KAON # 751

Next Generation Adaptive Optics System

Laser Guide Star Facility

Subsystem Control Sequencing

Preliminary Design

May 02, 2010

VersionV1.0

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REVISION HISTORY

Revision	Date	Author (s)	Reason for revision / remarks
1.0	May 4, 2010	JC	Preliminary Design Release

TABLE OF CONTENTS

1 INTRODUCTION

As part of the Next Generation Adaptive Optics (NGAO) System, a Laser System Control (LSC) will be implemented to control subsystems within the Laser Guide Star Facility (LGSF). The Laser System Control is shown in the circled area in **Error! Reference source not found.**. A more detailed description of the LSC can be found in KAON 511. These subsystems will be controlled via state machines operating in the LSC. This document provides the states of these subsystem and their allowable transitions among these states. These states will support the design and implementation of the software sequencer for controlling the subsystems within the LGSF, KAON 736. Complex subsystems such as the Beam Transport Control and the Laser Control will require significantly more control; while the Laser Camera Control and Environmental and Power Control will require minimal sequencer control. The Laser Safety System will not require any sequencer control based on the nature of its functionality.

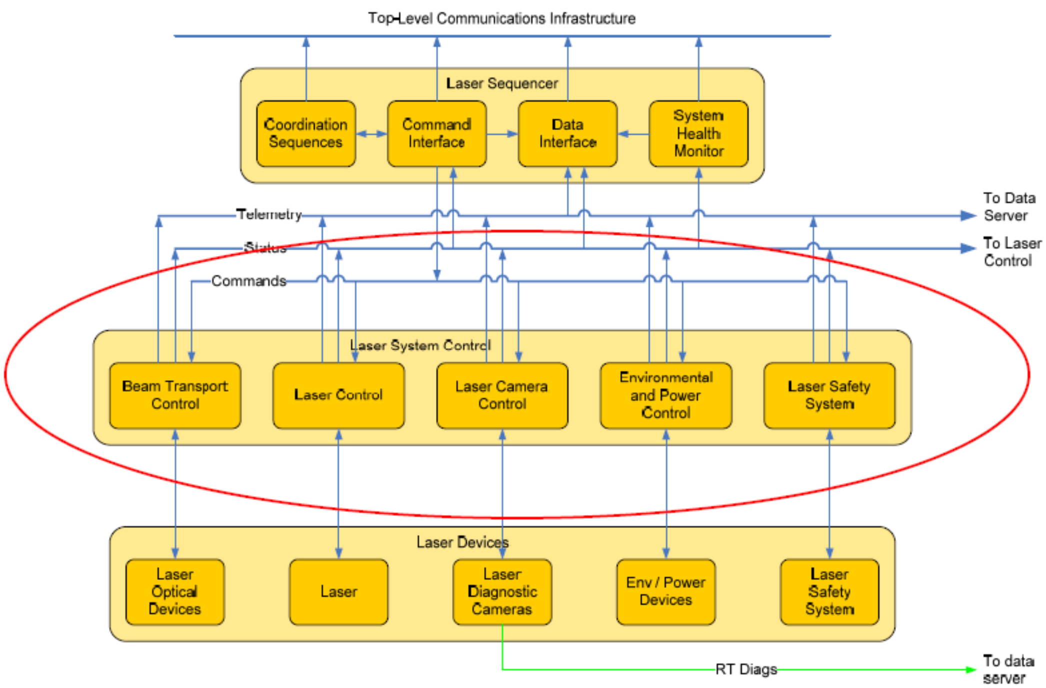

Figure 1: Laser System Control (KAON 511)

2 REFERENCES

2.1 Referenced Documents

Documents referenced are listed in Table 1. Copies of these documents may be obtained from the source listed in the table.

Ref. #	Document #	Revision or Effective Date	Source	Title
1	KAON 511	2.1	WMKO	NGAO System Design Manual
2	KAON 570	0.3	WMKO	NGAO Laser Facility System Design
3	KAON 736	1.0	WMKO	NGAO Controls Architecture Laser Sequence

Table 1: Reference Document.

