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Application Integration Framework Manual

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Note: All **REDLINE** sections are incomplete and/or deferred to later Builds.

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INTRODUCTION

This AWIPS Application Integration Framework Manual (AIFM) is intended to assist both field and headquarters personnel in using the AWIPS environment to develop and implement hydrometeorological applications. An AWIPS Local Applications Working Group (LAWG) with National, Regional, and field representation has been established to define the policy and mechanisms under which local development and distribution of AWIPS applications may proceed. The AIFM provides the technical guidance to the local software developer, and will be updated as often as warranted.

A very brief overview of the AWIPS architecture is given in AIFM Chapter 1. Chapter 2 and Appendix 6 describe the AWIPS environment, development resources, software tools, and guidelines on how to minimize the impact of local applications development on the operational AWIPS. Coding standards and guidelines are presented in Chapter 3, and in Attachments 1, 2, and 3. Documentation standards and guidelines are presented in Chapter 3 and Appendix 4. Chapter 4 describes the locations, content, and methods of access to the various national hydro meteorological data received and stored on AWIPS. The methods by which local applications may be launched is documented in Chapter 5, and the available mechanisms for disseminating official and draft products from AWIPS are presented in Chapter 6 and Appendix 5.

AWIPS is a complex environment in which to develop, integrate, and run applications software. However, procedures and Application Programming Interfaces (APIs), with the associated underlying software, are being incrementally defined to assist development. In one respect, applications that are designed to provide a display to a user can be thought of in two categories--those that utilize the AWIPS two-dimensional display (D2D) and those that don't. Three provisions for using D2D currently exist--Extensions, Applications, and Depictables. Extensions and Depictables are quite complex to use, and uninformed use could easily impact the operation of AWIPS. Alternatively to using D2D, displays can be created using standard X-Window calls, Tcl/Tk, or blt extensions to Tcl/Tk. Therefore, until safe paths for the use of D2D can be established, no attempt should be made to integrate into D2D. When these safe paths and system resources to utilize them become available, a separate chapter of the AIFM will describe them.

This AIFM was written and edited primarily by SAIC/General Sciences Corporation, under contract to the AWIPS Program, working with the Techniques Development Laboratory, other Governmental organizations, and Litton/PRC, Incorporated (PRC). Some material was taken from an AIFM prepared by PRC under Government contract for the Builds 1.0 and 2.0 architecture. Additional new material incorporating experience gained with the current AWIPS architecture and software was provided by PRC.

The AIFM is a work in progress. It will be updated in some evolving and complex subject areas, and has not yet had extensive review or use in the field. It is being provided in order to assist and guide

development of good- quality, well-documented local applications. Constructive criticism from software developers in the field is encouraged to allow this AIFM to be improved and should be given to your regional LAWG representative.

1.0 AWIPS Architecture

AWIPS is implemented as a client-server system. The application of client-server methods to AWIPS facilitates the reuse of functions and provides an expandable and scalable architecture to meet the evolving needs of long life-cycle systems.

A client-server mechanism enables multiple applications to share the services of various functions and allows functions to be reused. For example, database services and display services are shared. Through distribution of services, the system is expandable and scalable. This is accomplished by the ability to move services from one platform to another, and the ability to increase, incrementally if necessary, the computing capability needed by any one service. Both activities may be accomplished without affecting other services or changing mission applications.

In an integrated system such as AWIPS, the multiple functional implementations need to be managed independently of one another as much as is practical. For example, a change to the data management function should not cause a change to the display and interaction function or a change to hydromet processing. By separating the functionality, a degree of independence and isolation can be achieved. Consider an application that consists of data, processing, and user interaction. It can be implemented as one monolithic application, or it can be implemented as a set of clients that call upon services common to user interaction and multiple applications, such as data retrieval and storage. A client/server implementation permits services that are common to multiple applications to be made available to these applications, without the need to develop the service for each of the applications. Such an implementation results in reuse of services.

A client/server implementation also provides separation of client processing from server processing such that a client can execute on a computer physically different from the one on which the service executes. This is particularly important for AWIPS, since it is implemented with functionality executing on different computers. For example, workstations provide the user interface with which the forecaster interacts, data servers provide data management services to multiple applications, and application servers process hydromet data and run background applications. Client/server also helps achieve high availability of functions in the event a server fails by being able to switch to another server, for example, from a data service executing on one computer to the data service running on another computer. By constructing applications that separate functions, a switch to a backup server, due to the failure of the primary server, is transparent to the application.

1.1 System Hardware Architecture

The current AWIPS system architecture is now documented in detail in Chapter 2 of the [AWIPS System Manager's Manual for Release 4.3 \(SMM\)](#), and will no longer be included in the AIFM.

1.2 Major System Software Components

This section will only deal with the software components of the AWIPS hydrometeorological subsystem, since it is these that are of direct importance to the local applications developer. Formal documentation of the complete system software components is outside the scope of this document. For a complete description of the system software components within AWIPS refer to the System/Subsystem Design Description for Release 4.3.

Four major software components comprise the hydrometeorological subsystem of AWIPS: Display Two Dimensions (D2D), AWIPS Data Analysis and Product Preparation Tools (ADAP²T), the NWS River Forecast System (NWSRFS) at RFCs or the WFO Hydrologic Forecast System (WHFS) at WFOs, and the Local Data Acquisition and Dissemination (LDAD) subsystem. D2D provides a system for acquisition, processing, and display of the majority of the conventional and remotely-sensed observations and image data, forecast model grids and graphics, and AFOS text products. The D2D database is the source of these data sets, and consists of a combination of primarily flat file storage, with text product storage in the Informix RDBMS. The bulk of Section 4 of this document describes the storage formats and data access for the data sets in the D2D database.

ADAP²T provides tools for the initialization, entry, display, and editing of gridded, areal, and point forecast data. ADAP²T acquires, processes, and stores centrally- and locally-created objective and manual forecast guidance including Model Output Statistics (MOS), Local AWIPS MOS Program (LAMP) guidance, and NCEP Value-Added Grids (VAG). The Interactive Forecast Preparation (IFP) capability of ADAP²T [Limited-Use Interactive Computer Worded Forecast (ICWF) in Build 4.3] also creates local forecast data sets in the form of a Digital Forecast Matrix (DFM) which is stored and maintained in the Informix RDBMS, and generates textual and other official forecast products for editing and dissemination.

NWSRFS and WHFS are a suite of applications for hydrological data analysis, data display, and forecasting, and for maintenance of the supporting hydrological databases. The bulk of the hydrological data sets are stored and maintained in the Informix RDBMS. Documentation for the hydrological data sets, programming interfaces, and applications are available separately from RFCs and the Office of Hydrology, and are not included in this document.

The LDAD subsystem supports acquisition of hydrometeorological data from local systems external to AWIPS, and dissemination of AWIPS products to external systems by a number of mechanisms. Current (Build 4.3) LDAD dissemination mechanisms are restricted to the LDAD Bulletin Board Service. Future dissemination mechanisms planned for LDAD include fax, ftp, and web-based dissemination. Section 4 of this document describes the storage formats and data access for the data sets in the AWIPS side of the LDAD database. Section 6 will include a description of LDAD dissemination mechanisms, and references to current LDAD documentation.

1.3 Input and Output Devices

AWIPS input and output devices vary by machine and by site type (WFO or RFC). Some are shared

over the network, and others are available only to a specific host machine. Table 1.3-1 lists the primary I/O devices of interest to application developers.

Table 1.3-1. Input and output device availability and locations on AWIPS.

I/O DEVICE	HOST PLATFORM(S)				
	WS (x5)	Color X-Term (x5)	AS (x2)	DS (x2)	LAN Resource
Color Graphics Monitor	Two each	One each			
System Console			One shared between AS's and DS's		
Keyboard	One each	One each	One shared between AS's and DS's		
Mouse	One each	One each			
CD-ROM	One external drive shared between all WS's		One each	One each	
DAT Autoloader Tape Backup				One shared between DS's	
B&W Laser Printer (Postscript)					One
High Speed Laser Printer (Postscript)					One at RFCs
Color Inkjet Printer (Postscript)					One
Internal Disk Storage	3 GB each		4 GB each	6 GB each (Note 1)	
External Mass Storage				24 GB WFO 40 GB RFC	

Note 1: On the DS, a 300 MB partition will be set up for local applications development, and a 420 MB (WFO) or 1200 MB (RFC) partition will be set up as user space. Release 4.3 introduces a 990 MB partition set up for local application data (see Section 2.3.3).

2.0 Local Applications Development (non-D2D)

This section describes the software tools and the software development environment at AWIPS WFO and RFC sites. It gives guidelines for setting up a local software development environment which protects the baseline AWIPS data and software configurations.

2.1 Common Desktop Environment (CDE)

At its most basic level, the Common Desktop Environment is a graphical, window-based interface to many of the common UNIX functions without the need to learn UNIX commands and syntax. CDE provides a File Manager from which the user can perform functions such as copy, delete, edit, execute files; navigate through directories; create and delete directories, and find files or files with specific contents. CDE has its own text editor with print option capability, or can be reconfigured to substitute the text editor of your choice; a terminal window for the UNIX-capable; a print manager for printer setup and print job management; an e-mail application; a Help Manager for online help; a calculator, man page viewer, appointment calendar, and icon editor; and many other tools and utilities.

CDE has implemented a concept of workspaces, which is another level up from the concept of having multiple windows on the screen. Windowing gives you the capability of having several windows open on the screen at the same time, with the ability to switch between the single active window and the inactive windows. Workspaces, in essence, give you the capability of having several screens within one monitor, each able to containing its own set of multiple windows, with an ability to instantly switch between screens. The primary difference between windows and workspaces is that only one workspace is viewable on a monitor at any time--they can't be tiled or overlaid, i.e., they aren't windows-within-windows.

In a practical sense, workspaces allow you to keep your screen from getting too cluttered when you need to have several windows open and need to switch between them, or can allow you to organize related windows into groups contained within their own separate workspaces. Multiple workspaces don't give you more computing power, more memory, or multiple host machines--you only get a convenient way of having many windows open simultaneously on the same monitor with less screen clutter.

Another powerful feature of CDE is the Create Actions capability. Create Actions allows you to associate an icon with a UNIX command or script, and to have the command run in a newly-created terminal window, or have an application initiated by the command in the action run in a window of its own creation. The command line you enter in the Create Actions menu allows you to enter placeholders for input files to be acted on by the command. The power of the placeholder is that it allows you to select a file icon from the file manager window with the mouse, drag it on top of the Action's icon, and the command in the action will be executed on the file.

As an example, let's say you've found a non-copyrighted, freeware application to display a WSR-88D

Echo Tops product in pseudo-3-dimensional form in an X window, but don't have the time learn how to write a GUI to inventory and select the products from the AWIPS database and fire up the application. You could set up an action to run the application from the command line with the placeholder for the Echo Tops product file as an argument. To bring up the display, you would simply open a File Manager window and change to the AWIPS data subdirectory that holds the Echo Tops product data files (conveniently named by date and time), select and drag the file icon for the desired time over on top of the application's Action icon, and bingo, the application runs and up comes a window with the 3-D display of the selected Echo Tops product.

In its initial configuration, CDE will be set up on the WFO/RFC workstations in a minimal configuration with named workspaces for D2D (display and analysis package) and other packages. Other than workspace switching, few or none of the CDE tools or applications will be available while the workstation is logged in to the operational account. To gain access to the full CDE capabilities at the workstation, it will be necessary to log out of the operational account on the workstation, and log back in to the user or developer accounts. The System Manager will have to configure CDE for these accounts to make available whatever tools are needed by users or software developers.

Depending on local needs, CDE workspaces and applications may be configured differently at different sites by the System Manager. Also, the locations of applications within workspaces is a matter of convenience and standardization more than a system-enforced limitation. At any time, any active window can be copied or moved to another workspace, which gives the user a great deal of flexibility in their work preferences.

This section is just an overview of CDE, covering major items of interest. Detailed information can be found on your workstation in the online help documents included with the CDE installation, which can be accessed from (what else!) the CDE Help Manager facility.

2.2 Software Tools

Each WFO and RFC site is provided with a basic set of Commercial, Off-The-Shelf (COTS) software to support system management and maintenance, and local application development. The installed COTS packages include the following:

- HP-UX Operating System, includes:
 - Common Desktop Environment (CDE) and associated tools
 - *vi* text editor
 - Source Code Control System (SCCS)
 - *make* utility
 - *xdb* and *adb* debuggers
 - *m4* macro preprocessor, for all languages
 - others, see Table 2-3 of Programming on HP-UX
- HP-UX ANSI C Compiler

- HP-UX FORTRAN Compiler
- HP DDE Debugger (C/FORTRAN)
- X-Window System
- OSF Motif
- Visual Numerics FORTRAN Numerical Libraries (Statistics package)
- Informix RDBMS: On-Line Dynamic Server, SQL, ESQL/C
- OmniBack Backup Software
- MC/Service Guard (see Section 5.6)
- HP Process Resource Manager (see Section 2.3.5)

In addition to the commercial software installed on AWIPS, additional Off-the Shelf freeware packages that can be used in local software development have been included with the system. The terms for use of these freeware packages are generally contained in a README or other internal documentation file included with the package. These packages include:

- netCDF 3.4 (network Common Data Form; array-oriented data file system)
- Tcl/Tk 8.0p2 (Tool Command Language and Tool Kit; scripting and GUI tools)
- Perl 5.003_1 (scripting and text processing)
- netCDF Perl 3.4
- LDM (UCAR's Local Data Manager) (currently National Centers only)
- a2ps (ASCII-to-PostScript converter, and 'pretty-printer')
- BCS (Baseline Control System: code revision system using 'RCS')
- RCS (GNU RCS, Revision Control System for configuration items/objects)
- make (GNU make, build utility)
- ispell (GNU ispell: spell checker utility)
- blt 2.3 (extensions to Tcl/Tk)

A complete list can be found at the AWIPS Software Engineering web page at <http://isl715.nws.noaa.gov/awips/sw/cotsfree.html>.

COTS Software Locations and Licensing

A summary of the initial installed locations of the COTS packages and the license terms for their use is shown in Table 2.2-1. All COTS software has been placed in subdirectories under the */opt* directory, and freeware used in the AWIPS baseline is under */usr/local/freeware*. Non-baseline public domain or COTS software shall be installed in a site-controlled directory (i.e., */home/localapps*) with symbolic links from */usr/local* (if necessary). Commercial or freeware products SHALL NOT be installed directly into */usr/local* or */opt* since these directories are managed via the national baseline. License terms may vary from site to site. See your local System Manager if there are questions about the COTS locations and license terms.

Table 2.2-1. Installation locations and licensing terms for Commercial, Off-the-Shelf (COTS) software

provided with the Build 4.3 version of AWIPS at the WFO and RFC. Items in [] are under evaluation and have not been finalized for inclusion.

COTS Package	Installed Location	NFS Mounting	Licensing Terms 1) Runtime or Development 2) # platform(s), or site 3) NFS mountable? 4) # simultaneous users
HP-UX OS B.10.20, CDE, vi	All hosts	n/a	Dev; 1 per host; NFS; 2 Users (WS), 8 Users (DS/AS)
ANSI C Compiler	DS	Yes	Dev; DS1 and DS2; NFS; 1 User
FORTRAN Compiler	DS	Yes	Dev; Site; NFS; 1 User
Java development kit 1.12	LS	No	Dev; LS; no NFS; 1 User
DDE Debugger	DS	Yes	Dev; DS1 and DS2; NFS; 1 User
X-Window System x11R6	All HP-UX platforms	n/a	Dev; Site; no NFS; Users n/a
OSF Motif 1.2	All HP-UX platforms	n/a	Dev; Site; no NFS; Users n/a
Visual Numerics (IMSL) FORTRAN Numerical Libraries 3.0	DS	Yes	Dev; DS1 and DS2; NFS; No User Limits
Informix On Line 7.3	DS	Yes	Dev; DS1 and DS2; NFS; 32 concurrent database connections
Informix SQL 7.2	DS	Yes	Dev; DS1 and DS2; NFS; Development Phase Sites Only, 32 concurrent database connections
Informix ESQL/C 7.24	DS		Dev; DS1 and DS2; NFS; 16 Users
Netscape Fast Track Server (includes 4.0.7 Browser)	AS, LS	No	Runtime; AS1, AS2, LS; no NFS; 1 user
HP OmniBack II	DS	No	Runtime; Server-DS1 and DS2; Agent-All HP-UX platforms; no NFS; n/a
MC/Service Guard	DS; AS	No	Runtime; n/a; n/a; n/a
Process Resource Mgr.	DS/AS	No	Runtime; DS1, DS2, AS1, AS2; No NFS; Users n/a

As part of AWIPS site installation, a full suite of documentation is provided to the WFO/RFC for each licensed COTS package within the AWIPS delivery.

2.3 Setting up a Local Development Environment

This section contains guidelines for the site's developers and AWIPS System Manager to set up an environment for local application development. These guidelines necessarily lean towards the conservative to help insure that local applications development has no adverse impact on operations. The freedom and access that is allowed to local application developers should depend on the level of proficiency of the individuals involved, and this can only be judged on a case-by-case basis. The guidelines in this version of the AIFM are based on the assumption of development of stand-alone or minimally-integrated applications. Significantly greater resources and privileges would be required for development of D2D-integrated software, particularly those of the extension and depictable types, and for development of IFP and WHFS modifications and additions, or applications with external system interfaces.

General guidelines or "Rules to Live By" when making system changes:

- Always save backup copies of files being changed (i.e., **.mmddy*, **.orig* or **.old*);
- If a change is applicable to multiple platforms, change only one platform type at a time and evaluate the changes impact on the overall system. This is especially true when making system changes to DS/AS servers. If possible, do not change the Backup Server until the change is proven to accomplish its goal (also consider operating in failover mode). By doing this, a "pure" recovery (if needed) may be accomplished via a system disk image;
- Document what/when/why the change was made.

2.3.1 Local Development Host

Local software development should be hosted on a single workstation designated by site management as being available for development during times when it is not fully engaged in operations. The reasoning behind the selection of the WS is that it is at the extreme end of the processing stream, unlike the AS or DS which must serve multiple clients on a nearly-continuous basis. Also, it has the dedicated color monitors with full graphics capability, which is essential for running software development tools and developing display applications. Since neither the AS nor the DS have a monitor suitable for running software development tools or graphical applications, then independent of which host machine is used for local development, the developer must occupy a WS position to log into the development host. Compilation, testing, and debugging on a WS should not affect the performance of the other workstations, nor should it significantly impact their access to data and resources on the DS.

In an RFC, development of local applications and their operational execution may be performed on any workstation. The reasoning behind this is that many staff members are involved simultaneously in

development tasks, operating independently from workstations in many areas of the office. Development activity is dependent on office goals, available staff, and current hydrometeorological situations. Adequate, flexible access to an appropriate number of workstations as defined by the local office is essential for an RFC to effectively and efficiently perform its overall mission. When operationally installed, execution of local applications must occur on the workstation or server best suited to the overall performance and efficiency of the system. Some local applications must be executed via the CRONTAB for instance. It is the local office manager's responsibility to insure local applications activity does not adversely affect the performance of other workstations or the servers.

The directories that contain the compilers, tools, user space, and development space are physically located on the DS disks, but are NFS mounted and transparently available to the WS(s) on which development is expected to be performed. A disadvantage of using remote NFS mounting is that it slightly increases the local area network traffic during development-related file access (e.g. compilation, testing, debugging), however, this is likely not to be significant.

The best place to run a locally developed application should be based on a number of factors:

1. Mass storage requirements
2. Schedule
3. Memory requirements
4. Database requirements
5. Degraded mode requirements
6. LAN and NFS traffic

2.3.1.1 Locally attached non-AWIPS platforms

There is an NWS policy which allows connecting additional hardware (e.g., a PC) to your local AWIPS LAN. If this has been done, then an obvious place to execute locally developed applications is on these platforms. Consideration should be given to how to exchange data between these platforms and other AWIPS platforms if that is a requirement. The use of "rcp" has been proven to cause a lot of processes to be initiated on the remote platform if a user with a long and complicated *.rlogin* or *.chsrc* is used. It may be better to FTP or remote mount an NFS partition. Either of these methods, if used, shall be tested for their impact on any operational platform. Caution should be exercised in remote mounting partitions. NEVER mount a partition from a non-AWIPS platform onto an AWIPS server. This can cause severe system problems if the non-AWIPS platform goes offline and leaves a stale mount on the AWIPS server. Instead, use FTP or mount the AWIPS partition onto the non-AWIPS server.

2.3.1.2 Data Server

The DS is the best place to run applications that require a heavy use of the mass storage file system. See paragraph 3.9.2 for discussion of file system considerations. Applications that access the database can be run from any server or workstation, but if an application is generating a lot of short transactions versus a

few long ones, the DS may be the best location for the application.

2.3.1.3 Applications Server

The performance of AS1 is very critical in severe weather and is most impacted by severe weather because of the applications running on it. For this reason, AS1 shall be avoided for running locally developed applications. AS2 is heavily used by LAPS once an hour for about 10-20 minutes. Between these runs, however, the CPU is relatively idle. The "ucron" and Glance utilities can be used to view this pattern of execution.

2.3.1.4 Workstation

After locally attached non-AWIPS platforms, graphics or text workstations are probably the best choice to run locally developed applications. If a workstation is used, it does not impact all users and should not have an impact on the servers. If the graphics workstation is running D2D with many frames of image data, memory swapping may become an issue and will impact the performance of the local user. If you are going to use a workstation, use one with low usage, not the workstation at the Public or Aviation desks.

An application running on the workstation should have its executable located on the workstation. If the application is on an NFS partition, the application will load across the LAN (causing slower application loads), and also will swap across the LAN. If a program does not load very often and doesn't use enough memory to make swapping an issue, the trade off may not be significant. Future plans to increase the disks on workstations will allow more applications to be mounted locally on workstations.

2.3.1.5 LAN and CPU Considerations

The largest percentage of LAN traffic is NFS traffic. Any locally-developed software that extensively uses an NFS-mounted partition should be aware of the impact not only on the LAN but the server CPU utilization. It has been determined that if large files are being written to and from NFS partitions, CPU resources on the server can sometimes be reduced by moving the application to the server where the data resides. Case in point: The Satellite decoder was moved from the AS to the DS. The CPU utilization increase on the DS was essentially zero. The increase in the CPU utilization because of the Satellite decoder move was offset by the decrease in the nfsd CPU utilization. The AS CPU utilization and LAN utilization obviously decreased. PerfView is a good tool to see the traffic and CPU utilization of these kind of considerations. Use of PerfView is discussed in Appendix 6.

There is also a consideration of your site's hardware baseline. Some configurations have sufficient room on an AS while other sites may have more room on the DSs. The following table shows the different configurations and what the relative performance factors are (with the K100 as "1"). This should just be used for information. A better look at your system with GlancePlus or PerfView will give you a better feel for where there are available CPU resources.

Table 2.3.1.5-1. Possible Server Combinations.

DSs	ASs
K220/2	D350
D380/2	D370/1
D380/2	K100
K220/4	D350

Table 2.3.1.5-2. Performance Factors for AS and DS.

Relative Performance Factors - AS		Relative Performance Factors - DS	
K100	1	K220/2	2.5
K350	1	K220/4	4.8
D370/1	2.2	D380/2	3.5

2.3.2 Local Development User Accounts

Each AWIPS system will be configured with one user account on the Data Server. Other accounts specifically for local applications development should be set up by the System Manager. The user account for development shall be kept separate from the account(s) used in normal operations in order that the data access and system resources used in development can be controlled. A pseudo user shall be created to run locally developed applications. It will be easier to track the impact of the applications using the MeasureWare software and tools (See Appendix 6). Create a user called "localapps" and where possible execute the local applications as that user. The developer and user accounts shall be given read-only permission to AWIPS system and data files so that no crucial data are inadvertently overwritten or deleted. Creation of user accounts and setting of file permissions are covered in the Chapter 2 of the AWIPS System Manager's Manual.

2.3.3 Local Development User Resources

Disk space is a major issue for local development. Developers will need a allocation of disk space for their code and temporary data sets. The preset user account will be provided with a fixed partition of size 460 MB (WFO) or 2240 MB (RFC) of disk space. Developers will have an additional 300 MB area on the shared (mirrored) data volumes of the DS, in */awips/dev*. This area will be created as part of the site installation procedures. Both */home* and */awips/dev* are shared (mirrored) data volume of the DS. The System Manager will be able to create individual user areas under this directory.

Since these allocations are fixed, it is unlikely that a local applications developer will inadvertently "fill up" the disk storage on the DS with a runaway application. It is up to the System Manager to assure that

developers and users do not obtain or use access to other areas of the disk on the DS, or to disk storage on other machines. With 300Mb in the developer's partition, disk space will be at a premium, so either the system administrators will have to restrict developers from exceed disk sizes by maintaining quotas, or the site will have to develop a policy for storing and removing files.

Release 4.3 provides a new disk partition for site-specific applications and data. The partition, `/data/local`, is sized at 990 MB on the shared (mirrored) data volume of the DS. The primary purpose of this partition is for storage of local data acquired via LDAD. The partition may also used for other site-specific purposes such as site-developed executables and scripts required for operations. The site shall maintain these partitions below the 90% capacity level to prevent disk thrashing, as well as ITO alarms to the NCF.

2.3.4 Local Development Directory Structure

All shared tables, executable files, etc. shall be placed into the existing areas under the `/awips/dev` directory (`~/data`, `~/bin` and `~/sharedlib`). Home directories for site developed software or for special users (e.g. `fxa` or `informix`) shall not be in baselined operational or COTS directories (e.g., `/awips/fxa` or `/opt/informix`). All home directories for users and/or pseudo users shall reside in either the `/awips/dev` or `home` partitions.

Users can add paths to their local development area, or to the site's executable files, yet they shall not modify any of the AWIPS paths. When developing new software, users may wish to have the executable files placed into their own development area rather than overwriting an existing version of an application that is in general use. In addition the users shall maintain their own `~/tmp` space for storing temporary data files.

AWIPS utilizes the standard UNIX configuration directory structures. For instance, when storing man pages, these are always placed under the appropriate `man/man#` directory. This means that if an application is accessible to the site, then there shall be a `/man` directory in the development directory structure for any man pages or help documentation.

Source Code

Users shall utilize the `/awips/dev/develop/src` directory for storing their source code. There shall be a global Makefile for any directories under this directory, and a configuration file for the different Make options (MakeConfig). Any additional databases shall comply with Informix data replication requirements (see the System Manager's Manual). All source code shall be compatible with NIS, meaning that Internet addresses shall not be hard coded.

Executables

Once the development of a new function is complete, and has passed through the site's debugging and

testing cycle, the final version of the executable file(s) shall be placed in the */awips/dev/bin* or */awips/dev/sharedlib* areas. When source code from */awips/dev/develop/src/dir/* is compiled the Makefile shall place the executable file in the */awips/dev/bin* area.

FXA Areas

No source code or executable code shall be placed into the */awips/fxa/bin* or */awips/fxa/src* areas. In addition, since the data areas are for incoming data only, any processed data for local applications shall be stored in the local data area.

Data Files

All configuration files and shared data files shall be stored under the */awips/dev/data* directory. Users can then share those files which will not be modified each time a local application is invoked.

Local Data

Release 4.3 provides a new disk partition for site-specific applications and data. The partition, */data/local*, is sized at 990 MB on the shared (mirrored) data volume of the DS. The primary purpose of this partition is for storage of local data acquired via LDAD. The partition may also be used for other site-specific purposes such as site-developed executables and scripts required for operations.

Temporary Files

Local software developers should use */tmp* for writing temporary files. Files left on */tmp* will be purged, but usually have sufficiently long lifetimes to be used by transient applications. Developers should not use directories like */var/tmp* and */usr/tmp*.

Scheduled File Backup

OmniBack is the facility that makes a tape backup onto the archive tape, and is scheduled to run each night. The */home* and */awips/dev* areas are included under the basic AWIPS backup plan. It shall not be necessary for developers to institute any additional procedures for a guarantee that their work has been saved to tape archive. All site-specific files shall be saved (i.e., a backup copy made) in a directory covered by OmniBack. Common practice is to create a */home/siteID* (e.g., */home/CLE*) directory for these files. This shall include saving older versions of files in a predefined format (i.e., *filename.MMDDYY*).

2.3.5 CPU Allocation Control

Standard scheduling and resource allocation for processes under HP-UX are handled by the HP-UX Scheduler. The HP-UX Scheduler has its own dynamic, automatic methods of allocating CPU resources

to processes, and does not allow the setting or adjustment of CPU priorities. A separate CPU resource management tool, the Process Resource Manager (PRM), has been provided with the COTS suite on AWIPS. PRM is a low-overhead, configurable, process scheduler which allows the System Manager to control the dynamic HP-UX Scheduler priorities and control the amount of CPU available to users and applications during periods of heavy CPU demand. Detailed descriptions and instructions for set-up and use of the PRM are contained in the HP Process Resource Manager User's Guide, which has been delivered with the HP documentation package for AWIPS.

PRM allocates CPU resources by PRM groups, which are independent of other types of groups on the system, such as user groups. Individual users can be assigned to a PRM group, and then all their owned processes will inherit the user's PRM resource allocations of the group. In addition, individual applications can be assigned to a PRM group, and then the application will get the resource allocation of its assigned group, no matter what the resource allocation is for the user who is running the application. All system processes are initially assigned to PRM_SYS, a reserved process resource group (PRMID) of ID number 0 (zero). If not otherwise assigned, all other user and application processes are assigned to the OTHERS group, PRMID 1. Besides these two groups, up to 14 additional groups may be defined.

Each PRM group is assigned a percentage of total CPU, where the sum of the CPU percentages for all defined groups must equal 100%. While competition for CPU usage is low, processes are generally allowed as much CPU as necessary based on their resource demands. However, as total CPU usage begins to increase towards 100%, the PRM control on CPU resources kicks in to limit processes to as much CPU as their group has been allocated.

PRM's usefulness in controlling the resources required for local development depends on how the local development environment is set up. If all local software development takes place on a WS wholly dedicated to the local software developer, then the PRM will be of no use since it is only available on the AS and DS, and since there would be no competition for resources on the dedicated WS in any event. If local software development is performed via remote login to accounts on the AS or DS (not recommended), then PRM can be set up to assure that local development activities do not impact the operational servers and scheduled processes on those machines.

2.3.6 Controlling Permissions

As previously mentioned, local application developers shall be under a separate account for their activities, and that these user accounts be given read-only permission to AWIPS system files and operational data files. These restrictions will limit the chances that a local software development activity will result in a corruption of a critical file in the system or the database. It is up to the individual System Manager to determine whether to handle local developer accounts and file access permissions as a user group, or on an individual user account basis.

Access control for data contained in the Informix RDBMS must be handled differently than data in Unix files. Permission to directly access or modify information in tables in the database is handled through the

granting and revoking of privileges to individual users. Control of concurrent access to information in a database table is handled in real time through setting and releasing database locks on specified information in a table. Access to the Informix database is discussed in Section 4.1.6.

Since access to the text database in Informix is through a UNIX utility and not directly to the Informix database through SQL, there is no protection to this portion of the database besides the built-in limitations of the APIs. See Section 4.2.7.3 for cautions and guidance on use of the text database APIs.

2.3.7 Operating System

The guidance here is to NOT make any HP-UX operating system changes. This includes patches and kernel system parameters. Patches are carefully studied by PRC for dependencies and any conflicts with other patches, and then tested extensively with the AWIPS baseline. Patches are very hard to back out of cleanly and SHALL NOT be applied at all. If a patch is required, the request shall be routed through NWS HQ for consideration in a future build.

2.3.8 Network Information Services (NIS)

Changes to */etc/hosts*, */etc/passwd*, */etc/group* and */etc/services* are managed through NIS databases. All changes to these files must be done on DS1 and propagated via NIS. Reference the AWIPS SMM Section 3.0 for details. Modifications to "local versions" of these files are not allowed. Inconsistencies between NIS and "local versions" will cause software to behave unpredictably and/or erratically.

2.3.9 Informix dbspaces

An Informix *dbspace* is a named area of allocated disk storage. In the AWIPS baseline, Informix databases (see Section 4.1.2) are created in specific *dbspaces*. Informix *dbspace* assignments are defined via the national baseline and therefore SHALL NOT be changed by site personnel. Loading of site-specific databases is not allowed, except in the case of RFCs which have predefined *dbspaces* for this purpose.

2.3.10 Wide-Area Network

The WAN is designed and sized for NCF monitoring and product distribution. Any other use is unauthorized and subject to discovery and subsequent notification to the sites that are misusing the WAN. An example of misuse is NFS mounting of another sites' disks. This should now be disallowed in the router filtering at all sites. Another example of misuse is the export of displays across the WAN. The NCF does this occasionally when troubleshooting a site problem, and is acceptable in limited use during a long install, but this should NOT be done by the sites for any other reason. Use of the WAN for the exchange of products and files shall not be done on a regular basis.

2.3.11 Disk

This section discusses disk allocation and system file information, and it provides guidelines that are crucial for local software developers to consider for storing their applications.

The Mass Storage on AWIPS is redundant for reliability purposes. The mirroring of the mass storage makes writes to the mass storage slower than writes to non-mirrored storage. If a local application is creating a temporary file that does not need to be redundant, the best performance can be accomplished by writing to non-mirrored storage. Volume Groups 0 and 1 (vg00 and vg01) are the internal disks and are not mirrored; Volume Group 2 (vg02) is the mirrored mass storage device. A "bdf" command will show you what partitions are on what disks.

As a reminder, please clean up or overwrite temporary files.

2.3.11.1 Disk Allocations

Disk allocations are defined in the Mass Storage Design document and are controlled via the national baseline and therefore SHALL NOT be changed by site personnel. The unallocated disk space is evaluated on a per-release basis and is intended for future use. Local software development should be done in the */awips/dev* or */home* directory, using */home/localapps* for common source code and individual developers' subdirectories (e.g., */home/localapps/devname*) for other items. Release 4.3 provides a new disk partition */data/local* for site-specific applications and data. The primary purpose of this partition is for storage of local data acquired via LDAD. The partition may also be used for other site-specific purposes such as site-developed executables and scripts required for operations.

2.3.11.2 System File Information

The following table lists critical directories and files, and guidelines on their treatment by the developer or system manager.

Table 2.3.11.2-1. File System Guidelines.

File or Directory	Guidelines and Cautions
/ (root)	All directory ownerships and permissions at the root level shall be left alone.
/.profile /.rhosts	Changes to these files may severely impact operations of the platform.
/etc	This is a sensitive area and should be approached with caution. Be aware of NIS-managed files and, as discussed above, any changes to NIS-managed files MUST BE made on DS1 only.
/etc/rc.config.d	These files are especially sensitive and shall not be modified without prior discussions with Headquarters.

/etc/rc.config.d/netconf	This file shall only be change by the site when assigning the site-specific IP Address to the LDAD server. This assignment is made by the "ROUTE_DESTINATION[1]" entry. No other changes shall be made to this file. Changes to any "[0]" entries will impact WAN access.
/var	This partition contains many dynamic operating system files. Caution should be taken whenever files are being deleted. When freeing space in /var, files under /var/tmp and /var/adm/crash can be deleted.
var/spool/cron/crontabs	Files under this directory have been scheduled via the cron daemon. Files shall NEVER be added/deleted from this directory, as it could have adverse effects on the cron daemon. Proper submittal/removal of a user's cron is through the instructions in Chapter 18 of the SMM.
/stand	DO NOT TOUCH. This area is for HP-UX kernel rebuilds.
/usr	DO NOT TOUCH. This area contains UNIX tools. Many symbolic links exist here and critical to proper operations of HP-UX.
/opt /usr/local	These directories are managed via the national baseline and therefore SHOULD NOT be changed by site personnel. No products should be added/ removed from these directories. The size of these directories is evaluated whenever a new or upgraded product is recommended for release. If sites obtain non-AWIPS software products from HP that normally would be installed in /opt, or public domain software that normally would be installed in /usr/local, the installation of the package shall be in a site-controlled directory (i.e., /home/localapps) with symbolic links from /opt or /usr/local (if necessary).

3.0 Coding and Documentation Guidelines

The material in this section is meant to be a guide to development of robust, portable, maintainable software. The degree to which a local developer adheres to a coding style and a set of standards may be a matter of personal choice if that code will be used only by the developer or within the office. Each WFO, RFC, or Region may have its own set of more comprehensive software standards for software intended for wider distribution which may apply to a locally-developed application. Suggested changes should be provided to your regional LAWG representative to be included in future updates of this document.

The AIFM coding and documentation guidelines are adapted from those originally defined and used for AWIPS hydrometeorological applications development at the Techniques Development Laboratory and PRC, and for the DAR3E system at the Forecast Systems Laboratory. Additional guidelines for development using software tools and packages not originally part of AWIPS but used in D2D (e.g., Tcl/Tk, C++) inside WFO-Advanced may be included in future releases of this document.

3.1 Software Naming Conventions

This section contains AWIPS guidelines for naming of files, source directories, and code symbols. The degree to which these naming conventions need to be followed depends on the intended use for a local application, and the history of the application. Applications which are not intended to leave the local office or work in environments outside the core AWIPS hardware and software may not need to follow the guidelines. The guidelines may not be practical for medium or large applications which already exist (legacy code), and which would involve a great deal of re-engineering or modification to meet the guidelines. Adherence to the guidelines is required for new application development which is targeted for national or regional deployment, or which would have long lifetimes and portability to other platforms.

Naming conventions shall be used for locally developed applications; avoid using the same (or similar) names as already existing applications, file systems, or executables. This is especially true for common UNIX executables and utilities like **grep**, **more**, and **cat**. Common extensions shall be used, such as ".sh" for POSIX shell scripts, ".csh" for C Shell scripts, ".pl" for Perl scripts, and ".f" or ".for" for FORTRAN applications source code, ".c" for C-language source code, and ".C" or ".cpp" for C++ source code. Locally developed applications shall be stored in a "local" subdirectory (e.g., */data/fxa/localapps* or */home/localapps*) using the guidelines in Section 2.3.4. More detailed naming convention guidance is given in the sections that follow.

3.1.1 Name Lengths

File Name Length:

For portability, all file names, including programs, libraries, and the like, shall be 14 or fewer characters. Source file names shall be 12 or fewer characters to account for SCCS prefixes, for example:

/awips/dev/develop/src/ioutil/getGrid.c - contains the getGrid() function.

/awips/dev/develop/src/grib/loadObj.c - contains the loadObj() function.

Symbol Name Length:

Symbol names are the names used within the source and object code to reference procedures and parameters. For example, in FORTRAN, the name that follows in the PROGRAM, SUBROUTINE, or FUNCTION statement is the symbolic name of the module, and may differ from the filename of the file containing the source code for the module (see the above two C examples). ANSI standard name conventions are too restrictive at 6 characters. AWIPS allows symbol names to be unique up to 31 characters.

3.1.2 Public API Function and Subroutine Names

Public and Private APIs

Public APIs are those functions and subroutines which are not unique to a single application, or which may be used now or in the future by other applications (i.e., library routines, utility functions, services, etc.). Private APIs are the individual functions and subroutines comprising an application and unique to the application. It is a matter of judgement on the part of the developer as to whether a function or subroutine developed for an application is reusable by other applications and should be treated as a public API or utility. There is no specific symbolic or file naming convention for private APIs, although the names should attempt to be unique to the extent possible, and the routines should be organized into subdirectories according to Section 3.1.3.

The AWIPS public API naming convention for C is *verbNoun*, and for FORTRAN is in the form **VERB_NOUN**. The individual public API modules shall follow the *verbNoun* name convention. Note the use of case in the examples.

Example of a C prototype:

```
Status getGrid (Product_def the_criteria,
  DBObject mySelection, float * myGrid);
```

Example of a FORTRAN prototype:

```
SUBROUTINE LOG_ERROR ( Caller, Message, Error_Level )
```

3.1.3 Number/Naming of Subdirectories

The appropriate master directory shall be determined for each application or library, and for each source module comprising the application or library. Each master subdirectory shall be placed under the */awips/dev/develop/src* directory. Using the example from Section 3.1.1, the public API *getGrid* would be placed in the */ioutil* subdirectory, under */awips/dev/develop/src*:

/awips/dev/develop/src/ioutil/getGrid.c - contains the *getGrid()* function

The module *loadObj*, which is a private subroutine of a GRIB decoder, is placed in the */grib* subdirectory which holds all the private modules of the GRIB decoder application:

/awips/dev/develop/src/grib/loadObj.c - contains the *loadObj()* function.

All the non-utility (private) modules of an application shall reside under the master directory for the application. For large or complex applications, as many additional subdirectories as needed in order to organize the code may be defined under the master directory.

3.1.4 Symbol Names and Restrictions

Public Symbols (Variables, Constants, and Preprocessor Macros)

Public symbols are often declared as "extern" symbols in C, and declared in COMMON blocks in FORTRAN. The public symbol naming convention for AWIPS is adjectiveNoun for C, and ADJECTIVE_NOUN for FORTRAN. As with APIs, the public designation refers to symbols that are used and known system-wide or in more than one application.

Example of C public symbol:

```
extern int lastToken;
```

Examples of FORTRAN public symbols:

```
INTEGER LAST_TOKEN
PARAMETER LAST_TOKEN
```

Exceptions

The only exception to this naming convention is static functions and variables in C. The prefix *g_* notifies everyone of the scope of a C static symbol.

C Restrictions

Each language has a list of standard functions provided by the standard libraries. Those names are restricted. Additional standards committees have notified software developers about their intent to use additional symbols (for example POSIX and ANSI C). In addition to a specific list of standard X/Open functions and macros (see Systems Interfaces and Headers, Volume 2 of the X/Open Portability Guide, Issue 4), ANSI C reserves for future use all symbols beginning with:

```

__          macro (double underbar)
_[A-Z]     macro
E[A-Z|0-9] macro
LC_[A-Z]   macro
SIG_       macro
SIG[A-Z]   macro
_          function
is[a-z]    function
mem[a-z]   function
str[a-z]   function
to[a-z]    function
wcs[a-z]   function

```

In addition to ANSI C restrictions, POSIX reserves for future use all symbols that end with the following letters:

```

_t
_MAX

```

In addition to ANSI C restrictions, POSIX reserves for future use all symbols that begin with the following letters:

```

B[0-9]
F_
I
LC_[A-Z]
O
O_
S_
SA_
TC
V
c_

```

d_
l_ (lower case L)
gr_
pw_
sa_
st_
tm_
tms_

FORTRAN Restrictions

FORTRAN has a list of standard functions provided by the standard libraries, which are restricted. HP-UX FORTRAN provides a number of extensions to the standard libraries, which shall also be avoided. Refer to the HP FORTRAN/9000 Programmer's Reference, Vols. 1 and 2 for a list of HP FORTRAN intrinsics, utilities, and system functions.

3.1.5 Accommodating Backup/Failover: Floating names and addresses

All software shall be compatible with MC/Service Guard fail-over procedures (refer to Section 5.6). This means that when addressing the data servers and application servers from a local application, the application process must utilize the floating IP address strategies. These would be accessed by addressing either the data server (ds-<site>), or either application server (as1f-<site> or as2f-<site>). In the case of a fail-over each of these addresses will be mapped to the surviving CPU, and the appropriate packages will be restarted.

As a result, if the application uses services on the AS or DS that are protected under MC/Service Guard (e.g., access to D2D datasets on the DS), it will still be able to transparently access those services if the service's host machine switches to the designated backup machine. It does not imply that the local application itself will be switched to the backup machine or restarted if it fails. The application itself will be protected only if it is set up under MC/Service Guard, which is an uncommon scenario.

3.2 High Level Languages

Choice of Language

The language that is used for locally developed software should be based on a number of factors:

1. performance requirement of application,
2. performance impact on system,
3. frequency of application,
4. use of application.

High-Level (compiled) languages are the best choice where performance of the application or minimization of system impact is an issue. The following compiled development languages are supported for AWIPS: C, C++, and FORTRAN. The infrastructure development is in C or C++. Rendering components must interface with the X Window System in C, but may include calls to FORTRAN subroutines for data processing. File I/O routines that are built on the netCDF APIs for creating, reading, or writing netCDF data files may use their choice of the FORTRAN, C, or C++ netCDF APIs.

All C and C++ code shall be compiled with the ANSI option.

3.2.1 Allowable C and FORTRAN extensions and features

This section describes a process for bringing legacy code and new software into future versions of AWIPS. The information provided in this chapter draws on the experiences gained from the Design, Development, and Testing (DDT) teams, mainstream design, and prototyping efforts including Pathfinder.

Use of FORTRAN 77 Extensions

The following is a listing of the extensions to FORTRAN 77 that are allowed. Extensions that are anticipated to be part of the FORTRAN 90 standards are indicated (FORTRAN 90).

- BLOCK and LABELED DO LOOPS (FORTRAN 90).
- CYCLE statement (FORTRAN 90). The CYCLE statement is used to control the execution of DO loops. When the statement appears in a DO loop it causes the current iteration of the DO loop to be bypassed. The DO loop resumes execution at the next index value, for example:

```
DO 100 ICNT = 1,10
  IF (DB_PROD(ICNT).EQ.' ') CYCLE
  ZONEPRD(INUM) = DB_PROD(ICNT)
100 CONTINUE
```

- DO WHILE (FORTRAN 90). The DO WHILE statement is like the DO statement except that the DO WHILE statement uses a logical expression to control the loop, for example:

```
DO WHILE (DB_PROD(ICNT).NE.' ').AND.ICNT.LE.MAXZNE)
  NAME = DB_PROD(ICNT)
  ICNT = ICNT + 1
END DO
```

- EXIT (FORTRAN 90). The EXIT statement is used to control DO loop termination, for example:

```
DO 100 ICNT = 1,10
  NCNT = ICNT + NCNT
  IF (NCNT.GT.MAXNUM) EXIT
  JROW(ICNT) = NCNT
100 CONTINUE
```

- INCLUDE (FORTRAN 90). The INCLUDE statement allows the compiler to include and process subsequent source statements from a specified file. Note: \$INCLUDE statements are not allowed.
- IMPLICIT NONE (FORTRAN 90). The IMPLICIT NONE statement explicitly reinforces declaration of variable names, which helps eliminate typing errors. Although explicit declaration is encouraged for this purpose, the FORTRAN convention for implicit typing shall be followed.
- SELECT CASE (FORTRAN 90). The CASE statement allows for execution of a certain block of code based on the value of an integer, character, or logical expression, for example:

```
SELECT CASE (IELEMENT)
CASE(1)
  ELEHDR = '12 HR POP'
  CALL PROCPOP(...)
CASE(2)
  ELEHDR = 'TEMP'
  CALL PROCTEMP(...)
CASE(3)
  ELEHDR = 'MXMN'
  CALL PROCMXMN(...)
END SELECT
```

- Data types *n declarations. Explicit statements such as REAL*8 are allowed, when needed. The normal word length should be used when possible. Do not save memory by using INTEGER*2.
- STRUCTURE and RECORDS. The STRUCTURE statement defines the type, size, and layout of a structure's fields and assigns a name to the structure. RECORDS of the structure can then be declared. They allow the reading of temporary flat files and help to avoid excessively long argument lists, which detract from code readability. Mismatched argument lists are a frequent source of bugs. However, this is another level of abstraction and should be used only when needed. One example of when it is needed would be a long call sequence that is used many times.

Use of this call sequence only once does not justify a structure. An example of the structure statement is as follows:

```
STRUCTURE /EFPC_S/
CHARACTER *3 STATLIST(MAXSTA)
INTEGER ELEWARM12Z(21)
INTEGER ELECOLD12Z(21)
END STRUCTURE
```

- ALLOCATABLE, ALLOCATE, and DEALLOCATE statements. These statements allow dynamic memory allocation and deallocation.
- Intrinsic functions. Allowable intrinsic functions that are FORTRAN 77 extensions are as follows:
 - Bit manipulation - BTEST, IAND, IBCLR, IBITS, IBSET, IEOR, IOR, ISHFT, ISHFTC, IXOR, SHFT, MVBITS, NOT, RSHFT, XOR, ZEXT
 - HP-UX system intrinsic - GETARG, GETENV, IARGC, IGETARG
 - Miscellaneous - SIZEOF

Note: Because we are using the generic form, the variables used can be of different types (that is, type coercion of intrinsic arguments).

For more information, see the HP FORTRAN/9000 Programmer's Guide, Chapter

- Variable and subroutines names greater than 6 characters (FORTRAN 90). The limit is 31 characters.
- Underscore characters in variable and subroutine name (FORTRAN 90). \$ signs in character names are not allowed.
- Octal and Hexadecimal Constants. These constraints should be used where they are definitely preferable to decimal for understandability.
- Vector Library functions. These functions are allowed when they are adopted to improve performance and should be isolated when possible. For more information see the HP FORTRAN/9000 Programmer's Guide, Chapter 16.
- Character and Noncharacter data items can share the same storage space through the EQUIVALENCE statement (FORTRAN 90).
- *RETURN. Although the alternate return is part of FORTRAN 77, it should be used sparingly.

- WHATSTR. Although not a FORTRAN 77 extension issue, this is necessary Source Code Control System (SCCS) information, for example:

```
CHARACTER*100 WHATSTR
WHATSTR = "+[-] %W%"
```

- List directed internal input or output, for example:

```
CHARACTER*20 C
WRITE (C,*) I,J,K
```

FORTRAN Extensions That Are Not Allowed

- Dangling comments (FORTRAN 90). Dangling comments are comments at the end of a line following an !.
- ALIAS. The ALIAS statement provides a way to direct the compiler to use the appropriate parameter passing convention to communicate with routines written in other high-level languages such as C. A workaround is to use the + u compiler flag and pass everything as a reference. See the HP FORTRAN/9000 Programmer's Guide, page 19-29 for more information.
- Automatic array declaration (FORTRAN 90).
- BYTE and DOUBLE PRECISION data type declarations.
- Dollar sign (\$) characters in variable and subroutine names (FORTRAN 90).
- Lower case characters in a user-defined name (FORTRAN 90).
- TAB character formatting.
- Data initialization in a TYPE statement. A TYPE statement cannot be used to assign initial values to declared variables.
- Alternative interpretation of logical variables. Errors such as "Mixed data type assignments with logical variables," "Comparison of logical variables in a equation," and "Arithmetic operations on logical variable" are not allowed.
- Automatic character strings. Automatic character strings are character variables whose length is specified using a nonconstant, for example: SUBROUTINE A(C,L)

CHARACTER*LC

These strings are used to implement the socket connection between ICWF routines.

- The %VAL and %REF statements.
- ON statement. The ON statement specifies the action to be taken after the subsequent interruptions of a program's execution and allows for trapping interrupts. No other signaling mechanisms are available.

3.2.2 Inter-Language Communication

Complications arise when compiling and linking programs composed of source and object modules in different languages, for instance, calling a C function from a FORTRAN program. The most common problems encountered when calling routines of another language are summarized in the following paragraph. Refer to the Programmer's Guides for additional guidance.

Using C Functions in FORTRAN Subroutines and Vice Versa

For applications that must mix C or C++ with FORTRAN, remember that FORTRAN passes variables by reference, and C/C++ passes variables by value. Also, FORTRAN uses column-major for matrices, while C and C++ use row-major. Character strings in C are null-terminated, while in FORTRAN they are not explicitly null-terminated. Also, in FORTRAN, strings are represented as a string descriptor composed of an address and a length by value. The Programmer's Guides give suggestions on passing character strings between C/C++ and FORTRAN.

Certain other restrictions apply when using C++ compiled code in a mix with FORTRAN routines, even if the mixed routines are all C. The top level or main routine must be written in C++ or C when compiling and linking with the C++ compiler. All FORTRAN subroutines called from code compiled by the C++ compiler must be declared in a header file and be preceded by 'extern "C"' to prevent name mangling by the compiler. Any header files which do not have this must be wrapped by 'extern "C" {<headerfile.h>}' when they are included. FORTRAN libraries, such as 'vec' and 'U77', will need to have their paths explicitly defined when including them in your load list.

3.2.3 Source Code Compilation

Two high-level language compilers are provided with AWIPS in support of local applications development: the HP FORTRAN compiler, and the HP ANSI C compiler. Both the FORTRAN and C compilers are capable of compiling code under the respective ANSI standards.

Beginning with Release 5.0, several of the GNU family of freeware compilers are provided. Currently, both the gnu C and gnu C++ compilers are delivered and installed in /opt/gcc. The version of gcc used

on AWIPS is 2.95.2. Official documentation is limited but many websites and user groups are available to learn more about GNU and gcc.

3.2.3.1 To compile C code under the gnu C++ compiler

Reserved.

3.2.3.2 Compiler Flags

On most of the systems, ANSI C is delivered. It is more efficient than other options because it is precompiled and can be optimized for the platform. When using C, there are optimization flags that are recommended. To determine the model of the server or workstation on which you intend to run your software, type "uname -m". Use Table 3.2.3.2-1 to determine the model.

Table 3.2.3.2-1. Server and Workstation Models

All WKs	9000/770	J210
DS	9000/819	K200
	9000/859	K220
	9000/861	D370
	9000/871	D370
	9000/820	D380
AS	9000/809	K100
	9000/821	D350

When compiling use the following flags: *+DAModel +DSModel -* (e.g. *+DAD380 +DSD380*) If you want to make it so that your software will run on any of the platforms use *+DAportable* instead. This information is documented in detail in the man page for "cc". Optimization is upward compatible but not backward. Code optimized to run on a D series will not run on a K or J series platform.

