Gemini
Mount
Control
System
Report

MCS Preliminary Design Review Report

Gemini

15 December 1995

This report describes the minutes of the MCS PDR.

INTRODUCTION

The Gemini MCS PDR was held on Monday 11th December 1995. The following people were present:

J. Wilkes (RGO)
C. Carter (RGO)
A. Foster (RGO)
R. McGonegal (GPO)
J. Horne (GPO)
M. Warner (GPO)
K. Raybould (GPO)
C. Mayer (RGO)
M. Fisher (RGO)

The following people acted as virtual reviewers and submitted comments via e-mail:

M . Burns (GPO)
M. Ravensburgen (VLT)
T. Coleman (ANL)

Note that Tom Coleman’s comments arrived after the review so were not discussed at the meeting. His comments have been addressed by the MCS team. Thanks to everyone who has taken time to review our documents, all comments have been gratefully received.

The main body of this report describes the issues raised by real and virtual reviewers. Each paragraph will fall into one of the following categories :

1. Immediate action (marked by the ▼ symbol). This indicates an action that needs to be immediately resolved before PDR report is issued, this will usually mean a change to the CSDD or the SDD.

2. A comment (marked by the **C** symbol). This indicates that no a specific action is needed.

3. CDP Action (marked with a name in **bold type**). These actions shall be considered as CDP work, the responsibility being with the person specified.

THE ISSUES

The issues raised by the review are subdivided into general comments and then according to which chapter of the CSDD or SDD they relate to.

REVIEW OF CSDD

General

Just to be completely pedantic, it seems to me that the title of the document is redundant. The words "control system" appear twice consecutively. It seems that no meaning would be lost if the second "control system" were omitted.

> **C** - The title is valid since Mount Control System is the name of the work-package and Control System Design Description is the type of document.

Somewhere in the document (sorry, I could not find the location again) you wrote that there are no specific 'hard' numbers as requirements for the Gemini structure in combination with the MCS. I do suggest that you agree with the project office on some hard numbers. They must be derived from analysis/simulations and, if achieved, they give you a clear 'work-package finished' flag. A few items that characterise servo performance are:

a. Small signal bandwidth for the position loop (alternatively, settling time for small steps). This number directs the gain in the position loop that must be achieved.
b. Rejection of disturbance torque (wind). This can only be on the basis of an simulation analysis where the mathematical model of the velocity and position controller is integrated.
c. Quality of tracking at very low speeds. After the above steps, verify by simulation that the tracking at very low speeds (say < 0.1 arcsec/sec) meets the requirements. This 'test' is heavily influenced by the friction on telescope and motor axes.

> **M. Burns & R. McGonegal** - A spec. is to be produced.

The document touches at several locations the electronic design and transport of signals from one location to the other. This should be 'Gemini wide' designed. For VLT, we use a generic 'Electronic Design Spec', which does not only list standard components, but (much more important) specified signal connections between boxes/cabinets.

> **C** - We believe that Gemini are already doing this as all the cabling for the whole telescope is defined in one place, under the control of the systems group.

Section 1

Sec 1.1, paragraph 1: "It's" is a contraction for "it is". The possessive form is merely "its", without an apostrophe. ▼.

Sec 1.3: The abbreviation for milli-second is usually "ms" not "mS". The general rule is that units derived from proper names are capitalised, e.g. Newton. There was no Mr. Second, was there? ▼

Sec 1.4: Reference 6 should also include John Wilkes as an author. ▼.

Section 2

How is it intended to monitor the serial port of the MVME167?

> ▼ - Either with a dedicated VT100 type terminal or (more likely) with a terminal emulator running on the sun workstation.

Who is responsible for buying and routing cables ?

> ▼ - It is the responsibility of the Systems Group. We just specify signal names and connector types.

Is there anything that can be done to reduce the number of VME slots required?

> **C** - No. If we need more slots then the functionality of the MCS can be split and the service wraps, counterweights and monitoring subsystems can be housed in a separate card frame located near to the existing MCS crate. Note that it still feels rather odd that the Cassegrain rotator control system is not part of the MCS. However, no detailed design of the CRCS has been done, the plan being to copy the

MCS approach. The CRCS can then be thought of as being closely linked with the MCS even though it may be in a different physical location.

