Overview of the control system for the Keck Interferometer

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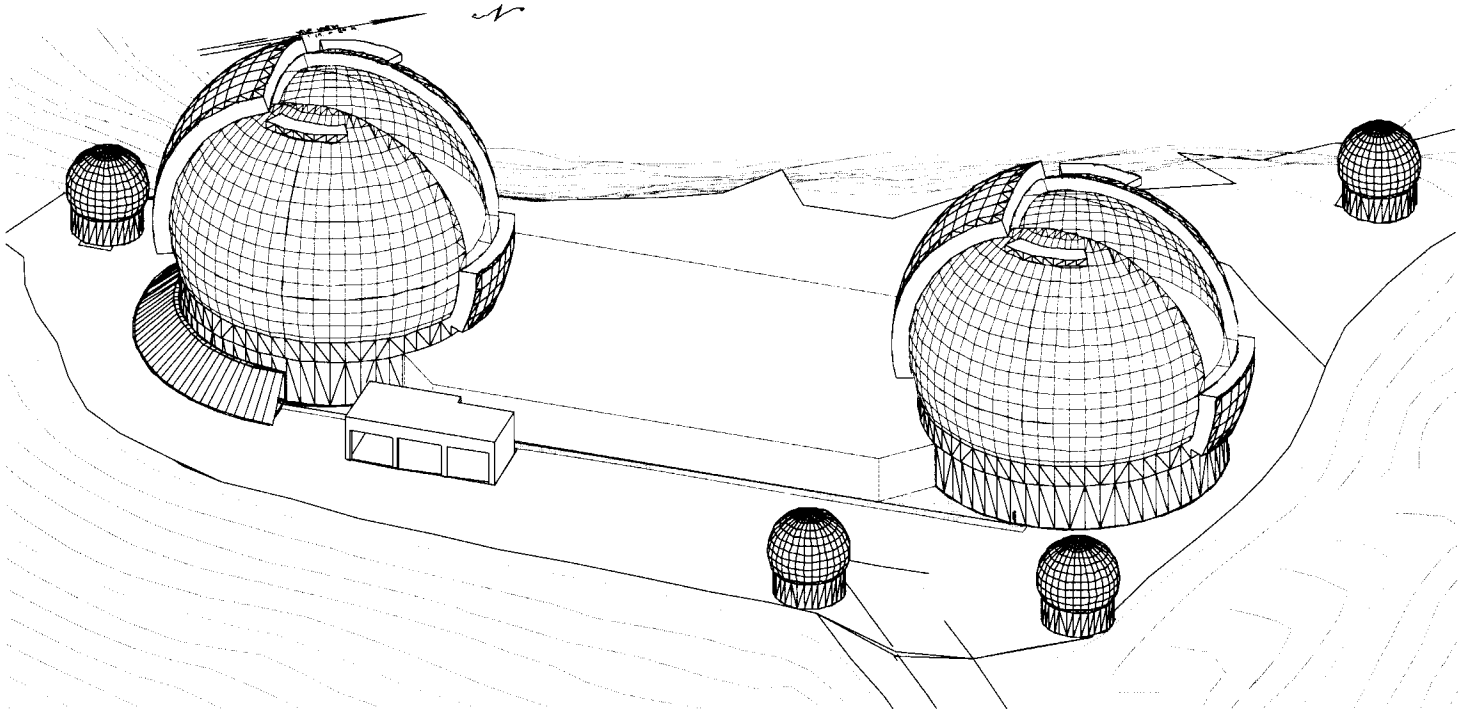
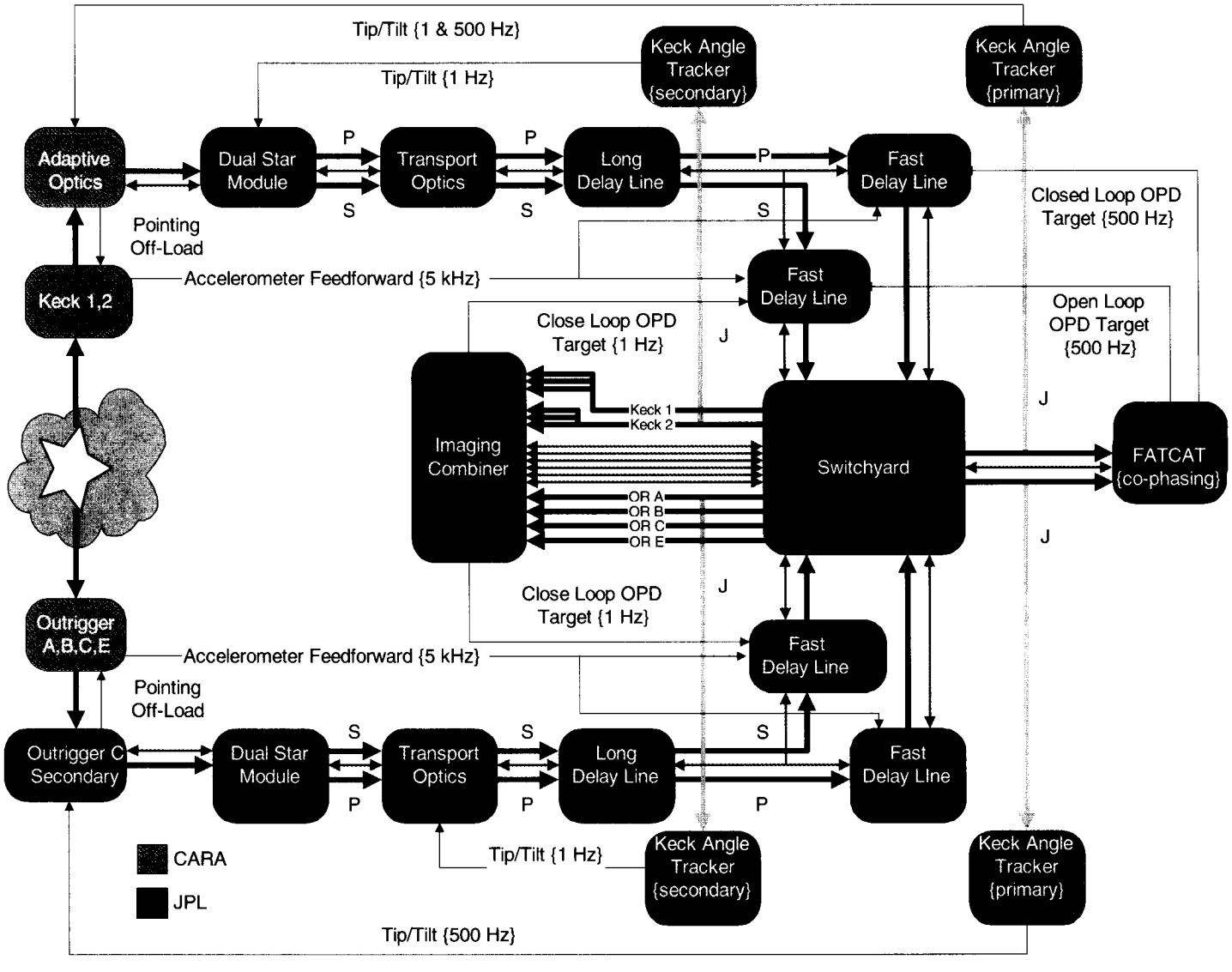
The Keck Interferometer



