MEC HA Framework Option Paper #3:
Recommended Input Factors

1.0 INTRODUCTION

This paper presents recommendations for input factors to be included in the MEC HA framework. These recommendations are based on the applicable performance criteria for input factors described in Option Paper 1. This paper also identifies three components that can be used to characterize explosive hazard. The organizational support that these components provide will assist in the identification of an optimum set of input factors, as well as provide support for the development of the MEC HA structure (as shown in Option Paper 4). The recommended input factors are presented in the context of describing these components of explosive hazard. The recommended input factors are summarized, as are issues to be addressed before the input factor selections are finalized.

1.1 Background

Input factors describe the characteristics of a site that determine the explosive hazard at the site. A large number of hazard assessment models exist that have used almost every kind of input factor that could possibly be related to the assessment of explosive hazards.

The recommended performance criteria for input factors (as described in Framework Options Paper 1) are:

1. Input factors can be clearly and unambiguously defined.
2. The values for input factors are easy to determine or estimate.
3. The ranges of possible input factors values encompass all likely values for that factor.
4. Input factors included in the framework add to the functionality of the MEC HA process – each factor contributes to assessing the level of hazard for a site
5. Input factors included in the framework address all site characteristics that may lead to explosive hazards.

This paper primarily addresses the fourth and fifth performance criteria. The fourth criterion essentially specifies that the selected input factors all be necessary for describing the explosive hazard – that there are no redundant or extraneous factors. The fifth criterion specifies that the selected input factors be sufficient to fully describe the site-specific explosive hazard. The remaining criteria address implementation issues – how the input factors are described and how their values are determined and subsequently described – and will not be explicitly addressed in this paper.

1.1.1 Summary of Previous Input Factor Discussions

The initial input factors were based on the structure of a CSM. Specifically, the factors are sorted into three categories, reflecting the three parts of the CSM:

- Source — factors that describe the explosive hazard inherent in the site.
- Pathway — factors that describe site characteristics that affect the likelihood that people will come into contact with MEC

- Receptors — factors that describe specific actions of receptors that may bring them into contact with MEC

Consensus was reached at the May meeting on the *tentative* identification of a core set of input factors for each of the three categories, recognizing that the category assignments could change as the MEC HA process and guidance is developed. These consensus factors are described below.

Consensus Source Factors: Input factors in this category will describe the explosive hazards inherent at the site due to past munitions-related use that occurred at the site. The group agreed that the following factors should be included in the "source" category:

- Type of MEC
- Fuzed or unfuzed
  - If fuzed, sensitivity of fuzing
  - If fuzed, fuze armed or unarmed
- Net explosive weight (NEW)
- Condition: fired (UXO), stressed by disposal activity (UXO), discarded (DMM)
- Source area type (e.g., target area, open detonation area, firing point)

Consensus Pathway Factors: The following input factors were identified for the "pathway" category:

- Current and future land use (may be separated into two factors)
- Site accessibility
- Site barriers (may be combined with Site Accessibility factor)
- MEC depth
- Potential for erosion or other migration mechanisms
- Intensity of activity, including intrusive depth (also included as a possible receptor factor)
- Physical site features such as topography and vegetation

Consensus Receptor Factors: Core input factors related to the receptor category included the following:

- Frequency of entry
- Intrusive depth
- Intensity of activity (also included as a possible pathway factor)
- MEC amount
- Portability

A number of issues were identified with this preliminary consensus. Among the issues is the difficulty in deciding which category certain input factors belong in (e.g. Pathway or Receptor). The discussion on the Components of Explosive Hazard below attempts to resolve this confusion and focus the input factors on the hazard effects.

2.0 COMPONENTS OF EXPLOSIVE HAZARD

In order to determine only the input factors that are necessary and yet sufficient to describe site-specific explosive hazard, it is first necessary to robustly define what the input factors are intended to describe. The MEC HA should be designed around the components of the explosive hazard problem at a site. This section identifies and defines the components of explosive hazard. Understanding of these components leads to a somewhat different organization of input factors than originally proposed.