Sec. 2.4 PMAC3 should be 60 MHz as is the others. I have found that the 20 MHz model has insufficient time to update the Servo Fixed Data Buffer DPRAM which provides, among other data, the actual positions of the motors. You'll need this buffer to report, for example, actual position at rates up to 50 Hz.

J. Wilkes - It is not currently planned to have the DPRAM option in PMAC3. If this decision is changed then we will go for a 60 MHz model.

Section 3

Sec. 3.1.2. Concerning 'sampling frequency ... approx. 2 kHz'. If this is required, it must be very well justified. This puts a high requirement on computing power! If the speed loop is analogue, which I assume because of the analogue tachos, the sampling rate must be defined to meet the requirements of the position loop. Depending on the algorithm that is chosen there, one can estimate a LOWER limit of about 20x the small signal bandwidth. Some people claim that there is a better disturbance rejection with higher sampling rates, but I never saw a detailed measurement report on that. For the VLT, we have 500 Hz and just Zero Order Hold in the position loop.

C - It is accepted that 2 kHz is faster than we need, and we have specified this only as a maximum. Work is currently being done with the non-linear model, to try and nail down the required sampling frequency.

There is no real problem with constraint on computing power since the position loops are to be implemented on PMAC cards, not the MVME167s as in the VLT case. The PMAC is a DSP based device that can quite happily cope with a 2 kHz sampling frequency.

Sec. 3.1.2 last sentence: '.. tacho loops are closed in the power amplifiers'. The big question here is if he power amplifiers provide enough facilities for tuning and maximising bandwidth in the velocity loop. (Commercial) power amplifiers have normally only a proportional/integral controller. I suppose that you need at least 'some' type of filtering in order to 'match' the mechanical dynamic performance with the speed controller. See e.g. my paper 'VLT main axes servo's' in the SPIE conference of KONA 1994.

C - It is extremely difficult to get information out of Inland motor concerning the FST-2 amplifier, especially from the U.K. However, Mike Burns has gleaned some information and it is claimed that the tacho controller that he uses in his model can be implemented on a FST-2. If this controller is not sufficient then it is hoped that we can compensate for this within the position loop (another reason for a high sample frequency here).

It was once proposed that there be a fibre optic interface between the PMAC card and the power amps in order to dynamically control current limits to avoid drive roller slip. Is this still the case?

J. Wilkes - I would prefer not to follow this path because it would mean upgrading to PMAC-2 cards. There are a number of other ways to control current limits :

- Remove velocity demand (Crude).
- Use the RS232 interface to the power amplifiers.
- Use a hardware current limiting circuit (as proposed by Mike Burns in his note 'Avoiding and Suppressing Slippage of the Azimuth Drive'.

These have to be looked into as part of the critical design, but a decision is needed quickly since Telas are very soon going to order the amplifiers.

Sec. 3.1.2. The GIS will also monitor motor current. **C**.

Sec. 3.1.3.1.1 Using DPRAM for commands in this manner seems reasonable and the current driver should be capable of doing this using 40 analogue output records. A few points to consider :

1) PMAC reads ahead in motion programs to pre-compute moves. Enough data points must always be ready in DPRAM to stay ahead. Consider using additional (three?) buffers.
2) Provisions should be made in the motion program to detect if it has stepped ahead of valid data.

J. Wilkes & A. Foster

Sec. 3.1.3.1.1. How does the demand passing scheme work during slewing?
Sec. 3.1.3.1.1: I wrote a note about 6 months ago (delay5.doc) on how one could reconstruct the velocity and acceleration commands from the stream of 20 Hz position demands. My note also addressed how to handle data-dropouts and sudden position changes. You don't want to let the acceleration become infinite for a step position changes.

> ▼ - The MCS software will work out a trajectory based upon interpolation of the demand positions (from TCS or MEC). This trajectory will be passed to the PMAC card via the Move Argument Buffer. This scheme means that the telescope may not always be able to keep up with demands from the MCS software, i.e. the PMAC following error may not always be close to zero - especially when slewing. The actual trajectory followed by the telescope will be confined by the velocity and acceleration limits set in PMAC.

