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Prioritization Methodology for Chemical Replacement

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ABSTRACT

Since United States of America federal legislation has required ozone depleting chemicals (class I & II) to be banned from production, The National Aeronautics and Space Administration (NASA) and industry have been required to find other chemicals and methods to replace these target chemicals. This project was initiated as a development of a prioritization methodology suitable for assessing and ranking existing processes for replacement "urgency."

The methodology was produced in the form of a workbook (NASA Technical Paper 3421). The final workbook contains two tools, one for evaluation and one for prioritization. The two tools are interconnected in that they were developed from one central theme -- chemical replacement due to imposed laws and regulations. This workbook provides matrices, detailed explanations of how to use them, and a detailed methodology for prioritization of replacement technology. The main objective is to provide a *GUIDELINE* to help direct the research for replacement technology.

The approach for prioritization called for a system which would result in a numerical rating for the chemicals and processes being assessed. A Quality Function Deployment (QFD) technique was used in order to determine numerical values which would correspond to the concerns raised and their respective importance to the process. This workbook defines the approach and the application of the QFD matrix.

This technique:

1. provides a standard database for technology that can be easily reviewed,
2. provides a standard format for information when requesting resources for further research for chemical replacement technology.

Originally, this workbook was to be used for Class I and Class II chemicals, but it was specifically designed to be flexible enough to be used for any chemical used in a process (if the chemical and/or process needs to be replaced).

The methodology consists of comparison matrices (and the smaller comparison components) which allow replacement technology to be quantitatively compared in several categories, and a QFD matrix which allows process/chemical pairs to be rated against one another for importance (using consistent categories). Depending on the need for application, one can choose the part(s) needed or have the methodology completed in its entirety. For example, if a program needs to show the risk of changing a process/chemical one may choose to use part of Matrix A and Matrix C. If a chemical is being used, and the process must be changed; one might use the Process Concerns part of Matrix D for the existing process and all possible replacement processes. If an overall analysis of a program is needed, one may request the QFD to be completed.

INTRODUCTION

This methodology serves to define a system for effective prioritization of efforts required to develop replacement technologies mandated by imposed and forecast legislation. The methodology used is a semi-quantitative approach derived from quality function deployment techniques (QFD Matrix). QFD is a conceptual map that provides a method of transforming customer wants and needs into quantitative engineering terms. This methodology aims to weight the full environmental, cost, safety, reliability, and programmatic implications of replacement technology development to allow appropriate identification of viable candidates and programmatic alternatives.

EXPLANATION OF MATRICES

Matrix A

Matrix A is a "chemical and use" matrix. The objective of this matrix is to define the target chemicals by the part and process in which they are used (the how and where the targeted chemicals are used). This matrix has some "bookkeeping" areas to help in tracking the particular chemical/part/process combination in other matrices. Parts of Matrix A will be used in all matrices. Each component of

Matrix A may not need to be filled out. The following is an explanation of the requested information for this matrix.

• *the target chemical*

The Class I or Class II chemical which has to be eliminated due to regulation should be put in this column. Any other chemical which needs evaluation for replacement could also be put in this column. It should be noted that some materials may contain several "target" chemicals. Those materials which have several chemicals should be grouped for identification purposes. This information will be necessary for subsequent matrices.

• *a chemical registry #*

This is the standard number (as might be found on a Material Safety Data Sheet (MSDS)) for the chemical. This is requested so that actual values necessary for evaluation can be found.

• *a chemical reference #*

This a bookkeeping number. It is assigned by the person filling out the chart. It is recommended that for every chemical the number is consistent (i.e. for all uses of TCA the number is 1, for all uses of CFC113 the number is 2, etc.). This number will be used throughout the rest of the matrices in the "chem #" column.

• *material*

This is the material that the chemical is in, identified for the specific process. This is a reference to assist defining the processes and parts. Generally this will be the manufacturing or common name.

• *the process in which the chemical is used*

This is the current process for which the chemical is being used. This process is dependent on the part, surface, etc. that will be affected. The process will be necessary for subsequent matrices.

• *a description of the part/component/subsystem which is being processed*

The part/component/ subsystem that will be processed will be completed in this part of the matrix.

