:	
1. Add WRF model for LAPS	1/1/05 –12/30/05
2. Continue to implement and improve LAPS real-time verification system (LRTVS)	1/1/05 – 12/30/05
3. Improve LAPS analysis and QPF	1/1/05 – 12/30/05
4. Continue running shadowing Hot Start CWB's LAPS system at FSL	1/1/05 – 12/30/05
5. Provide LAPS user training and documentation	7/30/05 – 12/30/05
Resources Required:	17% FSL/CWB
Deliverables:	
1. LAPS with WRF system and multiple background model options	11/30/05
2. LAPS real-time verification system for precipitation	11/30/05
3. Typhoon bogussing system within shadowing system	11/30/05
4. LAPS training materials	11/30/05

Task #2 – Warning Decision Support System (WDSS)

The National Severe Storms Laboratory (NSSL) will continue research towards the refinement and development of applications and algorithms required for the CWB and the WRA (Water Resources Agency) operations. The NSSL research is directed towards improving the monitoring and prediction of flash floods and severe storm short-term identification and forecasting for the Taiwan environment. The NSSL research and development will focus on four core areas: 1) data integration and quality control, 2) multi-sensor Quantitative Precipitation Estimation (QPE), 3) 0-1 hour Quantitative Precipitation Forecast (QPF), and 4) distributive hydrological model (Vflo).

During IA#17, NSSL will provide algorithm documentation and source code where appropriate in addition to conducting biannual training for CWB and WRA.

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

Performance Period:	
1. 0-1 Hour Quantitative Precipitation Forecast (QPF)	1/1/05 – 11/30/05
Advanced QC applications for QPF	1/1/05 – 11/30/05
Refine QPE-SUMS	1/1/05 – 11/30/05
Develop and test gap filling module	1/1/05 – 11/30/05
Implement gap filling module	1/1/05 – 11/30/05
QPF Data collection and case archive	1/1/05 – 11/30/05
QPF Case studies	1/1/05 – 11/30/05
QPF Prediction scale sensitivity evaluation	1/1/05 – 11/30/05
QPF Real-time script development	1/1/05 – 11/30/05
Real-time QPF implementation	1/1/05 – 11/30/05
Lightning data collection and ingest for QPE/QPF	1/1/05 – 11/30/05
2. Vflo – test distributed flood hazard and debris flow prediction module	1/1/05 – 11/30/05
3. Quarterly progress reports & annual review (presentation)	3/31/05, 6/30/05, 9/30/05, 11/30/05
Resources Required:	38% NSSL/CWB

Deliverables:	
1. Real-time 0-1 hour QPF scripts development	1/30/05
2. Real-time 0-1 hour QPF implementation	3/30/05
3. Lightning data collection and ingest for QPE/QPF	3/30/05
4. Develop and test gap filling module	6/30/05
5. Implement gap filling module	6/30/05
6. Advanced QC applications for QPF	6/30/05
7. 0-1 hour QPF data collection and case archive	9/30/05
8. 0-1 hour QPF Case studies and evaluation	11/30/05

9. Vflo – test distributed flood hazard and debris flow prediction module	9/30/05
10. Quarterly progress reports & annual review	3/31/05, 6/30/05, 9/30/05, 11/30/05

Task #3 – Forecast Assistant System

FSL and CWB will continue to enhance CWB's current forecast workstation, the Weather Integration and Nowcasting System (WINS), to take advantage of continued AWIPS modernization. FSL will support enhancement of WINS II in the area of severe weather warning and forecast capability.

During IA #16, FSL provided forecasters training on using SCAN and IFPS. FSL also provided technical support on D3D and FX-C software customization to CWB so that CWB could include these components as part of WINS II. During IA #16, FSL and CWB have investigated an existing 0-3 hour probability QPF system of short range forecasts of precipitation from remote-sensor observations using statistical extrapolative techniques. During IA #17, FSL will provide support to CWB to customize this 0-3 hour probability QPF system using statistical data collected in Taiwan.

Like SCAN (System for Convection Analysis and Nowcasting), FFMP (Flash Flood Monitoring and Prediction) is another integrated nowcast assistance tool for analyzing and monitoring precipitation and other data sets in order to detect and predict flash flood events. It automatically alerts forecasters of flash flood potential. FFMP uses small basin areas to improve accuracy of the basin average rainfall and provides a better estimate of accumulation and therefore flash flood potential. FFMP provides forecasters with accurate, timely, and consistent heavy precipitation warnings. FFMP can serve CWB as a "first alert" warning system and minimize False Alarms Reports (FAR). During IA #17, FSL will provide design approach information to CWB that follows the AWIPS/FFMP implementation document so CWB can assess the future value of their FFMP implementation in the Taiwan area.

SAFESEAS (System AWIPS for Forecasting and Evaluation Seas and Lakes) is another integrated nowcast assistance tool for monitoring weather conditions that threaten marine vehicles (ships, buoys, etc) and for helping forecasters to decide when to alert the marine community when dangerous conditions exist. During IA #17, FSL will provide support to port SAFESEAS code to WINS II, so CWB can expand SAFESEAS to monitor general point observations.

FXC (FX-Collaborate) has provided collaborative functions and elaborate drawing capabilities (analogous to white-boarding) to forecasters in US. FSL will provide technical support to customize FXC as a drawing tool for CWB forecasters during IA #17.