Sec 3.1.3.1.1. Text 'Note that at present, it is not clear whether both position and velocity.....'. What is needed here is a cross check on steady state servo errors in all operational modes. Normally, one accepts a servo error during pointing, but not during tracking. Analytically, this is cross checked with the 'Error coefficients', see control theory books. As soon as you introduce sampling, you can cross check with a simulation. The main thing to be checked is: Can we live with the error that is introduced during worst case acceleration during tracking, i.e. the azimuth motion for a star that touches the 'dead angle' around zenith.

> **J. Wilkes** - This will be done as part of the critical design of the servo subsystem. In the mean time we should consider passing positions and velocities at 200 Hz a maximum requirement as this should be more than sufficient.

Sec. 3.1.3.1.2. Universal Time should read TAI. ▼.

Sec. 3.1.3.1.2 How was your motion program started in your tests showing < 1 ms error? If synchronisation above this is needed, consider Triggered Time Base, PMAC User's Manual Addendum V1.14 & V1.15 pages 51-54.

> **J. Wilkes & A. Foster** - Our tests were done using the START/ line on the JPAN connector to start off a motion program. The triggered time base solution may be better - we will investigate.

Sec 3.1.3.1.2 How much less than 1 ms is the starting time error?

> **J. Wilkes & A. Foster** - We will investigate further when we have a EPICS PMAC driver.

Sec. 3.1.3.1.3 This feature has not yet been implemented in PMAC driver. I have anticipated using a wave form record for this. I will be considering how to make the data user selectable at run time.

> **J. Wilkes & A. Foster** - We were not aware that this function required a special implementation of the PMAC driver. We were planning to use the ASCII driver to set up the required I-variables and then start the data gather in a similar way to how we propose to start a move command. The actual data would be read into analogue input records connected to the relevant DPRAM addresses.

Sec 3.1.3.1.3 How will the data logging function be implemented?

> **J. Wilkes & A. Foster** - As detailed in section 3.1.3.1.3, we are proposing to use PMAC's in-built data gather function combined with the EPICS archiver client and some custom code to transfer data from PMAC DPRAM to some storage device (either a local hard disk or the hard disk associated with the sun workstation. In this way we should be able to log up to 24 PMAC variables at any speed up to the servo rate. This is still just a proposal, we intend to test this out as part of the critical design work.

Sec 3.1.3.1.3 How can logged data be synchronised with parameters that are external to PMAC.

> **J. Wilkes & A. Foster** - We plan to start the logging process in a similar way to how a move is started. Therefore, we know the start time of the data and the sample rate. The PMAC derives its servo clock

from the time card, so we can work out a time vector that is synchronised to TAI. This also needs to be checked out when we get the EPICS PMAC driver.

What is the status of the EPICS PMAC driver?

A. Foster - We are still waiting a beta release from Tom Coleman. We will chase this.

Note from Tom Coleman :

I have been using my EPICS PMAC device and driver support while developing applications for the Structural Biology Center at the Advanced Photon Source. I am currently re-writing the ASCII device support to use the DPRAM ASCII buffer instead of the Mailbox Registers. This will use asynchronous record processing and a separate process and queue per PMAC board. The interrupt for Mailbox will be available for user defined software interrupts from PMAC.

Sec. 3.1.3.2 Text '... that the velocity demand from PMAC shall be fanned out to all power amplifiers...'. This is over-defined!! The velocity loop will very likely need integral gain and this will force the friction coupling to slip in the proposed configuration. The amplifiers must be fed with a torque command, not with a speed command. If torque sharing is done, differences in motor torque coefficients, amplifier gain, etc. are easily balanced by the speed loop. One PMAC channel is OK, but four individual tacho loops not. This is another argument to let the amplifiers work in torque loop and make the velocity control separate.
Sec. 5.1.3 Text '..it may require extra hardware' (last paragraph). See my remark above about the velocity controller that is not part of the power amplifiers. So my statement here is that the extra hardware is needed anyway because of the required filtering.

