# AIR FORCE TACTICS, TECHNIQUES, AND PROCEDURES 3-32.13

8 DECEMBER 2023

# AIRFIELD MARKING AND STRIPING AFTER MAJOR ATTACK

DEPARTMENT OF THE AIR FORCE

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| BY ORDER OF THE SECRETARY OF THE AIR FORCE | AIR FORCE TACTICS, TECHNIQUES, AND PROCEDURES 3-32.13 |
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**8 DECEMBER 2023**

***Tactical Doctrine***

# *AIRFIELD MARKING AND STRIPING AFTER MAJOR ATTACK*

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This publication supports Air Force Instruction (AFI) 10-210, *Prime Base Engineer Emergency Force (BEEF) Program* and AFI 10-209, *RED HORSE Program.* This publication applies to the Regular Air Force, the Air Force Reserve, and the Air National Guard. This publication does not apply to the United States Space Force. It addresses necessary actions to provide an alternate airfield marking and striping sequence to meet the Air Component Commander's Air Tasking Order (ATO) after attack. Refer recommended changes and questions about this publication to the Office of Primary Responsibility using Department of the Air Force (DAF) Form 847, *Recommendation for Change of Publication*; route DAF Form 847 from the field through the appropriate functional chain of command and Major Command publications/forms managers. Ensure all records generated as a result of processes prescribed in this publication adhere to AFI 33-322, *Records Management and Information Governance Program*, and are disposed in accordance with the Air Force Records Disposition Schedule, which is located in the Air Force Records Information Management System. The use of the name or mark of any specific manufacturer, commercial product, commodity, or service in this publication does not imply endorsement by the DAF.

**SUMMARY OF CHANGES:** This document has been substantially revised and must be completely reviewed. Major changes include Unit Type Code (UTC) equipment updates and Personal Protective Equipment (PPE) required during operations.

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# Chapter 1

# INTRODUCTION

**1.1. Background.** To ensure Commanders can generate sorties following an attack, the Airfield Marking Team must apply expedient techniques to expeditiously mark and stripe minimum airfield operating surfaces (MAOS) to support the commander's post-attack ATO.

1.1.1. Aircraft movement is extremely hazardous without appropriate airfield pavement markings in a post-attack environment. Marking and striping the MAOS provides visual cues necessary for pilots to safely operate on a battle-damaged airfield during taxi, launch, and recovery operations.

1.1.2. The minimum operating strip (MOS) is the smallest acceptable length and width of operating surface that meets an aircraft's mission configuration for launch and/or recovery, allows minimum clearances for operations, and can be readied to meet mission ATOs. Marking and striping allow pilots to visually acquire the airfield's MOS on approach. The repaired surface may be larger than the absolute minimum requirements for operations when there is minimal damage to the runway and most of the runway is rapidly recoverable. The selected MOS allows launch and/or recovery after mitigating the unexploded explosive ordnance (UXO) threat, clearing debris, and repairing damage.

1.1.3. The MAOS consists of access routes to/from aircraft staging locations (e.g., hardened shelters, parking ramp revetments, or dispersed parking spots) as well as the MOS; these access routes must also be marked when damage requires deviation from normal routes.

**1.2. Overview.** After Explosive Ordnance Disposal (EOD) personnel have mitigated UXO allowing sufficient space on the MAOS for the airfield recovery teams to begin operations, the Civil Engineer (CE) Unit Control Center (UCC) directs the Marking and Striping Team to begin operations when and where appropriate.

1.2.1. Layout of the MAOS consists of identifying, with traffic cones or paint, taxiway access, MOS corners, threshold, departure, and centerline, installation locations for the aircraft arresting system (AAS), and airfield lighting system components. Access taxiway centerlines, lead-in and lead-out nose-wheel guidelines, holding position lines, and changes in direction (curves) are also identified.

1.2.2. Marker employment consists of assembly and placement of MOS threshold and departure end markers, edge markers, Runway Distance Remaining (RDR) markers, AAS markers, and AAS assembly and placement markers.

1.2.3. Painting consists of striping the threshold, MOS centerline, departure, and blackout of existing airfield markings that might cause confusion. In addition, stripe useable access taxiway lead-in/out guidelines, aircraft holding position lines, and changes in access taxiway direction.

**1.3. Variations of Procedures.** It is likely the entire MAOS cannot be accomplished without disruptions. Legacy procedures had MOS layout precede pavement repairs. However, the time allotted to repair the amount of expected damage and the available recovery equipment, personnel, and vehicles will likely dictate changes to the sequence of marking and striping from those described in Technical Order (T.O.) 35E2-6-1, *Minimum Operating Strip Marking System, Layout and Marking Procedures for Rapid Runway Repair*.

1.3.1. Legacy marking procedures used "T" clear zones to mark crater repair areas that should not be entered by support teams until the crater has been repaired. Following an attack by current threat actors, it is unlikely "T" clear zones will be used to mark repair areas, as doing so would likely produce "T" clear zones throughout the entire MOS and leave little to no real estate for support teams (e.g., AAS, Marking, Airfield Lighting, and Water and Fuel System Repair) to begin their recovery efforts.

1.3.2. The new procedures include creating repair zones to identify those areas marked for repair. Follow T.O. instructions and task sequencing to the greatest extent possible; however, when marking and striping processes conflict with other recovery operations, task sequencing may be performed as described in **Chapter 4** of this publication to help expedite the process.

**1.4. General Safety Considerations.** In standard and nonstandard construction practices, there are multiple known risk factors in performing Rapid Airfield Damage Recovery (RADR) duties. It is vital to protect workers from hazards such as high-pressure subsystems and components, harmful solvents and adhesives, and silica dust.

1.4.1. The risks and safety factors involved with materials and operations should be identified and briefed to all relevant personnel prior to commencing RADR duties.

1.4.2. A key responsibility of supervisors is to ensure personnel have and wear the necessary PPE and individual protective equipment (IPE) for the working environment. Unsafe field operations while conducting RADR could cause long and short-term injuries, health issues, disable equipment, and negatively affect the mission.

**1.5. Published Guidance.** Review applicable safety standards and technical manuals for additional safety requirements before performing RADR operations. Guidance can be found in the following subparagraphs. Compliance with technical order warnings and cautions is essential.

1.5.1. DAFMAN 91-203, *Air Force Occupational Safety, Fire, and Health Standards*, lists PPE for selected CE activities. Although T.O. and other job-related publications address proper wear and use of PPE and IPE, workers ultimately have the responsibility to properly use, inspect, and care for protective equipment assigned.

1.5.2. Consult AFI 48-137, *Respiratory Protection Program* for training documentation procedures and inhalation guidance. Refer to 29 CFR 1910.133, *Eye and Face Protection*, AFI 48-127, *Occupational Noise and Hearing Conservation Program*, 29 CFR 1910.134, *Respiratory Protection* and 29 CFR 1926.1153, *Respirable Crystalline Silica* for additional guidance and information.