• *a reference number for the specified part/component/subsystem*

This is a number assigned to the part/component/subsystem that will be processed. This number can be manufacturer specific as long as it can be referenced to the FMEA (NASA specific risk assessment). This number will be used in Matrix C - Risk Assessment and possibly in Matrix D for specifications of surface requirements.

• *the surface being considered*

After the part has been defined, a surface on the part may need to be specified to better define the process and requirements.

• *process # (Reference)*

This is the bookkeeping number for the process. It should be defined by the chemical, the material, the part (or group of parts), and the surface. The process (reference) # should be defined such that there will be no confusion between processes. Again this reference will be used in the other matrices for tracking purposes.

Chemical	Chem # (Reference #)	Process	Proc # (Reference)
Trichloroethane	1	Vapor Degrease (Case Segment)	1-1-1
Trichloroethane	1	Vapor Degrease (Bolts)	1-1-2

Figure 1

• *a manufacturing process number*

This is another reference point for the matrix. The manufacturing process number allows a check on the stage of manufacturing in which this particular process is being done. Again this is an optional part of the matrix. It would be defined as a number (i.e. if it is the second process - it is 2).

• *the number of manufacturing processes*

This is the total number of processes a part goes through as defined by the part specifications (for a refurbished part and for a non-renewable part)

• *the pounds of chemical used in the process (for the specified part) per year*

This category is strictly for informational purposes. It provides a prospective of the amount of the targeted chemicals used.

A blank Matrix A is included in Appendix A.

Matrix B

The technical maturity of the chemicals and processes are evaluated in Matrix B. The existing chemical/process from Matrix A and the developmental chemical/process are evaluated according to the number of parts to be processed (in the program life) and the testing which has been performed on the chemical, process, and processed parts. This matrix might be sent to the environmental, research and development, or manufacturing group for completion. This matrix was designed to accommodate the existing process and the possible replacement processes, but it can also be used specifically for comparison and evaluation of possible replacement chemicals. The matrix is broken into sections which ask for the identification of the chemical and process along with the corresponding reference numbers for each.

The reference numbers for the existing chemical/process were defined in Matrix A; these same numbers should be used for the chemical/process in Matrix B. For each existing chemical/process there should be a chemical/process replacement. For each "replacement" chemical a number should be assigned to correspond with the chemical it is replacing.

A space is provided to identify the existing (old) technology and the possible replacement technology (new).

The next item to be completed is "Years of Existence." This is the number of years the chemical/process has been available for commercial purchase.

Subsequent items deal with chemical, material, and process testing. In an effort to provide for every type of test, the "type tests" are very general in scope. This matrix is not necessarily complete for full analysis; it is provided to quantify the extent of testing for each chemical/material/process. Some materials and/or processes may not need a particular type (general) of test. For those areas where the test information requested is not applicable, note in the space that it was considered not necessary by placing a check in the corresponding box.

The following items are requested:

• *Toxicity Testing*

New chemicals must pass a series of toxicity tests before they are allowed to be used. By identifying the toxicity testing which has been completed, the new technology can be identified as a cost or scheduling conflict before completing the rest of the matrices.

• *Environmental Testing*

Environmental testing can be used to determine if the chemical/process is "environmentally safe." By identifying if the chemical/process has been tested, one can foresee the possibility of future environmental regulations.

• *Chemical Reactivity Testing*

By identifying the amount of chemical reactivity testing that has been done, one can see the amount of future necessary chemical reactivity testing that might possibility be needed before the chemical can be qualified for use.

• *Age Sensitivity Testing*

This category includes such areas as shelf-life, extensions of shelf life, viscosity changes over time, age sensitivity of the chemical while on the part, handling, etc. The information requested in this category is not restrictive in the nature of type of age testing; but when considering the extent of age testing for an existing chemical, the same type testing should be evaluated for the considered existing technology.

• *Misc. Testing*

This category includes any other type testing required for this chemical/process that cannot be included in one of the other categories. Again, the same consideration should be taken for testing with the existing technology and the replacement technology.

• *Parts to be Processed (Program Life)*

The program design life for the part and the number of expected parts to be produced during that time should be entered in this space. This allows for judgment of the necessity of finding a replacement technology.

