



Tech Note

M2 Controller ICD

Large Synoptic Survey Telescope (LSST)

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Tech Note No.	T14900-0124	Current Revision	B
CAGE Code	30KA0	Release Authority	See Document Change Record
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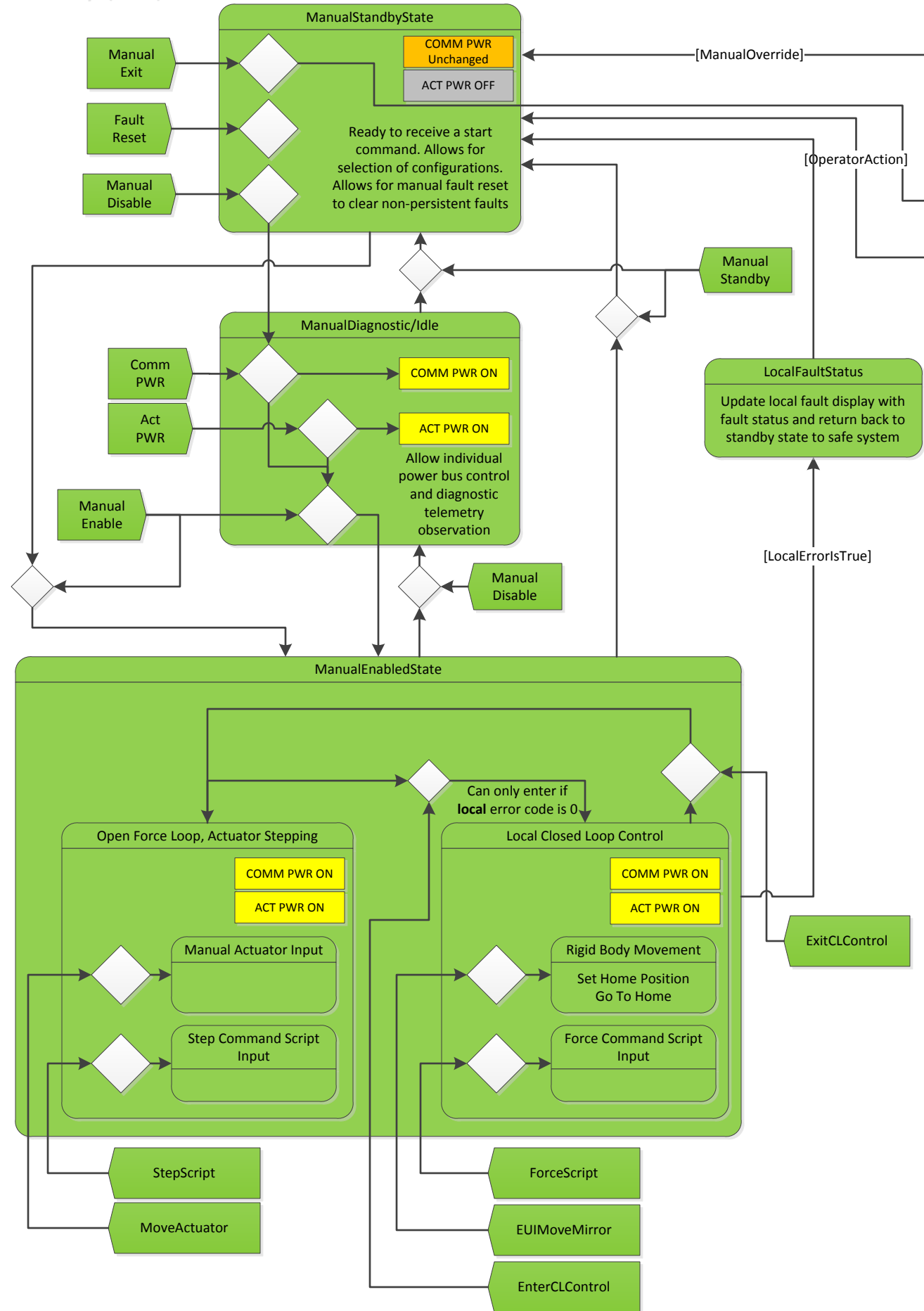
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Document Change Record

