A Specification for PLC Implementation of Instrument-Change Interlocks

Connie Rockosi and Jim Gunn
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This document describes the desired interaction of the PLC system with the LATCHES and the LIFT. The former include for purposes of this discussion.

1. The main instrument latches
2. The secondary instrument latches
3. The saddle latches
4. The Tbar latches in the camera
5. The slithead latches
6. The slithead doors
7. The camera tertiaries (for now the bolts, though these will change shortly, and will require some accompanying code changes)

For each of these, it is assumed that explicit directional PERMITS need to be issued for each to move. The normal state of all the latches is locked out.

The latches will be operated by the new latch control box, with the following functionality:

1. There is a 'direction' switch for the motion of the main, secondary, saddle, slithead, and tbar latches, which indicate that one desires for them to MOUNT an instrument on the telescope, or DISMOUNT one to be taken away by the lift. This switch does not actuate the latches, only indicate the desired action.

2. There is an actuation button for each of these five latches to accomplish the action corresponding to the direction switch. Permits and status are displayed adjacent to each button.

3. There is a momentary switch which commands the PLC to open or close the slithead doors. Again, there are permit and status displays.

4. There is a keyswitch which has three positions: AUTO (normal: the panel is active and the actions are conditional upon PLC permits), MANUAL (direct command, through the PLC, of the latch functions, irrespective of PLC permits; this is like the current kludge box--a flashing red LED will accompany this state to warn of the obvious dangers), and OFF, which completely disables the panel.

5. There are a set of related helpful status LEDs which inform the operator which instrument the PLC thinks is on the lift, the state of the doghouse door, etc.

This makes the whole operation controllable from one place on the telescope, and everyone's comments were very supportive of doing things this way for the sake of efficiency and safety.

The other main ingredient of the instrument change is the motion of the LIFT. It was decided that we will handle the lift by moving its connector to the already-installed PLC connector, which gives the PLC control over the functions we desire, and can override all of this simply by going back to the manual input connector, so no changes should be required here. When under PLC control, we need

1. For the PLC to be able to inhibit the motion of the lift either unidirectionally or bidirectionally
2. For the PLC to be able to read the position of the lift
3. For the PLC to be able to read the force on the lift

For the lift, it is most convenient to think not in terms of PERMITS but INHIBITS--i.e. the normal state of the lift is free-to-move, but under certain conditions outlined here its motion in one direction or the other or both is prevented. This sidesteps the issues involved in the fact that conditions change as the lift moves; we merely PREVENT its motion under certain static conditions.

I. NEW HARDWARE AND THE FULL IMPLEMENTATION OF ALREADY-BUILT-BUT-NOT-QUITE-FUNCTIONAL HARDWARE.

Much of what we need to do depends on the PLC system knowing something about the configuration on the lift, and though this was thought of at the beginning and most of the difficult hardware installed, it has never been implemented in any meaningful way. It must be possible for the PLC system to know what is on the lift and what is on the telescope. There are four proximity sensors on the lift with enough bits to sufficiently identify the instruments, but the necessary bolts to actuate them are certainly not in place on the camera or lens cart, and we may wish to change the configuration on the engineering camera and cartridge carts. We need to generate the signals (the bits are a suggestion which is close to the current implemetation; there may be a cleverer/safer way)

1. Camera_cart_on_lift (100X -- this needs installation, and see discussion below)
2. Cartrige_on_lift (1100 -- this needs change; it is currently 1110, and the OVERLOAD pin needs to be removed from the cart, both stations)
3. Lens_cart_on_lift (0101 -- this needs installation)
4. Eng_cam_on_lift (0110 -- this needs implementation/change. We do not know whether the current implementation of the first two bits is 01 or 10, and the OVERLOAD pin needs to be removed from the cart, both stations)
5. jhook_down (1001 -- installed 01/01)

The remarks about needed action are current as of Jan 31 2001.

These signals can only be generated once the lift has come up a few inches, so the sensors can 'see' what is there. This complicates the logic a bit, but not, we think, seriously. The last is an ancillary condition to (1); that is, it is asserted only if (1) is true AND the jhook sensor (the fourth, southmost proximity sensor) is asserted. This is accomplished automatically with the bit patterns suggested.

