Challenges in Standing Up New Analytical Laboratories

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Abstract: In 2010 Los Alamos National Laboratory finished building a new facility called the Radiological Laboratory Utility Office Building (RLUOB). Between 2010 and 2013 new laboratories for chemical reagent preparation and storage, non-destructive assay (NDA), mass spectrometry, and trace elements were outfitted, and these laboratories received their first radioactive samples in 2015. In 2016 the second phase of construction that outfitted remaining laboratory spaces started. This second phase of construction outfitted 7 new laboratories that would install or reconfigure labs for the NDA work, radiochemical processes, Mass spectrometry sample preparations, X-ray fluorescence work, Plutonium and Uranium assays, and nuclear forensics. This talk will go over some of the challenges faces by the Analytical chemistry team in preparing equipment, installing equipment, updating existing methods, writing documents, identifying gaps caused by changes in the requirements, future sample loads, regulations, and interpretations of DOE regulations.

Introduction

The Actinide Analytical Chemistry (AAC) group at LANL provides expertise in chemical and radiochemical analysis of materials where actinide elements make up a significant portion of the sample. This group can trace its creation back to the original Manhattan Project chemists and as the senior laboratory in the Department of Energy (DOE) system, LANL and AAC executes work in all of DOE's missions: national security, science, energy, and environmental management. Our contributions are part of what makes DOE a science, technology, and engineering powerhouse for the nation.

The AAC group is composed of approximately 120 people in 12 teams. Each team is organized around core analytical capabilities. In support of these capabilities, the group has glove boxes, hoods, analytical instrumentation in four separate key facilities: Chemistry and Metallurgy Research (CMR) facility, Plutonium Facility 4 (PF-4); Radiological Laboratory Utility Office Building (RLUOB), and Technical Area 59 (TA-59). These sites and the AAC personnel provide the space and technical expertise for safely handling and analyzing milligram to kilogram quantities of special nuclear materials. These analyses range from assay of the major components down to trace analysis of impurities—spanning over seven orders of magnitude of chemical analysis capability as well as morphological/physical characterization techniques.

The process of standing up analytical laboratories can be challenging due to various factors such as funding, designing, building facilities, acquiring equipment and instrumentation, recruiting qualified personnel, and implementing laboratory operating requirements, and quality assurance programs. Challenges during the early stages of construction can have significant impacts on laboratory operations when it becomes operational. This essay discusses the challenges faced during laboratory construction, their impact on operations, and steps taken to address them.

At LANL, the process of replacing the CMR based analytical laboratories started more than 20 years ago. During the early stages of that process, it was determined that remodeling the existing

CMR laboratories wouldn't work. The CMR facility was built in the late 1940s and was opened in 1952. The1940s/50s era building, electrical, and plumbing codes are drastically different to modern codes and the facility doesn't have modern heating and cooling systems and many of the CMR facility systems and structural components are aged, outmoded, eroding, and generally deteriorating. The cost of remodeling the facility quickly escalated beyond what building from scratch would cost. Initially PF-4, built in 1978, was screened out because it would need upgrading as well to handle modern analytical equipment. Instead, the plan was to build two new facilities that would house the CMR capabilities based on MAR inventories: a radiological facility for low level tasks and a nuclear facility to handle high levels of special nuclear materials. As part of the building new facilities, AAC and LANL management wanted spaces that were integrated; easier to maintain and work in; and that could be easily updated as new technology came along. In addition, existing equipment and instruments would not be transferred but would be purchased to install. This would allow for additional capabilities, improved methods, and environmental controls, and ensure that AAC would have an excellent foundation for future work.

Early Successes and Challenges

The initial plan and first phase of CMR replacement program (CMRR) was to plan and build two facilities: RLUOB and a Nuclear Facility (NF). Planning started in May 2005 with groundbreaking of the RLUOB facility in 2006. RLUOB construction was finished in 2010 while the interior offices and laboratories were officially finished in 2013. In this first phase only the trace element, mass spectrometry, non-destructive assay (NDA), and chemistry preparation laboratories were completed. The remaining laboratory modules were empty shells. This was to provide space that could be built out over time as new programs started or current programs expanded. The remainder of AAC capabilities including the sample preparation space for the trace element and mass spectrometry teams were to be in the planned NF building.

