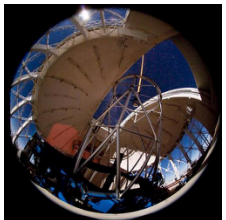


## Gemini Real-time Systems Software Upgrade



# Breaking Away From WindRiver

A viable alternative to VxWorks on the VME Platform



# Outline and Gemini Upgrade Overview



## Outline

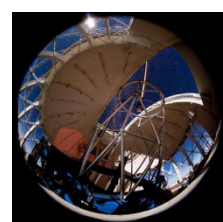
- What is it?
- Rationale to Upgrade
- RTEMS Real-time OS
- EPICS on RTEMS
- Upgrade Principles
- Control Architecture
- EPICS OSI

## What is the Gemini Upgrade?

- Refactor 14 Facility Control Systems for EPICS OSI compliance
- RTEMS  $\geq$  4.10.2 RT systems and Linux CentOS 7 for Soft IOC
- EPICS  $\geq$  3.14.12.4
- Write 'as-built' requirements, use cases and test plans

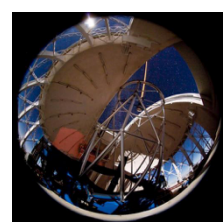


- Typical VME controller with PowerPC 2700
- Peripheral boards include PMAC, Xycom240, Xycom 566, Bancomm, IPAC Carrier



# Rationale for Upgrade

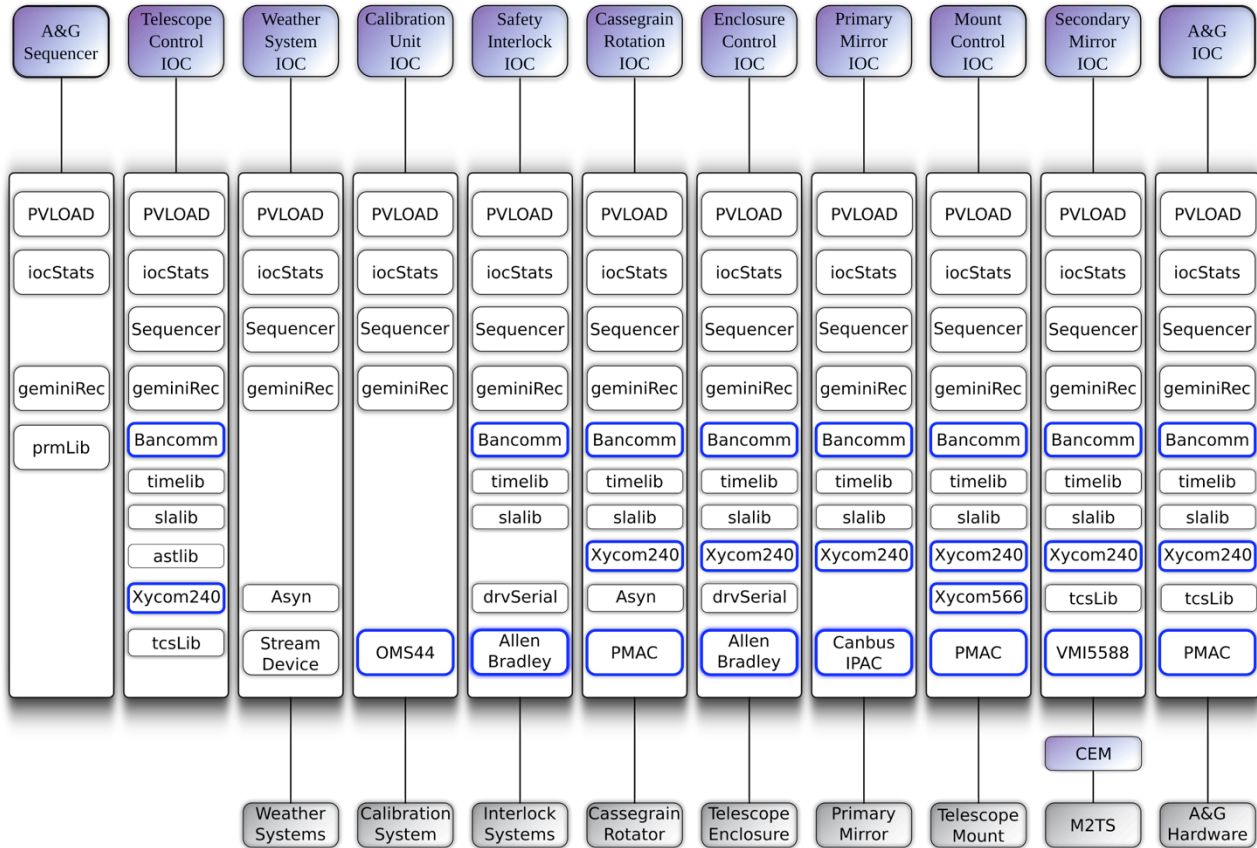
- Upgrade EPICS to 3.14.12.4 (**15+ plus years bug fixes**)
- VxWorks 5.5.1 (**gcc 2.95 July 31, 1999**) → RTEMS 4.10.2 (**gcc 4.4.7 March 13, 2012**)
- Rationalize VME drivers into common code base.
- 14 Telescope Facility Control Systems
  - 28 Real-time IOC's ← **project scope**
  - 6 AO Control Systems
  - 7 Science Instruments
- VxWorks support is limited/obsolete, yet we still pay
- Cumulative VxWorks costs exceed \$100,000 USD
- Upgrade estimates for VxWorks > \$200,000 USD
- Promote a viable long-term vision for **Free** OSS at Gemini
- Gemini not first to upgrade legacy RT systems:
  - Keck upgrade TCS on VME to Linux on PC
  - DLS retains older VME RT systems, but develops new systems with PC's and Linux
  - CLS adopted **Free** OSS for VME controllers using RTEMS on PowerPC