Note that each of these conditions except the camera cart on the lift with the jhook UP (1000) involves two and only two bits. Unfortunately, this last is a legal condition when the empty cart is being raised to take the camera away (but only then). It MIGHT be possible to arrange it so that jhook_down is 1001 and (jhook_up AND camera_cart_on_lift) is 1010, but the linkage will be tricky. Then all legal combinations would have exactly two bits; we will see if this can be done. Then

ccol_jhook_down = 1001
ccol_jhook_up = 1010

camera_cart_on_lift = ccol_jhook_down OR ccol_jhook_up
jhook_down = ccol_jhook_down

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NB!! As of 2001/01/31 the jhook mechanism does NOT set bit 0010 when it is UP, ONLY sets 0001 when it is down. The camera cart sets bit 1000 Note that in this description the northern proximity sensor is attached to the MSB of the nibble; the camera toggles the northermost sensor, the Jhook the southernmost.
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The other signals we need are provided by the instrument ID switches, which 'only' need to be installed and made to work properly. Specifically, we need signals which might be called

6. camera_on_telescope
7. cartridge_on_telescope

8. engcam_on_telescope
9. lens_on_telescope
10. saddle_on_telescope

Which can be generated by looking at the relevant combinations of bits from the ID switches. These names might be a little misleading--note that they SIMPLY refer to the ID switches and imply NOTHING else about the state of the lift or latches.

And an independent signal

11. telescope_empty

Which reliably says that NOTHING is on the telescope--ie there is NO depressed switch. To be safe, we must add brackets which depress SOME switch to anything which is mounted on the instrument surface, including the wagon wheel, the alignment telescope mount, and the dust cover. We do not need to know what is there, but do need to know that the telescope is NOT empty. It MUST BE NOTED that *NO* failure may be allowed to assert telescope_empty, because this condition enables unlatching the instrument latches)

II. EXISTING HARDWARE AND (IN PRINCIPLE) EXISTING PLC SIGNALS

In addition, we need a number of existing signals (these names are doubtless wrong, but the functionality, we hope, is clear):

12. camera_in_doghouse
13. doghouse_door_open
14. slithead_doors_open
15. slitheads_latched
16. primary_latches_latched
17. primary_latches_unlatched
18. secondary_latches_latched
19. secondary_latches_unlatched
20. saddle_latches_latched
21. saddle_latches_unlatched
22. tbars_latched
23. tbars_unlatched
24. camera_tertiaries_in
25. camera_tertiaries_out

The seeming multiplicities of these states exist and are necessary--for instance, (NOT primary_latches_latched) is most emphatically not the same as primary_latches_unlatched. The former means that the latches are EITHER unlatched or in some peculiar disallowed state; the latter means that they are properly unlatched and retracted. There are sensors which report both states directly. There are states we need which refer to the position of the telescope axes:

26a. telescope_pinned_at_zenith
26b. telescope_at_inst_change_azimuth
26c. rotator_inst_change

In addition, we need signals which refer to the state of the lift:

27. lift_on_floor
28. lift_down (height less than about 6 inches)

29. lift_hi. This is a signal whose generation depends on the configuration and reading of the lift height; it is actually the OR of four possible signals:

a. lift_hi_with_camera
b. lift_hi_with_cartridge
c. lift_hi_with_lens
d. lift_hi_with_engcam

which is individually asserted only if the relevant instrument/cart is on the lift and the height is correct within a set of tolerances which are called CAMMIN_HI and CAMMAX_HI, CARTMIN_HI and CARTMAX_HI, LENSMIN_HI and LENSMAX_HI, ENGMIN_HI and ENGMAX_HI, and the relevant instrument ID switches are thrown. Thus

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lift_hi_with_camera = camera_cart_on_lift          AND
                      lift_height < CAMMAX_HI      AND
                      lift_height > CAMMIN_HI      AND
                      camera_on_telescope          AND
                      saddle_on_telescope
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and similarly for the others.

*(#11/30: This was added to accomodate the fact that a less stringent condition is needed to INHIBIT the *lift near the mounting position than to ENABLE the latches. The latch condition is below:)

30. lift_up. This is a signal whose generation depends on the configuration and reading of the lift height and force and the rotator ID switches, and is actually an OR of four possible signals:

a. lift_up_with_camera
b. lift_up_with_cartridge
c. lift_up_with_lens
d. lift_up_with_engcam

which is individually asserted only if the relevant instrument is on the lift AND the height is correct within (a perhaps more stringent) set of tolerances, CAMMAX_UP, CAMMIN_UP, etc, AND the force is correct within tolerance AND the rotator ID switches are fired appropriately. For example