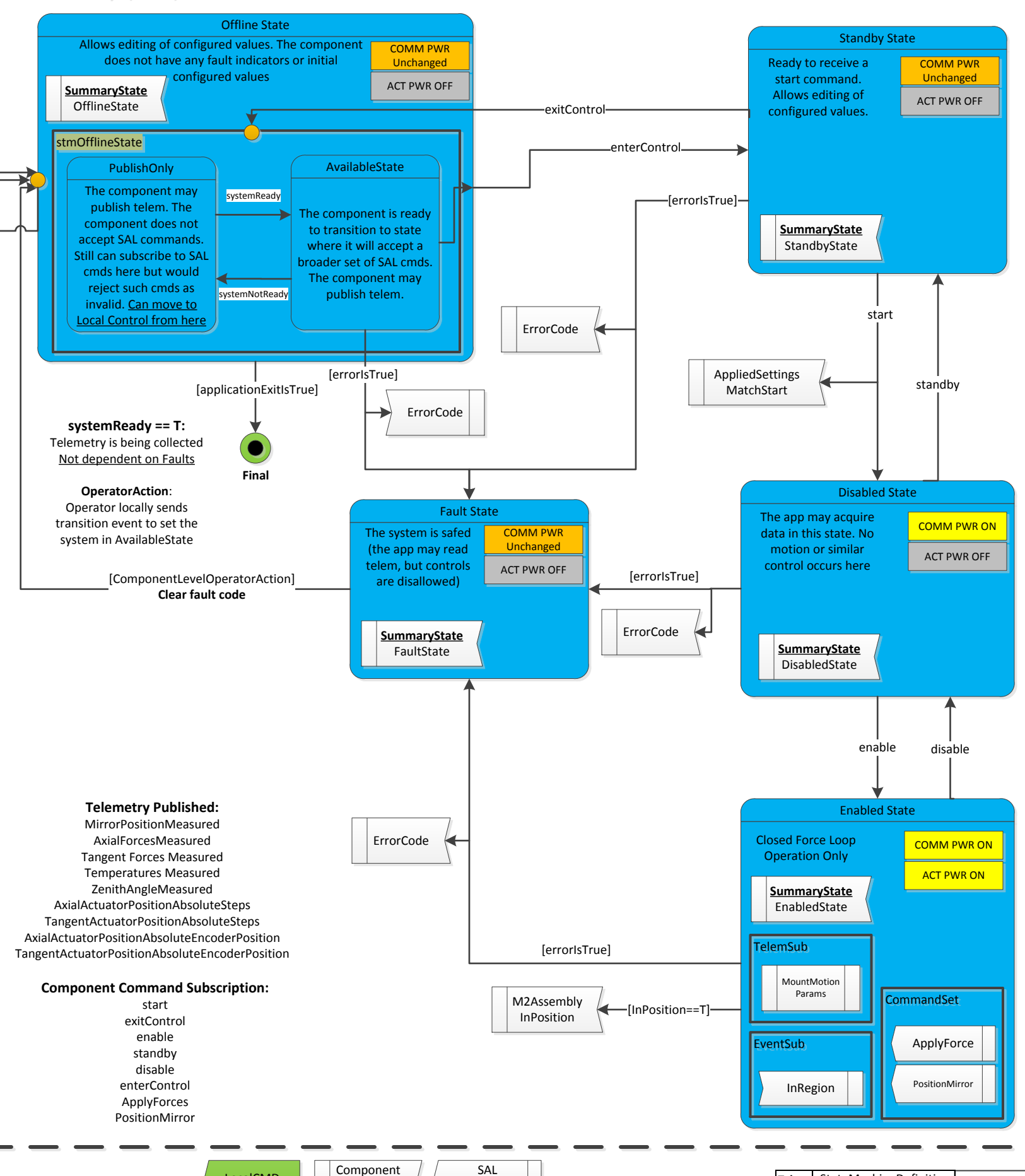
Rev.	Description	CN#	Date
-	Initial release	CN00000171149	9/15/2017
A	Updates to state transitions, faults, rules	CN00000185170	8/27/2018
B	Included troubleshooting page	CN00000185757	9/18/2018

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Locally (EUI) Controlled States



Remotely (SAL) Controlled States



systemReady == T:
 Telemetry is being collected
 Not dependent on Faults

OperatorAction:
 Operator locally sends transition event to set the system in AvailableState

Telemetry Published:
 MirrorPositionMeasured
 AxialForcesMeasured
 Tangent Forces Measured
 Temperatures Measured
 ZenithAngleMeasured
 AxialActuatorPositionAbsoluteSteps
 TangentActuatorPositionAbsoluteSteps
 AxialActuatorPositionAbsoluteEncoderPosition
 TangentActuatorPositionAbsoluteEncoderPosition