Unfortunately, by the time RLUOB became operational, the largest challenge occurred. The original two facility design had been defunded and the NF building was no longer going to be built. To solve the long-term problem of replacing CMR without the new nuclear facility required some creative thinking on the part of LANL. In 2014 LANL received funds for a second plan on replacement of CMR based splitting lower-level material assays into the RLUOB facility and the higher-level work into PF-4. In addition, this project would be wrapped into the overall modernization of PF-4 plant and support the widely publicized plutonium pit production program that was gearing up to restart. This remodeling was required as PF-4 was designed for research, development, and surveillance activities but not production work. LANL used computer aided modeling of AAC methods and RLUOB and PF-4 facility limitations, along with predicted sample analysis requirements from the pit production program to design a plan to split low level materials assays into RLUOB and high-level work into PF-4.

The result of this modeling could be described from AAC's perspective as happing in 3 separate phases as seen in Table 1. Phase I and Phase 2 occurred nearly concurrently with the AAC PF-4 spaces scheduled to complete approximately 18 months ahead of RLUOB spaces. Phase 3 planning had started in 2022 but has been paused due to funding priority changes.

Table 1: Plans for AAC method locations.

Phase I: PF-4	**Phase 2: RLUOB--Empty laboratories build out**	**Phase 3: RLUOB--Last 2 empty laboratories (capacity/back up)**
Additional/Upgrade SM cutting box	SM cutting boxes	SM cutting boxes
Dissolutions (metals, salts, oxides)	Dissolutions (metals, salts, oxides)	Dissolutions (metals, salts, oxides)
Solution Sample Preparation (Trace Element/XRF)	Solution Sample Preparation (Trace Element, Mass Spectrometry)	Pu Assay by Coulometry
Solid Sample Preparation (Grinding and pressing pellets)	Solid Sample Preparation (Grinding and pressing pellets)	Pu Assay by Ceric Titration
Loss on Ignition /Furnace operations	Loss on Ignition /Furnace operations	Iron assay by UV-Vis
Pu Assay by Ceric Titration	Pu Assay by Coulometry	C/S/O/N/H
Iron assay by UV-Vis (direct support of Ceric)	Iron assay by UV-Vis (direct support of Coulometry)	Pyro/IC
C/S/O/N/H	XRF (5 instrument)	XRF (1 instrument)
Pyrohydrolysis/Ion Chromatography	Radiochemistry methods	Thermogravimetric Analyzer
Additional RC box	NDA methods	High Resolution Mass Spectrometer
	R&D/Troubleshooting equipment	

Aside from the big impact cancelation of the NF made, AAC encountered a number of issues at RLUOB that impacted operations within the laboratories in a routine manner once the facility was declared operational in 2013. For instance:

1. The large outside argon storage tanks had temperature regulation issues that caused the argon gas to continuously escape from the large Dewars meant to supply the analytical equipment.
2. Pressure safety programs significantly changed their approaches resulting in analytical equipment at RLUOB being no longer exempted from formal evaluations and documentation.
3. MAR limits for the facility were very, very low.
4. RLUOB's waste tank for low level liquid wastes was not hooked into the lines leading to LANLs' Radioactive Liquid Waste Treatment Facility (RLWTF) in order to allow for the RLWTF to install new holding tanks and other facility upgrades to limit liquid discharges into the environment.
5. It was difficult to ship radiological material to the facility as LANL had not prepared or planned for routine shipping of radiological material between CMR and RLUOB or PF-4 and RLUOB in an easy way without the nuclear facility as the intermediary and was not included in large program scheduling of resources related to radiological shipments.

6. Validation of newly installed instrumentation was not included in construction planning. This meant AAC couldn't use the instruments until a program was willing to pay for them to be validated.
7. The operational funding of the facility was not set up under the same model as PF-4 and CMR causing competition between the sites for limited support resources and increased costs to any programs wishing AAC to analyze their samples that might use this new instrumentation and equipment.

