Feasibility Study for NAOMI EPICS Software Upgrade

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1.0 Introduction

This document describes a set of options for upgrading the EPICS software currently in use at the Isaac Newton Group, La Palma, for controlling the NAOMI adaptive optics system on the William Herschel Telescope. The options were specified in a document sent to Observatory Sciences by Stephen Goodsell of ING. The document includes background information about related EPICS software as well as the feasibility of, and estimated effort required, for the specified set of options.

The contents of this document were based on the information available to us at the time and any estimates of effort it contains should not be taken as a commitment for any future work undertaken by Observatory Sciences Ltd.

2.0 Abbreviations and Definitions

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ACR    - Assembly Control Record
ALTAIR - Gemini Adaptive Optics system
BSP    - Board Support Package (vxWorks)
CAD    - Command Action Directive
CAR    - Command Action Response
DCR    - Device Control Record
EPICS  - Experimental Physics and Industrial Control System
GCAL   - Gemini Calibration Unit
GMOS   - Gemini Multi-Object Spectrograph
GPOL   - Gemini Polarization facility
HROS   - Gemini High-Resolution Optical Spectrograph
IOC    - Input-Output Controller
SIR    - Status and Information Record
UAE    - Universal Application Environment
VME    - Versa Module Eurocard
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3.0 References

[1] *"Gemini Record Reference Manual"*, Bret Goodrich and Andy Foster, Gemini Project document reference SPE-C-G0070/02, June 1996.

[2] *"deviceControl Record Reference Manual"*, William Rambold, Jennifer Dunn & Angelic Ebbers, HIA document reference deviceControl/01, October 1998.

[3] *"Altair Users Manual: Device Control Record"*, Jennifer Dunn & Angelic Ebbers, HIA document reference aoDeviceControl.doc/01, March 2000.

[4] *"EPICS motionControl Record Reference"*, William Rambold, HIA document reference MotionControl/1.3, January 2003.

[5] *"assemblyControl Record Reference Manual"*, William Rambold, Jennifer Dunn & Angelic Ebbers, HIA document reference assemblyControl/02, October 1998.

4.0 Specification Supplied by ING

The following information is closely based on that originally supplied by Stephen Goodsell of the Isaac Newton Group:

4.1 NAOMI EPICS Background

The NAOMI mechanism control software was developed at the UKATC by Chris Tierney. The software was written using the R3.12.2Gem5 release of EPICS and VxWorks 5.2 for a mvme167 (68k) processor.

The software contains non-standard versions of the Device Control Record (DCR) and the Assembly Control Record (ACR). This makes the current versions and the NAOMI versions of these records incompatible. The current Gemini versions of these records contains many bug fixes. The NAOMI version of these records contains additional functionality to the Gemini versions.

The ING are looking to standardise the NAOMI EPICS software and make it maintainable, upgradeable and developable.

The "current" (in fact an upgrade) and "future" ING standard processor/VxWorks/EPICS configurations are:

	Processor	**VxWorks Version**	**EPICS Version**
Current	MVME147/167 (68k)	VxWorks 5.2	EPICS 3.13.1
Future	MPC7410 (PowerPC)	VxWorks 5.5 (Tornado 2)	EPICS 3.14.1

We are looking to firstly modify the software to include the robustness and functionality of the existing Gemini ACR and DCR, to upgrade to either the existing or future ING standard and finally to make our software independent of any specific Gemini release of EPICS.

4.2 Work Description

The ING requires OSL to research into the NAOMI EPICS software sufficiently to knowledgeably report on the following items.

1. The feasibility, associated risk, effort and cost in engineering the software so that it includes standard Gemini Records (I.e. CAD, CAR, SIR, DCR & ACR)
2. The feasibility, associated risk, effort and cost in upgrading NAOMI software to the current ING standard.
3. The feasibility, associated risk, effort and cost in upgrading NAOMI software to the future ING standard.
4. The feasibility, associated risk, effort and cost in separating the Gemini components of the EPICS release so that they may be loaded independently. Thus making future upgrades independent of changes in Gemini EPICS releases.
5. To comment on the feasibility, associated risk, effort and cost of upgrading the SDSU controller EPICS software.

