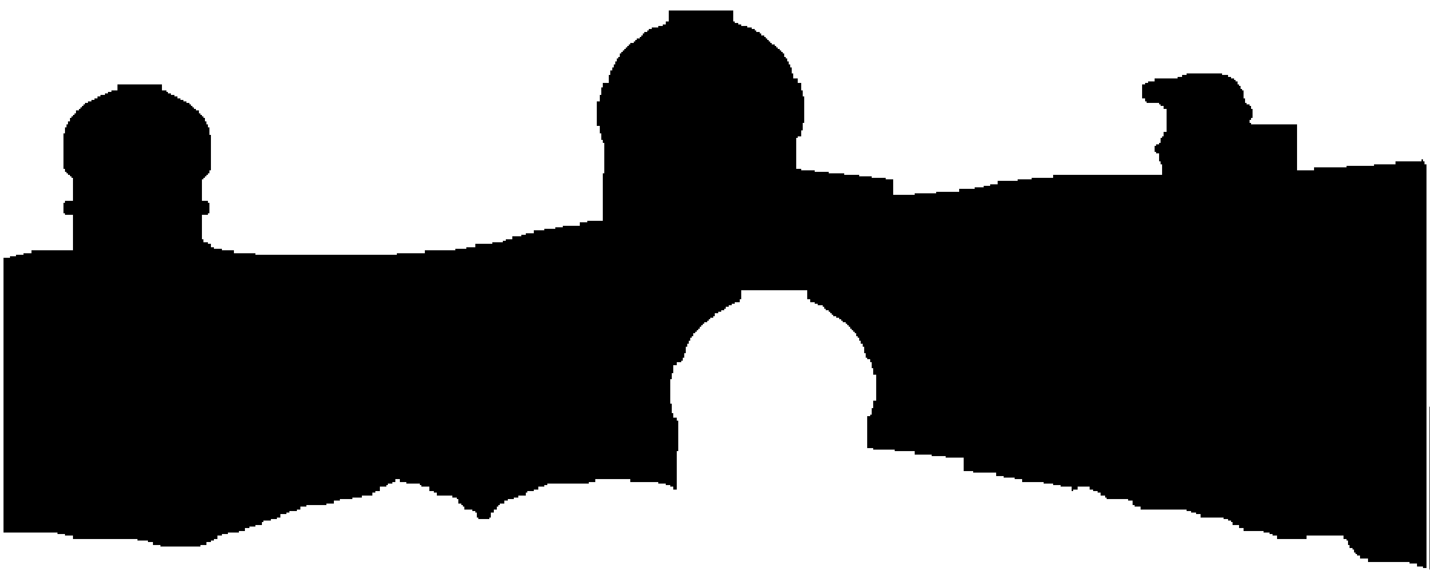
GEMINI
8-M Telescopes
Project

SPE-C-G0077
Revision 3.0

Weather Server Software Design Description



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Revision Control

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2. Revision Version 2.0
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   Revised by: Joseph Jensen
   Reason for / items changed: Added WS GUI specifications, etc.

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1.0 Description and Introduction

1.1 Purpose of this document

This document describes the software design associated with the Gemini Weather Server (WS), a principle subcomponent of the Environmental Monitoring System (EMS). Software specifications are included to guide construction of the graphical user interface (GUI) to the WS, and to assist in designing software interfaces to other systems.

1.2 Scope of this document

A brief overview of the purpose of the WS is included, along with a description of the functionality of the WS and its GUI. This document does not describe the software required for the Monitoring and Metrology (M&M) system, the other main component of the EMS. Interfaces to the EMS (both internal and external) are described in ICD 3.21.

