HOLISTIC RISK-BASED APPROACH TO IDENTIFY SIGNIFICANT ENVIRONMENTAL ASPECTS WITHIN AN ENVIRONMENTAL MANAGEMENT SYSTEM

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Abstract: Environmental Management Systems (EMSs), such as ISO 14001 and EMAS, are used by many organizations across the globe, with the overarching goal of continual improvement of environmental performance. Proponents claim that properly implemented, supported, and maintained EMSs will result in many organizational benefits; detractors claim EMSs are more akin to "greenwashing" and do not provide much in the way of organizational benefit. Central to EMSs is the identification of *significant* environmental aspects, which many consider to be the most important and the most difficult piece of the EMS process. Due to a lack of specificity in EMS guidance regarding how to determine significance, many different protocols have been independently developed. These many processes contain various weaknesses that limit their usefulness to broad application. The Aspect-Impact-Mitigation (AIM) Prioritization Program was originally developed to provide a holistic risk-based approach to identify significant environmental aspects in accordance with the guidance in the ISO 14001 standard. While the current version of AIM orders environmental aspects by relative risk (i.e., significance), it is not without its own shortcomings, which are addressed in this research. The outcome of this research — a revised AIM approach — will represent an improved process of identifying significant environmental aspects through its assessment of environmental impact risks and prioritized mitigation potentials. The verification and validation (V&V) process employed in this research was not found in a review of contemporary EMS decision support tools.

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CHAPTER I

INTRODUCTION

The focus of the research presented here is the discussion and development of an improved process for identifying significant environmental aspects—the *Aspect-Impact-Mitigation Prioritization Program* (hereinafter, the AIM Prioritization Program or simply, AIM). AIM provides a straightforward and consistent procedure to prioritize environmental aspects based on a holistic risk-based approach that is consistent with the requirements of ISO 14001 and the Eco-Management and Audit Scheme (EMAS). AIM has broad applicability to any type of organization desiring to implement an environmental management system (EMS) or even as a stand-alone tool to estimate the relative risks posed by identified environmental aspects.

The International Organization of Standards (ISO) first published ISO 14001 in 1996 and by the end of 2013 more than 300,000 certificates had been issued to organizations in 171 countries (ISO 2014). In the European Union, EMAS is also popular; more than 3,000 organizations operating 10,000 individual sites have EMAS-certified EMSs (EMAS 2014). Further, it is likely thousands more organizations globally have non-certified EMSs that are largely based on the ISO 14001 standard.

Proponents of EMSs claim that if an EMS is properly implemented, supported, and maintained, organizations will experience reduced risks associated with regulatory compliance and public stakeholder trust as well as benefits to overall business performance. Detractors contend that the time and money required implementing and maintaining an EMS is not warranted and see such systems as an additional layer of effort that does not produce tangible benefits to the organization and may best be described as "greenwashing."

Central to both ISO 14001 and EMAS implementation is the identification of *significant* environmental aspects. Many consider this step in the EMS implementation process to be *both* the most important and the most difficult (Johnston, Hutchison, and Smith 2000; Zobel et al. 2002; Zobel and Burman 2004; Darbra et al. 2005; Põder 2006; Gernuks, Buchgeister, and Schebek 2007; Lundberg, Balfors, and Folkeson 2007; Marazza, Bandini, and Contin 2010). Due to a lack of specificity in ISO 14001 and EMAS regarding how to determine significance, there exists several independently developed schemes that run the gamut from rather simplistic to quite complex with some having a narrow application to only one specific organization type.

An appreciation of the interconnectedness between an EMS and the importance of identifying significant environmental aspects can be obtained by looking to the EMS standards themselves. ISO 14001 defines *environmental management system* as "part of the management system used to manage ***environmental aspects***, fulfill *compliance obligations*, and address *risks and opportunities*" (ISO 2015; p. 2, emphasis added). *Environmental aspect* is defined as an "element of an organization's activities or products or services that interacts or can interact with the environment" (ISO 2015; p. 2). Significant environmental aspects result or can result in significant environmental impacts. An *environmental impact* is defined as "change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's environmental aspects" (ISO 2015; p. 3). The relationship between environmental aspects and impacts is one of cause and effect; environmental aspects *cause* environmental impacts (*effects).*

Managing significant environmental aspects to reduce significant environmental impacts permeates almost every section of ISO 14001 and EMAS and is the basis for measuring continual environmental performance improvement. While both standards provide general insight in identifying environmental aspects, less direction is given for determining those aspects that should be designated as significant. ISO 14001:2015 states:

> "An organization determines its environmental aspects and associated environmental impacts, and determines those that are significant and, therefore, need to be addressed by its environmental management system" (p. 23).

> "There is no single method for determining significant environmental aspects; however, the method used should provide consistent results. The organization sets the criteria for determining its significant environmental aspects" (p. 24).

The primary focus of this research project is to revise and improve the existing AIM Prioritization Program. The underlying algorithms and basic architecture of AIM were originally developed by Dr. Will Focht at Oklahoma State University. Over a period of several years, AIM was modified by environmental science graduate students working under Dr. Focht's supervision. The holistic risk-based approach used within the existing AIM program considers human health risks, ecological health risks, resource depletion risks, legal risks, and stakeholder risks.

While the current version of AIM produces a prioritized ranking of risk-based environmental aspects, it is not without its shortcomings. In the chapters that follow, each section of the AIM Prioritization Program will be thoroughly reviewed to identify opportunities for improvement. The culmination of this process will be a revised "proof-of-concept" AIM program that incorporates input from potential end users and other stakeholders and that has been subjected to a limited verification and validation (V&V) process. Inclusion of stakeholder inputs into the revised AIM design as well as the V&V process strives to maximize overall efficacy and efficiency of the revised AIM approach as well as to provide additional considerations for future revisions of the AIM program.

Before delving more deeply into a discussion of the extant procedures for determining significance of environmental aspects, which is the subject of Chapter III, Chapter II discusses ISO 14001 and

EMAS and summarizes the many motivations for EMS adoption and its business and environmental performance outcomes. This discussion will provide the context for appreciating the importance of an effective process of identifying significant environmental aspects within an EMS.

CHAPTER II

ENVIRONMENTAL MANAGEMENT SYSTEMS:
EMS CONTENT AND MOTIVATIONS FOR, AND OUTCOMES OF, EMS ADOPTION

The following discussion, while not directly addressing the focus of this research, provides background related to the interconnectedness of environmental aspect significance determinations and EMSs, and how that contributes to effective EMS implementation. General observations are provided at the end of the chapter that further supports the need for an improved methodology for defining environmental aspect significance within an EMS.

2.1 Overview of ISO 14001:2015 and EMAS

The goal of sustainability is to reach a balance among the environment, economy and society. The overarching purpose of ISO 14001:2015, as stated in the standard, "is to provide organizations with a framework to protect the environment and respond to changing environmental conditions in balance with socio-economic needs" (ISO 2015; p. vi). The essential requirements under EMAS are the same as those for ISO 14001. Thus, ISO 14001 and EMAS are both grounded in the concept of "sustainable development." Ultimately, the effectiveness of an EMS to deliver on its goal of sustainability depends on an organization-wide commitment led by top management (ISO 2015). Further, "successful implementation…can be used to assure interested parties that an effective environmental management system is in place" (ISO 2015; p. vi).

Identification and management of significant environmental aspects permeate nearly the entirety of ISO 14001 and EMAS. In fact, EMSs are systematic approaches designed to minimize significant environmental impacts through deliberate management of significant environmental aspects. As stated in the scope section of ISO 14001:2015, "This International Standard is applicable to…the environmental aspects…that the organization determines that it can either control or influence" (ISO 2015; p. 1). ISO 14001:2015 defines *environmental management system* as "the part of the management system used to manage environmental aspects" (ISO 2015; p. 2) and *environmental performance* as "performance as related to the management of environmental aspects" (ISO 2015; p. 6).

ISO 14001:2015 contains only elements that can be objectively audited and "does not state specific environmental performance criteria" other than those required to be included in the environmental policy statement (ISO 2015; p. 1). As such, similar organizations can have differing environmental performance criteria and yet still conform to ISO 14001 requirements to realize continual improvement. The major section headings of ISO 14001:2015 are as follows:

1 Scope
2 Normative references
3 Terms and definitions
4 Context of the organization
5 Leadership
6 Planning
7 Support
8 Operation
9 Performance evaluation
10 Improvement

ISO 14001:2015 and EMAS are built upon the Plan-Do-Check-Act (PDCA) continual improvement methodology. In fact, ISO 14001:2015 states that the PDCA model is the basis on which EMSs are founded. PDCA is an iterative process with the goal of continual improvement and may be applied to the entirety of an EMS or its individual parts (ISO 14001:2015). The PDCA model, as it relates to ISO 14001, is as follows (refer also to figure 1):

- **Plan**: establish environmental objectives and processes necessary to deliver results in accordance with the organization's environmental policy (section 6 of ISO 14001:2015 - *Planning*).
- **Do**: implement the processes as planned (sections 7 and 8 of ISO 14001:2015 – *Support* and *Operation*).
- **Check**: monitor and measure processes against the environmental policy, including its commitments, environmental objectives and operating criteria, and report the results (section 9 or ISO 14001:2015 – *Performance evaluation*).
- **Act**: take actions to continually improve (section 10 of ISO 14001:2015 – *Improvement*).

2.1.1 ISO 14001:2015 Update

The third edition of ISO 14001, which was released in September 2015, contains mostly structural changes to the standard so that it more closely mirrors the structure of other ISO management system standards (e.g., ISO 9001). Certain terms and definitions were also changed to be more similar with those found in other management systems. This harmonization should allow for more efficient adoption of multiple management systems and also assist auditors.

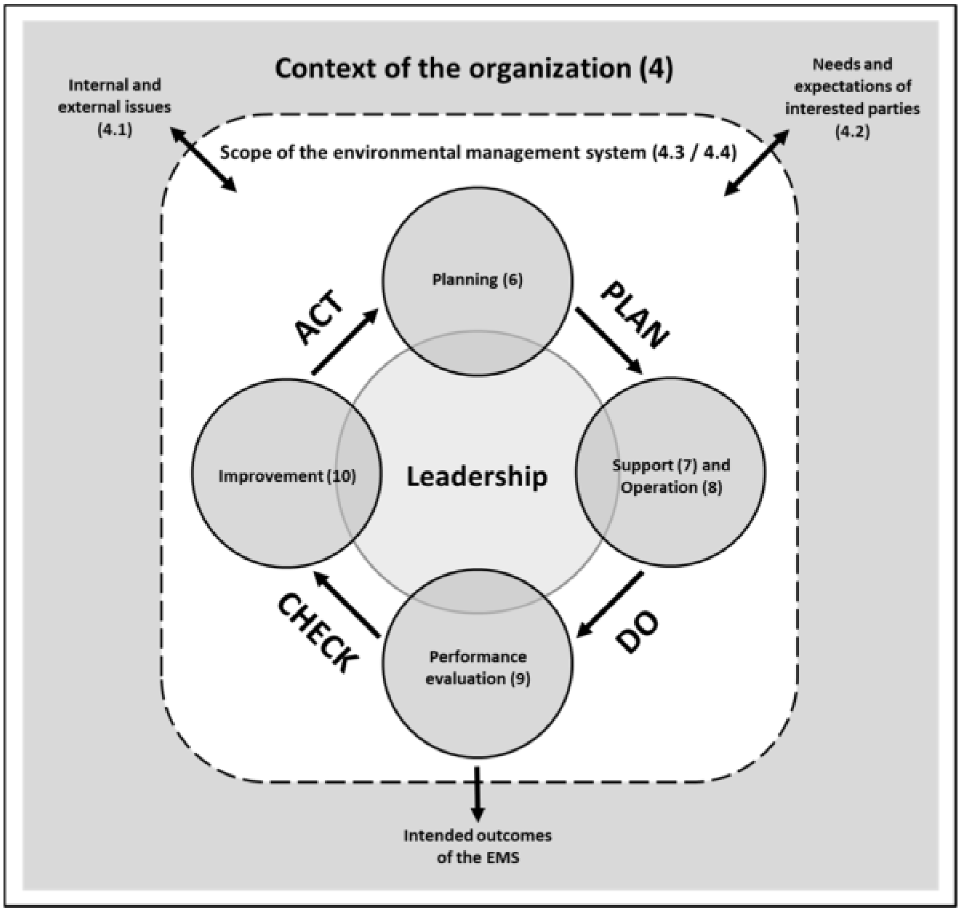

Figure 1. Relationship between ISO 14001 and PDCA (adapted from ISO 14001:2015). The parenthetical numbered references coincide with specific sections and subsections in ISO 14001:2015.

Regarding environmental aspects, ISO 14001:2015 states, "…the organization shall determine the environmental aspects of its activities, products and services that it can control and those that it can influence, and their associated environmental impacts, ***considering a life cycle perspective***" (p. 9, emphasis added). The inclusion of "considering a life cycle perspective" was not present in the previous version of ISO 14001. The relevant guidance section of the ISO 14001:2015 standard states.

> "When determining environmental aspects, the organization considers a life cycle perspective. This does not require a detailed life cycle assessment; thinking carefully about the life cycle stages that can be controlled or influenced by the organization is sufficient. Typical stages of a product (or service) life cycle include raw material acquisition, design, production, transportation/delivery, use, end-of-life treatment and final disposal. The life cycle stages that are applicable will vary depending on the activity, product or service" (p. 23).

AIM does not explicitly consider life cycle issues, although some of the elements within the five risk scales could be seen as *life cycle related* (e.g., resource usage). This raises at least two questions, one of which is directly pertinent to the research proposed herein. The first is: *How can an organization provide auditable evidence that "careful thought" was given to life cycle considerations?* This question lies beyond the scope of this research project. The second is: *Does an element of life cycle consideration need to be incorporated into AIM's significance prioritization process?* This is considered below.

Zobel et al. (2002) and Lewandowska (2011) describe procedures whereby life cycle assessment (LCA) can be used in conjunction with ISO 14001 to identify and assess environmental aspects. Both authors agree that LCA and EMS were developed for different purposes. The scope of an LCA surrounds a product life cycle, whereas the scope of an EMS is an organization. While both share some commonality, neither fits perfectly within the other and modifications have to be made to both to arrive at a hybridized process.

Hybridization of EMS and LCA need not be tedious, however. First of all, the ISO 14001 guidance states that a detailed life cycle analysis is not required. Second, and more specifically to the question of whether a life cycle assessment should be incorporated within AIM, the life cycle consideration required in ISO 14001 relates to environmental aspect identification. AIM is a decision support system for determining significance of identified environmental aspects and then mitigation prioritization. Since the identification of environmental aspects must be accomplished before using AIM, it is not necessary to incorporate a life cycle assessment into its architecture. Nevertheless, the organization should have auditable procedures in place within its EMS to verify a life cycle perspective was considered when identifying its environmental aspects.

2.1.2 Organizational Benefits of EMS Implementation

ISO 14001:2015 lists several benefits to organizations that implement its approach to continual improvement in environmental management, such as:

- environmental protection through prevention and mitigation of adverse environmental impacts;
- organizational protection through mitigation of adverse environmental conditions;
- organizational assistance with fulfillment of compliance obligations;
- enhanced environmental performance;
- prevention of unintentional environmental impacts by employing a life-cycle perspective;
- financial and operational efficiency through strengthened market position; and
- improved communication with and identification of interested parties (i.e., stakeholders).

Similarly, Milieu Ltd. and RPA Ltd. (2009; p. 11) summarize the benefits of EMAS registration as follows:

- reduced costs of resources and waste management;
- regulatory relief;
- risk minimization;
- improved relations with internal and external stakeholders;
- competitive advantage; and

- maintenance of regulatory compliance.

Notwithstanding the purported benefits of ISO 14001 and EMAS implementation, many more organizations could be implementing ISO 14001-styled EMSs given the correct set of motivational forces to do so. Following in the next section is a more detailed review of current literature regarding organizational motivations and performance results.

2.2 Motivations for EMS Adoption

Why would organizations—large and small, public and private, and within vastly different sectors—implement an additional and voluntary program such as ISO 14001? Stated more simply, what motivates an organization to adopt an EMS (beyond the self-described benefits of ISO 14001 and EMAS)? Similarly, once implemented, do EMSs deliver on the standard's promises? That is, what are the actual environmental and business performance impacts? The discussion that follows addresses these questions.

Scholarly interest has focused primarily on two theoretical perspectives: institutional and resource-based (Darnall, Henriques, and Sardosky 2008). Institutional motivations concern pressure from regulatory agencies, market dynamics, and society. Resource-based motivations focus on the resources available to an organization to implement and maintain an EMS.

2.2.1 Institutional (External) Pressures

Motivational factors for EMS adoption that concern the purported benefits to be gained by the organization are consistent with institutional theory. These benefits include gaining a technological advantage, differentiation from competitors, cost reduction, and social pressures such as public/community image and media attention (Zutshi and Sohal 2004a). Other benefits of EMS implementation are intangible and therefore difficult to measure or value monetarily (e.g., improved image, improved relationships, and improved communications). Below is a summary of the various pressures (or motivations) related to EMS adoption.

Regulatory Pressure

Organizations must comply with a myriad of legal requirements related to their actual and potential impacts on the environment. Failure to comply with environmental regulations can result in adverse financial and reputational consequences. Briggs (2006) argues that EMS implementation can assist in the reduction of the overall regulatory burden as well as create a system of more efficient management of remaining regulatory requirements that results in fewer costs associated with fines, legal fees, and the like.

Social Pressure

Companies are under increasing pressure by the public to operate in an environmentally responsible manner. EMS adoption may assist organizations in their claims of "greener" operations and improve their overall image. Edwards and Darnall (2010) found that organizations operating in predominantly minority areas in the United States were more likely to implement EMSs and take actions to improve environmental performance.

Financial Pressure

In an increasingly global and competitive marketplace, cost reductions—and concomitant increased profits—are attractive to most organizations. Financial benefits of EMS implementation are both direct and indirect and include pollution prevention activities, efficient use of natural resources, fewer fines, and preventative measures that reduce emergency response costs, to name a few (Briggs 2006).

Market Pressure

Determining EMS benefits that result in gaining a competitive advantage appear to be difficult to document (Morrow and Rondinelli 2002). It can certainly be argued that if the motivating factors described above are realized, it would place the organization at a competitive advantage in the market.

2.2.2 Internal Resource Availability

Research conducted by Darnall, Henriques, and Sardosky (2008) suggests that organizations with greater internal resources and capabilities adopt more comprehensive EMSs and reap greater positive business performance results. Organizations that adopt EMSs based solely on institutional pressures but lack complementary resources and capabilities normally develop an EMS that is more symbolic and does not result in sustained or improved business performance. Availability of resources and capabilities, as may be the case for larger publically-traded organizations, can also reduce the financial burden associated with EMS implementation (Darnall and Edwards 2006).

2.2.3 Stakeholder Roles

Stakeholder views should be incorporated into the decision-making process of organizations contemplating EMS adoption (Zutshi and Sohal 2004b). Effective communication and participation from all stakeholders is a key component within all management system-based programs (Griffith and Bhutto 2009). Stakeholders can include shareholders, management, rank and file employees, suppliers, customers, and the community.

Shareholders as Stakeholders

Some organizations identify shareholder pressure as a driving force behind EMS implementation (Zutshi and Sohal 2004b). Publically-traded companies have greater access to financial resources for internal environmental expertise development and overall personal risk can be spread out among the shareholders (Darnall and Edwards 2006). MacLean (2004) argues that an organization can achieve continuous improvement within its EMS yet still fall short in important business sustainability endeavors such as raising capital and increasing shareholder value. Shareholders may have little patience in investing money into an environmentally principled company that does not provide a financial return.

Top Management as Stakeholders

Without involvement and ongoing support from top management, EMS implementation will be difficult, if not impossible (Oktem et al. 2004). If senior management does not provide adequate support, typically in the form of commitment and resource allocation, most management system-based programs would fail.

Employees as Stakeholders

Employee involvement is also crucial. Shop floor employees are close to the activities and incidents at a facility and have a key role during EMS implementation and development (Zutshi and Sohal 2004b). Overall success of EMS implementation hinges on involving employees in the planning, checking, and review process (Koehn and Datta 2003).

Suppliers and Customers as Stakeholders

Many organizations require their suppliers to implement EMSs. Suppliers can assist with technical support, provide suggestions and feedback, and offer other implementation assistance (Zutshi and Sohal 2004b). Therefore their needs, capabilities, and competencies should be assessed and incorporated into EMS decision-making efforts (Hansen 2006). Furthermore, stronger stakeholder pressures—whatever they may be—can lead to higher quality EMSs (Gibson

2005) and are considered a key driver for EMS development and implementation (Botta et al. 2009).

The Public as Stakeholders

The public is also a stakeholder group. Many organizations have identified improved corporate image and better community relations as drivers for EMS implementation (Koehn and Datta 2003; Christini, Fetsco, and Hendrickson 2004; Hansen 2006). The perception of community goodwill has translated into fewer community complaints for some companies (Gallagher et al. 2004). As the public becomes increasingly educated regarding the potential for environmental harm, EMSs may provide a level of transparency that can be beneficial in mitigating certain concerns (Honkasalo 1999).

2.3 Business and Environmental Performance Outcomes Related to EMS Adoption

2.3.1 Business Performance Outcomes

Thousands of organizations around the globe have adopted EMSs. Though this has prompted scholarly interest in evaluating "the motivations of EMS adoption and the relationship between EMS adoption and improved environmental performance" (Darnall, Henriques, and Sardosky 2008, p. 364), less attention has been given to studying whether or not EMS adoption improves business performance (Darnall, Henriques, and Sardosky 2008). Yin and Schmeilder (2009) observe that a disparity in performance among firms that implement standardized management systems such as ISO 14001. One explanation may be the lack of a standardized definition of "business performance." Conventional economic thinking envisions investment beyond what is minimally required for compliance as detrimental to a company's economic performance. However, others may question this definition of performance.

EMS Comprehensiveness

Simply asking whether or not an organization has an EMS in place fails to recognize the variability with which they can be implemented and therefore fails to consider comprehensiveness. Facilities facing greater institutional pressures and having more resources and capabilities generally adopt more comprehensive EMSs.

Darnall, Henriques, and Sardosky (2008) postulate that facilities that adopt more comprehensive EMSs obtain positive business performance results. To evaluate this claim, they surveyed several hundred manufacturing facilities in Canada, United States, Germany, and Hungary to measure (1) EMS adoption, (2) business performance, (3) institutional pressures, and (4) resources and capabilities. Statistical analysis of the results supported their claim. They offer three contributions to theory and practice: (1) unlike previous studies, this study examined EMS adoption in three countries in addition to the United States, (2) EMS adoption creates business value, and (3) broader understanding of the relative contributions of institutional and resource-based perspectives affect decisions to adopt an EMS and the subsequent business performance outcomes.

EMS Implementation Costs

Proponents are quick to include financial gains as one of the benefits of EMS implementation, but what are the costs of implementing and maintaining an EMS? Does EMS implementation and adoption result in improved financial performance? If investment beyond what is minimally required to achieve regulatory compliance does not yield financial gains, there may be little incentive for organizations to adopt an EMS (Darnall, Henriques, and Sardosky 2008).

Although thousands of firms have implemented EMSs, making the "business case" for them still remains as an obstacle for even wider acceptance (Soyka 2006). In relative terms, larger firms typically spend more than smaller firms and private firms typically spend more than public firms when implementing an EMS. Overall, EMS implementation costs average about $100,000 and the implementation process can take 18 to 24 months to complete. On a per employee basis, Soyka (2006) reported EMS implementation costs of $257 (publically-traded organizations), $531 (privately-held organizations), and $1,441 (governmental organizations). This cost analysis agrees with research conducted by Darnall and Edwards (2006). Zutshi and Sohal (2004a) add that maturity of existing programs can reduce EMS implementation costs. de Vries, Bayramoglu, and von der Wiele (2012) conclude that the benefits of ISO 14001 implementation are generally sufficient to overcome implementation costs.

EMS Outcomes on Business Performance

Academic research on EMS implementation yields contradicting results with regard to the relationship between EMS practice and financial performance (Lo, Yeung, and Cheng 2010; de Jong, Paulraj, and Blome 2014). Calculating costs and benefits of EMS implementation would seem to be a straightforward endeavor, but there are difficulties and disagreements as to what costs to associate with EMS implementation and how to consider intangible benefits that are difficult or impossible to quantify (Steger 2000).

A study of 61 Malaysian small and medium enterprises concluded that ISO 14001 implementation has a positive and significant effect on facility operational and business performance (Nee and Wahid 2006). A study of more than 1500 firms in the U.S. supports the hypothesis that overall business performance was lowest in the absence of an EMS and highest when an ISO 14001 certified system was in place (Melynk, Scruffe, and Calantone 2002). Cost savings realized by construction firms in the U.S. that were attributable to ISO 14001 implementation included increased energy efficiency, reduced waste generation, improved employee safety, and reduced insurance premiums (Christini, Fetsco, and Hendrickson 2004). A study of U.S.-based firms in the fashion and textiles industry found positive and significant financial outcomes due to ISO 14001 certification over non-certified firms (Lo, Yeung, and Cheng 2010). Zutshi and Sohal (2004b) reported cost savings of up to $100,000 for firms in Australia and New Zealand that had implemented ISO 14001.

de Jong, Paulraj, and Blome (2014) admit that current research examining the relationship between EMS implementation and business financial performance has yielded mixed results. In a study of 219 ISO 14001-certified firms in the United States, they conclude that ISO 14001 certification can result in both short- and long-term positive financial performance. These benefits are realized in the top-line (net earnings) and bottom-line (gross sales or revenue). They differentiate their research from those who have concluded that ISO 14001 implementation generates negative business performance impacts by looking at performance indicators for up to five years after EMS certification. Short-term improvements seem to have immediate and positive effects on the bottom-line through efficiency improvements while longer-term top-line outcomes are realized through increased sales.