3.2.4 X-Windows System Libraries

The X libraries are installed on the systems and are available for compiling code into either C or C++ applications. There are several X references that may be useful. Some of these were included as system documentation:

- Xlib documentation for C Language X Interface information
 - HP XLIB EXTENSIONS
 - HP XLIB PROGRAMMING MANUAL VOL 1
 - HP XLIB REFERENCE MANUAL VOL 2

- X Toolkit Intrinsic documentation for C Language Interface information
 - HP X TOOLKIT INTRINSICS PROGRAMMING MANUAL VOL 4
 - HP X TOOLKIT INTRINSICS REFERENCE MANUAL VOL 5
 - HP X WINDOW SYSTEM C QUICK REFERENCE

The latest HP documentation may be found at the following Web links:

- Contents of the HP-UX 10.* (June 1999) Collection http://docs.hp.com/dynaweb/hpux10/@Generic_CollectionView
- Contents of Development Tools & Distributed Computing Collection http://docs.hp.com:80/dynaweb/hpux10/dtdcen0a/@Generic_CollectionView
- Using the X Window System http://docs.hp.com:80/dynaweb/hpux10/dtdcen0a/b696/@Generic_BookView
- X Window System C Quick Reference Guide http://docs.hp.com:80/dynaweb/hpux10/dtdcen0a/b670/@Generic_BookView

3.3 Scripting Languages

3.3.1 Tcl/Tk

Tcl/Tk is the current language used for most of the user interfaces. See the Software Engineering Working Group (SwEG) Freeware Page for the latest information on public domain software for AWIPS Releases 4.3, 5.0, 5.1.1 and proposed for 5.1.2. Tcl is an interpretive tool command language with additional utilities for scripting. Tk is the tool kit used by D-2D for creating graphical interfaces (windows, widgets, etc.). Since Tcl is an embeddable language, it is not dependent on system resources (doing ps's, etc.) like Perl is.

Tcl/Tk tends to utilize its own version of utilities, rather than the systems utilities (e.g., Tcl has its own sorting utility). In many cases, a C program might suffice in application development, but it would require the developer to write hundreds of lines of code compared to a single Tcl line. Tcl can spawn children, as the user can use the "exec" command, but otherwise the versions seem to be self-contained.

Tcl may not perform as well as other methods. The run-time application may not be as efficient as a C application, but the required development time for Tcl applications may be much less than that for C programming. In one test, an application was written in Tcl by a good Tcl programmer in 10-20% of the time it took for the same developer, also an expert C programmer, to write the program in C.

For applications with the following attributes, it makes sense to use a scripting language such as Tcl/Tk:

- the main task of the application is to integrate and coordinate a set of existing components or applications,
- the application must manipulate a variety of different things,
- it must have a graphical user interface,
- the application does a lot of string processing,
- the functionality of the application will evolve rapidly over time,
- the application is easy to extend and customize in the field,
- the application must run on a diverse set of platforms.

On the other hand, for applications with the following attributes it makes more sense to use a compiled programming language for the application:

- the application implements complex algorithms and data structures,
- execution speed is critical (e.g., the application must frequently scan datasets with tens of thousands of elements),
- the functions of the application are well defined and slow to change.

More information on Tcl/Tk can be found at:

<http://www.scriptics.com/products/tcltk/>

3.3.2 Shell Scripts

For most purposes, it is recommended that shell or Perl scripts not be used to implement operational programs. Because scripts require more computing overhead and take longer to execute than similar compiled programs, their use needs to be evaluated on a case-by-case basis. Several factors need to be considered to decide if scripts should be used or not: frequency of execution, load on the system caused by the program, and priority of execution of the program. If all or a combination of these factors is high then scripts may not be the right choice for this program. Some examples of when script should be used are: to start or stop other processes (daemon processes), installation programs, initialization programs, localization programs, rapid prototyping, or programs that don't get executed often (e.g., not more often than once every ten minutes).

Over the evolution of the prototype to the AWIPS baseline, a number of script-based applications have been rewritten into compiled C or C++ and the positive impact system has been phenomenal. For instance, the *purgeAllRedbook* script in R4.1 takes 14 minutes to run, uses an average of 60% of the CPU and is responsible for approximately 7000 processes to be executed. In R4.2, this process was included in the C language *master_purge* that purges everything (including the Redbook now) in less than two minutes.

Scripts have their place, however. Start and stop scripts, initialization scripts, installation scripts, and one-shot applications are OK, as is the use of scripts for rapid prototypes. However if an application is expected to run on a cycle, or if the frequency of the application is suspect, compiled languages are faster and also kinder to the system.

3.4 Environment Variables

Environment variables are a way of setting and passing environment information from the Unix shell to processes and subshells under it. Environment variables in HP-UX are discussed in a general fashion in Chapter 11 of the manual Using HP-UX. The manner in which environment variables are set and used depends on the shell that you are using. See the entries for the commands *cs***h**, *ksh*, or *sh* in HP-UX Reference, Volume 1. Depending on how a local software application interfaces with AWIPS components, it may be necessary for the application process to determine and use the value of environment variables defined for one or more of the AWIPS subsystems (e.g., D2D, IFP, WHFS).

Among other purposes, environment variables are used in D2D to set the locations of master directories for meteorological datasets and system-specific datasets, and to configure the local site. The system environment variable that will most commonly be required for local application development is \$FXA_DATA, which defines the path to the meteorological data directories (e.g., /radar, /sat[ellite], /point/METAR, /point/RAOB, /Grid subdirectories).

Environment variables for WFO-Advanced are defined in the file *~fxa/environs*, and may be locally overridden by *~fxa/environs.hostname*. They are set at login to the operational account, or can be set by a user by running the script *./usr/local/fxa/readenv.sh* (sh, ksh, or bash), or *readenv.csh* (csh, tcsh, or zsh) depending on the shell used. The environment variable \$LOCAL_BIN will be added to the D2D .*environs* file for Release 4.0. If the site creates applications that will tie into either D2D or the D2D display (see Section 5.1), then the PATH in \$LOCAL_BIN, which is set to */awips/dev/bin*, assures that the appropriate binary file will be found by D2D. Keep all local environment variables in the file */awips/dev/data/rc.<SITE>*, and then **source** this file upon login. Local environment variables shall be named *<SITE>_VAR*, etc.

While in the operational account, the names and values of all the currently set environment variables can be determined from the command line in the terminal window using the *env* command (from the C shell). It may be necessary to have the System Manager access the values of environment variables if file protections do not allow individual users to do so, or if the user is prevented access to a terminal window from the operational account.

The environment variables for the AWIPS components will not automatically be available to developers in their personal accounts. To use the AWIPS environment variables in a developer account, they or their initializing scripts must be either copied to the selected shell's login script for the developer's account, or **sourced** or manually entered at each session. Otherwise, their defined values must be literally incorporated into the code or script in which they are to be used, which is an undesirable

solution.

3.5 Shared and Archive Libraries

Libraries are files with collections of compiled object code that can be used in building a program. For example, when you want to use the **atan2** function in your C program, you can use the function available in the C compiler's math library. To do so, you tell the system where to find the function by including the math library in your program by using the *#include <math.h>* preprocessor directive. You don't have to write source code or compile the **atan2** function yourself--object code for the function resides in the C math library, and it only needs to be located and linked into your program in order for your program to use it. In a similar manner, individual developers can create libraries of related, reusable functions, and can use libraries created by others.

3.5.1 Descriptions

Two types of libraries can exist on HP-UX: archive and shared. The linking mechanism defines the primary difference between archive and shared libraries. In the case of an archive library function, a complete, separate copy of the referenced function's object code is created and linked with the main program's object code in assembly of the executable program. A program built of all archive library object code is a complete, stand-alone executable file.

In the case of a shared library, the linker does not link a copy of the referenced object code into the executable file, it only notes the address locations of where the function can be found. When the program is executed, a dynamic loader looks at the executable to see which shared library routines are required by the program, finds or brings them into memory, and binds them to the executable at run time. Chapter 2 of the [Programming in HP-UX](#) gives a description of archive and shared libraries, and tells how to identify whether a library file is archive or shared. Chapter 5 of the same manual describes how to select and incorporate functions from these libraries into your code.

Sharing of object code takes place when multiple executing processes simultaneously use the same function from a shared library. In this case, the multiple processes all use the same in-memory chunk of machine instructions ("text segment") for the function, although for each process, there is a separate set of data ("data segment") used by the function, which is specific and unique to the process. The HP-UX operating system automatically keeps track of which data segment belongs to which process, and keeps them separated.

The primary advantages of using shared libraries are threefold. First, it reduces the size of the executable program on disk, since the shared portions of the executable are in the library, not copied and inserted into the executable as in the case of archive library code. Second, it can reduce the total size of the executables in memory, since multiple processes which refer to it can share a single machine instruction memory segment relating to the shared library function. Third, it allows the shared library portions of the code to be modified, recompiled, and relinked separately, without the need to recompile and relink

the executables that use the library. Any executables that use the shared library will automatically see the updated version of the shared library, which will be attached at run time.

A disadvantage of using a shared library is that the executable is not complete since it doesn't contain the object code for the library function, so if the executable is moved to another platform, it won't work unless the shared libraries are also available on the new platform. Also, if the shared library is moved after being linked to a program, it may not be able to be found at run time. Another disadvantage is that since both the shared libraries and the main program must be accessed separately from the disk at run time, there is some performance overhead at the time the shared libraries are accessed and bound to the main program.

The way a library function must be compiled and its object code moved into a library differs depending on whether it is to be part of a shared or an archive library. These details will not be included in this document. Refer to Chapters 3 and 4 of the [Programming in HP-UX](#) manual for instructions on creating archive and shared libraries, respectively. It is worth noting that you can use a mix of archive and shared libraries in the building of an executable, but for a given library, you can only use one version of the library, either the shared or the archive version. If not otherwise specified, HP-UX will use the shared version of a library by default if both types exist and can be found, although this behavior can be overridden.

3.5.2 Recommendations for Use

There are no explicit guidelines or restrictions for or against the use of shared and archive libraries for local application development on AWIPS. If code portability is of the greatest concern, then it might be preferable to use archive libraries exclusively. If disk and memory space are critical to the application, or if large chunks of library code are used simultaneously by multiple processes, then the use of shared libraries may be of some benefit.

For most HP system libraries (such as the math library) provided under the HP-UX compilers, both an archive and a shared version are generally available. It is preferable to use the shared versions of system libraries wherever possible, since these libraries are likely to be available on most platforms and portability will not be a large issue. To minimize the possibility of configuration management and disk storage problems, only one version of a new, user-written library shall be created. For AWIPS system libraries, the existing version of the library shall be used (any other option will be nonexistent without access to the source and the proper compiler) and that no additional versions of AWIPS system libraries be created on-site.

3.6 Error Logging and User Notification

Error logging is called for cases where the developer wishes to perform error reporting from within the application, either as a result of internal application error checks, or from receipt of a non-success status value returned from a called function. Error logging information, by definition, gets written into an error

log which can be reviewed at a later time, or it may be able to be automatically redirected to some other destination within the system. The typical external destination for critical errors that need immediate attention is the Network Control Facility (NCF).

The types of conditions that should typically result in calls to standard error logging APIs include detection of:

- system or application errors that require some attention by the developer or maintainer of the code, where the error information is useful for debugging, and
- critical system warning or failure situations that need the attention of the System Manager or the NCF. Such situations may also require immediate user notifications to the user or System Manager. These conditions are not likely to be known to, or of concern to, the local software developer. Since the NCF is not responsible for local applications development, local developers must not log errors in their applications using options that would result in notifications to the NCF.

Diagnostics are generated and reported for the benefit of software developers and maintenance personnel. The simplest diagnostics are print statements within the code. Diagnostics are part of the development process but not meant for the operational code. They are removed from the source code or disabled through conditional compilation when the release version of the software is prepared.

Individual lines of code can be marked for conditional compilation in HP FORTRAN by placing a **D** in Column 1 of the statement. See Chapter 4, "Debugging FORTRAN Programs," of the HP FORTRAN 9000 Programmer's Guide for an explanation and example on the use of the **-D** conditional compilation option of the FORTRAN **f77** compiler.

In C, the ***#ifdef BUG_CHECK*** and ***#endif*** directives must be used to block off one or more sections of code for conditional compilation. The blocked section(s) of code is (are) included or ignored by the compiler depending on whether or not the symbol (called `BUG_CHECK` in this example) has been defined with a ***#define*** definition. To turn off (on) the conditional compilation of the blocked code, remove (add) the ***#define BUG_CHECK*** definition from (to) the source code.

User notification calls are made when status or error messages or informational data are to be immediately displayed to the user when a detected condition or error occurs. Situations in which user notification is performed are those cases where the code is working properly, but the user may need to take some corrective action (e.g., "Too Many Open Windows, Close A Window and Try Again"), or needs to be informed or warned about a temporary situation that prevents a request from being fulfilled (e.g., "Requested Data Not Available", or "File Locked By Another User").

Current APIs

Since the WFOs and RFCs do not typically have access to AWIPS source code or the C++ compiler, it is not possible to use the APIs described below in local applications development. The descriptions are included in anticipation of development of a set of generic APIs usable in local applications.

Error logging APIs exist for both D2D-integrated and non-D2D-integrated applications. The D2D-integrated error logging API is a C++ class called ***LogStream***.

The non-D2D error logging APIs are called ***hmHMU_logError*** (C language) and ***HM_HMU_LOG_ERROR*** (FORTRAN). These non-integrated APIs provide a consistent binding to a lower-level API, which may be changing. Their calling sequences are described in a manual page.

A user notification API currently exists only for integrated D2D applications. The user notification API is a C++ class called Announcer. When and if it becomes possible to use this API from local applications, it will be documented in the AIFM.

Location and Maintenance of Error Logs

AWIPS hosts already have established logging directories that may be used by local applications keeping in mind the following:

1. Daily server log directories located under */data/logs/fxa/YYYYMMDD* (e.g., */data/logs/fxa/990801*) already exist.
2. Persistent processes (those that run continuously once initiated) that create logs in (1) must ensure logs are broken at the start of a new day so proper purging can take place (***logStream*** may be available to sites in the future).
3. Operational logs should contain the minimum amount of information necessary; i.e., turn debug off.
4. Include timestamps and easily traceable filenames, PILs or WMO headers so data can be tracked through system when troubleshooting.
5. Report success and failure of process.
6. For non-persistent processes, use append to add logging information to existing logs. Do not create multitudes of small logs; they make navigating log directories cumbersome.
7. Error logging in local application directories can also be accomplished if care is taken. If log breaking and purging using existing infrastructure is not feasible it is necessary to explore other approaches including using the log file size as a measure of when to break the log. For instance, *filename.log* is moved to *filename.log.old* when a certain size is reached and the new log is written to. In this case only *filename.log* and *filename.log.old* ever exist, so purging is not necessary and disk space usage is known.

3.7 Internal Documentation

The guidelines for internal documentation of locally-developed FORTRAN, C, and C++ source code are the same as those used by the central AWIPS software development teams. These guidelines are documented fully in Attachment 1 (FORTRAN), Attachment 2 (C code), and Attachment 3 (C++ code), and the reader is referred to them for details. A few items will be discussed in an introductory manner in the following sections.

3.7.1 Prologues and Source Control

Prologues

Templates for prologues (also sometimes called headings) for files, functions, programs and subroutines are shown in the attached FORTRAN and C/C++ development guidelines. It is recommended that these templates be used for all new source code development, with modifications as appropriate. If a template other than these standard AWIPS guidelines is used, then it shall at least be consistent for all the new modules making up the application, and shall contain the same information as the AWIPS standard.

Existing (legacy) code from other systems, packages, or applications are often mixed and used in the development of new applications. If these outside sources of code are historically reliable and well-structured but are poorly documented, then it is a judgement call as to whether to use them as-is, or to try to improve their documentation. It is expected that existing code modules from a given source or package used in development of a new application shall at least be documented consistently within the package. If practical, and especially if the legacy code is being modified for use with a new application, existing code shall be upgraded to be consistent with the new application modules.

Source Code Control

HP-UX provides the SCCS (Source Code Control System) utility as part of the operating system software. Background and instruction of use of SCCS are described in Chapter 14 of the HP manual Programming on HP-UX. Additional freeware packages, RCS (Revision Control System) and BCS (Baseline Configuration System), are available for use by local developers. All these packages have been used successfully by different development organizations in controlling versions of national AWIPS software. Any local application development effort of significant size or which involves multiple developers should use a version control package to manage onsite application development. The advantages of a source code control system generally outweigh the costs of learning how to use the system.

The following description refers to use of SCCS keywords, and how they relate to source code prologues.

Source code control information about a module (e.g., revision number, data, or time; current time on retrieval, etc.) can be included in the source file by placement of keywords into the source file. ID keywords are "codes" that are typically placed in the prologue of the source module, either inside comment blocks or assigned to variables, as appropriate to the type of module (see "Where to Put ID

Keywords" in Chapter 14 of Programming on HP-UX). The keywords are automatically expanded (replaced with up-to-date values of their particular information, in plain-language) by the source code control system when the file is retrieved for anything other than editing. Then the *what* command can be used to access the keyword expanded values from the source, object, or executable files.

3.7.2 Header Files and Locations

Header files are typically used to hold declarations referred to in multiple source modules, and prototypes for functions used in more than one module. Header files specific to a module or function shall be named the same as the filename of the module, except with the .h (for C/C++) or .H (for FORTRAN) file extension. Essentially, every function used more than once shall have an associated header file containing both the function prototype and declarations used outside the module. Note that all C functions shall have prototypes defining all arguments in order to reduce the possibility of errors in their usage, and to meet the ANSI C standard. Constants used throughout an application, package, or system shall also reside in a header file with a descriptive name, e.g. *thermo_consts.h* for thermodynamic constants used by the utilities in a thermodynamic variable computation library. Header files shall contain no executable code.

Header files shall reside in the same subdirectory as their associated source code module(s), and shall be placed under source code control the same as source files containing the executable code. Refer to Chapters 7 and 8 of the TDL C Software Implementation Conventions for detailed guidelines on header files, functions, and their organization. FORTRAN programmers shall follow the same set of header file guidelines for those language features that are in common with C.

3.7.3 Standard Header Files

ANSI standard header files such as *limits.h*, *float.h*, and *stddef.h* contain definitions which support the portability of the resulting code in which they are used, and shall be used (along with others as needed) in all C and C++ applications. Note that with the new ANSI standard for C++, the extensions for the **primary** standard header files for C and C++ may change (C) or be dropped altogether (C++), although the old .h extensions should still be supported for C as **secondary** header files. Refer to the HP C++ language documentation provided with the HP aC++ compiler package (reference titles not available at the time of this writing).

3.8 External Documentation

The requirements for external documentation of a local application are driven by the need to: (1) support the continued maintenance of the application; (2) assess potential conflict areas with core software; (3) provide a reference for the NCF to use when troubleshooting issues that may arise at a site; (4) identify applications that could be affected by future builds, and (5) facilitate the sharing of local applications within regions and nation wide.

To satisfy these needs, the AWIPS local application external documentation shall include the following:

- Local Application Registration (LAR) information. The LAR information is submitted to the Local Application Database and must be submitted by the developer before an application can be registered for use by a site. The LAR includes:
 - application description (e.g., name, version, language),
 - software inventory (source code, header files, data files),
 - interfaces with AWIPS data files and databases
 - external connections (e.g., LDAD),
 - runtime signature information (e.g., host machines, CPU, disk usage, communications),
 - performance/system resource information, and
 - reference information (e.g., maintenance programmer).

Note: This information is required for all applications covered under the AWIPS Local Applications Policy (NWS 2000).

For applications that generate products covered by national policy or standards, a sample output shall be provided to the LAWG OM representative for consultation to ensure it meets the national standards.

- User information. Information needed to allow another user at the originating site or another location to effectively run the local application. The user information includes:
 - instructions for configuring the application*,
 - running the application and recovering from errors, and
 - maintaining (e.g., purge, clean-up) the application*.

Note: A '*' indicates that this information is required if a site has agreed to share its application with other sites.

- Installation information. Information need to allow another user install a local application. The installation information includes:
 - makefiles and/or instructions for compiling/linking executables,
 - application environmental information, and
 - installation procedures.

Note: This information is only required if a site has agreed to share its application with other sites.

- Maintenance information. Additional information needed to allow for the continued maintenance of the application by someone other than the originator of the application. This information

includes:

- design information, including data flows,
- scientific formulas and mathematical algorithms,
- testing information (e.g., procedures, data), and
- an application history including enhancements and known software deficiencies.

Refer to Appendix 4 for a detailed description of the local application requirements for AWIPS external documentation.

3.9 Input, Output, Display, and Printing

This section is not meant to be a tutorial on Unix I/O or the X Window System (X), so it will only summarize the required details about the devices, utilities, and options. Table 1.3-1 lists the I/O devices available on specific hosts on the WFO and RFC AWIPS. Access to these devices is controlled by the system setup and configuration. Details of the default setup of each of these devices is summarized in Table 3.9-1. You may need to contact your System Manager for specific information if your site setup varies from the initial AWIPS configuration.

Table 3.9-1. Input and output device configurations on AWIPS. In the table entries, XXX stands for the 3-character station ID of the WFO/RFC site.

I/O DEVICE	HOST	NAME	SETUP
Color Graphics Monitor	ws1-XXX, ws2-XXX, ws3-XXX, ws4-XXX, ws5-XXX xt1-XXX, xt2-XXX, xt3-XXX, xt4-XXX, xt5-XXX	ws1-XXX:0.0, ws1-XXX:0.1 ... ws5-XXX:0.0, ws5-XXX:0.1 xt1-XXX:0.0, ... xt5-XXX:0.0	
CD-ROM	ws?		
DAT Autoloader Tape Backup	DS (physical connections)		Each WS, DS, AS configured under OmniBack
B&W Laser Printer (PCL, Postscript)	LAN	lp1_XXX	
High Speed Laser Printer (PCL, Postscript)	LAN	lp3_XXX	RFC only

Color Inkjet Printer (PCL, Postscript)	LAN	lp2_XXX	
Internal Disk Storage	DS for local applications	under <i>/awips/dev</i>	NFS mounted
External Mass Storage (DAT drive)	As configured	As configured	Portable, host is as configured

Color Resource Conflicts in X

If you are running an application under the X Window System on the same host that is running D2D, ADAP²T, NWSRFS, or the Text Workstation, then your application must share the color resources of the X server. If the colors that your X application requires are not to be found in the default colormap in use in the AWIPS applications, then the likelihood exists of having a color resource conflict between your application's private colormap and the AWIPS packages. X application programmers should be aware of these potential problems and their effects, and proceed with caution. A detailed discussion of color issues in X are beyond the scope of this document, however, some practical guidelines which apply are given below.

If developers are creating applications which will utilize the X color tables, then they shall request colors in the 'shared' mode, or 'read only' mode. This will allow applications to share the color table. Creating color tables in the 'unshared', or 'read/write' mode may create a conflict with other applications. In this case unpredictable events may occur on the display. There is no formal policy on use or control of X color resources between local applications and AWIPS baseline applications. However, applications which have the potential for national implementation shall be developed so as not to have color conflicts with the AWIPS default colormaps.

These guidelines address output to a workstation display. Describing how to create new D2D depictables (integrated displays in D2D) is out of the scope of the AIFM. Local software developers should use Tcl/Tk or X to develop their own user interfaces and display windows for their applications.

Printing and Printers

Printing text files on AWIPS is a relatively trivial matter and local applications have been written to print from AWIPS. The **lp** command can be used, with options, to send a text file to the printer of choice. If the CDE Text Editor is used, there is a Print option in the File menu which will print the contents of the open text file in the editor.

The simplest way of printing the graphical contents of a screen or window on AWIPS is to use the standard utilities **xwd**, **xwud**, and **xpr** that HP-UX provides for X window screen capture, display, and printfile preparation, respectively. **xwd** captures the contents of a selected window and writes it into a user-specified X window dump file. **xwud** redisplay the contents of the captured dump file in a new window on the screen, which is a useful tool for visually validating what you have captured in **xwd**

before sending it to the printer. **xpr** takes an X window dump file and formats it for printing on a selected printer or printfile format (e.g., postscript) according to user-specified options. The last step in printing an **xwd** dump is to send the **xpr** output file to the printer queue with the **lp** command.

The dump files can be prepared for printing in color on the HP DeskJet 1600 printer by using the **xpr** options as follows:

```
xpr -device dj1200 -output <outfile> <infile>
```

X window dumps can also be printed in black-and-white on the laser printer, using **-device ljet**, but the results are unpredictable if the captured image has a lot of colors or gray shades. The number of gray shades in the printed output for the laser printer is controlled by the **-gray n** option of **xpr**, where *n* ranges from 2 to 4. If *n*=3, approximately nine gray shades will result. If *n*=4, then the number of discernable gray shades will be about 15. The maximum window size of the **xwd** captured image that can be printed on the LaserJet 4 without clipping, with the option **-gray 4**, is 600x787. Both **xwd** dump files and **xpr** output print files can be quite large depending on the options used and the size of the captured window, so it is important to delete the files (especially the usually-larger print files) once they are no longer needed.

Since both the LaserJet and DeskJet printers are postscript-capable as configured in AWIPS, **ps** (postscript) can be used as the print device option in **xpr**. Postscript files produced by **xpr** can also be exported from AWIPS for printing on any other postscript printers (see the discussion of the CDE ImageView tool, below, for other graphic file export options). It should be noted that the postscript option results in a much larger printfile than the device-specific options, yields no noticeable difference in the printed quality, and only produces black-and-white output on the color printer.

The X window dump utilities and **lp** can be run from the Unix command line, and Unix man pages exist that describe the options and capabilities of each utility. CDE also provides Action icons named Xwd Capture and Xwd Display which run the utilities **xwd** and **xwud**. These icons are located in the Desktop Tools submenu under the Applications Manager menu in the standard CDE setup. No corresponding CDE Action icons exist for printing. However, by using **xpr** and **lp** with predefined options, a set of CDE Actions could easily be created to print X window dump files to each available printer. With a little more ingenuity, the entire process of capturing a screen, printing the data, and cleaning up the intermediate files could be combined into a single Action or macro.

Besides Xwd Capture, CDE also provides another tool, Capture Screen, for capturing a window or a screen. It is located in the Digital Media submenu under the Applications Manager menu in the standard CDE setup. Capture Screen improves on Xwd Capture in that it allows the screen dump to be saved directly into one of several graphical image file formats, including **xwd**. The tool ImageView, in the same submenu, provides for display and manipulation of many types of existing graphic or image files (e.g., TIFF, PCX, XWD, GIF), as well as conversion of the files from one format to another. With ImageView, **xwd** dump files can be converted to standard graphics file formats for inclusion as

graphical figures in word processing applications, or for display by other image rendering or printing applications. ImageView also provides the capability to modify the brightness and contrast of the captured image/graphic data. If the tools and printers are properly set up, printing can be done directly from Print option of the ImageView File menu. On-line help is available from within CDE for all these tools.

4.0 Data Management and Access

AWIPS data is ingested from the SBN and WSR-88D and is processed through the system and finally stored in either an as-received format, in display-ready or some decoded format, or both. Products from the SBN are initially placed in */raw* directories. The Decoders then typically read them, process them, and delete the raw version. If the input requirement is for the raw product, the best way to accommodate this is to modify *acq_patterns.txt* file to direct the acquisition server to store the product into a locally defined directory. From this directory a local application could process the product and not have to contend with the baseline decoders that will delete the raw product. **CAUTION:** This directory could grow infinitely to fill the partition that it is in, so much care is required to assure that the directory is kept purged. There is discussion on purging of directories in the section 4.1.9 of these guidelines.

4.1 Data Storage/Access Packages (updated to Build 4.3)

Meteorological and hydrological data are stored in a multitude of manners and formats on AWIPS, but can be categorized into four main groups:

- flat files (Unix text and binary files of various formats),
- NetCDF (**net**work **C**ommon **D**ata **F**orm) files (flat files of a common format, with user-defined data contents and data types),
- plotfiles (binary flat files of specific format and content for rendering by D2D depictables), and
- Informix relational database tables.

Each combination of data source and type is considered a separate data class. Some data classes are stored in multiple formats in both raw and decoded form to support different applications on AWIPS. A summary of data storage methods and data formats for each of the existing AWIPS data classes is presented in Table 4.1-1.

Note: According to current plans, by AWIPS Build 5 all existing plotfile storage of decoded hydrometeorological data will be eliminated and replaced by netCDF.

Table 4.1-1 Storage formats and methods for the current classes of AWIPS online hydrometeorological data.

DATA CLASS	UNIX Files			RDBMS
	Flat File	NetCDF	Plotfile	Informix DB
NCEP Grids		All grids, decoded		

METAR		Hourly files. Most decoded elements, SI units, both hourly and specials, and coded METARs	Hourly Files. Selected elements, surface plot units, hourly only	Individual coded METAR reports. (circular storage, limited # of hours)
RAOBs		(Build 5) Decoded BUFR RAOB reports	Decoded BUFR RAOB report sections	Coded ASCII RAOB reports
Lightning		All elements	All elements	
Wind Profiler		All elements	All elements	
Maritime		All elements		
LDAD: - Hydro - Mesonet - Manual		All elements All elements All elements		All elements N/A N/A
WSR-88D	One image or graphic product (see Note 1), one volume scan time, per file			Alphanumeric and tabular data from text-only products or included with images and graphics
GOES Images		All		
Redbook Graphic	One coded product, one valid time, per file			
Text Products		Raw METAR, LDAD, Marine (See Section 4.2.3)		Selected AFOS PILs, coded (e.g., METAR) and plain-text products
ADAP ² T Digital Forecasts				All (TBD Build 5+)
BUFR MOS Forecasts	TDL file system, one model, cycle per file (decoded)			Raw BUFR encoded MOS reports (Build 5)
LAMP Forecasts	TDL file system			
Verification	Archive files (data older than 2 mos)			Latest 1-2 months data

Site-Specific (non-map)	D2D localization and ADAP ² T files			ICWF configuration data
Map Bkgds	Binary files, Shape and BCD formats			

Note 1 to Table 4.1-1: Radar items of the same product type with different Data Levels, Spatial Resolutions, Vertical Level or Elevation Angle, (e.g., Base Reflectivity), Center Point (Severe Weather Analysis), or Accumulation Period (User-Selectable Precip) are considered different products.

4.1.1 Flat Files

There are currently three primary categories of flat file data storage on AWIPS:

- NetCDF files hold decoded observational data including upper air soundings and METAR reports; decoded NCEP model grids; and remapped (locally, or by NESDIS) GOES images. NetCDF files can be read and written with a common set of netCDF APIs.
- Binary plot files are in various formats specified by the developer of the depictable code that reads them, and generally involve custom access routines to read (write) data from (to) them.
- Radar products received from the WSR-88D RPGs are in NEXRAD Level IV Archive format, also known as the RPG-to-PUP format. Except for text messages, they are stored exactly as received from the RPG, with one received product to a file.

Each of these formats is described briefly in the following sections.

4.1.1.1 NetCDF

A portion of the AWIPS data stream is processed by the suite of decoders and stored within */data/fxa* as netCDF files. These can be identified easily as they are stored in subdirectories named *netCDF*. Local applications can use these files as input keeping the following in mind: (1) netCDF files may not include all raw data, (2) netCDF files will be purged by **fxa-data.purge**; and (3) data is already displayable in AWIPS. Data for AWIPS data classes are stored in netCDF (**network Common Data Form**) files are accessed by netCDF APIs. NetCDF provides a method of organizing and storing array-oriented data, such as model grids, imagery, and sets of METARs, in a "self-describing" file structure. The software for accessing netCDF files is distributed and maintained by Unidata. WFO-Advanced uses both the C++ and the C versions of netCDF. A Perl interface for netCDF is available, but is not used in AWIPS.

Unidata has published the "NetCDF User's Guide for C" and the "NetCDF User's Guide for FORTRAN" to describe:

- the history, development, and philosophy of netCDF;
- the contents, organization, and structure of netCDF files; and
- the usage of netCDF software (APIs).

These two guides are well written, and include example code. Unidata has also published the "NetCDF C++ Interface" as a reference to the C++ classes and methods used for netCDF file access. All three publications may be viewed on the Internet at url "<http://www.unidata.ucar.edu/packages/netcdf>". This web site also includes a man page for netCDFPerl (the Perl interface for netCDF), and other useful documents.

The details of netCDF files and APIs as applied to specific AWIPS data classes is presented in the discussion of the various data classes.

NetCDF Terminology Primer

Quick definitions of some key netCDF vocabulary follows:

- **attribute**: data about data; ancillary data; metadata. **Attributes** give information about a specific netCDF **variable** or, in the case of **global attributes**, about the netCDF file as a whole.
- **CDL**: Common Data form Language. A convenient, readable way of describing or defining netCDF files. CDL is read by the netCDF utility program **ncgen** to create a new netCDF file.
- **coordinate variable**: a netCDF **dimension** that is also a netCDF **variable**. A **coordinate variable** is a physical coordinate that is also used as a netCDF **dimension**.
- **dimension**: used to specify the size of a netCDF array **variable**.
- **global attribute**: data about data; ancillary data; metadata. **Global attributes** give information about the netCDF file as a whole.
- **primary variable**: the data. A netCDF **variable** that is not a **coordinate variable**. The model output grids themselves; the satellite images themselves; the METAR field values themselves.
- **record dimension**: a netCDF **dimension** of unlimited size. A netCDF file can contain at most one **record dimension**.
- **record variable**: a netCDF **variable** whose first **dimension** (in C, C++, and Perl) or last **dimension** (in FORTRAN) is the **record dimension**.
- **unlimited dimension**: another name for **record dimension**.

- **variable**: an array of values of the same data type. **Variables** may be scalar (0-dimensional).

Six data types are supported by netCDF. These are given names as defined enumerated type values in netCDF's C++ software (in *netcdf.hh*), as **#define** constants in netCDF's C software (in *netcdf.h*), and as **PARAMETERs** in netCDF's FORTRAN software (in *netcdf.inc*). The names and programming language equivalents of the six types and strings are summarized in Table 4.1.1.1-1.

Table 4.1.1.1-1. Correspondence between netCDF and programming language variable types.

netCDF C++	netCDF C	netCDF FORTRAN	netCDF Perl	C++ and C	FORTRAN	INFORMIX	Perl
ncByte	NC_BYTE	NF_BYTE	netCDF:: BYTE	unsigned char	-	-	integer
ncChar	NC_CHAR	NF_CHAR	netCDF:: CHAR	char	CHARACTER	CHAR	integer
ncDouble	NC_DOUBLE	NF_DOUBLE	netCDF:: DOUBLE	double	DOUBLE PRECISION	FLOAT or DOUBLE PRECISION	double
ncFloat	NC_FLOAT	NF_FLOAT	netCDF:: FLOAT	float	REAL	REAL or SMALLFLOAT	double
ncLong	NC_INT	NF_INT	netCDF:: LONG	long	INTEGER*4 or INTEGER	INTEGER, INT, or SERIAL	integer
ncShort	NC_SHORT	NF_SHORT	netCDF:: SHORT	short	INTEGER*2	SMALLINT	integer
array of ncChar	array of NC_CHAR	array of NF_CHAR	array of netCDF:: CHAR	char *	CHARACTER*n	string	string

To use netCDF in C, you must include *netcdf.h* in each source file containing netCDF calls or references to netCDF pre-defined constants (located in */usr/local/netcdf-3.4/include*), and link to *libnetcdf.a* (located in */usr/local/netcdf-3.4*).

To use netCDF in C++, you must include *netcdf.hh* in each source file containing netCDF calls or references to netCDF pre-defined constants (located in */usr/local/netcdf-3.4/include*), and link to *libnetcdf_c++.a* (located in */usr/local/netcdf-3.4*).

To use netCDF in FORTRAN, you must include *netcdf.inc* in each source file containing references to netCDF pre-defined constants (located in */usr/local/netcdf-3.4/include*), and link to *libnetcdf.a* (located in */usr/local/netcdf-3.4*).

To work in Perl, the first line of the Perl script must be:

```
#!/usr/bin/perl
```

with the "#" being the first character in the line. To use netCDF in the Perl script, the second line must be "use NetCDF;" (without the quotes).

4.1.1.2 Plot Files

Current plans are to discontinue use of plotfiles as a duplicate manner of storage for METAR and other point data in the Build 5.x time frame. Any code that is written to access decoded point data shall, wherever possible, read only the netCDF data files.

4.1.1.2.1 Data Keys, Data Access Keys

Deferred.

4.1.1.3 WSR-88D Radar Products

WSR-88D products are provided to users in the form of a message which contains two or more blocks of information. The blocks are: a Message Header block, a Product Description block (PDB), a Product Symbology block (PSB), a Graphic Alphanumeric Attributes block (GAAB), and a Tabular Alphanumerics block (TAB). A WSR-88D product data message consists of the Message Header, PDB, and one or more of the remaining blocks. A WSR-88D product data file contains all of the blocks in the product data message, in the same order as which they are transmitted and received. A detailed description of the data blocks is beyond the scope of this document. For reference, the block formats are described in Section 3.5.1.3 of the NEXRAD RPG/Associated PUP Interface Control Document (ICD), which is maintained by the NEXRAD Operational Support Facility (OSF).

The radial or raster image data and any graphical data are contained in the PSB. Graphical annotations comprising storm attribute data and provided for display with image data or with special symbols products (e.g., with mesocyclone or tornado vortex signature symbols) are contained in the GAAB. These graphical overlays are produced by the RPG only for selected derived products. Text products and text-only portions of data describing WSR-88D site-adaptable parameters are contained in the TAB.

Image data for most WSR-88D base products and raster- and radial-format derived products are packed in run length encoded (RLE) format. The run length encoding algorithm transforms strings of duplicated data values into (1) a data value, and (2) the number of consecutive data points which take that value. WSR-88D image data in RLE format need to be unpacked prior to display generation or other processing. Unpacking of the RLE data consists of determining the data value and length of each RLE segment, and sequentially assigning these data values to the corresponding (length) number of bins or

pixels of the full radial or rectilinear data arrays.

Section 4.2.4.4 of this document describes the locations and functions of existing AWIPS routines which unpack the RLE data and extract the product data contained in the individual blocks.

4.1.1.4 Local Data Files

For Release 4.3, a new disk partition has been provided for site-specific applications and data. The partition, /data/local, is sized at 990 MB on the shared (mirrored) data volume of the DS. The primary purpose of this partition is for storage of local data acquired via LDAD. The partition may also be used for other site-specific purposes such as site-developed executables and scripts required for operations.

The AWIPS System Engineering team is currently (for Build 5) investigating the allocation of the reserve disk space for use in local application development and operations. This section and/or Section 2.3.3 will be updated with information when it becomes available.

4.1.2 Informix

Informix is a Relational Database Management System (RDBMS). Informix contains and manages databases; it is not a database itself. Each database under the Informix RDBMS contains a number of tables, which contain actual data. The Informix Dynamic Server provides user and application access to several baseline-defined databases in the Informix RDBMS. Those of primary interest are a database named *fxatext* used for storage of text products, a hydrologic database, and the *hmdb* database supporting ADAPT applications (Climate, HWR, TAF Monitoring, and Forecast Verification). The text database, on the whole, is an emulation of the capability provided by the Automation of Field Operations and Services (AFOS). The hydrologic database supports the hydrologic forecasting mission of the Weather Forecast Offices (WFOs) and River Forecasting Centers (RFCs). A detailed discussion of the schema of the databases is beyond the scope of this manual; however, there are tools available that allow a user to inspect these schemas.

There are two principal ways of accessing table data in any Informix database: via the *dbaccess* utility, and via programs which use Embedded Structured Query Language (ESQL). Both C and FORTRAN ESQL programming utilities are provided with Informix on AWIPS. In addition, the AWIPS *textdb* command-line interface can be used from the command line, from a script, or within a program to access the *fxatext* database (see Section 4.2.7).

4.1.2.1 The *dbaccess* utility

The *dbaccess* utility is an Informix-provided tool that can be used to access data elements from any database within Informix. The *dbaccess* utility is fully described in the *DB-Access User Manual*.

The most common use of *dbaccess* is to interactively browse a database. The *dbaccess* utility provides a

character-based interface which allows it. It is also possible to make changes to the schema of a database through *dbaccess*, but sites shall not do this to any database other than those that are strictly local (in other words, schema changes to the text and hydrologic database are prohibited).

Another way to use *dbaccess* is to write a script containing SQL statements and submit it directly to *dbaccess* on the command line, rather than having to tediously type each Structured Query Language (SQL) statement from within *dbaccess*; consult the manual for the proper syntax.

The final way to use *dbaccess* is to embed the command-line invocation of *dbaccess* into a script. This is the approach taken by the trigger mechanism, which is part of the text database. Consult the script */awips/fxa/informix/StoreWWProduct.sh* for an example of how to do this scripting.

4.1.2.2 Informix ESQL/C

The second major way of accessing a database is through Informix ESQL/C. ESQL/C is an application-programming interface (API). This API enables the developer to embed SQL statements directly into a C program. This is, by far, the most efficient way of accessing the database; drawbacks to this approach include the requirement to program in C and to master the large number of functions (and their return values) provided by ESQL. A detailed discussion is beyond the scope of this appendix; consult the Informix-provided, two-volume, *Informix-ESQL/C Programmer's Manual*.

4.1.2.3 Informix Databases

4.1.2.3.1 Text Product Database

The Text Product Database supports the Text Workstation functions on AWIPS. All incoming and locally-created AFOS and other text products are stored in tables in the Text Product Database, *"fxatext"*. The products can be accessed via AFOS-like commands using their AFOS Product Identifier Labels (PILs), and can also be accessed and displayed from the Browser menu of the Text Workstation. WSR-88D associated text and text-only products are also stored in the Text Product Database and are accessible from the Text Workstation. The Text Product Database and its contents are described in Section 4.2.7. All read/write interactions with the text product database shall be handled via the *textdb* utility (Section 4.2.7.3).

The other Informix storage of text products is the storage of individual raw METAR reports in the *rpt* table of the *hmdb* database. METARs can be accessed from the *rpt* table by a combination of their ICAO station call letters (e.g. KMCI) *"icao_loc_id"*, type of report (METAR or SPECI) *"report_type"*, report datetime *"date"* (from the body of the report), *"nominal"* date/hour, and posting (storage) datetime *"origin."* No APIs to access this database exist in the AWIPS baseline code installed in the field. Also, the *rpt* table is likely to be eliminated in the Build 5.x time frame as enhancements are made to the *fxatext* database.

4.1.2.3.2 ADAP²T (Digital Forecast) Database

Documentation of this database is deferred. The data storage mechanisms in the ongoing transition from the Interactive Computer Worded Forecast (ICWF) system to the Interactive Forecast Preparation System (IFPS) are in a state of change for Build 5.0.

4.1.2.3.3 Hydrologic Database

The hydrological database in AWIPS contains current, decoded, hydrological observations; river and reservoir stage and flooding data; gage, telemetry, location, and observer data; and other hydrological and applications data. The *schema* of this database is too complex to be described in this document, and is unlikely to be understood except by those trained in relational database design. Documentation of the hydrologic database exists and is available from the NWS Office of Hydrology (OH).

The hydrologic database is accessible by *dbaccess* and Informix ESQL/C. A third way of accessing the hydrologic database is through a set of APIs developed by the OH. The OH APIs consist of the source code and the libraries used by OH developers to build the executables that are installed at AWIPS sites. The APIs are not part of the AWIPS installed software, and there is no current plan to make them part of the installed WFO or RFC baseline, however, the RFC applications developers are probably aware of, and using, these APIs.

4.1.2.3.4 Verification and Climate (hmdb) Database

Verification data for the Build 4.3 AWIPS Verification Program (replacement for the AFOS VERIFY program) and the Daily and Monthly Climate Reports Formatter are stored in tables in the *hmdb* database in Informix. Unlike most other Informix data storage in AWIPS, verification data and (to a lesser extent) climate data are stored in a truly relational manner across a number of related data tables. As time permits, documentation of this database will be compiled and posted on the AWIPS Local Applications Home Page.

4.1.3 Data on a Remote AWIPS

If products input from another site is a requirement, then a way to get the data is to FTP the products from the site to your site. This is to be used cautiously because of the impact of the FTP on your local system, the WAN, and the remote system. There is little impact on the remote system. There can be a large impact on the WAN depending on the size and frequency of the requests as well as the number of sites that are doing this. In R4.3, some radar products will be distributed over the SBN and each site will be configured to ingest only those products from radars in their radar dial list. At this time, the sites that have implemented the FTP of radar products should cease this method and use the baselined method. The action of FTP also has an impact on the local system that is running the FTP client. This script shall not be done on the servers because of the impact to operations.

4.1.4 External Data

Products external to AWIPS have two methods of entering the system at this time. One is through LDAD, the other is through the Asynchronous Product Scheduler. The baseline decoders used in AWIPS are very sensitive to format and should not be used to process data from external sources. If external data has to be processed by a decoder, it is to be performed on the LDAD by a decoder implemented by the developer. Refer to Sections 6.1, 6.1.2, and 6.1.3 of the AIFM for further information.

4.1.5 Where and How to Access Data Sets

Data Files

In the data acquisition process, most of the incoming data are written to disk in flat files (netCDF included). The amount of data kept is set as a system parameter and depends on the disk space available. The data files are stored on the data server in different directories depending on the type of data and its format. A straightforward set of directory and file naming conventions is used to identify the location, format, and contents of AWIPS data files. The details of these file formats and directory locations are given in Section 4.2. Since the data directories on the system are NFS mounted, the data are transparently accessible to all users (depending on their permissions), no matter which machine within the local network they are using.

C++ APIs are used within the D2D system to display or to analyze the data. Use of the D2D APIs for data access in locally developed applications is not allowed at this time. The D2D APIs are complex and require that the data be accessed via their data keys (see Section 4.1.1.2.1), and are tightly tied to the D2D menus and depictables. Also, for many data types, the D2D APIs currently access only the depictable-specific plotfiles, not the netCDF files. Each of these plotfiles is in a unique format and requires a special API to access the data within.

Since all the data in plotfiles are (or will be) also contained in netCDF files, that local applications shall use netCDF APIs to access the netCDF data files wherever possible. Once the basic pattern of calls is known, it is easy to modify existing APIs or write new APIs which read netCDF data files. Also, utilities exist to automatically generate API source code in FORTRAN77 which reads any netCDF file. An example of the usage and results of these utilities for reading METAR netCDF files is included as Appendix 1 of this document. The native netCDF APIs are documented in the NetCDF User's Guide. Rather than coding directly from netCDF APIs, grids should be accessed using the wrapper and navigation APIs described in Section 4.2.2.4.

Radar products are the only data stored in flat files that are not also available in a corresponding netCDF format. These data are described in Section 4.2.4. A convenient set of stand-alone APIs to access and read these data from the AWIPS database does not currently exist. However, any code from outside sources which accepts WSR-88D radar data that is in the RPG-to-PUP (Archive level IV) format can

directly access and process the radar data files in the AWIPS database.

Informix Data Sets

NOTE: The `fxatext` database is undergoing a redesign for Build 5 to accommodate international products and product retrieval by WMO Header. The following description and the information in Section 4.2.7 represent AWIPS up through Build 4.3

AWIPS stores decoded text products in the Informix `fxatext` database. The `fxatext` database works on a circular buffer basis, storing the newest version of each product over the oldest. The number of versions of each product or category of products is specified in a table in the database. Locally-developed applications may not, and need not, access the text product database tables directly through embedded SQL. A Command Line Interface (CLI), `textdb`, is provided for access to and control of the text product database, and does not require a special setup of the database. Use of `textdb` is described in Section 4.2.7.3.

4.1.6 Data Inventory Methods

In most cases, the file name of an AWIPS data file is also the valid time or nominal hour of the data contained in the file. In most cases, a time inventory of a given data set is accomplished by simply obtaining a listing of the file names in the data subdirectory for a specific instance (e.g., GOES; visible; CONUS scale; Lambert projection) of the data type. The D2D subsystem of AWIPS provides specific methods for obtaining data inventories for each data type, but these APIs are currently not practical for use by local applications. The lack of APIs for performing data inventories is not a hindrance to local application development, since in most cases it is trivial to obtain an inventory for a specific data type.

Fixed-location, scheduled observations within a defined time period are placed into netCDF files for a fixed set of nominal times (e.g., hourly files for METAR). Each file contains observations within the time period for all reporting stations for the data type. A supporting file can be read to obtain the possible list of stations contained in the data file. It is necessary to read the data in the netCDF file to determine whether it contains a valid data element or report for a given station within the nominal time period covered by the file. Time periods of data stored in, and the supporting files for, each type of netCDF data file vary, and are documented under the appropriate subsections in Section 4.2.3.

For observations occurring at random locations and times (e.g., lightning reports), the data are generally partitioned by fixed time periods and placed into a single data file for that fixed period. It will be necessary to read the contents of the netCDF file to create a time inventory of the data at time resolutions finer than the fixed periods of the netCDF data files, or to partition station or random data into geographic subsets. See the appropriate subsection under Section 4.2 for the relationship between file names, supporting files, and the contents of the data file for the given data type.

Inventories for grid data are more complicated than those of the observational data sets; however, APIs useful for local applications are provided for grid inventory. The netCDF grid files contain all the grids for the analysis and forecast times of an entire run of a given model, and are named according to the model initial time. The grid access APIs described in Section 4.2.2.4 provide all the necessary capabilities for accessing and obtaining inventories (models, areal scales, initial and forecast times, levels, physical elements) of the grids contained in the AWIPS database of netCDF grid files.

Inventories for text products in the text database may be created by use of the *textdb* command with the **A** option. The output times will correspond to the storage times of the text product versions currently in the text database, not the product valid times. See Section 4.2.7.3 for details on the use of the *textdb* utility and the times of text products.

4.1.7 Time and Date Conventions

Date and time throughout AWIPS (except as otherwise noted elsewhere) are in Greenwich Mean Time (GMT), also (and more correctly!) called Universal Coordinated Time (UTC). Date and time within data and as used for computation are expressed as C-language type "long" variables representing seconds since 00:00:00 GMT, January 01, 1970. Time differences and intervals are expressed as C-language type "long" variables representing seconds. Dates used in file naming and data tagging (when done in ASCII) are in ASCII **yyyymmdd** format (**yyyy** is year, **mm** is month, and **dd** is day of month). Times used in file naming and data tagging (when done in ASCII) are in ASCII **hhmmss** format (**hh** is hour, **mm** is minute, and **ss** is second).

The *ctime* set of APIs provided with HP-UX, and callable from C++, C, and FORTRAN, includes APIs to convert between seconds since 00:00:00 UTC, January 01, 1970 and a structure containing separate integers for year, month, day of month, day of week, day of year, hour, minute, and second. The three primary APIs of interest are *mktime*, *gmtime*, and *localtime*. The function *mktime* assumes the time in the structure is local time, not UTC. The time in the structure produced by *localtime* will be local time, not UTC. The UNIX environment variable "TZ" indicates what time zone is "local time" for the user's session. On AWIPS workstations, "TZ" is set to Universal Coordinated Time. If you need to use local time, you are on your own. Refer to "Date and Time Manipulation" in Chapter 10 of Programming on HP-UX for more information on the *ctime* routines. See the Unix man page entries for *date*, *time*, and *gettimeofday* as a starting point for learning about and using HP-UX system times.

A couple of reminders:

- In normal places, for over half the year, "daylight savings time" must be accounted for when using local time.
- Current practice, in those states where "daylight savings time" is used, is to move clocks ahead one hour at 2 a.m. local standard time (2 a.m. becomes 3 a.m.) on the first Sunday of April, and back one hour at 2 a.m. local daylight time (2 a.m. becomes 1 a.m.) on the last Sunday of

October.

It is strongly recommended that you avoid local time. For further information on *ctime* and its APIs, see the man page for *ctime*.

Always allow/use four digits for year!

4.1.8 Data Access Controls

Deferred.

4.1.8.1 Informix Concurrency Controls: Database Locks

Deferred.

4.1.9 Purging

This section will address data purging; log purging was addressed in Section 3.6. Data purging, including temporary files created or used, is vital to overall system performance. All directories including */tmp* can be filled causing system-wide problems. Testing of any local application should take into account instances when a data maintenance process is not up for some reason to fully assess problems that may arise.

The AWIPS baseline is delivered with two mechanisms for maintenance of data storage.

- **Purge** is run every 30 minutes and is used to maintain the number of products in specified directories. If you add a new directory of products, a new line will be necessary in the purge configuration file to specify the directory to purge and the number of files to keep in the directory. Instructions for modifying the purge configuration file, */awips/fxa/bin/fxa-data.purge*, and potential ramifications are contained in sections 9.1 - 9.3 of the SMM.
- **Scour** is run once a day and is used to clean up log files and a few items not hit by *master.purge*. Scour deletes files based on date. Instructions for modifying the scour configuration file, */awips/fxa/bin/scour.conf*, are contained in section 9.1.1.1 of the SMM.

Consideration must be given to temporary data storage. The local application shall ensure temporary files are removed when processing is complete and add safeguards to ensure purging takes place if a handling process is down or slowed down due to data volume.

If you add data to any Informix database, you must write a custom purge utility to purge your data from that database if the data is not purged through existing routines (i.e., through **dbpurge** for the hydrology

database, **purge_report** for the hmdb, **rm_tables** and **delete_log_files** for ADAPT, and through **fxa-data.purge**, via **master_purge** and **scour**, for fxa data).

4.2 Data Classes

The hydrometeorological data sets on AWIPS are divided into several classes, based on the data source and the data type. The major data classes of AWIPS have been listed in Table 4.1-1. Details of the data locations, formats, content, and access methods for each data class are described in the following subsections.