5.0 Gemini EPICS Background

5.1 History

The very first EPICS release to be used by the Gemini Project was version 3.12.0 running under vxWorks 5.1.1. In November 1995, EPICS 3.12.2 was released and Gemini added their extensions shortly after. The CAD and CAR records to implement a command - action model on top of the standard EPICS system together with the SIR record to hold status information about the system. The Bancomm device and driver support was also added creating the first Gemini specific EPICS release.

A series of Gemini EPICS releases GEM4 (1997), GEM5, GEM6 (1998) and GEM6T (1999) were issued, each one adding new capabilities. GEM5 and GEM6 ran under vxWorks 5.2 while GEM6T was the first version to be compiled for the PowerPC architecture and ran under Tornado 1.0.1. However, one thing all of these releases had in common was their base EPICS system was 3.12.2.

Subsequently, further device and driver support was added and additional records created, including the Gemini apply and genSub records. The full set of Gemini standard records is described in the Gemini Record Reference Manual, see reference [1].

5.2 Present Day

Meanwhile, beginning in November 1996, EPICS 3.13 was released and was starting to be used by the EPICS community. By December 2000, the stable version of EPICS was 3.13.4 and the current version of vxWorks was Tornado 2.0.2. Gemini EPICS systems were then converted to use EPICS release 3.13.4 and this has evolved further, with ongoing bug fix and enhancement releases, so that the latest operational release at the time of writing is 3.13.4GEM8.4.

5.3 Future

The first stable version of EPICS 3.14 was only released recently (December 2002) and no significant work has yet been done within the Gemini project to make use of EPICS release 3.14.

6.0 NOAMI Software Inspection

The NAOMI software source code was provided to Observatory Sciences as two EPICS subsystems which use the UAE (Universal Application Environment) directory structure and build conventions. The subsystems were:

1. `naomiMechs`. An EPICS software subsystem to control the NAOMI mechanisms.
2. `naomiCam`. An EPICS software subsystem which provides an interface to the SDSU CCD camera controller. This subsystem also includes a substantial amount of non-EPICS assembler code specific to the Motorola 56000 Digital Signal Processor.

6.1 Documentation

The only useful NAOMI specific software documentation found was a few HTML pages dating from early 2000, written by Chris Tierney, which included a summary of directories used and a list of the mechanisms and EPICS device/driver support used.

This document mentions that VMIC-4515 and VMIC-3230 EPICS driver support is included and implies that these cards are used in the NAOMI EPICS system. However, there did not appear to be any actual use made of these I/O cards in the system, based on the source code as provided.

6.2 Building the NAOMI Software

The NAOMI systems use the UAE (Universal Application Environment), developed by Nick Rees (JAC) and William Lupton (formerly of Keck), which is the established development environment for real-time systems in the Gemini Project. It has proven to be extremely versatile whilst at the same time being relatively easy to use. Gemini have made many additions and modifications to UAE which have tailored the environment to its own particular requirements. The NAOMI system currently uses the UAE environment as supplied with Gemini EPICS release R3.12.2Gem5

Both NAOMI subsystems built correctly under EPICS 3.12.2.GEM5 without any significant problems.

6.3 Use of EPICS Records

The `naomiMechs` EPICS system is very small in terms of EPICS database size. There are only 90 EPICS records in the system as built. The record types and numbers are as follows:

Record Type	Number	Comments
assemblyControl	6	Each has specific device support
deviceControl	12	All using device type "`DEV CTL OMS 8/44`"
Gemini CAD	12	
Gemini CAR	12	
Gemini SIR	0	
Gemini Apply	0	

Record Type	Number	Comments
Gemini genSub	6	
Standard EPICS	42	Record types: `ai, bi, bo, dfanout, longin, longout, mbbi, mbbo, stringout`.

Note that no Gemini EPICS SIR or Apply records are used.

6.4 Device/Driver Support Code Statistics

In contrast, the amount of device, driver and subroutine support code is large. Statistics are as follows:

Type of code	Number of source files	Number of lines of C
assemblyControl device support modules	6	20442
deviceControl device support code	1	1480
driver code	1	1738
Record support code	2	8614
genSub subroutine code	7	1259
CAD subroutine code	2	114

Total = 33647 lines of C code.

