Next Generation Adaptive Optics System

Laser System Control Sequencers

(Draft)

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REVISION HISTORY

Revision	Date	Author (s)	Reason for revision / remarks
1.0	February 24, 2009	JC	Initial release

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INTRODUCTION

As part of the Next Generation Adaptive Optics (NGAO) System, a Laser System Control (LSC) will be implemented to control devices such as the Laser, Beam Transport System (BTS) and the Laser Safety System (LSS). 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.

References

1.1 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

Table 1: Reference Document.

1.2 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.

2 LASER SYSTEM CONTROL

The Laser System Control is shown in the circled area in Figure 1. A more detailed description of the LSC can be found in KAON 511. Sequencers will be needed to control complex subsystem such as the Beam Transport Control, Laser Control and Laser Safety System. Simple devices such as the Laser Camera Control and Environmental and Power Control will not require any sequencer control.

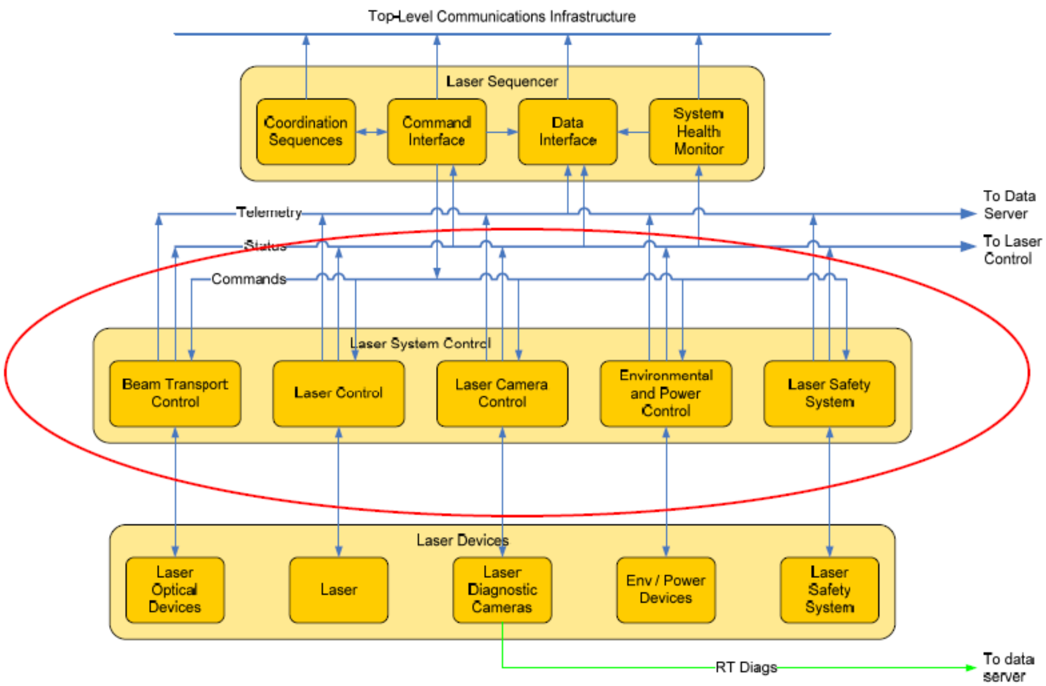

Figure 1: Laser System Control (KAON 511)

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 a super-sequencer informing 50 other sub-sequencers to start initializing their devices.

Sequencer operates between multiple states but is designed in two general directions, stepping up from a system that is off to operational and vice versa, stepping 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 stepping 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 stepping down process, the system travels between static states without transitional states. Since stepping down generally do not require substantial reconfiguration of the system, these static transitions are quicker and do not require transition states. Unlike stepping up, stepping down allows transitioning back down to its lowest rest state without going through several intermediary states. This ability will be system dependent.

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.