1.5.3. Handlers and users of any polymeric repair material should ensure a Safety Data Sheet from the manufacturer always accompanies the material. Before use, review and follow the Safety Data Sheet guidance for personal protective equipment and other safety precautions.

1.5.4. In accordance with Air Force Medical Readiness Agency Bioenvironmental Engineering (AFMRA/SG3PB) Policy Memo dated 30 Sept. 2020, “Commanders have the discretion to elect the use of the Joint Service General Purpose Mask M50 series protective mask as approved by Bioenvironmental Engineering or a National Institute for Occupational Safety and Health certified respirator for “Training events Only”. PPE is identified in **Table 1.1.**

**1.6. Personal Protective Equipment (PPE).** Supervisors should coordinate with the Bioenvironmental Engineering Flight and the Wing Safety office on the PPE needed to perform RADR operations. Brief safety procedures and appropriate PPE before operations and verify that all PPE has been approved for the work to be performed. See **Table 1.1** for listing of typical PPE for RADR operations.

**Note:** Breathing crystalline silica dust is a serious health hazard. Those performing duties where they may be exposed to silica dust should wear appropriate PPE (including respiratory and eye protection) according to Commander’s guidance.

**Table 1.1. Listing of Typical PPE by Operation.**

| Operation or Equipment | Typical PPE Required |
|---|---|
| Dump Truck | Safety-toe boots<br>Gloves |
| Loader, Grader, Sweeper, Backhoe, Bulldozer, Roller, Paver | Safety-toe boots<br>Gloves<br>Eye protection (dust and bright sun)<br>Hearing protection<br>Respiratory protection (if dusty)* |
| Jackhammer, Pneumatic Drill | Respiratory protection*<br>Safety-toe boots<br>Eye protection<br>Hearing protection<br>Gloves |
| Concrete Saw | Safety-toe boots<br>Eye protection<br>Hearing protection<br>Respiratory protection (if dusty)*<br>Gloves |
| Concrete Mixer | Safety-toe boots<br>Eye protection<br>Respiratory protection*<br>Hearing protection |
| Portable Power Tools | Eye protection<br>Hearing protection<br>Respiratory protection (if dusty)* |
| Paint Striping | Eye protection<br>Respiratory protection*<br>Gloves<br>Coveralls |
| *N-95, P-95, and R-95 respirator or M50 JSGPM, as directed by Commander. | |

**1.7. Additional Safety Precautions.** Personnel responsible for determining correct and proper MAOS marking and striping procedures should become thoroughly familiar with and frequently review the specific procedures and safety precautions listed in T.O. 35E2-6-1, *Minimum Operating Strip Marking System, Layout and Marking Procedures for Rapid Runway Repair,* and Paint Striping Set Operator's Manual.

1.7.1. Correct MAOS layout and marking is critical to the airbase recovery process. Incorrect MAOS striping or improper placement of edge, runway distance to go, and AAS markers may result in major aircraft damage and potential loss of life to flight and ground personnel.

1.7.2. Coordinate with Airfield Manager or designated representative on all matters pertaining to MAOS establishment to ensure appropriate setback clearances are achieved and/or appropriate airfield restrictions imposed/ disseminated to base agencies.

1.7.3. PPE (e.g., safety-toed boots, gloves, respirators, hearing and eye protection) are utilized by all personnel involved in layout, marking, and striping procedures.

1.7.4. Adhere to the following paint striping machine safety precautions.

1.7.4.1. Never put hands or other body parts under or near paint guns while the system is either running or under pressure. Injection of paint or other fluids such as hydraulic oil into the body may result in injury and possible amputation of the affected area. If fluid is injected into the skin, it is important to treat the injury as soon as possible.

1.7.4.2. Never attempt to repair high-pressure hoses or fittings—replace them.

1.7.4.3. Never attempt to stop or deflect leaks with your hand or body. Never plug a hose leak with your finger, with adhesive tape or other "stop-gap" device.

1.7.4.4. Never attempt to clean, oil, or adjust the paint machine while in use.

1.7.4.5. Never flush the paint machine system under high-pressure. Never spray solvent or other flushing material through the guns with spray tips in place. An explosion or fire may result from static electricity build-up in the presence of flammable vapors. Always remove spray tips prior to flushing the system.

1.7.4.6. Never wipe off build-up around the spray tips until pressure is fully relieved. When the need arises to work on paint guns and/or lines, always depressurize the entire system first.

1.7.4.7. Never use standard hardware to modify an airless or high-pressure system; use high-pressure fittings only. Call the manufacturer for proper replacement parts and components.

1.7.4.8. High-pressure hoses must never be kinked or bent less than a four-inch radius.

1.7.4.9. If static sparking or slight shock is felt while using the paint striping machine, stop spraying immediately. Check entire system for proper grounding.

**Note:** Do not use the system again until the problem has been identified and corrected. Ensure the ground strap, when provided, is always in place and in contact with the ground while operating.

1.7.4.10. It is recommended to mount a dry chemical fire extinguisher on the unit in a convenient location. Be familiar with its operation and keep it properly charged.

1.7.4.11. Never operate unit without guards or shields in place.

1.7.4.12. Wear safety glasses and hearing protection when operating the paint-striping machine. Loose clothing should not be worn when working around moving parts.

1.7.4.13. Never operate the unit without safety air relief valves in place. Keep them clean and in good working order.

# Chapter 2

# RESOURCES

**2.1. Personnel.** The MAOS Marking Team, totaling six individuals, is split into two crews to provide expeditious marking and striping capabilities.

2.1.1. Layout/Marker Placement Crew. An Engineering Journeyman (3E551) and three augmentees layout the MAOS and then place the remaining elements of the Minimum Airfield Operating Surface Marking System.

2.1.1.1. The Crew Chief (usually an Engineering Journeyman) should be sufficiently experienced on MAOS layout procedures, directing operations of the Layout/Marking Crew, and coordinating efforts through the RADR Support Chief.

2.1.1.2. The augmentees should be trained on basic layout requirements and be familiar with assembly of all markers. Crewmembers should be physically capable of handling and positioning marker components.

2.1.2. Paint Striping Crew. A Structural Journeyman (3E351) and one augmentee use the paint striping set to black out confusing/unnecessary lines and stripe the MAOS.

2.1.2.1. The Structures Journeyman should be sufficiently experienced to operate and maintain the paint striping equipment. They should also understand basic requirements for MAOS layout, directing efforts of the augmentee, and coordinate efforts with the Layout/Marking Crew Leader and the RADR Support Chief.

2.1.2.2. The augmentee should be familiar with the basic operations of the equipment and capable of operating the vehicle among base recovery operations. The augmentee should be physically capable of handling and loading heavy paint and retroreflective bead supplies.

