LAT Engineering Meeting

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LAT Integration Sequence Revision

Rev 3

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Agenda

- Goals of re-ordering the bay installation sequence
- Proposed bay integration sequence
- Issues factored into the re-ordering decision
- Other constraints affecting tower integration
- Details of the proposed integration sequence

Goals of Re-Ordering Bay Installation Sequence

- **Integrate TKR Tower-A in a location where it can be easily removed**
  - **There is lingering concern that Tower-A problems will worsen over time as it sees more operating hours. This trend has not been documented and the causal agents not yet identified, but…**
  - **Because of these problems, there is a risk that Tower-A will continue to trend downward and eventually not perform well enough to be used, and will need to be removed**
  - **To plan for this possibility, we need to look at where to put Tower-A such that it can be removed with the least amount of added risk to neighboring flight hardware**
- **Preserve flexibility to absorb delays in delivery of flight hardware, to avoid/reduce schedule slippage**
  - **The RFP for the bulk of the internal cables (e.g.: TEM-GASU and TPS-PDU) just went out on the street, so the RFI dates for these are just not known now**
  - **No Cable Tray parts have been ordered, so the RFI date is unknown**
  - **The "pair-wise" integration of neighboring modules requires (or strongly suggests) the use of flight cables and cable trays from the get-go. Using E-GSE cables with connector savers as stand-ins will likely not work because of space constraints between the tower pairs**
  - **Look at how to integrate flight towers using E-GSE cables for the first 2 towers**
- **Assemble 4 towers in a square pattern as early as practical**
  - **This will provide the first opportunity to look for cross-tower EMI problems**
  - **Ideally—and in the baseline plan—the first 4 modules are integrated into a 2x2 square pattern, so this check will come early**
  - **On the other hand, if it takes 5 or 6 modules before we get our first set of 4 together, it is not a big issue, since if we DO have problems, we could be in a world of hurt**

Goals of Re-Ordering Bay Installation Sequence (cont.)

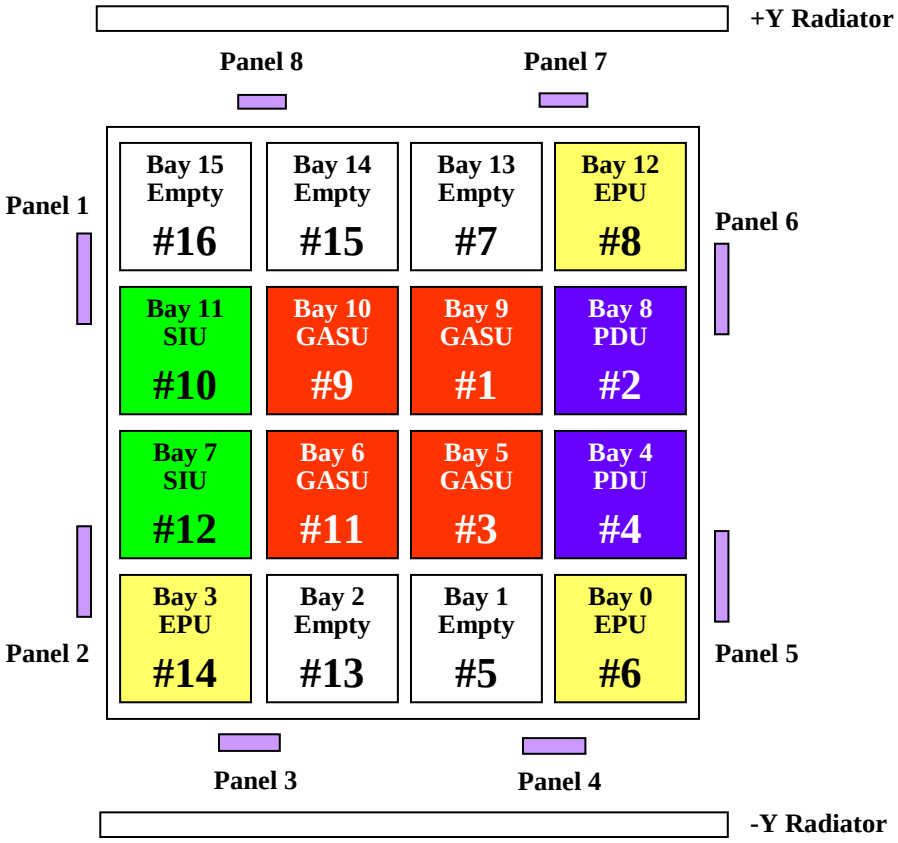
R2

- **Put towers with perceived lower quality around perimeter to preserve the best and most reliable for the center**
  - **There is a general feeling that the highest quality TKR modules should go in the center to produce the best tracks with the least dead channels**
  - **Tower A has most of its dead channels in the heavy converter trays, and there is some indication that better-quality heavy trays are most needed around the perimeter**
  - **Independent of where the higher-quality towers should go, it is very clear that losing a center tower (or a large fraction there-of) is much worse than a perimeter tower, since it leaves a hole in the field-of-view**