2.1 <u>Definitions</u>

The definitions and procedures contained in *MIL-STD-882D, Department of Defense Standard Practice for System Safety* (10 February 2000) provided a useful context for defining and analyzing explosive hazard.

MIL-STD-882D "…addresses an approach (a standard practice normally identified as system safety) useful in the management of environmental, safety, and health mishap risks encountered in the development, test, production, use, and disposal of DoD systems, subsystems, equipment, and facilities. The approach described herein … provides a consistent means of evaluating identified mishap risks."[1]

Useful definitions from the standard include[2]:

"3.2.3 Hazard. Any real or potential condition that can cause injury, illness, or death to personnel; damage to or loss of a system, equipment or property; or damage to the environment.

3.2.6 Mishap. An unplanned event or series of events resulting in death, injury, occupational illness, damage to or loss of equipment or property, or damage to the environment.

3.2.7 Mishap risk. An expression of the impact and possibility of a mishap in terms of potential mishap severity and probability of occurrence.

A.3.2.4 Mishap probability. The aggregate probability of occurrence of the individual events/hazards that might create a specific mishap.

A.3.2.5 Mishap probability levels. An arbitrary categorization that provides a qualitative measure of the most reasonable likelihood of occurrence of a mishap resulting from personnel error, environmental conditions, design inadequacies, procedural deficiencies, or system, subsystem, or component failure or malfunction.

A.3.2.6 Mishap risk assessment. The process of characterizing hazards within risk areas and critical technical processes, analyzing them for their potential mishap severity and probabilities of occurrence, and prioritizing them for risk mitigation actions.

[1] Excerpted from Item 3 of the Forward on page ii of the standard.
[2] Numbers preceding the definitions refer to paragraph numbers in the standard.

A.3.2.7 Mishap risk categories. An arbitrary categorization of mishap risk assessment values often used to generate specific action such as mandatory reporting of certain hazards to management for action, or formal acceptance of the associated mishap risk.

A.3.2.8 Mishap severity. An assessment of the consequences of the most reasonable credible mishap that could be caused by a specific hazard.

A.3.2.9 Mishap severity category. An arbitrary categorization that provides a qualitative measure of the most reasonable credible mishap resulting from personnel error, environmental conditions, design inadequacies, procedural deficiencies, or system, subsystem, or component failure or malfunction."

2.2 Components of Explosive Hazards

Applying these definitions to the MEC HA process, the mishap of concern is the unintended functioning of an MEC item due to the interaction of a member of the general public (i.e., a receptor) with the item. The MEC HA is being developed to assess the hazard, that is, the real or potential condition or conditions of the site that might lead to this mishap. In order to assess this hazard, the mishap risk, which is the probability and severity of the mishap, must be assessed.

The severity of the mishap can be described by a single component:

- The potential consequences (e.g., death, severe injury, property damage, etc.) of the item functioning.

The mishap probability is determined by three components:

- The likelihood that a receptor will be able to interact with an MEC item.
- The likelihood that the item will function due to receptor interaction.
- The likelihood that a receptor *will* interact with an MEC item.

The information needed to assess the third component would involve predicting human behavior, and the working group has already indicated that such predictions are not feasible to undertake in this effort (see notes for the May 4-5 meeting regarding the estimation of probabilistic risk). Therefore, the three components of explosive hazard that will be addressed by the MEC HA are:

- The potential severity of the impact to a receptor or receptors should an MEC item function.
- The likelihood that a receptor will be able to interact with an MEC item.
- The likelihood that the item will function if a receptor interacts with it.

These three components can be used to focus the input factor selection effort. They will also be useful in organizing and informing the development of the MEC HA structure.