**Note:** If the paint striper fails, manual application of paint with sprayers and rollers, and hand spreading of retroreflective beads will be necessary. Manual operations will likely require additional manpower to meet recovery timelines.

**2.2. System Equipment.** MAOS marking and paint striper equipment is available in two UTCs, which are the 4FWMS MAOS Marking Kit and the 4FWPS MAOS Paint Striper. Equipment items associated with the system are: 1) marking kit (e.g., traffic cones, edge markers, RDRs, and AAS markers) 2) paint striping kit (e.g., paint striper, paint, painting supplies, and tools). The MAOS Paint Striper UTC is primarily a RADR support UTC but is designed and equipped to support all deployed painting requirements.

2.2.1. Two full-size pickups (one for cones and markers and the other to mount the paint striper) with heavy-duty suspension and adequate loading/towing capacity; and one flatbed utility trailer, with at least a 1.5-ton capacity, to transport equipment (e.g., traffic cones, edge markers, and sandbags). The flatbed trailer facilitates loading and unloading of the equipment. The pickup and flatbed trailer are required to efficiently and quickly employ and layout the marking system. If a trailer is not available, a 1.5-ton cargo truck, or larger, may be required for cone and marker layout.

2.2.2. **Table 2.1** lists items of the marking kit and **Table 2.2** lists key items in the paint striper kit. The full inventory is located on the Expeditionary Engineering SharePoint™ at the following link: Paint Striper Full Inventory.

**Table 2.1. 4FWMS MAOS Marking Kit Items.**

| ITEM | QTY PER |
|---|---|
| AAS marker (**Figure 2.1**) | 4 |
| RDR (**Figure 2.1**) | 18 |
| Edge marker base (**Figure 2.1**) | 140 |
| Edge marker top (**Figure 2.1**) | 152 |
| Measuring wheel | 2 |
| Measuring tape, 300-ft | 3 |
| Shovel, D-handle, round point | 2 |
| Sandbags | 100 |
| Traffic cones, 18-inch | 50 |

**Table 2.2. 4FWPS Paint Striper Key Items.**

| ITEM | QTY PER KIT |
|---|---|
| Paint striper with accessories | 1 |
| Airless paint sprayer | 1 |
| Drum, 55-gal | 8 |
| Paint, traffic, black, 5-gal | 22 |
| Paint, traffic, white, 5-gal | 22 |
| Paint, traffic, yellow, 5-gal | 11 |
| Retroreflective Beads | 20 |
| Generator, 6kW | 1 |
| Assorted hand and electric tools and associated equipment | Various |
| **These quantities support up to a 10,000-foot MOS** | |

**Figure 2.1. Marking Kit Markers.**

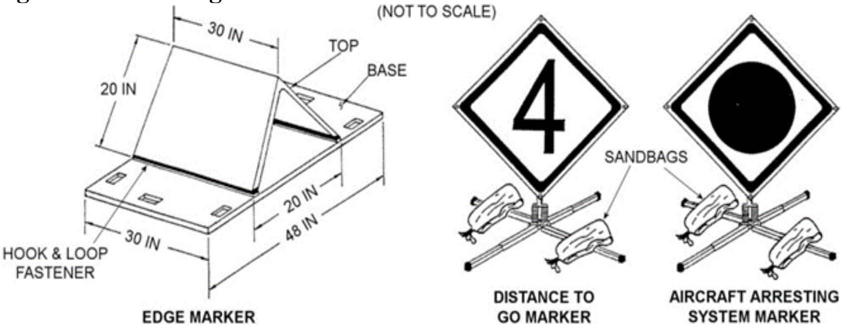
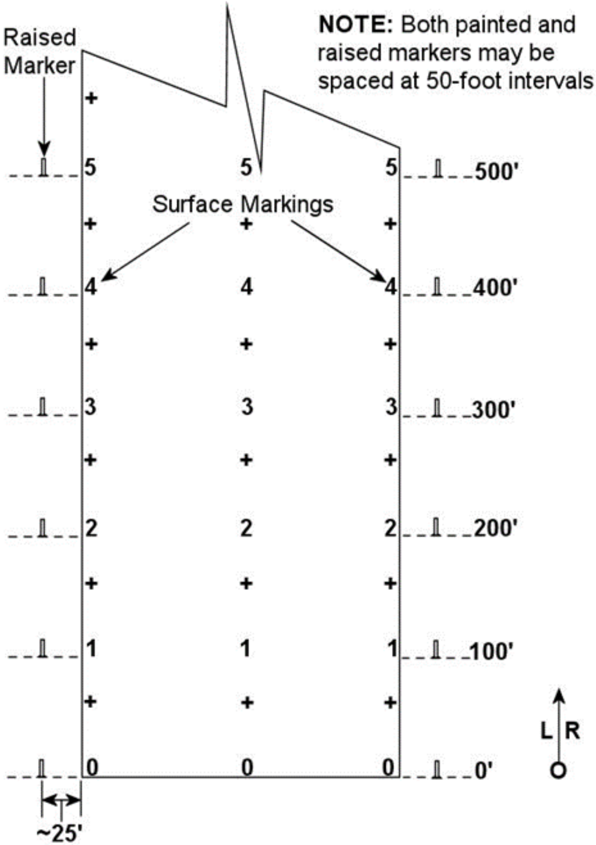



**Figure 2.2. EZ Liner AL120 Paint Striper.**

**Figure 2.3. MST-14 Skip Timer System.**


**2.3. Pavement Reference Marking System (PRMS).** The PRMS is not part of the marking kit but is used to identify locations on the runway (**Figure 2.3**). This reference system should be in place prior to an attack and able to withstand effects of an attack. To achieve maximum effectiveness, the PRMS should be employed on all takeoff or landing (ToL) surfaces. A zero point is established for each pavement surface.

**Figure 2.4. Typical Pavement Reference Marking System.**




2.3.1. To eliminate the need for time-consuming manual measurements, the PRMS provides visual cues to rapidly identify damage, UXO, Emergency Airfield Lighting System (EALS), AAS locations and MAOS coordinates. Damage and UXO are located by identifying distance from the zero point and distance right or left of the centerline.

2.3.2. Distance markings are painted on the pavement surface at 50- or 100-foot intervals along the centerline and along each pavement edge starting at the zero point. Additionally, raised markers (**Figure 2.5**) are placed at 50- or 100-foot intervals at a distance between 25 to 50 feet from the runway's edge on both sides of the runway to provide redundancy. Duplication and dispersal from the pavement edge helps ensure reference system survivability following an attack and during recovery operations. Normally, the raised markers are installed prior to an attack and included in the engineer attack preparation checklists in the CE Contingency Response Plan.

**Figure 2.5. PRMS Raised Marker.**


2.3.3. The PRMS employs three basic rules:

2.3.3.1. Zero Point Rule. For an airfield pavement section, the zero point is fixed. It does not switch from one end of the pavement to the other. The zero point is usually established at the runway threshold where normal aircraft operations occur.