A blank Matrix B is included in Appendix A of this report.

Matrix C

Matrix C is a risk assessment matrix which provides a valuable tool for determination of the critical safety and reliability parts and processes. This matrix is designed to allow the risk of failure of the hardware to perform its function, due to the process change, to be calculated numerically.

The existing targeted chemicals, process, and drawing numbers (from Matrix A) and the possible replacement chemicals and processes with appropriate drawing numbers should be filled in first. A space is provided to check which is "existing" technology and which is "new" technology.

The FMEA # is requested for reference purposes. The FMEA provides a ranking of criticality of the part and process which is given a "weight" or numerical value. This number will be assigned a 1, 3, or 9 for Crit 3, 2, and 1 respectively.

Chemical	Process	Proc #	Criticality	Severity Value
TCA	Vapor Degrease	1-1-1	C1	9

Figure 2

The probability of failure value is determined by weighting the factor of safety and the type inspection(s) performed. The scoring of 6-1 will be given to the Inspections in the order listed in the legend below the evaluation matrix (6 being Visual and 1 being Plug or other hardware specific, destructive test). The Safety Factor should be inverted and multiplied by the Inspection value to get the Probability Value. (See Figure 3.)

Chemical	Process	Inspections	Original S.F.	Probability Value
TCA	Vapor Degrease	NS	9	5/9

Figure 3

The risk evaluation (weight) is determined by multiplying the probability value by the severity value. This matrix might be sent to a risk assessment group.

Chemical	Process	Severity Value	Probability Value	Risk (= P*S)
TCA	Vapor Degrease	9	5/9	5

Figure 4

Again, a blank Matrix C is included in Appendix A.

Concerns

The following categories are the concern categories which are listed separately in the QFD matrix. Each concern category is given a separate matrix for simplification and facilitates the use of particular parts of the entire workbook The format in specifying the chemical/process pairs is the same as Matrix B. The code following each concern is specified by three letters (such as NMH) which are defined in the legend below the evaluation matrix (None, Minimal, High). The highest score is a 9 which in this case corresponds to "None". The lowest is 1 which corresponds to "High". If the question is not applicable then place a check mark in that box noting it was recognized as unnecessary. If the criteria described in the explanation can be rewritten to better evaluate the process, then make a note of the change in the explanation and use the updated criteria for ALL of the chemical/process pairs that are to be evaluated.

Each new process and chemical will be "scored" for each concern listed in Matrices D through J. Each "score" will be shown as most positive, neutral, or negative (or blank for no relation). Matrices D through J will also allow the concerns to be weighted for importance. These weighted factors will need to be considered in the final prioritization calculations. Additional information such as risk factors for part failure and technical maturity of the chemical and process will be used when trade-offs become necessary. These data will be evaluated using QFD methodology.

Appendix A includes example Matrices for use as guides in completing the prioritization process.

Matrix D

Matrix D addresses the chemical concerns for the existing and replacement technologies. Again this can be used alone or as a part of the QFD matrix. This matrix should give the user a firm understanding of how the chemical acts or reacts during its shelf life or use. An environmental engineering group and/or manufacturing should complete this matrix.

Matrix E

The process concerns deal with the way that a chemical acts or reacts during a process application. An environmental engineering group and/or manufacturing should complete this matrix.

Matrix F

Matrix F considers the regulatory impacts on a chemical/process. When completing this part of the matrix, one should consider the known dangers (i.e. known phase-out and reduction plans) when rating a chemical/process on meeting the laws. The regulatory concerns consider how OSHA requirements, federal, state, local environmental laws and regulations affect chemicals and processes. Sections of this matrix might be completed by safety, legal, and environmental management personnel.

Matrix G

The safety concerns are worker exposure, spill response, fire response, and explosion response. Sections of this matrix might be completed by safety, legal, and environmental management personnel.

Matrix H

The environmental concerns consider how chemicals impact the program environmentally. Sections of this matrix might be completed by safety, legal, and environmental management personnel.

Matrix I

The cost concerns evaluate how cost will deviate with the replacement of current technologies. This matrix might be completed by the project or program office (or their support personnel).

Matrix J

The scheduling concerns delineate how scheduling requirements will be met with respect to Environmental Regulations and NASA program schedules. This matrix might be completed by the project or program office (or their support personnel).