- 2 keck 10m telescopes with full AO
- Proposed 4-6 outrigger 1.8m telescopes with tip-tilt
- Baselines 30m to 135m (K-K 80m)
- Wavelengths J to N (AO operates in visible)
- Science: nulling, differential phase, astrometry, imaging

Complexity – Imaging Systems



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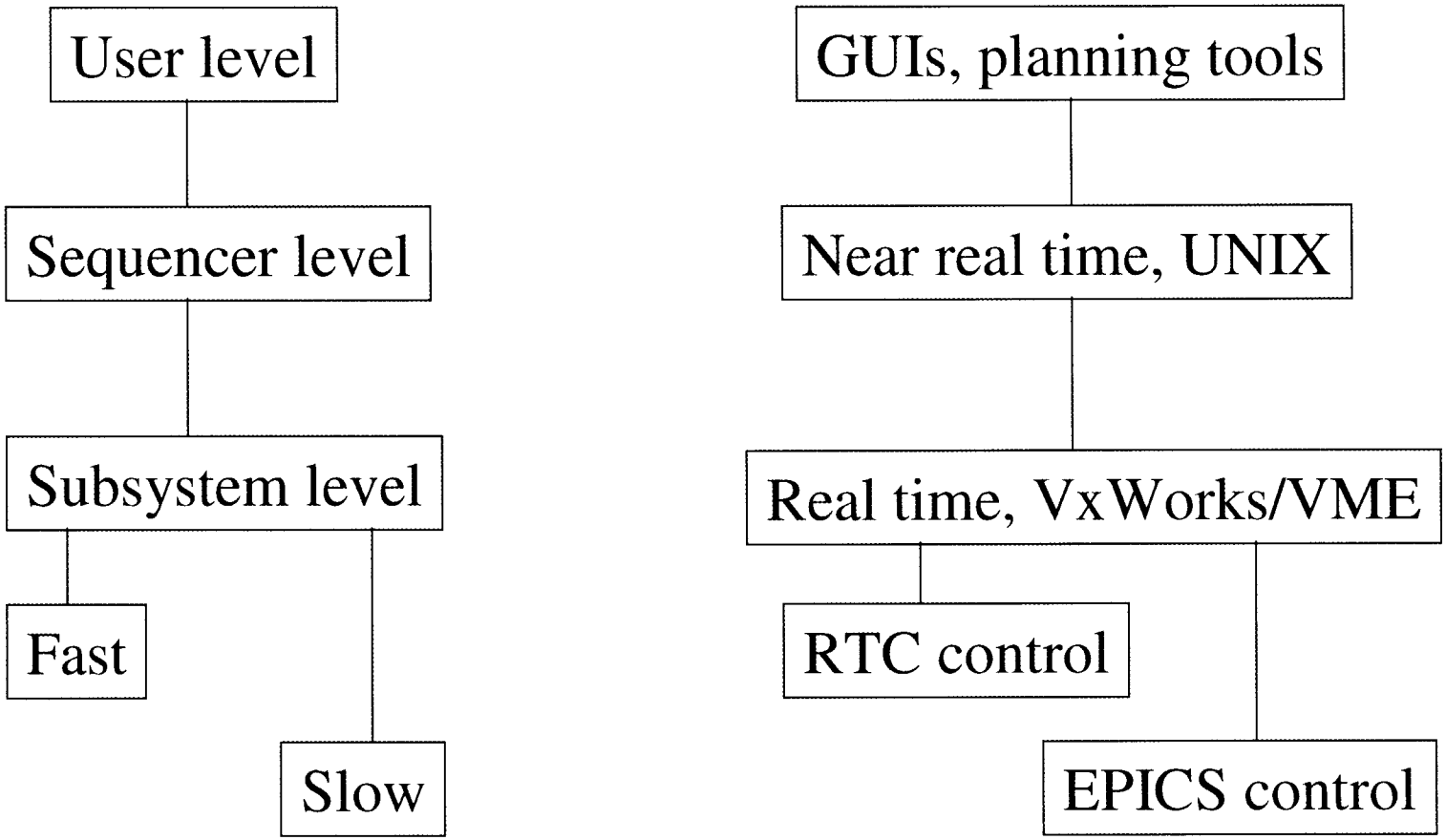
Complexity

- Many subsystems to control
  - Angle tracker, fringe tracker , fast delay lines, long delay lines, tip-tilt metrology, transport optics (off axis coude train), Dual star modules, telescope systems, AO systems
- Many copies of functionally identical subsystems
  - E.g. Imaging mode has 12-16 fast delay lines
- Many interactions between subsystems
  - E.g. fringe tracker feed back to fast delay lines
  - Large number of interfaces to control
- Two organizations
  - JPL: Initial interferometer development and testing to full operation
  - WMKO: Telescope systems, plus long term operation, maintenance, user support
- Requires high degree of reliability and ease of use