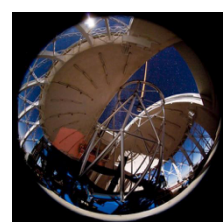


# RTEMS

- Real-time Executive for Multiprocessor Systems
- Project initiated in 80's from US Army Missile command.
- Has matured to support many targets:
  - Intel Pentium
  - Power PC
  - MIPS
  - ARM
- Development environment supports cross compilers for many hosts:
  - Linux, Windows, Free BSD, Mingw
  - Cygwin, Solaris
- Familiar concepts to VxWorks Scheduling
- Supports multiple scheduling algorithms
  - Deterministic Priority (255 levels)
  - Simple SMP (multiple cores)
  - Earliest Deadline First (EDF)
- Time-slicing and manual Round Robin preemption
- Managers
  - Memory, Task, Interrupt, Clock, Timer
- Real-Time objects
  - Semaphores
  - Message Queues
- Context switch and interrupt performance comparable to VxWork (or better\*)

# Gemini Control Systems





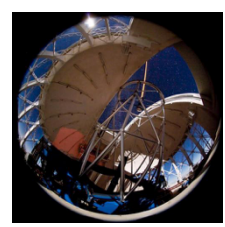
# EPICS OSI LAYER

How to make your EPICS driver operating system independent?

[https://wiki-ext.aps.anl.gov/epics/index.php/How\\_to\\_make\\_your\\_EPICS\\_driver\\_operating\\_system\\_independent](https://wiki-ext.aps.anl.gov/epics/index.php/How_to_make_your_EPICS_driver_operating_system_independent)

EPICS OSI build environment generates targets executable code for RTEMS, VxWorks and Linux

Legacy Code	OSI Code
<code>#include &lt;vxWorks.h&gt;</code>	
<code>#include &lt;stdlib.h&gt;</code>	<code>#include &lt;epicsStdlib.h&gt;</code>
<code>#include &lt;taskLib.h&gt;</code>	<code>#include &lt;epicsThread.h&gt;</code>
<code>#include &lt;semLib.h&gt;</code> <code>SEM_ID flag =</code> <code>semBCreate(SEM_Q_PRIORITY,</code> <code>SEM_EMPTY);</code> <code>semGive(flag);</code> <code>semTake(flag, WAIT_FOREVER);</code>	<code>#include &lt;epicsEvent.h&gt;</code> <code>epicsEventId flag =</code> <code>epicsEventMustCreate(epicsEventEmpty);</code> <code>epicsEventSignal(flag);</code> <code>epicsEventMustWait(flag);</code>



# Gemini Upgrade Project Status

Every CCB package defined requirements and test plans

128 Total test procedures verify 128 requirements

92 Passed

32 Waived (required driver functionality not used at Gemini)

4 Pending (Required for ECS and MCS commissioning)

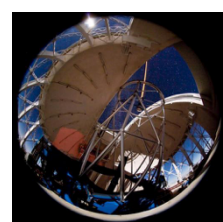
TST-112-09 XYCOM 566 Two card support for testing both Tacho and Motor Current inputs

TST-113-25 PMAC (MCS) Two card support to test both AZ and EL

TST-113-27 PMAC (MCS) Two continuous data streams using the MAB

TST-113-xx PMAC Fixed Data Servo Thread

TST-117-07 Two PLC Support for ECS



# Conclusion

- Gemini will recommission all facility Real-Time Control Systems in 2017
- EPICS 3.14.12.x
- Refactored EPICS OSI compliant drivers
- RTEMS 4.10.2
- Application development environment derives from DLS (Nick Rees) and integrates nicely with SVN
- RTEMS Driver's tested on PowerPC, EPICS include:
  - Bancom 635/637
  - Xycom 240 (DIO)
  - Xycom 566 (ADC)
  - PMAC
  - GreenSprings IPAC Carrier Board
  - Allen Bradley PLC (ABDf1) --based on drvSerial
  - VMIC-5588 Reflected Memory
  - OMS 44