Integrated Weather Radar Facility:
FY09 S-Pol Upgrade Plan

Detailed Engineering Plan

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1. Introduction

This document is intended to provide an overview of the work planned to upgrade S-Pol in collaboration with CHILL. The document is not a static document, but will be updated as plans evolves. The document details both the software and hardware changes required to implement the engineering team goals of the Integrated Weather Radar Facility.

2. Transmitter

The S-Pol transmitter is being replaced with the NEXRAD/FAA transmitter. The WSR-88D transmitter adds a long pulse mode, provides remote monitoring and control capabilities, and provides a source of parts for the transmitter and documentation. The remote monitoring and control capabilities are critical to us effectively implementing remote operation of S-Pol.

The replacement of the transmitter coincides well with the removal of VIRAQ from S-Pol (see Section ?) because it would not be easy to change VIRAQ to produce the triggers for the transmitter to support the NEXRAD/FAA WSR-88D.

3. Antenna

The plan for improving the S-Pol antenna has not been finalized yet. There are three options that we are considering which are described in this section.

3.1. Option 1: Use CHILL dish and feed

The CHILL center-fed parabolic dish and feed could be mechanically adapted for S-Pol. A new interface plate between dish and pedestal would need to be made, the shipping container for the dish would need to be modified, and we would need to purchase new waveguide pieces for the dish. It is estimated that this work would cost around $30k (rough estimate).

The significant disadvantage to this approach is that we would not be able to mount the Ka-band radar to S-Pol without building new mounting hardware. This would be an additional cost.

3.2. Option 2: Use CHILL feed with S-Pol dish

S-Pol could be adapted to use the feed of the CHILL center-fed parabolic dish. The inherent assumption associated with this option is that the cross-polarimetric performance of the S-Pol antenna is limited by the feed, and not the reflector. This assumption seems reasonable because we know that there are deficiencies in the feed, so use of the CHILL feed would likely improve the performance of the antenna.

John Hubbert has obtained a quote for this work from ARA, Inc./Seavey Engineering for $80,312.52. We have also requested a quote from General Dynamics SATCOM Technologies.

This option has several advantages. The CHILL reflector would be available for use on CP-2. Also, no modifications would be necessary to mount the K_a-band radar to S-Pol.

3.3. Option 3: Purchase new high performance feed

A new feed could be purchased for S-Pol. John Hubbert has obtained a rough order of magnitude price for a high performance feed from General Dynamics SATCOM Technologies. The estimate is $150k.

This option is the most expensive, and it is not clear whether the performance of the antenna with this feed would better than that of using the CHILL feed, because of inherent limitations in the reflector.

This option would also allow the CHILL reflector could be used on CP-2, and no modifications would be necessary mounting the Ka-band radar on S-Pol.

4. Timing, Data Acquisition, and Control (VIRAQ Replacement)

The VIRAQ VME chassis provides antenna control (through the Delta Tau PMAC), a timing card which generates timing signals for the radar and triggers for the transmitter, a single-board computer for system configuration and control, two intermediate frequency digitizer cards, a digital signal processing unit used for moment calculations, a display card to produce a real-time display of the radar data, and an interface card which allows VIRAQ to interface with power meters that measure the transmit and test pulse power. Each of these functions need to be replaced so that VIRAQ can be decommissioned.

Our strategy is to replace VIRAQ with software and hardware that has been developed by CSU for CHILL. By the end of FY09, we plan to have restored the basic operation of S-Pol, and we will have a system which will run common software so that improvements to one system will be portable to the other.

4.1. Timing and Waveform Generation

S-Pol will use the CHILL timing and waveform generator board. The board connects to a TS-7250 [1] single board computer running Linux. The Transmit Control Server software provides an interface to the timing and waveform generator from the radar LAN. The software also generates the wave table that is downloaded to the timing and waveform generator card.

The waveform generation capabilities of the card did not exist in VIRAQ. However, S-Pol currently supports a connection on the STALO drawer (J?) which allows an arbitrary waveform to be used as for the transmit signal instead of the 60 MHz coherent oscillator.

4.2. System Controller

The CHILL system controller software will be used at S-Pol. CHILL staff would like to update this software before it is used at S-Pol. I need more information about this software before I can plan the changes required. Does this software include the antenna control interface?

4.3. Antenna control

CHILL currently uses a UMAC motion controller from Delta Tau. The UMAC transfers the real time antenna angles from the encoders to an interface card in the Acquisition Node. S-Pol uses synchros and synchro to digital converters instead of encoders. The output of the synchro to digital converters is read by the RVP computer and the angle data inserted into the time series data stream. At S-Pol, we will continue to use this mechanism provided by RVP8 to acquire the real time angles instead of reimplementing this functionality with the CHILL hardware and software.

S-Pol does need a new synchro to digital converter unit because we are no longer able to get spare parts for the current unit. Both EOL and CHILL have a base design for a unit that could be used as a replacement. The CHILL unit does not incorporate the synchro to digital converters, but these could be easily added. I have encouraged the CHILL and EOL staff to see if a common solution can be found.