The three traditional input factor categories (source, pathway and receptor) will be useful to project teams in identifying the sources of information to determine input factor values. However, the three components derived here provide a more efficient and illuminating description of the circumstances leading to a potential explosive mishap. The relationships between the components of explosive hazard and the input factor categories as defined above are:

- Factors in the source category will describe the potential severity of impact, the likelihood that a receptor can interact with an item, and likelihood that an MEC item will function.
- Factors in the pathway category will describe the potential severity of impact and the likelihood that a receptor can interact with an item.
- Factors in the receptor category will describe the likelihood that an MEC item will function and the likelihood that a receptor can interact with the item.

2.3 Factors to Describe the Components of Explosive Hazards

Recommended input factors to describe each of the explosive hazard components are discussed below. When potential values for a factor are given, they are listed in descending order of hazard severity.

2.3.1 Factors to Describe the Potential Severity of Impact

Two primary munitions characteristics can describe the potential severity of impact should an MEC item function:

- Type of filler
- Amount of filler

Two additional input factors describe the potential severity of a result should an MEC item function:

- Proximity to Occupied Buildings or Commonly Used Facilities
- Proximity to Critical Infrastructure, Cultural Resources or Ecological Resources.

Each of these factors is discussed below.

Type of Filler: Values for this factor include:

- High Explosive (HE)
- Incendiary (e.g., white phosphorous)
- Spotting Charge
- Completely Inert

In the case where multiples types of fillers are at a site, the value assigned to this factor should be the filler that poses the most severe hazard. One issue is how to score incendiary fillers relative to HE fillers. The MRSPP EHE module classifies munitions containing white phosphorous (WP) as "sensitive", the highest (i.e., most hazardous) score. The reasons behind that classification will be considered during the development of the MEC HA.

Amount of Filler: This factor can be used to describe potential severity of impact in three different ways. First, this factor addresses the situation when the amount of spotting charge in an otherwise inert munition poses a significant hazard in itself. For example, large practice bombs may use 50 pounds of black powder as spotting charges. While these bombs are not high explosive, the large amount of black powder presents a hazard. In the development of the MEC HA guidance it will be important to determine the amount of black powder that poses a catastrophic hazard vs. the amount that will result in negligible consequences.

The second possible way to use this factor may require careful consideration during the framework development process. The amount of filler factor can be used to distinguish between the likely consequences of a detonation. In other words, the potential impact of the functioning of a 20mm projectile is different than the impact of the functioning of a 100 lb bomb. The functioning of any HE round can result in death. There is, however, probably a threshold below which death is highly unlikely, as well as one above which death is assured for any receptor close enough to the item to cause a detonation. The issue that must be addressed is whether it is necessary or desirable to distinguish between these levels of impact.

The third way to use this factor for HE, is with the next possible input factor to address the impact on people or facilities beyond an individual receptor.

<u>Proximity to Inhabited Buildings, or Commonly Used Public Facilities</u>: The explosive hazard components described above assume the functioning of a munition due to the interaction of a single individual, but it may be useful to incorporate the potential for injuring or killing additional people, in the determination of the severity of impact. If inclusion of this factor is deemed appropriate, then it may be most useful to assign values to the proximity factor based on the explosive quantity safety distance (or some similar measure) for the NEW of the filler.

<u>Proximity to Critical Infrastructure, Cultural Resources or Ecological Resources:</u> Breaking out of these factors recognizes that the severity of the explosive hazard will affect more than humans. Since the issue is not death, but destruction of important locations/infrastructure, valuation of this area must be carefully considered.

2.3.2 Factors To Describe The Likelihood That Receptor Will Be Able To Interact

The likelihood that a receptor will be able to interact with an MEC item is described by:

- Site accessibility
- Frequency of entry
- Amount of MEC
- Minimum depth of MEC relative to maximum intrusive depth of receptor activity
- Potential for migration of MEC items (by erosion, frost heave, etc.)