To overcome these challenges, short term fixes were often implemented to ensure routine operations until a long-term fix could be initiated, planned, or found. As an example, liquid argon tanks were brought in to run instrumentation instead of house argon. Or when the pressure safety program changed, several AAC personnel worked to become qualified to do the required documentation and inspections. They then implemented the required tracking of all the analytical equipment where pressure systems were involved. The CMR Replacement project then incorporated the need for pressure safety inspection, testing and documentation into the new plans for RLUOB.

A slightly more difficult challenge was the MAR limit. At the beginning the facility had a material at risk (MAR) limit of 8 grams. This is not a large amount of material and as production analysis needs increased, AAC would need higher levels to truly be able to function in a routine manner. To enable this, LANL requested DOE to allow RLUOB to immediately increase it's MAR limit to 38.6 grams. This request was granted in 2015 in part because LANL exceeded the standards for most low hazard facilities and built RLUOB to the NQA-1 standard [1] which normally is only required for Hazard Class III buildings. Because of the modeling that was done as part of original planning, LANL put into the overall CMR replacement plan a process to bring the facility up to a Hazard Class III facility with a MAR limit of 400 grams as 38.6 grams would not be enough to support the planned production work according to the modeling. Within the schedule it would take place once Phase II had been completed to allow for all the new operations to work at full capacity. Once this first increase was in place the first radiological samples came to the RLUOB laboratories.

Low level waste from the sinks, shipping of special nuclear materials, validation of the instruments, and a similar funding process for RLUOB facility operations started to be solved by 2017. By this time the RLWTF finished the construction that had delayed the initial use of sinks at RLUOB and had been connected to the facility waste tank. It was also in this time frame that the plutonium pit production program started to apply more pressure to align RLUOB with CMR and PF-4 operations in their own project schedules and how the facilities were funded for operations. AAC personnel developed a hand carry work authorizing document that allowed them to transport very limited amounts of radiological samples for mass spectrometry. And because the plutonium pit production program had a vested instrument in having the new instruments working for them, they managed to get an increasing number of shipments from CMR to RLUOB allowing validation of the trace element instrumentation to occur. By 2020, shipping materials between CMR and RLUOB had become routine allowing for both the mass spectrometry and trace element teams to perform their sample preparation at CMR with analyses at RLUOB.

Phase I and II challenges

Smaller spaces, limited ventilation options: One of the first challenges for RLUOB and PF-4 in was in designing and planning for analytical work to occur in spaces that were much smaller than

originally envisioned in the 2-facility plan. It also had to account for the lack of openfront space that much of the analytical work normally occurred within. This meant AAC personnel had to prioritize what would have to be in an openfront enclosure vs a glovebox enclosure. As an example of this type of evaluation is the plutonium analysis by coulometry and iron analysis by spectroscopy methods. These methods are entirely in openfronts at the CMR facility. The first consideration is the difference between handling the labware and equipment for these methods with heavy glove box gloves vs handling with the normal open front PPE of double surgical style gloves. Where do you need the most dexterity and least encumbrance? The next consideration was where the instrumentation and equipment would be located. Will one piece of equipment cause a problem with an instrument if they are next to each other or will being in a glovebox vs and openfront be detrimental to the ergonomics of operating the equipment or instrument?

For these two example methods it was determined that most if not all the iron method could go into a glovebox. The handing of material didn't require exceptionally fine dexterity, BUT it was very important that the UV-VIS spectrometer was not located right next to the heat lamps in an enclosed space. The analysts did not want unstable temperatures for the instrument, nor did they want the possibility of increase fumes from the heating process attacking the instrument. In this case all parts of the iron method were planned for a glovebox line EXCEPT the measurement of the solution at the instrument. That was put in an attached openfront. In coulometry the analyst wanted as much dexterity as they could get as they handle fragile glass, thin wires, and needed easy unrestricted arm movement to get the coulometry cell properly aligned with the cell cover. It was determined that the fuming process required for the samples prior to the coulometry analysis could be done in a glovebox. Also, the gloveboxes at RLUOB have HEPA filter intakes that openfronts do not have. This would reduce the chance of environmental iron from environmental dusst causing an interference in the method.