Component Command Subscription:
 start
 exitControl
 enable
 standby
 disable
 enterControl
 ApplyForces
 PositionMirror

LSST M2 Controller SAL Interface Table					
	Command Subscription	Event Publication	Event Subscription	Telemetry Subscription	Telemetry Publication (Ref 20Hz Update)
	ApplyForce	M2SummaryState	MTMount.InRegion	MTMount.MotionParameters	MirrorPositionMeasured
	PositionMirror	M2DetailedState			AxialForcesMeasured
	disable	M2AssemblyInPosition			TangentForcesMeasured
	enable	AppliedSettingsMatchStart			TemperaturesMeasured
	enterControl	ErrorCode			ZenithAngleMeasured
	exitControl				AxialActuatorPositionAbsoluteSteps
	standby				TangentActuatorPositionAbsoluteSteps
	start				AxialActuatorPositionAbsoluteEncoderPosition
					TangentActuatorPositionAbsoluteEncoderPosition
Msg Format:	m2ms_acceptCommand_'TOPIC'	m2ms_logEvent_'TOPIC'	MTMount.InRegion	MTMount.MotionParameters	m2ms_putSample_'TOPIC'

SAL Enumeration	Summary State
0	Offline State
1	Standby State
2	Disabled State
3	Enabled State
4	Fault State
SAL Enumeration	Detailed State
0	PublishOnly
1	AvailableState

	Message	Code	Description
Acknowledge/No Acknowledge Codes	SAL_CMD_ACK	300	Command/telemetry received successfully, all fields properly filled
	SAL_CMD_COMPLETE	303	The Command received has been properly initiated by the M2 Controller
	SAL_CMD_NOACK	-301	Errors in the command/telemetry - cannot process
	SAL_CMD_FAILED	-302	Accepted message format, but contents conflict with M2 Controller operation/unexpected