CHILL staff would like to try out a new scheme for controlling the antenna. The new scheme will involve moving the scan intelligence from the UMAC processor to a PC, and using the UMAC only to close servo loop. This scheme provides the advantage that scan information does not need to be read from the UMAC controller periodically, as is currently done with the UMAC, and also, complex scan control code can be written in a well known language such as C or C++. This new scheme seems to be well suited to using a new product from Delta Tau: the Power PMAC. The product provides a real-time Linux computer with the Delta Tau motion controller, in a single chassis. The servo loop is implemented with the Delta Tau ASIC, but higher level functions can be implemented in C/C++ in Linux.

The Power PMAC isn't available until January 2009 (it's been in beta for the last year), so there isn't much technical information available on DeltaTau's website yet. However, it appears that the Power PMAC does use the same chassis and I/O cards as the current UMAC Turbo CPU which means that we would be able to reuse components from the existing CHILL system. We will decide on whether to use the UMAC or the Power PMAC based on the results of the CHILL tests of the new antenna controller scheme and a review by all parties of the Power PMAC.

I anticipate incorporating a GUI antenna control interface into S-Pol FY10, once basic system function as been restored.

4.4. Digitization and Time Series Data

CHILL currently uses the ICS??? digitizer and S-Pol has an RVP-8 digitizer installed for the HAWK processor. The capabilities of these digitizers is comparable, so it does not make sense to purchase the ICS digitizer for S-Pol. In the future, when we decide to upgrade the CHILL digitizer, it will make sense then to upgrade both radars.

The CHILL Acquisition Server software makes the time series data stream (IQ data) available to the radar local area network (LAN). The server also provides housekeeping information such as real time angles. For S-Pol we will continue to use the time series distribution software Mike Dixon developed for HAWK. It will be upgraded to support the common time series data format defined by RAL, EOL, and which is in the process of being implemented at CP-2. The CHILL Acquisition Server software will also be changed to produce the common time series format.

4.5. Interface Server

The CHILL software suite includes a component called the Instrument Server. This component provide a network interface to the test and measurement equipment used in the radar. At S-Pol, the equipment includes power meters that measure transmit and test pulse power and frequency synthesizers that generate the stable local oscillator (STALO) and the test pulse.

At S-Pol, we will implement the communications channel between the Instrument Server and the test and measurement equipment using the same hardware as CHILL. The GPIB ports of the test and measurement equipment will be connected to a Prologix GPIB to Ethernet controller which will then be connected to the radar LAN. The Instrumentation Server may have to be adapted slightly, or preferably the configuration file for the Instrument Server changed, to interface correctly with our test and measurement equipment, but the software should not have to be modified significantly because the test and measurement equipment will support the Standard Commands for Programmable Instruments (SCPI) [2] command structure.

To use the CHILL Instrument Server, the transmit and test pulse power meters in S-Pol must be replaced. Our current units (HP 435As) are antiques, and do not provide a modern digital interface through with to read the power measurements. We will probably purchase two dual Agilent E4419B dual channel power meters. There of the four channels will be used to measure H and V transmit power, and test pulse power. The forth channel can be used for system diagnostics, calibration, and will also serve as a spare.

4.6. IQ Processing

The IQ processing software calculated the integrated moments (or covariances) from the time series (IQ) data. These calculations are implemented by iq2dsr in the HAWK system that runs at S-Pol, and by the Moment Calculation Server at CHILL.

HAWK will be updated to support the new time series format (Section 4.5) so that algorithm development for the NEXRAD program can continue at EOL. HAWK will also be updated to allow it to ingest the housekeeping data supplied by the CHILL software, so that data for the NEXRAD program can be collected at CHILL while S-Pol is being refurbished. HAWK will therefore be able to run in parallel to the CHILL Moment Calculation Server, and will provide us with a scientist display (CIDD) and real-time value added products of rain rate estimation, particle identification, and refractivity.

The CHILL Moment Calculation Server will be updated to support the common time series data format. The moments in from this software are packaged into the SDB data format, which is not supported by CIDD or the rain, PID, or refractivity algorithms that run in real-time at S-Pol. Therefore, format translators to convert SDB to MDV (the format required for CIDD) and SDB to DORADE (the format required for the value added products software will be written. In this way, we can add these capabilities easily to CHILL.

In the long term, our goal should be to define a common moment data format that can be used by all software and which will negate the need for format translators.

4.7. Real-time Display (aka Engineering Display)

The CHILL real-time display is already installed at S-Pol and configured to work with the HAWK processor.

4.8. Scientist Display

Currently, S-Pol provides access to data through CIDD. IDV is being evaluated for suitability as a scientist display. The JADE architecture developed by RAL could also be used to develop a new scientist display. In the interim, translators (described in Section 4.6) will be used to add CIDD visualization capability to CHILL.

5. References

[1] http://www.embeddedarm.com/products/board-detail.php?product=TS-7250

[2] http://en.wikipedia.org/wiki/Standard_Commands_for_Programmable_Instrumentation