Since workflows would be in smaller spaces, we constantly modeled the workflow through the spaces as we designed them. This process of imagining how a sample would move through the process in the new design ensured that we didn't have workspace issues once equipment was installed. We confirmed that we could do most of the iron process in a 3-workstation glovebox with the UV-VIS spectrometer placed immediately in the attached openfront minimized the back and forth that would have happen had we swapped where the heat lamps and UV-Vis were installed. This modeling also allowed us to design spaces that can do multiple tasks. For instance, because we have a centrifuge that can lower into a well with a cover, we can use both the remaining workstations for the precipitation, reagent addition, pH adjustment, and coloring steps to occur in the same floor space. This effectively reduced space requirements from 7 enclosure workstations at CMR to 4 at RLUOB.

Limited redesigns: Another design challenge was that AAC personnel was the CMRR program's desire to use the nuclear facility designs for gloveboxes and openfronts. This was a cost saving measure for the project overall and understood by AAC as a reasonable approach. However, because they were meant for a different building with different standards that meant the designs didn't always fit with what AAC needed in RLUOB. As a result, AAC asked for and received some allowed changes to the glovebox and openfront designs. Since the project was limited to already designed openfront lengths of 1-3 workstation, if a process needed more openfront space it would have to connect multiples of the smaller stations. However, this would create a wall block for movement throughout the two openfront sections. This would require the analysts to doff PPE and

done PPE between the two sides of the openfront train, as well as, bag out materials just to reintroduce them on the other side of the openfront wall. AAC suggested that a cutout be designed into the end walls that were being bolted together. This design was in use at CMR in one of the laboratories and worked quite well. An opening ~18 inches high and deep was designed which allowed analysts move materials and hands and arms through without having to come in and out of the openfronts.

Another change was to the floor wells in openfronts designed for centrifuges. These were large circular tubes with feed throughs to allow control of the centrifuge from the outside of the enclosures. However, in the decade or so between the original design of the nuclear facility and the planning of the RLUOB phase II labs, the centrifuges that fit into the wells and allowed for remote control of the operations had been discontinued by the manufacturer. Available centrifuges that would work for the process and be small enough for use in the glovebox were square would require significant customization to implement a remote-control process. This challenge saw the engineers and the analysts work to redesign the well to be square and include a floor jack that allowed the centrifuge to be raised and lowered with a crank. This allows analysts access to the controls on the front of the centrifuge along with a door plate flush with the floor of the glovebox. This allows the centrifuge to be lowered, protected against chemical spills and provide additional floor space needed for chemical operations.

AAC was not allowed to change computer rack designs that had attached to gloveboxes but had proven to be hard to use and not ergonomically friendly to the users. Since the size of computers had greatly decreased over time, the counter space for computers was much smaller and more user friendly than the attached stands were with laptops. As a result, these computer rack designs were eliminated. One item that AAC would have really liked to have removed for the RLUOB phase II designs were the large bolts that fit through feed-throughs on the front ledge of the openfronts. At the time there was no other approved option and since installation our experience has been that they catch on coats and badge lanyards. However, for the Phase III planning a low-profile bolt has been identified and has been added to the specifications for the glovebox and openfront designs.

Unexpected design changes: Because of the extended time frame from design to construction to installation of equipment some equipment didn't fit in the enclosure it was supposed to be installed into. It was never determined exactly how this was missed, but it is likely that personnel turnover occurred. With the transition of personnel, the change to a new model of equipment was missed and the size requirements not communicated to the project. To allow use of this instrument AAC personnel to had to work with engineers figure out a feed through that would work for the method with the instrument located on a bench next to the enclosure. As this process progressed it was also realized that the standard benchtop was not wide enough for the entire instrument. At that point AAC personnel called in a LANL machinist crew that measured the countertop and the instrument to build a custom bench top that could be mounted to the existing bench top.

