15.1.2.18 Accidents at Nearby Sites - Cruise Missile Testing at the UTTR

The staff has reviewed the information presented in Section 2.2.3 of the SAR, The Use of Ordnance on the UTTR. Information presented in Cole (1999a,b), U.S. Air Force (1999), Wagner and Girman (2000), Private Fuel Storage Limited Liability Company (2000b), and Girman and Wagner (2001) was also used in this review. The staff also contacted U.S. Air Force personnel at Hill Air Force Base.

The purpose of this review is to determine whether the hazards to the Facility from cruise missile testing at the UTTR are adequately determined and acceptable. This review is based on an evaluation of information concerning potential hazards, safety procedures adopted to minimize the hazard potential, and distance from the Private Fuel Storage Facility site to the potential areas where a cruise missile hazard may exist.

The applicant has submitted information regarding planning of the flight trajectory of a cruise missile test on the UTTR, establishment of flight avoidance areas, safety planning and review of the test, additional safety procedures conducted prior to and during the test, and the Flight Termination System (FTS) installed on all cruise missiles.

According to the U.S. Air Force (1999), Wagner and Girman (2000), and Girman and Wagner (2001), the cruise missiles currently tested at the UTTR include (1) AGM-86B Air Launched Cruise Missiles (ALCM), (2) AGM-86C Conventional Air Launched Cruise Missiles (CALCM), and (3) AGM-129 Advanced Cruise Missiles (ACM). Both the AGM-86B and AGM-129 missiles use inert warheads. About three to four cruise missiles of each type are tested in a year. The AGM-86C missile is tested once or twice per year with a live warhead (U.S. Air Force,1999). Tomahawk (BGM-109) cruise missiles were last tested at the UTTR in 1998 (Wagner and Girman, 2000). All of these missiles (AGM-86, AGM-129, and BGM-109) are subsonic and autonomous cruise missiles. They can fly preprogrammed flights along designated routes. Approximately six cruise missile tests are planned annually at the UTTR.

According to U.S. Air Force information (1999), an ALCM (AGM-86B) is an autonomous guided weapon system. It flies to a target following complex routes using a terrain contour-matching guidance system. Flight profiles vary but they may utilize all restricted areas and Military Operating Areas (MOA) in the South range, subject to restrictions. Missile profiles that transit from the UTTR South Area to the North Area MOAs (Lucin) exist, but are rarely flown. Flight times vary depending on profile, but generally last 3 to 3.5 hours (U.S. Air Force, 1999).

The conventional air launched cruise missile (CALCM) (AGM-86C) is a variant of the AGM-86 equipped with a live conventional warhead. It can fly complex routes to a target through the use of an onboard Global Positioning System in conjunction with its Internal Navigation System. Flight profiles allow it to fly only in restricted airspace and only over DOD withdrawn lands. Its flight time is approximately 1.5 hours (U.S. Air Force, 1999).

The improved version of the ALCM is the advanced cruise missile (AGM-129). AGM-129 missiles have a greater range and accuracy than AGM-86 missiles. Flight profiles vary but may utilize all restricted areas and MOAs in the South range, subject to restrictions. Missile profiles that transit from the South range to the North range MOA’s (Lucin) exist, but are rarely flown. Flight times vary depending on the profile, but generally last 4 to 5 hours (U.S. Air Force, 1999).

The Tomahawk cruise missile can fly autonomously at subsonic speed along a preprogrammed route for the entire mission. It was developed in the 1970s to be launched from surface ships or submarines against land targets. It can fly preplanned mission profiles to the target through the use of a very accurate inertial measuring unit and a global positioning system in conjunction with the digital maps stored on board.

The UTTR restricted airspace has an area of 8,125 square nautical miles. Additionally, another 8,875 square nautical miles belong to various Military Operating Areas adjacent to the UTTR. However, only 2,700 square nautical miles of the UTTR airspace lies above the Department of Defense land (Figure attached with Private Fuel Storage Limited Liability Company, 2001c). The remaining 14,300 square nautical miles of air space is situated over lands belonging to the Bureau of Land Management, the State of Utah, and some privately owned lands (Girman and Wagner, 2001). The air traffic at the UTTR is maintained by Clover Control (299th Range Control Squadron).