2.2 Acronyms and Abbreviations

Table 2 defines the acronyms and abbreviations used in this document.

Acronym/Abbreviation	Definition
BTS	Beam Transfer System
BTS	Beam Transport System
GUI	Graphical User Interface
KAON	Keck Adaptive Optics Note
KAON	To Be Determine
LCS	Laser Control System
LSC	Laser System Control
LSS	Laser Safety System
NGAO	Next Generation Adaptive Optics System
WMKO	W.M.K. Observatory

Table 2: Acronyms and Abbreviations.

3 STATE DEFINITIONS

Sequencers are similar to state machines by controlling the states or status that defines a system. The sequencer controls the allowable transitions between states as well as providing critical information to other subsystems that depends on the state of the sequencer. An example of this is that that the Beam Transport Control Sequencer must be properly tracking before the final shutter can be opened to propagate the laser beam onto the sky. Sequencers can also initiate other sequencers to change states. An example of this is the Multi Control Sequencer (MCS) informing 50 other sub-sequencers to start initializing their devices.

Sequencer operates between multiple states but is designed in two general directions, start up from a system that is off to operational and shut down from operational to an off state. States are either defined as static or transitional. When a system is in a static state, the system will remain in the static state until an intervention occurs. Interventions are triggered events such as user commands via a GUI or software operating in the background. Another example of an intervention is a system fault.

During the start up process, the system travels between static states as commanded by the user. Transitional states are intermediary states to inform the user that the system is changing its static state. Systems can reside in transitional states for long durations in cases a system is warning up or a motion device with long physical travels to find its home. The system will exit from the transitional state once its tasks are completed without user intervention.

During the shut down process, the system travels between static states without transitional states. Since shut down generally do not require substantial reconfiguration of the system, these static transitions are quicker and do not require transition states. Unlike start up, shut down can allow transitioning back down to its lowest rest state without going through several intermediary states. This ability will be system dependent.

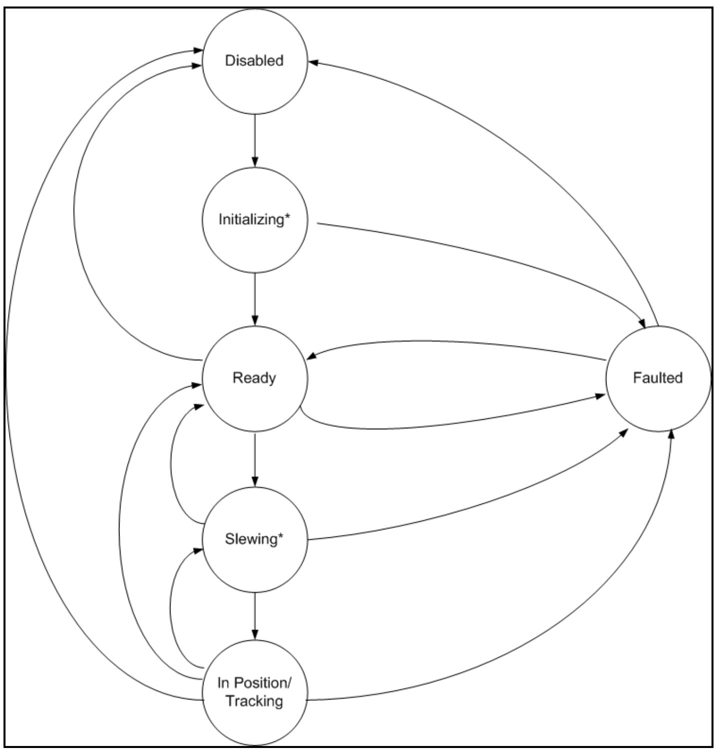

Figure 2: Example of Sequencer

Each system will also include a faulted static state. Systems will generally include health checks that will determine if the system has faulted. The system will remain in a faulted state until user intervention is applied. User intervention of faulted states will require correction of the fault and/or clearing the alarm associated with the fault. Faulted states can only transition to static states; generally the system will step down to the previous static state. Figure 2 provides an example of states of a simple motion device.