Tight requirements

- Demanding control requirements
  - Fast servos (to 5-10 kHz)
  - Precise control (<0.1λ)
  - Requires careful design of control systems for optimal performance
- Science measurements require high degree of automation
  - (interferometry requires careful calibrations)
  - Fast switching between science integration and internal calibrations
  - Fast switching between target and calibrator stars
  - Consistency of steps to achieve single science observation
  - Requires high degree of automation
    - Automated sequencing of subsystems
    - Automated sequencing of observations (queue scheduled observing)
    - Automated optical alignments
      - large numbers of optical elements
      - Long beam train distances

Control Hierarchy



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Subsystem control

- Fast
  - Hard real time control for fast servos (e.g. delay lines)
  - JPL developed control infrastructure – "RTC"
    - See Lockhart, this conference
  - Collaborative with other JPL testbeds
  - Object Oriented design, C++
  - VxWorks based in VME environment, Power PC CPUs
- RTC infrastructure
  - State machine framework for subsystems – "gizmos"
  - Factory design pattern use to instantiate gizmos
  - Configuration control and recording
  - Telemetry generation and distribution
  - Standard command interfaces
  - GUI framework and connection to command and telemetry

Subsystem control

- Slow
  - Real time control of "slow" elements, e.g. mirror pointing
  - EPICS based
    - Keck Observatory standard: gives useful expertise overlap and ease of handover
  - VxWorks based in VME environment, Power PC CPUs
- Use of common hardware for fast and slow systems
  - PPCs, IP modules, VME bus, PMAC device controllers

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Sequencing

- Levels of sequencing
  - Target list sequencer
  - Interferometer sequencer
  - Telescope sequencers
  - Subsystem sequencers
  - Real time sequencers

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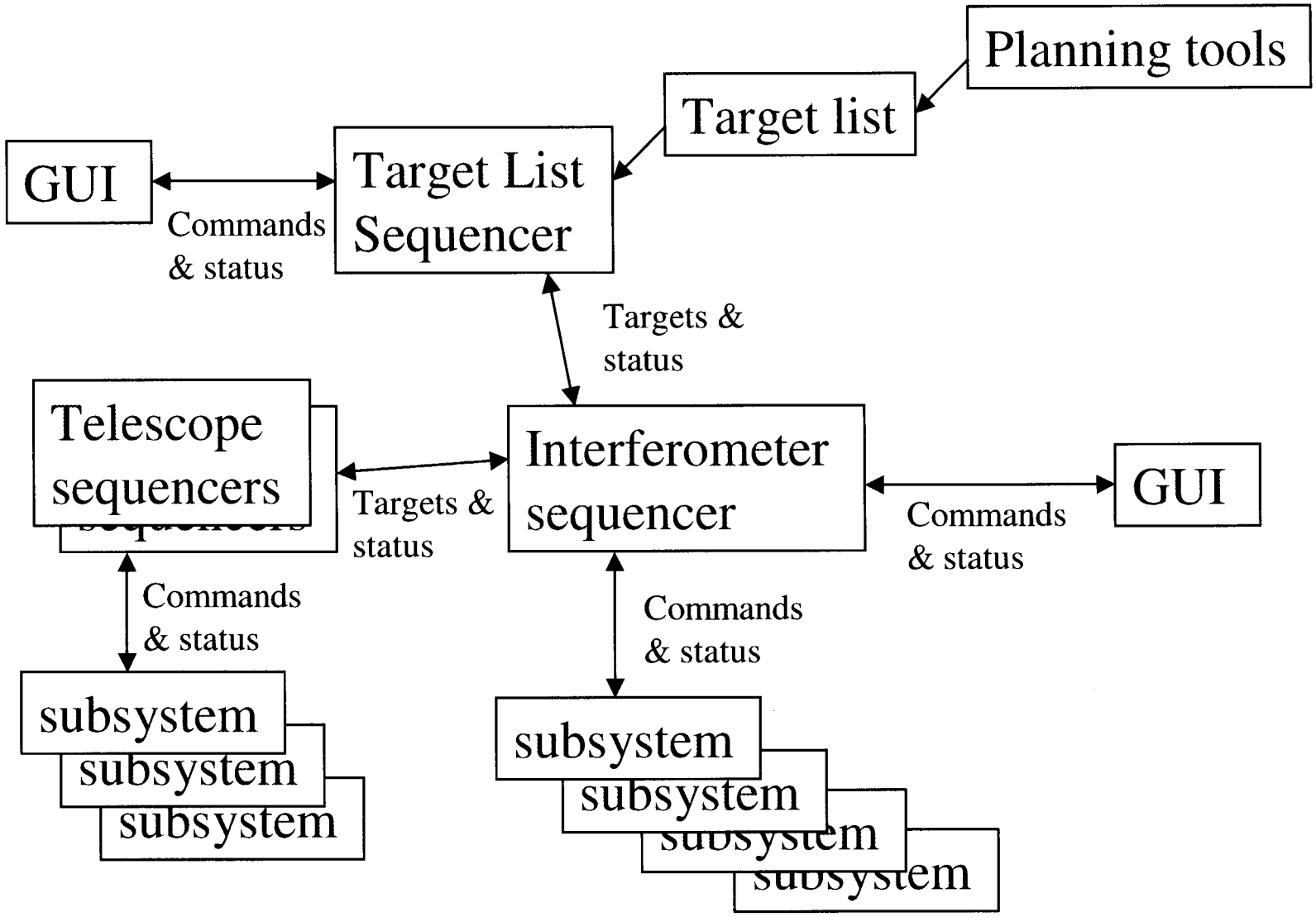
Target/Observation Sequencing Overview