C - There are few points that are not clear from the text :

- There is currently no pure integrator in the tacho loop.
- It is a requirement that the GIS needs to be able to move the telescope in the absence of the MCS. A velocity demand is a much better way to do this since the GIS does not have to worry about closing a tacho loop. So we either build our own tacho loop with analogue hardware to which both MCS and GIS send demands to. Or we operate the amplifiers in velocity mode. Since the specified amplifiers are quite flexible we decided on the later.
- Our method of averaging tachos is effectively the same as having a single tacho loop (assuming all velocity controllers are exactly the same).
- I believe that we can remove differential torque from a system with separate tacho loops by setting the tacho gains of each loop according to the steady state error of that loop. See Mike Burns's comment in Section 5.

Sec. 3.1.3.2: You point out that there will be one tacho loop per motor. You might want to add a few words on why this is so. There was some controversy on this because some people thought that we should have one tacho loop for each axis. I believe that one per motor is required because of the possibility of hidden oscillations caused by compliance in the azimuth ring. I examined this problem and wrote up my notes about a year ago (compl1.sam). **C**.

Note that the stiffness of the azimuth mounts is estimated to lead to a natural frequency of approx. 250-300 Hz.

Sec. 3.1.3.2. The elevation disks have a tolerance of approx. 2 mm in 8 metres. Is this a problem for the control system?

C - Because of the findings presented in Appendix A - No.

Is there an equivalent of the PMAC Executive software that uses the VME bus interface?

C - No. However, the MEC will try to copy some of the best features.

Sec. 3.1.3.3.1 Item 'Encoder'. I do not fully understand the Gemini encoder system, but it looks to me that 90,000 encoder pulses per revolution is not sufficient. Is this only for the Test Rig?

C - Yes, this encoder is for the test rig only.

Sec. 3.1.3.4 Is it possible to include the Cassegrain rotator in the HWILS model?

J. Wilkes - Yes, but it may be difficult to get a such a model to interact with the main axis models.

Sec. 3.2.1 Reference to [3] , This reference is a bit missing for me. Make sure that you cross check the design interface between Encoder and MCS thoroughly.

C - Accepted. The encoder is about to become part of the MCS work package so the interface shall be more fully described in later documents.

Sec. 3.2.2 Text ‘There may be systematic corrections to apply to each encoder input.’ This makes only sense for the strip encoder (which is repeatable), the friction coupled encoder is not repeatable. ▼.

Sec. 3.2.2 Text: ‘NOTE: Given a maximum velocity of 2 °/s...’ and the rest of that paragraph. This gives the impression that the Virtual Encoder starts from every 1 ms tic. If it is done that way, it will imply an accumulation of quantisation errors.

M. Ravensbergen - We don’t understand what is meant by this comment, please elaborate.

Sec. 3.2.2. - Who is responsible for buying and mounting the elevation tilt switch?

M. Warner & C. Carter - MCS will buy the tilt switch, TBEG must decide where to mount it.

Sec. 3.2.2. - Can the virtual encoder function with only one encoder input?

C - Yes.

Sec. 3.2.2. - Are fiducials needed if the Heidenhain LIDA tape encoding system is chosen?

J. Wilkes - No. However, the decision of which encoder to use is still yet to be made. There should still be a requirement for fiducial switches.

Sec. 3.2.2. - Are the elevation translation transducers really LVDTs? Who is responsible for buying them? If the run-out tolerance of the elevation axis is very good, maybe we don’t need them.

▼ - The transducers can be any high resolution linear measuring device, as long as it gives PMAC compatible input. The decision as to whether we need them and who pays can be made at a later time.

Sec. 3.2.3.1. - Is 8k of program memory enough, and is it expandable?

C - We believe 8k to be enough. Expansion would mean a firmware change.

Sec. 3.2.3.1. When estimating the number of PMAC CPU cycles available remember to account for cycles required for PMAC to report status and data to DPRAM. Many standard PMAC registers are copied to DPRAM buffers when enabled. My PMAC driver can use these and permits the user to specify additional values to be copied. See PMAC Users Manual Addendum 5/16/94 V1.14 & V1.15 pages 77-86. PROMS can be field upgraded for minimal cost.