2.3.2 Environmental Performance Outcomes

As with studies examining EMS effects on business performance, environmental performance impacts related to EMS implementation appear mixed (Nawrocka and Parker 2009). This may be partially explained in that there is no consensus of what "environmental performance" is and how best to measure it.

Improved environmental performance may be defined as increased compliance with environmental regulations or as reduction in environmental impacts. In fact, enhanced regulatory compliance was touted as one of the most compelling reasons for EMS implementation (Gibson 2005). Some researchers conclude that EMS implementation does not necessarily lead to a better compliance record. Gallagher et al. (2004) note that firms implementing ISO 14001 were not able to meet regulatory wastewater discharge limitations. Therefore, the existence of an EMS does not necessarily provide evidence of superior environmental performance or even minimal compliance.

Reducing negative impacts to the environment, which need not necessarily be tied to a permit limitations or other regulatory mechanism, is also touted as an important benefit of adopting an EMS, but even this is not always the case. MacLean (2004) notes that one of the largest pollution incidents in Brazil and a non-hazardous waste dumping scandal in Taiwan were perpetrated by organizations that were ISO 14001 certified. Rondinelli and Vastag (2000) state that ISO 14001 is not a panacea for addressing all environmental concerns nor does it ensure improved environmental performance. Nevertheless, other researchers conclude that EMS implementation does help to control adverse environmental impacts (Morrow and Rondinelli 2002; Christini, Fetsco, and Hendrickson 2004; Soyka 2006; Giles 2008; Botta et al. 2009; Yin and Schmeilder 2009).

2.3.3 EMS Performance Variability

Yin and Schmeidler (2009) ask the question: *Why do standardized EMSs lead to heterogeneous results insofar as environmental performance is concerned?* As stated above, some researchers conclude it does, while others conclude that it does not, and others find mixed results. This suggests that although an identical management model is adopted by these institutions, different implementation methodologies produce widely varying results (Yin and Schmeidler 2009).

Yin and Schmeidler's (2009) work has two overarching purposes: (1) examine the variability that exists with regard to ISO 14001 implementation and (2) examine how this variability may explain different environmental performance outcomes. They posit that (1) institutional theories and resource-based views suggest that organizations will implement standardized systems differently even under isomorphic conditions, (2) linking environmental performance to ISO 14001 implementation can provide practical management insight into how the implementation process can be improved, and (3) understanding how ISO 14001 implementation and improved performance are related may help resolve the controversy surrounding the value of ISO certification.

A survey was conducted of all ISO 14001-certified firms in the United States; usable responses were obtained from 292 single facilities and 64 multi-site organizations. Analysis shows that facilities vary in the extent to which ISO 14001 standards are integrated into daily operations and performance management elements. “It is clear that the implementation of ISO 14001 standards is far from a homogenous and unambiguous phenomenon” (Yin and Schmeidler 2009; p. 478). Organizations differ greatly in how ISO standards are designed, developed, and implemented. ISO 14001 certified firms are more likely to report that greater environmental performance improvements are directly attributable to EMS implementation if the ISO 14001 standard is more fully integrated into day-to-day operations and stretched to all levels of organizational life. Integrating performance management goals through clear definition, progress measurement, and program review realize the greatest positive performance.

2.4 Closing

From the discussion above, the following observations are made:

- Regarding EMS implementation pressures (motivations):
    - External pressures from regulatory, social, financial, and business markets can each play a role in organizations’ decisions to implement voluntary EMS programs.
    - Availability of greater internal expertise can play a role in organizations’ decisions to implement voluntary EMS programs.
- Regarding business performance impacts of EMS implementation:
    - The more comprehensive an EMS, the greater its positive business impacts.

  - The benefits of ISO 14001 implementation are generally sufficient to overcome implementation costs.
  - The relationship between EMS implementation and financial performance is variable.
- Regarding environmental performance and EMS implementation:
  - The relationship between EMS implementation and environmental performance is variable.
- Regarding availability of resources:
  - Organizations (commonly larger publically-traded enterprises with greater access to internal resources and capabilities) adopt more comprehensive EMSs and realize greater positive results (Darnall and Edwards 2006; Darnall, Henrques, and Sardosky 2008).
- Regarding support from top management:
  - While engagement is necessary from all identified stakeholders, a lack of support from senior management will doom most system-based programs to failure.

When these observations are considered along with the argument by many researchers that identification of significant environmental aspects is both the most important and most difficult step in the EMS implementation process, the availability of a tool that reduces the level of effort required to assess risks, determine aspect significance, and prioritize aspect mitigation will serve to decrease demand on internal resources and capabilities, which in turn can be expected to garner greater support from top management for EMS implementation.

CHAPTER III

REVIEW OF EXTANT METHODS FOR DETERMINING SIGNIFICANCE OF ENVIRONMENTAL ASPECTS

The identification of significant environmental aspects is paramount in the development of an organization's EMS. Presented below is a discussion of the general guidance found in ISO 14001 and EMAS regarding significance determinations of environmental aspects followed by a critical review and identification of weaknesses of existing significance determination methods. Lastly, a discussion of the strengths and weaknesses of the current AIM approach is provided.

3.1 Significant Environmental Aspects – EMS Guidance

Neither ISO 14001 nor EMAS provide more than general, and rather vague, guidance.

3.1.1 ISO 14001:2015

Two primary significance assessment qualifications are given in the ISO 14001 standard: (1) any method used to determine significance should provide consistent results and (2) the primary criteria used must deal with environmental impacts. Other criteria, such as legal requirements and interested party concerns may also be used.

3.1.2 EMAS

EMAS states that the following must be considered when making environmental aspect significance determinations: (1) potential to cause environmental harm; (2) fragility of the local, regional, or global environment; (3) size, number, frequency, and reversibility of the aspect or impact; (4) applicable regulatory requirements; and (5) importance to stakeholders.

3.2 Identification of Weaknesses of Extant Methods

Several methods have been independently developed, each of which purport to adhere to the ISO and EMAS standards. To varying degrees, each of these methods has its own shortcomings that weaken its value in EMS implementation. The following literature review is grouped by identified weaknesses determined to be present within the extant procedures, including the current AIM approach. Chapter IV is similarly organized by identified weaknesses along with discussion of how the improved AIM approach will overcome those weaknesses.

3.2.1 Limited Applicability

The *Strategic Overview of Significant Environmental Aspects* (SOSEA) described by Darbra et al. (2005) was developed specifically for use in seaports. The SOSEA method employs a predefined matrix of activities and associated aspects, as well as standardized questions, to assist the user in prioritizing environmental aspects and determining where additional resources may be required for mitigation. Thus, SOSEA's applicability only to seaports limits its usefulness.

Gernuks, Buchgeister, and Schebek (2007) describe a methodology developed for Volkswagen in Germany as a means to address EMAS requirements. Its significance determination is based on the *ecopoint* system that was developed by the Swiss Ministry of the Environment. While the Swiss factors were deemed appropriate for use in Germany, they are not generally reliable on a global scale. As of 2013, only Belgium, Sweden, Norway, the Netherlands, Jordan, and Japan, in addition to Switzerland, had developed their own versions of the ecopoints database (Frischknecht and Büsser 2013).

Põder (2006) uses a tiered approach of increasing complexity to determine environmental aspect significance. The first, and most simplistic, tier examines legal requirements as well as those aspects identified through previously performed environmental impact assessment (EIA) and environmental risk assessment (ERA). Many aspects may be identified as "significant" in this screening process without further consideration. Most organization-level processes will not have undergone a formal EIA or ERA process and thus Põder's (2006) *Tier I* approach will be of limited usefulness. Conversely, applying a *significance label* to every aspect based solely on the existence of legal requirements (or even due to a state of non-compliance) may be overly burdensome to the organization and dilute the distribution of available resources.

The method described by Marazza, Bandini, and Contin (2010) was developed specifically for use by local governmental authorities. The authors argue that local authorities, which are one of the fastest growing sectors with regard to EMS implementation, require a unique significance assessment protocol to assess local public sector environmental aspects. Features of municipalities that may not be present in more traditional EMS implementations include: highly varied activities (e.g., public education, municipal waste disposal, law enforcement, infrastructure); geographical responsibility; stakeholders include the entire citizenry, environmental benefits may be more diffuse for a local government (i.e., spread out among the entire citizenry rather than focused on a specific industrial location); and many municipalities are comprised of small populations (i.e., < 5000) and likely have small staffs (< 10) that lack specific environmental knowledge and scientific skills (Marazza, Bandini, and Contin 2010).

3.2.2 Simplistic Assessment

Põder's (2006) *Tier II* approach considers aspect significance (*AS*) as the product of the severity (*S*) of the impact expressed as a cost incurred or natural resource quantity consumed (e.g., energy, water, minerals, etc.) and the probability (*P*) that the impact with severity *S* will occur. The *Tier*

II approach does not consider other important elements specifically stated in the ISO 14001 and EMAS guidance such as stakeholder concerns. In addition, not all impacts can be measured in monetary or resource quantity terms, such as impacts on aesthetics or on cultural and religious resources.

The risk-based approach described by Johnston, Hutchison, and Smith (2000) uses a weighted risk-based approach to assign scores to environmental impacts; the higher the score, the greater the impact. Therefore, the most significant environmental aspects are those with the highest level of cumulative risk associated with their impacts. To arrive at an overall risk score for an impact, five risk categories are considered within weighted risk matrices: (1) extent of impact, (2) community concern, (3) regulatory impact, (4) environmental impact, and (5) business concern. These five categories do not address all of the risk factors associated with impact risks and aspect significance determination however. For example, specific consideration of the concerns of internal and other external stakeholders are not included.

The method supported by Ayers (2010) also uses a risk-based approach along with Likert scales to generate a score for each aspect/impact combination. Significance scores are generated from the following formula: [(Probability x Consequence) + (Regulatory Requirements + Concerns to Customer or Community)] x (Resource Requirements). Where *probability* is assigned a value from 1 to 5 depending upon how often an aspect occurs, *consequence* is assigned a value of 1 to 5 depending upon the level of adverse impact, *regulatory requirements* is assigned a value from 1 to 5 based on status of regulation, *concerns to consumer or community* is assigned a value from 0 to 3 based on level of concern, and *resource requirements* is assigned a value from 1 to 5 depending on level of controllability of the aspect/impact combination. Higher values represent greater significance. Many of the scales referenced are quite subjective and only allow for a most basic consideration. For example, while Ayers' (2010) formula includes a stakeholder element, it consolidates “customer or community” into a single Likert scale judgment that may not capture legitimate concerns of all stakeholders.

3.2.3 Poorly Defined Variables

Johnston, Hutchison, and Smith (2000) do not provide a basis for the values entered into the five weighted risk matrices. An example provided in their explanation of this method presents values ranging from 0-10 in the five matrices, but the text is mute on how values within this range is selected or if values greater than 10 could be used. Johnston, Hutchison, and Smith (2000) state only that “The team leader assigned numerical values to each square on the grids” (p. 193).

Põder’s (2006) *Tier III* approach considers aspect significance (AS) as $S \times P + SE + U$, where severity (S) includes magnitude, spatial extent, temporal dimension, and importance; probability (P) that the impact with severity S will arise; socioeconomic factors (SE) that include regulatory status, stakeholder concerns, controllability, etc.; and uncertainty (U). While Põder’s (2006) formula and general discussion make sense, and could possibly be used as a basis for significance determinations within an EMS, there is no detailed description of how this should be done. For example, regarding the socioeconomic (SE) term, Põder (2006) states, “Factors like regulatory status, stakeholders’ concerns, and aspects’ controllability could be involved in this component” (p.741).

3.2.4 Insufficient Consideration of Aspect-Specific Impact Risk Assessment

The procedure described by Johnston, Hutchison, and Smith (2000) is focused on determining significance of environmental impacts directly without regard to each impact’s associated environmental aspect. This method could conceivably cause issues as impact management and mitigation efforts will most always be performed at the aspect level, since the environmental aspects are the cause of the environmental impacts’ effect. Further, since significant environmental impacts arise from significant environmental aspects, if one prioritizes only the impacts to determine significance, this could result in every identified aspect being categorized as significant. For example, consider the following scenario of five aspects (1 through 5) with three impacts each ([A,B,C], [D,E,F]…[M,N,O]):

- Aspect 1 with Impacts A, B, C
- Aspect 2 with Impacts D, E, F
- Aspect 3 with Impacts G, H, I
- Aspect 4 with Impacts J, K, L
- Aspect 5 with Impacts M, N, O

If we only examine significance of impacts and we determine that we will consider the top five risk-ranked impacts to be significant and those top five turn out to be Impacts A, D, G, J, and M, which are associated with Aspects 1, 2, 3, 4, and 5, then all of our environmental aspects are, by definition, also significant and must therefore be addressed accordingly within our EMS. This may result in additional strain on already stretched resources to the detriment of environmental performance improvement efforts.

3.2.5 Insufficient Consideration of Impact Risks

The SOSEA method described by Darbra et al. (2005) and the ecopoint method described by Gernuks, Buchgeister, and Schebek (2007) only consider aspects in making significance determinations. The SOSEA developers rightly state that significant environmental aspects have or can have high risk environmental impacts, but SOSEA does not require the user to identify impacts associated with the pre-defined aspects. Since the relationship between aspects and impacts is one of cause and effect, and the overarching purpose of an EMS is continual environmental performance improvement (i.e., impact risk mitigation), it is difficult to understand how one can show improvement (or lack thereof) without identifying deleterious environmental impacts associated with environmental aspects.

3.2.6 Insufficient Consideration of Environmental Impacts

In the SOSEA method (Darbra et al. 2005), the Environmental Activities and Aspects Matrix is used to determine aspects that are significant. The matrix grid consists of pre-defined aspects in the rows and pre-defined activities in the columns. Blank rows and columns are provided to accommodate additional aspects and activities, respectively. For each aspect and activity, the user identifies which are applicable to their operation and then determines significance based on four criteria: (1) Legal regulations, (2) Local scale concern, (3) Global scale concern, and (4) Other (e.g., economic concerns that may impact environmental risks). For each cell in the matrix in which the user determines an aspect and corresponding activity to be significant, the user places a tick mark. Once the entire matrix is completed, tick marks are summed across the rows corresponding to the aspects. The highest summed value is used as a reference and any other summed values of at least 50% of the reference value are considered significant. While the criteria may all play a role in estimating risk, their treatment within SOSEA lacks robustness given the level of uncertainty and arbitrariness in judgments of significance using these criteria. Moreover, since SOSEA does not consider environmental impacts, it fails to meet the central mandate of ISO and EMAS to give highest priority to environmental impacts.

3.2.7 Insufficient Consideration of Mitigation Prioritization

Since limited resources (i.e., financial, human, environmental, technological, etc.) are available to mitigate the impacts of a given aspect, a mechanism within EMS significance determination is needed to prioritize aspects based on mitigation potential. Without such a mechanism, the organization may select its most significant environmental aspects for mitigation even though adequate resources do not exist. The methods described by Darbra et al. (2005), Johnston, Hutchison, and Smith (2000), and Põder (2006) do not adequately address resource availability for environmental aspect mitigation prioritization.

3.3 Strengths and Weaknesses of the Current AIM Approach

While the current AIM approach does produce a prioritized list of environmental aspects based on a holistic consideration of risk categories and resource availability, it is not without its shortcomings. Following is a critical review of the current AIM approach to identify potential areas that could be improved or, conversely, to offer an explanation as to why particular pieces should be preserved in their current form. Presented in the next chapter is a discussion of the actual and proposed future improvements to be implemented within the revised and potential future AIM updates.

3.3.1 General Discussion of Risk and the Risk Categories Used in AIM

The Aspect-Impact-Mitigation (AIM) Prioritization Program (Focht 2011) is a decision support system designed to assist EMS implementers in prioritizing environmental aspects to determine which aspects are *significant* as required by ISO 14001 and similar EMS standards and to prioritize significant aspects for mitigation. AIM employs a holistic approach to consider a combination of human health risks, ecological risks, resource depletion risks, legal risks, and stakeholder risks.

The five risk categories currently employed in AIM (human health, ecological health, resource depletion, legal, and stakeholder) as well as the weighting coefficient categories for risk magnitude and risk mitigation are appropriate to the purpose of prioritizing environmental aspects to determine those aspects that are most significant within the context of an EMS. This assertion is based largely on the guidance criteria provided within ISO 14001 and EMAS. Specifically, while ISO 14001:2015 does not prescribe a particular method for making significance determinations, it does state, "Environmental criteria are the primary and minimum criteria for assessing environmental aspects" and other criteria related to "organizational issues, such as legal requirements or interested party concerns" may also be used (p. 24). Similarly, EMAS (2009) does not define a rigid method for determining which environmental aspects are significant, but does require participating organizations to consider the following: potential to cause environmental harm; fragility of the local, regional or global environment; size, number, frequency and reversibility of an aspect or impact; existence and requirements of relevant environmental legislation; and importance to stakeholders and employees. The five discrete risk categories currently within AIM correlate well with the guidance offered in both ISO 14001:2015 and EMAS with regard to environmental aspect significance determinations (Table 1).

Table 1. Correlation of the Five AIM Risk Categories with the Significance Determination Guidance Provided in ISO 14001:2015 and EMAS

Risk Type	ISO 14001	EMAS
Human health	Environmental criteria	Potential to cause environmental harm Fragility of local, regional or global environments
Ecological health		
Resource depletion		
Legal	Legal requirements	Environmental legislation
Stakeholder	Interested party concerns	Importance to stakeholders and employees

Additionally, risk-based decisions should appeal to an *a priori* definition of acceptable risk, which is typically defined through one or more of the following approaches (Focht 2012):

- Zero risk = absolute safety
- Relative risk = reference to a natural background level
- *De minimis* risk =- reference to a level determined by government as “safe enough”
- Comparative risk = worst first
- Optimized risk = greatest risk reduction per dollar expended to reduce it
- Expert determined risk = reference to what a panel of experts state is acceptable
- Revealed preference risk = reference to those risks people are currently living with

- Expressed preference risk = reference to what people say they will accept

None of these definitions alone is perfect and any of them could be incorporated into AIM decision-making. AIM currently adopts the comparative risk approach in determining aspect significance and the optimized risk approach in mitigation prioritization. The “zero risk” method could be incorporated into a situation where the organization was examining the feasibility of raw material changes that would eliminate a particular hazard altogether. AIM also allows for incorporation of stakeholder perceptions regarding risks posed by the organization using the revealed and expressed preference risk approaches. This use of multiple acceptable risk definitions agrees with the NRC’s (1983) statement that “a single risk assessment method may not be sufficient” (p. 40).

3.3.2 Assessing Risks of Individual Impacts

Human health risk

The current AIM approach employs two human health risk assessment scales: (1) individual health risk and (2) population health risk. Given that AIM includes risk assessment to aid organizations in prioritizing mitigation of environmental impacts, it makes sense to compare AIM’s treatment of human health risk assessment against other human health risk assessment methodologies. The seminal work in this regard is the National Research Council’s (1983) “Red Book,” which described human health risk assessment as a process involving the followings steps: (1) hazard identification, (2) dose-response assessment (a.k.a., toxicity assessment), (3) exposure assessment, and (4) risk characterization. While subsequent maturation of risk assessment theory has seen the addition of an initial problem formulation phase and greater stakeholder involvement (NRC 1996; IPCS 2009; NRC 2009; WHO 2010), the basic elements of the Red Book paradigm remain at the heart of internationally accepted human health risk assessment. As is shown in Table 2, the current steps for human health risk assessment within AIM are quite similar to those of existing risk assessment protocols.

Table 2. Correlation between Human Health Risk Assessment and the AIM Protocol for Calculating the *Impact Human Health Risk*

Human Health Risk Assessment		AIM	
Step	*Description*	*Step*	*Description*
Hazard identification	Identifies the type and nature of adverse health effects	Impact identification	Impacts associated with identified aspects
Dose-response (toxicity) assessment	Qualitative or quantitative description of inherent properties of an agent having the potential to cause adverse health effects	Individual Health Risk	Likert scale judgment regarding severity of harm to the *most exposed individual* (MEI)
Exposure assessment	Evaluation of concentration or amount of a particular agent that reaches a target population	Population Health Risk	Likert scale judgment regarding extent of harm to populations
Risk characterization	Nature and magnitude of the risk	Impact Human Health Risk	Lower values represent lower risks

The main differences between the steps within AIM and those described in the EPA's *Risk Assessment Guidance for Superfund (RAGS) Volume I: Part A, Human Health Evaluation Manual* (EPA 1989) are within the *Individual Health Risk* and *Population Health Risk* scales The EPA (1989) defines *exposure assessment* as a process "conducted to estimate the magnitude of actual and/or potential human exposures, the frequency and duration of exposures, and the pathways by which humans are potentially exposed" (p. 1-6). Whereas the EPA's exposure assessment approach involves a three-step process that culminates in a quantified pathway-specific exposure estimate, *Population Health Risk* is addressed within the current AIM approach as a single five-point Likert scale that only considers the spatial extent of potential impacts:

Population Health Risk ("Pop")

- 5 = community (impacts extend beyond the adjacent neighborhood into the larger community)
- 4 = neighborhood (impacts extend beyond the facility property into the adjacent neighborhood)
- 3 = facility (impacts extend beyond the operational work area, but remain on the facility property)
- 2 = operation (impacts extend beyond the immediate work station, but remain within the operational work area)
- 1 = process (impacts are confined to the immediate process work station)

This simplified treatment may be seen by some as a weakness of the current AIM approach. Indeed, if AIM were to be used as a decision-making tool for the selection of remedial actions at Superfund sites, it is undoubtedly inadequate. However, the impetus behind AIM's development was the need for an enhanced decision-making tool for organizations implementing systems such as ISO 14001, specifically surrounding the identification and subsequent mitigation of significant environmental impacts. The current impacts judgment scale for *Population Health Risk* within AIM should be easily understandable to implementing organizations and stakeholders alike and require minimal effort to complete for each impact.

The *Individual Health Risk* piece of the current AIM approach offers a more complicated situation. On the one hand, in order for AIM to be an attractive tool for use by most organizations—especially small and medium-sized enterprises that may not have as much access to certain resources and capabilities as compared to larger organizations—it must be intuitive and relatively easy to use. Conversely, to arrive at a most meaningful measure on which to base decisions regarding where to focus mitigation efforts, the decision tool will no doubt require some level of detailed toxicological data input. *Individual Health Risk* within AIM is currently handled via the following single five-point Likert scale: 1 = *no potential harm*, 2 = *mild* (little harm potential), 3 = *moderat*e (harmful), 4 = *serious* (but not potentially fatal), and 5 = *severe/catastrophic* (potentially fatal). Given the need to balance ease of use and understandability with a meaningful measure on which to base decisions, the current treatment within AIM may be weighted too heavily on the side of ease of use.

Unfortunately, most organizations likely do not have toxicologists on staff and may not be willing to pay an outside source for that expertise. Furthermore, while many facilities may be tracking pollutant releases to various media, they may only be tracking these generically as volatile organic compounds (VOCs), hazardous air pollutants (HAPs), particulate matter (PM), total suspended solids (TSS), biological oxygen demand (BOD), etc. and may only track them as bulk quantities (e.g., pounds per hour, tons per year). In the case of air emissions, unless refined dispersion modeling was conducted as part of an operating permit application or bioassays performed in the case of wastewater discharge, the vast majority of locations will not have any inkling of potential exposure concentrations of individual contaminants at a receptor. In fact, according to the EPA (1989), "a great deal of professional judgment is required to estimate exposure concentrations. Exposure concentrations may be estimated by (1) using monitoring data alone, or (2) using a combination of monitoring data and environmental fate and transport models. In most exposure assessments, some combination of monitoring data and environmental modeling will be required to estimate exposure concentrations" (p. 6-24). Monitoring data and fate and transport models are expensive propositions.

Potential methods considered for addressing the above are as follows:

1. Maintain the current *Individual Health Risk* scale as-is and request feedback from potential end-users during verification and validation.

2. Maintain the current *Individual Health Risk* scale as-is and request feedback from an experienced and knowledgeable toxicologist(s) regarding the efficacy of the approach and potential improvements.
3. Develop a mechanism within AIM to reduce subjectivity by incorporating published toxicity data for individual contaminants and/or classes of contaminants (VOC, HAP, carcinogen, etc.) along with a method to extrapolate (model) endpoint concentration values.
4. A combination of two or more of the above.

Option 1 was selected for this work.

Ecological health risk

Whereas human health risk assessment deals with morbidity and mortality of individuals within a single species, ecological risk assessment is focused on mortality and fecundity of populations and communities across multiple species (EEA 2011). Therefore, differences exist between assessing risk to human health and ecological health, which should be captured within AIM. The U.S. EPA (1998) uses a three-phase process for conducting ecological risk assessment: Phase 1 – Problem formulation, Phase 2 – Analysis, and Phase 3 – Risk characterization. The analysis phase is composed of two parts: (1) characterization of exposure and (2) characterization of effects (EPA 1998). The current approach within AIM for assessing ecological health risk utilizes two five-point Likert scales; *Habitat Damage Potential ("Dam")* and *Habitat Population Size ("Siz").*

While the two ecological health risk scales appear to address only the "effects" or consequences side of the analysis step in the EPA's (1998) ecological risk assessment protocol, the exposure piece is actually addressed by the AIM user with impact identification (e.g., air pollution, water pollution). This is supported by the EPA (1998): "…data are evaluated to determine how exposure to stressors is likely to occur (characterization of exposure)" (p. 2). Further support is found within ISO 14001, which defines an environmental impact as a "change to the environment…resulting from an organization's environmental aspects" (ISO 2015, p. 3). Therefore, as shown in Table 3, the current AIM approach is sufficient for assessing ecological health risks within the context of an EMS.