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ErrorCode	Failure	Error Reported	Fault Tab	Resulting Mode/State	Cause of Error	Comment	SAL Mode Applicable	EUI Mode Applicable
0	No Error	None	N/A	N/A	No Error	This code is to inform SAL that our error is reset or the M2 does not have a fault.	N/A	N/A
6051	Actuator ILC Read Error	Fault	Communications	Fault State	ILC responded with: an exception code, did not respond at all (timeout), did not receive command, or reported fault status	Number of telemetry losses exceeded threshold	All States/Modes	Local Closed Loop Control
6052	Monitoring ILC Read Error	Warning	Communications	Unchanged	ILC responded with an exception code or did not respond at all (timeout)	Based on a monitoring ILC read error. Provides warning for any/all monitoring sensors. Further range checking is performed on signals critical for closed loop control (mirror temp)	All States/Modes	Local Closed Loop Control
6053	cRIO Communication Error	Fault	Communications	Fault State	Loss of communication between cRIO and M2 Controller	cRIO to detect the loss of communications also. cRIO itself goes into fault state.	All States/Modes	All States/Modes
6054	ILC State Transition Error	Fault	Control Sensor	Fault State	Internal ILC issue. ILC did not change state	Currently - three retries are implemented.	All States/Modes	All States/Modes
6055	Excessive Force Detected	Fault	Control Sensor	Fault State	Measured force exceeded programmable threshold	Evaluated on an individual actuator basis	All States/Modes	All States/Modes
6056	Actuator Limit Switch Triggered [Closed-loop]	Fault	Limit Switches	Fault State	An actuator responded with a closed limit switch in any direction	Over SAL, only one alarm, locally, log all alarms individually	All States/Modes	Local Closed Loop Control
6057	Actuator Limit Switch Triggered [Open-loop]	Warning	Limit Switches	Unchanged	An actuator responded with a closed limit switch in any direction	Over SAL, only one alarm, locally, log all alarms individually	N/A	Local Closed Loop Control
6058	Inclinometer Error [Fault]	Fault	Control Sensor	Fault State	Communication error or ILC reported fault	ILC reports bad value for inclinometer error	All States/Modes	Local Closed Loop Control
6059	Inclinometer Error [Warning]	Warning	Control Sensor	Unchanged	Communication error or ILC reported fault	ILC reports bad value for inclinometer error (when not actively using the inclinometer for closed loop control)	All States/Modes	Local Closed Loop Control
6060	Inclinometer Difference Error	Fault	Control Sensor	Fault State	Excessive angular difference between TCS elevation and local inclinometer	Difference error checking is configurable	All States/Modes	N/A
6061	Motor Power Supply(s) Over/Under Voltage [Fault]	Fault	Power Supply	Fault State	Measured voltage exceed programmable limits (2-sided)	Configurable thresholds for voltage tolerance.	Any state w/ Act power on	Any state w/ Act power on
6062	Motor Power Supply(s) Over/Under Voltage [Warning]	Warning	Power Supply	Unchanged	Measured voltage exceed programmable limits (2-sided)	Configurable thresholds for voltage tolerance.	Any state w/ Act power on	Any state w/ Act power on
6063	Comm Power Supply(s) Over/Under Voltage [Fault]	Fault	Power Supply	Fault State	Measured voltage exceed programmable limits (2-sided)	Configurable thresholds for voltage tolerance.	Any state w/ Comm power on	Any state w/ Comm power on
6064	Comm Power Supply(s) Over/Under Voltage [Warning]	Warning	Power Supply	Unchanged	Measured voltage exceed programmable limits (2-sided)	Configurable thresholds for voltage tolerance.	Any state w/ Comm power on	Any state w/ Comm power on
6065	Excessive Motor Current	Fault	Power Supply	Fault State	Measured current exceeds programmable limit (1-sided)	Initial error threshold setting based on measured values, but threshold will be configurable via software.	Any state w/ Act power on	Any state w/ Act power on
6066	Excessive Comm Current	Fault	Power Supply	Fault State	Measured current exceeds programmable limit (1-sided)	Initial error threshold setting based on measured values, but threshold will be configurable via software.	Any state w/ Comm power on	Any state w/ Comm power on
6067	Power Relay Opening Fault	Fault	Power Supply	Fault State	Power relay did not open when commanded by software.	Power is not measured after configurable delay when closing relays. Used for detecting the lack of opening of relays when attempting to remove power	All States/Modes	All States/Modes
6068	Power Supply Health Fault	Fault	Power Supply	Fault State	Binary outputs signal power supply health fault	Binary output from power supply signals determine health. Signals: Internal Fault, Power Supply ON.	All States/Modes	All States/Modes
6069	Multi-breaker Trip on Same COMM Power Feed	Fault	Power Supply	Fault State	Breaker feedback showed two or more breaker trips	Two breaker trips. Requires two breakers to open on the same feed to generate a fault.	All States/Modes	All States/Modes