C. Carter - We will conduct further tests when we have access to a PMAC with DPRAM option.

Sec. 3.2.3.2.1 ‘Encoding fiducials’ Please note that the encoder pointing accuracy depends straight on the repeatability of the fiducial switches. The repeatability of those switches must therefore be specified and the design of the switches tested for this. Some VLT experience (see for details my SPIE paper ‘Encoders for the VLT main axis’, Orlando 1995):

a. Some types of switches have temperature effects. Or, if the switches don’t have it, the telescope has it.
b. The trigger point of some switch design is a function of the rotational speed of the telescope axis (Gap sensor switch with threshold electronics, implying some ‘low pass filter effect’.

Whatever is the physical design of the Gemini ‘fiducial switches’, cross check for repeatability.

C. Carter - This investigation is being carried out as part of the critical design phase. Current estimates for repeatability of the switches about 5 μm (0.25 arcsecs). The repeatability of the telescope structure, however, is another matter.... It was agreed that a repeatability of 20 μm (1 arcsec) was sufficient.

Sec. 3.2.3.2.1. What is stopping us from making a decision concerning the encoding of the fiducial signals.

C. Carter - Nothing, we will do it for CDR.

Sec. 3.2.3.2.1 Item '1. An n-to-m Encoding scheme.' Note that in any case quite some field cabling is needed. **C**.

Sec. 3.2.3.2.2 Text 'The fiducial outputs will be coded TTL signals ....' and the rest of that paragraph. An electronic remark: NEVER use single ended TTL signals over cables outside a box or cabinet. Use at least symmetric TTL (RS 422 type signals) or 12V / 24V logic.
Sec. 3.5.3 Text 'A 12 bit digital word (TTL levels)......' As before, use at least symmetric TTL (RS422) or 12V/24V levels.
Sec. 3.7.2 Text 'The monitoring subsystem .... TTL format' See remark above about diff. TTL.
Sec. 4.2 Text '... single ended TTL signals'. See above about diff TTL.

C. Carter - We will ensure that all cabling that transmits logic signals over large distances will be specified as differential or 12/24V.

Fig. 3.6 The bus & node scheme also needs a 'Fiducial Passed' signal. ▼.

Sec. 3.2.3.2.2 Do we need to hardware latch the fiducial identifier word?

C. Carter - We don't think so, but we shall look in to it.

Sec. 3.2.3.3.1 What are the V.E.'s 'normal tasks'?

▼ - The tasks that are carried out during normal mode, i.e. reading encoder input counters, software extending, calibration algorithms etc.

Sec. 3.2.3.3.1 The virtual encoder does NOT automatically initialise on a MCS reboot, it waits for an initialisation command from the TCS or MEC. ▼.

Sec. 3.2.3.3.1 The MCS software will not allow a TCS move command until a VE initialise has been performed. ▼.

Sec. 3.2.3.3.1 Upon a MCS reboot, the virtual encoder shall assume an absolute position of zero. An alternative scheme for the azimuth axis is to use the absolute encoder reading. ▼.

Sec. 3.2.3.3.2 How is the constant velocity required by the calibration mode maintained?

C. Carter We don't believe it has to be totally constant. The whole necessity and implementation of the calibration mode will be investigated during the critical design phase.

Sec. 3.3 Note the generic terms for signals to and from the GIS :

Signals to the GIS are known as Interlock Events (c.f. Drive Enable).
Signals from the GIS are known as Interlock Demands (c.f. Drive Condition). ▼.

Sec. 3.3.3.2.2 It is not possible to mount a micro-switch to be activated by the wrap bridge.

▼ **J. Wilkes & J. Horne** - We are therefore reliant upon the topple bracket micro-switches and the coarse absolute encoder. I don't think this is sufficient.

Note that the GIS also has control over drive pre-load - this should be removed with brakes and amplifier power supply. **M. Burns**

Sec. 3.3.3.2.2 Who supplies micro-switches for the restricted azimuth zone during 0-15° elevation movement?

M. Warner - TBEG should supply and install the micro-switches in the relevant place. MCS software needs to know the location of these switches in the 0-540° range.

Sec. 3.3.3.2.2 There should also be a lower max. velocity limit in the restricted azimuth zone during 0-15° elevation movement. ▼.

Sec. 3.4 Whole subchapter (dealing with tacho). An easy and efficient ‘tacho OK test’ can be implemented with an analogue window comparator that checks each individual tacho signal. Also, the difference of 2 tacho signals must be ‘close’ to zero. As Gemini has ‘a lot’ of tachos per axis, a very good redundancy can be achieved.