Table 3. Correlation between Ecological Risk Assessment and the AIM Procedure for Calculating the *Impact Ecological Health Risk*

Ecological Risk Assessment		AIM	
Step	*Description*	*Step*	*Description*
Problem formulation	Definition of the problem	Aspect identification	Aspects associated with identified process
Analysis	Characterization of exposure	Impact identification	Impacts associated with identified aspects
	Characterization of effects	Habitat Damage Potential; Habitat Population Size	Likert scale judgments regarding severity of harm to habits and extent of harm to species
Risk characterization	Nature and magnitude of risk	Impact Ecological Health Risk	Lower values represent lower risks

Resource depletion risk

The four resource depletion risk scales identified in the current AIM approach encompass resource usage, natural resource degradation, natural resource renewal, and processed resource reuse. Two of these scales, *Resource Use Rate* and *Processed Resource Reuse Percentage* are generally adequate in their current form. Slight adjustments will be made to the *Resource Use Rate* ranges so that they are in equal amounts of 20% and *Processed Resource Reuse Percentage* will be shortened to *Resource Reuse Percentage*. Both of these scales simply require the user to compile resource usage rates and process/product feedstock information—which should be readily available—and determine a percentage range of use/reuse. This should only require time and knowing who to ask for the necessary information; it does not require any type of expert knowledge beyond simple mathematics calculations. The *Natural Resource Degradation Extent* and *Natural Resource Renewal Rate* scales are quite subjective in their current forms and potential future improvement to them will be discussed in Chapter IV.

Legal risk

AIM includes four legal risk scales: *Compliance Weight*, *Violation History*, *Current Compliance Status*, and *Tort Severity*. The scales are adequate in their current form for addressing legal requirements within the framework of ISO 14001. The legal risk scales require the user to consider past, present, and future conditions with minimal subjectivity and with what should be readily available information to most any organization. The only changes being made in the improved AIM will be to the scale names for *Compliance Weight* and *Tort Severity* as discussed in the following chapter.

Stakeholder risk

Before crafting an approach to consider stakeholder risks appropriately in an EMS, one must first define who the stakeholders are within a given context. Freeman (1984), who first detailed "stakeholder theory," defines stakeholders as "any group or individual who can affect or is affected by the achievement of the organization's objectives" (p. 46). This definition is too broad in practical EMS application as it could be interpreted to include just about anyone or any group. The current approach used in AIM identifies stakeholders as either *Economic Stakeholders* (e.g., employees, suppliers, insurers, etc.) or *Public Stakeholders* (e.g., interested and affected citizens and environmental interest groups). While Freeman's (1984) definition of stakeholder is too broad, the current stakeholder identification groupings within AIM may be too vague. The EMS user needs a better identification of stakeholders that captures the nuances of each class of stakeholders that can influence environmental aspect significance prioritizations.

3.3.3 Prioritizing Mitigation Potential

AIM incorporates differentially weighted coefficients to consider risk magnitude and risk mitigation potentials to arrive at the final risk ranking values assigned to environmental aspects. This method correlates well with the ISO 14001:2015 and EMAS guidance that organizations should consider size, number, frequency (i.e., magnitude) and reversibility (i.e., mitigation) of environmental impacts. ISO 14001:2015 additionally states that it applies to "the environmental aspects…that the organization…can either control or influence" (p. 1) for continual environmental performance improvement, which strongly suggests consideration of the magnitude and mitigation of impact risks associated with significant aspects.

3.3.4 Determining Significance of Individual Aspects

One of the AIM outputs is a *Weighted Aspect Risk Priority Score* (WARPS) for each identified environmental aspect. The WARPS values are a relative risk ranking for all aspects; the higher the WARPS, the greater the aspect risk or *significance*. Determining significance of aspects rather than of impacts is in agreement with ISO 14001 and EMAS guidance as well as the most logical method given that mitigation efforts will be directed at reducing the cause (aspects) of the deleterious environmental effects (impacts). A weakness of the current AIM approach is that it does not define a specific mechanism whereby the user defines the cut-off between significant and non-significant aspects. Focht (2011) suggests that a natural (i.e., obvious) break in WARPS ranking could serve as such a cut-off.

3.3.5 Conditions Type

When identifying environmental aspects, ISO 14001:2015 requires consideration of normal and abnormal operating conditions, shut-down and startup conditions, and reasonably foreseeable emergency situations. The current version of AIM does not have a mechanism whereby these various types of conditions are identified, which is considered a weakness.

3.3.6 Spreadsheet-based Program

The current and revised versions of AIM are spreadsheet-based. This can be seen as a strength and a weakness. Spreadsheets, chiefly Microsoft Excel, have become ubiquitous in today's business world. Environmental professionals rely heavily on spreadsheet tools for tracking and calculating a myriad of data such as air emissions, wastewater discharges, and hazardous waste disposal to name a few. The benefits of spreadsheets include familiarity among users, file sharing ability, and calculation and presentation of data (Rabson 2006). Unfortunately, spreadsheets are not very well suited for ad hoc reports (Hunton and Raja 1995) and AIM can be considered an ad hoc reporting system.

3.4 Closing

The foregoing discussion not only reveals weaknesses of existing methods used to identify significant environmental aspects (including those in the current version of AIM), but also frames the most important elements that should be present in such procedures: (1) a risk-based assessment of impacts, (2) determination of significant environmental aspects, and (3) prioritization of aspect mitigation potential. The following chapter discusses how the revised AIM approach and/or future versions of AIM may overcome the weaknesses discussed above.

CHAPTER IV

DISCUSSION OF CURRENT AND FUTURE IMPROVEMENTS TO AIM

Following is a detailed discussion of how the weaknesses identified in the previous chapter will be addressed in the revised AIM or may be addressed in future releases of the program. For ease of cross-reference, this chapter is organized in parallel to Chapter III. Additionally, a simplified verification and validation (V&V) process to be developed in conjunction with the improvements to be made to AIM is introduced and described in greater detail in Chapter V.

4.1 How the Revised AIM Approach Will Address Weaknesses of Extant Methods

4.1.1 Limited Applicability

As mentioned, AIM is broadly applicable to any type of organization. Its holistic risk-based approach is not limited to a particular industry type, regulatory burden, or geographical location. This is a strength of the AIM approach in comparison to the methods presented by Darbra et al. (2005); Põder (2006); Germuks, Buchgeister, and Schebek (2007); and Marazza, Bandini, and Contin (2010).

4.1.2 Simplistic Assessment

Several of the methods reviewed in the previous chapter (e.g., Johnston, Hutchison, and Smith (2000); Põder (2006); and Ayers (2010)) employ narrowly-defined categories that do not address many of the interactions needed to produce a holistic measure of risk. The AIM procedure addresses risk assessment of impacts, significance determination, and mitigation prioritization in a manner that satisfies the guidance provided in ISO 14001 and EMAS.

4.1.3 Poorly Defined Variables

At least two of the reviewed methods (Johnston, Hutchison, and Smith (2000) and Põder (2006)) did not provide well defined bases for inputs and other values for significance determination of environmental aspects. All of the scales, variables, terms, step-by-step instructions, etc. needed to successfully use the AIM program are clearly provided in the AIM User Manual, which is included as Appendix D.

4.1.4 Insufficient Consideration of Aspect-Specific Impact Risk Assessment

The procedure described by Johnston, Hutchison, and Smith (2000) determines the risk of environmental impacts without regard to each aspect's associated risk magnitude. Not only is this contrary to what is stated in ISO 14001 and fails to recognize the aspect-impact cause-effect relationship, but it can also result in aspects being considered significant when they are not. The AIM approach requires the user to identify aspects first and then their associated impacts. Significance rating is performed at the aspect level, rather than at the level of impacts, as this is where the organization will focus mitigation efforts with the goal of reducing impacts.

4.1.5 Insufficient Consideration of Impact Risks

The overarching goal of ISO 14001 is to encourage continual environmental improvement as measured by reducing deleterious impacts to the environment. If a procedure fails to identify impacts, as with the SOSEA method described by Darbra (2005), it begs the question, how is improvement measured? In the AIM approach, impacts must be identified, their composite risk quantified, and aspects ranked and judged for significance and subsequent mitigation based on their cumulative impact scores.

4.1.6 Insufficient Consideration of Environmental Impacts

The AIM approach is strongly risk-based. In fact, AIM may be best described as a *holistic risk-based approach to identify significant environmental aspects*. AIM uses five risk categories that correlate well with the guidance provided in ISO 14001 and EMAS (see table 1). Determining a level of "acceptable risk" may be accomplished via several different approaches as described in the previous chapter, all of which are incorporated into AIM. Employing a holistic risk-based approach within AIM should be of acute interest to EMS implementers as it allows AIM to be broadly applicable to any type of organization under any type of regulatory scheme and in any geographical location.

4.1.7 Insufficient Consideration of Mitigation Prioritization

As stated, the overarching goal of an EMS is continual improvement in environmental performance, as measured by reduction in risk. Whereas environmental impacts arise from environmental aspects, impact mitigation effort is focused on aspects. Allowing for consideration of mitigation potential is in agreement with ISO 14001 (2015) which requires organizations to identify environmental aspects "that it can control and that it can influence" (p. 9) as well as to "consider its technological options and its financial, operational and business requirements" (p. 10). From a more purely pragmatic perspective, mitigation potential is an important consideration given the limited availability of financial and human resources for mitigation efforts. The AIM approach allows the user to optimize significant aspects for mitigation based on consideration of ease of mitigation *and* the availability of resources.

4.2 How the Revised AIM Approach Will Address Weaknesses of the Current AIM Approach

4.2.1 Assessing Risks of Individual Impacts

As discussed in Chapter III, AIM assesses risks of individual impacts based on five risk categories: human health risk, ecological health risk, resource depletion risk, legal risk, and stakeholder risk. Within each risk category and for each identified impact, the user must assign a numerical value from a five-point Likert scale, which AIM uses to assess risk. By and large the current AIM approach is appropriate; however, there are a few improvements that can be made and incorporated into a revised AIM, which are discussed below. Additional improvements that are not specifically addressed in the revised AIM, but should be considered for future revisions, are discussed in the following section.

Human health risk

The weakness of the current approach within AIM for assessing *Individual Health Risk* is discussed at length in the previous chapter. While this is not addressed in the revised AIM program, a proposed approach is presented in the next section.

Legal risk

Only minor changes are proposed for the legal risk portion of AIM. These changes will affect only two of the four category names: *Compliance Weight ("Wt")* will be changed to *Regulated Status ("RS")* and *Tort Severity ("Tort")* will be changed to *"Civil Liability ("Civ")*. *Regulated Status* more closely reflects the scale judgment descriptions and, in the opinion of the author, *Civil Liability* is a much more commonly used term among environmental professionals.

Stakeholder risk

The current treatment within AIM employs the following four classes of stakeholder risks within the *economic* and *public* groups.

- Economic Stakeholder Concern Intensity (*"EInt")*
- Economic Stakeholder Concern Breadth (*"EBr")*
- Public Stakeholder Concern Intensity (*"PInt")*
- Public Stakeholder Concern Breadth (*"PBr")*

Each of the stakeholder groups above is ranked using a 5-point Likert scale. The Likert scale judgments for each of the four scales are then used to calculate the *Impact Stakeholder Risk Score* (*ISRS*) for each individual environmental impact as follows:

- $ISRS = [(EInt \times EBr \times PInt \times PBr) - 1] / 624$

As stated in Chapter III, the current stakeholder identification groupings within AIM may be overly simplistic and a new method is described in the next section that could be incorporated into future AIM revisions. Due to apparent limitations of Excel related to data processing speeds coupled with a desire to simplify the user interface and overall experience, the stakeholder identification groupings are only renamed for this work rather than expanded upon as discussed in the next section. The new naming convention is in agreement with the proposed expanded future methodology.

The revised AIM re-labels the four stakeholder classes as follows:

- Organizational Stakeholders (*"Org")*
- Supply Chain Stakeholders (*"SC")*
- Regulatory Stakeholders (*"Reg")*
- Societal Stakeholders (*"Soc")*

For each class of stakeholders, the Likert-scale judgements are ranked from *5 – Very High* to *1 – Very Low* to answer the question, *What is the level of perceived risk?* The algorithm for calculating stakeholder risk remains the same as in the current version.

4.2.2 Weighting Coefficients

AIM includes weighting coefficients for each of the five risk scales as well as for risk mitigation and risk magnitude. Users will receive AIM "pre-loaded" with default values for each weighting coefficient, but will have the ability to redefine them as desired. Currently, AIM does not elicit any justification or explanation from the user prior to changing the default values. The revised AIM will allow the user to identify the reason(s) for entering weighting coefficients that are different from the default values. This may be accomplished in a variety of ways within the spreadsheet architecture; for example, a selection from a drop down box, a free-form text field, or a combination of the two. The revised AIM program uses a free-form text box to allow the user an opportunity to provide a statement of justification for deviating from the default values.

4.2.3 Significance Sensitivity Setting

The current AIM approach results in WAMPS values for each environmental aspect identified by the user; the higher the WAMPS values, the greater the significance. AIM does not currently explicitly identify which of the top tier aspects (i.e., the most significant aspects) should be targeted for mitigation. The revised AIM method will have a mechanism whereby the user can identify, as a percentage from 1 to 100, on which aspects to focus mitigation efforts. For example, if an AIM user identified ten aspects and selects 40% as the significance sensitivity setting, then the top four aspects would be the primary focus of mitigation efforts.

4.2.4 Conditions Type

According to ISO 14001, the method used in determining aspects and impacts should consider normal and abnormal operating conditions, shut-down and start-up conditions, as well as reasonably foreseeable emergency conditions (ISO 2015). The revised AIM approach includes a drop-down selection box on the START worksheet to allow the user to identify the conditions type being modeled. This conditions type identification is reproduced on the AIM output summary worksheet.

4.3 How Future AIM Revisions Could Address Weaknesses of the Current AIM Approach

4.3.1 Assessing Risks of Individual Impacts

Human health risk

To summarize the weaknesses of the current AIM approach discussed in the previous chapter: (1) the current approach oversimplifies the toxicity assessment process and (2) most organizations lack the necessary resources and expertise required to complete a more robust toxicity assessment. Additionally, the time and cost investment required for users to obtain basic data required to perform a rudimentary human health toxicity assessment may be beyond their reach or willingness to overcome. A possible method to address this in future revisions of AIM could be to elicit feedback from experts in the field of human health toxicity assessment.

Resource depletion risk

The *Natural Resource Degradation Extent* and *Natural Resource Renewal Rate* scales currently in AIM could be improved to minimize subjectivity. For these two scales, rather than users subjectively selecting a value from the arbitrarily created scales, they could select a category of resource(s) known to be used (e.g., oil, gasoline, diesel, uranium, minerals, geothermal, solar, biomass, etc.) and AIM would in turn return an appropriate scale value. The scale values returned by AIM would ideally be based on published data that could be incorporated into lookup tables.

Stakeholder risk

The literature is ripe with identification, classification, and general discussions surrounding stakeholders (Freeman 1984; Goodpastor 1991; Clarkson 1995; Frooman 1999; Darnall, Seol, and Sarkis 2009, Mainardes, Alves, and Raposo 2011, to name only a few). In fact, as stated by Mainardes, Alves, and Raposa (2011),

> "The term is highly popular with businesses, governments, non-governmental organizations and even with the media. Despite this widespread usage, many who adopt the term neither define the concept nor provide any particularly clear understanding of what they mean as regards what a stakeholder actually is. Even in academic circles, countless definitions of "stakeholder" have been put forward without any of those suggested ever gaining consensus, and hence there is no single, definitive and generally accepted definition" (p. 228).

Clarkson (1995) identifies stakeholders as either *primary* or *secondary*. Primary stakeholders are paramount to the survival of the organization and include shareholders and investors, employees, customers and suppliers as well as public stakeholders such as governments and communities (Clarkson 1995). Secondary stakeholders are those that can influence, or be influenced by, the organization, but are not necessarily required for the organization's continued survival; such as, the media and certain special interest groups (Clarkson 1995). Darnall, Seol, and Sarkis (2009) identify stakeholders as either *internal* or *external*. Internal stakeholders include employees, while external stakeholders include the following groups: regulatory, societal (e.g., environmental and community groups, labor unions, professional organizations), and supply chain (suppliers, transporters, distributors, customers, etc.). Buysse and Verbeke (2003) use somewhat of a hybrid approach to identify four stakeholder groups: *external primary stakeholders* (customers and suppliers), *internal primary stakeholders* (employees, shareholders, and financial institutions), *secondary stakeholders* (competitors, environmental groups, and the media), and *regulatory stakeholders* (national and regional governments and local public agencies). Fassin (2009) offers yet another classification: *stakeholders* (internal constituents), *stakewatchers* (unions, environmental organizations, and other pressure groups), and *stakekeepers* (regulators).

Given the lack of consensus surrounding stakeholder definition and classification, positing *something better* may be merely an exercise in suggesting *something different*. Ultimately, the EMS implementer needs a simple and efficient method that adequately accounts for stakeholders' perceived risks from the organization so that an accurate environmental aspect prioritization is possible. Additionally, the method must be explainable to and supported by organizational management. Table 4 presents stakeholder classes and groups based on the author's judgment grounded in nearly 20 years of environmental management experience at a multinational, publically traded, US-based manufacturing and service organization.

Now that stakeholders have been classified, a method for quantification of stakeholder risks that can be used in prioritizing environmental aspects can be developed.

Step 1. Each of the four stakeholder groups (organization, supply chain, regulatory, societal) is assigned a weighting value, the sum of which must equal 1. These weighting values should be assigned based on the perceived influence each stakeholder group may exert on the organization with respect to a particular environmental impact. Default values will be assigned within AIM, but can be overridden and defined by the user.

Step 2. The level of perceived risk for each stakeholder class within each stakeholder group for each environmental impact is ranked using the following five-point Likert scale:

- 5 = Very High
- 4 = High
- 3 = Medium
- 2 = Low
- 1 = Very Low

Step 3. Using the Likert scale judgments above, individual *Impact Stakeholder Class Risk Scores* ("*ISCRS*") are calculated as follow

- Organization: *ISCRS-O = [(ME x nME x F x SH) – 1] / 624*
- Supply Chain: *ISCRS-C = [(Sup x Tran x Dist x Ware x Ret x Cust) – 1] / 15,624*
- Regulatory: *ISCRS-R = [(Int x Nat x R x SP x Loc) – 1] / 3124*
- Societal: *ISCRS-S = [(Com x EG x PO x Med x LU) – 1] / 3124*

Step 4. Each *ISCRS* is then multiplied by its appropriate weighting scale value from step 1 to obtain an *Impact Stakeholder Risk Score* ("*ISRC*").

Step 5. The sum of the products from step 4 determines the final *Impact Stakeholder Risk Score* (*ISRS*) for each individual environmental impact, which will be a value between 0 and 1.

4.3.2 Spreadsheet-based Program

Some of the weaknesses of spreadsheet-based systems can be neutralized with macros, drop-down boxes, and other means to provide users with pre-defined selection options for various scenarios (e.g., number of processes, aspects, and impacts). However, the first revision attempt to the current AIM program, which allowed virtually open-ended flexibility for the user to characterize the number of processes and associated aspects and impacts, was slowed to unacceptable processing speeds due to limitations within Excel. As such, the revised AIM presented herein is limited to a total of 10 processes. Each process is limited to 5 aspects with 10 impacts each. Due to these limitations, the revised AIM may be best considered a "proof-of-concept" program. Future versions of AIM should be created within a more robust database system.

Table 4. Stakeholder Classes and Groups Proposed for future AIM Revisions

Stakeholder Class	Stakeholder Groups within Classes	Abbreviation
Organization	Management Employees Non-Management Employees Financiers Shareholders	*ME* *nME* *Fin* *SH*
Supply Chain	Suppliers Transporters Distributors Warehouses Retailers Customers	*Sup* *Tp* *Dist* *Ware* *Ret* *Cust*
Regulatory	International National Regional State/Provincial Local	*Int* *Nat* *Reg* *SP* *Loc*
Society	Community Environmental Groups Professional Organizations Media Labor Unions	*Com* *EG* *PO* *Med* *LU*

4.4 Verification and Validation (V&V) of the Revised AIM Approach

High instances of errors in spreadsheets are reported in the literature (Howard and Harrison 2007a; Panko 2008; and Poon et al. 2014). Panko (2008) compiled a literature review of spreadsheet audit studies and determined that 88% of 113 spreadsheets examined since 1995 contained errors. These high spreadsheet error rates necessitate a quality assurance process that will increase confidence in data output. This is especially true for a program such as AIM that is intended to be used as a decision-support tool to identify environmental aspects to be mitigated. In theory, greater confidence in AIM's data output should result in broader support from stakeholders and increase legitimacy of an organization's EMS. Verification and validation (V&V) are important quality assurance concepts within the software development process that will be applied to AIM.

The CMMI Institute (CMMI 2015) describes V&V as follows:

> *Verification* ensures that the right product is created according to its requirements, specifications, and standards. That is, *are you building the product right?*
>
> *Validation* ensures the product will be usable once complete. That is, *are you building the right product?*

The V&V methodology applied to the revised AIM program is discussed in detail in Chapter V.

4.5 Closing

The improved AIM approach addresses many of the weaknesses identified in existing significance assessment methods and the current AIM program. The V&V process will add a level of robustness not seen (or at least not described) in the aspect significance assessment literature, which should greatly add to AIM's legitimacy as a decision support system for EMS implementers.

CHAPTER V

VERIFICATION AND VALIDATION (V&V) OF THE REVISED AIM APPROACH

Cantellops (2005) defines *spreadsheet verification* as "the process of evaluating the spreadsheet application for consistency and correctness of the software at each stage and between each stage of the development life cycle to ensure compliance with the analytical method. Verification activities are in-process activities (testing and measurement) performed concurrently with spreadsheet (workbook file) development and population" (p. 12). Cantellops, Bonnin, and Reid (2003) state, "validation is concerned with generating evidence to demonstrate that the system is fit for the purpose for which you use it, it continues to be so when it is operational, and there is sufficient evidence of management control" (p. 18). "Sufficient evidence" is provided in the form of auditable documentation.

While much of the literature regarding V&V appears to be directed at software applications that have a high degree of regulatory oversight and/or extreme safety concerns, such as at the US Food and Drug Administration and within the pharmaceuticals and nuclear industries, application of the process to AIM, as alluded to above, should make the tool more robust and lend legitimacy to its use. At the very least, the V&V process is a good idea to minimize errors.

5.1 Verification Methodology

Verification will be performed in-process at each stage of spreadsheet development via manual calculations as suggested by Cantellops (2005) and a second analyst may also be used to verify calculated results. The validation process, which is described in greater detail below, will be largely based on a process developed by ABB Engineering Services for validating Microsoft Excel spreadsheets. Although the ABB process has been most often used within the pharmaceuticals industry, Howard and Harrison (2007a) state, “it is simple and flexible and can be applied to all spreadsheets to provide assurance that the system performs as intended” (p. 31).

5.2 Validation Methodology

The ABB process employs an amended V-model as shown in Figure 2. This methodology was selected primarily for the following three reasons: (1) it was developed specifically for Microsoft Excel spreadsheet validation purposes; (2) the developers claim it to be simple, flexible, and applicable to all spreadsheets; and (3) there exists a series of articles written by the developers that appear to explain the process in enough detail so as to reproduce it to the extent necessary for validation of AIM.

The primary deliverables of the ABB process are a *Spreadsheet Specification Document* and a *Spreadsheet Qualification Document*, as shown in shaded areas in Figure 2. Other terms in Figure 2, which are discussed below, are: URS (User Requirement Specification), FS (Functional Specification), IQ (Installation Qualification), OQ (Operational Qualification), and PQ (Performance Qualification).

5.2.1 Spreadsheet Specification Document

Once the basic spreadsheet design has been determined, a User Requirement Specification (URS) and Functional Specification (FS) are used to create the Spreadsheet Specification Document (Howard and Harrison 2007a). The specification document is generated *after* completion of spreadsheet prototyping to avoid having to make several edits to the document as well as a management tool to combat “scope creep,” which could result in functional edits to the spreadsheet and introduction of errors (Howard and Harrison 2007b). The specification document is essentially a user manual that describes in detail not only how to use the spreadsheet, but why the spreadsheet was developed (URS) and how the spreadsheet functions (FS). The URS is written as a request for functionality (what the spreadsheet must or should do), while the FS is written as a response to the URS (what the spreadsheet will or does do). The specification document for the revised AIM is included as Appendix B.