1.3 Purpose of the EMS

The Environmental Monitoring System (EMS) is designed to provide critical environmental information to observatory staff and control systems to (a) protect the telescope and enclosure, (b) improve observing efficiency by allowing astronomers to adapt to changing weather conditions, and (c) control mirror temperature and wind-gate positions to minimize dome and telescope seeing. The EMS is comprised of two principal subsystems. The Weather Server (WS) monitors wind speeds, relative humidity, etc. both inside and outside the dome, retrieves weather data and forecasts from external (internet) sources, presents weather data to observatory staff, and archives relevant data in the engineering archives. The Monitoring and Metrology (M&M) subsystem combines engineering data from a large number of sensors (temperature, strain gauges, etc.) distributed throughout the enclosure which is used to optimize performance of telescope control servo loops and protect telescope systems from damage.

1.4 Purpose and Functionality of the Weather Server

The WS collects environmental data and presents relevant data to astronomers and operators in a format to facilitate efficient observing. Data is collected from a heterogeneous set of instruments, both inside and outside the enclosure, and from various internet sites. Dangerous weather conditions are identified and EPICS alarms set to protect the telescope and enclosure. A subset of the data is saved in the engineering archive. Weather server data must be available 24 hours a day to allow Gemini staff to plan queue observations and control mirror temperature to match the forecast temperature at the beginning of the night.

The WS receives data from the following sources:

a. Temperature, relative humidity, dew point, barometric pressure, wind speed, and wind direction from the Gemini/CFHT weather tower (Mauna Kea) or the Gemini weather station (Cerro Pachon)

b. Temperature, relative humidity, and dew points near the primary and at the top of the enclosure
c. Wind speeds through the wind gates
d. Airborne particulate count
e. Atmospheric seeing monitor
f. All-sky cirrus monitor
g. Satellite images
h. Weather forcasts
i. Radio optical depth (CSO tau meter, Mauna Kea)
j. Meteorological data from other observatories (e.g., UKIRT)

The WS provides data to the following systems:

a. The TCS and OCS receive wind, dust, and humidity data for normal operation and warnings of dangerous weather conditions.
b. The ECS needs wind data through the wind shutters and set-point temperatures for the primary mirror.
c. Selected weather data are saved in the Engineering Archive

The lists above are meant to be introductory, not comprehensive. The appropriate ICDs should be referenced for detailed interface information. Additional data sources and devices will be identified in the future.

2.0 Configuration

The WS runs on a host Unix workstation and target VxWorks IOC running EPICS with channel access (CA) communications. The EPICS system also provides a status-alarm database (SAD) for monitoring and logging by control systems. The Unix workstation provides engineering screens to the operator to monitor the local and remote sensors.

Weather sensors within the enclosure (wind speed, relative humidity, dust count, etc.) are controlled by the WS, although some of the data may be exported to other sites. The sensors are operated by the VxWorks IOC via either serial port or network interfaces. Some sensors on the telescope structure may be accessed via the M&M nodes through the MCS. Sensors located outside the enclosure but operated by Gemini (such as the seeing monitor) will also be operated by the IOC and accessed via serial port.

Remote sensors operated by other observatories (the Gemini/CFHT weather station, for example) will provide their data to the Gemini WS through various network mechanisms (HTTP or CA). These sensors will be read through the VxWorks IOC network interface. Satellite images will be downloaded by the Unix workstation through its own network connection to avoid loading the IOC with large data sets.

3.0 IOC

The IOC consists of a VME crate, CPU with serial and ethernet ports, the VxWorks operating system, and the EPICS control system. It is anticipated that the EPICS WS database will share the OCS IOC. Impact on the OCS CPU should not be greater than about 5% of total CPU and memory resources as long as images (satellite images or all-sky cloud images) and data retrieved via internet links are handled by the Unix workstation rather than the IOC.

3.1 Qualimetrics Weather Station (Cerro Pachon)

The Qualimetrics weather station communicates through an RS-232 serial cable attached to its communications module and one of the WS's serial ports. The communication protocol is described in the Qualimetrics User Manual. In brief, a command string is issued to the weather station and a reply string consisting of the current sensor probe readings is returned. The weather station has sensor probes for temperature (C), both at the bottom and top of the tower, barometric pressure (mb), relative humidity (%), dew point (C), solar radiation (W/m2), wind speed (mph), and wind direction (0-360 degrees).