4.2.1 Aircraft Observations

Automated aircraft observations are not available in AWIPS in Build 4.3. However, manual PIREPs are stored in the text database under their AFOS PILs.

4.2.2 Grids

4.2.2.1 Naming Conventions for Grid Directories and Files

In AWIPS Build 4.3, grids are stored in **netCDF** files once the grid has been unpacked (decoded from GRIB) or computed (in the case of isentropic levels or derived grid variables; or MAPS, LAPS, or LAMP). Thus, all grid I/O is done with **netCDF** APIs.

Almost all **netCDF** grid files are stored in a path named according to grid source, scale, and model. Each file contains the complete model output grid set for a single run of a given model and a given scale. The file names are based on run date and time. Here is a template:

```
$FXA_DATA/Grid/<source>/netCDF/<scale>/<model>/<yyyymmdd_HHMM>
```

```
|----- path -----| |----- file -----|
```

where:

`$FXA_DATA` is an environment variable specifying the root of the data directory tree. This variable's current value is `"/data/fxa"`.

`<source>` is either FSL, ISPAN, SBN, or TDL;

`<scale>` may be any of CONUS202, CONUS211, CONUS212, CONUS213, CONUS215, FSL_CONUS_C, LAMP_Grid, LAPS_Grid, LATLON, MAPS_National, MSAS, NAT203, NAT204, NAT205, NHEM201, REG207, and REG233;

`<model>` may be any of AVN, ECMWF, Eta, ETA_AIV, FCST, GWW, LAMP, LAPS, MesoEta, MRF, NGM, RUC, RUC_AIV, 40km_MAPS;

yyyy is the 4-digit year;

mm is the 2-digit month;

dd is the 2-digit day-of-month;

HH is the 2-digit initialization (run) time hour; and

MM is the 2-digit initialization (run) time minute (usually 00).

Three examples follow:

- Northern Hemispheric 201 grids of the September 13, 1996, 0000z run of the MRF model:

/data/fxa/Grid/SBN/netCDF/NHEM201/MRF/19960913_0000

- CONUS 202 grids of the September 13, 1996, 1200z run of the AVN model:

/data/fxa/Grid/SBN/netCDF/CONUS202/AVN/19960913_1200

- CONUS 202 grids of the September 14, 1996, 0000z run of the NGM model:

/data/fxa/Grid/SBN/netCDF/CONUS202/NGM/19960913_0000

The exceptions to the above file naming scheme include:

1. the ECMWF model, whose grids are stored in files having the path:

/data/fxa/Grid/SBN/netCDF/LATLON/ECMWF/NHEM/yyyymmdd_HHMM

[Note the extra directory level (NHEM) below (after) the model (ECMWF)],

2. LAMP grids, stored in files having the path:

/data/fxa/Grid/TDL/netCDF/LAMP_Grid/LAMP/yyyymmdd_HHMM

3. SCAN QPF grids, stored in files having the path:

/data/fxa/Grid/TDL/netCDF/QPF_Grid/QPF/yyyymmdd_HHMM

4.2.2.2 Organization of **netCDF** Grid Files

Note: The information in Section 4.2.2.2 and its subsections is provided for completeness of documnetation. It is not necessary to know this level of detail to successfully access and process AWIPS grids. The reader may wish to skip to Section 4.2.2.4.

All AWIPS **netCDF** grid files contain nineteen **global attributes**, eight common **dimensions**, and eight common **variables**. The files contain additional **dimensions** and **variables**, the names and numbers of these varying from file to file. There are no **coordinate variables** (**dimensions** that are also **variables** with values stored in them) for the vertical levels or the forecast (or valid) times of the grids.

While not at first intuitive, not using a **dimension** for the vertical levels of the grids does make some sense when you think about it. As an example, consider the AVN 213 (National CONUS) temperature grids. There are 22 of them for each forecast time: 2 meters above ground, every 50 mb from 1000 mb to 100 mb inclusive (that's 19 levels), the surface to 30 mb above surface boundary layer, and the tropopause. Since the values of a **dimension** must all be the same type and units, the 22 levels of the AVN temperature grid cannot straightforwardly be represented by a **dimension**. The AWIPS designers incorporated lists of the values of the grid levels both as a character **attribute** of each **netCDF** grid **variable** and as a *companion attribute* (this is AIFM terminology, it is not a **netCDF** term) **netCDF** character *variable*.

4.2.2.2.1 Global Attributes

AWIPS build 4.3 netCDF grid files have nineteen **global attributes**. They are as follows:

1. "CdIDate" = an 8-character string giving the date of the cdl file used to define the structure and contents of this file. This in effect identifies the version of this netCDF file structure. The date is given in "YYYYMMDD" format.
2. "DepictorName" = a 75-character string consisting of a unique identifier for the map projection / areal coverage combination for the grids in this file.
3. "ProjIndex" = a long int which identifies the projection of the grids stored in this file.
4. "projName" = a 42-character string giving the name of the map projection of the grids stored in this file.
5. "centralLat" = a float value giving the latitude (in degrees north) at which the map projection is tangent to the earth.
6. "centralLon" = a float value giving the longitude (in degrees east) at which north is "up" on the map projection.
7. "rotation" = a float value giving the angle (in degrees clockwise) the map projection's y-axis is rotated from north.
8. "xMin" = a float value giving an arbitrary cartesian coordinate for the map projection. This is for FSL's use in D-2D.
9. "xMax" = a float value giving an arbitrary cartesian coordinate for the map projection. This is for FSL's use in D-2D.
10. "yMax" = a float value giving an arbitrary cartesian coordinate for the map projection. This is for FSL's use in D-2D.
11. "yMin" = a float value giving an arbitrary cartesian coordinate for the map projection. This is for FSL's use in D-2D.
12. "lat00" = a float value giving the latitude (in degrees north) of the lower left (southwest) corner of the grid.
13. "lon00" = a float value giving the longitude (in degrees east) of the lower left (southwest) corner of the grid.
14. "latNxNy" = a float value giving the latitude (in degrees north) of the upper right (northeast) corner of the grid.

15. "lonNxNy" = a float value giving the longitude (in degrees east) of the upper right (northeast) corner of the grid.
16. "dxKm" = a float value giving the left-to-right (west-to-east) distance in kilometers between two adjacent gridpoints at the latitude and longitude given by **global attributes** "latDxDy" and "lonDxDy" defined below.
17. "dyKm" = a float value giving the bottom-to-top (south-to-north) distance in kilometers between two adjacent gridpoints at the latitude and longitude given by **global attributes** "latDxDy" and "lonDxDy" defined below.
18. "latDxDy" = a float value giving the latitude (in degrees north) at which the "dxKm" and "dyKm" (defined above) values are valid.
19. "lonDxDy" = a float value giving the longitude (in degrees east) at which the "dxKm" and "dyKm" (defined above) values are valid.

4.2.2.2.2 Dimensions and Coordinate Variables.

The **netCDF** grid files of AWIPS have no **coordinate variables** and only one **unlimited** (or **record**) **dimension**. The **unlimited dimension** is named "record". It represents the time dimension of the grids.

The **netCDF** grid files of AWIPS have eight common **dimensions** for dimensioning (sizing) variables (including grids). Additional **dimensions** representing the number of available levels of the model's grid **variables** vary from model to model. Every **dimension** in a **netCDF** file has a size. The eight common **dimensions** are:

1. "record" = number of valid times (initialization and forecast) available in this model run. Example: for the AVN model, the size of "record" is 17. This represents initialization (0h) and sixteen forecast times (3h, 6h, 9h, 12h, 15h, 18h, 21h, 24h, 30h, 36h, 42h, 48h, 54h, 60h, 66h, and 72h) for a total of seventeen valid times. "Record" is used as the time **dimension** of grid **variables**.
2. "n_valtimes" = maximum number of valid times (initialization and forecast) this model run could have. The dimension "n_valtimes" is used as the time **dimension** of *companion inventory variables* (see section 4.2.2.2.3.1).
3. "data_variables" = number of grid **variables** (physical elements; e.g., temperature, pressure, relative humidity) in the **netCDF** grid file. (This really should be a **global attribute**, not a **dimension**.)
4. "namelen" = maximum number of characters that can comprise a name. The size of "namelen" is fixed at 132 (names can be at most 132 characters long).
5. "charsPerLevel" = number of characters used to represent a (string) value of the *companion levels variables* (see section 4.2.2.2.3.1). Example: for the NGM model, "charsPerLevel" has size 11, meaning level values are 11-character strings.
6. "x" = number of gridpoints in the x dimension. Grid subscripts (indices) in the "x" direction increase from left to right, that is, from west to east.
7. "y" = number of gridpoints in the y dimension. Grid subscripts (indices) in the "y" direction increase from bottom to top, that is, from south to north.

8. "nav". This dimension, which currently always has a value of 1, is not now used. It is left over from an older CDL file.

The additional **dimensions** in each **netCDF** grid file are what shall henceforth be referred to as *levels dimensions*. Associated with each grid **variable** are two *companion attribute variables*. One of these is a string array (list) of values of the grid's vertical levels. The other is a character array serving as an inventory of what level and valid time combinations within the grid **variable** are present and which are missing. These two *companion attribute variables* will be discussed in detail later. The *levels dimension* is the number of vertical levels in the grid **variable** and its two *companion attribute variables*. *Levels dimensions* have names of the form "levels_*n*" or "levels_*nn*", where *n* and *nn* represent both the value of the *levels dimension* and the number of levels for the parent grid **variable(s)**. As an example, consider the hemispheric AVN grids. It has eight grid **variables**:

- "gh" (geopotential height)
- "t" (temperature)
- "uw" (west-east component of wind)
- "vw" (south-north component of wind)
- "pvv" (pressure vertical velocity)
- "p" (pressure)
- "pmsl" (mean sea level pressure), and
- "vss" (vertical speed shear).

Each of these eight grid variables has associated with it a *levels dimension* according to how many levels the *parent* grid variable has. So:

- "gh" has five levels (850 mb, 700 mb, 500 mb, 300 mb, and 250 mb). So its two *companion attribute variables* also have a vertical dimension of five. Therefore the **levels dimension** "levels_5", which has a value of 5, has been defined to serve as the vertical dimension of "gh" and its two *companion attribute variables*.
- "t" has five levels (850 mb, 700 mb, 500 mb, 250 mb, and "TROP"). So its two *companion attribute variables* also have a vertical dimension of five. Therefore the **levels dimension** "levels_5", which has a value of 5, has been defined to serve as the vertical dimension of "t" and its two *companion attribute variables*.
- "uw" and "vw", each has eleven levels. So its two *companion attribute variables* also have a vertical dimension of eleven. Therefore the **levels dimension** "levels_11", which has a value of 11, has been defined to serve as the vertical dimension of "uw" and "vw" and their two *companion attribute variables*.

To finish this example quickly:

- "pvv": "levels_9", which has a value of 9.
- "p": "levels_2" (the two levels being "SFC" and "TROP"), which has a value of 2.

- "pmsl": "levels_1" (the one level being "MSL"), which has a value of 1.
- "vss": "levels_1" (the one level being "TROP"), which has a value of 1.

So the **netCDF** grid file for the hemispheric AVN model has five *levels dimensions*: "levels_1", "levels_2", "levels_5", "levels_9", and "levels_11".

4.2.2.2.3 Variables, with their **Dimensions** and **Attributes**.

The **variables** in **netCDF** grid files can be divided into two groups:

- grid **variables** with their *companion attribute variables*, and
- **variables** specifying characteristics of a model run and scale as a whole, applicable to all grid **variables** within the file.

We will examine these two groups separately.

4.2.2.2.3.1 Grid **Variables** with their *Companion Attribute Variables*.

There are two "special" values that must be watched for when using gridpoint data: the "fill value" and the value representing "not defined".

- When space for a grid is created in the netCDF grid file, it is initialized to the "fill value" before any actual data are stored in it. If the grid is missing, then its space in the netCDF grid file will remain filled with the "fill value". When a grid is read in from the netCDF grid file, it will be either entirely filled with the "fill value", or no gridpoints at all will be filled with the "fill value". So if one point's value is equal to the "fill value", then the entire grid is missing. Therefore, after reading a grid in from a netCDF grid file, it is recommended that the programmer check any one gridpoint for the "fill value" before attempting to use the grid. The value of the "fill value" is found in "_FillValue", one of the attributes of the grid. See also the description of the "_FillValue" attribute below.
- Sometimes, an individual gridpoint's value is "not defined". An example of this is an isentropic surface gridpoint located where the isentropic surface is below ground. In AWIPS, a gridpoint whose value is "not defined" is assigned the value 1.0e+37. Because such numbers may not have an exact representation in a computer's floating point representation, programmers should allow some "pad" when checking for "not defined" gridpoint values. It is therefore recommended that the programmer use a gridpoint's value only if it is less than 1.0e+36.

Each of the grid variables (the number of them is the same as the size of the **dimension** named "data_variables") is a 4-dimensional "variable". The 4 **dimensions** are (in order):

- "record" (this is the time dimension)
- one of the *levels dimensions* (this is the vertical dimension)
- "y" (this is the south-to-north dimension), and
- "x" (this is the west-to-east dimension).

Each grid **variable** has six **attributes** and two *companion attribute variables*. The **attributes** are as follows:

- "long_name": a variable-length string containing a "spelled out" name of the meteorological variable stored in the grid.
- "units": a variable-length string specifying the units of the data stored in the grid.
- "valid_range": two float values giving the minimum and maximum values that the grid values can have.
- "_FillValue": a floating point number giving the value used to signify the entire grid is missing. For the MM5 model grids, this **attribute's** value is -99999.0 for some grid **variables**, and 9.9999999E+36 for the remaining grid **variables**. For all other models, this **attribute's** value is always -99999.0.
- "_n3d": a long integer value giving the number of 2-dimensional slabs that should be read to get a 3-dimensional description of the meteorological variable stored in the grid.
- "levels": a variable-length string containing a list of the vertical levels of the grid. It must be parsed to be correctly understood.

The first *companion attribute variable* is a variable-length list of the parent grid's vertical level values. This variable shall henceforth be called the *companion levels variable*. Each vertical level value is a variable-length string (the length of the string is fixed within a given **netCDF** grid file, but varies from one **netCDF** grid file to another). The name of this **variable** is of the form:

<parent_grid_variable_name>Levels

For example, if the *parent* grid **variable** is "av" (for "absolute vorticity"), then the name of the *companion levels variable* is "avLevels". *Companion levels variables* have two **dimensions**:

- a *levels dimension* - corresponds to the *parent* grid's vertical levels. This *levels dimension* is the same *levels dimension* associated with the *parent* grid **variable**.
- "charsPerLevel" - the length of the strings used to represent the vertical level values.

Companion levels variables have no **attributes**.

Companion levels variables are best thought of as a list or set of vertical level values concatenated together into one long string. The number of vertical level values is equal to the value of the *levels dimension*. Each of the vertical level values is expressed as a string whose length is equal to the value of the "charsPerLevel" **dimension**. The vertical level values must be parsed to be correctly understood.

Let's look at an example. One of the grid **variables** in the hemispheric scale AVN model is "vw" (the "v" or south-to-north component of the wind). Its *companion levels variable* is called "vwLevels", and its two **dimensions** are "levels_11" and "charsPerLevel". The value of "levels_11" is 11; the value of "charsPerLevel" is 8. So "vw" can be treated as a 88-character string constructed by concatenating together eleven vertical level values, each expressed as an 8-character string. The eleven vertical level values are:

"MB 1000 " = 1000 millibar level
 "MB 850 " = 850 millibar level
 "MB 700 " = 700 millibar level
 "MB 500 " = 500 millibar level
 "MB 400 " = 400 millibar level
 "MB 300 " = 300 millibar level
 "MB 250 " = 250 millibar level
 "MB 200 " = 200 millibar level
 "MB 150 " = 150 millibar level
 "MB 100 " = 100 millibar level
 "TROP " = tropopause.

So the 88-character string value of "vw" is "MB 1000 MB 850 MB 700 MB 500 MB 400 MB 300 MB 250 MB 200 MB 150 MB 100 TROP ".

The second *companion attribute variable* is an inventory indicating which valid times and vertical levels of the *parent* grid **variable** actually contain data, and which are missing. This **variable** shall henceforth be known as the *companion inventory variable*. The name of this **variable** is of the form:

<parent_grid_variable_name>Inventory

For example, if the *parent* grid **variable** is "av" (for "absolute vorticity"), then the name of the *companion inventory variable* is "avInventory". *Companion inventory variables* have two **dimensions**:

- "n_valtimes" - corresponds to the valid times of the *parent* grid.
- a *levels dimension* - corresponds to the *parent* grid's vertical levels. This *levels dimension* is the same *levels dimension* associated with the *companion levels variable* and the *parent* grid **variable**.

Companion inventory variables have no **attributes**.

Companion inventory variables are best thought of as a two-dimensional array, with rows (the first subscript) corresponding to valid times, and columns corresponding to vertical levels. Consider as an example the AVN model "t" (for "temperature") grid **variable**. Its *companion inventory variable* ("tInventory") has 11 rows or valid times (the "n_valtimes" **dimension** has a value of 13), and 5 columns

or vertical levels (its *levels dimension* is "levels_5", which has a value of 5). If programming in C or C++ (remember, subscripts in C and C++ start with 0, not 1), tInventory(2,0) indicates whether or not "t" contains actual data for the third valid time (the 12 hour forecast) and the first vertical level ("MB 850 ", meaning the 850 millibar level).

Formally, *companion inventory variables* are declared to contain **NC_CHAR** (character) data, but in practice, the values in this **variable** are treated as byte-sized integers. A non-zero value (usually 1) indicates the *parent* grid **variable** contains actual data for the value's valid time and vertical level, while a zero value indicates the corresponding valid time and vertical level in the *parent* grid **variable** are missing. So, for example (if programming in C or C++), tInventory(2,0) = 1 indicates that the temperature grid **variable** has actual data for the 850 millibar 12 hour forecast, while tInventory(9,4) = 0 indicates that the 60 hour tropopause temperature forecast is missing.

4.2.2.2.3.2 Variables Representing Overall File Characteristics

AWIPS **netCDF** grid files contain the following eight **variables** used to characterize the file (the model run and scale):

1. "valtimeMINUSreftime" = a one-dimensional array of valid times in seconds since the reference time (see the discussion of the variable "reftime" in this section). Values of this variable are of type **NC_LONG** (long int). This variable has one **dimension** ("n_valtimes") and one **attribute**. The **attribute** is a 7-character string called "units", and has the value "seconds".
2. "valtime" = a one-dimensional array of valid times in seconds since 00Z on January 01, 1970. Values of this variable are of type **NC_DOUBLE** (double). This variable has one **dimension** ("record") and two **attributes**. The first **attribute** is a 10-character string called "long_name", and has the value "valid time". The second **attribute** is a 35-character string called "units", and has the value "seconds since (1970-1-1 00:00:00.0)".
3. "reftime" = a one-dimensional array of reference times (model run times) in seconds since 00Z on January 01, 1970. Values of this variable are of type **NC_DOUBLE** (double). This variable has one **dimension** ("record") and two **attributes**. The first **attribute** is a 14-character string called "long_name", and has the value "reference time". The second **attribute** is a 35-character string called "units", and has the value "seconds since (1970-1-1 00:00:00.0)".
4. "origin" = the name of the person(s) or organization that produced the model run. The value of this **variable** is of type **NC_CHAR** (character or string). This **variable** has one **dimension** ("namelen") and no **attributes**. An example value of "origin" (with trailing spaces trimmed off) is "NCEP". (This really should be a **global attribute**, not a **variable**.)
5. "model" = the name of the numerical model that produced the grid **variables** in this file. The value of this **variable** is of type **NC_CHAR** (character or string). This **variable** has one **dimension** ("namelen") and no **attributes**. Example values of "model" (with trailing spaces trimmed off) are "126 wave triangular, 18 layer spectral aviation run" and "Nested Grid Model". (This really should be a **global attribute**, not a **variable**.)
6. "staticTopo" = a two-dimensional grid of float values giving the height of the model's surface in meters above mean sea level at each grid point. This **variable** has two **dimensions** ("y" and "x")

and three **attributes**. The first attribute is a 6-character string called "units", and has the value "meters". The second attribute is a 10-character string called "long_name", and has the value "Topography". The third attribute is called "_FillValue". Its value is a floating point number giving the value used to signify the entire grid is missing. This **attribute's** value is always -99999.0.

7. "staticCoriolis" = a two-dimensional grid of float values giving the value of the Coriolis parameter f . Now $f = 2 * \Omega * \sin(\phi)$, where Ω is the earth's rotation rate (2π radians per day, 1 day = 86400 seconds), and ϕ is the latitude. So $f = (2.0 * 2\pi * \sin(\text{latitude}) / 86400.0)$ in (seconds⁻¹) at each grid point. This **variable** has two **dimensions** ("y" and "x") and three **attributes**. The first attribute is a 7-character string called "units", and has the value "/second". The second attribute is a 18-character string called "long_name", and has the value "Coriolis parameter". The third attribute is called "_FillValue". Its value is a floating point number giving the value used to signify the entire grid is missing. This **attribute's** value is always -99999.0.
8. "staticSpacing" = a two-dimensional grid of float values giving the distance (in meters) between 2 adjacent grid points. This **variable** has two **dimensions** ("y" and "x") and three **attributes**. The first attribute is a 6-character string called "units", and has the value "meters". The second attribute is a 12-character string called "long_name", and has the value "Grid spacing". The third attribute is called "_FillValue". Its value is a floating point number giving the value used to signify the entire grid is missing. This **attribute's** value is always -99999.0.

4.2.2.3 Other supporting files

The files described in this section are part of the AWIPS source tree and will not be available at field sites. However, the information in the described files is listed in Appendix 2.

There are two viewable-with-system-editors data files of interest when reading grids from AWIPS netCDF grid files: "gridSourceTable.txt" and "virtualFieldTable.txt". The file "gridSourceTable.txt" contains, in the tenth field (called "name") of each logical record, the valid values for the "sourceId" calling argument to three of the APIs described in the next section. The structure and contents of the records of this file is described by comments at the top of the file. The file "virtualFieldTable.txt" contains in the first field of each logical record the valid values to the API "getGridSliceAccessKey", also described in the next section. The structure and contents of the records of this file are described in the file "README.GRIDS".

In addition to the above two files, the "cdl" (Common Data form Language) files may provide helpful information. "cdl" files are used to define the structure and contents of netCDF files. They are human-readable (and editable) using any text editor. D2D creates a netCDF grid file by running "ncgen" on the appropriate "cdl" file. The "cdl" files for AWIPS netCDF grid files are well documented with internal comments. For more information on "cdl" files and the "ncgen" program, see the "NetCDF User's Guide".

Additional documentation and information may be found in "gridTables.doc", "maksuparg.doc", and

"styleRules.doc". These files are located in directory "\$FXA_HOME/data/localization/documentation". They are html documents, best viewed using the Netscape browser.

4.2.2.4 Existing software (APIs) for reading netCDF grid files

None of the following will be able to be implemented by the field without access to the C++ compiler used to build the baseline code. However, a "Grid Server" is expected to be in place during Build 5, which will allow language-independent access to the AWIPS netCDF grids without the need for access to the AWIPS source code or libraries.

APIs for accessing AWIPS netCDF grid files and information about the grids are found in:

\$FXA_HOME/src/dataMgmt/GridSliceWrapper.h

FORTTRAN callers need not include anything to use the APIs defined in the above named file, but may view the file to see the function names and calling sequences.

There are several C-language APIs of interest in "GridSliceWrapper.h". Discussed here are one API to provide lists of IDs for what's available, three APIs for accessing grids, three APIs for accessing information about grids, and one API for getting the path (directory + file name) of the netCDF file in which grids of interest are stored.

The first API of interest is "gridSliceLists":

```
void gridSliceLists (
    char ***sourceIds , /* output */
    int *nSources , /* output */
    char ***fieldIds , /* output */
    char ***descriptions , /* output */
    int *nFields , /* output */
    char ***planeIds , /* output */
    int *nPlanes ) /* output */
```

This function constructs and returns lists (arrays) of valid "sourceId", "fieldId", and "planeId" values for the three input calling arguments to "getGridSliceAccessKey" discussed earlier. The calling arguments for "gridSliceLists" are as follows:

"descriptions" is (a pointer to) an array of string (char *) descriptions of each of the "fieldId" values returned in "fieldIds".

"fieldIds" is (a pointer to) an array of valid string (char *) values for the "fieldId" calling argument of function "getGridSliceAccessKey".

"nFields" is (a pointer to) the number of "fieldId" values in "fieldIds".

"nPlanes" is (a pointer to) the number of "planeId" values in "planeIds".

"nSources" is (a pointer to) the number of "sourceId" values in "sourceIds".

"planeIds" is (a pointer to) an array of valid string (char *) values for the "planeId" calling argument of function "getGridSliceAccessKey".

"sourceIds" is (a pointer to) an array of valid string (char *) values for the "sourceId" calling argument of function "getGridSliceAccessKey".

The function "gridSliceIdLists" will allocate memory space for "descriptions", "fieldIds", "planeIds", and "sourceIds"; you must free the memory space when you are done with it.

The three functions for accessing grids are:

```
unsigned long getGridSliceAccessKey (
```

```
    char *sourceId , /* input */
    char *fieldId , /* input */
    char *planeId ) /* input */
```

```
void gridSliceInventory (
    unsigned long key , /* input */
    long **refTimes , /* output */
    long **fcstTimes , /* output */
    int *nTimes ) /* output */
```

```
void gridSliceAccess (
    unsigned long key , /* input */
    long refTime , /* input */
    long fcstTime , /* input */
    float **data , /* output */
    float **data2 , /* output */
    int *nx , /* output */
    int *ny , /* output */
    int *nz , /* output */
```

```
float **levelValues ) /* output */
```

To use these APIs, you generally will first call "getGridSliceAccessKey" to get D2D's key for the combination of model, projection, scale, level, and field you desire. If you want the surface grid and all available isobaric levels for the desired field, pass in a NULL pointer for the calling argument "planeID". The D2D key for the desired grid(s) is returned as the function's value.

Generally, you will next call "gridSliceInventory" to get lists (arrays) of the reference times and forecast times for which the desired combination of model, projection, scale, level, and field is available. Use the key returned by "getGridSliceAccessKey" to specify the desired combination of model, projection, scale, level, and field. The function "gridSliceInventory" will allocate (malloc) the memory space for the two arrays, but it is the caller's responsibility to free the memory space when it is finished with the arrays. The number of reference and forecast times (the dimension of the two arrays) is returned in the calling argument "nTimes".

Now, call "gridSliceAccess" to get the desired grid(s). Use the key returned by "getGridSliceAccessKey" to specify the desired combination of model, projection, scale, level, and field. Use one of the reference times and one of the forecast times returned by "gridSliceInventory" to specify the reference time and forecast time for the desired grid(s). Call "gridSliceAccess" once for each combination of reference time, forecast time, and grid key. What "gridSliceAccess" returns depends on the "planeId" given to "getGridSliceAccessKey" and the rank (number of dimensions) of the desired field:

- If "planeId" was not a NULL pointer, and the desired field is scalar, "gridSliceAccess" will return NULL pointers for "data2" and "levelValues", zero for nz, (a pointer to the address of) the desired grid in "data", and (pointers to) the dimensions of the requested grid in "nx" and "ny".
- If "planeId" was not a NULL pointer, and the desired field is a two-component vector, "gridSliceAccess" will return a NULL pointer for "levelValues", zero for nz, (a pointer to the address of) the desired grid for the first (i) component of the desired field in "data", (a pointer to the address of) the desired grid for the second (j) component of the desired field in "data2", and (pointers to) the dimensions of the requested grid pair in "nx" and "ny".
- If "planeId" was a NULL pointer, and the desired field is scalar, "gridSliceAccess" will return a NULL pointer for "data2", (a pointer to the address of) all available isobaric grids and the surface grid for the desired field in "data", (a pointer to the address of) the array of the level values for the returned grids in "levelValues", (a pointer to) the number of returned grids (and level values) in "nz", and (pointers to) the dimensions of the returned grids in "nx" and "ny".
- If "planeId" was a NULL pointer, and the desired field is a two-component vector, "gridSliceAccess" will return (a pointer to the address of) all available isobaric grids and the surface grid for the first (i) component of the desired field in "data", (a pointer to the address of)

all available isobaric grids and the surface grid for the second (j) component of the desired field in "data2", (a pointer to the address of) the array of the level values for the returned grids in "levelValues", (a pointer to) the number of returned level values in "nz", and (pointers to) the dimensions of the returned grids in "nx" and "ny".

The function "gridSliceAccess" will allocate (malloc) memory for "data", "data2", and "levelValues". It is the calling routine's responsibility to free this memory space when finished with it.

As was noted earlier in this section, the programmer should:

- use a grid only if it is not missing, that is, if it is not filled with the "fill value" (usually -99999); and
- use a gridpoint value only if it defined, that is, only if the value is less than $1.0e+36$.

These caveats apply to the grids "data" and "data2", and to the gridpoint values in them.

Following are descriptions of the calling arguments for the above three APIs:

"data" is (a pointer to the address of) the array in which the requested grid(s) is (are) returned. If the requested field is a two-component vector (such as wind), the first (i) component will be returned in this variable, and the second (j) component will be returned in "data2".

"data2" is (a pointer to the address of) the array in which the second (j) component of a two-component vector (such as wind) will be returned. If the requested field is scalar, a NULL pointer will be returned for this variable.

"fcstTime" is the number of seconds after "refTime" at which the requested grid(s) is (are) valid. For example, if the requested grid(s) is (are) valid three hours after "refTime", "fcstTime" should be 10800.

"fcstTimes" is (a pointer to the address of) the array of forecast times available for the requested model and scale.

"fieldId" is (a pointer to) the name of the desired field (meteorological variable). Examples include "msl-P", "PoT", and "qVec". A current list of valid "fieldId" values can be obtained by running program testGridKeyServer with a command line argument of "v" (just enter "\$FXA_HOME/bin/testGridKeyServer v" at the Unix command prompt), or by writing a short driver (main program) to call "gridSliceIdLists" (described below) and then print out the "fieldIds" and "descriptions" arrays it returns. Either way, a considerable amount of output may be generated, so it is recommended you re-direct the output to a file, and then print the file or view it with an editor. A few sample output lines from a "\$FXA_HOME/bin/testGridKeyServer

"v" run may be viewed in Appendix 2, Exhibit A2-1.

"key" is D2D's internal long integer identification number for the desired model-scale-level-field combination. The only things you do with this variable (returned to you by "getGridSliceAccessKey") is pass it on to "gridSliceInventory" and "gridSliceAccess".

"levelValues" is (a pointer to the address of) the array of level values for the grid(s) returned to you by "gridSliceAccess".

"nTimes" is (a pointer to) the number of times returned in each of "refTimes" and "fcstTimes".

"nx" is the number of gridpoints in the x (west-to-east) dimension.

"ny" is the number of gridpoints in the y (south-to-north) dimension.

"nz" is the number of vertical level values returned in "levelValues". It is also the number of grids returned in "data" (and in "data2" if the requested field is a two-component vector).

"planeId" is (a pointer to) the name of the desired combination of level type and level value. Examples include "400MB", "Trop", "315K", and "1000MB-500MB". Note: if "planeID" is NULL, "gridSliceAccess" will return grids for the desired field for the surface and all available isobaric levels. A current list of valid "planeId" values can be obtained by running program "testGridKeyServer" with a command line argument of "p" (just type "\$FXA_HOME/bin/testGridKeyServer p" at the Unix command prompt), or by writing a short driver (main program) to call "gridSliceIdLists" (described below) and then print out the "planeIds" array it returns. Either way, a considerable amount of output may be generated, so it is recommended you re-direct the output to a file, and then print the file or view it with an editor. A few sample lines from a "\$FXA_HOME/bin/testGridKeyServer p" run may be viewed in Appendix 2, Exhibit A2-2.

"refTime" is the runtime (in seconds since 0Z, January 01, 1970) of the requested grid(s).

"refTimes" is (a pointer to the address of) the array of runtimes (in seconds since 0Z, January 01, 1970) available for the requested model and scale.

"sourceId" is (a pointer to) a string specifying a combination of model, projection, and scale. Examples include "avnNH", "mesoEta212", and "NGM202". A current list of "sourceId" values can be obtained by running program testGridKeyServer with a command line argument of "s" (just enter "\$FXA_HOME/bin/testGridKeyServer s" at the Unix command prompt), or by writing a short driver (main program) to call "gridSliceIdLists" (described below) and then print out the "sourceIds" array it returns. Either way, a considerable amount of output may be generated, so it is recommended you re-direct the output to a file, and then print the file or view it

with an editor. A few sample output lines from a "\$FXA_HOME/bin/testGridKeyServer s" run may be viewed in Appendix 2, Exhibit A2-3.

The three APIs for accessing information about grids are:

```
void getTextualUnits (
    unsigned long key , /* input */
    char **units ) /* output */
```

```
void gridSliceGeoInfo (
    unsigned long key , /* input */
    char **geoFile , /* output */
    int *nx , /* output */
    int *ny ) /* output */
```

```
void interpretGeoInfo (
    char *geoFile , /* input */
    int nx , /* input */
    int ny , /* input */
    float *latLL , /* output */
    float *lonLL , /* output */
    float *latLR , /* output */
    float *lonLR , /* output */
    float *latUL , /* output */
    float *lonUL , /* output */
    float *latUR , /* output */
    float *lonUR , /* output */
    int *projIndex , /* output */
    float *centralLat , /* output */
    float *centralLon , /* output */
    float *rotation , /* output */
    float *dx , /* output */
    float *dy , /* output */
    float *latDxDy , /* output */
    float *lonDxDy ) /* output */
```

The "getTextualUnits" API provides the textual representation of units for a grid specified by the calling argument "key". For the "key" value, use the value returned by "getGridSliceAccessKey". The units are read from the virtual field table, not the netCDF grid file. The units string is returned as a NULL pointer

if no units information is available for the grid of interest, and as an empty string if the grid of interest is dimensionless. This function will allocate the memory space for the "units" value, but it is the caller's responsibility to free the memory space when done.

The "gridSliceGeoInfo" API provides the name of the geo file (also called the depictor file) needed to get a grid's navigation parameters. The dimensions of the grid are also returned. The grid is specified by the calling argument "key", which is also the value returned by "getGridSliceAccessKey". The file name returned has neither directory nor the ".sup" extension. This function will allocate the memory space for the "geoFile" value, but it is the caller's responsibility to free the memory space when done.

The "interpretGeoInfo" API provides sixteen grid navigation parameters for a grid. The grid is specified by the calling arguments "geoFile", "nx", and "ny" which were returned by "gridSliceGeoInfo". The sixteen navigation parameters are defined in the next paragraph.

Following are descriptions of the calling arguments for the above three APIs:

"centralLat" is the tangent latitude (in degrees north) of the projection.

"centralLon" is the tangent longitude (in degrees east) of the projection.

"dx" is the approximate x direction grid spacing in kilometers.

"dy" is the approximate y direction grid spacing in kilometers.

"geoFile" is the name of the geographic information file (also called the depictor file).

"key" is D2D's internal long integer identification number for the desired model-scale-level-field combination. For this calling argument, use the value returned by "getGridSliceAccessKey".

"latDxDy" is the latitude (in degrees north) where dx and dy are valid.

"latLL" is the latitude (in degrees north) of the lower left (south west) corner of the grid.

"latLR" is the latitude (in degrees north) of the lower right (south east) corner of the grid.

"latUL" is the latitude (in degrees north) of the upper left (north west) corner of the grid.

"latUR" is the latitude (in degrees north) of the upper right (north east) corner of the grid.

"lonDxDy" is the longitude (in degrees east) where dx and dy are valid.

"lonLL" is the longitude (in degrees east) of the lower left (south west) corner of the grid.

"lonLR" is the longitude (in degrees east) of the lower right (south east) corner of the grid.

"lonUL" is the longitude (in degrees east) of the upper left (north west) corner of the grid.

"lonUR" is the longitude (in degrees east) of the upper right (north east) corner of the grid.

"nx" is the x or left-right (west-east) dimension of the grid.

"ny" is the y or bottom-top (south-north) dimension of the grid.

"projIndex" is the AWIPS projection index.

"rotation" is the angle (in degrees) of the grid's positive y-axis with respect to the centralLon meridian.

"units" is the text units read from the virtual field table.

The API to get the path (directory + file name) of the netCDF file in which grids of interest are stored is:

```
void getGridfilePath (
    char *sourceId , /* input */
    long refTime , /* input */
    char **pathName ) /* output */
```

Following are descriptions of the calling arguments for this API:

"pathName" is (a pointer to) a string containing the full path (directory + file name) in which the grids of interest are stored.

"refTime" is the runtime (in seconds since 0Z, January 01, 1970) of the grid(s) of interest.

"sourceId" is (a pointer to) a string specifying a combination of model, projection, and scale. Examples include "avnNH", "mesoEta212", and "NGM202". A current list of "sourceId" values can be obtained by running program testGridKeyServer with a command line argument of "s" (just enter "\$FXA_HOME/bin/testGridKeyServer s" at the Unix command prompt), or by writing a short driver (main program) to call "gridSliceIdLists" (described below) and then print out the "sourceIds" array it returns. Either way, a considerable amount of output may be generated, so it is recommended you re-direct the output to a file, and then print the file or view it

with an editor. A few sample output lines from a "\$FXA_HOME/bin/testGridKeyServer s" run may be viewed in Appendix 2, Exhibit A2-3.

The above APIs should provide all needed functionality for accessing grids in the AWIPS netCDF files, and navigation information for those grids. But to use those APIs, you must have the "cfront" C++ compiler. Most local applications developers do not have such access. Therefore, the Techniques Development Lab (TDL) is supplying the following API in:

/awips/adapt/nav/inc/Navigation.h (when calling from C), or
/awips/adapt/nav/inc/Navigation.H (when calling from C++)

to provide all necessary grid navigation information:

```
void get_grid_nav (
    const char *grid_source , /* input */
    float *dx , /* output */
    float *dy , /* output */
    float *lat1 , /* output */
    float *lat2 , /* output */
    float *lon1 , /* output */
    float *lon2 , /* output */
    long *nx , /* output */
    long *ny , /* output */
    long *projection , /* output */
    long *relativity , /* output */
    float *stdlat1 , /* output */
    float *angle2 , /* output */
    float *truelat , /* output */
    float *align , /* output */
    long *status ); /* output */
```

FORTTRAN callers need not INCLUDE anything to use this API, but may view the above named files to see the function names and calling sequences. Both of the include files named above require six other include files:

```
hmHMC_fileUtils.h
hmHMC_interpUtils.h
hmHMC_parseNum.h
hmHMC_STATUS.h
hmHMC_destroyObject.h
hmHMC_stringUtils.h
```

either directly or indirectly. These may be obtained from the TDL web site by doing the following:

1. First bring up the TDL home page (see section 7, "OnLine Resources and URLs", for the URL);
2. From there, click on the "AWIPS LOCAL APPLICATIONS SUPPORT" link to bring up the "AWIPS LOCAL APPLICATIONS DEVELOPMENT" page;
3. From there, click on the "DOWNLOAD/UPLOAD" link to bring up the "Available Files to Download" page;
4. From there, click on the "C++ Navigation Routines" choice, which will ftp the above six include files (and a few other files as well) to you.

All (C++, C, and FORTRAN) callers must link to

/awips/adapt/nav/lib/libNavigation.a

when building their executables. This API searches the navigation file (an ASCII flat file called "Navigation.txt") for the navigational information for the combination of forecast model, map projection, and geographic area of coverage specified by the calling argument "grid_source", and returns that information to the caller. The file "Navigation.txt" is stored in a directory named by the UNIX environment variable "NAVFILE_DIR". The software reads "NAVFILE_DIR" to find and open "Navigation.txt". Therefore, "NAVFILE_DIR" must be correctly set to the complete, absolute directory of "Navigation.txt" before "get_grid_nav" can be used. If "NAVFILE_DIR" is incorrectly set, or cannot be found, "get_grid_nav" will abort. The currently correct setting for "NAVFILE_DIR" is "/awips/adapt/nav/data/".

The calling arguments for "get_grid_nav", in alphabetical order, are as follows:

"align" = (a pointer to)

- a. for polar stereographic and Lambert conformal projections, the vertical longitude; the east longitude (in degrees) parallel to the map projection's positive y axis.
- b. for local stereographic, the rotation angle of the positive y axis in degrees clockwise from north.

"angle2" = (a pointer to)

- a. for a tangent cone projection, same as stdlat1.
- b. for a secant cone projection, the second (furthest from pole) latitude (in degrees north) at which the secant cone cuts the earth.

- c. for a stereographic projection, the longitude (in degrees east) of the center of the projection. A value of +/-90 indicates polar stereographic.

"dx" = (a pointer to) the left-right (west-east) grid spacing (in meters) at the latitude "truelat".

"dy" = (a pointer to) the bottom-top (south-north) grid spacing (in meters) at the latitude "truelat".

"grid_source" = (a pointer to) a string specifying the combination of model, map projection, and geographic scale of the grid for which navigational information is wanted. Examples include "avnNH", "mesoEta212", and "NGM202". A current list of "grid_source" values can be obtained by running program testGridKeyServer with a command line argument of "s" (just enter "\$FXA_HOME/bin/testGridKeyServer s" at the Unix command prompt), or by writing a short driver (main program) to call "gridSliceIdLists" (described below) and then print out the "sourceIds" array it returns. Either way, a considerable amount of output may be generated, so it is recommended you re-direct the output to a file, and then print the file or view it with an editor. A few sample output lines from a "\$FXA_HOME/bin/testGridKeyServer s" run may be viewed in Appendix 2, Exhibit A2-3. "grid_source" must be a C-language style string, that is, the character immediately following the last (rightmost) printable character of the string must be CHAR(0) in FORTRAN, or NULL (= (char) 0) in C and C++.

"lat1" = (a pointer to) the north latitude (in degrees) of the first or lower left gridpoint.

"lat2" = (a pointer to) the north latitude (in degrees) of the last or upper right gridpoint.

"lon1" = (a pointer to) the east longitude (in degrees) of the first or lower left gridpoint.

"lon2" = (a pointer to) the east longitude (in degrees) of the last or upper right gridpoint.

"nx" = (a pointer to) the number of gridpoints along a row (the right-to-left or west-to-east edges) of the grid.

"ny" = (a pointer to) the number of gridpoints along a column (the bottom-to-top or south-to-north edges) of the grid.

"projection" = (a pointer to) the integer GRIB code for the map projection:

- 1 = Mercator
- 3 = Lambert conformal
- 5 = stereographic.

"relativity" = (a pointer to) an integer code for how vector components are resolved:

0 = vector components are resolved relative to easterly and northerly directions.

1 = vector components are resolved relative to the defined grid in the direction of increasing x and y.

"status" = (a pointer to) get_grid_nav's return status. Possible values are:

0 = The requested navigation data was successfully found, extracted, and returned.

2 = The software did not recognize the input "grid_source" value.

6 = An attempt to allocate memory failed. Most likely, insufficient memory was available.

7 = Most likely, the file "Navigation.txt" is corrupted.

8 = The file "Navigation.txt" could not be read. This is not necessarily a problem with the file.

9 = Indicates an undefinable error, possibly a bug in the software.

"stdlat1" = (a pointer to):

- a. for a tangent cone projection, the tangency latitude; the latitude (in degrees north) at which the earth is tangent to the map projection.
- b. for a secant cone projection, the first (closest to pole) latitude (in degrees north) at which the secant cone cuts the earth.
- c. for a stereographic projection, the latitude (in degrees north) of the center of the projection.

"truelat" = (a pointer to) the north latitude (in degrees) at which the grid spacing (dx and dy) is defined. For AWIPS projections, "truelat" = "stdlat1".

Navigational information that is not applicable to the specified map projection and geographic area of coverage is returned with the value -9999.0 for type "float", or -9999 for type "long".

This API is designed to be callable from C++, C, and FORTRAN. Simple examples may be viewed in the Navigation man page or in the Navigation test drivers (navtest.C for C++, navtest.c for C, and navtest.f for FORTRAN; note that navtest.f will also need itlen.f). These may be obtained via the same procedure given above for getting the six include files needed by Navigation.h and Navigation.H.

4.2.2.5 Existing software (APIs) for writing netCDF grid files

Deferred.

4.2.3 Point Data (*Section/subsections current for Build 4.2*)

All decoded point data are stored in files in subdirectories under the *\$FXA_DATA/point* directory. *\$FXA_DATA* is currently */data/fxa*, and this disk partition is globally (NFS) mounted such that while the data only reside on a particular machine (the ds), the directories can be "seen" from any machine (ws3, as2, etc.) inside the AWIPS LAN, the same as if they were present on that machine. This disk partition is also mirrored (redundantly maintained) on both ds1 and ds2 for backup purposes, so that in case of failure of ds1, AWIPS can failover to ds2 with little or no loss of critical data.

4.2.3.1 METAR Data

4.2.3.1.1 File naming conventions

The METAR data files are found under the *\$FXA_DATA/point/metar* directory. The */Raw/* subdirectory (*\$FXA_DATA/point/metar/Raw*) holds the reports written before decoding, and */Bad/* is where the reports that were not correctly decoded are moved. The */netcdf/* subdirectory contains the netCDF format storage files, and the binary plot storage files are kept in */plot/*. A */tmp/* subdirectory (normally empty) also exists to hold incoming METAR data until the message transmission is completed, at which time the data are transferred to the */Raw/* subdirectory.

The convention for names of files in these directories is *YYYYMMDD_hhmm*, where *hhmm* is the **nominal time** in UTC (i.e., Z), to the hour, of the start of the data. For example, file *"19970206_1600"* contains the 16Z data for Feb 06, 1997. The METAR nominal time is such that each file holds 1 hour's worth of reports, for report times from 15 minutes before the hour to 44 minutes after the hour. For example, the 1200Z file contains METARs with reporting times from 1145Z through 1244Z.

4.2.3.1.2 Organization of files

METAR data are stored in both binary and netCDF formats. The binary plotfiles are utilized by D2D depictables for display purposes, while the netCDF files are intended to be accessed by other applications. The raw data arrive in text format as one singular report or as a collective report. The collective report contains data from several stations. These data are ingested and stored in the */Raw/* directory. As each report or collective is written to disk, a notification is sent to the Comms Router which then notifies the Text Controller, which then pings the METAR decoder that there are data to be processed. The decoder will process every file in the directory, not just the one for which it received a notification.

The raw METAR file is deleted once the report data are successfully decoded and stored. If a decoding error occurred, then the raw file is moved to the */Bad/* directory. The decoder then moves on to the next file in the */Raw/* directory. When it has finished processing all the current METAR files in the */Raw/* directory, the decoder waits for the next notification to arrive. The routine that writes the decoded

METAR data to binary plot and netCDF files is *dmStoreMETAR_PlotInfo.C*. It is called for every successfully decoded METAR. For additional information on the decoding process, refer to Chapter 7 of the WFO-Advanced Overview. The decoded METAR elements stored in binary plotfiles and netCDF files, and their units and format, are shown in Tables 4.2.3.1.2-1 and 4.2.3.1.2-2, respectively.

Note: Current plans are to discontinue use of the plotfiles as a duplicate manner of storage for METAR and other point data in the Build 5.x time frame. Any code that is written to access decoded point data shall, wherever possible, read only the netCDF data files.

Table 4.2.3.1.2-1. METAR data stored in a binary plotfile. Data types are C-language types.

NAME	METAR BINARY PLOTFILE VARIABLES	DATA TYPE
	UNITS / DESCRIPTION	
stationID		char of max length 5
timeObs	seconds since 1-1-1970	double
reportType		char of max length 6
skyCover		char array of 6 by 5
skyLayerBase	feet	float array of 6
visibility	statute miles	float
presWeather		char of max length 21
seaLevelPress	millibars	float
temperature	degrees F	float
dewpoint	degrees F	float
windDir	tenths of degrees true	float
windSpeed	knots	float
windGust	knots	float
precip1Hour	millimeters	float
precip3Hour	millimeters	float
pressChangeChar	Pressure tendency change char.	short
pressChange3Hour	millibars	short

Table 4.2.3.1.2-2. METAR data stored in a netCDF file. The variables wmoID, latitude, longitude, elevation and timeNominal do not appear in METARs, but are derived from other sources. The length of the character strings includes the null terminator: subtract 1 from the stated length to get the maximum

string length. Data types are C-language types.

NAME	METAR NETCDF FILE VARIABLES	DATA TYPE
	UNITS / DESCRIPTION	
wmoID		long
stationName		char of max length 5 (4+1)
latitude	decimal degrees, North	float
longitude	decimal degrees, East	float
elevation	meters	float
timeObs	METAR observation time, seconds since 1-1-1970	double
timeNominal	METAR nominal report hour, seconds since 1-1-1970	double
reportType	[METAR or SPECI]	char of max length 6 (5+1)
autoStationType		char of max length 6 (5+1)
skyCover	[CLR, FEW, SCT, BKN, OVC, SKC]	array of 6 char of max length 8 (7+1)
skyLayerBase	meters	float array of 6
visibility	meters	float
presWeather	using FMH-1 weather codes	char of max length 25 (24+1)
seaLevelPress	pascals	float
temperature	degrees Kelvin	float
tempFromTenths ¹	temperature, in Kelvin	float
dewpoint	degrees Kelvin	float
dpFromTenths ¹	dewpoint, in Kelvin	float
windDir	degrees true	float
windSpeed	meters/second	float
windGust	meters/second	float
altimeter	pascals	float
minTemp24Hour	in Kelvin	float
maxTemp24Hour	in Kelvin	float

precip1Hour	meters	float
precip3Hour	meters	float
precip6Hour	meters	float
precip24Hour	meters	float
pressChangeChar	pressure tendency change character (FMH-1 Table 12-7)	short
pressChange3Hour	pascals	short
correction	corrected METAR indicator: 1 = correction, 0 = original	long
rawMETAR	raw coded METAR/SPECI text message	char of max length 256 (255+1)

¹ Name is inconsistent with actual storage units.

4.2.3.1.3 Supporting files

Static station information for METARs is found in the ASCII text file */src/dataMgmt/metarStationInfo.txt*, and includes the following:

<u>number</u>	<u>ID</u>	<u>lat</u>	<u>lon</u>	<u>elev</u>	<u>station name</u>	<u>country</u>	<u>MTR or SAO</u>
(10)	(5)	(sn2.3)	(sn3.3)	(5)	(36)	(2)	(3)
		(deg. N)	(deg. E)	(m)			

The information in parentheses refers to the length and format of the entries. This file is the source of the wmoId, latitude, longitude, and elevation data values written to the METAR netCDF data file.

4.2.3.2 RAOB DATA

4.2.3.2.1 File naming conventions

Upper air data (Radiosonde Observations, commonly referred to as `RAOB') will be written in both netCDF and plotfile formats. Only the plotfiles are used in Build 4.3, with netCDF storage to be added in Build 5.0. RAOB data files will be stored in *\$FXA_DATA/point/raob/netcdf* and *\$FXA_DATA/point/raob/plot* directories, respectively. The convention for names of files in these directories is YYYYMMDD_TIME, where TIME is the UTC (i.e., Z) time of the start of the data (e.g., 19970206_1200 contains the 12Z data for Feb 06, 1997). Each file holds 12 hours worth of data, so the 0000Z plotfile contains all the RAOB data from 0000Z through 1159Z, and the 1200Z file contains 1200Z through 2359Z data.

4.2.3.2.2 Organization of files

RAOB data are currently received through the SBN and temporarily stored on disk as encoded BUFR messages in the */data/fxa/ispan/bufr/raob* directory. ASCII (text) RAOB data are no longer decoded in AWIPS, but Mandatory and Significant Level RAOB text reports are stored in the text database (Sec. 4.2.7) under the product identifiers *cccMANxxx* and *cccSGLxxx*, respectively. As data are received, the *RaobBufDecoder* is notified to decode the message and store it in the data files. As data become available for decoding, *RaobBufDecoder* reads and decodes the BUFR data file and stores the data in the appropriate fields as a plotfile. As new data arrive, the decoder determines whether the data are new, contain differences from earlier reports, etc., and appends or merges them with the existing data for that particular station and observation time. After the BUFR file is decoded and stored in (netCDF and) plotfile formats, the decoder deletes the file from the directory. Table 4.2.3.2.2-1 shows the RAOB data stored in the (netCDF files and) plotfiles.

Table 4.2.3.2.2-1. RAOB data stored in (netCDF files and) binary plotfiles. The length of the character strings includes the null terminator. The first mandatory level is the surface level. Data types are C-language types.