A device starts off in a DISABLE static state. Upon a user initialization, the device goes into a transitional INITIALIZING state to acquire its home position or reference. The system will report “initializing” to the user as the status for the device. Once the device completes its initialization, it will remain in the READY state and await further instruction. It is important to note that the READY state represents the device has knowledge of its reference or home position. When the device is commanded to the next position, the device will go into the S*lew* transitional state. Once the device reaches its destination, it will either go into the IN POSITION state for non-tracking devices or TRACKING state for tracking devices. The device can go into the static *Faulted* state any time a problem is determined. Once in the FAULT state, intervention is necessary for it to get out of this state. The example provided is for a single device; it is also possible to imagine a transition from DISABLED to INITIALIZING controlling multiple sub-sequencers controlling any number of devices.

4 LASER CONTROL SEQUENCER

The NGAO laser will have six internal modes. These laser modes will be mapped to software modes in the sequencer. The laser modes are used internally within the laser system for its control while the software modes are used by WMKO to determine the control and status of the system. These are shown in the following table:

Laser Mode Value	Laser Operation Mode	WMKO Software Mode
0	*OFF*	-
1	*STANDBY*	DISABLED
2	*READY*	-
3	*ON*	READY
4	*OBSERVATION*	LASER PROPAGATING
5	*MAINTENACE*	MAINTENANCE

Table 3: Laser Modes

In the laser *OFF* mode, the system is powered off. Communications with the laser control sequencer will not be available. Once powered on, the laser will transition into the *STANDBY* mode automatically. In this mode, the laser will start the process of warming up the equipment without generating any light. Once the next command is given to go to *READY*, the system will turn on its seed laser and pump lasers. This will take 30 minutes or longer for the system to enable and verify its loops are operating. Once the system is ready, the software can command the system to the *ON* mode when all the laser internal loops will be closed. The system will stay in this mode until the laser shutters are ready to open. When commanded to open, the laser will enter the *OBSERVATION* state. The laser state machine is shown in Figure 3.