6.5 Other Files

There are a significant number of Look-up-Table (.lut) files (18 in total). There are 21 DM screen definition (.adl) files.

7.0 Assembly Control and Device Control Records: Overview of Gemini Usage

It is important to note that *the Assembly Control and Device Control Records are not considered as standard Gemini records*. They are not included as part of any Gemini EPICS release. Instead, each individual Gemini application that uses them include their own version of these records in their systems.

The following is a survey of the current usage of the records in various Gemini control subsystems and is provided for background information only:

7.1 Assembly Control Record

Currently used in Gemini systems GPOL, GMOS and ALTAIR. The record code between GPOL and GMOS varies only vary slightly. GPOL does not follow the EPICS 3.13 naming convention. The ALTAIR version is now substantially different.

Documentation is available from the authors at the Hertzberg Institute of Astrophysics, Canada. See reference [5] for a description of the record version corresponding to that used in NAOMI.

7.2 Device Control Record

Currently used in Gemini systems GCAL, GPOL, GMOS, HROS and ALTAIR. The version in GCAL, GPOL, GMOS and HROS is almost identical - they could very easily be made the same and this should be done. However, the EPICS 3.13 naming convention is not being obeyed by GCAL, GPOL and HROS. The ALTAIR version is substantially different. The differences in the ALTAIR version are linked to the fact that it uses an OMS-58 motor controller rather than the older OMS-8/44. But, these differences should all appear in the device support code, not the record code.

Documentation is available from the authors at the Hertzberg Institute of Astrophysics, Canada. See reference [2] for a description of the record version corresponding to that used in NAOMI. Reference [3] describes the more recent version used in ALTAIR, whilst reference [4] describes the more capable motionControl record currently under development which may eventually supersede the Device Control record.

7.2.1 Device Support used with the DCR for different Gemini subsystems:

GCAL	devDeviceControlOMS
GPOL	devDeviceControlOMS
GMOS	devDcOms844
HROS	devDeviceControlOMS
ALTAIR	devDevControlOMS58

The device support for GCAL and GPOL is the same. The device support for GMOS and HROS is the same. The GCAL/GPOL code uses a different indexing algorithm to GMOS/HROS.

8.0 NAOMI Upgrade Options

The following sections correspond to the originally specified options shown in the Work Description in Section 4.2 on page 3.

Note: All the following estimates assume that the UAE build environment is retained for NAOMI. If a decision were taken to move to the alternative `makeBaseApp` environment then this would involve considerable extra effort.

8.1 The feasibility, associated risk, effort and cost in engineering the software so that it includes the standard Gemini Records (i.e. CAD, CAR, SIR, DCR, ACR).

If we are going to use the "standard" Gemini CAD, CAR and SIR records, this must imply that we are also upgrading to EPICS 3.13.4, since the latest records are those which run against 3.13.4. Note that *the Assembly Control and Device Control Records are not considered as standard Gemini records* and are not part of any Gemini EPICS release.

This option cannot be considered independently of others: see second and third solutions shown in Section 8.2 below.

8.2 The feasibility, associated risk, effort and cost in upgrading the software to run on an MVME167, under vxWorks 5.2 and EPICS 3.13.1.

8.2.1 Proposed Solution 1: Upgrade to EPICS 3.13, but do not change any EPICS records.

Feasibility: Definitely possible

Risk: Risk is that Gemini are currently running their systems with EPICS 3.13.4. There have been bugs fixed between 3.13.1 and 3.13.4 in the core release. So, it is possible that some of these may show themselves for the first time in the new system. A safer option would be to upgrade to Gemini's standard of EPICS 3.13.4 and the estimated effort assumes that this is the case.

Estimated Effort: 5 days *not including testing*. (Note: Sufficient testing time must be additionally allocated).

8.2.2 Proposed Solution 2: Upgrade to EPICS 3.13, update records to latest Gemini versions (excluding DCR and ACR)

Feasibility: Definitely possible

Risk: As above, but now we have the added complication that the Gemini records are written to run against 3.13.4 and have never been used with a release based on 3.13.1. It would be safer to upgrade to version 3.13.4 and the estimated effort assumes that this is the case.