QFD APPLICATION

The QFD matrix will be completed by the project office or program manager. The basic QFD format is shown in Figure 5.

QFD Format

Process Relationships

Concerns	Weighting	Process #1	Process #2	Process #3	Process/Chemical →
Regulatory	20	125	67		
Safety	14	78	101		
Process	12	55	40		
					Concern/Processes Relationships
Trade Offs		•	•		
Risk		•	•		
Technical Maturity		•	•		
Importance Rating		456	300		

Figure 5

The QFD Matrix is quite easy to understand if it is approached one step at a time. In the case of the chemical replacement, first list the customer (NASA or Contractor) concerns vertically on the left. Then list each chemical/process, old and new, horizontally. The relationship of each concern to each chemical/process is then rated on a scale of 1 - weak, 3 - medium, and 9 - strong. Next, a weighting factor is given to each concern. That is, on a scale of 1 to 20 in this case, assign a number rating the *importance* of each concern. To get the overall rating of each chemical/process, multiply the weighting factor times the relationship rating for each process to concern and sum the total down the page.

	Weighting Factor	Chemical/ Process #1	Chemical/ Process #2	Chemical/ Process #3
Concern 1	10	3	9	1
Concern 2	15	1	9	3
Concern 3	12	9	1	9
Overall Rating		153	237	163

Figure 6

Example: Chemical/process #1 would have an overall rating of (10 * 3) + (15*1) + (12*9) = 30 + 15 + 108 = 153. Chemical/process #2 would be (10 * 9) + (15 * 9) + (12 * 1) = 90 + 135 + 12 = 237. Chemical /process #3 would be (10 * 1) + (15 * 3) + (12 * 9) = 10 + 45 + 108 = 163. This methodology would rank #2 as the "better" alternative of the three.

The "roof" at the top of the matrix simply shows how strong the chemicals/processes relate to each other. This knowledge can applied when trade-offs become necessary. In fact, the QFD Matrix can include several different entries that could be included in trade-off studies. The Chemical Replacement Prioritization Methodology applies only a limited use of the QFD capabilities.

Since this methodology is used as a guideline for comparison for replacement technology, it should be noted that there are times when a full QFD evaluation should not be performed. The times that the QFD evaluation is not recommended are:

- when another tool or system is more applicable, such as when decision, risk analysis, or analytical process models are all that are needed
- there is not enough time or resources to do it *RIGHT*
- critical elements of the process are missing (i.e. customer feedback).

In these cases, one should consider using the most relevant matrices to assist in making judgment on replacement technology.

WEIGHTING

For each type of process, the weighting factors will vary (i.e. the weights for precision cleaning may differ from those in foam blowing).

Therefore a QFD weighting application is enclosed as Matrix K. This weighting box allows the concerns to be weighted against each other. The number in the box represents the score of that concern versus each of the other concerns. The more important concerns should be represented by higher numbers. The matrix can be expanded to weight any category or all of the concerns together. For each category, the weights should be normalized by dividing the weight by the # of concerns. A blank weighting worksheet (Matrix K) is included in Appendix A.

SCORING

Depending on the type of application, the scoring will be slightly different. If only part of the matrix packet is used then the weights should be multiplied by the number corresponding to that code. The total of these numbers is the "score" for that process. If the entire matrix packet is to be used as a QFD exercise, then for each of the concern matrices (D-J) the "score" should be determined as before by multiplying the weight by the number corresponding to the code then each concern category should be normalized by dividing by the total number of concerns in that category.

- Matrix A carries no numerical weight.

- Matrix C "scores" should be multiplied by 100 and added to the total from the concerns if using the QFD matrix as a prioritization tool or subtracted from the total if it is used as a replacement technology comparison tool.

- If the matrix packet is to be used as a comparison between alternate replacement chemicals/processes, then the percentage of testing completed as compared to the current technology (from Matrix B) should be determined for each category of tests. The total of these numbers should be added to the accumulated numbers. If the matrix packet is to be used to determine the ranking of "urgency" then this chart could be used as a reference to show the technical maturity of the existing technology. This chart does not necessarily need to be completed if it is to be used for this type of application.