Typically, cruise missiles are launched over Department of Defense (DOD) land west of Granite Mountain with adherence to the following limitations. The launches are confined to the northern and western parts of the UTTR. The launch sites are at least 30 statute miles away from the proposed PFS Facility site. The missiles are released from north-to-south or east-to-west directions. Therefore, the missiles are directed away from the proposed PFS Facility site (Wagner and Girman, 2000). The missiles are launched at altitudes between 15,000 and 20,000 ft above ground level, and descend to the planned altitudes after release. The nominal enroute altitudes depend on the mission profile and are usually between 10,000 to 500 ft above ground level.

There are four cruise missile target areas in the UTTR. The TS-1 target (Parkersville target complex about 5 mi northwest of Wig Mountain) is approximately 18 mi from the proposed PFS Facility site (Private Fuel Storage Limited Liability Company, 2000b, Tabs A and B; Girman and Wagner, 2001) and is located beneath the restricted airspace R-6402A. Target TS-2, located beneath R-6406A restricted airspace, is approximately 21 statute miles west of the proposed facility. Both the TS-3 and TS-4 targets are located beneath the restricted airspace of R-6407. These targets are approximately 42 and 44 statute miles west of the proposed facility (Private Fuel Storage Limited Liability Company, 2000b, Tabs A and B; Girman and Wagner, 2001). Cruise missiles with inert warheads launched over Department of Defense land west of Granite Mountain may impact at the Sand Island target complex (TS-4 target) (Enges-Maas,1999a).

The planning for a cruise missile test involves several organizations and requires a number of steps to ensure proper execution with maximum safety. The steps include mission planning (specifying test objectives, missile flight route selection with associated restrictions), target selection, missile and launch platform configuration specifications, mission firing plan (go/no-go decision criteria, mission recovery or termination requirements, contingency plans for anomalous events), and test system readiness assessment (Wagner and Girman, 2000). The 388th Range Squadron testing procedures for cruise missiles, developed by Air Force Flight Test Center, require operational hazard analyses and formal safety reviews of all test programs as well as safety reviews of a particular test mission. Safety review includes an operational hazard analysis comprising 31 steps to minimize risk. Steps that influence the safety of the proposed Facility from a cruise missile crash include:

- routes planned to avoid property and personnel,

- remote command and control capabilities to steer a missile,
- minimum weather characteristics to ensure chase aircraft can follow a missile,
- Airborne Range Instrumentation Aircraft to gather and relay telemetry data of vital missile parameters to the Mission Control Center,
- Mission Control Center real time picture for timely safety decisions,
- remote control system and FTS parameters and plans to keep the missile in safe areas,
- separate components for FTS and missile normal control,
- Airborne Range Instrumentation Aircraft relay of telemetry data to inform test conductors if the missile is receiving the FTS signal,
- Airborne Range Instrumentation Aircraft monitoring FTS signal to warn Mission Control Center of hazards,
- “what-if” procedures to decide on steps to follow under special circumstances, and
- multiple tracking capabilities monitoring the flight path at all time.

The 49th Test Squadron specifies additional safety criteria. In addition, the 49th Test Squadron maintains comprehensive lessons learned documentation from previous tests which is used in subsequent test planning. Additionally, contingencies for unusual events such as loss of Airborne Range Instrumentation Aircraft radio and chase aircraft radio relay; Remote Control and Command; and visual contact with the missile by the chase aircraft pilots, chase aircraft, Airborne Range Instrumentation Aircraft, and tanker(s) are reviewed before each test (Wagner and Girman, 2000).

The UTTR uses optical tracking, radar tracking, radio and telemetry relay, and ground stations that can transmit either remote control or flight termination instructions to a cruise missile. Transmitters located on the range will relay commands from the Mission Control Center. The Mission Control Center is located at Hill Air Force Base. The control center continuously receives signals from the missile in flight. Additionally, the Advanced Range Instrumentation Aircraft monitors the cruise missile test and relays telemetry data to the Mission Control Center.