NAME	RAOB BINARY PLOTFILE VARIABLES UNITS / DESCRIPTION	DATA TYPE
wmoStaNum		long
staName		char array of 6 bytes
staLat	station latitude, in degrees N	float
staLon	station longitude, in degrees E	float
staElev	meters	float
synTime	seconds since 1-1-1970	double
numMand	number of mandatory levels - maximum of 22	long
numSigT	number of significant levels with respect to (wrt) Temperature - max 150	long
numSigW	number of significant levels wrt Wind - maximum of 76	long
numMwnd	number of maximum wind levels	long
numTrop	number of tropopause levels	long
relTime	Sounding Release time, in seconds since 1-1-1970	double
sondTyp	Instrument type	long
prMan	Pressure - Mandatory level, in millibars	float array of 22

htMan	Geopotential - Mandatory level, in meters	float array of 22
tpMan	Temperature - Mandatory level, in Kelvins	float array of 22
tdMan	Dew Point Depression - Mandatory level, in Kelvins	float array of 22
wdMan	Wind Direction - Mandatory level, in degrees true	float array of 22
wsMan	Wind Speed - Mandatory level in meters/second	float array of 22
prSigT	Pressure - Significant level wrt Temperature, in millibars	float array of 150
tpSigT	Temperature - Significant level wrt Temperature, in Kelvin	float array of 150
tdSigT	Dew Point Depression - Significant level wrt Temperature, in Kelvin	float array of 150
htSigW	Geopotential - Significant level wrt Wind, in meters	float array of 76
wdSigW	Wind Direction - Significant level wrt Wind, in degrees true	float array of 76
wsSigW	Wind Speed - Significant level wrt Wind, in meters/second	float array of 76
prTrop	Pressure - Tropopause level, in millibars	float array of 4
tpTrop	Temperature - Tropopause level, in Kelvins	float array of 4
tdTrop	Dew Point Depression - Tropopause level, in Kelvins	float array of 4
wdTrop	Wind Direction - Tropopause level, in degrees true	float array of 4
wsTrop	Wind Speed - Tropopause level, in meters/second	float array of 4
prMaxW	Pressure - Maximum wind level, in millibars	float array of 4
wdMaxW	Wind Direction - Maximum wind level, in degrees true	float array of 4
wsMaxW	Wind Speed - Maximum wind level, in meters/second	float array of 4

4.2.3.2.3 Supporting files

RAOB id and location information is found in *src/dataMgmt/raobStationInfo.txt*,

and includes the following fields:

<u>wmo number</u>	<u>stn</u>	<u>lat</u>	<u>lon</u>	<u>elev</u>	<u>location</u>	<u>or</u>	<u>type</u>
(10 digits)	(5 char)	(deg. N)	(deg. E)	(meters)	(20 char)	(2 char)	(4 char)

The information in parentheses refers to the length and format of the entries. The variable "**or**" refers to Country of Origin.

Examples are:

0000070026|BRW|71.30|-156.78| 12|BARROW/POST-ROGE, AK|US|RAOB

0000072357|OUN|35.23|-97.47| 362|NORMAN, OK |US|RAOB

0000072363|AMA|35.23|-101.70| 1094|AMARILLO ARPT, TX |US|RAOB

0000072364|EPZ|31.87|-106.70| 1252|SANTA TERESA, NM |US|RAOB

4.2.3.3 Lightning Data

4.2.3.3.1 File naming conventions

The lightning data files are found in *\$FXA_DATA/point/binLightning/*. The plot data files are stored in the */plot/* subdirectory, and the netcdf data files are stored in the */netCDF/* subdirectory.

4.2.3.3.2 Organization of files

Lightning data collected by the National Lightning Detection Network (NLDN) and are received on the SBN network in an encoded binary format. After the lightning data are decoded they are stored in plotfiles and netCDF data files.

The variables for the netCDF file and the plotfile are the same. The number of records in the file is the number of lightning strikes. Lightning data in the file are shown in Table 4.2.3.3.2-1.

Table 4.2.3.3.2-1. Lightning data stored in netCDF and binary plotfiles. All data types are C-language types.

NAME	UNITS / DESCRIPTION	DATA TYPE
lat	strike latitude, in degrees north	float
lon	strike longitude, in degrees east	float
time	time of strike, in seconds since 1-1-1970	double
sigStr	normalized signal strength and polarity, in Kiloamps	float
mult	multiplicity of the flash	long

4.2.3.3.3 Supporting files

None.

4.2.3.4 Wind Profiler Data

4.2.3.4.1 File naming conventions

The wind profiler data files are found in the *\$FXA_DATA/point/profiler/plot* (binary plotfiles), *\$FXA_DATA/point/profiler/netcdf* (netCDF files) and *\$FXA_DATA/point/profiler* directories.

4.2.3.4.2 Organization of files

Wind profiler data elements in netCDF and plotfiles are identical. The information is stored in wind profiler files is shown in Table 4.2.3.4.2-1.

Table 4.2.3.4.2-1. Wind profiler data stored in netCDF and binary plotfiles. Data types are C-language types.

NAME	WIND PROFILER FILE VARIABLES	DATA TYPE
	UNITS / DESCRIPTION	
wmoStaNum	WMO numeric station ID	long
staLat	Station latitude, degrees N	float
staLon	Station longitude, degrees E	float
staElev	Elevation above MSL, in meters	float
windSpeedSfc	Surface wind speed, in meters/second	float
windDirSfc	Surface wind direction, in degrees	long
pressure	Pressure reduced to MSL, in hPa (millibars)	float
temperature	Surface temperature, in Kelvin	float
rainRate	Surface rainfall rate, in kg/meter ² /second (mm/sec)	float
relHumidity	Surface relative humidity, in percent	long
submode	NOAA wind profiler submode information, in code	long
staName	Alphanumeric station name	char array of length 6 (5+1)
timeObs	Time of observation, in seconds since 1-1-1970	double
levels	Height above station, in meters	float array of 43 levels
levelMode	Wind profiler mode information	long array of 43 levels
uvQualityCode	NOAA wind profiler quality control test results for u- and v-components	long array of 43 levels
consensusNum	Consensus number (hourly data only)	long array of 43 levels
uComponent	u (eastward) component, in meters/second	float array of 43 levels

vComponent	v (northward) component, in meters/second	float array of 43 levels
HorizSpStdDev	Horizontal wind speed standard deviation, in meters/second	float array of 43 levels
peakPower	Spectral peak power, in dB	long array of 43 levels
wComponent	w (upward) component, in meters/second	float array of 43 levels
VertSpStdDev	meters/second	float array of 43 levels

4.2.3.4.3 Supporting files

The following profiler info is found in *src/dataMgmt/profilerStationInfo.txt*:

<u>#name</u>	<u>wmoID</u>	<u>lat</u>	<u>lon</u>	<u>ht</u>
(5 char)	(5 digits)	(deg. N)	(deg. E)	(meters)

The information in parentheses refers to the length and format of the entries.

Examples are:

```
RWDM1|74433|40.08|-100.65| 800
LTHM7|74551|39.57| -94.18| 297
TCUN5|74731|35.08|-103.60|1241
```

4.2.3.5 Marine Report Data

Decoded marine reports of various types are stored together in a single type of netCDF file. Currently, C-MAN, ship, and fixed and drifting buoy reports that are available from the SBN data feed are decoded and stored in the hourly marine netCDF files.

4.2.3.5.1 File naming conventions

The marine report data files are found in the *\$FXA_DATA/point/maritime/netcdf* directory. The convention for names of files in these directories is *YYYYMMDD_hhmm*, where *hhmm* is the **nominal time** in UTC (i.e., Z), to the hour, of the start of the data. For example, file *"19970206_1600"* contains the 16Z data for Feb 06, 1997. Like METARs, the marine reports nominal time is such that each file holds 1 hour's worth of reports, for report times from 15 minutes before the hour to 44 minutes after the hour.

4.2.3.5.2 Organization of files

Decoded marine data elements for all marine platforms (land, ship, buoy; fixed and moving) are stored in hourly netCDF files. There is no corresponding marine reports plotfile after Build 4.1. The information stored is as defined in Table 4.2.3.5.2-1.

Table 4.2.3.5.2-1. Marine report data stored in netCDF files. Data types are C-language types.

NAME	MARINE NETCDF FILE VARIABLES UNITS / DESCRIPTION	DATA TYPE
stationName	Station, Buoy, or Ship call letters	char of max length 9 (8+1)
latitude	decimal degrees, positive North	float
longitude	decimal degrees, positive East	float
elevation	station height above MSL, meters	float
timeObs	date/time of observation, seconds since 1-1-1970 (unix ticks)	double
timeNominal	nominal date/hour of data in file, seconds since 1-1-1970 (unix ticks)	double
dataPlatformType	0 = stationary (moored buoy, CMAN) 1 = moving (drifting buoy or ship)	short
temperature	air temperature, kelvin	float
dewpoint	kelvin	float
wetBulbTemperature	kelvin	float
seaLevelPress	pascal	float
pressChangeChar	3 Hour pressure change character	short
pressChange3Hour	pascal	float
windDir	degree	float
windSpeed	meter/sec	float
windGust	meter/sec	float
visibility	meter	float
totalCloudCover	Fraction of sky covered by clouds tenths	float

cloudBaseHeight	Height category of lowest cloud layer: 0 = "0 to 100 ft"; 1 = "200 to 300 ft"; 2 = "400 to 600 ft"; 3 = "700 to 900 ft"; 4 = "1000 to 1900 ft"; 5 = "2000 to 3200 ft"; 6 = "3300 to 4900 ft"; 7 = "5000 to 6500 ft"; 8 = "7000 to 8000 ft"; 9 = "8500 or higher or no clouds"; -1 = "unknown or below sfc of stn";	short
presWeather	Present Weather, FMH-1 char. codes	char of max length 26 (25+1)
lowLevelCloudType	Low level cloud type, FMH-2 table (values 1-9), and 0 (no low clouds) or -1 (obscured)	short
midLevelCloudType	Middle level cloud type, FMH-2 table (values 1-9), and 0 (no middle clouds) or -1 (obscured)	short
highLevelCloudType	High level cloud type, FMH-2 table (values 1-9), and 0 (no high clouds) or -1 (obscured)	short
precip1Hour	1 Hour precipitation, meters	float
precip6Hour	6 Hour precipitation, meters	float
precip12Hour	12 Hour precipitation, meters	float
precip18Hour	18 Hour precipitation, meters	float
precip24Hour	24 Hour precipitation, meters	float
platformTrueDirection	Data platform true direction of movement, degrees	float
platformTrueSpeed	Data platform true speed of movement, meter/sec	float
seaSurfaceTemp	Sea surface temperature, kelvin	float
wavePeriod	Wave period, seconds	float
waveHeight	Wave height, meter	float
highResWaveHeight	High-resolution wave height, meters	float
equivWindSpeed10m	Equivalent wind speed at 10 meters	float
equivWindSpeed20m	Equivalent wind speed at 20 meters	float
maxWindSpeedTime	Time of observed maximum wind speed, seconds since 1-1-1970 (unix ticks)	double

maxWindSpeed	Maximum wind speed, meters/sec	float
maxWindDirection	Wind direction for wind speed maximum, degrees	float
rawMaritime	Raw maritime ASCII message	char of max length 257 (256+1)

4.2.3.5.3 Supporting files

The CDL file that defines the marine netCDF data file is located in the ASCII file *\$FXA_HOME/data/maritime.cdl* on the ds. The file *maritimeStationInfo.txt*, in the same directory, defines the station ID (call letters), latitude, longitude, elevation, full station name, country of origin, and report type for the marine stations whose decoded and raw reports are contained in the marine netCDF files. Included comment lines document the file contents. The file *maritimeWxCodes.txt*, in the same directory, is a lookup table defining the relationship between the FMH-2 numerical weather codes (e.g., 67) in the encoded marine reports, and the FMH-1 character weather codes (e.g., FZRA) stored in the marine netCDF file in the presWeather variable. The FMH-2 numerical codes are converted to FMH-1 character codes before storage in the netCDF file to support weather symbol plotting in station model plots of marine report data on the D2D display.

4.2.3.6 LDAD (Local Data Acquisition and Dissemination)

A full description of AWIPS data acquisition and storage under the LDAD subsystem is beyond the current scope of this document. The reader is referred to Chapter 8 of the AWIPS System Manager's Manual for a description and guide to local data acquisition via LDAD. The following sections will describe the location and format of decoded data acquired via LDAD and stored inside of AWIPS.

4.2.3.6.1 File naming conventions

Mesonet, cooperative observer, and other local (i.e., non-SBN and non-WAN) observational data acquired via the LDAD subsystem are stored in one of three types of LDAD netCDF data files after decoding and processing. The three types of LDAD netCDF files are called hydro, mesonet, and manual, and consist of hourly data files in the directories *\$FXA_DATA/LDAD/hydro/netCDF*, *\$FXA_DATA/LDAD/mesonet/netCDF*, and *\$FXA_DATA/LDAD/manual/netCDF*, respectively. A matching */plot* subdirectory may be found on AWIPS for each of the 3 file types at the */netCDF* level. This is a holdover from earlier designs. Plotfiles are not implemented for LDAD data in Build 4.3, and no plans exist to add them.

Each mesonet netCDF data file will have a companion file of original decoded data, augmented with quality-control (QC) information and the results of MSAS (MAPS Surface Analysis System) QC checks that have been performed on the data. The QC'ed mesonet data are located under the *\$FXA_DATA/LDAD/mesonet/qc* directory. Hydro and manual LDAD data currently are not quality controlled under MSAS.

The convention for names of files in the four LDAD netCDF data directories is YYYYMMDD_hhmm, where hhmm is the **nominal time** in UTC (i.e., Z) time, to the hour, of the start of the data. Each file holds 1 hour's worth of reports, for report times occurring within the hour (i.e., for 0 minutes, 0 seconds to 59 minutes, 59 seconds after the given hour), as determined by the time stamp within the report. In Build 4.3 installed configuration, the basic (temporal and validity) QC results are updated every five minutes, beginning at three minutes past the hour, only for the decoded observations received and stored during the previous five minutes. The spatial QC check is performed only once per hourly file, at 18 minutes past the hour. Any observations received and stored after 18 minutes past the hour will have no spatial QC check results in the QC netCDF file, only basic QC results. See your System Administrator to verify the current QC update schedules at your site.

4.2.3.6.2 Organization of files

The three tables that follow in this section describe the contents of the LDAD **hydro**, **mesonet**, and **manual** netCDF files. The LDAD QC **mesonet** file is too extensive to be summarized in these tables. Refer directly to the CDL file */awips/fxa/ldad/MSAS/fslparms/QCmesonet.cdl*, located on the *as1* machine, which defines the variables and the interpretation of their values within QC **mesonet** LDAD netCDF files.

Table 4.2.3.6.2-1. Hydrological data stored in LDAD **hydro** netCDF files. The length of the character variables is inclusive of the null terminator. Data types are C-language types.

NAME	LDAD HYDRO NETCDF VARIABLES UNITS / DESCRIPTION	DATA TYPE
providerId	Data Provider Station ID	char of max length 12
numericWMOid	Numeric WMO identification number	long
stationId	Alphanumeric station Id	char of max length 11
stationName	Alphanumeric station name	char of max length 51
handbook5Id	Handbook Id (AFOS id or SHEF id)	char of max length 11
homeWFO	Home WFO Id for the LDAD data	char of max length 4
stationType	LDAD hydro station type	char of max length 11
dataProvider	LDAD hydro data provider	char of max length 11
latitude	Decimal degrees north	float
longitude	Decimal degrees east	float
elevation	Meter	float
observationTime	Time of observation, seconds since 1/1/1970	double

reportTime	Time data was processed by the provider, seconds since 1/1/1970	double
receivedTime	Time data was received, seconds since 1/1/1970	double
riverStage	Meter	float
riverFlow	Meter ³ /Second	float
riverReportChangeTime	Time of last new river stage/flow report, seconds since 1/1/1970	double
precip5min	minute precip accumulation, mm	float
precip1hr	1 hour precip accumulation, mm	float
precip3hr	3 hour precip accumulation, mm	float
precip6hr	6 hour precip accumulation, mm	float
precip12hr	12 hour precip accumulation, mm	float
precip24hr	24 hour precip accumulation, mm	float
precipAccum	Precip accumulation with an unknown time period, mm	float
rawMessage	Raw text LDAD hydro report	char of max length 256

Table 4.2.3.6.2-2. As in Table 4.2.3.6.2-1, but for automated mesonet data stored in LDAD *mesonet* netCDF files.

NAME	LDAD MESONET NETCDF VARIABLES UNITS / DESCRIPTION	DATA TYPE
providerId	Data provider station ID	char of max length 12
stationID	Alphanumeric station ID	char of max length 6
handbook5Id	Handbook Id (AFOS id or SHEF id)	char of max length 6
stationName	Alphanumeric station name	char of max length 51
homeWFO	Home WFO Id for the LDAD data	char of max length 4
numericWMOid	Numeric WMO identification number	long
stationType	LDAD mesonet station type	char of max length 11
dataProvider	LDAD data provider	char of max length 11
latitude	Degree north	float
longitude	Degree east	float

elevation	Meter	float
dataPlatformType	Data Platform type	short
platformTrueDirection	Degrees / Data platform true direction	float
platformTrueSpeed	Meter/second - Data platform true speed	float
observationTime	Date and time of observation, seconds since 1-1-1970	double
reportTime	Date and time data were processed by the data provider, seconds since 1-1-1970	double
receivedTime	Date and time the data were received, seconds since 1-1-1970	double
temperature	Kelvin	float
tempChangeTime	Time of last temperature change, seconds since 1-1-1970	double
dewpoint	Kelvin	float
wetBulbTemperature	Kelvin	float
relHumidity	Percent	float
rhChangeTime	Relative Humidity time of last change, seconds since 1-1-1970	double
stationPressure	Pascal	float
stationPressChangeTime	Station pressure time of last change, seconds since 1-1-1970	float
seaLevelPressure	Pascal	float
pressChangeChar	Character of pressure change	short
pressChange3Hour	Pascal / 3 hour pressure change	float
altimeter	Pascal	float
windDir	Degree	float
windDirChangeTime	Wind direction time of last change, seconds since 1-1-1970	double
windSpeed	Meter/Second	float
windSpeedChangeTime	Wind speed time of last change, seconds since 1-1-1970	double
windGust	Meter/Second	float
windGustChangeTime	Wind gust time of last change, seconds since 1-1-1970	double

windDirMin	Degree / Wind direction at minimum windspeed	float
windDirMax	Degree / Wind direction max	float
skyCover	Sky Cover group	char array of 6 by 8
skyLayerBase	Meter / Sky cover layer base	float array of 6
visibility	Meter	float
totalCloudCover	Tenths / Fraction of sky covered by clouds	float
cloudBaseHeight	Height of the lowest cloud layer	short
presWeather	Present weather	char of max length 25
lowLevelCloudType	Low level cloud type	short
midLevelCloudType	Middle level cloud type	short
highLevelCloudType	High level cloud type	short array of 3
maxTempRecordPeriod	Maximum temperature recording period	short array of 3
maximumTemperature	Maximum temperature	float array of 3
minTempRecordPeriod	Minimum temperature recording period	short array of 3
minimumTemperature	Kelvin / Minimum temperature	float array of 3
precipAccum	mm	float
precipRate	Meter/Second	float
precipType	Precipitation type	short array of 2
precipIntensity	Precipitation intensity	short array of 2
timeSinceLastPcp	Time since last precip, seconds since 1-1-1970	double
solarRadiation	Watt/Meter ²	float
solarRadChangeTime	Solar Radiation time of last change, seconds since 1-1-1970	double
seaSurfaceTemp	Kelvin	float
wavePeriod	Second	float
waveHeight	Meter	float
rawMessage	Raw text LDAD mesonet message	char of max length 512
test1	User defined parameter - test # 1	char of max length 51
test2	User defined parameter - test # 2	char of max length 51
test3	User defined parameter - test # 3	char of max length 51
test4	User defined parameter - test # 4	char of max length 51
test5	User defined parameter - test # 5	char of max length 51

test6	User defined parameter - test # 6	char of max length 51
test7	User defined parameter - test # 7	char of max length 51
test8	User defined parameter - test # 8	char of max length 51
test9	User defined parameter - test # 9	char of max length 51

Table 4.2.3.6.2-3. As in Table 4.2.3.6.2-3, but for cooperative and dial-in data stored in LDAD *manual* netCDF files.

NAME	LDAD MANUAL NETCDF VARIABLES	DATA TYPE
	UNITS / DESCRIPTION	
providerID	Data provider station ID	char of max length 12
stationID	Alphanumeric Station ID	char of max length 11
stationName	Station location identifier	char of max length 51
homeWFO	Home WFO Id for the LDAD data	char of max length 4
unitsCode	Units Code	short
latitude	Decimal degrees north	float
longitude	Decimal degrees east	float
elevation	meters	float
observationTime	seconds since 1-1-1970	double
code10	Current 24 hour precipitation total, inches	float
code11	Incremental precip since previous 7 a.m., inches	float
code12	Precip criteria report from flash flood observer, inches	float
code13	4 hr precipitation total at previous 7 a.m. criteria report, inches	float
code14	24 hr precipitation total at 7 a.m. two day ago, inches	float
code15	Storm total precipitation, inches	float
code16	Weekly total precipitation, inches	float
code17	Monthly total precipitation, inches	float
code18	Off-Time precipitation report, inches	float
code19	Short intense precipitation durations, hours	float
code20	Precipitation type	short
code21	Degrees F / Current air temperature	float

code22	Degrees F / Daily maximum air temperature	float
code23	Degrees F / Daily minimum air temperature	float
code24	Degrees F / Average weekly maximum air temperature	float
code25	Degrees F / Average weekly minimum air temperature	float
code26	Degrees F / Water temperature	float
code27	Degrees F / Daily maximum soil temperature	float
code28	Degrees F / Daily minimum soil temperature	float
code29	Degrees F / Wet bulb temperature	float
code30	Number of hours temperature is below 25 degrees F	float
code31	Number of hours temperature is below 32 degrees F	float
code32	degrees F / Dew point temperature	float
code33	Feet / River stage at specified ob time	float
code34	Feet / River stage at previous 1 a.m.	float
code35	Feet / River state at previous 7 p.m.	float
code36	Feet / River stage at previous 1 p.m.	float
code37	Feet / River stage at previous 7 a.m.	float
code38	Feet / River stage at 7 a.m. 2 days ago	float
code39	River stage at observed crest time	char of max length 8
code40	Feet / River stage at observed crest	float
code41	River stage trend	short
code43	kcfs (1000's cubic feet / sec) / River discharge instantaneous measured	float
code44	kcfs / River discharge mean daily measured	float
code45	kcfs / River discharge instantaneous computed	float
code46	kcfs / River discharge mean daily computed	float
code47	kcfs / River discharge instantaneous from rating	float
code48	kcfs / River discharge mean daily from rating	float
code49	kcfs / River discharge peak	float
code50	kcfs / River discharge canal diversion	float
code52	Feet / Reservoir pool elevation at specified ob time	float
code53	Feet / Reservoir pool elevation at previous 0600 UTC	float
code54	Feet / Reservoir pool forecast, Day 1	float

code55	Feet / Reservoir pool forecast, Day 2	float
code56	Feet / Reservoir pool forecast, Day 3	float
code57	Feet / Reservoir tailwater elevation	float
code58	kcfs / Reservoir inflow, instantaneous	float
code59	kcfs / Reservoir inflow, mean daily	float
code60	kcfs / Reservoir outflow, instantaneous	float
code61	kcfs / Reservoir outflow, mean daily	float
code62	kcfs / Reservoir outflow forecast, mean daily, Day 1	float
code63	kcfs / Reservoir outflow forecast, mean daily, Day 2	float
code64	kcfs / Reservoir outflow forecast, mean daily, Day 3	float
code65	kaf / Reservoir storage at specified ob time	float
code66	Inches / Reservoir evaporation, 24 hour total, computed	float
code67	Percent / Snow cover, areal extent	float
code68	Inches / Snow depth, total on ground	float
code69	Inches / Snow depth, new snow	float
code70	Inches/inches Snow density	float
code71	Inches / Snow, water equivalent, total of snow and ice on ground	float
code72	Snow report	char of max length 5
code73	Percent / Ice cover, areal extent	float
code74	Miles / Ice extent from reporting area, up to downstream	float
code75	Miles / Ice open water, extent from reporting area, up or downstream	float
code76	Inches / Ice thickness	float
code77	Ice report	char of max length 5
code78	Inches / Depth of frost	float
code79	Inches / Depth of frost thawed	float
code80	Frost structure report	short
code81	Surface frost intensity	short
code82	State of ground	short
code83	Inches / Soil moisture	float
code84	Present weather	short

code85	Past 6 hour weather	short
code86	Percent / Relative Humidity	float
code87	Inches / Evaporation, measured, Class A pan or other	float
code88	Miles per hour / Wind speed	float
code89	Tens of degrees / Wind direction	float
code90	Sunshine, hours per day	float
code91	langleys / Solar energy, accumulated incoming	float
code92	Dew intensity	float
code93	Hours / Leaf wetness	float
code94	Degrees F / Water pan temperature maximum	float
code95	Degrees F / Water pan temperature minimum	float
code96	Miles / 24 hour wind flow	float
rawMessage	ROSA raw message	char of max length 256

4.2.3.6.3 Supporting files

The file *\$FXA_DATA/LDAD/data/LDADinfo.txt* determines which of the three types of files (hydro, mesonet, or manual) the decoded data from a given report type are written to. Additional LDAD configuration files may be found in under this directory. They are described in the LDAD documentation referenced in Section 7.0.

4.2.3.7 Model Soundings

Direct forecast model soundings from the eta model are scheduled to become available in AWIPS in the Build 5.0 time frame. Data will be formatted and transmitted from NCEP as BUFR-encoded messages. The data ingest, decoding, and storage of these data will be described here once the capabilities have been designed and implemented on AWIPS.

4.2.3.7.1 File naming conventions

Reserved.

4.2.3.7.2 Organization of files

Reserved.

4.2.3.7.3 Supporting files

Reserved.

4.2.3.8 Reading and writing to point data files

All local applications that use point data shall use the netCDF versions of the point data files, since the netCDF API is standard and supported. Plotfile versions of the files shall not be accessed where a netCDF option is available. Plotfiles are currently (Build 4.3 and earlier) used by the AWIPS D2D display applications, but are slated to be replaced by netCDF file usage for this purpose in Build 5, at which time the plotfiles will be eliminated.

As mentioned in Section 2.3.2, the access to AWIPS data files shall have been set to read-only for local application development. Therefore, local applications shall not be able to write to the AWIPS point data files or create files in the AWIPS data directories. If writing to an AWIPS point data file is required, it is suggested that a local copy of the file be created under the ownership of the development account, and that all writing be done to the local copy.

Refer to Section 4.1.1.1 for an introduction to netCDF data files and data types. The netCDF APIs to read from and write to netCDF data files are documented in the [NetCDF User's Guide](#). See Appendix 1 for examples of the use of selected netCDF APIs, and for an example of the use of a utility, *gennet.f*, which will generate FORTRAN 77 source code to read any existing netCDF data file.

4.2.4 RADAR Products (*Current to Build 4.3*)

RPG-created base and derived products and text and status messages are received and stored from one or more WSR-88Ds accessible to a WFO or RFC. The full-resolution base data from which the RPG creates the PUP display products are not currently available to AWIPS. The radar products are stored individually in flat files under a directory tree. Individual radar data files are given names matching their Volume Scan Time and Date. The subdirectories in the tree generally correspond to the product attributes that the user must select to narrow the list of all radar products down to a list of times (files) for a given product from a given radar. Text messages, alphanumeric tables, and site adaptation parameters extracted from RPG products are also stored in human-readable form in the AWIPS text database.

4.2.4.1 Naming conventions for radar product directories and files

The top level directory under which all radar products are stored is *\$FXA_DATA/radar*. Under *\$FXA_DATA/radar*, the directory tree for most products looks like one of two types, depending on whether the product is a (1) radial or raster image; or (2) a graphic, graphic overlay, or a text message.

For images, the directory tree is of the form:

~/radarName/productType/elevation/resolution/levels/

For a graphic, graphic overlay, or text message, the directory tree is of the form:

~/radarName/productType/

Individual files are named by their Volume Scan Time as either:

yyyymmdd_hhmm (for base and derived products)

or

yyyymmdd_hhmmss (for messages not related to a specific volume scan).

For example, the 0.54 NM (1 km), 0.5 elevation, 16-level Reflectivity image for 17 February 1997 at 1726 UTC from the Twin Lakes, Oklahoma, radar (KTLX) would be found in the file:

\$FXA_DATA/radar/ktlx/Z/elev0_5/res1/level16/19970217_1726

where *Z* is the shorthand name used for Base Reflectivity. The *radarName* portion of the directory

structure is always the lower-case conversion of the radar site call letters (*ktlx* for KTLX).

A Storm Tracking Information for the same Volume Scan would be found in the file:

\$FXA_DATA/radar/ktlx/STI/19970217_1726

where the *elevation*, *resolution*, and *levels* subdirectories are omitted for this type of product.

A General Status Message received from the RPG around the time of this Volume Scan would be found in:

\$FXA_DATA/radar/ktlx/GSM/19970217_172637

where 17:26:37 was the UTC receipt time of the GSM, to the second.

The *productType*, *elevation*, *resolution*, and *levels* subdirectory names used in the tree are defined in the tables below. The last column of the *productType* table indicates which, if any, of the *elevation*, *resolution*, and *levels* subdirectories apply to the pathname to the product. Note that for all image products, where one of these attributes does not apply to an image product a dummy subdirectory name (e.g., *level0*) is used in order to keep the number of subdirectories the same. **Appendix 3 contains the summary of all applicable radar data subdirectories below /radarName, by product type.** As always in UNIX, all the directory and file names are case sensitive.

Table 4.2.4.1-1. Subdirectory name definitions for the radar product data attribute *productType*. The ELEV/RES/LEVEL column indicates the number, if any, of additional subdirectories which are part of the pathname to the files for the product type. An E means *elevation* applies, an R means *resolution* applies, an L means *levels* applies, and none means there are no subdirectories beyond *productType*.

DIRECTORY NAME	NEXRAD ACRONYM	DESCRIPTION	/ELEV /RES /LEVELS
AAP	--	Alert Adaptation Parameter Message	none
AM	--	Alert Message	none
APR	APR	AP-removed Composite Reflectivity	E/R/L
CFC	--	Clutter Filter Control	E/R/L
CM	CM	Combined Moment	E/R/L
CS	CS	Combined Shear	none
CSC	CSC	Combined Shear Contour	none
CSCT	--	Combined Shear Contour Annotations	none

CST	--	Combined Shear Annotations	none
CZ	CR	Composite Reflectivity	E,R,L
CZC	CRC	Composite Reflectivity Contour	E,R
DHS	DHR	Digital Hybrid Scan Reflectivity	E/R/L
DPA	DPA	Digital Precipitation Array	E/R/L
DSTP	DSP	Digital Storm Total Precipitation	E/R/L
ET	ET	Echo Tops	E/R/L
ETC	ETC	Echo Tops Contour	none
FTM	FTM	Free Text Message	none
GSM	GSM	General Status Message	none
HDP	DPA	Hourly Digital Precipitation Array	E,R,L
HI	HI	Hail Index	none
HIT	--	Hail Index Annotation Table	none
HSR	HSR	Digital Hybrid Scan Reflectivity	E,R,L
LRA	LRA	Layer Composite Reflectivity (Average)	E,R,L
LRM	LRM	Layer Composite Reflectivity (Maximum)	E,R,L
M	M	Mesocyclone	none
MT	--	Mesocyclone Annotation Table	none
OHP	OHP	One Hour Precipitation Accumulation	E,R,L
OHPT	--	One Hour Precipitation Accumulation Annotation	none
PRR	--	Product Request Response	none
PTL	--	Products Available List (Message code 8)	none
RCM	RCM	Radar Coded Message	none
RCS	RCS	Reflectivity Cross Section (16 LEVEL)	E/R/L
SCS	SCS	Spectral Width Cross Section	E/R/L
SPD	SPD	Supplemental Precipitation Data	E,R,L (Note 1)
SRM	SRM	Storm-Relative Mean Radial Velocity (Map)	E,R,L
SRR	SRR	Storm-Relative Mean Radial Velocity (SWA Region)	E/R/L
SS	SS	Storm Structure	none
STI	STI	Storm Tracking Information	none
STIT	--	Storm Tracking Information Annotation	none
STP	STP	Storm Total Precipitation	E,R,L

STPT	--	Storm Total Precipitation Annotation	none
SW	SW	Base Spectrum Width	E,R,L
SWP	SWP	Severe Weather Probability	none
SWR	SWR	SWA Reflectivity	E/R/L
SWS	SWS	SWA Shear	E/R/L
SWV	SWV	SWA Base Velocity	E/R/L
SWW	SWW	SWA Base Spectrum Width	E/R/L
THP	THP	Three Hour Precipitation Accumulation	E,R,L
THPT	--	Three Hour Precipitation Accumulation Annotation	none
TVS	TVS	Tornado Vortex Signature	none
TVST	--	Tornado Vortex Signature Annotations	none
UAM	UAM	User Alert Message	none
USRA	USP	User Selectable Precipitation Accumulation	E/R/L
V	V	Base Velocity	E,R,L
VAD	VAD	Velocity-Azimuth Display	none
VADT	--	Velocity-Azimuth Display Annotation	none
VCS	VCS	Velocity Cross Section	E/R/L
VIL	VIL	Vertically-Integrated Liquid	E,R,L
VWP	VWP	VAD Wind Profile	none
WER	WER	Weak Echo Region	E/R/L
XSR	RCS	Reflectivity Cross Section (8 LEVEL)	E/R/L
XSV	VCS	Velocity Cross Section (8 LEVEL)	E/R/L
Z	R	Base Reflectivity	E,R,L
tstorm	n/a	Various SCAN thunderstorm threat and QPF data and configuration files. Not RPG products.	n/a

Note 1. Uses the res40 value for *resolution* attribute for the 1/4 LFM resolution grid. No longer applies in NEXRAD Build 9 version of product, which is alphanumeric only.

Table 4.2.4.1-2. Subdirectory name definitions for the radar product data attribute *elevation*.

DIRECTORY NAME	NEXRAD NAME	DESCRIPTION
----------------	-------------	-------------

layer0	--	A dummy subdirectory name used when no layer or elevation applies to image product, but there are resolution and data levels subdirectories to follow
layer1	LOW ALT	Low Layer
layer2	MID ALT	Middle Layer
layer3	HIGH ALT	High Layer
elev0_5	0.5 deg	0.5 elevation
elev1_5	1.5 deg	1.5 elevation
elev2_4	2.4 deg	2.4 elevation
elev2_5	2.5 deg	2.5 elevation
elev3_4	3.4 deg	3.4 elevation
elev3_5	3.5 deg	3.5 elevation
elev4_3	4.3 deg	4.3 elevation
elev4_5	4.5 deg	4.5 elevation
elev5_3	5.3 deg	5.3 elevation
elev6_0	6.0 deg	6.0 elevation
elev6_2	6.2 deg	6.2 elevation
elev7_5	7.5 deg	7.5 elevation
elev8_7	8.7 deg	8.7 elevation
elev9_9	9.9 deg	9.9 elevation
elev10_0	10.0 deg	10.0 elevation
elev12_0	12.0 deg	12.0 elevation
elev14_0	14.0 deg	14.0 elevation
elev14_6	14.6 deg	14.6 elevation
elev16_7	16.7 deg	16.7 elevation
elev19_5	19.5 deg	19.5 elevation

Table 4.2.4.1-3. Subdirectory name definitions for the radar product data attribute *resolution*.

DIRECTORY NAME	NEXRAD NAME	DESCRIPTION
res0_25	.13 NM	0.13 NM resolution (0.25 km)
res0_5	.27 NM	0.27 NM resolution (0.5 km)

res1	.54 NM	0.54 NM resolution (1 km)
res2	1.1 NM	1.1 NM resolution (2 km)
res4	2.2 NM	2.2 NM resolution (4km, also 1/40 LFM for HDP)
res40	--	1/4 LFM grid for (obsolete) supplemental precipitation data array (e.g., ~/SPD/layer0/res40/level8/)
res0	--	Dummy resolution name, used for the range vs. azimuth (B-scan) Combined Moment image/graphic product

Table 4.2.4.1-4. Subdirectory name definitions for the radar product data attribute *levels*.

DIRECTORY NAME	NEXRAD NAME	DESCRIPTION
level16	16 LEVEL	16-color-level displayable image data
level8	8 LEVEL	8-color-level displayable image data
level256	--	256-level non-displayable (on PUP) digital arrays. For digital precipitation arrays, linear for DSTP (DSP) product, scaled dBA for HDP (DPA) product, where dBA = 10log[accumulation/(1 mm)]. Also used for DHS [Digital Hybrid Scan Reflectivity] (DHR). See NEXRAD Product Specification ICD, 1208378G, for level and increment definitions.

4.2.4.2 Radar text products

Alphanumeric WSR-88D radar products, and text fields extracted from graphical radar products with tabular or other alphanumeric data (e.g., the Hail Index table, site adaptation parameters), are stored in the text database (see Section 4.2.7) under the AFOS Node (CCC portion of the CCCNNNXXX Product Identification Label [PIL]) identifier "WSR". Radar text products can be viewed from the AWIPS Text Workstation, or can be retrieved from the database using the *textdb* utility.

The type of text product is indicated by the NNN category identifier, and the radar site that the product data pertain to is given by the XXX location identifier. The XXX value is determined by dropping the leading character ("K" for CONUS) and taking the trailing three characters of the WSR-88D station ID. For example, for the Amarillo, Texas WSR-88D station ID (KAMA), the XXX value is "AMA", and its Free Text Messages would be stored in AWIPS under the PIL "WSRFTMAMA". The NNN radar text product categories and type(s) of data stored for each product type are defined in Table 4.2.4.2-1.

Table 4.2.4.2-1. Product category (NNN) identifiers for radar text products stored in the AWIPS text database.

XXX Identifier	Text Product Description
CSC	Combined Shear Adaptable Parameters (from Contour product)
CSH	Combined Shear Adaptable Parameters (from Image product)
FTM	Free Text Message
HAI	Hail Index Cell Table(s) and/or Adaptation Parameters
MES	Mesocyclone Cell Table(s) and/or Adaptation Parameters
OHP	One-Hour Precipitation Accumulation Parameters
PTL	RPG "Products Available" Table (One-Time or dial-out only)
RCM	Radar Coded Message
SPT	Storm Total Precipitation Accumulation Parameters
STI	Storm Cell Tracking/Forecast Table(s) and/or Adaptation Parameters
STP	RCM??
THP	Three-Hour Precipitation Accumulation Parameters
TVS	Tornadic Vortex Signature (TVS) Cell Table and/or TVS Adaptation Parameters
UAM	User Alert Message
VWP	VAD Wind Profile Adaptable Parameters

4.2.4.3 Radar product data format

WSR-88D radar product messages from the RPG are stored in as-received format, which corresponds to the NEXRAD Archive Level IV storage format, and also the RPG-to-Associated-PUP message format. A minimal amount of decoding is performed on the products as they are received in order to extract the attributes needed to identify the contents of the product message, time-stamp the product data via its file name, and create and store the radar product file in the correct directory. A full description of the format of WSR-88D radar products is beyond the scope of this document. It is strongly recommended that if there is a need to use radar data in a local application, that the developer contact a knowledgeable person in an organization (e.g., FSL, TDL, or the OSF) that has done applications development involving the use of these data.

4.2.4.4 AWIPS APIs for radar product processing

APIs for radar product processing fall into two categories: data access APIs and data processing APIs. Each of these API categories is described in the following subsections.

4.2.4.4.1 Radar Data Access

All current radar data inventory and access in AWIPS is through interactive display routines and processes in D2D. The APIs used for radar data access in the D2D interactive display environment do not readily apply to applications in a stand-alone environment, so a description of these APIs is deferred until suitable local application radar APIs are available. Until then, sufficient information has been provided in Section 4.2.4.1 to allow a local application developer to develop code to locate and access any specific radar product file based on its product attributes.

4.2.4.4.2 Radar Data Processing APIs

APIs are available to extract application-ready information from the various blocks of data that comprise the RPG products. Unlike the radar data access routines, the decoding routines are less embedded in the D2D environment, and may be practicably modified for stand-alone applications' use. These routines are originally C, minimally rewritten in C++. If needed, the original C functions should be available from FSL. Stand-alone APIs are planned to be available for use at some time in the future.

It is definitely preferable to use an existing set of APIs for decoding and processing RPG products rather than trying to write a new set of APIs. There are many mistakes and missing details in the NEXRAD documentation that have been overcome by FSL and other organizations through trial-and-error, and it is worthwhile to make use of this experience whenever possible.

The C++ routine **decodeRadar** in `~/src/dmRadar/` calls all of the functions that extract the product parameters and the image or graphic data from a single product data file. The **decodeRadar** routine contains three functions for the three basic data types: **decodeRadial**, **decodeRaster**, and **decodeGraphic**. Only one of these three functions is used to decode a product of a given type. The proper decode function is determined by the arguments provided in the call to **decodeRadar**.

The decode functions take as arguments the pathname to the radar product file and a pointer to the object type that contains the decoded data. The **decodeRadial** function takes two additional input arguments, **resolution** and **ring**. The **resolution** parameter refers to the gate spacing along the radial, and is used to determine how many gates are expected along a single radial, which is used to size the unpacked RLE image data array. The **ring** parameter controls whether a bounding ring is engraved into the image data at the maximum range of the product.

The three decode functions each call a set of common functions for decoding product blocks that are contained in all WSR-88D products. The routine **getWsrHdrInfo** reads the variables in the Message Header Block, including the NEXRAD Product Code, the source radar ID number, and the time of message creation. The routine **getWsrPdbInfo** reads the Product Description Block and provides the latitude, longitude, and height of the radar; the operational mode and Volume Coverage Pattern; the Volume Scan Time and Number, and product generation time; the elevation angle and index; and the center azimuth and range (for SWA and Cross Sections). The routine **getWsrPsbInfo** reads the Product Symbology Block ("the data"), and calls different routines depending on the data type.

Data levels and product legend information are read for radial and raster image products. Graphic product layers are separated from the product for graphic products. Image data arrays for radial and raster image products are received packed via a run-length-encoding (RLE) algorithm, and must be unpacked before use. The APIs **extractRaster** and **extractRadial** are called to unpack the RLE data into full arrays that can be processed into displays or used in other algorithms.

4.2.5 Satellite Imagery

4.2.5.1 Naming Conventions for Image Directories and Files

In WFO-Advanced, satellite images are stored in netCDF files once they have been decoded by the satellite decoder. Thus, all image Input/Output is done with netCDF APIs. Each file contains one image.

All netCDF image files are stored in a directory pathname consisting of two parts. The first (leading) part consists of six fields filled in according to image scale and band. Here is a template for the leading six fields of the path:

```
$FXA_DATA/sat/<source>/netCDF/<scale>/<projection>_<band>
```

where:

`$FXA_DATA` is an environment variable specifying the root of the data directory tree. This variable's current value is `"/data/fxa"`.

`<source>` is either *SBN* or *FSL* (subdirectory FSL is currently not used);

`<scale>` may be any of: *alaska*, *conusC*, *eastCONUS*, *hawaii*, *grid201*, *nhSat*, *puertoRico*, *superNat9*, or *westCONUS*;

`<projection>` may be any of: *akBig* (for scale alaska), *alaska* (for scale alaska), *conus* (for scales conusC, eastCONUS, and westCONUS), *fourSat* (for scale grid201), *nhem* (for scale nhSat), *prBig* (for scale puerto Rico), *puertoRico* (for scale puertoRico), or *super* (for scale superNat9); and

`<band>` may be any of: *i11* (for 11.0 micron infra-red images), *i12* (for 12.0 micron infra-red images), *i39* (for 3.9 micron infra-red images), *iwv* (for 6.7 micron water vapor channel infra-red images), or *vis* (for visible light images).

The second part of the path is not always present. When present, it consists of a subdirectory */clean/*, */regClip/* (for regional clip), or */remap/*. An understanding of these subdirectories is best obtained by a quick overview of some of the satellite directory tree, which follows:

The following directories contain raw NESDIS sectors for the northern hemisphere:

```
$FXA_DATA/sat/SBN/netCDF/nhSat/nhem_i11
```

```
$FXA_DATA/sat/SBN/netCDF/nhSat/nhem_i12
```

\$FXA_DATA/sat/SBN/netCDF/nhSat/nhem_iwv
\$FXA_DATA/sat/SBN/netCDF/nhSat/nhem_vis
\$FXA_DATA/sat/SBN/netCDF/nhSat/nhem_i39

The following directories contain links to *sat/SBN/netCDF/nhSat/nhem**:

\$FXA_DATA/sat/SBN/netCDF/nhSat/nhem_i11/clean
\$FXA_DATA/sat/SBN/netCDF/nhSat/nhem_i12/clean
\$FXA_DATA/sat/SBN/netCDF/nhSat/nhem_iwv/clean
\$FXA_DATA/sat/SBN/netCDF/nhSat/nhem_vis/clean
\$FXA_DATA/sat/SBN/netCDF/nhSat/nhem_i39/clean

The following directories contain raw North American NESDIS sectors (superNat):

\$FXA_DATA/sat/SBN/netCDF/superNat9/super_i11
\$FXA_DATA/sat/SBN/netCDF/superNat9/super_i12
\$FXA_DATA/sat/SBN/netCDF/superNat9/super_iwv
\$FXA_DATA/sat/SBN/netCDF/superNat9/super_vis
\$FXA_DATA/sat/SBN/netCDF/superNat9/super_i39

The following directories contain links to *sat/SBN/netCDF/superNat9/super**:

\$FXA_DATA/sat/SBN/netCDF/superNat9/super_i11/clean
\$FXA_DATA/sat/SBN/netCDF/superNat9/super_i12/clean
\$FXA_DATA/sat/SBN/netCDF/superNat9/super_iwv/clean
\$FXA_DATA/sat/SBN/netCDF/superNat9/super_vis/clean
\$FXA_DATA/sat/SBN/netCDF/superNat9/super_i39/clean

The following directories contain CONUS images, which are remapped from both the North American and high resolution east/west CONUS sectors:

\$FXA_DATA/sat/SBN/netCDF/conusC/conus_i11/remap
\$FXA_DATA/sat/SBN/netCDF/conusC/conus_i12/remap
\$FXA_DATA/sat/SBN/netCDF/conusC/conus_iwv/remap
\$FXA_DATA/sat/SBN/netCDF/conusC/conus_vis/remap
\$FXA_DATA/sat/SBN/netCDF/conusC/conus_i39/remap

The following directories contain links to *sat/SBN/netCDF/conusC/conus*/remap*:

\$FXA_DATA/sat/SBN/netCDF/conusC/conus_i11
\$FXA_DATA/sat/SBN/netCDF/conusC/conus_i12
\$FXA_DATA/sat/SBN/netCDF/conusC/conus_iwv

\$FXA_DATA/sat/SBN/netCDF/conusC/conus_vis
\$FXA_DATA/sat/SBN/netCDF/conusC/conus_i39

The following directories contain high resolution east CONUS sectors. Only one version of these are kept because they are used only for clipping and remapping:

\$FXA_DATA/sat/SBN/netCDF/eastCONUS/conus_i11
\$FXA_DATA/sat/SBN/netCDF/eastCONUS/conus_i12
\$FXA_DATA/sat/SBN/netCDF/eastCONUS/conus_iwv
\$FXA_DATA/sat/SBN/netCDF/eastCONUS/conus_vis
\$FXA_DATA/sat/SBN/netCDF/eastCONUS/conus_i39

The following directories contain high resolution west CONUS sectors. Only one version of these are kept because they are used only for clipping and remapping:

\$FXA_DATA/sat/SBN/netCDF/westCONUS/conus_i11
\$FXA_DATA/sat/SBN/netCDF/westCONUS/conus_i12
\$FXA_DATA/sat/SBN/netCDF/westCONUS/conus_iwv
\$FXA_DATA/sat/SBN/netCDF/westCONUS/conus_vis
\$FXA_DATA/sat/SBN/netCDF/westCONUS/conus_i39

The following directories contain high resolution east CONUS data clipped to the regional scale:

\$FXA_DATA/sat/SBN/netCDF/eastCONUS/conus_i11/regClip
\$FXA_DATA/sat/SBN/netCDF/eastCONUS/conus_i12/regClip
\$FXA_DATA/sat/SBN/netCDF/eastCONUS/conus_iwv/regClip
\$FXA_DATA/sat/SBN/netCDF/eastCONUS/conus_vis/regClip
\$FXA_DATA/sat/SBN/netCDF/eastCONUS/conus_i39/regClip

The following directories contain high resolution west CONUS data clipped to the regional scale:

\$FXA_DATA/sat/SBN/netCDF/westCONUS/conus_i11/regClip
\$FXA_DATA/sat/SBN/netCDF/westCONUS/conus_i12/regClip
\$FXA_DATA/sat/SBN/netCDF/westCONUS/conus_iwv/regClip
\$FXA_DATA/sat/SBN/netCDF/westCONUS/conus_vis/regClip
\$FXA_DATA/sat/SBN/netCDF/westCONUS/conus_i39/regClip

Following the path is the file name. The file names are based on image date and time. The format for WFO-Advanced **netCDF** image file names is:

yyyymmdd_HHMM

where:

yyyy is the 4-digit year;
 mm is the 2-digit month;
 dd is the 2-digit day-of-month;
 HH is the 2-digit hour; and
 MM is the 2-digit minute.

The following two examples illustrate how these pieces are put together:

/data/fxa/sat/SBN/netCDF/eastCONUS/conus_vis/regClip/19970425_1815

contains the eastern CONUS visible image clipped to the regional scale for 1815Z on April 25, 1997, and

/data/fxa/sat/SBN/netCDF/nhSat/nhem_iwv/20000229_1532

holds the northern hemisphere 6.7 micron water vapor channel image for 1532Z on February 29, 2000.

4.2.5.2 Organization of netCDF Image Files

The layout of netCDF image files in WFO-Advanced is simple and straightforward. There are nineteen **global attributes**. There are no **coordinate variables** (**dimensions** that are also **variables** with values stored in them). There are two **dimensions** and (including the image itself) three **variables**.

4.2.5.2.1 Global Attributes

The netCDF image files of WFO-Advanced have nineteen **global attributes**, all currently used for internal file documentation only. They are:

1. "channel" = a 23-character string identifying the wavelength of the satellite sensor used to make the original image.
2. "depictorName" = an 80-character string consisting of a unique identifier for the map projection / areal coverage combination for the image in this file.
3. "projIndex" = a long int which identifies the projection of the image stored in this file.
4. "projName" = an 80-character string giving the name of the map projection of the image stored in this file.
5. "centralLat" = a float value giving the latitude (in degrees north) at which the image's map projection is tangent to the earth.
6. "centralLon" = a float value giving the longitude (in degrees east) at which north is "up on the image's map projection.
7. "rotation" = a float value giving the angle (in degrees clockwise) the y-axis of the image's map projection is rotated from north.

8. "xMin" = a float value giving an arbitrary cartesian coordinate for the image's map projection. This is for FSL's use in D-2D.
9. "xMax" = a float value giving an arbitrary cartesian coordinate for the image's map projection. This is for FSL's use in D-2D.
10. "yMin" = a float value giving an arbitrary cartesian coordinate for the image's map projection. This is for FSL's use in D-2D.
11. "yMax" = a float value giving an arbitrary cartesian coordinate for the image's map projection. This is for FSL's use in D-2D.
12. "lat00" = a float value giving the latitude (in degrees north) of the lower left (southwest) corner of the image.
13. "lon00" = a float value giving the longitude (in degrees east) of the lower left (southwest) corner of the image.
14. "latNxNy" = a float value giving the latitude (in degrees north) of the upper right (northeast) corner of the image.
15. "lonNxNy" = a float value giving the longitude (in degrees east) of the upper right (northeast) corner of the image.
16. "dxKm" = a float value giving the left-to-right (west-to-east) size in kilometers of one pixel at the latitude and longitude given by **global attributes** "latDxDy" and "lonDxDy" defined below.
17. "dyKm" = a float value giving the bottom-to-top (south-to-north) size in kilometers of one pixel at the latitude and longitude given by **global attributes** "latDxDy" and "lonDxDy" defined below.
18. "latDxDy" = a float value giving the latitude (in degrees north) at which the "dxKm" and "dyKm" (defined above) values are valid.
19. "lonDxDy" = a float value giving the longitude (in degrees east) at which the "dxKm" and "dyKm" (defined above) values are valid.

4.2.5.2.2 Dimensions and Coordinate Variables.

The netCDF image files of WFO-Advanced have no **coordinate variables** and no **unlimited** (or **record**) **dimensions**.

Two **dimensions** are available in WFO-Advanced netCDF image files for dimensioning (sizing) **variables**. They are:

1. "y" = the number of pixels along the left and right (bottom-to-top or south-to-north) edges of the image.
2. "x" = the number of pixels along the bottom and top (the right-to-left or west-to-east edges) of the image.

4.2.5.2.3 Variables, with their Dimensions and Attributes.

Build 4.3 netCDF image files have only three **variables**. Here they are, with their **dimensions** and

attributes:

1. "image" = a two-dimensional array of pixels. This is the satellite image itself. Values of this **variable** are of type **NC_BYTE** (byte).

Before using a pixel value from "image", the programmer should check that it is neither 0 nor 255. FSL has tried to make 0 the value used to represent "not defined" because it makes for much more visually pleasing images when there have been large areas missing, as opposed to the value of 255 which was being used in the NESDIS files. FSL has tried to set it up so that a large consecutive area of 255s would get converted to 0s, but that a single 255 would not, in case it was real data. This has only been partially successful in cases where missing data is present in the middle of images, and it is possible that in the future FSL will just convert all 255s to 0s.

The **variable** "image" has two **dimensions** ("y" and "x") and no **attributes**.

2. "validTime" = the time of the image in whole seconds since 00Z on January 01, 1970. The value of this **variable** is of type **NC_DOUBLE** (double). This **variable** has no **dimensions** and two **attributes**. The first **attribute** is a 39-character string called "units", and has the value "seconds since 1970-1-1 00:00:00.00 0:00". The second **attribute** is a 10-character string called "long_name", and has the value "Valid Time".
3. "valid100thSecs" = hundredths of a second after "validTime" that the satellite began the scan that produced the image in this file. The value of this **variable** is of type **NC_BYTE** (byte). This **variable** has no **dimensions** and two **attributes**. The first **attribute** is a 12-character string called "units", and has the value "centiseconds". The second **attribute** is a 10-character string called "long_name", and has the value "Valid 100th of a second".