The VxWorks operating system has software driver support for the MVME-167 serial ports. In addition, EPICS serial driver support has been written for other serial devices. The WS has additional EPICS driver and device support for the communications format of the Qualimetrics weather station. This support performs the function of periodically commanding the weather station to return sensor probe readings.

EPICS device support interfaces the Qualimetrics driver with EPICS *analog in* ("ai") records. Device support at the EPICS level consists of INST_IO support with a two word input ("INP") link string containing the serial port name and the Qualimetrics weather station channel. The serial port name will look similar to the string "/tyCo/1" while the station channel will be an integer between 1 and 5. It is the responsibility of the EPICS database to map the appropriate channel number to the correct data.

Additional EPICS device support exists to send asynchronous commands to the Qualimetrics weather station. These commands may reset the weather station, change the update rate, averaging window, or filtering mechanism, or force a data dump. These functions are executed through EPICS analog out ("ao") device support. Like ai, the OUT string consists of two words containing the serial port name and the command name. Command names are found in the Qualimetrics weather station documentation.

3.2 Environmental Sensors Within the Enclosure

The relative humidity (%), temperature (C), and dew point (C) will be monitored near the top of the enclosure and at the mirror cell. It is anticipated that the sensors located on the telescope will be connected to the M&M nodes via the MCS. The WS will need to convert raw voltage values to calibrated temperatures and relative humidity. An alternative to the MCS nodes will be required if access to the sensors cannot be guaranteed 24 hours a day. Alternatively, these sensors can be connected via serial connection to a terminal server, and calibrated temperatures and relative humidity will be available to the WS directly from the device. Serial connections will be used if available as part of the M&M system on the rotating section of the enclosure. Humidity and temperature data will be retrieved approximately every 10 seconds. EPICS channels (variables) and alarms will be associated with this data to alert the operator of conditions which might result in condensation on the telescope optics.

Wind speeds (mph) will be monitored inside the enclosure using two (or more) Handar ultrasonic anemometers. Like the humidity probes, these devices can be read out via a serial connection or as an analog voltage which would have to be converted to mph downstream by the WS. Wind speeds will be measured approximately every 10 seconds. An EPICS alarm will be set if wind velocities through the wind gates or slit approach the limits for safe operation.

An airborne particulate monitor has been procured to monitor dust levels near the primary mirror. This device measures the number of particles in a volume of air every minute. The particle monitor sends and receives data via RS-232 serial connection, much like the Qualimetrics weather station. Simple numeric commands (0 through 4) set the particle size (1 followed by 1, 2, 3, or 4), sample time (2 followed by 60), take a single measurement (0), sample continuously (3), and stop (4). Data returned by the dust monitor after the sample time includes two integers (particle numbers in two bins) separated by a comma. The WS will need to keep track of the settings used to acquire the data (sample time and dust size) since these are not returned by the dust monitor. It is anticipated that an EPICS alarm will be set if the particle count exceeds a TBD limit.

3.3 Seeing Monitor

The atmospheric seeing monitor is a robotic 16-inch telescope equipped with a differential image motion monitor (DIMM) which determines r_0, a measure of the seeing. The system is under construction and will be installed temporarily on Mauna Kea around the end of 1998. The seeing monitor will be moved to Cerro Pachon after commissioning of Gemini-North.

The seeing monitor communicates with the WS IOC via RS-232 serial link, and like the Qualimetrics weather station, both accepts commands and returns measurements. During automatic operation, the seeing monitor will return r_0 (cm) and transparancy (flux or %) measurements approximately once per minute, all night long (weather permitting). When commanded, the seeing monitor will determine atmospheric extinction through the *B*, *V*, and *R* filters, probably once per night. Other commands include start/stop, acquire a new star, and open/close the seeing monitor enclosure. All these commands are TBD. It is anticipated that an engineering screen will be needed for the operator to monitor the seeing monitor system performance throughout the night and send commands as necessary. The seeing monitor only operates at night during during good weather.