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

Performance Period:

1. Support 0-3 hr probability QPF customization	1/1/05 – 12/30/05
2. Port SAFESEAS into WINS II	1/1/05 – 12/30/05
3. Investigate AWIPS/FFMP design approach	1/1/05 – 12/30/05
4. Provide technical support on D3D and FXC	1/1/05 – 12/30/05
5. Provide forecasters training at FSL	7/1/05 - 12/30/05

Resources Required: 27% FSL/CWB

Deliverables:

1. 0-3 hour probability QPF software	11/30/05
2. Initial SAFESEAS software	11/30/05
3. FFMP related document and information	11/30/05
4. FX-C software with enhanced drawing capability	11/30/05
5. Forecaster training	11/30/05

Task #4- 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 CWB. FSL's development activities in these areas continues, and further CWB/FSL interaction is important to keep CWB staff up-to-date on current developments. This task will allow continuing interaction at an appropriate level, including new software releases of the forecast information system including the internet-based forecast workstation, data assimilation, forecaster training, exchange of visits, copying papers and reports, and e-mail interaction.

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

Performance Period:

1. Continuing interaction on earlier cooperative projects	1/1/05 – 12/30/05
2. Provide HPC procurement and benchmark support; support CWB for further changes to SMS-based NFS code	1/1/05 – 12/30/05
3. NOAAPORT data support	1/1/05 – 12/30/05

Resources Required: 18% FSL/CWB

Deliverables:

1. Relevant documents, reports and electronic information	(as needed)
2. AWIPS upgrade software	11/30/05
3. NFS model with SMS derivatives to a CWB's platform	04/30/05
4. Wrap up of SMS-based NFS for benchmark suit	05/30/05

3.0 - Schedule

Functions	Milestones
1. Provide LAPS II software with Hot Start WRF model	12/05
2. Provide an initial WDSS including QPE-SUMS, and Vflo model	12/05
3. Provide FFMP and FXC software	12/05
4. Provide technical support of HPC, FXC, NOAAPORT data transmission relevant document and technical support on WINS II with AWIPS functions	12/05

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 (LAPS)												
LAP II and WRF with hot start	x	x	x	x	x	x	x	x	x	x	x	x
Improve analysis and QPF	x	x	x	x	x	x	x	x	x	x	x	x
Continue shadow system	x	x	x	x	x	x	x	x	x	x	x	x
Provide training and documentation							x	x	x	x	x	x
Task 2 (WDSS)												
Single radar SSAP products	x	x	x									
Refined QPE-SUMS	x	x	x	x	x	x						
0-1hour QPF products	x	x	x	x	x	x	x	x	x	x	x	x
Advanced QC applications	x	x	x	x	x	x	x	x	x	x	x	x
Maintenance of Vflo and interface to SOBEK model	x	x	x	x	x	x	x	x	x	x	x	x
Enhanced verification web page	x	x	x	x	x	x	x	x	x	x	x	x
Quarterly progress reports & annual review			x			x			x			x
Task 3 (Forecast Assistant System)												
FFMP design information support	x	x	x	x	x	x	x	x	x	x	x	x
Initial SAFESEAS porting	x	x	x	x	x	x	x	x	x	x	x	x
Provide technical support on WINS II on FXC drawing capability	x	x	x	x	x	x	x	x	x	x	x	x

Task 4 (interaction on earlier projects)												
Provide HPC, FXC and NOAAPORT technical support	x	x	x	x	x	x	x	x	x	x	x	x
Port SMS-based NFS code to CWB chosen platform for the desired resolution	x	x	x	x								
Wrap up of SMS-based NFS as part of benchmark suit	x	x	x	x	x							
Support CWB for further Changes to SMS-based NFS code						x	x	x	x	x	x	x

4.0 Budget

The following are the estimated costs for Implementing Arrangement #17

Tasks	**Personnel**	**Travel/Training**	**Total**
Task #1	$ 140,000	$ 15,000	$ 155,000
Task #2	$ 330,000	$ 15,000	$ 345,000
Task #3	$ 230,000	$ 20,000	$ 250,000
Task #4	$ 150,000	$ 20,000	$ 170,000
Total	**$ 850,000**	**$ 70,000**	**$ 920,000**

As stated in Implementing Arrangement #17, the funds available from CWB and the WRA (Water Resources Agency) to support the tasks, traveling and meeting expenses described in this Statement of Work, will be a total of US$ 920,000, of which US$ 670,000 will be provided by CWB and US$ 250,000 by WRA. All budget figures are estimates. 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 Forecast Systems Laboratory 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 FSL facility and all associated equipment and data.

FSL staff time is charged at the employee's salary plus the normal NOAA benefit, leave, and overhead charges. FSL 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 FSL

Several tasks encourage CWB staff in residence at FSL or NSSL. The primary effort of CWB staff at FSL during the Implementing Arrangement #17 period will be directed toward developing the LAPS hot start software, and deployment of FXC applications. It is important that CWB staff be available to work at FSL facilities during the period. Specific assignments will be made to most efficiently use the available personnel resources. Assignments for the CWB staff members would be as follows:

- Development of the Taiwan LAPS software and short term probability QPF (at FSL)