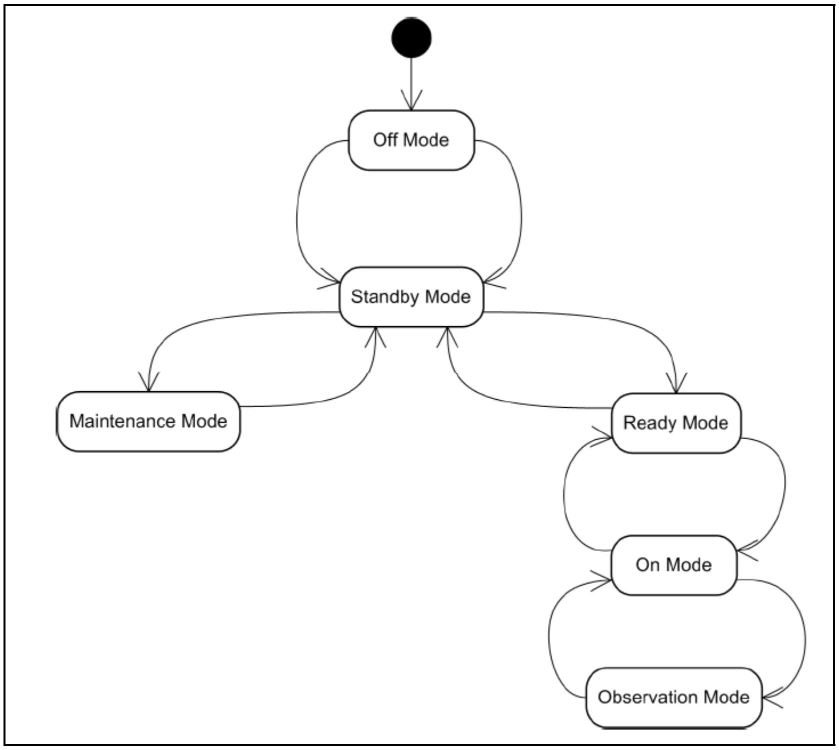

Figure 3: Laser State Machine

From the software sequencer's view, the system will be in the DISABLED mode when the laser is initially powered on. When commanded to initialize, the laser system transition through its *READY* and *ON* mode. The sequencer internally will command the laser through its modes to software mode READY. At this point, the laser is available for propagation. In the final command to LASER PROPAGATING, the laser will open its output shutter to note its *OBSERVATION MODE*. The laser can also be in the *MAINTENANCE* mode during servicing.

The laser will continuously monitor its internal health and transition into a faulted state if necessary. If at anytime a fault is detected, the sequencer shall also go into a FAULT state. Depending on the fault, the laser may remain in its current state, go back to its previous state, or possibly return to the *OFF* state for safety. User intervention will be necessary to acknowledge and/or clear the fault prior to continuing to the next state. Figure 4 shows a possible software sequencer state machine.

The NGAO laser system will provide a simulation mode to support testing of the software sequencer. The simulation mode will provide all the functionality of the laser without any hardware other than the microcontroller board interfacing with the Laser Sequencer. This mode will verify the communication protocol, test algorithms and sequences, as well as checking synchronization problems.

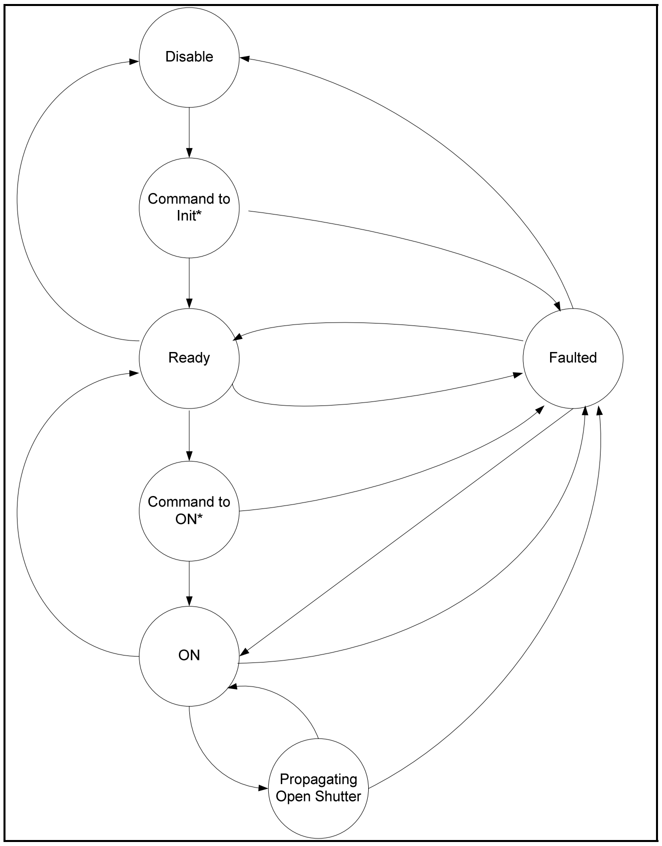

Figure 4: Laser Controller Sequencer

5 BEAM TRANSPORT SYSTEM CONTROL SEQUENCER

The BTS Sequencer provides control of the laser switchyard control, beam transport to the top end and the asterism generator (Figure 5). A more detailed description can be found in KAON 570. The BTS will be comprised of multiple motion control devices to properly steer the beam from the laser output shutter to the Laser Launch Telescope and ultimately the sky. Each motion device may include its own sub sequencer as described in the example in Section 3. The BTS sequencer will generate states that are comprised of information from multiple devices with each device contributing to the overall BTS state. During initialization, individual motion devices will be initialized to its home or nominal position. Once all of the devices have completed their initialization, the BTS will be in its READY state awaiting further command.