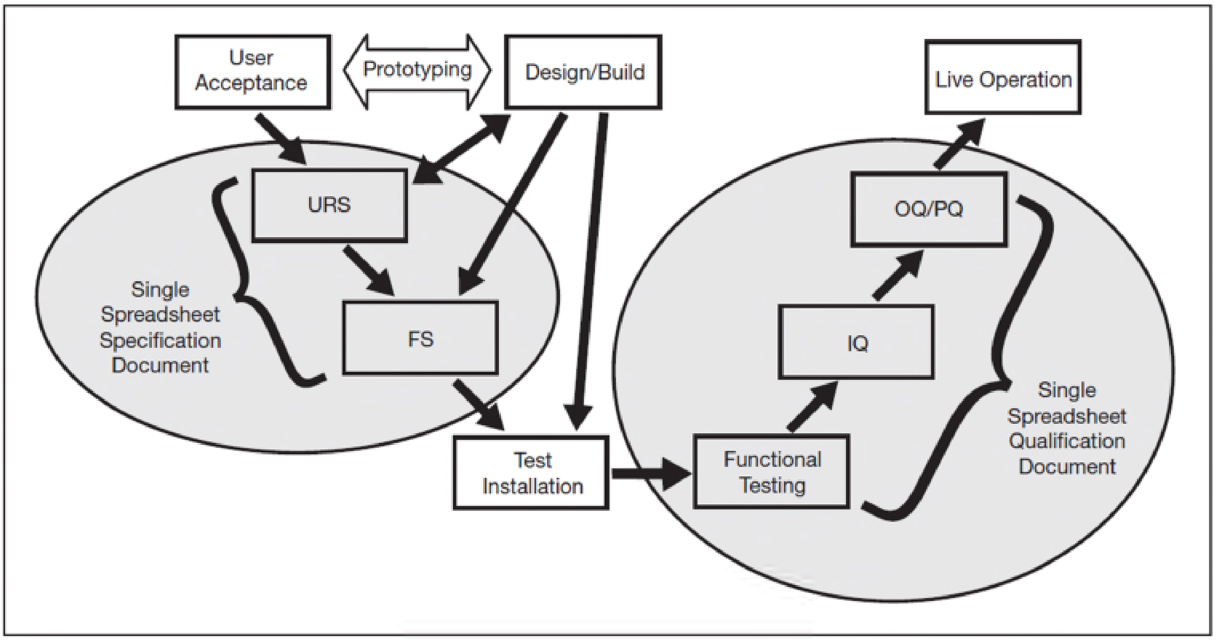

Figure 2. Amended V-Model for Excel Spreadsheet Validation

(from Howard and Harrison 2007a, Howard and Harrison 2007c)

5.2.2 Spreadsheet Qualification Document

The qualification process described by Howard and Harrison (2007c) includes the following stages, as shown in Figure 2: Functional Testing (FT), Installation Qualification (IQ), Operational Qualification (OQ), and Performance Qualification (PQ). The qualification process confirms calculation accuracy of the spreadsheet and ensures it operates as stated in the specification document.

The main body of the qualification document provides an overview of the spreadsheet being validated and a discussion of the testing philosophies. For AIM, the functional testing (FT) was the primary task of the developer. Items of focus within the FT included: testing the structure of the spreadsheet, testing the calculations in the spreadsheet, and testing any macros in the spreadsheet. Installation Qualification (IQ), or *Installation Testing*, involves verifying appropriate installation of the spreadsheet into the operating environment. IQ is more of an issue when dealing with multiple linked spreadsheets or other external data sources and is not currently applicable to the AIM program. Operational and performance qualification assessment (OP and PQ) involves collection, discussion, and assessment of input from potential end users (i.e., "expert panel"). A qualification document was not created for the revised AIM program; however, a discussion of the expert panel feedback is provided in the following section.

5.2.3 Expert Panel Feedback

Although Robinson and Brooks (2010) state that V&V is normally the responsibility of the developer, other than with large and complex (normally military) simulation models that traditionally undergo *Independent Verification and Validation* (IV&V), additional analysts were used in the AIM V&V process. The expert panel consisted of practicing environmental professionals from different organizations with varying EMS-related work experience. While AIM is applicable to any type of organization, the expert panel was comprised of individuals primarily working in the manufacturing sector.

Expert panel questionnaire

The expert panel questionnaire consisted of a total of 8 questions in the areas of ease of use (4 questions), effectiveness/usefulness (2 questions), and intuitiveness of output results (2 questions). In addition to the specific questions, each panelist was given the opportunity to provide additional written feedback. A total of four questionnaires were submitted and a total of four completed questionnaires were returned. Copies of the returned questionnaires and related correspondence are included in Appendix A; below is a summary of the questionnaire feedback.

Responses to questions

Table 5. Panelist Familiarity with EMSs

EMS Familiarity	Panelist			
	A	B	C	D
1. Low				
2. Medium		X		
3. High	X		X	X

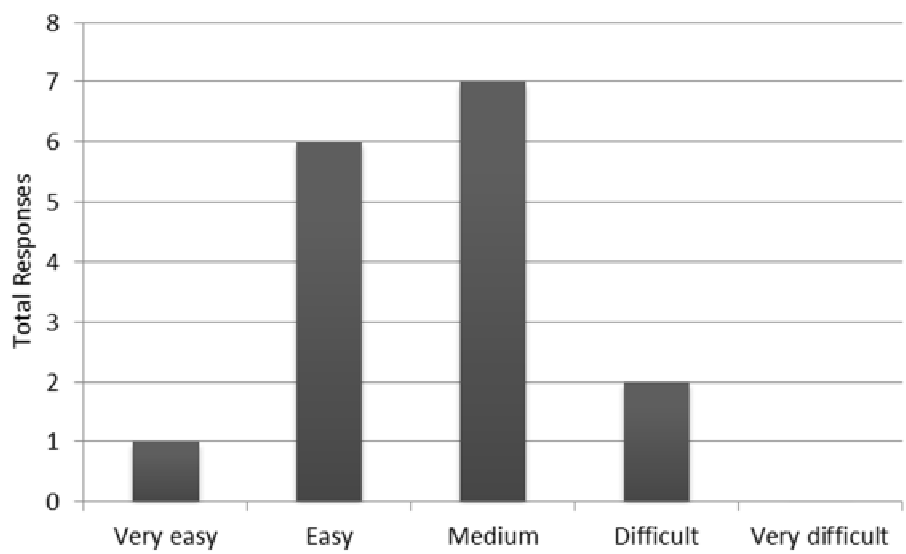

Figure 3. Ease of use questions – Composite Chart

Table 6. Ease of Use Questions

	Panelist			
	A	B	C	D
How easy was the AIM user manual to understand?				
1. Very easy				
2. Easy	X		X	
3. Medium		X		X
4. Difficult				
5. Very difficult				
How easy was it (or would it be) to obtain AIM input data?				
1. Very easy				
2. Easy			X	
3. Medium	X			X
4. Difficult				
5. Very difficult				
How easy was the AIM data entry process?				
1. Very easy	X			
2. Easy		X	X	
3. Medium				X
4. Difficult				
5. Very difficult				
How easy was the AIM program to understand?				
1. Very easy				
2. Easy			X	
3. Medium	X			X
4. Difficult	X	X		
5. Very difficult				

Table 7. Effectiveness / Usefulness Questions

	Panelist			
	A	B	C	D
How useful was the significance determination portion of AIM?				
1. Very useful				
2. Somewhat useful			X	
3. Medium	X			X
4. Somewhat useless	X	X		
5. Very useless				
How useful was the mitigation ranking portion of AIM?				
1. Very useful				
2. Somewhat useful	X	X		
3. Medium			X	
4. Somewhat useless				X
5. Very useless				

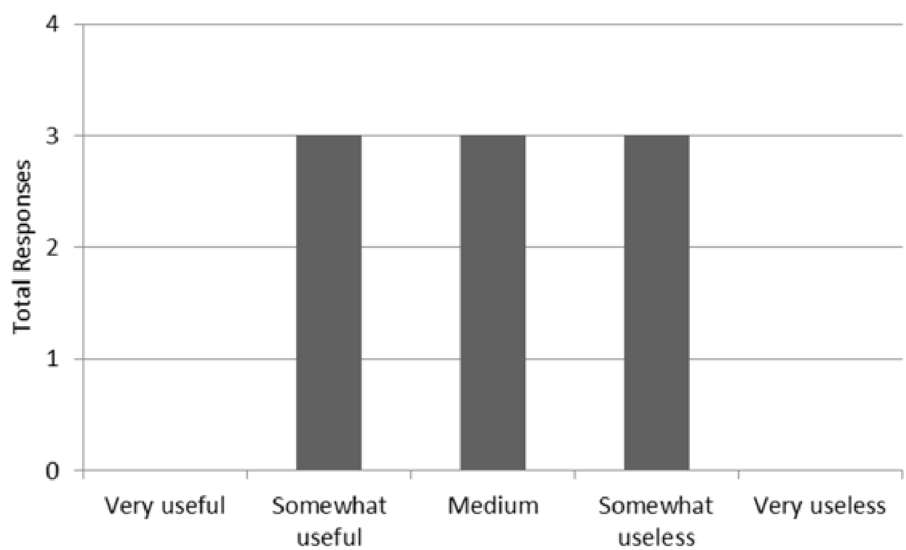

Figure 4. Effectiveness / Usefulness questions – Composite Chart

Table 8. Results Questions

	Panelist			
	A	B	C	D
Did the AIM program produce anticipated results?				
1. Yes		X	X	
2. No	X			X
Would your management team be willing to act on the results of the AIM program?				
1. Yes			X	
2. No	X	X		X

Written feedback

Ease of Use Questions

The User Manual

Two panelists provided written comments on the user manual. Panelist A noted a few spelling and grammatical errors. Panelist B stated that the manual was well-written, but recommended replacing the weighting coefficient's Greek symbols with Roman ones (e.g., for the *Human health risk weighting coefficient*, replace "π" with "H").

The Program

Panelist A suggested obtaining accurate Likert scale values may require an excessive amount of time and effort and in some cases "probably hard for ordinary people to discern." While panelist A said AIM may be useful to analyze the results of the time and effort required, it may not be a good tool to generate actions to reduce impact significance.

Regarding data entry, the general consensus from the panelists was that it was relatively easy, but in the words of Panelist B "tedious." Overall understandability of the AIM program by the panelists ranged from easy to difficult. Panelist A recommended to make it easier to see how changing *risk mitigation* affects *impact significance* and adding functionality to allow users to enter their own notes describing the same. Panelist B felt most elements of AIM were easy to understand, but had difficulty understanding the *significance sensitivity level* and the concept of Likert scale.

Effectiveness / Usefulness Questions

Significance Determination

Panelist A suggests that AIM results may be overly generalized due to a lack of granularity and subjectivity of the underlying Likert scales. Panelist A recommends requiring categories and quantities of process inputs (e.g., chemicals, energy, etc.) be documented so that year-over-year changes could be more readily measured.

Mitigation Ranking

Panelist A feels the mitigation ranking would be more useful if the user could input notes associated with the reasons for the ranking and to define actions needed to improve the score.

Results Questions

Panelists A and D felt that AIM may be too complicated and time-consuming. Panelist D said the program goes beyond what most organizations would require for the purposes of managing environmental risk. While Panelist D surmised AIM may be over-engineered for EMS purposes, with further development AIM could have utility in the area of Environmental Impact Assessment (EIA); especially for planning and assessment of infrastructure projects where the mitigation element of AIM could come into its own.

5.3 Closing

The V&V process described above resulted in a wealth of information to improve the AIM program. While some of this information will be used to improve the revised AIM that is the subject of this work, most of it will likely be incorporated into future versions of AIM. Additionally, a completely new AIM or "AIM-like" program may be developed in the future for use in EIA projects.

CHAPTER VI

SUMMARY, CONCLUSIONS, AND IMPLICATIONS

Hundreds of thousands of organizations from around the globe have adopted EMSs based on ISO 14001. Proponents of ISO 14001 claim that implementation will result in many organizational benefits, while detractors maintain the time and costs associated with implementation and maintenance of such systems outweigh any supposed benefits. The literature indicates a mixed bag of results with regard to the actual benefits of EMS adoption. This performance variability appears to be related to many factors, such as (1) types of motivating pressures to implement an EMS, (2) comprehensiveness of the EMS, (3) availability of capital and human resources, and (4) support from top management.

The most important and most difficult step in the EMS implementation process is the identification of *significant environmental aspects*. Unfortunately, ISO 14001 does not explicitly define significance or offer a method for significance determination. As such, many schemes have been independently developed. These significance determination schemes run the gamut from being rather simplistic to quite complex with some having narrow applicability to only one organization or industry type. Other weaknesses associated with these existing significance determination tools include poorly defined variables and insufficient consideration of risk and mitigation potential.

AIM was initially developed as a decision support tool to assist EMS implementers in identifying significant environmental aspects. The AM program employs a holistic risk-based approach to significance determination. AIM considers the following types of risk: human health risk, ecological health risk, resource depletion risk, legal risk, and stakeholder risk. In addition, AIM incorporates risk mitigation along with risk magnitude when calculating and ranking significance of environmental aspects. While AIM addresses the weaknesses identified in many contemporary systems, it is not without its own areas in need of improvement. The overarching goal of the research presented here was to develop a revised and improved AIM program as well as elicit feedback for future improvements.

The revised AIM program represents a complete rebuild of the original spreadsheet architecture to simplify the data input process for the user. This process was extensive and included writing over 15,000 lines of VBA code (see Appendix C for selected excerpts). Once the revised AIM program was complete and ready for beta testing, a detailed user manual was created. Lastly, and possibly the most insightful element to this research, was the V&V process and solicitation of feedback from a panel of environmental professionals with familiarity of EMSs. The panelists provided keen insight into and frank commentary on how to improve future versions of AIM.

Due to the aforementioned lack of specificity in ISO 14001 regarding the term "significant" and similarly on how to determine which environmental aspects meet that criteria coupled with the notion that this determination is both the most important and most difficult part of the EMS implementation process, there would appear to be a need for a "better" tool to assist organizations in identifying significant environmental aspects. The revised AIM program meets the minimal requirements for aspect significance determination provided by ISO 14001 as well as addresses the weaknesses of contemporary systems cited in the literature.

The following generalizations are made about the revised AIM program based on feedback from a group of environmental professionals with EMS experience: (1) obtaining the necessary data to input into AIM and the overall data input process were easy to medium in difficulty, (2) overall understandability of the AIM program itself was difficult, (3) the significance determination was deemed somewhat useful to somewhat useless while the mitigation ranking responses averaged as medium in usefulness; and (4) two of the four panelists agreed that the AIM program returned anticipated results while only one panelist indicated site management would be willing to act on those results.

In addition to answering a set of eight questions, the panelists also provided additional written responses, which should prove beneficial to future AIM revision efforts. Other than noting a few spelling errors and recommending minor changes to some of the symbols used, the panelists felt that the user manual was well-written. As far as using the program itself, the panelists generally felt that while the data entry process was relatively easy, the time required gathering the data and level of knowledge required making accurate scale judgments could outweigh the benefits. One panelist recommended adding functionality to allow the user to enter notes and comments. The same panelist opined that the Likert scale judgments lacked detail and introduced too much subjectivity to adequately measure year-over-year changes. Two of the panelists felt that AIM may be too complicated and over-engineered for EMS risk management purposes at most organizations.

Notwithstanding the critical nature of some of the panelists' comments, their input provides important insight into how the revised AIM program may be further improved. The V&V process employed herein, which was not found in the literature review for other EMS decision tools, brings to light certain limitations associated with this current research project. Future AIM revisions may be improved by employing a more robust and formalized V&V process than the limited one used in this research. Additional time and a larger sample of end-users could produce a more thorough understanding of user requirement and functional specification expectations of the final product. Due to limitations of the spreadsheet environment, AIM may be better suited for operation within a more traditional database system.

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APPENDICES

APPENDIX A

EXPERT PANEL QUESTIONNAIRE AND RESPONSES

APPENDIX B

SPREADSHEET SPECIFICATION DOCUMENT FOR THE REVISED AIM PROGRAM

APPENDIX C

VISUAL BASIC CODE EXCERPTS FROM THE REVISED AIM PROGRAM

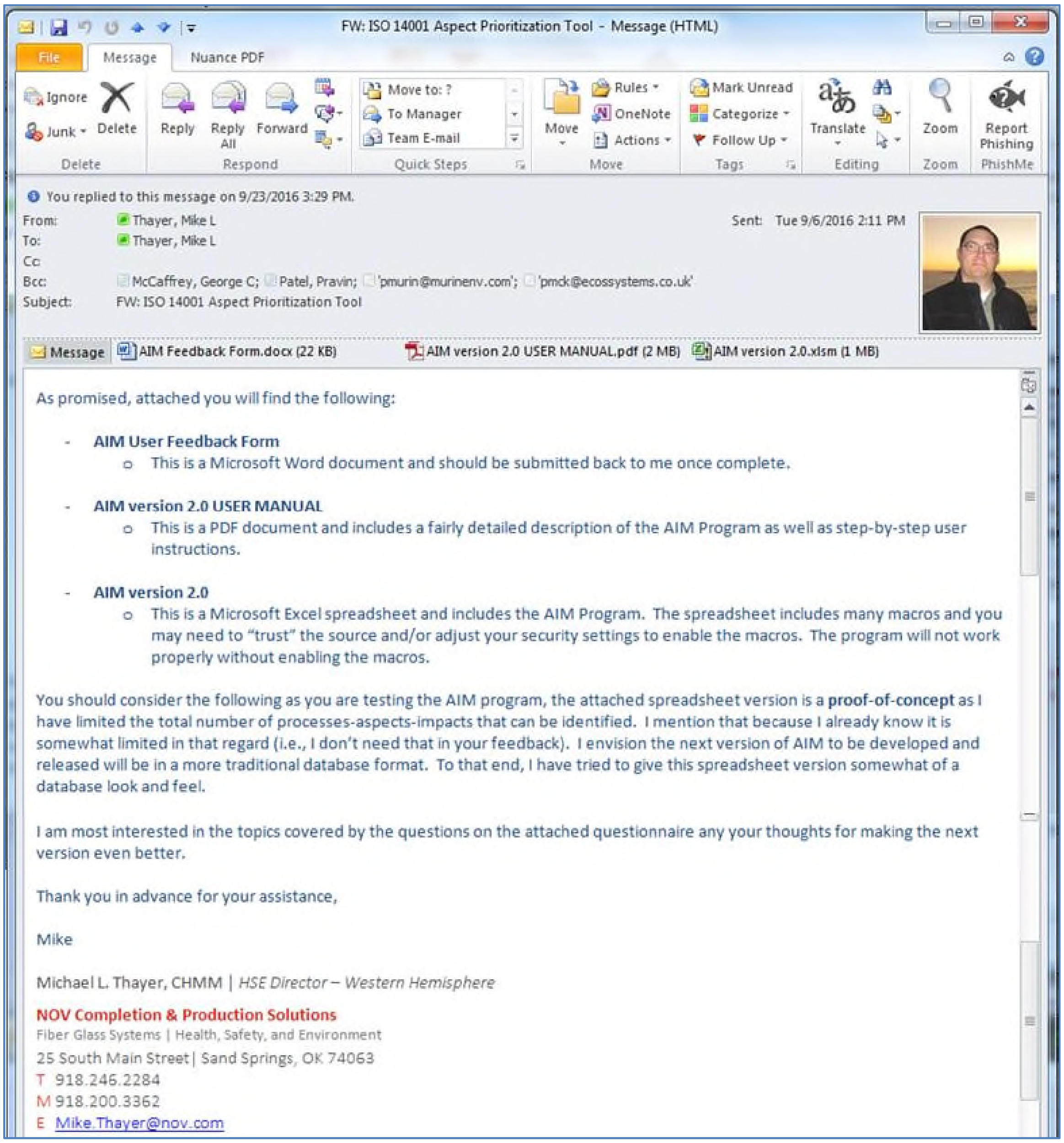
APPENDIX D

USER MANUAL FOR THE REVISED AIM PROGRAM

APPENDIX A

EXPERT PANEL QUESTIONNAIRE AND RESPONSES

A total of four panelists were each sent an AIM questionnaire, along with a copy of the revised AIM program and user manual. The panelists were asked to rate AIM in the areas of *ease of use*, *effectiveness/usefulness*, and *output results*. The initial email correspondence to the panelists as well as their completed questionnaires and other feedback are provided below.



FW: ISO 14001 Aspect Prioritization Tool - Message (HTML)

You replied to this message on 9/23/2016 3:29 PM.

From: Thayer, Mike L

Sent: Tue 9/6/2016 2:11 PM

To: Thayer, Mike L

Cc:

Bcc: McCaffrey, George C; Patel, Pravin; 'pmurin@murinenv.com'; 'pmck@ecossystems.co.uk'

Subject: FW: ISO 14001 Aspect Prioritization Tool

Message | AIM Feedback Form.docx (22 KB) | AIM version 2.0 USER MANUAL.pdf (2 MB) | AIM version 2.0.xlsm (1 MB)

As promised, attached you will find the following:

- **AIM User Feedback Form**
  - This is a Microsoft Word document and should be submitted back to me once complete.
- **AIM version 2.0 USER MANUAL**
  - This is a PDF document and includes a fairly detailed description of the AIM Program as well as step-by-step user instructions.
- **AIM version 2.0**
  - This is a Microsoft Excel spreadsheet and includes the AIM Program. The spreadsheet includes many macros and you may need to "trust" the source and/or adjust your security settings to enable the macros. The program will not work properly without enabling the macros.

You should consider the following as you are testing the AIM program, the attached spreadsheet version is a **proof-of-concept** as I have limited the total number of processes-aspects-impacts that can be identified. I mention that because I already know it is somewhat limited in that regard (i.e., I don't need that in your feedback). I envision the next version of AIM to be developed and released will be in a more traditional database format. To that end, I have tried to give this spreadsheet version somewhat of a database look and feel.

I am most interested in the topics covered by the questions on the attached questionnaire any your thoughts for making the next version even better.

Thank you in advance for your assistance,

Mike

Michael L. Thayer, CHMM | *HSE Director – Western Hemisphere*

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E Mike.Thayer@nov.com

AIM PRIORITIZATION PROGRAM

Expert Panel Questionnaire
Beta Testing and Feedback

Thank you for agreeing to act as a beta tester and providing important feedback on the AIM User Manual and the AIM Prioritization Program. Your feedback is an important part of this work and will be used to make the AIM program better.

There are a total of eight (8) questions (A through H). Question topics fall under "EASE OF USE," "EFFECTIVENESS / USEFULLNESS," and "RESULTS" and cover the user manual as well as the program itself. Each question allows the tester to provide additional comments. After the last question, the tester may provide any additional comments and feedback that may not be covered in the set of eight questions.

Tester Information

Name:	Pravin Patel		
Job Title:	HSE Manager		
Organization:	NOV XL SYstems		
Familiarity with environmental management systems:	Low ☐	Medium ☐	High ☒

<u>EASE OF USE QUESTIONS</u>

The User Manual

A. How easy was the AIM user manual to understand?

☐ 1. Very easy
☒ 2. Easy
☐ 3. Medium
☐ 4. Difficult
☐ 5. Very difficult

For ratings of 4 or 5, what is/are your recommendation for improvement?

Please type comments here, if any

The Program

B. How easy was it (or would it be) to obtain AIM input data?

☐ 1. Very easy
☒ 2. Easy

☐ 3. Medium
☐ 4. Difficult
☐ 5. Very difficult

For ratings of 4 or 5, what is/are your recommendation for improvement?

Please type comments here, if any

C. How easy was the AIM data entry process?

☐ 1. Very easy
☒ 2. Easy
☐ 3. Medium
☐ 4. Difficult
☐ 5. Very difficult

For ratings of 4 or 5, what is/are your recommendation for improvement?

Please type comments here, if any

D. How easy was the AIM program to understand?

☐ 1. Very easy
☒ 2. Easy
☐ 3. Medium
☐ 4. Difficult
☐ 5. Very difficult

For ratings of 4 or 5, what is/are your recommendation for improvement?

Please type comments here, if any

EFFECTIVENESS / USEFULLNESS QUESTIONS

E. How useful was the significance determination portion of AIM?

☐ 1. Very useful
☒ 2. Somewhat useful
☐ 3. Medium
☐ 4. Somewhat useless
☐ 5. Very useless

For ratings of 4 or 5, what is/are your recommendation for improvement?

Please type comments here, if any

F. How useful was the mitigation ranking portion of AIM?

- ☐ 1. Very useful
- ☐ 2. Somewhat useful
- ☒ 3. Medium
- ☐ 4. Somewhat useless
- ☐ 5. Very useless

For ratings of 4 or 5, what is/are your recommendation for improvement?

Please type comments here, if any

RESULTS QUESTIONS

G. Did the AIM program produce anticipated results?

- ☒ 1. Yes
- ☐ 2. No

If "no," please explain:

Please type comments here, if any

H. Would your management team be willing to act on the results of the AIM program?

- ☒ 1. Yes
- ☐ 2. No

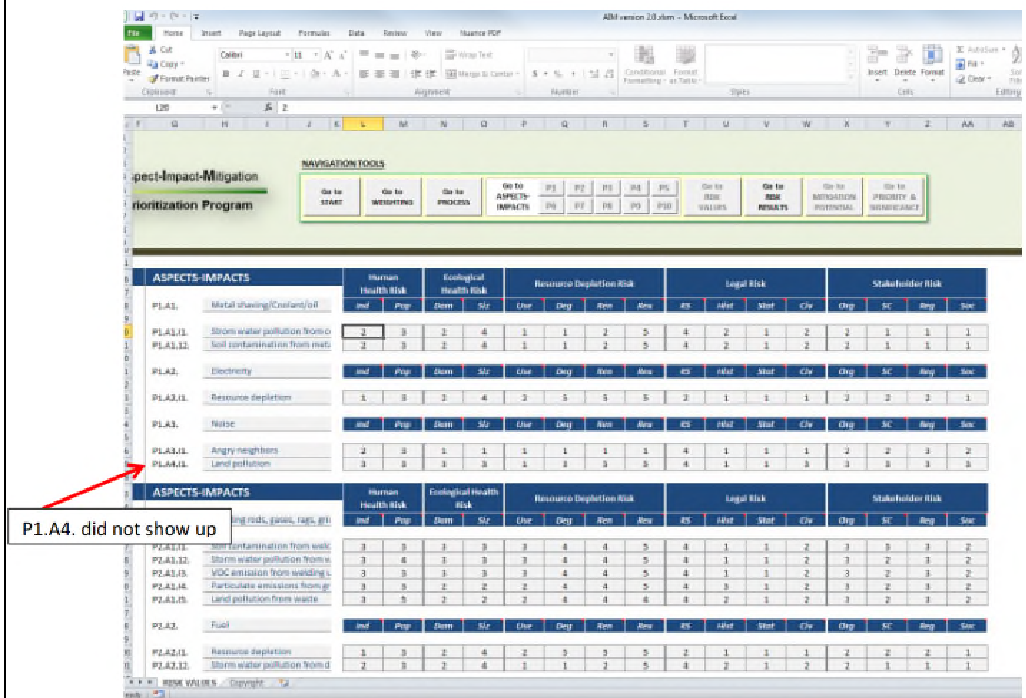
If "no," please explain:

Please type comments here, if any

ADDITIONAL COMMENTS & FEEDBACK

Please feel free to provide any additional comments and/or feedback that is not already addressed in the questions above. You may also use the space below to identify any spelling errors and/or program calculation errors discovered.