4.2.5.3 Other Supporting Files

None for build 4.3.

4.2.5.4 Software APIs for netCDF image file I/O

No APIs for reading from or writing to WFO-Advanced netCDF image files will be provided in build 4.3. To read in an image, program the following steps (described for C language programming):

1. construct the full path (directory + file name) for the netCDF file containing the desired image.
2. call "nc_open" to open the netCDF file. For the calling argument "filename", pass in the path constructed in the preceding step.
3. call "nc_inq_varid" to get the netCDF variable id for the image. For the calling argument "ncid", use the netCDF file id returned by the "nc_open" call in step 2 above. For the calling argument "name", pass in a string containing "image".

4. call "nc_inq_varid" to get the netCDF dimension id's for the image variable's two dimensions. For the calling argument "ncid", use the netCDF file id returned by the "nc_open" call in step 2 above. For the calling argument "varid", pass in the netCDF variable id returned by the "nc_inq_varid" call in step 3 above.
5. for each netCDF dimension id returned by the "nc_inq_varid" call in step 4 above (there should be two), call "nc_inq_dimlen" to get the dimensions of the image. For the calling argument "ncid", use the netCDF file id returned by the "nc_open" call in step 2 above. For the calling argument "dimid", use one of the netCDF dimension id's returned by the "nc_inq_varid" call in step 4 above.
6. using the dimensions returned by the two "nc_inq_dimlen" calls in the previous step, allocate (malloc) memory space for the image (an array of bytes).
7. call "nc_get_vara_uchar" to get the image. The calling arguments are as follows:

"ncid" - use the netCDF file id returned by the "nc_open" call in step 2 above.

"varid" - use the variable id returned by the "nc_inq_varid" call in step 3 above.

"start" - use an array consisting of two longs, both set equal to zero.

"count" - use an array consisting of two longs. Fill the array with the two dimensions returned by the two "nc_inq_dimlen" calls in step 5 above.

"up" - pass in the address of the image (the byte array) you allocated in step 6 above.

"nc_get_vara_uchar" will read the image into this array and return it to you.

8. call "nc_close" to close the netCDF file. For the calling argument "ncid", use the netCDF file id returned by the "nc_open" call in step 2 above.

As a part of build 3.0, TDL supplied the "get_image_nav" API to provide programs access to image navigation data. The API continues to be available in build 4.3. To use the API, use the following header files:

/awips/adapt/nav/inc/Navigation.h (when calling from C), or

/awips/adapt/nav/inc/Navigation.H (when calling from C++)

Here is the prototype for the API:

```
void get_image_nav (
    const char *image_source , /* input */
    const char *image_band , /* input */
    float *dx , /* output */
    float *dy , /* output */
    float *lat1 , /* output */
    float *lat2 , /* output */
    float *lon1 , /* output */
)
```

```

float *lon2 , /* output */
long *nx , /* output */
long *ny , /* output */
long *projection , /* output */
long *relativity , /* output */
float *stdlat1 , /* output */
float *angle2 , /* output */
float *truelat , /* output */
float *align , /* output */
long *status ); /* output */

```

FORTRAN callers need not include anything to use this API, but may view the header files to see the function names and calling sequences. Both of the include files named above require six other include files:

```

hmHMC_fileUtils.h
hmHMC_interpUtils.h
hmHMC_parseNum.h
hmHMU_STATUS.h
hmHMU_destroyObject.h
hmHMU_stringUtils.h

```

either directly or indirectly. These may be obtained from the TDL web site by doing the following:

1. First, bring up the TDL home page (see section 7, "OnLine Resources and URLs", for the URL);
2. From there, click on the "AWIPS LOCAL APPLICATIONS DEVELOPMENT SUPPORT" link to bring up the "AWIPS LOCAL APPLICATIONS DEVELOPMENT" page;
3. from there, click on the "DOWNLOAD/UPLOAD" link to bring up the "Available Files to Download" page;
4. From there, click on the "C++ Navigation Routines" choice, which will ftp the above six include files (and a few other files as well) to you.

All (C++, C, and FORTRAN) callers must link to:

```

/awips/adapt/nav/lib/libNavigation.a

```

when building their executables. This API searches the navigation file (an ASCII flat file called "Navigation.txt") for the navigational information for the combination of map projection, geographic area of coverage, and radiometric band specified by the calling arguments "image_source" and "image_band", and returns that information to the caller. The file "Navigation.txt" is stored in a directory named by the UNIX environment variable "NAVFILE_DIR". The software reads "NAVFILE_DIR" to find and open "Navigation.txt". Therefore, "NAVFILE_DIR" must be correctly set to the complete,

absolute directory of "Navigation.txt" before "get_image_nav" can be used. If "NAVFILE_DIR" is incorrectly set, or cannot be found, "get_image_nav" will abort. The currently correct setting for "NAVFILE_DIR" is "/awips/adapt/nav/data/".

The calling arguments for "get_image_band", in alphabetical order, are as follows:

"align" = (a pointer to)

- a. for polar stereographic and Lambert conformal projections, the vertical longitude; the east longitude (in degrees) parallel to the map projection's positive y axis.
- b. for a local stereographic projection, the rotation angle of the positive y axis in degrees clockwise from north.

"angle2" = (a pointer to)

- a. for a tangent cone projection, same as stdlat1.
- b. for the secant cone projection, the second (furthest from pole) latitude (in degrees north) at which the secant cone cuts the earth.
- c. for a stereographic projection, the longitude (in degrees east) of the center of the projection. A value of +/-90 indicates polar stereographic.

"dx" = (a pointer to) the left-right (west-east) pixel size (in meters) at the projection's "true" latitude.

"dy" = (a pointer to) the bottom-top (south-north) pixel size (in meters) at the projection's "true" latitude.

"image_band" = (a pointer to) a string specifying the radiometric band used by the satellite sensor to obtain the image data for which navigational information is wanted. Valid values are "i11" (for 11 micron infra-red), "i12" (for 12 micron infrared), "i39" (for 3.9 micron infrared), "iwv" (for the 6.7 micron infrared water vapor channel), and "vis" for visible.

"image_source" = (a pointer to) a string specifying the combination of map projection and geographic scale of the image for which navigational information is wanted. Valid values are "conusC", "eastCONUS", "nhSat", "superNat9", and "westCONUS".

"lat1" = (a pointer to) the north latitude (in degrees) of the first or lower left pixel.

"lat2" = (a pointer to) the north latitude (in degrees) of the last or upper right pixel.

"lon1" = (a pointer to) the east longitude (in degrees) of the first or lower left pixel.

"lon2" = (a pointer to) the east longitude (in degrees) of the last or upper right pixel.

"nx" = (a pointer to) the number of pixels along a row (the right-to-left or west-to-east) edges of the image.

"ny" = (a pointer to) the number of pixels along a column (the bottom-to-top or south-to-north) edges of the image.

"projection" = (a pointer to) the integer grib code for the map projection:

- 1 = Mercator
- 3 = Lambert conformal
- 5 = stereographic

"relativity" = (a pointer to) an integer code for how vector components are resolved:

- 0 = vector components are resolved relative to easterly and northerly directions.
- 1 = vector components are resolved relative to the defined grid in the direction of increasing x and y.

"status" = (a pointer to) get_image_nav's return status. Possible values are:

- 0 = The requested navigation data was successfully found, extracted, and returned.
- 2 = The software did not recognize the input combination of "image_source" and "image_band" values.
- 6 = An attempt to allocate memory failed. Most likely, insufficient memory was available.
- 7 = Most likely, the file "Navigation.txt" is corrupted.
- 8 = The file "Navigation.txt" could not be read. This is not necessarily a problem with the file.
- 9 = Indicates an undefinable error, possibly a bug in the software.

"stdlat1" = (a pointer to):

- a. for a tangent cone projection, the tangency latitude; the latitude (in degrees north) at which the earth is tangent to the map projection.
- b. for a secant cone projection, the first (closest to pole) latitude (in degrees north) at which the secant cone cuts the earth.
- c. for a stereographic projection, the latitude (in degrees north) of the center of the projection.

"truelat" = (a pointer to) the north latitude (in degrees) at which the projection's pixel size is defined. For AWIPS projections, "truelat" = "stdlat1".

The input arguments "image_source" and "image_band" must be C-language style strings, that is, the character immediately following the last (rightmost) printable character of the string must be CHAR(0) in FORTRAN or NULL [(char) 0] in C and C++.

Navigational information that is not applicable to the specified map projection and geographic area of coverage is returned with the value -9999.0 for type "float", or -9999 for type "long".

This API is designed to be callable from C++, C, and FORTRAN. Simple examples may be viewed in the Navigation man page or in the Navigation test drivers (navtest.C for C++, navtest.c for C, and navtest.f for FORTRAN; note that navtest.f will also need itlen.f). These may be obtained via the same procedure given above for getting the six include files needed by Navigation.h and Navigation.H.

Navigational data for images in the */clean*, */remap*, and */regClip* subdirectories are not available through this API.

4.2.6 Satellite Soundings

Deferred.

4.2.7 Text Database

The text subsystem consists of the text display, the Informix database, supporting files, and the storage/retrieval of text messages. The decoded text products are stored in the *fxatext* database in the Informix RDBMS. The products that are currently stored in the database include virtually all text products with AFOS Product Identification Labels (PILs), with additional PILs defined for Off-CONUS text products from Alaska and Pacific regions. The database works on a circular buffer basis, storing the newest version of each product over the oldest. The number of versions of each product or category of products is specified in a table in the file *versions_lookup_table.dat*. To improve performance, the storage space is fragmented based on the frequency of requests for a category of products; the typical read response time is 1 to 2 seconds.

The text database consists of six Informix tables:

- **textproductinfo**

This semi-static data table stores the controls and tracks version information for each product that is stored in the *fxatext* database. There are six columns in the table: *cccid*, *nnnid*, *xxxid*, *versionstokeep*, *latestversion*, and *largeproduct*. The *largeproduct* attribute determines whether a product is stored in the **largetextproducts** table (*largeproduct*=1) as Informix data type TEXT, or in the **stdtextproducts** table (*largeproduct*=0) as data type CHAR.

- **stdtextproducts**

This dynamic data table holds the individual METARs, TAFs, and other small-sized AFOS text products as CHAR data in the product column. There are seven columns in this table: *cccid*, *nnnid*, *xxxid*, *versionnumber*, *createtime*, *product*, and *productlength*. The *version_number* field corresponds with the *latestversion* field from the **textproductinfo** table for the corresponding product.

- **largetextproducts**

This dynamic data table holds the individual large- or unknown-sized text products as TEXT data in the product column. There are 6 columns in this table: *cccid*, *nnnid*, *xxxid*, *versionnumber*, *createtime*, and *product*. The *version_number* field corresponds with the *latestversion* field from the **textproductinfo** table for the corresponding product. When a new product whose PIL (and therefore, its typical size) is unknown is stored to the text database, it is stored to the **largetextproducts** table by default, since there is a larger size limitation on the TEXT data type.

- **state_match**

This semi-static data table contains a listing of all xxx_id and ccc_id combinations for a state. There are three columns in the table: state, xxx, and ccc.

- **versionstable**

This semi-static data table contains a "template" of a first-guess number of versions to store for a product category (NNN) for a given AFOS Node (CCC). It is localized to give a larger number of versions for products originating nearest the WFO, and products such as METARs that are numerous and often requested.

4.2.7.1 Text product identifiers

The AFOS Product Identifiers are as follows:

- CCC - code (currently, AFOS Node) for the site where the product entered
- NNN - code for the product category
- XXX - 1- to 3-character code for the valid area/site
- SS - 2-character state code.

4.2.7.2 Supporting files

The text subsystem uses flat files to hold related static data tables containing informational and control data. The function *initializeDicts* opens and reads the flat file data, and is called by *textWkstnStorage*, the main driver for the textDB decoder. It then initializes the dictionaries for the AFOS, collective, bit and upper air tables and loads the ISPAN, national and station arrays. For each incoming product, its data descriptor, a 4-6 character code, is compared to the collective table to see if it is a collective, upper air or standard product. Then the correct decoder for the type of product involved is called.

The data tables are as follows:

afos_lookup_table.dat - contains the origins mapped with the CCC

bit_table.dat - contains the NNN of National bit products mapped with AAA to be filled in with the local NWS office

collective_table.dat - contains the data descriptors of the collective products mapped with the AFOS ID CCCnnnXXX where nnn is the corresponding NNN for that product

ispan_table.dat - contains the WMO header (data descriptor + origin) for the non-collective products mapped with the AFOS ID, used as a last resort

national_category_table.dat - contains the XXX mapped with the CCC for collective products

upair_table.dat - contains the data descriptor for upper air products mapped with the AFOS ID CCCnnnXXX, where nnn is the corresponding NNN for that product

station_table.dat - contains the five digit station numbers mapped with the XXX for the upper air products

4.2.7.3 Text Database I/O APIs

The interface to the text database is a UNIX command named *textdb*. In order to maintain the integrity of the data in the text database, the use of the *textdb* utility to read from, write to, or modify the text database tables is recommended over programming directly in SQL or using the Informix *dbaccess* utility.

The *textdb* command line options **-r** and **-w**, respectively, are used to read from and write to the database, with the product ID given as an argument. Data are read from and written to standard input and standard output. The *textdb* command follows the UNIX convention of returning a status of zero upon success, and non-zero if an error occurs.

For example, the UNIX command line

```
textdb -r DENNOWDEN | more
```

will pipe the latest Denver nowcast into the UNIX text reader **more** for viewing from the terminal window, and the command line

```
textdb -w DENWRKNOW < workFile.txt
```

will store the contents of **workFile.txt** (ASCII text file created by an application program, for example) as a nowcast text product in the text database. A standard text product may be up to 2000 bytes.

A NOTE OF CAUTION:

In using the API, a great deal of care must be taken to assure that:

1. only known, meaningful product IDs are used in writing products to the database. The *textdb* utility will write any product to the database that has a CCCNNNXXX ID between 6 and 9 characters, whether or not that ID is a valid ID in a product table. Once the product is in the database there is no easy way to remove it, and so it will occupy permanent space at the expense of other, valid text products.

2. no valid, existing products are overwritten without a good reason to do so. Since only a fixed number of versions of a product are retained, a local application could cause all official versions of a product to be lost through a number of overwrites.

At this time, products in the text database only have the time attribute of **creationtime**, which is the system clock time (UTC), in UNIX ticks (seconds since 00:00, 1/1/1970) when the product was stored in the database. This time will normally have an offset from the valid time of the text product data itself. The only way to determine (set) the valid time of the text product is to read (write) it inside the text of the product.

The complete list of command line options is as follows (AFOS product syntax is used for afosCmd and productID parameters):

- r afosCmd do a standard AFOS read from the database
- productID write the product to the database
- w
- t productID { productID ... } get create time of last version(s)
- A productID get all times for one productID
- afosCmd read data from the database with special headers
- rh
- rd product ID a special header is inserted at the start of every individual product, to allow identification of each product
- v productID versions Change the number of versions to keep in the **textproductinfo** table in the database
- l nnn Change all NNN products to large text. A large text product may be 31936 bytes, versus 2000 bytes for a standard text product
- s -a state xxx ccc Add another ID to the SS.NNN lookup list in the **state_match** table
- s -d state xxx ccc Delete an ID from the SS.NNN lookup list in the **state_match** table
- s -r state Display current list for state in SS.NNN lookup list

For backward compatibility:

- read afosCmd same as -r afosCmd
- write afosCmd same as -w afosCmd

4.2.8 Digital Forecast Data

The Interactive Forecast Preparation (IFP) component of AWIPS is in a state of transition. IFP in Build 4.3 currently consists of the Interactive Computer Worded Forecast program, which primarily uses the Informix RDBMS for storage of digital forecast data. This is likely to change with the possible introduction of the Interactive Forecast Preparation System (IFPS) in Build 5.x. For those reasons, this section and its subsections are deferred until the time that the IFP software transition is settled and suitable APIs are available to provide local applications with safe access to the IFP database.

4.2.8.1 Grids

Deferred.

4.2.8.2 Zone DFM

Deferred. This section will describe the Digital Forecast Matrix (DFM) for forecast zones.

4.2.8.3 Station DFM

Deferred. This section will describe the DFM for forecast points.

4.2.8.4 IFP Database Access and APIs

Deferred.

4.2.9 Verification Data

Verification data for Public and Aviation (TAF) forecasts are present in AWIPS Build 4.3. Verification of other forecast program areas is scheduled for AWIPS Builds 5 and 6. This section and subsections are deferred.

4.2.9.1 Public

The public forecast verification data on AWIPS in Build 4.3 are the same data as produced by the AFOS VERIFY program. Refer to Section 8.4 of the [AWIPS User's Manual for Release 4.3](#), and Section 9.5 of the [System Manager's Manual for Release 4.3](#). However, unlike on AFOS, the verification data on AWIPS are stored in the Informix database. The storage of these data in Informix is complicated, and will be described in a separate document. Once this documentation is available, it will be referenced in Section 7 (if online) or 8 (if hard copy).

4.2.9.2 Aviation

Same as Section 4.2.9.1.

4.2.9.3 Marine

Deferred. No marine forecast verification data is available on AWIPS in Build 4.3, except for the marine verification products produced at NCEP and stored in the AWIPS text database.

4.2.9.4 Hazardous Weather

Deferred. No hazardous weather forecast verification is available on AWIPS in Build 4.3.

4.2.9.5 Fire Weather

Deferred. No fire weather forecast verification is available on AWIPS in Build 4.3.

4.2.9.6 Hydrologic

Deferred. No hydrological forecast verification is available on AWIPS in Build 4.3.

4.2.9.7 Verification Database Access and APIs

Deferred.

4.2.10 NCEP (REDBOOK) Graphics

Graphics products from NCEP provided to AWIPS are produced in the REDBOOK format. Many of these products are being phased out in favor of providing the raw data needed to produce them locally; however, many REDBOOK products will continue to be produced at NCEP for the foreseeable future. All REDBOOK products are currently displayable within D2D, and no need for use of these graphics in local applications development is expected.

REDBOOK graphics are stored in the *\$FXA_DATA/ispan/graph* subdirectory. The products are stored in individual flat files, in as-received format. A file naming convention is used to identify the individual graphics products, as follows:

<WMO ID>.<YYYYMMDD_HHMMSS.mmm> (Brackets not part of the name)

where **<WMO ID>** is the WMO designator for the product, as extracted from the WMO product header, and **<YYYYMMDD_HHMMSS.mmm>** is the date and time of the receipt of the product (not the date

and time of the data contained in the product). The **.mmm** part is the milliseconds of the time stamp. An example file name is:

PYMA85KWBC.19961217_120605.929

No decoding of the REDBOOK products is done to determine the data time. The time of receipt and the WMO ID are used in AWIPS to infer the actual data times, the list of which are known for each product.

4.3 Site-Specific Data Sets

These data sets are typically documented in the appropriate User's Guide and System Manager's Manual sections. Some information may already be found in these documents. Once all the appropriate data have been identified and their documentation sources have been found, they will be described in the following sections.

4.3.1 Site-Specific Static Data

Deferred.

4.3.2 Site Customization and Preference Data

Deferred.

4.3.3 Site-Specific Data Formats and Locations

Deferred.

4.3.4 Site-Specific Data Creation and Management

Deferred.

5.0 Initiation of Local Applications

A variety of mechanisms exist to launch programs on AWIPS. Six existing mechanisms are described in the sections that follow. The preferred method for initiating local applications has not been determined, and will probably depend to a great extent on the frequency at which the application needs to be run, the type of interaction that it has with the user and with AWIPS, and the environment in which it must be run.

5.1 From a D2D Menu

Applications can be launched from a D2D menu by adding a button for the application to one of the existing menus to the right of the D2D "Scale" menu, or by creating a new menu in this area. This is accomplished by adding entries to two D2D menu configuration files, which are editable ASCII text files. A user with appropriate permissions can add or remove menu items for applications by editing the configuration files, without needing to recompile the D2D software for the changes to take effect. D2D acts as a shell to launch the application executable by name, with command-line arguments. As an example, the Volume Browser in the D2D Volume menu is actually a stand-alone application that is initiated by D2D and brings up its own grid selection and loading menu.

An important feature to note about applications that are launched by D2D in this manner is that any standard input or output within the application is connected via Unix pipes to D2D's application interface, not to the keyboard or a terminal window. The application can send specific action requests to D2D by writing text to standard output (for example, the Volume Browser asks for selected grids to be loaded). The application can also receive notifications from D2D by reading from standard input. These behaviors are described in more detail in Chapter 11 of the WFO-Advanced Overview document found on the FSL Home Page.

Application initiation information for D2D is in the form of a line of delimited text which must be added to the file *\$FXA_HOME/data/appInfo.txt*. The format of an entry in the file *appInfo.txt* is:

```
key | label | executable | arguments | prestart | restart | one-instance
```

where:

- **key** is a unique text string that will be used as the application key
- **label** is the label that will appear on the D2D menu for launching the application
- **executable** is the file to execute (must be located in a D2D search path)
- **arguments** are (obviously fixed) command line arguments for the application
- **prestart** tells whether the application is started automatically each time D2D is started
- **restart** tells whether D2D automatically restarts the application if it ever terminates
- **one-instance** indicates whether D2D will allow only one copy of the application to be running at one time

Example:

```
vb | Volume Browser... | vb | | y | y | y
```

```
mineswp | Mine Sweeper... | mine_sweeper | -l expert | n | n | y
```

The file *\$FXA_HOME/data/localization/nationalData/dataMenus.txt* controls the D2D menu layouts and the buttons contained within the menus. In order for your application's initiation button to appear in a menu, an entry must be added to this file for the button. The syntax for the entries in the file is described in the file itself. The unique application **key** value

from *appInfo.txt* must be included in the entry in *dataMenus.txt*. This **key** serves as the linkage between the menu button entry in *dataMenus.txt* and the initiation instructions that are in *appInfo.txt*.

The executable code for the application must be placed in the search path that D2D uses to find executable code for locally-developed applications (see Section 2.3.4). Once the changes have been made to the two configuration files, D2D must be restarted for the changes to appear in the menu. If everything has been done correctly, pushing the application's button from its menu will initiate and run the application.

5.2 From the CDE Pop-Up Menu

The Common Data Environment (CDE) setup on AWIPS provides a configurable Pop-Up menu that is activated by positioning the mouse cursor on the desktop background and holding down the third button on the mouse. The option is selected by highlighting it in the menu, or on a submenu. Additional options can be added to the menu by editing the *dtwmrc* file in the *~.dt* subdirectory of the login home directory. This is something that shall not be attempted in the operational AWIPS account except by the System Manager, since an error could result in the inability to initiate the primary AWIPS capabilities.

5.3 From CDE Icons

An application can be initiated from CDE by using the Create Action utility to create a CDE action that initiates the program. The user can select the icon desired for the program or create a new icon for the application, and position the resulting Action icon in the CDE menu of choice. This capability has been previously described in Section 2.1, and its availability is dependent on the setup of CDE in the account under which it is run.

5.4 From the Command Line

A stand-alone application can be run from the command line of the Unix shell in a terminal window. A terminal window is brought up from the Telnet option in the CDE Pop-Up Menu, described above. To run the application, the user will need to log in to the host machine on which the application will run, under an account which has `execute` permission on the application's executable file or its initiation script, and type the command that launches the application.

5.5 From the **crontab**

Any application that can be initiated from the shell (i.e., from the command prompt) can be placed in a list file by **crontab** and initiated at scheduled days and times by **cron**. Entries in a **crontab** file contain initiation time information and a text string that corresponds to the command that initiates the application from the UNIX shell. Access to **crontab** is controlled by configuration files which specify which users can or cannot use it. All application scheduling via **crontab** must be coordinated with the System Manager, since the possibility exists of overloading the system if applications are scheduled at the same time as AWIPS system **cron** jobs.

The **at** utility can be used to schedule an application to run only once, at a specified time. The **batch** utility can be used to initiate an application as soon as system resources permit. It should be obvious that only background applications that can run to completion without user input should be initiated via **crontab**, **at**, or **batch**.

All of **at**, **batch**, **crontab**, and **cron** are UNIX utilities, and are documented in their respective UNIX **man** pages.

Care should be taken when selecting the time to run a time-scheduled application. AWIPS currently initiates hundreds of applications in this manner and, whenever possible, the local application crons shall not overlap the AWIPS baseline crons that may contend for resources. An AWIPS developed tool called "**ucron**" is described Appendix 6 and can be used to

graphically map out the execution of the crons on your systems.

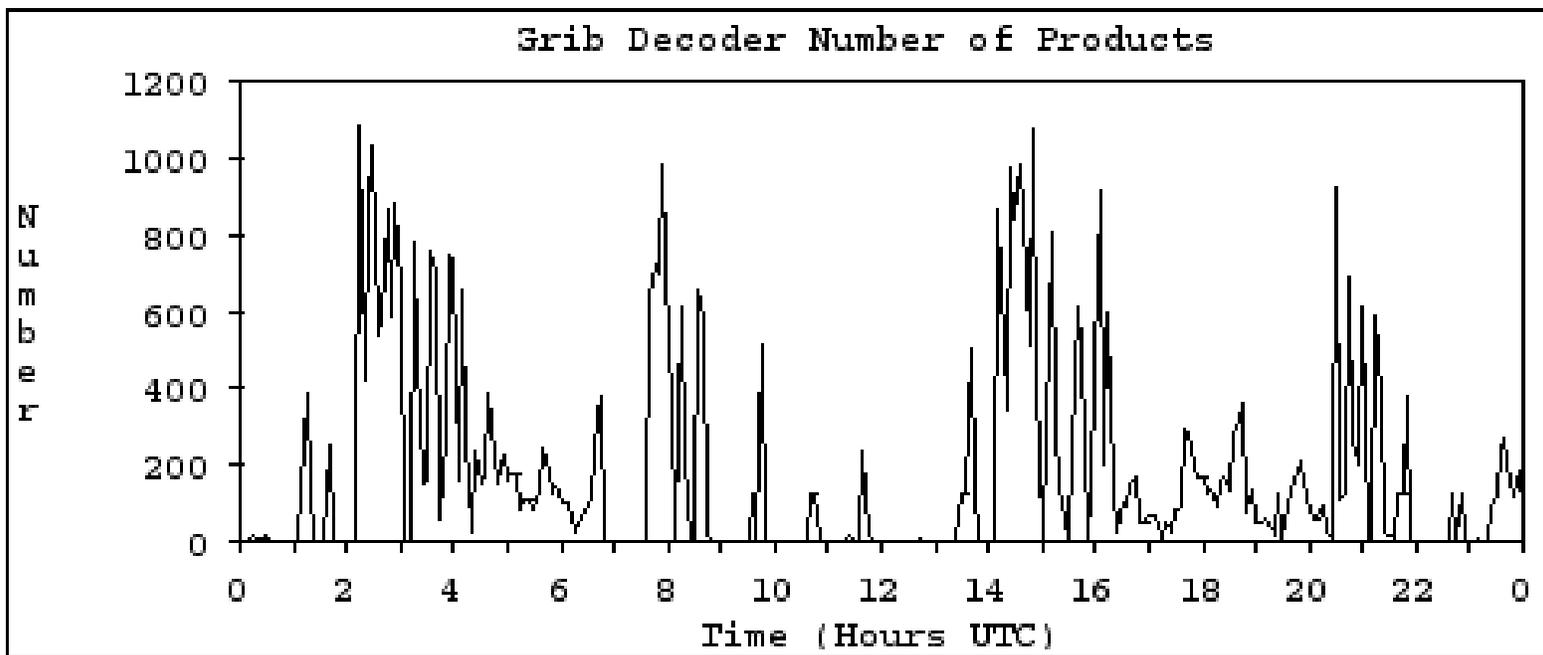


Exhibit 5.5-1. Arrival Pattern for Grids

Also, the products received on the SBN have a relatively well-known arrival pattern and, based on your application and its use of resources, care should be taken to avoid heavy ingest times. The graphs in Exhibits 3.3.1 and 3.3.2 are derived from decoder logs. They show the number of received products over the period of a day from 00Z to 00Z. The graph points represent 5-minute averages. With these graphs one can determine the low product activity times.

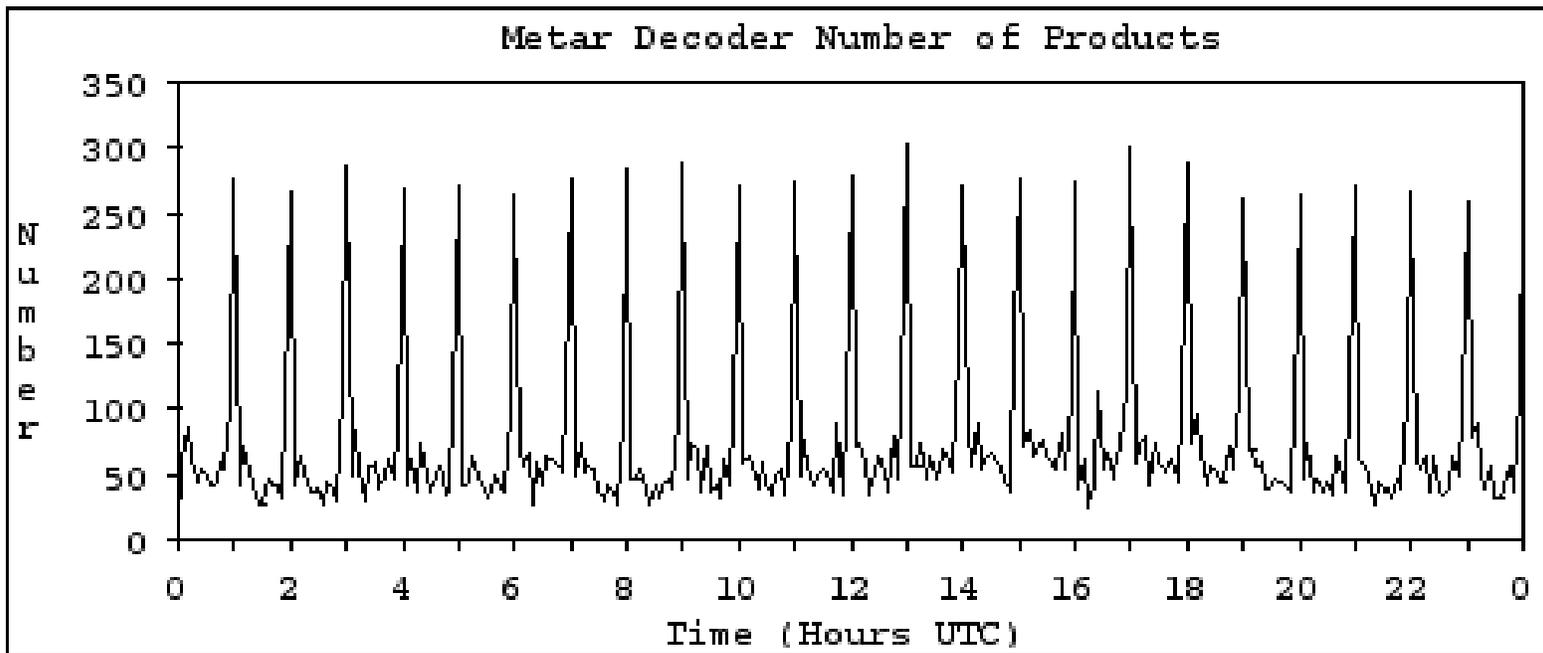


Exhibit 5.5-1. Arrival Pattern for METAR Products

5.6 HP MC/Service Guard

MC/Service Guard is a software package which provides the mechanisms for assuring that critical hardware and software components are continuously available in the event of failure of a system component. For example, the AWIPS hardware configuration has many redundant components (e.g., two DS's, AS's, FDDI networks, Simpact CP's, etc.). Each of these hardware components serves as a backup to the other in case of the failure of one of the two. MC/Service Guard is set up on AWIPS to manage the hardware transition to the backup configuration with no interruption of service.

In the same manner, critical applications which require high availability can be configured in MC/Service Guard such that they are shut down, moved to a different machine, or restarted in the case of hardware or software failures. The specific actions that are taken in response to failures can be configured in MC/Service Guard. The type of applications which should be configured within an MC/Service Guard package are those which are critical to operations and need to run continuously on the system. Examples of applications that might require high availability are the data ingest software, system monitoring software, or **cron**.

The MC/Service Guard software is fully documented in the HP manual Managing MC/Service Guard. Details are beyond the scope of this document. Note that configuration and management of MC/Service Guard is a PRC and/or System Manager responsibility, and shall not be made available to, or attempted by, the application developers.

The AWIPS system provides hooks (R4.3 or later) for individual sites to manage their site-specific applications during MC/ServiceGuard failover of the DS or AS swap packages. These hooks are in place to start/stop local site applications (for example, similar to the way that the shefdecoder process moves upon failover). The following site-controlled scripts that would be executed (if present):

- /sbin/init.d/dsSITEprocesses [start|stop] # For dsswap package
- /sbin/init.d/as1SITEprocesses [start|stop] # For as1swap package
- /sbin/init.d/as2SITEprocesses [start|stop] # For as2swap package

NOTE: The above are the "actual" filenames (i.e., DO NOT substitute Site_ID for "SITE").

MC/ServiceGuard will execute the applicable local script (if present) upon running/halting a swap package. These local /sbin/init.d script(s) should be developed similar to other /sbin/init.d scripts, especially when handling of the startup and shutdown of processes. Generation and maintenance of these three (3) /sbin/init.d files is the site's responsibility. The operational version of all three (3) scripts shall be placed on all servers. Though only the applicable script will be executed, this routine will simplify maintenance and provide an implicit backup copy.

With regard to persistent processes on a platform (i.e., not related to swap packages), the UNIX convention for bootup processes is the preferred mechanism.

1. Generate an */sbin/init.d* file for site-specific process
2. Create a startup link in the */sbin/rc3.d/Sxxx* symbolic link (where *xxx* should be > 950)
3. Create a shutdown link in the */sbin/rc2.d/Kyyy* symbolic link (where *yyy* should be < 50)
4. Symbolic link points to */sbin/init.d/zzzz* (where *zzzz* is a properly-developed script which accepts a [start | stop] argument.

With regard to Informix, local applications can be redirected from accessing the ONLINE engine (on DS1) to the ONLINE_REP engine (replicated Informix server on DS2) in one of two ways:

Method #1:

Currently, the OH applications "source" the file */awips/hydroapps/.Apps_defaults* for environment variable values.

Upon failover, the MC/ServiceGuard scripts updates this file to change ONLINE/ONLINE_REP for the "active" Informix engine. A newly started process could source in the correct database reference. This mechanism will not handle failover after the application has started, unless the application error handling was designed to re-source the environment (or at least the INFORMIXSERVER variable) upon database access failures.

Method #2:

Some applications, including the MetarDecoder and some OH "user" applications, have logic which utilizes the Informix "DBPATH=//ONLINE_REP" environment variable. This variable allows the application to look for an alternate engine, if the existing connection breaks and/or cannot be re-established. Details on the DBPATH mechanism can be found in the Informix Administrator's Guide, Volume 1, starting on page 25-23.

6.0 Product Dissemination

Product dissemination is the process by which products (official user products, or other products and messages) are delivered to users outside the local AWIPS configuration (outside the AWIPS LAN). This discussion will be limited to dissemination of ASCII text products.

6.1 Dissemination Mechanisms

AWIPS provides three basic mechanisms for distribution and dissemination of products: the Wide Area Network (WAN), the Local Data Acquisition and Dissemination (LDAD) subsystem, and the Asynchronous Product Scheduler (APS). A direct connection from AWIPS to AFOS also exists, along with software utility to transfer products between the two systems. However, since AFOS is slated for decommissioning, this mechanism will not be described here. Refer to the description of *handleOUP.pl* in the following section for a description of an alternate method of product distribution from AWIPS to AFOS.

WAN distribution allows products to be sent directly between AWIPS sites (WFO to WFO, WFO to RFC and the reverse), to the NOAA Weather Wire Service (NWWS), and to the Network Control Facility (NCF). From the NCF, products can be routed over the SBN to all AWIPS sites, and to the NWS Telecommunications Gateway (NWSTG). From NWSTG, products may be distributed over NOAAPORT, the Global Telecommunications System (GTS), the AFOS communications network, back to the SBN via the NCF, to the NWWS, to NCEP, etc.

LDAD distribution allows access to selected products by outside users, including authorized local agency users and the general public. The only current LDAD product dissemination method from AWIPS to LDAD to external users is to place AWIPS text products on the LDAD Bulletin Board Service (BBS) or into files on the LDAD Server.

APS product distribution allows text products to be routed to/from external PCs configured on AWIPS communications port if the PC is running Bubble or a similar program. APS supports text product dissemination from the PC to the CRS and NWWS, and storage of text products to the AWIPS text database.

6.1.1 WAN

Distribution of products over the WAN is supported by a pair of Command Line Interfaces CLIs, called with options and required arguments in the same manner as a UNIX command. The CLIs can be invoked manually from command line in the UNIX shell, from scripts, or from SYSTEM calls embedded in compiled code. The two CLIs are called *handleOUP.pl* and *distributeProduct*, and the selection of which one to use depends on the type of product to disseminate. These two CLIs are referred to a wrapper utilities; that is, they provide a convenient programmer interface to more complex utilities,

and isolate the programmer from future changes in the lower level utilities.

Note that once a product is stored in the text database (see Section 4.2.7), it may be manually addressed and distributed over the WAN from the AWIPS Text Workstation. This mechanism is fully described in Section 4.4 of the AWIPS User's Manual for Release 4.3. Since it is a manual process not initiated directly from a program, it will not be discussed further in the AIFM.

The *handleOUP.pl* and *distributeProduct* CLI executable files are located under the *\$FXA_HOME/bin* directory. To use either of these CLIs, *\$FXA_HOME/bin* must be in the executable path in your current shell, or the fully-qualified file name (e.g., *\$FXA_HOME/bin/distributeProduct*) must be used to invoke the CLI. Complete documentation for *handleOUP.pl* and *distributeProduct*, including examples of usage, is provided in Appendix 5 in the form of unix man pages for each CLI.

A product to be disseminated by *handleOUP.pl* or *distributeProduct* should be in the form of an ASCII text file, complete but without the inclusion of any of the AFOS, AWIPS, or WMO header lines or the AWIPS product identifier line (the NNNXXX second line). The necessary header lines will be formatted and prepended to the product upon transmission, based on its destination (AFOS or WAN) and on the AWIPS identifier specified in the CLI calling argument list. As an additional feature, the CLIs will also process the transmitted text (but not the original product file) to assure that each line of text is terminated with the <cr><cr><lf> characters expected by the NWSTG and other software.

It is important to note that for *handleOUP.pl* or *distributeProduct* to attach the correct AFOS or WMO communications header to the product, the product header information must be complete and correct in the *afos2awips.txt* file, and the CLI must be called with the correct AWIPS ID for the product. Otherwise, *handleOUP.pl* or *distributeProduct* will return an error status and the product will not be able to transmitted or stored in the fxatext database. See the *handleOUP.pl* man page in Appendix 5 for details and control file locations.

A brief description of each of the CLIs and guidelines for their use is given in the sections below.

6.1.1.1 The handleOUP interface

The *handleOUP.pl* CLI encapsulates several functions that need to be performed upon dissemination of Official User Products (OUPs). Official user products include watches, warnings, TAFs, State Forecast Products, Zone forecasts, etc., which are distributed to the public, the media, and/or external agencies. Official user products are all those for which there is an archive requirement at the WFO/RFC. Specifically, *handleOUP.pl* can be directed to:

- store the product locally in the fxatext database,
- archive the product locally in a file
- compose and attach any or all of the WMO, AFOS, and WAN distribution headers to the product, as needed

- distribute the product across the AWIPS WAN to the NCF, the SBN, and the NWSTG; and/or to the NWWS uplink, and
- send the product to the local AFOS interface when AWIPS is in pre-commissioned mode.

The handleOUP CLI does not accommodate point-to-point product distribution, i.e., the dissemination of a product to a particular site (e.g., to a single neighboring WFO) on the AWIPS WAN. Point-to-point distribution is provided by *distributeProduct*. Product distribution from calls to the *handleOUP.pl* CLI is determined by the product routing and handling tables in the NCF and the NWSTG, and the values of the predesignated primary and backup NWWS uplink sites specified in the file */awips/ops/data/mhs/nwwsup_dlist.data*. For a product sent to AFOS, its redistribution upon reaching AFOS is determined by the value specified for the AFOS routing node in the call to handleOUP, and by the internal AFOS product routing configuration.

6.1.1.2 The distributeProduct interface

The *distributeProduct* CLI encapsulates functions that need to be performed upon dissemination of generic text products. The capabilities of *distributeProduct* include the ability to:

- specify actions to be taken by the receiving site upon product receipt,
- enclose an ASCII or a binary file as an attachment to the product message (not recommended, and not a capability to be abused by sending large files over the WAN),
- compose and attach any or all of the WMO, AFOS, and WAN distribution headers to the product, as needed,
- distribute the product to a list of one or more specific AWIPS sites (any WFO, RFC, or National Center site on the AWIPS WAN), and
- distribute the product across the AWIPS WAN to the NCF, the SBN, and the NWSTG; and/or to the NWWS uplink.

Both point-to-point distribution and general distribution (via the NCF, NWSTG, SBN, and NWWS) of products are provided by *distributeProduct*. General product distribution from calls to the *distributeProduct* CLI is determined by the product routing and handling tables in the NCF and the NWSTG, and the values of the predesignated primary and backup NWWS uplink sites specified in the file */awips/ops/data/mhs/nwwsup_dlist.data*. The *distributeProduct* CLI does not provide a capability to send a product to the local AFOS, and no archiving of products sent via this CLI is performed.

Products and enclosures received at the destination AWIPS site of a *distributeProduct* invocation are stored in separate files located in the directory associated with the receive handling specification, under a name which includes the sending site ID and a message ID number (e.g., *PIT-12345*). Refer to the *distributeProduct* man page in Appendix 5.

The actions that can be taken upon receipt of a product at a site are specified by the action keyword (see the man page). A configuration file contains the command lines that relate to each action keyword, and

additional action keywords and commands can be added. However, it is not allowed for a local site to unilaterally define new actions and action keywords, since these items must be nationally configured to be present and identical at all AWIPS sites. If there is a need or desire for a local site to add new actions and action keywords, a request can be submitted via the AWIPS Local Applications Home Page (see Section 7 for URL information).

6.1.2 LDAD

LDAD is too complex and extensive to be documented in the AIFM. The reader is referred to the detailed LDAD documentation. Setup and configuration of LDAD and the BBS are documented in Chapter 8 of the AWIPS System Manager's Manual for Release 4.3. Other LDAD documentation describing the system integration procedures for addition of new external data sources exists online on the Internet (reference Section 7 for the URLs). As more complete LDAD documentation becomes available, the AIFM will be updated with references and location information where the material may be found.

6.1.3 Asynchronous Product Scheduler (APS)

The APS allows AWIPS to be configured so that specified products are sent to the PC upon receipt and storage in the AWIPS database, and in addition, the PC can issue one-time requests for additional products from AWIPS. Conversely, text products can be sent to AWIPS from the PC via the APS, and APS on AWIPS will store the product in the text database and can be configured to: 1) route the product to the Console Replacement System (CRS; i.e., NOAA Weather Radio), and/or 2) route the product to the NWWS. To interface with the AWIPS APS, the remote PC requires the Bubble program, or any other application that obeys the AFOS protocols and is software flow-enabled to communicate with APS. All the APS software (Build 4.3) is currently present only on AWIPS, not on the PC side. The APS is documented in Chapter 10 of the AWIPS System Manager's Manual for Release 4.3 (SMM), and no additional detail will be provided in this document.

6.2 Product Archive

As mentioned in Section 6.1.1.1 for the **handleOUP** CLI, **handleOUP** automatically archives all Official User Products transmitted via this mechanism. As described in the **handleOUP** man page in Appendix 5, the OUPs with their attached transmission headers are temporarily stored in files in the `/data/fxa/archive/OUP/scratch` directory. This directory is monitored hourly, at the end of which interval all stored products are moved to the `/data/fxa/archive/OUP/archive` directory.

AS AN INTERIM MEASURE AND ONLY IF ABSOLUTELY NECESSARY, local applications which produce text products to be archived, but which do not disseminate them via **handleOUP**, can place a copy of these products in files in the `/data/fxa/archive/OUP/scratch` directory. These products will then be automatically archived to the `/data/fxa/archive/OUP/archive` directory and purged from the `scratch` directory. Be sure that your application places **write** permissions at the **owner**, **group**, and **other**

levels on the files in the *scratch* directory so that they can be moved to the *archive* directory by the automated mechanism. Also, be sure to use a different file naming mechanism than **handleOUP** to distinguish your local application products from those disseminated by **handleOUP** and which are part of the “legal” product archive on AWIPS.

7.0 On-Line Resources and URLs

AWIPS Local Applications Home Page

The Techniques Development Laboratory maintains a home page for local application development information exchange. The Universal Resource Locator (URL) for the AWIPS Local Applications Home Page is:

http://tgsv5.nws.noaa.gov/tdl/awips/new_local/index.htm

The homepage contains links to six other web pages:

- The Applications, Libraries, and Utilities web page contains a listing of those applications that are available for local applications development, along with functional descriptions.
- The New Software Development web page contains a list of applications that are currently under development and which will be available in the near future.
- The Development Tips web page contains a link to downloadable and printfile versions of the on-line AIFM document, along with a description of helpful URLs for web pages outside the firewall. In addition, there is a link to a bulletin board, where users can share their development tips.
- The Bulletin Board web page gives viewers an opportunity to search the list of frequently asked questions, search the database of questions and answers, submit a reply or comment about a question or topic, or share a development tip.
- The Search web page permits the viewer to search the local applications database for a program or keyword reference.
- The Download/Upload web page permits users to download an application from the database, or upload an application to the database.

Internet

Many additional resources of interest to local application development are available through the Internet. Access to these resources is not available from AWIPS machines, which are isolated from the Internet inside the AWIPS network. Information accessed from the Internet must be obtained via a machine outside the AWIPS network and saved to disk. To get the material to AWIPS, it must be copied to a physical medium (tape or removable disk) and loaded into AWIPS, or it must be transferred through a safe firewall from the non-AWIPS machine to an AWIPS machine. **All transfers of external information onto AWIPS must be coordinated with the local System Manager, who has**

responsibility for system security and integrity.

Since information on the Internet changes frequently, URLs related to items in the AIFM will not be listed in the AIFM. Internet-accessible URLs of interest to local applications development are maintained on the Development Tips web page of the AWIPS Local Applications Home Page. Links to selected web pages from the Internet which are of wide interest or importance will be available. These will likely include:

- NetCDF User's Guide
- FX-ALPHA C and C++ Coding Conventions
- LDAD System Manager's Manual, User Guide, and programming guides

8.0 References

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_____, 1992d: Programming on HP-UX. HP Part No. B2355-90026, Hewlett-Packard Company, 412 pp.

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Litton/PRC Incorporated, 1999: System/Subsystem Design Description for Release 4.2. Available from AWIPS Program Office, NOAA, U.S. Department of Commerce.

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National Weather Service, 2000: AWIPS Local Applications Policy. National Oceanographic and Atmospheric Administration, U.S. Department of Commerce, 4pp.

National Weather Service, 2000: AWIPS Local Application Implementation Plan. National Oceanographic and Atmospheric Administration, U.S. Department of Commerce, 3pp.

Systems Interfaces and Headers, Volume 2 of the X/Open Portability Guide, Issue 4 (referenced in Section 3.1 of AIFM)

9.0 Acronyms and Abbreviations

The following acronyms and abbreviations are used in this document:

ADAP ² T	AWIPS Data Analysis and Product Preparation Tools
AIFM	Application Integration Framework Manual
AFOS	Automation of Field Operations and Services
ALERT	Automated Local Evaluation in Real Time
ANSI	American National Standards Institute
API	Application Programmer Interface
APS	Asynchronous Product Scheduler
AS	Applications Server
ASCII	American Standard Code for Information Interchange
ASOS	Automated Surface Observing System
AWIPS	Advanced Weather Interactive Processing System
BCS	Baseline Configuration System
BLOB	Binary Large Object
CDE	Common Desktop Environment
CD-ROM	Compact Disc-Read Only Memory
CDoT	Colorado Department of Transportation
CLI	Command Line Interface
CM	Configuration Management
CO	Communications CSCI
CONUS	Continental United States [Area]
COTS	Commercial Off-the-Shelf
CP	Communications Processor
CPU	Central Processing Unit
CSC	Computer Software Component
CSCI	Computer Software Configuration Item
D2D	[WFO-Advanced] Display 2-Dimensional
DAR3E	Denver AWIPS Risk Reduction and Requirements Evaluation
DAT	Digital Audio Tape
DB	Database
DC	Device Coordinates

DDT	Design, Development, and Testing [Team]
DFM	Digital Forecast Matrix
DM	Data Management CSCI
DS	Data Server
ESQL	Embedded Structured Query Language
FAC	File Access Controller
FDDI	Fiber Distributed Data Interface
FMH-1	Federal Meteorological Handbook, Volume 1
FSL	[NOAA] Forecast Systems Laboratory
GAAB	Graphic Alphanumeric Attributes Block
GB	Gigabyte
GIS	Geographic Information System
GMT	Greenwich Mean Time (see UTC)
GOES	Geosynchronous Operational Environmental Satellite
GRIB	Gridded Binary [Data Format]
GTS	Global Telecommunications Network
GUI	Graphical User Interface
HI	Human Computer Interface CSCI
HM	Hydrometeorological Applications CSCI
HP	Hewlett-Packard [Corporation]
HWCI	Hardware Configuration Item
ICD	Interface Control Document
ICWF	Interactive Computer-Worded Forecast [Application]
ID, id	Identifier
IFP	Interactive Forecast Preparation
IGC	Interactive Graphics Controller
km	kilometers
LAMP	Local AWIPS MOS Program
LAN	Local Area Network
LDAD	Local Data Acquisition and Dissemination [System]
LFM	Limited Fine Mesh [Model]
MB	Megabyte, Millibar
Mbps	Megabits per second
MC	Monitor and Control CSCI
METAR	Aviation Routine Weather Report

MHS	Message Handling System
MOS	Model Output Statistics
NCEP	National Centers for Environmental Prediction
NCF	Network Control Facility
NESDIS	National Environmental Satellite, Data and Information Service
NetCDF	Network Common Data Form
NEXRAD	Next Generation Weather Radar
NFS	Network File System
NLDN	National Lightning Detection Network
NM	Nautical Mile
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
NWSRFS	NWS River Forecasting System
NWSTG	NWS Telecommunications Gateway
OI	Object Interface
OS	Operating System
OSF	[NEXRAD] Operational Support Facility
OUP	Official User Product
PDB	Product Description Block
PIL	[AFOS] Product Identifier Label
PSB	Product Symbology Block
POSIX	Portable Operating System Interface for UNIX
PRC	Litton/PRC, Incorporated
PRM	[HP] Process Resource Manager
PUP	Principal User Processor
RAOB	Rawinsonde Observation
RCS	Revision Control System
RDBMS	Relational Data Base Management System
RGB	Red-Green-Blue [Color Components]
RLE	Run Length Encoded
RPG	Radar Product Generator
RSU	Remote Sensing Units
SBN	Satellite Broadcast Network
SCCS	Source Code Control System
SDN	Software Development Notebook

SPECI	Special METAR
SQL	Structured Query Language
SS	System Support CSCI
TAB	Tabular Alphanumerics Block
TAF	Aviation Terminal Forecast
TBD	To Be Determined
Tcl/Tk	Tool command language / Tool kit
TDL	[NOAA/NWS] Techniques Development Laboratory
TLCSC	Top-Level Computer Software Component
UI	User Interface
URL	Universal Resource Locator
UTC	Universal Time, Coordinated (see GMT)
VAG	[NCEP] Value-Added Grids
WAN	Wide Area Network [AWIPS Communications Network]
WFOA	WFO-Advanced [System]
WFO	Weather Forecast Office
WHFS	WFO Hydrometeorological Forecasting System
WMO	World Meteorological Organization
WS	Workstation
WSR-88D	Weather Surveillance Radar, 1988 Doppler
XT	X-Terminal

Application Integration Framework Manual

APPENDIX 1

NetCDF API examples for reading point data files

This section describes methods for reading and writing netCDF point data files, using METAR files as an example.

Two utilities included with netCDF convert between binary netCDF files and a text representation of netCDF files in the CDL language. The tools *ncgen* and *ncdump* are fully documented in the [NetCDF User's Guide](#). Since the output of one utility may be used as the input to the other, they may be considered inverses.

The *ncgen* routine will create a netCDF file from a CDL file. Additionally, it will generate either C or FORTRAN source code to create a netCDF file if given the proper flags. However, the source is useful only for relatively small CDL files since all the data is included in variable initialization in the generated program. Programs in C and FORTRAN were created from the *metar.cdl* file below, and there were 298 lines for the C code, and 401 lines for the FORTRAN code.

The routine *ncdump* produces the CDL text representation of a netCDF file on standard output. It may also be used to browse netCDF files for information about the dimensions, variables, and attributes, and to display the values of the data.