Another instrument challenge was the installation of a RAMAN instrument into a glovebox. During the lead up to the actual instrumentation work authorizing documents for the installation were being reviewed by a AAC subject matter expert (SME)when the SME realized that no one had accounted for the class 4 laser that was part of the RAMAN instrument. At LANL use of a class 4 laser requires interlocked lights and room access controlled any time a class 4 laser was in use. Neither of these requirements were part of the design. The SME stopped work until a light proof interlocked box for the laser and sample holder could be designed, built, and installed by LANL

machinists and AAC SMEs. This removed the requirements for having the interlocked lights and room access controls. This delayed the installation of the specific instrument for approximately 8 months.

Smaller design issues would also be found during installation of the equipment and instruments. For instance, plugs on heat lamps and hot blocks were too large to allow the equipment line up properly. This fortunately had an easy, quick, and inexpensive fix as the CMRR project had in house electricians exchange plugs to a lower profile, 90^{o} angle plugs. Or a fumehood was found to have a facet not aligned with a drain. This is not an issue that could be physically changed but can be accommodated by AAC by just having a flexible tube attached to the faucet that is long enough to reach the drain.

Personnel challenges: The overall time frame from when the project first started to when it finished (2005 to 2022) saw numerous challenges for personnel. Many very experience personnel nearing or at retirement while at the start of Phase II in 2014 AAC's was at it's smallest overall group size. In addition, by the end of phase II of the project, covid occured with the resulting shortage of available workers and high competition for those with the skills, knowledge and qualifications needed to work in a nuclear facility environment. But with AAC's encouragement the project planned for succession training to start in approximately 2017. With this approach AAC has been hiring 20-25 people a year. When new hires came into the group CMRR project paid their salary for 1 year to cover all initial training to become a radiological and nuclear material handler. In return, these folks helped the experienced SMEs in AAC to install instruments and equipment, write work authorizing documents, train to and perform the analyses at CMR and develop the expertise with the new instrumentation. This innovative approach allowed for the experienced personnel nearing retirement to train new personnel and support concurrent mission work at the same time as instrumentation installation was ongoing. This approach was continued until the last year of phase II, was a huge investment into and for our group resulting with a number of very successful new AAC SMEs. In fact, this approach set the stage for current large programs to pay for training new hires at LANL even outside of C-AAC group before current SMEs retire.

Unrealistic schedules: The original schedule was made by the CMRR program with little SME input. And as stated above, the requirement to use initial designs also meant copying what was in the original nuclear facility schedule and plans exactly as possible to minimize costs. This did not, however, account for numerous issues such as manufacturers no longer making the original specified instruments or rule or code changes that occurred over the intervening decade. What the original schedulers did get right was using lessons learned from the initial construction project for RLUOB and planning a 18–24-month buffer time to account for possible construction delays in developing an updated schedule. While this was a good plan, construction used all the allotted buffer time and ended up pushing into AAC schedules for instrument installations and testing. This often-caused conflicts in the schedule and with AAC being asked repeatedly to shorten their schedules for work.

In addition, the schedule also planned parts of the project to occur in parallel. Examples are noted in Table 2 below. While some of the initial planning changes by the program were successful, AAC had to renegotiate time frames often while retaining the original finish dates. Table 2 below reflects a partial list of the type of items negotiated and if these changes were successful.

Table 2: Negotiated schedule changes.