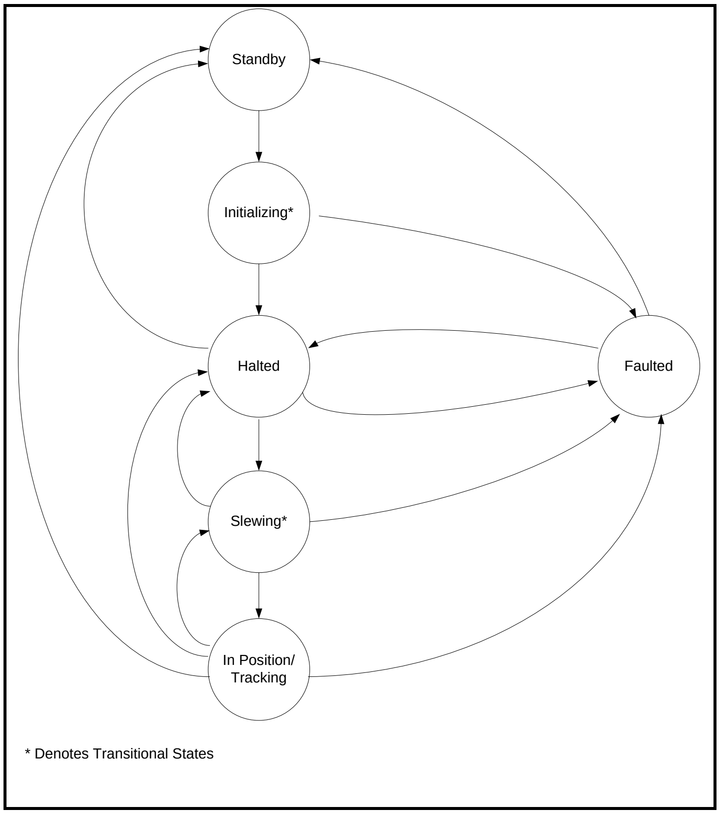

Figure 2: Example of Sequencer

A device starts off in a *Standby* 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 *Halted* state and await further instruction. It is important to note that the *Halted* 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 *faulted* 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 *Standby* to *Initializing* controlling multiple sub-sequencers controlling any number of devices.

4 LASER CONTROL SEQUENCER

A laser control sequencer is shown in Figure 3. The final sequences will depend on the operational model of delivered laser system. The proposed sequence is for a laser system generating sodium wavelength light via second harmonic generation from two other oscillator frequencies. The laser starts off in a static *Standby* state. In the step up phase, the laser is commanded to the *Initializing* transitional state. During this transitional state, the laser starts up its pump diodes and waveguide amplifiers to produce the necessary oscillator frequencies. This transitioning state may take minutes as the laser is warmed up. Once the diodes and oscillators are ready, the laser system will transit in the *Seed Light Ready* static state and awaits further instructions. Upon a new command, the laser will transition into the *Na Generation* transition state. During this transitional state, the laser will generate the high power sodium wavelength light; but confined to the laser system. The light will be directed into a shutter or beam dump. Once the required power is reached, the laser will transition and remain in the *Laser Ready* static state with the laser shutter closed. The laser reaches the final *Laser ON* state when the command is issued to open the laser shutter.

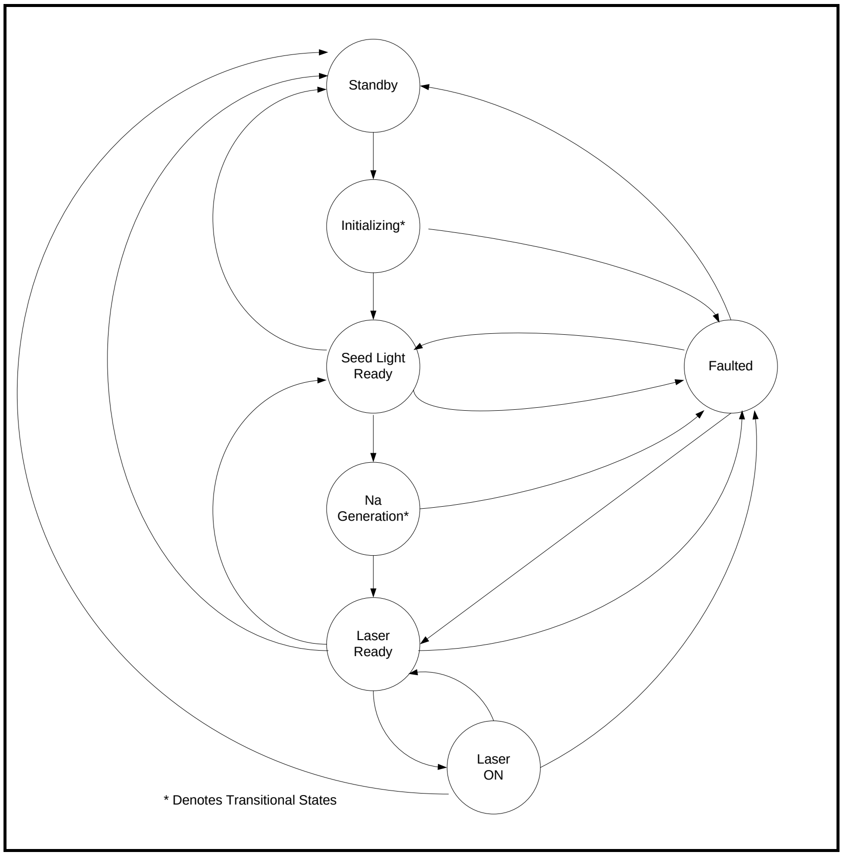

Figure 3: Laser Controller Sequencer

Figure 3 shows the laser may be able to step down from any static state back to the *Standby* state without having to go into intermediary states.

