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Performance Analysis: Work Control Events Identified January - August 2010

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Performance Analysis: Work Control

Events Identified January–August 2010

by
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1.0 Introduction

This analysis of LLNL's operational events was conducted in response to a letter received on August 31, 2010 from Alice Williams, NNSA Livermore Site Manager. In the letter, Ms. Williams states, "Over the past eight months, the LLNL has experienced a number of operational occurrences or events where the overall performance of the individual work activities had either near miss or other associated safety precursor type implications. These events question the overall effectiveness of recent work control improvements and /or the activity-level implementation of certain key process elements."

The letter listed seven "key activities or events of concern:"

- Maintenance of the B235 Dynamic Transmission Electron Microscope in violation of Radiation Generating Device (RGD) safety controls – August 2010
- Maintenance work on a B391 energized 480-volt electrical panel with improper application of the LLNL lock-out/tag-out controls – July 2010
- Processing of a uranium-lithium item in B332 resulting in an unexpected exothermic reaction and need for improved material characterization – July 2010
- A B332 continuous air monitoring alarm as a result of opening a plutonium item with ten-year old packaging outside of a glovebox – May 2010
- Machining activities in B321A involving a part containing beryllium material – February 2010
- B391 electrical work resulting in the inadvertent cutting of energized 208 volt AC 3-Phase electrical lines – February 2010
- Processing of an unapproved part in B851 – January 2010

The letter directed LLNL to "provide LSO an analysis of the events and any performance trends they represent." The letter further stated that the "analysis should not be limited to the above noted events but include other events and occurrences the Laboratory deems appropriate to evaluate the quality of work control processes and their implementation. The analysis should focus on the following:

- The overall collective significance of the events
- Underlying common causes or contributing factors
- Potential work control process and/or implementation weaknesses
- Human performance improvement and Safety-Culture factors
- Any applicable senior Laboratory management initiatives to improve performance"

The Performance Analysis and Reporting Section of the Contractor Assurance Office reviewed all of the known LLNL events from January-August 31, 2010 and included additional events beyond the seven listed above in the analysis. The final set of events analyzed comprise 21 occurrences reported to the DOE Occurrence Reporting and Processing System (ORPS), one

noncompliance reported to the DOE Noncompliance Tracking System (NTS) and two events not previously reported.

The end date of August 31, 2010, was selected to ensure that the individual causal analyses could be conducted and available in time for the performance analysis team to evaluate the collective set of events. The 24 events included in this performance analysis are listed in Table 1.

Table 1. Events Included in this performance analysis

Report Number	Categ. Date	Subject/Title
Not reported as an occurrence	1/27/2010	Processing of an unapproved part in B851
LLNL-2010-0004	2/12/2010	Machining of Legacy Part Leads to Indeterminate Beryllium Exposure of Machinist
LLNL-2010-0006	2/19/2010	Energized Electrical Conductor Cut Without Energy Isolation in Building 391
LLNL-2010-0010	3/04/2010	Personal Air Monitoring Sample Above ACGIH TLV For Silica Dust in Building 581
LLNL-2010-0011	3/04/2010	Work Control Process Management Concern
LLNL-2010-0012	3/04/2010	Alpha Survey Meters Sent Offsite for Repair Returned Due to Contamination
LLNL-2010-0014	3/26/2010	Management Concern - Actuation of Building 332 Legacy Alarm System
LLNL-2010-0015	3/29/2010	Building 332 Safety Basis Violation Relative to Functional Testing of the Mobile Weapons Platform
LLNL-2010-0016	3/31/2010	Unexpected Discharge of Flammable Gas While Drilling Into Gas Cylinder With a Hand Drill
LLNL-2010-0017	3/31/2010	Certified Unified Program Agency (CUPA) Inspection Notice of Violation At Site 300
NTS-LLNL-2010-0020	4/2/2010 (Event Date)	Failure to Follow Evacuation Procedure upon Activation of Tritium Activity Monitor Alarm
LLNL-2010-0019	5/03/2010	Management Concern - Routine Machining Activities Result In Two Lacerations Within A 24-Hour Period
LLNL-2010-0021	5/24/2010	Continuous Air Monitor (CAM) Alarm Actuation in Building 332 Radiological Materials Area (RMA)
LLNL-2010-0022	5/25/2010	Unsafe Vehicle Operations Recurring At LLNL
LLNL-2010-0023	5/28/2010	Radiological Contamination Found In Building 194 Spectrometer
Not reported as an occurrence	7/13/2010 (Event Date)	Processing of a Uranium-Lithium item in B332 resulting in an unexpected exothermic reaction and need for improved material characterization

Report Number	Categ. Date	Subject/Title
LLNL-2010-0028	7/19/2010	Discovery of Energized Electrical Source During Equipment Installation At Building 391
LLNL-2010-0029	7/20/2010	Management Concern Regarding FXR Venting Operations at Building 801
LLNL-2010-0031	7/23/2010	Building 174 Work Control Concerns
LLNL-2010-0032	7/26/2010	Failure To Follow Procedures Results In Power Outages To Buildings 431, 439 and 442
LLNL-2010-0036	8/9/2010	Building 190 Tube Furnace Minor Electrical Shock
LLNL-2010-0037	8/12/2010	Unexpected Discovery of A Pressurized Hydraulic Oil Line During Fire Sprinkler Upgrade In Building 311
LLNL-2010-0038	8/16/2010	Dynamic Transmission Electron Microscope Improper Shielding Removal in Building 235
LLNL-2010-0039	8/20/2010	Unauthorized Crossing of Construction Barrier In Building 131

Some events that occurred during the time period were not included because they were clearly not related to work planning and control. Other events related to controlling work were not included because they did not take place during the time period to be analyzed. Examples of events that were excluded are occurrences that reported discovery of as-found conditions such as suspect/counterfeit items, receipt of notices of violation in 2010 that reflected work in 2009, occurrences that were captured in subsequent occurrence reports (found to be recurring), and injuries and illnesses related to personnel transportation. Table 2 lists the reported occurrences that were not included in this analysis and notes the reason for the exclusion.

Table 2. Events reported to ORPS but not included in this performance analysis.

Report Number	Categ. Date	Subject/Title	Reason Excluded
LLNL-2010-0001	1/7/2010	DOT Steel Drum Closure Ring	(a)
LLNL-2010-0002	1/20/2010	Suspect/Counterfeit Transistors Discovered in the Building 174 Complex	(a)
LLNL-2010-0003	1/25/2010	Lighting Improperly Marked as UL Listed in Building 332	(a)
LLNL-2010-0005	2/16/2010	Savings Performance Contract (ESPC) Electrical Deficiency Management Concern	(a)
LLNL-2010-0007	2/22/2010	Deep Vein Thrombosis Resulting in Hospitalization After Business Travel	(e)
LLNL-2010-0008	2/25/2010	LLNL Employee Dosimeter with Indications of High Exposure	(c)
LLNL-2010-0009	2/25/2010	Unexpected Rolling Truck Near Miss	(d)

Report Number	Categ. Date	Subject/Title	Reason Excluded
LLNL-2010-0013	3/12/2010	Worker Sustains Lower Leg Fracture After Falling From Bicycle Near Building 142	(e)
LLNL-2010-0018	4/20/2010	Degradation Of The Building 332 Safety Significant Glovebox Nitrogen Supply System	(a)
LLNL-2010-0020	5/19/2010	Discrepant As Found Condition – Building 334 Ventilation System	(a)
LLNL-2010-0024	6/17/2010	Degradation of the Building 332 Safety Significant Emergency Battery Lighting System	(a)
LLNL-2010-0025	6/29/2010	Fractures Ankle After Stepping Off Curb Near Building 154	(e)
LLNL-2010-0026	6/29/2010	Summary of Violations from the Department of Toxic Substances, California Environmental Protection Agency	(b)
LLNL-2010-0027	7/7/2010	Degradation Of The Building 332 Safety Significant Emergency Battery Lighting System – Monthly Test	(a)
LLNL-2010-0030	7/23/2010	Suspect/Counterfeit Bolts Found on Ratchet Tie-Down Straps In MUSD	(a)
LLNL-2010-0033	7/29/2010	Slip/Trip on Floor Mounted Bracket Causes Ankle Injury In B111	(e)
LLNL-2010-0034	8/4/2010	Building 174 Discovery Of Additional Suspect/Counterfeit Tie-Down Strap Ratchet Mechanisms	(a)
LLNL-2010-0035	8/6/2010	Degradation of The Building 332 Safety Significant Fire Detection and Alarm System	(a)
LLNL-2010-0040	8/30/2010	Building 341 Boiler Issue Found During Air District Inspection	(c)
LLNL-2010-0041	8/30/2010	Site 300 Notice of Violation Issued During Tank Inspection	(b)
LLNL-2010-0042	8/31/2010	Notice of Potential Violations Identified During Hazardous Waste Compliance Inspection at Site 300	(b)

Notes:
(a) As-found condition
(b) Cause not analyzed
(c) Not related to work in 2010
(d) Event analyzed and documented in another report
(e) Injury or Illness related to transportation

This analysis report includes a review of the causes of each event, two relationship analyses (an evaluation to identify the ISMS function in which the cause occurred and an analysis of the common causes), a review of the human performance aspects of the collective events and management initiatives to improve performance.

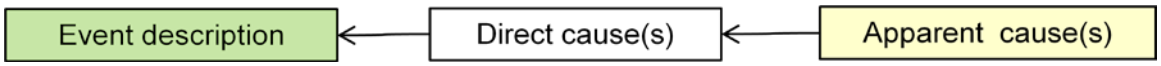
2.0 Causal analysis of events

The DOE process is to analyze most individual occurrences for apparent cause, conduct a performance analysis to identify recurring occurrences, then analyze each recurring occurrence for the root causes. If an occurrence is serious in itself, it is analyzed for root cause rather than apparent cause. This two-tier method ensures that valuable analytical resources are applied to the most pressing needs.

Most of the occurrences in 2010 were analyzed for apparent cause and a few were analyzed for root cause. Apparent cause analysis tends to identify active errors and the corrective actions tend to be localized. A root cause analysis, on the other hand, tends to identify organizational errors and latent weaknesses. For most of the events, the causal analysis was conducted and documented by the directorates. In some cases, the causal analysis was not available, and members of the Performance Analysis and Reporting Section, through interviews with the directorate points of contact, analyzed the events so that the causes of these events could be included in this analysis.

The causes from the causal analysis reports were diagramed so that they could be discussed within the context of similar events, events with similar work control process errors, and events with similar causes. The diagram consists of a series of boxes connected by associating arrows. The boxes in the diagram from left to right are: the event, the direct cause and the apparent cause(s). The causes of most events were mapped using a series of three boxes; however, in some cases where additional information was necessary to understand the event, the mapping included four boxes. The fourth box was added to include additional explanatory direct causes or apparent causes. Figure 1 shows how the events and causes are diagramed for the relationship analysis.

Figure 1. Events were diagramed using a series of connected boxes



After each event was mapped, the events were clustered by commonalities. The purpose of the clustering is to identify frequent causes that could be addressed by Laboratory-wide corrective actions. The goal is to implement corrective actions that prevent recurrence. The full set of causal diagrams are located in the appendices. Appendix A contains the relationship analysis flow diagrams grouped by ISMS function; Appendix B contains relationship analysis flow diagrams grouped by common-cause.

3.0 Potential work control process or implementation weaknesses

The first commonality analyzed is by ISMS function and the causes were clustered according to the ISMS functions. If the causal analysis reports identified causes in multiple functions, the cause in the earliest of the five sequential functions (not the earliest by time or date) was used to bin the event. It is understood that additional errors in later work control functions may also contribute to an occurrence; however, it is recognized that errors that take place later in the work control process often either compound the first error or are expressed only because the first error existed or implementation of the later functions are unable to overcome the first error.

Six of the events discussed in this report were also discussed in the performance analysis report of hazardous energy control. During the preparation of this report, additional information was collected on each event, resulting in a better understanding of the causes leading to the events. Based on this new information, four of the events were binned into different integrated safety management system functions. The analysts believe the new assigned function is more appropriate. The changes would not affect the analysis in the earlier report on hazardous energy control.

3.1 ISMS Function 1 - Define Work

For seven of the 24 events, the causal analyses and the corrective actions suggest that errors occurred during the step to define the work scope. Six of these events were reported to the DOE Occurrence Reporting and Processing System (ORPS), one was not reported. Table 3 lists these seven events.

Table 3. Events where the cause was during ISMS Function 1 – Define the work

Report Number	Categ. Date	Subject/Title
Not reported as an occurrence	1/27/2010	Processing of an unapproved part in B851
LLNL-2010-0006	2/19/2010	Energized Electrical Conductor Cut Without Energy Isolation in Building 391
LLNL-2010-0014	3/26/2010	Management Concern - Actuation of Building 332 Legacy Alarm System
LLNL-2010-0015	3/29/2010	Building 332 Safety Basis Violation Relative to Functional Testing of the Mobile Weapons Platform
LLNL-2010-0031	7/23/2010	Building 174 Work Control Concerns
LLNL-2010-0037	8/12/2010	Unexpected Discovery Of A Pressurized Hydraulic Oil Line During Fire Sprinkler Upgrade In Building 311
LLNL-2010-0038	8/16/2010	Dynamic Transmission Electron Microscope Improper Shielding

Report Number	Categ.	Date	Subject/Title
			Removal in Building 235

The event in Building 851 at Site 300 involved the use of an unapproved high-explosive (HE) part for purposes of conducting a training exercise, namely demonstration of the Liquid Abrasive Cutter (LAC), for a non-LLNL external customer. Weapons and Complex Integration (WCI) Primary Nuclear Design (PND) management and the customer agreed upon a scope of work for the exercise based on a specific HE part that was known to be classified. Work documents, i.e., an IWS as well as an associated WCI "Script/Work Permit," were developed and approved. When it was subsequently determined that the geometry of the selected part was unsuitable for the intended demonstration, PND management, in consultation with the customer, selected an alternate part that was believed by WCI employees to be unclassified. However, the work documents were not revised to reflect the part change, resulting in neither safety hazards (e.g., type of explosive) nor security (i.e., classification) issues being reevaluated. The LAC cut was performed on the part, including a video recording of the operation (which had not been part of the original work scope) that was stored on the hard drive of an unclassified computer operated by customer personnel. After the pieces of the part were returned to the Site 300 magazine, a WCI worker informed his supervisor that he believed the HE type of the part actually processed was inconsistent with the work documents generated for the part that was originally selected. This inconsistency was subsequently confirmed by WCI management, who also determined that the part actually processed, originally thought to be unclassified, was in fact classified. The failure to pause work and reevaluate the work scoping when the part was changed caused both a safety event (i.e., the LAC operation on and post-activity handling of a different type of HE than specified in the original work documents) and a security event (i.e., the filming of a classified part with unclassified equipment, and subsequent failure to protect that equipment).

In event LLNL-2010-0006, workers cut an energized 208-volt alternating current 3-phase power electrical conductor while removing wires from an electrical equipment chassis in Building 391 (the LLNL Nova laser facility), which was undergoing demolition. The project was being conducted in three phases: (1) a cleanup phase, including identification and cleanup of hazardous materials and removal of loose equipment, (2) a decommissioning phase, including "air-gapping" of electrical circuits to render them de-energized, and (3) a demolition phase, including removal of the Nova space frame. The work in progress at the time of the occurrence was phase 3. The NIF and Photon Science causal analysis for this event identified as one cause of the event that "The work plan for the demolition work in the Nova Target Bay did not adequately consider potential electrical hazards in the area." The report further noted, "Workers and managers were not cognizant of the electrical hazards and did not use or ensure the use of LOTO on the electrical circuits in the space frame area." The report alluded to a "folklore" that had arisen among workers and managers that all circuits were safe (i.e., de-energized) as a result of the "air-gapping" that had supposedly occurred in the decommissioning phase of the work, leading to worker complacency that all circuits were de-energized.

In event LLNL-2010-0014, Building 332 facility maintenance personnel were upgrading a security announcement system, which required removing the paging system from operation. In

the process, a new terminal block was being installed, which required moving leads from the existing block to a new block. When two of the wires were disconnected, the wires touched, completing a circuit that to the surprise of the workers activated a legacy sound generator unknown to them that generated a sound simulating a Building 332 safety alarm. The two wires that connected -- labeled as wires 16 and 17 -- were not on any drawings reviewed during the work planning process or that the workers had in their possession as they were performing the work. The causal analysis for this event noted that the workers "clearly had no idea that this legacy component [the legacy sound generator] was still in the system."

In event LLNL-2010-0015, Building 332 facility management determined that there had been a violation of a hazard control identified in the Building 332 Safety Basis relative to the location of a functional test performed on the Mobile Weapons Platform (MWP), operated by the Security Organization, within the Superblock Yard. As noted in the causal analysis for this event, the specific locations approved for the functional testing are identified in a safety basis amendment issued by the DOE/NNSA Livermore Site Office (LSO) on April 15, 2009, specifically as conditions of approval for the revised Superblock safety basis. Upon receiving conditional LSO approval of the safety basis, NMTP management removed the Technical Safety Requirement (TSR) controls from the safety basis, replacing them with the LSO conditions of approval. The conditions of approval governing approved locations for MWP testing were not, however, entered into the Superblock Yard Facility Safety Plan or into relevant Security Orders. The NMTP Safety and Work Control Manager, who based work scoping for testing of the MWP on the Facility Safety Plan and Security Orders, was unaware of the LSO conditions of approval. This lack of awareness during work scoping led to the approval of test locations that were not approved by LSO and thus to a violation of the LSO-approved Superblock safety basis.

In event LLNL-2010-0031, a worker in Building 174 paused maintenance activities due to concerns with worker qualification and training. A review of worker qualifications led to the discovery that the work control process was inadequately performed. Maintenance activities related to mounting video monitors and cable trays had begun, but because this work wasn't completed within the time frame stated on the work permit, it had to be halted. While working with an outside service provider to restart activities, Building 174 staff members proposed additional activities which were believed to be similar in nature. For this reason, it was decided to merely extend the dates on the original work permit rather than issue a new permit. This led to an inadequate review of the full work scope, which now included wall penetrations (drilling and cutting) in walls which contain asbestos in the joint/taping compound. After several scoping meetings, work resumed after about three weeks. Just prior to performing the cutting operation, a Building 174 employee questioned whether the workers to perform the task were qualified and adequately trained. A review of the work control documents (which included a discussion of hazards, controls and training requirements) and discussions with the industrial hygienist led to the determination that the workers' training was inadequate. Furthermore, a review of the work permit revealed that the scope wasn't sufficiently described to allow for a review of the hazards, and which would have made it much more likely that the appropriate controls, including work qualifications, were identified prior to the start of work (i.e., in the planning phase). The causal analysis for this event identified as the apparent causes (1) inadequate work package preparation, in that the revised work package did not have an adequate scope of work, (2) work scoping not

coordinated with all departments involved with the task and therefore new hazards associated with the expanded scope (most notably asbestos hazards) were not communicated to work planners, (3) the expanded scope of work not being perceived as significantly different from the original scope, leading work planners to erroneously conclude that they could use the existing work authorization documents without doing additional work scoping, and (4) work scoping not being conducted with inputs from facility walkdowns or task analysis.

In event LLNL-2010-0037, two LLNL plumbers were removing the coupling from what they believed to be a depressurized and drained two-inch black steel fire sprinkler water supply pipeline in Building 311, but discovered (due to the release of hydraulic fluid rather than water) the pipe to actually be a hydraulic fluid supply pipeline for a nearby elevator. Both the fire sprinkler water supply and hydraulic fluid supply pipelines and couplings were identical and unlabeled and were adjacent to each other. The work scoping process did not identify the unlabeled pipelines and their associated hazards during the work scoping process. Identified as an apparent cause of the inadequate work scoping was the incorrect belief of the plumber and the plumbing supervisor that they had exercised sufficient due diligence in verifying that the subject pipeline was the fire sprinkler water pipeline and that it was depressurized and drained of water. The causal analysis determined that the plumber and the plumbing supervisor (1) had failed to trace the subject pipes back to their respective sources, (2) relied on their experience that black steel pipelines with victaulic couplings were only used for fire sprinklers, (3) did not recognize the potential for the hydraulic oil pipeline to be routed through the area occupied by the sprinkler line, (4) depressurized the entire building fire sprinkler system, lulling workers into a false sense of security that they could work on any firewater pipeline without worry of its being pressurized, and (5) using a drawing that did not include the location of the two pipelines that were part of the work plan change (i.e., the pipelines that were selected as the alternate water supply when the original supply pipeline was determined to be inadequate).