Negotiated Schedule change	Successfully Implemented?
Documents were allowed to be updated as SMEs learned new facts for method/ equipment/instruments/rules	Partially
Added time for instrument testing with drafted documents.	Yes
Moved final approval for work authorizing documents until just before final walkdowns.	Yes
Moved validation plans until SMEs had some confidence in what method/instruments/required QA/QC would be.	Yes
Requested equipment ordering be delayed until 2-3 years before installation dates.	Yes
Requested program input clauses about warranties not starting until installation and include 2–3-year service contracts.	Yes
Requested program to not order MT&E or standards until ~ 6 months prior to final walkdowns	Partially
Requested program to pay for 6 months of equipment testing and validation once work authorizations occurred	Partially

AAC was successful in obtaining longer time frames for writing validation plans and work authoring documents to match existing document control processes. However, this was only partially successful as there were many delays in this process outside of either the project's or AAC's control. At the time, document control process didn't function particularly well, and reviews of documents often got lost on safety program desks due to personnel shortages and lack of follow-up by the document control administrators. By the end of the project, the program managers for the project had set up weekly status meetings with a document control point of contact so that documents wouldn't get forgotten or lost in the overall process. This significantly streamlined the turnaround for documents by the end of the project.

AAC also negotiated moving the validation plans to later in the schedule AFTER the initial drafting of the work authorization documents. This allowed SMEs for the methods to have thought about what quality controls and acceptance criteria made sense to include in the validation plans based on a better idea of how the methods and instruments were to be implemented and installed. In addition, there was agreement that the final versions of the work authorizing documents and validation plans were to be delayed until 2 months prior to the final walkdowns and assessments of the labs, equipment, and methods by safety programs and facility owners who would provide final operational approvals. This allowed multiple versions of the documents to occur, refining how the process steps were written and clarify what the new facility operators expected to be included within these documents.

The project agreed with AAC's request to delay ordering major pieces of instrumentation or equipment until 2-3 years before the scheduled installation and to include in the purchase contracts

that the manufacturer warranties would only start once installation occurred. This would prevent as much as possible the repurchasing or extensive service work that would be required if instruments and large pieces of equipment sat for 8 years prior to installation. This was a very successful approach and prevented the installation of obsolete equipment.

Initially the project resisted the AAC request not to order lab supplies, chemicals, and standards until 6 months prior to the authorization walkdowns. But as construction delays occurred and the fact that AAC had no location to store items that had been ordered the project agreed that continuing to order materials that had no storage locations or would expire prior to use would not be a cost-effective process. At that point orders for these items were delayed and in the schedule these order tasks were tied 6 months out from the method assessment start. In addition, a construction storage building was constructed next to the RLUOB facility where materials needed for the installation of all the equipment was being staged. The project set aside a portion of this facility for AAC instrumentation to reside until the room they were to go into had gotten to the point they could be installed.

Delays in construction caused overlap with equipment installs: Construction delays meant the CMRR Project was doing recovery plans where construction was happening in one lab while installation occurring in another lab. This happened both in the Phase I PF-4 buildout and in RLUOB. Since the PF-4 project was about 18 months ahead of RLUOB it did allow us to use some lessons learned from that phase to help in our installation approach at RLUOB. For example. At PF-4 the gloveboxes where the iron method equipment/instruments had been installed had several contamination incidents during the box pressure testing. First, during the actual pressure testing of the glovebox, clay that had been used around all seals got pulled into the glovebox. This coated all equipment including balance, centrifuge, heat lamps and UV-Vis instrument with a very, very fine layer of clay dust. In addition, a piece of testing equipment within the glovebox was found to be too large to get out the passthrough to the drop box at the end of the glovebox line. To remove it, the testing crew would have to cut it apart with a grinding wheel. This then caused a great deal of steel particles to be distributed throughout the box adding to the background iron contamination now coating all the installed equipment. This incident required AAC to continuously clean the inside of the box and all associated equipment multiple times for over a year before the method would return low blanks for iron.

At RLUOB, the AAC changed the installation technique so that ALL equipment inside the gloveboxes and hoods were individually wrapped with plastic wrap or bags which were then sealed with tape. Then any free-standing instrumentation outside enclosures were covered with plastic as well stanchions placed around them to help prevent them from being knocked into. As a final precaution, all the openings in glovebox and openfront enclosures were sealed with a sticky plastic sheeting until gloveboxes were fully sealed, ready for testing, and all major construction in a room was completed. These preventive measures were only partially successful as the sheeting covering on gloveboxes and openfronts were often bumped by construction crews and their equipment causing the covers to pop open. In addition, because of the delays, construction was often simultaneously occurring in neighboring labs so even if a lab that had been finished was wiped down, personnel were constantly having to reclean in the labs due to the tracking of construction debris as workers moved around. The mass spectrometry team even implemented a requirement that all personnel entering the mass spectrometry preparatory lab to put on booties just before entering their laboratory spaces to prevent construction dust from coming in on shoes. These

approaches were mostly successful in reducing the amount of time needed to get instruments running cleanly, but AAC still needed several months of repeated cleanings after work was authorized before control charts settled down into what was expected for the methods.