See comments below.



AIM PRIORITIZATION PROGRAM

Expert Panel Questionnaire
Beta Testing and Feedback

Thank you for agreeing to act as a beta tester and providing important feedback on the AIM User Manual and the AIM Prioritization Program. Your feedback is an important part of this work and will be used to make the AIM program better.

There are a total of eight (8) questions (A through H). Question topics fall under "EASE OF USE," "EFFECTIVENESS / USEFULLNESS," and "RESULTS" and cover the user manual as well as the program itself. Each question allows the tester to provide additional comments. After the last question, the tester may provide any additional comments and feedback that may not be covered in the set of eight questions.

Tester Information

Name:	George McCaffrey			
Job Title:	HSE Manager			
Organization:	NOV Corporate HSE			
Familiarity with environmental management systems:	Low ☐	Medium ☐	High ☒	

EASE OF USE QUESTIONS

The User Manual

A. How easy was the AIM user manual to understand?

☐ 1. Very easy
☒ 2. Easy
☐ 3. Medium
☐ 4. Difficult
☐ 5. Very difficult

For ratings of 4 or 5, what is/are your recommendation for improvement?

There are a few spelling / grammatical errors in the User Manual (ref. my notes in "ADDITIONAL COMMENTS & FEEDBACK" section below.

The Program

B. How easy was it (or would it be) to obtain AIM input data?

☐ 1. Very easy

☐ 2. Easy
☒ 3. Medium
☐ 4. Difficult
☐ 5. Very difficult

For ratings of 4 or 5, what is/are your recommendation for improvement?

> To accurately assign LIKERT values one would likely require physically watching the process (time demand), research from incident history (facility and industry), coordination with Operations personnel (potential scheduling issues) as well as meeting with or obtaining information from purchasing folks and management. One may also need to do an extensive amount of research to determine proper LIKERT values for Habitat Population Size values, as this is probably hard for ordinary people to discern.
> The AIM program appears to me to be a very good place to analyze the results of all of this research but may not be as good of a tool to generate actions to reduce Impact Significance.

C. How easy was the AIM data entry process?

☒ 1. Very easy
☐ 2. Easy
☐ 3. Medium
☐ 4. Difficult
☐ 5. Very difficult

For ratings of 4 or 5, what is/are your recommendation for improvement?

> In the "CONTACT INFORMATION" section when at the "Name" line one can't tab to the Telephone line (Tab takes you to the Significance Sensitivity score. Tab should go from Name to Telephone.

D. How easy was the AIM program to understand?

☐ 1. Very easy
☐ 2. Easy
☒ 3. Medium
☒ 4. Difficult
☐ 5. Very difficult

For ratings of 4 or 5, what is/are your recommendation for improvement?

> Make it easier to see how changing Risk Mitigation affects Impact Significance and include places to put notes to describe same.

EFFECTIVENESS / USEFULLNESS QUESTIONS

E. How useful was the significance determination portion of AIM?

- ☐ 1. Very useful
- ☐ 2. Somewhat useful
- ☒ 3. Medium
- ☒ 4. Somewhat useless
- ☐ 5. Very useless

For ratings of 4 or 5, what is/are your recommendation for improvement?

> The AIM tool does not force a consistent way to document in my opinion with sufficient granularity some critical Process inputs (Chemicals used and quantities ~i.e. 10 gallons of HCL per batch; Energy consumption and quantity ~i.e. 10 Megawatts of electricity per month and 100 cubic foot of natural gas per month), thus the results (identification of significant impacts) may be overly general, subjective and less useful. If the AIM tool required that categories of inputs (chemicals, energy, other resources such as steel stock, etc.) be documented it would be easier to get consistent results and identify changes year over year when reviewing A&I assessments. I recommend you add a requirement that at least chemicals used, energy use and stock used be defined and estimated. You could have an option to add optional information (Example: Production Rate).

F. How useful was the mitigation ranking portion of AIM?

- ☐ 1. Very useful
- ☒ 2. Somewhat useful
- ☐ 3. Medium
- ☐ 4. Somewhat useless
- ☐ 5. Very useless

For ratings of 4 or 5, what is/are your recommendation for improvement?

> The mitigation ranking would be more useful if the AIM tool user could input notes associated with the reasons for ranking and to define actions needed to improve the score.

RESULTS QUESTIONS

G. Did the AIM program produce anticipated results?

☐ 1. Yes
☒ 2. No

If "no," please explain:

Additional "Yes" results are obtained when the "Significance Sensitivity" is increased. Shouldn't this be the opposite? Also, the final results don't appear to differentiate or make clear "Yes" results for the various categories of Conditions Types (Example: A Yes significance may be expected for Emergency Situation because management has not taken steps to mitigate the potential for an emergency, but during Normal Operation the significance would not be significant because the process itself while operating has a low risk. The AIM tool should provide different scores for different Conditions Types.

H. Would your management team be willing to act on the results of the AIM program?

☐ 1. Yes
☒ 2. No

If "no," please explain:

Although the AIM program is a great analytical tool I feel management will view the time it takes to use the tool to be excessive (during this downturn in the Energy sector and where dedicated HSE resources are tight).

ADDITIONAL COMMENTS & FEEDBACK

Please feel free to provide any additional comments and/or feedback that is not already addressed in the questions above. You may also use the space below to identify any spelling errors and/or program calculation errors discovered.

Mike, the AIM Program is a great analytical tool. It appears to me that a few modifications can make it an even more useful.

1. For an organization to better be able to demonstrate compliance to ISO 14001:2015 and to document what is needed to improve environmental performance it would in my opinion be useful if the AIM tool had a place to enter actions needed to address internal and external contextual issues as well as actions needed to mitigate risks.
2. If the AIM Program structure and the Output Results page showed the overall process and then have that process broken down into smaller processes it would help one see the big picture while detailing areas where specific improvement can/should be considered.
3. If the AIM tool was to generate a process map of each process it would likely help folks understand more easily the inputs and outputs from their processes and it would make

it easier to identify process and/or input/output changes (Ref. page 1 of the AIM manual shows a simple process map for Moving the lawn).

4. A clarification may be in order for the LIKERT scale used to determine Individual Health Risk so as to differentiate between acute health risk and long term health risk.
5. I noticed that when on the Risk Values tab one can't see the full text in columns H-J and if you click on the cell to see the text you see the formula instead. I recommend making it so one can see the entire text.
6. A clarification may be in order for the phrase "…long periods…" in the LIKERT scale used for Ecological Health Risk rank #4. It states "Serious (habitat damage will persist for long periods without significant human intervention)". Is a long period considered to be more than a year (I draw this conclusion because LIKERT value #3 states "… restoration is expected within a year…")
7. I don't see how the AIM tool identifies or documents the Resources that are used, degraded, renewed or reused. Perhaps there can be a field that enables an AIM user to enter this.
8. It is great the AIM program allows the user to assign their own values for weighting and for significance sensitivity. I recommend that the program allow different weighting to be allowed for different Conditions Types (i.e. Normal, Abnormal, Shutdown/Startup, and Emergency Situation). This is to enable the user to be able to define and see more specific areas where improvements are needed.
9. I noticed the following spelling and/or grammatical errors:
    a. Page 1: The definition for Aspect should include the word "is" between "but _ limited to"
    b. Page 1: the acronym AIM is not capitalized in the Note. "Although ISO 14001 specifies that impact can be either positive (beneficial) or negative (adverse), Aim…"[should be "AIM"].
    c. Page 9 section 3.1: The word "is" should be changed to "it" in the sentence "Another benefit of the NAVIGATION TOOLS is that is… [should be "it"].
    d. Page 16: Need to remove the duplicate verbiage "the user" from the sentence "Upon completion of entering all of the risk values for each impact into the RISK VALUES worksheet, the user the user navigates…"

Feel free to contact me to get further clarification or if you would like to discuss further.

Thanks again for allowing me to beta test and comment on this great tool!

Kind regards,
George McCaffrey | *HSE Manager*

AIM PRIORITIZATION PROGRAM

Expert Panel Questionnaire
Beta Testing and Feedback

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There are a total of eight (8) questions (A through H). Question topics fall under "EASE OF USE," "EFFECTIVENESS / USEFULLNESS," and "RESULTS" and cover the user manual as well as the program itself. Each question allows the tester to provide additional comments. After the last question, the tester may provide any additional comments and feedback that may not be covered in the set of eight questions.

Tester Information

Name:	Pat Murin		
Job Title:	Principal		
Organization:	Murin Environmental Inc.		
Familiarity with environmental management systems:	Low ☐	Medium ☒	High ☐

EASE OF USE QUESTIONS

The User Manual

A. How easy was the AIM user manual to understand?

- ☐ 1. Very easy
- ☐ 2. Easy
- ☒ 3. Medium
- ☐ 4. Difficult
- ☐ 5. Very difficult

For ratings of 4 or 5, what is/are your recommendation for improvement?

I think the manual is very well written. Since my familiarity with all the EMS concepts is based on very sporadic work experience, I have more hurdles than may be normal in developing fluency in all the concepts and terminology. One recommendation for improvement: in explaining the weighting systems, use easier-to-understand symbols than Greek symbols. For example, use H for health, E for ecological, R for resource and so on. All use of symbols should be to facilitate understanding and the Greek symbols don't in my case.

The Program

B. How easy was it (or would it be) to obtain AIM input data?

- ☐ 1. Very easy
- ☐ 2. Easy
- ☐ 3. Medium
- ☐ 4. Difficult
- ☐ 5. Very difficult

For ratings of 4 or 5, what is/are your recommendation for improvement?

I'm not providing a rating here because without having a real system to start with complicates the characterization of an EMS.

C. How easy was the AIM data entry process?

- ☐ 1. Very easy
- ☒ 2. Easy
- ☐ 3. Medium
- ☐ 4. Difficult
- ☐ 5. Very difficult

For ratings of 4 or 5, what is/are your recommendation for improvement?

I would say this was easy but tedious. There are a lot of ratings to enter, and though having the rating definitions available by hovering the mouse over the column headings was helpful, it might have been more useful to have them display while getting ready to enter the data. When dealing with a lot of processes and aspects, having the definitions display with the data entry field would be more useful.

D. How easy was the AIM program to understand?

- ☐ 1. Very easy
- ☐ 2. Easy
- ☐ 3. Medium
- ☒ 4. Difficult
- ☐ 5. Very difficult

For ratings of 4 or 5, what is/are your recommendation for improvement?

I would say that most elements of AIM were actually easy to understand. The ones I found difficult, which result in the rating, were the significance sensitivity level (which I'm still struggling with) and the reference to the Likert scale. For the latter, just a brief background on the Likert type scale would be useful. I'm not sure what to do about improving the understandability of the former.

EFFECTIVENESS / USEFULLNESS QUESTIONS

E. How useful was the significance determination portion of AIM?

- ☐ 1. Very useful
- ☐ 2. Somewhat useful
- ☒ 3. Medium
- ☐ 4. Somewhat useless
- ☐ 5. Very useless

For ratings of 4 or 5, what is/are your recommendation for improvement?

Please type comments here, if any

F. How useful was the mitigation ranking portion of AIM?

- ☐ 1. Very useful
- ☒ 2. Somewhat useful
- ☐ 3. Medium
- ☐ 4. Somewhat useless
- ☐ 5. Very useless

For ratings of 4 or 5, what is/are your recommendation for improvement?

Please type comments here, if any

RESULTS QUESTIONS

G. Did the AIM program produce anticipated results?

- ☒ 1. Yes
- ☐ 2. No

If "no," please explain:

Please type comments here, if any

H. Would your management team be willing to act on the results of the AIM program?

☐ 1. Yes
☒ 2. No

If "no," please explain:

MEI doesn't employ ISO 14001 internally and we haven't been involved in any implementations of it recently.

ADDITIONAL COMMENTS & FEEDBACK

Please feel free to provide any additional comments and/or feedback that is not already addressed in the questions above. You may also use the space below to identify any spelling errors and/or program calculation errors discovered.

I only tested the program for a few hours so far but ran into a few anomalies. First, I had set up several processes with at least 2 aspects per process, with at least one impact per aspect. In entering risk values, the second aspect of the first process was not displayed, though multiple aspects were displayed for the other processes. Second, when I changed the number of aspects after their initial definition, I got a run-time error 1004. Clicking end got me out of that but I was also able to choose debug as well. Also a trivial note: I entered my phone number without any dashes. It was later displayed as an exponential number.

AIM PRIORITIZATION PROGRAM

Expert Panel Questionnaire
Beta Testing and Feedback

Thank you for agreeing to act as a beta tester and providing important feedback on the AIM User Manual and the AIM Prioritization Program. Your feedback is an important part of this work and will be used to make the AIM program better.

There are a total of eight (8) questions (A through H). Question topics fall under "EASE OF USE," "EFFECTIVENESS / USEFULLNESS," and "RESULTS" and cover the user manual as well as the program itself. Each question allows the tester to provide additional comments. After the last question, the tester may provide any additional comments and feedback that may not be covered in the set of eight questions.

Tester Information

Name:	Patrick McKeown			
Job Title:	Director			
Organization:	Ecossystems Ltd			
Familiarity with environmental management systems:	Low ☐	Medium ☐	High ☒	

<u>EASE OF USE QUESTIONS</u>

The User Manual

A. How easy was the AIM user manual to understand?

- ☐ 1. Very easy
- ☐ 2. Easy
- ☒ 3. Medium
- ☐ 4. Difficult
- ☐ 5. Very difficult

For ratings of 4 or 5, what is/are your recommendation for improvement?

Please type comments here, if any

The Program

B. How easy was it (or would it be) to obtain AIM input data?

- ☐ 1. Very easy
- ☐ 2. Easy
- ☒ 3. Medium
- ☐ 4. Difficult
- ☐ 5. Very difficult

For ratings of 4 or 5, what is/are your recommendation for improvement?

Please type comments here, if any

C. How easy was the AIM data entry process?

- ☐ 1. Very easy
- ☐ 2. Easy
- ☒ 3. Medium
- ☐ 4. Difficult
- ☐ 5. Very difficult

For ratings of 4 or 5, what is/are your recommendation for improvement?

Please type comments here, if any

D. How easy was the AIM program to understand?

- ☐ 1. Very easy
- ☐ 2. Easy
- ☒ 3. Medium
- ☐ 4. Difficult
- ☐ 5. Very difficult

For ratings of 4 or 5, what is/are your recommendation for improvement?

Please type comments here, if any

EFFECTIVENESS / USEFULLNESS QUESTIONS

E. How useful was the significance determination portion of AIM?

- ☐ 1. Very useful
- ☐ 2. Somewhat useful
- ☒ 3. Medium
- ☐ 4. Somewhat useless
- ☐ 5. Very useless

For ratings of 4 or 5, what is/are your recommendation for improvement?

Please type comments here, if any

F. How useful was the mitigation ranking portion of AIM?

- ☐ 1. Very useful
- ☐ 2. Somewhat useful
- ☐ 3. Medium
- ☒ 4. Somewhat useless
- ☐ 5. Very useless

For ratings of 4 or 5, what is/are your recommendation for improvement?

Please type comments here, if any

RESULTS QUESTIONS

G. Did the AIM program produce anticipated results?

- ☐ 1. Yes
- ☒ 2. No

If "no," please explain:

The AIM program appears to be too complicated for simply identification and determining the significance of environmental aspects. It goes beyond what most organisations would require for the purposes of managing environmental risk. However I think AIM does have the potential to be developed into an Environmental Impact Assessment (EIA) tool that could be used for planning and assessment of infrastructure projects. This is where the mitigation element of the program would come into its own.

H. Would your management team be willing to act on the results of the AIM program?

☐ 1. Yes
☒ 2. No

If "no," please explain:

Not for EMS purposes but as mentioned above could be developed for EIA purposes.

ADDITIONAL COMMENTS & FEEDBACK

Please feel free to provide any additional comments and/or feedback that is not already addressed in the questions above. You may also use the space below to identify any spelling errors and/or program calculation errors discovered.

A lot of hard work and thought has gone into this project and both developers should be commended for the output. However I feel the AIM program is over engineered for the assessment of significance of environmental risk when developing an EMS. It would be more suited to EIA projects where I can see the program (with some further development) delivering tangible benefits in identification and mitigation of environmental risk.

Pat's comments...

Hi Mike,

I eventually did mate but had a bit of difficulty opening at first because it was in an older version of excel. When I did get a chance to play around with it I enjoyed the challenge and should have provided you with feedback before now, so here goes.

What I would say at the outset is that it is well thought through but can be difficult to populate and correct (e.g. I found removing Aspects from AIM impossible). For EMS projects I fear it is a little too elaborate and over engineered and (e.g. Human Health Risk not required for ISO14001 and drilling down into subdivisions of headline risks not really necessary).

From a consultancy perspective it would require too much time to populate and when it is populated would require too much resource to maintain and train others in its use. In my experience organisations are looking for something simple that they can quickly take ownership of. That being said I do not want to be overly critical as I can see that a hell of lot of thought and good work has gone into developing this project.

As a tool I think it could be adopted very easily for Environmental Impact Assessment (EIA) projects, where it would have real value as it would peel back and present the layers of risk required for regulatory and planning purposes.

Hope the feedback is not too negative? I'll keep persevering with it though :-)

Kind Regards Pat

APPENDIX B

SPREADSHEET SPECIFICATION DOCUMENT FOR THE REVISED AIM PROGRAM

The validation process of the revised AIM has resulted in the creation of a *Spreadsheet Specification Document*. The methodology used to create this document is a modified version of that described by Howard and Harrison (2007b).

Spreadsheet Specification Document

Section 1 – Introduction

The Aspect-Impact-Mitigation Prioritization Program (AIM) provides a straightforward and consistent procedure to prioritize environmental aspects based on a holistic risk-based approach that is consistent with guidance found in ISO 14001 and the Eco-Management and Audit Scheme (EMAS). This specification document details what the AIM spreadsheet program does do for the end user.

Section 2 – System Overview

2.1 User Background

Direct AIM users will generally be environmental professionals with an understanding of environmental management systems (EMSs) and at least a basic understanding of spreadsheet use. Indirect users may be personnel involved with providing certain data to direct users and key decision-makers relying on AIM output to direct decision-making activities.

2.2 System Overview

The AIM user is initially required to either accept default values or enter their own values for various weighting coefficients. The next steps require the user to identify processes, aspects, and impacts to be associated with the EMS. For each impact, the user enters risk values from 1 through 5 for each risk category (Human Health, Ecological, Resource Depletion, Legal, and Stakeholder). Based on these user input values, AIM returns an *Impact Risk Score* for each impact in each of the five risk categories. Lastly, the user enters a value from 1 through 5 for each aspect for each mitigation category (Controllability, Available Resources, Management Support, Risk Reduction Potential, and Brand Value). Based on these final user input values, AIM returns a summary table that lists each identified aspect and ranks them based on overall weighted risk and mitigation potential and identifies those aspects that are significant.

2.3 Specification Methodology

This specification document contains information regarding user requirements (Section 3) and functional specifications (Section 4) based on those requirements. Section 3 is written as *must do* or *should do* statements, while Section 4 is written as *does do* statements.

Section 3 – User Requirements

3.1 Application Software

The AIM program must be compatible with Microsoft Excel 2010 version 14.

3.2 Spreadsheet Workbook Characteristics

The AIM program must be organized into worksheets and in such a manner that the user only sees a single worksheet open at a time.

The AIM program must have a separate worksheet for each major data entry and data output event.

3.3 Security and Protections

Each worksheet within the AIM program should have adequate security to guard against accidental or intentional modification or deletion of formulae and other data.

3.4 Macro Functionality

Navigation between the various AIM program worksheets should be controlled by the user selecting a button control from a set of navigation tools.

When navigating between worksheets, the origin worksheet should become hidden and the destination should become visible.

When navigating between sheets, if the user has not entered all required data into the origin worksheet a message box should appear to notify the user and not allow navigation to the destination worksheet until the data input issue is resolved.

When performing actions that will permanently delete certain data, a message box should appear notifying the user that continuing will result in a permanent loss of certain data.

3.5 User Manual

The AIM program should have a detailed user manual.

3.6 Data Calculation Requirements

The AIM program must accept user input data and calculate a *Weighted Aspect Mitigation Priority Score (WAMPS)* for each identified aspect.

The AIM program must rank WAMPS from highest value to lowest value.

The AIM program must identify which aspects are significant based on user sensitivity value input.

3.7 Input/Output Requirements

The AIM program should employ data validation, conditional formatting, worksheet and cell protection, and macros to guide the user through a streamlined data input process.

The AIM program output should provide a summary of results that is printable on standard sized paper.

Section 4 – Functional Specification

4.1 Application Software

The AIM program is compatible with Microsoft Excel 2010 version 14.

4.2 Spreadsheet Workbook Characteristics

The AIM program is organized into worksheets and in such a manner that the user only sees a single worksheet open at a time.

The AIM does have a separate worksheet for each major data entry and data output event

4.3 Security and Protections

Each worksheet within the AIM program is password protected to guard against accidental or intentional modification or deletion of formulae and other data.

4.4 Macro Functionality

Navigation between the various AIM program worksheets is controlled by the user selecting a button control from a set of navigation tools.

When navigating between worksheets, the origin worksheet becomes hidden and the destination becomes visible.

When navigating between sheets, if the user has not entered all required data into the origin worksheet a message box appears to notify the user and navigation to the destination worksheet is not allowed until the data input issue is resolved.

When performing actions that will permanently delete certain data, a message box appears notifying the user that continuing will result in a permanent loss of certain data.

4.5 User Manual

The AIM program does have a detailed user manual.

4.6 Data Calculation Requirements

The AIM program accepts user input data and calculates a *Weighted Aspect Mitigation Priority Score (WAMPS)* for each identified aspect.

The AIM program ranks WAMPS from highest value to lowest value.

The AIM program identifies which aspects are significant based on user sensitivity value input.

4.7 Input/Output Requirements

The AIM program employs data validation, conditional formatting, worksheet and cell protection, and macros that guide the user through a streamlined data input process.

The AIM program output provides a summary of results that is printable on standard sized paper.

APPENDIX C

VISUAL BASIC CODE EXCERPTS FROM THE REVISED AIM PROGRAM

The revised AIM relies heavily on marcos. Visual Basic for Applications (VBA) is the programming language used in Microsoft Excel to create macros. Walkenbach (2010a) describes a macro as "a sequence of instructions that automates some aspect of Excel so that you can work more efficiently and with fewer errors" (p. 795). Included below are a few excerpts of the VBA code used in the revised AIM.

Navigation Tools

The primary method of navigating through the AIM program is via the "Navigation Tools" buttons that appear at the top of each worksheet. When the user selects an available destination, a macro is initiated that closes the current worksheet and opens the destination worksheet.

Go to PROCESS

Below is an example of the VBA code that initiates the macro "Open_Process," which closes (i.e., hides) the current worksheet and opens (i.e., makes visible) the *PROCESS* worksheet when the user selects the "Go to PROCESS" button.

```
Sub Open_Process()

    Application.ScreenUpdating = False

    If Sheets("LOOKS").Range("N23") = "BAD" Then

        MsgBox ("The sum of user-defined weighting coefficients must equal 1.00.")

    End If

    If Sheets("LOOKS").Range("N23") = "GOOD" Then

        ActiveWindow.SelectedSheets.Visible = False
        Sheets("PROCESS").Visible = True
        Sheets("PROCESS").Select
        Range("C14").Select
```

```
    End If
End Sub
```

Notice also in the VBA code excerpt above that certain conditions, if not met, will result in a message box notification to the user. This particular message must be resolved before the user is allowed to continue to the *PROCESS* worksheet. Other message boxes may warn the user that data will be permanently deleted if a particular action is selected.