2.3.3.2. Centerline Rule. All distances along the length of the pavement section are measured along the centerline from the zero point of that pavement.

2.3.3.3. Right/Left Rule. Right and left of the centerline are determined as viewed down the centerline of the pavement away from the zero point.

# Chapter 3

# PLANNING FACTORS

**3.1. The Situation.** The MOS is based on width and length of a runway surface supporting aircraft and mission configurations for emergency launch and/or recovery. The actual ToL surface may be larger than minimum aircraft requirements depending upon numerous factors influencing recovery such as: 1) sortie generation deadline; 2) physical damage to the ToL surface; 3) resources available to perform recovery operations; and 4) number and type of UXO to mitigate.

3.1.1. The mission and recovery situation largely dictates markings used to identify the MOS. Markings provide acceptable wartime concessions to peacetime practices and standards in order to provide rapid launch and/or recovery.

3.1.2. The marking system can be employed within acceptable mission planning timeframes for most useable ToL surfaces. Depending upon sortie generation timetables, airfield marking may take place simultaneously with other airfield recovery tasks or be one of the final actions completed. Marking and striping operations should be coordinated with the following activities:

3.1.2.1. Damage assessment and MAOS selection.

3.1.2.2. Mitigating UXO on routes from dispersal sites to the MAOS.

3.1.2.3. Clearance of large debris on routes to the MAOS.

3.1.2.4. Crater, camouflet and spall repair operations.

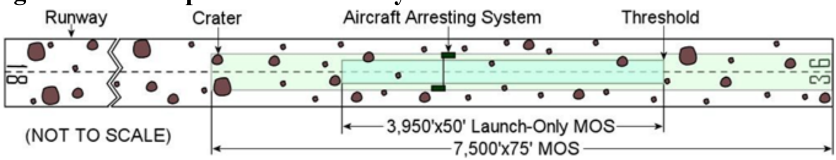
3.1.2.5. Final debris removal and sweeping of the MAOS.

3.1.2.6. AAS and airfield lighting installation.

3.1.3. Damage from the attack may require changes to the basic layout configuration described in the T.O. The MAOS layout is acceptable and meets launch and/or recovery criteria when it meets the requirements of the Senior Airfield Authority (SAA).

3.1.4. If the wing commander's priority is for immediate launch, the initial MOS may not be the final MOS and may not include all expedient markings. In this scenario, the MOS will probably be unidirectional. The theater mission and wing/installation commander's launch priorities can dictate one MOS for immediate launch purposes, while preparations for a fully capable, larger bi-directional MOS are under way for follow-on launch and recovery operations. **Figure 3.1** and the following two paragraphs provide an example of this possibility.

**Figure 3.1. Example of Launch-Only MOS.**




3.1.4.1. The SAA at Base X requires launch of one fighter squadron as soon as possible after the attack. The 150-foot by 10,000-foot runway is oriented in an 18/36 direction; the 36-end is the primary operational threshold. The runway is extensively damaged with large craters at both ends and ladder taxiways are also damaged. There are large numbers of spalls and UXO. Providing a MAOS for takeoff and landing will take at least 6.5 hours.

3.1.4.2. With less UXO mitigation and pavement sweeping required, a 50-foot by 3,950-foot launch-only MOS may be repaired and available in three hours. For this launch-only MOS, the SAA only requires edge and RDR markers, and a mobile aircraft arresting system (MAAS) installed 2,700 feet from the MOS threshold. While generating sorties from the launch-only MOS, EOD continues to mitigate UXO. Other CE forces begin repairing the 36-end and a ladder taxiway for a 75-foot by 7,500-foot ToL MOS. The final MAOS needs complete contingency marking and striping, an EALS, and relocating the MAAS.

**3.2. Planning Considerations.** Consider the following planning factors prior to commencing recovery operations.

3.2.1. The time to clear or repair the access route is a consideration in MAOS selection, therefore close coordination with EOD personnel is necessary. The entire width of the MOS is cleared and safed as a minimum, to include 300 feet beyond MOS edges and the first 1,500 feet before the MOS threshold (and departure end if the MOS will support bidirectional operations). Mitigating UXO precedes any marking activity by at least 2,000 feet ahead of the marking team.

3.2.2. Efficiencies may be gained by either the EALS crew or marking crew placing both edge lighting components and edge markers (**Figure 3.2**) simultaneously.

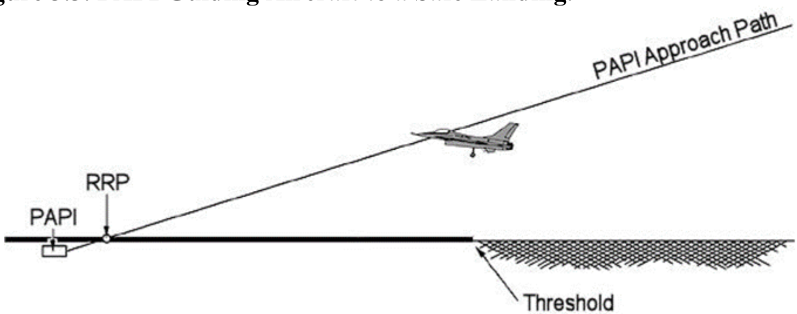
**Figure 3.2. Installing Contingency Lighting Inboard of Edge Markers.**

3.2.3. During initial MOS layout, set traffic cones at the correct positions for the approach lighting and Precision Approach Path Indicator (PAPI) units as a minimum in accordance with T.O. 35E2-6-1, *Minimum Operating Strip Marking System, Layout and Marking Procedures for Rapid Runway Repair*. If additional UXO and debris clearing is required in order to complete the lighting installation along with the MOS layout, ensure the airfield base recovery timetable reflects integration of the MOS layout and lighting installation.

3.2.4. **Table A2.1** of **Attachment 2** provides a checklist of actions (and questions to ask) that help determine system layout. The table is useful for planning runway recovery efforts along with airfield marking. It provides information to avoid conflicts during layout and installation of the marking and lighting systems. The CE Unit Control Center (UCC) and RADR Officer in Charge (OIC) may use portions of this table to track information required for layout.

**3.3. PAPI Location Factors.** It is particularly important, especially for emergency recovery of aircraft, to provide sufficient stopping distance on a short MOS. Adequate stopping distances are affected by the weather and pavement condition, especially in wet conditions. The pilot of an approaching aircraft depends upon the PAPI to help safely descend and land on the runway or MOS. A properly located and installed PAPI guides a pilot onto a runway's touchdown zone, maximizing aircraft rollout and safety margins for protection of both the pilot and the aircraft (**Figure 3.3**). For short MOS operations where stopping distance is a major consideration, there are four approaches to PAPI placement and installation that provide increased lengths for safer braking distances.