4.0 Workstation

The Unix workstation uses the Solaris operating system and is connected to the VxWorks IOC and to the internet. It is principally responsible for running the GUI through which astronomers and operators can monitor weather conditions and the enclosure environment. To prevent overloading the IOC computer running the EPICS SAD, the workstation will retrieve satellite images from internet sites and other image data needed by the WS.

4.1 Gemini/CFHT Weather Station (Mauna Kea)

Weather data from the tower located between Gemini-North and CFHT is being provided via internet link. Temperature (C), relative humidity (%), dew point (C), barometric pressure (mb), wind direction (0-360 degrees), and wind speed (mph) will be retrieved by the IOC approximately every 10 seconds. These variables will be loaded into an EPICS database and alarms set under conditions of high wind or humidity.

4.2 Satellite Images

Satellite images relevant for operations on Mauna Kea are available from the University of Hawaii Meteorology Department. Infrared, visible, and water vapor GIF images are available hourly in both large and small-scale formats; both will be needed. The URLs for these images are:

http://lumahai.soest.hawaii.edu/gifs/goes_7-8_vis.gif
http://lumahai.soest.hawaii.edu/gifs/goes_7-8_ir.gif
http://lumahai.soest.hawaii.edu/gifs/goes_7-8_wv.gif
http://lumahai.soest.hawaii.edu/gifs/hawaii_vis.gif
http://lumahai.soest.hawaii.edu/gifs/hawaii_ir.gif

Visible and infrared images with 10 minute resolution, but smaller field of view, are available from the National Weather Service. The IR images have 4 km resolution, while the visible images 1 km resolution:

http://www.nws.noaa.gov/pr/hnl/satellite/Hawaii_loop.gif (GIF loop, visible)
http://www.nws.noaa.gov/pr/hnl/satellite/sat_frames/BigIsland_gif_1.html (visible)
http://www.nws.noaa.gov/pr/hnl/satellite/Hawaii_IR_loop.gif (GIF loop, IR)
http://www.nws.noaa.gov/pr/hnl/satellite/sat_frames/HawaiiIR_gif_1.html (IR)

For Cerro Pachon, satellite images are available from the following URLs:

http://yabae.cptec.inpe.br/personal/metsat/imagset/as_1.gif (visible)
http://yabae.cptec.inpe.br/personal/metsat/imagset/as_3.gif (water vapor)
http://yabae.cptec.inpe.br/personal/metsat/imagset/as_4.gif (IR)

These satellite images will be archived in the engineering archives. In the future, better resolution (spatial and temporal) satellite images will be available for Hawaii. These images, which will be provided by the National Weather Service through the University of Hawaii, will be much larger files, and the WS will need to include access to specialized software to view and manipulate the images. Details will be provided when they become available.

4.3 Cirrus Monitor

The Cirrus Monitor has not yet been defined. It is anticipated that an infrared image of the sky will be captured by a frame grabber every few minutes. The WS Unix workstation will need to retrieve each image from a local ethernet connection for display and archiving.