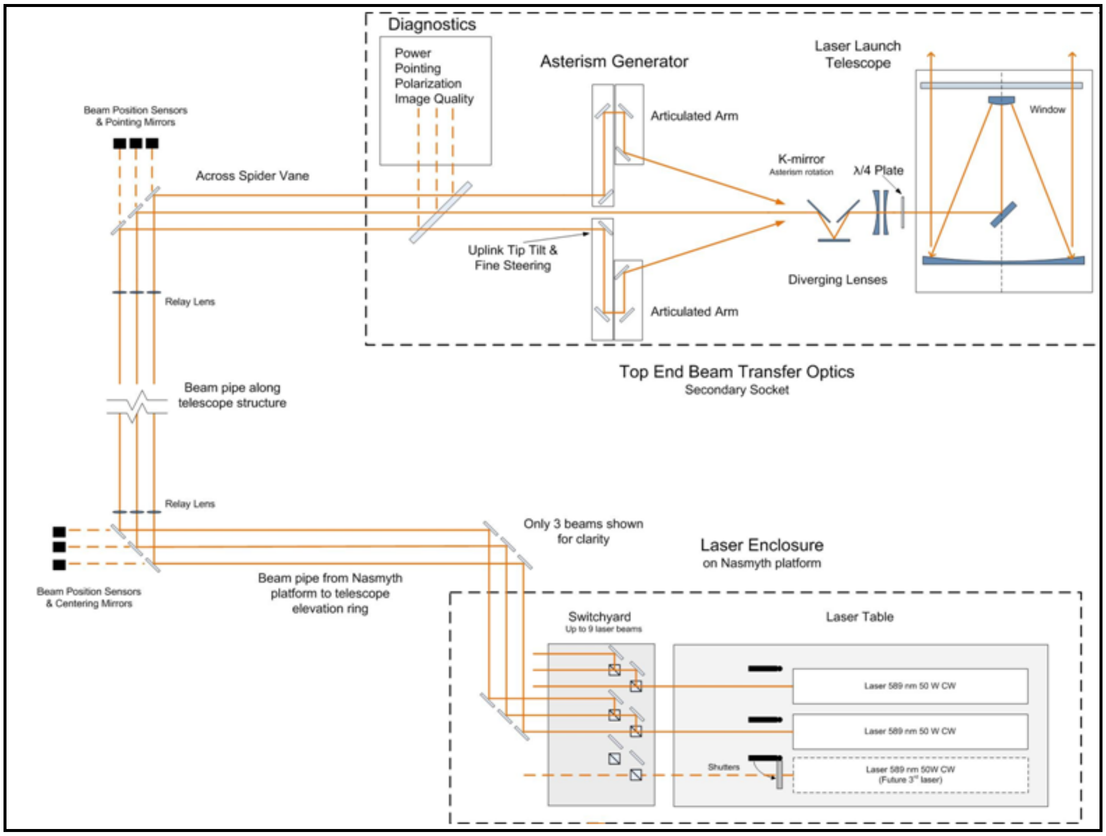

Figure 5: Laser Facility Optical System

6 CAMERA CONTROL SEQUENCER

The LGSF will include a number of cameras and possibly video servers which provide remote capabilities to monitor the laser asterism beams. The sequencer will enable these cameras at the start of observing and shutdown the cameras at the end of observing with the end of night script. It is unexpected any of the LGSF cameras will need any type of warm up period that will require sequencing of hardware events. However, the software will have communicate and capture the data for monitoring and processing.

7 ENVIRONMENTAL POWER AND CONTROL (EPC) SEQUENCER

The EPC system will include both static controls and non-static controls. Examples of the static control are the AO enclosure and the AO electronics vault. These systems have their own environmental control systems which will be autonomous and continuous. The EPC will have the ability to monitor and possibly make minor changes to set points remotely. The monitors shall be used for system health and generation of alarms. In the non-static cases, the EPC shall support power control for subsystems such as computer and power supplies. In some cases, the sequencing may support shutting down of equipment during non-NGAO usage. Unlike nominal sequencing of motors, the EPC sequencer shall mainly provide on/off switching of devices during system start-up and shutdown. The EPC will also be used to support troubleshooting for resetting devices.