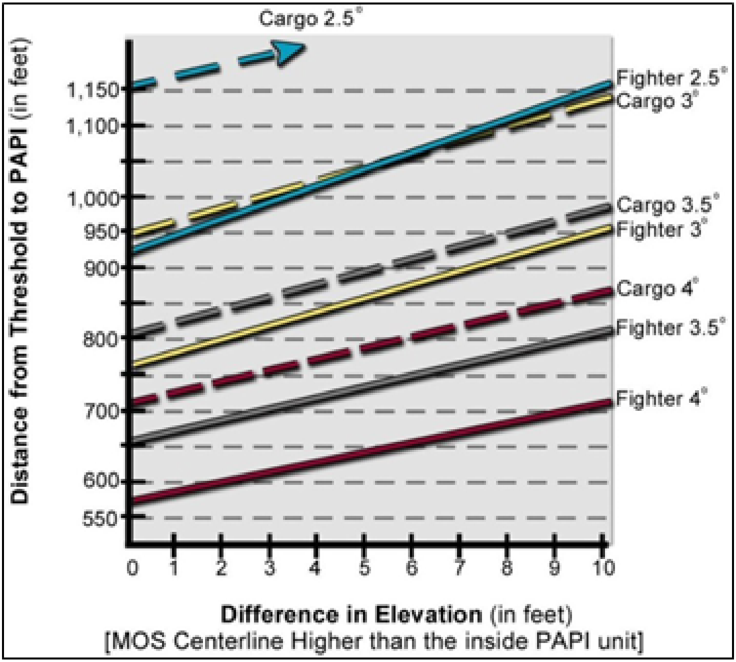
**Figure 3.3. PAPI Guiding Aircraft to a Safe Landing.**




3.3.1. The first approach is to use the exact PAPI to threshold distance (**Figure 3.4**) if that distance is less than the initial 950 feet location. **Figure 3.4** provides a graphic range of values for installing the PAPI from the threshold. It provides distances from the threshold to the PAPI location based on glide slope angles ranging from 2.5° to 4.0°, and height variations between 0 and 10 feet. The figure applies to fighter aircraft and cargo aircraft capable of, and approved for, short-field landings. Fighter aircraft can normally land with a PAPI distance to threshold less than the standard 950-foot distance. This is true even with large differences in elevation between the PAPI and the MOS. For example, with a glide slope of 3° and the PAPI installation site is 5-feet lower than the adjacent MOS centerline, the PAPIs may be installed 850-feet from the threshold. However, if the PAPI is adjusted for a 2.5° glide path approach angle for fighter aircraft, the 950-foot distance must be increased for height differences more than 2-feet.

3.3.2. A second approach is to raise the PAPIs so the centers of the lights are the same height as the runway reference point (RRP) at the MOS centerline (the RRP is on the MOS centerline where the pilot's line of sight intersects the runway according to the approach glide slope). This eliminates the need to increase the distance from the threshold or to change the standard 3.0° angle of the PAPI units. Using the same example as in **paragraph 3.3.1**, the PAPIs could be sited 760 feet from the threshold if raised to the height of the MOS centerline. The Layout/Marking Crew Leader determines the proper PAPI elevation.

**Figure 3.4. PAPI Distances from the Threshold.**




3.3.3. A third approach is to increase the glide path approach angle above 3° to provide additional runout area for stopping. This method is only feasible for fighter aircraft and cargo aircraft capable of, and approved for, short-field landings. Again, using the example in **paragraph 3.3.1**, if the glide slope were increased to 3.5° the PAPIs could be sited 735 feet from the threshold. The SAA approves this method.

3.3.4. The fourth approach is to use a combination of the methods above to increase aircraft runout and braking distance. For example, if the glide slope is 2.5° and the PAPI installation location is 10 feet below the adjacent MOS centerline, the glide slope could be raised to 3° and the PAPI could be raised 1 foot. Doing this would allow the PAPI to be placed 935 feet from the threshold. Again, the SAA approves this technique.

3.3.5. There may be numerous additional reasons requiring PAPI relocation other than braking concerns, such as conflicting with the required AAS location, the initial PAPI location is too close to the taxiway, damage at the runway or approach zones, or other obstructions.

3.3.6. The Emergency Operations Center (EOC) and CE-UCC should consider all the above when selecting the MOS. If a conflict becomes evident when siting the PAPI and/or AAS, contact the RADR OIC and the UCC/EOC to consider relocating the units based on the above approaches. Only the SAA can approve the relocation and adjustment of the PAPI units.

3.3.7. Even when there are no extreme variations in height along the MOS, consider leveling the PAPI installation area if there is a variation in elevation of more than 1 foot between the inside PAPI unit (beam center) and the MOS centerline. In this case, consider grading the areas between the MOS and the PAPI units to bring the units closer to the elevation of the MOS centerline. Contact the RADR Support Chief to address leveling the PAPI location if necessary.

3.3.8. Some airfields that slope up or down from the threshold may have already established peacetime adjustments for the threshold and glide path approach slope. If so, these peacetime adjustments for approach lighting should be considered for use if the MOS falls within the same runway elevation slopes. For more details on adjusting PAPI locations, based on runway to threshold slopes, see UFC 3-535-01, *Visual Air Navigation Facilities*.

3.3.9. An important point to keep in mind is the PAPI units within the EALS are a two-box L-881 system. Position the centerline of the inside unit 50 to 60-feet from the edge of the runway. Position the outside unit 20 to 30 feet from the inside unit. This separation is the distance between the outside edge of the inside PAPI unit and the inside edge of the outside PAPI unit. The larger separation increases the useable range of the system.

# Chapter 4

# MOS LAYOUT AND MARKING

**4.1. Introduction.** This chapter provides alternate MAOS marking and striping sequences after attack and may vary from the sequences given in T.O. 35E2-6-1 due to amount of damage resulting from the attack. The sequences provided in this chapter are recommended to reduce layout and marking time to the greatest extent possible. It is assumed pre-attack preparations have been accomplished as described in T.O. 35E2-6-1. The MAOS Marking Team Lead determines if the situation on the ground dictates a variation from the sequences given in T.O. 35E2-6-1 or this publication.

**4.2. Modified MOS Layout Sequence.** Layout the MAOS as shown in **Figure 4.1** when the layout sequence in T.O. 35E2-6-1 requires modification to meet post attack ATO requirements. The sequence shown is recommended when the MAOS is inundated with damage, repair crews, vehicles, or equipment preventing the layout sequence as described in the T.O. This sequence concentrates on layout of the peripheral locations to provide time for EOD and repair teams, to begin operations and progress down the MOS providing real estate needed to begin MOS layout. The layout crew follows paths made by the Foreign Object Debris (FOD) Team to the MOS threshold and begins MOS layout.

**Note:** If unable to follow the sequence above, move to the next task (if possible) and go back to the skipped task when appropriate. Whenever the situation prevents the team from beginning or continuing layout procedures, contact the RADR Support Chief to see if crewmembers may support the progress of striping, EALS, or AAS. Otherwise, assist repair teams or perform cleanup activities until layout operations can resume.