New Documented Safety Analysis: The current MAR limits for the facility would not handle the expected sample load, the mar for the facility needed to increase into a Hazard Category III level. By increasing only to 400 grams of Pu-239 equivalent, the facility wouldn't need to install new ventilation, new fire controls, or upgrade systems to become safety significant systems as evaluations for the facility had already determined that the facility would not impact the public with this new limit. But its new hazard evaluation required the exposure of collocated workers to be evaluation and rules and systems in place were required to ensure they would not have an exposure to more than 5 rems in an accident scenario.

To ensure this limit was met technical safety requirements (TSRs) for MAR were set for the facility and within facility locations, but these TSRs also limited the form of the material based on the uptake co-located workers might experience. As a result the following forms are required to be individually tracked: metal, molten metal, solid (oxides), solutions (salts/liquids), and high-pressure vessel dissolutions. The first 4 types are treated as a sum of fractions, with each form having its own established facility limit. The high-pressure vessel dissolutions are tracked independently and limited to 4 grams total in the entire facility.

To track these limits for the facility entirely new tools were required for as the current systems used PF-4 and at CMR were not equipped to do the same level or type of tracking as would be required at RLUOB. The solution to this problem was to use the existing sample tracking software AAC had already in place at CMR and update the system to track MAR by the nuclear material form. This system then needed to include permissions to change form, perform high pressure vessel dissolutions, move between locations, bring material into the building and ship material out of the building. Additional required features were to prevent movement of material when the facility was not in normal operations mode and new accounts and tasks for the facility operators, waste disposal team, and materials characterization teams that had never used the software before. The AAC laboratory information system SMEs required 3 years of programing work to successfully design, program, and implement these changes.

The final TSR level control occurred near the end of the project and after the first version of the DSA was approved. This new control was driven by events outside the project. In 2014 the Waste Isolation Pilot Project (WIPP) experienced an accidental radiological release driven by a TRU drum failure and exothermic reaction that took place within the drum. After several years of investigations, new requirements for waste that would be accepted at WIPP were implemented and the Safety Basis groups at LANL determined that new TSR level controls would be required at CMR, PF-4 and RLUO. This new control to prevent nitric acid and polysaccharide material from ever being in the same TRU drum required AAC and LANL to implement new waste acceptance criteria, increase levels of inspections on waste, restrict the type of wipes than can be used, and update all work control documents with new instructions related to the use and disposal of items exposed to nitric acid.

Another waste related challenge was that RLUOB had never generated TRU waste and did not have an acceptable knowledge (AK) document for generation of TRU waste. AAC project SME realized this had not been included in the overall project schedule and worked with waste services to write a

new AK document based on the equivalent CMR methods, CMR AK TRU waste document, and DSA method descriptions that were in use. This allowed RLUOB to generate solid TRU waste and have it dispositioned. However, AAC's high MAR liquid residues were still problematic as there wasn't a process set up at RLUOB to allow for this type material's dispositioning. The short-term solution implemented has RLUOB is shipping high level residues back to CMR for full characterization with subsequent dispositioning. Long term plans will have C-AAC characterizing the material at RLUOB and then dispositioning in several ways as cementation or reprocessing lines at PF-4 as determined most appropriate.

Fire Safety Programs: In the original construction of RLUOB laboratories, fire suppression systems were installed in the gloveboxes. However, by the time the Phase II build out of RLUOB occurred the company who had provided the fire suppression system was out of business and the equipment used in the original construction could no longer be maintained. The original systems were removed from existing laboratories and left the project with no way to provide fire suppression within any gloveboxes that would not have been prohibitively expensive or damage equipment if it malfunctioned. This change to having no fire suppression imposed drastic rule shifts that the project and AAC personnel had to navigate and implement.