The UNIX syntax for invoking *ncgen* and *ncdump* is:

```
ncgen [-b] [-o netcdf_file] [-c] [-f] [-n] cdl_file
```

```
ncdump [-c | -h] [-v var1,...], [-b lang] [-f lang] [-l len]
        [-p float_digits[,double_digits]] [-n name] [input_file]
```

The use of the flags is explained in the [NetCDF User's Guide](#).

The CDL file for the METAR data is as follows:

```
netcdf metar
{
dimensions:
```

```
maxAutoStaLen = 6; // Max automated station type length
maxAutoWeather = 5; // Max num of auto weather codes
maxAutoWeaLen = 12; // Max num of auto weather codes
maxRepLen = 6; // Max report type length
maxMETARLen = 256; // Max undecoded METAR length
maxSkyCover = 6; // Max num of sky cover groups
maxSkyLen = 8; // Max length of sky cover word
maxStaNamLen = 5; // Station name length
maxWeatherNum = 5; // Max num of present weather codes
maxWeatherLen = 25;
recNum = UNLIMITED;
```

variables:

```
// METAR ORIGIN INFO
```

```
// This variable does not appear in METARs.
```

```
long wmoId(recNum);
  wmoId:long_name = "numeric WMO identification";
  wmoId:_FillValue = -2147483647;
  wmoId:valid_range = 1, 89999;
  wmoId:reference = "station table";
```

```
char stationName(recNum, maxStaNamLen);
  stationName:long_name = "alphanumeric station identification";
  stationName:reference = "station table";
```

```
// This variable does not appear in METARs.
```

```
float latitude(recNum);
  latitude:long_name = "latitude";
  latitude:units = "degree_north";
  latitude:_FillValue = 3.40282346e+38f;
  latitude:reference = "station table";
```

```
// This variable does not appear in METARs.
```

```
float longitude(recNum);
  longitude:long_name = "longitude";
  longitude:units = "degree_east";
  longitude:_FillValue = 3.40282346e+38f;
  longitude:reference = "station table";
```

```
// This variable does not appear in METARs.
```

```
float elevation(recNum);
```

```
elevation:long_name = "elevation";  
elevation:units = "meter";  
elevation:_FillValue = 3.40282346e+38f;  
elevation:reference = "station table";
```

```
// METAR DATE AND TIME
```

```
double timeObs(recNum);  
timeObs:long_name = "time of observation";  
timeObs:units = "seconds since 1-1-1970";  
timeObs:_FillValue = 1.797693134862315700e+308;
```

```
// This variable does not appear in METARs.
```

```
double timeNominal(recNum);  
timeNominal:long_name = "METAR hour";  
timeNominal:units = "seconds since 1-1-1970";  
timeNominal:_FillValue = 1.797693134862315700e+308;
```

```
// REPORT TYPE
```

```
char reportType(recNum, maxRepLen);  
reportType:long_name = "report type";  
reportType:reference = "FMH-1";
```

```
// AUTO STATION TYPE
```

```
char autoStationType(recNum, maxAutoStaLen);  
autoStationType:long_name = "automated station type";  
autoStationType:reference = "FMH-1";
```

```
// SKY COVER GROUP
```

```
char skyCover(recNum, maxSkyCover, maxSkyLen);  
skyCover:long_name = "sky cover";  
skyCover:reference = "FMH-1";
```

```
float skyLayerBase(recNum, maxSkyCover);  
skyLayerBase:long_name = "sky cover layer base";  
skyLayerBase:units = "meter";  
skyLayerBase:_FillValue = 3.40282346e+38f;  
skyLayerBase:valid_min = 0;
```

```
// VISIBILITY GROUP
```

```
float visibility(recNum);  
visibility:long_name = "visibility";  
visibility:units = "meter";
```

```
visibility:_FillValue = 3.40282346e+38f;  
visibility:valid_min = 0.0;
```

// PRESENT WEATHER

```
char presWeather(recNum, maxWeatherLen);  
presWeather:long_name = "present weather";  
presWeather:reference = "FMH-1";
```

// SEA LEVEL PRESSURE

```
float seaLevelPress(recNum);  
seaLevelPress:long_name = "sea level pressure";  
seaLevelPress:units = "pascal";  
seaLevelPress:_FillValue = 3.40282346e+38f;
```

// TEMPERATURE

```
float temperature(recNum);  
temperature:long_name = "temperature";  
temperature:units = "kelvin";  
temperature:_FillValue = 3.40282346e+38f;
```

// TEMPERATURE TO TENTHS

```
float tempFromTenths(recNum);  
tempFromTenths:long_name = "temperature from tenths of a degree Celsius";  
tempFromTenths:units = "kelvin";  
tempFromTenths:_FillValue = 3.40282346e+38f;
```

// DEWPOINT

```
float dewpoint(recNum);  
dewpoint:long_name = "dewpoint";  
dewpoint:units = "kelvin";  
dewpoint:_FillValue = 3.40282346e+38f;
```

// DEWPOINT TO TENTHS

```
float dpFromTenths(recNum);  
dpFromTenths:long_name = "dewpoint from tenths of a degree Celsius";  
dpFromTenths:units = "kelvin";  
dpFromTenths:_FillValue = 3.40282346e+38f;
```

// WIND GROUP

```
float windDir(recNum);  
windDir:long_name = "wind direction";  
windDir:units = "degree";
```

```
    windDir:_FillValue = 3.40282346e+38f;
float windSpeed(recNum);
    windSpeed:long_name = "wind speed";
    windSpeed:units = "meter/sec";
    windSpeed:_FillValue = 3.40282346e+38f;
    windSpeed:valid_min = 0;
float windGust(recNum);
    windGust:long_name = "wind gust";
    windGust:units = "meter/sec";
    windGust:_FillValue = 3.40282346e+38f;
    windGust:valid_min = 0;

// ALTIMETER
float altimeter(recNum);
    altimeter:long_name = "altimeter setting";
    altimeter:units = "pascal";
    altimeter:_FillValue = 3.40282346e+38f;
    altimeter:valid_min = 0.0;

// 24 HOUR TEMPERATURE
float minTemp24Hour(recNum);
    minTemp24Hour:long_name = "24 hour min temperature";
    minTemp24Hour:units = "kelvin";
    minTemp24Hour:_FillValue = 3.40282346e+38f;
float maxTemp24Hour(recNum);
    maxTemp24Hour:long_name = "24 hour max temperature";
    maxTemp24Hour:units = "kelvin";
    maxTemp24Hour:_FillValue = 3.40282346e+38f;

// 1 HOUR PRECIP
float precip1Hour(recNum);
    precip1Hour:long_name = "1 hour precipitation";
    precip1Hour:units = "meter";
    precip1Hour:_FillValue = 3.40282346e+38f;
    precip1Hour:valid_min = 0.0;

// 3 HOUR PRECIP
float precip3Hour(recNum);
    precip3Hour:long_name = "3 hour precipitation";
    precip3Hour:units = "meter";
    precip3Hour:_FillValue = 3.40282346e+38f;
    precip3Hour:valid_min = 0.0;
```

```
// 6 HOUR PRECIP
float precip6Hour(recNum);
  precip6Hour:long_name = "6 hour precipitation";
  precip6Hour:units = "meter";
  precip6Hour:_FillValue = 3.40282346e+38f;
  precip6Hour:valid_min = 0.0;

// 24 HOUR PRECIP
float precip24Hour(recNum);
  precip24Hour:long_name = "24 hour precipitation";
  precip24Hour:units = "meter";
  precip24Hour:_FillValue = 3.40282346e+38f;
  precip24Hour:valid_min = 0.0;

// 3 HOUR PRESSURE CHANGE GROUP
short pressChangeChar(recNum);
  pressChangeChar:long_name = "character of pressure change";
  pressChangeChar:_FillValue = -32767s;
  pressChangeChar:reference = "FMH-1";
float pressChange3Hour(recNum);
  pressChange3Hour:long_name = "3 hour pressure change";
  pressChange3Hour:units = "pascal";
  pressChange3Hour:_FillValue = 3.40282346e+38f;
  pressChange3Hour:valid_min = 0.0;

// CORRECTION FLAG
long correction(recNum);
  correction:long_name = "corrected METAR indicator";
  correction:_FillValue = -2147483647;

// RAW METAR MESSAGE
char rawMETAR(recNum, maxMETARLen);
  rawMETAR:long_name = "raw METAR message";

// GLOBAL ATTRIBUTES
//:title = "METAR - Aviation Routine Weather Report";
}
```

A program to generate FORTRAN code that reads any netCDF file may be downloaded from the Unidata web site. The program *gennet.f*, written by Barry Schwartz, is found at <ftp://ftp.unidata.ucar.edu/>

pub/netcdf/contrib. After the program asks the user for the name of a netCDF file to read, it opens that file and gets information on the variables and their dimensions with netCDF calls. It then generates a FORTRAN program (*readnet.f*) that will read that netCDF file and any other file of that data type. The user only has to write FORTRAN statements to print the data or to pass the data to another program.

To compile the program on a UNIX system, type:

```
f77 +E6 gennet.f /usr/local/netcdf/lib/libnetcdf.a
```

The program *gennet.f* was compiled and run with a METAR file named 19970508_1200. The resulting program is listed below, and should read any AWIPS METAR netCDF file.

```
C   FORTRAN TEMPLATE FOR FILE= 19970508_1200
      PARAMETER (NVAR=32) !NUMBER OF VARIABLES
      PARAMETER (NREC= 2157) !CHANGE THIS TO GENERALIZE
C   VARIABLE IDS RUN SEQUENTIALLY FROM 1 TO NVAR= 32
      INTEGER*4 RCODE
      INTEGER*4 RECDIM
      CHARACTER*50 long_name(nvars)
      CHARACTER*50 name(100)
C   ****VARIABLES FOR THIS NETCDF FILE****
C   INTEGER*4      wmoId      (NREC)
      CHARACTER*1 stationName ( 5,NREC)
      REAL*4       latitude   (NREC)
      REAL*4       longitude  (NREC)
      REAL*4       elevation  (NREC)
      REAL*8       timeObs    (NREC)
      REAL*8       timeNominal (NREC)
      CHARACTER*1 reportType  ( 6,NREC)
      CHARACTER*1 autoStationType ( 6,NREC)
      CHARACTER*1 skyCover    ( 8, 6,NREC)
      REAL*4       skyLayerBase ( 6,NREC)
      REAL*4       visibility  (NREC)
      CHARACTER*1 presWeather ( 25,NREC)
      REAL*4       seaLevelPress (NREC)
      REAL*4       temperature (NREC)
```

REAL*4	tempFromTenths	(NREC)
REAL*4	dewpoint	(NREC)
REAL*4	dpFromTenths	(NREC)
REAL*4	windDir	(NREC)
REAL*4	windSpeed	(NREC)
REAL*4	windGust	(NREC)
REAL*4	altimeter	(NREC)
REAL*4	minTemp24Hour	(NREC)
REAL*4	maxTemp24Hour	(NREC)
REAL*4	precip1Hour	(NREC)
REAL*4	precip3Hour	(NREC)
REAL*4	precip6Hour	(NREC)
REAL*4	precip24Hour	(NREC)
INTEGER*2	pressChangeChar	(NREC)
<u>REAL*4</u>	pressChange3Hour	(NREC)
INTEGER*4	correction	(NREC)
CHARACTER*1	rawMETAR	(256,NREC)

C

```

character*80 input_file
INTEGER*4 START(10)
INTEGER*4 COUNT(10)
INTEGER VDIMS(10) !ALLOW UP TO 10 DIMENSIONS
CHARACTER*31 DUMMY

```

C

C LONG NAMES FOR EACH VARIABLE

C

```
data long_name/
```

- * 'WMO numeric station ID ',
- * 'Alphanumeric station name ',
- * 'latitude ',
- * 'longitude ',
- * 'elevation ',
- * 'time of observation ',
- * 'METAR hour ',

- * 'Report type '
- * 'Automated station type '
- * 'Sky cover '
- * 'Sky cover layer base '
- * 'visibility '
- * 'Present weather '
- * 'Sea level pressure '
- * 'temperature '
- * 'temperature from tenths of a degree Celsius '
- * 'dewpoint '
- * 'dewpoint from tenths of a degree Celsius '
- * 'Wind direction '
- * 'Wind speed '
- * 'Wind gust '
- * 'Altimeter setting '
- * '24 hour min temperature '
- * '24 hour max temperature '
- * '1 hour precip '
- * '3 hour precip '
- * '6 hour precip '
- * '24 hour precip '
- * 'Character of pressure change '
- * '3 hour pressure change '
- * 'Corrected METAR indicator '
- * 'Raw METAR message '/'

C

```
write(6,1)
```

```
1 format(' enter your input file')
```

```
read(5,2) input_file
```

```
2 format(a80)
```

```
ilen=index(input_file,'')
```

```
ncid=ncopn(input_file(1:ilen-1),0,rcode)
```

```
CALL NCINQ(NCID,NDIMS,NVARS,NGATTS,RECDIM,RCODE)
```

```
CALL NCDINQ(NCID,RECDIM,DUMMY,NRECS,RCODE)
```

```
C !NRECS! NOW CONTAINS NUM RECORDS FOR THIS FILE
```

```
C
C   statements to fill wmoId
C
   ivarid = ncvld(ncid,'wmoId ',rcode)
   CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)
   LENSTR=1
   DO 10 J=1,NVDIM
   CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)
   LENSTR=LENSTR*NDSIZE
   START(J)=1
   COUNT(J)=NDSIZE
10  CONTINUE
   CALL NCVGT(NCID,ivarid,START,COUNT,
+ wmoId ,RCODE)
C
C   statements to fill stationName
C
   ivarid = ncvld(ncid,'stationName ',rcode)
   CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)
   LENSTR=1
   DO 20 J=1,NVDIM
   CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)
   LENSTR=LENSTR*NDSIZE
   START(J)=1
   COUNT(J)=NDSIZE
20  CONTINUE
   CALL NCVGTC(NCID,ivarid,START,COUNT,
+ stationName ,LENSTR,RCODE)
C
C   statements to fill latitude
C
   ivarid = ncvld(ncid,'latitude ',rcode)
   CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)
   LENSTR=1
   DO 30 J=1,NVDIM
```

```
CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)
LENSTR=LENSTR*NDSIZE
START(J)=1
COUNT(J)=NDSIZE
30 CONTINUE
CALL NCVGT(NCID,ivarid,START,COUNT,
+ latitude ,RCODE)
C
C statements to fill longitude
C
ivarid = ncvid(ncid,'longitude ',rcode)
CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)
LENSTR=1
DO 40 J=1,NVDIM
CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)
LENSTR=LENSTR*NDSIZE
START(J)=1
COUNT(J)=NDSIZE
40 CONTINUE
CALL NCVGT(NCID,ivarid,START,COUNT,
+ longitude ,RCODE)
C
C statements to fill elevation
C
ivarid = ncvid(ncid,'elevation ',rcode)
CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)
LENSTR=1
DO 50 J=1,NVDIM
CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)
LENSTR=LENSTR*NDSIZE
START(J)=1
COUNT(J)=NDSIZE
50 CONTINUE
CALL NCVGT(NCID,ivarid,START,COUNT,
+ elevation ,RCODE)
```

C

C statements to fill timeObs

C

ivarid = ncvd(ncid,'timeObs ',rcode)

CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)

LENSTR=1

DO 60 J=1,NVDIM

CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)

LENSTR=LENSTR*NDSIZE

START(J)=1

COUNT(J)=NDSIZE

60 CONTINUE

CALL NCVGT(NCID,ivarid,START,COUNT,

+ timeObs ,RCODE)

C

C statements to fill timeNominal

C

ivarid = ncvd(ncid,'timeNominal ',rcode)

CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)

LENSTR=1

DO 70 J=1,NVDIM

CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)

LENSTR=LENSTR*NDSIZE

START(J)=1

COUNT(J)=NDSIZE

70 CONTINUE

CALL NCVGT(NCID,ivarid,START,COUNT,

+ timeNominal ,RCODE)

C

C statements to fill reportType

C

ivarid = ncvd(ncid,'reportType ',rcode)

CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)

LENSTR=1

DO 80 J=1,NVDIM

```

CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)
LENSTR=LENSTR*NDSIZE
START(J)=1
COUNT(J)=NDSIZE
80 CONTINUE
CALL NCVGTC(NCID,ivarid,START,COUNT,
+ reportType ,LENSTR,RCODE)
C
C statements to fill autoStationType
C
ivarid = ncid(ncid,'autoStationType ',rcode)
CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)
LENSTR=1
DO 90 J=1,NVDIM
CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)
LENSTR=LENSTR*NDSIZE
START(J)=1
COUNT(J)=NDSIZE
90 CONTINUE
CALL NCVGTC(NCID,ivarid,START,COUNT,
+ autoStationType ,LENSTR,RCODE)
C
C statements to fill skyCover
C
ivarid = ncid(ncid,'skyCover ',rcode)
CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)
LENSTR=1
DO 100 J=1,NVDIM
CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)
LENSTR=LENSTR*NDSIZE
START(J)=1
COUNT(J)=NDSIZE
100 CONTINUE
CALL NCVGTC(NCID,ivarid,START,COUNT,
+ skyCover ,LENSTR,RCODE)

```

```
C
C   statements to fill skyLayerBase
C
   ivarid = ncid(ncid,'skyLayerBase ',rcode)
   CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)
   LENSTR=1
   DO 110 J=1,NVDIM
   CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)
   LENSTR=LENSTR*NDSIZE
   START(J)=1
   COUNT(J)=NDSIZE
110 CONTINUE
   CALL NCVGT(NCID,ivarid,START,COUNT,
   skyLayerBase ,RCODE)
C
C   statements to fill visibility
C
   ivarid = ncid(ncid,'visibility ',rcode)
   CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)
   LENSTR=1
   DO 120 J=1,NVDIM
   CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)
   LENSTR=LENSTR*NDSIZE
   START(J)=1
   COUNT(J)=NDSIZE
120 CONTINUE
   CALL NCVGT(NCID,ivarid,START,COUNT,
+ visibility ,RCODE)
C
C   statements to fill presWeather
C
   ivarid = ncid(ncid,'presWeather ',rcode)
   CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)
   LENSTR=1
   DO 130 J=1,NVDIM
```

```
CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)
```

```
LENSTR=LENSTR*NDSIZE
```

```
START(J)=1
```

```
COUNT(J)=NDSIZE
```

```
130 CONTINUE
```

```
CALL NCVGTC(NCID,ivarid,START,COUNT,  
presWeather ,LENSTR,RCODE)
```

```
C
```

```
C statements to fill seaLevelPress
```

```
C
```

```
ivarid = ncvid(ncid,'seaLevelPress ',rcode)
```

```
CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)
```

```
LENSTR=1
```

```
DO 140 J=1,NVDIM
```

```
CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)
```

```
LENSTR=LENSTR*NDSIZE
```

```
START(J)=1
```

```
COUNT(J)=NDSIZE
```

```
140 CONTINUE
```

```
CALL NCVGT(NCID,ivarid,START,COUNT,  
seaLevelPress ,RCODE)
```

```
C
```

```
C statements to fill temperature
```

```
C
```

```
ivarid = ncvid(ncid,'temperature ',rcode)
```

```
CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)
```

```
LENSTR=1
```

```
DO 150 J=1,NVDIM
```

```
CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)
```

```
LENSTR=LENSTR*NDSIZE
```

```
START(J)=1
```

```
COUNT(J)=NDSIZE
```

```
150 CONTINUE
```

```
CALL NCVGT(NCID,ivarid,START,COUNT,  
+ temperature ,RCODE)
```

C

C statements to fill tempFromTenths

C

```
ivarid = ncvld(ncid,'tempFromTenths ',rcode)
CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)
LENSTR=1
DO 160 J=1,NVDIM
CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)
LENSTR=LENSTR*NDSIZE
START(J)=1
COUNT(J)=NDSIZE
160 CONTINUE
CALL NCVGT(NCID,ivarid,START,COUNT,
+ tempFromTenths ,RCODE)
```

C

C statements to fill dewpoint

C

```
ivarid = ncvld(ncid,'dewpoint ',rcode)
CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)
LENSTR=1
DO 170 J=1,NVDIM
CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)
LENSTR=LENSTR*NDSIZE
START(J)=1
COUNT(J)=NDSIZE
170 CONTINUE
CALL NCVGT(NCID,ivarid,START,COUNT,
+ dewpoint ,RCODE)
```

C

C statements to fill dpFromTenths

C

```
ivarid = ncvld(ncid,'dpFromTenths ',rcode)
CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)
LENSTR=1
DO 180 J=1,NVDIM
```

```
CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)
LENSTR=LENSTR*NDSIZE
START(J)=1
COUNT(J)=NDSIZE
180 CONTINUE
CALL NCVGT(NCID,ivarid,START,COUNT,
+ dpFromTenths ,RCODE)
C
C statements to fill windDir
C
ivarid = ncid(ncid,'windDir ',rcode)
CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)
LENSTR=1
DO 190 J=1,NVDIM
CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)
LENSTR=LENSTR*NDSIZE
START(J)=1
COUNT(J)=NDSIZE
190 CONTINUE
CALL NCVGT(NCID,ivarid,START,COUNT,
+ windDir ,RCODE)
C
C statements to fill windSpeed
C
ivarid = ncid(ncid,'windSpeed ',rcode)
CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)
LENSTR=1
DO 200 J=1,NVDIM
CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)
LENSTR=LENSTR*NDSIZE
START(J)=1
COUNT(J)=NDSIZE
200 CONTINUE
CALL NCVGT(NCID,ivarid,START,COUNT,
+ windSpeed ,RCODE)
```

```
C
C   statements to fill windGust
C
   ivarid = ncvd(ncid,'windGust ',rcode)
   CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)
   LENSTR=1
   DO 210 J=1,NVDIM
   CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)
   LENSTR=LENSTR*NDSIZE
   START(J)=1
   COUNT(J)=NDSIZE
210 CONTINUE
   CALL NCVGT(NCID,ivarid,START,COUNT,
+ windGust ,RCODE)
C
C   statements to fill altimeter
C
   ivarid = ncvd(ncid,'altimeter ',rcode)
   CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)
   LENSTR=1
   DO 220 J=1,NVDIM
   CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)
   LENSTR=LENSTR*NDSIZE
   START(J)=1
   COUNT(J)=NDSIZE
220 CONTINUE
   CALL NCVGT(NCID,ivarid,START,COUNT,
+ altimeter ,RCODE)
C
C   statements to fill minTemp24Hour
C
   ivarid = ncvd(ncid,'minTemp24Hour ',rcode)
   CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)
   LENSTR=1
   DO 230 J=1,NVDIM
```

```
CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)
LENSTR=LENSTR*NDSIZE
START(J)=1
COUNT(J)=NDSIZE
230 CONTINUE
CALL NCVGT(NCID,ivarid,START,COUNT,
+ minTemp24Hour ,RCODE)
C
C statements to fill maxTemp24Hour
C
ivarid = ncvid(ncid,'maxTemp24Hour ',rcode)
CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)
LENSTR=1
DO 240 J=1,NVDIM
CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)
LENSTR=LENSTR*NDSIZE
START(J)=1
COUNT(J)=NDSIZE
240 CONTINUE
CALL NCVGT(NCID,ivarid,START,COUNT,
maxTemp24Hour ,RCODE)
C
C statements to fill precip1Hour
C
ivarid = ncvid(ncid,'precip1Hour ',rcode)
CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)
LENSTR=1
DO 250 J=1,NVDIM
CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)
LENSTR=LENSTR*NDSIZE
START(J)=1
COUNT(J)=NDSIZE
250 CONTINUE
CALL NCVGT(NCID,ivarid,START,COUNT,
+ precip1Hour ,RCODE)
```

C

C statements to fill precip3Hour

C

```
ivarid = ncvld(ncid,'precip3Hour ',rcode)
CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)
LENSTR=1
DO 260 J=1,NVDIM
CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)
LENSTR=LENSTR*NDSIZE
START(J)=1
COUNT(J)=NDSIZE
260 CONTINUE
CALL NCVGT(NCID,ivarid,START,COUNT,
+ precip3Hour ,RCODE)
```

C

C statements to fill precip6Hour

C

```
ivarid = ncvld(ncid,'precip6Hour ',rcode)
CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)
LENSTR=1
DO 270 J=1,NVDIM
CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)
LENSTR=LENSTR*NDSIZE
START(J)=1
COUNT(J)=NDSIZE
270 CONTINUE
CALL NCVGT(NCID,ivarid,START,COUNT,
+ precip6Hour ,RCODE)
```

C

C statements to fill precip24Hour

C

```
ivarid = ncvld(ncid,'precip24Hour ',rcode)
CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)
LENSTR=1
DO 280 J=1,NVDIM
```

```
CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)
LENSTR=LENSTR*NDSIZE
START(J)=1
COUNT(J)=NDSIZE
280 CONTINUE
CALL NCVGT(NCID,ivarid,START,COUNT,
+ precip24Hour ,RCODE)
C
C statements to fill pressChangeChar
C
ivarid = ncvid(ncid,'pressChangeChar ',rcode)
CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)
LENSTR=1
DO 290 J=1,NVDIM
CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)
LENSTR=LENSTR*NDSIZE
START(J)=1
COUNT(J)=NDSIZE
290 CONTINUE
CALL NCVGT(NCID,ivarid,START,COUNT,
+ pressChangeChar ,RCODE)
C
C statements to fill pressChange3Hour
C
ivarid = ncvid(ncid,'pressChange3Hour ',rcode)
CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)
LENSTR=1
DO 300 J=1,NVDIM
CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)
LENSTR=LENSTR*NDSIZE
START(J)=1
COUNT(J)=NDSIZE
300 CONTINUE
CALL NCVGT(NCID,ivarid,START,COUNT,
+ pressChange3Hour ,RCODE)
```

C

C statements to fill correction

C

ivarid = ncvd(ncid,'correction ',rcode)

CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)

LENSTR=1

DO 310 J=1,NVDIM

CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)

LENSTR=LENSTR*NDSIZE

START(J)=1

COUNT(J)=NDSIZE

310 CONTINUE

CALL NCVGT(NCID,ivarid,START,COUNT,

+ correction ,RCODE)

C

C statements to fill rawMETAR

C

ivarid = ncvd(ncid,'rawMETAR ',rcode)

CALL NCVINQ(NCID,ivarid,DUMMY,NTP,NVDIM,VDIMS,NVS,RCODE)

LENSTR=1

DO 320 J=1,NVDIM

CALL NCDINQ(NCID,VDIMS(J),DUMMY,NDSIZE,RCODE)

LENSTR=LENSTR*NDSIZE

START(J)=1

COUNT(J)=NDSIZE

320 CONTINUE

CALL NCVGTC(NCID,ivarid,START,COUNT,

+ rawMETAR ,LENSTR,RCODE)

C following code: checks output code code against current input

C file

C

C

call ncinq(ncid,ndims,nvarsc,ngatts,nrecdim,rcode)

if(nvarsc.ne.nvars) write(6,340)

340 format('number of variables has changed')

```
C
CALL NCCLOS(NCID,RCODE)
C
C
C   HERE IS WHERE YOU WRITE STATEMENTS TO USE THE DATA
C
STOP
END
```

Since this generated program does not write out data values, it was re-written as a subroutine so that any program might access the METAR data values with an API. At the same time the subroutine was reorganized and rewritten, to the extent possible, according to the TDL FORTRAN Coding Guidelines (see Attachment 2 of the AIFM). Exceptions to the TDL FORTRAN capitalization rules were required to integrate with the NetCDF routines. This routine was tested against ncdump and produced the same results. The code for the manually-revised routine is as follows:

```
C
SUBROUTINE RDMETAR(CFILE,NREC,wmoId,stationName,latitude,
1   longitude,elevation,timeObs,timeNominal,reportType,
2   autoStationType,skyCover,skyLayerBase,visibility,
3   presWeather,seaLevelPress,temperature,tempFromTenths,
4   dewpoint,dpFromTenths,windDir,windSpeed,windGust,
5   altimeter,minTemp24Hour,maxTemp24Hour,precip1Hour,
6   precip3Hour,precip6Hour,precip24Hour,pressChangeChar,
7   pressChange3Hour,correction,rawMETAR,NCODE)
C
C   MAY 1997 PEACHEY GSC HP
C   JULY 1999 MORRIS GSC HP
C   CHANGED pressChange3hour TO REAL FROM INTEGER
C
C   PURPOSE
C   THIS ROUTINE RETURNS ALL THE VARIABLE VALUES IN A
C   METAR NETCDF FILE GIVEN THE FILE NAME.
C
```

C DATA SET USE

C CFILE - NAME OF METAR NETCDF FILE (INPUT)

C

C VARIABLES

C CFILE = METAR NETCDF FILE TO PROCESS (INPUT)

C (CHARACTER*80)

C NREC = NUMBER OF RECORDS IN THE FILE (INPUT)

C wmoId(NREC) = WMO NUMERIC STATION ID (OUTPUT)

C stationName(5,NREC) = STATION NAME (OUTPUT) (CHARACTER*1)

C latitude(NREC) = LATITUDE (OUTPUT)

C longitude(NREC) = LONGITUDE (OUTPUT)

C elevation(NREC) = ELEVATION (OUTPUT)

C timeObs(NREC) = TIME OF OBSERVATION (OUTPUT) (REAL*8)

C timeNominal(NREC) = METAR HOUR (OUTPUT) (REAL*8)

C reportType(6,NREC) = REPORT TYPE (OUTPUT) (CHARACTER*1)

C autoStationType(6,NREC)

C = AUTOMATED STATION TYPE (OUTPUT) (CHARACTER*1)

C skyCover(8,6,NREC) = SKY COVER (OUTPUT) (CHARACTER*1)

C skyLayerBase(6,NREC)

C = SKY COVER LAYER BASE (OUTPUT)

C visibility(NREC) = VISIBILITY (OUTPUT)

C presWeather(25,NREC)

C = PRESENT WEATHER (OUTPUT) (CHARACTER*1)

C seaLevelPress(NREC) = SEA LEVEL PRESSURE (OUTPUT)

C temperature(NREC) = TEMPERATURE (OUTPUT)

C tempFromTenths(NREC)

C = TEMPERATURE FROM TENTHS OF A DEGREE C (OUTPUT)

C dewpoint(NREC) = DEWPOINT (OUTPUT)

C dpFromTenths(NREC) = DEWPOINT FROM TENTHS OF A DEGREE C (OUTPUT)

C windDir(NREC) = WIND DIRECTION (OUTPUT)

C windSpeed(NREC) = WIND SPEED (OUTPUT)

C windGust(NREC) = WIND GUST (OUTPUT)

C altimeter(NREC) = ALTIMETER SETTING (OUTPUT)

C minTemp24Hour(NREC) = 24 HOUR MIN TEMPERATURE (OUTPUT)

C maxTemp24Hour(NREC) = 24 HOUR MAX TEMPERATURE (OUTPUT)

C precip1Hour(NREC) = 1 HOUR PRECIP (OUTPUT)
C precip3Hour(NREC) = 3 HOUR PRECIP (OUTPUT)
C precip6Hour(NREC) = 6 HOUR PRECIP (OUTPUT)
C precip24Hour(NREC) = 24 HOUR PRECIP (OUTPUT)
C pressChangeChar(NREC)
C = CHARACTER OF PRESSURE CHANGE (OUTPUT)
C pressChange3Hour(NREC)
C = 3 HR. PRESSURE CHANGE (OUTPUT)
C correction(NREC) = CORRECTED METAR INDICATOR (OUTPUT)
C rawMETAR(256,NREC) = RAW METAR MESSAGE (OUTPUT)
C NCODE = NETCDF ERROR MESSAGE (OUTPUT)
C
C CDUMMY = RETUNED VARIABLE NAME (INTERNAL)
C ICNT(10) = VECTOR OF NUMBER OF INDICES SELECTED ALONG EACH
C DIMENSION (INTERNAL)
C ILEN = LENGTH OF FILE NAME (INTERNAL)
C ISTART(10) = INDICES IN VARIABLE WHERE FIRST OF DATA
C VALUES READ (INTERNAL)
C IVARID = VARIABLE ID (INTERNAL)
C LENSTR = LENGTH OF STRING (INTERNAL)
C NCID = NETCDF ID (INTERNAL)
C NDIMS = RETURNED NUMBER OF DIMENSIONS FOR NETCDF FILE
C (INTERNAL)
C NDSIZE = SIZE OF DIMENSION (INTERNAL)
C NGATTS = RETURNED NUMBER OF GLOBAL ATTRIBUTES FOR
C NETCDF FILE (INTERNAL)
C NRCDIM = RETURNED ID OF THE UNLIMITED DIMENSION
C FOR THE NETCDF FILE (INTERNAL)
C NTP = RETURNED VARIABLE TYPE (INTERNAL)
C NVARSC = RETURNED NUMBER OF VARIABLES FOR NETCDF FILE
C (INTERNAL)
C NVDIM = NUMBER OF DIMENSIONS FOR VARIABLE (INTERNAL)
C NVDIMS(10) = VECTOR OF NVDIM DIMENSION IDS CORRESPONDING
C TO VARIABLE DIMENSIONS (INTERNAL)
C NVS = NUMBER OF VARIABLE ATTRIBUTES (INTERNAL)

```
C
C   ROUTINES CALLED
C   NCOPN, NCINQ, NCDINQ, NCVINQ, NCVID, NCVGT, NCVGTC
C
C   *****
C
C   DEFINE NUMBER OF VARIABLES
C   PARAMETER (NVAR=32)
C
C   CHARACTER*80 CFILE
C   CHARACTER*1 stationName(5,NREC)
C   CHARACTER*1 reportType(6,NREC), autoStationType(6,NREC)
C   CHARACTER*1 skyCover(8,6,NREC), presWeather(25,NREC)
C   CHARACTER*1 rawMETAR(256,NREC)
C   CHARACTER*31 CDUMMY
C
C   INTEGER NREC, wmoId(NREC), correction(NREC), NCODE
C   INTEGER pressChangeChar(NREC)
C   INTEGER ISTART(10), ICNT(10), NVDIMS(10), NRCDIM, LENSTR
C   INTEGER NCID, NDIMS, NGATTS, NTP, NVS, IVARID, ILEN, NVARSC
C   INTEGER NVDIM, NDSIZE
C
C   REAL latitude(NREC), longitude(NREC), elevation(NREC)
C   REAL*8 timeObs(NREC), timeNominal(NREC)
C   REAL skyLayerBase(6,NREC), visibility(NREC)
C   REAL seaLevelPress(NREC), temperature(NREC)
C   REAL tempFromTenths(NREC), dewpoint(NREC)
C   REAL dpFromTenths(NREC), windDir(NREC), windSpeed(NREC)
C   REAL windGust(NREC), altimeter(NREC)
C   REAL minTemp24Hour(NREC), maxTemp24Hour(NREC)
C   REAL precip1Hour(NREC), precip3Hour(NREC)
C   REAL precip6Hour(NREC), precip24Hour(NREC)
C   REAL pressChange3Hour(NREC)
C
C   *****
```

```
C
  ILEN=INDEX(CFILE,' ')
  NCID=NCOPN(CFILE(1:ILEN-1),0,NCODE)
  CALL NCINQ(NCID,NDIMS,NVARS,NGATTS,NRCDIM,NCODE)
  CALL NCDINQ(NCID,NRCDIM,CDUMMY,NRECS,NCODE)

C
C  STATEMENTS TO FILL wmoId
C
  IVARID = NCVID(NCID,'wmoId ',NCODE)
  CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
  LENSTR=1

C
  DO 10 J=1,NVDIM
  CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
  LENSTR=LENSTR*NDSIZE
  ISTART(J)=1
  ICNT(J)=NDSIZE
10  CONTINUE

C
  CALL NCVGT(NCID,IVARID,ISTART,ICNT,wmoId,NCODE)
  IF(NCODE .NE. 0) GOTO 900

C
C  STATEMENTS TO FILL STATION ID
C
  IVARID = NCVID(NCID,'stationName ',NCODE)
  CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
  LENSTR=1

C
  DO 20 J=1,NVDIM
  CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
  LENSTR=LENSTR*NDSIZE
  ISTART(J)=1
  ICNT(J)=NDSIZE
20  CONTINUE

C
```

```
CALL NCVGTC(NCID,IVARID,ISTART,ICNT,stationName,LENSTR,NCODE)
IF(NCODE .NE. 0) GOTO 900
```

```
C
C STATEMENTS TO FILL LATITUDE
```

```
C
IVARID = NCVID(NCID,'latitude ',NCODE)
CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
LENSTR=1
```

```
C
DO 30 J=1,NVDIM
CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
LENSTR=LENSTR*NDSIZE
ISTART(J)=1
ICNT(J)=NDSIZE
```

```
30 CONTINUE
```

```
C
CALL NCVGT(NCID,IVARID,ISTART,ICNT,latitude,NCODE)
IF(NCODE .NE. 0) GOTO 900
```

```
C STATEMENTS TO FILL LONGITUDE
```

```
C
IVARID = NCVID(NCID,'longitude ',NCODE)
CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
LENSTR=1
```

```
C
DO 40 J=1,NVDIM
CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
LENSTR=LENSTR*NDSIZE
ISTART(J)=1
ICNT(J)=NDSIZE
```

```
40 CONTINUE
```

```
C
CALL NCVGT(NCID,IVARID,ISTART,ICNT,longitude,NCODE)
IF(NCODE .NE. 0) GOTO 900
```

C STATEMENTS TO FILL ELEVATION

C

```
IVARID = NCVID(NCID,'elevation ',NCODE)
CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
LENSTR=1
```

C

```
DO 50 J=1,NVDIM
CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
LENSTR=LENSTR*NDSIZE
ISTART(J)=1
ICNT(J)=NDSIZE
```

50 CONTINUE

C

```
CALL NCVGT(NCID,IVARID,ISTART,ICNT,elevation,NCODE)
IF(NCODE .NE. 0) GOTO 900
```

C

C STATEMENTS TO FILL TIMEOBS

C

```
IVARID = NCVID(NCID,'timeObs ',NCODE)
CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
LENSTR=1
```

C

```
DO 60 J=1,NVDIM
CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
LENSTR=LENSTR*NDSIZE
ISTART(J)=1
ICNT(J)=NDSIZE
```

60 CONTINUE

C

```
CALL NCVGT(NCID,IVARID,ISTART,ICNT,timeObs,NCODE)
IF(NCODE .NE. 0) GOTO 900
```

C

C STATEMENTS TO FILL TIMENOMINAL

C

```
IVARID = NCVID(NCID,'timeNominal ',NCODE)
```

```
CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
```

```
LENSTR=1
```

C

```
DO 70 J=1,NVDIM
```

```
CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
```

```
LENSTR=LENSTR*NDSIZE
```

```
ISTART(J)=1
```

```
ICNT(J)=NDSIZE
```

```
70 CONTINUE
```

C

```
CALL NCVGT(NCID,IVARID,ISTART,ICNT,timeNominal,NCODE)
```

```
IF(NCODE .NE. 0) GOTO 900
```

C

```
C STATEMENTS TO FILL REPORT TYPE
```

C

```
IVARID = NCVID(NCID,'reportType ',NCODE)
```

```
CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
```

```
LENSTR=1
```

C

```
DO 80 J=1,NVDIM
```

```
CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
```

```
LENSTR=LENSTR*NDSIZE
```

```
ISTART(J)=1
```

```
ICNT(J)=NDSIZE
```

```
80 CONTINUE
```

C

```
CALL NCVGTC(NCID,IVARID,ISTART,ICNT,reportType,LENSTR,NCODE)
```

```
IF(NCODE .NE. 0) GOTO 900
```

C

```
C STATEMENTS TO FILL AUTOMATED STATION TYPE
```

C

```
IVARID = NCVID(NCID,'autoStationType ',NCODE)
```

```
CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
```

```
LENSTR=1
```

C

```
DO 90 J=1,NVDIM
CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
LENSTR=LENSTR*NDSIZE
ISTART(J)=1
ICNT(J)=NDSIZE
90  CONTINUE
C
CALL NCVGTC(NCID,IVARID,ISTART,ICNT,autoStationType,
+ LENSTR,NCODE)
IF(NCODE .NE. 0) GOTO 900
C
C  STATEMENTS TO FILL SKY COVER
C
IVARID = NCVID(NCID,'skyCover ',NCODE)
CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
LENSTR=1
C
DO 100 J=1,NVDIM
CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
LENSTR=LENSTR*NDSIZE
ISTART(J)=1
ICNT(J)=NDSIZE
100 CONTINUE
C
CALL NCVGTC(NCID,IVARID,ISTART,ICNT,skyCover,LENSTR,NCODE)
IF(NCODE .NE. 0) GOTO 900
C
C  STATEMENTS TO FILL SKY COVER LAYER BASE
C
IVARID = NCVID(NCID,'skyLayerBase ',NCODE)
CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
LENSTR=1
C
DO 110 J=1,NVDIM
CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
```

```
LENSTR=LENSTR*NDSIZE
```

```
ISTART(J)=1
```

```
ICNT(J)=NDSIZE
```

```
110 CONTINUE
```

```
C
```

```
CALL NCVGT(NCID,IVARID,ISTART,ICNT,skyLayerBase,NCODE)
```

```
IF(NCODE .NE. 0) GOTO 900
```

```
C
```

```
C STATEMENTS TO FILL VISIBILITY
```

```
C
```

```
IVARID = NCVID(NCID,'visibility ',NCODE)
```

```
CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,ncode)
```

```
LENSTR=1
```

```
C
```

```
DO 120 J=1,NVDIM
```

```
CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
```

```
LENSTR=LENSTR*NDSIZE
```

```
ISTART(J)=1
```

```
ICNT(J)=NDSIZE
```

```
120 CONTINUE
```

```
C
```

```
CALL NCVGT(NCID,IVARID,ISTART,ICNT,visibility,NCODE)
```

```
IF(NCODE .NE. 0) GOTO 900
```

```
C
```

```
C STATEMENTS TO FILL PRESENT WEATHER
```

```
C
```

```
IVARID = NCVID(NCID,'presWeather ',NCODE)
```

```
CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
```

```
LENSTR=1
```

```
C
```

```
DO 130 J=1,NVDIM
```

```
CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
```

```
LENSTR=LENSTR*NDSIZE
```

```
ISTART(J)=1
```

```
ICNT(J)=NDSIZE
```

130 CONTINUE

C

```
CALL NCVGTC(NCID,IVARID,ISTART,ICNT,presWeather,LENSTR,NCODE)
IF(NCODE .NE. 0) GOTO 900
```

C

C

STATEMENTS TO FILL SEA LEVEL PRESSURE

C

```
IVARID = NCVID(NCID,'seaLevelPress ',NCODE)
CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
LENSTR=1
```

C

```
DO 140 J=1,NVDIM
CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
LENSTR=LENSTR*NDSIZE
ISTART(J)=1
ICNT(J)=NDSIZE
```

140 CONTINUE

C

```
CALL NCVGT(NCID,IVARID,ISTART,ICNT,seaLevelPress,NCODE)
IF(NCODE .NE. 0) GOTO 900
```

C

C

STATEMENTS TO FILL TEMPERATURE

C

```
IVARID = NCVID(NCID,'temperature ',NCODE)
CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
LENSTR=1
```

C

```
DO 150 J=1,NVDIM
CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
LENSTR=LENSTR*NDSIZE
ISTART(J)=1
ICNT(J)=NDSIZE
```

150 CONTINUE

C

```
CALL NCVGT(NCID,IVARID,ISTART,ICNT,temperature,NCODE)
```

```
IF(NCODE .NE. 0) GOTO 900
```

C

```
STATEMENTS TO FILL TEMP FROM TENTHS OF A DEGREE C
```

C

```
IVARID = NCVID(NCID,'tempFromTenths ',NCODE)
```

```
CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
```

```
LENSTR=1
```

C

```
DO 160 J=1,NVDIM
```

```
CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
```

```
LENSTR=LENSTR*NDSIZE
```

```
ISTART(J)=1
```

```
ICNT(J)=NDSIZE
```

```
160 CONTINUE
```

C

```
CALL NCVGT(NCID,IVARID,ISTART,ICNT,tempFromTenths,NCODE)
```

```
IF(NCODE .NE. 0) GOTO 900
```

C

```
STATEMENTS TO FILL DEWPOINT
```

C

```
IVARID = NCVID(NCID,'dewpoint ',NCODE)
```

```
CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
```

```
LENSTR=1
```

C

```
DO 170 J=1,NVDIM
```

```
CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
```

```
LENSTR=LENSTR*NDSIZE
```

```
ISTART(J)=1
```

```
ICNT(J)=NDSIZE
```

```
170 CONTINUE
```

C

```
CALL NCVGT(NCID,IVARID,ISTART,ICNT,dewpoint,NCODE)
```

```
IF(NCODE .NE. 0) GOTO 900
```

C

```
STATEMENTS TO FILL DEWPOINT FROM 10THS OF A DEGREE C
```

C

```
IVARID = NCVID(NCID,'dpFromTenths ',NCODE)
CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
LENSTR=1
```

C

```
DO 180 J=1,NVDIM
CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
LENSTR=LENSTR*NDSIZE
ISTART(J)=1
ICNT(J)=NDSIZE
```

180 CONTINUE

C

```
CALL NCVGT(NCID,IVARID,ISTART,ICNT,dpFromTenths,NCODE)
IF(NCODE .NE. 0) GOTO 900
```

C

C STATEMENTS TO FILL WIND DIRECTION

C

```
IVARID = NCVID(NCID,'windDir ',NCODE)
CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
LENSTR=1
```

C

```
DO 190 J=1,NVDIM
CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
LENSTR=LENSTR*NDSIZE
ISTART(J)=1
ICNT(J)=NDSIZE
```

190 CONTINUE

C

```
CALL NCVGT(NCID,IVARID,ISTART,ICNT,windDir,NCODE)
IF(NCODE .NE. 0) GOTO 900
```

C

C STATEMENTS TO FILL WIND SPEED

C

```
IVARID = NCVID(NCID,'windSpeed ',NCODE)
CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
```

```
LENSTR=1
```

```
C
```

```
DO 200 J=1,NVDIM
```

```
CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
```

```
LENSTR=LENSTR*NDSIZE
```

```
ISTART(J)=1
```

```
ICNT(J)=NDSIZE
```

```
200 CONTINUE
```

```
C
```

```
CALL NCVGT(NCID,IVARID,ISTART,ICNT,windSpeed,NCODE)
```

```
IF(NCODE .NE. 0) GOTO 900
```

```
C
```

```
C STATEMENTS TO FILL WIND GUST
```

```
C
```

```
IVARID = NCVID(NCID,'windGust ',NCODE)
```

```
CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
```

```
LENSTR=1
```

```
C
```

```
DO 210 J=1,NVDIM
```

```
CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
```

```
LENSTR=LENSTR*NDSIZE
```

```
ISTART(J)=1
```

```
ICNT(J)=NDSIZE
```

```
210 CONTINUE
```

```
C
```

```
CALL NCVGT(NCID,IVARID,ISTART,ICNT,windGust,NCODE)
```

```
IF(NCODE .NE. 0) GOTO 900
```

```
C
```

```
C STATEMENTS TO FILL ALTIMETER
```

```
C
```

```
IVARID = NCVID(NCID,'altimeter ',NCODE)
```

```
CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
```

```
LENSTR=1
```

```
C
```

```
DO 220 J=1,NVDIM
```

```
CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
```

```
LENSTR=LENSTR*NDSIZE
```

```
ISTART(J)=1
```

```
ICNT(J)=NDSIZE
```

```
220 CONTINUE
```

```
C
```

```
CALL NCVGT(NCID,IVARID,ISTART,ICNT,altimeter,NCODE)
```

```
IF(NCODE .NE. 0) GOTO 900
```

```
C
```

```
C
```

```
STATEMENTS TO FILL MINIMUM TEMP IN 24 HOURS
```

```
C
```

```
IVARID = NCVID(NCID,'minTemp24Hour ',NCODE)
```

```
CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
```

```
LENSTR=1
```

```
C
```

```
DO 230 J=1,NVDIM
```

```
CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
```

```
LENSTR=LENSTR*NDSIZE
```

```
ISTART(J)=1
```

```
ICNT(J)=NDSIZE
```

```
230 CONTINUE
```

```
C
```

```
CALL NCVGT(NCID,IVARID,ISTART,ICNT,minTemp24Hour,NCODE)
```

```
IF(NCODE .NE. 0) GOTO 900
```

```
C
```

```
C
```

```
STATEMENTS TO FILL MAXIMUM TEMP IN 24 HOURS
```

```
C
```

```
IVARID = NCVID(NCID,'maxTemp24Hour ',NCODE)
```

```
CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
```

```
LENSTR=1
```

```
C
```

```
DO 240 J=1,NVDIM
```

```
CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
```

```
LENSTR=LENSTR*NDSIZE
```

```
ISTART(J)=1
```

```
      ICNT(J)=NDSIZE
240  CONTINUE
C
      CALL NCVGT(NCID,IVARID,ISTART,ICNT,maxTemp24Hour,NCODE)
      IF(NCODE .NE. 0) GOTO 900
C
C      STATEMENTS TO FILL PRECIP1HOUR
C
      IVARID = NCVID(NCID,'precip1Hour ',NCODE)
      CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
      LENSTR=1
C
      DO 250 J=1,NVDIM
      CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
      LENSTR=LENSTR*NDSIZE
      ISTART(J)=1
      ICNT(J)=NDSIZE
250  CONTINUE
C
      CALL NCVGT(NCID,IVARID,ISTART,ICNT,precip1Hour,NCODE)
      IF(NCODE .NE. 0) GOTO 900
C
C      STATEMENTS TO FILL 3 HOUR PRECIP
C
      IVARID = NCVID(NCID,'precip3Hour ',NCODE)
      CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
      LENSTR=1
C
      DO 260 J=1,NVDIM
      CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
      LENSTR=LENSTR*NDSIZE
      ISTART(J)=1
      ICNT(J)=NDSIZE
260  CONTINUE
C
```

```
CALL NCVGT(NCID,IVARID,ISTART,ICNT,precip3Hour,NCODE)
IF(NCODE .NE. 0) GOTO 900
```

C

C STATEMENTS TO FILL 6 HOUR PRECIP

C

```
IVARID = NCVID(NCID,'precip6Hour ',NCODE)
CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
LENSTR=1
```

C

```
DO 270 J=1,NVDIM
CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
LENSTR=LENSTR*NDSIZE
ISTART(J)=1
ICNT(J)=NDSIZE
```

270 CONTINUE

C

```
CALL NCVGT(NCID,IVARID,ISTART,ICNT,precip6Hour,NCODE)
IF(NCODE .NE. 0) GOTO 900
```

C

C STATEMENTS TO FILL 24 HOUR PRECIP

C

```
IVARID = NCVID(NCID,'precip24Hour ',NCODE)
CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
LENSTR=1
```

C

```
DO 280 J=1,NVDIM
CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
LENSTR=LENSTR*NDSIZE
ISTART(J)=1
ICNT(J)=NDSIZE
```

280 CONTINUE

C

```
CALL NCVGT(NCID,IVARID,ISTART,ICNT,precip24Hour,NCODE)
IF(NCODE .NE. 0) GOTO 900
```

C

C STATEMENTS TO FILL PRESSURE CHANGE CHARACTER

C

```
IVARID = NCVID(NCID,'pressChangeChar ',NCODE)
CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
LENSTR=1
```

C

```
DO 290 J=1,NVDIM
CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
LENSTR=LENSTR*NDSIZE
ISTART(J)=1
ICNT(J)=NDSIZE
```

290 CONTINUE

C

```
CALL NCVGT(NCID,IVARID,ISTART,ICNT,pressChangeChar,NCODE)
IF(NCODE .NE. 0) GOTO 900
```

C

C STATEMENTS TO FILL PRESSURE CHANGE IN 3 HOURS

C

```
IVARID = NCVID(NCID,'pressChange3Hour ',NCODE)
CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
LENSTR=1
```

C

```
DO 300 J=1,NVDIM
CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
LENSTR=LENSTR*NDSIZE
ISTART(J)=1
ICNT(J)=NDSIZE
```

300 CONTINUE

C

```
CALL NCVGT(NCID,IVARID,ISTART,ICNT,pressChange3Hour,NCODE)
IF(NCODE .NE. 0) GOTO 900
```

C

C STATEMENTS TO FILL CORRECTION

C

```
IVARID = NCVID(NCID,'correction ',NCODE)
```

```
CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
```

```
LENSTR=1
```

```
C
```

```
DO 310 J=1,NVDIM
```

```
CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
```

```
LENSTR=LENSTR*NDSIZE
```

```
ISTART(J)=1
```

```
ICNT(J)=NDSIZE
```

```
310 CONTINUE
```

```
C
```

```
CALL NCVGT(NCID,IVARID,ISTART,ICNT,correction,NCODE)
```

```
IF(NCODE .NE. 0) GOTO 900
```

```
C
```

```
C STATEMENTS TO FILL RAW METAR
```

```
C
```

```
IVARID = NCVID(NCID,'rawMETAR ',NCODE)
```

```
CALL NCVINQ(NCID,IVARID,CDUMMY,NTP,NVDIM,NVDIMS,NVS,NCODE)
```

```
LENSTR=1
```

```
C
```

```
DO 320 J=1,NVDIM
```

```
CALL NCDINQ(NCID,NVDIMS(J),CDUMMY,NDSIZE,NCODE)
```

```
LENSTR=LENSTR*NDSIZE
```

```
ISTART(J)=1
```

```
ICNT(J)=NDSIZE
```

```
320 CONTINUE
```

```
C
```

```
CALL NCVGTC(NCID,IVARID,ISTART,ICNT,rawMETAR,LENSTR,NCODE)
```

```
IF(NCODE .NE. 0) GOTO 900
```

```
C
```

```
C CHECKS OUTPUT CODE AGAINST CURRENT INPUT FILE
```

```
C
```

```
CALL NCINQ(NCID,NDIMS,NVARSC,NGATTS,NRCDIM,NCODE)
```

```
IF(NVARSC.NE.NVARS) WRITE(6,340)
```

```
340 FORMAT('NUMBER OF VARIABLES HAS CHANGED')
```

```
C
```

900 CALL NCCLOS(NCID,NCODE)

C

RETURN

END

APPENDIX 2

Sample output from "testGridKeyServer" to list valid values for AWIPS grid APIs

Exhibit A2-1. Sample output lines of "testGridKeyServer -v" to list valid values for **fieldID**.