CONCLUSION

Prioritization and Determination for Selection

The objective of this work was the development of a quantitative procedure for determination and ranking of replacement technologies and associated issues. The QFD matrices are designed to produce a numerical "importance" value. If the QFD matrix is completed, the final total will be the importance value. The higher number corresponds to the "higher priority" or "better selection" chemical/process -- depending on the application.

Several agencies have requested copies of this prioritization methodology workbook in its entirety; this includes several NASA offices, NASA contractors, Department of the Navy, Army representatives, university representatives, private consultants, and the US Environmental Protection Agency. At this point the feed back has been very positive from those that have reviewed the document. NASA contractors have actively used parts/variations of this methodology. Thiokol has used this method to determine the type of cleaner and process to be used for cleaning solid rocket motor parts. They also used parts of Matrix A and C to rank the importance (according to risk) of each use of the current cleaner. Martin Marietta has used parts of this methodology for work done in the TPS Materials Research Laboratory at Marshall Space Flight Center. Other feedback has been less specific, however, this publication has been recommended by the Commonwealth of Virginia Department of Environmental Quality and has been made available through the technical assistance library in that area.

MAPTIS (Materials and Processes Technical Information System) is a Marshall information system containing a working prioritization data base. The data base can be found within the NEIS (NASA Environmental Information System), which is a part of MAPTIS. The data base was designed to be "user friendly." It allows the users to select from the concerns listed in matrices D through J, or input another category and the concerns associated with that category. The data base, when told to process, will automatically normalize the weights and do all other necessary math calculations to get the overall score for each chemical/process pair. The data base will also allow the user to printout (on screen or hard copy) the individual scores, the category scores, or the overall scores for each chemical/process. The only matrices not included on this data base are the technical maturity and the risk assessment which are generally used for trade-off comparison and usually need to be done separately for other reasons.

For questions concerning the Prioritization Methodology or to receive a complete copy of this publication, contact:

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Appendix A

Matrix A - Chemicals and Uses For Prioritization Methodology

Chemical	Chem # (Registry #)	Chem # (Reference #)	Material	Process	Part/Component/Subsystem	Surface	Proc # (Reference)	Proc Step #	Total Process Steps (#)	Reference # (tracable to FMEA)	Amount Used In Process (lb/yr)

Matrix B - Technical Maturity of Substutite For Prioritzation Methodology

Chemical	Chem #	Process	Proc #	New	Old	Years of Existence	Toxicity Testing		Environmental Testing		Chemical Reactivity Testing			Age Sensivity Testing (shelf-life & aging)				Misc.Testing		# of parts to be processed (Program Life) -- old and new
							#	Type	#	Type	#	Results	Type	# Samples	Shelf Life	Type	Ext.	#	Type	

Appendix A

MATRIX C - Risk of System Failure

								Severity (S)		Probability (P)				
Chemical	Chem #	Process	Proc #	New	Old	Part/ Component/ Subsystem #	FMEA # (Ref.)	Criticality	Severity Value	Inspections	Original S.F.	Anticipated S.F.	Probability Value	Risk (= P*S)

	Inspections:		
6	V = Visual	3	W = Witness Panel
5	NS = NDE (UT, X-Ray, ect...)	2	WT = Witness Panel -- Tested
4	LC = LOX Cleanliness (NVR, Other)	1	P = Plug Test

Appendix A
Example Matrices D and E -- Chemical and Process Concerns

Weighting Factors to be Inserted Here →
1 - Less Important 20 - More Important

* NOTE: Either Numbers, Letters, or Symbols can be used to comple the Matrices.

Chemical Concerns

Chemical	Chem #	Process	Proc #	New	Old	# of Sources	Limited Resources for Manufacturing (NMH)	Availability (EMB)	Stability (Storage) (GFP)	Flammability (NMH)	Drying Ability (GFP)	Base Meterial Compatibility (GFP)	Toxicity (NMH)	Flash Point (NMH)	Ease of Maintenance (GFP)	Historical Data Base (CPN)	Desirable Reactivity (GFP)	Undesirable Reactivity (NMH)	Lot-to-Lot Variability (NMH)	Age Sensitivity - Processed Part (NMH)	Shelf Life (EMB)
TCA	1	V. D. - Final of Large metal part	1-1-1		X	2	N	B	G	H	G	G	M	H	G	C	/	N	N	N	M
Aqueous Soap	R1	Pressure Spray in Air - Large Metal Part	1-1R1-1	X		1	N	M	G	N	P	G	M	N	G	P	/	M	N	M	M
Terpene	R2	Aggitated Immersion	1-1R2-1	X		1	9	3	9	9	1	9	3	3	9	1	/	3	1	1	3

Process Concerns

Chemical	Contaminants Removed: # Req.	Contaminants Removed: # Produced	Process Steps: #	Process Steps: Δ Increase/Decrease	Parts Processed at One Time: #	Parts Processed at One Time: Δ Increase/Decrease	Req. Surface Prep.: Time	Req. Surface Prep.: Δ Increase/Decrease	Bondline Thickness: # Req.	Bondline Thickness: # Produced	Process Time (Δ)	Process Interaction (#)	Process Interaction (GFP)	Bond Strength Requred (EMB)	Operator Sensitivity (NMH)	Lot-to-Lot Variability (NMH)	General Cleaning Ability(GFP)	Surface Requirement (EMB)	Useful Life of Replacement Processed Parts (EMB)	Damage caused by Process (NMH)
TCA	?	-1	1	0	1	0	1m	0	/	/	0	1	G	/	N	M	G	M	M	M
Aqueous Soap	?	0	3	2	1	0	1m	0	/	/	-1	1	F	/	N	M	G	M	M	M
Terpene	?	-2	2	1	1	0	1m	0	/	/	-1	1	9	3	9	1	3	3	3	3

9	Exceeds (E)	Good(G)	None (N)	Complete (C)
3	Meets (M)	Fair (F)	Minimal (M)	Partial(P)
1	Below (B)	Poor (P)	High (H)	None (N)

Appendix A

Example of Matrices E - J -- Regulatory, Safety, Environmental, Cost, and Scheduling Concerns

Weighting Factors to be Inserted Here
1 - Less Important 20 - More Important

Chemical	Chem #	Process	Proc #	New	Old	Regulatory Concerns: OSHA Requirements (EMB)	State Environmental Laws (EMB)	Local Environmental Laws (EMB)	Federal Environmental Requirements (EMB)	Future Federal Regulations (EMB)	Safety Concerns: Worker Exposure Limits (NMH)	Spill Response Plans (CPN)	Fire Response Plans (CPN)	Explosion Response Plans (CPN)
TCA	1	Vapor Degrease	1-1-1		x	3	1	1	1	1	3	3	3	9
Aqueous Soap	1R	Spray in Air	1-1R1-1	x		3	3	3	9	9	3	3	9	9

Chemical	Environmental Concerns: Clean Air Monitoring (EMB)	Pollution Prevention (CPN)	Toxic Emissions (NMH)	Emissions Control (GFP)	Ozone Depletor Potential (NMH)	Chemical Storage Availability (CPN)	Resource/Ingredient Recovery and Recycling (CPN)	Hazardous Waste Management (EMB)
TCA	1	9	9	1	1	9	9	3
Aqueous Soap	9	9	3	9	9	9	3	3

Chemical	Cost Concerns: Labor $ (DNI)	Operations $ (DNI)	Facilities $ (DNI)	Materials $ (DNI)	Chemical $ (DNI)	Other Hardware $ (DNI)	Contracts $ (DNI)	Change of Specifications $ (DNI)	Specification Verification $ (DNI)	Change of Drawings $ (DNI)	Development of Procedure $ (DNI)	Waste Management $ (DNI)	Emissions Control Testing $ (DNI)
TCA	3	2	1	3	2	3	2	3	3	3	2	3	3
Aqueous Soap	2	2	2	3	6	3	2	2	1	2	2	3	3

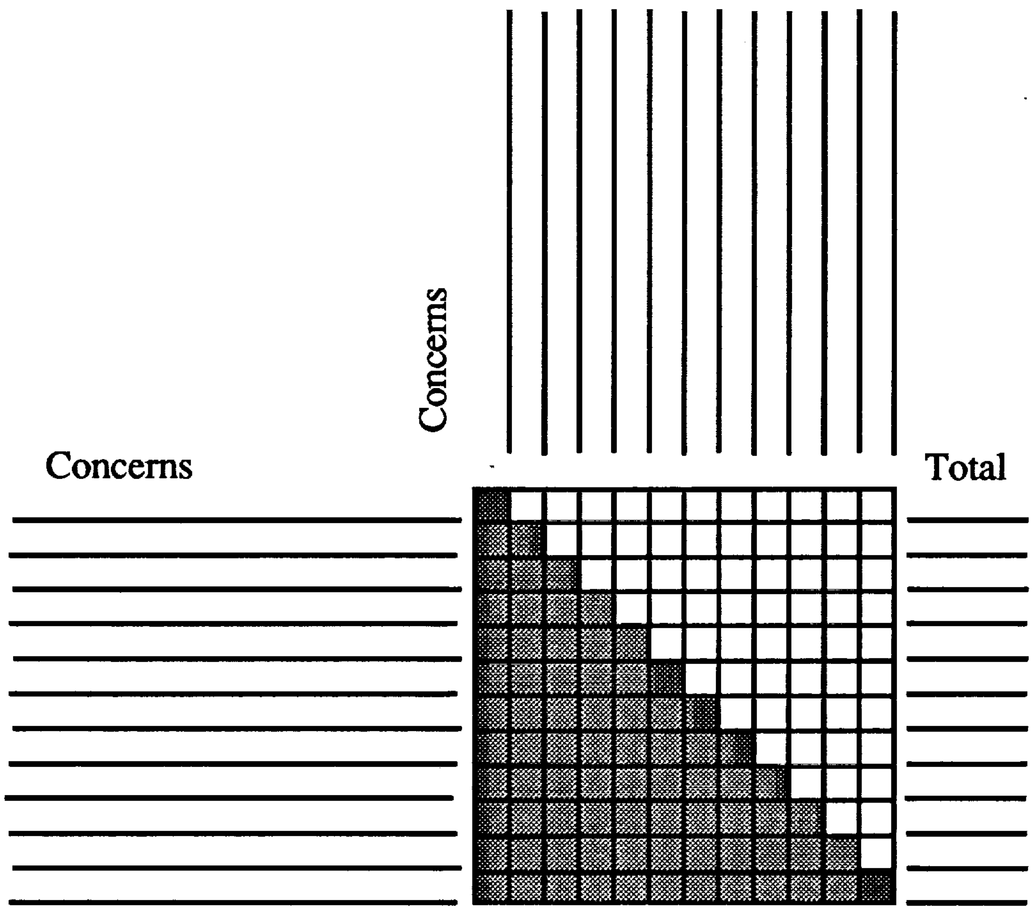
Chemical	Scheduling Concerns – Federal, State, and Local Regulations: Research (EMB)	Trade Studies (EMB)	Modification in Planning (EMB)	Specification Documentation (EMB)	Drawing/Design Changes (EMB)	Production Time (EMB) (New Equip.)	Testing (EMB)	Vendor Selection & Certification (EMB)
TCA	9	9	9	3	9	3	3	3
Aqueous Soap	9	9	3	3	3	9	3	3

Chemical	Scheduling Concerns – Present Program Schedule: Research (EMB)	Trade Studies (EMB)	Modification in Planning (EMB)	Specification Documentation (EMB)	Drawing/Design Changes (EMB)	Production Time (EMB) (New Equip.)	Production Time $ (EMB) (Hardware Avail)	Testing (EMB)	Vendor Selection & Certification (EMB)
TCA	9	9	9	3	9	9	9	9	9
Aqueous Soap	9	9	1	1	3	3	1	3	3

9	Large Decrease (D)
6	Slight Decrease (D)
3	No Change(N)
2	Slight Increase (I)
1	Large Increase (I)

9	Exceeds (E)	Good(G)	None (N)	Complete (C)
3	Meets (M)	Fair (F)	Minimal (M)	Partial(P)
1	Below (B)	Poor (P)	High (H)	None (N)

Appendix A
Matrix K -- Weighting Worksheet



1 = Less Important
20 = More Important

NOET - Prioritization for Chemical Replacement

COMPLIANCE STRATEGIES