<u>Site Accessibility</u>: Suggested values for this factor are:

- Fully accessible (includes sites wholly or partially surrounded by unguarded barbed-wire fencing)
- Accessibility limited by unguarded fence, dense vegetation, or moderately steep terrain
- Accessibility limited by guarded fence or less than 4 feet of water
- Accessibility limited by extremely steep terrain or more than 4 feet of water.

Frequency of Entry: Usually, the values for this input factor are specified as ranges of absolute numbers per day or week or month (e.g., 0-2 entries per day, 2-10 entries per week, etc.). Use of ranges of absolute values for this factor may limit its usefulness in helping to prioritize sites, for example, on MRAs or installations with multiple sites where the frequency of entries are all within one or two ranges. It may be more useful to determine the value of this factor based on MRA- or installation-specific relative rankings of the frequency of entry for all sites within the MRA or installation.

Amount of MEC: Ways of determining values for this factor were discussed in Issue Paper 6 from the briefing materials for the kick-off meeting (see pages C-26 to C-30 of the May 4-5, 2004 briefing book). The recommended option in that paper was to use the past munitions-related use of a site (i.e., the source area type) as an indicator of the amount of MEC, perhaps modifying the score for the factor based on intensity of past use and whether or not the site had been cleaned up. This is still the recommended approach to determine the values for this factor.

Minimum Depth of MEC and Maximum Intrusive Depth: Most existing hazard assessment methods treat these as two separate factors, but the contribution of these factors to the likelihood of receptor interaction comes from the relationship between these two depths. Explicitly quantifying this relationship for assessment in the MEC HA will highlight the importance of this factor in determining likely receptor exposure to MEC.

Potential for MEC Migration: This factor addresses the potential for MEC to migrate either laterally or vertically to a location that makes it accessible to receptors. An example of lateral migration is MEC "washing down" from an inaccessible area to an accessible one due to the mechanism of erosion. Another example is MEC washing up to an onshore MRS from an offshore source area. And of course, there may be the potential for the minimum MEC depth to decrease due to erosion or frost heave.

2.3.3 Factors to Describe the Likelihood that an Item will Function

Factors to describe the likelihood that an MEC item will function should a receptor interact with the item include:

- MEC Category
- Fuzing sensitivity
- MEC Portability
- Intensity of Receptor Activity

MEC Category: The values for this factor are:

- Unexploded Ordnance (UXO)
- Discarded Military Munitions (DMM)

UXO items are fuzed and assumed to be armed. DMM items are either unfuzed or fuzed but unarmed.

Fuzing Sensitivity: Fuzing sensitivity may be described by four values:

- UXO with sensitive fuzing
- UXO with fuzing of normal sensitivity
- DMM with HERO-sensitive (electronic) fuze
- DMM, unfuzed or with unarmed non-electronic fuze

This set of values takes into account the idea that unarmed, HERO-sensitive fuzes (i.e., electronic fuzes) may be somewhat more hazardous than other unarmed fuzes, due to the sensitivity to electromagnetic radiation. It may be necessary to more fully research this issue before finalizing this distinction. It will be necessary to identify what classes or types of fuzes qualify as sensitive when armed.

MEC Portability: The more portable an MEC item is, the more likely it is to be picked up or be moved in another way, either advertently or inadvertently. This increase in the likelihood that the item may be moved increases the likelihood that the item may function.

Intensity of Receptor Activity: This factor describes the amount of energy imparted to an MEC item by receptor activities. That energy can be mechanical (e.g. the impact of ATVs on a sub-surface UXO) or thermal (e.g. a campfire built over a cache of buried DMM). This factor has been used in other hazard assessment methodologies to capture the possibility that receptor activities on the surface may cause subsurface MEC items (presumably at shallow depths) to function.