11 *RH*: Rel Humidity % CONTOUR IMAGE
 27 *pV*: Pot Vorticity K/mb/1e5s CONTOUR IMAGE
 35 *ageoW*: Ageo Wind kts BARB ARROW

In each of the above three lines, the italicized portion is the "fieldId" value of interest; the next part (immediately after the colon) of the line is a more spelled-out description of the variable, and the next field is the units of the variable. Ignore the remainder of the line.

Exhibit A2-2. Sample output lines of "testGridKeyServer -p" to list valid values for **planeID**.

12 *400MB* STANDARD: 400.0 MB offset:-14
 49 *TROP* STANDARD: 0.0 TROP
 55 *1000MB-850MB* COMPOSITE: 1000.0 MB 850.0 MB (1000MB 850MB)
 66 *12kft* STANDARD: 3658.0 FH
 128 *350K* STANDARD: 350.0 K offset:-233

In each of the above five lines, the italicized portion is the "fieldId" value of interest. Ignore the remainder of the line.

Exhibit A2-3. Sample output lines of "testGridKeyServer -s" to list valid values for **sourceID** and **grid_source**.

1 *RUC* RUC
 /data/fxa/Grid/SBN/netCDF/CONUS211/RUC
 Ruc211 rucClip 385 RUC 75 56 1 2 3 4
 9 *avnNH* AVN
 /data/fxa/Grid/SBN/netCDF/NHEM201/AVN
 Avn201 grid201 -1 grid201 65 65 0
 14 *NGM213* NGM
 /data/fxa/Grid/SBN/netCDF/CONUS213/NGM
 Ngm213 grid213 -1 grid213 129 85 1

The output for each valid value of "sourceId" and "grid_source" consists of three lines. In each of the above three entries, the italicized portion is the "sourceId" or "grid_source" value of interest. Ignore the

remainder of each entry.

APPENDIX 3

Summary of applicable data subdirectories by WSR-88D product type

Radar data subdirectories are determined by assembling all possible permutations of product type, elevation, resolution, and data level names (the last 3, as applicable). For instance, for Composite Reflectivity (CZ), the possible data subdirectories are:

~/CZ/layer0/res1/level16

~/CZ/layer0/res1/level8

~/CZ/layer0/res4/level16

~/CZ/layer0/res4/level8

See Section 4.2.4.1 for the higher-level radar directory structure.

AAP:	No subdirectories		
AM:	No subdirectories		
APR:	Elevation(s):	layer1	
	Resolution(s):	res4	
	Data Level(s):	level8	
CFC:	Elevation(s):	layer0	
	Resolution(s):	res1	
	Data Level(s):	level8	
CM:	Elevation(s):	layer0	
	Resolution(s):	res0	
	Data Level(s):	level16	
CS:	No subdirectories		
CSC:	No subdirectories		
CSCT:	No subdirectories		
CST:	No subdirectories		
CZ:	Elevation(s):	layer0	
	Resolution(s):	res1	res4
	Data Level(s):	level16	level8

CZC: Elevation(s): layer0
 Resolution(s): res1 res4
 No Data Levels subdirectory

DHS: Elevation(s): layer0
 Resolution(s): res1
 Data Level(s): level256

DPA: Elevation(s): layer0
 Resolution(s): res4
 Data Level(s): level256

DSTP: Elevation(s): layer0
 Resolution(s): res2
 Data Level(s): level256

ET: Elevation(s): layer0
 Resolution(s): res4
 Data Level(s): level16

ETC: No subdirectories

FTM: No subdirectories

GSM: No subdirectories

HDP: Elevation(s): layer0
 Resolution(s): res4
 Data Level(s): level256

HI: No subdirectories

HIT: No subdirectories

HSR: Elevation(s): layer0
 Resolution(s): res1
 Data Level(s): level16

LRA: Elevation(s): layer1 layer2 layer3
 Resolution(s): res4
 Data Level(s): level8

LRM: Elevation(s): layer1 layer2 layer3
 Resolution(s): res4
 Data Level(s): level8

M: No subdirectories

MT: No subdirectories

OHP: Elevation(s): layer0

Resolution(s): res2
 Data Level(s): level16

OHPT: No subdirectories

PRR: No subdirectories

RCM: No subdirectories

RCS: Elevation(s): layer0
 Resolution(s): res1
 Data Level(s): level16

SCS: Elevation(s): layer0
 Resolution(s): res0_5
 Data Level(s): level8

SPD: Elevation(s): layer0
 Resolution(s): res40
 Data Level(s): level8

SRM: Elevation(s): elev0_5 elev14_0 elev19_5 elev2_5 elev4_3
 elev6_0 elev8_7 elev10_0 elev14_6 elev1_5
 elev3_4 elev4_5 elev6_2 elev9_9 elev12_0
 elev16_7 elev2_4 elev3_5 elev5_3 elev7_5
 Resolution(s): res1

Data Level(s): level16

SRR: Elevation(s): elev0_5 elev14_0 elev19_5 elev2_5 elev4_3
 elev6_0 elev8_7 elev10_0 elev14_6 elev1_5
 elev3_4 elev4_5 elev6_2 elev9_9 elev12_0
 elev16_7 elev2_4 elev3_5 elev5_3 elev7_5

Resolution(s): res0_5

Data Level(s): level16

SS: No subdirectories

STI: No subdirectories

STIT: No subdirectories

STP: Elevation(s): layer0
 Resolution(s): res2
 Data Level(s): level16

STPT: No subdirectories

SW: Elevation(s): elev0_5 elev14_0 elev19_5 elev2_5 elev4_3
 elev6_0 elev8_7 elev10_0 elev14_6 elev1_5

elev3_4 elev4_5 elev6_2 elev9_9 elev12_0
 elev16_7 elev2_4 elev3_5 elev5_3 elev7_5
 Resolution(s): res0_25 res0_5 res1
 Data Level(s): level8
 SWP: No subdirectories
 SWR: Elevation(s): elev0_5 elev14_0 elev19_5 elev2_5 elev4_3
 elev6_0 elev8_7 elev10_0 elev14_6 elev1_5
 elev3_4 elev4_5 elev6_2 elev9_9 elev12_0
 elev16_7 elev2_4 elev3_5 elev5_3 elev7_5
 Resolution(s): res1
 Data Level(s): level16
 SWS: Elevation(s): elev0_5 elev14_0 elev19_5 elev2_5 elev4_3
 elev6_0 elev8_7 elev10_0 elev14_6 elev1_5
 elev3_4 elev4_5 elev6_2 elev9_9 elev12_0
 elev16_7 elev2_4 elev3_5 elev5_3 elev7_5
 Resolution(s): res0_5
 Data Level(s): level16
 SWV: Elevation(s): elev0_5 elev14_0 elev19_5 elev2_5 elev4_3
 elev6_0 elev8_7 elev10_0 elev14_6 elev1_5
 elev3_4 elev4_5 elev6_2 elev9_9 elev12_0
 elev16_7 elev2_4 elev3_5 elev5_3 elev7_5
 Resolution(s): res0_25
 Data Level(s): level16
 SWW: Elevation(s): elev0_5 elev14_0 elev19_5 elev2_5 elev4_3
 elev6_0 elev8_7 elev10_0 elev14_6 elev1_5
 elev3_4 elev4_5 elev6_2 elev9_9 elev12_0
 elev16_7 elev2_4 elev3_5 elev5_3 elev7_5
 Resolution(s): res0_25
 Data Level(s): level8
 THP: Elevation(s): layer0
 Resolution(s): res2
 Data Level(s): level16
 THPT: No subdirectories
 TVS: No subdirectories
 TVST: No subdirectories

UAM: No subdirectories

USRA: Elevation(s): layer0

Resolution(s): res2

Data Level(s): level16

V: Elevation(s): elev0_5 elev14_0 elev19_5 elev2_5 elev4_3
 elev6_0 elev8_7 elev10_0 elev14_6 elev1_5
 elev3_4 elev4_5 elev6_2 elev9_9 elev12_0
 elev16_7 elev2_4 elev3_5 elev5_3 elev7_5

Resolution(s): res0_25 res0_5 res1

Data Level(s): level16 level8

VAD: No subdirectories

VADT: No subdirectories

VCS: Elevation(s): layer0

Resolution(s): res0_5

Data Level(s): level16

VIL: Elevation(s): layer0

Resolution(s): res4

Data Level(s): level16

VWP: No subdirectories

WER: Elevation(s): layer0

Resolution(s): res1

Data Level(s): level8

XSR: Elevation(s): layer0

Resolution(s): res1

Data Level(s): level8

XSV: Elevation(s): layer0

Resolution(s): res0_5

Data Level(s): level8

Z: Elevation(s): elev0_5 elev14_0 elev19_5 elev2_5 elev4_3
 elev6_0 elev8_7 elev10_0 elev14_6 elev1_5
 elev3_4 elev4_5 elev6_2 elev9_9 elev12_0
 elev16_7 elev2_4 elev3_5 elev5_3 elev7_5

Resolution(s): res0_25 res0_5 res1

Data Level(s): level16 level8

Appendix 4

External Documentation Standards for Locally-Developed AWIPS Applications

The detailed requirement for external documentation are provided in the following sections.

1.0 Local Application Registration Information

1.1 Application Description

- a. Name. List the application name(s).
- b. Version Number. List the latest version number of the software (e.g., XNOW 2.0).
- c. Version Date. List the date that the software was last updated.
- d. Type. Indicate the type of application (e.g., display, formatter, CRS, LDAD preprocessor, etc.).
- e. Description. Provide a detailed functional description of the application and describe its operational use.
- f. Languages. List the programming languages used in the application (e.g., FORTRAN 77, C, C++, Perl, netCDF Perl, Tcl/Tk, python, Perl/Tk). If there is a mix, each language and interpreter should be specified.
- g. Status. Indicate the current status (e.g., Planned, Under Development, or Operational).

1.2 References

- a. Originator. List the original developer (last name, first name) of application(s).
- b. Originating Office: List the office (e.g., AMA, ERH).
- c. Maintenance Programmer. List maintenance programmer (last name, first name) assigned to this application.
- d. Documentation. List the documentation available for this application (e.g., User, Installation, Maintenance). List any web site where more information is provided.

1.3 Software Inventory

- a. New Software Added. List the name and location of all new files added. Include which machine(s) (e.g., DS1,AS1) and full path name.
- b. COTS/Shareware/Freeware. List any COTS, shareware, or freeware packages required for this application to build or run. Include version and patch level information.
- c. Existing Files Changed/Deleted. List any existing file on the system that needs to be modified. Include which machine(s) (e.g., DS1,AS1) and full path name of all files. This should cover all changes whether to AWIPS software or otherwise such as standard Unix files. For any core system files (e.g., /etc/services, cron, allow, any Informix setup or parameter files, any operating system parameter files), explicitly describe what changes are being made.
- d. New Data Files. List all new data directories and data files that are specific to this application. Indicate file format, temporary or permanent, and size.
- e. New Databases/Tables. List any new Informix database tables created by this application. Include the Informix **dbspace**, database name and table name.

1.4 Data File/Database Interfaces.

- a. AWIPS System/HydroMet Data Files. Identify any existing data files accessed by the application. Include the data type (e.g., Grids, Satellite, METARs, RAOBs), file format (e.g., **netCDF**, native, plotfile), and how often they are being accessed.
- b. AWIPS Text Database Products. Identify any Text Database products accessed by this application. Include the AWIPS PIL of the product, in **cccNNNxxx** format, and how often it is being accessed.
- c. AWIPS RDBMS. Identify any Informix database tables accessed by this application. Include the Informix **dbspace**, database name and table, and how often it is being accessed.

1.5 External/Internal Interfaces.

Identify any AWIPS external or internal interfaces this item will access (e.g., NWWS, NWR, ASOS, LDAD) and how often it will interface.

1.6 Runtime Signature

- a. Host Machine. Identify the host(s) on which major processes of the properly-configured program

run. Does not include NFS access of data files residing on another machine's disks, or export of displayed output to another machine's monitor. For transient processes, describe when (how often, what times of day) they become active.

- b. CPU. Characterize in general terms how much CPU or memory the application is expected to use while running. The approximate running times (CPU time and Clock time) in whole seconds, when (if allowed by the application) run at the same time that normal AWIPS processes are running on the host machine(s). This applies to major subprocesses of primarily-interactive applications, not to the user interactions with the interface. See Appendix 6 of the AIFM for useful tools to evaluate the impact of a program on the system.
- c. Disk Usage. Identify the total disk space required for this application. Provide a separate total for executables, all application specific data files and application-specific RDBMS usage. It may be necessary to estimate requirements for data file space. The estimate should reflect a probable upper limit.
- d. Network/Communications. Describe any usage of the AWIPS WAN. In particular, describe how it is accessed (i.e., which APIs). Characterize the data flow over the WAN because of the application(s) (i.e. how much data, how often, what times of the day for peak transmission rates, etc.). Describe any usage of the AWIPS SBN. That is, note whether the application puts data on the WAN for distribution over the SBN. Characterize the data flow over the SBN because of the application(s).

1.7 Other Performance/System Resource Usage

- a. Performance. Assess usage of the Network File System (NFS) and Informix (e.g., triggers or otherwise). If known, describe any extra load being put on shared services (e.g., notificationServer, textNotificationServer, oninit, AsyncProductScheduler, NWWSScheduler, MHSserver). List anticipated issues with algorithmic performance for heavy number-crunching functions. Describe anticipated use of remote shell, rcp, or other such system calls.
- b. System Resource. Identify any anticipated use of Omniback/tape drive. Identify potential problematic use of special hardware resources (e.g., async mux ports, LDAD terminal server ports, modems).

2.0 User Information

1. Configuration. Provide instructions (if needed) for configuring the application for local use.
2. Execution. Provide instructions for running the application and for recovering from errors.
3. Maintenance. Provide instructions for maintaining (e.g., purge, clean-up) the data sets created

and used by the application.

3.0 Installation Information

- a. Tar File Information. List all *tar* files containing the program's source code and data files. The suggested format of this listing is extracted from the columnar format produced by the HP-UX **ls** command
- b. Makefiles. Describe all **makefiles** associated with building the program, their locations in the source tree, their interdependencies, and order of execution. Note that if **makefiles** are not provided with the package (an undesirable option), then this section must include a full set of the compile and link command lines needed to build the program, including references to libraries (AWIPS and/or standard). The use of **makefiles** is strongly recommended.
- c. Application Environment. Document the types and versions of the operating system, compilers, and other COTS (Commercial, Off-The-Shelf) packages under which the executable code is built and run. It includes the operating system and version (e.g., HP-UX 10.20) , compiler/interpreter and version (e.g., HP FORTRAN 9000 version 9.0), and list the names and definitions of all environment variables that need to be set for the application to be built and run. Only include those that are in addition to the AWIPS system environment variables required to be defined for AWIPS libraries or resources that are used by the application. Include the full name of the environment variable, the value of the environment variable, and indicate whether the variable is needed for runtime (R) or for setup/creation of the program (S), or both (R/S)
- d. Detailed Installation Procedures. Describe all the steps involved in setting up the environment, configuring the system, building the application, installing the executables, and, as needed, file decompression, relationships to other programs, creating and initializing the data files, creation and loading of RDBMS tables, setting up **cron** jobs and scripts, and directions on running scripts to automatically perform any of the above.
- e. Installation Scripts. Provide an inventory of any scripts that have been developed to automate the process of setting up the program build and runtime environments, and building and installing the program. It includes the absolute pathname for the single directory which contains the script files and a file listing of script files needed by the program. The suggested format for this listing is extracted from the columnar format produced by the HP-UX **ls** command.

4.0 Maintenance Information

The following information should be available to a maintenance programmer.

- a. Design information. A figure to illustrate the relationship among, as applicable, the disk files (data files, control files, and static data), the Relational Data Base Management System

(RDBMS), the program(s) or major processes, and the output data product(s) and/or the display (e.g., Data Flow Diagram). Summarize the flow of the program and the data in clear, simple statements that describe how the program works. Discuss any scientific formulas and mathematical algorithms to show the scientific foundation of the program. For C++ programs, provide a class diagram which shows categories, classes, attributes, methods, and relationships in a standard notation such as Booch-93.

- b. Testing information. Information on the testing performed on the application. This includes test procedures and test data that can simplify future regression testing.
- c. Application history. Listing of enhancements (versions) and known software deficiencies for the current version.

A suggested format and content for a maintenance document is provided in Appendix 7. This format is an adaptation of those standards used in the AFOS Computer Program (CP) series.

APPENDIX 5

man pages for *handleOUP.pl* and *distributeProduct* CLIs

Handling Of Official User Products (OUPs)

AWIPS Version 5.2.2

Name

handleOUP.pl

Synopsis

`handleOUP.pl [-w] [-m][-r] [-d ddHHMM] <AWIPS_ID> <product_pathname>`

where

[-w] specifies the WMO special message type,

[-m] selects test mode as the AWIPS operational mode,

[-r] specifies the receiving site on the AFOS network when AWIPS is in precommissioned or test mode,

[-d ddHHMM] specify the WMO message time stamp.

and <AWIPS_ID> and <product_pathname> are required arguments.

Description

handleOUP.pl automatically performs certain tasks associated with the handling of an Official User Product including local storage into the Informix database, product archival, distribution across the AWIPS WAN to the Network Control Facility (NCF) and to NOAA Weather Wire Service (NWWS) uplink sites, and distribution to the local AFOS interface

when AWIPS is in pre-commissioned mode.

Product distribution on the AWIPS communications system is accomplished by submitting a message request to the x.400 ISOCOR Message Handling System. *handleOUP.pl* uses the *distributeProduct* command line interface to create a x.400 message enclosing the <product_pathname> as an attachment. *distributeProduct* uses the <AWIPS_ID> passed from *handleOUP.pl* to create the message header which must precede the contents of a product in accordance with SRSI H.3 requirements for product dissemination on the AWIPS WAN. The message is submitted at a priority level associated with the category of the product, which is derived from the <AWIPS_ID> (A table lookup (/awips/fxa/data/awipsPriorities.txt) is performed using the category as a key.)

handleOUP.pl supports two operational mode for AWIPS: commissioned and pre-commissioned. The commissioned mode or status of an AWIPS site is contained in the configuration file /data/fxa/workFiles/wanMsgHandling/siteCommission.txt. Based on the value for the commissioned status, the product is distributed across the AWIPS WAN either with a test WMO header (ii=97 in TTAAii) or a valid WMO header. Generation of test WMO headers may also be accomplished by selecting the -m command line option -- effectively downgrading the operational status of an AWIPS site from commissioned to test mode. In either AWIPS pre-commissioned or test mode, products are transmitted to AFOS with a proper message header. For this reason, the <product_pathname> is assumed to contain the contents of the OUP only, without a communications header.

Upon successful dissemination to the NCF, or to the predesignated primary and backup NWS uplink sites (as specified in /awips/ops/data/mhs/nwswsup_dlist.data), or to AFOS during AWIPS pre-commissioning phase, a copy of <product_pathname> is stored in a predesignated holding directory for archival (/data/fxa/archive/OUP/scratch).¹ The product is archived and stored with the AWIPS WAN message header.

Options:

[-w WMO_special_message_type]

Specify the WMO message type. The supported BBB indicator values are AAx, CCx, RRx, Pxx where x = A-Z. These forms are only included in the abbreviated headings of amended, corrected, delayed, or segmented bulletins respectively. The legacy forms of the BBB indicator, AMD, COR, RTD, SUP, SPL are also supported.

[-m]

Specify test mode. Selecting this option results in the distribution of a product across the AWIPS WAN with a test WMO header as well as to AFOS with an AFOS-standard message header. Amendments are made to a copy of the product.

If the -m option is not selected, *distributeProduct* uses a site's commissioned status (obtained from /data/fxa/workFiles/wanMsgHandling/siteCommission.txt) to determine whether product is sent to AFOS and to the AWIPS WAN with a test WMO header.

[-r AFOS_routing_node]

Specify the three character AFOS receiving site. Examples of AFOS nodes include the following:

LOC, DEF, CEN, CES, CSW, EAS, SOU, WES, ALL

Default: DEF

If AWIPS is in test or in pre-commissioned mode, *handleOUP.pl* uses the AFOS_routing_node to generate the following 2 line AFOS message header:

```
CCCNXXADR
TTAAii CCCC DDHHMM[ BBB]
```

where

CCCNXXADR is the 7-9 character AFOS product identifier,

ADR is the 3 character AFOS routing node,

TTAAii is the WMO header,

CCCC is the 4 letter originating office identifier

DDHHMM is the date/time stamp (UTC format)

BBB is the WMO special message type.

[-d ddHHMM]

Specify the WMO message time stamp. This will default to the *currentsystem* time if not supplied.

Supported format:

ddHHMM = day of month, hour, min.

handleOUP.pl uses the `/awips/fxa/data/afos2awips.txt` configuration file to complete the message header: from the `<AWIPS_ID>`, *handleOUP.pl* obtains the equivalent AFOS product identifier, the WMO header, and the originating WFO identifier. The generated message header is subsequently prepended to a copy of the product.

If this option is not selected, a default value of DEF is assigned as the routing address. The DEF value instructs AFOS to search its default addressing configuration table for the given AFOS product identifier and obtain the intended recipient(s). If the product is not found in the table, AFOS sends the product to ALL sites on the AFOS network.

Required Arguments:

`<AWIPS_ID>` is the 8-10 character AWIPS identifier of the form CCCCNNNXXX

where

CCCC is the International Civil Aviation Organization (ICAO)-approved identifier of the office originating the product,

NNN is the 3 character product category,

XXX is the 1-3 character product designator

The NNNXXX is identical to the AFOS NNNXXX.

`<product_pathname>` is the fully qualified product filename. The file is assumed to contain only the contents of the product, without a communications header.

Return Values

handleOUP.pl returns the following error codes:

0 = successful

1 = error

Specifically, a successful return indicates that the product was successfully distributed to any one receiving site, was archived, and was stored in the text database. An unsuccessful return indicates that either one or more handling tasks failed to be completed.

Log File

If *handleOUP.pl* is invoked from the as or ds, the log file resides in the following date directory: `/data/logs/fxa/<YYMMDD>`

If *handleOUP.pl* is invoked from the workstation, the log file resides in the following date directory:

`/data/logs/fxa/display/<DISPLAY>/<YYMMDD>`

where

DISPLAY is value specified by the DISPLAY environment variable. (If the DISPLAY variable is not set, a log file is created in the date subdirectory in `/data/logs/fxa/display/:0.`)

The name of the *handleOUP.pl* log file is `handleOUP.log`.

The log file contains **all** logs for any *handleOUP.pl* invoked for that day. A header section for each invocation contains the `<pid>` where `<pid>` is the process id number. The log traces all OUP-related activities, from table lookups for message header generation and message composition for product distribution on the AWIPS WAN via the `distributeProduct` command line interface and to AFOS via the `sendafos` command line interface, to product storage and archival. This log file may be viewed in conjunction with the *distributeProduct* log file for complete traceback. The *distributeProduct* log file is stored in the same directory by the following name:

pre-AWIPS 5.1.1 release: `distributeProduct<pid><host><HHMMSS>`

AWIPS 5.1.1 release and later: `distributeProduct.log`

References

See also *distributeProduct* documentation

¹ The `/data/fxa/archive/OUP/scratch` directory is monitored hourly; at the end of which interval, all stored products are moved to the `/data/fxa/archive/OUP/archive` directory.

Product Distribution Across the WAN Version 5.2.2

Name

distributeProduct

Synopsis

distributeProduct [options] awips_id product_pathname

where options include the following:

[-c action, [,action]...]

[-s subject]

[-a addressee [,addressee]...]

[-p priority]

[-t message_type]

[-e enclosepath, [,enclosepath]...]

[-w wmo_special_message_type]

[-d ddHHMM]

[-m]

Description

distributeProduct creates a product message and submits it for distribution across the AWIPS WAN to the addressed sites. *distributeProduct* first prepares the product by creating the WAN communications header and prepending the header to a temporary copy of the product. Distribution requests, enclosing the temporary copy of the product, are subsequently made to the x.400 Message Handling System through the *msg_send* utility program.

Options:

[-c action_list]

Specify action(s) which the receiving site is to take upon receiving the product.

Current action keywords include the following (keywords defined further below):

TEST_ECHO

AFOS_STORE_TEXTDB
AWIPS_STORE_TEXTDB
NWS_UPLINK

Multiple actions may be specified in a comma delimited list without intervening spaces. The action is matched against codes derived from the message receive table to determine the appropriate handling routine at the receiving site.

Default action: MHS default (code 134) -- message is stored in the default receive queue directory (/data/x400/msg/inbox/<msg_type>) and logged.

[-s subject]

Specify the subject of the message. The subject is an ASCII character string with a maximum length of 40 characters. The subject must be enclosed in quotes if it includes spaces or

tabs.

[-a address_list]

Specify list of non-acknowledging recipients of the product message. Multiple recipients are specified through a comma-delimited list using either the 3 letter AWIPS site identifier

and/or special address keywords. Address keywords include the following:

DEFAULT
DEFAULTNCF
NWSUP

Default addressee: DEFAULT

(Distribution lists defined in '/awips/ops/data/mhs' config files.)

[-p priority]

Specify the priority of the message. Supported values are 0, 1, and 2, with level 2 representing the highest priority.

Default priority: 0

[-t message_type]

Specify the type of message. Supported message types include the following:

- Routine
- Supplement
- Amendment
- Correction
- Status
- Test
- Timing
- Command
- Inhibit
- Clear
- Warning Received
- Special
- Administrative
- Routine Transmission Delayed
- File Transfer

The entire name must be specified. If the name of the type has multiple words, the name must be enclosed in quotes.

Default type: Routine

Note: *msg_send* provides acknowledgment message types which are not supported by *distributeProduct* at this time. (These types are omitted from the above list.)

[-e enclosure_pathname_list]

Specify enclosure pathname(s). The path to the enclosure file may be relative or absolute. Enclosure files or attachments may be either text or binary.

[-w wmo_special_message_type]

Specify the WMO message type.

The supported BBB indicator values are AAx, CCx, RRx, Pxx where x = A-Z. These forms are only included in the abbreviated headings of amended, corrected, delayed, or segmented bulletins respectively. The legacy forms of the BBB indicator, AMD, COR, and RTD, SUP, SPL are also supported.

[-d ddHHMM]

Specify the WMO message time stamp. This will default to the *current* system time if not supplied. Supported format:

ddHHMM = day of month, hour, min.

[-m]

Specify test or AWIPS pre-commissioned operational mode. This option generates a test WMO header which is then prepended to a copy of the product. If not specified,

distributeProduct uses a site's commissioning status to determine whether a test WMO header will be generated.

Required Arguments:

awips_id

Specify the AWIPS identifier (CCCCNNNXXX) for the product. The AWIPS identifier is used to compose the WAN communications header.

product_pathname

Specify the absolute or relative pathname of the product.

IMPORTANT NOTE: *distributeProduct* assumes that every line in the product body is terminated with a single character, which is either CR (ASCII code = octal 015) or LF (ASCII code = octal 012). *distributeProduct* will convert this character to the WMO standard end of line sequence CRCRLF (\015\012\012)

Address Keywords

DEFAULT

Specifies adjacent sites as addressees based on the product's WMO id. Default specification is site configurable.

DEFAULTNCF

Specifies the Network Control Facility (NCF) as the addressee. At the NCF, the product may be further routed over the SBN, over the NWWS up-link, to the

NWSTG, etc.

NWWSUP

Specifies a site's primary and backup NWWS up-link sites as addressees.

Action Keywords

TEST_ECHO

Echoes "Code 1", the message id, the message subject, the product pathname, and any enclosures to /tmp/msg_log.

AFOS_STORE_TEXTDB

Stores the product in the Informix database using the AFOS product identifier as the argument. The subject command line option (-s) must be specified with the AFOS

identifier as the argument.

AWIPS_STORE_TEXTDB

Stores the product in the Informix database using the AWIPS product identifier as the argument. The subject command line option (-s) must be specified with the

AWIPS identifier as the argument.

NWWS_UPLINK

Transmits the product over the NOAA Weather Wire Service satellite up-link. The subject command line option (-s) must be specified with the AFOS identifier as the argument.

Return Values

distributeProduct returns the following error codes:

0 = successful

-1 = error

> 0 = # failed messages

The number of actions approximately determines the number of messages created and submitted.

In addition, *distributeProduct* logs and prints to standard output the error messages returned by *msg_send*, which include the following:

- 1 Invalid message type.
- 2 Failed to create the message for some reason.
- 3 Failed to add an addressee to the message.
- 4 Failed to add an enclosure to the message.
- 5 Failed to add the subject of the message.
- 6 Failed to set the priority of the message.
- 7 Failed to add the body to the message.
- 8 Failed to submit the message.
- 9 Failed to assign a message id to the message.

Examples

```
> distributeProduct -a DEFAULTNCF KLWXZFPMD /test/KLWXZFPMD.dat
```

distributeProduct creates a product message addressed to the NCF. The message is sent at the default lowest priority level (0). At the NCF, a product look-up is performed and the product may be forwarded to the NWSTG, to the SBN, etc.

```
>distributeProduct -a NWWSUP -c NWWU_UPLINK KLWXZFPMD /test/KLWXZFPMD.  
dat
```

distributeProduct creates a product message addressed to the primary and backup NWS up-link sites for the sending site. At the receiving sites, the product is transmitted over the NWS up-link.

```
>distributeProduct -a NHDW -c TEST_ECHO -s "Testing" KLWXZFPVA /test/  
KLWXZFPVA.dat
```

A copy of the product /test/KLWXZFPVA.dat is created with the WAN communications prepended to it. The product is sent to the NHDW. At the NHDW, the action TEST_ECHO is executed -- which records the MHS message id, the subject, the filename, and any enclosures, to /tmp/msg_log.

```
>distributeProduct -a NHDW -c AFOS_STORE_TEXTDB -s WBCZFPVA KLWXZFPVA /  
test/KLWXZFPVA.dat
```

A copy of the product /test/KLWXZFPVA.dat is prepared for distribution. The prepared product is sent to the NHDW where it is stored into the text database using the AFOS identifier as the key.

```
>distributeProduct -a NHDW -c AWIPS_STORE_TEXTDB -s KLWXZFPVA  
KLWXZFPVA /test/KLWXZFPVA.dat
```

The prepared product is sent to the NHDW where it is stored into the text database using the AWIPS identifier.

```
>distributeProduct -a NHDW -c TEST_ECHO,AFOS_STORE_TEXTDB -s WBCZFPVA  
KLWXZFPVA /test/KLWXZFPVA.dat
```

The product is sent to the NHDW where 2 handling actions are taken: information is echoed to /tmp/msg_log and the product is stored in the text database using the AFOS identifier.

Log File

If distributeProduct is invoked from the as or ds, the log file resides in the following date directory:

```
/data/logs/fxa/<YYMMDD>
```

If distributeProduct is invoked from the workstation, the log file resides in the following date directory:

```
/data/logs/fxa/display//<YYMMDD>
```

where

DISPLAY is value specified by the DISPLAY environment variable. (If the DISPLAY variable is not set, a log file is created in the date subdirectory in /data/logs/fxa/display/:0.)

The name of the distributeProduct log file is:

pre-AWIPS 5.1.1 release log file format: distributeProduct<pid><host><HHMMSS>

There is a unique distributeProduct log file for any distributeProduct process run for that day.

AWIPS 5.1.1 release log file format: distributeProduct.log

The distributeProduct log file contains **all** logs for any distributeProduct process run for that day. This logging format is accomplished using the \$LOG_PREF file to control LogStream's logging format, which has been incorporated into the baseline delivery.

References

See *msg_send* documentation prepared by Michael Buchness, PRC.

See *LogStream* documentation.

Appendix 6

Tools to Monitor Application Performance and Resources

Once a local application has been developed, the developer must ensure that its execution does not consume undue resources. The following paragraphs discuss some of the tools that allow a developer to monitor resource utilization by an application. The process of optimizing an application so that it consumes fewer resources is beyond the scope of this appendix.

1.0 Online Documentation

Whereas documentation is not strictly a performance-monitoring tool, we discuss it first because it is the source of valuable information about such tools.

1.1 UNIX man pages

The first source of online documentation or help is the UNIX "man" pages, short for manual pages.

To see a man page for a UNIX utility program, type at the command line:

```
man utility_name
```

Thus to obtain detailed information about the vmstat utility, type at the UNIX prompt:

```
man vmstat
```

1.2 Other Documentation

The tools and utilities provided by HP that go beyond the normal UNIX utilities are not always documented in man pages. Rather, the documentation for them is on a compact disk. In order to be usable, the compact disk must be inserted into a local machine's CD-ROM player and mounted (ask the site administrator for help on doing this). To verify that the CD is mounted, log on to the machine where the CD is mounted and type at the UNIX prompt:

```
bdf
```

The CD is viewed through a utility that has both a character-oriented and a graphical user interface. In order to use the more convenient graphical user interface, you must export the machine's display to a workstation (again, ask the site administrator for help). Once the CD has been mounted and the display exported, type at the UNIX prompt:

from

You will then be given menus, dialog boxes, etc., which will allow you to navigate through the CD. The Hewlett-Packard web site, <http://docs.hp.com>, has excellent documentation also.

2.0 Glance/Glance Plus

Glance/Glance Plus (or just Glance, for short) is a system performance monitoring and diagnostic tool for local site use. It is bundled with the GlancePlus Pack and is available on the DSs and ASs. It is not normally available on the workstations although free temporary licenses can be obtained for a 90-day trial. Glance provides near-real-time performance information about a computer system, which allows a developer to examine the impact of his or her application on the system. Glance provides the ability to view detailed information on individual processes, including CPU and memory use and time spent waiting for different system resources. Glance has both a character-based and a graphical-user interface (GUI).

The character-based interface is called "glance" whereas the GUI is called "gpm." There are man pages for both tools. For detailed information, refer to the *HP GlancePlus/UX User's Manual* on the compact disk referenced above.

3.0 Informix

Informix provides several utilities to monitor the performance of the database engine. What follows is a brief overview of their capabilities. Detailed descriptions are available in the *Informix Performance Guide for Informix Dynamic Server*.

3.1 Onstat Utility

The Informix onstat utility is used to check the status of the Informix engine and monitor its activities. The utility provides a wide variety of performance-related and status information. The most useful option of the onstat utility is -g, which accepts further parameters. For detailed information about onstat -g arguments, refer to the *Informix Administrator's Guide*.

3.2 Onperf Utility

The Informix onperf utility monitors Informix engine performance. The onperf utility uses a graphical-user interface (GUI). The utility provides the same information as onstat, but graphically and in real-time. For a detailed discussion of onperf, consult the *Informix Performance Guide for Informix Dynamic Server*.

4.0 MeasureWare Agent

The HP MeasureWare Agent collects comprehensive operating system activity data. The MeasureWare Agent is installed on all AWIPS ASs and DSs to collect performance data.

The MeasureWare Agent provides data to PerfView (see Section 5.0) for analysis. MeasureWare Agent data can also be exported to a variety of third-party products for capacity planning, statistical analysis, and performance and resource management (see Section 6.0 on Extract/Excel for an example of how this is done).

MeasureWare collects data on three levels: global, application, and process. The first two items are of interest in this discussion.

Global and application metrics are summarized and logged at five-minute intervals. The definition of what constitutes global data cannot be altered; however, what constitutes application data is user-configurable.

In order to collect data that is relevant to the local application under development, changes must be made to a configuration file, */var/opt/perf/parm*. This configuration file is also known as the "parm file." For a detailed discussion of the contents of the configuration file, consult the compact disk (see Section 1.2 of this Appendix). Briefly stated, this is what is required.

First, a new application group must be defined; this is done by inserting a line of the form:

```
application = application_group_name
```

into the parm file. This insertion should be made at such a point in the file that the new application group is the first to be defined. For instance, if a local developer has developed an application called *xyz*, he or she would insert (with assistance from the site administrator, if necessary), verbatim, the following line into the *parm* file of the machine on which the application is to be run:

```
application = xyz
```

This insertion would be made immediately before the first application statement already in the file.

One then associates the names of executables with the application group by inserting a line or lines of the following form into the *parm* file immediately after the line that defined the application group name, as follows:

```
file = executable_name1, executable_name2, ...
```

To continue our example, if the developer's application consists of two executables called *xyz1* and *xyz2*, then the developer would insert the following line into the *parm* file immediately after the previous line

inserted:

```
file = xyz1, xyz2
```

Note that the full pathname must NOT be used for the executable name, only the name of the executable (strictly, the process) which would appear if one typed:

```
ps
```

at the UNIX prompt when the process was executing (see Section 8.0 of this appendix for more information on the `ps` command). This is an important distinction.

After making the changes to the *parm* file, the developer (and site administrator) should verify that the *parm* file is still valid by typing at the UNIX prompt:

```
utility -xp
```

This command invokes a program (called *utility*) which scans the *parm* file for errors and produces a report documenting the results of the scan. If errors are reported, then the *parm* file must be altered. The most common source of error is the following: the maximum number of application groups that can be defined is 31. Should this error be reported, the *parm* file must be modified, either by eliminating or combining application groups until the error is removed. When the *parm* file is error-free, the MeasureWare Agent must be restarted. This is done by typing at the UNIX prompt:

```
/opt/perf/bin/mwa restart
```

Execution of this command requires root privileges.

5.0 PerfView

HP PerfView Analyzer enables users to graphically analyze and document long-term, historical resource-utilization data collected by MeasureWare Agent. Note that this is in contrast to Glance, which is near real time but provides no long-term storage of results. Currently PerfView is installed only at the NCF.

PerfView at the NCF can be accessed over the wide-area network (WAN). To do this, log on to a workstation, from there, log on to em1-ancf as user "guest" with password "awips", export the display back to the workstation and type at the UNIX prompt:

```
pv
```

This will bring up the main PerfView display. PerfView has extensive online help. Nevertheless, the

basic idea is to establish a connection between PerfView and the machine that is to be monitored. In PerfView terminology, this is called "managing the machine." This is done by selecting the machine name from the list of available machines, or, if the machine name is not available, adding it to the list and then selecting it. It is possible to manage several machines simultaneously; this allows for the comparison of machines to each other.

Once the machine on which the local application to be evaluated is being managed, it is possible to view both global metrics and application-based metrics (see the discussion of MeasureWare Agent above for the distinction between global and application metrics). Given that there are several hundred metrics available, it is not possible to discuss them all in this appendix; in any case such a discussion would duplicate the online help.

The key metrics that should be analyzed are:

1. CPU utilization (denoted GLOBAL_CPU_TOTAL_UTIL and APP_CPU_TOTAL_UTIL, for the global and application CPU utilization, respectively)
 - a. peak disk utilization (PEAK_DISK_UTIL)
 - b. memory utilization (MEM_UTIL)
 - c. swapout rates (MEM_SWAP_RATE)
 - d. pageout rates (MEM_PAGEOUT_RATE)

The contribution of the locally-developed application to the global resource metrics should be monitored; if the application causes undue increases in global resource metrics, then consideration should be given to ways of reducing those increases. As a rule of thumb, global CPU utilization should not exceed 70%; global peak disk utilization should not exceed 50%; global pageout rate should be less than 5 per second; and global swapout rate should be less than 1 per second.

6.0 Extract/MicrosoftTM Excel

It is possible to view data collected by the MeasureWare Agent through third-party tools. This obviates the need to use PerfView over the wide-area network, but requires the development of custom scripts, spreadsheets, and graphics to view the results.

Some such development has taken place and will be summarized in what follows. Any additional customization would be the responsibility of the local site.

It should be noted that the use of the tools described in this section requires access to a desktop version of MicrosoftTM Excel, either Windows or Macintosh. If no such access exists, the reader should skip to Section 7.0.

6.1 Extract

To view data collected by the MeasureWare Agent, extract the data from MeasureWare Agent's log files using the HP utility called "extract." There is a man page for extract, and it is fully documented in the compact disk (see Section 1.2). To summarize, the following steps are required:

1. Set up a format file that the extract utility will use in extracting the data. This format file is fully described in the documentation but a useable sample file is at Exhibit A6-1.

```
FORMAT DATAFILE
HEADINGS ON
SEPARATOR=" "
SUMMARY=5

DATA TYPE

    LAYOUT=SINGLE
    OUTPUT=gb1.dat

    DATE
    TIME

    GBL_CPU_TOTAL_UTIL
    GBL_MEM_UTIL
    GBL_MEM_PAGEOUT_RATE
    GBL_MEM_SWAP_RATE
    GBL_DISK_UTIL_PEAK

DATA TYPE APPLICATION

    LAYOUT=MULTIPLE
    OUTPUT=app.dat

    DATE
    TIME

    APP_CPU_TOTAL_UTIL
```

Exhibit A6-1. Sample Format File

This format file should be called "*rept.all*".

2. Extract the data by typing, at the UNIX prompt:

```
extract -r rept.all -m -xp d-1 -GA
```

All of the arguments to the extract utility are documented in the compact disk, but the few that are relevant here can be summarized as follows:

- The -r option tells extract that a format file is to be used; the -r option is followed by the file name.
- The d-1 option tells extract to extract data for the previous full day (we do this because our spreadsheets are set up to display a full day's worth of data).
- Finally, the -GA option informs extract that we wish to extract both global and application data.

3. Running the extract command with the options given and with the sample format file above will create two new files: *gbl.dat* and *app.dat*. These filenames are specified by the OUTPUT parameters in the sample format file. Note that these files apply only to the server on which the extract command was run.

An alternative way to run extract involves using a script, as displayed in Exhibit A6-2:

```
source=/home/user/source          # customize to your name
target=/home/user/results        # customize to your name

for i in ds1 ds2 as1 as2; do
    echo    $1
    rcp     $source/rept.all $i:/rept.all

    echo generating files...
    remsh $1 "if /opt/perf/bin/extract \
                -r rept.all -m -xp d-1 -GA 2> \
                dev/null; then \
                    echo OK; \
                else \
                    echo not OK; \
                fi"

    echo    copying files...
    rcp     $1:/gbl.txt $target/gbl.$1
    rcp     $1:/app.txt $target/app.$1
    remsh   $1 'if rm gbl.txt app.txt rept.all; then \
                echo OK; \
```

```

else \
                                echo not OK; \
fi'
done

```

Exhibit A6-2. Sample Script.

The user planning on using this script should set up two directories under his or her home directory, one called *source* and the other called *results*. This user should then put the *rept.all* file discussed above in the *source* directory, along with the script. The first two lines of the script must be modified to reflect the user's actual name. After running the script, the results directory will contain eight files, named *gbl.ds1*, *gbl.ds2*, *gbl.as1*, *gbl.as2*, *app.ds1*, *app.ds2*, *app.as1*, and *app.as2*. These eight files will contain global and application data for the previous day for the four servers at the local site. These eight files should now be moved, by whatever means apply, to the desktop platform where Microsoft™ Excel is available.

6.2 Microsoft™ Excel

To display the data from the eight files on the desktop machine, the Microsoft™ Excel template file must be opened from within Microsoft™ Excel. Once the template file is open, it will display a special custom toolbar (see Exhibit A6-3). (Note: The illustrations are for a Mac. The tool bars will look similar on a PC since they are custom tool bars.)



Exhibit A6-3. Excel Toolbar.

6.2.1 Open Button



The Open button,  , is used to load the template with the data from the eight files. (Note that this button is not the same button as the Open button which Microsoft™ Excel supplies automatically and which sits on its own toolbar with New and Save buttons.) In order to load data, the user should press the button.

The template will respond with a modal OK-Cancel Dialog Box. The template will not respond to any other user actions until the dialog box is dismissed by pressing either the Cancel or the OK button. Pressing the Cancel button interrupts the process of data loading; pressing the OK button initiates it.

If the OK button is pressed, the template will begin to load data from the eight files into the template. Status messages about the progress of the load operation are printed at the lower-left corner of the screen.

Once data are loaded, the user should press the Annotate button.

6.2.2 Annotate Button



The Annotate button, , is used to give the graphs a unique identification. Once the user presses the Annotate button, the template responds with the Title Selector dialog box. Enter an appropriate title into the text-edit area and press the OK button. As usual, pressing the Cancel button at any time interrupts the operation and leaves the title unchanged.

After selecting the OK button, the template displays the Date Selector dialog box. Enter an appropriate date; usually this is the previous day--that is what the scripts are set up for. The title and date entered are used by the template to annotate the graphs that are produced. These annotations are useful in distinguishing graphs from one another.

6.2.3 Print Button



Use the Print button, , to print the graphs corresponding to the eight files discussed above. Once this button is pressed, the template will respond with a Copies Selector dialog box. Enter the number of copies wanted and press the OK button. The template will print the graphs on the printer attached to the desktop machine.

6.3 Modifying the MicrosoftTM Excel Template

To plot data associated with an application, the developer will need to modify the template file. Changes need to be made to two of the worksheets in the template. The first concerns the data worksheet, the second the graph worksheet.

The data worksheet is worksheet 1 in the template. To add a new column, copy an existing column to a blank area of the worksheet, directly adjacent to the last column being used. The user should then modify the top two cells in the column to reflect the file the data is to come from and the name of the application that was used to set up the parm file for MeasureWare Agent (see Section 4.0).

Then switch to the graph worksheet (worksheet 2). An existing graph should be copied to an unoccupied area of the sheet and modified to point to the column set up in the previous paragraph. These two steps are sufficient to allow the developer's data to be plotted.

7.0 ucron Utility

The ucron utility can be used to monitor cron activity. The ucron utility produces a character-based graphic for a given day that depicts the times at which cron jobs were started and for how long they ran. To use ucron, type:

```
ucron "Mmm<sp>dd"
```

at the command line. The surrounding quotes are required. The month for which information is wanted must be entered as a three-letter abbreviation with an initial capital letter. The space (<sp>) between the month and the day of the month is required, too. The day of the month must be entered either as two digits or as a single digit preceded by a space. Thus, to obtain a graphic for the 4th of January, type at the command line:

```
ucron "Jan 4"
```

To obtain one for the 29 of June, type at the command line:

```
ucron "Jun 29"
```

If the cron log file for the day of interest has been deleted, an error message is printed and the utility exits.

The output of ucron has two parts: the first part lists the cron jobs that cron kicked off during the day for which data was requested, the second part displays a timeline of cron activity during the day.

The first part of the output, as was mentioned, lists the cron jobs that were kicked off. For each cron job, the utility prints the command that cron executed as well as a column number; the column number is used in the second part of the output.

The second part of the output is a 24-hour timeline for the day requested. Data is provided every minute, so that, altogether, the timeline covers 24 hours times 60 minutes. For each time interval and for each cron job, the utility prints a symbol at the intersection of the row corresponding to the time interval and the column corresponding to the job. Thus, to find the activity for a particular cron job, one must examine the first part of the output to ascertain the column of the cron job, and then trace the timeline to determine the cron job's activity.

The symbols printed are as follows:

- an upper-case X in the column means that the cron started and completed in that one-minute interval;

- a slash (/) means that the cron started in the interval;
- a vertical line (|) means that it continued;
- a number sign (#) means that it completed;
- a question mark (?) is used to indicate that there was overlap in the running of a cron job (which means that the particular job in question is taking longer to execute than the time interval in which it is being scheduled. Either it must be made more efficient or the time interval must be increased.).

The output of ucron can be used to help determine when to set up cron jobs by identifying slack time periods during which they might be scheduled. It can also be used to determine if cron jobs are completing in a reasonable amount of time.

8.0 UNIX Tools

Table A6-1 briefly describes some of the UNIX tools that can be used to monitor the performance of an application. In all cases, the man page for the utility should be consulted for detailed information about its use. See Section 1.1 for information on how to use man pages.

Table A6-1. UNIX Tools

Utility	Description
vmstat	The vmstat utility displays virtual-memory statistics. It can be used to determine if an application is forcing a lot of paging or swapping to the disk.
iostat	The iostat utility displays I/O utilization statistics for all active disks on the system. It can be used to determine how much additional I/O an application is causing, above the I/O being caused by all other applications.
sar	The sar utility produces system activity reports of CPU, memory, and disk usage. The sar utility combines the functionality of several of the other tools discussed in this section, including vmstat, iostat, and top.
ps	The ps utility displays information about process states.
netstat	The netstat utility displays statistics for network connections and protocols.
top	The top utility displays, in near real time, the active processes that are consuming the most CPU.

APPENDIX 7

Suggested Format for Maintenance Documentation

The format of the NWS Computer Program Series (CPS) document and the AWIPS Application Library (AAL) document are the same. The format for external documentation for a complete program is shown below. A different format is used for subprograms that are part of an AWIPS local applications library group. The subprogram format is shown in Section 2.0.

1.0 Format for complete programs

The following organization should be used in preparing documentation for complete programs.

a. Introduction

Present a brief background discussion of the program and the reason for developing it.

- b. Methodology and Software Structure Summarize the flow of the program and the data in clear, simple statements that describe how the program works. Discuss any scientific formulas and mathematical algorithms to show the scientific foundation of the program. For C and FORTRAN programs, provide a figure to illustrate the relationship among, as applicable, the disk files (data files, control files, and static data), the Relational Data Base Management System (RDBMS), the program(s) or major processes, and the output data product(s) and/or the display. For C++ programs, provide a class diagram which shows categories, classes, attributes, methods, and relationships in a standard notation such as Booch-93.

c. Cautions

Describe program limitations that can affect the use of the program and its output. Include possible operational failures and restrictions on the interpretation of the output.

d. References

List references to the published material that is cited in the text. The American Meteorological Society's Journal Reference System is the accepted standard.

e. Information and Procedures for Installation and Execution

This section contains information needed by those who will be building and using the program. There are four parts, A through D:

Part A. Program Information. This part lists the program characteristics, system requirements, and the non-application-specific AWIPS system and hydrometeorological data files and RDBMS data that will be needed. This part also includes descriptions of any vendor-specific and non-standard software usage and hardware requirements needed by the application. The detailed contents of Part A are shown in Exhibit A7-1.

Part B. Program File and Database Information. This part contains a complete inventory listing of all source code for the program, a listing of all application-specific data files used by the program, and a description of any application-specific RDBMS databases and tables and database schema used by the program. The detailed contents of Part B are shown in Exhibit A7-2.

Part C. Program Creation and Installation Procedure. This part contains instructions for setting up the application environment, and for building and installing the program. It also contains a listing of any *tar* files in which the application source and/or data files are provided, and a description and listing of all makefiles needed to build the program. The detailed contents of Part C are shown in Exhibit A7-3.

Part D. Execution Procedures and Error Conditions. This part gives the running instructions that users are to follow, and the important error conditions that users may encounter. ~~This part is limited to two pages.~~ The detailed contents of Part D are shown in Exhibit A7-4.

If the program is sufficiently complex, a separate User's Guide should be developed to describe its use and included as an appendix to the documentation (see item g, below). In this case, Part D should reference and defer to the User's Guide.

f. Figures

Include figures as a group, unless they can be intermixed with the text for greater clarity. Make all captions descriptive. Design the graphics so that they are comparable in quality to graphics produced by the printer/plotter module. Graphics should be in softcopy (scanned, screen-captured, or drawn with a graphics package), in a format compatible with word processing packages, and incorporated into the document. For compiled code, a figure that illustrates the program structure by showing the main program and subprograms is optional but recommended. There are software analysis tools available centrally to automatically generate structure diagrams for C and FORTRAN applications; however, results vary depending on the type and complexity of the application. If desired, a flowchart of the program can be located in an appendix.

g. Appendices

Include pertinent information that is not suitable for the main body of the text. For example, error condition listings that cause the Execution Procedure section to exceed a 2-page space limit should be placed in an appendix. However, do list the most important error conditions in the Execution Procedure section. If a User's Guide is developed for the program, it should be placed here in an appendix.

An example program structure diagram is shown below. Such a diagram should show the flow of the main program from top to bottom and the flow of the subroutines from left to right. In this diagram, the main program, WSANAL, references first RDCOEF, then CRSSET, and so forth. Subprogram CNTR3 references COLPT, then MAXMNI, which references ASCII. Then CNTR3 references LABEL, which also calls ASCII.

MAIN PROGRAM

WSANAL

SUBROUTINES

RDCOEF

CRSSET

SMOOTH

CNTR3

COLPT

MAXMNI

LABEL

ASCII

ASCII

In general, the length of the documentation for a program will reflect the complexity of the program. In some cases, especially for relatively simple programs, Section I, INTRODUCTION, and Section 2, METHODOLOGY and SOFTWARE STRUCTURE, will be brief. Section 3, CAUTIONS, Section 4, REFERENCES, and Section 7, APPENDICES may be omitted.

The contents of Parts A, B, C, and D for a full program are outlined below. Sample formats are shown in Exhibits A7-1 through A7-4. Documentation for a sample program, which includes completed Parts A-D, is shown in Appendix E.

Appendix E has not yet been completed. It will be added at a later date.

1.1 Contents of Part A for Programs

Part A, Program Information, contains the following information:

Program Title.