In event LLNL-2010-0038, a vendor worker removed a shielding component integral to the Dynamic Transmission Electron Microscope (DTEM) while it was running in Room 1210, Building 235. The removal of the shielding coupled with a misalignment of the electron beam allowed X-rays to exit the column. The LLNL worker gave the approval to remove the shielding without first requesting the permission of the responsible individual, which was in violation of safety controls stated in the IWS for the work. The operation of the DTEM without the shielding in place represents a violation of both the IWS and the Procurement Work Sheet (which covers vendor/subcontractor work). The causal analysis for this event identified various causes related to work scoping as summarized in the following discussion. The IWS did not explicitly define the scope of the work nor did it clarify expectations and controls for the work. The vendor’s belief that e-beam alignment was in his work scope led to the vendor requesting removal of the radiation shield (physically necessary to perform e-beam coarse alignment). The required level of interaction between the responsible individual and the vendor was not clear. While there was a degree of communication during the initial visit (the first day of the job), there was no expectation that the vendor would check in with or contact the responsible individual after that. Poor communication between the responsible individual and the vendor during the planning process (specifically, whether or not the vendor was to perform e-beam alignment) thus contributed to the event. The responsible individual's expectation that the vendor does not

perform e-beam coarse alignment was not documented. The restriction on current setting was likewise not covered in vendor safety or job scope documentation. The tasks and individual accountability were not made clear to the person assigned as the LLNL escort. The escort was not clear on what her role was in terms of supporting/observing the vendor. This confusion may have contributed to her decision to approve the request for removal of the shielding. While there was confusion between the responsible individual and the escort on the escort's role, that breakdown in communication can be considered internal to one work group. The main communication breakdown between work groups in this event was between the vendor and the responsible individual, specifically in regards to the limit on the vendor's scope and responsibility.

All of the events described in this section contain elements of work definition contributing to the event. What varies from event-to-event is the specific work definition aspect(s) at issue, e.g., defining the scope of work (whether initial scope or scope changes), defining specific work processes, defining roles and responsibilities of workers and managers, or defining the technical circumstances under which the work to be performed.

3.2 ISMS Function 2 – Analyze Hazards

For ten of the 24 events, the causal analyses and the corrective actions suggest that the work hazards were not adequately analyzed prior to the start of work, Integrated Safety Management System Function 2. Nine of the events were reported to the DOE ORPS, and ranged in Significance Category (SC) from 3 to 4. One event was not reported to ORPS, but is included in the letter from LSO as an event to analyze in this report. Table 4 lists these ten events.

Table 4. Events where the cause was during ISMS Function 2 – Analyze the Hazards

Report Number	Categ. Date	Subject/Title
LLNL-2010-0004	2/12/2010	Machining of Legacy Part Leads to Indeterminate Beryllium Exposure of Machinist
LLNL-2010-0010	3/04/2010	Personal Air Monitoring Sample Above ACGIH TLV For Silica Dust in Building 581
LLNL-2010-0019	5/03/2010	Management Concern - Routine Machining Activities Result In Two Lacerations Within A 24-Hour Period
LLNL-2010-0021	5/24/2010	Continuous Air Monitor (CAM) Alarm Actuation in Building 332 Radiological Materials Area (RMA)
LLNL-2010-0022	5/25/2010	Unsafe Vehicle Operations Recurring At LLNL
LLNL-2010-0023	5/28/2010	Radiological Contamination Found In Building 194 Spectrometer
Not reported as an occurrence	7/13/2010 (Event Date)	Processing of a Uranium-Lithium item in B332 resulting in an unexpected exothermic reaction and need for improved material characterization

Report Number	Categ. Date	Subject/Title
LLNL-2010-0028	7/19/2010	Discovery of Energized Electrical Source During Equipment Installation At Building 391
LLNL-2010-0029	7/20/2010	Management Concern Regarding FXR Venting Operations at Building 801
LLNL-2010-0036	8/9/2010	Building 190 Tube Furnace Minor Electrical Shock

The first two events, LLNL-2010-0004 and LLNL-2010-0010, included workers exposed to materials considered by the Occupational Safety and Health Administration (OSHA) and/or the American Conference of Governmental Industrial Hygienists (ACGIH) to be hazardous in nature. In February, a worker unknowingly machined a beryllium part in a non-beryllium work area (Building 321A Main Shop), and was exposed to the airborne machining dust containing beryllium. In this event, the root cause was determined to be, "Management did not ensure that processes used to control Assembly X were implemented and did not ensure that processes used in Building 321C to identify the hazards of Assembly X were adequate. This resulted in misidentification of the hazards and classification and allowed Assembly X to be handled and machined without the necessary controls." In the second event, in March, workers were exposed to silica dust from a concrete-cutting operation in a constrained working area (a tent used to control the dust generated from the operation) – this exposure was above the ACGIH threshold limit value (TLV) for silica dust. In this event, the hazards associated with cutting concrete and generating silica dust were not adequately analyzed for the actual work environment in a tent, resulting in the selection and use of inadequate personal protective equipment.

In the next event in May, LLNL-2010-0019, management became concerned when two workers were injured while using powered tools within a 24-hour time period (workers were doing unrelated work: one was using a hand-held disc sander, and the other using a stationary metal lathe). Only the event with the hand-held sander has a cause related to Function 2, "Analyze Hazards," so it is discussed in this section; the work with the lathe is not. A worker, wearing safety glasses while using a hand-held disc sander to de-bur a large metal plate was struck in the face by the sander when it suddenly kicked-back after "catching an edge" on the work piece. The worker sustained a broken nose and two facial lacerations. In this instance the causal analysis suggests that the worker had "lost awareness" of the specific hazards of the work, instead focusing on other aspects of the work. It was stated in the causal analysis that the worker's training doesn't specifically cover the use of "hand-held" power tools, and that he was likely unaware of the specific kick-back hazard when using the tool in this application. This hazard is typical of this particular tool use (referenced in the tool's operators manual) and should have been anticipated, analyzed and controlled prior to the start of work.

Also in May, in event LLNL-2010-0021, a continuous air monitor alarm sounded when a can containing special nuclear material was opened in a Building 332 radiological materials area. The material was wrapped in foil and placed in two plastic bags inside the can, but the plastic bags (considered the primary containment barrier) had degraded over several years in storage, allowing the contents to release to the inside of the can. These materials were then released to the

radiological materials area when the can lid was opened, activating the alarm. This particular hazard (the failure of the plastic bags) was not one that was anticipated or analyzed prior to the start of work. It was assumed that the operation of opening this can would be similar to operations conducted in the past and in the absence of specific knowledge of the plastic bag degradation (unanalyzed hazard), the can was opened in the room, causing the alarm.

Another event in May, LLNL-2010-0022, is based on the filing of two earlier occurrence reports, LLNL-2009-0028 (June 2009) and LLNL-2010-0009 (February 2010). LLNL-2009-0028 was a vehicle fatality that was presumably caused by the vehicle operator releasing the parking brake lever while the transmission was in reverse gear, because (it is assumed) he could not easily locate the parking brake release lever and had to open the vehicle door and lean out of the vehicle to locate it. The worker was not wearing a seatbelt. In the second event, a worker again could not easily locate the parking brake lever and stepped out of the vehicle to locate and release the parking brake. He did this while the vehicle was in reverse gear, causing it to roll backward. Both of these vehicles were of similar make, and had similar parking brake release lever configurations. The cause of these events was that the hazards associated with not being familiar with or easily locating vehicle safety devices were not adequately analyzed by LLNL prior to allowing workers to operate these government vehicles.

Again in May, in event LLNL-2010-0023, a post-experiment radiological survey of a vacuum chamber attached to a spectrometer showed elevated levels of alpha and beta contamination. This experiment used an Am-242m source being counted under vacuum. The contamination was confined to the inside of the vacuum chamber but was unexpected. The cause was listed as a defective or failed part (the americium source). The degradation or failure of this part was not expected due to previous experience using this source and was not analyzed prior to the start of work.

In another event not reported to ORPS, in July, an unexpected exothermic reaction occurred when water was added to lithium-uranium material in a Building 332 glovebox. The material was thought to be ready for this work in that it had been calcined, according to the understood process. However, it was concluded that the material may not have been calcined sufficiently. The worker doing the work was not a lithium-uranium expert and believed that it was fully calcined. The hazard associated with adding water to this material, with its actual level of calcination, was not fully evaluated.

In July, in event LLNL-2010-0028, work was conducted on a 480-volt electrical panel that was planned to be locked/tagged out (LOTO) using a single-point LOTO process. In actuality, the panel was powered by more than one power source, and could not be isolated using a single-point LOTO process; a complex LOTO procedure (plan) was required, but not implemented. There were no injuries associated with this work; however, the potential existed for the worker to contact 480-volt power. The panel's actual configuration and associated hazards were not fully analyzed prior to the decision to utilize the single-point LOTO process.

Also in July, in event LLNL-2010-0029, a worker was exposed to an undetermined amount of sulfur hexafluoride (SF6) decomposition products when the Building 801 Flash X-ray (FXR)

accelerator was vented during scheduled work activities on the system. Changes had been made to the process – having two workers in the vicinity of the system doing unrelated work when only one was required for FXR system work, and changing the orientation of the system venting stream direction by using a different line than usual – horizontal instead of the usual vertical orientation. This allowed the second worker to be in-line with the venting line when the system was vented. These changes to the process were not fully analyzed prior to the start of work.

In August, in event LLNL-2010-0036, a worker received a minor electrical shock when he inserted a wire into a tube furnace opening. The furnace was plugged-in and had power, but the worker believed it to be "de-energized" because the cover was cool to the touch. The wire he inserted touched internal energized electrical equipment causing the minor shock. The furnace should have been de-energized ("unplugged" for this type of equipment) for this work activity, but was not. The hazards associated with inserting a wire into the furnace while energized were not analyzed in the work control documents.

All of the above events are examples of allowing work to progress in the absence of an adequate understanding and analysis of the hazards associated with the work. A proper and thorough understanding of the work hazards would have allowed for a complete and sufficient set of controls to be implemented prior to the start of work.

3.3 ISMS Function 3 – Develop Controls

Two of the 24 events were caused by errors related to the development of controls, Integrated Safety Management System Function 3. In each of these events the procedures did not adequately describe controls to prevent the occurrence. Table 5 lists these two events.

Table 5. Events where the cause was during ISMS Function 3 – Develop Controls

Report Number	Categ. Date	Subject/Title
LLNL-2010-0012	3/04/2010	Alpha Survey Meters Sent Offsite for Repair Returned Due to Contamination
LLNL-2010-0017	3/31/2010	Certified Unified Program Agency (CUPA) Inspection Notice of Violation At Site 300

In the first event, LLNL-2010-0012, two alpha survey meters with detectable radiation were sent to an offsite vendor for repair. LLNL shipped the meters without knowing that there were detectable levels of contamination on the meters or probes. The levels were below unrestricted-release limits but above the levels allowed in the contract with the vendor. The technician had conducted surveys according to the procedure, but the procedure did not describe the survey technique appropriate for meters that would be sent to the vendor for repair. The LLNL procedure used by the health and safety technician was intended for surveying equipment that

would be transferred between facilities or users. The procedure did not describe how to survey for radioactivity to meet the vendor's contractual acceptance requirements.

In the second event, LLNL-2010-0017, LLNL received a Notice of Violation because it failed to keep records of each shipment of universal waste (batteries) from Site 300. LLNL was using a procedure appropriate for Site 200 (the main Livermore Site), where the batteries are transported within the site boundary; however, this procedure was not adequate to meet the requirements to ship the universal waste (batteries) on public roads from Site 300.

In each event the work was defined and the hazards were known, but the controls that were implemented were not adequate to address the hazards. The causes of the events were latent errors in the procedures that were identified by the event.

3.4 ISMS Function 4 – Perform Work

In six of the 24 events the cause was during the performance of the work, Integrated Safety Management System Function 4. There were no causes identified in the preceding functions: when the work was defined, the hazards analyzed or the controls developed. Table 6 lists these six events, with five reported to the DOE ORPS and one reported to the DOE NTS as a nuclear safety noncompliance.

Table 6. Events where the cause was during ISMS Function 4 – Perform Work

Report Number	Categ. Date	Subject/Title
LLNL-2010-0011	3/4/2010	Work Control Process Management Concern
LLNL-2010-0016	3/31/2010	Unexpected Discharge of Flammable Gas While Drilling Into Gas Cylinder With a Hand Drill
NTS-LLNL-2010-0020	4/2/2010	Failure to Follow Evacuation Procedure upon Activation of Tritium Activity Monitor Alarm
LLNL-2010-0019	5/3/2010	Routine Machining Activities Result In Two Lacerations Within A 24-Hour Period
LLNL-2010-0032	7/26/2010	Failure To Follow Procedures Results In One Minute Unplanned Power Outages To Buildings 431, 439 and 442
LLNL-2010-0039	8/20/2010	Unauthorized Crossing of Construction Barrier In Building 131

Occurrence LLNL-2010-0011 included three instances of concern where the work performed was either not scheduled or not properly released: an opportune repair of a pipe (i.e., work performed on days when it was not scheduled or released); replacement of a light pole previously damaged by the subcontractor doing the replacement; relocation of a carport structure. In all three instances, the workers knew what had to be done, but due to the nature and location of the work they did not recognize the work as needing to be scheduled and released as part of the

LLNL work control process. Not following the work release process precludes the possibility of coordinating the potential impact of the work on other workers.

The event that occurred at the end of March 2010, LLNL-2010-0016, involved a worker who drilled into a properly labeled gas cylinder with a hand drill causing an unexpected discharge of flammable gas. The worker was assigned to clean up the shop area and self-initialed the activity, including the task to dispose of the cylinder, without a pre-job briefing. This worker required direct supervision of a journey level craft person, who was unavailable.

In April 2010 workers disregarded a 15-second tritium activity monitor (TAM) alarm and failed to evacuate and secure the room as required. The hazards and controls for the actuation of the alarm had already been established; it was the response of the workers that was in error.

In May 2010, in event LLNL-2010-0019, a worker received a one-inch laceration to his left ring finger while fabricating a part on a metal lathe. The work generated long, spiral chips that the worker was removing with a chip removal tool, when some of the chips wrapped around his finger causing the laceration. The worker let a large amount of long chips accumulate during the fabrication process. The control for the hazard of accumulating chips is to practice good chip management and to maintain awareness of the amount and condition of chips generated while machining. The control had been developed, but was not implemented during the work phase in this event.

In June of 2010, in event LLNL-2010-0032, workers failed to follow the approved high-voltage switching order process when a switch in closed position in the field, but thought to be in open position based on the supervisory control and data acquisition (SCADA) board, was moved to open position, causing a one-minute power outage to certain facilities. Although potential inconsistencies are known to exist between the SCADA board and the actual switch position in the field, the control developed for this hazard is for worker #1 to call out to worker #2 the actual switch position in the field to verify consistency with the SCADA board; however, this step was not performed prior to moving the switch because the brass plate indicating whether the switch was open or closed was unreadable.

In August 2010, in event LLNL-2010-0039, workers evaluated the risk associated with crossing a construction barrier (i.e. red tape with the words “DO NOT ENTER”) to visit their soon-to-be new offices, and crossed it based on their own evaluation. The construction hazard was correctly controlled by the barrier; however, the workers, who were instructed not to cross the barrier, crossed it.

In all of the events discussed above, the hazards were known and controls had been developed, but when the work was performed, an error occurred causing the event: work was not recognized as work that needed to go through the work control process; work was self-initiated in error, a safety alarm or barrier was ignored, good chip management was not implemented, or an important step in a defined process could not be implemented.

3.5 ISMS Function 5 – Obtain Feedback and Improve

There were no events caused by an error that first occurred in Integrated Safety Management System Function 5.

3.6 Conclusion from analysis of ISMS function

The 24 events included in this analysis were caused by errors in the first four of the five ISMS functions. The most frequent cause was errors in conduct of Function 2, to analyze the hazards. The second most frequent cause was errors occurring when defining the work, Function 1, followed by errors during the performance of work, Function 4. Interestingly, very few errors resulted in events, as a result of not developing controls, Function 3. This leads one to conclude that if improvements are made to how we define the work and how we analyze the hazards, LLNL may reduce the frequency or severity of events. Table 7 shows the number of events caused by errors in implementation of the Integrated Safety Management System Functions.

Table 7. Frequency of causes related to ISMS function

ISMS Function	Count
Function 1 – Define the Work	7
Function 2 – Analyze Hazards	10
Function 3 – Develop Controls	2
Function 4 – Perform Work	6
Function 5 – Obtain Feedback and Improve	0

Note: The cause count totals 25 because one occurrence (LLNL-2010-0019) included two events with independent causes in two ISMS functions.

To identify the specific causes that may need to be addressed within the functional areas, a relationship analysis was conducted to identify common causes. The results of this analysis are presented in the next section.

4.0 Common underlying causes

This relationship analysis is based on clustering events by causes that may be related and evaluating the set for common causes. The causes were reviewed and the events were binned based on their similarity.

4.1 Workers, supervisors, or experts understanding of the work was incomplete

The common-cause analysis determined that nine events can be associated with the common cause "Worker, Supervisors, or Experts Understanding of Work was Incomplete." Eight of these events were reported to ORPS, one was determined not to be ORPS-reportable. Table 8 lists these nine events.

Table 8. Events where the cause was related to incomplete understanding of the work

Report Number	Categ. Date	Subject/Title
LLNL-2010-0004	2/12/2010	Machining of Legacy Part Leads to Indeterminate Beryllium Exposure of Machinist
LLNL-2010-0006	2/19/2010	Energized Electrical Conductor Cut Without Energy Isolation in Building 391
LLNL-2010-0010	3/04/2010	Personal Air Monitoring Sample above ACGIH TLV for Silica Dust in Building 581
LLNL-2010-0014	3/26/2010	Management Concern - Actuation of Building 332 Legacy Alarm System
LLNL-2010-0021	5/24/2010	Continuous Air Monitor (CAM) Alarm Actuation in Building 332 Radiological Materials Area (RMA)
LLNL-2010-0023	5/28/2010	Radiological Contamination Found in Building 194 Vacuum Chamber Attached to Spectrometer
Not reported as an occurrence	7/13/2010 (Event Date)	Chemical Reaction Inside Glovebox (B332-U-Li Event)
LLNL-2010-0031	7/23/2010	Building 174 Work Control Concerns (Workers working without required controls in Building 174)
LLNL-2010-0037	8/12/2010	Unexpected Discovery of A Pressurized Hydraulic Oil Line During Fire Sprinkler Upgrade In Building 311

The common-cause analysis divided this cause group into two sub-groups: one for events in which workers (i.e., the individuals actually performing the work activity) lacked complete understanding, the other for events in which the issue was supervisors or experts (e.g., those

"management" individuals doing work planning, supervising the work, or otherwise providing expert information that influenced the conduct of work) lacking complete understanding.

The analysis determined that the following events fall primarily into the "worker" sub-group:

In event LLNL-2010-0014, the workers believed ("understood") that the wires they were transferring from the old terminal block to the new one were all associated with the paging system on which they were working. Based on this understanding, they allowed themselves to continue work without pause even though two of the wires -- the two connected to legacy sound generator of which they were unaware -- did not appear on the drawings from which they were working.

In event LLNL-2010-0021, the workers understood that the work activity would be similar to prior operations that they had repeatedly completed successfully. This incomplete understanding led the workers to not anticipate the age-related failure of the primary containment barrier (i.e., the plastic bags) in the container. The workers' incomplete understanding was exacerbated by "management" similarly failing to anticipate this failure and develop appropriate controls (e.g., requiring older containers to be opened in a glovebox regardless of their expected condition).

In event LLNL-2010-0023, as in event LLNL-2010-0021, the workers "understood" that the work activity would be similar to prior operations that they had repeatedly completed successfully. Successful experience in prior experiments led workers to believe a Contamination Area around the B194 spectrometer was not necessary for the subject experiment. As for event LLNL-2010-0021, the workers' incomplete understanding was exacerbated by work planners ("management") failing to anticipate -- and develop appropriate controls for mitigating the hazards of -- the americium source wire failure that created the contamination in event LLNL-2010-0023.