6070	Multi-breaker Trip on Same MOTOR Power Feed	Fault	Power Supply	Fault State	Breaker feedback showed two or more breaker trips	Two breaker trips. Requires two breakers to open on the same feed to generate a fault.	All States/Modes	All States/Modes
6071	Single Breaker Trip	Warning	Power Supply	Unchanged	Breaker feedback showed single breaker trip	One breaker trip is a warning.	All States/Modes	All States/Modes
6072	Power Supply Load Sharing Error	Fault	Power Supply	Unchanged	Based on binary output from redundancy module	From redundancy module - balances input power from power supplies.	All States/Modes	All States/Modes
6073	cRIO 50 msec Cycle Time Monitor [Fault]	Fault	Control Sensor	Fault State	Measured loop time exceeded 50 ms for three consecutive cycles	If there are three consecutive warnings, this is a fault.	All States/Modes	Local Closed Loop Control
6074	cRIO 50 msec Cycle Time Monitor [Warning]	Warning	Control Sensor	Unchanged	Measured loop time exceeded 50 ms for one cycle.	Warning if a cycle is longer than 50 msec.	All States/Modes	Local Closed Loop Control
6075	Excessive Cell Temperature Differential	Warning	Env. Temp	Unchanged	Intake-Exhaust temperature diff exceeded programmable threshold	Configurable threshold. Will use the lowest of the inputs and the highest of the exhaust.	All States/Modes	N/A
6076	*** Reserved ***	X	X	X	This fault code is reserved for future expansion	X	X	X
6077	Configurable Parameter File Read Error	Fault	Configuration	Fault State	The software cannot properly read in the file or something is corrupted with the data read from the file	Is only assessed when software parameters are initialized	All States/Modes	All States/Modes
6078	Displacement Sensor Out of Range	Warning	Sensor Range	Unchanged	Sensor value out of range	Range not programmable (check for reasonableness)	All States/Modes	All States/Modes
6079	Inclinometer Out of Range	Fault	Sensor Range	Fault State	Sensor value out of range	Range not programmable (check for reasonableness)	All States/Modes	Local Closed Loop Control
6080	Mirror Temperature Sensor Out of Range [Fault]	Fault	Sensor Range	Fault State	Sensor value out of range	Range not programmable (check for reasonableness)	All States/Modes	Local Closed Loop Control
6081	*** Reserved ***	X	X	X	This fault code is reserved for future expansion	X	X	X
6082	Airflow Temperature Sensor Out of Range	Warning	Sensor Range	Unchanged	Sensor value out of range	Range not programmable (check for reasonableness)	All States/Modes	All States/Modes
6083	Axial Actuator Encoder Out of Range	Fault	Sensor Range	Fault State	Sensor value out of range	Range not programmable (check for reasonableness)	All States/Modes	All States/Modes
6084	Tangent Actuator Encoder Out of Range	Fault	Sensor Range	Fault State	Sensor value out of range	Range not programmable (check for reasonableness)	All States/Modes	All States/Modes
6085	Loss of TMA Communications on Enable	Fault	Communications	Fault State	The MTMount.MotionParameters telemetry is not available when in or transitioning to the Enable state	Issue a fault when the MTMount motion parameters are not available when in Enable (or transitioning to Enable). The controller cannot operate in SAL without TMA inclination	Enable State	N/A
6086	Loss of TMA Communications	Warning	Communications	Unchanged	The MTMount.MotionParameters telemetry is not available when in or transitioning to the Enable state	Issue a warning when the MTMount motion parameters are not available when NOT in Enable. The controller does not need the MTMount parameters at this time, therefore -> warning	All States/Modes Except Enable State	N/A
6087	User Identified Error (Emergency Stop)	Fault	Communications	Fault State	The user identifies an error condition that is not detectable via SAL.	A button is created on the EUI to inject a fault to the controller to allow state transitions when the SAL comm link is lost. Since there is no signal available to identify a loss of SAL comm, the state machine is stranded when SAL is lost. This fault kicks the state machine over to the fault state and allows the system to transition to a safe state where comm can be re-initialized. Can also be used to transition the system to the fault state when issues are observed and not captured under existing fault codes	All States/Modes	N/A
6088	Tangent Load Cell Fault	Fault	Alarms	Fault State	Tangent load cell calculations violate any of the four monitoring conditions	Tangent load cells are monitored with additional checks to ensure their sensible output. Using the weight of the mirror, orientation of the TMA inclination, and all four load bearing tangent actuator loads, the estimated mirror weight can be compared to the known mirror weight.	All States/Modes	All States/Modes