Proposed Bay Integration Sequence (LAT bottom view)

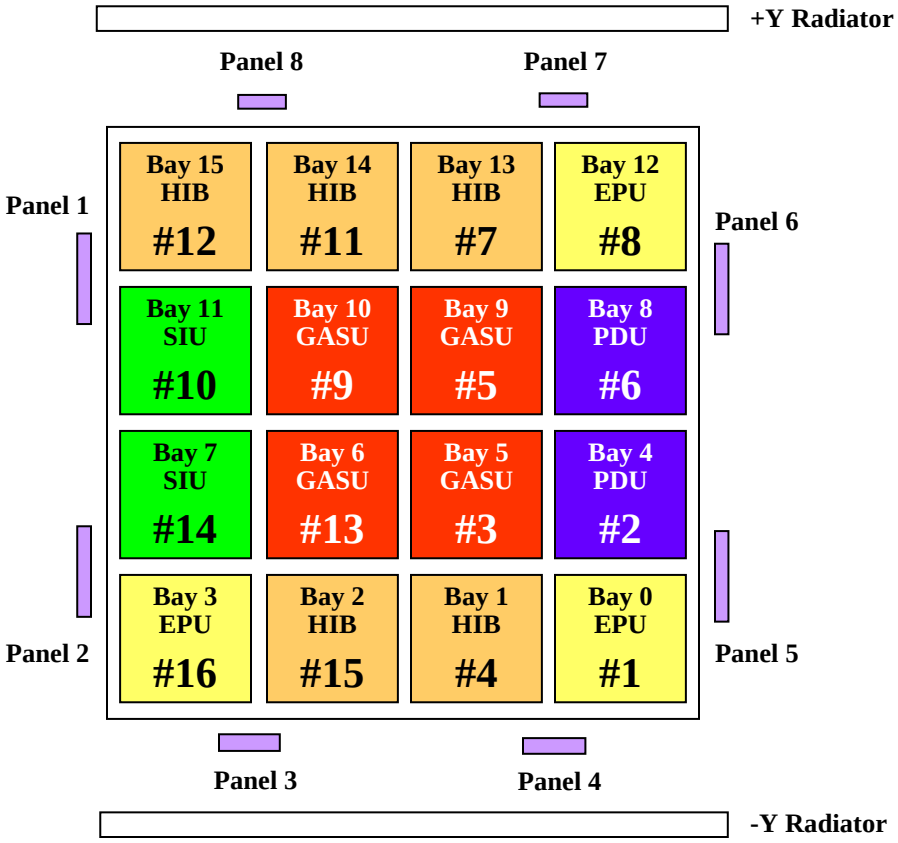
Baseline Sequence

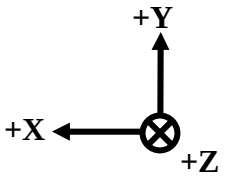
From LAT-00676-02 "LAT Integration Sequence," March 2004



Proposed Sequence

January 2005





Issues Factored into the Bay Integration Re-Ordering

- These factors and constraints were weighed in changing the bay integration order. They are listed in rough order of decreasing importance (* indicates that it is one of the goals)

- *Preferred location for TKR-A to allow de-integration
  - Stay away from bays where GASU and PDU are located, since de-integrating from under one of these requires disconnecting cables for all other bays already installed
  - Keep out of the middle to avoid needing to pull a TKR out from among other TKR's
  - ✓ Proposal: put TKR-A in a corner bay (0, 3, 12, or 15)
- *Configuration of first two towers together, but also allowing use of E-GSE cables
  - Keeping towers together is paramount, to ensure that 2-tower CPT starts ASAP
  - Original pairings of odd-even towers (e.g.: 0 and 1) don't work because TEM connectors point towards each other and E-GSE TEM-GASU cables would interfere
  - ✓ Proposal: choose a neighboring bay of the same parity (e.g.: 0 and 4 or 3 and 7)
- Cable length and ease of connection to the PDU and GASU
  - The bulkhead connectors in the PDU and GASU were located such that when the TEM and TPS cables are integrated in the baseline order, the connectors are plugged in from the "bottom" to the "top" of the box, making access very straightforward
  - Also, cable lengths were determined by prototyping the baseline connection sequence, since they are affected by 3-D runs in and out of cable trays
  - If flight cables are integrated out-of-order, some of the connectors will only be able to be plugged in by reaching past already-verified connections in very tight space
  - ✓ Proposal: preserve the "pair-wise" integration of flight cables
  - ✓ Proposal: integrate TKR-A on the –X (PDU) side of the LAT, to preserve the baseline cable routing and lay-down sequence so cable lengths are not affected