In event LLNL-2010-0031, worker understanding was incomplete in that the plumber and plumber supervisor incorrectly believed they had exercised sufficient due diligence to verify that the subject pipeline was for fire sprinkler water and that the pipeline had been depressurized and drained of water. This understanding was supported in part by prior experience that black-steel two-inch-diameter piping carried only firewater. As in the LLNL-2010-0014 event, the workers were sufficiently confident of their understanding that they proceeded with work even though they lacked drawings (in this case, showing pipeline locations and contents in the area of the building where they were working) that upon examination might have caused them to pause their work.

The analysis determined that the following events fall primarily into the "management" sub-group:

In event LLNL-2010-0004, management understanding was incomplete in that the root cause of the event was that "Management did not ensure that processes used to control Assembly X [the beryllium part at issue] were implemented and did not ensure that processes used in Building 321C to identify the hazards of Assembly X were adequate. This resulted in misidentification of

the hazards and classification and allowed Assembly X to be handled and machined without the necessary controls." The causal analysis determined that neither the nuclear weapons engineering coordinator, who selected parts for processing after determining they no longer had programmatic value and who was also available as an expert to provide information relating to sensitive, classified, or hazardous aspects of the parts, nor the Building 321C work planner, who was responsible for defining the machining process to be used, received the necessary briefing to understand the Building 131 de-inventory process. It is of interest to note that the machinist in this event had sufficient understanding of materials and of machining processes to recognize that the part on which he was working did not respond in a manner consistent with how it was identified, and that the worker's retrospective technical inquisitiveness led to the discovery that the part was actually beryllium.

In event 2010-0006, the workers' understanding of the work was incomplete in that, as noted in the NIF management report "there was a 'folklore' that all electrical circuits were safe, e.g., everything was disconnected or 'air-gapped'" during the earlier two stages of the project. According to the management report, this folklore was passed from managers to workers leading to a general understand that everything was safe (i.e., de-energized) and that LOTO was therefore not necessary to perform the demolition work.

In event LLNL-2010-0010, management believed that the OSHA-recommended controls for silica dust were sufficient for the identified scope of work. The controls recommended by OSHA (i.e., wet methods and half-mask respirators) are in fact not sufficient for all silica-generating activities. Consequently, the work planning process did not adequately analyze the hazards of performing the sawing work in a tent, resulting in less-than-adequate controls (e.g., ventilation, respirators) being identified to mitigate those hazards.

In event 2010-0031, management understanding was incomplete in that the work requestors ("management") failed to recognize that the expanded scope of work created additional hazards that were not communicated to the work planners.

In the Building 332 U-Li item event (no Occurrence Report), the fissile material handler, although not a lithium expert, believed as a trained chemist that he had sufficient understanding to proceed working with the subject item. The fissile material handler believed the item had been fully calcined to avoid adverse interactions with water. Nevertheless, as a precautionary measure he made what he understood to be a sufficient test for material compatibility, at which time the unanticipated reaction occurred. The NMTP causal analysis report for this event concluded that this event was a system-induced error, but recommended that guidance from a lithium subject matter expert be sought to prevent future recurrence and that methods of testing for material compatibility be evaluated. This recommendation suggests that the event is viewed more as an issue of work planning (i.e., "management") and less as an issue of incomplete understanding on the part of the individual worker.

In conclusion, all of these events show evidence of incomplete understanding of the work by workers, supervisors, or experts. It is important to note, however, that few events (LLNL-2010-0010 being one) are uniquely a case of "worker" or "management" lack of

understanding. Most events have elements of both, usually with incomplete understanding by workers being exacerbated by incomplete understanding on the part of management and/or work planners. Workers and managers relying on their past experience of similar but not exact work to develop the scope and hazards rather than doing a systematic and through review of the work may not be successful.

4.2 Incomplete, unclear or inaccurate documents directing the work

The common-cause analysis determined that eight events are associated with incomplete, unclear or inaccurate documents or directions directing the work. Events included in this cause group are those that in some manner can be attributed to problematic work control documents (e.g., work planning documents that provide insufficient or incorrect guidance) or other information provided to workers to facilitate performance of the work. All eight events were reported to ORPS. Table 9 lists these eight events.

Table 9. Events where the cause was related to incomplete, unclear or inaccurate documents

Report Number	Categ. Date	Subject/Title
LLNL-2010-0004	2/12/2010	Machining of Legacy Part Leads to Indeterminate Beryllium Exposure of Machinist
LLNL-2010-0006	2/19/2010	Energized Electrical Conductor Cut Without Energy Isolation in Building 391
LLNL-2010-0014	3/26/2010	Management Concern - Actuation of Building 332 Legacy Alarm System
LLNL-2010-0015	3/29/2010	Building 332 Safety Basis Violation Relative to Functional Testing of the Mobile Weapons Platform
LLNL-2010-0032	7/26/2010	Failure to Follow Procedures Results in One Minute Unplanned Power Outages to Buildings 431, 439 and 442
LLNL-2010-0036	8/09/2010	Building 190 Tube Furnace Minor Electrical Shock
LLNL-2010-0037	8/12/2010	Unexpected Discovery Of A Pressurized Hydraulic Oil Line During Fire Sprinkler Upgrade In Building 311
LLNL-2010-0038	8/16/2010	Dynamic Transmission Electron Microscope Improper Shielding Removal in Building 235

In event LLNL-2010-0004, the work documents were problematic in that the bag and shipping documents for the beryllium part had been separated from the part itself, resulting in the part identity being lost. The causal analysis for this event identified the following contributing causes that can be considered further evidence of work documents (or other information used in performing the work) contributing to the event. The legacy part identification process relied on non-primary documents without confirmation or supporting information from the original owner or programmatic users. This incomplete documentation contributed to the identity of the part being lost. The causal analysis additionally noted that work acceptance criteria for the Building

321 Complex shops relied on non-primary sources for legacy part identification. Consequently, the job order associated with the part did not have a positive link to the assembly (no part number). Inaccuracies in Controlled Materials Accountability and Tracking System (COMATS) records and inconsistent data entry practices facilitated loss of control of the item. COMATS confused the subject part with another, no-longer-existing part and incorrectly listed the location of that part as the location of subject part. In addition, the 2002 Computer System for Manufacturing, Orders, and Services (COSMOS) system used non-conservative default terms when entering part information. As noted in the causal analysis, the default entry for a 2002 COSMOS work entry, which is used by the Engineering shops to generate routing paperwork, was “UNCLASSIFIED” and “INERT.” Consequently, no positive action was required by the person entering data for the work to change its recorded status from a less-benign to a more-benign one in terms of either safety or security.

In event LLNL-2010-0006, the work documents were problematic in that as noted in the causal analysis, "The work plan for the demolition work in the Nova Target Bay did not adequately consider potential electrical hazards in the area." As further noted, the work documents also did not clearly describe roles and responsibilities in that the management chain defined in the authorizing IWS is significantly different from the management chain customarily used by the NIF Project and Construction Management Group. While the customary NIF management chain assigns separate responsibilities to the project management and to the construction management branches depending on the work being performed, the IWS chain for the subject work utilized personnel from both branches in a single line. As a result, there was not a common understanding of the roles and responsibilities for managing the work. The non-LLNS work managers in the IWS management chain lacked understanding of their responsibilities and authority to direct the work activities of LLNS employees. The authorizing individual and responsible individual were LLNS employees, the alternate responsible individual was an IAP subcontract employee, the construction manager was a Jacobs subcontract employee, and the Daily Work Team Leaders (DWTLs) and workers were LLNS employees. The causal analysis observed that, for example, “the construction manager and the alternate responsible individual did not appear to clearly understand that they had the responsibility and authority to direct the work of the LLNS technicians.”

In event LLNL-2010-0014, the work documents were problematic in that, the apparent cause of the event was "Poor documentation and legacy wires," reference to the fact that drawings associated with the work neither indicated the existence of the legacy sound generator nor the "wires 16 and 17" that were connected to the sound generator.

In event LLNL-2010-0015, the work documents were problematic in that the LSO-approved locations for MWP testing, specified in the conditions of approval for the Superblock safety basis, were not flowed down to the Facility Safety Plan and Security Orders directing the work. The work documents therefore did not inform the NMTP safety & work control manager, who based work scoping for testing of the MWP on the Facility Safety Plan and Security Orders, about the existence of the LSO conditions of approval. This lack of awareness led to his designating test locations that had not been approved by LSO and thus violated the LSO-approved Superblock safety basis.

In event LLNL-2010-0032, the work documents were problematic in that the high-voltage switching orders did not include a step requiring that before giving a command to open or close any switchable device (e.g., circuit breaker, load-sectionalizing switch, disconnect switch), the worker verify that the position of the device shown on the Map Board matched the position shown on the switching order. The high-voltage switching orders also did not provide guidance on actions to be taken in the event that switch position in the field could not be determined (e.g., due to illegible labels).

In event LLNL-2010-0036, the work documents (e.g., the IWS) did not communicate the expectation of LOTO (or the need to unplug a piece of equipment when working on it, which is an exemption from formal LOTO) for the work activity. The IWS also did not include a discussion of the subject electrical hazard and the associated controls (i.e., unplugging of equipment), neither in the body of the IWS or as an attachment.

In event LLNL-2010-0037, the work documents did not identify all of the hazards for the work (including the identical unlabeled pipelines running parallel and adjacent to each other above the ceiling). The drawing provided for the project showed only the west half of the hallway and the stairwell where the sprinkler head was to be added. The drawing indicated the diameter of the source pipeline as 1.5 inches; upon inspection, the pipeline diameter was found to be 1.25 inches, with insufficient capacity to accept a fourth sprinkler head. This discovery led the plumbers to seek an alternate source pipeline, i.e., the existing 2-inch-diameter black steel water pipeline in the hallway above the ceiling. This pipeline and the adjacent hydraulic-oil pipeline were not in the drawing provided to the workers.

In event LLNL-2010-0038, the work documents (e.g., the IWS) did not explicitly define the vendor work scope, particularly whether or not he was to perform coarse alignment of the e-beam, nor did they clarify expectations and controls for the work. The belief that e-beam alignment was in his work scope led the vendor to request removal of the radiation shield (as noted in the IWS, physically necessary to perform e-beam coarse alignment and allowed if responsible individual permission is first obtained). The documents also did not clearly define the roles and responsibilities of the LLNL escort, such as (1) the role that the escort plays for a given work activity (e.g., merely accompanying vendor personnel and protecting them from site hazards; or providing technical guidance and/or direction; or actually assisting in performance of work); (2) how this role is communicated to the escort and to the vendor, including associated escort authority consistent with responsibilities; and (3) what qualifications are required for an escort based on the escort's role and responsibilities for the work activity. As noted in the event causal analysis, "The escort was not clear on what her role was in terms of supporting/observing the vendor. This confusion may have contributed to her decision to approve the request for removal of the shielding."

All of these events contained elements of incomplete, unclear or inaccurate directions or documents directing the work as a cause of the event. What varies from event-to-event is how this incomplete, unclear or inaccurate direction manifests itself, e.g., as lack of clarity in defining the scope of work, lack of clarity in defining specific work processes, lack of specificity in

describing roles and responsibilities or workers and managers, or lack of technical information that allows the work to be performed in the manner intended.

4.3 Ineffective communication

There were four events with a common cause of ineffective communication: the unexpected discharge of flammable gas while drilling into a gas cylinder; discovery of an energized electrical source during equipment installation; dynamic transmission electron microscope improper shielding removal; unauthorized crossing of a construction barrier. These events are listed in Table 10.

Table 10. Events where the cause was related to ineffective communication

Report Number	Categ. Date	Subject/Title
LLNL-2010-0016	3/31/2010	Unexpected Discharge of Flammable Gas While Drilling Into Gas Cylinder With a Hand Drill
LLNL-2010-0028	7/19/2010	Discovery of Energized Electrical Source During Equipment Installation At Building 391
LLNL-2010-0038	8/16/2010	Dynamic Transmission Electron Microscope Improper Shielding Removal in Building 235
LLNL-2010-0039	8/20/2010	Unauthorized Crossing of Construction Barrier In Building 131

In two of the events, LLNL-2010-0016 and LLNL-2010-0039, the ineffective communication was between management and the worker(s). The worker who drilled into a gas cylinder with a hand drill did not receive a pre-job briefing from the supervisor communicating the limits of the work to be performed and the associated hazards. Without this communication, work was performed where the hazards were not understood by the worker. The unauthorized workers who crossed a construction barrier, even though the facility manager directed them not to cross the barrier, took this direction as playful banter. The communication between the facility manager and the workers was ineffective since the workers proceeded to cross the construction barrier after they were told not to cross the barrier.

In event LLNL-2010-0028, where an energized electrical source was discovered during equipment installation there were a number of instances of ineffective communication; however, there was a point in the planning of the work that if experts had communicated directly with each other about the proposed work process, this event could have been avoided. After it had been decided that a complex Lock Out/Tag Out (LOTO) procedure was required for the work to be performed, an electrical subject matter expert sent a low voltage electrician to discuss terms with the high voltage electrician that would make a single point LOTO possible. Based on miscommunication between the low and high voltage electricians it was incorrectly determined that single point LOTO was the acceptable control. Had the electrical subject matter expert and

the high voltage electrician directly discussed these terms, a complex LOTO procedure would have been used as appropriate and as initially thought.

In the last event, LLNL-2010-0038, the responsible individual and the vendor did not communicate effectively regarding the vendor's limitations associated with working on the dynamic transmission electron microscope. The responsible individual's expectation was that coarse e-beam alignment is an LLNL activity and only a limited number of LLNL personnel can perform this activity, the activity that the vendor performed. However, neither the vendor nor the escort had full knowledge of any restrictions or limitations of the vendor's work scope, nor were any restrictions/limitations discussed with either the vendor or the escort. Had the responsible individual understood the vendors intentions the RI could have communicated any restrictions/limitations on activities related to the dynamic transmission electron microscope, such as performing e-beam coarse alignment and the shield would not have been improperly removed allowing x-rays to exit the column.

All of the events discussed above displayed instances of ineffective communication: in two events limits/restrictions of the work to perform were not communicated in a pre-job briefing or by other means; workers who were told not to cross a safety barrier did it anyways; experts failed to communicate directly about the proper control to use to eliminate a hazard.

4.4 Workers accepting the risk of their actions

There were four events with a common cause of workers understanding the risk and requirements for the work and accepting the risk of their actions: unauthorized crossing of a construction barrier; disregard of a tritium activity monitor alarm; hand laceration while fabricating a part on a lathe; and the discovery of an energized electrical source during an equipment installation. The concern with workers accepting the risk of their actions is that they are not authorized to accept these risks. These events are listed in Table 11.

Table 11. Events where the cause was related to workers accepting the risk of their actions

Report Number	Categ. Date	Subject/Title
NTS-LLNL-2010-0020	4/2/2010	Failure to Follow Evacuation Procedure upon Activation of Tritium Activity Monitor Alarm
LLNL-2010-0019	5/03/2010	Management Concern - Routine Machining Activities Result In Two Lacerations Within A 24-Hour Period
LLNL-2010-0028	7/19/2010	Discovery of Energized Electrical Source During Equipment Installation At Building 391
LLNL-2010-0039	8/20/2010	Unauthorized Crossing of Construction Barrier In Building 131

For two of the events, the ongoing disregard of a tritium activity monitor (TAM) alarm (LLNL-2010-0020) and the unauthorized crossing of a construction barrier (LLNL-2010-0039), it was

noted in the respective causal analyses that the workers performed an instantaneous evaluation of the risk and decided to proceed with actions that went against Laboratory requirements. In the first event, both of the unauthorized workers who crossed the red tape with the words “DO NOT ENTER” evaluated the risk of doing so; one based the decision to cross the barrier on his/her past experience as a carpenter and the other thought entering the alcove only a couple feet, the open area around the construction area, was safe since all the work was occurring past the alcove. In the second event, experienced workers well trained in how to response to a TAM alarm, disregarded the alarm because they believed it was not possible for tritium to cause an alarm as short as 15 seconds, and therefore determined that it must have been spurious – they immediately evaluated the risk, and proceeded with actions counter to their procedures. Regardless of why the alarm sounded, workers were required to evacuate the facility but did not.

In event LLNL-2010-0019, the worker was fabricating a part on a lathe, which was producing long chips that caught on others in the chip tray, swinging them up to contact and lacerate the worker’s hand. The control established to avoid injury is to practice good chip management and to maintain awareness of the amount and condition of chips generated while machining. In this event the worker accepted the risk of letting the large amount of long chips accumulate, and continued to work.

In the last event, LLNL-2010-0039, the worker performing Lock Out/Tag Out (LOTO) during the process of installing equipment was following the prescribed process. Appropriate personal protective equipment was donned, the LOTO lock and tag was applied on the automatic transfer switch, the Fluke Meter was utilized to do a zero energy check on the electrical panel, a known electrical source was checked to ensure the meter was working, the panel was checked for zero energy, but the final step, of rechecking a known electrical source to ensure the meter was still functioning correctly, was not performed, even though this is a requirement and a standard practice used at LLNL. The qualified electrician perceived the work to be without risk in order to skip the final step of the LOTO process.

In all the events discussed above, workers understood the requirements for the work, but accepted the risk of their actions: crossing barrier tape that read, “DO NOT ENTER;” trained workers disregard of a 15-second tritium activity monitor alarm; trained worker not practicing good chip management when fabricating a part on a lathe; trained worker who skipped the last required step in the LOTO process.

4.5 WAL-A work not adequately reviewed

There were three events with a common cause of workers and supervisors spending less effort ensuring that they have a clear understanding of work scope and the associated hazard/controls of work authorization level (WAL) A work: the unexpected discharge of flammable gas while drilling into a gas cylinder; laceration to a worker when a hand-held sander kicked back while sanding an interior angle; unsafe vehicle operations recurring at LLNL. These events are listed in Table 12.

Table 12. Events where the cause was related to WAL-A work not adequately reviewed

Report Number	Categ. Date	Subject/Title
LLNL-2010-0016	3/31/2010	Unexpected Discharge of Flammable Gas While Drilling Into Gas Cylinder With a Hand Drill
LLNL-2010-0019	5/03/2010	Management Concern - Routine Machining Activities Result In Two Lacerations Within A 24-Hour Period
LLNL-2010-0022	5/25/2010	Unsafe Vehicle Operations Recurring At LLNL

In event LLNL-2010-0016 where the worker drilled into a gas cylinder, the worker did not have a clear understanding of the limits associated with WAL-A work. This worker was suppose to be performing supervised WAL-A work, but ended up conducting WAL-B work, drilling into a gas cylinder. Although the worker's supervisor was unavailable to provide adequate supervision that day, the worker self-initiated the task of cleaning out a facility without a pre-job briefing to discuss the work scope, hazards identification and controls needed to perform the task safely. Less effort was made to ensure the worker had a clear understanding of the work scope of the WAL-A work he was suppose to perform, since the worker ended up performing WAL-B work.

In the other two events, LLNL-2010-0019 and LLNL-2010-0022, the workers did not have a clear understanding of the hazards/controls associated with the work. The journeyman worker who used a hand-held sander to sand an interior angle, which is identified as WAL A work, was not aware of the potential kick back hazard associated with that particular tool in this particular application. In the other event a worker exited a running vehicle in gear to locate and release the emergency break because he was unfamiliar with the operating controls of the government vehicle. In both cases less effort was spent on ensuring the workers had a clear understanding of the associated hazards/controls of the WAL-A work: the kick back potential of the sander and potential for errors when employees are operating unfamiliar government vehicles.

In all three events the workers were supposed to perform WAL-A work and in one event the worker ended up performing WAL-B work. Regardless of the WAL of work actually performed, less effort was spent on ensuring that the workers had a clear understanding of the work scope and the associated hazards/controls related to the WAL-A work that was performed or that was suppose to be performed.

4.6 Work scope/work configuration changes and change not analyzed

There were two events where changes to the work process/configuration occurred, and those changes were not analyzed for additional hazards, or there was a change in the work scope after the start of work and those changes were not analyzed. These two events are listed in Table 13, below.