4.4 Weather Forecasts

Text of human-generated forecasts will also be available to operators through the internet. Specific forecasts for the observatories is still TBD, but general forecasts are available at the following sites:

http://www.nws.noaa.gov/pr/hnl/text/TBHW.html (Hawaii)
http://www.meteochile.cl/prognostico.html (Chile, text and graphics)

Images (mpeg movies) showing predicted (24 hour) cloud cover and water vapor can be selected for Hawaii from the Naval Research Lab:

http://www.nrlmry.navy.mil/sat-bin/cld_advect.cgi

4.5 Other External Weather Data

Several other observatories post relevant weather data to internet sites which the WS can use. UKIRT operates a weather station located between the UH and UKIRT domes, on the opposite side of the Gemini enclosure from the Gemini/CFHT weather tower. The UKIRT data includes temperature (C), relative humidity (%), barometric pressure (mb), wind speed (mph), wind direction (N/S/E/W etc.), averaged over 15 minutes. These data should be readily available to observers, but will not be archived.

http://jach.hawaii.edu/cgi-bin/getwx.pl/UKIRT

The optical depth of the atmosphere at radio wavelengths (225 GHz) is measured at the CSO every few minutes, and can be retrieved at the internet site

http://puuoo.caltech.edu/cgi-bin/tau_now.pl

and will be recorded in the engineering archives.

Other external weather data will become available in the future.

5.0 GUI and Engineering Screens

The user interfaces with the WS through a Unix workstation running a GUI. The WS screens may be EPICS dm displays. GUI controls will be accessible on the computer display from which the WS was started. Separate passive WS display screens will present sensor readings, strip charts, and images, but will not have active mouse or keyboard control. It is anticipated that the

WS GUI will be launched from a different workstation controlled by the SSA in the summit operations room (for example), not from the WS workstation itself. WS output screens may be echoed to other locations, including the summit lounge, while the active controls remain in a window on the display of the computer from which the WS was accessed. Because of the large quantity of information that will be presented to the user by the WS, it is preferable that two screens be used simultaneously: one screen should display sensor readings and strip charts, while the second screen should display images. Alternatively, the user could display all the WS output on a single wide 24" monitor, if available. Display options should be configurable by the user to allow for independent WS sessions to be run in different locations with different resources (one 24" wide monitor vs. one or two regular monitors). It is anticipated that WS displays will be up and running continuously, 24 hours a day, in control rooms both at the summit and at the base facilities.

Control Window (displayed on the computer from which the GUI was accessed):

a. Controls to select individual satellite image(s) to be displayed
b. Controls for selecting the amount of data to be displayed in the strip charts (6 or 24 hours toggled, or user-determined length of time)
c. Access to seeing monitor control screen
d. Access to dust monitor control screen
e. Access to control screens for other devices which accept serial input
f. Control locations and format of display screens
g. Access archived weather data and images
h. Access to WS EPICS records not normally displayed in the default display

Principle Data Display Screen:

a. Latest measurements and 10 minute averages: temperature (1 in Hawaii, 2 in Chile), relative humidity, dew point, and barometric pressure from the weather station
b. r_0 and transparency values from the seeing monitor, once per minute and 10 minute averages (when operating)
c. Number of dust particles once per minute, in two bins
d. Optical depth (tau) from the CSO monitor, every 10 minutes
e. Strip charts for everything in (a) through (d) for either the last 6 hours or 24 hours (or for some user-specified time), as set by the operator in the control window. Note that both temperature and dew point should be displayed on a single strip chart, as should both dust measurements. The dust plot will require a logarithmic scale. The same time scale should be used for all strip charts. Current data will be available from the WS, and the rest will be retrieved from the Engineering Archive.
f. Wind speed and direction (current values); 10 minute average and peak wind speeds
g. Vector plot showing both current wind direction and speed, with points indicating the location of the end of the vector for each 10 minute average for the past 6 or 24 hours. The cardinal directions and location of the Gemini enclosure relative to the weather tower should be indictated.
h. Data labels identifying time, units, or other characteristics (such as particle size for the dust monitor)

i. UKIRT or other external weather data, text forecasts, etc. as selected in the control window
j. Status alarms (either separately or as a change to red for a displayed data value that triggers an alarm)
k. Seeing monitor status

Secondary Data Display Screen:

a. Satellite image(s) and/or cirrus monitor image, as selected in the control window
b. Other data as appropriate, especially image data

Examples of potentially useful screen layouts are shown below. Note that all the display information could be diplayed on a single large-format 24" monitor, if available. Alternatively, one could toggle between display screens if only one monitor is available at the display site. Display options should be selected (in pull-down menus, for example) in the control window.