Tab:	Faults/Warnings
Title:	M2 Controller ICD
Doc#:	T14900-0124
Rev:	B
Page: 4 of 8	

ErrorCode	Failure	Error Reported	Cause of Error	Troubleshooting Next Steps
6051	Actuator ILC Read Error	Fault	ILC responded with: an exception code, did not respond at all (timeout), did not receive command, or reported fault status	Most likely an ILC that is not responsive/failed. Look at the telemetry data to see which ILC address does not show a correct broadcast counter that increments by 16 every time step. That will narrow down the ILC to troubleshoot. If an ILC needs to be replaced, reference T14900-1002 ILC Programming Document to reprogram and configure the software properly
6052	Monitoring ILC Read Error	Warning	ILC responded with an exception code or did not respond at all (timeout)	As delivered from Harris, the current firmware of the sensor ILCs generate this warning 4.5% of all samples. Updating to new firmware on the sensor ILCs should remedy this warning. For reference, updating firmware on the ILCs is described in T14900-1002 ILC Programming Document.
6053	cRIO Communication Error	Fault	Loss of communication between cRIO and M2 Controller	Check to see if power is lost to the cRIO. Check the ethernet connection between the Linux box and the cRIO.
6054	ILC State Transition Error	Fault	Internal ILC issue. ILC did not change state	Most likely an ILC that is not responsive/failed during startup. The EUI log window will describe which addresses violate the state transition timing. Look at the first address which failed to meet timing. If it is determined that an ILC needs to be replaced, reference T14900-1002 ILC Programming Document to reprogram and configure the software properly
6055	Excessive Force Detected	Fault	Measured force exceeded programmable threshold	Reference the EUI Manual T14900-1001 to determine the force limits for the state when the excessive force was detected. Look at the EUI Actuator Control view or Detailed Forces view to determine the actuator(s) which violated the force limits. In Manual mode, drive the actuator(s) away from the force limit. If the excessive force was originally detected in open loop, click the Enable Max OL Limits button to provide force relief to unload the actuators. If for some reason it is determined that the load cell has been compromised and needs to be replaced, reference T14900-3024 Axial Actuator Replacement.
6056	Actuator Limit Switch Triggered [Closed-loop]	Fault	An actuator responded with a closed limit switch in any direction	Check to see on the Alarms/Warnings tab which actuator(s) has triggered limit switches. Go into manual open loop mode to drive the offending actuator(s) off the limits. If both the extend and retract limit switches indicate they have been closed, a communication error has occurred with that ILC.
6057	Actuator Limit Switch Triggered [Open-loop]	Warning	An actuator responded with a closed limit switch in any direction	Check to see on the Alarms/Warnings tab which actuator(s) has triggered limit switches. Go into manual open loop mode to drive the offending actuator(s) off the limits. If both the extend and retract limit switches indicate they have been closed, a communication error has occurred with that ILC.
6058	Inclinometer Error [Fault]	Fault	Communication error or ILC reported fault	Check inclinometer sensor ILC for errors/disconnections
6059	Inclinometer Error [Warning]	Warning	Communication error or ILC reported fault	Check inclinometer sensor ILC for errors/disconnections
6060	Inclinometer Difference Error	Fault	Excessive angular difference between TCS elevation and local inclinometer	Check to see if local inclinometer has come loose from cell. Ensure TCS elevation is correct and calibrated. If necessary, reference T14900-0132 Inclinometer Calibration to recalibrate the local M2 inclinometer
6061	Motor Power Supply(s) Over/Under Voltage [Fault]	Fault	Measured voltage exceed programmable limits (2-sided)	Using proper ESD protocols, inspect the Motor Power cables for any possible soft or hard shorts.
6062	Motor Power Supply(s) Over/Under Voltage [Warning]	Warning	Measured voltage exceed programmable limits (2-sided)	Using proper ESD protocols, inspect the Motor Power cables for any possible soft or hard shorts.
6063	Comm Power Supply(s) Over/Under Voltage [Fault]	Fault	Measured voltage exceed programmable limits (2-sided)	Using proper ESD protocols, inspect the Comm Power cables for any possible soft or hard shorts.
6064	Comm Power Supply(s) Over/Under Voltage [Warning]	Warning	Measured voltage exceed programmable limits (2-sided)	Using proper ESD protocols, inspect the Comm Power cables for any possible soft or hard shorts.
6065	Excessive Motor Current	Fault	Measured current exceeds programmable limit (1-sided)	Run the SystemCheckout.scp script and look at the telemetry to see if any one actuator is causing the motor bus current to spike when moving. That could indicate an issue in that actuator's drivetrain and would need to be replaced. Using proper ESD protocols, inspect the Motor Power cables for any possible soft or hard shorts.
6066	Excessive Comm Current	Fault	Measured current exceeds programmable limit (1-sided)	Using proper ESD protocols, inspect the Comm Power cables for any possible soft or hard shorts.
6067	Power Relay Opening Fault	Fault	Power relay did not open when commanded by software.	Some latency in the power relay opening is causing this fault. Could be caused by a faulty relay, a slowly changing condition could also be slowing down the opening of the relays. If necessary, the power relay opening threshold can be increased in software.
6068	Power Supply Health Fault	Fault	Binary outputs signal power supply health fault	Binary signal that indicates the self-health monitoring within the power supplies have detected an issue. Repair or replace the offending power supply