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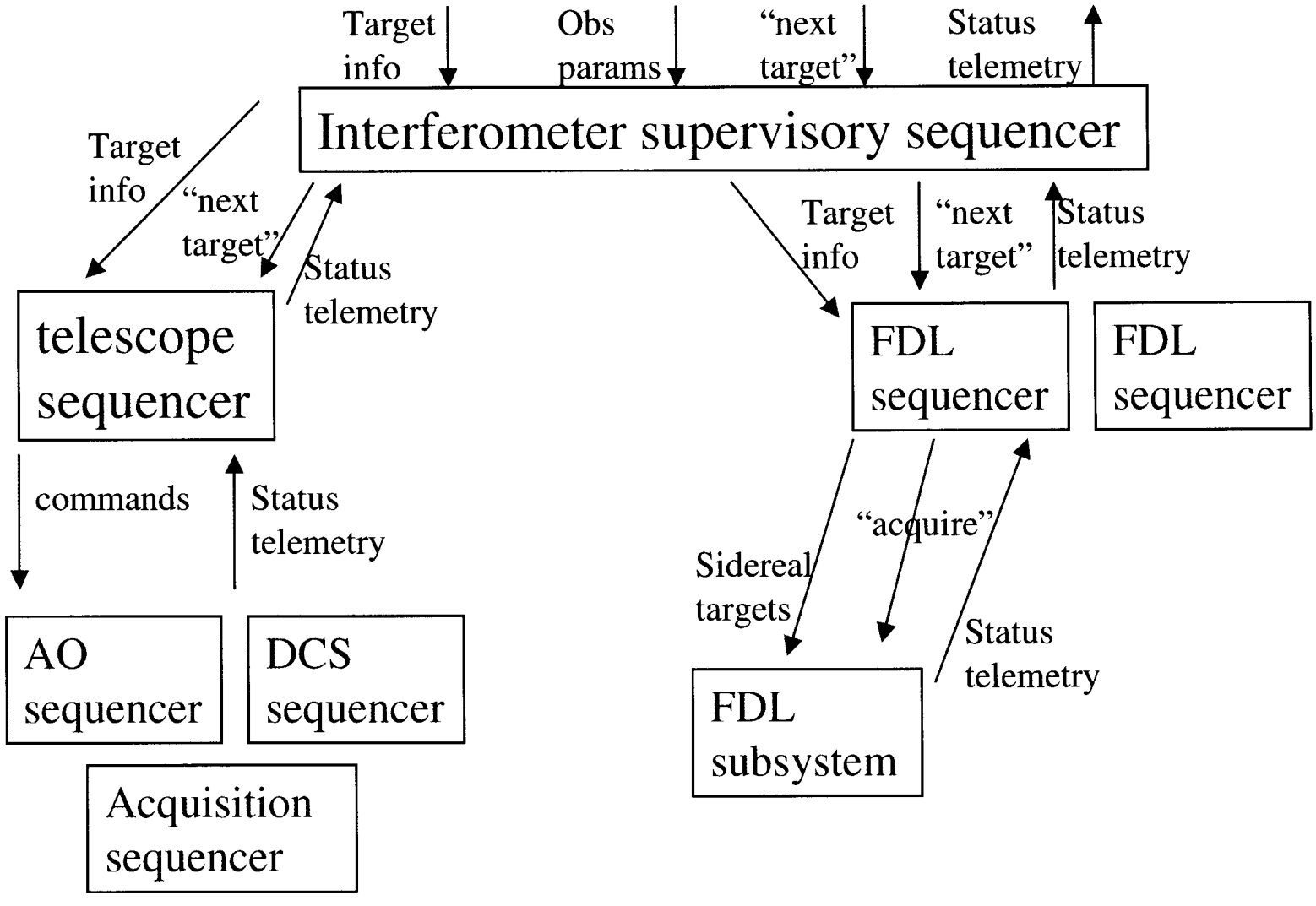
Interferometer Sequencer - Details