Table 13. Events where the cause was related to changes in the work that were not analyzed

Report Number	Categ. Date	Subject/Title
LLNL-2010-0029	7/20/2010	Management Concern Regarding FXR Venting Operations at Building 801
LLNL-2010-0037	8/12/2010	Unexpected Discovery of A Pressurized Hydraulic Oil Line During Fire Sprinkler Upgrade In Building 311

In July, in event LLNL-2010-0029, a worker was exposed to an undetermined amount of sulfur hexafluoride (SF6) decomposition products when the FXR accelerator in Building 801 was vented during scheduled routine work activities on the system. Changes were made to the work process/configuration – having two workers in the vicinity of the system doing unrelated work when only one was required and present for FXR system work, and, changing the orientation of the system venting stream direction by using a different venting line/path than usual – the horizontal instrumentation line was used instead of the usual vertically-oriented main line of the system. This allowed the worker not involved in the venting operation to be in the vicinity of the FXR worker and positioned in-line with the horizontal line now used when the FXR worker vented the system. The instrumentation line was of smaller diameter than the main line, and this caused the gas to vent at a higher velocity than usual, and caused residue from inside the line to be propelled out, into the face of the second worker. The contents of the line residue were analyzed later and found to be stainless steel; however, it is not certain to what degree the worker was exposed to Sulferhexafluoride (SF6) decomposition products when the system was first vented. The changes made to the work process were not analyzed prior to the start of work, so the proper controls to prevent an exposure were not implemented.

In the second event listed above, LLNL-2010-0037, LLNL plumbers were working in Building 311, upgrading the fire sprinkler system, when they removed a line coupling from 2-inch black pipe they believed was a de-pressurized fire sprinkler system water line – the line turned out to be the building's elevator system pressurized hydraulic line. Before they could re-tighten the coupling and stop the leak of hydraulic fluid, approximately three gallons or fluid sprayed onto the workers and the surrounding area, under pressure potentially as high as 430 psig. 911 was called and the fire department responded and the workers were taken for first aid and decontamination at LLNL Health Services. There were no injuries associated with this event. One of the causes of this event was determined to be that during the work scoping process, not all of the facility's piping was depicted on the work documents, and the hazards associated with the work were not fully analyzed (this is discussed fully in the Common Cause Section, "Incomplete, Unclear or Inaccurate Documents Directing the Work"). When the workers first encountered a different system configuration than what was depicted on their documents or what they expected they would find based upon previous experience with these types of systems, a work scope change was introduced. They consulted management to determine a proper course of action, however, the changes they encountered were not analyzed fully by the work planners, and a decision was made to proceed with the work, unaware that the new course of action would have them working on a pressurized hydraulic line. They were confronted with two identical,

unlabeled sections of 2-inch black pipe, and they believed that both of them belonged to the de-pressurized fire system. They were never aware of the possibility that the pipe they were working on could belong to another system – in this case the elevator's hydraulic system. The full extent of the work scope change was not analyzed fully by the work planners, and the workers were unaware of the hazards associated with the new work scope.

In both of these events, it is clear that changes introduced into the work process and changes in the work scope after the start of work allowed workers to encounter hazards that were not anticipated or analyzed when the work was planned. When workers identify that the scope of work has changed or when they find a hazard that hasn't been analyzed or adequately controlled after the work has been authorized and started, the process should be restarted. Failure to reenter the ISMS process after errors are identified and changes are made in the work results in continued errors.

4.7 Managers not adequately verifying or reinforcing process changes

Two events were caused by workers not following the new work control process that managers thought had been implemented. In each of these events, the managers had directed a change in the work planning and control processes; however, they had not adequately verified or reinforced implementation of the new work control process in the field. Table 14 lists these events.

Table 14. Events where the cause was related to managers not adequately verifying or reinforcing process changes

Report Number	Categ. Date	Subject/Title
Not reported as an occurrence	1/27/2010	Processing of an unapproved part in B851
LLNL-2010-0011	3/04/2010	Work Control Process Management Concern

The first event, handling of the unapproved high explosive part at Building 851, was caused by workers not following the new work control process. WCI managers had directed a change in the work planning and control processes; however, they had not adequately verified or reinforced implementation of the new work control process in the field. In this event, an explosive part was processed (used as the subject of a liquid abrasive cutter operation) on the firing table in Building 851 at Site 300. A work permit ("script") and other reference documents were prepared but not used during the work, which allowed an unapproved part to be processed on the table. Managers had commissioned a self-assessment of the implementation of the "script," and this self-assessment indicated the scripts were being prepared. The causal analysis determined, however, that the workers had not "bought into" the corrective action from a previous event (the High Explosive Drop) as completely as their managers understood; the managers did not take sufficient actions to ensure the expected change was implemented.

Occurrence 2010-0011, “Work Control Process Management Concern,” addresses three events that together concerned LLNL management.

1. During the week of February 8, 2010, on work order #PW00370717 at Building 471, to "Install a Water softener on City Water line," work was performed by the MUSD Pipe Shop and a subcontractor on days when it was not scheduled nor released. The pipe-fitter noticed that a pipe outside of a building that he had worked on the day before was leaking so he tightened the connection without notifying the facility manager or obtaining a work release.
2. During the weekend of February 13, 2010, a construction subcontractor relocated a carport structure from the Building 619 yard to the Trailer 5125 yard area. Neither a work order nor authorization to move the structure was approved by the authorized individual. Thus, no work release was obtained from the appropriate FMD work release center before this move commenced.
3. During the weekend of February 20, 2010, a construction subcontractor was involved with the replacement installation of a light pole that they had damaged while working on the north side of Building 341. The authorizing individual for the subcontractor was aware of the work taking place and had authorized the work request through work order #PW00369743, but did not realize the work needed to be authorized through the appropriate Facility Management Department (FMD) work release center. Thus, FMD personnel were unaware that the work had commenced and been completed over the weekend.

The cause of the three situations reported in this occurrence was that workers did not have a clear understanding of their roles and responsibilities in the implementation of work control processes. LLNL (F&I) management had changed the process for coordinating and releasing work and had developed and delivered training, but implementation had not been reinforced in the field. In response to the gap identified by these events, the training class was revised to specifically address work conducted outside of facilities.

In all of these events, the change to the work process that managers had instituted was not fully implemented. Management had defined the new processes, trained workers and conducted an assessment to verify implementation. Managers were not aware, however, that workers were encountering situations that did not fit their understanding of the training and were making decisions contrary to expectations. In the work setting at Site 300, workers did not see the new process as adding value so the implementation was only superficial. The workers were going through the motions of implementing the process, but not gaining benefit from it. The new process was being implemented to prevent recurrence of a serious event at S-300 and within the same organization.

4.8 Incorrect procedure used

There were two events with a common cause of the incorrect procedure being used: alpha survey meters sent offsite for repair with detectable radiation, and a Certified Unified Program Agency Inspection Notice of Violation where LLNL failed to keep records of each shipment of universal waste. These events are listed in Table 15.

Table 15. Events where the cause was incorrect procedure used

Report Number	Categ. Date	Subject/Title
LLNL-2010-0012	3/04/2010	Alpha Survey Meters Sent Offsite for Repair with Detectable Radiation
LLNL-2010-0017	3/31/2010	Certified Unified Program Agency (CUPA) Inspection Notice of Violation at Site 300

In the first event, LLNL-2010-0012, LLNL sent two alpha survey meters with detectable radiation to an offsite vendor for repair. LLNL shipped the meters without knowing that there were detectable levels of contamination on the meters or probes. The levels were below unrestricted-release limits but above the levels allowed in the contract with the vendor. The technician conducted surveys according to a procedure for transferring meters onsite between facilities or between uses; however, the procedure was not appropriate for surveying meters that would be sent to this vendor for repair. LLNL had not developed a procedure to meet the vendor's contractual requirements.

In the second event, LLNL-2010-0017, LLNL received a Notice of Violation because it failed to keep records of each shipment of universal waste (batteries) from Site 300. LLNL was using a procedure appropriate for Site 200 (Livermore Site), where the batteries are shipped within the site boundary; however, this procedure was not adequate to meet the requirements to ship the batteries on public roads from S-300.

In each event, a procedure was used that would have been correct in the appropriate situation, however; in each event the procedure was not the correct one for the task.

4.9 Material accepted for work was different than anticipated

There were two events with a common cause of material accepted for work that was different than anticipated: machining of a legacy part leads to indeterminate beryllium exposure of a machinist; processing of a Uranium-Lithium item in B332 resulting in an unexpected exothermic reaction and the need for improved material characterization. These events are listed in Table 16.

Table 16. Events where the cause was material accepted for work that was different than anticipated

Report Number	Categ. Date	Subject/Title
LLNL-2010-0004	2/12/2010	Machining of Legacy Part Leads to Indeterminate Beryllium Exposure of Machinist
Not reported as an occurrence	7/13/2010 (Event Date)	Processing of a Uranium-Lithium item in B332 resulting in an unexpected exothermic reaction and need for improved material characterization

In this first event, LLNL-2010-0004, a machinist received a work assignment from a work planner to demilitarize a legacy part referred to as Assembly X, in support of the legacy reduction project for Nuclear Weapons Engineering. When the task was assigned to the machinist, the part was thought to be tantalum and the inspection work order found co-located with Assembly X indicated that this part was "UNCLASSIFIED" and "INERT." The machinist proceeded to demilitarize Assembly X as if it were tantalum. When the machinist brought the unusual machining behavior of the part to the attention of the planner, the planner immediately recognized the part's behavior as characteristic of machining either beryllium or cast iron, not tantalum as originally thought.

In the second event, a fissile material handler added a small amount of water to a lithium-uranium sample for oxide washing to remove soluble contaminants. The material was thought to have been fully calcined; however, the exothermic chemical reaction that ensued when water was added to the sample revealed that the material had not been fully calcined. Further analysis indicated the presence of lithium oxide and uranium oxide in the material, an indication that the calcining process may not have been as effective as originally believed.

In both of the events discussed above, the material accepted for work was different than anticipated. Assembly X was thought to be tantalum, but was later identified as a classified part with beryllium as a component. The lithium-uranium material was thought to have been fully calcined prior to the oxide washing process, but was later determined to not have been fully calcined and to contain lithium oxide and uranium oxide. Acceptance criteria had not been established in these two cases.

4.10 Causes that are singular in nature

There were three events in this section. These events have at least one cause that is not shared with any common causes of the events discussed elsewhere in this report, however, they still represent failures in the work control process. These events are listed below, in Table 17.

Table 17. Events where a cause was not related to any other causes

Report Number	Categ. Date	Subject/Title
Not reported as an occurrence	1/27/2010	Processing of an unapproved part in B851
NTS-LLNL-2010-0020	4/2/2010	Failure to Follow Evacuation Procedure upon Activation of Tritium Activity Monitor Alarm
LLNL-2010-0031	7/23/2010	Building 174 Work Control Concerns

On January 27, 2010, an explosive part was processed (used as the subject of a liquid abrasive cutter operation) on the firing table in Building 851, at Site 300. The operation was guided by requirements in the FSP, however, it was determined that one of the causes was that the supervisors and workers did not really understand their responsibilities according to the facility safety plan and thus, they were not implemented during the course of work. This particular cause is not shared by the other events we analyzed. Some safety requirements and roles in the FSP were not implemented due to a lack of understanding by the workers. Not following the guidance directing work in the FSP due to a lack of understanding can have serious results in this facility.

In the second event, in April 2010, personnel were working in Building 298 when a tritium activity monitor alarm sounded for approximately 15 seconds and then fell silent. The workers, which included both experienced and less-experienced workers, did not immediately evacuate and isolate the room as required. Instead, they continued to work – in this case, looking for the possible abnormal source of the tritium in the room that might have caused the tritium activity monitor alarm. The Health and Safety technician responded to the room and was helping to find the source and to also coordinate bioassay sampling of the workers in the room. The Health Physicist also responded. Eventually, all the workers left for the day, and management secured the room by locking it and posting signs to prevent entry. The concern was that the proper response to the tritium activity monitor alarm was never initiated by the workers in this room. One of the causes for this event was that the less-experienced workers in this room were following the lead of the more experienced workers in not evacuating when the alarm sounded – they did not wish to seem unknowledgeable or “foolish” in their actions, compared to those of more experienced workers. This particular cause is not shared by the other events we analyzed. Additionally, all workers involved in this event were caught-up in the inertia created by first not evacuating, and then in the hunt to find the source of the alarm. This particular cause is also not shared by the other events we analyzed. The net effect of these actions allowed for a deviation in following the work control requirements, in this case, not evacuating the room when required to do so.

In the last event in this section, LLNL-2010-0031, maintenance work was paused in Building 174 due to concerns with worker qualification and training. The work scope had increased to include work that was not authorized by the current work permit, and some workers were not qualified or trained to conduct some of the work. These causes were discussed in earlier common cause sections of this analysis report. Another cause, that is more singular in nature, was that there was some emphasis on scheduling which exceeded the emphasis in methods (in this case,

the proper work scoping documents and approvals). This occurred because management wanted to complete the work during an available maintenance window of time. This work scheduling pressure facilitated the inadequate work scoping for the new work, and hazards analysis for that work. This cause was not identified in any other event analyzed for this report.

Although all three events have causation that differs from others we have grouped in the common cause analysis sections, the causes listed here are still failures to adequately apply the work planning process.

4.11 Common cause conclusion

Analysis of the 24 events resulted in the identification of ten causes. Some events had multiple causes, resulting in the mention of causes repeated times for a total of 39 listings of causes for the 24 events, as shown in Table 18. The most frequent cause was workers, supervisors, or experts believing they understood the work and the hazards based on their experience, but their understanding was incomplete. The second most frequent cause was unclear, incomplete or confusing documents directing the work. Together, these two causes were mentioned 17 times and contributed to 13 of the events.

Table 18. The number and the distribution of common causes

Cause	Count
Workers, supervisors, or experts believing they understood the work and the hazards based on their experience, but their understanding was incomplete	9
Unclear, incomplete or confusing documents directing the work	8
Ineffective communication between work groups or between supervisors experts or authorities and workers	4
Workers understanding the requirements for the work and accepting the risk of their actions	4
Workers and supervisors spend less effort ensuring that they have a clear understanding of work scope and the associated hazard/controls of WAL-A work	3
Work scope/work configuration changed and the new hazards were not analyzed.	2
Incorrect procedure used	2
Managers directed a change in the work planning and control process; however, they did not adequately verify or reinforce implementation in the field	2
Material accepted from another group was different from expected	2

Cause	Count
Causes that are singular in nature	3

Note: Some events have more than one cause and all causes are listed. Therefore, the count of causes will be greater than the number of events.

Less frequently mentioned was the cause of ineffective communication between work groups or between supervisors, experts or authorities and workers, and the cause of workers understanding the requirements for the work and accepting the risk of their actions (four times each). These causes are more challenging to address because they relate to levels of authority between workers and to employees following directions or controls established to ensure a safe working environment. These causes are influenced by social factors within the work environment.

5.0 Human performance improvement and safety-culture factors

In the previous sections, causes of events related to human performance and safety culture were discussed based on information from the causal analyses conducted by the individual directorates. This section presents the concepts of human performance and safety culture within the context of DOE's expectations as presented in the DOE Draft Human Performance Standard (http://www.hss.doe.gov/csa/csp/hpc/standard.html). The meaning of these and other terms used in this section can be found in Section 9.

The anatomy of an event, as described in the DOE draft Human Performance Standard, often involves active errors combined with latent organizational weaknesses that result in degraded defenses against hazardous conditions. Latent organizational weaknesses are deficiencies that are often hidden from the worker or are deficiencies that are not within the worker's ability to correct. These latent weaknesses exist in the system, waiting for active error to further reveal the flawed defenses, and result in an accident or near miss. Usually there is no immediate feedback that a latent weakness is present. They are difficult to prevent and once they are created they do not fade away but rather they accumulate in the system. Because of their hidden characteristic, it is management's primary challenge to limit the time these vulnerabilities exist.

Effective communication is also critical to good work processes. The DOE draft Standard identifies that in many events there was someone who knew something that if it had been communicated in time to the right people could have prevented the accident from taking place. It is this knowledge that reinforces the dictum that communication is the most effective defense against significant events.

This performance analysis has identified a number of examples of latent organizational weaknesses in the work control processes. They include actions, directives, and decisions that either create the preconditions for error or fail to prevent, catch, or mitigate the effects of errors on the physical facility. Examples of theses latent weaknesses include the less than adequate development of ISM functions (e.g., defining scope of work, analyzing hazards, and developing controls). Sections 3 and 4 of this report discuss in detail the common causes of events related to Latent Organizational Weaknesses identified during the last year at LLNL such as: 1) Work Scope/Work Configuration Changes; 2) Workers, Supervisors, or experts Understanding of the Work Was Incomplete; and 3) Ineffective Communications.

Human performance also involves employee behavior and results. This aspect of human performance cannot be separated from the concept of safety culture that involves the attitude of the organization and its workers about safety. The following occurrences provide examples where less than adequate behaviors or attitudes were evident. These occurrences are divided into two groups for the purpose of discussion. The first group, listed in Table 19, represents situations where the workers or work planners incorrectly perceived or accepted the risk of a hazard.

Table 19. Events where the workers or work planners incorrectly perceived the risk

Report Number	Categ. Date	Subject/Title
NTS - LLNL-2010-0020	4/2/2010	Failure to Follow Evacuation Procedure upon Activation of Tritium Activity Monitor Alarm
LLNL-2010-0019	5/3/10	Management Concern- Routine Machining Activities Result In Two Lacerations Within A 24-Hour Period
LLNL-2010-0021	5/24/10	Continuous Air Monitor (CAM) Alarm Actuation in Building 332 Radiological Materials Area (RMA)
LLNL-2010-0023	5/28/10	Radiological Contamination Found in Building 194 Spectrometer
LLNL-2010-0028	7/19/10	Discovery of Energized Electrical Sources During Equipment Installation At Building 391
LLNL-2010-0039	8/20/10	Unauthorized Crossing of Construction Barrier In Building 131

Everyone, as part of human nature, has an inherent value of risk acceptance that they bring to the work. People tend to overestimate their ability to maintain control when they are doing work. There are two reasons for this overestimation of ability. **First:** consequential error is a rare occurrence. Most of the time when errors occur, little or nothing happens. So people reason "nothing much can happen." **Second:** there is a general lack of appreciation of the limits of human capabilities.

People in general are poor judges of risk and commonly underestimate it. The following are some of the individual errors that people may make that can lead to underestimating risk.

- **Pride.** An excessively high opinion of one's ability; arrogance. Being self-focused, pride tends to blind us to the value of what others can provide, hindering teamwork.
- **Heroic.** An exaggerated sense of courage and boldness. Heroic reactions are usually impulsive. The thinking is that something has to be done fast, or all is lost. This perspective is characterized by an extreme focus on goal without consideration of hazards to avoid.
- **Invulnerability.** A sense of immunity to error, failure, or injury. Most people do not believe they will err in the next few moments; "That can't happen to me." Error is always a surprise when it happens. This is an outcome of the human limitation to accurately estimate risk.
- **Pollyanna - All is well.** People tend to presume that all is normal and perfect in their immediate surroundings. Humans seek order in their environment, not disorder. They tend to fill in gaps in perception and to see wholes instead of portions. Consequently, people unconsciously believe that everything will go as planned.
- **Bald Tire.** A belief that past performance is justification for not changing (improving) existing practices or conditions. A history of success can promote complacency and

overconfidence. Evidence of this attitude is characterized with quotes such as, “We haven't had any problems in the past,” or “We've always done it this way.”

Risk acceptance can also be highly influenced by the interpersonal dynamics among individuals on a team. Because individuals are usually not held personally responsible for a group's performance, some individuals in a group may not actively participate. Some people refrain from becoming involved, believing that they can avoid answering for their actions, or they “loaf,” in group activities. Team errors can be stimulated by, but are not limited to, one or more of the following social situations:

- **Halo Effect** – blind trust in the competence of specific individuals because of their experience or education—consequently, other personnel drop their guard against error by the competent individual, and vigilance to check the respected person's actions weakens or ceases altogether.
- **Pilot/Co-Pilot** – reluctance of a subordinate person (co-pilot) to challenge the opinions, decisions, or actions of a senior person (pilot) because of the person’s position in a group or an organization
- **Free Riding** – the tendency to “tag along” without actively scrutinizing the intent and actions of the person(s) doing the work or taking the initiative
- **Groupthink** – There can be a reluctance to share contradictory information about a problem for the sake of maintaining the harmony of the work group. This is detrimental to critical problem solving. This dynamic can be made worse by one or more dominant team members exerting considerable influence on the group's thinking (pilot/co-pilot or halo effect).

The second group of occurrences, listed in Table 20, provide examples of leadership’s role in setting expectations and following through with change they expect to enact and the danger of sending mixed messages to the work force in the conflict between schedule and safety.