During any of the transitions, the laser will monitor its internal health. If at anytime a fault is detected, the sequencer shall go into a *Faulted* static state. Since the *Faulted* state is static, user action is required to transition into the next state either via solving the fault or clearance of an alarm. The *Faulted* state can only return to another static state, usually the previous static state prior to the fault. The nature of the fault will determine what state the laser returns to.

5 BEAM TRANSPORT SYSTEM SEQUENCER

The BTS Sequencer provides control of the laser switchyard control, beam transport to the top end and the asterism generator (Figure 4). 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 2. The BTS sequencer will generate states that are comprised of information from multiple devices with each device contributing.

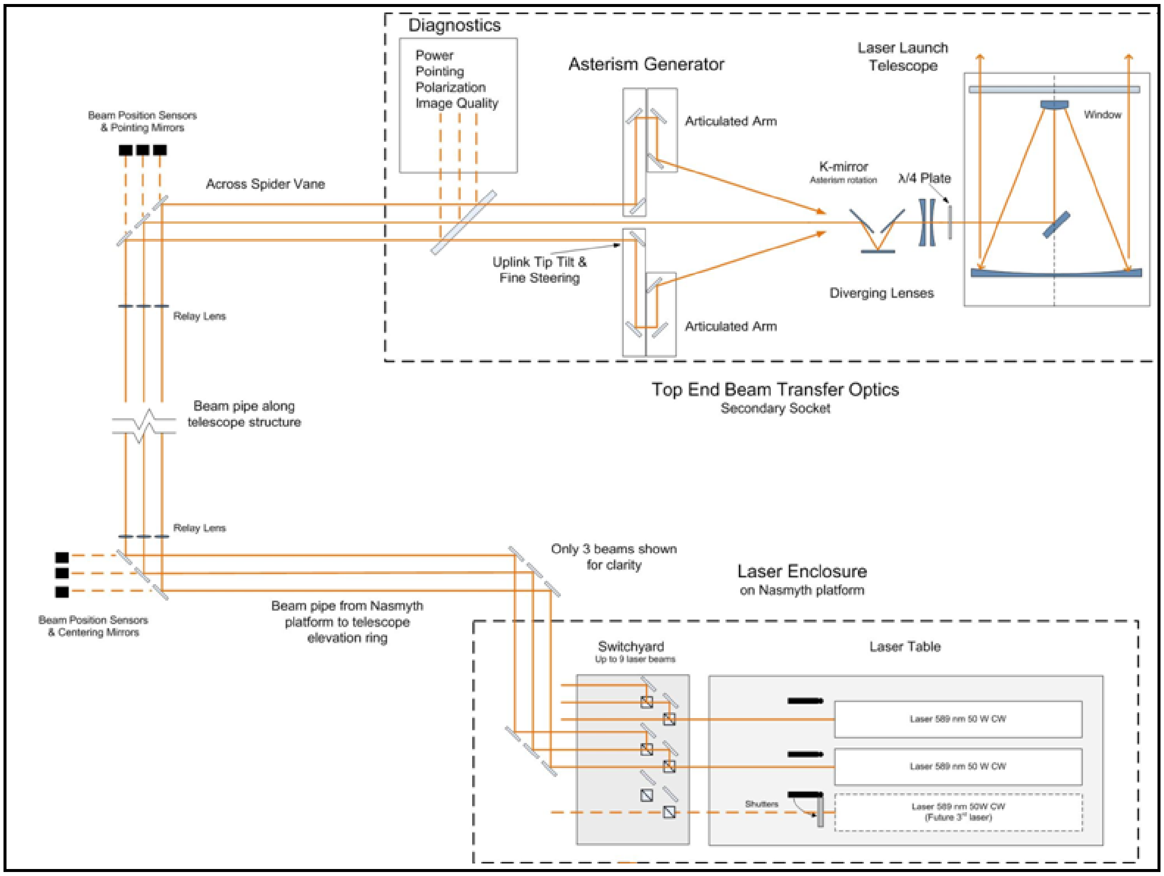

Figure 4: Laser Facility Optical System

The BTS sequencer is shown in Figure 5. The system starts off in the *Standby* state and steps up to the *Tracking* state. As in all motion devices, the first step is to transit into the *Initialization* state. During this transitional state, all devices in the BTS will go through its own sequence to find its reference or home. Once all the devices know their references, the BTS sequencer transits to the *Halted* state and await further command. For non tracking device, new commands will cause the device to transit to the *In Position* state via *Slewing*. An example of this is reconfiguring of the switch yard. The switch yard will move to control the proper number of laser beams to send to the asterism generator. Once the switch yard is configured, the sequencer will remain at this static state until a new command is issued.