Estimated Effort: 7 days *not including testing*. (Note: Sufficient testing time must be additionally allocated).

8.2.3 Proposed Solution 3: Upgrade to EPICS 3.13, update records to latest Gemini versions, including DCR and ACR

Feasibility: Definitely possible

Risk: As mentioned above as regards 3.13.1/3.13.4. It would be safer to upgrade to version 3.13.4 and the estimated effort assumes that this is the case.

Estimated Effort: 18 days *not including testing*. (Note: Sufficient testing time must be additionally allocated).

The extended time is required because we need to fully understand the differences between the NAOMI DCR/ACR records/device support and the current Gemini records/device support. The records NAOMI uses were spawned off in 1999, at a relatively early stage in the development of these records. Since then, the Gemini versions and the NAOMI versions have gone their own way. There appear to be a lot of bug fixes in the Gemini versions.

8.3 The feasibility, associated risk, effort and cost in upgrading the software to run on an MPC7410, under vxWorks 5.5 (Tornado 2) and EPICS 3.14.1.

NOTE: There is a possible misunderstanding in the specification: to be precise, vxWorks 5.5 is actually Tornado 2.2. Tornado 2.2 is the only version which has a BSP for the MPC7410 processor card, also known as the MVME 5100.

Feasibility: *Not currently possible as specified*. EPICS 3.14.1 has a problem in that it is known not to compile for the MVME 5100 with the cross-compiler issued as part of Tornado 2.2. This problem is due to be fixed in the next version of EPICS (3.14.2) which is due to be released in May 2003.

Risk: High. We would have to use a completely new release of EPICS that would have never been used with Gemini systems.

Estimated Effort: Assume we do have a suitable EPICS system (3.14.2) that works with an MVME 5100. A rough estimate of the effort would be about 37 days, comprising

1. Building of, and familiarization with, a new EPICS release (5 days)
2. All custom Gemini records to be upgraded (12 days)
3. UAE will need changes to make it compatible with the new make system in 3.14 (10 days)
4. Any problems are taken care of which arise with the new PPC 5100 processor and new BSP (5 days)
5. Miscellaneous tasks in porting the rest of the EPICS system (5 days)

8.4 The feasibility, associated risk, effort and cost in separating the Gemini components of the EPICS release so that they may be loaded independently

Feasibility: Definitely possible. For this estimate, we assume that we have already performed an upgrade to EPICS 3.13. The code and other files relevant to the Gemini standard records would be extracted and relocated so that they could be retained in any NAOMI upgrades, independently of any future Gemini releases.

Risk: Low, this is a straightforward and well-understood procedure.

Estimated Effort: 3 days *not including testing*. (Note: Sufficient testing time must be additionally allocated). This effort is in addition to that for any of the options previously mentioned.

8.5 The feasibility, associated risk, effort and cost of upgrading the SDSU controller EPICS software.

This option is currently rather ill-defined. The processor and EPICS release need to be specified. The EPICS software layer of the `naomiCam` subsystem is not complex, with no Gemini records and no Device or Assembly records. It may be possible to upgrade to EPICS 3.13/MV5100 relatively easily but the requirements need to be clarified.

If we assume that the upgrade is to the current Gemini EPICS 3.13 release, running on an MV167 processor, a rough estimate of the effort required might be 5 days.

9.0 Summary

The following table gives a brief summary of the estimated effort for the various options previously discussed:

Option	Brief Description	Estimated Effort (1)	Notes
1	Include "standard Gemini Records"	-	Incorporated within other options
2.1	Upgrade to 3.13/MV167, no records changed	5 days	
2.2	Upgrade to 3.13/MV167, no DCR & ACR upgrade	7 days	
2.3	Upgrade to 3.13/MV167, upgrade all records	18 days	
3	Upgrade to 3.14/PowerPC	37 days	High risk, assumes use of EPICS release that is not yet available
4	Make Gemini records independent	3 days	*In addition* to effort for other options
5	Upgrade SDSU Controller software	5 days?	Requirements not yet clarified

(1) Note that these effort estimates exclude time for testing.