Table 20. Events revealing the effect of leadership’s role in setting expectations and reinforcing implementation

Report Number	Categ. Date	Subject/Title
Not reported as an occurrence	1/27/2010	Processing of an unapproved part in B851
NTS-LLNL-2010-0020	4/2/2010	Failure to Follow Evacuation Procedure upon Activation of Tritium Activity Monitor Alarm
LLNL-2010-0031	7/23/10	Building 174 Work Control Concerns

Whereas management deals mostly with planning, organizing, and developing administrative control systems, leadership is a set of behaviors used to influence the values beliefs and practices of others. Leaders influence the behaviors that people adopt.

It is clear that it is management’s responsibility to establish the work control processes and the

atmosphere for workers to succeed and succeed safely. This includes the cultural controls of leadership practices that teach (consciously or unconsciously) people how to perceive, think, feel, and behave toward challenges to safety and risk acceptance. Management cannot be present at every work activity and were most likely not present during the events listed in Table 19. In setting an atmosphere of safe work practices related to these events, management can be clear that the work control process, when working properly, factors into the established controls an acceptable corporate and individual risk. Therefore, workers are expected to follow the control as established in the work control documents and associated signage, communication and warnings. Management needs to stress with its workers that if they cannot follow the established controls, they should pause or stop work until the concern is resolved and that schedule should never take precedence over safety.

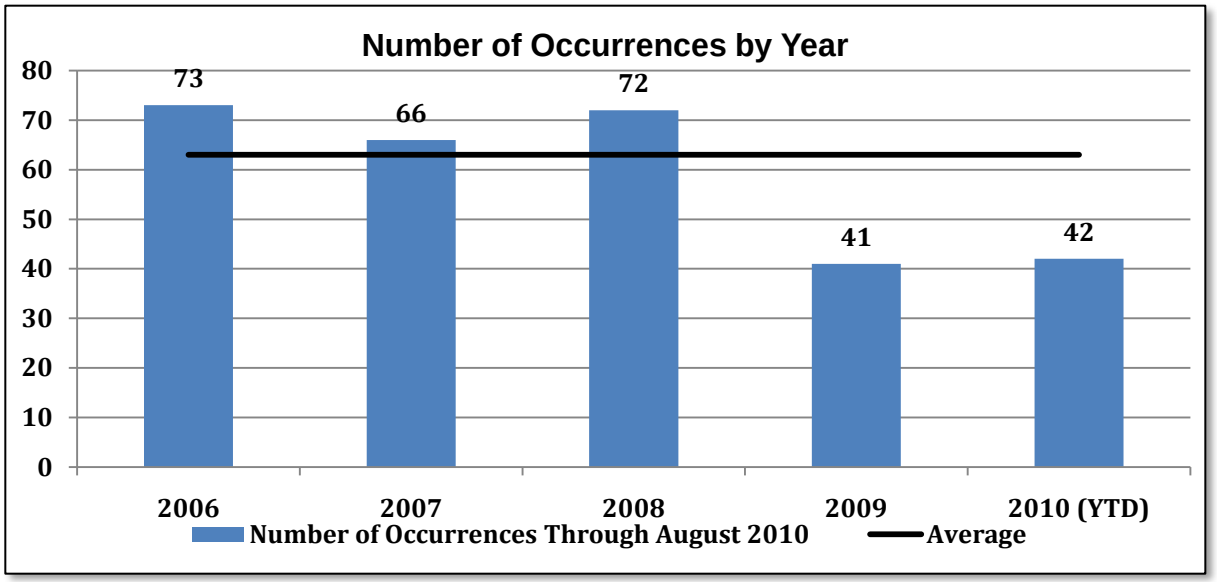
Sections 3 and 4 provide clear indications that human performance and cultural norms should be evaluated and addressed in any approach to corrective actions to address individual incidents or broad systemic issues. Managers should aggressively identify and correct latent organizational weaknesses such as vulnerabilities with controls and defenses at the earliest opportunity. To do this, reliance should be placed on field observations, self-assessments, benchmarking, apparent cause evaluations, and trending to provide management with information needed to improve performance and to eliminate vulnerabilities to facility events.

6.0 Overall collective significance of the events

The significance of the events during the first eight months of 2010 can be evaluated based on the frequency of events and the severity of the events. This section presents a comparison between 2010 and the previous four years. The graph and the comparison doesn't include the year 2005, when LLNL reported 110 occurrences.

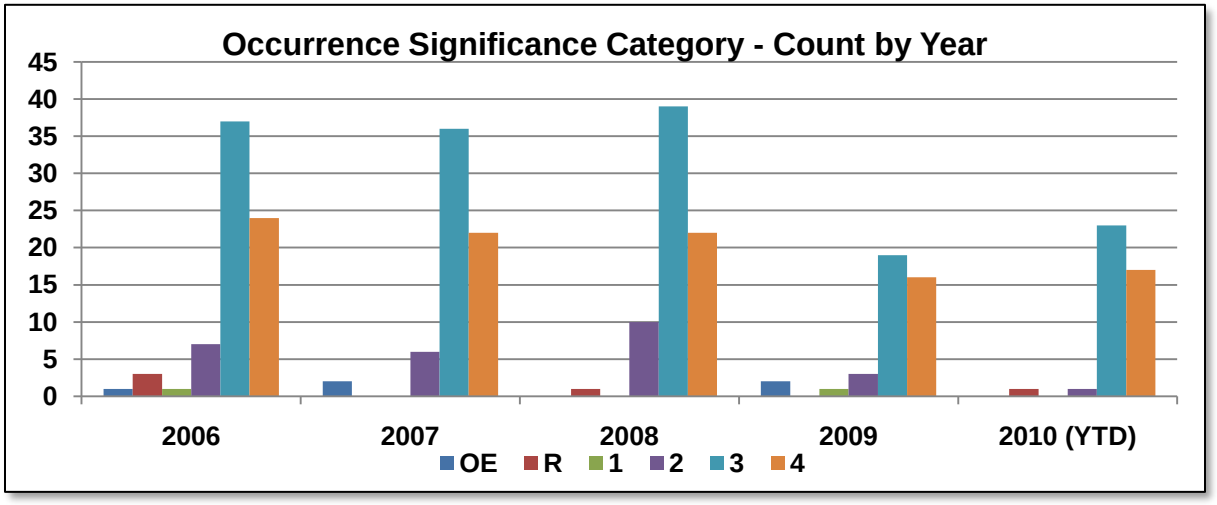
The frequency of events in 2010 is not greater than in previous years. As shown in Figure 2, the average number of occurrences per year at LLNL has been 63. If LLNL is experiencing an increased number of occurrences, the count would be greater than 47 in the first 75% of 2010; however, there have been only 42 occurrences.

Figure 2. Number of occurrences per year at LLNL



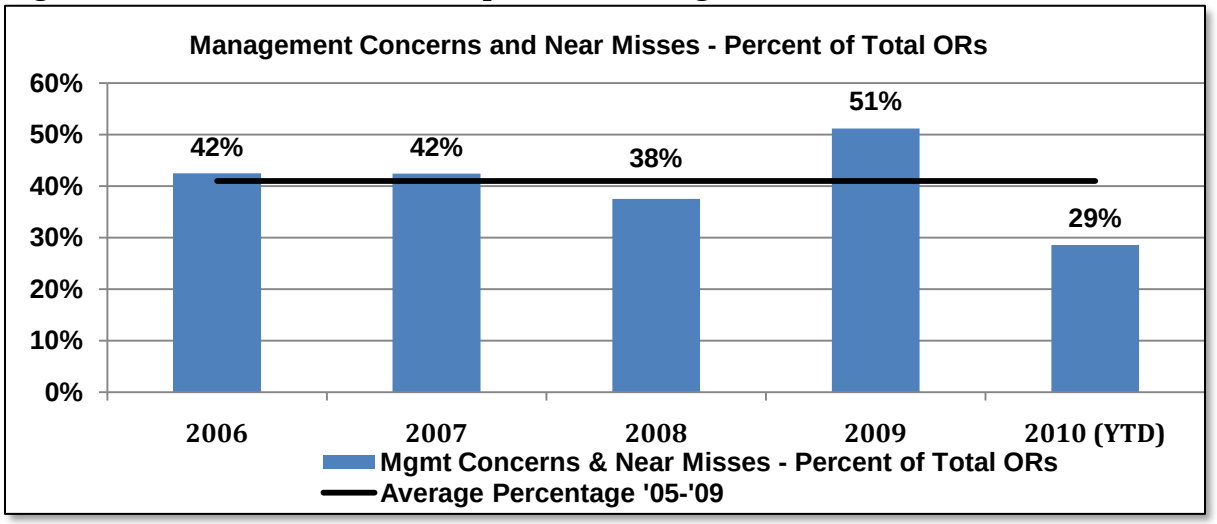
The severity of the events can be measured by the significance category and by the proportion of events that are reported under the "management concerns" reporting criteria. The frequency of reporting in each of the significance categories has not changed in 2010 compared to the previous four years and there is no change indicating a trend in the significance category. Approximately 85% of all occurrences have been reported in the two lowest significant categories, as shown in Figure 3. In 2010, 95% of LLNL's occurrences have been reported in the lowest two significance categories. There has been no increase in the proportion of occurrences reported in the higher significance category.

Figure 3. Occurrences by significance category and year



Over the previous four years, an average of 43% of the LLNL's reported occurrences have been reported as either "management concerns" or "near misses," as shown in Figure 4. Occurrences are reported under these criteria when the consequence of the event is below the threshold for reporting it under any of the reporting criteria. In 2010, 29% of the occurrences have been reported as "management concerns" or "near misses." This rate indicates that LLNL has been reporting fewer "management concern" and "near miss" occurrences compared to the previous four years. This reduction may be because managers have a better understanding of the DOE reporting processes. In 2009, many noncompliances reported to the DOE Noncompliance Tracking System (NTS) were also unnecessarily reported to ORPS as management concerns because some managers had a limited understanding of the purpose of the reporting databases and thought that when a noncompliance was reported in NTS, the situation should also be reported in ORPS.

Figure 4. Percent of occurrences reported as management concerns or near misses



Even considering the additional events included in this analysis that were not reported as occurrences, the collective significance of the events does not appear to have increased in 2010.

7.0 Management initiatives to improve performance

Management has continuously improved the implementation of integrated safety management since its implementation. Within the most recent two years, LLNL senior management has taken a series of initiatives to strengthen the work planning and control system with the primary objective to improve worker safety.

In February 2008, the LLNL Deputy Director established the Work Control Integrated Project Team to develop the core requirements and graded elements of an Institutional work planning and control system following the NNSA guidance in *Activity Level Work Planning and Control Processes, Attributes, Best Practices, and Guidance for Effective Incorporation of Integrated Safety Management and Quality Assurance*, NNSA, January 2006. By the end of 2008, the LLNL work planning and control system was documented and implementation had begun. An Institutional Work Control Review Board was chartered to administer and oversee work planning and control implementation, with membership representing each of the PADs and the ES&H Organization.

Beginning in January 2009, all employees were required to complete training on the requirements and use of the Institutional work planning and control process. Since June 2009, all newly proposed work is planned and analyzed following a risk-prioritized schedule to re-analyze all currently authorized work. At the time of this report, more than 50% of authorized Integration Work Sheets (IWSs) use the activity-based planning process. Based on interviews with more than 100 people conducted during management self assessments, the work control review board concludes that the activity-based work planning process has been generally embraced by LLNL workers and management

In early 2010, LSO independently reviewed the WP&C process with support provided by DOE Office of Health, Safety, and Security (HSS), and in April 2010, LSO confirmed to the Laboratory that the Integrated Safety Management (ISM) System was implemented. The 2010 HSS report identified weaknesses with regard to some task-based IWSs that lacked the specificity to ensure that hazards are fully analyzed, and that appropriate controls are developed. Senior management clearly recognizes these weaknesses to increase the potential for unplanned events, and continues to incorporate feedback for improvement.

Ongoing efforts to strengthen the work planning and control process and to improve the quality of LLNL work documentation continue. On October 31, 2010, LLNL completed the cross-PAD work planning and control management self-assessment. The self-assessment was performed by the WCRB with assistance from members of the EFCOG ISM/QA Work Management Subgroup. As of the date of this report LLNL senior managers are developing specific work control improvement actions for senior management consideration for implementation in FY11**.** The results from this report will be addressed in the development of these work control improvement actions.

8.0 Conclusion

This performance analysis evaluated 24 events that occurred at LLNL from January through August 2010. The analysis identified areas of potential work control process and/or implementation weaknesses and several common underlying causes. Human performance improvement and safety culture factors were part of the causal analysis of each event and were analyzed.

The collective significance of all events in 2010, as measured by the occurrence reporting significance category and by the proportion of events that have been reported to the DOE ORPS under the "management concerns" reporting criteria, does not appear to have increased in 2010. The frequency of reporting in each of the significance categories has not changed in 2010 compared to the previous four years. There is no change indicating a trend in the significance category and there has been no increase in the proportion of occurrences reported in the higher significance category. Also, the frequency of events, 42 events reported through August 2010, is not greater than in previous years and is below the average of 63 occurrences per year at LLNL since 2006. Over the previous four years, an average of 43% of the LLNL's reported occurrences have been reported as either "management concerns" or "near misses." In 2010, 29% of the occurrences have been reported as "management concerns" or "near misses." This rate indicates that LLNL is now reporting fewer "management concern" and "near miss" occurrences compared to the previous four years.

From 2008 to the present, LLNL senior management has undertaken a series of initiatives to strengthen the work planning and control system with the primary objective to improve worker safety. In 2008, the LLNL Deputy Director established the Work Control Integrated Project Team to develop the core requirements and graded elements of an institutional work planning and control system. By the end of that year this system was documented and implementation had begun. In 2009, training of the workforce began and as of the time of this report more than 50% of authorized Integration Work Sheets (IWS) use the activity-based planning process. In 2010, LSO independently reviewed the work planning and control process and confirmed to the Laboratory that the ISM System was implemented. LLNL conducted a cross-directorate management self-assessment of work planning and control and is developing actions to respond to the issues identified. Ongoing efforts to strengthen the work planning and control process and to improve the quality of LLNL work packages are in progress: completion of remaining actions in response to the 2009 HSS evaluation of LLNL's ISM System; scheduling more than 14 work planning and control self-assessments in FY11; continuing to align subcontractor work control with the Institutional work planning and control system; and continuing to maintain the electronic IWS application.

The 24 events included in this analysis were caused by errors in the first four of the five ISMS functions. The most frequent cause was errors in analyzing the hazards (Function 2). The second most frequent cause was errors occurring when defining the work (Function 1), followed by errors during the performance of work (Function 4). Interestingly, very few errors in developing

controls (Function 3) resulted in events. This leads one to conclude that if improvements are made to defining the scope of work and analyzing the potential hazards, LLNL may reduce the frequency or severity of events.

Analysis of the 24 events resulted in the identification of ten common causes. Some events had multiple causes, resulting in the mention of 39 causes being identified for the 24 events. The most frequent cause was workers, supervisors, or experts believing they understood the work and the hazards but their understanding was incomplete. The second most frequent cause was unclear, incomplete or confusing documents directing the work. Together, these two causes were mentioned 17 times and contributed to 13 of the events.

All of the events with the cause of "workers, supervisors, or experts believing they understood the work and the hazards but their understanding was incomplete" had this error in the first two ISMS functions: define the work and analyze the hazard. This means that these causes result in the scope of work being ill-defined or the hazard(s) improperly analyzed. Incomplete implementation of these functional steps leads to the hazards not being controlled. The causes are then manifested in events when the work is conducted. The process to operate safely relies on accurately defining the scope of work.

This review has identified a number of examples of latent organizational weakness in the execution of work control processes. These latent weaknesses include actions, directives, and decisions that either create the preconditions for error or fail to prevent, catch, or mitigate the effects of errors. Examples of theses latent weaknesses include the two most common causes identified: "Workers, supervisors, or experts understanding of the work was incomplete," and "Unclear, incomplete or confusing documents directing the work."

LLNL relies on a knowledgeable and experienced workforce, both in conducting research that is primarily knowledge-based and in performing operational work (e.g., maintenance of Laboratory infrastructure) that is often performed as skill-of-craft work. Use of an experienced, knowledgeable workforce is highly desirable, however, the events examined in this performance analysis and the identified common causes (especially "Workers, supervisors, or experts understanding of the work was incomplete") suggest that this attribute needs to be examined and supplemented.

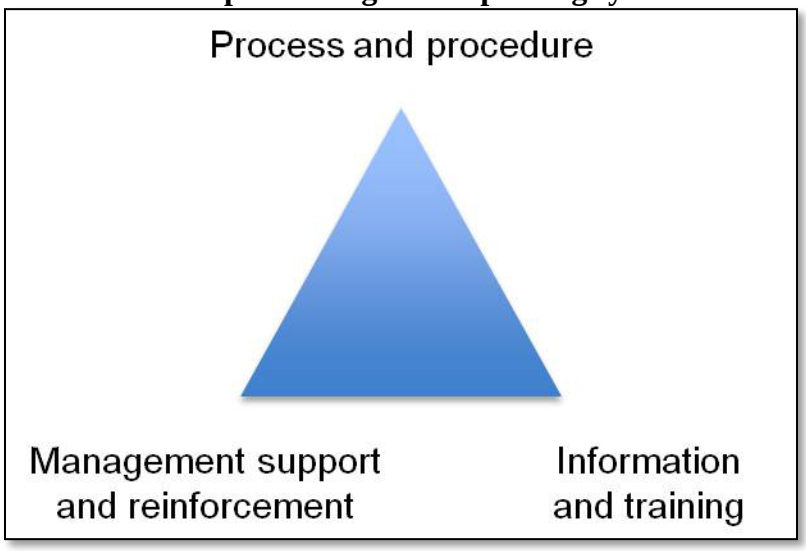
Over-reliance on past successes may introduce a bias in the work planning process that precludes a thorough and detailed analysis of work tasks and associated hazards. Also, the temptation for experts to provide advice beyond the scope of their specific expertise and for other personnel with authority to direct work without complete facts can produce misleading or misunderstood information. The events analyzed here showed that each of these human behavioral traits can lead to problems during performance of work, particularly when workers do not fully appreciate the field conditions and circumstances they encounter as well as they think they do. The current analysis shows that changes in work scope, material or circumstances represent error-likely conditions that ultimately result in events, rather than in thoughtful re-planning.

Human performance also involves employee behavior and results. This aspect of human performance cannot be separated from the concept of safety culture that involves historically reinforced attitudes about safety (organizational norms). Less desirable behaviors or attitudes were evident in a number of events in this analysis where the workers or work planners incorrectly perceived or accepted the risk of a hazard. Prominent examples among these events were the failure to follow the evacuation procedure upon activation of a tritium activity monitor alarm and the unauthorized crossing of a construction barrier.

Leadership's role in setting expectations, following through with changes they expect to be implemented and avoiding mixed messages to the workforce on balanced priorities (schedule and safety) were causes identified in two events in this analysis: processing of an unapproved high explosive part in Building 851 and the Building 174 work control concerns.

Implementation of new systems requires a three-sided approach, as shown in Figure 5. If any of the three elements are missing, implementation will lag. When improvements are desired, the same three elements will need to be addressed in the improvement plan. This analysis indicates that more emphasis may be needed in the area of management support and reinforcement.

Figure 5. Critical elements to implementing and improving systems.



It appears that the LLNL processes and the procedure describing the work planning and control system are basically sound and continue to be improved as described in Section 7 of this report. However, these events have revealed some systemic weaknesses in the details of implementation that could have been strengthened by improved information and training and by stronger management support and reinforcement of system implementation.

Three areas stand out as suggesting that LLNL management should develop additional understanding and thoughtful consideration prior to developing corrective actions:

- Impediments to conducting effective walkdowns and roundtable meetings during the

work planning
- Means to ensure field verifications of hazards and controls and to effectively confirm readiness and support managing unexpected conditions that may be encountered during the performance of the work.
- Influences that limit effective communication between workers, between different work groups and between workers and perceived authority figures (such as supervisors or subject matter experts).

The importance of management's support and reinforcement of the worker's or subject matter expert's ability to raise and resolve issues without an expressed or implied fear of impact to cost or schedule cannot be over-emphasized. In many of the analyzed events, issues that might have been raised during the work planning process could have avoided the negative consequences. Communications during pre-job briefings and during the course of performing work are also relevant settings to encourage this dialogue.