Creating Processes

From the PROCESS worksheet, the user can identify from 1 up to a maximum of 10 processes via a spin button control. This not only initiates non-VBA conditional formatting in the PROCESS worksheet, it will also warn the user with a message when reducing the number of processes (e.g., from 4 to 3) that all data associated with a deleted process will be permanently deleted. The *process number spin button* affects several worksheets in AIM. By defining the *screen updating* feature in VBA as *FALSE*, the user does not see any of the updating as it occurs, which has the added benefit of considerably speeding up macro execution (Walkenbach 2010b). Below is part of the macro "Process," which formats several other worksheets in AIM based on the user-defined process count.

```
Sub PROCESS()
' This macro adds and removes PROCESS data entry fields based on user preference
    Application.ScreenUpdating = False

    Sheets("RISK VALUES").Visible = True
    Sheets("RISK RESULTS").Visible = True
    Sheets("POTENTIAL").Visible = True
    Sheets("PRIORITY").Visible = True
    Sheets("P2").Visible = True
    Sheets("P3").Visible = True
    Sheets("P4").Visible = True
    Sheets("P5").Visible = True
    Sheets("P6").Visible = True
    Sheets("P7").Visible = True
    Sheets("P8").Visible = True
    Sheets("P9").Visible = True
```

```
        Sheets("P10").Visible = True
        Sheets("LOOKS").Visible = True

        ActiveSheet.Unprotect
        Sheets("RISK VALUES").Unprotect
        Sheets("RISK RESULTS").Unprotect
        Sheets("POTENTIAL").Unprotect
        Sheets("PRIORITY").Unprotect
        Sheets("P2").Unprotect
        Sheets("P3").Unprotect
        Sheets("P4").Unprotect
        Sheets("P5").Unprotect
        Sheets("P6").Unprotect
        Sheets("P7").Unprotect
        Sheets("P8").Unprotect
        Sheets("P9").Unprotect
        Sheets("P10").Unprotect

' This is for switching from 10 to 9 PROCESSES

        If Sheets("LOOKS").Range("N4") < 10 And Sheets("LOOKS").Range("K15") > 0 Then

            Ans = MsgBox("Continuing this action will permanently delete existing data.  Are you sure you
            want to continue?", vbYesNo + vbQuestion)

            If Ans = vbNo Then
            Sheets("LOOKS").Range("N4") = 10

                Sheets("RISK VALUES").Select
                Rows("619:685").Select
                Selection.EntireRow.Hidden = False
                Range("C18").Select

                Sheets("RISK RESULTS").Select
                Rows("619:685").Select
                Selection.EntireRow.Hidden = False
                Range("C18").Select

                Sheets("POTENTIAL").Select
                Rows("97:105").Select
                Selection.EntireRow.Hidden = False
                Range("C19").Select

                Sheets("PRIORITY").Select
                Rows("73:77").Select
                Selection.EntireRow.Hidden = False
                Range("C18").Select

                Sheets("PROCESS").Select
                Range("C14").Select

            End If

            If Ans = vbYes Then

            Range("C23").Select
            Selection.ClearContents

            Sheets("P10").Select
            Range("C18,C22:C31,H18,H22:H31,M18,M22:M31,R18,R22:R31,W18,W22:W31").Select
            Selection.ClearContents
            Range("C14").Select
```

```
    Sheets("LOOKS").Select
    Range("G76").Value = 0

    Sheets("RISK VALUES").Select
    Range("L623:AA632,L636:AA645,L649:AA658,L662:AA671,L675:AA684").Select
    Selection.ClearContents
    Rows("619:685").Select
    Selection.EntireRow.Hidden = True
    Range("C18").Select

    Sheets("RISK RESULTS").Select
    Rows("619:685").Select
    Selection.EntireRow.Hidden = True
    Range("C18").Select

    Sheets("POTENTIAL").Select
    Range("L100:P104").Select
    Selection.ClearContents
    Rows("97:105").Select
    Selection.EntireRow.Hidden = True
    Range("C19").Select

    Sheets("PRIORITY").Select
    Rows("73:77").Select
    Selection.EntireRow.Hidden = True
    Range("C18").Select

    Sheets("PROCESS").Select
    Range("C14").Select

End If

ElseIf Sheets("LOOKS").Range("N4") < 10 And Sheets("LOOKS").Range("K15") = 0 Then

    Range("C23").Select
    Selection.ClearContents

    Sheets("P10").Select
    Range("C18,C22:C31,H18,H22:H31,M18,M22:M31,R18,R22:R31,W18,W22:W31").Select
    Selection.ClearContents
    Range("C14").Select

    Sheets("LOOKS").Select
    Range("G76").Value = 0

    Sheets("RISK VALUES").Select
    Range("L623:AA632,L636:AA645,L649:AA658,L662:AA671,L675:AA684").Select
    Selection.ClearContents
    Rows("619:685").Select
    Selection.EntireRow.Hidden = True
    Range("C18").Select

    Sheets("RISK RESULTS").Select
    Rows("619:685").Select
    Selection.EntireRow.Hidden = True
    Range("C18").Select

    Sheets("POTENTIAL").Select
    Range("L100:P104").Select
    Selection.ClearContents
    Rows("97:105").Select
```

```
        Selection.EntireRow.Hidden = True
        Range("C19").Select

        Sheets("PRIORITY").Select
        Rows("73:77").Select
        Selection.EntireRow.Hidden = True
        Range("C18").Select

        Sheets("PROCESS").Select
        Range("C14").Select

    End If

    If Sheets("LOOKS").Range("N4") = 10 And Sheets("LOOKS").Range("K15") = 0 Then

        Range("C23").Select
        Selection.ClearContents

        Sheets("P10").Select
        Range("C18,C22:C31,H18,H22:H31,M18,M22:M31,R18,R22:R31,W18,W22:W31").Select
        Selection.ClearContents
        Range("C14").Select

        Sheets("LOOKS").Select
        Range("G76").Value = 0

        Sheets("RISK VALUES").Select
        Range("L623:AA632,L636:AA645,L649:AA658,L662:AA671,L675:AA684").Select
        Selection.ClearContents
        Rows("619:685").Select
        Selection.EntireRow.Hidden = False
        Range("C18").Select

        Sheets("RISK RESULTS").Select
        Rows("619:685").Select
        Selection.EntireRow.Hidden = False
        Range("C18").Select

        Sheets("POTENTIAL").Select
        Range("L100:P104").Select
        Selection.ClearContents
        Rows("97:105").Select
        Selection.EntireRow.Hidden = False
        Range("C19").Select

        Sheets("PRIORITY").Select
        Rows("73:77").Select
        Selection.EntireRow.Hidden = False
        Range("C18").Select

        Sheets("PROCESS").Select
        Range("C14").Select

    End If
```

The code continues through switching from 9 to 8 processes, 8 to 7, and so on until the routine is completed as follows:

```
    ActiveSheet.PROTECT DrawingObjects:=True, Contents:=True, Scenarios:=True
    Sheets("RISK VALUES").PROTECT DrawingObjects:=True, Contents:=True, Scenarios:=True
    Sheets("RISK RESULTS").PROTECT DrawingObjects:=True, Contents:=True, Scenarios:=True
    Sheets("POTENTIAL").PROTECT DrawingObjects:=True, Contents:=True, Scenarios:=True
    Sheets("PRIORITY").PROTECT DrawingObjects:=True, Contents:=True, Scenarios:=True
    Sheets("P2").PROTECT DrawingObjects:=True, Contents:=True, Scenarios:=True
    Sheets("P3").PROTECT DrawingObjects:=True, Contents:=True, Scenarios:=True
    Sheets("P4").PROTECT DrawingObjects:=True, Contents:=True, Scenarios:=True
    Sheets("P5").PROTECT DrawingObjects:=True, Contents:=True, Scenarios:=True
    Sheets("P6").PROTECT DrawingObjects:=True, Contents:=True, Scenarios:=True
    Sheets("P7").PROTECT DrawingObjects:=True, Contents:=True, Scenarios:=True
    Sheets("P8").PROTECT DrawingObjects:=True, Contents:=True, Scenarios:=True
    Sheets("P9").PROTECT DrawingObjects:=True, Contents:=True, Scenarios:=True
    Sheets("P10").PROTECT DrawingObjects:=True, Contents:=True, Scenarios:=True

    Sheets("RISK VALUES").Visible = False
    Sheets("RISK RESULTS").Visible = False
    Sheets("POTENTIAL").Visible = False
    Sheets("PRIORITY").Visible = False
    Sheets("P2").Visible = False
    Sheets("P3").Visible = False
    Sheets("P4").Visible = False
    Sheets("P5").Visible = False
    Sheets("P6").Visible = False
    Sheets("P7").Visible = False
    Sheets("P8").Visible = False
    Sheets("P9").Visible = False
    Sheets("P10").Visible = False
    Sheets("LOOKS").Visible = False

End Sub
```

Once the user has identified the number of processes and given each a name, the "P1" button may be selected from the navigation tools, which will initiate the macro "Open_P1."

```
Sub Open_P1()

    Application.ScreenUpdating = False

    If Sheets("LOOKS").Range("N8") = False Then

        MsgBox ("You must assign a name for each process or reduce the number of processes.")

    End If

    If Sheets("LOOKS").Range("N8") = True Then

        ActiveWindow.SelectedSheets.Visible = False
        Sheets("P1").Visible = True
        Sheets("P1").Select
        Range("C18").Select

    End If

End Sub
```

If more than one process is selected by the user, the navigation tools for other processes may be selected. If the “P2” button is available and selected, the macro “Open_P2” is initiated with the following VBA code. There is similar VBA code for the other process buttons.

```
Sub Open_P2()

    Application.ScreenUpdating = False

    If Sheets("LOOKS").Range("G4") = 0 Then
        MsgBox ("You must assign at least one aspect.")
        Exit Sub
    End If

    If ActiveSheet.Range("C18").Value = "" And Sheets("LOOKS").Range("G4") = 1 Then
        MsgBox ("You must assign a name for each aspect or reduce the number of aspects.")
        Exit Sub
    End If

    If ActiveSheet.Range("H18").Value = "" And Sheets("LOOKS").Range("G4") = 2 Then
        MsgBox ("You must assign a name for each aspect or reduce the number of aspects.")
        Exit Sub
    End If

    If ActiveSheet.Range("M18").Value = "" And Sheets("LOOKS").Range("G4") = 3 Then
        MsgBox ("You must assign a name for each aspect or reduce the number of aspects.")
        Exit Sub
    End If

    If ActiveSheet.Range("R18").Value = "" And Sheets("LOOKS").Range("G4") = 4 Then
        MsgBox ("You must assign a name for each aspect or reduce the number of aspects.")
        Exit Sub
    End If

    If ActiveSheet.Range("W18").Value = "" And Sheets("LOOKS").Range("G4") = 5 Then
        MsgBox ("You must assign a name for each aspect or reduce the number of aspects.")
        Exit Sub
        End If

    If Sheets("LOOKS").Range("N6") < 2 Then

        MsgBox ("You must identify additional process(es) to contiue this action.")

    End If

    Call P1_IMPACT_ROWS

    If Sheets("LOOKS").Range("N6") > 1 Then

        ActiveWindow.SelectedSheets.Visible = False
        Sheets("P2").Visible = True
        Sheets("P2").Select
        Range("C18").Select

    End If
End Sub
```

Creating Aspects and Impacts

From each process worksheet (i.e., P1, P2, P3…P10), the user can identify from 0 up to a maximum of 5 aspects via a spin button control. Each aspect can have up to a maximum of 10 impacts. This not only initiates non-VBA conditional formatting in the current process worksheet, it will also warn the user with a message when reducing the number of aspects that all data associated with deleted aspects will be permanently deleted. Similar to the *process number spin button*, the *aspect number spin button* affects several other worksheets in AIM. Below is part of the macro "P1_Clear_ASPECT_IMPACTS."

```
Sub P1_Clear_ASPECT_IMPACTS()

    Application.ScreenUpdating = False

    Sheets("RISK VALUES").Visible = True
    Sheets("RISK RESULTS").Visible = True

    ActiveSheet.Unprotect
    Sheets("RISK VALUES").Unprotect
    Sheets("RISK RESULTS").Unprotect

' This is for switching from 5 to 4 ASPECTS

    If Sheets("LOOKS").Range("G4") < 5 And Sheets("LOOKS").Range("C8") > 0 Then

        Ans = MsgBox("Continuing this action will permanently delete existing data.  Are you sure you want
        to continue?", vbYesNo + vbQuestion)

    If Ans = vbNo Then
        Sheets("LOOKS").Range("G4") = 5

        Sheets("RISK VALUES").Select
        Rows("70:82").Select
        Selection.EntireRow.Hidden = False
        Range("C18").Select

        Sheets("RISK RESULTS").Select
        Rows("70:82").Select
        Selection.EntireRow.Hidden = False
        Range("C18").Select

        Sheets("P1").Select
        Range("W18").Select
    End If

    If Ans = vbYes Then
        Range("W18:W22:W31").Select
        Selection.ClearContents
```

```
        Sheets("RISK VALUES").Select
        Range("L72:AA81").Select
        Selection.ClearContents
        Rows("70:82").Select
        Selection.EntireRow.Hidden = True
        Range("C18").Select

        Sheets("RISK RESULTS").Select
        Rows("70:82").Select
        Selection.EntireRow.Hidden = True
        Range("C18").Select

        Sheets("P1").Select
        Range("C18").Select
    End If

    ElseIf Sheets("LOOKS").Range("G4") < 5 And Sheets("LOOKS").Range("C8") = 0 Then

        Sheets("RISK VALUES").Select
        Rows("70:82").Select
        Selection.EntireRow.Hidden = True
        Range("C18").Select

        Sheets("RISK RESULTS").Select
        Rows("70:82").Select
        Selection.EntireRow.Hidden = True
        Range("C18").Select

        Sheets("P1").Select
        Range("W18:W22:W31").Select
        Selection.ClearContents
        Range("C18").Select
    End If

    If Sheets("LOOKS").Range("G4") = 5 And Sheets("LOOKS").Range("C8") = 0 Then

        Sheets("RISK VALUES").Select
        Rows("70:82").Select
        Selection.EntireRow.Hidden = False
        Range("C18").Select

        Sheets("RISK RESULTS").Select
        Rows("70:82").Select
        Selection.EntireRow.Hidden = False
        Range("C18").Select

        Sheets("P1").Select
        Range("W18:W22:W31").Select
        Selection.ClearContents
        Range("C18").Select
    End If
```

The code continues through switching from 4 to 3 aspects, 3 to 2, and so on until the routine is completed as follows:

```
    ActiveSheet.PROTECT DrawingObjects:=True, Contents:=True, Scenarios:=True
    Sheets("RISK VALUES").PROTECT DrawingObjects:=True, Contents:=True, Scenarios:=True
    Sheets("RISK RESULTS").PROTECT DrawingObjects:=True, Contents:=True, Scenarios:=True
```

```
    Sheets("RISK VALUES").Visible = False
    Sheets("RISK RESULTS").Visible = False

    Call P1_IMPACT_ROWS

End Sub
```

Similar VBA code as above is used for additional processes identified by the user.

Risk Values

Once the user has named aspects and impacts for each process, the "Go to RISK VALUES" button may be selected from the navigation tools. This action will initiate the macro "Open_Risk_Values," which is essentially a data validation check and will return any number of messages if certain data input requirements have not been met. The VBA code for this macro is as follows.

```
Sub Open_Risk_Values()

    Application.ScreenUpdating = False

    If Sheets("LOOKS").Range("N8") = False Then
        MsgBox ("You must assign a name for each process or reduce the number of processes.")
    End If

    If ActiveSheet.Name = "P1" Then

        If Sheets("LOOKS").Range("G4") = 0 Then
            MsgBox ("You must assign at least one aspect.")
            Exit Sub
        End If

        If ActiveSheet.Range("C18").Value = "" And Sheets("LOOKS").Range("G4") = 1 Then
            MsgBox ("You must assign a name for each aspect or reduce the number of aspects.")
            Exit Sub
        End If

        If ActiveSheet.Range("H18").Value = "" And Sheets("LOOKS").Range("G4") = 2 Then
            MsgBox ("You must assign a name for each aspect or reduce the number of aspects.")
            Exit Sub
        End If

        If ActiveSheet.Range("M18").Value = "" And Sheets("LOOKS").Range("G4") = 3 Then
            MsgBox ("You must assign a name for each aspect or reduce the number of aspects.")
            Exit Sub
        End If

        If ActiveSheet.Range("R18").Value = "" And Sheets("LOOKS").Range("G4") = 4 Then
            MsgBox ("You must assign a name for each aspect or reduce the number of aspects.")
```

```
        Exit Sub
    End If

    If ActiveSheet.Range("W18").Value = "" And Sheets("LOOKS").Range("G4") = 5 Then
        MsgBox ("You must assign a name for each aspect or reduce the number of aspects.")
        Exit Sub
    End If

    Call P1_IMPACT_ROWS
```

Similar VBA code was created for each process worksheet (P1, P2, P3…P10) before terminating as follows.

```
    End If

    ActiveWindow.SelectedSheets.Visible = False
    Sheets("RISK VALUES").Visible = True
    Sheets("RISK VALUES").Select
    Range("L20").Select

End Sub
```

Risk Results, Mitigation Potential, and Priority & Significance

The VBA code that is initiated when selecting the navigation buttons “Go to RISK RESULTS,” “Go to MITIGATION POTENTIAL.” and “Go to PRIORITY & SIGNIFICANCE” all close the active sheet and opens the selected sheet. The VBA code for each is as follows.

```
Sub Open_Risk_Results()

    Application.ScreenUpdating = False

    ActiveWindow.SelectedSheets.Visible = False
    Sheets("RISK RESULTS").Visible = True
    Sheets("RISK RESULTS").Select
    Range("L20").Select

End Sub

Sub Open_Potential()

    Application.ScreenUpdating = False

    ActiveWindow.SelectedSheets.Visible = False
    Sheets("POTENTIAL").Visible = True
    Sheets("POTENTIAL").Select
    Range("L19").Select

End Sub

Sub Open_Priority()
```

```
    Application.ScreenUpdating = False

    ActiveWindow.SelectedSheets.Visible = False
    Sheets("PRIORITY").Visible = True
    Sheets("PRIORITY").Select
    Range("A1").Select

End Sub
```

Weighting Coefficients

From the WEIGHT worksheet, the user can either use the default values for *Risk Category* and *Risk Magnitude and Mitigation* or input their own. The decision to do this involves the user selecting a drop-down tool with the selections of either "YES" or "NO" to answer the question *USE DEFAULT VALUES?* Selecting "NO" initiates certain conditional formatting on the worksheet as well as the macros described below.

Risk Category

The VBA code for the risk category weighting coefficients drop-down tool is as follows:

```
Sub User_Define_RiskCat()

    Application.ScreenUpdating = False

    If Sheets("LOOKS").Range("J21").Value = "1" Then
        ActiveSheet.Unprotect
        Range("J16:J20,L17:R20").Select
        Range("L17").Activate
        Selection.Locked = True
        Selection.FormulaHidden = False
        Range("L17").Select
        ActiveSheet.PROTECT DrawingObjects:=True, Contents:=True, Scenarios:=True
    End If

    If Sheets("LOOKS").Range("J21").Value = "2" Then
        ActiveSheet.Unprotect
        Range("J16:J20,L17:R20").Select
        Range("L17").Activate
        Selection.Locked = False
        Selection.FormulaHidden = False
        Range("L17").Select
        ActiveSheet.PROTECT DrawingObjects:=True, Contents:=True, Scenarios:=True
    End If

End Sub
```

Risk Magnitude and Mitigation

The VBA code for the risk magnitude and mitigation weighting coefficients drop-down tool is as follows:

```
Sub User_Define_RiskMagMit()

    Application.ScreenUpdating = False

    If Sheets("LOOKS").Range("L21").Value = "1" Then
        ActiveSheet.Unprotect
        Range("J27:J28,L28:R31").Select
        Range("L28").Activate
        Selection.Locked = True
        Selection.FormulaHidden = False
        Range("L28").Select
        ActiveSheet.PROTECT DrawingObjects:=True, Contents:=True, Scenarios:=True
    End If

    If Sheets("LOOKS").Range("L21").Value = "2" Then
        ActiveSheet.Unprotect
        Range("J27:J28,L28:R31").Select
        Range("L28").Activate
        Selection.Locked = False
        Selection.FormulaHidden = False
        Range("L28").Select
        ActiveSheet.PROTECT DrawingObjects:=True, Contents:=True, Scenarios:=True
    End If

End Sub
```

APPENDIX D

USER MANUAL FOR THE REVISED AIM PROGRAM

AIM

Aspect-Impact-Mitigation

Prioritization Program

Version 2.0

USER MANUAL

ABOUT THE AIM PRIORITIZATION PROGRAM

The AIM Prioritization Program (AIM) is a risk-based environmental management system (EMS) decision support tool. AIM prioritizes environmental aspects and identifies those that are significant.

Dr. Will Focht developed the original AIM algorithms. Early spreadsheet-based versions of AIM were created by Jeff Hartle in 2005 and revised by Sandra Rodriguez in 2006. Tracy Hammon developed AIM version 1.0 in 2007. In 2011, David Residorph and Mike Thayer developed AIM versions 1.3 and 1.3b respectively.

AIM version 2.0, was developed by Mike Thayer as the capstone project to his Ph.D. dissertation in environmental science from Oklahoma State University. AIM version 2.0 is a complete re-work of the previously developed spreadsheet architectures and offers a much more user-friendly interface. Due to certain limitations of a spreadsheet-based platform, AIM version 2.0 should be considered as more of a "proof-of-concept" program. It is envisioned that future versions of AIM will be housed within a true database platform.

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1.0 OVERVIEW OF AIM

AIM is designed around the following three terms: *Process*, *Aspect*, and *Impact*. To fully understand AIM, one must first understand the meanings of these terms as they are used within the program.

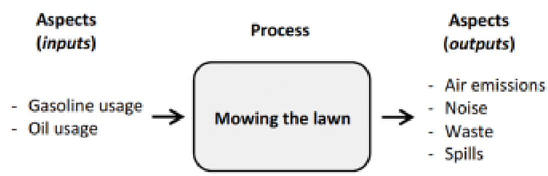
Process *means* a component of an operation, such as packaging, degreasing, rinsing, extruding, welding, grinding, loading, storing, inspecting, rolling, painting, stenciling, drying, heating, cutting, etc.

Aspect *means* an interaction of an operational process with the environment over which the organization has control or influence, including abnormal, shut-down/start-up, and emergency situations, the term includes, but is not limited to, "releases").

Impact *means* an actual/potential, adverse effect on the environment associated with an aspect. Impacts fall into two classes, (1) pollution effects and (2) resource effects.

Note: *Although ISO 14001 specifies that impacts can be either positive (beneficial) or negative (adverse), AIM version 2.0 only considers adverse impacts.*

Environmental aspects may be most easily understood as *inputs* and *outputs* of a process. Consider the process of mowing your lawn. If your lawnmower has a gasoline powered engine, the inputs and outputs may be as follows:



The relationship between environmental aspects and environmental impacts can be thought of in terms of *cause and effect*. Continuing with the lawn mowing analogy, we need to determine the effects (impacts) caused by the identified aspects (i.e., *What adverse environmental effects are caused by the inputs and outputs of the lawn mowing process?*).

Process (Mowing the lawn)	
Aspects (*cause*)	**Impacts (*effect*)**
- Gasoline usage	- Resource depletion - Air pollution
- Oil usage	- Resource depletion - Air pollution
- Noise	- Angry neighbors
- Waste	- Land pollution - Decreased landfill space
- Spills	- Land pollution - Water pollution - Air pollution

The lawn mowing example above is primarily for illustrative purposes to assist the reader in gaining an understanding of key terms and concepts used within AIM. The impacts identified in the example scenario may be too broad for real-world application. For example, "air pollution" may be identified as volatile organic compounds, particulate matter, or even speciated components such as styrene, xylene, or lead. However, AIM does not require a particular level of specificity.

The output of AIM is a listing of processes and environmental aspects identified by the user. The environmental aspects are ranked according to a differentially weighted combination of risk and mitigation potential. Significant environmental aspects are identified based on a user-defined *significance sensitivity* value. The Significance sensitivity value is entered as a whole number between 1 and 100 and represents the percentage of identified aspects that should be considered as *significant environmental aspects*. For example, if the user identifies 30 aspects and assigns a significance sensitivity value of 20, the top 6 aspects would be identified as significant (30 x 20% = 6).

AIM considers five categories, or types, of impact risk: *human health risk*, *ecological health risk*, *recourse depletion risk*, *legal risk*, and *stakeholder risk*. There are also five considerations regarding aspect risk mitigation potential: *mitigation controllability*, *available mitigation resources*, *management support*, *risk reduction potential*, and *brand value*. Note that risk estimation is applied to impacts and risk mitigation is applied to aspects. Consider the lawn mowing example: Noise (aspect-cause) and angry neighbors (impact-effect). A muffler could be used to lessen the risk of irate neighbors by reducing (mitigating) the engine noise level.

The five risk categories are differentially weighted for computing an overall risk magnitude estimate for each identified impact. It is usually prudent to give most weight to human health risk, followed by ecological health risk and resource depletion risk, since reducing these are the chief purposes of environmental management systems. Legal and stakeholder risk are assigned less value. The default risk weighting coefficients, which can be changed by the user, are:

- Human health risk weighting coefficient, $\pi = 0.40$
- Ecological risk weighting coefficient, $\varepsilon = 0.20$
- Resource depletion risk weighting coefficient, $\rho = 0.20$
- Legal risk weighting coefficient, $\lambda = 0.10$
- Stakeholder risk weighting coefficient, $\sigma = 0.10$

Note that the sum of these coefficients is 1.00.

- $(\pi + \varepsilon + \rho + \lambda + \sigma) = (0.40 + 0.20 + 0.20 + 0.10 + 0.10) = 1.00$

Risk magnitude and risk mitigation weighting coefficients, which are applied to each identified aspect in order to calculate a final ranking value, are also differentially weighted. Because it is desirable to reduce as much risk as feasible given constraints on funds and other resources, more weight is given to risk magnitude than to risk mitigation. Default values for these two weighting coefficients, which can also be changed by the user, are:

- Risk magnitude weighting coefficient, $\omega = 0.75$
- Risk mitigation weighting coefficient, $\mu = 0.25$

Again, note that the sum of these coefficients is 1.00.

- $(\omega + \mu) = (0.75 + 0.25) = 1.00$

2.0 DETAILS OF AIM

2.1 Calculating Risks of Individual Impacts

Once actual and potential impacts are identified for each aspect, the magnitude of each impact can be estimated to assess its significance. Significance assessment is necessary to identify which aspects should be the focus of initial environmental management efforts. As previously stated, although ISO 14001 specifies that impacts can be either positive (beneficial) or negative (adverse), AIM version 2.0 considers adverse impacts. The most significant aspects are therefore those that have the highest impact scores.

2.1.1 Health Risk Assessment Scales and Calculations

Many EMS-styled assessment tools use five-point Likert scales to estimate various dimensions of environmental impact magnitude. It is important that ratings be reliable, that is, enjoy high inter-coder correlation, which refers to the degree of agreement among individual raters. It may be helpful to use at least two raters for each scale value determination. The five impact risk categories previously discussed are each composed of various five-point Likert scales. These scales are described in the following sections along with the formulae AIM uses to combine the various scalar values into one impact risk score for each impact risk type identified by the user.