Four to eight F-16/F-14 chase aircraft (a minimum of three is required for conducting a cruise missile test) accompany the missile throughout its flight path to enhance safety. These aircraft remain behind the missile to monitor its performance until the missile impacts the ground. If the chase aircraft pilots detect any malfunction of the missile, the Advanced Range Instrumentation Aircraft can be alerted so that the missile can be flown manually, or its flight can be remotely terminated. These aircraft are fitted with Remote Command and Control pods for manually flying the missile, if required. Two aircraft always track the missile while other aircraft refuel from a tanker. Hence, there are substantial provisions for monitoring and controlling cruise missiles to maintain a low probability of an uncontrolled crash.

The Air Force uses avoidance as one of the primary safety measures to protect facilities. Specifically, according to Air Force regulations, pilots are required to avoid occupied sites and no-fly areas by a minimum of one nautical mile. However, a safety buffer of 2 nautical miles has been established by the 49th Test Squadron (the organization responsible for conducting operational tests of the cruise missiles at the UTTR) and by the 388th Range Squadron of 388th Wing of Air Combat Command (the organization responsible for the UTTR) to avoid known occupied sites and no-fly areas so as to minimize risks. Test personnel and chase pilots are informed of the known avoidance areas.

At present, there are 17 inhabited locations in Skull Valley. The 49th Test Squadron does not plan the flight path of a missile test within 10 nautical miles of the proposed PFS Facility due to flight restrictions in Skull Valley and Dugway Proving Ground, the missiles' turn radii, and the locations of the targets at the UTTR (Wagner and Girman, 2000). The test squadron has elected to avoid the entire Skull Valley, the northern part of Sevier B MOA, and restricted areas R-6406B, and R-6402B for cruise missile testing (Girman and Wagner, 2001).

The flight trajectory of a cruise missile test is selected under the restriction of the range avoidance rule of 2 nautical miles and no-fly regions. An extensive test planning process, involving all test participants, is used to prepare for a missile test. The trajectory of the missile is verified by the test members and is programmed to remain within the restricted air spaces and military operating areas.

All cruise missiles are fitted with an FTS that is installed prior to testing on the UTTR (U.S. Air Force, 1999) since the missiles have the capability to cross the UTTR range boundaries or endanger range assets, inhabited sites, and sensitive areas. The FTS is required by the U.S. Air Force to be designed, tested, documented, and certified under Range Commanders' Council Standard 319-92 or the latest revision and Flight Termination Commonality Standard Document 319-99 (Private Fuel Storage Limited Liability Company, 2000b, Tab B; Wagner and Girman, 2000). Compliance with these standards ensures that the FTS will be compatible with the range systems and procedures. FTSs are certified by the Air Force for the duration of a program in the UTTR. Recertification is necessary if any modifications are made to approved systems, components, or test procedures. An FTS is approved only after acceptance of the FTS report and successful demonstration of the complete system (Private Fuel Storage Limited Liability Company, 2000b, Tab B).

The current standard defines a reliability requirement for the FTS of 99.9 percent at a confidence level of 95 percent. According to the Range Safety Officer, it is not possible to guarantee that the missile being tested would meet the existing range reliability criteria. However, the U.S. Air Force reviews the missile reliability specifications during the safety review process. If the specifications do not meet the current range reliability criteria, compensating measures are implemented to achieve a comparable level of safety.

The approved FTS installed on each cruise missile can (1) alter or terminate its flight almost instantly on command from the Airborne Range Instrumentation Aircraft or the Range Safety Officer at the Mission Control Center, and (2) terminate its flight automatically after failing to receive a designated signal from the Airborne Range Instrumentation Aircraft or ground stations for a preset time period (generally within 60 seconds). The Airborne Range Instrumentation Aircraft and support aircraft can also override the missile's programmed flight path and redirect it, if necessary, using the FTS to avoid weather or any other hazards. The missile also transmits confirmation signals in addition to the critical operating parameters to the Mission Control Center throughout the flight so that the Mission Control Center can monitor the missile and flight status. Prior to launching a cruise missile from a bomber, the Mission Control Center verifies that the FTS as well as the flight control systems and the missile's remote control systems are working properly (U.S. Air Force, 1998; Cole, 1999a; Wagner and Girman, 2000).