During the first eight months of 2010 and to the present, LLNL managers continued converting to the new activity-based IWS. Simultaneously, LLNL conducted an assessment of work planning and control, as described above. Insight gained from these two activities should be integrated with the results of this analysis and considered in developing actions to continuously improve work planning and control.

9.0 Definitions

Active Error

Action (behavior) that changes equipment, system, or plant state triggering immediate undesired consequences.

Human Performance

For long-term, sustained value-added results, one must look closely at behavior; what influences it, motivates it, provokes it, shapes it, inhibits it, directs it, etc. Very simply then, human performance is behavior plus results. Behavior is what people do and say – it is *a means to an end*.

Latent Organizational Weaknesses

Latent organizational weaknesses are hidden deficiencies in management control processes (for example, strategy, policies, work control, training, and resource allocation) or values (shared beliefs, attitudes, norms, and assumptions) create workplace conditions that can provoke error (precursors) and degrade the integrity of defenses (flawed defenses). Latent errors typically manifest themselves as degradations in defense mechanisms, such as weaknesses in processes, inefficiencies, and undesirable changes in values and practices.

Safety Culture

Safety culture is about improving safety attitudes in people. It is also about good safety management established by organizations with a holistic, whole of community, whole of life approach. Good safety culture implies a constant assessment of the safety significance of events and issues so that the appropriate level of attention can be given. A strong safety culture is dependent first and foremost on the organization's ability to properly manage safety in the facility over time. These driving forces are *commitment, competence and cognizance.*

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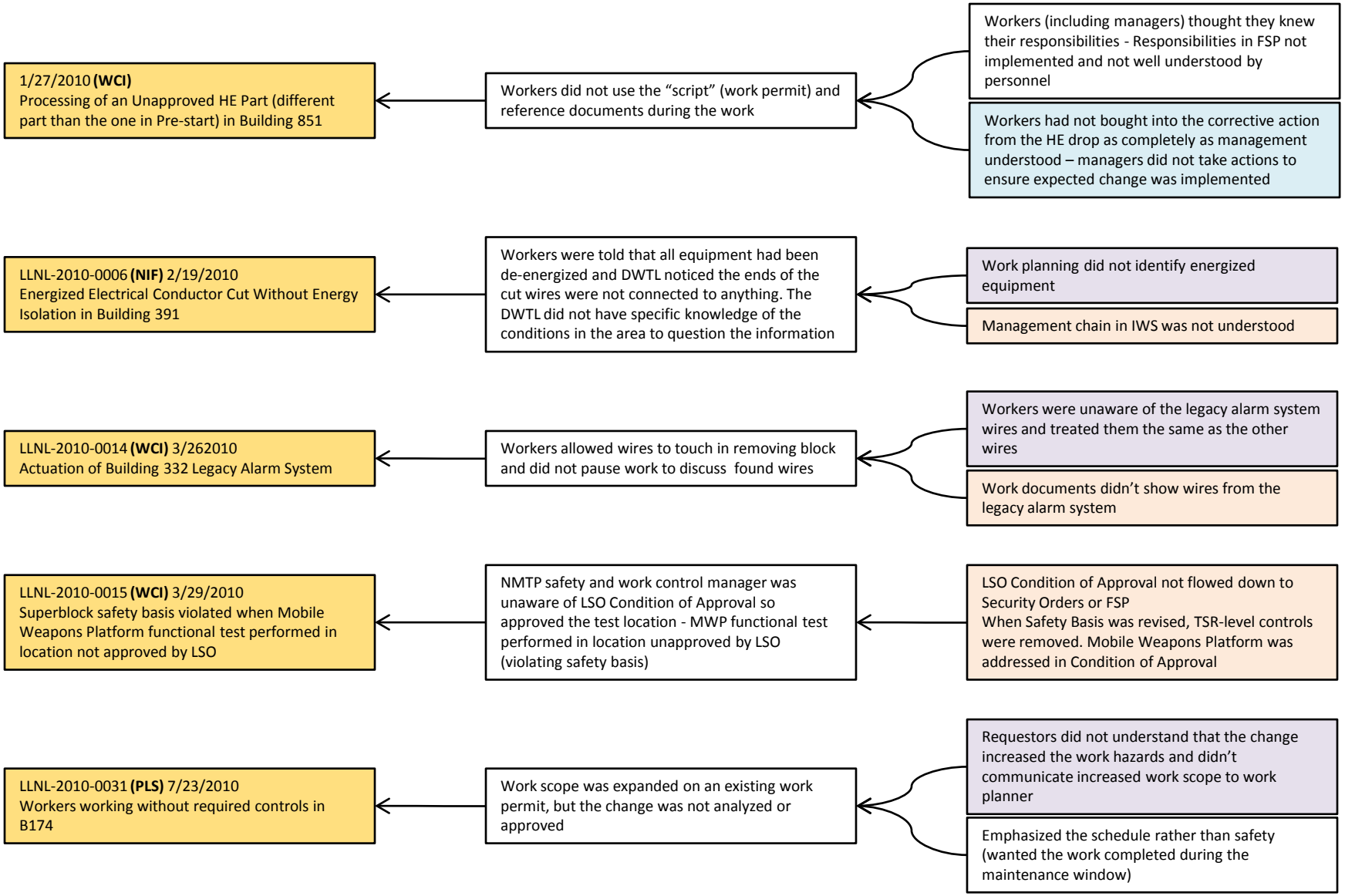
Appendices

Relationship Analysis Flow Diagrams

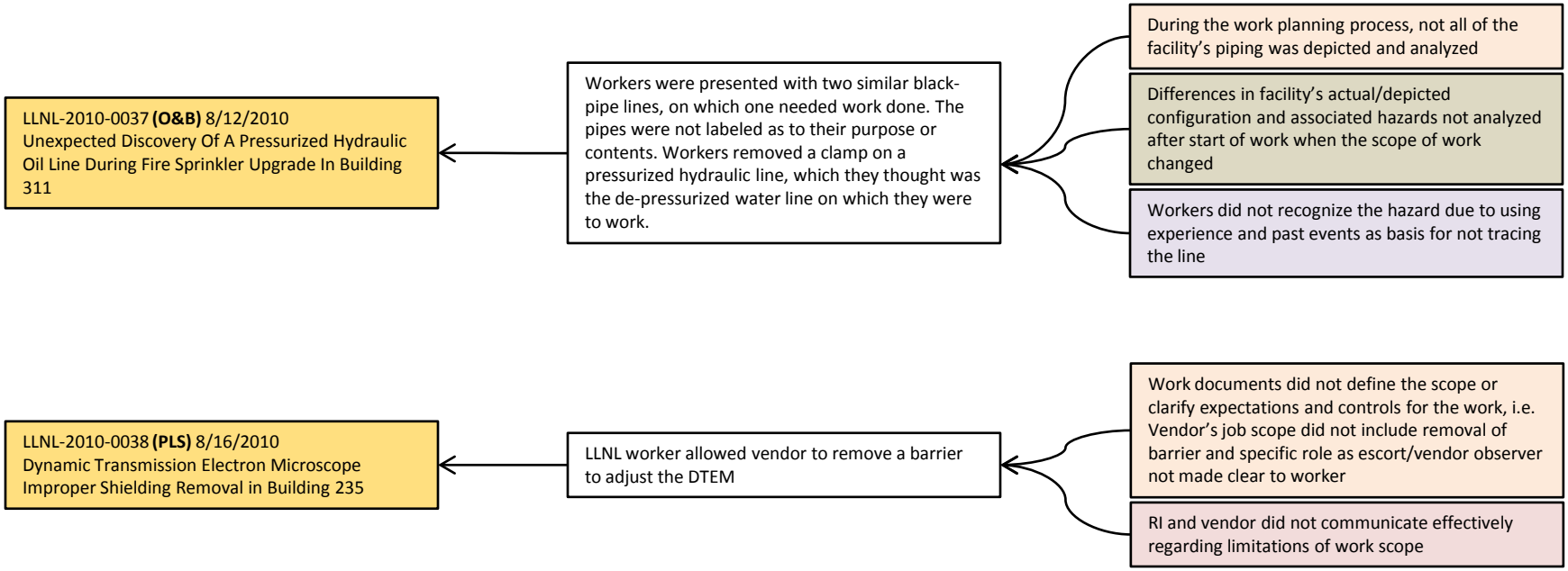
Appendix A:

ISMS Relationship Analysis Flow Diagrams

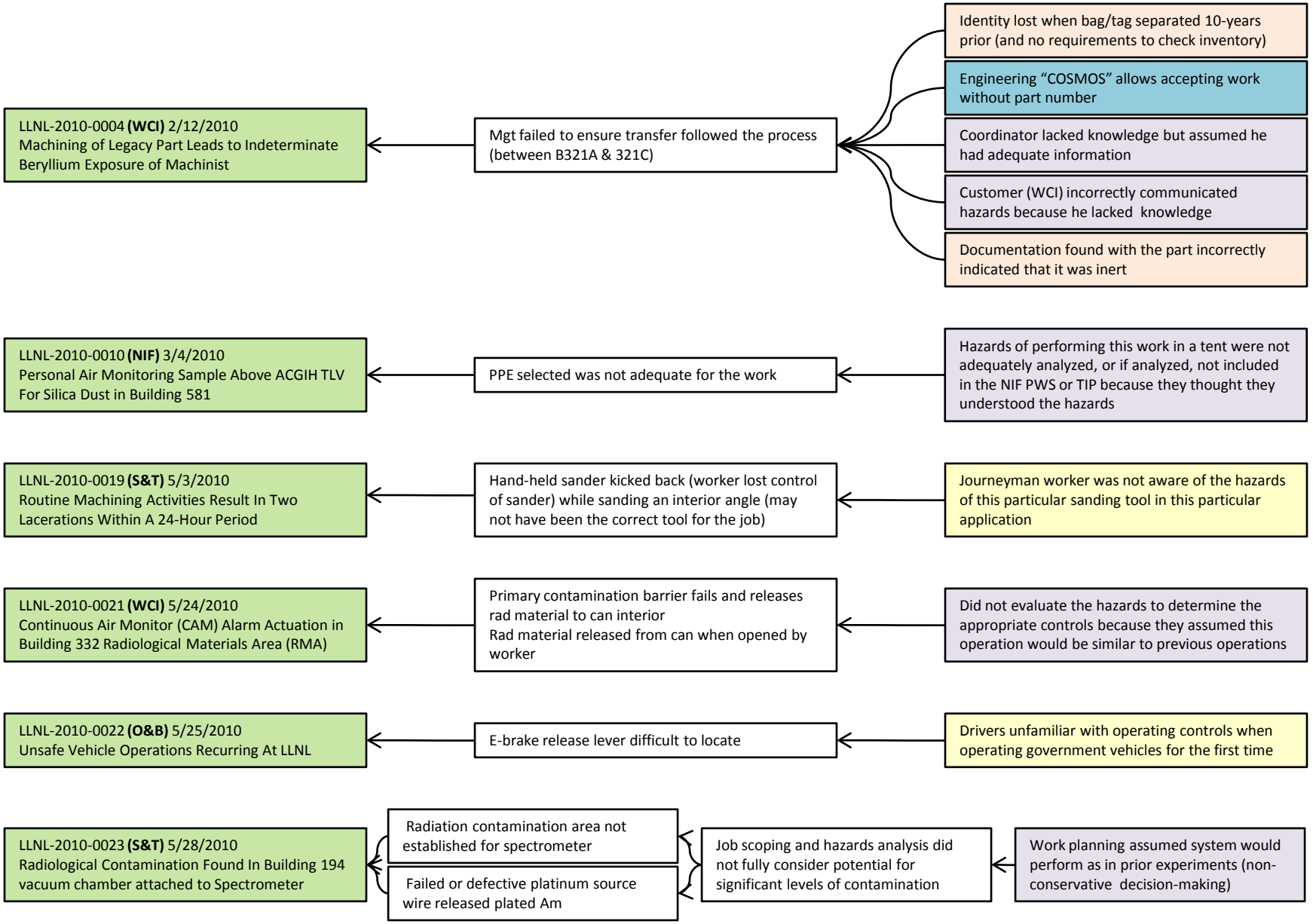
Events related to ISM Function 1: Define Work
Section 3.1



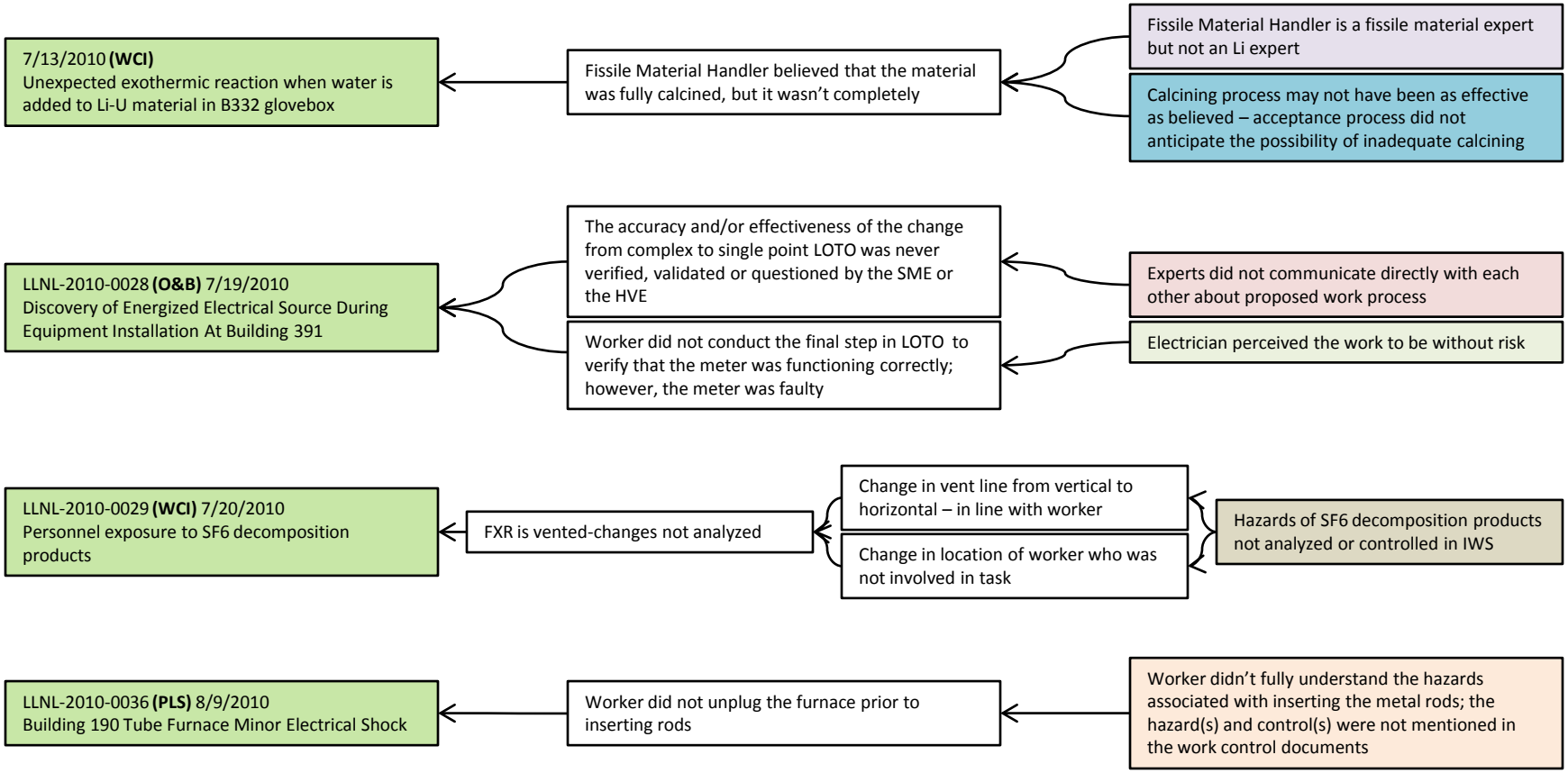
Events related to ISM Function 1: Define Work (cont.)
Section 3.1



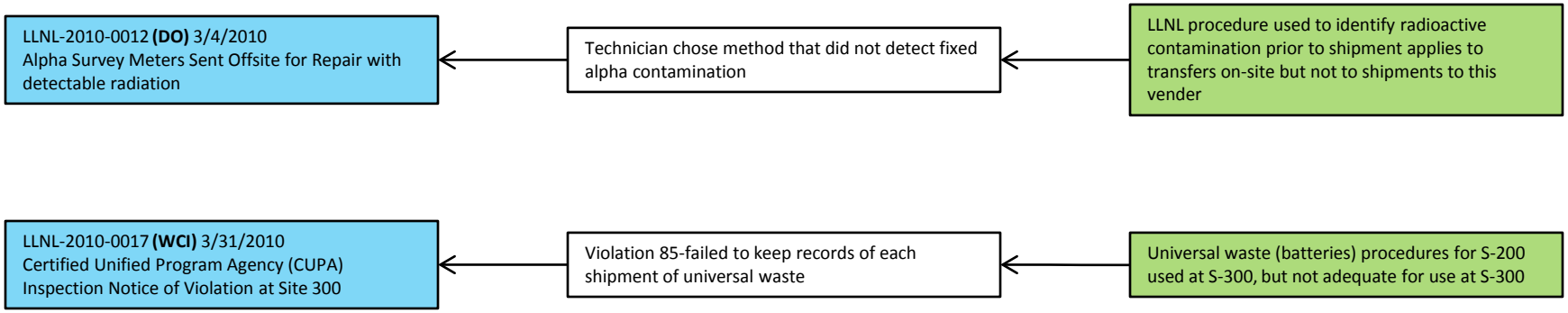
Events related to ISM Function 2: Analyze Hazards
Section 3.2



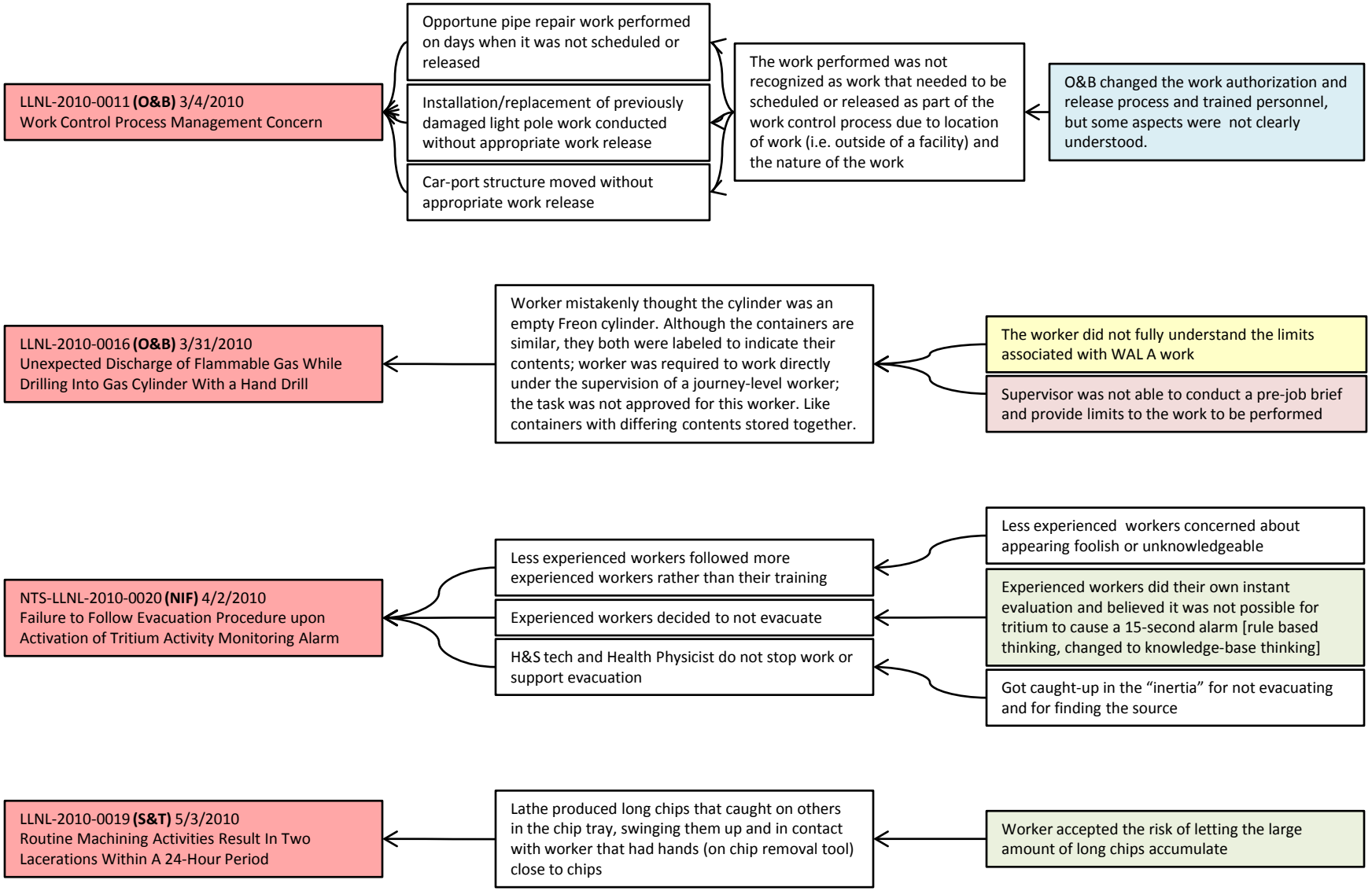
Events related to ISM Function 2: Analyze Hazards (cont.)
Section 3.2