Issues Factored into the Bay Integration Re-Ordering (cont. 1)

- **Ease of access and clearances for integrating TKR modules**
  - **Integrating TKR modules between already-installed modules decreases the access room considerably, and increases the risk of collision and other confined-space problems**
  - **TKR's *can* be integrated in any order, including dropping a module down into a hole surrounded by 4 neighbors—we should just avoid this if we can**
  - ✓ **Proposal: any re-sequence should not result in any boxing-in of a TKR module**
- R2 *** Preferred location for TKR-A to preserve sweet-spot for lower (perceived) risk modules**
  - **The baseline integration sequence would have put TKR-A in one of the center bays**
  - **Since TKR-A is perceived to have a higher risk of future module-level failure, it should not go in the center**
  - ✓ **Proposal: put TKR-A somewhere on the perimeter**
- **Installation of Cable Tray parts and cable routing**
  - **The baseline bay integration sequence was chosen largely to minimize the handling and temporary supporting of flight cables. This meant that cable way parts are installed as early as possible so the flight cables could be laid down permanently**
  - **To lay down cable tray sections, the adjoining bays need to be fully integrated, thus the way to achieve the goal of early cable tie-down is to integrate neighboring bays together, and not skipping around the LAT**
  - ✓ **Proposal: the sum of the above proposals preserves the integration of neighboring bays, so this will maintain the baseline of early cable tray installation**
  - ✓ **Proposal: with TKR-A going in bay 0 or 12 (on the –X side) leave the corresponding bays on the +X side of the LAT clear for as long as possible (thus, if TKR-A goes in bay 0, integrate bays 2, 3, 6, and 7 last). This leaves the cable trays adjoining the TKR-A bay less populated for longer so there is less impact on cable routing if TKR-A is removed**

Issues Factored into the Bay Integration Re-Ordering (cont. 2)

- **Installation of the Shear Plates (a.k.a.: "Menning Plates")**
  - **The baseline plan calls for integrating the Shear Plates as soon as possible after all neighboring bays have CAL's installed. This is needed so the flight cable trays can also be integrated and cables supported to reduce damage risk**
  - ✓ **Proposal: preserve the baseline by integrating Shear Plates ASAP. If TKR-A is ever de-integrated, we would need to remove neighboring Shear Plates, which carries some risk of damage, but this is deemed to be low**
- **EM-GASU and EM-PDU installation/removal and horsing flight cables around**
  - **The EM-GASU and EM-PDU need to be removed whenever we need access to a bay on which they sit**
  - **Every time these are removed, the flight TEM and TPS cables must be disconnected from the PDU or GASU at their connector savers, then folded back out of the way. This is not expected to be a problem, but it's something we want to minimize**
  - **To minimize this, the baseline plan integrates the center bays first and together**
  - ✓ **Proposal: preserve this scheme by integrating flight cables to bays 4, 5, 8, and 9 together**
- ***Integrating the first four towers in a 2x2 square**
  - **The EMI-test rationale for this is weak, but this is almost automatic if we preserve cable-connection order in the PDU**
  - ✓ **Proposal: do this since it is easy**

Other Constraints Affecting Tower Integration

- CAL and TKR module orientation
  - Both CAL and TKR modules can only be installed in one orientation in a bay
  - Neither CAL nor TKR modules can or will be rotated on the Grid from their nominal
- TEM/TPS mounting on the CAL
  - TEM and TPS boxes are pre-assembled prior to delivery to I&T. These are all identical
  - However, there are two orientations of the TEM/TPS set on the back of the CAL
    - Odd-numbered bays have TEM-GASU and TPS-PDU connectors on the –X side boxes
    - Even-numbered bays have the connectors on the +X side of the boxes
  - Thus, once a TEM/TPS set is mounted on a CAL (an off-line operation), its destiny is set for either an even or odd bay
- TEM-GASU cables
  - TEM's of different parity (odd-even pairs) have their connectors pointing toward each other
  - With any cable plugged into one of these connectors (E-GSE with connector saver, or flight) the paired neighboring CAL cannot be installed, since the cable overlaps the crenulations on the CAL base plate
  - This is why towers are integrated and tested in pairs
- EMI Skirt installation
  - The EMI Skirt pieces form a wall around the perimeter of the TEM, TPS, and special E-Boxes
  - For the outer TEM's, 2 of the 8 TKR flex cable connectors are on the outer side of the box, facing the inside of the EMI Skirt, with little room to spare for integrating the cable
  - Because of the tight space, all EMI Skirt pieces (except the Radiator Mount Brackets) are installed after all TEM/TPS boxes are installed

Other Constraints Affecting Tower Integration (cont.)