8 SAFETY SYSTEM SEQUENCER

Due to the nature of the safety system, a sequencer is unnecessary from a standpoint of control. The safety system will continuously and autonomously monitor the current status to protect personnel and the system. Status and monitor points may go into faulted states and will require user intervention to acknowledge and clear the fault; but responding to faults will be autonomous.

9 LGSF COORDINATE SEQUENCER

This section will address the coordinated sequencing that takes place to propagate the laser beams on sky. Prior to LGSF coordinated sequencer, each subsystem will be completed its own initialization sequence. Although each subsystem completed their initialization, the overall LGSF sequence is noted as DISABLE. The LGSF sequencer will then command the subsystems to close its loops to achieve the READY state. To achieve the READY state, the following must occur:

- Close the final shutter and fast shutter
- Open the laser shutter for the laser to go into Propagation mode
- Open the fast shutter
- Close the loop on the Switchyard steering devices and track based on telescope elevation
- Close the loop on the Switchyard steering devices and track based on position sensors within the Beam Generation System
- Close the loop on the BGS rotator based on telescope inputs
- Close the loop on the uplink tip/tilt stage
- Close the loop on all stages for per patrolling and asterism generated beams per the diagnostic camera

Once all of the above devices are tracking and maintaining position, the LGSF is considered TRACKING. The final shutter, in conjunction with the fast (safety) shutter, will be opened for ON-SKY propagation. The sequence of events is shown in Figure 6.

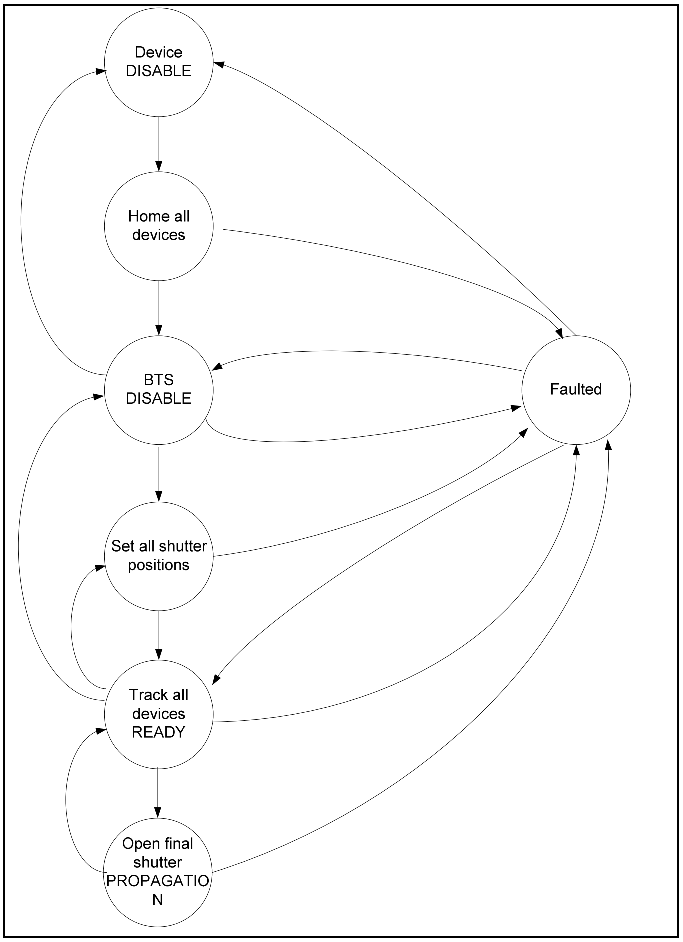

Figure 6: LGSF Sequencer