A missile is considered to have experienced an uncontrolled crash only if the crash occurred before reaching the programmed target (Enges-Maas, 1999a). On the basis of information from the Range Safety Officer, approximately 150 cruise missile tests have been conducted in the UTTR. Approximately 21 missiles (including some unmanned aerial vehicles) have been lost in mishaps in the State of Utah since 1983, with two of the mishaps involving the activation of the FTS (Cole 1999a, Banas 1999). Wagner and Girman (2000) and Girman and Wagner (2001) stated that 12 documented cruise missiles have crashed at the UTTR in the last 10 years out of approximately 80 tests.

There are two basic modes of malfunction of a test missile: (1) navigation system failure and (2) vehicle system failure. When required, a missile test is aborted either by diverting the missile path to an alternate path or by terminating the missile flight. Generally, the FTS would be activated only if the test data telemetry was downgraded or if a safety-related situation developed. All missile crashes in the UTTR listed by Banas (1999) are characterized as having met the range avoidance criterion. There was no case in which the FTS failed when it was needed to be activated. According to the U.S. Air Force (1999), the UTTR has never experienced an FTS failure. The staff examined the reported or estimated crash locations of cruise missiles and unmanned aerial vehicles in the UTTR. These locations were distributed in a pattern having a general north-south orientation trend, which correlates with the general flight path used in the missile tests (U.S. Air Force, 1999). Moreover, the crash locations cluster near Granite Mountain and Wig Mountain, the intended target sites for the missile tests.

FTS activation and missile diversion are effective only if there is sufficient time available. During low altitude test flights, it may not always be possible to activate the FTS in time to divert a malfunctioning missile away from a non-mission facility. Therefore, the flight trajectory is planned in such a way that a missile crash footprint, including debris, would avoid any non-mission facilities. The data show that the missiles generally crashed within half-mile or less of the intended flight trajectory. However, one case may have occurred in which the missile crashed more than one-half mile from the flight path (Lightfoot, 2000).

Cole (1999b) provided an excerpt from Accident Investigation Board Report, U.S. Air Force AGM–129, ACM, Serial Number 90-0061 (Department of the Air Force, 1998), about the crash of an AGM–129 ACM on December 10, 1997, near Dugway, Utah. The missile crashed after the completion of Nuclear WSEP test 98-02. The missile hit the ground at the site of a consortium of universities' cosmic ray observatory. Two trailers used for supporting telescope operations were damaged. According to the findings of the report, test planners were unaware of the astrophysical observation trailers on the Cedar Mountains. Therefore, the principal factor responsible for damage occurring to these trailers in this mishap was that the test planners were not informed of the presence of the observatory. The cosmic ray observatory is a non-mission facility located close to the target complex. The mission planners would have programmed the flight path of the missile differently had they been aware of the existence and location of the observatory (Department of the Air Force, 1998).

Another cruise missile crashed in June 1999 in the southern part of the Sevier B MOA on Bureau of Land Management property (Enges-Maas, 1999a). This cruise missile crashed in the Lake Sevier area, approximately 90 mi from the proposed Facility. Although the missile crashed outside DOD land boundaries, it remained within the UTTR air space. Accordingly, this crash does not reflect a cruise missile hazard to the proposed PFS Facility.

As discussed in Private Fuel Storage Limited Liability Company (2000b, Section XIII), the DOD maintains an Area Planning Guide. The guide is updated every 56 days. It is expected that the PFS Facility would be listed in the Area Planning Guide. Therefore, the mission planners would be aware of the existence and location of the Facility while planning for a flight path of a new cruise missile test. As the Facility will be a non-mission Facility for cruise missile tests, existing test planning procedures would direct the test planners to program the flight trajectories in such a way that the missile crash footprint including debris would avoid the Facility.