6069	Multi-breaker Trip on Same COMM Power Feed	Fault	Breaker feedback showed two or more breaker trips	Using proper ESD protocols, inspect the Comm Power cables for any possible soft or hard shorts.
6070	Multi-breaker Trip on Same MOTOR Power Feed	Fault	Breaker feedback showed two or more breaker trips	Using proper ESD protocols, inspect the Motor Power cables for any possible soft or hard shorts.
6071	Single Breaker Trip	Warning	Breaker feedback showed single breaker trip	Using proper ESD protocols, inspect the all power lines for any possible soft or hard shorts.
6072	Power Supply Load Sharing Error	Fault	Based on binary output from redundancy module	Could be caused by a bad power supply redundancy module or an actual mismatch in power supply load sharing. If the power supplies are not contributing equal loading, it may also be possible that the Power Supply Health Fault could be seen (6068). In either case, try replacing the redundancy module or using different power supplies.
6073	cRIO 50 msec Cycle Time Monitor [Fault]	Fault	Measured loop time exceeded 50 ms for three consecutive cycles	Look for additional processes that could be costing computation time on the cRIO
6074	cRIO 50 msec Cycle Time Monitor [Warning]	Warning	Measured loop time exceeded 50 ms for one cycle.	Look for additional processes that could be costing computation time on the cRIO
6075	Excessive Cell Temperature Differential	Warning	Intake-Exhaust temperature diff exceeded programmable threshold	Look at the diagnostics screen to see what the intake/exhaust temperatures are reading. Reference the configuration view to see what the temperature threshold is set to. Ensure threshold is set reasonably. Increase threshold if necessary. Otherwise, look for blockage in the exhaust path of the cell assembly.
6076	*** Reserved ***	X	This fault code is reserved for future expansion	X
6077	Configurable Parameter File Read Error	Fault	The software cannot properly read in the file or something is corrupted with the data read from the file	Check the /opt/lstst-m2/config/parameter_files file path to ensure all files are present and not corrupt in the closed_loop_controller and the luts folder. Reference T14900-1005 Configurable File Description Document to find all the necessary files and LUTs.
6078	Displacement Sensor Out of Range	Warning	Sensor value out of range	Most likely a failure of the displacement sensor. Look in the Utility view of the EUI to determine which displacement sensor is out of range. First inspect the sensor ILC associated with the offending displacement sensor. Ensure wiring is correct. Manually move the failed displacement sensor while monitoring the Utility view to determine if any valid readings are received. If not, it could be necessary to replace the displacement sensor or the sensor ILC
6079	Inclinometer Out of Range	Fault	Sensor value out of range	Unlikely failure to happen. If an inclinometer sensor ILC had trouble communicating, the Inclinometer warning/fault would be tripped. This fault is designed to ensure the inclination value received is within reason.
6080	Mirror Temperature Sensor Out of Range [Fault]	Fault	Sensor value out of range	Most likely a failure of the temperature sensor. Look in the Utility view of the EUI to determine which mirror temperature sensor is out of range. First inspect the sensor ILC associated with the out of range sensor. Since the mirror temp sensors are bonded to the mirror, alternative methods for replacing that signal must be explored.
6081	*** Reserved ***	X	This fault code is reserved for future expansion	X
6082	Airflow Temperature Sensor Out of Range	Warning	Sensor value out of range	Most likely a failure of the temperature sensor. Look in the Utility view of the EUI to determine which airflow temperature sensor is out of range. On the cell, inspect that offending airflow temperature sensor and replace if necessary.
6083	Axial Actuator Encoder Out of Range	Fault	Sensor value out of range	Most likely a failure of the encoder sensor. Look in the Detailed Forces view of the EUI to find the offending axial actuator. Inspect the wiring of the encoder of that actuator as well as the actuator ILC to ensure proper connects.
6084	Tangent Actuator Encoder Out of Range	Fault	Sensor value out of range	Most likely a failure of the encoder sensor. Look in the Detailed Forces view of the EUI to find the offending tangent actuator. Inspect the wiring of the encoder of that actuator as well as the actuator ILC to ensure proper connects.
6085	Loss of TMA Communications on Enable	Fault	The MTMount.MotionParameters telemetry is not available when in or transitioning to the Enable state	Inspect the output of the TCS elevation angle and its ability to travel to the M2 Controller. Potential wiring issue.
6086	Loss of TMA Communications	Warning	The MTMount.MotionParameters telemetry is not available when in or transitioning to the Enable state	Inspect the output of the TCS elevation angle and its ability to travel to the M2 Controller. Potential wiring issue.
6087	User Identified Error (Emergency Stop)	Fault	The user identifies an error condition that is not detectable via SAL.	User generated error, consult user that clicked this button to understand the rationale for the emergency stop
6088	Tangent Load Cell Fault	Fault	Tangent load cell calculations violate any of the four monitoring conditions	Possible causes: tangent actuator ILC, tangent actuator load cell, tangent actuator ILC wiring, bad inclination signal. If it is determined that a tangent actuator is to be replaced, reference T14900-3025 Tangent Actuator Replacement. If an ILC needs to be replaced, reference T14900-1002 ILC Programming Document