Initially the proposed changes would limit each enclosure train to 1 pound of "transient combustible" material, limit what chemicals could be used to those specifically evaluated, and imposed the condition that all trash must be removed from the enclosure at end of the workday. In addition, changes to the combustible programs at LANL limited the quantity of combustibles allowed to be out of a cabinet or drawers. AAC and the project pushed back and had the fire safety personnel relook at the current building and operational standards. It was found that the building codes and other standards only applied to the gloveboxes and not openfronts. As a result of this realization, most of the restrictions related to the quantity of transient combustibles, flammable combustibles, and requirements for paperwork were removed or greatly reduced for openfronts. For gloveboxes, the limit for 1 pound of transient combustibles still applied, but AAC would not be required to remove it completely from the GB line at the end of the day's operations. AAC personnel would be required to used fireproof containers to store the material within the glovebox. Also, as part of that agreement, AAC was funded to evaluate and replace the labware specified for a process if any equipment such as test tube racks, secondary containment for chemicals, etc., could be replaced with an equivalent noncombustible version. Another change the review caused were to update rules to remove requirements that limited the exact chemicals to screening against categories of chemical hazards. This would provide AAC flexibility as program and sample needs changed. AAC still had to live with very low limits of transient combustibles as a whole and very limited quantities of flammable liquids which were capped at 25% of the flammable limit in the glovebox when the glovebox was treated as a closed system. AAC adapted by updating processes to specify controls for flammable liquids for the locations being worked in and using the flexibility of openfronts not having the same limits as gloveboxes.

Chemical Safety Challenges: Original operations in RLUOB worked to what is called the protection action criteria (PAC)-3 limits set by DOE. However, as the hazard analysis reviews occurred for increased MAR limits it was realized that the facility had another set of limits that need to be applied. These limits were set by the International Building Codes (IBC). The difference between the two sets of limits come from the focus of each regulating entity. The PAC-3 limits are set by DOE based planning and response to uncontrolled releases of hazardous chemicals and is

based over 3000 individual chemicals while the IBC looks exclusively at hazard categories of chemicals such as corrosive, oxidative, flammable gas, flammable liquid, or toxic chemicals. The IBC doesn't evaluate specific chemicals. The AAC chemical hygiene officer originally developed a chemical management program for the RLUOB facility based on the PAC-3 limits. At the time, the CMR chemical inventory was evaluated against the PAC-3 limits as a way of predicting chemical use at RLUOB and found that of all the chemicals AAC has used in the past only the hydrochloric acid realistically had a chance of going over the PAC-3 limit. Thus, the existing management program at RLUOB only called out the hydrochloric acid limits for extra scrutiny. But with the inclusion of the IBC limits a different process needed to be developed that could monitor ALL the chemicals in the building, sort them into proper hazard categories, and compare them against PAC-3 and IBC limits in near real time. LANL's existing chemical inventory data base didn't have the tools needed for these kinds of report generation. It required LANL's industrial health, RLUOB facility operators, programmatic user groups (AAC and materials analysts) and LANL's CEREBRO initiative software specialists to develop special reports that the CERBROS software could put together from the chemical inventory system data.

Conclusions

Design, construction and standing up new labs takes significant time and cannot be done as a 'side" job by your ANALYTICAL SMEs. It is critical to high appropriate staff to accommodate increase workloads and cover the succession changes in personnel as the project progresses. Involve your analytical SMEs early and throughout the design, and construction process as they will help make the designs and schedules better and more accurate. Even with SME input, changes will need to occur on the fly throughout the project requiring excellent communications to occur with all stakeholders to develop innovative and timely solutions. Analytical SMEs will need to accept that all documents and programs are always one revision away from perfection and update documents throughout the project and as any good scientist, be flexible, adaptable and open to new ideas.