The title for the program that appears in the CPS document. The title should be descriptive of the function of the program.

Computer Program Series (CPS) Identifier. The number given to the program by regional or NWS headquarters, and the date of the publication. This identifier will serve as a reference to the documentation for the program. If the program is not part of a formal CPS, the identifier is omitted.

Section 1.0: Program Name.

The name given to the executable file, or the script, command, or menu item that initiates the program. This section also includes the items:

- a. Part Of, which is the package or suite of applications (if any) to which the program belongs, or in which the program runs.
- b. AAL Identifier and Revision Number. This will be the AAL for the program. It is assigned by the AAL. Leave these items blank. The revision number for the first version of a program will be _____. As revisions are made to the program, the revision number will be assigned by the AAL librarian.

Section 2.0: Purpose.

A brief description of what the program does, the data on which it operates, and the output product(s), data, or display(s).

Section 3.0: Program Information.

This section includes:

- a. Development programmer(s) - the personnel responsible for designing, coding, and testing the program.
- b. Location, phone, E-mail - the site where the program was developed and phone numbers and E-mail addresses of the developers.
- c. Maintenance programmer(s) - the personnel who are responsible for the program after development and testing are completed, and who will be notified to make corrections, revisions, or enhancements, if necessary.
- d. Location, phone, E-mail - as in (b), but for maintenance programmer(s).
- e. Language - the language of the source code. Compiled programs will be either FORTRAN 77, C, C++, or a mix of these. Interpreted programs may be Perl, netCDF Perl, Tcl/Tk, etc. If there is a mix, each language and interpreter is specified. Also indicated is the revision number of the compiler or interpreter.
- f. Executable Type - classification of the program as:
 1. Standard - a non-interactive executable program unit consisting primarily of a compiled main program and subprograms. The program may have a user interface (of interpreted or compiled code) with which to specify run parameters, will run to completion with no further user input after the initialization parameters are specified. A standard program may also be initiated by a cron job, a script, from the command line, or by another application.
 2. Interactive - a program with a user interface and a child process which both remain active while data and/or the display are being modified or operated upon by the application.
 3. Interpreted - a program or module comprised of non-compiled code such as shell scripts, Perl, or Tcl/Tk. An interpreted module (e.g., a UI built in Tcl/Tk) may be a part of an Interactive or Standard program.
- g. Running time - the approximate running times (CPU time and Clock time) in whole seconds, when (if allowed by the application) run at the same time that normal AWIPS processes are running on the host machine(s). This applies to major subprocesses of primarily-interactive applications, not to the user interactions with the interface.
- h. Disk space - the total required disk space in units of bytes. A separate total is given for the executable program files, for all application-specific data files combined, and for application-specific RDBMS usage. It may be necessary to estimate requirements for data file space. The estimate should reflect a probable upper limit.

- i. Host Machine(s) - The hosts (check all that apply) on which major processes of the properly-configured program run. Does not include NFS access of data files residing on another machine's disks, or export of displayed output to another machine's monitor.

Section 4.0: AWIPS Data File/Data Base Access (non-application-specific).

This section documents the program's usage of existing AWIPS data sets from flat files and from the RDBMS. It is broken down into three subsections, described below.

Section 4.1: Data File Usage (flat files).

This section includes the following:

- a. Accesses AWIPS System/HydroMet Data Files? - enter YES or NO in the space indicated. If yes, then fill in list in b, below.
- b. List of AWIPS System/HydroMet Data Files accessed by the program. This is a table with columns for the following:

TYPE - the data type; e.g., Grids, Satellite, METARs, RAOBs

FORMAT - the file format; e.g., **netCDF**, native, plotfile

Subtype(s)/Subdirector(ies) - for grids, radar, satellite, or other data with various resolutions, channels, sources, etc., indicates the specific data accessed by the application (normally distinguished by their data subdirectories). Enter each subtype on a separate line, or enter ALL if application uses, or has a choice of, any or all subtypes.

READ/WRITE - enter R if the file is read by the application, W if the file is written or modified by the application, R/W if both.

Section 4.2: AFOS/Text Database Product Usage

This section includes the following:

- a. Accesses AWIPS Text Database? - enter YES or NO in the space indicated. If yes, then fill in list in b, below.
- b. List of AWIPS Text Database products accessed by the program. This is a table with columns for the following:

ID - The AWIPS PIL of the product read or created by the program, in **cccNNNxxx** format. The specific **NNN** product IDs are mandatory. Note that specific identifiers are capitalized; for example, a specific surface observation (METAR) is WBCMTRIAD. Generalized identifiers are not. A generalized METAR is **cccMTRxxx**. Site configurability or localization requirements for **ccc** and **xxx** should be indicated in COMMENTS.

READ/WRITE - enter R if the product is read by the application, W if the product is written to the Text Database by the application, R/W if both.

COMMENTS - Any other important information related to how the individual text products are handled by the program. If written PIL is not a known or existing ID, indicate in COMMENTS section.

Section 4.3: AWIPS RDBMS Database/Table Usage

This section lists all data directories and data files that are specific to this application program, both input and output data files.

This section includes the following:

- a. Accesses AWIPS Informix Database Tables? - enter YES or NO in the space indicated. If yes, then fill in (b), below.
- b. List of AWIPS RDBMS items accessed by the program. This is a table with columns for the following:

dbspace - the Informix **dbspace** under which the AWIPS database is located

DATABASE NAME - the name of the AWIPS Informix database used by the application

TABLE NAME - the name of the table in the given database

PRIVILEGES - the privileges required for the application to use the database table

Section 5.0: Portability

This section contains two items:

- a. Vendor-Specific Hardware Requirements - describe any dependencies that the program has on specific pieces of hardware.
- b. Non-Standard OS/Software/Compiler Extensions - describe any non-standard operating system dependencies, any extensions to the ANSI standards and/or exceptions to the AWIPS guidelines for the high-level languages (C, C++, FORTRAN) that are used in the source code, and any vendor-specific compilation options required by the code.

1.2 Contents of Part B for Programs

Part B, Program File and Database Information, contains the following information:

Program Title.

As shown in Part A.

Section 1.0: PROGRAM FILE INFORMATION

This section contains listings of all source and data files specific to the application. It consists of two subsections:

Section 1.1: Source file inventory

This section lists all source code directories and files needed to build the executable program. It contains two items:

- a. Directory Name - the absolute pathname for the single directory which contains the files listed in (b). If the files are packaged in a *tar* file, this should match the directory under which the files will be restored when the files are extracted.
- b. List of AWIPS System/HydroMet Data Files accessed by the program. This is a table with columns for the following:

FILE LISTING - this is a list of all source code files (**makefiles** included) for the program that are in the directory indicated in (a), above. This listing is extracted from the columnar format produced by the HP-UX *ls* command with the **-l -o -g -F** options in effect. A sample *ls* output line is shown below:

```
-rw-r--r-- 1 10190 Feb 11 1997 hmHMU_convGridToEarthWindComp.f
```

The file type and permissions (**-rw-r--r--**) and the number of links to the file (**1**) should be removed from the listing, leaving:

```
10190 Feb 11 1997 hmHMU_convGridToEarthWindComp.f
```

where **10190** is the file size in bytes, the next element (**Feb 11 1997**) is the last modification date/time (or date/year if older than 6 mos.), and **hmHMU_convGridToEarthWindComp.f** is the full file name.

LANGUAGE - indicates the programming language for the source code contained in the file.

Items (a) and (b) above are repeated for each source code directory pertaining to the program.

Section 1.2: Application-Specific data file inventory

This section lists all data directories and data files that are specific to this application program, both input and output data files. This section includes the following:

- a. Uses Application-Specific Data Files? - enter YES or NO in the space indicated. If yes, then fill in (b) and (c), below.
- b. Directory Name - the absolute pathname for the single directory which contains the files listed in (b). If the files are packaged in a *tar* file, this should match the directory under which the files will be restored when the files are extracted.
- c. List of files accessed or created by the program. This is a table with columns for the following:

FILE LISTING - this is a list of all data files for the program that are in the directory indicated in (a), above. The format of this listing is extracted from the columnar format produced by the HP-UX *ls* command (see item b in Part B, Section 1.1, [Source File Inventory](#)). For the case where new-named files are created by each run of the program, show the template for the filename surrounded by <angle> brackets and define the template immediately below the listing.

FORMAT - the format of the data file: ASCII, binary, **netCDF**, **shapefile**, Informix **unload** file, etc.

R/W/C/T - file status and disposition. Enter R if the file is read by the application, W if the product is written to or modified by the application, C if the file is newly created when the application is run, and T if the file is supposed to be a temporary file. Enter as many as apply, separate by slashes, e.g., R/W/C.

Items (b) and (c) above are repeated for each datafile directory pertaining to the program.

Section 1.3: File Disposition

This section should provide a set of comments relating to file status and disposition for each file in Section 1.2. Comments tell the user briefly how the data sets are created if they do not already exist. For output files or temporary files, comments tell the user the status and disposition of each file, whether the file is created by the user or the program, and whether the file is left on disk after the program completes.

Section 2.0: RDBMS INFORMATION

This section will be filled in for applications which use their own RDBMS tables. It consists of three subsections.

Section 2.1: Database/Table Usage

This section lists all data directories and data files that are specific to this application program, both input and output data files. This section includes the following:

- a. Uses Application-Specific Informix Database Tables? - enter YES or NO in the space indicated. If yes, then fill in (b) and Sections 2.2 and 2.3, below.
- b. List of application-specific RDBMS items accessed by the program. This is a table with columns for the following:

dbspace - the Informix **dbspace** under which the application's database is created

SIZE - the size of the disk allocation for the **dbspace** containing the database(s), in the units of 2 kilobyte disk pages

DATABASE NAME - the name of the Informix database used by the application

TABLE NAME - the name of the table in the given database

Section 2.2: Database Schema

This section contains information on table and column definitions, data types, lengths, key definitions, constraints, indexes, default values, privileges, etc., needed to recreate the tables in the database. The **dbschema** command for Informix can create a listing of commands needed to recreate the database and tables, and this information can be saved to a file. In that case, an inventory and description of the files that contain the schema can constitute the information in this section. If the database tables are created by another program through ESQLE, then this section may consist of a reference to that program's CPS.

Section 2.3: Data Dictionary

This section lists the plain-language definitions for the variables in each column in the database tables in (b), above. Indicates units, range, format, case sensitivity, optionality, and business rules applying to the variable.

1.3 Contents of Part C for Programs

Part C, Program Creation and Installation Procedure, contains the following information:

Program Title.

As shown in Part A.

Section 1.0: tar File Information

This section includes the following:

- a. *tar* file(s) provided? - enter YES or NO in the space indicated. If yes, then fill in (b), below.
- b. MEDIUM - If the *tar* files are delivered on a portable magnetic or optical medium, this indicates the type; e.g., 8mm tape, optical.
- c. LABEL - the identification on the label applied to the disk or tape.
- d. Listing of *tar* files containing the program's source code and data files. The format of this listing is extracted from the columnar format produced by the HP-UX `ls` command (see item b in Part B, Section 1.1, Source File Inventory).

Section 2.0: Program Creation and Installation

This section gives the details of the environment set-up needed for the program to correctly run, and the versions of the operating system, compilers, and other packages under which the executable code is built and run. It also describes procedures for installation of the executable program. There are four subsections to this section.

Section 2.1: Makefiles

This section should describe all **makefiles** associated with building the program, their locations in the source tree, their interdependencies, and order of execution. If the makefiles are not included in the source file inventory of Section 1.1 of Part B, then an inventory should be included here.

Note that if **makefiles** are not provided with the package (an undesirable option), then this section must include a full set of the compile and link command lines needed to build the program, including references to libraries (AWIPS and/or standard). The use of **makefiles** is strongly recommended.

Section 2.2: Application Environment

This section documents the types and versions of the operating system, compilers, and other COTS (Commercial, Off-The-Shelf) packages under which the executable code is built and run. It includes the following items:

- a. Operating System and Version - e.g., HP-UX 10.20
- b. Compiler/Interpreter and Version - e.g., HP FORTRAN 9000 version 9.0. This item is repeated for as many compilers, interpreters (e.g., Tcl/Tk), and COTS code packages as are involved in the program code.
- c. Environment Variables - Lists the names and definitions of all environment variables that need to be set for the application to be built and run. Only include those that are in addition to the AWIPS system environment variables required to be defined for AWIPS libraries or resources that are used by the application. The following four items are to be listed:
 - NAME: the full name of the environment variable
 - DEFINITION: the value of the environment variable

- RUN/SETUP: indicates whether the variable is needed for runtime (R) or for setup/creation of the program (S), or both (R/S)

- SCOPE

Section 2.3: Detailed Installation Procedures

This section describes all the steps involved in setting up the environment, configuring the system, building the application, installing the executables, and, as needed, file decompression, relationships to other programs, creating and initializing the data files, creation and loading of RDBMS tables, setting up **cron** jobs and scripts, and directions on running scripts to automatically perform any of the above.

Section 2.4: Installation Scripts

This section provides an inventory of any scripts that have been developed to automate the process of setting up the program build and runtime environments, and building and installing the program. It includes the following:

1. Directory Name - the absolute pathname for the single directory which contains the files listed in (b). If the files are packaged in a *tar* file, this should match the directory under which the files will be restored when the files are extracted.
2. List of script files needed by the program. This is a table with columns for the following:

FILE LISTING - this is a list of all script files for the program that are in the directory indicated in (a), above. The format of this listing is extracted from the columnar format produced by the HP-UX **ls** command (see item b in Part B, Section 1.1, Source File Inventory).

SHELL - indicates the programming shell language for the commands contained in the script.

Items (a) and (b) repeat for each directory containing program-related scripts.

1.4 Contents of Part D for Programs

The contents of Part D, Execution Procedures and Error Conditions, are outlined below. A sample format is shown in Exhibit A7-4. A sample program is shown in Appendix E.

Part D (of Subsection e, above) contains the following information:

Computer Program Series (CPS) Identifier.

Same as Part A.

Program Title.

Same as Part A.

Program Name.

Same as Part A.

AAL Identifier and Revision Number.

Same as Part A.

Program Execution.

List the steps that the user should follow in running the program. Any additional programs that must be run prior to running the program are indicated by their AAL identifier, CPS reference, or other generally recognized label. The commands and options/switches are specified and examples given. Completion messages should be given in a form that the user will recognize easily.

Error Conditions.

A list of possible error conditions that the user may encounter in an operational setting. Most disk processing error returns (reading

or writing) do not have to be included. However, programmed display messages to the user are necessary, especially if user action is required. The list of error conditions in this section should cite the messages that the user will see during execution, the location (logfile or screen) where the user will see them, a straightforward and clear description of what the error messages mean, and a course of action for the user to follow as a response.

2.0 Documentation Format for a Subprogram

The information required for the external documentation of a subprogram is nearly the same as that required for programs. All subprograms (functions, subroutines) that are modules of a library or are expected to be used in more than one program should be externally documented. The following organization should be used in preparing documentation for subprograms.

a. Introduction

Present a brief background discussion of the subprogram and the reason for developing it.

b. Methodology and Software Structure

Summarize the flow of the subprogram and the data in clear, simple statements that describe how the subprogram works. Discuss any scientific formulas and mathematical algorithms to show the scientific foundation of the program.

For subprograms that call lower routines or have direct inputs or outputs (i.e., other than the passed parameters), provide a figure to illustrate the relationship among, as applicable, the disk files (data files, control files, and static data), the Relational Data Base Management System (RDBMS), lower-level subprogram(s) or major processes, and the direct output data and/or the display. For C++, provide a class diagram which shows categories, classes, attributes, methods, and relationships in a standard notation such as Booch-93.

c. Information and Procedures for Installation and Execution

This section contains information needed by those who will be compiling and using the subprogram. There are four parts, A through D:

Part A. Subprogram Information. This part lists the subprogram characteristics, system requirements, and the non-application-specific AWIPS system and hydrometeorological data files and RDBMS data that will be needed. This part also includes descriptions of any vendor-specific and non-standard software usage and hardware requirements needed by the application. The detailed contents of Part A are shown in Exhibit A7-5.

Part B. Subprogram File and Database Information. This part contains a complete inventory listing of all source code for the subprogram, a listing of all application-specific data files used by the subprogram, and a description of any application-specific RDBMS databases and tables and database schema used by the subprogram. The detailed contents of Part B are shown in Exhibit A7-6.

Part C. Program Creation and Installation Procedure. This part contains instructions for setting up the application environment, and for building and installing the subprogram. It also contains a listing of any *tar* files in which the application source and/or data files are provided, and a description and listing of all makefiles needed to build the subprogram. The detailed contents of Part C are shown in Exhibit A7-7.

Part D. Manual Page for Programmers. This part is intended to give all the information that a programmer needs in order to use the subprogram in an application. It is an adaptation of the format and content of the *man* page for UNIX utilities. It includes calling parameters, **include** files, error codes, language, limitations, and an example of use. The detailed contents of Part D are shown in Exhibit A7-8.

The contents and instructions for Parts A, B, C, and D are outlined below. Sample formats are shown in Exhibits A7-5 through A7-8. Documentation for a sample program, which includes completed Parts A-D, is shown in Appendix E.

Appendix E has not yet been completed. It will be added at a later date.

2.1 Contents of Part A for Subprograms

Part A, Subprogram Information, contains the following information:

Subprogram Title.

The title for the subprogram that appears in the CPS document. The title should be descriptive of the function of the subprogram.

Computer Program Series (CPS) Identifier. The number given to the subprogram by NWS headquarters, and the date of the publication. This identifier will serve as a reference to the documentation for the subprogram. If the subprogram is not part of a formal CPS, the identifier is omitted.

Section 1.0: Subprogram Name.

The name given to the subprogram as defined in the code and used in the call to the subprogram. This section also includes the items:

- a. Library Name is the name of the library to which the subprogram belongs.
- b. AAL Identifier and Revision Number. This will be the AAL for the subprogram. It is assigned by the AAL. Leave these items blank. The revision number for the first version of a subprogram will be _____. As revisions are made to the subprogram, the revision number will be assigned by the AAL librarian.

Section 2.0: Purpose.

A brief description of what the subprogram does, the data on which it operates, and the output product(s), data, or display(s).

Section 3.0: Subprogram Information.

This section is the same as for program documentation, except for:

- a. Executable Type - not required
- b. Running time - not required
- c. Disk space - the subtotal given for the subprogram files is for the object files.
- d. Host Machine(s) - not required

Section 4.0: AWIPS Data File/Data Base Access (non-application-specific).

This section is the same as for program documentation.

Section 4.2: AFOS/Text Database Product Usage

This section is the same as for program documentation.

Section 4.3: AWIPS RDBMS Database/Table Usage

This section is the same as for program documentation.

Section 5.0: Portability

This section is the same as for program documentation.

2.2 Contents of Part B for Subprograms

Part B, Subprogram File and Database Information, contains the same information as for program documentation, except for the following:

Section 2.2: Database Schema

If this information has been documented for a main program, this section should consist of a reference to that program's CPS. If not, then this section contains the same information as for program documentation.

Section 2.3: Data Dictionary

If this information has been documented for a main program, this section should consist of a reference to that program's CPS. If not, then this section contains the same information as for program documentation.

2.3 Contents of Part C for Subprograms

Part C, Subprogram Creation and Installation Procedure, contains the same information as for program documentation.

2.4 Contents of Part D for Subprograms

The contents of Part D, Manual Page for Programmers, are outlined below. A sample format is shown in Exhibit A7-8. A sample man page is shown in Appendix E.

Appendix E has not yet been completed. It will be added at a later date.

Computer Program Series (CPS) Identifier.

Same as Part A.

NAME

This section contains two items:

- a. routine_name - the name of the function or subroutine as it appears in the call
- b. a short, one-sentence description of the functionality of the module

SYNOPSIS

This section lists all **include** files needed to use the subroutine in the calling routine, any FORTRAN COMMON used, and shows the calling sequence as shown in Exhibit A7-8.

DESCRIPTION

This section consists of six parts:

- a. A complete but concise description of the routine, with enough detail to let another application programmer determine what the routine does, and how it works. It should describe basic algorithms, list references, describe limitations on use, etc.
- b. A list of calling parameters. List parameters by name, show data type and input/output usage, and define all parameters individually as shown in Exhibit A7-8. If FORTRAN COMMON variables are used for input or output, indicate these variables and any block labels in the list.
- c. OUTPUT - This section describes all direct outputs such as file creation, file writes, and error logs and messages.
- d. RESTRICTIONS - Describes any limitations on use of the subroutine (singularities, size restrictions, disallowed parameter values, etc.).
- e. COMMENTS - Optional information about the algorithm, code history, etc.
- f. LANGUAGE - The language in which the subroutine or function is written.

RETURN VALUES

This section lists the return values and their data types, with a short description of each.

ERRORS

This section lists the valid errors for the subprogram. Each entry contains two items:

- a. ErrorCode - the value of the returned error code
- b. a plain-language description of the error corresponding to the error code

EXAMPLES

This section shows one or more source code examples containing a call to the function or subroutine, with all calling arguments defined and dimensioned, and all necessary include files declared. It should be a reasonably complete and useful snippet of code, not just a single line of code with the call to the subprogram.

SEE ALSO

This section should list the names of any related or subordinate functions or subroutines for which there are manual pages of documentation; for instance, a callable higher-level subroutine with more functionality.

EXHIBITS for Appendix 7

PROGRAM DOCUMENTATION:

Exhibit A7-1. Contents and format for PART A: PROGRAM INFORMATION.

Exhibit A7-2. Contents and format for PART B: PROGRAM FILE AND DATABASE INFORMATION.

Exhibit A7-3. Contents and format for PART C: PROGRAM CREATION AND INSTALLATION PROCEDURE.

Exhibit A7-4. Contents and format for PART D: PROGRAM EXECUTION AND ERROR CONDITIONS.

SUBPROGRAM DOCUMENTATION:

Exhibit A7-5. Contents and format for PART A: SUBPROGRAM INFORMATION.

Exhibit A7-6. Contents and format for PART B: SUBPROGRAM FILE AND DATABASE INFORMATION.

Exhibit A7-7. Contents and format for PART C: SUBPROGRAM CREATION AND INSTALLATION PROCEDURE.

Exhibit A7-8. Contents and format for PART D: MANUAL PAGE FOR PROGRAMMERS.

PROGRAM TITLE

PART A: PROGRAM INFORMATION

1.0 PROGRAM NAME:

AAL ID:

PART OF:

Revision no.:

2.0 PURPOSE:**3.0 PROGRAM INFORMATION**

Development Programmer(s):

Location:

Phone:

E-Mail:

Maintenance Programmer(s):

Location:

Phone:

E-Mail:

Program Language(s):

(e.g. C, FORTRAN, Tcl/Tk)

Executable Type:

(Standard, Interactive, Interpreted)

Nominal Running time - CPU seconds: _____ CLOCK seconds: _____

Disk space - Executable file totals: _____ bytes

Application-specific data file totals: _____ bytes

RDBMS table totals: _____ bytes

Host Machine(s): _____ Workstation _____ X-Terminal _____ AS _____ DS

4.0 AWIPS Data File/Data Base Access (non-application-specific)**4.1 Data File Usage (flat files)**

Accesses AWIPS System/HydroMet Data Files (YES or NO): _____

<u>TYPE</u>	<u>FORMAT</u>	<u>Subtype(s)/Subdirector(ies)</u>	<u>READ/WRITE</u>
-------------	---------------	------------------------------------	-------------------

4.2 AFOS/Text Database Product Usage

Accesses AWIPS Text Database (YES or NO): _____

<u>ID</u>	<u>READ/WRITE</u>	<u>COMMENTS</u>
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4.3 AWIPS RDBMS Database/Table Usage

Accesses AWIPS Informix Database Tables (YES or NO): _____

<u>dbspace</u>	<u>DATABASE NAME</u>	<u>TABLE NAME</u>	<u>PRIVILEGES</u>
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5.0 Portability

Vendor-Specific Hardware Requirements:

Non-Standard OS/Software/Compiler Extensions:

Exhibit A7-1. Contents and format for PART A: PROGRAM INFORMATION.

PROGRAM TITLE

PART B: PROGRAM FILE AND DATABASE INFORMATION

1.0 PROGRAM FILE INFORMATION**1.1 Source file inventory**

Directory Name (Absolute): _____

File Listing:

<u>SIZE</u>	<u>DATE/TIME</u>	<u>FILENAME</u>	<u>LANGUAGE</u>
10190	Feb 11 1997	hmHMU_convGridToEarthWindComp.f	FORTRAN

. (Repeat Directory Name and File Listing for each directory)

1.2 Application-Specific data file inventory

Uses Application-Specific Data Files (YES or NO): _____

Directory Name (Absolute): _____

File Listing:

<u>SIZE</u>	<u>DATE/TIME</u>	<u>FILENAME</u>	<u>LANGUAGE</u>

. (Repeat Directory Name and File Listing for each directory)

1.3 File Disposition**2.0 RDBMS INFORMATION****2.1 Database/Table Usage**

Uses Application-Specific Informix Database Tables (YES or NO): _____

<u>dbspace</u>	<u>SIZE (2K pages)</u>	<u>DATABASE NAME</u>	<u>TABLE NAME</u>

2.2 Database Schema**2.3 Data Dictionary**

Exhibit A7-2. Contents and format for PART B: PROGRAM FILE AND DATABASE INFORMATION.

PROGRAM TITLE

PART C: PROGRAM CREATION AND INSTALLATION PROCEDURE

1.0 tar File Information

tar file(s) provided (YES or NO): _____

MEDIUM:

LABEL:

File Listing:

<u>SIZE</u>	<u>DATE/TIME</u>	<u>FILENAME</u>
-------------	------------------	-----------------

2.0 Program Creation and Installation**2.1 Makefiles****2.2 Application Environment**

Operating System:

Version:

Compiler/Interpreter:

Version:

.
 . (Repeat Compiler/Interpreter and Version for each used)

Environment Variables:

<u>NAME</u>	<u>DEFINITION</u>	<u>RUN/SETUP</u>	<u>SCOPE</u>
-------------	-------------------	------------------	--------------

2.3 Detailed Installation Procedures**2.4 Installation Scripts**

Directory Name (Absolute): _____

File Listing:

<u>SIZE</u>	<u>DATE/TIME</u>	<u>FILENAME</u>	<u>SHELL</u>
-------------	------------------	-----------------	--------------

.
 . (Repeat Directory Name and File Listing for each directory)

Exhibit A7-3. Contents and format for PART C: PROGRAM CREATION AND INSTALLATION PROCEDURE.

PROGRAM TITLE

PART D: PROGRAM EXECUTION and ERROR CONDITIONS

PROGRAM NAME:

AAL ID:

Revision no.:

PROGRAM EXECUTION

1.

2.

3.

ERROR CONDITIONSERROR LOG MESSAGES MEANING

1.

2.

SCREEN MESSAGES MEANING

1.

2.

Exhibit A7-4. Contents and format for PART D, PROGRAM EXECUTION AND ERROR CONDITIONS.

SUBPROGRAM TITLE

PART A: SUBPROGRAM INFORMATION

1.0 SUBPROGRAM NAME:

LIBRARY NAME:

AAL ID:

Revision no.:

2.0 PURPOSE:**3.0 SUBPROGRAM INFORMATION**

Development Programmer(s):

Location:

Phone:

E-Mail:

Maintenance Programmer(s):

Location:

Phone:

E-Mail:

Subprogram Language(s): _____

Executable Type: _____

Disk space - Object file totals: _____ bytes

Application-specific data file totals: _____ bytes

RDBMS table totals: _____ bytes

4.0 AWIPS Data File/Data Base Access (non-application-specific)**4.1 Data File Usage (flat files)**

Accesses AWIPS System/HydroMet Data Files (YES or NO): _____

<u>TYPE</u>	<u>FORMAT</u>	<u>Subtype(s)/Subdirector(ies)</u>	<u>READ/WRITE</u>
-------------	---------------	------------------------------------	-------------------

4.2 AFOS/Text Database Product Usage

Accesses AWIPS Text Database (YES or NO): _____

<u>ID</u>	<u>READ/WRITE</u>	<u>COMMENTS</u>
-----------	-------------------	-----------------

4.3 AWIPS RDBMS Database/Table Usage

Accesses AWIPS Informix Database Tables (YES or NO): _____

<u>dbspace</u>	<u>DATABASE NAME</u>	<u>TABLE NAME</u>	<u>PRIVILEGES</u>
----------------	----------------------	-------------------	-------------------

5.0 Portability

Vendor-Specific Hardware Requirements:

Non-Standard OS/Software/Compiler Extensions:

Exhibit A7-5. Contents and format for PART A: SUBPROGRAM INFORMATION.

SUBPROGRAM TITLE

PART B: SUBPROGRAM FILE AND DATABASE INFORMATION

1.0 SUBPROGRAM FILE INFORMATION**1.1 Source file inventory**

Directory Name (Absolute): _____

File Listing:

<u>SIZE</u>	<u>DATE/TIME</u>	<u>FILENAME</u>	<u>LANGUAGE</u>
10190	Feb 11 1997	hmHMU_convGridToEarthWindComp.f	FORTRAN

.

. (Repeat Directory Name and File Listing for each directory)

.

1.2 Application-Specific data file inventory

Uses Application-Specific Data Files (YES or NO): _____

Directory Name (Absolute): _____

File Listing:

<u>SIZE</u>	<u>DATE/TIME</u>	<u>FILENAME</u>	<u>LANGUAGE</u>
.	.	.	.

. (Repeat Directory Name and File Listing for each directory)

.

2.0 RDBMS INFORMATION

2.1 Database/Table Usage

Uses Application-Specific Informix Database Tables (YES or NO): _____

<u>dbspace</u>	<u>SIZE (2K pages)</u>	<u>DATABASE NAME</u>	<u>TABLE NAME</u>

2.2 Database Schema

2.3 Data Dictionary

Exhibit A7-6. Contents and format for PART B: SUBPROGRAM FILE AND DATABASE INFORMATION.

SUBPROGRAM TITLE

PART C: SUBPROGRAM CREATION AND INSTALLATION PROCEDURE

1.0 tar File Information

tar file(s) provided (YES or NO): _____

MEDIUM:

LABEL:

File Listing:

<u>SIZE</u>	<u>DATE/TIME</u>	<u>FILENAME</u>

2.0 Subprogram Creation and Installation

2.1 Makefiles

2.2 Application Environment

Operating System:

Version:

Compiler/Interpreter:

Version:

. (Repeat Compiler/Interpreter and Version for each used)

Environment Variables:

<u>NAME</u>	<u>DEFINITION</u>	<u>RUN/SETUP</u>	<u>SCOPE</u>
-------------	-------------------	------------------	--------------

2.3 Detailed Installation Procedures

2.4 Installation Scripts

Directory Name (Absolute): _____

File Listing:

<u>SIZE</u>	<u>DATE/TIME</u>	<u>FILENAME</u>	<u>SHELL</u>
-------------	------------------	-----------------	--------------

. (Repeat Directory Name and File Listing for each directory)

Exhibit A7-7. Contents and format for PART C: SUBPROGRAM CREATION AND INSTALLATION PROCEDURE.

SUBPROGRAM TITLE

PART D: MANUAL PAGE FOR PROGRAMMERS

NAME

routine_name - one-sentence description of the routine's functionality

SYNOPSIS

Lists all necessary #include's, and shows the full call sequence, as below.

```
#include ...
```

```
#include ...
```

```
int routine_name ( first parameter,
```

```
    one parameter per line,
```

```
last parameter);
```

DESCRIPTION

Provide a complete but concise description of the routine--enough detail to let a potential user determine what the routine does, and how it works. Give algorithms, references, etc. Bold and italicize the parameter names when they are included in this description. List by name, show data type and input/output usage, and define all parameters individually as shown below. **If specific units are required for a parameter that is a physical variable, be sure to indicate that information .**

parameter_name - provide a description in sentence form. (TYPE) (**INPUT/OUTPUT**)

OUTPUT:

Describe all direct outputs such as file creation, file writes, and error logs and messages.

RESTRICTIONS:

Describe any limitations on use of the subroutine (singularities, size restrictions, disallowed parameter values, etc.).

COMMENTS:

Optional information about the algorithm, code history, etc.

LANGUAGE:

The language in which the subroutine or function is written.

RETURN VALUES

List the return values and data types, with a short description of each. Include units for physical variables.

ERRORS

List the valid error codes (if any) and describe each, as below.

ErrorCode - description

EXAMPLES

Show a source code example of a call to the function or subroutine, with all calling variables defined and (if FORTRAN) dimensioned, and all necessary `include` files declared in the calling code.

SEE ALSO

None, or list the names of any related or subordinate routines for which there are manual pages of documentation.

Exhibit A7-8. Contents and format for PART D: MANUAL PAGE FOR PROGRAMMERS.

Attachment 1

TDL FORTRAN Coding Guidelines

TECHNIQUES DEVELOPMENT LABORATORY

FORTRAN SOFTWARE DEVELOPMENT AND DOCUMENTATION GUIDELINES

FOR AWIPS DESIGN, DEVELOPMENT, AND TESTING TEAMS

Harry R. Glahn

1. INTRODUCTION

The software development and documentation guidelines contained in this document were created for use by the Design, Development, and Testing (DDT) Teams for the development of applications for AWIPS. These are teams led by Techniques Development Laboratory employees and include support contractors, including the AWIPS contractor, PRC.

Perhaps it is just as important to say what this document is not, as to say what it is. It is not intended to describe a complete software development method, complete with design documents, code reviews, test procedures, etc. Those are important concepts and are being implemented according to the Software Development Plan (Techniques Development Laboratory 1995).

The critical importance of developing well documented and well structured code has become more obvious with time. Except for, possibly, some small programs/subroutines written exclusively to test an idea or structure that will soon be discarded, Government developed software will be inherited and maintained by others. "Tricky" coding in the name of efficiency is to be avoided (although the definition of tricky will vary with individual).

It is imperative that we follow good coding and documentation rules in the development of all code, and in particular code that is to be handed off for use outside of TDL. Reasons include:

- Most development today involves more than one person. With several persons involved in a project, it is important that guidelines be followed so that all can easily "read" another person's program.
- Usually, it will fall to someone other than the originator to modify or maintain a program at some time in the future. Again, if a program has been written and documented according to prescribed rules, revisions and maintenance are much easier. This applies to external documentation as well

as the code itself.

- Code developed by the DDTs is for the express purpose of implementation and integration into a much larger system. If all such code (including locally-developed code from the field) follows the same guidelines, understanding and dealing with it will be much easier, and we will be able to answer questions more readily than otherwise. Documentation will, of course, be mandatory.
- Standardization will reduce errors in coding and keystroking. The eye and mind become accustomed to "patterns," and a break in pattern may be an error. If there are no established patterns in the code, or if the patterns are considerably different from those to which the reader is accustomed, this human error detection feature cannot operate effectively.
- Converting a body of software from one computer system to another is easier if it is all written and documented to the same standards.
- Persons writing code and having it keystroked by others need not explain a preferred format; it will already be defined. Documentation may be assigned to a person other than the one writing the code; an established procedure makes individual coordination on a documentation format unnecessary.
- New employees with little or no programming experience can be more easily trained in good procedures if those procedures are written down and everyone follows them.
- Some simple optimization procedures, if followed, can reduce execution time considerably. However, the primary purpose for these guidelines is not central processor optimization. Also, what is optimum for one system may not be for another.

In summary, the objectives of these guidelines are to enhance clarity, testability, maintainability, and person-to-person and computer-to-computer transferability of software throughout its life cycle.

Any system of software guidelines or standards is somewhat arbitrary. Different organizations have different standards, and textbooks do not agree. It is not so important exactly what the guidelines are, as it is that there be guidelines (assuming some semblance of reasonableness, of course).

This document contains coding guidelines for FORTRAN; a companion document contains guidelines for the C language.

2. FORTRAN CODING GUIDELINES

The programming language to be used is the version of FORTRAN appropriate to the platform for which the code is intended. FORTRAN 77 (or its successor FORTRAN 90 when available) shall be used whenever available. Vendor-specific extensions to the FORTRAN 77 standard can be used when they

conform to FORTRAN 90 standards; when they do not, they should not be used unless absolutely necessary.

Appendix 1 of the AWIPS Application Integration Framework Manual (AIFM) provides a code example to which the reader should refer when reading the following guidelines.

Documentation Block - Every program and subroutine must start with a documentation block following the outline in AIFM Appendix 1. Starting column convention is imposed to promote readability. Generally, in the absence of specific guidelines, standard typing rules should be used in preparing the documentation. If the system being used supports lower case characters as well as upper case, then it is optional which is used for the documentation block. Lower case for documentation does distinguish that material from executable code (which shall be upper case) but does add a degree of complexity and non-uniformity among programs/programmers.

Program Name - The first line should be the subroutine name starting in Col. 7. If it is a main program, and the compiler doesn't permit a program name, substitute a Comment statement with the program name.

Date, Programmer, Organization, Computer - Maintaining the exact date is not important; it is not used, for example, as the date the routine was added to the library. The month and year are sufficient. Starting in Col. 10, the date, the programmer's name, TDL, and the computer system the program was written for are each put on the third line, after a blank comment line, separated by three spaces. Extra lines should be used here to indicate modification dates, etc., as appropriate. Spacing may be adjusted to "line up" names, etc.

Purpose - Following another blank line, the next line should contain the word PURPOSE starting in Col. 10. Following that will be a short paragraph explaining the purpose of the routine. This need not be extensive, as details can be placed in the program writeup (external documentation). However, it should be complete enough to be useful to the user. If the routine was written specifically for a calling routine, the comment CALLED BY XXX is useful. Start all lines in this paragraph in Col. 14.

Data Set Use - After the paragraph on "purpose" and a blank line, the next line should contain DATA SET USE starting in Col. 10. Listed below this line will be data set names followed by a brief explanation of them (see AIFM Appendix 1). The explanation should state whether the data sets are input, output, or internal. If no data sets are used by this routine, put NONE on the line following DATA SET USE.

Variables - The statement following those explaining data set use should contain the word VARIABLES starting in Col. 10. Following that, most, if not all, variables used in executable statements in the program should be defined in the format shown in AIFM Appendix 1. The equal sign should be in Col. 23 followed and preceded by one space. All lines except the one

defining the variable start in Col. 25 unless some further indentation seems appropriate, such as in lists. (Standardization here will allow copying from one routine to another when the variable is used in more than one routine. However, many times the explanation will have to be changed slightly for it to pertain to a particular routine.) Variables appearing only in COMMON need not be defined, but when a variable is used in COMMON and in other places in the routine, it must be defined. Variables used only to pass on to another subroutine should be defined, but is not mandatory. The cross reference list of the compiled source will identify where the variable is passed on.

List all variables in the subroutine call sequence, if any, first and in order. No other ordering is mandatory, but some logical sequence should be used and the best one to use may depend on the routine. The ordering might be alphabetical, especially if there are many variables. The order could be the approximate order the variables are first used in the program, especially the input variables; having the definitions of the input variables from an external source all in one place, and in order, has proven to be very useful. For each variable that is in the call sequence, place at the end of the comment either (INPUT), (OUTPUT), (INPUT-OUTPUT) or (INTERNAL) to indicate its use in the subroutine. (This is not appropriate for a main program.) This should also be done for variables actually used that are in COMMON. If, and only if, the type of variable is other than INTEGER*4 or REAL*4, place the type in parentheses at the very end of the comment, e.g., (CHARACTER*5).

Another option for grouping variables (other than those in the call sequence) is to have sections headed INPUT, OUTPUT, etc. (starting in Col. 14) and to put the appropriate variables under these headings.

Non-System Subroutines Used - The non-system subroutines used in the program are listed, separated by a comma and space and indented to Col. 14, following the section heading NON-SYSTEM SUBROUTINES USED, starting in Col. 10.

Declarative and Data Statements - Such statements, if any, should immediately follow the documentation block. An order such as PARAMETER, COMMON, TYPE, DIMENSION, EQUIVALENCE, and DATA is appropriate. Always use PARAMETER first, and DATA last.

PARAMETER - PARAMETER statements shall define a variable only where a DATA statement will not suffice, namely, in the definition of variable array dimensions or, rarely, when a computation is desired within the definition to retain the computed formula. The cross-reference lists provided by some compilers do not treat variables defined with PARAMETER statements the same way as other variables, and some ignore them altogether; this makes checkout more difficult. This convention will let the user know that any variables defined in PARAMETER statements are variable dimensions.

COMMON Blocks - COMMON blocks should be used sparingly, if at all. Generally, code is

easier to follow when the variables needed are passed through the call sequence rather than in COMMON, especially when some of the variables in the COMMON are used and some are not. Having variables in COMMON can also make it difficult to modify a program that has many subroutines. In any case, all COMMON should be labeled. The name of the block should be rather unique to keep to a minimum conflicts that might arise when a routine is used by others. For instance, XXXONE might be a good name for a program named XXX; this would be better than BLOCK1.

Type Statements - Type statements should not be used unless the type is "unusual." The CHARACTER type is unusual in this sense and is needed for character variables. Do not use type statements for REAL*4 or INTEGER*4 variables. (See Variable Naming below.)

Variable Naming - The FORTRAN predefined specification of integer and real variables shall be followed--INTEGER(I-N), REAL(A-H,O-Z). By using this convention, it is much easier to catch integer/real conversion errors than if the reader has to remember the type of all variables in a specific routine. With the advent of FORTRAN 77, reserving the letter "C" for CHARACTER variables in new code is recommended. Do not use the IMPLICIT statement. For maximum portability, limiting the variable name to six characters is advisable, but not imperative. Variables used for only one purpose (e.g., to hold values of dew point temperature) should be given easily recognizable names (e.g., DEWP). (Using an array for multiple purposes may make this difficult, if not impossible, but equivalencing should not be used to overcome the difficulty.) Generally, the use of single characters, such as "I" and "J," should be reserved for DO loop indices. In two-dimensional grid indexing, the use of "IX" for left to right and "JY" for bottom to top is a good practice, and the convention of using the first index to refer to the "IX" direction is mandatory. When a variable is passed to another routine, whenever practical use the same name for the variable in both routines.

EQUIVALENCE Statements - Equivalencing variables tends to make code harder to follow, and encourages mistakes. It may also hinder optimization in some compilers. Only in special cases or where much memory can be saved should equivalencing be used, or where character information must occupy an INTEGER or REAL variable.

DATA Statements - When values are specified in DATA statements, try to arrange them so that they can be easily read. This is especially important for multiply dimensioned arrays. Put on separate lines whenever practicable values pertaining to different dimensions.

In-Line Documentation - In-line documentation should be provided at appropriate points in the program. Somewhere between 10% and 50% of the total lines should be devoted to documentation (besides the documentation block). The comments are used to explain the code and should be subordinate to it. Therefore, with code that has executable statements starting in Col. 7, start all comments in Col. 10. One should expect to "read" the code with explanation by the comments, rather than vice versa. (Indentation for IF THEN ELSE structures with accompanying comments will be treated later.) A block of code can

be explained before the block by comments separated above and below by a blank line ("C" only on the line). A single line of code can be explained by a single comment following (or preceding) the executable line with no blank line. A comment should be used to explain the purpose of a called subroutine. Comments can be either upper or lower case, but the usage shall be consistent within a routine. Clarity is many times enhanced by inserting a blank line after a branch-type instruction. Comments are not to be put on the same line as an executable statement following an "!".

Length of Programs - Program (subroutine) length (number of lines of executable code) should be governed by the function of the routine, and not by some arbitrary rule such as "all programs will be between 10 and 100 lines of code." A specific maximum size is not as important as convenient program structure. Modularity is important when meaningful, and it usually is.

Top Down Coding - Program flow should be from the top down. With the IF THEN ELSE type of structures of FORTRAN 77, this is always possible with enough nesting. It is usually possible to do this even when the GO TO construction is used. Some slight duplication of code may be preferable to branching. In all cases, it is the clarity of the code that is important. It may be confusing to have nests more than, say, 6 deep. On the other hand, if a program essentially repeats itself when input data so indicate, a branch from somewhere (usually near the end) back to (near) an input statement should not be confusing, and may be more "natural" than trying to accommodate this option with an IF THEN ELSE construction.

Statement Labels - Statement labels should always start in Col. 2, no matter how many digits they contain. Number only those statements to which reference is made (i.e., only those it is necessary to number). Most cross reference lists will indicate any statement numbers that can be removed.

Some logical numbering sequence must be followed. Some possibilities are:

The numbers range from 1 through 9999 and be in sequence.

The numbers always contain 4 digits and be in sequence.

The primary numbering system start at 100 or above and end at 999, but, upon revision, when it is necessary to insert more numbers than space has been provided for, a fourth digit is added. Since all numbers start in Col. 2, they "appear" to be in order even though 1115 comes between 111 and 112 (this may be slightly inconvenient in some compiler's cross reference listings, as all 3-digit numbers may precede 4-digit numbers). Although this method may seem at first glance to be more complicated, it is really very simple and workable.

Statement Format - For programs that are basically not in the IF THEN ELSE structure, start all statements (except comments) in Col. 7. Continuation statements should be indented by at least 5 spaces unless there is a reason to do otherwise (a FORMAT statement can usually be split between lines with no problem--even a string of characters can be stopped and restarted on another line). Limit the line

length to the FORTRAN 77 standard, 72 characters.

Statements should not include blanks unless they are necessary to improve readability. Establish a pattern and stick with it. Examples as used in TDL programs are:

```

SUBROUTINE INTR(P,BY,BX,BB)
DIMENSION SAVE(2,2),P(61,81)
EQUIVALENCE (P(1,1),NPK(1)),(X,Y)
COMMON/M400/VRBL1(10),VRBL2(10)VRBL3(100),
1 VRBL4(1000)
CALL RDMOSH(N,NWDS,NROWS,NCOLS,JDATE,NERR)
WRITE(KFIL12,130)KDATE(MT),JDATE
130 FORMAT(' THERE IS A PROBLEM WITH THE INPUT DATA NEEDED, KDATE ='I8,'. ',
1 ' DATE FOUND IS ='I8)
X=IB(J)+IA(K)+3*(K+IC(J)**4)+M/N
CHARACTER*3 CWSFO,CNODE,CTIME(10)
DATA NCRIT/2,1,1,1,1/
PARAMETER (ND2=41,
1 ND3=39)
STOP 115

```

Note that a comment following an "!" shall not appear on the same line as an executable statement.

Continuation Lines - Continuation lines can be denoted by the sequence of numbers 1 through 9, then alphabetically starting with A. Occasionally, it may be desirable to start the sequence with 2 rather than 1 in DATA statements. As an option, the same character can be used for all continuation lines.

Spaces Versus Tabs - When spacing over to where a statement, statement label, or comment is to start, use the space bar, not the tab.

CONTINUE Statements - Continue statements should be used only where necessary, except a CONTINUE is always used at the end of a DO loop. End each DO loop with a separate CONTINUE statement even though this is not logically necessary. This serves the purpose of notifying the "reader" that this is the end of a DO loop, and may aid in optimization for some compilers. Each nest of a nested DO loop will have its own CONTINUE.

DO Loops - A blank comment should immediately precede a DO statement and follow the DO loop's CONTINUE statement. For very short, multiple nests, a separate blank for each loop is not needed.

FORMAT Statements - Format statements should be used in the code where they are referenced, and should be numbered in sequence along with other numbered lines. A FORMAT statement should immediately follow the first I/O statement which refers to it. For ease of possible later modification, it may be best to duplicate a FORMAT statement, except for its number, so that it can be with the statement that refers to it. If multiple statements refer to the same FORMAT, later modification may remove (or renumber) the FORMAT, even though it is referred to elsewhere in the program, and a compile error will occur. When looking at the printed output and the code that produced it, it is much easier to match the output to the FORMAT statement when the FORMAT and the I/O statement are together.

Indention - Several rules for indention of statements are given above in connection with other topics. In general, when the GO TO structure predominates, start executable statements in Col. 7 and comments in Col. 10. For IF THEN ELSE structures, some indention shall be used. One option is to indent each "nest" another 3 spaces. Comments could be indented 3 more spaces. Whatever convention is adopted for a routine, it must be used consistently within the routine.

I/O Device Reference - Device reference by FORTRAN number should be with an INTEGER variable, not a constant. For main programs, this variable should be given a value in a DATA statement. For subroutines, this variable should be passed through the argument list, after being defined in the main program. In some cases, it may be more convenient to read the variable name from a control file. A convenient convention is KFIL1 for Unit No. 1, etc. A device reference number should always be passed to a subroutine to be used for the default output. A convenient name is KFILDO and if used consistently can be easily identified for that purpose in all routines.

Variable Dimensions - Whenever there is a chance that the dimensions of a variable will be changed, and always when the dimensions are referred to in other statements (for example, to keep from overflowing the array), the dimensions should be declared by defining a variable in a PARAMETER statement. The actual number should never be referred to in the code, but rather referred to by the variable name used in the PARAMETER statement. Usually, variables and their dimensions should be carried to subroutines through the argument list.

Subroutine Call Sequence - No matter what rules are established, exceptions will occur. Common sense must prevail. However, to the extent practicable, the order should be as follows:

- If data set reference numbers are provided, put them first.
- Other input to the routine should follow.
- Variables used for both input and output or work area should then follow.

Output variables, ending with an error (return) code (if any) and finally the alternate return symbol(s) (return to a statement number--FORTRAN 77 uses an * for this purpose in the

SUBROUTINE statement) should come last. Alternate returns should be used sparingly, as following the program logic is usually more difficult than using an error (return) code and checking it for desired branches. However, alternate returns are very useful in some situations (e.g., repeated calls to a subroutine where the same action is to be taken for all such returns).

Variable dimensions for an array or arrays should follow the last array name in which they are used. Multiple dimensions passed for an array should occur in the same sequence as they occur in the DIMENSION statement. For extensive call sequences, the dimensions could all be put together near the end.

Subroutine Entry Points - Each subroutine should have only one entry point. Do not use the ENTRY statement.

End of File and Error Checks - Error checks for input should be used. Errors can be indicated by an error code returned to the calling routine (preferably with a print--actually a WRITE to the unit KFILDO--of the diagnostic in the routine itself and with the value returned in the variable IER), or exit can be made to an error handling routine. In case the error is fatal, it may be all right to stop in the routine itself with an appropriate diagnostic (see Program Termination below).

Error Codes - Whenever possible, the "no error" condition should be "0." Use these as INTEGER variables, not as, for example, LOGICAL.

Non-Standard Features - Most compilers will permit use of some non-FORTRAN 77 features. Sometimes a FORTRAN 77 statement and its older counterpart (e.g., FORTRAN 66) may both work. When converting a program to FORTRAN 77, if the compiler does not flag the "error," it may go unrecognized; this is inevitable. However, we should stick to the FORTRAN 77 version as best we know it and can. System subroutines whose likelihood of being used by another compiler is not high should be avoided.

Indexing Variables with Multiple Dimensions - Whenever practicable, in nested DO loops, index the first variable indexed with the innermost DO. This is computationally more efficient for some compilers and may help to reduce paging in large, complex systems. It may be impossible to always follow this rule, but it shall be followed whenever it is reasonable to do so.

Program Termination - Generally, main programs should indicate in the normal print medium a successful completion, such as "XXX COMPLETED," where XXX is the program name. Any other stop should:

Produce in the print medium an indication of the problem and where the stop occurred. The latter can be done by using a statement such as "STOP AT 1013" where 1013 is the statement number at or near where the stop occurred. The termination of the program should be with the statement STOP 1013.

If the stop is in a subroutine, an error statement which includes the subroutine name should be printed, such as "STOP IN XXX AT 1013" where XXX is the subroutine name and 1013 is the statement number at or near where the stop occurred. The reason for the stop with values of pertinent variables should also be printed if such would be helpful. The termination of the subroutine should be with the statement STOP 1013. A little time spent arranging for this diagnostic may save much time later on.

Generally, it is better to return an error code from a subroutine rather than to terminate when there is a problem; this should be done if the user can exercise judgment about how to proceed. However, if the error is unrecoverable, or if in the judgment of the author of the subroutine it would definitely be a mistake to continue, the stop can be in the subroutine. (The best procedure to use may vary with circumstance; a STOP in a subroutine may be prohibited in "operational" jobs.) In any case, the user must always be protected from bad results or data.

Printed Output - Output to be printed should be arranged in an easy-to-read format. For instance, line up columns of numbers. Also identify values printed in well-understood terms or in terms of variables defined in the program writeup.

3. REVISION OF EXISTING CODE

Much of the development done centrally and locally will consist of revision of existing code gathered from various organizations. Needless to say, this code will come in varying forms of completeness and documentation. When the decision is made as a group effort as to which code to use, it will be determined as to how much to make the code conform to the guidelines. For extensive rewrites, it may be advisable to make it roughly conform. However, for more minor changes, it will be better to follow the "style" of the existing code (provided, it has a consistent style). Two conflicting goals can provide some guidance: (1) Use existing code as much as possible, and (2) make sure each module is well structured and documented, as well as being reasonably efficient and fulfilling the required functions. Note that it is not necessary to remove all "GO TOs" to achieve optimum metrics.

4. DOCUMENTATION

External documentation will follow the standards defined in Appendix 4 of the AWIPS AIFM.

5. AWIPS SPECIFIC COMMENTS

At this writing, a number of issues regarding integration of code into AWIPS are unknown. For instance, the way error logging and user notification are to be treated are not defined.

6. REFERENCES

Techniques Development Laboratory, 1995: Software Development Plan for Producing WFO Hydrometeorological Applications for AWIPS. National Weather Service, NOAA, U.S. Department of Commerce, 18 pp. plus attachments.