Tab:	Troubleshooting	Page: 5 of 8
Title:	M2 Controller ICD	
Doc #:	T14900-0124	
Rev:	B	

Spec Verifications

#	Requirement ID	LSST Req ID	Requirement Description	Found on Tab:
1	LTS-146_152	LTS-146_3.5.4	The control system shall include all the commands in the command interface in the TCS to M2 Assembly Interface Control Document (LTS-162).	SAL_InterfaceTable
2	LTS-146_153	LTS-146_3.5.5	The control system shall be remotely controllable.	StateMachineDefinition
3	LTS-147_3	LTS-147_4.1	The telemetry stream from the mirror support system shall be structured into topics.	SAL_InterfaceTable
4	LTS-147_4	LTS-147_4.1	The name of each topic shall start with the following text "m2ms."	SAL_InterfaceTable
5	LTS-147_5	LTS-147_4.1	Each topic shall be associated with a clear definition and with an update frequency.	SAL_InterfaceTable
6	LTS-147_7	LTS-147_4.1	A document dedicated to the description of all the topics shall be submitted to LSST for approval.	SAL_InterfaceTable
7	LTS-147_8	LTS-147_4.1	The stream of telemetry from the telescope control system necessary for the mirror support system shall also be included in this interface.	SAL_InterfaceTable
8	LTS-162_15	TCS-M2-CMD-ICD-0020	The M2 Assembly shall accept the commands associated with the transitions on the State Machine model, as described in LTS-307.	StateMachineDefinition
9	LTS-162_36	TCS-M2-CMD-ICD-0029	Specification: The M2 Assembly shall publish a CellTemperatureHiWarning. The controller will set this value to True if and only if the measured cell temperature is more than the specified value above the conditioned supply air temperature	FaultsWarnings**
10	LTS-307_4	LTS-307_4.2.2.2	Each component controller shall define an external interface that allows an interfacing component (loosely, a client) to interact with that controller in a precise fashion.	StateMachineDefinition and SAL_InterfaceTable
11	LTS-307_5	LTS-307_4.2.2.3	This interface information shall be part of the design definition.	StateMachineDefinition
12	LTS-307_6	LTS-307_4.2.2.4	The component interface shall minimally include the external triggers to which it responds (i.e., data to which it subscribes), and the consequent behaviors (including data the component publishes).	StateMachineDefinition and SAL_InterfaceTable
13	LTS-307_8	LTS-307_4.2.2.6.1	The component name shall define a namespace.	StateMachineDefinition
14	LTS-307_9	LTS-307_4.2.2.6.2	The state machine definition shall explicitly and formally define all transitions (external and internal), States, and behaviors.	StateMachineDefinition
15	LTS-307_12	LTS-307_4.2.2.6.4	The triggers and States shall have names that are unique within the component.	StateMachineDefinition and SAL_InterfaceTable
16	LTS-307_13	LTS-307_4.2.2.7.2	The Summary component States and transitions shall conform to the definition in PerformTopLevelFunctions.	StateMachineDefinition
17	LTS-441_1	LTS-441_2.1.1	A software component shall comply with the Alarm taxonomy shown here.	FaultsWarnings
18	LTS-441_3	LTS-441_2.2.1.1	Each warning reportable by a component shall have its own SAL event topic defined on the component.	FaultsWarnings
19	LTS-441_17	LTS-441_2.3.1.1	Each component shall have a single ErrorCode topic.	FaultsWarnings
20	LTS-441_19	LTS-441_2.3.1.1.1.1	The component shall define each custom error code and its associated text in an error code file associated with the component.	FaultsWarnings
21	LTS-441_20	LTS-441_2.3.1.1.1.1.1	Each component shall define error codes within the range allocated to it.	FaultsWarnings

****The M2 Controller will not publish a CellTemperatureHiWarning message, but it will publish an ErrorCode associated with the cell temperature comparison**

State Transition Table

NextState State		Offline State	StandbyState	DisabledState	EnabledState	FaultState	Initial	Final
		S0	S1	S2	S3	S4	S5	S6
OfflineState	S0		enterControl					applicationExitIsTrue
StandbyState	S1	exitControl		Start		errorsTrue		
DisabledState	S2		Standby		Enable	errorsTrue		
EnabledState	S3			Disable		errorsTrue		
FaultState	S4	FaultReset						
Initial	S5	Establish DDS Connection						
Final	S6							

Operational Rules

This page is intended to provide general system operational rules as they were implemented. The full responses of all M2 software systems were not defined in requirements or literature therefore rules were created and documented to cover missing reactions during M2 operation.

Description	Response
In Region Flag in Manual Mode	When in Manual Mode, ignore the In Region Flag from the TCS and assume the level is false meaning we stay in the high gain setting.
ApplyForces in Manual Mode	When switching to Manual Mode from Remote, any commanded forces from the ApplyForces vector will be removed.
Inclination Checking Manual Mode	In Manual Mode, inclination comparison (local-TMA) is disabled to accommodate the case where the TMA inclination is lost.