An uncontrolled crash of a cruise missile onto the Facility is possible only if there is a series of multiple failures of redundant safety features. Specifically, this would require simultaneous failures (e.g., operational or procedural error, component failure) associated with test planning and operations, Range Control Officer and Mission Control personnel, personnel at Airborne Range Instrumentation Aircraft, chase pilots, and the remote control and FTS. The probability of failure or malfunction of each of these elements of the overall system for missile safety and control is small. Therefore, the combined probability of a missile crash onto the Private Fuel Storage Facility site due to the failure of a series of safety features is judged to be extremely low.

Moreover, as discussed above, avoidance of a non-target facility is one of the primary safety measures used by the U.S. Air Force. The Air Force does not plan any cruise missile flight path to be closer than 10 nautical miles of the proposed PFS Facility. Also, as discussed earlier, the provision of the FTS provides an additional reliable means of termination of the missile flight before it can reach the proposed facility. Further, a qualitative assessment of the cruise missile hazard to the Facility can be made on the basis of historical data by considering the distribution of uncontrolled crash locations. The reported strike locations show an approximate orientation in a north-south direction, approximately the general flight path followed by these missiles. These locations are also generally clustered near the target locations. Hence, the distribution of reported crashes supports the expectation that probability of a crash onto the Facility site is negligibly low.

The staff reviewed the information with respect to potential hazards of cruise missile testing at the UTTR. The staff found the information acceptable because:

- Verifiable information from the U.S. Air Force was used to determine the number of cruise missile tests carried out annually, targets used in these tests, and the location of previous crashes.

- The U.S. Air Force uses avoidance as one of the primary safety measures to protect facilities. It establishes a 2-mi wide avoidance area from all non-mission facilities and no fly areas. The U.S. Air Force does not plan the flight path of a missile test within 10 nautical miles of the proposed PFS Facility and, in addition, avoids the entire Skull Valley. Test personnel and chase pilots are informed of the known avoidance areas.

- The U.S. Air Force uses operational hazard analyses and formal safety reviews for all cruise missile tests. Additionally, a comprehensive list of lessons learned is maintained.

- The UTTR, using optical tracking, radar tracking, radio and telemetry relays, and ground stations, monitors missile flights throughout a missile test and provides remote control or flight termination instructions to a cruise missile.

- Redundant and independent missile control is provided through Mission Control and Airborne Range Instrumentation Aircraft.

- Chase pilots verify the performance of the test missile including flight status and location at all times.

- All cruise missiles are equipped with an FTS, which will terminate the missile if it does not receive a radio signal. The FTS also can destroy and terminate the cruise missile flight on command from the Mission Control Room in case a weapon anomaly is detected. Based on the available information on FTS performance, the FTS would be able to terminate the missile flight significantly before it could reach the proposed facility, if required.

- Almost all, if not all, previous crashes are within one half-mile from the planned flight path.

- If there is a non-mission facility in the path of a non-functioning missile, the missile will be diverted or terminated to avoid a strike.

- It is expected that cruise missile test planners will be aware of the existence and location of the Facility, if constructed, through the flight avoidance instructions in the Department of Defense Area Planning Guide.

Based on the foregoing information, there is reasonable assurance that a cruise missile test at the UTTR will not pose a hazard to the Facility, because (1) the selected impact areas are at substantial distances from the proposed Facility site, (2) several low probability events need to take place before a cruise missile would hit a non-mission target within the UTTR, (3) run-ins for the weapons delivery do not cross Skull Valley, (4) a thorough safety review process is conducted prior to testing, (5) telemetry and chase planes are used to ascertain the flight of the cruise missile, (6) no-fly areas are established during the test, (7) an approved FTS system on all weapons is used, (8) historical data indicate a clustering of the missile strikes in areas in close proximity to intended targets, and (9) the frequency of cruise missile testing is relatively low.