2.1.1.1 Human Health Risk

The human health risk score is used to estimate the risk to humans posed by each impact. An explanation of the two scales used to judge these risks are presented below. The two human health risk scales encompass its two major contributors: intrinsic health damage and size of population exposed.

The two human health risk scales are:

Individual Health Risk ("Ind")

- 5 = Severe/catastrophic (potentially fatal)
- 4 = Serious (but not potentially fatal)
- 3 = Moderate (harmful)
- 2 = Mild (little harm potential)
- 1 = No potential harm

Population Health Risk ("Pop")

- 5 = Community (extends beyond the adjacent neighborhood into the larger community)
- 4 = Neighborhood (extends beyond the facility property into the adjacent neighborhood)
- 3 = Facility (extends beyond the operational work area but remains on the facility property)
- 2 = Operation (extends beyond the immediate work station, but confined to the operational work area)
- 1 = Process (confined to immediate process work station)

To calculate the impact human health risk score (IHRS) for an individual impact, AIM combines the results of the Likert scale judgments for each of these two scales using the following formula:

Impact Human Health Risk Score ("IHRS") = [(Ind x Pop) – 1] / 24

This formula will produce an IHRS ranging from 0-1. Higher scores represent more serious human health risks posed by that impact.

2.1.1.2 Ecological Health Risk

The ecological health risk score is also calculated using two risk scales, but this time they refer to potential extent of harm to an ecological community and the size of the community affected.

The two ecological health risk scales are:

Habitat Damage Potential ("Dam")

- 5 = Severe/catastrophic (habitat is permanently destroyed)
- 4 = Serious (habitat damage will persist for long periods without significant human intervention)
- 3 = Moderate (potential or actual harm to the habitat, but restoration is expected within a year without human intervention)
- 2 = Mild (potential or actual harm to species, but no harm to their habitat)
- 1 = No potential harm

Affected Population Size ("Siz")

- 5 = Multiple communities (extends beyond the local community into other communities)

- 4 = Community (extends to an entire local community)
- 3 = Multiple species (extends to several species, but not to an entire local community)
- 2 = Species (threat extends to an entire species, but does not extend to an entire local community)
- 1 = Subspecies (at most, only a few members of a single species is affected within a local community)

To calculate the impact ecological health risk score (IERS) for an individual impact, AIM combines the results of the Likert scale judgments for each of these two scales using the following formula:

Impact Ecological Health Risk Score ("IERS") = [(Dam x Siz) – 1] / 24

This formula will produce an IERS ranging from 0-1. Higher scores represent more serious ecological health risks posed by that impact.

2.1.1.3 Resource Depletion Risk

Resource depletion rates depend on four factors: the percentage of total energy, water, and natural resources used by the process having the aspect compared to that used by the entire facility; degree of degradation of a natural resource; natural resource renewal rate; and percentage of reused processed resources in the material feedstocks.

The four resource scales are:

Resource Use Rate ("Use")

- 5 = Major use (80-100% of total facility resources used by the process)
- 4 = Significant use (60-79% of total facility resources used by the process)
- 3 = Moderate use (40-59% of total facility resources used by the process)
- 2 = Minor use (20-39% of total facility resources used by the process)
- 1 = Trivial use (<20% of total facility resources used by the process)

Natural Resource Degradation Extent ("Deg")

- 5 = Complete degradation (cannot serve its intended use as a resource)
- 4 = Major degradation (resource can be used, but only after significant restoration)
- 3 = Moderate degradation (resource can be used, but only after some restoration)
- 2 = Minor degradation (resource has suffered slight degradation and can still be used)
- 1 = No degradation (the resource has suffered no degradation in either quality or quantity)

Natural Resource Renewal Rate ("Ren")

- 5 = Effectively non-renewable (>30 years)
- 4 = Difficult renewability (20-30 years)
- 3 = Moderate renewability (10-19 years)
- 2 = Easy renewability (<10 year)
- 1 = Immediately renewable (instantaneous)

Processed Resource Reuse Percentage ("Reu")

- 5 = Entirely virgin stock (0% reused)
- 4 = Low reused stock (1-32% reused)
- 3 = Medium reused stock (33-66% reused)
- 2 = High reused stock (67-99% reused)
- 1 = Entirely reused stock (100% reused)

To calculate the impact resource depletion risk score (IRRS) for an individual impact, AIM combines the results of the Likert scale judgments for each of these four scales using the following formula:

Impact Resource Depletion Risk Score ("IRRS") = [(Use x Deg x Ren x Reu)-1] / 624

This formula will produce an IRRS ranging from 0-1. Higher scores represent more serious resource depletion risks posed by that impact.

2.1.1.4 *Legal Risk*

The legal risk score is used to estimate the legal risk posed by each impact. The four legal risk scales are:

Regulated Status Weight ("RS")

- 5 = Very high (current statutory or regulatory requirement)
- 4 = High (potential future statutory or regulatory requirement)
- 3 = Moderate (formal organizational policy)
- 2 = Low (informal organizational practice)
- 1 = Very low (unregulated)

Violation History ("Hist")

- 5 = Continuous (non-compliance found in more than three successive inspections/audits)
- 4 = Frequent (non-compliance found in 2-3 successive inspections/audits)
- 3 = Intermittent (non-compliance found more than once, but never in successive inspections/audits)
- 2 = Rare (non-compliance found only once)
- 1 = Never (non-compliances have never been found)

Current Compliance Status ("Stat")

- 5 = Poor (currently under enforcement action for statutory or regulatory violations)
- 4 = Unsatisfactory (non-compliances noted, but enforcement action not (yet) taken)
- 3 = Fair (non-compliances discovered during internal audits and are being corrected)
- 2 = Good (non-compliances discovered during past internal audits, but are not occurring now)
- 1 = Excellent (non-compliances have not been detected in internal audits nor external inspections)

Civil Liability ("Civ")

- 5 = Very high (credible lawsuits have been filed and were successful)
- 4 = High (credible lawsuits have been filed and are pending resolution)
- 3 = Moderate (credible lawsuits have been threatened or lawsuit has been dismissed)
- 2 = Low (evidence or complaints could reasonably lead to lawsuits if not properly handled)
- 1 = Very low (no complaints or evidence received that are expected to lead to lawsuits)

To calculate the impact legal risk score (ILRS) for an individual impact, AIM combines the results of the Likert scale judgments for each of these four scales using the following formula:

Impact Legal Risk Score ("ILRS") = [(Wt x Hist x Stat x Trt) – 1] / 624

This formula will produce an ILRS ranging from 0-1. Higher scores represent more serious legal risks posed by that impact.

2.1.1.5 *Stakeholder Risk*

The stakeholder risk score will be used to estimate the level of perceived risk posed by each impact. There are four stakeholder risk scales, each representing a different group of stakeholders. *Organizational* stakeholders may include employees, shareholders, and financial institutions; *Supply Chain* stakeholders may include material and equipment suppliers, transportation partners, and customers; *Regulatory* stakeholders will include regulatory agencies at applicable regulatory levels (i.e., international, national, local, etc.); *Societal* stakeholders may include the potentially affected community, environmental groups, professional organizations, and the media.

The four stakeholder risk scales are:

Organizational Stakeholders ("Org")

What is the level of perceived risk?

- 5 = Very high
- 4 = High
- 3 = Medium

- 2 = Low
- 1 = Very low

Supply Chain Stakeholders ("Sup")

What is the level of perceived risk?

- 5 = Very high
- 4 = High
- 3 = Medium
- 2 = Low
- 1 = Very low

Regulatory Stakeholders ("Reg")

What is the level of perceived risk?

- 5 = Very high
- 4 = High
- 3 = Medium
- 2 = Low
- 1 = Very low

Societal Stakeholders ("Soc")

What is the level of perceived risk?

- 5 = Very high
- 4 = High
- 3 = Medium
- 2 = Low
- 1 = Very low

To calculate the impact stakeholder risk score (ISRS) for an individual impact, AIM combines the results of the Likert scale judgments for each of these four scales using the following formula:

Impact Stakeholder Risk Score ("ISRS") = [(EInt x EBr x PInt x PBr) – 1] / 624

This formula will produce an ISRS ranging from 0-1. Higher scores represent more serious stakeholder risks posed by that impact.

2.2 Calculating Type-Specific Aspect Risk Scores to Combine Risks from all Aspects

After completing the impact scoring processes described above for each impact associated with a particular aspect, it is possible to compute a cumulative impact risk score for each type of risk for each aspect. This is achieved by adding impact scores associated with each impact.

The general formula for calculating aspect risk scores is:

Aspect Risk Score = ∑(Impact Risk Scores) / n, where n is the number of impacts per aspect

The value of each aspect risk score will vary from 0 to 1. The higher the aspect risk score, the more risk a particular type (e.g., *human* vs. *legal*) that aspect poses.

The five risk-specific aspect risk score formulae are listed below.

Aspect Human Health Risk Score ("AHRS") = ∑(IHRS) / n, where n is the number of impacts per aspect

Aspect Ecological Health Risk Score ("AERS") = ∑(IERS) / n, where n is the number of impacts per aspect

Aspect Resource Depletion Risk Score ("ARRS") = ∑(IRRS) / n, where n is the number of impacts per aspect

Aspect Legal Risk Score ("ALRS") = ∑(ILRS) / n, where n is the number of impacts per aspect

Aspect Stakeholder Risk Score ("ASRS") = ∑(ISRS) / n, where n is the number of impacts per aspect

2.3 Calculating Weighted Aspect Risk Priority Scores (WARPS) to Combine all Types of Risk

Environmental management systems are based on a comparative risk approach in which aspect risks should be ordered from highest composite risk to lowest. Thus, human health, ecological health, resource depletion, legal, and stakeholder risks are added together. However, these risks need not be equally weighted.

AIM uses the following weighting coefficients to proportion the amount of risk considered for each risk category:

- Human health risk weighting coefficient, $\pi = 0.40$
- Ecological health risk weighting coefficient, $\varepsilon = 0.20$
- Resource depletion risk weighting coefficient, $\rho = 0.20$
- Legal risk weighting coefficient, $\lambda = 0.10$
- Stakeholder risk weighting coefficient, $\sigma = 0.10$

The values shown above for each weighting coefficient are the default values in AIM and can be changed by the user. However, the sum of the weighting coefficients must in all cases equal 1.00.

Given these weighting coefficients, AIM can now calculate a composite aspect risk score, which is the *Weighted Aspect Risk Priority Score* (WARPS). The formula for this calculation is:

Weighted Aspect Risk Priority Score (WARPS)

$$= \pi(AHRS) + \varepsilon(AERS) + \rho(ARRS) + \lambda(ALRS) + \sigma(ASRS)$$

$$= 0.40(AHRS) + 0.20(AERS) + 0.20(ARRS) + 0.10(ALRS) + 0.10(ASRS)$$

Higher WARPS values represent higher weighted aspect risks. The range of WARPS is 0 to 1.

2.4 Evaluation of Aspect Mitigation Potential

Now that baseline aspect risk priority scores have been estimated, consideration can be given to aspect mitigation. To do this, Likert scales are used similar to those used to assess impacts. Aspect mitigation potential is hypothesized to be related to the degree of controllability that the organization has over the aspect to reduce impacts (technically, administratively, and legally), the resources that are available to devote to reduction of impacts, and the willingness of the organization to dedicate these resources. It is presumed that the willingness to dedicate resources to mitigation is equivalent to the consistency of mitigating that aspect with the stated goals in the organization's policy statement and overall financial/business impacts. Willingness to dedicate resources will also be influenced by the impact that mitigation will have on brand value (increasingly businesses are seeking to increase brand value through green marketing). An Aspect Mitigation Score (AMS) is calculated for each identified aspect. The scales discussed below are used to calculate the AMS.

2.4.1 Aspect Mitigation Score (AMS)

The Aspect Mitigation Score (AMS) will be used to rank the ease with which impacts from aspects can be mitigated. The following five scales are used.

Mitigation Controllability ("Cntr")

- 5 = Directly controllable (first party—the organization itself—has control)
- 4 = Indirectly controllable (dependent second party has control, e.g., via contract)
- 3 = Influenceable (independent second party has control, e.g., customer)
- 2 = Indirectly influenceable (independent third party has control)
- 1 = Uncontrollable (no control or influence possible by anyone)

Available Mitigation Resources ("Res")

- 5 = Trivial (mitigation can be obtained with little if any resources)
- 4 = Relatively easy (resources can be accommodated within operational area's budget)
- 3 = Moderately difficult (resources will be needed from other operational areas)

- 2 = Very difficult (organization's resources will be severely strained)
- 1 = Impossible (organization cannot mitigate with available resources)

Management Support ("Sup")

- 5 = Automatic support (mitigation would be supported without discussion)
- 4 = Cautious support (mitigation would likely attract support after brief discussion)
- 3 = Weak support (mitigation support is likely only with compelling rationale)
- 2 = Little support (mitigation support would be difficult, but possible)
- 1 = No support (mitigation support is impossible)

Risk Reduction Potential ("Red")

- 5 = Very high risk reduction (81-100% reduction)
- 4 = High risk reduction (61-80% reduction)
- 3 = Moderate risk reduction (41-60% reduction)
- 2 = Low risk reduction (21-40% reduction)
- 1 = Very low risk reduction (0-20% reduction)

Brand Value ("Brnd")

- 5 = Very high brand value increase (>10% improvement in value)
- 4 = High brand value increase (5-10% improvement in value)
- 3 = Moderate brand value increase (2-4% improvement in value)
- 2 = Low brand value increase (>0-1% improvement in value)
- 1 = No impact or negative impact on brand value (≤0% improvement in value)

The formula used to compute the AMS is:

Aspect Mitigation Score ("AMS") = [(Cntr x Res x Sup x Red x Brnd) – 1] / 3124

The range of AMS is 0-1, with higher scores representing higher impact mitigation potential.

2.5 Prioritizing and Selecting Aspects for Mitigation

Now the risk magnitude component of aspect prioritization, as measured by WARPS, can be combined with aspect mitigation potential, as measured by AMS. ISO 14001 does not require mitigation of all significant risks; rather it specifies that they should be identified—and thus by extension that their mitigation be at least considered. By combining WARPS and AMS, AIM can assign an overall Weighted Aspect Mitigation Priority Score (WAMPS).

In determining which aspects should be targeted for mitigation (risk reduction), consideration must be given to both the magnitude of the risks posed by the aspects' impacts and the desirability of reducing those risks given the legitimacy of the various alternatives for mitigation. Since both risk assessment and risk reduction will affect this choice, the relative importance of each component must be weighted.

Since environmental management systems are primarily concerned with reducing risks, the greatest weight is assigned to risk magnitude, i.e., those aspects that pose the greatest risks should be elevated in importance for risk reduction. As a result, a weight of 0.75 is assigned to risk magnitude. Thus, the weighting coefficient for risk magnitude (as measured by WARPS) is $\omega = 0.75$. The remaining weight is assigned to the ease and desirability of risk mitigation. Thus, the weighting coefficient for aspect mitigation potential (as measured by AMS) is $\mu = 0.25$. As with the other weighting coefficients, AIM allows the user to assign his own values.

The overall aspect mitigation priority score is computed using the following formula:

Weighted Aspect Mitigation Priority Score ("WAMPS")

$= \omega(\text{WARPS}) + \mu(\text{AMS})$

= 0.75(WARPS) + 0.25(AMS)

Again, higher WAMPS values represent higher mitigation priorities. The range of WAMPS is 0-1.

2.6 Assessing Aspect Significance

The aspects can now be risk-ranked, which is useful for comparing risks and judging their significance. ISO 14001 does not define *significance* and clearly states that there are many methods for determining significant environmental aspects. ISO 14001 only requires that the method and criteria used should provide consistent results. As previously discussed, AIM version 2.0 requires the user to identify a *significance sensitivity value* that calculates a percentage of the highest ordered WAMPS results and identifies those as significant.

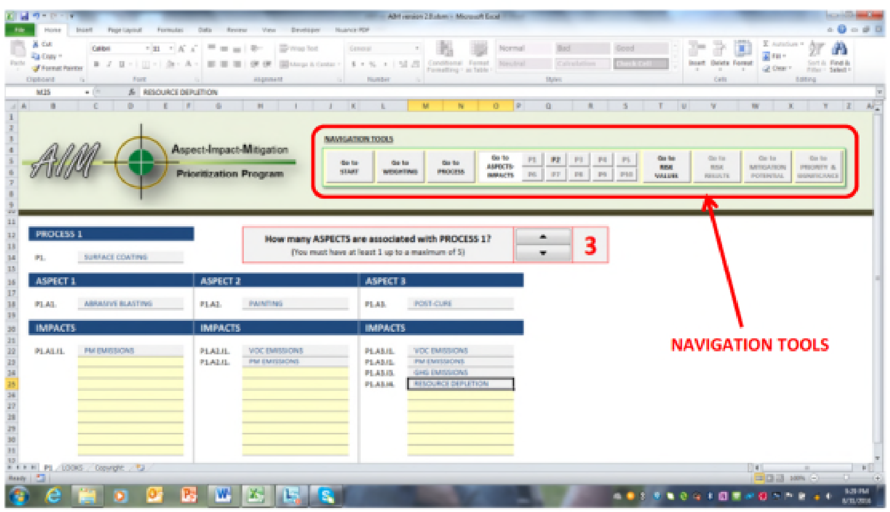
2.7 Presentation of Results

Upon completion of data input, AIM will create a summary table (AIM PRIORITIZATION PROGRAM OUTPUT RESULTS) that lists all of the identified processes and associated aspects along with each aspect's calculated WARPS, AMS, WAMPS, ordinal risk rank, and aspect's significance determination. Additionally, the output results summarize the conditions type (*normal*, *abnormal*, *shut-down / start-up*, or *emergency*), the significance sensitivity value, and all of the weighting coefficients.

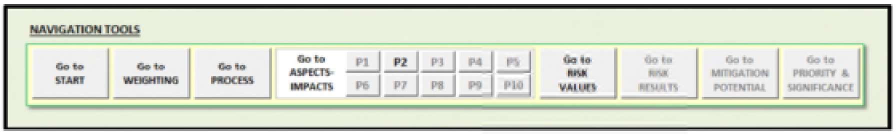
3.0 STEP-BY-STEP (WITH SCREEN SHOTS)

3.1 Navigation Tools

Although AIM version 2.0 is in a spreadsheet platform and is composed of several individual worksheets, there are only two worksheets visible to the user at any given time; one is the active worksheet (the active worksheet is for entering data or for viewing output or both) and the other is the copyright worksheet. The copyright worksheet is always visible. The NAVIGATION TOOLS, which are visible on every page, allow the user to easily move between worksheets. Another benefit of the NAVIGATION TOOLS is that it forces the user to move through the various worksheets in a specific order, which is important to proper function of the program.



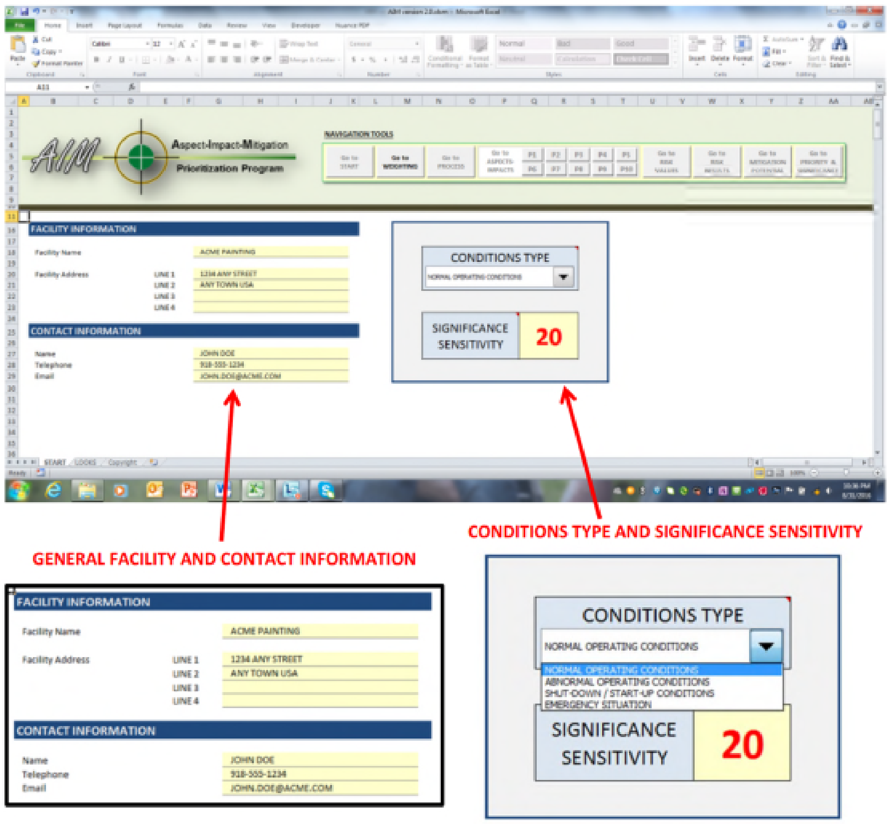
The NAVIGATION TOOLS menu is located at the top of every worksheet.



Notice that some buttons are *grayed-out*, which indicates they are unavailable to the user.

3.2 START Worksheet

The START worksheet allows the user to enter general information about the facility (facility name and address) and contact person as well as specific information regarding *conditions type* (normal, abnormal, shut-down / start-up, and emergency) and *significance sensitivity*.



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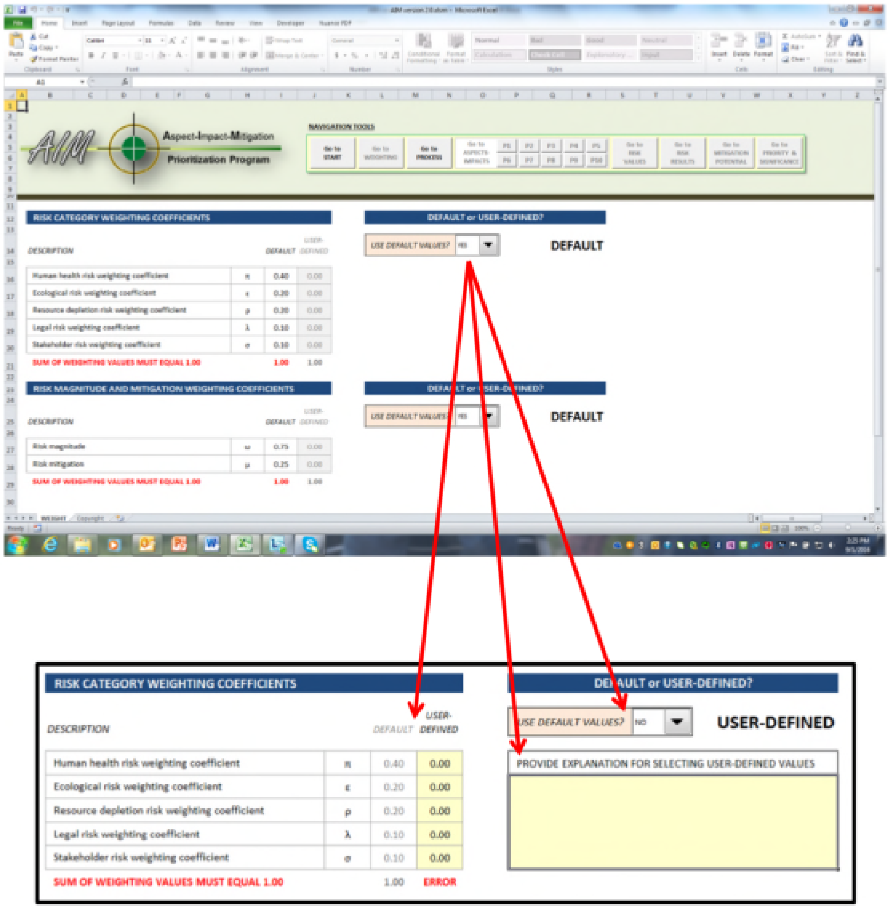
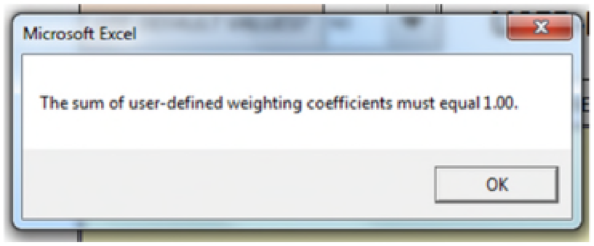
3.3 WEIGHT Worksheet

The WEIGHT worksheet gives the user the option of using the default values for the *risk category weighting coefficients* and the *risk magnitude and mitigation weighting coefficients* or designating their own *user-defined* weighting coefficients. If the user elects to not use the default values, AIM will not allow navigation away from the WEIGHT worksheet until the user enters weighting coefficients that sum to 1.00. The user is also requested to indicate the reason for selecting user-defined values.