> **M. Burns** - It should be noted that the tachos mentioned in this chapter are different to those connected to the motor shafts. There is no reason, however, why the GIS cannot monitor these tachos as well for a bit of extra redundancy. The azimuth absolute encoder may also be used for this.

Sec. 3.4 Note that MCS shall provide the over velocity tachos, but not the drive roller. **Mark Warner**.

Sec. 3.5 It is desirable to be able to move the counterweights without the MCS.

> **C** - This shall not be possible. However, there will be no need to have the MCS software running as the PMAC card that drives the counterweights can be controlled from a P.C. running the PMAC Executive software. We are fairly confident of having at least a working PMAC on site by the time the TBEG will want to move counterweights around.

Sec. 3.5 There is no requirement for the TCS to move the counterweights. **C**.

Sec. 3.5 When will the mechanical design of the counterweights be finalised? **M. Warner**

Sec. 3.5.3 Regarding the note that counterweight function will not require DPRAM. You will want to use DPRAM for reporting status and positions in PMAC3 and should equip it as the others. I also suggest that demand positions be given to PMAC via DPRAM even if the motion program is not running continuously and needs only one at a time. This separates the data from the program RUN command.

> **J. Wilkes** - I am not convinced that the DPRAM option is necessary for the counterweights or service-wraps, though it may mean reducing the monitoring frequency of the servo-variables.

Sec. 3.6 Note that there will only be one elevation wrap initially. The second will be implemented, only if needed. **C**.

Sec. 3.6 The mechanical design of the cable wraps should be finalised by June/July 1996. **C**.

Sec. 3.6.1 Text ‘In order to minimise the disturbance torque .....’ Yes, absolutely. It is not only advisable, it is necessary. Or one has to accept and agree on a budget for the unbalance and friction. The servo problem with cable wraps is NOT the unbalance, but the static friction and the FAST changes in torque during the motion. The last 2 are difficult to ‘freeze’ in a specification. **C**.

Sec. 3.6.2 Text ‘The service wrap-ups subsystem shall receive....’ This looks contradictional with fig. 3.17 where the wrap is a slaved system of the axis. The difference is measured with an LVDT.

> **C** - The LVDT is the differential encoder.

Sec. 3.6.2 Text ‘Since the failure of a service ....’ and the rest of that paragraph. This is not automatically true. One has to consider:

a. Fault of the cable wrap drive system.
b. Cable wrap mechanically blocked.

In case a, it makes sense to be able the drag the cable wrap with the telescope. In case b, it is not good to destroy the cable wrap! Use an interlock to detect this. This interlock must also be valid if the axis is driven with a ‘manual drive’, if existing.

Sec. 3.6.3 Text ‘ 3. Drag plates - Physical plates......’ See remark above about blocked cable wrap.

> **M . Burns** - In the two cases mentioned above, I believe it is sufficient to lock out the associated main drive from the limit switches on the differential encoder. The only issue then, is how to allow cable wrap dragging in the absence of the MCS (this is a requirement). This is a GIS, not a MCS, issue.

Sec. 3.6.3 Is the differential encoder really a LVDT?

M. Warner, G. Pentland, J. Horne & M. Fisher - There seems to be a difference of opinion of exactly what accuracy is required from the differential encoder. As far as the MCS hardware is concerned - We don't care what the device is, as long as it gives a PMAC compatible output.

Sec. 3.7 Note that there is a monitoring system within the enclosure that uses a RS485 serial bus and has sensors that directly connect to the bus. It is our feeling that this may be too expensive and not general enough for our requirements. **C**.

Sec. 3.7 The monitoring subsystem is not responsible for monitoring things inside the other MCS subsystem, i.e. motor currents. **C**.

Sec. 3.7.2 There may be some quantities that need to be monitored at a faster rate than 1 Hz (e.g. 100 Hz). For instance, accelerometers and wind sensors.

C. Carter - Although the requirement for sampling is 1 Hz, it is expected that the system will be capable of a faster rate - though what this rate will be is yet unknown. The sampling rate is limited by CANbus and EPICS. It will be dependant upon how many variables are being monitored. It may be possible to have some kind of 'fast' mode of the monitoring subsystem that monitors only a few variables at a much faster rate.