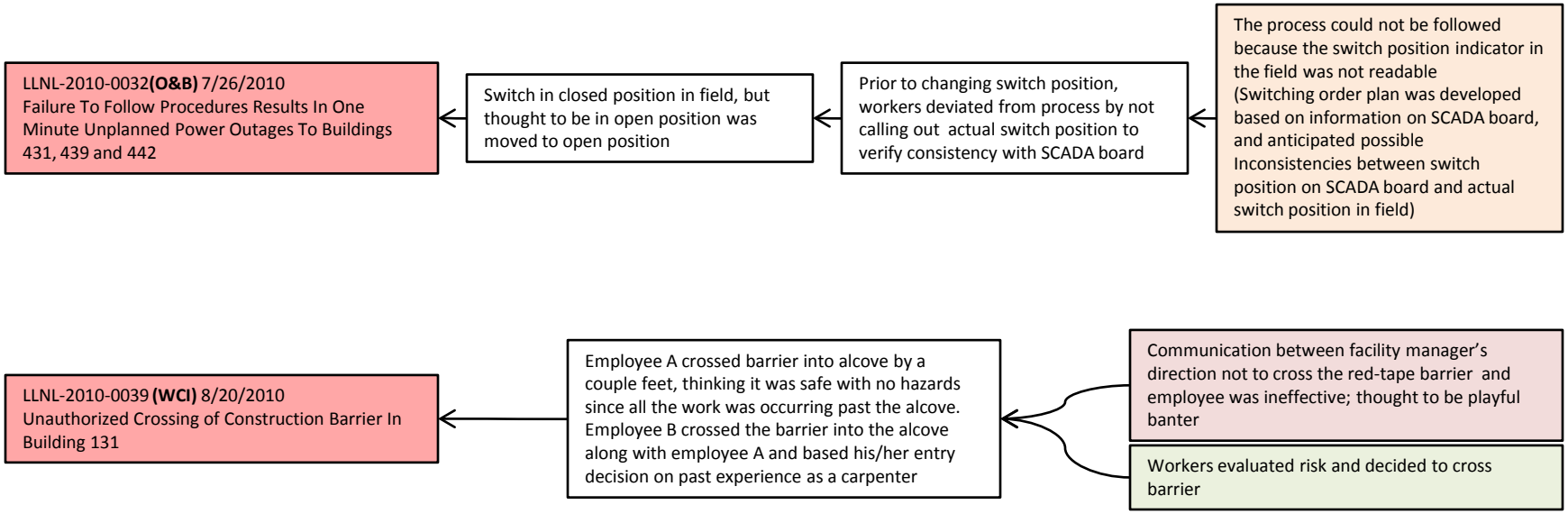
Events related to ISM Function 3: Develop Controls
Section 3.3



Events related to ISM Function 4: Perform Work
Section 3.4



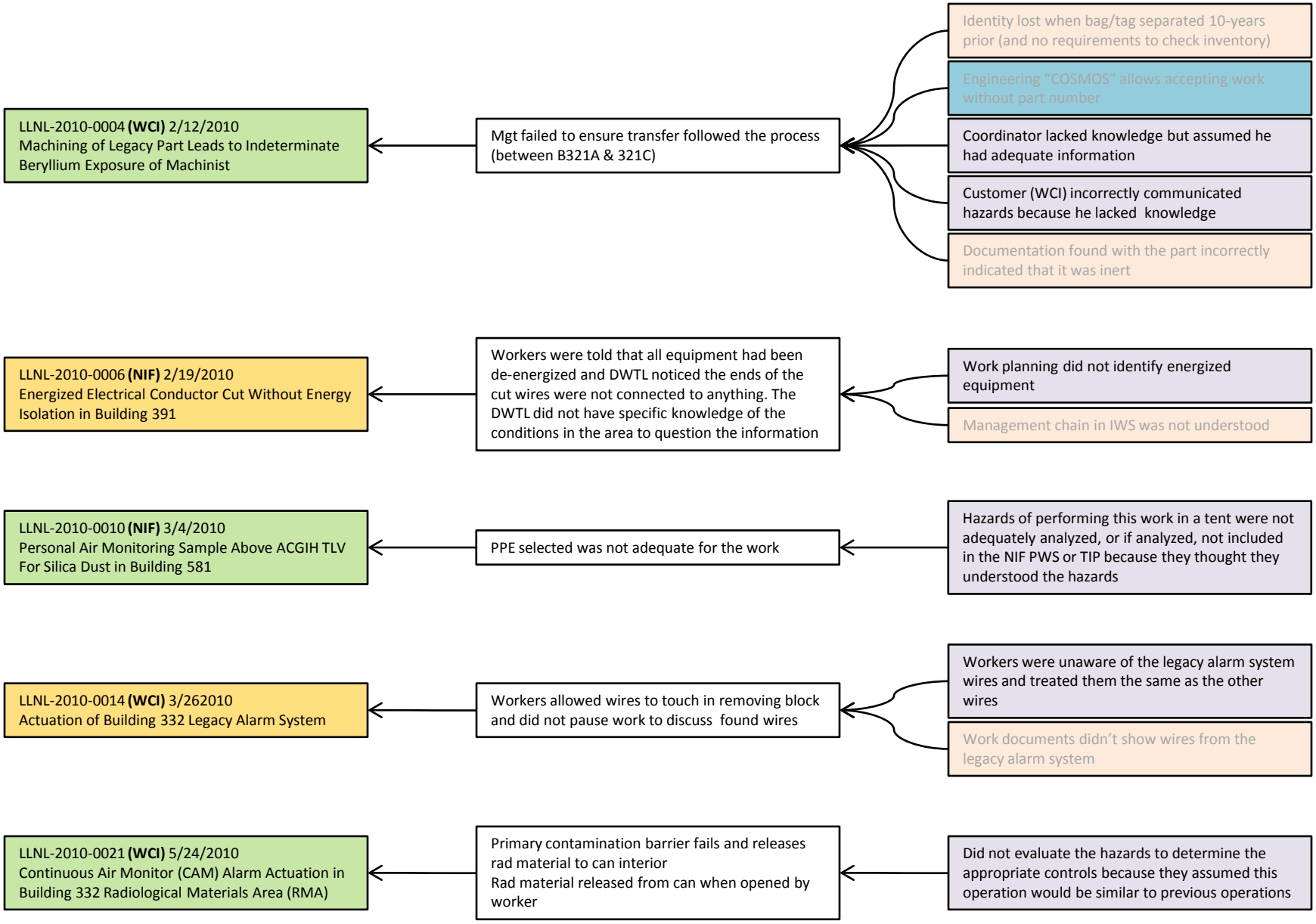
Events related to ISM Function 4: Perform Work (cont.)
Section 3.4



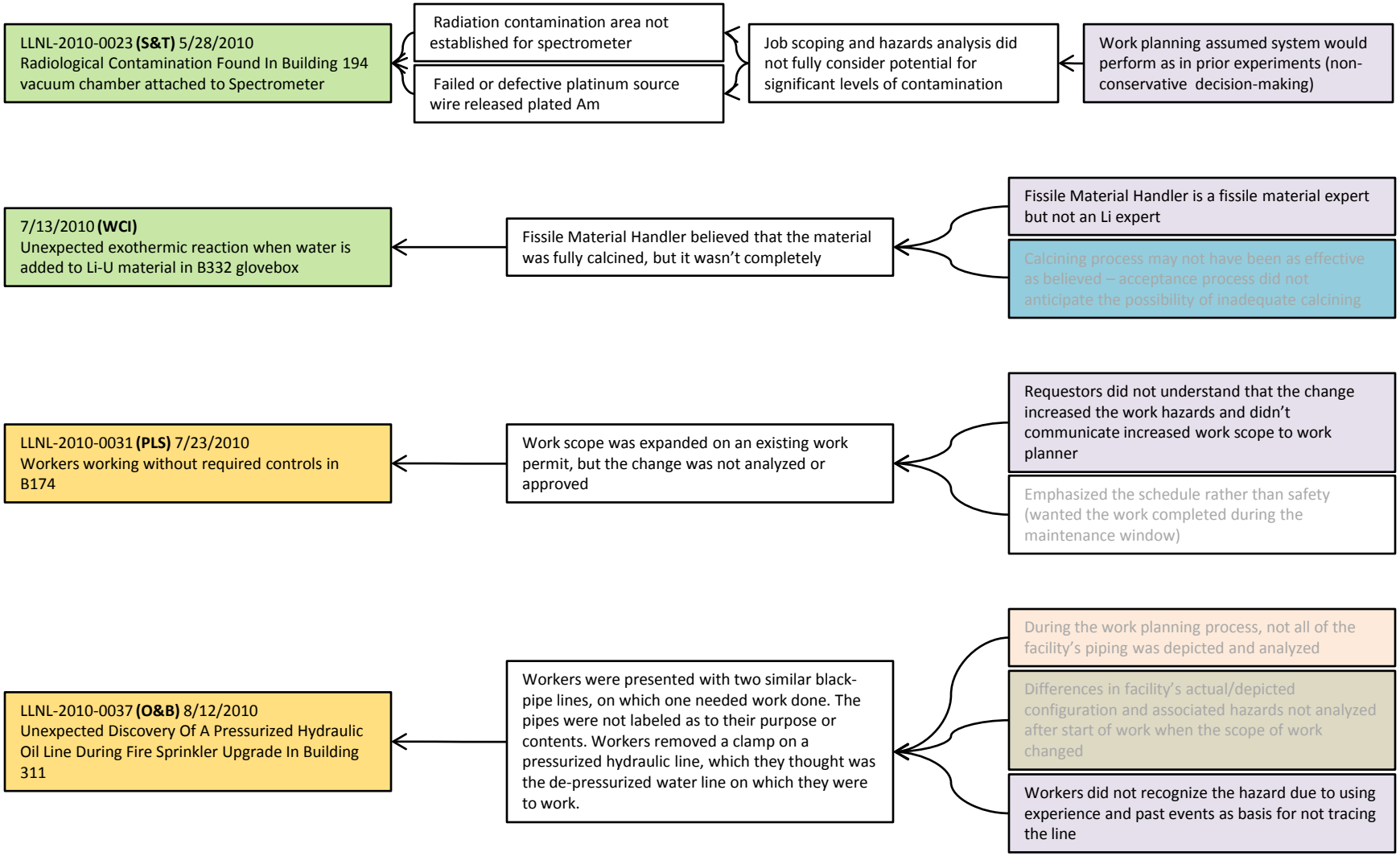
Appendix B:

Common Cause Relationship Analysis Flow Diagrams

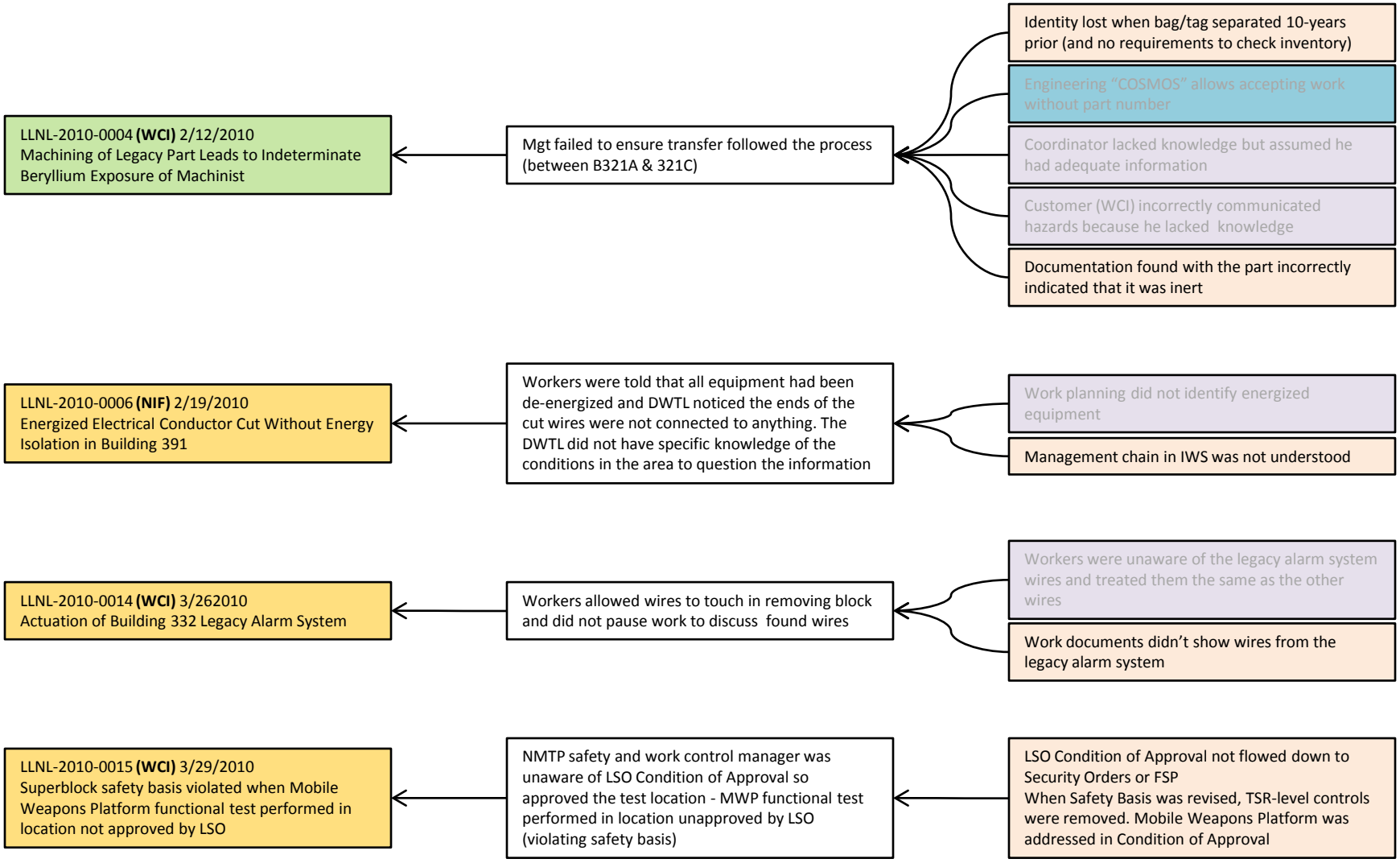
Common Cause: Worker, supervisors, or experts understanding of the work was incomplete
Section 4.1



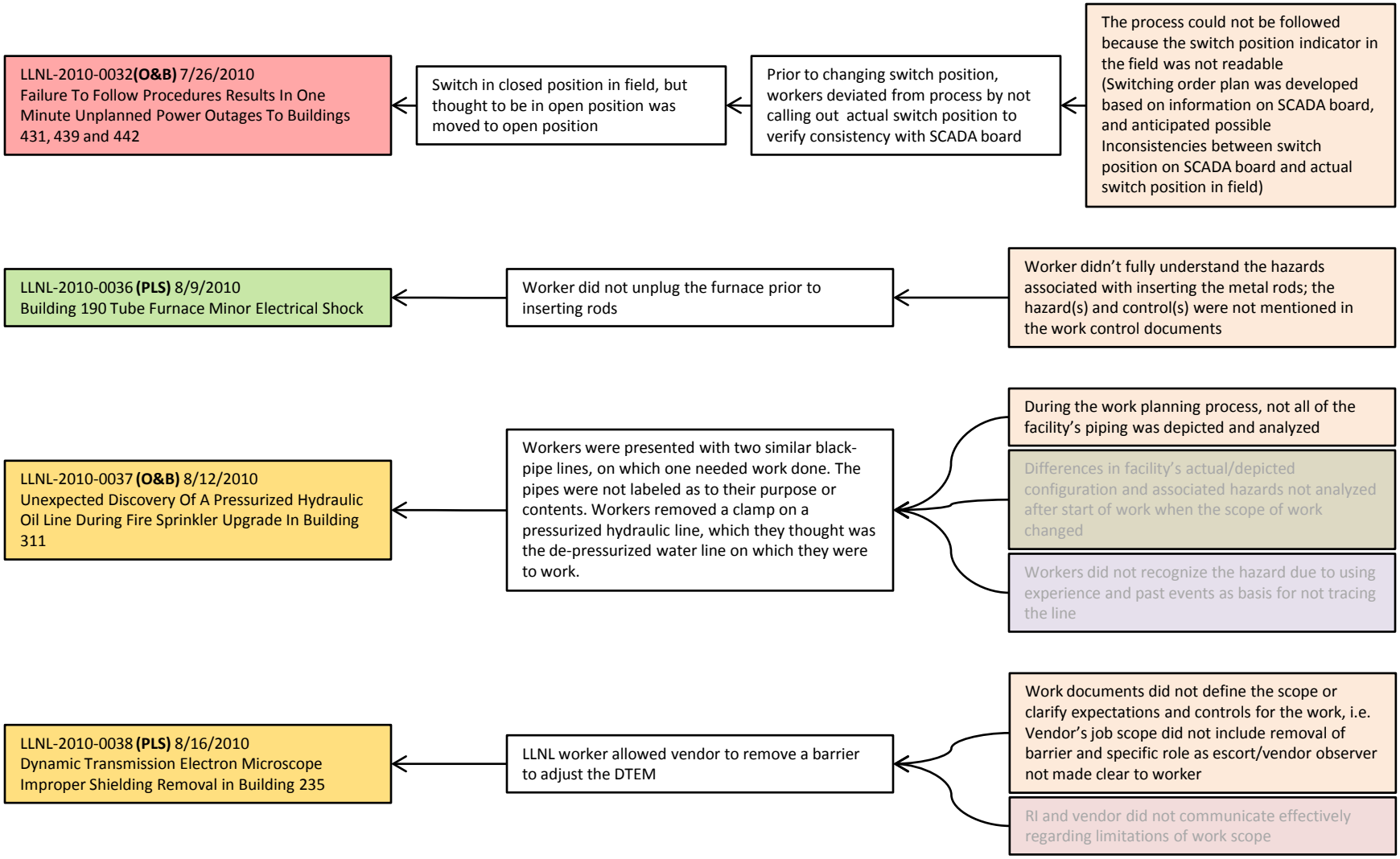
Common Cause: Worker, supervisors, or experts understanding of the work was incomplete (cont.)
Section 4.1