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Sequencer Implementation

- Prototyping in scripting languages
  - E.g. Tcl/Tk
  - See Reder et.al., this conference
- Interferometer Sequencer version 1.0
  - Use of I-Logix tool "Rhapsody"
  - UML based, VPE interface, C++ code generation
  - Solaris run time, PC development
  - Modular design
- Target list sequencer
  - Scripting language implementation
  - Solaris
- Telescope sequencers
  - WMKO development
  - EPICS state notation language
  - Solaris

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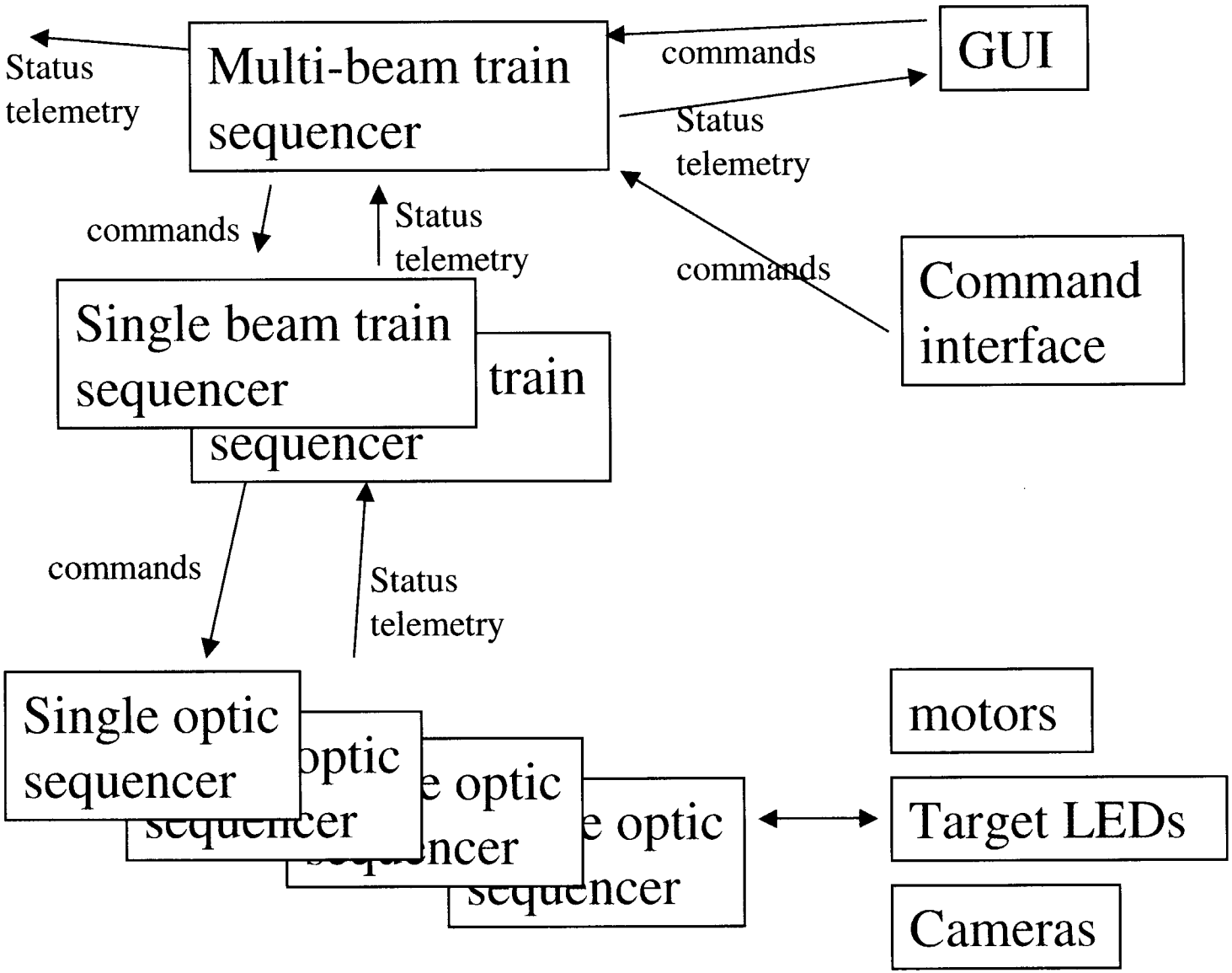
Autoalignment Overview