Sec. 3.7.3 Do we need a node at the top end of the tube?

▼ - It would be nice but we are prevented from doing this because of thermal constraints related to positioning heat sources above the level of the primary mirror. Any sensors on the top end will be connected to either node A or E.

Sec. 3.7.3.1.1 Text 'These are the standard facilities that ...' I propose to make it configurable and also to add digital outputs. It might look overkill now, but be sure that 'somebody' will come later that want to install shutters, flat field lamps .....

C - Current thinking is that each node will contain a motherboard which has the CANbus interface plus circuitry to provide 16 analogue inputs, 16 digital inputs and two 8-bit digital words. A daughter board can be plugged on to this which is user defined and expected to house signal conditioning circuitry. To get more inputs per node, a daughter board with a multiplexer could be produced or more than one logical node could exist at each physical node. There is no effective limit to the number of logical nodes.

Section 4

This section contains the information needed to provide a set of ICDs for the MCS. After the PDR, the document will be divided into sub-documents in order to provide a main CSDD and a number of ICDs. **J. Wilkes & C. Carter**.

Table 3 is incomplete as it does not contain interfaces to the time card. **J. Wilkes & C. Carter**

Sec. 4.2.1.3 Interlock Interface Subsystem - AzDriveCond_H/_L is an I/L:I/P not I/L:O/P. ▼.

Sec. 4.2.1.3 Interlock Interface Subsystem - Rows 5 through 10 which relate to drive enable and drive condition signals for the counterweights and service wraps should be deleted. ▼.

Sec. 4.2.1.3 Interlock Interface Subsystem - The signal type IL consists of two complimentary single ended TTL signals with the same return signal. The names of the signals should reflect this instead of using the _H/_L convention which implies a differential signal. Also, the cable type should probably not be TP/OS. ▼.

There is disagreement about the sequence of operations when a move command is issued. Should the servo loop be closed before or after the brakes are released. Closing the servo loop first may cause a step demand (which may be large if the integrator is enabled) to be applied to the motors which is bad. Releasing the brakes first may be dangerous in elevation if the tube is badly out of balance, though this may not be the case since the tacho loop is closed as part of the same operation of releasing the brakes. The test rig may help in this investigation. Note that it takes the brakes approx. 0.5 seconds to release. **J. Wilkes**.

Sec. 4.2.1.3 Monitoring Subsystem - Who is responsible for providing PSU transducers for monitoring things such as frequency stability? **R. McGonegal**.

Sec. 4.2.2 Regarding EPICS update of PMAC data reporting up to 50 Hz. I am currently running updates from PMAC at 10 Hz. There is a separate task performing these PMAC reads. After PMAC DPRAM has been read into IOC memory, “I/O Intr” processing is scheduled for the respective records. The repetition rate of this process can be changed. Currently this must be set to a multiple of sysClkRateGet(). On my IOC (MVME167) this base rate is 1/60 of a second. How in general do you plan for 50 Hz and 20 Hz EPICS processing? Have you added rates to the standard SCAN rates?

> **C** - The Gemini IOC's base rate will be 1/200 of a second, and we have added extra SCAN rates to the Gemini release of EPICS which will allow us to process at 20 Hz and 50 Hz. Please note that 50 Hz is considered a maximum rate, it may well be less than this.

Sec. 4.2.2 Is there no software interface to the power amplifiers?

> **J.Wilkes** - There is none planned other than monitoring motor current via the ADC card. We will investigate the requirement and implementation of a link based upon the serial link.

Sec. 4.2.2 Servo System Functions - There should be an entry for the data logging function. ▼.

Sec. 4.2.2 Encoder System Functions - The TBEG are responsible for specifying the encoders. A 16-bit encoder with suitable gearing would be fine. **M. Warner & K. Raybould.**

Section 5

Sec 5.1.1: I think that it would work to lump all of the motors together under one PMAC, provided that each motor has its own inner loop (i.e. velocity loop with its own tacho). My reasoning is that the outer position loop, through the PMAC would have an integrator, and thus drive out steady-state errors. The inner velocity loops would be type-zero, and thus be able to tolerate small differences in rates. This would lead to some motors having slightly higher errors and thus higher torques than others, but I believe that this difference would be small. We can get a back of the envelope estimate for the differences in torque by calculating the DC gain of the type-zero velocity loops (they’re modelled in the simulation) and multiplying by the difference in error signals (estimated from the eccentricity of the azimuth axis or the tacho errors, which ever are larger). Since the eccentricity is small, even a large DC gain would lead to modest torque differences between the various motors. **C**.