Some WS data will be accessed by other systems and displayed independently of the WS GUI. The TCS, for example, will incorporate wind speed and direction, temperatures, and humidities inside the dome into its engineering displays.

6.0 Archiving

A subset of the WS data will be saved in the engineering archive:

a. 10 minute average weather data from the weather station
b. 10 minute average temperature, relative humidity, dewpoint, and wind speeds measured inside the enclosure (along with enclosure and wind gate status)
c. Dust monitor output (10 minute average)
d. Seeing monitor output (r0 and transparency every minute, extinction once per night)
e. IR and water vapor satellite images, once per hour
f. Cirrus monitor images, once every 30 minutes
g. Optical depth (tau) from CSO every 10 minutes
h. Any EPICS alarms recorded

7.0 Applicable Documents and Drawings

7.1 Related Documents

ICD 3.21

"Site Monitoring at the Gemini Telescopes", TN-PS-G0050

The M&M system is partially described in the Mount Control System Control System Design Description (CSDD), Section 3.7

Integration Plans were written for both the WS (Site Monitoring) and the M&M systems (1/98).

Qualimetrics Weather Station User Manual

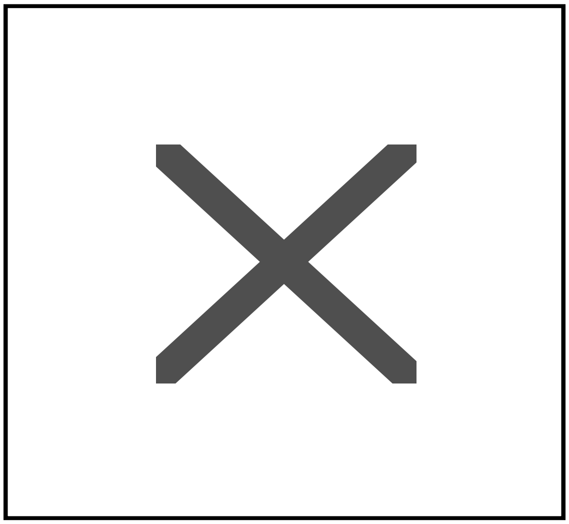
GreenTek Particle Counter User Manual

DFM Seeing Monitor User Manual

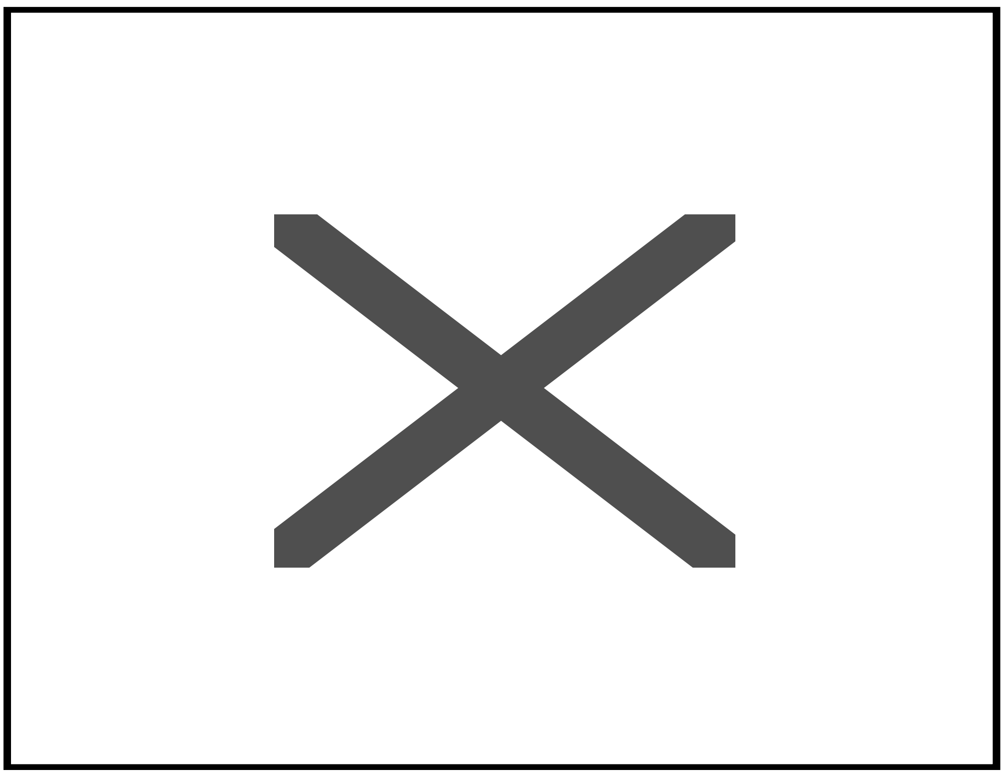
7.2 Related Interface Control Drawings

Examples of Potential Screen Layouts for the WS GUI

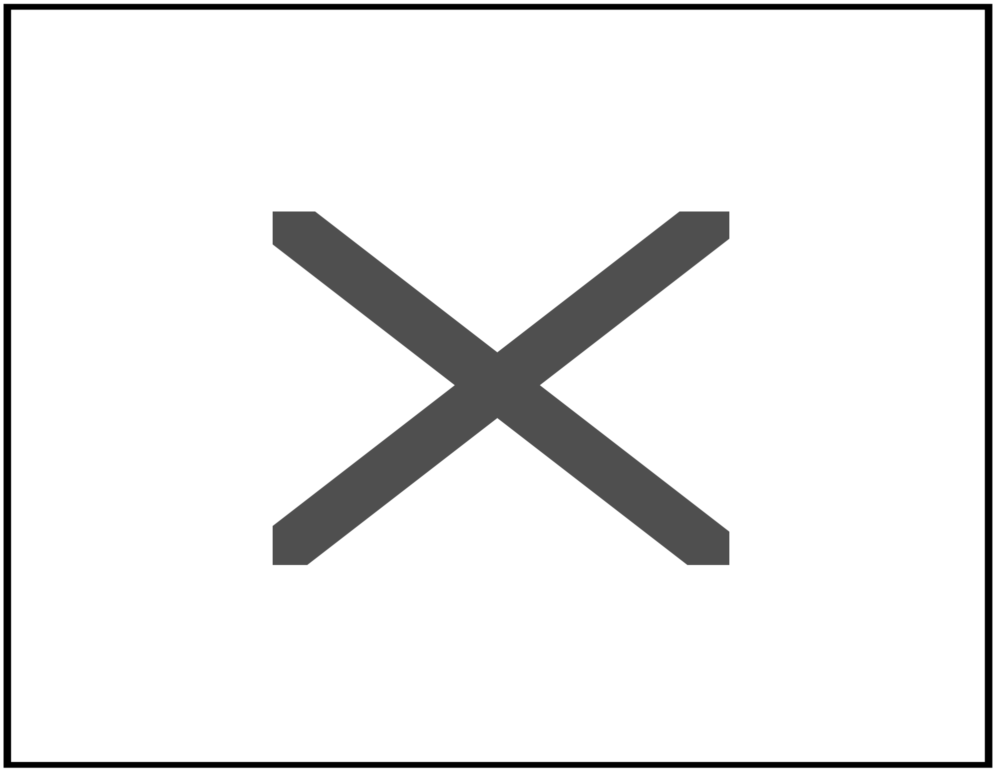
Control Window: (pull-down menus or other types of controls might be better for some controls)



Screen 1:



Screen 2:



One wide-format display: