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A Guide for Performing Economic Analyses of USAF ESOH Projects

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Justifying the costs associated with workplace safety and health improvements is a daunting challenge for many environment, safety and occupational health (ESOH) professionals. Nonetheless, the ability to align safety and health enhancements with economic benefits can smooth the path for approval of recommended changes. This report describes considerations for conducting an economic analysis of projects that address ESOH concerns at United States Air Force installations. The report introduces the concept of economic analysis as a means of facilitating objective decision-making; briefly reviews approaches to controlling ESOH hazards in the workplace; describes procedures for conducting an economic analysis and using the information to make decisions among competing alternatives; and provides examples of economic analyses performed for ESOH recommendations in a corrosion control facility at Columbus AFB, MS. By systematically examining and describing the costs, benefits, and risks associated with ESOH improvement efforts, ESOH professionals can provide stronger justifications and achieve increased support for investments in ESOH-related projects.

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ABBREVIATIONS AND ACRONYMS

AETC	Air Education and Training Command
AFB	Air Force Base
AFI	Air Force Instruction
AFMAN	Air Force Manual
AFPD	Air Force Policy Directive
AFIERA	Air Force Institute for Environment, Safety and Occupational Health Risk Analysis
AFMIA	Air Force Manpower and Innovation Agency
APF	Assigned Protection Factor
COTS	Commercial Off-The-Shelf
ESOH	Environment, Safety and Occupational Health
HVLP	High-Volume, Low Pressure
LTP	Low-slung Tele-operated Positioner
MEK	Methyl Ethyl Ketone
OSHA	Occupational Safety and Health Administration
PAPR	Powered Air Purifying Respirator
PMB	Plastic Media Blasting
PPE	Personal Protective Equipment
ROI	Return On Investment
TO	Technical Order
USAF	United States Air Force

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EXECUTIVE SUMMARY

This guide was developed to assist environment, safety and occupational health (ESOH) professionals in preparing an economic analysis for projects or recommendations that address ESOH concerns at United States Air Force (USAF) installations. *Economic analysis* is the process of systematically examining and describing the costs, benefits, and risks of various alternatives. It is used to determine whether the expected benefits of a particular project would exceed its anticipated costs, or to assist a decision-maker in selecting one option from a range of alternatives. By examining and documenting the costs and benefits associated with ESOH improvement efforts, ESOH professionals can provide stronger justifications and achieve increased support for investments in ESOH-related projects.

This guide is structured in the following manner:

Section 1 introduces the concept of economic analysis as a means of facilitating rational decision-making. It also describes current Air Force initiatives that increase the need for ESOH professionals to be conscious of ESOH costs and to seek ways of reducing costs through the application of ESOH expertise.

Section 2 briefly describes approaches to controlling ESOH hazards in the workplace.

Section 3 describes the procedures for conducting an economic analysis, and using this information to make decisions among competing alternatives.

Section 4 describes the documentation that should accompany an economic analysis.

Appendix A contains examples of economic analyses performed in support of recommendations to reduce ESOH costs and risks at a corrosion control facility at Columbus AFB, Mississippi.

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1.0 INTRODUCTION

This technical guide was developed to help environment, safety and occupational health (ESOH) professionals apply economic analysis (also known as cost and benefit analysis) procedures to recommendations that address ESOH concerns at United States Air Force (AF) installations. The Air Force is committed to providing safe and healthy workplaces, and to conducting operations in a manner that minimizes the risk to both the environment and the safety and health of Air Force personnel and the public. Ensuring that this goal is achieved in a cost effective manner is critical to the Air Force's ability to meet its mission essential tasks.

The purpose of *economic analysis*, as defined in AFI 65-501, *Economic Analysis*, is to systematically examine the alternative means of satisfying an objective, and to describe the costs, benefits, and risks associated with each option. It is primarily a management tool; its goal is to ensure decision-makers have the relevant facts to make an informed decision, and to reduce the incidence of serious omissions or the introduction of personal bias into the decision making process. While economic analysis can't replace good judgment, it can be a useful means for determining whether the expected benefits of a particular project would exceed its costs, and for selecting an option from a range of alternatives.

Although cost has always been a consideration in the implementation of workplace changes, the need for ESOH professionals to be aware of the costs associated with their recommendations and to express benefits in financial terms has become increasingly important. This heightened emphasis is driven in part by the Secretary of Defense's Year 2000 goal[1] for each Service to develop a system that provides "...routine visibility into weapon system life cycle costs," and the Secretary of the Air Force directive[2] to "...seek ways to reduce total ownership costs." Until recently, ESOH related costs were given little attention; they had limited visibility and were considered part of the "cost of doing business." Now, there is increasing evidence that ESOH costs are not only significant, but can be reduced. A number of AF policy statements now mention cost reduction as a goal of AF ESOH programs. For example, AFPD 90-8, *Environment, Safety, and Occupational Health*, states that "Installation ESOH professionals will provide ESOH technical expertise to commanders, functional managers, and supervisors to support operational risk management (ORM), performance improvement, and *cost reductions*." Likewise, AFI 48-145, *Occupational Health Program*, declares that "the purpose of the AF Occupational Health Program is to enhance overall mission effectiveness by protecting human resources in the workplace, *reducing costs,* and improving performance."

Technically speaking, ESOH projects do not require an economic analysis unless they require a total investment of $1,000,000, or incur annual costs of $200,000 or more. If these thresholds

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[1] **Secretary of Defense**: *Achieving National Performance Review Defense Acquisition Reinvention Impact Center Goals by Year 2000 Memorandum,* 22 Nov 1997

[2] **Secretary of the Air Force**: *Air Force Reduction in Total Ownership Costs Policy Memorandum,* 22 Mar 2000.

are met, AFI-65-501 states that the installation financial analysis office must perform an economic analysis. However, even if these conditions are not met, economic analysis can be a powerful tool for persuading commanders and supervisors that all of the implications surrounding a proposed ESOH improvement have been considered, and that the change adds value to the organization. Economic analysis ensures that objectives and alternatives are clearly defined; costs and benefits are completely presented; and that all important assumptions and considerations are identified. In short, effective application of economic analysis can help the ESOH professional achieve *both* risk and cost reduction goals.

This guide is not intended to supersede formal AF guidance on economic analysis as provided in AFI 65-501 and AFMAN 65-506, *Economic Analysis*. Rather, this guide is intended to serve as a supplement, with examples directed specifically at AF ESOH professionals. It begins with a brief recap of the common strategies used to control potential ESOH hazards in the workplace. It then identifies some of the types of costs and benefits that may be associated with implementing various hazard control measures. Approaches for comparing costs and benefits and using this information for decision-making are presented. Documentation of economic analysis results is discussed; and finally, examples of economic analyses for proposed ESOH improvements are provided in the appendix to this guide.

2.0 THE ESOH FOCUS: WORKPLACE OPERATIONS, POTENTIAL HAZARDS, AND CONTROL OPTIONS

The AF is unique in the diversity of operations conducted at its installations. These operations are comprised of a wide variety of processes and activities, each involving a host of procedures, materials and equipment. Many of these operations are conducted in unique physical environments. Therefore, it is no surprise that AF workers regularly encounter a plethora of physical and chemical hazards in the workplace. For example, workers on the flight line may be exposed to inclined or elevated work surfaces, static or awkward postures, temperature extremes, and a wide variety of chemical contaminants (e.g., jet fuel, lead, chromates). Each of these hazards pose varying levels of risk to the worker, and require specific control measures to ensure that the safety and health of the worker are preserved.

Hazardous conditions in the workplace are best addressed up-front, i.e., at the time facilities are designed, operating procedures are developed, and equipment is purchased. However, even with foresight and planning, it is virtually impossible to eliminate all hazards from the workplace. As a result, ESOH professionals are frequently called upon to examine workplaces for hazards and to recommend measures to eliminate or mitigate the risk posed by the hazard to the workers. The basic principles for controlling hazards in the occupational environment are well described in a wide variety of industrial hygiene texts, and are only briefly mentioned below.

- Permanent engineering controls are the preferred approach to eliminating known workplace hazards. Engineering controls can involve substituting less hazardous materials, processes or equipment for those that are causing problems in the workplace; imposing a barrier between workers and identified hazards (isolation); or strategically adding or removing air from the work environment (ventilation).
- In the absence of engineering controls, administrative (work practice) controls may be used to limit worker exposure to known health hazards. Administrative controls include changes in work schedules, operational procedures, and training. Administrative controls are considered less desirable than engineering controls because their effectiveness depends on management commitment and employee compliance with workplace rules and procedures.
- Finally, personal protective equipment (PPE), consisting of clothing or other personally worn devices that place a barrier between the worker and the hazard, can be used as a "last resort" when neither engineering nor administrative controls are available or adequate to limit the risk to the worker. PPE can interfere with dexterity and movement, limit vision and communication, and increase heat stress and metabolic burden. As a result, work performance can be significantly degraded during PPE use due to heightened fatigue or increased errors. Even in situations where work performance is not materially impacted by PPE use, the time required to don, doff and maintain PPE can be notable.

While not all control principles are applicable to every hazard, virtually all occupational hazards can be controlled to some extent through one of these approaches. Ingenuity, experience, and a thorough understanding of the circumstances that create the hazard are required to select the method that not only provides adequate control, but offers the best overall economic value.

Some of the additional factors that should be considered in the selection of an appropriate control measure are described in the next section.

3.0 COST AND BENEFIT CONSIDERATIONS FOR ESOH CONTROLS

The process of ensuring that ESOH hazards are controlled in a cost effective manner must address a variety of potential concerns. The seriousness of the hazard, and the degree to which the control reduces the risk to the worker/environment are always relevant factors. However, other issues that might influence the selection of a control include:

- The availability of the proposed control measure. For example, a commercial product will almost always be preferred to an alternative that requires significant research and development work. Note that even commercial items may not be readily "available" if the technology requires item manager approval or a technical order change before it can be implemented.
- The accessibility of funding and/or other resources to implement and maintain the proposed measure in operation.
- The anticipated impact of the measure on a shop's overall efficiency, productivity and quality.
- The ability of the control measure to easily integrate/interface with other workplace processes and components, both now and in the future.
- The acceptability of the control measure to workers (includes comfort, convenience, and ease to use considerations).

Incorporating all of these considerations into the selection of an ESOH control measure can appear to be a daunting task; nonetheless, it is an undertaking that can be accomplished successfully by following established procedures for conducting an economic analysis. The key elements in this process include:

- Clearly defining the goal or desired outcome;
- Identifying hypothetical alternatives for achieving the specified outcome;
- Formulating appropriate assumptions;
- Determining the cost (inputs) and benefits (outputs) of each alternative;
- Comparing costs and benefits of all alternatives and ranking the alternatives; and
- Testing the sensitivity of major uncertainties on the outcome of the analysis.

Each of these elements is described in further detail in the following paragraphs.

3.1 DEFINING THE DESIRED GOAL OR OUTCOME

Perhaps the most important step in selecting an ESOH control measure for a recognized hazard is to define the objective. Simply stated, an objective is some fixed standard of accomplishment. By establishing an objective, we concurrently and implicitly establish the criteria by which we will measure the relative benefits and costs of each alternative.

Although elimination of hazards and/or compliance with existing laws and regulations is always a primary objective of ESOH control measures, objectives can also include reducing process costs and improving performance. The desired outcome of the analysis could alternately be defined as identifying the control that

- Has the least cost for a given level of worker protection;
- Produces the largest ratio of benefits to cost for a given level of protection; or
- Produces the most benefits and/or protection at a given level of cost.

3.2 IDENTIFYING ALTERNATIVES

Once the desired goal of the analysis has been determined, the next step is to identify potential means for meeting the project goal. As described in section 2, there may be several alternatives for controlling worker exposure to e.g., airborne chemicals, ranging from substituting a less hazardous substance, to installing a ventilation system, to providing workers with respirators. In many cases, alternatives can be subdivided into additional options based on the availability of different technologies (e.g., airline vs. air-purifying respirators).

Economic analysis always addresses at least two alternatives. By convention, one of the options is usually the existing situation (i.e., making no change). The current situation and its costs and benefits then serve as a common reference point (base case) in the analysis of all other identified options.

At the other end of the spectrum, there is really no limit to the number of alternatives that can be considered in an economic analysis. Certainly, it is best to keep the number of alternatives to a manageable level. For example, some alternatives that emerge from a brainstorming session can be eliminated from the full analysis if they are clearly infeasible, or don't meet all of the specified objectives. However, the fact that these options were identified and subsequently rejected should be documented.

3.3 FORMULATING ASSUMPTIONS

Assumptions are statements made to support and reasonably limit the scope of a study. Because an assumption is a "given" as opposed to a "fact," it usually implies a degree of uncertainty. For this reason, assumptions made during the course of the analysis should be clearly identified in any documentation prepared for the analysis.

Two assumptions that are made in all economic analyses concern the "economic life" of each alternative, and the time period for comparison. The economic life of a project is the period of time over which the benefits from a project are expected to accrue. For hardware, it is usually equal to the time the equipment will be used before it has to be replaced (either because it has been physically exhausted or become technologically obsolete). The period of comparison is the time over which all alternatives are expected to perform to a specified level or yield a particular benefit. If alternatives have different economic lives, adjustments may be required to ensure alternatives can be fairly contrasted over the period of comparison.

3.4 DETERMINING COSTS

Costs are the resources required to acquire, maintain or operate a project or activity. In most cases, the costs associated with ESOH alternatives are not only easier to estimate than the benefits, but are usually measurable in conventional monetary terms. Costs are typically divided into two categories: nonrecurring and recurring. Nonrecurring costs are one-time costs that are usually realized at the initiation of a project. These costs are sometimes referred to as *startup costs* or *capital costs*. Some examples of nonrecurring costs include:

- Research and development costs;
- Costs associated with the acquisition or modification of land, buildings, machinery, equipment, or computer software;
- Costs associated with the installation of new machinery or equipment, including the cost of purchasing equipment fittings and the labor required to rearrange tools, workstations or facilities to accommodate new equipment items; and
- Costs associated with providing any initial training.

In contrast, recurring costs are the periodic costs that are realized during routine operation of the affected activity. They include:

- Personnel/labor costs, i.e., all direct and indirect costs related to both civilian and military personnel involved in the operation. The number of operators and the time required to perform a job usually drive personnel costs. Support activities such as performing occupational examinations, shop surveys, permitting, or recordkeeping activities are often overlooked, but the effort involved in carrying out these activities should also be considered in calculating labor costs.

- Supply/material costs, i.e., the costs of materials and supplies used and/or consumed by the activity. These include the cost of utility services (electric power, water, etc.)

- Periodic maintenance and repair costs associated with buildings, grounds, tools and equipment. These costs could include the cost of maintenance contracts.

A third category of costs is *sunk costs*. These are expenses that were incurred at a time prior to performance of the economic analysis. These could include the costs to implement any control technologies that were previously used by the shop, or the costs to perform the study to identify the new alternatives. Because these costs are already irrevocably committed to a program or project, and are therefore beyond the reach of the decision maker, they should not be included in subsequent cost comparisons.

> For example, if the government pays a contractor $50,000 for a series of industrial hygiene surveys that result in a number of recommendations, the $50,000 should not be included in economic analyses for the recommendations. The $50,000 represents a sunk cost that cannot be recovered, even if the government subsequently decides not to implement any of the recommendations provided by the contractor.

To illustrate these concepts, consider the variety of costs that might be associated with purchasing a solvent distillation unit for a paint shop. The unit would be used to recycle paint solvents, which are now used and disposed of as a hazardous waste.

Table 1. Cost Table (Distillation Unit Purchase)

	Current Method (Use and dispose of solvent)	Proposed Method (Recover, distill and reuse solvent)
Total Capital Costs (Purchase and install solvent distillation unit, and conduct training)	**$0**	**$5,755**
Annual Labor Costs	$2,340 (52 hrs/yr @ $45/hr)	$4,680 (104 hr/yr @ $45/hr)
Annual Material Costs	$5,800 (800 gal of solvent at $7.25/gal)	$1,160 (160 gal of solvent at $7.25/gal)
Annual Supply (Electricity) Costs	$0	$38 (480 kw-hr/yr @ $0.08/kw-hr)
Annual Waste Disposal Costs	$380 (729 gal waste solvent or 1267 lbs/yr at $0.30/lb)	$38 (128 lbs/yr of sludge at $0.30/lb)
Annual Operational Costs	**$8,520**	**$5,916**

Notice that calculating labor costs requires the assumption of a labor rate. There are many systems used to set pay throughout the Federal government. Hourly labor costs also vary across the country and change over time. Nonetheless, information to estimate labor costs can be readily obtained over the Internet. For example, the DoD Civilian Personnel Management Service maintains information about hourly labor rates for civilian workers on its website at http://www.cpms.osd.mil/wage/wage.html. Although figures for calculating military pay are available from the Defense Finance and Accounting Service, most of the services also publish composite values that can be used to estimate enlisted and officer manpower costs. Standard composite labor rates by grade for the Air Force are available at http://www.saffm.hq.af.mil/.

3.5 DETERMINING BENEFITS

Strictly speaking, *benefits* are the "output" of a project or undertaking. They can include government earnings from a project, such as royalties, lease fees, rents, as well as other factors that are not easily described in dollar figures. The benefits of ESOH projects can include

- Impacts on legal or environmental liability;
- Occupational health effects;
- Influences on worker motivation and organizational morale.

Note that costs avoided by implementing a proposed alternative are not considered "benefits."

Even though the benefits associated with some alternatives can be hard to express monetarily, benefits should be described in a quantitative fashion where possible. For example, the "safety and health effects" of a workplace change might be expressed in terms of the expected reduction in the level of exposure, or the anticipated decline in the number of employees exposed to the hazard.

Even benefits that aren't easily quantified can usually be categorized or ranked using a rating scale. Ordinal scales can be established to assign values to options along a given dimension, and to order alternatives according to some hierarchy of values. Although some scales use numerical values, others use adjectives (e.g., excellent, good, poor) to indicate conformance to desired goals or features. Anchoring these scales with descriptors (establishing, e.g., what distinguishes "good" from "poor") can prevent subjective bias from influencing the value assigned to each alternative. This use of this approach will be further discussed and illustrated in section 3.6.2.

3.6 COMPARING COSTS AND BENEFITS

Once the likely costs and benefits associated with each option are described, alternatives can be compared to one another using a systematic evaluation procedure.

As mentioned in section 3.2, the impacts of any project must be assessed relative to a "base" case. In the example provided in Table 1, the current method of handling paint solvents in the paint shop would likely serve as the base case for comparing alternatives to this method. Although using the "status quo" or "as-is" situation as the baseline is a common practice in most cost and benefit comparisons, the base case can be any representation of past, current or possible future conditions.

Note that success in making judgments between alternatives requires that options be truly "comparable." Options are comparable if:

- All options are self-contained and independent of other options or projects. Being self-contained means that alternatives are not linked together or dependent on other projects or pre-conditions. Being independent means that options recognize only those benefits and costs that result solely from their implementation.
- All of the benefits and costs that vary among the options are considered, including any short-term transitional benefits and costs.
- The benefits and costs are evaluated to the degree necessary to distinguish among options.
- The effects of all options span the same timeframe, and the timeframe is long enough to ensure that all significant impacts are considered.

Benefits and costs that are the same for all options (including the base case) do not need to be considered. If the costs associated with all of the identified alternatives are equal, the analysis simply becomes a matter of identifying the option likely to yield the greatest benefit. Likewise, if the benefits associated with all of the identified options are the same, the alternative with the lowest cost should be recommended. However, the most common circumstance is the one where the costs and benefits associated with each alternative vary significantly. In this situation, a method must be selected to weigh the costs and benefits associated with each alternative and to identify the option most likely to satisfy the stated objective. Some of the methods that can be used to make this assessment are described in the following paragraphs.

3.6.1 Comparisons Based on Financial Criteria

When the costs and benefits associated with competing alternatives can be described in monetary terms, financial analysis procedures often provide an appropriate means for comparing alternatives. Some of the criteria that can be used to evaluate proposed projects on a financial basis include:

- Net present value method
- Payback method
- Return on investment

The procedures for deriving these criteria are described in the paragraphs that follow.

3.6.1.1 Net present value. The net present value of an alternative is simply the overall value of the project at the time of its implementation. It is calculated by assigning monetary values to anticipated benefits and costs, discounting future benefits and costs using an appropriate discount rate, and subtracting the total costs from the total benefits. *Discounting* is a financial management tool used to correct for the time value of money, i.e., the fact that a dollar of cost or benefit realized in the future is worth less than a dollar of cost or benefit realized today, primarily due to the interest that can be earned on investments. Costs or benefits realized in the future are converted to present-day values using the formula

$$PV = FV(1/1+r)^t$$

where

PV = the present-day value of the cost or benefit
FV = the value of the cost or benefit at the time it is actually realized,
r = the discount rate, and
t = the number of time periods from the present that the cost or benefit is realized.

The *discount rate* is the value by which future benefits or costs must be adjusted so that they can be compared with present-day values. According to AFMAN 65-506, the discount rate for use in government cost benefit analyses is the government's cost of borrowing, as reflected in the interest rates on Treasury notes and bonds with maturities of 3, 5, 7, 10 and 30 years. The rate selected should correspond to the project life. These discount rates are updated annually and can be accessed at http://www.saffm.hq.af.mil/fmc/index.html.

If a project is expected to generate annual costs or benefits that remain the same year after year, the present value of this stream can be calculated using this formula

$$PV = A*[(1+r)^t - 1] / [r*(1+r)^t]$$

where

PV = the present-day value of the cost or benefit
A = the annual costs or benefits generated by the alternative
r = the discount rate, and
t = the project life, in years

To illustrate, suppose a new piece of equipment requires annual maintenance at a cost of $2000 a year for each of the next three years. The discount rate is 3.2%. The present day value of these costs after discounting is equal to:

$$\$2,000*[(1.032)^3 - 1] / [(.032)*(1.032)^3] =$$

$$\$2,000*(0.099) / (0.035) = \ \$5,663.13$$

Note that if discounting had not been applied, the value of the costs over the same three-year period would have been estimated at $6,000. In this case, discounting reduced the present day value of the costs by approximately $337, or 5.6%. If discount rates are low, project costs are small (e.g., < $1M) and project life is limited (e.g., < 5 years), it is probably not critical that discounted factors be used in cost benefit comparisons. The examples included in the Appendix meet these criteria and, hence, future cost and savings estimates are not discounted. However, projects that require significant initial investment, with the expectation of long-term benefits, should be evaluated using a procedure that applies discounting.

In most cases, any project with a positive net present value (i.e., with benefits that outweigh the costs) is considered a good candidate for implementation. Among a set of mutually exclusive options, the alternative with the greatest positive net present value (or the smallest negative net present value) would be considered the best investment.

For example, using the data provided in Table 1 and assuming a discount rate of 3.2% and a project life of 6 years, the net present value of a decision to continue disposing of solvent after one-time use would be calculated as

$$-\$8,520 * [(1.032)^6 - 1] / [(.032)*(1.032)^6] = -\$45,850.08$$

Likwise, a decision to purchase and implement a solvent distillation unit would have a net present value of

$$-\$5,916 *[(1.032)^6 - 1] / [(.032)*(1.032)^6] - \$5,755 = -\$37,591.71$$

Since the net present value of the costs associated with purchasing a solvent distillation unit are lower than the net present value of the costs associated with using and disposing of solvent, purchasing a solvent distillation unit would be considered the preferred alternative (difference of $8,258.37 over the period of comparison).

3.6.1.2 Payback method. The payback method is used to determine how many periods into the future it would take for a project to realize financial gains equal to the initial cost of the project. As in the net present value method, future costs and benefits should be converted to present day values if appropriate. The payback period is calculated using the following formula:

$$PB = C/S$$

where

PB = payback period in months, years, etc., corresponding to S
C = total startup cost for the project, in $
S = periodic benefits or savings, in $, per month, year, etc. S can be calculated by subtracting the recurring costs associated with the proposed project, from the recurring costs associated with the base case (usually the current method of performing the operation).

Note that if PB is a negative number, there is no payback - the alternative costs more than it saves.

Using the data presented in Table 1, the payback period associated with purchasing the solvent distillation unit (ignoring the effects of discounting) would equal

$5,755 / ($8,520 - $5,916) per year = 2.2 years

3.6.1.3 Return on investment. Return on investment (ROI) represents the percentage of the costs associated with implementing a project that are recovered as savings over a set period of time. The one-year ROI is calculated using the formula.

$$ROI = (S - C) / C * 100\%$$

where C once again represents the total startup cost for the project, and S represents the annual (or first year) monetary benefits or savings associated with the project. An ROI for a longer time period (e.g., three years) could be calculated by substituting the savings that would accrue over the new time span for S.

To illustrate using the data presented in Table 1, the one-year and three year ROIs associated with purchasing the solvent distillation unit would equal the following:

One year ROI: [($2,642 - $5,755) / $5,755] * 100% = -54%

Three year ROI: [($7,926 - $5,755) / $5,755] * 100% = 37.7%

Note that because the savings associated with this project would not exceed the costs until the third year of the project, the one-year ROI is negative while the three-year ROI is positive. The time period for calculating the ROI should be selected based on the constraints faced by the decision-maker. While some organizations may find alternatives acceptable if they show a positive return sometime during the life of the project, others may be reluctant to implement a project unless it can show a positive return within a shorter period of time (e.g., one year or less).

3.6.2 Comparisons based on Multiple Criteria

Most, if not all, ESOH projects involve goals and objectives that go well beyond financial considerations. However, if all of the alternatives under consideration meet specified worker and environmental protection criteria, determining which option produces the greatest financial return may well be the deciding factor. This is probably a rare condition; it is more likely that the proposed alternatives will vary significantly in their ability to satisfy stated criteria. In these situations, a framework for comparing alternatives based on multiple factors should be employed. This framework may be graphical or tabular in format.

To illustrate how this comparison can be conducted, consider the graph shown in Figure 1. The Priority Rating Graph was developed by the Air Force Institute for Environment, Safety and Occupational Health Risk Analysis (AFIERA) to evaluate proposed ESOH projects along two dimensions: the ease of implementing the project (x-axis) and its anticipated impact (y-axis). "Ease of implementation" incorporates the cost of the recommendation and the time required to put it in place into a single measure; projects are designated as "easy" to implement if they can be put into action in 30 days or less, at a cost of $2,500 or less (i.e., they can be paid for using the government IMPAC card). "Impact" considers the degree to which the risk posed to the worker is reduced by the measure, and the extent to which the monetary savings realized by the project outweigh its cost (i.e., how quickly payback is achieved). Projects are considered to have "high" impact if they significantly reduce risk to the worker and the environment, and they achieve payback in 3 years or less. Projects that are both "easy" to implement and have "high" impact are designated as "green" and highly recommended for execution. Projects that are "hard" to implement and have "low" impact are designated as "red", and not recommended for action.

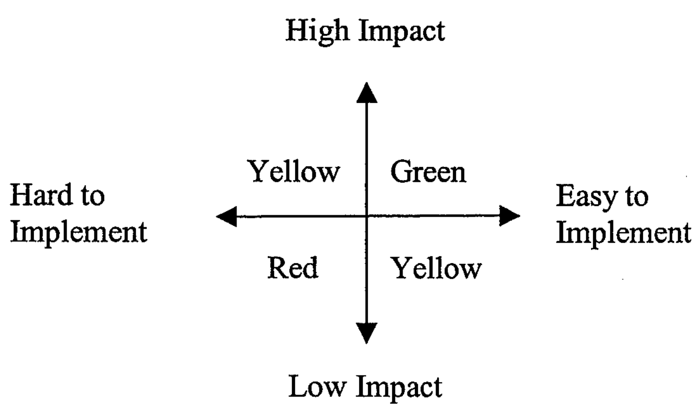

Figure 1. Priority Rating Graph for Potential Control Measures

The graphical approach works well if alternatives are being compared along two dimensions that are relatively equal in importance. However, if the comparison involves more than two evaluation criteria, a decision matrix can be constructed. An example of such a matrix is provided in Table 2 below. The matrix lists all of the evaluation criteria in the left-most column of the table, and all of the options for satisfying these criteria in the top row. A quantitative or qualitative descriptor of each alternative relative to each evaluation factor can be entered in the corresponding cell. Alternatives can then be assessed using one of the following methods:

- "Acceptability" thresholds can be established for one or more of the evaluation criteria. Only those options that meet the acceptability limit for those evaluation factors receive further consideration.
- The evaluation criteria can be rank ordered in importance. Alternatives are then compared along the dimension that is designated as the most important. Alternatives that are highly ranked along this dimension are then compared along the second most important factor. Options that are highly ranked along both dimensions are compared on the third most-important factor. This process continues until one alternative emerges as the most preferred.
- A weighting factor can be assigned to each criterion relative to its importance in the evaluation. The values assigned to each alternative for each criterion can be multiplied by their respective weighting factors and summed. The alternative that emerges with the largest sum value is the preferred option.

Table 2. Table for Evaluating Alternatives Along Multiple Criteria.

Evaluation Criteria	Alternatives			
	Option A	Option B	Option C	Option D

The following example is adapted from a scenario contained in the *Environmental, Safety and Health (ESH) Cost Analysis Guide* (22 May 1998). In this case, alternatives for the replacement of the F-15E canopy are compared. Replacement of the current canopy was desired to reduce the probability of property damage and personnel loss resulting from birdstrikes on the canopy. The identified alternatives included the following:

1. Increase canopy strength and eliminate Through-the-Canopy ejection
2. Increase canopy strength and add a canopy severancing system
3. Use a low profile canopy
4. Change to a relofted windshield/canopy

The following table was constructed to compare the options.

Table 3. Table for Evaluating F-15E Canopy Alternatives.

Evaluation Criteria	Alternatives			
	1	2	3	4
Birdstrike risk reduction	Good	Good	Good	Good
Visibility	Good	Fair	Fair	Good
Maintenance	Fair	Poor	Good	Good
Weight	Poor	Poor	Good	Fair
Aerodynamic performance	Good	Good	Good	Fair
Aviator acceptance	Poor	Fair	Fair	Good
Cost	Good	Poor	Good	Poor

Since birdstrike risk reduction is the primary goal of the project (i.e., the most important factor), one approach for assessing the options could be to eliminate all of the options rated as "Poor" on this criterion from further consideration. However, because all four options are rated as "Good," this criterion provides no basis for selecting one option from among the alternatives.

If all of the other factors are considered equal in importance, the qualitative ratings assigned to each criteria could be converted to a quantitative score, i.e., "Good" could be assigned a value of 3 points, "Fair" allocated 2 points, and "Poor" awarded 1 point. The scores could be summed for each alternative to derive an overall "composite" score (see Table 4).

Table 4. Evaluating F-15E Canopy Alternatives Using Numerical Ratings.

Evaluation Criteria	Alternatives			
	1	2	3	4
Birdstrike risk reduction	Good (3)	Good (3)	Good (3)	Good (3)
Visibility	Good (3)	Fair (2)	Fair (2)	Good (3)
Maintenance	Fair (2)	Poor (1)	Good (3)	Good (3)
Weight	Poor (1)	Poor (1)	Good (3)	Fair (2)
Aerodynamic performance	Good (3)	Good (3)	Good (3)	Fair (2)

Aviator acceptance	Poor (1)	Fair (2)	Fair (2)	Good (3)
Cost	Good (3)	Poor (1)	Good (3)	Poor (1)
Composite Score	**16**	**13**	**19**	**17**

Using this process, the option with the highest composite score (Option 3) would be selected as the preferred alternative.

However, it could be the case that one or more of the criteria are considered more important to the decision than the others; therefore, the ratings assigned for those criteria should be given more weight. Using the example above, if cost and aviator acceptance were considered twice as important as the other factors, the scores awarded for these criteria could be multiplied by a factor of two (i.e., "Good" would be awarded a score of 6 instead of 3). Under this scoring procedure, Option 1 would receive a composite score of 20, Option 2 would be given a score of 16, Option 3 would have a score of 24, and Option 4 would be awarded a score of 21. Once again, Option 3 would emerge as the preferred alternative.

3.7 ASSESSING THE EFFECT OF UNCERTAINTY

Since most important decisions involve elements of uncertainty, an economic analysis should address areas of doubt that have potential to significantly affect the analysis results. One means of dealing with uncertainty in economic analysis is through sensitivity analysis. Sensitivity analysis is applied in situations where the expected value of key parameters is unpredictable. As a hedge against uncertainty, the analyst might substitute several values (e.g., best and worst case) for these parameters in an attempt to see how the final ranking of alternatives responds to the variations in these factors. The analyst can examine the effect of changing one variable at a time (leaving all others constant), or the effect of changing groups of variables all at once using *scenario analysis*. Scenario analysis is based on the assumption that some factors aren't necessarily independent of others considered in the analysis, and that changes in some variables can produce predictable changes in others. This realization allows the analyst to combine levels of different factors in consistent combinations.

The application of sensitivity analysis can be illustrated using the information presented in Table 1. An assumption of this analysis is that solvent use is a function of the number of aircraft components processed by the paint shop that year. Another assumption is that the number of aircraft components painted by the shop varies from year to year. The analyst may decide to repeat the analysis using different values for annual volume of paint solvent use. Specifically the analyst could re-compute the payback period that would result from the purchase of a distillation unit assuming that current volume of solvent used by the shop equals 600 and 1000 gallons annually (Tables 5 and 6). Note that labor, supply and waste disposal costs are all a function of solvent usage.

Table 5. Solvent Disposal vs. Distillation (600 gallons of solvent)

	Current Method (Use and dispose of solvent)	Proposed Method (Recover, distill and reuse solvent)
Total Capital Costs (Purchase and install solvent distillation unit, conduct training)	$0	$5,755
Annual Labor Costs	$1,755 (39 hrs/yr @ $45/hr)	$3,510 (78 hr/yr @ $45/hr)
Annual Material Costs	$4,350 (600 gal of solvent at $7.25/gal)	$870 (120 gal of solvent at $7.25/gal)
Annual Supply (Electricity) Costs	$0	$29 (360 kw-hr/yr @ $0.08/kw-hr)
Annual Waste Disposal Costs	$285 (547 gal waste solvent or 950 lbs/yr at $0.30/lb)	$29 (96 lbs/yr of sludge at $0.30/lb)
Annual Operational Costs	$6,390	$4,438
Payback	$5,755/($6,390 - $4,438) = 2.9 years	

Table 6. Solvent Disposal vs. Distillation (1000 gallons of solvent)

	Current Method (Use and dispose of solvent)	Proposed Method (Recover, distill and reuse solvent)
Total Capital Costs (Purchase and install solvent distillation unit, and conduct training)	$0	$5,755
Annual Labor Costs	$2,925 (65 hrs/yr @ $45/hr)	$5,850 (130 hr/yr @ $45/hr)
Annual Material Costs	$7,250 (1000 gal of solvent at $7.25/gal)	$1,450 (200 gal of solvent at $7.25/gal)
Annual Supply (Electricity) Costs	$0	$48 (600 kw-hr/yr @ $0.08/kw-hr)
Annual Waste Disposal Costs	$475 (911 gal waste solvent or 1584 lbs/yr at $0.30/lb)	$48 (160 lbs/yr of sludge at $0.30/lb)
Annual Operational Costs	$10,650	$7,396
Payback	$5,755 / ($10,650 - $7,396) = 1.8 years	

Using this approach, the analyst can demonstrate that even if the volume of solvent used by the shop fell by 25% (from 800 to 600 gallons), the solvent distillation unit would still pay for itself within 3 years. Alternately, the analyst can show that increasing business in the shop would reduce the time needed to pay back the investment in the recycling unit.

3.8 ADDITIONAL CONSIDERATIONS IN COST BENEFIT COMPARISONS

Ultimately, economic analysis can be a powerful tool for justifying the need for ESOH improvements to a wide variety of audiences. That the analysis should be tailored for a specific audience is, however, a consideration that is often overlooked. It is important to remember that, despite appearances, no process is the responsibility of a single organization. In the Air Force, many organizations may have roles and responsibilities for supporting a given shop and the activities it performs. Figure 2 below illustrates how several functional areas – each with their own budgets and financial concerns - can be involved in the accomplishment of a single industrial process.

The key point is that when changes are made to a process, many organizations are likely to be impacted. Furthermore, it is highly unlikely that the costs and benefits associated with the change will be shared equally or proportionately among these organizations. Some organizations that are asked to bear significant costs may actually realize fewer benefits than other organizations that made lesser investments in the alternative. In constructing the economic analysis, it therefore becomes important to identify *who* bears the costs, and *who* realizes the benefits associated with each alternative. This allows each organization affected by the decision to compare the costs they will assume, to the benefits that they will realize. Segregating costs and benefits in this manner achieves two goals: it leads to a search for "hidden" costs and benefits that accrue to organizations not directly engaged in the affected process; and it leads to better decisions that have the concurrence of all parties affected by the change.

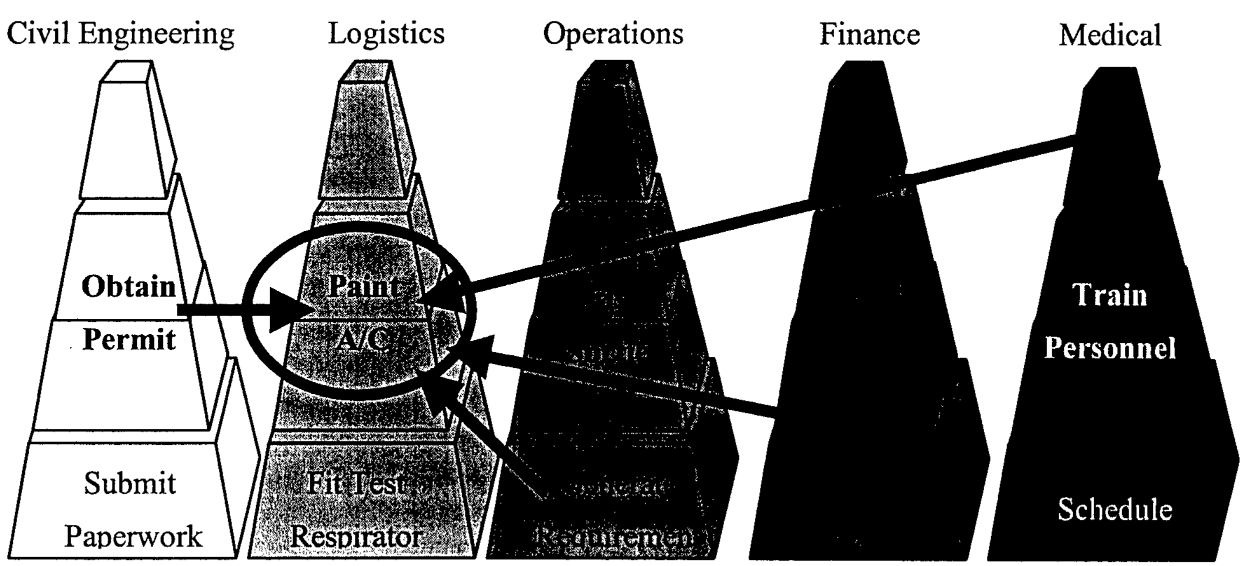

Figure 2. Organizations Involved in Painting Aircraft

> For example, consider the situation where a shop supervisor is asked to invest in the purchase of a costly piece of material handling equipment to reduce the risk of compensable back injury to workers. The economic analysis assumes that the reduction in workers' compensation costs will exceed the cost of the equipment. Presented in this manner, this justification is likely to be ineffective, in part because the shop does not bear the burden of the workers' compensation payments. In other words, the shop has little incentive to invest in the change, since it will not reap the benefits associated with it.

Fortunately, many ESOH improvement measures do have ancillary benefits apart from risk reduction; in this example, introducing equipment to automate the material handling task may reduce the time required by the worker to perform the job. Identifying this savings to the shop may persuade the decision-maker to invest in the change, especially if the reduction in labor costs outweighs the cost of the equipment, and the worker can be used effectively to perform other work in the shop. In any case, the importance of identifying all costs and benefits, and allocating them to the responsible organization cannot be overlooked.

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4.0 DOCUMENTING ECONOMIC ANALYSIS RESULTS

As important as an accurate and complete accounting of costs and benefits are to a successful economic analysis, providing the documentation to support the conclusions and recommendations of the study is a critical step in the economic analysis process. Documentation should ensure that a reader not otherwise familiar with the study would arrive at the same set of conclusions regarding the viability of the proposed alternatives. Although there is no standard format for documenting an economic analysis, there are some standard elements that the analysis report should contain. They include:

1. A description of the problem being addressed. This section should also include a statement of the objectives, requirements, and constraints that will ultimately drive the choice of an alternative. As previously noted, these objectives form the basis for the criteria that will be used to evaluate the proposed alternatives.
2. A listing and brief description of the proposed options for addressing the problem.
3. A description of the assumptions used to assess the costs and benefits associated with each of the proposed alternatives. At a minimum, this section should identify the economic life of each alternative, the period of comparison, and the discount rate (if applied).
4. A comprehensive listing of the costs and benefits associated with the proposed solutions. Note that the sources of cost or benefits data or the methods used to estimate their magnitude must be identified and/or described.
5. A description of the criteria and/or method(s) used to compare alternatives to one another.
6. A summary evaluation that recommends a specific course of action based on the data and evaluation results. The summary should explicitly state whether the proposed solution meets the objectives, requirements and constraints identified at the outset of the analysis. It should also provide any additional technical information (e.g., vendor names and specification sheets) that might be needed to complete the description of the concept and to assist the decision-maker in implementing the recommended option.

Appendix A contains several examples of economic analysis summaries for proposed ESOH projects. It is important to note that the summary does not have to be lengthy, as long as all the critical elements are identified and addressed. Suggested formats for documenting economic analysis results are also contained in Attachment 8 to AFMAN 65-506.

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APPENDIX A

Reducing Corrosion Control Costs through Environment, Safety and Occupational Health (ESOH) Improvements at Columbus AFB, Mississippi

INTRODUCTION

At the request of Headquarters, Air Education and Training Command (HQ AETC), the Risk Analysis Directorate of the Air Force Institute for Environment, Safety and Occupational Health Risk Analysis (AFIERA/RS) conducted a survey to identify potential environment, safety and occupational health (ESOH) improvements in the Corrosion Control facility at Columbus AFB, Mississippi. This survey focused specifically on the aircraft wash, depaint using Plastic Media Blasting (PMB), and paint processes. The goal of the study was to identify means of improving production capacity and worker efficiency while reducing ESOH risks and their associated costs.

PROCESS DESCRIPTION

Corrosion control operations at Columbus AFB are accomplished by approximately 25 contractor personnel (DynCorp) working on two shifts. The contractor depaints and paints aircraft (T-37, T-38, T-1), on- and off-aircraft equipment and aerospace ground equipment. (AGE)

Paint removal is accomplished either by plastic media blasting, or by scuff sanding. After depaint, aircraft and parts are washed and treated with alodine (as appropriate) before a primer and top-coat are applied. Depending on the item, painting is accomplished using high-volume low pressure (HVLP) paint guns (T-38, most parts) or electrostatic paint guns (T-1, some AGE). In addition to aircraft from Columbus, the corrosion control shop also depaints T-37 and T-38 aircraft flown in from Vance AFB. In FY98, the facility blasted 12 T-37s, 12 T-38s, 27 transient aircraft, 3 pieces of off-aircraft equipment and 81 pieces of AGE. In the same time period, the facility also painted 18 T-37s, 31 T-38s, 3 pieces of off-aircraft equipment, and 81 pieces of AGE.

In addition to airplanes undergoing PMB, the corrosion shop also washes aircraft and AGE on a regular cycle (90 days for aircraft and 120 days for AGE). In FY 98, the shop washed 180 T-1s, 375 T-37s, and 366 T-38 aircraft. In most cases, it also applied touch-up paint to the aircraft after washing was completed.

METHODS AND PROCEDURES

Personnel from the Industrial Hygiene Branch, the Hazardous Waste Branch, and the Ergonomics Function at AFIERA conducted a site visit to Columbus AFB on 12-13 Jun 00. The site visit was preceded by the development of Activity and Activity-Based Cost (ABC) models of the Columbus corrosion control facilities by the Air Force Manpower and Innovation Agency. These models provide baseline cost measures (including ESOH costs) for these processes, against which to assess the magnitude of potential improvements. During the site visit, AFIERA staff met with local ESOH professionals, conducted visits to the work areas to meet with workers and supervisors, observed work activities, and recorded work tasks on videotape.

A preliminary list of recommendations was developed and presented to Columbus for review on 10 Aug 00. Improvement ideas included the following:

1. Obtain a MEK/Polyurethane thinner wipe solvent replacement. [A]
2. Use leading edge tape during aircraft painting tasks. [A]
3. Using high speed (fan blast) stripping nozzles in the plastic media blast (PMB) booth. [B]
4. Install semi-automated depaint device in the PMB unit. [B]
5. Use roll-on paint for small-scale painting operations (e.g., painting leading edges). [B]
6. Use thickness gauges to measure paint/primer coating thickness. [B]
7. Use a polysulfide (non-chromated) primer. [B]
8. Conduct additional air sampling needed to permit substitution of powered air purifying respirators for supplied air respirators. [B]
9. Investigate use of SpongeJet, Magic or another alternative form of blast media. [B]
10. Purchase and use a recycling paint gun cleaning cabinet. [B]
11. Install a plural paint proportioning system. [B]
12. Using pressurized spray equipment for washing aircraft. [C]
13. Improve hanger climate control (mainly cooling) or provide cooling vests. [C]
14. Conduct regular checks on spray gun air cap pressure, or equip guns with pressure gauges. [C]
15. Investigate use of Sempens or blot-on/blot-off products for touch-up work. [C]

A: Base has already implemented, or will implement without further analysis
B: Base requested more information/analysis
C: Considered infeasible, or previously investigated by base

Base personnel, in coordination with AFIERA, classified these ideas into three categories, designated A, B, and C. "A" recommendations consisted of ideas that Columbus had already implemented, or agreed should be implemented without further research or investigation by the team. "B" recommendations were ideas that the group agreed had potential to reduce costs, but required further research, technical review and cost justification. "C" recommendations were concepts considered infeasible, or that had been previously evaluated by the base and discarded. From the original list of 15 suggestions, 2 were identified as "A" recommendations, and 9 were identified to the AFIERA team as "B" recommendations for further examination and development.

A cost benefit analysis was conducted for each idea selected for further examination by the installation. The analysis weighed the costs associated with implementing the change, against the labor, equipment, materials and hazardous waste disposal savings expected to result. In most cases, the costs to implement each recommendation were estimated from information provided by vendors and manufacturers of commercial off-the-shelf (COTS) equipment. FY98 costs provided in the AFMIA ABC study were used as the basis for assessing expected labor, equipment, hazardous waste and material cost reductions.

Using the cost benefit analysis information, a Priority Rating Graph was constructed. The Priority Rating Graph (Figure A-1) is a two dimensional scale, used to simultaneously evaluate proposed countermeasures on their ease of implementation (x-axis) and their potential to impact costs (y-axis). Once placed in the appropriate location on the graph, recommendations were assigned to categories based on the following criteria:

Green — Alternatives that fall into the upper right quadrant of the graph. These changes are easy to implement and provide a high overall impact. Implementation time is projected at 30 days or less at a cost of less than $2,500. Payback occurs in 3 years or less. The base should consider implementing these recommendations immediately.

Yellow — Alternatives that fall into either the upper left or lower right quadrants. These changes are either more difficult to implement (more than 30 days, or at a cost greater than $2,500) with the potential for quick payback, or easy to implement but with lower impact (payback in more than 3 years). The base should closely consider these recommendations, although they may require long-term planning and budgeting to implement.

Red — Alternatives that fall into the lower left quadrant are considered "no go" recommendations due to their low impact (payback in more than 3 years) and implementation difficulty (more than 30 days, or at a cost greater than $2,500). However, technological advancements that increase the feasibility and impact of these suggestions should be monitored.

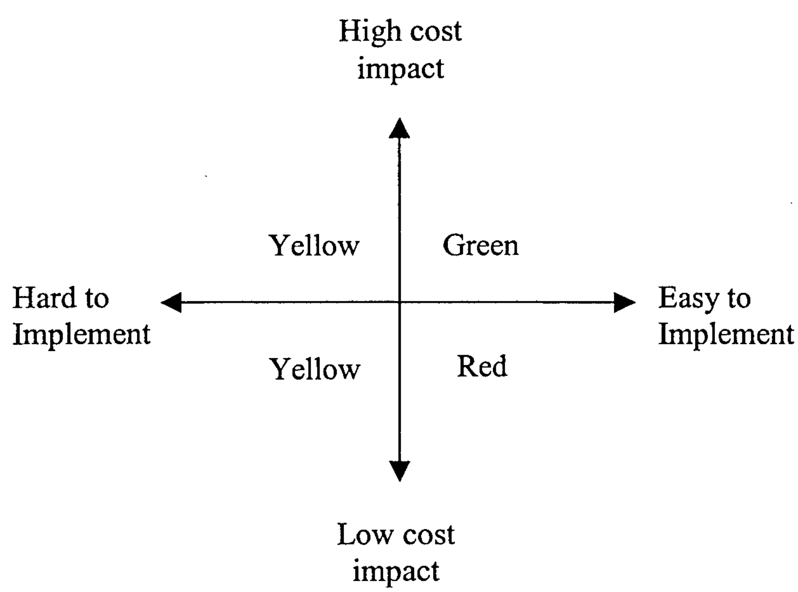

Figure A-1. Example Priority Rating Graph for Alternatives

RESULTS

The final set of categorized recommendations is presented in Table A-1. Of the eight ideas evaluated by the team, four (50%) are classified as "Green," and are strongly recommended. One countermeasure (13%) is designated as "Yellow," indicating that the shop could potentially realize benefits (some intangible) from its implementation, but long-term planning and/or budgeting may be needed. The remaining three countermeasures are categorized as "Red," indicating that the costs associated with implementing the recommendation are expected to outweigh the near-term benefits. These ideas are not recommended for implementation at this time, although technological advances/improvements may increase the attractiveness of the investment in the future. A detailed description of each recommendation follows Table A-1. Based on current estimates, implementing the "Green" recommendations would require an initial investment of less than $5,000, would incur annual maintenance costs of less than $1,000, and would result in an annual savings of nearly $25,000 (payback in about 2 months).

Table A-1. Recommendation Summary

	Expected Labor Savings	Expected Equip /Material Savings	Waste Disposal Savings	Total Annual Savings	Total One Time Cost to Implement	Annual Cost	Payback Period	Priority Rating
	$/year	$/year	$/year	$/year	$	$	Months	G, Y, R
Roller or brush paint application for parts	$ -	$ 2,356	$ -	$ 2,356	$ 47	$ 47	0.2	G
High speed (fan blast) stripping nozzles	$11,109	$308	$97	$11,514	$1,695	-	1.8	G
Powered air purifying respirator substitution	$ 6,269	$ 1,872	$ -	$ 8,141	$1,828	$818	3.9	G
Electronic thickness gauge	$ -	$ 2427	$ -	$ 2,427	$1,174	$ -	5.8	G
Paint gun cleaning cabinet	$329	$696	$3,960	$4,985	$5,285	$261	13	Y
Plural component proportioning system	$553	$5,859	$ 1,238	$ 7,650	$ 35,000	$ -	55	R
Semi-automated depaint device	$7,059	$890	$ -	$7,949	$120,000	$ -	181	R
Blast media alternative (e.g., Magic, SpongeJet)	Not available							R

APPLICATION OF PAINT TO PARTS BY ROLLING OR BRUSHING

Description of Problem and Proposed Alternative

The application of touch-up paint to aircraft parts using a roller or brush instead of a spray gun is proposed. The USAF Corrosion Prevention and Control Office encourages use of roller or brush painting, provided that TO 1-1-8 is followed (see Chapter 4 for more information). The corrosion control shop at Dover AFB currently employs this method on the C-5 aircraft and parts. They paint the entire leading edge and aircraft panels while the plane is in the Iso-dock or on the flightline. The panels are 10' x 20'. Both primer and a high solids topcoat are applied using foam brushes and/or rollers. There are some requirements that demand brush application, such as painting porous surfaces that require brushing-in for adequate coverage and penetration. Randolph AFB personnel stated they have tried roller/brush painting in their paint facilities. Although they were successful in achieving an acceptable coating protection factor using this method, the appearance of the paint job was less than desired (at least for aircraft exteriors). They used stock-listed items.

Advantages

- Increased transfer efficiency of primer and paint may be achieved; brush-on may "take" better than spraying high solids, low VOC paints.
- Decreased hazardous waste since no gun cleaning will be required.
- Reduced PPE requirements; workers probably need gloves only.

Disadvantages

- Finish quality is not as good as sprayed-on paint - technique may not be applicable to aircraft exterior, but may be applicable to aircraft parts.
- Foam rollers that work satisfactorily with high-gloss paints have not been identified, although some manufacturers (e.g., Sherwin Williams) are continuing to examine this issue. AFIERA will continue to work with Columbus AFB to identify an appropriate manufacturer for this equipment.
- Paint thickness is not as easy to control with a roller as it is with a spray gun.

Economic Analysis

The economic analysis assumes the following:

- Savings is achieved through decrease in supply usage (barrier paper) or extended equipment life (exhaust filters).
- 50% of all Small Paint items can be painted using a brush or roller.

Recommendation

Pending the outcome of additional testing by the shop to determine whether acceptable quality levels can be attained, this alternative is highly recommended for immediate implementation and is classified as "Green."

Table A-2. Economic Analysis of Paint Rolling Recommendation

Cost of Rolling Paint	
Cost of 7 inch roller ($4.05/kit 2 rollers/kit)	$ 2.02
Cost of 3 inch brush ($11.42/36 brushes)	$ 0.32
Total cost/event	$ 2.34
Small Paint events/year (p 17)	39
50% of Small Paint events	20
Total initial cost	**$ 46.80**
Annual maintenance cost	**$ 46.80**
Labor Savings	$ -
Material Savings	$ 2,355.77
Waste Disposal Savings	$ -
Total Annual Savings	**$ 2,355.77**
Net Savings = total annual savings - annual maint. costs	$ 2,308.97
Payback (months)	**0.2**

Projected savings	
Silver Barrier Paper 36"x200 yds	$ 2,880.08
MEK	$ 22.55
Filters 1st Stage Bldg 220	$ 408.00
Breathing Air Hood	$ 840.00
Bullard Breathing Air Hose Kit	$ 46.40
Wilson Clear Cover Lens	$ 142.50
Air Line Respirator	$ 240.00
Breathing Air Hose	$ 132.00
Total	**$ 4,711.53**
50% savings	**$ 2,355.77**

USE OF HIGH SPEED (FAN BLAST) STRIPPING NOZZLES IN THE PLASTIC MEDIA BLAST (PMB) BOOTH

Description of Problem and Proposed Alternative

This analysis addresses the substitution of high-speed, wide-path stripping nozzles for the conventional plastic media blast nozzles currently being used in the Columbus PMB shop. "Fan-blast" nozzles (Figure A-2) are similar to conventional blast nozzles; they use the same media flow rates and air pressures and employ standard 1.25 inch hose fittings (see description attached). The primary difference is that the fan-blast nozzle has a blasting pattern two to three times wider than a conventional nozzle.

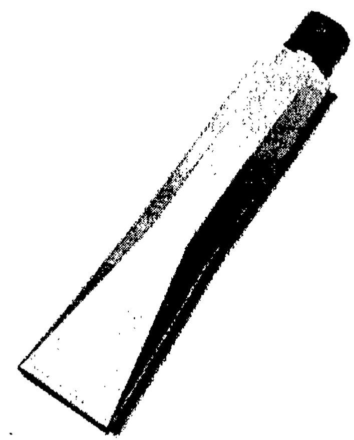

Figure A-2. FanBlast Nozzle

Advantages

- A primary advantage of the fan-blast nozzle is a potential increase in coating removal. The 1/2 inch (12.7 mm) equivalent FanBlast FBN-8 Nozzle (manufactured by Pauli Systems) has a 2.2 inch (5.6 cm) wide coating removal path that distributes media particles evenly across a rectangular area. The 3/8 inch (9.5 mm) equivalent has a 1.6 inch (4.1 cm) wide coating removal path.).
- A secondary advantage is realized due to the uniformity in the blast pattern produced by the fan-blast nozzle. Fan-blast nozzles distribute media particles evenly across a rectangular area. With conventional round nozzles, the pattern center is blasted more than the edges due to a higher volume of media in the blast stream center. Therefore, there is also a potential saving associated with reduced media consumption.
- Unlike previous attempts to increase nozzle size, the FanBlast nozzle is not significantly larger or more unwieldy than a conventional PMB nozzle. The FanBlast nozzle features a stainless steel heat-treated liner with a soft, low-rebound urethane jacket for added protection and operator comfort.

Disadvantages

- Unlike round nozzles, which can be held and moved in any direction, FanBlast nozzles must be held and maneuvered in a specific orientation to produce the wide blast pattern. Because of this limitation, operators may have difficulty using the nozzle to remove paint from corners or tight crevices without assuming awkward or dangerous working postures. A redesign of the nozzle or its casing, allowing operators to rotate (change the orientation of) the nozzle during blast operations, would reduce or eliminate this problem.
- As of mid Oct 00, final approval to use the FanBlast nozzle for T-37 and T-38 depaint processes had not yet been attained, although OO-ALC/LCES (T-38/T-37 Structures) is currently seeking this approval. Also, the AF Coating Technologies Integration Office (CTIO) has received approval from OO-ALC/LCES (T-38/T-37 Structures) to conduct further testing of the fan nozzle on AETC T-37 and T-38 aircraft. CTIO plans to test the nozzle at Columbus AFB in Jan 01.

Economic Analysis

Tests conducted on the KC-135 by Pauli Systems indicates that FanBlast production is double that produced with conventional nozzles. Although preliminary tests at Randolph do not indicate that the FanBlast nozzle increases strip rates dramatically, strip rates might increase after workers become used to the equipment. Therefore, the economic analysis assumes the following:

- Blast time can be reduced at least 20% through introduction of the fan-blast nozzle. (Personnel costs associated with PMB activity equal $55,547 annually.) The savings can be used to reduce the shop's manning or to increase shop throughput.
- Plastic media consumption (and associated costs) can be reduced by 5%.
- Costs associated with plastic media disposal can be reduced by 5%.

Table A-3. Economic Analysis of Using a FanBlast Nozzle

Annual Labor Savings	
Annual Labor Savings (based on 20% reduction in labor costs)	***$ 11,109***

Annual Material Savings	
Annual Material Savings (based on 5% reduction in plastic media use)	***$ 308***

Annual Waste Disposal Savings	
Annual Waste Disposal Savings (based on 5% reduction in costs associated with disposing of spent plastic media)	***$ 97***

Payback		
Payback = Initial cost/net savings X 12 months		
Cost		
Initial Cost of Alternative: 3 nozzles at $565 each	$	1,695
Annual on-going cost/maintenance cost	$	-
Annual Savings		
Labor Savings (20% of $55,547)	$	11,109
Material Savings (5% reduction in plastic blast media use)	$	308
Waste Disposal Savings	$	97
Total Annual Savings	**$**	**11,514**
Net Savings = total annual savings - annual maintenance costs	$	11,514
Payback (months)		**1.8**

Recommendation

Pending the outcome of additional testing of the fan nozzle by the Coatings Technology Integration Office (currently underway), this alternative is highly recommended for immediate implementation and is classified as "Green."

USE OF POWERED AIR PURIFYING RESPIRATORS (PAPRS) IN THE PAINT SHOP

Description of Problem and Proposed Alternative

This proposal addresses the use of a PAPR instead of a continuous flow loose-fitting hood in the paint shop. Switching from supplied air to a PAPR is permissible only if (1) worker exposures to chromates can be effectively controlled by a PAPR during priming, *and* (2) worker exposures to isocyanates can be effectively controlled by PAPRs during spray painting. PAPRs consist of a cartridge, blower, and battery pack that mount on the worker's belt. Air is provided to the worker through a breathing tube fitted to either a tight-fitting facepiece or a loose-fitting respiratory inlet covering. There are three types of loose-fitting coverings:

(1) Loose-fitting hood: A covering that completely covers the head and neck and may cover portions of the shoulder.

(2) Loose-fitting helmet: A covering that provides head protection against impact and penetration.

(3) Loose-fitting facepiece: A covering that sits on the head and forms only a partial seal with the face, does not cover the neck and shoulders, and may or may not provide head protection. These are also called "airhats."

Type (3) (the loose-fitting facepiece) should not be used because it does not provide the same level of protection as the other two devices. A PAPR requires no external air compressors and airlines, reducing costs associated with maintenance of the air delivery system and eliminating the chance for infiltration of contaminated air into the airline. There are no requirements for testing of breathing air, and carbon monoxide/high temperature alarms are not required. PAPRs are relatively lightweight; the cartridge, blower, and battery pack together weigh about four pounds. They provide the worker greater freedom of movement during spraying operations than supplied-air respirators.

Advantages

A loose-fitting hooded PAPR has several benefits compared to a tight-fitting, facepiece respirator.

- Hoods don't require either fit-testing or positive/negative seal (fit) checks before use, reducing training time for workers.
- Hoods provide a wider field of view and better peripheral vision. They allow civilians to wear beards and glasses, increasing their acceptance.
- Airflow into the hood provides cooling and makes it more comfortable to wear than tight-fitting facepieces in hot environments. There are no valves, straps, or rubber facepieces to inspect and wear out.
- Most hoods are disposable, reducing time needed to clean the respirator.
- Supplied-air respirators present a safety hazard in painting environments. Supplied-air respirators can be tripping hazards, cumbersome to move, and frequently become tangled or

wrapped around equipment. Switching to air-purifying respirators would decrease the potential for a fall and reduce the number of workers being exposed.

Economic Analysis

The economic analysis assumes the following:

- Labor costs associated with donning, doffing, and wearing PPE in the Paint shop are reduced by 25% since PAPRs do not restrict worker movement to the same extent that supplied air respirators do. The costs associated with PPE wear are approximately 4% of the total costs to operate the paint shop.
- Breathing air quality samples are taken every 45 days (required if the compressor is oil-lubricated)

The cost of air sampling to determine airborne concentrations of chromates and isocyanates is included in the cost of the changeover. This sampling is recommended to determine the appropriate level of respiratory protection. However, this sampling is not absolutely necessary based on the assigned protection factors (APFs) listed in *American National Standard for Respiratory Protection, ANSI Z88.2-1992.* This standard lists the assigned protection factors of both the continuous flow loose fitting hood and the loose fitting hood PAPR as 1000. Therefore, a switch to the PAPR will not result in a lower level of protection. (Note: The USAF does not recognize these APFs in the ANSI standard; however, tests are planned to validate the APFs.)

If the contractor is subject to USAF respiratory protection requirements, and chromate exposures are not at a level that would allow a switch to PAPRs, substitution of a polysulfide (non-chromated) primer for the primer currently in use may help to reduce chromate exposures below the limit value. TO 1-1-8 allows use of polysulfide primers, although the ultimate approval to apply this type of primer to a specific aircraft must be provided by the system program office. The costs (if any) associated with switching to this type of primer are not included in the analysis provided below.

Recommendation

Additional sampling to determine isocyanate exposure levels in the shop during spray painting activities must be completed before a final recommendation can be made. However, assuming that isocyanate exposure levels are low enough to permit the use of powered air purifying respirators, the economic analysis suggests that making this change would result in benefits to the shop that would exceed its costs. Based of the relative ease in implementing this change in the workplace, this alternative is classified as "Green," and recommended for immediate implementation pending the outcome of additional air sampling studies.

Table A-4. Economic Analysis of Switching to Powered Air-Purifying Respirators

Cost of Switching to PAPR		
Air sampling to validate PAPR	$	1,500.00
PAPR assembly (unit cost)	$	432.96
Four PAPRs for start-up	$	1,731.84
PAPR cartridges (6/box)	$	96.36
Paint events/year		73
PAPR cartridge changeout freq. (1/3 paint events)	$	24.00
Boxes of cartridges/year		4
Cartridge cost/year	$	385.44
Total initial cost	**$**	**1,828.20**
Annual maintenance cost (cartridges plus one new PAPR)	**$**	**818.40**
Annual Savings		
Labor Savings	$	6,268.59
Material Savings	$	1,872.25
Waste Disposal Savings	$	-
Total Annual Savings	**$**	**8,140.84**
Net Savings = total annual savings - annual maint. costs	$	7,322.44
Payback (months)		**3.9**

Projected Cost Savings		
CO monitor calibrate	$	25.50
CO filter	$	35.00
Air supply hose	$	153.25
Sfco Bullard Breathing Air Hood	$	1,050.00
Sfco Bullard Air hose clamp	$	22.50
Breathing air hose	$	66.00
Breathing air quality test ($65/test x 8 tests/yr)	$	520.00
Total O&M for 1 compressor and supplied air hood	$	1,872.25

ELECTRONIC THICKNESS GAUGE

Description of Problem and Proposed Alternative

In the Columbus paint shop, primer and topcoat thickness are determined based on the painter's subjective judgment (i.e., appearance plus the painter's knowledge of the material quantities typically required for each type of aircraft). While this method may be acceptable in most cases, there should be a quality control step to validate that excess material is not being applied to the aircraft. TO 1-1-8 specifies acceptable thickness ranges for each primer and topcoat. Excess primer will degrade the adhesion characteristics of the topcoat and may result in premature corrosion. At one base visited during an industrial hygiene survey, personnel applied three times as much primer than was necessary.

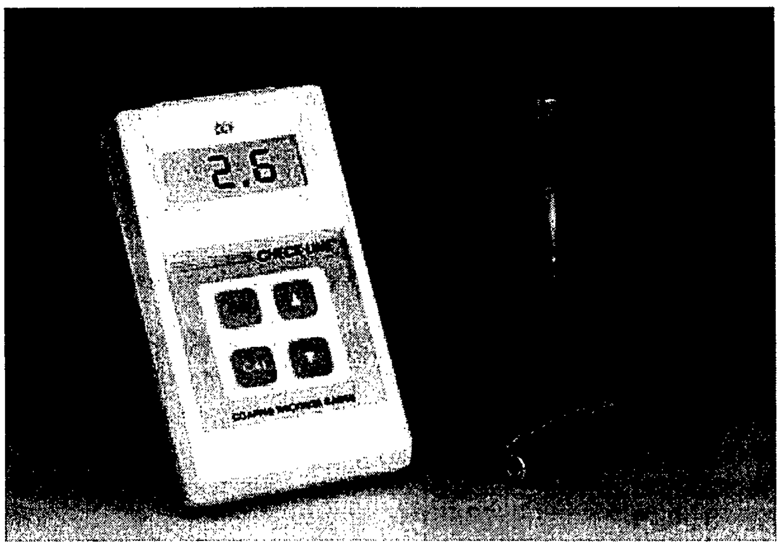

Figure A-3. Electronic Thickness Gauge

Advantages

- Potential for better corrosion control (prevents overapplication of primer)
- Potential reduction in usage of hazardous materials (primer and paint)

Economic Analysis

The economic analysis assumes the following:

- Workers are currently applying 10% more primer/paint than necessary (Total annual cost of polyurethane paint, epoxy primer, and polyurethane primer in FY98 = $24,271.58)
- Using an electronic thickness gauge will have negligible impact on labor requirements.
- Reductions in hazardous waste disposal costs are minimal.

Recommendation

Based on the savings associated with this alternative relative to its cost, and the relative ease in implementing this alternative in the workplace, the electronic thickness gauge is classified as a "Green" alternative and recommended for immediate implementation.

Table A-5. Economic Analysis of Using Electronic Thickness Gauge

Annual Labor Savings		
Annual Labor Savings	***$***	**-**

Annual Material Savings		
Annual Material Savings	***$***	***2,427.16***

Annual Waste Disposal Savings		
Annual Waste Disposal Savings	***$***	**-**

Payback		
Payback = (Initial cost/net savings) X 12 months		
Cost		
Initial Cost of Countermeasure: One electronic thickness gauge	$	1,174
Annual on-going cost/maintenance cost	$	-
Annual Savings		
Labor Savings	$	-
Material Savings (10% reduction in paint/primer use)	$	*2,427.16*
Waste Disposal Savings	$	-
Total Annual Savings	**$**	***2,427.16***
Net Savings = total annual savings - annual maintenance costs	$	*2,427.16*
Payback (months)		**5.8**

PAINT GUN CLEANING CABINET

Description of Problem and Proposed Alternative

The manual cleaning of paint guns can be labor intensive and can generate significant quantities of solvent waste. Automatic paint gun washers can reduce both the amount of solvent used and the waste generated by up to 50% compared to manual paint gun cleaning. Since automatic paint gun washers are sealed units, worker exposure to hazardous materials is also greatly reduced.

Automatic paint gun washers are similar to conventional home dishwashing machines, except that the thinners and solvents in the automatic washers are not heated in the process. The washers can be used to clean conventional air spray, HVLP, electrostatic, airless, or air-assisted paint guns. Solvents used in the automatic paint gun washer are recycled and reused in the cleaning process. The paint gun to be cleaned is attached to a nozzle within the automatic paint gun washer, and the machine is sealed. Most automatic paint gun washers can wash two to three paint guns at a time. The exterior of the paint gun is cleaned with atomized paint thinner using a dishwasher action. Circulating solvent through the nozzle attachment cleans the interior of the paint gun. Automatic paint gun washers collect used solvent in a reservoir. Impurities in the used solvent are filtered out in the reservoir. The filtered solvent is then ready for reuse instead of being disposed as hazardous waste. The solvent impurities form a sludge, which is collected and disposed. The typical solvent capacity of the spray gun washer is 3 gallons. The washer solution must be changed every 3 to 8 weeks, depending on usage.

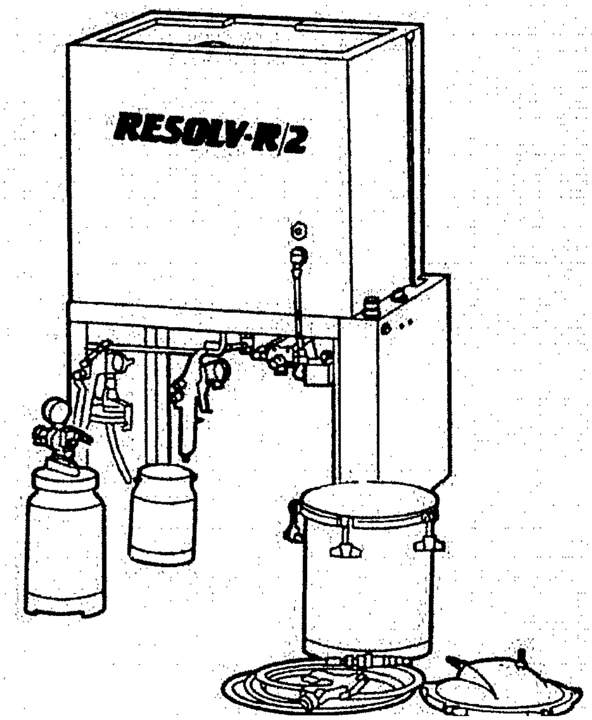

Figure A-4. Paint Gun Cleaning Cabinet

Advantages

- Reduces worker exposure to solvent, hazardous waste and hazardous air emissions. Depending on solvent usage quantity, a 70 to 80 percent cost savings could be realized due to solvent recycling and reuse.
- Localized handling site for solvents used for paint gun washing.
- The solvent recycling feature of the automatic paint gun washer allows facilities to use and store fewer solvents on site, thereby decreasing the possibility that a facility will meet any of

the reporting thresholds of SARA Title III for solvents (40 CFR 300, 355, 370, and 372; and EO 12856).

- Because solvent storage is localized, procurement of standardized solvent(s) is possible for this maintenance action.
- Accurate waste solvent classification for this maintenance action is simplified.
- Fully automatic, reduces labor.
- Pneumatically operated (non-electric) washer does not increase utility costs.
- Since the automatic paint gun washer is sealed, the likelihood of the facility requiring an air permit under 40 CFR 70 and 71 is diminished.

Disadvantages

- Users of automatic paint gun washers have noticed that if they delay washing the paint guns, the cleaning efficiency is reduced, and additional hand cleaning of the equipment is required.
- According to HQ AFCEE/EQP, some installations have noted a drop in cleaning efficiency if 'virgin' cleaner/solvent is not used. Optimum efficiency can be obtained by adding an external filter, such as from Gulf Coast Filters, Inc.

Economic Analysis

See Table A-6.

Recommendation

Although the savings associated with this alternative are expected to outweigh initial costs in a relatively short period of time, the high initial costs associated with this alternative may pose a short-term barrier to implementation. Therefore, this alternative is classified as "Yellow," meaning that the shop would likely realize significant benefit from its implementation, and should initiate the necessary actions to allow its eventual procurement.

Table A-6. Economic Analysis of Paint Gun Washing

Annual Labor Savings	
Current Cycle Time (sec/gun)	312
Projected Cycle Time (sec/gun)	60
Projected labor cost to maintain paint gun cleaner	$ 135.08
Cycle Time Savings (sec/gun)	252
Number of Guns Cleaned (avg./yr.)	438
Current Labor Costs ($/hr)	$ 15.15

Assumptions	
Number of guns requiring cleaning after painting (fewer guns are used for painting AGE parts than aircraft)	3.00
Electrical and PPE cost changes are negligible	NA
Auto. Gun Cleaner Labor Cost ($/yr.) Disposal bag must be changed twice a week (5 minutes per event). Labor rate $15.15/hr.	$ 131.30
Auto. Gun Cleaner Labor Cost ($/yr.) Manufacturer states it takes 15 minutes to change oil (required once annually)	$ 3.78
Auto. Gun Cleaner Material Cost (gallons/month) Solvent required for automatic gun cleaning	1.75
Auto. Gun Cleaner Material Cost ($/yr.) Manufacturer states automated machine reduces solvent use by 95%.	$ 91.25

Table continued from previous page

Labor Savings ($/yr.) = [(Avg. # guns cleaned/yr. X (Time Savings(sec/unit) X (1 min/60 sec)) X (Labor Cost ($/hr) X (1 hr/60 min))-projected time to maintain gun cleaner)]	
Annual Labor Savings	***$ 329.42***

Annual Material Savings	
Solvent required for manual gun cleaning (gal/month)	2.91
Solvent required for automatic gun cleaning (gal/month)	1.75
Solvent procurement cost ($/gal)	$ 50.00

Annual Material Savings	***$ 696.00***

Annual Waste Disposal Savings	
Manual gun cleaning	$ 4,949.39
Automatic Gun Cleaning	$ 989.87
Annual Waste Disposal Savings	***$ 3,959.52***

Payback	
Cost	
Initial Cost of Countermeasure	$ 5,285.00
Annual on-going cost/maintenance cost	$ 261.34
Annual Savings	
Labor Savings	$ 329.42
Material Savings	$ 696.00
Waste Disposal Savings	$ 3,959.52
Total Annual Savings	**$ 4,984.94**
Net Savings = total annual savings - annual maintenance costs	**$ 4,723.60**
Payback (months)	***13***

Manual Gun Cleaning Disposal Cost ($/yr.) Estimated 30% of the total hazardous waste disposal costs are from manual gun cleaning	$ 4,949.39
Auto. Gun Cleaner Disposal Cost ($/yr.) Manufacturer states automated system used with Z-mesh reduces waste by 80%.	$ 989.87
Auto. Gun Cleaner Maintenance Cost ($/yr.) Replacement oil cost	$ 35.00
Auto. Gun Cleaner Maintenance Cost ($/yr.) Need 2 paint gun cleaner collection bags a week ($1.75/bag)	$ 160.00
Need Z-Mesh-100 powder to treat still bottoms - require 1/4 pound per process. Expect 2 process per week **Auto. Gun Cleaner Maintenance Cost ($/yr.)**	$ 66.34

Required Conversions
(($1824.9 MEK/yr.) / ($260.7/5 gal)) = 35 gal/yr. or 2.9 gal/month

PLURAL COMPONENT PROPORTIONING SYSTEM

Description of Problem and Proposed Alternative

Epoxy paint mixtures in the paint shop are prepared by premixing a base and a catalyst, and combining them in appropriate proportions in a separate container by hand. After mixing and waiting the specified time, the paint can be applied to the workpiece. Epoxy paint ingredients have a limited pot life once mixed that cannot be exceeded without affecting the characteristics of the paint. If the pot life is exceeded, the mixture must be disposed, and the application equipment must be cleaned with a solvent. Under conventional methods, the mixture is prepared by hand. This frequently results in the generation of excess paint, which requires solvent cleanup and disposal of the paint and solvent as a hazardous waste.

Plural component proportioning systems are self-contained epoxy paint proportioning and mixing systems. These systems mix only the amount of paint required by an operation. One of its chief advantages is that it minimizes waste. An additional benefit is that since the mixing is automated it also tends to be more accurate and consistent than conventional mixing systems.

Plural component proportioning systems are used in conjunction with application devices. The proportioning and application system layout typically includes the following components: 1) proportioning pump module, 2) mix manifold, 3) mixer, 4) application device, 5) material supply module, and 6) purge or flush module. These systems optimize painting operations by maximizing efficiency and minimizing waste generated.

The plural component proportioning system for epoxy paints provides total control of materials from container(s) to application. They are accurate and can provide more consistent material quality than hand mixing. These systems can also keep pace with higher production requirements. They mix on demand (i.e. as the gun is triggered), which results in no significant quantities of wasted materials. Material cleanup requires less labor and maintenance, and generates less waste because the mixed material can be purged with solvent from the mix manifold, mixer, hose, and applicator before it cures. The plural component proportioning system is a closed system and, as a result, there are fewer spills, less contamination or waste to clean up, and less contact between personnel and potentially hazardous materials. In addition, the proportioning system makes bulk purchase of material practical.

If an epoxy paint requires a significant induction time (15 minutes or longer) the plural component proportioning system can still be used, provided that the mixed paint is allowed to stand in a separate container prior to application.

A PrecisionMixTM (P-Mix) controller for the plural component proportioning system may also be implemented. The P-Mix controller is an electronic system that continuously mixes resin and catalyst at a pre-selected ratio in small batches, delivering the mixed material on command. The P-Mix can detect ratio problems and prevents off-ratio coatings from being applied. This often results in a significant reduction in rejection rates. The P-Mix system also reduces the time required for color changes, because the required mix ratios are entered electronically. All materials are contained in the system; the electronic control allows color changes and flushing to take place without exposing the operator to hazardous materials. The P-Mix system can also generate hard copy reports for environmental and product usage information. Some of the operating parameters reported are flow rate, mix ratio, resin usage, catalyst usage, and solvent usage.

No new waste streams are generated using Plural Component Proportioning Systems as compared to conventional methods.

Advantages

- Plural component proportioning system provides total control of materials from container to application.
- Paint is generated on an as-needed basis, eliminating the generation of excess paint. Under conventional methods, this excess paint is frequently disposed as hazardous waste.
- Plural component proportioning systems are effective for many two component paint systems besides epoxy paints, such as polyurethane paints.
- The use of cleanup solvents is minimized.
- Less potential for spills.
- Less contact between personnel and potentially hazardous materials
- Cost savings associated with buying paint in bulk.

Disadvantages

- Plural component proportioning systems need to be designed for specific applications.
- Plural component proportioning systems are only effective where production utilizes significant quantities of paint and where color or types of coating are not changed routinely.

Economic Analysis

A summary statement, followed by separate analyses for using the plural proportioning system with both polyurethane and epoxy paints, is provided in Table A-7 below. In the Air Force, approval authority is local and does not require engineering approval. The authorization for use of this equipment is being added to T.O.1-1-8.

Note that the material specification data for the epoxy paint needs to be evaluated with respect to the proportioning and application system components to ensure material compatibility. The materials used for the pumps and packings need to be evaluated individually. Stainless steel and Teflon® components do not pose compatibility problems with most materials used in epoxy paint operations.

Recommendation: Based on the cost of this alternative, the lengthy payback period associated with its implementation (> four years), and the inability to implement this recommendation quickly, this proposal is classified as "Red." See the tables that follow for details.

Table A-7. Economic Analysis of Plural Paint Proportioning System

Annual Labor Savings		
Annual Labor Savings	*$*	*552.98*

Annual Material Savings		
Annual Material Savings	*$*	*5,858.59*

Annual Waste Disposal Savings		
Annual Waste Disposal Savings	*$*	*1,237.50*

Payback		
Payback = Initial cost/net savings X 12 months		
Cost		
Initial Cost of Countermeasure	$	35,000.00
Annual on-going cost/maintenance cost	$	-
Annual Savings		
Labor Savings	$	552.98
Material Savings	$	5,858.59
Waste Disposal Savings	$	1,237.50
Total Annual Savings	**$**	**7,649.07**
Net Savings = total annual savings - annual maint. costs	**$**	**7,649.07**
Payback (months)		***55***

Polyurethane Paint Analysis

Annual Labor Savings	
Current Cycle Time - time to hand mix paint and clean equipment other than the paint guns (sec/event)	1,800
Projected Cycle Time (sec/event)	900
Projected annual labor cost to maintain plural proportioning system	$ -
Time Savings (sec/event) (50% reduction)	900
Number of mixings per year (avg/yr)	73
Current Labor Costs ($/hr)	$ 15.15
Labor Savings ($/yr) = [(Avg # guns cleaned/yr. X (Time Savings(sec/unit) X (1 min/60 sec)) X (Labor Cost ($/hr) X (1 hr/60 min))-projected time to maintain gun cleaner)]	
Annual Labor Savings	***$ 276.49***

Annual Material Savings	
Annual paint use for hand mixing (gal)	503
Annual solvent use for hand mixing (gal)	585
Annual paint usage for plural system (gal) - (15% reduction)	427
Annual solvent usage for plural system (gal) - (50% reduction)	292
Paint procurement cost ($/gal)	46.53
Thinner procurement cost ($/gal)	5.73
Annual Material Savings	***$5,215.17***

Base Case Data	
FY 98 total polyurethane paint costs	$ 19,676.00
FY 98 paint usage (gal)	503
Average paint gallon cost	$ 46.53
FY 98 total polyurethane thinner costs	$ 3,353.22
FY 98 polyurethane thinner usage (gal)	585
Average thinner gallon cost	$ 5.73
FY 98 total corrosion control hazardous waste disposal costs	$ 16,497.97

Assumptions	
Total time to mix paint was 30 minutes (1800 sec)	
Number of planes/AGE/small parts painted/yr. Assumed 50% used polyurethane and 50% used epoxy	NA
No difference in Electrical and PPE costs before and after implementation.	
Solvent usage, solvent waste, labor, and paint wastes would be reduced by 50%	NA
A plural proportioning system would reduce paint usage by 15% (mfg estimate)	NA
50% of thinner is disposed of as waste	
Manufacturer states no annual maintenance required on proportioning system	
Assumed 10% of total corrosion control waste disposal is attributable to waste poly paint/thinner resulting from mixing.	$ 1,649.79

Annual Waste Disposal Savings	
Annual polyurethane paint/thinner waste generated using hand mixing ($)	$ 1,650.00
Annual polyurethane paint/thinner waste generated using automatic mixing ($)	$ 825.00
Annual Waste Disposal Savings	***$ 825.00***

Other Benefits Not Quantified
Occupational and Environmental Exposures to paint and solvents would decrease

Manufacturer Information received from Mr.Dave West, Technical Information Specialist, Graco Industries, (800)-731-3926; ext.2627

Equipment Name: Pro Mix Plural Component Paint Mixer
http://www.graco.com/Distributors/DLibrary.nsf/Files/305-828/$file/305-828r.pdf

Payback	
Payback = Initial cost/net savings X 12 months	
Cost	
Initial Cost of Countermeasure	$ 21,000.00
Annual on-going cost/maintenance cost	$ -
Annual Savings	
Labor Savings	$ 276.49
Material Savings	$ 5,215.17
Waste Disposal Savings	$ 825.00
Total Annual Savings	**$ 6,316.66**
Net Savings = annual benefit - annual maint. Costs	**$ 6,316.66**
Payback (months)	***40***

Epoxy Paint Analysis

Annual Labor Savings	
Current Cycle Time - time to hand mix paint and clean equipment other than the paint guns (sec/event)	1,800
Projected Cycle Time (sec/event)	900
Projected annual labor cost to maintain plural proportioning system	$ -
Cycle Time Savings (sec/event) (50% reduction)	900
Number of mixings per year (avg/yr)	73
Current Labor Costs ($/hr)	$ 15.15
Labor Savings ($/yr) = [(Avg. # guns cleaned/yr. X (Time Savings(sec/unit) X (1 min/60 sec)) X (Labor Cost ($/hr) X (1 hr/60 min))-projected time to maintain gun cleaner)]	
Annual Labor Savings	***$ 276.49***

Annual Material Savings	
Annual paint usage for hand mixing (gal)	84
Annual solvent usage for hand mixing (gal)	65
Annual paint usage for plural system (gal) - (15% reduction)	71
Annual solvent usage for plural system (gal) - (50% reduction)	33
Paint procurement cost ($/gal)	29.58
Thinner procurement cost ($/gal)	8.09
Annual Material Savings	***$ 643.42***

Base Case Data	
FY 98 total poly paint procurement costs	$1,242.36
FY 98 paint usage (gal)	84
Average paint gallon cost	$ 29.58
FY 98 total poly thinner procurement costs	$ 525.83
FY 98 poly thinner usage (gal)	65
Average thinner gallon cost	$ 8.09
FY 98 total corrosion control haz. Waste disposal costs	$16,497.97

Assumptions	
Assumed total time to mix and prepare paint was about 30 minutes or 1800 sec	1,800
Number of planes/AGE/small parts painted/yr. Assumed 50% used poly and 50% used epoxy	NA
Electrical and PPE cost changes are negligible	NA
A plural proportioning system would reduce solvent usage, solvent waste, labor, and paint wastes by 50%	NA
A plural proportioning system reduces paint usage by 15% (mfg estimate)	NA
50% of thinner is disposed of as waste	NA
Manufacturer states no annual maintenance required on proportioning system	$0.00
Assumed 5% of total corrosion control waste disposal is attributable to waste epoxy paint/thinner resulting from mixing.	$ 825.00

Annual Waste Disposal Savings	
Annual poly paint/thinner waste generated using hand mixing ($)	$ 825.00
Annual poly paint/thinner waste generated using automatic mixing ($)	$ 412.50
Annual Waste Disposal Savings	***$ 412.50***

Payback	
Payback = Initial cost/net savings X 12 months	
Cost	
Initial Cost of Countermeasure	$ 21,000.00
Annual on-going cost/maintenance cost	$ -
Annual Savings	
Labor Savings	$ 276.49
Material Savings	$ 643.42
Waste Disposal Savings	$ 412.50
Total Annual Savings	**$ 1,332.41**
Net Savings = annual benefit - annual maint. Costs	**$ 1,332.41**
Payback (months)	***189***

Other Benefits Not Quantified
Occupational and Environmental Exposures to paint and solvents would decrease

Manufacturer Information Received from
Mr.Dave West, Technical Information Specialist, Graco Industries, (800)-731-3926; ext.2627
Equipment Name: Pro Mix Plural Component Paint Mixer; for brochure, see website below...
http://www.graco.com/Distributors/DLibrary.nsf/Files/305-828/$file/305-828r.pdf

SEMI-AUTOMATED DEPAINT DEVICE IN PMB BOOTH

Description of Problem and Proposed Alternative

This proposal addresses the implementation of a semi-automated system for supporting and manipulating PMB hoses and nozzles during depainting (blasting) operations. A low-slung tele-operated positioner (LTP) (Figure 5) has recently been installed at Warner Robins ALC to assist in depaint operations. At Columbus, support and manipulation of the blast nozzles is performed entirely by human operators. This work is tedious and fatiguing. Under this proposal, the LTP would be configured with a PMB nozzle to depaint large, relatively flat surfaces of the aircraft underbody, while human operators would continue to strip smaller, irregularly-shaped, or top surfaces that would be difficult for the LTP to access. An operator would drive the LTP to the desired position under the aircraft (using a joystick and push button actuators); elevate a positioning gimbal to acquire the surface; and activate the contour tracking programs to initiate operation.

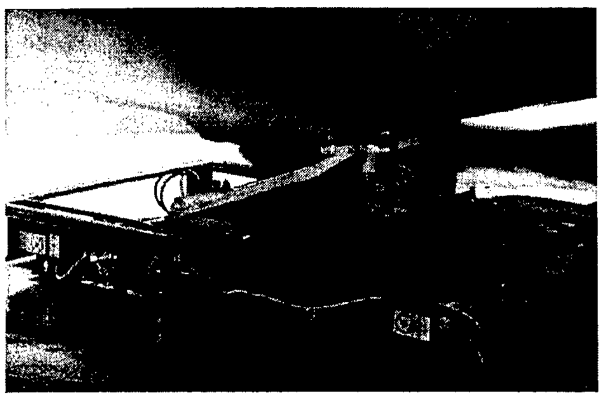

Figure A-5. LTP Removing Paint from a C-130 at Robins AFB, GA

Advantages

Using an LTP device to assist in depainting the aircraft underbody reduces worker exposure to airborne chemical hazards, and alleviates discomforts and safety issues associated with under-aircraft maintenance work. According to the manufacturer, workers can operate the LTP from up to 50 feet away. Although an operator is required to activate and monitor the device while it is in operation, the use of the LTP would reduce PPE use and associated labor costs associated with the aircraft strip process.

Disadvantages

The primary disadvantage associated with the LTP is its cost. As of Oct 00, the only LTP in existence was located at Robins AFB, and was configured for use with a medium pressure water blast system. The manufacturer (General Lasertronics) states that reconfiguring the passive gimbal for use with a PMB system would not be technically challenging; they have already discussed adapting the LTP for PMB use with Robert Pauli (president of Pauli Systems, a manufacturer of PMB equipment). However, the cost to develop a second LTP for PMB use is currently estimated at $120,000. Once this model is perfected, the cost of subsequent units could be reduced to between $80,000 and 85,000.

Economic Analysis

The economic analysis shown in Table A-8 assumes the following:

- LTP would be used on aircraft only (not AGE or off-aircraft parts).
- Operators would continue to manually strip portions of the aircraft not accessible by the LTP; therefore PPE costs (equipment and labor) associated with aircraft blast would be reduced by 50% but not eliminated.
- Although the LTP would likely require regular maintenance, the magnitude of those costs are unknown.

Recommendation

Based on the cost of this alternative, the lengthy payback period associated with its implementation, and the inability to implement this recommendation quickly, this proposal is classified as "Red." However, continued development and testing of this product may increase the feasibility of implementing this alternative at a later time (especially if the device can be adapted for use on multiple types of aircraft).

Table A-7. Economic Analysis of LTP System

Annual Labor Savings		
Annual Labor Savings	***$***	***7,059***

Annual Material Savings		
Annual Material Savings	***$***	***890***

Annual Waste Disposal Savings		
Annual Waste Disposal Savings	***$***	***-***

Payback		
Payback = Initial cost/net savings X 12 months		
Cost		
Initial Cost of Countermeasure	$	120,000
Annual on-going cost/maintenance cost	$	-
Annual Savings		
Labor Savings (50% of costs associated with donning, doffing and wearing PPE in the PMB facility during T-37, T-38 and transient aircraft blast. Labor costs associated with PPE use are assumed to be equal 9.4% of total cost for blasting T-37, T-38 and transient aircraft..)	$	7,059
Material Savings (50% of costs for PMB PPE Equipment and Supplies associated withT-37, T-38, and transient aircraft blast)	$	890
Waste Disposal Savings	$	-
Total Annual Savings	**$**	**7,949**
Net Savings = total annual savings - annual maintenance costs	**$**	**7,949**
Payback (months)		***181***

SPONGE BLAST, MAGIC OR ANOTHER FORM OF BLAST MEDIA

Description of Problem and Proposed Alternative

This proposal addresses the substitution of an alternative form of blast media for the plastic media currently used in the depaint facility. In recent years, a number of alternative blast technologies have been introduced and promoted as having advantages over traditional blasting means (e.g., the plastic media currently used in the Columbus bead blast facility). Examples include the Sponge Blasting™ System, manufactured by Sponge-Jet; Envirostrip, a corn hybrid polymer stripping media manufactured by ADM; and Magic. Sponge Media is an open-celled, water based polyurethane impregnated with abrasives that is touted for its low-dust properties. The pliant nature of Sponge Media allows its particles to flatten on impact, exposing the abrasive. After leaving the surface, the media constricts, pulling and encapsulating material that would normally have become an airborne contaminant. Envirostrip is a 100% organic, non-toxic, biodegradable media that is touted as having superior properties to other starch-based media, and eliminating the need for post-strip solvent cleaning.

Advantages

The benefits associated with alternative forms of blast media vary. Because of its low-dust properties, the need for respiratory protection would likely be reduced in a facility using sponge media. Labor costs associated with post-strip cleaning of aircraft and component parts might be reduced or eliminated if Envirostrip media were substituted for plastic media.

Disadvantages

None of the media described above are approved for use in Air Force maintenance facilities, on Air Force weapon systems. Boeing is currently testing Sponge and Magic media for use on the KC-135; however, there is no projected date for completion of this study.

Recommendation

None of the alternative blast technologies can be considered a viable alternative for the Columbus PMB shop at the current time. Based on the uncertainties concerning the costs associated with this alternative, and the inability to implement this recommendation without further testing, this proposal is classified as "Red." However, continued development and testing of these products may increase the feasibility of implementing these technologies at a later time.

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