Sec 5.1.2: I believe that your model of figure 5.1 is not detailed enough to examine the trade-off between using one tacho per axis or one tacho per motor. My reasoning is that the compliance of the azimuth ring needs to be modelled. Therefore, instead of summing the torques from 8 motors and applying them to a lumped mass, a more detailed azimuth structure is needed, requiring 8 masses, 8 springs, and 8 motors.

> ▼ - The mounting stiffness of each motor is modelled, Kg(1) through Kg(8). This stiffness is expected to be a lot less than the stiffness of the actual ring. Therefore ring compliance can be considered negligible. Note that each motor model consists of a mass, friction and stiffness.

Sec. 5.1.4 Text ‘Only one PMAC channel ......’ Use the individual tacho signals for ‘tacho OK’ and ‘Over-speed’ detection.

> **C**. Note that the reason that we do not rely upon the motor tachos for over velocity protection is that the motors will not always be pre-loaded against the drive track.

Sec. 5.2.2 Last paragraph on page 59. If this happens, it destroys the friction gear. One can detect at least ‘over-speed’ per tacho.

J. Wilkes - We will be very careful with the test rig to try and not damage it. However, the nature of the tests mean that sooner or later slippage will occur and damage may occur. It is better to damage the test rig than the azimuth track!

Addition Of Encoders To The MCS Work Package

The choice of main encoding system to use, and the electrical interface to it is an issue that needs to be resolved quickly. It has been agreed that the MCS work scope will be expanded to include this work. A work breakdown structure and cost for a modified MCS work package will be worked out after the review.

REVIEW OF SDD

General

The MCS code will be generally implemented along these lines:

- Hardware Interfaces will use EPICS.
- MCS intelligence will use C and sequence programming.
- Interface to TCS and MEC will use EPICS CAD/CAR.

C.

The size of the MCS code (EPICS database and C code) is not thought to be beyond the capabilities of the MVME167. **C**.

The fastest loop running inside the MCS software is 20 Hz, though there is capability to run loops at 200 Hz. **C**.

Section 3

Sec. 3.2 We need to define modes and restrict access the MCS so that clients get the correct privileges (i.e. Read Only or Read and Write) in given modes. EPICS security features can probably help with this, but it needs to be simple so that non-software people have a fighting chance of using it correctly. Note that it was not our intention to give the software a number of operational modes, it is just important that we know in which client a command originated. **A. Foster**.

Sec. 3.3.1 Will logged data be archived to a local MCS hard disk or the workstation hard disk?

▼ - We shall assume that the ethernet connection is good enough for us to use the hard disk on the workstation. We shall consider a local disk only if forced to.

Sec. 3.3.2 What data rate is required to implement the logging function?

▼ - If the software was archiving 24 parameters from each PMAC card at a rate of 2 kHz then data must be stored at a rate of 0.5 Mega-Bytes per second.

Sec. 3.3.3 There is no requirement for the TCS to be able to change velocity and acceleration limits, so the System command is just for changing in position limits. ▼.

Sec. 3.3.3 The MCS will calculate ‘in position’ status and report this to the TCS. Note that any alarms associated with this status should be switched off during a slew. ▼.

Sec. 3.3.6 The MCS_GIS_Interface module is not part of the MCS_Hardware_Interface module since it is not an interface that directly controls hardware, it is an interface that communicates to a peer system. **C**.

Section 4

Sec. 4.4.1 Context diagram needs an interface to the SAD. ▼.

Sec. 4.4.3 The external signals are missing from the top level data flow diagram. ▼.

Sec. 4.4.2 The event list is incomplete. Some things to consider are :

- What happens if the time service is lost (e.g. when MCS/TCS re-boots).
- Are there any more fault conditions, note that Sec. 4.4.2.4 is a catch all.

A. Foster.