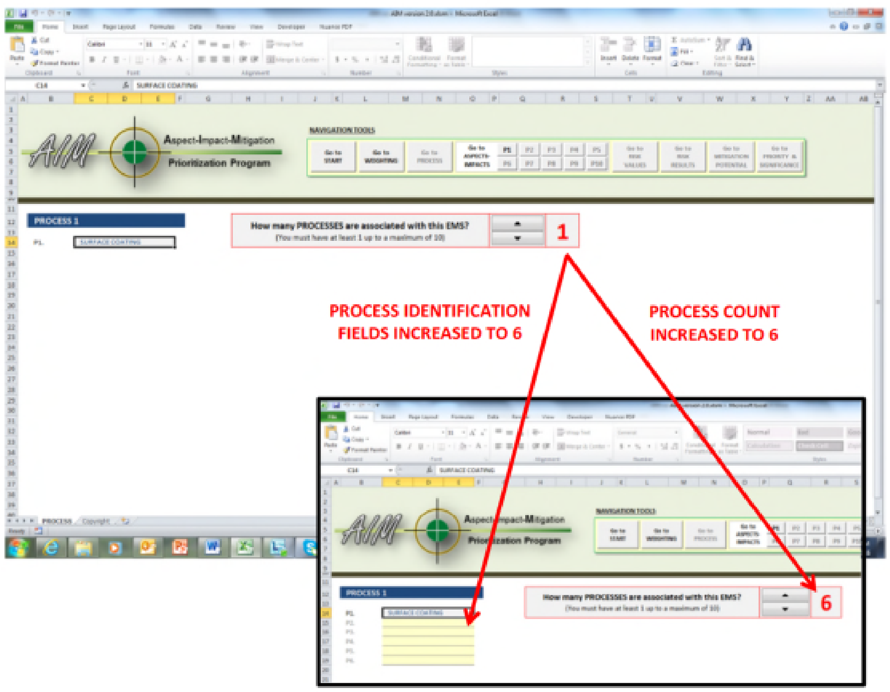
Note changes when *USE DEFAULT VALUES?* Is selected as "NO" for risk category weighting coefficients

If the user attempts to navigate away from the WEIGHT worksheet **and** the weighting coefficients **do not** sum to 1.00, the following message box is displayed. The user cannot navigate away from the WEIGHT worksheet until the weighting coefficients sum to 1.00.

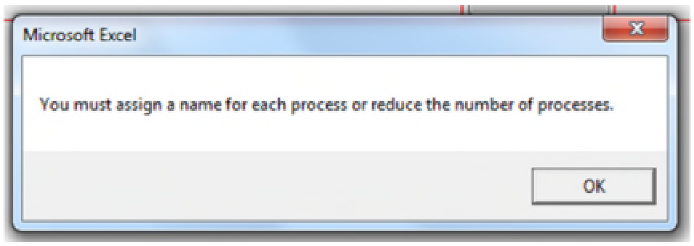


3.4 PROCESS Worksheet

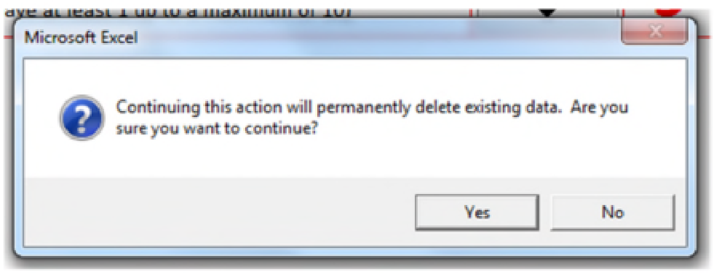
In the PROCESS worksheet the user selects the total number of processes to be considered as well as assigns a name to each process. AIM will not allow navigation away from the PROCESS worksheet until the user assigns a name to each process.



If the user attempts to navigate away from the PROCESS worksheet **and does not** enter a name for each process, the following message box is displayed. The user cannot navigate away from the PROCESS worksheet until all processes are named.



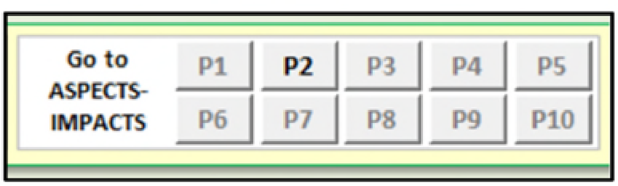
The user can also reduce the number of processes from the PROCESS worksheet. If the user attempts to reduce the number of processes **and** the process being eliminated has already been named, the following message box is displayed.



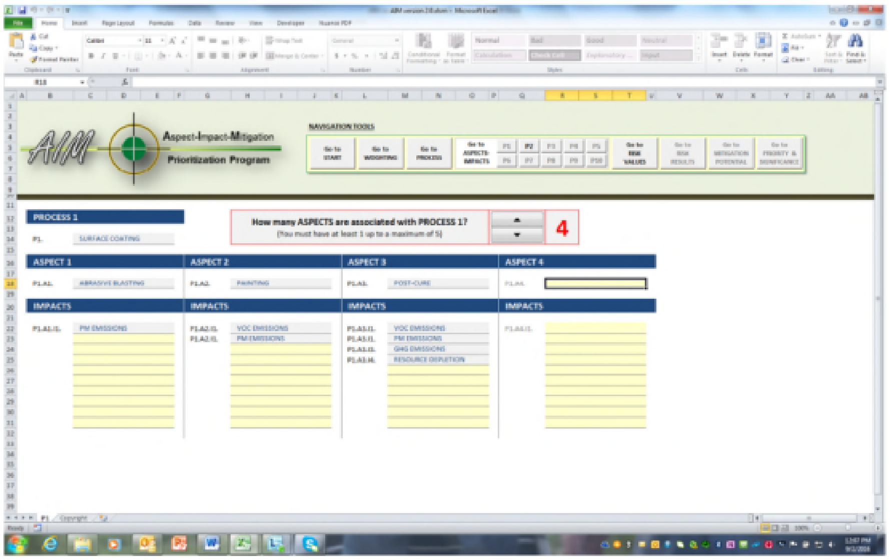
Existing data includes not only the data on the PROCESS worksheet, but all other data on other worksheets that is associated with the process being deleted.

3.5 ASPECTS-IMPACTS Worksheets

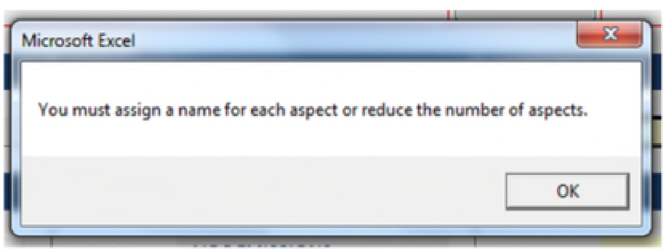
There are ten (10) ASPECTS-IMPACTS worksheets; P1 through P10, which correspond to the maximum number of processes that can be identified in the PROCESS worksheet. The ASPECTS-IMPACTS navigation group shown below only allows the user to navigate to the next ordered process. For example, the user may navigate from P3 to P4, but cannot navigate from P3 to P7. The user also cannot move backwards from within the ASPECTS-IMPACT navigation group. If the user wishes to move from P4 to P2, she must select the "Go to PROCESS" button, select "P1" and then select "P2." This forced navigation may appear somewhat inconvenient, but it is important to preserving the integrity of the program output results.



The ten (10) ASPECTS-IMPACTS worksheets (P1 through P10) allow the user to select and name up to five (5) aspects for each process and enter up to ten (10) impacts for each aspect. The process name is automatically copied over from the PROCESS worksheet.



If the user attempts to navigate away from an ASPECTS-IMPACTS worksheet **and does not** enter a name for each aspect, the following message box is displayed. The user cannot navigate away from an ASPECTS-IMPACT worksheet until all aspects are named.



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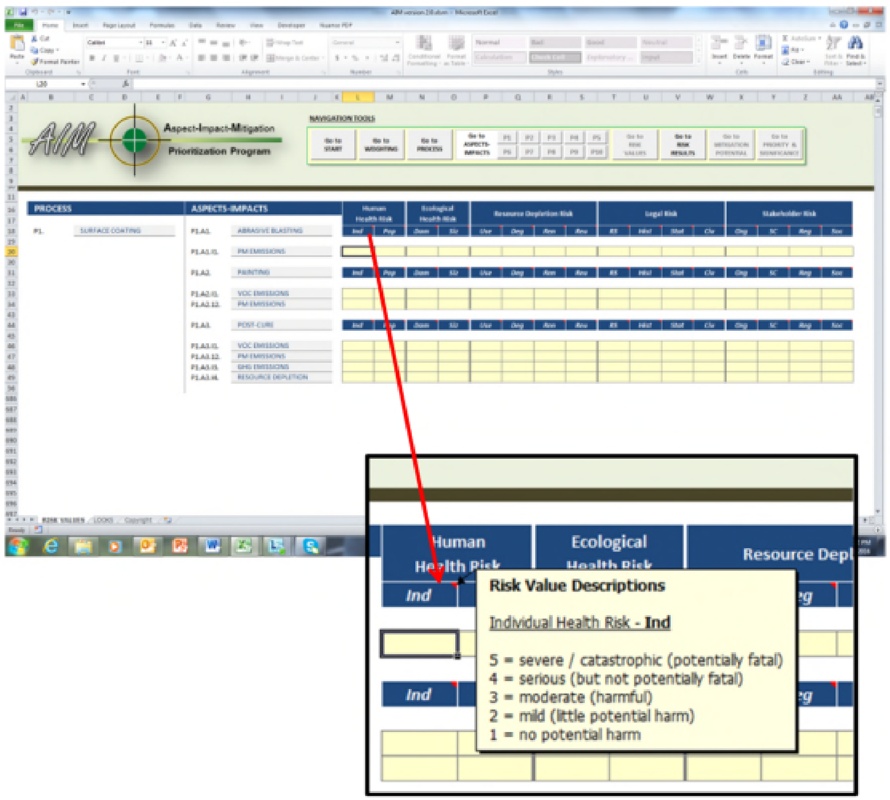
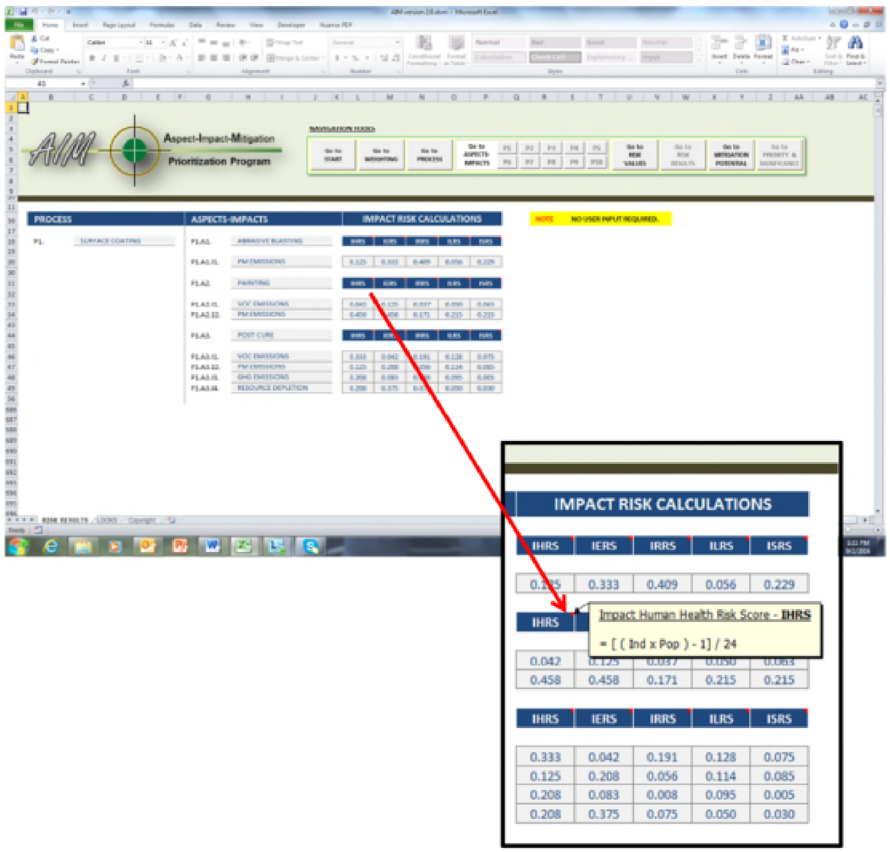
3.6 RISK VALUES Worksheet

After identifying processes, aspects, and impacts, the user navigates to the RISK VALUES worksheet to enter Likert scale judgement values for the various types of risk (i.e., *human health risk, ecological health risk, resource depletion risk, legal risk, and stakeholder risk*) for each impact. The judgement scales values and descriptions can be viewed from within the program by "mousing over" the risk scale name in the header. A full listing and description of the risk scales are also included at the end of this manual.



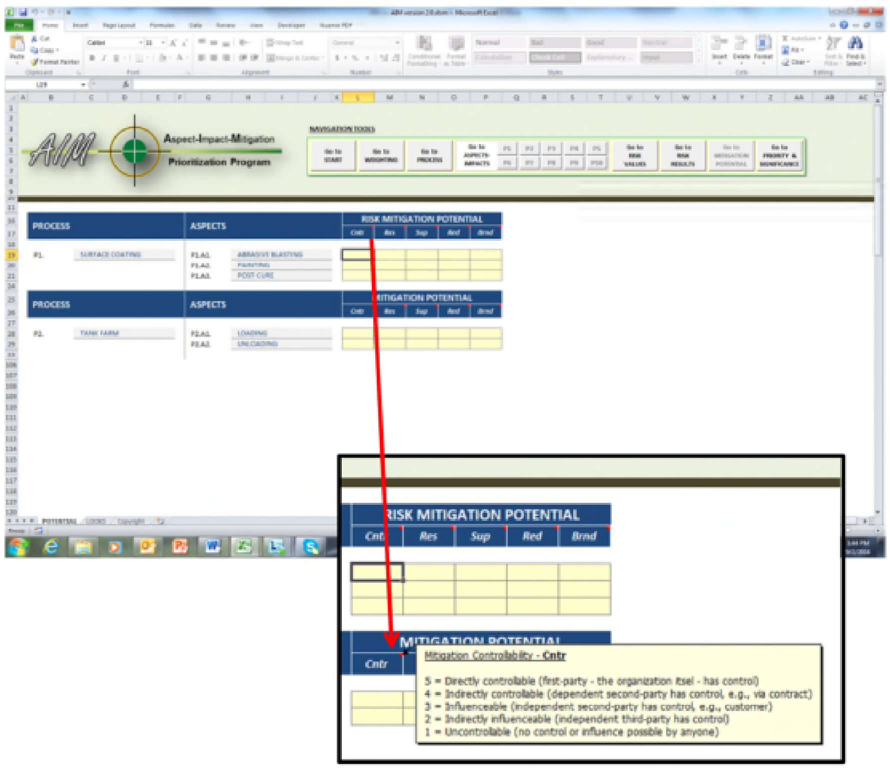
3.7 RISK RESULTS Worksheet

Upon completion of entering all of the risk values for each impact into the RISK VALUES worksheet, the user navigates to the RISK RESULTS worksheet. The RISK RESULTS worksheet contains output only; no user data input is required. The output shown in the RISK RESULTS Worksheet is as follows: IHRS (*Impact Human Health Risk Score*), IERS (*Impact Ecological Health Risk Score*), IRRS (*Impact Resource Depletion Risk Score*), ILRS (*Impact Legal Risk Score*), and ISRS (*Impact Stakeholder Risk Score*). The risk score names, descriptions, and formulae can be viewed from within the program by "mousing over" the risk score name in the header. A full listing and description of the risk scores are also included at the end of this manual.



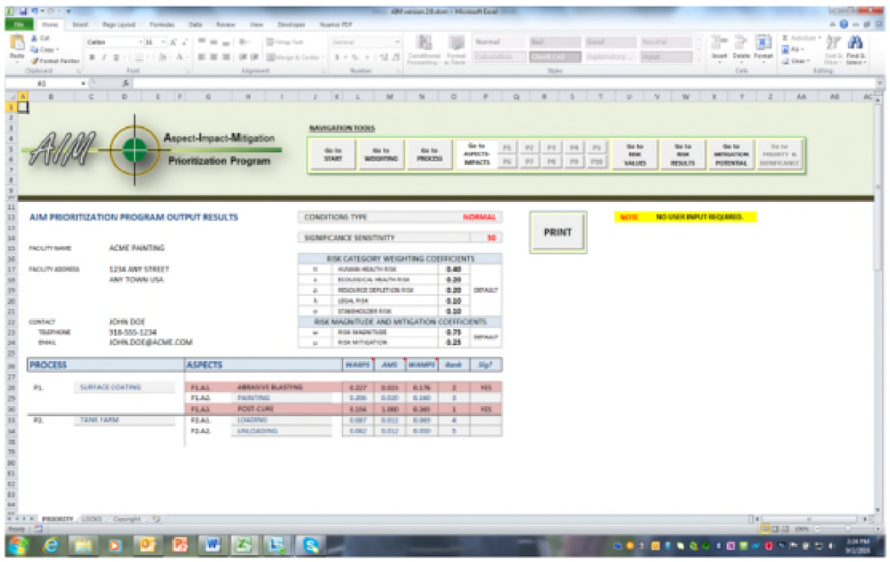
3.8 (*MITIGATION*) POTENTIAL Worksheet

After viewing the RISK RESULTS worksheet, the user navigates to the (*MITIGATION*) POTENTIAL worksheet. Here, the user must enter Likert scale judgement values regarding mitigation potential for each aspect based on five (5) categories; *mitigation controllability*, *available mitigation resources*, *management support*, *risk reduction potential*, and *brand value*. The judgement scales values and descriptions can be viewed from within the program by "mousing over" the risk mitigation potential name in the header. A full listing and description of the risk mitigation potential scales are also included at the end of this manual.



3.9 PRIORITY (& *SIGNIFICANCE*) Worksheet

Upon completion of entering all of the risk mitigation potential values for each aspect into the (*MITIGATION*) POTENTIAL worksheet, the user the user navigates to the PRIORITY & (*SIGNIFICANCE*) worksheet. The PRIORITY (& *SIGNIFICANCE*) worksheet contains output only; no user data input is required. This is the final output of the program. At the top of the sheet is a summary of some of the general information (facility location and contact), the conditions type, significance sensitivity value, as well as the weighting coefficient values used. The table directly following is a listing of the processes, aspects, calculated output values, relative risk ranking of the aspects, and identification of significant environmental aspects (highlighted in red).



REFERENCE GUIDE TO LIKERT SCALE VALUES

Risk Scales

Human Health Risk (2 scales)

The human health risk scales encompass the two major contributors to this category of risk: intrinsic health damage to an individual (traditionally measured at the *maximally exposed individual* or *MEI*) (**Ind**) and the size of the population exposed (**Pop**).

Individual Health Risk - **Ind**	
5	Severe/catastrophic (potentially fatal)
4	Serious (but not potentially fatal)
3	Moderate (harmful)
2	Mild (little harm potential)
1	No potential harm

Population Health Risk - **Pop**	
5	Community (extends beyond the adjacent neighborhood into the larger community)
4	Neighborhood (extends beyond the facility property into the adjacent neighborhood)
3	Facility (extends beyond the operational work area but remains on the facility property)
2	Operation (extends beyond the immediate work station, but confined to the operational work area)
1	Process (confined to immediate process work station)

Ecological Health Risk (2 scales)

The two ecological health risk scales consider the potential extent of harm to an ecological community (**Dam**) as well as the size of the ecological community affected (**Siz**).

Habitat Damage Potential - **Dam**	
5	Severe/catastrophic (habitat is permanently destroyed)
4	Serious (habitat damage will persist for long periods without significant human intervention)
3	Moderate (potential or actual harm to the habitat, but restoration is expected within a year without human intervention)
2	Mild (potential or actual harm to species, but no harm to their habitat)
1	No potential harm

Habitat Population Size - **Siz**	
5	Multiple communities (extends beyond the local community into other communities)
4	Community (extends to an entire local community)
3	Multiple species (extends to several species, but not to an entire local community)
2	Species (threat extends to an entire species, but does not extend to an entire local community)
1	Subspecies (at most, only a few members of a single species is affected within a local community)

Resource Depletion Risk (4 scales)

There are four scales associated with resource depletion rates: the percentage of total energy, water, and natural resources used by the process having the aspect compared to that used by the entire facility (**Use**); degree of degradation of a natural resource (**Deg**); natural resource renewal rate (**Ren**); and percentage of reused processed resources in the material feedstocks (**Reu**).

Resource Use Rate - **Use**	
5	Major use (80-100% of total facility resources used by the process)
4	Significant use (60-79% of total facility resources used by the process)
3	Moderate use (40-59% of total facility resources used by the process)
2	Minor use (20-39% of total facility resources used by the process)
1	Trivial use (<20% of total facility resources used by the process)

Natural Resource Degradation Extent - **Deg**	
5	Complete degradation (cannot serve its intended use as a resource)
4	Major degradation (resource can be used, but only after significant restoration)
3	Moderate degradation (resource can be used, but only after some restoration)
2	Minor degradation (resource has suffered slight degradation and can still be used)
1	No degradation (the resource has suffered no degradation in either quality or quantity)

Natural Resource Renewal Rate - **Ren**	
5	Effectively non-renewable (>30 years)
4	Difficult renewability (20-30 years)
3	Moderate renewability (10-19 years)
2	Easy renewability (<10 year)
1	Immediately renewable (instantaneous)

Processed Resource Reuse Percentage - **Reu**	
5	Entirely virgin stock (0% reused)
4	Low reused stock (1-32% reused)
3	Medium reused stock (33-66% reused)
2	High reused stock (67-99% reused)
1	Entirely reused stock (100% reused)

Legal Risk (4 scales)

The four legal risk scales are used to describe the level of current regulatory scrutiny (**RS**), past compliance history (**Hist**), current compliance status (**Stat**), and status or civil actions (**Civ**).

Regulated Status Weight - **RS**	
5	Very high (current statutory or regulatory requirement)
4	High (potential future statutory or regulatory requirement)
3	Moderate (formal organizational policy)
2	Low (informal organizational practice)
1	Very low (unregulated)

Violation History - **Hist**	
5	Continuous (non-compliance found in more than three successive inspections/audits)
4	Frequent (non-compliance found in 2-3 successive inspections/audits)
3	Intermittent (non-compliance found more than once, but never in successive inspections/audits)
2	Rare (non-compliance found only once)
1	Never (non-compliances have never been found)

Current Compliance Status - **Stat**	
5	Poor (currently under enforcement action for statutory or regulatory violations)
4	Unsatisfactory (non-compliances noted, but enforcement action not (yet) taken)
3	Fair (non-compliances discovered during internal audits and are being corrected)
2	Good (non-compliances discovered during past internal audits, but are not occurring now)
1	Excellent (non-compliances have not been detected in internal audits nor external inspections)

Civil Liability- **Civ**	
5	Very high (credible lawsuits have been filed and were successful)
4	High (credible lawsuits have been files and are pending resolution)
3	Moderate (credible lawsuits have been threatened or lawsuit has been dismissed)
2	Low (evidence or complaints could reasonably lead to lawsuits if not properly handled)
1	Very low (no complaints or evidence received that are expected to lead to lawsuits)

Stakeholder Risk (4 scales)

There are four stakeholder risk scales, each representing a different group of stakeholders. *Organizational* stakeholders (**Org**) may include employees, shareholders, and financial institutions; *Supply Chain* (**Sup**) stakeholders may include material and equipment suppliers, transportation partners, and customers; *Regulatory* stakeholders (**Reg**) will include regulatory agencies at applicable regulatory levels (i.e., international, national, local, etc.); *Societal* stakeholders (**Soc**) may include the potentially affected community, environmental groups, professional organizations, and the media

Organizational Stakeholders - **Org**	
What is the level of perceived risk?	
5	Very high
4	High
3	Medium
2	Low
1	Very low

Supply Chain Stakeholders - **Sup**	
What is the level of perceived risk?	
5	Very high
4	High
3	Medium
2	Low
1	Very low

Regulatory Stakeholders - **Reg**	
What is the level of perceived risk?	
5	Very high
4	High
3	Medium
2	Low
1	Very low

Societal Stakeholders - **Soc**	
What is the level of perceived risk?	
5	Very high
4	High
3	Medium
2	Low
1	Very low

Aspect Mitigation Scales

There are five (5) aspect mitigation scales that are used in determining the Aspect Mitigation Score (AMS). These scales describe controllability (**Cntr**), resource availability (**Res**), management support (**Sup**), level of potential risk reduction (**Red**), and potential effect(s) on brand value (**Brnd**).

Mitigation Controllability - **Cntr**	
5	Directly controllable (first party—the organization itself—has control
4	Indirectly controllable (dependent second-party has control, e.g., via contract)
3	Influenceable (independent second-party has control, e.g., customer)
2	Indirectly influenceable (independent third-party has control)
1	Uncontrollable (no control or influence possible by anyone)

Available Mitigation Resources - **Res**	
5	Trivial (mitigation can be obtained with little, if any, resources)
4	Relatively easy (resources can be accommodated within operational area's budget)
3	Moderately difficult (resources will be needed from other operational areas)
2	Very difficult (organization's resources will be severely strained)
1	Impossible (organization cannot mitigate with available resources)

Management Support - **Sup**	
5	Automatic support (mitigation would be supported without discussion)
4	Cautious support (mitigation would likely attract support after brief discussion)
3	Weak support (mitigation is likely only with compelling rationale)
2	Little support (mitigation support would be difficult, but possible)
1	No support (mitigation support is impossible)

Risk Reduction Potential – **Red**	
5	Very high risk reduction (81-100% reduction)
4	High risk reduction (61-80% reduction)
3	Moderate risk reduction (41-60%)
2	Low risk reduction (21-40% reduction)
1	Very low risk reduction (0-20% reduction)

Brand Value - **Brnd**	
5	Very high brand value increase (>10% improvement in value)
4	High brand value increase (5-10% improvement in value)
3	Moderate brand value increase (2-4% improvement in value)
2	Low brand value increase (>0-1% improvement in value)
1	No impact or negative impact on brand value (≤0% improvement in value)

VITA

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Candidate for the Degree of

Doctor of Philosophy

Thesis: HOLISTIC RISK-BASED APPROACH TO IDENTIFY SIGNIFICANT ENVIRONMENTAL ASPECTS WITHIN AN ENVIRONMENTAL MANAGEMENT SYSTEM

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