**4.3. Modified Marker Employment Sequence.** When damage, repair crews, vehicles, or equipment prevent marker deployment sequence as described in T.O. 35E2-6-1, *Minimum Operating Strip Marking System, Layout and Marking Procedures for Rapid Runway Repair*, install the RDR and AAS markers first (ensure

UXO have been mitigated in the installation location before installing markers). Then, employ edge markers as the situation permits (**Figure 4.2**).

**Figure 4.1. Layout Order of Operations—Unidirectional MOS.**

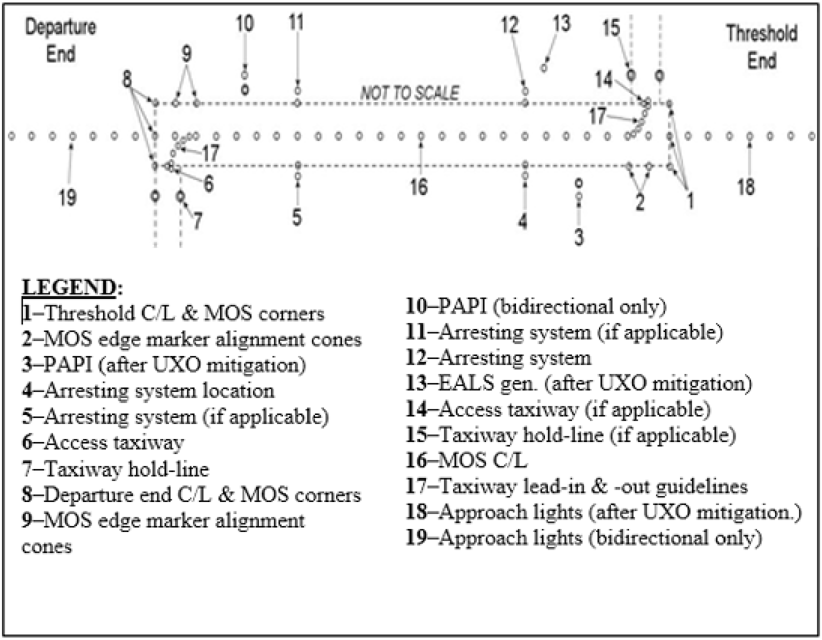
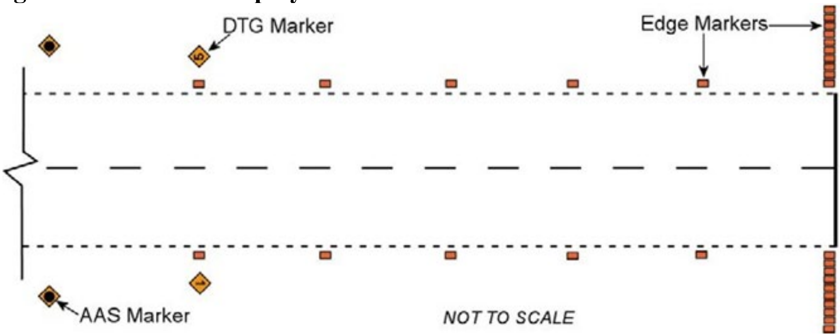


**Figure 4.2. Marker Employment.**



# Chapter 5

# MOS BLACKOUT AND STRIPING

**5.1. Introduction.** This chapter provides an alternate blackout and striping sequence after attack from those found in T.O. 35E2-6-1 due to amount of damage. The Team Lead decides if the situation on the ground dictates variation from procedures found in the T.O. or from those found in this publication.

5.1.1. The sequences presented here are recommended to reduce blackout and striping time to the greatest extent possible. It is assumed pre-attack preparations have been accomplished as described in T.O. 35E2-6-1.

5.1.2. To meet recovery timelines, striping cannot wait until all teams are out of the way as was the case during legacy Rapid Runway Repair operations. The Striping Crew works as it can, where it can. If an area is available for paint, but repairs have not initially cured (~45 minutes for concrete cap or when asphalt caps have reached 150°F), use a hand-wand to paint stripes on the repairs.

5.1.3. The paint striper can store two 55-gallon drums each with a different color. Switching between the drums can be accomplished without cleaning the paint striper. Because set-up of the striper is done pre-attack, initially load the striper with black and white paints based on T.O. priorities.

5.1.4. Normally, striping with white paint should be done first, blackout painting second, and access taxiway striping with yellow paint last. However, with the expected amount of damage being repaired on the MOS, blackout painting is likely to be first followed by white striping. Coordinate paint priorities with the RADR Support Chief.

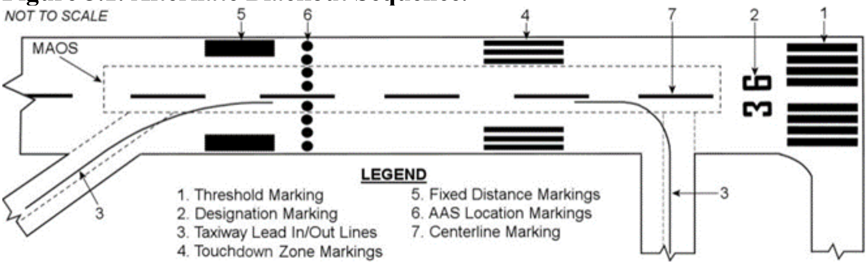
**5.2. Striping Sequence.** When possible, use the blackout priorities listed in T.O. 35E2-6-1; however, when operations prevent using this prioritized list, it is recommended to blackout markings in the order shown in **Figure 5.1**. This sequence allows time for the repair team(s) to open MOS areas and may vary depending on the situation. The Striping Crew begins by following the path made by the FOD Team to the threshold.

5.2.1. White centerline stripes are painted as areas become available. The striper does not require cleaning when switching between two colors which allows for easy changing between new striping and blacking out original markings. Therefore, not all blackout or striping needs to be completed before switching between operations which provides the flexibility to paint areas as they become available without having to perform time consuming cleanout of paint striper components.

5.2.2. Upon completion of blackout and white striping the striper requires cleaning to switch to yellow paint for taxiways.

5.2.3. The Crew Lead informs the Support Chief when personnel have completed their tasks so they may be loaned to other teams as necessary.