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Alignment Sequencers

- Modular design
- Multi-element sequencers
  - Combine beam trains as set of single element sequencers
  - Rhapsody
  - C++, Solaris run time
- Single element sequencers
  - Align a single optic in beam train
  - EPICS state notation language
  - VxWorks

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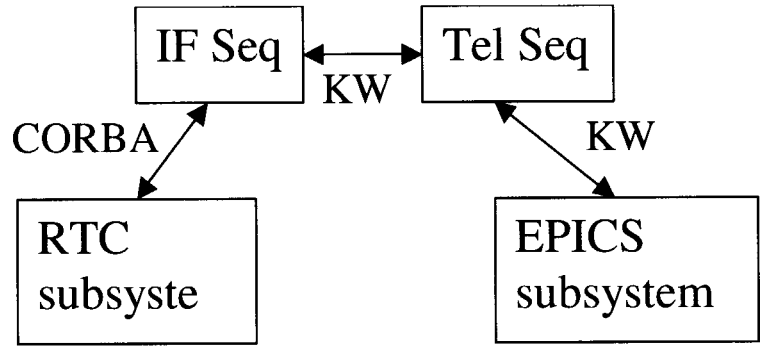
Interfaces

- Many interfaces
  - Subsystem – subsystem
  - Subsystem – sequencer
  - Sequencer – sequencer
  - Command and telemetry
  - Client – server
- Two operating systems
  - RTC - EPICS
  - Different internal interfaces
- EPICS
  - Keyword – value layer on top of channel access
  - WMKO legacy interface
  - Used by all pure EPICS systems for command and telemetry

Interfaces

- RTC
  - Interprocessor communication mechanism: subsystem – subsystem
    - Internal interface via shared memory or fire-wire
  - External interfaces all implemented in CORBA
    - OO
    - Generic telemetry interface definition
    - Standard format command interfaces defined using IDL
- CORBA to Keyword interfaces restricted
  - Mostly at sequencer level



  - Few at subsystem level
    - Provide generic thin layer interfaces for all combinations

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Status

- Keck–Keck single baseline in V^2 mode operational
  - All required real time subsystem gizmos operational
    - FDLs, fringe tracker, angle tracker, tip-tilt metrology, path length metrology
  - Sequencing Version 1.0 implemented
    - Post prototype
    - Fully sequences internal calibrations
    - Interfaced to telescope sequencers
    - Manual version target list sequencer operational
  - On sky testing and preliminary science in process
- Auto-alignment
  - Beam train auto-alignment operational
    - Full beam train sequencing near completion
  - Subsystem internal alignment in process
    - Angle tracker alignment sequencer just deployed

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