*(#11/28: wording tightened)

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lift_up_with_camera =  camera_cart_on_lift         AND
                       lift_height < CAMMAX_UP     AND
                       lift_height > CAMMIN_UP     AND
                       lift_force  < CAMMAX_FRC    AND
                       lift_force  > CAMMIN_FRC    AND
                       camera_on_telescope         AND
                       saddle_on_telescope

lift_up_with_cartridge = cartridge_on_lift         AND
                       lift_height < CARTMAX_UP    AND
                       lift_height > CARTMIN_UP    AND
                       lift_force  < CARTMAX_FRC   AND
                       lift_force  > CARTMIN_FRC   AND
                       cartridge_on_telescope
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And similarly for the lens and engineering camera.

From these a number of possible lift and telescope motion inhibits, latch permits, and possible sounding of the PLC sonalert alarm can be asserted.

We must be able to inhibit any telescope axis and the motion of the lift, either unidirectionally or bidirectionally. We must be able to permit the actuation of any one or combination of the latches. The latches occupy a central role in this system and we need to get it right. (We INCIDENTALLY need to make the latch indicators more robust--we stand to lose a large amount of time futzing around if they do not work, which they now do not dismayingly often.)

With these, it should be possible to design an intelligent system which relies not at all on being told what the operator is trying to do, though when we get the computer aid in it will be necessary for the operator to inform the machine what he is doing (ie dismounting a cartridge, mounting a cartridge, installing the camera, etc) so the steps are right, so at that point there is no reason why the PLC should not be so informed as well...but it is not clear that this information is really useful to the PLC.

III. THE INTERLOCKS

With this lengthy preamble, we can define a list of conditions which will improve instrument handling safety greatly with or without computer-aided change; the only significant improvement (we think) which computer-aided change would effect is the sequencing, which we believe can be addressed in other ways.

1. Protect the camera Tbar kinematics (extension)

There has recently been implemented a set of protective interlocks and warnings to protect the camera kinematcs. To this we would add one more:

Sound the warning if

tbars_unlatched AND camera_in_doghouse AND doghouse_door_open

This would warn you if you were about to move the camera with the tbars unlatched. This condition may arise when taking biases in the doghouse and the operators forget to latch the tbars down when finished. (We still have to figure out how the tbars are controlled..see the suggestion above about a switch on the latch console)

2. Disallow activity unless the telescope is pinned at the zenith, and telescope is at instrument_change azimuth and the rotator is at instrument change.

INHIBIT all lift motion and latch activity unless the telescope is pinned at the zenith and is at the instrument_change azimuth and the rotator is at instrument change, OR lift_down is asserted, in which case the lift is allowed to go DOWN. (recall that lift_down is defined as the last 6 inches of travel.) This last is to allow the lift plate to be gotten out of the way at any time.

3. Protect the lens if mounted

INHIBIT lift UP motion if

(camera_cart_on_lift OR engcam_on_lift) AND lens_on_telescope

We THINK this is the only combination for which protection is needed--when a cartridge or the engcam (or the camera, for that matter) is on the telescope, there is really no danger of trying to install something else, but the camera breaking the lens is a real possibility. Whether the engcam can break the lens depends on the details of its filter configuration, but in any case it is not supposed to have the lens in place. One could, of course, have a full set of illegal conditions.

Note that this inhibit cannot take effect until the lift gets high enough that it can detect X_on_lift. This means that the lift will STOP or that the operator will simply not be able to go up.

4. Protect instruments/latches/doors agaist lift collisions

INHIBIT lift UP motion if there are inappropriate latches latched (which would collide with and damage the instruments). This will never happen in the course of operations, but could in the course of daytime diagnostic or engineering activity. This should be prevented at the very beginning of a move; the latches may well be in funny states when you are trying to latch up an instrument. Thus we should INHIBIT lift UP motion if

(camera_cart_on_lift AND NOT camera_on_telescope) AND
lift_down AND (NOT rotator_camera_change) AND
(NOT primary_latches_unlatched OR NOT secondary_latches_unlatched
OR NOT saddle_latches_unlatched)
OR
(cartridge_on_lift AND NOT cartridge_on_telescope) AND
lift_down AND (NOT rotator_instrument_change) AND
(NOT primary_latches_unlatched OR NOT slithead_doors_open
OR slithead_latches_latched)
OR
(engcam_on_lift AND NOT engcam_on_telescope) AND
lift_down AND (NOT rotator_instrument_change) AND
(NOT primary_latches_unlatched OR NOT secondary_latches unlatched)
OR
(lens_on_lift AND NOT lens_on_telescope) AND
lift_down AND (NOT rotator_instrument_change) AND
(NOT secondary_latches_unlatched OR NOT primary_latches unlatched)