**Figure 5.1. Alternate Blackout Sequence.**

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## Attachment 1

## GLOSSARY OF REFERENCES AND SUPPORTING INFORMATION

***References***

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29 CFR 1910.134, *Respiratory Protection,* 20 April 2006

29 CFR 1926.1153, *Respirable Crystalline Silica*, 13 September 2023

UFC 3-535-01, *Visual Air Navigation Facilities*, 11 April 2017

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AFPAM 10-219, Volume 4, *Airfield Damage Repair Operations*, 28 May 2008

T.O. 35E2-6-1, *Minimum Operating Strip Marking System, Layout and Marking Procedures for Rapid Runway Repair*, 4 November 2013

***Prescribed Forms***

None

***Adopted Forms***

DAF Form 847, *Recommendation for Change of Publication*

*Abbreviations and Acronyms*

**AAS—**Aircraft Arresting System
**AFI—**Air Force Instruction
**AFTTP—**Air Force Tactics, Techniques, and Procedures
**ATO—**Air Tasking Order
**CE—**Civil Engineer
**C/L—**Center line
**DAF—**Department of the Air Force
**EALS—**Emergency Airfield Lighting System
**EOC—**Emergency Operations Center
**EOD—**Explosive Ordnance Disposal
**FOD—**Foreign Object Debris
**IPE**—Individual Protective Equipment
**MAOS—**Minimum Airfield Operating Surface
**MAOSMS—**Minimum Airfield Operating Surface Marking System
**MOS—**Minimum Operating Strip
**OPR—**Office of Primary Responsibility
**PAPI—**Precision Approach Path Indicator
**PPE—**Personal Protective Equipment
**PRMS—**Pavement Reference Marking System
**RADR—**Rapid Airfield Damage Recovery
**RDR—**Runway Distance Remaining
**RRP—**Runway Reference Point
**SAA—**Senior Airfield Authority
**T.O.—**Technical Order
**ToL—**Takeoff or Landing

**UCC—**Unit Control Center

**UTC—**Unit Type Code

**UXO—**Unexploded Explosive Ordnance

***Office Symbols***

**AF/A4C—**Director of Civil Engineers
**AFMRA/SG3PB—**Air Force Medical Readiness Agency, Bioenvironmental Engineering

***Terms***

**Access Route**—The route aircraft must take to/from the parking area/shelter to a ToL surface. Typically, the route meanders to avoid damage. The terms "transition path," "taxiway," and "transition route" are sometimes used to indicate an access route on a ToL surface.

**Airfield**—An area prepared for the accommodation (including any buildings, installations, and equipment), landing, and takeoff of aircraft.

**Air Tasking Order (ATO)**—A method used to task and disseminate to components, subordinate units, and command and control (C2) agencies projected sorties, capabilities and/or forces to targets and specific missions. Normally provides specific instructions to include call signs, targets, controlling agencies, etc., as well as general instructions.

**Approach Zone**—The end of the runway nearest to the direction from which the final approach is made. In relation to the EALS, the 1,400-foot clear zone before the MOS/runway threshold where approach zone lighting is installed.

**Apron**—A defined area on an airfield intended to accommodate aircraft for the purposes of loading or unloading passengers or cargo, refueling, parking, or maintenance.

**Bidirectional Runway**—A runway that supports aircraft operations in both directions.

**Contingency**—An emergency involving military forces caused by natural disasters, terrorists, subversives, or by required military operations. Due to the uncertainty of the situation, contingencies require plans, rapid response, and special procedures to ensure the safety and readiness of personnel, installations, and equipment.

**Damage Assessment**—The process of identifying and locating damage and unexploded ordnance following an attack. Damage assessment activities generally are separated into two categories: airfield pavements and facility/utility.

**Dispersal**—Relocation of forces for the purpose of increasing survivability.

**Explosive Ordnance**—All munitions containing explosives, nuclear fission or fusion materials, and biological and chemical agents. This includes bombs and warheads; guided and ballistic missiles; artillery, mortar, rocket, and small arms ammunition; all mines, torpedoes, and depth charges; demolition charges; pyrotechnics; clusters and dispensers; cartridge and propellant actuated devices; electro-explosive devices; clandestine and improvised explosive devices; and all similar or related items or components explosive in nature.

**Explosive Ordnance Disposal (EOD)**—The detection, identification, on-site evaluation, rendering safe, recovery, and final disposal of unexploded explosive ordnance. It may also include explosive ordnance, which has become hazardous by damage or deterioration.

**MAOS Selection**—The process of plotting damage and UXO locations on an airbase runway map and using this information to select a portion of the damaged runway which can be repaired most quickly to support aircraft operations.

**Minimum Airfield Operating Surface (MAOS)**—The combined requirement for airfield surfaces for both runway and access routes. The MOS is part of the MAOS.

**Minimum Airfield Operating Surface Marking System (MAOSMS)**—A visual marking system that provides material and equipment to mark a MOS between 50 and 150 feet wide and 10,000 feet long. In addition, the system can mark 25 to 75-feet wide taxiways.

**Minimum Operating Strip (MOS)**—1. A runway which meets the minimum requirements for operating assigned and/or allocated aircraft types on a particular airfield at maximum or combat gross weight. 2. The MOS is the smallest amount of area to be repaired to launch and recover aircraft after an attack. Selection of this MOS will depend upon mission requirements, taxi access, resources available, and estimated time to repair.

**Mitigation**—Activities designed to reduce or eliminate risks to persons or property or to lessen the actual or potential effects or consequences of an incident.

**Obliteration**—To do away with previous airfield pavement markings by painting over them with black paint.

**Ordnance**—Explosives, chemicals, pyrotechnics, and similar stores, e.g., bombs, guns and ammunition, flares, smoke, or napalm.

**Ramp**—see "apron."

**Recovery**—The development, coordination, and execution of service and site restoration plans for impacted communities and the reconstitution of government operations and services through individual, private-sector, nongovernmental, and public assistance programs that: identify needs and define resources; implement additional measures for community restoration; incorporate mitigation measures and techniques.

**Render Safe Procedures**—The portion of the explosive ordnance disposal procedures involving the application of special explosive ordnance disposal methods and tools to provide for the interruption of functions or separation of essential components of unexploded explosive ordnance to prevent an unacceptable detonation.

**Response**—Activities that address the short-term, direct effects of an incident. Response includes immediate actions to save lives, protect property, and meet basic human needs. Response also includes the execution of emergency operations plans and of incident mitigation activities designed to limit the loss of life, personal injury, property damage, and other unfavorable outcomes.

**Runway**—A defined rectangular area of an airfield, prepared for the landing and takeoff run of aircraft along its length. A runway is measured from the outer edge of the thresholds from one end of the runway to the others. The width of the runway is typically measured from the outer edge of the load-bearing pavement on one side to the outer edge of the load-bearing pavement on the other side. In some cases, the runway may be measured from the outside edge of the runway marking line on one side to the outside edge of the marking line on the other side and any remaining load bearing pavement is considered shoulder.

**Runway Designation**—A two-digit number that designates the magnetic heading of a runway. As viewed from an inbound aircraft, measure the heading of the runway centerline clockwise from magnetic north. Round the compass reading to the nearest 10° and drop the last digit (a zero). For example, when the magnetic heading of a runway/MOS is 068°, the runway designation is 07 (round 068 to 070 and drop the last digit). When viewed from the opposite direction, consider the pavement a separate runway, and its designation is 25 (180° in the opposite direction). Painted designations are normally on ends of runways, but not on a MOS.