- **Grid and TKR Module temperatures** (R2)
  - Heat from the TKR's and CAL's flows to the +Y and –Y edges of the Grid, where it is transported off the Grid to the Radiators
  - This produces temperature gradients in the Grid in the Y direction
  - There are also gradients in the X and Z directions due to location of heat sources/sinks
  - The result is that the corner TKR modules run 2-3 degC colder than the center 4 modules
    - During normal operation, they run cooler, which is generally considered a more benign state
    - During survival hold when the LAT is off, they will likely also run a bit colder, which means they will be closer to the TKR minimum survival temperature
  - Since this is only a 2-3 degC calculated difference, it is not deemed large enough to be a factor in where a module should be placed
- **Tower alignment, "flaring," and TKR-A location** (R3)
  - The TKR modules barely fit within their stayclear, and a number of Grid interface holes were machined out-of-tolerance
  - This led to concern that when TKR modules go onto the Grid, there may be insufficient clearance between modules to ensure that they do not collide during test/launch
  - To protect against this risk, we had proposed to "flare" the modules, tipping them slightly away from the LAT Z-axis and buying extra clearance at the top of the modules
  - However, the TKR-A module is measured to be within its stayclear, and analysis of the Grid interface holes show that they will still accurately place TKR modules
  - The "flaring" concept was shelved since it did not look like it would be needed
  - Installing TKR-A in the corner in a "non-flared," vertical orientation will prevent the use of flaring for the entire quadrant
  - This appears to be OK, but TKR-B and Grid optical survey results would reduce this risk

Proposed Bay Integration Sequence

- Integrate bay 0 then 4
  - TKR-A goes in bay 0, TKR-B goes in bay 4
  - Use E-GSE cables and connector savers, with no cable trays
  - Run 2-tower CPT in this configuration, connecting to off-Grid E-GSE
  - Then remove E-GSE cables from both towers
- Integrate bay 5 then 1
  - Integrate in bay 5, then connect flight TEM-GASU and TPS-PDU cables to bay 5 and 4 towers
  - Integrate in bay 1, then connect flight cables to bay 1 and 0
  - This completes 4-5 and 0-1 pairs and LAT quadrant III (-X/-Y quadrant)
  - Install Shear Plates at 0-1-4-5 location and in bay 0 corner
- Integrate bay 9 then 8
  - EM-PDU can now stay in position for all future bay installs
  - Integrate cable trays in front of PDU to tie-off all remaining flight cables
- Integrate bay 13 then 12
  - Quadrant II (-X/+Y) and -X half of LAT is complete
- Integrate bay 10 then 11
- Integrate bay 14 then 15
  - This completes quadrant I (+X/+Y)
  - All cables and cable ways on the +Y side of the LAT are installed
- Integrate bay 6 then 7
- Integrate bay 2 then 3
  - Integrate these bays last to minimize the cables running past bay 0

Next Step

- If this proposal is accepted, we will take the following steps:
  - Systems Integration
    - Revise LAT-MD-00676-02, "LAT Integration Sequence" to include the updated sequence
    - Further revise the Integration Sequence to strip out all detail that is now captured in integration procedures (this is needed no matter what the decision)
    - Generate a XR to capture this change and include this presentation
  - I&T
    - Revise integration materials to reflect the new sequence
    - Use the updated sequence for the integration work orders and AIDS that will be generated
- Issues to work prior to implementing this in Bldg 33
  - TKR-A is non-compliant in that it does not have bare spots on the sidewalls for routing instrumentation cables
    - Not a problem for a center bay, so the NCR was apparently closed with "use as-is" disposition
    - In a corner bay, we will need to add some provision for routing accel and TC cables from the top of the TKR down the sides
    - Since TKR-A has not yet been delivered, I recommend re-opening the NCR for this and working this problem in the TKR subsystem
  - Review TKR-B alignment data and Grid optical survey results to verify that "flaring" is not needed
  - Installing a TKR in the corner bay first means that we need to have a procedure in-hand sooner for plugging in the outer TKR flex cables into the TEM
    - Two of the eight flex cable connectors in the corner TEM's are tough to access because the Radiator Mount Bracket blocks clear access
    - Making this connection may require a tool, and definitely requires prototyping
    - This needs to be done now, whereas the baseline plan had a corner bay being populated 4th, so we had a bit more time