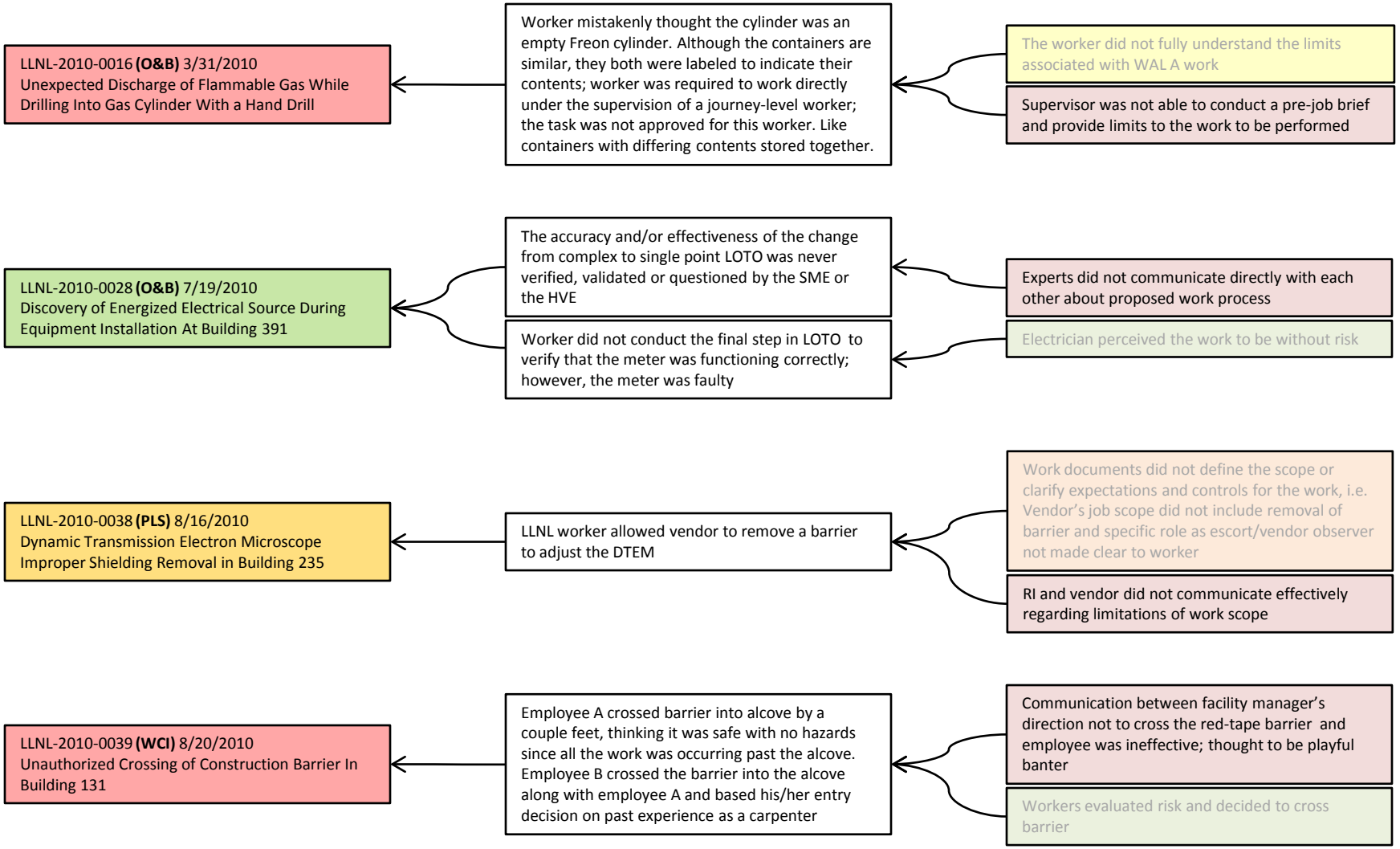
Common Cause: Incomplete, unclear or inaccurate documents directing the work
Section 4.2



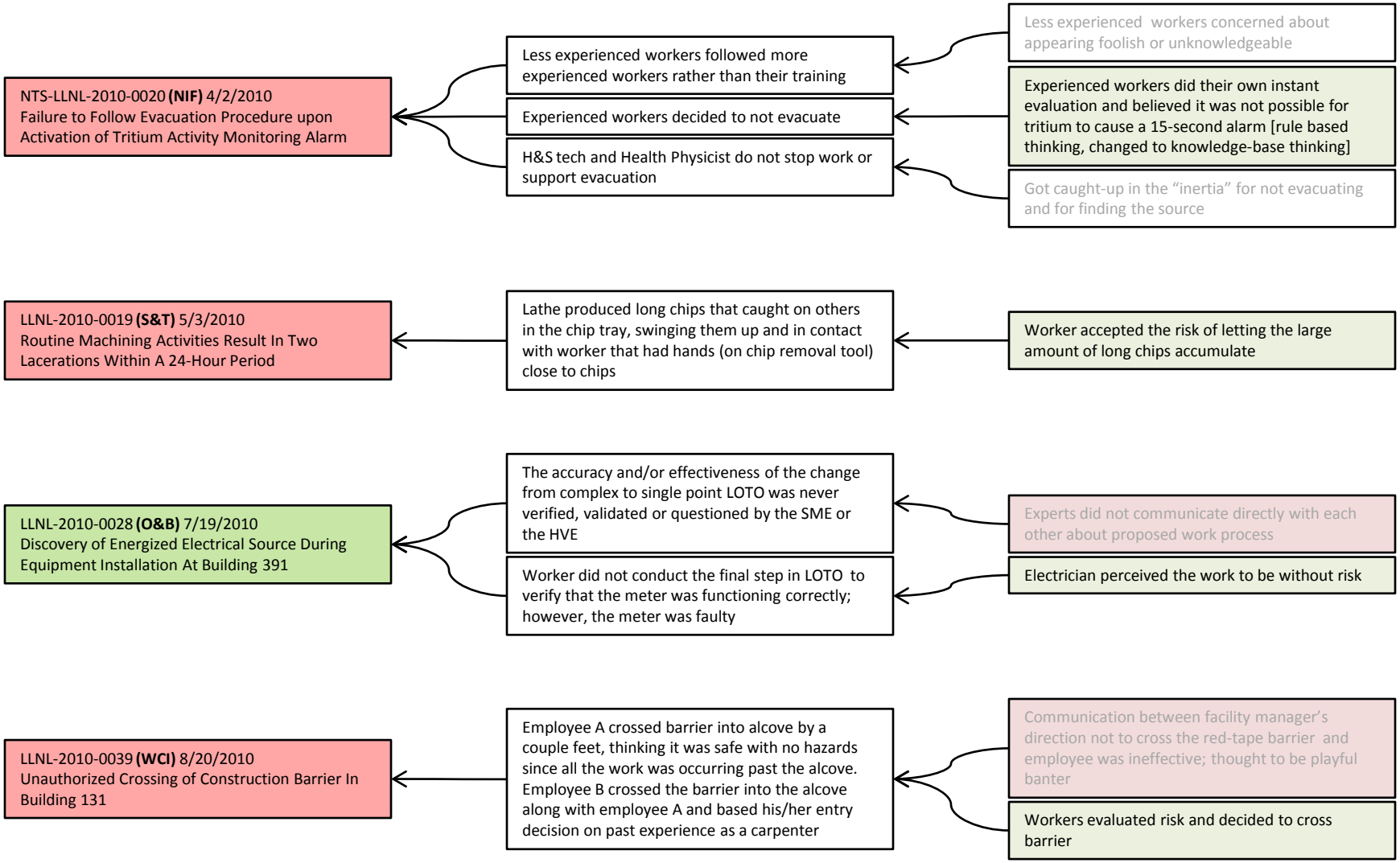
Common Cause: Incomplete, unclear or inaccurate documents directing the work (cont.)
Section 4.2



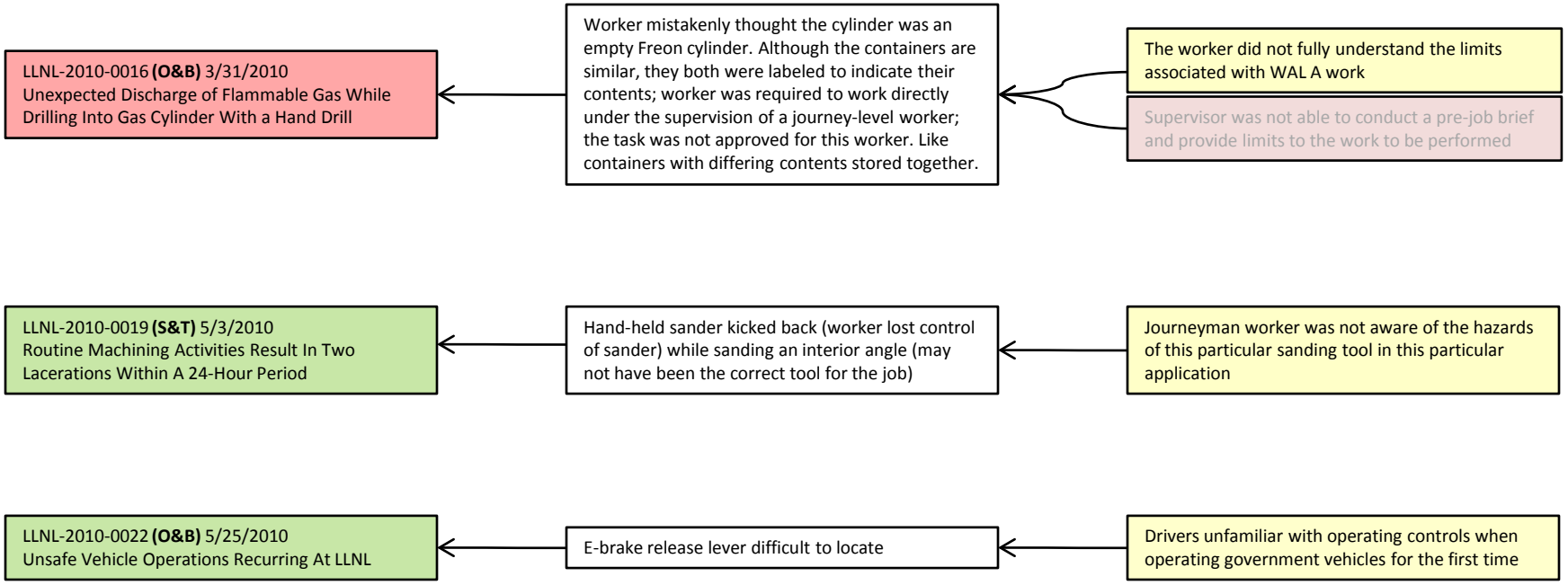
Common Cause: Ineffective communication
Section 4.3



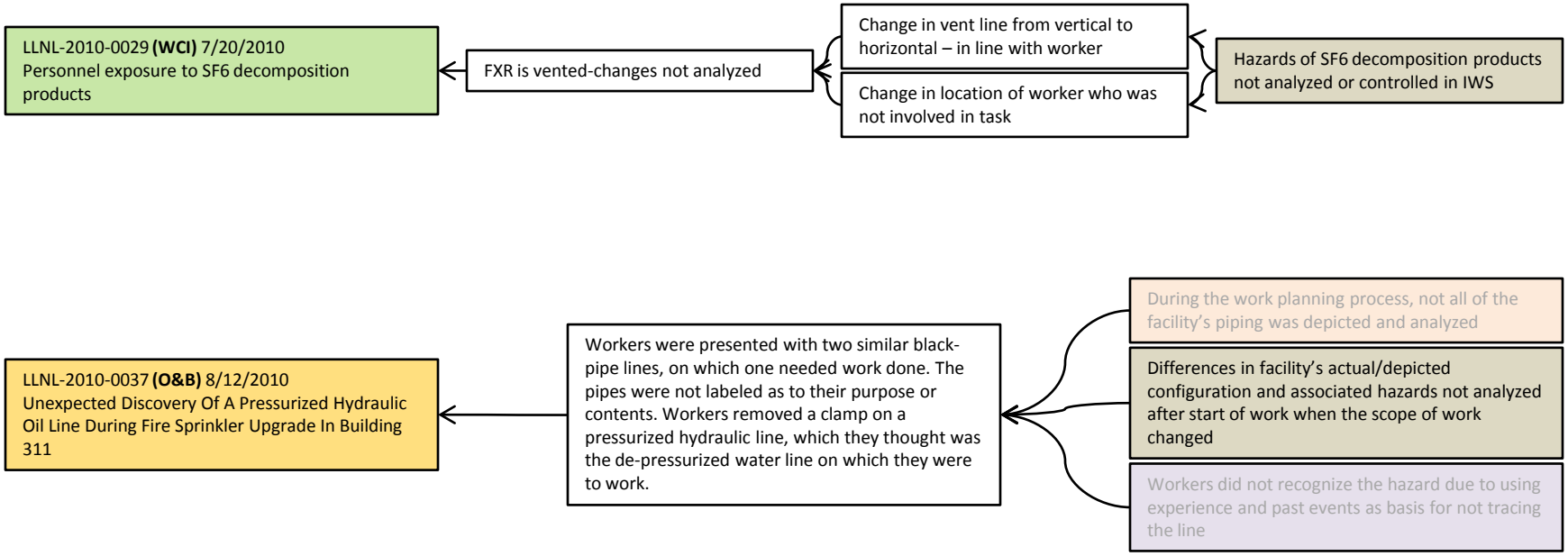
Common Cause: Workers accepting the risk of their actions
Section 4.4



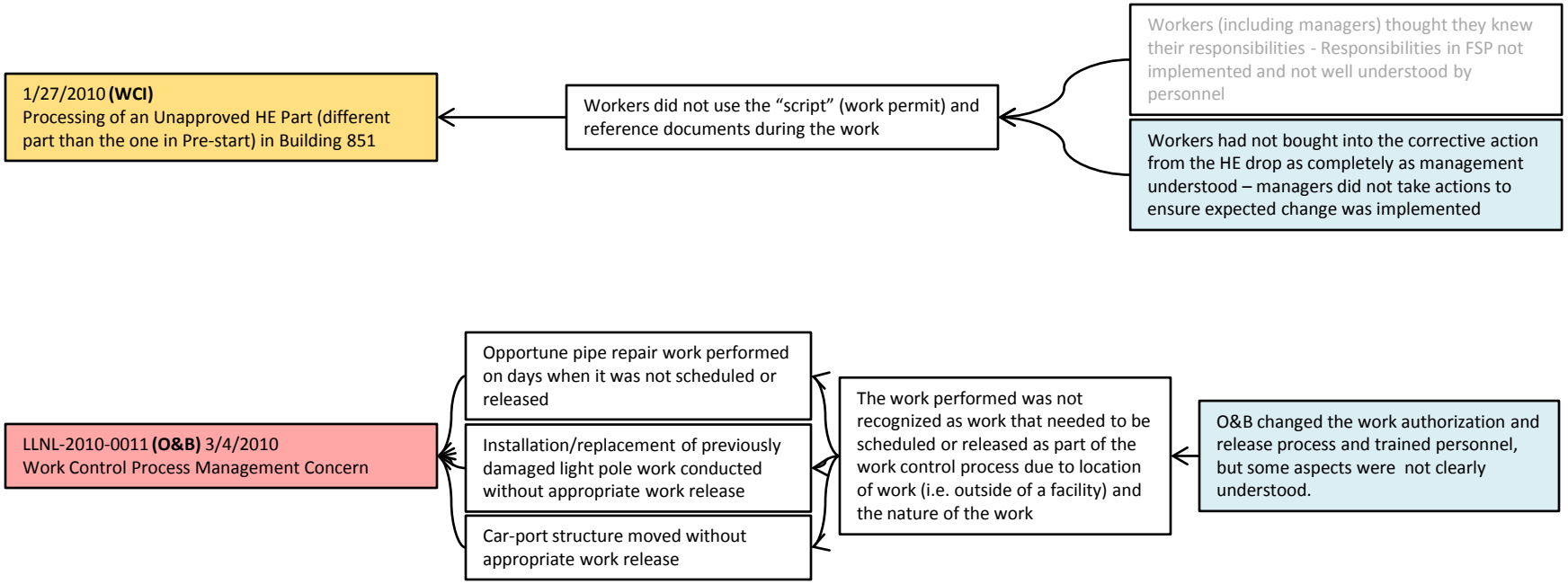
Common Cause: WAL-A work not adequately reviewed
Section 4.5



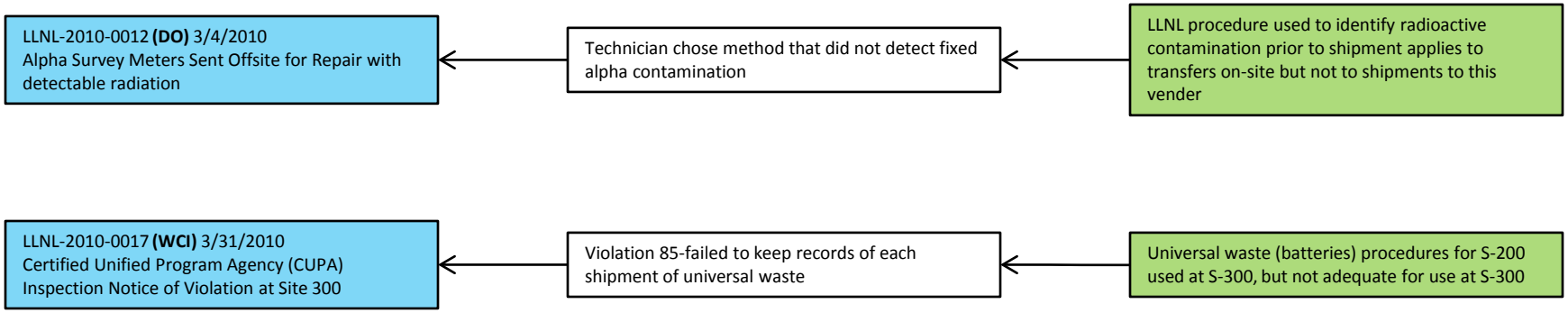
Common Cause: Work scope/work configuration changes and change not analyzed
Section 4.6



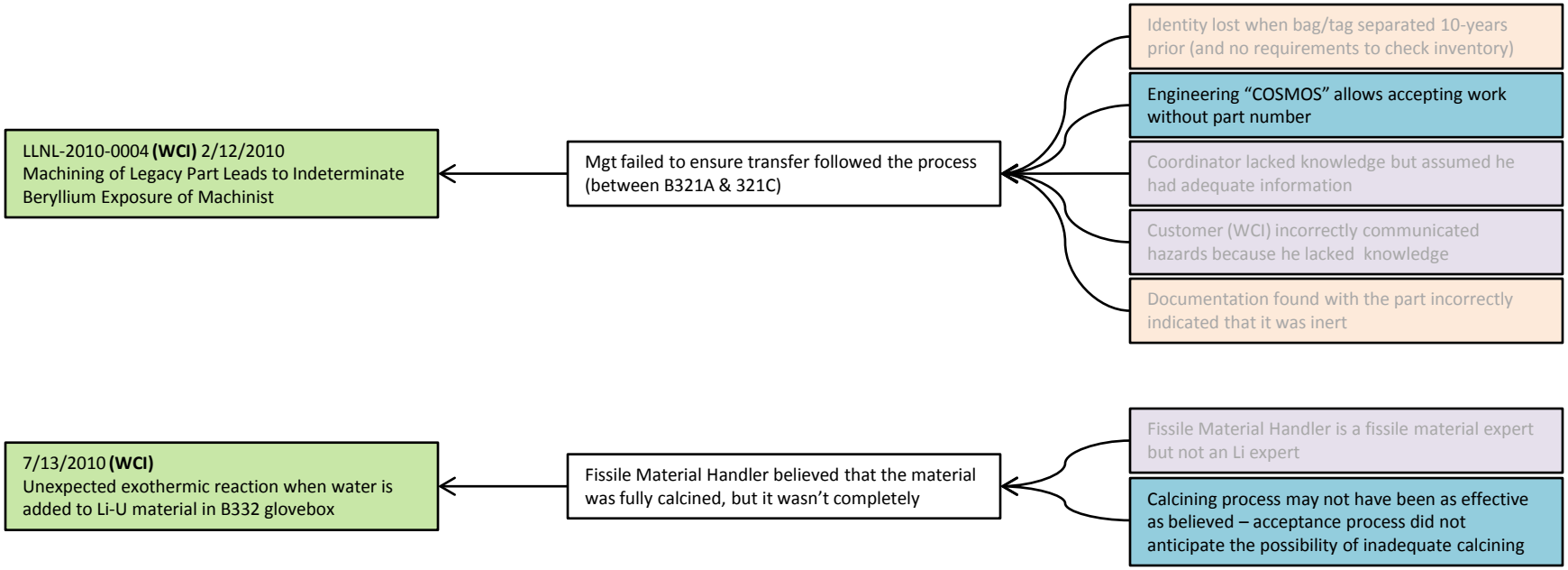
Common Cause: Managers not adequately verifying or reinforcing process changes
Section 4.7



Common Cause: Incorrect procedure used
Section 4.8



Common Cause: Material accepted for work was different than anticipated
Section 4.9



Causes that are singular in nature
Section 4.10