**Runway Reference Point (RRP)**—The point on the runway centerline where the PAPI visual glide path intersects the runway.

**Runway Threshold**—A line perpendicular to the runway centerline designating the beginning of that portion of a runway usable for landing. Green lights mark the threshold end. When the threshold of a runway is co-located with the end of the opposite runway, the threshold/end lights have a split lens with green on one side and red on the other.

**Senior Airfield Authority (SAA)**—An individual designated/appointed by the component responsible for airfield operations at direction of the Joint Force Commander. The SAA is responsible for control, priorities, operation and maintenance of an airfield to include runways, associated taxiways, parking ramps, land, and facilities whose proximity affect airfield operations.

**Taxiway**—A specially-prepared or designated path on an airfield or heliport, other than apron areas, on which aircraft move under their own power to and from landing, takeoff, service, and parking areas.

**Unexploded Explosive Ordnance (UXO)**—Explosive ordnance which has been primed, fused, armed, or otherwise prepared for action, and which has been fired, dropped, launched, projected, or placed in such a manner as to constitute a hazard to operations, installations, personnel, or material, and remains unexploded either by malfunction or design.

**Unidirectional Runway**—A condition where, for whatever reason, aircraft take-off and land on the runway in only one direction. If that condition is not temporary, approach lights and strobes are required only at the approach end, and place RDR markers and lights only on the right side of the runway.

## Attachment 2

## MAOSMS Layout and MOS Planning Checklist

**Table A2.1. MAOSMS Layout and MOS Planning Checklist.**

| *Application* | *Required Action* |
|---|---|
| __1. MOS required in lieu of full runway | __1) Are standard marking criteria required?<br><br>__2) Contingency lighting:<br>__ a) Full layout?<br>__ b) PAPI only?<br><br>__3) Marking:<br>__ a) Full layout?<br>__ b) RDR and AAS marking?<br><br>__4) Striping:<br>__ a) Centerline?<br>__ b) Lead-in/out taxiway access?<br>__ c) Taxiway deviations?<br>__ d) Threshold/departure lines?<br>__ e) Blackout? |

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|---|---|
| __2. MOS | __1) What is the width?<br><br>__2) What is the length?<br><br>__3) Is the MOS unidirectional or bidirectional?<br><br>__4) Which end is the (primary) operational threshold? |
| __3. AAS | __1) Determine MAAS and MRES requirement.<br><br>__2) Determine if conflicts exist with other locations (RDR & edge markers, edge lights, & PAPIs).<br><br>__3) Determine installation method (soil, anchored, deadman). |

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| __4. UXO | __1) If UXO are present, obtain estimated time to clear work area and 300 feet from centerline.<br><br>__2) If layout requires work at both ends of MOS, inform Emergency Operations Center (EOC) that EOD may have to mitigate both MOS threshold and departure to allow initial MOS layout.<br><br>__3) Ensure EOD is aware of which end of MOS will be the threshold (for early UXO mitigation).<br><br>__4) Determine acceptable threat (determines QD calculations).<br><br>__5) Determine EOD capabilities (influences mitigation times). |
| __5. Threshold marking | __1) Will inverted "T" and centerline be required initially if initial MOS is for launch only?<br><br>__2) Will threshold markers be required initially if initial MOS is for launch only?<br><br>__3) Ensure "T" width at threshold and departure matches centerline stripe width. |

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| __6. Centerline | __1) Based on MOS length, local conditions, available paint/bead supply, and set-up of paint striper, determine width of centerline stripe (e.g., 30 to 36 inches wide).<br><br>__2) Are any crater repairs located within the MOS?<br><br>__3) If the MOS uses existing centerline, determine if EOC requires repainting of undamaged centerline stripes. |

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| __7. PAPI location<br><br>See UFC 3-535-01, *Visual Air Navigation Facilities*, for more information on siting PAPIs, to include when it may be necessary to install PAPIs on right side of MOS/runway. | __1) Measure 950 feet from the threshold end down left edge of MOS. Then measure 50 feet outboard of the MOS edge and estimate the MOS centerline height above this point. Determine the PAPI location correction distance as described in T.O. 35E2-6 (See UFC 3-535-01 for instances when PAPI must be sited on right side of runway).<br><br>__2) If sited area has major variations in height, coordinate with RADR Support Chief to coordinate leveling if possible. Otherwise, PAPI location must be adjusted.<br><br>__3) Are landing requirements or new obstructions requiring a change in location or adjustment of the glide path approach angles? |

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| __8. Edge Markers | __1) Establish standard edge marker setback distance (4 to 10 ft) from MOS edge.<br>**Note**: Install edge lights 1-ft inside edge markers.<br><br>__2) Align initial edge markers at threshold to allow 10 markers on the left and right sides of the MOS.<br><br>__3) If AAS is required, do not place markers in tape sweep area. |
| __9. RDR markers | __1) Determine available distance for RDR setback.<br>Consider UXO clearance, debris clearance, MOS width, & AAS setback requirements.<br><br>__2) Check for conflicts with AAS marker.<br><br>__3) Determine spacing distances for RDRs if uneven increments of 1,000 feet. |

| | |
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| __10. Access Taxiway centerline | __1) Obtain the minimum taxiway turning radius acceptable for mission aircraft from EOC.<br>**Note**: If specific data is not available, most fighter aircraft can use a 50-foot radius at low speed. Cargo aircraft (C-17 & C-130) emergency short-field operations can use a 90- ft radius.<br><br>__2) Determine beginning and end (e.g., lead-in and lead-out) locations for taxiway stripe arcs at the MOS.<br><br>__3) Check for conflicts with edge clearance. |
| __11. Holding Position Lines | __1) Holding position lines are painted across an access taxiway. Determine if existing "holding position lines" requires blackout and moved to accommodate the new MOS.<br><br>__2) If needed, paint new "holding position lines" 100 feet from and parallel to the MOS edge.<br><br>__3) Holding position lines consist of six-inch wide solid line and a six-inch wide dashed line separated by a six-inch wide gap. Dashes and spaces alternate every three feet. |

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| __12. Striping Blackout | __1) Determine if blackout of any pavement marking is required if MOS is for immediate launch.<br><br>__2) Determine airfield markings to blackout for normal MOS operations (e.g., launch and recovery). |
| __13. Reporting to RADR OIC/EOC | __1) Any conflicts with marking system installation criteria?<br><br>__2) Any UXO & debris clearance problems or set- back conflicts unresolved by RADR OIC/EOD?<br><br>__3) Any leveling problems or conflicts in siting the AAS and PAPI?<br><br>__4) Must marking criteria be changed to allow workarounds?<br><br>__5) Contact EOC to obtain SAA approval for workarounds. |