2.4 Relationship of Recommended Factors to Recommended Consensus Factors

It is recognized that in some instances the input factors recommended here are different than the recommended consensus factors. One of the outcomes of the analysis and recommendations in this paper are the identification of the characteristics of the more general input factors such as “type of MEC” and “Current and future land use” that are essential to describing site-specific explosive hazard. For example, the four munitions characteristics that are recommended here (filler type, filler amount, fuzing type and portability) are determined by the type of MEC present at the site. Land use characteristics recommended here include proximity to inhabited buildings and other facilities; frequency of entry; maximum intrusive depth; and intensity of activity. The following table summarizes the relationships between the input factors recommended in this paper and the recommended consensus input factors.

Explosive Hazard Component	Recommended Input Factor	CSM Based Input Factor Category	Relationship to Recommended Consensus Input Factors Identified at May Meeting

Potential severity of the impact should an MEC item function.	Type of filler	Source	Characteristic of “Type of MEC”
	Amount of filler	Source	Related to NEW, also a characteristic of “Type of MEC”
	Proximity to Inhabited Buildings or Commonly Used Public Facilities	Pathway	Characteristic of current or future land use
	Proximity to Critical Infrastructure, Cultural Resources, or Ecological Resources	Pathway	Characteristic of current or future land use
Likelihood that a receptor can interact with an MEC item	Site accessibility	Pathway	Same; also addresses characteristics of “Physical Site Features” and “Site Barriers”
	Frequency of entry	Receptor	Same, also a characteristic of land use
	Amount of MEC	Receptor	Same
	Minimum MEC depth/Maximum intrusive depth	Pathway/ Receptor	Both factors are the same; maximum intrusive depth is related to land use
	Migration potential	Pathway	Same as “Potential for Erosion or Other Migration Mechanisms”
Likelihood that item will function should receptor interaction occur	MEC Category	Source	Encompasses “MEC condition” and fuzed or unfuzed
	Fuzing sensitivity	Source	Same
	MEC portability	Receptor	Same
	Intensity of Activity	Receptor	Same; also a characteristic of land use

The only recommended consensus input factor that is not explicitly recommended here is the Source Area Type factor. However, it is expected that this factor will be used as the source of input factor values for “Amount of MEC”, as recommended in previous issue paper 6.

3.0 RECOMMENDATIONS

The MEC HA will be organized around the Components of Explosive Hazard. By systematically considering each Component of Explosive Hazard, the key input factors necessary to efficiently assess explosive hazard can be identified.

The following table summarizes the recommended input factors described above. In addition, specific issues of concern associated with these factors are presented. These issues will be addressed by the TWG-HA as part of the development of the MEC-HA.

Explosive Hazard Component	Input Factor	Issues of Concern	Comment
Potential severity of the impact should an MEC item function.	Type of filler	Scoring of WP relative to HE	
	Amount of filler	Determine what use or uses this factor will have: apply this factor to spotting charges; use for HE to determine likely consequences of detonation; use for HE in conjunction with the proximity factor	Need to determine amount of spotting charge that poses catastrophic hazard and amount below which only negligible hazard can be assumed.
	Proximity to Inhabited Buildings or Commonly Used Public Facilities	See above	Proximity may be valued in terms of explosive quantity safety distance (EQSD) or other similar measure.
	Proximity to Critical Infrastructure, Cultural Resources, or Ecological Resources	See above	Proximity may be valued in terms of explosive quantity safety distance (EQSD) or other similar measure.
Likelihood that a receptor can interact with an MEC item	Site accessibility	NA	NA
	Frequency of entry	Use absolute scoring, or use relative ranking of site within an MRA or installation	NA
	Amount of MEC	NA	Recommend that source area type be used to represent MEC amount
	Minimum MEC depth/Maximum intrusive depth	NA	NA
	Migration potential	NA	NA
Likelihood that item will function should receptor interaction occur	MEC Category	NA	NA
	Fuzing sensitivity	Determination of which fuzes qualify as sensitive when armed	Research hazard of unarmed HERO-sensitive fuzes
	MEC portability	NA	NA
	Intensity of Activity	Only apply when MEC has armed, sensitive fuze	NA