5. Allow only appropriate latch activity when instrument is being installed/removed.

PERMIT relevant latch operation (primary, secondary, saddle, tbar, slithead) only if lift_up is asserted (recall that lift_up is a complex function of X_on_lift and a set of lift motion and force within tolerances depending on what X is AND the assertion of the correct instrument ID switches). Specifically,

a.) PERMIT the (primary, secondary, saddle, tbar) latches if lift_up_with_camera
b.) PERMIT the secondary latches if lift_up_with_lens
c.) PERMIT the (primary, slithead) latches if lift_up_with_cartridge
d.) PERMIT the primary latches if lift_up_with_engcam

6. Allow latch activity as necessary to properly configure telescope to receive instrument or to do biases in doghouse

Other latch permits are probably necessary to avoid Catch-22 situations which might arise throgh manual 'engineering' intervention and to allow other desirable combinations. The only desideratum here is to make it difficult to set up grossly illegal combinations inadvertantly, but to be able to get out of problems which arise in (4) above. We think the best combination might be

a). PERMIT UNLATCH of the (primary, secondary, saddle) latches if
camera_cart_on_lift AND lift_down AND telescope_empty AND
telescope_pinned_at_zenith
b.) PERMIT UNLATCH of the (primary, slithead) latches if
cartrige_on_lift AND lift_down AND lens_on_telescope AND
NOT cartridge_on_telescope AND telescope_pinned_at_zenith
c.) PERMIT UNLATCH of the (primary, secondary) latches if
lens_cart_on_lift AND lift_down AND telescope_empty AND

telescope_pinned_at_zenith

d.) PERMIT UNLATCH of the (primary, secondary) latches if engcam_on_lift AND lift_down AND telescope_empty AND telescope_pinned_at_zenith

e.) PERMIT the Tbar latches if camera_in_doghouse AND doghouse_door_closed

7. Prevent lowering the lift when up with an instrument unless latches are safely configured

INHIBIT LOWERING the lift if it is up unless all appropriate latches are either fully engaged or fully disengaged, and, in the case of the camera, the umbilical is properly configured. Thus the lift would be INHIBITED from going DOWN if

(camera_cart_on_lift AND lift_hi AND ((NOT primary_latches_latched OR
NOT secondary_latches_latched OR
NOT saddle_latches_latched OR
NOT tertiary_bolts_in OR
NOT jhook_down)
AND
(NOT primary_latches unlatched OR
NOT secondary_latches_unlatched OR
NOT saddle_latches_unlatched OR
NOT tertiary_bolts_out OR
NOT jhook_down))

OR

(cartridge_on_lift AND lift_hi AND ((NOT primary_latches_latched OR
NOT slithead_latches_latched)
AND
(NOT primary_latches unlatched OR
NOT slithhead_latches unlatched))

OR

(engcam_on_lift AND lift_hi AND ((NOT primary_latches latched)
AND
(NOT primary_latches unlatched))

OR

(lens_on_lift AND lift_hi AND ((NOT secondary_latches latched)
AND
(NOT secondary_latches unlatched))

Note that the lift cannot come down with the camera cart OR the camera unless the umbiical is on the jhook--while this is not strictly necessary when lowering the cart away without the camera, it is still good practice.

8. Protect the telescope/instruments from collision with the lift plate.

Inhibit all TELESCOPE motion unless lift_on_floor is asserted. This can result in a catch-22, in which one does not lower the lift all the way, goes and pulls the pin, and the telescope moves of its own volition because of balance, etc, that the pin cannot be reinserted. Nothing can move in this situation. For this reason, condition (2) is stated as it is; unless lift_down is well reached, no cart can come free, but one can inadvertantly NOT go all the way to the floor. Notice that this set of conditions (nor any we anticipated for the full-up instrument change) cannot keep someone from running the telescope into an instrument and cart LEFT under the telescope. There is no simple way to avoid this except keeping marginally awake. Pulling the pin when the lift is not all the way down should sound the alarm (?) As a note to the observers, this is NOT frivolous--the spectrograph dewars can foul the lift plate if it is even an inch above its fully retracted position!