BTS tracking can be subdivided into two categories, tracking for telescope flexure and tracking on sky. As the telescope moves, the beam between the switchyard and the asterism generator will move due to flexure on the telescope. In order to keep the beams locked into the asterism generator, the mirrors between the switchyard and the asterism generator will move to compensate for telescope flexure. These same motors will also function to keep the beam properly pointed on the sky. Once these devices are properly tracking, the BTS sequencer will enter and remain in the *Tracking* static state. The fast shutter can only be opened if the BTS is in a tracking state. Any other transitional or static state will require the fast shutter to be closed. As with all sequencers, the BTS sequencer will include a *Faulted* state for faults and a recovery process to transition out of the faulted state.

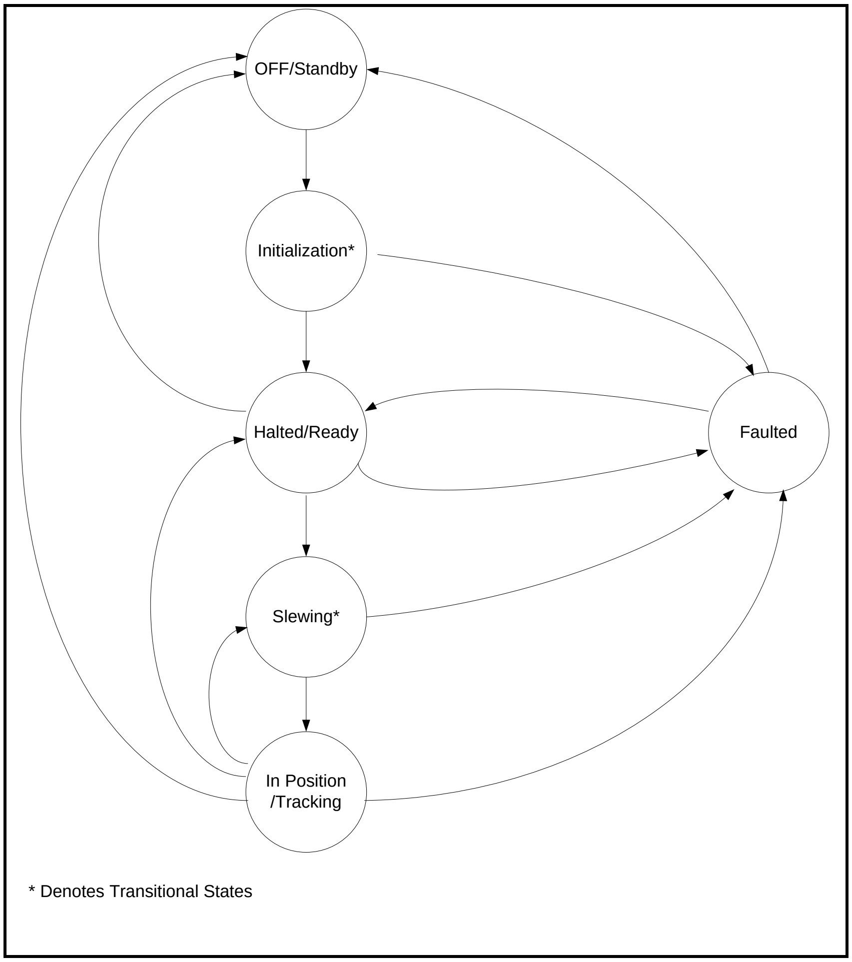

Figure 5: Beam Transport System Sequencer

6 SAFETY SYSTEM SEQUENCER

Unlike the previous two systems, the safety system is constantly operating and will not include any standby state. The sequencer is simply shown in Figure 6 and has two static states. The state of the safety system is used primary to provide triggers for other subsystems. For example, a *Faulted* state in the safety system should automatically close the laser shutter and the fast shutter. Outside intervention is necessary to recover from a *Faulted* state.

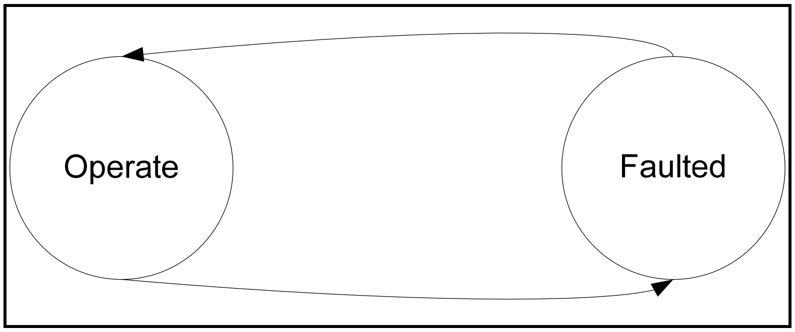

Figure 6: Safety System Sequencer